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Abstract. Deeply Virtual Compton Scattering (DVCS) is one of the simplest processes that can be described in terms of Generalized Parton Distributions (GPDs). The target single-spin asymmetry (target SSA) in the reaction $e\vec{p} \rightarrow ep\gamma$ is directly proportional to the imaginary part of the DVCS amplitude, and gives access to a combination of GPDs namely $\tilde{H}$, H, and E. This asymmetry will be measured in a dedicated experiment at Jefferson Lab using the CEBAF 6-GeV polarized electron beam, a polarized solid-state $^{14}NH_3$ target, and the CEBAF Large Acceptance Spectrometer (CLAS) together with the Inner Calorimeter (IC). The expected asymmetry from leading-order calculations is in the range of 20% to 40%, depending on the kinematics and on the GPD model used. The DVCS amplitude will be mapped out in the Q^2 region from 1 to 4 GeV^2, x_B from 0.15 to 0.55 and $-t$ from 0.1 to 2 GeV^2 providing new constraints on the GPDs.

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MOTIVATION

The Generalized Parton Distributions formalism allows to describe the nucleon in terms of fully correlated quark distributions in both coordinate and momentum space. These distributions contain crucial information such as the angular momentum distribution of quarks in the nucleon [1, 2, 3].

The cleanest way to access GPDs is through the Deeply Virtual Compton Scattering, the electro-production of a photon off one of the quarks in the proton. As shown in Fig. 1, this exclusive process can be factorized into a hard scattering part and a nucleon structure part parameterized via GPDs.

The soft process is described by 4 GPDs: H, $\tilde{H}$, E, and $\tilde{E}$, which depend on the momentum fraction of the struck quark, x, the longitudinal momentum fraction transferred to the proton, $\xi = x_B/(2-x_B)$, and the momentum transfer. t, between virtual and real photons. GPDs provide a link between the charge density measured with elastic scattering (form factors) and longitudinal parton momentum fraction measured in Deep Inelastic Scattering (DIS). More precisely, in the DIS limit of $t = \xi = 0$, H and $\tilde{H}$ become the unpolarized and polarized parton distributions, $q(x)$ and $\Delta q(x)$, respectively, while the first moments of the GPDs correspond to the form factors:

$$\int_{-1}^{1} H^q(x,\xi,t)dx = F_1^q(t), \qquad \int_{-1}^{1} E^q(x,\xi,t)dx = F_2^q(t), \qquad (1)$$

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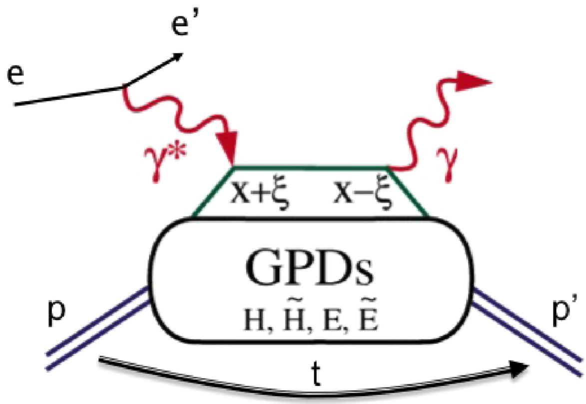

FIGURE 1. Handbag diagram for the DVCS process.

$$\int_{-1}^{1} \tilde{H}^q(x,\xi,t)dx = G_A^q(t), \qquad \int_{-1}^{1} \tilde{E}^q(x,\xi,t)dx = G_P^q(t), \quad \forall\xi. \tag{2}$$

From the experimental point of view, the DVCS cannot be disentangled from Bethe Heitler process, where the final-state photon is emitted by either the incoming or the outgoing electron,

$$\frac{d^4\sigma}{dQ^2dx_Bdtd\phi} \propto |T_{\rm DVCS} + T_{\rm BH}|^2. \tag{3}$$

The Bether Heitler cross section can dominate over the DVCS amplitude depending on the kinematics and the beam energy, however the DVCS signal can be enhanced measuring asymmetries which are proportional to the interference between the two processes.

$$A = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} \propto \frac{I}{|T_{\rm DVCS}|^2 + |T_{\rm BH}|^2 + I}, \tag{4}$$

where $I = T_{\rm DVCS}T_{\rm BH}^* + T_{\rm DVCS}^*T_{\rm BH}$. Depending on the beam and target polarization configuration, one can extract different asymmetries which have different sensitivity to GPDs. For instance, the beam-spin asymmetry $A_{\rm LU}$, measured in the dedicated CLAS experiment [4, 5], can be expressed as [6]

$$A_{\rm LU}(\phi) \propto \Im{\rm m}\left\{F_1\mathscr{H} + \frac{x_{\rm B}}{2-x_{\rm B}}(F_1+F_2)(\widetilde{\mathscr{H}} - \frac{\Delta^2}{4M^2}F_2\mathscr{E}) + ...\right\}\sin\phi\,, \tag{5}$$

where $\Im{\rm m}\mathscr{H} \propto H(x=\pm\xi)$ etc, is sensitive to H, $\tilde{H}$, and E, particularly to H in the CLAS kinematic. The longitudinal target-spin asymmetry $A_{\rm UL}$

$$A_{\rm UL}(\phi) \propto \Im{\rm m}\left\{F_1\widetilde{\mathscr{H}} + \frac{x_{\rm B}}{2-x_{\rm B}}(F_1+F_2)(\mathscr{H} + \frac{x_{\rm B}}{2}\mathscr{E}) + ...\right\}\sin\phi\,, \tag{6}$$

is equally sensitive to H and $\tilde{H}$. Furthermore the transversely-polarized target measurement provides additional sensitivity to E. A measurement of the target asymmetry is crucial to gain knowledge on GPDs, in particular $\tilde{H}$, to constrain GPDs models and ultimately understand the structure of the nucleon.

THE DVCS EXPERIMENT WITH A LONGITUDINALLY POLARIZED TARGET AND THE CLAS DETECTOR

The first dedicated DVCS experiment with the longitudinally polarized target is scheduled to run at Jefferson Lab at the beginning of 2009 [7]. The Continuous Electron Beam accelerator Facility (CEBAF) delivers an electron beam with an energy up to 6 GeV to three experimental halls. Hall B hosts the CEBAF Large Acceptance Spectrometer (CLAS), which allows multiple-particle identification with a nearly 2π acceptance. The beam is scattered off a longitudinally polarized solid, 1.5-cm-long, ammonia target ($^{14}NH_3$), polarized up to 70% via Dynamic Nuclear Polarization [8]. Two Helmholtz coils around the target provide the uniform ($\Delta B/B = 10^{-4}$) holding field of 5 T for the polarization and at the same time focus the low-energy Moller electrons toward the beam line. The trigger is a signal in the Cherenkov counters and the electromagnetic calorimeters, which allow the identification of electrons. Protons, deflected by a superconducting toroidal field, are detected by three layers of drift chambers, for momentum identification, and scintillators paddles, for time-of-flight identification. Neutral particles are detected by the electromagnetic calorimeter from 17° to 43°, and by the Inner Calorimeter (IC) from 4-15°. The IC was build for the dedicated DVCS experiment [4] in order to detect the photons of the DVCS reaction which are emitted mostly at low angles. The IC consists of 424 lead tungstate ($PbWO_4$) crystals, 16 cm in length (18 radiation lengths) with an energy and angle resolution of 4.5% and 4 mrad, respectively. The large acceptance of the CLAS detector in conjunction with the IC allows to completely detect the three final state particles from the reaction ep $\rightarrow$ epγ over a large kinematic range. The complete detection of the final state allows to apply kinematic cuts that drastically reduce the nuclear background from ^{14}N. Contamination from π^0 is corrected by measuring the epπ^0 asymmetry and by estimating the amount of contamination using Monte Carlo simulations. The accessible range in Q^2 is from 1 to 4 GeV^2, and in x_B from 0.15 to 0.55.

OUTLOOK

The longitudinal target single spin asymmetry has been measured for the first time, both at HERMES [9] and at CLAS [10]. The CLAS measurement was an outcome of the eg1 experiment, which was run in 2000 with beam energies from 1.6 to 5.7 GeV, with the primary goal to measure the spin structure function g_1 of the proton and the neutron. With a factor 10 increase in running time and a factor of 2 improvement in acceptance, due to the addition of the IC, the proposed experiment is expected to have statistical errors 4 times smaller and systematic errors 2 times smaller than the previous CLAS measurement. The increased statistics will allow for the first time to map out the Q^2,

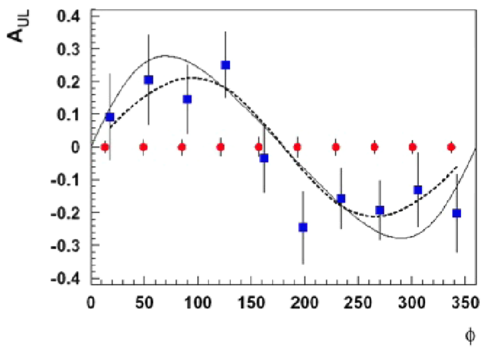

FIGURE 2. The ϕ dependence of the target single spin asymmetry. The square points are the result in [10], the circle points illustrate the expected statistical accuracy for the proposed experiment.

x_B, and t dependence of the target single-spin asymmetry over a large kinematic range, providing new constraints for the GPDs. Figure 2 shows the comparison between the CLAS results by Chen *et al.* and the expected results from the proposed experiment. Finally, since the experiment will be run using a beam of longitudinally polarized electrons (with polarization up to 80%), the double spin asymmetry will be extracted, providing additional information on the real part of the DVCS amplitude.

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