# Exclusive Leptoproduction of Real Photons from a Longitudinally Polarised Target

The HERMES Collaboration

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The HERMES experiment was located at the DESY research centre in Hamburg, Germany. It measured interactions of the 27.6 GeV electron or positron beam from the HERA storage ring with various gaseous targets. The experiment aims to increase understanding of the internal structure of nucleons (protons or neutrons), in particular the spin structure of the proton.

Generalised Parton Distributions (GPDs) have been identified as being a promising way to access new information on nucleonic structure. These distributions can potentially yield information on the total angular momentum of partons in the nucleon or the two-dimensional spatial distributions of partons correlated with a longitudinal momentum fraction, if measured sufficiently well. However, the distributions are difficult to access using current experimental techniques.

Generalised Parton Distributions are dependent on four kinematic variables: $x$ is the longitudinal momentum fraction of the nucleon carried by the struck parton in a frame in which the nucleon moves quickly, $2\xi$ is the change in the fraction of the nucleon's longitudinal momentum during the process, $t$ is the Mandelstam variable, the momentum transfer to the target nucleon squared and $Q^2$ is the negative square of the mediating virtual photon's four momentum.

The Deeply Virtual Compton Scattering (DVCS) process is the hard exclusive leptoproduction of a real photon from a parton in the nucleon that remains intact. It is currently the simplest way to access information on GPDs. The distribution and yield of the real photons can be used to retrieve information on GPDs. At HERMES kinematic conditions, hard exclusive leptoproduction of real photons is dominated by the Bethe-Heitler (BH) process, the elastic scattering of the incident lepton with the target nucleon, where a photon is produced as Brehmsstrahlung from the incident or scattered lepton. The DVCS and BH processes interfere, meaning that the scattering amplitude has three separate contributions: one from DVCS, one from BH and one from their interference. At HERMES kinematic conditions, the interference is the largest contribution and measurement of it can most easily be used to access information on GPDs.

HERMES is uniquely placed in the field of DVCS research because it has taken data on many different combinations of beam and target states. Different combinations of beam and target polarisations yield information on different combinations of GPDs and by taking measurements with different beam charges, HERMES can access even more information. In the analysis presented in this paper, data was taken with a positron beam polarised along the direction of its momentum and a hydrogen target polarised in the same direction, referred to as the "longitudinal" direction. In this combination at HERMES kinematics, measurements of the distribution of produced photons allows access mostly to the GPD $\widetilde{H}$. This GPD contains the polarised parton distribution function $\Delta q$ that was previously measured at HERMES as a limiting case for $\xi \to 0, t \to 0$.

Figure 1 shows the asymmetry amplitudes of a sinusoidal dependence fitted to the distribution ($\phi$) of produced photons for a set of data in which only the target is longitudinally polarised. The data is plotted in a single bin, and as projections in $t$, $x_{\mathrm{B}}$ (which is directly related to $\xi$, above) and $Q^2$. A GPD model predicts the size of the $\sin\phi$ amplitude quite well, but the size of the $\sin(2\phi)$ amplitude is surprising, and not well understood.

Figure 2 shows the asymmetry amplitudes of a co-sinusoidal dependence fitted to a data set comprising a longitudinally polarised beam and target. The data is plotted similarly to Fig. 1. The GPD model accurately predicts the sizes of both the $\cos(0\phi)$ and $\cos\phi$ amplitudes, which are dominated by sizeable contributions from the BH term in the scattering amplitude.

The GPD model does not include calculations for the case where a resonant state of the proton is created. The expected fractional yield of resonant states in the data set is shown in the bottom row of each figure.

These data are currently the best way to access GPD $\widetilde{H}$ at HERMES kinematics. It is, therefore, expected that these measurements will be used in future fits of GPD models as a valuable way to access that GPD.

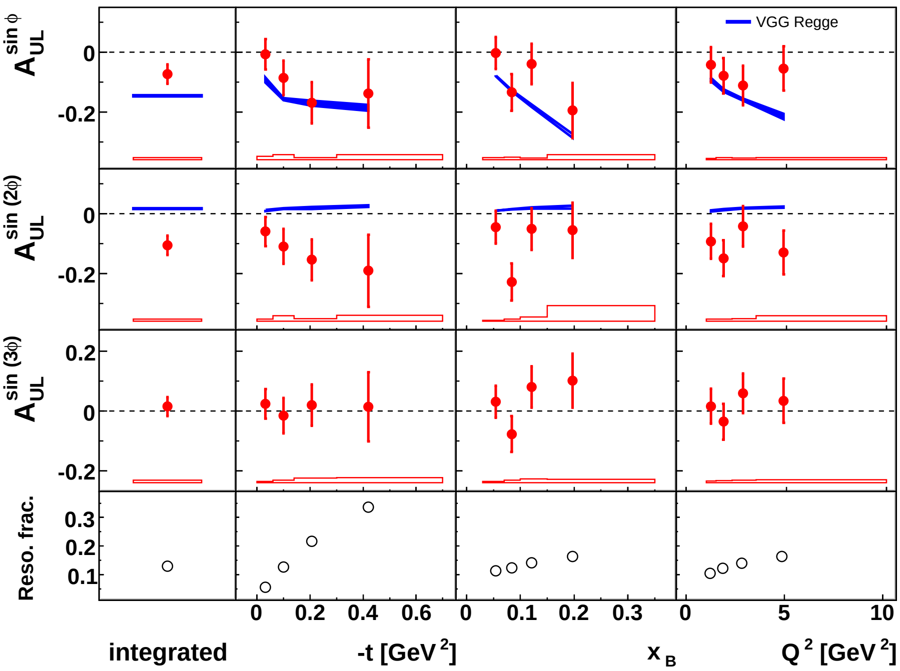


Figure 1: The result of a fit of a sinusoidal dependence to the produced photon distribution for an unpolarised beam and a longitudinally polarised target. The magnitude of the amplitudes can provide information on certain GPDs. The theory lines come from the predictions of a GPD model that includes contributions to the amplitudes from the Bethe-Heitler process, in addition to DVCS. The model does not include any contribution from resonance production, however. The expected yield of resonance production in each bin is shown in the bottom row of the figure.

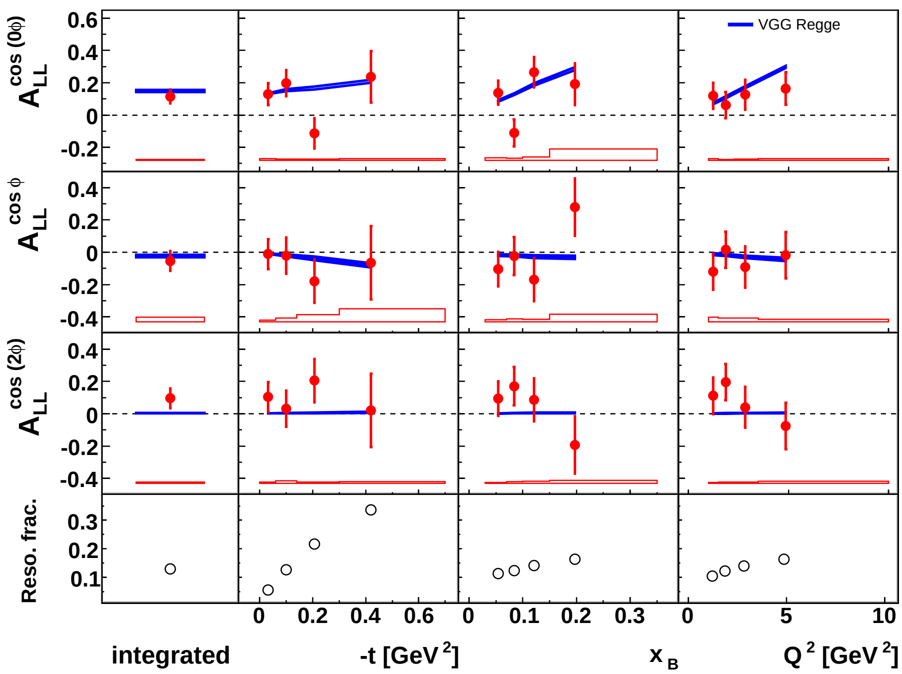


Figure 2: The result of a fit of a co-sinusoidal dependence to the produced photon distribution for a polarised beam and a longitudinally polarised target. Details are the same as in Fig. 1.