Transverse Target Spin Asymmetry in Exclusive Vector Meson Production at HERMES

S. Gliske

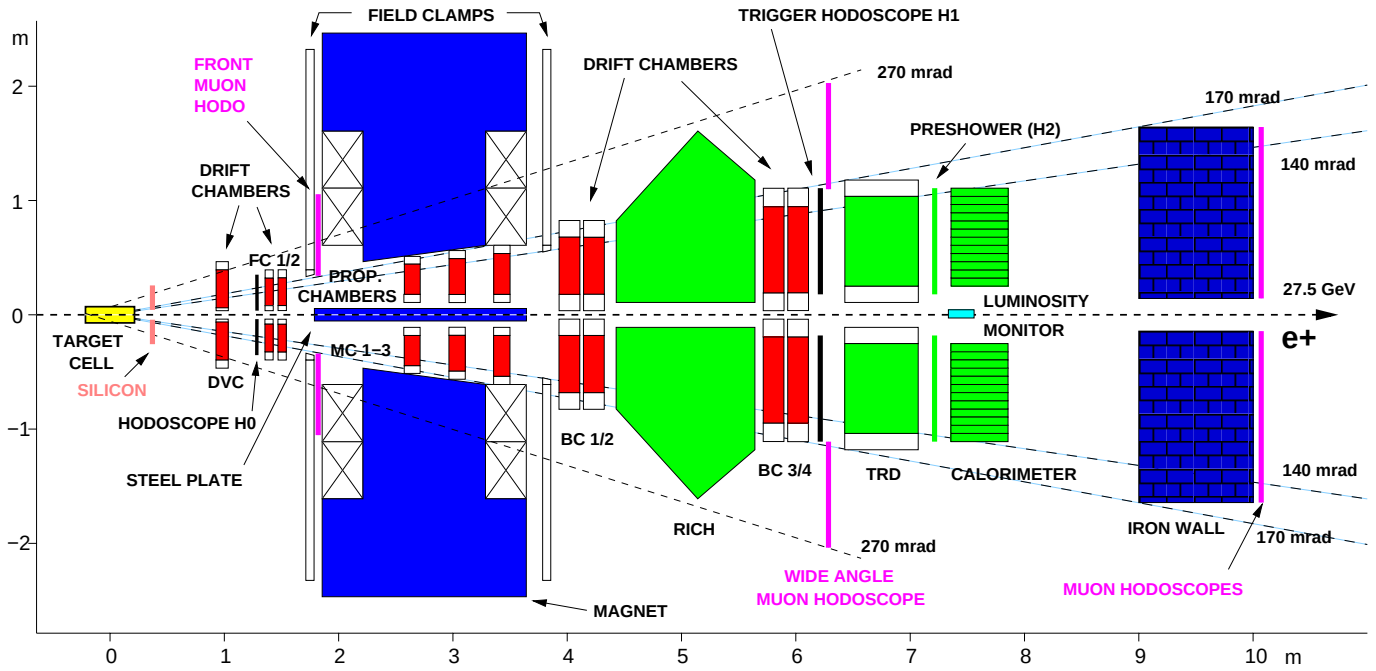
University of Michigan
for HERMES Collaberation

APS April Meeting Session H16, April 15, 2007

Outline

Outline

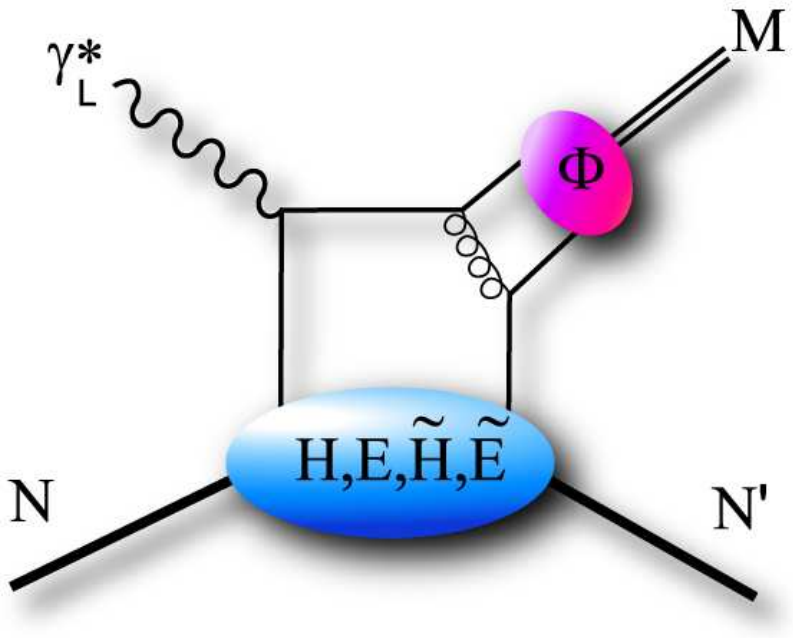
HERMES EXPERIMENT



- 27.6 GeV $e^{\pm}$ (polarized) beam on fixed polarized target
- Exclusive diffractive ρ^0 production: $\gamma^* p \rightarrow \rho^0 p$

Outline

Generalized Parton Distribution Functions

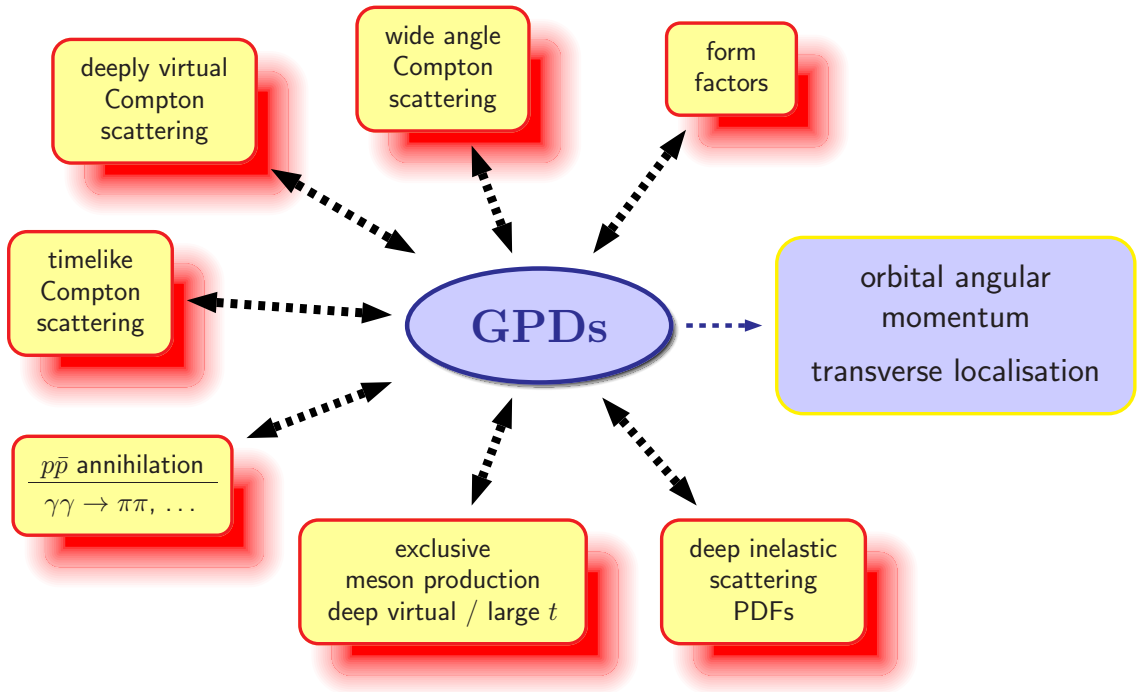


-Collins, Frankfurt, Strikman (1997)-

$x \pm \xi$	longitudinal momentum fraction of the quark
-2ξ	exchanged longitudinal momentum fraction
t	squared momentum transfer

- Factorization Theorem proven for longitudinal photons only
- Soft hadronization process given by Φ
- Soft quark-gluon correlations given by GPDs H, E, $\tilde{H}$, $\tilde{E}$
- Similar diagram for DVSC

Access to GPDs



Vector mesons (ρ, ω, ϕ) sensitive to GPDs: H E

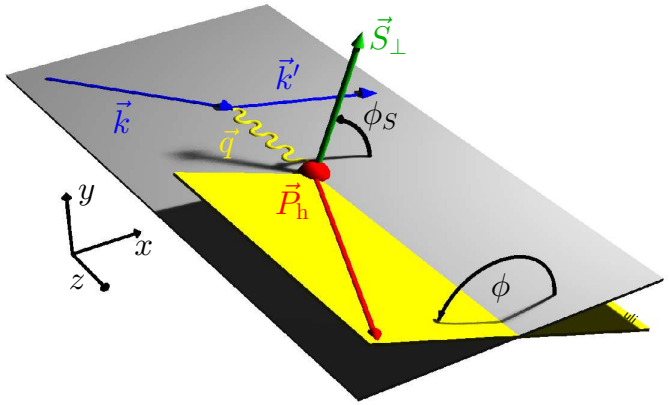
GPDs and Nucleon Spin

- Ji relation:

$$J_q = \frac{1}{2} \lim_{t \to 0} \int_{-1}^{1} x \left(H_q(x, \xi, t) + E_q(x, \xi, t) \right) dx = \frac{1}{2} \Delta\Sigma + L_q$$

- Contributions of quark spin to the nucleon spin measured through polarized DIS
- Measuring J_q determines contribution of orbital angular moment
- To leading twist, transverse target spin asymmetry (A_{UT}) linear in E

Production Kinematics



- Angles define according to Trento convention
- ϕ is angle between lepton and hadron planes
- $\vec{S}_\perp$ is spin vector transverse to photon momentum
- ϕ_S is angle between lepton plane and $\vec{S}_\perp$

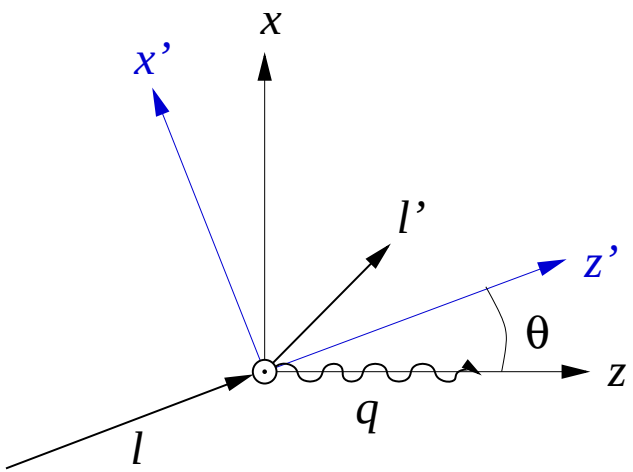
Transverse Target Spin Asymmetry

- Transverse target polarization relative to virtual photon direction:

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

- Transverse target polarization relative to lepton beam direction (measured):

$$A_{UT}^{l}(\phi,\phi_s) = \frac{1}{P_T}\frac{d\sigma(\phi,\phi_s) - d\sigma(\phi,\phi_s+\pi)}{d\sigma(\phi,\phi_s) + d\sigma(\phi,\phi_s+\pi)}$$



$$P_T A_{UT}^{l}(\phi_s) = S_T(\theta_\gamma,\phi_s)A_{UT}^{\gamma^*}(\phi_s) + S_L(\theta_\gamma,\phi_s)A_{UL}^{\gamma^*}$$

$$\left|\frac{S_L}{S_T}\right| < 0.15$$

Outline

Angular Distribution

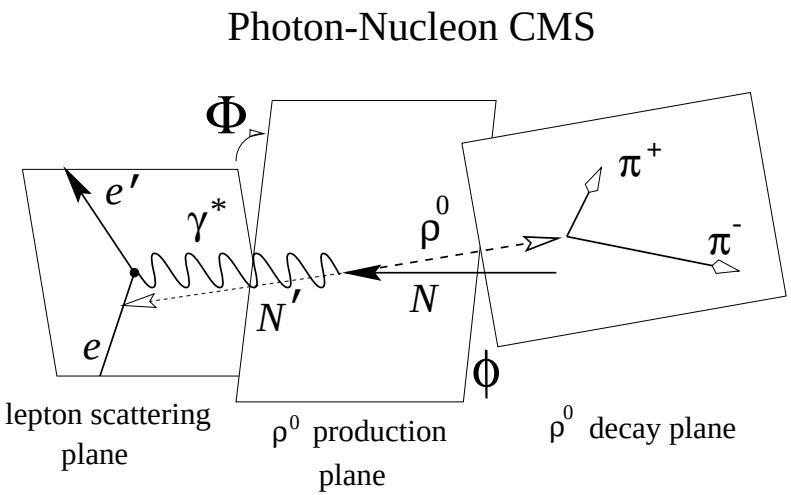
- Angular (ϕ, ϕ_s) distribution can be written in terms of asymmetries,

$$W(P_T, \phi, \phi_s) \propto 1 + A_{UU}(\phi) + P_T A^{l}_{UT}(\phi, \phi_s),$$

- where $A_{UU}(\phi)$ and $A^{l}_{UT}(\phi, \phi_s)$ are parameterized as

$$\begin{aligned}
A_{UU}(\phi) &= A_{UU}^{\cos(\phi)} \cos(\phi) + A_{UU}^{\cos(2\phi)} \cos(2\phi) \\
A^{l}_{UT}(\phi, \phi_s) &= A_{UT}^{\sin(\phi_s)} \sin(\phi_s) + A_{UT}^{\sin(\phi-\phi_s)} \sin(\phi - \phi_s) \\
&\quad + A_{UT}^{\sin(\phi+\phi_s)} \sin(\phi + \phi_s) + A_{UT}^{\sin(2\phi-\phi_s)} \sin(2\phi - \phi_s) \\
&\quad + A_{UT}^{\sin(2\phi+\phi_s)} \sin(2\phi + \phi_s) \\
&\quad + A_{UT}^{\sin(3\phi-\phi_s)} \sin(3\phi - \phi_s).
\end{aligned}$$

ρ^0_L, ρ^0_T Separation



- Each ρ^0 polarization state has a characteristic decay angular distribution
- Can use ρ^0 CM angle $\Theta_{\pi\pi}$ of π-meson to separate ρ^0_L, ρ^0_T

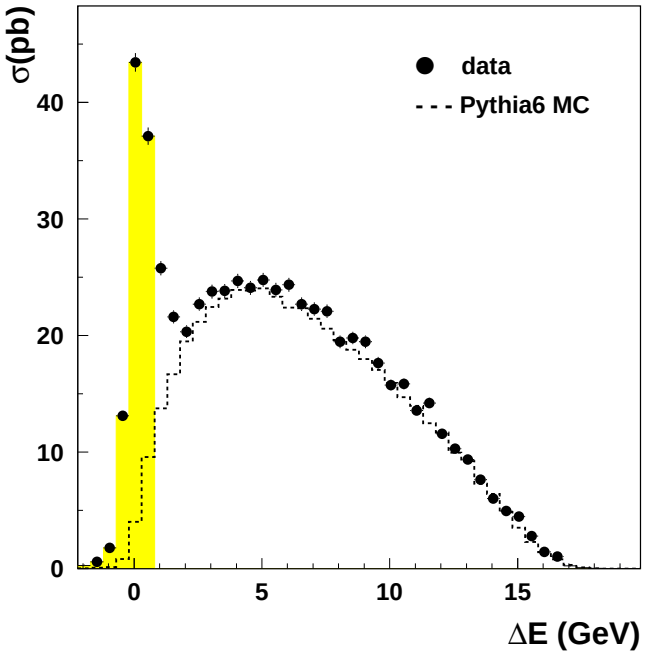
$$W(P_T, \cos\theta_{\pi\pi}, \phi, \phi_s) \propto$$
$$\Big[\cos^2\theta_{\pi\pi}\ r^{04}_{00} \Big(1 + P_T A^I_{UT,\rho_L}(\phi,\phi_s) + A_{UU,\rho_L}(\phi)\Big) +$$
$$\frac{1}{2}\sin^2\theta_{\pi\pi}\ (1 - r^{04}_{00})\Big(1 + P_T A^I_{UT,\rho_T}(\phi,\phi_s) + A_{UU,\rho_T}(\phi)\Big) \Big]$$

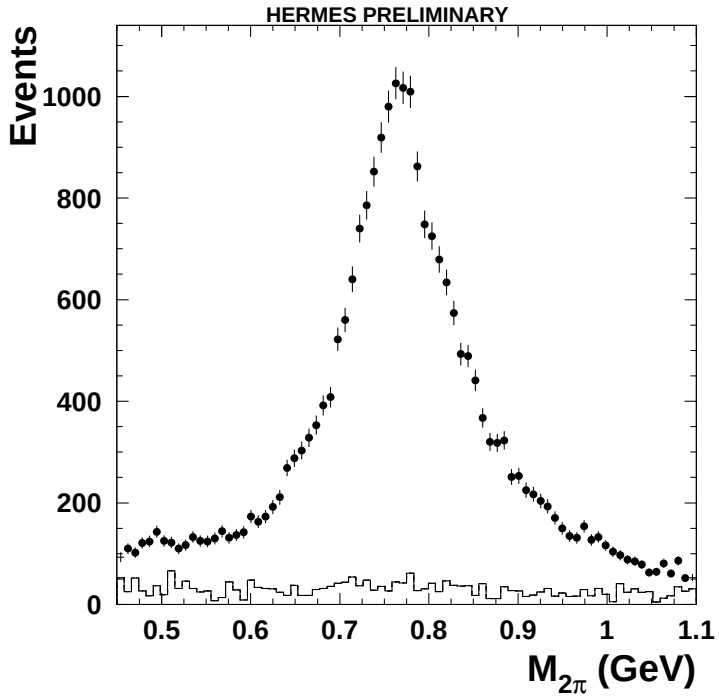
Data Processing

- Kinematic cuts:
  $W^2 > 4GeV^2,\ Q^2 > 1GeV^2,\ y < 0.85$
- Exclusive cuts:
  $0.6 < M_{2\pi} < 1.0GeV,\ \Delta E < 0.6GeV,\ -t' < 0.4GeV^2$
- Take into account target and beam polarizations
- Monte Carlo studies
  - Determine background contamination
  - Acceptance effects
  - Cross Contamination between asymmetry moments
  - Check L-T separation
  - Kinematic dependencies of Acceptance/Asymmetry

Exclusive Production

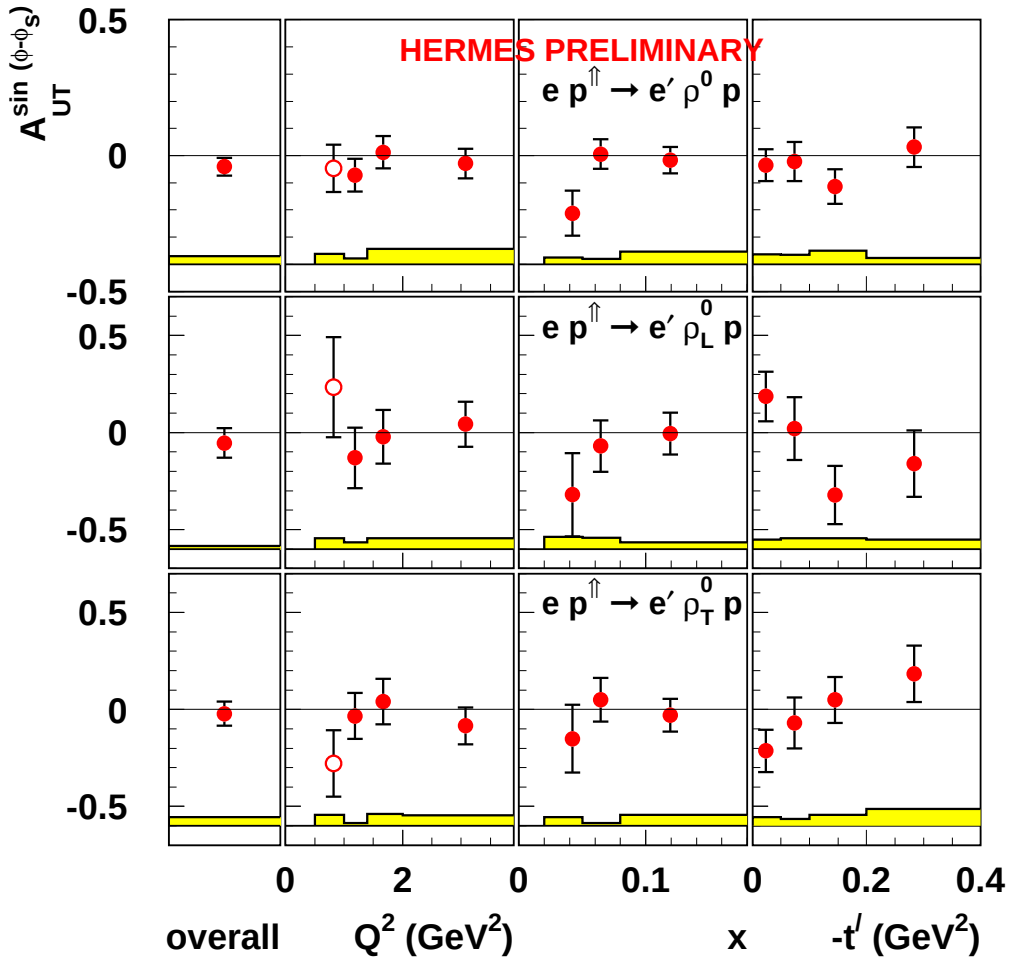
- $ep \rightarrow e'p\rho^0$, $\rho^0 \rightarrow \pi^+\pi^-$
- Exclusive ρ^0 through Energy and Momentum transfer
- $\Delta E = \frac{M_x^2 - M_p^2}{2M_p}$, $t' = t - t_0$



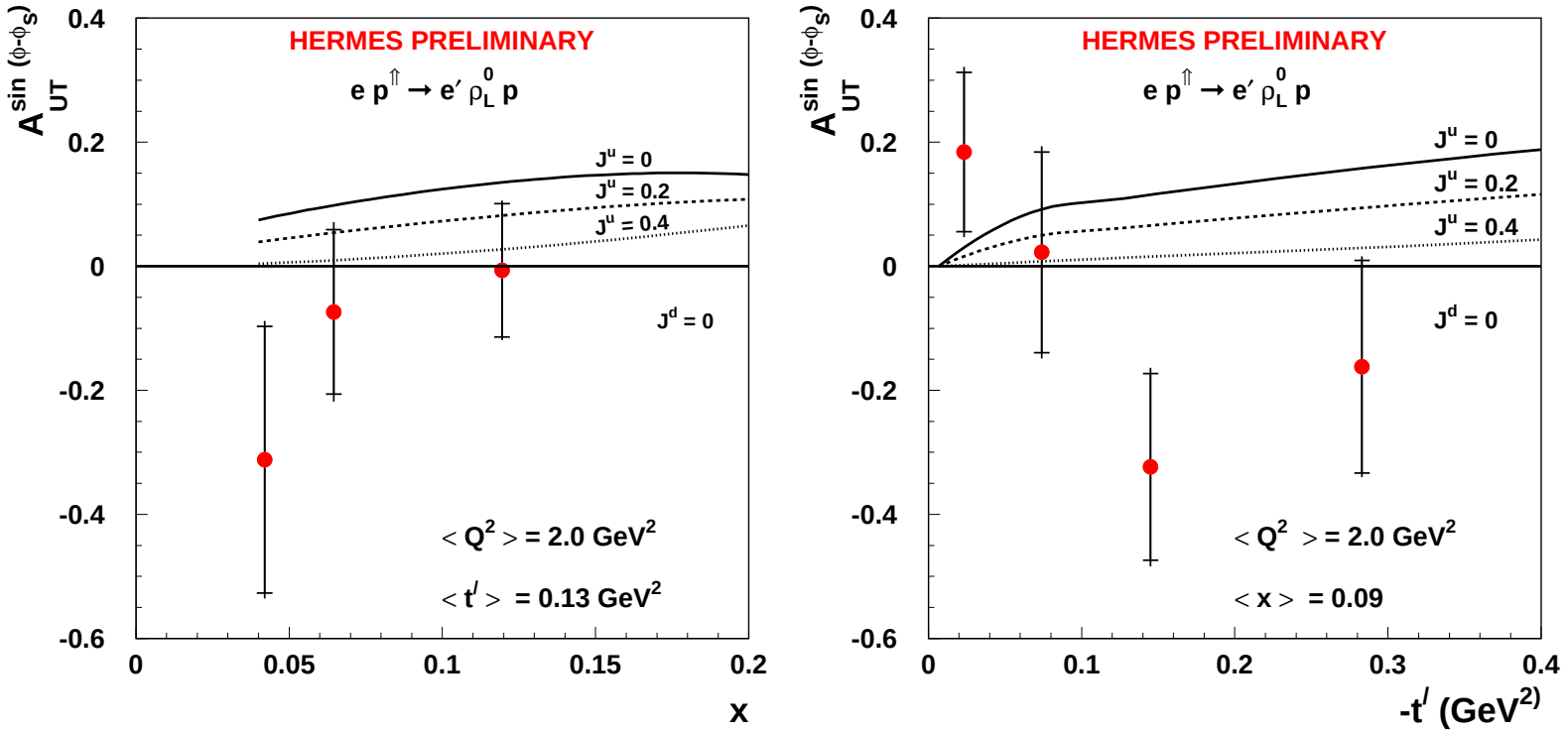


Outline

Results


HERMES PRELIMINARY
$A_{UT}^{\sin(\phi-\phi_S)}$
$e\,p^{\Uparrow} \to e'\,\rho^0\,p$
$e\,p^{\Uparrow} \to e'\,\rho_L^0\,p$
$e\,p^{\Uparrow} \to e'\,\rho_T^0\,p$
0.5
0
-0.5
0
2
0.1
0.2
0.4
overall
Q^2 (GeV^2)
x
$-t'$ (GeV^2)

Comparison with GPD prediction



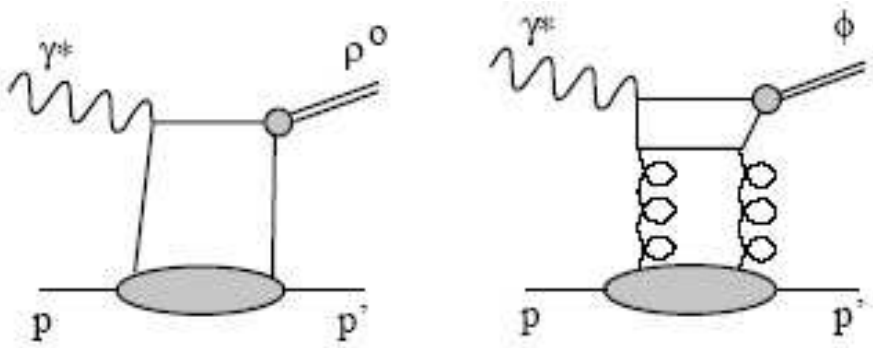
- F. Ellinghaus, W.D. Novak, A.V. Vinnikov, Z.Ye, hep-ph/0506264
- Data and theory agree within statistical errors
- More effort needed to make statement concerning J^u

Outline

Summary and Outlook

- $A_{UT}^{\sin(\phi-\phi_s)}$ extracted separately for ρ_L^0 and ρ_T^0 by using a fit on the $\phi, \phi_s, \cos\theta_{\pi\pi}$ distributions
- Interpretation of results in terms of J_q forthcoming
- Also ϕ-meson A_{UT} results forthcoming

ϕ-meson



- Significantly different production process
- Should directly access gluon portion of GPDs
- Ongoing discussion with theorists about relating ϕ A_{UT} with GPDs
- HERMES ϕ $A_{UT}^{\sin(\phi+\phi_s)}$ and $A_{UT}^{\sin(\phi-\phi_s)}$ results available soon