Spectator-Tagged Deeply Virtual Compton Scattering on Light Nuclei

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Abstract

A three-dimensional picture of how quarks and gluons are distributed in the proton set to be revealed through Deeply virtual Compton scattering (DVCS) while a critically important puzzle in the one-dimensional picture remains, namely, the origins of the EMC effect. Incoherent DVCS on a nucleon inside a nucleus can in principal reveal the 3D partonic structure of a *bound nucleon*. However, as is the case for the EMC effect ratio, the Fermi motion of the struck nucleon and final-state interactions (FSIs) complicate the parton level interpretation. With the plane wave impulse approximation (PWIA), tagging the recoiling spectator system, with one nucleon removed, the struck nucleon's initial momentum can be inferred, however, off-shell effects and FSIs will ultimately undermine a clear interpretation of the results. To pin down the EMC effect's origin all nuclear effects must be simultaneously and systematically under control. Through spectator-tagged DVCS, a fully detected final state presents a *unique opportunity* to systematically study these nuclear effects and cleanly observe possible modification of the nucleon's quark distributions.

We propose to measure the DVCS beam-spin asymmetries (BSAs) on ^{4}He and deuterium targets. The reaction $^4\mathrm{He}(e, e'\gamma\, p\, ^3\mathrm{H})$ with a fully detected final state has the rare ability to simultaneously quantify FSIs, measure initial nucleon momentum, and provide a sensitive probe to other nuclear effects at the parton level. The DVCS BSA on a (quasi-free) neutron will be measured by tagging a spectator proton with a deuteron target. Similarly, a bound neutron measurement detects a spectator ^{3}He off a ^{4}He target. These two observables will allow for a self-contained measurement of the neutron *off-forward EMC Effect*.

We will also measure the impact of final state interactions on incoherent DVCS when the scattered electron, the real photon, and the struck proton are detected in the final state. This will help understand the measurements performed on helium during the previous CLAS E-08-024 experiment and will allow better measurements of the same channel where both statistics and kinematic coverage are extended. The measurement of neutron DVCS by tagging the recoil proton from a deuterium target is highly complementary to the approved CLAS12 experiment E12-11-003 which will also measure quasi-free neutron DVCS by detecting the scattered neutron.