ABSTRACTS OF THE 22ND EUROPEAN COSMIC RAY SYMPOSIUM

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PREFACE

European Cosmic Ray Symposium (ECRS) is a biennial forum where scientists from Europe and other parts of the world can gather and discuss the current problems and new findings in cosmic ray physics. Traditionally ECRS covers the whole spectrum of cosmic-ray related studies, from solar-terrestrial to ultra-high energy. The series of ECRS has been initiated in 1968 and since then takes place every two years, between biennial International Cosmic Ray Conferences. During its 42-year history ECRS has been hosted in several European countries: Czechoslovakia (Slovakia), France, Germany, Hungary, Italy, the Netherlands, Poland, Spain, Switzerland, UK, USSR (Russia), and in 2010 it takes place in Finland, the first time in a Nordic country.

The current ECRS is 22nd in the series and covers traditional topics related to cosmic rays, from terrestrial and solar/heliospheric effects to high-energy and ultra-high energy cosmic rays, from sophisticated models to precise beyond-imagination experiments, both ground-based and space-borne. During the Symposium we will learn about recent developments and new results, will exchange ideas and opinions, will meet new young members of the cosmic ray community and pay tribute to those who passed away.

The 22nd European Cosmic Ray Symposium (ECRS) is taking place in Turku, Finland, and is organized jointly by the three largest Finnish Universities of Helsinki, Turku and Oulu.

The ECRS-2010 organizers wish all of You a successful and productive Symposium and hope that You will enjoy your stay in the nice city of Turku!

Scientific and Local Organizing Committees

ACKNOWLEDGEMENTS

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Plenary lectures

DARK MATTER SIGNATURES IN COSMIC RAYS

L. Bergström,[1,2]

[1]The Oskar Klein Centre for Cosmoparticle Physics, Stockholm University
[2]Invited talk

Recently, several sets of new cosmic ray data have appeared containing features in the spectrum of gamma-rays, electrons and positrons, which by some researchers have been interpreted as signatures of dark matter decay or annihilations in the Galactic dark matter halo. So far, none of the effects have been without ambiguities, and alternative, less spectacular explanations have also been proposed as being plausible.

This talk will contain a very brief review of the status of dark matter in cosmology and particle physics, and a summary of the various observations. A few key future observations will be singled out as being particularly important for solving one of the most outstanding problems of contemporary physics – that of the nature of the dark matter.

Astrophysics with very and ultra-high energy gamma-rays

Alessandro De Angelis [1]

[1] INFN and INAF; University of Udine, Italy, and LIP/IST, Lisboa, Portugal.

High-energy photons are a powerful probe for astrophysics and for fundamental physics under extreme conditions. During the recent years, our knowledge of the most violent phenomena in the universe has impressively progressed thanks to the advent of new detectors for very-high-energy gamma rays (above 100 GeV). Observation of gamma-rays gives an exciting view of the high-energy universe; in particular ground-based detectors like the Cherenkov telescopes (H.E.S.S., MAGIC and VERITAS) recently discovered more than 80 new very-high-energy sources. This talk reviews the present status of very-high-energy gamma astrophysics, with emphasis on the recent results and on the experimental developments, keeping an eye on the future. The impact on fundamental physics and on cosmic-ray physics is emphasized.

SCIENTIFIC ACTIVITY OF ACADEMICIAN SERGEI VERNOV IN APATITY (KOLA PENINSULA) AND LENINGRAD DURING 1968–1982 YEARS

V. A. Dergachev

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Academician Sergei Vernov (1910–1982), an outstanding Russian space physicist was the first national scientist who initiated the program of cosmic ray and radiation studies on board of the first Soviet artificial satellites.

It was my great fortune to meet with Academician S.N.Vernov for the first time in the autumn of 1964 during the USSR national conference on cosmic rays in the town of Apatity, and then from 1968 to 1982 I took part in compiling the agenda and program for winter schools on space physics in Apatity (1968–1969) and scientific activity on space physics in Leningrad (1969–1982) in the organizing committees headed by Academician S. N. Vernov.

S. N. Vernov was the initiator of holding USSR national winter school in Apatity and Leningrad seminars on space physics. He was the chairman of Fifth and Sixth winter school in 1968 and 1969 and twelve Leningrad seminars. Beginning the first seminar in June 1969 up to the 12th, in February 1982, he took active part both at the stage of forming the program and at the holding of the seminar. And the topic of the next XIII-th Leningrad seminar was proposed by S. N. Vernov not far from his death. The meeting of the 19–21 November, 1982 was devoted to the problem of solar activity and solar cosmic rays.

S. N. Vernov started studying cosmic rays in 1931 when he entered post-graduate school. Back in those days there wasn't too much known about cosmic rays. In 1935 S. N. Vernov got his M.Sc. in "Studying cosmic rays in stratosphere using radio-probes" and PhD degree in 1939 with the work called "Wide cosmic rays effect in stratosphere and checking the cascade theory". In 1946 S. N. Vernov had stated a problem of studying the primary protons absorbtion and generating the second component, like an electron-photon one. 1950s were probably the most essential and active years for S. N. Vernov. The circle of his scientific interests in cosmic rays was very wide. In that years he suggested to perform the regular measurements of cosmic ray (CR) fluxes in the Earth's atmosphere by means of regular radio sound launching. Since then till the present time the regular measurements of charged particle fluxes in the atmosphere of polar and middle latitudes have been carried out.

For about 50 years of his scientific activity S. N. Vernov has created a huge scientific school. He was always a leader supporting the creative hard-working atmosphere.

ACADEMICIAN SERGEI NIKOLAEVICH VERNOV AND FOUNDATIONS AND DEVELOPMENT OF COSMIC RAY VARIATIONS RESEARCH IN USSR

L. I. Dorman[1,2]

[1]Israel Cosmic Ray & Space Weather Center, Tel Aviv University and Israel Space Agency, Israel
[2]Cosmic Ray Department, N.V. Pushkov IZMIRAN, Russian Ac. of Sci., Russia

On my long way in science (about 60 years) I was happy to met and cooperate with many brilliant scientists. One of them was Academician Sergei Nikolaevich Vernov. In 1949–1951 he together with Nikolai Vasil'evich Pushkov and Yurii Georgievich Shafer organized the first soviet net of cosmic ray stations equipped by automatically worked big ionization chambers shielded by 10 cm Pb (of Compton type). In 1955 in connection with preparing Soviet net of CR stations to take active part in the International Geophysical Year (1957–1958), S. N. Vernov founded and headed special Section in Academy of Science of USSR and asked me to be his deputy. This Section organized production for Soviet net of CR stations neutron monitors of Simpson's type. In 1959–1960 Sergei Nikolaevich Vernov together with Nikolai Vasil'evich Pushkov prepared special Declaration of Soviet Government on taking active part in International Quiet Sun Year (1964–1965). This Declaration was accepted by Soviet Government and signed by Prime Minister at beginning of 1961, after money reform 1:10, and thanks to mistake of Government's bureaucrats the total financiering was increased about 10 times. It gives a great support for sufficient increasing of experimental basis of CR variations research as well as in other fields in Sun-Solar physics. I would like to show in my report that the science on CR variations in Soviet Union was mainly founded and developed thanks to special properties of Sergei Nikolaevich Vernov as a great Scientist and as a great Organizer of Science.

IBEX – THE HELIOSPHERE AT THE SOLAR MINIMUM

H. Fichtner[1] and H. Fahr[2]

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[2] Argelander Institut fuer Astronomie, Universitaet Bonn, Germany

The recently launched Interstellar Boundary Explorer (IBEX) spacecraft has completed its first all-sky maps of the interstellar interaction at the edge of the heliosphere by imaging energetic neutral atoms (ENAs) emanating from this region. In addition to the new information about the global structure of the outer heliosphere that has been obtained this way, a bright ribbon of ENA emission has been found that was unpredicted by prior models or theories. This ribbon is superposed on globally distributed flux variations ordered by both the solar wind structure and the direction of motion through the interstellar medium. The results indicate that the external galactic environment may have strong imprints on the outer heliosphere. First modelling attempts will be discussed along with implications for the heliospheric structure and, in turn, for the modulation of cosmic rays.

TERRESTRIAL EFFECTS OF COSMIC RAYS

E.O. Flückiger

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The energy input from cosmic rays into the system Earth is small, roughly the same as that of starlight. However, galactic and sporadic solar cosmic rays have a multitude of effects on terrestrial, biological, and technological systems.

Historically, the cosmic ray cascade and the production of secondaries in the interactions with the Earth's atmosphere were among the first topics in cosmic ray research. Over the years, the focus has shifted from the study of the fundamental physical processes to an interdisciplinary field of effects, e.g. the production of long lived radioisotopes that are subsequently stored in terrestrial archives. The analysis of ^{10}Be in polar ice cores and ^{14}C in tree rings clearly reveals solar and geomagnetic modulation of the cosmic ray flux on different time scales ranging from decades to millennia. Such analysis yields extremely valuable information about climate changes in the past. Detailed knowledge about the radiation environment and its variability in near-Earth space is also essential for radiation protection reasons, e.g. at aircraft flight altitudes, as well as for geophysical studies using exposure age dating methods.

Cosmic rays are a major source, and below ~35 km the main source of ionization in the atmosphere. The increased ionization in the polar ionosphere due to an intense flux of solar particles can lead to complete disruptions in high frequency radio communication. Electric fields, air conductivity, and global electric circuits are constantly modified either by changes in the cosmic ray spectrum near Earth and/or variations in the geomagnetic shielding of the Earth from cosmic rays. Together with catalytic photochemical reactions, atmospheric ionization by solar cosmic rays leads to increased NOx and HOx production and associated ozone depletion during solar particle events. It has been shown that the production of nitric oxide in the stratosphere during a major solar proton event can be comparable to or even larger than the total average annual production by galactic cosmic rays. The identification of solar super events in the past by measurement of nitric oxide concentration in ice cores is now widely established. It has also been suggested that cosmic ray induced changes in atmospheric ionization could be related to weather phenomena such as rain, lightning, thunderclouds, and hurricanes. Currently the hypothesis of a causal relationship between the near-Earth cosmic ray intensity and global cloud cover, and therefore a key role of cosmic rays in the long term variation of the Earth's climate, is the subject of intense and controversial discussions.

Significant progress in measuring, understanding, and modeling of many of the terrestrial effects has been made in recent years. The review talk summarizes fundamentals of cosmic rays and their interaction with the geospace environment. Major effects, recent observations, advanced theories as well as scientific controversies are illustrated on the basis of selected examples.

Ultra High Energy Cosmic Rays

Piera Luisa Ghia [1]

[1] IFSI/INAF, Torino, Italy and IPN/CNRS, Orsay, France

The study of ultra-high energy cosmic rays (UHECR) has an impact on all aspects of high-energy astrophysics as well as on the the study of particle interactions at orders of magnitude higher energy than can be achieved in terrestrial laboratories. Recent measurements of UHECR are reviewed, from the point of view of arrival directions, energy spectrum and mass composition. Future prospects for the study of UHECR are also discussed.

COSMIC RAYS IN THE KNEE ENERGY RANGE

Andreas Haungs[1]

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In the energy range (100 TeV - 1 EeV) of the knee one expects to identify the end of the galactic origin and the transition to cosmic rays of extragalactic origin. Measurements of these high-energy particles are performed via the detection of extensive air showers by extended arrays of particle or Cherenkov detectors. Multidimensional analyses of such air shower data indicate a distinct knee in the energy spectra of light primary cosmic rays and an increasing dominance of heavy ones towards higher energies. This provides implications for discriminating astrophysical models of the origin of the knee. To improve the reconstruction quality and statistics at higher energies where the transition can be expected, presently several experiments are in operation or going to be in operation. First results of these experiments, as well as perspectives of future efforts in this energy range will be discussed.

Magnetic-Field Amplification and Particle Acceleration at Supernova Shocks

J. R. Jokipii[1], J. Giacalone[1] and J. Kota[1]

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Astrophysical fluid flows are almost always turbulent, and the resulting ambient large-scale turbulence has a large effect on shocks. Significant effects have been observed in situ at heliospheric shocks propagating past spacecraft. The effect of ambient interstellar turbulence on the much stronger supernova shocks is expected to be much larger. Turbulent density fluctuations upstream of a strong shock have a large effect on the magnetic field downstream [1]. For high-Alfven-Mach-number shocks, the downstream magnetic field is amplified considerably above the value obtained from the shock jump conditions. This effect may provide a robust and natural understanding of recent observations at supernova shocks. Non-turbulent density fluctuations may also contribute. The magnetic-field amplification implied by simulations exceeds factors of 100, much larger than expected from the jump conditions and consistent with observed X-rays from supernova remnants, which require magnetic fields of 100 microgauss. The magnetic field upstream of the shock is not amplified, so cosmic-rays with energies approaching the ḱneeín the spectrum require rapid acceleration, which can occur at the quasi-perpendicular part of the supernova blast wave, where the turbulent field-line mixing plays a large role. We have carried out a global test-particle simulation of acceleration at a spherical blast wave propagating into a uniform magnetic field. We find that although most of rapid particle acceleration occurs in the équatorialb́and, where the upstream magnetic field is quasi-perpendicular, the ongoing temporal evolution of the shock brings most of the particles to the quasi-parallel ṕolarṕart of the shock. This is in agreement with observational constraints, and allows the rapid acceleration at the quasiperpendicular shock. Recent model calculations illustrating this temporal evolution of particles are presented.

[1] Giacalone and Jokipii, Ap. J., 633, L41, 2007

TOWARDS REALISTIC MODELS OF INTERPLANETARY TRANSPORT OF SOLAR ENERGETIC PARTICLES

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Real solar wind exhibits a complicated behavior in time and coordinate space, due to changing boundary conditions at the Sun and the stream interaction in the interplanetary medium. Corresponding interplanetary magnetic field structures can strongly affect the solar energetic particle (SEP) transport to a spacecraft. Impulsive SEP events are associated with corotating solar wind structures, while gradual SEP events are associated with wide and fast coronal mass ejections (CMEs) and their continuation in the interplanetary space. CMEs often come in series, so that SEPs from a new CME have to propagate in the structures formed by previous CMEs traveling in the interplanetary medium. This report is focused on the new SEP modeling schemes, which are applicable to a general case of the energetic particle propagation in dynamic, structured solar wind, with particle cross-field transport included. Accurate analysis of a SEP even, as well as a prediction of the SEP intensity-time profile near the Earth's orbit, should employ a modeling of the particle transport in realistic solar wind, which can be done with use of coronal and solar wind data, numerical 3-D MHD modeling of solar wind, the high-energy particle flux anisotropy measurements, and the recent [1–4] and anticipated SEP modeling schemes to be reviewed in this report.

[1] J. Kóta, W. B. Manchester, J. R. Jokipii, D. L. de Zeeuw and T. I. Gombosi, Simulations of SEP acceleration and transport at CME-driven shocks, *The Physics of Colissionless Shocks, AIP Conf. Proc.*, **781**, 201, 2005.

[2] L. Kocharov, V. J. Pizzo, D. Odstrcil, and R. D. Zwickl, A unified model of solar energetic particle transport in structured solar wind, *J. Geophys. Res.*, **114**, A05102, 2009.

[3] M. Zhang, G. Qin, and H. Rassoul, Propagation of solar energetic particles in three-dimensional interplanetary magnetic fields, *Astrophys. J.*, **692**, 109, 2009.

[4] W. Dröge, Y. Y. Kartavykh, B. Klecker, and G. A. Kovaltsov, Anisotropic three-dimensional focused transport of solar energetic particles in the inner heliosphere, *Astrophys. J.*, **709**, 912, 2010.

High Energy Neutrino Astronomy

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Several projects are concentrating their efforts on opening the high-energy neutrino window on the Universe with km-scale detectors. Neutrinos constitute a unique probe since they escape from their sources, travel undisturbed on virtually cosmological distances and are produced in high energy hadronic processes. In particular they would allow a direct detection and unambiguous identification of the sites of acceleration of high energy baryonic cosmic rays, which remain unknown.
The detection principles rely on the instrumentation of large volumes of naturally abundant material (water or ice) with photomultipliers (PMTs) housed into pressure resistant glass spheres. These PMTs detect the Cherenkov light emitted by secondary particles produced by neutrino interactions in the surrounding detector medium. This experimental technique, relevant for the detection of high-energy ($\geq$ TeV) neutrinos, will be described. The main results achieved with the detectors currently in operation will be reviewed. In the southern hemisphere, the IceCube detector, located at the geographic South Pole, should be complete in 2011 with at least 4800 PMTs installed on 80 strings for a total instrumented volume of 1 $\sim \mathrm{km}^3$. In the Northern hemisphere, while the pioneering Baikal telescope, has been operating for 10 years, most of the activity now concentrates in the Mediterranean Sea. The ANTARES collaboration has completed in May 2008 the construction of a 12 line array comprising $\sim$900 photomultipliers. The efforts undertaken by both collaborations towards a multi-messenger approach will be mentioned. Finally we will report on the perspectives opened by new projects, such as KM3NeT, and prototypes being currently developed.

THE VOYAGERSV́IEW OF COSMIC RAYS IN THE HELIOSHEATH AND THE SHAPE OF THE ENA HELIOSPHERE

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The LECP instruments on Voyagers 1 (V1) and 2 (V2) measure the intensities, energy spectra, and angular distributions of energetic ions and electrons. We summarize measurements of low-energy ions (28 keV - few tens of MeV) made in the heliosheath (HSH) at V1 since 2004/351 (94-113 AU at latitude N35°) and at V2 since 2007/242 (84-91 AU at latitude S27-29°). This suprathermal ion population is the high-energy tail of pickup ion (PUI) distributions that mediate termination shock (TS) structure and dominate the energy density of the HSH plasma. The CRS instruments extend the LECP measurements to higher cosmic ray energies, and MAG and PLS instruments complement these with information on the local magnetic field and plasmas, respectively. Cosmic rays in the HSH apparently are no longer modulated by solar activity. Anomalous cosmic rays (ACR), originally thought to be accelerated at the solar wind termination shock, continue to be modulated in the heliosheath. The angular distributions of the suprathermal ions also enable estimates of the plasma flow in the HSH (in the R-T plane). Recent results from the LECP data taken in the HSH at V1 of convective angular distributions of 40-140 keV ions show a steady decrease in the radial component of HSH plasma flow from $\approx$55-65 km/s in mid-2007 to $\approx$10-20 km/s in early 2010. Further, although, on average, the intensities of low-energy HSH ions are comparable at V1 and V2, there are marked differences between the two spacecraft in the amplitudes and durations of intensity fluctuations. Nevertheless, the in situ V1 and V2 measurements may not be representative of the hot plasma distribution throughout the heliosphere. Recently, however, through measurements of energetic neutral atoms (ENA) by the Cassini/INCA spacecraft in orbit around Saturn [1] and the Earth-orbiting IBEX spacecraft [2], it has been possible to sample the hot plasma distribution over the celestial sphere over an extended (0.2 eV to 55 keV) energy range, with surprising results. A belt of high ($>$ 5 keV) energy hot plasma was found to envelop much of the heliosphere, as well as a ribbon at lower ($\approx$ 1 keV) energies, although less extended in angular dimensions. These new discoveries are substantiated by the V1 and V2 in situ measurements and lead into new interpretations of the shape and dynamics of the solar systemś motion through the local interstellar cloud.

[1] S. M. Krimigis et al, Science, 326, 971, 2009
[2] D. J. McComas et al, Science, 326, 959, 2009

ENERGETIC PARTICLE OBSERVATIONS IN THE HELIOSPHERE: PAST, PRESENT AND FUTURE

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Energetic particle measurements have been acquired since the dawn of the space age using instruments on a multitude of spacecraft at locations throughout the heliosphere. These observations have shown the particle population to be highly dynamic, with large variations in space and time, intensity, energy, and composition. Much progress has been made in understanding the complex interplay of source population, injection, acceleration and transport that determines the characteristics of the radiation measured by a given observer at a given location in the heliosphere. Nevertheless, a full understanding of the detailed processes remains elusive. A key factor in this regard, particularly in the case of solar energetic particles, is the need to make comprehensive measurements as close as possible to the acceleration site in order to reduce the effects of interplanetary propagation. Future missions such as Solar Orbiter and Solar Probe Plus are expected to provide these much-needed observations. In this paper I will present an overview of our current knowledge of the energetic particle populations in the heliosphere, with emphasis on the open questions, and look ahead to the future missions that are likely to provide some of the answers.

THE BESS EXPERIMENTAL ASTROPARTICLE PHYSICS PROGRAM

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[6] The University of Tokyo, Bunkyo, Tokyo 113-0033, Japan
[7] University of Denver, Denver, CO 80208, USA

The Balloon-borne Experiment with a Superconducting Spectrometer (BESS) measures cosmic-ray nuclei and antiprotons to study the early Universe and to provide fundamental data on the spectra of light cosmic-ray elements and isotopes. The BESS Collaboration uses the energy spectra of cosmic-ray antiprotons to investigate signatures of possible exotic sources, such as dark-matter candidates, and searches for heavier antinuclei that might reach Earth from antimatter domains formed during symmetry-breaking processes in the early Universe. Since 1993, the BESS Collaboration has carried out eleven high-latitude balloon flights, two of long duration, that have defined the study of antiprotons below about 4 GeV, provided standard references for light element and isotope spectra, and set the most sensitive limits on the existence of antideuterons and antihelium. Simultaneous measurements of low-energy proton and antiproton spectra spanning a full solar activity cycle and a solar magnetic field reversal test models of charge-sign dependent solar modulation. The BESS program reached an important milestone with the Antarctic flight of BESS-Polar II, during the 2007-2008 Austral Summer. This flight took place near solar minimum, when the sensitivity of the low-energy antiproton measurements to a primary source is greatest. BESS-Polar II recorded data on over 4.7 billion cosmic-ray events during 24.5 days of operation, more than double the combined data from all earlier BESS flights and 10-20 times the BESS data recorded during the previous solar minimum. The instrumentation and scientific results of the BESS program will be summarized, focusing on the long-duration BESS-Polar flights.

LONG-TERM VARIATIONS OF GALACTIC COSMIC RAYS INFERRED FROM COSMOGENIC RADIONUCLIDES

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Cosmogenic radionuclide records can provide reliable estimates of past changes in cosmic ray intensity entering Earth's atmosphere. The production rate of cosmogenic radionuclides depends on the helio- and geomagnetic shielding of galactic cosmic rays.

Cosmogenic radionuclides measured e.g. in tree rings in the case of 14C or ice cores in the case of 10Be show distinct changes in the past that can be related to the variable solar shielding. Cosmogenic radionuclide records, however, can also be influenced by changes in climate. The identification of such climate-induced changes is crucial for the reliable reconstruction of past changes in cosmic ray variations. This is especially important in the discussion about a solar influence on climate since unidentified climate signals could feign a solar influence on climate.

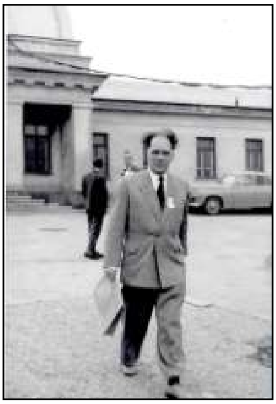
Variations on centennial time scales can be quite robustly attributed to solar modulation of galactic cosmic rays. However, much less is known about changes on time scales of millennia since there are differences between different cosmogenic radionuclide records that are not yet fully understood.

COSMIC RAY PHYSICS IN SPACE: THE ROLE OF SERGEY VERNOV

M. Panasyuk

Skobeltsyn Institute of Nuclear physics of Lomonosov Moscow state University

This talk is devoted to the memory of outstanding Russian scientist Sergey Vernov (1910 – 1982). He was involved in cosmic ray study before the World War II and he continued these researches for many years after. He and his group in Moscow State University developed a numerous experiments on ground and on balloons, after the WWII he fulfilled some experiments on board high altitude rockets, launched from Kapustin Yahr launch pad.



The next and the most important step of his biography were satellite's experiments in space. He was the first scientist who installed the first physical instrument onboard satellite. It was the simple Geiger –Muller counter. The consequences of the first experiments in space were the discovery of radiation belts of the Earth. It was done independently of Van Allen's group. Then, He and his group achieved some other very important scientific results in the Earth's magnetosphere in the interplanetary space and in the vicinity of the Moon, Venus and Mars. It was the beginning of space physics era.

Understanding Cosmic Rays and Searching for Exotic Sources with PAMELA

P. Picozza[1] on behalf of the PAMELA Collaboration

[1]INFN and University of Rome Tor Vergata

Results on high-energy spectra of cosmic-ray electrons, positrons, protons, antiprotons, helium and light nuclei will be presented. These measurements have been performed with the satellite-borne experiment PAMELA, launched from the Baikonur cosmodrome and collecting data since July 2006. The apparatus is designed to study charged particles in the cosmic radiation, with a particular focus on antiparticles for searching annihilation. Data will be discussed in relation to dark matter search , mechanisms of acceleration and propagation of cosmic rays in the Galaxy, solar modulation and terrestrial magnetosphere.

S. N. VERNOV AND STUDY OF COSMIC RAYS IN THE ATMOSPHERE

Y. Stozhkov and G. Bazilevskaya

Lebedev Physical Institute, Russian Academy of Sciences, Moscow, Russia

Brief historical review of study of cosmic rays in the Earth's atmosphere initiated by S. N. Vernov is presented. He started the cosmic ray investigation in the early 1930s and was the first person who launched an automatic radio sound for charged particle measurements in the stratosphere. In 1957 S. N. Vernov organized regular monitoring of cosmic rays in the atmosphere of polar, middle and low latitudes. These observations have been continued till present. The main results obtained in this experiment are discussed. They include research of galactic cosmic ray modulation, solar cosmic ray generation, and the role of charged particles in the atmospheric processes.

THE HISTORY OF COSMIC RAY RESEARCH IN FINLAND

P. Tanskanen

Department of Physics, University of Oulu

A historical overview will be given of Cosmic Ray Research and instrument development in Finland. Emphasis will be given to research activities at the Department of Physics, University of Oulu involving the time period starting from 1961 to present time.

Highlights of GeV Gamma-ray Astronomy

David J. Thompson [1]

[1] NASA Goddard Space Flight Center, on behalf of the Fermi Large Area Telescope Collaboration

Because high-energy gamma rays are primarily produced by high-energy particle interactions, the gamma-ray survey of the sky by the Fermi Gamma-ray Space Telescope offers a view of sites of cosmic ray production and interactions. Gamma-ray bursts, pulsars, pulsar wind nebulae, binary sources, and Active Galactic Nuclei are all phenomena that reveal particle acceleration through their gamma-ray emission. Diffuse Galactic gamma radiation, Solar System gamma-ray sources, and energetic radiation from supernova remnants are likely tracers of high-energy particle interactions with matter and photon fields. This talk will present a broad overview of the constantly changing sky seen with the Large Area Telescope (LAT) on the Fermi spacecraft.

THE ALPHA MAGNETIC SPECTROMETER ON INTERNATIONAL SPACE STATION

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The Alpha Magnetic Spectrometer is a TeV multi-purpose magnetic spectrometer designed and built to measure electrons, positrons, protons, antiprotons as well as nuclei up to the energy of 1 TeV. The experiment has been upgraded recently so that it can stay on the International Space Station for the lifetime of the Space Station (2028). The construction, the tests at CERN and at ESTEC as well as the final preparation before transport to Kennedy Space Center will be presented. The physics potential of this detector will also be presented.

History of high-energy astronomy in Finland

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Finland entered the age of space research and modern astronomy relatively late. During the birth and growth of space-related astronomy in the world, Finland was not a member of the European Space Agency, nor of the European Southern Observatory, the two main international organizations. For various complicated (and nowadays obscure) reasons, there was also political opposition to engaging in international space research. In addition, up to the early 1980s astronomical research in Finland was mainly of the traditional type, focusing on classical areas such as celestial mechanics and positional astronomy. Thus, although Academician Yrjö Väisälä, founder of the Tuorla Observatory, had already immediately after the war suggested the use of rock-ets and, later, satellites for astronomical purposes, Finland was slow to enter the Space Age and, consequently, the field of high-energy astronomy which, of course, is almost totally dependent on satellite observations.

From these unpromising beginnings high-energy astronomy has, somewhat surprisingly, emerged as one of the most important research areas of Finnish astronomy. I will describe how this happened as a combination of the efforts of a few pioneering scientists, surprising coincidences, unforeseen connections, and, last but not least, the growth of Finnish high technology sector

PARTICLE ACCELERATION AT RELATIVISTIC SHOCKS WITH APPLICATIONS TO GAMMA-RAY BURSTS AND UHECRS

E. Waxman

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Particle acceleration in collisionless shocks is believed to be responsible for the production of cosmic-rays over a wide range of energies, from a few GeV to > 10^{20} eV, as well as for the non-thermal emission of radiation from a wide variety of high energy astrophysical sources. A theory of collisionless shocks based on first principles does not, however, exist. I will review the characteristics of collisionless relativistic shocks, which are inferred from observations of Gamma-Ray Bursts (GRBs), and will discuss our current theoretical understanding and main open questions. Implications for models of UHECR production in GRBs will be discussed.

Reviews [1, 2] provide some background.

[1] E. Waxman, Plasma Physics and Controlled Fusion 48, B137 (2006).
[2] E. Waxman, Nuclear Physics B51, 46 (2006).

Session 1: Solar and Heliospheric Cosmic Rays (Talks)

Conveners: B. Heber and R. Vainio

FORBUSH-EFFECTS WITH SUDDEN AND GRADUAL ONSET

A. Abunin[1], A. Belov[1], E. Eroshenko[1], V. Oleneva[1] and V. Yanke[1]

[1] Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation (IZMIRAN)

For overall studying of the Forbush-effects (FEs) and their relation to the solar and geomagnetic activity database of transient phenomena in the cosmic rays and inter-planetary space was created, which is continuously supplemented by the data on the new events. Various dependences of the FE size on the internal and external characteristics were examined and different groups of events were distinguished on the basis of these data. Both recurrent (rotation of the highspeed solar wind streams from the coronal holes together with the sun) and sporadic (coronal mass ejections) events have been considered.

The groups of events beginning with the shock wave arrival (SSC), and with-out shock are allocated and studied. It is shown that derived relationships (dependence of the FE magnitude on the parameters of interplanetary disturbance, FE magnitude on the indices of geomagnetic activity, etc.) are significantly different for these groups. Most likely these differences are caused by predominance of different kind of sources of the solar wind disturbance (coronal mass ejections or the coronal holes) in separated groups.

Coronal Shock Acceleration of Protons and Minor Ions In Self-generated Turbulence

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Acceleration in coronal and interplanetary CME-driven shocks is currently considered the primary source of large solar energetic particle (SEP) intensities. In large SEP events, protons accelerated at the shock generate Alfvénic turbulence in the ambient medium, which facilitates particle trapping and repeated shock crossings, thus bootstrapping the acceleration process. In order to study this process, we have developed a Monte Carlo simulation method, where particles are traced in prescribed large-scale electromagnetic fields utilizing the guiding center approximation.

In our simulations, particles are scattered in the turbulence according to quasilinear theory, with the scattering amplitude directly proportional to the intensity of Alfvén waves at gyro-resonant wavenumbers. The Alfvén waves are traced simultaneously with the particles, so that the wave field is propagated outwards from the Sun using WKB propagation supplemented with a phenomenological wavenumber diffusion term and a growth rate computed from the net flux of the accelerated particles.

We have previously reported on effects on accelerated populations by different shock velocities, shock-normal angles and injected proton populations. We now extend our study by injecting, in addition to the slightly suprathermal ambient proton population, a small portion of minor ions (He^3, He^4 and Fe), and following the temporal and spatial evolution of their energy distributions.

INVITED

PAMELA measurements at the minimum of cycle 23 and potential of cycle 24

M. Casolino [1], N. De Simone [1], V. Di Felice [1] and P. Picozza [1]

[1] INFN and University of Rome Tor Vergata

PAMELA is a satellite borne experiment designed to study with great accuracy cosmic rays of galactic, solar, and trapped nature in a wide energy range (protons: 80 MeV-1200 GeV, electrons 50 MeV-400 GeV). Main objective is the study of the antimatter component: antiprotons (80MeV-190 GeV), positrons (50 MeV-270 GeV) and search for antimatter.

The experiment, housed on board the Russian Resurs-DK1 satellite, was launched on June, 15th 2006 in a 350 600 km orbit with an inclination of 70 degrees. The detector consists of a permanent magnet spectrometer core to provide rigidity and charge sign information, a Time-of-Flight system for velocity and charge information, a Silicon-Tungsten calorimeter and a Neutron detector for lepton/hadron identification. An Anticounter system is used off-line to reject false triggers coming from the satellite.

In this work we will discuss the observation of cosmic rays at the 23rd solar minimum from space, comparing with existing ground and space data. We will focus on the the following topics:

1. Solar Particle events of 13 and 14 december 2006 and the subsequent Forbush decrease;

2. Solar modulation of galactic cosmic rays;

3. Measurement of particles of secondary (reentrant albedo) and trapped nature. We will also discuss the prospects for future joint observations with ground and space detectors as we progress toward the next solar maximum.

SEQUENCES OF ELECTRON AND PROTON EVENTS WITH SIMILAR CHARACTERISTIC DECAY TIMES

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We consider the characteristic time, T, of the exponential decay of proton and electron SEP events (E_p few MeV, E_e few hundred keV), $J = J_0 \exp(-t/T)$, $J_0 = 10$–10^4 (cm^2 s sr MeV)$^{-1}$ and define the sectors of homogeneity in the inner heliosphere as regions where T is nearly constant. It is pointed out that in many events $T =$ const for a period of 3–5 days, sometimes up to a week, that corresponds to the spread of the sector of homogeneity up to about 90°. Sometimes the interval of homogeneity may extend to two, three or more successive SEP events with equal T, which suggests spatial homogeneity over longer time intervals, sometimes two weeks and even longer (then the spread of the sector of homogeneity is >180°). This means that more than the half of near-Sun space has quasi-stationary characteristics of magnetic field and its fluctuations, or satisfies the stability of convection and adiabatic deceleration conditions, governing particle motion and providing the invariance of T.

Such wide spread regions of homogeneity derived simultaneously from both p- and e-decays are observed only in about 50% of all events. In many cases one can find quasi-stable interplanetary medium either for p or e, which suggests that only those parts of the spectrum of magnetic field fluctuations are invariable which correspond either to high (e) or low (p) frequencies throughout these periods. All exponential SEP event p- and e-decays are examined from this aspect using CPME instrument data aboard IMP-8 in 1974–2001.

COSMIC RAY ANISOTROPY DURING THE FORBUSH EFFECTS AS A POSSIBLE INDICATOR OF THE SOLAR SOURCE LOCATION

E. Eroshenko [1], A. Belov [1], A. Papaioannou [2], A. Abunin [1], H. Mavromichalaki [2], V. Oleneva [1], A. Asipenka [1] and V. Yanke [1]

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Cosmic ray anisotropy, deduced by worldwide neutron monitor measurements by the Global Survey Method (GSM) has shown possible indications of the solar source of Forbush decreases, specifically, for 800 identified with solar sources Forbush decrease events during the last 55 years. These events were divided on five groups by heliolongitude of associated X-ray flares and behavior of the cosmic ray vector anisotropy have been studied within each of separated group. The examples of typical behavior of CR anisotropy are presented for each group. For example, sources of 161 Forbush decreases have a far western origin. By a statistical filtering it was shown that only a dozen events, of this category, indicated large magnitude (> 6

ON THE DETERMINATION OF GALACTIC COSMIC RAY PROTON SPECTRA FROM THE 21^{st} TO 23^{rd} SOLAR CYCLE - RESULTS FROM ULYSSES COSPIN/KET

J. Gieseler,[1] and B. Heber[1] on behalf of the Ulysses/KET collaboration
M. Boezio,[2] M. Casolino,[3] N. De Simone,[3] and V. Di Felice[3] on behalf of the PAMELA collaboration

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[2]INFN, Sezione di Trieste, Trieste, Italy
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Ulysses, launched on the 6th of October 1990, was placed in an elliptical, high inclined (80.2°) orbit around the Sun, and was finally switched off in June 2009. It has been the only spacecraft exploring high-latitude regions of the inner heliosphere. The Kiel Electron Telescope (KET) aboard Ulysses measures electrons from 3 MeV to a few GeV and protons as well as helium in the energy range from 6 MeV/nucleon to above 2 GeV/nucleon. Here we determine the energy spectra of protons using GEANT3 simulations. Although the simulations already result in a better understanding of the measurements, no comparable observations in this energy range were available until 2006, when the PAMELA space borne experiment was launched. This apparatus measures electrons, positrons, protons, anti-protons and heavier nuclei from about 100 MeV to several hundreds of GeV. Preliminary energy spectra of galactic cosmic ray protons from the 21st to 23rd solar cycle will be presented.

Antiproton modulation in the Heliosphere and prediction for AMS-02

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[3]CILEA, Segrate (MI) (Italy)
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Galactic Cosmic Rays (GCRs) are nuclei, with a small component of leptons, produced mainly from supernova events, confined by the galactic magnetic field and forming an isotropic flux inside the galaxy. Before reaching the Earth orbit they have to enter the Heliosphere passing through the interplanetary magnetic field carried out by the Solar Wind. In this environment they undergo the Solar modulation: diffusion, convection, magnetic drift and adiabatic energy loss, which reduce the flux of particles at low energy (<1-10 GeV) depending on the solar activity and polarity. We improve a quasi time-dependent 2D Stochastic Simulation of Solar Modulation that describes with this scenario. We reproduced the modulated spectra at the Earth position for any kind of light cosmic ion. In this contribute we focused our attention on to the GCRs antiproton component and to the antiproton-to-proton ratio, which have been measured by several space and balloon experiments. We show that, especially during periods of minimum solar activity, a full drift model is needed in order to take into proper account the effects due to the charge sign. We find a good agreement with the antiproton-to-proton ratio measured by AMS-01, HEAT, Caprice 98, BESS and Pamela, and present a prediction for the AMS-02 Experiment.

ENERGETIC ION FLUXES DURING RECENT SOLAR MINIMA

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Energetic ions detected at different regions of the heliosphere are influenced by solar activity in different ways. The extended, deep solar activity minimum of solar cycle 23 provides a good opportunity to compare ion fluxes of solar, heliospheric, and cosmic origin with those measured at earlier minima. The exceptionally low solar activity levels and relatively large inclinations of the heliospheric current sheet help in separating the components of different origins. Most neutron monitor fluxes reached record high levels during the short final period of the last minimum when the current sheet inclination reached the low values that also characterized previous solar activity minima.

Ion fluxes measured by both Voyagers in the heliosheath during the extended solar minimum are of particular interest. As CME effects of solar origin were minimal, the behaviour of ions of different energies reflected the state and dynamics of the heliosheath as well as its interaction with the interstellar medium. The surprisingly different behaviour of energetic particle fluxes as seen by the two Voyagers both at low and at high energies will be discussed. At low (MeV) energies solar rotation still appears to have an effect on flux variations at Voyager-2, but not at Voyager-1. At high (> 70 MeV) energies measured fluxes continued to increase throughout the minimum period at Voyager-1, while at Voyager-2 they leveled off during the last year.

Comparison will also be made with recent IBEX results on energetic neutral atoms.

INVITED

Origin of Solar Cosmic Rays: Flares, CMEs and other coronal activity

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Several manifestations of solar activity are statistically associated with transient enhancements of energetic particles (solar energetic particle events - SEP events) up to relativistic energies in space. The most intense SEP events can be traced back to eruptive activity, i.e. solar flares and coronal mass ejections (CMEs). But quiescent active regions are also seats of long duration particle acceleration whose signatures are prolonged (days) radio emissions from subrelativistic electrons in the corona and from electron beams in interplanetary space. This suggests that active regions are able to provide bursts of energetic particles up to relativistic energies as well as suprathermal seed populations for further acceleration in the high corona and interplanetary space by travelling large-scale shock waves at CMEs.

We exploit the unique means offered by the Sun to study signatures of energetic particles by direct measurements (spaceborne and ground-based detectors) and through their radiation together with the plasma environment where the acceleration likely occurs, including the temporal evolution of particle populations and coronal and interplanetary structures. This contribution will start with a brief overview of solar activity of relevant to large SEP events. We will then address from an observational viewpoint (a) the relative timing of SEP onset measured in space and coronal activity at radio, X-ray and gamma-ray wavelengths, and (b) the magnetic structures that guide energetic particles through the corona and interplanetary space. It will be shown, using the example of the 20 Jan 2005 flare and CME, that energetic particles come from the Sun with a timing that can be related to the evolution of the underlying activity, including the flare and the CME. We will then illustrate the magnetic structure around SEP-producing active regions. We show that they are able to inject particles into a broad range of heliolongitudes, even when the active region is not nominally well connected, and that large CMEs may play a major role in the interplanetary transport of SEPs.

This kind of investigation will largely benefit from particle measurements closer to the Sun, since most acceleration signatures have been smoothed by interplanetary propagation by the time particles reach the Earth. This is a powerful motivation for the *Solar Orbiter* mission

MAJOR SOLAR ENERGETIC PARTICLE EVENTS IN THREE DIMENSIONS

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Using *SOHO* particle and EUV detection and radio spectrograms from both ground-based and spaceborne instruments, we study the first phase of two major solar energetic particle (SEP) events associated with solar eruptions centered at different solar longitudes. A major solar energetic particle (SEP) event observed on 4 April 2000 was associated with western solar flare and fast and wide coronal mass ejection (CME). The SEP event near the eruption's core starts with deka-MeV/n helium- and relativistic electron- rich production from coronal sources identified with the electromagnetic diagnostics. Observations of the initial phase of the 'well-connected' major SEP event support the idea that acceleration of SEPs starts in the helium-rich plasma of the eruption's core well behind the CME leading edge, in association with coronal shocks and/or magnetic reconnection caused by the CME liftoff; and those 'coronal' components dominate during the first $\sim$1.5 hour of the SEP event, not yet being hidden by the CME-bow shock in solar wind. The 12 September 2000 eruption's center was angle-distant with respect to the *SOHO*-connected heliolongitude. The event began with a hard-spectrum, first-phase SEP production that was extremely poor in helium, and onset of the first stage of the SEP event as observed on *SOHO* was delayed by an extra half hour, compared to the 'well-connected' event of 4 April 2000. In both cases, the event first phase is followed by a second-phase SEP production associated with a decelerating CME-driven shock wave in solar wind, which accelerates deka-MeV/n ions from a helium-poor particle population for $\sim$6–12 hours, until the interplanetary shock slows down to below $\sim$1000 km s^{-1}. Based on these and other *SOHO* observations, we discuss what findings we can expect from *STEREO* in the *SOHO* era perspective.

FORBUSH DECREASES INFLUENCE ON REGISTERED HIGH ENERGY

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The influence of Forbush decreases on high energy muon flux has been investigated. The flux of the high energy muons, with energy threshold 220 GeV, has been measured by the Baksan Underground Scintillation Telescope (BUST) [1]. The correlations between muon flux and data of the Baksan Neutron Monitor [2] have been studied. The amplitude of primary cosmic rays intensity variation with energy about 1 TeV near the identified Forbush decreases has been measured. An energy dependence of this amplitude has been obtained for a wide range of primary energies using both the BUST data and the net of neutron monitors.

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Case studies on the effect of pre-event background in solar particle event timing

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The onset of a Solar Energetic Particle (SEP) event has been traditionally determined by using the velocity dispersion analysis (VDA). In this method the injection of the first particles at the Sun is determined by fitting the solar injection time and the path length of the particles to match the observed event onset at 1 AU for several SEP energy channels. Recently, this approach has been questioned by simulation studies, which take into account the effect of the interplanetary scattering on the arrival time of the first particles to 1 AU. Particularly when the pre-event particle background is strong, significant errors for the onset can be expected, up to tens of minutes for protons of energies 1-100 MeV.

In this work, we continue to study the effect of the pre-event background to the SEP event onset at 1 AU, and its consequences to the determination of the SEP event evolution at the Sun. We study the use of the steepness of the event onset, as observed at 1 AU, as a parameter for the systematic error for the determined SEP injection time at the Sun, by analysing the steepness and the error in the in the simulated events. We will then proceed with this estimate to analyse observed SEP events, on case-by-case basis, and study how the solar and coronal imprints of the solar eruptions can be connected to the obtained SEP onset when the systematic error is taken into account. We will report the newly obtained connections in the events, concentrating on events which hitherto have been found difficult or unreliable for the study, due to, e.g., long pathlength obtained from the VDA method for the first particles. Based on the systematic error treatmentś successfulness in connecting the solar eruption imprints to the SEP onset, we will re-evaluate the usability of the VDA method when using the appropriate corrections required to take into account the pre-event background.

INVITED

Corotating Interaction Regions, Coronal Mass Ejections and Energetic Particles

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In this work, energetic particle observations in the 1-40 MeV/n range by the COSPIN/LET instrument onboard the Ulysses spacecraft, the first spacecraft ever to fly over the poles of the Sun, during periods of intense solar activity in the declining phase of Solar Cycle 23 are presented. We study the effects of solar activity from a near-ecliptic vantage point at 5 AU radial distance from the Sun and focus in particular on the origin of the complex particle increases observed at the location of the spacecraft. A composition analysis is carried out which provides useful clues in this regard, allowing distinction between particles accelerated in transient events, associated with Coronal Mass Ejections (CMEs) (i.e. Solar Energetic Particles, SEPs) and particles accelerated at Corotating Interaction Regions (CIRs) or Stream Interaction Regions (SIRs), during CME/CIR combination periods. Furthermore, multi-point plasma and energetic particle observations of the same CIR events by the twin STEREO spacecraft and the ACE spacecraft, during the recent unusually low solar activity minimum are presented and compared. Several cases where the presence of Interplanetary Coronal Mass Ejections (ICMEs) in the vicinity or embedded in the CIR is accompanied by significant changes in the CIR structure and in the associated energetic ions (as observed by the STEREO/SEPT instrument) are discussed.

A fully integrated model for Ulysses/HISCALE and ACE/EPAM data

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There are three important aspects to in-situ particle events detected by instruments on board spacecraft: (1) the source function for the particles (injection from shocks/flares), (2) the propagation effects that the particles suffer from the source to the detectors, and (3) the process happening inside the detector itself. We present here a model that allows us to recover aspect (1) by incorporating aspects (2) and (3) in the simulations that provide the synthetic particles events. By comparing data and model, we recover the injection function back at Sun for the near-relativistic electrons detected by the HISCALE instrument on the Ulysses spacecraft, and for the electrons detected by the EPAM instrument on the ACE spacecraft. The model incorporates a kinematic propagation code, including aspects like pitch angle scattering, adiabatic focusing and adiabatic deceleration, whose results are then fed to a GEANT4 simulation of the instruments. The GEANT4 Monte Carlo simulation package models the full geometry of the detector and its response to electrons and protons for various energy ranges and incident angles. We illustrate the importance of doing the instrumental convolution by showing the difference between propagation only, and propagation plus instrumental response modeling, in the inversion of the observed data for a series of events, observed by ACE and Ulysses during solar cycle 23, which show relatively hard spectra.

Solar proton events and passive Carrington longitudes on the Sun

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We investigate the space-time distribution of the sources of the solar proton events (SPE) during 1956-2009. It is found that the ranges of passive Carrington longitudes determined earlier in our works [1, 2] are preserved until now. We compare SPE characteristics with other solar activity manifestations observed at that time. Tentative physical interpretation is suggested based on the ideas of the long lasting global asymmetry of the magnetic fields and activity on the Sun and in the heliosphere. The results of this study can be used for reliable evaluations of the "radiation safety windows" during space missions.

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Modeling of the high-energy galactic cosmic-ray anisotropy

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Galactic cosmic rays are high-energy nuclei, mostly protons, accelerated in our galaxy and continuously arriving at the earth after traveling through the interstellar medium and the heliosphere. Past cosmic-ray experiments including ground-based air-shower arrays as well as underground muon telescopes reported a cosmic-ray anisotropy in the sidereal time frame with an amplitude of $\sim$0.1%, suggesting that there are two distinct broad structures in the anisotropy; one is a deficit in the cosmic-ray flux (called the "loss-cone"), distributed around 150° to 240° in Right Ascension; the other is an excess in the cosmic-ray flux (called the "tail-in"), distributed around 40° to 90° in Right Ascension. Recent air-shower experiments including the Tibet air-shower experiment studied the anisotropy in more detail at multi-TeV energies [1, 2, 3]. The observed anisotropy of galactic cosmic rays at TeV energies are considered to reflect the structure of the local interstellar magnetic field, since charged cosmic rays gyrate around the local interstellar magnetic field line while traveling through the interstellar medium.

The Tibet air-shower (AS) array, located at 90.522° E, 30.102° N and 4300 m above sea level, has been successfully observing cosmic rays with energies above a few TeV with an effective area of 37000 m^2. Based on the data obtained with the Tibet air-shower array, the cosmic-ray anisotropy in the sidereal time frame at multi-TeV energies will be discussed. The large-scale cosmic-ray anisotropy in the sidereal time observed with the Tibet air-shower array is well modeled in terms of a superposition of the Global Anisotropy component and the Additional Excess component; the Global Anisotropy is expressed as a combination of a uni-directional and bi-directional flows of galactic cosmic rays in the local interstellar space, while the Additional Excess is expressed as two midscale intensity enhancements placed along Gurnett's Hydrogen Deflection Plane [4].

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INVITED

SHOCK ACCELERATION IN THE SOLAR CORONA

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Acceleration of ions in coronal mass ejection (CME) driven shock waves is the best developed theory of the genesis of gradual solar energetic particle (SEP) events. The underlying mechanism is the diffusive shock acceleration (DSA) in which the ions crisscross the shock front many times by scattering off magnetic fluctuations in the upstream and downstream regions, gaining energy on each back and forth trip.

The turbulence required for the DSA can either be an ambient background or generated by the accelerating ions themselves in larger events in which the ion intensities are high enough for sufficient wave growth. In smaller events efficient scatter-free acceleration, leading to energy gain by a factor of the order of 100, is possible if the upstream magnetic field shows suitable large scale inhomogeneities, i.e. intensity gradients and curvature [4]. Such field geometries can be found e.g. near active regions in the solar corona.

Observations have revealed that the characteristics of heavy ions are very energy dependent in large gradual events, and in a few cases the abundance ratios and average charge states approach values that are typical to impulsive events. As the ^{3}He/^{4}He ratio may also be elevated the role of flares in gradual events has been discussed during the past decade. If remnant flare-accelerated ions are present in the corona, they can act as energetic seed particles for DSA and can to some extent explain the unexpected abundance ratios and charge states [8, 9, 5, 6]. An alternative explanation is that interaction between flares and shocks is not important, and that these hybrid events are just superposed gradual and impulsive events [1, 2].

The most extreme SEP events are the ground level enhancements (GLEs) in which the ions are accelerated into GeV/nucl energy range, allowing them to to penetrate through the Earth's magnetosphere and atmosphere. It is not clear at present what is the dominant acceleration mechanism, as the GLEs are associated with X-class flares and fastest CMEs. Many GLEs occur in an elevated SEP background produced by the same active region [3], suggesting that an enhanced turbulence background and energetic seed particles may be available for the subsequent CME. In such a scenario an expanding coronal shock sweeping through the magnetic field of an active region may accelerate protons to GeV energy range [7].

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Decoding high-frequency solar wind turbulence with nonrelativistic linearized Vlasov-Maxwell instability theory

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A rigorous analytical study of the dispersion relations of weakly amplified and weakly propagating transverse fluctuations with wave vectors parallel to the uniform background magnetic field in an anisotropic bi-Maxwellian magnetized electron-proton plasma is presented. The conditions for the excitement of the weakly amplified LH-handed polarized Alfven-proton-cyclotron and RH-handed polarized Alfven-Whistler-electron-cyclotron wave branches as well as weakly propagating fluctuations, such as firehose, mirror and magnetized Weibel, are determined.

The results of the instability study are applied to the observed solar wind magnetic turbulence. The main characteristic properties of the observed solar wind fluctuations are well explained by the combined action of Alfven wave and mirror and firehose instabilities. Especially, the observed confinement limits at small parallel plasma beta values are explained. The resulting constraints on the plasma beta provide a new explanation of the observed magnetic field equipartition in comic dilute plasma systems.

MAGNETIC FIELD-LINE SOURCE REGIONS AND VARIABILITY IN HEAVY-ION COMPOSITION IN GRADUAL SOLAR ENERGETIC PARTICLE EVENTS

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We report on an exploratory study examining correlations between the nature of interplanetary magnetic field-line source regions and heavy-ion composition in gradual solar energetic particle (SEP) events. This study is based on 12 events observed in 2004-2006, when both ACE and WIND were at L1. We find that SEP elemental composition at ∼0.1-10 MeV/nucleon falls into two classes, depending on whether the associated solar wind, and correspondingly the footpoint of the open magnetic field along which the SEPs are transported, is from *near an active region* or from *a coronal hole*. Specifically, the observed SEP Fe/O ratio is preferentially enhanced in the case of active-region footpoints. Events with lower-than-average SEP C/O are also preferentially associated with active-region footpoints. By contrast, the distributions of Fe/O and C/O for the in-situ solar-wind thermal particles in these time intervals are essentially indistinguishable. Pending a larger-scale study, these results tentatively suggest that suprathermal ions are the preferred seed particles for shock acceleration, with suprathermals associated with active regions having larger heavy-ion enhancements than suprathermals associated with coronal holes. To our knowledge, these results are the first successful example of tracking SEP event-to-event compositional variation back to differences in the solar source regions. These results open a new window on the origin of SEPs, as well as the possibility of using SEP data to improve solar and heliospheric magnetic-field mapping techniques.

FEATURES OF RELATIVISTIC SOLAR PROTON SPECTRA DERIVED FROM GLE MODELING

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With the developed by the authors GLE modeling technique the modeling study of 34 large GLEs for the period 1956-2006 has been carried out. The basic characteristics of relativistic solar protons (RSP) are obtained: a rigidity (energetic) spectrum, anisotropy axis direction, pitch-angular distributions and their dynamics studied in each of events. It is shown, that almost at each event there exists two components (population) of relativistic solar particles: prompt and delayed ones. Prompt component (PC) prevails in the beginning of event. It is characterized by an impulsive profile, strong anisotropy and exponential energetic spectrum: $J(E) = J_0 \exp (E/E_0)$. Delayed component (DC) dominates at a maximum and at a decline phase of event. It has a gradual intensity profile, a moderate anisotropy and the power law energetic spectrum: $J(E) = J_1 E^{-\gamma}$. The analysis of the large number GLE shows, that the value of E_0 in the exponential spectrum of PC has rather stable meaning ~0.5 GV in the majority of events. Only in a few cases the meaning of E_0 becomes close to 1 and higher. The value of a spectral exponent γ is distributed from 4 up to 6 with a maximum at $\gamma = 5$.

The exponential spectrum of PC with E_0~0.5 GV well agrees to the spectrum obtained by a simulation of acceleration of protons in an electric field, arising during the magnetic reconnection in the solar corona. The power law spectrum of DC with a spectral exponent γ=5 is close to the modeled spectrum arising in the process of stochastic acceleration in a turbulent solar plasma. Another possible way for DC generation is acceleration by a coronal shock wave.

It is noted, that derived by GLE modeling the DC spectrum well agrees with time of maximum (TOM) spectrum obtained from direct measurements by spacecrafts and balloons of solar protons in an adjacent energy range 50-500 MeV. The spectrum of PC has no continuation in lower energy area that is probably connected to features of its generation mechanism.

THE THREE DIMENSIONAL NON STATIONARY MODEL OF THE FORBUSH DECREASE OF GALACTIC COSMIC RAY INTENSITY WITH THE CHANGEABLE SOLAR WIND VELOCITY

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We develop three dimensional (3-D) non stationary model of the Forbush decrease (Fd) of the galactic cosmic (GCR) intensity based on the Parkerś transport equation taking into account diffusion, convection, drifts due to gradient and curvature of the interplanetary magnetic field (IMF), and on the heliospheric neutral sheet with the energy changes in the diverged solar wind. We include in the model of the Fd the change of the solar wind velocity and corresponding interplanetary magnetic field (IMF) components found as a solution of the Maxwellś equations. Besides, the model implements temporal changes of the exponent ν of the Power Spectral Density ($PSD \propto f^{-\nu}$, f is a frequency) of the IMF turbulence. We confirm a relationship between the rigidity spectrum exponent γ ($\delta D(R)/D(R) \propto R^{-\gamma}$) of the Fd and the exponent ν based on the numerical solutions of the 3-D non stationary model of Fd. We show that the results of the theoretical modelling are in good agreement with the experimental data.

Session 1: Solar and Heliospheric Cosmic Rays (Posters)

Conveners: B. Heber and R. Vainio

OBSERVATION OF SOLAR ENERGETIC PARTICLE (SEP) EVENTS ASSOCIATED WITH NARROW CMES

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We report on two proton energetic particle events observed by Energetic and Relativistic Nuclei and Electron (ERNE) instrument on the Solar and Heliospherical Observatory (SOHO), with intensities of $> 10^{-3}$ cm^{-2} sr^{-1} s^{-1} MeV^{-1} at the energy range of tens of MeVs. Both events were associated with CMEs of angular widths $< 60°$ and linear speed > 800 km s^{-1}. In one of the events there was no associated solar flare which indicate that the first injected protons were completely due to the associated CME and in the second event the calculated first injection time for protons of energies ~ 45 MeV and propagating along 1.2 AU path length, is before the starting time of the soft X-ray emission from the associated solar flare. These observations are inconsistent with the view that narrow fast CMEs are not associated with SEP events.

GROUND LEVEL ENHANCEMENTS OF SOLAR COSMIC RAYS AND THE RELATED SOLAR ACTIVITY DURING THE SOLAR CYCLE 23

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Abstract

Solar cycle 23 seems to be of great interest for the researchers due to many peculiarities. Having a relatively small sunspot number, an unusual distribution of the extreme solar events and especially of the ground level enhancements of the cosmic ray intensity, an unusual duration etc. was rather different from the previous ones. A study of the parameters of the sixteen ground level enhancements recorded during the approximately 12-year period of it (1996-2008) together with the associated solar activity, including the main properties of the solar flares, the coronal mass ejections and the radio bursts, has been realised. All studied cases seem to be connected with very intense flares of long duration, having a mean importance value of X3.8 and a mean duration of 164.5 min, with either halo or partial halo coronal mass ejections with a mean linear velocity of 1876 km/sec as well as with intense radio bursts. It is also noticed that the ground level enhancements of the 23rd solar cycle occurred after the onset time of the associated solar X-ray flares with a mean time delay of about 38 min, very useful result for their monitoring and prediction.

Effect of perpendicular diffusion on Heliosphere modulation of Cosmic Rays

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Galactic Cosmic Rays (GCRs) produced mainly from supernova events, are confined by the interstellar magnetic field to form a isotropic flux inside the galaxy. Before reaching the Earth they enter the Heliosphere and pass through the interplanetary magnetic field carried out by the Solar Wind; in this enviroment they undergo diffusion, convection, magnetic drift and adiabatic energy loss, resulting in a reduction of particles flux at depending on solar activity and polarity, called Solar modulation. Solving the famour Parkerś Fokker-Planck equation that describes the propagation of GCRs in the expanding Solar Wind we realized a quasi time-dependent 2D Stochastic Simulation of Solar Modulation that includes magnetic drift. In our model the simple Parker magnetic field is modified following the Jokipii-Kota approach that was developed to reproduce the Ulysses observation of a smaller latitudinal gradient in the polar regions. Our model is able to reproduce GCRs fluxes at 1 AU, supposed known the Local Interstellar Spectrum. We focused our attention on the diffusion tensor, in particular the perpendicular diffusion, related to the radial and latitudinal coefficients. We evaluated the importance of an enhanced perpendicular diffusion in the polar regions, that seems to be required in drift models. In this way we were able to reproduce with a better accuracy GCRs measurements in both solar periods.

DETERMINATION OF SOURCE FUNCTION, TIME OF EJECTION, AND DIFFUSION COEFFICIENT FOR SEP BY SATELLITE DATA, 1. THE CASES WHEN SIMULTANEOUSLY WERE OBSERVED ALSO GLE

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By one-min satellite data for different energy ranges we determine the changes in time of the Solar Energetic Particle (SEP) differential energy spectrum. Then by solving inverse problem we determine the SEP source function on the Sun, time of ejection into solar wind, and diffusion coefficient in interplanetary space. Because in this paper we consider cases when simultaneously was observed also GLE, we determine the changes of rigidity spectrum of SEP in high energy region out of the atmosphere and magnetosphere by using ground based neutron monitors (NM) data and the method of coupling functions (for transferring to the space, see in [1], Chapter 3). This method was applied to one minute data of different multiplicities obtained from NM on Mt. Gran Sasso (Italy) for the big GLE (Ground Level Event) at 29 September 1989 (see in [2], Chapter 2) and also for total neutron intensity by using two or several NM [3]. After determining how changed the rigidity spectrum of high energy SEP in space, we solve an inverse propagation problem and determine the time of ejection, source function, and diffusion coefficient for SEP propagation in interplanetary space. We compare results obtained for high energy SEP (by NM data) with obtained for small energy SEP (by satellite data) on SEP source function on the Sun, time of ejection into solar wind, and SEP propagation parameters in interplanetary space.

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[2]. L.I. Dorman, *Cosmic Ray Interactions, Propagation, and Acceleration in Space Plasmas*, Springer, Netherlands, 2006.
[3]. L. Dorman, A. Belov, E. Daibog, E. Eroshenko, R. Gushchina, V. Kalegaev, F. Keshtova, V. Kurt, I. Myagkova, M. Panasyuk, L. Pustil'nik, V. Yanke, B. Yushkov, and I. Zukerman "Forecasting model of expected SEP rigidity spectrum time variation on the basis of NM data at the beginning of GLE", Report on ECRS-2010.

DETERMINATION OF SOURCE FUNCTION, TIME OF EJECTION, AND DIFFUSION COEFFICIENT FOR SEP BY SATELLITE DATA, 2. THE CASES WHEN GLE SIMULTANEOUSLY DOES NOT OBSERVED

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In paper [1] we considered cases when simultaneously were observed Solar Energetic Particle (SEP) events on satellites and Ground Level Events (GLE) measured by NM. In present paper we consider only cases when SEP events on satellites were observed but it was no GLE. It means that these events were caused by SEP with relatively much smaller energy which cannot cross the atmosphere. By one- or five- min satellite data for different energy ranges we determine the changes in time of the SEP differential energy spectrum. Then by solving inverse problem (see in [2], Chapter 2) we determine the SEP source function on the Sun, time of ejection into solar wind, and diffusion coefficient in the interplanetary space. Then can be determined the change in time of SEP spectrum during full event and estimated the radiation hazard. For checking the model, we compare obtained results for historical events with observation data. This procedure may be realized in real time scale, what give important possibility to forecast automatically the expected time variation of SEP fluxes and estimate expected radiation hazard for space-probes and satellites, and in some cases for airplanes at high latitudes and high altitudes (mostly for regular air lines at about 10 km), and produce corresponding ALERT.

References:

[1]. L. Dorman, A. Belov, E. Daibog, E. Eroshenko, R. Gushchina, V. Kalegaev, F. Keshtova, V. Kurt, I. Myagkova, M. Panasyuk, L. Pustil'nik, V. Yanke, B. Yushkov, and I. Zukerman”Determination of source function, time of ejection, and diffusion coefficient for SEP by satellite data, 1. The cases when simultaneously were observed also GLE”, Report on ECRS-2010.

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FORECASTING MODEL OF EXPECTED SEP RIGIDITY SPECTRUM TIME VARIATION ON THE BASIS OF NM DATA AT THE BEGINNING OF GLE

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The rigidity spectrum of solar energetic particles (SEP) out of the atmosphere and magnetosphere may be determined by ground based neutron monitors (NM) with using for transferring to the space the method of coupling functions, see in [1], Chapter 3). This method was applied to one minute data of different multiplicities obtained from NM on Mt. Gran Sasso (Italy) for the big GLE (Ground Level Event) at 29 September 1989. It was shown that by this method is possible to determine how changed the rigidity spectrum of SEP in space, and then by solving an inverse propagation problem to determine the time of ejection, source function, and diffusion coefficient for SEP propagation in interplanetary space (see review in [2], Chapter 2). This procedure may be realized in real time scale, what give important possibility to forecast automatically the expected time variation of SEP fluxes and estimate expected radiation hazard for space-probes and satellites, for airplanes and some objects on the ground, and produce corresponding ALERT.

In present paper we extend the mention method by using only total neutron intensity data but obtained by two or several NM with different cutoff rigidities and with the same or with different altitudes (i.e., with different coupling functions). After determining by spectrographic method SEP rigidity spectrum in space at different moments of time, we try to solve inverse problem and determine the time of ejection, source function, and diffusion coefficient for SEP propagation in interplanetary space. In the first we made this for the GLE at 29 September 1989 and compare with previous results obtained by using only one NM, but with different multiplicities. After this we estimate the expected time variation of SEP fluxes during all event and recalculate by method of coupling functions of what intensity must be detected different NM. The comparison with observations will show from what Δt after beginning of GLE will start to work well the extended model. The checking of the model we suppose to made also by data of some other big GLE.

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[2]. L.I. Dorman, *Cosmic Ray Interactions, Propagation, and Acceleration in Space Plasmas*, Springer, Netherlands.

LONG-TERM GALACTIC CR VARIATIONS AND FORECASTING OF RADIATION DOZES FOR SPACECRAFTS AND AIRCRAFTS

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For long-line aircrafts on regular airlines at altitude about 10 km and crossed high latitudes as well as for long-lived spacecraft missions to Mars or other planets the radiation dozes are determined mostly by galactic cosmic rays (CR). To estimate the expected radiation doze we, at the first, determine the dimension of modulation region, radial diffusion coefficient, and other parameters of convection-diffusion and drift mechanisms of galactic CR long-term variation in dependence of particles energy, level of solar activity (SA) and general solar magnetic field. The important information we obtain based on CR and SA data in the past taking into account the theories of convection-diffusion and drift global modulation of CR in the Heliosphere (see in [1], Chapter 2). By using these results and published regularly elsewhere predictions of expected SA variation we may made prediction of expected in near future long-term cosmic ray intensity variation. We introduce new nominations: integral multiplicity and coupling function for radiation dose inside aircraft or spacecraft caused by galactic CR (similar to used for CR as was described in [2], Chapter 3). By the method of coupling functions, we estimate the connection between CR intensity long-term variation and radiation hazard for aircrafts in dependence of altitude, geomagnetic cutoff rigidity, and shielding inside aircraft and for spacecraft in dependence of trajectory in interplanetary space and shielding. We show that by this way we may made monitoring and prediction of expected radiation doze from galactic CR for any aircraft lines (characterized by dependence from several parameters: altitude, cutoff rigidity, and shielding) and for any spacecraft missions.

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THE INVERSE PROBLEM FOR SEP PROPAGATION AND GENERATION IN THE FRAME OF ANISOTROPIC DIFFUSION AND IN KINETIC APPROACH

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It is well known that energy spectrum of solar energetic particles (SEP), observed by ground based neutron monitors and muon telescopes (in high energy region; the transfer to the space from the ground observations is made by the method of coupling functions, see in [1], Chapter 3), and by detectors on satellites and space-probes (in small energy region) changed with time very much (usually from very hard at the beginning of event to very soft at the end of event). The observed spectrum of SEP and its change with time is determined by three main parameters: energy spectrum in source, time of ejection, and propagation mode. In the past we considered the first step for forecasting of radiation hazard: the simple isotropic mode of SEP propagation in the interplanetary space [2]. It was shown that on the basis of observation data at several moments of time could be solved the inverse problem and determined energy spectrum in source, time of ejection, and diffusion coefficient in dependence of energy and distance from the Sun. Here we consider the inverse problem for the complicated case: mode of anisotropic diffusion and kinetic approach. We show that in this case also the inverse problem can be solved, but it needs NM data at least at several locations on the Earth. We show that in this case the solution of inverse problem starts to work well sufficiently earlier than solution for isotropic diffusion, but after 20-25 minutes both solutions give about the same results. It is important that obtained results and reality of used model can be controlled by independent data on SEP energy spectrum in other moments of time (does not used at solving of inverse problem). On the basis of obtained results can be estimate the total release energy in the SEP event and radiation environment in the inner Heliosphere, in the magnetosphere, and atmosphere of the Earth during SEP event.

References:

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FORBUSH DECREASES - CLOUDS RELATION IN THE NEUTRON MONITOR ERA

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The proposed influence of cosmic rays on cloud formation is tested for the effect of sudden intensity changes of CR (Forbush decreases) on cloudiness. An attempt is made to widen investigated period beyond the period covered by satellite observation of cloudiness. As an indicator of cloud cover, the diurnal temperature range (a quantity anticorrelated with cloudiness) is then inspected for the days around a set of Forbush decreases. The results of superposed epoch analysis for different climate zones are presented.

Solar event onset detection on board LISA-PF

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LISA (Laser Interferometer Space Antenna) is the first mission devoted to the detection of gravitational waves in the frequency range 10^{-4} - 10^{-1} Hz in space.
A LISA precursor mission, the LISA Pathfinder (LISA-PF) was designed to meet the LISA requirements within one order of magnitude. The LISA-PF launch is scheduled in April 2012; the data taking will last a period spanning from 6 months to 1 year. Galactic cosmic-ray (GCR) and solar energetic particles charge free-fall test-masses used for gravitational wave detection. Therefore, high energy particles constitute one of the most relevant sources of noise on board the LISA missions. Radiation monitors (RM) were built for LISA-PF for overall proton and helium detection above 100 $MeV(/n)$. We present a preliminary work on solar event nowcasting on LISA-PF using RM count-rate and particle ionization energy losses. We carried out a Monte Carlo simulation using the Fluka program to investigate the detection capabilities of flare onset by the LISA-PF RM. The GCR background, modulated by short-term fluctuations, was taken into account. The results of this work, correlated with test-mass charging, will indicate if it will be necessary to build improved particle detectors for LISA for solar electron detection allowing solar event forecasting.

SOLAR PROTON EVENT'S PRODUCTION IN RELATION TO THE ASSOCIATED CORONAL MASS EJECTIONS

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In this work a study of the main properties of all detected coronal mass ejections (CMEs) from the Solar and Heliospheric Observatory (SOHO) mission from January 2006 until December 2008 as well as their association with the connected solar proton enhancements is performed. The primary findings of this study are that the coronal mass ejections escaping from the Sun vary in the same way as the sunspot number only during the rising phase of the solar cycle 23, while in the maximum and the declining phase of this cycle they present large fluctuations and secondly that these ejections seem to be well connected with SXR flares with importance > M4 (correlation coefficient $r = 0.7$). The probability of detection of a solar proton enhancement with flux > 0.1 pfu at energy > 10 MeV at the Earth's orbit before or after the associated coronal mass ejections with respect to different properties such as their linear speed and kinetic energy, is also estimated giving interesting results for Space Weather applications.

LATITUDINAL AND RADIAL GRADIENTS OF GALACTIC COSMIC RAY PROTONS IN THE INNER HELIOSPHERE - PAMELA AND ULYSSES OBSERVATIONS

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The PAMELA (Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics) space borne experiment was launched on the 15th of June 2006 and is continuously collecting data since then. The apparatus measures electrons, positrons, protons, anti-protons and heavier nuclei from about 100 MeV to several hundreds of GeV. Ulysses, launched on the 6th of October 1990, was placed in an elliptical, high inclined (80.2°) orbit around the Sun, and was finally switched off in June 2009. It has been the only spacecraft exploring high-latitude regions of the inner heliosphere. The Kiel Electron Telescope (KET) aboard Ulysses measures electrons from 3 MeV to a few GeV and protons as well as helium in the energy range from 6 MeV/nucleon to above 2 GeV/nucleon. Due to the spacecraft's trajectory, the measurements reflect not only the temporal variations but also the spatial distribution. In order to determine the radial and latitudinal gradients of galactic cosmic rays in the inner heliosphere, we use the PAMELA measurements close to Earth, which reflects their temporal variation. In this contribution we focus on the 23rd solar minimum and report the corresponding gradients for protons in the energy range from $\sim$1 GV to above 4 GV.

27 - DAY VARIATION OF GALACTIC COSMIC RAYS IN THE 23RD CYCLE

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We study the 27-day variations of the galactic cosmic ray (GCR) intensity and three dimensional anisotropy connected with the solar rotation in the last cycle of solar activity. We established that the amplitudes of the 27-day variations of the galactic cosmic ray intensity and anisotropy in the minimum epochs of solar activity in the positive polarity period are greater than in the negative polarity period are related with the heliolongitudinal asymmetry of the solar wind velocity. We found that the long - lived (22 years) active regions of the heliolongitudes are the sources of the long-lived 27-day variation of the solar wind velocity during the A > 0 polarity period. We compare our recent findings based on the data of the last minimum epoch of solar activity with our earlier results.

SOLAR DYNAMO PROBLEM IN THE 27-DAY VARIATION OF THE GALACTIC COSMIC RAYS INTENSITY

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It is very well known that differential rotation can produce a toroidal field from a poloidal one. But the nature of a vise-versa process arises a problem - how to describe the physical mechanism which generates poloidal component of the magnetic field.
Analysing a long period changes (1958-2009) of the 27-day variation of the galactic cosmic rays intensity, solar activity, solar wind and geomagnetic activity parameters we found a clear recurrence in the temporal changes of the amplitudes of the 27-day variation of the GCR and in some parameters of solar activity and solar wind. For being precise, we recognize noticeably established recurrence (cycling) with duration of three Carrington rotations period (3-CRP). We assume that a creation of the 3-CRP could be related with the Sun's differential rotation causing a conversion of the Sun's poloidal magnetic field into the toroidal.

EXTREMES OF THE LONG-TERM MODULATION OF COSMIC RAYS IN FIVE LAST SOLAR CYCLES

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We have carried out the analysis of the extreme values for long-term cosmic ray (CR) variations received from continuous near-earth space and on the Earth observations. The results are compared to the data of solar magnetic fields and sunspot numbers observations in five last cycles of solar activity (SA). The research is executed to compare SA cycles and to reveal the similarity and differences of CR modulation in them.

CR variations during the 19-23 SA cycles (1953-2009) for rigidity 10 GV are received with use of the global method in which three-parametrical form of rigidity spectrum of the isotropic part of CR variations is provided. As SA characteristics we used the sunspot numbers, average intensity of solar magnetic field and the tilt angle of the heliospheric current sheet. The main characteristics are obtained on the surface of a solar wind source at a distance of 2.5 solar radii and analyzed for the period 1953-2009 including direct observations of solar magnetic fields from the Wilcox Solar Observatory in 1976-2008 and indirect in 1953-1976.

The extremes behavior of the above-mentioned characteristics is considered during epoch of SA minima and maxima for 19-23 cycles separately on monthly and yearly average values. It is received that the 22-year wave in CR intensity is observed in SA minima and the amplitude of this wave grows from a cycle to a cycle reaching the greatest value in last years. Features of behavior of the extremes values modulation parameters in considered cycles and their relation with corresponding extremes values of long-term CR variations are discussed.

REAL TIME GLE MODELING AND RELATIVISTIC SOLAR PROTON PARAMETERS DEFINITION

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The technique of definition in real time of the characteristics of relativistic solar protons (RSP) using the data of neutron monitors (NM) from the NMDB data base is developed. The international Neutron Monitor Data Base (NMDB) was created (2008) in a frame of the 7-th European Framework Programme (FP7) Project. At present 25 NM stations, mostly European, submit real-time data with 1-minute resolution to the database. It allows operatively to discover a Ground Level Event (GLE) onset, and also to determine RSP parameters from the NM data. The limiting factors here are the limited number of NM stations (25 instead of usually used 35-40), and also allowable time of computations. They include calculations of asymptotic view cones of NM stations for the given moment of time and definition of RSP parameters by a least squares method. We developed a "truncated" technique of definition of solar proton parameters from the data of the limited number of NM stations and with a simplified procedure of computations. The truncated technique uses a number of simplifying assumptions about parameters of the RSP flux, which allow reducing the bulk and time of computations. Thus, we calculate asymptotic cones only for vertically incident particles. In a complete technique the contribution of oblique incident particles is taken into account also. A rigidity spectrum of particles is represented by a simple power law function that, by the way, is correct for the maximal phase of event. The results of computations of solar proton spectra with the short-cut technique practically do not differ from spectra obtained with a complete technique at energies less than 5 GeV. Thus the good agreement between derived from the neutron monitor data intensities of solar protons in the energy range of hundreds MeV with the data of direct measurements of solar protons at GOES-series spacecraft is observed. The maximum of increase on neutron monitors outstrips for several hours (5-10) an appropriate maximum of radiation-dangerous fluxes, registered by spacecrafts of GOES series. Thus, the real-time forecast of radiation hazard in space on the data of neutron monitors can be realized.

The Evolution of the galactic cosmic ray helium spectrum during an unusual solar minimum

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The scientific payload of the Solar and Heliospheric Observatory (SOHO), launched in December 1995, enables comprehensive studies of the Sun from its interior, to the outer corona and solar wind. In its halo orbit around the Lagrangian point of the Sun-Earth system the Comprehensive Suprathermal and Energetic Particle Analyzer (COSTEP) measures in-situ energetic particles in the energy range 44 keV /particle to >53 MeV In. The current 2000 solar minimum has been found to be exceptional low. The solar wind speed, its density and the interplanetary magnetic field strength is much lower than ever measured by in-situ instruments. The count rates of galactic cosmic rays as measured by neutron monitors and spacecraft close to Earth however, is not as high as expected by modulation models. Of special interest is therefore a detailed analysis of the cosmic ray spectra. Here we will present a new analysis of EPHIN data in order to determine the time profiles of galactic cosmic ray helium above the nominal energy range.

IN SITU EVIDENCE OF PARTICLE ACCELERATION IN SHOCK-SHOCK INTERACTION

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We present a multi-spacecraft study of interplanetary (IP) shock interaction with the bow shock of the Earth on August 10, 1998. During the event, ACE was located near the Lagrangian point L1, Wind at $X_{\rm GSE}$ = 78 $R_{\rm E}$ (1 $R_{\rm E}$ = 6371 km), while IMP8, Geotail, and Interball-Tail where in front of the Earth bow shock, at dusk-side, nose, and dawn-side, respectively.

The interplanetary magnetic field cone angle before the IP shock passage is quasi-parallel, about 23 degrees. Hence the foreshock of the bow shock covers most of the dayside and extends far into the solar wind: both Interball and Geotail observations show evidence of foreshock type fluctuations. The solar wind speed before the IP shock passage is 400 km/s, and the Alfvén Mach number of the flow is about 8. (Alfvén speed is 49 km/s is the free solar wind and 61 km/s in the foreshock).

The IP shock crosses first ACE and Wind and then IMP8, Geotail, and Interball, in that order, thus hitting the bow shock from the flank. According to our analysis, the IP shock was already interacting with the bow shock at the time it crossed IMP8. The IP shock causes inward motion of the bow shock, launching perturbations along the bow shock and particles along magnetic field lines back to the solar wind.

Geotail observed an increase in the low energy particles during the IP shock crossing. However, the high energy particles peaked 2 minutes later, when the spacecraft was magnetically connected to the shock-shock interaction region. We attribute these particles to be accelerated by the interaction.

NEXT GENERATION OF COSMIC RAY APPLICATION: SPACE AND GROUND BASED CME IMAGING WITH HIGHLY MINIATURIZED COSMIC RAY MONITORS

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The paper describes the physics behind and status of CME imaging by cosmic rays. In contrast to space based UV telescope for imaging CMEs, space based telescopes for primary cosmic ray measurements and ground based cosmic ray muon telescopes are much better space weather prediction tools. The physics and technology behind space based CME imaging cosmic ray telescopes and results of space weather forecast from the international Ground based Muon Detector Network (GMDN) will be presented and compared. In addition highly miniaturized cosmic ray monitors foreseen for usage in space to measure the cosmic ray spectrum during space weather storm conditions will also be sketched.

Interplanetary magnetic field structures guiding relativistic solar particles

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The origin and the propagation of relativistic solar particles (450 MeV- few GeV) in the interplanetary medium remains a complex topic. These particles, detected at the Earth by neutron monitors (called Ground level enhancements, GLE), have been previously accelerated close to the Sun. Before being detected at the Earth, these relativistic particles have to travel along the interplanetary magnetic field (IMF) connecting the acceleration site and the Earth.

The Parker spiral is most often considered for ensuring the magnetic connection to the Earth. However, in most GLEs the IMF is highly disturbed, and the active regions associated with the GLEs are not always located close to the footprint of the nominal Parker spiral. If it is not the nominal Parker spiral, which IMF connects the acceleration site and the Earth during the GLEs? A possible explanation of relativistic particle propagation under these circumstances are transient magnetic structures, travelling in the IMF as Interplanetary coronal mass ejections (ICMEs). In order to check this interpretation, we studied in detail the interplanetary medium in which 10 GLEs of the last solar cycle propagate.

Using the magnetic field and the plasma parameter measurements (MAG and SWEPAM experiments aboard ACE), we found widely different IMF configurations during the GLES of the last activity cycle. Those included obvious cases of propagation in an ICME, as well as some cases consistent with a Parker Spiral. But we also found cases correponding to the propagation of relativistic particles in a highly disturbed Parker like IMF.

In an independant approach we applied the velocity dispersion analysis (VDA) of energetic particle arrival times at the SoHO/ERNE experiment and at the ground-based neutron monitor network. The derived path lengths travelled by energetic particles are fully consistent with the IMF shape determined previously. Thus, the length associated to particles propagating along the nominal Parker spiral is of the order of 1-1.2 AU, while the lengths associated with a disturbed interplanetary magnetic filed are found in the range 1.3-1.8 AU. For particles in an ICME, the velocity dispersion analysis gives a length approching 2 AU.

Strong solar X-ray bursts without energetic particle events

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Solar energetic particle (SEP) events are an important element of solar-terrestrial relations and space weather. Considerable efforts are devoted to develop the understanding of their relationship with flares and coronal mass ejections (CMEs), and to devise schemes for their prediction. Because of its easy availability, soft X-ray emission is widely used as an indicator of solar flares and as an element to forecast SEPs. This is based on empirical correlations of SEP peak fluxes with soft X-ray parameters, despite the fact that there need not be a direct link between the thermal soft X-rays and non thermal energetic particles. We investigate how close this association actually is, using GOES observations during the 23rd solar cycle (1996-2006). We compare the complete list of GOES soft X-ray bursts in the western solar hemisphere having peak flux above 10^{-4} W /m^2 (GOES X class; 69 events) with SEP observations in space. We confirm that the GOES list of major SEP events maintained at NOAA, which contains 93 events during the same time interval, is incomplete for several reasons. Even after its completion, however, a significant fraction of the western GOES X class flares are found to not be accompanied by SEP detected by the GOES spacecraft. We undertake a detailed study of the radio emission of these SEP-less flares and their association with CMEs, in order to identify if these events produced energetic particles in the corona, and if these particles were able to escape to interplanetary space.

WWW.NMDB.EU: The real-time Neutron Monitor database

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The *Real time database for high-resolution neutron monitor measurements* (NMDB) project, which was supported by the 7th Framework Program of the European Commission, hosts data on cosmic rays in the GeV range from European and some non-European neutron monitor stations. It offers a variety of user-friendly applications ranging from the representation and retrieval of cosmic ray data over solar energetic particle alerts to the calculation of ionisation doses in the atmosphere and radiation doses at aircraft altitudes. Furthermore the web site comprises public outreach pages in twelve languages and offers training material on cosmic rays for university students and researchers and engineers who want to get familiar with cosmic rays and neutron monitor measurements. This contribution presents an overview of the provided services and indications on how to access the database. Operators of other instruments are welcome to submit their data to NMDB.

THE ANALYTICAL DESCRIPTION OF GCR DISTRIBUTION AT THE TERMINATION SHOCK OF THE HELIOSPHERE

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A stationary approximation in case of spherical symmetry for a two-layer medium which consists of with moving magnetic inhomogeneties (solar wind) and all residual space with standing inhomogeneties (interstellar space) are considered. For interstellar space we use the phase density of GCR – $N_{out}(r, p, t)$ and for space of solar wind – $N_{in}(r, p, t)$. The density $N_{in}(r, p, t)$ satisfies the convection diffusion equation but the density $N_{out}(r, p, t)$ satisfies diffusive equation. At the termination shock $r = r_0$ we suppose the continuity particles densities ($N_{out} = N_{in}$) and streams ($j_{in} = j_{out}$) as a consequence of distribution function continuity [1]. After the solutions of the given mathematical problem it is possible to receive N_{out} and N_{in} for high (>2500 MeV) and low (<1400 MeV) energy particles. It has been analytically shown that on heliosphere border appears more particles of high energy CR than in the interstellar medium, whereas the particles of small energy are less (see Fig.1). These results correspond to the results obtained experimentally on the Voyager spacecraft [2, 3]. The distribution of cosmic rays for different values of the ratio of diffusive coefficients in a fixed interstellar medium and in a moved solar wind (χ_{in}/χ_{out}) are considered. The obtained signs of flows ($j_{high\ energy}(r, p) > 0$ and $j_{low\ energy}(r, p) < 0$) indicate that the low energy particles “are involved” into a heliosphere, and high energy particles “are pushed out” from it for stationary distribution. From the discovered anisotropy for high and low energy particles it is shown, that its module is increased from zero by the Sun to the maximum value on heliopause, and behind it, on the coutrary, decreases from a maximum to zero. The module of anisotropy for small energies is more than for the high energies in this case.

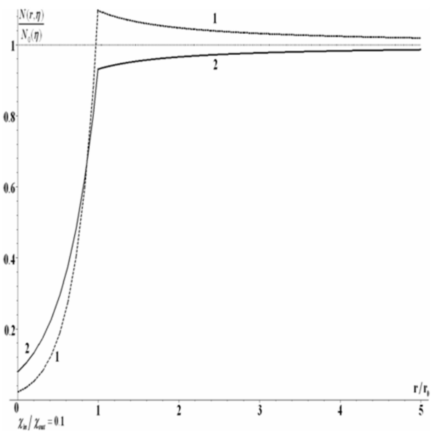

Figure 1: Dependency of CR concentration normalized to concentration on infinity $N(r, \eta)/N_0(\eta)$ from heliosphere distance r for low (curve-2) and high energy (curve-1) particles. The case $\chi_{in}/\chi_{out} = 0.1$ is shown.

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THE CONNECTION BETWEEN FORBUSH EFFECTS AND CORONAL HOLES IN THE LAST MINIMUM OF SOLAR ACTIVITY

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Forbush effects, connected with coronal holes, were investigated within the anomalous low solar and geomagnetic activity in 2007. These events are studied in this work, using hourly mean variation of cosmic ray density and anisotropy, derived from data of the neutron monitor network. Density and anisotropy of cosmic rays are analyzed together with the different components of the interplanetary magnetic field (IMF intensity, velocity, temperature and density of solar wind, date of SSC and time of SSC arrival at Earth), geomagnetic activity indices Kp and Dst using complex database, including cosmic ray density and anisotropy (equatorial component of the first harmonic of anisotropy). We use the Global Survey Method [1, 2] for the calculation of cosmic ray density and anisotropy components. The cosmic ray density variations, obtained for 10 GV rigidity, reflect solar disturbances responsible for the Forbush decreases with high accuracy. The connection between Forbush effects and coronal holes as well as features of cosmic ray anisotropy behavior are analyzed for the last minimum of solar activity.

[1] A. Asipenka, A. Belov, et al. Adv. Space Res., 43, 708, 2009.
[2] A. Belov, L. Baisultanova et al. J. Geophys. Res., 110, A09S20, 2005.

The Innsbruck Hafelekar CR observatory - a heritage with new perspectives

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The Hafelekar observatory is located in the mountains north of the city of Innsbruck, Austria, at an altitude of 2290 m. Soon after Victor Franz Hess was appointed Professor at the University of Innsbruck in the year 1931, a formerly used shack was tansformed into a laboratory for continuous measurements of cosmic rays. This presentation summarizes the history of the Hafelekar observatory and gives an overview about early scientific results that were obtained.

Besides the historic Apparatus of Steinke, which is still viewable in the museum part of the station, the observatory is equipped with a neutron monitor (NM-64, four tubes) and two muon scintillator telescopes. Plans will be presented to reestablish the station by renewing the registration system of the neutron monitor. Doing so, one aim is to include the Hafelekar station into the neutron monitor data base (NMDB).

CASTILLA-LA MANCHA NEUTRON MONITOR: SITUATION, DESIGN AND SIMULATIONS

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This work shows the present status of the Castilla-La Mancha Neutron Monitor (CaLMa). The design ant its develops is being performing thanks to recently funds granted by the Castilla-La Mancha Comunity government of Spain, this new station will be building and placed in the Alcalá University campus in Guadalajara. Being operative in a provisional site at the end of 2010 year. Although in its initial stage the active reactive was decided to be ^{3}He, as result of problems with ^{3}He availability, a new design based on $^{10}BF_3$ has been necessary. Nowadays, the station will be equipped with 6 BP28 and 12 LND SK01479 $^{10}BF_3$ counter tubes detectors, state of the art data acquisition systems and a design that will make it fully compatible with the Neutron Monitor Database (NMDB), providing data in real time. Details about geomagnetic conditions, design, schedule and first tests are presented.

THE HELIOLONGITUDINAL DEPENDENCE OF SOLAR WIND VELOCITY AND THE 27-DAY VARIATION OF COSMIC RAYS

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We develop a three dimensional (3-D) model of the 27-day variation of galactic cosmic ray (GCR) intensity with the heliolongitudinal dependence of the solar wind velocity. Maxwell equations are numerically solved to derive a divergence-free interplanetary magnetic field with variable solar wind speed reproducing in situ observations. We propose a model for the 27-day variation of the GCR intensity based on the Parker transport equation using the changeable solar wind velocity and the corresponding magnetic field. The predictable profile of the 27-day variation of cosmic ray intensity is compatible with neutron monitors experimental data. We show that the expected profile of the 27-day variation of cosmic ray intensity is inversely correlated with the modulation parameter z being proportional to the product of the solar wind velocity V and the interplanetary magnetic field strength B (z VB).

NUCLEAR INTERACTIONS IN THE FLARE SITES

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The production of light isotopes (D, T and ^{3}He) due to nuclear interactions of energetic protons and alpha-particles in flare regions is considered. The Monte Carlo method allows us to take into account several steps of particle interactions with ambient plasma as well as spatial diffusion and acceleration of ions. In our model the high abundance ratios of ^{3}He/^{4}He are obtained at certain simulation parameters. Subsequent interplanetary propagation effects could result in the energy spectra of ^{3}He, ^{4}He nuclei similar to the observed ones.

COSMIC RAY INTENSITY CHANGES AND GEOMAGNETIC DISTURBANCES ON THE PHYSIOLOGICAL STATE OF AVIATORS

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Over the last few years researches have resulted to the wide acceptance from the scientific community that geomagnetic disturbances and cosmic ray variations are related to the human physiological state. In this study medical data regarding 4018 Slovak aviators were analyzed in relation to daily variations of geomagnetic activity and cosmic ray intensity. Specifically daily data concerning mean values of heart rate and diastolic and systolic blood pressure, which were registered during the medical examinations of the Slovak aviators, were related to daily variations of cosmic ray intensity, as measured by the Neutron Monitor Station on Lomnicky Stit, provided by the high resolution neutron monitor database (http://www.nmdb.eu) and daily variations of Dst and Ap geomagnetic indices. All subjects were men in good health of age 18–60 years. This particular study refers to the time period January 1, 1994 till December 31, 2002. Statistical methods were applied to establish a statistical significance of the effect of geomagnetic activity levels and cosmic ray intensity variations on the aforementioned physiological parameters for the whole group. The Pearson r-coefficients were calculated and the Analysis of Variance (ANOVA) method was applied to establish the statistical significance levels (p-values) of the effect of geomagnetic activity and cosmic ray intensity variations on heart rate, arterial diastolic and systolic blood pressure up to three days before and three days after the respective events. Results show that there is an underlying effect of geomagnetic activity and cosmic ray intensity variations on the cardiovascular functionality.

About Shape of an Interplanetary Shock Front.

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The form of an interplanetary shock front has been investigated by the statistical methods. Results of determination the components of normals to the interplanetary shock fronts obtained from data of MAG and SWEPAM-I/E experiments at the ACE during from 1998 till 2003 years (about 200 measurements) are used. By the Bernoulli distribution slight asymmetries are revealed: 1) At probability 95% value of the north-south is 17%. Possibly, it is caused by more activity of the north semi-sphere of the Sun. 2) Similar east-west asymmetry is 44%. This asymmetry is ratio west part of area to whole area of shock front. Possibly, it is formed at propagation of a shock in the interplanetary space. The reason of asymmetry may be self-generation turbulence by the accelerated particles which influences on velocity of shock propagation. Quasi azimuth shape of the interplanetary shock front has been determined by the Monte Carlo method.

Calculation of the Cosmic Rays Intensity Dynamics Before the Geomagnetic Storms Onset Caused by the Interplanetary Shocks.

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The galactic cosmic rays intensity dynamics before geomagnetic storm onset in 9 September, 1992 have been calculated by the developed kinetic method. Comparison calculations with the observational data of muon detectors Nagoya and Sakashita and ones of World Network of neutron monitors shows in general satisfactory consensus both on amplitude and in time. The cosmic rays intensity dynamics in real interplanetary magnetic field (non Parker type) have been studied too. Obtained results can be used for classification of the geomagnetic storms precursors dynamics depending on the solar wind parameters.

MHD SIMULATIONS OF THE EVOLUTION OF SHOCK STRUCTURES IN THE CORONA: IMPLICATIONS FOR CORONAL SHOCK ACCELERATION

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Various transient phenomena such as EIT waves, metric type II bursts and solar energetic particle (SEP) events occur commonly in the solar corona following the eruption of coronal mass ejections (CMEs). While the exact nature and genesis of these disturbances is under debate, it is clear that impulsive CMEs induce large-amplitude waves in the solar corona during the lift-off process that influence the coronal environment. For instance, it is widely believed that large SEP events are associated with CME-driven shocks. Therefore, knowledge of the waves produced by evolving CMEs is essential for gaining insight into these dynamic phenomena.

In this study, we employ magnetohydrodynamic (MHD) simulations of an erupting CME to study the shocks and other large-amplitude waves induced by the eruption. Our model consists of a background steady state solar wind model accelerated by an ad-hoc heating function, on which an eruptive CME is superimposed. Paying special attention to the first ten minutes of the eruption, we study the evolution of the generated shocks and address their possibility to produce energetic particles.

THE SUNSPOTS AND COMETS

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For solution of the problem of the origin of sunspots and quasi-periodicity of changes of their number, first of all 11-year cycle, many various models connected to processes which occur or could occur on the Sun have been offered. However the satisfactory solution has not been found yet. This is confirmed by unexpectedly long minimum of the 24-th solar cycle. In this connection it seems expedient to consider a possibility of formation of sunspots as a result of external influence on the solar surface. As carriers of such influence various heavy bodies (comets, asteroids, and other celestial bodies) falling on the Sun can be considered. At movement of such bodies in the solar system, gravitational fields of the Sun and planets influence them. And periodicity of the rotation of planets around the Sun will generate quasi-periodicity among heavy bodies falling on the Sun. For example, such situation appears when large planets are concentrated in one sector and form a kind of gravitational lens focusing (defocusing) the flux of heavy bodies which enter into the boundaries of solar system. The probability of falling of heavy bodies on the Sun can depend on the position of the center of the Sun relative to the center of mass of the solar system (the center of mass of the solar system can be either inside the Sun or outside it).

It is known that the Sun has a magnetic field. In the beginning of each new 11-year cycle this field has a poloidal structure. Then due to differential rotation of the solar photosphere it gradually becomes a toroidal one. Falling of heavy bodies on solar photosphere causes disturbance of the toroidal magnetic field and serves as "a trigger hook" for the beginning of the process of formation of active regions and sunspots.

Unfortunately, possibilities of the experimental verification of this hypothesis are rather limited since it is extremely difficult to observe small heavy bodies falling on the visible part of the Sun. Heavy bodies falling near the edge of the solar disk can be an exception, but for their reliable identification the coincidence of several factors is required.

Apparently, such event took place on January 3, 2010 when the Sun was hit by the comet which was found by an Australian fan-astronomer Alan Watson on January 2. Falling of the comet occurred near the spot group area 1035 which was positioned at that time on the side of the Sun invisible from the Earth. On January 7 this area has appeared at the eastern edge of the Sun and on January 8 has obtained the number 1040. Taking into account the 27-day period of the Sun rotation and the time of occurrence of this area at the solar edge on January 7, it is possible to calculate that on January 2-3 the azimuth of the sunspot group 1035 was close to the azimuth of the center of mass of the solar system. Calculations show that on January 1-7, 2010, the center of mass of the solar system was at the distance of ~1.02 solar radius from the center of the Sun. In the table, azimuth of the Earth (φ_{Earth}), distance of the solar system mass center from the center of the Sun

(R_c), azimuth of the center of mass (φ_c) and that of the sunspot group area 1035 (φ_{1035}) in HAE (Heliocentric Aries Ecliptic) system of coordinates are presented.

Table 1. Position of the Earth, of the center of mass of the solar system and approximate azimuth of the sunspot group area 1035 in HAE system of coordinates.

Date	φ_{Earth},°	R_c, a.e.	φ_c,°	φ_{1035},°
01.01.2010 00:00	100.452	0.0047596	322.151	296.6
02.01.2010 00:00	101.470	0.0047586	322.225	309.9
03.01.2010 00:00	102.489	0.0047575	322.300	323.3
04.01.2010 00:00	103.508	0.0047565	322.375	336.6
05.01.2010 00:00	104.527	0.0047554	322.450	349.9
06.01.2010 00:00	105.546	0.0047544	322.525	3.3
07-01-2010 00:00	106.565	0.0047533	322.599	16.6

It is seen from the table that on January 3 the sunspot group area 1035 was close to the center of mass of the solar system. At this time the comet fell in this area. In Fig. 1, position of the center of the solar system mass and the direction to the Earth on 3.01.2010 00:00 UT are shown.

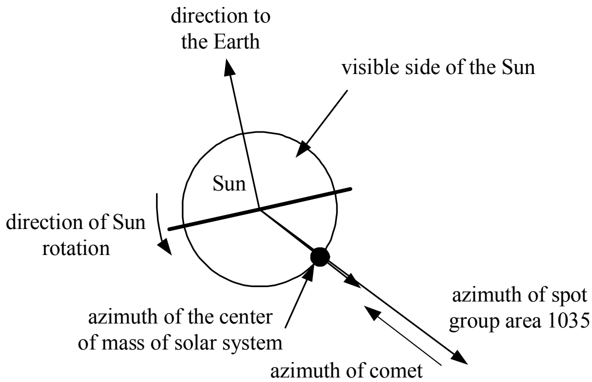

Figure 1. The scheme of azimuths of the comet, group of sunspots and the center of the mass of the solar system on January 3, 2010 00:00 UT. The view from the North Pole of the Sun in the ecliptic plane.

Thus, the coincidence of the azimuths of sunspot group area and the comet arrival on the Sun took place at the moment when they were in azimuthal closeness with the centre of mass of the solar system. This fact, certainly, cannot be the proof of the validity of the considered hypothesis of the sunspot formation by the heavy bodies hitting the solar surface. But it testifies to the necessity of the study of similar events.

TESTING COSMIC-RAY PERIODICITIES DURING A FORBUSH DECREASE

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Several solar flares occurred in September 2005 from the active region 10808. Ten of them had X-class greater than X 1.0. The first one (class X 17.0) occurred on September 7 at 17:40 U.T. and produced a large emission of Solar Energetic Particles (SEPs), as recorded by the on-board instruments of spacecrafts and satellites. The complex travelling perturbation associated with the activity of this huge solar storm generated a long-lasting Forbush decrease (FD), starting on September 10, 2005 at 24 UT (see Fig. 1). Even during the FD recovery two other big flares (both X 1.6 class) occurred on day 13 (at 19:27 U.T. and 20:04 U.T., respectively) and produced further effects on particle records obtained by the instruments on space vehicles as well as by the ground-based neutron monitors.

The 5-min neutron monitor data of September 2005 [1] recorded by SVIRCO Observatory and Terrestrial Physics Laboratory of IFSI-Roma (41.86° N, 12.47° E, about s.l.) were used to investigate the behaviour of cosmic ray (CR) periodicities (up to about 100 h) before and during the Forbush decrease.

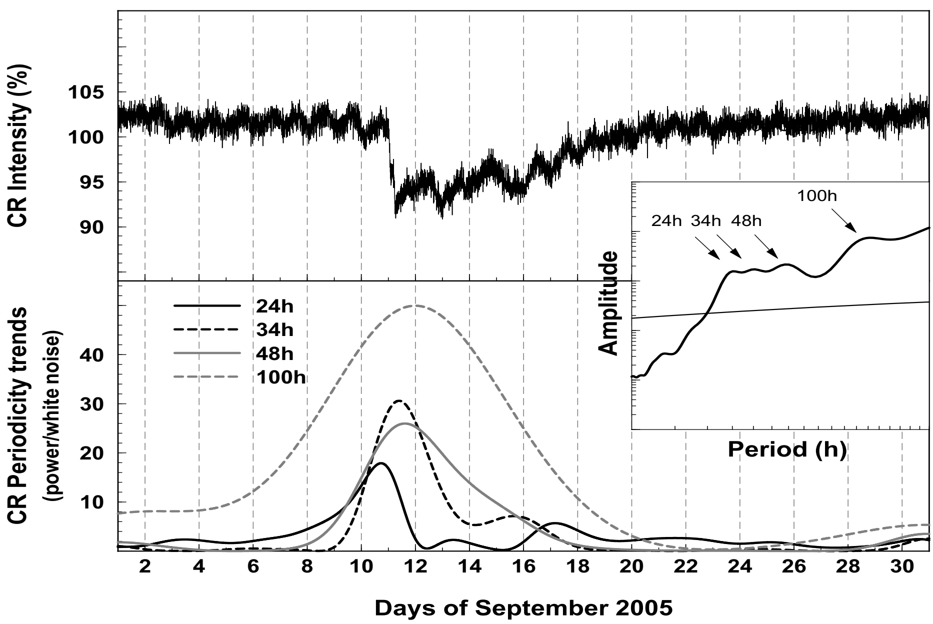

Figure 1. CR intensity recorded by Rome Neutron monitor (upper panel); power/noise ratio of the identified periodicities during September 2005 (lower panel); GWPS versus period (inset) from the 5-min Rome CR data.

The wavelet technique [2] was applied to the Rome time series (see upper panel of Fig.1) by using the Morlet mother function (plane wave modified by a Gaussian envelope; $\omega = 6$, $d_j = 0.0625$) and the main periodicities were identified.

The Morlet mother wavelet was chosen for its high capability in detecting the significant periodicities and their localization within the investigated time interval. It was found that four main periodicities have a persistent significant value (power/noise > 1), as shown in the lower panel of Fig.1. They are 24h, 34h, 48h, and 100 h (see the **GWPS** [Global Wavelet Power Spectrum] reported in the enclosed box of Fig.1); they were detected with an uncertainty lower than 4.5% (e.g. 24 h +/- 1 h).

Some modulation signatures on the cosmic-ray periodicities, identified before the Forbush decrease of September 10, 2005, were discussed by Diego and Storini [3]. Here attention is paid to the above periodicities and their interpretation.

Work partly performed inside ESS2 Project of the Italian Space Agency and partly for an ICES/IFSI-Roma Research Project. Rome neutron monitor is supported by INAF/UNIRomaTre collaboration. Thanks are due to C. Torrence and G. Compo for the original wavelet software (http://paos.colorado.edu/research/wavelet).

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THE RELATION BETWEEN LONG-PERIOD VARIATIONS OF THE GALACTIC COSMIC RAY INTENSITY AND THE INTERPLANETARY MAGNETIC FIELD TURBULENCES IN DESCENDING EPOCH OF SOLAR ACTIVITY (2002–2009)

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Data of super neutron monitors and data of the B_x, B_y, B_z components of the interplanetary magnetic field (IMF) have been used to study the relation of the long-period variations of the galactic cosmic ray intensity with the interplanetary magnetic field turbulences in descending epoch of solar activity (2002–2009). We have found the changes of the rigidity spectrum exponent γ of galactic cosmic rays (GCR) intensity variations and exponents ν_y, ν_z, ν_x of the power spectral density (PSD) of the B_y, B_z, B_x components of the IMF turbulences from 2002 to 2009. Thus, the different values of γ and ν and their relation above period shows, that during the ascending epoch of solar activity radical changes, of the large-scale structure of the interplanetary magnetic field fluctuations must take place.

PECULIARITIES OF MICROWAVE RADIO BURSTS AND CORONAL ACTIVITY FROM THE SOLAR FLARES PRECEDING TO THE LARGE FORBUSH DECREASE

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From the observational data NM Lomnicki Stit during 1997-2006 we analyzed the Forbush Decrease (FD) events with large amplitudes ($> 4 - 6\%$). For these events the features of solar flares at optical and radio ranges were studied.

As the rules, the flares preceding to the large FD were characterized by the power microwave bursts ($f = 15.5$ GHz) with fluxes increased to $10^2 - 10^3$ times. Usually during these flares were observed radio bursts of II,III types, CME with large velocities, disturbances at solar wind and geomagnetic storms with Dst < 100 nT (if $B_z < 0$ exists) and with delay about 2 days.

As the example, we discuss the events FD during the flares of X-XI 2003 and I 2005. The relations between FD and microwave bursts may be explained by the large amount of plasma and accelerated particles, ejected during the flares with power microwave and HXR bursts.

LONG-TERM CHANGES COSMIC RAYS INTENSITY AND SOLAR WIND TURBULENCE FOR THE LAST FOUR SOLAR ACTIVITY CYCLES

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We have analyzed the long-term changes of cosmic ray intensity and the energetic part of the spectrum of solar wind turbulence in the frequency range between $2.2 \cdot 10^{-6}$ and $1.39 \cdot 10^{-4}$ Hz for the last four solar cycles (1964-2009). We have shown that the turbulence spectrum of the last cycle No.23 is essentially different from the three preceding ones Ns.20-22. While the mean power of fluctuations was roughly constant for the interplanetary magnetic field strength as well as for the velocity and density of solar wind plasma, the level of relative small-scale irregularities of the solar wind was, and still remains, greatly reduced. We discuss implications of these peculiar features for the rising observed variations of cosmic ray intensities in end the solar cycle No.23.

Particle transport in a helical magnetic field in non-zero gyroradius approximation

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The cosmic ray transport in a gyrotropic turbulent medium with strong large scale magnetic field is considered. General expressions for the transverse diffusion coefficient and for the pitch angle diffusion coefficient are obtained in the drift approximation including the second order of ratio of the particle gyroradius and the correlation length of large scale magnetic fields. It is shown that the magnetic helicity gives contribution to the both diffusion coefficients in the first order of this ratio.

A SHANNON'S ENTROPY APPROACH TO THE TEMPORAL EVOLUTION OF SEP ENERGY SPECTRA

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The kinetic energy spectra of solar energetic particle (SEP) events contain information on the particle acceleration mechanisms. Several spectral laws have been proposed in the past, such as power law [1], soft exponentials, power law modulated by an exponential [2], broken power law [3]. The spectral shape is related to the characteristics of the CME-driven shock, which is believed to be responsible for particle acceleration in gradual SEP events [4]. Moreover, the particle spectra can be highly dynamic during each event due also to propagation effects [5-6]. On the other hand, impulsive SEP events are thought to be accelerated in solar flares and to propagate almost scatter-free from the Sun, and hence their spectrum should be that of accelerated particles.

Here, we have examined spectral characteristics and timing of some SEP events of solar cycle 23, obtained by using particle data from ACE/EPAM and SOHO/ERNE. Association with the solar sources is provided, when considering solar and interplanetary conditions for each SEP event.

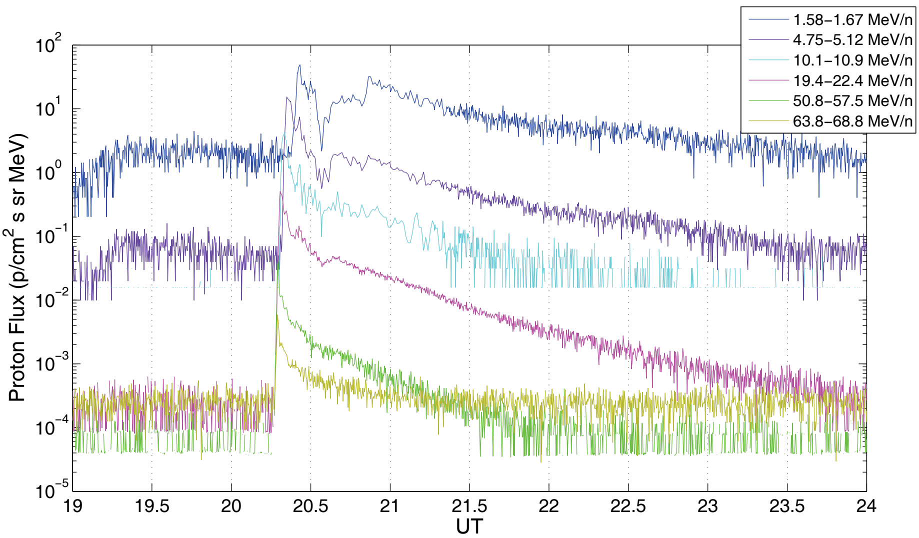

Figure 1. 20 February 2002 SEP event from some SOHO/ERNE energy channels.

In order to understand the nature of the considered events, the energy spectra evolution is studied by evaluating the time evolution of Shannon's entropy derived from the SEP energy spectra (see [7] and references therein). An example is given for the 20 February 2002 SEP event, reported in Figure 1. Lower panel of Figure 2 depicts the SEP flux

(Log F) as a function of time and particle energy. The temporal evolution of Shannon's entropy (upper panel in Figure 2) shows two main peaks, suggesting the existence of two different processes. A two component particle injection during the SEP event is proposed, which may result from the superposition of two solar events or from two different acceleration mechanisms.

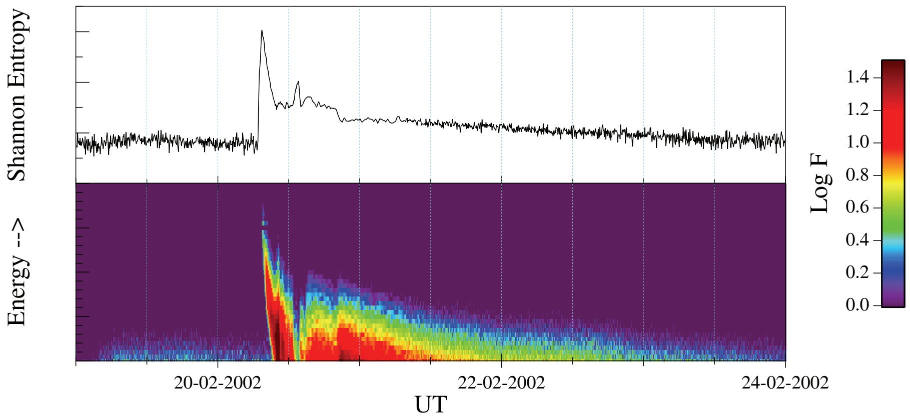

Figure 2. Time evolution of the Shannon information entropy (top) and of energy spectra (bottom) for 20 February 2002 SEP event.

Work performed for the BepiColombo Mission and the ESS2 Project of the Italian Space Agency.

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COSMIC RAYS IN THE CURRENT DEEP SOLAR ACTIVITY MINIMUM

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The experimental data on the galactic cosmic ray fluxes obtained from the measurements in the atmosphere during the period from 1957 till now are presented. They include the unusual long-term period of the solar activity minimum of 2006 - 2009. In 2009 we observed the highest cosmic ray flux (particles with energy more than 0.1 GeV) for the whole history of such measurements. Possible reasons of the extremely low solar modulation of galactic cosmic ray fluxes are discussed, among them the extremely low strength of the interplanetary magnetic field in 2008-2009.

NEW MAUNDER MINIMUM IN SOLAR ACTIVITY AND COSMIC RAY FLUXES IN THE NEAREST FUTURE

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During several years we have very low solar activity. As a result of it in 2009 the highest cosmic ray flux for the whole history of its monitoring was recorded. The analysis of the solar activity in the past and its relationship with the position of the solar system center mass shows that with a high probability we are at the beginning of long-term solar activity minimum like Maunder or Dalton ones. Our prediction on very low solar activity in the current solar cycle was made in 2008 and since the data on sunspot number confirm our prognosis. So, we expect high cosmic ray fluxes and low modulation of galactic particles during 23-rd solar cycle and subsequent ones.

SOLAR PROTON INJECTION IN DIFFERENT PHASES OF GRADUAL FLARES

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Time moments of 100 MeV solar proton injections into the heliosphere are plotted on flare plasma temperature time profiles for some gradual SEP events of the 23-rd solar cycle. Time moments of proton injection have been estimated from onsets of proton intensity enhancements in different locations in the heliosphere (GOES and ULYSSES) and temperature time profiles have been calculated from GOES soft X-ray data. The flare plasma temperature depends on balance between heating (electron spectrum and target density) and cooling (plasma expansion). Hard X-ray emission and charge particle injection close to the ecliptic plane data provide evidences that particle acceleration with hard spectrum may occurred in different physical conditions as for rising well as decaying temperature on a time scale of 15-20 min. The temperature decay corresponds to rise of the acceleration region height and decrease of the plasma density, i.e. operation of the coronal source of interplanetary propagating particles. At these moments the gamma-line intensity is arbitrary below the threshold of modern detectors. The release of solar energetic particles into the polar regions occurs during the late decay phase of gradual solar flares.

TEST OF THE NEUTRON MONITOR RESPONSE FUNCTION USING SPACE- AND BALLOON-BORNE DATA

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The ground-based network of neutron monitors is the principal instrument to study variations of cosmic rays on the long-term scale, since 1951. Although a neutron monitor (NM) is an energy-integrating device and cannot measure the energy spectrum of cosmic rays, one can, using a theoretically calculated yield function of the standard NM and data from NM's at different latitude, reconstruct the spectrum of primary cosmic rays, under an assumption on the spectral shape. It has been shown [1] that the energy spectrum of cosmic rays can be reconstructed from the NM data in the framework of the force-field approximation [2], as verified by several fragmentary balloon and space-borne measurements. On the other hand, there are uncertainties in the NM yield function computations, especially in the low energy range, as given by different groups.

There is another long-term data series of cosmic ray measurements – balloon-borne data of the ionizing radiation in the troposphere-stratosphere, obtained by the Lebedev Physical Institute [3]. These measurements, carried out routinely since 1957, provide the integrated flux of cosmic rays with energy above $\approx$180 MeV.

Here we make a comparison of the two long data sets, in the following way. First, using spectrum reconstruction based on NM data since 1951 ([1] and its extension at http://cosmicrays.oulu.fi/phi/phi.html) we computed monthly values of the corresponding integral flux above 180 MeV. Second, we compared these computed values with the measurements of the same quantity by the Lebedev institute balloons. The agreement is excellent for the major fraction of the last 50 years, confirming the validity of the approach and calibration of the NM yield function. On the other hand, there is a significant discrepancy during short periods in 1987 and 2009, which correspond to the solar minima with A- orientation of the interplanetary magnetic field. This may indicate that the sensitivity of a NM to low energy cosmic ray may be somewhat underestimated.

We discuss the overall agreement between the two data sets, and the reasons which can lead to the discrepancy, as well as possible implications for the long-term studies of cosmic ray modulation.

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THREE DIMENSIONAL (3-D) MODELS OF THE INTERPLANETARY MAGNETIC FIELD, 27-DAY VARIATIONS AND FORBUSH DECREASE OF THE GALACTIC COSMIC RAY INTENSITY

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Numerical solutions of Maxwell's equations for three dimensional (3-D) heliosphere with the heliolongitudinal and heliolatitudinal dependent radial solar wind speed for minimum epoch of solar activity are presented. We show that an inclusion of the spatial distributions of B_r , B_φ and B_θ components of the interplanetary magnetic field (IMF) makes 3-D models of the Forbush decrease (Fd) and the 27-day variations of the galactic cosmic ray (GCR) intensity more realistic and compatible with experimental data. As a source of the 27-day variations of the GCR intensity is considered a heliolongitudinal asymmetry of the solar wind velocity, while for the Fd that is changes of the IMF turbulence. Problem of intersections of the magnetic field lines is considered in case of interactions of the fast and slow streams of solar wind plasma. A possible formation of the heliolatitudinal component B_θ of the IMF near the helioequatorial region owing to existence of the heliolatitudinal component of the solar wind speed is discussed, as well.

Session 2: Cosmic Rays at Earth and Planets (Talks)

Conveners: S. McKenna-Lawlor and I. Usoskin

SIMULTANEOUS DETERMINATION OF LONG-TERM AVERAGE FLUXES OF CR MUONS AND SOLAR pp-NEUTRINOS

Ivan V. Aničin, for LOREX – collaboration *)

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The Allchar mine of southern FYR Macedonia contains the world's largest known concentration of thallium bearing minerals. LOREX (acronym for the geochemical LORandite EXperiment) is an international collaboration exploring the opportunity to use the rare mineral lorandite ($TlAsS_2$) for the simultaneous determination of both the average cosmic ray (CR) muon flux and the average pp-solar neutrino flux, over the 4.3 million year age of the deposit. Both fluxes will be determined by counting the extremely small number of atoms of the long-lived ^{205}Pb present in the mineral, produced by both muons and neutrinos in the reactions with the most abundant stable isotope, ^{205}Tl. CR muons participate in the reaction $^{205}Tl(\mu p,n)^{205}Pb$, whereas the neutrinos induce the capture reaction $^{205}Tl(\nu_e,e)^{205}Pb^* \rightarrow {}^{205}Pb$. Assuming a constant solar luminosity and using the currently favoured LMA WSM neutrino oscillation scenario and the estimated neutrino capture cross-section, the expected concentration of neutrinogenic ^{205}Pb is ~23 atoms per gram of lorandite. In contrast with the production of ^{205}Pb by solar neutrinos, which is independent of depth, cosmogenic ^{205}Pb production is strongly depth-dependent and, therefore, very sensitive to the long-term erosion history of the field area. The neutrinogenic ^{205}Pb component will be estimated by measuring, at the GSI, the total (neutrinogenic + muogenic) ^{205}Pb concentration at different depths in the Allchar mine, and extrapolating the downwards decreasing trend. The muogenic component is then obtained by subtracting the neutrinogenic, and the small depth-independent background concentration, from the total ^{205}Pb. The average CR muon flux is henceforth deduced by taking into account the experimentally determined erosion rate at the mining field, while the average solar neutrino flux is obtained from the knowledge of the experimentally determined neutrino capture cross section (to be hopefully measured at the GSI in near future). The best expected resolution of the proposed method is at present of the order of 30% at the 68%CL, i.e. we will be able to detect long-term departures from the modern neutrino and/or fast muon fluxes if they were bigger than 30%. Current status of this complex experiment will be discussed in some detail.

*) LOREX collaboration

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DAILY DISTRIBUTION OF HIGH IONIZATION COSMIC RAY COMPONENT ON THE “DOCH-4M” TELESCOPE

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During 5 year monitoring of high ionization cosmic ray component (25.07.01-08.02.06) on the vertical scintillation telescope “Doch-4M” with “living” time exposition more then 1200 days the large season variations were observed. Using the same material in the paper daily cosmic ray variations with tenfold ionization in telescope are studied. We observed the considerable daily variations before and it was reported in previous papers [1, 2].

But statistics collected for the latest years made it possible to introduce the results both summarized daily distribution of the telescope events selected by 5 years and selected daily distributions by seasons and by special Jupiter version of its nature in the 3-month Jupiter opposition (see Fig. 1, 2).

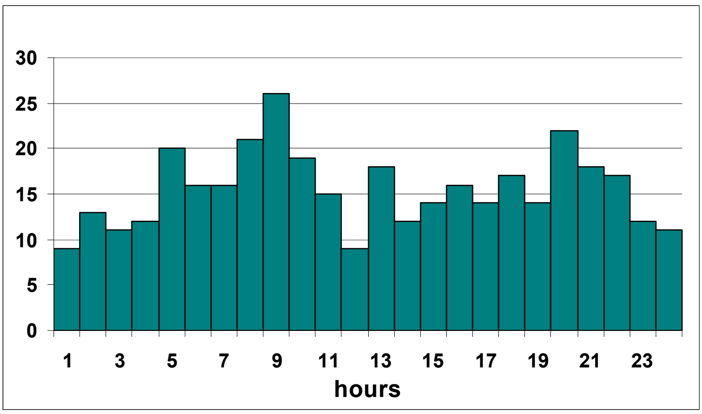

Figure 1. Total daily distribution of events (10м) of the telescope "Doch-4m" selected by 3 mohths of Earth-Mars opposition with annual shift on a month beginning from (Nov 2001- Jan 2002) to (Feb-Apr 2005)

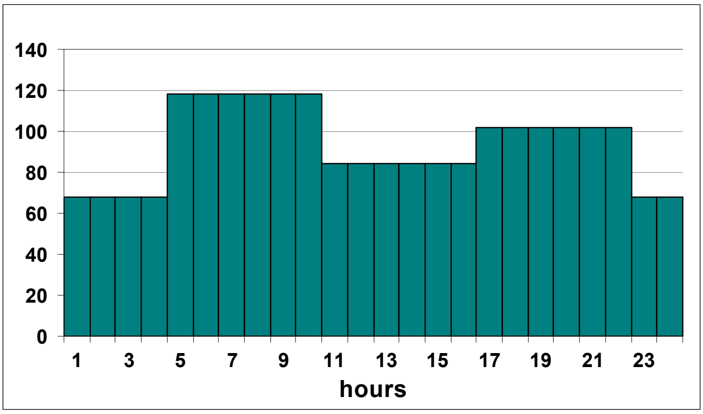

Figure 2. Total daily - 6-hourly distribution of 10м-events of the telescope "Doch-4m" selected by 3 mohths/year of Earth-Mars opposition (2001-2005)
Δ= (morning+evening) - (night+day) =
(118+102) - (68+84) = (220 - 152) = 68 +/- 19,3 (3,5 σ)

To explain the nature of these events by the Jupiter version the summation by various phases of the Earth-Jupiter disposition was made. The explanation of the morning & evening events excess, obtained in daily variations (up to 3.5 σ) within the frame of the Erzion model has been suggested.

In the work another kinds of selection concerning their daily distribution were analyzed too.

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PARTICLE FLUXES FROM THUNDERSTORM CLOUDS

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Thunderstorm and lightning are natural phenomena usual and enigmatic in the same time. Despite multiyear intensive research many questions, like high energy phenomena, are escaping from convincing experimental detection and theories and models are lacking to explain how lightning works. The cosmic rays ionize enough of the atmosphere to start an electron-photon to initiate electron-photon avalanche in the atmosphere in presence of strong electrical fields. Measured fluxes of energetic particles, as well as broad band radio emission, can provide necessary information for the new theories of the physical processes involved in the thunderstorm and lightning. The Aragats Space Environment Center facilities are routinely measuring fluxes of neutral and charged secondary cosmic rays incident the earth's surface. In 2009 we detect simultaneously very large fluxes of electrons, gamma-quanta and neutrons correlated with thunderstorm activity. During the period of the count rate enhancements lasting tens of minutes, millions of additional particles were detected. The energy spectra of electrons and gamma-quanta are rapidly falling and vanish at approximately 40 MeV. Here we show that our measurements support the particle multiplication and acceleration mechanism operated in the low atmosphere during the thunderstorms.

SPATIAL CHARACTERISTICS OF HIGH ENERGY ELECTRON AND POSITRON FLUXES OF SECONDARY ORIGIN IN THE NEAR EARTH SPACE

L.A. Grishantseva,[1] V.V. Mikhailov,[1] on behalf of the PAMELA collaboration

[1] National Research Nuclear University "MEPhI"

This paper presents precise measurements of spatial characteristics of quasi-trapped secondary electron and positron fluxes with energy more than 80 MeV below the Earth Radiation Belt (altitudes between 350 and 600 km). The results were obtained onboard the Resurs-DK satellite by the PAMELA spectrometer, a general purpose cosmic-ray detector system built around a permanent magnet spectrometer and a silicon-tungsten calorimeter. The satellite was launched on an elliptical orbit with inclination $70°$ on June 15^{th} 2006. A big volume of the experimental data allows a very detail analyzing of latitudinal and longitudinal dependences of the differential electron and positron spectra. These results are important both for investigation of different processes of particle generation and propagation in the near Earth space and for solving applied problems such as an estimation of radiation environment while developing instruments for spacecrafts.

GLOBAL HURRICANE ACTIVITY INTERCONNECTION WITH COSMIC RAY INTENSITY CHANGES

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In our previous works [1, 2, 3] we compared the behavior of single hurricane development with cosmic ray (CR) intensity changes in a comparatively small interval of time. Now we have data [4] for the general hurricane activities calculated for every single day since January 1, 1979. They are presented with the vortex velocity (W) and its change (dW/dt) averaged over all observed Thunder Storms (TS) and Hurricanes (H) over all parts of the Globe for the chosen day. It appeared that in 90.42% of all 10958 days of the 30 years period (1979–2008) somewhere over the oceans an atmospheric turbulence had occurred.

The active hurricane season is the late summer. So the global hurricane activities during the first part of the years are due to the turbulences in the Southern hemisphere and those in the periods June–November reflect mainly the combined hurricane developments in the Northern part of the globe. With the new data it is easy to estimate the averaged date of the hurricane North–South transition.

We compared the values of W and dW/dt calculated on the basis of all direct measurements in this 30 year period with the corresponding CR intensity data measured on different latitudes: from the extreme North to the extreme South. Different parallels between these data are made. The obtained relatively high correlation coefficients showed a well expressed interconnection between them. Obviously the ionization of the upper atmospheric layers due to the CR particles enhances the hurricane vortexes. Several conclusions about the effectiveness of forecasts based on CR intensity are made. A more detailed quantitative analysis of these dependencies is in progress.

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[4] J. B. Elsner – private communication 2010.

INVITED

Energetic particles near Earth: relations to Space Weather studies

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Measurements of energetic particles in the vicinity of Earth are important tool for space weather studies. Fluxes of particles energized within the magnetosphere as well as those arriving from interplanetary space and consequently influenced by the magnetosphere, are variable with strong changes during the events driven from solar surface. Cosmic rays measured on the Earth include the information about the interplanetary anisotropy and on the magnetospheric transmission variability. Magnetospheric particle populations are redistributed during the geomagnetic storms. Solar energetic particles and particles accelerated in interplanetary space penetrate the magnetosphere, and the boundary of penatration depends on the status of magnetosphere. Low altitude polar orbiting satellites observing energetic particles with instruments having large geometrical factor bring the information useful for checking validity of geomagnetic field models. An attempt to review selected recent results contributing to the study of space weather with use of energetic particle measurements provided within the magnetosphere is done and some of the open questions are emphasized.

STRONG VARIATIONS OF COSMIC RAY INTENSITY DURING THUNDERSTORMS AND ASSOCIATED PULSATIONS OF THE GEOMAGNETIC FIELD

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Strong variations of the intensity of secondary cosmic rays during thunderstorms, earlier interpreted as a consequence of feedback-loop generation of electrons and positrons in the strong electric field of thunderclouds, are found to be accompanied in some cases by very clear pulsations of the geomagnetic field. The experiment is carried out in the Baksan Valley, North Caucasus, the Carpet air shower array being used as a particle detector. Magnetic measurements are made with high-precision magnetometers located deep underground in the tunnel of the Baksan Neutrino Observatory, several kilometers apart from the air shower array.

Pitch-angle distribution of isotropes of protons trapped in radiation belt

Vitaly V. Malakhov [1], Vladimir V. Mikhailov [1], Lyubov A. Grishantseva [1] and Andrey G. Mayorov [1] for Pamela Collaboration

[1] National Research Nuclear University "MEPhI"

The PAMELA apparatus is installed on board of the Russian satellite Resurs DK-1 in a low Earth orbit with an inclination of about 70 degrees and altitudes between 350 to 600 km. The satellite has 3-axes stabilization with pointing accuracy better than one degree. PAMELA instrument was developed for the study of an antimatter component of cosmic rays in near-earth space in the energy range 80 MeV - 190 GeV for antiprotons and 50 MeV - 270 GeV for positrons. The device is also capable to measure charged particle spectra of protons, electrons, light nuclei and their isotopes, with a large statistic along its orbit. The PAMELA apparatus comprises a time-of-flight system, a magnetic spectrometer, a silicon-tungsten electromagnetic calorimeter, an anticoincidence system, a shower tail catcher scintillator and a neutron detector. Good angular resolution of Pamelaś tracking system make it possible to measure direction of particlesf́light in space with high accuracy. That allows to reconstruct pitch-angular distributions of particles in radiation belt and equatorial region. Angular efficiency of the instrument was calculated by Monte-Carlo modeling. A method of reconstruct pitch-angular distribution is presented here. This method is very important for analysis of trapped particle in the Radiation belt and is used for data processing in PAMELA-experiment. Pitch-Angular distributions was obtained on boundaries of SAA for proton and its isotopes of different rigidities in range from 0.5GV up to 3-4 GV.

Measurement of the charge ratio of atmospheric muons with the CMS detector

M. Mulders [1] and for the CMS Collaboration [2]

[1] European Organization for Nuclear Research (CERN)
[2] Cosmic Muon Solenoid collaboration – http://cms.cern.ch

A measurement is presented of the flux ratio of positive and negative muons from cosmic-ray interactions in the atmosphere, using data collected by the CMS detector at ground level and in the underground experimental cavern [1]. The excellent performance of the CMS detector allowed detection of muons in the momentum range from 3 GeV/c to 1 TeV/c. For muon momenta below 100 GeV/c the flux ratio is measured to be a constant 1.2766 +- 0.0032 (stat) +- 0.0032 (syst), the most precise measurement to date. At higher momenta an increase in the charge asymmetry is observed, in agreement with models of muon production in cosmic-ray showers and compatible with previous measurements by deep-underground experiments.

[1] The CMS Collaboration, Physics Analysis Summary, MUO-10-001, 2010. http://cdsweb.cern.ch/record/1259232?ln=en

COSMIC RAYS AND THE WIDTH OF TREE RINGS

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In October 2009, an interesting report was given by Dengel, Aeby and Grace [1]. They have measured the width of the tree ring collected at Scotland and tried to seek any periodicity involved in the data. Surprisingly they have found an 11 years cycle of the growth rate in the tree ring. They have compared their data with various parameters, humidity, and temperature and so on. But no strong correlation was found in those parameters. While what they have found is a correlation with solar activity. The tree ring grew up when the solar activity was low. They gave an interpretation for this correlation. According to the data analysis obtained from the meteorological station of Scotland, the cloudiness over Scotland changed with the solar activity. When the intensity of cosmic rays increased, the cloudiness over Scotland was also increased [3]. When the sky was covered by the cloud, the sunlight arrived on the tree as the diffused light. Then photosynthesis was advanced. The diffuse light is more effective for the growth of trees than the direct sunlight since it irradiates from all directions to the leaves of the trees with different wave length in comparison with the direct sunlight.

The purpose of this paper is to testify their report with use of another sample of tree collected in Japan. The tree was sampled in 1998 and has a record since 1607. We have searched any periodicity hidden in the width of the tree ring by the Fourier analysis method. We have found an interesting fact by this analysis and it may be worthwhile to report in this conference. In this paper after giving an explanation of our sample of the tree, we will provide results of analysis. Then in the last part, we will give a summary of this work.

[1] S. Dengel, D. Aeby and J. Grace, New Phytologist. 184 (2009) 545.
[2] M. Kulmala et al, New Phytologist, 184 (2009) 511.
[3] H. Svensmark and E. Friis-Christensen, J. Atmospheric and Solar-Terrestrial Physics 59 (1997) 1225.

ATMOSPHERIC DATA OVER A SOLAR CYCLE: NO CONNECTION BETWEEN GALACTIC COSMIC RAYS AND AEROSOL FORMATION EVENTS

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[3]Finnish Meteorological Institute, Finland
[4]Sodankylä Geophysical Observatory (Oulu unit), University of Oulu, Finland
[5]Institute of Physics, University of Tartu, Estonia
[6]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Germany
[7]Meteorologisches Observatorium Hohenpeissenberg, Deutscher Wetterdienst (DWD), Germany
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Aerosol particles affect the Earth's radiative balance by directly scattering and absorbing solar radiation and, indirectly, through their activation into cloud droplets. Both effects are known with considerable uncertainty only, and translate into even bigger uncertainties in future climate predictions [1-3]. More than a decade ago, variations in galactic cosmic rays were suggested to closely correlate with variations in atmospheric cloud cover and therefore constitute a driving force behind aerosol-cloud-climate interactions [4]. Later, the enhancement of atmospheric aerosol particle formation by ions generated from cosmic rays was proposed as a physical mechanism explaining this correlation [5].

Here, we report unique observations on atmospheric aerosol formation based on measurements at the SMEAR II station, Finland, over a solar cycle (years 1996-2008) that shed new light on these presumed relationships. By noting that i) ion production is driven by galactic cosmic rays over most of the atmosphere [6], ii) aerosol formation via ion-induced nucleation is thermodynamically easier than via neutral pathways [7] and iii) aerosol formation is a frequent phenomenon in the atmosphere [8], we make the following hypothesis: if cosmic ray –induced ionization intensity (CRII) was one of the major factors contributing to atmospheric ion numbers and if these ions had a significant effect on particle formation and growth, a connection between CRII and aerosol formation should be observed at any location. We study this hypothesis by comparing the intensity of atmospheric particle formation and particle number concentrations recorded at a boreal forest site in Hyytiälä, Finland, to corresponding CRII and geomagnetic activity at the same site. The correlations between CRII, geomagnetic activity and atmospheric particle numbers were further compared to solar radiation and its connection to particle formation. To study the fraction of ion-induced nucleation of total particle formation rates, we present results on the relative fraction of charged to neutral sub-3 nm particles and their formation rates in Hyytiälä and two other European sites (Hohenpeissenberg and Melpitz) as well as during airborne measurement campaign over central Europe.

Our analysis shows that none of the quantities related to aerosol formation (particle formation event frequencies, aerosol formation rates or the growth of the freshly-formed particles) correlates with the cosmic ray-induced ionisation intensity (see Fig. 1 for an example of the comparison between particle formation frequency and CRII). We also examined the contribution of ions to new particle formation on the basis of novel ground-based and airborne observations. A consistent result is that ion-induced formation contributes typically significantly less than 10% to the number of new particles, which would explain the missing correlation between CRII and aerosol formation. Our main conclusion is that galactic cosmic rays appear to play a minor role for atmospheric aerosol formation events, and so for the connected aerosol-climate effects as well (see also [9]).

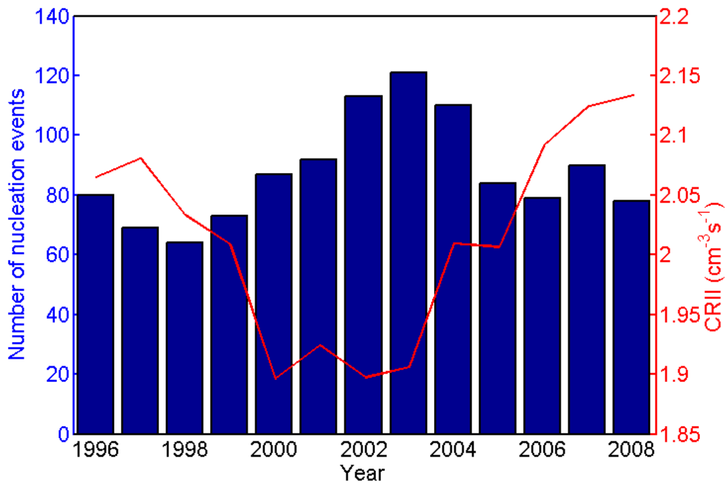

Figure 1. Particle formation events and CRII at the SMEAR II station in Hyytiälä, Finland during 1996-2008. The yearly numbers of particle formation events (blue bars) and the yearly median values of CRII (red line).

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Background radioactivity in the scaler mode technique of the ARGO-YBJ detector

I. Bolognino[1], C.Cattaneo[1], E.Giroletti[2], G.Liguori[2], P.Salvini[1] and on behalf of the ARGO-YBJ Collaboration[3]

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[3]

ARGO-YBJ is an extensive air shower detector located at the Yangbajing Cosmic Ray Laboratory (4300 m a.s.l., 606 g/cm2 atmospheric depth, Tibet, China). It is made by a single layer of Resistive Plate Chambers (for a total surface of about 6700 m2) grouped into 153 units called "clusters". The lowest energy threshold of the experiment is obtained using the "scaler operation mode", simply counting all the particles hitting the detector without any reconstruction of the shower size and arrival direction. For each cluster the signals generated by these particles are put in coincidence in a narrow time window (150 ns) and read by four independent scaler channels, giving the counting rates of >=1, >=2, >=3 and >=4 hits. The study of these counting rates has given unexpected results: while the MC simulations can account fairly well for the coincident counting rates, the expectation for channel >=1 is about half of the measured value. Moreover, the regression coefficient with the atmospheric pressure for channel >=1 is also about half of the value measured for the coincident counting rates: seemingly half of these counts did not cross the atmosphere. A measurement of the radioactivity of the ground below the detector and a MC simulation to estimate the contribution from this background effect on our counting rates is presented and discussed.

INVITED

Solar Energetic Particles and their effects on the chemistry of the middle and upper atmosphere

A. Seppälä

British Antarctic Survey (NERC), Cambridge, United Kingdom

This presentation will give an overview of what we have recently learned about the impact of Solar Energetic Particle (SEP) and the more general Energetic Particle Precipitation (EPP) on the polar middle and upper atmosphere atmosphere, the area of the Earth's atmosphere covered by altitudes from about 20 to 150 km (stratosphere - mesosphere - lower-thermosphere). Much new information of the particle impact on the polar middle and upper atmosphere has been gained in the recent years thanks to large data sets from atmosphere monitoring satellites becoming available. Of key role have been especially the observations made from satellite platforms such as the European Space Agency's Envisat satellite, *e.g.* observations from the GOMOS (Global Ozone Monitoring by Occultation of Stars) instrument as shown in Figure 1.

The focus of this presentation will be particularly on observations of the effects of particle precipitation on the chemical composition, such as ozone, NO_x, and HO_x of the polar middle and upper atmosphere. In addition to observations, results from modelling the effects of SEP events using a detailed ion and neutral chemistry model of the atmosphere will also be shown. Long term effects on the atmosphere and possible links to climate variability will be discussed.

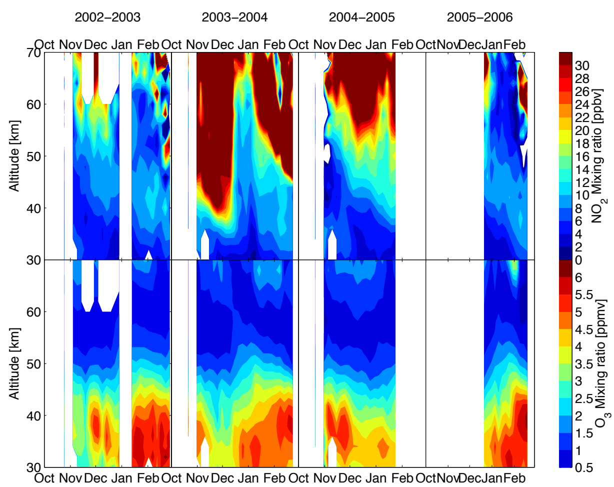

Figure 1: *GOMOS observations of Northern Hemisphere polar NO_x and O_3 showing enhancements of NO_x due to increased particle precipitation (e.g. Oct-Nov 2003) into the atmosphere and consequent ozone decreases.*

Atmospheric Ionization - comparison of data and simulation.

T.Sloan [1], G.A. Bazilevskaya [2], V.S. Makhmutov [2], Y.I. Stozhkov [2] and N.S. Svorzhevsky [2]

[1] Dept of Physics, Lancaster University, UK.
[2] Lebedev Physical Institute Russian Academy of Sciences, Moscow, Russia.

A long-term series of balloon-borne measurements of the charged particle flux in the atmosphere has been (and continues to be) performed by the Lebedev Physical Institute since 1957 at various latitudes and altitudes. These data at altitude above 15 km from the Earthś surface act as a good proxy for the primary cosmic rays. However, some additional temporal variations have been observed in the troposphere during the last 10 years or so. The measurements are compared with computations of the fluxes of particles originating from the interactions of cosmic ray primaries. Some deviations from the computations are noted.

SOLAR ENERGETIC PARTICLES IN THE TERRESTRIAL POLAR CAPS

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The short- and medium- term variability of several minor atmospheric components (e.g., O_3, NO, NO_2, OH, ClO, HOCl, HNO_3) have been extensively investigated in connection of the presence/absence of solar energetic particles (SEPs). SEP-induced ionization and/or atypical meteorological phenomena (e.g., stratospheric warming) are the sources of these variations in the Polar Regions. Since this issue is relevant not only for the Earth's environment (e.g. [1-3]) but also for other planets characterized by an atmosphere, currently we are continuing its study by using data from the Microwave Limb Sounder (MLS) on board the EOS AURA [4] and GOES [5] satellites.

The polar orbit of AURA allows the evaluation of the hemispheric impact of SEP events on the atmospheric components by using data from the same instrument. Our studies are mainly related to the 75-82 deg. geographic latitudes; this band is chosen because:

1. it is a suitable region to perform investigations by using zonal means on a daily basis.
2. it is completely located inside the polar caps, where SEP impact is quite uniform.
3. it is outside the auroral belt and this prevents a noticeable impact of other sources of ionization.
4. it is an area where the condition of winter night is roughly maintained for many months.
5. it is inside the core of the polar vortex;
6. it is a region less disturbed by planetary waves.

In particular, the large reactivity and the short life of HO_x components allow a detailed study of large/medium SEPs entering the Earth's environment. Our main results can be summarized as follows. The investigation of several SEP events occurred during solar cycle 23, showed that only a very large ionization, associated with outstanding SEP events, makes it possible to single out relevant variations in the mesospheric chemistry of the summer hemisphere (e.g. [1]). Storini and Damiani [2], instead, showed that it is possible to follow the mesospheric trail of SEP events inside the terrestrial polar caps (geomagnetic latitudes greater than 60 deg.), by using the recorded OH abundances during the winter time. Damiani et al. [3], studying the main SEPs occurred in 2005, underlined that a clear induced OH signature was present at that time mainly in the winter hemisphere, whereas in the summer one the effects were hidden by the elevated background values. In other words, the mesospheric OH abundance can be used as indicator for the SEP presence in the terrestrial environment, provided that meteorology is also taken into account.

Progress on the topic will be presented at the ECRS2010.

Work partly performed inside ESS2 Project of the Italian Space Agency (ASI contract I/015/07/0) and PNRA of Italy. Work at the Jet Propulsion Laboratory, California Institute of Technology, was done under contract with the National Aeronautics and Space Administration.

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MUON DIAGNOSTICS AS A NEW APPROACH TO ENVIRONMENT MONITORING AND FORECASTING

D.A.Timashkov

Scientific and Educational Center NEVOD, National Research Nuclear University MEPhI, Moscow, Russia

Galactic cosmic rays as well as secondary cosmic rays in the Earth atmosphere are under impact of various dynamic atmospheric and extra-atmospheric processes. This opens possibility to use cosmic rays as a natural source of penetrative radiation with a high level of background stability and isotropy for monitoring of phenomena in the Earth atmosphere, near-Earth space and the heliosphere which cannot be revealed or explored by traditional ways. Such applications of cosmic rays are discussed for many years (see [1-2] and refs. therein) with different results of practical realizations (e.g. [3]).

At present, a new approach – muon diagnostics – for solution of this task is being developed [4]. Muon diagnostics is based on simultaneous detection of muon flux generated by high energy primary particles from the whole upper hemisphere. To develop such method it is necessary to create a special "screen" which can detect cosmic ray muons in real-time mode with sufficient angular resolution. For the first time, the detector of such type (muon hodoscope TEMP) was constructed in MEPhI (Russia) in 1995 [5]. TEMP setup consists of two pairs of coordinate layers each including two planes assembled of 128 narrow scintillation strips with PMTs. The number of different reconstruction directions for the hodoscope in the upper hemisphere is more than 60 thousand. The analysis of TEMP data, obtained during many year exposition, exhibited existence of significant correlations between active processes of atmospheric and extra-atmospheric origin and spatial and time muon flux variations.

The next step on this road was made with development of muon hodoscope URAGAN [6]. The detector is composed of a number of separate assemblies (supermodules). Each supermodule consists of eight layers of streamer tube chambers equipped with two-coordinate system of external readout strips and detects muons with high spatial and angular accuracies (1 cm and 1°, respectively) over a wide range of zenith angles (0°÷80°). The track parameters (two projection angles) are reconstructed in real-time mode and are accumulated in a two-dimensional array (muon matrix) during 1-min interval. Muon hodoscope URAGAN allows to detect and to reconstruct muon tracks from any direction of the upper hemisphere thus forming practically continuous angular distribution of muon flux.

A few sets of adjustment measurements were performed with a pilot URAGAN supermodule assembly in 2005. Now, all four supermodules of URAGAN are under operation and total area of the hodoscope has reached 46 m2. The on-line counting rate of URAGAN as well as the muon snap-shot of the upper hemisphere during the last hour of exposure is presented at web-page [http://nevod.mephi.ru/English/graph.htm]. For the analysis, URAGAN data are corrected both for barometric and temperature effects.

During last five years, a plenty of interesting and promising results have been obtained using URAGAN hodoscope. For example, the last GLE event in 23rd solar cycle was detected in muon flux, and 2D-images of muon flux dynamics during GLE have been obtained [7]. Analysis of muon rate variations during Forbush decreases (FD) registered by means of the URAGAN hodoscope gives possibility to study dependences of FD amplitudes on primary proton energy above the range accessible to neutron monitors and to obtain unique "muon images" reflecting angular dynamics of muon flux in events [8].

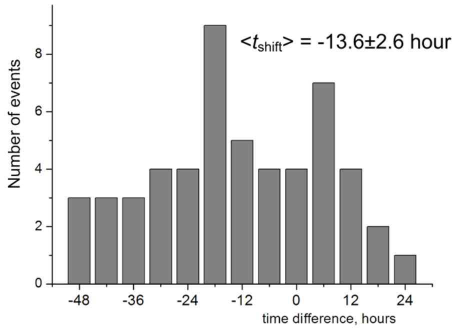

Figure 1. Distribution of difference of event onset in URAGAN and ACE

Promising opportunities muon diagnostics gives for forecasting goals. Analysis of URAGAN data during heliospheric disturbances shows that distortions in anisotropy of muon flux appear with time shift more than 10 hours before shock arrival to the Earth orbit determined from ACE data (Fig. 1).

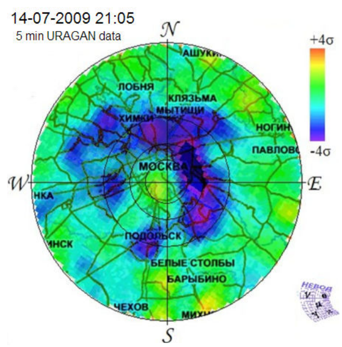

Figure 2. Muon snap-shot of thunderstorm cell

Time and angular resolutions make the muon hodoscope a unique instrument for study of local dynamic processes in the Earth atmosphere. Study of several tens of thunderstorms in the Moscow region shows that 80 percents of events are accompanied by the response in spatial-angular characteristics of muon flux [9]. The powerful thunderstorms were observed in muon snap-shots (Fig. 2), analysis of which allows to trace the atmospheric disturbance and to determine its size and structure.

In this talk, results obtained by means of URAGAN setup will be overviewed and main perspective directions of further development of muon diagnostics will be outlined.

The research is performed with the support of the Federal Target Program "Scientific and educational cadres for innovative Russia" and RFBR grant (08-02-01204-a).

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[9] A.S. Mikhaylenko et. al., will be presented at 22nd ECRS, Turku, Finland, 2010.

INVITED

COSMIC RAYS AND GLOBAL WARMING – AN UPDATE

A. D. Erlykin,[1] B. Laken,[2] T. Sloan,[3] and A. W. Wolfendale[4]

[1]Lebedev Institute, Moscow, Russia
[2]Sussex University, UK
[3]Lancaster University, UK
[4]Durham University, UK

Recent work of ours, and others, is examined from the standpoint of its relevance to the question: "what is the fraction of the terrestrial cloud cover – and with it the surface temperature – that is affected by the cosmic radiation?"

It is concluded that the fraction is very small, but finite.

Session 2: Cosmic Rays at Earth and Planets (Posters)

Conveners: S. McKenna-Lawlor and I. Usoskin

LARGE AREA SCINTILLATION MUON HODOSCOPE FOR MONITORING OF ATMOSPHERIC AND HELIOSPHERIC PROCESSES

N.V. Ampilogov, I.I. Astapov, N.S. Barbashina, V.V. Borog, D.V. Chernov, A.N. Dmitrieva, K.G. Kompaniets, A.A. Petrukhin, V.V Shutenko, A.I. Teregulov, I.I. Yashin

Scientific and Educational Center NEVOD, National Research Nuclear University MEPhI, Moscow, Russia

One of new and promising fields of the solar-terrestrial physics is muon diagnostics, intended to provide continuous remote monitoring and forecasting of the conditions of the atmosphere and near-terrestrial space. The experimental methods of muon diagnostics are based on simultaneous detection of muons from all directions of celestial hemisphere. The muon flux is generated in the upper atmosphere as a result of interactions of primary cosmic rays with air atomic nuclei, and, on the one hand, brings information about active processes in the heliosphere, which modulate the primary cosmic ray flux, and, on the other hand, about processes of geophysical origin, which occur in the atmosphere. The analysis of spatial-angular variations of muon flux detected in a real-time mode gives possibility to study such processes and to trace the dynamics of their changes, in particular, to reveal the disturbed regions, to determine directions and speeds of their movement and to evaluate the time of their appearance at a certain point. For these purposes the elaboration of detectors with large sensitive area (> 40 m^2) sufficient to provide required statistics in all directions of muon arrival and also with high angular (< 2°) accuracy is necessary.

The possibilities of muon diagnostics were demonstrated by means of detectors TEMP and URAGAN, both are located in MEPhI, Russia. Experience of their operation shows that the optimal detecting system for muon hodoscope design is the assembly of scintillation strips with the light collection on the basis of wavelength shifting (WLS) optical fibers. Such hodoscope represents a multichannel system for detection and reconstruction in the real-time mode of the tracks of every particle crossing the setup to provide the continuous zenith-azimuthal sensitivity to low-level variations (~ 0.1%) of the muon flux. Muon hodoscope has a modular structure and is constructed from basic units – modules, witch are constituted by 64 strips with WLS fibers coupled to one 64–pixel photodetector. Two such modules assembled in one plane represent the detection layer in order to cover 3.5×3.5 m^2 sensitive area. Two layers with orthogonally oriented strips make up a coordinate plane providing $X-Y$ track information. Supermodule of new scintillation muon hodoscope consists of several such coordinate planes.

Features of the hodoscope design are described and results of the tests of a full-scale basic detection module prototype are discussed.

The research is performed in Scientific and Educational Centre NEVOD with the support of the Federal Target Program "Scientific and educational cadres for innovative Russia".

STUDY OF TEMPORAL CHANGES OF THE FORBUSH DECREASE AMPLITUDE SPECTRUM EXPONENT BY MEANS OF MUON HODOSCOPE URAGAN

N.S. Barbashina, I.I. Astapov, A.N. Dmitrieva, L.I. Dushkin, K.G. Kompaniets, A.Yu. Kuzovkova, A.S. Mikhaylenko, A.A. Petrukhin, V.V. Shutenko, D.A. Timashkov, E.I. Yakovleva, I.I. Yashin

Scientific and Educational Centre NEVOD, National Research Nuclear University MEPhI, Moscow, Russia

Forbush decrease (FD) is one of the bright examples of solar activity impact on cosmic rays. It represents a sharp decrease of cosmic ray (CR) intensity caused by disturbances in interplanetary magnetic field connected with shocks in the solar wind. Studies of FDs at the Earth surface are mainly carried out by means of neutron monitors. This approach is used more than 50 years and is sensitive to variations of the cosmic rays with relatively low energies (units of GeV), which correspond to large amplitudes of observed effects. Now, neutron monitors are united into a worldwide network which allows to perform observations of cosmic ray variations over the globe, using detectors located at different points (e.g. [1]).

Creation of new type of cosmic ray detectors – muon hodoscopes [2, 3], which measure the cosmic ray muon flux simultaneously from different directions of the upper hemisphere with good angular resolution, allowed to study spatial-angular variations of muon flux and the dynamics of CR modulations in the near-Earth space by means of a single detector. In particular, measurements of zenith-angular dependences of the muon flux during FD allow to investigate this phenomenon in a wide energy range at different stages of the event development at a single point of observation.

In this talk, an analysis of muon flux intensity changes during Forbush effects detected by muon hodoscope URAGAN [4] on a decline stage of the 23rd solar activity cycle is presented. For the analysis, integral muon counting rate (10-minute data) corrected for barometric and temperature effects as well as counting rates in five zenith-angular intervals are used. The amplitudes of the decrease of muon counting rate during FD were obtained using a special unified technique [5]. Median energies of primary protons ($E_{0.5}$) which give the contribution to the changes of counting rate of the muon hodoscope for different zenith angle intervals were calculated and lie within the limits from 13 to 24 GeV [5]. The obtained dependences of the amplitudes on median energy of primary protons were fitted by a power function $E^{-\alpha}$. In Fig.1, these dependences are presented for two FDs detected on November 9 and December 14, 2006.

The main attention in this work is pointed at study of the changes of amplitude spectrum exponent α during different phases of Forbush effects. A similar research was performed earlier for the Forbush decrease of September 9, 2005 using the data of three neutron monitors and muon telescope at Nagoya [6]. Temporal and angular resolution of the muon hodoscope URAGAN allows to solve this task using a single detector.

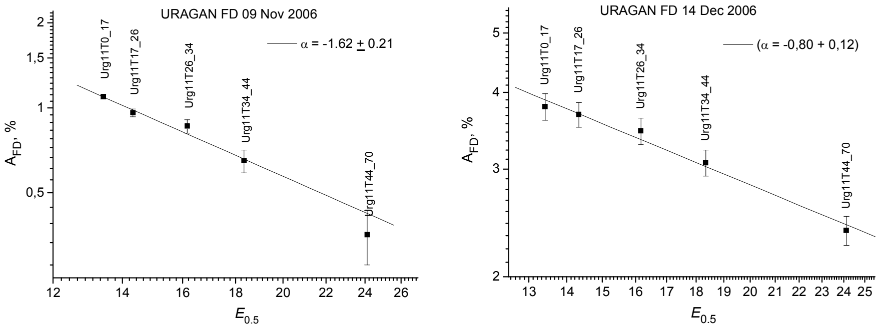

Figure 1. Dependence of FD amplitudes on median energy of primary CR.

On the basis of the analysis of Forbush decreases at the last stage of the 23rd solar cycle, the dynamics of the energy spectrum of the Forbush decrease amplitudes was obtained at three main phases of FD development: decrease, minimum, and recovery (Fig.2). Each of these phases can be associated with different stages of the development of corresponding heliospheric events: the phase of decrease is the approaching of the heliospheric disturbance to the Earth, the phase of the minimum corresponds to position of the Earth inside the perturbated region, the phase of recovery is a consequence of going away of the heliospheric disturbance. Comparison with the results obtained at lower energies is also discussed.

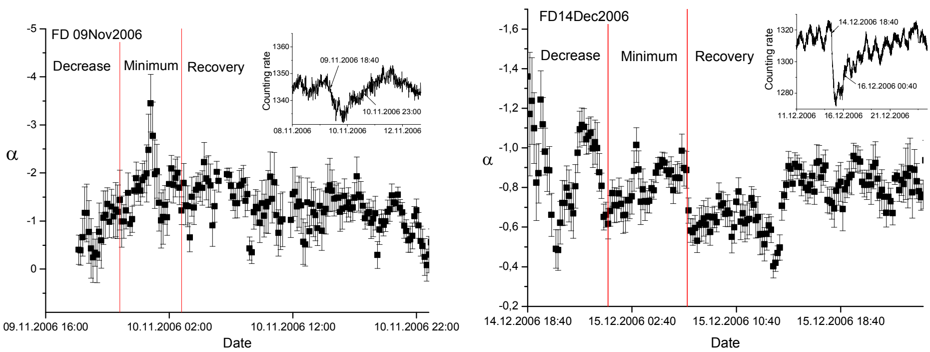

Figure 2. Changes of the FD energy spectrum exponent
for events on 09 November and 14 December, 2006.

The research is performed with the support of the Federal Target Program "Scientific and pedagogical cadres for innovative Russia" and RFBR grant (08-02-01204-a).

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BIOEFFECTIVENESS OF COSMIC RAYS ON THE EARTH'S SURFACE

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[1]Kola Science Centre, Russian Academy of Sciences
[2]Space Research Institute (IWF), Austrian Academy of Sciences
[3]Polar Geophysical Institute Kola Science Centre, Russian Academy of Sciences

In our research we study the bioeffectiveness of cosmic rays on the Earth's surface at the high latitudes, where intensity of secondary cosmic rays (CR) is more higher, than at middle latitudes. The work bases on experimental data obtained by using of cell cultures [1, 2, 3], microflora [4], human peripheral blood [4, 5], physiological [6], psycho-emotional indices [7] and the model systems (water) [8]. It was shown that variations of secondary cosmic rays near Earth surface have universal importance for functional state of different cell systems and induce the synchronous deviations in them. Our experiments carried out during a great solar events, when the solar particle fluxes increase in 105 in near-earth space and when secondary cosmic rays near the Earth's surface increase on 100%, revealed the multiple lesion of DNA containing material in cell systems. The increase of the nucleon component of the secondary CR near the Earth's surface (GLEs) during the Solar proton events in October 1989 were associated with local radiation effects in the cell cultures on the all levels of cellular structures. The effects of geocosmical agents on the growth of the microflora have analyzed by technology of system reconstruction and by compared analysis of dynamics of pathogenic microflora growth and variations of geocosmical agents near the Earth's surface. It was found that the growth of the pathogenic and nonpathogenic microflora are determined by different groups of geocosmical agents. Moreover, the neutrons near the Earth's surface and the solar wind plasma density have a main significance for the modulation of pathogenic microflora growth. The results of research manifest that the pathogenic microflora is more sensitive to variations of the secondary CR, than the nonpathogenic microflora. By comparison of functional state of human blood in the years with high geomagnetic activity (1991) and low (1996, 2008) geomagnetic activity we found that the decrease of geomagnetic activity and the increase of intensity of CR affect on composition of peripheral blood. We reveal that functional and psycho-emotional states of healthy and ill human organism are modulated by exposure to CR. The experiments carried out on the water [8] allow think that water inside of biosystems could be the main target for exposure to cosmic rays.

The research was supported by Grant of RFBR and the Administration of the Murmansk region, project number 10-04-98809-r_sever_a "

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TEMPERATURE EFFECT OF MUON COMPONENT AND PRACTICAL QUESTIONS OF ITS ACCOUNT

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The method of real time practical account of temperature effect of the cosmic ray muon component registering by the muon telescopes of different geometry has been developed. Wide use of muon detectors at research of cosmic rays variations is restrained by presence of the big temperature effect inherent to muon component of secondary cosmic rays. To except such effect the data of aerologic sounding close to the detector location are necessary. More often such data are absent in general and it is impossible to restore them in retrospective, or the soundings aren't carried out regularly.

The problem can be solved by using the results of meteorological models. On the base of generalized meteorological data models which make it possible to obtain the temperature profile of the atmosphere in any place and at any time are developed. At the present time the prognostic models have been developed as well making it possible to obtain the temperature profile of the atmosphere for the current time. It provides a way to allow for the temperature effect in real time.

In the paper the data of temperature modeling of the Global Forecast System – GFS representing by the National Centers for Environmental Prediction — NCEP (USA) has been made use of (http://www.nco.ncep.noaa.gov/pmb/products/gfs/). GFS model makes it possible to obtain both retrospective and prognostic data. By using this meteorological model namely vertical temperature profiles for the standard isobaric levels for the hourly data of muon telescopes the method of accounting the temperature effect in real time has been developed. The method developed has been used for processing of data accessible in real time. It is the data of Nagoya telescope (17 directions), Yakutsk telescope on the sea level (3 directions), Yakutsk telescope on the 7 mwe level (3 directions), YangBaJing telescope in Tibet (9 directions), and Moscow telescope (17 directions). Comparison between the data obtained via direct sounding of the temperature profile and the data obtained via GFS model let us assert that proposed approach decides the problem well. The discrepancy between the forecast results for current time and the results of GFS model is several degrees that is quite sufficient for the required accuracy. The free from the temperature effect data of all the telescopes are available at address: ftp://cr0.izmiran.rssi.ru/COSRAY!/FTP_TEL/ .

Radiation doses along selected flight profiles during two extreme solar cosmic ray events

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The radiation dose rates at flight altitudes may be hazardously increased during solar cosmic ray events. The additional contribution caused by solar cosmic rays is not yet included in most current models for computing the radiation dose rate. The application "Ionization and Radiation Dose Rates in the Earth's Atmosphere", developed under the FP7 project "NMDB" (www.nmdb.eu), is capable of taking into account both components: the galactic and the solar cosmic ray flux in near real-time. The calculations of the radiation dose rates are based on the Geant4 [1] model PLANETOCOSMICS [2]. Within the scope of this paper we investigate the total accumulated radiation doses, i.e. the contribution of galactic and solar cosmic rays during the two extreme solar cosmic ray events on 29 September 1989 and on 20 January 2005 along selected flight profiles. In addition, the paper will discuss the consequences of possible solar cosmic ray flux approximations (e.g. isotropic instead of anisotropic flux, constant spectral form of the solar cosmic ray flux during the entire solar event) on the results of the radiation dose computations.

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Measurement of Deuterium and 3He component in cosmic rays with Pamela experiment

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PAMELA is a satellite borne experiment designed to study with great accuracy cosmic rays of galactic, solar, and trapped nature in a wide energy range (protons: 80 MeV-700 GeV, electrons 50 MeV-400 GeV). Main objective is the study of the antimatter component: antiprotons (80MeV-190 GeV), positrons (50 MeV-270 GeV) and search for antimatter.

The experiment, housed on board the Russian Resurs-DK1 satellite, was launched on June, 15th 2006 in a 350 600 km orbit with an inclination of 70 degrees. The detector consists of a permanent magnet spectrometer core to provide rigidity and charge sign information, a Time-of-Flight system for velocity and charge information, a Silicon-Tungsten calorimeter and a Neutron detector for lepton/hadron identification. An Anticounter system is used off-line to reject false triggers coming from the satellite.

The beta and rigidity information allow to identify isotopes for Z=1 and Z=2 particles in the energy range 100MeV/n to 1 GeV/n. In this work we will present observation of cosmic rays D and He isotopes at the 23rd solar minimum from 2006 to 2008. Specifically we will discuss the ratios D/H and 3He/4He as a function of time and compare the results with existing measurements and models.

Search for large A/Z particles in cosmic radiation with Pamela experiment

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In this work we will describe the search for particles with high Mass/ Charge (A/Z) ratio with Pamela experiment.

It has been speculated that quark matter could exist in stable or meta-stable form in cosmic rays. These objects - often named strangelets for their hypothesized strange quark content - could be produced in the Big Bang or more probably be ejected in the stellar collapse, producing quark stars. In the current models these particles would not be bounded in A number. These particles would appear as heavy nuclei with a small electric charge due to the negative charge contribution of the s quark.

Pamela is a multi-purpose device composed of a permanent magnet spectrometer to provide particle charge, rigidity and incoming angle information. A series of six segmented scintillator counters arranged at its extremities provides redundant Time-of-Flight and charge information.

The redundant nature of the detector systems makes it particularly suited to search for heavy mass, light charge particles: they would appear as slow events (with low $\beta = v/c$ from the Time of Flight) and high rigidity R in the tracker. Particle mass/charge ratio is evaluated as $\frac{A}{Z} = \frac{R}{m_p \beta \gamma}$

We will discuss the capabilities of this analysis technique and future perspectives.

FACILITIES OF THE ARAGATS SPACE ENVIRONMENTAL CENTER AT THE START OF 24 SOLAR ACTIVITY CYCLE

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Particle fluxes in the vicinity of Earth are the global geophysical parameters and basics of Space Weather. Time series of intensities of high energy particles can provide cost-effective information on the key characteristics of the interplanetary disturbances. Surface monitors located at Aragats Space Environmental Center (ASEC) on Mt. Aragats in Armenia at 1000, 2000 and 3200 m altitudes detect charged and neutral components of secondary cosmic rays with different energy thresholds and various angles of incidence. Information on the changed fluxes of various species of secondary cosmic rays is used to predict the expected hazard of upcoming geomagnetic storms hours before shock arrival and detection by the magnetometers on ACE and SOHO. In 2010 we add new particle detectors, magnetometers and radio emission detectors. Total number of time series measured exceeds hundreds, covering primary proton energies from 4 till 20 GeV. The one-minute time series of gamma rays, neutrons, electrons and muons are measured with accuracy (relative MSD) 0.12% – 2%.

Aragats station 3,200 m. above sea level:

1. Aragats Neutron monitor – Neutrons (no energy available, register secondary hadrons, namely neutrons and protons, with energy starting from 5 MeV). Minimal energy of the primary proton initiated cascade in the atmosphere which can end up with a neutron registered in the neutron monitor equals 7 GeV. Relative error (RE) of the one minute count rate 0.7%, surface 18 m^2;

2. Aragats Solar Neutron Telescope (ASNT) – combination of the thin (5 cm, registering mostly electrons and muons, energy > 15 MeV) and thick (60 cm, registering neutrons and gamma rays if upper thin scintillator is used as a veto), primary proton energy 9 GeV, RE=0.45%, surface 4 m^2; if signal is registered in both layers (combination 11), i.e., coincidence of 5 and 60 cm scintillators, the minimal energy of the electrons/muons is 25 MeV , primary proton energy 11 GeV, RE=1.1%;
   Near vertical (0 – $\pm$30 degrees), and inclined trajectories are detected separately and time series are available; additional information as histograms of the energy releases in thick scintillators, correlation matrices, etc is stored each minute.

3. Three layered SEVAN module, measure fluxes of electrons/muons with energy > 15 MeV, primary proton energy 9 GeV, RE = 0.8%, surface 1 m^2; gamma-rays and neutrons, primary proton energy 7 GeV, RE = 3%, surface 0.25 m^2; electrons/muons with energy > 200 MeV, primary proton energy 13 GeV, RE = 1.5%; and electrons/muons with energy > 100 MeV, primary proton energy 11 GeV, RE = 1.5%;

4. Aragats Multidirectional Muon Monitor (AMMM) muons with Energy > 5 GeV; primary proton Energy > 20 GeV; RE=0.15%, surface 90 m^2; electrons/muons with

Energy > 10 MeV; primary proton Energy 9 GeV; RE=0.13%, surface 27 m^2;

5. MAKET electrons/muons with energy > 10 MeV; primary proton Energy 9 GeV; RE=0.18%, surface 16 m^2; Extensive air shower (EAS) triggers with energy 10^{13} and 10^{14} eV.

Nor Amberd 2000 m a.s.l.

6. Nor Amberd Neutron monitor – Neutrons (no energy available, starting from 5 MeV) primary proton energy 7 GeV, Relative error (RE) of one minute data 0.9%, surface 18 m^2;
7. Nor Amberd Multidirectional Muon Monitor (NAMMM) upper layer, mostly muons/electrons with energy > 15 MeV, RE=0.3% , surface 10 m^2 (2 units); bottom layer, mostly muons/electrons with energy > 100 MeV, RE=0.4% , surface 10 m^2 (2 units); 5 Different angles of incidence from NAMMM;
8. Nor Amberd SEVAN the same as for Aragats

Yerevan, 1000 m a.s.l.

9. SEVAN modules.

FIRST RESULTS FROM THE SPACE ENVIRONMENTAL VIEWING AND ANALYSIS NETWORK (SEVAN)

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A network of particle detectors located at middle to low latitudes, SEVAN (Space Environmental Viewing and Analysis Network), aims to improve fundamental research of the particle acceleration in the vicinity of the sun and the space environment. The new type of particle detectors will simultaneously measure changing fluxes of most species of secondary cosmic rays, thus turning into a powerful integrated device used for exploration of solar modulation effects. The first SEVAN modules are under test operation at Aragats Space Environmental Center in Armenia, in Bulgaria and Croatia. We present the first results of SEVAN operation, as well as some characteristics of the detector setup.

ON THE PCA AND GEOMAGNETIC FIELD VARIATIONS DURING SOLAR PROTON EVENTS IN OCTOBER 2003

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One of the largest and most complex active regions of solar cycle 23, labeled NOAA 10486, produced several intense flares as the X17 (S16, E08) and the X10 (S15, W02) occurred on 28/10 (11:30 UT), 29/10 (20:54 UT) respectively. Using the characteristics of the associated CMEs measured with SoHO/Lasco coronographs and the temporal evolution of solar energetic protons/electrons recorded by GOES11/GOES10 spacecrafts, we investigated the correlated observations of the interplanetary perturbations (ICMEs), the ionospheric absorption measured by riometers at Antarctic station of Casey (76° 44' S, 183° 93' E geomagnetic coordinates) and Davies (76° 49' S, 128° 20' E geomagnetic coordinates) and the geomagnetic activity recorded at Scott Base (Antarctica).

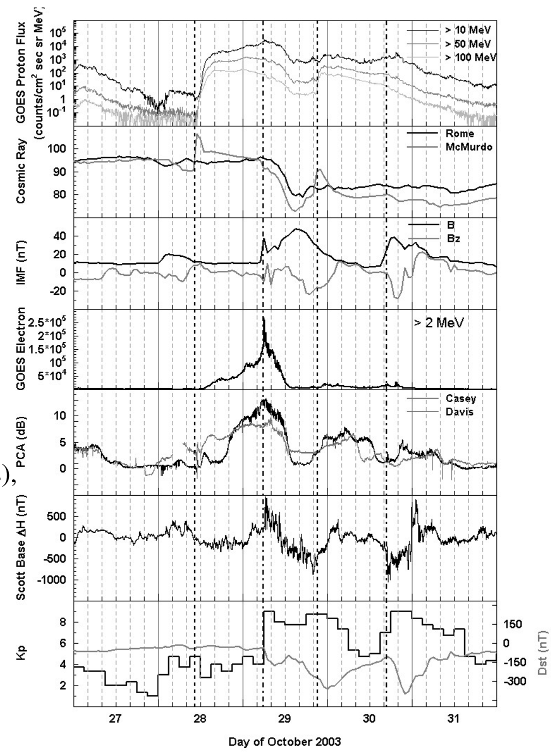

Figure displays the occurrences of the above mentioned solar flares (dashed lines) and the starts of geomagnetic disturbances (after the dot/dashed lines). Enhancements of relativistic solar protons (GLE) were well detected by a polar neutron monitors such as McMurdo observatory while lower-energy particles were recorded by GOES spacecrafts. Behavior of the Polar Cap Absorption (PCA) shows a good sensitivity to the incoming solar protons and electron flux, as well to the interplanetary and geomagnetic field perturbations.

Data analyses have suggested possible clues for forecast evaluation of effects produced by the interplanetary perturbations at the Earth's orbit. Moreover Antarctic observations have again resulted to be useful for the comprehension of these Sun-Earth connections.

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THE ANTIMATTER COMPONENT INDUCED BY COSMIC RAYS IN THE ATMOSPHERE

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After comparing the energy spectrum of nucleon-antinucleon at very high altitude with the BESS experiment, we have simulated the fluxes of antiprotons and antineutrons generated at various atmospheric depths. The simulations are carried out with the help of CORSIKA program involving a primary energy spectrum starting above the energy threshold of antiparticle production up to 1 PeV. Different abundances of alfa and heavy primaries in the primary composition are combined. Specific effects are investigated when the energy of the antiparticles is close to the maximum of the annihilation cross section in antiproton-Air interaction. Typical signatures are expected in detectors at atmospheric depths of 100-300 g/cm^2.

TECHNIQUE OF TEMPERATURE EFFECT CORRECTION FOR GROUND-BASED MUON HODOSCOPES

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Studies of cosmic ray variations at ground level are being carried out more than a half of century [1-3]. The longest series of cosmic ray variation data have been obtained by means of neutron monitors. The use of muon detectors provides valuable additional opportunities in comparison with neutron monitors: sensitivity to higher energies of primary particles, possibility to measure arrival directions of muons and, as a consequence, to study directional cosmic ray variations by means of a single setup. However analysis of muon intensity variations requires more complicated calculations of the atmospheric corrections taking into account both barometric and temperature effects [3-4].

In this work, influence of atmospheric temperature and pressure on ground level muon flux is considered. Results of differential temperature coefficients (DTC) calculations for muon hodoscopes at different zenith angles and method of experimental data correction will be presented at the conference. DTC calculations [5] are based on formulas describing muon production and propagation in the atmosphere. Examples of intensity of reconstructed events in one supermodule of the URAGAN hodoscope [6] in period March 2007–December 2008 without and with corrections for atmospheric effects are presented in Fig. 1. This was a period of quite heliospheric weather and therefore there was no sharp changes in corrected muon counting rate.

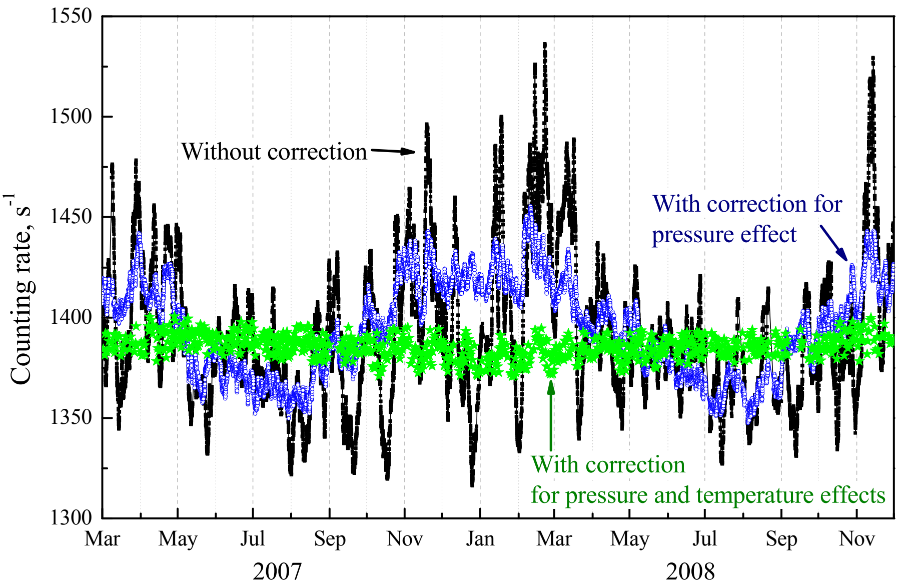

Figure 1. The counting rate of reconstructed events in the URAGAN supermodule during March 2007–December 2008

Thus, the use of the calculated DTC for atmospheric effect corrections decreases the difference between the current and non-disturbed values of muon counting rate from ~15 % to several tenths of per cent.

Variations of muon counting rate during the Forbush decrease (14 December 2006) for a limited zenith angle interval are presented in Fig. 2 (also without and with corrections for atmospheric effects).

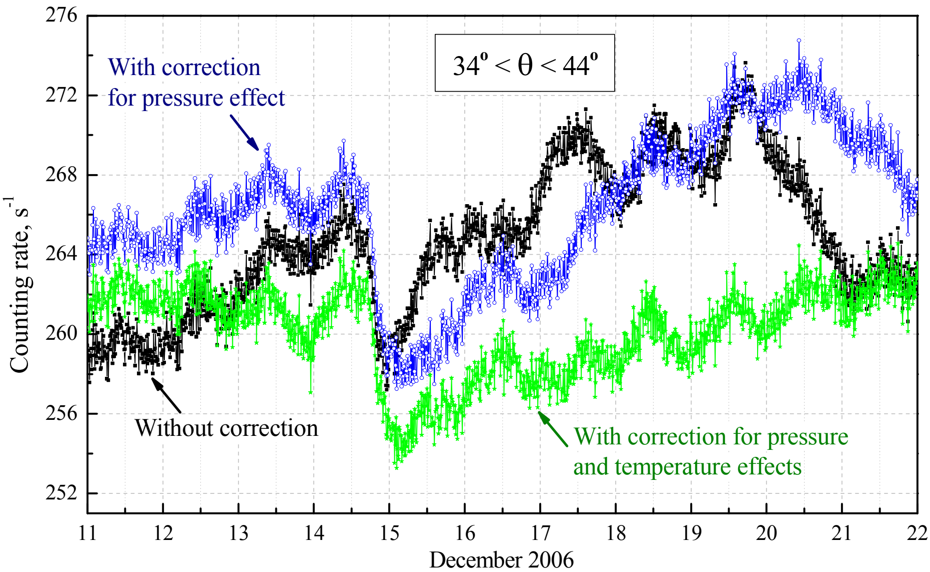

Figure 2. Forbush decrease (14 December 2006) in reconstructed event counting rate of the URAGAN supermodule

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COSMIC RAY VARIATIONS FOR DIFFERENT MULTIPLICITIES ACCORDING TO MT. HERMON NEUTRON MONITOR DATA

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For investigations of different types of CR variations (11-year, annual, 27-day, Forbush effects, and solar-daily anisotropy) we used data on multiplicities m = 1, 2, 3, 4, 5, 6, 7, and ≥ 8 obtained by neutron monitor on Mt. Hermon during 1998-2010. For interpretation of obtained experimental results we use analytical approximation of coupling functions for different multiplicities (see Chapter 3 in Dorman, 2004) and determine approximately the rigidity spectrum of primary CR variations out of the atmosphere. Then, by using information on CR behaviour in the Earth's magnetosphere (Dorman, 2009), we determine primary CR variations out of magnetosphere.

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Status of the Belgrade CR laboratory and some preliminary results

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The Belgrade CR Laboratory (44°49′N, 20°28′E, vertical rigidity 5.3GV, 78m a.s.l.) consists of two separate, corridor connected laboratory spaces, about 25m apart. One laboratory is located on the ground level (GLL), while the other one is a shallow (25mwe) underground laboratory (UL). Both laboratories are equipped with identical instrumentation, consisting of a big (100×100×5 cm) and small (50×23×5 cm) plastic scintillators each and analyzing electronics (Quad FADC, CAEN N1728). The UL houses a radiopure HPGe detector (35% eff). The FADC continuously record the background events of all the detectors, with time resolution of 10 ns, and amplitude resolution of 1 V in 2^{14} channels. Full permanent record is kept of all the events, for later off-line analyses. It is estimated that both setups together will produce more than 1 TB of data per year. In this way only direct spectra of the detectors are measured in real time, while coinciding the events, in any wanted combination, is performed off-line. We would thus be able to spectrally measure in both laboratories continuously and simultaneously all the following events, as well as their mutual coincidences, prompt and arbitrarily delayed: 1. Muon events, 2. EM shower events, 3. Decoherence curves, 4. Angular distribution, 5. Time series, of any spectral portion of any of registered radiations, 6. The signatures of background processes induced by CR in the environment and in our detectors, especially in HPGe. Preliminary results of some of these measurements will be presented.

RESPONSE IN THE OPERATION OF CSB SYSTEMS TO THE STRONG GEO-MAGNETIC STORMS ON THE RUSSIAN NORTHERN RAILWAYS.

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Each of the seventeen severe magnetic storms that occurred within the period from 2000 to 2005, and in March 1989 as well, had a response in the operation of the system of Signalization, Centralization and Blockage (SCB) in some divisions of the high-latitude (58-64ON) Russian railways. This response was revealed as false traffic-light signals about occupation of the railways. It turned out, that such signals on the Northern railways appeared exactly during the main phases of the strongest geomagnetic storms characterized by large values of the geomagnetic indices Dst and Kp (Ap). Moreover, durations of these anomalies coincided with the period of the greatest geomagnetic disturbances in a given event. Geomagnetically induced currents (GIC) during significant strengthening of geomagnetic activity are supposed to be the obvious reason for such kind of anomalies.

EAS HADRONIC COMPONENT AS REGISTERED BY A NEUTRON MONITOR

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Extended Air Showers (EAS) are created in the atmosphere by cosmic ray particles of super high energy (10^{14} eV and higher). An EAS consist of huge amount of particles of different kinds (electrons, photons, muons, hadrons). Till now a hadronic component of EAS remains little investigated. We studied the hadronic component of EAS with the help of installation uniting the detector EAS "Carpet" and the standard neutron monitor 6NM64. The installation is at the Baksan Neutrino Observatory, North Caucasus, 43.28N, 42.69E, 1700 m a.s.l. The EAS array "Carpet" has an effective area 200 m^2 and registers, basically, the electron-photonic component of EAS. The neutron monitor has the effective area 6 m^2 and a lower energy detecting threshold for nucleons ~50 MeV. Our new data acquisition system for the neutron monitor allows us to register not only separate pulses, but also intervals between them with accuracy as high as 1 microsecond. With this system we studied the temporal and spatial distribution of hadrons in an EAS. We analyzed temporal distribution of the neutron monitor pulses after a 'master pulse' given out by the "Carpet" at registration of an EAS. The characteristic time of registration of hadronic component in an EAS is ~1 ms. The characteristic size of hadronic EAS core > ~5 m^2. The essential difference of a multiplicity spectrum of the EAS hadronic component from a background spectrum, connected with galactic cosmic rays of moderate energies is marked. We compared the distribution of the neutron monitor pulses before and after the EAS onset (several milliseconds before and after a 'master pulse'). It is revealed, that after a 'master pulse' a NM multiplicity event with a great number (> 10) is observed. The incident particles cover all the neutron monitor area (6 m^2). Duration of a multiplicity event is ~1 ms. Thus, one can estimate the characteristic spatial size of hadronic EAS core as several meters. And corresponding time scale is 1 ms.

FINE STRUCTURE OF NEUTRON MULTIPLICITY IN A NEUTRON MONITOR

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Three neutron monitors (NMs) in Barentsburg (Spitzbergen), Apatity and Baksan (Northern Caucasus) were equipped with an advanced registration system that enables recording not only pulses, but time intervals between them with accuracy as high as 1 microsecond. It allows studying such fast and fine phenomenon as a neutron multiplicity. A multiplicity event is an isolated sequence (cluster) of pulses with short time intervals among them. The multiplicity can be created by the local generation of neutrons in a lead shell surrounding counting tubes in a neutron monitor. It was believed for a long time as the main cause of multiplicity. Another cause of multiplicity can be local atmospheric hadronic cascades. With our new equipment and technique of data processing we were able to study the temporary distribution of pulses within a multiplicity event, and also fixing a place of occurrence of a pulse: a counting tube (one of 18, included in structure of a NM).

The multiplicity events with number of pulses M from 5 up to 30 were studied. As the events with large M (> 20) are rather rare, it was required to process large bulk of data: 220 day of continuous registration at 3 above mentioned NM stations. The specific temporary structure of a pulse cluster in events of multiplicity is found out. Irrespective of number of pulses in a cluster, the regular increase of time intervals between pulses by the end of event (from 50 up to 200 μs) is observed.

Main result is that multiplicity events with M > 7 are caused by the hadronic component of a local atmospheric shower. Namely, the events with M > 7 necessarily include a local atmospheric hadronic cascade with the characteristic spatial size of order of several meters and time scale 1 ms. Monte-Carlo GEANT4 simulations of neutron interactions in a NM confirms lack of local showers generated in lead causing a multiplicity greater 7 (provided neutron energy < 1 GeV). Thus the events with M > 7 necessarily must include a local atmospheric hadronic cascade covering all the NM (effective area of a 6-tube section of 6NM64 is 6 m^2; three sections total 18 m^2) with time scale 1 ms.

STATISTICAL ANALYSIS OF THUNDERSTORM TRIGGERED ENHANCEMENTS IN COSMIC RAY DATA

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Particle detectors of Aragats Space Environmental Center (ASEC) located in Armenia routinely measure changing fluxes of the different species of the secondary cosmic rays. Along with Solar modulation effects (Forbush decreases, Ground level enhancements, Geomagnetic effects) detectors registered several coherent enhancements associated with thunderstorm activities. 44 such events detected in 2007-2009, when Solar activity was minimal, unambiguously point on Relativistic Runaway Electron Avalanche (RREA) process in thunderstorm clouds in presence of strong electrical fields. In present paper we perform initial taxonomy of events and investigate distribution of events in different secondary fluxes by duration and magnitude. Also nontrivial correlations between measurements by different particle detector were outlined and discussed.

Helium counters for low neutron flux measurements

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Comparison of some characteristics of counters for measurements of low intensity neutron flux will be presented.

We focus on neutron flux density measurements in low backgaund laboratories. It can be measured by standard gas helium counters. But because of extremely low counting rate (few events per hour or less), we must take into account counter qualities which are meaningless under regular conditions, that is: background from internal alpha radioactivity, percentage of events in full energy peak, and the width of this peak. The α-background depends on residual radioactivity of the counter tube material so can't be eleminated, but full energy peak characteristics can be specified by counter gas composition.

We will present comparison of four types of helium gas counters, produced by different manufacturers. Results of measurementes as well as Monte Carlo simulations with Geant4 will be presented.

IRRADIATION BY SOLAR COSMIC RAY NUCLEI: DISORDERING AND CHEMICAL MODIFICATION OF LUNAR SOIL SILICATE GRAINS

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There is currently considerable interest in radiation-induced redistribution of elements in silicate crystals [1-3]. Radiation-enhanced diffusion in solid matter can result in their significant chemical modification. Our investigations of the lunar regolith material [4] showed the possibility of measuring radiation effects of solar cosmic ray (SCR) nuclei in individual silicate microcrystals using VH-group tracks. For these reasons, investigations of the redistribution within individual lunar regolith silicate microcrystals subjected to SCR protons, alpha-particles, and VH-group nuclei are important. In this report, we present new results on the study of the radiation parameters in individual olivine microcrystals in lunar regolith and some results of their chemical modification .

The olivine and pyroxene grains of 127÷200 μm size fraction have been hand-picked from the Luna 16, 20, and 24 soil columns. The total number and volume distribution of the marked tracks in about 100 grains were taken for the calculation of the track density in each microcrystal. Numbers of grains showing outstanding track density gradients were observed. For 11 crystals, on the freshly revealed internal cut-off surfaces, compositional cross-crystal profiles were measured using electron microprobe technique.

Total proton and alpha-particle exposure doses were estimated based on the relation for the VH-nuclei track production rate $(d\rho/dt)_x$ *vs* depth (x) of a scoop near the lunar regolith surface. The olivine grains did not feature track-density gradients and have a uniform track distribution of $\rho = 10^6 \div 10^7$ track cm^{-2}, which was accumulated in submillimeter regolith depth for the time $T = (1\div10)\times10^6$ yr. Corresponding SCR proton and alpha-particle integral fluxes estimated in that way were obtained (Table 1).

Table 1. Radiation parameters of the SCR exposure in the Luna-24 soil olivine grains

Group	Number of grains	Track density, ρ cm^{-2} (*)	Exposure age, m.y. (**)	Dose, cm^{-2} $(\times10^{17})$ (***) Protons	Alpha - particles
I	14	$\le1.5\times10^5$	≤ 0.015	≤ 0.05	≤0.0035
II	29	$(0.3\div0.8)\times10^6$	$0.05\div0.12$	$0.15\div0.36$	$0.01\div0.025$
III	22	$(0.2\div3.0)\times10^7$	$0.3\div4.5$	$0.9\div13.5$	$0.06\div0.9$

(*) Track density (ρ) for the SCR VH-nuclei, $E_{VH} = (10\div100)$ MeV $nucleon^{-1}$;
(**) Estimation by the relation $\rho_{0.1\ cm} = 6.7\times10^6$ track cm^{-2}·per 10^6 years;
(***) Integral fluxes of SCR protons: $I_{P,E\geq1MeV} = 10^4$ protons $cm^{-2}\cdot s^{-1}$ and SCR alpha-particles $I_{\alpha,E\geq1MeV/nucl} = 0.07\times I_{P,E\geq1MeV}$ particles $cm^{-2}\cdot s^{-1}$.

Calculation of the implant range profile of protons and alpha-particles [5] showed that the ion-induced degree of the crystal lattice disordering at $E \geq 10$ MeV varied in the olivine grain from several percent to ~50 %.

Track densities apply to estimating of the proton and alpha-particle doses, and results of the electron microprobe chemical analysis in individual olivine grains are presented in Table 2. Practically all observed tracks are caused by VH nuclei of SCR. The track density due to spontaneous and induced fission of Th and U is negligible ($\leq 1\times10^4$ track cm^{-2}) and was not taken into account.

Table 2. Track density (ρ), SiO_2 concentration (wt %), and relative Mg and Fe concentrations (atom %) in the analysed olivine crystals from the Luna 24 column

Sample	ρ, cm^{-2}	SiO_2, wt %	Mg/(Mg+Fe), atom %	Fe/(Mg+Fe), atom %
1	4.0×10^3	38.6±0.2	0.74	0.27
2	2.0×10^3	37.3±0.1	0.69	0.31
3	2.3×10^5	29.5±0.1	0.05	0.95
4	8.0×10^4	52.6±0.1	0.69	0.32
5	1.0×10^4	35.3±0.1	0.55	0.45
6	5.5×10^5	37.6±0.1	0.66	0.34
7	3.0×10^4	32.9±0.1	0.32	0.68
8	9.0×10^4	34.9±0.1	0.71	0.29
9	5.3×10^5	34.2±0.1	0.54	0.46
10	4.5×10^4	33.4±0.1	0.45	0.55
11	8.0×10^6	29.6±0.1	0.11	0.89
		- 0.63±0.19 (*)	- 0.54±0.21 (*)	0.54±0.21 (*)

(*) Correlation coefficient R in relation to SiO_2 (wt %), Mg/(Mg+Fe) and Fe/(Mg+Fe) (atom %) concentrations *vs* ρ.

The results obtained showed variations in Mg, Fe and Si average concentrations in lunar regolith silicate grains. This can be due to sufficiently high doses (up to $\sim10^{16}\div10^{18}$ protons cm^{-2} and $\sim10^{14}\div10^{16}$ alpha-particles cm^{-2}) of SCR irradiation which initiated significant disordering in the crystal lattice and appropriate increase of effective radiation-induced diffusion.

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INVESTIGATION OF EXTREMELY DISTURBED GEOMAGNETIC CONDITIONS AND ASSOCIATED COSMIC RAY INTENSITIES

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The study discuss the behaviour of cosmic rays during the phase of highly intense or ultra intense geomagnetic conditions, as shocks driven by energetic coronal mass ejections (CME's) and other interplanetary (IP) transients are mainly responsible for initiating large and intense geomagnetic storms. Observational results indicate that galactic cosmic rays (CR) coming from deep surface interact with these abnormal solar and IP conditions and suffer modulation effects. In this paper a systematic study has been performed to analyze the CRI variation during extremely disturbed geomagnetic conditions i.e. very intense geomagnetic storms with Dst index ≥ -300 nT. The neutron monitor data of three stations Oulu (Rc = 0.77 GV), Climax (Rc = 2.97 GV) and Huancayo (Rc = 13.01 GV) well distributed over different latitudes and hourly values of IMF parameters derived from satellite observations near Earth IP medium from OMNI Data base is used for the period spanning over solar cycles 20, 21, 22 and 23. It is found that AP and AE indices show rise before the forward turnings of IMF, while the Dst index shows a classic storm time decrease. The analysis indicates that the magnitude of all the responses depends on BZ component of IMF being well correlated with solar maximum and minimum periods. Transient decrease in CR I with slow recovery is observed during the storm phase duration.

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COSMIC RAY INTENSITY CHANGES AND THEIR INFLUENCEON SOME PROCESSES IN THE UPPER ATMOSPHERE

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It is already well known that several purely meteorological processes in the terrestrial atmosphere are connected with the changes in cosmic ray (CR) intensity, the solar activity, and the magnetosphere variations [1].

Surely slight changes in the ionization of the upper atmosphere are connected with CR intensity variations. The possibilities of some triggering effects, initiating atmospheric turbulence were investigated. An interconnection between these effects and the starting processes of the hurricane formation were suggested. The daily global index (H), presenting averaged hurricane characteristics was used [2]. A similar generalized CR index was created correspondingly. Parallels between those indexes were investigated. The obtained results could contribute to an early hurricane forecasts.

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Temperature variations of high energy muon flux

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Temperature dependence of high energy muon flux (with energy threshold of 220 GeV) based on the Baksan Underground Scintillation Telescope (BUST) [1] data has been obtained. Temperature measurements for different altitudes have been made every 12 hours by weather balloons. The corresponding correlation coefficients have been calculated and their dependence on the angles (at which muons move in the atmosphere) and on the altitudes of the points (where the temperature has been measured) will be presented. Our results have been compared with the results of previous experiments, including [2].

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TIME-SCALE PATTERN FEATURES IN THE NEUTRON MONITOR INTENSITY BEFORE EARTHQUAKES

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The clear relation between the geodynamical processes in the Earth's lithosphere and corresponding ionosphere phenomena has been established in the last time. Underlying physics of the problem consists in the formation of high electrical potential for the stressed rock volume under pre-earthquake conditions. This surface potential for shallow earthquakes will generate corresponding changes in the ionosphere. The experimental researches of the correlations between strong local seismic activity and ionosphere responses have further shown that maximum perturbation was observed during pre-seismic periods for such earthquakes.

In the present work, by studying the time-scale pattern features in the neutron monitor (NM) intensity, we intend to estimate the detectability of precursory phenomena for relatively weak earthquakes. The variations of scales in the temporal patterns have to be analyzed for several tens hours before events. Such approach will allow us to reveal emergence of precursory patterns in the different range of scales.

Rearrangements of the Earth's lithosphere arising at pre-earthquake conditions correspond to complex non-stationary processes with fractal structures. The intermittent behavior of rock stresses dominate in such strong interactions between overlapping structures at many different scales. The ionosphere perturbations have to reflect these peculiarities and, therefore, have to have intermittency features at the corresponding scales. These responses are too weak in order to change the cosmic ray intensity. However, they can modulate the appropriate frequency or scale range of intensity and, therefore, the time-scale patterns of the signal have to be intermittent.

The specifications of the fine structure analysis have to be very carefully fitted. The best study of the non-stationary data with intermittent features, where the time of occurrence of events is important to the description of the phenomenon, can be performed with computation of the local energy density of signal in the wavelet transform. In this technique the Mexican hat wavelet is chosen as the mother wavelet. Computing is performed on the basis of wavelet analysis software tools in the MATLAB environment [1]. The significance of this approach is obvious. This quantity reveals how much each scale contributes at any given point in time, so evolution in the time is observable. It can be viewed as a microscope for looking into the time-scale signal characteristics. The result is 2D surface (a counter plot) which displays the time on the horizontal and the scale on the vertical axes. Data of Kazakhstan National Data Center [2] can be used for retrospective analysis of earthquakes.

Previous reports have shown [3-5], that cosmic ray can be considered as an indicator of the local geodynamical environment. In the present work more detailed analyses in the new period 20061226-20091104 have been performed. The events, that occurred at distances up to 250 km from receiving place (Almaty NM), were chosen. To search for the time-scale variability of the NM intensity, 400-hours interval of the time series has been selected in the each event. Earthquake's time point corresponds to the middle point of this interval. We have focused on a small range of scales, from 1 hour to 9 hours. The wide range of results have been obtained for the different events. For the part of events, the clear time-scale evolution patterns have been obtained for the local energy density "before earthquakes". These patterns have clear intermittent features. On the other hand, there are some events without any evolution patterns. The average rate of events with the clear pattern of time-scale correlations is 0.56 ± 0.17

The results for two events with well-isolated time-scale patterns are presented on Fig. 1. The 2D counter plots display evolution of the different scales over selected interval (70 hours) of the time series. The head line above each plot contains in consecutive order: earthquake date, coordinates, magnitudes (in epicentre/in Almaty), azimuth direction and distance from Almaty, the earthquake moment - X. The appropriate color on the line below plots represents the local energy density of the according time-scale point.

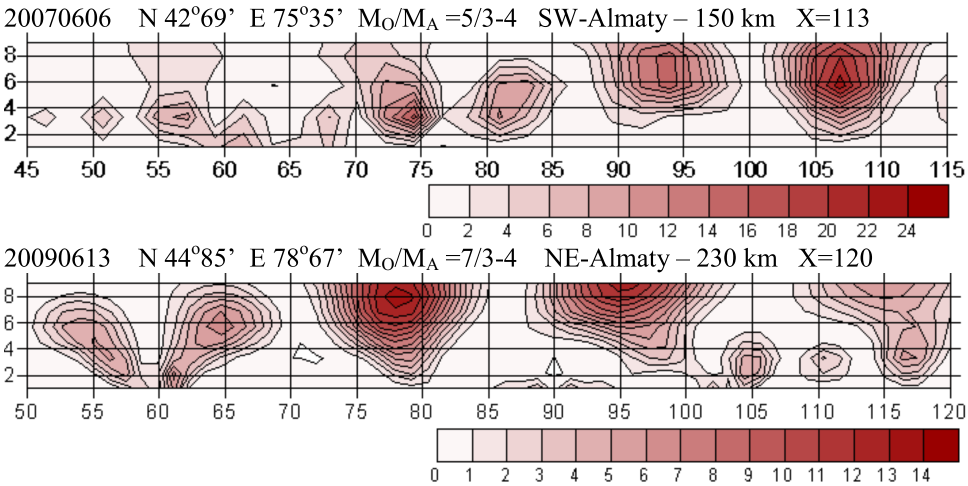

Figure 1. The time-scale pattern features in the NM intensity "before earthquakes".

It should be stressed that the second plot corresponds the sum of superimposed intensities for three 3 earthquakes in the 40-minutes interval.

So, in the part of events with relatively weak magnitudes, the intermittent time-scale correlations have been recognized in the NM intensity for several tens hours "before earthquakes". The average rate of such events is 0.56 ± 0.17.

The additional researches and understanding of the underlying problems are need.

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SPECTRA OF THE THUNDERSTORM CORRELATED ELECTRONS AND GAMMA-RAYS MEASURED AT ASEC ON 19 SEPTEMBER 2009

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For the first time we present the electron and gamma ray energy spectra produced in the avalanche processes in the atmosphere during thunderstorms and detected by surface particle monitors. The huge flux of thunderstorm correlated particles was detected by the experimental facilities of Aragats Space Environmental Center (ASEC) on 19 September 2009. Using ASEC detectors with various energy thresholds, spectrum of thunderstorm correlated electrons was obtained. GEANT4 based detector response calculation of the Aragats Solar Neutron Telescope (ASNT) allows us to reconstruct gamma ray spectrum from the energy release spectra measured by ASNT. We also present a comparison of the September 19 event with a smaller event on May 21, 2009.

KAZAKHSTAN SPACE ENVIRONMENT EXPERIMENTAL COMPLEX FOR COSMIC RAY INVESTIGATION

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Kazakhstan space environment experimental complex is a center for an experimental study of the non-stationary processes caused by cosmic rays of different origin in the interplanetary and near-Earth space, so as their influence on the state of the Earth's magnetosphere and the upper atmosphere layers. An experimental complex near the city of Almaty, Kazakhstan includes three experimental setups for registration of cosmic ray intensity (neutron monitors) at altitude of 3340, 1750 and 850 m above sea level (the ATHLET collaboration [1]), geomagnetic observatory and setup for registration of solar fluxes density with frequency 1 and 3 GHz. with 1 second time resolution. The results of space environment monitoring in real time are presented on sites (http://89.250.81.12/cosray/index.htm, http://89.250.81.120/ and http://89.250.81.98/solar2010/index.htm). This experimental information is used for space weather investigations and different cosmic ray effects.

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ANALYSIS OF MUON FLUX RESPONSE FOR THUNDERSTORM EVENTS IN MOSCOW REGION

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Monitoring of dangerous weather phenomena such as thunderstorms and severe squalls remains the actual problem of the day. Many of local weather disturbances cannot still be detected in advance, despite of the existence of a network of meteorological stations and weather satellites. At present, a new approach to monitoring of such processes by means of detectors sensitive to the muon component of cosmic rays is being developed [1].

In this work, data of muon hodoscope are used to analyze variations of muon flux at the surface of the Earth. Muon hodoscope is a new type detector capable detecting muons simultaneously from different directions of celestial hemisphere. Muon hodoscope URAGAN [2] has been created at the Scientific and Educational Center NEVOD (MEPhI) in 2005. It is a wide-aperture coordinate detector consisting of four separate supermodules with total area 46 m^2 and registers about 5500 muons/s. To compare the data with the real weather, various atmospheric parameters in the vicinity of the muon hodoscope were recorded. To obtain the most complete picture of the thunderstorm activity, several sources of atmospheric data have been used, each of them served to indirectly verify the others. Twenty thunderstorm events were revealed during the period May-September 2009 in Moscow region.

Analysis of the integral counting rate of the muon hodoscope URAGAN shows that during the thunderstorm event a minimum (Fig. 1, top) is observed. As an angular variation characteristics of muon flux the local anisotropy vector is used, which indicates the average direction of muon arrival. Local anisotropy vector is calculated as the sum of unit vectors, each representing the direction of the individual track, normalized to the total number of muons [3]. The length of the vector depends on the shape of the angular distribution of the muon flux. The average direction of anisotropy vector is very close to vertical but during atmospheric (and extra-atmospheric) disturbances rather strong deviations from the mean value, such as during a thunderstorm event on 14-15 July 2009 (Fig. 1, bottom) are observed.

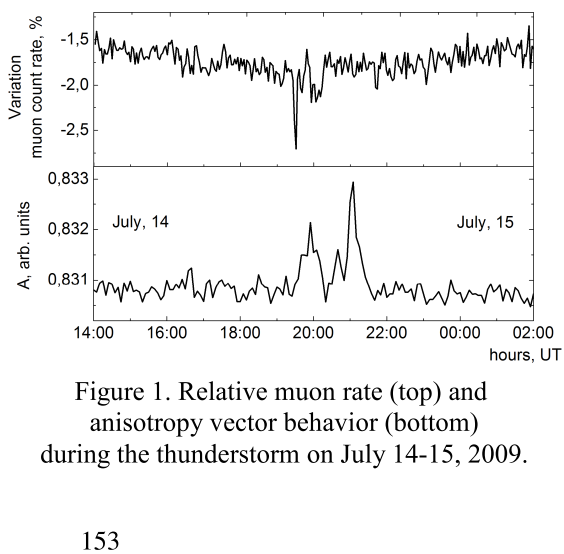

Figure 1. Relative muon rate (top) and anisotropy vector behavior (bottom) during the thunderstorm on July 14-15, 2009.

The main format of muon hodoscope data is a two-dimensional muon intensity matrix. On-line track reconstruction gives values of both zenith and azimuth angles, or projection zenith angles θ_X, θ_Y of muon track (in local coordinate system), on the basis of which the track is put in a corresponding cell of the matrix. To study muon flux variations, for every cell of this matrix the average number of muons (estimated during preceding 24 hours and corrected for atmospheric pressure) is subtracted, and results are divided by standard deviations (Fig. 2). To smooth Poisson fluctuations, the data were averaged over 5-minute intervals and a special Fourier filter was also used. Scales at the figures denote values of muon intensity changes in standard deviation units. Tints represent excess or deficit of muons coming from a certain direction. Thin lines identify North-South and West-East directions. The circles correspond to zenith angles 30°, 45° and 60°. Statistics of each image exceeds one million tracks. In Fig. 2, the matrixes for the thunderstorm event on July 14-15, 2009 are presented. During the quiet atmosphere, perturbation in muon “snap-shot” is practically not seen (upper-left matrix). On the other matrixes disturbances are clearly visible, which correspond to the maximum of the event (21:00-21:10). This is consistent with a peak in the anisotropy vector plot and the minimum in the counting rate.

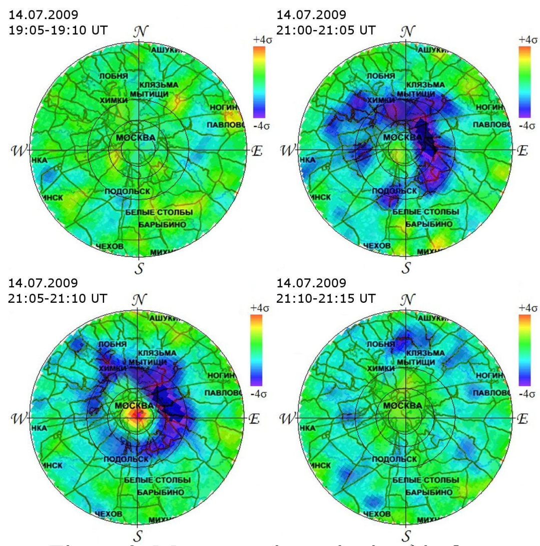

Figure 2. Muon matrixes obtained before and during thunderstorm event.

Analysis of the muon hodoscope data obtained during summer 2009 showed that approximately in 80% of thunderstorm events clear responses in muon hodoscope data were observed. Effects were detected both in the total counting rate and in angular dynamics of the muon flux. Thus, the flux of cosmic-ray muons is sensitive to local atmospheric disturbances. This result indicates promising perspectives of cosmic ray application as a tool for monitoring of atmospheric phenomena.

The work was supported by the Federal Target Program “Scientific and pedagogical cadres for innovative Russia”.

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Using astroparticle methods for space climate studies

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The field of cosmic ray is connected with particle physics and astrophysics and also with space studies. This new and interesting field is rapidly extending during the last years after the discovery and observation of new phenomena. In this field one of the most convenient technique is the Monte Carlo simulation, namely the cascade process in the Earths atmosphere.

At the same time several recent studies demonstrate clear direct correlation between low cloud cover and CRs in few regions, which roughly corresponds to model predictions. In this connection are demonstrated recent capabilities of CORSIKA code [1] for simulations related to improvement of Sofia model for cosmic ray induced ionization. The simulations of Cherenkov light produced in EAS are basis for development of a model for atmospheric transparency estimation. The scientific potential is widely discussed.

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THE SIMULATIONS OF MUON CHARGE RATION IN EAS AS OBSERVED BY WILLI DETECTOR

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The WILLI detector installed in IFIN-HH, Bucharest, Romania, was used to measure the atmospheric muon charge ratio at low energy ($E < 1$ GeV). The detector was extended with a mini-array consists of 12 detection stations placed at aprox. 50 m from WILLI. We have investigated, how the finite angular acceptance of the WILLI spectrometer, positioned at a particular accurately defined distance from the shower core and observing muons from a particular direction, will affect the pronounced predicted variation of the charge ratio of the observed muon density. By using different incident showers with different energies and different coming directions, the influence of the hadronic interaction models (QGSJET2, EPOS and SYBILL), on the EAS muon charge ratio have been studied. Choosing two hadronic interaction models DPMJET and QGSJET2, the variation of the low energy muon charge ratio with the azimuthal and zenithal orientation of WILLI have been simulated for 4500 H and 500 He showers, with the energy of the primary in the range of $10^{13} < E_{primary} < 10^{15}$ eV.

COSMIC RAYS AND NEW TYPE OF CLOUD CHAMBERS

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We have fabricated two different types of cloud chamber: These chambers were fulfilled with various kind of air, and tracks of cosmic rays were investigated. Surprisingly, cosmic ray tracks were ob-served in air containing few aerosol particles. We postulate the following hypothesis and have worked to confirm it: in the formation process of the tracks of cosmic rays, not only the ions but also the Aitken particles (small size aerosols with the dimension less than 100nm) behave an essential role. We have repeated those experiments until now. What we have obtained is a fact that even we install *pure* air or *polluted* air by the Aitken particles inside the chambers, the tracks of cosmic rays can be seen. Although at the beginning of the experiment, smoke of the water vapour can be seen in the casein the cloud chamber of the polluted air, but after tens of minutes, the quality of the tracks has become the same. Therefore the hypothesis on the track formation in the cloud chamber by Sir Wilson may be correct. We could not confirm our hypothesis that those cosmic ray tracks must be formed by after an aid of the Aitken particles hidden in the Wilson cloud chamber. Of course there remains a possibility that in our system we could not remove completely the attached Aitken particles from the wall of the cloud chambers. Our investigation may be useful to explain the relationship proposed by Svensmark and Friis-Christensen since those tracks induced by cosmic rays in the atmosphere may assist the cloud formation.

Projectile fragmentation cross sections for intermediate-energy trans-iron nuclei ($Z \geq 26$) on H and C using CR-39 track detector

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Measurements of projectile fragmentation cross section for heavy ion on targets constituting of interstellar medium such as hydrogen, helium and carbon at intermediate energies (from a few hundred MeV/n to a few GeV/n) are very important for the study of the origin of galactic cosmic ray [1].Many experimental and theoretical works on heavy ion fragmentation reactions have been already performed for the purpose of not only cosmic ray astrophysics but also other fields such as radiotherapy, space dosimetry and radiation shielding [2-8]. However, there remain considerably inconsistent results between experiments and models as well as between experiments which purport to measure the same things. For instance, an agreement within an error of 10~15% between experimental data and models is desirable for use in many cosmic ray propagation models [9][10]. The level of disagreement between previous results ranges over a factor of up to 6 [11]. Therefore, we aim to perform precise and systematically measurements of fragmentation cross sections for intermediate energy heavy ions from C up to trans-iron nuclei ($Z \geq 26$) on some interstellar medium targets using CR-39 track detectors.

The CR-39 track detector has two more excellent advantages compared to active detectors such as scintillation counter, Si detector, and Cherenkov counter used in the most of previous works. One is the position sensitivity with micrometer (μm) accuracy and the other is better charge resolution for a wide range of projectile elements with atomic number (Z) greater than three at intermediate energies. These advantages provide information on e.g., reaction point in target material determined with a few micrometer (μm) accuracy, fragment emission angles, branching ratios of the produced fragments. The information enable us to benchmark theoretical nuclear reaction models, such as Quantum Molecular Dynamics (QMD) [12, 13]. To be able to extract more information from the fragmentation reaction using the CR-39 track detector, we have developed a new measurement system [14-16].

In this work, we performed measurements of fragmentation cross sections for trans-iron projectiles, Fe and Ge on hydrogen and C targets using the new measurement system. The hydrogen cross section (σ_H) is essential for the study of cosmic ray propagation, and it is obtained from the C and polyethylene (CH_2) data according to the relation, $\sigma_H=(\sigma_{CH2} - \sigma_C)/2$. Previously, there exist some experimental data for Fe because of its importance [2, 17-19], however, agreements of their results with each other are still not enough for in the use in cosmic ray astrophysics, and no experimental results for Ge have been reported before. Because some models to calculate the cross section [6] are optimized for nuclei up to Fe, we investigated discrepancies between the measured cross sections and the calculated ones using these models for Fe and Ge. Besides, the experimental data of emission angles and branching ratios have previously not been obtained. Comparison of measured and simulated fragmentation cross sections, branching ratios and emission angles will be presented.

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COSMIC RAY INTENSITY CHANGES AND GEOMAGNETIC DISTURBANCES ON THE PHYSIOLOGICAL STATE OF AVIATORS

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Abstract

Over the last few years researches have resulted to the wide acceptance from the scientific community that geomagnetic disturbances and cosmic ray variations are related to the human physiological state. In this study medical data regarding 4018 Slovak aviators were analyzed in relation to daily variations of geomagnetic activity and cosmic ray intensity. Specifically daily data concerning mean values of heart rate and diastolic and systolic blood pressure, which were registered during the medical examinations of the Slovak aviators, were related to daily variations of cosmic ray intensity, as measured by the Neutron Monitor Station on Lomnicky Stit, provided by the high resolution neutron monitor database (http://www.nmdb.eu) and daily variations of Dst and A_p geomagnetic indices. All subjects were men in good health of age 18-60 years. This particular study refers to the time period January 1, 1994 till December 31, 2002. Statistical methods were applied to establish a statistical significance of the effect of geomagnetic activity levels and cosmic ray intensity variations on the aforementioned physiological parameters for the whole group. The Pearson r-coefficients were calculated and the Analysis of Variance (ANOVA) method was applied to establish the statistical significance levels (p–values) of the effect of geomagnetic activity and cosmic ray intensity variations on heart rate, arterial diastolic and systolic blood pressure up to three days before and three days after the respective events. Results show that there is an underlying effect of geomagnetic activity and cosmic ray intensity variations on the cardiovascular functionality.

ASSEMBLING A NEW MODULAR COSMIC RAY DETECTOR

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Since the beginning of 2002 several tests have been performed at SVIRCO Observatory & Terrestrial Physics Laboratory (IFSI-Roma/INAF) to evaluate the performances of the helium proportional counters and their utilization in neutron detectors with different geometries.
At first the efficiency of the ^{3}He proportional counters (LND 25373 type) was analyzed and compared with the one of the $^{10}BF_3$ counters (BP-28 type) used in the SVIRCO NM-64 as well as in most of the IQSY detectors of the world-wide network for cosmic ray measurements.
The helium counter performances were compared by recording simultaneous data from a completely bare counter, a second counter provided with moderator (polyethylene tube) and a third one operating in a lead free NM-64 configuration (neutron flux meter).
Afterwards one boron trifluoride counter of the SVIRCO detector was replaced with a helium one to verify its proper response to the nucleonic component of incoming cosmic rays and its compatibility with the $^{10}BF_3$ counters (see, for instance, [1-3]).
Finally, with the financial support of the Italian PNRA, a 3NM-64_^{3}He was assembled in Rome and accurately calibrated with the standard neutron monitor of SVIRCO. At the end of January 2007 the new 3NM-64_^{3}He started operating at the Antarctic Laboratory for Cosmic Rays on King George Island (South Shetlands) [4, 5].
The geometry of this detector is just the same of the standard 3NM-64 one, with regard to the polyethylene reflector, moderator and the lead producer whereas the proportional counters are the LND 25373 (length 190.8 cm, diameter 5.08 cm).

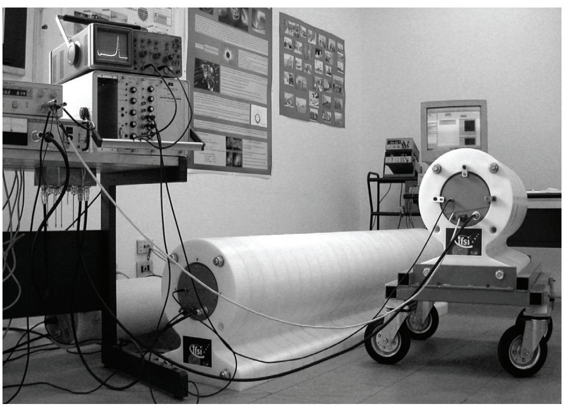

Figure 1. The mobile modular detector running since 2006 (right) and the new modular one which started operating in March 2010 (centre).

Another LND helium counter was tested at SVIRCO with the aim to realize a mobile neutron detector to be used for measurements outside the Observatory. The shorter LND 25382 tube (length 65.2 cm) has the same 2 inch diameter design of the longer LND 25373. Actually this diameter is very common for helium counters which are available in a wide set of sensitive length just in this size. This opportunity suggested us the design of a modular neutron monitor with an adaptable structure for proportional counters with different lengths.

In a recent paper [6] we described a small mobile detector operating at SVIRCO & TPL since the end of 2006 (see Fig. 1, right). It has been equipped with the LND 25382 tube and characterized by a modular geometry. The overall dimensions, without the hand-cart, are: width 37 cm, height 50 cm, length 79 cm and its total mass is about 265 Kg.
In March 2010 a bigger modular detector has been assembled using again the longer LND 25373 counter. In this configuration the detector has reached the length of 216 cm with a mass of ~ 800 Kg. Either neutron detectors are realized with the same modules (7 for the small one, 23 for the other) and closed by a plate at their both ends. The frontal plate has a hole for the tube and a bay for the electronics box fixed on the head of the counter, whereas the rear one is plane. Each module is composed by a polyethylene round shaped frame (outer reflector) with a tongue and groove joint to lock into one another. The central hole of the frame encloses a lead ring (producer) housing an interlocking polyethylene allow cylinder (inner moderator) which is the modular slot of the proportional counter. Four tie-rods block in the whole frame preventing any movement of the single elements which are boxed up with a strict mechanical accuracy.

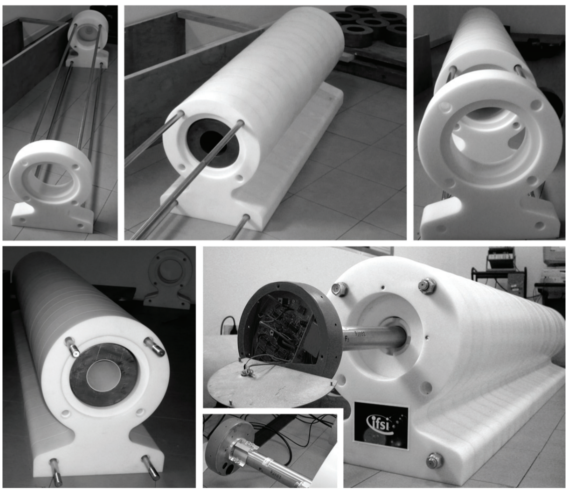

Figure 2. The step by step assembly of the new modular cosmic ray detector.

The step by step assembly of the new modular neutron monitor is shown in Fig. 2. Despite its overall weight, only one operator is required to assemble the whole detector, as the modular design made each loose component reasonably light, since the weight of the heaviest element (lead ring) is about 23 Kg.
At the ECRS2010 we are going to present details on the preliminary data we will have acquired with the new modular cosmic ray detector, compared with the ones of the standard NM-64 as well as with the records of the modular mobile detector.

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ANALYSIS OF SOLAR ACTIVITY AND GEOMAGNETIC FIELD INFLUENCES ON THE DYNAMIC OF OUTER RADIATION BELT ELECTRONS

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We analyzed the dynamic of relativistic electrons with energies 0.3-0.6 MeV fluxes measured on Universitetskiy-Tatiana micro-satellite [1] during 12 strong and moderate geomagnetic storms in the time period of years 2005-2006.

The observed proportionality between the value of relativistic electrons with energies 0.3-0.6 MeV maximum position L_{max} and the minimum value of Dst index Dst_{min} ($|Dst_{min}| \sim L_{max}^{-4}$) indicates on the penetration of relativistic electron, manly during magnetic storm periods in Earthward direction.

These fluxes good correlated with some indices, which are a measure of geomagnetic field activity level. The correlation coefficients between electron fluxes and Dst, Kp and AE indices were r=0.50, 0.57 and 0.89. The correlation of these fluxes with solar activity was in this time interval much less.

The correlation coefficient of electrons fluxes with combined quantity $Dst\ v_{sw}$ (r=0.63) is higher in comparison with correlation coefficients of single quantities Dst (r=0.50) and v_{sw} (r=0.12). A good correlation was obtained also between Dst index and product of $v_{sw}\ B_z$ (r=0.85), where B_z is southward component of IMF and also between Dst index and B_z (r=-0.58). This testifies the fact about connection between geomagnetic and solar activities and IMF orientation.

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VARIATIONS IN GEOMAGNETIC CUTOFF RIGIDITY OF COSMIC RAYS IN AUGUST 2005

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Variations in geomagnetic cutoff rigidity (August 2005) are calculated using data from ground-based observations of cosmic ray intensity at the worldwide network of stations. The calculated variations in geomagnetic cutoff rigidity are presented together with Dst-variations of the geomagnetic field. Paper also presents survey of variations in geomagnetic cutoff rigidity for different levels of disturbance of the geomagnetic field at different instants of the period under consideration.

VARIATIONS OF RIGIDITY SPECTRUM AND ANISOTROPY OF COSMIC RAYS IN AUGUST 2005

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Using the method of spectrographic global survey, variations of galactic cosmic ray (CR) rigidity spectrum and anisotropy (August 2005) were studied with the data from ground-based observations of cosmic rays at the worldwide network of stations.

A high degree of anisotropy was revealed ($\sim 30 - 70\%$ and $\sim 5 - 7\%$) for the first and second spherical harmonics, respectively) for particles with rigidity of 4 GV at the moments of maximum cosmic-ray modulation. The high degree of anisotropy (including the bidirectional one in the CR angular distribution) and their phases' variability evidence, firstly, ejection of magnetic clouds and loop-like IMF structures by coronal mass ejections and, secondly, a high degree of the IMF regularity in these structures.

MEASUREMENTS OF THERMAL NEUTRON CONCENTRATION NEAR THE GROUND SURFACE

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The thermal neutron flux near the Earth's surface has been measured using large unshielded neutron scintillator detectors of a new type [1], based on ZnS(Ag) and lithium fluoride, enriched with ^{6}Li up to 90%. The detectors of 0.75 m^2 area were placed at various levels (from - 4 m through 10.5 m) inside the experimental building and at several levels in open air. Measurements have shown an existence of a gradient of thermal neutron density inside the building similar to that observed in [2]. Monte-Carlo simulations of transportation of neutrons produced by cosmic rays in the atmosphere as well neutrons produced by natural radioactivity in soil, gave similar result thus confirming the effect.

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AN OPPORTUNITY FOR HIGH MOUNTAIN CR OBSERVATORIES

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The High Mountain Observatories (HMOs) played a relevant role not only for Nuclear Physics but also for Astrophysics. For example, before the construction of the particle accelerators, cosmic ray (CR) measurements performed at high altitudes were the only way to investigate high-energy interaction mechanisms. The first HMOs (dated to the first half of the past century) were witnesses of an intense research activity performed by outstanding physicists (many of them awarded with a Nobel Prize); new detection techniques were introduced and new particles were discovered. Nowadays, HMOs are still of importance for fundamental research, as well as for instrument calibration, validation and integration of satellite data. Certainly, the HMOs, their instruments and obtained data series are a scientific heritage that should not be lost.

During the International Conference on *Astronomy and World Heritage: across time and continents* (Kazan, 19 - 24 August 2009), following the invitation by the Coordinator (Ms. A. Sidorenko-Dulom) of the UNESCO World Heritage (thematic initiative: *Astronomy and Word Heritage*), it was proposed to include HMOs with special historical and scientific interest in a list to be submitted to the UNESCO World Heritage Committee. The request is in complete agreement with was established at the 29th Session of the World Heritage Committee of the World Heritage Centre:

"... to further explore the thematic initiative "Astronomy and World Heritage" as a means to promote, in particular, nominations which recognize and celebrate achievements in science. Following this recommendation, all States Parties were invited to identify national focal-points in charge of coordinating the implementation of all activities relevant to the Initiative, in consultation with the UNESCO World Heritage Centre, the Advisory Bodies and national authorities"

Indeed, it is an important UNESCO Initiative, aiming to link astronomy research with cultural sites and monuments around the world. For this reason, at the ACP Symposium on Atmospheric Chemistry and Physics at Mountain Sites (Interlaken – Switzerland, 8-10 June 2010) a round table discussion on the topic will be chaired by Dr. M. Huber (President of the *Jungfraujoch Kommission*, Swiss Academy of Science). The discussion will include three HMO categories:
1. HMOs related to CR research;
2. HMOs devoted to atmospheric research and meteorology;
3. HMOs correlated with biology, medicine and physiology.

Of course, the first category is well inside the UNESCO Initiative because it provides relevant information on the Universe (such as origin and composition). For the other two categories a special check and selection of key sites should be promoted.

We believe that the historical importance of HMOs and their contribution to the development of the modern science in may fields, requires an effort of the worldwide scientific community for their identification. Results from the Interlaken Discussion will be summarized at the ECRS2010 and new input will be furnished.

Work partly supported by the Turin Section of the National Institute of Nuclear Physics and partly by IFSI-Roma of the National Institute for Astrophysics.

NEUTRON SPECTRA DEPENDENCE ON ATMOSPHERIC PARAMETERS AT HIGH MOUNTAIN OBSERVATORIES

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Extended measurement campaigns of neutron spectra (energy range: 10 keV – 20 MeV; see also [1-3]) have been carried out at Chacaltaya Observatory (Bolivia, 16° 21' S – 68° 07' W; 5240 m a.s.l.; see Fig. 1) during 2008.

Figure 1. Chacaltaya High Mountain Observatory

The experimental campaigns were performed by using the passive *Bubble Detector Spectrometer* (BDS [4]), based on six superheated drop detectors with different energy thresholds (10 keV, 100 keV, 600 KeV, 1 MeV, 2.5 MeV and 10 MeV).

The detectors were inserted in a thermostatic and pressurized box, as shown in Fig. 2, to maintain a constant temperature and pressure (20°C – 1 atmosphere). This setup allowed to keep the experiment outside the Observatory building, avoiding the internal radiation background and the energy attenuation induced by the building walls.

Figure 2. Positioning of bubble dosimeters inside the pressurized box, as used at Chacaltaya.

The acquired data were elaborated by using the unfolding code BUNTO [5]. The influence of the different atmospheric conditions on the neutron energy distribution was carefully analyzed and results are here described.

Thanks are due to the technical staff of the Chacaltaya Observatory for assistance. Authors are indebted with their Institutions for financial supports

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PECULIARITY AMPLITUDE DISTRIBUTION OF IONIZATION JERKS IN THE CAMERA ASK-1 FROM PROLONGED MEASUREMENTS

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A unique device, the ionization chamber ASK-1 with the lead screen of about 12 sm, is a part of the Yakutsk cosmic ray spectrograph. The chamber allows to study physical characteristics, so-called ionization "jerks", i.e. the sharp increases of ionization current caused by a passage of strongly ionizing particles of space origin through the device. The increases of current are caused by the major nuclear - cascade "showers" formed by cosmic ray particles mainly on the screen of chamber. For the whole period of observations (more than 50 years) the ASK-1 chamber registered 59125 jerks. Their properties and nature are still studied insufficiently, especially in the field of middle and high amplitudes. We have constructed the differential distribution of jerks by their amplitudes. In the distribution some peculiarities (maxima) which demand not trivial explanation have been found. The possible nature of jerks of various quantity value is discussed.

PRIMARY ENERGY RECONSTRUCTION FROM THE S(500) OBSERVABLE RECORDED WITH THE KASCADE-GRANDE DETECTOR

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Previous EAS investigations have shown that the charged particle density becomes independent of the primary mass at large but fixed distances from the shower core and that it can be used as an estimator for the primary energy. Such particular distances depend on the detector layout and for the KASCADE-Grande experiment it was shown to be around 500 m. The charged particle density recorded by KASCADE-Grande at this specific distance, S(500), has been shown by extensive simulation studies to map the primary energy.

We present results on the reconstruction of the primary energy spectrum of cosmic rays from the experimentally recorded S(500) observable using the KASCADE-Grande array. The constant intensity cut (CIC) method is applied to evaluate the attenuation of the S(500) observable with the zenith angle. A correction is subsequently applied to correct all recorded S(500) values for attenuation. The all event S(500) spectrum is obtained. A calibration of S(500) values with the primary energy has been derived from simulations and has been used for conversion thus obtaining the primary energy spectrum (in the energy range accessible to the KASCADE-Grande array, 10^{16}-10^{18} eV). An evaluation of systematic uncertainties induced by different factors is also given and a correction matrix is applied in order to compensate for the effects of the fluctuations on the reconstructed spectral index.

PRODUCTION OF COSMOGENIC BERYLLIUM ISOTOPES IN THE ATMOSPHERE: A FULL NUMERICAL MODEL

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A new quantitative model of production of the cosmogenic isotopes, produced by spallation of atmospheric constitutes by the nucleonic component of cosmic rays induced cascade in the Earth's atmosphere is presented. The model is based on the CRAC (Cosmic Ray induced Atmospheric Cascade) core [1, 2, 3], which is a a full numerical Monte-Carlo simulation of the nucleonic–electromagnetic–muon cascade induced by cosmic rays in the atmosphere, using a CORSIKA [4] simulation tool. We presents the results for Beryllium cosmogenic isotopes ^{7}Be and ^{10}Be The model able to compute the isotope's production rate at any given 3D location (geographical and altitude) and time, for all possible parameters including solar energetic particle events. The model was tested against the results of direct measurements of production of ^{10}Be and ^{7}Be in a number of dedicated experiments to confirm its quantitative correctness. A set of tabulated values for the yield function is provided along with a detailed numerical recipe forming a 'do-it-yourself' kit, which allows anyone interested to apply the model for any given conditions. This provides a useful tool for applying the cosmogenic isotope method in direct integration with other models, e.g., dynamical atmospheric transport.

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HIGH-ENERGY PHOTONS CONNECTED TO ATMOSPHERIC PRECIPITATIONS

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Results of the gamma - radiation monitoring in the surface layer of atmosphere with scintillation gamma – spectrometers are discussed. Instruments consist of a NaI (Tl) crystal with a photomultiplier. The data are transmitted to a computer with a special card with the 4096 channel pulse-amplitude analyzer. The gamma-ray monitoring is presently carried out at two high-latitude points: Apatity (N 65.57, E 33.39) and Baretnburg, Spitsbergen (N 78.06, E 14.22). Together with gamma-spectrometer in Apatity a precipitation measuring device (PMD) was installed, which allows to estimate presence and intensity of precipitations. Information about precipitations in Barentsburg was taken from the local meteorological observatory.

The observations have shown that sporadic increases of gamma - radiation registered by spectrometers are almost always accompanied by intensive precipitations (rain, snowfall). The measured spectrum of gamma - radiation was rather smooth and did not show peaks in a range from 1 up to 200 KeV. Two basic hypotheses of an origin of high-energy photons during precipitations are discussed. The first is probable connection with atmospheric radionuclides, which are attached to aerosols and are taken out from the atmosphere by precipitations. Against this hypothesis speaks lack of peaks on gamma-ray spectrum. The gamma-spectrum from radionuclides usually has characteristic and expressed spectral lines. The second probable cause is the X-ray radiation arising at deceleration in air of free electrons, accelerated in an electric field between clouds and ground. All cases of precipitations are accompanied by dense cloudiness and strengthening of an atmospheric electric field. The arguments for this mechanism are resulted.

THE REGISTRATION EFFICIENCY AND RESPONSE FUNCTIONS OF THE NEUTRON DETECTORS OF DIFFERENT GEOMETRY

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In the work the modeling of the neutron monitors response on the passage of neutrons and other secondary particles of cosmic rays through the device aperture is carried out. For the determination of the response functions of different neutron monitors the modeling of the development of the cascade activated by the flux of secondary particles (protons, and also neutrons, muons and pions) in the energy range from the slow to 100 GeV incident on the detector is carried out. The calculations are made on the base of the FLUKA package. For this purpose the software system involving the mathematical model of the neutron detectors, the processes in the proportional counters and electronics response to energy deposition in the gas was created.

Along with the standard neutron monitors NM57 and NM64 another neutron component detectors sensitive to the incident flux of the particles in the different energy range are under consideration. These are so-called lead-free neutron monitors of different design using in a number of applied problems. For all the considering detectors the influence of the environment and underlying surface (snow, soil) is studied. The characteristics of the neutron monitor NM64T equipping now some new cosmic ray stations were also obtained. Such super monitor contains not 6 boron counters but 8 helium counters with the same geometry and the same lead and polyethylene content. The calculation method is described in detail. The comparison of the obtained results with the earlier calculations and the experimental data is carried out. The response functions of the neutron detectors are calculated with good statistics and with accuracy up to several percents in the energy range from the slow to 100 GeV.

DETECTION OF TRAPPED ANTIPROTONS IN THE EARTH INNER RADIATION BELT

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[6]KTH, Department of Physics, and the Oskar Klein Centre for Cosmoparticle Physics, AlbaNova University Centre, 10691 Stockholm, Sweden.
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It is well known existence of the inner Earth radiation belt populated mainly with trapped protons. The trapped protons are mostly produced by the decay of neutrons originated in their turn in interaction of cosmic rays with the upper atmosphere. The same mechanism should also produce antineutrons and therefore trapped antiprotons [1]. The first measurement of trapped antiprotons in the inner Earth radiation belt was in the MARIA-2 experiment [2] and yielded the upper limit of antiprotons to protons flux ratio $5 \cdot 10^{-3}$.

Object of this paper is the description of the detection of the antiprotons trapped in the inner radiation belt (South Atlantic Anomaly) with the PAMELA instrument. During orbits PAMELA pass through the south Atlantic anomaly where it encounter geomagnetically trapped particles from the inner radiation belt. The instrument is able to identify charge particles in the cosmic radiation with an array of detectors which includes a time-of-flight system, a magnetic spectrometer, a silicon-tungsten electromagnetic calorimeter [3].

The geomagnetically trapped antiprotons in the South Atlantic Anomaly are observed for the first time. The antiproton to proton flux ratio is 10^{-5} at energies below 1 GeV.

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Session 3: Space and Balloon-borne Cosmic Ray Experiments (Talks)

Conveners: G.A. Bazilevskaya and E. Valtonen

INVITED

Measurement of the Cosmic-Ray electron spectrum with the Fermi LAT

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We present the measurement of the Cosmic-Ray electron spectrum between 7 GeV and 1 TeV based on the data collected by the Large Area Telescope, on board the Fermi Gamma-Ray Space Telescope, during its first year of operation. Preliminary results on the search for anisotropies in the arrival directions will also be briefly discussed.

Observational capabilities and techniques for the study of Light-Nuclei in Cosmic Rays with the PAMELA experiment.

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PAMELA is a satellite-borne experiment [1] built to detect charged particles in cosmic rays with particular attention to antiparticles. PAMELA is in orbit from June 15th 2006. All the detectors are working nominally and analysis is in progress to achieve many scientific goals: principally the search for antimatter in primary radiation, the search for dark matter sources but also the measurement of fluxes and ratios of the different components of the cosmic radiation and the study of interactions of the radiation itself with Sun and Magnetosphere. To reach all these scopes, PAMELA is composed by several instruments perfectly integrated: a Time-of-Flight system, a magnetic Spectrometer, a silicon-tungsten electromagnetic Calorimeter, an Anticoincidence system, a shower tail catcher scintillator and a Neutron Detector.

The study of the nuclear component of the cosmic radiation at energies higher then 200 MeV/n is a main topic for the PAMELA experiment. It is strictly connected to a better understanding of the propagation properties, which has great importance for the study of signatures of new physics in Cosmic Rays [2]. For example, indirect signals of dark matter pairs annihilating in the halo of our Galaxy could be found in antiproton, antideuteron or positron CRs but this research is limited by the uncertainties in the propagation parameters and fluxes of charged particles located in the whole diffusive halo [3]. The PAMELA experiment will contribute to this issue measuring light nuclei fluxes and ratios with good accuracy, also in some unexplored energy range. To achieve those scientific goals we can use and combine measurements of dE/dx and momentum of the passing particles from three main subdetectors of PAMELA: the magnetic spectrometer [4], the calorimeter [5] and the Time-of-Flight system [6].

For example, the measurement of the energy loss of passing particles inside the planes of the ToF is a powerful tool for identification of light nuclei. Starting from such measurement, the algorithm to reconstruct Z of the nucleus is complex because many intrinsic topics of the instrumental components, such as attenuation length, Birks saturation of scintillators, saturation of PMTs exc., produce deviation from linearity of the response of the detector. Those effects have to be taken into account, evaluated and corrected; only after that it is possible to define Z starting from measured β and dE/dx according to Bethe-Bloch equation.

To evaluate the energy of the passing nucleus we can instead apply two different methods: we can derive it from the rigidity measured by the spectrometer or from the measured β from ToF; the first method is really powerful especially in the higher part of the explored energy range, the second one can be instead very useful in the lower part (up to about 3

GeV/n).

The algorithms for the identification and energy reconstruction of light nuclei, from Lithium up to Oxygen, will be described in this contribution together with an overview of the instrumental performance in different energy ranges.

[1] P. Picozza, et al., *PAMELA: a Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics*, Astroparticle Physics 27 296-315 (2007)

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High Energy Cosmic-Ray Proton and Helium Spectra

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The work was done within the framework of PAMELA experiment [1]. The PAMELA is the space experiment for study charged particle spectra of cosmic radiation in wide energy range was launched June 15 2006 and has performed until now. This work is a description of cosmic ray proton and helium spectra determination with energy more than 50 GeV based on using sampling electromagnetic calorimeter [2]. The applied method is based on a measurement of total deposited energy in calorimeter and usage of certain selection criteria of events connected with electromagnetic component of hadronic shower. The helium-proton separation was performed by scintillator detectors of of PAMELA instrument Time of Flight system. This method is indispensable to widen the measurable energy range and to obtain additional information in PAMELA experiment. As a result the energy spectra of protons and helium measured by this method are presented.

[1] P . Picozza et al. Astrophysics Astroparticle Physics. 2007. V. 27. P. 296-315.

[2] M. Boezio et al. Nuclear Instruments and Methods Research A. 2002. V. 487. P. 407-422

Preliminary results about nuclei cosmic ray component from PAMELA mission

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The PAMELA (Payload for Antimatter Matter Exploration and Light nuclei Astrophysics) satellite-borne experiment was launched from the Baikonour site on the 15^{th} of June 2006, and has been collecting data since July 2006. PAMELA consists of a permanent magnet spectrometer, to provide rigidity and charge sign information; a Time-of-Flight and trigger system, for velocity and charge determination; a silicon-tungsten electromagnetic calorimeter, for lepton/hadron discrimination; a shower tail catcher scintillator and a neutron detector. An anticoincidence system is used offline to reject false triggers. The telescope allows for precision studies of the charged cosmic radiation to be conducted over a wide energy range with high statistics. The primary scientific goal of PAMELA investigation is the search for evidence of non-baryonic particles falling outside Standard Model particle physics, as dark matter candidates, new matter and primary antimatter. Another important objective of the mission is the study of the isotopic and nuclear components of the cosmic rays. Accurate measurements of the elemental composition are required in order to understand the origin, propagation and lifetime of the cosmic radiation. While the primary cosmic rays (e.g. C, N and O) propagate through the interstellar medium giving information about the composition at the source, the secondary elements (e.g. Li, Be, and B) are tracers of amount of matter traversed by the cosmic rays. Both cosmic ray source composition and propagation history are imprinted in their abundances. The relative abundances of the constituents of galactic cosmic rays provide information about cosmic-ray transport within the Galaxy, allowing a better estimation of the background. Related to this field, PAMELA has been measuring the light nuclear component of galactic cosmic rays from hydrogen up to oxygen in a wide energy range and with very high statistics. This paper reviews some preliminary results obtained with the PAMELA experiment about nuclei component.

GLOBULAR CLUSTER OF ANTISTARS AS A SOURCE OF ANTIHELIUM

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A profound signature of non-homogeneous baryosynthesis in the very early Universe is a possibility of generation of antibaryon excess in macroscopic regions[1,2] of baryon asymmetrical Universe[3]. Annihilation with surrounding matter determines the minimal size of such antimatter domains, surviving to the present time[2, 4]. Observations of gamma ray background put upper limit on the possible amount of antimatter in our Galaxy [2](see for review and refs [5]). These two conditions leave a window 1000-100000 Solar masses of antimatter that can exist in our Galaxy in the form of a globular cluster of antistars [2]. We obtain a prediction for the flux of antihelium in near-Earth space originated from this source of antinuclei in the Galaxy. We consider the injection of antihelium nuclei from a source in the interstellar medium, their diffusion in the magnetic halo of Galaxy, estimate the probability of antihelium interactions with interstellar gas and take into account the effect of solar modulation in the propagation of antihelium in the Heliosphere. The results show that the probability of antihelium detection increases with energy. The experimental upper limits for the flux ratio antihelium/helium, obtained in experiments BESS [6] and AMS-01 [7], put constraints on the mass of the globular cluster of antistars in our Galaxy.

[1] V.M.Chechetkin, M.Yu.Khlopov M.G.Sapozhnikov and Ya.B.Zeldovich. Astrophysical aspects of antiproton interaction with He (Antimatter in the Universe). Phys. Lett. (1982), V. 118B, PP. 329-332.
[2] M.Yu.Khlopov. An antimatter globular cluster in our Galaxy - a probe for the origin of the matter. Gravitation & Cosmology (1998), V. 4, PP. 69-72.
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[7] Alcaraz et al.. Search for antihelium in cosmic rays. Phys. Lett. B 461 (1999), pp. 387-396.

SEARCH FOR ANTIHELIUM IN COSMIC RAYS IN PAMELA EXPERIMENT

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One of the most important questions of cosmology is the explanation of the observed baryon asymmetry in the Galaxy. The real value of this asymmetry can be established by direct measurements of antinuclei in the cosmic rays. Therefore, among the objectives of the experiment "PAMELA" is a search of antihelium nuclei [1]. An important feature of the experiment is to seek the antinucleus at high energies, because with decreasing energy significantly increases the cross section of annihilation, which complicates their passage through the solar system. We analyzed data from August 2006 to December 2009 and present the results of measuring the antihelium/helium upper limit. In any case, the result will be useful for theoretical models that predict the existence and propagation of antihelium in the Galaxy.

[1] Picozza, P. et al. PAMELA - A payload for antimatter matter exploration and light-nuclei astrophysics. Astropart. Phys. 27, 296-315 (2007).

COSMIC RAY ELECTRON AND POSITRON SPECTRA MEASURED BY PAMELA

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[3] INFN, Sezione di Florence, Italy

The PAMELA experiment is carried out on board of the satellite Resurs DK1 launched on June 15^{th} 2006 on polar orbit (the inclination is $70°$, the altitude is 350-600 km). The instrument which consists of magnetic spectrometer, silicon-tungsten imaging electromagnetic calorimeter gives a possibility to measure electron and positron fluxes over wide energy range from hundreds MeVs to hundreds GeVs. Measurements made in 2006-2009 are presented and compared with other recent results. Positron spectrum appears to be harder than standard diffusive propagation models predict.

Detection of Neutrons at ISS by SEDA-AP

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A solar neutron detector has been launched on the Japan Exposure Module (JEM) of the International Space Station (ISS) on August 2009 (Figure 1). The detector comprises scintillation fiber and two 256 channel multi anode photomultipliers. The detector is designated as the Space Environment Data Acquisition (SEDA)-FIB [1,2]. It tacks the recoil protons induced by neutrons and measurement of the proton energy is made by using the range method. The energy resolution of the detector was measured using the proton beam at Riken [3].

Herein, we report the behavior of the FIB detector onboard the ISS; the special distribution of neutrons, directional information of neutrons and the energy distribution of neutrons that are mainly produced by the collisions of the galactic cosmic rays with the material of the ISS. If large solar flare occurs before the conference, we will report quickly the results of neutrons obtained by the SEDA-AP FIB detector.

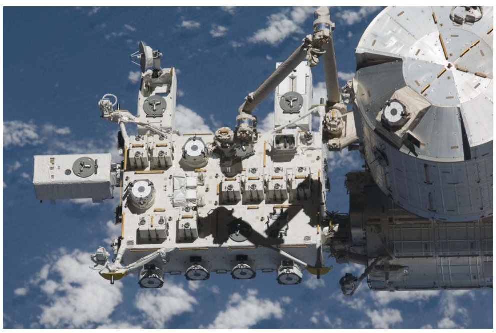

Figure 1: SEDA-FIB detector on board the International Space Station. (Photo has been taken by NASA.)

[1] K. Koga et al., Proceed. of the 21st ICRC (Kosice), edited by K. Kudela. (2008) 199.
[2] H. Matsumoto et al., Proceed of the 21st ICRC (Kosice) edited by K. Kudela, (2008) 288.
[3] I. Imaida et al, NIMA, A421 (1999) 99.

Measuring the B/C ratio with TRACER

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Energy spectra of individual cosmic-ray elements are measured with the balloon-borne detector TRACER up to energies of 10^{14} eV/particle. The instrument had an Arctic long-duration balloon flight in 2006. In this presentation we focus on the measurement of the Boron-to-Carbon ratio. The data are used to investigate the propagation of cosmic rays in the Galaxy. We will present the results of the Arctic flight and discuss their implications within the framework of a leaky box model with a finite residual pathlength. We will show that the results of the 2006 flight are compatible with previously published data from the flight in 2003. In order to investigate the significance of the new results, data corrections and model assumptions will be scrutinized, and other possible propagation modes will be outlined.

POSSIBLE STRUCTURE OF THE COSMIC RAY ELECTRON SPECTRUM MEASURED BY THE ATIC-2 AND ATIC-4 EXPERIMENTS

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The first result of measurements of the electron spectrum in the balloon-borne experiment ATIC in the energy region from 20 GeV to 3 TeV [1] revealed an excess in the form of a broad peak in the energy range 200–700 GeV (ATIC's excess). This indicated a possible nearby source of electrons and caused wide discussion in the scientific community due to a possible connection of the ATIC's excess with annihilation of dark matter particles. A new analysis of the electron spectrum measured by ATIC was carried out by Moscow State University. This new analysis is completely independent of previous work and is carried out with different criteria for selection of electrons from the proton background. Some improvements of the analysis are related to the methods of accounting for the influence of the residual atmosphere to the spectrum. The new results (not yet approved by all members of the collaboration) confirm ATIC's excess and suggest that the spectrum above ~200 GeV can be represented by a number of narrow peaks (Fig. 1). Even though the number of events is not large (see Fig.1, right panel), the high energy resolution of the ATIC spectrometer allowed this study. Our analysis indicates that the observed peaking structure is characterized by a relatively large amplitude, with high statistical significance, and is reproduced in both successful scientific fights of the apparatus: ATIC-2 (2002-2003) and ATIC-4 (2007-2008), see Fig.1, the left panel. The statistical significance of the observed structure is calculated with autocorrelation and cross-correlation analysis and is estimated as about 0.999 (the exact number will be presented in the talk).

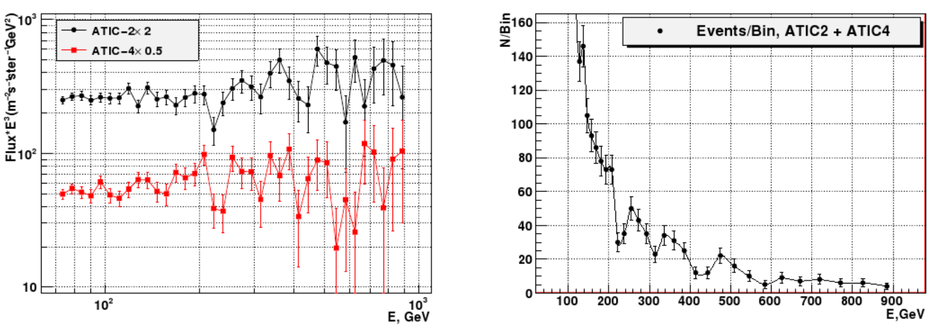

Fig.1 Left: Electron spectrum measured by ATIC-2 and ATIC-4 (preliminary). Right: the number of events per energy bin in the spectrum of ATIC-2 + ATIC-4.

The possible methodical origin of the observed structure was investigated by a number of ways. 1) Studying the statistics related to hadron cosmic-ray spectra free from electrons. No statistically significant structures were found in them. 2) Studying the electron filtering techniques of different nature. All studied filters produce the same result for the structure of the electron spectrum, therefore the structure is not method-dependent. 3) Studying different cut values of the electron filters that means the selection of electrons with different efficiency and different possible proton contamination of the electron spectrum. The structure is reproduced with different cuts (as should be expected). 4) Studying the electron spectra for different partial solid angles in the aperture of the apparatus. The structure is reproduced with different angles. Therefore no signatures of methodical effects were found, but, of course, the final conclusion about the observed structure may be deduced only after confirmation the ATIC's results by independent experiments with sufficiently high resolution and high statistics in the cosmic ray electron spectrum.

If confirmed, the observed structure would be most consistent with electron production in nearby supernova remnants and/or pulsars. The structure similar to observed in the ATIC's electron spectrum was predicted in [2] and it was argued there that such structure may be used as a signature that might differentiate between annihilation or decay of dark matter particles and other sources of electrons like nearby pulsars. Dark matter generally could not produce multiple bumplike features [2].

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Towards the Low Energy Cosmic Ray Measurement with PERDaix

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The Proton Electron Radiation Detector Aix-la-Chapelle (PERDaix) [1, 2] is a detector designed for a measurement of a flux of cosmic ray particles in a range from 0.5 to 5 GeV with the maximal detectable rigidity of a 9.6 GV. It comprises a permanent magnet, a scintillating fiber tracker, a transition radiation detector and a time-of-flight system for identifying electrons, positrons, protons and helium. The PERDaix is going to be launched with the stratosphere balloon in October 2010 in the framework of the German-Swedish Balloon-borne Experiments for University Students (BEXUS) program. The main measurement is supposed to take place for at least 2 hours at the hight of 30 km. The exact flight duration depends on the meteorologic conditions.

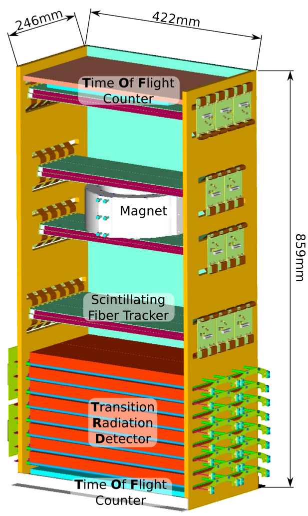

Figure 1: Schematic view of the PERDaix detector.

The main goal of the experiment is the contribution to the further understanding of charge-sign dependent solar modulation of cosmic rays flux. It will add further data to the existing series of measurements in the present solar cycle for better understanding. Also PERDaix will provide a start platform for a larger project with testing the novel detector technologies in the operation condition.

This work presents the results of the Geant4 simulation of the detector and estimation of the expected performance in delivering the absolute fluxes of cosmic ray particles as well as the positron fraction. The study of the systematic uncertainties in the correction of atmospheric backgrounds is discussed in detail.

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[2] PERDaix web site:
`http://accms04.physik.rwth-aachen.de/~perdaix/`

STATUS AND PERSPECTIVES OF CALET EXPERIMENT ON ISS

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We are developing the CALorimetric Electron Telescope, CALET, mission for the Japanese Experiment Module - Exposed Facility, JEM-EF, of the International Space Station, ISS. Major scientific objective is a search for the nearby cosmic ray sources and for dark matter by carrying out a precise measurement of the electrons in 1 GeV – 10 TeV and the γ-rays in 10 GeV – several TeV energy intervals. CALET has a unique capability to observe the electrons and the γ-rays in the trans-TeV region since the hadron rejection power is larger than 10^5 and the energy resolution better than a few % over 10 GeV. The detector consists of the imaging calorimeter of scintillating fibers and tungsten plates and the total absorption calorimeter with PWO scintillators. The total depth detector is nearly 30 X_0 and the mean free path for protons is 1.34 λ. Therefore, CALET has a capability to measure cosmic ray H, He and heavy ions up to 1000 TeV. It will also have a function to monitor the solar modulation of electron flux in 1–10 GeV at high latitudes. By adding a specific detector, the γ-ray bursts in 7 keV – 20 MeV will be monitored. The CALET mission has been approved for proceeding to the phase B in April 2010; the launch is scheduled in 2013 by the H-IIB Transfer Vehicle HTV, for a 5-year observation.

THE POSSIBILITIES OF SIMULTANEOUS DETECTION OF GAMMA RAYS, COSMIC-RAY ELECTRONS AND POSITRONS ON THE GAMMA-400 SPACE OBSERVATORY

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[6]Istituto Nazionale di Fisica Nucleare, Sezione di Trieste, Italy
[7]Istituto Nazionale di Fisica Nucleare, Sezione di Roma 2, and Physics Department of University of Rome "Tor Vergata," Rome, Italy
[8]Istituto Nazionale di Fisica Nucleare, Sezione di Firenze, and Physics Department of

The GAMMA-400 space observatory will provide precise measurements of gamma rays, electrons, positrons in the energy range 0.1–3000 GeV, and high-energy nuclei. The good angular and energy resolutions, as well as identification capabilities of the observatory (angular resolution 0.05°, energy resolution 3%, e/p rejection factor $\sim 10^6$) will allow us to study the main galactic and extragalactic sources, diffuse gamma-ray background, gamma-ray bursts, fluxes of electrons, positrons, and nuclei. Simultaneous detection of gamma rays, cosmic-ray electrons and positrons can give information on significant problems concerning the origin of cosmic rays and their propagation in our galaxy, this particularly relates to Dark Matter searches.

Balloon-borne gamma-ray telescope with nuclear emulsion

Shigeki Aoki,[3] Tsutomu Fukuda,[4] Kaname Hamada,[4] Toshio Hara,[3] Atsushi Iyono,[5] Jiro Kawada,[2] Masashi Kazuyama,[4] Koichi Kodama,[1] Masahiro Komatsu,[4] Shinichiro Koshiba,[4] Hirotaka Kubota,[4] Seigo Miyamoto,[4] Motoaki Miyanishi,[4] Kunihiro Morishima,[4] Naotaka Naganawa,[4] Tatsuhiro Naka,[4] Mitsuhiro Nakamura,[4] Toshiyuki Nakano,[4] Kimio Niwa,[4] Yoshiaki Nonoyama,[4] Keita Ozaki,[3] Hiroki Rokujo,[3] Takashi Sako,[4] Osamu Sato,[4] Yoshihiro Sato,[6] Kazuya Suzuki,[4] Atsumu Suzuki,[3] Satoru Takahashi,[4] Ikuo Tezuka,[6] Junya Yoshida,[4] Teppei Yoshioka,[4]

[1]Aichi University of Education
[2]ISAS/JAXA
[3]Kobe University
[4]Nagoya University
[5]Okayama University of Science
[6]Utsunomiya University

We are planning to observe cosmic gamma-ray in the energy range 10MeV to 100GeV by balloon-borne gamma-ray telescope with nuclear emulsion. Nuclear emulsion is a precise tracker of which spatial resolution is sub-μm. By detecting starting point of electron pair, gamma-ray direction can be determined precisely (1.4mrad@1-2GeV). This is much better than Fermi Gamma-ray Space Telescope launched June 2008. We have implemented time stamp technique using nuclear emulsion multi-stage shifter, which can move several emulsion sheets in individual time periods[1]. Tracks recorded in emulsion sheets have different position displacement after track reconstruction depending on the arrival timing as shown in Fig. 1. This track displacements can be converted into arrival time information as shown in Fig. 2. The incident direction of gamma-ray in celestial coordinates can be obtained by using track time stamp information and attitude monitor of the telescope. Track measurements system have already been constructed in emulsion analysis facility for OPERA experiment by Nagoya university group. Now we are developing the gamma-ray telescope with nuclear emulsion and are planning to observe known gamma-ray sources by balloon flight. Potential, overview and status of our telescope are presented in this symposium.

[1] S. Takahashi et al., "Time stamp technique using a nuclear emulsion multi-stage shifter for gamma-ray telescope", Nuclear Inst. and Methods in Physics Research, A (accepted 14 March 2010. Available online 30 March 2010)

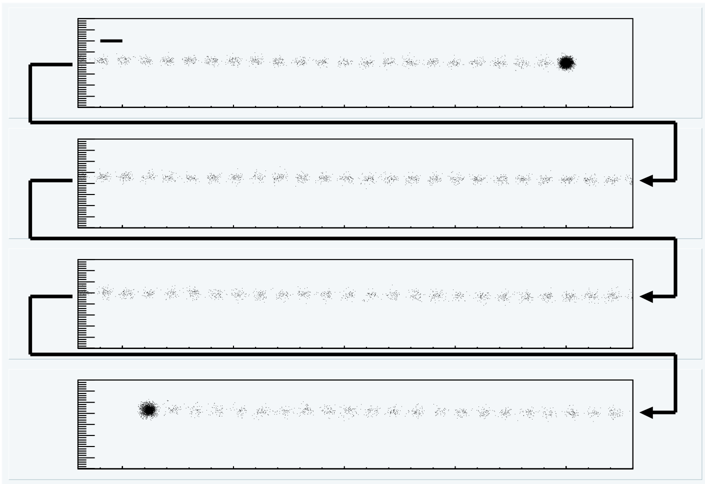

Figure 1: The distribution of position displacement after track reconstruction. The bar in the topmost figure shows 100μm scale. Each cluster between dense clusters corresponds to accumulation for 465s. Totally, the multi-stage shifter was operated for 12.1h.

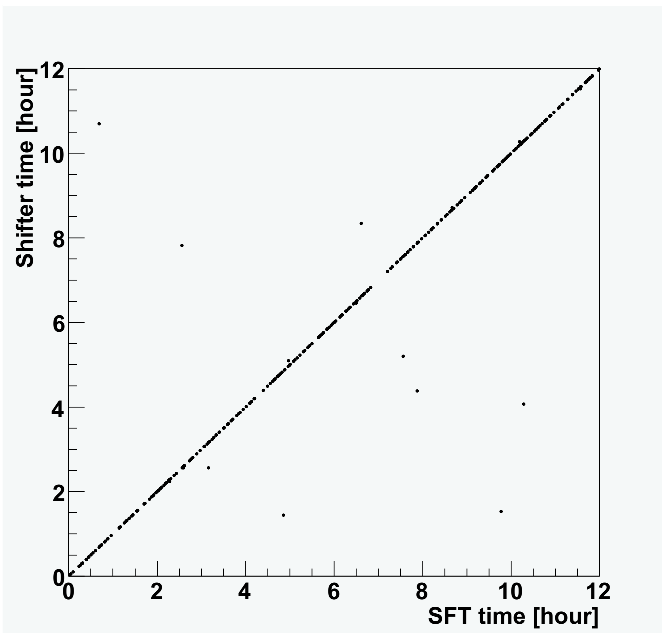

Figure 2: The comparison between arrival timing tagged by Scintillating Fiber Tracker(SFT) (holizontal) and reconstructed timing by the multi-stage shifter (vertical)

Measurements of Cosmic Ray Antiprotons with PAMELA

J. Wu[1] on behalf of the PAMELA collaboration

[1]Department of Physics, KTH, Sweden

The PAMELA experiment is a satellite-borne apparatus designed to study charged particles, and especially antiparticles, in the cosmic radiation. The PAMELA apparatus is mounted on the Resurs DK1 satellite which was launched on June 15th 2006. Until now the instrument has been traveling around the earth along an elliptical and semi-polar orbit for almost four years. The PAMELA instrument mainly consists of a permanent magnetic spectrometer, a time of flight system and an electromagnetic imaging calorimeter, which allows antiprotons to be identified from a dominating cosmic-ray background.

New measurements of the cosmic-ray antiproton flux and the antiproton-to-proton flux ratio between 0.1 GeV and 180 GeV are presented, employing the data collected between June 2006 and December 2008. Compared to previous experiments, PAMELA extends the energy range of antiproton measurements and provides significantly higher statistics. The derived antiproton flux and antiproton-to-proton flux ratio indicates that the main source of cosmic ray antiprotons is considered to be secondary production and no primary contribution has to be invoked.

Session 3: Space and Balloon-borne Cosmic Ray Experiments (Posters)

Conveners: G.A. Bazilevskaya and E. Valtonen

ANOMALOUS PAMELA EFFECT AND ITS POSSIBLE EXPLANATION

Y. Stozhkov

Lebedev Physical Institute, Russian Academy of Sciences, Moscow

The ratio of galactic positron flux to (electron + positron) one obtained in the PAMELA experiment in the energy range from 1 GeV up to ~ 100 GeV is considered. The increase of this ratio in the high-energy range can be understood if we take into account that active red dwarf stars generate cosmic rays during stellar flares. Part of these particles falling on the stellar surface could give additional flux of positrons via process of plus pion production and succeeding its decay of $\pi^+ \rightarrow \mu^+ \rightarrow e^+$.

Results from Ionizing Radiation Imaging Detectors Medipix-2 and Timepix on stratospheric balloon campaigns

J.Urbar [1], J.Scheirich [2] and J.Jakubek [3]

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[2]Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Microelectronics, Prague, Czech Republic
[3]Czech Technical University in Prague, Institute of Experimental and Applied Physics, Prague, Czech Republic

Results of the first two experiments on stratospheric balloon campaigns using the semiconductor pixel detectors of the Medipix family for energetic particle imaging in the stratospheric environment are presented. The original detecting device was based on the hybrid pixel detectors of Medipix-2 and Timepix developed at CERN with USB interface developed at Institute of Experimental and Applied Physics of Czech Technical University in Prague. The detectors were used in tracking mode allowing them to operate as an "active nuclear emulsion". The actual flight time of BEXUS-7 with Medipix-2 on 8th October 2008 was over 4 hours, with 2 hours at stable floating altitude of 26km. BEXUS-9 measurements of 3.5 hour duration by Timepix, Medipix-2 and STS-6 Geiger telescope instruments took place in arctic atmosphere till ceiling altitude of 24km on 11th October 2009. Stratospheric balloon platform is the optimal realization for such in-situ measurements of atmospheric ionization. Optimal not only because of the high altitudes reached, but also due to its slow ascent velocity for statistically relevant sampling of the ambient environment for improving cosmic ray induced ionisation rate model inputs. The flight opportunity for BEXUS student projects was provided by Education department of the European Space Agency (ESA) and Eurolaunch - Collaboration of Swedish National Space Board (SNSB) and German Space Agency(DLR). The scientic goal was to check energetic particle type altitudinal dependencies, simultaneously testing proper detector calibration by detecting fluxes of ionizing radiation while evaluating instrumentation endurance and performance. Extensive dataset of different types of cosmic ray particle image tracks were acquired in the stratospheric radiation environment, sorted and analyzed.

SOLAR ENERGETIC PARTICLE MEASUREMENTS WITH EPD/LET ONBOARD SOLAR ORBITER

E. Valtonen[1] and the Solar Orbiter EPD/LET team

[1]Space Research Laboratory, Department of Physics and Astronomy, University of Turku, FI-20014 Turku, Finland

The Low Energy Telescope (LET) of the EPD suite of particle instruments onboard Solar Orbiter is designed to identify elements from H to Ni with excellent element and energy resolution over the range from ~1.5 to ~60 MeV/nuc. It will separate ^{3}He from ^{4}He down to levels of ~1% and resolve Ne and Mg isotopes. The broad dynamic range will also allow measurements of trans-Fe elements with $30 \leq Z \leq 83$. With its flux-adaptive geometric factor, LET is able to perform measurements with good statistical accuracy near 1 AU as well as to maintain full functionality and performance during the expected occasional extreme flux conditions near the Sun. LET consists of two units each with three independent telescopes pointing to various directions and providing 3-D anisotropy information both in and out of the ecliptic plane. The scientific objectives addressed by LET include particle acceleration in both large solar energetic particle (SEP) events associated with fast and wide coronal mass ejections (CMEs) and in small impulsive flare-related events. 'Seeing' with SEPs of their sources will be improved significantly due to small heliocentric distances of Solar Orbiter and due to exceptionally accurate directional measurements with EDP/LET. This will allow resolving different components and evolutions associated with CME-liftoff in the beginning of major SEP events. Elemental and isotopic composition measurements, including trans-Fe elements, will be used to investigate the signatures of SEP events and to distinguish between the sources of particles. Accurate measurements of spectral shapes of various ions will give insights into the causes of spectral steepening in the energy range from ~3 to 30 MeV/n in gradual SEP events. Timing, compositional, spectra, and anisotropy observations of SEPs by LET and the other EPD sensors will be a key to understanding SEP acceleration processes and discriminating between particle escape mechanisms from the source regions.

Session 4: HE/UHE Cosmic Ray and Neutrino Experiments (Talks)

Conveners: K. Kampert and T. Suomijärvi

INVITED

The cosmic ray energy spectrum in the range 10^{16} - 10^{18} eV measured by KASCADE-Grande

M. Bertaina[1] for the KASCADE-Grande Collaboration

[1]Department of General Physics, Torino University, Italy

The KASCADE-Grande experiment, located at Forschungszentrum Karlsruhe (Germany) is a multi-component extensive air-shower experiment devoted to the study of cosmic rays and their interactions at primary energies 10^{14} - 10^{18} eV. One of the main goals of the experiment is the measurement of the all particle energy spectrum in the 10^{16} - 10^{18} eV range. The Grande detector samples the charged component (N_{ch}) of the air shower while the KASCADE array provides a measurement of the muon component (N_{μ}). The combined information of N_{ch} and N_{μ} is used to estimate the energy on an event-by-event basis and to derive the all particle energy spectrum. Since the calibration of the observables in terms of the primary energy depends on Monte Carlo simulations, three different methods with partially different sources of uncertainties, have been considered and compared to each other to derive the systematics on the energy spectrum. The different methods employed to derive the spectrum and their uncertainties, as well as the implications of the obtained result, will be discussed in detail. A short overview of other analyses performed by KASCADE-Grande will also be presented.

Constraints on ultra-high energy neutrino flux from radio observations of the Moon

S. Buitink,[1] O. Scholten,[2] J. Bacelar,[3] R. Braun,[4] A.G. de Bruyn,[5,6] H. Falcke,[6,7] K. Singh,[2] B. Stappers,[8] R.G. Strom,[6,9] and R. al Yahyaoui[2]

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[2]Kernfysisch Versneller Instituut, University of Groningen, 9747 AA, Groningen, The Netherlands
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[5]Kapteyn Institute, University of Groningen, 9747 AA, Groningen, The Netherlands
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[8]School of Physics & Astronomy, Alan Turing Building, Univ. of Manchester, Manchester, M13 9PL
[9]Astronomical Institute 'A. Pannekoek', University of Amsterdam, 1098 SJ, The Netherlands

We present new limits on the flux of cosmic neutrinos above 10^{22} eV that were obtained with radio observations of the Moon. When ultra-high energy neutrinos hit the Moon, they initiate an hadronic cascade below the surface. The cascade has a negative charge excess that propagates faster than the local speed of light, producing radio Cherenkov emission. The NuMoon project aims to detect these lunar radio pulses from the Earth with radio telescopes. The first phase consisted of 47.6 hours of observation with the Westerbork Radio Synthesis Telescope array. The Moon was observed in 4 frequency bands between 113 MHz and 175 MHz at a sampling rate of 40 MHz. From the results, an upper limit on the neutrino flux can be derived that is an order of magnitude below existing limits. In the second phase, the sensitivity will be further improved by observations with the Low Frequency Array (LOFAR).

INVITED

General Overview of Recent Results from the Pierre Auger Observatory

Rossella Caruso[1,2] and Pierre Auger Collaboration[3]

[1]Dipartimento di Fisica e Astronomia, University of Catania, Catania-Italy
[2]INFN-Section of Catania- Italy
[3]Observatorio Pierre Auger, Malargue (Mendoza)-Argentina

Since April 2008 the high energy cosmic ray Pierre Auger Observatory is taking data in its final configuration. Two main upgrades have been completed: the High Elevation Angle Telescopes (HEAT) and an infill in the surface region covered by HEAT, with the main goal of bringing the energy threshold down to 1017 eV. In this presentation I will show an overview of the main recent results of the Observatory. More specifically, I will discuss the all particle energy spectrum and the evidence for the GZk features, the measurement of the elongation rate and the evidence for anisotropy in the subset of the highest energy events.

INVITED

KM3NeT status

E. de Wolf [1], on behalf of the KM3NeT consortium

[1] Nikhef/University of Amsterdam

KM3NeT is a future research facility in the Mediterranean Sea, which will include a telescope for the observation of high-energy neutrinos. Following a four year design study the technical design report for the facility has been published. Construction of the facility is being prepared in an EU funded preparatory phase of the project. The neutrino telescope will have a total volume of several cubic kilometres. Since the principal scientific objective of KM3NeT is the observation of cosmic point-like sources of neutrinos, the design of the telescope has been optimised with a main focus on these sources. The sensitivity of KM3NeT for the observation of point-like sources and other cosmic processes, such as gamma ray bursts and dark matter, will be presented, together with the technical solutions employed to achieve these sensitivities.

Limits on the diffuse flux of ultra high energy neutrinos using the Pierre Auger Observatory

O. Deligny[1], for the Auger Collaboration

[1] CNRS/IN2P3 - Universite Paris 11, IPN Orsay

The array of water-Cherenkov detectors of the Pierre Auger Observatory is sensitive to neutrinos of all flavours in the EeV energy range. These interact through charged and neutral currents in the atmosphere (down-going) and, for tau neutrinos, through the Éarth skimmingḿechanism (up-going). Both types of neutrinos can be identified by the presence of a broad time structure of signals in the water-Cherenkov detectors in the inclined showers that they induce when interacting close to ground. Using data collected since 1 January 2004, we present a competitive limit on the all-flavour diffuse neutrino flux and discuss the implications. Sources of possible backgrounds and systematic uncertainties are also discussed.

Do we see an Iron Knee ?

A.D. Erlykin[1] and A.W. Wolfendale[2]

[1] P.N.Lebedev Physical Institute, Moscow, Russia
[2] Department of Physics, Durham University, Durham, UK

An update of the fine structure in the cosmic ray (CR) energy spectrum at PeV and tens of PeV energies is presented. The existence of the bump at 50-80-PeV found in GAMMA experiment is supported by 9 other experiments. If it is a real feature it might indicate the existence of the so called Iron Knee, i.e. the end of contribution of a Single Source to the background of CR from other sources. We argue that the new feature in the fine structure of the CR energy spectrum makes the evidence in favour of the pres-ence of a Single Source even stronger than before.

Cosmic ray primary composition studies through the Gerasimova-Zatsepin effects of heavy nuclei at LAAS

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[1]Okayama University of Science, Okayama 700-0005, Japan
[2]Kawasaki Medical School, Kurashiki 701-0192, Japan
[3]Nara University of Industry, Nara 636-8503, Japan
[4]Yonago National College of Technology, Tottori 683-8502, Japan
[5]Kinki University, Osaka 577-8502, Japan
[6]Hirosaki University, Hirosaki 036-8561
[7]Okayama Shoka University, Okayama 700-86011
[8]Kochi University, Kochi 780-8520
[9]Ashikaga Institute of Technology, Ashikaga 326-8558, Japan

Possibility to determine directly the cosmic ray nuclei mass number A had been proposed in 1950's by Gerasimova and Zatsepin [1](Gerasimova-Zatsepin effect). In their scenario, the photo-disintegration of cosmic ray nuclei with solar photons($\sim$ 1eV) allows to study the cosmic ray composition above 10^{18} eV. Because the nucleon stripped from heavy nucleus and surviving nucleus have different magnetic rigidities in the interplanetary magnetic fields, they could make the two separate, simultaneous and parallel EASs arriving at the earth in the some separation distance. The comparison of each energy of nucleon E_n and surviving nucleus E_N could directly determine the mass number of the primary nuclei[2] :$A = (E_\mathrm{n} + E_\mathrm{N})/E_\mathrm{n}$.

The probabilities of photo-disintegration process of cosmic ray nuclei with solar photons and the resulting separation distance at the observatories on the earth have been calculated thoroughly in previous works[2, 3, 4].

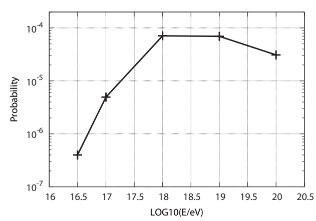

Figure 1: Simulation results on the fraction of Gerasimova-Zatsepin effects within the separation distance less than $2R_\mathrm{E}$ arriving at the earth.

The Large Area Air Shower (LAAS) experiments [5] have observed EASs above PeV energies at multiple compact EAS arrays scatted over Japan since 1996, with the accuracy of μs UT time stamp system provided by GPS-disciplined 10MHz oscillator, in order to identify simultaneous and parallel EAS pairs deriving from Gerasimova-Zatsepin effects of heavy nucleus. LAAS have maintained several arrays in different baselines from 1km to 800km. The typical angular resolution observed by compact arrays is about 7 degree.

In this paper, we analyzed the data obtained by LAAS long baseline EAS arrays($>$ 100km) as well as numerical calculations of Gerasimova-Zatsepin events. We have simulated cosmic ray nuclei trajectories, of which starting positions were away from 5AU from the earth and were directed to the earth. We also calculated the photo-disintegration probability while cosmic ray nuclei traveled to the earth. Once this process occurs, we numerical trace their remnants such as neutron, proton and surviving nucleus in between the interplanetary magnetic fields. The maximum probability that we can observe such events is shown in Fig. 1 as function of cosmic ray primary energy. The maximum value is about 10^{-4} around 10^{18}eV. This probability is too small to observe typical EAS array experiments. In other words, we always have observed one Gerasimova-Zatsepin effect every 10^4 EAS events. The photo-disintegration probability depends on the angle between the direction of cosmic ray velocity and of the solar photon, which was maximized in case of head-on collisions. We can see the correlation of GZ probability in both solar direction and anti-solar direction as shown in fig. 2

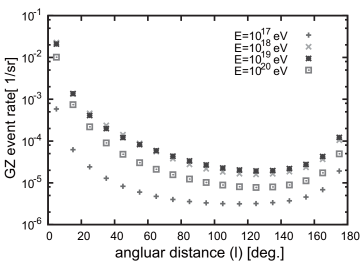

Figure 2: Simulation results on the direction correlation between sun and Gerasimova-Zatsepin events.

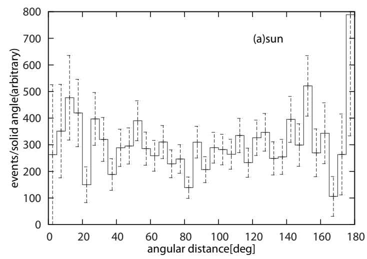

Figure 3: The angular distance distribution of Gerasimova-Zatsepin candidates from the sun direction.

We analyzed 12M EAS events observed by LAAS arrays, and data period is Aug. 1996 to Dec. 2006. The event selection criteria were 1)more than 5 coincidence events which corresponds to $E > 10^{15}$eV in simulation study, 2)baseline length more than 100km, 3) time difference less than 5ms due to geographical location of each array, and 4) angular distance of EAS pair less than 15 degree. Finally we selected 574 EAS events (287 EAS pairs) from 12M events. The angular correlation of EAS events with sun direction were shown in fig. 3. Lafebre et al. pointed out in the reference [4] that the complexity of the magnetic field near sun could make the trajectory deviation larger. And higher event rate would be expected in anti-solar direction. Data shown in fig. 3 seems favor to anti-solar direction at this moment.

[1] N. Gerasimova and G. Zatsepin, Soviet Phys. JETP, **11** 899, 1960.
[2] L. Epele, S. Mollerach and R. Esteban, Journal of High Energy Physics, **3**, 17, 1999.
[3] G. Medina-Tanco and A. Watson, Astropart. Phys. **10**, 157, 1999.
[4] S. Lafebre et al., A&A 485, **1**, 1, 2008.
[5] N. Ochi et al., J. Phys. G Nucl. Part. Phys. **29**, 1169, 2003.
[6] H. Matsumoto et al., Nucl. Instrum. Methods A, **6142**, 475, 2010.

INVITED

The IceCube Observatory – Status and Initial Results

Timo Karg[1] for the IceCube collaboration[2]

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The IceCube collaboration is building a cubic kilometer scale neutrino telescope in 2 km depth at the geographic South Pole, utilizing the clear Antarctic ice as Cherenkov medium to detect cosmic neutrinos. The IceCube observatory is complemented by IceTop, a square kilometer air shower array on top of the in-ice detector. The construction of the detector is nearly finished with 79 of a planned 86 strings and 73 of 80 IceTop stations deployed. Completion is expected in the winter 2010/11. Using data from the partially built detector, initial results of searches for neutrinos from astrophysical point sources such as supernova remnants, active galactic nuclei, and gamma ray bursts, for anisotropies in cosmic rays, and constraints on the spin-dependent dark matter scattering cross section will be presented. The new DeepCore extension of IceCube and R&D activities towards new neutrino detection techniques will also be discussed.

Measurement of the All-Particle Cosmic Ray Energy Spectrum with IceTop

F. Kislat,[1] for the IceCube Collaboration

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The IceTop air shower array is currently under construction at the geographic South Pole as part of the IceCube Observatory. In its final configuration IceTop will consist of 80 detector stations on a triangular grid with a nominal spacing of $125\,\mathrm{m}$ on the ice surface above the deep-ice component of the IceCube neutrino telescope. In January 2010, 73 detector stations were completed.

IceTop measures the energy density distribution in an air shower, which is the input to a dedicated shower recostruction algorithm. The resulting shower size observable is related to the primary energy. In order to obtain the primary energy, the relation between the shower size observable and the primary energy as a function of zenith angle and assumed primary composition is determined with CORSIKA simulations of air showers.

In this paper an overview of the current status and the physics program of IceTop will be given. We will focus on the application of the method mentioned above on data taken in 2007 with the 26 station configuration and the resulting all-particle Cosmic Ray energy spectrum.

INVITED

The Northern Site of the Pierre Auger Observatory

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[1]Institute for Data Processing and Electronics, Karlsruhe Institute for Technology, Karlsruhe, Germany

The Pierre Auger Observatory observes cosmic ray extensive air showers with energies in the EeV range and above with a hybrid instrument of a surface detector array and air fluorescence telescopes. The southern observatory was completed in June 2008 in Malargüe, Province of Mendoza, Argentina. It instruments an area of over over 3,000 km^2 with 1,600 water Cherenkov detectors [1] together with 24 fluorescence telescopes in 4 buildings on the perimeter of the array [2]. In addition the Pierre Auger Collaboration plans to build a northern observatory in southeast Colorado (USA) in the rural environment of Lamar.

The motivation for the construction of the northern observatory are manyfold:

- Only with observatories on both hemisperes the detection of cosmic rays from all directions in the universe is possible (full sky coverage).
- Results from Auger South [3][4][5] show compelling evidence that the sources of cosmic rays above 60 EeV are distributed anisotropically, but correlate with the positions of AGN (active galactic nuclei) in the our vicinity of about 100 Mpc. The study of cosmic rays at highest energies is thus of particular importance to learn the accelaration mechansism of individual extra-galactic sources.
- The flux at the highest energies is extremly low and in addition surpressed by the interaction with the cosmic microwave background (GZK effect) for distant sources. As a consequence, the design of Auger North is different from Auger South. To achieve highest statistical precision the covered area will be about 20,000 km^2, seven times bigger then Auger South. Furthermore, all detectors will be optimised for a higher energy range.

In this paper, we discuss the proposed Auger North layout, the changes in the design of the detectors, and the current activities to test improvements with an Research and Development Array (RDA).

[1] I. Allekotte, et al., Nucl. Instr. Meth. **A586** (2008),409-420
[2] Pierre Auger Collaboration, The Fluorescence Detector of the Pierre Auger Observatory, submitted to NIM
[3] The Pierre Auger Collaboration, Phys. Rev. Lett. **101**, 061101 (2008)
[4] The Pierre Auger Collaboration, Astropart. Phys. **29** (2008) 188-204
[5] The Pierre Auger Collaboration, (9 November 2007) Science **318** (5852), 938

THE DEPTH OF MAXIMUM SHOWER DEVELOPMENT AND ITS FLUCTUATIONS: COSMIC RAY MASS COMPOSITION AT $E_0 \geq 10^{17}$ eV

S. Knurenko,[1] A. Sabourov[1]

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We present a new data on Cherenkov light observations obtained during 1994-2009 period, after a modernization of the Yakutsk EAS array. A complex analysis of $x_{\max}$ and its fluctuations $\sigma\,(x_{\max})$ was performed in a wide energy range. With the new data, according to QGSJet II model, an estimation was made of cosmic rays mass composition for $E_0 \sim 10^{17} - 3 \times 10^{19}$ eV. The result points towards a mixed composition with a large portion of heavy nuclei at $E_0 \sim 10^{17}$ eV and the dominance of light nuclei at $E_0 \sim 10^{19}$ eV. The analysis of $\sigma(x_{\max})$ energy dependence for the same energies qualitatively confirms this result. A shape of $x_{\max}$ distribution at fixed energy 10^{18} eV is analysed to make more precise conclusion on cosmic ray mass composition.

UNDERGROUND MULTI-MUON EXPERIMENT EMMA

P. Kuusiniemi[1], L. Bezrukov[2], T. Enqvist[1], H. Fynbo[3], L. Inzhechik[2], P. Jones[4], J. Joutsenvaara[1], T. Kalliokoski[4], J. Karjalainen[1], K. Loo[1], B. Lubsandorzhiev[2], V. Petkov[2], T. Räihä[1], J. Sarkamo[1], M. Slupecki[4], W.H. Trzaska[4], A. Virkajärvi[4]

[1]University of Oulu, Finland, [2]Russian Academy of Sciences, Moscow, Russia, [3]University of Århus, Denmark, [4]University of Jyväskylä, Finland

According to the CORSIKA [1] simulations with a 50 GeV muon energy cut-off the muon lateral density distributions are sensitive to the energy and mass of the primary cosmic-ray particle. This is illustrated in Fig. 1 (left panel) where the average density distributions of 1, 3 and 10 PeV proton and iron initiated air-showers are shown.

On the basis of Fig. 1 (left panel) two interesting details seem evident: i) the primary energy translates to the muon density at shower core and is somewhat independent on mass, and ii) the tails are steeper for proton initiated showers than those of iron because of the larger total number of muons for the latter. Thus one assumes that the muon density at the shower core and the muon density gradient can be used to estimate the energy and mass of primary cosmic-rays, respectively.

These two somewhat straightforward observations are put to the test in the underground muon experiment EMMA [2] (Experiment with MultiMuon Array) that is being built at a depth of 75 metres (or 240 m.w.e) in the Pyhäsalmi mine, Finland, and is designed to measure multiplicities and lateral density distributions of air-shower initiated high-energy muons in order to measure the composition around the knee energy.

The EMMA array consists of nine muon detector stations. Each station (out of which currently four are installed) has a detector area of approximately 15 m^2. EMMA employs two types of detectors. The bulk area is covered with former LEP-DELPHI MUBs [3], or planks, which are gas-filled at 1 atm with Ar(92%):CO_2(8%)-mixture. The gas mixture is delivered from ground via a 100 m pipeline through the rock. Each plank consists of seven position sensive drift chambers (365$\times$20 cm^2, position resolution in the order of $\pm$1 cm^2) arranged in lenghtwise half-overlapping groups of 3+4 (area of 2.9 m^2 each).

While outermost detector stations host only one layer of planks (five planks placed side by side) the three central ones (marked with cross in Fig. 1, right panel) have three layers with the vertical distances of approximately 1.1 m. These enable muon tracking for which, using the above given position resolutions and vertical distances, the angular resolution is better than one degree for single muons. The latter is important in order to estimate the energy cut-off and thus losses in the number of muons for each air-shower.

Despite the good position resolution of drift chambers their multi-muon detection efficiency is limited to a few muons within the chamber area because of pile-up signals in

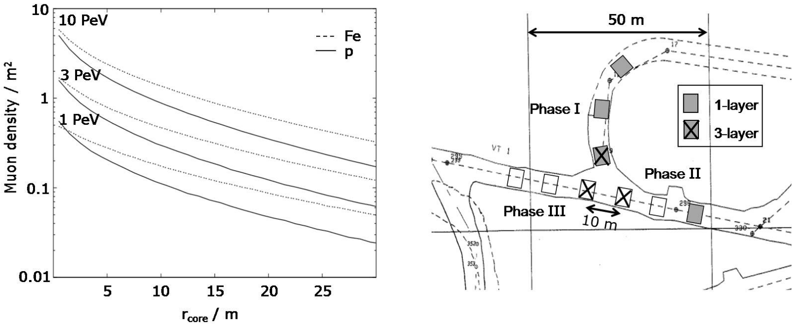

Figure 1: Left: Simulated (by CORSIKA+QGSJET 01 [1]) lateral muon density distributions of high-energy muons ($E_\mu > 50$ GeV) of proton and iron initiated air-showers at 1, 3 and 10 PeV energies. Right: Layout of the EMMA array. The shaded detector stations are currently installed. Phase I, II and III refer to the three branches of the array.

multi-muon events. Thus high muon multiplicities at the shower centre may result in problems (i.e. detector saturation). In order to overcome this limitation EMMA employs another set of detectors placed underneath the bottom layer of planks in the central stations. These are plastic scintillators equipped with APDs (Avalanche Photo Diodes) [4] used in an underground cosmic-ray experiment for the first time. These state-of-the-art detectors (or SC16s) consist of 4×4 individual small-size ($12 \times 12 \times 3$ cm^3) pixels having an active area of 0.5×0.5 m^2. The total number of SC16s is 96 which translates to 24 m^2 or 1536 individual pixels providing EMMA with a large capacity of muon detection power, particularly for muon bundles with high muon multiplicities.

The data recording in the first tracking station started in the beginning of 2010. These data are used, among others, for software development which particularly in case of tracking is essential as the data are complex and difficult to simulate to a full extent. Parallel to the software development the scintillators are checked (pixel by pixel) after their delivery in the beginning of 2010. Yet another task is the repair and calibration of another 40 planks which with the gas-filled detectors is often time-consuming. Therefore our ambitious aim is to complete Phase II (see Fig. 1, right panel) by autumn 2010.

While EMMA has its limitations for the composition study before Phase III is completed because of inaccurate shower axis determination there are still interesting topics available even for Phase I. One is the excess of very high-multiplicity muon bundles ($N_\mu \gtrsim 80$) indicated by the cosmic-ray experiments at LEP (DELPHI, CosmoALEPH and L3+C, see for example [5]), which fit poor into the model predictions.

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[4] E.V. Akhrameev *et al.*, NIM A 610 (2009) 419.
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DIRECTIONAL CORRELATIONS BETWEEN UHERCs AND NEUTRINOS OBSERVED WITH IceCube

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Ultrahigh energy cosmic rays (UHECR) above a threshold of tens of EeV are expected to undergo only small deflections due to interstellar magnetic fields, typically on the order of a few degrees deviation. Their arrival directions could thus point to regions of possible hadronic acceleration processes, which are likely to be also sources of high energy neutrinos.

To search for such cosmic accelerators, a study of directional correlations between neutrino candidates from the IceCube Observatory and UHECR events can be performed. The first large statistics analysis of this type is presented here. An event selection based on data taken with IceCube in a configuration of 22 strings allowed for the first time to cover not only the northern but also a major part of the southern celestial hemisphere. This provided the framework for using published data from both the Pierre Auger Observatory and the HiRes experiment as reference directions in a stacking search for coincidences with neutrinos.

The analysis was optimized according to strict blindness criteria and showed an excess of neutrino candidates close to UHECR directions with a probability of 1% to occur as a random fluctuation. This is still compatible with a backgroundonly hypothesis. The correlation search is currently being extended to include more recent IceCube data from 1 year of live time with 40 strings, the status and latest results of which will be presented.

INVITED

The ANTARES detector

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The ANTARES detector has been completed in May 2008. The full setup consists of 885 optical modules arranged on a lattice of 12 lines anchored at the seabed. The detector includes several calibration and positioning systems, complementary instruments for environmental parameter monitoring and 36 hydrophones for R&D on neutrino acoustic detection.

Data have been accumulated in 2007 with 5 detector lines and, since December 2007, with 10 lines and more.

In 2009 line repair was successfully carried out with the recovery, repair and redeployment of some malfunctioning detector lines. Results from various physics analyses from the neutrino telescope as well as from the complementary devices will be presented.

Overview of radio-detection of cosmic ray air showers and prospects for a larger scale experiment

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Since its revival in 2004, radio-detection of cosmic ray air showers has made tremendous progress. Today, several experiments are routinely detecting radio signals associated with air showers. Large cosmic ray observatories such as the Pierre Auger Observatory are also pursuing radio-detection activities.

As an introduction, in this talk we will summarize the main results from the first generation of radio-detection experiments: LOPES and CODALEMA. Then, we will show which questions about the radio emission mechanism can be answered from larger scale experiments such as LOFAR and the Auger Engineering Radio Array (AERA); which is a 20 km^2-scale antenna array under construction near other upgrades at the Pierre Auger Observatory. Finally, we will show how radio-detection can be used to explore the transition between galactic and extragalactic cosmic rays, in particular by using a super-hybrid analysis that combines information from radio, surface detectors, and fluorescence telescopes.

ENERGY SPECTRA MEASUERED BY A LHC FORWARD EXPERIMENT : LHCf

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The uncertainties of the hadron interaction models used for air shower simulations are one of main sources of systematic errors in high energy cosmic ray measurements. The uncertainties is due to the lack of experimental data in the energy range above 2×10^{14}eV. However now the Large Hadron Collider (LHC) gives unique opportunities for us to take data in the much higher energy region of 10^{17}eV.

The LHCf experiment is one of the six LHC physics experiments, realized to measure the energy and transverse momentum spectra of neutral particles in the very forward region ($\eta > 8.4$) of LHC collisions by means of two calorimeters installed at +/-140m from the IP1 LHC interaction point. LHC had first collisions of two 450GeV proton beams on November 23th, 2009. The machine was running smoothly until the end of 2009, allowing LHCf to successfully take data. We got about 6,000 shower events by the both detectors. LHC is also making proton-proton collisions at much higher energy (3.5TeV+3.5TeV) from 30th March 2010 and LHCf is actually taking data. We will present some results at 450GeV+450GeV collisions and preliminary results at 3.5TeV+3.5TeV collisions.

INVITED

DETECTING ULTRA-HIGH-ENERGY COSMIC RAYS FROM SPACE, WITH UNPRECEDENTED ACCEPTANCE: OBJECTIVES AND DESIGN OF THE JEM-EUSO MISSION

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The Extreme Universe Space Observatory onboard the Japanese Experiment Module of the International Space Station (JEM-EUSO) is an international mission aiming at studying the ultra-high-energy cosmic rays (UHECRs) above a few 10^{19} eV, through the detection and analysis of the fluorescence light emitted by the extensive showers induced in the Earth atmosphere. JEM-EUSO will be able to detect ≥ 1000 UHECR events in the GZK range, to discover the origin and identify the main sources of UHECRs in the nearby universe, thanks to an unprecedented aperture reaching the key value of $10^6\,\mathrm{km}^2\,\mathrm{sr\,yr}$, after 5 years of operation from its expected launch date in 2015. JEM-EUSO's full sky coverage will allow, for the first time, a consistent study of the large scale distribution of the UHECRs, providing key information about the sources and the underlying high-energy astrophysics. In addition to these main objectives, JEM-EUSO will study UHE photons and neutrinos, investigate the high-energy behavior of neutrino cross sections as well as some predictions of top-down scenarios, and explore relativity and quantum gravity effects at extreme energies. Finally, JEM-EUSO will study transient luminous events (TLE) in the atmosphere and other meteors with unprecedented angular and time resolution. We review main characteristics of the JEM-EUSO instrument and its scientific goals.

INVITED

Tunka-133: Methods of Extensive Air Shower Parameters Reconstruction

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The new array Tunka-133 started data taking since the end of 2009. The apparatus records the extensive air shower (EAS) Cherenkov light pulse waveform with the 133 optical detectors deployed at the area of about 1 km^2. The methods of primary cosmic particle parameters reconstruction by this data both for EAS core inside and outside the array geometry are discussed. Using of the outside registration method may enlarge the effective area to 5 – 10 times for the showers of energy more than $5\cdot10^{17}$ eV.

DEVELOPMENTS IN SHOWER RECONSTRUCTION AND COMPOSITION ANALYSIS FOR CARPET-3 EAS ARRAY

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[2]University of Oulu, Finland

The Carpet-3 EAS array [1] is a multipurpose array, a proposed experiment for studying the EAS with at least six parameters.

A study of lateral distribution function of charged particles in EAS at the knee region was done with the Carpet-array[2]. The study involves the development of EAS in the atmosphere as simulated with CORSIKA code. The shower reconstruction method used in the simulation analysis approximates the method used for the analysis of measured data. Shower sizes were reconstructed by fitting the NKG-function with $s = 1.0$ and $R_M = 94$ m on the shower plane. The primary spectrum was simulated in the energy and angular intervals, $0.3 - 30$ PeV and $0 - 30$ degrees. This corresponds to the shower sizes measured with the array. An example comparison between the simulated and measured average lateral distribution is shown in Fig. 1.

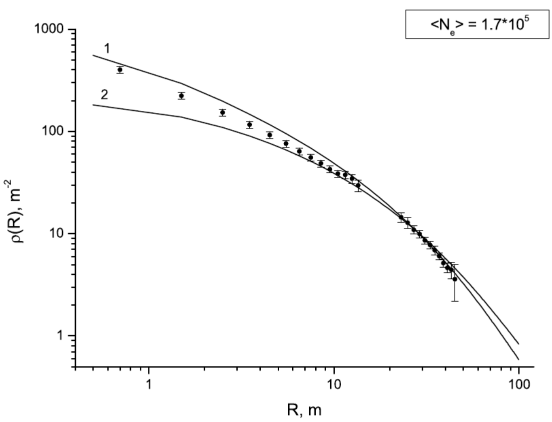

Figure 1: The average lateral density distribution as measured with Carpet-array for average shower size $\langle N_e \rangle = 1.7 \cdot 10^5$ (error bars) compared with simulations (lines, 1 - pure proton spectrum, 2 - pure iron spectrum, $\gamma = -2.7$)

For analysis of the cosmic-ray composition there is a need to accomodate more aspects of detector response in to the shower reconstruction procedures. Development of the procedures include studies on different fit methods, the array geometry, uncertainties in the reconstruction of the shower arrival direction and shower axis position as well as Monte Carlo generator for the detector response.

The development and prospects of the shower reconstruction procedure for Carpet-3 array are discussed.

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ALTA/CZELTA – A Sparse Very Large Air Shower Array: overview and recent results

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The Alberta Large-area Time-coincidence Array (ALTA) and the CZEch Large-area Time-coincidence Array (CZELTA) are sparse networks of stations for the detection of cosmic rays with energy more than 10^{14} eV. At present, the detector system covers large regions in Canada and in the Czech Republic. The primary objective of the common project ALTA/CZELTA is to find correlations in the arrival times of air showers over large distances and to find non-random component of air showers arriving at a single site. Precise correlation is achieved by fast signal coincidence and GPS timing. The detection stations are placed mainly on the roofs of high schools buildings in Canada and the Czech Republic. Recent results of the study of correlations in the arrival times of extensive air showers over large distances are presented.

Figure 1: Typical ALTA/CZELTA detection site: The three stations shown house scintillating detectors

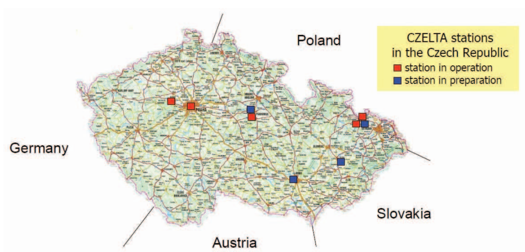

Figure 2: A map of CZELTA detector sites in Czech Republic.

INVITED

Cosmic ray physics by the ARGO-YBJ experiment

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One of the main scientific goals of the ARGO-YBJ experiment is cosmic ray physics below and around the knee of the primary energy spectrum ($10^{12} \div 10^{16}\ eV$), where the transition from direct to indirect measurement techniques takes place. The ARGO-YBJ experiment, currently operating at the Cosmic Ray Observatory of Yangbajing (Tibet, P.R. of China, $4300\ m$ a.s.l.), is a full coverage Extensive Air Shower array of about $6600\ m^2$ of active area. Besides gamma-ray astronomy observations, the detector space-time granularity, performance and location offer a unique chance to make a detailed study of the structure of cosmic ray showers, in particular of the hadronic component.

In this work we will focus on the main experimental results concerning cosmic ray and hadronic interaction physics: primary cosmic ray energy spectrum and composition, antiproton over proton ratio, anisotropy in the cosmic ray flux, proton-air cross-section. Moreover, the possible data analysis improvements based on the use of all detailed information on the shower front (curvature, time width, rise time, ..), as well as the extension of the explorable energy range, allowed by the analog RPC readout, will be discussed.

INVITED

Results from the Telescope Array Experiment

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[1]University of Utah, Salt Lake City, UT, USA

The Telescope Array (TA) is the largest experiment studying ultrahigh energy cosmic rays in the northern hemisphere. It consists of a surface array of 507 scintillation counters deployed on a 1200m rectangular grid, and three fluorescence detectors which overlook the surface array. About two years of data from TA have been collected. Results will be presented on the spectrum of cosmic rays, measured from the surface detector, the fluorescence detectors operating in monocular mode, and the two detector systems operating together in hybrid mode. A composition measurement will also be presented. This is a measurement of the mean depth of shower maximum performed using fluorescence detectors in stereoscopic mode.

INVITED

LAGUNA – LARGE APPARATUS FOR GRAND UNIFICATION AND NEUTRINO ASTROPHYSICS

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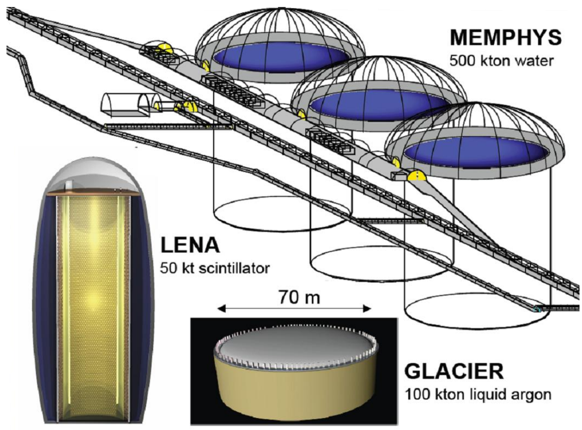

Figure 1: Artist's view of the three proposed detector options for LAGUNA: a 500 kton water Cherenkov detector MEMPHYS, a 50 kton organic scintilator LENA, and a 100 kton liquid argon Time Projection Chamber GLACIER.

In response to the rapid growth of interest and the relevance of experimental astroparticle physics in addressing the fundamental questions of modern science the next generation of European deep underground neutrino observatories is proposed. The name of the project is LAGUNA – Large Apparatus for Grand Unification and Neutrino Astrophysics. Over the past two years LAGUNA Infrastructure Design Study has been evaluating the proposed sites and assessing the cost and the time needed to prepare large-scale underground laboratories for LAGUNA detectors. To be a worthwhile successor of Super-K – currently the largest experiment of this kind – LAGUNA detector has to bring an order of magnitude increase in size or achieve the same gain by the use of more refined detection techniques. Such a detector would need a cavern with a span of up to 100 m and an overburden of up to 1.4 km of rock. Seven European sites are being investigated: Pyhäsalmi in Finland (mine), Fréjus in France (road tunnel), Boulby in the UK (mine), Umbria region in Italy (a virgin site), Sieroszowice in Poland (mine), Canfranc in Spain (road tunnel) and Slanic in Romania (mine). In each site up to three detector options were studied: GLACIER (liquid argon), LENA (liquid scintillator) and MEMPHYS (water Cherenkov). The Design Study is financed in part by the Framework Programme 7 of the EC. The work involves over 100 physicists and engineers from 10 countries. In the presentation the three detector options will be discussed and the highlights of the findings of the Design Study will be given. The full report by the LAGUNA Infrastructure Design Study is expected by the end of 2010 and the earliest realistic date to start the construction is 2012.

Session 4: HE/UHE Cosmic Ray and Neutrino Experiments (Posters)

Conveners: K. Kampert and T. Suomijärvi

NEW RESULTS ON COSMIC RAY ERZIONS SEARCH, RECEIVED ON THE SCINTILLATION SPECTROMETRIC TELESCOPES "DOCH-4M,C"

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In 1999 **i**n MADI Technical University on a telescope "Doch-4" it was received the first results on possible discovery of new stable heavy charged particle (Erzion) in cosmic rays [1-4]. The hypothesis of such particles existence first had been proposed in 1982 to explain abnormal vertical cosmic ray muon energy spectrum [5]. After that to check the fact of detection of new particles in cosmic rays the telescope has been automated and has worked continuously in a PC line already on the territory of Russian Science Center «Kurchatov Institute», as a telescope "Doch-4M" since July 2001 till May 2009 [6].

Thus, for 8 years of continuous operation of a telescope «Doch-4M» in the personal computer it is saved up the richest peak material (>7,000,000 events with the digitized shape of impulses from crystals CsI and NaI) from charged components of Cosmic Rays with total "alive" time - T_{Σ}>2,000 days for various corners of their arrival (0° <θ <60°) from a vertical for the south.

The design of the telescope «Doch-4M» is vertical coaxial scintillation telescope consisting of thin crystal CsI (∅63x0.35 mm^2) from above and thick crystal NaI (∅150x100 mm^2) from below a telescope with automatic registration of synchronizing of signals amplitudes of crystals CsI and NaI, by their numbering and a conclusion to a personal computer (PC) by means of a 2 channel ADC - LA-n10, built in the PC. In the subsequent operating modes of installation «Doch-4M» the "shirt" from 6 standard polystyrene plastic scintillation detectors (PSD) has been added to 2 crystal telescope. So it is the alone cosmic ray telescope in the world which accumulates the detectors amplitudes data in digital form and it provides to select events from high ionization component for different ionization level.

For such long time telescope «Doch-4M» monitoring it was received some new interest results for high ionization cosmic ray component: season & day variation, abnormal absorption dependence and etc. [7, 8]. But the main purpose for us was to repeat the discovery of new stable heavy charged particle (Erzion) in cosmic rays. For it we have changed the telescope axes and convertor material above the telescope to convert neutral Erzion to negative one according to Erzion mirror model [9-12]. So we have received first small confirmation (11 events) in 2008. To strengthen this results we have modernized our telescope again by liquidation of the "shirt" from 6 standard polystyrene plastic scintillation detectors (PSD) and by changing of small CsI detector (∅63x0.35 mm^2) by 10 time larger one (∅200x10 mm^2), named already as telescope «Doch-4C».

These new results from both telescopes «Doch-4M,C» are presented and analyzed in framework of Erzion model.

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ANOMALOUS ABSORPTION DEPENDENCE IN HIGH IONIZATION COSMIC RAY COMPONENT, RECEIVED ON THE SCINTILLATION SPECTROMETRIC TELESCOPE "DOCH"

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[3]State Technical University (MAI), Moscow, Russia

On the scintillation spectrometric telescopes "Doch-4M" it was received the anomalous absorption dependence of the studied high ionization (>10 relativistic particles) cosmic ray component in the passive absorber (lead & polyethylene) placed above the telescope (up to 200 g/cm^2). These new unusual results, contradicted orthodox cosmic ray physics, can be explained in framework of Erzion model [1,2].

[1] Yu. N. Bazhutova and G. M. Vereshkov, New Stable Hadrons in Cosmic Rays, their Theoretical Interpretation & Possible Role in Catalysis of Cold Nuclear Fusion, Preprint No.1, Central Research Institute of Machine Building, 1990.

[2] Yu. N. Bazhutov, G. M. Vereshkov, and V. I. Kuksa, On a Possibility of Existing New Stable Hadrons-Hypothetical Catalyst of Cold Nuclear Transmutation, RCCF&NT-3 Proc., Dagomys-1995, Moscow, pp. 157–201, 1996.

LARGE SEASON VARIATIONS OF THE HIGH IONIZATION COSMIC RAY COMPONENT, OBSERVED ON THE SCINTILLATION SPECTROMETRIC TELESCOPE "DOCH"

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Earlier on the 18-th European Cosmic Ray Symposium we had been presented results on detection of high daily variations (∼100%) for events caused by the high ionization cosÂ mic ray component, passing through a telescope "Doch-4A" [1]. On the scintillation spectrometric telescopes "Doch-4M" running during (2001–2006) it is received the new results of season variations of the high ionization cosmic ray component (∼5,000,000 events with the digitized shape of impulses from crystals CsI and NaI) from charged components of Cosmic Rays with total "alive" time - $T_\Sigma \sim 1220$ day for various corners of their arrival ($0° < \theta < 60°$) from a vertical to the south [2]. For the first time it was observed in cosmic rays the large variations (A∼30%), practically independent on zenith orientation of the telescope "Doch-4M" axis (0–45°) to the south. These new unusual results, inexplicable in frame of orthodox cosmic ray physics, are analyzed in framework of Erzion model [3,4].

[1] Yu. N. Bazhutov, Yu. V. Kozlov, Yu. A. Kumantseva et al., Abs. 18th EuCRSym., HE22P, Moscow, 2002.
[2] Yu. N. Bazhutov, V. N. Vyrodov, Yu. V. Kozlov et.al, The Results of Monitoring of the Sun Erzions on the "Doch-4m" Telescope, Proc. RCCNT-9, Moscow, p. 26–37, 2002.
[3] Yu. N. Bazhutov and G. M. Vereshkov, New Stable Hadrons in Cosmic Rays, their Theoretical Interpretation & Possible Role in Catalysis of Cold Nuclear Fusion, Preprint No.1, Central Research Institute of Machine Building, 1990.
[4] Yu. N. Bazhutov, G. M. Vereshkov, and V. I. Kuksa, On a Possibility of Existing New Stable Hadrons-Hypothetical Catalyst of Cold Nuclear Transmutation, RCCF&NT-3 Proc., Dagomys-1995, Moscow, pp. 157–201, 1996.

ARIANNA: A 100 km^3 scale detector for extremely high-energy neutrinos

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Above the GZK energy ($\sim 6 \cdot 10^{19}$ eV), cosmic rays interact with the cosmic microwave background over a typical length of 50 MPc. The neutrinos that are produced in this process are important messenger particles. In contrast with charged cosmic rays, they can propagate in a straight line over cosmological distances, and probe the evolution of the EHE universe. In order to measure $\sim$100 GZK neutrinos in a few years time, a detector volume of $\sim$100 km^3 is needed.

The Ross Ice shelf in Antarctica offers a unique opportunity to reach that scale with relatively modest resources. When a neutrino interacts in the ice, part of the energy is converted into a hadronic shower. This shower develops a negative charge excess, that propagates faster than the local speed of light, resulting in a pulse of coherent radio Cherenkov emission. This process is known as the Askaryan effect. The Earth is opaque for EHE neutrinos, so a detector should be able to detect downward going neutrinos. An ice shelf offers exactly that possibility, because radio signals that travel downwards are reflected on the water-ice boundary at the bottom. Since the attenuation length of radio waves in ice is expected to be of the order of 1 km, the reflecting signals can reach the surface, eliminating the need to bury detectors deep in the ice. Instead, the detector volume can be efficiently instrumented by building an array of radio antennas just below the surface.

This winter, a prototype ARIANNA station has been deployed at the Ross Ice Shelf. It consists of 4 log-periodic dipole antennae. The system is triggered when 2 or more antennae observe a signal. The preamplifier chain covers the range 50 MHz to 800 MHz; data is recorded by a 2 Gigasamples/second switched capacitor array. Power is provided by solar panels during the Austral summer, and a wind generator during the winter. The main goals of the prototype are to study the characteristics of the site, and serve as a technology demonstrator.

Multiple Scattering measurement with laser events

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The Pierre Auger Observatory Fluorescence Detector (FD) performs a calorimetric measurement of the primary energy of cosmic ray showers. The level of accuracy of this technique is determined by the uncertainty in several parameters, among them the fraction of shower light (both from fluorescence and Cherenkov light) that reaches the detector after being multiply scattered (MS) in the atmosphere. This component depends on atmospheric conditions, namely on Rayleigh and Mie scattering processes. Using laser events it is possible to study these processes and deconvolute them from the shower's electromagnetic lateral distribution.

We propose a new method to measure the Rayleigh and Mie MS component seen in laser events, and correlate it with atmospheric conditions. In order to study in detail the effect of such conditions in the scattering of photons, a Geant4 dedicated laser simulation was developed. In this framework photons are individually followed through the atmosphere allowing for any number of scatterings, from both processes.

This combination of a MS dedicated data analysis with a realistic laser simulation enables to explore MS characteristics, in particular the evolution with time, altitude and distance from the FD.

NEUTRINOS FROM STARBURST-GALAXIES

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As contribution to this conference the results of a stacking analysis performed with data from the IceCube neutrino observatory will be presented. The stacking technique is an analysis technique which is sensitive to a cumulative signal from a generic source class.

In the analysis presented seven source classes were analyzed aiming for a high energy neutrino signal. The analyzed source classes were Starburst-Galaxies, Fanaroff-Riley I and II galaxies, Flat Spectrum Radio Quasars, Compact Steep Spectrum Sources and Gigahertz Peaked Sources, Blazars and as a galactic source class pulsars.
The IceCube neutrino observatory is a detector for high energy neutrinos located at the geographic South Pole. IceCube uses digital optical modules (DOMs) to detect Cherenkov light emitted by muons which where produced in neutrino nucleon interactions in the ice. When completed in 2011 IceCube will consist of 5160 DOMs arranged along 86 strings deployed in depths between 1450 m and 2450 m in the antarctic ice. The presented analysis used data obtained in 7 years of operation of IceCube's predecessor AMANDA and data obtained in 276 days of operation of IceCube in its configuration with 22 strings.

The talk will give an overview over the analyzed source classes focusing on Starburst-Galaxies as well as the source stacking analysis. Finally the results of the analysis will be presented which yield improved neutrino flux limits of the analyzed source classes.

Baksan Underground Scintillation Telescope upgrade and DAQ of additional layers

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The project of the Baksan Underground Scintillation Telescope (BUST) [1] upgrade is presented. Additional outer layers of the detectors with fine spatial resolution will be mounted around BUST [2]. It is planned to use scintillation counters based on multi-pixel avalanche photodiodes. Optimal dimensions of a counter, 12.2x12.2x3 cm, were chosen with a simulation program. These scintillation counters allow reconstruction of more than 1000 trajectories of muons crossing BUST. This modernization allows us to study knee region using muon number spectrum measurements. The functional diagram of DAQ of the BUST additional layers is presented. We plan to use LVDS standard to transfer the information from scintillation counters. Implementation of serializers and deserializers reduces amount of cables. The standard device V1495 simplifies the development of DAQ and enhances its reliability. Chips of programmable logic device provide flexibility of DAQ during its design and adjustment.

[1] E.N.Alexeyev et al., Proc. 16th ICRC, Kyoto, v.10, p.276, 1979.
[2] I.M.Dzaparova et al., Proc. 31th ICRC, Lodz, Poland, 0241, 2009.

HADRONS WITH ENERGIES OF $E_h > 50$ MeV IN EAS WITH $N_e = 10^5 - 10^7$

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A hadron spectrum for $E_h > 50$ MeV has been obtained for EAS with $N_e = 10^5 - 10^7$ at a distance of 17 – 30 m from EAS axis using 6NM64 neutron monitor of the complex Baksan shower array "Carpet-2". New registration system of the neutron monitor allowed us to measure the time intervals between pulses with a precision of $\sim$1 μs. The results of the experiment have been compared with CORSIKA (QGSJet01c) simulations.

A simulation study on the JEM-EUSO performances with ESAF

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[2] University of Torino, Torino, Italy
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In this paper we present a simulation study on the scientific performances of the JEM-EUSO mission based on the EUSO Simulation and Analysis Framework (ESAF). Developed in the context of the EUSO mission, ESAF has been updated and extended to take into account the JEM-EUSO new mission configuration. After briefly describing ESAF and the main features of the instrumentś current baseline, we discuss the trigger strategy and algorithms, and the reconstruction technique. We eventually present the expected performances of the mission, focusing on trigger efficiency, and on the angular and energy resolution.

Study of cosmic ray composition through muon bundle properties using coincident IceTop/IceCube measurements

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Currently the IceCube Neutrino Observatory consists of 79 strings instrumented between 1450 and 2450 m deep in the South Pole ice and 73 IceTop stations on the surface. For coincident events the electromagnetic and high energy muon component of (sub-)PeV to EeV cosmic ray air showers are probed by the IceTop and the deep detector respectively.

The shower size, measured by the IceTop surface array, is sensitive to the primary energy while the high energy (>500 GeV) muon bundles which reach the deep detector are mainly sensitive to the primary composition.

Using a likelihood method which takes the ice properties and light propagation into account, we will show how the energy loss of muon bundles passing through the deep detector can be reconstructed. The properties and energy loss of these muon bundles are then combined with the shower size measured by IceTop to study primary energy and composition in simulated and experimental data.

ON THE RECONSTRUCTION OF UHE EAS DEVELOPMENT IN THE ATMOSPHERE FROM THEIR OPTICAL IMAGES

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One of the methods for detecting extensive air showers produced by ultra-high energy cosmic rays in the atmosphere is measuring their optical images by large telescopes (as in the Fly's Eye, HiRes and the Pierre Auger Observatory experiments). The main contribution to the light flux emitted by a shower is the fluorescence of the excited nitrogen molecules. The number of fluorescence photons is proportional to the energy deposited in the atmosphere by the shower particles, so that by integrating it over the shower track one would get practically the energy of the primary particle E_0.

However, the fluorescence light is not the only component of the light flux emitted by shower particles. About 1/3 of shower electrons (both signs) emit Cherenkov radiation which, although collimated with particle directions, can contribute to the total registered light mainly as scattered to the sides.

Here, we describe how the Cherenkov light (direct and scattered) can be taken into account in evaluating the primary energy of a shower.

Our method is based on universal characteristics of large showers: the shape of the energy spectrum of electrons at a given level of its development depends only on the age parameter of the shower at this level. Also lateral distribution of electrons (expressed in the Moliere radius) and their angular distributions depend on the shower age only. Thus, assuming a depth of a shower maximum X_{max} and a shower curve $N(X)$ (number of particles as a function of depth in the atmosphere) for a given energy E_0 (practically unique) we can predict the fluorescence and Cherenkov fluxes arriving at a detector (assuming that the atmosphere properties are known). X_{max} and E_0 which fit the shower data best are the reconstructed shower characterics. In recent reconstruction programs (as in Auger) showers with large Cherenkov fluxes are being rejected. We hope that our method will work for showers with any amount of Cherenkov light, providing most of its curve $N(X)$ is seen in the telescope. Examples of some reconstructed showers (simulated and real) will be shown.

Studies of the sidereal modulation in the distribution of arrival directions of ultra high energy cosmic rays recorded with the Pierre Auger Observatory

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The Pierre Auger Observatory in Argentina measures air showers initiated by cosmic rays at EeV energy scales (10^{18} eV). An important goal of the collaboration is to study the distribution of arrival directions of the primary particles and quantify potential anisotropies therein. Using data collected by the surface detector array of the Pierre Auger Observatory since January 1st, 2004, we study large scale anisotropies in different energy windows above 0.2 EeV. A Fourier analysis shows the presence of a ~3 % modulation in the period of a solar day which is caused by local effects such as a varying array exposure and weather effects on the shower development in the atmosphere. Modulations in a sidereal period are studied by means of the Rayleigh method accounting for these effects and the East-West differential method, which is essentially independent of them. We present the results for both methods in terms of the first harmonic amplitude of the sidereal modulation.

STUDY OF EAS NEUTRON COMPONENT TEMPORAL STRUCTURE

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EAS neutron component carries information about the primary cosmic ray flux as well as about parameters of hadronic interactions at ultra-high energy [1]. Data obtained with the NEUTRON array, which is a prototype of a novel type of EAS array PRISMA, are presented. The prototype consists of 5 large area scintillator detectors (0.75 m^2 each) placed in the corners and in the center of 5 m side square. The scintillator based on $ZnS(Ag)+^6LiF$ is shaped as a thin layer of grains covered with thin transparent plastic film [2].

The same detectors are used for measuring the electron component and for triggering. It is shown that recorded thermal neutron delay distribution can be fitted with double exponent function, thus confirming the existence of two EAS neutron sources: solid materials near the detector (local neutrons) and air above the detector (atmospheric neutrons).

[1] Yu. V. Stenkin at al. Recording of thermal neutron flux underground as a method to study EAS properties. Proc. 31st ICRC, Lodz, Poland, 2009 (electronic form). Paper ID 0571.
[2] D.M. Gromushkin at al. On thermal neutron concentration near the ground surface. Proc. 31st ICRC, Lodz, Poland, 2009 (electronic form). Paper ID 0963.

Air Shower Measurements with LOFAR

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Understanding the radio emission from air showers requires high precision measurements of the radio pulse front. LOFAR is a new radio telescope that is being built in the Netherlands. Built as an astronomical telescope, the core of LOFAR will have a higher density of radio antennas and better calibration than a dedicated air shower array. This makes LOFAR a unique tool to study the radio properties of single air showers and thus test and refine our theoretical understanding of the radio emission process.

LOFAR is currently being built, with more than half of the stations already in the field. At the same time we are working on a triggering system for air showers and other radio transients, and on the analysis pipeline to extract air shower parameters from the recorded waveform data.

Triggering on the radio emission from air showers means detecting a nano-second radio pulse and discriminating real events from radio interference. At LOFAR, we will search for pulses in the digital data stream and use pulse-form parameters to discriminate real events from background. We will also have a small scintillator array to test and confirm the performance of the radio-only trigger and to provide additional measurements for the air shower reconstruction and analysis.

ENHANCEMENT OF THE YAKUTSK ARRAY BY THE SET OF ATMOSPHERIC CHERENKOV TELESCOPES TO STUDY COSMIC RAYS IN THE ENERGY RANGE ABOVE 10^{15} EV

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The purpose of the Yakutsk array enhancement project is to create an instrument aimed to study the highest energy galactic cosmic rays (CRs) - their sources, energy spectrum and mass composition. Additionally, there will be unique capabilities for investigations in the transition region between galactic and extragalactic components of CRs.

Using the well developed atmospheric Cherenkov telescope technique adapted to target energy region we are planning to measure the longitudinal structure parameters of the shower, e.g., angular and temporal distributions of the Cherenkov signal related to X_{max} and mass composition of CRs.

The main advantages of the Yakutsk array including multi-component measurements of extensive air showers and the model independent CR energy estimation based on the Cherenkov light measurements will be inherited by the modernized array.

Linsley's EAS time structure method for the primary cosmic ray spectrum at LAAS

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A compact extensive air shower (EAS) array of eight plastic scintillators covering a total area of 2m^2 is built in the rooftop of the Faculty of Technology building, Okayama University of Science (abbreviated as OUS1), and operated since April 2006. We have installed a shift register system in our EAS array to record EAS particle arrival time within 5μs. We have also performed detector simulations on the basis of the database obtained from the AIRES simulator and developed the procedures to estimate the primary cosmic ray energy from Linsley method [**?**, **?**], which formulated empirically the average behavior of dispersion $<\sigma_t>$ of EAS particle arrival time as function of EAS core distance r:

$$< \sigma_t >= \sigma_{t0}(1+\frac{r}{r_t})^b \qquad (1)$$

where $\sigma_{t0} = 1.6$ns, $r_t = 30$m, and $b = (2.08 \pm 0.08) - (-0.4 \pm -0.06)\sec\theta + (0 \pm 0.06)\log(E/10^{17}\text{eV})$.

Applying this method to our EAS data obtained at EAS array OUS1 and the simulation result, we derived the energy spectrum from 10^{16} to $10^{19.5}$ eV as shown in Fig.1. Consequently, we obtained the power-law index of $-3.2 + 0.46 - 0.8$ in the primary energy range of 10^{16} to $10^{18.5}$ eV, and obtained that a change around 10^{18} eV appeared if not taking account of the zenith angle distribution of primary cosmic rays. We also showed the improvement of energy resolution by applying the restriction of zenith angle of primary cosmic rays in our simulation, as well as the potential of Linsley method with a mini array.

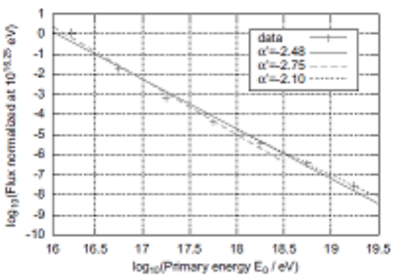

Figure 1: The primary energy spectrum obtained by the OUS1. The symbol + and the lines represent data and the least square fitting, respectively.

In order to apply this zenith angle restriction, we have constructed EAS array system (abbreviated as OUS4 in the first story of four-storied building, which can select EAS events of which zenith angle less than 25.6 degree nominally. The spectral index value of the energy spectrum by using OUS1 with OUS4 zenith angle restriction have a better linearity than using OUS1 solely as shown in Fig. 2, because of minimizing the shower size fluctuation due to EAS zenith angles as shown in Fig. 3. In this paper, we will also present results on the energy spectrum obtained by using Linsley method, when applying the restriction of zenith angle of primary cosmic rays using OUS1 and OUS4 experimentally. We are going to implement the shift-register system for Linsley method to most of the EAS arrays maintained by Large Area Air Shower (LAAS) experiments[**?**] in order to search multiple, simultaneous and parallel EASs deriving from the photo-disintegration of cosmic ray heavy nuclei above 10^{18}eV with solar radiations predicted by Gerasimova and Zatsepin in 1960s [**?**]. We will shortly discuss the advantages of Linsley method to search Gerasimova-Zatsepin effects.

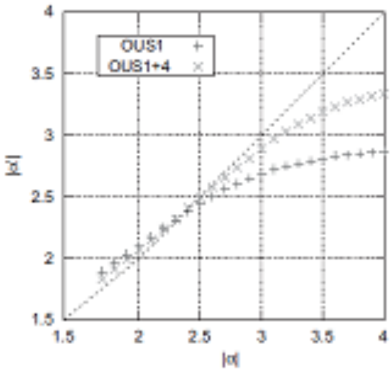

Figure 2: The comparison between the indices of the primary energy spectra and the obtained ones.

[1] J. Linsley and L. Scarsi, Phys. Rev. **128**, 2384, 1962.
[2] J. Linsley, J. Phys. G Nucl. Phys. **12**, 51, 1986.
[3] H. Matsumoto et al., Nucl. Inst. and Meth. A **614**, 475, 2010.
[4] N. Ochi et al., J. Phys. G Nucl. Part. Phys., **29**, 1169,2003.
[5] N. Gerasimova and G. Zatsepin, Soviet Phys. JETP, **11** 899, 1960.

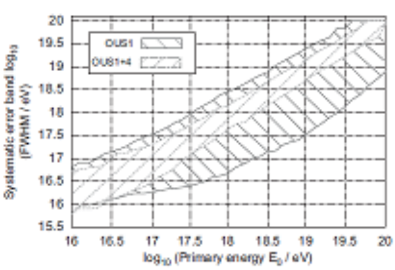

Figure 3: The energy resolution as a function of primary energy E_0. The hatched area of solid line and dashed line represent the energy resolution in the case of the OUS1 and the OUS1+4.

NuMoon at LOFAR: a next-generation lunar Cherenkov experiment

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The goal of the NuMoon project is to detect the sub-microsecond Askaryan (coherent Cherenkov) radio pulses expected from the interactions of the most energetic cosmic rays and neutrinos in the outer layers of the Moon. The next stage in the project is to use LOFAR (the Low Frequency Array) to search for these particles. However, achieving maximum sensitivity will be technically challenging. Data from the central stations must be formed electronically into coherent beams covering the entire visible lunar surface, and the dispersion due to the Earth's ionosphere corrected for. The data must then be searched for short-duration lunar-pulses whilst excluding RFI events – and all these steps must be performed in real time over 48 MHz bandwidth. Once a candidate event has been discovered, buffers at each antennas will enable the full 100 MHz bandwidth from all stations to be analysed in detail off-line. In this contribution, we describe how this will allow us to achieve an order of magnitude improvement in sensitivity, allowing us to probe below the Waxmann-Bahcall neutrino flux limit, and test the majority of 'top-down' models of ultra-high energy particle production.

THE JEM-EUSO INSTRUMENTS

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The Extreme Universe Space Observatory JEM-EUSO with a large and wide-angle telescope on the International Space Station has been planned as a space mission to explore the extreme universe through the investigation of extreme energy cosmic rays by detecting UV photons which accompany air showers developed in the earth's atmosphere.

The main object of JEM-EUSO is to perform astronomy and astrophysics through the particle channel with extreme energies above about 10^{20} eV with a significant statistical evidence.

The telescope consists of high transmittance optical Fresnel lenses with a diameter of about 2.5m, 200k channels of multianode-photomultiplier tubes, front-end readout, trigger and system electronics. An infrared camera and a LIDAR system will be also used to monitor the earth's atmosphere.

Overview and recent progress of the JEM-EUSO instruments are described in this paper.

Discovery of Specific Tracks (Pits) in Plastic Solid-State Track Detectors in Space

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With the aim of further investigation firstly observed [1] and than explanation with help of the suggested cosmic ray Erzion mechanism [2-5] in film piles of plastic Solid State Track Detector (SSTD) exposed in a free Space on the satellite orbit it was discovered the new kind of tracks – pits, tracks with specific pit form and very small size. For their study the depth in stacks of cellulose nitrate CN-85 intensity distribution of such pits and all other kind of observed tracks were measured. Total results, obtained by means of an optical microscope observation, for different pits diameters has been in more detail investigated and presented in Table 1.

Table 1. Track-density (ρ, cm^{-2}) of the two pit groups of different diameters on the CN-85 plate surfaces from the satellite exposed column FB-19 in 1995 year.

D, μm	ρ, cm^{-2} ($\times10^5$) in CN-85 plate numbers $^{(*)}$					
	2	5	10	20	25	30
1-2	8.1±0.5	3.9±0.3	3.5±0.3	3.0±0.3	2.8±0.3	2.4±0.25
3-4	2.5±0.25	1.5±0.2	0.8±0.1	0.6±0.04	0.25±0.03	0.28±0.03

$^{(*)}$ Track-pits were detected and accounted in 100-1000 microscope field of view with surface area $S_{n=1} = 4\times10^{-6}$ cm^2.

For precise interpretation of the obtained FB-19 column-depth track-pit density distribution it was considered two main very short (length L < 3 μm) track sources. (a) Possible formation of chemically etchable tracks from the solar cosmic ray protons before their stopping in CN-85, and (b) formation of short tracks due to recoil nucleus.In Table 2 the results of theoretical estimation of the surface pite-density, which can be formed by the stopping cosmic ray protons, are presented.

Table 2. Theoretically estimated numbers of the cosmic ray protons stopping in the layers of h ~ 10 μm on the head and lower surfaces of CN-85 in FB-19 column.

Number of plate in the column	E, MeV $^{(*)}$		J, proton fluence				Track-pit density $^{(****)}$ $\times10^2$	
			$J\times10^{-5}$ $^{(**)}$		$J_{70,2\pi}\times10^3$ $^{(***)}$			
	head	lower	head	lower	head	lower	head	lower

2	2.8	4.3	30.0	8.3	11.4	3.15	6.56	1.81
5	6.4	7.4	4.3	3.7	1.63	1.41	0.73	0.63
10	10.2	10.8	2.7	3.0	1.03	1.14	1.43	1.58
15	13.1	13.6	3.7	3.9	1.41	1.48	1.96	2.06
20	15,5	16.0	4.25	4.35	1.61	1.65	2.24	2.29
25	17.5	18.0	4.6	4.7	1.75	1.79	2.43	2.49
30	19.6	19.9	5.05	5.1	1.92	1.94	2.67	2.70

(*) Energy of protons, at which they run up to head and lower surfaces of each plate;

(**) Flow of the solar and galactic cosmic ray protons J in units of $(cm^2 \cdot s \cdot sr \cdot MeV)^{-1}$;

(***) Flow of these protons $J_{70,2\pi}$ in units of $(cm^2 \cdot MeV)^{-1}$, corresponding to 70 days of FB-19 column exposure at 2π sr; $J_{70,2\pi} = 6.048 \cdot 10^6 \times 6.28 = 3.8 \cdot 10^7 \times J$;

(****) The surface track-pit density of D = 2-3 μm (in units of cm^{-2}). The effective thickness of plate surface, in which the stopping protons can be registered as short pit-like tracks, estimated from the data: $\rho = J_{70,2\pi} \times \Delta E$, where ΔE – energy interval, corresponding to plate layer thickness of $\Delta h \approx 2D$, that is smaller of 5 μm, and in average for used CN-85equal to ~ 5×10^{-2} MeV.

Comparison of these results with the experimental data in Table 1 indicate , that the possible contribution due to stopping cosmic ray protons in observed track-pite density of D = 2-3 μm is by the 2-3 orders of magnitude lower of the detected values.

Results of theoretical estimation of the possible addition formation from the pit-like track-density of D = 2-3 μm, which can be formatted by the recoil nucleus in CN-85 plates, is practically the same for pits to experimentally determined values (see the column plates No 2, Table 1. Thereby, the precision investigation of depth-dependent the pit-like surface-average track-density distribution indicate on non-registrability of some additional radiation effects, partially conditioned with the Erzion hypothesis. Provided that, to proof this hypothesis the further measurements of the pit-groups, discovered in our investigation of the cosmic ray exposed CN-85 column and CR-39 and CZ SSNTD's has been presented in the second report in this Conference.

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SUPERHEAVY (Z>50) GALACTIC COSMIC RAY NUCLEI CHARGE DISTRIBUTION BY THE METEORITIC OLIVINE TRACK DATA

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In the framework of the project OLYMPIA [1] basic problem for the heavy and super heavy galactic cosmic ray (GCR) nuclei of the charge determination are considered. For this purpose chemically etched lengths and track-etch rate of the not-annealed traces of the braking nuclei in the olivine crystals from the Marjalahti pallasite are used.

The chosen methodology is based on precise measurements of the nucleus track parameters in the course of the step-by-step chemical etching of the olivine crystals. Parameters of tracks are traced and recorded by a modern, high-precision, completely automated measuring system PAVICOM [2]. The emphasis is done on measurements of the next main parameters: the etched during certain time-interval track length (L) and the etching rate (V) along the different parts of the base zone formation of tracks. Recognizing, that the zone of the crystal structure disordering, that is corresponding to chemical etching, is in an interval of the nucleus energy E_{MAX} - E_{MIN} , where the specific losses of energy $(dE/dx)_{EL}$ exceed the critical value of 18±2 MeV/mg·cm^{-2} [3], the length of a track with increase of a nuclei charge also increases.

Calibration of track parameters in the olivine crystals from Marjalahti pallasite was performed on UNILAC accelerator in Durmstadt, Germany. Xe and U accelerated nucleus beams were used. On base of obtained track-length distributions the L_{max} (Xe) = 80 ± 5 μm and L_{max} (U) = 85 ± 5 μm were determined. Within the limits of measurement errors these track lengths coincides with the values accounted by the SRIM2006 [4] and GEANT4 [5] programs. The track etching velocity (V) for these nuclei of E_{max} = 11.4 MeV/nucl varies in limits (5÷ 20) μm/hour. The last have been carried out using additionally the data of the olivine crystals irradiation by the accelerated U nuclei of energy 150 MeV/nuclon [6].

Detailed consideration of the dynamic and geometrical parameters for 853 revealed up to this time tracks with the etched and registered length L= 50-500 μm in comparison to the data of the calibration experiments have been performed. Distribution of the registered nuclei on the identified charge values in comparison with the equipment measuring [7,8] and indicate trends correlated in the charge interval 2-5 units. In this connection it is need note the determined by used up to day method of Z values determination in a majority of cases gives only any lowered Z-values in comparison to the true nucleus charge meaning. Relative abundance of the some groups of the galactic cosmic ray super heavy nuclei (Z>56), identified by the track parameters in the Marjalahti pallasite olivine crystals, are given in Table.

Received on the given stage of researches the results of identification of a charge spectrum of the super heavy nuclei group (Z>50) of the galactic cosmic ray, based on measurements of the geometrical and dynamic parameters of tracks, chemically etched in the olivine crystals from the Marjalahti pallasite, have shown: (1) From the common number of the registered 853 tracks with the charge Z>50 four of them corresponds to Th-U group nuclei; (2) Ratio of registered in our up to day investigation nuclei with Z>50 to nuclei of iron group (23<Z<28) has made ~ 1.2×10^{-6} and ~ 6×10^{-7} for the Pt-Pb and Th-U groups correspondly.

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Table. Relative abundance of the GCR super heavy nuclei of charge $56 \le Z \le 92$ by the track data in the olivine crystals from the Marjalahti pallasite.

Charge group	Number of tracks, N_Z (*)	L, μm (**)	Track density, cm^{-3}	Relative abundance
$23 \le Z \le 28$	~3000	3-14	$(1 - 5) \times 10^9$	1
$56 \le Z \le 59$	133	100-150	6.0×10^4	2×10^{-5}
$60 \le Z \le 69$	282	150-300	1.3×10^5	4.3×10^{-5}
$70 \le Z \le 79$	146	300-500	6.6×10^4	2.2×10^{-5}
$80 \le Z \le 89$	8	500-700	3.6×10^3	1.2×10^{-6}
$90 \le Z \le 92$	4	> 800	1.8×10^3	6×10^{-7}

(*) Number of tracks, registered and measured in the total olivine volume ~2.2 mm^3 from 27 crystals under investigation;
(**) Chemically etched length of tracks, continuously measured during of the (3-4)-times of 48 hour etching period.

Observation of Pit Swarms in Plastic Solid State Track Detectors Exposed in Space

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For further check of the pit nature Erzion hypothesis [1] it has been executed the precise, at high 1200-multiple magnification in optical microscope attendance of a large square in the Plastic Solid-State Track Detectors (PSSTD), which were satellite exposed in Space. It was analyzed films of PSSTD CN-85, CR-39 and CZ from different piles and satellite flights. By this manner on the total of searched PSSTD surface about 20 cm^2 have been primarily discovered a range of the specific, compact pit groups, characteristics for which indicate that their source are the swarms of the not-knowing origin particles in the track-detector matter. Some examples of the visual observed of pit group pictures are presented in Fig.1.

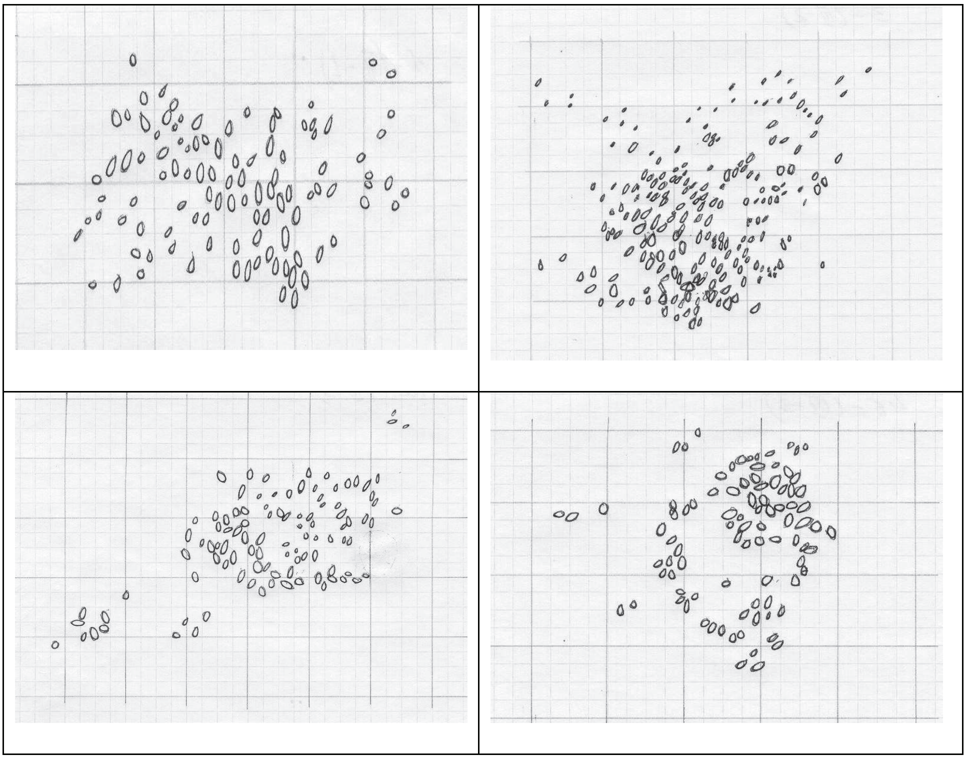

Fig.1 Four pit-track groups, observed on the chemically etched surface of CR-39 PSSTD exposed in Space by the solar and galactic cosmic rays. The log grid in minority square equal to 5x5 μm.

As a result of layer-by-layer investigation of the exposed CN-85 stock arrangement PSSTD it was observed a pit swarm exactly correlated with the end of track formed by high ionizing primary charge particle. Schematically this event is presented in Fig. 2.

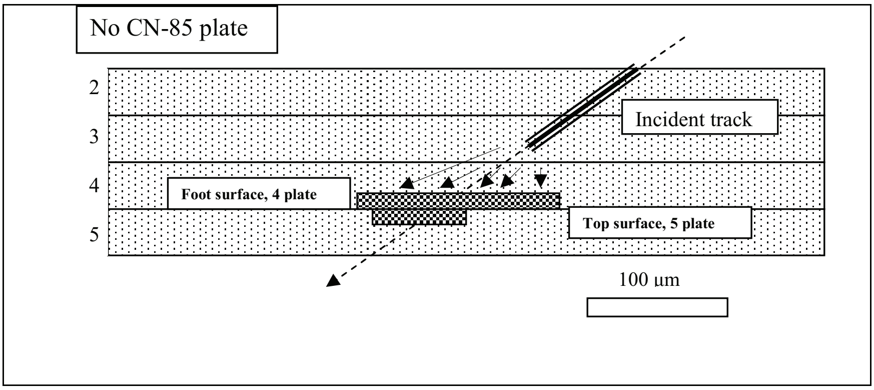

Fig. 2. Said view of the four CN-85 plates with incident primary track of the charged particle and recorded on the two adjoined each other surfaces of PSSTD pit-track groups, corresponding to particle swarm, designated as arrow.

In each of the observed pit-groups it was recorded near 100 of pits that corresponding to the surface density of (2-10)x10^6 cm^{-2}. These values in comparison with the average pit-like points on the same surface of CR-39 plate by two-three orders of magnitude are higher. All determined pits in the first approximation can be separated in three groups due to size intervals: 0.5-1, 1-2 and 2-3 μm. Relative number of these pit-types in different pit-groups is varied (see Fig. 1). In any case of pit-groups it can be marked preemptive orientation of prolonged (as the short micro-tracks in the drop-like forms) pits that can be considered as the directed particle swarm.

All obtained for the pit-groups results are discussed in according with submission expected from stopping negative charged cosmic ray Erzions [2-5].

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Measurements and interpretation of registration of large number of neutrons generated in lead.

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We register events with large number of neutrons at the ground level as well as in the underground laboratory. These neutrons are produced in secondary cosmic ray interactions with matter surrounding the neutron detectors. We used the set of helium-3 filled gas proportional counters and plastic scintillators. We made detector calibration and estimated detector efficiency.
With GEANT4 simulation of experimental setup we estimated number of neutrons required to explain our measurements. Still unknown nature of interaction producing large number of neutrons will be discussed.

The Focal Surface of the JEM-EUSO Instrument

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The Extreme Universe Space Observatory on JEM/EF (JEM-EUSO) is a space mission to study extremely high-energy cosmic rays. The JEM-EUSO instrument is a wide-angle refractive telescope in near-ultraviolet wavelength region to observe timeresolved atmospheric fluorescence images of the extensive air showers from the International Space Station. In this paper we describe in details the main features and technological aspects of the focal surface of the instrument. The JEM-EUSO focal surface is a spherical curved surface, with an area of about $4.5m^2$. The focal surface detector is made of more than 5,000 multi-anode photomultipliers (MAPMTs). Current baseline is Hamamatsu R8900-03-M36, while R11265-03-M64 is currently tested as advanced option. The approach to the focal surface detector is highly modular. Photo-Detector-Modules (PDM) are the basic units that drive the mechanical structure and data acquisition. Each PDM consists of 9 Elementary Cells (ECs). The EC, which is the basic unit of the MAPMT support structure and of the front-end electronics, contains 4 units of MAPMTs. In total, about 1,300 ECs or about 150 PDMs are arranged on the whole of the focal surface of JEM-EUSO.

The *Balloon-the-Shower* programme of the Pierre Auger Observatory

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The southern part of the Pierre Auger Observatory in Argentina investigates cosmic rays with energies above about $5 \cdot 10^{17}$ eV. Especially high-energy events which have been recorded with both detector components - surface water-Cherenkov tanks and fluorescence telescopes - are crucial for the energy calibration of the entire detector system. Using this method, the energy reconstruction of extensive air showers relies on a proper fluorescence light reconstruction depending on atmospheric conditions like pressure, temperature and water vapour varying with altitude and time. Therefore, a dedicated monitoring programme has been started in March 2009 for measuring actual atmospheric profiles with meteorological radio soundings shortly after detecting a high-energy air shower with $E_0 > 2 \cdot 10^{19}$ eV.

We will present the technical implementation of this programme as well as a reconstruction analysis using the data obtained. The reconstructed primary energy of air showers and the position of the shower maximum are compared with those results using monthly models for the local atmospheric conditions and meteorological models.

PERFORMANCE OF THE NEW MEASURING SYSTEM OF MULTIPURPOSE CHERENKOV WATER DETECTOR NEVOD

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Description of new measuring system of Cherenkov water detector (CWD) NEVOD with volume 2000 m^3 is presented. Multipurpose CWD NEVOD was constructed in 1995 and was intended for detection of all basic components of cosmic rays at the Earth's surface including muons from the bottom hemisphere generated by neutrino. The detection system is represented by a spatial lattice of quasi-spherical measuring modules (QSM) which allow to detect Cherenkov light from any direction with practically equal efficiency. Each QSM consists of six PMTs directed along rectangular coordinate axes. QSM are clustered in strings with 3 – 4 modules in each. New measuring system was designed to provide both detection of single muons from any direction (hodoscopic mode) and measurements of energy deposits of multi-particle events and cascade showers (calorimetric mode). The autonomous and combined (with other detectors of experimental complex, DECOR [1] and URAGAN [2]) operation modes are foreseen. Measuring system has hierarchical structure of data processing with the lower trigger level at the string (cluster) of QSMs and includes inner-module electronics, blocks of electronics of the clusters (BEC), external system of trigger formation and DAQ. BEC provides collection of data from QSM of a single string, digitization of PMT signals, generation of trigger signals for each QSM, storage of data and asynchronous data traffic to external electronic systems. The results of tests of the first configuration of the detector consisting of 9 clusters with 27 QSMs are presented.

The research is performed in Scientific and Educational Centre NEVOD with the support of the Federal Target Program "Scientific and pedagogical cadres for innovative Russia".

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32 MHz RADIO MEASUREMENTS AT THE YAKUTSK EAS ARRAY

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Results on extensive air showers radio emission measurements at 32 MHz for energy $E \geq 10^{17}$ eV are presented. Lateral distribution of radio signal is analysed. It is shown that radio emission from giant showers can be confidently registered at large core distances. From relation of signal magnitudes at $r = 175$ m and $r = 725$ m a preliminary estimation of $x_{\max}$ is derived. A preliminary approximation for primary energy reconstruction from the signal amplitude is given.

MONITORING OF HIGHER AND LOWER ATMOSPHERE USING THE YAKUTSK EAS ARRAY DATA

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In this work we present preliminary results on atmospheric spectral transparency, seasonal variations of aerosol optical depth, stratospheric temperature and ground-level electric field obtained in composite measurements at the Yakutsk EAS setup.

SEARCH FOR RARE EVENTS AT THE BAKSAN UNDERGROUND SCINTILLATION TELESCOPE

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The analysis of the large sample of the Baksan underground scintillation telescope (BUST) data (2001-2009 years) used in the search of collapse neutrinos has been performed to search for rare events. The BUST is a four-floor building with 17x17x11 m^3 dimensions located in a cave under the mountain Andyrchy slope [1]. The floors and the four vertical sides of the building are fully covered with standard liquid scintillation detectors (3156 in total), each of 0.7x0.7x0.3 m^3 dimension. There is a set of monitoring programs which allows one to examine the operation of each detector. One of the current tasks of BUST is to search for neutrino bursts from gravitational collapse [2, 3]. The signal from a supernova explosion will appear as a series of singly triggered detectors. The data have been used to search for rare events which form aligned single detector tracks in a succession of time with 1 to 1000 ms interval.

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HEAT - a low energy enhancement of the Pierre Auger Observatory

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The High Elevation Auger Telescopes (HEAT) are three tiltable fluorescence telescopes which represent a low energy enhancement of the Fluorescence Telescope System of the Pierre Auger Observatory.

The Pierre Auger Observatory is a hybrid cosmic ray detector consisting of 24 fluorescence telescopes to measure the fluorescence light of extensive air showers complemented by 1600 water Cherenkov detectors to determine the particle densities at ground. In this configuration air showers with a primary energy of 1EeV and above are investigated.

By extending this energy range by approximately one order of magnitude to lower primary energy, HEAT provides the possibility to study the very interesting energy range, where the transition from galactic to extragalactic cosmic rays is expected to happen.

The installation of HEAT was finished in 2009 and data are taken continuously since September 2009. In this poster the HEAT concept is presented and first data are shown.

A MOBILE DTETECTOR FOR MEASURMENTS OF THE ATMOSPHERIC MUON FLUX

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Measurements of the underground atmospheric muon flux are important in order to determine accurately the overburden in mwe (meter water equivalent) of an underground laboratory for appreciating which kind of experiments are feasible for that location. Slanic-Prohava is one of the 7 possible locations for the European large underground experiment LAGUNA (Large Apparatus studying Grand Unification and Neutrino Astrophysics). A new mobile device consisting of 2 scintillator plates (approx. 0.9 m^2, each) one above the other and measuring in coincidence, was set-up for determining the muon flux. The detector is installed on a van which facilitates measurements on different positions at the surface or in the underground and is in operation since autumn 2009. The measurements of muon ?uxes presented in this contribution have been performed in the underground salt mine Slanic-Prahova, Romania, where IFIN-HH has built a low radiation level laboratory, and at the surface on different sites of Romania, at different elevations from 0 m a.s.l up to 655 m a.s.l. Based on our measurements we can say that Slanic site is a feasible location for LAGUNA in Unirea salt mine at a water equivalent depth of 600 mwe. The results have been compared with Monte-Carlo simulations performed with the simulation codes CORSIKA and MUSIC.

NOY: a neutrino observatory network project based on stand alone air shower detector arrays

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We have developed a self powered stand alone particle detector array dedicated to the observation of horizontal tau air showers induced by high energy neutrinos interacting in mountain rock. Air shower particle detection reaches a 100% duty cycle and is practically free of background when compared to Cerenkov light or radio techniques. It is thus better suited for rare neutrino event search. An appropriate mountain to valley topological configuration has been identified and the first array will be deployed on an inclined slope at an elevation of 1500 m facing to Southern Alps near the city of Grenoble (France).

A full simulation has been performed. A neutrino energy dependent mountain tomography chart is obtained using a neutrino and tau propagation code together with a detailed cartography and elevation map of the region. The array acceptance is then evaluated between 100 TeV and 100 EeV by simulating decaying tau air showers across the valley. The effective detection surface is determined by the shower lateral extension at array location and is hence much larger than the array geometrical area. A single array exposure will be 1014 cm^2.sr.y at 100 PeV.

The embedded data acquisition system consists of an 8 channels, 12 bits, 250 MHz digitizer associated to a FPGA containing a trigger definition design, a time tagging referenced by a GPS board and a Linux core processor. PMT high voltage supplies are remote controlled via serial or USB port. Data and slow control data are stored on a flash memory. Remote control and data transfer are operated under a commercial wireless communication system. This low consumption data acquisition system is self powered via solar energy.

Several independent arrays can be deployed with the aim of constituting a large virtual observatory. Some other sites are already under study. At last, special care is dedicated to the educational and outreach aspects of such a cosmic ray detector.

On the energy spectrum of cosmic ray muons in 100 TeV region

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Differential and integral energy spectra of cosmic ray muons in the energy range from several TeV to ~ 1 PeV obtained by means of the analysis of multiple interactions of muons (pair meter technique) in the Baksan underground scintillation telescope are presented. The additional muon flux is observed at energies ~ 100 TeV. This flux may be explained by the contribution of muons from charmed particles with the parameter $R \simeq 3 \cdot 10^{-3}$.

Search for neutrino bursts at the Baksan Underground Scintillation Telescope

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The results of the study of singly triggered detector at the facility after high energy deposition (> 500 MeV) are presented. The current state of the experiment on recording neutrino bursts is presented.

ENERGY OF THE GALACTIC COSMIC RAY NUCLEI BY THE TRACK DATA IN OLIVINE CRYSTALS FROM THE MARJALAHTI PALLASITE.

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Are present the results of investigation in the framework of OLYMPIA project [1] there was developed a basic method for the heavy and super heavy galactic cosmic ray (GCR) nuclei charge determination. Received the preliminary experimental results the energy of the GCR nuclei by by the track method in olivine crystals from the meteorite Marjalahti.

Geometrical (track-length L) and dynamical (track-etch rate V) parameters of chemically etched tracks in non-annealed olivine crystals from the Marjalahti pallasite are analyzed [2]. The method for identification of GCR heavy and super-heavy nuclei includes precise measurements of the L and V for step-by-step chemical etching of the olivine crystals. Parameters of individual tracks are recorded with a help of a unique highly effective measuring facility PAVICOM [3]. For the calibration of track parameters the olivine crystals from the Marjalahti pallasite were exposed with Xe and U beams of UNILAC accelerator in Darmstadt (Germany).

For research of influence of orientation of crystal axes on efficiency of etching of channels of tracks the roentgen-structural analysis of some crystals olivine from pallasite Marjalahti irradiated with accelerated ^{132}Xe has been carried out [4]. The spent measurements have shown that almost completely there is no dependence of track-etch rate on their orientation rather crystallographic axes of symmetry of each of investigated crystal. This result is the extremely important for the further researches of tracks in olivine from pallasite for the purpose of studying of chemical compound of space beams.

The limits of the given job calibration of crystals olivine on bunch of kernels of gold with energy about 10 MeV/nucleon is executed, and comparison of results of calibration with results of calculations is spent. Modeling calculations with use of software package SRIM and fuller and late creation on time of program complex GEANT4 are already spent. It is necessary for increase of reliability of the received results at their comparison. For modeling package Hadr01 which is a part GEANT4 as official example of its application was used created with the assistance of employees of our group. He allows to model passage of bunches of protons and ions through substance, receiving on exit various distributions (power allocation along track, spectra of secondary particles, charging distribution etc.) Test calculations of passage of ^{131}Xe, ^{207}Pb, ^{238}U nuclei through matter in wide spectrum energy and materials have been spent. Results of modeling calculations give the quite good consent with tables [5] to which brake abilities and run of ions with charges for range energy from 2,5 to 500 MeV/nucleon in various materials are presented.

Values of energy of the GCR nuclei theoretically calculated under program SRIM-2003 [6], tracks from which are formed in olivine crystals, being on depth $H_{\theta=0}$= 40 mm from up to pre-atmospheric surfaces of the Marjalahti meteorite, directed at an angle $\alpha = \theta$ in interval (0-180) about at normally focused plane of etching surface of the crystals (γ nearby 0) are resulted in Table 2 and on schedules of Figure 1.

Dependence of length of run of nuclei of different elements on their energy was defined for average matter of the Marjalahti pallasite, mineralogical and chemical compound of which: ~65 volume % of olivine (Mg0.88Fe0.12) Si_2O_4 and ~33 volume % of iron-nickel Fe0.70Ni0.30 alloy.

In Figure 2 are resulted calculated for nuclei of different elements of size of the energy necessary for penetration of these nuclei on depth (H) findings of crystals olivine in the Marjalaht pre-atmospheric meteorite body.

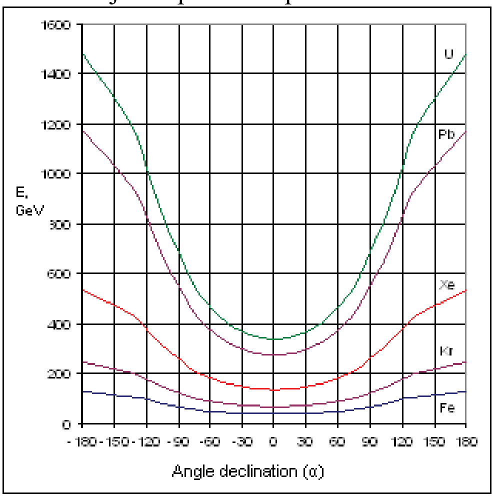

Fig. 1. Energy of nuclei of various elements at different angles of slope of tracks $\alpha = \Theta$ concerning direction to the nearest point on the meteorite surface at γ~0.

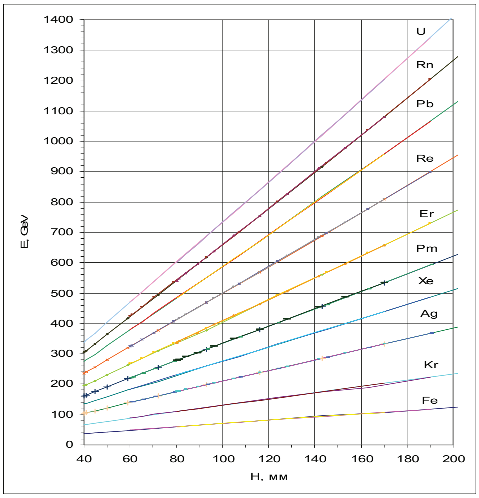

Fig. 2. Energy of nuclei of various elements of GCR, forming tracks in crystals olivine on depth H in body of the meteorite Marjalahti.

From the obtained results of theoretical calculations follows that the full interval of energy which can be measured by means of the track analysis of crystals olivine, a part pallasite Marjalahti, makes, for example, for iron and uranium nuclei ~ (0.7 – 2.2) the GeV/nucleon and ~ (1.6 – 6.1) the GeV/nucleon, accordingly.

Graphically calculated sizes of error of measurement of energy for interval of corners $\delta\alpha$ = (10-15) hailstones, specify that accuracy of definition of energy of nuclei can be finished to several percent at registration of corners to within several degrees. It is reached by means of highly precision measurement of co-ordinates of tracks on PAVICOM [3], and also by using of calibration experiments results [7].

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STUDY OF THE PRIMARY SPECTRUM AND COMPOSITION AROUND THE KNEE AT THE ANDYRCHY-BUST EXPERIMENT

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In the range of primary energies of $10^{14} - 10^{15}$ eV per nucleus, direct methods for studying the energy spectrum and nuclear composition of primary cosmic rays become inefficient because of a decrease in the flux of primary particles with an increase in their energy. Therefore, at these and, of course, higher energies, indirect methods based on simultaneous measurement of the characteristics of different components of extensive air showers (EASs), which are initiated by the primary particle in the atmosphere, are used.

A study of the primary cosmic rays spectrum and composition around the knee has been carried out at the Andyrchy-BUST experiment. The experimental data on the knee, as observed in the electromagnetic and high energy muon components, are presented. The electromagnetic component in the experiment is measured using the "Andyrchy" EAS array [1]. High energy muon component (with 230 GeV threshold energy of muons) is measured using the Baksan Underground Scintillation Telescope (BUST) [2]. The location of the "Andyrchy" right above the BUST gives us a possibility for simultaneous measurements of both EAS components. The three types of experimental data, taken in our experiment, have been analyzed: high energy muon number spectrum, EAS size spectrum and dependence of the mean number of high energy muons on EAS size. Integral muon number spectrum has been measured using the Baksan Underground Scintillation Telescope (BUST) [3]. The EAS size spectrum has been measured using the "Andyrchy" EAS array [4]. The dependence of the mean number of high energy muons on EAS size has been measured by simultaneous operation of both devices [5], [6]. CORSIKA code [7] with different hadronic interaction models has been used for EAS simulations.

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LOWER LIMITS ON THE LIFETIME OF MASSIVE NEUTRINO RADIATIVE DECAY FROM THE 2006 TOTAL SOLAR ECLIPSE

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We report on the results obtained in the search for a possible neutrino radiative decay signal, in occasion of the 2006 March 29 Total Solar Eclipse (TSE) [1]: $\nu_2 \rightarrow \nu_1 + \gamma; \quad m_{\nu 2} > m_{\nu 1}$.

The experiment is the most recent of similar attempts done in occasion of the 2002 [2] and 1999 [3] TSEś. Pioneering observations of this kind were reported in [4], but the hypotheses used in that analysis are no more reliable today. The aim of all those experiments is to look for visible photons emitted in the decay, during the flight of solar neutrinos between the Moon and the Earth in occasion of total solar eclipses, tacking advantage on the large solar neutrino flux at the Earth level ($\Phi \simeq 7 \cdot 10^{10}$ cm^{-2} s^{-1}) and on the Moon as an absorber for the light of the Sun. It should be stressed that ν_1 and ν_2 represent neutrino *mass* eigenstates.

After a short review of the existing lifetime lower limits for neutrino radiative decays, we present the characteristics of the observation site (in the Libyan Sahara) and the experimental setup used. The good conditions on the site allowed us to deploy an experiment with better characteristics in terms of sensitivity and resolution than in our previous attempts.

The experimental data, consisting in more than 200 digital pictures of the central dark region of the Moon (aligned with respect to the center of the Sun) are also discussed in some detail. Due to a dedicated acquisition software, we could impose such exposition conditions that the moonscape is clearly visible in the ashen light (the light of the Sun reflected by the Earth towards the Moon). As the ashen light is the main source of background for such experiments, the flux of the decay photons has to be at least of the same order of magnitude in order to be detected.

The data analysis is based on the wavelet decomposition of the obtained images, in order to maximize the signal to background ratio. The expected signal is as predicted by the Monte Carlo model described in [5]. No decay pattern was seen, both for the $\nu_2 \rightarrow \nu_1$ ($\Delta m^2 = 6 \cdot 10^{-5}$ eV^2) and the $\nu_3 \rightarrow \nu_{2,1}$ ($\Delta m^2 = 2.4 \cdot 10^{-3}$ eV^2) possible channels. The lower limits (at 95% C.L.)for the proper lifetime of the radiative neutrino decay are presented in function of the ν_1 mass.

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The experiment was funded by the University and INFN Section of Bologna. The support from the Italian Institute of Culture of Tripoli is also acknowledged. The analysis was partially founded under CNCSIS Contract 539/2009. We are grateful to the organizers of the SPSE 2006 event for their efforts that allowed to perform our experiment. Special thanks are due to the Winzirk Group and to the Libyan Air Force for their assistance.

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Tunka-133: the New EAS Cherenkov Light Array for Study of the Cosmic Rays in the Energy Range 10^{15} – 10^{18} eV

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The new EAS Cherenkov light array Tunka-133, with about 1 km^2 geometric area, has been installed in the Tunka Valley (50 km from Lake Baikal). The array will permit a detailed study of cosmic ray energy spectrum and mass composition in the energy range of 10^{15} – 10^{18} eV. The total array consisting of 19 clusters each composed of 7 optical detectors has started data taking since October 2009. We describe the array construction and DAQ, preliminary results and plans for the future development – deployment of radio-antennas and muon detectors networks.

MASS COMPOSITION ANALYSIS USING HYBRID DATA OF THE PIERRE AUGER OBSERVATORY

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The measurement of chemical composition of cosmic rays as a function of their energy provides a significant clue in the understanding of cosmic ray origins, representing one of the most important items of research of the Pierre Auger Observatory. The Pierre Auger Observatory has been designed to measure cosmic rays above 10^{18} eV with unprecedent statistics and precision. The Observatory has been taking data since 2004, as the detector deployment went on. The detector building finished in early 2008. The present analysis reports the recent composition results obtained by the Auger Observatory using hybrid data with energies above 10^{18} eV. These data, being recorded by both fluorescence telescopes and ground stations, allow to sample the shower longitudinal development and to precisely measure the depth of shower maximum reached in atmosphere, which is considered one of the most sensitive observable to the primary composition. The elongation rate and the depth of maximum fluctuations have been measured and will be discussed in the presentation.

EVENT RECONSTRUCTION IN EMMA

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Measurements with the first underground tracking station of the EMMA experiment [1] (Experiment with MultiMuon Array) were started in February 2010 and the first high-multiplicity muon events have been reconstructed. The measurements are used to develop the track reconstruction program and to gain experience of experimental data after which the angular and multiplicity distributions of muons can be extracted. The first tracking station is already suitable for testing high-multiplicity events recorded at some LEP experiments.

The reconstruction of events with high muon densities requires a good hit position resolution. The main part of EMMA consists of former LEP-DELPHI MUB [2] drift chambers that are arranged in groups of seven chambers, called planks. Each chamber provides three signals from which the hit position can be reconstructed with $\sim$ 1 cm position resolution in a horizontal plane.

We have developed the track reconstruction program ETANA for reconstructing hit positions and the tracks of muons in detector stations. The program is ready but still some testing and fine-tuning are needed to optimize its output. In the tracking stations, where the planks are placed in three layers with 1.1 m vertical separations, the tracks can be reconstructed on the basis of their parallelism. Including the angular spread of muons caused by the scattering in the rock, the reconstruction accuracy of $\sim$ 0.5 degrees for the shower arrival direction can be achieved.

Furthermore, the track reconstruction is improved after testing and placing small-size scintillation detectors [3] ($12 \times 12 \times 3$ cm^3) into the tracking stations below the bottom layer of planks. They cover the area of 24 m^2 which is devided between the three tracking stations. The combined information from the planks and scintillation detectors is expected to improve especially the reconstruction of high-multiplicity events above 10 muons / m^2.

The optimisation of track reconstruction algorithm requires careful evaluation of the effect of rock overburden. We have developed a simulation program that includes a detailed model of the rock overburden based on several drilling samples, allowing us to take into account the open pit, caverns and variations in rock densities. The rock layer corresponds to the 50 GeV average energy cut-off and, because of multiple scattering, results in the

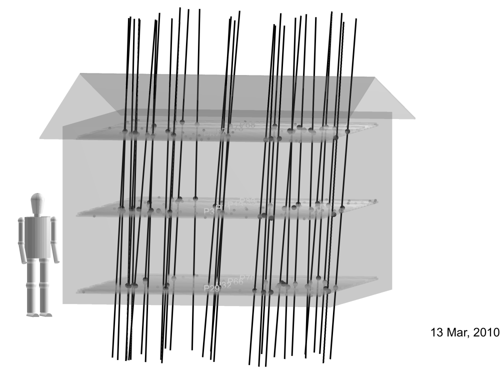

Figure 1: A multi-muon event of 30 tracks reconstructed with the first tracking station.

dispersion of tracks up to one degree with respect of the shower arrival direction. In addition, muon-induced electrons are challenging for the track reconstruction but can be mostly separated by their largely deviated tracks.

Some experiments at LEP (DELPHI [4], CosmoALEPH [5], L3+C [6]) measured muon bundles with very high multiplicities not expected on the basis of interaction models. The long running time of EMMA and the sufficient position resolution of detectors enables the reconstruction of high-multiplicity muon bundles with good statistics allowing to test modern models.

For event visualisation we have developed the visualisation program EMMAEve using OpenGL and Root's TEve classes. The program can be used to visualise simulated and reconstructed events for underground detector stations and for the detector calibration setup in the surface laboratory. It also offers the possibility to browse event information diversely by tables and histograms. In Fig. 1 is shown a reconstructed event with 30 tracks measured with the tracking station and visualised by EMMAEve.

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A RELATION BETWEEN CHARGED PARTICLES AND MUONS WITH THRESHOLD ENERGY 1 GeV IN EXTENSIVE AIR SHOWERS REGISTERED AT THE YAKUTSK EAS ARRAY

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For a long time the three main components of extensive air showers have been measured at the Yakutsk array: the whole charged component, muons with $\varepsilon_{\text{th}} \geq 1$ GeV and Cherenkov light. Using these data we reconstruct energy of primary cosmic particle (with quasi-colorimetric method), estimate the depth of shower maximum (by the shape of charged particles lateral distribution and a pulse shape of Cherenkov light response in differential detector, $\tau_{1/2}$) and measure relative muon content at different core distances. In this work we consider a relation $\rho_\mu/\rho_{\text{ch}}$ between charged and muon components in showers and its fluctuations at fixed energies. The goal of this analysis is to make a comparison between experimental and computational data for different primaries and to obtain an estimation of cosmic rays mass composition in the ultra-high energy domain.

CHARACTERISTICS OF COSMIC RAY BACKGROUND, ELECTRIC FIELD AND FEATURES OF VLF-RADIATION DURING THUNDERSTORM ACTIVITY AND CALM PERIODS

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We present the data obtained in simultaneous measurements of cosmic rays, electric field and VLF-radiation performed at the Yakutsk EAS array. Cosmic rays were measured with 7 scintillation detectors ($0.1 - 2$ m^2) with different thresholds: 0.5 MeV and 1.5 MeV for electron component and 1 GeV for muons. Electric field was measured with electrostatic fluxmeter. VLF-radiation was measured with two crossed frames (9×30 m, 15 loops) and with a 10 m rod antenna in the range $4 - 100$ KHz. Thunderstorm discharges were located with a lightning direction finding system.

During the passage of thunderstorm cloud abrupt changes of electric field intensity occur. Bursts of VLF-radiation are also observed. At the same time count rate from scintillation detectors located at surface level with low energy threshold increases exceeding mean background by factor $3 - 5$. Within each group the signal consists of alternating peaks with a small time interval. Surface and underground detectors with high threshold register undisturbed background.

Data on VLF-radiation during EAS events are also presented. Results of measurements during 2009 and 1985 summer periods are discussed.

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Measurement of cosmic ray air showers with the digital radio interferometer LOPES

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LOPES is a digital radio interferometer which measures the radio emission of extensive cosmic ray air showers (EAS). It mainly consists of 30 absolute amplitude calibrated dipole antennas which are located at the Karlsruhe Institute of Technology (KIT) in Germany, at the same place as the EAS experiment KASCADE-Grande. Whenever KASCADE-Grande detects a high energy cosmic ray event ($\gtrsim 10^{16}$ eV), it triggers LOPES which then digitally records the radio emission in the frequency band from 40 to 80 MHz. Due to its precise time calibration with a beacon, LOPES can be used as an interferometer by digitally forming a cross-correlation beam into the direction of the air shower axis. This way, LOPES is able to successfully detect EAS induced radio pulses, even in the noisy environment of Karlsruhe. It proved that it is possible to reconstruct the primary energy and arrival direction by radio measurements, and could confirm the historic results that the radio pulse is of geo-magnetic origin. Furthermore, measurements of the polarization of the radio pulse and its lateral distribution allow to investigate the – yet unknown – details of the radio emission mechanism. Revealing those details will be mandatory to study the accuracies of the reconstruction of primary energy and composition. Lately, progress was made in understanding the EAS radio emission mechanism: REAS 3 which is based on the geo-synchrotron model, seems to be the first simulation program which is able to reproduce the magnitude and slope of most of the measured lateral distributions. Beyond that, LOPES also serves as a test bench for measurement and analysis techniques as well as sophisticated electronics and antennas. Thus, LOPES has yielded valuable experience for the extension of the radio detection method to larger scales, like it is presently done with LOFAR, in Europe, and with AERA at the southern Pierre Auger Observatory, in Argentina.

Heavy neutrino decay at SHALON

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Ground based telescopes are designed to detect the Cherenkov light of the shower produced when a 0.1 - 100 TeV photon enters the atmosphere. The light burst in a photon (or electron) air shower has a profile that can be distinguished from the one from primary protons or atomic nuclei, which are a diffuse background in such observations (see [1. 2] for a review). Cosmic rays may also offer an opportunity to study the properties of elementary particles. The main objective in experiments like IceCube [3] or Auger [4] is to determine a flux of neutrinos or protons as they interact with terrestrial matter. These interactions involve energies not explored so far at particle colliders, so their study should lead us to a better understanding of that physics. In addition, the size of the detector and its distance to the interaction point is much larger there than in colliders, which may leave some room for unexpected effects caused by long-lived particles. It could well be that in the near future cosmic rays play in particle physics a complementary role similar to the one played nowadays by cosmology (in aspects like dark matter, neutrino masses, etc.). In this paper we describe what we think may be one of such effects. It occurs studying the response of the SHALON telescope [5] to air showers from different zenith angles, in a sub-horizontal configuration where the signal from cosmic rays should vanish.

The SHALON mirror telescope. SHALON is a gamma-ray telescope [6, 7] located at 3338 meters a.s.l. in the Tien-Shan mountain station. It has a mirror area of $11.2m^2$ and a large field of view above 8^o, with an image matrix of 144 PMT and a 0.1^o angular resolution. The telescope has been calibrated according to the observation of extensive air showers at $\theta = 0^o$ zenith angle, i.e., at an atmospheric depth of $670g/cm^2$. Every two-dimensional image of the shower (an elliptic spot in the light receiver matrix) is characterized by parameters widely used in gamma-ray astronomy. SHALON has been operating since 1992 [5, 7, 8], with the observation of over 2 million extensive air showers. During this period it has detected gamma-ray signals from well known and also from new sources of different type: Crab Nebula, Tycho's SNR, Geminga, Mkn 421, Mkn 501, NGC 1275, SN2006 gy, 3c454.3 and 1739+522 [8, 9].

The study of extensive air showers at large zenith angles included observations at the sub-horizontal direction $\theta = 97^o$ [5, 8]. The configuration of the telescope is depicted in Fig. 1. The mountain projects a shadow of about 7^o over the horizon. The distance of the telescope to the opposite slope of the gorge is about 7 km, which corresponds to 16.5 radiation lengths and a depth of $640g/cm^2$. From that point the trajectory finds between 800 and 2000 km of rock before reappearing in the atmosphere.

The analysis of the signal at different zenith angles (θ) has included observations from the

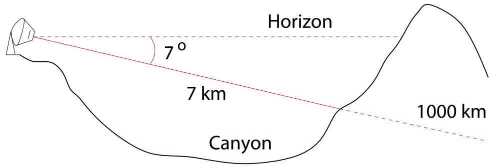

Figure 1: Configuration at $\theta = 97^o$

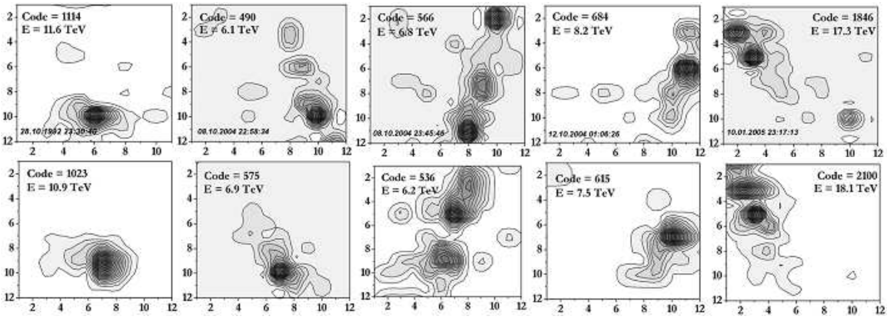

Figure 2: Top: Cherenkov Radiation of EASs Observed at 97^o Zenith Angles by SHALON; Bottom: Cherenkov Radiation of EASs Observed at 0^o Zenith Angles by SHALON

sub-horizontal direction $\theta = 97^o$. This inclination defines an Earth skimming trajectory with 7 km of air and around 1000 km of rock in front of the telescope. During a period of 324 hours of observation, after a cut of shower-like events that may be caused by chaotic sky flashes or reflections on the snow of vertical showers, we have detected 5 air showers of TeV energies. We argue that these events may be caused by the decay of a long-lived penetrating particle entering the atmosphere from the ground and decaying in front of the telescope. We show that this particle can not be a muon or a tau lepton. As a possible explanation, we discuss two scenarios with an unstable neutrino of mass m about $0.5GeV$ and $c\tau$ about $30m$. Remarkably, one of these models has been recently proposed to explain an excess of electron-like neutrino events at MiniBooNE.

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Results from the High Resolution Flys Eye Experiment

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The High Resolution Flys Eye (HiRes) experiment is an experiment studying ultrahigh energy cosmic rays, that had two fluorescence detectors located atop desert mountains in west-central Utah. HiRes has the largest data set of cosmic ray air showers in the northern hemisphere. The HiRes collaboration performed the first observation of the GZK cutoff. HiRes results on the spectrum, composition, and anisotropy of cosmic rays will be presented.

An air shower array for LOFAR

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LOFAR is a new form of radio telescope which can detect radio emission from air showers induced by very high energy cosmic-rays. To complement the radio detection, we are setting up a small particle detector array LORA (LOfar Radboud Air shower array) within the LOFAR core area. It will help in triggering and confirming the radio trigger of the LOFAR antennas. LORA consists of 5 stations with 4 detectors each. The detectors are plastic scintillators and they are placed within an area of 300m diameter with spacings $\sim (50 - 100)$m between them. At this symposium, we will give an overall view about LORA and present the first results.

Simulation of IceTop VEM calibration and the dependency on the snow layer

A. Van Overloop for the IceCube Collaboration

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Six years of construction on the IceTop air shower array has led to the current setup of 146 ice filled tanks. The tanks are paired as stations over an area of 1 square kilometer. A continuous and automatic procedure calibrates each tank via the extraction of the vertical equivalent muon peak in the tank charge spectrum.

Over the years snow drifted unevenly on top of the tanks. The overburden of snow influences the charge spectrum as the electromagnetic part of an air shower is attenuated more than the muonic part. The impact on individual tanks affects trigger rates and the air shower event structure.

We will present tank response studies with Monte Carlo simulations and compare them to measured IceTop charge spectra in light of the varying thickness of the snow layer.

NEUTRINO BURSTS FROM GRAVITATIONAL STELLAR COLLAPSE WITH LVD

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The main goal of the Large Volume Detector (LVD), in the INFN Gran Sasso National Laboratory (Italy), is the study of neutrino bursts from gravitational stellar collapses. Both the detector and the data analysis procedure have been optimized for this purpose. The modularity of the apparatus allows to obtain a duty cycle that is very close to 100%, so that the experiment is continuosly monitoring the Galaxy.
The analysis is performed online, with the selection of alarms for SNEWS, and offline. In both cases, LVD is able to disentagle a cluster of neutrino signals from the background, and its sensitivity extends to the whole Galaxy. In the lack of a positive detection the 90% c.l. limit to the rate of Supernova collapses in the Galaxy is discussed.

Session 5: HE/UHE Cosmic Ray Theory (Talks)

Conveners: R. Schlickeiser and R. Vainio

INVITED

Shocks, magnetic field and energetic particles

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Magnetic field plays an important role in particle acceleration and transport in astrophysics. It has been shown theoretically that a non-resonant instability driven by cosmic rays may provide the amplified fields needed to accelerate cosmic rays to high energy and account for the large shock-related fields inferred from x-ray observations of supernova remnants and extragalactic jets.

Cosmic ray streaming can also produce magnetic field by a different resistive process which is well-known in laser-plasma experiments. High energy charged particles streaming through a thermal plasma carry an electrical current which must be balanced by a return current carried by the thermal plasma. If the thermal plasma is collisional with a non-uniform resistivity, the electric field drawing the return current is also non-uniform. A magnetic field is generated if the electric field has a non-zero curl. Cosmic rays produced by supernovae during initial star and galaxy formation in the early universe may stream freely into the previously cold unmagnetised intergalactic medium and generate a magnetic field of order 10^{-16} Gauss. This small field may then act as a seed for dynamo amplification to produce the intergalactic field of the present era.

Mass Composition and Cross-section from the Shape of Cosmic Ray Shower Longitudinal Profiles

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The longitudinal development of extreme energy cosmic ray showers has a characteristic Universal Shower Profile when normalized and translated to the shower maximum. We propose a new parametrization for the longitudinal profile with parameters that can be connected with experimentally accessible observables, allowing a better characterization of the average shape and the deviation for each event.

By describing the full shape of the profile more information can be extracted in an event-by-event basis. In particular, the distance from the first interaction to the depth of maximum can be measured, using a new shape variable, and that can lead to a cosmic ray composition analysis with independent extraction of the primary cross-sections.

INVITED

Scaling theory for cross-field transport of cosmic rays in turbulent fields

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The transport of charged particles (e.g., cosmic rays) in astrophysically relevant, turbulent magnetic fields (like they exist, e.g., in the solar wind) is investigated. Generic theoretical models-using concepts and insights developed recently in the context of magnetic confinement fusion research-are applied to the present problem and confirmed by means of numerical simulations. At high energies, a novel transport regime is found, in which the particles decorrelate on a gyro-orbit timescale. Explicit scaling laws for the cross-field diffusivities in various limits are derived.

INVITED

Numerical modelling of relativistic shock acceleration

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The shock acceleration mechanism is invoked to explain non-thermal cosmic rays in Supernova Remnants, Active Galactic Nuclei Jets and Gamma ray Bursts. Especially, the importance of achieving the highest observed cosmic ray energies by such a mechanism in given extragalactic astrophysical environments, such as radio galaxies, or Gamma Ray Bursts, is a recurring theme. In this talk, Monte Carlo simulation studies of relativistic, subluminal and superluminal shocks will be presented. An emphasis will be given on relativistic shocks properties and acceleration efficiency, in connection to the acquired ultra high energy cosmic ray energies, applied to extragalactic candidate sources.

Ultrahighenergy galactic cosmic rays from distributed focused acceleration

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Large-scale spatial variations of the guide magnetic field of interstellar plasmas cause the adiabatic focusing term in the Fokker-Planck transport equation of cosmic rays. As a consequence of the adiabatic focusing term, the diffusion approximation to cosmic ray transport in the weak focusing limit gives rise to first-order Fermi acceleration of energetic particles if the product HL of the cross helicity state of Alfvenic turbulence H and the focusing length L is negative. The basic physical mechanisms for this new acceleration process are clarified and the astrophysical conditions for efficient acceleration are investigated. It is shown that in the interstellar medium this mechanism preferentially accelerates cosmic ray hadrons over 10 orders of magnitude in momentum to ultrahigh momentum values . Due to heavy Coulomb and ionisation losses at low momenta, injection or preacceleration of particles above the threshold momentum $p_c \simeq 0.17Z^{2/3}$ GeV$/c$ is required.

Simulation of Charged Particle Diffusion in MHD plasmas

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[2]Institut für Astro- und Teilchenphysik, Universität Innsbruck, Austria

The transport of cosmic rays in turbulent magnetic fields has been studied in last decades by means of analytical theory. Quasilinear theory [1, 2] has explained many details of the transport phenomenology, but is limited by simplifying assumptions about the underlying turbulence. And only recent additions to the quasilinear theory [3] have made rigorous attempts to solve the question of transport perpendicular to the mean magnetic field.

Simulations on the other hand are not limited by simplifications to ease calculations, but also here the turbulence used for the particle transport is usually only implemented through statistical fluctuations. This results in an incomplete representation of real turbulence encountered in the interstellar medium and the heliosphere.

We will present our approach to the simulation of the transport parameters: using compressible as well as incompressible MHD, simulations have been performed providing realistic turbulent fields. Employing a test-particle approach energetic particle trajectories are simulated. From these trajectories the Fokker-Planck-coefficients may then be computed. A major advantage of this approach is the possibility of using realistic turbulent spectra, which are anisotropic in the presence of background magnetic fields [5], to determine transport parameters.

The results presented include the pitch-angle diffusion coefficient $D_{\mu\mu}$ and the mean free path for incompressible and compressible plasma. Also the influence of the temporal evolution of the turbulent field is taken into account. We will identify the physical processes contributing to scattering and analyse the relative importance.

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WHY THE KNEE AT 100 PEV COULD NOT BE SEEN?

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If the knee at 3-5 PeV in cosmic ray spectrum is a result of a break in primary proton spectrum, as it was claimed by the KASCADE collaboration, and energy of the knee for different primary particles (Z, A) is proportional to Z (or A), then one should expect "iron knee" existence at $\sim$100 (or 200) PeV. Discovery of this "iron knee" was one of the main goal for KASCADE-GRANDE experiment [1]. But, the data obtained in this experiment [2] as well as in other experiments, did not show any change of the spectrum slope in expected region. Why? The answer could be easily found if one takes into account a new approach to the knee problem [3]. I this phenomenological approach the knee should be seen only in electromagnetic components and its position should occur at energy of $\sim$100 TeV / nucleon for all primary particles. This is a critical point in EAS development when the equilibrium between hadronic and electromagnetic EAS components undergo a break at observation level even for pure power law primary spectrum. Therefore, the knee visible in PeV region should be assign to iron primaries while "proton knee" is expected to be seen at $\sim$100 TeV. This approach agrees with the Tibet ASγ experiment conclusion [4] that the knee in PeV region is connected with heavy primaries.The sharpness of PeV knee is an additional evidence for its heavy mass origin because proton originated EAS have large fluctuations and could not form sharp knee. As for real "proton knee", it was observed in some experiments (including early KASCADE) with energy threshold much lower than 100 TeV.

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PARTICLE ACCELERATION TIMESCALES IN RELATIVISTIC JETS

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Recent observations of certain blazar objects showing strong variability in timescales of minutes offer valuable tools for studying particle acceleration processes in these objects. By comparing different particle energisation mechanisms together with various energy loss timescales we can exclude acceleration and radiation models as well as find the most significant mechanisms working in these sources. Furthermore, we can estimate the maximun obtainable particle energies as well as set limits for turbulence-generating processes.

In this talk we shall review the use of particle acceleration timescale analysis in studying physical properties of relativistic jet sources with emphasis on TeV blazars showing minute-scale flaring; evaluate different acceleration mechanisms and their plausibility for being responsible for the observed phenomena; and discuss the suitability of the second-order Fermi process for explaining the "inverse" energy-dependent time delays (so-called hard lags) in certain blazars.

EXPLORING COSMIC RAY SPECTRA IN SUPERNOVA REMNANTS

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[3]Iowa State University, Ames, United States

It is currently assumed that Galactic cosmic rays (CR) are accelerated at the blast waves of Supernova Remnants (SNRs) through stochastic scattering in turbulent magnetic fields upstream and downstream of the shock. This process known as Diffusive Shock Acceleration (DSA) is well described by a time-dependent diffusion-convection equation in energy and space. Typically, the CR differential number density spectrum should be a power-law with an index close to s=2. However, in the observed TeV-band spectra of SNRs we see softer spectra, which has not been understood to date. We investigate which SNR parameters may affect the resulting spectral indices of CRs. For this purpose we calculate the hydrodynamical evolution of SNRs using approximate methods valid for arbitrary surrounding media and determine solutions to the transport equation of CRs in the flow pattern thus derived. The high efficiency of this approach allows us to vary the initial parameters of the problem and study CR acceleration in SNRs in a uniform as well as a nonuniform interstellar medium. We present some insights on possible ways to modify CR spectra in SNRs and compare our results with observations.

On the possible correlation between the high energy electron spectrum and the cosmic-ray secondary to primary ratios

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Department of Astrophysics/IMAPP, Radboud University Nijmegen, 6500 GL Nijmegen, The Netherlands

Observations of high energy cosmic-ray electrons by the Fermi-LAT and the HESS experiments between 20 GeV and 5 TeV have found that the energy spectrum follow a broken power-law with spectral indices $\Gamma_1 \approx 3$ and $\Gamma_2 \approx 4$ with a break at around 1 TeV. On the other hand, measurements of cosmic-ray secondary-to-primary ratios like the boron to carbon ratio indicate a possible change in the slope at energies around 100 GeV/n. Here, we present a possible explaination for the observed break in the electron spectrum and its possible correlation with the observed flattening in the secondary-to-primary ratios at higher energies. In our model, we assume that cosmic-rays, after acceleration, remain confined within the sources before they are released into the interstellar medium. During this time, the high-energy electrons suffer from radiative energy losses and the cosmic-ray nuclei undergo nuclear fragmentations due to their interactions with the matter.

INVITED

COMPOSITION OF THE ANKLE

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[2]Department of Physics, Durham University, Durham, UK.

Recent results of PAO [1] have been analysed hoping to derive a strong statement about the mass composition in the region of the ankle, where the change from Galactic (G) to ExtraGalactic (EG) cosmic ray flux should take place, at least according to our theoretical predictions. The data published this year consist of a high statistics energy spectrum data, the average position of the shower maximum ($x_{\max}$) and the spread of this maximum as a function of energy in the range above 10^{18} eV up to 3×10^{19} eV.

We have assumed the model proposed some time ago [2]. The Galactic component has a power law spectrum with an index of -2.7 and it is cut by a Z-dependent Gaussian factor. The EG component is a power law with an index of -2.1 with a cut related to GZK or photodisintegration cut-off. The model was tested with simulation of UHECR propagation in different regular magnetic field structures assuming commonly acceptable values of the regular, and random field. The proposed description was successfully adjusted to the recent 'world average' energy spectrum of UHECR and used to make some conclusions about the composition of both G and EG components.

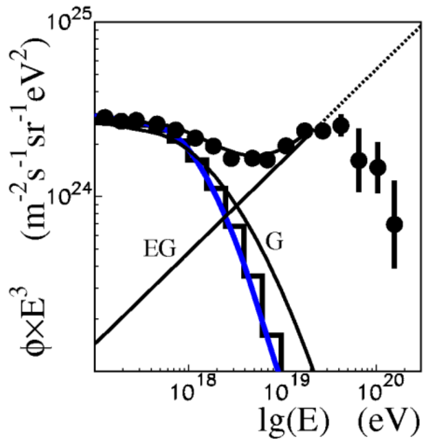

Figure 1: The UHECR flux and its G and EG components shown with the comparison of simulated Galactic component cosmic rays from sources distributed uniformly in the Galactic disk.

The histogram, and the smoothed line in the Fig.1, shows predictions of the Galactic flux (with typical, low energy mass composition) observed in the vicinity of the Solar Ssystem assuming a uniform distribution of CR sources in the Galactic disk. As is seen, our assumption about the Gaussian shape of the cut-off work very well in the case of realistic Galactic magnetic fields.

The composition was found independently for G and EG component and we found it very similar in both cases. It is dominated by CNO nuclei in general. The lighter, He nuclei are present in a fraction of about 30%. There is a fast falling component of Galactic protons seen. This change of proton contents of UHECR flux is responsible for the changes in average $x_{\max}$ and its spread up to 10^{19} eV.

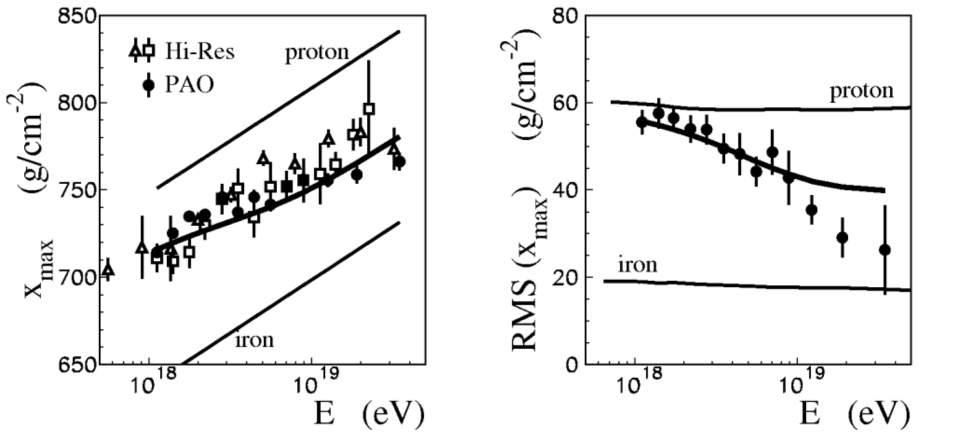

Figure 2: (left) Average position of the shower maximum as a function of primary particle energy. Thick solid line shows results of the composition fit. Solid symbols: PAO [1] and open circles: HiRes [3]. (right) RMS of the $x_{\max}$ from the fit (thick line) and PAO data. (An addition of excess EG iron nuclei above 10^{19} eV, from a nearby source, would improve both fits).

The recently discussed UHECR anisotropy has been studied using the Galactic transport simulation. We found that the effect starts above 10^{19} eV where the overall contribution of the Galactic flux is below 10%.

In our view, Galactic sources, such as those in Cygnus, should soon start to be visible at the highest energies.

A somewhat similar analysis has been made, very recently, by Hooper and Taylor [4].

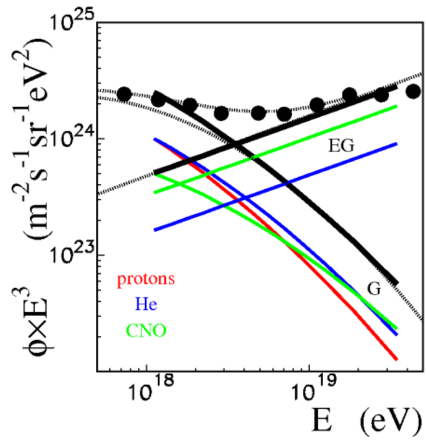

Figure 3: Final UHECR spectrum fit shown separately for G and EG mass components.

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Session 5: HE/UHE Cosmic Ray Theory (Posters)

Conveners: R. Schlickeiser and R. Vainio

Cosmic-ray energy spectrum around the knee observed with the Tibet air-shower experiment

M. Amenomori,[1] X. J. Bi,[2] D. Chen,[3] S. W. Cui,[4] Danzengluobu,[5] L. K. Ding,[2] X. H. Ding,[5] C. Fan,[26] C. F. Feng,[6] Zhaoyang Feng,[2] Z. Y. Feng,[7] X. Y. Gao,[8] Q. X. Geng,[8] Q. B. Gou,[2] H. W. Guo,[5] H. H. He,[2] M. He,[6] K. Hibino,[9] N. Hotta,[10] Haibing Hu,[5] H. B. Hu,[2] J. Huang,[2] Q. Huang,[7] H. Y. Jia,[7] L. Jiang,[28] F. Kajino,[11] K. Kasahara,[12] Y. Katayose,[13] C. Kato,[14] K. Kawata,[3] Labaciren,[5] G. M. Le,[15] A. F. Li,[6] H. C. Li,[24] J. Y. Li,[6] C. Liu,[2] Y.-Q. Lou,[16] H. Lu,[2] X. R. Meng,[5] K. Mizutani,[1217] J. Mu,[8] K. Munakata,[14] H. Nanjo,[1] M. Nishizawa,[18] M. Ohnishi,[3] I. Ohta,[19] S. Ozawa,[12] T. Saito,[20] T. Y. Saito,[21] M. Sakata,[11] T. K. Sako,[3] M. Shibata,[13] A. Shiomi,[22] T. Shirai,[9] H. Sugimoto,[23] M. Takita,[3] Y. H. Tan,[2] N. Tateyama,[9] S. Torii,[12] H. Tsuchiya,[24] S. Udo,[9] B. Wang,[2] H. Wang,[2] Y. Wang,[2] Y. G. Wang,[6] H. R. Wu,[2] L. Xue,[6] Y. Yamamoto,[11] C. T. Yan,[25] X. C. Yang,[8] S. Yasue,[26] Z. H. Ye,[27] G. C. Yu,[7] A. F. Yuan,[5] T. Yuda,[9] H. M. Zhang,[2] J. L. Zhang,[2] N. J. Zhang,[6] X. Y. Zhang,[6] Y. Zhang,[2] Yi Zhang,[2] Ying Zhang,[27] Zhaxisangzhu,[5] and X. X. Zhou[7]
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The energy spectrum and chemical composition of cosmic rays are key information for studying their acceleration and propagation mechanisms as well as their origin. The cosmic-ray energy spectrum has been measured with ground-based air-shower arrays and various instruments on board satellites and balloons, featuring a power-law shape ($\propto E^{-\gamma}$) from 30 GeV to 100 EeV or greater energies. It is known that the energy spectrum has a prominent structure at $\sim$4000 TeV, called the "knee", where the spectral index γ changes from 2.7 to 3.1 [1]. Although the existence of the knee has been well established experimentally, its origin remains to be fully understood.

The Tibet air-shower (AS) array, located at 90.522° E, 30.102° N and 4300 m above sea level, has been successfully observing cosmic rays with energies above a few TeV with an effective area of 37000 m^2. Recent results from the Tibet air-shower experiment on the all-particle cosmic-ray energy spectrum and the chemical composition of cosmic rays around 10^{15} eV will be reported.

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A COMPARISON OF SUPERPOSITION AND FRAGMENTATION MODELS OF NUCLEUS-NUCLEUS COLLISIONS IMPLEMENTED IN CORSIKA CODE

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Superposition and fragmentation models are two alternative approximations to nucleus-nucleus collisions widely used in simulations of extensive air showers (EASs) of cosmic rays (CRs). Our aim is to compare the main observable parameters of EAS in two models: ionization integral, shower maximum, particle densities at the fixed distances from the shower core. The approximation accuracy is essential in estimation of CR astrophysical parameters basing on EAS measurements.

Semi-analytical model of cosmic ray electron transport

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Recently the leptonic component of the cosmic ray spectrum has gained new attention. New observations from ATIC [1], PAMELA [2] and Fermi [3] show a deviation from a power-law in the form of an excess in both the electron and positron spectra. Annihilating dark matter and nearby pulsars (among other things) have been proposed as possible sources of the excess leptons. Regardless of the source, a new propagation model is needed to connect the energy spectrum measured on earth with the injection spectra.

We present our semi-analytical cosmic ray transport model in application to the high energy electron transport in the ISM. Spatial and momentum diffusion, particle escape, acceleration via Fermi I and continuous energy losses were taken into account and their effects on the steady-state energy spectrum analyzed. In solving the transport equation we employed quasi-linear transport theory, the diffusion approximation and a separation of the spatial and momentum problem to obtain the leaky-box-equation, which was then solved numerically. The spatial problem was solved analytically in cylindrical and prolate spheroidal coordinates.

The transport model was employed to calculate the spectrum of secondary electrons in our galaxy. We assume the leptons from pion decay to be the dominating component of the secondary spectrum. The electron spectrum from collisions of highly relativistic cosmic ray protons with thermal protons in the ISM was calculated using the parametrisations of pion production in p-p-collisions from [4] and used as the injection spectrum for the transport modell. The resulting electron flux in the vicinity of the solar system shows a spectral break in the energy range of the Fermi-bump and lies less than an order of magnitude below the measured flux. This allows us to fit the Fermi bump very nicely with realistic simulation parameters assuming a generic power-law primary spectrum.

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Study of primary CR composition on the basis of radial scale factors of electron lateral distribution in EAS

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Scaling property of lateral distribution of EAS electrons [1,2] allows to extract the infromation about the primary particle type from single parameter - root mean square radius of electrons [3,4]. The theoretically motivated scaling formalizm was successfully applied to the description of experimental data of KASCADE [6] and AGASA [3-5]. However its implementation to Yakutsk and MSU air shower arrays data met with problems [7-9].

In our recent papers [10,11] the generalization of scaling approach by concerning the rate of change of biased radial scale factors with energy was proposed. We also took into account [10] the shower classification procedure in different experiments which is significant, due to the effect of fluctuations, for comparisons of lateral distributions measured by relatively small ground-based shower arrays to LDFs calculated theoretically for fixed primary energy.

In this paper different LDFs were implemented to evaluate electron radial scale factors from the experimental data of MSU, KASCADE, KASCADE-Grande and Yakutsk air shower arrays. Consistent model-independent results on average primary mass variation with energy were obtained using generalized scaling approach irrespective of the exact form of the the LDF used for experimental data fitting.

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On the role of Stellar Flares to the acceleration process of Cosmic Rays at SNRs

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In the previous cosmic ray conference [1], the author has proposed a new hypothesis on the acceleration process of cosmic rays at Super Nova Remnants. The hypothesis describes that cosmic rays are accelerated at the SNRs beyond 100 TeV from the ions but the seed particles must be already accelerated particles by the stellar flares that have been frequently observed in various parts of our Galaxy.

In this paper the author will estimate the contribution of the first acceleration process by the stellar flare to the acceleration process into cosmic rays. In other words, the hypothesis can be described as follows: ions are accelerated beyond 100 GeV by the stellar flares and those particles are spread everywhere in the Galactic arm. When those particles are captured by SNR accelerators, they will be accelerated into higher energy such as 100 TeV by the shock acceleration process. Stellar flares must be the first step accelerator and the SNRs must be the second accelerator like SPS machine.

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Transport of ultra-high energy cosmic rays in expanding univers

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The simple numerical code that describes the transport of ultra-high energy protons and nuclei through the background radiation in the expanding Universe is presented. The potentials of the code are illustrated with a few examples of cosmic-ray source spectra and composition[1]

[1] V.S. Ptuskin, S.I. Rogovaya, V.N. Zirakashvili, Bull. Russian Academy of Sciences: Physics,73,552,2009.

HIGH-ENERGY ATMOSPHERIC NEUTRINO FLUX DEPENDING ON THE HADRONIC MODEL

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[3]Higher Mathematics Department, Irkutsk State Railway University

High-energy atmospheric neutrinos arising from decays of mesons, produced through the cosmic rays collisions with air nuclei, form unavoidable background noise in the strophysical neutrino detection problem. New calculation of the atmospheric neutrino flux in the wide energy range is made within the approach to solve nuclear cascade equations in the atmosphere [1], which takes into account non-scaling behavior of inclusive particle production cross-sections, rise of total inelastic hadron-nuclei cross-sections and non-power-law character of the primary cosmic ray spectrum. Shown is the spread in the neutrino flux predictions due to the diversity of high-energy hadronic models (QGSJET-II, SIBYLL 2.1 etc.), charm production models, as well as to the ambiguity concerning the primary cosmic ray spectra and compositions arond knee. The calculations are compared with the data of the AMANDA-II [2, 3] and IceCube [4, 5] experiments.

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COPLANAR EMISSION IN COSMIC RAY INTERACTIONS AND EARLIEST LHC RESULTS

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The coplanar emission is most frequently observed in cosmic ray emulsion chambers around 10 PeV. Our understanding of this unusual nuclear interaction can progress with the results of the LHC especially when providing the relation between the average transverse momentum <Pt> and the central density of rapidity. The CMS results correspond now to a primary energy of 3 PeV in laboratory system (30 PeV and 100 PeV are expected to be attained by the LHC in one year).
In this work we have concentrated our attention on the characteristic of the clearest events observed in the stratosphere which have the advantage to suffer a minimal cascading after the first interaction. We have conducted our calculations in 3 directions:
1/ the fragments of nuclei deviated by the geomagnetic field during 20-30 km
2/ the secondary particles of p-air collisions also deviated by the geomagnetic field in special individual Pt's configuration
3/ new aspects in p-air interaction near 10 PeV
In this last circumstance, a valence quark and diquark generator is introduced to appreciate the effect of very large Pt's generated by the fragmentation of high tension strings resulting for the valence diquark breaking.

Session 6: HE/UHE Gamma-rays (Talks)

Conveners: F. Aharonian and J. Poutanen

Observations with the High Altitute GAmma-Ray (HAGAR) telescope array in the Indian Himalayas

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The High Altitude GAmma-Ray (HAGAR) array is a wavefront sampling array of 7 telescopes, set-up at Hanle, at 4270 m amsl, in the Ladakh region of the Himalayas (North India). It constitues the first phase of the HImalayan Gamma-Ray Observatory (HIGRO) project. HAGAR is the first array of atmospheric Cherenkov telescopes established at a so high altitude, and was designed to reach a relatively low threshold (currently around 200 GeV) with quite a low mirror area (31 m^2). Regular source observations are running since Sept. 2008. Estimation of the sensitivity of the experiment is undergoing using several hours of data from the direction of Crab nebula, the standard candle source of TeV gamma-ray astronomy, and from dark regions. Data were acquired using the On-source/Off-source tracking mode, and by comparing these sky regions the strength of the gamma-ray signal could be estimated. Gamma-ray events arrive close to telescope axis direction while the cosmic-ray background events arrive from the whole field of view. We discuss our analysis procedures for the estimate of arrival direction, estimate of gamma-ray flux from Crab nebula, the sensitivity of the HAGAR system, etc in this paper.

INVITED

Different Concepts of Next Generation IACT Arrays

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The idea of using the Earth's atmosphere as part of a γ-ray detector is the basis for an Atmospheric Cerenkov Technique. Pioneered by the Whipple group, the *Imaging* Atmospheric Cerenkov Technique brought the first detection of VHE γ-ray emission in 1989. It has proven to be the best approach to study sub- and TeV γ-ray emission from galactic objects like pulsars, pulsar-wind nebulae, SNRs, binary systems and OB associations, as well as to study extragalactic objects like AGNs and starburst galaxies. The number of detected VHE γ-ray sources now numbers $\simeq 100$, with the source count roughly doubling in a time scale of $\simeq 3$ years [2].

Having matured over a few decades, the IACT technique is ready to widen its energy domain as well as to increase sensitivity in its core region (0.1 - 50 TeV) by as much as one order of magnitude as compared to existing facilities. This will allow to use γ astronomy to search for dark matter, probe intergalactic space and quantum gravity as well as to make efficient observations of extended sources [3].

The design of a new-generation IACT array is motivated by the key science questions it should address and by its target performance characteristics optimized with the regard to the available funding. A number of characteristics impact the scientific capabilities, not just point-source sensitivity, but also field-of-view, angular resolution, energy threshold and others.

In this talk, I will highlight the IACT array design studies to narrow down the multidimensional space of design options and optimizing the relation between performance and cost of the instrument. The choices for array layout, optical and mechanical designs as well as possible designs for telescope cameras and telescope trigger criteria will be covered. In particular, designs of the IACT arrays being studied in CTA and AGIS collaborations will be discussed.

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[2] P. Colin and S. LeBohec. Optimization of large homogeneous Air Cherenkov Arrays and application to the design of a 1TeV-100TeV γ-ray observatory., arXiv:0909.3792v1

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STATISTICAL TECHNIQUES IN BACKGROUND REJECTION FOR THE IMAGING ATMOSPHERIC CHERENKOV TELESCOPES

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The initial method for enumerated the air shower images as they appear in the matrix of light receivers of the Atmospheric Cherenkov Telexcope (ACT) was proposed by Michael Hillas; so called "Hillas" parameters till now are widely used in ACTs of next generation for the "purification" of the initial image samples. Proceeding from the estimated image parameters different approaches to construct the image classification procedure could be developed. These strategies could be divided into two big categories:

1. *a-priori* strategy, proceeding from the simulation of the gamma and hadron-initiated showers and it's propagation in the atmosphere. For each shower the Cherenkov light image is obtained and parameterized. The distribution functions of the "pseudo experimental" image parameters corresponding to both gamma and hadron primaries are given in nonparametric form as subsets of simulation trials corresponding to the particular primary with definite angles of incidence, energy and, of course, inherent instrumental accuracies and hardware solutions chosen for construction of ACT and trigger.
2. *a-posteriori* strategy, proceeding from already registered, so called,
   - "ON" -sample obtained with telescope axes oriented in direction of the putative gamma-ray source and
   - "OFF" -sample, obtained by pointed telescope axes in direction of the same celestial co-ordinates, but after the source already leave the destination.
   - If the field of view of the telescope is enough large it is possible to take "ON" and "OFF" scans simultaneously, selecting within field of view samples pointed to source and to "empty" space.

Having 2 samples, one containing signal, another not, it is possible to search for, so called, "signal domain", one or multidimensional boundary outlining the space in parametric space where signal concentration is relatively higher comparing with noise, those enlarging the signal-to-noise ratio.

Just first comparisons of simulated showers obtained by the codes developed for the Whipple 109 phototube camera reveal big differences in shape and orientation of the gamma and hadron images. The main activity of Whipple collaboration was directed to invention of the single "best parameter," combining shape and orientation differences. First attempt to develop statistical theory of background rejection was done in [1]. Overall scheme of statistical inference from simulated samples, including method of selecting "best" multivariate subset of image parameters was checked by simulated samples performed with code developed by A. Plyasheshnikov [2]. (Plyasheshnikov, Bignami, 1985).The combination of image parameters including image shape parameters and orientation parameter gives record value of the detection significance of the CRAB nebula by the WIPPLE collaboration [3, 4].

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INVITED

Cherenkov Telescope Arrays

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I will discuss the current concepts and construction plans for arrays of imaging Cherenkov telescopes for gamma-ray astronomy in the energy range of a few GeV to around 1 PeV. I will emphasise the potential of these instruments, their science goals and the technical challenges to be overcome.

From Gamma-1 to HEGRA and H.E.S.S.: contribution of the Altai gamma-ray research group

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This paper is dedicated to the memory of Professor Alexander Plyasheshnikov, whose untimely death occurred in 2008. Prof. Plyasheshnikov was a creator and for many years a leader of Altai gamma-ray research group. In the early 70s he developped new technique based on the Monte-Carlo simulation and the numerical solution of adjoint cascade equations, so-called semi-analytical Monte-Carlo method. The high intrinsic accuracy, combined with unexcelled computational effectiveness, make this thechnique the most powerfull tool for detailed study of high energy gamma-ray cascade phenomena. This approach paved the way to essential steps forward in the field of gamma-ray astronomy. The Altai code, developped under the supervision of Prof. Plyasheshnikov in Altai University, became the simulation tool for new experiments HEGRA and H.E.S.S. Much of the thought contained in the present paper has been stimulated by his ideas and pioneer studies.

AN EVALUATION OF ELECTRON-PHOTON CASCADES DEVELOPING IN MATTER, PHOTON AND MAGNETIC FIELDS

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Investigations of electron-photon cascades developing in matter, photon and magnetic fields are very important for astrophysical studies, as strongly pointed out by Aharonian and Plyasheshnikov [1] indicating their results derived with their adjoint method. We make another approach to solve cascades developing in matter, photon and magnetic fields by a *numerical implement for shower integration arithmetic*, based on the standard numerical method to solve integro-differential equations.

Main characteristic points of our method are as follows:
• The diffusion equations for the shower development with inhomogeneous cross-sections for primary and secondary energies, like Akhiezer et al's [2] or Zdziarski's [3], are solved.
• Applicable to other cascade processes or cross-sections, without using other special approximations or interpolations.
• As integrated over logarithm of energies, times necessary for the calculation are reduced to be proportional to $\ln E_0/E$ or $\ln^2 E_0/E$, much less than E_0/E in Monte Carlo methods.

Transition curves of electron components for showers developing in matter, photon field, and magnetic field derived by our method are indicated in Figs. 1-3, respectively. Detailed analyses and comparisons of our results with those derived by the adjoint method will bring us more accurate informations and predictions about electron-photon cascades developing in astrophysical environments.

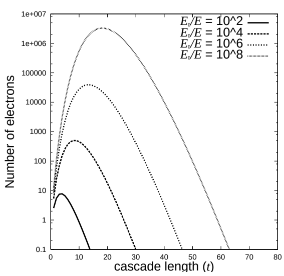

Figure 1: Showers developing in matter with E_0/E of 10^2, 10^4, 10^6, and 10^8, from bottom to top.

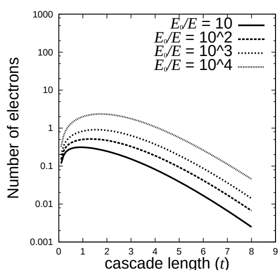

Figure 2: Showers in photon fields with $\varepsilon_0\omega_0$, product of incident and photon energies in mc^2, of 10^3.

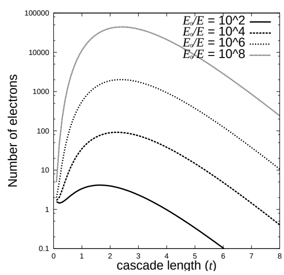

Figure 3: Showers in magnetic fields. Cascade length is defined by $3.9 \times 10^6(\frac{H}{H_c})^{2/3}\frac{x}{cm}/(\frac{E_0}{GeV})^{1/3}$.

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Search for high energy gamma-ray bursts

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Gamma Ray Bursts (GRBs) with photon energy more than a few GeV can be registered by ground based arrays operating in the "single particle" operation mode (e.g. [1]). In such experiments the total count rate of all detectors of the array is measured. We report a search for GRBs in the energy range 10-1000 GeV. The search has been performed by "Andyrchy" EAS array [2]. For this purpose the single particle counting rate of the array has been used [3], [4]. The data were collected during 1996 - 2006 years with the total live time of 2290 days. In the sky survey, the high energy GRBs were searched for as short duration increases ($\Delta t \leq 1$ s) in the flux of secondary charged particles. The limits on the rate of GRBs with different fluencies have been obtained. The search for high energy radiation in correlation with GRBs detected by space-born experiments operated in 1996 – 2006 has been performed. We investigated 179 well localized GRBs that occurred in the field of view of "Andyrchy" array with a zenith angle $\theta \leq 50°$. Using epoch folding method around trigger time of bursts the upper limits on the fluence during the different time intervals around the burst trigger were obtained. In particular we also obtained the upper limits of 10-1000 GeV emission for GRB 980124, GRB 970411 and GRB 981203 registered with TASC calorimeter of EGRET/BATSE experiment [5].

[1] S. Vernetto, Astroparticle Physics, v. 13, p. 75, 2000.
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On the origin of GeV breaks in blazars

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We present a simple model for origin of the GeV breaks in blazars.

VERY-HIGH ENERGY GAMMA-RAY ASTRONOMY OF GALACTIC AND EXTRA-GALACTIC SOURCES BY SHALON

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The development of the atmospheric Cherenkov imaging technique has led to significant advances in gamma-ray detection sensitivity in the energy range from 800 GeV to 100 TeV. The SHALON Observatory [1] telescope has detected the galactic and extragalactic sources in the Northern Hemisphere. Cherenkov technique operates in an energy regime where the physics of particle interactions is relatively well understood and where there exist advanced Monte Carlo programs for the simulation of particle cascades. The urgent advances in technique used in VHE gamma-ray astronomy is the development of the atmospheric Cherenkov imaging technique, which led to the efficient rejection of the hadronic background and then to detection of gamma-ray sources and their spectra.

Table. Current Cherenkov telescope systems [2]

Group	Location	Latitude	Longitude	Height	Telescopes	Threshold (TeV)	Start
SHALON	Russia	43°N	77°E	3340 m	11,2 m^2×2	0,8	1992
TACTIC	India	25°N	73°E	1300 m	9,5 m^2×4	1	2000
CANGAROO	Australia	31°S	137°E	160 m	57 m^2×4	0,2	2004
HESS	Namibia	23°S	16,5°E	1800 m	107 m^2×4	0,1	2004
MAGIC	Canary Is.	29°N	18°W	2200 m	237 m^2×1	0,07	2004
VERITAS	Arisona	32°N	111oW	1268 m	110 m^2×4	0,1	2007

The gamma-ray sources form a new class of high-energy objects in the Universe, including active galactic nuclei, radio galaxies, galactic binaries, pulsar wind nebulae, in addition to supernova remnants which are assumed to be the origin of cosmic rays for a long time. Exploring the emission mechanism from these objects is a big challenge in astrophysics. Non-thermal nature of emission inherently needs multiwavelength observations to study the phenomena, involving astronomers working in other wavelength.

The spectrum of Crab Nebula $I(>E_\gamma) \propto E_\gamma^{-1.40\pm0.07}$ observed by SHALON is close to the predicted flux of γ-rays due to Inverse Compton scattering of low energy photons by multi-TeV electrons in the Nebula if the magnetic field of 67 nT in the region responsible for X-ray emission is taken into account.

The neutron star Geminga γ-ray flux value obtained by SHALON is $(0.48\pm0.17)\times10^{-12}cm^{-2}s^{-1}$ for energies > 0.8 TeV. Within the range 0.8 - 5 TeV, the integral energy spectrum is well described by the single power law $I(> E_\gamma) \propto E_\gamma^{-0.58\pm0.11}$.

Tycho's SNR has long been considered as a candidate for a cosmic ray hadron source in the Northern Hemisphere. The detection of gamma-rays at energies 10 - 80 TeV by SHALON provides an evidence of their hadronic origin.

The galactic source CygX-3, has been regularly observed since 1995 with an average gamma-quantum flux of $F(E_0 > 0.8TeV) = (6.2\pm0.5)\times10^{-13}cm^{-2}s^{-1}$. The energy spectrum of CygX-3 at 0.8 − 65 TeV can be approximated by the power law $F(> E_0) \propto E^{k\gamma}$, with $k_\gamma = -1.21 \pm 0.05$. Extreme variability in different wavelengths including VHE gamma rays is one of most the distinctive feature of Cygnus X-3 binary system.

The understanding of mechanisms in active galactic nuclei requires the detection of a large sample of very high energy gamma-ray objects at varying redshifts. During the period 1992 - 2010, SHALON has been used for observations of the metagalactic sources NGC1275 (z=0.0183), SN2006gy (z=0.019), Mkn421 (z=0.031), Mkn501 (z=0.034), Mkn180 (z=0.046), OJ 287 (z=0.306), 3c454.3 (z=0.895), 1739+522 (z=1.375). The most distant object 1739+522, seen in TeV energy, is also the most powerful. Thus, the modern gamma-astronomical observations put forward the question: what mechanisms might be responsible for the currently observed gamma-ray fuxes from the remote metagalactic sources?

Table. The extragalactic γ -quantum sources catalogue, observed by SHALON; R – is a relative intesity of source if the Crab intensity is taken as a unit.

Sources	Type of source	Observable flux ($\times10^{-12}cm^{-2}s^{-1}$)	Distance	R
Mkn421	Blazar	(0.63±0.14)	124	3.8×10^9
Mkn501	Blazar	(0.86±0.13)	135	4.46×10^9
Mkn180	Blazar	(0.65±0.23)	182	6.2×10^9
NGC1275	Seyfert Galaxy	(0.78±0.13)	71	1.2×10^9
SN2006gy	Extragalactic Supernova	(3.71±0.65)	83	4.2×10^9
3c454.3	FSRQ	(0.43±0.13)	4685	5.3×10^{12}
1739+522	FSRQ	(0.53±0.10)	7500	1.4×10^{13}

The γ-ray spectra and fluxes of known blazars Mkn421, Mkn501 as the spectrum of NGC1275 and distant flat-spectrum radio quasars 1739+522 and 3c454.3 are presented: for NGC1275 k_γ=-2.26±0.10; for Mkn421 k_γ=-1.87±0.11; for Mkn501 k_γ=-1.89±0.11; for 3c454.3 k_γ=-0.95±0.10; for 1739+522 k_γ=-1.09±0.06. So, the energy spectrum of metagalactic sources Mkn421, Mkn501, NGC 1275 at range 10^{12} - 10^{13} eV differs from spectra of distant quasars 1739+522 and 3c454.3 that don't contradict to united energy spectrum $F(>E_\gamma) \sim E_\gamma^{-1.2\pm0.1}$.
The essential features of galactic and extragalactic sources can be traced with observed properties along the wide range of of electromagnetic spectrum. The multiwavelength spectral energy distributions of Crab, Cyg X-3, NGC1275, Mkn421, Mkn501, 3c454.3 and 1739+522 are presented.

Extragalactic diffuse background radiation blocks the propagation of TeV γ-ray over large distances (z>0.1) by producing electron-positron pairs. The redshifts of SHALON very high energy γ-ray sources range from z=0.0183 to z=1.375. Spectral energy distribution of Extragalactic Background Light constrained from observations of Mkn421 (0.031), 3c454.3 (z=0.859) and 1739+522(z=1.375) together with models and measurements are presented. Observations of distant metagalactic sources have shown that the Universe is more transparent to very high-energy γ-rays than previously believed.

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INVITED

The High Altitude Water Cherenkov (HAWC) Telescope

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Recent progress in TeV astronomy has justified the construction of a new generation of TeV gamma-ray instruments. Results from Milagro have proven the sensitivity of the water Cherenkov technique and demonstrated the need for a TeV instrument with a wide-field of view. The HAWC (High Altitude Water Cherenkov) Observatory, is a next generation all-sky TeV gamma ray observatory. With 15 times the sensitivity of Milagro HAWC is well suited to extend the GeV measurements of the Fermi telescope to higher energies and study the diffuse and extended sources within our Galaxy. HAWC will be capable of surveying the northern hemisphere to a level of 40-mCrab after four years of operation. The large field-of-view and continuous operation enable HAWC to view every object in the hemisphere every day - allowing for the long-term monitoring of active galaxies, without the need for a ÒtriggerÓ from another telescope. HAWC will be located at 4100m above sea level at the volcan Sierra Negra in Mexico. In this talk I will discuss the design and scientific goals of HAWC.

Observation of the *Fermi* bright Galactic sources at TeV energies with the Tibet air-shower experiment

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The *Fermi Gamma-ray Space Telescope (Fermi)* was launched in June 2008, with a sensitivity nearly a hundred time better than that of the Energetic Gamma Ray Experiment (EGRET). The Large Area Telescope (LAT) on board *Fermi* conducted an entire-sky survey for 3 months, resulting in a bright source list above 100 MeV that contains 205 sources detected at a significance greater than $\sim 10\sigma$ [1]. Many new gamma-ray pulsars were detected in the survey. Typical 95% uncertainty radii of the source positions in the list range from $10'$ to $20'$, remarkably improved from those of the EGRET. This makes possible a more accurate and unbiased search for sources across multi wavelengths than ever before. The Milagro experiment recently detected 14 sources out of the 34 *Fermi* sources selected from the list, at a false-positive significance of 3σ or more at the representative energy of 35 TeV [2].

The Tibet air-shower array, located at 90.522° E, 30.102° N and 4300 m above sea level, has been successfully observing cosmic rays and cosmic gamma rays with energies above a few TeV with an effective area of 37000 m^2. The first result at TeV energies of the northern sky survey of the *Fermi* bright Galactic sources will be reported. We search for TeV gamma-rays from 27 potential Galactic sources in the early list of bright sources obtained by the *Fermi* Large Area Telescope at energies above 100 MeV [3]. Among them, we detect 7 sources at a statistical significance of 2σ or more, with 0.61 sources expected. The chance probability from the Poisson statistics would be estimated at 3.8×10^{-6}, showing that the *Fermi*sources have a statistically significant correlation with TeV gamma-ray excesses. We also find that all the 7 sources are associated with pulsars, and that 6 of them are coincident with the sources detected by the Milagro experiment.

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Gamma ray sources observation with the ARGO-YBJ detector

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The ARGO-YBJ experiment, operating at the Cosmic Ray Observatory of Yangbajing (Tibet, China, 4300 m a.s.l.), is a full coverage Extensive Air Shower array of about 6600 m^2 of active area. One if its main scientific goals is the observation of gamma ray sources in the energy range E > 0.3 TeV. The large field of view (> 2 sr) and the high duty cycle (> 90%) of the detector allows the continuous monitoring of the sky in the declination band from -10 to +70 degrees. In this work we present the results of our observations from December 2007 to April 2010, focusing our attention on the blazar Mrk421, in particular during the June 2008 and February 2010 flaring periods, when the observed TeV flux mantained a level of several Crab units for a few days, making this source the most luminous gamma ray object of the sky. The results of the observations of galactic sources are also reported, with a particular attention to the Cygnus region and to the extended source MGROJ1908+06.

Session 6: HE/UHE Gamma-rays (Posters)

Conveners: F. Aharonian and J. Poutanen

STATUS REPORT ON THE RESEARCH AND DEVELOPMENT FOR A BISTATIC HIGH SPECTRAL RESOLUTION LIDAR FOR ATMOSPHERIC MONITORING OF VERY HIGH ENERGY GAMMA RAY CHERENKOV TELESCOPE ARRAYS

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In this report, we aim to improve the method of LIDAR measurements in Very High Energy gamma ray experiments by a dedicated LIDAR alternative in order to obtain measurements necessary to characterize the state of the atmosphere during the measurements of Cherenkov radiation, a work motivated by the design work on the CTA observatory. The Cherenkov photons are produced during the interaction of very high energy gamma rays with atmosphere. Since the measured number of the Cherenkov photons is related to the energy of the original gamma ray, it is necessary to have an accurate knowledge of the level of absorption and scattering of the Cherenkov radiation, so that a correction (with some calibration) to the gamma ray energy is achieved. This type of measurements in currently operating experiments (HESS, MAGIC) are carried out using the Raman LIDAR technique. The present work focuses to the development of an alternative LIDAR called High Spectral Resolution LIDAR (HSRL), aiming to more accurate measurement of the absorption and scattering coefficients for Cherenkov radiation in the atmosphere. In the first phase of its development, we will use a DPSS CW SLM laser as light source and expect to have the capability to measure the aerosol phase function. We present in section 1, the optical design of the laser-telescope-receiver system. We discuss the details of the subsystems of the HSRL under design, in the following three sections.

We have used the Oslo Ray Tracing for simulation of the Bistatic Lidar FP Receiver. From the design of the receiver, we have optimized the position of the optical elements in the simulation program OSLO-VersionEDU. The simulation done with this Ray Tracing prepares as input angular dispersion a typical value, say 0.007 rad, corresponding to the size of the scattering volume in the atmosphere that is seen by the receiver. Additional parameters given by the simulation program are paraxial, chromatic, Seidel, focal aberration etc. In the Ray Tracing, we are using alternative types of lenses to control the paths of the rays from the object up to the projection screen (on the CCD active surface), thus allowing optimization of the system.

Development of the two-channel receiver of the HSRL. The proposed receiver consists of two channels called aerosol (Mie) and molecular channel, respectively. The first channel consists of a Fabry-Perot etalon with 70 mm diameter, and spacer length 100 mm. Its reflectance, based on dielectric multilayers has a UV reflectivity of about 97%. The second channel consists of another Fabry-Perot etalon with spacer length of 1mm or possibly a molecular iodine filter. One such etalon will be assembled this spring and it will be tested for measuring its finesse and accurate measurement of its spacer length. The etalon is housed in a suitable vacuum chamber in order to avoid the effects due to fluctuations of air refractive index. More specifically, for accurate measurement of free spectral range two methods are studied.

The first follows from the interferogram recording of a low pressure mercury lamp, and fitting the peaks corresponding to its isotopes with these corresponding to simulated interferogram using accurate literature isotope shift values. We shall present the results of this analysis leading to accurate values to obtained for the spacer length of the etalon used. The second method, is a recent development, within our group, based on a technique proposed by W. K. Meissner (1941), using modern computational tools. The outcome of this work leads to simplification of the analysis of interferogram from a pair of known lines from literature and determination of the spacer length of the etalon with an accuracy of the order of nm [the latter work to be submitted to Siena Topical Conference 2010].

The SLM laser system. The development of SLM laser system based on an IR active material Nd:YVO_4, with wavelength tunability up to near UV region, using non-linear optics techniques. This is planned for the HSRL emitter. We have also available a 100 mW commercial laser 532 nm, with a coherence length greater than 50 m. Its line width will be validated under realistic environmental conditions, corresponding to existence of external mechanical vibrations and laser cavity temperature variations from a set value. In this work, we present data on the laser frequency stability by studying the (stability of) interference fringe pattern, when both the laser and the interferometer are mounted on an antivibration table and both equipped with suitable temperature controllers. The laser cavity stability will be also continuously recorded by an Optical Spectrum Analyzer.

Pulsed laser source. We are developing a pulsed laser system at 1064 nm, based on a CW seed Nd:YVO_4 laser and a power amplifier as a slave laser (MOPA). The amplifier design follows the technique of Ref. [1]. The gain medium is a Nd3+-doped YVO_4 crystal, pumped by a laser diode, operating at 808 nm. The crystal selection was made because it is an efficient material which exhibits large stimulated emission cross-section as well as large absorption at laser diode frequency [2], in comparison with the Nd:YAG material. It is therefore expected that this amplifier architecture will produce a strong output power.

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Searching for very short gamma-ray bursts from evaporating primordial black holes

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Constraints on the number density of evaporating primordial black holes (PBHs) have been obtained using EAS array "Andyrchy" [1] data. The specific evaporation model was analysed. In this model during PBH evolution a quasistatic configuration "PBH+restructured vacuum" is formed as a result of relativistic phase transitions in the radiation flow of the PBH [2]. Explosion of such a configuration at the final stage of evolution of the PBH leads to formation of the supershort ($\sim 10^{-13}$ s) burst of gamma radiation with the spectrum having maximums of intensity at 100 MeV and 100 GeV, which agree with the scale of the relativistic phase transitions in the Standard Model of the elementary particles. Supershort gamma-ray bursts with characteristic energy gamma 100 GeV can be registered at the altitude of mountains by EAS arrays as uniformly distributed showers. Using data for live time of 4.23 year, the limitation on concentration of evaporating PBH in a local region of the galaxy has been obtained.

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[2] O.D. Lalakulich, V.B. Petkov and G.M. Vereshkov, Third Rome Workshop on Gamma-Ray Bursts in the Afterglow Era, ASP Conference Series, v. 312, p.453, 2004

POLAR: A space-borne X-ray polarimeter for transient sources

S. Orsi for the POLAR collaboration

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POLAR is a novel compact X-ray polarimeter designed to measure the linear polarization of Gamma Ray Bursts (GRB) and other strong transient sources such as solar flares in the energy range 50-500 keV. A detailed measurement of the polarization from astrophysical sources will lead to a better understanding of the source geometry and of the emission mechanisms. POLAR is expected to observe every year several GRBs with a minimum detectable polarization smaller than 10%, thanks to its large modulation factor, effective area, and field of view (1/3 of the visible sky). POLAR consists of 1600 low-Z plastic scintillator bars, read out by 25 flat-panel multi-anode photomultipliers. The incoming photons undergo Compton scattering in the bars and produce a modulation pattern; simulations and experiments have shown that the polarization degree and angle can be retrieved from this pattern with the accuracy necessary for pinning down of the GRB mechanisms.

This paper presents the first POLAR measurements using 100% polarized synchrotron radiation. The beam test took place in December 2009 at the ESRF (European Synchrotron Radiation Facility) in Grenoble, using monochromatic X-ray beams in the nominal energy range from 50 to 500 keV. The results demonstrate the excellent polarimetric capabilities of the instrument.

Energy reconstruction method for sub-10 GeV threshold imaging atmoshperic Cherenkov telescope

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Imaging atmospheric Cherenkov telescopes have emerged as the most powerful instruments for gamma-ray astrophysics in the energy range of about 100 GeV and above. The next generation of these telescopes with a diameter of above 20 m may allow us to achieve an energy threshold as low as 10 GeV. At such low energies, the background events will be dominated by cosmic ray electrons only. At the same time, the cosmic ray protons with energies above the rigidity cutoff can produce showers, which at the level of data reduction can be classified as gamma events with significantly lower energies, i.e. appear in the sub-10 GeV energy region. Here we present the primary gamma-rays energy reconstruction method for the 20 m diameter imaging telescope installed at 5 km above sea level. The energy estimate is applied on the simulated Monte-Carlo bank of primary gamma-rays, cosmic ray protons and electrons.

15 YEARS OBSERVATIONS of TeV GAMMA-RAY EMISSION FROM NGC 1275 by SHALON

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Galaxy clusters have been consider as sources of TeV γ-rays emitted by high-energy protons and electrons accelerated by large scale structure formation shocks, galactic winds, or active galactic nuclei. The Perseus cluster of galaxies is one of the best studied clusters due to its proximity and its brightness. Galaxy NGC 1275 is the central dominant galaxy of the Perseus Cluster of Galaxies and is of Seyfert galaxy class. NGC 1275 is known as powerful X-ray and radio source. Many studies explored correlations of X-ray radio optical and ultraviolet emission (see e.g. [1]).

In 1996 year a new metagalactic source was detected by SHALON at TeV energies [2, 3, 4](fig. 1). This object was identified with Seyfert galaxy NGC 1275 (with redshift z=0.0179); its image is shown in fig. 1, 2. The maxima of the TeV γ-ray, X-ray [5] and radio emission coincide with the active nucleus of NGC 1275. In contrast, the X-ray and TeV emission disappears almost completely in the vicinity of the radio lobes. The correlation TeV with X-ray emitting regions was found whereas the integral γ-ray flux for this source is found to be $(0.78 \pm 0.13) \times 10^{-12} cm^{-2} s^{-1}$ at energies of > 0.8 TeV. The energy spectrum of NGC 1275 at 0.8 to 40 TeV can be approximated by the power law $F(> E_O) \propto E^{k_\gamma}$, with $k_\gamma = -2.25 \pm 0.10$ [6]. The Seyfert galaxy NGC 1275 has been also observed with the Tibet Array (about 5 TeV)[7] and then with Veritas telescope at energies about 300 GeV at 2009 [8]. The recent detection by the Fermi LAT [9] of high-energy gamma-rays from the radio galaxy NGC 1275 makes the observation of the very high energy ($E > 100$ GeV) part of its broadband spectrum particularly interesting. The search for gamma-rays from radio galaxies is important for the understanding of the dynamics and structure of active galactic nuclei.

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[9] A. A. Abdo et al., The Astrophysical Journal, **699** (2009) 31-39

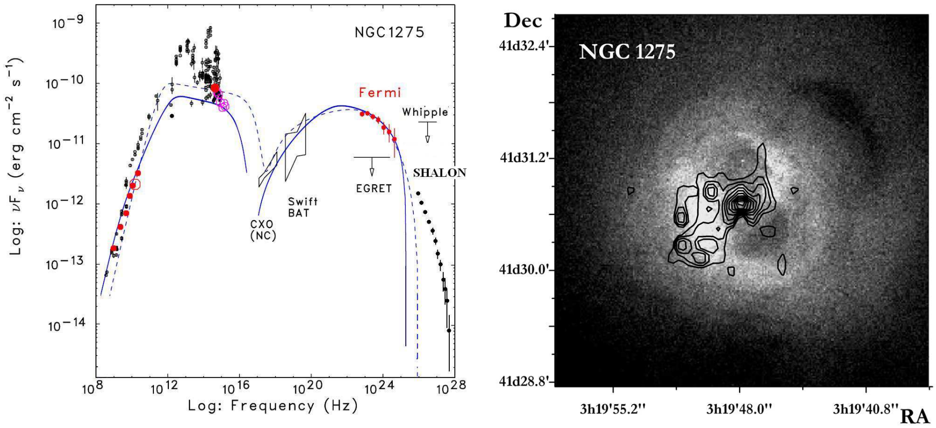

Figure 1: left: Overall spectral energy distribution of NGC 1275. The low energy data from [9]. The TeV energy spectrum of NGC 1275 from SHALON, 15 year observations; right: Chandra X-ray image of NGC 1275. The contour lines show the TeV - structure by SHALON observations.

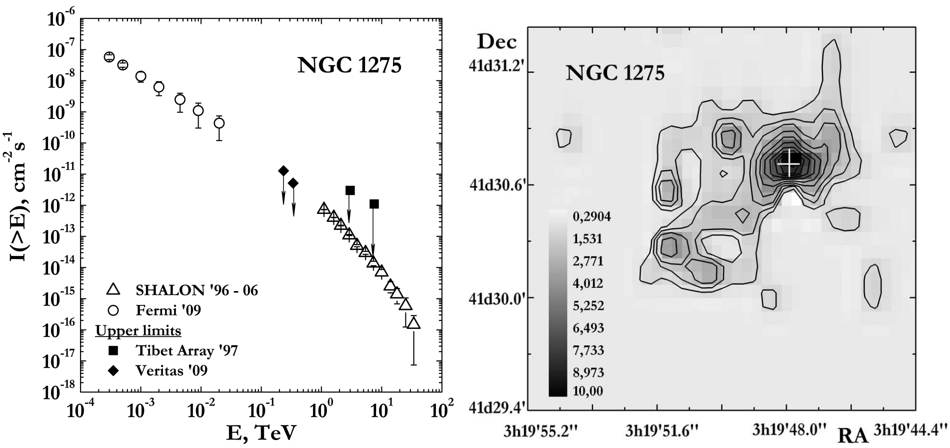

Figure 2: left: The NGC 1275 observational data by SHALON: the γ-quantum integral spectrum; right: The NGC 1275 image at energy range of > 0.8 TeV;

GEMINGA and TYCHO'S SNR VIEWED IN TeV GAMMA-RAYS BY SHALON

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A neutron star in the constellation Gemini is the second brightest source of high-energy gamm-rays in the sky, discovered in 1972, by the SAS-2 satellite. Geminga is the closest known pulsar to Earth. Geminga is one of the brightest source of MeV - GeV gamma-ray, but the only known pulsar that is radio-quiet. Geminga has been the object for study at TeV energies with upper limits being reported by three experiments Whipple'93, Tata'93, Durham'93 and very recently by VERITAS [1]. Also Geminga has observed with Milagro at energies of 20TeV and 35 TeV[2] and Fermi LAT at energies 30MeV - 200GeV [3]. The spectrum by Fermi is fitted with a power law with exponential cut-off in the form: $dN/dE = N_0 \times (E^{-\gamma})exp(-E/E_0)$, where $N_0 = (1.19 \pm 0.08) \times 10^{-6} GeV^{-1} cm^{-2} s^{-1}$,$\gamma = 1.3 \pm 0.05$, $E_0 = (2.47 \pm 0.19)GeV$ (Fig. 1). The SHALON results for Geminga gamma-source are presented. The value Geminga flux obtained by SHALON is lower than the upper limits published before [4, 5]. Its integral gamma-ray flux is found to be $(0.48 \pm 0.17) \times 10^{-12} cm^{-2} s^{-1}$ at energies of > 0.8 TeV. Within the range 0.8 - 6 TeV, the integral energy spectrum is well described by the single power law $I(> E)E^{-0.58\pm0.11}$. The energy spectrum of supernova remnant Geminga is harder than Crab spectrum.

Tycho's supernova remnant has been detected by SHALON atmospheric Cherenkov telescope of Tien-Shan high-mountain observatory. Tycho's SNR has long been considered as a candidate to cosmic ray hadrons source in Northern Hemisphere although it seemed that the sensitivity of the present generation of Imaging Atmospheric Cherenkov System's too small for Tycho's detection. A nonlinear kinetic model of cosmic ray acceleration in supernova remnants is used in [6] (Fig. 2). The π^o- decay gamma-quantum flux turns out to be some greater than inverse Compton flux at 1 TeV becomes strongly dominating at 10 TeV. The predicted gamma-quanta flux is in consistent with upper limits published by Whipple, and HEGRA. The expected π^o- decay gamma-ray flux from Tycho's SNR $F_\gamma \sim E_\gamma^{-1}$ extends up to > 30 TeV, whereas the inverse Compton gamma-ray flux has a cutoff above a few TeV. Hence, the detection of gamma-rays at energies 10 - 50 TeV by SHALON provides an evidence of their hadronic origin (Fig. 2). The spectral energy distribution of the gamma-ray emission from Tychos SNR, as a function of gamma-ray energy ϵ_γ , for a mechanical SN explosion energy of $E_{SN} = 1.2 \times 10^{51} erg$ and four different distances d and corresponding values of the interstellar medium number densities NH is presented (Fig. 2). All cases have dominant hadronic gamma-ray flux. The additional information about parameters of Tycho's SNR can be predicted in frame of nonlinear kinetic model [6] if the TeV gamma- quantum spectrum of SHALON telescope is taken into account: a source distance 3.1 - 3.3 kpc and an ambient density N_H $0.4 - 0.5 cm^{-3}$ and the expected π^o-decay gamma-ray energy spectrum extends up to about 100 TeV. Thus, the shell-type supernova remnants should be detected in the Northern Hemisphere at the

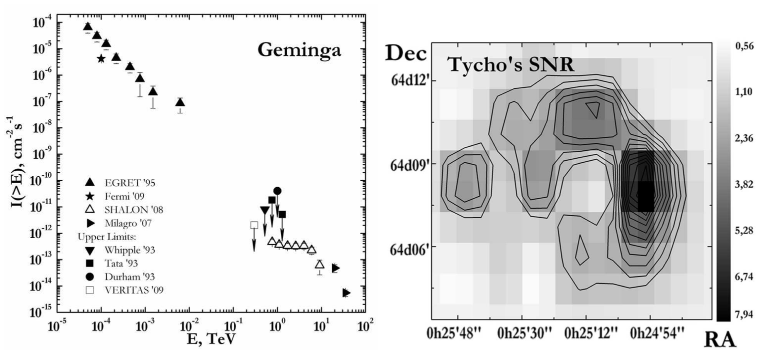

Figure 1: left: The Geminga gamma-quantum integral spectrum by SHALON in comparison with other experiments [1 - 4]; right: the image of gamma-ray emission from Tycho's SNR by SHALON;

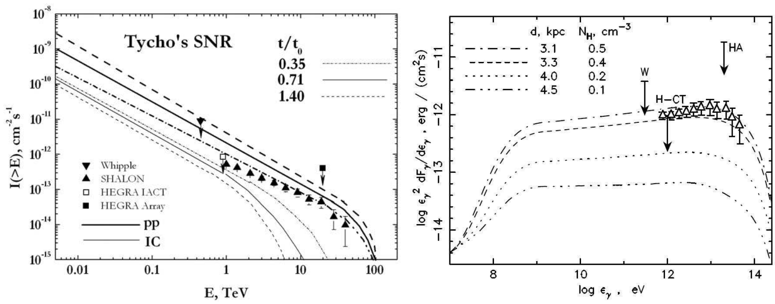

Figure 2: left: The Tycho's SNR gamma-quantum integral spectrum by SHALON in comparison with other experiments: the observed upper limits Whipple, HEGRA IACT system, HEGRA AIROBICC and calculations: IC emission (thin lines), π^o - decay (thick lines). right: spectral energy distribution of Tycho's SNR [6]

TeV energy range in gamma-rays of predominantly, hadronic origin and the expected flux of gamma-quanta from π^o-decay $(2-5)\times 10^{13} erg/(cm^2 s)$ extends up to almost 100 TeV if the distance is within the range 3.1-3.3 kpc (Fig. 2).

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TeV ACTIVITY OF CYGNUS X-3 MICROQUSAR

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Cygnus X-3 is peculiar X-ray binary system discovered about 40 years ago. Cygnus X-3 has been observed throughout wide range of the electromagnetic spectrum (Fig. 1). It is one of the luminous X-ray sources in our Galaxy, displaying high and low states and rapid variability in X-rays. In addition to being a powerful x-ray source, Cygnus X-3 is seen in the infrared and is a strong and variable radio source. It is also the strongest radio source among X-ray binaries and shows both huge radio outbursts and relativistic jets. The radio activity with the huge radio outbursts is closely linked with the X-ray emission and the different X-ray states. Cygnus X-3 is a high mass X-ray binary and microquasar, with a compact object, which is either a neutron star or may be a black hole, and a companion object, which is a Wolf-Rayet star. The nature of the compact object is still uncertain.

Based on the high energy gamma-ray signal from this source, it was supposed that Cyg X-3 can the one of the most powerful source of the cosmic rays in the Galaxy. The searches for TeV emission had been carried out since the mid of 1970s and continued through the mid 1980s. Two observations were particularly important: the Kiel results and contemporaneous observation at Haverah Park. These results indicated a very large UHE flux from Cygnus X-3. So, these results stimulated the construction of many of new detectors.

Cygnus X-3 galactic binary system has been regularly observed since a 1995 by SHALON Atmospheric Cherenkov telescope. The energy spectrum of Cygnus X-3 at 0.8 - 100 TeV is obtained and the average integral flux is $F(E_O > 0.8TeV) = (6.8 \pm 0.7) \times 10^{-13} cm^{-2} s^{-1}$ (Fig. 1), [1, 2]. The binary Cygnus X-3 came to new period of flaring activity at radio-and X-ray energies in 2006. In May and July 2006 the significant increase of Cyg X-3 flux have detected with SHALON at TeV energy. The gamma-ray flux detected by SHALON in 2006 was estimated as $(1.47 \pm 0.24) \times 10^{-12} cm^{-2} s^{-1}$. This intensity increase was also observed by Crimea Observatory and the integral flux was estimated as $F(E_O > 1TeV) \sim (3 - 5) \times 10^{-12} cm^{-2} s^{-1}$. [3]. Earlier, in 1997 and 2003 a comparable increase of the flux over the average value was also observed and estimated to be $(1.79 \pm 0.33) \times 10^{-12} cm^{-2} s^{-1}$ and $(1.2 \pm 0.5) \times 10^{-12} cm^{-2} s^{-1}$ respectively. In observations of SHALON telescope the formation of jets (like jet of active galactic nuclei) during the activity periods have been found (Fig. 2). The last significant increase of very high energy gamma-quantum flux have detected in May 2009, which is correlated with flaring activity at lower energy range of X-ray and at observations of Fermi LAT [4]. Confirmation of the variability of very high-energy gamma-radiation from Cygnus X-3 by the future observations would be important for understanding the nature of this astrophysical object.

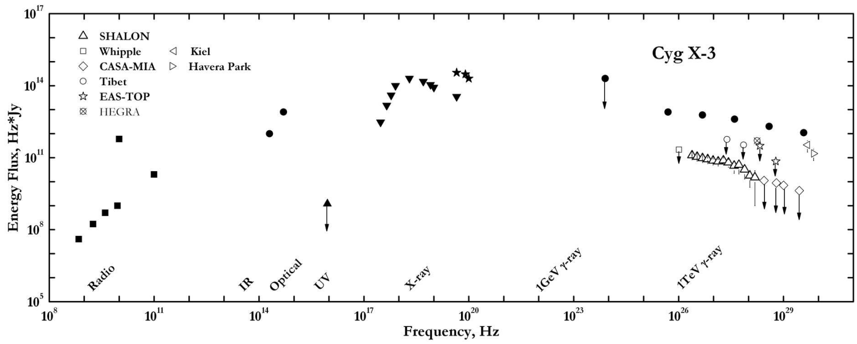

Figure 1: The spectral energy distribution of Cygnus X-3. Black points are the archival data from Cordova, (1986). The high level points in radio and X-ray bands correspond to radio-frequency activity and increased x-ray activity of the source. TeV range is represented with integral spectrum by SHALON (open triangles) in comparison with other experiments.

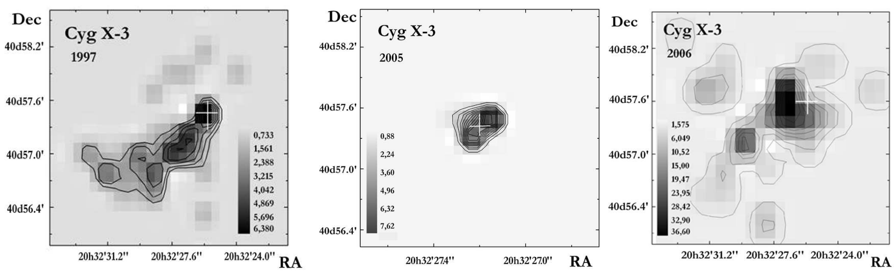

Figure 2: The images of gamma-ray emission from Cygnus X-3 in 1997, 2005 and 2006 years, from flaring to quiet and back to flaring period.

The variability of very high-energy gamma-radiation and correlation of radiation activity in the wide energy range can, also, provide essential information on the particle mechanism production the up to the very high energies.

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EXTRAGALACTIC BACKGROUND LIGHT EXPECTED FROM OBSERVATION OF DISTANT METAGALACTIC SOURCES 1739+522 (z=1.375) and 3C454.3 (z=0.859)

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The EBL spectrum contains information about star and galaxy formation on early stages of Universe evolution. As the TeV gamma rays can be absorbed due to interaction of low-energy photons of Extragalactic Background Light (EBL), the observations of active galactic nuclei can also be used for the study background light from UV to far infrared and even cosmic microwave background. TeV gamma-rays, radiated by distant sources, interact with photons of background via $\gamma + \gamma \rightarrow e^+e^-$ resonant process, then relativistic electrons can radiate gamma-ray with energies less than of primary gamma-quantum. As a result, primary spectrum of gamma-source is changed, depending on spectrum of background light. So, a hard spectra of Active Galactic Nuclei with high red shifts of 1 -1.8 allow to determine an absorption by Extragalactic Background Light and thus spectrum of EBL. The redshifts of SHALON very high energy gamma-ray sources range from z=0.0183 to z=1.375. During the period 1992 - 2010, SHALON has been used for observations of the metagalactic sources NGC1275 (z=0.0183), SN2006gy (z=0.019), Mkn421 (z=0.031), Mkn501 (z=0.034), Mkn180 (z=0.046), OJ 287 (z=0.306), 3c454.3 (z=0.895), 1739+522 (z=1.375). Among them bright enough AGNs of BLLac type (Mkn421, Mkn 501) and FSRQ type (3c454.3, 1739+522) those spectra are resolved in the TeV energy band from 1 to 20-30 TeV. The most distant object 1739+522 (with redshift z=1.375), seen in TeV energy, is also the most powerful: its integral gamma-ray flux is found to be $(0.53 \pm 0.10)^{-12} cm^{-2}s^{-1}$ at energies of > 0:8 TeV. The integral gamma-ray flux of 3c454 (z=0.859) was estimated as $(0.43 \pm 0.13)^{-12} cm^{-2}s^{-1}$. The fit of a simple power law function to the observational data is presented in [1]. As it is seen from the fig. 1 and from [1] the measured spectrum can be fitted by a power law with an exponential cutoff: $F(> E) \propto E^{-\gamma} \times exp(-E/E_{cutoff})$ with hard power indices of about $\gamma \sim 1.55$ for Mkn 421 and Mkn 501 and $\gamma \sim 0.6$ for 3c454.3 and 1739+522. The value of E_{cutoff} ranges from 11 ± 2 TeV for Mkn421, Mkn 501 and to 7 ± 2 TeV for distant sources. It has mentioned that the observed spectra are modified by gamma-ray attenuation, i.e. $F_{observed}(E) = F_{intrinsic}(E) \times exp(\tau(E, z))$ where $\tau(E, z)$ is optical depth for pair creation for a source at redshift z, and at an observed energy E. According to the definition of the optical opacity the medium influences on the primary source spectrum at $\tau \geq 1$, but for $\tau < 1$ the medium is transparent, so the measuring of source spectrum in the both range of τ can give the intrinsic spectrum of the source to to constrain the EBL density. The optical depth for sources at redshifts from 0.031 to 1.375 was calculated with assumption of EBL shapes shown in fig 2. We used the averaged EBL shape from best-fit model and Low-SFR model [4] (see fig. 2 upper black curve) to calculate the attenuated spectrum of Mkn 421 in assumption of simple power low intrinsic spectrum of the source with spectrum index of $\gamma = 1.5$, taken from the range of $\tau < 1$. The result is shown at fig.

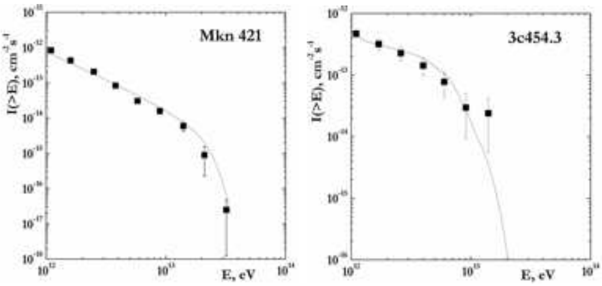

Figure 1: The integral measured spectra for Mkn 421, 3c454.4 (black squares) together with spectra attenuated by EBL.

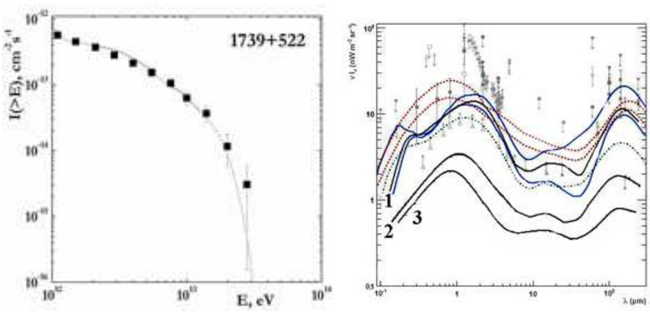

Figure 2: left: The integral measured spectra for 1739+522 (black squares) together with spectra attenuated by EBL; right: Spectral energy distribution of Extragalactic Background Light: models [2], [4] and measurements [3]; **1** - averaged EBL shape from best-fit model and Low-SFR model [4], **2** - EBL shape from constrained from observations of 3c454.3 (z=0.859); **3** - EBL shape from constrained from observations of 1739+522 (z=1.375)

1 with thin line; the black squares are observational data for Mkn 421. The shapes of EBL density constrained from the spectra of the high redshift sources 3c454.3 (z=0.859) and 1739+522 (1.375) are shown in fig 1, 2 with curves 2 for and 3, accordingly. For these FSRQ sources the slope of intrinsic spectrum is taken $\gamma = 0.4$. The attenuated spectra for 3c454.3 and 1739+522 are also presented at fig. 1, 2 (thin lines) together with observational data. Observations of distant metagalactic sources have shown that the Universe is more transparent to very high-energy gamma-rays than previously believed.

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TeV GAMMA-RAY EMISSION FROM CRAB NEBULA

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The Crab Nebula, most famous supernova remnant, pays an important role in the modern astrophysics. No other space object has such impact on the progress and development of the modern experimental and theoretical astrophysics methods. Pulsar located at the centre of the Crab Nebula is the first who's optical, X-ray and gamma-emission has been detected. As in many other bands of electromagnetic spectrum, the Crab Nebula has become the standard candle for TeV gamma-ray astronomy. It is available as steady source to test and calibrate the telescope and can be seen from both hemispheres. Since the first detection with ground based telescope the Crab has been observed by the number of independent groups using different methods of registration of gamma-initiated showers. Recently Crab has observed with Fermi LAT at energies 100MeV - 300Gev [1]. Improvements in analysis techniques and methods of imaging Cherenkov techniques developed on Crab Nebula data have led to the detections of the Active Galactic Nuclei and other supernova remnants in out Galaxy.

Crab Nebula has an extraordinary broad spectrum, attributed to synchrotron radiation of electrons with energies from GeV to PeV. This continuous spectrum appears to terminate near 108 eV and photons, produced by relativistic electrons and positrons (1015 eV) via Inverse Compton, form a new component of spectrum in GeV TeV energy range. [2]. Crab Nebula has been regularly observed by high mountain (3340m a.s.l.) SHALON Atmospheric Cherenkov telescope. The integral spectra, spectral energy distribution and images of Crab supernova remnant by SHALON are presented [3]. The integral energy spectrum in the energy range of 0.8 - 11 TeV is well described by the power law $I(>E_\gamma) \propto E_\gamma^{-1.44\pm0.07}$ (Fig. 1, 2). Detailed images of gamma-ray emission at E>0.8TeV from Crab Nebula by SHALON telescope are presented (Fig. 1). Also, in order to find relation between TeV and X-ray emission and source characteristics, the combination of SHALON and Chandra images (Fig. 1) [4] were analyzed. The correlation of TeV and X-ray emission region is shown. The average magnetic field in the region of VHE gamma-ray emission is extracted from the comparison of TeV (SHALON data) and X-ray (Chandra data) emission regions. Then using the complete spectrum of the Crab Nebula, the spectrum of relativistic electrons is deduced, and the spectrum of the inverse Compton emission that they would generate is in good agreement with the observed by SHLAON gamma-ray flux, if the average magnetic field [4] in the region where these scattered photons originate is 67nT.

The TeV gamma-quantum spectrum of Crab by SHALON is generated via Inverse Compton of soft, mainly optical, photons which are produced by relativistic electrons and positrons, in the nebula region around 1.5' from the pulsar with specific average magnetic field of about 67nT.

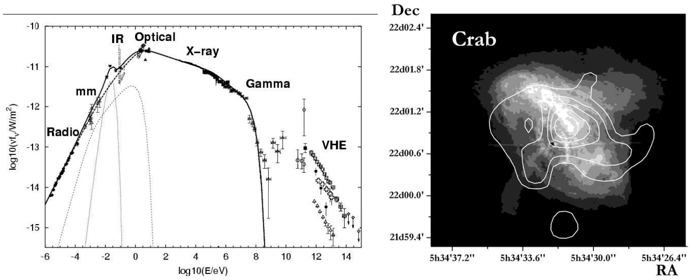

Figure 1: left: The Crab Nebula spectral energy distribution in the wide energy range; right: Chandra X-ray image of Crab Nebula. The central part 200” × 200” of Crab Pulsar Wind Nebula in the energy range 0.2-20 keV [4]. The white contour lines show the TeV - structure by SHALON observations.

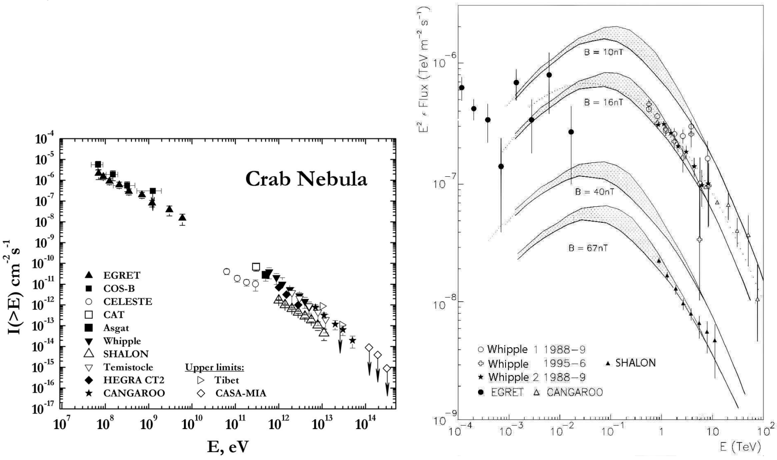

Figure 2: left: The Crab Nebula gamma-quantum integral spectrum by SHALON in comparison with other experiments: EGRET, COS-B, CELESTE, CAT, Asgat, Whipple, Themistocle, HEGRA CT2, CANGAROO, Tibet, CASA-MIA; right: The Crab gamma-quantum spectrum by SHALON together with other experimentsand with the predicted inverse Compton spectrum for the different field strengths [2] and for the 67 nT

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GAMMA RAY BURSTS MONITORING WITH THE ARGO-YBJ EXPERIMENT IN SCALER MODE

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This presentation reports on the search for Gamma Ray Bursts (GRBs) in the energy range $1 - 100\ GeV$ in coincidence with the prompt emission detected by satellites, using the Astrophysical Radiation Ground-based Observatory at YangBaJing (ARGO-YBJ). With its big active surface ($\sim$ 6700 m^2) and large field of view ($\approx$2 sr) the ARGO-YBJ air shower detector is particularly suitable to detect unpredictable and short duration events such as GRBs. The search has been performed using the single particle technique in time coincidence with satellites both for the single events and for the piling up of all the GRBs in time and in phase.
Since December 2004 all GRBs detected by different satellites (mainly Swift and Fermi) and occurred within the field of view of ARGO-YBJ ($\theta \leq 45^0$) have been considered. For 88 of these we searched for a GeV counterpart in the ARGO-YBJ data finding no statistically significant emission.
In the lack of a positive detection the fluence upper limits have been calculated. Search methods and results will be here discussed.

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About ECRS

European Cosmic Ray Symposium (ECRS) is a biennial forum where scientists from Europe and other parts of the world can gather and discuss the actual problems and new findings in cosmic ray physics. Traditionally ECRS covers the whole spectrum of cosmic-ray related studies, from solar-terrestrial to ultra-high energy. The series of ECRS has been initiated in 1968 and since then takes place every two years, between biennial International Cosmic Ray Conferences. During its 40-year history ECRS has been hosted in 12 European countries (see the list below), and in 2010 takes place in Finland, the first time in a Nordic country.

ECRS	Year	Location
1st	1968	Bern (Switzeland) and Lodz (Poland)
2nd	1970	Amsterdam (the Netherlands) and Leeds (UK)
3rd	1972	Göttingen (Germany) and Paris (France)
4th	1974	Lodz (Poland) and Frascatti (Italy)
5th	1976	Leeds (UK)
6th	1978	Kiel (Germany)
7th	1980	Leningrad (USSR)
8th	1982	Rome (Italy)
9th	1984	Košice (Czechoslovakia)
10th	1986	Bordeaux (France)
11th	1988	Balaton (Hungary)
12th	1990	Nottingham (UK)
13th	1992	Geneva (Switzerland)
14th	1994	Balatonfüred (Hungary)
15th	1996	Perpignan (France)
16th	1998	Madrid (Spain)
17th	2000	Lodz (Poland)
18th	2002	Moscow (Russia)
19th	2004	Florence (Italy)
20th	2006	Lisbon (Portugal)
21st	2008	Košice (Slovakia)
22nd	2010	Turku (Finland)