T 13: Cosmic Rays I

Time: Monday 16:00–18:20 Location: Tm

Group Report T 13.1 Mon 16:00 Tm
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 observatory for ultra-high energy cosmic rays (UHECRs), covering an instrumented area of 3000 km^2. Its 1660 Surface Detector (SD) stations and 27 Fluorescence Detector (FD) telescopes are designed to collect data of unprecedented statistics and quality.

Recent results have revealed new features in the energy spectrum of UHECRs, while their mass composition is best described as mixed with increasing primary particle masses towards the highest energies. Additionally, several significant large- and medium-scale anisotropies have been established. Searches for neutrinos and photons have yielded the most significant constraints on their fluxes in a substantial energy and directional range. Furthermore, the data indicate that there are significantly more muons produced in air showers than expected in state-of-the-art simulations. About 1600 elves, lightning-related luminous events in the ionosphere, have been detected with the FD, making it a unique contributor to high-energy atmospheric physics research.

An upgrade of the Pierre Auger Observatory, called AugerPrime, is nearing completion. It will add scintillation and radio detectors together with improved electronics to the SD stations. AugerPrime will improve particle identification and therefore enhance the overall UHECR mass composition sensitivity for the full-duty-cycle SD.
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T 13.2 Mon 16:20 Tm
Performance of the surface detector calibration of the Pierre Auger Observatory — •Alexander Streich, David Schmidt, Darko Veberic, Markus Roth, and Ralph Engel for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie (KIT), Karlsruhe, Deutschland

After more than a decade since the start of its data acquisition, the Pierre Auger Observatory is undergoing a major upgrade phase, the so-called AugerPrime upgrade. This phase includes, among other things, the installation of a variety of new detector components and the replacement of the electronics boards of all the 1660 Surface Detector stations. With the accompanying changes of hardware and software, the adaptation of the calibration procedures of the different detectors and devices becomes essential. This presentation focuses on the analysis of the calibration performance of both, the currently implemented algorithms of the non-upgraded Surface Detector stations, as well as the modifications and optimizations applied to these algorithms to match the changes in the data. In addition, we provide a short overview on the current status of the AugerPrime upgrade.

T 13.3 Mon 16:35 Tm
Improved reconstruction of events recorded by the surface detector of the Pierre Auger Observatory — •Quentin Luce for the Pierre Auger-Collaboration — Karlsruhe Institute for Technologie, Karslruhe, Germany

For the last fifteen years, the Surface Detector of the Pierre Auger Observatory is continuously recording, at ground level, the footprint of Extensive Air Showers initiated by Ultra-High Energy Cosmic-Rays. Each triggered Water-Cherenkov detector participating in an event, provides two information: the time at which the first particles of the shower hit the detector and the signal produced by all the particles going through it. While from the timing information the arrival direction of cosmic-rays is reconstructed, its energy is estimated, using the signal information, with the reconstruction of the lateral profile and the determination of the shower size $S(1000)$. With increase of statistics and the evolution of our knowledge, this reconstruction procedure is improving. The latest developments of the algorithms, i.e. correction of the azimuthal asymmetries, improvements of the lateral profile, used to reconstruct the properties of the cosmic-rays and the resolution associated to these developments are described in this presentation.

T 13.4 Mon 16:50 Tm
Correction of the asymmetry of the signal measured by the surface detector of the Pierre Auger Observatory — •Quentin Luce for the Pierre Auger-Collaboration — Karlsruhe Institute für Technologie, Karslruhe, Germany

For the last fifteen years, the Surface Detector (SD) of the Pierre Auger Observatory is continuously recording the footprint of Extensive Air Showers (EAS) initiated by Ultra-High Energy Cosmic-Rays at ground level. To reconstruct most accurately as possible the lateral profile of the EAS recorded, the asymmetry of the signal measured by the water-Cherenkov detectors has to be corrected. The correction applied is first derived from simulated data sets, from which the true arrival direction and thus the position of each detectors in the shower-plane is known. In addition to the SD, 27 fluorescence telescopes are deployed looking over the SD. Thus a sub-set of events can be reconstructed by two independent procedures. Thanks to this hybrid design, the use of simulated data sets is complemented by a study of hybrid events to optimize the correction, specially with an addition of a scaling factor of the muonic component of the EAS. This addition takes into account the discrepancies between measured and simulated data on the number of muons published in the litterature.

T 13.5 Mon 17:05 Tm
Propagation of core uncertainties in subordinate surface detector reconstructions at the Pierre Auger Observatory — •Tobias Schulz, David Schmidt, Quentin Luce, Darko Veberič, and Markus Roth for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany

A better understanding of ultra-high-energy cosmic rays is one of the goals of the AugerPrime upgrade at the Pierre Auger Observatory. Together with the existing Water Cherenkov Detectors, Surface Scintillation Detectors are currently being deployed to measure air showers induced by cosmic rays. The measured signals of these detectors are samples of the shower footprint at ground and are also dependent on the distance to the shower axis.

The shower geometry reconstructed from measurements of the Water Cherenkov Detectors of the surface detector array is commonly used in subsequent steps of event reconstruction, especially those pertaining to subordinate detectors, such as the scintillator detectors. An uncertainty on the reconstructed position of the shower core translates into uncertainties in the position of each station relative to the true location of the core. The uncertainties of the core position may therefore influence the results of shower reconstructions of other detector measurements and thus should be propagated into the subsequent reconstruction procedures. Here, we present a method of propagating core uncertainties and the resulting impact on the reconstruction of the shower size with the Surface Scintillation Detector.

T 13.6 Mon 17:20 Tm
A new end-to-end calibration of the fluorescence detector of the Pierre Auger Observatory — •Christoph Schäfer for the Pierre Auger-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology (KIT)

A crucial part of the Pierre Auger Observatory is the fluorescence detector composed of 27 large-aperture wide-angle Schmidt telescopes. In the past, the absolute calibration of these fluorescence telescopes was performed with a large-diameter light-source, which illumines the whole aperture of one telescope at once, roughly once every three years, while a relative calibration is performed every night. In this contribution a new technique for an absolute end-to-end calibration of the fluorescence telescopes is presented. This new technique employs a calibrated portable Lambertian light-source which scans across the aperture of each telescope. The analysis of the readout of the PMT camera at each position of the light source provides an absolute calibration of the telescope. We will give a brief overview of this novel calibration method and its current status, as well as preliminary results from the measurement campaigns performed so far.

T 13.7 Mon 17:35 Tm
Measurement of laser tracks from the Aeolus satellite with the Pierre Auger Observatory — •Felix Knapp for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie

The Pierre Auger Observatory is the world's largest experiment for the observation of ultrahigh-energy cosmic rays. These cosmic-ray particles initiate extensive air showers in the atmosphere that can be studied via the measurement of secondary particle densities with surface detectors or by the observation of the light induced by a shower along its trajectory through the atmosphere with fluorescence telescopes.

Aeolus is a satellite operated by the ESA. It uses an UV-laser pointed towards Earth to measure the flow of air in the atmosphere. This laser beam traverses the Pierre Auger Observatory several times throughout the year. Light that scatters off the laser beam produces tracks in the atmosphere that trigger the fluorescence telescopes of the observatory.

In this talk we will give an overview of the reconstructed laser shots and the possibility of utilizing them for a study of aerosols over the Observatory.

T 13.8 Mon 17:50 Tm

Calibration of the Underground Muon Detector in the Pierre Auger Observatory — •Marina Scornavacche[1,2], Federico Sanchez[1], Juan Manuel Figueira[1], Markus Roth[2], and Ana Martina Botti[1,2] for the Pierre Auger-Collaboration — [1]Instituto de Tecnologias en Deteccion y Astroparticulas, Comision Nacional de Energia Atomica, Buenos Aires, Argentina — [2]Institut für Astroteilchenphysik, Karlsruher Institut für Technologie, Karlsruhe, Deutschland

The Pierre Auger Observatory was designed to answer the key questions about the origin and composition of ultra-high energy cosmic rays. One of the most sensitive observables to the mass composition is the muon content of the air showers. The Underground Muon Detector (UMD) is optimized to perform a direct measurement of this component in the ankle-region of the energy spectrum and has two complementary ways to estimate the number of muons: counting mode and integrator mode. In case of the integrator mode, the output signal is based on the total signal charge and the number of muons can be estimated by dividing this signal by the mean charge of a single muon. In this work, we show how to calibrate the integrator on simulations to obtain the mean charge left by a single muon. In order to compare with UMD field data, simulations of a single muon were performed following the distributions on energy and zenith angle of the atmospheric muons. The simulated muons were also asked to satisfy the same condition of recontruction that is requested (for the binary channel) in the field. We will report on the status and recent developments.

T 13.9 Mon 18:05 Tm

Measurement of the ultrahigh-energy cosmic-ray composition using a Markov Chain Monte Carlo approach — •Olena Tkachenko for the Pierre Auger-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Germany

To understand the nature and to constrain the possible astrophysical sources of ultrahigh-energy cosmic rays (UHECRs) the determination of the mass composition is essential. One of the most sensitive observables to the cosmic-ray mass composition is the depth of atmospheric shower maximum, X_{max}. The fractions of different mass groups can be estimated by comparing the X_{max} distributions, as measured by the Fluorescence Detector of the Pierre Auger Observatory, to the predictions obtained from air shower simulations.

In this talk we present an estimate of the mass composition from the X_{max} distribution with the Markov Chain Monte Carlo methods (MCMC). We test the performance of the algorithm on the simulated data with different benchmark mass composition scenarios and study the statistical properties of the outcome. Furthermore, we fit real data from the Pierre Auger Observatory and compare the estimated fractions with the previous results. The most important advantage of the MCMC mass composition analysis is the possibility to sample from the posterior distribution of the composition fractions. We will present the example applications like the average rigidity of cosmic rays as a function of energy.