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Neural Network Models for Muon Trace Discrimination in Simulated Water Cherenkov Detectors

This article presents a novel approach for discriminating the muonic component within extensive air showers (EAS) using water Cherenkov detectors (WCDs). The WCD used in this study has a capacity of 20,000 liters and is equipped with a photomultiplier tube (PMT) mounted on its top. Through Monte Carlo simulations of both the EAS and the WCD, we obtain the temporal distribution of photons reaching the PMT, generated by passing particles, referred to as "traces." These traces are analyzed using advanced neural network algorithms to classify traces containing muons from those without muons.
We explore and compare the performance of several neural network architectures, including Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and fully connected Multi-Layer Perceptrons (MLPs). Each model is trained and tested on simulated data to evaluate its effectiveness in muon discrimination. By maintaining the same detector configuration, this work validates the potential of neural networks to enhance the identification of the muonic component in EAS.
The study highlights the versatility of neural networks in analyzing complex patterns in trace data, offering a promising alternative to traditional methods. This research contributes to the ongoing development of cost-effective and high-performance detection systems for gamma-ray astronomy and cosmic ray observatories, demonstrating the value of advanced computational techniques in particle physics.

Collaboration(s)

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