Single-Spin Asymmetries for Exclusive Electroproduction of π^+ and ρ^0 Mesons

- Generalized Parton Distributions in Leading Twist
- The HERMES Spectrometer
- Exclusive π^+ and ρ^0 Identification
- Results for the Target Spin Asymmetries

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Generalized Parton Distributions (GPDs)

Four GPDs in leading twist:

$\underbrace{H \quad E}$ $\qquad\qquad$ $\underbrace{\tilde{H} \quad \tilde{E}}$

unpolarized GPDs $\qquad\qquad$ polarized GPDs

can be probed by

$\rho^0 \longleftarrow$ exclusive vector meson production $\qquad\qquad$ exclusive pseudoscalar meson production $\longrightarrow \pi^+$

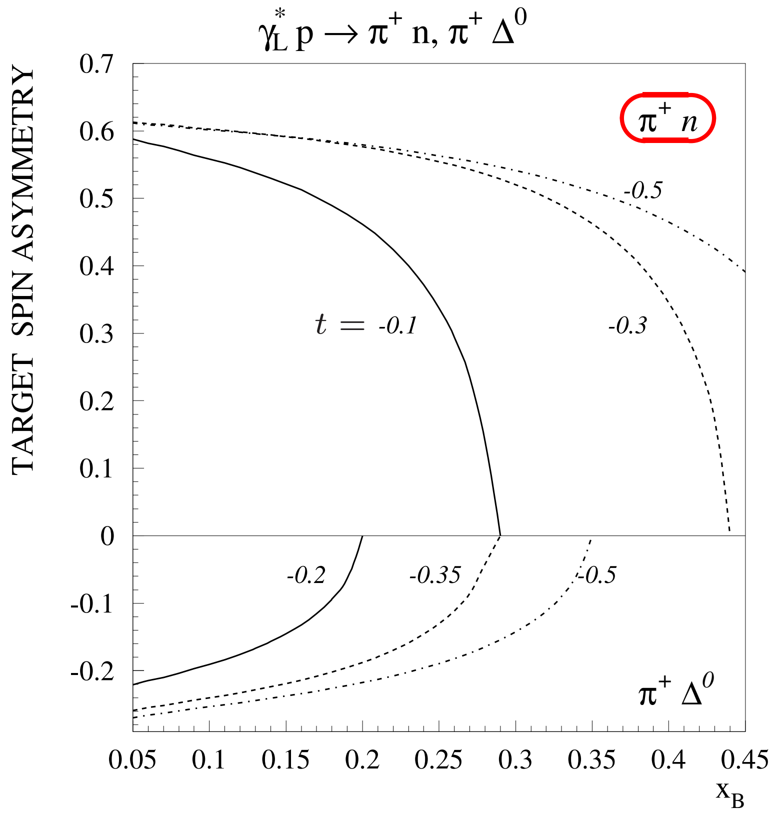
factorization theorem for longitudinally polarized photons [Phys. Ref. D **56** (1997) 2982]

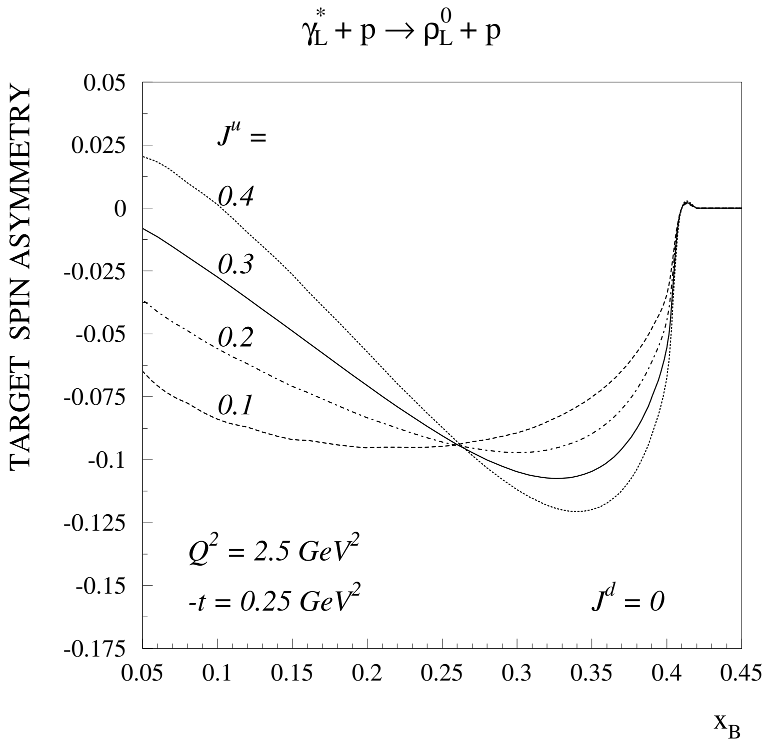
➜ structure of nucleon is reflected by GPDs
independently of the reaction which probes the nucleon

<u>relevant observables:</u> cross section and transverse target-spin azimuthal asymmetry

Predictions

Goeke, Polyakov, Vanderhaeghen [Prog. Part. Nucl. Phys. **47** (2001) 401]
using phenomenological parametrizations of GPDs

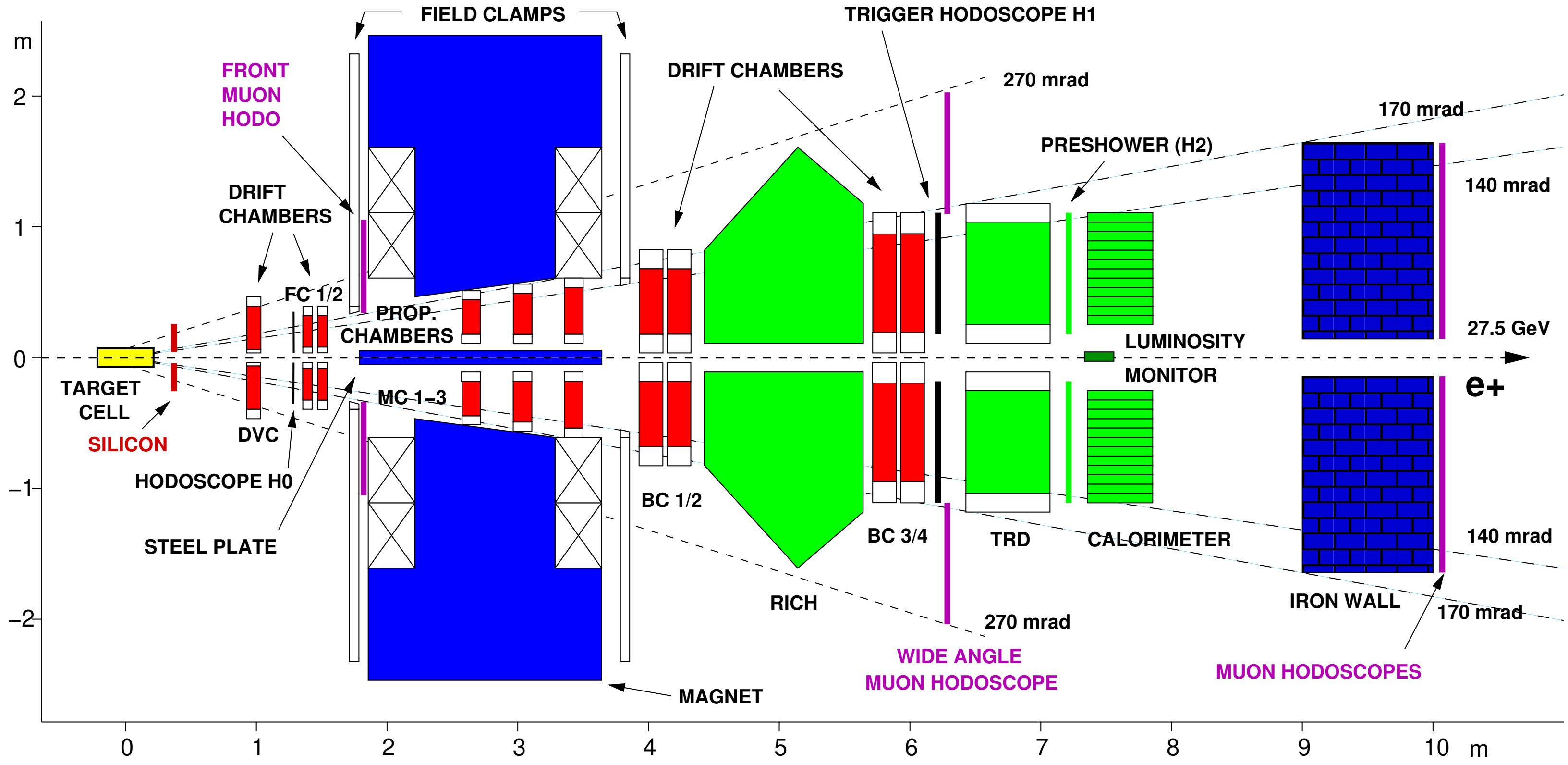




compatible predictions with χQSM
from Frankfurt,Pobylitsa,Polyakov,Strikman
[Phys. Rev. D **60** (1999), 014010]

J^u, J^d: total angular momentum contribution of the u, d–quarks to the proton spin

The HERMES Spectrometer



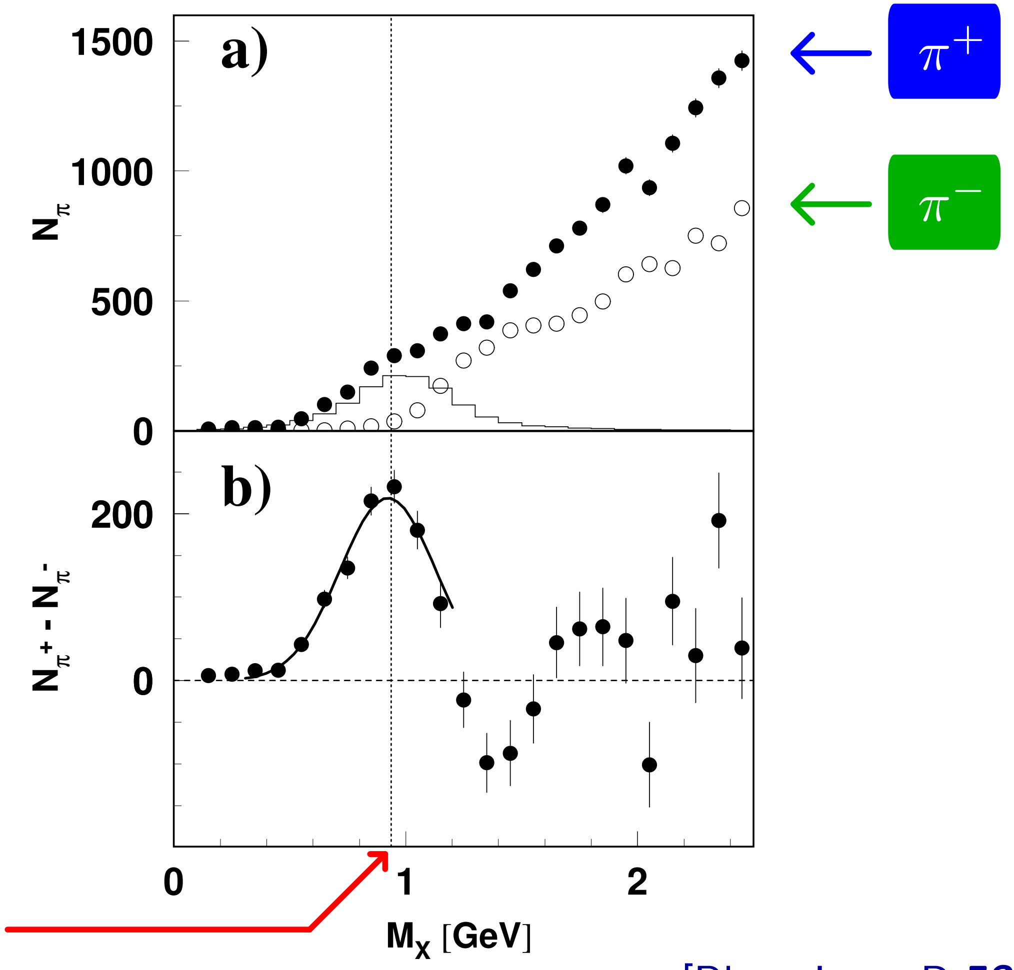
- Threshold Čerenkov Detector replaced by RICH in 1998
- Tracking Detectors ➜ momentum resolution: < 2.2 % with Čerenkov
  < 2.6 % with RICH
- Particle Identification ➜ lepton identification 99 %

π identification: > 90 % for $p > 5$ GeV with Čerenkov
98 % for $p > 1$ GeV with RICH

Exclusive π^+ Identification

$$e^+ + p \rightarrow e^+ + \pi^+ + X$$

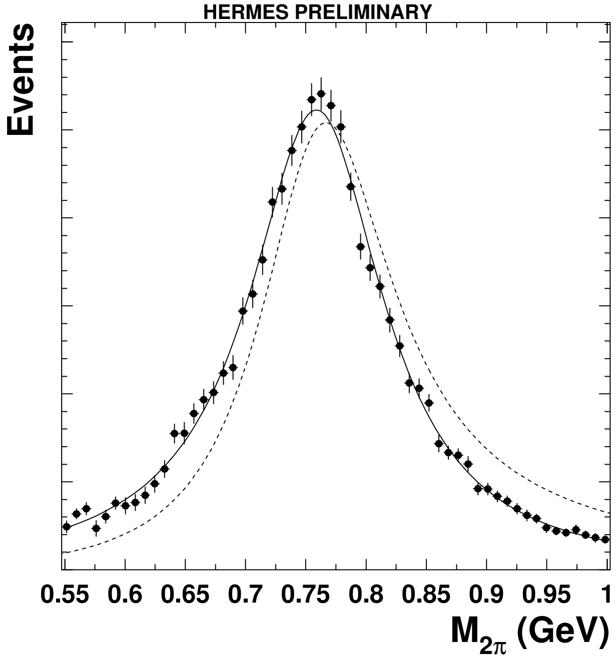
Missing mass distribution:



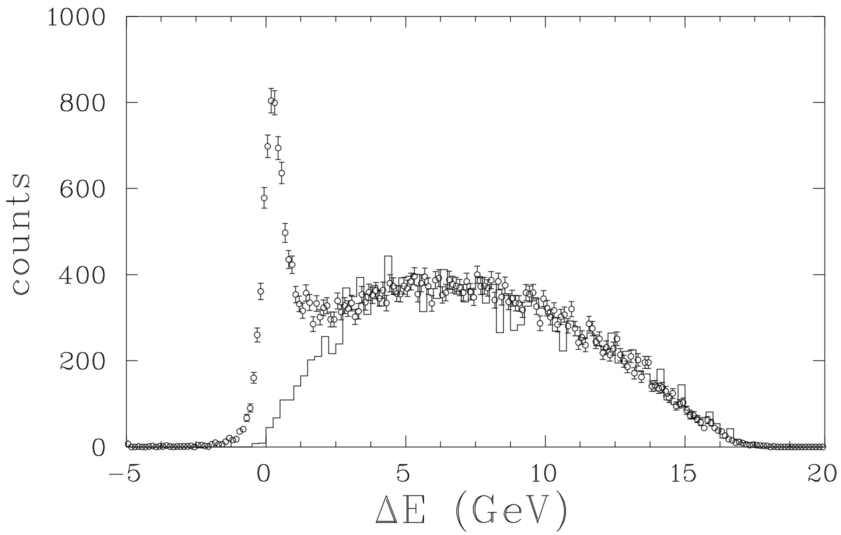
[Phys. Lett. B **535** (2002), 85]

Exclusive ρ^0 Identification

One lepton and two pions are identified with:



$0.6 < M_{2\pi} < 1.0$ GeV
$M_{2K} > 1.06$ GeV



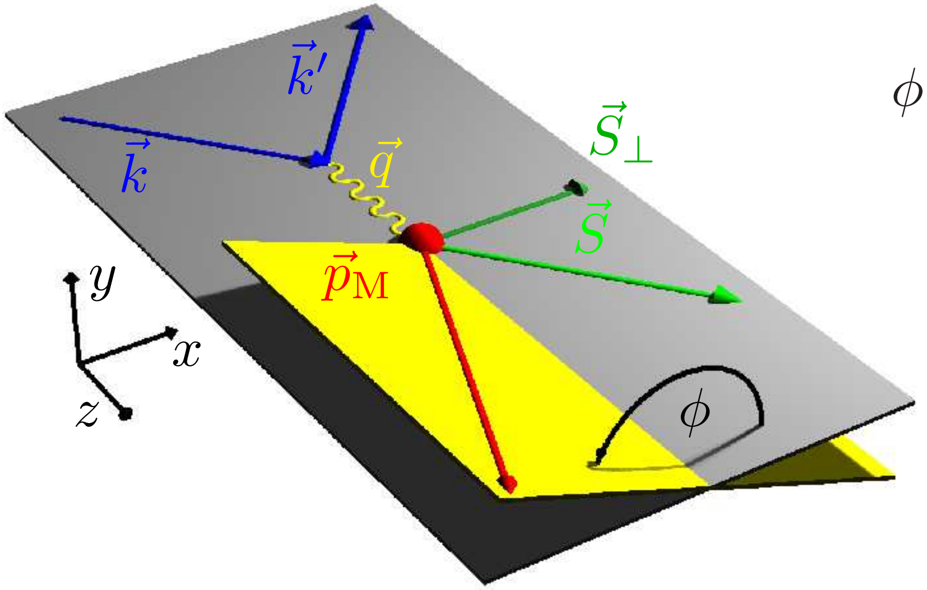
$\Delta E < 0.6$ GeV
$-t' < 0.4$ GeV^2

subtraction of non–resonant background and fit with skewed Breit–Wigner

Monte Carlo simulation of non–exclusive (DIS) background

The Azimuthal Angle ϕ

Longitudinally polarized target:



ϕ: angle between the scattering and the reaction plane

$$\cos\phi = \frac{(\vec{q}\times\vec{k})(\vec{q}\times\vec{p}_{\mathrm{M}})}{|\vec{q}\times\vec{k}||\vec{q}\times\vec{p}_{\mathrm{M}}|}$$

➜ longitudinally polarized target contains on the order of 10 % transverse polarization

$$S_\perp = |S|\sin\theta_\gamma$$

Longitudinal Target Spin Asymmetry

polarized cross section:

$$\sigma_S \sim [S_\perp \sigma_\mathcal{L} + S_\parallel \sigma_{\mathcal{LT}}]\, A_{\mathrm{UL}}^{\sin\phi} \, \sin\phi$$

unpolarized beam — longitudinally polarized target

azimuthal asymmetry:

$$\begin{aligned} A_{UL}(\phi) &= \frac{1}{\langle S\rangle}\frac{\sigma^+(\phi)-\sigma^-(\phi)}{\sigma^+(\phi)+\sigma^-(\phi)} \\ &= \frac{1}{\langle S\rangle}\frac{N^+(\phi)-N^-(\phi)}{N^+(\phi)+N^-(\phi)} \overset{\text{fit}}{=} A_{\mathrm{UL}}^{\sin\phi}\cdot\sin\phi \end{aligned}$$

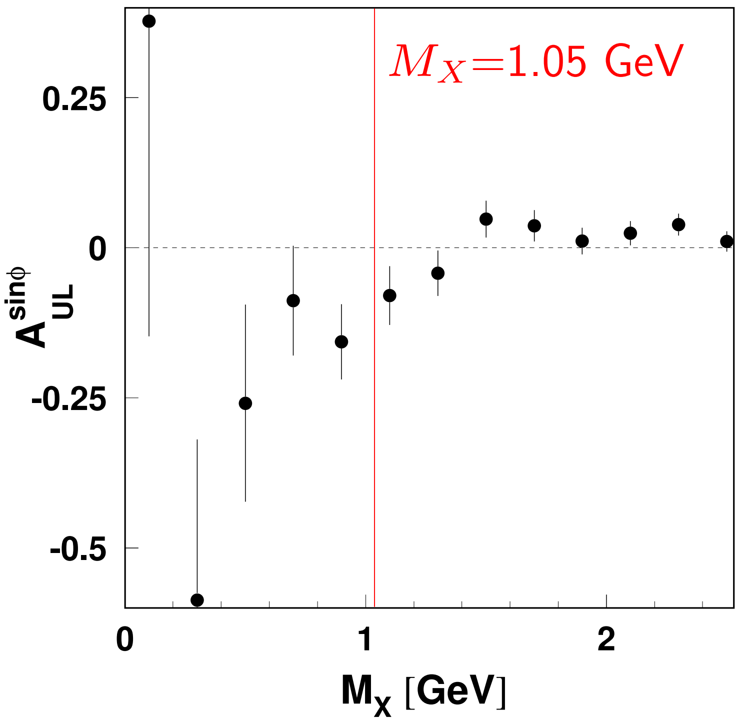
➜ $\sin\phi$ moment $\mathbf{A}_{\mathrm{UL}}^{\sin\phi}$

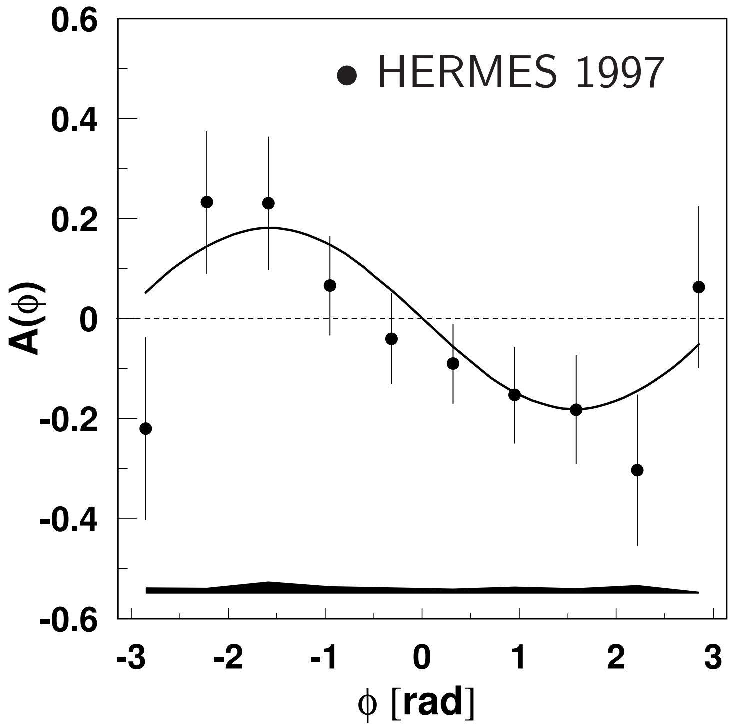
$+$: target spin anti-parallel to the beam momentum

π^+ Target Spin Asymmetry

$$\mathbf{e^+ + p \rightarrow e^+ + n + \pi^+}$$

without background subtraction:



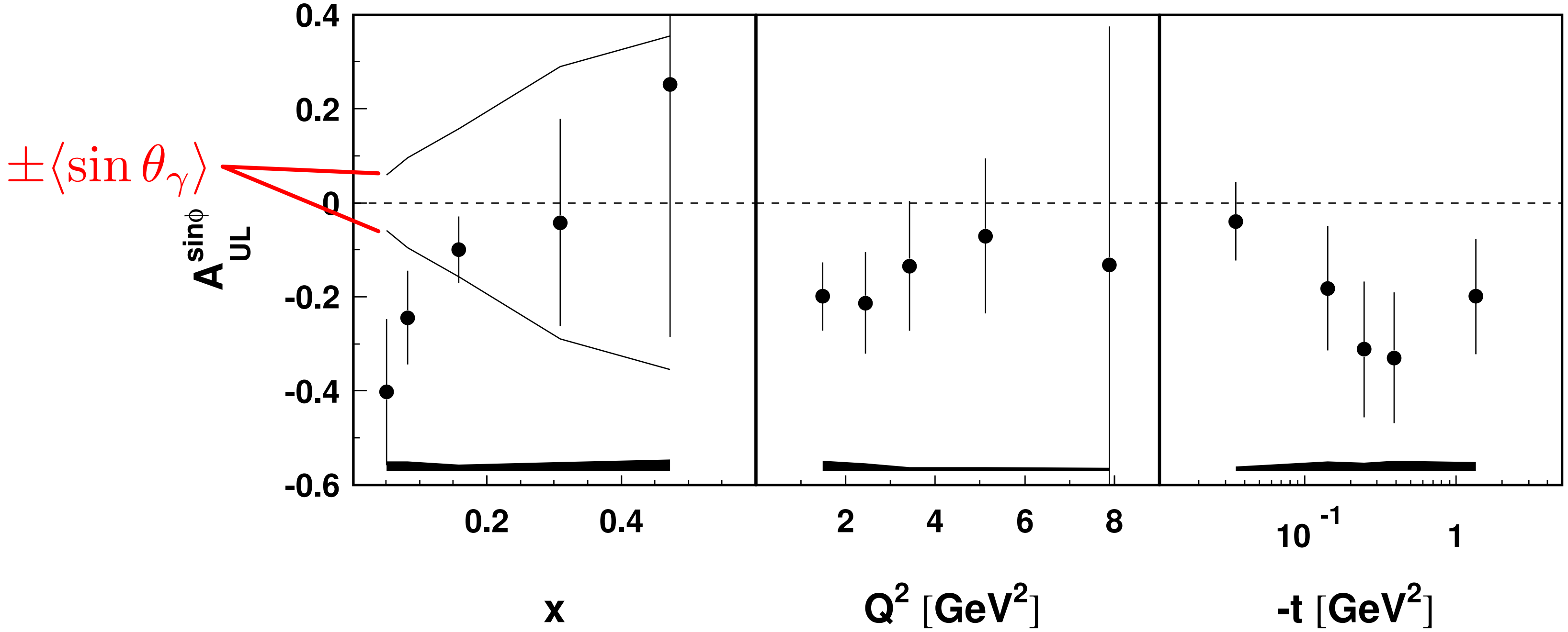


$\langle x \rangle$ = 0.15, $\langle Q^2 \rangle$ = 2.2 GeV^2

$\langle t \rangle$ = -0.46 GeV^2

$$\mathbf{A_{UL}^{\sin\phi} = -0.18 \pm 0.05 \pm 0.02}$$

Dependence on the Kinematic Variables x, Q^2, t



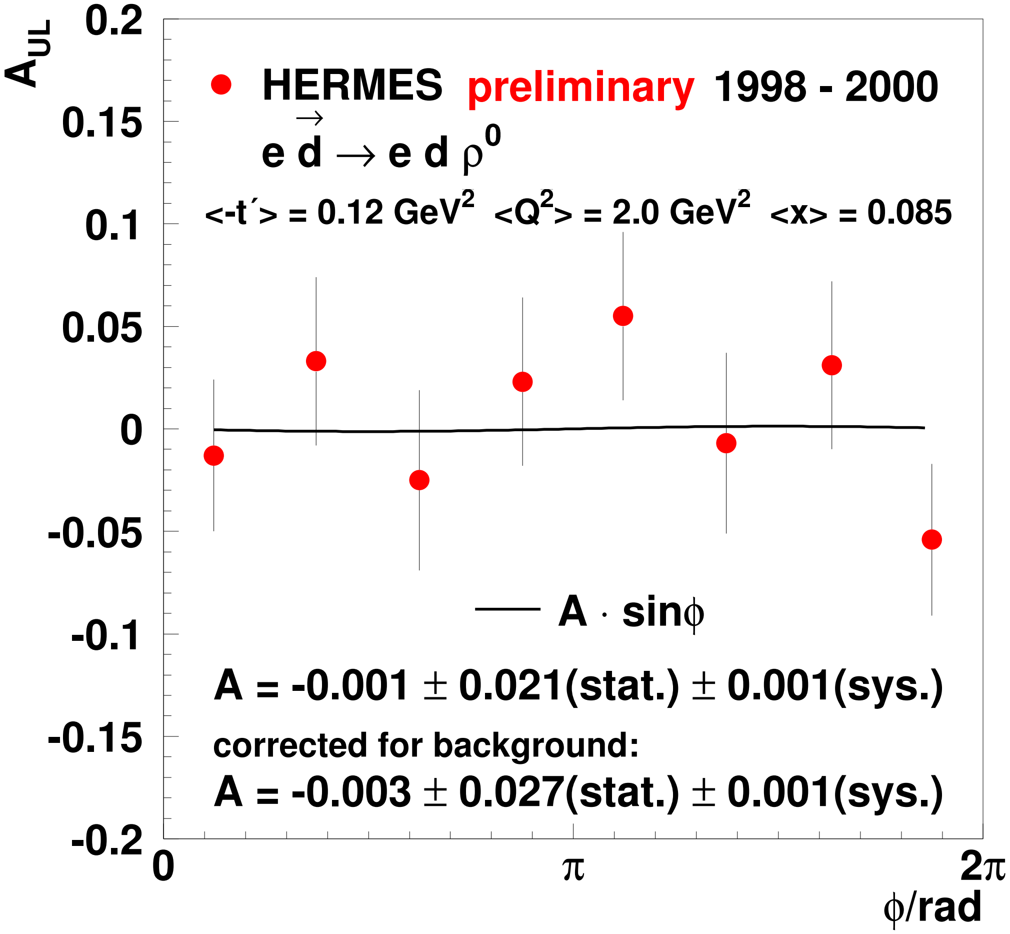
Assuming no contribution from $S_\parallel$:

$$A_{UL}^{\sin\phi} = \langle\sin\theta_\gamma\rangle \cdot A_{UT}^{\sin\phi} \qquad \text{because} \qquad \frac{1}{|S|} = \frac{\sin\theta_\gamma}{S_\perp}$$

➜ $S_\parallel$ must contribute for low x bins

ρ^0 Target Spin Asymmetry

$$e^+ + d \rightarrow e^+ + d + \rho^0$$



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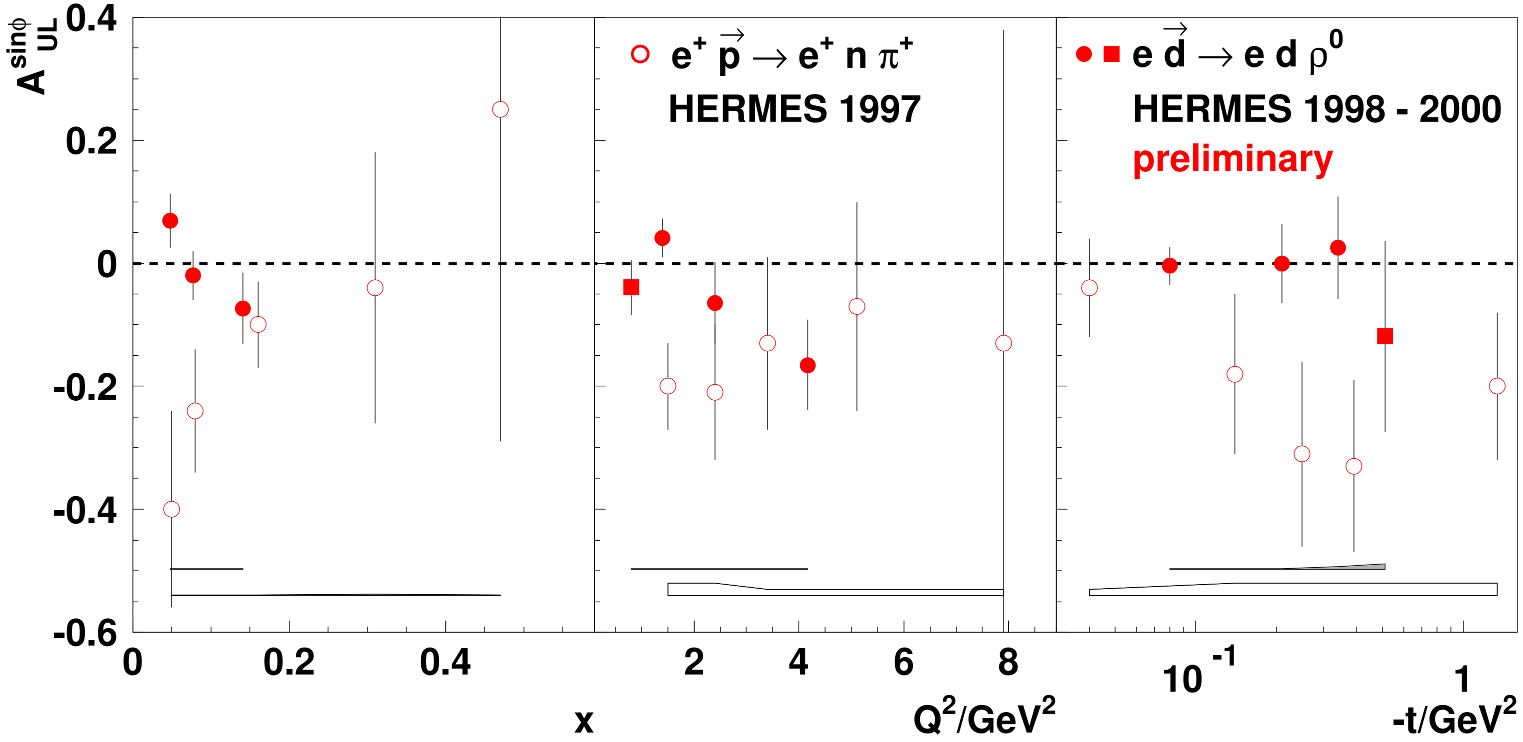
Comparison of Target Spin Asymmetries



- higher statistic for Deuterium data
- smaller asymmetry for ρ^0 mesons

Summary

- GPDs in leading twist can be probed by hard exclusive meson production.
- For π^+ mesons a large $A_{\mathrm{UT}}^{\sin\phi}$ is predicted.
- A longitudinally polarized target contains a small transverse component.
- Results for longitudinal target spin asymmetries of π^+ and ρ^0 mesons were presented.
- The asymmetry of ρ^0 mesons is compatible with zero with an uncertainty of 3 %.
- At low x the target spin asymmetry of π^+ mesons must arise from the longitudinal target polarization component.
- Results of data collected with a transverse target will come.