T 20: Cosmic Rays I

Time: Monday 16:15–17:45 Location: KS 00.006

T 20.1 Mon 16:15 KS 00.006

The Roving Laser System for Absolute Energy Calibration of the Fluorescence Telescopes at the Pierre Auger Observatory* — •Rukije Uzeiroska-Geyik for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal

The Fluorescence Detector (FD) of the Pierre Auger Observatory provides energy measurements of primary cosmic rays that are largely independent of specific interaction models. The FD energy measurement is crucial for calibrating the energy reconstruction of the Surface Detector. Consequently, the accuracy of the FD energy calibration plays a significant role in the systematic uncertainties associated with nearly all scientific results of the Observatory. To this end, a laser with a well-defined energy output will be fired in the field of view of the FD telescopes. Unlike other calibration methods, the response of the telescopes to the laser closely simulates its reaction to an actual cosmic-ray air shower. The system was designed with special attention to the depolarization of the laser beam to ensure a consistent relationship between energy output and directional light yield.

This contribution presents the results of the laboratory test measurements of the laser system, which were performed to validate and optimize its performance before field deployment. In addition, we report on the preparations for the first in-field calibration campaign of the FD telescopes in Argentina.

T 20.2 Mon 16:30 KS 00.006

Estimating the GZK Photon Flux from Extragalactic Cosmic Rays — •Chiara Jane Papior, Marcus Niechciol, and Markus Risse — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Extragalactic cosmic-ray sources emit particles with energies beyond 100 EeV. At ultra-high energies, charged particles interact with the cosmic microwave background via photo-pion production, also referred to as the Greisen-Zatsepin-Kuzmin (GZK) effect, generating so-called GZK photons. The photon flux at Earth originating from this effect and other interactions depends on parameters of the cosmic-ray spectrum like the spectral index or potential cutoffs. Other variables like the distance distribution of sources and the cosmic-ray mass composition have an impact on the expected photon flux as well. Simulations based on different input parameters have been performed with the CRPropa code and the expected GZK photon yields will be presented. The goal is to update the allowed range of the expected GZK photon flux based on current measurements of cosmic-ray observatories at ultra-high energies.

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T 20.3 Mon 16:45 KS 00.006

Cosmic-Ray energy spectrum measurements with IceTop — •Fahim Varsi for the IceCube-Collaboration — Karlsruhe Institute of Technology, Karlsruhe, Germany

IceTop, the surface ice-Cherenkov array of the IceCube Neutrino Observatory, detects extensive air showers generated from the interaction of the cosmic rays with the atmosphere. It measures cosmic rays in the PeV-EeV energy range, targeting the transition region between galactic and extragalactic cosmic-ray origins, including spectral features such as the knee and the second knee. A novel two-component LDF method is used for event reconstruction, providing an energy estimator along with mass-dependent parameters. An unfolding procedure is then employed to derive the all-particle energy spectrum from the energy estimator parameter. The details of the analysis will be presented in the conference.

T 20.4 Mon 17:00 KS 00.006

Neural Network-Based Estimation of Muon Content from Data Recorded by the SD-1500 of the Pierre Auger Observatory — •Steffen Hahn for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany

Ultra-high-energy cosmic rays (UHECRs) offer insights into the physics beyond the energies of human-made accelerators. However, to fully understand processes such as their acceleration, precise knowledge of their mass composition is crucial. Since the direct detection of UHECRs is infeasible, determining the mass of the primary particles is challenging. One method of accessing this information is to estimate the number of muons produced in extensive air showers (EASs). The direct measurement of high-energy muons in an EAS can be achieved by using arrays of buried detectors, such as the Underground Muon Detector (UMD) at the Pierre Auger Observatory. However, the instrumentation area of the UMD is limited in size. One of the central components of the Pierre Auger Observatory is the Surface Detector (SD), which consists of multiple triangular grids of hybrid detector stations. These stations record the time signals of the secondary particles that are produced in EASs that reach the ground. In this contribution, we present a neural network (NN) that utilizes SD-1500 data, the main surface detector array of the Pierre Auger Observatory, to predict the muon content of EASs. This NN is calibrated indirectly to the UMD measurements using a calibrated NN designed for the SD-750, the second-largest surface detector array located near the UMD.

T 20.5 Mon 17:15 KS 00.006

Observation of EarthCARE Laser Emissions with the Pierre Auger Observatory — •Thara Caba Pineda for the Pierre Auger-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — Observatorio Pierre Auger, Av. San Martín Norte 304, 5613 Malargüe, Argentina

The Atmospheric Lidar (ATLID) onboard the Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) satellite has been repeatedly observed by the Fluorescence Detector of the Pierre Auger Observatory. Side-scattered ultraviolet light from ATLID laser pulses is recorded by the Auger fluorescence telescopes, which are primarily designed to measure the longitudinal development of extensive air showers initiated by ultra-high-energy cosmic rays. These measurements enable a precise reconstruction of the atmospheric trajectory of the laser beam over the Observatory and provide a unique opportunity for systematic studies of the local atmospheric aerosol content. Furthermore, EarthCARE laser tracks can be observed at the Telescope Array Experiment in the USA within a few days during the same moon cycle, opening the possibility for a direct cross-calibration of the energy scales of the two cosmic-ray observatories. We present first reconstruction results from ATLID observations following EarthCARE*s launch in 2024. These results highlight the potential of satellite-based lidar observations to support calibration and atmospheric characterization efforts at the Pierre Auger Observatory.

T 20.6 Mon 17:30 KS 00.006

First results of the Auger Radio Infill SKALA Extension (ARISE) — •Carmen Merx[1], Stef Verpoest[2], Ben Flaggs[2], and Frank Schröder[1,2] for the Pierre Auger-Collaboration — [1]Karlsruhe Institute of Technology — [2]University of Delaware

Radio detection of extensive air showers has become a powerful technique for studying high-energy cosmic rays. To further enhance these measurements, the Pierre Auger Observatory in Argentina, one of the world‘s largest cosmic-ray experiments, has been upgraded with radio antenna stations. This upgrade aims to improve the precision of air-shower energy measurements in the energy range of several tens of PeV and above.

Within this framework, a new experiment, ARISE (“Auger Radio Infill SKALA Extension”), has been deployed at the Pierre Auger Observatory. ARISE consists of six stations, each comprising three SKALA antennas installed around a surface detector in the denser infill region.

This presentation will present first air-shower measurements from ARISE recorded in coincidence with the Auger surface detector array.