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Energy Spectrum Reconstruction of Air-Shower Components with a Multi-Hybrid Detector Station

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Ultra-high-energy cosmic rays (UHECRs) initiate extensive air showers (EAS) through their interactions with molecules in the Earth's atmosphere, producing massive cascades of secondary particles. Measurements of these showers enable the study of both the properties of the primary cosmic rays and the high-energy hadronic interactions that govern shower development. However, due to the intrinsic limitations of air-shower experiments, the energy spectrum of air-shower components at ground level has not yet been measured.

This thesis investigates the feasibility of reconstructing the energy spectra of different shower components by employing a multi-hybrid detector station composed of a surface scintillator detector (SSD), a water Cherenkov detector (WCD), and resistive plate chambers (RPCs). Additionally, we evaluate the performance of the MARTA prototype station, which integrates a WCD and four RPCs and is deployed within the 750 m-spaced Surface Detector (SD) array of the Pierre Auger Observatory. Bridging the gap between simulations and real data constitutes a key step towards the development of a complete end-to-end analysis framework for energy spectrum reconstruction.

We establish the proof-of-concept by demonstrating that regions in the combined detector signal space can be mapped to corresponding regions in the spectral space. Future work will focus on developing concrete transformation methods to enable the full reconstruction of the original energy spectra.

Field of Research/Work

Particles and Fields

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