Exploring the Structure of the Bound Proton with Deeply Virtual Compton Scattering

M. Hattawy et al. (CLAS Collaboration), Phys. Rev. Lett. **119**, 032502 (2019)

A wealth of information on the structure of hadrons lies in the correlations between the momentum and spatial degrees of freedom of the partons, i.e., quarks and gluons. These correlations can be revealed through deeply virtual Compton scattering (DVCS), i.e., the hard exclusive lepto-production of a real photon, which provides access to a three-dimensional (3-D) imaging of partons within the generalized parton distributions (GPDs) framework. In this Letter, we have presented the first exclusive measurement of the beam-spin asymmetry in DVCS off a bound proton in ^{4}He, which provides a unique access to the modification of the partonic structure of the bound nucleons.

The experiment (E08-024) took place in Hall-B of Jefferson Lab using a longitudinally polarized electron beam from the Continuous Electron Beam Accelerator Facility (CEBAF) at an energy of 6.064 GeV. The data were accumulated over 40 days using a 6-atm-pressure gaseous ^{4}He target centered 64 cm upstream of the CEBAF Large Acceptance Spectrometer (CLAS).

The bound proton DVCS beam-spin asymmetries as a function of azimuthal angle (shown in Fig. 1) have been measured as a function of different kinematical variables. The amplitude of *sin*-modulation, A_{LU}, has been compared to the free proton one measured using the same experimental setup and show significant difference (25% to 40%).

Our results have been compared to model calculations based on different assumptions of the nuclear medium effects at the partonic level. The bound-proton BSA is largely suppressed compared to the free proton BSA. This result is a first step in using a novel experimental method of understanding the properties of bound nucleons directly from the basic degrees of freedom of QCD. Planned experiments at Jefferson Lab will continue and extend these studies of the bound nucleon structure using DVCS. We have an experimental program called ALERT using the CLAS12 detector in the Hall-B of Jefferson Lab.

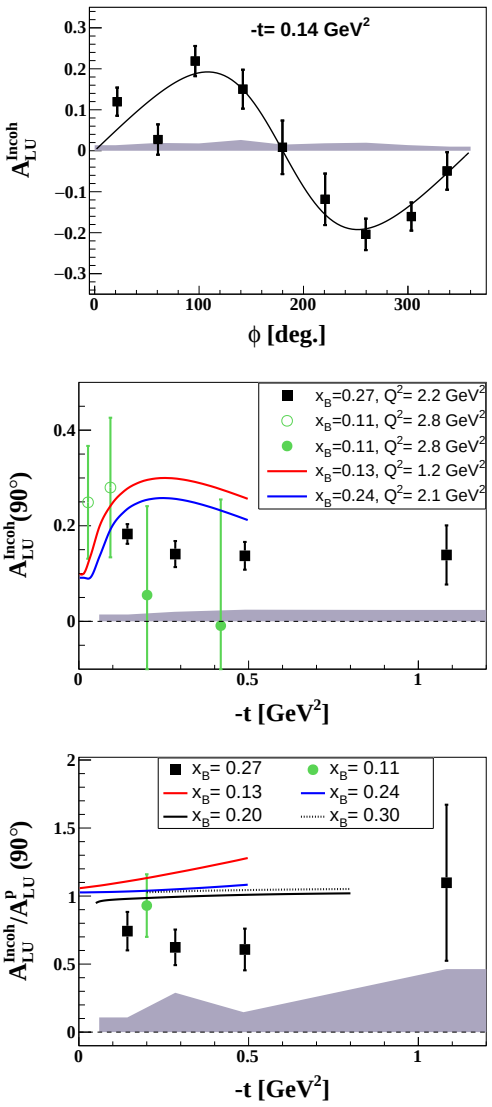

Figure 1: (Top) The measured A_{LU} as a function of ϕ in a t bin. The error bars represent the statistical uncertainties. The gray bands represent the systematic uncertainties. The black curve is the fit in the form $\frac{a_0 \sin(\phi)}{1+a_1 \cos(\phi)}$. (Middle) The t dependence of the fitted A_{LU} at $\phi = 90°$. The solid (empty) green circles are the HERMES $-A_{LU}$ (a positron beam was used) inclusive measurements for the incoherent (coherent) enriched region; the curves represent theoretical calculations from off-shell model. (Bottom) The A_{LU} ratio of the bound to the free proton at $\phi = 90°$ as a function of t. The black squares are from this work, the green circle is the HERMES measurement. The blue and red curves are results of off-shell calculations. The solid and dashed black curves are from on-shell calculations.