T 100: Cosmic Ray 5

Time: Thursday 16:15–18:30 Location: T-H32

T 100.1 Thu 16:15 T-H32

Low-Energy Cosmic Ray Composition with IceCube and IceTop — •Julian Saffer for the IceCube-Collaboration — Institut für Experimentelle Teilchenphysik, Karlsruher Institut für Technologie (KIT)

IceTop is the surface component of the IceCube Neutrino Observatory at the geographic South Pole and dedicated to the indirect detection of cosmic rays (CRs). Studying the primary CR spectrum and mass composition around the knee requires a dedicated IceTop trigger for smaller air showers initiated by lower-energy primaries as well as the combination of surface (predominantly electromagnetic) and corresponding in-ice (muonic) signals. Monte-Carlo simulation data of air showers at IceCube ranging down to $E_0 = 10^5$ GeV have been used to train boosted decision trees for the reconstruction of shower core position, zenith angle, primary energy and mass of the incoming CR particles.

This talk presents the input features fed into the different machine learning models, the chosen model architectures and reconstruction results for four primary mass types. Additionally, plans towards an enhancement of the reconstruction utilizing a set of convolutional neural networks are discussed.

T 100.2 Thu 16:30 T-H32

Simulation Study of Atmospheric Muons with IceCube-Gen2 — •Jonathan Messner, Agnieszka Leszczynska, and Andreas Haungs for the IceCube-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

The next generation of the IceCube Neutrino Observatory called IceCube-Gen2 will extend the detector's capabilities in both, neutrino and cosmic-ray measurements. In particular, the combination of the in-ice optical modules and the large array of surface detectors will enhance the understanding of extensive air showers and the studies of cosmic rays. Muons produced in air showers can deliver relevant information not only about incoming cosmic rays but also about properties of the air showers. Conventional atmospheric muons are produced by decays of pions and kaons, while prompt muons originate mainly from decay of charmed and unflavoured mesons. This prompt component is expected to dominate the muon flux at higher energies. Due to larger aperture for coincident measurements, with surface and in-ice arrays, IceCube-Gen2 has the potential to measure this prompt component in relation to the properties of parent cosmic rays. In this contribution high energy muons, especially prompt muons, will be studied based on air shower simulations in order to better understand the capabilities of IceCube-Gen2.

T 100.3 Thu 16:45 T-H32

Improving gamma-hadron separation for air showers at the IceCube Neutrino Observatory — •Federico Bontempo for the IceCube-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

The IceCube Neutrino Observatory is an experiment located at the geographic South Pole. It is composed of two detectors: an optical array deep in the ice and an array of ice-Cherenkov tanks at the surface called IceTop. The combination of the two detectors can be exploited for the study of cosmic rays. The in-ice detector measures the high-energy muonic component of air showers, whereas the signal strength on IceTop is dominated by the electromagnetic component. The aim of this work is to discriminate between photon and hadron initiated air showers. This discrimination was already attempted using a machine learning technique named Random Forest. Here, a different approach is presented which uses both Random Forests and deep learning techniques, in particular, supervised learning techniques that predicts unknown data after studying labeled data. The physics quantities used for this study are the charges measured by the in-ice detector, the reconstructed zenith angle, the in-ice containment of the shower, the reconstructed energy and a likelihood estimator that captures both the presence of individual muons and charge fluctuations in the surface array.

Furthermore, the planned enhancement of IceTop, comprised of surface radio antennas and scintillator panels, will contribute to the improvement of the gamma-hadron separation.

T 100.4 Thu 17:00 T-H32

Mass-sensitive parameter with the IceTop surface array — •Donghwa Kang for the IceCube-Collaboration — Karlsruher Institut für Technologie (KIT)

IceTop, the surface component of the IceCube Neutrino Observatory at the South Pole, measures the air showers of cosmic ray with energies from PeV up to EeV. By means of the charge signal measurements only with the IceTop surface array, a parameter sensitive to the muon content was defined and estimated event by event. In this contribution, the estimated mass-sensitive parameter and its dependencies on the hadronic interaction models will be presented. In addition, the applicability of energy and mass composition reconstruction of cosmic rays will be discussed.

T 100.5 Thu 17:15 T-H32

Sensitivity of IceCube-Gen2 for High-Energy Cosmic Ray Anisotropy Studies — •Wenjie Hou and Donghwa Kang for the IceCube-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology (KIT), Karlsruhe

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. Although the sources of high-energy cosmic rays remain unknown, one expects to identify them by studying the anisotropy in their arrival directions. Recently, the cosmic ray anisotropy measurements in TeV to PeV energy range were updated from IceCube using its nine years of data. IceCube-Gen2 is designed to have a detector volume about 8 times larger than IceCube and will achieve an increased exposure to cosmic rays by a factor of 30. This improvement could allow us to obtain high-quality measurements of cosmic ray air showers and investigate the cosmic ray anisotropy with higher sensitivity.

The sensitivity of IceCube-Gen2 to anisotropy is purely a matter of statistics. Hence, based on the simulation of IceCube-Gen2, the first attempt is to make an exposure map taking into account detection efficiency and resolution. We will build a Monte Carlo toy simulation model of IceCube-Gen2. In this case, the expected maps will be generated with random events, resulting in the angular power spectrum. Eventually, we can determine under what conditions IceCube-Gen2 could achieve the highest sensitivity to observe cosmic ray anisotropy. In this contribution, the current studies on the anisotropy with the simulation will be discussed.

T 100.6 Thu 17:30 T-H32

First results of the IceCube Surface Array Enhancement Prototype — •Marie Oehler for the IceCube-Collaboration — KIT, Karlsruhe, Germany

The IceCube Observatory is a cubic-kilometer neutrino detector installed in the ice at the geographic South Pole. To increase the efficiency of detecting astrophysical neutrinos the upgrade IceCube-Gen2 is under development. To also boost the sensitivity of the surface array, IceTop, an enhancement consisting of a hybrid scintillation-detector and radio-antenna array is planned.

An optimized prototype station, consisting of eight scintillation detectors and three radio antennas, was deployed in January 2020. Both, scintillation detectors and radio antennas, are read out by a central hybrid data acquisition system (DAQ). The scintillation detectors transfer digitized integrated signals to the DAQ to minimize the amount of transmitted data and trigger the radio antennas. The radio waveforms are transferred as analog signals to the central DAQ and are digitized and read out, when triggered by the scintillation detectors. In this contribution the first measurement results will be shown.

T 100.7 Thu 17:45 T-H32

Measurements with the IceCube Surface Array Enhancement prototype — •Hrvoje Dujmovic for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT)

IceTop, the surface array of the IceCube Neutrino Observatory, currently consists of 162 ice Cherenkov tanks distributed over an area of 1 km. IceTop is used for cosmic-ray air shower detection and as a veto for the in-ice neutrino detector. The science case of IceTop will be greatly improved by complementing the existing detectors with an array of radio antennas and scintillator panels. The enhancement array will cover the same footprint as IceTop and will consist of 32 stations. One such station, consisting of 3 radio antennas and 8 scintillator panels, was deployed at the South Pole in January 2020. In this talk, we will present the measurements with the prototype station. The results obtained from the prototype station will help us better understand the full capabilities and physics potential of the IceCube*s surface enhancement.

T 100.8 Thu 18:00 T-H32

Status of the R&D and production of the scintillation detectors for the Surface Array Enhancement — •Shefali Shefali for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany

The IceCube Neutrino Observatory is a cubic kilometer scale detector deployed in the Antarctic ice and is involved in cosmic ray physics. The surface array of IceCube, IceTop, operates as a veto for the astrophysical neutrino searches and calibration detector for the IceCube in-ice instrumentation. Despite its contribution, the snow accumulation on top of these detectors results in an increased energy uncertainty in the detected particles and consequently, the shower reconstruction. Moreover, the enhancement of IceTop will lead to a better measurement of the extensive air showers and improve the astrophysics of the high-energy cosmic-ray sky.

Enhancing IceTop with a hybrid array of scintillation detectors and radio antennas will lower the energy threshold for air-shower measurements, provide more efficient veto capabilities, enable the separation of the electromagnetic and muonic shower components and improve the detector calibration by compensating for snow accumulation. Following the success of the first complete prototype station consisting of three radio antennas and eight scintillation detectors deployed at the South Pole in 2020, the R&D and production of detectors for a total of 32 stations is ongoing. The production challenges, deployment status, and calibration methods of the scintillation detectors will be discussed in this contribution.

T 100.9 Thu 18:15 T-H32

An IceCube Surface Array Enhancement station for deployment at Telescope Array — •Noah Goehlke for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT), Karlsruhe

The IceTop array, located on the surface of the IceCube Neutrino Observatory, will be enhanced with hybrid radio and scintillator stations. The DAQ of each station is housed in a FieldHub. In January 2020 a full prototype station was deployed and is successfully operating and taking data. For the planned IceCube-Gen2 facility, the DAQ of the surface array and the in-ice array will be combined, using a modified FieldHub. The development of this FieldHub will be performed by the University of Utah, which is also contributing to the Telescope Array (TA), an air-shower detector array located in Utah.

By deploying a prototype station at TA, the Univerity of Utah is provided with the preliminary hardware of the future surface array, which is needed to design the new FieldHub. In addition, it can serve as a testing platform for IceCube-Gen2 and it enables cross calibration with TA. Since the environment and infrastructure in Utah and the South Pole differ significantly, adjustments of the prototype station are in development. As example, the detectors have to be able to measure air-shower particles at much higher ambient temperature and humidity levels as found at the South Pole.

In this contribution the adapted design of the prototype station as well as experiments done to investigate the detectors behavior at higher temperatures will be presented.