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Deep Learning-Based Attempt for Multi-Type Particle Discrimination

Abstract Due to the heterogeneous composition of space radiation and the differential response characteristics exhibited by distinct particle species across various detector configurations, it is experimentally challenging to fully calibrate waveform responses of all particle types in detection systems. This study employs an autoencoder (AE) method from deep learning to perform discrimination and classification of particle waveform signals with limited prior information, establishing critical data infrastructure for space particle identification research. Furthermore, convolutional neural networks (CNNs) were implemented to achieve high-efficiency particle discrimination. The results demonstrate that the AE method effectively enables particle classification in both standalone CLYC+SiPM detectors and composite scintillator-configured CLYC+SiPM detection systems. Specifically, five characteristic signal categories were identified in standalone CLYC+SiPM detectors, while three distinct signal types were observed in composite scintillator systems. Leveraging CNN algorithms, precise discrimination of the two dominant signal types (cumulative proportion >99.8%) in composite scintillator-based CLYC+SiPM detection systems was achieved, with a figure of merit reaching 3.17. This study conclusively validates the efficacy of unsupervised deep learning methodologies in particle discrimination, providing a solid foundation for deploying advanced algorithmic architectures to achieve refined particle identification in complex space radiation

Key words Neutron/Gamma discrimination, Pulse shape discrimination, Deep learning, Space radiation

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