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Extraction of the Muon Signals Recorded with the Surface Detector of the Pierre Auger Observatory Using Recurrent Neural Networks

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We present a method based on the use of Recurrent Neural Networks to extract the muon component from the time traces registered with water-Cherenkov detector (WCD) stations of the Surface Detector of the Pierre Auger Observatory. The design of the WCDs does not allow one to separate, for all events, the contribution of muons to the time traces from those of photons, electrons and positrons. Separating the muon and electromagnetic components is crucial for the determination of the nature of the primary cosmic rays and properties of the hadronic interactions at ultra-high energies.

We trained the neural network to extract the muon and the electromagnetic components from the WCD traces using a large set of simulated air showers, with around 450 000 simulated events. For training and evaluating the performance of the neural network, simulated events with energies between $10^{18.5}$ eV and 10^{20} eV and zenith angles below 60 degrees were used. We also study the performance of this method on experimental data of the Pierre Auger Observatory and show that our predicted muon lateral distributions agree with the parameterizations obtained by the AGASA collaboration.

Keywords

Astroparticle physics, Pierre Auger Observatory, cosmic rays, Cherenkov detectors, muon component, machine learning, neural networks, deep learning, recurrent neural networks

Collaboration

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