$\rho^0$ Transverse Target Spin Asymmetry at HERMES

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Outline

1. Physics behind our measurement, why $\rho^0$
   - Generalized Parton Distribution Functions and Ji sum rule
   - Why $\rho^0$, production mechanism and sensitivity

2. HERMES Experiment
   - Transverse Target Spin Asymmetry

3. Analysis
   - Data Processing
   - Exclusive Production
   - $\rho_L^0$, $\rho_T^0$ Separation

4. Results
   - Comparison with GPD prediction
   - Summary and Outlook
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Physics behind our measurement, why $\rho^0$

**HERMES Experiment**

**Analysis**

**Results**

**Generalized Parton Distribution Functions and Ji sum rule**

- Vector mesons ($..\rho, \phi..$): unpolarized GPDs: $H E$(AUT sensitive)
- Ji sum rule: (Ji,PRL 78(1997) 610)

$$\frac{1}{2} \int_{-1}^{1} dx \ x \ [H(x, \zeta, t) + E(x, \zeta, t)] \ t \rightarrow 0 \ J_q$$

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$\rho^0$ TTSA at HERMES
Physics behind our measurement, why $\rho^0$

**HERMES Experiment**

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Why $\rho^0$, production mechanism and sensitivity

Sensitive to quark and gluon exchange

$$\gamma^*(q) + p \rightarrow \rho^0_L + p$$

$$Q^2 = 2.5 \text{ GeV}^2$$

$$-t = 0.25 \text{ GeV}^2$$

$$J^d = 0$$

$\text{HERMES}$

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$\rho^0$ TTSA at HERMES

-Goeke, Polyakov, Vanderhaeghen (2001)-
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THE POLARISED TARGET

- Pure Gaseous Polarised Target, with high Polarisation $\approx 75$
- Flip of helicity every 90 sec in 0.5 sec, very small systematics
Physics behind our measurement, why $\rho^0$

Transverse Target Spin Asymmetry

Production Kinematics, angles

- Angles define according to Trento convention
  \[ A_{UT} = -\frac{\pi}{2} A_{GPV} \]
- $\phi$ is angle between lepton and hadron planes
- $\vec{S}_\perp$ is spin vector transverse to photon momentum
- $\phi_s$ is angle between lepton plane and $\vec{S}_\perp$
Physics behind our measurement, why $\rho^0$

**HERMES Experiment**

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Transverse Target Spin Asymmetry

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

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

Transverse target polarization relative to virtual photon direction:

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

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

$$\left| \frac{S_L}{S_T} \right| < 0.15$$
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Kinematic cuts:
\[ W^2 > 4 \text{GeV}^2, \quad Q^2 > 1 \text{GeV}^2, \quad y < 0.85 \]

Exclusive cuts:
\[ 0.6 < M_{2\pi} < 1.0 \text{GeV}, \quad \Delta E < 0.6 \text{GeV}, \quad -t' < 0.4 \text{GeV}^2 \]

Take into account beam polarization related terms in fit procedure

Monte Carlo studies
- Determine background contamination
- Acceptance effects
- Cross Contamination between asymmetry moments
- Check L-T separation
- Kinematic dependencies of Acceptance/Asymmetry
Physics behind our measurement, why $\rho^0$

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

![Graph showing $\Delta E$ vs Yield and $M_{2\pi}$ vs Events](image_url)
Physics behind our measurement, why $\rho^0$

HERMES Experiment

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$\rho_L^0, \rho_T^0$ Separation

Each $\rho^0$ polarization state has a characteristic decay angular distribution

Can use $\rho^0$ CM angle $\Theta_{\pi\pi}$ of $\pi$-meson to separate $\rho_L^0, \rho_T^0$

\[
W(P_T, \cos \theta_{\pi\pi}, \phi, \phi_s) \propto \cos^2 \theta_{\pi\pi} r_{00}^{04} \left( 1 + P_T A_{UT, \rho_L}^l(\phi, \phi_s) + A_{UU, \rho_L}(\phi) \right) + \frac{1}{2} \sin^2 \theta_{\pi\pi} (1 - r_{00}^{04}) \left( 1 + P_T A_{UT, \rho_T}^l(\phi, \phi_s) + A_{UU, \rho_T}(\phi) \right)
\]

(Diehl, Sapeta: hep-ph/0503023)
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Physics behind our measurement, why $\rho^0$...
Data hints positive $J^U$

In agreement with HERMES DVCS result
Summary and Outlook

- First extraction of $A_{UT}^{\sin(\phi - \phi_s)}$
- In SCHC separately for $\rho_0^L$ and $\rho_0^T$ by using a fit on the $\phi, \phi_s, \cos \theta_{\pi\pi}$ distributions
- $\phi$-meson $A_{UT}$ results coming soon