

Partonic Structure of Light Nuclei

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Abstract

We propose to study the partonic structure of ${}^4\text{He}$ by measuring the Beam Spin Asymmetry (BSA) in coherent Deep Virtual Compton Scattering (DVCS) and Meson Production (DVMP). In the latter, coherent production of ϕ mesons will be measured. Despite its simple structure, a light nucleus such as ${}^4\text{He}$ has a density and a binding energy comparable to that of heavier nuclei. Therefore, by studying ${}^4\text{He}$ nucleus, one can learn typical features of the partonic structure of atomic nuclei. In addition, due to its spin-0, only one chiral-even GPD, H_A , at twist-2 parameterizes its partonic structure.

A major goal of this proposal is to cover a wide kinematical range and collect higher statistics leveraging the knowledge obtained during eg6 running (E08-024), where, for the first time, exclusive coherent DVCS off ${}^4\text{He}$ was successfully measured. The real and imaginary parts of the ${}^4\text{He}$ Compton form factors (CFFs) will be extracted in a model independent way from the experimental asymmetries, allowing us to access the nuclear transverse spatial distributions of quarks and their spin correlations.

An equally important focus of this proposal is to study the gluonic structure of nuclei for the first time through the measurement of exclusive coherent ϕ meson electroproduction off a ${}^4\text{He}$ target in tandem with the DVCS measurement. The kinematic regime to be explored includes very low $|t|$ up to the first diffractive minimum as found in ${}^4\text{He}$ elastic scattering ($|t'| \simeq 0.6 \text{ GeV}^2$), Q^2 up to 8 GeV^2 , and x_B up to 0.3. The ϕ meson will be detected primarily through the charged K^+K^- channel, with the neutral $K_S^0K_L^0$ channel also available through $K_S \rightarrow \pi^+\pi^-$. Differential cross-sections for ϕ electroproduction off ${}^4\text{He}$ will be measured for the first time.

The combination of CLAS12 and the ALERT detector provides a unique opportunity to study both the quark and gluon structure of a dense light nucleus. Coherent exclusive DVCS off ${}^4\text{He}$ will probe the transverse spatial distribution of quarks in the nucleus as a function of the quarks' longitudinal momentum fraction, x . In parallel, the average transverse gluon density of the ${}^4\text{He}$ nucleus will be extracted within a GPD framework using the measured longitudinal cross-section of coherent ϕ production. Additionally, threshold effects of ϕ production can be explored by exploiting the ALERT detector's large transverse acceptance for low $|t|$ events. This experiment will complement the previously approved experiment E12-12-007 that will study the gluon contribution to the proton structure using a very similar framework.