Machine Learning Approaches for ALERT Track Reconstruction at Jefferson Lab

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Abstract

Understanding how the structure of bound nucleons is modified within the nuclear medium remains a central challenge in hadronic physics. Deeply Virtual Compton Scattering (DVCS) offers a powerful probe of the partonic structure of light nuclei, providing access to their three-dimensional distributions via Generalized Parton Distributions (GPDs) and enabling studies of associated in-medium stimulated effects.

The recently completed CLAS12 experiment at Jefferson Lab employed the newly built A Low Energy Recoil Tracker (ALERT) detector to study tagged DVCS by impinging an 11 GeV polarized electron beam on ^{4}He or ^{2}H. The ALERT detector is comprised of a hyperbolic drift chamber (AHDC) and a time-of-flight (ATOF) array to provide an effective separation of low-momentum nuclear-recoil fragments, including ^{1}H, ^{2}H, ^{3}H, ^{3}He, and ^{4}He, down to 70 MeV/c across a broad kinematic range.

Recent advances in artificial intelligence (AI), particularly in model architectures, have demonstrated strong performance in high-rate experiments with significant background noise, such as the AHDC case. To this end, AI-based techniques have been developed to enhance AHDC track-finding efficiency, purity, and processing speed relative to conventional algorithms, as well as to identify recoil fragments and optimize matching between AHDC tracks and ATOF hits. In this talk, I will present a highlight of the ALERT physics program and provide an update on the ongoing development and optimization of AI-assisted track reconstruction and particle identification for both simulated and real data.

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