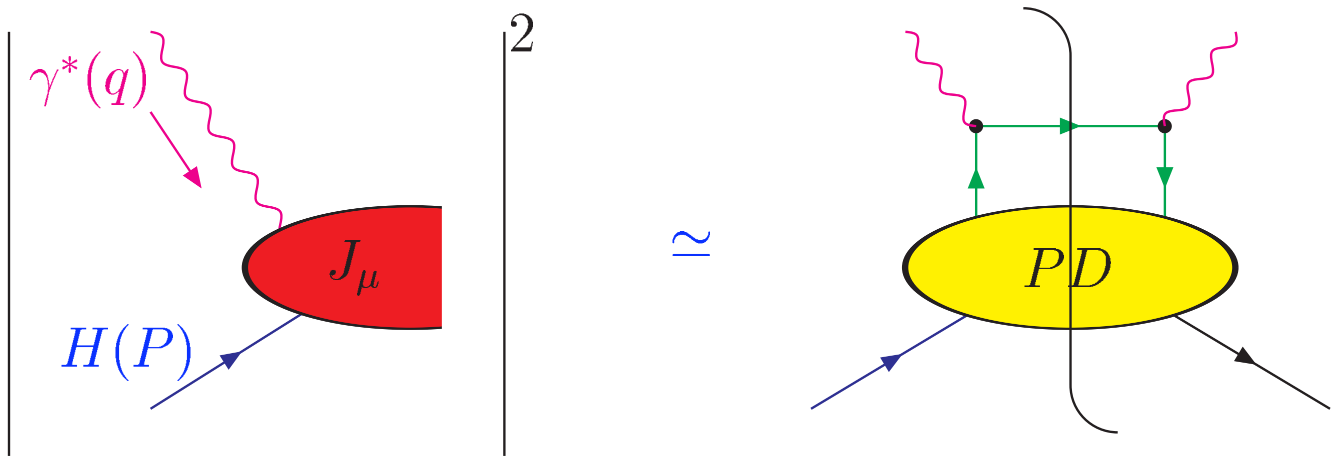
Deeply Virtual Compton Scattering measured by HERMES

International Workshop on Diffraction in High Energy Physics, Cala Gonone, Sardinia, September 2004

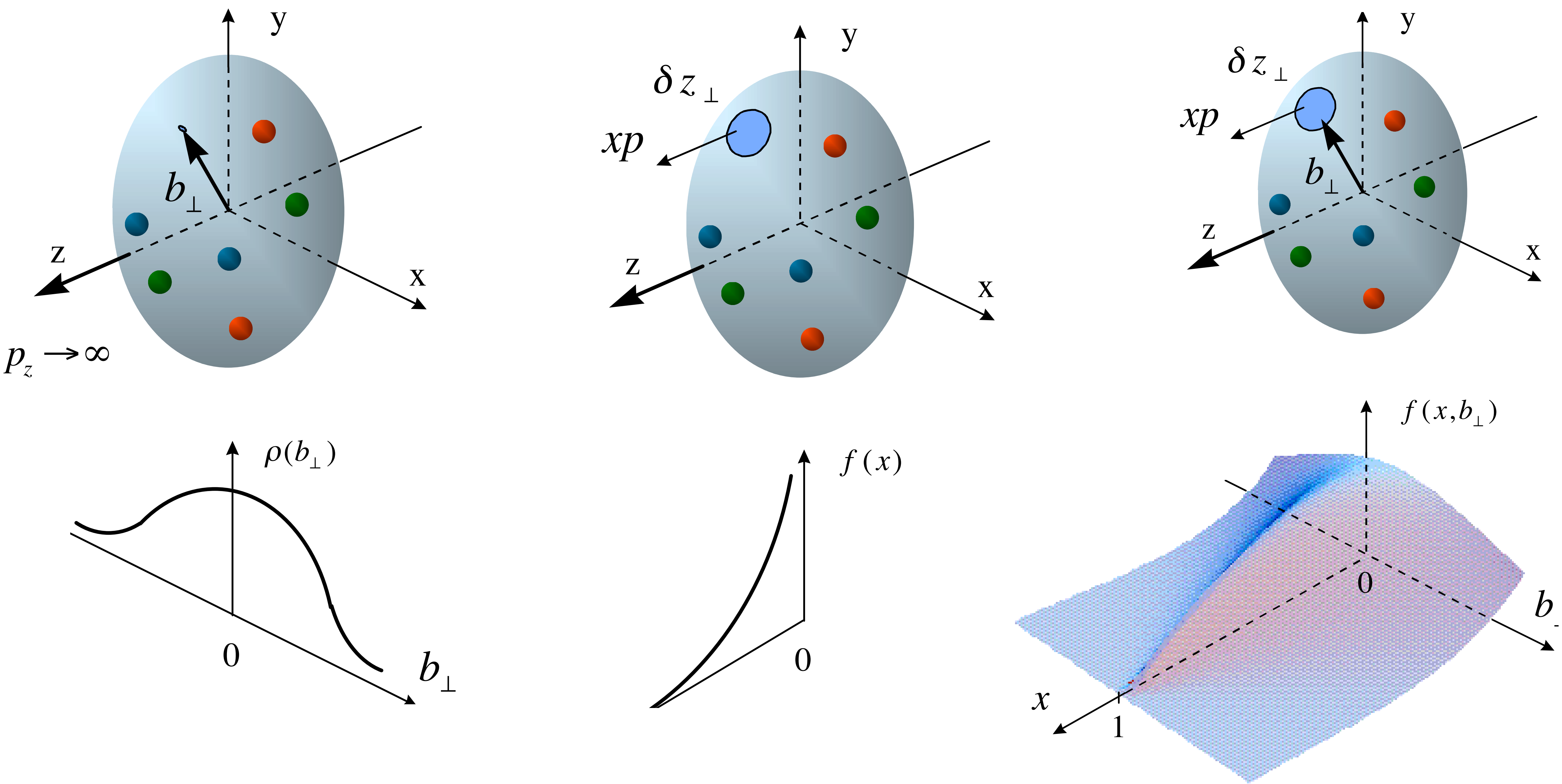
Björn Seitz on behalf of the HERMES Collaboration

From DIS to GPDs



- DIS cross section from forward Compton amplitude via optical theorem
- Hadron described by PDF

(Generalised) Distribution Functions



Formfactor

Parton density

Generalised Parton Distribution

GPDs in Exclusive Reactions

Pseudoscalar Mesons

$\tilde{H}^q, \tilde{E}^q$

Deeply Virtual Compton Scattering

$H^q, E^q, \tilde{H}^q, \tilde{E}^q$

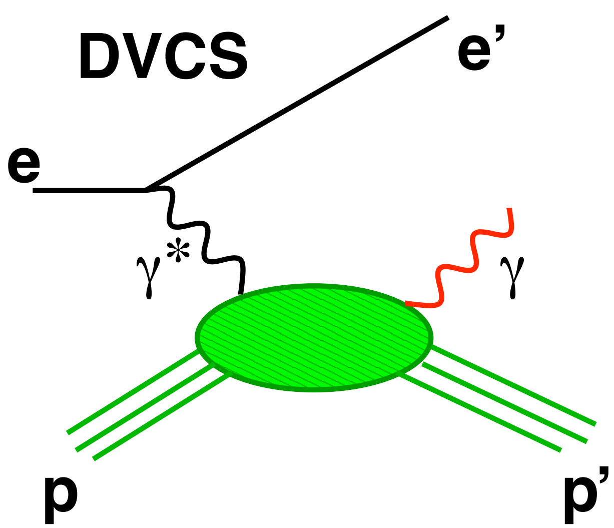
Vectormesons

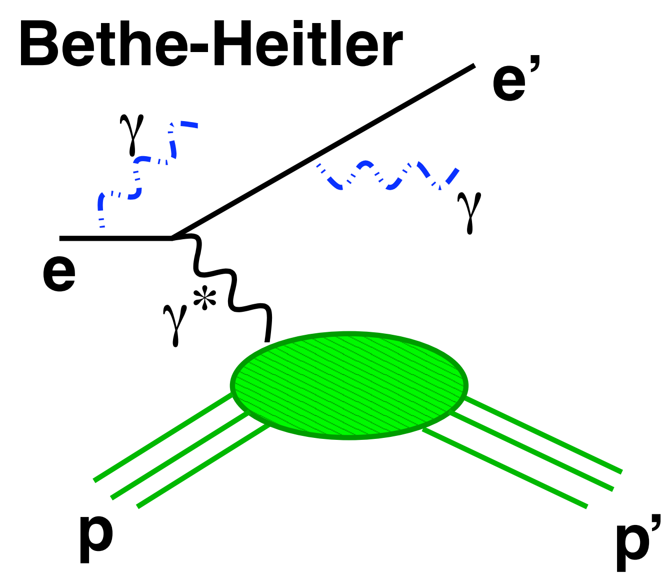
H^q, E^q

$$J^q = \lim_{t \to 0} \frac{1}{2} \int_{-1}^{1} dx\, x \left[H^q(x.\xi, t) + E^q(x, \xi, t)\right]$$

Total angular momentum: Ji 's sum rule

Deeply Virtual Compton Scattering

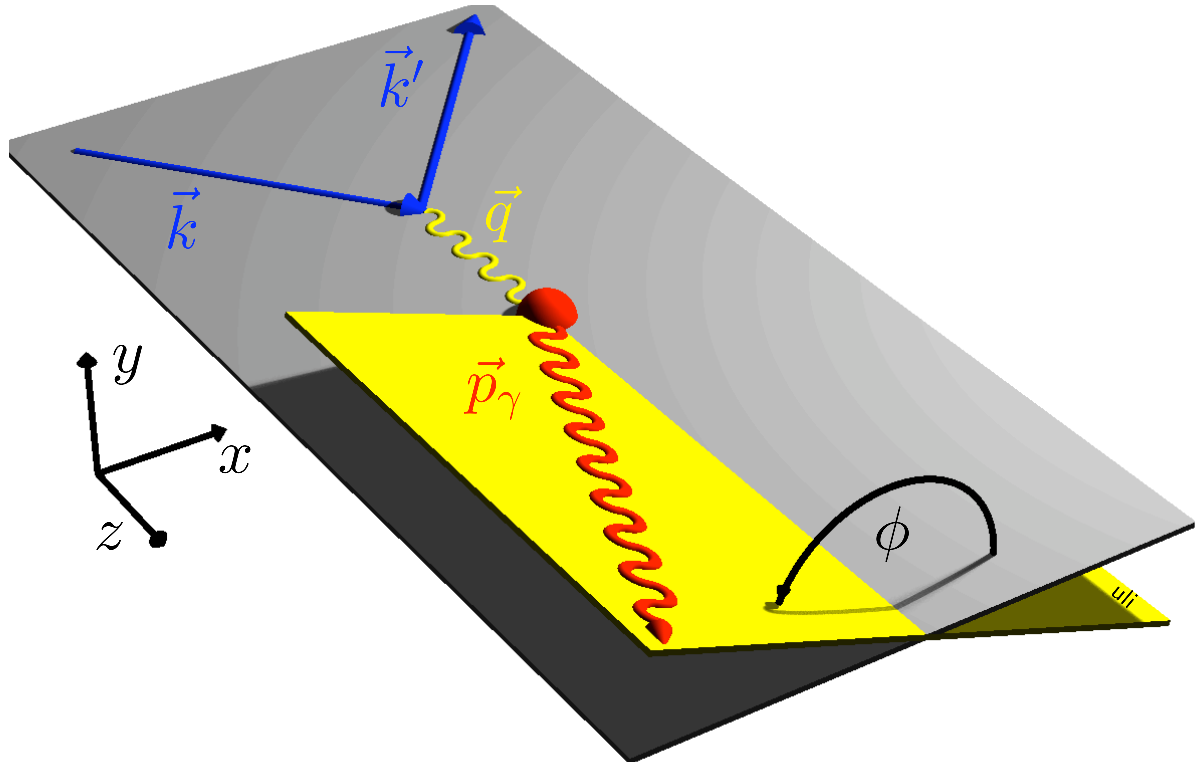




- hard electro-production of a real photon
- same final state as Bethe Heitler process
- quantum-mechanical interference on amplitude level
- at HERMES: use BH als lever arm for DVCS

$$\frac{d\sigma}{dx_B\, dQ^2\, d|t|\, d\phi} = x_B\, y^2 \frac{|\tau_{BH}|^2 + |\tau_{DVCS}|^2 + \overbrace{\tau_{DVCS}\,\tau_{BH}^* + \tau_{DVCS}^*\,\tau_{BH}}^{I}}{32\,(2\pi)^4\, Q^4\, \sqrt{1 + 4\, x_B^2\, M_p^2 / Q^2}}$$

Measuring DVCS Asymmetries

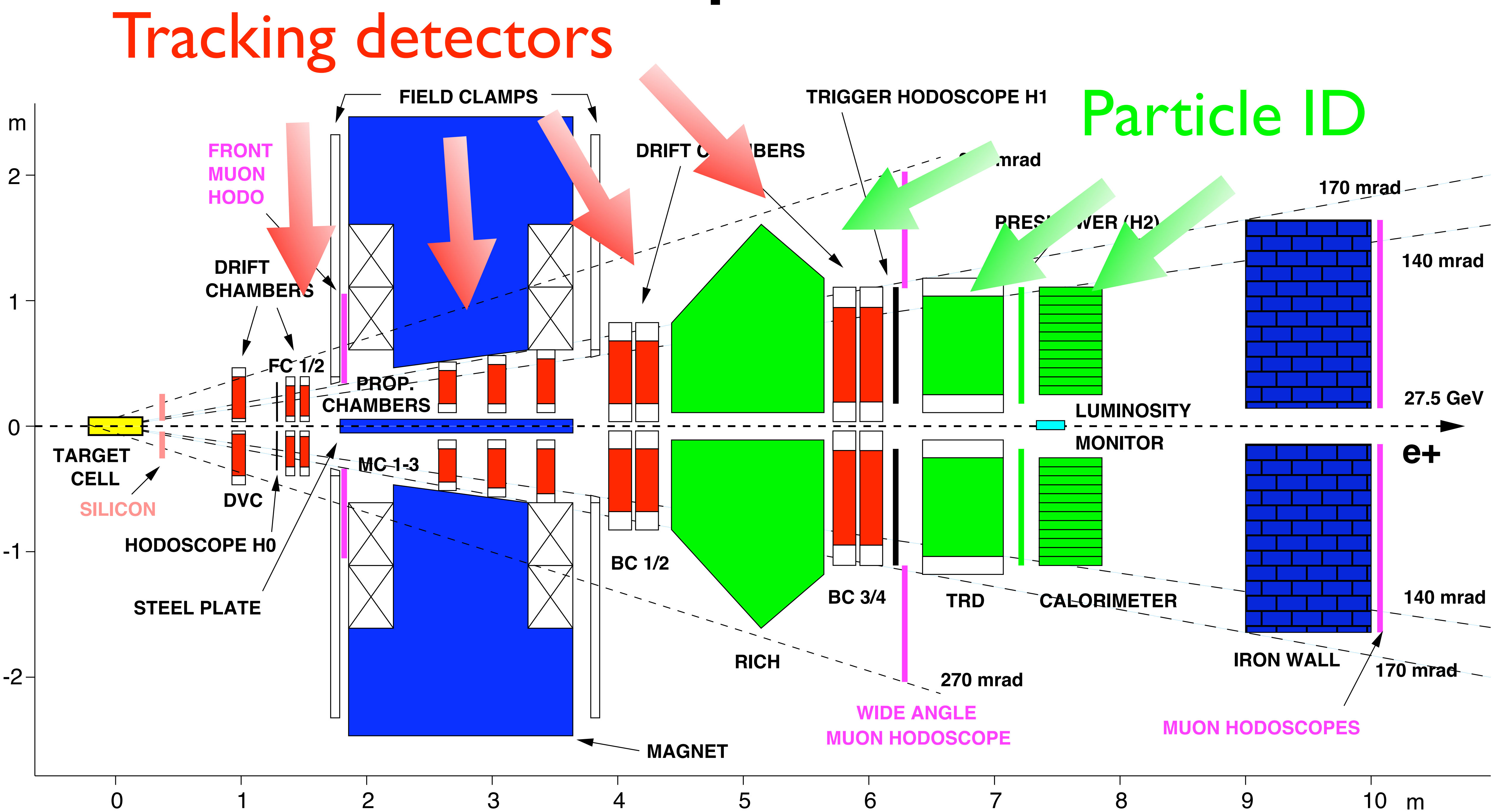


- DVCS BH interference gives direct access to amplitudes
- Beam Charge Asymmetry gives the real part
- Beam Spin Asymmetry gives the imaginary part

$$I = \pm \frac{4\sqrt{2}\, m\, e^6}{t\, Q\, x_B} \frac{1}{\sqrt{1-x_B}} \times \left[\cos\phi \frac{1}{\sqrt{\epsilon(\epsilon-1)}} \Re M^{1,1} - P_l \sin\phi \sqrt{\frac{1+\epsilon}{\epsilon}} \Im M^{1,1}\right]$$

$$M^{1,1} = F_1 \mathcal{H}_1 + \frac{x_B}{2-x_B}(F_1+F_2)\tilde{\mathcal{H}}_1 - \frac{t}{4M^2} F_2 \mathcal{E}_1$$

HERMES Spectrometer

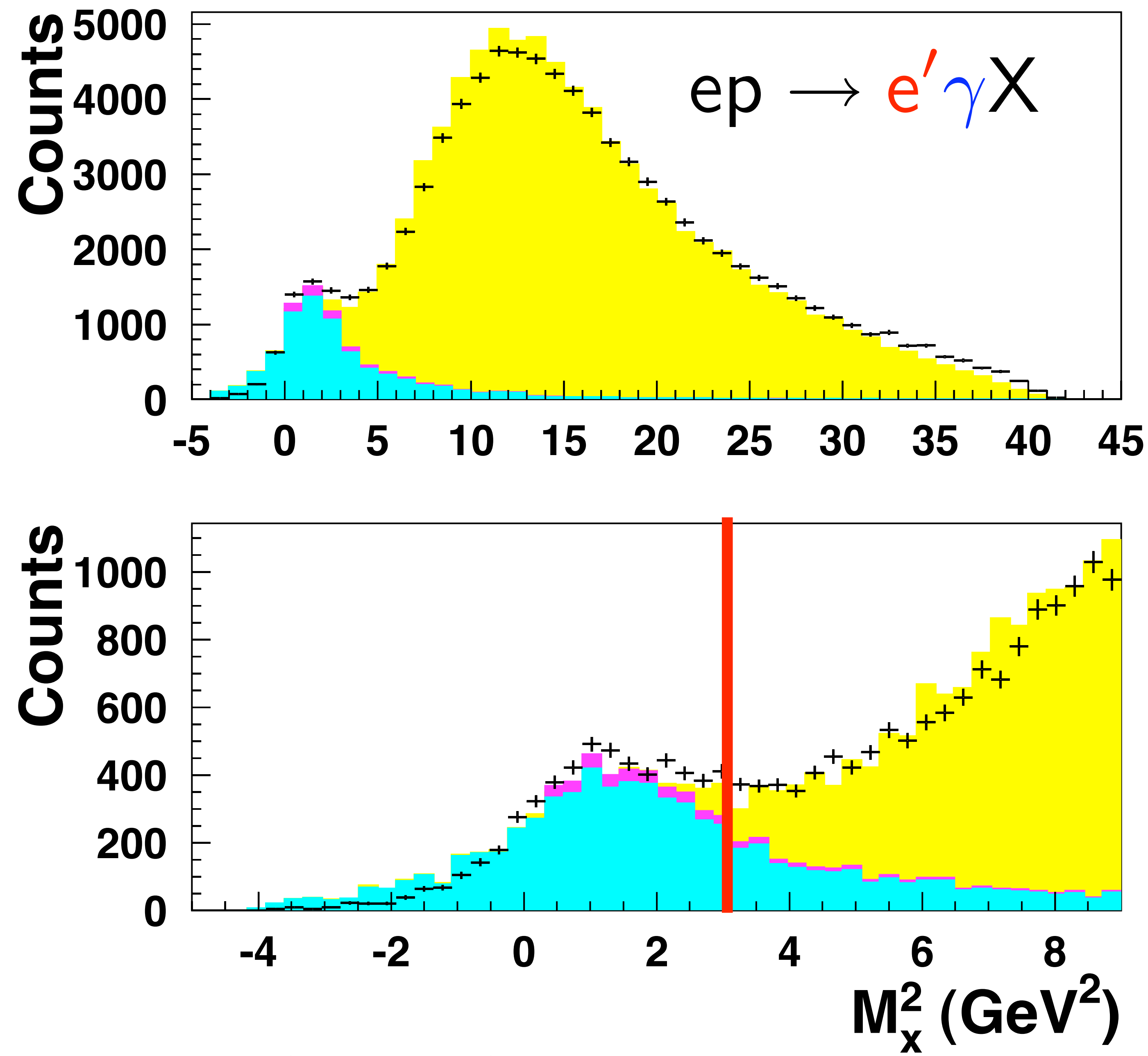


Targets : $\vec{p}, \vec{d}, H_2, D_2, {}^{20}Ne, {}^{84}Kr$ $\Delta P/P < 1.6\%$

$\langle P_B \rangle \approx 0.55 \quad \langle P_T \rangle \approx 0.85$ $\epsilon_{e^\pm} \geq 97\%$

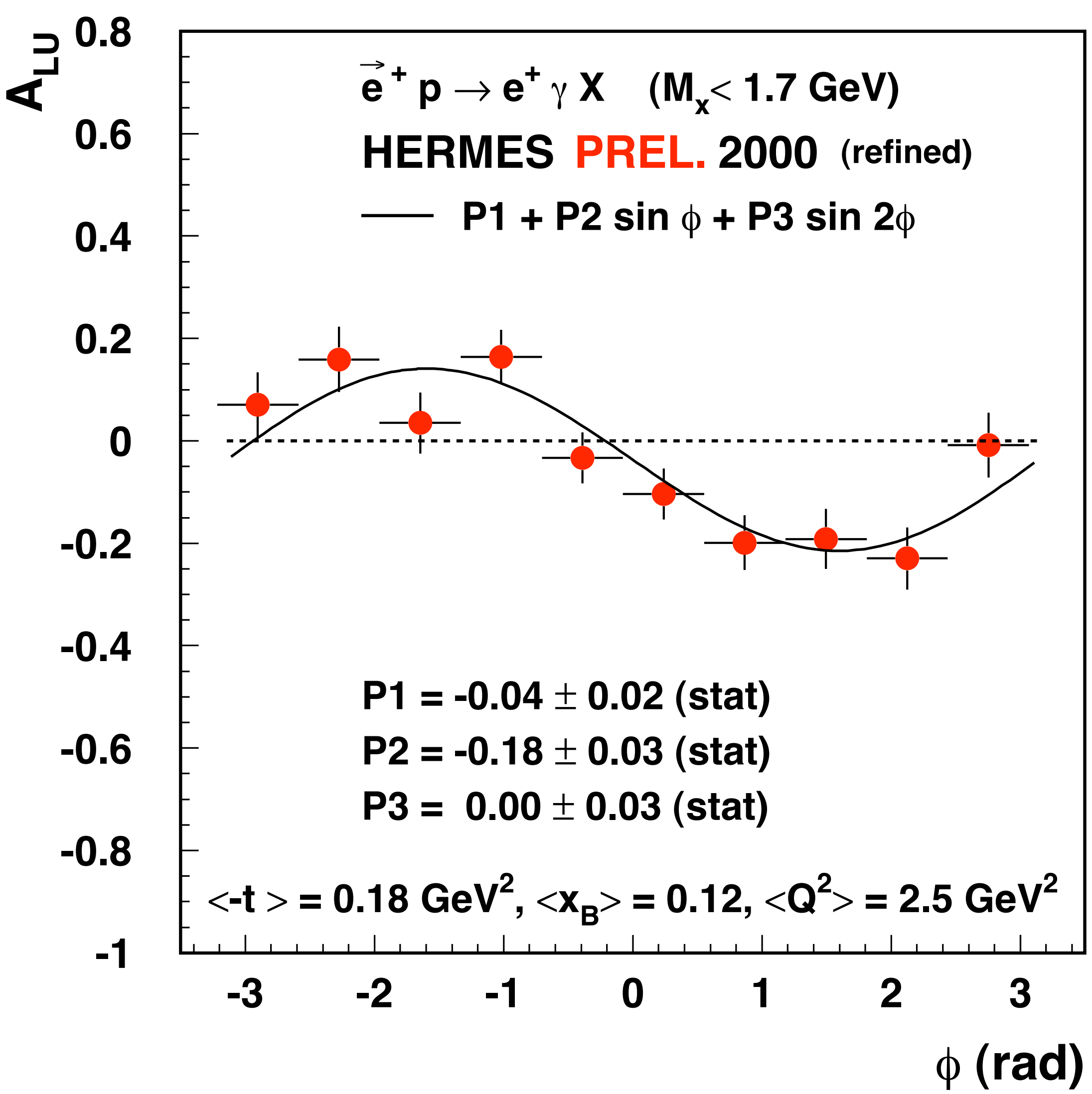
Current Analysis Strategy

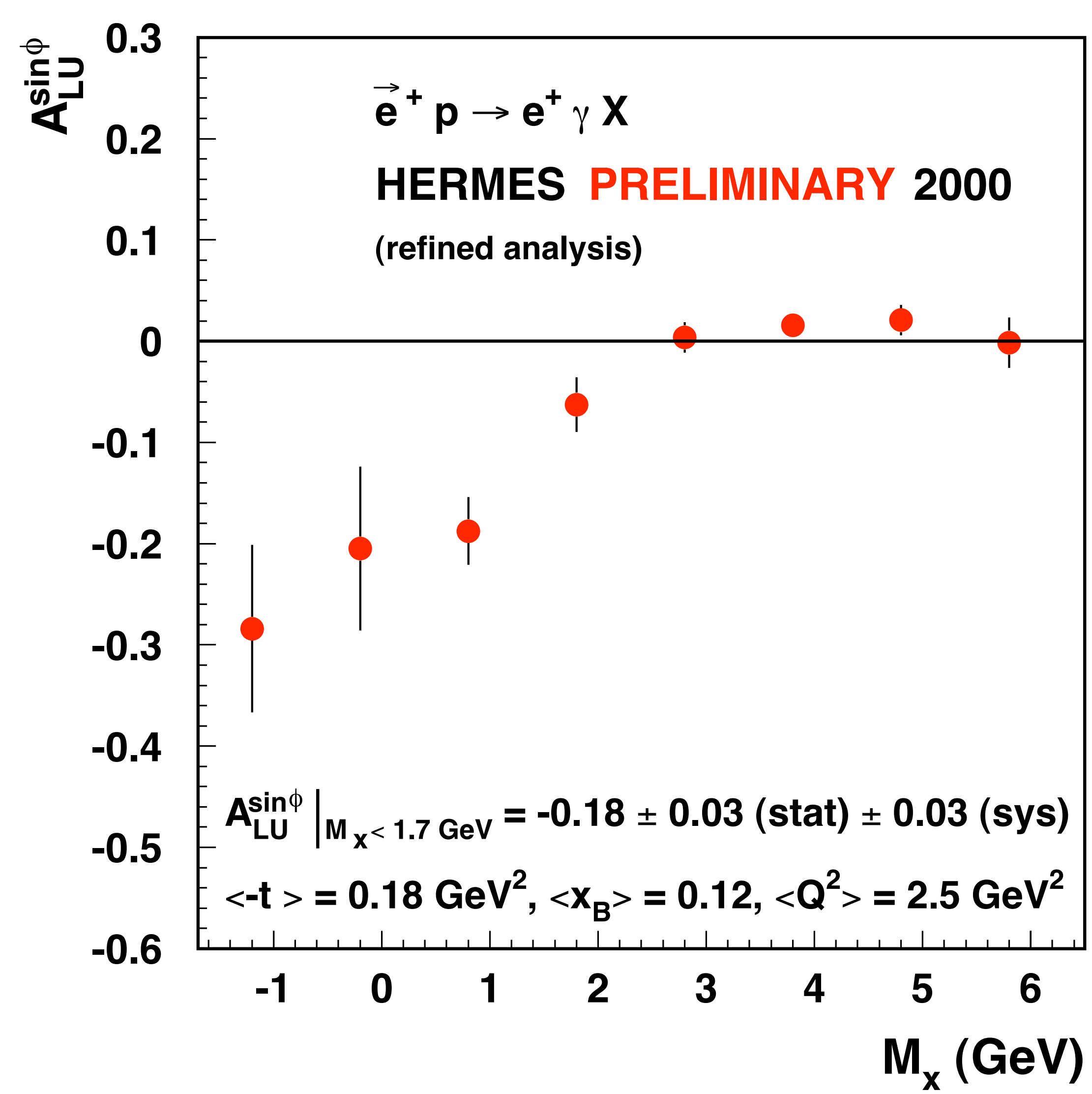
- Spectrometer detects photon and lepton
- missing particle: recoil proton
- identify reaction by missing mass cut
- measure asymmetries with respect to azimuthal angle ϕ



$$M_x^2 = m_p^2 + 2m_p\left(\nu - E_\gamma\right)$$

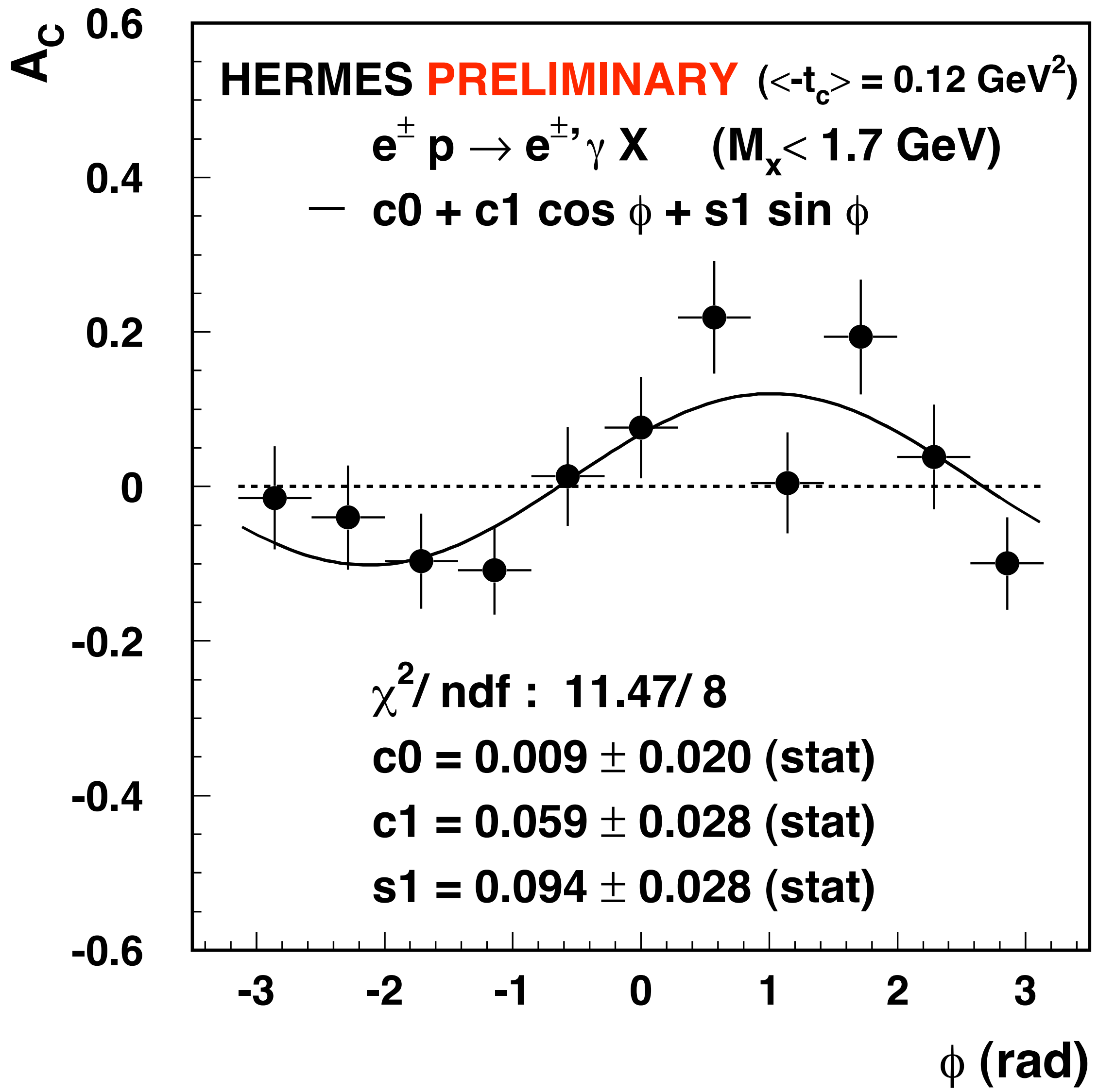
Getting the imaginary part: Beam Spin Asymmetry

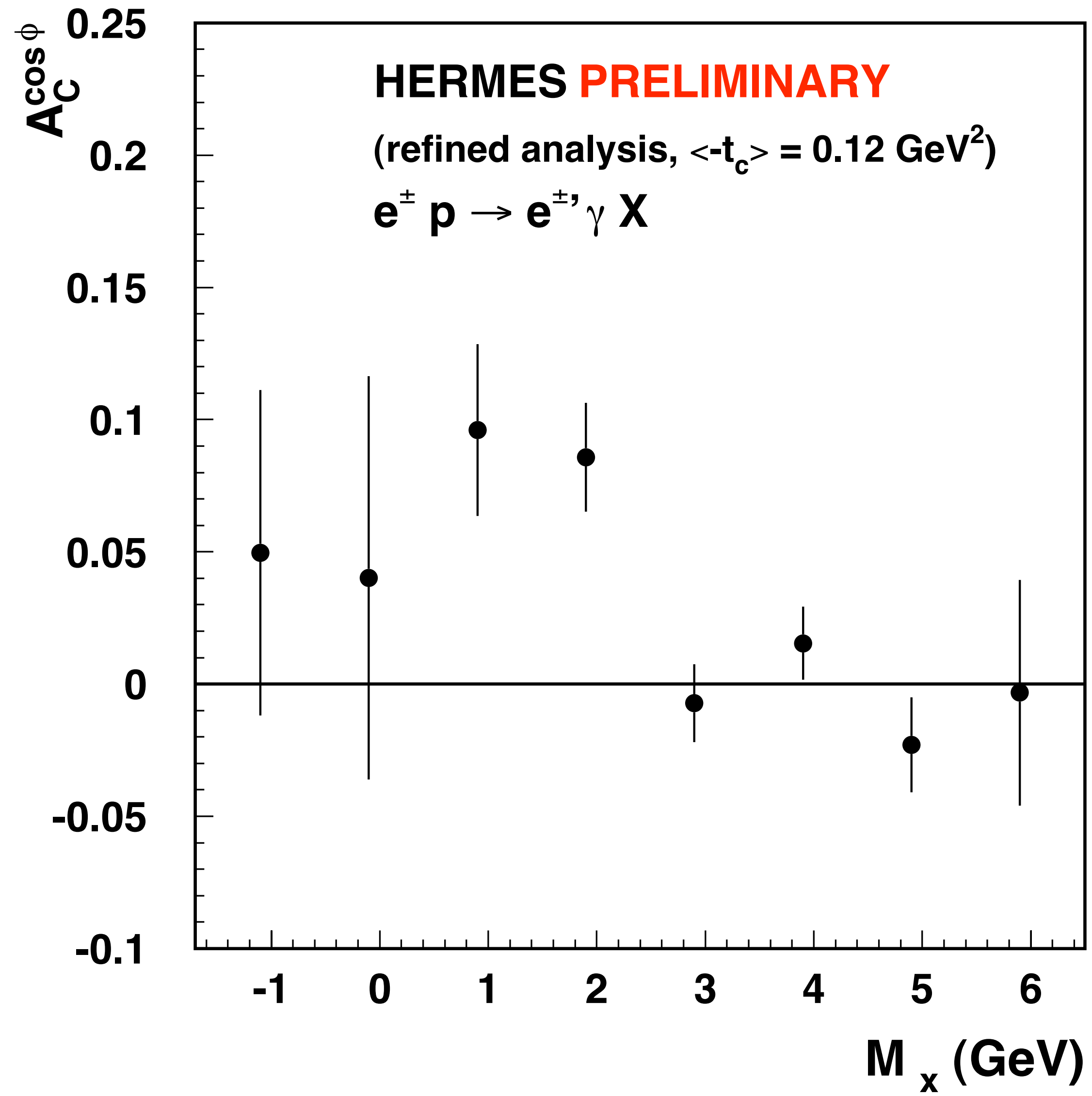




$$I = \pm \frac{4\sqrt{2}\, m\, e^6}{t\, Q\, x_B} \frac{1}{\sqrt{1 - x_B}} \times \left[\cos\phi \frac{1}{\sqrt{\epsilon(\epsilon - 1)}} \Re M^{1,1} - P_l \sin\phi \sqrt{\frac{1+\epsilon}{\epsilon}} \Im M^{1,1}\right]$$

Getting the real part: Beam Charge Asymmetry





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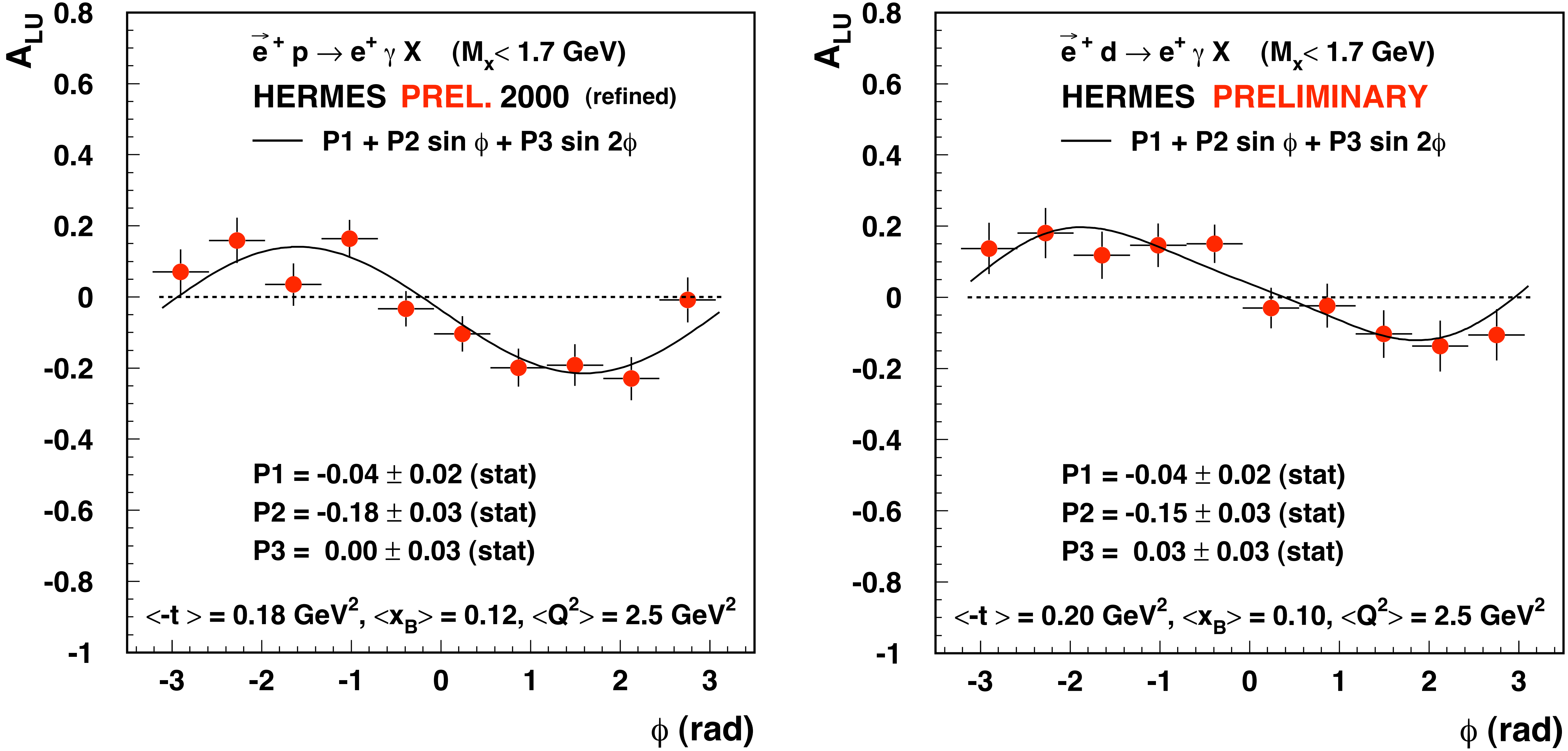
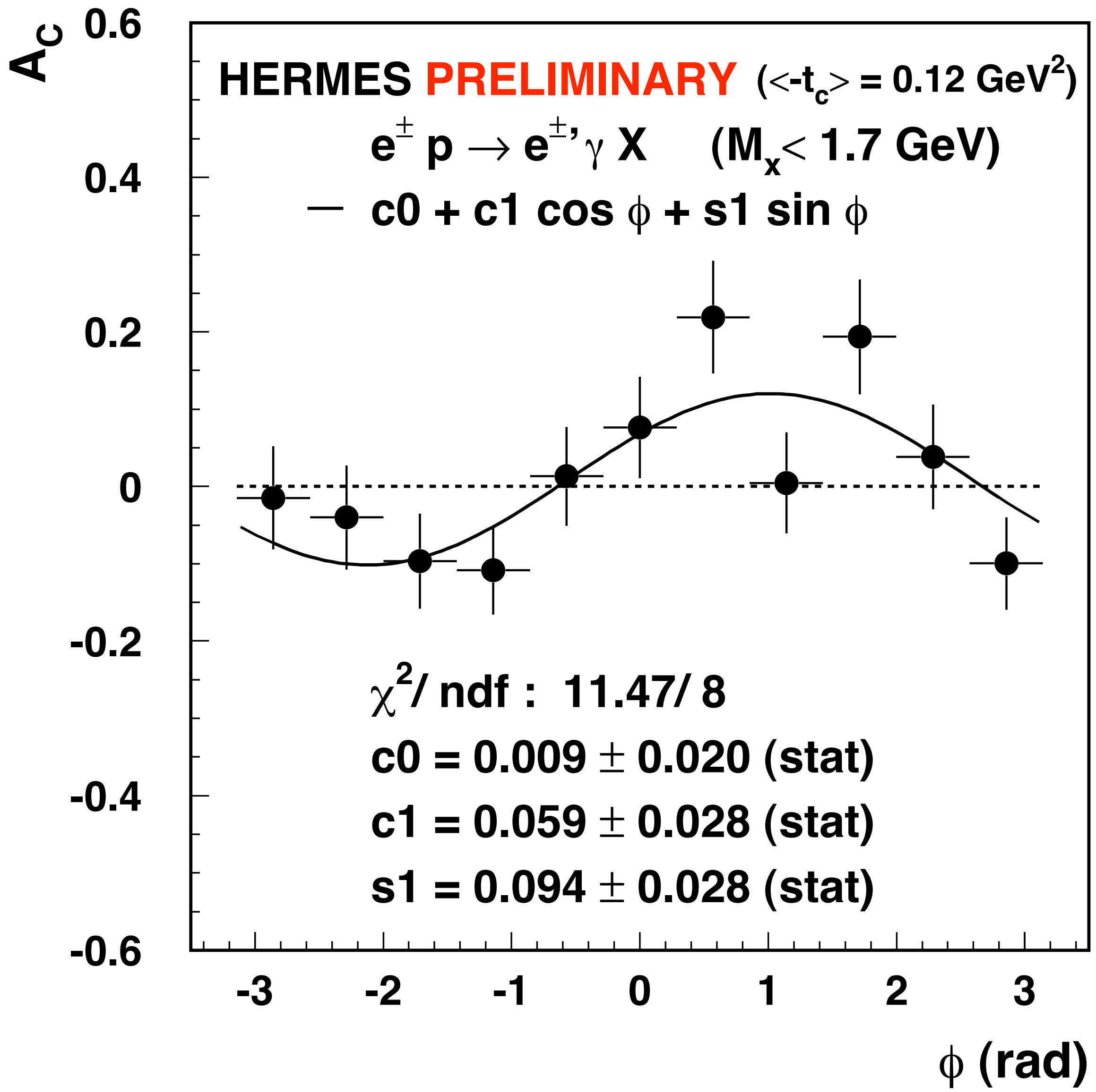
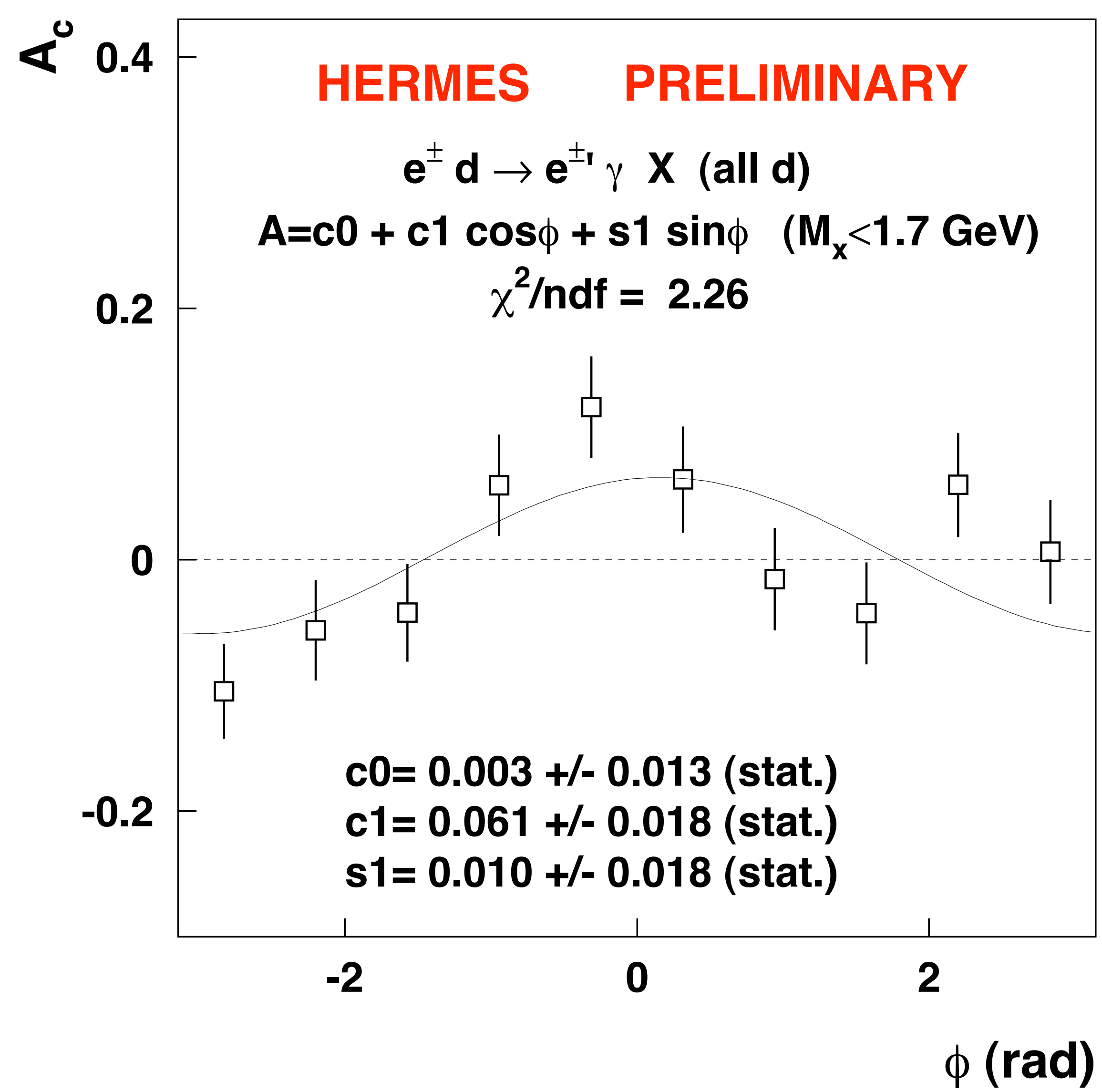
BSA on proton and deuteron



Amplitudes consistent with calculations of Kirchner/Müller hep-ph/0202279

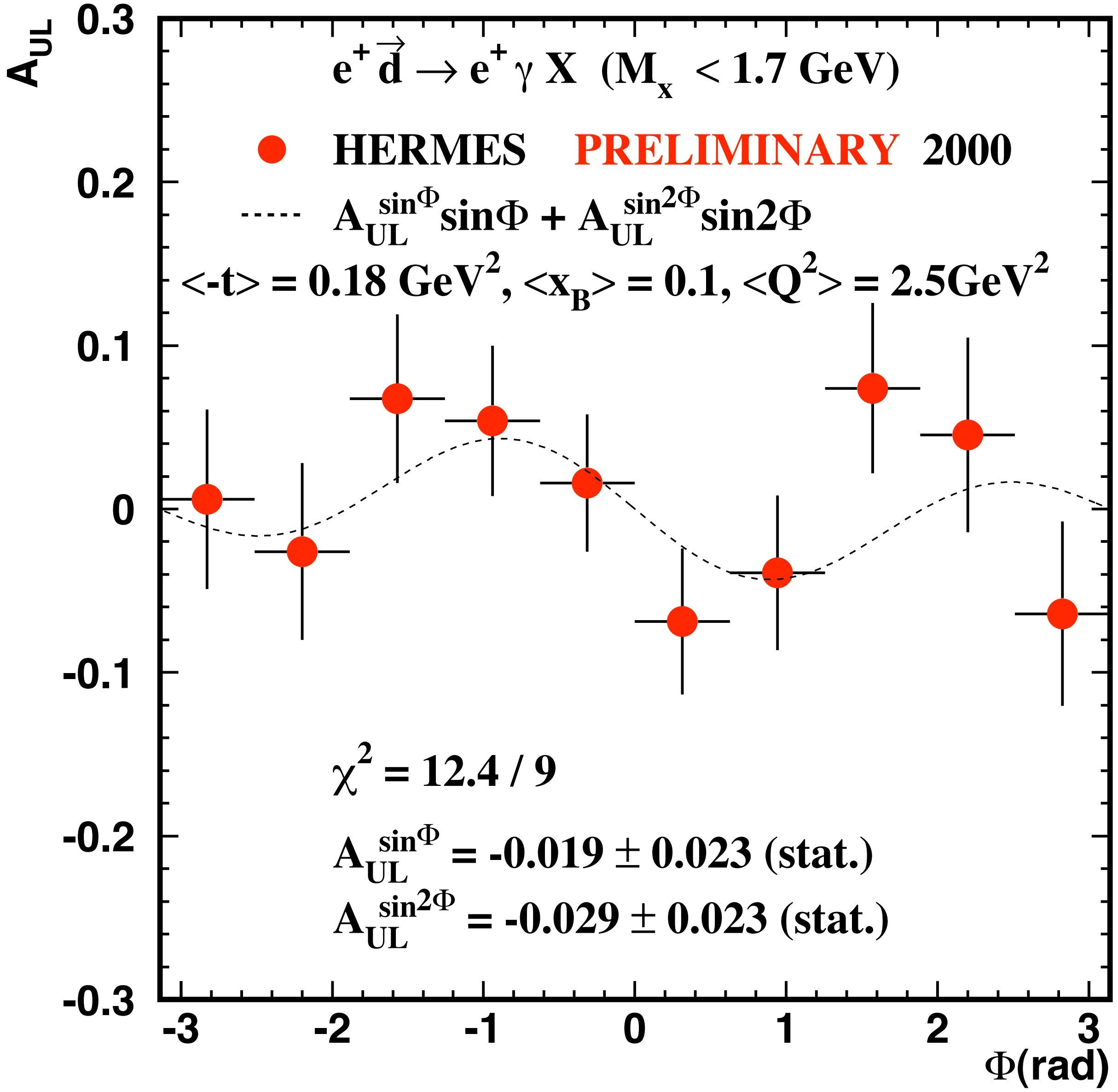
BCA on proton and deuteron





Similarity suggests that incoherent scattering on p in d is the dominant process

Deuteron Target Spin Asymmetry



- first experimental observation of TSA
- sizeable sin(ϕ) and sin(2ϕ) contributions
- d data p dominated
- sin(ϕ) gives access to $\tilde{H}$

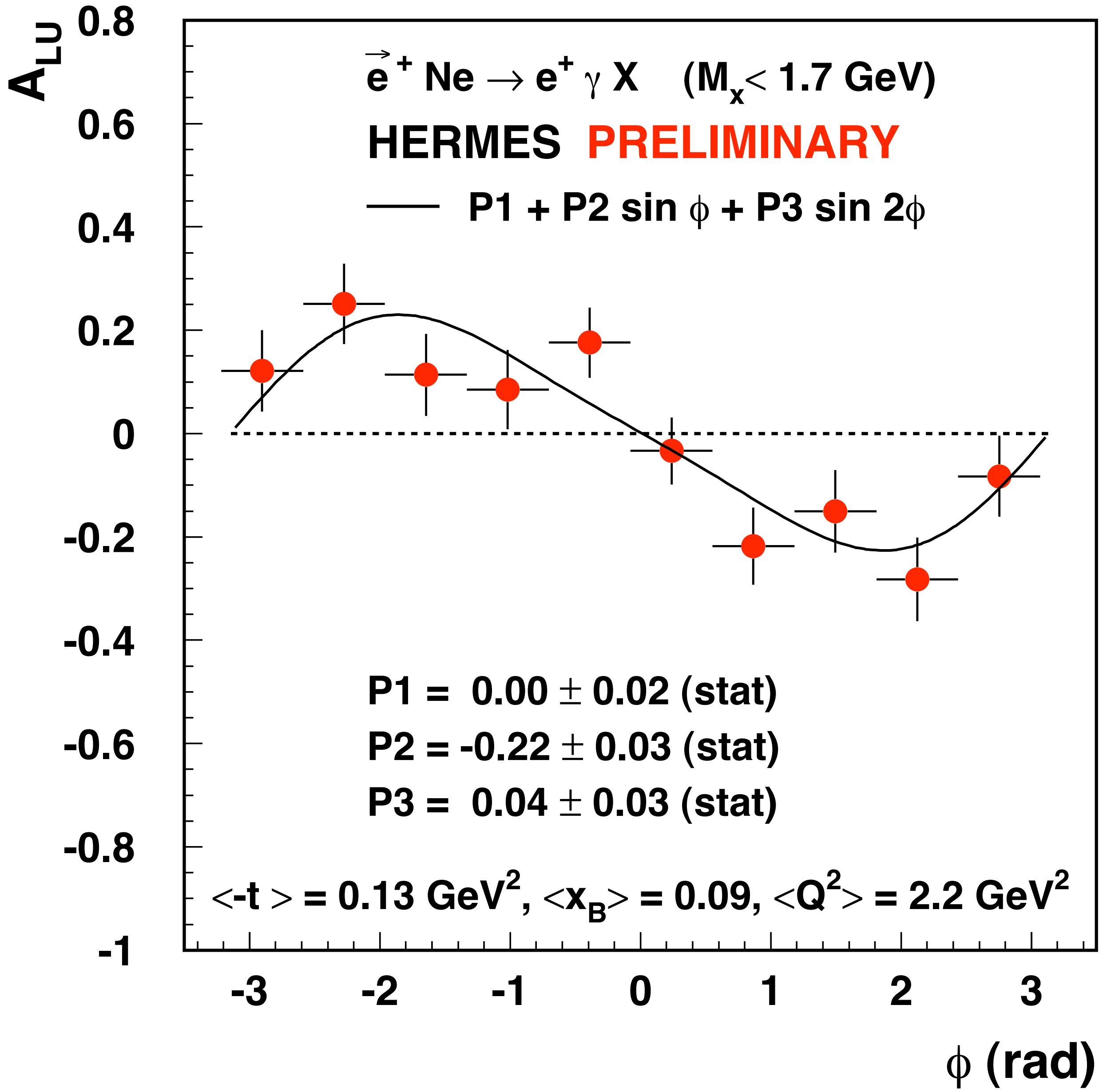
$$A_{UL} \propto \mathrm{Im}\left[\frac{x}{2-x}(F_1+F_2)\left(\mathcal{H}_1+\frac{x}{2}\mathcal{E}_1\right)+\boxed{F_1\tilde{\mathcal{H}}_1}+\frac{x}{2-x}\left(\frac{x}{2}F_1+\frac{\Delta^2}{4M^2}F_2\right)\mathcal{E}_1\right]\boxed{\sin\phi}$$

Heavy Targets: DVCS on Nuclei

- Holography of nuclei: 3D distributions of quarks and gluons
- A new window to study nuclear degrees of freedom
- Allows to study binding effects in nuclei from a new perspective
- provides new constraints on the nucleus wave functions

Link fundamental and nuclear degrees of freedom !

Heavy Targets: BSA on Neon

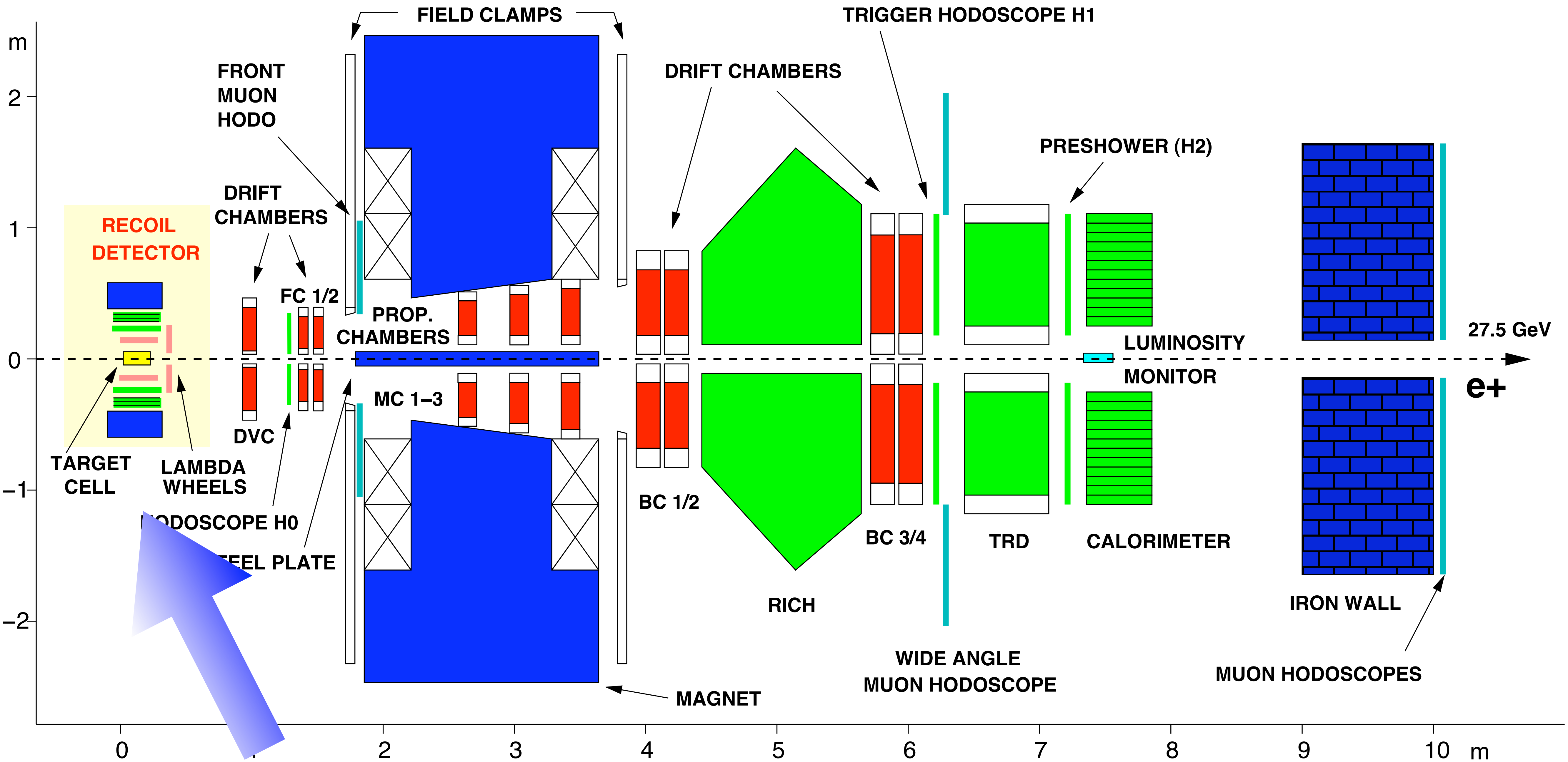


- Ne acts as scalar target
- sizeable BSA observed, comparable to BSA on p
- comparison to theory requires separation into coherent and incoherent part
- separation into coherent and incoherent difficult (recoiling nucleus not detected)
- study of t-dependence in progress

Summary

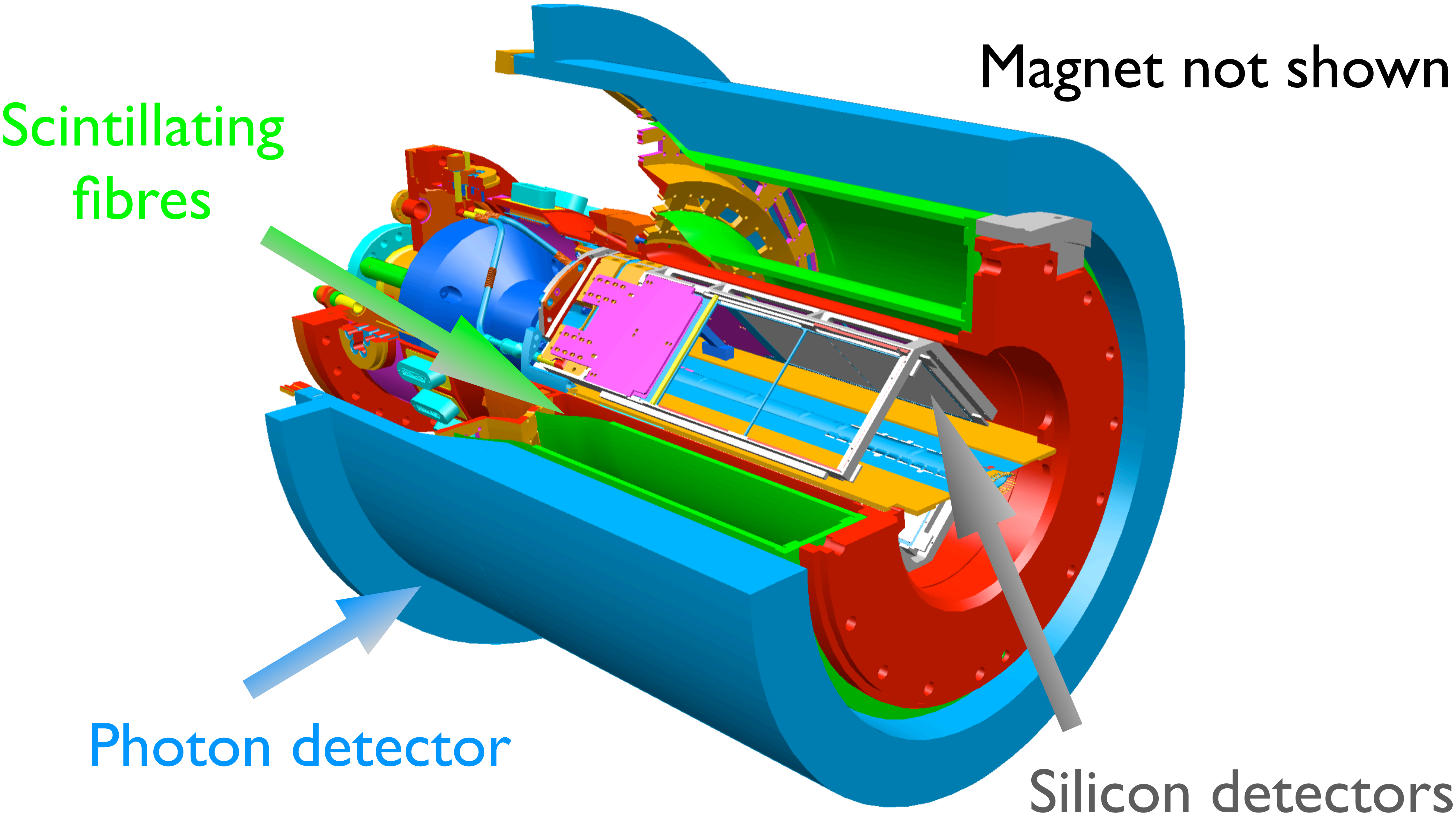
- DVCS observed by HERMES on p,d,Ne,(Kr)
- identification by missing mass, resonance contributions included in systematic error
- HERMES measures BeamSpin, BeamCharge and TargetSpin Asymmetries thus accessing the full DVCS amplitude
- These data map GPDs H and $\tilde{H}$
- Study of kinematical dependencies underway
- Data from transverse target will allow access to E
- more precise data and fine binning in x,t from 2005 on using dedicated recoil detector

HERMES in the future

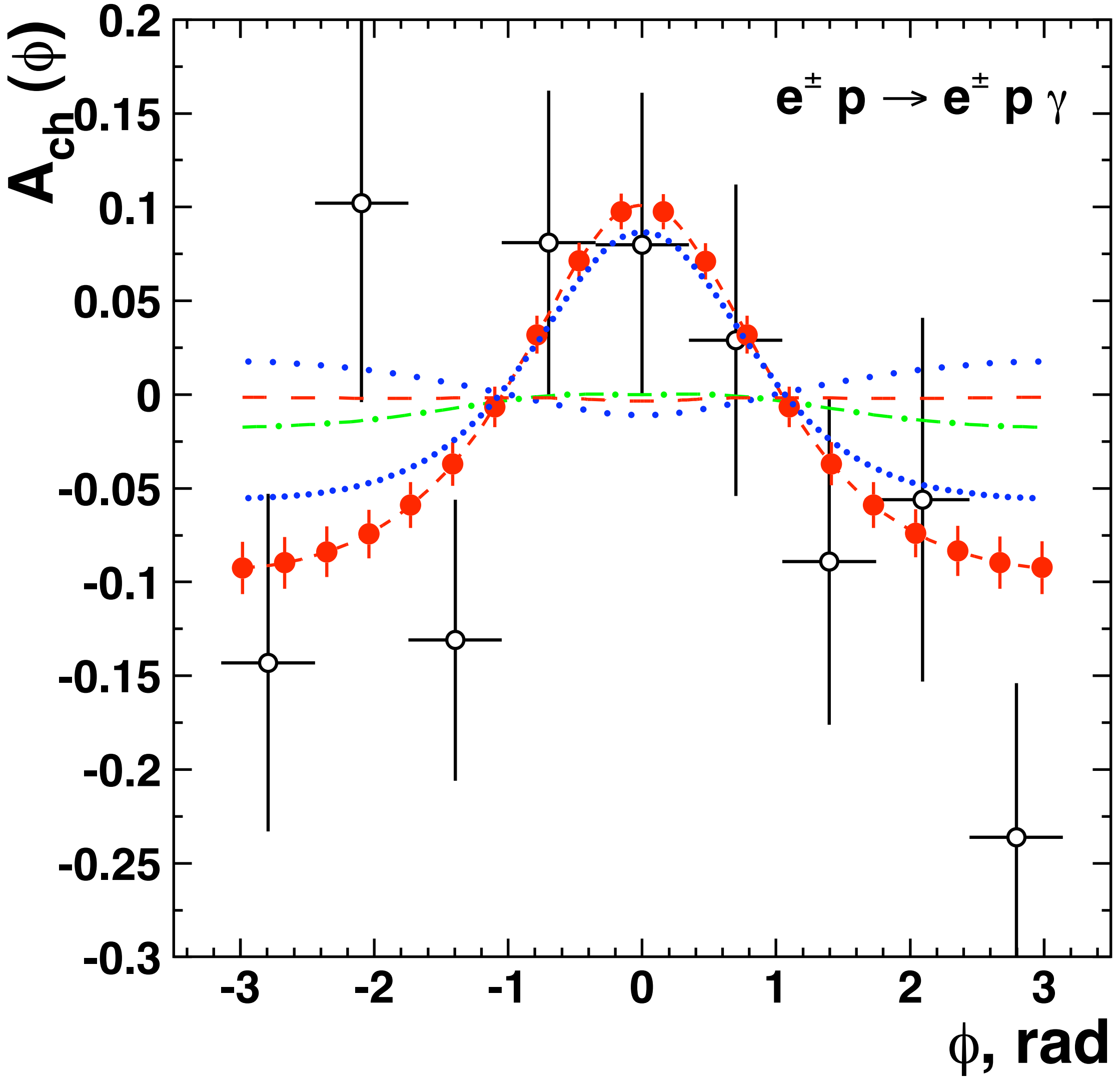


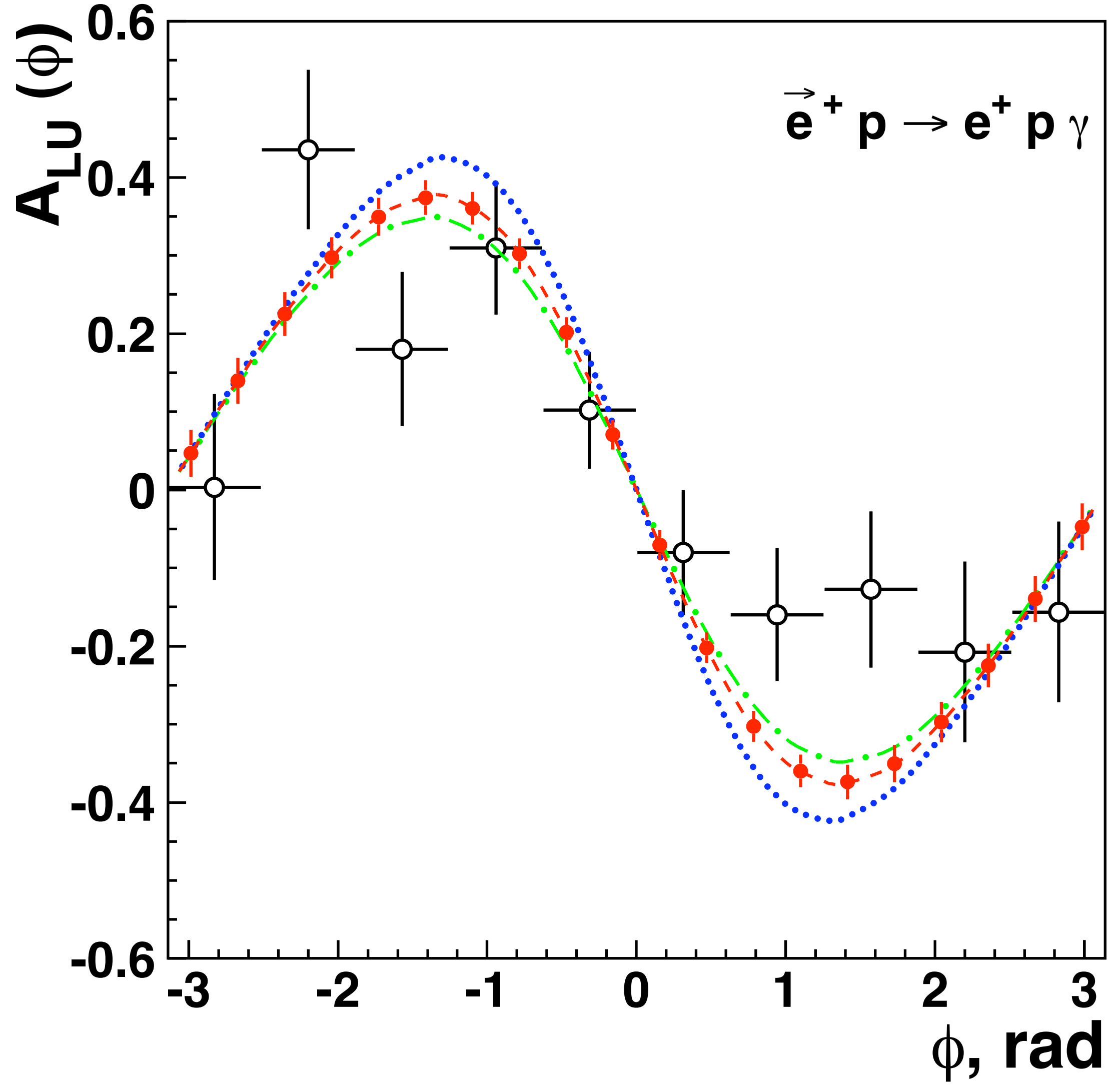
Recoil Detector surrounding target region

HERMES Recoil detector



What we aim for ...





- improved statistical precision (based on 2 fb^{-1})
- clean reaction identification
- detector resolution will allow binning in x and t

A wealth of very exiting results so far ...

... stay tuned for HERMES data with recoil detection