Thesis abstract S. Alvarado

« Exploring the Nucleon Structure via Deep Electroproduction Processes »

Understanding the internal structure of the nucleon is a fundamental goal of modern physics, which aims at a comprehensive framework describing the internal dynamics of quarks and gluons. Among other structure functions, Generalized Parton Distributions (GPDs) offer a powerful framework for describing the nucleon dynamics by correlating the longitudinal momentum and the transverse position of its internal partons. Such a correlation provides a three-dimensional picture of the nucleon and enables access to fundamental properties, including the internal pressure distributions and the parton's angular momentum contribution to the nucleon's total spin, thereby playing a central role in resolving the nucleon spin puzzle.

At the Thomas Jefferson National Facility (JLab), polarized electron beam experiments allow for probing GPDs through the measurement of hard exclusive processes. Among the cleanest experimental channels, we find the electro-production of a real photon through the Deeply Virtual Compton Scattering (DVCS) mechanism. The first data-taking period of the CLAS12 program, taking place in 2018, allowed for unique DVCS Beam Spin Asymmetry (BSA) measurements in the phase space covered by a 10.6 GeV polarized electron beam impinging on an unpolarized liquid hydrogen target. Although detecting all final-state particles ensures exclusivity of the process, conservation laws indicate that it is not mandatory. I adopt an approach omitting the direct detection of the recoil proton, providing a simplified yet effective event selection strategy that boosts statistics and gives access to a larger phase space sensitive to the underlying GPD dynamics through BSA and cross section measurements.

The Double DVCS (DDVCS) process promises a dedicated mapping of GPDs. Contributing to the electro-production of a lepton pair cross-section, the DDVCS reaction extends DVCS by allowing the final-state photon to be virtual, enriching the kinematic phase space and providing unique access to the internal correlations encoded by GPDs. A feasibility study is conducted to assess the potential of future DDVCS measurements at Jefferson Lab and the future Electron-Ion Collider (EIC). While Jefferson Lab will provide DDVCS measurements in the valence region through the SoLIDμ and μCLAS12 experimental projects, in the long term, the EIC will provide complementary measurements in the sea region, both accessing unprecedented information about GPDs in a phase space region otherwise inaccessible.

Taken together, these investigations demonstrate both the current capabilities and future opportunities for probing GPDs through exclusive processes. The experimental analysis of DVCS at CLAS12 provides precise measurements within an established framework, while the phenomenological study of DDVCS opens the door to richer and more comprehensive explorations with future detectors and facilities.