T 9: Cosmic rays 2

Time: Monday 16:00–18:00 Location: Geb. 30.22: Lehmann-HS

T 9.1 Mon 16:00 Geb. 30.22: Lehmann-HS

Radio Measurements with an IceCube-Gen2 Surface Station installed at the Pierre Auger Observatory — •Carmen Merx[1], Sara Reina Torres[2], Benjamin Flaggs[2], and Frank Schröder[1,2] for the Pierre Auger and IceCube-Collaboration — [1]Karlsruher Institut für Technologie, Institut für Astroteilchenphysik — [2]University of Delaware, Bartol Research Institute

As radio detection of air showers has become a powerful tool to study high-energy cosmic rays, the surface array of the IceCube Neutrino Observatory at the South Pole is planned to be enhanced by radio antennas. The goal is to improve the accuracy of air shower measurements of energies of several 10 PeV and above. To this end, a prototype station composed of three SKALA antennas and eight scintillation panels is taking data at the South Pole in varying setups since 2020. In addition, an equal prototype station has been deployed at the Pierre Auger Observatory in Argentina in 2022 for tests and comparisons. In this presentation, first measurements of this protype station at the Pierre Auger Observatory will be discussed.

T 9.2 Mon 16:15 Geb. 30.22: Lehmann-HS

Geometry Alignment of IceAct and the IceCube Neutrino Observatory using Coincident Measurements of Cosmic-Rays — •Jonas Häussler, Lukas Brusa, Lars Heuermann, Merlin Schaufel, Lea Schlickmann, and Christopher Wiebusch for the IceCube-Collaboration — RWTH Aachen University, Aachen, Deutschland

IceAct is an array of Imaging Air Cherenkov Telescopes located at the South Pole as part of the IceCube Neutrino Observatory. The main goal of IceAct is the hybrid detection of air-showers for cross-calibrating the IceCube in-ice and IceTop surface detectors, enhancing cosmic-ray flux and composition measurements, and vetoing air-shower induced neutrinos. To properly combine the information from IceCube and IceTop with IceAct, the geometric alignment of the telescopes to the detector coordinates has to be known. We have developed a likelihood-based method to determine the alignment using coincident air-shower events. Applying this algorithm to the two already deployed telescopes at the South Pole, we achieve a resolution of a few percent of the pixel resolution.

T 9.3 Mon 16:30 Geb. 30.22: Lehmann-HS

Radio emission-mechanism of horizontal air showers measured with AERA at the Pierre Auger Observatory* — •Rukije Uzeiroska for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Wuppertal, Deutschland

The Pierre Auger Observatory is the world's largest detector measuring ultra high energy cosmic rays. The Auger Engineering Radio Array (AERA) is an ensemble of 153 antennas covering an area of 17 km^2 and is used to detect the radio emissions from extensive air showers (EAS). The radio emission consist of two main components: the geomagnetic and the charge-excess emission. These components can be disentangled by measuring the direction of the electric field vector.

This talk presents current efforts by the Pierre Auger Collaboration to determine the relative contributions of these two processes using the polarization pattern of the antenna stations for events measured with AERA, which helps to understand the development of air showers. The goal is to develop a reliable and robust analysis for determining the emission ratio a for horizontal EAS. Furthermore, theoretical expectations for this quantity within CoREAS simulations of horizontal air showers are verified. The simulations were reconstructed with the analysis framework of the Pierre Auger Observatory, offline. Comparisons of the simulated results with those already measured by LOFAR show agreement within the expected range of uncertainties.

Supported by BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A23PX1)

T 9.4 Mon 16:45 Geb. 30.22: Lehmann-HS

Transforming AERA into a powerful Terrestrial Gamma-ray Flash detector* — Markus Cristinziani[1], Qader Dorosti[1], Stefan Heidbrink[2], •Vivek Janardhana[1], Noah Siegemund[1], Jens Winter[2], and Michael Ziolkowski[2] for the Pierre-Auger-Collaboration — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Elektronikentwicklungslabor, Naturwissenschaftlich-Technische Fakultät, Universität Siegen

Terrestrial Gamma-ray Flashes (TGFs) are intense bursts of high-energy gamma rays originating from Earth's atmosphere during thunderstorms. Being under active research, it is assumed that the interactions of relativistic runaway electron avalanches, which are accelerated in large electrical fields of thunderstorms, are responsible for the production of TGFs.

The Pierre Auger Observatory has exploited its surface detectors to measure the TGF events. With AERA's 1-ns timing, the 3D imaging of lightning may be carried out with a metre-precision resolution. Given that the lightning process lasts several seconds, efforts are underway to modify the AERA digitizer board to increase lightning signal readout time from microseconds to several seconds. These efforts aim to enrich our understanding of TGFs by enabling more comprehensive data collection during thunderstorms.

*Supported by the BMBF Verbundforschung Astroteilchenphysik

T 9.5 Mon 17:00 Geb. 30.22: Lehmann-HS

Search for a mass dependent anisotropy of UHECRs with the Pierre Auger Observatory — •Edyvania Emily Pereira Martins for the Pierre-Auger-Collaboration — Karlsruhe Institute of Technology, ETP, Karlsruhe, Germany

The origin of cosmic rays (CRs) is an open and exciting topic in astrophysics. On this theme, the Pierre Auger Observatory investigates the anisotropies of the ultra-high-energy cosmic rays (UHECRs) — which possess energies above $\sim$1 EeV — at small, intermediate, and large angular scales. The Observatory (with the surface detector stations spread over 3000 km^2) has been collecting data for nearly 20 years, reaching more than 135 000 km^2 yr sr of accumulated exposure. So far, one of the most significant discoveries is a large-scale dipole structure with an amplitude of $\sim$7%. This results from a modulation in right ascension for events with energies above 8 EeV, where the dipole equatorial component has a statistical significance of over 5σ. The source of this structure is not yet understood. It could arise from diffusion and deflection of CRs in magnetic fields, and/or could be caused by the anisotropic distribution of nearby sources. In either case, a dependence on the charge and/or mass of the CRs is expected on both the amplitude and direction of the observed dipole. For the first time, the Auger Observatory is preparing to include information on the UHECR composition in a search for a mass-dependence signature on the observed dipole. In this contribution, we discuss the prospects of anisotropy searches in light of mass-composition information of Phase I of the Pierre Auger Observatory.

T 9.6 Mon 17:15 Geb. 30.22: Lehmann-HS

Depth of Maximum of Air-Shower Profiles above $10^{17.6}$ eV Measured with the Fluorescence Detector of the Pierre Auger Observatory and Mass-Composition Implications — •Thomas Fitoussi for the Pierre-Auger-Collaboration — IAP, KIT, Karlsruhe, Gerrmany

After seventeen years of operation, the first phase of measurements at the Pierre Auger Observatory finished and the process of upgrading it began. In this work, we present distributions of the depth of air-shower maximum, $X_{\max}$, using profiles measured with the fluorescence detector of the Pierre Auger Observatory. The analysis is based on the Phase I data collected from 01 December 2004 to 31 December 2021.

The $X_{\max}$ measurements take advantage of an improved evaluation of the vertical aerosol optical depth and reconstruction of the shower profiles. We present the energy dependence of the mean and standard deviation of the $X_{\max}$ distributions above $10^{17.6}$ eV. Both $X_{\max}$ moments are corrected for detector effects and interpreted in terms of the mean logarithmic mass and variance of the masses by comparing them to the predictions of post-LHC hadronic interaction models. We corroborate our earlier findings regarding the change of the elongation rate of the mean $X_{\max}$ at $10^{18.3}$ eV with higher significance. We also confirm, with four more years of data compared to the last results presented in 2019, that around the ankle in the cosmic rays spectrum, the proton component gradually disappears and that intermediate mass nuclei dominate the composition at ultra-high energies.

T 9.7 Mon 17:30 Geb. 30.22: Lehmann-HS

Updating the hybrid search for photons with the low-energy extensions of the Pierre Auger Observatory* — •Tim Fehler, Marcus Niechciol, and Markus Risse for the Pierre-Auger-Collaboration — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Ultra-high-energy (UHE) photons can reliably be detected with air-shower arrays, which have been primarily designed to efficiently observe cosmic rays at the highest energies. The diverse detector systems of the Pierre Auger Observatory have been utilized to place stringent upper limits on the diffuse, i.e. the direction-independent, unresolved, integral flux of UHE photons across several orders of magnitude in energy. A key focus has been on pushing the energy threshold of these analyses down to 10^{17} eV and below, as this energy range offers numerous connections to various aspects of multimessenger astrophysics. Currently, upper limits down to a threshold of 2×10^{17} eV have been determined using the low-energy extensions of the Observatory, namely the high-elevation fluorescence telescopes and the sub-array of the surface detector with spacing of 750 m. This contribution details the ongoing studies, based on simulations, to update this analysis and optimize the search strategy. The aim is to leverage the full Phase-1 dataset, which would more than double the statistics compared to the last publication in 2022.

**Supported by the BMBF Verbundforschung Astroteilchenphysik*

T 9.8 Mon 17:45 Geb. 30.22: Lehmann-HS

Measuring photon-induced air showers with the AugerPrime Radio Detector — •Jannis Pawlowsky for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany

The AugerPrime upgrade represents a significant enhancement in the capability of the Pierre Auger Observatory to detect air showers. Central to this advancement is the installation of a radio antenna atop each existing Surface Detector (SD) station, constituting the Radio Detector (RD). RD enhances the sensitivity of the SD to the electromagnetic component of air showers. Hence, the new detector presents an opportunity for the discovery of rare particles such as ultra-high-energy photons.

This presentation focuses on the detection and reconstruction of photon-induced air showers at the highest energies. The radio trigger designed for the detection of photon events will be outlined and the trigger efficiency and reconstruction accuracy in simulation studies will be discussed. The presentation will conclude by summarizing the effectiveness and discrimination power of the new detector component.

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