HK 27.7

Measurements of azimuthal asymmetries in DVCS and associated processes at HERMES

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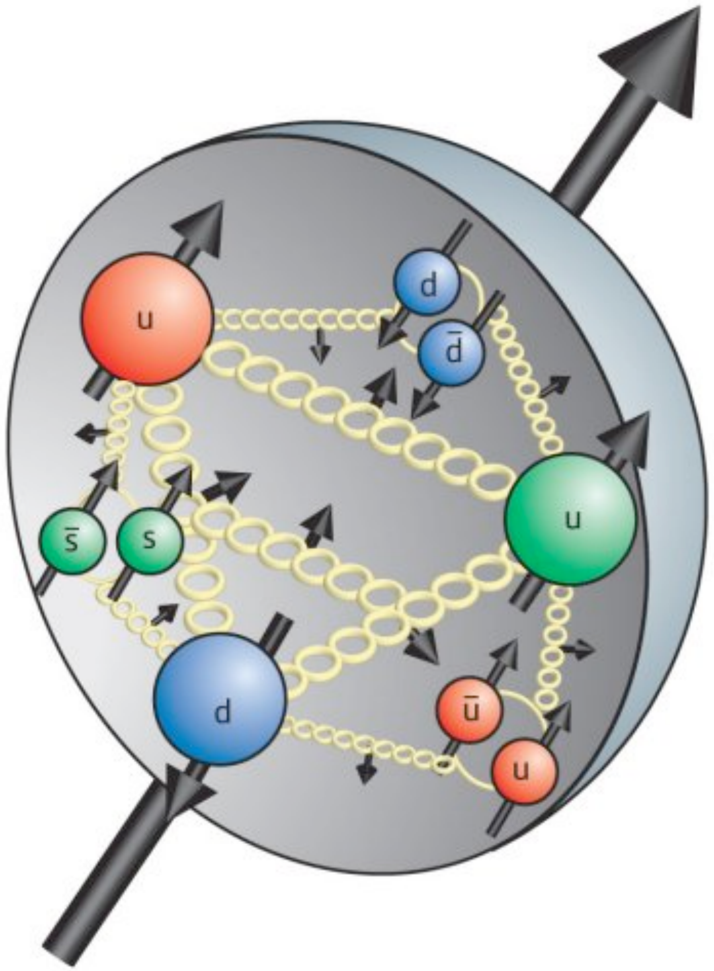


The proton spin puzzle

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

contribution by quarks lower than expected from naive quark model

$$J_q = \frac{1}{2} \cdot \Delta\Sigma + L_q$$

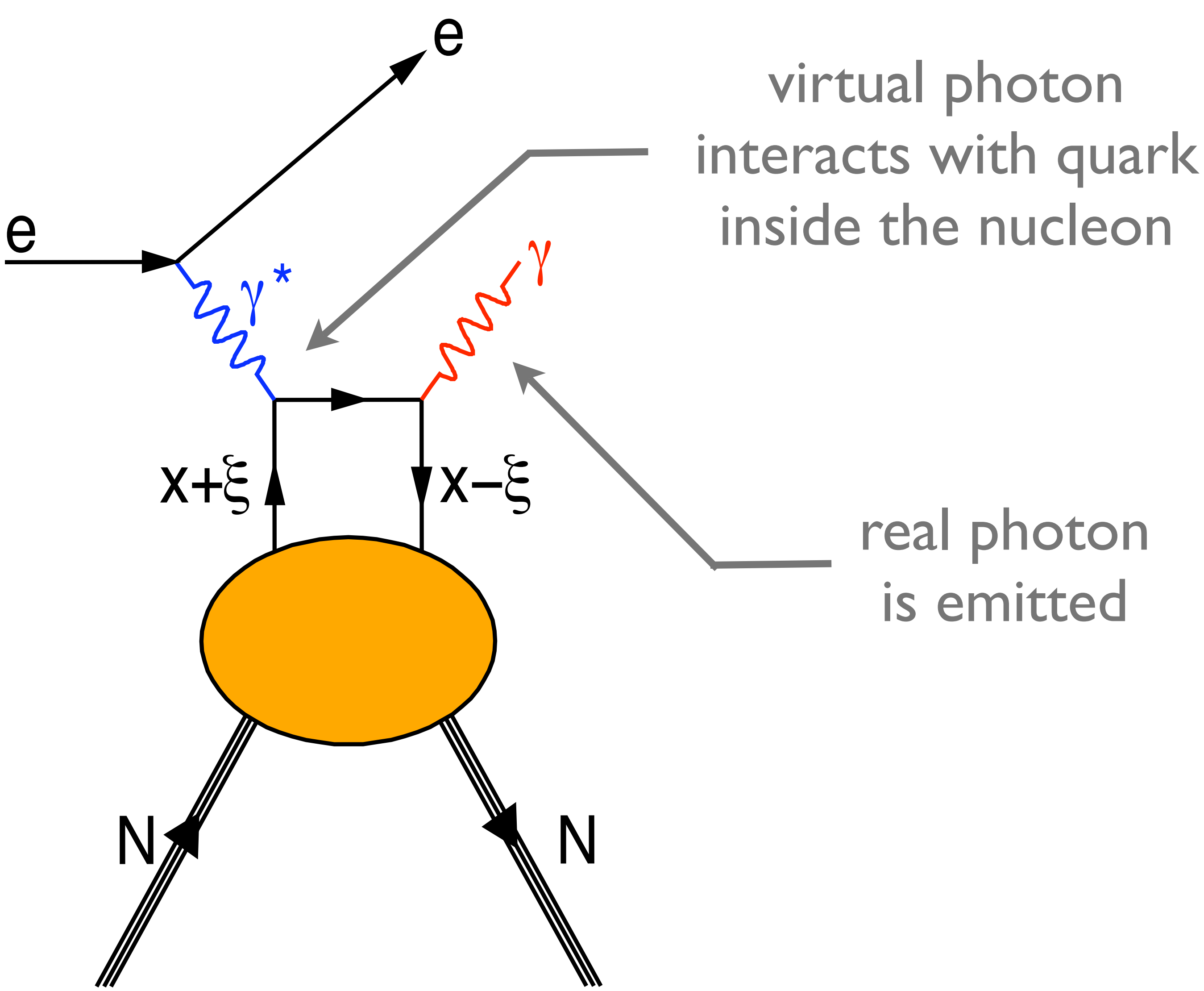
Ji found a way to access total angular momentum through GPDs [X. Ji, Phys. Rev. Lett. 78 (1997) 610]:

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

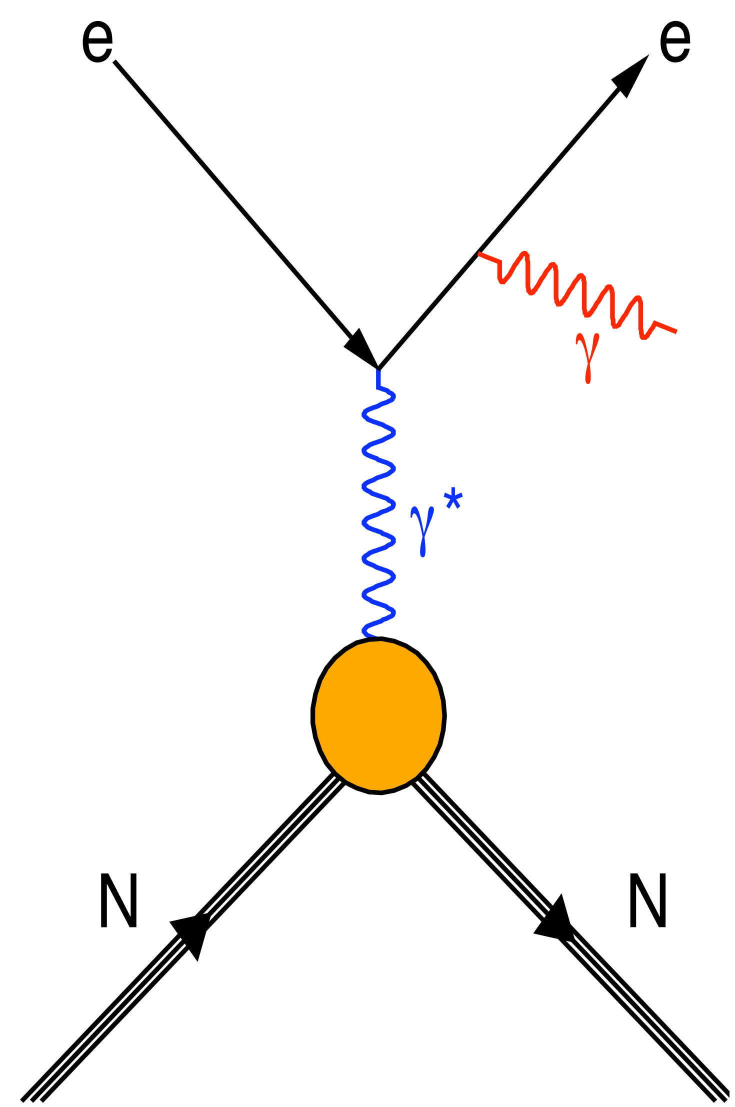
GPDs

DVCS

Theoretically cleanest access to GPDs through DVCS



DVCS



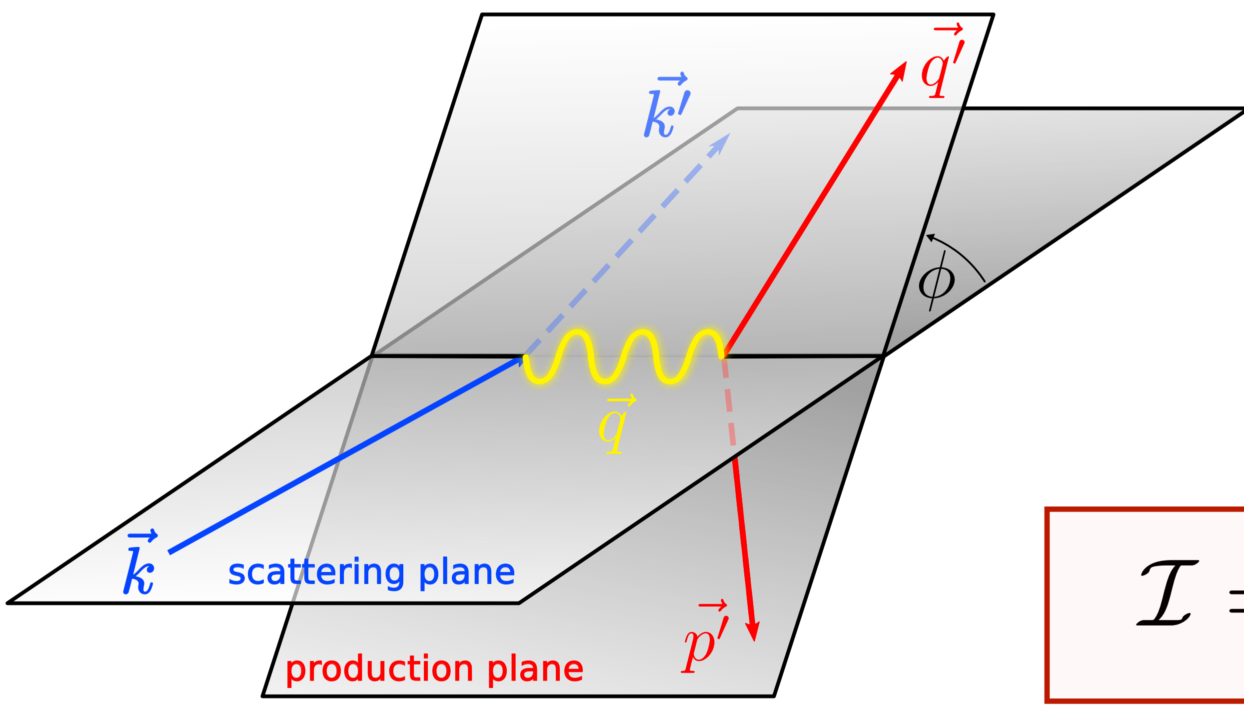
BH

But: final state is equal to Bethe-Heitler scattering (BH)

$$\frac{\mathrm{d}^4}{\mathrm{d}Q^2\mathrm{d}x_B\mathrm{d}t\mathrm{d}\phi} = \frac{x_B e^6}{32(2\pi)^4 Q^4 \sqrt{1+\epsilon^2}} \left|\mathcal{T}_{ep\to ep\gamma}\right|^2$$

Amplitude of Bethe-Heitler scattering is dominant at HERMES kinematics

$$\left|\mathcal{T}_{ep\to ep\gamma}\right|^2 = \left|\mathcal{T}_{BH}\right|^2 + \left|\mathcal{T}_{DVCS}\right|^2 + \mathcal{I}$$



DVCS amplitude is amplified by BH in the interference term

$$\mathcal{I} = \mathcal{T}_{BH}\mathcal{T}^*_{DVCS} + \mathcal{T}_{DVCS}\mathcal{T}^*_{BH}$$

hermes

Access through the measurement of asymmetries:

$$\mathcal{A}_{\mathrm{LU}}(\phi, e_l) = \frac{\sigma_{\mathrm{LU}}(\phi, e_l, \lambda = +1) - \sigma_{\mathrm{LU}}(\phi, e_l, \lambda = -1)}{\sigma_{\mathrm{LU}}(\phi, e_l, \lambda = +1) + \sigma_{\mathrm{LU}}(\phi, e_l, \lambda = -1)}$$

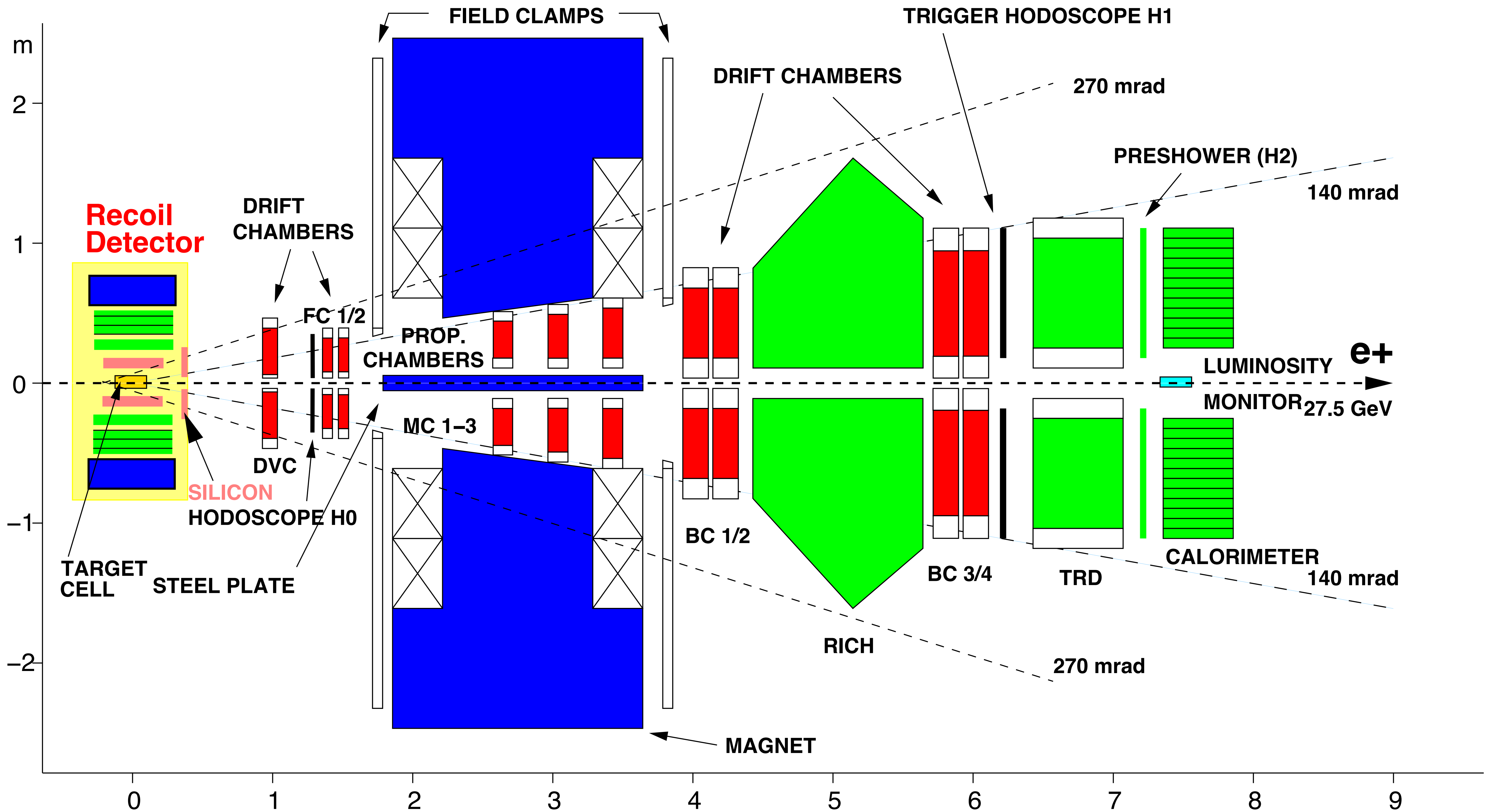
$$= \frac{1}{\sigma_{\mathrm{UU}(\phi, e_l)}} \left[K_{DVCS}\, s_1^{DVCS} \sin\phi - \frac{e_l K_{\mathcal{I}}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)} \sum_{n=1}^{2} s_n^{\mathcal{I}} \sin(n\phi) \right]$$

longitudinal polarized beam, unpolarized target

Fourier coefficients comprise Compton-Form factors (CFFs) which are convolutions of the GPDs on the hard scattering kernel.

Example:

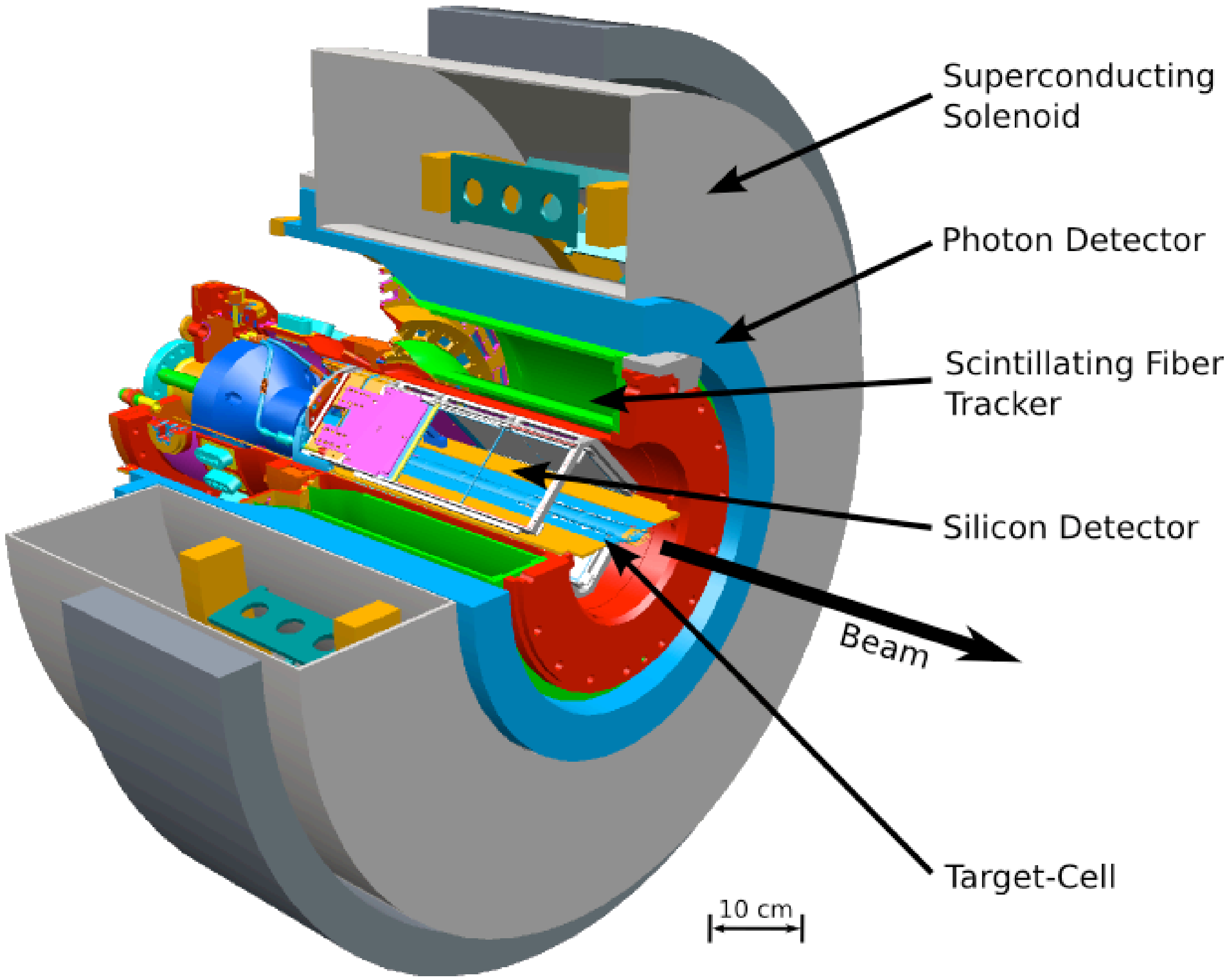
$$A_{\mathrm{LU}}(\phi) \sim \pm \frac{x_B}{y} \frac{s_1^{\mathcal{I}}}{c_0^{\mathrm{BH}}} \sin(\phi) \propto \Im\mathrm{m} \left\{ F_1 \mathcal{H} + \frac{x_B}{2 - x_B}(F_1 + F_2)\widetilde{\mathcal{H}} - \frac{\Delta^2}{4M^2} F_2 \mathcal{E} \right\} \sin(\phi)$$



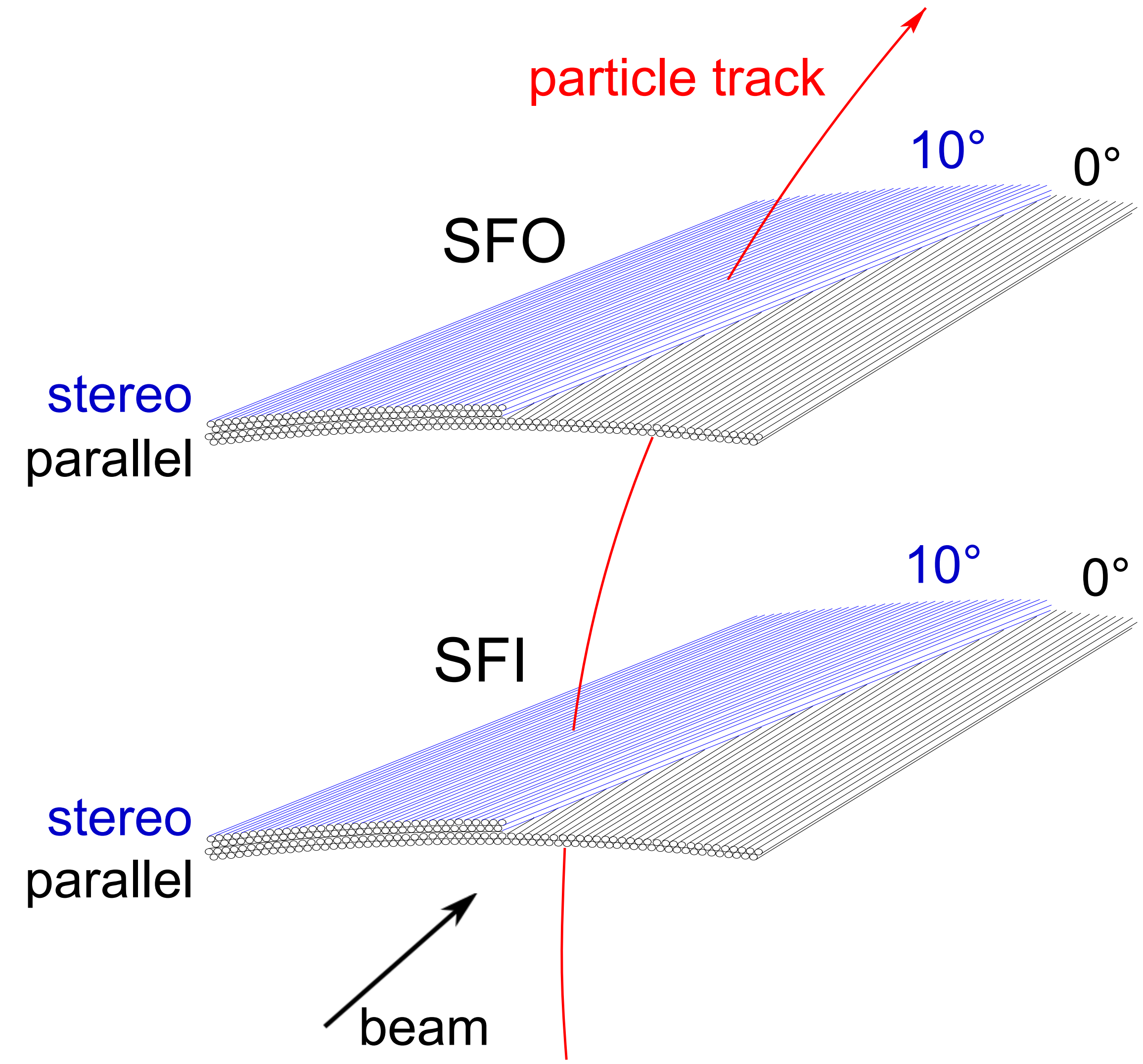
Schematic view of the HERMES experiment after being upgraded with the recoil detector during the years 2006 and 2007

The HERMES recoil detector

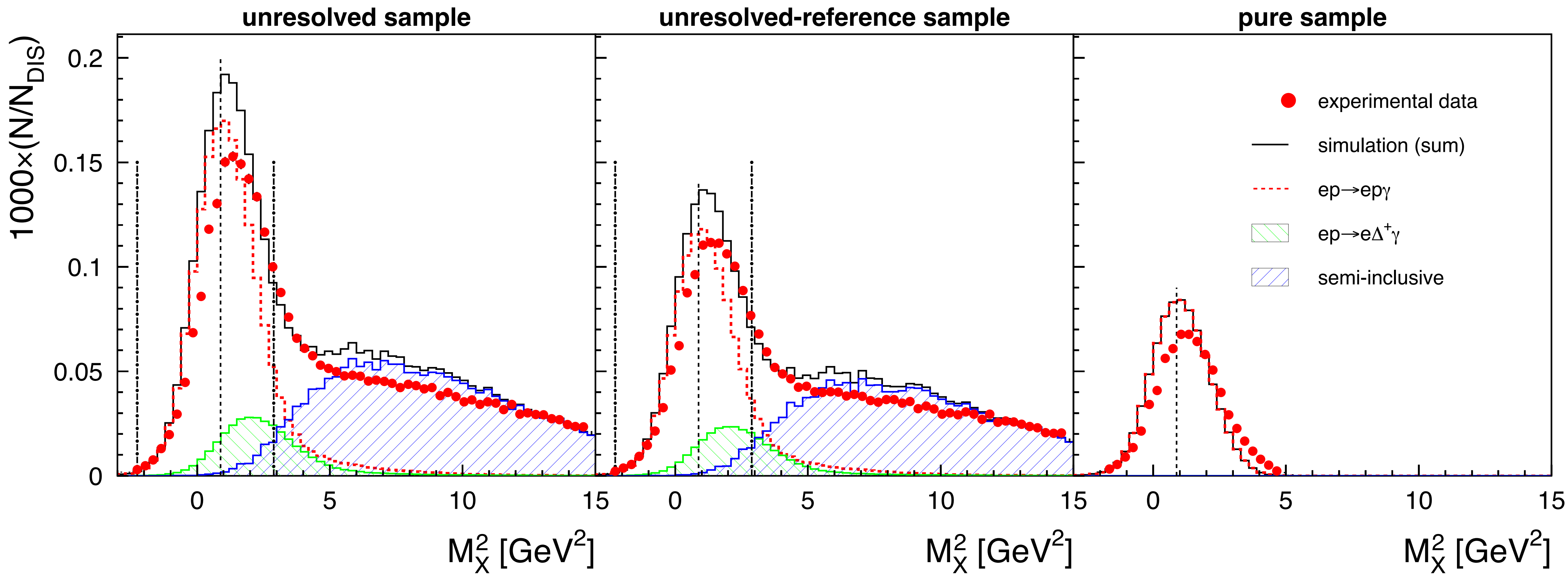
Side view of the recoil detector



Schematic design of the scintillating fibre tracker (SFT)



Enables the measurement of the recoiling particle and therefore full event reconstruction in case of ep→epγ



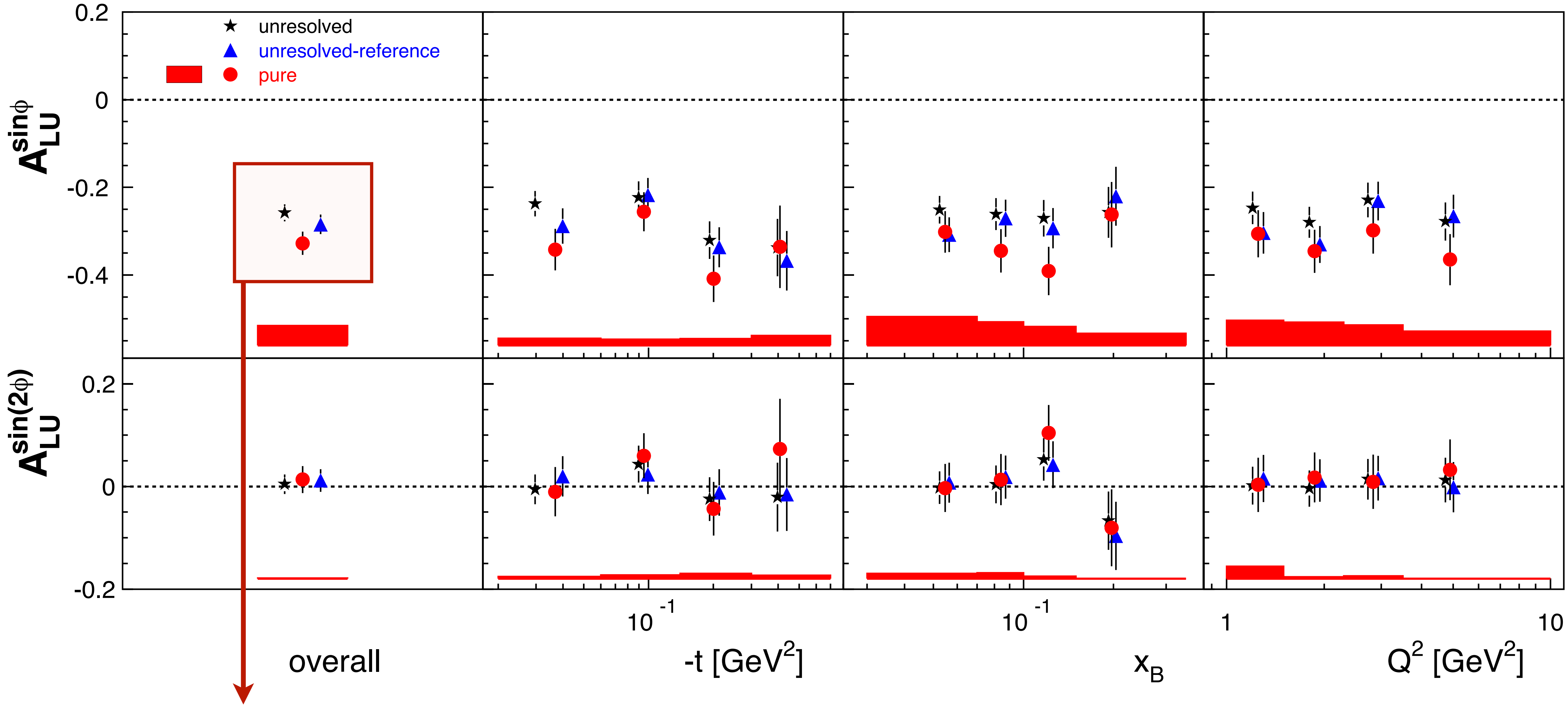
Kinematic fitting allows a background free selection of events of the type ep→epγ

$$\chi^2_{pen} = \sum_{i=1}^{9} \frac{(r_i^{fit} - r_i^{meas})^2}{\sigma_i^2} + T \cdot \sum_{j=1}^{4} \frac{\left[f_j(r_1^{fit}, \ldots, r_9^{fit})\right]^2}{(\sigma_j^f)^2}$$

χ^2-value of interest — penalty term — constraints

Beam-spin asymmetries ep→eγp

A. Airapetian et al, JHEP10 (2012) 042

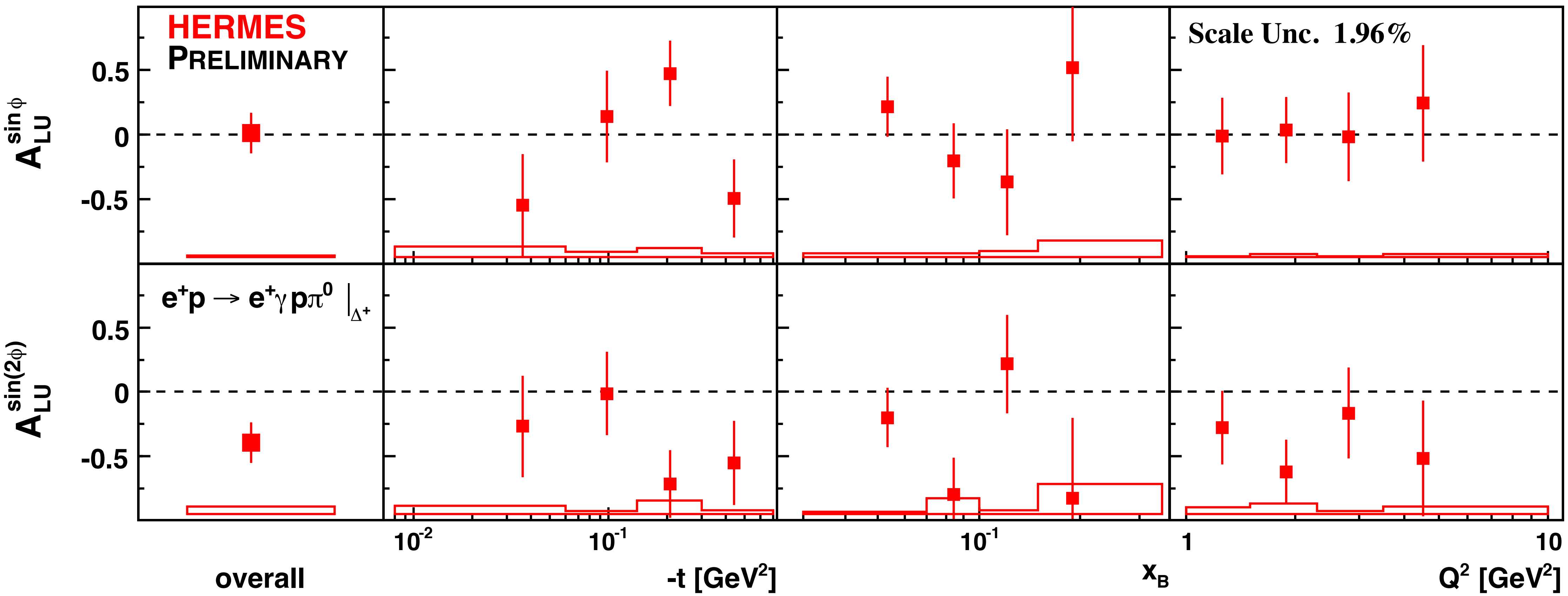


Magnitude of the leading asymmetry has increased by 0.054 ± 0.016

All sets are strongly correlated but the unresolved samples contain an average contribution of 12 -14 % of associated processes

Beam-spin asymmetries $ep \to e\gamma(\Delta^+ \to p\pi^0)$

Selection feasible due to measurement of the recoiling particle and kinematic fitting with an additional lower cut on the elastic hypothesis and considering particle identification

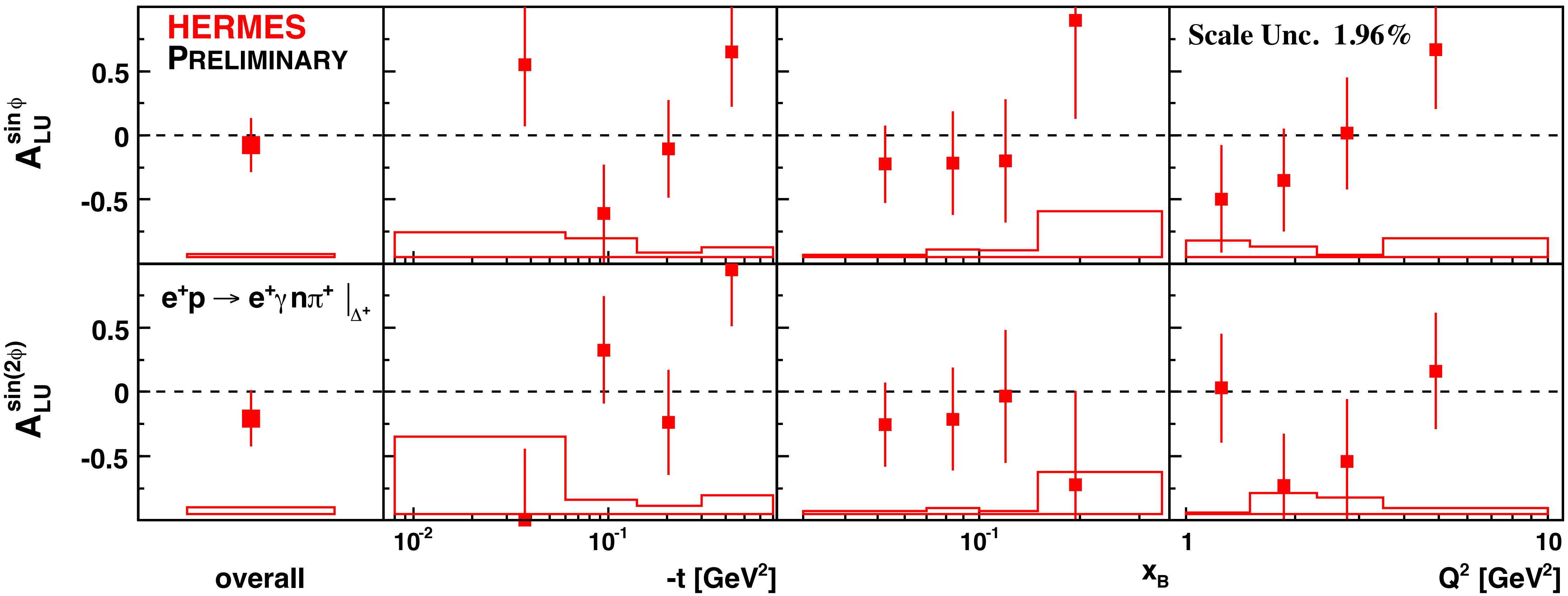


Shown amplitudes are corrected for background (only overall fractions are shown):

Associated DVCS/BH ($ep \to e\gamma p\pi^0$)	85.7 ± 1.8
Elastic DVCS/BH ($ep \to e\gamma p$)	1.1 ± 0.1
SIDIS	13.2 ± 1.9

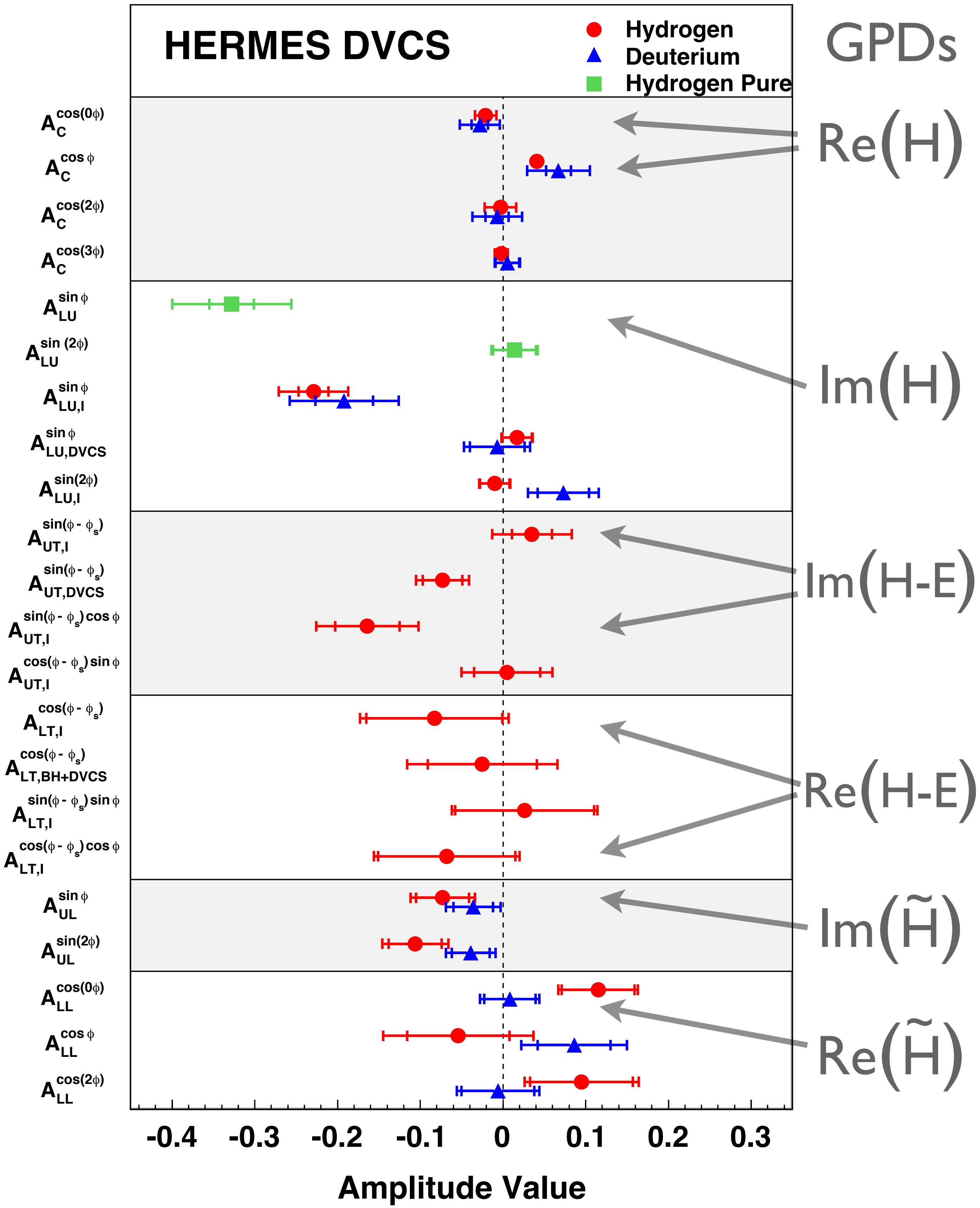
Beam-spin asymmetries $ep \to e\gamma(\Delta^+ \to n\pi^+)$

Selection feasible due to measurement of the recoiling particle and kinematic fitting with an additional lower cut on the elastic hypothesis and considering particle identification



Shown amplitudes are corrected for background (only overall fractions are shown):

Associated DVCS/BH ($ep \to e\gamma n\pi^+$)	75.6 ± 2.6
Elastic DVCS/BH ($ep \to e\gamma p$)	0.1 ± 0.1
SIDIS	24.4 ± 3.4



A. Airapetian et al, JHEP 06 (2008) 066

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A. Airapetian et al,
Nucl. Phys. B 842 (2011) 265-298

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A. Airapetian et al, JHEP 10 (2012) 042

Summary and outlook

- Recoil detector allowed background free selection of the elastic process
- This leads to an increase in the measured leading asymmetry
- Selection of associated processes is feasible with the recoil detector
- All but one amplitude are found to be consistent with zero within large experimental uncertainties
- Analysis of beam-charge asymmetries are ongoing