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Likelihood and Deep Learning Analysis of the electron neutrino event sample at Intermediate Water Cherenkov Detector of the Hyper-Kamiokande experiment

The Hyper-Kamiokande (Hyper-K) is a next-generation long baseline neutrino experiment. One of its primary physics goals is to measure neutrino oscillation parameters precisely, including CP-asymmetry measurement. As the conventional νμ beam from the J-PARC neutrino production baseline contains only 1.5% of the electron neutrino interaction of the total, it is very challenging to measure electron (anti)neutrino scattering cross-section on nuclei. To address these challenges and mitigate systematic uncertainties associated with background events, an Intermediate Water Cherenkov detector (IWCD) will be built at a distance of about 1 km from the J-PARC, which will study neutrino interaction rate peaked at different energies with higher accuracy. The presented, simulated data comprises νeCC0π as the main signal, and NCπ0 and νμCC are major background events. To reduce this background contamination, initially, a log-likelihood-based reconstruction algorithm to select candidate events was used, which, however, sometimes struggles to distinguish π0 events properly from electron-like events. Therefore, a Machine Learning-based framework has been developed to enhance the purity and signal efficiency rate of electron neutrino events. It was found that implementing it notably enhances both the efficiency and purity of νe signals compared to the conventional approach.

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