Asymmetries in Exclusive Electroproduction at HERMES

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on behalf of
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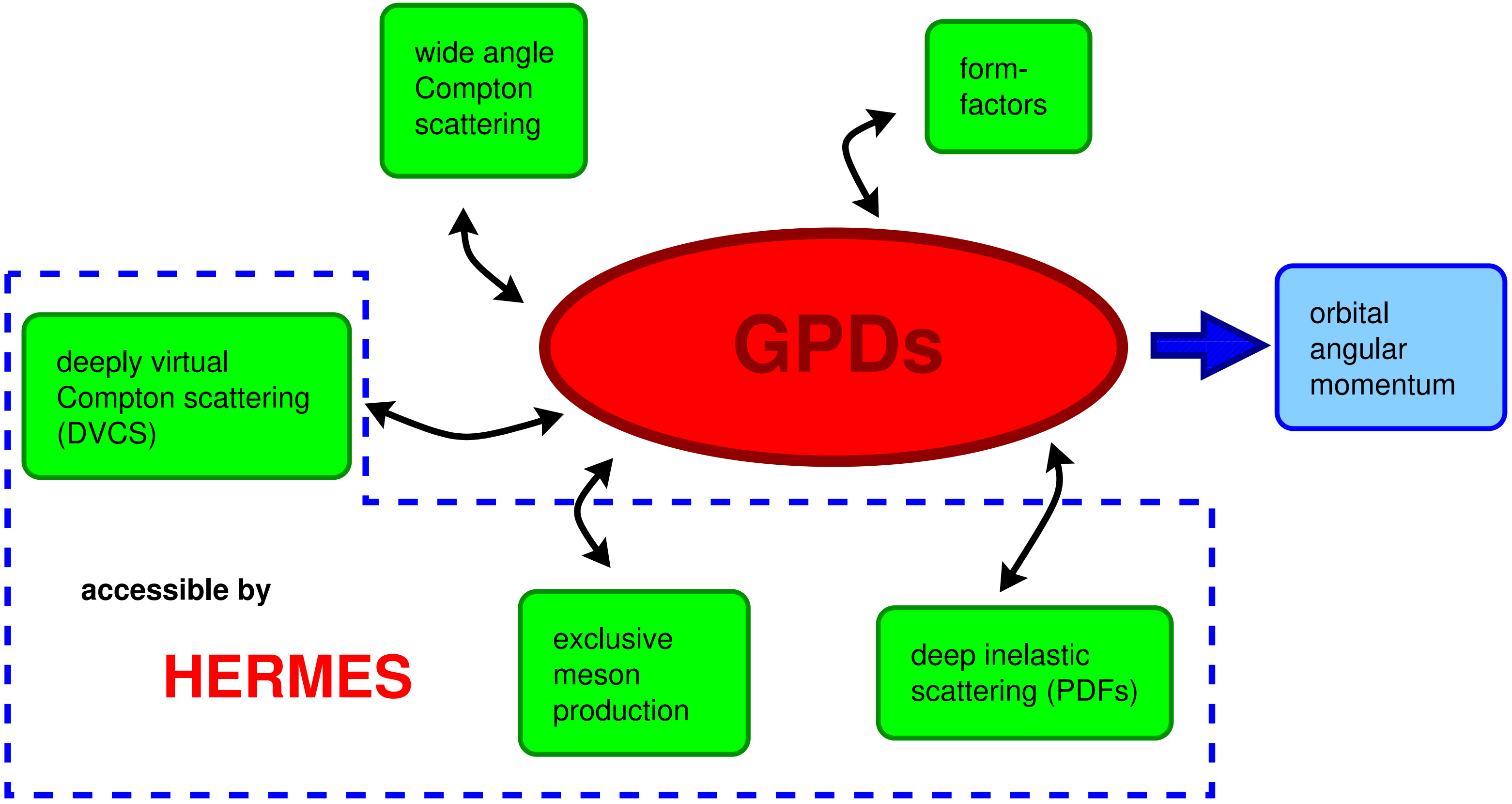
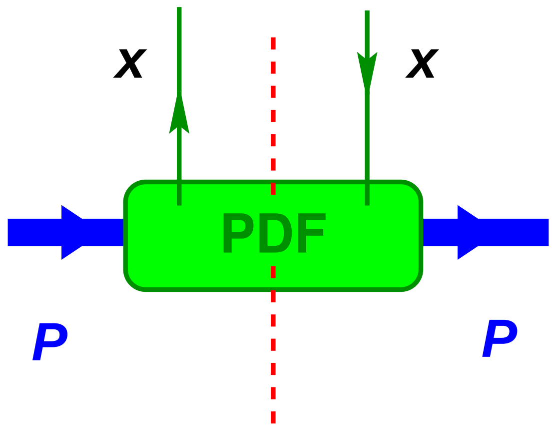
- Why measure exclusive reactions ?
- Experiment and Kinematics
- Deeply Virtual Compton Scattering: from cross sections to amplitudes
- Putting the spin filter: exclusive pion production

Why measure Generalized Parton Distributions . . . ?

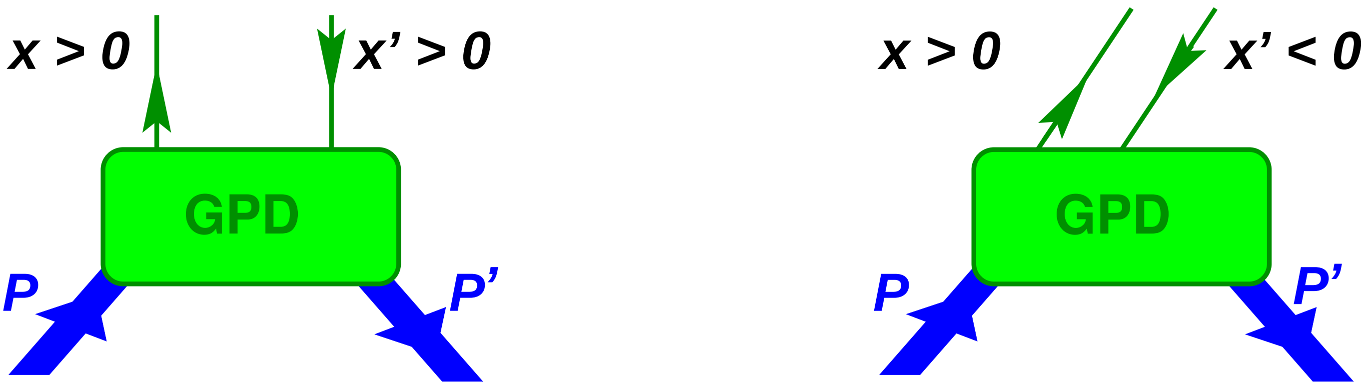


Unified approach to a plenty of processes !

A little more on GPDs



- Probab. to find parton with momentum fraction **x**
- occurs in DIS ($\sigma \propto Im(\mathcal{A})$)



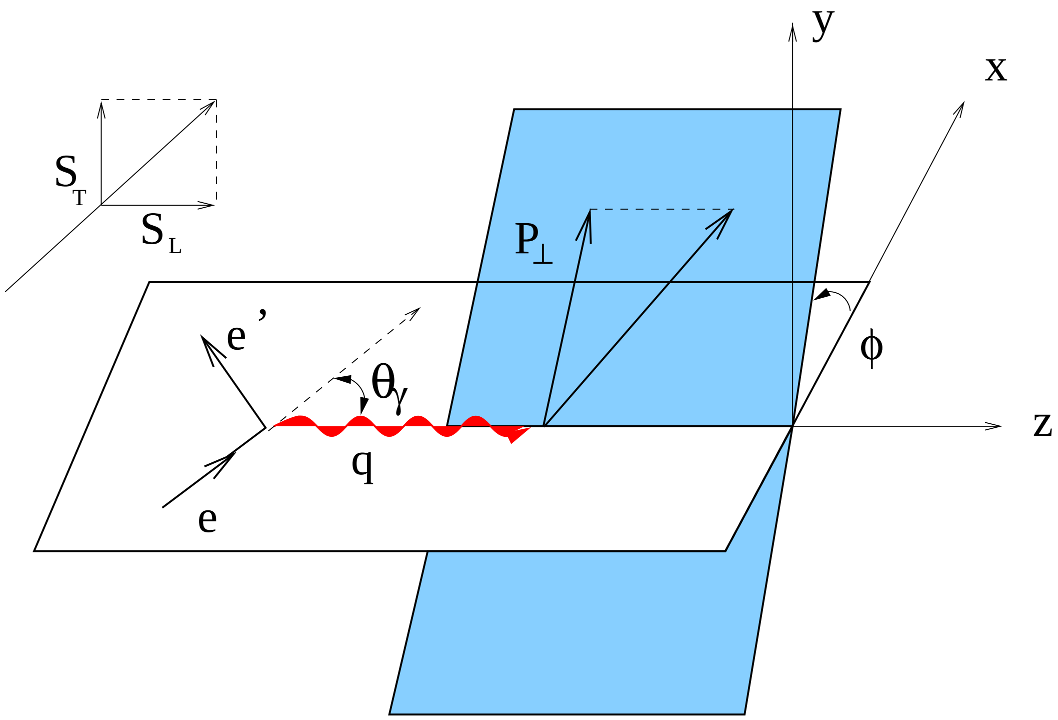
- interference of different configurations

$\rightarrow$ take parton with **x** and reinsert with $\mathbf{x}'$

$\rightarrow$ take parton with **x** and antiparton with $\mathbf{x}'$

- occurs in e.g. Compton amplitude (full $\mathcal{A}$)
- four functions: $\tilde{E}, \tilde{H}, E, H$

Kinematics



Detected: e' and π^+ or e' and γ

$$-q^2 \stackrel{\text{lab}}{=} 4EE'\sin^2(\theta/2) = Q^2$$

$$x_B = \frac{Q^2}{2Pq}$$

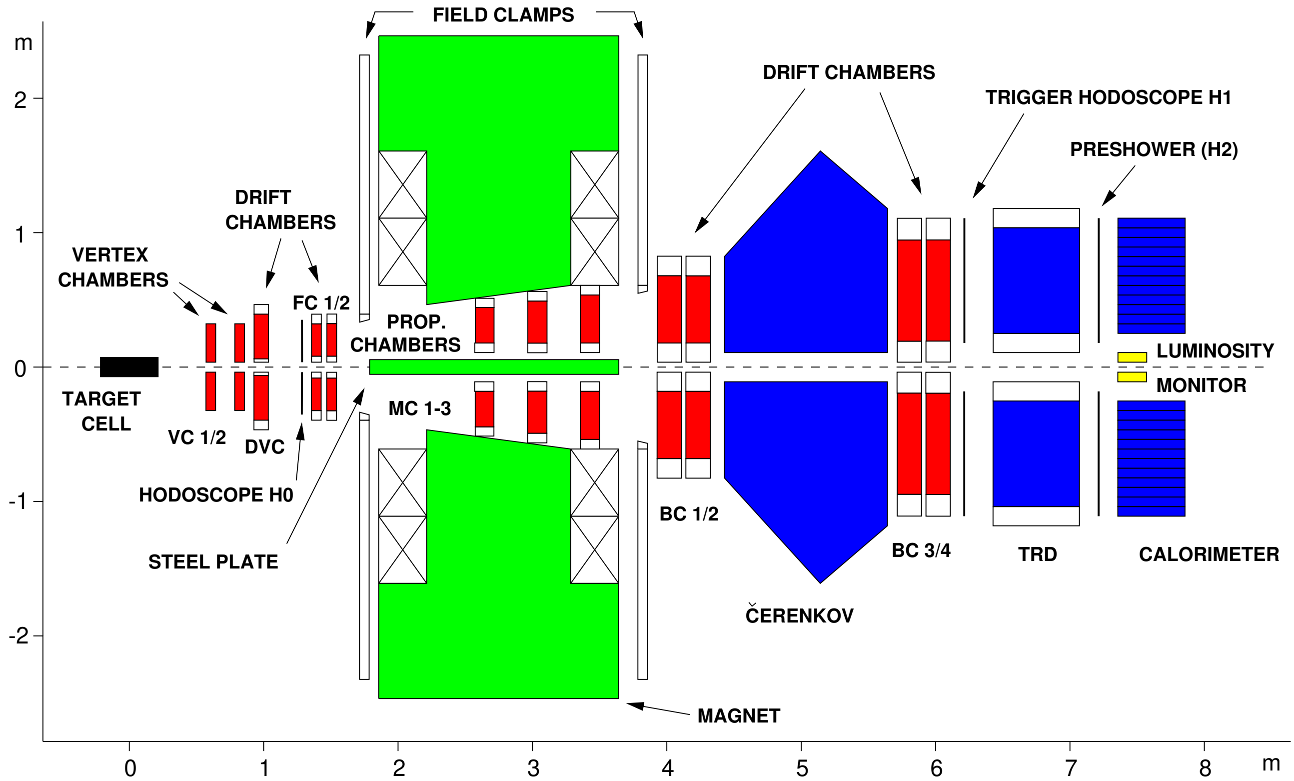
$$\phi = \text{Azimuthal angle of reaction product with } q$$

$$M_x^2 = (P + q - p)^2$$

$$t = (q - p)^2 = (P - N)^2$$

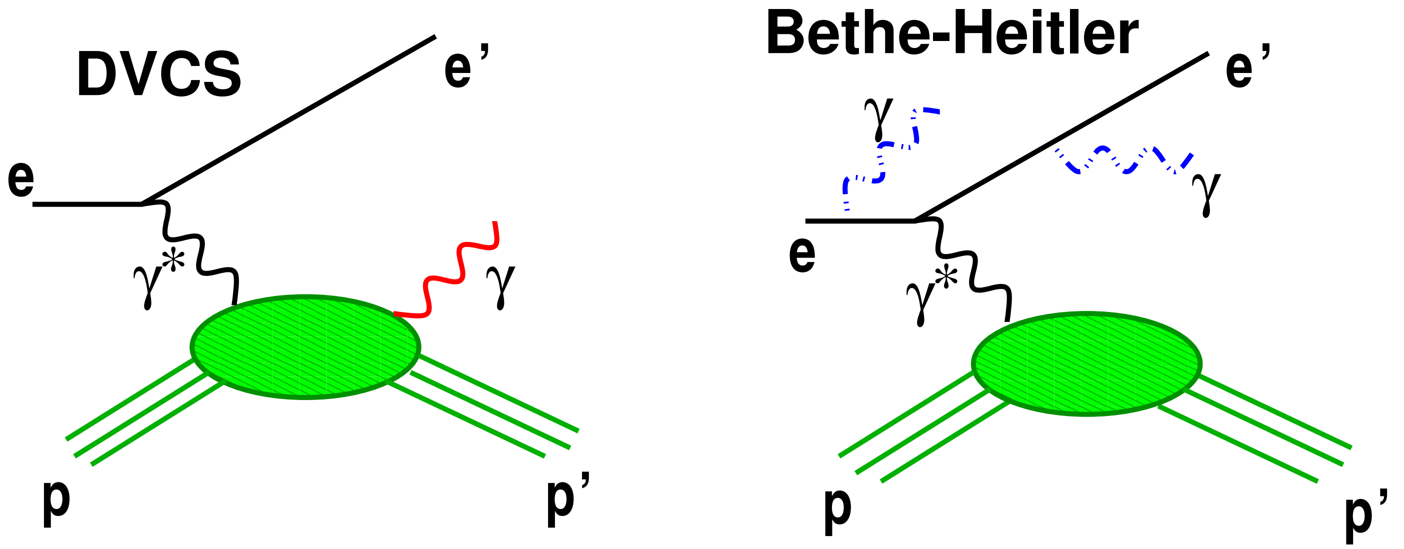
$$S_T, S_L = \text{target spin projections}$$

The HERMES Detector



- Beam: 27.6 GeV, e^+ or e^-, $\langle P_B \rangle \approx 0.55$
- Target: long. pol. H, $\langle P_T \rangle \approx 0.88$, unpol H_2
- kinematical coverage: $0.02 \leq x_B \leq 0.8$ for $Q^2 > 1$ GeV^2 and $W^2 > 4$ GeV^2
- tracking: 57 tracking planes, $\delta P/P < 1.3\%$
- PID: Calorimeter, Čerenkov, TRD; $\epsilon_e \approx 0.99$

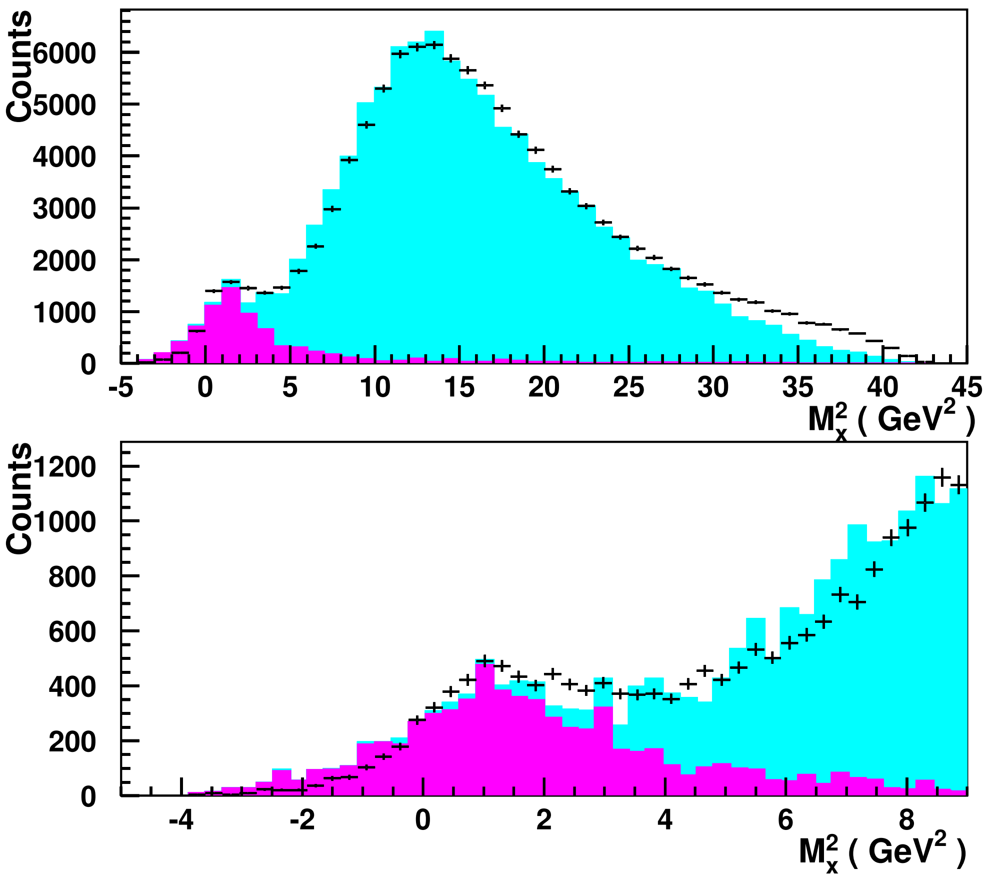
BH - DVCS interference



$$\frac{d^4\sigma}{d\phi dt dQ^2 dx_B} \propto |\tau_{BH}|^2 + |\tau_{DVCS}|^2 + \tau_{BH}\tau^*_{DVCS} + \tau^*_{BH}\tau_{DVCS}$$

- BH drops out in asymmetry measurements
- use BH as lever arm to enhance DVCS signal

Exclusivity in DVCS

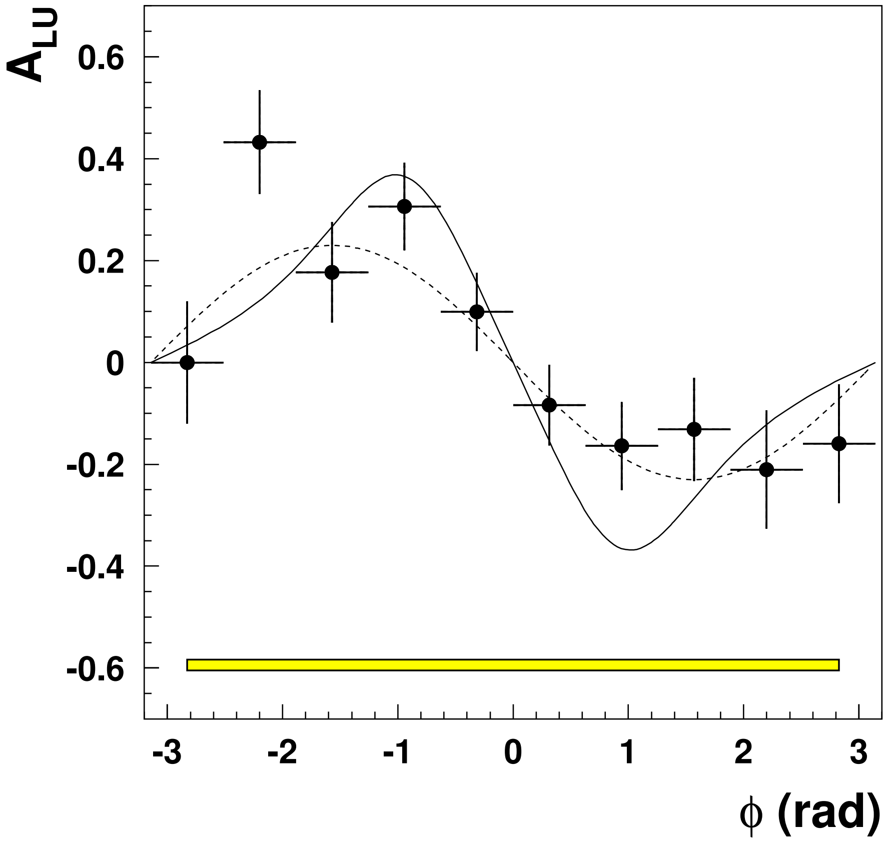


$$M_x^2 = (q + P_p - p)^2$$

$M_x^2 = -\sqrt{-M_x^2}$ due to finite resolution in q and p

Monte Carlo simulation of photons from fragmentation and Bethe–Heitler processes compared with data (+)

Beam Spin Asymmetry in DVCS

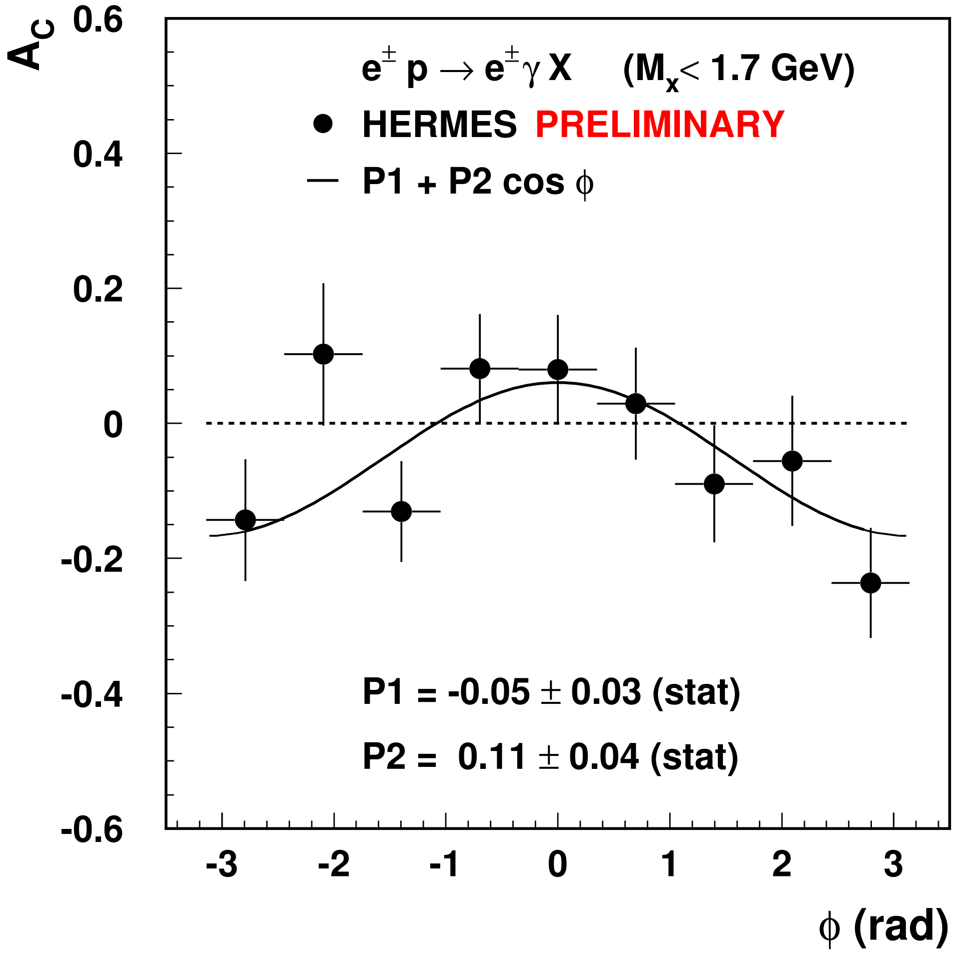


— GPD calculations: N. Kivel et al.
(Phys. Rev. **D 63** (2001) 114014)

$$d\sigma(e^{\rightarrow}p) - d\sigma(e^{\leftarrow}p) \propto \sin\phi \times Im\tilde{M}^{1,1}$$

Exploit $\sin\phi$ moment with polarized beam
$\Rightarrow$ direct access to **Imaginary part** of amplitude

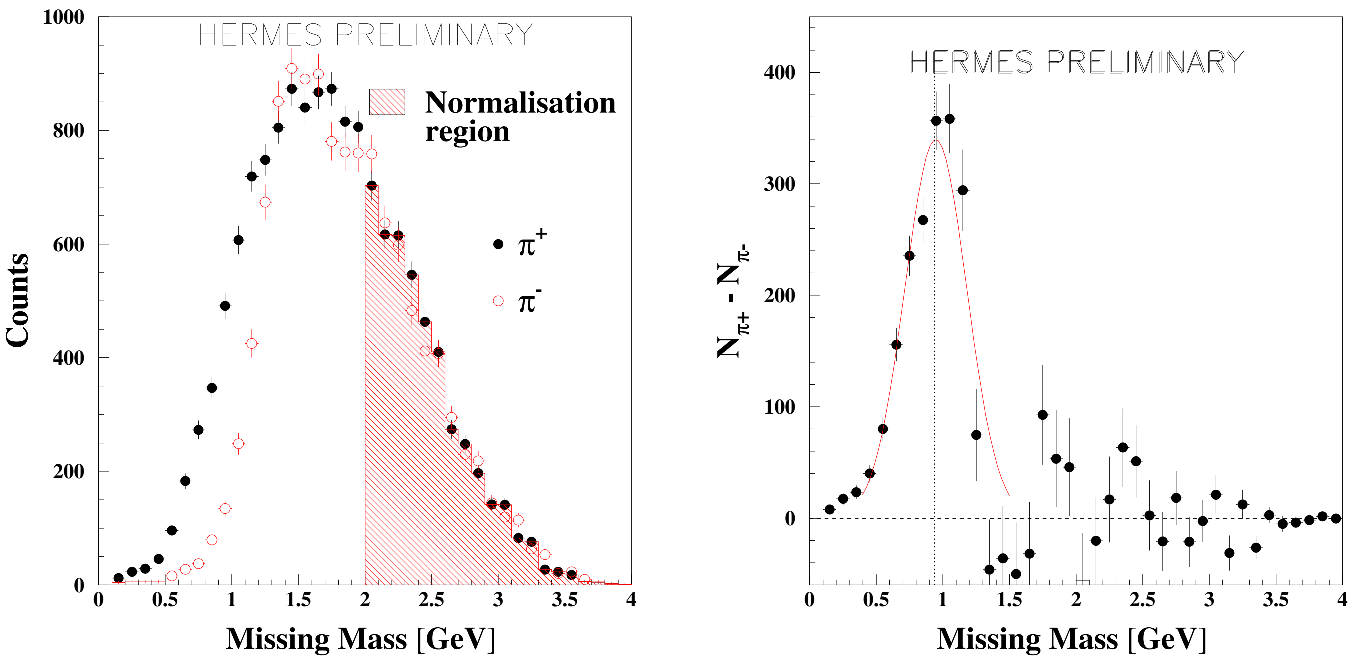
Beam Charge Asymmetry in DVCS



$$d\sigma(e^+p) - d\sigma(e^-p) \propto \cos\phi \times Re\tilde{M}^{1,1}$$

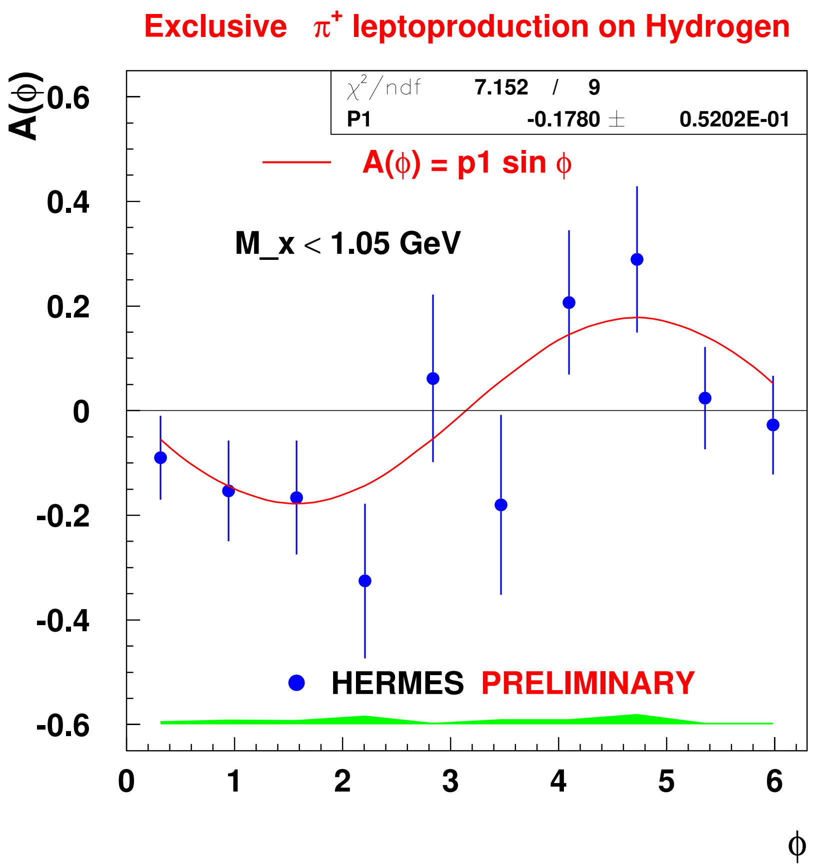
Exploit $\cos\phi$ moment with different beam charges
$\Rightarrow$ direct access to **Real part** of amplitude

Exclusivity for π^+



- Normalize π^- to π^+ for $M_x > 2$ GeV
- Clear M_x peak around nucleon mass
- Small debt at $M_x \approx 1.3 - 1.6$ due to different σ $e + p \to e + \Delta^\circ + \pi^+$ and $e + p \to e + \Delta^{++} + \pi^-$
- SSA for Semi–Inclusive Region $\approx 2.8 \pm 1.4\%$ incl. into systematic error

Target Spin Asymmetry in excl. π^+



$$A_{UL}(\phi) = \frac{1}{\langle|P_T|\rangle}\frac{N^+(\phi) - N^-(\phi)}{N^+(\phi) + N^-(\phi)} = -0.18 \pm 0.05$$

$\langle Q^2 \rangle = 2.2$ GeV^2 $\quad\langle x_B \rangle = 0.15$ $\quad\langle -t \rangle = 0.46$ GeV^2

No predictions available !

One Experiment to address many open questions:

- DVCS: **B**eam **S**pin **A**symmetry $\Rightarrow Im(\mathcal{A})$
  Beam **C**harge **A**symmetry $\Rightarrow Re(\mathcal{A})$

$\rightarrow$ first glimpse on Generalized Parton Distributions

- excl. π^+: SSA A_{UL} has been measured, sizeable twist–3 contribution needed to explain data

- In addition: HERMES vectormeson data sensitive to GPD calculations

The HERMES road to GPDs:

- from data on tape: $\gamma, \pi^\pm, \pi^\circ, \eta, K, \ldots$ on p and d (SSA (UL/LU), $d\sigma/dt$, BCA)

- HERMES Run II: running with a transversely polarized target $\Rightarrow$ direct access to many GPD predictions

- In Future: installation of a recoil detector dedicated to measure the recoil from exclusive reaction
  ($\Rightarrow$ Poster HK 14.18, M. Düren HK 49.1)