T 62: Cosmic rays II

Time: Wednesday 16:30–19:05 Location: L-3.002

Group Report T 62.1 Wed 16:30 L-3.002
The Pierre Auger Observatory – Status, Results, Prospects — •Michael Schimp for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

The Pierre Auger Observatory is the world's largest cosmic ray observatory. The surface detector (SD) covers an area of 3000 km^2 instrumented with 1660 stations. Surrounding the SD, 27 telescopes at 4 sites comprise the fluorescence detector (FD). The SD stations sample the lateral particle distributions of extensive air showers (EASs) on the ground while the FD measures the longitudinal profile of the EASs. Combined, SD and FD allow for 100 % duty cycle calorimetric EAS detection.

Recent results show that the energy spectrum of UHECRs has more features than known before, and that the UHECR mass composition is best described as mixed with overall increasing primary particle masses towards the highest energies. Additionally, several significant large and medium scale anisotropies have been revealed. Searches for neutrinos and photons have lead to the most significant constraints on their fluxes in a substantial energy and directional range.

An upgrade of the Pierre Auger Observatory, called AugerPrime, is underway. It will add scintillation and radio detectors together with improved electronics to the SD stations. AugerPrime will allow for improved particle identification and therefore enhance the overall UHECR mass composition sensitivity for the full-duty-cycle SD.

T 62.2 Wed 16:50 L-3.002
Scintillation and Radio Detectors for an Enhancement of the IceTop Air-Shower Array — •Frank G. Schröder for the IceCube-Collaboration — Institut für Kernphysik (IKP), Karlsruher Institut für Technologie (KIT) — Bartol Research Institute, Department of Physics and Astronomy, University of Delaware

IceTop is the 1 km^2 surface array of the IceCube neutrino observatory. IceTop detects cosmic-ray air showers in the PeV to EeV energy range, but is losing sensitivity due to snow coverage. A planned enhancement by scintillation and radio detectors on the surface will solve this problem and increase the measurement accuracy for the energy and mass of the primary particles initiating the air showers. In addition to providing a veto and calibration tool for in-ice detectors, the more accurate measurement of the cosmic-ray mass composition and absolute flux will help us to better understand atmospheric muon and neutrino fluxes, which are important backgrounds for IceCube's astrophysical neutrino measurements. Moreover, the increase in accuracy and sky coverage compared to the current IceTop will enable new science goals: The improved classification of the primary particle will help to determine the transition from Galactic to extragalactic sources expected at energies between 100 PeV to a few EeV, and the search for PeV photons provides direct discovery potential for the - yet unknown - most energetic Galactic sources. This talk will provide an overview about the prototype detectors existing at the South Pole, and the plans for the upgrade of the full IceTop arrays in the next years.

T 62.3 Wed 17:05 L-3.002
Event Reconstruction with the Surface Scintillator Detectors of AugerPrime — Markus Roth[1], •David Schmidt[1], Alexander Streich[1,2], Alvaro Taboada[1,2], and Darko Veberic[1] for the Pierre Auger-Collaboration — [1]Karlsruher Institut für Technologie (KIT) — [2]Universidad Nacional de San Martin (UNSAM)

Reconstructing the mass of ultra-high-energy cosmic rays from measurements performed at ground hinges on disentanglement of the electromagnetic and muonic components of extensive air showers. The AugerPrime upgrade to the Pierre Auger Observatory will do exactly this by equipping each of the existing water-Cherenkov detector stations in its surface detector array with a 4 m^2 Scintillator Surface Detector, which is more sensitive to the electromagnetic component of showers. As part of the deployment plan, 77 detectors were switched on in March of 2019, and thousands of events have been collected since. We present the calibration of measurements performed by the upgraded stations as well as the first event reconstructions enhanced with information from the new detectors here.

T 62.4 Wed 17:20 L-3.002
IceScint: The Scintillator Upgrade of IceTop - Performance of the Prototype Array — •Thomas Huber for the IceCube-Collaboration — Institut für Kernphysik (IKP), Karlsruher Institut für Technologie (KIT) and Deutsches Elektronen-Synchrotron (DESY)

The IceCube Collaboration foresees to upgrade IceTop, the present surface array, with scintillation detectors augmented by radio antennas. As one of several goals the detectors will be used to measure and mitigate the effects of snow accumulation on the IceTop tanks: The increasing energy threshold and efficiency loss are nowadays the sources of the largest systematic uncertainties in shower reconstruction and mass composition analysis. In addition, the upgrade will provide useful experience for the development of next generation neutrino detectors proposed for the South Pole.
Beginning of 2018 two full prototype stations were installed near the center of the IceTop array. Each station features custom-designed electronics and consists of seven detectors, each having an active area of 1.5 m^2 plastic scintillator and wavelength shifting fibers read out by a Silicon Photomultiplier (SiPM).
In this talk the DAQ and detector R&D decicions, the calibrations methods and the performance are reviewed and results from more than one year of operation of the prototype station are shown. During that year several thousand air-shower events have been measured in coincidence with IceTop. In addition, the future plans for instrumenting the whole IceTop surface with scintillation detectors and radio antennas will be presented.

T 62.5 Wed 17:35 L-3.002
Composition Measurements with AugerPrime using Deep Learning* — •Sonja Schröder for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

The AugerPrime upgrade of the Pierre Auger Observatory in Argentina enhances the precision of primary particle composition measurements made by the surface detector. This is achieved using the different responses of the Water-Cherenkov-Detector (WCD) and the Surface-Scintilator-Detector (SSD) on top, to the electromagnetic and muonic component of the extensive air shower. While the upgrade is still in progress, the cosmic ray composition sensitivity of AugerPrime can already be probed using current machine learning techniques, such as deep neural networks, on simulations.

In this presentation a deep learning approach is shown to be able to reconstruct the depth of shower maximum X_{max}, a mass sensitive observable, on an event-by-event basis. A combination of deep convolutional neural networks is used to process information from both WCD and SSD signals. These signals are extracted from full AugerPrime detector simulations containing a mixed composition of protons, helium, nitrogen and iron. The sensitivity of the reconstruction will be shown, as well as its estimated bias and resolution.
* *Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A17PX1).*

T 62.6 Wed 17:50 L-3.002
Design and preliminary results of the radio antennas array of the first complete prototype station inside IceTop footprint — •Roxanne Turcotte for the IceCube-Collaboration — Institut für Kernphysik (IKP), 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. Snow accumulated on the tanks which reduces the detector sensitivity and resolution. In order to improve those, an enhancement of IceTop is planned in the next few years which consists of an array of scintillator panels and radio antennas. Upgrading IceTop with radio antennas will improve the measurement accuracy and the field-of-view for the detection of cosmic rays, which will lead to a better estimation of the mass composition as well as a better mitigation of the atmospheric neutrino background for the in-ice neutrino. In January 2019, the first two antennas were deployed alongside seven scintillators. As a follow-up, a refurbished station with three antennas and eight scintillators, in the station layout planned for the full array, will be deployed in January 2020. This talk will focus on this prototype station. I will present the radio front-end electronics, the antenna structure and give an overview of the first data recorded by the surface antennas at the South Pole.

T 62.7 Wed 18:05 L-3.002

Paving the way to an event-by-event level estimation of the masses of UHECRs with AugerPrime and Air Shower Universality — •Maximilian Stadelmaier[1], Markus Roth[1], Ralph Engel[1], and Federico Sanchez[2] for the Pierre Auger-Collaboration — [1]KIT, Karlsruhe, Germany — [2]ITeDA, Buenos Aires, Argentina

Reconstructing the primary masses of ultra high-energetic cosmic rays (UHECRs) on event level can give insight into a manifold of open questions in astrophysics, for instance identifying individual sources or source regions. A reconstruction based on Air Shower Universality allows the determination of the relative muon content, R_μ, and the atmospheric depth of the shower maximum, $X_{\max}$, of an extensive air shower with data collected only from a surface detector. Both these observables can be linked to the mass of the cosmic ray. The upgraded surface detector of the Pierre Auger Observatory, *AugerPrime*, will allow an accurate reconstruction of these mass sensitive observables on an event level. We present the principles of Air Shower Universality as well as first results based on simulations to reconstruct the relative muon content of extensive air showers produced by ultra high-energetic cosmic rays using AugerPrime.

T 62.8 Wed 18:20 L-3.002

Characterisation of the radio background at the future IceTop upgrade site — •Hrvoje Dujmovic for the IceCube-Collaboration — Institut für Kernphysik, Karlsruher Institut für Technologie (KIT)

IceTop, the surface array of the IceCube Neutrino Observatory, currently consists of 162 ice Cherenkov tanks and is used for the detection of air showers, besides being used as a veto and calibration device for the in-ice neutrino detector. The analyses of the IceTop data have led to many important results in cosmic ray physics. The science case of IceTop can be further enhanced by complementing the existing detector with an array of radio antennas and scintillator panels. Due to the unique location at the geographic South Pole and the radio-quite environment, the radio antennas are expected to provide an excellent characterisation of the electromagnetic shower component. This will help us identify primary particle mass and give us a good sensitivity to inclined air showers, in particular interesting for those arriving from the direction of the Galactic Centre. As a test for the deployment of the full array, a first prototype station with scintillator panels and two radio antennas has been deployed at the Pole in January 2019. The data collected from this station has been crucial for giving us a better understanding of the radio background at the IceTop site, giving us a more realistic estimate of the future array performance and helping us with design decision for the final array hardware. In this talk, I will show the background measurements obtained from the prototype station and give a summary of the analysis results.

T 62.9 Wed 18:35 L-3.002

Signal processing aspects of the AERA absolute energy scale analysis — •Vladimir Lenok for the Pierre Auger Collaboration — Karlsruhe Institute of Technology, Institute for Nuclear Physics, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

Determination of the absolute energy scale of cosmic-ray measurements is one of the present goals of great importance for astroparticle physics. Recently, significant progress towards this direction has been achieved by the Auger Radio Engineering Array (AERA), a digital detector of air-shower radio emission within the Pierre Auger Observatory. AERA pioneered the use of well physically motivated values in the analysis of radio emission of air showers such as energy fluence, and in application of the axially asymmetrical radio-emission footprint models for sparse arrays. For the time being, AERA is approaching a new milestone — validation of the absolute energy scale of cosmic-ray observations with radio measurements. This analysis consists of several steps on different levels. The proper signal processing is the foundation of all higher level steps for a correct estimation of the energy scale. In the talk I will present a comprehensive evaluation of the signal processing pipeline of AERA from the perspective of a consistent estimation of the energy fluence.

T 62.10 Wed 18:50 L-3.002

Development of a scintillation and radio hybrid detector station at the South Pole — •Marie Oehler[1], Tim Bendfelt[3], Hrvoje Dujmovic[1], Andreas Haungs[1], Bernd Hoffmann[1], Thomas Huber[1], Timo Karg[2], Matt Kauer[3], John Kelley[3], Marko Kossatz[2], Max Renschler[1], Frank Schröder[1], Karl-Heinz Sulanke[2], Delia Tosi[3], Roxanne Turcotte-Tardif[1], Andreas Weindl[1], and Chris Wendt[3] — [1]KIT, Karlsruhe, Germany — [2]DESY, Zeuthen, Germany — [3]UW, Madison, USA

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), researched, developed and built by a cooperation of DESY, UW-Madison and KIT. 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 enhanced prototype station and its DAQ will be presented and first measurement results will be shown.