Experimental overview of latest DVCS results

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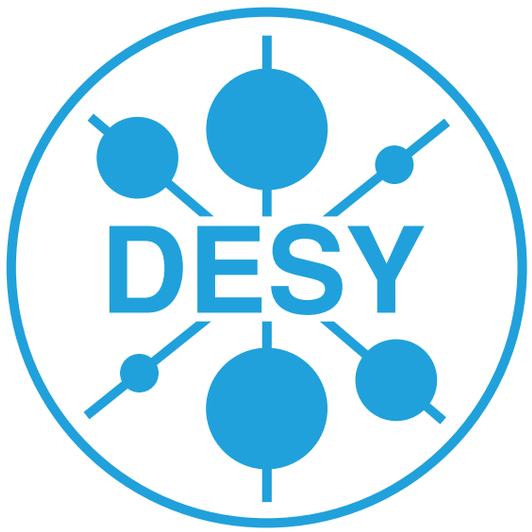
for the HERMES collaboration

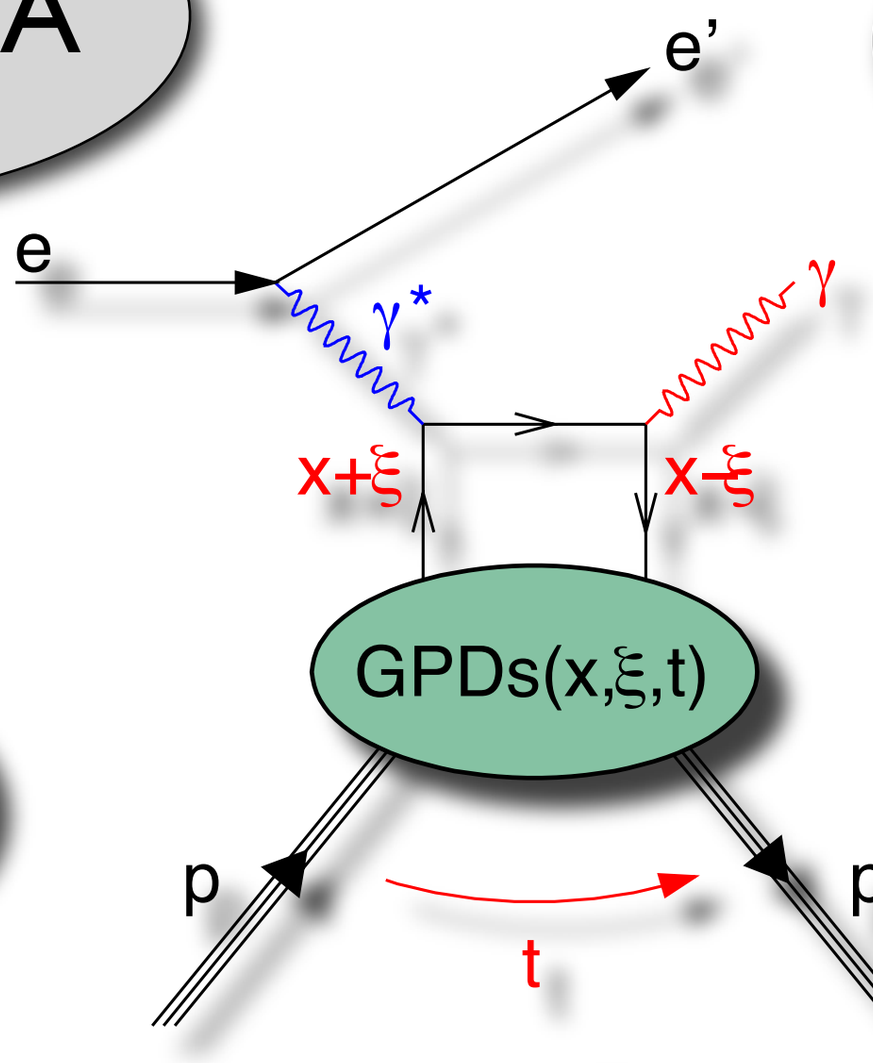


EINN 2009
30/09/09, Milos Island, Greece

Outline

combined
BCA & BSA
on proton

combined
BCA & BSA
on deuteron

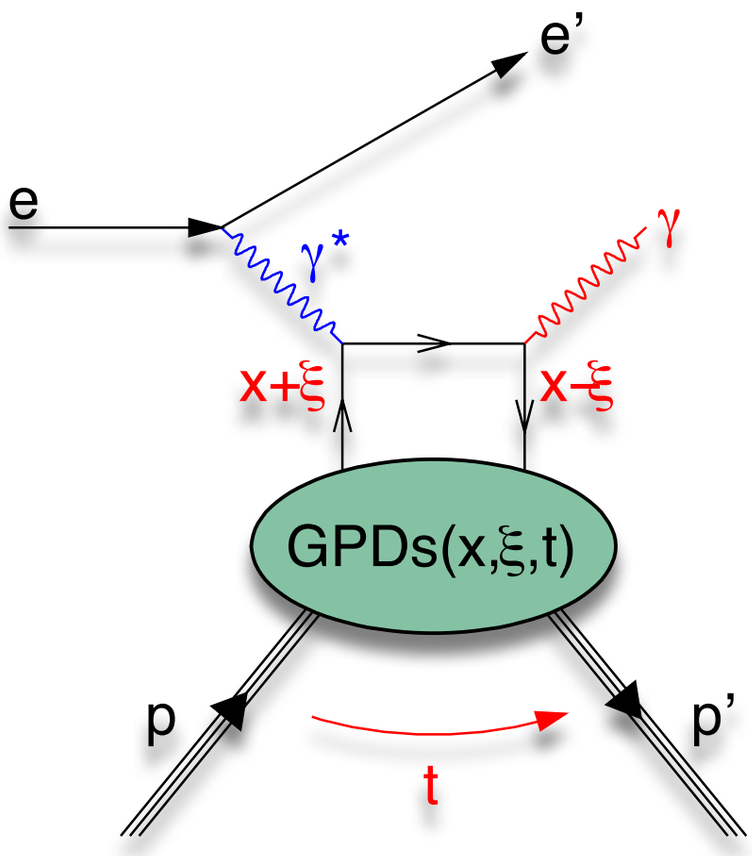


TTSA
on proton

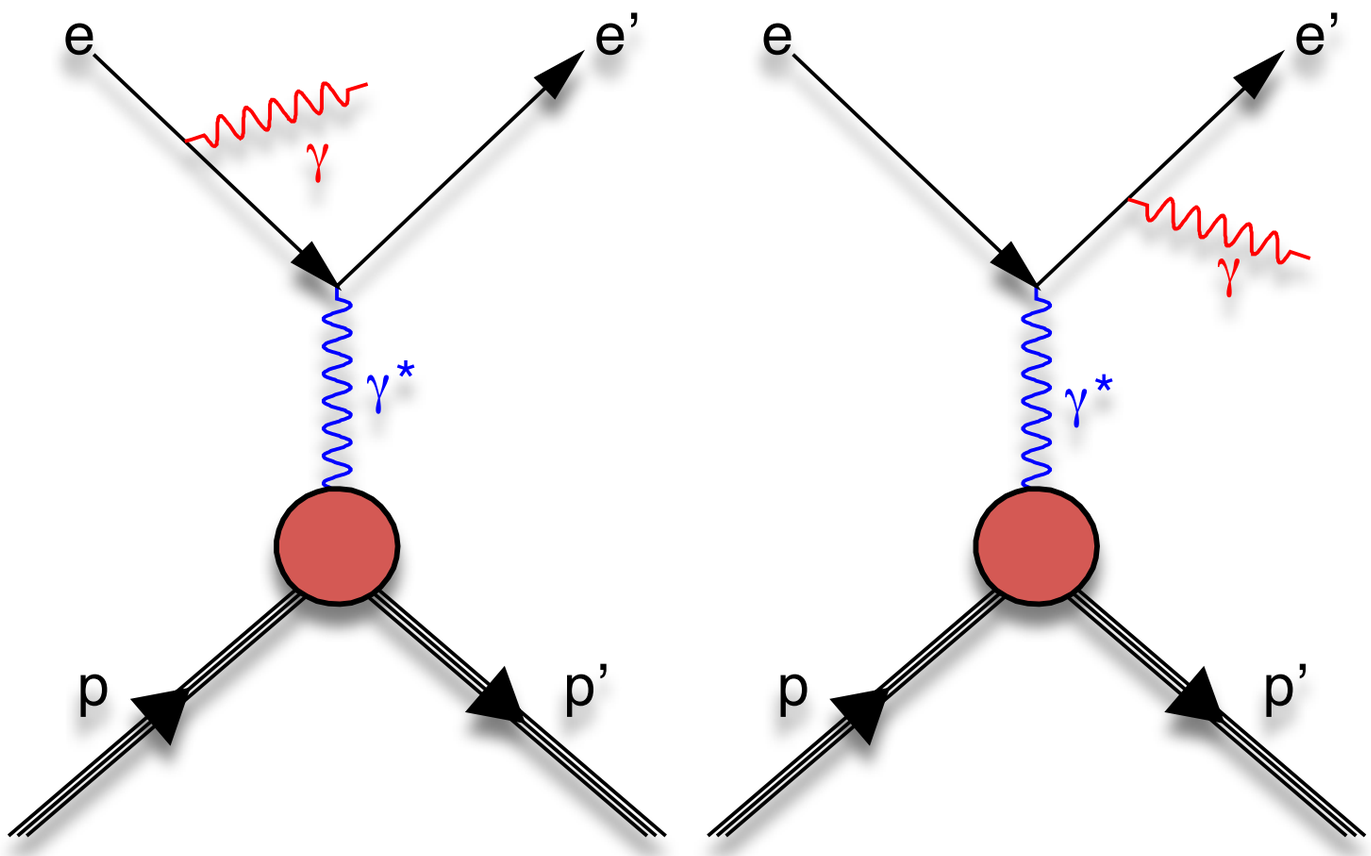
BCA & BSA
on nuclear targets

BCA* & BSA*
on proton & deuteron

Access to GPDs



DVCS



Bethe-Heitler

- DVCS and Bethe-Heitler have same final state
- Bethe-Heitler dominates at HERMES kinematics
- Access to GPDs through cross-section differences and azimuthal asymmetries via interference term

$$d\sigma(eN \to e'N'\gamma) \propto |\mathcal{T}_{BH}|^2 + |\mathcal{T}_{DVCS}|^2 + \mathcal{T}_{BH}\mathcal{T}^*_{DVCS} + \mathcal{T}^*_{BH}\mathcal{T}_{DVCS}$$

Azimuthal Asymmetries

- Cross-section

$$\sigma_{LU}(\phi; P_B, C_B) = \sigma_{UU}\left[1 + P_B A_{LU}^{DVCS} + C_B P_B A_{LU}^{I} + C_B A_C\right]$$

- Beam Helicity Asymmetry

$$A_{LU}^{DVCS}(\phi) = \frac{(\sigma^{+\rightarrow} - \sigma^{+\leftarrow}) - (\sigma^{-\leftarrow} - \sigma^{-\rightarrow})}{(\sigma^{+\rightarrow} + \sigma^{+\leftarrow}) + (\sigma^{-\leftarrow} + \sigma^{-\rightarrow})} = \frac{1}{D(\phi)} \cdot \frac{x_B^2 t \mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}{Q^2} s_1^{DVCS} \sin(\phi)$$

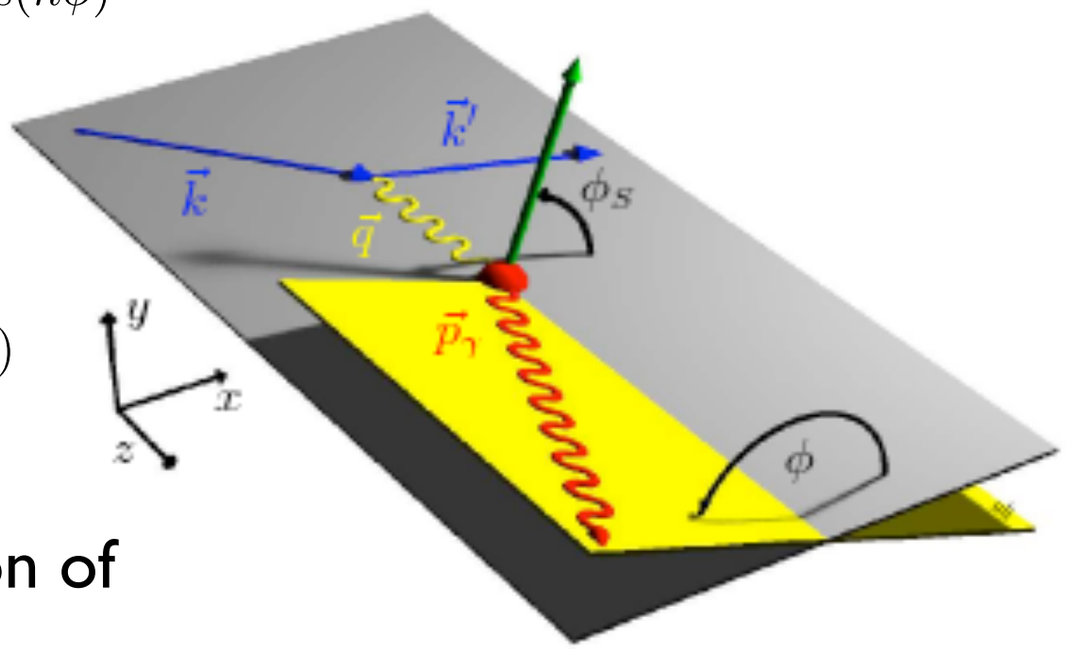
$$A_{LU}^{I}(\phi) = \frac{(\sigma^{+\rightarrow} + \sigma^{-\leftarrow}) - (\sigma^{+\leftarrow} + \sigma^{-\rightarrow})}{(\sigma^{+\rightarrow} + \sigma^{-\leftarrow}) + (\sigma^{+\leftarrow} + \sigma^{-\rightarrow})} = \frac{1}{D(\phi)} \cdot \frac{x_B^2}{Q^2} \sum_{n=1}^{2} s_n^I \sin(n\phi)$$

- Beam Charge Asymmetry

$$A_C(\phi) = \frac{(\sigma^{+\rightarrow} + \sigma^{+\leftarrow}) - (\sigma^{-\leftarrow} + \sigma^{-\rightarrow})}{(\sigma^{+\rightarrow} + \sigma^{+\leftarrow}) + (\sigma^{-\leftarrow} + \sigma^{-\rightarrow})} = \frac{1}{D(\phi)} \cdot \frac{x_B^2}{y} \sum_{n=0}^{3} c_n^I \cos(n\phi)$$

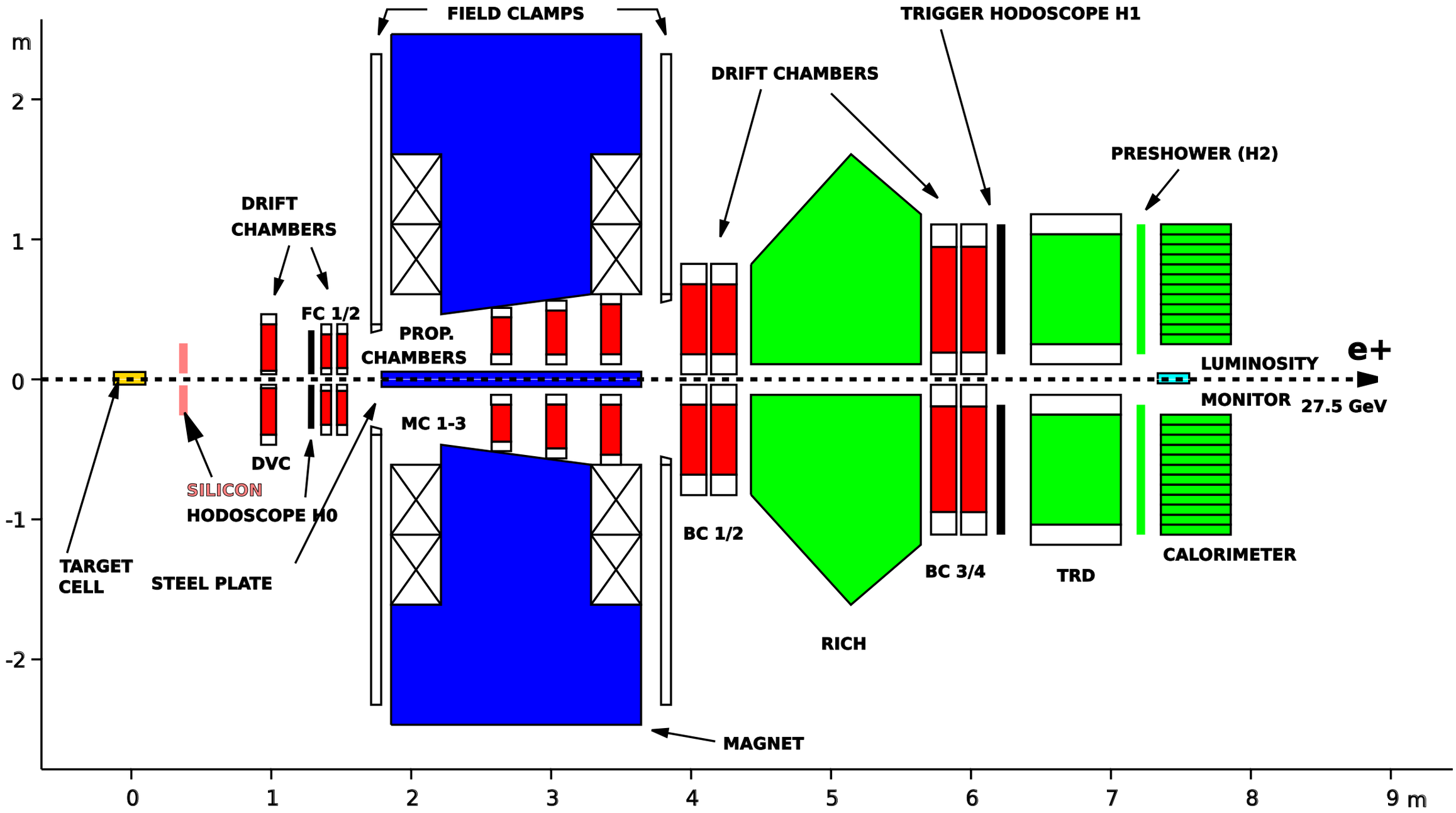
- Dependence on ϕ in denominator

$$D(\phi) = \frac{\sum_{n=0}^{2} c_n^{BH} \cos(n\phi)}{(1+\varepsilon^2)^2} + \frac{x_B^2 t \mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}{Q^2} \sum_{n=0}^{2} c_n^{DVCS} \cos(n\phi)$$



- Combined BSA & BCA analysis allows separation of DVCS and Interference-Term amplitudes

The HERMES Spectrometer



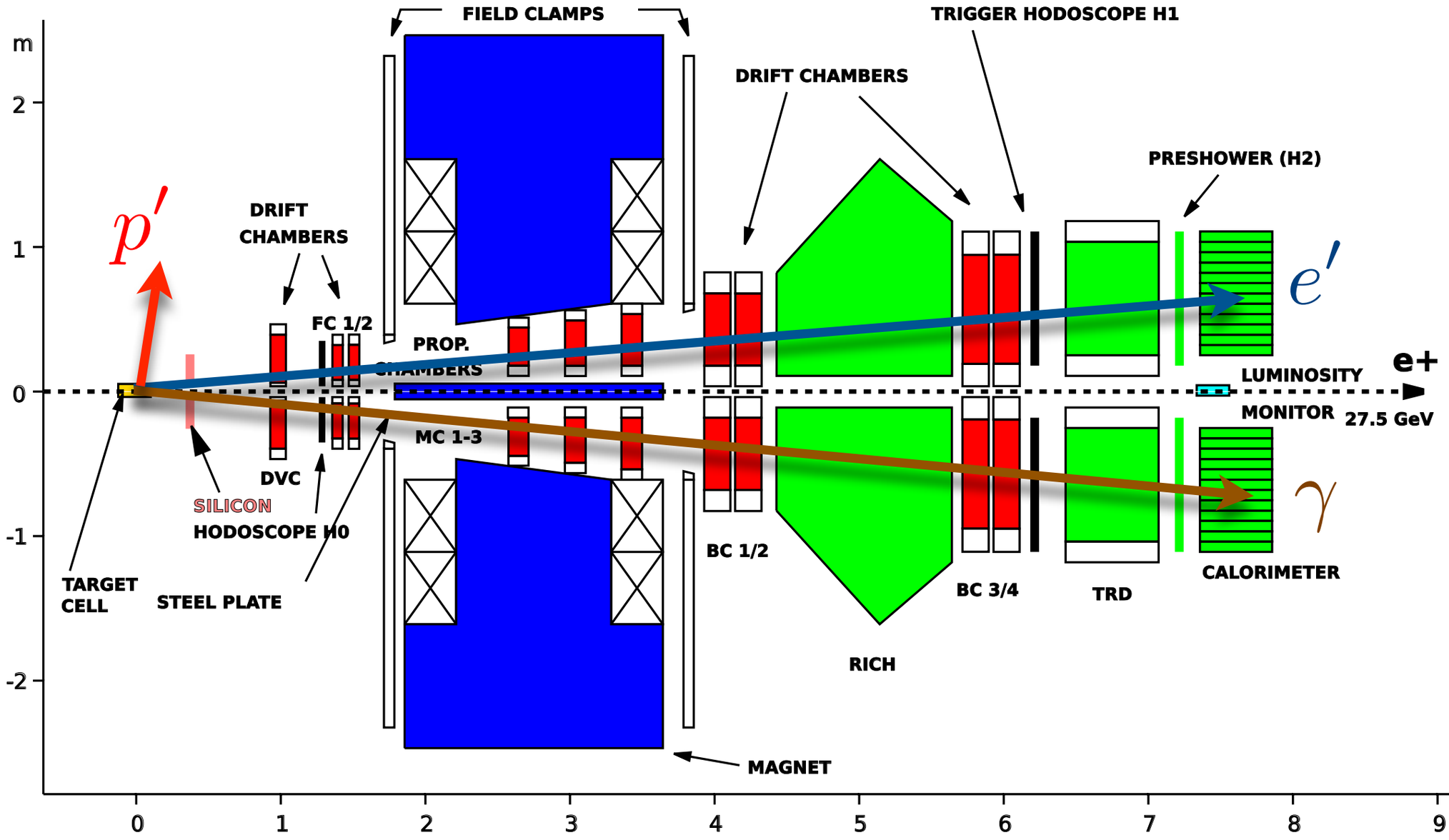
Gas targets:

- Longitudinally polarized H, D
- Unpolarized H, D, ^{4}He, N, Ne, Kr and Xe
- Transversely polarized H

Beam:

- Longitudinally polarized e^+ and e^- with both helicities
- Energy 27.6 GeV

DVCS at HERMES



- Exactly one lepton detected in spectrometer
- Exactly one untracked cluster in calorimeter
- Recoiling proton remains undetected

➡ Exclusivity via missing mass technique

$$ep \to e'\gamma X$$

Kinematic requirements

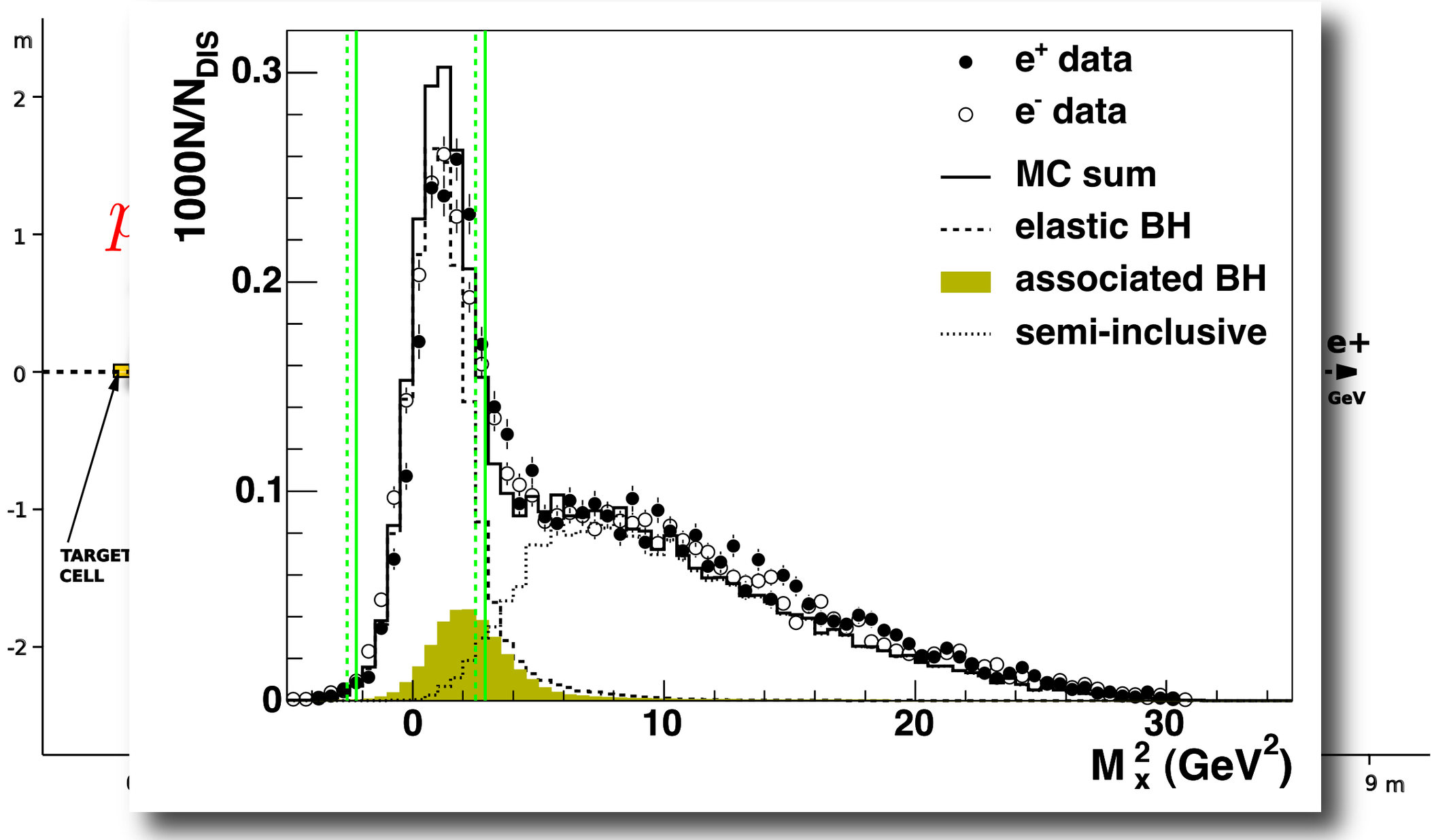
$$0.03 < x_B < 0.35$$

$$1\ \mathrm{GeV}^2 < Q^2 < 10\ \mathrm{GeV}^2$$

$$-t < 0.7\ \mathrm{GeV}^2$$

$$E_\gamma > 5\ \mathrm{GeV}^2$$

DVCS at HERMES

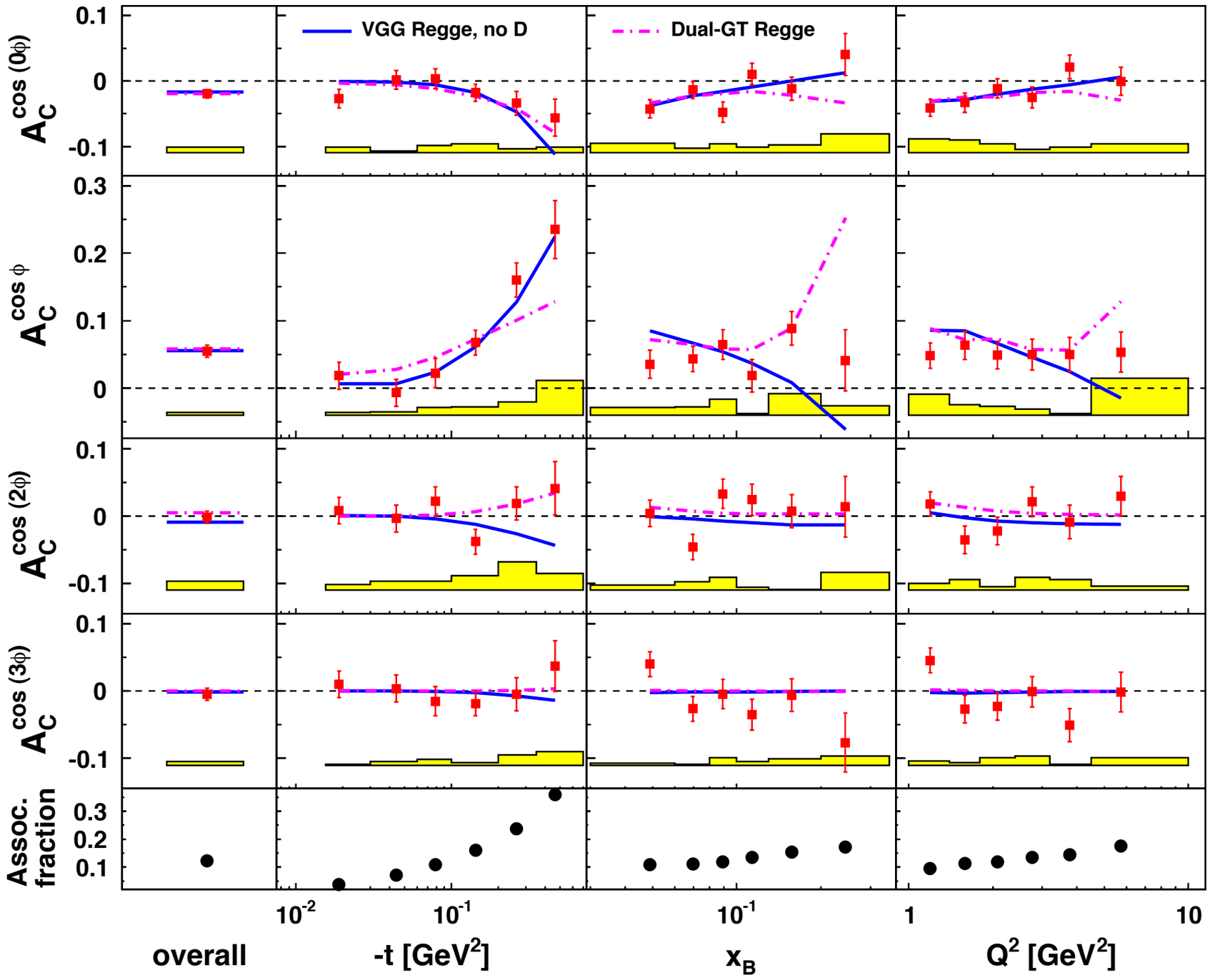


- Semi-inclusive BG treated as dilutions for charge dependent asymmetries
  - ➡ For pure DVCS term: asymmetry extracted from π^0 data
- Associated Bethe-Heitler $ep \rightarrow e'\gamma\Delta^+$ (12%) is part of signal

Beam Charge Asymmetry on Proton

New analysis of 1996-2005 data

submitted to JHEP - arXiv:0909.3587



$$\propto -A_C^{\cos\phi}$$

$$\propto \Re\left[F_1\mathcal{H}\right]$$

higher twist

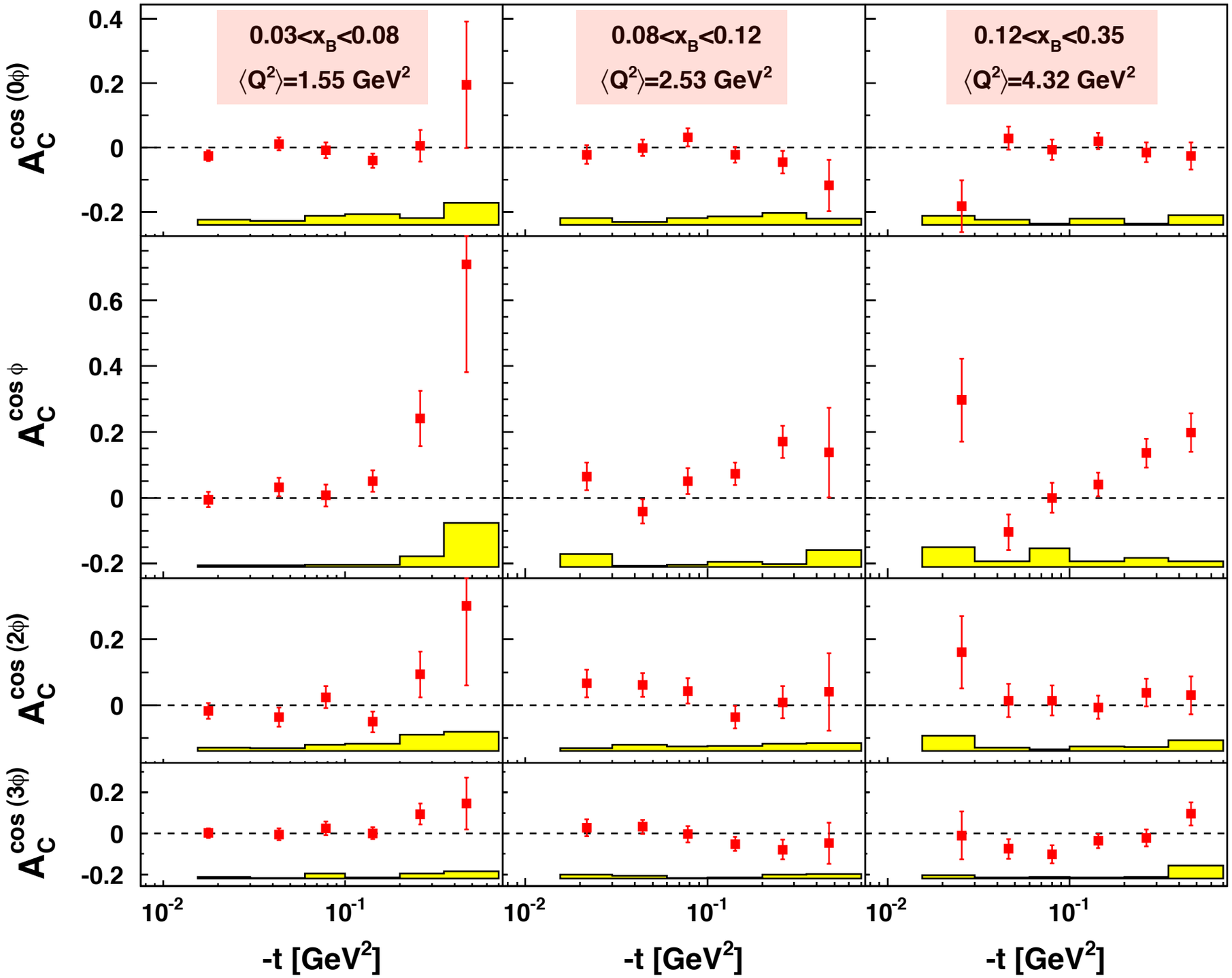
gluon leading twist

resonance fraction

$$ep \to e'\Delta^+\gamma$$

➡ VGG variant with D-term is disfavored by data

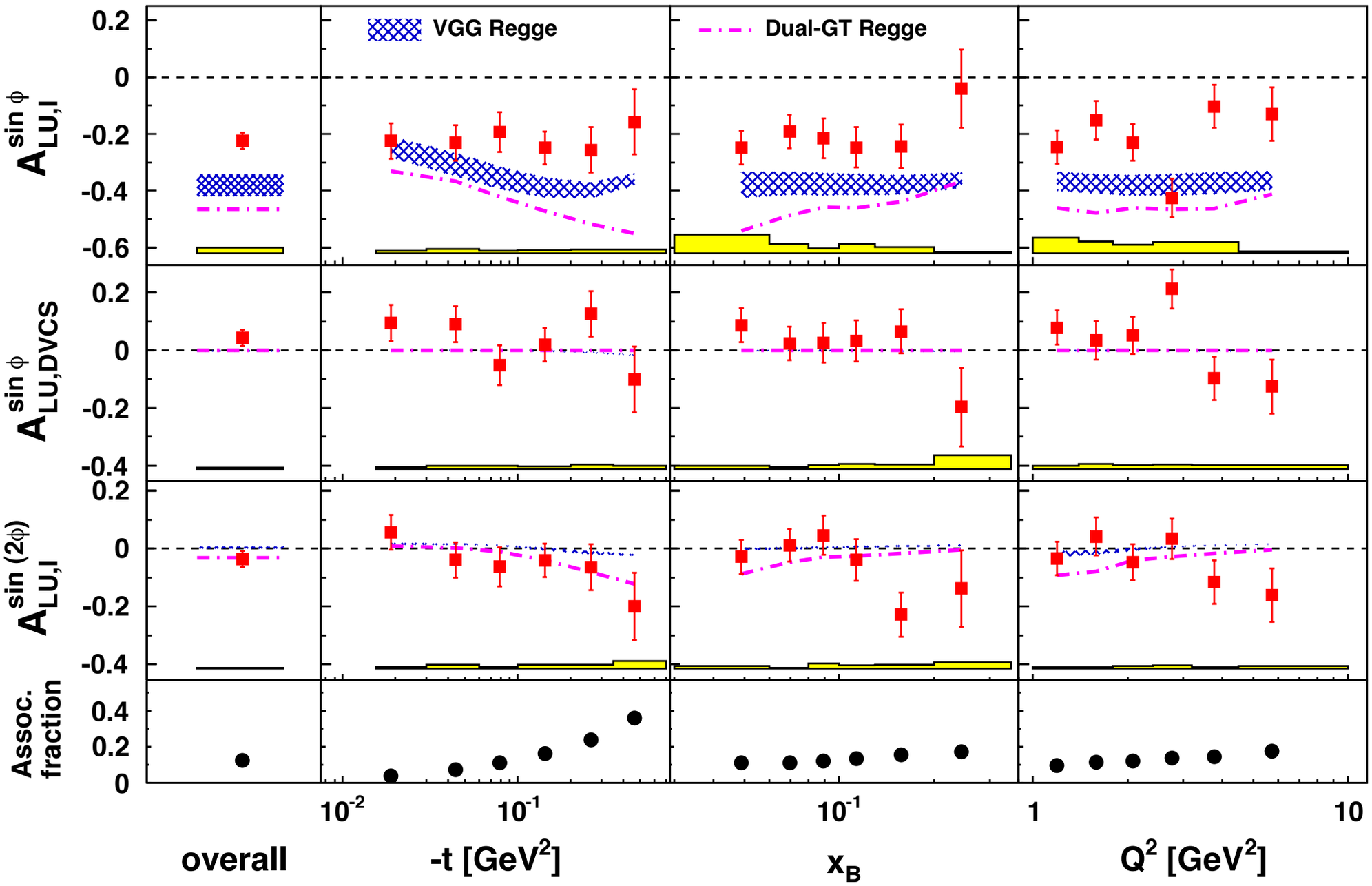
2D Binning of Beam Charge Asymmetry



Leading asymmetry amplitudes vs. $-t$ for different x_B ranges

➡ Can provide additional input to study ξ and $-t$ dependence of GPDs

Beam Helicity Asymmetry on Proton



$\propto \Im\left[F_1\mathcal{H}\right]$

$\propto \left[\mathcal{H}\mathcal{H}^* + \widetilde{\mathcal{H}}\widetilde{\mathcal{H}}^*\right]$

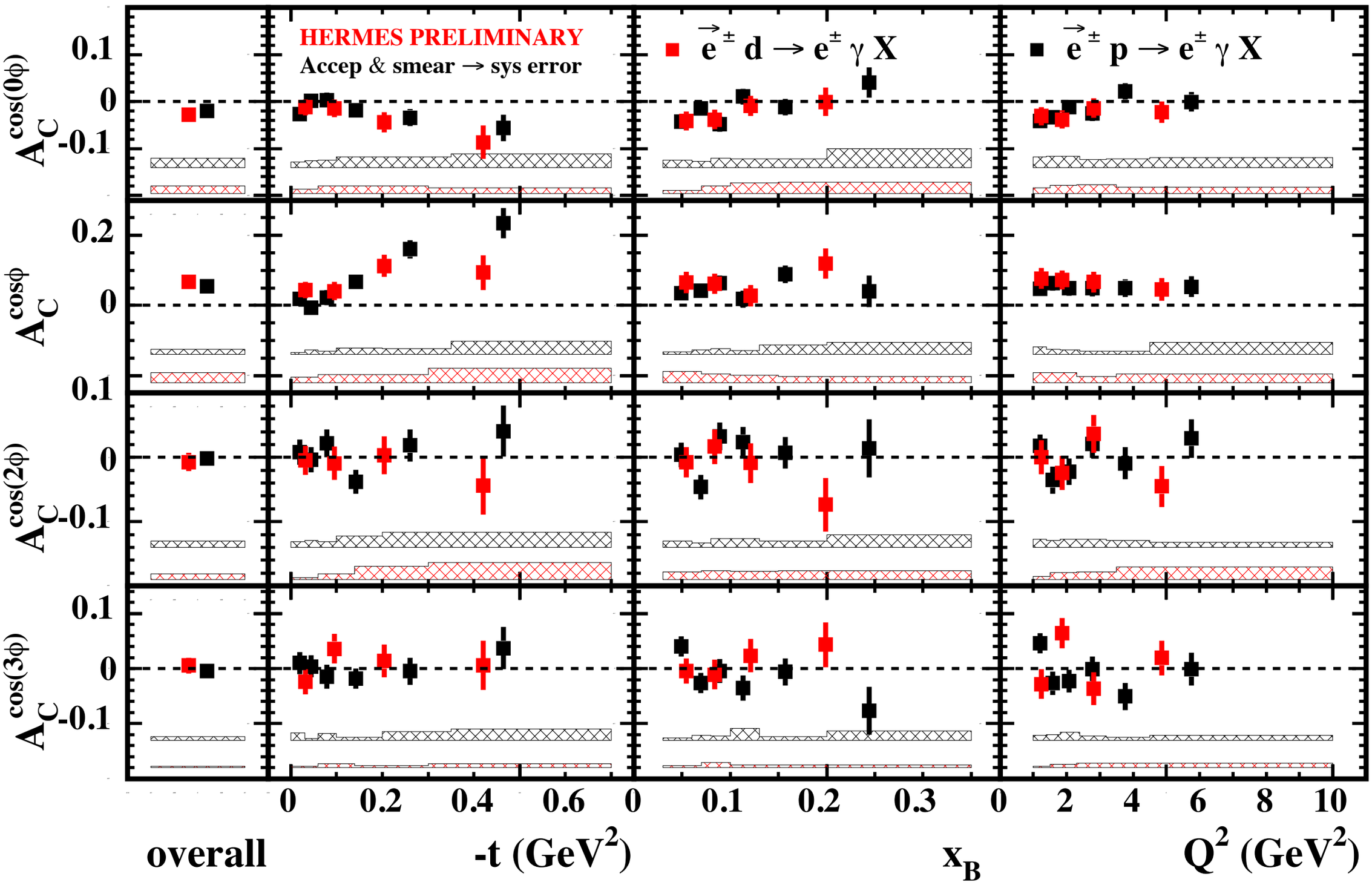
higher twist

resonance fraction

$ep \to e'\Delta^+\gamma$

- VGG bands obtained by varying b_{val} and b_{sea} input parameters
- VGG model predictions overestimate size of asymmetry

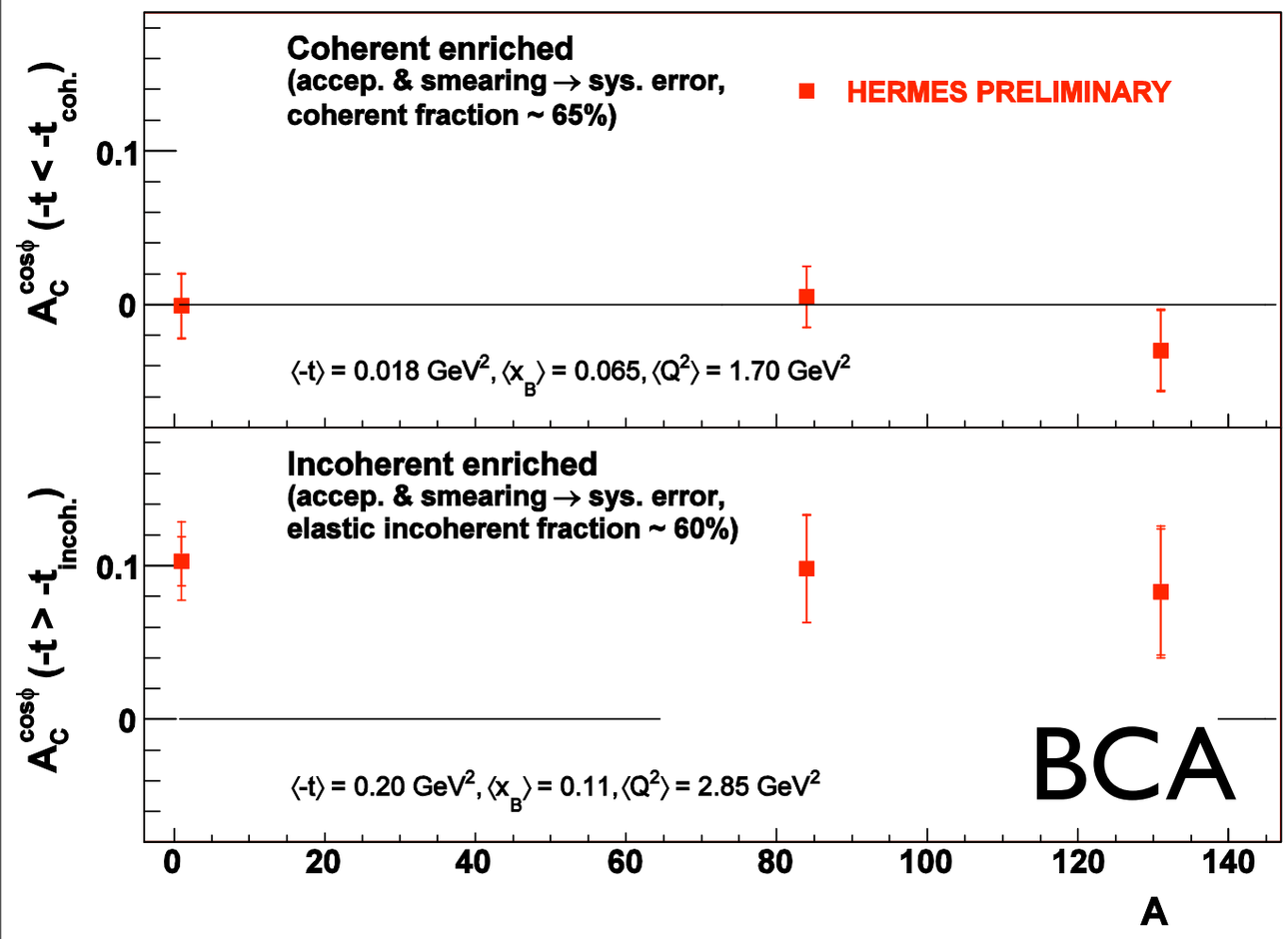
Comparison of Proton and Deuteron Data (BCA)

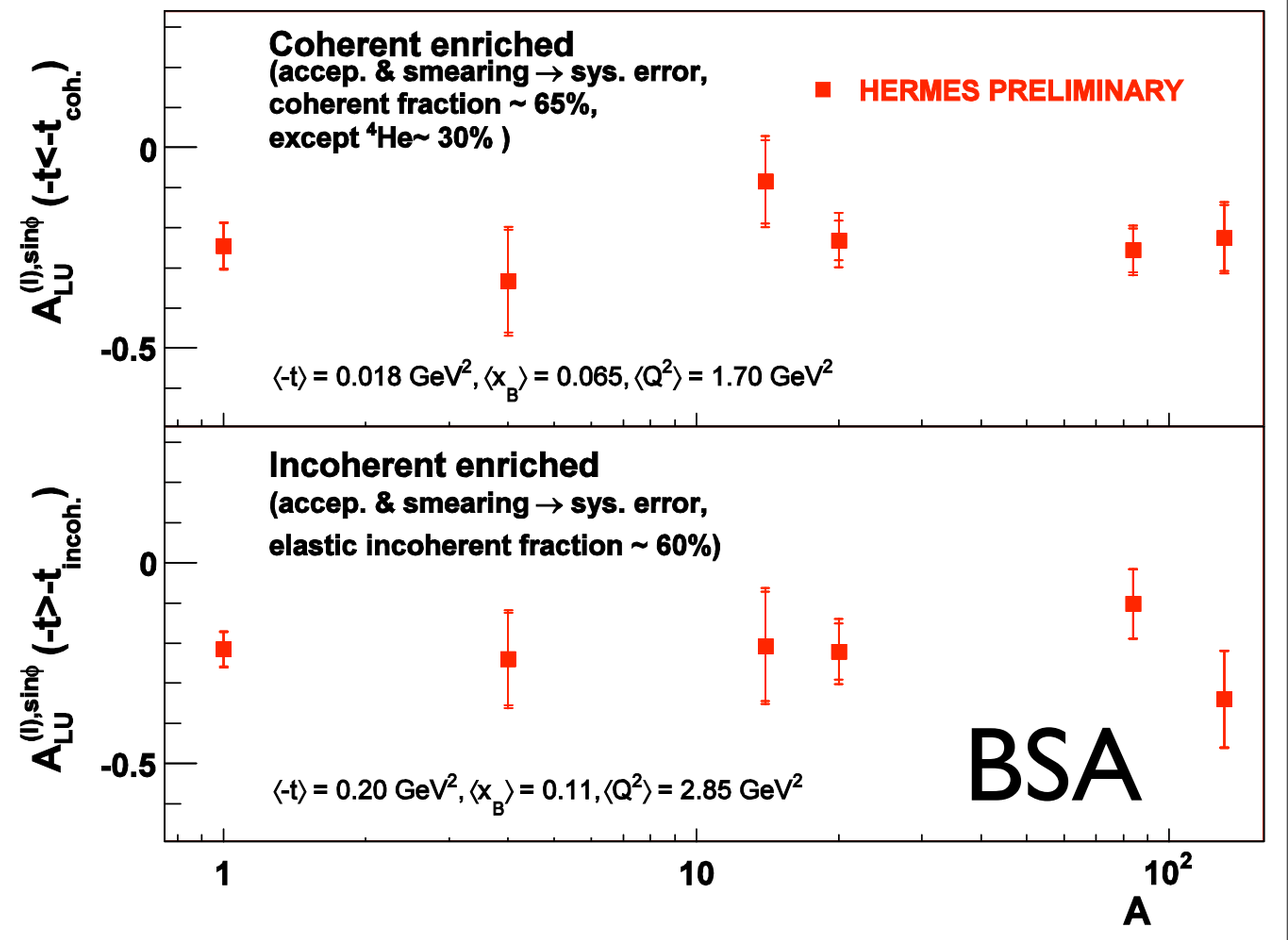


➡ Proton and Deuteron results are compatible for all leading asymmetry amplitudes

DVCS on Nuclear Targets

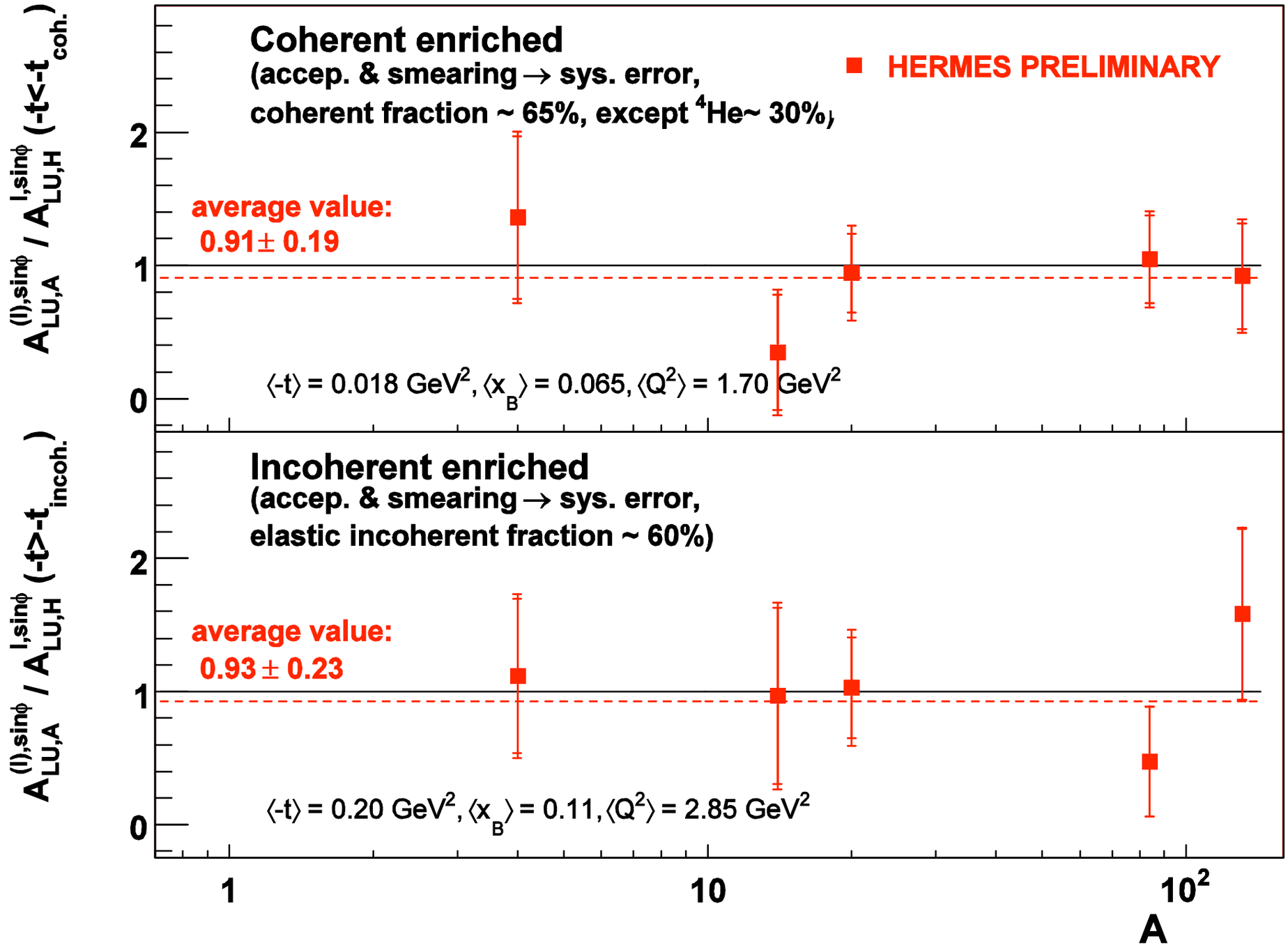
- Provides additional information on GPDs and their modification in nuclear matter
- Involves two contributions
  - Coherent: target remains intact
  - Incoherent: nuclear target breaks up
  - Can be separated by cut on $-t$





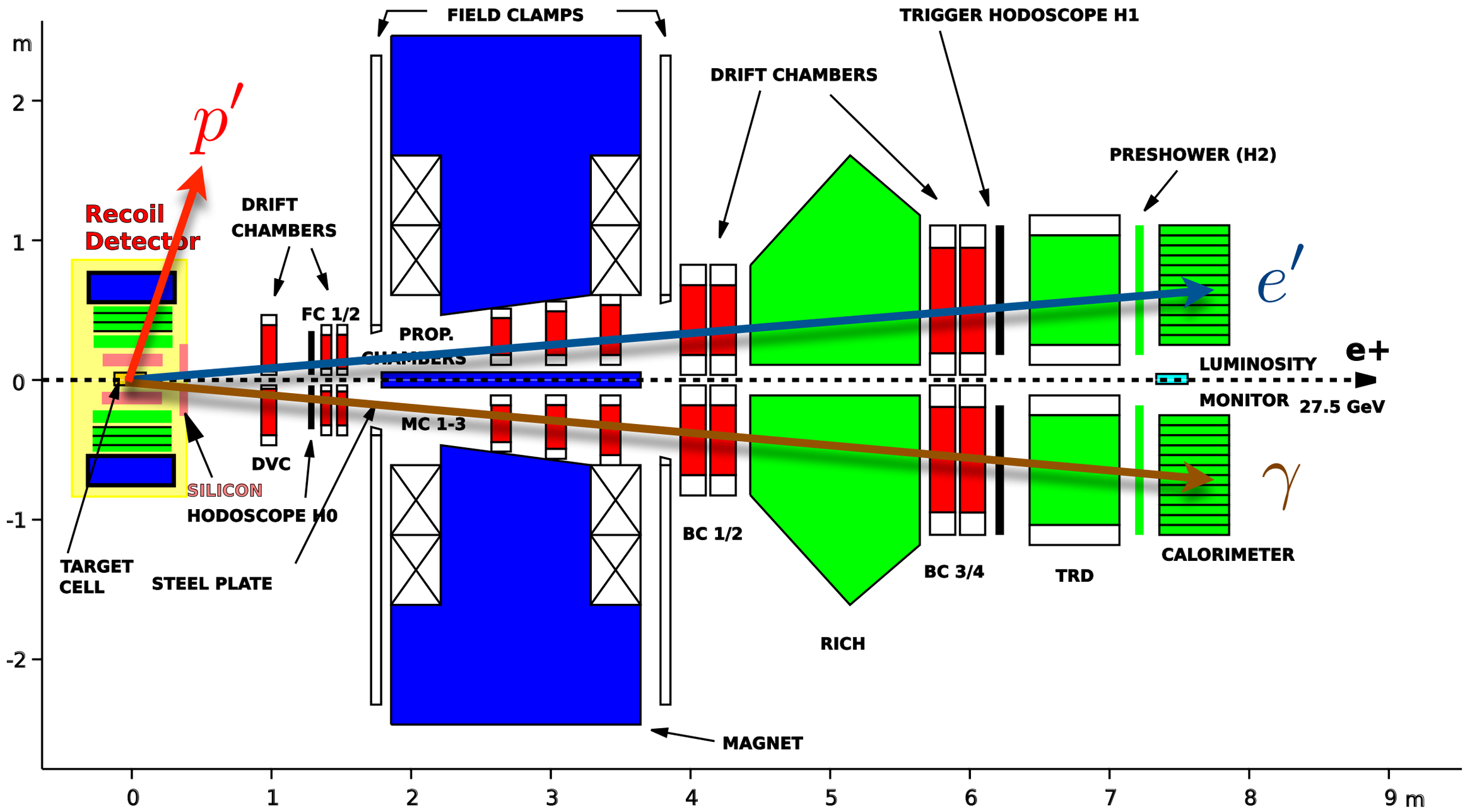
Ratios of Leading Beam Helicity Asymmetry Amplitudes

- $A_{LU,A}^{I,\sin\phi} / A_{LU,H}^{I,\sin\phi}$



- Results contradict model predictions of strong A-dependence

Improved Exclusivity: The Recoil Detector



- Installed during 2006/2007
- Two beam helicities
- Two beam charges

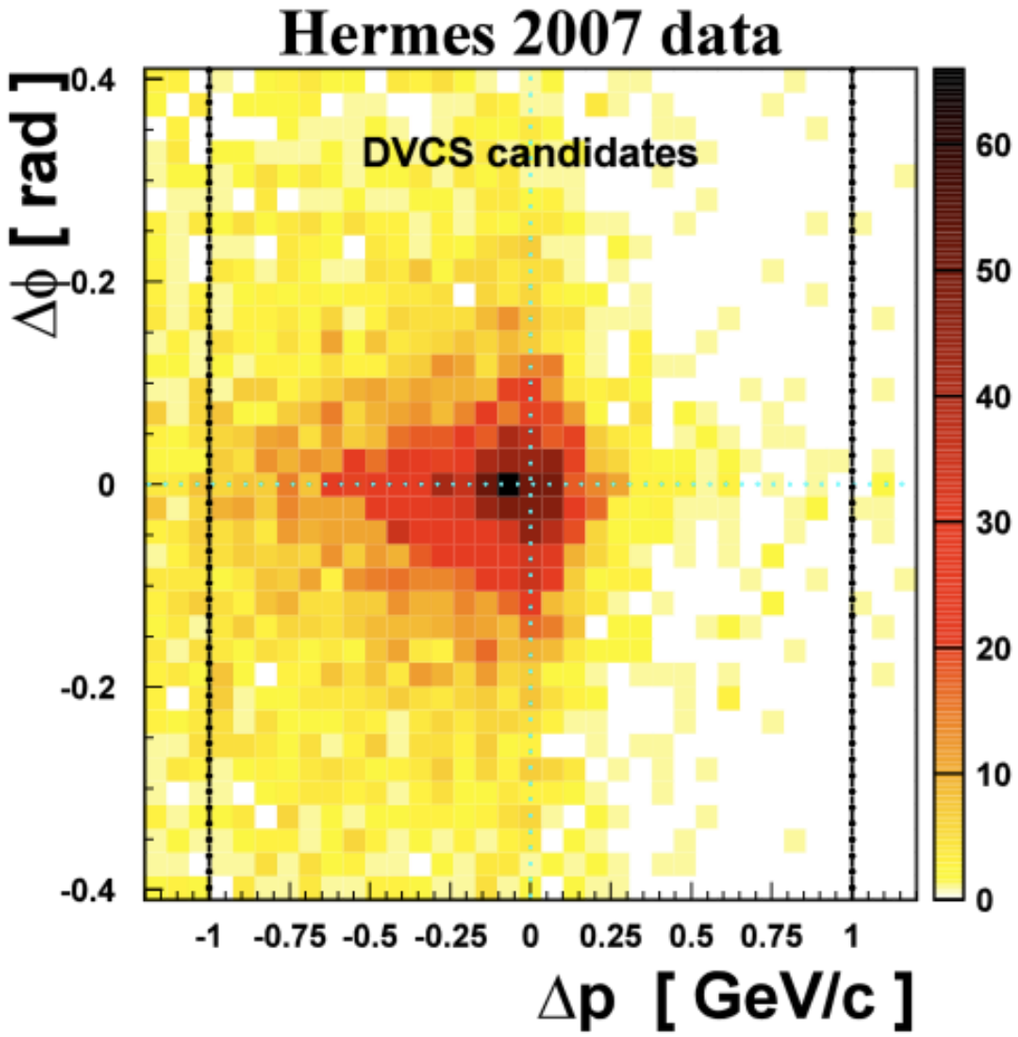
- 38M DIS events off Hydrogen (41k DVCS)
- 10M DIS events off Deuterium (7.5k DVCS)

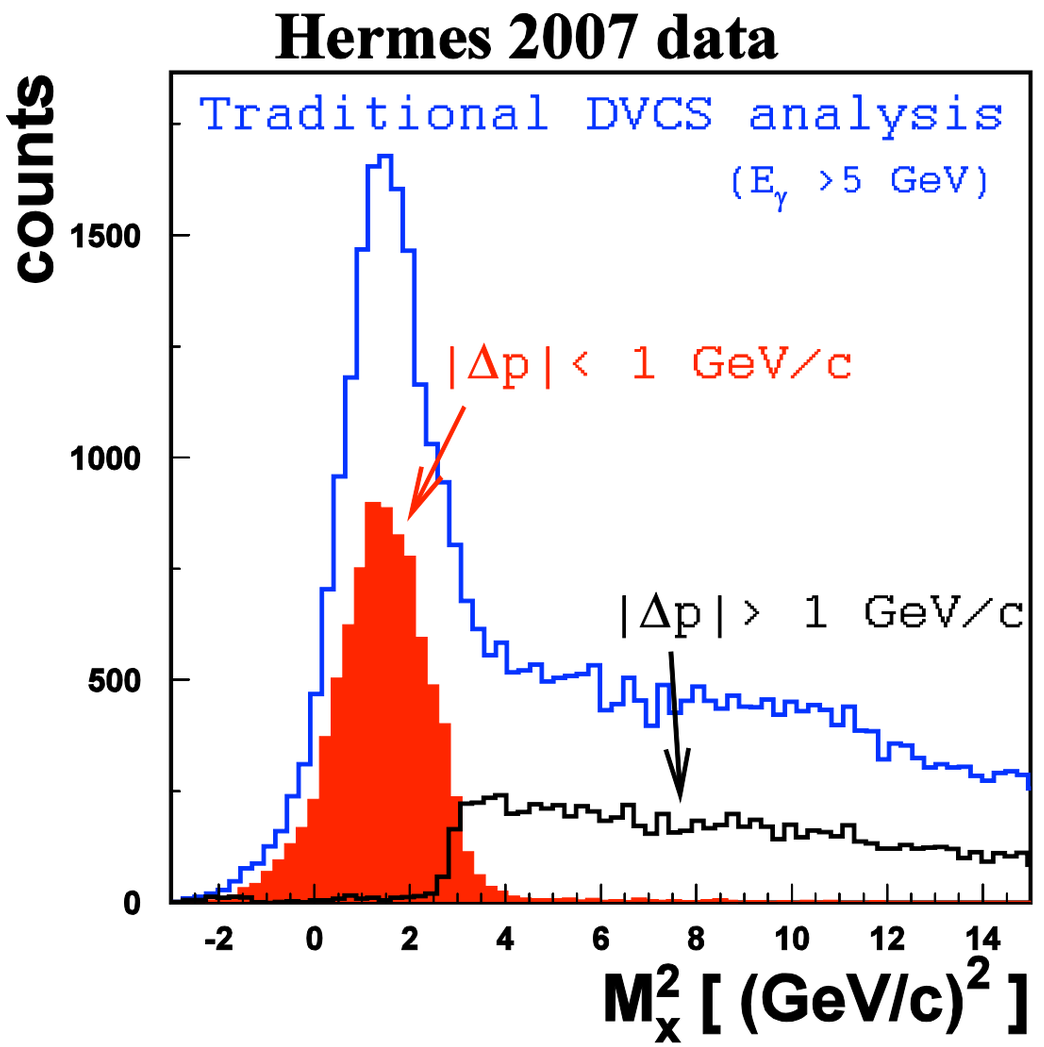
DVCS with Recoil Detector

- „Classic“ style HERMES DVCS analysis
  - Exactly one lepton and one photon detected in spectrometer

} DVCS candidate event

- Calculate kinematics of recoiling proton
- Look for a correlated track in recoil detector
  - $\Delta\phi = \phi_{measured} - \phi_{calculated}$
  - $\Delta p = p_{measured} - p_{calculated}$





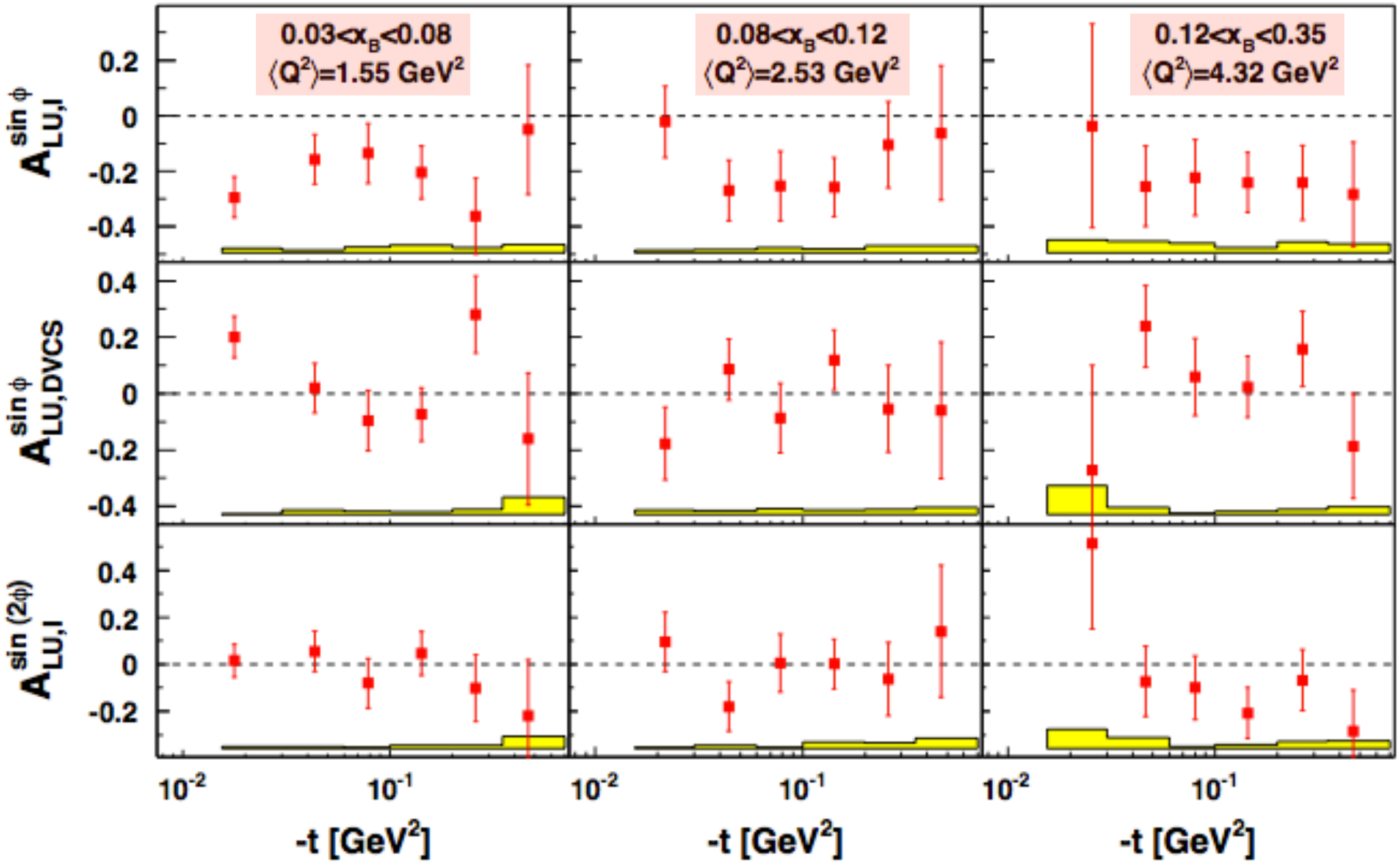
Summary and Outlook

- HERMES has provided a wide variaty of DVCS results to constrain GPDs
  - Beam charge and beam helicity asymmetries on both proton and deuteron targets
    - ➡ GPD H
  - No nuclear mass dependence of asymmetry amplitudes is observed for nuclear targets
    - ➡ Nuclear GPD models
  - Transverse target spin asymmetry
    - ➡ GPD E, model-dependent constraint on J_u vs. J_d
  - Longitudinal target spin asymmetry
    - ➡ GPD H

- Large data set including information from the recoil detector
  - ➡ Improved exclusivity for BSA and BCA
  - ➡ Associated Bethe-Heitler can be separated
  - ➡ Results can be used to refine DVCS analysis before 2006

Backup

2D Binning of Beam Spin Asymmetry



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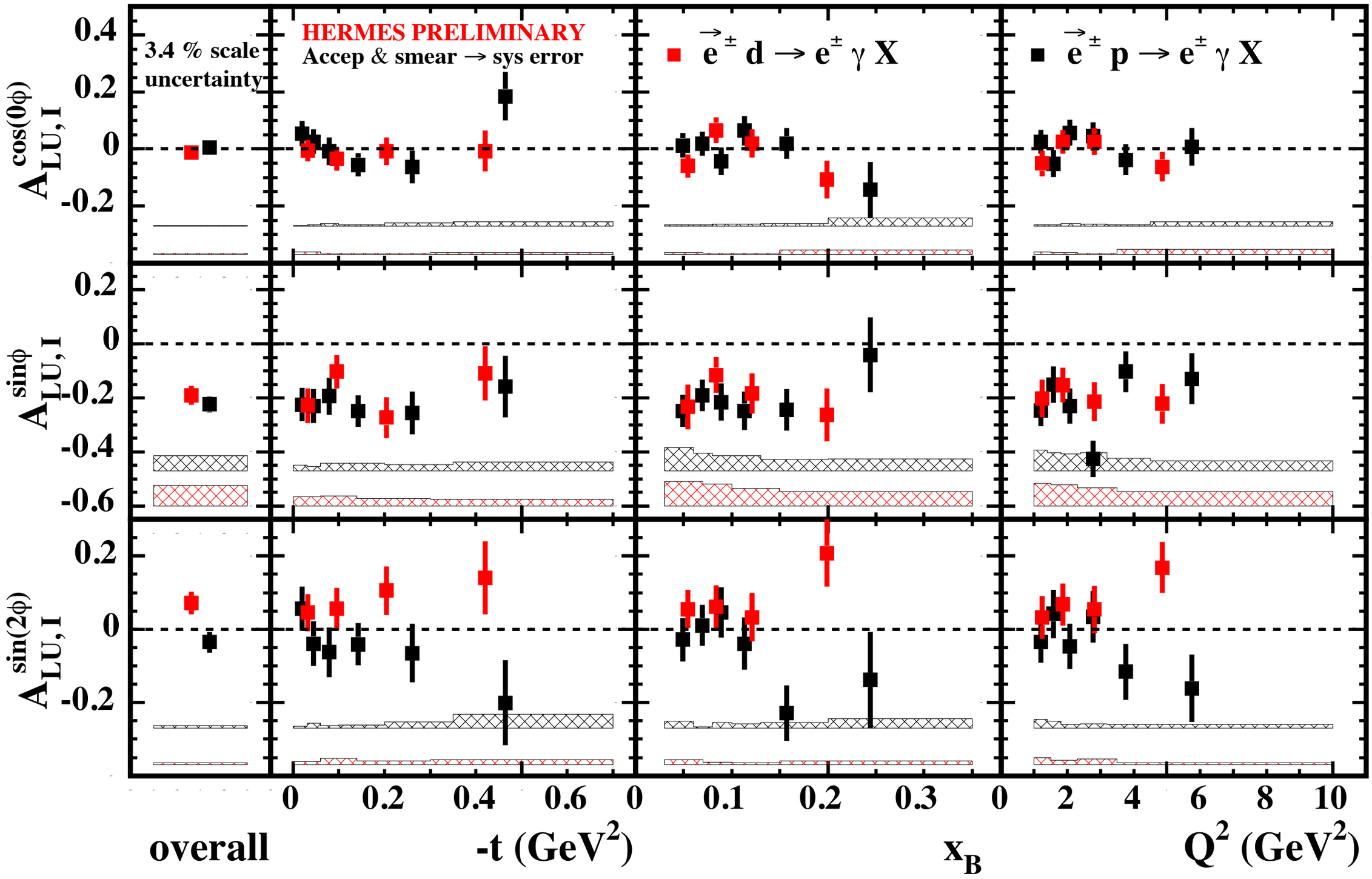
Comparison of Proton and Deuteron Data (BSA Interference)



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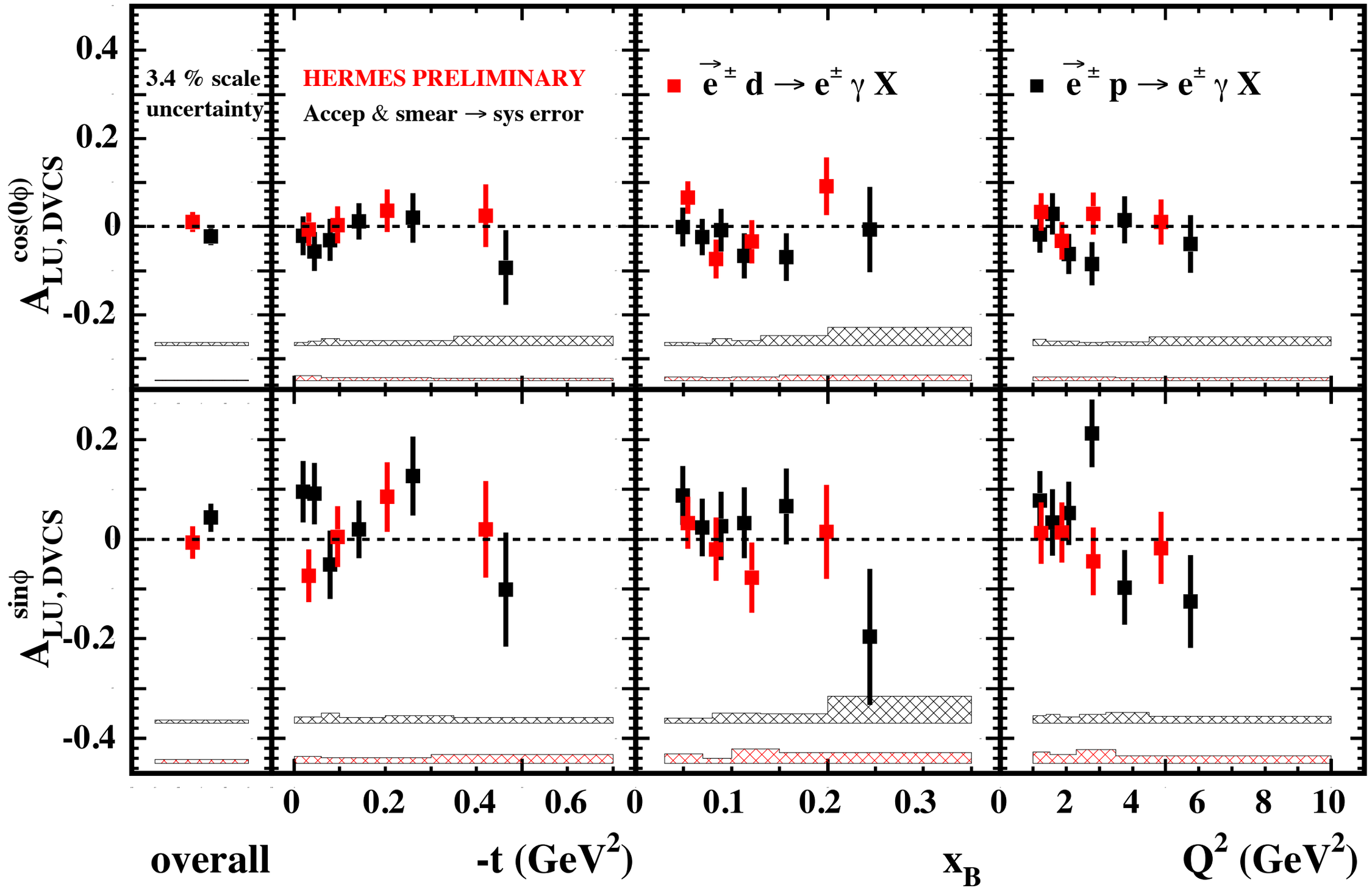

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