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Pulse Shape Discrimination of Neutrons and Gamma Rays in Liquid Scintillator at the PMT Nonlinear Region Using Convolutional Neural Network Technique

Neutrino oscillation is a key phenomenon for testing beyond the Standard Model. Due to the weak interaction of neutrinos, large-volume detectors and effective background discrimination are required. Liquid scintillator (LS) is a suitable medium for constructing large-volume detectors. Light produced in LS is generally amplified by photomultiplier tubes (PMTs) and converted into electronic signals. Distinguishing gamma rays from neutrons is crucial for reducing background events in neutrino detection, and pulse shape discrimination (PSD) techniques are commonly used to differentiate these signals. Maintaining PMT linearity is important for accurate signal analysis; however, it sometimes conflicts with achieving high PMT resolution, making the study of the nonlinear response region necessary. Convolutional Neural Networks (CNNs) have shown great potential in solving complex nonlinear problems. This study applies CNN to PSD analysis in the PMT's nonlinear region to evaluate its efficiency compared to previous methods. Signals were simultaneously collected using 10- and 2-inch PMTs under different conditions to generate training data and classification labels for CNN. The results demonstrate the potential of CNN to be an effective PSD method in the nonlinear region of PMTs.

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