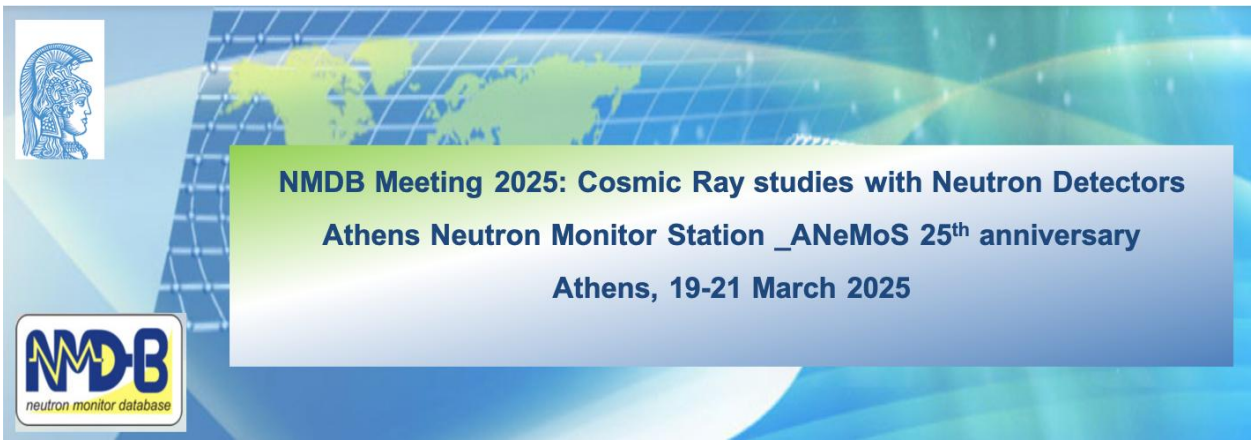

ABSTRACT BOOK

NMDB Meeting 2025:
Cosmic Ray studies with Neutron Detectors

19 – 21 March 2025

Seminar Room, Department of Physics,

Panepistimioupolis, Zografos

Athens 2025

INTRODUCTORY TALKS

The Significance of Neutron Monitor Measurements over Time

Erwin O. Flueckiger
University of Bern

Abstract

Neutron Monitors (NM) have been in continuous operation in a global network since the International Geophysical Year (IGY) 1957/58. Their main purpose is the ground-based observation of temporal fluctuations in the low GeV part of the energy spectrum of cosmic ray particles hitting the Earth's atmosphere. The focus in the use of NM data has however significantly changed over time, from fundamental astrophysical research in the past to applications in the space weather era, and more recently in the domains of environmental metrology as well as geotechnical and agricultural engineering. In this process, the establishment of the real-time database NMDB was essential, and its continued operation is of utmost importance.

The history and the current status of the Neutron Monitor DataBase

Christian T. Steigies
Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel

Abstract

The Neutron Monitor DataBase (NMDB) has been created as an EU FP7 project in 2008. Since then, NMDB has grown from 12 participating institutes with 15 stations to more than 50 stations, about half of them currently provide data in real-time. While we created NMDB for the use of Cosmic Ray researchers, the data has been quickly found by and is nowadays being used in many different fields of research. Over the years not only has the database software changed, but also the setup of the database servers. I will describe our journey from a single MySQL server via a set of distributed mirrors to a single MariaDB Galera Cluster, the problems that have been solved, the problems that have been created, and the problems that we will face in the (near) future.

Session 1: Cosmic Rays in the Heliosphere

Observational evidence on the mechanism of relativistic particle acceleration in solar eruptions

Karl-Ludwig Klein
Observatoire de Paris

Abstract

Ground-level enhancements (GLE) designate events where relativistic protons and ions of solar origin trigger a cascade of secondary nucleons in the Earth's atmosphere that can be detected on ground. GLEs require primary particles with energies of at least 430 MeV/nucleon, with a spectrum that may extend to several tens of GeV. They are extremes of solar particle acceleration, which pose challenging problems to candidate acceleration processes. The association with eruptive solar flares suggests processes related to magnetic reconnection in the flaring corona and shock waves driven by particularly fast coronal mass ejections. Pion-decay gamma-rays, which come from the interaction of nucleons with energies above 300 MeV/nucleon with the low solar atmosphere, have shown that relativistic proton acceleration is much more frequent than GLEs. In this talk I will review observational evidence on the acceleration process and discuss the pros and cons of the two categories invoked in the literature.

GLE alert and afterwards

Rolf Bütikofer*, Erwin Flückiger, Lukas Bäni*
University of Bern

Abstract

The availability of high time resolution NM data in near real-time through NMDB makes it possible to generate GLE alerts. Potential stakeholders are researchers in the field of space weather as well as e.g. airlines who have to assess the radiation dose exposure of crew members and passengers along the flight routes. Currently, at least two institutions operate such alert applications. These routines continuously monitor the NM data provided by NMDB. A GLE alarm is triggered as soon as predefined criteria are met, and the registered interested parties get an immediate notification by e-mail. While this approach is certainly adequate for many of the service subscribers, more interested parties lack further information. We, therefore, discuss whether forecasts can be made of the development of a GLE based on NM data in the course of an event and how this information could be made available e.g. through a continuously updated webpage.

Shape and extend of the solar wind transition surfaces: Solar Alfven and Sonic surfaces, the heliosphere and CR modulation

George Exarhos (Siemens AE), ***Xenophon Moussas***
University of Athens

Abstract

We investigate the shape and extend of the solar wind transition surfaces, namely the slow (sonic), the fast magnetosonic and the Alven surface, as a function of heliospheric latitude using actual experimental data from Ulysses, Parker Solar Probe and Solar Orbiter pole to pole journey. We also derive the temporal variation of the radius of these surfaces using measurements from spacecraft at 1 au. Moreover, a semi-analytical calculation of the shape and extend of the heliosphere, the heliospheric termination shock and CR modulation is made based on spacecraft data input for the initial conditions. We estimate directly the consequences of the solar wind latitudinal variation on the shape of the termination shock. The model that we use is an approximate gas-dynamic model based on Fahr et al. 1993; Nerney & Suess 1995. We develop a semi-analytical model that can use any spacecraft measurements as data input to give the distance and shape of the termination shock from the Sun in a simple computational way that gives realistic results. A comparison is made of the Voyager crossing of the termination shock and NM CR data.

Session 2: Intense Events of 2024

Neutron Monitors and Cosmic Ray Science

Monica Laurenza
INAF- Istituto di Astrofisica e Planetologia Spaziali, Roma, Italy

Abstract

Neutron monitors (NMs) have been continuously measuring the secondary nucleonic component of the galactic cosmic ray (CR) intensity for more than 70 years. NMs have played a fundamental role in our understanding of: solar modulation, namely significant global and temporal variations in the galactic CR intensity and energy spectra as a function of position inside the heliosphere on long time scales (11-year solar activity cycle, 22-year magnetic polarity cycle); short-term variations such as Forbush decreases, i.e. depressions in the GCR intensity due to effect of interplanetary perturbations; ground level enhancements produced by the arrival of relativistic solar particles (the so-called solar cosmic rays) in the Earth atmosphere. This tutorial provides an overview of neutron monitors measurements and cosmic ray science, focusing on the physical processes in the interplanetary space responsible for CR short-term variations and those favoring the high energy particle acceleration at the Sun.

GOES Solar Energetic Particle Observations During the Ground Level Enhancements 74-76 of 2024

Juan Rodrigue*, Brian Kress, Athanasios Boudouridis*
University of Colorado CIRES

Abstract

During 2024, three ground level enhancements (GLEs) were observed, with onsets on 11 May, 8 June, and 21 November. GOES-16 and -18 made observations during all three GLEs, and additionally GOES-19 (launched 7 July 2024) made observations during GLE 76. Each satellite carries three solar energetic particle (SEP) instruments: two Solar and Galactic Proton Sensors (SGPS), looking eastward and westward in the orbit, and the Energetic Heavy Ion Sensor (EHIS), looking toward zenith. SGPS is the primary instrument for observing solar proton (1-500 MeV, >500 MeV) and alpha particle (1-224 MeV/n) fluxes. EHIS reports heavy ion fluxes by atomic number (Z) in five energy channels whose energies vary with Z (18-334 MeV/n for carbon, 38-826 MeV/n for iron). We use the 2024 GLEs as a framework for describing the status of the GOES SEP observations, including recent cross-calibrations, and we summarize current and planned availability of retrospective and real-time data.

Forbush Effects and their Connection with Solar, Interplanetary and Geomagnetic Phenomena

***Maria Abunina**, Anatoly Belov*
IZMIRAN

Abstract

Forbush decrease (or, in more wide sense, Forbush effect) - it is a storm in cosmic rays, which is a part of heliospheric storm and is very often observed simultaneously with a geomagnetic storm. All these three kinds of perturbations: disturbances in the solar wind, magnetosphere and cosmic rays are closely interrelated and caused by the same active processes on the Sun. In the report, they will be considered in common.

Solar events of the 25th activity cycle

Ashot Chilingarian
Yerevan Physics Institute

The surprising increase in solar activity in 2024, following a relatively tranquil 24th cycle, suggests that we are approaching the solar maximum of the 25th cycle. The complex interplay between disturbed interplanetary and geomagnetic fields affects the cosmic rays reaching the Earth's surface in various ways. Positioning the particle spectrometers at elevated altitudes, which analyze the energy spectra of muons and neutrons, is a strategic decision aimed at comprehending the intricate interactions between colliding interplanetary and geomagnetic fields and the solar proton accelerators. Direct comparison between the measured energy spectra of secondary neutrons and muons (MeV) via appropriate simulations is related to energy spectra of solar energetic protons (GeV). The report highlights advanced instrumentation and data analysis methods to investigate solar-induced phenomena in cosmic rays by analyzing the solar events of the 25th cycle.

High energy proton recordings during GLE74 on 11 May 2024

***Athanasios Papaioannou** (National Observatory of Athens), Anastasios Anastasiadis, Mateja Dumbovic, Jan Gieseler, Bernd Heber, Malte Hörlöck, Manon Jarry, Sergey Koldobskiy, Marlon Köberle, Patrick Kühl, Nick Larsen, Monica Laurenza, Eleni Lavasa, Alexander Mishev, Christian Palmroos, Osku Raukunen, Alexis P. Rouillard, Narsin Talebpour Sheshvan, Ilya Usoskin, Rami Vainio, George Vasalos, Robert Wimmer-Schweingruber*

Abstract

Ground-level enhancements (GLEs) represent the highest-energy end of solar energetic particle (SEP) events, forming a distinct class where ions are accelerated to relativistic speeds. This leads to a sudden, significant increase in cosmic rays detected by ground-based instruments, primarily neutron monitors (NMs). This work focuses on GLE74, which occurred on May 11, 2024. Proton

observations up to ~ 2.4 GV, gathered from neutron monitors, SOHO, GOES, and STEREO-A, are combined with soft X-ray flare data, CME detections, and radio bursts to determine the solar origin of the event. A time-shift analysis was also performed to correlate detected particles with their solar sources. Finally, GLE74 is compared to past events to provide further insight into its characteristics.

GLE #75 caused by a solar energetic particle event on 8 June 2024

Stepan Poluianov *(University of Oulu, Finland), Alexander Mishev (University of Oulu, Finland), Olga Kryakunova (Insitute of Ionosphere, Almaty, Kazakhstan), Botakoz Seifullina (Insitute of Ionosphere, Almaty, Kazakhstan), Nikolay Nikolayevskiy (Insitute of Ionosphere, Almaty, Kazakhstan), Ilya Usoskin (University of Oulu, Finland)*

Abstract

Some solar energetic particle (SEP) events can be registered by ground-based neutron monitors (NMs) measuring the variability of cosmic rays. Those events are called Ground-Level Enhancements (GLEs) and are seen as rapid increases in NM count rates over the background of galactic cosmic rays. GLEs are rare, but the year 2024 was rich for three of them. We report the second GLE of the year that happened on 8 June 2024, initially overlooked but discovered retrospectively after a review of NM data. That GLE #75 is associated with an SEP event induced by the same active region 13697/13664 that caused the previous GLE #74. During GLE#75, there were statistically significant responses at NMs DOMC, PWNK, and SOPO/SOPB, and an enhancement of the proton flux measured by satellite GOES-16. We present the GLE, reconstructed SEP spectra and angular distributions, and describe the procedure of assessment of the statistical significance of increases.

Modeling the solar event responsible for GLE74 in May 2024

Manon Jarry *(IAASARS - NOA), Alexis P. Rouillard, Nasrin Talepbour (IRAP-CNRS), Athanasios Papaioannou (National Observatory of Athens), Rami Vainio, Jan Gieseler, Anastasios Anastasiadis (National Observatory of Athens)*

Abstract

A Ground-Level Enhancement (GLE) was detected on May 11, 2024, following a significant Forbush decrease. Simultaneously, a powerful Solar Energetic Particle (SEP) event was measured at the Lagrange L1 point and by the Solar-Terrestrial Relations Observatory Ahead (STEREO-A). This event was triggered by an X5.8 flare and a fast Coronal Mass Ejection (CME) with a speed >1500 km/s which generated a shock wave in the solar corona.
We modelled this coronal shock wave using a 3D reconstruction technique and a magneto-hydrodynamic model. The results of this reconstruction are presented with an observational analysis of the SEP event and electromagnetic signatures. This work was coordinated under the Horizon Europe SPEARHEAD project.

High latitude muon and neutron observation of the Forbush decrease during the May 2024 solar storms

Martin Schrön *(Helmholtz Centre for Environmental Research GmbH - UFZ, Leipzig, Germany), EEE Collaboration, Lasse Hertle, Ombretta Pinazza, Francesco Riggi*

Abstract

A series of intense solar flares occurred in May 2024. Among other effects, a remarkable Forbush decrease in the cosmic ray flux was observed on the Earth. This event was observed by neutron and muon detectors installed at the Svalbard, in a high latitude site, characterized by a weak geomagnetic shielding. For this analysis we employed at Ny-Alesund three scintillator-based muon telescopes of the Extreme Energy Events (EEE) project, 14 channels of a Bonner Sphere neutron Spectrometer (BSS), thermal and epithermal neutron sensors used for hydrological monitoring, and data from NM Barentsburg. Most sensors showed significant responses and correlation during the event. The observed relative magnitude of the Forbush decrease was estimated to be ≈ 9% for thermal neutrons, ≈ 8% for high-energy neutrons, and ≈ 3% for muons. A correlation analysis of the time series provided by all these detectors will be discussed in this contribution.

Session 3: Cosmic Rays and Space Weather effects

Neutron Monitor Data as input to European projects: SWESNET and PECASUS

Norma Bock Crosby, *Mark Dierckxsens, Erwin De Donder*
Royal Belgian Institute for Space Aeronomy

Various European projects that provide space weather services, such as spacecraft operations and aviation, rely on neutron monitor data. In this presentation, two major European projects will be discussed, respectively ESA Space Safety Program (S2P) Space WEather Service NETwork (SWESNET, https://swe.ssa.esa.int/) and Pan-European Consortium for Aviation Space weather User Services (PECASUS, https://pecasus.eu/). Neutron monitor data is used by several products in the SWESNET Space Radiation Expert Service Centre (R-ESC) product portfolio (e.g., ANeMoS, AVIDOS, COMESEP, and UTU-SEP products). PECASUS relies on neutron monitor data to estimate the radiation exposure at flight level, a key input for compiling ICAO radiation advisories. To maintain these products continued operation of neutron monitor stations must be ensured. Further extensions and support of the current network with new or updated stations and services in terms of reliable real-time data is thus encouraged.

The response of ANeMoS GLE Alert system to the recent Ground Level Enhancements of 2024

Maria Gerontidou*, Pavlos Paschalis,*
Helen Mavromichalaki, Maria Papailiou, Dimitra Lingri
University of Athens

Abstract

Three years after GLE 73 (October 28, 2021), three distinct GLEs took place before the end of 2024.The first event, GLE 74 registered on May 11, 2024, followed by GLE75 on June, 8 and GLE 76 on November 21. Each event exhibited unique characteristics in terms of intensity, temporal evolution, and spectral properties. Notably,GLE 74 occurred during an irregular Forbush Decrease with sharp amplitude reduction and rapid recovery. Specifically, a 15% decrease was recorded, followed by an exceptionally fast 10% recovery within 1.5 hours, as observed by the Oulu neutron monitor station.This event triggered the strongest geomagnetic storm in two decades (May 10–11, 2024), causing auroras at unprecedented latitudes worldwide.
In this study, we analyze and present the response of the GLE Alert system to these Ground Level Enhancements, offering insights into their implications for space weather forecasting and radiation hazard.

Comparison of GLE event of 11 May 2024 and Magnetospheric effect 5 November 2023

Balabek Sargsyan
Yerevan Physics Institute

Abstract

We examine the energy spectra of secondary particles linked to solar events to identify and classify Forbush decreases (FD), ground-level enhancements (GLE), and magnetospheric effects (ME) detected by particle detector networks on Earth's surface.
We present energy spectra of neutrons related to the magnetospheric effect observed on November 5, 2023, and the GLE on May 11, 2024. We refine the definition of the Magnetospheric Effect (ME). Our classification is based on the following observations:
1. Antarctic and near-polar NMs did not register flux enhancement, while middle latitude NMs and SEVAN detectors coherently registered count rate enhancements throw distances of 5,500 km.
2. Due to atmospheric cutoff rigidity, NMs and SEVAN detectors located on mountain tops at middle latitudes demonstrated flux enhancement, while ones at sea level did not.
3. The energy spectra of secondary cosmic rays are essential for identifying ME.

Energy Sensitivity of a Neutron Monitor: A Monte Carlo Study

Danislav Sapundjiev
Royal Meteorological Institute of Belgium

Abstract

Neutron monitors (NMs) play a crucial role in studying cosmic-ray interactions and atmospheric neutron cascades. However, their response to high-energy neutrons (above 20 MeV) remains uncertain due to the limited availability of neutron cross-section data in simulation frameworks such as GEANT4. This study aims to evaluate the energy sensitivity of a neutron monitor using Monte Carlo techniques, focusing on its differential energy and directional response. By analyzing the contributions of thermal, epithermal, and fast neutrons, produced within atmospheric cascades, we assess the limitations of current response models. Understanding these factors is essential for improving the applicability of neutron monitor data and the neutron monitor response function.

Selection of the Solar-Diurnal Anisotropy of Cosmic Rays by Local and Global Methods

Nataly Shlyk*, Maria Abunina, Anatoly Belov, Victoria Oleneva, Victor Yanke*
IZMIRAN

Abstract

According to the data of Moscow and Climax neutron monitors, using harmonic analysis, the characteristics of the solar-diurnal anisotropy of cosmic rays on quiet days have been obtained for

a long period from 1957 to 2023. A comparison with the average daily characteristics of the equatorial component of cosmic rays vector anisotropy, obtained from the data of the worldwide neutron monitor network using the global survey method showed a good agreement between the results of the two methods. From a comparison of local and global results, estimates were obtained for the coupling coefficients of the first harmonic of the cosmic ray anisotropy for Moscow and Climax neutron monitors, and a new experimental method for calculating the coupling coefficients of individual detectors was proposed. The limitations of the local method, as well as the possibility of continuing and expanding this study, have been discussed and justified.

Ground-based observations of temporal variation of cosmic ray spectrum during Forbush decreases

Warit Mitthumsiri (Mahidol University), David Ruffolo (Mahidol University), Kazuoki Munakata (Shinshu University), Pradiphat Muangha (Mahidol University), ***Alejandro Sáiz*** *(Mahidol University), Paul Evenson (University of Delaware), Pierre-Simon Mangeard (University of Delaware), John Clem (University of Delaware), Surujhdeo Seunarine (University of Wisconsin River Falls), Waraporn Nuntiyakul (Chiang Mai University), the GMDN Collaboration*

Abstract

Temporary decreases in the GCR flux due to the passage of an ICME can be observed in ground-based neutron monitors (NMs) and muon detectors. The details of these Forbush decreases are useful for space weather studies and alerts. We derive hourly variations in the GCR rigidity spectrum during several Forbush decreases using a global fit to count rates from the NM and muon-detector networks, and by calculating a "leader fraction" from the timing distributions of pulses in each NM counter at South Pole station. Results are consistent with daily variations in the spectral index as measured by AMS-02 onboard the ISS. Thus ground-based observations can be used to monitor GCR spectral variations during space weather events in real time. Partially supported by Thailand's NSTDA and NRCT: High-Potential Research Team Grant Program (N42A650868), and the NSRF via the Program Management Unit for Human Resources & Institutional Development, Research and Innovation (B39G670013).

Measurement of Cosmic-ray Neutrons with a High Efficiency Spectrometer

Ariel Tarifeno-Saldivia *(Instituto de Fisica Corpuscular (CSIC-UV)), Alvaro Quero (Universidad de Granada), Nil Mont-Geli (Universitat Politecnica de Catalunya), HENSA++ Collaboration*

Abstract

The High Efficiency Neutron Spectrometry Array (HENSA) project develops advanced neutron spectrometers for underground laboratories and cosmic-ray studies. Utilizing a modified Bonner Spheres System (BSS), HENSA achieves ten times higher efficiency than BSS, detecting neutrons from thermal energies to 10 GeV. This enables real-time spectral analysis of solar events such as Ground Level Enhancements and Forbush Decreases.
In 2020, a HENSA detector mapped cosmic-ray neutrons at altitudes up to 3000 m and magnetic rigidities from 5.5 to 8.5 GV. Building on these results, a new spectrometer, HENSA++, was developed with improved energy resolution and began commissioning in 2024, first in Valencia

and later at the Observatorio Astrofisico de Javalambre, in Spain. This talk presents HENSA's latest results, including the evolution of the neutron spectrum and analyses of selected solar events. Finally, we outline future plans for continuous cosmic-ray neutron monitoring through the second half of Solar Cycle 25.

Solar Energetic Particle transport during the GLE73 event on 28 October 2021

Eleni Lavasa *(NKUA, NOA and ATHENA RC), Jaclyn Lang (Center for Space Research, North-West University, South Africa), Athanasios Papaioannou (National Observatory of Athens), Du Toit Strauss (Center for Space Research, North-West University, South Africa), Athanasios Kouloumvakos (The Johns Hopkins University Applied Physics Laboratory, USA), Anastasios Anastasiadis (National Observatory of Athens), Ioannis A. Daglis (University of Athens), Alexander Hillaris (University of Athens), Bernd Heber (Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany), Patrick Kuhl (Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany)*

Abstract

We investigate the transport of solar energetic particles (SEPs) during the 28 October 2021 (GLE73) event, focusing on their longitudinal spread. Multi-spacecraft observations revealed a remarkably wide longitudinal diffusion, enabling particles to reach very high energies. In this work, we incorporate SEP measurements from STEREO A, SolO/HET & SEPT, and SOHO/EPHIN, as well as newly available penetrating proton data from SolO/HET and SOHO/EPHIN. To interpret the observed time profiles, we carry out 1D and 2D numerical simulations of SEP transport, tuning free model parameters for optimal agreement with the measurements. From this inverse modelling procedure, we derive key physical parameters—such as the parallel and perpendicular mean free paths, acceleration and escape times, and the injection region size. We specifically explore the rigidity dependence of the physical parameters and discuss the broader physical implications of our findings.

Session 4: Cosmic Ray Detection Instrumentation

CaLMa's way, from the space to ground

Juan José Blanco Ávalos*, Miguel Ángel Hidalgo, David Arrazola, Carlo Luis Guerrero-Contreras, Alejandro Lopez-Comazzi, Pablo Cerviño Solana, Oscar Garcia-Poblacion, Juan Ignacio García-Tejedor, Alberto Regadio, Sindulfo Ayuso*
(University of Alcalá)

Abstract

Cosmic rays below a few hundred GeV and solar energetic particles are key to understanding how the Sun is interacting with its own solar system, as they respond to the magnetic field that fills the entire Heliosphere, not only during quiet times, but also during episodes of solar activity, as they change the propagation conditions of cosmic rays and solar energetic particles through the Heliosphere. Direct observations of these two types of energetic particles can be made in space using detectors aboard spacecraft such as the Energetic Particle Detector aboard the Solar Orbiter and/or the AMS aboard the International Space Station, for example, and indirect observations using ground-based detectors such as neutron monitors and muon telescopes that measure secondary particles produced through the interaction between cosmic rays and solar energetic particles with atmospheric nuclei.

An ideal ground-based detector to investigate the solar-terrestrial relationship should provide the flux of energetic particles, their energy, their identity and their spatial distribution. Neutron monitors and muon telescopes are the usual instruments for this purpose. Neutron monitors can give the neutron count rate although they may have some response to protons and muons. Although direct measurement of the energy/rigidity of energetic particles is not possible, the combination of several neutron monitor stations at different geomagnetic latitudes can provide a spectrum for these particles and the isotropy of energetic particles in the sky. A rough estimate of this energy can also be provided by a single neutron monitor if it can detect multiplicities by recording the time between successive neutron detections or by capturing height pulses. Muon telescopes provide count rates of charged particles, mainly muons, entering the detector; their configuration usually allows estimation of incoming particle directions and a better estimate can be achieved if several geographically well separated muon telescopes are used. However, due to the energy threshold for muon production, these detectors are less sensitive to solar energetic particles than neutron monitors. In recent years, our group has developed and deployed a type of detectors that can provide both neutron and muon count rates, some information about the cosmic and solar particle spectra, and the arrival directions of muons in the detector volume. This is a combination of a neutron monitor and a muon telescope that share the same structure. At the moment, one of them is operating at the Spanish Antarctic Base Juan Carlos I and a second one is operating at the Izaña Observatory, on the slope of Mount Teide, on the island of Tenerife. We present our ground based detectors, including our first neutron monitor, CaLMa, and our minineutron monitor, miniCaLMa, a multipurpose neutron monitor, as well as our latest results on solar events and the response of neutron monitors as a function of altitude.

Neutron Monitors at Jungfraujoch

***Lukas Baeni**, Rolf Bütikofer, Erwin Flückiger*
University of Bern

Abstract

Two neutron monitors, an 18-IGY since 1958 and a 3-NM64 since 1986, are in operation at the High Altitude Research Station Jungfraujoch in Switzerland. Both neutron monitors are located close to each other but with a difference in altitude of about 100 m (IGY: 3570 m asl, NM64: 3475 m asl). Due to their locations in a high alpine environment, the two neutron monitors are exposed to high winds and snow accumulation on and around the detector housing. Updated readout electronics are in operation since end of 2022 at both neutron monitors. In this presentation, we give a status overview of the continuous cosmic ray measurements at Jungfraujoch.

The Forbush decrease observed by the SEVAN particle detector network in the 25th solar activity cycle

Tigran Karapetyan
Yerevan Physics Institute

Abstract

The variations in cosmic-ray intensity, measured by ground-based detectors at various latitudes, longitudes, and altitudes, are associated with disturbances in the interplanetary magnetic field near Earth. When these variations interact with the magnetosphere, they cause worldwide Forbush decreases (FD), followed by a gradual recovery. The extent of the flux depletion depends on the type and energy of the detected particles, which are influenced by geographical coordinates, the detector's energy threshold, and selective power. The SEVAN particle detector network, with nodes in Europe and Armenia, identifies three types of particles that exhibit coherent depletion and recovery, corresponding to different energy galactic protons interacting with disturbed magnetospheric plasmas.
We present measurements of these FDs performed at mountain altitudes in Aragats (Armenia), Lomnicky Stit (Slovakia), Mileshovka (Czechia), and DESY (Hamburg, Germany) at sea level. We compared FD measurements made by the SEVAN detector and neutron monitors.

miniTRASGO: A Compact RPC Tracker for Global Cosmic Ray and Space Weather Monitoring

Alberto Blanco (Laboratorio de Instrumentacao e Fisica Experimental de Particulas (LIP)),
***Cayetano Soneira-Landín** (Complutense University of Madrid)*

Abstract

miniTRASGO is a compact and cost-effective detector for secondary charged cosmic rays, designed for research in solar activity, cosmic ray modulation, and atmospheric physics. Utilizing Resistive Plate Chambers (RPCs), it ensures stable detection rates and high sensitivity, as demonstrated by the observation of Forbush Decreases in March and May 2024 at the Madrid station (40,4º N, 7GV), where the first operational miniTRASGO unit successfully measured these events despite its small active area of 0.1 m^2. With deployments in Warsaw, Puebla, and Monterrey by early 2025, miniTRASGO will expand coverage across latitudes (52º N, 19º N, 25º N) and cutoff rigidities (2.5 GV, 8.2 GV, 8.5 GV), forming a scalable global muon monitoring network, even though it can also complement NMDB stations, such as CaLMa, which is near the Madrid station. Beyond flux monitoring, miniTRASGO enables angular-resolved studies of cosmic ray variations, geomagnetic effects, and solar modulation, reinforcing its role in multi-site research.

ARTEMIS–JEAN LOUIS STEINBERG (ARTEMIS-IV/JLS) Multichannel Solar Radio Spectrograph Upgrading the Instrument & a Study of Type III Bursts

Fanis Smanis
HERON LAB/University of Thessaly

Sun's radiospectroscopy, at different wavelengths, provides information on many phenomena, which extend through the interplanetary medium upto Earth. The ARTEMIS solar radiospectrograph records the dynamic spectrum of solar radio bursts on a daily basis. It is located at the Satellite Communication Center station (SCC)of COSMOTE at Thermopylae, Greece. The HERON LAB has undertaken its upgrade and operation, in collaboration with the Universities of Athens and Ioannina. We present the work that has been done so far and our plans for the future. The facilities hardware and software improvements will incorporate ground-based radio measurements into the broader community, introducing a new era of the instrument. This will add to the ongoing research on already-acquired radio data of active solar phenomena. An important aspect of ARTEMIS is its synergy with other ground and space instruments. As ESA's Solar Orbiter mission and NASA's Parker Solar Probe mission will continue to observe the sun until 2025/2027, the new ARTEMIS can provide ground coverage.

Research of cosmic rays at the Lomnicky stit observatory

Ján Baláž, Pavol Bobík, ***Ján Kubančák****, Ronald Langer, Šimon Mackovjak, Igor Strhársky, Samuel Štefánik et al.*
Institute of Experimental Physics SAS

Abstract

In our lecture we will look at the history and present of cosmic ray research by the staff of the Institute of Experimental Physics SAS at the Lomnickom Peak site. We will summarize the history of the site and measurements, the results of our work and future perspectives. You will learn, for example, about how the cosmic ray observations with different instruments since 1957 and what

instruments we use to observe cosmic rays today. We are also looking forward to a discussion focusing on new opportunities for research and collaboration in the future.

On the usability of small-scale scintillation muon telescopes

***Semyon Belov**, Victor Yanke*
IZMIRAN

Abstract

A small-scale (under 1 square meter) scintillation muon telescope experiment was started at IZMIRAN a few years ago. It turned out, that despite small surface area, the count rate was big enough to provide statistically supported results. For example, several Forbush-effects were observed in the data. The talk will cover details of the instrument construction, data collection and processing. Special attention will be given to temperature correction as it's very important for muon component of cosmic rays. The perspective of using such instruments data for global modelling methods will also be discussed.

HLEA and THIMON: Enhancing Neutron Monitor Data from the Summit of Haleakalā

Veronica Bindi
Physics & Astronomy Department, The University of Hawaii at Manoa, USA

Abstract

The recent deployment of two new neutron monitors, HLEA and THIMON, at the summit of Haleakalā, Hawaii, represents a significant advancement in the global neutron monitor network. Positioned at 3,055 meters above sea level, these monitors benefit from reduced atmospheric interference, providing high-quality measurements of galactic cosmic rays (GCRs) and solar neutrons. Operational since December 2024, HLEA and THIMON are filling a critical geographical gap in the Pacific Ocean region. Their strategic location offers unique opportunities to compare measurements with other neutron monitors, aiding in cross-calibration efforts and enhancing the reliability of the global network. This presentation will cover the technical specifications of HLEA and THIMON, their initial performance metrics, and the first scientific results. We will also discuss their integration into the neutron monitor database. As part of the broader scientific community's efforts to maintain and expand neutron monitor capabilities, HLEA and THIMON underscore the importance of investing in new stations, maintaining robust data repositories, and fostering international collaboration.

Session 5: Databases and Catalogues

The ARTEMIS-IV\JLS free access database (ARTDB): Off to a Good Start-With Room for Improvement

Spiridon Armatas (University of Athens), Costantine Bouratzis (University of Athens), ***Alexander Hillaris*** *(University of Athens), Panagiota Preka-Papadema (University of Athens), The ARTEMIS-IVJLS Group*

Abstract

Open-access data is vital for advancing solar and space physics, promoting collaboration and combination of diverse datasets. To this end, the ARTEMIS-IV/JLS free-access database (ARTDB), presented by the ARTEMIS-IV/JLS Group, provides extensive solar radio observations from the ARTEMIS-IV Multichannel Radiospectrograph, operated by the University of Athens at Thermopylae, Greece (Lat: 38° 49'N, Lon: 22° 41'E), since 1996.
ARTEMIS-IV records daily spectra (05:30–15:00 UT) across 20–650 MHz using two receivers: 1. The Global Spectral Analyser (ASG)–covering the full band at 10 samples per second. 2. The high resolution Acousto-Optic Spectrograph (SAO)–1.4 MHz, 100 samples/s in the 265–450 MHz range.
Generating ~1.5 GB of data per day, ARTDB provides FITS-formatted spectral recordings and daily overview images ("Quick Looks"). The website (http://artemis-iv.phys.uoa.gr) also features select radio burst spectra, scientific publications, and educational resources.
Future improvements of the ARTDB include expanding event catalogs and implementing automated data processing for enhanced calibration and quality control.

Neutron background monitoring for the IAXO-D0 detector prototype

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Abstract

The International Axion Observatory (IAXO) is a planned gaseous detector helioscope designed to detect axions, theorised to be dark matter candidates. A baseline detector prototype, IAXO-D0, is at present undergoing tests in Zaragoza. This prototype is sensitive to background high-energy neutrons that could induce false positive axion detections. A neutron monitor has been proposed as a way to provide a continuous measurement of ambient neutrons. A prototype neutron monitor was designed and assembled. It consists of three He-3 proportional counter tubes surrounded by

several layers of HDPE and lead. It has been in operation since March 2024 inside the laboratory where IAXO-D0 is being commissioned. We present Monte Carlo simulations performed to characterise the monitor and the first results of the neutron count rate during the Forbush decrease observed in May 2024, once noise and pile-up have been taken care of, and atmospheric pressure effects have been corrected for.

The current Status of NEST

Nicolas Fuller
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I will be presenting the Nest tool (nest.nmdb.eu), dedicated to the representation of the data stored in the NMDB database. Nest has been around for a long time and has evolved over time with new features. As the latest changes to the historic web site are cosmetic in nature, I'd like to take a closer look, in the form of a live demonstration, at the pages that have been developed recently and which offer a more interactive experience with the data. Feedback from users is essential if these tools are to evolve towards greater usefulness and efficiency.

e-posters

Session 2: Intense Events of 2024

Sympathetic flares including multiples detected by the GOES in solar cycles 21–24

Ramy Mawad (Al-Azhar University, Cairo), ***Xenophon Moussas*** *(University of Athens)*

Abstract

We have studied the sympathetic flares detected by the GOES satellites during the solar period 1975–2017 (i.e., solar cycles 21–24). We found 2204 sympathetic solar flares out of all 77604. The frequency of the occurrence of sympathetic flares depends on the solar cycle activity. The number of sympathetic solar flares increases with the increase in solar activity and decreases as solar activity decreases. Multiple flares have also studied.

The Severe Geomagnetic Storm G4 Observed on 10-11 October 2024

Maria Livada, *H. Mavromichalaki*
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Abstract

On October 10-11, 2024, a severe geomagnetic storm (G4) was recorded during the 25th solar cycle accompanied by a Forbush decrease in galactic cosmic ray intensity. In this study, a detailed analysis of this severe event in regard to the accompanying solar activity, interplanetary conditions and solar energetic particle events is provided. The Forbush decrease during this storm is analyzed. The cosmic ray spectral analysis during the Forbush decrease of October 2025 was performed following the technique of Wawrzynczak and Alania (2010). Specifically in this technique the galactic cosmic ray spectral index was calculated using the coupling coefficient method. A yield function by Xaplanteris et al. (2021) based on the Quantum Field Theory (QFT) was applied in the spectral analysis of the Forbush decrease. Moreover, the result of NKUA“apPrediction tool” concerning this storm event is presented.

Session 3: Cosmic Rays and Space Weather effects

On solar sources of interplanetary disturbances before the high-energy magnetospheric electrons enhancements

Olga Kryakunova *(Institute of Ionosphere), Botakoz Seifullina (Institute of Ionosphere), Irina Tsepakina (Institute of Ionosphere), Artem Abunin (IZMIRAN), Anatoly Belov (IZMIRAN), Maria Abunina (IZMIRAN), Nikolay Nikolayevskiy (IZMIRAN), Nataly Shlyk (IZMIRAN)*

Abstract

Based on measurements of magnetospheric electron fluxes with energies >2 MeV in geostationary orbits, solar wind velocity, and geomagnetic activity for the period 1995-2023, a catalog of electron enhancements in which the electron fluence exceeds dangerous level has been compiled. For the events of this catalog, disturbances of interplanetary space have been determined, after which enhancements in high-energy electrons begin, and their solar sources have been determined. It has been found that in more than half of the events of electron enhancements, the solar sources of disturbances are high-speed solar wind streams (HSSs) from coronal holes. In 97.2% of the events, HSSs from coronal holes were one of the solar sources of disturbances, in the formation of which coronal mass ejections after solar flares and the disappearance of solar filaments also participated. The average behavior of the electron flux, cosmic rays, solar wind velocity and geomagnetic activity is obtained.

Precursors of large Forbush decreases: The threshold value 0.8% of the equatorial anisotropy

Maria Papailiou *(University of Athens), Maria Abunina (IZMIRAN), Helen Mavromichalaki (University of Athens), Nataly Shlyk (IZMIRAN), Semyon Belov (IZMIRAN), Artem Abunin (IZMIRAN), Maria Gerontidou (University of Athens), Anatoly Belov (IZMIRAN), Victor Yanke (IZMIRAN)*

Abstract

Precursors (pre – decreases/pre – increases of the cosmic ray intensity) are observed preceding Forbush decreases. The Cosmic Ray Groups of NKUA and IZMIRAN have studied large Forbush decreases (magnitude > 5%) accompanied by geomagnetic storms (i.e., Dst < -100 nT and 5 ≤ Kp-index ≤ 9) regarding precursors. The threshold value of the equatorial anisotropy one hour before the onset of the event (Axyb, %) was set at 0.8%. In total, 59 events with Axyb ≥ 0.8% (test group) and 68 events with Axyb < 0.8% (control group), from 1957 to 2023, were examined. The 'Forbush Effects and Interplanetary Disturbances' database was used for selecting events and analyzing the solar, interplanetary, and geomagnetic conditions during each event. The method 'Ring of Stations' was also used. The chosen threshold is well set at 0.8%, since precursors are clearly present in the test group and principally absent in the control group.

Statistical Analysis of GLE events

Maria Gerontidou, ***Eleni Natalia Proimou***
University of Athens

This study presents a statistical analysis of various properties of all recorded until now Ground Level Enhancement (GLE) events, focusing on their association with solar sources. Specifically, we examine the time difference between the onset of the solar flare and the onset of GLE events as well as the correlation between GLE occurrence and amplitude with the main solar flare characteristics, such as longitude and intensity. Our preliminary results indicate an average time

delay of 37 minutes between solar flares and GLE onset, with the mean solar flare class estimated at X4.93. The longitudinal distribution suggests a dominant solar flare location at 43.6° West. Additionally, we calculate the time correlation between GLE onset and the onset of >100 MeV proton flux. The results of this study could significantly contribute to several key domains within space weather research.

Session 4: Cosmic Ray Detection Instrumentation

Neutron Monitor based Approaches of the Incoming Flux Correction for Cosmic-Ray Neutron Sensing of Soil Moisture

Lasse Hertle *(Helmholtz-Centre for Environmental Research), Steffen Zacharias (Helmholtz-Centre for Environmental Research), Nicholas Larsen (Sodankyla Geophysical Observatory, University of Oulu), Daniel Rasche (GFZ Helmholtz Centre for Geosciences), Martin Schrön (Helmholtz-Centre for Environmental Research)*

Abstract

Hydrological monitoring using cosmic ray neutrons is strongly dependent on heliospheric and geomagnetic conditions. To correct for changes in the heliosphere, the most common approach is to use neutron monitor data. Multiple neutron monitor-based correction methods have been proposed. The derivation, inherent assumptions, and limitations of these methods were examined and a novel method derived. Further, a model-based approach is also introduced. All correction methods were evaluated on long-term neutron monitor data and their impact assessed using artificial cosmic ray neutron sensor data.