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Using Machine Learning to Identify Neutron Captures in Gd Loaded Water Cherenkov Detectors

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Hyper-Kamiokande is the proposed next generation Water Cherenkov neutrino detector in Kamioka, Japan that began construction in 2020. Hyper-K will have an order of magnitude larger fiducial mass than the existing Super-Kamiokande detector, enabling the survey of topics in neutrino physics with improved sensitivity. One handle on detecting neutrino versus anti-neutrino interactions is to detect the neutron in the inverse beta decay of anti-neutrinos on proton. When an anti-neutrino collides with a proton in the atomic nucleus, it yields an anti-lepton and a free neutron. The Cherenkov light from the lepton is promptly detected, while the neutron captures on Gd about one hundred microseconds later. The low-energy signal from the neutron capture (totalling about 8 MeV of gamma rays) is recorded by only tens of PMTs, making neutron captures difficult to distinguish from dark noise and radioactive backgrounds. This talk presents various machine learning approaches to optimize the neutron capture detection capability in the new Intermediate distance Water Cherenkov (IWCD) detector for Hyper-K. The methods benchmarked are graph neural network models (Graph Convolutional Networks, attention-based networks), Multi-Layered Perceptron, XGBoost on engineered features, and a likelihood-based classifier.

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Experiment

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