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Presenter Forum

All contributions which are not featured within the Discussion Sessions will be scheduled for small-group discussions with the presenter and interested participants during two "Presenter Forum" sessions. The "Presenter Forum" - is scheduled for two time slots.

Presenters are expected to be online, in both sessions, and ready to discuss their contributions, with participants from all time zones.

We use the remo tool for that. Here you get an idea: https://www.youtube.com/watch?v=P01JxUBNU2Y
Each contribution will be assigned a virtual "table" for up to 5 visitors (in a meeting "room", on a "floor", in a "building") with a whiteboard where posters, slides and papers can be shown and discussed.

16 July | 18:00 – 19:30 (Berlin Time) | Friday
19 July | 12:00 – 13:30 (Berlin Time) | Monday

Presenter Forum Hall 1

Table Number	**1 - 131**
Branch	**CRI**
Session I – Friday	https://live.remo.co/e/icrc-presenter-forum-1-hall-1
Session II – Monday	https://live.remo.co/e/icrc-poster-hall-12

Presenter Forum Hall 2

Table Number	**132 – 254**
Branch	**GAI**
Session I – Friday	https://live.remo.co/e/icrc-presenter-forum-1-hall-2
Session II – Monday	https://live.remo.co/e/icrc-poster-hall-12-copy

Presenter Forum Hall 3

Table Number	**255 – 387**
Branch	**GAD | MM | NU**
Session I – Friday	https://live.remo.co/e/icrc-presenter-forum-1-hall-3
Session II – Monday	https://live.remo.co/e/icrc-poster-hall-32

Presenter Forum Hall 4

Table Number	**388 – 510**
Branch	**CRD | SH**
Session I – Friday	https://live.remo.co/e/icrc-presenter-forum-1-hall-4
Session II – Monday	https://live.remo.co/e/icrc-poster-hall-42

Presenter Forum Hall 5

Table Number	**511 – 594**
Branch	**Exhibition | DM | O&E**
Session I – Friday	https://live.remo.co/e/icrc-presenter-forum-1-hall-5
Session II – Monday	https://live.remo.co/e/icrc-poster-hall-52-copy

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Presenter Forum

1 Table Number

Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-1
Access Monday Session https://live.remo.co/e/icrc-poster-hall-12

Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The Upgrade of Horizon-T Detector

Presenter
Dmitriy Beznosko
Author and Co-Author
Dmitriy Beznosko

Abstract
'The Horizon-T experiment is located at the elevation of 3346 m above sea level near the city of Almaty, Republic of Kazakhstan. A thorough comparison of the spatial and temporal characteristics of charged components of Extended Air Showers (EAS) with delayed particles with the simulated EAS using CORSIKA simulation package has been conducted using the selection from the experimental data set of events with two pulses recorded by a detector at ~600 m distance from axis [1]. This comparison has shown that events with delayed particles cannot be described within existing simulation models.\r\n\r\nThe significance of these results prompted the upgrade of the Horizon-T experiment. New points have been added at the ~600m to enhance data at that distance. Fast glass-based detectors have been added to the detector center point for accurate measurements of the pulse widths with radiative material layer option. This poster covers these upgrades and the latest data statistics from the new Horizon-T detector from the physics run 2020-2021.\r\n\r\n[1] Rashid Beisembaev, et al., 2019. “Extensive Air Showers with Unusual Spatial and Temporal Structure.” In EPJ Web Conf., 208: Pp. 06002.'

Collaborations
other (fill field below), Horizon-T
Keywords and Comments
upgrade, Horizon-T, cosmic rays, TSHASS, detectors, Dmitriy Beznosko'For the Horizon-T collaboration'

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2 **Table Number**

Access Friday Session	https://live.remo.co/e/icrc-presenter-forum-1-hall-1
Access Monday Session	https://live.remo.co/e/icrc-poster-hall-12
Branch	CRI | Cosmic Ray Indirect
Subcategory	Experimental Methods & Instrumentation

Titel
Study of the energy spectrum of cosmic rays obtained at the Hadron 55 installation located at an altitude of 3340 m.

Presenter
Tleu Berdykhalyk
Author and Co-Author
Tleu Berdykhalyk | Bakhtiyar Iskakov | Yernar Tautayev | Turlan Sadykov | Dmitriy Besnosko | A.kh. Argynova | V.V. Zhukov | O.A. Novolodskaya | V.V. Piscal | V.A. Ryabov | Zh.T. Sadykov | N.M. Salikhov | A.S. Serikkanov

Abstract
'The complex installation "Hadron-55" is one of the installations of the Tien-Shan high-mountain scientific station. The installation consists of two blocks spaced 2.2 meters apart. Upper unit - gamma block comprises two rows of ionization chambers arranged in mutually perpendicular directions. This block is used in determining the energy of electron-photon component and in conjunction with all detectors determines the trajectories of particles. At the level of the gamma block, scintillation detectors are installed on an area of 350 m2. The lower unit consists of six rows of ionization chambers containing iron absorber. This unit is used to measure the energy of the neutral and charged components of cosmic radiation, as well as to determine the trajectory of particles. In this work, a brief description of the installation and calculation of the energy spectrum of cosmic rays, obtained by experimental data installation. In addition, the daily variation of cosmic ray energy is processed, which is planned to be used in the future for a new experiment on monitoring seismically dangerous zones.'

Collaborations

Keywords and Comments
gamma, hadron, installation, energy, cosmic ray, spectrum, Tleu Berdykhalyk''

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4 Table Number

Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-1
Access Monday Session https://live.remo.co/e/icrc-poster-hall-12

Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The Electron-Neutron Detector Array (ENDA), Status and Coincidence with LHAASO

Presenter
Bingbing Li
Author and Co-Author
Liqiao Yin | Bingbing Li | Tianlu Chen | Dixuan Xiao | Cong Shi | Oleg Shchegolev | Vladimir Stepanov | Denis Kuleshov | Liangwei Zhang | shuwang Cui | Xinhua Ma | Luobu Danzeng | Maoyuan Liu | Fan Yang | Yuri StenKin

Abstract
'Hadrons are the “skeleton” of extensive air shower (EAS). They possess favorable information concerning the cosmic ray components and energy. The electron-neutron detector (EN-detector) can detect both electrons and thermal neutrons generated by EAS hadrons in surrounding matter. The electron-neutron detector array (ENDA) was proposed to add into the LHAASO project to improve its capability of EAS hybrid detection. Up to present 64 EN-detectors have been produced and are running in China. In 2018, a cluster (of 16 EN-detectors) was installed at Yangbajing (YBJ), Tibet. In 2019, another cluster so called ENDA-16-HZS was installed in LHAASO at Haizishan (HZS), Daocheng, Sichuan. Besides, 2 clusters are tested at Hebei Normal University (HNU), Shijiazhuang, Hebei. ENDA-16-HZS is running normally and get amount of EAS events at energy above 100 TeV. Moreover, a number of coincident events between ENDA and the LHAASO electron detector (ED) and muon detector (MD) arrays composed the KM2A, as well as Cherenkov detectors WFCTA and WCDA are obtained. The events with cores falling into ENDA were selected. The ED array and ENDA accurately offers the EAS directions and the core positions respectively. Both the lateral distributions of neutrons, electrons and muons and the longitudinal development of atmospheric Cherenkov lights are effectively sampled. A hybrid detection of EAS including thermal neutrons, electrons, muons and Cherenkov lights can provide a strong capability of cosmic nuclei discrimination as well as energy measurement with high resolution. In this report, the status of the clusters at the different places are summarized, and the preliminary results of coincident events between ENDA and the LHAASO array are presented.'

Collaborations
Lhaaso,

Keywords and Comments
, Bingbing Li''

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5 **Table Number**

Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-1
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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Time calibration of the LHAASO-WCDA detectors with small shower events

Presenter
Jinyan Liu
Author and Co-Author
Jinyan Liu | Min Zha | Zhiguo Yao

Abstract
'The LHAASO (Large High Altitude Air Shower Observatory) is a multi-purpose experiment for measuring the high energy gamma rays and cosmic rays. One of the major detectors is the 78,000 m^2 WCDA (Water Cherenkov Detector Array), equipped with 3120 PMTs, which aims to survey the gamma-ray sky continuously in a wide energy range, from 100 GeV to 30 TeV. Precisely calibrating the time offsets of every detector cells is essential to obtain a good angular resolution for observing the gamma ray sources. Dividing the detector into many overlapped regions and fitting shower fronts in small regions, the shower curvature influence turns negligible, and the edge effect of the detector array can be elegantly solved. This time calibration method and the calibration results are presented in the talk.'

Collaborations
Lhaaso,

Keywords and Comments
Time calibration, Jinyan Liu''

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6 Table Number

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Telescope Array Cloud Ranging Test

Presenter
Takeshi Okuda
Author and Co-Author
Takeshi Okuda | For the Telescope Array Collaboration.

Abstract
'The Telescope Array (TA) experiment detects air-showers induced by ultra high energy cosmic rays. The TA atmospheric Fluorescence telescopic Detector(TAFD) observes cosmic ray airshower, which is incident very far from the telescope. The observation does not take place in overcast night. However, the cloud status changes quickly and sometimes there are some isolated clouds. If the cloud is behind the airshower as viewed from the TAFD, the cloud presents no problem for airshower reconstruction. However if the cloud obscures the airshower, it does create a problem for airshower reconstruction. The problematic event can be rejected by airshower profile at reconstruction. However, the estimation of exposure with isolated cloud is difficult. And it should be affected more at higher energy event with relatively further from the telescope, which is lower statistics and more important for the ultra high energy cosmic ray physics. Therefore, to test the method for evaluating the correction of exposure, we installed stereo cloud cameras near one of FD sites. I report the status of the study of the Telescope Array Cloud Ranging Test.'

Collaborations
Telescope Array,
Keywords and Comments
Airshower, Fluorescence Detector, Cloud, Takeshi Okuda"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Mass composition compatibility test using $X_{\rm max}$ distributions recorded by the Pierre Auger and Telescope Array Observatories

Presenter
Nicusor Arsene
Author and Co-Author
Nicusor Arsene

Abstract
'In this paper we infer the mass composition of the ultra high energy cosmic rays (UHECRs) from measurements of $X_{\\rm max}$ distributions recorded at the Pierre Auger (2014) and Telescope Array (TA) (2016) Observatories, by fitting them with all possible combinations of Monte Carlo (MC) templates from a large set of primary species (p, He, C, N, O, Ne, Si and Fe) as predicted by EPOS-LHC, QGSJETII-04 and Sibyll 2.1 hadronic interaction models. We use the individual fractions of nuclei reconstructed from one experiment in each energy interval to build equivalent MC $X_{\\rm max}$ distributions which we compare with the experimental $X_{\\rm max}$ distributions of the other experiment, applying different statistical tests of compatibility: Kolmogorov - Smirnov (KS), Anderson – Darling (AD) and $p-value$ as goodness of fit.\r\nThe results obtained from both experiments confirm that the mass composition of the UHECRs is dominated ($\\gt 70\\%$) by protons and He nuclei on the entire energy spectrum. The indirect comparisons between the $X_{\\rm max}$ distributions recorded by the two experiments show that the two data sets are not compatible to each other on the entire energy range $\\lg E (\\rm eV) = [18.2 - 19.0]$. We obtain very low probabilities of compatibility ($< 10^{-5}$) especially at lower energies but becoming increasingly large around and above the \\textit{ankle} ($\\lg E (\\rm eV) \\sim 18.7$), obtaining excellent agreement in some high energy intervals.'

Collaborations
Keywords and Comments
mass composition, fitting fractions of X_{max} distributions, Nicusor Arsene"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Radio-Morphing: a fast, efficient and accurate tool to compute the radio signals from air-showers

Presenter
Simon Chiche
Author and Co-Author
Simon Chiche Olivier Martineau | Kumiko Kotera | Krijn de Vries | Matías Tueros

Abstract
'The preparation of next generation large-scale radio detectors such as GRAND requires to run massive air-shower simulations to evaluate the radio signal at each antenna position. Radio-Morphing was developed for this purpose. It is a semi-analytical tool that enables a fast computation of the radio signal emitted by any air-shower at any location, from the simulation data of one single reference shower at given positions. Radio-Morphing was demonstrated to generate the electric field time traces with amplitudes in good agreement (<30% difference for two thirds of signals) with microscopic simulations, while reducing the computation time by several orders of magnitude. However, several features still needed to be addressed for the tool to be fully efficient and accurate. We present here major improvements on the Radio-Morphing method that have been implemented recently. The upgraded version is based on revised and refined scaling laws, derived from physical principles. It also includes a new spatial interpolation technique, thanks to which an excellent signal timing accuracy can be reached. We will present the methodology, performances and possible applications of this universal tool.'

Collaborations
Keywords and Comments
Air-shower, numerical simulations, radio-signal parametrization, radio-detection, Simon Chiche"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
LOgging UnifieD for ASTRI Mini Array

Presenter
Alessandro Costa
Author and Co-Author
Alessandro Costa | Kevin Munari | Federico Incardona Pietro Bruno | Alessandro Grillo | Stefano Germani | Eva Sciacca | Gino Tosti | Joseph Schwarz | Fabio Vitello | Giuseppe Tudisco

Abstract
'The ASTRI (Astrofisica con Specchi a Tecnologia Replicante Italiana) Mini-Array project is a wide international effort led by the Italian National Institute for Astrophysics aiming at operating an array of nine ASTRI Cherenkov telescopes. The Mini-Array will operate in the energy range 1-100 TeV and beyond and will be dedicated to very high-energy gamma ray astrophysics and optical intensity interferometric observations of bright stars. It will be installed at the site of the Teide Observatory in Tenerife (Spain).\r\nThe core of the ASTRI Mini-Array is the Supervision Control and Data Acquisition (SCADA), the hardware and software system monitoring and controlling all the operations carried out at the ASTRI Mini-Array site. \r\nLOUD the LOgging UnifieD system is one of the main components of SCADA. LOUD is the subsystem that provides the service tailored to gather, filter, expose and persist log events collected by all the array devices and assemblies (telescopes, LIDAR etc.). We present here its architecture and the software stack explicitly designed for distributed computing environments employing Internet of Things technologies.'

Collaborations
other (fill field below), ASTRI
Keywords and Comments
astri, astri-ma, monitoring, logging, alarms, Alessandro Costa"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Zenith Angle Distribution of Incoherent Cosmic Ray Muon Flux Using CREDO Smartphones

Presenter
Tadeusz Wibig
Author and Co-Author
Tadeusz Wibig | Michał Karbowiak | for the CREDO Collaboration

Abstract
'The Cosmic-Ray Extremely Distributed Observatory (CREDO) was established to detect and study ultra high-energy cosmic ray particles. In addition to making use of traditional methods for finding rare and extended cosmic ray events such as professional-grade EAS arrays, as well as educational ‘class-room’ detectors, CREDO also makes use of cameras in smartphones as particle detectors. Beyond the primary scientific goal of the CREDO project, to detect Cosmic Ray Ensembles, is the equally important educational goal of the project. To use smartphones for EAS detection, it is necessary to demonstrate that they are capable of effectively registering relativistic charged particles.\r\nIn this paper we have shown that the distribution of the zenith angle of particles responsible for the emergence of tracks in the smartphone captured images is in agreement with the expected distribution of the zenith angle of single, incoherent, cosmic ray muons. It is difficult, if not impossible, to imagine different mechanisms leading to such a distribution, and we believe it clearly demonstrates the suitability of smartphone-based detectors in supporting the more traditional cosmic ray detectors. We confirm the idea that smartphones can operate in practice as ’particle pocket detectors’, sensitive to charged relativistic cosmic particles and hence can be used effectively by the CREDO Project and other similar initiatives.'

Collaborations
, Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
particle detection, incoherent muons, zenith angle distribution, Tadeusz Wibig'The main results covered by this article will be summarised in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Study Anti-correlation between Neutron Detection Efficiency of the Electron-Neutron Detector Array (ENDA) and Soil Moisture

Presenter
Cong Shi
Author and Co-Author
Yuri Stenkin | Cong Shi | Dixuan Xiao | Mao-Yuan Liu | Oleg Shchegolev | Luobu Danzeng | Denis Kuleshov | Bing-Bing Li | Tian-Lu Chen | Liangwei Zhang | Vladimir Stepanov | Shu-Wang Cui | Fan Yang | Xin-Hua Ma

Abstract
'The measurement of thermal neutrons generated by cosmic ray extensive air showers (EAS) on the Earth’s surface provides a new method for studying the composition and energy of cosmic rays with energy in the so-called “knee” region. A new type of thermal neutron detector prototype array was installed in LHAASO, Haizishan, Daocheng, Sichuan, China. The array consists of 16 electron-neutron detectors (EN-detectors), so called ENDA-16-HZS, which utilize a new type scintillator based on a compound alloy of ZnS(Ag) and B2O3 with natural boron.\r\nAccording to our previous paper about the performance of EN-detectors in Yangbajing, Tibet, during the period from August 2019 to January 2020, the number of neutrons in periods of rain season is significantly (~10%) lower than that in periods of dry season. In order to quantify the anti-correlation between neutron detection efficiency and soil moisture, we adopts WKTSH1920-4G version of soil moisture meter. It works in frequency domain reflection (FDR) principle. With 4G network interface, the collected data can be uploaded to the TLINK cloud in real time, and users can obtain temperature and humidity data. Five soil moisture meters have been successfully installed at different depths inside ENDA-16-HZS in August 2020. By analyzing the data in September 2020, it is demonstrated that neutron detection efficiency of EN-detector is negatively correlated with soil moisture. The obtained anti-correlation parameters are beneficial for correction of neutrons detected in EAS events and then reduction of systematic uncertainties in the final energy spectrum recovering of different primary cosmic ray components.'

Collaborations
Lhaaso,

Keywords and Comments
, cong shi"

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12 Table Number

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Updates from the OVRO-LWA: Commissioning a Full-Duty-Cycle Radio-Only Cosmic Ray Detector

Presenter
Kathryn Plant
Author and Co-Author
Kathryn Plant | Andres Romero-Wolf | Washington Rodrigues de Carvalho | Konstantin Belov | Gregg Hallinan

Abstract
'The Owens Valley Radio Observatory- Long Wavelength Array (OVRO-LWA) in Eastern California is currently undergoing an expansion to 352 dual-polarization antennas and new signal processing infrastructure. The upgraded array will operate a full-duty-cycle cosmic ray detector simultaneously with a variety of radio astronomy observations. Expanding the methods introduced in a previous demonstration, this detector will operate on the radio signals alone to trigger data capture, identify cosmic rays in the presence of radio-frequency interference (RFI), and reconstruct the air shower properties: energy, direction, and Xmax. When fully commissioned, the OVRO-LWA will observe thousands of cosmic rays per year at energies 10^17-10^18 eV and will constrain the cosmic ray composition across the cosmic ray spectrum’s second knee with a typical Xmax precision of <20g/cm^2 per air shower, thereby offering new composition information across the energy limits of Galactic accelerators. Commissioning for the OVRO-LWA is ongoing and is planned for completion in late 2021. I will present the trigger design, RFI flagging strategy, and a progress update from early commissioning.'

Collaborations

Keywords and Comments
radio, airshowers, Kathryn Plant"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Reconstructing inclined extensive air showers from radio measurements

Presenter
Tim Huege
Author and Co-Author
Tim Huege | Felix Schlüter

Abstract
'We present a reconstruction algorithm for extensive air showers with zenith angles between 65° and 85° measured with radio antennas in the 30-80 MHz band. Our algorithm is based on a signal model derived from CoREAS simulations which explicitly takes into account the asymmetries introduced by the superposition of charge-excess and geomagnetic radiation as well as by early-late effects. We exploit correlations among fit parameters to reduce the dimensionality and thus ensure stability of the fit procedure. Our approach reaches a reconstruction efficiency near 100% with an intrinsic resolution for the reconstruction of the electromagnetic energy of well below 5%. It can be employed in upcoming large-scale radio detection arrays using the 30-80 MHz band, in particular the AugerPrime Radio detector of the Pierre Auger Observatory, and can likely be adapted to experiments such as GRAND operating at higher frequencies.'

Collaborations

Keywords and Comments
extensive air showers, radio detection, reconstruction algorithms, Tim Huege''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Estimation of aperture of the Tunka-Rex radio array for cosmic-ray air-shower measurements

Presenter
Vladimir Lenok
Author and Co-Author
Vladimir Lenok | for the Tunka-Rex Collaboration

Abstract
'The recent progress in the radio detection technique for air showers paves the path to future cosmic-ray radio detectors. Digital radio arrays allow for a measurement of the air-shower energy and depth of its maximum with a resolution comparable to those of the leading optical detection methods. One of the remaining challenges regarding cosmic-ray radio instrumentation is an accurate estimation of their efficiency and aperture. We present a probabilistic model to address this challenge. We use the model to estimate the efficiency and aperture of the Tunka-Rex radio array. The basis of the model is a parametrization of the radio footprint and a probabilistic treatment of the detection process on both the antenna and array levels. In this way, we can estimate the detection efficiency for air showers as function of their arrival direction, energy, and impact point on the ground. In addition, the transparent internal relationships between the different stages of the air-shower detection process in our probabilistic approach enable to estimate the uncertainty of the efficiency and, consequently, of the aperture of radio arrays. The detail of the model and its application to the Tunka-Rex data will be presented in the contribution.'

Collaborations
other (fill field below), Tunka-Rex
Keywords and Comments
, Vladimir Lenok"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
A reconstruction procedure for very inclined extensive air showers based on radio signals

Presenter
Valentin Decoene
Author and Co-Author
Valentin Decoene Olivier Martineau | Matias Tueros | Simon Chiche

Abstract
'Very inclined extensive air showers, with both down-going and up-going trajectories, are particularly targeted by the next generation of extended radio arrays, such as GRAND. However, the reconstruction of their\xa0incoming\xa0direction,\xa0core position, primary energy and composition, remains underdeveloped.\r\n\r\nTowards that goal, we present a new reconstruction procedure based on the arrival times and the signal amplitudes, measured at each antenna station. This hybrid reconstruction method, harness the fact that the emission is observed, at the antenna level, far away from the emission region, thus allowing for a point-like emission description. Thanks to this assumption, the arrival times are modelled following a spherical wavefront emission, which offers the possibility to reconstruct the radio emission zone as a fixed point along the shower axis. From that point the amplitude distribution at the antenna level is described through an Angular Distribution Function (ADF) taking into account at once all geo-magnetic asymmetries and early late effects as well as additional signal asymmetries featured by very inclined extensive air showers. This method shows promising results in terms of arrival direction reconstruction, within the 0.1° range, even when taking into account experimental uncertainties, and interesting possibilities for the energy reconstruction and primary composition identification.'

Collaborations
other (fill field below), GRAND
Keywords and Comments
Extensive-Air-Shower , Reconstruction , Radio-Detection, Valentin Decoene''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Discrimination of Muons for Mass Composition Studies of Inclined Air Showers Detected with IceTop

Presenter
Aswathi Balagopal V.
Author and Co-Author
Aswathi Balagopal V. | For the IceCube Collaboration

Abstract
'IceTop, the surface array of IceCube, measures air showers from cosmic rays within the energy range of 1 PeV to a few EeV and a zenith angle range of up to ≈ 36°. This detector array can also measure air showers arriving at larger zenith angles at energies above 20 PeV. Air showers from lighter primaries arriving at the array will produce fewer muons when compared to heavier cosmic-ray primaries. A discrimination of these muons from the electromagnetic component in the shower can therefore allow a measurement of the primary group. A study to discriminate muons using Monte-Carlo air showers of energies 20-100 PeV and within the zenith angular range of 45°-65° will be presented. The discrimination is done using charge and time-based cuts which allows us to select muon-like signals in each shower. The methodology of this analysis, which aims at categorizing the measured air showers as light or heavy on an event-by-event basis, will be discussed.'

Collaborations
IceCube,

Keywords and Comments
cosmic rays, air showers, IceTop, mass composition, muon discrimination, Aswathi Balagopal V."

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Study of the effect of seismically-induced geoelectric and geomagnetic fields on secondary particle detection at a LAGO site.

Presenter
Diego Alberto Coloma Borja
Author and Co-Author
Diego Alberto Coloma Borja | Edgar Carrera Jarrin | For The LAGO Collaboration

Abstract
"The aim of this project is to study the potential effect that the changes in geoelectric and geomagnetic fields, produced by seismic activity, could have on the detection of secondary particles from extensive \u200bair showers in the atmosphere. For this purpose, simulations for flux of secondaries are performed using ARTI, a tool developed by the LAGO Collaboration that combines Magnetocosmics, CORSIKA, and Geant4 packages to account, respectively, for the propagation of a shower by a primary particle, the geomagnetic effect on particle flux, and the detector response. To run these simulations, the ground level is taken with reference to the position of the LAGO water Cherenkov tank at Universidad San Francisco de Quito (2200 m a.s.l.) in Ecuador. Regular conditions for the Earth's electromagnetic field are taken from records of fair-weathered days above the location. Variations from this regularity are introduced based on relevant studies on seismic activity. The results show that there exists an effect on the number of secondary particles at ground level, which could, in principle, be detected by a LAGO WCD detector."

Collaborations
other (fill field below), LAGO
Keywords and Comments
Simulations, secondary particle detection Geoelectric Field, Geomagnetic field, Seismic Activity, LAGO,, Diego Alberto Coloma Borja"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
UCIRC2: EUSO-SPB2's Infrared Cloud Monitor

Presenter
Rebecca Diesing
Author and Co-Author
Rebecca Diesing | Alexa Bukowski | Noah Friedlander | Alex Miller | Stephan Meyer | Angela Olinto | for the JEM-EUSO Collaboration

Abstract
'The second generation of the Extreme Universe Space Observatory on a Super Pressure Balloon (EUSO-SPB2) is a balloon instrument for the detection of ultra high energy cosmic rays (UHECRs) with energies above 1 EeV and very high energy neutrinos with energies above 10 PeV. EUSO-SPB2 consists of two telescopes: a fluorescence telescope pointed downward for the detection of UHECRs and a Cherenkov telescope pointed towards the limb for the detection of tau lepton-induced showers produced by up-going tau neutrinos and background signals below the limb. Clouds inside the field of view of these telescopes reduce EUSO-SPB2's geometric aperture, in particular that of the fluorescence telescope. For this reason, cloud coverage and cloud-top altitude within the field of view of the fluorescence telescope must be monitored throughout data-taking. The University of Chicago Infrared Camera (UCIRC2) will monitor these clouds using two infrared cameras centered at 10 and 12 microns. By capturing images at wavelengths spanning the cloud thermal emission peak, UCIRC2 will measure cloud color-temperatures and thus cloud-top altitudes. In this contribution, we provide an overview of UCIRC2, including an update on its construction and a discussion of the techniques used to calibrate the instrument.'

Collaborations
Keywords and Comments
UHECR, EUSO-SPB2, clouds, IR camera, Rebecca Diesing"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The atmospheric transparency of Telescope Array observation site by the CLF

Presenter
Takayuki Tomida
Author and Co-Author
Takayuki Tomida | Tomoyuki Nakamura Katsuya Yamazaki | John Matthews | For the Telescope Array collaboration

Abstract
'The Telescope Array (TA) experiment continues to observe Ultra High Energy Cosmic Rays (UHECRs) both with its original TA detectors as well as with the new TAx4 expansion detectors. These observations employ Fluorescence Detectors (FDs) to capture the air shower induced by the primary UHECRs. The FD observes fluorescence light emitted from atmospheric nitrogen molecules excited by air shower particles. The observation of the FD extends over tens of kilometers, and the fluorescence light is attenuated by scattering from atmospheric molecules and aerosols during the propagation process. Seasonal dependence was found when assessing the attenuation of fluorescence by aerosols. We also captured the weather characteristics. We report on the effect of aerosols on the atmospheric transparency of the TA sites.'

Collaborations
Telescope Array,

Keywords and Comments
Atmospheric transparency, Calibration, Laser, Takayuki Tomida''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Small shower array for education purposes. CREDO-Maze Project

Presenter
Michał Karbowiak
Author and Co-Author
Michał Karbowiak | Tadeusz Wibig | Jerzy Orzechowski | for the CREDO Collaboration

Abstract
"We have noticed in many places around the world in recent years an increasing interest in small-scale extensive air shower experiments designed to satisfy young people's scientific curiosity and develop their interest in science and in physics in particular. It is difficult to think of ways and opportunities to introduce practical classes in modern high-energy physics, astrophysics, or particle physics into school curricula and after-school activities. Small EAS array experiments are just such a proposal. As part of the CREDO-Maze project, we plan to equip local high schools with sets of four small detectors, with a simple system for triggering, recording, and online communication with the world. Networked experiments from several schools add significant new educational value to the process of developing good behavior appropriate to scientific communities. Cooperation and competition at the stage of own research and information exchange are essential new and valuable values in educating young generation. Small local arrays connected to the global CREDO network will provide additional data and opportunities for important cosmic ray studies, what is an additional benefit of the CREDO-Maze Project.\r\nIn this paper we will present the characteristics of our detectors and the results of the EAS detections by CREDO-Maze prototype array."

Collaborations
, Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
cosmic ray ensembles, large scale cosmic ray correlations, extensive air showers, detectors, CREDO-Maze, physics education, Michał Karbowiak'The main results covered by this article will be summarised in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Interferometric Air Shower Reconstruction With LOFAR

Presenter
Hershal Pandya
Author and Co-Author
Hershal Pandya | For the LOFAR CR-KSP

Abstract
'LOFAR radio telescope and its scintillator array component regularly measure cosmic-ray air showers with energy more than 10^16.5 eV. The current standard air shower reconstruction method does a plane-wave fit for arrival direction reconstruction and a simulation-based radio footprint Chi^2 minimization for shower core and X_max reconstruction. In this conference proceeding, we present the first results from implementing interferometric reconstruction of air shower properties. We can achieve angular reconstruction at least as good as plane-wave fit and present the possibility and challenges in reconstructing X_max interferometrically.'

Collaborations
LOFAR,

Keywords and Comments
radio emission in air showers, cosmic-ray air showers, beamforming, inteferometry, LOFAR,, Hershal Pandya''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Observing Ultra-High Energy Cosmic Rays using Camera Image Sensors

Presenter
Wakiko Takano
Author and Co-Author
Wakiko Takano Hibino Kinya

Abstract
'We propose a new approach for observing UHECR by detecting charged particles in the core region of EAS using a cost-effective and compact detector with a CMOS camera image sensor. In general, the core region of EAS is excluded from the measurement due to the very high particle density at which the signal saturates. However, the results of the EAS simulation predict that the particle density in the core depends on the distance from the axis and the angular distribution depends on the arrival direction of the primary cosmic ray. Therefore, the core might be useful for collecting information about EAS effectively.\r\n\r\nMeanwhile, Camera image sensors are sensitive to ionizing radiations in addition to optical photons. It is advantageous to use thin and small sensors to detect particles in the dense region, such as the EAS core. The length of the particle-track is related to depletion thickness and incident angle to the surface of the sensor. If depletion thickness is evident, we can reconstruct the incident angles of primary particles roughly.\r\nWe demonstrate the result of simulation to show the characteristics of UHECRs core as well as the reaction of sensors for charged particles. We also report the result of our experiment using a prototype of the CMOS sensors with Raspberry PI to detect radiations.'

Collaborations

Keywords and Comments
UHECR, EAS, CMOS sensor, Wakiko Takano"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Machine learning aided noise filtration and signal classification of the CREDO smartphone data

Presenter
Łukasz Bibrzycki
Author and Co-Author
Łukasz Bibrzycki | Olaf Bar | Piotr Homola | Michał Niedźwiecki | Marcin Piekarczyk | Krzysztof Rzecki | Sławomir Stuglik | for the CREDO Collaboration

Abstract
'The wealth of smartphone data collected by the Cosmic Ray Extremely Distributed Observatory (CREDO) greatly surpasses the capabilities of manual analysis. So, efficient means of rejecting the non-cosmic-ray noise and identification of signals attributable to extensive air showers are necessary. To address these problems we discuss a Convolutional Neural Network-based method of artefact rejection and complementary method of particle identification based on common statistical classifiers as well as their ensemble extensions. These approaches are based on supervised learning, so we need to provide a representative subset of the CREDO dataset for training and validation. According to this approach over 2300 images were chosen and manually labeled by 5 judges. The images were split into spots, tracks, worms (collectively named signals) and artefacts classes. Then the preprocessing consisting of luminance summation of RGB channels (grayscaling) and background removal by adaptive thresholding was performed. For purposes of artefact rejection the binary CNN-based classifier was proposed which was able to distinguish between artefacts and signals. The classifier was fed with input data in the form of Daubechies wavelet transformed images.\r\nIn the case of cosmic ray signal classification, the well-known feature-based classifiers were considered. As feature descriptors, we used Zernike moments with additional feature related to total image luminance.\r\nFor the problem of artefact rejection, we obtained an accuracy of 98%. For the 4-class signal classification, the best performing classifiers achieved a recognition rate of 92%.'

Collaborations
, Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
machine learning, pattern recognition, large scale cosmic ray correlations, extensive air showers, Łukasz Bibrzycki'The main results covered by this article will be summarised in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Expected performance of interferometric air-shower measurements with radio antennas

Presenter
Felix Schlüter
Author and Co-Author
Felix Schlüter | Tim Huege

Abstract
'Interferometric measurements of the radio emission of extensive air showers allow reconstructing cosmic-ray properties. A recent simulation study with an idealised detector promised measurements of the depth of the shower maximum $X_\\mathrm{max}$ with an accuracy better than 10$\\,$g$\\,$cm^{-2}. \r\nIn this contribution, we evaluate the potential of interferometric $X_\\mathrm{max}$ measurements of (simulated) inclined air showers with realistically dimensioned, sparse antenna arrays. We account for imperfect time synchronisation between individual antennas and study its inter-dependency with the antenna density in detail. We find a strong correlation between the antenna multiplicity (per event) and the maximum acceptable inaccuracy in the time synchronisation of individual antennas. From this result, prerequisites for the design of antenna arrays for the application of interferometric measurements can be concluded. For data recorded with a time synchronisation accurate to 1$\\,$ns within the commonly used frequency band of 30 to 80$\\,$MHz, an antenna multiplicity of $\\geq 50$ is needed to achieve an $X_\\mathrm{max}$ reconstruction with an accuracy of 20$\\,$g$\\,$cm^{-2}. This multiplicity is achieved measuring inclined air showers with zenith angles $\\theta \\geq 77.5^\\circ$ with 1$\\,$km spaced antenna arrays, while vertical air showers with zenith angles $\\theta \\leq 40^\\circ$ require an antenna spacing below 100$\\,$m. Furthermore, we find no improvement in $X_\\mathrm{max}$ resolution applying the interferometric reconstruction to measurements at higher frequencies, i.e., up to several hundred MHz.'

Collaborations
Keywords and Comments
Radio Detection, Interferometry, Extensive Air Showers, Ultra-high-energy cosmic rays, Reconstruction, Felix Schlüter"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Extraction of the Muon Signals Recorded with the Surface Detector of the Pierre Auger Observatory Using Recurrent Neural Networks

Presenter
Juan Miguel Carceller
Author and Co-Author
Juan Miguel Carceller | For the Pierre Auger Collaboration

Abstract
'We present a method based on the use of Recurrent Neural Networks to extract the muon component from the time traces registered with water-Cherenkov detector (WCD) stations of the Surface Detector of the Pierre Auger Observatory. The design of the WCDs does not allow one to separate, for all events, the contribution of muons to the time traces from those of photons, electrons and positrons. Separating the muon and electromagnetic components is crucial for the determination of the nature of the primary cosmic rays and properties of the hadronic interactions at ultra-high energies.\r\n\r\nWe trained the neural network to extract the muon and the electromagnetic components from the WCD traces using a large set of simulated air showers, with around 450 000 simulated events. For training and evaluating the performance of the neural network, simulated events with energies between $10^{18.5}$ eV and 10^{20} eV and zenith angles below 60 degrees were used. We also study the performance of this method on experimental data of the Pierre Auger Observatory and show that our predicted muon lateral distributions agree with the parameterizations obtained by the AGASA collaboration.'

Collaborations
Auger,

Keywords and Comments
Astroparticle physics, Pierre Auger Observatory, cosmic rays, Cherenkov detectors, muon component, machine learning, neural networks, deep learning, recurrent neural networks, Juan Miguel Carceller''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Monte Carlo simulations for the Pierre Auger Observatory using the VO Auger grid resources

Presenter
Eva Santos
Author and Co-Author
Eva Santos For the Pierre Auger Collaboration

Abstract
"The Pierre Auger Observatory, located near Malargüe, Argentina, is the world's largest cosmic-ray detector. It comprises a $3000\\:\\mathrm{km}^{2}$ surface detector and 27 fluorescence telescopes, which measure the lateral and longitudinal distributions of the many millions of the air-shower particles produced in the interaction of a cosmic ray in the Earth's atmosphere. The determination of the nature of cosmic rays and studies of the detector performances rely on extensive Monte Carlo simulations describing the physics processes occurring in extensive air showers and the detector responses.\r\n\r\nThe Monte Carlo simulations task aim is to produce and provide the Auger Collaboration with reference libraries used in a wide variety of analyses. All multipurpose detector simulations are currently produced in local clusters using Slurm and HTCondor. The bulk of the shower simulations are produced on the grid, via the Virtual Organization Auger, using the DIRAC middleware. The job submission is made via python scripts using the DIRAC API.\r\n\r\nThe Auger site is undergoing a major upgrade, which includes the installation of new types of detectors, demanding increased simulation resources. The novel detection of the radio component of extensive air showers is the most challenging endeavor, requiring dedicated shower simulations with very long computation times, not optimized for the grid production.\r\n\r\nFor data redundancy, the simulations are stored on the Lyon server and the DPM and are accessible to the Auger members via iRODS and DIRAC, respectively. The CVMFS is used for software distribution where, soon, the Auger Offline software will also be made available."

Collaborations
Auger,

Keywords and Comments
Grid usage, VO Auger, High Performance Computing, Eva Santos"

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Branch	CRI | Cosmic Ray Indirect
Subcategory	Experimental Methods & Instrumentation

Titel
Universality of Cherenkov Light in EAS

Presenter
Isaac Buckland
Author and Co-Author
Isaac Buckland | Douglas Bergman

Abstract
'Reconstruction of an EAS seen using non-imaging Cherenkov detectors requires simulating the Cherenkov yield of many EAS's with given shower parameters. Since Shower Universality parameterizes both the angular distribution and energy distribution of charged particles within a shower, one can calculate the Cherenkov photon yield (at a fixed point) from the Cherenkov cones of electrons. In this work, we compare both the CWLD (Cherenkov Width Lateral Distribution) and arrival time distributions from Cherenkov universality calculations with those from CORSIKA iact (imaging atmospheric Cherenkov telescope) simulations. Since universality calculations are much less computationally expensive than shower simulation programs like CORSIKA, reconstruction could be accomplished more efficiently using Cherenkov data.'

Collaborations
Telescope Array, nuSpaceSim

Keywords and Comments
Cherenkov Universality, Isaac Buckland"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Feasibility Studies on improved Proton Energy Reconstruction with IACTs

Presenter
Alicia Fattorini
Author and Co-Author
Alicia Fattorini Wolfgang Rhode | Dominik Elsaesser | Dominik Baack | Maximilian Noethe

Abstract
'Air showers induced by cosmic protons and heavier nuclei constitute the dominant background for very high energy gamma-ray observations of Imaging Air Cherenkov Telescopes (IACTs). Even for strong very high energy gamma-ray sources the signal-to-background ratio in the raw data is typically less than 1:5000. Therefore, a very large statistic of events, induced by cosmic protons and heavier nuclei, is easily available as a byproduct of gamma-ray source observations. In this contribution, we present a feasibility study on improved reconstruction of the energy of primary protons. For the latter purpose, we used a random forest method trained and tested by using Monte Carlo simulations of the MAGIC telescopes, for energies above 70GeV. We employ the aict-tools framework, including machine learning methods for the energy reconstruction. The open-source Python project aict-tools was developed at TU Dortmund and its reconstruction tools are based on scikit-learn predictors. Here, we report on the performance of the proton energy regression with the well-tested and robust random forest approach.'

Collaborations

Keywords and Comments
protons, IACT, random forest, energy reconstruction, air shower, Alicia Fattorini''

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Branch	CRI | Cosmic Ray Indirect
Subcategory	Experimental Methods & Instrumentation

Titel
Operations of the Pierre Auger Observatory

Presenter
Rossella Caruso
Author and Co-Author
Rossella Caruso | For the Pierre Auger Collaboration

Abstract
'The construction of the first stage of the Pierre Auger Observatory, designed\r\nfor the research of ultra-high energy cosmic rays, began in 2001 with a\r\nprototype system. It has been collecting data since early 2004 and was\r\ncompleted in 2008. The Observatory is placed at 1400 m above sea level\r\nnear Malargüe, (Mendoza province) over a vast plain of 3000 km^2 covered by\r\ndetectors, known as the Pampa Amarilla in western Argentina. It is the first\r\nexperiment characterized by very high performance using the hybrid\r\ntechnique where 1660 water Cherenkov stations, forming the Surface\r\nDetector (SD), and 27 peripheral fluorescence telescopes, comprising the\r\nFluorescence Detector (FD), are operating. With time the Auger Observatory\r\nhas been enhanced with different R&D prototypes and recently subjected to\r\nan important upgrade (AugerPrime).\r\nIn the present contribution, the general operations of the SD and FD will be\r\ndescribed. In particular the FD shift procedure - executable locally in\r\nMalargüe or remotely by teams in control rooms abroad within the\r\nCollaboration - and the newly (operating since 2019) SD shifts will be\r\nexplained. Additionally, the SD and FD maintenance campaigns, as well as\r\nthe data taking and data handling at a basic level, will be reported.'

Collaborations
Auger,

Keywords and Comments
Pierre Auger Observatory, Fluorescence Detector, Surface Detector, maintenance, shift, data taking, data handling., Rossella Caruso''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Boosting the performance of the neural network using symmetry properties for the prediction of the shower maximum using the water Cherenkov Detectors of the Pierre Auger Observatory as an example

Presenter
Steffen Hahn
Author and Co-Author
Steffen Hahn | Markus Roth | David Schmidt | Darko Veberic

Abstract
'To probe physics beyond the scales of human-made accelerators with cosmic rays demands an accurate knowledge of their primary mass composition. Using fluorescence detectors, one is able to estimate this by measuring the depth of the shower maximum $X_\\text{max}$. These, however, exhibit a very low duty cycle of typically below 15 %.\r\n\r\nInferring $X_\\text{max}$ from a surface detector array (SD) such as the water-Cherenkov array of the Pierre Auger Observatory is highly non-trivial due to the inherent complexity and fluctuations of the shower footprint. Moreover, the sheer amount of data makes it non-trivial to find hidden patterns in the spatial and temporal distributions of detector signals. Neural networks provide a straightforward way of tackling such a problem doing a data-driven analysis. \r\n\r\nRelying solely on geometrical quantities, timing, and the signal-time information of the SD stations, we show that by exploiting the symmetries due to their triangular arrangement, we are able to boost a standard analysis network significantly without modifying its architecture or training process. Furthermore, these considerations yield a standardization procedure which also enables us to encode the footprint's information in a memory-efficient way. The presented procedure can also be generalized and extended to systems whose setup has an underlying hexagonal geometry.'

Collaborations
Keywords and Comments
pierre auger observatory, mass estimation of primary, neural network analysis, Steffen Hahn''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Study of the calibration method using the stars measured by the EUSO-TA telescope

Presenter
Zbigniew Plebaniak
Author and Co-Author
Marika Przybylak | Zbigniew Plebaniak Daniele Gardiol | Dario Barghini | Mario Bertaina | for the JEM-EUSO Collaboration | Lech Wiktor Piotrowski | Jacek Szabelski | Kenji Shinozaki | Roman Lipiec | Marco Casolino

Abstract
'EUSO-TA is a ground-based experiment, placed at Black Rock Mesa of the Telescope Array site as a part of the JEM-EUSO (Joint Experiment Missions for the Extreme Universe Space Observatory) program. The fluorescence detector with a field of view of about 11$^\\circ$ x 11$^\\circ$ consisting of 2304 pixels (36 Multi-Anode Photomultipliers, 64 channels each) works with 2.5-microsecond time resolution. An experimental setup with two Fresnel lenses allows for measurements of Ultra High Energy Cosmic Rays in parallel with the TA experiment as well as the other sources like flashes of lightning, artificial signals from UV calibration lasers, meteors or stars. The stars crossing the field of view as the point-like sources, increase counts on pixels. In this work, we discuss the method for calibration of EUSO fluorescence detectors based on signals from stars registered by the EUSO-TA experiment during several campaigns. As the star positions during measurements are known, the analysis of signals gives an opportunity to determine the pointing of the detector. This can be applied to space-borne or balloon-borne EUSO missions. We describe in details the method of the analysis which provides information about detector parameters like the shape of the point spread function and is the way to perform absolute calibration of EUSO cameras.'

Collaborations
, JEM-EUSO

Keywords and Comments
Cosmic Rays, EUSO-TA, Fluorescence Detector, Absolute calibration, Star UV measurements, Zbigniew Plebaniak''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Reconstruction the production depth of muon in air shower

Presenter
liping wang
Author and Co-Author
liping wang lingling Ma | cunfeng Feng

Abstract
'One possible way to determine the mass of cosmic rays is to study the longitudinal development of the air shower. The depth of the muon production maximum is sensitive to the nature of the primary particles and also helps to provide insight on whether new physics phenomena take place. The muon detectors of KM2A in Large High Attitude Air Shower Observation (LHAASO) record hitting time and number of muons which reach the ground. The arrival times of the muons allow the reconstruction of their geometrical production heights along the shower axis. The air shower is simulated using CORSIKA with QGSJETII-04 and EPOS-LHC models for the energy of shower about 10 PeV and zenith about 45°, KM2A detectors is simulated with GEANT4. The time decay due to kinematic effect and muon production are studied by tracking the muon in CORSIKA. The distance of muon to the shower core is optimized in order to keep the geometry time delay is the dominant factors. Using the KM2A simulation data, the muon production depth in the air shower is reconstructed according the geometry effect. The reconstructed depth will compare with the production depth of muon in CORSIKA to validate the reconstruction method.'

Collaborations

Keywords and Comments
Muon production depth, liping wang''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
A study of analysis method for the identification of UHECR source type

Presenter
Fugo Yoshida
Author and Co-Author
Fugo Yoshida Yuichiro Tameda | for the Telescope Array Collaboration

Abstract
'The autocorrelation analysis using the arrival direction of Ultra High Energy Cosmic Rays (UHECRs) has been previously reported by the Telescope Array (TA) experiment. It is expected that the autocorrelation function reflects the source distribution. We simulate the expected arrival direction distribution of the cosmic rays using the catalogs of candidate sources. We take into account random deflection in the magnetic fields, with the magnitude of deflection determined by the charge and energy of the cosmic rays, coherence length and magnitude of the extragalactic magnetic field, and by distance to source. In addition, in order to compare with the results of TA, we consider the TA exposure. We compare the autocorrelation of the arrival directions corresponding to different source catalogs with the isotropic distribution. We calculate the autocorrelation function for each type of source candidates using this procedure. We will discuss the ability of this method to identify the source type of UHECRs.'

Collaborations
Telescope Array,
Keywords and Comments
UHECR, anisotropy, EGMF, radio galaxy, autocorrelation, Fugo Yoshida"

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Subcategory Experimental Methods & Instrumentation

Titel
K-EUSO detector with refractive optical system

Presenter
Sergei Sharakin
Author and Co-Author
Sergei Sharakin Pavel Klimov | Yoshiyuki Takizawa | Anastasiia Perevoznikova

Abstract
'The K-EUSO detector is the central project of the JEM-EUSO international collaboration, the purpose of which is to measure the UV fluorescence due to extensive air shower produced by ultra-high-energy cosmic rays from the ISS. Over the years, the design of the detector has undergone various changes associated with both funding constraints and technical difficulties. In particular, to meet the requirements for the transportation and deployment of the equipment, a new engineering model was developed with a rectangular aperture of 120 by 240 cm, which made it possible to minimize the number of optical segments. In this case, the most natural variant of the optical design turned out to be a two-lens telescope, in which three of the four optical surfaces are Fresnel, and the fourth one is a diffractive. We present the values of the parameters of all surfaces obtained as a result of optimization in Zemax in a field of view of 36 degrees are given. All optical surfaces are spherical with a radius of curvature of 5.5 m, the concave focal surface has a radius of curvature of 2 m. A more detailed assessment of the characteristics of the optical system (efficiency, image size and resolution) was made with special ray tracing code. The full exposure of the K-EUSO telescope, taking into account portion of night measurements at the level of 14%, will be almost 2*10^4 km2 sr year.\r\nThe possibility of manufacturing lenses with a Fresnel and diffractive structure of this type is shown. At present, the production of the first lens from PMMA material transparent in the near UV on RIKEN high-precision equipment has begun.'

Collaborations
other (fill field below), JEM-EUSO
Keywords and Comments
Orbital detector, UV telescope, Optical system, Sergei Sharakin"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Atmospheric depth Models in the Field of View of LHAASO-WFCTA

Presenter
J.J Xia
Author and Co-Author
J.J Xia H.Y Jia | F.R Zhu

Abstract
"Tne of the main components of the Large High Altitude Air Shower Observatory\xa0(LHAASO) located in Daocheng, China. WFCTA detects cosmic rays by detecting photons generated by secondary particles of atmospheric showers. Changes in atmospheric depth in WFCTA's field of view will lead to changes in the number of photons in WFCTA. Therefore, the variation of atmospheric depth in the WFCTA is of great significance for the quantitative study of the variation of cosmic ray observation by WFCTA. In this paper, the temporal variation of atmospheric depth at LHAASO is studied based on the MSISE-90 atmospheric model, and the comparison of MSISE-90 atmospheric model with the American standard atmospheric model, satellite experimental data, and meteo data at LHAASO station. We fitted MSISE model data in the operation period of WFCTA to develop a new LHAASO Atmospheric depth model."

Collaborations
Lhaaso,
Keywords and Comments
, JJ Xia"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Study of Longitudinal Development of Cosmic-Ray Induced Air Showers with LHAASO-WFCTA

Presenter
hu liu
Author and Co-Author
hu liu

Abstract
'The Wide Field of View Cherenkov Telescope Array (WFCTA) is an important component of Large High Altitude Air Shower Observatory(LHAASO), which aims to measure the individual energy spectra of cosmic rays from ~30TeV to a couple of EeV. WFCTA consisting of 18 imaging air Cherenkov telescopes, each have 32 × 32 pixels, covering a field of view 16o × 16o (each pixel corresponding to 0.5o × 0.5o), The first telescope started in operation since February 2019, up to now, there are 16 telescopes in operation. Since the Cherenkov photon detected by different pixels were generated at different height (or different traversed material), we reconstruct a function from the image of WFCTA, which describe the air shower longitudinal development along the shower axis (similar to the longitudinal distribution function of air shower). In this paper, the energy reconstruction and particle identification will be studied based on this function with MC simulated events. Comparison of the development function between data and MC will also be shown.'

Collaborations
Lhaaso,

Keywords and Comments
longitudinal development, Cherenkov telescope, energy reconstruction, particle identification, hu liu''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Current Status of electromagnetic particle detectors for LHAASO-KM2A

Presenter
jia liu
Author and Co-Author
jia liu | Xiangdong Sheng | Xiaopeng Zhang | Jing Zhao | 超 侯 | Hongkui Lv | Quanbu Gou

Abstract
'The Large High Altitude Air Shower Observatory (LHAASO) is a new generation hybrid cosmic ray observatory which is expected to reveal the mystery of the origin of cosmic rays. The one square kilometer array (KM2A) containing 5242 Electromagnetic particle Detectors (ED) and 1188 Muon Detectors (MD) is a sub-array of the LHAASO. The EDs are designed to measure the density and arriving time of the secondary particles of cosmic rays.\r\n 1/2 scale KM2A have been in operation from Decemember 2019 to November 2020. KM2A reaches its 3/4 scale by December 2020. 3978 electromagnetic particle detectors (EDs) and 917 muon detectors (MDs) are now in stable operation. In this paper, we will introduce the construction process of ED, the performances and long-term stability of the detectors.'

Collaborations
Lhaaso,

Keywords and Comments
LHAASO-KM2A, Electromagnetic particle detector, performance, long-term stability, jia liu"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Optimization of CoREAS simulations for the GRAND project

Presenter
Chao Zhang
Author and Co-Author
Chao Zhang | Tim Huege | Tanguy Pierog for the GRAND collaboration

Abstract
"Abstract: A planned array of 200,000 antennas covering an area of 200,000 km^{2} - the GRAND project - is proposed to detect cosmic-ray,gamma-ray, and neutrino primaries in the energy range beyond 10^{17}eV. The GRAND array will be able to detect upward-going air showers initiated by neutrino interactions in the rocks on its mountainous site, furthermore, it may also detect very inclined and atmosphere-skimming air showers initiated by cosmic rays. So the corresponding shower geometry differs from the other experiments and asks for a detailed investigation. To meet the requirements of GRAND, we develop an update of CORSIKA7 for the simulation of upward-going air showers. Furthermore, we apply today's best knowledge of parameters of the GRAND project, in particular realistic on-site atmospheres, in an extensive library of inclined air showers. Finally, we evaluate expected signal-to-noise ratios and detection thresholds for the GrandProto300 phase of GRAND."

Collaborations
other (fill field below), GRAND

Keywords and Comments
GRAND, CoREAS, CORSIKA7, Upward-going air shower, S/N ratio, Chao Zhang"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Design and simulation of a cost-affordable Cosmic Ray Muon Tomographer

Presenter
Javier Rengifo Gonzáles
Author and Co-Author
Javier Rengifo Gonzáles Jose Bazo

Abstract
'Atmospheric muons can be used to image a volume due to multiple Coulomb scattering and absorption of different materials. This work presents the design and CORSIKA/Geant4 simulation of a prototype composed of an array of detectors. The detectors are based on plastic scintillators and silicon photomultipliers targeting new and cost-affordable technology. In order to image a volume we study the possibility to discriminate different materials (e.g. lead, concrete, iron, water, aluminum) by measuring the absorption and incoming and outgoing angles of muons passing through these materials. We optimize the geometry and angular resolution of the array using simulations with the aim to scan structures such as large buildings and natural formations with muon tomography.'

Collaborations

Keywords and Comments
Simulation, Cosmic Rays, Muons, Tomography, Detectors, Javier Rengifo Gonzáles''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Update of the Offline Framework for AugerPrime

Presenter
Lukas Nellen
Author and Co-Author
Lukas Nellen | for the Pierre Auger Collaboration

Abstract
'Work on the Offline Framework for the Pierre Auger Observatory was started in 2003 to create a universal framework for event reconstruction and simulation. The development and installation of the AugerPrime upgrade of the Pierre Auger Observatory require an update of the Offline Framework to handle the additional detector components and the upgraded Surface Detector Electronics.\r\n\r\nThe design of the Offline Software proved to be sufficiently flexible to accommodate the changes needed to be able to handle the AugerPrime detector. This flexibility has been a goal since the development of the code started. The Framework separates data structures from processing modules. The detector components map directly onto data structures. It was straightforward to update or add processing modules to process the additional information from the new detectors.\r\n\r\nWe will discuss the general structure of the Offline Framework, explaining the design decisions that provided its flexibility and point out the few of the features of the original design that required deeper changes, which could have been avoided in hindsight. Given the disruptive nature of the AugerPrime upgrade, the developers decided that the update for AugerPrime was the moment to change also the language standard for the implementation and move to the latest version of C++, to break strict backward compatibility eliminating deprecated interfaces, and to modernize the development infrastructure. We will discuss the changes that were made to the structure in general and the modules that were added to the Framework to handle the new detector components.'

Collaborations
Auger,
Keywords and Comments
Air Shower, Software, Lukas Nellen''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
TA SD energy and arrival direction estimation using deep learning

Presenter
Oleg Kalashev
Author and Co-Author
Oleg Kalashev

Abstract
'A novel ultra-high-energy cosmic rays energy and arrival direction reconstruction method for Telescope Array surface detector is presented. The analysis is based on a deep convolutional neural network using detector signal time series as the input and the network is trained on a large Monte-Carlo dataset. This method is compared in terms of statistical and systematic energy and arrival direction determination errors with the standard Telescope Array surface detector event reconstruction procedure.'

Collaborations
Telescope Array,

Keywords and Comments
ultra-high-energy cosmic rays, machine learning, event reconstruction,Telescope Array surface detector, Oleg Kalashev"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Geometry and optics calibration of WFCTA telescopes using star light

Presenter
Suhong Chen
Author and Co-Author
Suhong Chen | Lingling Ma | Yudong Wang | Shoushan Zhang

Abstract
'Wide field of view of Cherenkov telescope array (WFCTA) is one of main detectors of LHAASO project. The main scientific goal of WFCTA is to study the energy spectrum and composition of cosmic rays. The primary energy reconstruction and mass sensitive parameter (e.g. length and width), relies on the shape of the Cherenkov image on the camera. The pointing accuracy of each telescope is crucial for the direction reconstruction for the primary particles. UV bright stars are used to calibrate the pointing of the telescope and to study the optical properties of the camera, the spot size of the mirror. The first WFCTA telescope started its operation at the end of January 2019 at LHAASO site, eight more in January 2020 and sixteen more in January 2021. The preliminary results of the pointing and the optical properties of the camera will be shown in the paper.'

Collaborations
Lhaaso,

Keywords and Comments
, Zhiyong You"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
"Chronotron" timing detectors for EAS studies

Presenter
Aliya Baktoraz
Author and Co-Author
Aliya Baktoraz | Nurzhan Saduyev | Orazaly Kalikulov | Dmitriy Beznosko | Yerzhan Mukhamejanov | Saken Shinbulatov | Shynbolat Utey | Nurzhan Yerezhep | Askhat Zhumabayev | Valeriy Zhukov | Alexander Shepetov

Abstract
'The EAS detector system consisting of timing detection is being built for the reconstruction of the EAS axis direction using chronotron timing information. This system consists of eight scintillator-based individual detectors (100 x 100 x 1 cm) using wavelength shifting fibers for light collection. The goal of the project is to supplement the Horizon-T detector system that is located at the elevation of 3340 m at the TSHASS near the city of Almaty, Kazakhstan, with the system of detectors with fast timing. To improve the pulse time resolution beyond the several ns that is available for the scintillator-based systems, the approach to use the optical glass as the particle detection medium is also being tested. This work presents the current design, the characteristics from the simulation and the performance of the prototype.'

Collaborations

Keywords and Comments
EAS, cosmic rays, Aliya Baktoraz"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The EOSC-Synergy cloud services implementation for the Latin American Giant Observatory (LAGO)

Presenter
Hernán Asorey
Author and Co-Author
Antonio Juán Rubio Montero | Raúl Pagán Muñoz | Iván Sidelnik | Hernán Asorey | Rafael Mayo García | for the LAGO Collaboration

Abstract
"The Latin American Giant Observatory (LAGO) is a distributed cosmic ray observatory at a regional scale in Latin America, by deploying a large network of Water Cherenkov detectors (WCD) and other astroparticle detectors in a wide range of latitudes from Antarctica to México, and altitudes from sea level to more than 5500 m a.s.l.\r\n\r\nDetectors telemetry, atmospherics conditions and flux of secondary particles at the ground are measured with extreme detail at each LAGO site by using our own-designed hardware and firmware (ACQUA). To combine and analyse all these huge amounts of data produced by ACQUA, LAGO developed ANNA, our data analysis framework. Additionally, ARTI, a complete framework of simulations was designed and implemented to simulate the expected signals in our detectors coming from primary cosmic rays entering the Earth atmosphere, allowing a precise characterization of the sites at different atmospheric, geomagnetic and detector conditions.\r\n\r\nAs the measured and simulated data started to flow, we are facing a challenging scenario given the large amount of data emerging from our detectors and from the computational simulations we performed on a diversity of computing architectures and e-infrastructures. All these data need to be transferred, analyzed, catalogued, preserved, and provided for internal and public access and data-mining under an open e-Science environment. In this work, we present and describe the implementation of ARTI on the EOSC-Synergy cloud-based services as the first example of LAGO' frameworks that will follow the FAIR principles, enabling the provenance, data-curation and re-using of data. Moreover, we show how this deployment could help not only LAGO data production and analysis but other data-intensive cosmic rays observatories and muography experiments."

Collaborations
other (fill field below), LAGO
Keywords and Comments
Big-dat, cloud-services, EOSC, astroparticle data, astroparticle simulations, Hernán Asorey"Don't know why co-authors are not allowed. This contribution has one presenter but five main authors and the collaboration"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Expected performance of the AugerPrime Radio Detector

Presenter
Felix Schlüter
Author and Co-Author
Felix Schlüter

Abstract
'The AugerPrime Radio Detector will significantly increase the sky coverage of mass-sensitive measurements of ultra-high energy cosmic rays with the Pierre Auger Observatory. The detection of highly inclined air showers with the world’s largest 3000 km^2 radio-antenna array in coincidence with the Auger water-Cherenkov detector provides a clean separation of the electromagnetic and muonic shower components. The combination of these highly complementary measurements yields a strong sensitivity to the mass-composition of cosmic rays.\r\nWe will present the first results of an end-to-end simulation study of the performance of the AugerPrime Radio Detector. The study features a complete description of the AugerPrime radio antennas and reconstruction of the properties of inclined air showers, in particular the electromagnetic energy. The performance is evaluated utilizing a comprehensive set of simulated air showers together with recorded background. The estimation of an energy- and direction-dependent aperture yields an estimation of the expected 10-year event statistics. The potential to measure the number of muons in air showers with the achieved statistic is outlined. Based on the achieved energy resolution, the potential to discriminate between different cosmic-ray primaries is presented.'

Collaborations
Auger,

Keywords and Comments
Cosmic Ray, Mass separation, Reconstruction, Extensive Air Shower, Radio, Felix Schlüter''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
TAROGE experiment and reconstruction technique for near-horizon impulsive radio signals induced by Ultra-high energy cosmic rays

Presenter
Yaocheng Chen
Author and Co-Author
Yaocheng Chen | Pisin Chen | Jian-Jung Huang | Ming-Huey A. Huang | Chung-Yun Kuo | Tsung-Che Liu | Jiwoo Nam | Yu-Shao Shiao | Min-Zu Wang | Shih-Hao Wang | Yu-Hsin Wang

Abstract
'Taiwan Astroparticle Radiowave Observatory for Geo-synchrotron Emissions (TAROGE) is antenna arrays sitting on high coastal mountains of Taiwan, pointing to the Pacific Ocean for the detection of near-horizon extensive air showers (EAS) induced by ultra-high energy cosmic rays and Earth-skimming tau neutrinos. TAROGE would improve the detection capability by collecting both the direct-emissions and the ocean-reflected signal on a vast area of ocean which is visible from Taiwan’s high mountains. Four TAROGE stations in Taiwan have been deployed in the past few years. Except for the first station, which is a prototype station for the purposes of radio survey and optimization of instrument parameters, other three stations are still operating.\r\nWe develop a new angular reconstruction method based on a deconvolution of radio reflection on the ground which is an important systematic effect for the near-horizon events. The response of the ground reflection is measured with a drone-borne calibration pulser. We achieved a sub-degree angular resolution for near horizon event. In this paper, we discuss details of the method and the results. A brief status report of the TAROGE project will also be reported.'

Collaborations
other (fill field below), TAROGE

Keywords and Comments
Ultra high energy cosmic rays, Radio wave, Angular reconstruction, Drone-borne calibration, Yaocheng Chen''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
High-mountain hybrid installation for multicomponent detection of air-showers induced by ultra-high energy cosmic rays

Presenter
Saken Shinbulatov
Author and Co-Author
Saken Shinbulatov | Nurzhan Saduyev | Dmitriy Beznosko | Orazaly Kalikulov | Valeriy Zhukov | Yerzhan Mukhamejanov | Dmitriy Kostunin | Aliya Baktoraz | Nurzhan Yerezhep | Shynbolat Utey | Askhat Zhumabayev | Pavel Bezyazeekov | Oleg Fedorov

Abstract
"Measuring the fluxes of ultra-high energy cosmic rays is a unique tool for studying and testing physics beyond the standard cosmological and elementary particle interaction models. The observation of their fluxes above PeV is of particular interest, since the detection of extensive air-showers produced by these particles allows testing the energy range that is beyond the reach of modern colliders.\r\nIt is proposed to deploy a new setup consisting of several high-frequency antennas and combine it with the existing Horizon-T setup into a single complex, which allows simultaneous studies of the phenomena of charged particles delayed from the air-shower front.\r\nThe modernized hybrid installation will detect the charged particles and radio emission from air-showers, which allows us to probe in high-resolution space and time distributions in the air-shower cores arriving at the installation at zenith angles up to 85°. This will make it possible to search for exotic particles and new processes beyond standard model that arise during the propagation of cosmic rays through the Earth's atmosphere.\r\nIn this work we present our plans on the development and deployment of a new hybrid installation and the details of the technical implementation of new detectors."

Collaborations

Keywords and Comments
cosmic rays, extensive air showers, exotic particles, antenna,, Saken Shinbulatov"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Development of bases and qualification tests of Photomultiplier Tubes for the AugerPrime scintillation detectors

Presenter
Julian Rautenberg
Author and Co-Author
Karl-Heinz Becker | Urs Grosse-Rhode | Karl-Heinz Kampert | Stephan Keller | Christian Pauly | Jannis Pawlowsky | Dennis Pfeifer | Julian Rautenberg | Simon Strotmann | Rukije Uzeiroska | Natalia Weimer

Abstract
'We describe two test benches that were designed and constructed to perform a set of acceptance tests for about 1200 Photomultiplier Tube (PMT) units to be operated in the surface scintillation detectors of AugerPrime. Besides robustness, long-term reliability, and low power consumption, the dynamic range of the PMT-unit is required to cover signals ranging from a single to more than 20,000 minimum ionizing particles with not more than 5% deviation from linear response. This poses a particular challenge that was met by combining a specially selected 1.5“ PMT type with a custom-made Cockcroft Walton type base. The characteristics of the PMT units and qualification results obtained for a large quantity will be presented and discussed.\r\nBesides measuring the gain and linearity for each PMT-unit for different supply voltages, we also measured for a sub-sample of about 10% the quantum-efficiency of the photocathode as a function of wavelength and its homogeneity across the full photocathode area with 1 mm spatial resolution. The latter is of importance because of the fiber-optical readout of the scintillation detectors.'

Collaborations

Keywords and Comments
PMT qualification test setup, high linearity photon detection, quantum-efficiency homogeneity, Julian Rautenberg"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Simulating the signal of the AMIGA underground detectors of the Pierre Auger Observatory

Presenter
Ana Martina Botti
Author and Co-Author
Ana Martina Botti | Federico Sánchez | Markus Roth | Alberto Etchegoyen

Abstract
'In this work, we present a detailed description of the simulation development and validation of the underground detector signal for the Auger Muons and Infill for the Ground Array (AMIGA), a low-energy enhancement at the Pierre Auger Observatory. To this aim, the detection system was thoroughly characterized in the laboratory. It consists of plastic-scintillator strips with optical fibers that conduct light towards silicon photomultipliers whose output is then processed with two complementary read-out channels. These measurements allowed us to design a fast and reliable simulation chain that fully reproduces the signal of single muons impinging on the scintillators.'

Collaborations
Keywords and Comments
, Ana Martina Botti"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Influence of Simultaneous particles on the LAGO's Water Cherenkov Detectors

Presenter
Luis Otiniano
Author and Co-Author
Luis Otiniano | Franz Machado | Christian Sarmiento Cano | Mauricio Suárez-Durán | Hernán Asorey | for the LAGO Collaboration

Abstract
"The Latin American Giant Observatory (LAGO), operates an extensive network of Water Cherenkov Detectors (WCD) by a non-centralized and collaborative network of Universities and Research Institutes in Iberoamerica. To estimate the charge distribution produced by secondaries particles interacting with WCDs, LAGO developed a simulation framework (ARTI). ARTI comprises a chain of simulations that starts with the well known primary flux of galactic cosmic rays that reach Earth and finish estimating the expected WCDs signals at any site on ground.\r\n\r\nBased on the first stage of ARTI, that uses COSIKA to simulate the expected flux of secondaries that reach LAGO sites, we re-analyze this flux searching for simultaneous particles reaching the detectors. We perform a spatial analysis of CORSIKA's simulated air showers in the field of view of four typical WCD in extreme sites of the LAGO network and in time windows of the electronic acquisition system.\r\n\r\nWe have found that simultaneous particles reaching the WCD modify the deposited energy distribution into the detector even for low energy range and low altitude sites, compared with the previous single-particle approach. This result impacts the WCD's calibration and could play an important role in discriminating primaries and defining observables for GRBs detection at high altitude LAGO sites."

Collaborations
, LAGO
Keywords and Comments
LAGO, WCD, secondary cosmic rays, Luis Otiniano''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Calibration system of EAS Cherenkov arrays using commercial drone helicopter.

Presenter
Almaz Fazliakhmetov
Author and Co-Author
Dmitry Voronin | Almaz Fazliakhmetov

Abstract
'EAS Cherenkov arrays are a powerful instrument for studies of primary cosmic rays in a wide range of energy. In this approach the Earth's atmosphere is used as a calorimeter providing EAS Cherenkov arrays high energy resolution. Another advantage of the method is its high time resolution which results in a good angular resolution. Usually EAS Cherenkov array is a sparsely instrumented array with a distance of 100 m (or more) between individual Cherenkov photon detectors (optical stations/modules) covering hundreds of square meters or a few thousands of square kilometers. So, to calibrate such arrays is not simple task. We developed a calibration system of EAS Cherenkov arrays based on a single fast light source on board of remotely controlled commercial drone helicopter. The light source is based on a single high power blue InGaN LED driven by avalanche transistors driver. The light source provides light pulses with 2-3 ns (FWHM) width and 10^10-10^11 photons per pulse. Preliminary results of test flights of the calibration system are presented.'

Collaborations
Keywords and Comments
, Almaz Fazliakhmetov''

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Subcategory Experimental Methods & Instrumentation

Titel
First results from the AugerPrime Radio Detector

Presenter
Tomáš Fodran
Author and Co-Author
Tomáš Fodran

Abstract
'The Pierre Auger Observatory investigates the properties of the highest-energy cosmic rays with unprecedented precision. The aim of the AugerPrime upgrade is to improve the sensitivity to the primary particle type. The improved mass sensitivity is the key to exploring the origin of the highest-energy particles in the Universe. The purpose of the Radio Detector (as part of AugerPrime) is to extend the sensitivity of the mass measurements to zenith angles above 60°. A radio antenna, sensitive in two polarization directions and covering a bandwidth from 30 to 80 MHz, will be added to each of the 1661 surface detector stations over the full 3000 km² area, forming the world’s largest radio array for the detection of cosmic particles. Since November 2018, an engineering array\r\ncomprised of ten stations has been installed in the field.\r\nThe radio antennas are calibrated using the Galactic (diffuse) emission. The sidereal modulation of this signal is monitored continuously and is used to obtain an end-to-end calibration from the receiving antenna to the ADC in the read-out electronics. The calibration method and first results will be presented.\r\nThe engineering array is also fully integrated in the data acquisition of the Observatory and records air showers regularly. The first air showers detected simultaneously with the water-Cherenkov detectors and the Radio Detectors will be presented. Simulations of the detected showers, based on the reconstructed quantities, have been conducted with CORSIKA/CoREAS. A comparison of the measured radio signals with those predicted by simulations exhibits satisfying agreement.'

Collaborations
Auger,

Keywords and Comments
comic rays, air showers, radio detector, galactic calibration, Tomáš Fodran''

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-1
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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Hybrid cosmic ray measurements using the IceAct telescopes in coincidence with the IceCube and IceTop detectors

Presenter
Merlin Schaufel
Author and Co-Author
Larissa Paul | Matthias Plum | Merlin Schaufel | For the IceCube Collaboration Thomas Bretz | Giang Do | John Hewitt | Frank Maslowski | Florian Rehbein | Johannes Schäfer | Adrian Zink

Abstract
'IceAct is a proposed surface array of compact (50 cm) and cost-effective Imaging Air Cherenkov Telescopes installed at the site of the IceCube Neutrino Observatory at the geographic South Pole. Since January 2019, two IceAct telescope demonstrators, featuring 61 silicon photomultiplier (SiPM) pixels have been taking data in the center of the IceTop surface array during the austral winter. We present the first analysis of hybrid cosmic ray events detected by the IceAct imaging air-Cherenkov telescopes in coincidence with the IceCube Neutrino Observatory, including the IceTop surface array and the IceCube in-ice array. By featuring an energy threshold of about 10 TeV and a wide field-of-view, the IceAct telescopes show promising capabilities of improving current cosmic ray composition studies: measuring the Cherenkov light emissions in the atmosphere adds new information about the shower development not accessible with the current detectors, enabling significantly better primary particle type discrimination on a statistical basis. The hybrid measurement also allows for detailed feasibility studies of detector cross-calibration and of cosmic ray veto capabilities for neutrino analyses. We present the performance of the telescopes, the results from the analysis of two years of data, and an outlook of a hybrid simulation for a future telescope array.'

Collaborations
IceCube,

Keywords and Comments
Astroparticle physics, Cosmic Rays, Imaging Air Cherenkov Telescope, Hybrid detection, Merlin Schaufel"

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Presenter Forum

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-1
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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
CoREAS simulations of inclined air showers predict refractive displacement of the radio-emission footprint

Presenter
Marvin Gottowik
Author and Co-Author
Marvin Gottowik | Tim Huege | Julian Rautenberg | Felix Schlüter

Abstract
"Simulating the radio emission of inclined extensive air showers for a ground based radio-antenna array we find a systematic displacement of the radio emission with respect to the Monte-Carlo shower impact point. We corrected the radio-emission footprint for the asymmetries due to the superposition of geomagnetic and charge-excess radiation as well as for the early-late effect. The remaining displacement is found to be \\SI{\\sim 1500}{m} along the ground plane for showers with a zenith angle of \\SI{85}{\\degree}, which is relevant for air shower detectors.\r\nA model describing this displacement by refraction in the atmosphere based on Snell's law yields good agreement with our observations from CoREAS simulations.\r\nWe thus conclude that the displacement is caused by refraction in the atmosphere."

Collaborations

Keywords and Comments
Radio-detection of cosmic rays, inclined air shower, refractivity, CoREAS simulation, Julian Rautenberg'Subcategory would be more phenomenology.'

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
First results from the TRAGALDABAS Cosmic ray detector at the Univ. of Santiago de Compostela

Presenter
Juan A. Garzón
Author and Co-Author
Hector Alvarez-Pol | Marwan Ajoor | Alberto Blanco | Pablo Cabanelas | Filomena Clemencio | Miguel Cruces | José Cuenca | Julian Flores | Paulo Fonte | Yanis Fontenla | Damián García-Castro | Juan A. Garzón | Georgy Kornakov | Teresa Kurtukian | Luis Lop

Abstract
'TRAGALDABAS is a high performance, high granularity, tracking detector of the Trasgo family. It is installed at the Univ. of Santiago de Compostela (42.876N, 8.560W), Spain. The detector is based on the RPC technology (Resistive Plate Chamber) offering a surface of 1.8m2 with granularity of 120 cells, multitracking capability, time resolution of ~0.4ns, an angular resolution close to 3º and an angular acceptance of 40º.\r\nAs a significant feature, the detector offers muon-electron separation capability with a rough electron calorimetry. This is attained by means of a software algorithm based on the analysis of the shape of the associated electromagnetic showers.\r\n\r\nThe detector is now taking data regularly at a rate of about 7 millions of events per day. After the detector calibration, efficiency evaluation and atmospheric corrections, preliminary results on cosmic ray rates with different multiplicities and the angular distribution dependence will be presented. We will show how a Trasgo detector is capable of measuring the properties of both isolated and bundles of particles, opening a new way of analyzing cosmic rays from the Earth surface.'

Collaborations

Keywords and Comments
Tracking detector, Resistive Plate Chamber, secondary cosmic rays, ground detector, muons, electrons, Juan . Garzon"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
A photomultiplier tube model for the water Cherenkov detectors of the LAGO

Presenter
Jesús Peña-Rodríguez
Author and Co-Author
Jesús Peña-Rodríguez | Yesid León-Carreño | Sandra Hernández-Barajas | Luis A. Núñez | Luis Otiniano

Abstract
"The Latin American Giant Observatory (LAGO) is an international experiment spanning over 10 Latin American countries and Spain. LAGO scientific objectives include the study of gamma-ray bursts and space weather phenomena using water Cherenkov detectors (WCDs) deployed at different latitudes and altitudes. Large area (8-9 inches) photomultiplier tubes (PMTs) sense the Cherenkov radiation produced by secondary particles, induced by primary cosmic particles in the atmosphere, crossing the WCDs.\r\n\r\nWe present a photomultiplier model applied to the Hamamatsu R5912 tube used in the LAGO' WCDs. The ARTI simulation framework, developed by the LAGO collaboration, can incorporate it. The model depends on the number of dynodes, the bias voltage, the number of incident photons, the photodetection efficiency, and the bias network. The model implementation includes a simulation of the LAGO's front-end, allowing the system linearity evaluation under different conditions. \r\n\r\nThe model was validated with data recorded by the MuTe-Chitagá (Bucaramanga, LAGO-Colombia) and Nahuelito (Bariloche, LAGO-Argentina) WCDs. The ARTI simulation chain estimates the number of Cherenkov photons arriving at the detector's PMT. We compare the anode/dynode pulse amplitude ratio predicted by the model with detector measurements. We also contrast the estimated and measured vertical equivalent muon signal. The estimated vertical-muon charge (321.6 UADC) differs by 4% from the measured by the MuTe WCD (333 UADC)."

Collaborations
, LAGO

Keywords and Comments
photomultiplier tube, mathematical model, water Cherenkov detector, front-end electronics, Jesús Peña-Rodríguez"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Assessment of moisture reserves by CR secondary neutrons sounding method

Presenter
Lev Dorman
Author and Co-Author
Lev Dorman

Abstract
'The technique of monitoring the moisture content in soil using CR neutron detectors of special design is being actively developed. For mountainous areas and northern countries, monitoring of the thickness of the snow cover is also relevant. The technology makes it possible to bridge the gap between local measurements and remote sensing on a catchment scale (100×100 km2) using spacecraft. It provides an opportunity to measure in real time the content of soil moisture and the thickness of the snow cover on a scale of ten hectares, determined by the range of neutrons travel in the lower atmosphere, which is ~ 250 m. We used data from two types of such detectors: 1) an epithermal neutron detector with 6 boron counters, counting rate about 13 pps (pulses per second) and 2) a thermal neutron detector (a single counter without a moderator, 2 pps). We estimated the amount of moisture in the soil and on its surface in the form of snow. Having a long series of measurement data for epithermal and thermal neutrons (since 2010), in this work we considered in detail the results for 2018-2021. Special attention is paid to the method of introducing various corrections. The method used to estimate moisture is relative and therefore requires the calibration of such a detector. For the winter period, such a calibration was carried out. The thickness of the snow cover in the periods under consideration reached 11 g/cm2 (including melting), the error is estimated as \uf0b10.2 (stat) \uf0b10.4 (sys) g/cm2.'

Collaborations
Keywords and Comments
cosmic ray application agriculure, Lev Dorman''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Characteristics of thunderstorm activity at LHAASO observatory

Presenter
Daihui Huang
Author and Co-Author
Peihan Wang | Daihui Huang | Xunxiu Zhou | Zhicheng Huang | Hucheng Feng | Ruolin Huang | Gerui Chen | Kai Wu | Tao Yan | Kegu Axi | Lin Chen

Abstract
'Thunderstorms are common weather phenomena at high altitudes, accompanying with lightning, strong winds, floods and other disasters. During thunderstorms, the strength of atmospheric electric fields could be up to 1000 V/cm or even higher. The intensity fluctuates violently and the polarity could change multiple times. So, direct measurement of the thunderstorm electric field is a quite challenging work. The High Altitude Cosmic Ray Observatory (LHAASO), under the construction of a project at Daocheng (4410 m a.s.l, Sichuan, China), is featured with frequent thunderstorms, especially in summer. The distribution of thunderstorm parameters is presented by analyzing the near-earth atmospheric electric field of the LHAASO station in this work. The polarity and intensity variation characteristics of the electric field in the early, mature and dissipating stages of thunderstorm are also discussed. The results show that the thunderstorms mainly occur in the period of a time from early afternoon to evening. They are more frequent and stronger in summer. During the mature stage, the field changes more dramatically. Our results could be helpful in understanding the variations of cosmic rays at LHAASO during thunderstorms, and provide valuable information for studying global thunderstorm activity.'

Collaborations
Lhaaso,

Keywords and Comments
Thunderstorm activity, Atmospheric electric fields, Variations, Cosmic rays, LHAASO observatory, Daihui Huang''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
New Constraints on Cosmic Particle Populations at the Galactic Center using X-ray Observations of the Molecular Cloud Sagittarius B2

Presenter
Field Rogers
Author and Co-Author
Field Rogers | Shuo Zhang | Kerstin Perez | Afura Taylor

Abstract
'Measurements of cosmic particle fluxes are key to indirect dark matter detection and to modeling galactic transport of cosmic rays, but all direct measurements have been made within or near our solar system, i.e. $\\sim$8 kpc from the center of the Milky Way. In this work, we constrain MeV to GeV scale electron and proton populations within the central 100 pc of the Galaxy on the basis of X-ray emission from ionizing particle interactions in the Galactic Center Molecular Cloud Sagittarius B2 (Sgr B2). X-ray emission from Sgr B2, including the characteristic Fe K$\\alpha$ fluorescence line at 6.4 keV, has previously been dominated by a variable component attributed to reflection of a past outburst from the supermassive black hole Sagittarius A*. Meanwhile, any local low energy particles would also produce X-rays in Sgr B2 via ionization and excitation of the molecular gas, contributing a constant baseline flux. Since the year 2001, Fe K$\\alpha$ emission from Sgr B2 has decreased by $>$ 90%, raising the possibility that it may now be dominated by particle interactions. Measurements of cosmic particle populations near the Galactic Center could help constrain models of cosmic particle transport in the Galaxy.'

Collaborations

Keywords and Comments
Cosmic-ray protons, Cosmic-ray electrons, Galactic center, Molecular cloud, Sagittarius B2,, Field Rogers''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
On the nature of primary particles producing air showers with energies greater than 5 EeV

Presenter
Igor Petrov
Author and Co-Author
Igor Petrov | Stanislav Knurenko

Abstract
'To study the nature of particles with energies greater than 5 EeV, the database of the Yakutsk array was analyzed. The array has been operating continuously for 50 years, and during this time period, unique material has been collected on the main components of air showers: the electron-photon component, muons, Cherenkov and radio emissions. Including the arrival directions of primary cosmic rays that produce cascades of secondary particles of relativistic energies in the atmosphere. Attention is drawn to the time sequence of the air showers arrival within 24 hours of continuous observations at the array. A small-scale variation in showers with an average period of 8 hours was found. Physical characteristics of consecutive showers: energy, zenith and azimuthal angles were in one case close or slightly different in magnitude. In addition very close relative muon number in these showers. For example, there were pairs of showers with a low muon content, i.e. showers "poor in muons". According to model calculations, these showers are probably produced by primary ultrahigh-energy gamma rays. Therefore, it can be assumed that double showers are formed by primary particles of the same or similar nature of origin.'

Collaborations

Keywords and Comments
EAS, ultra high energies, cosmic rays, arrival directions, Yakutsk., Igor Petrov''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Looking for long-range correlations among the EEE telescopes

Presenter
Paola La Rocca
Author and Co-Author
Paola La Rocca

Abstract
'The search for long-range correlations among air showers is one of the main goal of the Extreme Energy Events (EEE) Project. The existence of such events has only been supposed theoretically through several physical mechanisms, the most convincing being the so-called GZ effect, based on the photodisintegration of a heavy primary nucleus in the solar field. Even with a large detector coverage current rate expectations are of few events per year.\r\nTo measure time correlations among distant air showers, sparse arrays of detection stations spread over large areas are needed. A very limited number of experimental setups can perform this measurement and few experimental results have been reported over the past years.\r\nStarted in 2006 the EEE project is a network of 61 cosmic muons tracking telescopes made by 3 wide area MRPCs, sensitive to the direction of incident charged cosmic particles. The telescopes are distributed over the whole Italian territory, thus making the EEE array an ideal tool for the detection of long-range time correlations between extensive air showers.\r\nI will describe the analysis strategies adopted to search for such rare correlation events, together with the results obtained analysing the full statistics collected by the EEE telescopes in 10 years of operations.'

Collaborations
other (fill field below), EEE (Extreme Energy Events)
Keywords and Comments
long-range correlations, GZ effect, sparse array, MRPC telescope,, Paola La Rocca'if the abstract is not accepted for a talk, please consider it for a poster contribution.'

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
UHECR mass composition from anisotropy of their arrival directions with the Telescope Array SD

Presenter
Mikhail Kuznetsov
Author and Co-Author
Mikhail Kuznetsov | for the Telescope Array Collaboration

Abstract
'We propose a new method for the estimation of ultra-high energy cosmic ray (UHECR) mass composition from a distribution of their arrival directions. The method employs a test statistic (TS) based on a characteristic deflection of UHECR events with respect to the distribution of luminous matter in the local Universe modeled with a flux-weighed 2MRS catalog. Making realistic simulations of the mock UHECR sets, we show that this TS is robust to the presence of galactic and non-extreme extra-galactic magnetic fields and sensitive to the mass composition of events in a set. While the statistical power of the method depends somewhat on the magnetic fields parameters, this dependence decreases with the growth of statistics. We apply the method to the Telescope Array surface detector data and derive new independent constraints on UHECR mass composition at highest energies.'

Collaborations
Telescope Array,
Keywords and Comments
UHECR, mass composition, anisotropy, Mikhail Kuznetsov"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
The ASTRI-Horn telescope: comparison with the auxiliary UVscope measurements as calibration tool.

Presenter
Antonio Alessio Compagnino
Author and Co-Author
Antonio Alessio Compagnino | Teresa Mineo | Maria Concetta Maccarone | Osvaldo Catalano | Domenico Impiombato | Salvatore Giarrusso | for the ASTRI Project

Abstract
ASTRI-Horn is an Image Atmospheric Cherenkov Telescope located at the INAF &quot,M.C. Fracastoro&quot, observing station (Mt. Etna, Italy) characterized by a dual-mirror optical system and a curved focal surface equipped with SiPM sensors managed by an innovative fast front-endelectronics based on the peak detector technique.\r\nASTRI-Horn represents the prototype of nine similar telescopes developed for the ASTRI-MiniArray project that will be installed at the Teide Astronomical Observatory, in Tenerife (Canary Islands, Spain). The ASTRI-Horn camera is almost blind to the diffuse night sky background (NSB) but is able to detect the (Poissonian) fluctuations produced by the NSB. The noise generated by this effect is proportional to the level of the NSB.\r\nIn this work, we present the analysis of the background data collected in ASTRI-Horn observations during the period December 2018-March 2019 and the comparison of the results with the absolute night sky background levels measured by the UVScope instrument, which is capable of counting individual photons in the range 300-650nm, with a time resolution of 10ns. The instrument is mounted on the external structure of the ASTRI-Horn telescope.\r\nThe main result of this work is a strong correlation between the absolute flux measured by UVScope and the fluctuations measured by the ASTRI-Horn camera that can be used as diagnostic tool to ensure the right behavior of the camera in view of the ASTRI-MiniArray implementation.'

Collaborations
other (fill field below), ASTRI Project

Keywords and Comments
IACT\r\nASTRI-Horn\r\nUVscope, Antonio Alessio Compagnino"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Observations of the cosmic ray detector at the Argentine Marambio base in the Antarctic Peninsula

Presenter
Noelia Ayelén Santos
Author and Co-Author
Noelia Ayelén Santos Sergio Dasso | Adriana Gulisano | Omar Areso | Matías Pereira | For the LAGO collaboration

Abstract
'On March 2019 a Space Weather Laboratory was deployed at Marambio base in the Antarctic Peninsula. The main instrument installed was a cosmic ray detector based on water Cherenkov radiation. This detector is the first permanent Antarctic node of LAGO (Latin American Giant Observatory) Collaboration and it has been working continously since its installation. LAGO Project is an extended Astroparticle Observatory and It is mainly oriented to basic research in three branches of Astroparticle physics: the Extreme Universe, Space Weather phenomena, and Atmospheric Radiation at ground level. The LAGO Space Weather program is directed towards the study of how the variations of the flux of secondary cosmic rays at ground level are linked with the heliospheric and geomagnetic modulations.\r\n\r\nObservations made during 2019 and 2020 will be presented here. The corrected count rate observed with our WCD is compared with observations of Oulu neutron monitor with similar rigidity cut off than the Marambio site (2,32 GV). During the summer Antarctic campaign of 2020 a new acquisition system was implemented. With this new system we are able to get a count rate related to the flux of secondary particles in a specific range of deposited energy into the detector. We analyze the effect of pressure and temperature in each of these count rates.'

Collaborations
, LAGO

Keywords and Comments
Water Cherenkov detector, Space Weather, Antartctic Peninsula, Noelia Santos"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Data-driven Estimation of Invisible Energy below EeV

Presenter
Jakub Vícha
Author and Co-Author
Jakub Vícha Vladimír Novotný | Jan Ebr

Abstract
'The calorimetric energy of a cosmic-ray shower is measured by optical telescopes from the emission of isotropic fluorescence light or from the collimated Cherenkov light through the number of charged secondary particles. To reconstruct the energy of the primary cosmic ray, the calorimetric energy needs to be further corrected for the fraction that is not deposited in the atmosphere. This invisible energy is a substantial source of systematic uncertainties in the energy spectrum of cosmic rays measured by optical telescopes below 1 EeV. Usually, estimations of the invisible energy below 1 EeV used Monte Carlo simulations despite the fact that models of hadronic interactions have problems in describing the measured air-shower data. We apply a data-driven method to derive the invisible energy for air showers using the publicly available data of the KASCADE and IceTop experiments. The universal relation between the invisible energy and the number of muons measured by the detectors was utilized. In this way, we determine the invisible energy from measured data between PeV and EeV energies.'

Collaborations

Keywords and Comments
Cosmic rays, optical detection, invisible energy, Jakub Vícha''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Studies of a muon-based mass sensitive parameter for the IceTop surface array

Presenter
Donghwa Kang
Author and Co-Author
Donghwa Kang | Sally Browne | Andreas Haungs | for the IceCube collaboration

Abstract
'IceTop is the surface instrumentation of the IceCube Neutrino Observatory at the South Pole. It is designed to measure extensive air showers of cosmic rays in the primary energy range from PeV to EeV. Air showers induced by heavier primary particles develop earlier in the atmosphere and produce more muons observable at ground level than lighter cosmic rays with the same primary energy. Therefore, the fraction of muons to all charged particles measured by IceTop characterizes the mass of primary particles. This analysis seeks a muon-based mass sensitive parameter by using the charge signal distribution for each individual cosmic ray event. In this contribution we present the analysis method for the mass-sensitive parameter and our studies of its possible application to the measurement of cosmic ray mass composition with the IceTop surface array.'

Collaborations
IceCube,
Keywords and Comments
IceTop, cosmic ray mass composition, Donghwa Kang"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Simulation Study of the Observed Radio Emission of Air Showers by the IceTop Surface Extension

Presenter
Alan Coleman
Author and Co-Author
Alan Coleman | for the IceCube Collaboration

Abstract
'Multi-detector observations of individual air showers are critical to make significant progress to precisely determine cosmic-ray quantities such as mass and energy of individual events and thus bring us a step forward in answering the open questions in cosmic-ray physics. An enhancement of IceTop, the surface array of the IceCube Neutrino Observatory, is currently underway and includes adding antennas and scintillators to the existing array of ice-Cherenkov tanks. The radio component will improve the characterization of the primary particles by providing an estimation of Xmax and a direct sampling of the electromagnetic cascade, both important for per-event mass classification. A prototype station has been operated at the South Pole and has observed showers, simultaneously, with the three detectors types. The observed radio signals of these events are unique as they are measured in the 100-350 MHz band, higher than many other cosmic-ray experiments. We present a comparison of the detected events with the waveforms from CoREAS simulations, convoluted with the end-to-end electronics response, as a verification of the analysis chain. Using the detector response and the measurements of the prototype station as input, we update a Monte-Carlo-based study on the potential of the enhanced surface array for the hybrid detection of air showers by scintillators and radio antennas.'

Collaborations
IceCube,
Keywords and Comments
IceCube, IceTop, Radio,, Alan Coleman''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
The EUSO@TurLab project in view of Mini-EUSO and EUSO-SPB2 missions

Presenter
Mario Edoardo Bertaina
Author and Co-Author
Hiroko Miyamoto Matteo Battisti | Alexander Belov | Mario Edoardo Bertaina | Francesca Bisconti | Francesca Capel | Giorgio Cotto | Renato Forza | Pavel Klimov | Massimiliano Manfrin | Marco Mignone | Lech Wiktor Piotrowski | for the JEM-EUSO collaboration

Abstract
'The TurLab facility is a laboratory, equipped with a 5 m diameter and 1 m depth rotating tank, located in the fourth basement level of the Physics Department of the University of Turin. \r\nIn the past years, we have used the facility to perform experiments related to the observations of Extreme Energy Cosmic Rays (EECRs) from space using the fluorescence technique for JEM-EUSO missions with the main objective to test the response of the trigger logic. In the missions, the diffuse night brightness and artificial and natural light sources can vary significantly in time and space in the Field of View (FoV) of the telescope. Therefore, it is essential to verify the detector performance and test the trigger logic under such an environment. By means of the tank rotation, a various terrestrial surface with the different optical characteristics such as ocean, land, forest, desert and clouds, as well as artificial and natural light sources such as city lights, lightnings and meteors passing by the detector FoV one after the other is reproduced. The fact that the tank located in a very dark place enables the tests under an optically controlled environment.\r\nThanks to the Mini-EUSO data taken since 2019 onboard the ISS, it was possible to verify the reliability of the light conditions reproduced at TurLab. This contribution will report on the comparison between TurLab and ISS measurements in view of future experiments at TurLab. Moreover, in the forthcoming months we will start testing the trigger logic of the EUSO-SPB2 mission. We will report also on the plans and first measurements for this purpose.'

Collaborations
other (fill field below), JEM-EUSO

Keywords and Comments
Mini-EUSO, photodetection, UHECR, EECR, trigger, ISS, Hiroko Miyamoto''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Study of mass composition of cosmic rays with IceTop and IceCube

Presenter
Paras Koundal
Author and Co-Author
Paras Koundal | Matthias Plum | Julian Saffer | For the IceCube Collaboration

Abstract
'The IceCube Neutrino Observatory is a multi-component detector at the South Pole which detects high-energy particles emerging from astrophysical events. These particles provide us with insights into the fundamental properties and behaviour of their sources. Besides its principal usage and merits in neutrino astronomy, using IceCube in conjunction with its surface array, IceTop, also makes it a unique three-dimensional cosmic-ray detector. This distinctive feature helps facilitate detailed cosmic-ray analysis in the transition region from galactic to extragalactic sources. We will present the progress made on multiple fronts to establish a framework for mass-estimation of primary cosmic rays. The first technique uses advanced methods in Graph Neural Networks to use the full in-ice shower footprint, in addition to global shower-footprint features from IceTop. The second technique relies on a likelihood-based analysis of the surface signal distribution and improves upon the standard reconstruction technique. A comparison between the two methods for composition analysis as well as a possible extension of the analysis techniques for sub-PeV cosmic-ray air-showers will also be discussed.'

Collaborations
IceCube,

Keywords and Comments
Cosmic Rays, Cosmic Ray Composition, Deep Learning, Graph Neural Network, Machine Learning, IceCube Observatory,, Paras Koundal"

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Presenter Forum

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Cosmic Ray Detection at the Murchison Radio-astronomy Observatory – a pathfinder for SKA-Low

Presenter
Alexander Williamson
Author and Co-Author
Clancy James | Tim Huege | Justin Bray | Steven Tingay | Alexander Williamson

Abstract
'We present the status of cosmic-ray detection activities at the Murchison Radio-astronomy Observatory. Using 128 antennas of the Murchison Widefield Array radio telescope in its extended configuration, we detect the radio emission from extensive air showers in the 122-154 MHz range at a rate of slightly less than once per hour, each with an approximate energy of 10^17 eV. We have developed a bespoke filter inversion to obtain high-time-resolution data from this general-purpose astronomy instrument, and trigger data capture directly from the radio signal. Our future plans include the implementation of a particle-triggered mode, and expanded operations with the low-frequency component of the Square Kilometre Array, which will have ~100,000 antennas deployed on the same site.'

Collaborations
Keywords and Comments
, Clancy James"

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Presenter Forum

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Reconstruction of air shower events measured by the surface detectors of the TAx4 experiment

Presenter
Hyomin Jeong
Author and Co-Author
Hyomin Jeong Telescope Array collaboration

Abstract
'The source, propagation and acceleration mechanism of Ultra High Energy Cosmic Rays (UHECRs) has been investigated since the first discovery of UHECRs to solve the mystery about the extremely-high energy universe. The Telescope Array times 4 (TAx4) experiment, which currently consists of 257 Surface Detectors (SDs) and 2 Fluorescence Detector (FD) stations, had been built in Utah, USA in 2019. The TAx4 SDs are detecting secondary particles in an extensive air shower induced by UHECRs, and we reconstructed arrival directions and energies of UHECR using the signals measured by SDs. We present the reconstruction procedure and preliminary results of the reconstructed energies and arrival directions of UHECRs detected by the TAx4 SDs.'

Collaborations
Telescope Array,

Keywords and Comments
TA, UHECR, SD, Hyomin Jeong"

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Presenter Forum

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-1
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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Analysis of TAx4 hybrid trigger and events

Presenter
Sangwoo Kim
Author and Co-Author
Sangwoo Kim | Telescope Array Collaboration

Abstract
'The Telescope Array is the largest ultra-high energy cosmic ray hybrid detector in the Northern hemisphere. While the TAx4 Surface Detector (TAx4 SD) has a duty cycle of ~ 100%, it should be noted that the TAx4 Fluorescence Detector (TAx4 FD) observes the full longitudinal profile of the cosmic ray air showers and therefore is able to determine their energies more accurately than TAx4 SD. In addition, observing cosmic rays in hybrid mode (“hybrid events”) has several advantages. Events seen in hybrid mode by the TAx4 FD and SD are used to establish the energy scale of the TAx4 SD. Moreover, the FD longitudinal profile is used to determine the mass composition of the primary comic ray particles, when the event geometries are well constrained by FD and SD measurements simultaneously. Despite large differences in the TAx4 SD/FD stand-alone performances, both detector types complement each other in measuring important physical quantities. Since August 2019, direction, energy, and Xmax can be obtained from reconstructing hybrid events. In this poster, preliminary analysis of TAx4 hybrid trigger and TAx4 hybrid events will be presented with focus on energy and Xmax observations.'

Collaborations
Telescope Array,

Keywords and Comments
Cosmic-Ray, Ultra-High-Energy-Cosmic-Ray(UHECR), Telescope Array(TA), Sangwoo Kim"

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Presenter Forum

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Estimation of the exposure of the TUS space based cosmic ray observatory

Presenter
Francesco Fenu
Author and Co-Author
Francesco Fenu Mikhail Zotov | Kenji Shinozaki | Mario Bertaina | Pavel Klimov | for the JEM-EUSO collaboration

Abstract
'The TUS observatory, as a part of the JEM-EUSO program, aimed at the detection of Ultra High Energy Cosmic Rays (UHECR). TUS was the first UHECR detector to operate in space and was launched on April 28th 2016 from the Vostochny cosmodrome in Russia. It operated until December 2017 and collected ~80000 events with a time resolution of 0.8 μs. A fundamental parameter to be determined for the measurement of cosmic rays properties is the exposure. Such a parameter is important to estimate the average expected event rate as a function of energy and to calculate the absolute flux in case of event detection. We present here a study for the determination of the exposure that TUS accumulated during its flight. The role of clouds, detector dead time, man made sources, storms, lightning discharges, airglow and moon phases is studied in detail. An exposure estimate with its dependence on the energy and with its geographical distribution is presented. We report on the applied technique and on the perspectives of this study in view of future missions of the JEM-EUSO program.'

Collaborations
other (fill field below), JEM-EUSO

Keywords and Comments
TUS, exposure, JEM-EUSO, Francesco Fenu''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Simulations studies for the Mini-EUSO detector

Presenter
Francesco Fenu
Author and Co-Author
Francesco Fenu Hiroko Miyamoto | Mario Bertaina | Marco Casolino | Antonio Montanaro

Abstract
'Mini-EUSO is a mission of the JEM-EUSO program flying onboard the International Space Station since August 2019. Since the first data acquisition in October 2019, more than 35 sessions have been performed for a total of 52 hours of observations. The detector has been observing Earth at night-time in the UV range and detected a wide variety of transient sources all of which have been modeled through Monte Carlo simulations. Mini-EUSO is also capable of detecting space debris and meteors and we performed simulations for such events to estimate their impact on future missions for cosmic ray science from space.\r\nWe show here examples of the simulation work done in this framework to analyze the Mini-EUSO data. The expected response of Mini-EUSO with respect to ultra high energy cosmic ray showers has been studied. The efficiency curve of Mini-EUSO as a function of primary energy has been estimated and the energy threshold for Cosmic Rays has been confirmed to be above \$10^{21}\$ eV. We compared the morphology of several transient events detected during the mission with cosmic ray simulations and excluded that they can be due to cosmic ray showers. To validate the energy threshold of the detector, a system of ground based flashers is being used for end-to-end calibration purposes. We therefore implemented a parameterization of such flashers into the JEM-EUSO simulation framework and studied the response of the detector with respect to such sources.'

Collaborations
other (fill field below), JEM-EUSO
Keywords and Comments
MIni-EUSO, simulations, data analysis, JEM-EUSO, Francesco Fenu''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
The performances of the LHAASO-KM2A tested by the observation of cosmic-ray Moon shadow.

Presenter
Yuncheng Nan
Author and Co-Author
Yuncheng Nan | Songzhan Chen | Zhe Li | Sha Wu | Yizhuo Li | Cunfeng Feng | for the LHAASO Collaboration

Abstract
"The half array of the KM2A in LHAASO has been operated since the end of 2019. It is a major ground-based array for the researches on cosmic rays around knees and the gamma-ray astronomy at ultra-high energy, which depends heavily on its performances. The cosmic-ray Moon shadow, which is observed by KM2A with monthly significance of 25 standard deviation, is used as an unique and powerful source to test the array's performances. Through the observation of the characteristics of the Moon shadow, including the displacement from the centre, the shape, the deficit, and their variation with the time and energy, we discuss the pointing error, the angular resolution, the long-term stability of the KM2A and the absolute energy scale of the primary cosmic-ray particles. In particular, the position of Moon varies within a declination band of about ±25°, the pointing errors of KM2A to observe sources at different declinations are thoroughly tested in this work."

Collaborations
Lhaaso,

Keywords and Comments
Moon Shadow；performance of LHAASO-KM2A, Yuncheng Nan'I submitted two substracts. If the other substract is determined to be oral, I will change the type of this to poster. If not, I will still keep the oral form of this report.'

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Performance and simulation of the surface detector array of the TAx4 experiment

Presenter
Kozo Fujisue
Author and Co-Author
Kozo Fujisue | For the Telescope Array Collaboration

Abstract
'The TAx4 experiment is a project to observe highest energy cosmic rays by expanding the detection area of the Telescope Array (TA) experiment with newly constructed surface detectors (SDs) and fluorescence detectors (FDs). New SDs are arranged in a square grid with 2.08 km spacing at the north east and south east of the TA SD array. We use CORSIKA simulations and implement the calibration data of the new SDs to calculate the performance of the new SDs. We compare the data with the simulation and validate the performance of the SDs. The comparison and the performance will be shown in the presentation.'

Collaborations
Telescope Array,
Keywords and Comments
Ultra high energy cosmic rays, simulation, etc., Kozo Fujisue"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Event-by-event reconstruction of the shower maximum X_max with the Surface Detector of the Pierre Auger Observatory using deep learning

Presenter
Jonas Glombitza
Author and Co-Author
Jonas Glombitza | For the Pierre Auger Collaboration

Abstract
'The measurement of the mass composition of ultra-high energy cosmic rays constitutes one of the\r\nbiggest challenges in astroparticle physics. Most detailed information on the composition\r\ncan be obtained from measurements of the depth of maximum of air showers, $X_\\mathrm{max}$, with the use of fluorescence telescopes, which can be operated only during clear and moonless nights.\r\n\r\nUsing deep neural networks, it is now possible for the first time to perform an event-by-event\r\nreconstruction of $X_\\mathrm{max}$ with the Surface Detector (SD) of the Pierre Auger Observatory. Therefore, previously recorded data can be analyzed for information on $X_\\mathrm{max}$, and thus the cosmic-ray composition. Since the SD operates with a duty cycle of almost 100% and its event selection is less strict than for the Fluorescence Detector (FD), the gain in statistics with respect to the FD is almost a factor of 15 for energies above $10^{19.5}$ eV.\r\n\r\nIn this contribution, we introduce the neural network particularly designed for the SD of the Pierre Auger Observatory. We evaluate its performance using three different hadronic interaction models and verify its functionality using Auger hybrid measurements. \r\nFinally, we quantify the expected systematic uncertainties and show that the method permits to determine the first two moments of the $X_\\mathrm{max}$ distributions up to the highest energies.'

Collaborations
Auger,

Keywords and Comments
machine learning, mass composition,, Jonas Glombitza''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Tunka-Grande array for high-energy gamma-ray astronomy and cosmic-ray physics: preliminary results.

Presenter
Anna Ivanova
Author and Co-Author
Anna Ivanova | Roman Monkhoev | for TAIGA Collaboration

Abstract
'The Tunka-Grande scintillation array is a part of the TAIGA experimental complex designed for high-energy gamma-ray astronomy and cosmic-ray physics.\r\nIn this work methods of reconstruction of primary particles parameters are presented, as well as the accuracy of reconstruction of the EAS core position, energy, and arrival direction, obtained by comparing the reconstruction results with the data of the Tunka-133 and TAIGA-HiSCORE Cherenkov arrays. The preliminary all-particle energy spectrum based on 3 operation seasons of the installation is presented.'

Collaborations
TAIGA,
Keywords and Comments
High energy cosmic rays, air shower, scintillation detectors, energy spectrum., Anna Ivanova''

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Subcategory Experimental Results

Titel
Study horizontal air showers with LHAASO-KM2A

Presenter
Quanbu Gou
Author and Co-Author
Quanbu Gou | Zhuo Li | Giuseppe Di Sciascio | Chao Hou | Jiangtao Liu | Xiaochuan Chang | Hongkui Lv | Lili Yang | Sujie Lin | Andrea Addazi | Xuewen Liu | Mingming Kang | Antonino Marciano | Jinsheng Gou | Shiyu Yin | Yaping Wang | Zihan Yang | Xishui T

Abstract
'LHAASO-KM2A is a sub-array of the Large High Altitude Air Shower Observatory (LHAASO) with an area of 1.3 km2. It consists of 5195 electromagnetic detectors (EDs, 1 m2 each) and 1171 muon detectors (MDs, 36 m2 each). Horizontal Air Showers (HAS) are a fundamental tool to detect penetrating particles like neutrinos and to study hadronic interactions. HAS detected at ground are mainly constituted by secondary muons. In this contribution first observations of HAS with EDs of LHAASO-KM2A are reported. We discuss the zenith angle distribution of EAS and the transition from electromagnetic-dominated showers to muon-dominated ones above a zenith angle of 60 degree. Muon contents together with hadronic interaction models will also be discussed.'

Collaborations
Lhaaso,

Keywords and Comments
horizontal air showers,muon contents, hadronic interaction models, Quanbu Gou''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Simulation Study on Scaler Mode in LHAASO-KM2A

Presenter
Daihui Huang
Author and Co-Author
Zhicheng Huang | Daihui Huang | Xunxiu Zhou | Jing Zhao | Huihai He | songzhan Chen | Xinhua Ma | Dong Liu | Kegu Axi | Bing Zhao

Abstract
'LHAASO, located at Daocheng in Sichuan province of China with an altitude up to 4410 m above the sea level, takes the function of hybrid technology to detect cosmic rays. As the major array of LHAASO, KM2A is composed of 5195 electromagnetic particle detectors (EDs) and 1188 muon detectors (MDs). In the ground-based experiments, there are two common independent data acquisition systems, corresponding to the scaler and shower operation modes. In order to learn more about the scaler mode in LHAASO-KM2A, we adopt the CORSIKA to study the shower development and employ the G4KM2A (based on Geant4) to simulate the detector responses. For one cluster (composed of 64 EDs) in the array of KM2A-ED, the event rates of showers having a number of fired EDs ≥1, 2, 3 and 4 (in a time coincidence of 100 ns) are recorded. The average rates of the four multiplicities are ~88 kHz, ~1.4 kHz, ~210 Hz, ~110 Hz, respectively. For the array of KM2A-MD, there are 16 MDs in one cluster. The average rates with multiplicities ≥1 and ≥2 are ~84 kHz and ~890 Hz, respectively. The corresponding primary energies are also given. According to our simulations, the energy threshold of the scaler mode can be lowered to ~ 100 GeV. At the same time, the energy threshold of LHAASO-KM2A in shower mode is presented for comparison. The simulation results in this work are beneficial for the online trigger with scaler mode, and also be useful in understanding the experiment results in LHAASO-KM2A.'

Collaborations
Lhaaso,
Keywords and Comments
Scaler mode, Shower mode, LHAASO-KM2A, Monte Carlo simulations, Cosmic rays, Xunxiu Zhou''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Latest results from the PolarquEEEst missions

Presenter
Marcello Abbrescia
Author and Co-Author
Marcello Abbrescia | for the EEE collaboration

Abstract
'The PolarquEEEst scientific programme consists in a series of measurements of the cosmic ray flux up to the highest latitudes, well beyond the Polar Article Circle. It started in Summer 2018, when one telescope for cosmic rays was installed on a sailboat leaving from North Iceland, to circumnavigate the Svalbard archipelago and land in Tromsø. It collected data up to 82N, measuring with unprecedented precision the charged particle rate at sea level in these regions.\r\n\r\nDuring Fall of the same year and Spring 2019 the PolarquEEEst programme continued with a series of measurements performed using the same detector, which took place first in Italy, with the southernmost point reached at Lampedusa, and then in Germany, with the goal to measure the dependence of cosmic charged particle rate with latitude.\r\n\r\nThen, in May 2019, the PolarquEEEst collaboration accomplished another important result, installing a cosmic ray observatory for the detection of secondary cosmic muons at Ny Alesund, at 79N, made of three independent identical detectors positioned a few hundred meters from each other, and synchronized in order to operate together as a network. This configuration allows high precision measurements never performed before at these latitudes on a long term, also interesting for their connection with environmental phenomena.\r\n\r\nHere the various missions will be presented, and the latest results from the measurements performed will be shown.'

Collaborations
other (fill field below), Extreme Energy Events (EEE)
Keywords and Comments
secondary cosmic rays, latitude dependance, Marcello Abbrescia''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
On the cosmic-ray energy scale of the LOFAR radio telescope

Presenter
Katharine Mulrey
Author and Co-Author
Katharine Mulrey For the LOFAR CR-KSP

Abstract
'Cosmic rays are measured at LOFAR simultaneously with a dense array of antennas and with the LOFAR Radboud air shower Array (LORA) which consists of 20 scintillators. In this contribution we present cosmic-ray energy reconstruction using radio and particle techniques and discuss the event-by-event and absolute scale uncertainties. The energies reconstructed with each method are shown to be in good agreement. The radio-based reconstruction has smaller uncertainty on an event-to event basis, so LOFAR analyses will use that technique in the future. We also present the radiation energy of air showers measured at LOFAR. Radiation energy scales quadratically with the electromagnetic energy in an air shower, which can be related to the energy of the primary cosmic ray. Once the local magnetic field is accounted for, the radiation energy can be used to compare the energy measured at different locations using different techniques. We compare the LORA particle-based energy scale to that of the Pierre Auger Observatory and find that they agree to within (6 $\\pm$ 20)% for a radiation energy of 1 MeV. The uncertainty on the comparison is dominated by the antenna calibration of each experiment. We plan to reduce this uncertainty in the future using a portable radio array to cross-calibrate the energy scales of different experiments using radiation energy and the same antennas.'

Collaborations
LOFAR,

Keywords and Comments
energy scale, radiation energy, Katharine Mulrey''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Lateral density distributions of muons and electrons in EAS from the KASCADE-Grande data for different zenith angle intervals.

Presenter
David Rivera-Rangel
Author and Co-Author
David Rivera-Rangel Juan Carlos Arteaga Velazquez | Andreas Haungs | for the KASCADE-Grande Collaboration

Abstract
'KASCADE-Grande was a cosmic ray experiment located at the Karlsruhe Institute of technology (110 m a.s.l., 49°N, 8°E), Germany, and it was designed to study extended air showers (EAS) initiated by primary nuclei in the energy range between 10 PeV and 1 EeV. KASCADE-Grande was capable of measuring the local density of charged particles, muons and of electrons of the EAS at ground level using different types of particle detectors. Using such data, we have estimated the mean radial density distributions of muon and electrons in EAS. The study was done in the radial range from 150 m to 650 m and zenith angles from 0 to 40 degrees. The zenith angle interval was divided in three bins with the same acceptance: [0°, 21.78°], [21.78°, 31.66°] and [31.66°, 40°]. Moreover, the data was further subdivided into distinct intervals in the total number of charged particles. The measurements were confronted against expectations of Monte Carlo shower simulations with iron nuclei and protons as primaries. The simulations were performed using the hadronic interaction models SIBYLL 2.3, QGSJET-II-04, SIBYLL 2.3 c and EPOS-LHC.'

Collaborations
KASCADE-Grande,
Keywords and Comments
, David Rivera-Rangel''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
A search for ultra-high-energy photons at the Pierre Auger Observatory exploiting air-shower universality

Presenter
Pierpaolo Savina
Author and Co-Author
Pierpaolo Savina For the Pierre Auger Collaboration

Abstract
'The Pierre Auger Observatory is the most sensitive detector to primary photons with energies\r\nabove ~ 0.2 EeV. It measures extensive air-showers using a hybrid technique that combines\r\na fluorescence detector (FD) with a ground array of particle detectors (SD). The signatures\r\nof a photon-induced air-shower are a larger atmospheric depth at the shower maximum\r\n(Xmax) and a steeper lateral distribution function, along with a lower number of muons with\r\nrespect to the bulk of hadron-induced background. Using observables measured by the\r\nFD and SD, three photon searches in different energy bands are performed. In particular,\r\nbetween 1 and 10 EeV, a new analysis technique has been developed by combining the FD\r\nbased measurement of Xmax with the SD signal through a parameter related to its muon\r\ncontent, derived from the universality of the air-showers. This technique has led to a better\r\nphoton/hadron separation and, consequently, to a higher search sensitivity, resulting in a\r\ntighter upper limit than before. The outcome of this new analysis is presented here, along\r\nwith previous results below 1 EeV and above 10 EeV. From the data collected by the Pierre\r\nAuger Observatory in about 15 years of operation, the most stringent constraints on the\r\nfraction of photons in the cosmic flux are set over about three decades in energy.'

Collaborations
Auger,

Keywords and Comments
UHE-photons, universality, photons, gamma-rays, Pierre Auger Observatory, extensive air showers, shower depth, muonic content, Fisher test,, Pierpaolo Savina''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Measurement of large angle muon flux in GRAPES-3 experiment using triggerless DAQ system

Presenter
Balakrishnan Hariharan
Author and Co-Author
Balakrishnan Hariharan

Abstract
'The large area muon telescope of GRAPES-3 has been operating continuously for more than two decades with a DAQ which has several limitations. At present, this DAQ is in the process of being upgraded with a FPGA based system. The new DAQ system is designed to be triggerless and capable of recording every hit from the 3712 proportional counters along with a time-stamp (10 ns accuracy) which has significantly expanded the physics horizon of the experiment. This triggerless feature allows the detection of muons beyond the nominal zenith range of the current system (0<45$^\\circ$). The upgraded DAQ system has been deployed for 25% of the telescope. An offline software trigger has been developed for the reconstruction of muon tracks by using the timing and pulse height information of each hit in the raw data. For the first time the muons are reconstructed in the entire zenith angle range. The extensive air showers (EAS) at large angles can be studied through the muon component. We present measurements of the flux of the large angle muons and their correlation with EAS triggers.'

Collaborations
other (fill field below), GRAPES-3

Keywords and Comments
GRAPES-3, Muons, Balakrishnan Hariharan'for the GRAPES-3 collaboration'

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
A Review of Cosmic Rays of LHAASO

Presenter
Shoushan Zhang
Author and Co-Author
Shoushan Zhang | Lingling Ma | Liping Wang | Feng Xiaoting | Liqiao Yin | Zhiyong You | Hengying Zhang

Abstract
'Large High-Altitude Air Shower Observatory (LHAASO) has one square kilometer array of scintillator detectors and muon detectors, 18 Imaging Atmospheric Cherenkov telescopes and a 78,000 square meter Water Cherenkov Detector Array. LHAASO located at very high altitude (around 4410 m a.s.l.) in China. Multi-parameter observation of showers allows to measurement the energy spectrum, elemental composition and anisotropy with high resolution, which give us an excellent opportunity to understand the origin, acceleration and propagation of ultra-high energy cosmic rays. The 1/4, the 1/2, the 3/4 LHAASO array have started running in September 2019, in January 2020, in December 2020 respectively. Preliminary results and the prospect of the energy spectrum, elemental composition and anisotropy measured by LHAASO experiment will be presented in the paper.'

Collaborations
Lhaaso,

Keywords and Comments
LHAASO,   Elemental composition, Energy spectrum, Anisotropy, Shoushan Zhang"

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Subcategory Experimental Results

Titel
Mass composition of Telescope Array's surface detectors events using deep learning

Presenter
Ivan Kharuk
Author and Co-Author
Ivan Kharuk | Mikhail Kuznetsov | Yana Zhezher | Grigory Rubtsov | Oleg Kalashev | For the Telescope Array Collaboration

Abstract
"The mass composition of ultra-high-energy cosmic rays can be analyzed by employing deep neural networks. We present an improved version of such analysis for Telescope Array's surface detectors data. Our neural network was trained on a large Monte-Carlo dataset simulating the expected experimental data distribution, and then was applied to the actual experimental data. Systematic and model errors are discussed."

Collaborations
Telescope Array,

Keywords and Comments
machine learning, neural networks, mass composition, ultra-high-energy cosmic rays, Ivan Kharuk"

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-12

Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Measurement of UV light emission of the nighttime Earth by Mini-EUSO for space-based UHECR observations

Presenter
Kenji Shinozaki
Author and Co-Author
Kenji Shinozaki | Dario Barghini | Matteo Battisti | Alexandar Belov | Mario Bertaina | Francesca Bisconti | Karl Bolmgren: | Giorgio Cambie | Francesca Capel | Marco Casolino | Alessio Giolzio | Pavel Klimov | Viktoria Kungel | Laura Marcelli | Hiroko Mi

Abstract
'The JEM-EUSO Program aims at the realization of the ultra-high energy cosmic ray (UHECR) observation in the satellite orbit by the air fluorescence technique. The Mini-EUSO mission is the first space-based pathfinder mission of the program that has been conducted on the International Space Station since 2019. The Mini-EUSO detector consists of a 25 cm refractive optics that focuses the UV light on the 2304-pixel array of the multi-anode photomultiplier tubes with ultra-fast readout electronics. In the mission, Mini-EUSO is operated by cosmonauts a few days per month. From the nadir-looking window of the Russian Module Zvezda, the detector is capable of continuously monitoring a ~300 km x 300 km area at night. The objectives of the mission include to understand the properties of the diffuse UV light emission from the earth and atmosphere. Such light originates from the airglow emission, back-scattered light of astronomical origin as well as the artificial light. The intensity of this light varies over the time, geographic location, atmospheric conditions. It is a key factor that determines the performance for the scientific objectives, i.e., the search for strange quark matter, observation of meteors, study of the transient luminous events etc. The data also allows for the study of the role of such light as the main background for the future UHECR space-based observation missions. In this contribution, we report the result of Mini-EUSO as well as the discussion with those of the past balloon-borne and ground-based pathfinders and perspectives for the future missions.'

Collaborations
other (fill field below), JEM-EUSO
Keywords and Comments
Mini-EUSO, International Space Station, ultra-high energy cosmic rays, fluorescence technique, airglow, Kenji Shinozaki"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Zenith angle dependence of pressure effect in GRAPES-3 muon telescope

Presenter
Meeran Zuberi
Author and Co-Author
Meeran Zuberi | for the GRAPES-3 Collaboration

Abstract
'A large area (560 m^2) muon telescope in the GRAPES-3 experiment at Ooty, India records muon intensity at high cutoff rigidities (15–24 GV) along 169 independent directions spanning a field of view of 2.3 sr. The threshold energy of the recorded muons is sec(θ) GeV along a direction with a zenith angle (θ) and with the average angular accuracy of ~4°. The directional capabilities of the muon telescope are exploited for studying the effect of atmospheric pressure on the muon flux as a function of θ. The analysis details and results will be presented.'

Collaborations
, GRAPES-3
Keywords and Comments
, Meeran Zuberi"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Measurement of the improved angular resolution of GRAPES-3 EAS array by the observation of the Moon shadow

Presenter
Diptiranjan Pattanaik
Author and Co-Author
Diptiranjan Pattanaik for the GRAPES-3 Collaboration

Abstract
'The Moon prevents cosmic rays along its direction from reaching Earth, giving rise to a deficit in the flux of cosmic rays. The observed deficit can be used for obtaining the absolute calibration of the angular resolution and to verify the pointing accuracy of the array. GRAPES-3 is an extensive air shower experiment located at Ooty, India consisting of a dense array of scintillator detectors. It records $\\sim10^9$ showers per year with a median energy of 10 TeV. With the precise determination of the arrival time of shower particles and an accurate correction for the shower front curvature, a major improvement in the angular resolution of the array has been achieved. We present a verification of the angular resolution estimated using the division of the array into left-right and even-odd sub-arrays as well as the pointing accuracy by observing the shadow of the Moon.'

Collaborations
other (fill field below), GRAPES-3
Keywords and Comments
Angular resolution, Moon shadow, EAS, cosmic rays, gamma rays, GRAPES-3,, Diptiranjan Pattanaik''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Vetoing the high energy showers in the GRAPES-3 experiment whose cores lie outside the array

Presenter
Medha Chakraborty
Author and Co-Author
Medha Chakraborty | for the GRAPES-3 collaboration

Abstract
'The GRAPES-3 experiment located at Ooty, India, consists of an array of 400 plastic scintillators which records the particle densities and relative arrival times of secondaries in an air shower. The particle densities recorded in individual detectors are then fitted by the well known NKG function to obtain the shower parameters, namely the shower core, age and size. High energy showers with cores simulated using CORSIKA with true cores far away from the array center are also capable of triggering the array. Some of those showers are mis-reconstructed such that the cores appear to lie within the array, leading to contamination which can affect the measurement of the energy spectrum of cosmic rays. To reduce this contamination, we have devised a selection technique employing several shower properties, the details of which will be presented here.'

Collaborations
other (fill field below), GRAPES-3
Keywords and Comments
Shower core, GRAPES, EAS,, Medha Chakraborty''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
An extensive study for correcting the nonlinear particle density measured by GRAPES-3 scintillator detectors

Presenter
Anuj Chandra
Author and Co-Author
Anuj Chandra | For the GRAPES-3 Collaboration

Abstract
'The GRAPES-3 extensive air shower (EAS) array located at Ooty is equipped with 400 plastic scintillator detectors spread over an area of 25000 m^2 and a muon telescope of area 560 m^2 built with 3,712 proportional counters. One of its principal objectives is to measure the primary cosmic ray energy spectrum in the TeV-PeV energy region. The response of the photo-multiplier tubes (PMTs) used in the plastic scintillator detectors becomes nonlinear at densities >50 particles per m^2 in large EAS. We describe a technique to correct for the nonlinearity of these PMTs, thereby extending the dynamic range of the detector for observed particle densities up to 1000 particles per m^2. The details of the technique will be presented.'

Collaborations
other (fill field below), GRAPES-3
Keywords and Comments
Primary Cosmic Rays, PMT, Non-Linearity, Particle density, Scintillator detector, Proportional counter, Anuj Chandra"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Atmospheric Electric Field Effects on Cosmic Rays detected at Sierra Negra, Mexico

Presenter
Bertha Jania Newton Bosch
Author and Co-Author
Bertha Jania Newton Bosch | Luis Xavier González Méndez José Francisco Valdés Galicia | Oscar Gustavo Morales Olivares | Yasushi Muraki | Yutaka Matsubara | Takashi Sako | Kyoko Watanabe | Fernando Monterde Andrade

Abstract
'The effect of thunderstorms' atmospheric electric field on secondary cosmic rays (CR) detected at high altitude was studied. We analyzed the data obtained during the period of October 2019 to March 2020 by the Solar Neutron Telescope (SNT) and a Boltek EFM-100 electric field monitor installed in the Sierra Negra Cosmic Ray Observatory (SNCRO) located at 4580 m a.s.l. in Puebla, Mexico. Based on the measurements of the Boltek EFM-100, 15 thunderstorms were identified in the established period. When the majority of thunderstorms occurred, fluctuations in the average counting rate of 2 SNT channels were observed. On the basis of the general theory of atmospheric electric field effects in the secondary CR components proposed by Dorman, we calculated as a first approximation the effect on the total charged component and the neutron component at the observation level of SNCRO. Simulations of air showers in the presence of a simplified electric field were performed with the CORSIKA code to complete the calculations. The observations were consistent with the calculated intensity variations.'

Collaborations
Keywords and Comments
Secondary cosmic rays, atmospheric electric field, Bertha Jania Newton Bosch"

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
The TRISTAN detector. Cosmic ray survey between latitudes 38ºN and 53ºS along the Atlantic Ocean

Presenter
Damián Garcia-Castro
Author and Co-Author
Hector Alvarez-Pol | Marwan Ajoor | Alberto Blanco | Pablo Cabanelas | Miguel Cruces | Jose Cuenca | Paulo Fonte | Yanis Fontenla | Damián Garcia-Castro | Juan A. Garzon | Georgy Kornakov | Teresa Kurtukian | Luis Lopes | João Saraiva | Marcos Seco | Vict

Abstract
'TRISTAN (TRasgo para InveSTigaciones ANtarticas) is a high granularity tracking detector of the Trasgo family. It was developed to complement the other detectors of the ORCA observatory that have been installed in one of the Spanish bases in Antarctica. TRISTAN is composed of three RPC planes (Resistive Plate Chambers) and offers, (i) a surface of 1.8 m2, (ii) a high multiplicity tracking capability of charged particles, (iii) a position of resolution of around 30 cm2, and (iv) an angular resolution near 0.2 sr. The detector was equipped with a 1cm lead (Pb) plate in order to separate muons from the low energy electromagnetic radiation background.\r\n\r\nBefore being installed in the definitive location, we used the TRISTAN detector to collect data \r\nduring three journeys through the Atlantic Ocean between latitudes 36ºN and 52ºS on board of the Sarmiento de Gamboa and BIO Hesperides oceanographic vessels. The trips took place between Nov. 2018 and Dec. 2019 with the main purpose of analysing the capability of a Trasgo detector to explore the geomagnetic field variations and the different atmospheric behaviours at both hemispheres and in the Equator region.\r\n\r\nThe main technical aspects of the detector and its performance (efficiency, resolutions, and acceptances) will be discussed and the preliminary results on the analysis of the correlations between the measured cosmic ray rates at different arrival angles with the geomagnetic field will be presented.'

Collaborations

Keywords and Comments
Tracking detector, Resistive Plate Chambers, Secondary Cosmic Rays. Ground detector, Geomagnetic field, muons, electrons, Juan . Garzon''

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Branch CRI | Cosmic Ray Indirect

Subcategory Experimental Results

Titel
Muography background sources: simulation, characterization, and machine-learning rejection

Presenter
Jesús Peña-Rodríguez
Author and Co-Author
Jesús Peña-Rodríguez | Mauricio Suárez-Durán | Adriana Vásquez Ramírez | Hernán Asorey | Luis A. Núñez | Ricardo deLeón-Barrios | David Villabona-Ardila | Alejandro Ramírez-Muñóz

Abstract
'Muography scans large-size objects, natural or anthropic, by detecting atmospheric muon flux after crossing these buildings. Muography suffers an overwhelming background noise because of the weakness of the emerging muon flux from scanned objects. The background noise sources are scattered muons, electromagnetic particles of Extensive Air Showers (EAS), backward particles, and particles arriving simultaneously. We carried out a muography background analysis using Monte Carlo simulations (CORSIKA-GEANT4) and data recorded by MuTe (a hybrid Muon Telescope composed of a scintillator hodoscope and a water Cherenkov detector).\r\n\r\nWe estimated the scattered muon energy-angular spectra and the EAS components impinging the MuTe. We quantified the muography background using measurements of the Time-of-Flight and deposited energy of particles. We found that the spectrum of particles impinging on MuTe is mainly composed of muons (~3 GeV/c average) and electromagnetic particles (~20 MeV/c average). The scattering probability of muons increases inversely with the energy and relative incidence angle concerning the object surface. For muons with momentum < 1 GeV/c, the scattering angle is above 1 degree. Backward impinging particles represent up to 22% of the flux and depend on their elevation angle. Two processes cause multiple particle backgrounds. Independent particles from the atmospheric radiation background and correlated particles (mainly a muon pair) originated in the same EAS, with relative arriving times > 300 ns and < 100 ns, respectively. This study offers a better understanding of background sources in muography and proposes machine learning methods to filter them.'

Collaborations
, Muon Telescope (MuTe)

Keywords and Comments
muography, background noise, muon scattering, machine learning, Jesús Peña-Rodríguez''

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Branch CRI | Cosmic Ray Indirect

Subcategory Future projects

Titel
The Zettavolt Askaryan Polarimeter (ZAP) mission concept: radio detection of ultra-high energy cosmic rays in low lunar orbit.

Presenter
Andres Romero-Wolf
Author and Co-Author
Andres Romero-Wolf | Jaime Alvarez-Muñiz | Luis A. Anchordoqui | Douglas Bergman | Washington Rodrigues de Carvalho | Austin Cummings | Peter Gorham | Casey Handmer | Nate Harvey | John Krizmanic | Kurtis Nishimura | Eric Oberla | Mary Hall Reno | Harm Sc

Abstract
'Probing the ultra-high energy cosmic ray (UHECR) spectrum beyond the cutoff at ~40 EeV requires an observatory with an acceptance that is impractical to achieve with ground arrays. We present a concept, designated the Zettavolt Askaryan Polarimeter (ZAP), for radio detection of UHECRs impacting the Moon's regolith from low-lunar orbit. ZAP would observe several thousands of events above the cutoff (~40 EeV) with a full-sky field of view to test whether UHECRs originate from Starburst Galaxies, Active Galactic Nuclei, or other sources associated with the matter distribution of the local universe at a distance > 1 MPc. The unprecedented sensitivity of ZAP to energies beyond 100 EeV would enable a test of source acceleration mechanisms. At higher energies, ZAP would produce the most stringent limits on super heavy dark matter (SHDM) via limits on neutrinos and gamma rays resulting from self-annihilation or decay.'

Collaborations

Keywords and Comments
radio detection, ultra-high energy cosmic rays, space-based, Andres Romero-Wolf"

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Branch CRI | Cosmic Ray Indirect

Subcategory Future projects

Titel
Expected Performance of the EUSO-SPB2 Fluorescence Telescope

Presenter
George Filippatos
Author and Co-Author
George Filippatos | Matteo Battisti | Mario Bertaina | Francesca Bisconti | Johannes Eser | Fred Sarazin | Lawrence Wiencke | for the JEM-EUSO Collaboration

Abstract
'The Extreme Universe Space Observatory Super Pressure Balloon 2 (EUSO-SPB2) is under development, and will prototype instrumentation for future satellite-based missions, including the Probe of Extreme Multi-Messenger Astrophysics (POEMMA). EUSO-SPB2 will consist of two telescopes. The first is a Cherenkov telescope (CT) being developed to identify and estimate the background sources for future (below-the-limb) very high energy (E>10 PeV) astrophysical neutrino observations, as well as above the limb cosmic ray induced signals. The second is a fluorescence telescope (FT) being developed for detection of Ultra High Energy Cosmic Rays (UHECRs). In preparation for the expected launch in 2023, extensive simulations, tuned by preliminary laboratory measurements have been performed to understand the capabilities of the FT. The energy threshold has been estimated at 10$^{18.2}$eV, and results in a maximum detection rate at 10$^{18.5}$eV, taking into account the shape of the UHECR spectrum. EUSO-SPB2 will be the first opportunity to perform a shower reconstruction from near-space. Using the JEM-EUSO OffLine framework, the reconstruction capabilities of the instrument have been estimated. In addition, online software has been developed based on the simulations as well as experience with previous EUSO missions. This includes a level 1 trigger to be run on the limited flight hardware, as well as a deep learning based prioritization algorithm in order to accommodate the balloon’s telemetry budget. These techniques could be used for future, space-based missions.'

Collaborations
, JEM-EUSO

Keywords and Comments
UHECR,Balloon based,Fluorescence,Simulation, George Filippatos''

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Subcategory Future projects

Titel
A performance study of the K-EUSO space based observatory

Presenter
Francesco Fenu
Author and Co-Author
Francesco Fenu Sergei Sharakin | Mikhail Zotov | Mario Bertaina | Yoshiyuki Takizawa | Naoto Sakaki | Pavel Klimov | Marco Casolino | for the JEM-EUSO collaboration

Abstract
'K-EUSO is a planned mission of the JEM-EUSO program for the study of Ultra High Energy Cosmic Rays (UHECR) from space. The K-EUSO observatory consists of a UV telescope, to be deployed on the International Space Station, with a wide field of view, that aims at the detection of the fluorescence light emitted by Extensive Air Showers (EAS) in the atmosphere. The EAS events will be sampled with a time resolution of 1μs to reconstruct the entire shower profile with high precision. The detector, consisting of ~ 10^{5} independent pixels, will allow a spatial resolution of ~500 m on ground. From 400 km altitude, K-EUSO will achieve an enormous exposure to sample the highest energy range of the UHECR spectrum. In this contribution, we present the performance of the observatory. We will first of all, present an estimation of the expected exposure and triggered event rate as a function of energy. The event reconstruction technique will be then described in detail. The triggered events will be reconstructed and we will present a summary of the event reconstruction performance. The resolution of the arrival direction and of the energy reconstruction, as well as the reconstruction efficiency as a function of the true shower parameters will be presented.'

Collaborations
other (fill field below), JEM-EUSO

Keywords and Comments
K-EUSO, Simulations, JEM-EUSO, Francesco Fenu"

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Branch CRI | Cosmic Ray Indirect

Subcategory Future projects

Titel
Study of the potential of MATHUSLA as a cosmic ray detector

Presenter
Arturo Fernandez Tellez
Author and Co-Author
Arturo Fernandez Tellez | Cristiano Alpigiani | Juan Carlos Arteaga-Velazquez | Davide Boscherini | Karen Salome Caballero-Mora | Paolo Camarri | Roberto Cardarelli | Dennis Cazar Ramirez | Giuseppe Di Sciascio | Henry Lubatti | Oscar Morales-Olivares

Abstract
'MATHUSLA is a proposal to build a hodoscope of large dimensions at ground level, close to the interaction point of the CMS detector at CERN, to search for displaced vertices from the decay of neutral long-lived particles (LLP) during the High Luminosity LHC runs in an environment with low background. LLPs are predicted by different models, which try to solve open problems in fundamental particle physics. The idea behind MATHUSLA is to monitor a large volume of air (100 m x 100 m x 25 m) with a series of layers of tracking detectors to look for displayed vertices produced by the LLPs. MATHUSLA design considers 9 m x 9 m units of extruded scintillators bars (4.6 m x 4.5 cm x 2 cm) in each detector plane, which will provide spatial and timing information of impinging charged particles. Due to its configuration, MATHUSLA could be also sensitive to air showers induced by cosmic rays. However, it would be limited as an air shower detector due to hit saturation. To enhance the capabilities of MATHUSLA to the detection of extensive air showers above 100 TeV, it was proposed to add an extra layer of RPCs. We present the results of a MC study to analyze the sensitivity of MATHUSLA to cosmic ray detection. We will show that MATHUSLA could offer different advantages for cosmic ray research: it could provide unique spatial and temporal measurements of an EAS for studies of the energy spectrum, composition and arrival distribution of cosmic rays, as well as for tests of hadronic interaction models. In addition, it offers potential tracking capabilities particularly for inclined events.'

Collaborations
other (fill field below), MATHUSLA

Keywords and Comments
LLP,secondary cosmic rays, CERN, MATHUSLA, Arturo Fern´sndez éellez''

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Branch CRI | Cosmic Ray Indirect

Subcategory Future projects

Titel
Cross-calibrating the energy scales of cosmic-ray experiments using a portable radio array

Presenter
Katharine Mulrey
Author and Co-Author
Katharine Mulrey S. Buitink | A. Corstanje | H. Falcke | B. M. Hare | J. R. Hörandel | T. Huege | G. K. Krampah | P. Mitra | A. Nelles | H. Pandya | J. P. Rachen | O. Scholten | S. ter Veen | S. Thoudam | T. N. G. Trinh | T. Winchen | K. De Vries | R. Stanley | E. Santiag

Abstract
'Different experiments use different techniques to detect and reconstruct cosmic-ray events, yielding different energy scales. Having a method to compare the energy scales of different experiments with minimal uncertainty is necessary in order to make meaningful comparisons of their spectra and composition measurements, which are used to create global models of cosmic-ray sources, acceleration and propagation. Comparing energy scales has proven to be difficult, given that uncertainties on energy measurements depend on the location, technique and equipment used. In this contribution we introduce a new radio-based technique which will be used to build a universal cosmic-ray energy scale. Radio detection provides a measure of the radiation energy in air showers, which scales quadratically with the electromagnetic energy. Once the local magnetic field strength is taken into account, radiation energy can be directly compared at different locations. A portable array of antennas will be built and deployed at various experiments, measuring radiation energy in conjunction with the host experiment's traditional air shower measurements. The energy measured at each location can then be directly compared via the contemporaneous radiation energy measurements. Using radiation energy to compare the energy scales eliminates uncertainties due to measurements being made at different locations, and using the same array at each site eliminates the uncertainties associated with the equipment and calibration. This will allow for a cross-calibration of the energy scales of different experiments with minimal uncertainty. Here we present the technique and report on the status of a prototype array that began taking data in January 2021.'

Collaborations
LOFAR,

Keywords and Comments
energy scale, cross-calibration, radiation energy, Katharine Mulrey''

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Branch CRI | Cosmic Ray Indirect

Subcategory Future projects

Titel
Performance of SKA as an air shower observatory

Presenter
Stijn Buitink
Author and Co-Author
Stijn Buitink

Abstract
'The low frequency segment of SKA in Australia will have an extremely dense antenna array spanning an area of roughly 0.5 km^2. It offers unique possibilities for high-resolution observations of air showers. Compared to LOFAR, it will have a much more homogeneous ground coverage, an increased frequency bandwidth (50-350 MHz), and the possibility to continuously observe with nearly 100% duty cycle.\r\n\r\nSKA will observe air showers in the range 10^{16} eV - 10^{18} eV with a reconstruction resolution on Xmax of around 10 g/cm^2. This allows for a high-precision study of mass composition in the energy regime where a transition is expected from Galactic to extragalactic origin. In addition, SKA will be able to put constraints on hadronic interaction models, which is crucial for interpreting the data in this complex energy range.\r\n\r\nIn this talk, we will show the results of a full detector simulation and demonstrate the capabilities of SKA, including energy and Xmax reconstruction, as well as more advanced methods to constrain the shape of the longitudinal development of air showers.'

Collaborations
LOFAR, SKA HECP focus group

Keywords and Comments
SKA, radio detection of air showers, Stijn Buitink''

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Branch CRI | Cosmic Ray Indirect

Subcategory Future projects

Titel
Classification and Denoising of Cosmic-Ray Radio Signals using Deep Learning

Presenter
Abdul Rehman
Author and Co-Author
Abdul Rehman Alan Coleman | Frank G. Schröder | Dmitriy Kostiunin

Abstract
'The radio detection technique with advantages like inexpensive detector hardware and full year duty cycle can prove to be a vital player in cosmic-ray detection at the highest energies and can lead us to the discovery of high energy particle accelerators in the universe. However, radio detection has to deal with continuous irreducible background. The Galactic and thermal backgrounds, which contaminate the radio signal from air showers, lead to a relatively high detection threshold compared to other techniques. For the purpose of reducing the background, we employ a deep learning technique namely, convolutional neural networks (CNN). This technique has already proven to be efficient for radio pulse recognition e.g., in the Tunka-Rex experiment. We train CNNs on the radio signal and background to separate both from each other. The goal is to improve the radio detection threshold on the one hand, and on the other hand, increase the accuracy of the arrival time and amplitude of the radio pulses and consequently improve the reconstruction of the primary cosmic-ray properties. Here we present two different networks: a Classifier, which can be used to distinguish the radio signals from the pure background waveforms, and a Denoiser, which allows us to mitigate the background from the noisy traces and hence recover the underlying radio signal.'

Collaborations

Keywords and Comments
Deep Leaning, Radio Signals,, Abdul Rehman''

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Branch CRI | Cosmic Ray Indirect

Subcategory Outreach and Education

Titel
Status and Future Prospects of the KASCADE Cosmic-ray Data Centre KCDC

Presenter
Andreas Haungs
Author and Co-Author
Andreas Haungs | Donghwa Kang | Katrin Link | Frank Polgart | Victoria Tokareva | Doris Wochele | Jürgen Wochele

Abstract
"KCDC, the 'KASCADE Cosmic-ray Data Centre', is a web-based interface where initially the scientific data from the completed air-shower experiment KASCADE-Grande was made available for the astroparticle community as well as for the interested public. Over the past 7 years, we have continuously extended the data shop with various releases and increased both the number of detector components from the KASCADE-Grande experiment and the data sets and corresponding simulations. With the latest releases we added a new and independent data shop for a specific KASCADE-Grande event selection and by that created the technology for integrating further data shops and data of other experiments, like the data of the air-shower experiment MAKET-ANI in Armenia. In addition, we made available educational examples how to use the data, more than 100 cosmic ray energy spectra from various experiments, and recently attached a public server with access to Jupyter notebooks. In this paper we present a brief history of KCDC, the main features of the recent release as well as will discuss future development plans.\r\n."

Collaborations
Keywords and Comments
Open Data Plattform, Andreas Haungs"

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
On the possible method of identification of two probably cognate extensive air showers

Presenter
Dmitriy Beznosko
Author and Co-Author
Manana Svanidze | Yuri Verbetsky | Piotr Homola | Dmitriy Beznosko | for the CREDO Collaboration

Abstract
'The persistent attempts are undertaken to show existence and investigate the special pairs of Extensive Air Showers (EAS) that can be suspected in common origin in the near space, i.e. to observe some consequence of existence of Cosmic Ray Ensembles (CRE). The remote cosmic ray stations observing EAS events are useful for this investigation. Such stations are operating within the GELATICA net (GEorgian Large-area Angle and TIme Coincidence Array) and are planed within the CREDO Collaboration (Cosmic Ray Extremely Distributed Observatory) as the CREDO-Maze project. The possible criteria are developed in the paper for detecting of two specific showers which ancestors have probable mutual proximity in their past.'

Collaborations
, Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
cosmic ray ensembles, large scale cosmic ray correlations, extensive air showers, pair of showers, relativistic invariant parameters, proximity definition,, Dmitriy Beznosko'The main results covered by this article will be summarised in a highlight talk to be presented by a representative\xa0speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate\xa0request will b

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-1
Access Monday Session https://live.remo.co/e/icrc-poster-hall-12

Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
Simulations of radio emission from air showers with CORSIKA 8

Presenter
Nikolaos Karastathis
Author and Co-Author
Nikolaos Karastathis | Remy Prechelt | Tim Huege | Juan Ammerman Yebra

Abstract
'CORSIKA 8 is a new framework for air shower simulations implemented in modern C++17, based on past experience with existing codes like CORSIKA 7. The flexibility of this framework allows for the inclusion of radio-emission calculations as an integral part of the program. Our design makes radio simulations general and gives the user the freedom to choose between different formalisms, such as the “Endpoints” and “ZHS” formalisms. In addition, it takes advantage of the flexibility of the CORSIKA 8 environment and geometry design, allowing future updates to more complex scenarios such as showers crossing from air into dense media. Our first results, along with comparisons with other simulation programs like CoREAS in CORSIKA 7 and ZHAireS are going to be presented. In the future, based on our design, the opportunity arises for radio simulations to achieve a significant boost in performance by deploying parallel computing techniques, in particular employing GPUs, and hence, perform more sophisticated radio-emission studies.'

Collaborations
CORSIKA-8,
Keywords and Comments
, Nikolaos Karastathis''

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Branch	CRI | Cosmic Ray Indirect
Subcategory	Theoretical Methods

Titel
Parametrization of the Relative Amplitude of Geomagnetic and Askaryan Radio Emission from Cosmic-Ray Air Showers using CORSIKA/CoREAS Simulations

Presenter
Ek Narayan Paudel
Author and Co-Author
Ek Narayan Paudel | Alan Coleman | Frank G. Schröder

Abstract
'Cosmic rays are messengers from highly energetic events in the Universe. These rare ultra-high-energy particles can be detected efficiently and in an affordable way by large arrays of radio antennas. Linearly polarized geomagnetic emission is the dominant emission mechanism produced when charged particles in air showers get deflected in the Earth’s magnetic field. The sub-dominant Askaryan emission is radially polarized and produced due to the time-varying negative-charge excess in the shower front. The relative amplitude of these two emission components depends on various air shower parameters, such as the arrival direction and the depth of the shower maximum. We studied these dependencies using CoREAS simulations of the radio emission from air showers at the South Pole using a star-shaped antenna pattern. On the one hand, the parametrization of the Askaryan-to-geomagnetic ratio can be used as input for a more accurate reconstruction of the shower energy. On the other hand, if measured precisely enough, this ratio may provide a new method to reconstruct the atmospheric depth of the shower maximum.'

Collaborations
Keywords and Comments
Cosmic rays, radio detection, Ek Narayan Paudel"

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
Analysis of capability of detection of extensive air showers by simple scintillator detectors

Presenter
Jerzy Pryga
Author and Co-Author
Jerzy Pryga | Weronika Stanek | for the CREDO Collaboration

Abstract
'One of the main objectives of the CREDO project is to search for so-called Cosmic-Ray Ensembles (CRE). To confirm the existence of such phenomena a massive scale observation of even relatively low energy Extensive Air Showers (EAS) and an analysis of their correlations in time must be performed. To make such observations possible, an infrastructure of widely spread detectors connected in a global network should be developed using low-cost devices capable of collecting data for a long period of time. For each of these detectors or small detector systems the probability of detection of an EAS has to be determined. Such information is crucial in the analysis and interpretation of collected data. The standard approach based on detailed and extensive simulations is not possible for many such systems, thus a faster method is developed. Knowing the characteristics of EAS from more general simulations any required probability is calculated using appropriate parametrization taking into account EAS spectrum, energy dependence of particle density and zenith angle dependence. This allows to estimate expected number of EAS events measured by a set of small detectors. Results of calculations are compared with first measurements using a test system. These results can also be useful for the design of more effective small systems in the future.'

Collaborations
, Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
cosmic ray ensembles, CORSIKA simulations, cosmic-ray detection, extensive air showers, Jerzy Pryga'The main results covered by this article will be summarised in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
COSMOS X as a general purpose air shower simulation tool

Presenter
Takashi Sako
Author and Co-Author
Takashi Sako Toshihiro Fujii | Katsuaki Kasahara | Hiroaki Menjo | Naoto Sakaki | Nobuyuki Sakurai | Akimichi Taketa | Yuichiro Tameda | COSMOS team

Abstract
'An air shower simulation package COSMOS was born in 1970's and has been continuously developing. A recent major update enables particle tracking not only in the atmosphere but also in liquid and solid material by combining with the EPICS detector simulation package. This paper describes the properties of this extended version of COSMOS, namely COSMOS X. COSMOS X is coded using the FORTRAN language and can be compiled using the gFortran compiler and cmake tool. Combination of gas, liquid and solid materials in spherical shells with a common center can be defined as environment. Users can also arbitrary define the electric and magnetic fields. These features allow shower simulations even in the soil, concrete, sea and ice. Also simulations at the Sun and Mars are possible applications. Flexible output control since the previous versions of COSMOS, a set of user hook functions, is also available. In predefined user functions information of each particle in transportation can be easily accessed and users can extract information from them. General introduction to COSMOS and new functions of COSMOS X together with some interesting application cases will be presented in the conference.'

Collaborations
Keywords and Comments
air shower simulation tool, Takashi Sako"

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
A complete model of the signal in surface detector arrays and its application for the reconstruction of mass-sensitive observables.

Presenter
Max Stadelmaier
Author and Co-Author
Max Stadelmaier | Ralph Engel | Markus Roth | Schmidt David | Darko Veberic

Abstract
'The principle of Air Shower Universality yields a method of understanding Extensive Air Showers of UHECRs as a superposition of different particle components whose spatial and temporal distributions follow individual analytical profile functions. We present a model of the expected densities of particles in time and space that uses the depth of the shower maximum,\r\n$X_\\text{max}$, and the relative muonic content of the shower, $R_\\mu$, as input parameters. The model is fine-tuned and tested with simulated showers using different hadronic interaction models. Furthermore, we present results for the reconstruction of $X_\\text{max}$ and $R_\\mu$ that allow for an event-by-event estimation of the mass of the primary particle, based on the responses of the water-Cherenkov and scintillator surface detectors of the Auger Observatory.'

Collaborations
Keywords and Comments
Air Shower Universality, Pierre Auger, Auger, Air Showers, UHECR, Max Stadelmaier"

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
Parameterization of muon production profiles in the atmosphere

Presenter
Stef Verpoest
Author and Co-Author
Stef Verpoest | Thomas Gaisser

Abstract
'Production of high-energy muons in cosmic-ray air showers, relevant for deep underground detectors, depends on the properties of the primary cosmic ray as well as the atmospheric temperature through the competition between decay and re-interaction of charged pions and kaons. We present a parameterization of muon production profiles based on simulations as a function of the primary cosmic-ray energy, mass and zenith angle, the minimum energy for a muon to reach the detector and an atmospheric temperature profile. We illustrate how this can be used to calculate muon bundle properties such as multiplicity and transverse size and their seasonal variations in the context of underground measurements in coincidence with a surface detector which fixes the primary cosmic-ray energy.'

Collaborations
Keywords and Comments
Muons, Multiplicity, Underground, Seasonal variation, Cosmic rays, Air showers, Stef Verpoest''

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
On the need for unbiasing azimuthal asymmetries in signals measured by surface detector arrays

Presenter
Quentin Luce
Author and Co-Author
Quentin Luce | Markus Roth | David Schmidt | Darko Veberic

Abstract
'A surface detector array samples the lateral distribution of an extensive air-shower (EAS) at the ground, i.e. the density of particles as a function of the distance from the axis of the shower. The azimuthal symmetry of this measured lateral distribution is broken for EAS with a non-zero zenith angle. The resulting asymmetry, caused by atmospheric attenuation and geometrical effects, increases with the inclination of the shower and introduces a bias in the reconstruction of the shower parameters.\r\nUsing simulated sets of air-showers, we present a model to correct the azimuthal asymmetry in signals measured by water-Cherenkov detectors and exemplified using the geometry and detector response of the Pierre Auger Observatory. Testing showers initiated by proton and iron primaries using EPOS-LHC and QGSJetII-04 as hadronic models, we developed a fine-tuned model of the amplitude of the asymmetry as a function of the zenith angle, shower size and distance of a detector from the shower axis. The improvements resulting from the application of the correction are quantified in terms of the biases and resolutions in the impact-point and arrival direction.'

Collaborations

Keywords and Comments
asymmetry, lateral distribution function, energy estimation, models of hadronic interactions, simulation of extensive air showers, Darko Veberic''

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
The impact of photonuclear reaction models on propagation of ultrahigh energy cosmic rays

Presenter
Eiji Kido
Author and Co-Author
Eiji Kido | Tsunenori Inakura | Yutaka Utsuno | Kimura Masaaki | Shigehiro Nagataki | Atsushi Tamii

Abstract
'Ultrahigh energy cosmic ray (UHECR) nuclei with Lorentz factors greater than about 10^9 lose their energies by the photodisintegration with cosmic microwave background photons in intergalactic space. The photodisintegration is a main process of the energy losses at the highest energies, so it is important to understand the model dependence of the photodisintegration to simulate propagation of UHECR nuclei. We implemented photonuclear reaction models which were obtained using calculations of the random-phase approximation (RPA) in a cosmic ray propagation code CRPropa and simulated the cosmic ray propagation. We present the comparison of the simulated observables such as energy spectra and compositions between the models.'

Collaborations

Keywords and Comments
Ultrahigh energy cosmic rays, Cosmic ray propagation, Eiji Kido"

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
Modeling the influence of the solar cosmic rays protons on the Earth's atmosphere over a wide range of heights

Presenter
Eugeny Maurchev
Author and Co-Author
Eugeny Maurchev | Yury Balabin | Alexey Germanenko | Boris Gvozdevsky

Abstract
'The important applied problem of the cosmic ray physics is the assessment of radiation safety during solar flares, especially when events of an increase in the count rate on neutron monitors - GLE (Ground level enhancement) are observed. This effect is explained by the fact that the flux of primary protons with energies from 1 GeV to 10 GeV increases, which are capable of losing their energy both in ionization processes and through nuclear interactions. At the Polar Geophysical Institute, the RUSCOSMICS software package was developed, one of the possibilities of which is the ability to obtain an altitude ionization profiles for a given area of the atmosphere, using the spectra of primary protons of solar cosmic rays as input data. It should be noted that the methodology for calculating spectra, as well as reception cones and pitch-angle distributions, was also developed in the Polar Geophysical Institute. The important feature of this work can be called the use of parallel computing, which made it possible to expand the applicability of the model from a local site to the global geometry of the entire atmosphere of the Earth. The paper presents the results obtained for solar cosmic rays at heights from 1 km to 80 km with a step of 1 km for all values of latitude and longitude with a step of 5 degrees. Model verification was carried out in earlier works using data obtained during the launch of balloons.'

Collaborations

Keywords and Comments
cosmic rays,Monte-Carlo method,radiation safety, Eugeny Maurchev''

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Methods

Titel
A Spectral Cosmic Ray Model for Cosmological Simulations

Presenter
Ludwig Böss
Author and Co-Author
Ludwig Böss Klaus Dolag | Harald Lesch

Abstract
'Cosmic Rays are the most likely source of non-thermal emission in galaxy clusters. These emissions are found at merger shocks where they can be observed as highly polarized radio relics, in jets of AGNs and sometimes as a diffuse radio halo across the entire galaxy cluster. Self-consistent simulations of these observations have been a challenge over the last decades, as they require models for (re-)acceleration of CRs at shocks, by AGN, or turbulence as well as accurate treatment of energy losses of CRs and their spacial diffusion. Since most of these effects depend on the distribution function of the CR population a simple two-fluid approach of CRs and gas is often not sufficient to self-consistently reproduce observations. We present a spectral cosmic ray model implemented in the cosmological MHD code OpenGadget3 that shows excellent scaling and can be used for the next generation of galaxy and galaxy cluster simulations that include the effects of both, magnetic fields and cosmic ray electrons and protons. After a detailed description of the model and its coupling to our large-scale simulation code, we will discuss the use case of a galaxy cluster merger simulation that includes magnetic fields and cosmic rays with a spectrum represented by up to 96 momentum bins. This simulation allows us to self-consistently investigate the emission from CR electrons while also constraining the kinematic impact of CR protons.'

Collaborations

Keywords and Comments
Structure Formation, MHD Simulations, Fokker-Planck-Solver, Spectral Cosmic Ray Model,, Ludwig Böss''

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Branch	CRI | Cosmic Ray Indirect
Subcategory	Theoretical Results

Titel
AGN jet heating with cosmic rays in magnetized, turbulent galaxy clusters

Presenter
Kristian Ehlert
Author and Co-Author
Kristian Ehlert | Christoph Pfrommer | Rainer Weinberger | Volker Springel

Abstract
'Feedback processes by active galactic nuclei in the centres of galaxy clusters appear to prevent large-scale cooling flows and impede star formation. However, the detailed heating mechanisms remain uncertain. Promising heating scenarios invoke the dissipation of Alfvén waves that are generated by streaming cosmic rays (CRs) or the dissipation of cluster turbulence. In order to study the idea of CR heating, we use three-dimensional magneto-hydrodynamical simulations with the Arepo code that follow the evolution of jet-inflated bubbles filled with CRs in a turbulent, magnetized cluster atmosphere. We find that a single injection event recovers the correct CR distribution and heating rate for a successful heating model in Perseus over a duty cycle of 30 Myrs. In order to study the idea of turbulent heating, we analyzed the impact of active galactic nuclei (AGN)-induced turbulence on X-ray line broadening and compared our results to recent Hitomi data. We find that AGN jets drive turbulence, which however remains localized in the wake of the buoyantly rising bubbles after the jets have terminated. Cluster turbulence as inferred from broadened X-ray lines and Faraday rotation measures must hence be driven by other processes such as precipitation due to thermal instability or cosmological infall. In the final part, we present new simulations that study the interplay of radiative cooling and heating induced by AGN jets that self-regulate the cooling cluster cores and may provide the long-thought solution to the cooling flow problem in galaxy clusters.'

Collaborations

Keywords and Comments
AGN, CR feedback, MHD simulations, galaxy clusters,, Kristian Ehlert''

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
The contribution of distant sources to the observed flux of ultra high-energy cosmic rays

Presenter
Ellis Owen
Author and Co-Author
Ellis Owen Qin Han | Kinwah Wu | Y. X. Jane Yap | Pooja Surajbali

Abstract
"The Greisen-Zatsepin-Kuz'min (GZK) horizon traditionally sets the distance limit for sources generating the UHE CR flux detected on Earth. This horizon is caused by the strong attenuation of Ultra-high-energy (UHE) cosmic rays (CRs) due to their hadronic interactions with cosmic microwave background radiation. It has been argued that the propagation distance of UHE CRs of energies $\\sim (10^{18}-10^{20})~{\\rm eV}$ would be about several tens Mpc. We demonstrate that a non-negligible fraction of the UHE CRs arriving on Earth could originate from beyond the GZK horizon when heavy nuclear CRs, and the population and evolution of UHE CR sources are taken into account. Here we present how the multi-particle CR horizon is modified by different source populations and discuss how this leads to the natural emergence of an isotropic background component in the observed flux of UHE CRs. This background component would coexist with an anisotropic contribution associated with nearby foreground sources within the GZK horizon"

Collaborations

Keywords and Comments
cosmic ray sources, ultra-high energy cosmic radiation, secondary cosmic ray, astronomical radiation sources, extragalactic astronomy, Ellis Owen"

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Predicting the UHE photon flux from GZK-interactions of hadronic cosmic rays using CRPropa 3

Presenter
Philip Ruehl
Author and Co-Author
Philip Ruehl | Anna Bobrikova | Marcus Niechciol | Markus Risse

Abstract

'The spectrum of ultra high energy (UHE) cosmic rays as measured by the Pierre Auger Observatory indicates a strong flux suppression above 50 EeV. The origin of this suppression is still unclear. One possible explanation is the Greisen-Zatsepin-Kuzmin (GZK) process, in which UHE protons interact with the cosmic microwave background. Indirect evidence for the GZK-process could be provided by the search for UHE photons produced in such an interaction. A signal of UHE photons could not yet be identified among the cosmic rays. Hence, upper limits on the UHE photon flux have been derived from experimental data of various experiments. In order to interpret these limits, theoretical predictions are needed.\r\nIn this contribution, new predictions on the UHE photon flux above 0.1 EeV are derived assuming both pure and mixed compositions of the initial cosmic rays. The \r\nsimulation study has been done using CRPropa 3 taking into account latest results \r\nregarding the composition as measured by the Pierre Auger Observatory \r\nand the extragalactic medium. For all compositions, the predictions stay below the current upper limits on the UHE photon flux derived from experimental data. The main uncertainties on the predictions originate from the lack of knowledge about the sources of UHE cosmic rays. Future experiments like the AugerPrime upgrade of the Pierre Auger Observatory are expected to shed further light on the origin and composition of UHE cosmic rays and, hence, will help to improve the predictions.'

Collaborations

Keywords and Comments
cosmic ray propagtion, CRPropa 3, GZK-process, GZK-cutoff, ultra-high-energy photons,, Philip Ruehl''

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
The pervasive mechanism that accelerates cosmic rays at all the energies

Presenter
Antonio Codino
Author and Co-Author
Antonio Codino

Abstract
'The mechanism accelerating cosmic rays in the Galaxy and galaxy clusters is identified and described. The acceleration of cosmic rays is a purely electrostatic process which operates up to the maximum energies of 10^{23} eV in galaxy clusters. Galactic cosmic rays are accelerated in a pervasive electrostatic field active in the whole Galaxy except in restricted regions shielded by interstellar and stellar plasmas as, for instance, the region occupied by the solar system.\r\nIt is proved that the energy spectrum of the cosmic radiation in the Milky Way Galaxy in the region where the solar system resides, has a constant spectral index comprised between 2.64-2.68 and the maximum energies of Galactic protons are $3.0 \\times 10^{19}$ eV. The agreement of these results with the experimental data is discussed in detail and underlined.\r\nThe physical processes that maintain the stability of the electrostatic structure in the Milky Way Galaxy are the same that generate the Galactic magnetic field. Accordingly, the intensity, orientation and direction of the Galactic magnetic field are evaluated. The results of the calculation are compared with the observational data, optical and mostly radio astronomy data. The accord of the intensity, orientation and direction of the observed magnetic field with calculation is excellent.'

Collaborations

Keywords and Comments
Cosmic-ray acceleration, Antonio Codino"

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
New cross section determination for secondary cosmic ray electron and positrons in the light of new data from collider experiments

Presenter
Luca Orusa
Author and Co-Author
Luca Orusa Michael Korsmeier | MATTIA DI MAURO | Fiorenza Donato

Abstract
'The cosmic-ray fluxes of electrons and positrons ($e^{\\pm}$) are measured with high precision by the space-borne particle spectrometers AMS-02. To infer a precise interpretation of the dominant production process for $e^{\\pm}$ in our Galaxy, it is necessary to have a correct description of the secondary component, produced by the interaction of cosmic-ray proton and helium with the interstellar medium. We update the parametrization of the $e^{\\pm}$ cross sections in order to obtain a new estimate of the lepton secondary component flux of the cosmic radiation. In the light of new cross section measurements performed at collider experiments of p+p→$\\pi^{\\pm}$+X and p+p→$K^{\\pm}$+X, we update the parametrization of the cross sections for these processes and then compute the $e^{\\pm}$ ones from $\\pi^{\\pm}$ and $K^{\\pm}$ decays. We use for the first time in this field the $e^{\\pm}$ spectrum obtained from the muon decay computed till the next to leading order. By using pp, pHe and pC data we estimate the uncertainty on the Lorentz invariant cross section for p+He→$\\pi^{\\pm}$+X. The peculiarity of this work is the experiment based approach, that we adopt in order to obtain a better shape determination and a significant reduction of uncertainty of the current secondary cosmic ray $e^{\\pm}$ flux predictions.'

Collaborations

Keywords and Comments
AMS-02, leptons, cross section, collider, secondary production,, Luca Orusa''

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Simulations of Cosmic Ray Ensembles originated nearby the Sun

Presenter
David Alvarez-Castillo
Author and Co-Author
David Alvarez-Castillo | Piotr Homola | Dariusz Gora | Dhital Niraj | Gabriela Opiła | Justyna Mędrala | Bożena Poncyljusz | for the CREDO Collaboration

Abstract
"Cosmic Ray Ensembles (CRE) are yet not observed groups of cosmic rays with a common primary interaction vertex or the same parent particle. One of the processes capable of initiating identifiable CRE is an interaction of an ultra-high energy (UHE) photon with the solar magnetic field which results in an electron pair production and the subsequent synchrotron radiation. The resultant electromagnetic cascade forms a very characteristic line-like front of a very small width (~meters), stretching from tens of thousands to even many millions of kilometers. In this contribution we present the results of applying a toy model to simulate detections of such CRE at the ground level with an array of ideal detectors of different dimensions. The adopted approach allows us to assess the CRE detection feasibility for a specific configuration of a detector array. The process of initiation and propagation of an electromagnetic cascade originated from an UHE photon passing near the Sun, as well as the resultant particle distribution on ground, were simulated using the CORSIKA program with the PRESHOWER option, both modified accordingly. The studied scenario results in photons forming a cascade that extends even over tens of millions of kilometers when it arrives at the top of the Earth's atmosphere, and the photon energies span practically the whole cosmic ray energy spectrum. The topology of the signal consists of very extended CRE shapes, and the characteristic, very much elongated disk-shape of the particle distribution on ground illustrates the potential for identification of CRE of this type."

Collaborations
other (fill field below), Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
cosmic ray ensembles, large scale cosmic ray correlations, extensive air showers, David Alvarez-Castillo'The main results covered by this article will be summarised in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Modeling the spectrum and composition of ultrahigh-energy cosmic rays with two populations of extragalactic sources

Presenter
Saikat Das
Author and Co-Author
Saikat Das Soebur Razzaque | Nayantara Gupta

Abstract
We fit the ultrahigh-energy cosmic-ray (UHECR, $E>0.1$ EeV) spectrum and composition data from the Pierre Auger Observatory at energies $E>5\\cdot10^{18}$ eV, i.e., beyond the ankle using two populations of astrophysical sources. One population, accelerating dominantly protons (^{1}H), extends up to the highest observed energies with maximum energy close to the GZK cutoff and injection spectral index near the Fermi acceleration model, while another population accelerates light-to-heavy nuclei (^{4}He, ^{14}N, ^{28}Si, ^{56}Fe) with a relatively low rigidity cutoff and hard injection spectrum. A significant improvement in the combined fit is noted as we go from a one-population to two-population model. For the latter, we constrain the maximum allowed proton fraction at the highest-energy bin within 3.5$\\sigma$ statistical significance. In the single-population model, low-luminosity gamma-ray bursts turn out to match the best-fit evolution parameter. In the two-population model, the active galactic nuclei is consistent with the best-fit redshift evolution parameter of the pure proton-emitting sources, while the tidal disruption events could be responsible for emitting heavier nuclei. We also compute expected cosmogenic neutrino flux in such a hybrid source population scenario and discuss possibilities to detect these neutrinos by upcoming detectors to shed light on the sources of UHECRs.'

Collaborations

Keywords and Comments
Ultrahigh-energy cosmic rays, Cosmogenic neutrinos, Hadronic interactions, UHECR composition, Shower depth distribution, Saikat Das'Journal Ref:\r\nEur. Phys. J. C 81, 59 (2021)\r\n\r\nDOI:\r\n10.1140/epjc/s10052-021-08885-4'

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Upper limits on the cosmic-ray luminosity of supernovae in nearby galaxies

Presenter
Rodrigo Sasse
Author and Co-Author
Rita de Cassia dos Anjos | Rodrigo Sasse

Abstract
'Interactions between cosmic rays and also between cosmic rays and particles of the Cosmic Microwave Background and the Extragalactic Background Light produce charged and neutral pions. The mechanisms that can produce gamma-ray fluxes associated with cosmic rays are the decay of neutral pions, bremsstrahlung, and inverse Compton scattering from pions. These cascading processes show a correlation between the upper limit on the integral GeV-TeV gamma-ray flux and the upper limit on the UHECR luminosity, motivating the study of the multi-messengers to calculate luminosities of UHECRs for specific point sources. We examine the possible sites of ultra-high energy cosmic-ray acceleration in supernovae in nearby galaxies, which were measured by the High Energy Stereoscopic System (H.E.S.S.). The upper limits on the UHECR cosmic-ray luminosity of these sources are calculated with a particular focus on the sources that produce a mixed composition.'

Collaborations
Auger,

Keywords and Comments
UHECR, Gamma-Ray, Luminosity., Rodrigo Sasse''

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-12

Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Particle density fluctuations and correlations in low energy Cosmic-Ray showers simulated with CORSIKA

Presenter
Weronika Stanek
Author and Co-Author
Weronika Stanek Jerzy Pryga | for the CREDO Collaboration

Abstract
'The current studies of cosmic rays are focused on most energetic particles entering the atmosphere and producing a single Extensive Air Shower (EAS). There are, however, models predicting that interactions of high energy particles may result in Cosmic-Ray Ensembles (CRE) created far from the Earth. They could be observed as some number of correlated air showers of relatively low energies spread over a large area. The objective of the Cosmic Ray Extremely Distributed Observatory (CREDO) is to search for CRE using all available data from different detectors and observatories including even small but numerous detectors spread over large areas.\r\n\r\nInterpretation of such measurements require precise information on properties of EAS in a very wide energy spectrum. Low energy EAS are analysed using events from CORSIKA, the program performing air shower simulations. The primary cosmic ray particle energy range extends from 1 TeV up to 4 000 TeV. The secondary particles at the ground level are studied, their density fluctuations and correlations in location and time. Although the fluctuations observed in multiplicity distributions are consistent with random the more detailed analysis reveals that near a selected particle the density of other particles is enhanced over that expected in the absence of correlations. The results of the analysis may be useful in further calculations, for example to obtain probability of detection of an EAS without special simulations.'

Collaborations
, Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
cosmic ray ensembles, extensive air showers, CORSIKA simulations, particle density fluctuations, particle location correlations, Weronika Stanek'The main results covered by this article will be summarised in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-12

Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
EXTREMELY HIGH ENERGY (E > 10^{20} eV) COSMIC RAYS: OBSERVATIONS AND POTENTIAL SOURCES

Presenter
Vadym Voitsekhovskyi
Author and Co-Author
Roman Hnatyk | Vadym Voitsekhovskyi

Abstract
'Determination of the nature and sources of ultrahigh energy cosmic rays (UHECR, E>10^{18} eV) is still unsolved problem in cosmic ray physics. The observed high degree of UHECR isotropy, caused mainly by the deviations of the UHECR trajectories in extragalactic and Galactic magnetic fields, together with a significant uncertainty in their chemical composition (atomic mass), don't allow observed events to be linked to their sources. It is possible to reduce the influence of magnetic deflection in two ways - by considering events with extremely high energy (EHECR, E> 10^{20} eV) and taking into account modern models of the Galactic magnetic field for correction of their trajectories. In our work, the observed by Auger and TA detectors EHECR arrival directions are corrected for the influence of Galactic and random extragalactic magnetic fields. New (corrected) EHECR arrival directions are compared to four samples of potential EHECR sources: 17 AGNs with powerful gamma-ray emission (from the 2FHL catalog), 23 radio-flux-selected star-burst galaxies, as well as 42 radio-galaxies from the parameterized catalog of radio-galaxies. Taking into account the energy loss lengths of the EHECR nuclear components (H, He, C, Si, Fe) in the extragalactic environment and the expected typical distances to potential sources (~100 Mpc for H and Si – Fe and ~50 Mpc for He, C), the astrophysical objects of the above samples that could be sources of relevant EHECR events are highlighted. The potential acceleration mechanisms in the selected objects are analyzed, and the contribution of possible Galactic sources (magnetar giant flares) to the observed EHECR events is evaluated.'

Collaborations

Keywords and Comments
ultra high energy cosmic rays, active galaxy nuclei, radio-galaxies, magnetars, Roman Hnatyk''

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Formation and propagation of cosmic-ray ensembles

Presenter
Oleksandr Sushchov
Author and Co-Author
Oleksandr Sushchov | Piotr Homola | for the CREDO Collaboration

Abstract
'High-energy particles undergo different interactions while propagating through the Universe. As a result, they initiate particle cascades of various types and sizes, referred to as\r\ncosmic-ray ensembles (CRE). Since recently, Cosmic-Ray Extremely Distributed Observatory \r\n(CREDO) Collaboration aims at pursuing a mission dedicated to CRE, since this observation\r\nchannel, i.e. correlated observation of cosmic rays on the global scale, complements the current\r\napproach to cosmic-ray research, which focuses on air showers initiated by individual cosmic rays. Recent results of Monte Carlo simulations showing that there might be a chance of observing a CRE originating from synchrotron radiation occurring even as far away from the Earth as at distances exceeding the Galaxy size, are presented. The issues and perspectives of the CRE-oriented research are discussed as well.'

Collaborations
, Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
Cosmic rays, Cosmic ray ensembles, Oleksandr Sushchov'The main results covered by this article will be summarised in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Cosmic-ray transport in blazars: diffusive or ballistic propagation?

Presenter
Patrick Reichherzer
Author and Co-Author
Julia Becker Tjus | Marcel Schroller | Mario Hörbe | Fabian Schussler | Wolfgang Rhode | Ilja Jaroschewski | Patrick Reichherzer

Abstract
'The detection of a PeV high-energy neutrino of astrophysical origin, observed by the IceCube Collaboration and correlated with a 3$\\sigma$ significance with Fermi measurements to the gamma-ray blazar TXS 0506+056, further stimulated the discussion on the production channels of high-energy particles in blazars. Many models also consider a hadronic component that would not only contribute to the emission of electromagnetic radiation in blazars but also lead to the production of secondary high-energy neutrinos and gamma rays. \r\n\r\nRelativistic and compact plasma structures, so-called plasmoids, have been discussed in such flares to be moving along the jet axis. The frequently used assumption in such models that diffusive transport can describe particles in jet plasmoids is investigated in the present contribution. While there is scientific consensus that the transport of particles in turbulent fields is diffusive in the limit of infinitely large times, the question arises under which conditions and on which time scale such a limit consideration is appropriate. \r\n\r\nWe present conditions based on analytical calculations that determine the time scale to reach the diffusion phase as a function of the model parameters in the jet.\r\nWe show that the type of the charged-particle transport, diffusive or ballistic, has a large influence on many observable parameters, including the spectrum of high-energy particles.'

Collaborations

Keywords and Comments
AGN, Blazar, Diffusion, Ballistic, Transport, Patrick Reichherzer"

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-12

Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Acceleration of UHECR by local supermassive black hole candidates

Presenter
Arman Tursunov
Author and Co-Author
Arman Tursunov | for the CREDO Collaboration

Abstract
'The origin and acceleration mechanism of ultra-high-energy cosmic rays (UHECR) with energy exceeding the GZK-cutoff limit remain unknown. It is often speculated that supermassive black holes (SMBHs) located at the centers of many galaxies can serve as possible sources of UHECR. This is also supported by recent observations of high-energy neutrinos from blazar, as neutrinos are the tracers of UHECR. In this contribution, we explore the capabilities of nearby SMBHs (located within 100Mpc distance) to accelerate UHECR of certain energy and composition by the novel, ultra-efficient regime of the magnetic Penrose process, in which protons and ions are energized near SMBH by the ionization or decay of low-energy neutral particles, such as e.g. a hydrogen ionization or neutron beta-decay. Extreme conditions around SMBHs increase chances for engagement of the accelerated UHECR in the production of the cosmic ray ensembles (CRE), i.e. a group of correlated two or more cosmic ray particles, including photons with the same parent particle or a common primary interaction vertex. We discuss the unique signatures of UHECR and CRE produced around SMBHs and potentially observable with a global network of detectors, as proposed by the Cosmic-Ray Extremely Distributed Observatory – CREDO.'

Collaborations
other (fill field below), Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
Particle acceleration, UHECR, black holes, AGN, energy extraction, local universe, cosmic ray ensembles, CREDO,, Arman Tursunov'The main results covered by this contribution will be summarized in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Probing UHECR and cosmic ray ensemble scenarios with a global CREDO network

Presenter
Arman Tursunov
Author and Co-Author
Arman Tursunov | for the CREDO Collaboration

Abstract
'Among theoretical approaches in unveiling the physics of ultra-high-energy cosmic rays (UHECR) one can distinguish the models assuming interactions of exotic super-heavy matter (including extra dimensions, Lorentz invariance violation, cosmic strings, dark matter particles or particles beyond the standard model etc.) and acceleration scenarios describing processes, in which the particles are accelerated by a particular astrophysical object (shocks in relativistic plasma jets, unipolar induction mechanisms, second-order Fermi acceleration, energy transfer from black holes or compact stars etc.). Special interest is also paid to understanding of the cosmic ray ensembles (CRE) – the phenomena composed of at least two cosmic ray particles, including photons, with a common primary interaction vertex or the same parent particle with correlated arrival directions and arrival times. In this contribution, we review various theoretical UHECR models and CRE scenarios potentially observable by the global Cosmic Ray Extremely Distributed Observatory (CREDO) network.'

Collaborations
other (fill field below), Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
UHECR, particle acceleration, cosmic ray ensembles, large scale cosmic ray correlations, CREDO,, Arman Tursunov'The main results covered by this article will be summarized in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
Improvised Explosive Devices and cosmic rays

Presenter
Adriana Vásquez Ramírez
Author and Co-Author
Adriana Vásquez Ramírez | Michael Ariza Gómez | Marcos Carillo Moreno | Victor G Baldovino Medrano | Hernán Asorey | Luis A. Núñez

Abstract
"Homemade antipersonnel mines are improvised explosive devices (IED) deployed from unconventional local techniques and materials. IEDs kill thousands of civilians every year, inflicting grievous physical injuries, spreading fear and disruption across affected communities. Colombian mines, made of a combination of ammonium nitrate and fuel oil known as ANFO, may also pack faeces, glass, and plastic scrap for causing infectious diseases on the victims. Therefore, the detection and dismantling of such harmful devices must alleviate the insidious consequences of the internal conflicts that have plagued the country for more than half a century. In this work, we present results that suggest that cosmic rays can be used to detect the type of IED used in Colombia. We implement a GEANT4 simulation of an ANFO sphere of NH4NO3+diesel interacting with cosmic rays flux at the Bucaramanga level (959 m a.s.l.). Simulations considered the IED buried into different soil types: dry soil model, two humid soils, and two fertilized soils. The simulation showed that the studied interaction generates emerging electrons, gammas, neutrons, and protons. Notably, in the IED-soil interaction, protons' energy led to an excess of around 0.58 MeV. This peak is quite pronounced for all soil models, giving a clear indication of the feasibility of using a cosmic ray-based detector for detecting these IEDs in the different types of soils."

Collaborations
Keywords and Comments
, Adriana Vásquez Ramírez"

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Branch CRI | Cosmic Ray Indirect

Subcategory Theoretical Results

Titel
GDAS atmospheric models in astroparticle shower simulations

Presenter
Jennifer Grisales-Casadiegos
Author and Co-Author
Jennifer Grisales-Casadiegos For de LAGO Collaboration | Luis A. Núñez | Christian Sarmiento-Cano

Abstract
"Atmospheric conditions affect the development of secondary particles produced by primary cosmic rays. In this work, we present a methodology to simulate the impact of the Global Data Assimilation System (GDAS) atmospheric models in secondary particle flux at the Earth's surface. GDAS implements global atmospheric models based on meteorological measurements and numerical weather predictions. GDAS gives latitude-longitude-altitude dependent profiles of the atmosphere's main state variables like temperature, pressure, and humidity.\r\n\r\nTo validate our methodology, we built monthly GDAS atmospheric profiles over Malargüe-Argentina between 2006 and 2011. The verification analysis consisted of comparing the maximum atmospheric depth (Xmax) with those calculated with the Auger atmospheric option used in CORSIKA simulations. The difference between the GDAS-based and the Auger standard atmospheric Xmax lags behind 2%.\r\n\r\nThe methodology was implemented for the city of Bucaramanga-Colombia, using ARTI for the year 2018. ARTI is a full computational framework, developed by the Latin American Giant Observatory (LAGO) Collaboration, to estimate the particle spectra on Water Cherenkov Detectors depending on the geographical coordinates. We observed that the most significant total flux differences, from the predefined atmospheric profile (subtropical) and GDAS-based, occur in November (~10.22%) and April (~24.12%). An inverse correlation also results between the particle flux and the monthly average temperature. Similarly, for muons on these dates, the difference is between 9.58% and 22.25% respectively. These results confirm the significance of the atmospheric variation in the flux of secondary particles measured at ground level during the year."

Collaborations
, LAGO

Keywords and Comments
Astroparticle flux, Atmospheric models, Extensive air showers, Luis Nunez"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The first cross-calibration of Imaging Atmospheric Cherenkov Telescopes with a UAV-based airborne calibration platform

Presenter
Jacques Muller
Author and Co-Author
Jacques Muller | Anthony M. Brown | Mathieu de Naurois

Abstract
"The Cherenkov Telescope Array (CTA) will have unprecedented accuracy and sensitivity, affording us the ability to understand the mysteries of the high energy universe. This unprecedented accuracy does however also force us to adapt current calibration procedures, or indeed pioneer new techniques, to ensure the envisaged CTA performance. CTA will infer the energy of the gamma-rays it detects by the amount of Cherenkov radiation it observes. As such, the optical efficiency of the telescopes needs to be monitored and also its wavelength dependent degradation, which might be different for different telescope types, needs to be determined. Based on the results of a feasibility study, a novel cross-calibration method with an unmanned aerial vehicle (UAV) was tested on the H.E.S.S. telescope array, leading to the World's first cross-calibration of an Imaging Atmospheric Cherenkov Telescope (IACT) array with a single light source. In this talk, we present the cross-calibration results from a first campaign in which we determine the relative optical efficiencies of the four HESS-I telescopes by successfully recording light from the UAV-mounted nanosecond pulsed UV light source simultaneously in all four telescopes. In addition, we show that the UAV data can be used to monitor the pointing accuracy at least at the level of tens of arcseconds and we give an outlook on other potential use cases of the UAV such as the monitoring of the atmospheric state."

Collaborations
Keywords and Comments
Gamma-ray, IACT, calibration, cross-calibration, optical efficiency, UAV,, Jacques Muller''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The search for high altitude sites in South America for the SWGO detector

Presenter
Michele Doro
Author and Co-Author
Michele Doro | Arthur Moraes | Marcos Santander | Dusan Mandat | Luis Miguel Mendes | Marco Giammarchi Jakub Vícha | Ibrahim Torres | Fabian Schussler | Andres Sandoval

Abstract
'The Southern Wide-field Gamma-ray Observatory (SWGO) is a project for a new generation of extensive air shower detectors, based on the water Cherenkov technique, to be located in the Southern Hemisphere, where no other instruments of that kind is currently operating in the TeV energy range. The reference configuration of SWGO foresees an array of about 6,000 water Cherenkov tanks deployed over a circle of 320 m diameter, about 80,000 square meter area. In order to reach a sensitivity at energies around and below 1 TeV competitive with current and future detectors, SWGO will be placed at altitude above 4,400 m a.s.l. Preliminary site searches have found several candidate sites in Argentina, Bolivia, Chile and Peru. The major challenge will be the water provision, considering more than 100 kt of water are possibly required. This poster will present the challenges and status of the SWGO site search in South America.'

Collaborations
SWGO,
Keywords and Comments
EAS, detector, PeV, Michele Doro"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
TAIGA-IACT control and monitoring software status

Presenter
Dmitriy Zhurov
Author and Co-Author
Dmitriy Zhurov | Dmitriy Lukyantsev | Oleg Gress

Abstract
'The TAIGA-IACTs are part of the hybrid TAIGA experimental complex, located near lake Baikal in Tunka valley, Siberia, Russia. The telescopes have segmented mirrors in Davis-Cotton design with the reflector diameter of 4.3 m and an imaging camera with PMTs in its focus to detect nanosecond flashes of Cherenkov light from EAS. The TAIGA-IACTs are operating in wobble mode. Their operation requires high pointing and tracking accuracy, especially important for long exposure times. The telescope positioning system consists of steppers motors, 17-bit angular encoders and a CCD camera for accurate monitoring of the telescope pointing by stars in its field of view and related calibration procedures. The telescope is controlled by using the custom software based on the EPICS (Experimental Physics and Industrial Control System) package. This report presents an overview of the TAIGA-IACT control and monitoring software, pointing accuracy and the relevant calibration procedures.'

Collaborations
TAIGA,

Keywords and Comments
IACT, telescope, control, monitoring, software, Dmitriy Zhurov"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The Architecture of ASTRI Mini Array Cherenkov Camera Software Supervisor

Presenter
Mattia Corpora
Author and Co-Author
Mattia Corpora | Alessandro Grillo | Pierluca Sangiorgi | Milvia Capalbi | Osvaldo Catalano | Giuseppe Sottile | Federico Russo | Gino Tosti | Andrea Bulgarelli | Fabrizio Lucarelli | Nicolò Parmiggiani | Joseph Hilary Schwarz | Salvatore Scuderi

Abstract
'The ASTRI Mini-Array (MA) is an INAF project to construct and operate an experiment to study gamma-ray sources emitting up to the TeV spectral band. The ASTRI MA consists of an array of nine Imaging Atmospheric Cherenkov Telescopes that will be deployed at the Observatorio del Teide (Tenerife, Spain). These telescopes will be an evolution of the two-mirror ASTRI-Horn telescope, successfully tested since 2014 at the Serra La Nave Astronomical Station of the INAF Observatory of Catania. Each telescope will be equipped with the new version of the ASTRI Silicon Photo-Multiplier (SiPM) Cherenkov Camera.\r\nThe ASTRI-MA will be monitored and controlled by a Supervisory Control And Data Acquisition (SCADA) system which consists of different software subsystems. One of these is the Cherenkov Camera Supervisor (CCS) that controls each Cherenkov Camera.\r\nIts main functionality is to realize an interface between each Camera and the central SCADA software.\r\nThe CCS provides the services to control and monitor the Camera through the Alma Common Software (ACS). This is a framework based on object-oriented CORBA middleware, which gives the infrastructure for the exchange of messages between distributed objects and system wide services. The CCS is based on the Open Platform Communications - Unified Architecture (OPC-UA) protocol, a platform-independent service-oriented architecture.\r\nThis work presents the design and the technologies used by the ASTRI Camera team to implement the CCS. It describes architecture and functionalities starting from the definition of the use cases and the system requirements.'

Collaborations
other (fill field below), ASTRI Mini Array
Keywords and Comments
, Mattia Corpora"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The Online Observation Quality System for the ASTRI Mini Array.

Presenter
Nicolò Parmiggiani
Author and Co-Author
Nicolò Parmiggiani | Andrea Bulgarelli | Leonardo Baroncelli | Antonio Addis | Valentina Fioretti | Ambra Di Piano | Milvia Capalbi | Osvaldo Catalano | Vito Conforti | Michele Fiori | Fulvio Gianotti | Fabrizio Lucarelli | Maria Concetta Maccarone | Tere

Abstract
'The ASTRI Mini-Array is an international collaboration led by the Italian National Institute for Astrophysics (INAF), aiming to construct and operate an array of nine Imaging Atmospheric Cherenkov Telescopes to study gamma-ray sources at very high energy (TeV) and perform Stellar intensity interferometry observations. \r\n\r\nThis contribution describes the design and the technologies used by the ASTRI team to implement the Online Observation Quality System (OOQS). \r\n\r\nThe main objective of the OOQS is to perform data quality analyses in real-time during Cherenkov and Intensity Interferometry observations to provide feedback to both the Array Control System and the Operator. The OOQS perform the analysis of a set of key data quality parameters and can generate alarms to other sub-systems for a fast reaction to solve critical conditions in real-time. The results from the data quality analyses are saved into the Quality Archive for further investigations. The main challenge addressed by the OOQS design is the high data rate (up to 3Gbit/s) produced by each telescope and acquired by the Array Data Acquisition System that sends it to the OOQS. \r\n\r\nIn the current OOQS design, developed on the basis of the definition of specific use cases and requirements, the Redis NoSQL database manages the data throughput generated by the telescopes, and the Slurm workload scheduler executes in parallel the high number of data quality analyses. The Operator can visualise the OOQS results (e.g. camera plots, histograms, tables and more) through a Graphical User Interface as soon as they are produced.'

Collaborations
other (fill field below), ASTRI Mini Array
Keywords and Comments
online data quality, gamma-ray, Cherenkov telescope, data quality, real-time analysis, Nicolò Parmiggiani''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Intensity interferometry with the MAGIC telescopes

Presenter
Carlos Delgado
Author and Co-Author
Carlos Delgado | For the MAGIC Collaboration Nicolas Produit | Roland Walter | Daniel Guberman | Luca Zampieri | Michele Fiori | Miguel Polo | Carlos Diaz | Salvatore Mangano

Abstract
'Due to their large mirror size, fast response to single photons, sensitivity and telescope baselines in the order of 100 m, Imaging Atmospheric Cherenkov Telescopes are ideally suited to make intensity interferometry observations. In 2019 a test readout setup was installed in the two 17-m diameter MAGIC telescopes to allow performing interferometry measurements with them. The first on-sky measurements were able to detect correlated intensity fluctuations consistent with the stellar diameters of three different stars: Adhara ($\\epsilon$ CMa), Benetnasch ($\\eta$ UMa) and Mirzam ($\\beta$ CMa). After the upgrade of the setup in 2021, MAGIC is now equipped with a high duty cycle intensity interferometer, already in operation. A technical description of the interferometer and first results of several known and yet unknown stellar diameter measurements are presented.'

Collaborations
MAGIC,
Keywords and Comments
photodetection,interferometry,Cherenkov Telescopes, Carlos Delgado''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The Application of 20 inch PMT in LHASSO-WCDA

Presenter
Xiaohao You
Author and Co-Author
Xiaohao You | Bo Gao | Mingjun Chen

Abstract
'In the Large High Altitude Air Shower Observatory (LHAASO), the main physics objective of the Water Cherenkov detector array (WCDA) is able to survey the gamma-ray sky continuously in the energy range from 100 GeV to PeV. The water Cherenkov detector array, covering an area of about 78,000 m2 area, is constituted by 3120 detector units divided into 3 separate ponds. Each unit of the first 150x150 m2 pond are placed 8 inch PMT while the second and third pond are placed 20 inch PMTs. The newly developed 20 inch PMT uses microchannel-plate (MCP) instead of the traditional dynodes enables better energy resolution, good detector response etc. Here plans to give you a full view about the test result of 20 inch MCP-PMT before and after water proof potting with electronics, including TTS, peak-to-valley ratio, and the geomagnetic effect on PMT.'

Collaborations
Lhaaso,

Keywords and Comments
20 inch MCP_PMT, water proof potting,geomagnetic field effect, Xiaohao You''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
A single photoelectron calibration system for the NectarCAM camera of the Cherenkov Telescope Array Medium-Sized Telescopes

Presenter
Pooja Sharma
Author and Co-Author
Pooja Sharma Barbara Biasuzzi | Jonathan Biteau | Martin Bourgaux | Sami Caroff | Giulia Hull | Michaël Josselin | Kevin Pressard | Patrick Sizun | Tiina Suomijärvi | Thi Nguyen Trung | for the CTA NectarCAM project

Abstract
"This contribution aims to introduce the single photoelectron system designed to calibrate the camera of the Medium-Sized Telescopes of the Cherenkov Telescope Array (CTA). This system will allow us to measure accurately the gain of the camera's photodetection chain and to constrain the systematic uncertainties on the energy reconstruction of gamma rays detected by CTA. The system consists of a white painted screen, a fishtail light guide, a flasher and an XY motorization to allow movement. The flashes, guided by the fishtail, mimic the Cherenkov radiation and illuminate the focal plane under the screen homogeneously. Then, through the XY motorisation, the screen is moved across the entire focal plane of the NectarCAM camera, which consists of 1855 photo-multiplier tubes. In this contribution, we present the calibration system and the study on its optimum scan positions required to cover the full camera effectively. Finally, we will show the results of the calibration data analysis and discuss the performance of the system."

Collaborations
CTA,
Keywords and Comments
Cherenkov Telescope Array, NectarCAM, Medium-Sized Telescopes, single photoelectron calibration system, Pooja Sharma'The abstract has been verified and accepted by the CTA publication and conference committee (SAPO).'

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Subcategory Experimental Methods & Instrumentation

Titel
CTbend: A Baysian open-source framework to model pointing corrections of Cherenkov telescopes

Presenter
Gerrit Spengler
Author and Co-Author
Gerrit Spengler | Ullrich Schwanke | Dmitriy Zhurov

Abstract
'The pointing of Cherenkov telescopes is subject to imperfections which are, e.g. related to\r\nthe bending of the mechanical structure. These imperfections must be measured, modeled and finally corrected for to\r\nachieve an optimal telescope pointing precision. The measurement of pointing deviations is typically\r\nperformed while the telescope points to different stars and a CCD camera\r\nmonitors the offsets of the star images to the center of the focal plane. Outlier in these\r\nmeasurements can propagate into the pointing model and lead to imprecise model predictions.\r\nCTbend is a simple and standalone open-source framework which uses a Baysian\r\nanalysis with an outlier resilient likelihood function to model the pointing of Cherenkov\r\ntelescopes with parametric standard models like TPoint.\r\nThe framework is in the following described on the basis of simulated data.'

Collaborations
Keywords and Comments
Cherenkov telescope, pointing model, Baysian statistics, Gerrit Spengler''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The Monitoring, Logging, and Alarm system for the Cherenkov Telescope Array

Presenter
Alessandro Costa
Author and Co-Author
Alessandro Costa | Federico Incadona | Kevin Munari Stefano Germani | Igor Oya | Bruno Pietro | Alessandro Grillo | Eva Sciacca | Ugo Becciani | Mario Raciti

Abstract
'We present the current development of the Monitoring, Logging and Alarm subsystems in the framework of the Array Control and Data Acquisition System (ACADA) for the Cherenkov Telescope Array (CTA). The Monitoring System (MON) is the subsystem responsible for monitoring and logging the overall array (at each of the CTA sites) through the acquisition of monitoring and logging information from the array elements. The MON allows us to perform a systematic approach to fault detection and diagnosis supporting corrective and predictive maintenance to minimize the downtime of the system. We present a unified tool for monitoring data items from the telescopes and other devices deployed at the CTA array sites. Data are immediately available for the operator interface and quick-look quality checks and stored for later detailed inspection.\r\nThe Array Alarm System (AAS) is the subsystem that provides the service that gathers, filters, exposes, and persists alarms raised by both the ACADA processes and the array elements supervised by the ACADA system. It collects alarms from the telescopes, the array calibration, the environmental monitoring instruments and the ACADA systems. The AAS sub-system also creates new alarms based on the analysis and correlation of the system software logs and the status of the system hardware providing the filter mechanisms for all the alarms. Data from the alarm system are then sent to the operator via the human machine interface.'

Collaborations
CTA, ASTRI Mini Array

Keywords and Comments
monitoring, logging, alarms, Cherenkov Telescope, CTA, Alessandro Costa''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Excess estimation in On/Off measurements including single-event variables

Presenter
Giacomo D'Amico
Author and Co-Author
Giacomo D'Amico Michele Doro | Tomislav Terzić | Jelena Strišković | Marcel Strzys | Juliane van Scherpenberg

Abstract
'Signal estimation in the presence of background noise is a common problem in many scientific disciplines. An “On/Off” measurement is when the background itself is imprecisely measured, which is the case for instance of observations performed in astronomy. The ‘frequentist’ and Bayesian approaches for signal estimation in “On/Off” measurements are reviewed and compared, focusing on the weakness of the former and on the advantages of the latter in correctly addressing the Poissonian nature of the problem. We propose a new method for estimating the signal rate based on the Bayesian formalism. It uses information on single-event variables and their distribution for the signal and background population. Events are thereby weighted according to their likelihood of being a signal or a background event and background suppression can be achieved without performing data selection cuts. Simulating “On/Off” measurements from imaging atmospheric Cherenkov observations, we conclude that this new method is capable of increasing the resolution of the signal estimation, in particular for background dominated observations.'

Collaborations

Keywords and Comments
Excess estimation, On/Off measurements, Bayesian, inference, statistic, Giacomo D'Amico''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
GPU Accelerated optical light propagation in CORSIKA8

Presenter
Dominik Baack
Author and Co-Author
Dominik Baack

Abstract
"Optical photons, created from fluorescence or Cerenkov emission in atmospheric cascades induced through high energetic cosmic rays are of major interest for several experiments. Experiments like CTA require a significant amount of computing time and funds for the simulation with CORSIKA.\r\n\r\nSince individual photons don't interact they can be simulated without any order as in the traditional sequential approach and on the contrary leads to reduced utilization of modern hardware infrastructure. The calculations on each photon have low complexity, compared to the other aspects of the simulation. This, as well as the fact that besides the photon itself nearly no additional data is needed, favors a data-parallel approach in which several photons are propagated. The new CORSIKA 8 framework enables the implementation and verification of these methods.\r\n\r\nWith the use of dedicated high parallel acceleration hardware like GPUs the possible benefits with this data-parallel approach are even higher. First results and comparisons based on different algorithms and precision levels are shown."

Collaborations
CORSIKA-8,
Keywords and Comments
GPU, Simulation, CORSIKA, performance, Chrenkov Radiation, Fluorescence,, Dominik Baack"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Development of a Detector Prototype for future High Energy Gamma Ray Experiments

Presenter
Abaz Kryemadhi
Author and Co-Author
Abaz Kryemadhi | Matthew Farrar | Brandon Weindorf | Aeowyn Kendall | Al Mokris

Abstract
'Development of instruments capable of detecting gamma rays across vast ranges of energies is important for understanding different astrophysical objects. Instruments are constrained by cost, power, autonomous operation and sensitivity over wide range of energies. Photomultiplier tubes have been the main photon detection technology for these experiments because they can be manufactured in large sizes hence higher light yields. The drawbacks of these devices is their higher voltage of operation, bulky size, and a limited number of vendors producing them. Silicon photomultipliers (SiPMs) are the solid-state equivalents which operate at lower voltage and there is an increase in the number of vendors producing them. The main drawbacks of SiPMs is their small surface area and higher dark rate. In order to circumvent their small area we have constructed a Cherenkov detector prototype with variety of wavelength shifters (WLS) in combination with SiPMs to increase light collection efficiency and report on the detector performance.'

Collaborations
other (fill field below), Small R & D collaboration

Keywords and Comments
Cherenkov, Silicon Photomultipliers, Wave Length Shifters, Light collection, Abaz Kryemadhi"

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Branch	GAI | Gamma Ray Indirect
Subcategory	Experimental Methods & Instrumentation

Titel
Gamma/hadron discrimination using a small-WCD with four PMTs

Presenter
Ruben Conceição
Author and Co-Author
Ruben Conceição | Pedro Assis | Filipe Assunção | Alena Bakalová | Ulisses Barres de Almeida | Clécio R. Bom | João Correia | Alessandro De Angelis | Luciana Dias | Borja S. Gonzaléz | Alberto Guillén | Giovanni La Mura | Nuno Lourenço | Penousal Machado

Abstract
"The Southern Wide-field Gamma-ray Observatory (SWGO) is the next-generation gamma-ray observatory, currently in a three-year R&D phase. The experiment is expected to have a large array of water Cherenkov detectors (WCD) placed at a high elevation (> 4.4 km a.s.l.) in South America. Here we present a WCD concept with reduced surface area and height stations comprising four PMTs at the bottom. We show that it is possible to reach an excellent gamma/hadron discrimination by analysing the data gathered by this station with machine learning techniques. Such performance can be achieved by analysing the shower patterns at the ground or through the PMTs signal time structure to tag muons. Moreover, it is shown that the station's performance does not depend on the array configuration (dense or sparse) nor on the shower inclination (theta < 40 deg). Such a concept reduces the cost associated with the transport of massive amounts of water to high elevation sites while keeping a high physics performance. Therefore, it could be a good candidate station for SWGO, enabling it to reach good sensitivities from low energies (~100 GeV) up to the PeV region, covering large ground surface areas (few square km)."

Collaborations
SWGO,

Keywords and Comments
Detector concept, Gamma-ray wide-field observatory, Gamma/hadron discrimination, Machine Learning, Ruben Conceição"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Lake Deployment of Southern Wide-field Gamma-ray Observatory (SWGO) Detector Units

Presenter
Hazal Goksu
Author and Co-Author
Hazal Goksu | For the SWGO Collaboration

Abstract
'Southern Wide-field Gamma-ray Observatory (SWGO) will be a next-generation high altitude gamma-ray survey observatory in the southern hemisphere consisting of an array of water cherenkov detectors. With its energy range, wide field of view, large duty cycle, and location it will complement the other existing and planned gamma-ray observatories. In this contribution, we will describe the lake concept for SWGO, an alternative to the HAWC-like separate detector unit design, and the LHAASO-style artificial ponds. In the lake concept, instead of having tanks filled with water, bladders filled with clean water are deployed near the surface of a natural lake, where each bladder is a light-tight stand-alone unit containing one or more photosensors. We will give an overview of the advantages and challenges of this design concept and describe the first results obtained from prototyping.'

Collaborations
SWGO,
Keywords and Comments
wcd, gamma-ray survey,, Hazal Goksu''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Status of the VERITAS Stellar Intensity Interferometry (VSII) System

Presenter
David Kieda
Author and Co-Author
David Kieda | for the VERITAS Collaboration

Abstract
'The VERITAS Imaging Air Cherenkov Telescope array IACT) was augmented in 2019 with high-speed focal plane electronics to allow the use of VERITAS for Stellar Intensity Interferometry (SII) observations. Since that time, a number of improvements have been made to increase the sensitivity of VSII and increase the speed of nightly data processing. This poster will describe the use of IACT arrays for performing ultra-high resolution (sub-milliarcsecond) astronomical observations. The poster presentation will include a description of the VERITAS-SII focal plane, data acquisition, and data analysis systems. The poster concludes with an evaluation of the VSII observatory's system's current sensitivity, and plans for a future upgrade of the VSII instrument.'

Collaborations
VERITAS,
Keywords and Comments
Intensity Interferometry, stellar diameters, IACT arrays, stellar envelopes, limb darkening, David Kieda''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Monitoring the pointing of the Large Size Telescope prototype using star reconstruction in the Cherenkov camera

Presenter
Luca Foffano
Author and Co-Author
Luca Foffano | Alessandro Carosi | Mykhailo Dalchenko | Domenico della Volpe | Matthieu Heller | Teresa Montaruli for the CTA LST project

Abstract
'The first Large Size Telescope (LST-1) proposed for the forthcoming Cherenkov Telescope Array (CTA) has recently started to operate in La Palma. The large structure of LST-1 - with a 23 m mirror dish diameter - imposes a strict control of its deformations that could affect the pointing accuracy and its overall performance. According to CTA specifications that are conceived to resolve e.g. the fine structure of galactic sources, the LST post-calibration pointing accuracy should be better than 14 arcseconds. To fulfill this requirement, the telescope pointing precision is monitored with two dedicated CCD cameras located at the dish center. The analysis of their images allows us to disentangle different systematic deformations of the structure.\r\nIn this work, we investigate a complementary approach with lower precision but offering the possibility to monitor the pointing of the telescope during the acquisition of Cherenkov data. After properly cleaning the events from the Cherenkov showers, the reconstructed positions of the stars imaged in the camera FoV are compared to their nominal expected positions in catalogues. This provides a direct measurement of the telescope pointing, that can be used to cross-check the other methods and as a real-time monitoring of the optical properties of the telescope and of the pointing corrections applied by the bending models. Additionally, this method benefits from not relying on specific hardware or dedicated observations.\r\nIn this contribution we will illustrate this analysis and show results based on sky data of LST-1.'

Collaborations
CTA, LST

Keywords and Comments
Gamma rays: instrumentation, Cherenkov telescopes: data quality monitoring, Cherenkov telescopes: pointing, Luca Foffano"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Plans and Tests for Stereoscopic and Monoscopic Operation of Four IACTs of the TAIGA Hybrid Experiment

Presenter
Pavel Volchugov
Author and Co-Author
Andrey Grinyuk | Evgeny Postnikov | Pavel Volchugov

Abstract
'The 2nd TAIGA imaging air Cherenkov telescope (IACT) has successfully been put into operation in the Tunka Valley in fall 2020. Currently two more telescopes are under construction and completion. The ability to use the telescopes in the so-called stereo mode of image analysis by taking into account the unusually large distance between them (from 320 m to 500 m), well exceeding the inter-telescope distances in conventional IACT stereo systems, is being explored and discussed. \r\nThe results of the dedicated Monte Carlo are compared with the experiment data from the 1st and the 2nd TAIGA-IACTs.'

Collaborations
TAIGA,

Keywords and Comments
IACT, Tunka, hybrid, stereo, Monte Carlo, simulation, image analysis, Evgeny Postnikov''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Technological options for the Southern Wide-field Gamma-ray Observatory (SWGO) and current design status

Presenter
Felix Werner
Author and Co-Author
Felix Werner Lukas Nellen | for the SWGO Collaboration

Abstract
'The Southern Wide-field Gamma-ray Observatory (SWGO) Collaboration is in the process of designing and prototyping a wide field of view, high duty cycle complement to CTA and the existing ground-based particle detectors of the Northern Hemisphere (HAWC and LHAASO). In this contribution, we will compare the various technological options for designing the detector and present an overarching system design accommodating them. We will introduce a feasible reference configuration that is used for the first large-scale simulations and cost estimates, and show ongoing prototyping work focused on reaching a maintenance-free and cost-effective detector.'

Collaborations
SWGO,
Keywords and Comments
, Felix Werner"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Prototype Schwarzschild-Couder Telescope for the Cherenkov Telescope Array: Commissioning the Optical System

Presenter
Deivid Ribeiro
Author and Co-Author
Deivid Ribeiro | for the CTA SCT Project

Abstract
'The Schwarzschild-Couder Telescope (SCT) is a candidate for medium-sized telescopes of the Cherenkov Telescope Array (CTA). CTA will enable improvements in multi-wavelength and multi-messenger observations due to higher angular resolution and increased sensitivity, capable of detecting Crab-like gamma-ray point sources nearly 100 times faster than current arrays. A prototype SCT (pSCT) has been constructed at the Fred Lawrence Whipple Observatory. The pSCT uses a dual-mirror design with a 9.7 m primary mirror and 5.4 m segmented secondary mirror. It has a wide field of view (8 degrees), and allows a compact, high-resolution SiPM camera (0.067 deg per imaging pixel), and substantially improves the off-axis performance giving better angular resolution across all of the field of view with respect to single-mirror telescopes. The novel optical system requires a submillimeter-precision custom alignment system, which was successfully achieved with an on-axis PSF of 2.8 arcmin prior to first-light detection of the Crab Nebula in 2020. Future commissioning work aims to meet the on-axis PSF design goal of 2.6 arcmin, measurement and improvement of the off-axis PSF and development of techniques to maintain alignment stability over telescope structural deformations from pointing and temperature variations. In this contribution, we report on the commissioning status, the alignment procedures, and alignment results during the ongoing commissioning phase of the optical system of the prototype SCT to meet remaining design specifications.'

Collaborations
CTA,
Keywords and Comments
Atmospheric Cherenkov telescopes, Telescopes, Optical alignment, Optical instrument design, Alignment procedures, Mirrors, Point spread functions, Silicon photomultipliers, Deivid Ribeiro''

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Subcategory Experimental Methods & Instrumentation

Titel
Commissioning of the camera of the first Large Size Telescope of the Cherenkov Telescope Array

Presenter
Takayuki Saito
Author and Co-Author
Takayuki Saito | Carlos Delgado | Oscar Blanch Bigas Manuel Artero | Juan Abel Barrio | Franca Cassol | Carlos Diaz Ginzo | Daniela Hadasch | Dirk Hoffmann | Julien Houles | Yusuke Inome | Maurizio Iori | Lea Jouvin | Yukiho Kobayashi | Daniel Kerszberg | Hidetoshi Kubo | Gustavo Martinez | Daniel Mazin | E

Abstract
'The first Large Size Telescope (LST-1) of the Cherenkov Telescope Array has been operational since October 2018 at La Palma, Spain, and its camera has been under commissioning. The camera of LST consists of 265 modules, each of which is equipped with 7 PMTs. An analog trigger system is implemented where PMT signals from 3 modules (21 pixels) are summed up before a discriminator. Upon the triggers, the events are readout with a high speed DAQ system with a 60 Gbps bandwidth. In addition, the dedicated system that provides a ~2 ns width UV laser pulse, whose intensity is monitored with a 1% precision, is used to monitor and calibrate the camera performance on a daily basis. \r\n In this contribution we report on the results obtained during the camera commissioning. The commissioning process of the camera required to perform tasks such as flatfielding of PMT gains with a 2% homogeneity, timing calibration for the analog sum trigger with a few ns precision, synchronization of the clock and the trigger propagation within 1 ns accuracy. Moreover, the requirement for the DAQ system was to acquire data at a trigger rate higher than 15 kHz. A deep understanding of the night sky background light and its impact on the trigger and the signal readout were also essential.'

Collaborations
CTA,
Keywords and Comments
IACT, photodetection, camera,, Takayuki Saito"

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Subcategory Experimental Methods & Instrumentation

Titel
SiPM Based Imaging Camera for 4m Class Telescope

Presenter
Varsha Chitnis
Author and Co-Author
Varsha Chitnis | S. S. Upadhya | K. S. Gothe | S. Duhan | S. K. Rao | B. B. Singh | M. Ranjan | N. K. Parmar | A. Chatterjee | R. L. Deshmukh | P. Dorjey | N. Dorji | A. P. K. Kutty | B. K. Nagesh | V. A. Nikam | S. R. Patel | A. Roy | M. N. Saraf | A.

Abstract
'In last few years, SiPMs have emerged as a viable alternative to PMTs used in the imaging atmospheric Cherenkov telescopes. In addition to their higher photon detection efficiency, SiPMs provide attractive features like possible increase in observation duty cycle owing to their safe operation under partial moonlight conditions. Design and development of 256 pixel based SiPM camera for a 4m class Cherenkov telescope is currently at an advanced stage. This camera is proposed to cover a field of view of 5 deg X 5 deg, with a pixel size of ~ 0.3 deg. The camera being developed, is planned to be mounted in the focal plane of one of the vertex elements of TACTIC telescope system which is currently operational at Mt Abu, in the north-western part of India. The associated camera electronics will also be mounted in focal plane of telescope behind the SiPM pixels. The camera will have modular structure, with each module consisting of 16 pixel sensors and the associated front end electronics. The signal generated from the pixels on registration of a Cherenkov event will be passed to “back-end” electronics for trigger generation, digitization @1GSPS and the subsequent data recording. A 16-pixel prototype module has already been developed and tested in our laboratory. A “mini-camera” consisting of 64 pixels has also been assembled and is currently at advanced stage of testing. After completion of the successful testing of the “mini-camera”, field tests at the telescope site will be conducted. Salient features of the SiPM based camera, results from the tests conducted by us and status report will be presented.'

Collaborations

Keywords and Comments
Gamma Ray Telescope, Atmospheric Cherenkov Technique, VHE gamma Rays, Varsha Chitnis"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Camera Calibration of the CTA-LST prototype

Presenter
Yukiho Kobayashi
Author and Co-Author
Yukiho Kobayashi Akira Okumura | Franca Cassol | Hideaki Katagiri | Julian Sitarek | Pawel Gliwny | Seiya Nozaki | Yuto Nogami | For the CTA LST project

Abstract
'The Cherenkov Telescope Array (CTA) is the next-generation gamma-ray observatory that is expected to reach one order of magnitude better sensitivity than that of current telescope arrays. The Large Size Telescopes (LSTs) have an essential role in extending the energy range down to 20 GeV. The prototype LST (LST-1) proposed for CTA was built in La Palma, the northern site of CTA, in 2018. LST-1 is currently in its commissioning phase and moving towards scientific observations. The LST-1 camera consists of 1855 photomultiplier tubes (PMTs) which are sensitive to Cherenkov light. PMT signals are recorded as waveforms sampled at 1 GHz rate with Domino Ring Sampler version 4 (DRS4) chips. Fast sampling is essential to achieve a low energy threshold by minimizing the integration of background light from the night sky. Absolute charge calibration can be performed by the so-called F-factor method, which allows calibration constants to be monitored even during observations. A calibration pipeline of the camera readout has been developed as part of the LST analysis chain. The pipeline performs DRS4 pedestal and timing corrections, as well as the extraction and calibration of charge and time of pulses for subsequent higher-level analysis. The performance of each calibration step is examined, and especially charge and time resolution of the camera readout are evaluated and compared to CTA requirements. We report on the current status of the calibration pipeline, including the performance of each step through to signal reconstruction, and the consistency with Monte Carlo simulations.'

Collaborations
CTA,

Keywords and Comments
, Yukiho Kobayashi"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
VERITAS throughput calibration

Presenter
Mireia Nievas Rosillo
Author and Co-Author
Mireia Nievas Rosillo the VERITAS Collaboration

Abstract
'Imaging Air Cherenkov Telescopes are continuously exposed to varying weather conditions that have short and long-term effects on their response to Cherenkov light from extensive air showers. This work presents the implementation of a throughput calibration method for the VERITAS telescopes taking into account changes in the optical response and detector performance over time. Different methods to measure the total throughput of the instrument, sum of optical response and detector performance, are discussed as well as the effect of its evolution on energy thresholds, effective collection areas, and energy reconstruction. The application of this calibration in the VERITAS reconstruction process is discussed, including the validation using Monte Carlo simulations and observations of the Crab Nebula'

Collaborations
VERITAS,

Keywords and Comments
Cherenkov light, throughput measurements, signal calibration, instrument response functions, VERITAS, photodetection, Mireia Nievas Rosillo"

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Subcategory Experimental Methods & Instrumentation

Titel
A data-driven evaluation of Fermi-LAT extrapolation schemes to the VHE regime.

Presenter
Mireia Nievas Rosillo
Author and Co-Author
Mireia Nievas Rosillo | Tarek Hassan

Abstract
'After 10 years of operations of the Large Area Telescope (LAT), a high-energy pair-creation telescope onboard the Fermi satellite, the Fermi Collaboration has produced two major catalogs: the 4FGL and the 3FHL. These catalogs represent the best sample of potential very high energy (VHE) emitters that may be studied by Imaging Atmospheric Cherenkov Telescopes (IACTs). Several methods are used to extrapolate the Fermi-LAT spectra to TeV energies, generally using simple analytical functions. The recent success of IACTs has motivated the creation of catalogs listing the discoveries of these experiments. Among these initiatives, gamma-cat excels as an open-access tool to archive high-level results in the VHE field, such as catalogs, spectra and light curves. By using these resources, we present a data-driven methodology to test the reliability of different VHE extrapolation schemes used in the literature and evaluate their accuracy reproducing real VHE observations.'

Collaborations

Keywords and Comments
VHE, AGN, extrapolations, Fermi-LAT, spectra, Mireia Nievas Rosillo"

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Subcategory Experimental Methods & Instrumentation

Titel
Simulation Studies of MACE Gamma Ray Telescope : Estimation of Integral Sensitivity, Angular Resolution and Energy Resolution

Presenter
Chinmay Borwankar
Author and Co-Author
Chinmay Borwankar Nilay Bhatt | Subir Bhattacharyya | Mridul Sharma

Abstract
'The **MACE** (Major Atmospheric Cherenkov Experiment) is an Imaging Atmospheric Cherenkov Telescope (IACT) located in Hanle, India. It has highest altitude of 4270 m among all the IACTs in the world. The high altitude of MACE along with its large reflector having diameter of 21 m is expected to yield wide energy coverage of ~20 GeV to ~20 TeV. We have carried out detailed Monte Carlo simulations of the MACE response to gamma and cosmic ray showers in this energy range for various zenith angles between 0° to 60°. We estimated the variation of integral flux sensitivity, angular resolution and energy resolution as a function of energy, at various zenith angles. We find that the energy threshold of the MACE remains steady between ~30 GeV to ~50 GeV over the zenith angle range of 0° to 40° with integral flux sensitivity of ~2 % Crab. The Angular resolution of the MACE improves from 0.21° near the energy threshold to 0.07° at energy of > 1 TeV for zenith angle range of 0° to 40°. The expected energy resolution of the MACE in the zenith angle range of 0° to 40° varies from ~40% near energy threshold to ~20% for energies above 1 TeV. The MACE will detect Crab like point source within few minutes at all zenith angles, with best detection time of ~80 seconds occurring at zenith angle of 25°.'

Collaborations
other (fill field below), MACE

Keywords and Comments
IACT , Cherenkv Telescope , Gamma ray astronomy, Chinmay Borwankar''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Cross-calibration and combined analysis of the CTA-LST prototype and the MAGIC telescopes

Presenter
Yoshiki Ohtani
Author and Co-Author
Yoshiki Ohtani Alessio Berti | Davide Depaoli | Federico Di Pierro | David Green | Lea Heckmann | Moritz Hütten | Tomohiro Inada | Ruben Lopez-Coto | Elisabetta Medina | Abelardo Moralejo | Daniel Morcuende | Giorgio Pirola | Marcel Strzys | Yusuke Suda | Ievgen Vovk

Abstract
'The Cherenkov Telescope Array (CTA) will be the next generation gamma-ray observatory, which will consist of three kinds of telescopes of different sizes. Among those, the Large Size Telescope (LST) will be the most sensitive in the low energy range starting from 20 GeV. The prototype LST (LST-1) proposed for CTA was inaugurated in October 2018 in the northern hemisphere site, located in La Palma (Spain), and is currently in its commissioning phase.\r\n MAGIC is a system of two gamma-ray Cherenkov telescopes of the current generation, located approximately 100 m away from LST-1, that have been operating in stereoscopic mode since 2009. Since MAGIC and LST-1 can observe the same air shower events initiated by gamma rays, we can compare the brightness of the showers, estimated energies, and other parameters event by event, which can be used to cross-calibrate the telescopes. Ultimately, by performing combined analyses of the events triggering the three telescopes, we can reconstruct the shower geometry more accurately, leading to better energy and angular resolutions, and a better discrimination of the background showers initiated by cosmic rays. \r\nFor that purpose, as a part of the commissioning of LST-1, we performed joint observations of established gamma-ray sources with MAGIC and LST-1. Also, we have been developing Monte Carlo simulations, and an analysis pipeline for such joint observations which finds event coincidence in the offline analysis based on their timestamps. In this talk, we present the results of the inter-telescope cross-calibration, and the expected performance of joint observations.'

Collaborations
CTA, MAGIC

Keywords and Comments
IACT, CTA, LST, MAGIC, cross-calibration,, Yoshiki Ohtani"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Event rates of UHE photons cascading in the geomagnetic field at CTA-North

Presenter
Kevin Almeida Cheminant
Author and Co-Author
Kevin Almeida Cheminant | Dariusz Góra | for the CREDO Collaboration

Abstract
'Photons in the EeV range and beyond are expected from top-down models of UHECR production and from the GZK effect. As they reach the Earth, they have a non-zero probability of converting into an electron/positron pair in the geomagnetic field and producing an electromagnetic shower above the atmosphere. In this paper, we present a new method to search for cascading UHE photons with gamma-ray telescopes based on Monte-Carlo simulations and multivariate analyses. Considering the future CTA-North experiment in La Palma, Spain, we show that such a method provides an efficient cosmic-ray background rejection with little loss of cascading UHE photon events. We also estimate that if gamma-ray bursts photon emission extends to the EeV regime, the number of expected events in 30 hours of observation time can go up to 0.17.'

Collaborations
other (fill field below), Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration
Keywords and Comments
cosmic ray ensembles, ultra-high energy photon, CTA, GRB, Kevin Almeida Cheminant'The main results covered by this article will be summarised in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Standardized formats for gamma-ray analysis applied to HAWC observatory data

Presenter
Laura Olivera-Nieto
Author and Co-Author
Laura Olivera-Nieto | Vikas Joshi | Harm Schoorlemmer | for the HAWC Collaboration | Axel Donath

Abstract
'A wide range of data formats and proprietary software have traditionally been used in gamma-ray astronomy, usually developed for a single specific mission or experiment. However, in recent years there has been a shift towards making astronomical data open and accessible. Within the gamma-ray community this has translated to the creation of a common data format across different gamma-ray observatories: the "gamma-astro-data-format" (GADF). Based on a similar premise, open-source analysis packages, such as Gammapy, are being developed and aim to provide a single, robust tool which suits the needs of many experiments at once. In this contribution we show that data from the HAWC observatory can be made compatible with the GADF and present the first GADF-based production of event lists and instrument response functions for a wide-field instrument. We use these data products to reproduce with excellent agreement the published HAWC reference spectrum using Gammapy. Having a common data format and analysis tools facilitates joint analysis between different experiments and effective data sharing. This will be especially important for next-generation instruments, such as the proposed Southern Wide-field Gamma-ray Observatory (SWGO) and the planned Cherenkov Telescope Array (CTA).'

Collaborations
HAWC,

Keywords and Comments
HAWC, gamma-astro-data-format, wide-field, data format, open source, Gammapy,, Laura Olivera-Nieto'Axel Donath is not a member of the HAWC collaboration and should be listed after "for the HAWC Collaboration".'

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The Small Size Telescopes for the Southern Site of the Cherenkov Telescope Array

Presenter
Richard White
Author and Co-Author
Richard White | for the CTA SST Project

Abstract
'The Cherenkov Telescope Array (CTA) will use three telescope sizes to efficiently detect cosmic gamma rays in the energy range from several tens of GeV to hundreds of TeV. The Small Sized Telescopes (SSTs) will form the largest section of the array, covering an area of many square kilometres on the CTA southern site in Paranal, Chile. Up to 70 SSTs will be implemented by an international consortium of institutes and teams as an in-kind contribution to the CTA Observatory. The SSTs will provide unprecedented sensitivity to gamma rays above 1 TeV and the highest angular resolution of any instrument above the hard X-ray band. CTA has recently finalised the technology that will be used for the SSTs: the telescopes will be a dual-mirror design with a primary reflector of ~4 m diameter, equipped with an SiPM-based camera with full waveform readout from ~2000 channels covering a ~9 degree field of view. Thanks to the aplanatic and small plate-scale Schwarzschild-Couder configuration of the optics, the camera can be compact (diameter ~50 cm, mass ~50 kg) and low cost. In this contribution, we describe the experience gained operating telescope and camera prototypes during the CTA preparatory phase, and the development of the final SST design, including the technologies involved and the implementation plan for series production.'

Collaborations
CTA,

Keywords and Comments
IACT, technology, SiPMs,, Richard White''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Study of water Cherenkov detector to determine air shower arrival directions with accuracy

Presenter
Atsushi Shiomi
Author and Co-Author
Atsushi Shiomi | Hiroki Nakada | Yusaku KATAYOSE | Munehiro Ohnishi | Takashi K. Sako | Hibino Kinya

Abstract
'In recent years, a few groups have reported detections of gamma rays in the 100 TeV region from astronomical objects in the galaxy using extensive air shower arrays.\r\nThese observations have certainly taken a new step in the research of cosmic-ray acceleration mechanisms.\r\nSeveral spread TeV gamma-ray sources have been observed in the galaxy.\r\nTo study the acceleration mechanisms, it is important to investigate a correlation between gamma-ray source and molecular cloud and to identify the exact gamma-ray emission region.\r\nIn extensive air shower experiments, an arrival direction of a cosmic ray is determined by estimating the shape of its air shower front based on a detected secondary particle density distribution and detection time.\r\nHere, we report a study on shapes of water Cherenkov detector to determine arrival directions of air showers with good accuracy.'

Collaborations

Keywords and Comments
WCD, 100 TeV gamma-ray, air shower, Atsushi Shiomi''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Towards a fast simulation of a water Cherenkov detector for gamma ray and cosmic ray experiments.

Presenter
Analisa Gabriela Mariazzi
Author and Co-Author
Patricia Hansen | Diego Gabriel Melo | Analisa Gabriela Mariazzi | Lukas Nellen

Abstract
'The secondary particles produced during the interaction of primary gamma rays or cosmic rays in the atmosphere can be measured using Water Cherenkov Detectors (WCD).\r\nDetailed simulations of the WCD signals produced by the interactions of the secondaries inside the detector are computationally time consuming, so a fast simulator is desirable.\r\nIn this work, we use complete and detailed simulations of a water Cherenkov detector based on Geant4 to obtain a parametrization of the average signal response for different types of secondary particles as a function of the particle energy and incident angle. This parametrization is used to generate approximate signals which match the signals generated by the full detector simulation.'

Collaborations

Keywords and Comments
Gamma rays, Cosmic rays, Water cherenkov detector, Geant4 Simulation, Analisa Gabriela Mariazzi"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
“Star coverage”, a simple tool to schedule an observation when FOV rotation matters

Presenter
Simone Iovenitti
Author and Co-Author
Simone Iovenitti Giorgia Sironi

Abstract
'During a tracking observation, every telescope with an alt-azimuthal mount shows a rotation in the field of view (FoV) due to the diurnal motion of the Earth. The angular extension of the rotation depends mainly on the time-length of the observation, but also on the latitude and the telescope’s pointing direction, as it is determined by the evolution of the parallactic angle of the target.\r\nIn many cases, the rotation of the FoV can be exploited to assess some optomechanical properties of the telescope, e.g. the alignment of the optical elements or the motors’ precision during the tracking. As a consequence, it could happen that a proper simulation of the FoV rotation, considering the observable range of the telescope, is crucial to program an observation aiming at the calibration of the whole system.\r\nWe present a tool to simulate the apparent rotation of the FoV, calculating the actual “star coverage” exploitable for scientific goals. Given the FoV and the pointing direction, the software calculates the angular extension of the rotation, considering only the stars observable by the telescope below the magnitude limit. This tool will be adopted to schedule the pointing calibration runs of the innovative ASTRI-Horn Cherenkov telescope, developed by INAF for gamma-ray ground-based astronomy, but with the potentiality to produce sky images as an ancillary output, using the so-called Variance method. By exploiting the FoV rotation with the Variance method, the critical assessment of the camera axis can be successfully performed.'

Collaborations
other (fill field below), ASTRI
Keywords and Comments
FoV rotation, simulation, stars, variance, calibration, observation, schedule,, Simone Iovenitti"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The Cherenkov Telescope Array transient and multi-messenger program

Presenter
Alessandro Carosi
Author and Co-Author
Alessandro Carosi | Alicia López-Oramas | Francesco Longo

Abstract
'The Cherenkov Telescope Array (CTA) is a next generation ground-based very-high-energy gamma-ray observatory that will allow for observations in the >10 GeV range with unprecedented photon statistics and sensitivity. This will enable the investigation of the yet-marginally explored physics of short-time-scale transient events. CTA will thus become an invaluable instrument for the study of the physics of the most extreme and violent objects and their interactions with the surrounding environment. The CTA Transient program includes follow-up observations of a wide range of multi-wavelength and multi-messenger alerts, ranging from compact galactic binary systems to extragalactic events such as gamma-ray bursts (GRBs), core collapse supernovae and bright AGN flares. In recent years, the first firm detection of GRBs by current Cherenkov telescope collaborations, the proven connection between gravitational waves and short GRBs, as well as the possible neutrino-blazar association with TXS 0506+056 have shown the importance of coordinated follow-up observations triggered by these different cosmic signals in the framework of the birth of multi-messenger astrophysics. In the next years, CTA will play a major role in these types of observations by taking advantage of its fast slewing (especially for the CTA Large Size Telescopes), large effective area and good sensitivity, opening new opportunities for time-domain astrophysics in an energy range not affected by selective absorption processes typical of other wavelengths. In this contribution we highlight the common approach adopted by the CTA Transients physics working group to perform the study of transient sources in the very-high-energy regime.'

Collaborations
CTA,

Keywords and Comments
, Alessandro Carosi'for the Transients Working Group on behalf of the CTA Consortium'

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
A simulation study on the performance of the ALPAQUITA experiment

Presenter
Sei Kato
Author and Co-Author
Sei Kato | for the ALPACA collaboration

Abstract
'Aiming at exploring the southern gamma-ray sky in the highest energy range, we are proceeding with the ALPACA project. Also, as the prototype experiment of ALPACA, the ALPAQUITA experiment is in preparation, and its detector is now under construction. ALPAQUITA consists of a surface air shower array and an underground water Cherenkov muon detector. To get the most out of ALPAQUITA, we work on a detailed Monte Carlo simulation and evaluate the ALPAQUITA performance. As a result, we find that ALPAQUITA achieves an angular resolution of $\simeq$0.2° and an energy resolution of $\simeq$25% for gamma rays in the 100 TeV range. \r\n Moreover, using the muon detector alongside the surface array, the ALPAQUITA sensitivity to gamma rays is enhanced by a factor of $\simeq$10 in the 100 TeV range compared to using only the surface array. The aforementioned enables us to detect several southern gamma-ray sources with ALPAQUITA beyond 100 TeV in one calendar year observation. \r\n This presentation comprehensively introduces the ALPAQUITA performance and current observational situation of gamma-ray sources detectable with ALPAQUITA.'

Collaborations
, the ALPACA collaboration
Keywords and Comments
southern gamma-ray astronomy, VHE gamma rays, international project,, Sei Kato''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Autonomous Environmental and Scientific SWGO site Characterization Instrument

Presenter
Ladislav Chytka
Author and Co-Author
Ladislav Chytka | Dusan Mandat | Miroslav Pech | Staník Daniel | Jakub Vícha | Petr Travnicek | Martina Boháčová | Petr Tobiška | for the SWGO Collaboration

Abstract
'The project Southern Wide-field Gamma-ray Observatory (SWGO) aims to build an array of air-shower detectors in the Southern hemisphere. Preliminary site searches identified suitable sites in Argentina, Bolivia, Chile and Peru. Site environment (including weather, seismic activity and also the electric field) is one of the key aspects to be considered in the site selection and should be based on reliable and comparable measurements.\r\nWe describe an environmental monitoring device to equip several candidate sites proposed for the SWGO. The individual monitoring sensors, control unit and the data storage together with the power system and data transfer concepts are specified. We present also the results of a long term cross-calibration campaign and a climate chamber evaluation of the proposed devices.'

Collaborations
SWGO,

Keywords and Comments
SWGO, Aerosite, environmental characterization, Ladislav Chytka"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Time and charge calibration of the LHAASO electromagnetic particle detectors

Presenter
Binyu Pang
Author and Co-Author
Binyu Pang | Hongkui Lv | Xiangdong Sheng | Jia Liu | Xiaopeng Zhang | for the LHAASO Collaboration

Abstract
'The one square kilometer array (KM2A), a sub-array of LHAASO experiment, consists of 5195 ED and 1188 MD detectors, has been built over three-quarters scale and began operation since December 2020. Its main scientific goal is to study gamma ray sources at energies above 100 TeV. In this work, an offline self-calibration method was used to calibrate the KM2A-ED array to guarantee the key performances of the array such as angular resolution and pointing accuracy within 0.1° during long-term operation. Half of the KM2A array has been operated since December 2019 and the three-quarters has been operated since December 2020. The experimental results of the 1/2 and 3/4 arrays show that this method can be used to determine the detector time offset with an accuracy of 0.5ns and the particle number with an accuracy of a few percent. Furthermore, we monitor the calibration parameters in real time and update the calibration results regularly to ensure the data quality of the detector. As a result, the observation of moon shadow is used to further check the reliability of calibration results.'

Collaborations
Lhaaso,
Keywords and Comments
, binyu pang''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The precision of the IACT mechanical mounts of the TAIGA observatory

Presenter
Artur Borodin
Author and Co-Author
Yaroslav Sagan | Anatoliy Pan | Leonid Tkachev | Artur Borodin | Andrey Grinyuk | Dmitriy Zhurov

Abstract
'The TAIGA (Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy) observatory is located in the Tunka valley (~50 km west from the southern shore of Lake Baikal) at an altitude of 675m a.s.l. The TAIGA observatory aims to address gamma-ray astronomy at energies from a few TeV to several PeV and CR physics from 100 TeV to several EeV. Its main feature is the complementary, hybrid approach to distinguish CR events from those of gamma rays. Currently TAIGA consists of ~80 wide-angle air Cherenkov detectors (HiSCORE stations), three ~4m diameter IACTs and several hundred surface and underground muon detectors, grouped in three jointly operating arrays. The exceptional feature of the TAIGA IACT array is it's topology that allows one to aim for the optimal cost/performance by scanning the optimal inter-telescope distances from 300m up to 600m. The IACTs have alt-azimuth type mounts and 576-pixel imaging cameras in the foci, covering 9.6° aperture in the sky. The segmented reflectors of ~10m² area follow the Davis-Cotton design. The largest diameter of the hexagonal shape reflector is 4.3m and the focal length is 4.75 m. The rigid telescope mount provides a maximum displacement of EAS image below 2mm (i.e. ≤ 0.024°) in the photodetector plane. The main parameters of IACTs are of a crucial importance for their efficient operation and will be presented in this report.'

Collaborations
TAIGA,

Keywords and Comments
Gamma astronomy, Imaging TAIGA-IACT array, telescope parameters measurement, Artur Borodin"

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Subcategory Experimental Methods & Instrumentation

Titel
Monte Carlo Simulations and Validation of NectarCAM, a Medium Sized Telescope Camera for CTA

Presenter
Thomas Armstrong
Author and Co-Author
Thomas Armstrong Jean-Philippe Lenain | Thomas Tavernier | Ullrich Schwanke | Heide Costantini | Jean-Francois Glicenstein

Abstract
'The upcoming Cherenkov Telescope Array (CTA) ground-based gamma-ray observatory will open up our view of the very high energy Universe, offering an improvement in sensitivity of an order of magnitude over previous experiments. NectarCAM is one of the proposed cameras for the Medium-Sized Telescopes (MST) which have been designed to cover the core energy range of CTA, from 100 GeV to 10 TeV. The final camera will be capable of GHz sampling and provide a field of view of 8 degrees with its 265 modules of 7 photomultiplier each (for a total of 1855 pixels). In order to validate the performance of NectarCAM, a partially equipped prototype has been constructed consisting of only the inner 61 modules. It has so far undergone testing at the integration test-bench facility in CEA Paris-Saclay (France) and on a prototype of the MST structure in Adlershof (Germany). To characterize the performance of the prototype, Monte Carlo simulations were conducted using a detailed model of the 61 module camera in the CORSIKA/sim_telarray framework. This contribution provides an overview of this work including the comparison of trigger and readout performance in the lab and trigger and image parameterization performance during on-sky measurements.'

Collaborations
CTA,
Keywords and Comments
, Thomas Armstrong"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Design and performance of the prototype Schwarzschild-Couder Telescope camera

Presenter
Leslie Taylor
Author and Co-Author
Leslie Taylor | for the CTA SCT Project

Abstract
"The Cherenkov Telescope Array (CTA) is the next-generation ground-based observatory for very-high-energy gamma-ray astronomy. An innovative 9.7 m aperture, dual-mirror Schwarzschild-Couder Telescope (SCT) design is a candidate design for CTA Medium-Sized Telescopes. A prototype SCT (pSCT) has been constructed at the Fred Lawrence Whipple Observatory in Arizona USA. Its camera is currently partially instrumented with 1600 pixels covering a field of view of 2.7 degrees. The small plate scale of the optical system allows densely packed silicon photomultipliers to be used, which combined with high-density trigger and waveform readout electronics enable the high-resolution camera. The camera's electronics are capable of imaging air shower development at a rate of one billion samples per second. We describe the commissioning and performance of the pSCT camera, including trigger and waveform readout performance, calibration, and absolute GPS time stamping. We also present the upgrade to the camera, which is currently underway. The upgrade will fully populate the focal plane, increasing the field of view to 8 degrees, and lower the front end electronics noise, enabling a lower trigger threshold and improved reconstruction and background rejection."

Collaborations
CTA,

Keywords and Comments
IACT, CTA, SCT, gamma rays,, Leslie Taylor"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Measurement and long monitoring of the water transparency in LHAASO-WCDA

Presenter
Huicai Li
Author and Co-Author
Huicai Li | Mingjun Chen | Bo Gao | Cheng LIU | Xiaohao You | Kai li

Abstract
'As one of the major components of the LHAASO project, WCDA, a water Cherenkov detector array with an area of 78,000 m2, contains 350,000 tons of purified water, dividing into 3120 detector cells. The water transparency and its stability are critical for a successful long-term operation of the project. In this paper, with the help of the distribution of single cosmic muon signals , the methods of water transparency measurement and monitoring have being applied to the project, and the results are presented.'

Collaborations
Lhaaso,
Keywords and Comments
LHAASO-WCDA, Cosmic muon, Water transparency, Huicai Li''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Operation of the LHAASO-WCDA

Presenter
Cheng LIU
Author and Co-Author
Mingjun Chen | Bo Gao | Minhao Gu | Shicong Hu | Huicai Li | Cheng LIU | Zhiguo Yao | Xiaohao You

Abstract
'The Water Cherenkov Detector Array (WCDA) is one of the major component of the Large High Altitude Air Shower Observatory (LHAASO). WCDA, divided into 3 separate arrays, will make the survey observation on the gamma-ray sky of 100 GeV - 30TeV. The first array (150m×150m), denoted as WCDA-1, has already be operated in April, 2019 and one more array of the same size, referred to as WCDA-2, has also been in operation since November 2019. The third array, WCDA-3, with a size of 300m ×110m, is being tested and the full array of WCDA will be in operation this year. This paper will describe the operation status of the LHAASO-WCDA since April 2019.'

Collaborations
Lhaaso,
Keywords and Comments
LHAASO-WCDA, Gamma Ray, operation,, Cheng LIU'On behalf of the LHAASO Collaboration'

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Time calibration of the LHAASO-WCDA detectors

Presenter
Bo Gao
Author and Co-Author
Bo Gao | Zhiguo Yao | Jinyan Liu | Min Zha | Huicai Li | Mingjun Chen | Hanrong wu

Abstract
'The LHAASO (Large High Altitude Air Shower Observatory) is a multi-purpose experiment for measuring the high energy gamma rays and cosmic rays. One of the major detectors is the 78,000 m2 WCDA (Water Cherenkov Detector Array), equipped with 3120 PMTs, which aims to survey the gamma-ray sky continuously in a wide energy range, from 100 GeV to 30 TeV. Precisely calibrating the time offsets of each detector cell is essential to obtain a good angular resolution for observing the gamma ray sources. A dedicated system composed of LED light sources and fibers guided lights to every cell is used for time offset calibration of the whole array. Besides, Cosmic-ray shower events are analyzied for caliculating the time offsets and the charge-time correlations. Finally the observation to the Crab Nebula is visited to fix the pointing error brought by above calibration and calculations. Above calibration procedure and the final calibration results are presented in this talk.'

Collaborations
Lhaaso,
Keywords and Comments
LHAASO-WCDA, time calibration, LED calibration system, time offsets, Bo Gao"

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Subcategory Experimental Methods & Instrumentation

Titel
Performance of a proposed event-type based analysis for CTA

Presenter
Tarek Hassan Collado
Author and Co-Author
Tarek Hassan Collado | Orel Gueta | Gernot Maier | Maximilian Nöthe | Michele Peresano | Ievgen Vovk | for the CTA Consortium

Abstract
'The Cherenkov Telescope Array (CTA) will be the next-generation observatory in the very-high-energy (20 GeV to 300 TeV) gamma-ray astroparticle physics field. Classically, data analysis in the field maximizes sensitivity by applying quality cuts on the data acquired. These cuts, optimized using Monte Carlo simulations, select higher quality events from the initial dataset. Subsequent steps of the analysis typically use the surviving events to calculate one set of instrument response functions (IRFs). An alternative approach is the use of event types, as implemented in experiments such as the Fermi-LAT. In this approach, events are divided into sub-samples based on their reconstruction quality, and a set of IRFs is calculated for each sub-sample. The sub-samples are then combined in a joint analysis, treating them as independent observations. This leads to an improvement in performance parameters such as sensitivity, angular and energy resolution. Data loss is reduced since lower quality events are included in the analysis as well, rather than discarded. In this study, machine learning methods will be used to classify events according to their expected angular reconstruction quality. We will report the impact on CTA high-level performance when applying such an event-type classification with respect to the standard procedure.'

Collaborations
CTA,

Keywords and Comments
Cherenkov Telescope Array, Analysis, Performance estimation, Monte Carlo, Simulations, Tarek Hassan Collado''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Muons as a tool for background rejection in imaging atmospheric Cherenkov telescope arrays

Presenter
Laura Olivera-Nieto
Author and Co-Author
Laura Olivera-Nieto | Alison Mitchell | Jim Hinton

Abstract
'The presence of muons in air-showers initiated by cosmic ray protons and nuclei is well established as a powerful tool to separate such showers from those initiated by gamma-rays. However, so far this approach has been exploited only for ground level particle detecting arrays. In this contribution, we explore the feasibility of using Cherenkov light from muons as a background rejection tool for imaging atmospheric Cherenkov telescope arrays at the highest energies. We adopt an analytical model of the Cherenkov light from individual muons to allow rapid simulation of a large number of showers in a hybrid mode. This allows exploration of the very high background rejection power regime at acceptable cost in terms of computing time. We find that for very large telescopes (~20 m diameter), efficient identification of muons would provide a major improvement with respect to standard background rejection techniques at energies above several tens of TeVs.'

Collaborations
Keywords and Comments
IACTs, muon, background rejection,, Laura Olivera-Nieto''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The charge calibration of LHAASO-WCDA

Presenter
Shicong hu
Author and Co-Author
Shicong hu | Yong Huang | Chuandong Gao | Zongkang Zeng | Huicai Li | Bo Gao | Xiurong Li | Cheng LIU | Min Zha | Zhiguo Yao

Abstract
'Water Cherenkov detector array (WCDA), one of major parts of LHAASO project, has been partly operated since April 2019. Each detector cell of the first pool (WCDA-1) has one 8" PMT and one 1.5" PMT. 20" PMT and 3" PMT are hung in each cell of WCDA-2 and WCDA-3. In order to achieve an optimal energy reconstruction, and cosmic ray background suppression for the air showers, we develop an off-line method to calibrate number of photoelectron (NPE) of signals. By matching signals caught by different kinds of PMT, we bridge their linear measurement range to obtain equivalent NPE of signals up to 200000PEs. Besides, detector monitoring and various measurements show the PMT among cells are slightly different in quantum efficiency and collection efficiency, and the light attenuation and depth of water in the pool are also varying with time, especially in the very beginning of the operation. Above inhomogeneity and instability influences the detection efficiency of cells on secondary air shower particles. Based on previous research, the single particle peak mainly formed by muon signals are used to calibrate the detection efficiency difference as well as long term variation of all the detector cells. A possibly more flexible efficiency calibration method of Constant Rate Scaling (CRS) is also under study. The analysis method and the calibration results as well as its long term stability of the first two pools are presented in this talk.'

Collaborations
Lhaaso,

Keywords and Comments
LHAASO-WCDA, charge calibration, Shicong hu''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
The upgraded Data Acquisition System of the H.E.S.S. telescope array

Presenter
Sylvia Jiechen Zhu
Author and Co-Author
Sylvia Jiechen Zhu | Tim Holch | Thomas Murach | Stefan Ohm | Matthias Fuessling | Mathieu de Naurois | Fabian Krack | Klemens Mosshammer | Rico Lindemann

Abstract
'The High Energy Stereoscopic System (H.E.S.S.) is an array of five Imaging Atmospheric Cherenkov Telescopes located in the Khomas Highland of Namibia. H.E.S.S. observes gamma rays above tens of GeV by detecting the Cherenkov light that is produced when Very High Energy gamma rays interact with the Earth’s atmosphere. The H.E.S.S. Data Acquisition System (DAQ) coordinates the nightly telescope operations, ensuring that the various components communicate properly and behave as intended. It also provides the interface between the telescopes and the people on shift who guide the operations. The DAQ comprises both the hardware and software, and since the beginning of H.E.S.S., both elements have been continuously adapted to improve the data-taking capabilities of the array and push the limits of what H.E.S.S. is capable of. Most recently, this includes the upgrade of the entire computing cluster hosting the DAQ software, and the accommodation of a new camera on the large 28m H.E.S.S. telescope. We discuss the performance of the upgraded DAQ and the lessons learned from these activities.'

Collaborations
H.E.S.S.,

Keywords and Comments
DAQ, data acquisition system, hardware, cluster, computing, Sylvia Jiechen Zhu"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
FACT - Database-based Analysis and Spectrum Calculations

Presenter
Bernd Schleicher
Author and Co-Author
Bernd Schleicher | Axel Arbet-Engels | Dominik Baack | Matteo Balbo | Noah Biederbeck | Adrian Biland | Thomas Bretz | Jens Buss | Daniela Dorner | Laura Eisenberger | Dominik Elsaesser | Dorothee Hildebrand | Roman Iotov | Karl Mannheim | Dominik Neise

Abstract
'The First G-APD Cherenkov Telescope (FACT) is a telescope located at the Observatory Roque de los Muchachos on the Canary island La Palma. It uses the imaging air Cherenkov technique to detect gamma rays. With the help of the silicon based photosensors of the camera, FACT is a perfect instrument to monitor a small sample of sources with a high cadence. The automatic operation of the telescope allows an increase of the duty cycle of the instrument. The SQL database is part of the automatic analysis chain, which is used to store the data event-wise basis. This way of storing the data has a lot of advantages. It provides easy web-access to all taken data with no need of creating different user accounts for the analysers and without using special software or powerful hardware. The data selection is done via simple queries to the database. This allows very flexible and powerful queries with for example user defined time binning or background suppression. By using observed and simulated events, the complete analysis chain can be done up to calculating the measured energy spectrum. This could also be implemented to the Quick Look Analysis to provide the information during the night with a low latency.'

Collaborations
, FACT

Keywords and Comments
First G-APD Cherenkov Telescope, FACT, Imaging Air Cherenkov Technique, Analysis, Database,, Bernd Schleicher''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Effect of SiPM correlated noise and Photon Detection Efficiency into Imaging Atmospheric Cherenkov Telescopes

Presenter
Andrii Nagai
Author and Co-Author
Andrii Nagai | Teresa Montaruli | Domenico della Volpe | Matthieu Heller | Mykhailo Dalchenko | David Medina Miranda

Abstract
'Silicon Photomultiplier SiPM detectors have become the preferred photosensors for many applications in high-energy particle and astroparticle physics, LIDAR and medical imagining. Due to robustness, low working voltage, ability to work during moon light and high photon detection efficiency the SiPM devices are good choice for cameras of Imaging Atmospheric Cherenkov Telescopes (IACTs) as pioneering works of FACT and SST-1M demonstrated. However, the overvoltage (difference between applied and breakdown voltages) effects almost all device parameters like gain, PDE, uncorrelated and correlated noise. In particular, by increasing the overvoltage the high PDE of 60% can be reached. On the other had high overvoltage leads to higher correlated noise what affects image reconstruction.\r\n In this work we study the effect of SiPM correlated noise and PDE into IACT in therm of charge resolution. With the goal to find the optimal overvoltage value which provides the best balance between PDE and correlated noise. The study was done with Monte Carlo simulation (i.e. sim_telarray – simulation of the imaging atmospheric Cherenkov technique) and validated with measurements at laboratory with calibrated light sources (one to mimic Cherenkov light and another for night sky background NSB). The studies were performed for SiPM devices produced by Hamamatsu: S13360-3050, S14520-3050 and FBK HD-NUV. The studies were performed at different NSB levels from 3MHz up to 1 GHz of photons per sensor at room temperature (T = 25 C).'

Collaborations

Keywords and Comments
SiPM, Cherenkov Telescopes, Cross-talk, photon detection efficiency, night sky background, Andrii Nagai''

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Subcategory Experimental Methods & Instrumentation

Titel
Fundamental Paricle Physics with SWGO

Presenter
Andrea Albert
Author and Co-Author
Andrea Albert

Abstract
'The Southern Wide-field Gamma-ray Observatory (SWGO) is a proposed experiment that will continuously monitor the TeV gamma-ray sky. Similar to the High Altitude Water Cherenkov (HAWC) Observatory, is will have a wide field of view, nearly 100% duty cycle, and will therefore observe ~2/3 of the sky every day. It will use water cherenkov detectors and be located in the southern hemisphere. SWGO is planned to be the most sensitive gamma-ray observatory in the southern hemisphere above ~10 TeV. SWGO will be able to perform several searches for physics beyond the standard model. Specifically we will discuss searches for Axion Like Particles and Lorentz Invariance Violation.'

Collaborations
SWGO,
Keywords and Comments
, Andrea Albert''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Methods & Instrumentation

Titel
Science verification of the new FlashCam-based camera in the 28m telescope of H.E.S.S.

Presenter
Gerd Pühlhofer
Author and Co-Author
Gerd Pühlhofer Konrad Bernlöhr | Baiyang Bi | German Hermann | Jim Hinton | Ira Jung | Fabian Leuschner | Vincent Marandon | Alison Mitchell | Dan Parsons | Simon Sailer | Heiko Salzmann | Simon Steinmassl | Felix Werner | for the H.E.S.S. collaboration

Abstract
'In October 2019, the central 28m telescope of the H.E.S.S. experiment has been upgraded with a new camera. The camera is based on the FlashCam design which has been developed in view of a possible future implementation in the medium-sized telescopes of the Cherenkov Telescope Array (CTA). We report here on the results of the science verification program that has been performed after commissioning of the new camera, to show that the camera and software pipelines are working up to expectations.'

Collaborations
H.E.S.S.,

Keywords and Comments
H.E.S.S., Cherenkov camera, FlashCam, Science verification, Gerd Pühlhofer''

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Subcategory Experimental Methods & Instrumentation

Titel
White Rabbit in the TAIGA-Observatory: From Precision Timing to Fast Event Classification

Presenter
Ralf Wischnewski
Author and Co-Author
Dmitriy Zhurov | Ralf Wischnewski | Andrea Porelli | Martin Brückner

Abstract
'Sub-nsec precision time synchronization is requested in modern large-scale astroparticle experiments, with detector components distributed over up to tens of km2. The White-Rabbit (WR) technology allows to build flexible, high-performing hierarchical systems, which deliver phase and time to the detector subsystems. We implemented WR for the TAIGA-Observatory, a facility for Gamma-Ray astronomy now under construction in the Tunka valley, Siberia. It contains the 1km2 size wide-aperture Air-Cerenkov HiSCORE timing array, and three IACTs.\r\n\r\nThe application makes multiple use of WR, to (1) distribute the central clock to all detector elements, synchronizing the distributed clocks in the field, (2) time-stamp trigger-signals in the front-end boards (e.g. PMTs fired from EAS), and propagate the trigger-messages to the DAQ-center. Key element of the setup is a general-purpose multi-channel TDC unit, which was implemented in firmware on a widely used WR-node (SPEC-card). Its main features are: a TDCs with 1 nsec resolution, running deadtime-free and delivering time stamps in absolute TAI (UTC). With an off-the-shelve mezzanine board, up to 5 TDC channels are available per node. A high trigger-rate optimized version is currently under evaluation.\r\n\r\nWe describe the concept of redundant trigger time-stamping, that gives a natural way to cross-check in-situ the delivered clock stability - which we find helpful for large systems.\r\nWe report on on-line event reconstruction based on WR time-stamps and fast event reconstruction, to search for special event classes – e.g. fast transient candidate events.'

Collaborations
Keywords and Comments
, Andrea Porelli"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Search for Very High Energy Emission from the millisecond pulsar PSR J0218+4232

Presenter
Sidika Merve Colak
Author and Co-Author
Sidika Merve Colak Brent Limyansky | Pablo Miguel Saz Parkinson | Alessia Spolon | on behalf of the MAGIC and Fermi-LAT Collaborations

Abstract
'PSR J0218+4232 is a millisecond pulsar (MSP) with high magnetic field strength at the light-cylinder radius (B_{LC} ~ 3.2 × 10^{5} G), making it one of the best candidates for VHE gamma-ray emission. It was one of the first MSPs detected by Fermi-LAT at high energy. The source is possibly an aligned rotator with large unpulsed component(~50%) in radio and X-rays.\r\nFor this study, we have analyzed 11.5 years of Fermi-LAT data and 90 hours of MAGIC observations (MJD 58424 - 58791). Fermi-LAT analysis shows evidence for pulsed emission above 25GeV. MAGIC observations were performed with a sub-100GeV optimized Sum-Trigger II system. Due to the unpulsed component, we searched for pulsed emission by using a new background subtraction approach. We did not find any evidence for pulsed or unpulsed VHE emission. Lack of VHE emission detection with our instruments is compatible with our theoretical modeling.'

Collaborations
MAGIC, Fermi-LAT

Keywords and Comments
pulsars, gamma-rays, PSR J0218+4232, Sidika Merve Colak''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Performance of the Cherenkov Telescope Array in the presence of clouds

Presenter
Mario Pecimotika
Author and Co-Author
Mario Pecimotika Julian Sitarek | Dijana Dominis Prester | Dario Hrupec | Gernot Maier | Dorota Sobczyńska | Saša Mićanović | Michał Szanecki | Katarzyna Adamczyk | Lovro Pavletić | Orel Gueta

Abstract
'The Cherenkov Telescope Array (CTA) is the future ground-based observatory for gamma-ray astronomy at very-high energies. The atmosphere is an integral part of every Cherenkov telescope. Different atmospheric conditions, such as clouds, can reduce the fraction of Cherenkov photons produced in air showers that reach ground-based telescopes, which may affect the performance. Decreased sensitivity of the telescopes may lead to misconstructed energies and spectra. This study presents the impact of various atmospheric conditions on the CTA performance. The atmospheric transmission in a cloudy atmosphere in the wavelength range from 200 nm to 1000 nm was simulated for different cloud bases and different optical depths using the MODerate resolution atmospheric TRANsmission (MODTRAN) code. MODTRAN output files were used as inputs for generic Monte Carlo simulations. Analysis was performed using the MAGIC Analysis and Reconstruction Software (MARS) adapted for CTA. As expected, the effects of clouds are most evident at low energies, near the energy threshold. Even in the presence of dense clouds, high energy gamma rays may still trigger the telescopes if the first interaction occurs lower in the atmosphere, below the cloud base. A method to analyze very-high energy data obtained in the presence of clouds is presented. The systematic uncertainties of the method are evaluated. These studies help to gain more precise knowledge about the CTA response to cloudy conditions and gives insights on how to proceed with data obtained in such conditions. This may prove crucial for alert based observations and time-critical studies of transient phenomena.'

Collaborations
CTA,

Keywords and Comments
Cherenkov telescopes, clouds, CTA, MODTRAN, Monte Carlo simulations, Mario Pecimotika''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
MAGIC observations of the nearby short GRB 160821B

Presenter
Koji Noda
Author and Co-Author
Koji Noda | Lara Nava | Susumu Inoue | Satoshi Fukami | Michele Palatiello | Alessio Berti | Francesco Longo

Abstract
'Gamma-ray bursts (GRBs), the most luminous explosions in the universe, have at least two types known. One of them, short GRBs, have been thought to originate from binary neutron star (BNS) mergers. The discovery of GW170817 together with a GRB was the first and only direct proof of the hypothesis, and thus the properties of the short GRBs are poorly known yet. Aiming to clarify the underlying physical mechanisms of the short GRBs, we analyzed GRB 160821B, one of the nearest short GRBs known at z=0.162, observed with the MAGIC telescopes. A hint of a gamma-ray signal is found above 0.5 TeV at a significance of >3 sigma during observations from 24 seconds until 4 hours after the burst, as presented in the past.\r\nRecently, multi-wavelength data of its afterglow emission revealed a well-sampled kilonova component from a BNS merger, and the importance of GRB 160821B increased concerning GRB-GW studies. Accordingly, we investigated GRB afterglow models again, using the revised multi-wavelength data. We found that the straightforward interpretation with one-zone synchrotron self-Compton model from the external forward shock is in tension with the observed TeV flux, contradicting the suggestion reported previously.\r\nIn this contribution we discuss the implication from the TeV observation, including alternative scenarios where the TeV emission can be enhanced. We also give a brief outlook of future GeV-TeV observations of short GRBs with imaging atmospheric Cherenkov telescopes, which could shed more light on the GRB-BNS merger relation.'

Collaborations
MAGIC, Fermi-LAT

Keywords and Comments
GRB, short GRB, kilonova, very high energy gamma rays, IACT, Koji Noda'on behalf of the MAGIC and Fermi/LAT Collaborations'

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
BL Lac object 1ES 0647+250, a decade of MWL observations

Presenter
Jorge Otero-Santos
Author and Co-Author
Jorge Otero-Santos Daniela Dorner | Daniel Morcuende | David Paneque | Vandad Fallah Ramazani | Elisa Prandini | Giacomo Bonnoli | on behalf of the MAGIC and Fermi-LAT Collaborations and MWL partners

Abstract
'The High-peaked BL Lac object 1ES 0647+250 is one of the few distant blazars detected at very-high-energy (VHE, E > 100 GeV) gamma rays during non-flaring activity. Its redshift is still uncertain, but a lower limit of z>0.29 was recently calculated, based on the minimum equivalent width of absorption features expected from the host galaxy. This blazar was first detected by the MAGIC telescopes between 2009 and 2011 during its low state, displaying around 2% of the Crab Nebula flux above 100 GeV, but it has shown several periods of large activity, where the VHE gamma-ray flux increased by more than 1 order of magnitude. For the first time for this object, the detailed broadband spectral energy distribution will be presented for different activity levels. Based on the datasets collected from 2009 to 2020, the multi-band variability and correlations among various energy bands will be discussed in the context of the different emission models.'

Collaborations
MAGIC, Fermi-LAT
Keywords and Comments
AGN, BL Lac object, VHE, gamma-rays, blazar, Jorge Otero-Santos''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Observation of a relatively low luminosity long duration GRB 201015A by the MAGIC telescopes

Presenter
Yusuke Suda
Author and Co-Author
Yusuke Suda | Manuel Artero | Katsuaki Asano | Alessio Berti | Lara Nava | Koji Noda | Kenta Terauchi | For the MAGIC Collaboration

Abstract
'Starting from the first unequivocal detection of very high energy (VHE) emission from the luminous gamma-ray burst (GRB) GRB 190114C by the MAGIC telescopes, four detections of VHE emission from GRBs by ground-based telescopes were reported as of today. Such new energetic components were missing for a long time and these observations have become a new probe to explore GRB physics. In order to deepen our understanding, more GRB observations by VHE instruments are crucial. GRB 201015A was detected by the Swift/BAT and the duration of its prompt emission was measured as 9.78 +- 3.47 seconds. We started fast follow-up observations of this GRB with the MAGIC telescopes about 30 seconds after its onset under good observational conditions. Subsequent optical observations measured the redshift of the host galaxy as 0.42 and found the associated type Ic-BL supernova. The total isotropic equivalent energy of the prompt emission is then estimated to be the order of 10^50 erg, which means this is a long GRB with a relatively low luminosity. In this sense, GRB 201015A may have similar properties to GRB 190829A whose VHE emission was detected by the H.E.S.S. telescopes. The accurate analysis of the MAGIC data confirms the strong hint of detection, implying a significant energy release in the TeV range, comparable with that of the prompt emission in the keV-MeV band. We report these results and theoretical interpretation of GRB 201015A emission.'

Collaborations
MAGIC,

Keywords and Comments
GRB, very high energy emission, MAGIC, Yusuke Suda''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Gamma-ray Observation of the Cygnus Region with the Tibet Air Shower Array

Presenter
Yusaku KATAYOSE
Author and Co-Author
Yusaku KATAYOSE | For the Tibet AS-gamma Collaboration

Abstract
'The Tibet air shower (AS) array and underground water-Cherenkov-type muon detector (MD) array have been successfully operated since 2014, at an altitude of 4,300m in Tibet, China. The gamma-ray energy and arrival direction are determined by the Tibet AS array, while the MD array enables us to suppress more than 99.9% of background cosmic rays above 100 TeV, by means of counting the number of muons in an air shower at 2.4m underground. We report on the observation of gamma-ray emission from the Cygnus region in our Galaxy.'

Collaborations
, Tibet AS-gamma

Keywords and Comments
Cygnus region, ultra high energy gamma-ray,, Yusaku KATAYOSE"

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Subcategory Experimental Results

Titel
The VERITAS-Stellar Intensity Interferometry (VSII) survey of Stellar Diameters

Presenter
David Kieda
Author and Co-Author
David Kieda | the VERITAS Collaboration

Abstract
'The VERITAS Imaging Air Cherenkov Telescope (IACT) array was augmented in 2019 with high-speed focal plane electronics to allow the use of VERITAS for Stellar Intensity Interferometry (SII) observations. Since January 2019, VSII recorded more than 127 hours of moonlit observations on 22 different bright stars and binary systems (m_V < 3). The observations resulting in the measurement of the diameters of several stars at an effective optical wavelength of 417 nm with better than 5% resolution. This talk will describe the results of selected VSII observations, and discuss the sensitivity of these results to stellar phenomena such as limb darkening, rapid rotation, and other astrophysical effects.'

Collaborations
VERITAS,

Keywords and Comments
Intensity Interferometry, stellar diameters, IACT arrays, stellar envelopes, limb darkening, David Kieda''

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Subcategory Experimental Results

Titel
Physics Performance of the Large Size Telescope prototype of the Cherenkov Telescope Array

Presenter
Ruben Lopez-Coto
Author and Co-Author
Ruben Lopez-Coto Manuel Artero | Andres Baquero | Maria Isabelle Bernardos | Jose Luis Conteras | Federico Di Pierro | Enrique Garcia | Daniel Kerszberg | Marcos Lopez-Moya | Alvaro Mas Aguilar | Abelardo Moralejo | Daniel Morcuende | Maximilian Nöthe | Seiya Nozaki | Yos

Abstract
'The Large Size Telescope (LST) prototype of the future Cherenkov Telescope Array (CTA) is located at the Northern site of CTA, on the Canary Island of La Palma. It is designed to provide optimal performance in the lowest part of the energy range covered by CTA, observing gamma rays down to energies of tens of GeV. The LST prototype started performing astronomical observations in November 2019 during the commissioning of the telescope and it has been taking data since then. In this contribution, we will present the tuning of the characteristics of the telescope in the Monte Carlo (MC) simulations to describe the data obtained, the estimation of its angular and energy resolution, and an evaluation of its sensitivity, both with simulations and with observations of the Crab Nebula.'

Collaborations
CTA,
Keywords and Comments
, Ruben Lopez-Coto''

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Subcategory Experimental Results

Titel
"The ASTRI Mini-Array: a breakthrough in the Cosmic Ray study"

Presenter
MARTINA CARDILLO
Author and Co-Author
MARTINA CARDILLO For the ASTRI Mini-Array Collaboration

Abstract
'Despite the enormous efforts done in very recent years, both theoretically and experimentally, the basic three questions about the CR origin remain without clear answers: what are their sources, how are they accelerated, how do they propagate?\r\n\r\nGamma-ray astronomy plays a fundamental role in this field. Both relativistic protons and electrons can emit in the gamma-ray band with different processes but only the detection of hadronic gamma-ray emission is a direct proof of Cosmic-Ray acceleration. Distinguishing leptonic and hadronic components is one of the most tricky issues in high energy astrophysics, however, a gamma-ray detection at about 100 TeV would be a direct proof of the hadronic origin of the emission. Consequently, not only would it directly confirm the presence of CR acceleration in a source but also it gives us a large amount of information about their sources, their parent protons and their propagation. The ASTRI Mini-Array, with its unprecedented sensitivity at E > 10 TeV, will provide a fundamental contribution to close some of the most important CR open issues. It will provide fundamental additional data at the highest gamma-ray energies for some candidate Pevatron sources, confirming or disproving their hadronic nature. In the same way, its observations will bring a breakthrough in the understanding of the Crab 100 TeV emission and of the diffusion coefficient behavior near some Supernova Remnants. In this talk, some of the most important results expected by the ASTRI MA are illustrated.'

Collaborations
other (fill field below), ASTRI Mini-Array

Keywords and Comments
Gamma-ray, Cherenkov Telescopes, origin of cosmic rays, pevatrons. radiation processes, MARTINA CARDILLO''

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Subcategory Experimental Results

Titel
H.E.S.S. ToO program on nearby core-collapse Supernovae : search for very-high energy gamma-ray emission towards the SN candidate AT2019krl in M74

Presenter
Nukri Komin
Author and Co-Author
Nukri Komin | Rachel Simoni | Matthieu Renaud | Stuart Ryder | for the H.E.S.S. Collaboration

Abstract
'While the youngest known supernova remnants (SNRs), such as Cas A, have been proven to be able to accelerate CRs only up to $\\sim 10^{14}\\,\\mathrm{eV}$, recent studies have shown that particle energies larger than a few PeV ($10^{15}\\,\\mathrm{eV}$) could actually be reached during the early stages of a core-collapse Supernova (cc-SN), when the high-velocity forward shock expands into the dense circumstellar medium (CSM) shaped by the stellar progenitor wind. Such environments, in particular the type IIn SNe whose progenitors may exhibit mass loss rates as high as $10^{-2}\\,M_\\odot \\, \\mathrm{yr}^{-1}$, would thus lead to gamma-ray emission from $\\pi^0$ decay in hadronic interactions, potentially detectable with current Cherenkov telescopes at very-high energies (VHE). In that context, the High Energy Stereoscopic System (H.E.S.S.) has been carrying out a Target of Opportunity (ToO) program since 2016 to search for such an early VHE gamma-ray emission towards nearby (up to $\\sim 10\\,\\mathrm{Mpc}$) cc-SNe and SN candidates, within a few weeks of discovery. After giving an overview of this H.E.S.S. ToO program, we will present the results obtained from July 2019 observations towards the transient AT2019krl, originally classified as a type IIn SN, which occurred in the galaxy M74 at $\\sim 9\\,\\mathrm{Mpc}$. Although its nature still remains unclear, the derived H.E.S.S. constraints on this transient will be placed in the general context of the expected VHE gamma-ray emission from cc-SNe.'

Collaborations
H.E.S.S.,
Keywords and Comments
supernovae, gamma rays, particle acceleration, Nukri Komin"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
A search for spectral hardening in HAWC sources above 56 TeV

Presenter
Kelly Malone
Author and Co-Author
Kelly Malone | for the HAWC Collaboration

Abstract
'The High Altitude Water Cherenkov (HAWC) Observatory is a wide-field-of-view gamma-ray observatory that is optimized to detect gamma rays between ~300 GeV and several hundred TeV. The HAWC Collaboration recently released their third source catalog (3HWC), which contains 65 sources. One of these sources, the ultra-high-energy gamma-ray source 3HWC J1908+063, may exhibit a hardening of the spectral index at the highest energies (above 56 TeV). At least two populations of particles are needed to satisfactorily explain the highest energy emission. This second component could be leptonic or hadronic in origin. If it is hadronic in origin, it would imply the presence of protons with energies up to ~1 PeV near the source. We have searched other 3HWC sources for the presence of this spectral hardening feature. If observed, this would imply that the sources could make good PeVatron candidates.'

Collaborations
HAWC,
Keywords and Comments
pevatrons, TeV, TeV gamma rays, HAWC, PWN, Galactic, Kelly Malone''

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Table Number

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
VTSCat: The VERITAS Catalog of Gamma-Ray Observations

Presenter
Sameer Patel
Author and Co-Author
Sameer Patel | Gernot Maier | For the VERITAS collaboration

Abstract
"We present a catalog of results published from 2008 to 2020 through gamma ray observations made by **VERITAS**. VERITAS is a ground based imaging atmospheric Cherenkov telescope observatory located at the Fred Lawrence Whipple Observatory (FLWO) in southern Arizona, sensitive to gamma-ray photons with energies in the range of $\\sim$ 100 GeV - 30 TeV. Its observation targets include galactic sources such as binary systems, pulsar wind nebulae, and supernova remnants, and extragalactic sources like active galactic nuclei, star forming galaxies, and gamma-ray bursts and some unidentified sources. The catalog includes all of the results published in 112 papers using VERITAS data and currently contains data on 57 sources. The catalog has been made accessible via GitHub and at NASA's HEASARC."

Collaborations
VERITAS,
Keywords and Comments
observational catalog, gamma ray data, HEASARC, Sameer Patel"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Studying High-Mass Microquasars with HAWC

Presenter
Chang Dong Rho
Author and Co-Author
Chang Dong Rho | Ke Fang for the HAWC Collaboration

Abstract
'High-mass microquasars (HMMQs) are powerful particle accelerators, but their mechanism of the high-energy emission is poorly understood. To date, only a handful of these particle engines have ever been observed to emit gamma-ray photons and are thus potential TeV gamma-ray emitters. In this work, we study four HMMQs, namely, LS 5039, Cyg X-1, Cyg X-3, and SS 433 using the data from the High Altitude Water Cherenkov (HAWC) observatory. We report the most stringent limit to date on the gamma-ray emission above 10 TeV for each HMMQ. Also, by stacking the fitted likelihoods of the HMMQs, we constrain the fraction of the jet luminosity in emitting very-high-energy (VHE) gamma rays and high-energy neutrinos. We show that the non-detection of VHE gamma rays implies a significant magnetic field, which challenges synchrotron radiation as the dominant mechanism of the microquasar emission between 10 keV and 10 MeV. Furthermore, we perform time dependent analysis on each HMMQ to look for any periodic variations in their flux.'

Collaborations
HAWC,

Keywords and Comments
Gamma rays, High-mass x-ray binaries, Chang Dong Rho''

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Branch	GAI | Gamma Ray Indirect
Subcategory	Experimental Results

Titel
MAGIC observations of HESS J1809-193 using the Very Large Zenith Angle technique at energies above TeV

Presenter
Darko Zaric
Author and Co-Author
Darko Zaric David Green | Marcel Strzys | Ievgen Vovk | on behalf of the MAGIC collaboration

Abstract
The origin of Galactic Cosmic rays (GCRs), whose spectrum extends to PeV energies, is one of the longest-standing problems in astroparticle physics. One of the main sources of GCRs are regarded to be Supernova remnants (SNRs). While SNRs are known to accelerate protons, so far there is no evidence that SNRs can accelerate CRs to PeV energies. Providing that ~10% of the parent Cosmic ray energy is converted to gamma rays, the gamma-ray spectrum extending up to ~100 TeV would be a signature of a so-called Galactic PeVatron, an object responsible for the production of protons up to the knee of the Cosmic ray spectrum. The current multi-wavelength data indicate that HESS J1809-193 is one of the most promising Galactic PeVatron candidates. So far, no firm identification on the source nature has been established as there are several possible counterparts at lower energies, one of them being SNR G11.0−0.0. We report here the results of an observational campaign performed by the MAGIC telescopes on HESS J1809-193 since 2019 in the very-high-energy gamma-ray domain (E>100 GeV). The data were obtained with the Very Large Zenith Angle (VLZA) technique, which increased the collection area significantly to about one square kilometer. We used ~60 hours of collected VLZA data to explore the spectrum and the morphology of the source at energies above several TeV.'

Collaborations
MAGIC,

Keywords and Comments
gamma rays, very large zenith angles, HESS J1809-193, PeVatron, Darko Zaric"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Study of the morphology of the region surrounding eHWC J1850+001

Presenter
Chad Brisbois
Author and Co-Author
Chad Brisbois | For the HAWC Collaboration

Abstract
'Although at extreme energies (>50 TeV) γ-ray sources generally have large angular separations from one another as observed on Earth, at lower energies in the galactic plane this is often not the case. HAWC observes extended emission from the source eHWC J1850+001 exceeding 50 TeV, and at lower energies this region appears to consist of multiple sources of γ-ray emission. These include the 3HWC J1849+001 source but also two nearby H.E.S.S. sources observed in their Galactic Plane Survey. Therefore, a full description of the region requires a morphological study including the full energy range of HAWC data. Understanding the spatial features of the emission in this region is important to associate the sources observations at other wavelengths, which may point to hadronic or leptonic origins for the γ-ray emission. There are multiple pulsar wind nebulae and super nova remnant systems in the vicinity that may be responsible for the emission in this region, including the pulsar PSR J1849+001 and its pulsar wind nebula, which is a likely candidate for the >50 TeV energy emission seen by HAWC.'

Collaborations
HAWC,
Keywords and Comments
VHE, PWN, SNR, HAWC, multisource, likelihood,, Chad Brisbois''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Characterizing gamma-ray sources with HAL (HAWC Accelerated likelihood) and 3ML

Presenter
Chad Brisbois
Author and Co-Author
Chad Brisbois | For the HAWC Collaboration

Abstract
'The open-source Multi-Mission Maximum likelihood (3ML) Framework allows for the common analysis of diverse datasets. The ability to consistently fit and characterize astronomical data across many decades in energy is key to understanding the origin of the emission we measure with many different instruments. 3ML uses plugins to encapsulate the interfaces to data and instrument response functions. The user can then define a model with one or multiple sources to describe a given region of interest. The model is fit to the data to determine the locations, spatial shapes, and energy spectra of the sources in the model. The High Altitude Water Cherenkov (HAWC) Observatory, a wide FoV instrument sensitive to energies from 300 GeV to above 100 TeV, has used 3ML for data analysis for several years using a plugin optimized for single source analysis. As multisource fitting became more common, a faster plugin was required. Spectral fits to the Crab Nebula and the nearby source HAWC J0543+233 obtained using HAL, the HAWC plugin for 3ML, will be presented.'

Collaborations
HAWC,
Keywords and Comments
software, 3ML, crab, likelihood, Chad Brisbois''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Limits on the Diffuse Gamma-Ray Background with HAWC

Presenter
Mora Durocher
Author and Co-Author
Mora Durocher | For the HAWC Collaboration Pat Harding

Abstract
'The high-energy Diffuse Gamma-Ray Background (DGRB) is expected to be produced by unresolved extra-galactic objects such as active galactic nuclei and isotropic Galactic gamma rays. At TeV energies, observations or stringent limits on the DGRB could have significant multi-messenger implications, such as constraining the origin of TeV-PeV astrophysical neutrinos detected by IceCube. With its continuous sensitivity to gamma rays from 300 GeV to 100 TeV and its wide field-of-view, the High Altitude Water Cherenkov (HAWC) observatory is well-suited to significantly improve searches for the DGRB. In this work, strict cuts have been applied to the HAWC dataset to better isolate gamma-ray air showers from background hadronic showers. The sensitivity to the DGRB was then verified using 535 days of Crab data and Monte Carlo simulations, leading to a new limit on the DGRB above 24 TeV.'

Collaborations
HAWC,
Keywords and Comments
, Mora Durocher"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Detection of the Crab Nebula by the prototype Schwarzschild-Couder Telescope

Presenter
Brent Mode
Author and Co-Author
Brent Mode | for the CTA SCT Project

Abstract
'The Schwarzschild-Couder Telescope (SCT) is a medium-sized telescope technology proposed for the Cherenkov Telescope Array. It uses a novel dual-mirror optical design that removes comatic aberrations across its entire field of view. The SCT camera employs high-resolution silicon photomultiplier (SiPM) sensors with a pixel size of 4 arc minutes. A prototype SCT (pSCT) has been constructed at the Fred Lawrence Whipple Observatory in Arizona, USA. An observing campaign in 2020, with a partial camera of 1600 pixels (2.7 degrees by 2.7 degrees field of view) resulted in detection of the Crab Nebula at 8.6 sigma statistical significance. Work on the pSCT camera and optical system is ongoing to improve performance and prepare for an upcoming camera upgrade. The pSCT camera upgrade will replace the current camera modules with improved SiPMs and readout electronics and will expand the camera to its full design field of view of 8 degrees in diameter (11,328 pixels). The fully upgraded pSCT will enable next-generation very-high-energy gamma-ray astrophysics through excellent background rejection and angular resolution. In this presentation we will describe first results from the successful operation of the pSCT and future plans.'

Collaborations
CTA,

Keywords and Comments
gamma rays, Crab Nebula, CTA, IACT, Brent Mode''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
VERITAS Observations of the Galactic Center Region at Multi-TeV Gamma-Ray Energies

Presenter
James Ryan
Author and Co-Author
James Ryan for the VERITAS Collaboration

Abstract
'The Galactic Center region hosts a variety of powerful astronomical sourcesand rare astrophysical processes that emit a large flux of non-thermal radiation. We present the analysis of the very-high-energy gamma-ray emission above 2 TeV of the region around the Galactic Center known as the Central Molecular Zone using 125 hours of data taken with the VERITAS imaging-atmospheric Cherenkov telescope between 2010 and 2018. This analysis employs new shower reconstruction algorithms and instrument response functions optimized for data taken at large zenith angles such as the Galactic Center sources. We report positions and spectra for point sources VER J1745-290, G0.9+0.1, and HESS J1746-285, along with a light curve for VER J1745-290, the brightest source in the region consistent with the position of the supermassive black hole Sagittarius A*. We also measure the spectrum of the diffuse emission from the Galactic Center ridge region, which has been claimed as evidence of a Galactic PeVatron.'

Collaborations
VERITAS,

Keywords and Comments
Galactic Center, Central Molecular Zone, James Ryan''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Unveiling the complex correlation patterns in Mrk 421

Presenter
Axel Arbet-Engels
Author and Co-Author
Axel Arbet-Engels David Paneque | Lea Heckmann | for the MAGIC, FACT and Fermi-LAT Collaborations and multi-wavelength collaborators

Abstract
The blazar Mrk421 (redshift $z=0.031$) is one of the brightest and closest BL Lac type objects, making it an ideal target to probe blazar physics. We report on an extensive multi-wavelength observing campaign in 2017, during which the intra-band correlation patterns show some disparity and complex behaviours. Observations from several instruments are used to achieve an optimal temporal coverage from radio to TeV energies. In particular, four multi-hour NuSTAR observations organised simultaneously with MAGIC allow to obtain a precise measurement of the falling segments of the two spectral components. A detailed investigation of the very-high-energy (VHE, >100 GeV) versus X-ray flux correlation is performed, by binning the data into several sub-energy bands. A positively correlated variability is observed, but the correlation characteristics change substantially across the various bands probed. Furthermore, during the simultaneous MAGIC and NuSTAR observations a clear change of the Compton dominance is detected without a simultaneous change in the synchrotron regime, indicating "orphan gamma-ray activity". We also investigate an intriguing bright flare at VHE without a substantial flux increase in the X-rays. Within a leptonic scenario, this behaviour is best explained by the appearance of a second population of highly-energetic electrons spanning a narrow range of energies. Finally, our multi-wavelength correlation study also reveals an anti-correlation between the UV/optical and X-ray bands at a significance level above 3 sigma.'

Collaborations
MAGIC, FACT, Fermi-LAT

Keywords and Comments
BL Lacertae objects, AGN , gamma rays, radiation mechanisms, modelling, Axel Arbet-Engels''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
TeV Analysis of the Probable PWN Component of 3HWC J2031+415

Presenter
Ian Herzog
Author and Co-Author
Ian Herzog | For the HAWC Collaboration

Abstract
'The Cygnus Cocoon region is a complex region containing an OB star cluster that is prominent in the TeV energy range. Located in this region is 3HWC J2031+415, a significant TeV gamma ray source whose emission is possibly associated with 2 components, the Cygnus OB2 star cluster and a pulsar wind nebula (PWN). In this work, several modelling methods are presented to best describe the emission. These models disentangle emission believed to be from the Cocoon and isolate the component emitted by the probable PWN. I will present several spectral models to describe the emission of the probable PWN using the latest data set from the High-Altitude Water Cherenkov (HAWC) observatory. Furthermore, I will present an energy morphology study of the PWN component of 3HWC J2031+415 in distinct energy bins.'

Collaborations
HAWC,
Keywords and Comments
Gamma ray, Morphology study, Ian Herzog''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Effective pointing of the ASTRI-Horn telescope using the Cherenkov camera with the Variance method

Presenter
Simone Iovenitti
Author and Co-Author
Simone Iovenitti Giorgia Sironi | Osvaldo Catalano | Alberto Segreto | Teresa Mineo | for the ASTRI project

Abstract
'Cherenkov telescope cameras are not suitable to perform astrometrical pointing calibration since they are not designed to produce images of the sky, but rather to detect nanosecond atmospheric flashes due to very high-energy cosmic radiation. Indeed, these instruments show only a moderate angular resolution (fractions of degrees) and are almost blind to the steady or slow-varying optical signal of starlight. For this reason, auxiliary optical instruments are typically adopted to calibrate the telescope pointing. However, secondary instruments are possible sources of systematic errors. Furthermore, the Cherenkov camera is the only one framing exactly the portion of the sky under study, and hence its exploitation for pointing calibration purposes would be desirable.\r\nIn this work, we present a procedure to assess the pointing accuracy of the ASTRI-Horn telescope by means of its innovative Cherenkov camera. This instrument is endowed with a statistical method, the so-called Variance method, implemented in the logic board and able to provide images of the night sky background light as ancillary output.\r\nTaking into account the convolution between the optical point spread function and the pixel distribution, Variance images can be used to evaluate the position of stars with sub-pixel precision. In addition, the rotation of the field of view during observations can be exploited to verify the alignment of the Cherenkov camera with the optical axis of the telescope, with a precision of ~1 arcsec. This information is essential to evaluate the effective pointing of the telescope, enhancing the scientific accuracy of the system.'

Collaborations
other (fill field below), ASTRI
Keywords and Comments
pointing, assessment, FOV rotation, variance, ASTRI, runtime, alignment, tracking,, Simone Iovenitti"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Monitoring the radio galaxy M87 with HAWC

Presenter
Tomás Capistrán
Author and Co-Author
Tomás Capistrán | Daniel Avila Rojas | Maria Magdalena Gonzalez | Nissim Fraija | Ruben Alfaro | For the HAWC Collaboration

Abstract
"Studies of radio galaxies at TeV energies are of particular interest because their jets are misaligned with respect to our sightline. This provides us with a unique opportunity for studying the structure of their jets, the radiative processes, and the acceleration mechanisms involved in them. Some radio galaxies have presented variability in their emission, like the giant radio galaxy M87, which has reported several activity periods. Due to its duty cycle > 95% and instantaneous field of view of 2 sr, HAWC is providing daily monitoring of variable sources visible from the Northern Hemisphere. In this work, we show the results of monitoring M87 between January 2015 and December 2019. HAWC's observation are consistent with the low acivity state reported by other instruments (like H.E.S.S and MAGIC). However, after September 2017 (~MJD 58000), the HAWC measurements of M87 show hints of higher activity."

Collaborations
HAWC,

Keywords and Comments
Radio Galaxies, High Energy, HAWC, Tomás Capistrán"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Study of the eHWC J1825-134 at the Highest Energy with HWAC

Presenter
Dezhi Huang
Author and Co-Author
Dezhi Huang | Francisco Salesa Greus | Sabrina Casanova | Petra Huentemeyer

Abstract
'eHWC J1825-134 is one of the brightest Galactic gamma-ray sources above 50 TeV observed by High Altitude Water Cherenkov Gamma-Ray Observatory (HAWC). Detailed morphological studies have revealed a new point-like source inside this region with a spectral energy distribution extending beyond 200 TeV without any cutoff. These very-high-energy gamma rays emission can originate from leptonic or hadronic processes. The new point-like source is located in a region containing PWNe and a high density giant molecular cloud [MML2017]99. If the source emission is associated with the hadronic scenario the TeV gamma rays may have been produced by cosmic rays colliding with ambient gas. If this were the case, eHWC J1825-134 is an indicator of the existence of a galactic PeVatron in the region that accelerates particles up to PeV energies.'

Collaborations
HAWC,
Keywords and Comments
, Dezhi Huang''

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Subcategory Experimental Results

Titel
Follow-up Analysis to Geminga's contribution to the Local Positron Excess with HAWC Gamma-Ray Observatory

Presenter
Ramiro Torres Escobedo
Author and Co-Author
Ramiro Torres Escobedo | Hao Zhou | For the HAWC collaboration | Mattia Di Mauro

Abstract
'The experiments PAMELA and AMS-02 measured an anomalous local positron excess above energies of 10 GeV. The reason for this excess is not well understood but has been considered as indirect evidence of dark matter, but could also be produced from nearby pulsars. The HAWC collaboration previously studied the extended gamma-ray emission of two nearby pulsars, Geminga and PSR 0656+14, but found these two pulsars did not contribute a significant amount to this excess. The previous study of HAWC led to the reinterpretation of our result and initiated the concept of inverse Compton (IC) halos. Fitting a new halo model together with 1343 days of data from the HAWC gamma-ray observatory may better constrain the contribution of these pulsars to the positron excess. This halo model utilizes 3D templates of gamma-ray emission from electron IC interactions to fit the diffusion coefficient and electron injection spectral index. This model can further help study the energy dependent diffusion and incorporate anisotropic diffusion with the proper motion of the pulsar.'

Collaborations
HAWC,

Keywords and Comments
Gamma-ray, halo, PWNe, Ramiro Torres Escobedo''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Fast X-ray variability of radio galaxy M87

Presenter
Ryo Imazawa
Author and Co-Author
Ryo Imazawa Yasushi Fukazawa | Hiromitsu Takahashi | Mahito Sasada

Abstract
M87 is one of the nearest radio galaxy. We can study the core, jet, and some components by radio to X-ray observations. \r\nRegarding TeV gamma ray observations, it is known to show an intra-day variability.\r\nSuch fast variability may occur at the particle acceleration region. But due to rough angular resolution, we cannot know which component causes this variability.\r\nWe searched for fast X-ray variability of the M87 from long-exposure X-ray archive data. As a result, we found an intra-day variability during Suzaku/XIS data in 2006.\r\nSuzaku/XIS cannot resolve each component, but HST-1 was the brightest component in the X-ray band in this period, core had 1/4 of HST-1 flux.\r\nTherefore, this variability possibly comes from HST-1, but we cannot rule out the possibility of large core variability.\r\nA soft photon index > 2.0 in the X-ray band indicates that variability component is synchrotron emission from accelerated electrons in HST-1 or core.\r\nIn addition, we also find a possible variability of core on the Chandra/HRC observation in 2017.\r\nIn this period, NuSTAR X-ray spectra have a power law with a photon index of 1.8, and thus not likely a synchrotron spectrum from the jet. Here the X-ray emission from the core was dominant in this period.\r\nAlso, we find that one NuSTAR observation showed a higher flux than other NuSTAR observations by a factor of 2.5.\r\nFrom these results, both core and HST-1 can be the origin of the X-ray variability.\r\nWe will discuss the variability site and emission mechanism.'

Collaborations

Keywords and Comments
AGN, X-ray, Ryo Imazawa"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
The Crab Nebula: observations and a search for gamma-ray flares at UHE with LHAASO

Presenter
Lingyu Wang
Author and Co-Author
Lingyu Wang songzhan chen | Zhen Cao | Huihai He | Sha Wu | Cong Li | Zhe Li | on behalf of the LHAASO collaboration

Abstract
'The Crab Nebula is a steady radiation source, which has been used as a reference source in very high energy gamma-ray astronomy for calibration and verification of detectors, however the gamma-ray flares around GeV from the Crab Nebula have been observed many times by AGILE and Fermi-LAT since 2007. These observations challenge the standard models for particle acceleration in pulsar wind nebula. One square kilometer detector array (KM2A) of the Large High Altitude Air Shower Observatory (LHAASO) is designed to detect gamma ray sources with high sensitivity at 100 TeV. Half of the LHAASO-KM2A array has been running stably since the end of 2019. In this work, the observations of the Crab Nebula in energy range above 10 TeV and the results of searching for gamma-ray flares will be reported by using about 1-year data of the half-array LHAASO-KM2A'

Collaborations
Lhaaso,
Keywords and Comments
PWN, Crab, Flare, 玲玉 王"

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Subcategory Experimental Results

Titel
Observations of the brightest UHE Gamma-Ray Sources With the LHAASO-KM2A

Presenter
sha wu
Author and Co-Author
sha wu chao hou | songzhan chen | Ruoyu Liu | jun fang

Abstract
'Cosmic rays are high energy particles that come from outside of the solar system. It plays an important role in the evolution of our Galaxy. Gamma rays, produced by cosmic rays , are unique probe of cosmic rays and their accelerator. As a key sub-array of the Large High Altitude Air Shower Observatory (LHAASO), KM2A is the most sensitive gamma-ray detector at ultra-high energy (UHE, >100TeV). Here, we report two of the brightest UHE sources, LHAASO J1908+0621 and LHAASO J2018+3651. The morphology and spectral energy distribution of this two region are studied respectively using the KM2A data collected from December 2019 to December 2020. The origin of the UHE gamma-ray emission is also discussed taking into account multi-wavelength observations.'

Collaborations
Lhaaso,

Keywords and Comments
LHAASO-KM2A, UHE gamma-ray, 莎 武'for the LHAASO Collaboration'

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Studying the long-term spectral and temporal evolution of 1ES 1959+650

Presenter
Shunsuke Sakurai
Author and Co-Author
Shunsuke Sakurai | Wrijupan Bhattacharyya | Daniela Dorner | Pietro Grespan | Daniel Morcuende | Yasuyuki Nabatame | Elisa Prandini | Bernd Schleicher | Mari Takahashi | Mitsunari Takahashi | on behalf of the MAGIC Collaboration

Abstract
'The high-frequency peaked BL Lac type object (HBL) 1ES 1959+650 is one of the brightest blazars in the very-high-energy (VHE, E > 100 GeV) gamma-ray sky. HBLs have been proposed as possible neutrino emitters implying the presence of hadrons in the emission mechanisms. In 2002, AMANDA reported neutrino candidates from this source simultaneously observed with a gamma-ray flaring activity without an X-ray emission enhancement, interpreted as an orphan flare. Standard one-zone synchrotron self-Compton emission models cannot explain this behavior.\r\nThe MAGIC telescopes have been observing 1ES 1959+650 since 2004. An extreme outburst triggered by multi-wavelength observations reaching 300% of the Crab nebula flux level above 300 GeV was detected in 2016. Leptonic and hadronic models are equally successful in describing the observed emission. To study the long-term behavior and the characteristics in different emission states of 1ES 1959+650, we have monitored it densely since 2017 for more than 300 hours. Together with the FACT monitoring (more than 2000 hours since 2012), this is the most intense monitoring for any blazar after Mrk 421 and Mrk 501 in the VHE range. The monitoring showed a decline of the VHE flux with occasional flaring episodes reaching in 2019 a low-state emission corresponding to 10% of the Crab nebula.\r\nWe will present the long-term monitoring study results using multi-wavelength data from MAGIC, FACT, Fermi-LAT, and Swift. Furthermore, we will discuss the differences in the spectral energy distributions between the flaring states from 2016 and the low state in 2019.'

Collaborations
MAGIC,
Keywords and Comments
, Shunsuke Sakurai'on behalf of the MAGIC Collaboration.'

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Data analysis and key science results of LHAASO-WCDA

Presenter
Min Zha
Author and Co-Author
Min Zha | Guangman Xiang | Shicong Hu | Jinyan Liu | Yanjin Wang | Chuandong Gao | Ran Wang | Zhiguo Yao

Abstract
'Large High Altitude Air Shower Array (LHAASO) is a large\r\nhybrid EAS experiment located in Haizi Moutain, Daocheng, Sichuan\r\nprovince of P.R.C . Water Cherenkov Detector Array (WCDA) is one\r\nof subarrays aiming at VHE gamma ray astronomy. LHAASO-WCDA\r\nhas finished 2 pools installation and data-taking in the year of 2020.\r\nBased on these data a lot of works and implementation have been\r\nproceed, such as the gamma emssions from the full northern sky.\r\nThe preliminary analysis results, including observed significant\r\nsource candidates, the spectrum measurement and other related\r\nworks are presented in this talk.'

Collaborations
Lhaaso,

Keywords and Comments
gamma astronomy, sky survey, SED, Min Zha''

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Subcategory Experimental Results

Titel
Observing the gammas rays emission from the Markarian 421 with the LHAASO-WCDA

Presenter
Ran Wang
Author and Co-Author
Ran Wang | Min Zha | Cunfeng Feng

Abstract
'Abstract: Mrk421 is one of the brightest blazars in the northern sky. The radiation of Mrk421 is a broadband continuum ranging from radio through X-rays to gamma-rays. In the Large High Altitude Air Shower Observatory (LHAASO), the water Cherenkov detector array(WCDA) has the advantage of low energy threshold in observation of VHE flares, and is dedicated in surveying the northern sky for sources of gamma rays (100GeV to 30TeV). In this work, we report the monitoring results of Mrk421 over period from 2019 July to 2020 February. Based on the Fermi-LAT observation on the flux levels, we split the observation time into periods, classified as steady and flaring phases. The spectrum of the two phases\r\nare calculated, and to be presented in this talk.'

Collaborations
Keywords and Comments
, Ran Wang"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Telescope Array search for EeV photons

Presenter
Oleg Kalashev
Author and Co-Author
Oleg Kalashev | Grigory Rubtsov

Abstract
'We present updated results of the search for the ultra-high energy photons with primary energies greater than 1 EeV. The data of the Telescope Array Surface Detector collected over 12 years are used in this work. The method is based on the machine learning classifier, which trains on both the reconstructed composition-sensitive parameters of the event and the calibrated waveform signals at each triggered station of the Surface Detector.'

Collaborations
Telescope Array,
Keywords and Comments
ultra high energy cosmic rays, GZK photons,Telescope Array, Surface Detector, Oleg Kalashev''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Multiwavelength variability and correlation studies of Mrk421 during historically low X-ray and γ-ray activity in 2015–2016

Presenter
Biswajit Banerjee
Author and Co-Author
Biswajit Banerjee | Pratik Majumdar | David Paneque | Tomislav Terzić | For the MAGIC, FACT, Fermi-LAT Collaboration and MWL partners.

Abstract
In this work, we report multi-band flux variability and correlations of the nearby (z=0.031) blazar Markarian 421 (Mrk421) using multi-wavelength (MWL) data from November 2014 until June 2016. In this period, Mrk421 exhibited historically low activity in X-rays and very-high-energy gamma rays (VHE, E>0.1 TeV). During this period, an additional spectral component was observed by Swift-BAT. The highest flux variability occurs in X-rays and VHE which, despite the low activity, show a significant positive correlation with no time lag. The hardness ratios in the X-rays and VHE gamma rays show the "harder-when-brighter" trend observed in many blazars. Interestingly, the trend flattens at the highest fluxes, which suggests different processes dominating the brightest states. Enlarging our data set with data from the years 2007 to 2014, we measured a positive correlation between the optical and GeV emission centered at zero time lag, and a positive correlation between the optical/GeV and the radio emission over a range of about 60 days centered at a time lag of 43+9/-6 days. This observation is consistent with the radio-bright zone being located about 0.2 parsec downstream from the optical/GeV emission regions. In most of the energy bands, the flux distribution follows the Lognormal, rather than the Normal function, indicating that the variability may be dominated by a multiplicative process.'

Collaborations
MAGIC, FACT, Fermi-LAT Collaboration and MWL partners

Keywords and Comments
galaxies: active – BL Lacertae objects: individual: Mrk 421 – methods: data analysis – methods: observational – radiation mechanisms: non-thermal, BISWAJIT BANERJEE"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Statistical properties of flux variations in blazar light curves at GeV and TeV energies

Presenter
Sarah Wagner
Author and Co-Author
Sarah Wagner | Daniela Dorner | Karl Mannheim

Abstract
'Despite numerous detections of individual flares, the cause of the rapid variability observed from blazars remains uncertain. Using Bayesian blocks and the HOP algorithm, we characterize all significant flux variations in a set of light curves and determine the statistical properties of the rise and decay behavior in order to constrain the physical mechanisms driving blazar variability. Long-term gamma-ray light curves of TeV-bright blazars observed with the First G-APD Cherenkov Telescope (FACT) are compared to those of GeV-bright blazars observed with the Fermi Gamma-ray Space Telescope (Fermi-LAT). Furthermore, we test for time-reversal invariance which is expected if the light curves can be described by a stochastic model such as the Ornstein-Uhlenbeck process.'

Collaborations
other (fill field below), FACT
Keywords and Comments
AGN, blazars, variability, Sarah Wagner''

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Subcategory Experimental Results

Titel
Search for gamma rays above 30 TeV from the Crab Nebula with the GRAPES-3 experiment

Presenter
Diptiranjan Pattanaik
Author and Co-Author
Diptiranjan Pattanaik For the GRAPES-3 Collaboration

Abstract
'The GRAPES-3 is a high-altitude, near-equator extensive air shower array at Ooty, India which is designed to observe cosmic and gamma rays in TeV-PeV energy range. It consists of a dense array of 400 scintillator detectors operating in conjunction with a 560 m^2 area muon telescope. Due to recent improvements in the measurements of shower arrival time and size and age dependent corrections for shower front curvature, the angular resolution of the array has been significantly improved (0.4$^\\circ$ at 30 TeV). Also employing an efficient rejection of the cosmic ray background using the muon content of the shower, a search for gamma rays above 30 TeV from the Crab Nebula has been performed. The results will be presented during the conference.'

Collaborations
other (fill field below), GRAPES-3
Keywords and Comments
GRAPES-3, Crab Nebula, Gamma ray, cosmic ray sources,, Diptiranjan Pattanaik"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Characterizing the isotropic diffuse gamma-ray flux (10-300 TeV) by the GRAPES-3 experiment

Presenter
Bhanu Pant
Author and Co-Author
Bhanu Pant For the GRAPES-3 Collaboration

Abstract
'A diffuse gamma-ray emission at $\\sim$100 TeV can be expected as a result of the interactions of ultra-high-energy cosmic rays (UHECRs) with the cosmic microwave background (CMB) during their propagation. This radiation carries the information on the distribution of energetic sources and hence the cosmological evolution of the Universe. The GRAPES-3 is an extensive air shower (EAS) array, located at Ooty in southern India. It consists of 400 plastic scintillators (each 1 m^2) and a large area (560 m^2) muon telescope. The muon telescope has the ability to differentiate the gamma-rays from charged cosmic rays through their muon content. We report on the study of isotropic diffuse gamma-ray flux from GRAPES-3 over 10$-$300 TeV.'

Collaborations
other (fill field below), GRAPES-3

Keywords and Comments
diffuse radiation, gamma-rays, grapes-3, extensive air shower, Bhanu Pant"

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Searching for >100 TeV emission in the vicinity of Mrk 501 with HAWC

Presenter
Andrea Albert
Author and Co-Author
Andrea Albert

Abstract
'The High Altitude Water Cherenkov (HAWC) Observatory surveys 2/3 of the gamma-ray sky each day for gamma rays from 300 GeV to over 100 TeV. Using recently improved energy reconstruction, HAWC has detected several Galactic sources with emission above 100 TeV. We extend this analysis to search for >100 TeV emission in the vicinity of Mrk 501. High-energy emission from Mrk 501 could, for example, be evidence of Axion Like Particles, a theoretical dark matter candidate. We found a hint of two >100 TeV lobes about 0.5 degrees above and below Mrk 501. Specifically, a preliminary analysis shows that the flux of each of the potential lobes has a pretrials significance of ~3 sigma above the background assuming a power law flux with and index of -2. We will summarize our analysis and discuss potential origins of this emission.'

Collaborations
HAWC,
Keywords and Comments
, Andrea Albert''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Satellite-based Calibration of the TAIGA-HiSCORE Cerenkov Array by the LIDAR on-board CALIPSO

Presenter
Andrea Porelli
Author and Co-Author
Andrea Porelli | Ralf Wischnewski | For the TAIGA Collaboration

Abstract
The wide-angle Air-Cerenkov array HiSCORE is a major component of the TAIGA facility in the Tunka valley, built for Gamma Astronomy and Cosmic Ray research. HiSCORE will contain 120 stations distributed over a 1km2 area.\r\n\r\nHere, we report a multi-year detection of light flashes in HiSCORE from the LIDAR on-board the Sun-synchronous CALIPSO satellite, obtained from 2015-2021. The 100mJ laser (532nm) is observed up to distances beyond 10km away from the ground light spot. This study complements first observations of a space-based LIDAR, performed in 2015/2017 with the 28-station HiSCORE prototype and the CATS LIDAR on-board the International Space Station. We present HiSCORE calibration methods developed for the LIDAR events to optimize the pointing resolution of the array, and additionally perform a detailed array performance analysis over 6 years.\r\n\r\nThe angular resolution for this special class of HiSCORE events - bright flashes, with a plane wave light front - is found to be <0.05°, which is much below the high-energy limit of ~0.1° for air-showers. The satellite event sample allows to optimize rare event search strategies, like for optical flashes of astrophysical origin. We will also report on scheduled joint LIDAR observation by HiSCORE and TAIGA-IACTs, as well as optical ground instruments - to independently calibrate the absolute array-pointing precision.'

Collaborations
TAIGA,

Keywords and Comments
timing array, LIDAR, time calibration, ground Cherenkov detection, gamma astronomy, satellite, Andrea Porelli''

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Subcategory Experimental Results

Titel
TAIGA-Observatory: First 5 years of operation of the HiSCORE Air-Cerenkov Array

Presenter
Andrea Porelli
Author and Co-Author
Andrea Porelli | Ralf Wischnewski | For the TAIGA Collaboration

Abstract
'TAIGA-HiSCORE is a wide-aperture Air-Cherenkov array, and is a major component of the TAIGA-Observatory (Tunka Instrument for high-energy gamma-ray astronomy and cosmic ray physics), located in the Tunka valley, 50km from Lake Baikal, Russia. A main science target of TAIGA is gamma ray astronomy above ten's of TeV, in particular the search for sources of few 100 TeV gamma rays (candidate "PeVatrons"), the possible sites of Galactic cosmic ray acceleration. The HiSCORE array will consist of 120 optical Cerenkov stations, deployed on an area of 1km2. Its construction will be finished in 2021.\r\n\r\nThis report presents the performance of HiSCORE during the\xa0 first 5 years of operation, in\xa0 various configurations, from 28 to 88 stations. A key for high sensitivity to gamma point sources is precision timing of the whole array down to sub-nsec level, required to be stable for the observation period. We apply different methods to reach this goal. The pointing resolution of the array for extended air-showers is obtained as 0.1° for highest energies, and is experimentally verified, based on independent approaches. We present results of a 5-year-search for gamma-like point sources with HiSCORE, and compare to MC-predictions.'

Collaborations
TAIGA,

Keywords and Comments
EAS, gamma astronomy, cosmic rays, timing array, angular resolution, time calibration, ground Cherenkov detection, Andrea Porelli''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
News from the African Gamma-ray sky: Highlights from the H.E.S.S. experiment

Presenter
Stefan Wagner
Author and Co-Author
Stefan Wagner for the H.E.S.S. collaboration

Abstract
'The H.E.S.S. experiment has entered a new phase with an advanced camera, improved hardware, optimized operational procedures and enhanced open source analysis tools. This results in a significant gain in performance, observing time and sensitivity with corresponding benefits for quantity and quality of observational results in time-domain and time-integrated studies.\r\n\r\nBeyond individual results, recent studies provide major steps towards population studies, scan multidimensional parameter spaces for different types of objects and extend the base for the science program of more sensitive, future facilities. \r\n\r\nThe combination of improved angular resolution and extended spectral coverage sharpens conclusions on prototypical sources and focuses goals in formulating the next scientific questions.\r\n\r\nMoreover, an extended time-domain program is combined with a thorough multi-frequency program to relate temporal variability throughout the electromagnetic spectrum and explore relations to other messengers.\r\n\r\nIn this presentation we will describe the highlights of the recent observations and the advancements of the H.E.S.S. experiment that enable these results. The implications for specific physical interpretation will be discussed in the broader context of different source classes.'

Collaborations
H.E.S.S.,
Keywords and Comments
, Stefan Wagner"

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Subcategory Experimental Results

Titel
Periodicity Analysis of Mrk 501 and Mrk 421 in Gamma Rays

Presenter
Roman Iotov
Author and Co-Author
Roman Iotov | Thomas Bretz | Thompson Dave | Daniela Dorner | Vincent Eberle | Torsten Ensslin | P. Frank | A. Kostic | Michael Kreter | Boettcher Manuel | Volodymyr Marchenko | Arras Phillip | Bernd Schleicher | Mariusz Tarnopolski | Fabian Theissen |

Abstract
'Results from different methods searching for Quasi periodic oscillations\r\n(QPOs) in blazars will be shown, indicating no significant evidence for periodic signals beyond the noise level. Blazars are a subclass of active galactic nuclei (AGN), and are highly variable objects. QPOs, which might originate from a binary black hole located at the AGN core, have been found in some blazar light curves. For the blazars Mrk 421 and Mrk 501, we test the possible QPO behaviour using a variety of methods (generalized Lomb-Scargle Periodogram, CARMA, Wavepal and A-T plane), studying in detail systematic effects. We use gamma-ray light curves from FACT, a ground-based imaging air Cherenkov telescope and Fermi-LAT, a gamma-ray satellite. Furthermore, we explore the possibility to search for periodicities with the information field theory.'

Collaborations
other (fill field below), FACT

Keywords and Comments
periodicity, gamma-rays, blazars, Roman Iotov''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
A northern sky survey for ultra-high-energy gamma-ray source using the Tibet air-shower array and muon-detector array.

Presenter
Xu Chen
Author and Co-Author
Xu Chen The Tibet ASγ Collaboration

Abstract
'The Tibet ASγ experiment located at 4300 m above sea level, Tibet, China, has a wide field of view and large effective area. It consists of the Tibet air-shower array (Tibet-AS), the air-shower core-detector array (YAC) and the underground water-Cherenkov muon-detector array (Tibet-MD). The Tibet-MD array significantly improves gamma-ray sensitivity in the 10-1000 TeV energy region by an order of magnitude better than any other previously existing experiments in the world. In this talk we will present the catalog of TeV gamma-ray sources using 720 days of data from the Tibet ASγ experiment. The catalog represents the most sensitive survey of the northern gamma-ray sky at energies above several tens of TeV. These ultra-high-energy gamma-ray sources are believed to be related to pulsars and supernova remnants.'

Collaborations
other (fill field below), The Tibet ASγ Collaboration
Keywords and Comments
northern sky survey,, Xu Chen''

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
Southern African Large Telescope Spectroscopy of BL Lacs for the CTA project

Presenter
Eli Kasai
Author and Co-Author
Eli Kasai | For the CTA Collaboration

Abstract
'In the last decade, very-high-energy gamma-ray astronomy has reached maturity: over 200 sources have been detected, both Galactic and extragalactic by ground-based experiments. At present, Active Galactic Nuclei (AGN) make up about 40% of the 200+ sources detected at very high energies with ground-based telescopes, the majority of which are blazars, i.e. their jets are closely aligned with the line of sight to Earth and three quarters of which are classified as high-frequency peaked BL Lac objects. One challenge to studies of the cosmological evolution of BL Lacs is the difficulty of obtaining redshifts from their nearly featureless, continuum-dominated spectra. It is expected that a significant fraction of the AGN to be detected with the future world-wide Cherenkov Telescope Array (CTA) observatory will have no spectroscopic redshifts, compromising the reliability of BL Lac population studies, particularly of their cosmic evolution. We started an effort in 2019 to measure the redshifts of a large fraction of the AGN that are likely to be detected with CTA, using the Southern African Large Telescope. In this talk, we present some preliminary results of this on-going collaborative multi-facility effort among African, European, North and South American institutions.'

Collaborations
CTA, None

Keywords and Comments
AGN, BL Lacs, Redshifts, Spectroscopy, Eli Kasai'This will be a talk on redshift measurements of BL Lacs with the Southern African Large Telescope for the future CTA project.'

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Branch GAI | Gamma Ray Indirect

Subcategory Experimental Results

Titel
P1 and P2 Emission of the Crab Pulsar for Medium to Large-Size IACT Calibration

Presenter
Razmik Mirzoyan
Author and Co-Author
Razmik Mirzoyan Giovanni Ceribella | Yuki Iwamura | Takayuki Saito | Masahiro Teshima | Giacomo D'Amico

Abstract
'Mid to large size imaging atmospheric Cherenkov telescopes for gamma-ray astrophysics in the very high energy domain have a typical threshold of (20 – 200) GeV. In this energy range sensitive observations of the Crab Nebula reveal the emission from the Crab pulsar at phases P1 and P2. Observations of MAGIC show that the P2/P1 is monotonically increasing function of energy. In tens of GeV energy range sensitivity of MAGIC overlaps with that of the Fermi-LAT mission. Comparison of the P2/P1 ratio from the MAGIC and Fermi-LAT Crab pulsar data provides an alternative method to cross-calibrate the two instruments and minimize the impact of Monte Carlo simulations. Here we explore this possibility for absolute calibration of the operational energy range of IACTs.'

Collaborations

Keywords and Comments
IACT, calibration, Crab pulsar, pulsar emission phase, IACT-Fermi intercalibration, P1 and P2, Razmik Mirzoyan''

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
Performance of the ASTRI Mini-Array at the Observatorio del Teide

Presenter
Saverio Lombardi
Author and Co-Author
Saverio Lombardi Lucio Angelo Antonelli | Ciro Bigongiari | Cardillo Martina | Stefano Gallozzi | Jarred Green | Fabrizio Lucarelli | Francesco Gabriele Saturni | for the ASTRI Project

Abstract
'The ASTRI Mini-Array is a project led by INAF to build and operate an observatory of next-generation Imaging Atmospheric Cherenkov Telescopes for ground-based gamma-ray astronomy in the energy range between 1 TeV and 200 TeV and beyond. It will be composed by 9 small-sized (4 meter in diameter) and large field-of-view (~10 degrees) double-mirror telescopes equipped with silicon photomultiplier cameras. The ASTRI Mini-Array will be deployed within the next few years at the Observatorio del Teide (Tenerife, Spain) and will perform deep observations of the galactic and extragalactic sky with a significantly improved performance at multi-TeV energies with respect to current arrays of Cherenkov telescopes. In order to assess the performance of the system at the Teide site and to generate suitable Instrument Response Functions for high-level scientific studies, dedicated Monte Carlo simulations have been generated and subsequently reduced with A-SciSoft (ASTRI Scientific Software), the official scientific software package of the ASTRI Project. In this contribution, we present the performance of the ASTRI Mini-Array achieved with the aforementioned Monte Carlo simulations and describe the main features of both the simulation and data processing chains.'

Collaborations
, ASTRI

Keywords and Comments
gamma rays, cosmic rays, Cherenkov telescopes, IACT technique, Monte Carlo simulations, data analysis, Saverio Lombardi''

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
The Cherenkov Telescope Array: layout, design and performance

Presenter
Orel Gueta
Author and Co-Author
Orel Gueta

Abstract
'The Cherenkov Telescope Array (CTA) will be the next generation very-high-energy gamma-ray observatory. CTA is expected to provide substantial improvement in accuracy and sensitivity with respect to existing instruments thanks to a tenfold increase in the number of telescopes and their state-of-the-art design. Detailed Monte Carlo simulations are used to further optimise the number of telescopes and the array layout, and to estimate the observatory performance using updated models of the selected telescope designs. These studies are presented in this contribution for the two CTA sites located on the island of La Palma (Spain) and near Paranal (Chile) and for different operation and observation conditions.'

Collaborations
CTA, CTA Observatory
Keywords and Comments
, Orel Gueta'for the CTA Consortium and the CTA Observatory'

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Subcategory Future projects

Titel
Active Galactic Nuclei population studies with the Cherenkov Telescope Array

Presenter
Anthony Brown
Author and Co-Author
Anthony Brown Atreya Acharyya | Alberto Dominguez | Tarek Hassan | Jean-Philippe Lenain | Santiago Pita

Abstract
'The Cherenkov Telescope Array (CTA) is the next generation ground-based imaging atmospheric Cherenkov telescope (IACT) observatory. Building on the strengths of current IACTs, CTA is designed to achieve an order of magnitude increase in sensitivity, with unprecedented angular and energy resolution. CTA will also increase the energy reach of ground-based gamma-ray astronomy, observing photons in the energy range of 20 GeV to beyond 100 TeV. These improvements in telescope performance will see CTA heralding in a new era for ground-based gamma-ray astronomy, with the emphasis shifting from source discovery to population studies and precision measurements. In this talk we discuss CTA's ability to conduct population studies of gamma-ray bright Active Galactic Nuclei, and how this ability will enhance our understanding of the redshift evolution of this important gamma-ray source type.'

Collaborations
CTA,

Keywords and Comments
CTA, AGN, population studies, Anthony Brown'for the CTA Consortium.'

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Subcategory Future projects

Titel
Extragalactic Observatory Science with the ASTRI Mini-Array at the Observatorio del Teide

Presenter
Francesco Gabriele Saturni
Author and Co-Author
Francesco Gabriele Saturni Lucio Angelo Antonelli | Cornelia Arcaro | Barbara Balmaverde | Josefa Becerra González | Alessandro Caccianiga | Milvia Capalbi | Elisabete Elisabete M. de Gouveia Dal Pino | Roberto Della Ceca | Jarred Green | Alessandra Lamastra | Saverio Lombardi | F

Abstract
'The ASTRI Mini-Array is a system of nine imaging atmospheric Cherenkov telescopes to be deployed at the Observatorio del Teide (Tenerife, Spain). In a first phase, the instrument will be operated as an experiment, with an observation schedule focused on primary science cases at multi-TeV energies (origin of cosmic rays, cosmology and fundamental physics, GRBs and multi-messenger astrophysics). Afterwards, a guest-observer observatory phase will follow, in which other significant targets will be pointed at. In this contribution, we focus on this second phase, presenting the observational feasibility of the most relevant extragalactic gamma-ray emitters (high-synchrotron peaked blazars, Seyfert 2 galaxies, self-interacting dark matter dominated dwarf spheroidal galaxies) and astrophysical processes detectable over long-term time scales that best complement and expand the ASTRI Mini-Array core science. In order to derive our results, detailed simulations have been performed by means of the most up-to-date ASTRI Mini-Array instrument response functions. The prospects of observing extragalactic targets with the ASTRI Mini-Array include the characterization of spectral shape and features of the multi-TeV emission from the analyzed classes of AGN with mid-to-long duration (5 to 500 h) observations, the improvement of the constraints on cross section and lifetime of dark matter particles with 100-h observations of optimal dwarf galaxies, and the possibility to serendipitously detect ancillary sources falling in the same field of view (a few degrees) of the ASTRI Mini-Array main pointings.'

Collaborations
other (fill field below), ASTRI Project

Keywords and Comments
Telescopes, Gamma Rays, Galaxies, Blazars, Dark Matter, Francesco Gabriele Saturni''

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
The Southern Wide-field Gamma-ray Observatory reach for Primordial Black Hole evaporation

Presenter
Ruben Lopez-Coto
Author and Co-Author
Ruben Lopez-Coto Michele Doro | Alessandro De Angelis | Mose Mariotti | Pat Harding | for the SWGO Collaboration

Abstract
'The search for Primordial Black Hole (PBH) signatures is very broad in techniques and the origin of these signatures. Searches for imprints of evaporation involve several observables such as the Extragalactic Gamma-Ray background or direct measurement of different species of cosmic rays. Using these observables, one can put very tight constraints on the PBH number density in a mass range ~10^14 g. To perform direct observations of the evaporation of these PBHs, one needs to perform observations in the Very High Energy gamma-ray range, either using Imaging Atmospheric Cherenkov telescopes or wide field of view gamma-ray arrays. The Southern Wide-field Gamma-ray Observatory is a projected ground-based gamma-ray detector that will be located in the Southern Hemisphere and it is now in its design phase. In this contribution, we will show the anticipated sensitivity for PBH evaporation achievable by SWGO.'

Collaborations
SWGO,

Keywords and Comments
, Ruben Lopez-Coto''

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Presenter Forum

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
Benchmarking the Science for the Southern Wide-Field Gamma-ray Observatory (SWGO)

Presenter
Ulisses Barres de Almeida
Author and Co-Author
Ulisses Barres de Almeida | Gwenael Giacinti | for the SWGO Collaboration

Abstract
"The Southern Wide-field Gamma-ray Observatory (SWGO) is the project to build a new extensive air shower particle detector for the observation of very-high-energy gamma-rays in South America. SWGO is currently planned for installation in the Southern Hemisphere, which grants it a unique science potential among ground-based gamma-ray detectors. It will complement the capabilities of CTA, working as a wide-field instrument for the monitoring of transient and variable phenomena, and expand the sky coverage of Northern Hemisphere facilities like HAWC and LHAASO, thus granting access to the entire Galactic Plane and the Galactic Center. SWGO aims to achieve excellent sensitivity over a very large target energy range from ~100 GeV to beyond a PeV, and improve on the performance of current sampling array instruments in all observational parameters, including energy and angular resolution, background rejection, and single-muon detection capabilities. The directives for the final observatory design will be given by a number of key science goals which are being defined over the course of the Project's R&D phase. In this contribution we will present the selected core science topics and target performance goals that serve as benchmarks for SWGO's design configuration."

Collaborations
SWGO,

Keywords and Comments
Gamma-ray Astronomy, EAS detector, SWGO, Ulisses Barres de Almeida"

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
CTA prospects for probing cosmology and fundamental physics with gamma rays

Presenter
Ievgen Vovk
Author and Co-Author
Ievgen Vovk | Jonathan Biteau | Manuel Meyer | Humberto Martínez-Huerta | Santiago Pita | For the CTA Consortium

Abstract
'The Cherenkov Telescopic Array (CTA), the next-generation ground-based gamma-ray observatory, will have unprecedented sensitivity in the very-high-energy gamma-ray regime, elucidating open questions in gamma-ray cosmology and fundamental physics. Using simulations of active galactic nuclei observations foreseen in the CTA Key Science Program, we find that CTA will measure gamma-ray absorption by the extragalactic background light with a statistical error below 15% up to the redshift of 2 and detect or establish limits on gamma halos induced by an intergalactic magnetic field of at least 0.3 pG. Extragalactic observations using CTA also demonstrate the potential for testing physics beyond the Standard Model. The best state-of-the-art constraints on the Lorentz invariance violation from astronomical gamma-ray observations will be improved at least two- to threefold. CTA will also probe the parameter space where axion-like particles can represent a significant proportion - if not all - of dark matter. Joint multiwavelength and multimessenger observations, carried out together with other future observatories, will further foster the growth of gamma-ray cosmology.'

Collaborations
CTA,

Keywords and Comments
CTA, extragalactic background light, Lorentz invariance violation, intergalactic magnetic field, dark matter, Ievgen Vovk"

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
Study of the water Cherenkov detector design for the SWGO experiment

Presenter
Francesca Bisconti
Author and Co-Author
Francesca Bisconti Andrea Chiavassa | for the SWGO Collaboration

Abstract
'The Southern Wide-field Gamma-ray Observatory (SWGO) is a next-generation ground-based gamma-ray detector under development to reach a full sky coverage together with the current HAWC and LHAASO experiments in the northern hemisphere. It will complement the observation of transient and variable multi-wavelength and multi-messenger phenomena, offering moreover the possibility to access the Galactic Centre. SWGO will consist of an array of water Cherenkov tanks, with a high fill-factor inner array and a low-density outer array, covering an overall area of one order of magnitude larger than HAWC. To reach a high detection efficiency and discrimination capability between gamma-ray and hadronic air showers, various tank designs were studied. Double-layer tanks with several sizes, shapes and number of photomultiplier tubes have been considered. Single-particle simulations have been performed to study the tank response, using muons, electrons, and gamma-rays with energies typical of extensive air showers particles, entering the tanks with zenith angles from 0 to 60 degrees. The tank response was evaluated considering the particle detection efficiency, the number of photoelectrons detected by the photomultiplier tubes, and the time resolution of the first photoelectron. The study allowed to compare the performance of tanks with circular, square and hexagonal base, to understand which design optimizes the performance of the array. The method used in the study and the results will be discussed in this paper.'

Collaborations
SWGO,

Keywords and Comments
Gamma-rays, water Cherenkov detector, simulations, Francesca Bisconti''

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
The ASTRI Mini-Array Core Science Program

Presenter
Stefano Vercellone
Author and Co-Author
Stefano Vercellone for the ASTRI Project

Abstract
'The portion of the electromagnetic spectrum above a few Teraelectronvolt (TeV) is currently being investigated by means of both ground-based imaging atmospheric Cherenkov telescopes and water Cherenkov detector arrays. In a few years, an array composed of at least nine ASTRI dual-mirror, Schwarzschild-Couder telescopes will be deployed and start scientific observations at the Observatorio del Teide (Tenerife, Spain). The ASTRI Mini-Array will devote the first three to four observing years to specific science topics, with the aim of providing robust answers to a few selected open questions in the very high-energy (VHE, E > 0.1 TeV) domain. We identified the following Core Science topics, a.k.a. the "Science Pillars", to be investigated: the origin of cosmic rays, the extra-galactic background light and the study of fundamental physics, the novel field in the VHE domain of gamma-ray bursts and other multi-messenger transients, and finally the usage of the ASTRI Mini-Array to investigate ultra high-energy cosmic rays and to address stellar intensity interferometry studies. We review the results obtained by means of dedicated scientific simulations, proving the potential of the ASTRI Mini-Array in pursuing breakthrough discoveries and discuss the synergies with current and future VHE facilities.'

Collaborations
other (fill field below), ASTRI
Keywords and Comments
IACTs, Cosmic ray acceleration, Blazars, PWN, SNR,, GRBs, Stefano Vercellone''

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
Half ALPACA and its sensitivity to sub-PeV gamma rays from the Galactic Center

Presenter
Yoshichika Yokoe
Author and Co-Author
Yoshichika Yokoe

Abstract
'ALPACA is a project aimed at the wide field-of-view observation of cosmic rays and gamma rays with an 83,000 m^2 air shower array composed of approximately 400 surface scintillation counters and a large underground muon detector array, at an altitude of 4,740m near the Chacaltaya mountain in Bolivia. After a prototype air-shower array currently under construction, we plan to expand the array to ‘half\r\nALPACA’, which covers an area of 83,000 m^2 with roughly 200 surface scintillation counters. Also, we will\u3000construct an underground muon detector array with an area of 4,000 m^2 that allows us to dramatically improve the sensitivity to gamma rays by discriminating gamma rays from cosmic rays based on the number of muons\u3000in air showers.\r\n One of our main interests is the detection of gamma rays beyond 100 TeV from\u3000the Galactic center.\u3000In 2016, H.E.S.S observed the diffuse gamma-rays around the Galactic\u3000center. This data suggests that a cosmic-ray accelerator exists around it.\r\n   In this presentation, we report on the performance of half ALPACA, especially its sensitivity to sub-PeV gamma rays from the Galactic center, based on our detailed MC simulations.'

Collaborations
Keywords and Comments
, Yoshichika Yokoe''

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
Galactic Science with the ASTRI-Mini Array during the Observatory phase of the project

Presenter
Antonino DAi
Author and Co-Author
Antonino DAi

Abstract
'The ASTRI-Mini Array will be composed of nine imaging atmospheric Cherenkov telescopes\r\nat the Teide Observatory site. The array will observe in the 1-200 TeV range with an\r\nangular resolution of few arc-minutes and an energy resolution of about 10%.\r\nA core-science programme will be devoted in the first three years to\r\na limited number of key science targets. Additionally, thanks to a field-of-view\r\nof about 6 degree radius, ASTRI-MA will collect data from many other field sources\r\nthat will constitute the base of a long-term Galactic observatory programme.\r\nIn this contribution, I will overview the main themes for this extended observatory science programme for the different astrophysical Galactic environments, e.g. pulsar wind nebulae, supernova remnants, gamma-ray binaries, globular clusters, and dark matter search.'

Collaborations
other (fill field below), ASTRI

Keywords and Comments
ASTRI-Mini Array, IACT, Galactic VHE sources,, Antonino DAi''

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
Untangling the Complexity in the Galactic Centre: a way to understand the origin of the gamma-ray emission from the inner Galaxy

Presenter
Sofia Ventura
Author and Co-Author
Sofia Ventura

Abstract
'The origin of the high-energy gamma-ray emission from the Milky Way centre is still unclear and debated because of the impact of systematics afflicting the measurements from current experiments. Several theories and phenomenological models attempt to explain the intricate panorama. The presence of a *PeVatron* in the Central Molecular Zone or in its vicinity, the contribution of the hard component of the diffuse gamma-ray emission, and dark matter annihilation scenario are among the most promising mechanisms to describe the observed excess. The development of increasingly precise models able to reproduce the measured gamma-ray emission is the challenge for the scientific community in view of the next generation telescopes.\r\nA detailed treatment of phenomenological models for the dubbed *Cosmic Rays Sea* (CR-*sea*) characterised by different configurations is scrutinised in comparison with the observed spectra in several regions of the inner Galaxy using recently distributed DRAGON2 and HERMES codes. Updated maps of atomic and molecular components of the gas distribution in Our Own Galaxy are considered, as well as the systematics arising from the analysis of *Fermi*-LAT data performed with different approaches.'

Collaborations
Keywords and Comments
, Sofia Ventura"

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
Double-layered Water Cherenkov Detector for SWGO

Presenter
Samridha Kunwar
Author and Co-Author
Samridha Kunwar | for the SWGO Collaboration

Abstract
'The Southern Wide-field-of-view Gamma-ray Observatory (SWGO) will use the well-established and cost-effective technique of detecting Cherenkov light produced in water-filled detection units for TeV gamma-ray astronomy. Leveraging detector material reflectivity together with optimised aspect-ratio is an option to improve the performance of an array of such detector units. The double-layered Water Cherenkov Detector units comprise chambers with single photosensors in each. A reflective upper compartment enhances sensitivity to impinging secondary particles. A shallow lower compartment enables muon tagging and consequently improves the gamma hadron separation power of the observatory. Here we present detailed studies on the double-layered unit design.'

Collaborations
SWGO,
Keywords and Comments
Gamma-ray, SWGO, Water Cherenkov Detector, Double-layered WCD, samridha kunwar''

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
Simulating the performance of the Southern Wide-view Gamma-ray Observatory

Presenter
Harm Schoorlemmer
Author and Co-Author
Harm Schoorlemmer | Ruben Conceição | Andrew James Smith | for the SWGO Collaboration

Abstract
'Abstract: The Southern Wide-view Gamma-ray Observatory (SWGO) will be a next-generation gamma-ray observatory using a large array of particle detectors at a high elevation site in South America. This project is currently in a three years R&D phase in which the design will be optimised for cost and performance. Therefore it is crucial to efficiently evaluate the impact of different design options on the scientific objectives of the observatory. In this contribution, we will introduce the strategy and the simulation framework in which this evaluation takes place. This development builds upon the established simulation framework by the HAWC collaboration and simultaneously adapts to ideas and concepts of the broader gamma-ray and astroparticle communities.'

Collaborations
SWGO,
Keywords and Comments
water-Cherenkov detector, Wide-field of view, gamma-ray instrumentation., Harm Schoorlemmer''

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Branch GAI | Gamma Ray Indirect

Subcategory Future projects

Titel
The COMET multiperspective event tracker for wide field-of-view gamma-ray astronomy

Presenter
Gašper Kukec Mezek
Author and Co-Author
Gašper Kukec Mezek | for the ALTO/COMET Collaboration Yvonne Becherini | Martin Tluczykont | Patrizia Romano | Ahmed Saleh | Satyendra Thoudam | Stefano Vercellone | Mohanraj Senniappan | Tomas Bylund | Michael Punch | Jean-Pierre Ernenwein

Abstract
'The ALTO/COMET R&D project focuses on the development of a new technique for the observation of very high-energy (VHE) gamma-rays from the ground at energies above ~200 GeV, thus covering emission from soft-spectrum sources. The ALTO/COMET proposed array under study combines 1241 particle detector units, distributed over a circular area of ~160 m in diameter and placed at a very high altitude (5.1 km), with atmospheric Cherenkov light detectors.\r\n\r\nThe atmospheric Cherenkov light detectors, inspired by the "HiSCORE" design and improved for the energy range of interest, can be operated together with the particle detectors during clear nights. As such, the instrument becomes a Cosmic Multiperspective Event Tracker (COMET). ALTO/COMET is expected to improve the reconstruction of arrival direction, energy and shower maximum determination for gamma-ray-induced showers during darkness, which is crucial for the reduction of background contamination from cosmic rays. Prototypes of both particle and atmospheric Cherenkov light detectors are already installed at the Linnaeus University in Sweden, while we simulate the detector response and estimate the reconstruction improvement for gamma-ray events.\r\n\r\nIn this contribution, we present Monte-Carlo simulations of the detector array, consisting of CORSIKA shower simulations and custom detector response simulations, together with the coupling of particle and atmospheric Cherenkov light information, the reconstruction strategy of the complete array and the detection performance on point-like VHE gamma-ray sources. In addition, we briefly present the prototype experience.'

Collaborations
other (fill field below), ALTO/COMET
Keywords and Comments
gamma-rays, wide field-of-view, Cherenkov radiation, very high-energies, atmospheric showers, Gašper Kukec Mezek"

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Branch GAI | Gamma Ray Indirect

Subcategory Theoretical Methods

Titel
On the Use of Convolutional Neural Networks for Turbulent Magnetic Field Helicity Classification

Presenter
Nicolò Oreste Pinciroli Vago
Author and Co-Author
Nicolò Oreste Pinciroli Vago | Ibrahim A. Hameed | Michael Kachelriess

Abstract
'The presence of non-zero helicity in intergalactic magnetic fields (IGMF) is a smoking gun for their primordial origin. Helical magnetic fields break CP invariance, what can be sued as an experimental signature. An estimator Q based on the triple scalar product of the wave vectors of photons generated in electromagnetic cascade from, e.g., TeV blazars has been suggested previously. Here, we propose the application of deep learning to helicity classification, by means of a Convolutional Neural Network (CNN), and show that this method outperforms the Q estimator.'

Collaborations

Keywords and Comments
intergalactic magnetic fields, helical magnetic fields, TeV photons, electromagnetic cascades, machine learning, Nicolò Oreste Pinciroli Vago"

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Branch GAI | Gamma Ray Indirect

Subcategory Theoretical Results

Titel
Modification of the gamma-ray spectra from active galaxies by soft radiation of transiting luminous stars

Presenter
Wlodek Bednarek
Author and Co-Author
Wlodek Bednarek | Julian Sitarek

Abstract
"Gamma-ray emission in active galaxies is expected to originate in a close priximity of the supermassive black hole surrounded by a reach cluster of luminous stars. We consider the effects of luminous stars (early type of red supergiant, separate or in binary systems) crossing accidentally the gamma-ray beam close to the observer's line of sight. We show that soft radiation of massive stars can create enough target for transient absorption of the gamma rays in multi-GeV to TeV energy range. We predict characteristic, time-dependent effects on the gamma-ray spectra due to the encounter with stars. As an example, we consider such effects on the spectra observed from a typical blazar, 1ES 1959+650 (in an active state) and also in the case of a radio galaxy M87 (in a low state). Observation of such transient characteristic features in the gamma-ray spectra of blazars and radio galaxies lays within the sensitivity of the future Cherenkov Telescope Array."

Collaborations
Keywords and Comments
AGN,, Wlodek Bednarek"

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Branch GAI | Gamma Ray Indirect

Subcategory Theoretical Results

Titel
Magnetic field amplification by turbulent dynamo in relativistic collisionless shocks

Presenter
Sara Tomita
Author and Co-Author
Sara Tomita | Yutaka Ohira

Abstract
'Cosmic rays are thought to be efficiently produced in collisionless shocks in high-energy astrophysical sources, where cosmic rays are diffusively scattered by magnetic fluctuations. The magnetic field near the shock decides the maximum energy of cosmic rays\u3000accelerated in the shock and the emission by the accelerated particles. However, the magnetic field strength and structure around the shock are not understood yet. Recent magnetohydrodynamics (MHD) simulations of shocks propagating into inhomogeneous media show that the ambient magnetic field is amplified by turbulent dynamo in the downstream region. According to these simulations, the turbulent dynamo always works as long as the magnetic energy is smaller than the kinetic energy of the downstream turbulence. However, the shocks formed in astrophysical phenomena are often driven by collisionless plasma, where non-thermal particles are generated, so that it is unknown whether or not the MHD approximation is applied to the downstream flow. In particular, for shocks in gamma-ray bursts, the size of density fluctuations has to be about ten times the gyroradius of the thermal protons to amplify the magnetic field by the downstream turbulence. We perform particle-in-cell simulations of relativistic collisionless shocks propagating into a pair plasma with a density clump whose size is ten times the gyroradius of downstream thermal plasmas. We found that the magnetic field amplification does not work if the amplitude of the upstream density fluctuation is below a critical value.'

Collaborations
Keywords and Comments
Magnetic field amplification, Collisionless shock, Particle acceleration, Gamma-ray burst,, SARA TOMITA"

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Branch GAI | Gamma Ray Indirect

Subcategory Theoretical Results

Titel
Analytical Model of Magnetically Dominated Jets: Jet Launching, Acceleration, and Collimation

Presenter
Liang Chen
Author and Co-Author
Liang Chen | Bing Zhang

Abstract
'Jets are ubiquitously in association with different celestial objects. However, most of previous theoretical studies of them rely on numerical calculations, not being able to provide a more convenient way for understanding rather abundant observational results. Now we have obtained a general analytical solution for describing a magnetically dominated jet, through separating the jet “core equation” (which maintains the radial dynamic equilibrium) into rotating and non-rotating terms, finding that each of the two-term equations can be solved analytically, and the two solutions match each other very well. The analytical model based on this solution can explain the main results of jet observations and numerical simulations, such as jet shape configuration, acceleration profile (from non-relativistic to relativistic), and polarization pattern etc. Furthermore, the solution is applicable to, e.g., limb-brightening (a hollow jet), periodical variability (a helical jet), and "complex" proper motion pattern (a stratified jet) etc. I this talk, I will present the details of the theory, examples of comparing with observations, and a variety of predictions (Ref. Chen & Zhang, 2021, ApJ, 906, 105).'

Collaborations

Keywords and Comments
Relativistic jets, Magnetic fields, Gamma-ray bursts, Active galactic nuclei, Charged black holes, Gamma-rays, Cosmic rays, Pulsars, Neutron stars, Liang Chen''

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Branch GAI | Gamma Ray Indirect

Subcategory Theoretical Results

Titel
Modeling non-thermal emission from SN 1987A

Presenter
Robert Brose
Author and Co-Author
Robert Brose | Jonathan Mackey

Abstract
"The remnant of SN 1987A is the best-studied object of its kind. The rich data-set of its thermal and non-thermal emission across the electromagnetic spectrum poses a unique testbed for the elaboration of particle-acceleration theory.\r\n\r\nWe use 2D simulations of the progenitor's wind to obtain hydro-profiles for the medium around the supernova explosion. Various cones along prominent features of the ambient medium are then used in our time-dependent acceleration code RATPaC to model the evolution of the emission of SN 1987A and compare it to observational data.\r\n\r\nWe solve for the transport of cosmic rays, magnetic turbulence, and the hydrodynamical flow, in the test-particle limit. The simulation code relies on 1D profiles but the large expansion speed of the young remnant renders lateral transport unimportant.\r\n\r\nWe find that the increase in thermal X-ray emission predates the increase in the low-energy gamma-ray brightness by several years. The increase of the gamma-ray brightness at lower energies is followed by a smooth increase at the highest energies. The gamma-ray spectrum at the highest energies appears soft during the brightening but hardens as more material in the equatorial ring gets shocked. The X-ray and gamma-ray brightness remain almost constant once the SNR blast-wave passed the region of peak-density in the equatorial plane."

Collaborations

Keywords and Comments
SNR, SN 1987A, modeling, X-ray, gamma-ray, CSM, Robert Brose"

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Branch GAI | Gamma Ray Indirect

Subcategory Theoretical Results

Titel
Sensitivity reach of gamma-ray measurements for cosmological magnetic fields

Presenter
Alexander Korochkin
Author and Co-Author
Alexander Korochkin | Oleg Kalashev | Andrii Neronov | Dmitri Semikoz

Abstract
'A primordial magnetic field with the strength in the 1-10 pG range can resolve the tension between different measurements of the Hubble constant and provide an explanation for the excess opacity in the 21 cm line at redshift $15<z<20$, if it is present during the recombination and reionization epochs. This field can also survive in the voids of the large-scale Structure in the present day universe. We study the sensitivity reach of the gamma-ray technique for measurement of cosmological magnetic field using deep exposure(s) of the nearest hard spectrum blazar(s) with CTA telescopes. We show that the gamma-ray measurement method can sense the primordial magnetic field with a strength of up to 10−11~G. Combination of the cosmic microwave background and gamma-ray constraints can thus sense the full range of possible cosmological magnetic fields to confirm or rule out their relevance to the problem of the origin of cosmic magnetic fields, as well as their influence on recombination and reionization epochs.'

Collaborations

Keywords and Comments
Intergalactic Magnetic Field, AGN, Gamma-ray astronomy, Alexandr Korochkin"

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Branch GAI | Gamma Ray Indirect

Subcategory Theoretical Results

Titel
The gamma—ray signal from core—collapse supernovae.

Presenter
Pierre Cristofari
Author and Co-Author
Pierre Cristofari | Matthieu Renaud | Alexandre Marcowith | Vincent Tatischeff | Vikram Dwarkadas

Abstract
'The shock wave resulting from the core-collapse of a massive star can accelerate particles up to PeV energies in the first few days to weeks after explosion. This can lead to the production of a potentially detectable gamma—ray signal. The gamma-ray flux however is strongly affected by the two photon—annihilation process, where gamma—ray photons interact with photons from the SN photosphere. It is therefore not surprising that there has been no confirmed detection of gamma-rays from core-collapse supernovae at very high energies.\r\n\r\nIn order to probe the detectability of the gamma-rays with current and upcoming gamma-ray observatories, we estimate the gamma—ray flux from typical type IIp core collapse supernovae (CCSNe). These are the most common type of supernovae, and are presumed to arise from red supergiant progenitors. We include a detailed time-dependent calculation of two—photon absorption. Our results will be very useful in creating a strategic observing program to detect CCSNe with the next generation gamma—ray observatory, such as the Cherenkov Telescope Array (CTA).'

Collaborations

Keywords and Comments
supernova, cosmic ray, gamma--ray astronomy, gamma rays, particle acceleration, Pierre Cristofari"

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-2
Access Monday Session https://live.remo.co/e/icrc-poster-hall-12-copy

Branch GAI | Gamma Ray Indirect

Subcategory Theoretical Results

Titel
Modelling Spatial and Temporal Emission Properties of the Young Pulsar Wind Nebula Kes 75

Presenter
Christo Venter
Author and Co-Author
Christo Venter Carlo Van Rensburg

Abstract
'The H.E.S.S. Collaboration has firmly detected gamma-ray emission from HESS J1846-029, which is spatially coincident with Kes 75 (G29.7-0.3), one of the youngest composite supernova remnants in the Galaxy. This remnant contains the nebula of PSR J1846-0258, a glitching young pulsar with a particularly high spin-down luminosity that has manifested magnetar-like bursts in 2006. However, H.E.S.S. was not able to distinguish between shell and nebular emission. This source may also plausibly be associated with the HAWC-detected source 2HWC J1844-032. Recent *Chandra* observations revealed a rapid expansion of the embedded pulsar wind nebula over the past two decades and an X-ray flux decrease of 10% in 7 years. We apply a multi-zone spatio-temporal pulsar wind nebula model to the morphological and spectral data over several epochs, and find reasonable fits to the broadband radiation spectrum, X-ray surface brightness profile, expansion rate and photon spectral index in the X-ray energy range. Such spectral and morphological fitting constrains the model parameters, and may aid in clarifying the nature of the gamma-ray emission.'

Collaborations
Keywords and Comments
, Christo Venter''

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Presenter Forum

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-2
Access Monday Session https://live.remo.co/e/icrc-poster-hall-12-copy

Branch GAI | Gamma Ray Indirect

Subcategory Theoretical Results

Titel
Ultra-high Energy Inverse Compton Emission from Galactic Electron Accelerators

Presenter
Mischa Breuhaus
Author and Co-Author
Mischa Breuhaus | Joachim Hahn | Carlo Romoli | Brian Reville | Gwenael Giacinti | Richard Tuffs | Jim Hinton

Abstract
'With the High-Altitude Water Cherenkov Observatory (HAWC), the Large High Altitude Air Shower Observatory (LHAASO), and the future SWGO and CTA observatories, our view of the gamma-ray sky above 100 TeV energies will improve rapidly. It is generally held that emission at such high energies from astrophysical objects unambiguously demonstrates the presence of PeV protons or nuclei, due to the unavoidable Klein–Nishina suppression of inverse Compton (IC) emission from electrons. However, if the spectrum of accelerated electrons is hard enough in the Klein-Nishina regime, significant leptonic IC emission >100 TeV is possible. Such spectra occur as the result of equilibrium between particle injection and energy losses in IC cooling dominated environments. We show that the environmental requirements can naturally be met in spiral arms, and in particular in regions of enhanced star formation activity. These are also the natural locations for the most promising electron accelerators: powerful young pulsars. Regions with magnetic fields less than a few micro Gauss, for example associated to superbubbles, exhibit the required conditions irrespective of infrared or optical radiation fields due to the omnipresence of the cosmic microwave background. Our scenario suggests a population of hard ultra-high energy sources is likely to be revealed in future searches, and may also provide a natural explanation for the 100 TeV sources recently reported by HAWC.'

Collaborations

Keywords and Comments
High energy astrophysics, Gamma-rays, Pulsars, Inverse Compton emission, Radiation dominated cooling, HAWC, Galactic, Mischa Breuhaus''

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Presenter Forum

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-3
Access Monday Session https://live.remo.co/e/icrc-poster-hall-32

Branch GAD | Gamma Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
High Energy Gamma-Ray Emission from the Coma Cluster Region: Deep Morphological and Spectral Studies.

Presenter
Davit Zargaryan
Author and Co-Author
Davit Zargaryan Vardan Baghmanyan | Felix Aharonian | Sabrina Casanova | Jonathan Mackey | Ruizhi Yang

Abstract
"The Coma Cluster of Galaxies (at z=0.023) is one of the largest gravitationally-bound astrophysical structures in the local Universe (linear size of more than 2 Mpc). Considering the proximity of Coma in addition to the relatively large intracluster density and the high-velocity accretion shocks (estimated speed of 2-3 thousand km/s) that occur within-cluster, it provides a unique environment to search for high energy (HE) gamma-rays. Using 12.3 years of Fermi-LAT Pass 8 data, we analyzed the Coma cluster region between 100 MeV and 1 TeV energies. Here we report the detection of HE gamma-ray emission from the direction of the Coma cluster with significance ~5.6 sigma, which confirms the first detection of gamma-ray emission toward the Coma cluster region (Xi et al. (2018)). The resulting energy flux is $(1.43\\pm0.31)\\times10^{−12}$ erg cm^{-2} s^{-1} with $\\Gamma=2.53\\pm0.22$ photon spectral index. To understand the origin of the $\\gamma$-ray excess, detailed morphological and spectral studies of the cluster region have been implemented by applying different spatial models based on the residual structures in the 100 MeV-1 GeV and >1 GeV energy bands. Within the Coma cluster's virial radius, two point-like structures have been investigated, at $\\sim0.34$ Mpc distance from each other. They were successfully modelled with two similar $\\Gamma \\sim2.5$ power-law spectral indexes above 100 MeV with the detection significances of 4.2 $\\sigma$ and 3.3 $\\sigma$, respectively. Finally, we briefly discuss the origin of the detected gamma-ray emission."

Collaborations
Keywords and Comments
Gamma Rays from Cluster of Galaxies, Coma Cluster, etc, Davit Zargaryan"

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-32

Branch GAD | Gamma Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
High-resolution Imaging Calorimeter based on position-sensitive virtual Frisch-grid CdZnTe detectors for gamma-ray space instruments

Presenter
Aleksey Bolotnikov
Author and Co-Author
Aleksey Bolotnikov | On behalf of the GECCO collaboration

Abstract
'We will present a conceptual design for an Imaging Calorimeter for space instruments based on a 3-dimensional position-sensitive virtual Frisch-grid CdZnTe (CZT) detectors. The calorimeter aims to measure photons with energies from 50 keV to 20 MeV with energy resolution of < 1% FWHM at 662 keV, and the photon interaction sites location accuracy of <1 mm in all 3 dimensions. Each detector is a crystal bar with dimensions of 8x8x30 mm3. The bars are arranged in 4x4 modules that can be integrated into a larger array of any shape. The 3D corrections approach solves a long-standing problem of CZT detectors associated with material non-uniformities that hamper their performance and limit their thicknesses. In addition, it allows us to relax the requirements to the quality of the crystals, while maintaining good performance, and reduce the instrument cost. Such imaging calorimeter can be used in space instruments as a standalone Compton telescope, and as focal plane detectors for a Coded Aperture Mask telescope with the superior angular resolution for imaging gamma-ray sources. This calorimeter can provide suitable energy resolution to enable spectroscopic measurements of gamma-ray lines from nuclear decays. We will present the test results for the calorimeter prototype. This imaging calorimeter combined with the Coded Aperture Mask is the heart of the Galactic Explorer with a Coded Aperture Mask Compton Telescope, GECCO, and can also be adopted for All-Sky Medium Energy Gamma-ray Observatory AMEGO.'

Collaborations
, GECCO

Keywords and Comments
CdZnTe, CZT, position sensitive detectors, gamma rays, Compton telescope, virtual Frisch-grid detectors, Aleksey Bolotnikov''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
GECCO, the Facets of its Science related to Active Galaxies

Presenter
Eugenio Bottacini
Author and Co-Author
Eugenio Bottacini | Chris Shrader | Steven Sturner | for the GECCO Collaboration

Abstract
'Technological breakthroughs in telescope development have always driven discoveries in astronomy. Discoveries are yet to be made in the energy band between a few hundreds keV and a few MeV, which is currently very little explored due to the lack of sensitive enough telescopes. The telescope technology is challenged by the changing nature of the photon-matter interaction used to detect the astrophysical radiation. To address this issue, the Galactic Explorer with a Coded Aperture Mask Compton Telescope (GECCO) features a coded-mask telescope and a Compton telescope. The former allows disentangling sources in crowded regions with its high angular resolution of ~1 arcmin, which is complemented by the latter due to its high sensitivity to the diffuse emission. The ability to differentiate the diffuse and point sources allows for exploring the possible past high-energy activity of our Milky Way galaxy. The study of the activity in other galaxies is also possible only due to the superb, for this challenging energy band, angular resolution. This property of GECCO allows also for the serendipitous detection and identification of rare active galaxies including those at high redshift that hold the key for the assembly of supermassive black holes early in the Universe. In this talk we will review the science with GECCO related to active galaxies.'

Collaborations
other (fill field below), GECCO Collaboration
Keywords and Comments
AGN science (blazars, Seyferts), Eugenio Bottacini''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
A modern phoswich instrument for detecting gamma-ray transients on-board a SmallSat

Presenter
Joshua Wood
Author and Co-Author
Joshua Wood | Michelle Hui | Colleen Wilson-Hodge | Michael Briggs

Abstract
'We present an updated phoswich detector design that uses modern digital pulse processing techniques along with a silicon photomultiplier (SiPM) light collection system. The main benefits of this design, which incorporates both a primary detection volume and active shield into a single device, are its compact size and additional background rejection power provided by the active shield. Detectors with these improvements will be especially useful for SmallSats, which have tight mass, volume, and power constraints, but could also be used for gamma-ray burst (GRB) survey detectors in a multi-instrument Explorer supporting multi-wavelength / messenger science. The background reduction provided by these detectors may be critical to maintaining current localization capabilities of gamma-ray transients with SmallSats, for which typically smaller detectors will be required, without relying on detections from multiple spacecraft.'

Collaborations
Keywords and Comments
SmallSat, phoswich, Joshua Wood''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
A monitor of the Cosmic X-ray Background

Presenter
Hancheng Li
Author and Co-Author
Hancheng Li Nicolas Produit | Roland Walter

Abstract
We propose a monitor that attempts to measure the Cosmic X-ray Background (CXB) in the 10-100 keV energy band with unprecedented precision, so as to: 1). help to understand the source population of CXB, most of which are proposed to be Active Galactic Nuclei (AGNs), 2). study the anisotropy of CXB intensity over the sky, which helps to understand the large-scale structure of the Universe. An obstacle of the above studies is the difficulty of measuring the absolute intensity of the CXB. Detectors working at X-ray bands suffer from time-dependent backgrounds which are hard to be subtracted. Our design is similar to the projected MVN (Monitor Vsego Neba) Russian experiment, which mainly consist of four collimated spectrometers with a rotating aperture shutter on top. In this paper, we will show its detailed performance simulations and some preliminary tests of the prototype, we will also discuss some launch opportunities.'

Collaborations

Keywords and Comments
Cosmic X-ray Background (CXB), Active Galactic Nuclei (AGNs), absolute intensity, anisotropy, spectrometer, Hancheng LI"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The Advanced Particle-astrophysics Telescope: Simulation of the Instrument Performance

Presenter
Wenlei Chen
Author and Co-Author
Samer Al Nussirat | Corrado Altomare | Richard Bose | James Buckley | Jeremy Buhler | Eric Burns | Roger Chamberlain | Wenlei Chen | Michael Cherry | Georgia De Nolfo | Leonardo Di Venere | Manel Errando | Stefan Funk | Francesco Giordano | Zachary Hughes

Abstract
'We will present simulations of the instrument performance of the Advanced Particle-astrophysics Telescope (APT), a mission concept of a $\\gamma$-ray and cosmic-ray observatory in a sun-Earth Lagrange orbit. The key concepts of the APT detector include a multiple-layer tracker composed of scintillating fibers and an imaging calorimeter composed of thin layers of CsI:Na scintillators and wavelength-shifting fibers. The design is aimed at maximizing effective area and field of view for $\\gamma$-ray and cosmic-ray measurements and subject to constraints on instrument cost and total payload mass. We simulate a detector design based on $3m$ scintillating fibers and develop reconstruction algorithms for $\\gamma$-rays from a few hundreds of keV up to a few TeV energies. At the photon energy above $30MeV$, a pair-production reconstruction is applied and the result shows that the APT could provide an order of magnitude improvement in effective area and sensitivity for $\\gamma$-ray detections compared with Fermi-LAT. A multiple-Compton-scattering reconstruction at photon energies below $10MeV$ achieves sensitive detections of faint $\\gamma$-ray bursts (GRBs) and other $\\gamma$-ray transients down to $\\sim0.01MeV/cm^2$ with a sub-degree level of localization error. The sensitivity of the polarization measurement in terms of degree of polarization for $\\sim1MeV/cm^2$ GRBs is below 20%. The multiple ionization-energy-loss measurements with the imaging calorimeter of the APT also makes it a capable detector for ultra-heavy cosmic-ray composition measurements. In addition, we will present the simulation of the instrument performance of the Antarctic Demonstrator for APT, a balloon experiment using a small portion $<1\\%$ of the APT detector.'

Collaborations
other (fill field below), APT (the Advanced Particle-astrophysics Telescope)

Keywords and Comments
Gamma-ray detection, Multi-messenger astronomy, Gamma-ray burst, Wenlei Chen'for the APT Collaboration'

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Gamma-ray observations of W44 and its surroundings

Presenter
Giada Peron
Author and Co-Author
Giada Peron Felix Aharonian | Sabrina Casanova | Roberta Zanin | Carlo Romoli

Abstract
'We present the analysis of 9.7 years Fermi-LAT data of the middle-aged supernova remnant (SNR) W44 and the massive molecular gas complex that surrounds it. The derived spectral energy distribution of the SNR, derived over three decades is improved, with respect to previous observations, both at low (< 100 MeV) and at higher energies (> 100 GeV) allowing us to strongly constrain the hadronic origin of the emission. We also unveil the presence of two extended $\\gamma$-ray structures located at two opposite edges of the remnant along its major axis. These two sources do not coincide with any peak in the gas distribution, therefore are interpreted as “CR clouds”, namely as regions of enhanced CR density, consisting of particles that escaped collectively from the remnant along the magnetic field.'

Collaborations

Keywords and Comments
Gamma-rays, Cosmic Rays, Supernova Remnants, Particle acceleration, particle escape., Giada Peron''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Low-energy gamma-ray observations above 1 GeV with CALET on the International Space Station

Presenter
Nicholas Cannady
Author and Co-Author
Nicholas Cannady | for the CALET Collaboration

Abstract
'The CALorimetric Electron Telescope (CALET) was launched in August 2015 and installed on the International Space Station (ISS) Japanese Experiment Module Exposed Facility. Alongside the primary science targets of GeV—TeV energy cosmic-ray electrons and cosmic-ray hadrons up to PeV energies, CALET is sensitive to gamma rays from 1 GeV up to 1+ TeV, limited by statistics. Access to energies below 10 GeV is enabled by a dedicated low-energy gamma (LE-γ) trigger which is active only at low geomagnetic latitudes. In this work we review the analysis of gamma-ray events collected with this trigger including the mitigation of a secondary photon background from cosmic-ray interactions with ISS structures in the CALET field-of-view, the observation of persistent galactic and extragalactic sources, and the detection of emission from the quiescent Sun.'

Collaborations
CALET,
Keywords and Comments
, Nicholas Cannady''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Exploring the variability properties of gamma-ray emission from blazars

Presenter
Gopal Bhatta
Author and Co-Author
Gopal Bhatta

Abstract
'I present the results of variability study of a sample of 20 powerful blazars using Fermi/LAT (0.1-300 GeV) observations. We studied decade-long observations applying various analysis tools such as flux distribution, symmetry analysis, and RMS-flux relation. It was found that the γ-ray flux distribution closely resembles a log-normal probability distribution function and can be characterized by linear RMS-flux relation. The power spectral density analysis shows the statistical variability properties of the sources as studied are consistent with flicker noise, an indication of long-memory processes at work. Statistical analysis of the distribution of flux rise and decay rates in the light curves of the sources, aimed at distinguishing between particle acceleration and energy-dissipation timescales, counterintuitively suggests that both kinds of rates follow a similar distribution and the derived mean variability timescales are on the order of a few weeks. The corresponding emission region size is used to constrain the location of γ-ray production sites in the sources to be a few parsecs. Additionally, using Lomb-Scargle periodogram and weighted wavelet z-transform methods and extensive Monte Carlo simulations, we detected year-timescale quasi-periodic oscillations in the sources S5 0716+714, Mrk 421, ON +325, PKS 1424-418, and PKS 2155-304. We also performed recurrence quantification analysis of the sources and directly measure the deterministic quantities, which suggest that the dynamical processes in blazars could be a combination of deterministic and stochastic processes, while some of the source light curves revealed significant deterministic content.'

Collaborations

Keywords and Comments
AGN, blazars, gamma-ray emission, relativistic jets, non-thermal emission, particle acceleration, time series analysis, Gopal Bhatta"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
The gamma-ray Moon seen by the Fermi LAT over a full solar cycle

Presenter
Salvatore De Gaetano
Author and Co-Author
Salvatore De Gaetano Francesco Loparco | Mario Nicola Mazziotta | Nicola Giglietto

Abstract
'The Moon is among the brightest gamma-ray sources in the sky. We have reconstructed its gamma-ray spectrum in the energy range from 30 MeV up to a few GeV using the data collected by the Fermi Large Area Telescope during its first 13 years of operation since its launch in 2008, a period covering the duration of a whole solar cycle. We have also studied the evolution of the lunar gamma-ray emission by measuring the spectra in 6 months time intervals. The data show a strong correlation with the solar activity. Gamma rays produced on the lunar surface are in fact originated in the interactions of cosmic rays (mainly proton and helium), whose fluxes are affected by solar modulation. We have also developed a model based on the FLUKA simulation code to evaluate the yields of photons produced by cosmic-ray protons and helium nuclei impinging on the Moon. We have then folded the gamma-ray yields obtained from the model with the primary proton and helium spectra measured by the AMS-02 and PAMELA experiments in different time intervals and we have compared the simulation results with the experimental data, showing that the simulation reproduces correctly the time evolution of the lunar gamma-ray flux.'

Collaborations
Ferrmi-LAT,
Keywords and Comments
, Salvatore De Gaetano"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Study of Al-26 in the COSI 2016 Superpressure Balloon Flight

Presenter
Jacqueline Beechert
Author and Co-Author
Jacqueline Beechert For the COSI collaboration

Abstract
"The Compton Spectrometer and Imager (COSI) is a balloon-borne compact Compton telescope (CCT) designed to survey the gamma-ray sky in 0.2-5 MeV. COSI's wide field of view, excellent energy resolution from cross-strip high-purity germanium semiconductor detectors, and improved angular resolution make it uniquely capable to probe this under-explored energy regime and make contributions to understanding of stellar nucleosynthesis, particularly through studies of diffuse emission from radioisotope Al-26 at 1.809 MeV. In 2016, COSI was launched from Wanaka, New Zealand on a NASA Superpressure balloon and flew for 46-days. The flight was a technologic and scientific success, boasting live detection and polarization studies of GRB160530A, imaging of the Crab Nebula and the 511-keV positron annihilation emission at the Galactic Center, and detection of Cyg-X1. This presentation details a new maximum-likelihood search for the 1.809 MeV signature of Galactic Al-26 in the 2016 data. The analysis reveals promising signs of an Al-26 signature, and further exploration is currently underway to solidify a measurement. Hence, this work demonstrates COSI's ability to reveal critical astrophysical nuclear lines and the powerful capabilities of CCTs like COSI on a balloon platform."

Collaborations
other (fill field below), Compton Spectrometer and Imager (COSI)

Keywords and Comments
Al-26, nucleosynthesis, gamma-ray detector, Compton telescope, COSI, balloon, diffuse emission, spectroscopy, Jacqueline Beechert"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Constraints on the antistar fraction in the Solar System neighborhood from the 10-years Fermi Large Area Telescope gamma-ray source catalog

Presenter
Simon Dupourqué
Author and Co-Author
Simon Dupourqué | Luigi Tibaldo | Peter von Ballmoos

Abstract
'It is generally taken for granted that the observable Universe does not contain anti-matter objects or domains. Recently, the possible detection of anti-helium nuclei in cosmic rays by AMS-02 challenged this idea and reopened the debate on the existence of nearby reservoirs of antimatter, most plausibly in antistars. As antimatter domains surrounded by normal matter would produce a gamma-ray signal from baryon-antibaryon annihilation, we use the 10-years *Fermi* Large Area Telescope (LAT) gamma-ray source catalog to set constraints on the abundance of antistars in our local Galactic environment. We identify 14 antistar candidates not associated with any object belonging to established gamma-ray source classes and featuring spectra compatible with baryon-antibaryon annihilation. We evaluate the sensitivity of the LAT to antistars and set upper limits on the local antistar fraction with respect to normal stars using both a parametric and a Monte Carlo method. For antistars with properties similar to those of disk-population stars we derive constraints that are 20 times stronger than those previously available. For a primordial population of antistars in the Galactic halo, gamma-ray data combined with microlensing observations constrain the density of antistars to lower than O(10^{-5} pc$^{−3}$) to O($10^{−2}$ pc$^{−3}$) depending on their masses. Our limits can constrain models for the origin and propagation of anti-nuclei in cosmic rays.'

Collaborations
Keywords and Comments
Antistar, Monte Carlo, Antimatter, Unassociated Sources, Simon Dupourqué''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
GeV-radio correlation in Markarian 421

Presenter
Sliusar Vitalii
Author and Co-Author
Sliusar Vitalii | Roland Walter | Matteo Balbo

Abstract
'Markarian 421 is a high-synchrotron-peaked blazar showing relentless variability across the electromagnetic spectrum from radio to gamma-rays. We use 5 years of radio and GeV observations to study the correlation and connected variability in radio and GeV bands. Radio data was obtained in a 15GHz band by the OVRO 40-m radio telescope and GeV data is from Fermi Large Area Telescope. To determine the location of the gamma-ray emission regions in Mrk 421 we correlate GeV and radio light curves. We found that GeV light curve varies independently and accurately leads the variations observed in radio. Using a fast-rise-slow-decay profile derived for shock propagation within a conical jet, we manage to reproduce the radio light curve from GeV variations. The profile rise time is comparable with the Fermi-LAT binning, the decay time is about 7.6 days. The best-fit value for the response profile also features a 44 days delay between the GeV and radio, which is compatible with the wide lag range obtained from the correlation. Such a delay corresponds to 10^17 cm/c, which is comparable with the apparent light crossing time of the Mrk 421 radio core. Generally, the observed variability matches the predictions of the leptonic models and suggests that the physical conditions vary in the jet. The emitting region is moving downstream the jet while the environment becomes first transparent to gamma rays and later to the radio.'

Collaborations

Keywords and Comments
AGN, Mrk 421, blazar, gamma-rays, radio, Sliusar Vitalii''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
High-energy gamma-ray observations above 10 GeV with CALET on the International Space Station

Presenter
Masaki Mori
Author and Co-Author
Masaki Mori | for the CALET Collaboration

Abstract
"Since the deployment of the CALorimetric Electron Telescope (CALET) on the exposure facility of the Japanese Experiment Module (JEM) 'Kibo' of the International Space Station in 2015, CALET is accumulating cosmic ray data steadily without any serious faults up to now. Although CALET is basically a high-energy cosmic-ray detector, its composite and thick detector structure allow us to separate gamma rays from charged cosmic rays clearly up the TeV energy region.\r\nIn this paper, analysis of gamma-ray events above 10 GeV obtained by the `high-energy' triggers, which is the basic trigger mode of CALET for cosmic-ray observations and is always effective regardless of the ISS position in orbit, are reported. Especially, good energy resolution (less than 3% at 10 GeV) of CALET enables us to search for spectral features in the gamma-ray energy spectrum such as lines possibly caused by annihilation of dark matter particles and preliminary studies will be presented. Lower energy gamma-ray observations and transient events are reported separately."

Collaborations
CALET,

Keywords and Comments
CALET, International Space Station, gamma rays, Masaki MORI"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
A model-driven search for extreme BL Lacs among Fermi-LAT blazar candidates.

Presenter
Mireia Nievas Rosillo
Author and Co-Author
Mireia Nievas Rosillo Graziano Chiaro | Alberto Domínguez | Giovanni La Mura

Abstract
'The emission of very-high-energy photons (VHE, E>100 GeV) in active galactic nuclei (AGN) is closely connected with the production of ultra-relativistic particles. Among AGN, the subclass of extreme BL Lacertae are of particular interest because they challenge state-of-art models on how these cosmic particle accelerators operate. By cross-matching two gamma-ray catalogs (this is, 4FGL-DR2 and 2BIGB), we identified 23 high-synchrotron-peaked (HSP) blazar candidates with photometric or spectroscopic redshifts, good multi-wavelength coverage, that are possibly detectable by VHE instruments. We performed a new analysis of Fermi Large Area Telescope data including the effects of attenuation from the extragalactic background light and complemented these results by collecting multiwavelength data from optical, radio and X-ray archival observations. Their broadband spectral energy distributions were interpreted in terms of synchrotron-self-Compton models with external-Compton components and compared with the properties of prototypical extreme HSP blazars. Finally, we test their detectability with imaging atmospheric Cherenkov telescopes (IACTs) and propose a new method for selecting these extreme targets for these ground-based telescopes.'

Collaborations
Ferrmi-LAT,

Keywords and Comments
extreme blazars, emission models, jets, agn, Mireia Nievas Rosillo''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
X-ray binaries with the Fermi Large Area Telescope: a large scale survey in time and space.

Presenter
Max Harvey
Author and Co-Author
Max Harvey | Paula M. Chadwick | Cameron B. Rulten

Abstract
'X-ray binaries present a particularly interesting class of gamma-ray emitter, with most emitting no detectable gamma-rays at all, and those that are detected falling into two distinct morphological classes: microquasars and gamma-ray binaries. Given the highly variable, and often faint, nature of these systems discovering them represents a unique challenge to the gamma-ray astronomy community, and a one size fits all approach fails to work for the majority of these systems. \r\nWe use 12.5 years of P8R3 Fermi-LAT observations, in addition to (when available) complementary AAVSO optical data and Swift-BAT X-ray data, to a detailed survey at the positions of approximately 300 X-ray binary systems. Spectral and variability analysis are carried out on a range of potential gamma-ray sources which are found to be coincident with the positions of the survey population.\r\nWe present initial results from our forthcoming works on this topic, and discuss the next steps to verifying whether any of these 300 systems can be confirmed as gamma-ray emitters.\r\nWe also discuss the challenges associated with a large data-driven project such as this, including statistical practices to avoid data dredging, and accounting for phenomena such as the Look-Elsewhere effect.'

Collaborations

Keywords and Comments
X-ray binaries, gamma-rays, survey, Fermi-LAT, Max Harvey''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
On the origin of the gamma-ray emission toward HESS J1813-178 with Fermi-LAT

Presenter
Yuliang Xin
Author and Co-Author
Yuliang Xin | Xiaolei Guo

Abstract
'Supernova remnants (SNRs) are widely believed to be the dominant accelerators of Galactic cosmic rays (CRs) with energies up to the knee. The electrons and protons can be accelerated to be the ultra-relativistic particles by the shock of SNRs via the diffusive shock acceleration (DSA) mechanism. HESS J1813-178 is one of the brightest and most compact objects detected by the HESS Galactic Plane Survey and MAGIC observations. A young SNR G12.8–0.0 locates within the TeV extent of HESS J1813-178. And a pulsar wind nebula (PWN) driven by an energetic X-ray pulsar PSR J1813-1749 is embedded in the SNR. Previous studies show that the GeV emission around HESS J1813-178 is much more extended than its TeV emission. With the Fermi-LAT analysis, we did a detailed morphological and spectral analysis in the region of HESS J1813-178 and found that the GeV gamma-ray morphology is consistent with the TeV contours of MAGIC. Meanwhile, the GeV spectrum is hard with index of ~2.0, which connects smoothly with that of HESS J1813-178. The possible origins of the gamma-ray emission from HESS J1813-178 are discussed.'

Collaborations
Keywords and Comments
, Yuliang Xin''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
The gamma-ray emission in the region of W49A with Fermi-LAT

Presenter
Yuliang Xin
Author and Co-Author
Yuliang Xin | Xiaolei Guo

Abstract
'The young star clusters/star forming regions have been believed to be the Galactic CRs contributors. As the CR acceleration sites, the collective effect of stellar winds and/or supernova activity in the young stellar associations can produce a large-scale shock, which will accelerate the particles up to energies of hundreds of TeV. And these high-energy particles can produce the multi-wavelength emission by the different radiation mechanisms. The GeV or TeV gamma-ray emission from such sources also have been detected, like Cygnus Cocoon, Westerlund 1, etc. The W49 region is one of the most interacting regions in the Galaxy to study the CR acceleration and it contains two components: a star forming region W49A and a young SNR W49B. W49A, located 0.21o to the west of the SNR W49B, is one of the massive star formation region in the Galaxy and one of the richest clusters known. Using the Pass 8 Fermi-LAT data, we did a detailed analysis around W49A and found that the gamma-ray emission contains two spectral components. One has the soft spectrum and steady emission, while another has the hard spectrum and variable emission. We also discuss the possible origins of the gamma-ray emission of different components.'

Collaborations
Keywords and Comments
, Yuliang Xin''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
The Origin of Gamma-ray Emission from Circinus Galaxy

Presenter
Xiao-Lei Guo
Author and Co-Author
Xiao-Lei Guo | Yu-Liang Xin | Neng-Hui Liao | Yi-Zhong Fan

Abstract
'The Circinus galaxy is a nearby composite starburst/active galactic nucleus (AGN) system. In this work we re-analyze the GeV emission from Circinus with 10 years of Fermi-LAT data. Our 0.1–500 GeV flux is several times lower than that reported in previous literature, which is roughly in compliance with the empirical relation for star-forming and Local Group galaxies and might be reproduced by the interaction between cosmic rays and the interstellar medium. The ratio between the γ-ray luminosity and the total infrared luminosity is near the proton calorimetric limit, indicating that Circinus may be a proton calorimeter.'

Collaborations
Keywords and Comments
, Xiao-Lei Guo"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Observations of gamma-ray sources with DAMPE

Presenter
Kai-Kai Duan
Author and Co-Author
Kai-Kai Duan Zhao-Qiang Shen | Wei Jiang | Zun-Lei Xu | Xiang Li | on behalf of the DAMPE collaboration

Abstract
'DArk Matter Particle Explorer (DAMPE), a space-borne high energy cosmic ray and gamma-ray detector, has surveyed the whole sky for five years and collected more than 220,000 photons above 2 GeV since the launching on Dec. 17, 2015. The instrument response functions (IRFs) are derived and a dedicated software named DmpST is developed for the gamma-ray data analysis of DAMPE. Here we present the method of DAMPE bright gamma-ray sources search and the spectral analyses of these sources.'

Collaborations
DAMPE,

Keywords and Comments
, Kai-Kai Duan"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Search for gamma-ray lines in the Galaxy with DAMPE

Presenter
Zun-Lei Xu
Author and Co-Author
Zun-Lei Xu Zhao-Qiang Shen | Kai-Kai Duan | Xiang Li | Mazziotta M. N. | on behalf of the DAMPE collaboration

Abstract
'DArk Matter Particle Explorer (DAMPE) is a high energy cosmic-ray and gamma-ray observatory with an excellent energy resolution, and therefore has an advantage in searching for gamma-ray line structures. Based on the 5-yr DAMPE observation, we construct a dedicated data set for line search which balances the energy resolution and acceptance. We also make use of the photons converted in the BGO calorimeter. We use the summed unbinned likelihood with sliding windows technique and calculate the 95% confidence limits of the velocity-averaged cross section for `$\\chi\\chi \\to \\gamma\\gamma$` and the decay lifetime for `$\\chi \\to \\gamma\\nu$`.'

Collaborations
DAMPE,
Keywords and Comments
, zunlei xu"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Inter Galactic Magnetic field constraints through the gamma ray observations of the Extreme High-frequency-peaked BL Lac candidate HESS 1943+213

Presenter
Paolo Da Vela
Author and Co-Author
Paolo Da Vela | Stefano Silvestri | Sofia Ventura | Giacomo Bonnoli

Abstract
'Extreme High-frequency-peaked BL Lac (EHBL) objects, a subclass of blazars characterised by a synchrotron peak frequency exceeding 10^17 Hz, and, in some cases, an inverse Compton peak energy exceeding 1 TeV, are ideal sources to study the InterGalactic Magnetic Field (IGMF) due to the hardness of their spectrum. HESS J1943+213 is a Very High Energy (VHE, >100 GeV) γ-ray source shining through the Galactic Plane discovered by HESS. Recently, also VERITAS published a VHE spectrum spanning from 200 GeV up to about 2 TeV consistent with that of HESS within the errors (photon index=2.8). The archetypical EHBL source is 1ES 0229+200 which has a redshift z=0.14 and a similar VHE slope (photon index=2.9). Since the observed flux of HESS J1943+213 at 1 TeV is more than a factor of two larger, and its redshift is bigger (z<0.23), a much larger reprocessed power is expected, which allowed us to study the magnetic field strength with great accuracy. We used the simulation code CRpropa 3 to simulate the cascade emission assuming different IGMF configurations and a detailed analysis of the 10 years of Fermi-LAT data to extend the observed VHE spectrum down to 5 GeV. Comparing the cascade spectrum with the combined spectra from Fermi-LAT and Cherenkov telescopes we derived a lower limit on the IGMF strength of the order of 6e-14 G which is at least a factor of 4 larger than previously published results obtained with the source 1ES0229+200. Effects of the duty cycle are also taken into consideration.'

Collaborations

Keywords and Comments
AGN, Inter Galactic Magnetic Field, Paolo Da Vela"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Systematic X-ray study of GeV gamma-ray emitting radio galaxies

Presenter
Hiroto Matake
Author and Co-Author
Hiroto Matake Yasushi Fukazawa

Abstract
Black Holes (BHs) at the center of galaxies have a 10^6 - 10^9 \r\nsolar mass and thus are called Supermassive Black hole (SMBH). When a large amount of matter accretes onto SMBH, the accreting matter shines brightly, and this phenomenon is called active galactic nuclei (AGN). Only 10$¥%$ of AGNs have a powerful radio jet, and these objects are roughly classified either radio galaxy or blazar. Blazar is bright but its radiation almost comes from the core jet because of strong beaming effect, while radio galaxy whose beaming effect is weak show various emission components from outer-layer jet, outer jet, and disk/corona. Therefore, radio galaxies are considered to be important objects to understand jet structure. To study the relation between jet and disk is considered to be an important point to understand jet ejection mechanism X-ray emission from radio galaxies contain both jet and disk/corona radiation. Thus, we have to investigate contributions from jet and disk/corona to the X-ray band.\r\nIn this work, we investigate X-ray and Gamma-ray properties of GeV emitting radio galaxies listed in the 4FGL-DR2 catalog. We use X-ray data of Swift/XRT. We studied time variability, the relation between X-ray and gamma-ray photon index, together with accretion rate, and found they are classified into 3 groups, X-ray emission in the first group is dominated by jet emission, X-ray of the second group is dominated by disk/corona emission, and for the third group both jet and disk/corona contribute to the X-ray band.'

Collaborations

Keywords and Comments
AGN, Radio Galaxy, Hiroto Matake''

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Subcategory Experimental Results

Titel
Observation of sub-GeV atmospheric gamma rays on GRAINE 2018 balloon experiment and comparison with HKKM calculation

Presenter
Hiroki Rokujo
Author and Co-Author
Hiroki Rokujo GRAINE collaboration

Abstract
'We report a precise measurement of the sub-GeV atmospheric gamma-ray spectrum at balloon altitude on GRAINE 2018 experiment, and comparisons with the predictions calculated by the latest HKKM, which is widely known as a model for atmospheric neutrino flux calculation.\r\nUnderstanding the interactions between cosmic rays and atmospheric nuclei is important for accurate atmospheric neutrino flux calculations. Observation data of sub-GeV atmospheric gamma rays at balloon altitudes are useful for verifying such hadronic interaction models and pion productions in the low energy region.\r\nIn April 2018, we conducted a balloon experiment (GRAINE 2018) in Australia with the aim of detecting and imaging cosmic gamma rays with the nuclear emulsion telescope. Following flight data analysis, we derived an atmospheric gamma-ray spectrum in 0.1-1 GeV region at altitudes of ~36 km (residual depth ~4 g/cm^{2}). The flux around the 1 GeV region is in good agreement with the HKKM prediction and smoothly connects to the multi-GeV observations of past balloon experiments. On the other hand, the flux around 0.1 GeV shows a discrepancy with the prediction.\r\nIn this presentation, the balloon experiment, flight data analysis, and observation results will be described in detail.'

Collaborations
other (fill field below), GRAINE

Keywords and Comments
atmospheric gamma ray, hadronic interaction, atmospheric neutrino, balloon experiment, nuclear emulsion, Hiroki Rokujo''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
Observational constraints on the blazar jet wobbling timescale

Presenter
Jakub Juryšek
Author and Co-Author
Jakub Juryšek | Vitalii Sliusar | Roland Walter

Abstract
'Blazars are a subclass of radio-loud active galactic nuclei, where the jet is aligned close to the line of sight. Blazars emission is dominated by non-thermal processes, where Doppler boosted radiation originates from a relativistic population of charged particles within the jet. From radio to TeV energies, blazars are highly variable on timescales from minutes to over a year. There are several mechanisms proposed to explain such extreme variability, including changes in the viewing angle of the jet, propagating along the rotation axis of the accretion disc. If the angular momentum of matter accreting onto a spinning supermassive black hole (SMBH) is misaligned with the SMBH spin, Lense-Thirring precession of such tilted disc can be expected, which leads to variation of Doppler beaming of the jet emission. Such explanation is supported by radio observations of jet precession observed for some sources. The radio-emitting regions, however, are located far from the central engine, and thus the observed time scales in this band can be affected by e.g. a variation of the bulk Lorentz factor along the jet.\r\n\r\nIn this contribution, we derive expected time scales of the jet wobbling using SMBH masses and compare them with the time intervals between flares in long-term (over $\\sim15$ years) X-ray light curves of bright blazars observed by Swift-XRT. We found that for Mrk 421 and 3C 273, the derived time scales are consistent with the observational constraints, while for the other sources we are mostly limited by an uncertainty in the Doppler beaming factor.'

Collaborations
Keywords and Comments
, Jakub Juryšek''

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
AstroSat View of Blazar OJ 287: A complete evolutionary cycle of HBL Component from end-phase to disappearance and Re-emergence

Presenter
Pankaj Kushwaha
Author and Co-Author
Pankaj Kushwaha K. P. Singh | A. Sinha | S. Chandra | V. R. Chitnis | Main Pal | G. C. Dewangan | A. Gopakumar | S. B. Markoff | S. Doeleman | A. Agrawal

Abstract
'We report three AstroSat observations of BL Lacertae object OJ 287. The three observations caught it in very different flux states that are connected to different broadband spectral states. These observations trace the source spectral evolution from the end-phase of activity driven by a new, additional HBL like emission component in 2017 to its complete disappearance in 2018 and re-emergence in 2020. The 2017 observation shows a comparatively flatter optical-UV and X-ray spectrum. Supplementing it with the simultaneous NuSTAR monitoring indicates a hardening at the high-energy-end. The 2018 observation shows a harder X-ray spectrum and a sharp decline or cutoff in the optical-UV spectrum revealed thanks to the Far-UV data from AstroSat. The brightest of all, the 2020 observation shows a hardened optical-UV spectrum and an extremely soft X-ray spectrum, constraining the low-energy peak of spectral energy distribution at UV energies – a characteristic of HBL blazars. The contemporaneous MeV-GeV spectra from LAT show the well-known OJ 287 spectrum during 2018 but a flatter spectrum during 2017 and a hardening above ~1 GeV during 2020. Modeling broadband SEDs show that 2018 emission can be reproduced with a one-zone leptonic model while 2017 and 2020 observations need a two-zone model, with the additional zone emitting an HBL radiation.'

Collaborations

Keywords and Comments
radiation mechanisms: non-thermal – galaxies: active – BL Lacertae objects: in-\r\ndividual: OJ 287 – galaxies: jets – gamma-rays: galaxies – X-rays: galaxies., Pankaj Kushwaha"

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Branch GAD | Gamma Ray Direct

Subcategory Experimental Results

Titel
An Investigation into the Origin of short-term flaring Gamma-ray Emission of TON 599

Presenter
Jacob Green
Author and Co-Author
Jacob Green

Abstract
'The FSRQ TON 599 is one of the most luminous $\\gamma$-ray emitting AGN. Data from the Fermi-LAT are used for these analyses. It shows variability on time scales down to minutes during strong flares detected by the Fermi-LAT. A flux above 100 MeV during hourly time intervals could exceed $\\sim 10^{-5}$ photons cm$^-2$ s$^-1$ and the spectrum for the flaring period extends up to 100 GeV with a hard photon index of $\\sim2$.\r\nThis short term variability time scale is the indication of the compactness of the $\\gamma$-ray emission region size (< 10^{16} cm). Thus, this study of TON 599 was undertaken to give an understanding of $\\gamma$-ray emission from AGN. Different scenarios are discussed to explain the short-term variability.'

Collaborations
Keywords and Comments
AGN, Fermi, Jacob Green''

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Branch GAD | Gamma Ray Direct

Subcategory Theoretical Methods

Titel
Spectrum of the Isotropic Diffuse Gamma-ray Background

Presenter
Meenakshi Rajagopal
Author and Co-Author
Meenakshi Rajagopal Markus Ackermann | Marco Ajello

Abstract
'The isotropic diffuse γ-ray background (IGRB) comprises of all extragalactic diffuse emission that is not resolved into sources and is found to be approximately isotropic on large angular scales. The initial measurement of the IGRB intensity with the Fermi Large Area Telescope (LAT) was performed in 2010 using the first 10 months of sky-survey data. After improvements were made in event selection and characterization of cosmic-ray backgrounds, a second measurement using 50 months of LAT data allowed for a refinement and a better understanding of the IGRB measurement, this time covering an energy range from 100 MeV to 820 GeV. The result was a spectrum defined by a power law with exponential cutoff with a spectral index of 2.32±0.02. A total intensity of (7.2±0.6) × 10−6 cm−2 s−1 sr−1 above 100 MeV was seen with about +15%/-30% systematic uncertainty attributed to Galactic diffuse foregrounds. This systematic uncertainty dominates the measurement uncertainties over most of the observed energy range. In the current analysis, therefore, the primary goal is to refine the measurement of the IGRB, employing 8 years of pass8 Fermi data and the 4FGL source catalog. A reduction of the systematic uncertainties arising from the DGE emission will be achieved through improved modeling of this emission, as well as a careful selection of analysis regions. A few other improvements including, wider energy range (between 50 MeV - >1 TeV), larger dataset, more powerful fitting techniques etc., will also be achieved in the current analysis.'

Collaborations
Keywords and Comments
gamma-ray, diffuse, isotropic, Meenakshi Rajagopal"

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Branch GAD | Gamma Ray Direct

Subcategory Theoretical Methods

Titel
Bispectrum analysis of the unresolved gamma-ray background

Presenter
Ebo Peerbooms
Author and Co-Author
Ebo Peerbooms

Abstract
'In recent years, properties of the unresolved gamma ray background (UGRB) have been constrained by measuring the anisotropy in the form of the angular power spectrum (APS). The energy dependence of the anisotropy has been found to be consistent with a broken power law, suggesting the existence of two distinct source classes above and below $\\sim$2 GeV. In this work, we aim to go beyond the angular power spectrum, and use the bispectrum to further constrain the source classes that contribute to the UGRB. As in the case of the APS, for a skymap consisting of unresolved, randomly distributed point sources, we expect the bispectrum to be independent of multipole and therefore to be fully characterised by a single amplitude b_{src}. We adapt the formalism developed in the context of CMB research and apply the resulting analysis pipeline to Fermi-LAT data in the energy range 0.7 GeV – 1 TeV. We verify the robustness of our analysis pipeline by applying it to simulated realizations with a predetermined value of the bispectrum amplitude. Additionally, bispectrum amplitudes obtained from the UGRB data are compared to simulated, purely isotropic realizations of the UGRB in order to test for deviations from Poissonianity across the entire energy range. Finally, we check if the energy-dependence of the bispectrum amplitude is consistent with the same broken power-law is in the case of the APS.'

Collaborations

Keywords and Comments
bispectrum,IGRB,UGRB,anisotropy,skewness,unresolved gamma-ray background,, Ebo Peerbooms''

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Branch GAD | Gamma Ray Direct

Subcategory Theoretical Methods

Titel
Decelerated sub relativistic material with energy Injection

Presenter
Boris Betancourt Kamenetskaia
Author and Co-Author
Boris Betancourt Kamenetskaia | Nissim Fraija | Maria Giovanna Dainotti | Antonio Gálvan-Gámez | Rodolfo Barniol Duran | Simone Dichiara

Abstract
'We investigate the evolution of the afterglow produced by the deceleration of the non-relativistic material due to its surroundings. The ejecta mass is launched into the circumstellar medium with equivalent kinetic energy expressed as a power-law velocity distribution $E\\propto \\left(\\Gamma\\beta\\right)^{-\\alpha}$. The density profile of this medium follows a power law $n(r)\\propto r^{-k}$, with k the stratification parameter, which accounts for the usual cases of a constant medium ($k=0$) and a wind-like medium ($k=2$). A long-lasting central engine, which injects energy into the ejected material as $E\\propto t^{1-q}$ was also assumed. With our model, we show the predicted light curves associated with this emission for different sets of initial conditions and notice the effect of the variation of these parameters on the frequencies, timescales and intensities. The results are discussed in the Kilonova scenario.'

Collaborations

Keywords and Comments
mergers, black holes, neutron stars, compact binary stars, radiation mechanism, nonthermal, ISM, GRB, Boris Betancourt Kamenetskaia''

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Branch GAD | Gamma Ray Direct

Subcategory Theoretical Results

Titel
Fermi acceleration and $\gamma-\gamma$ obscuration along the orbit of η Carinae

Presenter
Matteo Balbo
Author and Co-Author
Matteo Balbo Roland Walter

Abstract
$\\eta$Carinae is the first observed $\\gamma$-ray binary system which does not contain compact objects. It is a natural laboratory to study particle acceleration and $\\gamma$-ray emission. The dense wind of the primary star shocks against the fast light wind coming from the companion star, creating the conditions to accelerate particles up to relativistic energies via Fermi mechanism. These particles subsequently dissipate energy as non-thermal radiation. Fermi-LAT and H.E.S.S. detections of $\\eta$Carinae confirmed such hypotheses for the very first time, creating a brand new class of $\\gamma$-ray emitting sources.\r\nHydrodynamic simulations provide a convincing match to the observations if few percent of the wind mechanical energy dissipated in the shock goes into particle acceleration. The intrinsic $\\pi^0$ decay spectrum is a complex convolution of the maximum energy, luminosity, particle drift and obscuration. Accelerated particles cool down mainly via inverse-Compton, synchrotron radiation, and proton-proton collisions. High-energy $\\gamma$-rays interact also with the anisotropic UV photon field emitted by the luminous star, creating $e^\\pm$ pairs and strongly modifying the observed spectrum. Quick variations of the optical depth are expected along the orbit, due to changes in shape, position, and gas density of the shocked regions. Flux variability down to few days timescale could be detected with future $\\gamma$-ray detectors above 40GeV. Detailed studies of the optical depth variability will help: disentangling the intrinsic particle spectral cut-off from that related to $\\gamma$-$\\gamma$ opacity, determining the flux of relativistic protons and positrons injected in the interstellar medium, studying the geometry of the colliding wind region and the magnetic field configuration, spatially constraining the location where relativistic photons are produced and the orientation of the binary system.'

Collaborations

Keywords and Comments
$\\eta$Carinae, Particle acceleration, colliding wind binary, optical depth, shocks, Matteo Balbo"

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Branch GAD | Gamma Ray Direct

Subcategory Theoretical Results

Titel
Detection of new Misaligned Active Galactic Nuclei in the Fermi-LAT Fourth Source Catalog using machine learning techniques

Presenter
Luca Deval
Author and Co-Author
Fiorenza Donato | Mattia Di Mauro | Luca Deval

Abstract
'Active galactic nuclei (AGN) are the most luminous and abundant objects in the γ-ray sky. AGN with jets misaligned along the line-of-sight (MAGN) appear fainter than the brighter blazars, but are expected more numerous. Fermi Large Area Telescope (LAT) detected 40 MAGNs compared to 1943 blazars. The aim of this study is to identify new MAGN candidates in the blazars of uncertain type (BCUs) listed in the Fermi-LAT 10-years Source Catalog using an artificial neural network (ANN). \r\nThe statistical tests applied to the trained ANN reveals that a classification with machine learning techniques is feasible with high accuracy and precision. The trained ANN has been applied to the 1120 BCUs which have been classified into 655 BL Lacs and 314 Flat Spectrum Radio Quasars (FSRQs). Among the re-classified BCUs, the possible MAGN candidates have been determined by applying thresholds on the spectral index and gamma-ray luminosity. Our results led to 36 possible MAGN candidates, which respect the main physical properties of the 40 MAGN already listed in the Fourth Fermi Catalog.'

Collaborations

Keywords and Comments
AGN, MAGN, Machine learning,, Luca Deval''

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Subcategory Theoretical Results

Titel
Investigating the millisecond pulsar and dark matter interpretations of the gamma ray excess of the Andromeda Galaxy

Presenter
Fabian Zimmer
Author and Co-Author
Fabian Zimmer | Oscar Macias

Abstract
There has been a recent discovery of an excess in the gamma ray emission from the Andromeda Galaxy (M31) observed with the Fermi Large Area Telescope. The origin of this excess, however, is completely unknown. The goals of this work are (1) to show that the excess is indeed real and not due to improper treatment of the back-/foreground models, (2) to analyze the morphology and spectrum of the signal with robust statistical methods, and (3) to test different source models (either astrophysical or exotic), which could explain this excess.\r\nThe first goal is accomplished by using different combinations of the individual back-/foreground components, constructed to trace hydrogen gas or emission due to Inverse Compton scattering. The region around M31 was excised from these maps and inpainted over with machine learning techniques. With these different templates and multiple inpainting algorithms, these back-/foreground models are used to get to the systematic uncertainties, to ultimately see how significant the excess really is.\r\nWe achieve the second and third goals by testing a variety of spatial and spectral models, both accounting for point-like and extended source signals.\r\nFurthermore, we constructed more sophisticated stellar maps containing old populations of red giants, serving as tracers for pulsars. This serves to contribute to a long-standing debate, whether the signal could come from an unresolved population of millisecond pulsars. Finally, the more exotic but exciting claim, that the signal could come from dark matter annihilation is tested with a variety of spatial density profiles.'

Collaborations

Keywords and Comments
Gamma Rays, Andromeda, Inpainting, millisecond pulsar, Fabian Zimmer"

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Branch GAD | Gamma Ray Direct

Subcategory Theoretical Results

Titel
HI absorption and Galactic Center Excess

Presenter
Chris Gordon
Author and Co-Author
Martin Pohl | Phaedra Coleman | Chris Gordon | Oscar Macias

Abstract
'Pohl et al. (2008) used a gas-flow model based on a SPH simulation to deconvolve Galactic CO data. They employed an iterative method to successively reduce signal in the line spectrum and place it at the eight best-matching distance intervals, until there is only noise left. In Macias et al. (2018) an analogous deconvolution of HI data was found to provide a better fit to the diffuse gamma-ray emission from the Galactic-center region than do the gas maps of the standard Fermi-LAT data analysis pipeline. The absorption correction was minimal and involved only self-absorption with constant excitation temperature of 170 K. Continuum emission was ignored, which means weak positive signal was deemed optically thin and negative signal had to be disregarded. In the Galactic-center region these simplifications lead to a potentially significant underestimation of the mass of atomic gas, and hence a deficit in the predicted diffuse gamma-ray emission and an artificial indication for new emission components. \r\n\r\nIn this talk we will present an advanced model of atomic gas in the Galaxy and apply it to the analysis of gamma-ray emission from the Galactic center. We account for both line and continuum emission in the radiation transport, which allows the modelling of negative line intensity and traces gas in both emission and absorption. We find good fits to the HI data for a broad range of excitation temperatures. We will also discuss whether the new maps provide a better fit to the Fermi-LAT Galactic-center data and whether the estimates of the Galactic-center excess are affected.'

Collaborations

Keywords and Comments
Galactic center Excess, Fermi-LAT, HI density distribution, Chris Gordon''

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Branch GAD | Gamma Ray Direct

Subcategory Theoretical Results

Titel
The imprint of protons on the emission of extended blazar jets

Presenter
Michael Zacharias
Author and Co-Author
Michael Zacharias | Anita Reimer | Andreas Zech

Abstract
'Blazars – active galaxies with the jet pointing at Earth – emit across all electromagnetic wavelengths. The so-called one-zone model has described well both quiescent and flaring states, however it cannot explain the radio emission. In order to self-consistently describe the entire electromagnetic spectrum, extended jet models are necessary. Notably, kinetic descriptions of extended jets can provide the temporal and spatial evolution of the particle species and the full electromagnetic output. Here, we present the initial results of a recently developed hadronic extended-jet code. As protons take much longer than electrons to lose their energy, they can transport energy over much larger distances than electrons and are therefore essential for the energy transport in the jet. Furthermore, protons can inject additional leptons through pion and Bethe-Heitler pair production, which can explain a dominant leptonic radiation signal while still producing neutrinos. We will present a detailed parameter study and provide insights into the different blazar sub-classes.'

Collaborations

Keywords and Comments
AGN, kinetic model, extended jet,, Michael Zacharias''

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Branch GAD | Gamma Ray Direct

Subcategory Theoretical Results

Titel
The ablation of gas clouds by blazar jets and the long-lasting flare in CTA 102

Presenter
Michael Zacharias
Author and Co-Author
Michael Zacharias | Jonathan Heil | Markus Böttcher | Felix Jankowsky | Jean-Philippe Lenain | Stefan Wagner | Alicja Wierzcholska

Abstract
'Long-lasting, very bright multiwavelength flares of blazar jets are a curious phenomenon. The interaction of a large gas cloud with the jet of a blazar may serve as a reservoir of particles entrained by the jet. The size and density structure of the cloud then determine the duration and strength of the particle injection into the jet and the subsequent radiative outburst of the blazar. In this presentation, a comprehensive parameter study is provided showing the rich possibilities that this model offers. Additionally, we use this model to explain the 4-months long, symmetrical flare of the flat spectrum radio quasar CTA 102 in late 2016. During this flare, CTA 102 became one of the brightest blazars in the sky despite its large redshift of z=1.032.'

Collaborations

Keywords and Comments
AGN, blazars, long-lasting flares, Michael Zacharias"

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Branch GAD | Gamma Ray Direct

Subcategory Theoretical Results

Titel
Bayesian inference of three-dimensional gas maps: Galactic CO

Presenter
Philipp Mertsch
Author and Co-Author
Philipp Mertsch | Andrea Vittino

Abstract
'The three-dimensional distribution of both atomic and molecular gas in the Galaxy is a crucial modelling input, both for the generation of diffuse emission in gamma-rays and the transport of cosmic rays. Here, we present new 3D maps of molecular hydrogen based on the Dame et al. (2001) CO survey compilation. We consider the deprojection as a Bayesian variational inference problem. The posterior distribution of the gas densities allows us to estimate both the mean and uncertainty of the reconstructed density. Unlike most of the previous attempts, we take into account the correlations of gas on a variety of scales which allows curing some of the well-known pathologies, like fingers-of-god effects. Both gas flow models that we adopt incorporate a Galactic bar which induces radial motions in the inner few kiloparsecs and thus offers spectral resolution towards the Galactic centre. We compare our gas maps with those of earlier studies and characterise their statistical properties, e.g. the radial profile of the average surface mass density. We briefly comment on an ongoing deprojection of atomic hydrogen.'

Collaborations
Keywords and Comments
diffuse emission, gamma-rays, ISM, molecular gas, statistical methods, Philipp Mertsch''

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Branch MM | Multi-Messenger

Subcategory Experimental Methods & Instrumentation

Titel
Invitation to the Comic Ray Extremely Distributed Observatory

Presenter
Piotr Homola
Author and Co-Author
Piotr Homola for the CREDO Collaboration

Abstract
'Cosmic Ray Ensembles (CRE) are very large, yet not observed particle cascades initiated above the Earth atmosphere. Such cascades could be formed both within classical models (e.g. products of photon-photon interactions) and exotic scenarios (e.g. result of decay of Super Heavy Dark Matter particles and subsequent interactions). Some of CRE might have a significant spatial extent which could serve as a unique signature detectable with the existing cosmic ray infrastructure taken as a network of detectors. This signature would be composed of a number of air showers with parallel axes. An obvious, although yet not probed, CRE „detection horizon" can be located somewhere between an air shower induced by an CRE composed of tightly collimated particles (preshower effect), and undetectable CRE composed of particles spread so widely that only one of them have a chance to reach Earth. Probing the CRE horizon with a global approach to the cosmic ray data, as proposed by the newly formed Cosmic Ray Extremely Distributed Observatory (CREDO), defines an extensive scientific program oriented on the search for physics manifestations at largest energies known, with potential impact on ultra-high energy astrophysics, the physics of fundamental particle interactions and cosmology. In this talk the current status and perspectives of CREDO will be summarized, with an open invitation for the colleagues interested in a global approach to cosmic ray studies, and in particular in observing and investigating multi-primary cosmic ray events such as CRE.'

Collaborations
other (fill field below), Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
cosmic ray ensembles, large scale cosmic ray correlations, extensive air showers, Nicolas Martin Peschau"

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Branch MM | Multi-Messenger

Subcategory Experimental Results

Titel
VERITAS follow-up observation of the blazar TXS 0506+056

Presenter
Weidong Jin
Author and Co-Author
Weidong Jin

Abstract
'The gamma-ray blazar TXS 0506+056 was found with an enhanced gamma-ray emission state in spatial and temporal coincidence with the IceCube high energy neutrino event IC170922A. This is the most significant association by far between a high-energy neutrino event and a blazar in a flaring state. Studying the time evolution and spectral behavior of the blazar emission may help in identifying the sources of the diffuse neutrino flux observed by IceCube and the origin of energetic cosmic rays. TXS 0506+056 was detected by the VERITAS gamma-ray observatory with a significance of 5.8 standard deviations above 110 GeV in a 35 hour data set collected between September 23, 2017 and February 6, 2018. This talk will present results from recent VERITAS observations and an associated multiwavelength campaign, collected between October 10, 2018 to March 1, 2021. A relatively quiet very high energy gamma-ray emission state was observed during this time period, and flux upper limits are used to constrain the potential variability of this blazar.'

Collaborations
VERITAS,

Keywords and Comments
TXS 0506+056, VERITAS, Multiwavelength campaign, Weidong Jin''

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Branch MM | Multi-Messenger

Subcategory Experimental Results

Titel
Multi-Messenger observations of the Fermi-LAT blazar 4FGL J0658.6+0636 consistent with an IceCube high-energy neutrino

Presenter
Raniere de Menezes
Author and Co-Author
Raniere de Menezes | Sara Buson Simone Garrappa | Marcos Santander | Uwe Bach | Yvonne Becherini | Elisa Bernardini | Alessio Berti | Mieke Bouwhuis | Matteo Cerruti | Florian Eppel | Marcello Giroletti | Andrea Gokus | Paul Hancock | Jonas Heßdörfer | Clancy James | Weidong Jin | Matth

Abstract
'The detection of cosmic neutrinos raised many new questions in astroparticle physics, the most important of which is the identification of the neutrino emitters. After more than a decade of IceCube operations, the most promising neutrino astrophysical association remains the very-high-energy (VHE, >100 GeV) blazar TXS 0506+056.\r\n\r\nRecently, on November 14, 2020 the IceCube observatory reported the detection of a well-reconstructed high-energy neutrino event, IceCube-201114A, with a high probability of being astrophysical. Within the 90% IC201114A localization region only one known gamma-ray (>100 MeV) source is found. This is 4FGL J0658.6+0636, associated with the active galaxy NVSS J065844+063711.\r\n\r\nIn this contribution, we will present results from the rich multi-messenger campaign triggered by the IceCube-201114A neutrino detection which has allowed us to collect simultaneous and quasi-simultaneous data for the gamma-ray source potentially associated with the neutrino. We find that NVSS J065844+063711 is a blazar and that its broadband properties resemble those of a high-synchrotron peaked object, making it a promising TeV emitter. Indeed, the detection of VHE photons (> 100 GeV) by the Fermi-LAT provides the first evidence of such emission from this object, making this blazar only the second VHE object found within the 90% confidence region of a well-reconstructed, high-energy IceCube event.'

Collaborations
Ferrmi-LAT, VERITAS, H.E.S.S., MAGIC, MWA, TELAMON

Keywords and Comments
blazar, neutrino, IceCube, Fermi-LAT, Raniere de Menezes'On behalf of the Fermi-LAT, VERITAS, H.E.S.S., MAGIC, MWA, TELAMON collaborations'

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Branch MM | Multi-Messenger

Subcategory Experimental Results

Titel
X-ray emission study of extreme Blazars using AstroSat data

Presenter
Pranjupriya Goswami
Author and Co-Author
Pranjupriya Goswami | Ranjeev Misra | Atreyee Sinha | Rupjyoti Gogoi

Abstract
'The X-ray spectral curvature in high energy peaked BL Lac (HBL) sources has been interpreted in terms of either shock acceleration, where accelerated electrons attain maximum energy (Lorentz factor, $\\gamma_{max}$) (Kirk et al.1998,A$\\&$A,333,452) and consequently emit synchrotron radiation, or due to energy-dependent electron diffusion from the acceleration regions (Goswami et al.2018,MNRAS,480, 2046). However, the X-ray emission features in the extreme class of blazars (EHBLs) are difficult to interpret due to insufficient data at these energies. The high cadence blazar monitoring programme of the *AstroSat*, covering UV to X-ray energy range, has given us unprecedented simultaneous data from the SXT (0.3-10 keV) and the LAXPC (3-80 keV) instruments. This wideband data can be used to constrain a wide range of blazar emission mechanisms.\r\n\r\nIn this contribution, we present a detailed spectral and timing study of EHBLs, RGBJ0710+591, 1ES1741+196 and HBL 1ES2322-409 using data from *AstroSat* and simultaneous multi-frequency observations. The *AstroSat* observations of RGBJ0710+591, 1ES1741+196 and 1ES2322-409 were made during 2016, 2019 and 2020 respectively (each with 40ks exposure). The results highlight their X-ray spectral curvature features and the observed considerable shifts in their synchrotron spectral peak energies between different flux states. For RGBJ0710+591, the SXT/LAXPC spectrum shows unusually strong curvature than earlier quasi-simultaneous analysis of *Swift-XRT/NuSTAR* data. We show such a strong curvature can be an outcome of a change in maximum electron energy of the accelerated electrons (Goswami et al. 2020,MNRAS,492,796). We further quantify the X-ray variability of these sources and observe significant variability at longer scales, shown by combined *Swift-XRT* and AstroSat data.'

Collaborations

Keywords and Comments
AGNs, BL Lacs, Particle acceleration, Pranjupriya Goswami"

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Branch MM | Multi-Messenger

Subcategory Experimental Results

Titel
Galactic Bulge VHE tau-neutrino and gamma-ray Monitor with Ashra-1 and NTA detectors

Presenter
Satoru Ogawa
Author and Co-Author
Satoru Ogawa | Makoto Sasaki | for the ashra NTA collaboration

Abstract
'The Ashra-1 detector has been developed to efficiently take fine images of air-shower (AS) Cherenkov (CE) and fluorescence (FL) light induced by the Earth-skimming $\\nu_{\\tau}$ and $\\gamma$-ray ASs. Based on Ashra-1, we have planned a new extension, i.e. Neutrino Telescope Array (NTA), an AS imaging $\\nu$ and $\\gamma$-ray observation system for "Clear Discovery and Identification of Non-thermal Hadronic Processes in the Universe.", consisting of four NTA stations deployed at 3000-3500~m a.s.l. on Mauna Loa. NTA can watch the air volume surrounding Mauna Loa including the surface of Mauna Loa, the largest volcano, Hawaii Island and sea around it to efficiently detect CE and FL light from $\\nu_{\\tau}$ ASs with both short and long decay lengths and $\\gamma$-ray ASs. The NTA $\\nu_{\\tau}$ sensitivity is sufficient to probe Pevatrons, an extension of the IceCube detected astrophysical neutrino flux and predictions of the cosmogenic neutrino flux.The point-back accuracy is evaluated to be within 0.2$^{\\circ}$ with respect to the original direction of the PeV-scale ES $\\nu_{\\tau}$\'s. As the first step observation with the minimal systematic deployment, we propose to monitor 10 TeV-10PeV $\\gamma$-rays from the Galactic bulge with Ashra-1 as well as Earth-skimming $\\nu_{\\tau}$\'s with NTA simultaneously to clearly identify the Pevatrons and comprehensively understand the emission process there. The effective detection area of Ashra-1 and NTA for the Galactic bulge $\\gamma$-rays with the energies around 1~PeV is more than 10 and 100 times respectively larger than that of a ground array with 500m scale.'

Collaborations
other (fill field below), Ashra NTA

Keywords and Comments
VHE neutrino, tau neutrino, gamma-ray, galactic bulge, origin of cosmic ray, heavy dark matter, Satoru Ogawa''

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Branch MM | Multi-Messenger

Subcategory Experimental Results

Titel
A model-independent analysis of neutrino flares detected in IceCube from X-ray selected blazars

Presenter
Ankur Sharma
Author and Co-Author
Ankur Sharma | Erin O'Sullivan

Abstract
'Blazars are among the most powerful steady sources in the Universe. Multi-messenger searches for blazars have traditionally focused on their gamma-ray emission, which can be produced simultaneously with neutrinos in photohadronic interactions. However, X-ray data can be equally vital to constrain the SED of these sources, since the hadronically co-produced gamma-rays could get absorbed by the ambient photon fields and cascade down to X-ray energies before escaping. In this work, we present an untriggered, time-dependent analysis of neutrino flares from the direction of X-ray selected blazars using 10 years of IceCube data. A binomial test is performed on the population to reveal if a subcategory of sources has statistically significant emission. The sources are selected from RomaBZCat, and the p-values and best-fit flare parameters are obtained for each source using the method of unbinned likelihood maximisation.'

Collaborations
IceCube,

Keywords and Comments
AGN, Blazars, IceCube, X-rays from blazars, Neutrino flares, multi-messenger, Ankur Sharma"

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Branch MM | Multi-Messenger

Subcategory Experimental Results

Titel
ANTARES search for neutrino flares from the direction of radio-bright blazars

Presenter
Giulia Illuminati
Author and Co-Author
Giulia Illuminati | for the ANTARES Collaboration

Abstract
'In 2017, a high-energy muon neutrino detected by IceCube was found positionally coincident with the direction of a known blazar, TXS 0506+056, in a state of enhanced $\\gamma$-ray emission. Soon after, IceCube reported a compelling evidence for an earlier neutrino flare from the same direction found in the archival data, this time not accompanied by any observed electromagnetic activity. \r\nThe IceCube findings suggest searching for flaring neutrino emissions from astrophysical sources, not necessarily accompanied by flares detected in $\\gamma$-rays. The analysis presented in this contribution scans the events collected by the ANTARES neutrino telescope in 13 years of data taking in a search for clustering in space and time. The analysis method is based on an unbinned maximum likelihood approach. A generic Gaussian profile is assumed for the signal time emission, with both the Gaussian mean (time of the peak of the flare) and sigma (duration of the flare) being free parameters in the likelihood maximization. The time-dependent approach is applied to the catalog of radio-bright blazars for which a promising directional correlation with IceCube muon tracks was recently reported [ApJ 894 (2020) 101, ApJ 908 (2021) 157].'

Collaborations
Antares,

Keywords and Comments
ANTARES, neutrino, blazars, Giulia Illuminati''

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Branch MM | Multi-Messenger

Subcategory Future projects

Titel
Astrophysical Implications of Neutrino Target-of-Opportunity Observations with Space-based and Suborbital Optical Cherenkov Detectors

Presenter
Tonia Venters
Author and Co-Author
Tonia Venters | Mary Hall Reno | John Krizmanic | For the EUSO-SPB2 and POEMMA Collaborations

Abstract
'Cosmic-ray accelerators capable of reaching ultra-high energies are expected to also produce very-high energy neutrinos via hadronic interactions within the source or its surrounding environment. Many of the candidate astrophysical source classes are either transient in nature or exhibit flaring activity. Leveraging the Earth as a neutrino converter, suborbital and space-based optical Cherenkov detectors will be able to detect upward-moving extensive air showers induced by decay tau-leptons generated from cosmic tau neutrinos (with energies ~ 10 PeV and above), reaching sensitivities at the level of modeled neutrino fluences for several classes of astrophysical transients. We discuss the astrophysical implications of neutrino Target-of-Opportunity observations with the super-pressure balloon mission EUSO-SPB2 and the proposed satellite-based mission POEMMA.'

Collaborations
other (fill field below), EUSO-SPB2; POEMMA

Keywords and Comments
Astrophysical transients, Neutrino detection, Multimessenger, Space-based experiments, Suborbital Experiments, Tonia Venters"

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Branch MM | Multi-Messenger

Subcategory Theoretical Methods

Titel
The Blazar Hadronic Code Comparison Project

Presenter
Matteo Cerruti
Author and Co-Author
Matteo Cerruti | Michael Kreter | Maria Petropoulou | Annika Rudolph | Foteini Oikonomou | Markus Böttcher | Stavros Dimitrakoudis | Anton Dmytriiev | Shan Gao | Susumu Inoue | Apostolos Mastichiadis | Kohta Murase | Anita Reimer | Joshua Robinson | Xavi

Abstract
'Blazar hadronic models have been developed in the past decades as an alternative to leptonic ones. In hadronic models the gamma-ray emission is associated with synchrotron emission by protons, and/or secondary leptons produced in proton-photon interactions. Together with photons, hadronic emission models predict the emission of neutrinos that are therefore the smoking gun for acceleration of relativistic hadrons in blazar jets. The simulation of proton-photon interactions and all associated radiative processes is a complex numerical task, and different approaches to the problem have been adopted in the literature. So far, no systematic comparison between the different codes has been performed, preventing a clear understanding of the underlying uncertainties in the numerical simulations. To fill this gap, we have undertaken the first comprehensive comparison of blazar hadronic codes, and the results from this effort will be presented in this contribution.'

Collaborations
Keywords and Comments
Blazar , Hadronic models, Neutrino, Gamma-rays, AGN, Numerical simulations, Matteo Cerruti"

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Interpretation of blazar flares of various types in a unified model

Presenter
Ze-Rui Wang
Author and Co-Author
Ze-Rui Wang | Ruo-Yu Liu | Maria Petropoulou | Foteini Oikonomou | Rui Xue | Xiang-Yu Wang

Abstract
'Blazars have very complex variability properties. They sometimes exhibit multi-wavelength and other times "orphan" flares in specific wavelength. Different models have been proposed to explain specific flares. In this paper, we propose a unified model to explain different blazar flares in the same framework naturally. We consider a model in which the emission of a blazar consists of two components during the flare period. One arises from a strong dissipation zone that may occur randomly along the jet. This component is responsible for the sudden enhancement of the blazar\'s flux. The other is a quasi-stable component, which results from the superposition of numerous but comparatively weak dissipation zones, which constitute background emission or the low state emission of the blazar. The spectral feature of a flare depends on the position where the strong dissipation occurs. Generally speaking, if the strong dissipation occurs at a small/large distance from the SMBH, the inverse Compton/synchrotron radiation dominates and an orphan $\\gamma$-ray/optical flare tends to appear. On the other hand, we may expect a multiwavelength flare if the dissipation occurs at a moderate distance. The model can be successfully applied to reproduce the spectral energy distribution of different flares from the flat spectrum radio quasar 3C 279 and the BL Lac object PKS 2155-304, respectively.'

Collaborations
other (fill field below), Nanjing University
Keywords and Comments
blazar, orphan flare, leptonic model, Zerui Wang''

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Suppression of the TeV pair-beam plasma instability by a weak intergalactic magnetic field

Presenter
Mahmoud Al-Awashra
Author and Co-Author
Mahmoud Al-Awashra | Martin Pohl

Abstract
"Several gamma-ray observations from distant blazars show a suppressed GeV band emission of the inverse Compton cascade of the blazar-induced pair beams. There are two possible justifications, the first one is the deflections of the pair beam electrons and positrons by magnetic fields in the intergalactic medium. The second one is the drain of the pair energy by plasma beam instabilities resulting in heating the cold intergalactic plasma. Commonly, the analytical studies of the plasma instabilities of blazar-induced pair beams in the literature assume a non-magnetized intergalactic medium. However, the existence of an intergalactic magnetic field with sufficient strength suppresses the plasma instabilities as we show in this paper. In this work, we investigate the effect of a weak intergalactic magnetic field, with a spatial scale much smaller than the pair beam energy loss scale, on the plasma instability. We found that such weak fields, even if they don't modify the dispersion relation describing the electrostatic waves, they increase the angular distribution of the particles in the beam, which in turn reduce the linear growth rate of the electrostatic instability. Taking into account two damping processes of the electrostatic waves, we approximate the energy loss time scale for the beam instability for each IGMF strength and spatial scale. Comparing this time with that for the inverse - Compton scattering, we found the limit in the ($B_\\text{IGM},$ $\\lambda_\\text{B}$) parameter space where the growth of the plasma oscillations starts to be suppressed."

Collaborations
Keywords and Comments
gamma rays: general - BL Lacertae objects: general - plasma instabilities - intergalactic magnetic fields, Mahmoud Al-Awashra"

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Neutrino Emission from Supermassive Binary Black Hole Mergers

Presenter
Ilja Jaroschewski
Author and Co-Author
Ilja Jaroschewski Oliver de Bruijn | Julia Becker Tjus | Peter L. Biermann | Imre Bartos | Wolfgang Rhode

Abstract
'The first high-probability association of an extragalactic neutrino to the blazar TXS 0506+056 in 2017 identified such active galaxies as potential high-energy neutrino emitters.Two distinct episodes of neutrino emission were detected within 3 years, indicating a possible periodicity. Such periodic behavior is explainable by a supermassive binary black hole system close to its merger as a result of jet precession and jet interactions with surrounding molecular clouds.\r\nWe present a model for predicting the arrival times of neutrino flares and gravitational waves for such systems and apply it on TXS 0506+056 assuming that it is an ongoing binary merger. We conclude that the next neutrino emission could already have occurred, possibly still hidden in IceCube’s not-yet-analyzed data, and deliver binary properties for a successful detection of its gravitational waves by LISA.\r\nAs supermassive black hole mergers could occur more frequently due to merging of\r\ntheir host galaxies, we further investigate a possible connection between their radiated gravitational wave energy and the diffuse astrophysical neutrino flux that is measured by IceCube. We estimate the contributions of these mergers and binary stellar mass black hole mergers in starburst galaxies on top to the diffuse neutrino flux.'

Collaborations

Keywords and Comments
AGN, Neutrinos, Gravitational Waves, Ilja Jaroschewski''

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Coincident neutrino and gamma-ray emission from blazars

Presenter
Marcel Schroller
Author and Co-Author
Marcel Schroller Julia Becker Tjus | Patrick Reichherzer | Ilja Jaroschewski | Mario Hörbe | Wolfgang Rhode

Abstract
'Active galactic nuclei (AGN), and the accompanied AGN jets, are some of\r\nthe most fascinating and luminous objects in the observable Universe.\r\nBoth the active cores and their jets are candidates for the engine of\r\ncosmic rays, gamma rays, and neutrinos with the highest energies measured at Earth.\r\nA deep understanding of the processes related to jets will not only\r\nfuel the field of high energy cosmic rays, but will also give insights in\r\nfundamental plasma, astro, and particle physics. The physical and\r\nmathematical modeling of an AGN jet is challenging, with ambiguous\r\nsignatures that need to be understood by numerical simulations of\r\ncosmic ray transport and interactions. Based on the work of Hoerbe et al.\r\n(MNRAS 2020), a simulation framework for hadronic constituents and\r\ntheir interactions inside of a plasmoid, propagating along the AGN jet\r\naxis, was made. The final goal of the simulation is to give\r\npredictions in the context of multimessenger astrophysics. This talk will present\r\nthe first results, discuss the question of diffusivity of the particles and examine the scenario, where neutrino and gamma-ray flares coincide.'

Collaborations

Keywords and Comments
AGN, AGN jets, Blazar, Neutrino, Gamma-rays, numerical, Marcel Schroller''

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Multimessenger Constraints on Intergalactic Magnetic Fields from Flaring Objects

Presenter
Andrey Saveliev
Author and Co-Author
Andrey Saveliev | Rafael Alves Batista

Abstract
'The origin of magnetic fields in the universe is an open problem. Seed magnetic fields possibly produced in early times may have survived up to the present day close to their original form, providing an untapped window to the primeval universe. The recent observations of high-energy neutrinos from the blazar TXS 0506+056 in association with an electromagnetic counterpart in a broad range of wavelengths can be used to probe intrinsic properties of this object and the traversed medium. Here we show that intergalactic magnetic fields (IGMFs) can affect the intrinsic spectral properties of this object reconstructed from observations. In particular, we point out that the reconstructed maximum gamma-ray energy of TXS 0506+056 can be significantly higher if IGMFs are strong. Finally, we use this flare to constrain both the magnetic-field strength and the coherence length of IGMFs.'

Collaborations
Keywords and Comments
blazars, TXS 0506+056, intergalactic magnetic fields, gamma rays, neutrinos, Andrey Saveliev"

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Possible photohadronic origin of the IC-201114A alert

Presenter
Alberto Rosales de Leon
Author and Co-Author
Alberto Rosales de Leon | Anthony M. Brown | Paula M. Chadwick

Abstract
'The Icecube neutrino observatory is a cubic-kilometer particle detector located at the South Pole. A system of public real-time alerts on neutrino candidate events likely to be of astrophysical origin has been operating since 2016. On November 14th 2020, a track-like event with a high probability of being of astrophysical origin (IC-201114A) was reported. 4FGL J0658.6+0636, a source of the blazar type, was identified inside the 90% localisation region of the alert 0.8° from the best-fit event position by the Fermi-LAT collaboration. In this work, we analyse 12.3 years of Fermi-LAT data from 4FGL J0658.6+0636. No indication of significant gamma-ray activity was found around the time of the alert, however, two periods in which the source was detected significantly were identified and studied considering a lepto-hadronic scenario. We investigate a possible photohadronic origin for high energy neutrinos and calculate the gamma-ray contribution to the spectral energy distribution (SED). The predicted neutrino flux and the expected time for a neutrino detection from the source during a flaring state were calculated for the periods of significant activity. Assuming the historical behaviour of the source, an approximation of the gamma-ray and neutrino flux coming from photohadronic interactions around the IC-alert is also given.'

Collaborations
Keywords and Comments
Gamma-rays, Blazars, Neutrinos, High energy astrophysics, Alberto Rosales de Leon''

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
PeV-EeV neutrinos from gamma-ray blazars due to ultrahigh-energy cosmic-ray propagation

Presenter
Saikat Das
Author and Co-Author
Saikat Das Nayantara Gupta | Soebur Razzaque

Abstract
'Blazars are potential candidates of cosmic-ray acceleration up to ultrahigh energies ($E > 10^{18}$ eV). For an efficient cosmic-ray injection from blazars, $p\\gamma$ collisions with the extragalactic background light (EBL) and cosmic microwave background (CMB) can produce neutrino spectrum with peaks near PeV and EeV energies, respectively. We analyze the contribution of these neutrinos to the diffuse background measured by the IceCube neutrino observatory. The fraction of neutrino luminosity originating from individual redshift ranges is calculated using the distribution of BL Lacs and FSRQs provided in the \\textit{Fermi}-LAT 4LAC catalog. Furthermore, we use a luminosity dependent density evolution to find the neutrino flux from unresolved blazars. The results obtained in our model indicate that as much as $\\approx10\\%$ of the flux upper bound at a few PeV energies can arise from cosmic-ray interactions on EBL. The same interactions will also produce secondary electrons and photons, initiating electromagnetic cascades. The resultant photon spectrum is limited by the isotropic diffuse $\\gamma$-ray flux measured between 100 MeV and 820 GeV. The latter, together with the observed cosmic-ray flux at $E>10^{16.5}$ eV, can constrain the baryonic loading factor depending on the maximum cosmic-ray acceleration energy.'

Collaborations

Keywords and Comments
Gamma-Rays, Blazars, Neutrino Astronomy, High-energy cosmic rays, Saikat Das'Accepted for Publication in \r\nThe Astrophysical Journal\r\narXiv e-print: https://arxiv.org/abs/2012.13877'

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Subcategory Theoretical Results

Titel
Study of the production of high-energy neutrinos in the environment of binary-neutron-star mergers.

Presenter
Simone Rossoni
Author and Co-Author
Simone Rossoni Denise Boncioli | Guenter Sigl

Abstract
'Gamma-rays and neutrinos are important probes of astrophysical sources and acceleration mechanisms of ultra-high energy cosmic rays (UHECRs). UHECRs can interact with the radiation field and the baryonic material within the source and produce neutrinos in pion decay chains. These neutrinos are subject mostly to redshift and flavour oscillation during their propagation to Earth and contain information on sources otherwise not accessible.\r\nWe focus on compact objects surrounded by an accretion disk, of the type that are likely end states of a binary-neutron-star (BNS) merger. We model the target photon field in the source as a black body, using a modified version of the code SimProp v2r4 to simulate the propagation and interactions of UHECRs in this environment. We explore various combinations for composition, spectral index, high-energy cutoff of the UHECR primaries.\r\nThe neutrino fluxes arriving at Earth are compared to the astrophysical IceCube flux, and some constraints on the BNS merger rate can be deduced.'

Collaborations

Keywords and Comments
High-energy neutrinos,Binary-neutron-star merger,Cosmic ray interactions, Simone Rossoni''

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Improved Limits on Cosmogenic Fluxes from Ultra-High Energy Cosmic Rays

Presenter
Kathrine Mørch Groth
Author and Co-Author
Kathrine Mørch Groth Yoann Génolini | Markus Ahlers

Abstract
'Ultra-high energy cosmic rays (UHE CRs) interacting with the cosmic radiation background produce two cosmogenic messengers: neutrinos with energies in the EeV range and gamma rays accumulating in the GeV-TeV range. The most optimistic scenario for cosmogenic fluxes assumes the dominance of protons above the Greisen-Zatsepin-Kuzmin threshold of resonant scattering with photons in the cosmic microwave background. Whereas these optimistic cosmogenic fluxes are testable with present observatories, the corresponding predictions of heavier UHE CR composition models are orders of magnitude smaller, falling within the domain of more sensitive future detectors. In this study we use the latest results of the Pierre Auger observatory for the UHE CR spectrum and chemical composition to derive conservative lower limits on the cosmogenic neutrino and gamma ray fluxes. We investigate the prospects and requirements of future large-scale neutrino and CR observatories to observe these fluxes.'

Collaborations

Keywords and Comments
Ultra-high energy cosmic rays, Cosmogenic neutrinos, Cosmogenic gamma-rays, High energy neutrino astronomy, Kathrine Groth"

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
An AGN-starburst composite multi-messenger model of NGC 1068

Presenter
Ralf-Jürgen Dettmar
Author and Co-Author
Björn Eichmann Ralf-Jürgen Dettmar

Abstract
'Recent multi-wavelength observations indicate that some starburst galaxies show a dominant nonthermal contribution from its central region. These active galactic nuclei (AGN)-starburst composites are of special interest, as both phenomena on their own are potential sources of high-energetic cosmic rays. In this presentation we will focus on NGC 1068, which is known since several years from its atypical radio-gamma-ray correlation. Recently this source has also shown strong indications of high energy neutrino emission. We present a first semi-analytical, two-component multi-messenger model that gives some constraints on the AGN-starburst composite characteristics of NGC 1068.'

Collaborations
Keywords and Comments
NGC 1068, starburst, AGN, Björn Eichmann"

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Branch	MM | Multi-Messenger
Subcategory	Theoretical Results

Titel
Multi-zone model as origin of hard gamma-rays spectrum in extreme BL Lacs

Presenter
Edilberto Aguilar
Author and Co-Author
Edilberto Aguilar | Nissim Fraija

Abstract
"The emission of the so-called extreme blazars challenges the particle acceleration models. The hardness of its spectrum, <2, demands extreme parameters using the standard one-zone SSC model in the high energy band. Some authors use both two-zone or hadronic/leptohadronic models to relax these extreme values. In this work, we present a leptohadronic multi-zone model to explain the broadband emission, where the contribution of two components forms the hard-spectrum in the $\\gamma$-rays band. The first is produced by the photopion process, where accelerated protons in an inner blob located close to the core interact with the X-ray photons coming from a pair plasma. This mechanism will be responsible for $\\gamma$-rays in the TeV's energies range. The second component is produced by an outer blob, which corresponds to the source of X-rays and $\\gamma$-rays via the standard SSC model. Additionally, neutrinos with $\\sim$ TeV's energies are expected and could be restricted by IceCube's observations."

Collaborations

Keywords and Comments
Blazar emission, gamma rays, Cosmic Rays, Astrophysical Neutrinos., Edilberto Aguilar"

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Black-hole X-ray binaries in the new era of multi-messenger astronomy

Presenter
Dimitrios Kantzas
Author and Co-Author
Dimitrios Kantzas Sera Markoff | Matteo Lucchini | Atul Chhotray | Chiara Ceccobello

Abstract
'Since their discovery, cosmic rays (CRs) remain among the most mysterious phenomena of modern physics. The dominant sources, as well as the exact acceleration mechanisms, remain unknown. The CRs up to the knee, are considered to originate in the shock waves of supernova remnants, however, due to the lack of a “smoking-gun” TeV counterpart in many cases, this scenario has been recently questioned. In this talk, I will motivate how the small-scale analogues of active galactic nuclei (AGN), namely black-hole X-ray binaries (BHXBs), can potentially contribute to the Galactic CR spectrum. To investigate this idea, I developed a new, multi-zone, lepto-hadronic jet model to take advantage of the entire broadband multiwavelength spectra observed by BHXBs. I applied this model to the first-ever simultaneous radio-to-X-ray spectrum of Galactic BHXB Cygnus X-1 obtained in 2016 (via the CHOCBOX program), and to a quasi-simultaneous dataset of another Galactic BHXB, GX339-4, during a bright outburst in 2010. In this talk, I will discuss how the different assumptions on proton acceleration affect both the jet properties and the observed spectrum. In particular, I will focus on the GeV-to-TeV regime and discuss its strong dependence on the rest of the multiwavelength spectrum. Finally, I will discuss the implication of my results for the next-generation gamma-ray facilities, such as the Cherenkov Telescope Array (CTA), as well as next-generation neutrino detectors, such as KM3NeT, concluding how they can help to constrain the potential BHXB contribution to the Galactic CR spectrum.'

Collaborations

Keywords and Comments
XRBs, gamma-rays, Galactic sources, black holes,, Dimitrios Kantzas"

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Modelling TXS0506+056 with internal $\gamma -\gamma$ secondaries

Presenter
sunanda .
Author and Co-Author
sunanda . | Reetanjali Moharana

Abstract
'A flare in 2017 from TXS0506+056 has 3.5$\\sigma$ spatial as well as temporal correlation with IceCube-170922A neutrino event above energy 290 TeV. The multi-wavelength modeling of the source is one of the viable way to figure out its energetics to produce neutrino. Several models on considering lepto -hardronic channels to produce the gamma rays and neutrino from this blazar has already been done. We report here the secondary contribution resulted from the $\\gamma -\\gamma \\rightarrow e^+e^-$ interaction between self synchrotron (SSC) and synchrotron photon in the blazar TXS0506+056. This study would help in understanding the maximum energy of the electrons produced at the source.'

Collaborations
Keywords and Comments
AGNs, Neutrinos, Gamma rays, Sunanda .'Presenter Sunanda'

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Rigorous theory for the spectrum of secondary cosmic-ray electrons

Presenter
Alexei Ivlev
Author and Co-Author
Alexei Ivlev | Kedron Silsbee | Marco Padovani | Daniele Galli

Abstract
'CRs interacting with the gas generate electron-ion pairs, with electrons having sufficient energy to produce further ionization. These processes of primary and secondary ionization are characterized by the respective ionization rates, $\\zeta_p$ and $\\zeta_{\\rm sec}$. While $\\zeta_p$ can be straightforwardly derived for a given CR spectrum, computing $\\zeta_{\\rm sec}$ is a much more subtle task.\r\n\r\nWe derive a balance equation for the energy spectrum of secondary electrons, which is similar to the degradation equation by Spencer & Fano. This allows us to rigorously compute the spectrum of electrons produced in molecular gas by interstellar CRs as a function of gas column density N traversed by the CRs, and thus accurately calculate characteristics of various important processes driven by CRs, such as the generation of UV and X-ray photons, gas heating, production of atomic hydrogen, etc.\r\n\r\nIn particular, we compute the local value of the secondary ionization rate of molecular hydrogen, $\\zeta_{\\rm sec}(N)$, as a function of the local primary ionization rate, $\\zeta_p(N)$. We show that the ratio $\\zeta_{\\rm sec}/\\zeta_p$ increases monotonically with N, and can considerably exceed the value of $\\approx0.67$ commonly adopted in the literature. The dependence $\\zeta_{\\rm sec}/\\zeta_p$ versus N is practically insensitive to the particular shape of the interstellar CR spectrum, and thus is a general characteristic of the secondary CR ionization in dense gas.'

Collaborations
Keywords and Comments
, Alexei Ivlev''

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Branch MM | Multi-Messenger

Subcategory Theoretical Results

Titel
Millisecond Pulsars Modify the Radio-SFR Correlation

Presenter
Takahiro Sudoh
Author and Co-Author
Takahiro Sudoh | Tim Linden | John Beacom

Abstract
'The observed correlation between the far-infrared and radio luminosities of galaxies illustrates the close connection between star formation and cosmic-ray production. Intriguingly, recent LOFAR observations find a peculiar radio excess in galaxies with low star-formation rates and high stellar masses. We show that recycled/millisecond pulsars (MSPs) can dominate the nonthermal emission in these massive quiescent galaxies and explain the excess. This is in line with recent gamma-ray observation suggesting that MSPs may also efficiently accelerate cosmic-ray electrons. We find that MSP-based models provide a significantly improved fit to the LOFAR data. We discuss the implications for the radio and gamma-ray excesses in M31 and local electron and positron observations.'

Collaborations

Keywords and Comments
Pulsars, cosmic-ray electrons, radio emission, galaxies, Takahiro Sudoh"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Simulation of the propagation of CR air shower cores in ice

Presenter
Simon De Kockere
Author and Co-Author
Simon De Kockere | Krijn de Vries | Nick van Eijndhoven

Abstract
'Currently new techniques are being explored to detect astrophysical neutrinos beyond the PeV scale interacting in polar ice by means of the emitted radio waves. Due to the long attenuation length of radio waves in a medium, it can be expected that such instruments will also be sensitive to the in-air radio emission of cosmic ray air showers. Furthermore, cosmic ray air showers hitting a high-altitude layer of ice will initiate an in-ice particle cascade, also leading to radio emission. We present the first results of detailed simulations of these cosmic-ray induced particle cascades in ice, using a combination of the CORSIKA Monte Carlo code and the Geant4 simulation toolkit. We give an overview of the general features of such particle cascades and present a parameterization in terms of Xmax of the longitudinal and lateral particle distributions. We discuss the feasibility of observing the in-ice particle cascades, both through the detection of the Askaryan radio emission as well as by using RADAR reflection techniques. Based on these results we find that the expected signals from the in-ice cosmic-ray induced particle cascades will be very similar to neutrino signals. This means a thorough understanding of these events is necessary in the search for neutrino candidates, while it also promises an interesting in-situ natural calibration source.'

Collaborations
other (fill field below), ARA (Askaryan Radio Array); RNO-G (Radio Neutrino Observatory Greenland); RET (Radar Echo Telescope)

Keywords and Comments
simulation, CORSIKA, Geant4, cosmic rays, ice, radio, RADAR, parameterization, Simon De Kockere'We believe this subject is mostly of interest for people aiming to detect astrophysical neutrinos by means of the detection of emitted radio waves, and therefor indicate the "NU | Neutrinos & Muons" track. However, as the subject of the talk itself is co

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Energy reconstruction with the Radio Neutrino Observatory Greenland (RNO-G)

Presenter
Christoph Welling
Author and Co-Author
Christoph Welling

Abstract
'Starting in summer 2021, the Radio Neutrino Observatory Greenland (RNO-G) will search for cosmic neutrinos with energies above 10PeV by detecting Askaryan radio emission from particle showers in the ice of Greenland. It will consist of 35 independent detector stations, each featuring 24 antennas deployed up to a depth of 100m. To cover a large volume, stations are spaced over 1km apart, so that in most cases, a detection will only be made by a single station. Combined with the low signal-to-noise ratio expected for most events, this makes their reconstruction challenging. On this poster, we show how the energy of a detected neutrino can still be reconstructed, which will be important in order to interpret any detected neutrinos and distinguish between astrophysical and cosmogenic neutrino flux.'

Collaborations
other (fill field below), RNO-G
Keywords and Comments
radio, high-energy neutrinos, event reconstruction, RNO-G, Christoph Welling"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Supernova Neutrino Detection with LHAASO-MD

Presenter
Dong Liu
Author and Co-Author
Dong Liu | Jinfan Chang | Shaomin Chen | Hongliang Dai | Cunfeng Feng | Bo Gao | Guanghua Gong | Minhao Gu | Fei Li | Xinhua Ma | Xi Wang | Zhe Wang | Xiong Zuo | on behalf of the LHAASO collaboration

Abstract
'The core-collapse supernova releases a tremendous number of neutrinos, which can provide insight into many research areas, including particle physics, astrophysics, nuclear physics, and cosmology. We can detect the signal through a positron produced from the inverse beta decay (IBD) interaction between the electron antineutrino and water. The Large High Altitude Air Shower Observatory Main detector (LHAASO-MD) with 51-kton water can serve this purpose. The MD detectors have been designed to have a scattered layout as well as spatial uniformity. We have designed a dedicated supernova trigger system in the data acquisition system to take advantage of these unique detector characteristics. The large numbers of MeV-scale supernova burst neutrinos can be observed from a collective rise in all photomultiplier rates on top of the dark noise. This system effectively suppresses the cosmic ray background, optimizes the neutrino detection sensitivity, and realizes the supernova neutrino detection by optimizing the online trigger, data acquisition, and offline data analysis at LHAASO. The trigger system is estimated to be fully sensitive to 1987A-type supernova bursts throughout most of the Milky Way and can eventually help LHAASO join the SuperNova Early Warning System (SNEWS).'

Collaborations
Lhaaso,
Keywords and Comments
supernova, neutrino , inverse beta decay , LHAASO, trigger, Dong Liu"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Studies of systematic uncertainty effects on IceCube's real-time angular uncertainty

Presenter
Cristina Lagunas Gualda
Author and Co-Author
Cristina Lagunas Gualda | Yosuke Ashida | Ankur Sharma

Abstract
'Sources of astrophysical neutrinos can be potentially discovered through the detection of neutrinos in coincidence with electromagnetic or gravitational waves. Real-time alerts generated by IceCube play an important role in this search since they act as triggers for follow-up observations with instruments sensitive to other wavelengths. \r\n\r\nOnce a high-energy event is detected by the IceCube real-time program, a complex and time-consuming method is run in order to calculate an accurate localisation. To investigate the effect of systematic uncertainties on the uncertainty estimate of the location, we simulate a set of high-energy events with a wide range of directions for different ice model realisations. This makes use of a novel simulation tool, which allows the treatment of systematic uncertainties with multiple continuously varied nuisance parameters. These events are then reconstructed using various reconstruction methods. This study will enable us to include systematic uncertainties in a robust manner in the real-time direction and error estimates.'

Collaborations
IceCube,

Keywords and Comments
, Cristina Lagunas Gualda''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Low energy radioactivity BG model in Super-Kamiokande detector from SK-IV data

Presenter
Guillaume Pronost
Author and Co-Author
Guillaume Pronost

Abstract
"The radioactivity background are among the main backgrounds (BGs) affecting low energy neutrino analysis in Super-Kamiokande (SK), like the solar neutrino analysis. Among them, the main contribution is coming from Rn-222, which is spread in the detector's water due to the water source and to the PMTs emanations. However, up to now, its exact distribution in the detector was not known. Using our knowledge of the radon concentration in the detector water, and the SK-IV solar data, we developed a model of the radon distribution in the detector. We also studied and modeled the impact of the Tl-208 decays from the PMTs, which affect the same energy region than Rn-222.\r\n\r\nThis model will allow to improve our understanding of the low energy BGs affecting the SK experiment, it could also be useful for future experiments like Hyper-Kamiokande."

Collaborations
, Super-Kamiokande
Keywords and Comments
Neutrino, Radon, Model, Low background, Guillaume Pronost"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Short-Baseline neutrino oscillation searches with the ICARUS detector

Presenter
Umut Kose
Author and Co-Author
Alessandro Menegolli | Umut Kose

Abstract
'The ICARUS collaboration employed the 760-ton T600 detector in a successful three-year physics run at the underground LNGS laboratories studying neutrino oscillations with the CNGS neutrino beam from CERN, and searching for atmospheric neutrino interactions. ICARUS performed a sensitive search for LSND-like anomalous $\\nu_e$ appearance in the CNGS beam, which contributed to the constraints on the allowed parameters to a narrow region around 1 eV^2, where all the experimental results can be coherently accommodated at 90% C.L. After a significant overhaul at CERN, the T600 detector has been installed at Fermilab. In 2020 cryogenic commissioning began with detector cool down, liquid Argon filling and recirculation. ICARUS has started operations and is presently in its commissioning phase with the aim of collecting the first neutrino events from the Booster Neutrino Beam and the NuMI off-axis beam. The main goal of the first year of ICARUS data taking will then be the definitive verification of the recent claim by NEUTRINO-4 short baseline reactor experiment both in the $\\nu_\\mu$ channel with the BNB and in the $\\nu_e$ with NuMI. After the first year of operations, ICARUS will commence its search for evidence of a sterile neutrino jointly with the SBND near detector, within the Short Baseline Neutrino (SBN) program. The ICARUS exposure to the NuMI beam will also give the possibility for other physics studies such as light dark matter searches and neutrino-Argon cross section measurements. The proposed contribution will address ICARUS achievements, its status and plans for the new run at Fermilab and the ongoing developments of the analysis tools needed to fulfill its physics program.'

Collaborations
other (fill field below), ICARUS

Keywords and Comments
Sterile neutrinos, Liquid argon TPC,, Alessandro Menegolli"The abstract is being submitted by the chair of the Speaker's Board of the ICARUS Collaboration. Therefore the name is only a placeholder. The final name of the speaker will be communicated after the talk will be confirmed."

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Sensitivity estimates for diffuse, point-like and extended neutrino sources with KM3NeT/ARCA

Presenter
Rasa Muller
Author and Co-Author
Rasa Muller | Alfonso Garcia Soto | Aart Heijboer | Barbara Caiffi | Vladimir Kulikovskiy | Matteo Sanguineti

Abstract
'The identification of cosmic objects emitting high energy neutrinos could provide new insights about the Universe and its active sources. The existence of these cosmic neutrinos has been proven by the IceCube collaboration, but the big question of which sources these neutrinos originate from, remains unanswered. The KM3NeT detector for Astroparticle Research with Cosmics in the Abyss (ARCA), with a cubic kilometer instrumented volume, is currently being built in the Mediterranean Sea. It will excel at identifying cosmic neutrino sources due to its unprecedented angular resolution for muon neutrinos (< 0.2 degree for E > 10 TeV events). KM3NeT has a view of the sky complementary to IceCube, and is sensitive to neutrinos across a wide range of energies. In order to identify the signature of cosmic neutrino sources in the background of atmospheric neutrinos and muons, statistical methods are being developed and tested with Monte-Carlo pseudo-experiments. This contribution presents the most recent sensitivity estimates for diffuse, point-like and extended neutrino sources with KM3NeT/ARCA.'

Collaborations
KM3NeT,

Keywords and Comments
Sensitivity, high energy, cosmic neutrinos, diffuse flux, point sources, extended sources, astroparticle physics, KM3NeT, ARCA,, Rasa Muller''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Enhancing IceCube's sensitivity to extremely high energy neutrinos: Study on improved rejection of muon bundle background

Presenter
Maximilian Meier
Author and Co-Author
Maximilian Meier

Abstract
'Observations of cosmogenic neutrinos with energies above 10^8 GeV provide a unique probe of the origin of cosmic rays at energies near the GZK cutoff. In IceCube, high-multiplicity muon bundles from cosmic-ray air showers are a major background in the search for cosmogenic neutrino events. The classification of single muons with IceCube is a challenging task because individual muons within a bundle cannot be resolved. However, the stochasticity of muons increases with energy, so that single muons and muon bundles can be distinguished using differences in their energy loss profiles. We present an improvement to the event selection of extremely high energy neutrinos with IceCube by more effectively identifying and rejecting high multiplicity muon bundles.'

Collaborations
IceCube,
Keywords and Comments
, Maximilian Meier"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Design of a Robust Fiber Optic Communications System for Future IceCube Detectors

Presenter
Robert Halliday
Author and Co-Author
Robert Halliday | Tyce DeYoung | Chris Ng | Darren Grant | Brian Ferguson | For the IceCube Collaboration

Abstract
"In this work we discuss ongoing development of a hybrid fiber optic/electrical data and timing infrastructure for the future IceCube Gen2 detector. The IceCube Neutrino Observatory is a kilometer-scale detector operating with 86 strings of modules. These modules communicate and transfer time stamps utilizing a custom protocol to mitigate the challenges of multi-kilometer cables such as signal attenuation, crosstalk and power delivery. Moving past the limitations of a copper-based backbone will enable larger future IceCube detectors with sub-nanosecond timing and approximately six times IceCube's current per-sensor throughput to accommodate innovative future modules. To this end, the upcoming IceCube Upgrade offers an opportunity to deploy a pathfinder for the new fiber optic infrastructure, called the Fiber Test System. This design draws on experience from AMANDA and IceCube and incorporates recently matured technologies such as ruggedized fibers and White Rabbit timing to deliver robust and high-performance data and timing transfer."

Collaborations
IceCube,
Keywords and Comments
IceCube, Fiber, White Rabbit, DAQ, Networking, Neutrinos, Astrophysics, Precision Timing, Robert Halliday"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
An End-to-End Test of the Sensitivity of IceCube to the Neutrino Burst from a Core-Collapse Supernova

Presenter
Spencer Griswold
Author and Co-Author
Spencer Griswold

Abstract
'The next Galactic supernova presents a once-in-a lifetime opportunity to obtain detailed information about the explosion of a star and the extreme conditions found within its core. A core-collapse supernova will produce a neutrino burst visible up to half a day before electromagnetic radiation from the explosion, so the burst will provide an early warning for optical follow-up. Since local supernovae are exceedingly rare, it is critical that neutrino detectors provide prompt alerts after the arrival of a burst. The IceCube Neutrino Observatory operates with >99% uptime and is sensitive to a variety of supernova models at levels >10σ within the Milky way. Also, the IceCube Supernova Data Acquisition (SNDAQ) online triggering system is capable of issuing alerts within 7 minutes of a triggering event. IceCube’s high sensitivity, near perfect uptime, and ability to issue prompt alerts makes it a critical component of the worldwide network of detectors known as the SuperNova Early Warning System (SNEWS 2.0). A "fire drill" system was designed to inject false supernova signals into the IceCube online systems, upstream in the data pipeline from SNDAQ. We will discuss IceCube’s sensitivity to supernova near the Milky Way, and describe the data challenges used to ensure the readiness of SNDAQ, the IceCube Neutrino detector and its operators. We will also discuss coordination of IceCube alerts and data challenges with SNEWS 2.0.'

Collaborations
IceCube,

Keywords and Comments
, Spencer Griswold''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Exploring the Potential of Multi-Detector Analyses for Core-Collapse Supernova Neutrino Detection

Presenter
Meriem Bendahman
Author and Co-Author
Meriem Bendahman Alexis Coleiro | Marta Colomer Molla | Jaime Dawson | Gwenhaël De Wasseige | Thierry Foglizzo | Davide Franco | Jérôme Guilet | Antoine Kouchner | Matteo Bugli | Jérôme Novak | Micaela Oertel | Aurélien Pascal | Thomas Patzak | Sabrina Sacerdoti | Yahy

Abstract
'The core-collapse supernova (CCSN) SN1987A has been the first extragalactic transient source observed in neutrinos, and the 25 events detected by the neutrino telescopes running at the time marked the beginning of neutrino astronomy. Despite the very large number of CCSNs detected in the electromagnetic spectrum since 1987, neutrino telescopes could not perform another observation due to the far distances of the sources. It is thus of primary importance to optimize the detection channel of sensitive detectors in anticipation of a forthcoming Galactic CCSN. Beyond being used as an early warning of a close-by CCSN, neutrinos can provide unique information on the explosion mechanisms, and can be used to probe neutrino flavor evolution in dense environments. In this contribution, we will present the potential of multi-detector analyses to enhance the scientific outputs from the next close-by CCSN. Combining the expected light curves in neutrino detectors sensitive to different flavors, we will study the constraints that could be set on the properties of the progenitor itself, such as its mass, as well as on the neutrino oscillation parameters. We will also present the results of a triangulation algorithm using a prior source map in the definition of the region of interest.'

Collaborations

Keywords and Comments
Core-collapse supernova, Neutrino, Light curve, Meriem Bendahman"

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Branch Dark Matter

Subcategory Experimental-Methods-and-Instrumentation

Titel
Towards observations of nuclearites in Mini-EUSO

Presenter
Lech Piotrowski

Author and Co-Author

Abstract
Mini-EUSO is a small orbital telescope with a field of view of 44x44 deg, observing the night-time Earth mostly in 320-420 nm band. Its time resolution spanning from microseconds (triggered) to milliseconds (untriggered) and more than 300x300 km of the ground covered, allows it to register thousands of meteors. Such detections make the telescope a suitable tool in the search for hypothetical heavy compact objects, which would leave trails of light in the atmosphere due to their high density and speed. The most prominent example are the nuclearites - hypothetical lumps of strange quark matter that could be stabler and denser than the nuclear matter.rnrnThe presentation will focus on the discovery potential of Mini-EUSO in this area, as well as experimental challenges exemplified by the observed meteors

Collaborations
JEM-EUSO

Keywords and Comments

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Detection of Small-Scale Components in Power Law Spectra via the Applicaton of Functional Data Analysis

Presenter
Tim Ruhe
Author and Co-Author
Tim Ruhe | Wolfgang Rhode

Abstract
'Spectra in astroparticle physics are commonly approximated by simple power laws. The steeply falling nature of these power laws, however, makes the detection of additional components rather challenging. This holds true especially, if the additional components are small compared to the established ones. Energy spectra of muon neutrinos are an interesting example of such a scenario, where the conventional and astrophysical components to the spectra have been established by the use of different analysis methods, such as likelihood fits or spectral deconvolution. The prompt component, although expected from theoretical models, has not yet been experimentally observed. This contribution presents a different approach to the analysis of power-law spectra, which is based on functional data analysis. The method itself and its implications are discussed using neutrino energy spectra as an example. Furthermore, the required resolution in future deconvolutions of energy spectra is estimated.'

Collaborations
Keywords and Comments
power-law spectra, data analysis, prompt neutrinos, atmospheric neutrinos, Tim Ruhe"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
KM3NeT Core Collapse Supernovae observation program in standalone and multi-messenger modes

Presenter
Vladimir Kulikovskiy
Author and Co-Author
Damien Dornic | Massimiliano Lincetto | Marta Colomer Molla | Alexis Coleiro | Vladimir Kulikovskiy

Abstract
'The KM3NeT research infrastructure in the Mediterranean is a multi-purpose cubic-kilometer neutrino observatory consisting of two detectors optimized to study cosmic and atmospheric neutrinos between GeV to PeV energies. Additionally, KM3NeT multi-photomultiplier optical modules allow the detection of nearby MeV interaction products by selecting nanosecond coincidences within the photomultipliers of the same module. Distribution of the number of photomultipliers forming a coincidence (multiplicity) for the whole supernova emission behaves as a proxy of the average neutrino energy. An optimised coincidence selection allows the KM3NeT detectors to be sensitive to Galactic supernovae and beyond. The large KM3NeT effective volume allows a high number of detected events for a core collapse supernovae explosion and the measurement of the neutrino light curve properties, such as the light curve start time and the presence of the standing accretion shock instability oscillations. Sub-millisecond time synchronization between KM3NeT detectors allows common observation. Such a scheme can be also a viable solution to synchronize the KM3NeT telescopes with other detectors aiming to observe neutrino emission from core collapse supernovae through the SNEWS network.'

Collaborations
KM3NeT,

Keywords and Comments
supernova, neutrinos, Vladimir Kulikovskiy'on behalf of KM3NeT collaboration'

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Muography in the Andes region: applications on geophysics, industry, mining and safeguard applications in Latin America

Presenter
Hernán Asorey
Author and Co-Author
Hernán Asorey

Abstract
'Nowadays muography is a fast-evolving and non-invasive imaging technique, and it is a direct application of basic research in astroparticle physics with important social impacts, such as its usage for the evaluation of volcanic risks. Coming from several astroparticle and high energy physics institutions in Latin American, we are building a new collaboration involving several scientists from Colombia, Perú and Argentina. In this work, we summarize the research, developments and innovative designs of new modular muographers we are carrying out in the Andes region, with special emphasis on their applications in geophysics, underground laboratories basic research, mining prospection, industry, and safeguard.'

Collaborations
other (fill field below), TBA
Keywords and Comments
Muography, geophysics, astroparticle detectors, Hernán Asorey'We submitted several papers on this conference in different topics of muography, so we are planning to include a talk to summarize all the involved developments. In case you think it is not necessary, please feel free to not accept this contribution. Th

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Design of four pixels (2x2) Muon Modular Wireless Detector

Presenter
Daniel Alejandro Almela
Author and Co-Author
Daniel Alejandro Almela Juan Vega | Rolando Calderón-Ardila | Manuel Garcia Redondo | Nicolas Leal | Adrian Rielo | Adrian Sedoski Croce | Carlos Varela | Mariano Gómez Berisso | Luis Otiniano | Hernán Asorey

Abstract
'Currently, available muon detectors are bulky, heavy, and difficult to transport. Their use are limited to dedicated laboratory facilities or specific study sites. A modular wireless muon detector will facilitate transportation and installation in-situ. Furthermore, a modular detector allows adapting its geometry to optimize the study of the object of interest. These detectors would improve and facilitate measurements primarily in applications related to geophysics, civil structures, and nuclear materials.\r\nThis work presents the design of a modular wireless detector with four \$41\\,mm \\times 41\\,mm\$ pixels, in a \$2 \\times 2\$ array. Muon detection will be performed using coincidence techniques between plastic scintillator strips based on the experience of The Pierre Auger Observatory in Mendoza, Argentina. The light produced by the scintillators will be measured using silicon photomultipliers together with an electronic system providing signal conditioning and processing. The first prototypes of these detectors will be built using 3D printers and will be organized into arrays of planes to allow reconstruction of the muon trajectory.\r\nThe signals from the modules must be communicated to a centralized processing system, which will search for temporal matches and determine the direction of arrival of the particles. This system must provide flexibility to operate with a variable amount of detectors. To achieve this flexibility, the modules must be synchronized to allow a uniform identification of events. The module electronics will also be equipped with a monitoring system able to sense operational and environmental variables. Telemetry and measurement data will be pre-analysed by the detector electronics and transferred via a wireless communication system using low-cost radio modules.'

Collaborations
other (fill field below),
Keywords and Comments
Muon Detectors, Wireless Detectors, Muography, Coincidence Detectors, Daniel Alejandro Almela"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Methods & Instrumentation

Titel
Development muon detectors using doble-synchronized electronics detection for geophysical applications

Presenter
Rolando Calderón-Ardila
Author and Co-Author
Rolando Calderón-Ardila Alejandro Almela | Adrian Sedoski Croce | Carlos Varela | Nicolas Leal | Mariano Gómez Berisso | Hernán Asorey

Abstract
'Muography is an imaging technique that uses the absorption of the directional flux of atmospheric muons to study geophysical objects or strategic structures. This is possible by constructing an image based on the differential absorption of the muon flux produced during the interaction of cosmic rays with the atmosphere.\r\n \r\nIn this work we present a development and implementation of a modular muon detector that aims to improve spatial resolution for each panel. Our detector uses plastic scintillators with embedded WLS fibers and multi-anode photomultipliers (64 anodes, 1 dynode). In this case the improvement in resolution and performance is achieved by the modular design and double synchronized detection at the end of each scintillator bar. Our panel prototype is made of 24 scintillators of (4.1cmx1cmx100cm) consisting of 4 arrays of 12 crossbars with a photomultiplier at each end. The modular configuration of the panels allows to change the panel geometries (in size and in shape) adapting to the studied object, allowing to obtain faster or more detailed muography images. \r\n\r\nThe detection technique is based on an analytical model used for the calibration of each photomultiplier and the collected signals at the dynode as reference. With this, we are able to find the operating point for each photomultiplier. To improve the resolution, we take advantage of the photomultiplier at each end of the bars to determine the muon passage using the previous model to account for the signal attenuation in each anode, and then determine the position of the incoming muon with sub-pixel spatial resolution. This novel strategy is optimized to increase the spatial resolution by at least a factor of two.'

Collaborations
Keywords and Comments
Muography, Volcanoes, Muon Imaging, Cosmic-ray muons,\r\nAstroparticle Techniques, Experimental Particle Physics., Rolando Calderón-Ardila"

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Branch	NU | Neutrinos & Muons
Subcategory	Experimental Methods & Instrumentation

Titel
KM3NeT Acquisition Electronics: New Developments and Advances in Reliability

Presenter
Diego Real
Author and Co-Author
Diego Real | David Calvo | Vincent Van Beveren | Peter Jansweijer | Paolo Musico | Stephane Colonges | Giuliano Pellegrini

Abstract
'The KM3NeT Collaboration is currently building a neutrino observatory at the bottom of the Mediterranean Sea. The telescopes are equipped with thousands of Digital Optical Modules hosted in glass spheres, instrumenting a volume of several cubic kilometers. The acquisition electronics is housed inside the glass sphere performing the readout of the 31 PMTs of the Digital Optical Module. In the present work is presented the latest developments in the acquisition electronics including the increase in efficiency on the Power Board, the new developments on the Central Logic Board and the different reliability methods used in KM3NeT to make the acquisition electronics more reliable.'

Collaborations
KM3NeT,
Keywords and Comments
Acquisition electronics, electronics reliability, Diego Real"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
First direct evidence of the CNO fusion cycle in the Sun with Borexino

Presenter
Sindhujha Kumaran
Author and Co-Author
Sindhujha Kumaran

Abstract
'The Borexino experiment has recently provided the first direct experimental evidence of the sub-dominant CNO-cycle in the Sun, which is assumed to be the main energy production mechanism in heavier stars. Borexino is a liquid scintillator detector located at the Laboratori Nazionali del Gran Sasso, Italy with the main goal to measure solar neutrinos. The extreme radiopurity of the scintillator and the successful thermal stabilisation of the detector have proven to be valuable assets in the quest for CNO neutrinos.\r\nThe low abundance of CNO neutrinos and the similarity of its spectral shape to that of pep solar neutrinos and the intrinsic ^{210}Bi background, make CNO neutrino detection challenging. Therefore, it is necessary to constrain these backgrounds independently. The energy and radial distribution of the events can then be exploited to perform a multivariate fit, which requires a careful evaluation of the systematic uncertainty associated with the Monte-Carlo spectral shapes used. Borexino has successfully rejected the null hypothesis of CNO-cycle neutrinos in the Sun at greater than 5.0σ with 99% C.L. This talk will present the overview of the strategy and methods used to achieve this result and the consequence of this result for solar and stellar physics.'

Collaborations
Borexino,

Keywords and Comments
Borexino, CNO neutrinos, Sun, Liquid scintillator detectors, solar metallicity, solar fusion reaction,, Sindhujha Kumaran''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Update of the supernova neutrinos monitoring with the LVD experiment

Presenter
CARLO FRANCESCO VIGORITO
Author and Co-Author
CARLO FRANCESCO VIGORITO GIANMARCO BRUNO | WALTER FULGIONE | ANDREA MOLINARIO

Abstract
'The Large Volume Detector (LVD) at the INFN Gran Sasso National Laboratory, Italy, is a neutrino observatory designed to study low energy neutrinos from gravitational stellar collapses. The detector, 1000 tons of liquid scintillator, is sensitive to core-collapse supernovae via neutrino burst detection with 100\\% efficiency in the Milky Way.\r\n\r\nIn this paper we discuss methods of the neutrino burst search and we present the results of the last run, lasting from 2014, January 1st to 2021, Jan 4th for a total live time of 2504 days.\r\n\r\nIn the lack of a positive observation in this dataset and including all previously published results since 1992 for a total lifetime of 9839 days, the upper limit on the rate of core collapse and failed supernova explosions out to distances of 25 kpc is 0.085 year^{-1} at 90\\% c.l. .'

Collaborations
other (fill field below), LVD Collaboration
Keywords and Comments
Supernova, Neutrinos, Detector, CARLO FRANCESCO VIGORITO"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Comparison of the measured atmospheric muon rate with Monte Carlo simulations and sensitivity study for detection of prompt atmospheric muons with KM3NeT

Presenter
Piotr Kalaczyński
Author and Co-Author
Piotr Kalaczyński

Abstract
'The KM3NeT Collaboration has successfully deployed the first detection units of the next generation undersea neutrino telescopes in the Mediterranean Sea at the two sites in Italy and in France. The data sample collected between December 2016 and January 2020 has been used to measure the atmospheric muon rate at two different depths under the sea level: 3.5 km with KM3NeT/ARCA and 2.5 km with KM3NeT/ORCA . Atmospheric muons represent an abundant signal in a neutrino telescope and can be used to test the reliability of the Monte Carlo simulation chain and to study the physics of extensive air showers caused by highly-energetic primary nuclei impinging the Earth's atmosphere. At energies above PeV the contribution from prompt muons, created right after the first interaction in the shower, is expected to become dominant, however its existence was not yet experimentally confirmed. In this contribution data collected with the first detection units of KM3NeT are compared to Monte Carlo simulations based on MUPAGE and CORSIKA codes. The main features of the simulation and reconstruction chains are discussed and presented. Additionally, sensitivities of both KM3NeT/ARCA and KM3NeT/ORCA to the prompt muon component are derived using CORSIKA code.'

Collaborations
KM3NeT,

Keywords and Comments
CORSIKA, KM3NeT, ORCA, ARCA, DU, Detection Unit, muon, neutrino, CR, Cosmic Ray, air shower, simulation, MUPAGE, Mediterranean Sea, underwater neutrino telescope, PMT, DOM, Piotr Kalaczyński"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
High-Energy Neutrinos From Core-Collapse Supernovae

Presenter
Jannis Necker
Author and Co-Author
Jannis Necker | For the IceCube Collaboration

Abstract
"IceCube is a cubic kilometer neutrino detector array in the Antarctic ice that was designed to search for astrophysical, high-energy neutrinos. It has detected a diffuse flux of astrophysical neutrinos that appears to be of extragalactic origin. A possible contribution to this diffuse flux could stem from core-collapse supernovae. The high-energy neutrinos could either come from the interaction of the ejecta with a dense circumstellar medium or a jet, emanating from the star's core, that stalls in the star's envelope. In this poster, I will present results of a Stacking Analysis to search for this high-energy neutrino emission from core-collapse supernovae."

Collaborations
IceCube,

Keywords and Comments
High-Energy Neutrinos, Supernovae, core-collapse, Supernovae, interacting, Supernovae, choked-jet, Neutrino Astronomy,, Jannis Necker"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Searches for neutrinos from precursors and afterglows of Gamma-ray Bursts using the IceCube Neutrino Observatory

Presenter
Kunal Deoskar
Author and Co-Author
Kunal Deoskar | Elizabeth Friedman | Paul Coppin | For the IceCube Collaboration

Abstract
'Gamma-ray bursts (GRBs) are among the most powerful events observed in our universe and have long been considered as possible sources of ultra-high-energy cosmic rays, which makes them promising neutrino source candidates. Previous IceCube searches for neutrino correlations with GRBs focused on the prompt (main emission) phase of the GRB and found no significant correlation between neutrino events and the observed GRBs. This motivates us to extend our search beyond the prompt phase. We perform analyses looking for evidence of neutrino emission up to 14 days before and after the prompt phase of GRBs. These analyses rely on a sample of candidate muon-neutrino events observed by IceCube from May 2011 to October 2018. The analyses are model-independent. Two of them scan different time-windows for possible neutrino emission, while a third analysis targets precursor emission based on GRB precursor observations by Fermi-GBM. We discuss the results and implications of these searches including limits on the contribution of GRBs to the diffuse neutrino flux.'

Collaborations
IceCube,

Keywords and Comments
IceCube Neutrino Observatory, GRB, astrophysical neutrinos, astrophysical neutrino sources, muons, precursors, afterglows, prompt phase, Kunal Deoskar''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
ANTARES - Baikal GVD Alerts Analysis

Presenter
Sergio Alves Garre
Author and Co-Author
Sergio Alves Garre

Abstract
'ANTARES and Baikal-GVD are both Cherenkov neutrino telescopes located in\r\nthe Northern Hemisphere. As a consequence, their fields of view overlap al-\r\nlowing for a combined study of the sky. ANTARES sends alerts after a fast on-\r\nline analysis based on energy and reconstruction direction of track-like events.\r\nFrom December of 2018 up to the beginning of 2021, Baikal-GVD received 38\r\nANTARES alerts, and followed up a total of 32.\r\n\r\nNo prompt coincidence was found. However, a search into the Baikal-GVD cas-\r\ncade sample showed some events falling within an angular distance of less than\r\n5° for three of the ANTARES alerts in a time span of 48 hours. The 4.5° angular\r\nresolution of Baikal-GVD allows for the possibility of these events to be spatially correlated, which makes them of special interest.\r\n\r\nA dedicated offline analysis based on the full ANTARES data sample has been\r\nstarted to search for additional coincident tracks and cascades at a 3σ signifi-\r\ncance. With this contribution we present the final results on the offline analysis\r\nof the three ANTARES alerts: limits on the astrophysical neutrino fluency as ob-\r\ntained by this analysis are reported.'

Collaborations
Antares, Baikal-GVD

Keywords and Comments
Astroparticle Physics: Neutrinos: ANTARES: Baikal-GVD: Cherenkov Neutrino Telescope: Mediterranean Sea: Follow-up Analysis: Neutrino Fluence:, Sergio Alves Garre'Co-authors I could not find: Federico Versari, A.D Avrorin, Zh. -A. Dzhilkibaev, M.D. Shelepov and O.V. Suvorova'

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
First neutrino oscillation measurement in KM3NeT/ORCA

Presenter
Lodewijk Nauta
Author and Co-Author
Lodewijk Nauta | For the KM3NeT collaboration Zineb Aly | Valentin Pestel | Paul De Jong

Abstract
'KM3NeT is a Cubic Kilometer Neutrino Telescope that is currently being constructed at the bottom of the Mediterranean Sea. The KM3NeT/ORCA detector will be used for oscillation physics with atmospheric neutrinos, with as main goal establishing the neutrino mass ordering.\r\n\r\nIn 2019, 4 out of the total of 115 vertical lines carrying the light sensors of the ORCA detector had been deployed, while 6 are operational from early 2020.\r\n\r\nWith this partial detector configuration, neutrino oscillations can already be observed. Neutrino flavor oscillations depend on the energy the neutrino carries and the distance it travelled. The distance the atmospheric neutrino travelled can be probed by using the incoming angle in the detector. By measuring the number of events as function of incoming angle and energy in the detector one has a proxy for finding the oscillation parameters.\r\n\r\nDue to multiple background channels, of which atmospheric muons are the largest component, on average three in every one million triggered events comes from a neutrino interacting in the sea water. This contribution focuses on extracting the neutrino signal from the data, results from data/MC comparisons, and how to determine the oscillation parameters $\\theta_{23}$ and $\\Delta m_{31}^2$ by fitting an oscillation model and estimating the associated systematic uncertainties that have to be taken into account.'

Collaborations
KM3NeT,

Keywords and Comments
Neutrino oscillation physics, Atmospheric neutrinos, Atmospheric muons, VLVnT, Neutrino mass ordering,, Lodewijk Nauta''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Observation of the cosmic ray shadow of the Sun with the ANTARES neutrino telescope

Presenter
Matteo Sanguineti
Author and Co-Author
Andrey Romanov | Matteo Sanguineti

Abstract
'The ANTARES neutrino telescope is operating in the Mediterranean Sea in its full configuration since 2008. On their journey to the Earth, cosmic rays (CRs) can be absorbed by celestial objects, like the Sun, leading to a deficit in secondary muons produced by CR interactions from the solid angle region covered by the Sun, the so-called Sun "shadow" effect. This phenomenon can be used to evaluate fundamental telescope characteristics: the detector angular resolution and pointing accuracy. This work describes the study of the Sun "shadow" effect using the ANTARES data collected between 2008 and 2017. The statistical significance of the Sun shadow observation is 3.7σ and the estimated angular resolution value of the ANTARES telescope for downward-going muons is $0.59^{\circ} \pm 0.10^{\circ}$. This result is consistent with the expectations obtained from the Monte Carlo simulations and also with the estimation from the Moon "shadow" analysis of 2007-2016 years. No evidence of systematic pointing shift is found and the resulting pointing accuracy is in agreement with the expectations.'

Collaborations
Antares,

Keywords and Comments
Cosmic ray & astroparticle detectors, Cosmic ray propagation, Neutrino detectors, Andrey Romanov''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
All-flavour search for a diffuse cosmic neutrino flux with ANTARES

Presenter
Luigi Antonio Fusco
Author and Co-Author
Luigi Antonio Fusco | For the ANTARES Collaboration

Abstract
'The ANTARES neutrino telescope, located in the Mediterranean Sea, is the longest-operated under-sea neutrino detector, having collected data for more than 14 years and since 2008 in its full configuration. These data have been used to search for a diffuse flux of cosmic neutrinos, upgrading previously published results both in terms of livetime and in search method. In particular, a new event selection strategy, developed for the study of the atmospheric neutrino flux, allows a further rejection of atmospheric foregrounds, thus enabling a considerable reduction of previous systematic uncertainties connected with the background estimation . The results of this new analysis are reported in this contribution.'

Collaborations
Antares,
Keywords and Comments
, Luigi Antonio Fusco'on behalf of the ANTARES Collaboration'

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Every Flare, Everywhere: An All-Sky Untriggered Search for Astrophysical Neutrino Transients Using IceCube Data

Presenter
Francesco Lucarelli
Author and Co-Author
William Luszczak | Francesco Lucarelli

Abstract
'Recent results from IceCube regarding TXS 0506+056 suggest the presence of neutrino flares that are not temporally coincident with a significant corresponding gamma ray flare. Such flares are particularly difficult to identify, as their presence must be inferred from the temporal distribution of neutrino data alone. Here we present the results of using a novel method to search for all such flares across the entire neutrino sky in 10 years of IceCube data, using both gaussian and box-shaped flare hypotheses. Unlike for past searches, that looked for only the most significant neutrino flare in the data at a given direction, here we implement an algorithm to combine information from multiple flares associated with a single source candidate. This represents the most detailed description of the neutrino sky to date, providing the location and intensity of all neutrino cluster candidates in both space and time. These results can be used to further constrain potential populations of transient neutrino sources, serving as a complement to existing time-integrated and time-dependent methods. We additionally present the results of applying this method to a catalog of gamma-ray emitters which has previously been found to contain an excess of neutrinos at the level of 3.3 sigma. Notably, this catalog contains both TXS 0506+056 and NGC 1068, both sources which have also shown elevated emission under previous time-integrated studies.'

Collaborations
IceCube,
Keywords and Comments
Neutrinos, AGN, Statistical Methods, IceCube, Multi-messenger, William Luszczak''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
A Combined Analysis of IceCube's Muon Track and Cascade Neutrino Data

Presenter
Erik Ganster
Author and Co-Author
Erik Ganster | Richard Naab | Zelong Zhang | For the IceCube Collaboration

Abstract
"The IceCube Neutrino Observatory first observed a diffuse flux of high energy astrophysical neutrinos in 2013. Since then, this observation has been confirmed in multiple detection channels such as high energy starting events, cascades, and through-going muon tracks. Combining these event selections into a global fit of IceCube's neutrino data could strongly improve the understanding of the astrophysical neutrino flux properties: challenging the simple unbroken power-law flux model as well as the astrophysical neutrino flux composition. One key component of such a combined analysis is the consistent modelling of systematic uncertainties of different event selections. This can be achieved using the novel SnowStorm Monte Carlo method which allows constraints to be placed on multiple systematic parameters from a single simulation set. We will report on the status of a new combined analysis of through-going muon tracks and cascades, which is currently being prepared. It is based on a consistent all flavor neutrino signal and background simulation using, for the first time, the SnowStorm method to analyze IceCube's high-energy neutrino data."

Collaborations
IceCube,
Keywords and Comments
, Erik Ganster"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Searches for and Characterization of Astrophysical Neutrinos using Starting Track Events in IceCube

Presenter
Manuel Silva
Author and Co-Author
Manuel Silva | Sarah Mancina Albrecht Karle

Abstract
'The IceCube Neutrino Observatory is a cubic kilometer-sized detector designed to detect neutrinos of astrophysical origin. However, muons created by cosmic rays interacting in the atmosphere pose a significant background for these astrophysical neutrinos particularly in the southern equatorial sky. Correctly identifying neutrino events that start in the detector allows us to reduce the atmospheric muon component while retaining a high rate of starting neutrino events. The method presented today also rejects atmospheric neutrinos if they are accompanied by muons from the same cosmic ray shower, lowering the 50% purity threshold for astrophysical-to-atmospheric neutrinos from 100 TeV to ~10 TeV at declinations less than -25°. This allows us to measure the diffuse astrophysical neutrino spectrum to ~10 TeV with excellent precision. In addition, we discuss searches for galactic plane point sources and diffuse galactic plane neutrino emission in the Southern sky and our plans to release high astrophysical-purity real-time alerts to the multi-messenger community using starting track events.'

Collaborations
IceCube,

Keywords and Comments
icecube, low background, starting track, galactic plane, diffuse neutrino,, Manuel Silva''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Searching for neutrino transients below 1 TeV with IceCube

Presenter
Michael Larson
Author and Co-Author
Michael Larson | Justin Vandenbrouck | Alex Pizzuto

Abstract
"Recent observations of GeV gamma-rays from novae have led to a paradigm shift in the understanding of these objects. While it is now believed that shocks contribute significantly to the energy budget of novae, it is still unknown if the emission is hadronic or leptonic in origin. Neutrinos could hold the key to definitively differentiating between these two scenarios, though the energies of such particles would be much lower than are typically targeted with neutrino telescopes. IceCube's densely instrumented DeepCore sub-array provides the ability to reduce the threshold for observation from 1 TeV down to approximately 10 GeV. We will discuss recent measurements in this low energy regime, details of a new sub-TeV selection, and prospects for future searches for transient neutrino emission."

Collaborations
IceCube,

Keywords and Comments
Sub-TeV, Neutrino Astronomy, Michael Larson"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
A time-independent search for neutrinos from galaxy clusters with IceCube

Presenter
Mehr Nisa
Author and Co-Author
Mehr Nisa Andrew Ludwig | Srinivasan Raghunathan | Marcos Santander

Abstract
'Clusters of galaxies — with their turbulent magnetic fields and abundant matter content — are a promising class of potential neutrino sources. Cosmic rays accelerated within the large-scale shocks, Active Galactic Nuclei (AGN), or both can be confined in galaxy clusters over cosmological timescales and produce a steady flux of neutrinos in secondary interactions. The IceCube Neutrino Observatory has detected a diffuse flux of high-energy astrophysical neutrinos. After ten years of operations, however, the origin of this flux remains largely unconstrained. In this work, we perform a stacked search for neutrinos, using a population of over one thousand galaxy clusters detected by the Planck Satellite via the Sunyaev-Zeldovich (SZ) effect up to a redshift $z = 1$. We present the first results on the contribution of galaxy clusters to the diffuse neutrino flux and discuss the implications for various models of cosmic-ray acceleration in large-scale structures.'

Collaborations
IceCube,

Keywords and Comments
Particle acceleration, Clusters, AGN., Mehr Un Nisa"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Searching for High Energy Neutrinos from Magnetars with IceCube

Presenter
Ava Ghadimi
Author and Co-Author
Ava Ghadimi Marcos Santander | On behalf of the IceCube Collaboration

Abstract
"Magnetars are neutron stars with very strong magnetic fields on the order of 10^{13} to 10^{15} G. Young magnetars with oppositely-oriented magnetic fields and spin moments may emit high-energy (HE) neutrinos from their polar caps as they may be able to accelerate cosmic rays to above the photomeson threshold (Zhang, et. al 2003). Giant flares of soft gamma-ray repeaters (a subclass of magnetars) may also produce HE neutrinos and therefore a HE neutrino flux from this class is potentially detectable (Ioka, et.al 2005). Here we present plans to search for neutrino emission from magnetars listed in the McGill Online Magnetar Catalog using 10 years of well-reconstructed IceCube muon-neutrino events looking for significant clustering around magnetars' direction. IceCube is a cubic kilometer neutrino observatory at the South Pole and has been fully operational for the past ten years."

Collaborations
IceCube,

Keywords and Comments
magnetars, neutrinos, point source, icecube, Ava Ghadimi"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Searching for time-dependent high-energy neutrino emission from X-ray binaries with IceCube

Presenter
Qinrui Liu
Author and Co-Author
Qinrui Liu Ali Kheirandish

Abstract
'X-ray binaries are long-standing candidates for the source of Galactic cosmic rays and neutrinos. The compact object in a binary system can be the site for cosmic-ray acceleration, while high-energy neutrinos can be produced by the interactions of cosmic rays in the jet of the compact object, the stellar wind, or the atmosphere of the companion star. We report a time-dependent study of high-energy neutrinos from X-ray binaries with IceCube using 7.5 years of muon neutrino data and X-ray observations. In the absence of significant correlation, we report upper limits on the neutrino fluxes from these sources and provide a comparison with theoretical predictions.'

Collaborations
IceCube,

Keywords and Comments
astrophysical neutrinos, Galactic neutrino source, X-ray binary, IceCube, Qinrui Liu"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Characterization of the PeV astrophysical neutrino energy spectrum using down-going tracks

Presenter
Yang Lyu
Author and Co-Author
Yang Lyu

Abstract
'The IceCube Neutrino Observatory has observed a diffuse flux of astrophysical neutrinos with energies from TeV to a few PeV. Recent IceCube analyses are not sensitive to PeV neutrinos because their fluxes are attenuated by the Earth and the Extremely High Energy (EHE) result targets cosmogenic neutrinos only above 10 PeV. In this work, we present a new event selection that fills the gap between 1 PeV and 10 PeV. This sample is obtained by selecting high-energy down-going through-going tracks from 8 years of data. To achieve a high signal-to-background ratio, the atmospheric muon backgrounds are reduced by using the stochasticity information of the events and the IceTop surface array as a veto. To characterize the astrophysical neutrino flux and test the existence of a cut-off in the neutrino energy spectrum at a few PeV, a global fit will be performed by combining this sample with results from the 7-year High Energy Starting Events (HESE) analysis.'

Collaborations
IceCube,

Keywords and Comments
Astrophysical neutrino, downgoing tracks, diffuse, IceTop veto, Yang Lyu''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
The diffuse supernova neutrino background in Super-Kamiokande

Presenter
Sonia El Hedri
Author and Co-Author
Sonia El Hedri

Abstract
'Neutrinos have played a key role in astrophysics, from the\r\ncharacterization of nuclear fusion processes in the Sun to the\r\nobservation of supernova SN1987A and multiple extragalactic events. The\r\nSuper-Kamiokande experiment has played a major part in past in these\r\nastrophysical studies by investigating low energy O(10)~MeV neutrinos\r\nand currently exhibits the best sensitivity to the diffuse neutrino\r\nbackground from distant supernovae. Here, I present an overview of the\r\nsearch for the diffuse supernova background in Super-Kamiokande, and\r\ndiscuss how the current strategies will evolve after the SuperK-Gd upgrade.'

Collaborations
other (fill field below), Super-Kamiokande

Keywords and Comments
Neutrinos, Supernovae, Super-Kamiokande, Sonia El Hedri"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
An atmospheric neutrino flux calculation constrained by measurements of cosmic muon fluxes

Presenter
Juan-Pablo Yanez
Author and Co-Author
Juan-Pablo Yanez | Anatoli Fedynitch

Abstract
'Atmospheric neutrinos, produced by cosmic ray interactions, are a unique probe to study neutrino oscillations and exotic phenomena beyond the standard model, as well as the main background to measurements of astrophysical neutrinos. Due to the higher precision of next generation detectors, flux uncertainties are increasingly impacting such studies, in particular driven by the lack of measurements from hadronic particle production in the very forward region. In this work we introduce constraints provided by inclusive muon flux measurements into the calculations of lepton fluxes provided by the MCEq code to obtain a new atmospheric neutrino flux prediction. We also explore the potential that new muon flux data could have on further reducing the uncertainties in atmospheric neutrino fluxes.'

Collaborations
Keywords and Comments
atmospheric neutrinos, neutrino astronomy, hadronic physics, Juan-Pablo Yanez"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Searches for Neutrino Sources with IceCube Cascade Events

Presenter
Stephen Sclafani
Author and Co-Author
Stephen Sclafani | Mirco Hünnefeld

Abstract
IceCube has discovered a flux of astrophysical neutrinos, and more recently has used muon-neutrino datasets to present evidence for one source, a flaring blazar known as TXS 0506+056. However, the sources responsible for the majority of the astrophysical neutrino flux remain elusive. Opening up new channels for detection can improve sensitivity and increase the chance of a discovery. In this work we present a new neutrino dataset relying heavily on Deep-Neural-Networks (DNN) to select cascade events produced from neutral-current interactions of all flavors and charged-current interactions with flavors other than muon-neutrino. The speed of DNN based selections allows the event selection to be performed in near-realtime with a single GPU. Cascade events have reduced angular resolution when compared to muon-neutrino events, however the resulting dataset has a lower energy threshold in the southern sky and a lower background rate. These benefits lead to an improved sensitivity to sources in the southern sky when compared to muon-neutrino datasets. This improvement is particularly promising for identifying transient neutrino sources in the southern sky and neutrino production from the galactic plane.'

Collaborations
IceCube,

Keywords and Comments
, Stephen Sclafani"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
The Diffuse Supernova Neutrino Background in Super-Kamiokande

Presenter
Alberto Giampaolo
Author and Co-Author
Alberto Giampaolo

Abstract
'Detecting the Diffuse Supernova Neutrino Background at Super-Kamiokande requires designing state-of-the-art background removal technique to reject radioactivity induced by cosmic muon spallation, and identify atmospheric neutrino interactions. Identifying the neutron produced by the interaction of DSNB antineutrinos would allow to remove most of these backgrounds, but is particularly challenging in pure water. With the advent of the SK-Gd era, the efficiency of the neutron tagging procedure will increase dramatically, and the SK experiment will make significant gains in its sensitivity to the DSNB. I will present the role of neutron tagging and the challenges it provides, as well as how this technique could evolve to take full advantage of the SK-Gd capabilities.'

Collaborations
other (fill field below), Super-Kamiokande
Keywords and Comments
, Alberto Giampaolo"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Seasonal Variations of the Unfolded Atmospheric Neutrino Spectrum with IceCube

Presenter
Karolin Hymon
Author and Co-Author
Karolin Hymon Tim Ruhe | For the IceCube Collaboration

Abstract
"The IceCube Neutrino Observatory is a detector array at the South Pole with the central aim of studying astrophysical neutrinos. However, the majority of the detected neutrinos originates from cosmic ray interactions in the atmosphere. The rate of these atmospheric neutrinos shows a seasonal variation indicating that the rate changes with the temperature in the stratosphere. These seasonal changes of the atmospheric neutrino energy spectrum will be investigated using the Dortmund Spectrum Estimation Algorithm (DSEA). Based on results obtained from 10% of IceCube's atmospheric muon neutrino data, taken between 2011 and 2018, the differences of the measured fluxes during the Austral summer and winter will be discussed."

Collaborations
IceCube,

Keywords and Comments
atmospheric neutrinos, unfolding, Dortmund Spectrum Estimation Algorithm, IceCube, seasonal variations, spectrum reconstruction, Karolin Hymon"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
KM3NeT/ARCA sensitivity to transient neutrino sources

Presenter
Juan Palacios González
Author and Co-Author
Juan Palacios González Marta Colomer Molla | Agustín Sánchez Losa | Francisco Salesa Greus | Damien Dornic | Sebastien Le Stum | on behalf of the KM3NeT collaboration

Abstract
'The KM3NeT collaboration is constructing a km3 volume neutrino telescope in the Mediterranean sea, called ARCA (Astroparticle Research with Cosmics in the Abyss), that will achieve an unprecedented sensitivity to high-energy cosmic neutrinos. This telescope will be able to reconstruct the arrival direction of the neutrinos with a precision of ~0.1 degrees. The configuration of ARCA makes it sensitive to neutrinos in a wide energy range, from sub-TeV up to tens of PeV. Moreover, this detector has a large field of view and a very high duty cycle, allowing for full-sky (and all-flavours) searches. All these features make ARCA an excellent instrument to study transient neutrino sources.\r\n\r\nAtmospheric muons and neutrinos, produced by primary cosmic rays, constitute the main background for ARCA. This background can be several orders of magnitude higher than the expected cosmic neutrino flux. In this work, we introduce an event selection which reduces the background up to a negligible level inside the region of interest and within the search time window. In particular, we apply this method to estimate the ARCA sensitivity to some example targets such as interesting gravitational wave events (e.g. GW170817) and TeV gamma-ray bursts (e.g. GRB 190114C). The ARCA performance to detect a given neutrino flux, including the discovery flux, sensitivity and effective area, are provided for this particular selection.'

Collaborations
KM3NeT,

Keywords and Comments
neutrino, ARCA, sensitivity, transient sources, Juan Palacios González''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Latest results on neutrino non-standard interactions with ANTARES and KM3NeT/ORCA Phase 1

Presenter
Jerzy Manczak
Author and Co-Author
Jerzy Manczak Nafis Rezwan Khan Chowdhury | Sergio Navas

Abstract
'Neutrino Non Standard Interactions (NSI) are one of the sub-dominant effects which can affect neutrinos propagating through matter via observable changes in their oscillation patters predicted by the standard oscillation parameters. These interactions should modify neutrino flavour ratio observed in neutrino telescopes measuring atmospheric neutrino flux. \r\nThe ANTARES neutrino telescope has already proven its sensitivity for NSI with 10 years of data taking. KM3NeT, the ANTARES successor, is a next-generation neutrino telescope currently under construction in the Mediterranea Sea. ORCA is a dense array that constitutes the low-energy branch of KM3NeT with the main aim of resolving the neutrino mass hierarchy. By now, the KM3NeT/ORCA Phase 1 has already been deployed, which makes 6 out of the planned 115 detection lines operational. Even with this limited capability, neutrino oscillations can already be measured and studied. \r\nIn this contribution, a summary of the most recent results on NSI from the ANTARES detector, which has produced best worldwide limits in some interesting regions of the parameter space, will be shown. These results will also be compared to projections from different configuration stages of the KM3NeT/ORCA detector. For the first time, the combined NSI measurements from 4 months of data taking with 4 detection units and 1 year with 6 DUs of KM3NeT/ORCA will be presented.'

Collaborations
KM3NeT, Antares
Keywords and Comments
neutrino telescope, non standard interactions, neutrino oscillations, Jerzy Manczak''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
KM3NeT performance on oscillation and absorption tomography of the Earth

Presenter
Lukas Maderer
Author and Co-Author
Lukas Maderer Veronique van Elewyck | Joao Coelho | Edouard Kaminski

Abstract
'The KM3NeT neutrino telescope, currently under construction, consists of two detectors in the Mediterranean Sea, ORCA and ARCA, both using arrays of optical modules to detect the emitted Cherenkov light from charged particles created in neutrino interactions. Although originally designed for neutrino oscillation and astrophysical research, this experiment also bears unprecedented possibilities for other fields of physics. Here we present its performance for neutrino tomography, i.e. the study of the Earth's internal structure and composition.\r\nOwing to the different energy ranges covered by its two detectors ORCA and ARCA, KM3NeT will be the first experiment to perform both oscillation and absorption neutrino tomography. Resonance effects in the oscillations of GeV neutrinos traversing the Earth will allow KM3NeT/ORCA to measure the electron density along their trajectory, leading to potential constraints of the proton-to-nucleon (Z/A) ratio in the traversed matter. Absorption tomography aims at the detection of neutrinos in the TeV-PeV range with KM3NeT/ARCA. At PeV energies, the Earth is opaque for neutrinos which leads to a reduction of the upgoing neutrino flux at the detector side from which conclusions can be drawn about the density of the inner layers of the Earth.\r\nWe show here first sensitivity studies of the potential of KM3NeT to address open questions of geophysics concerning the chemical composition and matter distribution in the Earth's core and mantle through neutrino tomography.'

Collaborations
KM3NeT,
Keywords and Comments
Atmospheric neutrinos, Absorption tomography, Oscillation tomography,, Lukas Maderer''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Latest Results from the Daya Bay Experiment

Presenter
Tadeas Dohnal
Author and Co-Author
Tadeas Dohnal | For the Daya Bay Collaboration

Abstract
'The Daya Bay Reactor Neutrino Experiment, located in southeast China, was designed to measure short baseline oscillation of electron antineutrinos originating from six 2.9 GW_{th} nuclear reactors. Since 2011, it has collected an unprecedented sample of millions of reactor antineutrino candidates, the largest sample in the world up to date, which led to the discovery of the non-zero $\\theta_{13}$ mixing angle just in 2012. In this talk, we present an overview of the latest results from Daya Bay including the measurement of oscillation parameters driving the reactor antineutrino disappearance at short baseline, with the most precise measurement of the $\\theta_{13}$ mixing angle in the world, search for light sterile neutrino mixing and search for electron antineutrinos associated with gravitational wave events among others.'

Collaborations
other (fill field below), Daya Bay
Keywords and Comments
, Tadeas Dohnal"

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Tuning parametric models of the atmospheric muon flux in MUPAGE to data from the KM3NeT detector

Presenter
Brían Ó Fearraigh
Author and Co-Author
Brían Ó Fearraigh

Abstract
'The muons produced by cosmic ray interactions in the upper atmosphere constitute the main background for underwater neutrino detectors such as KM3NeT (the Cubic Kilometre Neutrino Telescope), which is currently being deployed in the Mediterranean Sea at two distinct locations. Situated at different depths, the KM3NeT/ARCA and KM3NeT/ORCA detectors experience a different flux of muons, and thus are uniquely positioned to study their evolution and propagation from cosmic ray showers. It is imperative to the main physics goals of the experiment that the atmospheric muon background is modelled correctly, which aids in benchmarking and understanding the detector response to the constant flux of these particles. \r\n\r\nIn this study, the data from the KM3NeT/ORCA detector is used and compared with the Monte Carlo prediction from the MUPAGE (MUons from PArametric formulas: a fast GEnerator for neutrino telescopes) software package, which generates the energy spectrum, lateral distribution, and muon multiplicity of muon bundles according to a specific parametrisation. This parametrisation consists of many free parameters which can be tuned such that simulated physical observables in the detector agree with those measured in data. In this way, improvements to the data-Monte Carlo agreement are achieved by quantitatively comparing the level of agreement between simulated and measured observables in the KM3NeT detector.'

Collaborations
KM3NeT,

Keywords and Comments
atmospheric muon background, KM3NeT, ORCA, ARCA, DU, Detection Unit, muon, neutrino, CR, Cosmic Ray, air shower, simulation, MUPAGE, Mediterranean Sea, underwater neutrino telescope, PMT, DOM, Brían Ó Fearraigh''

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Branch NU | Neutrinos & Muons

Subcategory Experimental Results

Titel
Observations of track-like neutrino events with Baikal-GVD

Presenter
Dmitry Zaborov
Author and Co-Author
Dmitry Zaborov | for the Baikal-GVD Collaboration

Abstract
'Baikal Gigaton Volume Detector (Baikal-GVD) is a km^3-scale neutrino detector currently under construction in Lake Baikal, Russia. The detector currently consists of 2016 optical modules arranged on 56 vertical strings. Further extension of the array is planned for March 2021. The data from the partially complete array have been analyzed using a $\\chi^2$-based track reconstruction algorithm. After suppression of the downward-going atmospheric muon background, a flux of upward-going neutrino events is observed, dominated by the atmospheric neutrinos. The reconstructed energy spectrum is compared with the expectations for the atmospheric neutrino and diffuse astrophysical neutrino fluxes.'

Collaborations
other (fill field below), Baikal-GVD

Keywords and Comments
atmospheric neutrino, diffuse astrophysical neutrino flux, atmospheric muons, neutrino telescope, Baikal-GVD, Nicolas Martin Peschau"

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-32

Branch NU | Neutrinos & Muons

Subcategory Future projects

Titel
Optimization of the optical array geometry for IceCube-Gen2

Presenter
Anastasiia Omeliukh
Author and Co-Author
Anastasiia Omeliukh | for the IceCube-Gen2 Collaboration

Abstract
'IceCube-Gen2 is a planned extension of the IceCube Neutrino Observatory at the South Pole designed to study the high-energy neutrino sky from TeV to EeV energies with a five times better point source sensitivity than the current IceCube detector. This is achieved by deploying 120 new strings with attached optical sensors in a pattern around IceCube that features considerably larger distances between individual strings than the ~125m for the existing detector. Here, we present the results of an optimization study searching for the best point source sensitivity while varying the IceCube-Gen2 string spacing between 150m and 350m.'

Collaborations
IceCube-Gen2,
Keywords and Comments
IceCube-Gen2, point source sensitivity, detector geometry, optimization., Anastasiia Omeliukh"

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Branch NU | Neutrinos & Muons

Subcategory Future projects

Titel
PLEnuM: A global and distributed monitoring system of high-energy astrophysical neutrinos

Presenter
Lisa Schumacher
Author and Co-Author
Matthias Huber | Lisa Schumacher | Matteo Agostini | Mauricio Bustamante | Foteini Oikonomou | Elisa Resconi

Abstract
'High-energy astrophysical neutrinos, discovered by IceCube, are now regularly observed, albeit at a low rate due to their low flux. As a result, open questions about high-energy neutrino astrophysics and particle physics remain limited by statistics at best, or unanswered at worst. Fortunately, this situation will improve soon: in the next few years, a host of new neutrino telescopes, currently under planning and construction, will come online. It is natural to combine their collected observing power: we propose the Planetary Neutrino Monitoring System (PLEnuM), a concept for a global repository of high-energy neutrino observations, in order to finally give firm answers to open questions. PLEnuM will reach up to four times the exposure available today by combining the exposures of current and future neutrino telescopes distributed around the world $-$ IceCube, IceCube-Gen2, Baikal-GVD, KM3NeT, and P-ONE. Depending on the declination and spectral index, PLEnuM will improve the sensitivity to astrophysical neutrinos by up to two orders of magnitude. We present first estimates on the capability of PLEnuM to discover Galactic and extragalactic sources of astrophysical neutrinos and to characterize the diffuse flux of high-energy neutrinos in unprecedented detail.'

Collaborations
Keywords and Comments
high-energy neutrinos, neutrino astronomy, PLEnuM, astrophysical neutrinos, galactic neutrinos,, Lisa Schumacher''

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Branch NU | Neutrinos & Muons

Subcategory Future projects

Titel
Neutrino mass ordering determination through combined analysis with JUNO and KM3NeT/ORCA

Presenter
João Pedro Athayde Marcondes de André
Author and Co-Author
João Pedro Athayde Marcondes de André Nhan Chau | Marcos Dracos | Antoine Kouchner | Veronique van Elewyck | Leonidas Kalousis | on behalf of the KM3neT Collaboration

Abstract
'The determination of neutrino mass ordering (NMO) is one of the prime goals of several neutrino experiments. KM3NeT/ORCA and JUNO are two next-generation neutrino oscillation experiments both aiming at addressing this question. ORCA can determine the NMO by probing Earth matter effects on the oscillation of atmospheric neutrinos in the GeV energy range. JUNO, on the other hand, is sensitive to the NMO by investigating the interference effects of fast oscillations in the reactor electron antineutrino spectrum at medium baseline. This poster presents the potential of determining the NMO through a combined analysis of JUNO and ORCA data. When measuring the $\\Delta m^2_{31}$ with a wrong ordering assumption, the best-fit values are different between the two experiments. This tension, together with good constraints on the $\\Delta m^2_{31}$ measurement by both experiments, enhances the combined NMO sensitivity beyond the simple sum of their sensitivities. The analysis shows that 5$\\sigma$ significance is reachable in less than 2 years of data taking with both experiements for true normal neutrino mass ordering assuming current global best-fit values of the oscillation parameters, while 6 years will be needed for any other parameter set.'

Collaborations
KM3NeT, juno
Keywords and Comments
Neutrino mass ordering,JUNO, KM3NeT,ORCA,combined analysis, João Pedro Athayde Marcondes de André''

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Branch NU | Neutrinos & Muons

Subcategory Future projects

Titel
Interpreting the high-energy neutrino sky through an angular power spectrum analysis

Presenter
Ariane Dekker
Author and Co-Author
Ariane Dekker Marco Chianese | Shin'ichiro Ando

Abstract
'The origin of high-energy neutrinos, observed in the last 10 years by IceCube, is unknown. We gain more insight by studying the expected angular distribution of potential source populations, considering that IceCube observes a neutrino sky consistent with an isotropic distribution.\r\nWe simulate neutrino skymaps by applying statistical distributions for the fluxes of extra-galactic sources and investigate the sensitivities of current (IceCube) and future (IceCube-Gen2 and KM3NeT) experiments. I will show that the angular power spectrum is a powerful probe to assess the angular characteristics of neutrino data and demonstrate that we can constrain rare and bright source classes with current IceCube data.\r\nAnother potential source is the decay or annihilation of dark matter, suggested by the observed excess in the High-Energy-Starting-Event (HESE) data set of IceCube. These neutrinos are expected to correlate with the galactic centre, allowing us to distinguish between dark matter and astrophysical origin. We apply the angular power spectrum analysis to the HESE data, and set model-independent limits on dark matter properties. This method relies only on the angular distribution of neutrino events and is therefore stable against astrophysical uncertainties.\r\nMoreover we perform a sensitivity forecast for IceCube-Gen2 and KM3NeT exposure for different decaying and annihilating channels. KM3NeT is especially sensitive to low dark matter masses due to its visibility towards the galactic centre. We therefore extend to masses above 100 GeV, and find that even at lower energies, the angular power spectrum analysis offers a robust way to interpret the neutrino sky.'

Collaborations
Keywords and Comments
Neutrino Telescopes, Angular power spectrum, High-energy neutrinos, Ariane Dekker''

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Methods

Titel
Unified thermal model for photohadronic neutrino production in astrophysical sources

Presenter
Damiano F. G. Fiorillo
Author and Co-Author
Damiano F. G. Fiorillo Stefano Morisi | Arjen Van Vliet | Walter Winter

Abstract
Astrophysical neutrino fluxes are often modeled as power laws of the energy. This is reasonable in the case of hadronic sources, but it does not capture the behavior in photohadronic sources, where the spectrum depends on the properties of the target photons on which protons collide. This limits the possibility of a unified treatment of different sources. In order to overcome this difficulty, we model the target photons by a blackbody spectrum. This model is sufficiently flexible to reproduce neutrino fluxes from known photohadronic sources, we apply it to study the sensitivity of Dense Neutrino Arrays, Neutrino Telescopes and Neutrino Radio Arrays to photohadronic sources. We also classify the flavor composition of the neutrino spectrum in terms of the parameter space. We discuss the interplay with the experiments, studying the changes in the track-to-shower ratio induced by different flavor compositions, both within and outside the region of the Glashow resonance.'

Collaborations

Keywords and Comments
Photohadronic sources, astrophysical neutrino production, Damiano Francesco Giuseppe Fiorillo''

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Methods

Titel
Seasonal variation of atmospheric muons

Presenter
Thomas Gaisser
Author and Co-Author
Thomas Gaisser Stef Verpoest

Abstract
'Competition between decay and re-interaction of charged pions and kaons depends on the temperature/density profile of the upper atmosphere. The amplitude and phase of the variations depend on the minimum muon energy required to reach the detector and on muon multiplicity in the detector. Here we compare different methods for characterizing the muon production profile and the corresponding effective temperature, with application to measurements of single and multiple muons by MINOS and NOvA in mind. A muon production profile based on a parameterization of simulations of muons as a function of primary energy is compared with approximate analytic solutions of the cascade equation integrated over primary energy. One goal is to determine the extent to which the geometrical effect of muon production at higher altitude when the temperature is higher can explain the anti-correlation with effective temperature observed for multiple muon events. Another is to compare different methods in the literature for defining effective temperature.'

Collaborations
Keywords and Comments
muons, multiplicity, variation, underground, Thomas Gaisser"

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Methods

Titel
Arrival time distribution of muons from extensive air showers

Presenter
Allan Machado Payeras
Author and Co-Author
Allan Machado Payeras | Anderson Campos Fauth | For the Pierre Auger Collaboration

Abstract
'The upgraded surface detectors of the Pierre Auger Observatory will provide data that enables the separation of signals due to the muonic component of extensive air showers. Such information permits the application of new event reconstruction methods, that will contribute to composition studies of high-energy cosmic rays and the understanding of their origin. Considering the idea of using the muonic signals from the upgraded surface detectors, we studied the characterisation of muon distributions in extensive air showers using CORSIKA simulations of showers initiated by protons and calcium nuclei with energy of $10^{19}\\ \\mathrm{eV}$ and QGSJet-04 as the model of hadronic interaction for high-energies. We analysed the time distribution of muons arriving at the observation level for different radial distances to the shower core. The results were compared with analytical expressions, and agreement was found. The understating of such distributions is crucial for the development of reconstruction methods that can be applied to data from the upgraded Auger Observatory.'

Collaborations
Auger,
Keywords and Comments
extensive air shower, muons, Corsika simulation, simulation, arrival-time distribution, Allan Machado Payeras''

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Methods

Titel
A shell like kilometer spaced array around Icecube

Presenter
Daniele Fargion
Author and Co-Author
Daniele Fargion

Abstract
'Icecube neutrino detector traces energetic TeVs-PeVs neutrino signals by their cascades or by their tracks inside its kilometer icy cube volume. Cascades are mostly for electron or tau or neutral current, tracks for muons. Cascades show mostly poor directionality. Tracks are sharp in directionality. TeVs-PeVs muon tracks are either born inside, HESE, or outside Icecube. These more abundant trough-going upward muons have their interactions outside the Icecube mainly in dense rock around. Such kilometer long tracks offer much precise ideal neutrino astronomy. Moreover highest tens TeV or PeVs neutrinos are opaque to the Earth, arriving mainly upward and horizontally crossing short Earth cord. Therefore we considerfor this upgrade Icecube detector, a widest kilometers spaced concentric array rings around Icecube each ring a kilometer far from the other. To discover upward-horizontal kilometer muon tracks we neglect (and save) the denser Icecube array structures needed to detect cascades. Therefore we save the hundred meter distances from each vertical array, as volumetric dense present Icecube detectors. In a more simple configuration we suggest the widest building of a shell like spiral array, centered on Icecube, spaced nearly one kilometer each ring from next ring leading to largest array net able to trace most upward horizontal muon tracks neutrino Astronomy. Such wider (km) empty array volumes for the same array number, may at best amplify, almost quadratically, the observed mass volume, in comparision to a more dense cubic (hundred meter) dense full volumes. In a first approximation one may obtain in place of a cubic 10 kilometer Icecube a shell like spiral volume about 100 kilometer mass-volume detector.'

Collaborations

Keywords and Comments
Icecube, Tracks, Muons, neutrino,cascades, Daniele Fargion''

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Methods

Titel
A Numerical Approach to Angular Distributions in Hadronic Cascades

Presenter
Tetiana Kozynets
Author and Co-Author
Tetiana Kozynets | Anatoli Fedynitch | D. Jason Koskinen

Abstract
'Hadronic interactions of highly energetic projectiles in matter induce rich cascades of daughter particles, an example being atmospheric neutrinos produced in cosmic ray air showers. Fully analytical modelling of such cascades, due to the amount and the complexity of the coupled processes involved, is infeasible, while Monte Carlo simulations remain computationally expensive. These complications are mitigated in the numerical Matrix Cascade Equation (MCEq) code, which reaches Monte Carlo-like precision at extremely low computational costs. Previously, the MCEq framework has included longitudinal-only development of the hadronic cascades.\r\n\r\nTo accurately model secondaries at MeV-GeV energies in particle cascades, we extends the one-dimensional cascade equation solver to 2D by including angular development. The distributions are computed via the Fourier spectral method and compared to those produced with the Monte Carlo cascade codes. The potential applications of this study include fast numerical calculations of particle fluxes in air showers and atmospheric lepton flux calculations, which will benefit simulation chains of the cosmic ray and neutrino experiments.'

Collaborations
Keywords and Comments
atmospheric air showers, cosmic rays, hadronic cascades, low energy, atmospheric neutrinos, atmospheric muons, cascade equations, MCEq, neutrino flux, Tetiana Kozynets''

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Subcategory	Theoretical Methods

Titel
Upgrade of Honda atmospheric neutrino flux calculation with implementing recent hadron interaction measurements

Presenter
Kazufumi Sato
Author and Co-Author
Kazufumi Sato | Hiroaki Menjo | Yoshitaka Itow | Morihiro Honda

Abstract
'Atmospheirc neutrino flux calculation by M. Honda (Honda flux [1]) has used as a flux prediction in many experiments including the oscillation analysis in Super-Kamiokande, and has greatly contributed in the neutrino physics. In this talk, we will present an upgrade of the neutrino flux calculation with accelerator-data-driven modifications.\r\nThe dominant uncertainty of the Honda flux arises from insufficient understanding of the hadron interactions inside air showers. Such uncertainty has been evaluated by using atmospheric muon observation data at the ground. This introduces relatively large uncertainties in the momentum regions below 1 GeV and above O(10) GeV, the former is due to energy deposition of muons before reaching the ground and the latter is due to the kaon contribution to the neutrino production.\r\nSeveral precise measurements for hadron production using accelerator beams have been recently performed or planned, like NA61, HARP, and BNL-E910. These data will compensate the muon observation by providing information for different phase space and kaon production. We incorporate these accelerator-data-driven modifications into the flux calculation. This allows the systematic uncertainty of atmospheric neutrino oscillation analysis to be evaluated based on the accelerator measurements. \r\n[1] M. Honda, et. al., Phys. Rev. D 92, 023004 (2015)'

Collaborations
Keywords and Comments
atmospheric neutrino, neutrino flux, simulation,, Kazufumi Sato''

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Methods

Titel
Vertex and energy reconstruction of UHE particles using in-ice radar for the RET experiment

Presenter
Uzair Abdul Latif
Author and Co-Author
Uzair Abdul Latif | Vesna Lukic | Dieder Van den Broeck | Dylan Frikken | Enrique Huesca Santiago for the Radar Echo Telescope collaboration

Abstract
'The Radar Echo Telescope (RET) experiment plans to use the radar technique to detect Ultra-High Energy (UHE) cosmic rays and neutrinos in the polar ice sheets. When a UHE particle collides with an ice molecule, it produces a shower of relativistic particles, which leaves behind a trail of plasma in the ice. Radiowaves can be reflected off this plasma and be detected by receiving antennas. Vertex and energy reconstruction of the primary UHE particle is dependent upon an understanding of the radar signal properties. We will be discussing various methods to simulate the radar signal and calculate our vertex and energy reconstruction resolution.'

Collaborations
other (fill field below), Radar Echo Telescope

Keywords and Comments
Radar,Ice,Vertex,Cosmic Rays,Neutrinos,Ultra High Energy,, Uzair Latif"

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Results

Titel
Sub-GeV atmospheric neutrinos, CP violation

Presenter
Ara Ioannisian
Author and Co-Author
Ara Ioannisian

Abstract
'Sub-GeV atmospheric neutrino oscillations are a promising source of information on the leptonic CP phase δ. In that energy range the oscillations are very fast, far beyond the resolution of modern neutrino detectors. However, the necessary averaging over those fast oscillations does not wash out the CP violation effects. The propagation/oscillation of 3 neutrinos is reduced to 2 neutrino propagation/oscillation inside the Earth. The analytic results are very accurate and physically transparent for interpretation/understanding.'

Collaborations

Keywords and Comments
neutrino, atmospheric neutrino, CP violation, Ara Ioannisian"

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Results

Titel
Neutrinos from charm: forward production at the LHC and in the atmosphere

Presenter
Yu Seon Jeong
Author and Co-Author
Weidong Bai | Milind Diwan | Maria Vittoria Garzelli | Yu Seon Jeong | Fnu Karan Kumar | Mary Hall Reno

Abstract
'Theoretical predictions of the prompt atmospheric neutrino flux have large uncertainties associated with charm hadron production, by far the dominant source of prompt neutrinos in the atmosphere. The flux of cosmic rays, with its steeply falling energy spectrum, weights the forward production of charm in the evaluation of the atmospheric neutrino flux at high energies. The current LHCb experiment at CERN constraints charm production in kinematic regions relevant to the prompt atmospheric neutrino flux. The proposed Forward Physics Facility has additional capabilities to detect neutrino fluxes from forward charm production at the LHC. We discuss the implications of the current and planned experiments on the development of theoretical predictions of the high energy atmospheric neutrino flux.'

Collaborations

Keywords and Comments
Prompt atmospheric neutrinos, forward charm production, Yu Seon Jeong''

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Results

Titel
Cosmic Ray Elemental Spectra and Atmospheric Neutrino Fluxes

Presenter
Rachel Scrandis
Author and Co-Author
Rachel Scrandis | Deven Bowman | Eun-Suk Seo

Abstract
'Atmospheric neutrinos are produced when cosmic rays interact with Earth’s atmosphere. The relationship between the cosmic ray spectrum and the neutrino spectrum is especially important around the cosmic ray all-particle knee. These energies correspond to the regime in which astrophysical neutrinos begin to dominate the neutrino flux, so accurate modeling of the cosmic-ray spectrum around the knee can be used to help separate background from signal. Currently, direct measurements of elemental spectra reach their upper energy limit just below the all-particle knee, requiring extrapolation in order to probe the transitional neutrino source energy regime. In this work, the cosmic ray knee is modeled as a transition between acceleration sources, each with a rigidity dependent acceleration limit. Cosmic-ray particles reach the limit at Z * E$_{max}$ where Z is the particle charge and E$_{max}$ is the proton’s limit. Utilizing the Matrix Cascade Equations code, the cosmic-ray elemental spectra were used to calculate resulting atmospheric neutrino fluxes. Various parameterizations to model cosmic rays are explored, and the effects of the resulting elemental spectra on the neutrino fluxes are investigated. The neutrino results are also compared to experimental data.'

Collaborations

Keywords and Comments
atmospheric neutrinos, cosmic ray all-particle, MCEq, cosmic rays, neutrinos, elemental spectra,, Rachel Scrandis"

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Results

Titel
Uncertainties of the energy loss by inelastic interactions of muons with nuclei

Presenter
Alexander Sandrock
Author and Co-Author
Alexander Sandrock | Edgar Bugaev | Rostislav Kokoulin | Anatoly Petrukhin

Abstract
'High-energy muons loose their energy by ionization, pair production, bremsstrahlung and inelastic interaction with nuclei. The process with the largest uncertainty is the inelastic interaction with nuclei. Since the energy loss is dominated by soft interactions with small momentum transfer, parton distribution functions are not applicable and phenomenological parametrizations have to be used. The parametrizations of the proton structure functions that are commonly used in muon transport simulation tools such as PROPOSAL, MUM, MUSIC or Geant4 were determined on the basis of the data available about 20 years ago. In this contribution, we refit several commonly used parametrizations to the data on deep inelastic scattering available today, including the precise combined data from the HERA experiments H1 and ZEUS, which have become available a few years ago. We compare the goodness of fit and calculate the uncertainty of the average energy loss from the uncertainties and correlations of the fit parameters.'

Collaborations
Keywords and Comments
, Alexander Sandrock''

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Results

Titel
A Modern High-Precision Calculation of Deep Underground Cosmic Ray Muons

Presenter
William Woodley
Author and Co-Author
William Woodley Marie-Cécile Piro | Anatoli Fedynitch

Abstract
"We present a new efficient calculation to propagate cosmic ray muons from the surface of the Earth to deep underground laboratories, allowing us to look at the physics and performance of various models of high-energy cosmic rays. The evolution of cosmic rays in the Earth's atmosphere is computed with MCEq (Matrix Cascade Equation), taking into account different combinations of primary and hadronic interaction models in order to calculate the muon flux at the surface. The latter serves as an input for the Monte Carlo code PROPOSAL (Propagator with Optimal Precision and Optimised Speed for All Leptons) to propagate the muons through the rock. A forward prediction for underground muon spectra at different slant depths, including the muon survival probabilities and underground energy spectra, is calculated with very high precision. The reliability of this state-of-the-art calculation was achieved by comparing the results obtained for the vertical muon intensity and total muon flux with the measured data at various underground sites with both flat overburdens and mountains. The implications of the results as well as the seasonal variation of the muon flux will also be discussed."

Collaborations

Keywords and Comments
Cosmic ray muons, Deep underground laboratories, Underground muon spectra, Seasonal variation of the muon flux, William Woodley"

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Results

Titel
Hadronic uncertainties of inclusive atmospheric lepton fluxes from fixed-target accelerators

Presenter
Anatoli Fedynitch
Author and Co-Author
Anatoli Fedynitch | Matthias Huber

Abstract
'Theoretical atmospheric neutrino flux estimates serve as a crucial input for the determination of the neutrino mass hieararchy, the unitarity of the PMNS matrix and the atmospheric mixing angle $\\theta_{23}$ in underground neutrino detectors, such as the Super-Kamiokande, IceCube DeepCore and KM3Net ORCA. With the expected reduction of detector-induced systematic uncertainties by the IceCube Upgrade, and the substantial gain in effective volume of the upcoming Hyper-Kamiokande and KM3NeT ORCA detectors, the theoretical uncertainty of the non-oscillated neutrino flux and flavor composition will ultimately impact the achievable precision of future measurements. In this work, we tackle the uncertainty associated with modeling of hadronic interactions, which has the largest effect on the calculation. We develop an empirical, data-driven model (DDM), derived from high-precision accelerator data from the recent CERN North Area (NA) fixed-target experiments, and a few simple model-dependent arguments. The model is well constrained in the intermediate energy range above a few GeV up to a hundred GeV and achieves good agreement with atmospheric muon data without explicitly using it. We compare our result to reference calculations of the atmospheric neutrino flux.'

Collaborations
Keywords and Comments
Atmospheric muons, atmospheric neutrinos, inclusive leptons, muons, neutrinos, hadronic interactions, uncertainties, hadronic uncertainties, fixed-target, NA61, IceCube, DeepCore, ORCA, Hyper-K, MCEq, Anatoli Fedynitch"Originally, this talk should have been given by Matthias but since he's heading off to industry in April, he will not attend this ICRC. I originally planned to give a talk on a different topic (cosmic rays and life), but since this work has been a long p

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Results

Titel
An analytical derivation of the survival probability of muon penetrating through matters

Presenter
Takao Nakatsuka
Author and Co-Author
Atsushi Iyono | Takao Nakatsuka | Kazuhide Okei | Saya Yamamoto | Shuhei Tsuji | Hiroki Matsumoto

Abstract
'The survival probabilities of muon after penetrating through matters are evaluated analytically by solving the diffusion equation, taking account of positron-electron pair production, bremsstrahlung and photonuclear interactions, together with ionization loss. Accuracies of the results are discussed by comparing them with those derived by a Monte Carlo method. Qualitative properties of the probability for muon are also investigated by comparing the results with those for electron taking account only of bremsstrahlung.'

Collaborations
Keywords and Comments
muon, cascade shower, Atsushi Iyono"

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Branch NU | Neutrinos & Muons

Subcategory Theoretical Results

Titel
A novel multimessenger study of Starburst galaxies: implications for neutrino astronomy

Presenter
Antonio Marinelli
Author and Co-Author
Antonio Marinelli Antonio Ambrosone | Marco Chianese | Damiano Francesco Giuseppe Fiorillo | Gennaro Miele | Ofelia Pisanti

Abstract
'Starburst galaxies (SBGs) and more in general starforming galaxies represent a class of galaxies with a high star formation rate (up to 100 Mo/year). Despite their low luminosity, they can be considered as guaranteed “factories” of high energy neutrinos, being “reservoirs” of accelerated cosmic rays and hosting a high density target gas in the central region. The estimation of their point-like and diffuse contributions to the neutrino astrophysical flux measured by IceCube can be crucial to describe the diffuse neutrino spectral features as well as the peculiar point-like excess like NGC1068. To this aim we use the latest gamma-ray catalog of this class of objects to perform a multimessenger study and describe their gamma-ray emission through a calorimetric scenario.\r\nFor the diffuse analysis we perform a blending of the measured spectral indexes and obtain a multi-component description of extragalactic background light (EGB), high energy starting events (HESE) and high-energy cascade IceCube data. Remarkably, we find that, differently from recent prototype scenarios, the spectral index blending allows starburst galaxies to account for up to 40% of the HESE events at 95.4% CL and favors a maximal energy of the accelerated cosmic rays at tens of PeV.\r\nFor the point-like analysis we apply the calorimetric approach to the known SBGs within 100 Mpc, considering, where possible, a source-by-source description of the star formation rate. These results are then compared with what IceCube and ANTARES have seen at TeV energies as well as with what can be expected from the incoming KM3NeT.'

Collaborations

Keywords and Comments
radiation mechanisms: non-thermal, galaxies: starburst , gamma-rays: diffuse background, gamma-rays: point like, neutrino expectations, Antonio Marinelli''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
An Helium calorimeter for Anti-Deuteron identification in cosmic rays

Presenter
Francesco Nozzoli
Author and Co-Author
Francesco Nozzoli | Roberto Iuppa | Ester Ricci | Paolo Zuccon

Abstract
'Low energy anti-deuterons in cosmic rays are considered a golden channel for the search of Dark matter annihilations in the galaxy.\r\nAnti Deuteron Helium Detector (ADHD) project is aiming to study the signatures offered by an high pressure Helium target for the identification of anti-deuterons in cosmic rays.\r\nIn particular exotic atoms are produced by stopping anti-protons/anti-deuterons in the gas and the captured particle can orbit the Helium nucleus for microseconds before the annihilation. This meta-stability is a unique feature for the Helium target and the characteristic delayed annihilation is a distinctive signature to identify the antimatter nature of the stopping particle. \r\nA possible configuration for ADHD space/balloon detector consists of a pressurized helium calorimeter surrounded by scintillator layers for velocity measurement.\r\nAnti-deuterons are identified by combining the spectrometric measurement of the stopping particle (velocity/energy) with the delayed emission of outgoing charged pions caused by the annihilation.\r\nA prototype of the pressurized calorimeter, filled by 200 Bar Helium acting as a scintillator, has been characterized with cosmic muons and with 70-240 MeV proton beam in the INFN-TIFPA laboratory.\r\nSensitivity of the possible Anti-Deuteron-Helium-Detector for the measurement of low energy anti-deuterons and anti-protons in cosmic rays will be summarized and the results of the measured performance of the helium calorimeter prototype will be addressed.'

Collaborations
, ADHD

Keywords and Comments
Antimatter, dark matter, antideuteron, antiproton, detector, Francesco Nozzoli''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The Plastic Scintillator Detector of the HERD space mission

Presenter
Dimitrios Kyratzis
Author and Co-Author
Dimitrios Kyratzis | For the HERD Collaboration

Abstract
'The High Energy cosmic Radiation Detector (HERD) is one of the prominent space-borne instruments to be installed on board the upcoming Chinese Space Station (CSS) in 2026 and is the result of a collaboration among chinese and european institutions. Primary scientific goals of HERD include: precise measurements of the cosmic ray (CR) energy spectra and mass composition at energies up to few PeV, electron/positron spectra up to tens of TeV, CR anisotropy, gamma ray astronomy and transient studies, along with indirect searches for Dark Matter particles. HERD is configured to accept incident particles from both its top and four lateral sides. Owing to its pioneering design, more than one order of magnitude increase in geometric acceptance is foreseen, with respect to previous and ongoing experiments.\r\nThe Plastic Scintillator Detector (PSD) constitutes an important sub-detector of HERD, particularly aimed towards photon tagging and precise charge measurements of incoming CR nuclei in a range of Z = 1 - 26. Main requirements concerning its design, include: high detection efficiency, broad dynamic range and good energy/charge resolution. In order to define the optimal layout, two configurations are currently under investigation: one based on long scintillator bars and the other on square tiles, with both layouts being readout by Silicon Photomultipliers (SiPMs). Ongoing activities and future plans regarding the HERD PSD will be presented in this work.'

Collaborations
other (fill field below), HERD
Keywords and Comments
Space detectors, Cosmic Rays, Gamma-ray astronomy, Plastic scintillators, Silicon Photomultipliers,, Dimitrios Kyratzis''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Data Acquisition Software for a Prototype of LET Spectrometer

Presenter
Wenrui Sun
Author and Co-Author
Wenrui Sun | Zhe Cao | Li Wang | Changqing Feng | Lei Zhao

Abstract
'Silicon Micro-strip Detector (SMD) has been widely used in detecting charged particles. Using SMD as detector, and to measure the Linear Energy Transfer (LET) generated by the ionizing radiation in manned spacecraft, a prototype of LET spectrometer is designed. This paper presents the design of the data acquisition (DAQ) software for the LET spectrometer. To read out and preliminarily analyze the data, the DAQ software is consist of three modules, which are readout and control module, data real-time imaging module, and offline data analysis module. Multiple data tests are included in the DAQ software as a result of reliability requirement of the data. The DAQ software realizes the dual communication interface through the Ethernet interface of the back-end electronics, which are used to summarize the data generated from the three detectors of the prototype in the experiment, and the USB interface of the front-end electronics for debugging a single detector. Qt is used as the development tool for Windows platform, because of its excellent reliability and maintainability. Its cross-platform-ability is also important to operate in other platforms. Due to the small amount of data and high demand of efficiency, it is appropriate to choose C + + as the programming language. In the tests, the DAQ software shows good performance and fits the needs of application.'

Collaborations
Keywords and Comments
LET spectrometer, data acquisition software, Qt, Wenrui Sun"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Study of Backscattering Effects on the Particle Identification

Presenter
Eun-Suk Seo
Author and Co-Author
Jayoung Wu | Eun-Suk Seo For the ISS-CREAM collaboration

Abstract
'One of the consequences of having a high-density calorimeter as part of an experiment is a large number of secondary shower particles generated in the calorimeter -- some of which scatter back up towards the charge measurement devices. This so-called "backscatter effect" can interfere severely with accurate charge measurement of the primary nucleus, especially at high energies, as the number of backscattered particles increases with the incident energy. In this analysis, we study the effect of backscattered particles on particle identification by simulating the ISS-CREAM instrument model detector response using the GEANT3 simulation package with the FLUKA hadronic model. Our study shows the importance of the fine segmentation of charge detectors above the calorimeter. It can minimize backscattered particle contamination in the same charge detector segment as the incident particle to avoid its charge misidentification. We will present simulation results regarding charge measurements, including the tracking resolution, backscattering effects, and charge determination efficiency.'

Collaborations
ISS-Cream,

Keywords and Comments
Backscattering Effects, Particle Identification, Jayoung Wu"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The High Energy Particle Detector operational status during 3 years of flight on board the China Seismo-Electromagnetic Satellite

Presenter
Cinzia De Donato
Author and Co-Author
Cinzia De Donato Giuseppe Masciantonio

Abstract
The China Seismo-Electromagnetic Satellite is a multi-instrument space mission dedicated to the investigation of the topside ionosphere structure and dynamics (plasma parameters, electromagnetic fields and charge particles fluxes) and the possible correlation of its perturbations with the occurrence of high magnitude earthquakes. \r\nThe main contribution of the Italian collaboration to the mission is the High Energy Particle Detector (HEPD), designed and built for the detection of electrons and protons in the energy range 3-100 MeV and 30-200 MeV, respectively \\[[1]\\].\r\nThe satellite was launched on February 2, 2018 from the Jiuquan Satellite Launch Center (Inner Mongolia, China) and HEPD is fully operational since July 28, 2018. \r\nTo ensure correct operations and optimal performances during the expected life time of 5 years, the HEPD onboard software hosts the Control & Housekeeping system responsible for the detector management and monitoring.\r\nThe system handles instrument data acquisition and calibrations, HEPD configuration and monitoring and acts as the main interface of the detector with the satellite platform. The continuous monitoring of HEPD status allows to control the detector functionality, to check electronics stability, to identify anomalous behaviors and to perform recovery actions if necessary. Besides, the high configurability of the detector allows to modify HEPD configuration in order to preserve its detection efficiency that can deteriorate along with the detector age.\r\nIn this paper we describe the HEPD Control & Housekeeping system and HEPD operational status during its 3 years of flight.\r\n\r\nREFERENCES\r\n\\[[1]\\] Scientific goals and in-orbit performance of the High-Energy Particle Detector on board the CSES. Picozza P, et al., ApJS 2019,243(1):16. [http://dx.doi.org/10.3847/1538-4365/ab276c][1]\r\n\r\n\r\n [1]: http://dx.doi.org/10.3847/1538-4365/ab276c'

Collaborations
other (fill field below), CSES-Limadou
Keywords and Comments
Low Earth orbit satellites, Space detectors, Earth Observing System, Cinzia De Donato''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The HEPD-02 Data Processing and Control Unit for the CSES-02 mission

Presenter
Giuseppe Masciantonio
Author and Co-Author
Giuseppe Masciantonio Cinzia De Donato | Alessandro Sotgiu

Abstract
'The China Seismo-Electromagnetic Satellite (CSES) is a multi-instrumental space mission devoted to the study of the ionosphere, with the main aim to investigate possible correlations between fluctuations of the ionosphere environment and the occurrence of an earthquake. The first satellite (CSES-01) was launched on 2018, while a second one (CSES-02) is currently under development and the launch is expected by 2022. As CSES-01, the second satellite includes a particle detector (HEPD-02, High-energy Particle Detector) to measure the increase of the electron and proton fluxes due to short-time perturbations of the radiation belts induced by solar, terrestrial, or anthropic phenomena \\[[1]\\]. The explored energy range is 3-100 MeV for electrons and 30-200 MeV for protons .\r\nThe HEPD-02 Electronic Subsystem (ELS) contains all the electronics that perform the control of the apparatus and the processing of the signals provided by the sensitive detectors. It consists of the following boards: Trigger, Tracker Data Acquisition (T-DAQ), and Data Processing and Control Unit (DPCU). The DPCU will carry out the functions of management and control of the HEPD-02 operations and the communication with the satellite computer. The DPCU board will implement HOT / COLD redundancy and rely on a Zynq XC7Z7045 Xilinx System on Chip (SoC). The boot and all the functional checks of the SoC will be carried out by a MICROSEMI ProASIC3E FPGA.\r\nWe present the main DPCU characteristics and functionalities, highlighting the electronic architectural choices to guarantee reliability and radiation tolerance during the entire mission life span.\r\n\r\nREFERENCES\r\n\\[[1]\\] The High Energy Particle Detector for the 2nd Chinese Seismo Electromagnetic Satellite, Masciantonio G., 2019 IEEE NSS/MIC, [DOI:10.1109/NSS/MIC42101.2019.9060030][1]\r\n\r\n\r\n [1]: https://doi.org/10.1109/NSS/MIC42101.2019.9060030'

Collaborations
other (fill field below), CSES-Limadou
Keywords and Comments
Low earth orbit satellites, Space detectors, Earth Observing System., Giuseppe Masciantonio"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
CSES-Limadou data processing at ASI-SSDC

Presenter
Matteo Mergè
Author and Co-Author
Matteo Mergè

Abstract
'The CSES space mission, an international collaboration between China and Italy, aims at monitoring the perturbations originated by electromagnetic emissions in the ionosphere, magnetosphere and in the Van Allen radiation belts, and at investigating possible correlations with seismic events. The Italian collaboration, named LIMADOU, contributed to the mission with the realization of the High Energy Particle Detector (HEPD), an instrument developed on the basis of a long experience in developing advanced space detectors for charged and neutral particles and gamma rays – on a wide range of energies – for applications in solar physics as well as in extra-galactic astrophysics\r\nand cosmology. The CSES Satellite was launched from the Jiuquan Satellite Launch Center on February 2, 2018 and the expected mission lifetime is of 5 years. Satellite data are transferred to the Institute of Crustal Dynamics (ICD) of the China Earthquake Administration (CEA) in Beijing, China. \r\nAfter the donwlink HEPD raw data are transferred to the Italian Ground Segment. In the IGS, HEPD raw data are processed from level0 to level2 after calibration and equalization and are then stored in a high-availability processing server and stored in a high-resilience storage. In this poster we present a schematic of the HEPD detector data structure and the processing pipeline that has been built at the Italian Space Agency – Space Science Data Center'

Collaborations
, Limadou

Keywords and Comments
, Matteo Mergè''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Machine learning applications on event reconstruction and identification for ISS-CREAM

Presenter
Monong Yu
Author and Co-Author
Monong Yu Chen Yu | Coutu Stephane | Link Jason | Mognet Isaac | Mitchell John | Nutter Scott | Sakai Kenichi

Abstract
'We explore applications of machine learning in particle astrophysics. A supervised machine learning algorithm is applied to the visual representations of the energy deposits in two orthogonal views of the calorimeter of ISS-CREAM. Convolutional Neural Networks (CNNs) backed by Tensorflow are used to calibrate the sampled energy of the calorimeter and reconstruct the total primary energy of cosmic rays (CR), as well as for CR identification. The CNN regression models are trained on detailed Monte Carlo simulated events reproducing the behavior of the ISS-CREAM instrument suite, and the results indicate that a calorimeter energy reconstruction resolution of as good as 20% is achieved. The energy sampled in the calorimeter is determined with a resolution as good as 10%. The CNN classification model can reach a CR identification accuracy of up to 93%. The results from machine learning methods are consistent with a simple scaling of the sampled energy. The increased accuracy of this CNN energy reconstruction comes from the additional information of the longitudinal and lateral energy deposit profiles. This machine learning approach is widely applicable to a range of particle physics and astrophysics problems.'

Collaborations

Keywords and Comments
Machine learning, Energy reconstruction, Shower profile, Cosmic ray,, Monong Yu''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The High Energy cosmic Radiation Detector (HERD) Trigger System

Presenter
Miguel Angel Velasco
Author and Co-Author
Miguel Angel Velasco | for the HERD Collaboration

Abstract
'The High Energy cosmic Radiation detector (HERD) facility has been proposed to be installed onboard the future China's Space Station (CSS).\r\n\r\nHERD will address major problems in fundamental physics and astrophysics with the precise measurement of charged cosmic-rays and gamma-rays from few GeV to PeV energies by means of a large acceptance detector based on an innovative concept.\r\n\r\nThe detector consists of a very thick (3 lambda, 55 X0) calorimeter made of nearly 7500 LYSO crystals arranged into an octagonal prism, surrounded by a scintillating fiber tracker, a plastic scintillator detector and a silicon charge detector to precisely identify and measure high energy particles. Additionally, a transition radiation detector provides accurate energy calibration.\r\n\r\nHERD is designed to accept incident particles from both its top and four lateral faces thus providing an effective geometrical factor one order of magnitude larger than that of current experiments.\r\n\r\nThe large geometrical acceptance of the system requires detailed studies to define an efficient trigger system, which is able to identify the event samples for science and calibration purposes and keep the trigger rate to the level required by the acquisition system.\r\n\r\nWe will present the studies performed with the use of up-to-date models based on the most recent data, detailed simulations of the detector response and a CSS model to define the HERD trigger strategy.'

Collaborations
other (fill field below), HERD
Keywords and Comments
, Miguel Angel Velasco''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The HEPD-02 trigger and PMT readout system for the CSES-02 mission

Presenter
Marco Mese
Author and Co-Author
Marco Mese | Antonio Anastasio | Donatella Campana | Vincenzo Masone | Giuseppe Osteria | Francesco Perfetto | Valentina Scotti | Antonio Vanzanella | For the CSES-Limadou Collaboration

Abstract
'This contribution describes the Trigger board of the High-Energy Particle Detector, which will be placed onboard the second China Seismo-Electromagnetic Satellite for CSES-Limadou mission.\r\nThis mission will monitor variations in ionospheric parameters that are supposed to be related to earthquakes.\r\nThe first satellite is already in orbit and the second one will be launched in 2023.\r\nThe HEPD detector will be composed by a tracker made of CMOS sensors (ALPIDE sensors), followed by two segmented planes of plastic scintillators used for trigger signals generation.\r\nThe actual calorimeter will be composed by twelve planes of plastic scintillator and two segmented planes of an inorganic scintillator called LYSO. The calorimeter is surrounded by five scintillator planes used as a veto system.\r\nAll the scintillators are coupled with PMTs, whose signals are acquired and digitized by the Trigger board, that also implements the trigger system for the whole apparatus.\r\nThe ongoing work on the Trigger board consists in the design of both the hardware and the firmware used for the communication with the other boards of the detector, power managing, and the interfacing with the ASIC used for PMTs' readout. \r\nEventually the Trigger board will be tested to verify its functionalities and its compliance with the HEPD design specifications. Next developments are the integration of the Trigger board with the other systems on the detector and the environmental testing of the whole system.'

Collaborations
other (fill field below), CSES-Limadou

Keywords and Comments
electronics, High-Energy Particle Detector, satellite, earthquakes, calorimeter, trigger system, CSES, Limadou, Low earth orbit satellites, Space detectors, Marco Mese''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Deep learning based event reconstruction for Limadou HEPD

Presenter
Francesco Maria Follega
Author and Co-Author
Francesco Maria Follega | Roberto Iuppa | Marco Cristoforetti | For the CSES-Limadou collaboration

Abstract
'Deep learning algorithms have gained importance in astroparticle physics in the last years. They have been shown to outperform traditional strategies in particle identification, tracking and energy reconstruction.\r\nThe attractive feature of these techniques is their ability to model large dimensionality inputs and catch non-trivial correlations among the variables, which could be hidden or not easy to model. This contribution focuses on the application of deep neural networks to the event reconstruction of the Limadou High-Energy Particle Detector on board of the China Seismo-Electromagnetic Satellite. We describe the model adopted for the neural network and report on the performance measured on simulated and real data.'

Collaborations
other (fill field below), CSES-Limadou
Keywords and Comments
detector simulation, charged particles, cosmic ray, event reconstruction, deep learning, Francesco Maria Follega''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The analysis strategy for the measurement of the electron flux with CALET on the International Space Station

Presenter
Eugenio Berti
Author and Co-Author
Eugenio Berti | Lorenzo Pacini | Yosui Akaike | for the CALET Collaboration

Abstract
'The CALorimetric Electron Telescope (CALET), operating aboard the International Space Station since October 2015, is an experiment dedicated to high-energy astroparticle physics. The primary scientific goal of the experiment is the measurement of the electron+positron flux up to the multi-TeV region. In this poster, we will present the analysis strategy employed for this measurement. At first, we will describe the careful selection of all variables used in the analysis in order that they are well reproduced by simulations. Then, we will discuss the analysis itself, which is divided in two main steps. The first step consists of a set of selections to obtain a sample of well reconstructed candidates, removing particles outside the detector acceptance and particles with a charge Z>1, while keeping a high selection efficiency for electrons. The second step consists of a final rejection to remove the residual proton background: this is the most crucial point of the analysis and is performed using different methodologies. We will demonstrate that, at low energies, it is enough to use a simple single cut that makes use of the reconstructed longitudinal and lateral profile, whereas, at high energies, it is necessary to use a more powerful cut that combines all detector information by the use of a multivariate analysis technique. Finally, we will show that this rejection algorithm leads to very stable performances at all energies, strongly reducing the impact of the associated uncertainty, which is the main source of systematic uncertainty in the high energy region.'

Collaborations
CALET,

Keywords and Comments
Electron+Positron, Electron/Proton Discrimination, Analysis methods, Detector Performance, Eugenio Berti'On behalf of the CALET Collaboration'

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Design and expected performances of the large acceptance calorimeter for the HERD space mission.

Presenter
Lorenzo Pacini
Author and Co-Author
Lorenzo Pacini | on behalf of the HERD collaboration Nicola Mori | Jin-kun Zheng | Lin-wei Lyu | Xing-zhu Cui | Wei-wei Cao | Ming Xu | Yang Yang | Zhi-cheng Tang | Rui-jie Wang | Raffaello D'Alessandro, | Xin Liu | Tian-wei Bao | Valerio Formato | Alessio Tiberio | Yong-lin Bai | Zhi-gang Wang | Jun-jun Qi

Abstract
'The High Energy cosmic-Radiation Detection (HERD) is a future space experiment which will be installed on the China’s space station around 2025. The main goal of the experiment is the measurement of cosmic rays up to energies which are not explored by the instruments currently operating in space, in particular proton with energies up to PeV, nuclei up to hundreds of TeV per nucleon and electrons up to tens of TeV. The instrument will consist of silicon charge detectors, anti-coincidence scintillators, scintillating fiber trackers, a transition radiation detector and a deep calorimeter.\r\nThe latter is a homogeneous 3D segmented calorimeter made by about 7500 LYSO cubic crystals: thanks to this innovative design, it will achieve large acceptance, good energy resolution and excellent electron/proton discrimination. In order to increase both energy calibration capabilities and redundancy of the instrument, the LYSO scintillation light will be read-out by two independent systems: one is made by wave-length shifting fibers coupled with imaged intensified IsCMOS, and the other one consists of photodiodes with different active areas connected to a custom front-end electronics. Both read-out systems are designed to have a large dynamic range and a low power consumption. The design of the calorimeter is validated by several Monte Carlo simulations and beam test results obtained by detector prototypes. In this presentation we describe the anticipated performances of the calorimeter and the current status of the double read-out system, and we discuss recent developments of both the HERD prototype and the flight model design.'

Collaborations
other (fill field below), HERD
Keywords and Comments
calorimeter, comsic ray, Lorenzo Pacini''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
FIT: the scintillating fiber tracker of the HERD space mission

Presenter
Chiara Perrina
Author and Co-Author
Chiara Perrina | For the HERD Collaboration

Abstract
'The High Energy cosmic-Radiation Detection (HERD) facility is a space payload proposed to be installed onboard the China's Space Station (CSS). The aim of HERD is the direct detection of cosmic rays towards the “knee” of the spectrum (~ 1 PeV) and the monitoring of the gamma ray sky up to 1 TeV. The HERD core is a calorimeter capable of accepting particles incident on its top and four lateral sides, each equipped with a sector of the scintillating fiber tracker: FIT. The top sector hosts 5 tracking planes while a side sector hosts 9 tracking planes. Each tracking plane is made of 16 modules. The module, composed of a fiber mat and 3 arrays of SiPMs, is the elementary brick of FIT. Several FIT modules have been built and tested with particle beams at CERN. A FIT prototype, made of two partially instrumented tracking planes, has been assembled and sent through vibrational and thermal-vacuum space qualification tests. The results of all the tests as well as the detailed design of FIT will be presented in this contribution.'

Collaborations
, HERD
Keywords and Comments
tracker, scintillating fiber, SiPM, cosmic ray, gamma ray, Chiara Perrina"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Development of a Carbon-fiber reinforced polymer-based mechanics for embedding ALPIDE pixel sensors in the High-Energy Particle Detector space module onboard the CSES-02 satellite.

Presenter
Silvia Coli
Author and Co-Author
Silvia Coli | Massimo Angeletti | Corrado Gargiulo | Roberto Iuppa | Enrico Serra

Abstract
'The mission CSES (China Seismo-Electromagnetic Satellite) will put into orbit satellites to study perturbations in the ionosphere, possibly correlated with the occurrence of seismic events. CSES-02, the second satellite of the constellation, will be supplied with a High-Energy Particle Detector (HEPD), composed by a tracker, a trigger system and a calorimeter, designed for the detection of electrons (protons) in the 3-150 (30-250) MeV energy range. The tracker is based on the innovative monolithic pixel sensors ALPIDE, developed for the ALICE experiment, at CERN. The adaptation of the ALPIDE technology to the use in space environments, demanded for ad-hoc solutions for the mechanics, as supporting structures have to withstand structural and vibrational stresses in a wide energy range, maintaining their capability to dissipate the heat generated by ALPIDE operations. This work presents the HEPD-02 tracker, consisting of 150 pixel sensors, supported by Carbon Fiber reinforced Plastic (CFRPs) and enclosed in an Aluminum frame, focussing on the little impact that devised solutions have on the physics performance. We report results from an intense campaign of qualification tests, conducted according to the space register and constituting an important premise for using monolithic active pixel sensors in future space cosmic ray experiments.'

Collaborations
other (fill field below), CSES-Limadou
Keywords and Comments
, Silvia Coli''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Ultra-Heavy Cosmic Ray Analysis with CALET on the International Space Station: Established and Developing Procedures

Presenter
Anthony Ficklin

Author and Co-Author
Anthony Ficklin | Brian Rauch | Wolfgang Zober | Nicholas Cannady | for the CALET Collaboration

Abstract
'The CALorimetric Electron Telescope (CALET) has collected over 60 months of uninterrupted data on the flux and spectrum of the Ultra-Heavy (UH) cosmic rays from Z=30 to 40. Using the latest data provided from CALET's UH trigger, we present a newly developed UH analysis complementary to the ongoing analysis presented at this conference by Zober et al. This work introduces a new Ultra-Heavy Analysis (UHA) dataset produced from CALET production data allowing for more streamlined analysis. We detail temporal and spatial correction algorithms using both the 26Fe and 14Si peaks to improve charge resolution in the Z > 26 region. Additionally, this work presents a new method for removing the contributions from low-Z nuclei using the McIlwain L-shell parameter in place of the previously used vertical rigidity cutoff. We show that parameterization of the data with L-shell, calculated from the IGRF13 and T05 (Tsyganenko 05) geomagnetic field models, leads to fewer events being removed from the dataset, while maintaining improved charge resolution for Z > 26. Furthermore, we introduce Tarle function peak fitting to perform charge corrections needed as a result of any quenching effects. We show the most recent CALET UH results showing the effect of these improvements in the analysis.'

Collaborations
CALET,

Keywords and Comments
, Anthony Ficklin"

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Presenter Forum

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-4
Access Monday Session https://live.remo.co/e/icrc-poster-hall-42

Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The innovative particle tracker for the HEPD space experiment onboard the CSES-02

Presenter
Roberto Iuppa
Author and Co-Author
Roberto Iuppa | Sergio Bruno Ricciarini | Silvia Coli | Stefania Beole | Lorenzo De Cilladi | Giuseppe Gebbia | Ester Ricci | Paolo Zuccon

Abstract
'China Seismo-Electromagnetic Satellites are the most advanced initiative for the study of the ionosphere-lithosphere coupling from space. They are sensitive to any type of short- to long-lasting perturbations in the ionosphere, thanks to the variety of instruments that they host on board. Among them, the High-Energy Particle Detector is devoted to the observation of electrons and protons with energy thresholds of 3 MeV and 30 MeV respectively. The Limadou collaboration has designed an improved version of the HEPD for the second satellite of the CSES constellation, whose launch is scheduled for mid-2022. The main upgrade pertains to the tracker, which will be made of Monolithic Active Pixel Sensors, never used so far in space. With respect to the standard hybrid silicon microstrip technology, MAPS are more precise, more robust, easier to control and readout, cheaper and less invasive. On the other hand, they are still relatively small-sized and power-demanding. \r\n\r\nWe report on the process of spatialisation carried out by the HEPD-02 tracker team, which has adapted the operation mode of the ALPIDE sensor to realize a modular and compact particle detector, made of 5 turrets, each one containing 3 stacked sensitive planes. All of 150 ALPIDE sensors are controlled and readout with a Hybrid Integrated Circuit and supported by Carbon Fiber Reinforced Plastics staves, housed in an aluminium case. We describe in detail the HEPD-02 tracker project, demonstrating the advantages of using MAPS in space and manifesting the pioneering nature of the project for next-future larger size space missions.'

Collaborations
other (fill field below), CSES-Limadou
Keywords and Comments
Monolithic Active Pixel Sensors, Particle tracking, Low background, Cosmic-ray detector, Roberto Iuppa"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Enabling low-power MAPS-based space trackers: a sparsified readout based on smart clock gating for the High Energy Particle Detector-02

Presenter
Sergio Bruno Ricciarini
Author and Co-Author
Sergio Bruno Ricciarini | Stefania Beole | Lorenzo De Cilladi | Giuseppe Gebbia | Roberto Iuppa | Ester Ricci | Paolo Zuccon

Abstract
'The adoption of pixel sensors for space-based tracking detectors requires low power consumption and enhanced heat dissipation to cope with the satellite power and cooling constraints. The High Energy Particle Detector (HEPD) tracker onboard the CSES-02 will be the first application of monolithic active pixel sensors (MAPS) to a satellite-based experiment. This result is achieved with a parallel sparsified readout architecture implemented on a single low-power FPGA chip, which manages the 150 ALPIDE chips of the three-plane tracker. The power consumption is reduced by reading out the ALPIDE chips via the control line instead of the high speed data link, and by distributing the clock only to the portions of the detector crossed by a particle. The readout concept presented in this contribution allows to deal with both the required performance and the power constraints, and is scalable to larger and more complex detectors.'

Collaborations
other (fill field below), CSES-Limadou
Keywords and Comments
, Sergio Bruno Ricciarini"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Expected performance of the High-Energy Particle Detector onboard the second China Seismo-electromagnetic Satellite

Presenter
Zouleikha Sahnoun
Author and Co-Author
Zouleikha Sahnoun | Francesco Maria Follega | Roberto Iuppa | Alberto Oliva | Michele Pozzato | Ester Ricci

Abstract
'The High Energy Particle Detector (HEPD) is one of the scientific payloads of the China Seismo-Electromagnetic Satellite (CSES). The first satellite of the constellation was launched in February 2018 and has been operational in nominal conditions since then. With the launch of the CSES-02 scheduled for mid 2022, the realisation of the HEPD-02 detector is ongoing.\r\nThe Limadou collaboration, in charge of the payload, updated the HEPD design to improve its performance and correct minor issues observed in HEPD-01.\r\nA Monte Carlo simulation has been developed using the GEANT4 tool, in order to study the response of the new detector to protons, electrons and light nuclei and validate the new design. The comparison between simulation results and data collected during tests will also allow to calibrate the detector response and to train a specifically designed neural network for event reconstruction. We report preliminary results from the simulation and show that the updated HEPD meets the scientific requirements of the CSES-02 mission.'

Collaborations
other (fill field below), CSES-Limadou
Keywords and Comments
, Zouleikha Sahnoun''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Charge measurement of cosmic rays by Plastic Scintillantor Detector of DAMPE

Presenter
Pengxiong Ma
Author and Co-Author
Pengxiong Ma Margherita Di Santo | Zhihui Xu | Yongjie Zhang | For the DAMPE Collaboration

Abstract
'Plastic Scintillantor Detector (PSD) is part of DArk Matter Particle Explorer (DAMPE), which plays a crucial role of charge measurement for charged cosmic rays and acts as a veto for gamma rays. In this work, we give some updated correction methods to enhance the quality of charge measurement, especially for heavy nuclei. DAMPE has collected nearly 10 billions events by end of 2020, it has substantial potential to measure the spectra of cosmic rays nuclei up to hundreds of TeV energies, which could be benefited from these corrections for charge measurement.'

Collaborations
DAMPE,

Keywords and Comments
“Plastic Scintillantor, Cosmic rays, Charge measurement ”, Pengxiong Ma''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
On-Orbit Energy Calibration of the Calorimeter on the ISS-CREAM Instrument Using the Boronated Scintillator Detector

Presenter
Yu Chen
Author and Co-Author
Yu Chen Jason Link | Scott Nutter | Tyler Anderson | Tyler LaBree | John W. Mitchell | S.A. Isaac Mognet | Kenichi Sakai | Stephane Coutu | Jacob Smith | Monong Yu

Abstract
'The Cosmic Ray Energetics And Mass instrument on the International Space Station (ISS-CREAM) aims to measure the energy spectra of cosmic ray (CR) nuclei from Z=1 to Z=26 with energies from 10^{12} eV to 10^{15} eV. The calorimeter (CAL) was designed to measure the energy of the CR particles. The ISS-CREAM on-orbit data provide evidence that the CAL may have either suffered from an efficiency problem or its energy scale may be in need of calibration. As a result, a careful scrutiny of the absolute energy calibration of the CAL is needed. We propose an approach to calibrate the energy scale using the on-orbit data of the boronated scintillator detector, which is independent of CAL data and reduces potential bias. In this talk we will discuss the issues revealed by the on-orbit data, demonstrate how this can be corrected using the boronated scintillator detector and present preliminary results.'

Collaborations

Keywords and Comments
energy calibration, Yu Chen''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Application of Desensitized Nuclear Emulsion films for Chemical Composition Study of Cosmic-ray Nuclei in GRAINE 2018 balloon-borne experiment

Presenter
Atsushi Iyono
Author and Co-Author
Atsushi Iyono | Saya Yamamoto | Shigeki Aoki | Hiroki Rokujo | Satoru Takahashi

Abstract
'We have developed the desensitized nuclear emulsion films suitable for the detection of heavy cosmic ray nuclei in the high speed image processing systems (HTS) which was utilized at Nagoya University. And we have carried out our balloon flight of nuclear emulsion telescope for high resolution gamma-ray imaging of Vela Pulsar in April, 2018. We have deployed the emulsion chamber which consisted of several sensitivity type of desensitized nuclear emulsion films in this balloon flight.\r\nWe are going to report the results of this pilot studies of the application of desensitized films for the detection of cosmic ray nuclei, and the potential of sensitivity control of nuclear emulsion films suitable for image analysis.'

Collaborations
other (fill field below), GRAINE collaboration

Keywords and Comments
cosmic ray nuclei, desensitized nuclear emulsion film, Atsushi Iyono'on behalf of the GRAINE collaboration'

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Study of Desensitized Nuclear Emulsion Films with HIMAC heavy ion beams

Presenter
Moegi Okuyama
Author and Co-Author
Moegi Okuyama | Atsushi Iyono | Saya Yamamoto | Koshiro Izumi | Shigeki Aoki | Satoshi Kodaira

Abstract
'By adding suitable amount of Rh compound (Na$_3$RhCl$_6$·5H$_2$O) during the production of nuclear emulsion gel, it enabled to reduce the sensitivity of the nuclear emulsion films and realized the selection of heavy nuclei by using image processing system suitable for minimum ionized particles. We have carried out the beam exposure of desensitized nuclear emulsion films in October, 2019 at Heavy Ion Medical Accelerator in Chiba(HIMAC). When charged particles passed through the nuclear emulsion films, the track were measured as a series of silver grains of which size is typically less than one micrometer, and we traditionally determine their charge amount by measuring ionization loss signals such as grain density, delta-ray count. In this study, we measured the energy losses of heavy ion beams in desensitized emulsion films exposed horizontally to emulsion layer, and we have estimated the desensitization effect for heavy ion deltections.'

Collaborations
other (fill field below),

Keywords and Comments
Desensitized nuclear emulsion films, Comic ray nuclei, Moegi Okuyama"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Machine learning methods for helium flux analysis with DAMPE experiment

Presenter
Mikhail Stolpovskiy
Author and Co-Author
Mikhail Stolpovskiy | David Droz | Arshia Ruina | Tykhonov Andrii | Xin Wu

Abstract
'DAMPE is a space-borne experiment for the measurement of the cosmic- ray fluxes at energies up to around 100 TeV per nucleon. At energies above several tens of TeV, the electronics of DAMPE calorimeter would saturate, leaving certain bars with no energy recorded. It is also observed that at high energies the tracker and the scintillator detector that serve for the charge identification become heavily populated with back-splash tracks. Both effects interfere in precise measurements of the helium flux at highest energies. In the present contribution we discuss the application of machine learning techniques for the treatment of DAMPE data, to compensate the calorimeter energy lost by saturation and to identify helium events.'

Collaborations
DAMPE,
Keywords and Comments
, Mikhail Stolpovskiy''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Monte-Carlo simulation of the NUCLEON-HERO orbital detector.

Presenter
ILYAS SATYSHEV
Author and Co-Author
ILYAS SATYSHEV | Leonid Tkachev | Anatoliy Pan

Abstract
'A project of the OLVE-HERO space detector is proposed for CR measurement in the range 1012-1016 eV and will include a large ionization 3D calorimeter with a high granularity and geometric factor of ~16 m2・sr. The 3D structure of the calorimeter will allow registering CR particles coming from different directions. As the main NUCLEON-HERO detector is expected an image calorimeter of a boron loading of plastic scintillator with tungsten absorber. Such a calorimeter allows to measure an additional neutron signal which will improve the energy resolution of the detector. The more important, the rejection power between electromagnetic and nuclear CR components will be increased by factor 30-50 in the whole energy range. The boron loading scintillator detector prototype was designed and tested at the H8 beam test area at CERN SPS. Results of the Monte-Carlo simulation of the NUCLEON-HERO detector will be presented in the report.'

Collaborations
Keywords and Comments
, Anatoliy Pan"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The GAPS Instrument: A Large Area Time of Flight and High Resolution Exotic Atom Spectrometer for Cosmic Antinuclei

Presenter
Sean Quinn
Author and Co-Author
Sean Quinn For the GAPS Collaboration

Abstract
'Low-energy cosmic ray antideuterons (< 0.25 GeV/n) are a compelling, mostly uncharted channel of many viable dark matter models, and they benefit from a highly sup-pressed astrophysical background. The General Antiparticle Spectrometer (GAPS) is a first-of-its-kind Antarctic balloon-borne experiment specialized for the detection of low energy antiprotons, antideuterons, and antihelium with a targeted launch in 2022.\r\n\r\nThe results of our novel technology development and a summary of our current construction status are the focus of this contribution. GAPS exploits an antiparticle identification technique based on exotic atom formation and decay, allowing more active target material for a larger overall acceptance since no magnet is required. The GAPS instrument consists of a large-area ($\\sim 50$ m^2) scintillator time-of-flight, ten planes of custom silicon detectors with dedicated ASIC readout, and a novel oscillating heat pipe cooling approach.\r\n\r\nThis contribution will briefly introduce the exotic atom detection technique and expected flux sensitivities. Following this, the instrument design will be discussed, and a detailed description of experimental hardware and expected performance will be presented, followed by a summary of the progress on construction and testing while also highlighting developments of a scaled, integrated prototype.'

Collaborations
GAPS,

Keywords and Comments
tof,sipm,tracker,antiproton,antideuteron,antihelium,balloon,exotic atom,daq,, Sean Quinn''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
ISS-CREAM detector performance and tracking algorithms

Presenter
Kenichi Sakai
Author and Co-Author
Kenichi Sakai | for the ISS-CREAM Data Analysis Collaboration

Abstract
'The goal of the ISS-CREAM experiment is to measure spectra of cosmic-ray particles up to 1000 TeV from protons to iron nuclei. The detector was designed to complement other current space-based cosmic-ray missions, and was installed on the ISS on August 22, 2017. During 539 days of on-orbit operations, ISS-CREAM recorded over 58 million events. The instrument consists of a 4-layer silicon charge detector, a tungsten/scintillating-fiber sampling calorimeter for energy measurement, top and bottom scintillating detectors to create a trigger, and a boronated scintillator detector for additional shower sampling. A variety of subsystem issues developed during on-orbit operations, requiring careful data filtering, the development of extensive calibrations, and multiple tracking algorithms. We report on the performance of the ISS-CREAM instrument and present details of the analysis.'

Collaborations

Keywords and Comments
Cosmic ray, ISS, ISS-CREAM, Kenichi Sakai"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
On-orbit performance of the DAMPE BGO calorimeter

Presenter
Yifeng Wei
Author and Co-Author
Yifeng Wei | F.C.T. Barbato | E. Casilli | F. de Palma | G. Marsella | on behalf of the DAMPE Collbaration

Abstract
'The DArk Matter Particle Explorer (DAMPE) is a Chinese cosmic-ray direct detection experiment. It has been operating smoothly on-orbit since its successful launch at the end of 2015. Currently, its sub-detectors and the satellite are in good working order. The DAMPE payload employs a BGO Calorimeter for energy measurements, trigger and e/p identification. The calorimeter is constructed of 308 BGO crystals, and PMTs are coupled to the crystals with optical filters to readout scintillation light. In this work, we will present the status and performance of the calorimeter, including orbit calibration, energy measurement, especially in TeV range, detector endurance, and long term performance in a duration of 5 years.'

Collaborations
DAMPE,

Keywords and Comments
DAMPE, calorimeter, energy measurement, long term performance, Yifeng Wei"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Simulation of the DAMPE detector

Presenter
Wei Jiang
Author and Co-Author
Wei Jiang | Zhan-Fang Chen | David Droz | Yifeng Wei | Yongjie Zhang | on behalf of DAMPE Collbaration

Abstract
'Extensive Monte Carlo (MC) simulations are essential in understanding the detector's response for high-energy particle detection experiments. We present the infrastructure and status of MC simulations of the DArk Matter Particle Explorer (DAMPE), a satellite project for the direct detection of high-energy cosmic rays and gamma rays. The DAMPE simulation tool employs two widely used softwares, GEANT4 and FLUKA, which implement various physics lists to simulate the interactions of particles in the detector. The framework of the simulation tool, the production farms, the data-MC comparison, and the performance of MC simulations on the analysis are summarized.'

Collaborations
DAMPE,
Keywords and Comments
, Wei Jiang"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Charge Loss Correction in the Silicon-Tungsten Tracker-Converter for Proton-Helium Charge Identification in the DAMPE Detector

Presenter
Arshia Ruina
Author and Co-Author
Arshia Ruina | Mikhail Stolpovskiy | Maksym Deliyergiyev | Yuxing Cui

Abstract
'The DArk Matter Particle Explorer (DAMPE) is a satellite-borne experiment, in operation since 2015, aimed at studying high-energy gamma rays and cosmic nuclei fluxes. Of the various sub-detectors in the DAMPE payload, the Silicon-Tungsten tracKer-converter (STK) plays a significant role in the charge measurement of incoming ions. Depending on the angle of inclination of the impinging particle and its position of impact on these strips, the collected charge can spread between the strips which results in a small fraction of signal loss. The $\\eta$ variable is used to identify this spread of charge across the strips and correct for the associated charge loss. This brings us closer to accurate determination of particle charge which is crucial for ensuring a good discrimination between particles. The $\\eta$-correction is, therefore, expected to play an important role in the determination of heavy ions by the DAMPE detector. It has helped reduce the proton background for the helium identification in STK by a factor of 1.5 for MIP tracks.'

Collaborations
DAMPE,

Keywords and Comments
, Arshia Ruina''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Performance of the DAMPE silicon-tungsten tracker during the first 5 years of in-orbit operation

Presenter
Chiara Perrina
Author and Co-Author
Chiara Perrina | for the DAMPE Collaboration Philipp Azzarello | Enrico Catanzani | Andrii Tykhonov | Xin Wu

Abstract
'Since its launch, in December 2015, the DAMPE (DArk Matter Particle Explorer) satellite is taking data smoothly. The Silicon-Tungsten Tracker (STK) of DAMPE consists of six tracking planes (6x, 6y) of single-sided silicon strip detectors mounted on seven support trays. Tungsten plates (1 mm thick) are integrated in the 2nd, 3rd and 4th tray from the top to serve as photon converters. The STK is able to precisely reconstruct the track of charged particles and converted photons, and to measure the charge of the incoming cosmic rays thus improving the particle identification. Commissioned rapidly after the launch, the STK is running extremely well since then. The STK in-orbit calibration and performance during its first 5 years of operation, including the noise behavior and the thermal and mechanical stability, will be presented in this contribution.'

Collaborations
DAMPE,

Keywords and Comments
tracker, silicon strip detector, satellite, dark matter, Chiara Perrina''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Harmonic Interference of Earth's Orbital Velocity and the Sidereal Cosmic Ray Anisotropy

Presenter
Juan Carlos Díaz Vélez
Author and Co-Author
Juan Carlos Díaz Vélez | Rasha Abbasi | Paolo Desiati | Frank McNally Hannah Woodward

Abstract
"When cosmic-ray arrival directions are observed in celestial coordinates, they appear to have a small anisotropy whose origin is still largely unknown. In addition to this celestial anisotropy, the Earth's revolution around the Sun produces a faint Compton-Getting dipole anisotropy with an excess oriented towards the direction of motion in solar coordinates. The relative rotation of the celestial and solar reference frames over a calendar year causes interference between the two sources of anisotropy. It is possible to characterize the resulting yearly modulations by studying the side-bands to the diurnal and sidereal frequencies in anti- and extended-sidereal time frames. This work provides a numerical simulation of the interference between anisotropies in sidereal and solar reference frames to predict the anti-sidereal and extended-sidereal frames' distributions."

Collaborations
Keywords and Comments
Cosmic Ray Anisotropy, Monte Carlo, Integration, Systematics, Juan Carlos Díaz Vélez''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
The Trans-Iron Galactic Element Recorder for the International Space Station (TIGERISS)

Presenter
Brian Rauch
Author and Co-Author
Nathan Walsh | Brian Rauch Makoto Sasaki | Marcus Alfred | J. Vanderlei Martins | Tyler Anderson | Stephane Coutu | Terri Brandt | Michaela Amoo | James Buckley | Don Engel | Kenichi Sakai | A.W. Labrador | Wolfgang Zober | Jason Link | Nicholas Cannady | Georgia A. de Nolfo | S

Abstract
'TIGERISS is an Ultra-Heavy Galactic Cosmic Ray (UHGCR) detector to be proposed to the NASA Astrophysics Pioneers program capable of measuring the abundance relative to $_{26}$Fe of every element from $_{5}$B to $_{82}$Pb. It is evolved from the LDB TIGER and SuperTIGER balloon instruments and the Heavy-Nuclei Explorer SMEX, and compared to its predecessors, TIGERISS will have a greatly improved capability to definitively identify UHGCR nuclei. This has been demonstrated in component accelerator tests at CERN, including silicon strip detectors in place of scintillators. The geometry factor for TIGERISS is estimated to be from 1.1 to 1.7 m^{2} sr depending on the ISS attachment point, compared to 0.6 m^{2} sr for TIGER. Within one-year TIGERISS would observe $\\sim$27 $_{56}$Ba nuclei, a 20$\\%$ statistically significant result comparable to the current SuperTIGER data set. Not requiring corrections for atmospheric interactions and scintillator saturation effects the TIGERISS results would be cleaner, and they would also make preliminary measurements to higher charges that will test models for cosmic-ray origins and acceleration. TIGERISS will measure UHGCR nuclei resulting from neutron-capture nucleosynthesis in heavy stars, supernovae, and binary neutron-star mergers and will probe the relative contribution of r-process elements to the cosmic rays.-process elements to the cosmic rays.'

Collaborations
other (fill field below), TIGERISS
Keywords and Comments
ultra-heavy cosmic-ray nuclei, particle detectors, space station, Brian Rauch''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Determination of Expected TIGERISS Observations

Presenter
Brian Rauch
Author and Co-Author
Nathan Walsh | Wolfgang Zober | Brian Rauch

Abstract
'We present the method used to estimate the cosmic-ray observations expected for that the Trans-Iron Galactic Element Recorder for the International Space Station (TIGERISS), which is designed to measure the abundances of the rare Ultra-Heavy Galactic Cosmic Rays (UHCR) $_{30}$Zn and heavier. TIGERISS uses planes of crossed silicon strip detectors at the top and bottom for charge and trajectory determination and acrylic and aerogel Cherenkov detectors for velocity and charge determination. Instruments are modeled in configurations for the Japanese Experiment Module (JEM) "Kibo" Exposed Facility ($\\sim$1.66 m^{2} sr), as an European Space Agency Columbus Laboratory external payload ($\\sim$1.16 m^{2} sr), and as an ExPRESS Logistics Carrier (ELC) experiment ($\\sim$1.10 m^{2} sr). Differential geometry factors determined for detector orientations within the geomagnetic field over the ISS 51.6$^{\\circ}$ inclination orbit are used to determine geomagnetic screening. Energy spectra are integrated using the higher of the energies needed to trigger the instrument or penetrate the geomagnetic field for time-weighted bins of geomagnetic latitude, instrument orientation, and incidence angle. Finally, abundances are reduced by the fraction of events calculated to fragment in the instrument.'

Collaborations
other (fill field below), TIGERISS
Keywords and Comments
ultra-heavy cosmic-ray nuclei, particle detectors, space station, Brian Rauch''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
SuperTIGER Ultra-Heavy Galactic Cosmic Ray Atmospheric Propagation Corrections and Uncertainty Analysis

Presenter
Brian Rauch
Author and Co-Author
Brian Rauch | Nathan Walsh

Abstract
'The SuperTIGER (Super Trans-Iron Galactic Element Recorder) balloon-borne ultra-heavy galactic cosmic-ray (UHGCR) detector has flown twice in the stratosphere over Antarctica at altitudes up to $\\sim$130,000 ft. Corrections for propagating through the last $\\sim$0.5$\\%$ of the atmosphere are based on those developed for the preceding TIGER instrument. Changes due to nuclear interactions are determined by finding top of the atmosphere (TOA) elemental abundances that yield those measured in the instrument after solving networks of equations for all elements with partial and total charge changing cross sections stepping through fine slabs of material. Varying rates of energy loss in the atmosphere for different elements yield different TOA minimum energies for the acrylic Cherenkov detector threshold (~350 MeV/nuc). TOA abundances corrected for nuclear interactions for each element are scaled with the fraction of the integral energy spectrum for its TOA minimum energy, using the iron spectrum for the UHGCR. Statistical uncertainties are derived at the TOA by shifting the abundance of each element individually up and down by the measured uncertainty in the instrument and calculating the TOA abundance of that element. Systematic uncertainties previously were estimated by simultaneously shifting the partial and then the total cross sections for all elements up and down by their uncertainties and finding TOA abundances compared to the nominal values. Here we present a Monte Carlo study of the systematic impact of simultaneously randomly varying atmospheric propagation parameters over many trials to find the normal range of variation in the resulting TOA element abundances. Total and partial charge changing cross sections for each element are individually varied in each sampling.'

Collaborations
other (fill field below), SuperTIGER

Keywords and Comments
ultra-heavy cosmic-ray nuclei, atmosphere corrections, stratospheric balloon, Brian Rauch"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Methods & Instrumentation

Titel
Calibration of Aerogel Tiles for the RICH of the HELIX Experiment

Presenter
stephan o'brien
Author and Co-Author
stephan o'brien

Abstract
'HELIX (High Energy Light Isotope eXperiment) is a balloon-borne instrument designed to measure the chemical and isotopic abundances of light cosmic-ray nuclei. In particular, HELIX is optimized to measure 10Be and 9Be in the range 0.2 GeV/n to beyond 3 GeV/n. To achieve this, HELIX utilizes a 1 Tesla superconducting magnet with a high-resolution gas drift tracking system, time-of-flight detector, and a ring-imaging Cherenkov (RICH) detector. The RICH detector consists of aerogel tile radiators (refractive index ~1.15) with a silicon photomultiplier detector plane. To adequately discriminate between 10Be and 9Be isotopes, the refractive index of the aerogel tiles must be known to a precision of 0.1%. In this contribution, detailed mapping of the refractive index across the aerogel tiles is presented and the methodology used to obtain these measurements is discussed.'

Collaborations
other (fill field below), HELIX
Keywords and Comments
cosmic ray, RICH, aerogel, Calibration, balloon, stephan o'brien'For the HELIX collaboration'

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Results

Titel
Neural Networks aproach to event reconstruction for the GAPS experiment

Presenter
Nadir Marcelli
Author and Co-Author
Nadir Marcelli

Abstract
'The General Antiparticle Spectrometer (GAPS) is a balloon-borne detector, whose first flight is scheduled in the austral summer 2022,and is designed to measure low energy (<0.25 GeV/n) cosmic antinuclei. A particular focus is on antideuterons, which are predicted to have an ultra-low astrophysical background as compared to signals from dark matter annihilation or decay in the Galactic halo. GAPS uses a novel technique for particle identification based on the formation and decay of exotic atoms. To achieve sufficient rejection power for particle identification, an accurate determination of several fundamental quantities is needed. The precise reconstruction of the energy deposition pattern on the primary track is a particularly intricate problem and we exhibit a strategy devised to solve this using modern machine learning techniques. In the future, this approach can be used for particle identification. Here, we present preliminary results of these efforts obtained from simulated data.'

Collaborations
GAPS,

Keywords and Comments
, Nadir Marcelli'On behalf of the GAPS collaboration'

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Results

Titel
Studies of cosmic ray anisotropies with DAMPE

Presenter
Shijun Lei
Author and Co-Author
Shijun Lei | Enrico Catanzani | Wei Jiang | Chuan Yue

Abstract
'A small anisotropy in the arrival directions of comic rays has been consistently observed by ground detectors based on very large sample of events. The Dark Matter Particle explorer (DAMPE) has so far accumulated nearly 10 billion events above GeV with relatively high spatial and energy resolution, expected to be the space detector to observe the anisotropy of cosmic rays. We introduce in this poster our optimizations in the direction measurement, data sampling and anisotropy analysis. The anisotropy predicted by the east-west effect due to the Earth magnetic field and the Compton-Getting effect due to the Earth revolution are then applied to the validation of our analysis.'

Collaborations
DAMPE,
Keywords and Comments
Anisotropy, Shijun Lei"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Results

Titel
Precision Measurement of low energy positron fluxes by AMS

Presenter
maura graziani
Author and Co-Author
Fabian Machate maura graziani | weiwei xu

Abstract
'The detailed measurement of the positron fluxes from May 20, 2011 to October 29, 2019 with the Alpha Magnetic Spectrometer on the International Space Station, is presented. Time variation of the fluxes on different time scales associated with the solar activity over half solar cycle 24 is shown. The measured effect of charge sign dependent effects on particles with the same mass is discussed.'

Collaborations
AMS,
Keywords and Comments
, Fabian Machate"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Results

Titel
Searching for fractionally charged particles based on DAMPE

Presenter
Chengming Liu
Author and Co-Author
Chengming Liu Pengxiong Ma | For the DAMPE Collaboration

Abstract
'The existence of fractionally charged particles (FCP) in present is some extensions to the Standard Model of particle physics, and their detection would be a significant breakthrough. Most of the previous cosmic-rays (CRs) studies are mainly focused on the secondary CRs from the extensive air shower, but there is rarely on-orbit study to search FCP from primary CRs. The DArk Matter Particle Explorer (DAMPE) was launched into space on the 17th December 2015, and it has been working well in space for more than five years with the purpose of measuring CRs and gamma-rays and as today a large amount of scientific data has been acquired. In this work the five years' on-orbit data of DAMPE have been analyzed for the search of 2/3 fractionally charged particle (FCP). The FCP is assumed to have high penetration capability, and therefore in the selections the particle is required to penetrate the entire detector from top to bottom. Two sub-detectors, the Plastic Scintillator Detector (PSD) and the Silicon Tungsten tracKer (STK), are used for charge discrimination. The Geant4 simulations toolkit is used to investigate the signal region and selection efficiency of 2/3 FCP in the detector. The detailed selection methods and progress will be presented and discussed.'

Collaborations
DAMPE,

Keywords and Comments
Cosmic ray direct, Fractionally charged particles, New physics, Chengming Liu''

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Results

Titel
Interplay between eclipses and soft cosmic rays

Presenter
Shreya Roy
Author and Co-Author
Shreya Roy Sayak Chatterjee | Sayan Chakraborty | Saikat Biswas | Supriya Das | Sanjay K. Ghosh | Sunil K. Gupta | Atul Jain | Indranil Mazumdar | Sibaji Raha

Abstract
'Astronomical events such as Solar and Lunar eclipses provide the opportunity for studying the disturbance produced in the atmosphere by these events and its effect on cosmic ray intensity. There are earlier reports on decrease in secondary cosmic gamma ray (SCGR) flux during solar eclipse and enhancement of the same during lunar eclipse. We present the results from the measurement of SCGR using NaI(Tl) scintillator detectors during a total solar eclipse, an annular solar eclipse and two lunar eclipses that took place during 2017-2019. For the total solar eclipse of August 21, 2017, visible in parts of North America, our aim was to examine if there are any variation in the SCGR flux at Kolkata, India due to the occurrence of the eclipse in America. There were decrement and increment in SCGR flux in certain energy regions, which are interpreted as effects of the Travelling Ionospheric Disturbances (TIDs) during the solar eclipse in America. The annular eclipse of December 26, 2019, visible from Ooty, India provided a great opportunity to verify its direct effect on cosmic rays. We present the results from analysis of SCGR data from Cosmic Ray Laboratory (CRL) at TIFR, Ooty. We have also measured the variation of SCGR flux during the lunar eclipse of 31 January, 2018 and of 27 July, 2018, that took place in India. Both the measurements have been carried out in the Detector laboratory of Bose Institute, Kolkata, India. We observed a slight increment of SCGR during the lunar eclipse of January, whereas no significant changes during lunar eclipse of July. Details of all the measurements and the results will be presented.'

Collaborations

Keywords and Comments
, Shreya Roy"

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Branch CRD | Cosmic Ray Direct

Subcategory Experimental Results

Titel
Beam Test Results of the ISS-CREAM Calorimeter

Presenter
Hongguang Zhang
Author and Co-Author
Hongguang Zhang

Abstract
'The Cosmic Ray Energetics And Mass experiment for the International Space Station (ISS-CREAM) was installed on the ISS to measure high-energy cosmic-ray elemental spectra for the charge range Z=1 to 26. The ISS-CREAM instrument includes a tungsten scintillating-fiber calorimeter preceded by carbon targets for energy measurements. The carbon targets induces hadronic interactions, and showers of secondary particles develop in the calorimeter. The calorimeter was calibrated with electron beams at CERN. This beam test included position, energy, and angle scans of electron and pion beams together with a high-voltage scan for calibration and characterization. Additionally, an attenuation effect in the scintillating fibers was studied. In this paper, beam test results, including corrections for the attenuation effect, are presented.'

Collaborations
ISS-Cream,
Keywords and Comments
Cosmic Ray, ISS-Cream, Calibration, attenuation effect, Hongguang Zhang"

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Branch CRD | Cosmic Ray Direct

Subcategory Future projects

Titel
Cosmic Antiproton Sensitivity for the GAPS Experiment

Presenter
Field Rogers
Author and Co-Author
Field Rogers

Abstract
'The General Antiparticle Spectrometer (GAPS) experiment is a balloon payload designed to measure low-energy cosmic antinuclei during at least three ~35-day Antarctic flights, with the first flight expected in December, 2022. With its large geometric acceptance and novel exotic atom-based particle identification method, GAPS will detect ~1000 antiprotons per flight and produce a precision cosmic antiproton spectrum in the kinetic energy range of 0.03 − 0.23 GeV at float altitude, corresponding to 0.085 − 0.30 GeV at the top of the atmosphere. With these high statistics in a measurement extending to lower energies than any previous experiment, and with orthogonal systematic uncertainty compared to a magnetic spectrometer, the GAPS antiproton measurement will be sensitive to physics including dark matter annihilation, primordial black hole evaporation, and cosmic ray propagation. The antiproton measurement will also validate the GAPS exotic atom technique for the antideuteron and antihelium rare-event searches and provide insight into models of cosmic particle attenuation in the atmosphere. This contribution demonstrates the GAPS sensitivity to antiprotons using a full instrument simulation, event reconstruction, and solar and atmospheric effects.'

Collaborations
GAPS,

Keywords and Comments
GAPS, Antiproton, Dark Matter, Primordial Black Hole, Exotic Atom, Field Rogers''

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Branch CRD | Cosmic Ray Direct

Subcategory Future projects

Titel
Characterization of a prototype imaging calorimeter for the Advanced Particle-astrophysics Telescope from Anarctic balloon flight and CERN beam test data.

Presenter
Zachary Hughes
Author and Co-Author
Zachary Hughes | for the APT collaboration Yosui Akaike | Scott Nutter

Abstract
'We report the results and accompanying analysis methods from field-testing calorimeter prototypes for the Advanced Particle-astrophysics Telescope (APT) during the 2019 austral Antarctic balloon season and during a 2018 CERN beam test. The Advanced Particle-astrophysics Telescopeis a proposed space-based gamma- and cosmic-ray instrument that utilizes a novel dispersed imaging calorimeter for both particle tracking and energy reconstruction. The imaging CsI calorimeter (ICC) consists of a CsI:Na scintillator read out by (WLS) fibers in both the x- and y-planes. To function both as a gamma-ray and cosmic-ray instrument APT must operate over a large dynamic range, from the single photon-election regime for low energy gamma-ray events to electronics-saturating cosmic-ray events. Analysis from a 150 mm x 150 mm calorimeter prototype accompanying the 2019 SuperTIGER-2.3 flight demonstrates successful event reconstruction from the long scintillation tail of saturating cosmic-ray events by utilizing the deep memory depth available to the TARGET readout electronics. Spatial reconstruction of events are performed using a two-sided Voigt profile and show position localization within the imaging calorimeter plane to < 3 WLS fiber widths. Charge resolution was evaluated on a 50 mm x 50 mm prototype placed in the 150 GeV/nuc, A/Z = 2.2 CERN SPS beam line. Nuclei were tagged using HNX silicon-strip detectors and allowed for fragmentation cuts in the data. The vastly saturating signals were reconstructed from the CsI:Na scintillation tail and show an APT charge resolution up to Z = 12 (with experimental limitations preventing full evaluation for Z > 12) and linearity in the CsI:Na signal response up to lead.'

Collaborations
other (fill field below), APT

Keywords and Comments
Cosmic rays, instrumentation, APT, Zachary Hughes''

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Branch CRD | Cosmic Ray Direct

Subcategory Theoretical Methods

Titel
A Data-Driven approach for the measurement of ^{10}Be/^{9}Be flux ratio in Cosmic Ray with magnetic spectrometers

Presenter
Francesco Nozzoli
Author and Co-Author
Francesco Nozzoli | Cinzia Cernetti

Abstract
'Cosmic Rays (CR) are a powerful tool for the investigation of the structure of the magnetic fields in the galactic halo and the property of the Inter-Stellar Medium.\r\nTwo parameters of the Cosmic Ray propagation models: the galactic halo thickness, H, and the diffusion coefficient, D, are loosely constrained by current CR flux measurements, in particular a large degeneracy exists being only H/D well measured.\r\nThe ^{10}Be/^{9}Be isotopic flux ratio (thanks to the 2 My lifetime of ^{10}Be) can be used as a radioactive clock providing the measurement of CR residence time in the galaxy. This is an important tool to solve the H/D degeneracy. \r\nPast measurements of ^{10}Be/^{9}Be isotopic flux ratio in CR are scarce, limited to low energy and affected by large uncertainties. Here a new technique to measure ^{10}Be/^{9}Be isotopic flux ratio with a Data-Driven approach in magnetic spectrometers is presented. \r\nAs an example by applying the method to Beryllium data collected and published by PAMELA collaboration it is now possible to determine this important measurement avoiding the prohibitive uncertainties coming from the Monte Carlo simulation. It is shown that the accuracy of PAMELA data permits to infer a value of the halo thickness H within 25\\% precision.'

Collaborations

Keywords and Comments
radioactive cosmic rays, propagation models, halo thickness, beryllium, Francesco Nozzoli'Here a new (preliminary) measurement of 10Be/9Be at "high" energy is obtained by analyzing old data with a new technique. Maybe this could be tagged also as "Experimental results".'

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Branch CRD | Cosmic Ray Direct

Subcategory Theoretical Methods

Titel
A perturbative approach to a nonlinear advection-diffusion equation of particle transport

Presenter
Dominik Walter
Author and Co-Author
Dominik Walter | Horst Fichtner | Yuri Litvinenko | Frederic Effenberger

Abstract
'We explore analytical techniques for modeling the nonlinear cosmic ray transport in various astrophysical environments which is of significant current research interest. While nonlinearity is most often described by coupled equations for the dynamics of the\r\nthermal plasma and the cosmic ray transport or for the transport of the plasma waves and the cosmic rays, we \r\nstudy the case of a single but nonlinear advection-diffusion equation. The latter can be approximately solved\r\nanalytically or semi-analytically, with the advantage that these solutions are easy to use and, thus, can \r\nfacilitate a quantitative comparison to data. We present our previous work in a twofold manner.\r\nFirst, instead of employing an integral method to the case of pure nonlinear diffusion, we apply an expansion\r\ntechnique to the advection-diffusion equation. We use the technique systematically to analyze the effect of nonlinear diffusion for the cases of constant and spatially varying advection \r\ncombined with time-varying source functions. Second, we extend the study from the one-dimensional, Cartesian\r\ngeometry to the radially symmetric case, which allows us to treat more accurately the nonlinear diffusion problems on larger scales\r\naway from the source. The results are compared to numerical solutions, which are also extended to more complex situations.'

Collaborations
Keywords and Comments
, Dominik Walter''

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Branch CRD | Cosmic Ray Direct

Subcategory Theoretical Methods

Titel
Simulating the galactic cosmic ray with non-uniform grids

Presenter
Yu-Hai Ge
Author and Co-Author
Yu-Hai Ge | Hua Yue | Su-Jie Lin | Hong-Bo Hu

Abstract
'In the cosmic ray (CR) spectrum related studies, the CR propagation function was always numerically solved with the software that using the finite-difference method (FDM), i.e. GALPROP. In these solutions, the Galaxy is divided into uniform girds, which would require a huge amount of computing resources when the problem is related to the CR density nearby the solar system. For example, when we try to study how the local interstellar magnetic field within 50 pc influences the CR anisotropy, we need to divide the local area into $\\mathcal{O}(10)$ pc grids, which would occupy $\\sim$ 1000 times more memory than the usual cases.\r\n\r\nIn order to efficiently solve this kind of problem, we adopt a non-uniform-grid method. In this method, we design a set of non-uniform grids in which only the area around the solar system is finely divided while the area relatively far away is roughly divided, and then performed a nonlinear coordinate transformation to transform the problems into problems with uniform grids before applying the FDM.\r\n\r\nWith this method, we adopt the local interstellar magnetic field to predict the CR anisotropy and reach a reasonable result.'

Collaborations
Keywords and Comments
Cosmic ray propagation, Cosmic ray anisotropy, 苏杰 林"

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Branch CRD | Cosmic Ray Direct

Subcategory Theoretical Results

Titel
On the overflowing of cosmic rays from galaxies and the expansion of cosmic matter

Presenter
Antonio Codino
Author and Co-Author
Antonio Codino

Abstract
'Particles of the cosmic radiation, electrons and nuclei, transport a dominant positive electric charge. A tiny fraction of these particles of extremely high energies in favorable conditions overflow from galaxies. The overflowing of positively charged cosmic nuclei into the intergalactic space uncovers an equal amount of negative charge in the parent galaxy. Negative charge is mainly stored by quiescent electrons. After adequate particle propagation neither the negative electric charge located in the galaxies nor the positive electric charge of the overflowed cosmic nuclei can be neutralized due to the enormous distances.\r\nIn several ways it is proved that the total electric charge retained by clusters of galaxies after an appropriate time interval generate a repulsive force between clusters which overwhelms gravity. After a few billions years of electrostatic repulsion, peripheral clusters attain relativistic velocities and their mutual distances increase accordingly. Several facts suggest that the expansion of the universe, as determined by optical observations since a century, has been caused by the electrostatic repulsion of the positively charged cosmic nuclei overflowed from galaxy clusters.'

Collaborations
Keywords and Comments
High-energy cosmic rays, Cosmology, Antonio Codino''

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Branch CRD | Cosmic Ray Direct

Subcategory Theoretical Results

Titel
Galactic Molecular Clouds As Sources of Secondary Positrons

Presenter
Agnibha De Sarkar
Author and Co-Author
Agnibha De Sarkar | Sayan Biswas | Nayantara Gupta

Abstract
'Secondary positrons produced inside Galactic Molecular Clouds (GMCs) can contribute significantly to the observed positron spectrum on earth. Multi-wavelength data on GMCs are particularly useful to build this model. Very recent survey implemented the optical/IR dust extinction measurements, to trace 567 GMCs within 4 kpc of Earth, residing in the Galactic plane. We use the updated list of GMCs reported in recent papers, which are distributed in the Galactic plane, to find the secondary positrons produced in them in interactions of cosmic rays with molecular hydrogen. Moreover, by analysing the \\textit{Fermi}-LAT data, new GMCs have been discovered near the Galactic plane. We also include some of these GMCs closest to the Earth where cosmic ray interactions are producing secondaries. It has been speculated earlier that cosmic rays may be reaccelerated in some GMCs. We select 7 GMCs out of 567 GMCs recently reported, within 4 kpc of Earth, where reacceleration due to magnetized turbulence is assumed. We include a hardened component of secondary positrons, produced from interaction of reaccelerated CRs in those 7 GMCs. We use publicly available code \\textbf{DRAGON} for our simulation setup to study CR propagation in the Galaxy and show that the observed positron spectrum can be well explained in the energy range of 1 to 1000 GeV by our self-consistent model.'

Collaborations

Keywords and Comments
cosmic rays, gamma rays, Nayantara Gupta''

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Branch CRD | Cosmic Ray Direct

Subcategory Theoretical Results

Titel
Large-scale simulations of antihelium production in cosmic-ray interactions

Presenter
Anirvan Shukla
Author and Co-Author
Anirvan Shukla | Philip von Doetinchem | Amaresh Datta | Diego-Mauricio Gomez-Coral | Carina Kanitz

Abstract
'The possibility of antihelium production in interaction of cosmic rays with the interstellar gas is studied using large-scale Monte Carlo simulations. For this purpose, an energy-dependent coalescence mechanism developed previously is extended to estimate the production of light antinuclei (antihelium-3 and antihelium-4). The uncertainty in the coalescence parameter and its effect on the expected antiparticle flux is also investigated. The simulated background antihelium fluxes are found to be lower than the fluxes predicted by simplified models using numerical scaling techniques. Ongoing measurements to improve these results, at NA61/SHINE at CERN-SPS, are also discussed.'

Collaborations
, NA61/SHINE

Keywords and Comments
Cosmic-ray propagation, Cosmic-ray spectra, Coalescence model, Anirvan Shukla'Full paper available at Phys. Rev. D 102, 063004'

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Branch CRD | Cosmic Ray Direct

Subcategory Theoretical Results

Titel
Origin of Cosmic Rays and Thought Travels with CR Particles in Galaxy and in the Universe

Presenter
Lev Dorman
Author and Co-Author
Lev Dorman

Abstract
'We will show that Solar Energetic Particles (SEP), as well as energetic particles generated in magnetospheres of the Earth, Jupiter, Saturn and other planets, in interplanetary space, and in atmospheres of stars have the same nature as Galactic and Intergalactic CR: they are all runaway particles from the Maxwell-Boltzmann distribution of background plasma where they were generated. Energy of these run-away particles is much higher than average energy of background thermal particles. It is shown in this work that the energy of all these run-away particles have the same general nature: it is always transfer energy from the Macro-objects and Macro-processes directly to Micro World (to charged runaway particles). This transfer energy is formatted in dynamic plasma with frozen in magnetic fields: really magnetic fields 'glues' billions thermal background particles into Macro-objects and Macro-processes. So, thank to frozen in magnetic fields runaway particles can interact not only with thermal background particles (and loose energy), but also directly with Macro-objects and Macro-processes with very high macro-energy (many order higher than energy of run-away particle). Thermodynamically Macro-objects have much bigger "effective temperature" than runaway particles and though the energy always transferred from Macro World to runaway particles of Micro World. We also consider by thought travel together with CR particles of different energy how looked stars, planets, Galaxy and other objects.\r\nIt is important to understand what will be radiation hazards during real relativistic travels in future.'

Collaborations
Keywords and Comments
CR origin, Lev Dorman"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Application of the verified neutron monitor yield function for GLE analysis

Presenter
Alexander Mishev
Author and Co-Author
Alexander Mishev Ilya Usoskin | Sergey Koldobsky | Gennady Kovaltsov, | Leon Kocharov

Abstract
'Systematic studies of solar energetic particles (SEPs) provide a basis to understand their acceleration and propagation in the interplanetary space. During solar eruptive processes, such as solar flares and/or coronal mass ejections solar ions can be accelerated to high energy. In the majority of cases, the maximum energy of the accelerated solar ions is several tens of MeV/nucleon, but sometimes it exceeds 100 MeV/nucleon and can even reach GeV/nucleon range. In this case, the energy is sufficiently high to initiate an atmospheric cascade in the Earth’s atmosphere, whose secondary particles can reach the ground, being eventually registered by ground-based detectors, specifically neutron monitors. This particular class of events is known as ground-level enhancements (GLEs). Several methods for analyses of GLEs, using neutron monitor data were developed over the years. Here, we present a method for assessment of the spectral and angular features of the GLEs using data from the world-wide neutron monitor (NM) network, namely by modeling the global NM network response with the new verified yield function. The method is based on consecutive steps, specifically detailed computations of asymptotic acceptance cones and geomagnetic cut-off rigidity for each station used in the analysis and optimization of the global NM network response over experimental and modeled count rate increase. The method is compared with other methods, including in-situ measurements of SEPs. A very good agreement between our method and space-borne measurements performed by PAMELA space probe, specifically the derived fluence of solar protons during GLE 71 was achieved, confirming verification of the method.'

Collaborations
Keywords and Comments
ground level enhancement, neutron monitor, data analysis, Alexander Mishev''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Pulse height-length analysis of data from neutron monitors DOMC/DOMB with a new data acquisition system

Presenter
Stepan Poluianov
Author and Co-Author
Markus Similä Ilya Usoskin | Stepan Poluianov | Alexander Mishev | Gennady Kovaltsov, | Du Toit Strauss

Abstract
'Two high-altitude polar neutron monitors DOMC and DOMB (Dome C, Concordia station, Antarctic plateau, 3233 m a.s.l.) received a major electronics upgrade in 2019. While a typical standard neutron monitor data acquisition (DAQ) system only registers the number of pulses from a cosmic-ray particle detector, the new system digitizes all pulses with 2 MHz sampling rate and stores this information in raw data files. This feature makes it possible to conduct a pulse height-length analysis of the neutron monitor data on a routine basis. In this study, we have analysed several months of the cosmic-ray data recorded with the new DAQ system during 2019-2020 (more than 10 million pulses). We identified several pulse branches corresponding to different processes: (a) secondary particles from individual cosmic-ray cascades, (b) noise, (c) double pulses originated from particles of the same local cascade, (d) high multiple pulses likely related to atmospheric muons, (e) double pulses potentially caused by contamination by neutrons scattered in the neighbouring instrument. We also studied the waiting time distributions of pulses and have shown that two peaks can be clearly distinguished: (1) at about 1 millisecond, which is related to the intra-cascade particles, and (2) at 30-1000 milliseconds related to different uncorrelated cosmic-ray cascades. Our conclusions are supported by theoretical estimates of the waiting times in different scenarios.'

Collaborations
Keywords and Comments
neutron monitor, multiplicity, DOMC, DOMB,, Stepan Poluianov''

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-42

Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
A major update of the International GLE Database: Correction for the variable GCR background

Presenter
Ilya Usoskin
Author and Co-Author
Ilya Usoskin | Sergey Koldobskiy | Gennady Kovaltsov | Agnieszka Gil | Inna Usoskina | Teemu Willamo | Askar Ibragimov

Abstract
'The main detector to provide data to study highly energetic (above ~400 MeV) solar particles is the network of ground-based neutron monitors (NMs). Solar events recorded on the ground are called ground-level enhancements (GLEs). All GLE-related data from the NM network are collected in the International GLE Database (IGLED, https://gle.oulu.fi), which provides formal NM count-rate increases above the constant pre-increase level which is due to galactic cosmic rays (GCR). However, the basic formal assumption that the GCR background level remains constant throughout a GLE event is often violated. We have carefully revised the IGLED and provided a new data set of detrended NM count-rate increases that accounts for the variable GCR background. This had led to a significant revision of the corresponding integral omnidirectional fluences of solar particles reconstructed from the GLE data. The database of the detrended NM count rate is revised for most GLE events since 1956. Integral omnidirectional fluences were re-assessed for 58 GLE events and parametrised for 52 reasonably strong events by applying the modified Ellison-Ramaty spectral shape. This forms the basis for more precise studies of parameters of SEP events and thus for solar and space physics.'

Collaborations

Keywords and Comments
Neutron monitors, solar energetic particles, Ilya Usoskin''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Direct Determination of a Bare Neutron Counter Yield Function

Presenter
Waraporn Nuntiyakul
Author and Co-Author
Waraporn Nuntiyakul Pierre-Simon Mangeard | David Ruffolo | Paul Evenson | John Bieber | John Clem | Allan Hallgren | James Madsen | Roger Pyle | Alejandro Sáiz | Serap Tilav

Abstract
"Ground-based neutron counters are a standard tool for detecting atmospheric showers from GeV range primary cosmic rays of either solar or galactic origin. Bare neutron counters, a type of lead-free neutron monitor, function much like standard neutron monitors but have different yield functions primarily because they are more sensitive to neutrons of lower energy. When operated together with standard monitors, the different yield functions allow estimates to be made of the energy spectrum of galactic or solar particles. In 2010 a new array of 12 bare neutron detectors was installed at the South Pole to operate together with the neutron monitor there. Prior to installation, two of the detectors were operated on a ship that traveled from Sweden to Antarctica and back from November 2009 to April 2010. The purpose of this latitude survey was to use Earth's magnetic field, which blocks cosmic rays below the local cutoff rigidity (momentum per unit charge), as a spectrometer allowing the response function versus rigidity of these bare counters to be determined. By comparing the measured response function to direct measurements of the cosmic ray spectrum taken by the PAMELA spacecraft, we were able to make a direct determination of the yield function for the bare counters."

Collaborations

Keywords and Comments
neutron monitor, bare neutron detector, primary cosmic ray spectrum, solar modulation, yield function, latitude survey, Waraporn Nuntiyakul"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Validation of Monte Carlo Yield Function of a Semi-Leaded Neutron Monitor using Latitude Survey Data in 2019 and 2020

Presenter
Achara Seripienlert
Author and Co-Author
Achara Seripienlert Waraporn Nuntiyakul | David Ruffolo | Pierre-Simon Mangeard | Alejandro Sáiz | Sidarat Khamphakdee | Kanokkarn Fongsamut | Peng Jiang | Pongpichit Chuanraksasat | Paul Evenson | KAZUOKI MUNAKATA | James Madsen | Boonrucksar Soonthornthum | Siramas Komonji

Abstract
'A neutron monitor (NM) is a ground- (or sea-) based detector of the flux of cosmic ray particles in space. The high-energy cosmic rays in the GeV primary range interact in the upper atmosphere, producing a cascade of subatomic particles, some of which reach Earth’s surface. A neutron monitor is mostly sensitive to the neutron component of the atmospheric cascade. The standard-design neutron monitor (NM64) contains lead, the nuclei of which fragment when struck by a high-energy particle. Some of the fragments are neutrons, moderated and trapped by polyethylene, acting as a reflector and moderator. These neutrons can then be detected by induced nuclear fission of 10B in a 10BF3 gas proportional counter. The Changvan neutron monitor is a portable neutron monitor assembled in Thailand and housed in a standard insulated shipping container to conduct long-term research in polar regions. There are three proportional counters housed in the insulated shipping container, but the central counter lacks the lead producer. Since the detector has a non-standard semi-leaded design, we examine the response functions of the Changvan for neutrons and other atmospheric secondary particles with varying angles of beam generating particles. Deadtime, the specific time after each event during which the electronics cannot record another event, is also applied to the responses. This will allow us to find the yield function from the simulation. We can validate the Monte Carlo model using the latitude survey data, as a step toward using the unleaded/leaded count rate ratio from a single detector at a fixed location to study spectral variations.'

Collaborations
Keywords and Comments
, Achara Seripienlert''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Quality survey of Neutron Monitor data sources for 1951-2019

Presenter
Pauli Väisänen
Author and Co-Author
Pauli Väisänen | Ilya Usoskin | Kalevi Mursula

Abstract
'Long-term measurements from the global neutron monitor (NM) network allow to study galactic cosmic ray (GCR) variations for the last seven decades. However, the network offers data of quite different quality from the many sources. Historically, NM data is distributed through different data repositories, which include the Neutron Monitor Database (NMDB), World Data Center for Cosmic Rays (WDCCR), The Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation (IZMIRAN) repositories and individual homepages of stations/teams.\r\n\r\nHere we present a detailed quality survey by comparing the consistency of hourly resolution NM datasets of different origin. The analysis includes 300 datasets from 147 NMs in 1951-2019. As the main result of the survey, we found that the data of individual stations are not often uniform across the different sources. This results in problems with the reliability and reproducibility of scientific results. Our survey also underlines that special efforts should be given to a proper documentation of the datasets. This is particularly true for the oldest data that are in danger of getting lost to time. We also offer a list of currently recommended data sources for each station, based on their comparison with a ``prime'' dataset composed from long-lived NM stations that fulfil specific quality criteria.'

Collaborations
Keywords and Comments
Neutron monitor, Galactic Cosmic Ray Variation, Data, Data quality, Pauli Väisänen''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Determination of Yield Functions of Neutron Counters at the South Pole from Monte-Carlo Simulation

Presenter
Audcharaporn Pagwhan
Author and Co-Author
Audcharaporn Pagwhan Achara Seripienleart | Waraporn Nuntiyakul | Paul Evenson | Pierre-Simon Mangeard | Alejandro Sáiz | David Ruffolo | Seunarine Surujhdeo

Abstract
"Neutron monitors (NM64) are ground-based cosmic ray detectors that measure the flux of primary cosmic rays at the GeV-energy range by counting (primarily) secondary neutrons in atmosphere cascades. They have a lead producer to generate evaporation neutrons that are moderated before being detected in a $^{10}BF_{3}$ or ^{3}He gas-filled proportional counter. By omitting the lead, a so-called “bare detector” responds to lower energy particles on average and can be used in concurrence within NM64 to estimate the primary cosmic rays' energy spectrum. This research uses Monte-Carlo FLUKA simulation to refine our understanding of two types of bare neutron detector and three NM64 units located inside and outside, respectively, of the Amundsen-Scott station at the South Pole. One bare design uses paraffin and wood to moderate high-energy neutrons, and another bare design has no moderator. All bares are mounted together in a single assembly. The bares and NM64 all use 3He gas-filled proportional counters. In our previous work, the energy-dependent effective area (yield function) of the paraffin-moderated bares was directly determined from a ship-borne latitude survey in 2009 - 2010. The influence of the container and the environment on the ship significantly affects the measured yield function. In this work, we use simulations to relate the measured yield functions to the actual configuration at the South Pole and apply our results to study spectral variations of solar energetic particles during Ground Level Enhancements."

Collaborations

Keywords and Comments
Neutron monitor, FLUKA simulation,, Audcharaporn Pagwhan"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Commissioning of CALLISTO spectrometers in Peru and observations of type III Solar Radio Bursts

Presenter
Jose Bazo
Author and Co-Author
Jose Bazo | Javier Rengifo | Veronica Loaiza-Tacuri | Walter Guevara Day

Abstract
'Two radio spectrometer stations belonging to the e-CALLISTO network were installed in Peru by the Astrophysics Directorate of CONIDA. Given their strategic location near the Equator, it was possible to observe the Sun evenly throughout the whole year and the detector was unique in its time-zone coverage. The receiver located nearby the capital city of Lima took data in the metric and decimetric bands looking for radio bursts. To assess the suitability of the sites and the performance of the antennas, we analysed the radio ambient background and measured their radiation pattern and beam-width. To show the capabilities of the facilities to study solar dynamics in these radio frequencies we have selected and analysed type III Solar Radio Bursts. We have characterised the most common radio bursts with the following mean values: a negative drift rate of -25.8 $\\pm$ 3.7 MHz/s, a duration of 2.6 $\\pm$ 0.3 s and 35 MHz bandwidth in the frequency range of 114 to 174 MHz. In addition, for some events, it was possible to calculate a global frequency drift, which on average was 0.4 $\\pm$ 0.1 MHz/s.'

Collaborations

Keywords and Comments
instrumentation: spectrographs, Sun: radio radiation, Jose Bazo"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
ICaRO: a new cosmic ray detector at Izaña Atmospheric Observatory

Presenter
Juan José Blanco Avalos
Author and Co-Author
Juan José Blanco Avalos | Juan Ignacio García-Tejedor | Óscar García-Población | Sindulfo Ayuso de Gregorio | Iván Vrublevskyy | Alejandro López-Comazzi | Almudena Gomis Moreno | David Moure García | Emilio Cuevas | África Barreto Velasco | Ramón Ramos

Abstract
'A twin detector of ORCA, the cosmic ray detector operating at Juan Carlos I Spanish Antarctic Base, is foreseen to be installed at Izaña Atmospheric Observatory (IZO) during the second part of 2021. IZO belongs to the State Meteorological Agency of Spain (AEMET) and it is located at the top of a mountain plateau in Teide volcano at Tenerife Island (28º18'N, 16º29'W, 2373 m a.s.l.) at vertical cut-off rigidity of 11.5 GV. ICaRO (Izaña Cosmic Ray Observatory) is composed of a BF3-based 3NM64 (ICRO), 3 bare BF3 counters (ICRB). The neutron monitor is complemented by a muon telescope sharing a common room in a single stack. The muon telescope follows the MITO approach, and thus is composed of two scintillator layers, Top and Bottom. It is able to provide muon counting rate and muon impact points on the scintillator layers. MITO's layers are 1.365 m apart with the two BF3 sets, ICRO and ICRB, in between. As such, the lead surrounding ICRO acts as filter for particles traversing throughout Top and Bottom. ICaRO will provide counting rates of neutrons in two energy thresholds, muon counting rate and muon incoming directions throughout the detector volume.'

Collaborations
Keywords and Comments
Neutron Monitor, Solar Activity, Cosmic Ray, Solar Energetic Particles, Juan José Blanco Avalos''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Development of the Solar Neutron TRACking (SONTRAC) Concept

Presenter
J. Grant Mitchell
Author and Co-Author
J. Grant Mitchell Georgia de Nolfo | Alessandro Bruno | Jeffrey Dumonthier | Iker Liceaga-Indart | Jason Link | Jason Legere | Richard Messner | James Ryan | George Suarez | Teresa Tatoli

Abstract
'Fast neutrons (> 0.5 MeV) are ubiquitous in nature, originating from nuclear interactions in environments including the solar corona, within planetary atmospheres, and in the lunar regolith. However, measurements of fast neutrons of solar origin are extremely limited due to the challenges imposed by high backgrounds and the relatively short lifetime of free neutrons before they undergo beta decay. Traditional double-scatter neutron spectrometers require an incident neutron to elastically scatter in two widely spaced detectors, allowing the reconstruction of the incident neutron’s energy and direction onto an annulus. While double-scatter spectrometers are well-proven, they suffer from low effective area due to spacecraft size constraints as well as limited resolution due to the possibility of the recoil protons escaping the detector volume. The Solar Neutron TRACking (SONTRAC) concept overcomes these limitations through the use of stacked planes of plastic scintillating fibers arranged in an orthogonal configuration, to measure the ionization tracks of recoil protons. The recoil protons’ energy and direction supplant the need to measure the neutron’s time-of-flight between detectors, thereby dramatically increasing the effective area and detection efficiency. SONTRAC employs modern, miniature silicon photomultipliers (SiPM) to measure the light output from the fibers. SiPMs offer significant advantages over other photodetectors such as photomultiplier tubes due to their compact size and low bias voltages. The SONTRAC concept, combined with recent developments, including the development of a new fiber-bundle without an epoxy binder, testing of new high-performance application-specific-integrated-circuits, and development of new readout and reconstruction techniques are presented.'

Collaborations

Keywords and Comments
Neutron Spectroscopy, Solar Neutrons, Solar Flares, Silicon Photomultipliers, J. Grant Mitchell"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Response functions of semi-leaded neutron monitor count rates and leader rates from latitude surveys during 2019-2020

Presenter
Panutda Yakum
Author and Co-Author
Panutda Yakum Sidarat Khamphakdee | Waraporn Nuntiyakul | David Ruffolo | Paul Evenson | Pierre-Simon Mangeard | Alejandro Saiz | Chanoknan Banglieng | Achara Seripienlert | Peng Jiang | Pongpichit Chuanraksasat | Kazaoki Munakata | James Madsen | Boonrucksar Soonthorn

Abstract
'We have developed a portable “Changvan” neutron monitor with three counters for latitude surveys to investigate cosmic ray spectral variations. This uses the NM64 design except the middle counter lacks the lead producer, so we call this a “semi-leaded” neutron monitor. The Changvan was operated on two voyages on the Chinese icebreaker Xuelong between China and Antarctica during 2019 and 2019-2020. The standard measurement during a latitude survey is the count rate as a function of geomagnetic cutoff rigidity, i.e., the response function of the total count rate. Repeated measurements with the same detector over different phases of the solar cycle provide precise information about cosmic ray spectral variation. In addition, we have tested two techniques to track spectral variations, which have or could be implemented at fixed stations. 1) The count rate ratio of unleaded vs. leaded counters varies strongly with geomagnetic cutoff rigidity, indicating sensitivity to the cosmic ray spectrum. This measurement could be implemented at fixed stations and may have advantages relative to using a "bare" counter in that this "unleaded" counter is shielded from the environment by the reflector and has a higher count rate due to the adjacent lead. 2) We use histograms of the time delay between successive neutron counts to determine the leader fraction, as previously used to monitor short-term and solar-cycle spectral variations. Thus we report measurements of the response functions of the count rates and leader rates of the unleaded and leaded counters during these two latitude surveys.'

Collaborations

Keywords and Comments
neutron monitor, latitude survey, Leader fraction, time delay histograms, Panutda Yakum''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
Development and Production of Modular Cosmic Ray Telescopes

Presenter
Xiaochun He
Author and Co-Author
Xiaochun He | Carola Butler | Sawaiz Syed | Patrick Tarrant | Nan Chen | Ting-Can Wei

Abstract
'While the quest of searching for the origins of the most energetic cosmic rays and the associated dynamics continues, there is a growing interest in recent years of the use of the cosmic rays for practical applications following the advancement of particle detection technologies. One of these important applications is to study the correlations between the cosmic ray flux variations and the space and earth weather at global scale in real-time at low cost. Key to these efforts is improving the understanding the correlation patterns to increase the accuracy, reliability, and timeliness of space-earth-weather forecasts. A state-of-the-art portable and modular cosmic ray muon and neutron detector prototype has been developed at Georgia State University for the measurement of cosmic ray muon and neutron flux variations simultaneously. The detector consists of three layers of plastic scintillator and a neutron-cell with liquid scintillator mounted on an extruded aluminum frame. The scintillation light is collected through embedded wavelength shifting fibers which are coupled to silicon photomultipliers (SiPM) for signal readout. The modular, portable and low cost nature of this cosmic ray telescope provides a technological choice to quantify the cosmic ray flux variation around the globe in an unprecedented spacial and time resolution. In the talk, we will highlight the details of the detector design, assembly and mass production. An initial test result will also be presented.'

Collaborations
other (fill field below), to be established as a consortium of global cosmic ray detector network

Keywords and Comments
portable cosmic ray detector, space and earth weather monitoring, global detector network, low cost cosmic ray detector, Xiaochun He''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Methods & Instrumentation

Titel
A web application for monitoring cosmic rays and solar activity

Presenter
David Pelosi
Author and Co-Author
David Pelosi | Nicola Tomassetti | Matteo Duranti

Abstract
"The flux of cosmic rays in the heliosphere is subjected to variations that are related to the Sun's magnetic activity. To study this effect, updated time series of multichannel observations are needed. Here we present a web application that collects real-time data on solar activity proxies, interplanetary plasma parameters, and charged cosmic-ray data. The data are automatically retrieved on daily basis from several space missions or observatories. With this application, the data can be visualized and download into a common format. Along with observational data, the application aims to provide real-time calculations for the solar modulation of cosmic rays in the heliosphere."

Collaborations
Keywords and Comments
, Nicola Tomassetti"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Halloween GLEs on October-November 2003, spectra and angular distribution- new revised results

Presenter
Alexander Mishev
Author and Co-Author
Alexander Mishev Ilya Usoskin | Leon Kocharov

Abstract
'Precise studies of solar energetic particles provide an important basis to understand their acceleration and propagation in the interplanetary space. A specific interest is paid to solar protons possessing with energy high enough to induce an atmospheric cascade in the Earth's atmosphere, whose secondary particles can reach the ground, being eventually registered by ground-based detectors e.g. neutron monitors. This particular class of events is known as ground-level enhancements (GLEs). The solar cycle 23 provided several very strong GLEs. The first strong GLE event of the cycle was observed on 14 July 2000 (the Bastille day event), while the last was observed on 13 December 2006. In addition, the period of late October - early November 2003 was characterized by strong cosmic-ray variability and a sequence of three GLEs, which is the focus of this study. Here we performed a precise analysis of neutron-monitor records and derived the spectral and angular characteristics of the solar energetic particles for these events. We modelled the particle propagation in the Earth's magnetosphere and atmosphere using a newly computed and verified neutron-monitor yield function computed for different altitudes above sea level. The solar-protons spectra and pitch angle distributions were obtained in their dynamical development throughout the events. We briefly discussed the revealed features of the Halloween events.'

Collaborations
Keywords and Comments
solar energetic particles, neutron monitor, data analysis, Alexander Mishev'Here we present new revised results of Halloween GLEs employing newly computed and verified NM yield function and verified method for data analysis.'

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Diurnal anisotropy enhancement due to non-Earth directed coronal mass ejections

Presenter
David Ruffolo
Author and Co-Author
Nutthawara Buatthaisong | David Ruffolo | Alejandro Sáiz | Chanoknan Banglieng | Warit Mitthumsiri | Tanin Nutaro | Waraporn Nuntiyakul

Abstract
'In addition to solar modulation according to the ~11-year sunspot cycle and the ~22-year solar magnetic cycle, the time profile of the Galactic cosmic ray flux can also exhibit short-term (~2-week) modulation events. These are distinct from Forbush decreases in that they are more symmetric in time and are not associated with the local passage of an interplanetary shock and/or coronal mass ejection (CME). Using data from the Princess Sirindhorn Neutron Monitor at the summit of Doi Inthanon, Thailand, with the world's highest geomagnetic cutoff rigidity for a fixed station (16.7 GV), we have examined the solar diurnal anisotropy and find that it exhibits strong peaks during such short-term modulation events, which are indeed stronger than the diurnal anisotropy variation from sunspot minimum to maximum. We attribute these short-term modulation events to non-Earth directed CMEs, and propose specific CME associations for notable events. We propose that even when not directed to the observer, CMEs (possibly single, multiple, or interacting) that propagate beyond the observer can temporarily inhibit the access of cosmic rays. The local diffusion coefficient is apparently undisturbed, but the reduced inflow past the CME coupled with an unabated flux decrease near the Sun due to adiabatic deceleration leads to a temporary, strong gradient that generates the strong anisotropy. We contrast the physics of these short-term events with the overall ~11-year solar modulation, which has a greater effect on the Galactic cosmic ray flux but a weaker effect on its anisotropy.'

Collaborations

Keywords and Comments
neutron monitor, diurnal anisotropy, coronal mass ejection, solar modulation, David Ruffolo"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Geoeffective space weather events signatures in cosmic rays during the ascending phase of the solar cycle 24

Presenter
Agnieszka Gil
Author and Co-Author
Agnieszka Gil | Renata Modzelewska | Szczepan Moskwa | Agnieszka Siluszyk | Marek Siłuszyk | Anna Wawrzaszek | Anna Wawrzynczak

Abstract
"Solar originating events are continually evident in galactic cosmic ray (GCR) flux registered at the ground by neutron monitors and in situ by space probes. We analyze time intervals of sporadic Forbush decreases during the ascending phase of solar cycle 24. We consider cosmic rays flux, as well as, solar, heliospheric and geomagnetic activity parameters, around these periods, using different mathematical tools. Moreover, for this epoch of solar activity we compute geoelectric field for the Poland's region using a 1-D layered conductivity Earth model. Against the background of the above-mentioned parameters, we analyze the number of failures in southern Poland transmission lines. Our results reveal the increase in the superposed averaged number of failures around the appearance of solar transients visible in the GCR flux, suggesting their potential coupling."

Collaborations
Keywords and Comments
galactic cosmic rays, space weather, transmission lines, Agnieszka Gil"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Solar magnetic polarity effect on neutron monitor count rates from latitude surveys versus Antarctic stations

Presenter
Kledsai Poopakun
Author and Co-Author
Kledsai Poopakun Waraporn Nuntiyakul | David Ruffolo | Paul Evenson | Peng Jiang | Pongpichit Chuanraksasat | Marc Duldig | John Humble | Suyeon Oh

Abstract
'The Galactic cosmic ray spectrum manifests subtle variations over the 22-year solar magnetic cycle in addition to more pronounced variations over the 11-year sunspot cycle. We conducted numerous latitude surveys by operating a neutron monitor onboard an icebreaker that traveled across a wide range of geomagnetic cutoff rigidities. Here we revisit our previous work to study spectral changes using 13 annual latitude surveys from 1994 to 2007 by comparing with neutron monitor data from Mawson instead of McMurdo, which closed in 2017, in order to allow a comparison with more recent latitude surveys. We confirm linear trends between count rates at different geomagnetic cutoff rigidities and changes in slope before and after the polarity reversal in 2000 as an effect of solar magnetic polarity. We performed two more latitude surveys (in 2019 and 2019-20) with a monitor similar to the 3NM64 in the previous surveys but without lead rings around the central tube, a so-called “semi-leaded neutron monitor.” We also found similar results for the relationship between the count rate of the semi-leaded neutron monitor and that of the Jang Bogo and Mawson neutron monitor stations in Antarctica.'

Collaborations

Keywords and Comments
neutron monitor, solar modulation, solar magnetic polarity, crossover, latitude survey, Kledsai Poopakun"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Galactic cosmic ray modulation in the heliosphere based on Australian muon telescopes data. Recurrent variations of cosmic rays intensity and anisotropy

Presenter
Renata Modzelewska
Author and Co-Author
Renata Modzelewska | Harjit Ahluwalia

Abstract
'We study the galactic cosmic ray modulation in the heliosphere based on Australian muon telescopes data. We analyze the modulation parameters of galactic cosmic ray transport in the heliosphere retrieved from GCR anisotropy for solar cycle 24 covering the period 2006-2018. \r\nWe use the Fourier analysis and wavelet methods to study the periodicity in the GCR intensity and anisotropy. We re-analyze the polarity dependence of the recurrent 27-day GCR variations for high energy cosmic rays (Rm~60 GV) in 2007-2009 for negative A<0 solar magnetic polarity and 2017-2018 for positive A>0. Results will be confronted with current modulation theories. We examine the diffusion-convection-drift implications and the solar cycle and solar magnetic polarity dependence of cosmic ray modulation for muon data.'

Collaborations
Keywords and Comments
, Renata Modzelewska"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
The High-Energy Particle Detector (HEPD) as a space weather monitoring instrument on board the CSES-01 satellite

Presenter
Francesco Palma
Author and Co-Author
Francesco Palma

Abstract
'CSES-01 (China Seismo-Electromagnetic Satellite) is the first element of an\r\nextended constellation of LEO (Low Earth Orbit) satellites, dedicated to monitoring\r\nperturbations of electromagnetic fields, plasma and charged particle fluxes induced\r\nby natural sources and artificial emitters in the near-Earth space. One of the eight\r\npayloads on board CSES-01 is the Italian High-Energy Particle Detector (HEPD),\r\nwhich is equipped with a silicon tracker and a range calorimeter to detect electrons\r\n(3-100 MeV), protons (30-250 MeV), and light nuclei. Since the launch of CSES-01\r\nin February 2018, HEPD has already returned valuable information about variations\r\nin the Earth-Sun interaction during geomagnetic-storm transients. One of such events\r\nwas the G3-class geomagnetic storm that impacted the Earth's magnetosphere in late\r\nAugust 2018, causing a temporary rearrangement of the charged particle environment\r\naround the planet. In this work, the HEPD response to this magnetospheric\r\ndisturbance is presented on the base of electron rate variation measurements in the\r\nouter Van Allen radiation belts. The study of such events is crucial to better\r\nunderstand mechanisms taking place during solar events and to prevent their harmful\r\neffects on technological and anthropic systems, as well as on human health. The\r\npresented results confirm the HEPD capabilities in monitoring the near-Earth\r\nenvironment and contributing to establish a nowcasting/forecasting network in the\r\nnearest possible future.'

Collaborations
other (fill field below), Limadou
Keywords and Comments
, Francesco Palma"

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Branch	SH | Solar & Heliospheric
Subcategory	Experimental Results

Titel
Proton fluxes inside the South Atlantic Anomaly measured by the High-Energy Particle Detector (HEPD) on board the CSES-01 satellite during the 2018-2021 period

Presenter
Matteo Martucci
Author and Co-Author
Matteo Martucci

Abstract
'Despite notable improvements made in the last decades, the characterization of the near-Earth proton radiation environment is incomplete, with major uncertainties affecting the description of high-energy particles (>50 MeV) in the South Atlantic Anomaly (SAA) region. \r\nThe High-Energy Particle Detector (HEPD) on board the China Seismo-Electromagnetic Satellite (CSES-01), launched on February 2018 on a Low-Earth Orbit and with an altitude of about 507 km, is a light and compact payload suitable for measuring electrons (3-100 MeV), protons (30-300 MeV), and light nuclei (up to a few hundreds of MeV) with a high energy resolution and a wide angular acceptance. Thanks to its good identification performance, it can carry out precise and comprehensive measurement of particle fluxes, including angular information. The observations of HEPD could be fundamental not only for space weather purposes, but because they could help set important constraints on trapping and interaction processes in the Earth’s atmosphere and magnetosphere. Furthermore, they enable the testing and validation of current theoretical and empirical models of the inner radiation belt, like the NASA AP9. In this contribution, we report a preliminary analysis of >30 MeV protons detected inside the SAA region between 2018 and 2021.'

Collaborations
other (fill field below), Limadou

Keywords and Comments
Trapped Protons, SAA, HEPD, Matteo Martucci'on behalf of the Limadou Collaboration\r\nhttp://cses.roma2.infn.it/node/53'

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Measurement of the neutron travel time distribution inside a neutron monitor

Presenter
Kullapha Chaiwongkhot
Author and Co-Author
Kullapha Chaiwongkhot David Ruffolo | Wittawat Yamwong | Jirawat Prabket | Pierre-Simon Mangeard | Chanoknan Banglieng | Ekawit Kittiya | Waraporn Nuntiyakul | Warit Mitthumsiri

Abstract
'Using a setup for testing a prototype for a satellite-borne cosmic-ray ion detector, we have operated a stack of scintillator and silicon detectors on top of the Princess Sirindhorn Neutron Monitor (PSNM), an 18-counter NM64 detector at 2560-m altitude at Doi Inthanon, Thailand. Monte Carlo simulations have indicated that about 15% of the neutron counts by PSNM are due to interactions (mostly in the lead producer) of GeV-range protons among the atmospheric secondary particles from cosmic ray showers, which can be detected by the scintillator and silicon detectors. Detection of incoming charged particles associated with neutron counts in the NM64 allows a measurement of the travel time distribution of such neutrons as they scatter and propagate through the NM64, processes that are nearly the same whether the interaction was initiated by an energetic proton (for 15% of the count rate) or neutron (for 80% of the count rate). This travel time distribution underlies the time delay distribution between successive neutron counts, from which we can determine the leader fraction (inverse multiplicity), which has been used to monitor Galactic cosmic ray spectral variations over ~1-40 GV. In the present experiment we have measured both the coincidence rate of incident charged shower particles with neutron counts in the NM64 and the neutron travel time distribution. We utilize these measurements to validate Monte Carlo simulations of atmospheric secondary particle detection by the NM64 and the resulting yield functions used to interpret the count rate and the leader fraction.'

Collaborations
Keywords and Comments
neutron monitor, Monte Carlo simulation, leader fraction, spectral variation, Kullapha Chaiwongkhot''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
COSMIC RAY VARIATIONS in November–December, 2012

Presenter
Anna Lukovnikova
Author and Co-Author
Anna Lukovnikova

Abstract
'Using ground-based observations of cosmic rays (CR) from the World Network of Neutron Monitor Stations and a method of spectrographic global survey, we have examined variations in rigidity spectrum and galactic CR in November–December 2012.'

Collaborations

Keywords and Comments
Neutron Monitors, rigidity spectrum, COSMIC RAY VARIATIONS, Anna Lukovnikova"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Measurement of the re-entrant lepton spectrum with the High-Energy Particle Detector on board CSES-01

Presenter
Alessandro Sotgiu
Author and Co-Author
Alessandro Sotgiu

Abstract
'The High-Energy Particle Detector (HEPD-01) is one of the two particle detectors installed on board the China Seismo-Electromagnetic Satellite (CSES-01). The instrument consists of different subdetectors, including two planes of double-sided silicon microstrip sensors, a calorimeter constituted by 16 plastic scintillators and a layer of LYSO crystals, and a scintillator veto system surrounding the calorimeter. \r\nThe detector is dedicated to the measurement of proton (30-250 MeV) and electron (3-100 MeV) fluxes, and their variations induced by short-time perturbations of the radiation belts due to solar, terrestrial, or anthropic phenomena. Although the detector is capable to measure particles with a galactic origin, due to its energy range and to the CSES-01 polar orbit, HEPD collects particles below the local geomagnetic cutoff for a large fraction of its total live time. \r\nIn this work, the differential spectrum of re-entrant leptons (the downward-moving component of secondary electrons and positrons produced in the interactions of cosmic ray protons with the atmosphere) is measured in the near-equatorial region (altitude about 500 km) in the energy interval between 5 and 100 MeV where there is a lack of recent experimental data.'

Collaborations
, Limadou
Keywords and Comments
, Alessandro Sotgiu''

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Subcategory Experimental Results

Titel
The global search for correlations between cosmic rays and seismic activity

Presenter
Piotr Homola
Author and Co-Author
Piotr Homola | for the CREDO Collaboration

Abstract
'One of the interdisciplinary opportunities arising from a global approach to cosmic ray studies is the search for correlations between the intensities of low energy secondary cosmic radiation and seismic activity, taking into account that the two research domains are physically connected via the geomagnetic field. Despite quite a long history of the concept, no convincing evidence for such correlations has been found concerning the local occurrence of such correlations, and no successful global studies were carried out. In this talk we summarize the status of the corresponding research in the latter direction being pursued within the scientific program of the Cosmic Ray Extremely Distributed Observatory (CREDO). In our novel approach we compare the global earthquake number with the public scaler cosmic ray data from the Pierre Auger Observatory and from the Neutron Monitor Database to point to the effects that promise a potential evidence of correlations with a precursor character. The work is motivated by the perspective of a contribution from the cosmic ray field to the multi-messenger, interdisciplinary earthquake early warning system being considered by both the astroparticle physics and geophysics communities. Since the analysis to be presented is progressing dynamically, it is expected that the results shown at the time of the conference will be significantly closer to valuable scientific conclusions than they are at the time of submitting this abstract.'

Collaborations
, Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration

Keywords and Comments
secondary cosmic ray intensities, seismic activity, geomagnetic field, Piotr Homola'The main results covered by this article will be summarised in a highlight talk to be presented by a representative speaker of the CREDO Collaboration, if only the Conference Organizers agree that such a talk is given (an appropriate request will be sent

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Subcategory Experimental Results

Titel
Role of heavier-than-helium nuclei in neutron monitor response: latest results

Presenter
Sergey Koldobskiy
Author and Co-Author
Sergey Koldobskiy | Ilya Usoskin | Gennady Kovaltsov

Abstract
'Heavier-than-proton nuclei are responsible for up to 50% of neutron monitor (NM) response depending on the solar modulation and geomagnetic rigidity cutoff for given NM. Therefore, careful consideration of these species is important for careful analysis of NM data, including the reconstruction of the solar modulation potential using NM network data. Recently, the AMS-02 experiment allowed us to directly verify the NM response to heavy particles. In this work, we compare the expected contribution of heavy nuclei into the NM response considering different models of the local interstellar spectrum and different levels of solar activity.'

Collaborations
Keywords and Comments
, Sergey Koldobskiy''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Modeling of the TeV cosmic-ray anisotropy based on intensity mapping in an MHD-simulated heliosphere

Presenter
Takashi K. Sako
Author and Co-Author
Takashi K. Sako | For the Tibet ASgamma Collaboration

Abstract
"Arrival directions of galactic cosmic rays observed at the Earth are not completely uniform, at TeV energies there are small yet significant anisotropic features with amplitudes of roughly 0.1% such as large-scale deficit and excess regions called “Loss-Cone” and “Tail-In”, respectively. The origin of the anisotropy has not been known yet, although the anisotropy is considered to reflect how cosmic rays propagate through magnetic fields in the heliosphere and the surrounding interstellar medium. Recent studies make use of the ‘intensity-mapping’ method, in which heliospheric magnetic field structures are reconstructed by MHD simulations, trajectories of cosmic rays are calculated in the MHD-simulated heliosphere, and then the cosmic-ray intensity distribution observed at the Earth is mapped onto that at the outer boundary ideally outside the heliosphere based on Liouville's theorem.\r\nIn this presentation, we preform the modeling of the TeV cosmic-ray anisotropy outside the heliosphere using experimental data taken by the Tibet AS$\\gamma$ experiment. In the intensity-mapping process, we take into account for the first time the rigidity distribution of cosmic-ray particles observed by the experiment. We also discuss the influence of the heliospheric modulation on the cosmic-ray intensity distribution by varying the distance of the outer boundary from the Sun in the intensity-mapping process."

Collaborations
, The Tibet ASgamma Collaboration
Keywords and Comments
, Takashi K. Sako"

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Subcategory Experimental Results

Titel
Observation of Z>2 trapped nuclei by AMS on ISS

Presenter
Martha Valencia
Author and Co-Author
Martha Valencia | Francesca Giovacchini | Alberto Oliva for the AMS collaboration

Abstract
'The Alpha Magnetic Spectrometer collected over 150 billion cosmic rays events during the first 8.5 years of operation aboard the International Space Station. A component of Z>2 ions with rigidities below the rigidity cutoff and located in the South Atlantic Anomaly have been measured both in the down-going and up-going direction.'

Collaborations
AMS,
Keywords and Comments
, Martha Valencia"

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Subcategory Experimental Results

Titel
The effects of magnetic boundary on the uniform distribution of energetic particle intensities observed by multiple spacecraft

Presenter
Yang Wang
Author and Co-Author
Yang Wang | Dan Lvy | Gang Qin | Boxi Xiao

Abstract
'In the decay phase of solar energetic particle (SEP) events, particle intensities observed by widely separated spacecraft usually present comparable intensities (within a factor of 2-3) that evolve similarly in time. The phenomenon of SEP events is called reservoir, which could be observed frequently in intensive gradual SEP events. In this work, we examine the effects of magnetic boundary on the formation of reservoir phenomenon in energetic proton and electron events. In the 1978 January 01 and the 2000 November 08 SEP events, we find the effects of magnetic boundary associated with the reservoir phenomenon were observed simultaneously in the sheath of magnetic cloud (MC)/interplanetary coronal mass ejection (ICME). Based on the observations, we suggest that the effects of magnetic boundary could be due to the magnetic mirrors and/or the small diffusion coefficients in the sheath region, and could help to form the reservoir phenomenon in both energetic proton and electron events in some large SEP events.'

Collaborations
Voyager, ACE; Ulysses; Helios

Keywords and Comments
Particle emission , Particle acceleration, Particle transport, Coronal mass ejections,, Wang Yang"

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Subcategory Experimental Results

Titel
Evolution of electron spectrum during March 2012 by ARINA spectrometer data

Presenter
Vladimir Mikhailov
Author and Co-Author
Sergey Aleksandrin Temir Zharaspayev | Vladimir Mikhailov

Abstract
'Electron fluxes with energies of 3-30 MeV were analyzed using data from the ARINA satellite experiment. The changes in the spectrum of high-energy electrons in March 2012 were analyzed.'

Collaborations
Keywords and Comments
, Sergey Aleksandrin''

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Subcategory Experimental Results

Titel
Disturbances in communication and radar work on the air traffic control tower of the military airport in Deblin.

Presenter
Krzysztof Iskra
Author and Co-Author
Krzysztof Iskra | Justyna Tomaszewska | Marek Siłuszyk | Michał Borkowski | Jan Baranski | Magdalena Baranska | Tomasz Zienkiewicz | Tomasz Seredyn

Abstract
"We study the impact of electromagnetic conditions in the Sun, in interplanetary space and the Earth's magnetosphere (that is the so-called space weather) on possible disturbances with radar work and loss of communication with aircraft on the air traffic control tower (ATC) of the military airport in Dęblin.\r\nAt the beginning, the period of maximum solar activity in 2014 was examined\r\nAn analysis was performed using solar parameters such as: sunspot numbers(SSN), sunspot areas SSA,the solar flare index (SFI), the 10.7-cm solar radio flux, coronal mass ejection (CME), interplanetary parameters i.e. heliospheric magnetic field (HMF), proton temperature, proton density, solar wind (SW) speed,SW pressure, and geomagnetic parameters i.e.: geomagnetic field, DST index, Ap index, Kp index ,local K index from Belsk and their possible impact on radar disorders and loss of communication.\r\nThe preliminary results obtained indicate the possible impact of an increase in solar activity and associated disturbances in interplanetary space and the Earth's magnetosphere on the work of radars and communication between the ATC tower and the aircraft Our research are continued and are important from the point of view of flight safety for both manned and unmanned aircraft."

Collaborations

Keywords and Comments
space weather ,loss of communication with aircraft, Krzysztof Iskra"

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Subcategory Experimental Results

Titel
Measurement of interplanetary magnetic field in short period using the cosmic-ray Sun shadow measured by LHAASO

Presenter
Yuncheng Nan
Author and Co-Author
Yuncheng Nan | Songzhan Chen | Cunfeng Feng | for the LHAASO Collaboration

Abstract
"The interplanetary magnetic field (IMF) between the Sun and the Earth induces the displacement of the cosmic-ray Sun shadow from the optical position. Previously, the average IMF has been measured by the ARGO-YBJ and the Tibet-ASgamma experiments through several years of data. With the improvement of the sensitivity, the first pool of WCDA in LHAASO, which has obtained nearly one year's scientific data, has observed the Sun shadow with significance exceeds 70 standard deviation. Using the data collected by WCDA from July 26 to August 22, 2019, we measured the displacements of Sun shadow at the energy of 6.2 TeV every two or three days. Combining with the simulation of Sun shadow, the IMF is measured and is comparable with the satellite observations. This is the first time to measure the IMF using Sun shadow in a short period, and the expectation for space weather forecast is discussed."

Collaborations
Lhaaso,

Keywords and Comments
IMF；Sun shadow, Yuncheng Nan"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Relativistic Electron Precipitation Observations with CALET on the International Space Station

Presenter
Alessandro Bruno
Author and Co-Author
Alessandro Bruno | Georgia A. de Nolfo | Anthony Ficklin | T. Gregory Guzik | Lauren Blum | for the CALET Collaboration

Abstract
'The CALorimetric Electron Telescope (CALET) is a high-energy astroparticle physics experiment installed on the International Space Station, and taking data since October 2015. While designed for studying the origin and the propagation of galactic cosmic rays, CALET is also able to provide a continuous monitoring of space-weather phenomena affecting the near-Earth environment, including solar energetic particle and relativistic electron precipitation (REP) events. In this work we present preliminary results of the REP observations made over a four-year acquisition time (2015-2019), investigating their correlations with the interplanetary and geomagnetic conditions. We also took advantage of a multi-spacecraft study using the twin Van Allen Probe measurements to complement CALET detections in low-Earth orbit, enabling a more complete picture of the global precipitation rates and drivers.'

Collaborations
CALET,
Keywords and Comments
Relativistic Electron Precipitation, Space Weather, Earths Radiation Belts, Alessandro Bruno''

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Subcategory Experimental Results

Titel
Search for neutrinos associated with solar flare

Presenter
Kohei Okamoto
Author and Co-Author
Kohei Okamoto | Nakano Yuuki | Ito Shintaro

Abstract
"The importance of search for neutrino generation during solar flare has been discussed for last 50 years while the detection has not been succeeded yet. Since neutrinos are not affected by interplanetary magnetic field, neutrinos associated with solar flares (solar flare neutrino) provides us information about a particle acceleration mechanism during solar flare. According to theoretical predictions, the solar flare neutrino flux on the earth depends on the location of a solar flare on the Sun. Super-Kamiokande(SK), the world's largest underground water Cherenkov detector, has observed neutrinos since 1996. The predicted probability of detection in SK is $8.5 x 10^{-1}$ event/flare for a solar flare which occurs on the opposite side of Sun surface from the earth (rear side), and $1.0 x 10^{-3}$ event/flare from a solar flare of the other side (front side). In order to reduce atmospheric neutrino background for solar flare neutrino search, we have set the search window for the production time of neutrino during a solar flare occurred on front side of the Sun by analyzing data recorded by solar satellites, such as GOES, RHESSI, and Geotail [*Sol Phys* 295, 133 (2020)]. We used Coronal Mass Ejection(CME) event catalog which is made by NASA from SOHO satellite data to determine a search window for solar flare neutrino search from solar flare occurred on rear side of the Sun. In this presentation, we will present the current status of solar flare neutrino search in SK."

Collaborations
other (fill field below), Super-Kamiokande

Keywords and Comments
Solar flare ,Particle acceleration, Neutrino, Kohei Okamoto"

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Subcategory Experimental Results

Titel
Precision Measurement of Daily Helium Fluxes by the Alpha Magnetic Spectrometer

Presenter
cristina consolandi
Author and Co-Author
cristina consolandi

Abstract
'The precision measurement of the daily helium fluxes from May 20, 2011 to October 29, 2019 with the Alpha Magnetic Spectrometer on the International Space Station, is presented. The period of observation covers half solar cycle 24 from the ascending phase through its maximum going toward its minimum. Time variation of the fluxes on different time scales associated to the solar activity, are shown. We found that the p/He flux ratio is inversely proportional to the proton flux in a similar way in daily and longer time scales. Detailed time variations of fluxes and ratio will be presented.'

Collaborations
AMS,
Keywords and Comments
Galactic cosmic rays, helium, proton over helium flux ratio, time dependent, solar modulation, cristina consolandi'AMS02 Collaboration'

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Precision measurement of daily electrons fluxes by AMS¶

Presenter
Weiwei Xu
Author and Co-Author
Weiwei Xu | Fabian Machate | maura graziani | Tong Su

Abstract
'The detailed measurement of the daily electron fluxes from May 20, 2011 to October 29, 2019 with the Alpha Magnetic Spectrometer on the International Space Station, is presented. Time variation of the fluxes on different time scales associated with the solar activity over half solar cycle 24 is shown. The measured effect of charge sign dependent effects on particles with the same mass is discussed.'

Collaborations
AMS,
Keywords and Comments
, Weiwei Xu"

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Subcategory Experimental Results

Titel
New Data from the ISOIS instrument Suite on Parker Solar Probe

Presenter
Eric Christian
Author and Co-Author
Eric Christian | David McComas | Christina Cohen | Alan Cummings | Andrew Davis | Mihir Desai | Georgia A. de Nolfo | J. Giacalone | M.E. Hill | C.J. Joyce | A.W. Labrador | R.A. Leske | W.H. Matthaeus | R.L. McNutt Jr. | R.A. Mewaldt | D.G. MItchell | J.

Abstract
'NASA's Parker Solar Probe (PSP) mission's first eight orbits include perihelia as close as ~11 million km (~16 solar radii), much closer to the Sun than any prior human-made object. Onboard PSP, the Integrated Science Investigation of the Sun (ISOIS) instrument suite makes groundbreaking measurements of solar energetic particles (SEPs). Here we discuss the near-Sun energetic particle radiation environment over PSP's first two and a half years, which reveal where and how energetic particles are energized and transported. We find a great variety of energetic particle events accelerated both locally and remotely. These include co-rotating interaction regions (CIRs), “impulsive” SEP events driven by acceleration near the Sun, and events related to Coronal Mass Ejections (CMEs). These ISOIS observations made so close to the Sun provide critical information for investigating the near-Sun transport and energization of solar energetic particles, which has been difficult to resolve from prior observations. The Parker Solar Probe ISOIS data are made public soon after the receipt at Earth (which can be many months after the observations). We will also discuss how to get access to the data.'

Collaborations

Keywords and Comments
Solar Energetic Particles, acceleration, inner heliosphere,, Eric Christian''

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Subcategory Experimental Results

Titel
STUDY OF THE MODULATION OF GALACTIC POSITRONS AND ELECTRONS FROM 2006-2016 WITH THE PAMELA EXPERIMENT

Presenter
Vladimir Mikhailov
Author and Co-Author
Vladimir Mikhailov Mirko Boezio | Riccardo Munini | Donald Ngobeni | O.P.M Aslam | Marius Potgieter | Driaan Bisschoff | Sergey Aleksandrin | Sergey Koldobskiy

Abstract
'The PAMELA experiment had operated almost ten years on board of the Resurs DK1 satellite. The satellite was launched on 15 June 2006 and placed in orbit with an inclination of 70° and an altitude of 350–610 km. The experiment continuously measured electron and positron fluxes of galactic cosmic rays in a wide energy range from 50 MeV to hundreds of GeV. The spectra of electrons and positrons were analysed from the end of 23th until the beginning of 24th solar cycle including the prolonged deep solar minimum period from 2006 to the end of 2009 and the solar magnetic polarity reversal period in 2012-2014. Here, we present these spectra along with a comparison with experimental data obtained by the AMS-02 instrument, which has been operating in orbit since 2011, and with numerical solutions of a comprehensive three-dimensional drift model of solar modulation. The comparison of observations and modelling provides valuable insight into how the diffusion process changes and to what extent drift effects occur during a complete solar cycle.'

Collaborations
PAMELA,
Keywords and Comments
electrons, positrons, magnetic spectrometer, heliospheric modulation, Vladimir Mikhailov"

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Subcategory Experimental Results

Titel
Variation of proton fluxes of galactic cosmic rays during 2012-2020 according to data from the Russian spacecraft in geostationary orbit

Presenter
Evgeny Bondarev
Author and Co-Author
Evgeny Bondarev | Alexander Koziukov | Grigory Protopopov | Pavel Chubunov | Andrey Repin | Valentina Denisova | Alexey Tsurgaev

Abstract
'In this paper, we study the effect of solar modulation over the past decade, and also conduct a comparative analysis with the data provided by the GOES spacecraft.\r\nThe measurements were carried out using the Russian spacecraft on the geostationary orbit. The detector has 5 channels for detecting protons with energies E $\\geq$ 3.5 MeV, E $\\geq$ 15 MeV and also with energies E = 13.7-23 MeV, E = 23-42 MeV , E = 42-112 MeV.'

Collaborations
Keywords and Comments
Galactic cosmic rays, solar modualtion, Evgeny Bondarev''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Study of the solar modulation for the cosmic ray isotopes with the PAMELA experiment

Presenter
Alex Lenni
Author and Co-Author
Alex Lenni | Mirko Boezio | Riccardo Munini | Wolfgang Menn | Nadir Marcelli | Marius Potgieter | Driaan Bisschoff | Donald Ngobeni | O.P.M Aslam

Abstract
'The space-borne PAMELA experiment was launched on the 15th June 2006 on board the Russian satellite Resurs-DK1 from the Baikonur cosmodrome. From the beginning PAMELA performed high-precision measurements of cosmic rays over a wide energy range until January 2016. Owing to its long-duration operation, PAMELA had turned out to be an optimal detecting apparatus for studies of the solar modulation of cosmic rays over time. The PAMELA collaboration has already published time-dependent proton, Helium and electron spectra as well as the positron to electron ratio over ten years of data. These results are fundamentally important in the fine-tuning of propagation and modulation models of cosmic rays through the Heliosphere.\r\n\r\nIn this talk, the yearly average spectra for proton, Deuterium, Helium3 and Helium4 are presented for the 23rd solar minimum (July 2006 - January 2009) and the first part of the 24th solar maximum (until September 2014). The isotopic composition was measured between 0.1 and 1.1 GeV/n using two different detector systems. As expected, the measured spectra display a rising trend towards solar minimum followed by a decreasing trend which has continued as solar maximum approached. The subsequent time-dependent ratio of these isotopes is also presented. \r\n\r\nAccording to solar modulation studies, a non-constant ratio is expected due to the different charge-to-mass ratios (and therefore the appropriate rigidities) and the different shapes of the respective local interstellar spectra. Additionally, it is of interest to analyze the observed spectra with state-of-the-art solar modulation models to obtain a deeper understanding of the relative importance of the mechanisms responsible for the propagation of cosmic rays in the Heliosphere over time.'

Collaborations
PAMELA,
Keywords and Comments
, Alex Lenni"

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
Test particle simulations of SEPs originating from an expanding shock-like source

Presenter
Adam Hutchinson
Author and Co-Author
Adam Hutchinson | Silvia Dalla | Timo Laitinen | Charlotte Waterfall

Abstract
'Solar Energetic Particles (SEPs) are known to be accelerated at Coronal Mass Ejection (CME)-driven interplanetary shocks. Traditionally their propagation has been described via focussed transport approaches, limited to 1 or 2 spatial dimensions. We use 3D test particle simulations, which naturally incorporate the effect of drifts and of the Heliospheric Current Sheet (HCS), to simulate the propagation of SEPs from a moving shock-like source. We investigate the effect of an expanding shock-like source propagating through interplanetary space, as opposed to an SEP source within the corona, on the observable properties of SEPs at 1 au and at locations nearer the Sun. We derive intensity profiles, anisotropies and longitudinal and latitudinal distribution of SEPs, with the aim of supporting observations from Solar Orbiter and Parker Solar Probe'

Collaborations

Keywords and Comments
SEPs, Particle Propagation, Shock accelerated particles, Interplanetary Transport, Adam Hutchinson''

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Branch SH | Solar & Heliospheric

Subcategory Experimental Results

Titel
MODULATION OF LONG-TERM COSMIC RAY VARIATIONS DURING SOLAR ACTIVITY MINIMUM OF THE 24TH SOLAR CYCLE

Presenter
Lev Dorman
Author and Co-Author
Lev Dorman | Lev Pustilnik

Abstract
'*The observed weakening of the global magnetic field of the Sun, which began at the end of the 22nd cycle of solar activity (SA) raise the question of the response of this phenomenon in cosmic rays (CR) propagating in the heliosphere. Weak long-term modulation in the 23rd and 24th cycles of SA is the result of the trend of the solar field in cycles with different signs of the total magnetic field of the Sun (qa±1) for particles in the rigidity range we studied (1-25GV). The work was carried out on the material of continuous CR observations (1957-2020) by a network of neutron monitors, telescopes, and stratospheric balloon probes. The spectrum of CR variations in the minimum of 24/25 (2019-2020) was determined using the global spectrographic method developed by us. The spectral characteristics of the variations of the anomalous 24th SA cycle are compared (base 1.1987-12.1987) with the corresponding characteristics of the previous SA cycles (19-23). At SA minimum of 24/25 a flat (confirming the drift modulation theory for qA+1) maximum of the CR flow is observed from 2018 to the present time. At the same time, the amplitude of variations for low-energy particles (observed in the stratosphere) exceeds the value of the base period variations by ~8% and is 0.8% of the amplitude of the CR variations at the minimum of 23/24 in 2009. Max particle flow medium and high energies observed in neutron monitors and telescopes 1-2% lower than that of 23/24. If distribution of achieving minimum 23/24 particles of different energies indicated the beginning of a new cycle in CR.'

Collaborations

Keywords and Comments
minimum of solar activity, CR modulation, Lev Dorman''

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Branch SH | Solar & Heliospheric

Subcategory Future projects

Titel
Performance of the current and extended global NM network for solar particle registration and analysis

Presenter
Alexander Mishev
Author and Co-Author
Alexander Mishev Ilya Usoskin

Abstract
'Over the years the global neutron monitor network (NMN) was extensively and successfully used to study variable fluxes of Galactic cosmic rays accelerated solar ions, the latter known as energetic solar particles. Recently, the NMN has been used also for space weather purposes, specifically event alerts, and to provide crucial information necessary for the assessment of the exposure to radiation at flight altitudes. Here, we discuss the current status and applications of the global NMN, specifically its capability to study solar energetic particles, including assessments of their spectral and angular distributions during large strong solar proton events e.g. ground level enhancements. Several examples are presented, accordingly. We also discuss the existing gaps in the network and propose an improvement of the network, namely a plan for an extension of the existing network with several new monitors, in order to provide a more precise analysis of strong solar proton events and to respond to the enhanced need for the current space weather services. We discuss the ability of the optimized global neutron monitor network to study different populations of solar energetic particles and to provide reliable space weather services.'

Collaborations
Keywords and Comments
neutron monitor, solar energetic particles, space weather, Alexander Mishev'Program for extension of the current global neutron monitor network.'

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Branch SH | Solar & Heliospheric

Subcategory Future projects

Titel
SOlar Neutron and Gamma-ray Spectroscopy Mission: SONGS

Presenter
Kazutaka Yamaoka
Author and Co-Author
Kazutaka Yamaoka Tajima Hiroyasu | Daiki Nobashi | Masaki Usami | Kikuko Miyata | Takaya Inamori | Kazuhiro Nakazawa | Koji Matsushita | Kazuya Ito | Satoshi Masuda | Hiromitsu Takahashi | Kyoko Watanabe

Abstract
'Fast neutrons generated by the interaction between ions and the solar atmosphere are important observation probles to clarify the ion acceleration mechanism in the Sun, but so far neutrons have been detected from only 12 X-class solar flares in the highland on the ground due to the influence of atmospheric absorption. As for observations in space, SEDA-AP at the International Space Station continued to operate until 2018 and succeeded in neutron detections from 52 solar flares, but there are currently no dedicated space missions. In order to overcome this situation, we have been designing and developing 3U CubeSat and novel neutron / gamma ray sensors since 2018 with the aim of performing satellite observations from outer space. The sensor consists of the multi-layered plastic scintillator bars readout with Si PM, which is a semiconductor photosensor, and detects fast neutrons from the tracks of ejected protons by elastic scattering. Furthermore, by placing a GAGG scintillator array at the bottom, it is designed to be sensitive to gamma rays based on the principle of the Compton camera. In this presentation, we will report on the scientific purpose and the development status of CubeSat and neutron / gamma-ray sensors.'

Collaborations
Keywords and Comments
Microsatellite, Solar flares, Neutron and gamma-rays, scintillators, semiconductor photosensor, Kazutaka Yamaoka"

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Branch SH | Solar & Heliospheric

Subcategory Outreach and Education

Titel
Health threat from cosmic radiation during manned missions to Mars

Presenter
Alexandra D Bloshenko
Author and Co-Author
Alexandra D Bloshenko | Jasmin M. Robinson | Rafael A. Colon | Luis A. Anchordoqui

Abstract
'Cosmic radiation is a critical factor for astronauts' safety in the context of evaluating the prospect of future space exploration. The Radiation Assessment Detector (RAD) on board the Curiosity Rover launched by the Mars Scientific Laboratory mission collected valuable data to model the energetic particle radiation environment inside a spacecraft during travel from Earth to Mars, and is currently doing the same on the surface of Mars itself. The Martian Radiation Experiment (MARIE) on board the Mars Odyssey satellite provides estimates of the absorbed radiation dose in the Martian orbit, which are predicted to be similar to the radiation dose on Mars' surface. In combination, these data provide a reliable assessment of the radiation hazards for a manned mission to Mars. Using data from RAD and MARIE we reexamine the risks for a crew on a manned flight to Mars and discuss recent developments in space exploration.'

Collaborations

Keywords and Comments
cosmic radiation threat to astronauts, mission to Mars, Alexandra Bloshenko"

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Branch SH | Solar & Heliospheric

Subcategory Outreach and Education

Titel
Low Cost Neutron and Muon Detectors for Soil Moisture Monitoring

Presenter
Patrick Stowell
Author and Co-Author
Patrick Stowell | Paula M. Chadwick | Anthony Brown | Cameron B. Rulten

Abstract
'Water scarcity is a significant challenge for the world’s population. With the likelihood of extreme droughts increasing each year, technologies to promote sustainable irrigation and improve resilience to water shortage are needed. Continuous monitoring of soil moisture in arid regions is a major problem as existing techniques such as point sensors or satellite mapping can have high associated costs per hectare.\r\n\r\nCosmic Ray Neutron Sensing (CRNS) of soil moisture is a well established technique in the hydrological community. Helium-3 CRNS probes placed above a site can detect cosmic ray neutrons backscattered from the surrounding soil 130-240m away. By monitoring the variation in the total neutrons observed over time (and correcting for cosmic ray intensity) it is possible to estimate the average volumetric soil moisture content for a site. With a large detector footprint, the technique can bridge difference in length scales between point probes and satellite data, however the high cost of Helium-3 is a barrier for adoption outside of the hydrological community.\r\n\r\nWe are currently developing new boron-nitride based cosmic ray detectors as alternatives to expensive Helium-3 detectors. Taking advantage of developments in scintillator composites within the nuclear industry, and low power single photon counting instrumentation, these cost efficient detectors will be specifically optimised for use on smallholder farms. In this talk, I will present the optimisation and testing of these new systems before discussing the use of low cost muon sensors to automatically correct for temporal variations in the incoming cosmic ray intensity.'

Collaborations

Keywords and Comments
Instrumentation, Neutron, Scintillator, Industrial Application, Soil Monitor,, Patrick Stowell''

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Methods

Titel
Cosmic rays modulation in heliosphere models on GPU

Presenter
Michal Solanik
Author and Co-Author
Michal Solanik | Pavol Bobík | Ján Genči

Abstract
'Parker's transport equation stochastic solution for simulation cosmic rays distribution in the heliosphere is demanding on computing resources. Simulations can last days, weeks, or even months with certain input parameters. We implemented 1D Forward-in-time and Backward-in-time models for GPU with successful acceleration ranged from ~7x to 86x. This acceleration was gained with not a negligible reduction of accuracy, especially with changing the entire simulation from double-precision float-point format to floating-point format. This led to a certain deviation that we called pulsations that showed in results with input time step less than 2.0 s. In this paper, \r\nwe discuss the parallelization process on GPU. We also discuss the comparison of our solution with Dunzlaff et al. and the overall accuracy of results gained from GPU implementation of 1D Forward-in-time and Backward-in-time models.'

Collaborations
Keywords and Comments
Heliosphere, Cosmic rays, GPU, Parker's transport equation, Michal Solanik"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Methods

Titel
Cosmic-ray interactions with the Sun

Presenter
Mario Nicola Mazziotta
Author and Co-Author
Mario Nicola Mazziotta

Abstract
'The solar disk is a bright gamma-ray source in the sky. The interactions of cosmic rays with the solar atmosphere produce secondary particles which can reach the Earth. In this work we present a comprehensive calculation of the yields of secondary particles such as gamma-rays, electrons, positrons, neutrons and neutrinos, performed with the FLUKA code. We also estimate the intensity at the Sun and the fluxes at the Earth of these secondary particles by folding their yields with the intensities of cosmic rays impinging on the solar surface. The results are sensitive to the assumptions on the magnetic field near the Sun and to the cosmic-ray transport in the magnetic field in the inner solar system.'

Collaborations
Ferrmi-LAT,
Keywords and Comments
Solar disk emission,, Mario Nicola Mazziotta''

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Methods

Titel
On the solar poloidal magnetic field as one of the main factors for maximum GCR intensity for the last five sunspot minima

Presenter
Mikhail Krainev
Author and Co-Author
Mikhail Krainev | Boris Gvozdevsky | Mikhail Kalinin | O.P.M. Aslam | Donald Ngobeni | Marius Potgieter

Abstract
'The conditions in the heliosphere are considered during the minimum phase of the sunspot cycle when the intensity of galactic cosmic rays (GCRs) attains its maximum at the Earth. These times of maximum GCR intensity are determined for the last five sunspot minima, including the present one. From the quantitative correlation between the heliospheric factors important to the modulation of GCRs in the heliosphere and the index of high-latitude photospheric magnetic field (all determined during times of GCR intensity maxima) the conclusion is made that the poloidal magnetic field of the Sun is one of the main governing factors for these heliospheric characteristics.\r\nFollowing this up, the dependence of GCR proton spectra on the index as mentioned above for the last five sunspot minima 21/22 - 24/25 is calculated and discussed with special attention paid to the comparison of spectra for the current and previous sunspot minima and to the energy at which spectral cross-overs occur when the polarity of the heliospheric magnetic field is changed.'

Collaborations

Keywords and Comments
GCR intensity, solar modulation in heliosphere, 3D transport equation, 2D transport equation, Mikhail Krainev''

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Methods

Titel
New insights from cross-correlation studies between Solar activity and Cosmic-ray fluxes

Presenter
Nicola Tomassetti
Author and Co-Author
Nicola Tomassetti | Bruna Bertucci | Emanuele Fiandrini

Abstract
"The observed variablity of the cosmic-ray intensity in the interplanetary space is driven by the evolution of the Sun's magnetic activity over its 11-year quasiperiodical cycle. Investigating the relationship between solar activity indices and cosmic-ray intensity measurements is then essential for understanding the fundamental processes of particle transport in the heliosphere. In this work, we present global characterization the solar modulation of cosmic rays over the solar activity cycle and for different energies of the cosmic particles. We present our cross-correlation studies using data from space experiments, neutron monitors and solar observatories collected over several solar cycles."

Collaborations
Keywords and Comments
, Nicola Tomassetti"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Methods

Titel
Statistical error for cosmic rays modulation evaluation by 1D and 2D models

Presenter
Viacheslav Mykhailenko
Author and Co-Author
Viacheslav Mykhailenko | Pavol Bobík

Abstract
"The propagation of cosmic rays through the heliosphere is solved for more than half a century by stochastic methods based on Ito's lemma. This work presents the estimation of statistical error of solution of Foker – Plank equation by 1D forward stochastic differential equations method. \r\n\r\nThe error dependence on simulation statistics and energy is presented for different combinations of input parameters. The 1% precision criterium in intensities and 1% criterium in standard deviation are defined as a function of solar wind velocity and diffusion coefficient value. The implications for 1D backward and 2D models are also discussed."

Collaborations

Keywords and Comments
Cosmic rays, Fokker - Planck equation, heliosphere, SDE method., Viacheslav Mykhailenko"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Methods

Titel
Statistical analysis of Sunspot Area and their Heliospheric Effect for the Period 1986-2016

Presenter
Prithvi Raj Singh
Author and Co-Author
S.L. Agrawal | C. M. Tiwari | Abhay Kumar Singh | Prithvi Raj Singh

Abstract
'Sunspot area varies over the Sun's disk and is to be heliospheric behavior during the descending phase of solar cycle 22 to 24. Galactic Cosmic rays encounter an outward-moving solar wind with cyclic magnetic-field fluctuation and turbulence. This causes convection and diffusion in the heliosphere. We have observed that the galactic cosmic rays recoveries are much faster than the solar parameter (sunspot area) with negative time lag during the descending phase of solar cycles 22 and 24. Statistical analysis of absolute asymmetry (A) of sunspot area is carried out for quasi-biennial (QBO) period is ~1.95years with high amplitude during 2001. The significant Rieger-type periods (~124 to ~175 days) of the absolute asymmetry (A) of the sunspot area have been investigated using Morlet Wavelet Techniques (MWT) for combined solar cycles 22-24.'

Collaborations

Keywords and Comments
Solar activity, Sunspot Area of Northern and Southern hemisphere of the Sun, Galactic Cosmic rays, Prithvi Raj Singh"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Methods

Titel
Data driven analysis of Galactic cosmic rays in the heliosphere: diffusion of cosmic protons and nuclei

Presenter
Nicola Tomassetti
Author and Co-Author
Nicola Tomassetti | Bruna Bertucci | Federico Donnini | Emanuele Fiandrini | Maura Graziani | Behrouz Khiali | Alejandro Reina Conde

Abstract
'Galactic cosmic rays (GCRs) inside the heliosphere are affected by magnetic turbulence and Solar wind disturbances which result in the so-called solar modulation effect. To investigate this phenomenon, we have performed a data-driven analysis of the temporal dependence of the GCR flux over the solar cycle. With a global statistical inference of GCR data collected in space by AMS-02, PAMELA, and CRIS on monthly basis, we have determined the dependence of the GCR diffusion parameters upon time and rigidity. In this conference, we present our results for GCR protons and nuclei, we discuss their interpretation in terms of basic processes of particle transport and their relations with the dynamics of the heliospheric plasma.'

Collaborations
Keywords and Comments
, Nicola Tomassetti"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Methods

Titel
Anisotropy of Cosmic Rays and Chaotic Trajectories in the Heliosphere

Presenter
Vanessa López-Barquero
Author and Co-Author
Vanessa López-Barquero | Paolo Desiati

Abstract
"As cosmic rays (CRs) propagate in the Galaxy, they can be affected by magnetic structures that temporarily trap them and cause their trajectories to display chaotic behavior, therefore modifying the simple diffusion scenario. When CRs arrive at the Earth, they do so anisotropically. These chaotic effects can be a fundamental contributor to this anisotropy. Accordingly, this requires a comprehensive description of chaos in trapping conditions since it is necessary to assess their repercussions on the CR arrival directions. This study utilizes a new method described in López-Barquero & Desiati(2021) to characterize chaotic trajectories in bound systems. This method is based on the Finite-Time Lyapunov Exponent (FTLE), a quantity that determines the levels of chaos based on the trajectories' divergence rate. The FTLE is useful since it adapts to trapping conditions in magnetic structures or even propagating media changes. \r\nHere, we explore the effects that chaos and trapping can have on the TeV CR anisotropy. Concretely, we apply this method to study the behavior of CRs entering the heliosphere. Specifically, how the distinct heliospheric structures and CR impinging directions from the ISM can affect chaos levels. \r\nThe heliosphere has an intrinsic directionality that affects CRs differently depending on where they enter it. This feature causes preferential directions from which particles tend to be more chaotic than others. This eventually translates into changes in the arrival maps which are not uniformly distributed. Instead, we expect sectors in the map to change separately from others, creating a time-variation that could be detected. Consequently, this result points to the idea that time-variability in the maps is essential to understanding the CR anisotropy's overall processes."

Collaborations

Keywords and Comments
Anisotropy, heliosphere, chaos, trapping, confinement, magnetic fields, MHD, solar wind, energetic particles, magnetic mirror, propagation,\xa0heliospheric,\xa0chaotic, cosmic rays, maps,, Vanessa López-Barquero"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
Sensitivity estimation of LHAASO-WCDA for observing GLE events

Presenter
yunfeng zhang
Author and Co-Author
yunfeng zhang Yonglin Feng | Huanyu Jia

Abstract
'Ground Level Enhancement (GLE) events of solar cosmic ray refer to the sudden, sharp and short-lived enhancement of ground level energetic particles generated from solar flare. The study of GLE events has been playing an important role in the study of solar activity and basic physics of cosmic rays. The Large High Altitude Air Shower Observatory (LHAASO), a multi-component instrument, is located at high altitude (4410 m a.s.l.) in Daocheng, Sichuan province, P.R. China, with the one of the main aims to observe GLE events. The sensitivity of LHAASO-WCDA to observe GLE events has been estimated in this paper. The minimum flux needed for LHAASO-WCDA to observe GLE event has been calculated by using the energy spectrum of 13 GLE events during 22 solar cycles. The result shows that LHAASO-WCDA can observe GLE events with the energy exceeds 50, 100, 200 or 500 GeV.'

Collaborations
Keywords and Comments
sensitivity, GLE, LHAASO-WCDA, yunfeng zhang''

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
Using magnetic ray-tracing to reproduce the Sun's cosmic-ray shadow as seen by IceCube

Presenter
Jens Kleimann
Author and Co-Author
Jens Kleimann | Frederik Tenholt | Niklas Döpper | Mike Kroll | Julia Becker Tjus | Horst Fichtner | Paolo Desiati

Abstract
'The cosmic-ray Sun shadow is caused by high-energy charged cosmic rays (CRs) being blocked and deflected by the Sun and its magnetic field, thereby modulating the resulting shadow in both size and shape. Recent Sun shadow observations by ground-based particle observatories have established a novel and potentially fruitful link between solar physics and high-energy particle astrophysics. Most notably, the shadow's size and depth was recently shown to correlate with the 11-year solar cycle.\r\nThis talk addresses the observational situation, the general setup and implementation of our group's Sun shadow simulations, test cases, and actual simulations of increasing complexity. Based on extrapolations from magnetograms, we create artificial shadow images by numerically computing trajectories of charged CRs in the coronal magnetic field for the energy range of 5-316 TeV and for various mass numbers and typically measured CR spectra, and analyze these images in comparison to data from the IceCube neutrino observatory. We confirm the observationally established correlation between the magnitude of the shadowing effect and both the mean sunspot number and the polarity of the magnetic field during the solar cycle. Contrary to previous findings, a non-monotonous dependence on energy during solar minimum is identified and modeled using a simplified (dipolar) configuration for the coronal magnetic field.'

Collaborations

Keywords and Comments
particle tracing, imaging, solar corona, magnetic field, Jens Kleimann"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
Cosmic Rays from the Termination Shock to the Heliopause: the Role of the Heliospheric Current Sheet

Presenter
Jozsef Kota
Author and Co-Author
Jozsef Kota

Abstract
"The large-scale heliospheric current sheet (HCS), dividing the two hemispheres of the opposite magnetic polarities is a dominant large-scale feature of the Heliosphere and is known to play a crucial role in the modulation of anomalous and galactic cosmic rays (ACRs and GCRs).. \r\nThe present work investigates how the HCS may affect the acceleration of ACRs at the solar wind termination shock (TS) and the transport of ACR and GCRs throughthe Inner Heliosheath (IHS). A 2D 'hoop model' model is employed, which can capture the most essential effects of the wavy HCS. We also discuss how do ACRs leave and GCRs enter the Heliosphere."

Collaborations

Keywords and Comments
Anomalous Cosmic rays, Particle acceleration, drift, termination shock, Heliopause, Jozsef Kota"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
Numerical modeling of the solar modulation of helium isotopes in the inner heliosphere

Presenter
Donald Ngobeni
Author and Co-Author
Donald Ngobeni O.P.M. Aslam | Driaan Bisschoff | Innocentia Ramokgaba | Chris Ndiitwani | Marius Potgieter

Abstract
'The observation of cosmic ray Helium isotopes (Helium-3 and Helium-4) at the Earth had been done with the PAMELA and AMS-02 space detectors, from July 2006 to December 2007 and May 2011 to November 2017, respectively. These available observations span time frames that include the solar magnetic field reversal epoch. In this work, a comprehensive, three-dimensional numerical modulation model for the transport of cosmic rays in the heliosphere is utilized to compute the modulation of galactic Helium isotopes from minimum to maximum solar activity. The computed ratio of Helium-3 to Helium-4 is compared with the observed ratio from PAMELA and AMS-02 taken between 2006 and 2017. It will be shown how the rigidity and time dependence of this ratio depends on the level of solar activity and what the underlying physics is for this behaviour'

Collaborations
Keywords and Comments
Cosmic rays · Heliosphere · Solar modulation ·\r\nSolar activity · Galactic helium isotopes, Donald Ngobeni"

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-42

Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
TeV Cosmic Rays at the Sun: A Diffusive Approach

Presenter
Jozsef Kota
Author and Co-Author
Jozsef Kota | Federico Fraschetti | Joe Giacalone

Abstract
'TeV and multi TeV cosmic rays (CRs) cross the heliosphere in almost straight lines and are deflected only in the close vicinity of the Sun. Particles hitting the Sun create a cosmic-ray shadow (Amenomori et al. 2013, PRL, 111A, 1101) and can also create high-energy gamma rays seen by Fermi LAT (Linden et al. 2019, PRL 121, 1103). In this work we make an attempt to relate the solar cycle variation of the total area of the cosmic-ray shadow to the flux of gamma rays produced.. Both of these are proportional to the fraction of CRs hitting the Sun. While the Tibet collaboration developed a sophisticated CR back-tracing trajectory simulation, the first theoretical work on the production of gamma rays (Steckel, Stanev, and Gaisser 1991, Ap.J. 382, 652) applied a simple diffusion equation to predict the GCR flux at the bottom of the corona. These early predictions are in striking contrast with the Fermi/LAT observations, vastly underestimating the high-energy gamma-flux .\r\n\r\nWe revisit the diffusive analysis adopting an alternative equation that retains the full pitch-angle distribution of cosmic rays and remains applicable at high CR rigidities. Preliminary results will be presented and some implication for the expected gamma flux will be discussed.'

Collaborations
Keywords and Comments
TeV Cosmic Rays, Sun, particle propagation, gamma rays, Jozsef Kota"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
Implications of Solar Magnetograms for the Drifts of Cosmic Rays

Presenter
Horst Fichtner
Author and Co-Author
Horst Fichtner | Andreas Kopp

Abstract
'While gradient and curvature drifts are well-established elements of\r\nthe propagation of cosmic rays in the heliospheric magnetic field,\r\ntheir perturbation by the solar activity-induced large-scale\r\ndistortions of dipole-like field configurations even during solar\r\nminima and by magnetic turbulence is an open problem. Various\r\nempirical or phenomenological approaches have been suggested to\r\nquantify these effects so that they can be straightforwardly\r\nincorporated in modulation models covering the 22-year periodicity\r\n(including the sign) of solar activity. These approaches, however,\r\neither lack clear physics-based parametrizations (e.g., in terms of\r\nthe tilt-angle of the heliospheric current sheet) or have been shown\r\nto be incompatible with measurements (like a dependence on the\r\nnormalized turbulence level $\\delta B/B$). We propose here a new\r\napproach to the treatment of drifts over an entire solar cycle\r\nincluding maximum periods, which is based on solar magnetograms. This\r\nnot only provides a physics-based approach to the reduction of drifts\r\nduring solar activity maxima but also a treatment that is fully\r\nconsistent with those MHD models of the solar wind and the embedded\r\nheliospheric magnetic field that exploit solar magnetograms as inner\r\nboundary conditions.'

Collaborations
Keywords and Comments
cosmic rays: drifts, Sun: magnetograms, Horst Fichtner"

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
A study of variations of galactic cosmic ray intensity based on a hybrid data-processing method

Presenter
Zhenning Shen
Author and Co-Author
Zhenning Shen Qin Gang

Abstract
'The low energy cosmic-ray (CR) fluxes measured by space-borne instruments are \r\ngenerally considered to consist of the gradually changing galactic cosmic rays \r\n(GCRs) and the short-lived solar energetic particles (SEPs). The SEP events cause the sharp and ephemeral increases in the time profile of CR observations with higher occurrence rate in solar maximum. It is necessary to eliminate such \r\nspikes and obtain the pure GCR component while studying the modulation of GCRs \r\nboth in short and long time scales. A hybrid data processing method based on \r\nspike detection and time series analysis techniques is developed to remove\r\nthe spikes and decompose the GCR data observed by the Interplanetary Monitoring \r\nPlatform 8 (IMP 8) into the long-term variation trend and the 27-day variation components. With the hybrid data processing method, the 11-year \r\nand 27-day variations in the intensity of low energy GCR can be studied \r\nsystematically. Using the fitted trend component, the time lag in solar modulation of low energy GCRs is studied, and the results show that the time lag is both epoch and energy dependent. The obtained 27-day variation component is anti-correlated with the changes in solar wind velocity even during solar maximum. Implementing the running Fourier series fit procedure, the 27-day \r\nvariation amplitude of proton flux is computed. It is found that the yearly averaged values show clearly 11- and 22-year variation cycles. In addition, \r\nthe energy spectrum of the 27-day variation amplitude is softer in $A<0$ solar minimum than that in $A>0$ solar minimum.'

Collaborations

Keywords and Comments
, Zhenning Shen''

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
Suprathermal Electron Acceleration by an ICME-driven Quasi-perpendicular Shock on 2000 Feb 11

Presenter
Fanjing Kong
Author and Co-Author
Gang Qin | Fanjing Kong

Abstract
'Using test-particle simulations we study the acceleration of suprathermal electrons at an ICME-driven quasi-perpendicular shock on 2000 Feb 11 observed by Wind spacecraft. The downstream electron distribution in several energy channels from ~0.3 to ~40 keV are obtained assuming an initial distribution based on the observed upstream electron intensities. It is shown that in each energy channel the ratio of downstream to upstream intensities peaks at about 90° pitch angle, and in each pitch angle direction the downstream electron energy spectral index is much larger than the theoretical index of diffusive shock acceleration. In addition, assuming the dominance of shock drift acceleration mechanism and the conservation of the phase space density before and after the acceleration, we find that the estimated drift length is proportional to the electron energy but the drift time is almost energy independent. Furthermore, we construct a theoretical model based on SDA to describe the energy dependence of drift length and drift time. These results indicate the importance of SDA in the acceleration of electrons by quasi-perpendicular shocks, consistent with Yang et al. conclusion.'

Collaborations
Keywords and Comments
acceleration of particles, shock waves, turbulence, Fanjing Kong"

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Branch	SH | Solar & Heliospheric
Subcategory	Theoretical Results

Titel
Study of momentum diffusion with the effect of adiabatic focusing

Presenter
junfang wang
Author and Co-Author
junfang wang | Gang Qin

Abstract
'Momentum diffusion of the energetic charged particles is an important mechanism of the\r\ntransport process in astrophysics, physics of the fusion devices, and laboratory plasmas. \r\nIn the light of observations, for the investigation of energetic particle\r\ntransport through magnetized plasma, one usually assumes the\r\nmagnetic field configuration as the superposition of the background\r\nmagnetic field B_0 and the turbulent component $\\delta B$. \r\nThe fact that large-scale magnetic field is nonuniform in space\r\ngives rise to the so called adiabatic focusing effect\r\nof the energetic particles. \r\nPrevious authors found that the along-field focuing \r\ncan lead to the convective term in momentum space. \r\nHere, we explore the momentum diffusion depending on the adiabatic focusing \r\neffect along the background magnetic field. \r\nBy employing the iteration method, \r\nwe derive the momentum diffusion coefficient $A(\\xi)=A_0+\\mathcal{M}_4(\\xi)$ \r\nwith the uniform field momentum diffusion coefficient A_0 and \r\nthe modifying term $\\mathcal{M}_4(\\xi)=M_1(\\xi)+M_2(\\xi)+M_3(\\xi)+M_4(\\xi)$ \r\nby retaining up to the fourth order of the focusing parameter $\\xi$. \r\nThereafter, we evaluate the modifying term $\\mathcal{M}_4(\\xi)$\r\nto find that it is not equal to zero for most of the cases, so that we obtain \r\na new second order acceleration mechanism of energetic charged particles.\r\nAfter evaluating the modifying term, \r\nwe find that it is determined by \r\nthe sign of the focusing characteristic length \r\nand the cross helicity of turbulent magnetic field.'

Collaborations
Keywords and Comments
Interplanetary turbulence , Magnetic fields, Solar energetic\r\nparticles, junfang wang''

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
Characteristics of the N-component of the heliospheric magnetic field observed by IMP and ACE over 46 years

Presenter
Renier Burger
Author and Co-Author
Renier Burger Amore Nel | Nicholas Engelbrecht

Abstract
Ab initio modulation models use a turbulence spectrum as input, and changes in this spectrum over multiple solar magnetic cycles can have significant effects on the calculated level of modulation. In this project, turbulence quantities are calculated for 27-day intervals and then binned and presented in 378-day intervals, using IMP and ACE magnetic field data from late 1973 to the last solar minimum in late 2020. For the N-component of the magnetic field, we find that the average spectral index of the inertial range is 1.69$\\pm$0.06 and that of the energy range 1.03$\\pm$0.22. The breakpoint between the energy- and the inertial range is at a timescale of around 68 min but with a large spread, this quantity is believed to be solar-cycle dependent but difficult to resolve accurately. The spectral levels of both the energy- and the inertial range show a clear solar-cycle dependence for ACE data, but this dependence is much less obvious for IMP data before 1998. The lowest yearly-averaged magnetic field magnitude and the lowest magnetic variance since 1974 occur in the interval that includes the 2020 solar minimum, 4.16 nT and 4.4 nT^2 respectively, both quantities are lower than the corresponding 2009 solar minimum values. The ratio of the square root of the average variance to the average magnetic field magnitude, $\\delta$B/B, is remarkably constant at 0.52$\\pm$0.03 over the 46-year period.'

Collaborations

Keywords and Comments
IMP spacecraft, ACE spacecraft, heliospheric magnetic field, turbulence, spectral index, spectral level, magnetic variance, Renier Burger"

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Branch	SH | Solar & Heliospheric
Subcategory	Theoretical Results

Titel
TIME-DEPENDENT PROPAGATION TIMES AND ENERGY LOSSES OF PROTONS IN THE HELIOSPHERE: A SOLAR MODULATION MODELLING IN LIGHT OF NEW COSMIC-RAY DATA FROM OBSERVATIONS

Presenter
Behrouz Khiali
Author and Co-Author
Behrouz Khiali | Nicola Tomassetti | Emanuele Fiandrini | Bruna Bertucci

Abstract
'After entering the Galactic cosmic rays (CRs) into the heliosphere, their intensities decrease during their propagation toward the Earth. This effect is subjected to a variety of physical processes through their propagation which referred to as CR solar modulation. The key ingredients in the study of this phenomenon are the knowledge of the local interstellar spectrum (LIS) of Galactic cosmic rays and the understanding of how the solar modulation affects the LIS inside the heliosphere. For this purpose, here we present an improved data-driven description of the solar modulation phenomenon, that is, the temporal evolution of the CR flux inside the heliosphere caused by the 11-year variability cycle of the Sun’s magnetic activity. The model was applied to the Galactic proton flux measured by Voyager 1, AMS-02, and PAMELA missions which provide valuable information, allowing us to shed light on the shape of the LIS and the details of the solar modulation for the time period from mid- 2006 to mid-2017. The new results for the temporal dependence of the key model parameters, their relationship with solar activity proxies, the implications for the CR transport in magnetic turbulence, and the new insights on our understanding of the solar modulation effect are presented. The study of the time variation of GCR spectra observed at Earth can shed light on the underlying physical processes, specifically diffusion and particle drifts.'

Collaborations

Keywords and Comments
Cosmic-rays , solar modulation , heliosphere, Behrouz Khiali''

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Branch SH | Solar & Heliospheric

Subcategory Theoretical Results

Titel
Comparison of the energy spectra between pileup shock and converging shock

Presenter
Xin Wang
Author and Co-Author
Xin Wang | Xueshang Feng | Yihua Yan | Mingde Ding

Abstract
'We present a few possibilities for forming an extended energy spectrum and producing a varied slope in different double-shock models. In our previous work, the converging double-shock model would provide more kinetic energy injecting into the particles acceleration. The high efficient injection rate excited by amplified magnetic turbulence from the converged region make the extended energy spectrum be possible. In our present work, the pileup-shock model provide a opportunity of the re-accelerated processes of the particles on the merged shock precursor region. With the expended precursor region, more and more particles can participate into the pileup-shock system, the 'concave' slope of the energy spectrum would be produced due to the enhancement magnetic turbulence between the merged pileup-shock. We have proved that the converging double-shock model taken a negative effect on the accelerated particles and produce an energy 'break' slope. And we investigate that a positive effect on particle acceleration in pileup twin-shock scenario can produce a 'concave' slope on the energy spectrum.'

Collaborations

Keywords and Comments
GLE, acceleration of particles--methods:numerical--shock waves--solar wind--Sun:coronal mass ejections(CMEs), Xin Wang''

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Branch Exhibition

Subcategory Industry Fair

Titel
CAEN s.p.a.

Presenter
Ferdinando Giordano
Author and Co-Author
Ferdinando Giordano

Abstract
'/'

Collaborations
Keywords and Comments
, Nicolas Martin Peschau''

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Branch Exhibition

Subcategory Industry Fair

Titel
Amsterdam Scientific Instruments B.V.

Presenter
Hans Radhoe
Author and Co-Author
Hans Radhoe

Abstract
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Collaborations
Keywords and Comments
, Nicolas Martin Peschau"

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Branch Exhibition

Subcategory Industry Fair

Titel
Hamamatsu Photonics Deutschland GmbH

Presenter
Christoph Seibel
Author and Co-Author
Christoph Seibel

Abstract
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Collaborations
Keywords and Comments
, Nicolas Martin Peschau"

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Branch Exhibition

Subcategory Science Fair

Titel
International Elementary Particle Laboratory/STEAM Program

Presenter
Waleska Aldana Segura
Author and Co-Author
Waleska Aldana Segura | Felix Julian

Abstract
'International Elementary Particle laboratory working with STEAM program to promote science advocacy, awareness and interest.\r\nWe present the International Elementary Particle Laboratory where new pedagogical models have been established successfully. Over the last 15 years, the laboratory participates in significant International Collaborations like DUNE and MINERvA of the Fermi National Accelerator Laboratory and prominent outreach programs like STEAM Program binationally with Guatemala.\r\nThe hands-on model has allowed, during the pandemic, to plan, to design and remotely construct over 30 original prototypes for radiation detection.\r\nAlso, at the same time, outreach strategies have been implemented like the Leon Lederman Seminar Series and participate in online workshops like Falling Walls, Berlin Science Week Physics with presentations like Flight in the Little Prince World.\r\nDuring the Science Fair, we want to introduce a small video to show the work and some preliminary obtained results in the radiation detection innovation.'

Collaborations
Keywords and Comments
, Nicolas Martin Peschau"

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Branch Exhibition

Subcategory Science Fair

Titel
KATRIN outreach from KIT

Presenter
Manuel Klein
Author and Co-Author
Manuel Klein

Abstract
'Discover the KATRIN experiment online inside your browser!\r\nThe KArlsruhe TRItium Neutrino (KATRIN) experiment performs a model-independent measurement of the electron neutrino mass via the tritium beta spectrum near its energetic endpoint.\r\nKATRIN employs the MAC-E filter principle in a 70 meter long beamline, including a 20 meter long main spectrometer and a high-luminosity tritium source.\r\nThis contribution to the Science Fair takes you on a virtual trip to the KATRIN experiment and shows you the scale and complexity of its beamline in five 3D panoramas.\r\nTake the guided tour (in German) or discover the technology and history of KATRIN in free exploration and at numerous info points – maybe even some scientists from the KATRIN collaboration will drop by and talk about their work.\r\nIn a second application, you can further take an interactive look at the KATRIN detector section and its layered setup.'

Collaborations
Keywords and Comments
, Nicolas Martin Peschau"

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Branch Exhibition

Subcategory Science Fair

Titel
The Cherenkov Telescope Array Observatory Virtual Exhibition Experience

Presenter
Alba Fernández-Barral
Author and Co-Author
Megan Grunewald | Alba Fernández-Barral

Abstract
'The Cherenkov Telescope Array Observatory (CTAO) will be the first ground-based gamma-ray observatory and the world’s largest and most sensitive instrument for the exploration of the high-energy Universe. Not only will it break new ground in our understanding of the Universe, it will be the first of its kind to be open to the world-wide astronomical and particle physics communities as a resource for data from unique, very-high energy astronomical observations. The CTAO is launching its new virtual exhibition for the ICRC, which will host a wide variety of materials and multimedia for visitors to explore. Additionally, scheduled live broadcasts or chat sessions with our experts will allow participants to ask questions and discuss the scientific prospects of CTA. And no exhibit would be complete without free giveaways!'

Collaborations
Keywords and Comments
, Nicolas Martin Peschau"

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Branch Exhibition

Subcategory Science Fair

Titel
Exploring the High Energy Universe - a planetarium dome show a introducing the CTA

Presenter
Michael Burton
Author and Co-Author
Michael Burton

Abstract
'This is a short (10-min) full dome planetarium show which introduces the high energy universe that gamma-ray astronomy probes, and then describes the next generation telescope for the field – the Cherenkov Telescope Array.\r\nThis show was written and produced at the Armagh Observatory and Planetarium (AOP) during the lock down and is designed for the public. It has yet to be shown in our Dome, however, as we are still closed due to Covid.\r\nThis presentation will be a flat-screen projection of the full dome show, which results in a circular field of view with the principal subject matter in the lower portion of the field. Of course this lacks the full immersive experience of being under the dome, nevertheless the story can still be told.\r\nOnce lockdown is over and we are able to play the show in our dome in Armagh we will publicly (and freely) release it worldwide via the Digistar cloud, so that it may be played in any Digistar planetarium.   \r\nScript Michael Burton, production PhD student Kerem Osman Cubuk, Narration Senior Education Officer Heather Alexander, all of the Armagh Observatory and Planetarium.'

Collaborations
CTA,
Keywords and Comments
, Nicolas Martin Peschau"

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Branch Exhibition

Subcategory Science Fair

Titel
Doing your PhD in Multimessenger Astronomy

Presenter
Wiebke Schubotz
Author and Co-Author
Wiebke Schubotz

Abstract
'Hello there!\r\nWe want to introduce you to the International Helmholtz-Weizmann Research School for Multimessenger Astronomy (MMS)! The topic of multimessenger astronomy, the exploration of the Universe using a multitude of cosmic messengers, has led to several groundbreaking discoveries during the last few years. Thus, the MMS was opened in 2019 and serves as a platform for a coordinated PhD on this topic. It offers a world-class international training environment with theoretical and experimental expertise in the various messengers (electromagnetic radiation, neutrinos, gravitational waves, cosmic particles). It is an international school with partner institutions in Germany (DESY, University of Potsdam, Humboldt University) and Israel (Weizmann Institute of Science). The collaboration between students and researchers is facilitated through various meetings and events. As a MMS student you will have access to data from leading observatories such as the Cherenkov Telescope Array, the IceCube neutrino observatory or the Zwicky Transient Facility. An accompanying course program and planned exchange visits (once COVID-19 is over) offer the chance for professional and personal qualification. The next round of applications will start in October 2021. For more information, visit our website or talk to us at ICRC 2021!'

Collaborations
, The International Helmholtz-Weizmann Research School for Multimessenger Astronomy
Keywords and Comments
, Nicolas Martin Peschau"

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Branch Exhibition

Subcategory Science Fair

Titel
The Einstein Telescope – the next-generation gravitational wave observatory

Presenter
Achim Stahl
Author and Co-Author
Achim Stahl | Harald Lück

Abstract
'Based on the success of the current generation of gravitational wave detectors, we are planning the construction of a new observatory with 10-fold sensitivity and an extended frequency range. It is called the Einstein Telescope. It is a new research infrastructure designed to observe the entire Universe using gravitational waves. ET will be a multi-interferometer observatory covering the whole gravitational wave spectrum observable from Earth. It will achieve a greatly improved sensitivity by increasing the size of the interferometer from the 3km arm length of the Virgo detector to 10km and by implementing a series of new technologies. These include a cryogenic system to cool some of the main optics to 10 – 20K, new quantum technologies to reduce the fluctuations of the light, and a set of infrastructural and active noise-mitigation measures to reduce environmental perturbations.\r\nPlease visit us, to discuss about the science and technologies of the project.'

Collaborations
, Einstein Telescope

Keywords and Comments
, Nicolas Martin Peschau''

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Branch Exhibition

Subcategory Science Fair

Titel
Making cosmic particle accelerators visible and audible

Presenter
Stefan Ohm
Author and Co-Author

Abstract
In a collaboration between astroparticle physicists, animation artists from the award-winning Science Communication Lab, and musician Carsten Nicolai (a.k.a. Alva Noto), two cosmic particle accelerators have been brought to life: the massive binary star Eta Carinae, and the exploding star, which resulted in the gamma-ray burst GRB190829A. For Eta Carinae, the computer-generated images are close to reality because the measured orbital, stellar and wind parameters were used for this purpose. Particle acceleration in the jet of GRB190829A has also been animated at a level of detail not seen before. The internationally acclaimed multimedia artist Carsten Nicolai, who uses the pseudonym Alva Noto for his musical works, exclusively composed the sound for the animations. The multimedia projects aim at making the discoveries more accessible to the general public, and to mediate scientific results and their reference to reality from an artistic point of view

Collaborations

Keywords and Comments

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Branch Exhibition

Subcategory Science Fair

Titel
HIRSAP – the Helmholtz International Research School for Astroparticle Physics and Enabling Technologies

Presenter
Katrin Link (KIT)

Author and Co-Author
Irmgard Langbein

Abstract
HIRSAP is a graduate school of the Karlsruhe Institute of Technology (KIT) in Germany and the Universidad Nacional de San Martín (UNSAM) in Buenos Aires, Argentina and was installed in April 2018.
It is dedicated to the development and application of cutting-edge particle detection techniques and corresponding analysis methods in high-energy astroparticle physics.
More than 20 students from Karlsruhe and Buenos Aires are working together with leading physicists and engineers in the fields of particle detection technologies, data analysis, simulation, and model building. A key element of HIRSAP is the close cooperation of the partner institutes and the joint supervision of PhD students from both universities. PhD students are staying twice for several months at the respective partner institute which gives them the option of receiving Double Doctoral Degree of both universities.
Another key element is the truly international and structured doctoral education program. Courses are offered that range from broad overview lectures to highly specialized hands-on classes at research level.

Collaborations

Keywords and Comments

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Branch DM | Dark Matter

Subcategory Experimental Methods & Instrumentation

Titel
Searching for dark matter sources in Fermi-LAT's unIDs with Machine Learning

Presenter
Viviana Gammaldi
Author and Co-Author
Viviana Gammaldi Javier Coronado-Blázquez | Miguel A. Sánchez-Conde | Bryan Zaldivar

Abstract
'Around one third of the point-like sources in the Fermi-LAT catalogs remain as unidentified sources (UniDs) today. Indeed, these unIDs lack a clear, univocal association with a known astrophysical source identified at other wavelengths, or to a well-known source type emitting only in gamma rays (such as certain pulsars). If the dark matter (DM) is composed of weakly interacting massive particles (WIMPs), there is the exciting possibility that some of these unIDs may actually be DM sources, emitting gamma rays by WIMPs annihilation. We propose a new search methodology that uses Machine Learning classification algorithms calibrated to a mixed sample of both experimental (known astrophysical objects) and theoretical (expected DM) data. With our methodology, we can correctly classify a promisingly high percent of astrophysical sources, opening a window to robustly search for DM source association among Fermi-LAT unIDs.'

Collaborations

Keywords and Comments
Machine Learning, dark matter, Fermi-LAT, unidentified sources, classification algorithms,, Viviana Gammaldi''

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Branch DM | Dark Matter

Subcategory Experimental Methods & Instrumentation

Titel
High-multiplicity neutron events registered by NEMESIS experiment

Presenter
Marcin Kasztelan
Author and Co-Author
Marcin Kasztelan | Timo Enqvist | Jacek Szabelski | Wladyslaw Henryk Trzaska | Karol Jędrzejczak | Pasi Kuusiniemi | Julia Puputti | Marika Przybylak | Jari Joutsenvaara | Jerzy Orzechowski

Abstract
'Neutron-induced interactions contribute to the signal-mimicking background in deep-underground searches for exotic phenomena such as Dark Matter, neutrino-less double beta decay, proton decay, etc. Apart from radioactive decay, the primary source of neutrons underground are high-energy muons from cosmic showers. While the maximum number of fission neutrons is around six and energies around one MeV, muon-induced interactions may generate hundreds of neutrons, also with high energies. Furthermore, these processes are not yet reproduced numerically with sufficient reliability. The main goal of the NEMESIS experiment is to improve our knowledge and understanding of cosmic muon-induced neutron production in high-Z targets. NEMESIS (New Emma MEasurement with neutronS In cosmic Showers) is taking data at a depth of 210 m.w.e. in Callio Lab at the Pyhäsalmi mine in Finland. The neutron setup consists of 14 ^{3}He counters in polyethylene blocks. Data from the helium counters and muon scintillation arrays are collected by proprietary electronics digitizing signal waveforms with adequate time overlap to detect delayed coincidences. The presented neutron spectra will include a 300-day run with a 565 kg Pb target, a 150-day run without the target, and the outcome of the relevant Geant4 simulations. The extracted neutron multiplicity spectrum shows a linear behaviour on a doubly logarithmic scale. The largest registered event had 36 neutrons. Correcting for a 10% detection efficiency, determined with Geant4, indicates the emission of 360 neutrons in this mega-event.'

Collaborations
other (fill field below), NEMESIS

Keywords and Comments
Neutron, Dark Matter, Muons, neutron detection, Marcin Kasztelan''

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Presenter Forum

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-5
Access Monday Session https://live.remo.co/e/icrc-poster-hall-52-copy

Branch DM | Dark Matter

Subcategory Experimental Methods & Instrumentation

Titel
Design and construction of a high temperature superconducting demonstrator coil of a toroidal magnet for an astroparticle physics experiment in space

Presenter
Lucio Rossi
Author and Co-Author
Lucio Rossi | Magnus Dam | Gijs de Rijk | Enrico Chesta | Roberto Iuppa | Rita Carpentiero

Abstract
'Magnetic spectrometers detect the rigidity of charged particles by measuring the bending of their trajectories as they pass through a magnetic field. A novel magnetic spectrometer for an astroparticle physics experiment in space should have a maximum detectable rigidity of about 100 TV. This motivates the design of a toroidal spectrometer magnet with a bending strength of 3 T m. To facilitate operation temperatures of about 20 K, the toroid consists of twelve high temperature superconducting (HTS) coil packs, where each coil pack contains two coils. The toroid is about 2 m in outer diameter and 2 m in height. The toroidal magnet requires about 60 km of 12 mm wide REBCO tape with a current density of 1200 A/mm2, and has a peak magnetic field of about 12 T. Within the HTS Demonstrator Magnet for Space (HDMS) project, we have designed and are building a small-scale demonstrator coil pack for the toroidal magnet system. The demonstrator coil pack consists of two individually built racetrack-shaped soldered metal insulation coils enclosed with copper bands. Self-protection against quenches is obtainable with the use of soldered metal insulation coils. The surrounding copper bands function as current leads and layer jumps. The coils are supported by a lightweight mechanical structure made from aluminium alloy. A copper block electrically connects the two coil layers. We describe the design and manufacturing method of the demonstrator coil.'

Collaborations

Keywords and Comments
Magnetic Spectrometers\r\nDetector Magnets\r\nLarge Scale Superconductivity\r\nSpace magnets, Lucio Rossi''

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-52-copy

Branch DM | Dark Matter

Subcategory Experimental Methods & Instrumentation

Titel
Searching for cosmic antihelium nuclei with the GAPS experiment

Presenter
Achim Stoessl
Author and Co-Author
Achim Stoessl

Abstract
'At low-energies, cosmic antideuterons and antihelium provide an ultra-low background signature of dark matter annihilation, decay, and other beyond the Standard Model theories. The General Antiparticle Spectrometer (GAPS) is an Antarctic balloon experiment designed to search for low-energy (0.1-0.3 GeV/n) antinuclei and is planned to launch in the austral summer of 2022. While optimized for an antideuteron search, GAPS has unprecedented capabilities for the detection of low-energy antihelium nuclei as well, utilizing a novel detection technique based on the formation, decay, and annihilation of exotic atoms. The AMS-02 collaboration has recently reported several antihelium nuclei candidate events, which sets GAPS in the unique position to set constraints on the cosmic antihelium flux in an energy region which is essentially free of astrophysical background. In this talk, we will illustrate the capabilities of GAPS to search for cosmic antihelium-3 utilizing complete instrument simulations, event reconstruction, and the inclusion of atmospheric effects. We will show that GAPS is capable of setting unprecedented limits on the cosmic antihelium flux and thus opening a new window on exotic cosmic physics.'

Collaborations
GAPS,

Keywords and Comments
dark matter,antinuclei,anti helium,cosmic ray,exotic atom,x-ray,low background,exotic physics,Antarctica,balloon,LDB,, Achim Stoessl''

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Branch DM | Dark Matter

Subcategory Experimental Methods & Instrumentation

Titel
Characterization of the DIMS system based on astronomical meteor techniques for macroscopic dark matter search

Presenter
Dario Barghini
Author and Co-Author
Dario Barghini | Kenji Shinozaki | Simone Valenti | Shinsuke Abe | Mizuho Arahori | Mario Edoardo Bertaina | Marco Casolino | Alberto Cellino | Toshikazu Ebisuzaki | Yasunori Fujiwara | Daniele Gardiol | Maria Hajdukova | Ryushin Ide | Yugo Iwami | Fumiy

Abstract
'Nuclearites are SQM conglomerates that are hypothesized as possible candidates of macroscopic dark matter. When impacting the Earth’s atmosphere, they should undergo quasi-elastic collisions with the air molecules and emit black-body radiation, thus generating atmospheric luminous events similar to meteors. However, nuclearites could be distinguished from meteors mainly by their altitude, velocity, and motion direction of the bright flight. For instance, nuclearites of galactic origins are expected to have a typical velocity of 220 km/s, whereas meteors observed in the Earth’s atmosphere are bounded to 72 km/s. In the case of meteoroids of interstellar origin, this value may be exceeded but, considering the stellar velocity distribution in the vicinity of the Sun, only by several kilometers per second. The DIMS (Dark matter and Interstellar Meteoroid Study) experiment was designed to search for such fast-moving particles by observing the sky with wide-field, high-sensitivity CMOS cameras. We derived the calibration of the DIMS sensors by astrometry and photometry techniques applied to observed stars in the FOV and assessed the achieved positional precision and sensitivity levels. Since nuclearites and meteor events feature quite distinct observational conditions, we designed simulations to optimize the DIMS setup and analysis pipeline. Nuclearites may also have a certain spectrum of mass and velocity. We consequently evaluated the variability of nuclearites’ dynamics in the atmosphere in this respect and assessed its impact on the search algorithm performances for such events, in comparison to standard meteor trigger schemes. In this contribution, we will present the current status of this work.'

Collaborations
, DIMS

Keywords and Comments
macroscopic dark matter, strange quark matter, nuclearites, meteorites, meteors, meteoroids, interstellar meteoroids., Dario Barghini''

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Branch DM | Dark Matter

Subcategory Experimental Methods & Instrumentation

Titel
Development of a Vacuum Ultraviolet Detector for Dark Photon Searches

Presenter
Abaz Kryemadhi
Author and Co-Author
Abaz Kryemadhi | Niklas Hellgren | Ryan Thurber

Abstract
'Dark photon arises as the extra gauge boson in a U(1) Standard Model extension and it couples to ordinary photon via kinetic mixing. The parameter space spans many orders of magnitude in energy and has been explored widely by terrestrial and astrophysical measurements. In this work, we focused on development of a detector system to study a narrow energy band from 7-8 eV motivated by other studies. The photons in this energy band have large absorption due to molecular oxygen where absorption length is of order of cm at atmospheric pressure, and the detection system has to be setup in vacuum or use nitrogen purging to reduce their attenuation. We constructed our detector system using low dark rate photomultipliers sensitive at these energies with aluminum reflector akin to FUNK experiment to enhance collection, and setup our experiment in a vacuum chamber. Results on performance and preliminary sensitivity will be reported.'

Collaborations
other (fill field below), Small R & D collaboration

Keywords and Comments
Dark Photon, ultra-light dark matter, vacuum ultraviolet, Abaz Kryemadhi''

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-52-copy

Branch DM | Dark Matter

Subcategory Experimental Methods & Instrumentation

Titel
Solar Power Supply and Environmental Control System for DIMS Experiment

Presenter
Daiki Shinto
Author and Co-Author
Daiki Shinto | Kaoru Nadamoto | Yugo Iwami | Fumiyoshi Kajino | Yuichiro Tameda | for the DIMS collaboration

Abstract
'The DIMS (Dark matter and Interstellar Meteoroid Study) experiment is designed to study macroscopic dark matters such as nuclearites/strange quark matters (SQM) and interstellar meteoroids. The DIMS experiment system is under construction at the Telescope Array (TA) cosmic-ray experiment site in Utah, USA. The system consists of 4 high-sensitivity CMOS camera stations which will be installed at 3 sites, CLF (Central Laser Facility) and BRM(Black Rock Mesa fluorescence telescope site) of the TA experiment and Hinckley town in the Utah desert each about 20 km apart. \r\nSince electric power is not supplied to the CLF site by the power company, a solar power system is required. Therefore, we have developed a new solar power supply system and conducted observation tests in Japan. \r\nAs we are going to operate the camera system every night for an extended period of time, we need to control environmental parameters such as temperature, humidity inside the camera stations as well as monitoring conditions inside and outside the container. We, therefore, developed an environmental control system for the camera station.\r\nIn this paper, we will present details of the development and test results of the solar power supply system to be installed in CLF and the environmental monitoring and control system of the camera stations.'

Collaborations
, DIMS

Keywords and Comments
macroscopic dark matter, nuclearite, strange quark matter, SQM, meteor, meteoroid, interstellar meteoroid, solar power supply, environmental monitor,, Daiki Shinto''

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Branch DM | Dark Matter

Subcategory Experimental Methods & Instrumentation

Titel
Reconstruction of antinucleus-annihilation events in the GAPS experiment

Presenter
Alessio Tiberio
Author and Co-Author
Alessio Tiberio For the GAPS Collaboration

Abstract
'The General Antiparticle Spectrometer (GAPS) experiment is designed to detect low-energy (< 0.25 GeV/n) cosmic-ray antinuclei as indirect signatures of dark matter. Several beyond-the-standard-model scenarios predict a large antideuteron flux due to dark matter decay or annihilation compared to the astrophysical background. The GAPS experiment will perform such measurements using long-duration balloon flights over Antarctica, beginning in the 2022/23 austral summer. The experimental apparatus consists of ten planes of Si(Li) detectors surrounded by a time-of-flight system made of plastic scintillators. The detection of the primary antinucleus relies on the reconstruction of the annihilation products: the low-energy antinucleus is captured by an atom of the detector material, forming an exotic atom then de-excites by emitting characteristics X-rays. Finally, the antinucleus undergoes nuclear annihilation, producing a “star” of pions and protons emitted from the annihilation vertex. Several algorithms were developed to determine the annihilation vertex position and to reconstruct the topology of the primary and secondary particles. An overview of the event reconstruction techniques and their performances, based on detailed Monte Carlo simulation studies, will be presented in this contribution.'

Collaborations
GAPS,

Keywords and Comments
GAPS, cosmic rays, low energy, reconstruction, annihilation, antinuclei, antideuteron, antiproton, Hough, Alessio Tiberio"

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Branch DM | Dark Matter

Subcategory Experimental Methods & Instrumentation

Titel
A Search for Neutrinos From Decaying Dark Matter in Galaxy Clusters and Galaxies with IceCube

Presenter
Minjin Jeong
Author and Co-Author
Minjin Jeong

Abstract
'When the lifetime of dark matter is much longer than the age of the Universe, the current abundance of dark matter can be explained with non-thermal, superheavy dark matter models. In these scenarios, dark matter decays can produce highly energetic neutrinos, along with other Standard Model particles. To date, the IceCube Neutrino Observatory is the world's largest neutrino telescope, located at the geographic South Pole. In 2013, the IceCube collaboration reported the first observation of high-energy astrophysical neutrinos. Since then, IceCube has collected a large amount of astrophysical neutrino data with energies up to tens of PeV, allowing us to probe the superheavy dark matter models using neutrinos. We search the IceCube data for neutrinos from decaying dark matter in galaxy clusters and galaxies. The targeted dark matter masses range from 10 TeV to 10 PeV, and the sources are stacked to optimize the sensitivity of the analysis. In this contribution, we present the method and sensitivities of the analysis.'

Collaborations
IceCube,

Keywords and Comments
dark matter, IceCube, galaxies, galaxy clusters,, Minjin Jeong''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Cherenkov Telescope Array sensitivity to branon dark matter models

Presenter
Alejandra Aguirre-Santaella
Author and Co-Author
Alejandra Aguirre-Santaella | Viviana Gammaldi | Miguel Sánchez-Conde | Daniel Nieto

Abstract
'TeV DM candidates are gradually earning more and more attention within the community. Among others, extra-dimensional brane-world models may produce thermal DM candidates with masses up to 100 TeV, which could be detected with the next generation of very-high-energy gamma-ray observatories such as the Cherenkov Telescope Array (CTA).\r\nIn this work, we study the sensitivity of CTA to branon DM via the observation of dwarf spheroidal galaxies.\r\nWe computed annihilation cross section values needed to reach a 5σ detection as a function of the branon mass. Additionally, in the absence of a predicted DM signal, we obtained 2σ upper limits on the annihilation cross section.\r\nThese limits lie 1.5-2 orders of magnitude above the thermal relic cross section value.\r\nYet, CTA will allow to exclude a significant portion of the brane tension-mass parameter space in the 0.1-60 TeV branon mass range, and up to tensions of ~10 TeV. More importantly, CTA will significantly enlarge the region already excluded by AMS and CMS, and will provide valuable complementary information to future SKA radio observations.\r\n[Based on JCAP 10 (2020) 041, arXiv:2006.16706]'

Collaborations
CTA,

Keywords and Comments
dark matter indirect searches, branons, Alejandra Aguirre-Santaella''

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Branch	DM | Dark Matter
Subcategory	Experimental Results

Titel
Search for dark matter annihilation towards the inner Milky Way halo with the H.E.S.S. Inner Galaxy Survey

Presenter
Alessandro Montanari
Author and Co-Author
Alessandro Montanari | Denys Malyshev | Emmanuel Moulin, for the H.E.S.S. collaboration

Abstract
'The presence of dark matter (DM) is suggested by a wealth of astrophysical and cosmological measurements. However, its underlying nature is yet unknown. Among the most promising candidates are weakly interacting massive particles (WIMPs): particles with mass and coupling strength at the electroweak scale and thermally-produced in the early universe have a present relic density consistent with that observed today. WIMP self-annihilation would produce Standard Model particles including gamma-rays, which have been long-time recognized as a prime messenger to indirectly detect dark matter signals. The centre of the Milky Way is predicted as the brightest source of DM annihilations. The H.E.S.S. collaboration is currently performing a survey of the inner region of the Milky Way, the Inner Galaxy Survey (IGS), intended to achieve the best sensitivity to faint and diffuse emissions in a region of several degrees around the Galactic Centre. We analyzed 2014-2020 observations taken with the five-telescope array to search for a DM annihilation signal. With the current dataset of about 600 hours, we found no significant excess and therefore derived the strongest constraints on the velocity-weighted annihilation cross-section so far. TeV thermal WIMPs can be probed in different annihilation channels.'

Collaborations
H.E.S.S.,

Keywords and Comments
Dark matter, IACTs, Galactic halo, Alessandro Montanari''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Upper limits on the WIMP annihilation cross section from a joint analysis of dwarf spheroidal satellite galaxy observations with the MAGIC telescopes

Presenter
Camilla Maggio
Author and Co-Author
Camilla Maggio | Daniel Kerszberg | Daniele Ninci Vincenzo Vitale | For the MAGIC Collaboration

Abstract
'Dwarf spheroidal satellite galaxies (dSphs) are among the best candidates to perform indirect search for DM, having the highest known mass-to-light ratio and being free of gamma-ray emitting sources. The Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescopes, located on the Canary Island of La Palma, have observed a fair amount of optimal dSphs in the recent years. This is the outcome of diversifying the observation strategy in order to avoid possible biases in target selection and to improve previous results.\r\nIn this contribution we will report on new MAGIC results obtained from 52 hours of observation of the Draco dSph in 2018 and 50 hours of the Coma Berenices dSph in 2019. We will also present the results of a joint analysis of Draco and Coma Berenices dSphs with other dSphs observed by MAGIC so far. The selected dataset accounts for 355 hours of good quality data, resulting in one of the largest dSphs samples ever collected by an array of Cherenkov telescopes. This allows us to derive the most constraining limits, among Cherenkov telescopes, on the WIMP annihilation cross section for different annihilation channels in the WIMP mass range 70 GeV to 100 TeV.'

Collaborations
MAGIC,

Keywords and Comments
dark matter, WIMP, dSphs, indirect DM searches, VHE gamma rays, IACTs, Camilla Maggio''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Indirect Dark Matter searches in the gamma-ray channel toward the Sun with the Fermi LAT

Presenter
Francesco Loparco
Author and Co-Author
Francesco Loparco Mario Nicola Mazziotta | Davide Serini

Abstract
'The Sun is a possible target for indirect dark matter (DM) searches, as it can gravitationally capture DM particles from the Galactic halo, which can be trapped in external orbits or sink into the solar core. We have performed a dedicated analysis of solar gamma rays collected by the Fermi Large Area Telescope (LAT) to search for possible flux excesses, which could be ascribed to DM. Gamma rays in final states of DM annihilations occurring outside the Sun can in fact reach the Earth and be detected by the LAT. Alternatively, DM particles can annihilate inside the Sun core into pairs of long-lived mediators, which are able to escape from the Sun and can decay outside the Sun, yielding gamma rays in the final state. All these processes are expected to yield an excess in the gamma-ray flux from the Sun, which appears as a specific spectral feature. Although no evidence of a DM signal has been found, we have obtained upper limits on the DM gamma-ray flux, which have been converted into constraints on the DM-nucleon scattering cross sections.'

Collaborations
Ferrmi-LAT,

Keywords and Comments
, Francesco Loparco''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
New results from NEMESIS experiment

Presenter
Wladyslaw Henryk Trzaska
Author and Co-Author
Wladyslaw Henryk Trzaska

Abstract
"A new experiment collects data at a depth of 210 m.w.e. in the Callio Lab [1] at the Pyhasalmi mine [2] in Finland. The setup, called NEMESIS (New Emma MEasurement with neutronS In cosmic Showers), incorporates infrastructure from the EMMA experiment [3] with neutron and large-area plastic scintillator detectors of the MAZE system [4]. The experiment's primary aim is to combine muon tracking with position-sensitive neutron detection to measure precision yields, multiplicities, and lateral distributions of high-multiplicity neutron events induced by cosmic muons in various materials. The data are relevant for background evaluation of the deep-underground searches for Dark Matter, neutrino-less double beta decay, etc. The setup consists of 4 layers of position-sensitive muon counters, two large-area, amplitude-sensitive scintillators, and 14 He-3 proportional counters in polyethylene casting for neutron detection. The detectors surround a removable target. The results of a 300-day run with a 565 kg Pb target and preliminary simulations will be presented. A significant upgrade of the setup is being prepared to improve the performance and increase the detection efficiency by one order of magnitude. The upgraded experiment would be well suited for searching for Dark Matter WIMP inelastic scattering events associated with the emission of an energetic charged lepton [5].\r\n\r\n1. Callio, https://callio.info \r\n2. W.H. Trzaska et al., (2018), https://arxiv.org/abs/1810.00909 \r\n3. P. Kuusiniemi et al., AP 102(2018)67 https://www.sciencedirect.com/science/article/abs/pii/S092765051730333X \r\nM. Kasztelan et al., (2006) Proc. the 20th ECRS, Lisbon\r\nhttps://www.lip.pt/events/2006/ecrs/proc/ecrs06-s0-92.pdf\r\n5. T.E. Ward et al., APS April Meeting 2019, https://meetings.aps.org/Meeting/APR19/Session/G17.1"

Collaborations
other (fill field below), NEMESIS

Keywords and Comments
CR-induced muons, muon-induced neutron yields, high-multiplicity neutron events, NEMESIS experiment, Wladyslaw Henryk Trzaska"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
VERITAS dark matter search in dwarf Spheroidal galaxies: an extended source analysis

Presenter
Chiara Giuri
Author and Co-Author
Chiara Giuri

Abstract
'Dark matter (DM) is largely believed to be the dominant component of the matter content of the Universe. Astronomical measurements can be utilized to search for Standard Model annihilation or decay products of DM, complementing direct and collider-based searches. Among DM particle candidates, Weakly Interacting Massive Particles (WIMPs) are an attractive one. Their decay or annihilation could produce secondary particles including very-high-energy (VHE: E>100 GeV) gamma rays, which could be detected by imaging atmospheric Cherenkov Telescopes (IACTs). One of the most favourable target classes for DM searches are Dwarf Spheroidal galaxies (dSphs), dark matter-dominated objects with a negligible predicted gamma-ray emission due to apparent absence of gas and on-going star formation. The IACTs, whose Point Spread Function (PSF, defined as 68% containment) is typically 0.1 deg at 1 TeV, have the necessary angular resolution to detect extended emission from some dSphs. Thus, an extended source analysis may give an improvement to DM sensitivity, compared to a point source analysis. In this work, we use observations made since 2007 by VERITAS, an array of four imaging atmospheric Cherenkov telescopes sensitive to VHE gamma rays in the 100 GeV - 30 TeV energy range. We perform an unbinned combined likelihood analysis incorporating the dSph angular profiles of several dSphs. A new analysis technique utilising boosted decision trees has also been applied, to improve the overall dark matter sensitivity of the experiment. We interpret the results in terms of the DM self-annihilation cross-section as a function of the DM particle mass.'

Collaborations
VERITAS,

Keywords and Comments
Dark Matter search in Dwarf Spheroidal galaxies with VERITAS (IACT), Chiara Giuri''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Antihelium-3 fluxes near Earth using data-driven estimates for annihilation cross section

Presenter
Laura Šerkšnytė
Author and Co-Author
Laura Šerkšnytė | For the ALICE Collaboration

Abstract
'The studies of antinuclei cosmic rays (CR) are currently of great interest as they represent one of the most promising indirect probes of annihilations or decays of dark matter (DM) candidates and few experiments are looking for traces of antideuterons and antihelium near Earth. However, the antinuclei CR also contain a background contribution from antinuclei produced in CR collisions with interstellar gas. To properly simulate the signal and background contributions one needs antinuclei production, annihilation cross sections, and a state-of-the-art propagation model.\r\n\r\nWe studied the antihelium-3 CR using the GALPROP propagation model and we calculated the fluxes stemming from DM and from secondary processes. The results are based on the available production cross sections of antihelium-3, while the annihilation cross sections of antihelium-3 are estimated for the first time using a data-driven approach based on the novel measurements of antihelium-3 disappearance probability in the material of the ALICE detector at CERN LHC. To this purpose, the antihelium-3 annihilation on proton and helium-4 targets are obtained using the antihelium-3 cross sections implemented in Geant4, which have been scaled accordingly to the results obtained by ALICE.\r\n\r\nWe show that in the case of antihelium-3 stemming from DM one loses around half of the antinuclei due to annihilations in collisions with interstellar gas, while in the case of the background antihelium-3 flux, a strong energy-dependence, ranging from 75% at low energies and around 10% at high energies, is observed.'

Collaborations
, ALICE
Keywords and Comments
DM, antinuclei, antihelium, annihilation, cosmic rays, LHC, particle acceleration, ALICE, Laura Serknyte''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Characterization of natural radioactivity in the BSUIN and EUL underground laboratories based on the developed standard scheme

Presenter
Katarzyna Szkliniarz
Author and Co-Author
Katarzyna Szkliniarz Agata Walencik-Łata | Kinga Polaczek-Grelik | Jan Kisiel | Karol Jędrzejczak | Marcin Kasztelan | Jacek Szabelski

Abstract
'Underground laboratories (ULs) are now becoming more and more popular, not only for scientific reasons. However, they are still very important as potential dark matter search sites. Therefore, the idea was born to create a network of underground laboratories operating in the Baltic Sea region. The result was the BSUIN (Baltic Sea Underground Innovation Network) project and its current continuation in the EUL (Empowering Underground Laboratories Network Usage) project. One of the most critical parameters in characterizing the ULs is the natural background radiation (NBR), mainly from surrounding bedrock and used construction materials. To this end, a standard scheme was created containing the NBR measurement results to characterize selected ULs participating in the BSUIN project. The developed scheme allows for an easy and transparent comparison of underground places (halls/rooms) in terms of the conditions prevailing there, not only in one UL but also between equal ULs. In this way, a potential client can choose the most convenient place to conduct his research or other types of tasks. This scheme is still supplemented with new measurement results and applied to other underground locations as one of the EUL project activities.\r\n\r\n\r\nThe scheme includes the results of in-situ measurements (gamma-ray, the radon concentration in air, thermal neutron flux measurements) and the results of laboratory measurements of rock and water samples taken from the studied locations. During the session, this scheme will be presented on the example of one of the ULs participating in the BSUIN and EUL projects.'

Collaborations

Keywords and Comments
underground laboratory, natural background radiation, Katarzyna Szkliniarz''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Model independent search for macroscopic dark matter with EUSO-SPB2

Presenter
Thomas Paul
Author and Co-Author
Thomas Paul | Angela Olinto | Luis Anchordoqui

Abstract
'Macroscopic dark matter (or macro) provides a broad class of alternative \r\ncandidates to particle dark matter. These candidates would transfer \r\nenergy primarily through elastic scattering, and this linear energy \r\ndeposition would produce observable signals if a macro were to traverse \r\nthe atmosphere. We study the fluorescence emission produced by a macro \r\npassing through the atmosphere. We estimate the sensitivity of EUSO-SPB2 \r\nto constrain the two-dimensional parameter space ($\\sigma$ vs. M), \r\nwhere M is the macro mass and $\\sigma$ its cross sectional area.'

Collaborations
Keywords and Comments
macro, microscopic dark matter, EUSO-SPB2, Thomas Paul"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Search for secluded dark matter with 6 years of IceCube data --- Christoph Toennis

Presenter
Christoph Toennis
Author and Co-Author
Christoph Toennis

Abstract
'The IceCube neutrino observatory--installed in the Antarctic ice--is the largest neutrino telescope to date. It consists of 5,160 photomultiplier-tubes spread among 86 vertical strings making a total detector volume of more than a cubic kilometer. IceCube detects neutrinos via Cherenkov light emitted by charged relativistic particles produced when a neutrino interacts in or near the detector. The detector is particularly sensitive to high-energy neutrinos of due to its size and photosensor spacing. In this analysis we search for dark matter that annihilates into a metastable mediator that subsequently decays into Standard Model particles. These models yield an enhanced high-energy neutrino flux from dark matter annihilation inside the Sun compared to models without a mediator. Neutrino signals that are produced directly inside the Sun are strongly attenuated at higher energies due to interactions with the solar plasma. In the models considered here, the mediator can escape the Sun before producing any neutrinos, thereby avoiding attenuation. We present the results of an analysis of six years of IceCube data looking for dark matter in the Sun. We consider mediator lifetimes between 1 ms to 10 s and dark matter masses between 200 GeV and 75 TeV.'

Collaborations
IceCube,

Keywords and Comments
IceCube, Dark Matter, Sun, Secluded Dark Matter, Christoph Toennis''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Constraining non-standard Dark Matter-Nucleon Interactions with IceCube

Presenter
Lilly Peters
Author and Co-Author
Lilly Peters | Koun Choi | for the IceCube Collaboration

Abstract
'After scattering off nuclei in the Sun, dark matter particles can be gravitationally captured by the Sun, accumulate in the Sun's core and annihilate into Standard Model particles. Neutrinos originating from these annihilations can be detected by the IceCube Neutrino Observatory, located at the South Pole. Due to the non-observation of these neutrinos, constraints on the standard spin-dependent and spin-independent dark matter-nucleon scattering cross sections have been placed. Based on these constraints, we present upper limits on the coupling constants of the non-relativistic effective theory of dark matter-nucleon interactions, including velocity and momentum dependent interactions.'

Collaborations
IceCube,

Keywords and Comments
, Lilly Peters"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Indirect Dark Matter searches from the Sun direction with ANTARES

Presenter
Chiara Poirè
Author and Co-Author
Chiara Poirè For the ANTARES Collaboration

Abstract
'Dark matter particles, produced in astrophysical sources and gravitationally captured in massive celestial objects, can be indirectly detected through their annihilation into Standard Model particles.\u2028\r\nThe centre of those massive objects is, therefore, a place where to look for a possible neutrino excess from dark matter annihilations, using neutrino telescopes.\r\nThe deep-sea neutrino telescope ANTARES, located in the Mediterranean Sea, has shown to be very competitive on the quest for dark matter WIMPs produced in the Galactic Center.\r\nThe closest potential DM source is the Sun, where it is possible to have a very clean signal since the background from astrophysical sources is not expected.\r\nIn this work we show the results on the search for dark matter WIMPs from the Sun, using 13 years of data collected by ANTARES.\r\nThe results yield solar limits on the WIMP dark matter mass in the range of 50 GeV/c^2 to 20 TeV/c^2.'

Collaborations
Antares,
Keywords and Comments
, Chiara Poirè'on behalf of the ANTARES Collaboration'

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Branch	DM | Dark Matter
Subcategory	Experimental Results

Titel
Indirect searches for dark matter in the Galactic Centre with IceCube

Presenter
Nadège Iovine
Author and Co-Author
Nadège Iovine | Juan Antonio Aguilar Sánchez | Sebastian Baur | Chaïmae El Aisati | Michael Gustafsson | Thomas Hambye

Abstract
'Even though there are strong astrophysical and cosmological indications to support the existence of dark matter, its exact nature remains unknown. We expect dark matter to produce standard model particles when annihilating or decaying, assuming that it is composed of Weakly Interacting Massive Particles (WIMPs). These standard model particles could in turn yield neutrinos that can be detected by the IceCube neutrino telescope. The Milky Way is expected to be permeated by a dark matter halo with an increased density towards its centre. This halo is expected to yield the strongest dark matter annihilation signal at Earth coming from any celestial object, making it an ideal target for indirect searches. In this contribution, we present the sensitivities of two indirect searches for dark matter in the Galactic Centre using IceCube data. Together, these searches allow us to cover dark matter masses ranging from 5 GeV to 40 TeV. The sensitivities of both searches show considerable improvements over previous IceCube results in their respective energy range.'

Collaborations
IceCube,
Keywords and Comments
Dark matter, Neutrino telescope, IceCube, Neutrino, Galactic Centre, Nadège Iovine"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
First muon-induced neutron yields from NEMESIS experiment

Presenter
Karol Jędrzejczak
Author and Co-Author
Karol Jędrzejczak | Marcin Kasztelan | Jacek Szabelski | Wladyslaw Henryk Trzaska | Timo Enqvist | Marika Przybylak | Jari Joutsenvaara | Pasi Kuusiniemi | Julia Puputti | Jerzy Orzechowski

Abstract
'The NEMESIS experiment (New Emma MEasurement with neutronS In cosmic Showers) \r\n is located in Pyhasalmi Mine (Finland), and operates at a depth of 75\u202fm (210\u202fm.w.e.), \r\n corresponding to 50\u202fGeV cutoff energy for vertical muons.\r\n \r\n The experiment consists of a pixelized (11cm x 11cm) scintillation\r\n telescope, 14 helium counters, 2 1m^2 scintillating detectors,\r\n and Pb target. The scintillation telescope detect the cosmic ray muons\r\n passing through the Pb-target, while the helium counters detect the\r\n neutrons produced in Pb. The aim of the experiment is to precisely\r\n investigate production of neutrons and check whether it is well described\r\n by simulations. This is important for experiments which look for rare\r\n phenomenas, as the detector shelters are often made of lead.\r\n\r\n Detector was measuring for one year. One of the parameter is\r\n neutron yield per muon. Preliminary analysis of our data\r\n show the yield equal to 4.5 (+/- 0.5) e-4 per square centimeter\r\n per gram or the mean for muon energy = 50 GeV. This result is similar\r\n to yields reported in the literature.\r\n\r\n This work was financially supported by the EU (INTERREG for Baltic Sea\r\n program) as part of the BSUIN project, and by the Polish Ministry\r\n of Science and Higher Education (grant no. 3988/INTERREG BSR/2018/2).'

Collaborations
other (fill field below), NEMESIS
Keywords and Comments
muons,neutron production, underground, Karol Jędrzejczak"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Search for dark matter from the center of the Earth with 8 years of IceCube data

Presenter
Giovanni Renzi
Author and Co-Author
Giovanni Renzi

Abstract
'The nature of Dark Matter remains one of the most important unresolved questions of fundamental physics. Many models, including the Weakly Interacting Massive Particles (WIMPs), assume Dark Matter to be a particle and predict a weak coupling with Standard Model matter. If Dark Matter particles can scatter off nuclei in the vicinity of a massive object, such as a star or a planet, they may lose kinetic energy and become gravitationally trapped in the center of such objects, including Earth. As Dark Matter accumulates in the center of the Earth, self-annihilation of WIMPs into Standard Model particles can result in an excess of neutrinos which are detectable at the IceCube Neutrino Observatory, situated at the geographic South Pole. A search for excess neutrinos from these annihilations has been performed on 8 years of IceCube data, and results have been interpreted in the context of a number of WIMP annihilation channels ($\chi\chi \rightarrow \tau^+\tau^-/W^+W^-/b\bar{b}$) and masses ranging from 10 GeV to 10 TeV. We present the latest results from this analysis and compare the outcome with previous analyses by IceCube and other experiments, showing competitive results, which are even world-leading in some parts of the phase space.'

Collaborations
IceCube,

Keywords and Comments
dark matter, WIMPs, Earth, neutrinos, IceCube, scattering, self-annihilation,, Giovanni Renzi"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Combined dark matter searches towards dwarf spheroidal galaxies with Fermi-LAT, HAWC, H.E.S.S., MAGIC, and VERITAS

Presenter
Celine Armand
Author and Co-Author
Celine Armand | Vincent Poireau | Emmanuel Moulin | MATTIA DI MAURO | Louise Oakes | Chiara Giuri | Daniel Kerszberg | Eric Charles | Tjark Miener | Pat Harding | Elisa Pueschel | Dan Salaza | Kristen Tollefson | Javier Rico | Lucia Rinchiuso | Benjamin Z

Abstract
'Cosmological and astrophysical observations suggest that 85% of the total matter of the Universe is made of Dark Matter (DM). \r\nHowever, its nature remains one of the most challenging and fundamental open questions of particle physics. \r\nAssuming particle DM, this exotic form of matter cannot consist of Standard Model (SM) particles. Many models have been developed to attempt unraveling the nature of DM such as Weakly Interacting Massive Particles (WIMPs), the most favored particle candidates.\r\nWIMP annihilations and decay could produce SM particles which in turn hadronize and decay to give SM secondaries such as high energy gamma rays.\r\nIn the framework of indirect DM search, observations of promising targets are used to search for signatures of DM annihilation.\r\nAmong these, the dwarf spheroidal galaxies (dSphs) are commonly favored owing to their expected high DM content and negligible astrophysical background. In this work, we present the very first combination of 20 dSph observations, performed by the Fermi-LAT, HAWC, H.E.S.S., MAGIC, and VERITAS collaborations in order to maximize the sensitivity of DM searches and improve the current results. We use a joint maximum likelihood approach combining each experiment individual analysis to derive more constrained upper limits on the WIMP DM self-annihilation cross-section as a function of DM particle mass. We present new DM constraints over the widest mass range ever reported, extending from 5 GeV to 100 TeV thanks to the combination of these five different instruments.'

Collaborations
H.E.S.S., VERITAS, MAGIC, HAWC, FERMI-LAT

Keywords and Comments
Gamma rays, indirect detection, dark matter, dwarf galaxies, Celine Armand''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Limits on Diffuse Dark Matter with HAWC

Presenter
Mora Durocher
Author and Co-Author
Mora Durocher | For the HAWC Collaboration Pat Harding

Abstract
'In addition to dense regions of dark matter, such as galaxy clusters and dwarf galaxies, dark matter annihilation and decay are also expected to have a nearly isotropic distribution across the sky. This isotropic component is less model-dependent than the flux from isolated dark matter targets, and would produce both galactic and extra-galactic contributions to the Diffuse Gamma-Ray Background (DGRB). With its continuous monitoring of the gamma-ray sky from 300 GeV to 100 TeV and its wide field-of-view, the High Altitude Water Cherenkov (HAWC) observatory is well-suited to search for dark matter contributions in the DGRB. In this work, 535 days of HAWC data and Monte Carlo simulations were studied to set a limit on annihilating or decaying diffuse dark matter at TeV energies. With this data, we consider both leptonic and hadronic dark matter channels and are able to constrain dark matter up to masses >100 TeV.'

Collaborations
HAWC,
Keywords and Comments
, Mora Durocher"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Search for TeV decaying dark matter from the Virgo cluster of galaxies

Presenter
Mehr Nisa
Author and Co-Author
Mehr Nisa | Pat Harding for the HAWC Collaboration

Abstract
"Galaxy clusters' dynamics constitute a major piece of evidence for the existence of dark matter in astrophysical structures. The decay or annihilation of dark matter particles is hypothesized to produce a steady flux of very-high-energy gamma rays correlated with the direction of a cluster of galaxies. The Virgo cluster, being only ~16 Mpc away and spanning several degrees across the sky is an excellent target to search for signatures of particle dark matter interactions. The High Altitude Water Cherenkov (HAWC) observatory, due to its wide field of view and sensitivity to gamma rays at an energy-scale of 300 GeV—100 TeV is well-suited to perform the aforementioned search. We perform a search from the Virgo cluster for gamma-ray emission, assuming various dark matter sub-structure models using 1323 days of HAWC data. Our results provide the strongest constraints on the decay life-time of dark matter for masses above 10 TeV."

Collaborations
HAWC,
Keywords and Comments
Galaxy clusters, WIMPs, decaying dark matter, Mehr Un Nisa"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
An Optimized Search for Dark Matter in the Galactic Halo with HAWC

Presenter
Pat Harding
Author and Co-Author
Joseph Lundeen | Pat Harding

Abstract
'With a mass of approximately ~10^12 solar masses, the Galactic Halo is the closest known large dark matter halo and a prime candidate for indirect dark matter detection. The High Altitude Water Cherenkov Observatory (HAWC) is a high energy (300 GeV to 100 TeV) gamma ray detector located in central Mexico. HAWC operates via the water Cherenkov technique and has both a wide field of view of ~2 sr and a >95% duty cycle, making it ideal for analysis of highly extended sources. We made use of these properties of HAWC and a new background-estimation technique optimized for extended sources to probe a large region of the Galactic Halo for dark matter signals. With this approach and taking into account electroweak corrections to the gamma-ray spectra, we set improved constraints on dark matter annihilation and decay between masses of 10 and 100 TeV Our constraints also take into account detector simulation systematics and are robust against uncertainties in the Galactic dark matter spatial profile.'

Collaborations
HAWC,

Keywords and Comments
dark matter, galactic, constraints, HAWC, gamma ray, Joseph Lundeen''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Nuclearite search with ANTARES

Presenter
Mohammed Bouta
Author and Co-Author
Mohammed Bouta Jürgen Brunner | Abdelilah MOUSSA | Gabriela Emilia Pavalas | Yahya TAYALATI | For the ANTARES Collaboration

Abstract
'ANTARES is a Cherenkov underwater neutrino telescope operating in the Mediterranean Sea since 2008 in its full configuration. Even though optimised for the search of cosmic neutrinos, this telescope is also sensitive to nuclearites of strange matter.\r\n\r\nWe discuss here the possible detection of non-relativistic down-going nuclearites with the ANTARES telescope and present the first results of an updated analysis using data collected in the period 2009-2017.'

Collaborations
Antares,

Keywords and Comments
ANTARES, nuclearite, exotic particles, strange quark matter, Mohammed Bouta"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
New flux limit in the low relativistic regime for magnetic monopoles at IceCube

Presenter
Frederik Lauber
Author and Co-Author
Frederik Lauber

Abstract
'Magnetic monopoles are hypothetical particles that carry magnetic charge. Depending on their velocity, different light production mechanisms exist to facilitate detection. In this work, a previously unused light production mechanism, luminescence of ice, is introduced. This light production mechanism is nearly independent of the velocity of the incident magnetic monopole and becomes the only viable light production mechanism in the low relativistic regime (0.1-0.55c). An analysis in the low relativistic regime searching for magnetic monopoles in seven years of IceCube data is presented. While no magnetic monopole detection can be claimed, a new flux limit in the low relativistic regime is presented, superseding the previous best flux limit by 2 orders of magnitude.'

Collaborations
IceCube,

Keywords and Comments
Magnetic, Monopole, luminescence, IceCube, limit,, Frederik Lauber''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Light (anti)nuclei production cross section studies in p+C collisions at the NA61/SHINE experiment.

Presenter
Michał Naskręt
Author and Co-Author
Michał Naskręt

Abstract
'NA61/SHINE is a large-acceptance fixed-target experiment located at the CERN SPS, which studies final hadronic states in interactions of various particles and nuclei. It is unique in terms of providing data on a variety of collision systems at different collision energies. This allows for wide deuteron, antiproton and antideuteron production cross-section studies. The latter are currently considered a possible dark matter interaction signal with exceptionally small background. The measurements on carbon target are important to reduce systematic experimental effects due to experiment-internal antideuteron production, as the most abundant element in the path of an incoming particle for the AMS-02 experiment is carbon. My talk will focus on analysis of NA61/SHINE data on p+C thin target collisions in context of light (anti)nuclei production. I will present a preliminary analysis of experimental data and discuss quality cuts and the particle identification method as well as present deuteron and antideuteron yields.'

Collaborations
, NA61/SHINE
Keywords and Comments
dark matter indirect signals, antideuterons, low background, heavy ion collisions,, Michał Naskręt"

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Limits on the flux of heavy compact objects from the the "Pi of the Sky" project

Presenter
Lech Piotrowski
Author and Co-Author
Lech Piotrowski | for the Pi of the Sky collaboration

Abstract
'The existence of heavy compact objects has been suggested many times throughout the years. In terms of sizes, they would belong to the realms of nuclear or atomic physics, but in terms of masses could extend to the macroscopic world, reaching kilograms, tones or more. The most notable candidates are nuclearites - hypothetical lumps of strange quark matter, Q-Balls, magnetic monopoles or primordial black holes. These objects may have originated in the early universe or could be produced by some stellar phenomena. Especially in the first case, they could be a component of dark matter.\r\n\r\nIf they exist, it is likely that they reach our planet at high speeds and cross the atmosphere, leaving behind a trail of light in the air. We present results of a search for such objects in visual photographs of the sky taken by the "Pi of the Sky" experiment, exemplified with the most stringent limits on the flux of incoming nuclearites of the masses spanning between 100 g and 100 kg.'

Collaborations
other (fill field below), Pi of the Sky

Keywords and Comments
nuclearites, strangelets, heavy compact objects,, Lech Piotrowski''

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Branch DM | Dark Matter

Subcategory Experimental Results

Titel
Constraining the diffuse supernova axion-like-particle background with high-latitude Fermi-LAT data

Presenter
Christopher Eckner
Author and Co-Author
Christopher Eckner | Francesca Calore | Alessandro Mirizzi | Pierluca Carenza

Abstract
"Axions and axion-like particles (ALPs) are thought to be produced along with Standard Model particles in a variety of astrophysical processes. Core-collapse supernovae (SNe) have been identified as a promising target to probe the existence of these hypothetical particles, which could make up at least a fraction of the universe's dark matter content.\r\nThe cumulative signal from all past SNe events would contain an ALP component and create a diffuse flux with energies $\\mathcal{O}(50)$ MeV. Due to their coupling to photons and the related Primakoff process, the diffuse SNe ALP flux is converted into a diffuse gamma-ray flux while traversing the magnetic field of the Milky Way. The spatial morphology of this signal is expected to follow the shape of the Galactic magnetic field lines.\r\nWe perform a template-based analysis to constrain the ALP parameter space via the spatial structure of this ALP-induced diffuse gamma-ray flux using Fermi-LAT data from 12 years and an energy range from 50 MeV to 500 GeV. We find an improvement of the upper limit on the ALP-photon coupling constant $g_{a\\gamma}$ of about an order of magnitude compared to a previous analysis solely based on the spectral shape of the signal. Our results are robust against variations in the modelling of high-latitude Galactic diffuse emission and systematic uncertainties of the LAT."

Collaborations
Keywords and Comments
, Christopher Eckner"

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Branch DM | Dark Matter

Subcategory Future projects

Titel
Dark Matter Phenomenology from Upcoming Neutrino Telescopes:

Presenter
Andrew Cheek
Author and Co-Author
Andrew Cheek Suzan Basegmez du Pree | Chiara Arina | Marco Chianese | Ariane Dekker | Shin'ichiro Ando

Abstract
'Experimental developments in neutrino telescopes are drastically improving their ability to constrain the annihilation cross-section of dark matter. In this talk we project the future sensitivity of a Neutrino telescope similar to KM3NeT. Focusing on particle models for dark matter, we assess how these future limits will complement the existing landscape of dark matter searches. This brings together results from gamma-ray telescopes, measurements of the cosmic microwave background and direct dark matter detection. We will emphasisze the importance of using the Angular Power Spectrum method, which is a powerful tool for reducing astrophysical uncertainties. We find that neutrino telescopes will be able to competitively probe significant portions of parameter space and will provide critical complementary information. Furthermore, we identify models that can potentially be explored where the relic abundance is achieved through thermal freeze-out.'

Collaborations
Keywords and Comments
Dark Matter, Neutrino Telescopes, Particle Phenomenology, Global Studies., Andrew Cheek"

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Branch DM | Dark Matter

Subcategory Future projects

Titel
Probing the properties of superheavy dark matter annihilating or decaying into neutrinos with ultra-high energy neutrino experiments

Presenter
Claire Guépin
Author and Co-Author
Claire Guépin | Roberto Aloisio | Luis A. Anchordoqui | Austin Cummings | John Krizmanic | Angela V. Olinto | Mary Hall Reno | Tonia Venters

Abstract
'The evidence for dark matter particles, $\\chi$, is compelling based on Galactic to cosmological scale observations. Thus far, the promising weakly interacting massive particle scenario have eluded detection, motivating alternative models of dark matter. We consider scenarios involving superheavy dark matter (SHDM) that potentially can decay or annihilate to neutrinos and antineutrinos.\r\n\r\nIn the mass range $m_\\chi = 10^7-10^{15}\\,{\\rm GeV}$, we evaluate the sensitivities of future observatories POEMMA and GRAND for indirect dark matter detection via the measurement of neutrino-induced extensive air showers (EAS). We compare their sensitivities to the dark matter thermally averaged annihilation cross section and dark matter decay width with the ones of IceCube, Auger and ANITA. We also show that the uncertainties related to the dark matter distribution in the Galactic halo have a large impact on the neutrino flux.\r\n\r\nWe show that a ground-based radio detector such as GRAND can achieve high sensitivities due to its large effective area and high duty cycle. Space-based Cherenkov detectors such as POEMMA that measure the EAS optical Cherenkov signal have the advantage of full-sky coverage and rapid slewing, enabling an optimized SHDM observation strategy focusing on the Galactic Center. We show that increasing the field of view of the Cherenkov detectors can significantly enhance the sensitivity. Moreover, POEMMA's fluorescence observation mode that measures EAS above 20 EeV will achieve state-of-the-art sensitivity to SHDM properties at the highest mass scales.'

Collaborations
, POEMMA, GRAND
Keywords and Comments
superheavy dark matter, indirect detection, ultra-high energy neutrinos, Claire Guépin''

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Branch DM | Dark Matter

Subcategory Theoretical Methods

Titel
gammaALPs: An open-source python package for computing photon-axion-like-particle oscillations in astrophysical environments

Presenter
Manuel Meyer
Author and Co-Author
Manuel Meyer | James Davies

Abstract
'Axions and axion-like particles (ALPs) are hypothetical particles that occur in extensions of the Standard Model and are candidates for cold dark matter. They could be detected through their oscillations into photons in the presence of external electromagnetic fields. gammaALPs is an open-source python framework that computes the oscillation probability between photons and axions/ALPs. In addition to solving the photon-ALP equations of motion, gammaALPs includes models for magnetic fields in different astrophysical environments such as jets of active galactic nuclei, intra-cluster and intergalactic media, and the Milky Way. Users are also able to easily incorporate their own custom magnetic-field models. We review the basic functionality and features of gammaALPs, which is heavily based on other open-source scientific packages such as Numpy and Scipy. Although focused on gamma-ray energies, gammaALPs can be easily extended to arbitrary photon energies.'

Collaborations
Keywords and Comments
axion-like particles, gamma rays, open-source code, Manuel Meyer''

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Branch DM | Dark Matter

Subcategory Theoretical Methods

Titel
Formation models for cosmic ray antinuclei

Presenter
Jonas Tjemsland
Author and Co-Author
Jonas Tjemsland

Abstract
'The expected low background of light antinuclei, such as antideuteron and antihelium-3, make them ideal detection channels for exotic physics, such as dark matter annihilations. At the same time, their small binding energies and composite structures make them promising probes for the QCD phase diagram in heavy ion collisions. In order to correctly interpret experimental data, however, a solid description of the formation process is needed. This can be achieved using phase space coalescence models based on the Wigner function representation of the produced nuclei states. Here, we discuss topics related to the production of light (anti)nuclei with a focus on its relevance for cosmic ray studies. In particular, we consider the importance of including both two-particle correlations and the size of the formation region on an event-by-event basis when describing the production in small interacting systems, such as e^+e^-, pp, pN and peripheral NN collisions. As such, we review the newly developed WiFunC model (Wigner Functions with Correlations) and comment on its generalisation to larger interacting systems.'

Collaborations
Keywords and Comments
antinuclei, cosmic ray, coalescence, WiFunC, Wigner function, antideuteron, antihelium, AMS-02, GAPS, heavy ion, Jonas Tjemsland"

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Presenter Forum

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-5
Access Monday Session https://live.remo.co/e/icrc-poster-hall-52-copy

Branch DM | Dark Matter

Subcategory Theoretical Methods

Titel
χarov: a tool for neutrino flux generation from WIMPs

Presenter
Qinrui Liu
Author and Co-Author
Qinrui Liu Jeffrey Lazar | Carlos Arguelles | Ali Kheirandish

Abstract
'Indirect searches for signatures of corpuscular dark matter have been performed using all cosmic messengers: gamma rays, cosmic rays, and neutrinos. The search for dark matter with neutrinos is important since they are the only courier that can reach detectors from dark matter processes in dense environments, such as the core of the Sun or Earth, or the edge of the observable Universe. One thing essential to experiments is the prediction of the neutrino signature in the detector. I will introduce χarov, a software that bridges the dark sector and Standard Model by predicting neutrino fluxes from different celestial dark matter agglomerations in diverse scenarios. This package includes updated computation of neutrino production and propagation to the detector.'

Collaborations

Keywords and Comments
indirect dark matter detection, neutrino, software, Monte Carlo simulation, Qinrui Liu'based on arxiv:2007.15010'

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-52-copy

Branch DM | Dark Matter

Subcategory Theoretical Results

Titel
Searching for Millicharged particles produced in cosmic-ray showers

Presenter
Víctor Muñoz
Author and Co-Author
Víctor Muñoz

Abstract
'Particles with fractional electric charge can be copiously produced in cosmic rays showers, propagating through the atmosphere and penetrating the earth until they reach different kinds of underground experiments. We will revisit their atmospheric production and provide novel sensitivity estimates for both, Cherenkov and Scintillator-based experiments.'

Collaborations
Keywords and Comments
, Víctor Muñoz''

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Branch DM | Dark Matter

Subcategory Theoretical Results

Titel
Decaying Dark Matter at IceCube and its Signature in High-Energy Gamma-Ray Experiments

Presenter
Barbara Skrzypek
Author and Co-Author
Barbara Skrzypek Carlos Argüelles | Marco Chianese

Abstract
'Observations of high-energy astrophysical neutrinos in IceCube have opened the door to multi-messenger astronomy, by way of which questions in particle physics could be explored collaboratively between IceCube and optical experiments such as Fermi-LAT. However, the origin of these astrophysical neutrinos is still largely unknown. Among the tensions that still need to be resolved, for example, is the excess of neutrinos in the High Energy Starting Event (HESE) sample in the energy range of 40-200 TeV, a contribution that could come from dark matter decay. The dark matter decay hypothesis can be tested through comparisons with Fermi-LAT gamma-ray data, as the latter places strong constraints on decay parameters. However, HESE predicts a soft neutrino spectrum that extends below around 50 TeV, while such a spectrum is incompatible with current gamma-ray measurements and suggests that gamma-rays become heavily suppressed for sources dominating in this lower-energy range. A reason for this is that properties of the traversed medium, which consists of extragalactic background light (EBL), the cosmic microwave background (CMB), and the intergalactic magnetic field, significantly alter the final gamma ray spectrum that reaches telescopes on Earth. The existence of competing photon background models, moreover, complicates estimates of dark matter constraints. In this presentation, we address these questions by studying the impact that these different models have on indirect measurements of dark matter decay. I present my predictions for galactic, inverse-Compton, and extragalactic gamma-ray spectra undergoing attenuation by different backgrounds.'

Collaborations

Keywords and Comments
, Barbara Skrzypek''

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Branch DM | Dark Matter

Subcategory Theoretical Results

Titel
Decaying dark matter in dwarf spheroidal galaxies: Prospects for X-ray and gamma-ray telescopes

Presenter
Fabian Zimmer
Author and Co-Author
Fabian Zimmer | Ebo Peerbooms | Shin'ichiro Ando

Abstract
'In this work we revise the estimate of dark matter (DM) decay signals from dwarf galaxies in the Milky Way. They are ideal for indirect DM searches, since they are known to be DM dominated systems. We test both warm and cold DM candidates, i.e., sterile neutrinos decaying into X-ray photons and a heavier DM candidate decaying into gamma rays.\r\nWe analyze the sensitivity to such a signal for both ground- and space-based detectors: Athena, XRISM and eROSITA for X-rays and HAWC and CTA for very-high-energy gamma rays. We consider sterile neutrinos with masses between 4-20 keV and masses for the heavier DM candidate in the range of 200 TeV to 20 PeV, decaying via a $b\\bar{b}$ or a $\\tau^+\\tau^-$ channel.\r\nWe make projections for future dwarf galaxies that would be newly discovered with the Vera Rubin Observatory Legacy Survey of Space and Time, which will further improve the expected sensitivity to DM decays both in the keV and TeV mass ranges. Our results show that all of these X-ray telescopes will be able to critically assess the claim of 7 keV sterile neutrino decays from stacked galaxy clusters and nearby galaxies, reaching sensitivities of $\\sin^2(2\\theta) \\sim 10^{-12} – 10^{-13}$.\r\nFor TeV dark matter, both HAWC and CTA will be sensitive to DM lifetime of $10^{27} - 10^{28}$ seconds.'

Collaborations
Keywords and Comments
Sterile Neutrinos, Dwarf Galaxies, Sensitivity Projection, eROSITA, XRISM, ATHENA, HAWC, CTA, Fabian Zimmer"

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Branch DM | Dark Matter

Subcategory Theoretical Results

Titel
Dark matter constraints from measurements of cosmic-ray positrons

Presenter
Isabelle John
Author and Co-Author
Isabelle John

Abstract
'Cosmic-ray positron measurements provide a powerful probe of dark matter annihilation. A possible contribution to the measured positron flux could come from dark matter annihilating or decaying into e+e- pairs. In this work, we combine a detailed scan of the cosmic-ray propagation parameter space using Galprop with a new time-, charge- and rigidity-dependent model for solar modulation to present improved constraints on the dark matter mass in the range from 20 to 600 GeV from recently published cosmic-ray positron data. Our models provide particularly strong constraints on dark matter annihilation into leptonic final states, which fall below the thermal cross-section for much of our mass range.'

Collaborations
Keywords and Comments
, Isabelle John"

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Branch DM | Dark Matter

Subcategory Theoretical Results

Titel
Searching for Dark Matter Neutrino Scattering in the Galactic Centre with IceCube

Presenter
Adam McMullen
Author and Co-Author
Adam McMullen | Aaron Vincent | Carlos Arguelles

Abstract
'While there is evidence for the existence of dark matter, its properties have yet to be discovered. Simultaneously, the nature of high-energy astrophysical neutrinos detected by IceCube remains unresolved. If dark matter and neutrinos are coupled to each other, they may exhibit a non-zero elastic scattering cross section. Such an interaction between an isotropic extragalactic neutrino flux and dark matter would be concentrated in the Galactic Centre, where the dark matter column density is greatest. This scattering would attenuate the flux of high-energy neutrinos, which could be observed in IceCube. Using the seven-year Medium Energy Starting Events (MESE), we perform an unbinned likelihood analysis, searching for a signal based on four possible DM-neutrino interaction scenarios. We search for a suppression of the high-energy astrophysical neutrino flux in the direction of the Galactic Centre, and compare these constraints to complementary low-energy information from large scale structure surveys and the cosmic microwave background.'

Collaborations
IceCube,
Keywords and Comments
Dark matter, neutrino, scattering, bayesian analysis, emcee, markov chain monte carlo,, Adam McMullen''

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Branch DM | Dark Matter

Subcategory Theoretical Results

Titel
Cosmic-ray combined analyses to shed light in the antiproton excess and its possible dark matter origin

Presenter
Pedro De la Torre Luque
Author and Co-Author
Pedro De la Torre Luque Daniele Gaggero | Mario Nicola Mazziotta

Abstract
'Recent cosmic-ray (CR) antiproton studies have claimed the possibility of an excess of data over the predicted flux at around 10 GeV, which can be the signature of dark matter annihilating into antiprotons. Nevertheless, this excess is subject to many uncertainties related to the evaluation of the antiproton spectrum produced from spallation interactions of CRs. \r\n\r\nWe implement a combined Markov chain Monte Carlo analysis of the secondary-to-primary ratios of B, Be and Li and the antiproton-to-proton spectrum (ap/p), also including nuisance parameters to consider the uncertainties related to the spallation cross sections (nuclear uncertainties). This analysis allows us to constrain the Galactic halo size and the rest of propagation parameters, evaluate the impact of the nuclear uncertainties in the determination of the antiproton spectrum and test the excess of antiprotons. We show that our predictions turn out to be compatible with the AMS-02 data, within the uncertainties related to the prediction of the antiproton spectrum from CR collisions. Nevertheless, we find that there is still an excess of ap/p data over our prediction, although this has a slightly different morphology with respect to that previously reported, due to the additional constraints on the diffusion coefficient that we include. Indeed, this leads to a possible signal of a WIMP of mass a factor 2 greater than that usually quoted and a thermal-averaged cross section of 3-10 times greater than previous studies claim.'

Collaborations

Keywords and Comments
Dark matter indirect search, cosmic-ray antiprotons, cosmic ray diffusion, Pedro De la Torre Luque''

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Branch	DM | Dark Matter
Subcategory	Theoretical Results

Titel
Testing the stability of heavy dark matter with up-coming radio neutrino telescopes

Presenter
Rasmi Hajjar
Author and Co-Author
Rasmi Hajjar | Marco Chianese | Stefano Morisi | Damiano Francesco Giuseppe Fiorillo | Ninetta Saviano | Gennaro Miele

Abstract
'In the next decade, ultra-high-energy neutrinos in the EeV-ZeV energy range will be potentially detected by next-generation neutrino telescopes. Although their primary goals are to observe cosmogenic neutrinos and to gain insight into extreme astrophysical environments, they have the great potential of indirectly probing the nature of dark matter. In this talk, we study the projected sensitivity of up-coming radio neutrino telescopes, such as RNO-G, GRAND and IceCube-gen2 radio array, to decaying dark matter scenarios. We investigate different dark matter decaying channels and masses, from 10^{7} to 10^{15} GeV. By assuming the observation of cosmogenic or newborn pulsar neutrinos, we forecast conservative constraints on the lifetime of heavy dark matter particles. We find that these limits are competitive with and highly complementary to previous multi-messenger analyses.'

Collaborations

Keywords and Comments
Heavy dark matter, UHE neutrinos, neutrino telescopes, Marco Chianese"

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Branch DM | Dark Matter

Subcategory Theoretical Results

Titel
Testing of Palatini f(R) gravity Power law model in Cosmological Perspectives

Presenter
Dhruba Jyoti Gogoi
Author and Co-Author
Dhruba Jyoti Gogoi Umananda Dev Goswami

Abstract
'We study the cosmological expansion history of the f(R) gravity Power law model in Palatini formalism by solving the field equations and expressing Hubble parameter as a function of redshift z. We also used a Markov Chain Monte-Carlo (MCMC) simulation to estimate the best fitting luminosity distance function value for a combination of cosmological parameters viz., matter density distribution and the Hubble uncertainty parameter. We used the Lambda Cold Dark Matter (ΛCDM) model results to constrain the priors of the Power law model. The study constrains the model and we found that the model is consistent with the Observational Supernovae type 1A Data.'

Collaborations

Keywords and Comments
Lambda Cold Dark Matter, Modified Gravity, Dhruba Jyoti Gogoi''

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Branch DM | Dark Matter

Subcategory Theoretical Results

Titel
A detectable antihelium flux from dark matter annihilation

Presenter
Martin Winkler
Author and Co-Author
Martin Winkler | Tim Linden

Abstract
'Recent observations by the Alpha Magnetic Spectrometer (AMS-02) have tentatively detected a handful of cosmic-ray antihelium events. Such events have long been considered as smoking-gun evidence for new physics, because astrophysical antihelium production is expected to be negligible. However, the dark-matter-induced antihelium flux is also expected to fall below current sensitivities, particularly in light of existing antiproton constraints. Here, we demonstrate that a previously neglected standard model process -- the production of antihelium through the displaced-vertex decay of bottom-baryons -- can significantly boost the dark matter induced antihelium flux. This process can triple the standard prompt-production of antihelium, and more importantly, entirely dominate the production of the high-energy antihelium nuclei reported by AMS-02.'

Collaborations

Keywords and Comments
antihelium, cosmic ray, dark matter, Martin Winkler'based on arXiv:2006.16251, accepted for publication in PRL'

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Transformation of the Physics and Astronomy courses

Presenter
Dmitriy Beznosko
Author and Co-Author
Dmitriy Beznosko | Tatiana Krivosheev | Alexander Iakovlev

Abstract
'The science education in universities has several deferring moments for the general student population outside of the Physics/Astronomy fields or STEM in general. A large contribution to that comes from the high cost of the textbooks that is typical for the introductory physics and astronomy courses. Another is the lack of supporting class materials, such as audio-video materials and support tools for activities. This poster will cover the class transformation activities under the ALG grant to adopt the free textbooks from OpenStax for the intro Physics 1-2 and Astronomy 1-2 sequences, and to create the supporting materials such as presentations, tests, audio-video materials and in-browser run online tools for the class activities as applicable to the courses listed above. Adaptations to online or hybrid teaching style will be also noted, and students' survey results will be included as well.'

Collaborations

Keywords and Comments
science education, class transformation, free textbook, class materials, Dmitriy Beznosko"

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-42

Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Outreach and educational activities within the EEE cosmic ray network

Presenter
Chiara Pinto
Author and Co-Author
Chiara Pinto

Abstract
'The Extreme Energy Events (EEE) network consists in a sparse array of telescopes based on Multigap Resistive Plate Chambers, installed in high school buildings all over the Italian territory and at CERN. Besides the many research activities concerned with extensive air shower detection, long distance correlation studies and additional physics results obtained during the last decade, the EEE project is extensively employed for educational and outreach activities, exploiting a unique opportunity to promote a fruitful and close collaboration between students, high school teachers and researchers. The involvement is at all levels, from the construction of the chambers during short stages at CERN over the past 15 years, with the participation of several hundred high school students and teachers, to the installation, monitoring and data taking with the telescopes by high school teams, to master classes, physics lectures, data analysis sessions and joint discussions on the results and their interpretation. Recent developments of the EEE network led to the installation and use of additional detectors in the Arctic region and on board of sailing ships, to measure the cosmic ray flux over large latitude intervals. Periodical remote and in presence (pre-Covid era) meetings allowed in these years a large participation (several thousand people) from the high school community to the EEE activities. National and local outreach initiatives in cosmic ray physics are also carried out around Italy by the EEE network, as a contribution to the dissemination of science among young people.'

Collaborations
other (fill field below), EEE Collaboration
Keywords and Comments
, Chiara Pinto'The selected contribution type is talk, but I would also be willing to contribute with a poster.'

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Almost Two Decades of Teaching Astronomy and Astrophysics, and Providing Educational Resources, to Chicago Public School Students and Teachers

Presenter
Vikram Dwarkadas
Author and Co-Author
Vikram Dwarkadas

Abstract
Over two decades, I have been actively involved in teaching astronomy and astrophysics to Chicago Public School (CPS) students and their teachers. This work was mainly in collaboration with Don York and the CUIP group. Don is now retired, but I am carrying on doing E/PO. Valuable resources that we have created for schools include the Multiwavelength Astronomy Website, with modules for infrared, optical, ultraviolet, X-Ray and Gamma-Ray Astronomy. The content of each lesson is derived from interviews with scientists, archived oral histories, and/or memoirs. Lessons were evaluated by a science educator and at least one subject matter expert before being produced for the web. They are supplemented by NASA media, archival material from the University of Chicago Library and other archives, and participant contributed photographs, light curves, and spectra. Summer programs provided training to CPS teachers to use the resource in their classroom. I have given several talks to CPS teachers, mainly on X-ray astronomy. Currently I am leading the CHARM (Chicago Area Research Mentoring) initiative. I am working with a class of 17 diverse 11th grade honors students at the UC Charter School, Woodlawn. Through frequent lectures (~ every 3-4 weeks), these students are exposed to astrophysical topics and concepts not normally not covered in a school curriculum (such as particle acceleration at shocks), to be followed by research projects in areas including high-energy astrophysics. The aim is to develop their critical thinking, and introduce them to research methods and techniques. This will prepare them for a STEM career, particularly one that prioritizes research. In this talk I will highlight the various projects, educational resources and results achieved.'

Collaborations

Keywords and Comments
school projects, under-represented students, educational resources, teacher training, outreach, Vikram Dwarkadas''

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Extreme19: when art and science make the front page

Presenter
Elisa Prandini
Author and Co-Author
Elisa Prandini | Michele Doro | Manuela Mallamaci | Barbara Montolli | Daria Mauri

Abstract
'Back in mid 2018, we were organizing Extreme19, a conference on astro-particle physics held in Padova on the topic of extremely energetic emission from galaxies. For the preparation of the graphical material in support of the conference we seeked for a collaboration with talented art students. To this purpose, we joined the Italian programme ‘PCTO’ (percorsi per le competenze trasversali e per l’orientamento) of high school student stages in job centers. Emily, Beatrice, and Chiara from the high school “Liceo Artistico Modigliani” in Padova accepted our invitation and started a 6-month stage at the Padova University in close contact with us. The challenge was to interbreed our scientific description of a relativistic jet of a powerful galaxy and their artistic assimilation and subsequent representation of it. During this period, they elaborated excellent and innovative graphical material used for the webpage as well as the conference poster. The quality of the graphics was indeed excellent: one of their drawings became the cover of the February 2020 issue of the prestigious Nature Astronomy journal.'

Collaborations
Keywords and Comments
education, school projects, art and science, Elisa Prandini''

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Branch	O & E | Outreach and Education
Subcategory	Outreach and Education

Titel
Making particle physics and cosmology accessible for high school students

Presenter
Hannes Stoppel
Author and Co-Author
Hannes Stoppel

Abstract
'One often needs to decide how far to introduce students to topics from the abstract scientific and mathematical perspective. It goes hand in hand with Stoffdidaktik (Dilling et al., 2020).\r\nReferring to this question we developed and tested educational materials on Particle Physics and Cosmology for students of grade 9 to 12 at secondary and upper secondary level, and for gifted students in special courses academies as Deutsche Schülerakademie or competitions like Jugend forscht, taking their prior knowledge into consideration. Our material contains, among other things, experiments supported by DESY and the University of Wuppertal. The theoretical parts of our course material include Maxwell's equations and the Klein-Gordon equation (according to Ellwanger, 2012), which require basic knowledge in differential equations and group theory (according to Wong, 2013).\r\nTo evaluate the results and the material and the courses from a cognitive as well as a psychological point of view, we used students' notebooks, their learning diaries, questionnaires, and interviews collected over a school year (Stoppel, 2019).\r\nThe Poster Presentation will take a look at the scientific content, emphasizing educational and psychological aspects.\r\n\r\nDilling, F., Stricker, I., Tran, N. C., & Vu, D. P. (2020). Development of Knowledge in Mathematics and Physics Education. In S. F. Kraus & E. Krause (Eds.), MINTUS. (pp. 299–344). Wiesbaden: Springer. \r\nEllwanger, U. (2012). From the universe to the elementary particles. Berlin: Springer. \r\nStoppel, H.-J. (2019). Beliefs und selbstreguliertes Lernen. Wiesbaden: Springer.\r\nWong, C. W. (2013). Introduction to Mathematical Physics (2. ed.). Oxford: Oxford Univ. Press.'

Collaborations
, Max-Planck-Gymnasium Gelsenkirchen
Keywords and Comments
School projects, particle, cosmology, experimental and theoretical parts, psychological aspects, Hannes Stoppel"

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Discovering cosmic rays with OCRA: outreach activities for students and teachers

Presenter
Sabine Hemmer
Author and Co-Author
Sabine Hemmer | Carla Aramo | Elisabetta Bissaldi | Valerio Bocci | Bianca Bottino | Mario Buscemi | Lorenzo Caccianiga | Gabriella Cataldi | Francesco Dimiccoli | Federico Di Pierro | Carmelo Evoli | Alessia Giampaoli | Giuseppe La Vacca | Alessandro Men

Abstract
'The Outreach Cosmic Ray Activities (OCRA) project offers a platform for all outreach activities focusing on cosmic rays within the Italian Istituto Nazionale di Fisica Nucleare (INFN). Created in 2018, OCRA now counts 21 of the institute's divisions all over Italy as members. The project's core activity is the participation of all its members in the International Cosmic Day, organized by DESY, inviting high school students to carry out hands-on measurements of the cosmic ray flux and learn about the related physics background. Two students from each division are then selected to participate in the annual OCRA science camp, a three-day full immersion into the life of a physicist. \r\nThe national activities are complemented by local initiatives of the OCRA member groups: workshops and secondments, science competitions and the development of new detectors for outreach activities offer a multitude of possibilities for students to engage with our researchers and to explore the world of cosmic rays. \r\nSince spring of 2020 OCRA offers also a series of online laboratories on its website https://web.infn.it/OCRA/, designed not only to be used by students individually but also to be offered in the classroom by teachers. \r\nThis talk will give an overview on all activities offered by OCRA with a particular focus on the 2020 online event organized in occasion of the International Cosmic Day, that saw the participation of more than 3000 students.'

Collaborations
other (fill field below), OCRA

Keywords and Comments
student activities, teacher activities, International Cosmic Day, online laboratories, Sabine Hemmer"

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Outreach, Education and Communication Initiatives of the CTA Observatory

Presenter
Alba Fernández-Barral
Author and Co-Author
Alba Fernández-Barral | Megan Grunewald | for the CTA Observatory

Abstract
'The Cherenkov Telescope Array Observatory (CTAO) will be the first ground-based gamma-ray observatory for the exploration of the extreme Universe that will be open to all scientific communities as a resource for data from unique, high-energy astronomical observation. The CTAO will have tens of telescopes located on two array sites, covering the entire gamma-ray sky: CTA-North located at the Roque de los Muchachos Observatory (La Palma, Spain) and CTA-South near the Paranal Observatory (Atacama Desert, Chile). In this talk, we will present the Outreach, Education and Communication (OEC) programme and activities carried out at the global and site levels. \r\nWe will, first, present the CTAO's approach to education, covering the educational activities and materials we use to bring the gamma-ray Universe into the classroom, as well as the “Physicists On-Call” programme that puts CTA experts in contact with educational centres and astronomical associations around the world. Moreover, we will delve into the initiatives under the CTAO's Astrodiversity project, which aims to create and support activities within the inclusion and diversity framework, including the annual “Women of CTA” event and best practices for the colour-blind and visually-impaired. Finally, we will discuss the latest developments and releases, including an open seminar series for researchers and the general public, as well as the CTAO's ongoing series of films to explore the science, technology, sites and people behind the construction of the largest, most powerful gamma-ray observatory on the planet.'

Collaborations
, CTA Observatory (CTAO)
Keywords and Comments
high-energy outreach, education, diversity, inclusion, films, good practices, gender,, Alba Fernández-Barral"

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Online Masterclass built on the KASCADE Cosmic ray Data Centre

Presenter
Katrin Link
Author and Co-Author
Katrin Link | Victoria Tokareva | Andreas Haungs | Doris Wochele | Frank Polgart | Donghwa Kang | Paras Koundal | Olena Tkachenko | Jürgen Wochele

Abstract
'During the ongoing Covid-19 pandemic, people all over the world were forced to think about new ways of interacting with each other and this has especially challenged academics in their outreach activities with pupils. New online formats needed to be developed, and we used this opportunity to design and implement an (not only) online Masterclass using data from the KASCADE experiment. The masterclass is built on the KASCADE Cosmic Ray Data Centre and uses Jupyterhub and Notebooks for data analysis. We gained first practical experience during the International Cosmic Day with students at the age of 14-19 years. The Masterclass includes lectures on cosmic ray physics and data analysis, which are then consolidated in a hands-on part. By performing a cosmic-ray composition analysis on KASCADE data, the participants gain experience in using the KCDC open data web platform, working in the Jupyter environment, preprocessing data from a real astroparticle physics experiment, programming Python and performing exploratory data analysis.\r\nIn this presentation, we will describe the content of the masterclass as well as the choice of implementation tools (such as platform, programming language and libraries) and organizational aspects of the event.'

Collaborations

Keywords and Comments
Masterclass, KCDC, Jupyter, KASCADE-Grande, Cosmic Ray, Outreach,, Katrin Link''

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Presenter Forum

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-42

Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Completing Aganta Kairos: Capturing Metaphysical Time on the Seventh Continent

Presenter
Jim Madsen
Author and Co-Author
Jim Madsen | Laurent Mulot | Christian Spiering Andrea Dixon | John Hardin | Josh veitch-michaelis | Martin Wolf

Abstract
'This presentation will provide an overview of the art project Aganta Kairos (To Fish the Metaphysical Time). It celebrates the neutrino, the ghost particle, which is considered as a cosmic messenger by scientists, and as a link between people who care about their relationship to the cosmos and question their origins, for the artist. The artwork is based on a performance of celebration and seeks to build a human community crossing different knowledges and interpretations of the universe. This crossing of knowledges is realized during the performance of placing the plaque, held with witnesses, and during subsequent exhibitions. Images, sounds, videos and sculpture testify to the diversity of approach to questioning our origins ranging from traditional western science to ancient shamanism. The sites were selected to cover the globe and, for the South Pole, Mediterranean and Lake Baikal, their connection to ongoing neutrino experiments. In December 2020, a plaque was installed at South Pole IceCube Laboratory, the seventh and final site. Images and video from the South Pole installation will be featured.'

Collaborations
IceCube,
Keywords and Comments
, Jim Madsen''

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Presenter Forum

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Access Monday Session https://live.remo.co/e/icrc-poster-hall-42

Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Towards Equitable, Diverse, and Inclusive science collaborations: The Multimessenger Diversity Network

Presenter
Ellen Bechtol
Author and Co-Author
Jim Madsen | Ellen Bechtol

Abstract
'The Multimessenger Diversity Network (MDN), formed in 2018, extends the basic principle of multimessenger astronomy – that working collaboratively with different approaches enhances understanding and enables previously impossible discoveries – to equity, diversity, and inclusion (EDI) in science research collaborations. With support from the National Science Foundation INCLUDES program, the MDN focuses on increasing EDI by sharing knowledge, experiences, training, and resources among representatives from multimessenger science collaborations. Representatives to the MDN become engagement leads in their collaboration, extending the reach of the community of practice. An overview of the MDN structure, lessons learned, and how to join will be presented.'

Collaborations
IceCube,

Keywords and Comments
Equity, Diversity, Inclusion, Jim Madsen''

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Presenter Forum

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Access Friday Session https://live.remo.co/e/icrc-presenter-forum-1-hall-4
Access Monday Session https://live.remo.co/e/icrc-poster-hall-42

Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
A scientific and educational experience to engage high school students to gamma-ray physics

Presenter
Carla Aramo
Author and Co-Author
Carla Aramo | Piera Romano

Abstract
'In this paper we introduce an original scientific and educational experience conducted with Italian 16/17 years-old students attending Scientific Lyceum "Mangino" of Pagani (Italy). It was inserted in an Italian Educational Program PCTO (i.e. Percorsi per le Competenze Trasversali e per l\'Orientamento), active in High Schools on a national level, with the aim to make students consolidate and expand the curricular content's knowledge via internships in private or public working environments. For this specific item, concerned CTA-PCTO (Cherenkov Telescope Array-PCTO), the students, led by a teacher and an INFN researcher, venture out into the innovative technology and the future scientific achievements of CTA, which will be the first ground-based gamma-ray observatory and the world's most sensitive and powerful gamma-ray instrument. All the activities carried out during the CTA-PCTO were organized as an action-research to develop an alternative, effective, and motivating approach to the study of astroparticle physics, and in particular of gamma-ray physics. In this way students benefited to the scientific and technology information of CTA and its telescopes, and they were engaged in producing different didactic items, also useful to introduce CTA technologies to other students. They created a paper model of the CTA\'s Large-Sized Telescope (LST), realized a crossword puzzle and write an article, and finally, they presented their work to the general public during the "European Researchers\' Night" in November 2020. The mere need to report their results has produced remarkable results in their ability to write and communicate on scientific items.'

Collaborations
CTA,

Keywords and Comments
gamma-ray, CTA, didactic, Carla Aramo"

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Making cosmic particle accelerators visible and audible

Presenter
Stefan Ohm
Author and Co-Author
Stefan Ohm | Konrad Rappaport | Carsten Nicolai | Till Mundzeck Matthias Fuessling | Sylvia Jiechen Zhu | Andrew Taylor | Dan Parsons

Abstract
'In a collaboration between astroparticle physicists, animation artists from the award-winning Science Communication Lab, and musician Carsten Nicolai (a.k.a. Alva Noto), two cosmic particle accelerators have been brought to life: the massive binary star Eta Carinae, and the exploding star, which resulted in the gamma-ray burst GRB190829A. For Eta Carinae, the computer-generated images are close to reality because the measured orbital, stellar and wind parameters were used for this purpose. Particle acceleration in the jet of GRB190829A has also been animated at a level of detail not seen before. The internationally acclaimed multimedia artist Carsten Nicolai, who uses the pseudonym Alva Noto for his musical works, exclusively composed the sound for the animations. The multimedia projects aim at making the discoveries more accessible to the general public, and to mediate scientific results and their reference to reality from an artistic point of view.'

Collaborations
Keywords and Comments
, Stefan Ohm"

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
The REINFORCE Project

Presenter
Rémy Le Breton
Author and Co-Author
Rémy Le Breton Vincent Bertin | Paschal Coyle | Gwenhaël De Wasseige | Hervé Glotin | Carlo Guidi | Feifei Huang | Séverine Martini | Antoine Kouchner | Christian Tamburini | Véronique Van Elewyck

Abstract
'Large research infrastructures have opened new observational windows, allowing us to study the structure of matter up to the entire Universe. However, society hardly observes these developments through education and outreach activities. This induces a gap between frontier science and society that may create misconceptions about the content, context, and mission of public funded science.\r\n\r\nIn this context, the main goal of the European Union’s Horizon 2020 “Science with and for Society” REINFORCE project (REsearch INfrastructure FOR Citizens in Europe) is to minimize the knowledge gap between large research infrastructures and society through Citizen Science. A series of activities is being developed on the Zooniverse platform, in four main fields of frontier physics involving large research infrastructures: gravitational waves with the VIRGO interferometer, particle physics with the ATLAS detector at LHC, neutrinos with the KM3NeT telescope, and cosmic rays at the interface of geoscience and archeology. Using real and simulated data, Citizen Scientists will help building a better understanding of the impact of the environment on these very high precision detectors as well as creating new knowledge. \r\n\r\nThis poster describes the REINFORCE project, with a special emphasis on the Deep Sea Hunter demonstrator involving the KM3NeT neutrino telescope, in order to show practical examples of Citizen Science activities that will be proposed through the project.'

Collaborations
KM3NeT, REINFORCE
Keywords and Comments
REINFORCE, Citizen Science, Zooniverse, Rémy Le Breton"

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
“A scuola di Astroparticelle”: a synergy between school education and scientific research

Presenter
Roberta Colalillo
Author and Co-Author
Roberta Colalillo | Carla Aramo | for OCRA Collaboration (https://web.infn.it/OCRA/collaborazione/)

Abstract
"The outreach program “A scuola di Astroparticelle” was proposed in 2016 by the\r\nNational Institute of Nuclear Physics (INFN – Napoli Division) in collaboration with the Physics Department “Ettore Pancini” of the Federico II University in Napoli, CNR-SPIN and CNR-ISASI Institutes. Its main goal is to engage teachers and students of High Secondary Schools in astroparticle physics projects. For the third edition (2018/19), the activities, which are also part of the Italian Educational Program PCTO – “Percorsi per le Competenze Trasversali e per l'Orientamento”, involved 18 schools for a total of 21 projects on several topics. Some projects were strictly related to astroparticles as cosmic rays, while others were more technical, as the development of particle detectors, or cross-disciplinary projects. Students worked for the entire school year and prepared for the final event. More than 600 students attended the event and presented their work to a jury with a poster and an oral presentation in plenary sessions.\r\nSince 2018, the program is part of OCRA - Outreach Cosmic Ray Activities - a national outreach project of INFN with the aim of collecting, within a common framework, the numerous outreach activities in cosmic-ray field carried out at the local level.\r\nThe fourth edition (2019-20), in spite of the difficult situation due to the COVID-19 pandemic, has also seen the participation of 22 schools that carried out part of the activities in an online format. \r\nSome projects will be presented in detail as the one performed using public data of the Pierre Auger Observatory."

Collaborations
other (fill field below), OCRA Collaboration - https://web.infn.it/OCRA/collaborazione/

Keywords and Comments
school project, astroparticle, Auger Observatory public data, Roberta Colalillo"

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Students work like astroparticle physicists with Cosmic@Web

Presenter
Philipp Lindenau
Author and Co-Author
Philipp Lindenau | Carolin Schwerdt | Michael Walter

Abstract
'Cosmic@Web is an online learning resource developed at DESY Zeuthen, Germany as part of the outreach activities in the framework of Netzwerk Teilchenwelt. Via Cosmic@Web, high school and university students can access data from astroparticle physics experiments and experience the workflow of scientific research in this field by pursuing their own or suggested research questions. Data from various experiments located in different areas of the world can be used to study cosmic weather effects and muon properties. The analysis can be performed without any coding experience. The graphical interface allows to visualize data in several plot types and offers possibilities of data fitting as well as data reduction and corrections.\r\nSo far Cosmic@Web has been used by German high school students during internships at research institutes like DESY, for a research component as part of their high school degree as well as within projects in software development and coding.\r\nThis talk will present examples of workflow with Cosmic@Web, particularly linking aspects of astroparticle physics – especially the measurement of cosmic muons – with other established contents of high school physics curricula. Furthermore, the acceptance of the tool by students and teachers as well as their feedback during and after its introduction in dedicated training workshops will be discussed.'

Collaborations
other (fill field below), Netzwerk Teilchenwelt
Keywords and Comments
high school, data analysis, experiment, learning ressource, muons, Cosmic@Web, Netzwerk Teilchenwelt, Philipp Lindenau''

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Technological semiotic mediators in didactic to approach cosmic rays and improve students' scientific knowledge

Presenter
Ilaria VERONESI
Author and Co-Author
Francesco Saverio Tortoriello | Roberta Colalillo | Ilaria VERONESI | Carla Aramo

Abstract
'The “Mathematical High School” research project is an extracurricular educational path dedicated to high school students developed by the Department of Mathematics of the University of Salerno (Italy). In this context, an experimental research-laboratory in the field of astroparticle physics was presented in collaboration with the National Institute of Nuclear Physics (INFN) – Napoli Division (Italy). The laboratory activities concerned the analysis of the data detected by the Cosmic Ray Cube (CRC), a muon detector designed in the Gran Sasso (Italy) laboratories together with a dedicated software for the data acquisition, available also for mobile devices. The pandemic emergency due to covid-19 and the consequent closure of schools with the activation of distance learning, led the researchers and teachers involved in the laboratory activities, to re-elaborate and develop the activities in a convenient format for e-learning platforms. The course also pursued to create a bridge between the worlds of research, universities and schools, to aim at creating the necessary synergies needed to stimulate and to activate participation of students, also with the use of the most recent scientific discoveries.\r\nThe didactic impact of the activities will be illustrated in this work. It will describe not only the involvement in the development of fascinating topics not usually carried out in Italian curricula, but also the skills acquired thanks to the development of interdisciplinary themes that highlight how the different fields of the scientific world such as mathematics, physics, chemistry, astrophysics, engineering, cooperate for the advancement of knowledge in research.'

Collaborations

Keywords and Comments
Technology-enhanced learning, interdisciplinarity, astroparticle physics, mathematics, Ilaria VERONESI''

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Branch O & E | Outreach and Education

Subcategory Outreach and Education

Titel
Draw me a Neutrino: the first art contest organized by the KM3NeT Collaboration

Presenter
Marco Circella
Author and Co-Author
Meriem Bendahman | Juande Zornoza | Marco Circella | Gogita Papalashvili | Revaz Shanidze | Gwenhaël De Wasseige | Jessica-Sheay Verrall | Harold Yepes Ramirez | Tzamarioudaki Katerina | Paschal Coyle | Cristiano Bozza | Soebur Razzaque | Sara Rebecca Go

Abstract
'While the KM3NeT neutrino detector is currently being deployed in the Mediterranean Sea, the Collaboration has been searching for illustrations of the neutrinos it will detect. The participants to the contest were invited to submit their best interpretation of a neutrino using any technique or support. Each neutrino flavour corresponded to a different age category. \r\nMore than 500 drawings were submitted from 16 different countries and the winners were selected based on the originality and creativity of the realization, as well as the harmony with the properties and origin of the neutrinos.\r\nAfter announcing the results in an online ceremony with the participation of a large international audience, the winning drawings have been put on display in a dedicated KM3NeT Virtual Neutrino Art Centre.\r\nIn this contribution, we will review the interest and motivation for a large experimental collaboration to organize such a contest. We will also present the results of an impact study carried out during the contest.'

Collaborations
KM3NeT,

Keywords and Comments
neutrino astronomy, drawing contest, Marco Circella''