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Reconstruction of Events Recorded with the Water-Cherenkov and Scintillator Surface Detectors of the Pierre Auger Observatory

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With the knowledge and statistical power of over a decade and a half of measurements, the Auger Collaboration has developed, assessed, and refined robust methods for reconstructing the energies and arrival directions of the highest-energy cosmic rays from the signal and timing measurements of its surface detector array. Concurrently, the unearthing of an increasingly complex astrophysical scenario and tensions with hadronic interaction models have demanded the addition of primary mass as an observable measurable using the surface detector. Access to information on the mass hinges on the disentanglement of the electromagnetic and muonic components of extensive air showers. Consequently, an upgrade to the Observatory, AugerPrime, is being carried out by equipping each of the existing water-Cherenkov stations with a 3.8 m^2 Scintillator Surface Detector (SSD). The SSDs, with their high sensitivity to electrons and positrons, will provide samples of the lateral distribution of particles at the ground that complement those of the water-Cherenkov detectors, which are significantly more sensitive to muons. When used together, the two measurements enable extraction of the number of incident muons, which is a quantity that strongly correlates with primary mass. We describe the reconstruction methods applied to measurements of the surface detector of the Observatory with a particular focus on the enhancement of these methods with data of the SSDs of AugerPrime. Results from the reconstruction of thousands of high-energy events already measured with deployed SSDs are also shown.

Keywords

surface detector; scintillator; water-Cherenkov detector; AugerPrime; reconstruction; air showers; ultra-high-energy cosmic rays; composition; mass

Collaboration

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