T 120: Cosmic Ray V

Time: Thursday 15:50–17:20 Location: POT/0013

T 120.1 Thu 15:50 POT/0013

Unfolding the Atmospheric Muon Spectrum Using Stopping Muons in IceCube* — •Lucas Witthaus for the IceCube-Collaboration — TU Dortmund University

The IceCube Neutrino Observatory is a cubic kilometer neutrino detector located in the ice sheet close to the geographical South Pole. Its primary goal is the observation of neutrinos. However, the majority of detected events is caused by atmospheric muons produced in cosmic ray induced air showers in the upper layers of the atmosphere. Upon entering the antarctic ice, the muons are subject to significant energy losses due to interactions with the surrounding matter, resulting in a limitation of their propagation length. This talk presents the unfolding of the stopping muons depth intensity, providing information about the abundance of atmospheric muons in the South Pole ice. It is conducted on a subset of events, comprising single muons, which stop inside the IceCube detector. Deep neural networks are used to perform the event classification and reconstruction tasks.

* Supported by the BMBF and the DFG (SFB 1491)

T 120.2 Thu 16:05 POT/0013

Improved Measurements of Seasonal Variations of the Atmospheric Neutrino Flux with IceCube — •Shuyang Deng, Jakob Bötter, Hannah Erpenbeck, Philipp Fürst, Erik Ganster, Matthias Thiesmeyer, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut B RWTH Aachen University

The IceCube Neutrino Observatory is proven to be highly efficient in detecting atmospheric neutrinos that originate from cosmic-ray induced air showers. The high statistics allow measuring the correlation between the atmospheric neutrino flux and atmospheric properties such as temperature. This correlation depends particularly on the early hadronic development of air showers in the upper atmosphere. In this talk we present the extension of a previous analysis from six years to about ten years of observations. Furthermore, we investigate improved descriptions of atmospheric temperature profiles, and test the prediction of different hadronic interaction models.

T 120.3 Thu 16:20 POT/0013

Searching for the Prompt Component of the Atmospheric Muon Flux — Pascal Gutjahr, Jean-Marco Alameddine, Mirco Hünnefeld, and •Ludwig Neste for the IceCube-Collaboration — Astroparticle Physics WG Rhode, TU Dortmund University, Germany

The muon is connected to many challenges in current physics, such as the muon puzzle in cosmic-ray induced air showers. The prompt component of the atmospheric muon flux has not been measured with high significance, yet. Understanding and measuring the prompt muon flux could help to better understand these challenges and help to test hadronic interaction models.

Atmospheric muons stem from the decay of particles created in hadronic interactions and their flux can be divided into a conventional and a prompt component. In the conventional part, muons originate from the decay of long-lived particles, mainly pions and kaons. In the prompt part, muons are produced by the decay of short-lived mesons. They consist of charmed mesons, strange mesons and unflavored ones.

In this talk, the current state of the analysis, which aims to confirm the existence of the prompt muon flux with the IceCube detector, is presented. Previous analyses suffered from statistical and systematic uncertainties in Monte Carlo simulations. Thus, we evaluate and create a new set of Monte Carlo simulations specialized to measure the prompt component.

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T 120.4 Thu 16:35 POT/0013

Sensitivity of IceCube-Gen2 for Cosmic-Ray Anisotropy Studie — •Wenjie Hou for the IceCube-Gen2-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology (KIT)

At which energy the transition from Galactic to extra-galactic cosmic rays (CRs) takes place is one of the major unresolved issues of cosmic ray physics. One expects to get strong constraints by studying the anisotropy in the cosmic-ray arrival directions. Recently, the cosmic ray anisotropy measurements in the TeV to PeV energy range were updated from IceCube using its 11 years of data. Moreover, IceCube-Gen2 is designed to achieve an exposure about 8 times larger than the IceCube area, as well as more statistics and capability to investigate the cosmic-ray anisotropy with higher sensitivity. The sensitivity of IceCube-Gen2 to anisotropy is in particular a matter of statistics. Taking into account the detector exposure of IceCube-Gen2 and the dipole input, we build a Monte Carlo toy model for IceCube-Gen2 and randomly generate the arrival directions for 10 years of measurements. In this case, the relative intensity maps, significance maps and angular power spectrum can be investigated. More importantly, by scanning the dipole declination and zenith threshold, we can determine under what conditions IceCube-Gen2 could achieve the highest sensitivity to observe the cosmic-ray anisotropy. In general, the current studies on the sensitivity of IceCube-Gen2 for CR anisotropy will also be discussed.

T 120.5 Thu 16:50 POT/0013

Studies on Monte Carlo generator tuning for cosmic-ray induced air shower simulations * — Kevin Kröninger, Salvatore La Cagnina, and •Michael Windau — TU Dortmund, Fakultät Physik

Monte Carlo (MC) generators are a fundamental tool in particle and astroparticle physics. To achieve a high-quality simulation of physical processes involving hadrons, the hadronic interaction model of the generator must be tuned efficiently. The free parameters of MC generators are optimized with the help of experimental data and Bayesian methods.

One area of application for MC generators is the simulation of cosmic-ray induced air showers in the Earth's atmosphere. Since hadronic interactions have a direct influence on the composition of secondary particles in the shower formations, tuning the parameters of these hadronic models has an impact on crucial observables such as the muon number.

In this talk, studies on the tuning of Monte Carlo generators for cosmic-ray induced air showers are presented.

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T 120.6 Thu 17:05 POT/0013

Fixed-target $\pi^{\pm}$ C interactions at GeV energies simulated with PYTHIA8* — •Chloé Gaudu — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany

Understanding the properties of extensive air showers (EAS) is of prime importance for extracting the properties of ultra high-energy cosmic rays from data, such as collected by the Pierre Auger Observatory. Inferring their primary energy and, most importantly, their primary mass relies on detailed comparisons of EAS measurements with corresponding air shower simulations. The largest uncertainties in such simulations are caused by limited knowledge of hadronic interactions at high energies. To assess the effect of such uncertainties, different hadronic interactions are applied in EAS simulations, each of them being tuned to accelerator data. PYTHIA8 is a hadronic interaction model that is frequently used in the context of LHC experiments and is well suited to be tuned to accelerator data, but up to now has only rarely been used in EAS simulations. This contribution focuses on studying the production cross-sections and p_T-integrated particle spectra from charged pion-carbon fixed-target collisions at momenta between 3 and 350 GeV/c and comparing them against the newest version of the hadronic interaction model PYTHIA8. Three distinct datasets from the HARP, HARP-CDP, and NA61/SHINE collaborations are used for this purpose. The validity of the model to describe the experimental datasets is investigated using the RIVET interface. We discuss the results of this comparison as well as the effects to the uncertainties of EAS simulations. **Supported by DFG (SFB 1491).*