Preliminary HERMES results from a combined beam charge and helicity analysis of DVCS data

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for the hermes collaboration

DPG Bochum, 16.03.2009

bmb+f - Förderschwerpunkt
HERMES
Großgeräte der physikalischen Grundlagenforschung

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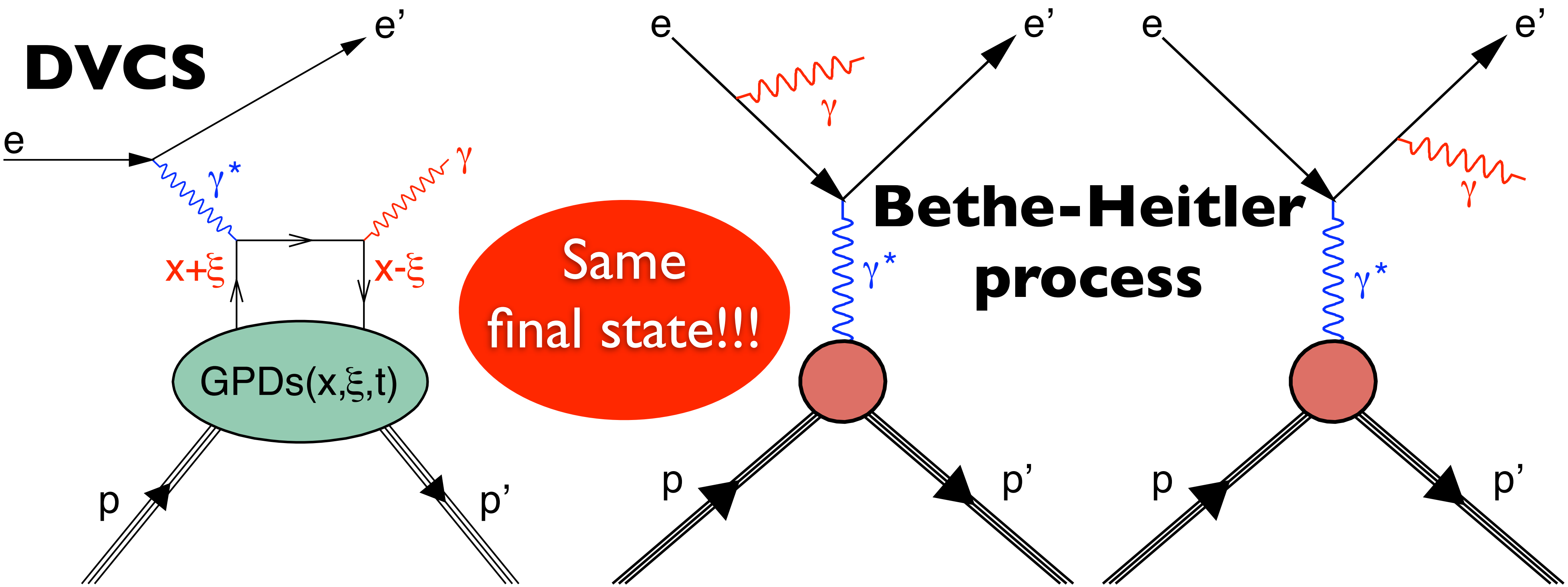
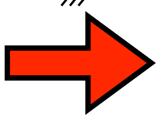
Deeply virtual Compton Scattering





The (differential) cross section:

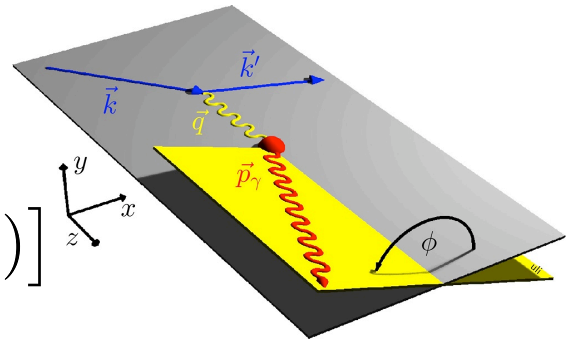
$$\frac{d\sigma}{dx_{\mathrm{B}}\ dQ^2\ dt\ d\phi} = \frac{\alpha_{\mathrm{em}}^3 x_{\mathrm{B}} y}{16\pi^2 Q^2 e^6} \frac{|\mathcal{T}_{\mathrm{BH}}|^2 + |\mathcal{T}_{\mathrm{DVCS}}|^2 + \mathcal{I}}{\sqrt{1 + 4x_{\mathrm{B}}^2 M^2 / Q^2}}$$

DVCS amplitude measurable despite $|\mathcal{T}_{\mathrm{BH}}|^2 \gg |\mathcal{T}_{\mathrm{DVCS}}|^2$ at HERMES kinematics.

Azimuthal dependencies

Signatures for different azimuthal amplitudes:

Beam polarization λ, beam charge e_l



$$|\mathcal{T}_{\rm BH}|^2 = \frac{K_{\rm BH}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\left[c_0^{\rm BH} + c_1^{\rm BH} cos(\phi) + c_2^{\rm BH} cos(2\phi)\right]$$

$$|\mathcal{T}_{\rm DVCS}|^2 = K_{\rm DVCS}\left[c_0^{\rm DVCS} + c_1^{\rm DVCS} cos(\phi) + c_2^{\rm DVCS} cos(2\phi)\right] + \lambda K_{\rm DVCS}\, s_1^{\rm DVCS} sin(\phi)$$

Beam helicity asymmetry

$$\mathcal{I} = e_l \frac{K_{\rm Int}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\left[c_0^{\mathcal{I}} + c_1^{\mathcal{I}} cos(\phi) + c_2^{\mathcal{I}} cos(2\phi) + c_3^{\mathcal{I}} cos(3\phi)\right]$$

Beam charge asymmetry

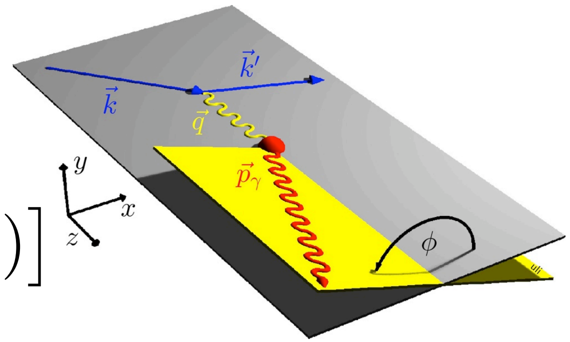
$$+ e_l\lambda \frac{K_{\rm Int}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\left[s_1^{\mathcal{I}} sin(\phi) + s_2^{\mathcal{I}} sin(3\phi)\right]$$

Beam charge/helicity asymmetry

Azimuthal dependencies

Signatures for different azimuthal amplitudes:

Beam polarization λ, beam charge e_l;



$$|\mathcal{T}_{\mathrm{BH}}|^2 = \frac{K_{\mathrm{BH}}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)} \left[c_0^{\mathrm{BH}} + c_1^{\mathrm{BH}} cos(\phi) + c_2^{\mathrm{BH}} cos(2\phi)\right]$$

$$|\mathcal{T}_{\mathrm{DVCS}}|^2 = K_{\mathrm{DVCS}} \left[c_0^{\mathrm{DVCS}} + c_1^{\mathrm{DVCS}} cos(\phi) + c_2^{\mathrm{DVCS}} cos(2\phi)\right] + \lambda K_{\mathrm{DVCS}}\, s_1^{\mathrm{DVCS}} sin(\phi)$$

Beam helicity asymmetry

$$\mathcal{I} = e_l \frac{K_{\mathrm{Int}}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)} \left[c_0^{\mathcal{I}} + c_1^{\mathcal{I}} cos(\phi) + c_2^{\mathcal{I}} cos(2\phi) + c_3^{\mathcal{I}} cos(3\phi)\right]$$

Beam charge asymmetry

$$+ e_l \lambda \frac{K_{\mathrm{Int}}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)} \left[s_1^{\mathcal{I}} sin(\phi) + s_2^{\mathcal{I}} sin(3\phi)\right]$$

Beam charge/helicity asymmetry

Propagators include additional azimuthal dependence! The unpolarized terms stay as dilution in the asymmetries!

Relation to Compton Formfactors

$$c_1^{\mathcal{I}} \propto \frac{\sqrt{-t}}{Q} Re\left[F_1\mathcal{H} + \xi(F_1+F_2)\tilde{\mathcal{H}} - \frac{t}{4M^2}F_2\mathcal{E}\right]$$

$$c_0^{\mathcal{I}} \propto -\frac{\sqrt{-t}}{Q} c_1^{\mathcal{I}}$$

Both, real and imaginary part of CFF H can be extracted.

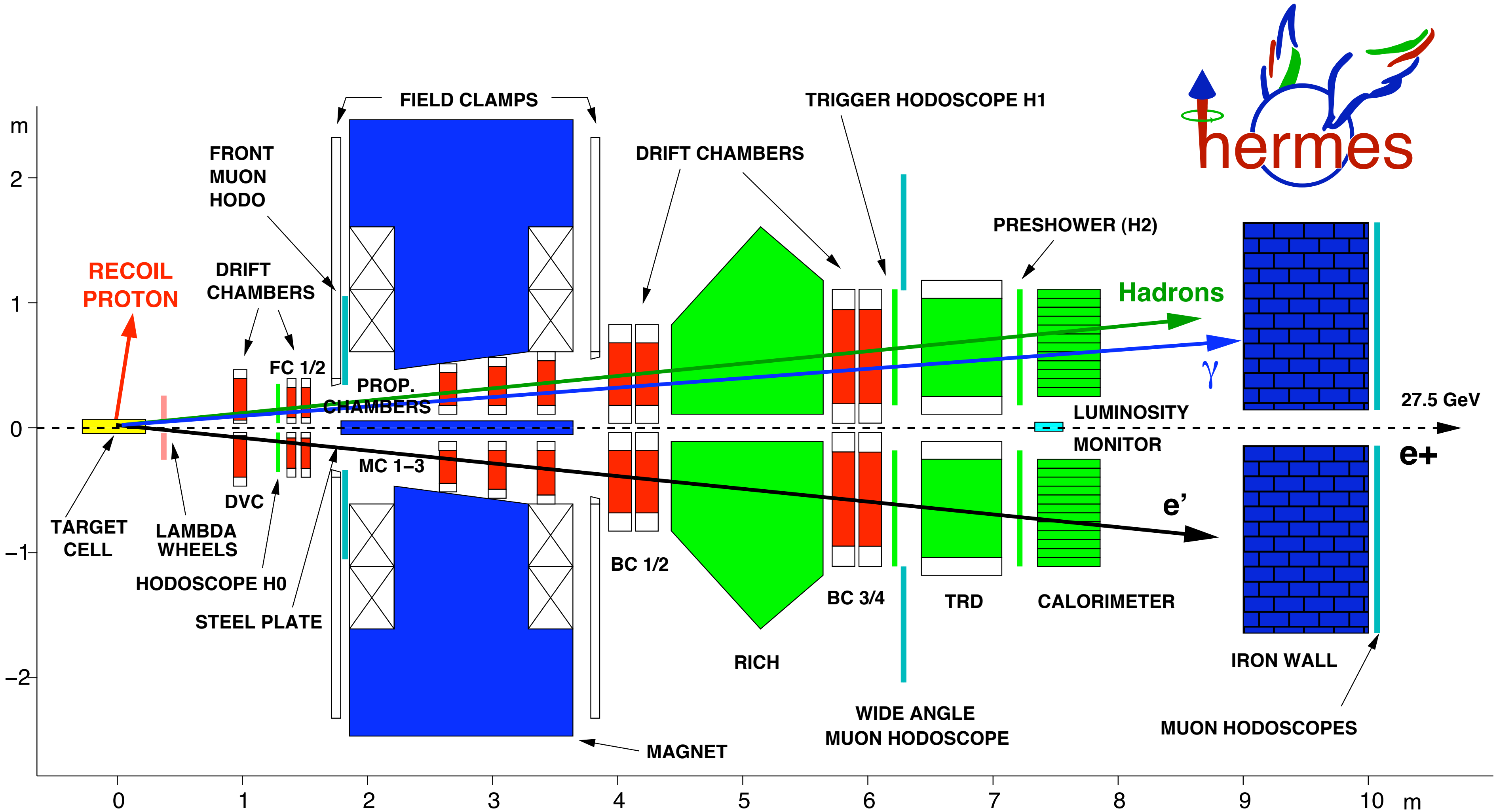
$$s_1^{\mathcal{I}} \propto \frac{\sqrt{-t}}{Q} Im\left[F_1\mathcal{H} + \xi(F_1+F_2)\tilde{\mathcal{H}} - \frac{t}{4M^2}F_2\mathcal{E}\right]$$

BUT we can only measure effective asymmetries:

$$\mathcal{A}_{\mathrm{LU}}^{\mathrm{I}}(\phi) = \frac{-\frac{K_{\mathrm{I}} e_l}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\left[\sum_{n=1}^{2} s_n^{\mathrm{I}} \sin(n\phi)\right]}{\frac{K_{\mathrm{BH}}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\sum_{n=0}^{2} c_n^{\mathrm{BH}}\cos(n\phi) + K_{\mathrm{DVCS}}\sum_{n=0}^{2} c_n^{\mathrm{DVCS}}\cos(n\phi)}$$

$$= \sum_{n=1}^{2} A_{\mathrm{LU,I}}^{\sin(n\phi)}\sin(n\phi) + \sum_{n=0}^{1} A_{\mathrm{LU,I}}^{\cos(n\phi)}\cos(n\phi)$$

The HERMES experiment

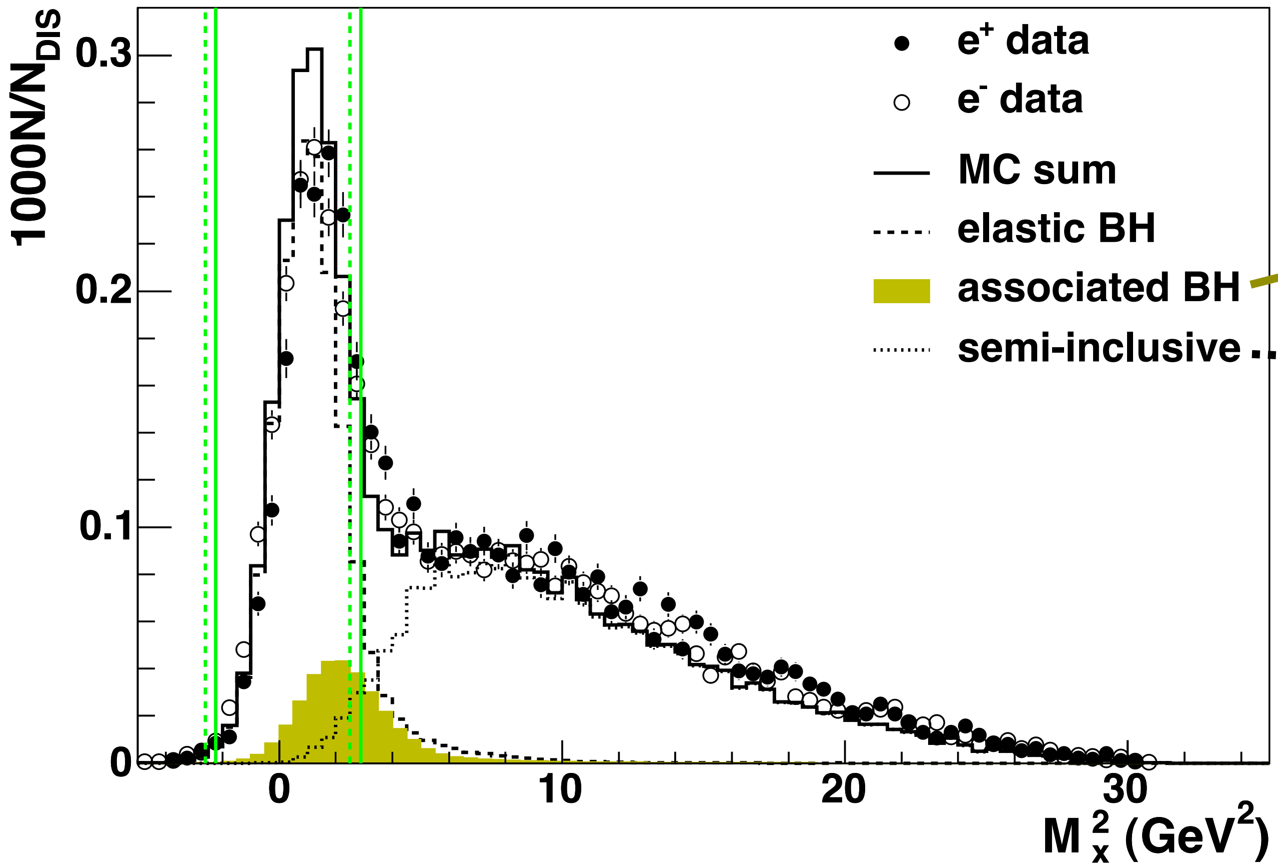


All data has been taken without the Recoil Detector.

Signal and background

<u>Identification by missing mass technique:</u>

$$e^{\pm} + p/d \rightarrow e^{\pm} + \gamma + X$$



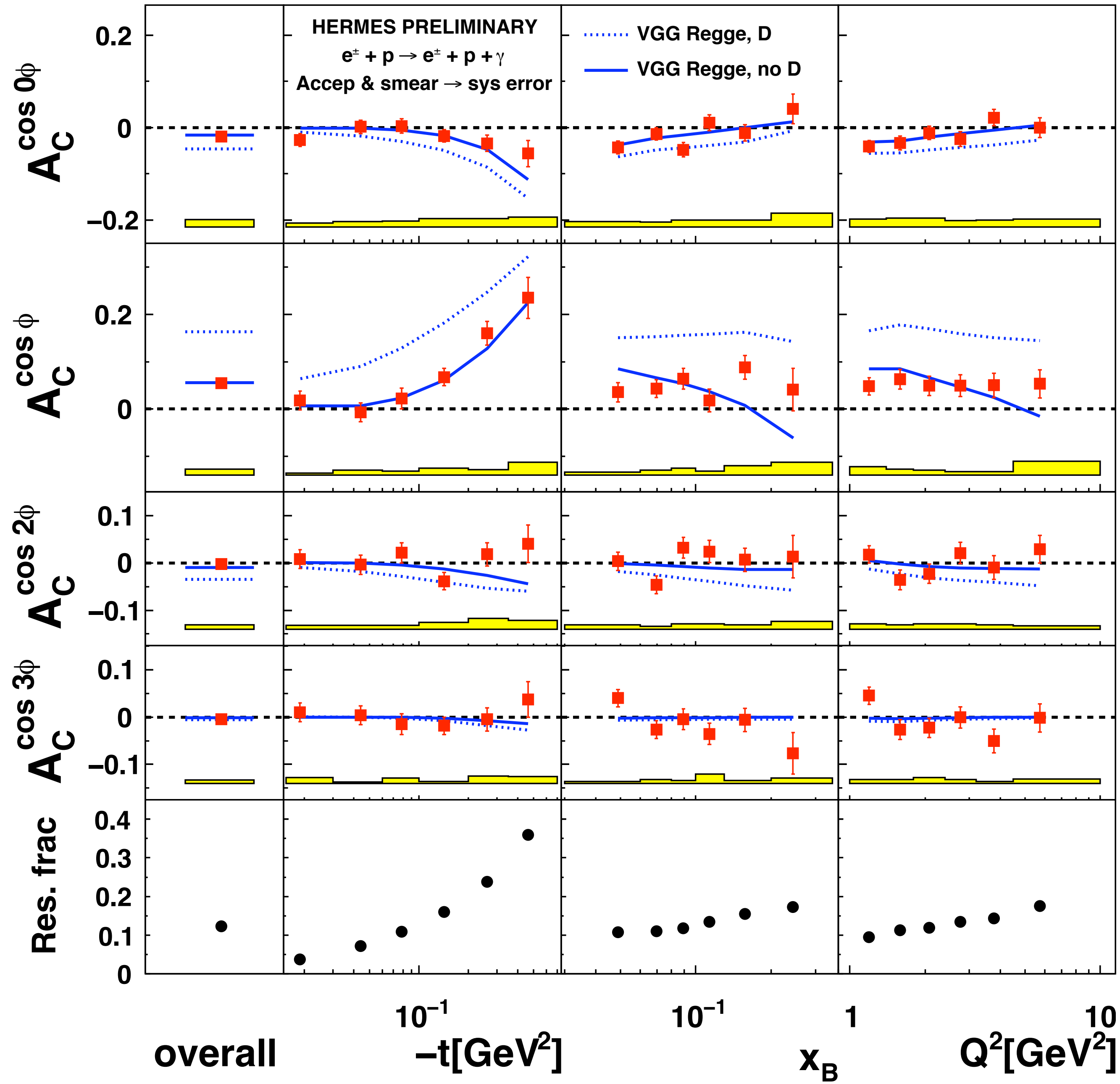
<u>After all cuts:</u>

~ 12 %

~ 3 %
(mainly pion production)

Semi-inclusive background was corrected for.
Associated (resonance) production is part of the signal.

Beam Charge Asymmetries



$\propto -A_{\mathrm{C}}^{cos\phi}$

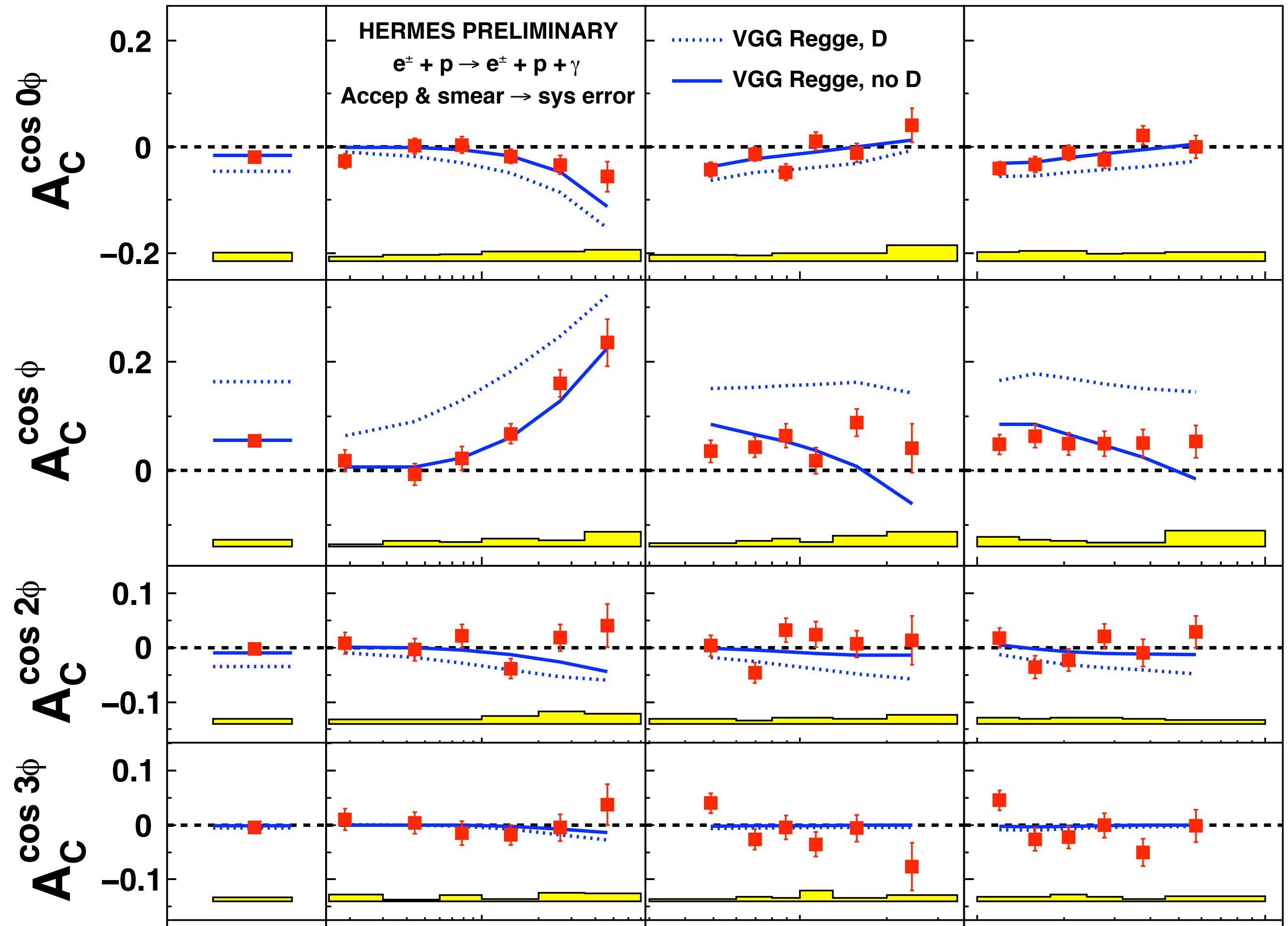
$\propto \ \mathrm{Re}[F_1\mathcal{H}]$

(higher twist)

(gluon leading twist)

Bin-wise fractions of associated (resonance) production.

Beam Charge Asymmetries



$\propto -A_{\rm C}^{cos\phi}$

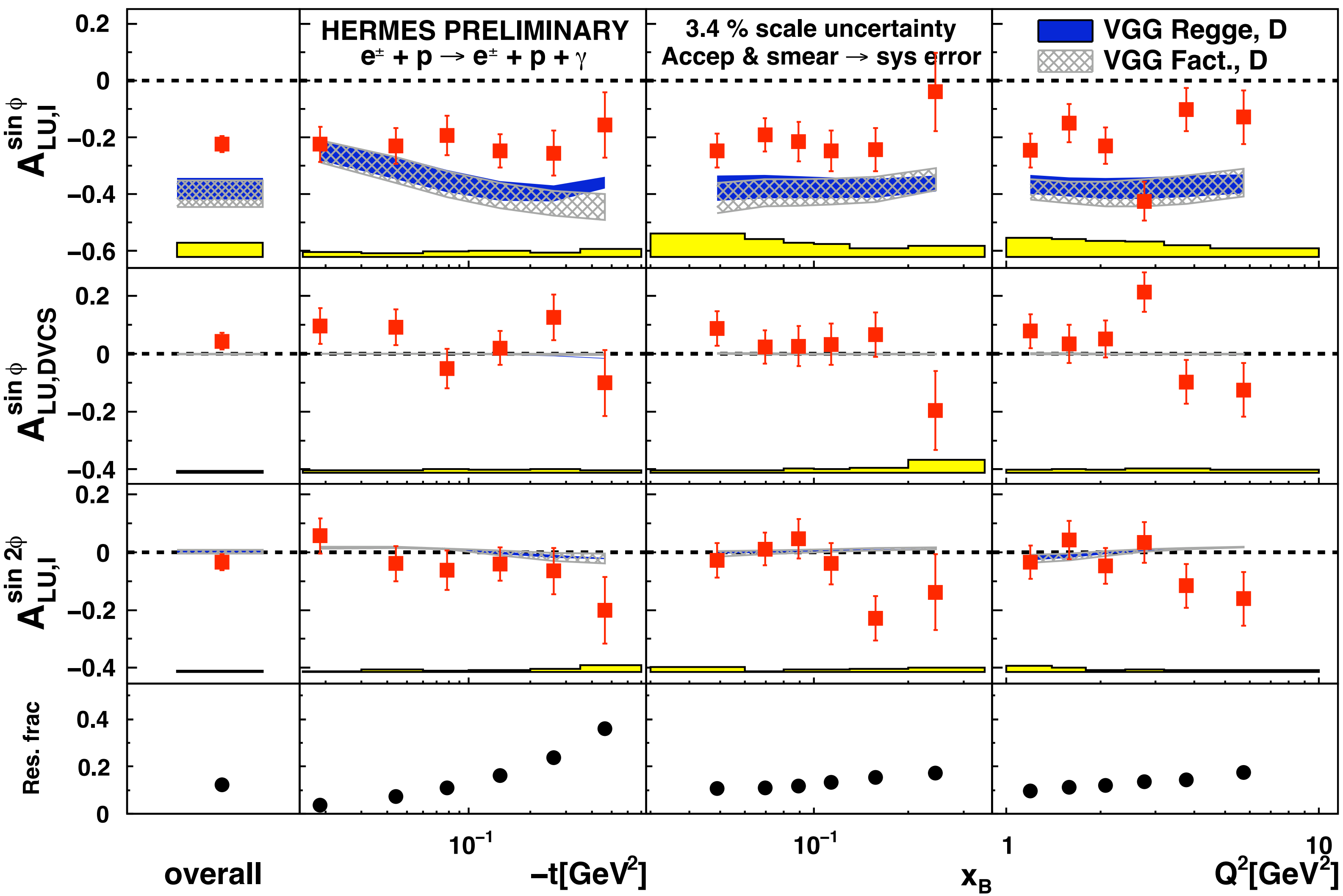
$\propto \ \mathrm{Re}[F_1\mathcal{H}]$

(higher twist)

(gluon leading twist)

Constant and cosine moments are in agreement with each other. VGG (no D-term) can describe data well.

Beam Helicity Asymmetries



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

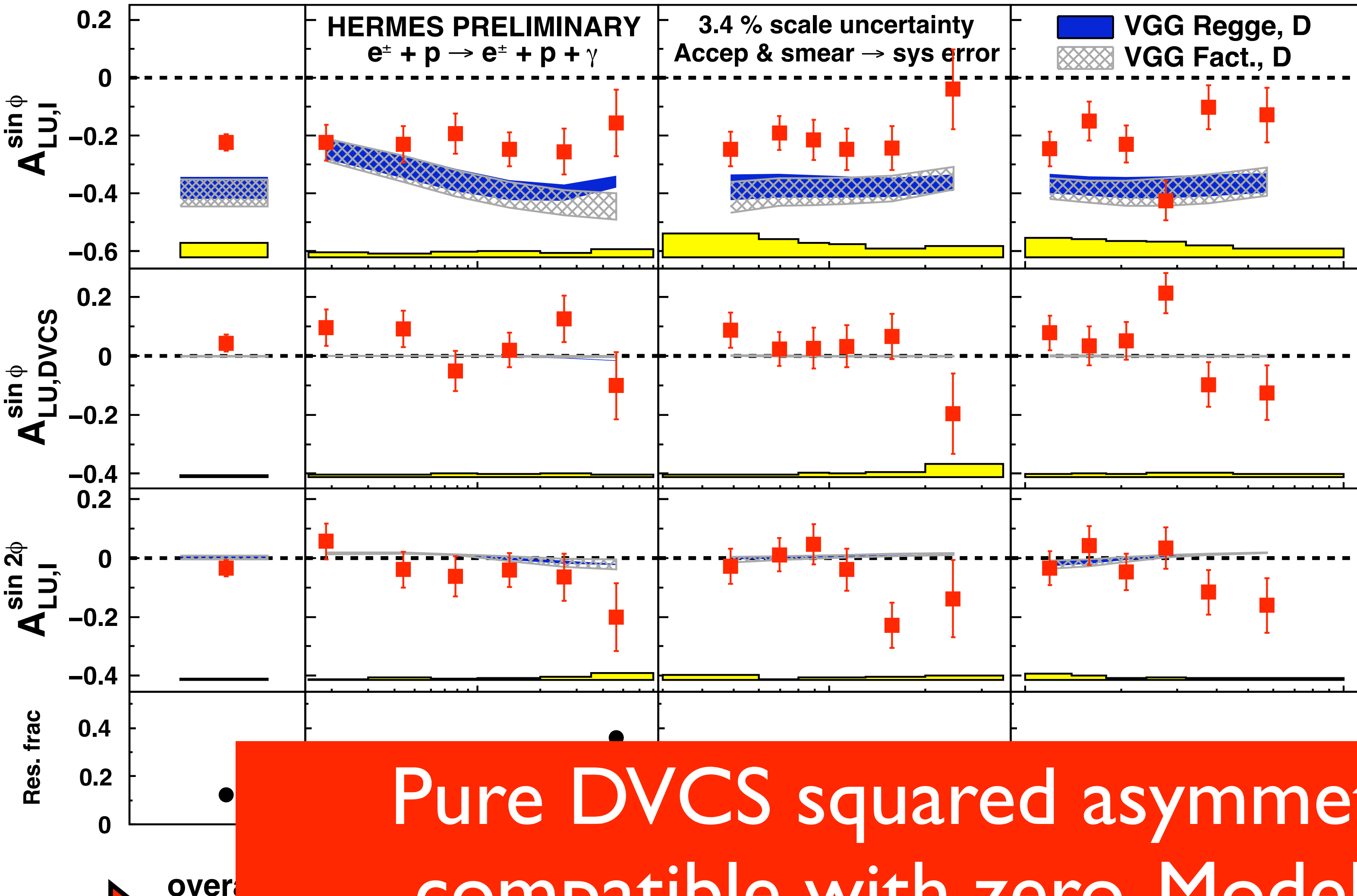
$\propto \left[\mathcal{H}\mathcal{H}^* + \tilde{\mathcal{H}}\tilde{\mathcal{H}}^*\right]$

(higher twist)

Bin-wise fractions of associated (resonance) production.

VGG bands obtained by varying input parameters b_{val} & b_{sea} between 1 and 9.

Beam Helicity Asymmetries



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

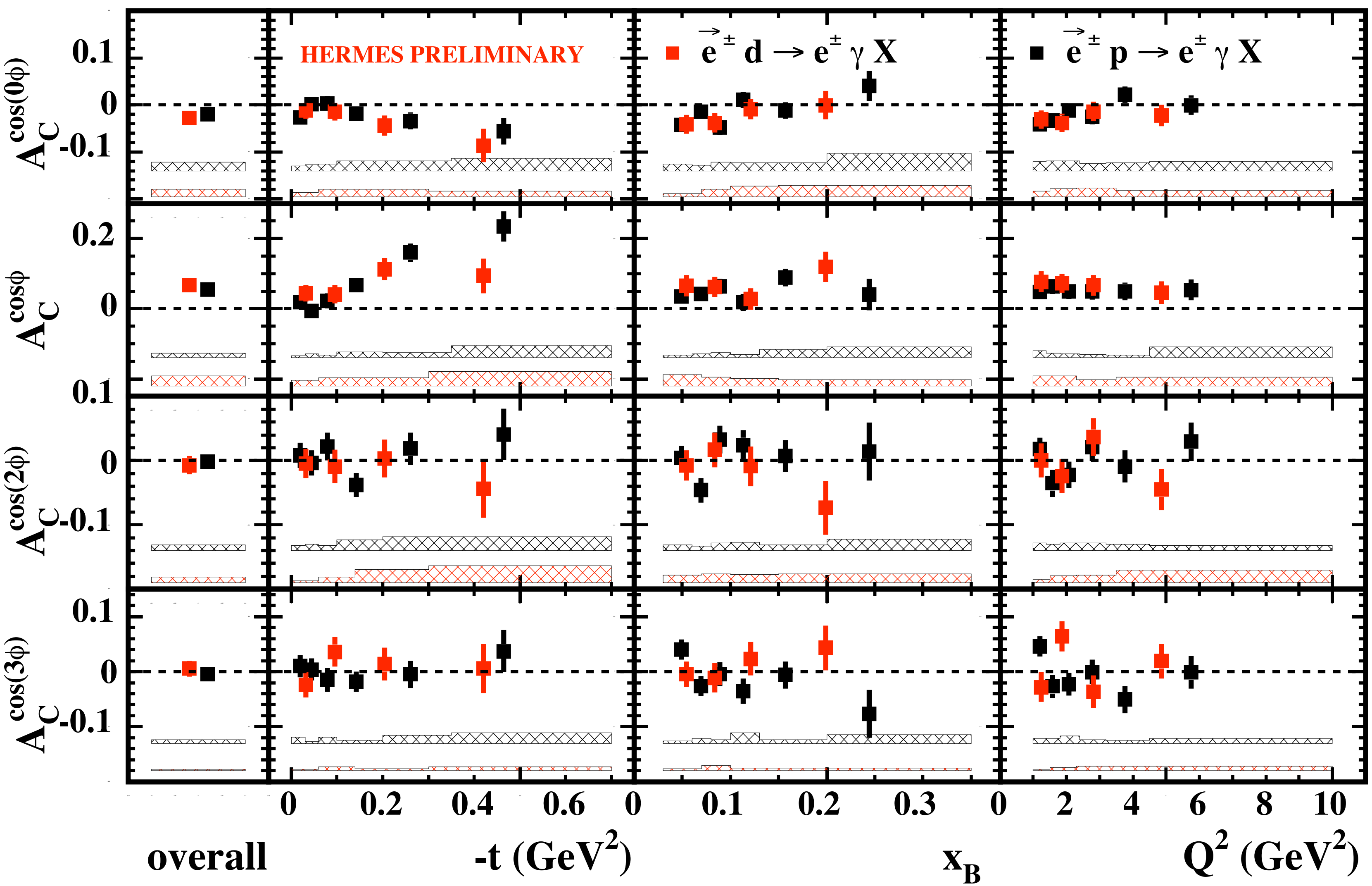
$\propto \left[\mathcal{H}\mathcal{H}^* + \tilde{\mathcal{H}}\tilde{\mathcal{H}}^*\right]$

(higher twist)

Bin-wise fractions

Pure DVCS squared asymmetries are compatible with zero. Model curves overestimate charge-dependent beam-helicity asymmetry.

Comparison to Deuterium Data



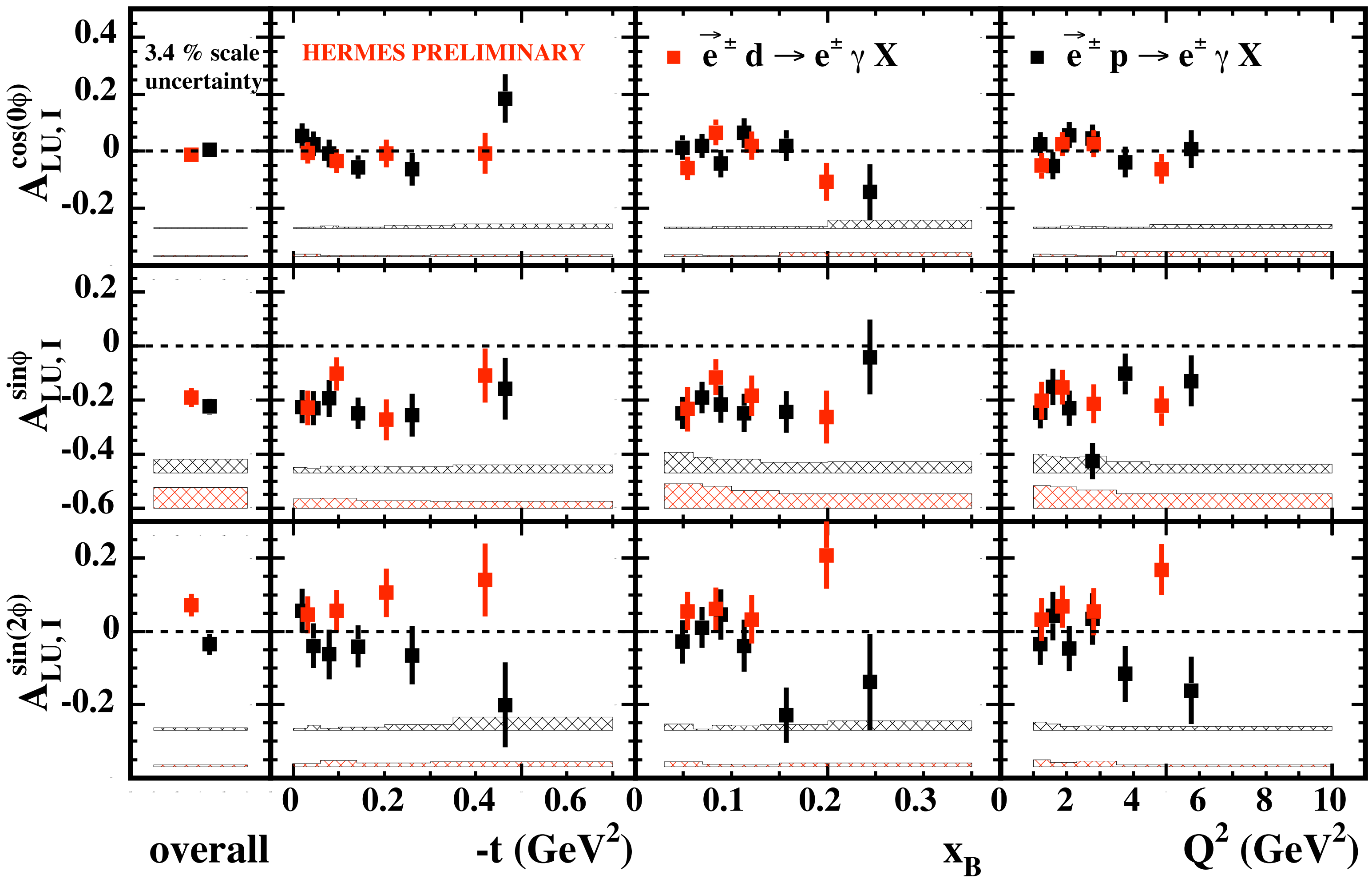
Proton and deuterium results are compatible. Both, in low t ($t<0.06$ GeV^2; 40% coherent) and high t (incoherent) region.

Summary

- HERMES released new preliminary results on BCA and BSA from an analysis on the proton with much more statistics than in previous publications.
- The BCA clearly disfavors all factorized model variants and the inclusion of a D-term in VGG.
- The associated (resonance) production needs to be accounted for in the BSA. The statistical precision allows for strong constraints on GPDs.
- In the 2006/2007 data the associated (resonance) process can be identified with the information from the Recoil Detector.
- Also a combined analysis of the deuterium data has been released. The results on the different targets agree very well for all leading twist amplitudes.

BACKUP

Comparison to Deuterium Data



The sin ϕ moment from the interference term is significantly negative over the whole kinematic range for both targets.