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ML-Enhanced Neutron Detection in CLAS12 for Short-Ranged Correlation Studies

Short-ranged correlations (SRCs) provide insight into the fundamental forces that drive nuclear dynamics. Current experimental goals in this area include increasing precision in two-nucleon (2N) observables and the discovery and characterization of 3N SRCs. Exclusive measurements for these efforts require immense statistics and, given the tensor force's preference for neutron-proton pairing, precise detection of both protons and neutrons.

CLAS12 is well-suited for such measurements due to its high luminosity and large angular coverage. In particular, the CLAS12 central detector offers complete azimuthal and broad polar-angle acceptance, as well as two dedicated scintillator arrays for neutral particle reconstruction. However, imperfect efficiency in tracking introduces a major source of background as untracked protons are generally reconstructed as neutrons.

To address this challenge, we design and implement a machine-learning algorithm that uses signals from the central detector to predict whether a CLAS-reconstructed neutron is correctly identified or instead an untracked charged particle. Our model is purely data-driven, with training and test samples taken from multiple exclusive reaction channels. As a baseline, we correctly reclassify over 90% of misidentified protons, with performance stable across kinematic ranges and reaction channels.

I will present initial results using this model to extract the $e'pn/e'p$ cross-section ratio in ^{4}He, providing both a validation of its performance and a significant improvement in the precision of this measurement of the short-range two-nucleon interaction.

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