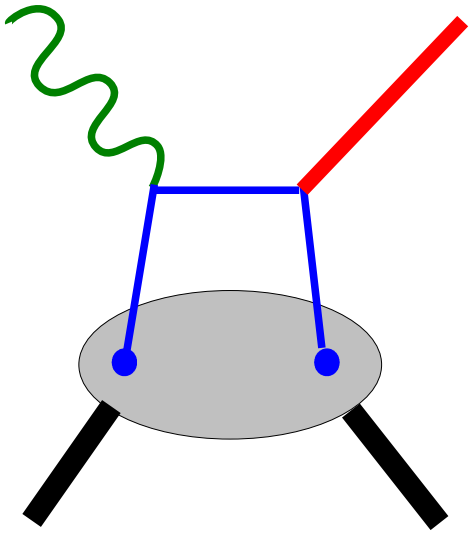
HERMESでのHard Exclusive生成過程による核子内クォーク全角運動量についての研究



- Generalized Parton Distribution
  - GPD and J_q
- Target Transverse Spin Asymmetry
  - Deeply Virtual Compton Scattering
  - Exclusive ρ production
- HERMES results
- Summary

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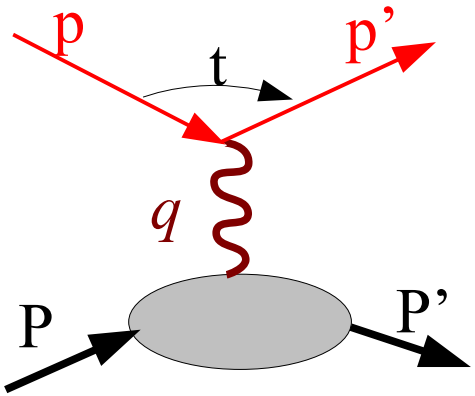
他 HERMES collaboration

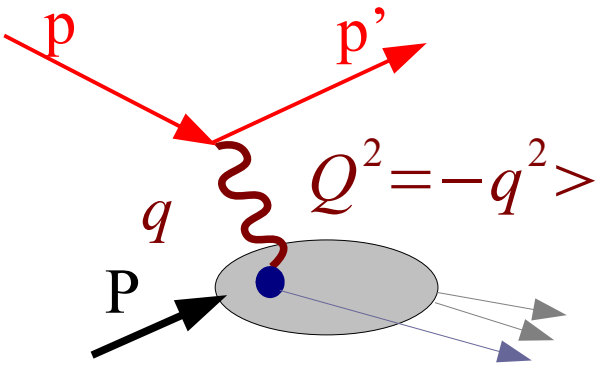
Generalized Parton Distribution

Elastic scattering



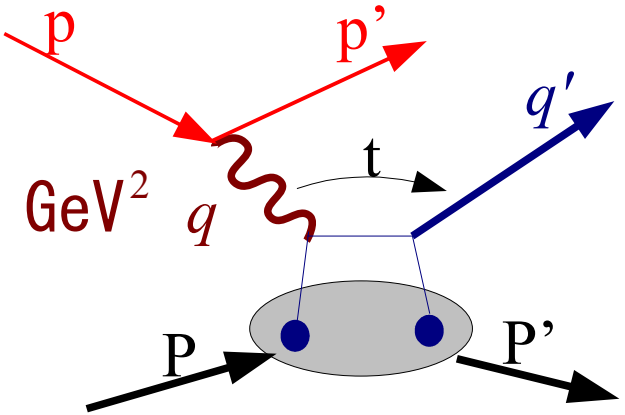
Form Factor: F(t), G(t)

Deep Inelastic Scattering



Parton distribution: **q(*x*), Δq(*x*), δq(*x*)**

Hard Exclusive Production:



$Q^2=-q^2>1$ GeV^2 q

$$e+N\rightarrow e'+N'+\{\gamma,\ \rho,\ \pi,\ldots\}$$

Generalized Parton Distribution:

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

Generalized Parton Distribution

Generalized Paton Distributions

Vector $H(x,\ \xi,\ t)$

Tensor $E(x,\ \xi,\ t)$

Axial vector $\tilde{H}(x,\ \xi,\ t)$

Pseudo scalar $\tilde{E}(x,\ \xi,\ t)$

for quarks and gluon

Forward Limit: $\xi \to 0,\ t \to 0$

$$H^q(x,\ 0,\ 0) = q(x)$$
$$\tilde{H}^q(x,\ 0,\ 0) = \Delta q(x)$$

Form Factors:

$$\int_{-1}^{+1} dx\, H^q(x,\ \xi,\ t) = F_1^q(t) \quad \text{Dirac}$$
$$\int_{-1}^{+1} dx\, E^q(x,\ \xi,\ t) = F_2^q(t) \quad \text{Pauli}$$
$$\int_{-1}^{+1} dx\, \tilde{H}^q(x,\ \xi,\ t) = g_A^q(t) \quad \text{Axial vector}$$
$$\int_{-1}^{+1} dx\, \tilde{E}^q(x,\ \xi,\ t) = h_A^q(t) \quad \text{Pseudoscalar}$$

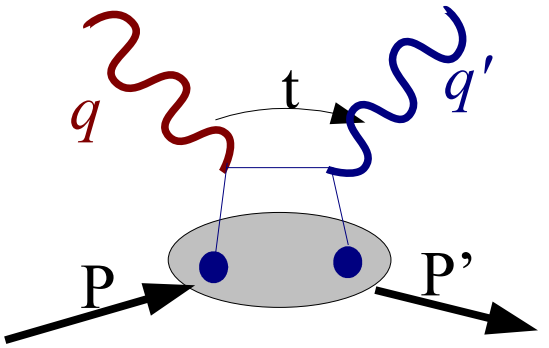
GPD and total angular momentum of parton

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

Hard Exclusive Production and GPD

Deeply Virtual Compton Scattering: **(DVCS)**

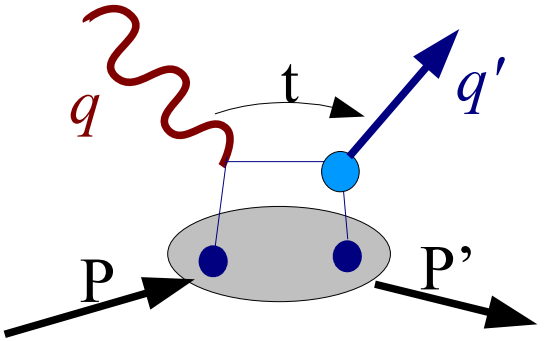
$$e + N \rightarrow e' + N' + \gamma$$



Involved GPDs: H, E, $\tilde{H}$, $\tilde{E}$
clean reaction

Hard exclusive meson production:

$$e + N \rightarrow e' + N' + \{\rho,\ \pi, \ldots\}$$

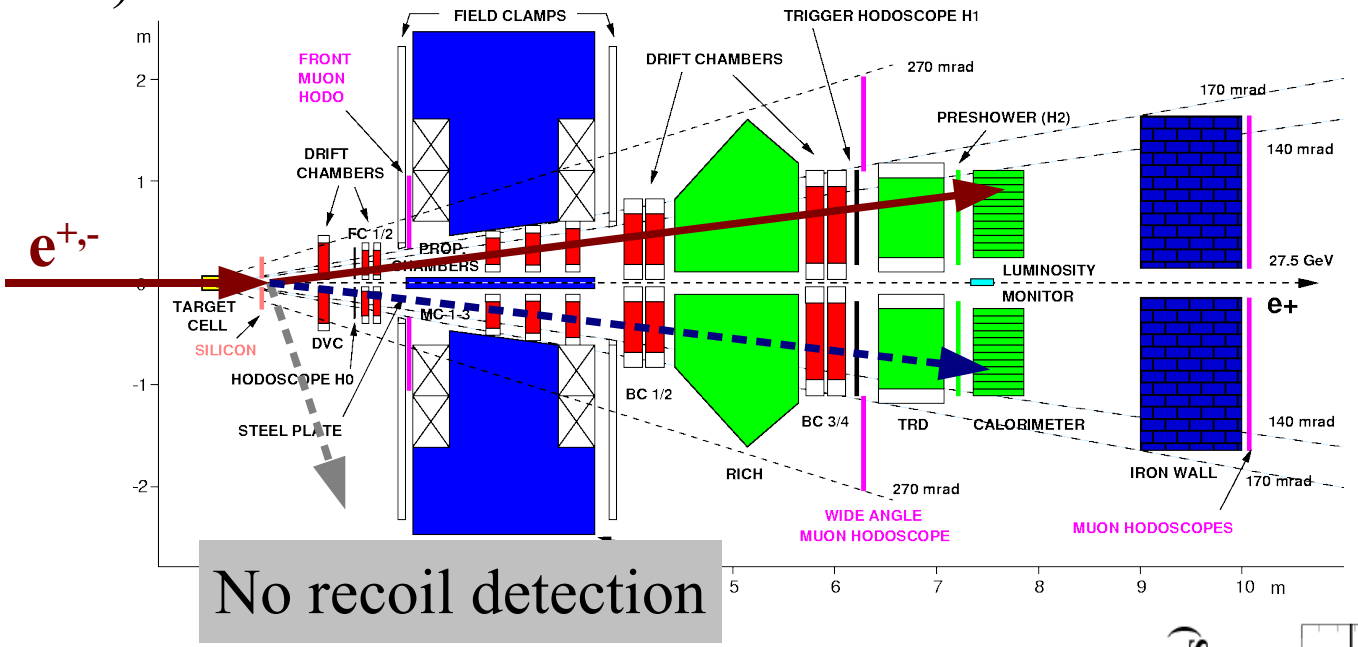


vector meson: H, E
pseudo-scalar meson: $\tilde{H}$, $\tilde{E}$

Factorization for longitudinal photons only
Meson Amplitude should be taken care
Quark flavor sensitivity

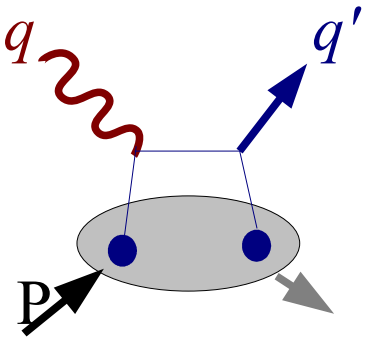
HERMES spectrometer

ex.) DVCS



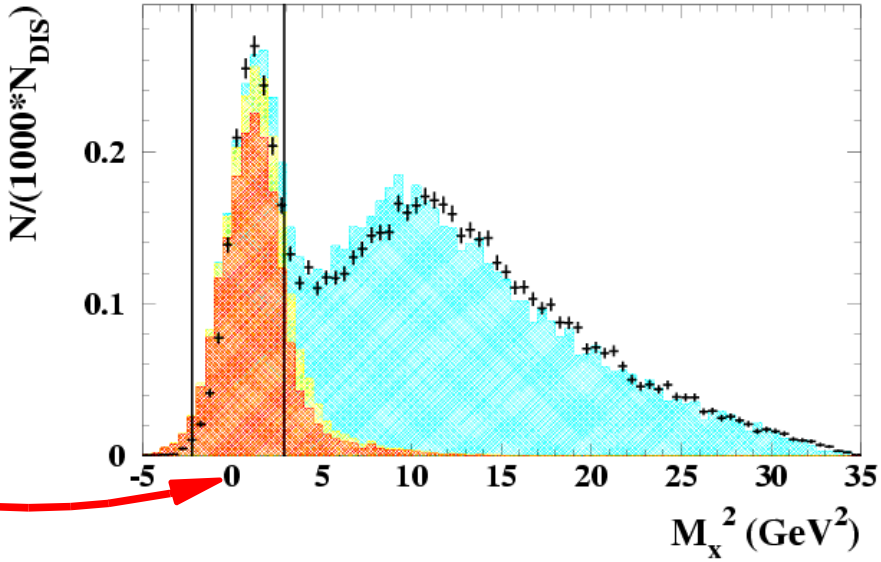
$e^{+,-}$

No recoil detection



Exclusive reaction:
via missing mass

$$M_X^2 = (q + P - q')^2$$



Exclusive production events were selected with a M_x cut

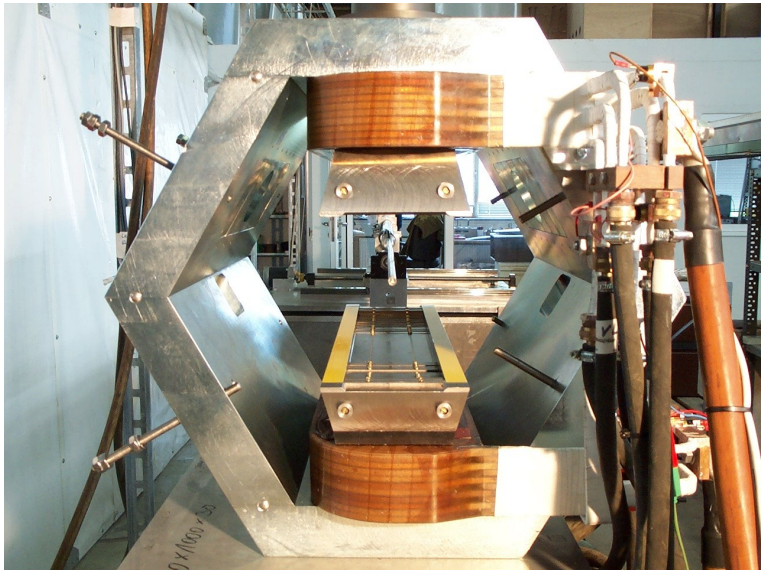
Target Spin Asymmetry: A_{UT}

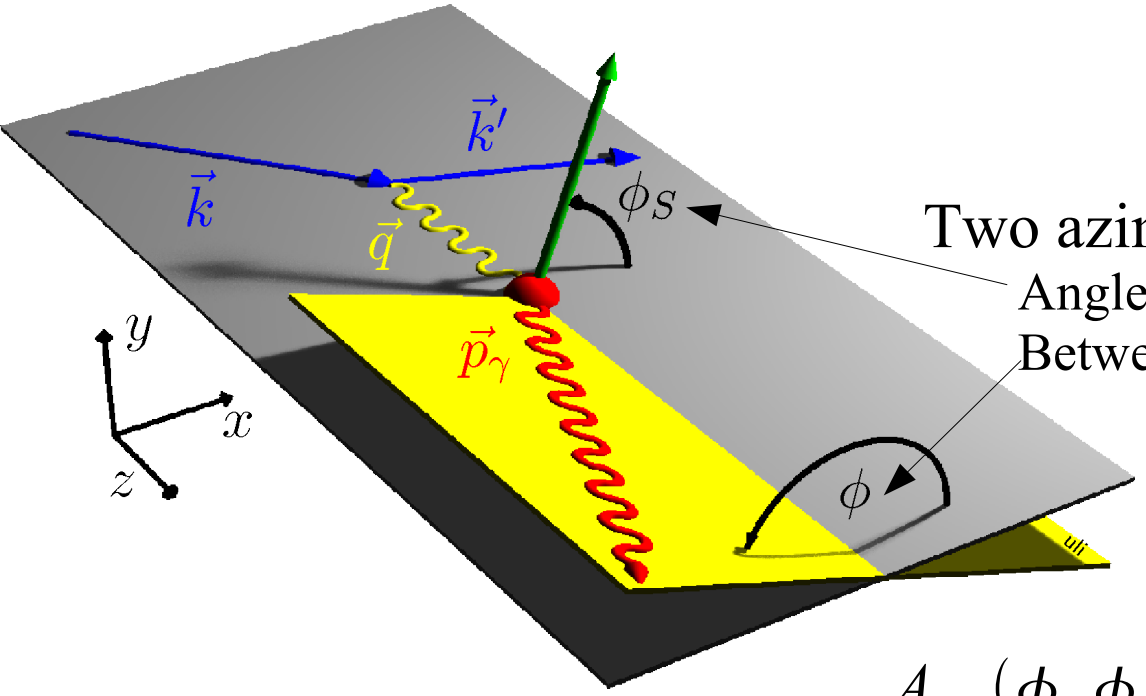
Transversely hydrogen gas target

2002 – 2005

analysis are based on 2002-2004 data.

$<|P_T|> \sim 80\%$





Two azimuthal angles:

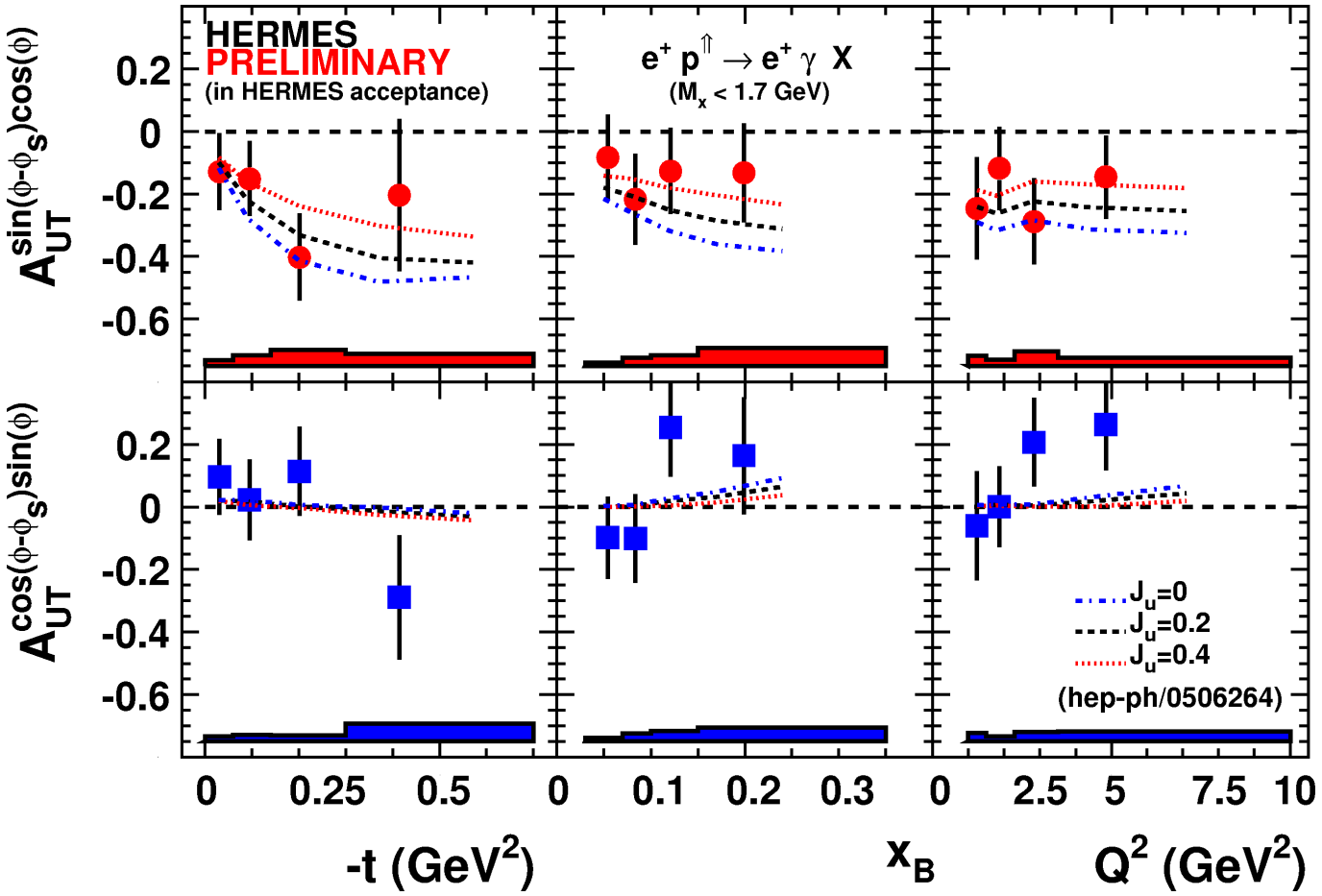
Angle of the target spin direction

Between the lepton and photon (meson) planes

$$A_{UT}(\phi,\phi_S)=\frac{1}{S_\perp}\frac{d\sigma(\phi,\phi_S)-d\sigma(\phi,\phi_S+\pi)}{d\sigma(\phi,\phi_S)+d\sigma(\phi,\phi_S+\pi)}$$

DVCS Target Spin Asymmetry

$$A_{UT}(\phi,\phi_S) \propto A_{UT}^{\sin(\phi-\phi_S)\cos\phi}\sin(\phi-\phi_S)\cos\phi + A_{UT}^{\cos(\phi-\phi_S)\cos\phi}\cos(\phi-\phi_S)\cos\phi$$



$$\sim -\frac{t}{4M^2}\cdot[F_2\mathcal{H} - F_1\mathcal{E}]$$

$$\rightarrow J_q$$

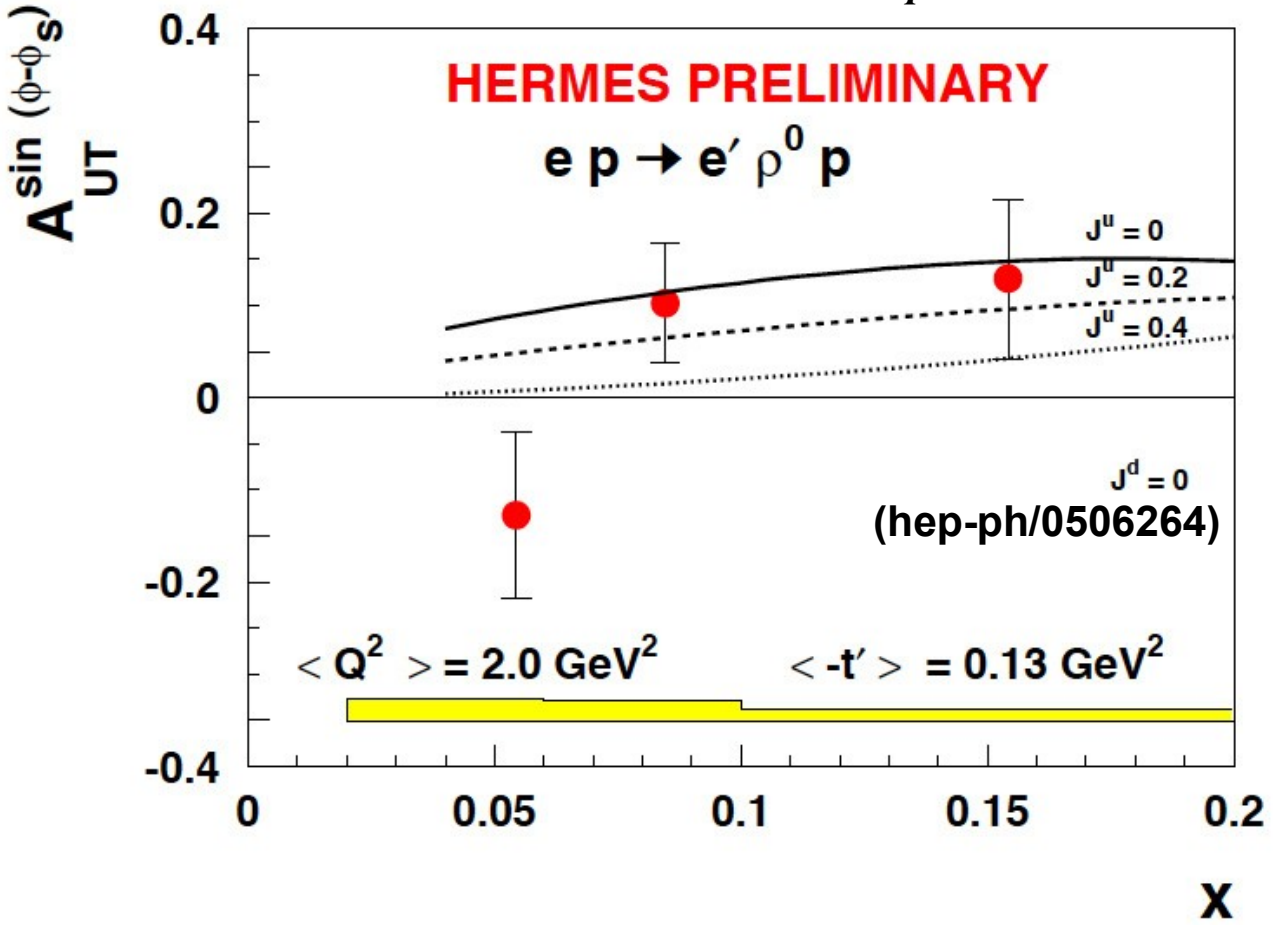
$$\sim -\frac{t}{4M^2}\cdot[F_2\tilde{\mathcal{H}} - F_1\xi\tilde{\mathcal{E}}]$$

Exclusive ρ Target Spin Asymmetry

$$A_{UT}^{\sin(\phi-\phi_S)} \sim E \cdot H$$

ex.) *Goeke et. al., Prog. Part. Nucl. Phys. 47 (2001) 401*

→access to J_q



Including 2005 data doubles the total statistic of DVCS and ρ production.

Summary

- Generalized Parton Distribution
  - Connect PDFs and Form factors
  - Access to the total angular moment
- Single Spin Asymmetry in Hard Exclusive Production
  - DVCS is clean process to access GPD
  - Transverse Target Spin Asymmetry is sensitive to J_q
- HERMES measured
  - non-zero TSA in DVCS and Exclusive ρ production
  - Data taken in 2005 doubles the statistic.