The 3rd International Symposium on Cosmic Rays and Astrophysics (ISCRA-2021)

Report of Contributions

https://indico.nevod.mephi.ru/e/iscra-2021

Contribution ID: **3** Type: **Original**

Modeling of threshold energy of a small-size Cherenkov telescope with a SiPM camera

Thursday, 10 June 2021 13:40 (15 minutes)

Full-particle Monte-Carlo simulations of extensive air showers (EASs)
induced by 0.3-30 TeV cosmic gamma-rays and cosmic ray protons
as well as of Cherenkov radiation generated by such showers have
been carried out. Further modeling of Cherenkov photon transport in the
optical system and camera of a ˜10 m(2) mirror area imaging Cherenkov telescope
based of modern OnSemi/MicroFJ silicon photomultipliers has been undertaken.
It has been shown that even with strict selection criteria which would ensure
a high quality of the EAS images recorded by the detector camera,
the threshold detection energy would not exceed 0.8 TeV, which is approximately
twice as low as the threshold currently achieved at the small-size TAIGA-IACT
telescope with similar mirror area and a camera based on vacuum photomultiplier tubes.

Primary authors: KRASSILCHTCHIKOV, Alexander (Ioffe Institute); Dr KHOLUPENKO, Eugene (Ioffe Institute); BADMAEV, Danr (Ioffe Institute)

Presenters: KRASSILCHTCHIKOV, Alexander (Ioffe Institute); Dr KHOLUPENKO, Eugene (Ioffe Institute)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **4** Type: **Overview**

Study of environmental thermal neutron fluxes: from EAS to Geophysics

Tuesday, 8 June 2021 10:15 (25 minutes)

The electron-neutron detectors (en-detectors) were developed at INR RAS in the framework of the PRISMA project to study Extensive Air Shower (EAS) hadronic component through thermalized neutrons. By continuous monitoring of neutron background with the en-detectors we have found interesting variations in the environmental thermal neutron flux. Environmental neutrons are produced by two sources: cosmic rays and natural radioactivity. They are in equilibrium with media and are therefore sensitive to many geophysical or Sun-Earth phenomena in accordance with the source of production. Some results are presented and discussed.

Primary author: STENKIN, Yuri (INR RAS)

Presenter: STENKIN, Yuri (INR RAS)

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **5** Type: **Overview**

Status of the Yakutsk air shower array and future plans

Tuesday, 8 June 2021 11:30 (25 minutes)

The Yakutsk Extensive Air Shower Array has been continuously operating for more than 50 years (since 1970) and up until recently it has been one of world's largest ground-based instruments aimed at studying the properties of cosmic rays in the ultra-high energy domain. In this report we discuss results recently obtained at the array — on cosmic rays energy spectrum, mass composition and directional anisotropy — and how they fit into the world data. Special attention is paid to the measurements of muonic component of extensive air showers. Theoretical results of particle acceleration at shocks are also briefly reviewed. Future scientific and engineering plans on the array modernization are discussed.

Primary author: KSENOFONTOV, Leonid (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS)

Presenter: KSENOFONTOV, Leonid (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS)

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **6** Type: **Overview**

CALET observations during the first 5 years on the ISS

Thursday, 10 June 2021 15:00 (25 minutes)

The CALorimetric Electron Telescope CALET is collecting science data on the International Space Station since October 2015 with excellent and continuous performance.
Energy is measured with a deep homogeneous calorimeter (1.2 nuclear interaction lengths, 27 radiation lengths) preceded by an imaging pre- shower (3 radiation lengths, 1mm granularity) providing tracking and 10^{-5} electron/proton discrimination. Two independent sub-systems identify the charge Z of the incident particle from proton to iron and above (Z<40). CALET measures the cosmic-ray electron+positron flux up to 20 TeV, gamma rays up to 10 TeV, and nuclei up to 1 PeV. In this paper, we report the on-orbit performance of the instrument and summarize the main results obtained during the first 5 years of operation, including the electron+positron energy spectrum and the individual spectra of protons, heavier nuclei and iron. Solar modulation and gamma-ray observations are also concisely reported, as well as transient phenomena and the search for gravitational wave counterparts.

Primary author: Prof. MARROCCHESI, Pier Simone (University of Siena and INFN Pisa)

Co-author: CALET COLLABORATION

Presenter: Prof. MARROCCHESI, Pier Simone (University of Siena and INFN Pisa)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **7** Type: **Original**

Comparison of models of nucleus-nucleus interactions implemented in CORSIKA

Wednesday, 9 June 2021 17:20 (15 minutes)

Program CORSIKA is the unique and the most common tool for Monte-Carlo simulation of the formation and development of extensive air showers. CORSIKA offers the user a set of hadronic interactions models for both high and low energies, leaving the choice of the model to the user. Thus the comparison of these models is of particular interest.

In the work, four CORSIKA models for high energy hadronic interactions are considered: EPOS-LHC, QGSJET-II, SIBYLL and DPMJET. These models are used to describe the interactions of protons and nuclei of helium, nitrogen and iron of primary cosmic rays with nuclei of atmospheric nitrogen. Checking for laws of energy, momentum and electric charge conservation is of primary importance. The comparison of distributions of the number of secondary particles and the fraction of the collision energy they are carrying, as well as mean values of these quantities has been performed

Primary author: NIKOLAENKO, Roman

Co-authors: KOKOULIN, Rostislav (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); BOGDANOV, Aleksei (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); PETRUKHIN, Anatoly (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Presenter: NIKOLAENKO, Roman

Session Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Track Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Contribution ID: **8** Type: **Original**

Recent developments on EPOS

Wednesday, 9 June 2021 17:05 (15 minutes)

Currently, EPOS-LHC is the public EPOS version, heavily used by experimental groups in high energy and cosmic ray physics. It is based on an S-matrix approach, being the ideal framework for multiple scattering in small systems. However, factorization and binary scaling does not come for free, it is a very complex issue, and in the current model it is simply not properly done. Another topic concerns flow, which is only implemented as "parameterized" which quite limited application. There was substantial progress during the past few year, referred to as "EPOS4 project", to develop a consistent formalism, which accommodates a multiple scattering S-matrix approach, factorization, and saturation, all of these topics being closely related to each other. In addition, secondary interactions are considered, most importantly a full hydrodynamic evolution. In this talk, we will report about the status of the EPOS4 project.

Primary author: Prof. WERNER, Klaus

Co-author: Dr PIEROG, Tanguy (KIT)

Presenter: Prof. WERNER, Klaus

Session Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Track Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Contribution ID: **9** Type: **Original**

Variations of atmospheric muons and background measured with Large Volume Detector

Wednesday, 9 June 2021 15:05 (15 minutes)

The analysis of atmospheric muons detected in the LVD underground low-background experiment (Gran Sasso, Italy) has been completed. The average intensity of the registered muons is 3.31 × 10−4 m −2 s −1. The paper presents measurements of seasonal variations of muons in different directions.
The low-energy background, which is registered by the detector, also experiences seasonal (annual) changes. This background is created by gamma quanta from decays of 222Rn daughter nuclei. Gamma radiation is generated mainly by bismuth nuclei, which, due to-decay, transform into polonium with a characteristic time of 19.7 min. The energy spectrum of gamma radiation covers the range from 0.6 to 2.5 MeV. The detector also observes daily and weekly background variations. Variations are due to seasonal fluctuations in radon concentration and additional injection of radon from groundwater associated with tectonic activity.
With deformations of the earth's crust, stress arises, the number of microcracks increases, which leads to an increase in the concentration of radon. At the LVD experiment, research is underway to identify the relationship between the behavior of radon fields and seismic activity. The paper will discuss various sources of variations associated with geophysical aspects (the influence of the moon's motion; changes in pressure, humidity and temperature; seismic activity).

Primary authors: Dr AGAFONOVA, Natalia (Institute for Nuclear Research of RAS); FILIMONOVA, N.A. (MPhTI, INR RAS); DOBRYNINA, E.A. (INR RAS); RYAZHSKAYA, O.G. (INR RAS); SHAKYRIANOVA, I.R. (INR RAS); ASHIKHMIN, V.V. (INR RAS); YAKUSHEV, V.F. (INR RAS); ENIKEEV, R.I. (INR RAS)

Presenter: Dr AGAFONOVA, Natalia (Institute for Nuclear Research of RAS)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **11** Type: **Overview**

Cosmic Ray Mass Composition Problem: towards model-independent evaluation based on the analysis of the spatial and temporal structure of EAS charged components

Wednesday, 9 June 2021 10:25 (25 minutes)

The determination of the mass composition of primary cosmic rays is at present stage the crucial issue for understanding their origin and propagation through the interstellar medium. The mass composition above 10^{14} eV is inferred from the extensive air shower (EAS) observations by comparisons with simulations results, which rely on accurate description of air shower physics including hadronic interaction models uncertain in the relevant energy range. Numerous methods and techniques are implemented, including analysis of mean values, fluctuations, correlations or even particular features of distributions of different observables characterized both longitudinal and spatial shower development (depth of maximum, muon production depth, total number of electrons and muons at the observation level and their local densities at various distances from the shower axis, particles arrival time profiles, spatial distributions of radio emission and Cherenkov light etc.). Large efforts have been made recently in both gaining experimental data with increased resolution in detection of various EAS components and developing improved methods for physical interpretation of the data along with evolving hadronic interaction models after the LHC results. Nevertheless, the composition results still remain ambiguous in the entire energy range available for EAS studies.

The discrepancies between estimates of mass composition derived by various methods from the data of different experiments, in addition to insufficiency in statistics, are apparently caused by complex of instrumental and methodological systematic biases of different nature, as well as by strong model dependence of the observables, mostly in case of muon component characteristics (so-called “Muon Puzzle”), disadvantages in taking into account meteorological effects etc.

A possible solution might be achieved with refined (multi-)hybrid measurements together with generalizations of the analysis by revealing universal features, based on the intrinsic physic properties of air showers, evaluation of new parameters and functionals, which are weakly sensitive to the hadronic interaction model being good primary mass indicators.

In this paper we present the updated analysis of spatial distributions of electrons and muons with respect to the scale invariance in lateral distribution (LD) functions (the extended scaling formalism). We demonstrate that this formalism enables accurate description of lateral distributions of electrons and muons by one-parametric scale-invariant functions in wide primary energy and radial distance ranges. The scale-invariance of LD and air shower universality manifesting through the functional dependence between radial scale factors and longitudinal shower age are both insensitive to hadronic interaction models. An additional composition sensitive observable, which can be included in the multicomponent analysis of experimental data obtained by 100% duty cycle ground-based detectors, is time profile of charged particles measured by surface scintillation counters at different ranges of radial distances.

Thus, integrated spatial and temporal characteristics of the charged EAS component can be effectively used as a source of the improved cosmic ray mass composition results when interpreting the experimental data of the ground-based EAS arrays. The proposed approach could be implemented for the present and future (multi-)hybrid air shower observations by TAIGA, Yakutsk Complex Air Shower Array, Auger and Telescope Array observatories taking into account their upcoming upgrades, as well as for re-analysis and cross-calibration of the data collected from different air shower arrays within the single method in a broad primary energy range.

Primary authors: RAIKIN, Roman (Altai State Univesrity); LAGUTIN, Anatoly (Altai State University); SEREBRYAKOVA, Tatyana (Altai State University); VOLKOV, Nikolay (Altai State University); SOLDATKIN, Sergey (Altai State University); PALKOWSKI, Evgeniy (Altai State University)

Presenter: RAIKIN, Roman (Altai State Univesrity)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **12** Type: **Overview**

Status and first results of LHAASO

Wednesday, 9 June 2021 12:15 (25 minutes)

The origin□acceleration and transport mechanisms of the cosmic rays are fundamental but yet unresolved problems that have been the focus of astroparticle physics researches. The Large High Altitude Air Shower Observatory (LHAASO), which will be completed by the end of 2021, is a new generation hybrid experiment with the advantages of high sensitivity, high duty cycle and large field of view. LHAASO consists of three detector arrays, the Kilometer Square Array (KM2A), the Water Cherenkov Detector Array (WCDA) and the Wide Field of-view Cherenkov Telescope Array (WFCTA), located at 4410 m above sea level in Sichuan Province, China. LHAASO serves as the most sensitive γ-ray detector for energies above a few tens of TeV, and is expected to give revolutionary insights in the VHE domain of astroparticle physics, such as the origin and propagation of CRs, as well as the nature of VHE γ-ray sources. In this paper, we will report the status and first results of LHAASO.

Primary author: ZHANG, Yi (Purple Mountain Observatory, CAS)

Presenter: ZHANG, Yi (Purple Mountain Observatory, CAS)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **13** Type: **Original**

Electron-Neutron Detector Array (ENDA)

Tuesday, 8 June 2021 13:10 (15 minutes)

By accurate measurement of components and energy spectrum in the knee region, problem of origin of cosmic ray can be solved. In one extensive air shower (EAS), high energy hadrons, which constitute the EAS skeleton as G.T. Zatsepin called it, carry important information for multi-parameter correlation studies. The nuclear reaction between hadrons and matter in the surrounding environment (such as soil, buildings, detector materials, and air) produces a large number of evaporation neutrons; moderating by matter in the surrounding environment, the evaporation neutrons become thermal neutrons. At the beginning of the 21th century, a new technology, electron-neutron detector (EN-detector) was designed by Y. Stenkin and his colleagues, and the PRImary Spectrum Measurement Array (PRISMA) project was proposed to reinforce array capability of cosmic ray composition separation and then improve measurement accuracy of cosmic ray components and energy spectrum. Besides, EN-detectors can be used for continuous environmental thermal neutron flux monitoring and its variation study needed not only for EAS experiment background estimation but also for geophysical applications (e.g. earthquakes, thunderstorms, radioactive aerosol control, etc) and solar activity study (e.g. solar flares, Forbush effects, etc).
Under the Chinese-Russian cooperation, we put forward to build so called EN-Detector Array (ENDA) at high altitude in China. In 2013, we placed a small array of 4 EN-detectors, so called PRISMA-YBJ in the ARGO-YBJ experimental hall at Yangbajing (YBJ) (4300m a.s.l.), Tibet, China, with which we achieved the simultaneous detection of thermal neutrons and electromagnetic components in EAS coincident events between PRISMA-YBJ and ARGO-YBJ. Up to now, one cluster composed of 16 EN-detectors based on new type boron compound scintillator is running in Moscow. Meanwhile, there are four clusters running in China for detectors and arrays specification test: one so called P-16-YBJ at YBJ, one so called ENDA-16-HZS at LHAASO (4410m a.s.l.), Daocheng, Sichuan, and two at Hebei Normal University (HNU) near sea level, Shijiazhuang, Hebei. ENDA-16-HZS has obtained coincident events with LHAASO. In the near future, we plan to extend ENDA to ENDA-64 with array area of 1000 m2 inside LHAASO to study the knee region of the light components (H and He). After it, ENDA will be extended up to 400 detectors with array area of 10000 m2 to study the knee region of the heavy components like Fe.

Primary authors: LI, Bing-Bing (Hebei Normal University); CHEN, Tian-Lu (Tibet University); CUI, Shu-Wang (Hebei Normal University); DANZENG, Luobu (Tibet University); GAO, Wei (Institute of High Energy Physics, Chinese Academy of Sciences); KULESHOV, D. A. (Institute for Nuclear Research of Russian Academy of Sciences); LEVOCHKIN, K. R. (Institute for Nuclear Research of Russian Academy of Sciences); LIU, Mao-Yuan (Tibet University); LIU, Ye (Hebei University of Economics and Business); MA, Xin-hua (IHEP-CAS); SHCHEGOLEV , O. B. (Institute for Nuclear Research of Russian Academy of Sciences); SHI, Cong (Hebei Normal University); STENKIN, Yu. V. (Institute for Nuclear Research of Russian Academy of Sciences); XIAO, Di-Xuan (Tibet University); YANG, Fan (Hebei Normal University); YIN, Li-Qiao (Institute of High Energy Physics, Chinese Academy of Sciences); ZHANG, Liang-Wei (Hebei Normal University)

Presenter: MA, Xin-hua (IHEP-CAS)

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **14** Type: **Original**

Investigating thunderstorm activity in Moscow region via the method of muonography

Thursday, 10 June 2021 11:05 (15 minutes)

Thunderstorms, being one of the dangerous atmospheric phenomena, are studied by means of various methods. Measurements of the muon flux variations using muon hodoscopes offer a tool for detection, study and possible prediction of the thunderstorm activity.

The URAGAN muon hodoscope (MH), located in Moscow, Russia, allows simultaneous detection of muons from all directions of the upper hemisphere. Using its data, muon imaging (muonography) method can be applied to visualize disturbed areas of the atmosphere, and the muon counting rate and muon flux anisotropy can be acquired. Using these characteristics, 235 thunderstorm event candidates were identified during the spring and summer periods of 2014 – 2020. 211 (90 %) of the event candidates were accompanied by a thunderstorm cell detection via an independent method within a ± 6-hour interval.

By comparing muon snapshots (muonographs) and meteorological maps obtained by the Doppler weather radar DMRL-C it was shown that disturbed areas with decreased muon counting rate correspond to the regions of thunderstorm activity. It was established that the thunderstorm events detected using muon hodoscope URAGAN data are mainly associated with thunderstorm cells that occurred in the time interval of ± 2.5 hours from the event.

Primary author: KACHUR, Alexandra (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Co-authors: BARBASHINA, Natalia (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); PETRUKHIN, Anatoly (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); PAVLYUKOV, Yuri (Federal State Budget Institution "Central Aerological Observatory"); SEREBRYANNIK, Natalya (Federal State Budget Institution "Central Aerological Observatory"); SHUTENKO, Victor (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Presenter: KACHUR, Alexandra (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **15** Type: **Overview**

Muonography method and the prospects of its further development

Thursday, 10 June 2021 10:00 (25 minutes)

Muonography is an analog of other concepts as x-ray graphy, electronography, neutronography etc. based on the registration of penetrating radiation, the interaction of which with investigated objects causes some changes in the initial flux of used particles. Unlike all other particles, the fluxes of which are formed artificially, muons are of natural origin, because they are formed as a result of the interactions of primary cosmic rays with the nuclei of atoms in the atmosphere. Since muons with a good accuracy preserve the direction of motion of primary particles, this opens up the possibility of studying by means of the muon flux of perturbations in the heliosphere and magnetosphere of the Earth, the perturbations in which lead to variations in the flux of primary cosmic rays. Disturbances in the atmosphere directly affect the muon flux. The report considers examples of the use of muonography for the study of various processes and phenomena in the heliosphere, magnetosphere and atmosphere, as well as some results of the search for predictors of dangerous disturbances in these three regions. As a part of the further development of muonography, the expediency of creating a network of muon hodoscopes in the Russian Federation is considered to solve the problem of early detection of dangerous processes and phenomena over its territory.

Primary author: Dr BARBASHINA, Natalia (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Co-authors: PETRUKHIN, Anatoly (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); Dr SHUTENKO, Victor (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Presenter: Dr BARBASHINA, Natalia (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **16** Type: **Overview**

Studies of heliospheric modulation of cosmic rays at ShICRA SB RAS and prospects of their further development

Wednesday, 9 June 2021 14:40 (25 minutes)

The ShICRA SB RAS has been conducting theoretical and experimental studies of cosmic rays and their modulation in the heliosphere for over 60 years. The results of experimental studies of variations in the cosmic ray intensity include the creation of original methods for the primary processing of the registration data of neutron monitors and muon telescopes, in particular, the methods of crossed telescopes, receiving vectors, and global survey, which are currently used to solve various fundamental and applied problems. In 1964, an analysis of the data obtained at the Yakutsk spectrograph was used to explain the nature of the observed daily variation in the cosmic ray intensity. A significant contribution to the theoretical study of cosmic rays was the discovery of the regular (diffusion) acceleration mechanism in 1977. Based on this mechanism, a theory of cosmic ray acceleration in the solar corona in linear and quasilinear versions was developed, the observation of storm particles at the interplanetary shock fronts was explained, and the acceleration at the Earth's bow shock was described. Thus, this mechanism explains the origin of cosmic rays in the heliosphere in a wide energy range from 10^3 to 10^10 eV. Using the global survey method to predict geomagnetic storms in real-time, the Institute maintains continuous ground-based monitoring of cosmic rays. We study the tensor anisotropy of cosmic rays, the north-south asymmetry of the heliosphere, and the behavior of the energy spectrum of cosmic ray decrease in large-scale disturbances of the solar wind. A great achievement was creating a basic model of heliospheric modulation of cosmic rays, which correctly describes the 11-year variations in the intensity of cosmic rays with energies from tens of MeV to tens of GeV observed in various experiments.

In recent years, we study cosmic ray decrease in magnetic clouds. A new mechanism for the Forbush decrease formation in magnetic clouds is proposed. The Forbush decrease occurs due to energy losses of particles in the inductive electric field of a moving cloud and their quasi-trapping in the helical magnetic field. There are no free parameters in this theory; the calculation results agree with observations.

The registration of cosmic rays will be continued on the new Yakutsk spectrograph. The analysis of its data will allow us to determine the cosmic ray anisotropy parameters, isolate the effects of the east-west asymmetry, and study the energy spectra of Forbush decreases in detail ground-level enhancements of solar cosmic rays. In future theoretical studies, it is planned to consider several topical issues of space physics, in particular, the injection of solar cosmic rays into the interplanetary space; their composition; self-consistent acceleration of charged particles, and generation of MHD turbulence in flare processes; the effect of coronal mass ejections on the space-time distribution of solar and galactic cosmic rays. As a result, this will help to understand the physical processes in the heliosphere better and, therefore, more accurately predict the space weather in the vicinity of the Earth.

Primary authors: Mr GOLOLOBOV, Petr (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS); Dr STARODUBTSEV, Sergey (Yu.G. Shafer Institute of Cosmophysical Research

and Aeronomy SB RAS); Prof. KRYMSKY, Germogen (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS); Dr PETUKHOV, Stanislav (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS); Dr GRIGORYEV, Vladislav (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS); Dr PETUKHOV, Ivan (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS); Mrs PETUKHOVA, Anastasiya (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS); Dr GERASIMOVA, Sardaana (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS); Dr TANEEV, Sergey (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS); Dr KOZLOV, Valeriy (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS); Mr ZVEREV, Anton (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS)

Presenter: Mr GOLOLOBOV, Petr (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB RAS)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **17** Type: **Original**

Machine learning techniques applications for the ENDA experiment data analysis

Tuesday, 8 June 2021 13:25 (15 minutes)

Using of machine learning (ML) and deep learning (DL) techniques in data analysis becomes a mainstream today and is presented in papers of leading experiments. These modern methods allow sometimes to increase the accuracy of for example mass composition reconstruction significantly. In current work ML and DL are applied for core location, zenith angle estimation, primary energy and mass reconstruction based on data of ENDA experiment and corresponding CORSIKA + GEANT4 Monte-Carlo simulations. ENDA (Electron Neutron Detector Array) is an extensive air shower (EAS) experiment based on idea of simultaneous recording of electromagnetic component of EAS and thermal neutrons produced by the hadron component of the shower. Results of the analysis are presented.

Primary author: SHCHEGOLEV, Oleg (INR RAS)

Co-authors: Mr STEPANOV, V. I. (INR RAS); LEVOCHKIN, K. R. (Institute for Nuclear Research of Russian Academy of Sciences); KULESHOV, D. A. (Institute for Nuclear Research of Russian Academy of Sciences); STENKIN, Yu. V. (Institute for Nuclear Research of Russian Academy of Sciences); MA, Xinhua (IHEP-CAS); Mr LI, B B

Presenter: SHCHEGOLEV, Oleg (INR RAS)

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **18** Type: **Overview**

Review of investigations of muon bundles generated by very-high energy cosmic rays

Tuesday, 8 June 2021 12:45 (25 minutes)

Autumn 2018, the working group WHISP had compiled the results of various experiments in which cosmic ray muon bundles were registered. In some experiments, an excess of the number of muons is observed in comparison with Monte-Carlo simulations with different hadronic interaction models at energies of primary nuclei above 10 PeV. However, not all experiments showed an excess. We present a review of methods for detecting muon bundles by various installations which data were investigated by WHISP group.

Primary author: VOROBEV, Vladislav (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Co-author: PETRUKHIN, Anatoly (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Presenter: VOROBEV, Vladislav (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **19** Type: **Overview**

Diagnostics of electromagnetic conditions in the heliosphere on effects in cosmic rays

Tuesday, 8 June 2021 17:00 (25 minutes)

A review is given of some results of diagnostics of the electromagnetic characteristics of the heliosphere and Earth's magnetosphere within the framework of the model of modulation of cosmic rays by large-scale electromagnetic fields of the heliosphere, obtained by the method of spectrographic global survey from ground-based observations of cosmic rays on the world network of stations.

Primary authors: SDOBNOV, Valeriy; Dr KRAVTSOVA, Marina (Federal State Budgetary Institution of Science Institute of Solar-Terrestrial Physics, Siberian Branch of the Russian Academy of Sciences, Irkutsk)

Presenter: SDOBNOV, Valeriy

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **20** Type: **Original**

On the very local interstellar spectra for galactic Helium-isotopes, deuteron, positrons and antiprotons

Wednesday, 9 June 2021 15:35 (15 minutes)

The very local interstellar spectra (vLIS) for protons and total Helium (He), amongst other galactic cosmic rays (GCRs), were observed in situ by Voyager 1 below about 340 MeV/nuc since it had moved across the heliopause (HP). The latter is considered to be the boundary where the solar modulation (GCRs) commences. Together with high precision PAMELA and AMS observations above 50 GeV at the Earth, we reported previously on new vLIS calculated for protons, total He, other heavier isotopes and also for electrons from 1 MeV to 100 GeV. We now follow up on this procedure to report on the vLIS detached for the isotopes He-4, He-3, and H-2. Combining computations done with the galactic propagation code, GALPROP, and our 3D modulation model for GCRs in the heliosphere, we have computed also vLIS's for positrons and anti-protons. This is done assuming that the essential modulation processes between the HP and the Earth for protons, electrons, He-isotopes, H-2, positrons and anti-protons are essentially similar, except for particle drifts of oppositely charged particles. These new vLIS's will be shown, discussed and evaluated within the context of the total modulation of these GCR particles in the heliosphere over a full solar activity cycle.

Primary author: Prof. POTGIETER, Marius S (IEAP, CA University in Kiel)

Co-authors: Dr BISSCHOFF, Driaan (North-West University, South Africa); Dr ASLAM, OPM (North-West University, South Africa); Dr NGOBENI, Donald (North-West University, South Africa); Dr MIKHAILOV, Vladimir (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); Dr BOEZIO, Mirko (INFN, Trieste); Dr RICCARDO, Munini (INFN, Trieste)

Presenter: Prof. POTGIETER, Marius S (IEAP, CA University in Kiel)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **21** Type: **Original**

Muon tomography of large-scale objects

Thursday, 10 June 2021 10:50 (15 minutes)

Cosmic ray muons arriving from the upper hemisphere to the Earth's surface, are currently used to develop methods of muonography (analogous to radiography) of the internal structure of large-scale objects and relief, such as volcanoes, blast furnaces, nuclear reactors, etc. The article discusses various aspects, methods and specific examples of penetrating muonography, in particular, as applied to the study of the structure o nuclear reactors.

Primary authors: YASHIN, Igor (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); Mr DOVGOPOLYY, Alexandr (National Research Institute for Nuclear Power Plant Operation); Dr FAKHRUTDINOV , Rinat (NRC «Kurchatov Institute» - IHEP, Protvino); Dr KAVERZNEV, Mikhail (National Research Institute for Nuclear Power Plant Operation, Moscow); Dr KOMPANIETS, Konstantine (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); Mr KONEV, Yury (National Research Institute for Nuclear Power Plant Operation, Moscow); Dr KOZHIN, Boris (NRC «Kurchatov Institute» - IHEP, Protvino); Mr PASYUK, Nikita (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); Mr TZELINENKO, Maxim (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); Prof. YUSCHENKO, Oleg (NRC «Kurchatov Institute» - IHEP, Protvino); Dr ZOLOTAREVA, Oksana (National Research Institute for Nuclear Power Plant Operation, Moscow)

Presenter: YASHIN, Igor (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **22** Type: **Overview**

Multi-component study of extensive air showers at the Tien Shan mountain station of LPI and peculiarities of the particles flux behavior in the central region of the (1-100) PeV EAS

Tuesday, 8 June 2021 10:40 (25 minutes)

New experimental complex of the Tien Shan mountain cosmic ray station incorporates a set of detector subsystems for simultaneous investigation of different components of extensive air showers (EAS) which arise from interaction of the (1-100) PeV cosmic ray particles in atmosphere. Thus, a wide-spread system of the charged particles detectors is used for the measurement of local density of EAS electrons and for estimation by its spatial distribution of the main EAS parameters, while a set of radio-antennas provides an alternative way for investigation of the EAS charged component. The ionization-neutron calorimeter and the neutron monitor give information on EAS hadrons with the energy above 0.1 TeV, while the low-threshold neutron and gamma detectors can be applied for registration of the prolonged flux of thermalized neutrons after EAS passage. The underground muon detector is used for detection of the muonic component of cosmic rays in an exclusively wide range of muon energies, starting from 5 GeV and up to tens and thousands of TeV, and with estimation possibility of the energy of muon. The multi-component technique practiced now at Tien Shan permits to study effectively those aspects of high energy cosmic ray interaction which were never considered in former experiments. In particular, it is possible now to register the flow of EAS particles just around the region of EAS core which opens a real opportunity to solve the long standing problem of the 3 PeV knee in the energy spectrum of cosmic ray particles. Some examples of physical results gained lately at the Tien Shan detector complex are presented here for performance illustration of the newly elaborated methods of EAS investigation.

Primary author: SHEPETOV, Alexander (LPI RAS)

Presenter: SHEPETOV, Alexander (LPI RAS)

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **23** Type: **Original**

Search for astrophysical nanosecond optical transients with TAIGA-HiSCORE array

Thursday, 10 June 2021 12:40 (15 minutes)

A wide-angle Cerenkov array TAIGA-HiSCORE (FOV ˜0.6 ster), was originally created as a part of TAIGA installation for high -energy gamma-ray astronomy and cosmic ray physics. Array now consist on nearly 100 optical stations on the area of 1 km^2. Due to high accuracy and stability (˜1 ns) of time synchronization of the optical stations the accuracy of EAS arrival direction reconstruction is reached 0.1°. It was proven that the array can also be used to search for nanosecond astrophysical transients of the optical range. The report discusses the method of searching for astrophysical transients using the HiSCORE array and demonstrates its performance on a real example of detecting signals from an artificial Earth satellite. The search for optical transients in the HiSCORE data of the winter season 2018-2019 is carried out. One candidate for repeated transients has been detected, but the estimated probability of random simulation of such a transient by background EAS events is not less than 10%, which does not allow us to say that the detected candidate corresponds to a real astrophysical transient. An upper bound on the event frequency of optical transients with an optical quantum flux density of more than 1.5×10^{-4} erg/sec/cm^2 and a duration of more than 5 ns is established as $\sim\ 2 \times 10^{-3}$ events/sr/hour.

Primary author: PANOV, Alexander (SINP MSU)

Presenter: PANOV, Alexander (SINP MSU)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **24** Type: **Overview**

Geophysical aspect of the cosmic ray studies at the Tien Shan mountain station: monitoring of radiation background, investigation of atmospheric electricity phenomena in thunderclouds and the search for earthquake precursor effects.

Tuesday, 8 June 2021 15:45 (25 minutes)

The detector complex of the Tien Shan mountain station provides a mean for studies in the different ranges of experimental geophysics. The particles detectors of the station can be used for monitoring of the various types of radiation background. The system of high- altitude detectors permit to register the flow of particles accelerated by atmospheric electric field in thunderclouds, while combination of diverse radiation receivers can be used for detection of lightning emission simultaneously in different frequency ranges of electromagnetic spectrum. For effectiveness illustration of the Tien Shan experimental complex Thunderstorm a sample of unique data is presented here which were obtained in vicinity to the region of lightning development in thunderclouds, such as the temporal distributions and energy spectra of accelerated up to (1-100) MeV electrons, of the (30-3000) MeV gamma rays, of the optic and radio emission bursts. Another direction of geophysical studies at Tien Shan anticipates using of the neutron, muon, gamma, and electromagnetic detectors for investigation of the various effects of seismic origin, and for search for supposed correlation between such signals and interaction of the cosmic ray particles with the matter of the earth's crust. Perspectives of such investigation are discussed here for the seismological forecast problem and earthquake prediction in the surrounding region of the Tien Shan station.

Primary author: RYABOV, Vladimir (LPI RAS)

Presenter: RYABOV, Vladimir (LPI RAS)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **25** Type: **Original**

Application of digital processing of muonogram time series to the analysis of extreme events in the heliosphere

Thursday, 10 June 2021 11:20 (15 minutes)

Extreme events in the heliosphere that lead to anomalous muon flux variations, registered by the URAGAN muon hodoscope (MH), developed by MEPhI, are analyzed. MH measures two-dimensional muon flux intensity distribution functions (MFIDF) for a system of solid angles with a predefined sampling step, that are concatenated into matrix data time series of muonograms – the MFIDF outpur data from the MH. It can be assumed that the corresponding input MFIDF time series fall on the MH detectors. Assuming the MH linearity, input and output MFIDF are related by the hardware function (HF).
Occurrence of extreme events leads to occurrence of spatial and temporal MFIDF anomalousness in muonograms. Here, the task of development of the necessary mathematical tools for solving the problems of the mentioned extreme events is formulated, based on digital processing of muonogram time series.
The methods and algorithms propose here are divided into two categories. The first (supplementary) category includes one- and two-dimensional filtering algorithms for reducing temporal and spatial noises in muonograms, including elimination of daily variations, and the HF estimation algorithms. The second (main) category comprises the variants of anomalousness - local anisotropy (LA) - recognition methods for input MFIDF based on time series of muonograms.
To reduce noises in muonograms, the algorithms have been developed for one-dimensional sequential and parallel temporal and two-dimensional spatial filtering. A method has been developed for estimating the normalized HF for MH based on multiparameter models. The method has been tested on model and experimental muonograms.
A method has been proposed for LA analysis by estimating normalized variations (1) of input MFIDF with respect to normalized HFs, using spatial-temporal filtering. The method has been tested on model and experimental muonograms.
A method has been proposed for LA analysis by estimating normalized variations (2) of input MFIDF with respect to averaged output MFIDF, using spatial-temporal filtering. The method has been tested on model and experimental muonograms.
A method has been proposed for LA analysis in muonograms, based on calculation of confidence intervals systems for estimates of mathematical expectations of muonograms on reference and current confidence intervals. An algorithm is designed for LA analysis (recognition), based on decision making procedures. The algorithm has been tested on model and experimental muonograms.
The proposed digital processing is a mathematical toolkit, the effectiveness of which for the analysis of extreme events in the heliosphere has been confirmed by testing.
This work was funded by the Russian Science Foundation (project No. 17-17-01215).

Primary authors: GETMANOV, Viktor (The Geophysical Center of the RAS); Prof. GVISHIANI, Alexei (Geophysical Center of the Russian Academy of Sciences (GC RAS)); Dr DOBROVOLSKY, Michael; SIDOROV, Roman (Geophysical Center of the Russian Academy of Sciences); Dr SOLOVIEV,

Anatoly (Geophysical Center of the Russian Academy of Sciences); CHINKIN, Vladislav (The Geophysical Center of the RAS); Dr DMITRIEVA, Anna (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); KOVYLYAEVA, Anna (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); YASHIN, Igor (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Presenter: GETMANOV, Viktor (The Geophysical Center of the RAS)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **26** Type: **Overview**

Large scale modulation: view from the earth points

Tuesday, 8 June 2021 15:20 (25 minutes)

he current knowledge and ideas, obtained from groundlevel observations and concerning the solar modulation of cosmic rays, are reviewed. The following topics are discussed:
observations of the cosmic ray modulation at the Earth and main characteristics of the accumulated experimental data; manifestations of the solar magnetic cycle in cosmic rays; the effect of hysteresis and its relation to size of the heliosphere; the rigidity spectrum of long-term cosmic ray variations and its comparison with direct measurements on spacecraft; calibration of ground-based monitoring data using direct measurements on spacecraft in comparable energy ranges; the place of ground level observations in current studies of cosmic ray modulation and their future prospects.
Particular consideration is given to the correlation of long-term cosmic ray variations with different solar-heliospheric parameters, and to empirical models of cosmic ray modulation.

Primary author: YANKE, Victor (IZMIRAN)

Co-authors: Dr BELOV, Anatoly (IZMIRAN); Dr OLENEVA, Victoriya (IZMIRAN); Dr GUSHCHINA, Raya (IZMIRAN)

Presenter: YANKE, Victor (IZMIRAN)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **28** Type: **Overview**

Solar energetic particles and trapped radiation in the near-Earth's Space: space experiments and modelling

Tuesday, 8 June 2021 16:10 (25 minutes)

Among the factors of space weather, one of the most dangerous phenomena is radiation. Radiation in space exists due to the presence of charged particles of different nature and creates problems for the "vitality" of not only the spacecraft, but also of humans. The main radiation threats are solar and galactic cosmic rays, fluxes of precipitating magnetospheric particles and trapped particles of the Earth's radiation belts. Solar and geomagnetic activity, which determine space weather, can cause drastic changes in physical conditions in geospace, which affect technological systems located both in space and in polar regions on the surface of the Earth. To prevent emergencies associated with cosmic factors, it is necessary to constantly monitor the solar activity and the state of the space environment.
Experimental studies and operational monitoring of trapped radiation and cosmic rays have been conducted by MSU' Institute of Nuclear Physics since the beginning of the space age. The Institute has accumulated extensive experience in creating instrumentation for measuring ionizing radiation from spacecraft. On the basis of the experiments carried out, modern models of the space environment have been created, on the basis of which several national and international standards have been developed. Satellite measurement data and models of the space environment are the basis for continuous monitoring of radiation conditions in space. Space Monitoring Data Center has been established at SINP MSU for analysis and forecasting of the space environment radiation state.

Primary author: KALEGAEV, Vladimir (SINP MSU)

Presenter: KALEGAEV, Vladimir (SINP MSU)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **31** Type: **Original**

Non-classical diffusion of the cosmic rays in the Galaxy: Energy spectra of primary nuclei

Wednesday, 9 June 2021 11:05 (15 minutes)

In the last decade, measurements of the cosmic ray (CR) nuclei in the GV–TV rigidity region by new-generation balloon-borne and satellite instruments allowed to establish new features in CR spectra. It was found that both spectra of most abundant primary CR nuclei and the secondary cosmic rays at rigidity $R > 100$—200 GV exhibit a hardening with increasing rigidity. Thus they deviate from a single power law.

These newly discovered features are not easy to explain under standard scenario of cosmic ray origin, acceleration and propagation in the Galaxy. Under the standard theory, the primary nuclei are thought to be produced, up to at least several PV, by supernova remnant shock waves by diffusive shock acceleration mechanism that predicts power-law spectra $J \propto R^{-\gamma}$ with slope γ 2.0—2.2. The subsequent CR transport in the turbulent Galactic magnetic fields is modeled as a diffusion process in quasi-homogeneous medium with the diffusion coefficient $D(R) = D_0(R/1$ GV$)^{\delta}$, with $\delta \approx (0.3$—$0.8)$. Under these assumptions, the spectrum of primary nucleus i generated by the global-scale steady state distribution of sources $S(r, R)$ is described by a single power law with index $\eta = \gamma + \delta$, which is clearly at odds with the observed hardening of CR hadrons at GV–TV region.

However, theory and observations show that the ISM is inhomogeneous (fractal-like) at the scale of hundreds of parsecs. Stars formation regions also demonstrate fractal features with spatial scales up to about a kpc. Since the particles emitted by Galactic sources en route to the Solar system pass through regions of the Galaxy that have different properties, in such a inhomogeneous ISM, the normal diffusion model is certainly not kept valid.

The non-homogeneous character of matter distribution and associated spatially intermittent magnetic field leads to the need to incorporate these ISM features into the cosmic ray diffusion model. A possible way to generalize the normal diffusion model is to replace the assumption about statistical homogeneity of inhomogeneities distribution by their fractal distribution. Non-classical diffusion is manifested, in particular, by abnormally large free paths of particles (so-called "Lévy flights") and a long stay of particles in inhomogeneities, leading to a presence of the so-called "Lévy traps".

In the current study, we demonstrate that non-classical diffusion model of the cosmic rays in the inhomogeneous Galaxy, developed by the authors, allows to describe the main features of nuclei spectra observed in the Solar system. Particularly, in this model the key feature of the all particle energy spectrum — the knee at $3{\cdot}10^{15}$ eV — appears naturally without additional assumptions. The observed changes in the slope of energy spectra of primary nuclei at rigidity $R > 100$—200 GV caused by the transition from the contribution of multiple distant Galactic sources to the contribution of mainly local ones.

Primary authors: LAGUTIN, Anatoly (Altai State University); VOLKOV, Nikolay (Altai State University)

Presenter: LAGUTIN, Anatoly (Altai State University)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **32** Type: **Original**

Orbital High Energy Cosmic Rays Observatory - stages of development

Thursday, 10 June 2021 16:40 (15 minutes)

Current status and preliminary design of the High-Energy Ray Observatory (HERO) are presented. The HERO is planned to be launched onboard a heavy satellite. This experiment is based on the application of a deep and wide aperture ionization calorimeter with mass from 10 to 70 tonns. The effective geometrical factor of the observatory varies from 12 to 62 m2sr respectively, depending on the mass of the calorimeter. Under the 5-7 years exposure, this mission will allow to measure the cosmic ray composition and energy spectra of nuclei around the knee and up to 10ˆ17 eV with high precision and to solve the most actual problems of high energy astrophysics. Stages of development are presented; details of technical realization are discussed.

Primary author: PODOROZHNY, Dmitry (M.V.Lomonosov Moscow State University, Skobeltsyn Institute of Nuclear PhysicsM.V.Lomonosov Moscow State University, Skobeltsyn Institute of Nuclear Physics)

Co-authors: Dr PANOV, Alexander (SINP MSU); Mr KURGANOV, Alexandr (SINP MSU); TURUNDAEVSKIY, Andrey (SINP MSU); Dr KARMANOV, Dmitry (SINP MSU); Dr TKACHEV, Leonid (Joint Institute for Nuclear Research)

Presenter: PODOROZHNY, Dmitry (M.V.Lomonosov Moscow State University, Skobeltsyn Institute of Nuclear PhysicsM.V.Lomonosov Moscow State University, Skobeltsyn Institute of Nuclear Physics)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **33** Type: **Overview**

Results form the DAMPE space mission

Thursday, 10 June 2021 15:25 (25 minutes)

The DArk Matter Particle Explorer (DAMPE) is a satellite-borne, calorimetric type, high-energy-resolution space cosmic ray and gamma-ray detector. It was launched in December 2015 and has been stably operated for more than five years. Precise measurements of the all-electron, proton and Helium spectra in wide energy ranges have been obtained, shedding new light on the research of cosmic ray physics and dark matter properties. We will present and discuss the above results together with the ongoing work on data analysis for heavier nuclei.

Primary author: DE MITRI, Ivan (Gran Sasso Science Institute (GSSI) and INFN-LNGS)

Presenter: DE MITRI, Ivan (Gran Sasso Science Institute (GSSI) and INFN-LNGS)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **34** Type: **Overview**

Temperature effect of muons in the atmosphere and diagnostics of the thermobaric regime of the atmosphere using cosmic rays

Thursday, 10 June 2021 11:35 (25 minutes)

Variations in the intensity of cosmic rays observed in the depth of the atmosphere include the atmospheric component of the variations. Muon telescopes of cosmic rays, along with the barometric effect, have a significant temperature effect due to the instability of the detected particles. These variations, caused by changes in atmospheric temperature, are superimposed on continuous observations of muon telescopes. Therefore, their exclusion is extremely necessary, especially in the data of modern muon telescopes, the statistical accuracy of which is very high. The contributions of different layers of the atmosphere to the total temperature effect for muons are not the same. This contribution is characterized by the distribution of the density of temperature coefficients for muons in the atmosphere. To correctly take into account the temperature effect in the data of muon telescopes, it is necessary to know the distribution of the density of temperature coefficients for muons in the atmosphere and data on the altitude profile of the atmospheric temperature. Temperature coefficients have been found by now using calculations that contain a number of assumptions and do not take into account many geometric and design features of telescopes. The availability of upper-air sounding data is limited. The estimation of the meteorological coefficients of the intensity of muons recorded in the depth of the atmosphere was carried out according to the data of long-term continuous observations using various methods of factor analysis: correlation-regression analysis and the method of principal components. The temperature component of variations in the intensity of muons was found using spectrographic analysis of data from a complex of observations of the nuclear-active, common ionizing and muon components of cosmic rays. The results obtained from the experimental data are compared with the results of theoretical calculations. Based on the data of the multichannel complex in Novosibirsk, which provides registration of the nuclear-active, common ionizing and muon components, temperature variations at various isobaric levels of the atmosphere over a long period have been found. The results obtained are compared with the data of aerological sounding. As a result, there is no need for aerological sounding data for muon telescopes. In the near future, it is planned to solve a similar problem for the Yakut cosmic ray spectrograph. Thus, cosmic ray stations with muon telescopes can also provide information on the temperature regime of the atmosphere.

Primary author: Dr YANCHUKOVSKY, Valery (IPGG SB RAS)

Co-author: KUZMENKO, Vasiliy

Presenter: KUZMENKO, Vasiliy

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **35** Type: **Overview**

Prospects of “muon puzzle” solution with the NEVOD-DECOR-TREK complex

Tuesday, 8 June 2021 11:05 (25 minutes)

Muon puzzle is a growing with cosmic ray energy excess of muons in EAS in comparison with simulations performed using various models of hadron interactions and even assuming a heavy composition of cosmic rays. The main contribution to investigation of the energy dependence of the muon excess was done by NEVOD-DECOR experiment. To separate two possible reasons of muon excess appearance (cosmophysical or nuclear-physical ones), measurements of the energy deposit of muon bundles are required. Such experiment is conducted at the NEVOD-DECOR complex, and the first results evident in favor of the nuclear-physical reason. But both detectors NEVOD and DECOR have some drawbacks: non-symmetric arrangement of modules of PMTs in Cherenkov water detector NEVOD and small area (about 70 sq. m) and insufficient spatial accuracy of muon track measurements (˜ 1 cm) in coordinate-tracking detection DECOR. Nowadays, the complex is being complemented with a new coordinate detector TREK with area 250 sq.m based on multiwire drift chambers that will have spatial accuracy of 1 mm. In parallel, modernization of the Cherenkov water detector NEVOD will be fulfilled. NEVOD-DECOR-TREK complex will allow us investigate the muon component of inclined extensive air showers in a very wide energy region from 10ˆ14 to 10ˆ19 eV and to solve the muon puzzle by means of simultaneous measurements of the number of muons in DECOR-TREK system and their energy deposit in Cherenkov water calorimeter NEVOD.

Primary author: ZADEBA, Egor (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Co-authors: KOKOULIN, Rostislav (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); PETRUKHIN, Anatoly (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); Dr KHOKHLOV, Semyon (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)); YASHIN, Igor (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Presenter: ZADEBA, Egor (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **36** Type: **Original**

Particle acceleration and radiation processes in supernova remnants.

Wednesday, 9 June 2021 12:55 (15 minutes)

Diffusive shock acceleration and production of non-thermal emission in galactic supernova remnants is briefly reviewed. We describe gamma ray and X-ray observational features of young and old remnants. The corresponding discussion of Galactic cosmic ray origin is given.

Primary author: ZIRAKASHVILI, Vladimir (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation, Moscow, Russia)

Presenter: ZIRAKASHVILI, Vladimir (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation, Moscow, Russia)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **38** Type: **Original**

GAMMA-400 gamma-ray observations in GeV and TeV energy range

Thursday, 10 June 2021 12:55 (15 minutes)

Future space-based GAMMA-400 gamma-ray telescope will operate aboard Russian astrophysical observatory in the highly elliptic orbit during 7 years. Observing gamma-ray sources from Galactic plane, gamma-ray bursts, emission from diffuse gamma rays, the Sun, dark matter particles will be performed uninterruptedly for a long time (˜100 days) in point-source mode in contrast to scanning mode for Fermi-LAT and other space- and ground-based instruments. GAMMA-400 will measure gamma rays in the energy range from ˜20 MeV to several TeV, have the unprecedented angular (˜0.01° at Eγ = 100 GeV) and energy (˜2% at Eγ = 100 GeV) resolutions better than the Fermi-LAT, as well as ground gamma-ray telescopes, by a factor of 5-10, and perfectly separate gamma rays from cosmic-ray background.

Primary author: Dr TOPCHIEV, Nikolay (LPI RAS)

Co-author: Prof. GALPER, Arkady (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Presenter: Dr TOPCHIEV, Nikolay (LPI RAS)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **40** Type: **Overview**

Cosmic ray study at the Astrophysical Complex TAIGA: results and plans

Wednesday, 9 June 2021 10:00 (25 minutes)

TAIGA (Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy) Astrophysical complex is being developed for studies of gamma rays and charged cosmic rays in the energy range of 10^13 - 10^18 eV. The complex is located in the Tunka Valley, about 50 km from Lake Baikal. In this report we present the experiment status and plans for study of high-energy cosmic-ray physics as well as main results reached by wide-angle TAIGA-HiSCORE and Tunka-133 Cherenkov arrays of the Astrophysical complex. Plans to study cosmic rays with other arrays of the complex namely scintillation array Tunka-Grande and new TAIGA-muons array and system of IACT telescopes are discussed too.

Primary author: Dr KUZMICHEV, Leonid (SINP MSU)

Presenter: Dr KUZMICHEV, Leonid (SINP MSU)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **41** Type: **Original**

Atmospheric effects of electron and muon components of cosmic rays: Sensitivity theory approach and data of operational satellite monitoring

Wednesday, 9 June 2021 15:20 (15 minutes)

The results of a complex approach to the study of sensitivity of spatial distributions of electron and muon components of extensive air showers (EAS), measured by scintillation detectors, to variations in the temperature profile of the atmosphere are presented.
To describe the lateral dependence of the spatial distribution function of electrons in electron-photon cascades, the method of the adjoint equations and also the variational theory of sensitivity developed by the authors were used. Spatial distributions of electron and muon components of EAS, as well as the corresponding differential temperature coefficients, were simulated by the Monte Carlo method.
To assess the effect of variations in the temperature profile of the atmosphere on the lateral distribution of particles measured by scintillation detectors, satellite monitoring of main parameters of the system “atmosphere - underlying surface” was carried out in zones of Yakutsk complex EAS array and TAIGA observatory.
As a result of the studies, coefficients of differential sensitivity of the spatial distribution of electron and muon EAS components to variations in the temperature profile of the atmosphere were obtained for the first time. Corrective functions that relate the energy release in scintillation detectors of various thicknesses with the particles density above the detector at various distances from the shower axis were established.
Based on the obtained data, a method for correcting the EAS detectors readings in view of the temperature effect has been developed. It is shown that changes in the lateral distribution function of the EAS electromagnetic component due to variations in the atmospheric temperature profile in one annual cycle of operation can exceed 10%.

Primary authors: LAGUTIN, Anatoly (Altai State University); GONCHAROV, Alexander (Altai State University); RAIKIN, Roman (Altai State Univesrity); REVIAKIN, Artemy (Altai State University); VOLKOV, Nikolay (Altai State University)

Presenter: VOLKOV, Nikolay (Altai State University)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **42** Type: **Overview**

Muonography of large natural and industrial objects

Thursday, 10 June 2021 10:25 (25 minutes)

The fundamentals of the muonography method are presented, and an overview of the main major experiments is presented. The results of modern muonographic studies in Russia, carried out on the basis of this method with the use of emulsion track detectors, are presented.

Primary author: POLUKHINA, Natalia (LPI RAS)

Co-authors: ALEXANDROV, A.B.; GALKIN, V.I.; GRACHEV, V.M.; GONCHAROVA, L.A.; VASINA, S.G.; KONOVALOVA, N.S.; MANAGADZE, A.K.; OKATIEVA, N.M.; ROGANOVA, T.M.; SADYKOV, Zh.T.; STARKOV, N.I.; STARKOVA, E. N.; TYUKOV, V. E.; CHERNYAVSKY, M.M.; SHCHEDRINA, T.V.

Presenters: POLUKHINA, Natalia (LPI RAS); SADYKOV, Zh.T.

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **44** Type: **Overview**

Investigation of anomalous effects in cosmic rays.

Tuesday, 8 June 2021 13:40 (25 minutes)

Abstract.
Studying the spectrum of secondary particles at the Large Hadron Collider (LHC) at energies equivalent to 1-100 PeV in the laboratory system, scaling behavior is observed. At the same energies, a number of effects are observed in cosmic rays (CR) that are incompatible with this behavior. In the spectrum of extensive atmospher showers (EAS), a break (knee) is observed at an energy of 3 PeV. According to the large ionization calorimeter at the Tien Shan, the absorption length of hadron showers increases in the same energy region. In the hybrid HADRON experiment, there is a scaling violation in the spectrum of secondary hadrons and an anomalous excess of muons in proton showers. According to the data of X-ray emulsion chambers , events with halos appear in the knee area and effect of alinement in energy centers of gamma-hadron events are observed.. Given the LHC data, these anomalies should be explained by astrophysical reasons, i.e. changes in the composition of cosmic rays.

Primary author: Prof. SHAULOV, Sergey (LPI RAS)

Presenter: Prof. SHAULOV, Sergey (LPI RAS)

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **45** Type: **Original**

The analysis of muon component of extensive air showers from the SUGAR data

Tuesday, 8 June 2021 11:55 (15 minutes)

The Sydney University Giant Air-shower Recorder (SUGAR) measured the muon component of extensive air showers from muon-detector readings. Data of SUGAR allows us to reconstruct the empirical dependence of muon density on the distance from the axis of the shower -lateral distribution function (LDF). We compare this function with the predictions of hadronic interaction model QGSJET-II-04 for proton and iron with primary energy 10**17 – 10**18.5 eV.

Primary authors: RUBTSOV, G.I. (Institute for Nuclear Research of the Russian Academy of Sciences); KARPIKOV, I. S. (Institute for Nuclear Research of the Russian Academy of Sciences); ULRICHS, J (School of Physics, University of Sydney); BELLIDO, J. A. (Physics Department, The University of Adelaide); KALMYKOV, N. N, (SINP MSU); CLAY, R. W. (Physics Department, The University of Adelaide); TROITSKY, S. V. (Institute for Nuclear Research of the Russian Academy of Sciences)

Presenter: KARPIKOV, I. S. (Institute for Nuclear Research of the Russian Academy of Sciences)

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **46** Type: **Original**

Hints at axion-like particles from TeV astrophysics

Thursday, 10 June 2021 13:10 (15 minutes)

Axion-like particles (ALPs) are a generic prediction of many extensions of the Standard Model. They are very light pseudo-scalar bosons which mainly couple to two photons. In the presence of an external field, photon-ALP oscillations take place. They play a leading role in very-high-energy (VHE) astrophysics. The aim of my talk is to report on two hints at ALPs. One comes from the fact that conventional physics prevents Flat Spectrum Radio Quasars (FSRQs) to emit above about 30 GeV — barring ad hoc proposals – because of the existence of the broad line region (BLR). But MAGIC has detected them up to 400 GeV. I show that photon-ALP oscillations in the jet magnetic field, inside standard emission models, allows VHE photons to overcome the BLR and be emitted with the observed SED. As a case study we have taken PKS 1222+2167. A second hint comes from the analysis of the largest sample of IBL and HBL BL Lacs out to z = 0.6. After EBL de-absorption, we have found that the best-fit to the emitted spectral indices is a parabola as a function of z, thereby implying that they are statistically correlated, a fact that looks mysterious. Putting ALPs into the game and redoing the same analysis, the above best-fit becomes a straight line with z = constant, Hence the previous correlation disappears, in agreement with physical intuition.

Primary authors: RONCADELLI, Marco (Italian Institute of Nuclear Physics INFN - Sezionne di Pavia – Italy); Dr TAVECCHIO , Fabrizio (Italian Institute of Astrophysics IASF - Milano (Italy)); Dr GALANTI, Giorgio (IASF -Italian Institute of Astrophysics INAF); Prof. DE ANGELIS, Alessandro (Physics Department, University of Padua)

Presenter: RONCADELLI, Marco (Italian Institute of Nuclear Physics INFN - Sezionne di Pavia – Italy)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **47** Type: **Original**

The Carpet-3 EAS array for investigation of gamma-radiation with energy E > 100TeV

Wednesday, 9 June 2021 12:40 (15 minutes)

Abstract. The Carpet-3 experiment for investigation of gamma-radiation with energy above 100 TeV is currently being prepared at the Baksan Neutrino Observatory of the Institute for Nuclear Research, Russian Academy of Sciences. At present the plastic scintillation counters with a total continuous area of 410 m2 are installed in the muon detector (MD) underground tunnel, and they are totally equipped with electronics. The counters' gains and thresholds have been adjusted. Fifteen modules of shower detectors are placed on the surface of the MD absorber. Ten of them contain 9 standard plastic counters with an area of 1 m2 each. Also 24 modules without counters are arranged on the territory of the array. These modules will accomplish a surface part of the Carpet-3 array. The preliminary estimates show that the new array will have the best sensitivity to the flux of primary gamma rays with energy in region 100TeV-1PeV.The increased area of the surface part of the array will allow one to have larger area of location of shower axes, thereby increasing the statistics of detected events and decreasing the energy threshold for primary cosmic radiation. The Carpet-3 experiment will start at the end of 2021.

Primary author: KUDZHAEV, Aleksander

Presenter: KUDZHAEV, Aleksander

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **48** Type: **Original**

Generation of cosmic rays of high energy

Thursday, 10 June 2021 16:55 (15 minutes)

Report will review and discuss possible mechanisms of generation of high and ultra high energy cosmic rays and gamma radiation.

Primary author: BELOTSKY, Konstantin (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Presenter: BELOTSKY, Konstantin (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **49** Type: **Overview**

Inelastic diffraction at CMS

Wednesday, 9 June 2021 16:25 (25 minutes)

CMS measurements of inelastic diffraction are reviewed. Agreement of newly obtained results on diffraction in pPb collisions in parallel with previously obtained results on diffraction in pp collisions with generators, in particularly with cosmis ray generators, is discussed.

Primary author: KHEYN, Lev (SINP MSU)

Presenter: KHEYN, Lev (SINP MSU)

Session Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Track Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Contribution ID: **50** Type: **Overview**

The TAIGA Experiment Status and Results

Thursday, 10 June 2021 12:15 (25 minutes)

TAIGA (Tunka Advanced Instrument for Gamma-ray and cosmic ray Astrophysics) aims at covering the TeV to PeV energy range, where the long-sought Pevatrons can be detected. To this end, TAIGA is implementing a hybrid detection technique for Extensive Air Showers (EAS) from the TeV to PeV energy range with good spectral resolution. Currently the hybrid TAIGA detector combines two wide angle shower front Cherenkov light sampling timing arrays (HiSCORE and Tunka-133), two ˜ 4m class, ˜10° aperture Imaging Air Cherenkov Telescopes (IACTs) and ˜ 240 m² surface and underground charged particle detector stations. Our goal is to introduce a new hybrid reconstruction technique, combining the good angular and shower core resolution of HiSCORE with the gamma-hadron separation power of the imaging telescopes. This approach allows to maximize the effective area and simultaneously to reach a good gamma-hadron separation at low energies (few TeV). At higher energies, muon detectors are planned to enhance gamma-hadron separation. During the commissioning phase of the first and second IACT, several sources were observed. First detections of known sources with the first telescope show the functionality of the TAIGA IACTs. Here, the status of the TAIGA experiment will be presented, along with first results from the current configuration.

Primary authors: TLUCZYKONT, Martin; TAIGA COLLABORATION

Presenter: TLUCZYKONT, Martin

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **52** Type: **Overview**

Cosmic Ray Nuclei: Results from AMS-02

Thursday, 10 June 2021 15:50 (25 minutes)

AMS is a multi-purpose high energy particle detector designed to perform high precision direct cosmic ray measurements onboard of the International Space Station. AMS can measure and identify cosmic ray nuclei with unprecedented precision and, thanks to its large acceptance and the long exposure time, it is able to provide precision studies of cosmic ray nuclei in the GV-TV region. In 10 years of operation, AMS has collected more than 170 billion cosmic rays triggers. In this contribution, the precision measurement of primary and secondary cosmic rays fluxes from protons to Silicon (Z=14), and the primary Iron flux (Z=26), in the rigidity range from 2 GV up to 3 TV is presented. These measurements are based on the data collected by AMS from May 2011 to May 2018

Primary author: DONNINI, Federico (INFN Sez. Perugia)

Presenter: DONNINI, Federico (INFN Sez. Perugia)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **53** Type: **Original**

About cosmic ray sources in Galaxy

Wednesday, 9 June 2021 10:50 (15 minutes)

In the last two decades the new expeimental data on cosmic rays about energy spectra in a wide energy range up to 10ˆ13 eV, isotropy, ratio of positron flux to electron one, and others were obtained. These data came from balloons and mainly from satellites. It is difficult to understand and to explain these experimental data within a generally accepted framework of cosmic ray sources, namely, that supernova explosions are the main sources of cosmic rays in Galaxy.
We consider the question that with the high probability the active red dwarfs could be cosmic ray sources up to energy of 10ˆ14-10ˆ15 eV.

Primary author: Prof. STOZHKOV, Yuri (LPI RAS)

Co-author: Dr LOGACHEV, Valery (LPI RAS)

Presenter: Prof. STOZHKOV, Yuri (LPI RAS)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **54** Type: **Overview**

Investigation of cosmic ray modulation effects by the regular sounding of charged particle fluxes in the atmosphere and on the ground

Tuesday, 8 June 2021 14:55 (25 minutes)

For the period from 1957 to present time the results of observations of charged particle fluxes in the atmosphere of the northern and southern polar latitudes and the middle nothern one at the altitudes from the ground level up to 30-35 km are presented. The questions of the long-term modulation effecrts and its relationships with solar activity are discussed.
Cosmic rays are the main ionization source in the Earth's atmosphere. The role of charged particles in the atmospheric electrical phenomena is considered such as cloud and thundercloud formation, ligthning production and the role of charged particles in climate change. Some results of the international experiment CLOUD in CERN are given.

Primary author: STOZHKOV, Yuri (LPI RAS)

Co-author: MAKHMUTOV, Vladimir (LPI RAS)

Presenter: MAKHMUTOV, Vladimir (LPI RAS)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **55** Type: **Overview**

Recent ALICE results on antinuclei inelastic cross sections and the implications for antinuclei fluxes near Earth

Wednesday, 9 June 2021 16:00 (25 minutes)

The presence of antinuclei in cosmic rays remains one of the most intriguing questions of modern physics, with several ongoing or planned experiments looking for traces of antinuclei in space near Earth. An observation of antideuteron or antihelium nuclei in cosmic rays would most probably mean a breakthrough in searches for "new physics", as the antinuclei production from ordinary collisions between cosmic rays and interstellar medium is expected to be very low, especially in the low kinetic energy range. However, to correctly interpret future results, one needs to know as precisely as possible both the antinuclei production mechanism and their nuclear inelastic cross sections. The latter defines the probability that antinuclei produced in the Galaxy can reach the detectors near Earth. Unfortunately, these inelastic cross sections are known very poorly from the experiment, which hampers precise calculations of expected antinuclei fluxes.

The ALICE collaboration has recently performed several measurements of antideuteron and antihelium-3 inelastic cross sections, providing the first experimental information of this kind. The antideuteron inelastic cross sections have been measured for the first time in the low momentum range $0.3 < p < 4$ GeV/c using collisions at the LHC as a source of antideuterons and the material of ALICE experiment as a target. The method has been later extended to antihelium-3 nuclei in the momentum range of $0.85 < p < 10$ GeV/c. The results are compared to the parameterisations used in Geant4 toolkit, and in the case of antihelium-3 a much steeper rise of the inelastic cross section is observed at low momentum.

We show how the measurement of antinuclei inelastic cross section with ALICE provides one of the necessary constraints for the study of antinuclei in space. To this purpose, the impact of ALICE results on the antinuclei fluxes near Earth has been studied using a state-of-the-art propagation model implemented in GALPROP framework. The fluxes of antihelium-3 nuclei near Earth have been calculated for typical dark matter scenarios and for collisions of cosmic rays with the interstellar medium. We show that in the case of antihelium-3 stemming from dark matter one loses around half of the antinuclei due to annihilations in collisions with interstellar gas. As for the background antihelium-3 flux, this loss is strongly energy-dependent, ranging from 75% at low energies down to around 10% at high energies.

Primary author: VOROBYEV, Ivan

Presenter: VOROBYEV, Ivan

Session Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Track Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Contribution ID: **56** Type: **Original**

Searching for neutrino and ultra-high-energy gamma ray counterparts of gamma-ray bursts and neutrinos on the GCN/TAN

Thursday, 10 June 2021 13:25 (15 minutes)

The Baksan Neutrino Observatory setups are currently performing search for neutrino and ultra-high-energy gamma ray counterparts of gamma-ray bursts and neutrinos on the GCN/TAN. GCN/TAN (The Gamma-ray Coordinates Network, Transient Astronomy Network) is a system for distributing alerts from gamma-ray bursts, transients. Muon neutrinos and antineutrinos with energies above 1 GeV are registered with the Baksan Underground Scintillation Telescope. Ultra-high-energy gamma rays are registered with the «Carpet-2» setup. Registration of events and analysis of alerts occurs in real time. Alerts from Swift BAT, Fermi GBM, LAT, INTEGRAL, IceCube, HAWC are used. This work presents the description of the alert processing program and preliminary results.

Primary authors: UNATLOKOV, Islam (BNO INR RAS); PETKOV, Valery; DZAPAROVA, Irina; KOSTYUK, Mikhail; KOCHKAROV, Makhti; KURENYA, Alexander; NOVOSELTSEV, Yuri; NOVOSELTSEVA, Rita; STRIGANOV, Petr; YANIN, Alexei

Presenter: UNATLOKOV, Islam (BNO INR RAS)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **62** Type: **Overview**

The main results of the PAMELA space mission in cosmic ray measurements and its current status

Thursday, 10 June 2021 16:15 (25 minutes)

As of today, the PAMELA experiment is widely known amongst the researchers specializing is the physics of cosmic rays. Application of obtained scientific results ranges from hypothetical dark matter particles, to galactic objects and properties of interstellar medium, solar and solar-terrestrial physics, as well as physics of near-Earth space. Despite the end of the flight stage of the experiment in 2016, large amounts of unique data are still being processed and analyzed today. In this talk we present an overview of the already obtained results, discuss their impact on the cosmic ray physics and adjacent fields of study, and describe the status of the ongoing research, that still holds the importance to both the fundamental and applied physics. We also propose some in-development theoretical models, which are partly based on the obtained experimental results.

Primary author: MAYOROV, Andrey (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Presenter: MAYOROV, Andrey (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute))

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **65** Type: **Original**

QGSJET-III model: novel features

Wednesday, 9 June 2021 16:50 (15 minutes)

I discuss the physics content of the QGSJET-III model,paying a particular attention to the treatment of higher twist and color fluctuation effects. The consequences for the energy dependence of both interaction cross sections and particle production will be analyzed. Further, the implementation of the pion exchange mechanism will be described, concentrating on its relevance to the interpretation of the data of the LHCf experiment.

Primary author: Dr OSTAPCHENKO, Sergey (SINP MSU)

Presenter: Dr OSTAPCHENKO, Sergey (SINP MSU)

Session Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Track Classification: Nucleus-nucleus interactions at high energies (models and experiments)

Contribution ID: **66** Type: **Overview**

Recent Results of Cosmic Ray Measurements from the IceCube Neutrino Observatory

Thursday, 10 June 2021 17:10 (25 minutes)

The IceCube Neutrino Observatory is a cubic-kilometer Cherenkov detector in the deep ice at the geographic South Pole, accompanied by a surface detector array, IceTop. The dominant event yield in the deep ice detector consists of penetrating atmospheric muons with energies above several 100GeV, produced in extensive air showers. In addition, IceTop measures low-energy muons around 1 GeV at the surface and the electromagnetic signal of the air shower. This hybrid detector setup provides unique opportunities to study cosmic rays with unprecedented statistics in great detail.

We will present the latest results of comic ray measurements from the IceCube Neutrino Observatory, including the energy spectrum from 250 TeV up to the EeV range and the mass composition above 3 PeV. We will also report a measurement of the density of muons in the GeV range with IceTop and discuss its consistency with predictions from recent hadronic interaction models. Finally, we will present results of a combined measurement of the cosmic ray anisotropy using data from the IceCube and HAWC observatories.

Primary author: SOLDIN, Dennis (University of Delaware)

Presenter: SOLDIN, Dennis (University of Delaware)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **70** Type: **Original**

Status and Prospects of UHECRs Studying by Orbiting Telescopes

Wednesday, 9 June 2021 11:20 (15 minutes)

Despite the long-term operation of large ground installations, the problem of sources of ultra-high-energy cosmic rays (UHECRs) is still far from its solution. An important step towards solving the problem may be the use of a new technique for registering extensive air showers (EAS) in the atmosphere of Earth, namely measuring a fluorescent track from orbit. This observation method allows one to achieve a large exposure and to record events throughout the celestial sphere with one device.

A program for registering UHECRs from Earth's orbit is being implemented in a series of projects. The first of them, the TUS detector, was launched aboard the Lomonosov satellite in 2016. During the operation of the detector, the spatiotemporal structure of the UV glow of the atmosphere was studied, and information was obtained on transient flashes that trigger the detector. A number of UV tracks similar to those expected from EAS were recorded in the nocturnal atmosphere.

The next step should be a full-scale telescope with a larger optical system and a field of view, which allows recording dozens of events per year beyond the GZK cut-off. Such a project, named KLYPVE-EUSO is being developed by the JEM-EUSO collaboration for installation on board the International Space Station. Variants of the lens and mirror telescopes are considered.

During the preparation of the K-EUSO projecta number of pathfinders are being developed: balloon experiments EUSO-Balloon and EUSO-SPB1, fluorescence detector at the Telescope Array site. The UV Atmosphere (Mini-EUSO) experiment is operating onboard the Russian Segment of the ISS since October, 2019.

A more advanced experiment POEMMA (Probe of Extreme Multi-Messenger Astrophysics) is planned to be implemented after K-EUSO. It is aimed at detecting both UHECRs and high-energy (above 20 PeV) neutrinos. POEMMA is a system of two telescopes on separate spacecrafts that provide a stereoscopic image of the EAS track and registration of the direct Cherenkov radiation from ascending showers of energetic neutrinos. Currently EUSO-SPB2 project with Cherenkov and fluorescence cameras is in preparation for a launch in Spring 2023 in the path of K-EUSO and POEMMA missions. SINP MSU develops a digital data processing system for the flourescent telescope photodetecting modules.

Primary author: KLIMOV, Pavel (SINP MSU)

Presenter: KLIMOV, Pavel (SINP MSU)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **71** Type: **Overview**

The TRASGO Program. Current status and first results

Tuesday, 8 June 2021 16:35 (25 minutes)

Research in cosmic rays is of interest for many fields of science: from Astrophysics and Solar Physics to the forecasting of magnetic storms or vulcanology. For such purposes many detectors using different techniques have been designed and are operative all around the world. A common feature of most of the neutron and muon monitors used at the Earth's surface for the regular survey of the cosmic ray background is that they are constrained to the measurement of single particles. As a consequence they only provide integral fluxes above a given energy threshold.

TRASGO is the acronym of "TRAck reconStructinG bOx" and the name corresponds to a project aiming the development of a set of high granularity tracking cosmic ray detectors sensitive to bundles of either muons or electrons and even of making a rough calorimetry of electrons. These features do allow a single ground based detector to measure cosmic ray background fluxes above different energy thresholds and, making use of the response function, to survey the primary cosmic ray flux in different energy ranges.

Actually, two Trasgo detectors are operative: TRAGALDABAS, located in Santiago de Compostela and TRISTAN, located in a Spanish Base in Antarctica. Two new detectors are being built as a part of the STRATOS project and will be installed at a distance of about 100 km far from TRAGALDABAS.

In this talk we will review the main features of the Trasgo detectors and some tools that are being developed within the framework of the program. We will also present some results related with the muon/electron separation capability of TRAGALDABAS and two cosmic ray surveys at different geomagnetic latitudes performed by the TRISTAN detector between Vigo (Spain) and Punta Arenas (Chile) in 2018 and 2019.

Primary author: GARCIA-CASTRO, Damian (LABCAF - IGFAE / USC)

Co-authors: BLANCO, A. (LIP Coimbra); PAZOS, A. (IGFAE / USC); LOUREIRO, C. (U.Coimbra); CLEMENCIO, F. (U.Coimbra , U.Porto); Dr KORNAKOV, G. (Faculty of Physics, Warsaw University of Technology); Prof. ALVAREZ-POL, H. (IGFAE / USC); FLORES, J. (CITIUS); SARAIVA, J. (LIP Coimbra); XUNA, J. (LABCAF - IGFAE / USC); Prof. GARZON, J.A. (LABCAF - IGFAE / USC); Dr CUENCA-GARCIA, J.J. (Karlsruhe Institute of Technology); LOPES, L. (LIP Coimbra); AJOOR, M. (LABCAF - IGFAE / USC); CRUCES, M. (IGFAE / USC); Dr SECO, M. (IGFAE / USC); Dr CABANELAS, P. (IGFAE / USC); FONTE, P. (LIP Coimbra); KURTUKIAN, T. (CENBG Burdeaux); FONTENLA, Y. (LABCAF - IGFAE / USC)

Presenter: GARCIA-CASTRO, Damian (LABCAF - IGFAE / USC)

Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays

Contribution ID: **75** Type: **Overview**

Cosmic Rays and Supernova remnants: an observational challenge

Wednesday, 9 June 2021 13:10 (25 minutes)

Supernova remnants are established sources of gamma-ray emission, detected from space and from ground. To establish this source class as accelerators of the bulk of Galactic cosmic rays has nevertheless proven to be challenging. I will review the observational status of ground-based observations and discuss their implications.

Primary author: PUEHLHOFER, Gerd (University of Tuebingen)

Presenter: PUEHLHOFER, Gerd (University of Tuebingen)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **76** Type: **Original**

Implications of astrophysical neutrino detections for TeV-PeV gamma-rays

Thursday, 10 June 2021 13:55 (15 minutes)

Since its first detection by the IceCube Neutrino Observatory in 2013, the diffuse flux of astrophysical neutrinos has been confirmed in several channels with increasing significance and precision. With a decade of IceCube data, we have now gained a solid picture of the astrophysical neutrino flux from the TeV up to the PeV range. Another significant milestone was the announcement of the first source of astrophysical neutrinos - the gamma-ray bright Blazar TXS 0506+056 in 2018. Although the origin of a large fraction of the astrophysical neutrino flux remains unknown, it is expected that neutrinos and gamma rays are produced in close connection at nearly the same energies. In this talk, I review the current searches that connect astrophysical neutrinos to gamma rays from different source populations. Furthermore, I will cover physical and experimental challenges, as well as the role of current and future experiments.

Primary author: Dr GLAUCH, Theo (Technical University of Munich)

Presenter: Dr GLAUCH, Theo (Technical University of Munich)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays

Contribution ID: **77** Type: **Overview**

Update on the WHISP combined analysis of muon measurements from air shower experiments

Tuesday, 8 June 2021 12:25 (20 minutes)

I am presenting an update of the results from the Working group on Hadronic Interactions and Shower Physics (WHISP) on the meta-analysis of muon measurements. In this analysis, muon data from several experiments from a few PeV to tens of EeV were combined and studied in a unified framework. Above 10 PeV, we find a muon excess with respect to simulations for all hadronic interaction models considered. This excess is increasing with shower energy, and for the models EPOS-LHC and QGSJet-II.04 the slope of the increase is found to be significant with more than 8 sigma. In this talk we review the analysis and show an investigation of the influence of each experiment on the positive slope of the z-scale and its significance.

Primary author: DEMBINSKI, Hans (TU Dortmund University)

Presenter: DEMBINSKI, Hans (TU Dortmund University)

Session Classification: Multicomponent EAS investigations

Track Classification: Multicomponent EAS investigations

Contribution ID: **78** Type: **Overview**

Resent results from the Pierre Auger Collaboration

Wednesday, 9 June 2021 11:35 (25 minutes)

With increased statistics, the energy spectrum of cosmic rays reveals peculiar features at the highest energies that will be discussed in this contribution. In addition, knowing the composition of cosmic rays is important to be able to understand the data. Our composition measurement, as provided by the depth of the shower maximum and fluctuations of this depth can be compared to measurements of the muon content of air showers, revealing a discrepancy in those results. In this contribution both aspects will be discussed.

Primary author: BRETZ, Thomas (University of Aachen)

Presenter: BRETZ, Thomas (University of Aachen)

Session Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Track Classification: Energy spectrum and mass composition around and above the knee (direct and EAS measurements)

Contribution ID: **79** Type: **Original**

An overview of high-energy diffuse gamma-ray emission measured by Fermi LAT and H.E.S.S.

Wednesday, 9 June 2021 13:35 (15 minutes)

I will give a short overview of high energy diffuse gamma-ray emission measured by the Fermi LAT and H.E.S.S. experiments. The talk will consist of two parts. In the first part I will talk about the diffuse emission itself, what it can teach us about Galactic cosmic rays (CRs), the search for sources of PeV CRs, populations of faint Galactic and extragalactic sources. In the second part I will talk about the use of diffuse emission measurements in setting limits on new physics, such as dark matter annihilation and evaporation of primordial black holes.

Primary author: MALYSHEV, Dmitry (Erlangen Center for Astroparticle Physics)

Presenter: MALYSHEV, Dmitry (Erlangen Center for Astroparticle Physics)

Session Classification: TeV-PeV gamma rays

Track Classification: TeV-PeV gamma rays