T 72: Cosmic Ray 3

Time: Wednesday 16:15–18:30 Location: T-H31

T 72.1 Wed 16:15 T-H31

Using in-ice muons for Cosmic-Ray composition analysis at IceCube Observatory — •Paras Koundal for the IceCube-Collaboration — Institute for Astroparticle Physics, KIT Karlsruhe, Germany

Understanding the dynamics of astrophysical sources is a pursuit that is very dear to many astrophysicists. Cosmic-Rays (CRs), charged particles from these astrophysical accelerators, provide us with a unique opportunity to discern the fundamental properties and behavior of such sources. IceCube Neutrino Observatory, concealed deep under the South-Pole Antarctic ice, detects the particles from these astrophysical sources. The integrated operation of the in-ice array of IceCube (primarily a neutrino detector), with its surface array, IceTop, affords us unique three-dimensional detection capabilities for CR-induced air showers.

The talk will discuss the work done to use the in-ice shower-footprint primarily caused by high-energetic muons in cosmic-ray air-showers, for improving cosmic-ray composition estimation at IceCube Observatory. The work will introduce new composition-sensitive parameters with minimal dependence on hadronic-interaction models. Hence, the work provides a suitable solution for detailed composition analysis while reducing systematic effects of choosing a hadronic-interaction model for interpretation of observed real data.

T 72.2 Wed 16:30 T-H31

Unfolding the Atmospheric Muon Spectrum Using Stopping Muons in IceCube — •Lucas Witthaus, Karolin Hymon, Johannes Werthebach, Janina Bolles, and Jan Soedingrekso for the IceCube-Collaboration — Astroparticle Physics WG Rhode, TU Dortmund University, Germany

The IceCube Neutrino Observatory is a cubic-kilometer neutrino detector located in the ice sheet close to the geographical South Pole. However, the majority of detected events is caused by atmospheric muons created in cosmic ray induced air showers in the upper layers of the atmosphere. Upon entering the antarctic ice, they lose energy in interactions with the surrounding matter, resulting in a limitation of their propagation length.

This talk presents the unfolding of the stopping muon depth intensity by means of a maximum likelihood approach. 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.

T 72.3 Wed 16:45 T-H31

Towards the Energy Spectrum of Cosmic Rays using Atmospheric Stopping Muons in IceCube — •Janina Bolles, Karolin Hymon, Johannes Werthebach, Lucas Witthaus, and Jan Soedingrekso for the IceCube-Collaboration — Astroparticle Physics WG Rhode, TU Dortmund University, Germany

In the IceCube Neutrino Observatory the main type of detected events are muons being produced by cosmic ray particles interacting with the Earth's atmosphere. In the context of neutrino analyses, these muons are the dominant background. In case of cosmic ray physics the energy losses of the muons within the detector can be used as an indicator to reconstruct the cosmic ray energy spectrum.

In this work, muon events stopping inside the detector are selected to use the range to the stopping point as a proxy for the muon energy. This approach takes advantage of the high statistics of atmospheric muons. Strict cuts on the reconstruction can be applied to obtain an event sample of single muons with high resolution. The reconstructed range of the muons can be used to estimate the cosmic ray energy spectrum. First results of the unfolded cosmic ray flux are presented.

T 72.4 Wed 17:00 T-H31

An updated model of galactic diffuse neutrinos for future IceCube searches — •Georg Schwefer[1,2], Philipp Fürst[2], Erik Ganster[2], Philipp Mertsch[1], and Christopher Wiebusch[2] — [1]RWTH Aachen University - Institute for Theoretical Particle Physics and Cosmology, Aachen, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

Diffuse galactic neutrinos are produced in interactions of hadronic cosmic rays with the interstellar medium in the Milky Way. This flux is a practically guaranteed signal for high-energy neutrino observatories. It has not been identified yet, but recent searches indicate that a discovery might be in reach within the next few years.

Because of the large background from atmospheric neutrinos, these searches require detailed modelling of the signal. These models also relate the (non-)observations to the propagation and injection properties of galactic cosmic rays at PeV energies.

In this talk, we present an updated model for the galactic diffuse neutrino flux tuned to the latest direct cosmic ray and diffuse gamma ray measurements, and discuss its systematic dependencies. We also show sensitivity estimates for future IceCube galactic plane searches with this model.

T 72.5 Wed 17:15 T-H31

Neural networks for cosmic ray simulations — •Pranav Sampathkumar, Antonio Augusto Alves Junior, Tanguy Pierog, and Ralf Ulrich for the CORSIKA 8-Collaboration — Institute for Astroparticle Physics (IAP) - KIT

Simulating cosmic ray showers at high energies is very memory and time intensive. Current model-dependent hybrid techniques are constrained by our ability to model from known physics. This contribution discusses novel machine learning techniques in order to bypass explicit simulations, and extract features which can't be modeled easily from first principles. The potential of Generative Adversarial Neural Networks (GANs) in learning and emulating cosmic ray simulations is discussed, along with a presentation of preliminary attempts in using a GAN in generating universal electron-positron distributions associated to showers with varying primaries and energies. The applicability and potential pitfalls in using a neural network based approach for cosmic ray simulations is also discussed. Finally, a CONEX (hybrid simulations using cascade equations) inspired Recurrent Neural network (RNN) model is presented. Preliminary results obtained from training an RNN using a cosmic ray simulation dataset for electromagnetic cascades generated using CORSIKA8 are summarized.

T 72.6 Wed 17:30 T-H31

Extrapolation uncertainty of meson-air cross-sections in UHECR air shower simulations — •Maximilian Reininghaus[1,2], Ralf Ulrich[1], Ralph Engel[1], and Tanguy Pierog[1] — [1]Karlsruher Institut für Technologie, Karlsruhe, Deutschland — [2]Instituto de Tecnologías en Detección y Astropartículas, Buenos Aires, Argentina

The interaction cross-sections of long-lived hadrons with air nuclei are an important ingredient in the simulation of air showers initiated by high energy cosmic rays. For protons they are tightly constrained by LHC measurements. For other species, in particular pions, which are the most abundant hadrons in air showers, however, precise measurements are available only at low energies. Since there exists significant leeway in a large energy range up to the highest energies, hadronic interation models differ in their extrapolations by up to 30 %.

In this contribution, we study the impact of this extrapolation uncertainty on air shower phenomenology by introducing ad hoc, energy-dependent factors to scale the cross-sections for each species independently. Using a hybrid setup with CORSIKA 8 and CONEX, we simulate UHECR air showers with these modified cross-sections and study the effect on muon content, shower maximum and muon production depth. We find that the longitudinal development is sizeably affected, while the particle content changes only to a minor degree.

T 72.7 Wed 17:45 T-H31

Simulating radio emission from air showers with CORSIKA8 — •Nikolaos Karastathis[1], Remy Prechelt[2], Tim Huege[1,3], and Juan Ammerman-Yebra[4] for the CORSIKA 8-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Department of Physics and Astronomy, University of Hawaii Manoa, Hawaii, USA — [3]Astrophysical Institute, Vrije Universiteit Brussel, Brussels, Belgium — [4]Instituto Galego de Física de Altas Enerxías, Universidade de Santiago de Compostela, Santiago de Compostela, Spain

CORSIKA 8 (C8) is a new framework for air shower simulations implemented in modern C++17, based on past experience with existing codes like CORSIKA 7. It is a project structured in a modular and flexible way that allows the inclusion and development of independent modules that can produce a fully customizable air shower simulation. The calculation of radio emission from the simulated particle showers is incorporated as an integral module of C8, including signal propagation and electric field calculation at each antenna location using the "Endpoints" and ZHS formalisms simultaneously. Due to C8's flexibility, the radio functionality can be used both to validate other physics modules and to investigate specific physical scenarios. In this talk, we are going to present air shower simulations generated with C8 and compare their predicted radio emission with corresponding air showers simulated with CORSIKA 7 and ZHAireS. Radio calculation validation, a comparison of the "Endpoints" and ZHS formalisms along with the future steps of radio in C8 are also going to be shown.

T 72.8 Wed 18:00 T-H31

Energy Reconstruction using a Template Method for Radio Signal of Air Showers recorded by the Prototype Station of the IceCube Surface Enhancement — •Roxanne Turcotte for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT)

The IceTop array, located at the surface of the IceCube Neutrino Observatory, is currently used as a veto for the in-ice neutrino detection as well as a cosmic-ray detector. Over the years, snow accumulated on the IceTop detector leading to a reduction of its sensitivity and resolution. In order to improve the detector, an enhancement of IceTop is planned in the coming years which consists of an array of scintillation panels and radio antennas. The radio antennas will lead to a better resolution of the energy and the depth of shower maximum (X_{max}) around the second knee region of the cosmic-ray energy spectrum. Eventually, hybrid detection will enable a better estimation for the mass of the primary cosmic ray.

In January 2020, a prototype station comprising three antennas and eight scintillation panels was deployed at the South Pole. We developed the tools necessary to use a template-matching method for energy reconstruction and applied it to some of the radio events recorded. This template method uses Monte-Carlo simulations and compares it to recorded data. For this, a set of simulations is created using the reconstruction by IceTop as input to CORSIKA/CoREAS. In this talk, we will present the method and the preliminary results.

T 72.9 Wed 18:15 T-H31

IceAct Upgrade Status - SiPM Based Compact Imaging Air-Cherenkov Telescopes for IceCube — •Hannah Erpenbeck, Thomas Bretz, Lars Heuermann, Cengiz Kuruoglu, Frank Malowski, Mark Meyers, Florian Rehbein, Merlin Schaufel, and Christopher Wiebusch for the IceCube-Collaboration — RWTH Aachen University - Physics Institute III B, Aachen, Germany

IceAct is an array of compact imaging air Cherenkov telescopes that are optimized for the harsh conditions of the South Pole. Since January 2019 two IceAct telescopes, featuring 61 SiPM pixels and a Fresnel lens based optics, operate at the surface above IceCube in the center of IceTop. By hybrid measurements of cosmic rays together with the IceTop and the IceCube detectors, they enable improved cosmic ray studies and cross calibrations. Six new telescopes are currently being assembled as an upgrade for IceAct. To ensure high instrument reliability, each of the telescopes is tested individually including field tests and strict quality assurance of all components. This talk will report on the project status as well as on the construction and the testing results of the new telescopes.