DVCS at HERMES

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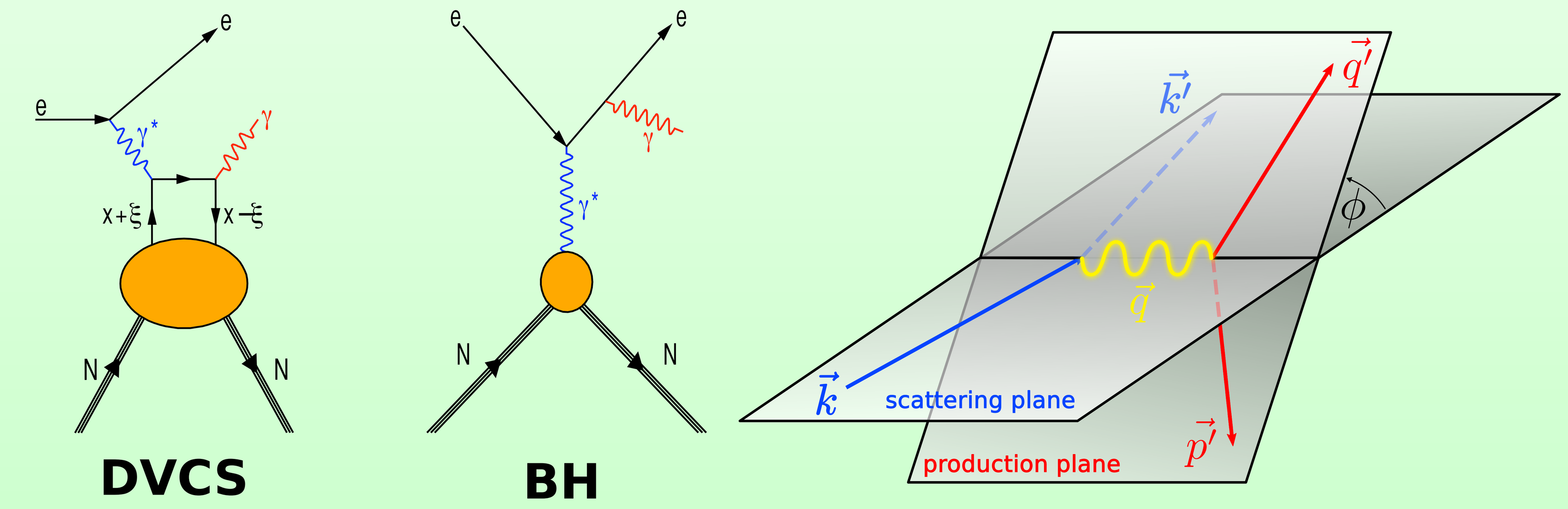
DVCS

Deeply Virtual Compton Scattering (DVCS) $\gamma^* N \to \gamma N'$ provides the theoretically cleanest access to Generalized Parton Distributions (GPDs).



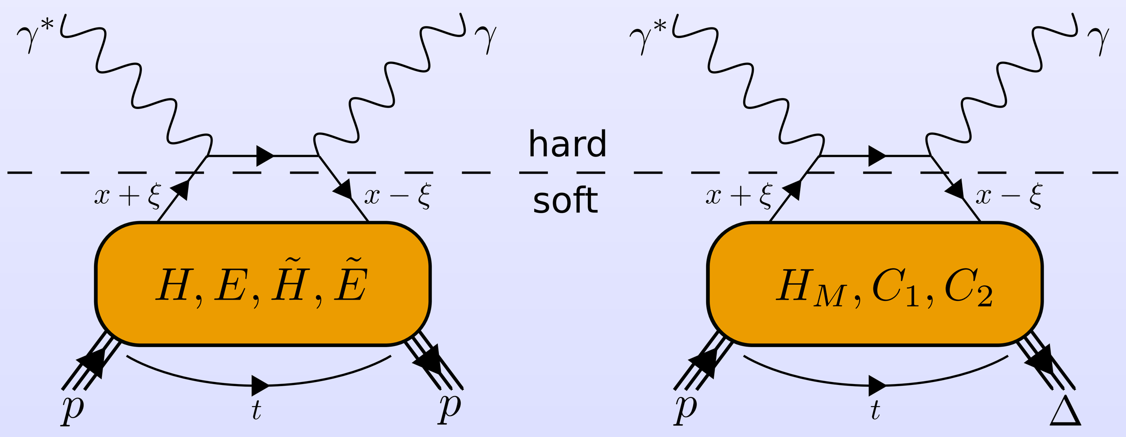
At HERMES, the DVCS term is experimentally accessed as the interference of the DVCS and Bethe-Heitler (BH) processes.

$$|\mathcal{T}|^2 = |\mathcal{T}_{\mathrm{DVCS}}|^2 + |\mathcal{T}_{\mathrm{BH}}|^2 + \underbrace{\mathcal{T}_{\mathrm{DVCS}}\mathcal{T}^*_{\mathrm{BH}} + \mathcal{T}^*_{\mathrm{DVCS}}\mathcal{T}_{\mathrm{BH}}}_{\mathcal{I}}$$

BH is dominant at HERMES kinematics, but the DVCS term is amplified through the interference term. Each of the terms can be expanded in a Fourier series in ϕ, where the Fourier coefficients for the DVCS and the interference term involve various Compton Form Factors (CFFs), which are convolutions of hard scattering amplitudes with the corresponding GPDs.

GPDs

Hard exclusive reactions can be factorized in the Bjorken regime and the soft, non-pertubative part is described in the formalism of GPDs. Being hybrids of the usual form factors and parton distributions, GPDs depend on four kinematic variables: x, ξ, t and Q^2. They are able to reveal a three dimensional picture of hadrons by correlating transverse spacial with longitudinal momentum distributions.



One of the most important properties of GPDs is their connection to the total angular momentum carried by the quarks inside the nucleon.

$$J_q = \frac{1}{2}\cdot\Delta\Sigma + L_q = \frac{1}{2}\int_{-1}^{1}\mathrm{d}x\, x\,[H_q(x,\xi,t=0) + E_q(x,\xi,t=0)]$$

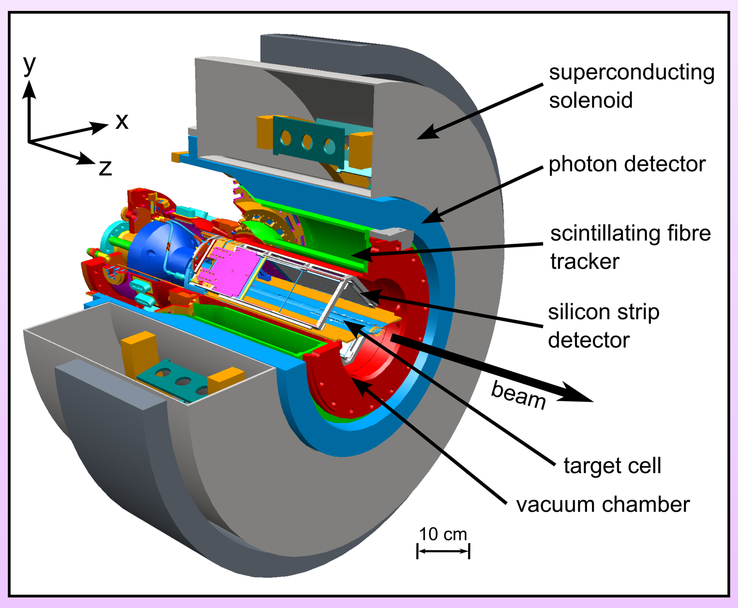
This offers a unique path to the 'nucleon spin puzzle', as it uncovers how the helicities and orbital angular momenta of quarks and gluons are combined to form the spin of the nucleon.

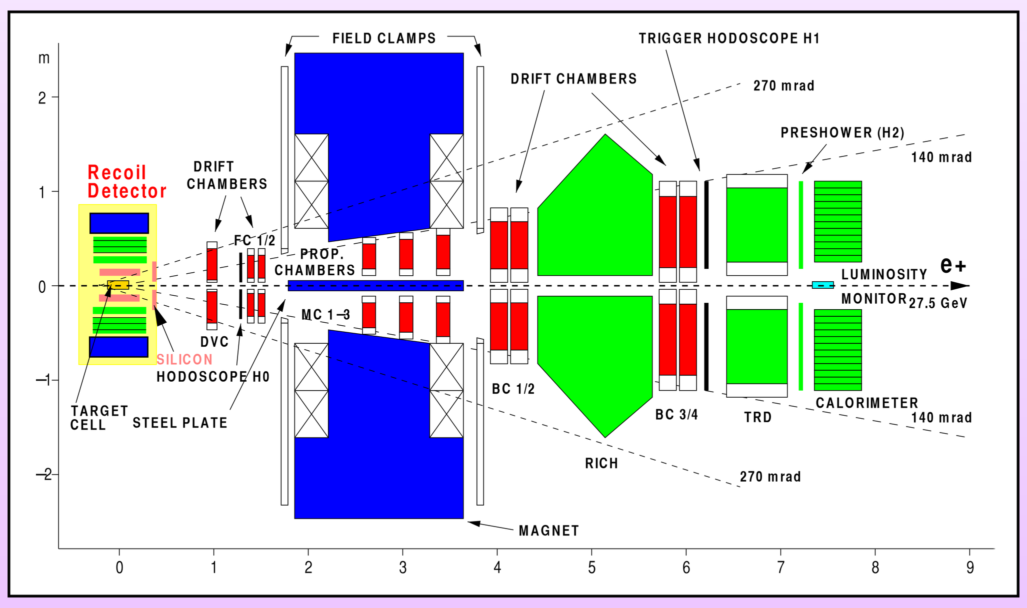
$$s_z = \frac{1}{2} = \frac{1}{2}\cdot\Delta\Sigma + \Delta G + L_q + L_g$$

The Experiment

The HERMES Recoil detector

- installed in 2006
- main purpose was the detection of the recoiling target proton with momenta between 135 MeV/c and 1400 MeV/c
- Scintillating Fibre Tracker and Silicon Detector provided tracking with up to four space points per track





The HERMES forward spectrometer

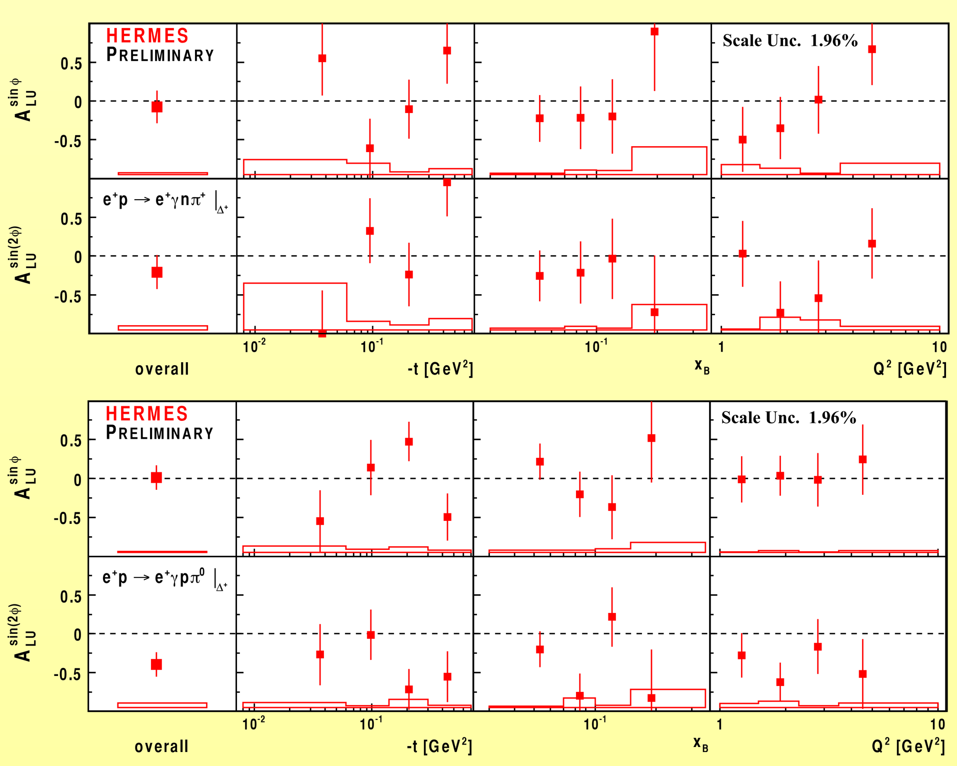
- in operation from 1995 till 2007
- used the longitudinally polarized 27.6 GeV lepton beam of HERA with both beam charges (e^+ and e^-) available
- storage cell target was filled with hydrogen, deuterium and other gases. Prior to 2006 it also allowed longitudinal and transverse polarization

Associated DVCS

Prior to the installation of the HERMES Recoil detector, the associated DVCS process $\gamma^* p \to \gamma N \pi$ in the Δ-resonance region constituted the main background for the selection of 'elastic' DVCS with an estimated average contribution of about 12%.

Measurements involving the Recoil detector did not only allow a background free (pure) elastic measurement, but enabled a selection of the associated process itself. Measurements of associated DVCS help to understand the influence of the unresolved background for the $ep \to e\gamma p$ process in earlier HERMES DVCS publications. In addition they allow access to vector and axial vector GPDs, which also can be utilized to carry out flavor decomposition of the nucleon GPDs.

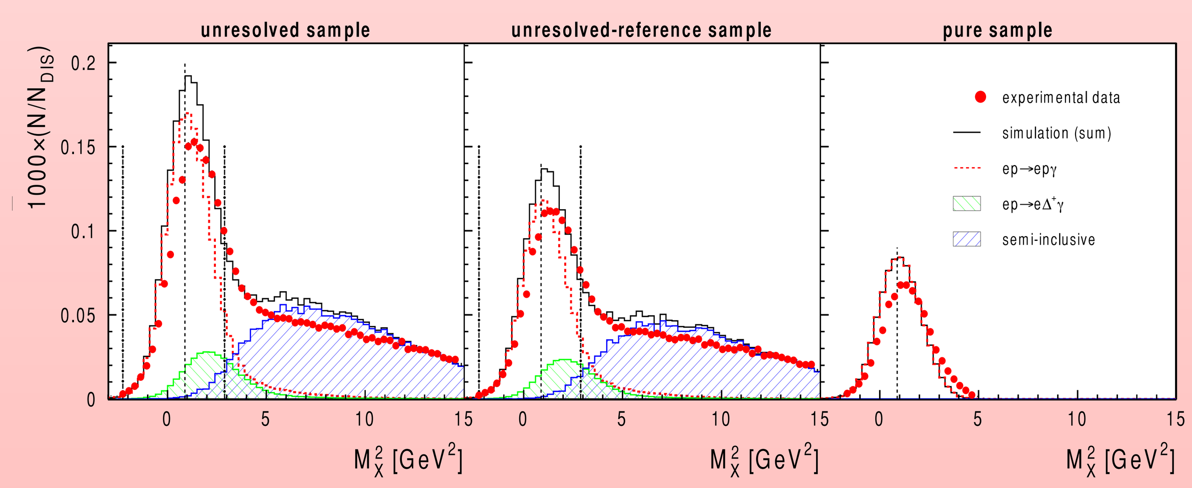
The Recoil detector allows the detection of the charged decay particle of the Δ-resonance and hence a kinematic fit of the final event state with two kinematic constraints. The accomplished purity is about of 86% (76%) for the decay channel $ep \to e\gamma p\pi^0$ ($ep \to e\gamma n\pi^+$) with the main background arising from semi-inclusive deep-inelastic scattering (SIDIS), which is corrected for.



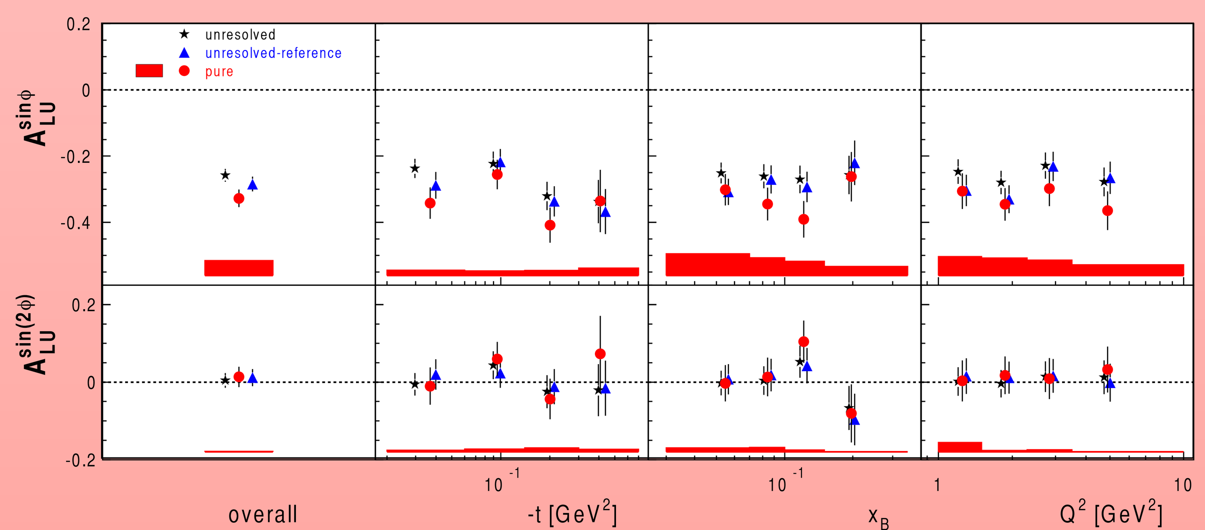
DVCS Results

The exclusiveness of the selected event samples prior to the installation of the Recoil detector was ensured by requiring the square of the missing mass to be within an 'exclusive region' around the squared proton mass. This so-called 'unresolved sample' contains background from mainly associated DVCS and SIDIS.

The 'unresolved-reference sample' is defined as a subset of the 'unresolved sample', where kinematics are restricted to be in the acceptance of the Recoil detector.



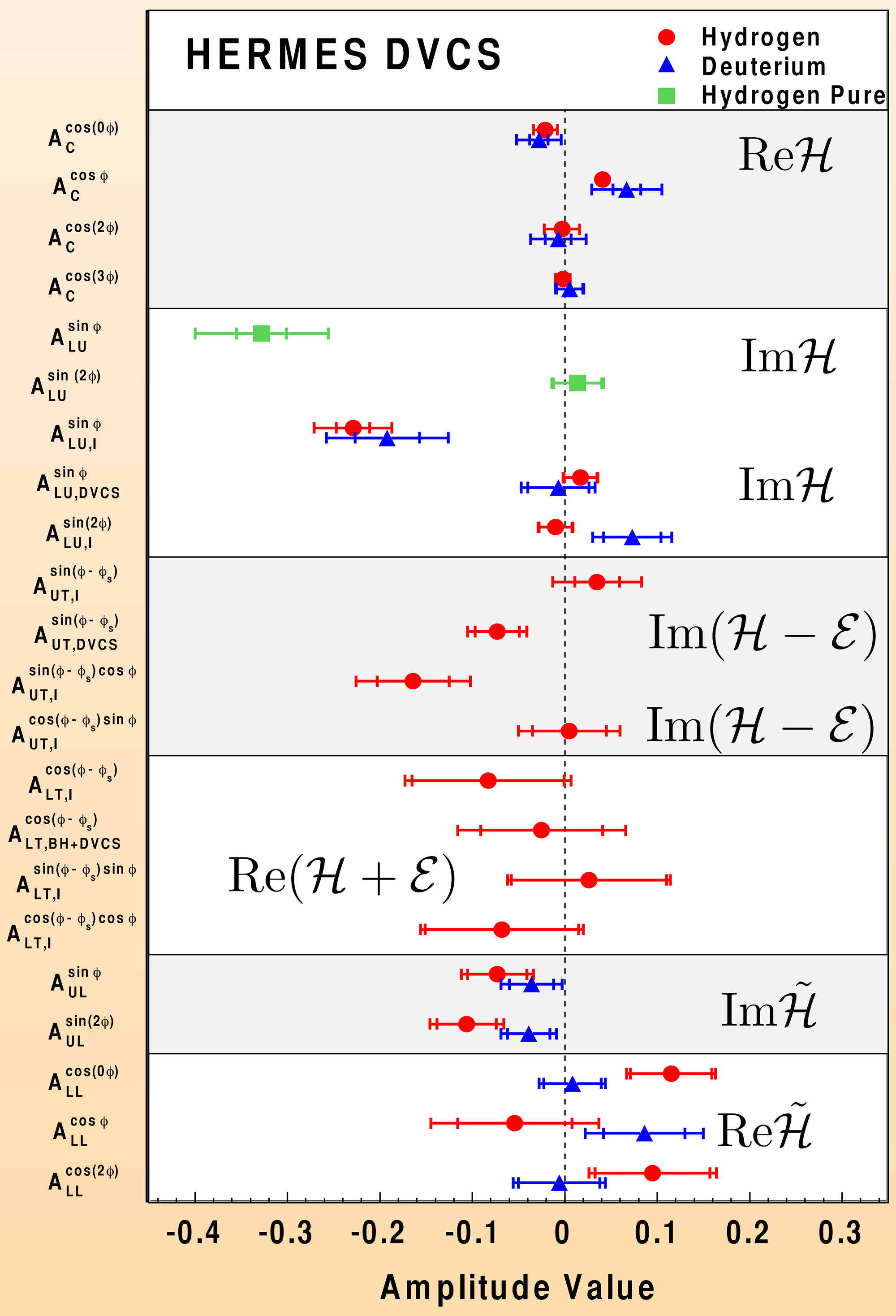
The 'pure sample' is almost free of any background (background contamination <0.2%) and has the same kinematic restrictions as the 'unresolved-reference sample'. This was done carrying out a kinematic fit to the distribution of all final-state particles.



An increase of the magnitude of the leading asymmetry amplitude by 0.054±0.016 is obtained, which is well described by recent fits to previously published data on DVCS and exclusive meson production.

Summary

This summary shows the published HERMES DVCS measurements. Next to the data points the Compton Form Factors (CFFs) are denoted that are most sensitive to the extracted asymmetries.



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