T 19: Cosmic Ray 1

Time: Monday 16:15–18:20 Location: T-H32

Group Report T 19.1 Mon 16:15 T-H32

The Pierre Auger Observatory – Status, Results, Prospects — •Philip Ruehl for the Pierre Auger-Collaboration — Center for Particle Physics Siegen, Experimental Astroparticle Physics, University of Siegen

With an instrumented area of about 3000 km^2, the Pierre Auger Observatory is the world's largest experiment for measuring cosmic particles. Its surface detector (SD) array is comprised of 1660 water Cherenkov detectors with a next-neighbor spacing of 1.5 km. The atmosphere above the SD is monitored by 27 fluorescence telescopes.

Precision measurements of the cosmic-ray energy spectrum have recently been extended down to 10^{17} eV using the SD-750 low-energy enhancement of the SD array, showing a gradual transition of the spectral index just above the "knee". A first measurement of the fluctuations in the muon content of air showers at ultra-high energies can be used to constrain hadronic interaction models trying to explain the observed muon deficit in air shower simulations. Recent advancements in the application of deep neural networks to Auger data enabled the successful reconstruction of $X_{\max}$ from SD data and an extraction of the muon component of simulated SD signal traces. The construction of the AugerPrime upgrade together with the AMIGA enhancement is in progress and will further enhance the mass discrimination power of the Observatory with additional scintillation and radio detector units in the SD array.

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T 19.2 Mon 16:35 T-H32

Analysis of laser shots of the Aeolus satellite in the Pierre Auger Observatory — •Felix Knapp for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie

The Pierre Auger Observatory is a large-scale facility for the investigation of ultra-high-energy cosmic rays. It uses a combination of surface detectors and fluorescence telescopes to measure extensive air showers initiated by cosmic-ray particles. Aeolus is an ESA-operated satellite with the mission of conducting global wind profile measurements. To this end, a UV-lidar is employed which emits laser beams towards Earth. When passing over the Pierre Auger Observatory, light that scatters off the laser beam in the atmosphere is detected by the Fluorescence Detector of the Observatory. This allows for a reconstruction of the laser tracks from the Fluorescence Detector data for several overpasses each year. These laser tracks provide a unique opportunity for analyses of the atmosphere above the Observatory.

In this presentation, we will explain the process of reconstructing laser tracks from data taken by the fluorescence telescopes and give an overview of the possible application for aerosol measurements. Furthermore, some results of the laser reconstruction are shown, including the most recent overpasses under a special orbital configuration of the satellite.

T 19.3 Mon 16:50 T-H32

A method to determine baselines of time traces at the Pierre Auger Observatory — •Tobias Schulz, David Schmidt, Darko Veberič, and Markus Roth for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany

The calibration and identification of detector signals is crucial for minimizing systematic uncertainties in measurements. A constant offset, called the baseline, which is generated by the electronics, has to be determined to properly estimate the size of the signals. At the Pierre Auger Observatory, two detector types, namely Water Cherenkov and Surface Scintillation Detectors, are used to measure the lateral distribution of extensive air showers at the ground. To determine the signal produced by the particles that enter the detectors, photomultiplier tubes (PMTs) are used to collect the emitted Cherenkov or scintillation light. The PMTs have one low gain channel and one amplified high gain channel. The analog pulses are read out and sampled with a flash analog to digital converter in a FADC time trace.

After a signal, the output of the PMTs is reduced by an undershoot, resulting in a lowered baseline, that recovers after a certain time period. Accidental muons or late air shower components can result in additional signal in the traces, which complicate the estimation of the baseline. Here, we present a method to estimate the baseline, that is robust to signal contributions in the trace and accounts for undershoot of the PMT.

T 19.4 Mon 17:05 T-H32

Combined analysis of the ultrahigh-energy cosmic-ray mass composition and hadronic interaction cross-sections — •Olena Tkachenko for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology, Karlsruhe, Germany

Studies of the cosmic-ray mass composition and hadronic interaction properties can improve our understanding of the origin and nature of the ultrahigh-energy cosmic rays. However, neither the mass composition nor the interaction cross sections are well measured at ultrahigh energies and normally the standard analyses require certain assumptions on either of these quantities to estimate the other one.

In this talk, we present a method for the independent and simultaneous estimation of the cosmic-ray composition fractions and proton-proton interaction cross-sections. We perform a standard mass composition fit using the measured distributions of the shower maximum of air showers ($X_{\max}$) while varying at the same time the interaction cross-sections and thus getting the best-fit combination of the estimated quantities without making any underlying assumptions on either of them. For this purpose, we modify the proton-proton interactions and the corresponding nucleus-nucleus cross-sections are then rescaled via the Glauber theory. We test the performance of this method and its sensitivity for the different composition and cross-section scenarios and compare the outcomes to the standard approach. We also study the effects of the $X_{\max}$ range selection and $X_{\max}$ scale uncertainty on the fit. Finally, we apply the method to data collected at the Pierre Auger Observatory and discuss the results.

T 19.5 Mon 17:20 T-H32

Measurement of the Energy Spectrum of UHECRs with the Fluorescence Detector of the Pierre Auger Observatory — •Kathrin Bismark for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie, Karlsruhe, Germany

The origin of ultrahigh-energy cosmic-rays (UHECRs) is one of the unsolved mysteries of modern-day astrophysics. The flux of UHECRs at Earth provides an important constraint on the luminosity density of their sources and the features in the UHECR energy spectrum shed light on the properties of astrophysical accelerators and on the propagation of cosmic rays through extragalactic photon fields.

Combining the measurements of the surface (SD) and fluorescence detector (FD) of the Pierre Auger Observatory allows us to determine a high resolution hybrid energy spectrum. Due to the partially redundant measurement of air showers with FD and SD, most event selection criteria and environmental influences on detection capabilities and reconstruction parameters can be investigated using measured data instead of simulations.

This presentation will focus in particular on the condition-independent visibility range of the FD, the so-called fiducial distance, given by the trigger efficiency of the FD. This trigger efficiency can be measured by determining the conditional probability to trigger a fluorescence telescope given an air shower detected by SD. The results of this study are compared to predictions from detector simulations and their impact on improvement of the precision of the measured spectrum will be discussed.

T 19.6 Mon 17:35 T-H32

Effects of magnetic fields on anisotropies in the arrival direction of ultra-high-energy cosmic rays — •Luca Deval, Ralph Engel, Thomas Fitoussi, and Michael Unger — Karlsruhe Institute of Technology, Institut für Kernphysik, Karlsruhe, Germany

The source of ultra-high-energy cosmic rays (UHECRs) is still an open question in astrophysics. The latest analysis of the dataset from the Pierre Auger Observatory revealed presence of anisotropy in the arrival direction of UHECRs which is an indication of the signal contribution of nearby sources. A maximum likelihood analysis found a statistical significance of 4σ for the correlation of the measured arrival directions with a sample of nearby starburst galaxies (SBG). Although, the dependence of the galactic magnetic field (GMF), which is expected to have a key role in the arrival direction of charged particles, has not been considered.

In this work we present a study of the effects of the GMF on the arrival directions of particles related to different source populations, namely SBG and active galactic nuclei. We assume an injected cosmic ray spectrum with a mixed composition and a maximum rigidity. The extragalactic propagation is simulated with CRPropa3 while the deflections of cosmic rays in the Galaxy are calculated assuming the GMF model of Jansson&Farrar (2012). The obtained results show that it is possible to recover scenarios which are compatible with the results obtained by the Pierre Auger Collaboration although the signal fraction related to the source contribution has to be increased. Moreover no contribution of the extragalactic magnetic field is necessary.

T 19.7 Mon 17:50 T-H32

Measuring the muon content of inclined air showers using the radio and particle detector of the Pierre Auger Observatory* — •Marvin Gottowik for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal

A first measurement of the muon content of an air shower using hybrid radio and particle detection is presented. For inclined air showers with zenith angles above 60 °, the water Cherenkov detector (WCD) of the Pierre Auger Observatory performs an almost pure measurement of the muonic component, whereas the Auger Engineering Radio Array (AERA) reconstructs the electromagnetic energy independently using the radio emission of the air shower. The analysis of more than 6 years of AERA data shows a deficit of muons predicted by all current-generation hadronic interaction models for energies between 4 EeV and 20 EeV. This deficit, already observed with the Auger Fluorescence Detector, is now confirmed using for the first time radio data. The analysis is limited by low statistics due to the small area of AERA and the high energy threshold originating from the WCD reconstruction. With the AugerPrime Radio Detector currently being deployed, this analysis can be extended to the highest energies to allow for in-depth tests of hadronic interaction models with large statistics.

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T 19.8 Mon 18:05 T-H32

Optimization of Radio Reconstruction for Inclined Air Showers with AERA at the Pierre Auger Observatory* — •Jelena Petereit for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, Wuppertal, Germany

The Pierre Auger Observatory is the world's largest cosmic ray observatory. Its Auger Engineering Radio Array (AERA) consists of more than 150 antenna stations that cover an area of about 17 km^2 and is used to detect radio signals emitted by extensive air showers. These measurements are used to reconstruct properties of the primary cosmic rays inducing the air showers.

This talk describes the improvements that have been made on the AERA analysis with the Auger reconstruction framework. Using CoREAS simulations for measured event geometries, noise extracted from data can be added to a simulated pure signal. Various parameters for identifying noise dominated stations for the rejection in the geometry reconstruction, such as the time difference between the pure signal and the signal with noise, are examined and modified in order to improve the event reconstruction.

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