Transverse single-spin asymmetry of exclusive ρ^0 from HERMES

QCDN06, Rome, Italy

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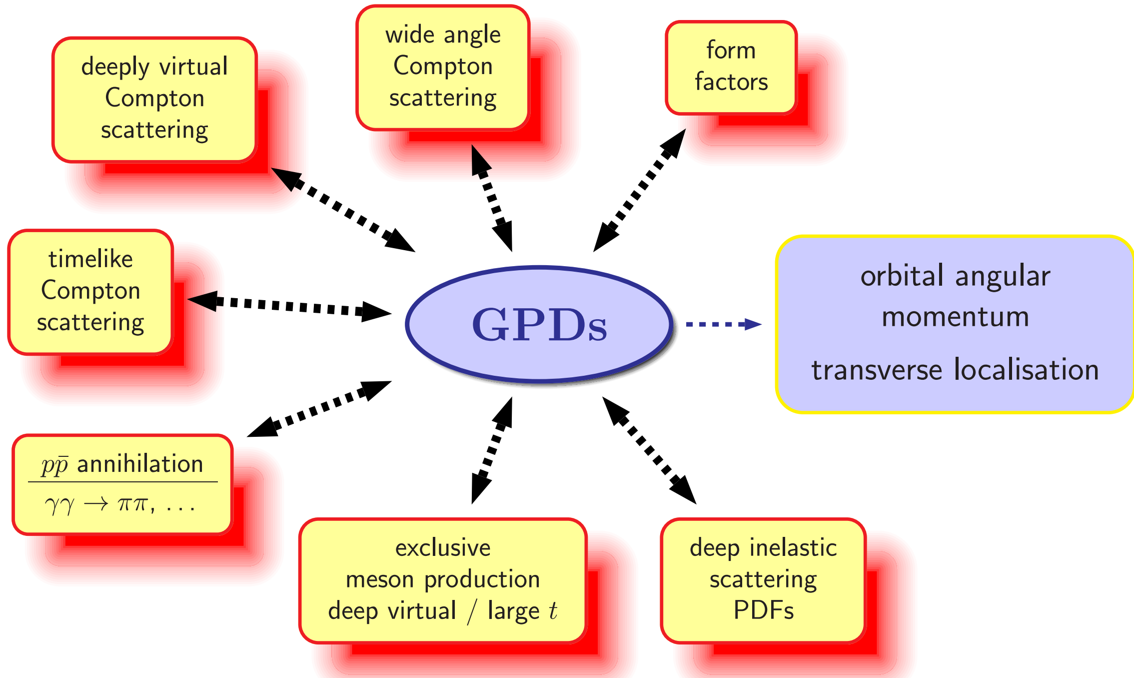
(on behalf of the HERMES collaboration)

(DESY)

Access to GPDs

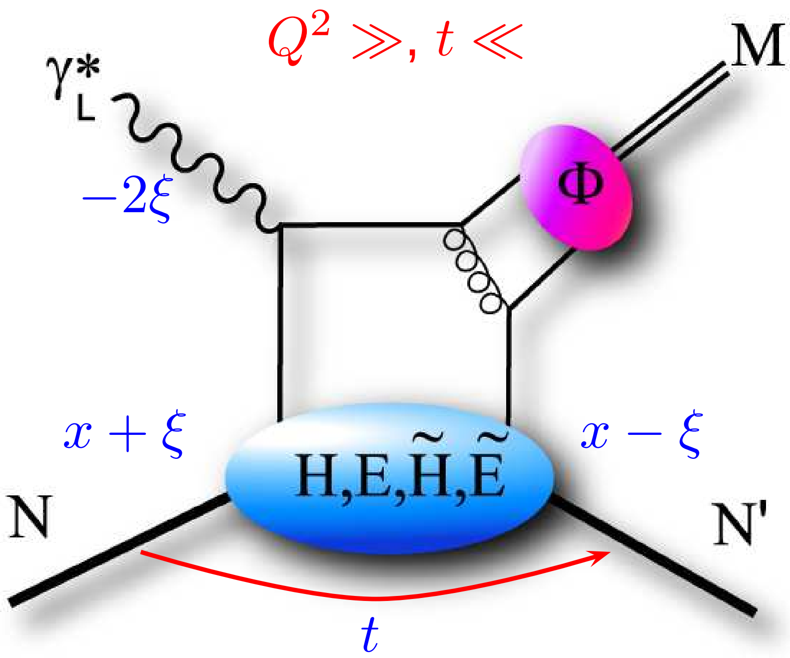


$\Downarrow$

- vector mesons (ρ, ω, ϕ): unpolarized GPDs: H E
- Ji sum rule:

$$\frac{1}{2}\int_{-1}^{1} dx\, x\, [H(x,\zeta,t) + E(x,\zeta,t)] \stackrel{t\to 0}{=} \frac{1}{2}\Delta\Sigma + \Delta L_q$$

Factorization theorem



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

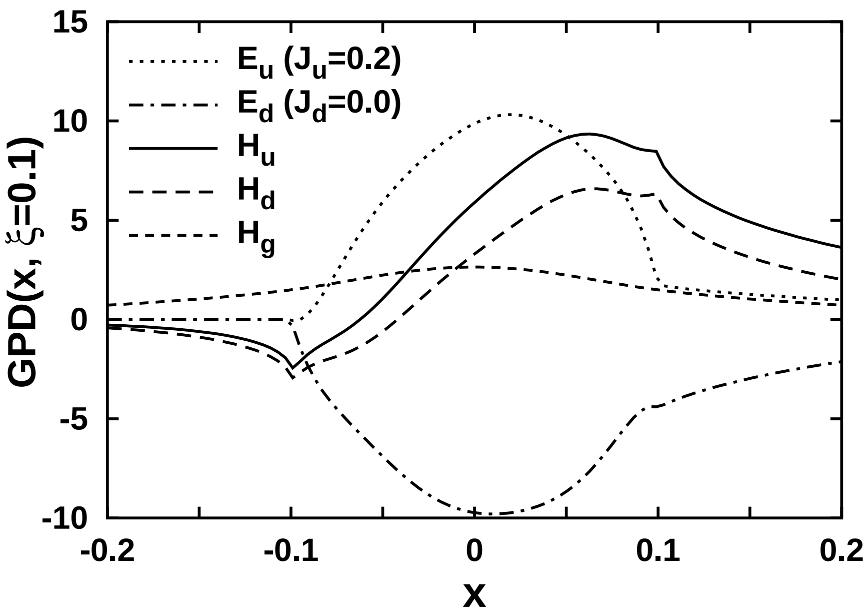
- Factorization for longitudinal photons only
- Suppression of transverse component of the X-section:

$$\frac{\sigma_T}{\sigma_L} \sim \frac{1}{Q^2}$$

Advantage of exclusive ρ^0 production

- gluons and quarks enter at the same order of α_s
- gluon GPDs can be probed (for $x_B < 0.2$)

-Ellinghaus,Nowak,Vinnikov,Ye (2005)-



-VGG code-

no model for E_g

- expectation: E_g is not large

$$\int_0^1 dx\ E_g + \sum_q \int_1^1 dx\ xE_q = 0$$

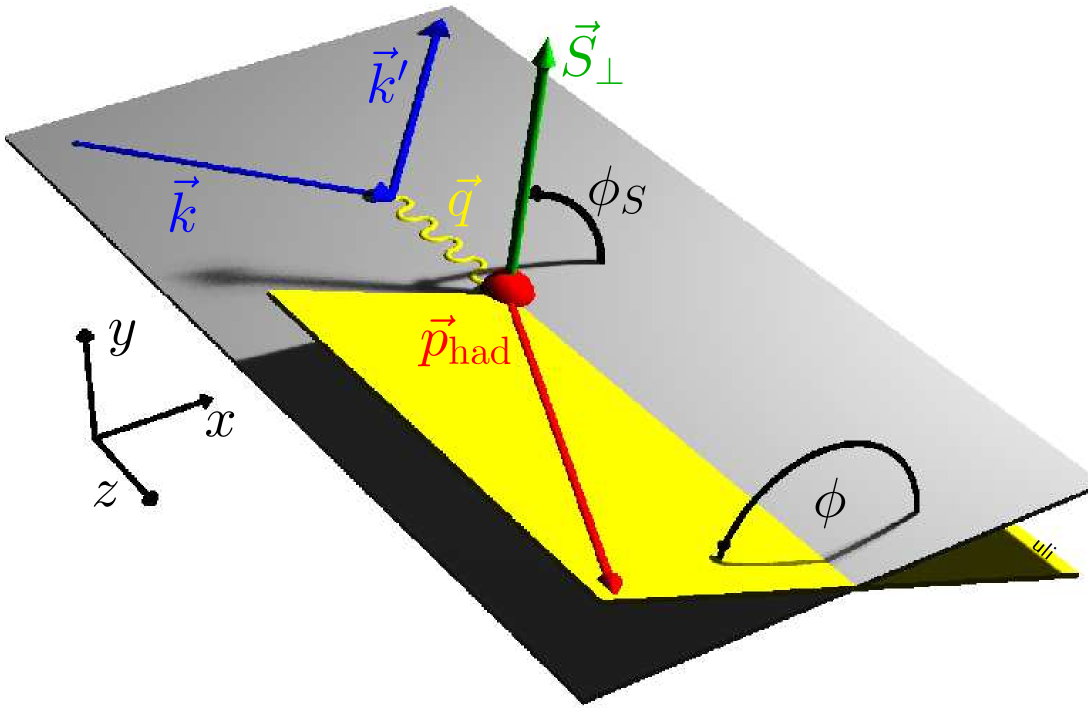
- 'passive' gluons: $E_g = 0$

Advantage of TTSA

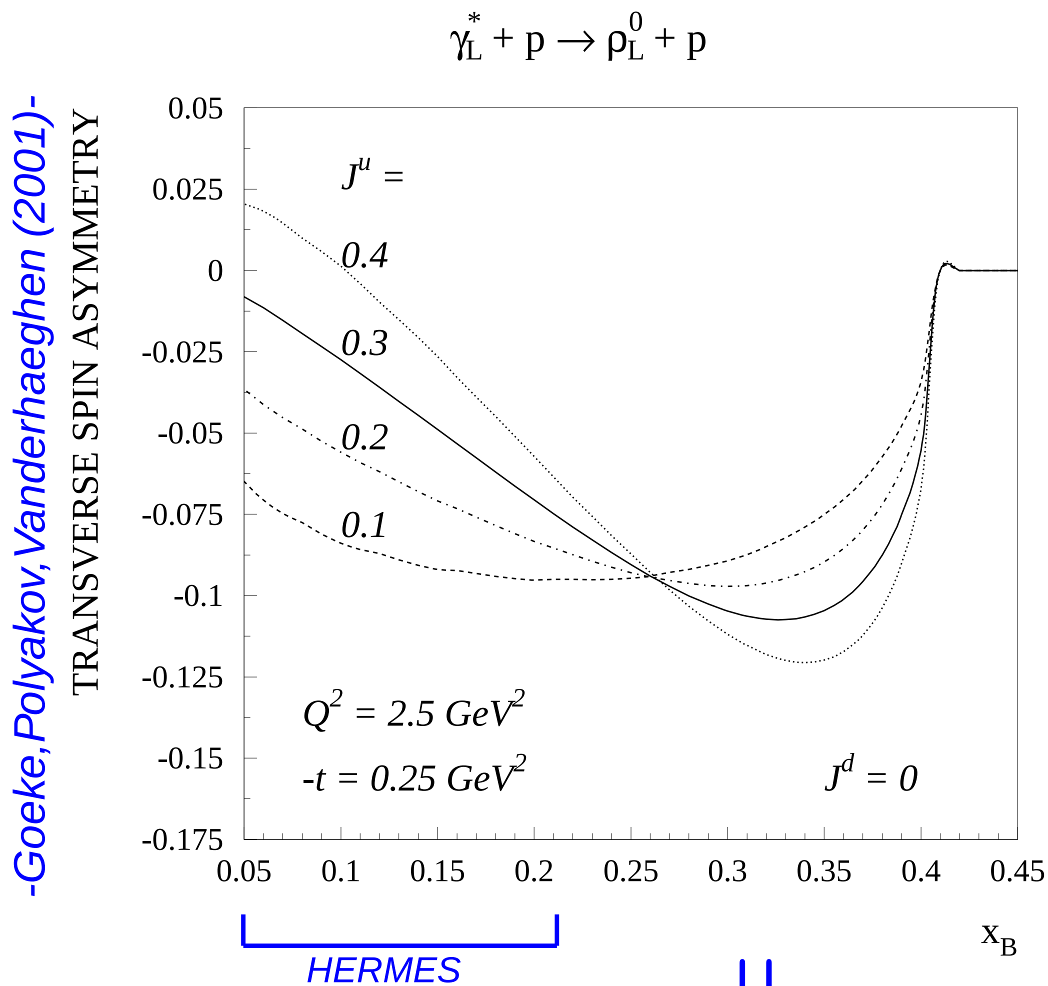
- higher order corrections in α_s cancel
- linear dependence on GPDs:

$$A_{UT}^{\sin(\phi-\phi_s)} \sim \frac{E}{H} \sim \frac{E_q + E_g}{H_q + H_g}$$

- E is kinematically not suppressed
- TTSA promising observable which allow an access to E

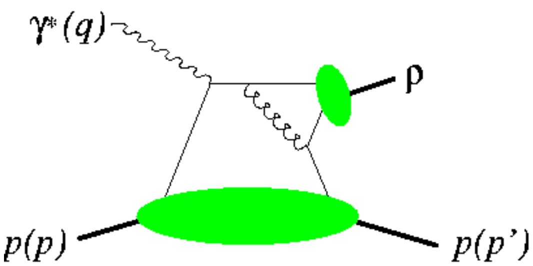


Available theoretical predictions



$\Rightarrow$

- quark exchange dominance



- Trento convention:

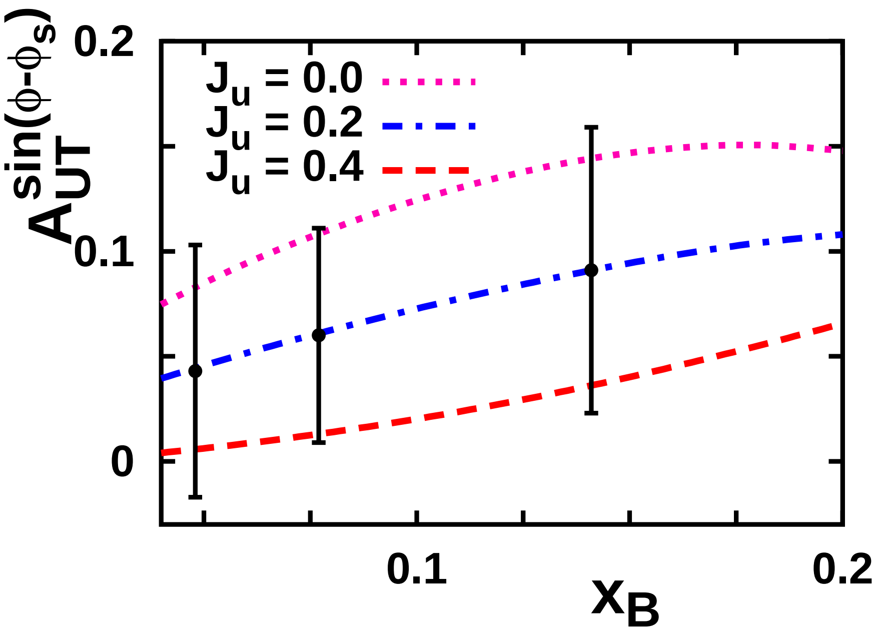
$$A_{UT} = -\frac{\pi}{2}\mathcal{A}_{thoer.}$$

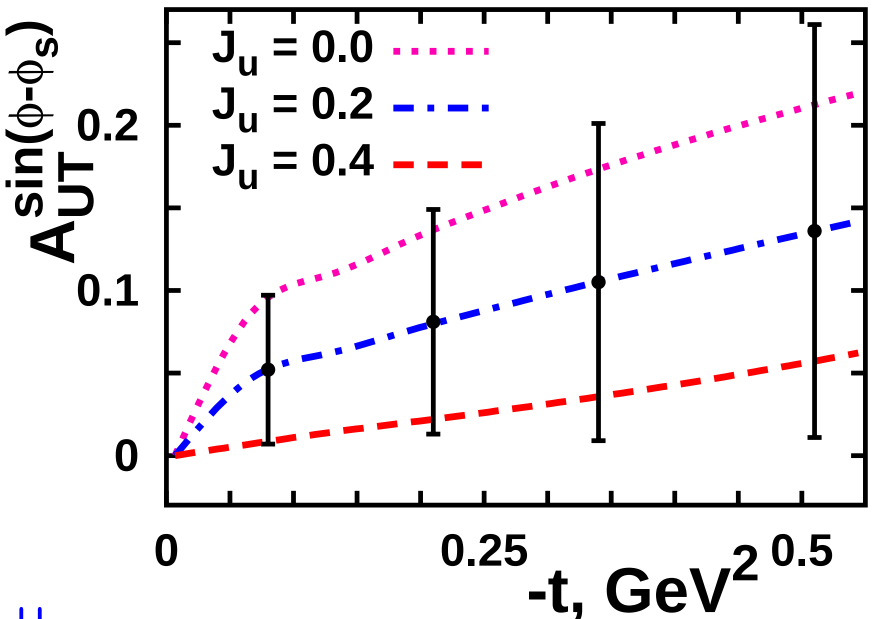
$\Downarrow$

$$E \rightarrow 2J^u + J^d$$

Available theoretical predictions

-Ellinghaus,Nowak,Vinnikov,Ye (2005)-

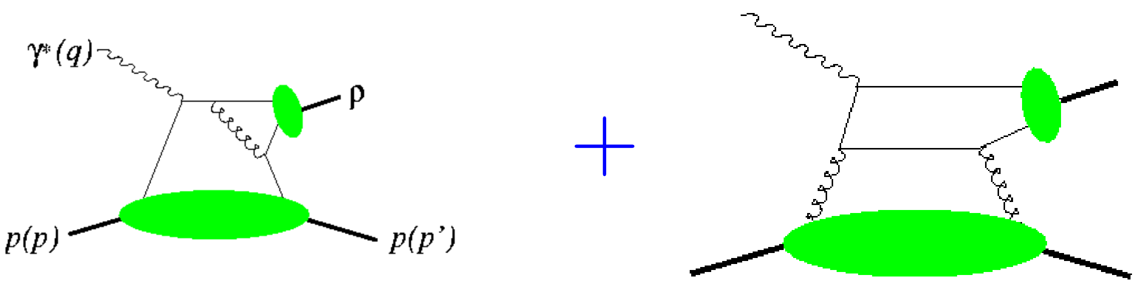




statistical error for 8M DIS

$\Downarrow$

- quark and gluon exchange mechanisms are taken into account



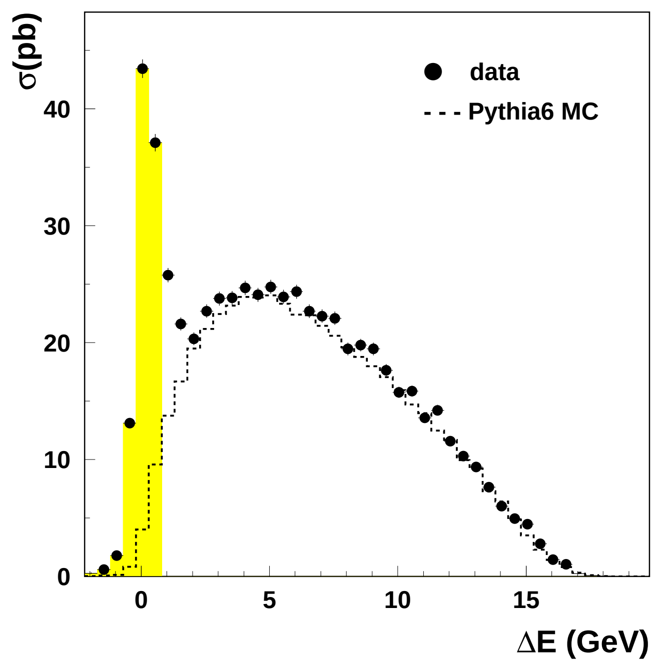
- the results are scaled by a factor of $\pi/2$ (Trento convention)

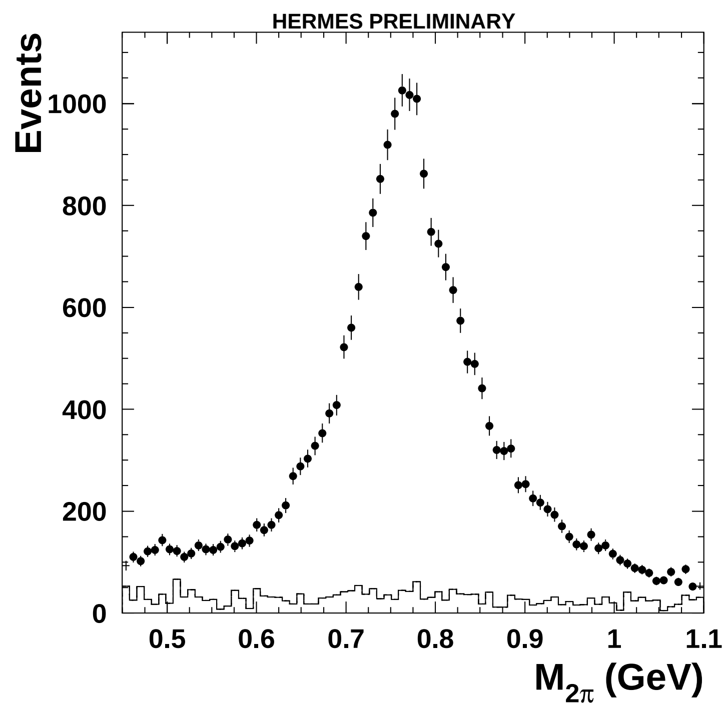
Exclusive production: ($ep \rightarrow e'p\rho^0$)

$\rho^0 \rightarrow \pi^+ \pi^-$

- no recoil detection
- exclusive ρ^0 sample through the energy and momentum transfer:

$$\Delta E = \frac{M_x^2 - M_p^2}{2M_p} \qquad t' = t - t_0$$





Definition of TTSA

- The differential cross section of exclusive ρ^0 production:

$$d\sigma(\phi,\phi_s) = \sigma_0 + \sigma_1|\vec{S}_\perp|\sin(\phi-\phi_s) + \ldots$$

- $\sin(\phi-\phi_s)$ dependence of the cross section appears in the transverse spin asymmetry:

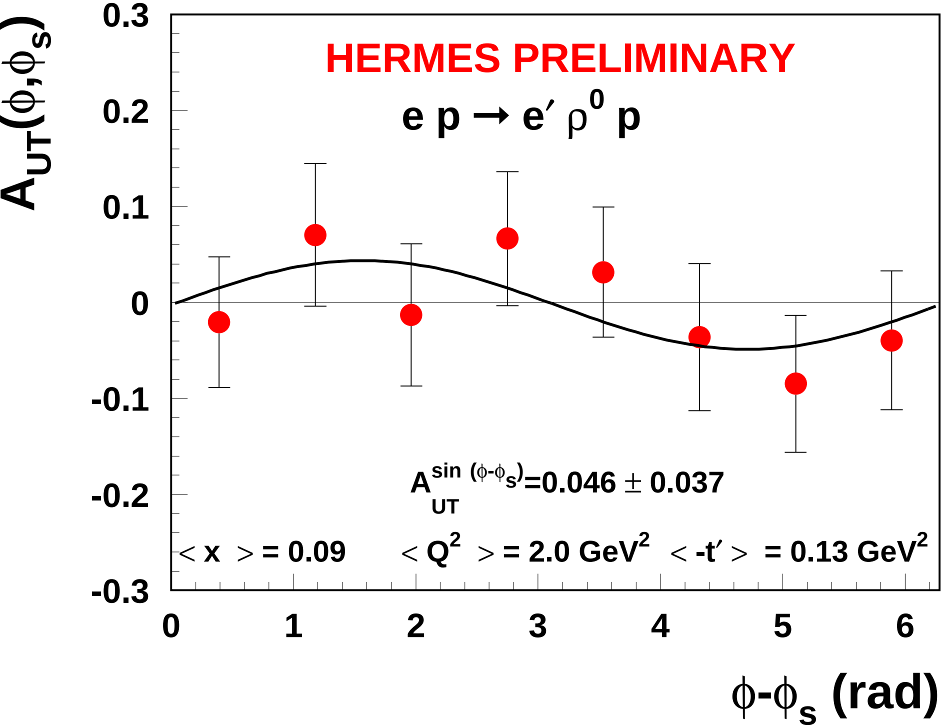
$$\mathcal{A} = \frac{1}{|\vec{S}_\perp|}\frac{\int_0^\pi \sigma(\phi-\phi_s)d(\phi-\phi_s) - \int_\pi^{2\pi}\sigma(\phi-\phi_s)d(\phi-\phi_s)}{\int_0^{2\pi}\sigma(\phi-\phi_s)d(\phi-\phi_s)} = \frac{2\sigma_1}{\pi\sigma_0}$$

- Experimentally the asymmetry is defined:

$$A_{UT}(\phi,\phi_s) = \frac{d\sigma(\phi,\phi_s) - d\sigma(\phi,\phi_s+\pi)}{d\sigma(\phi,\phi_s) + d\sigma(\phi,\phi_s+\pi)} = \frac{\sigma_1}{\sigma_0}$$

$$A_{UT}(\phi-\phi_s) = A_{UT}^{\sin(\phi-\phi_s)}\cdot\sin(\phi-\phi_s) + \text{constant}$$

Definition of TTSA



$$A_{UT}^{\sin(\phi-\phi_s)} = 0.046 \pm 0.037$$

Factorization theorem for ρ_L^0 only!

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L/T separation of the $\gamma^* p$ X-section

$$d\sigma(\phi, \phi_s) = \sigma_0 + \sigma_1 |\vec{S}_\perp| \sin(\phi - \phi_s) + \ldots$$

$$\sigma_0 \rightarrow \sigma_T + \epsilon \sigma_L$$

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- unpolarized X-section:

$$\sigma_L = \frac{R}{1+\epsilon R}\sigma$$

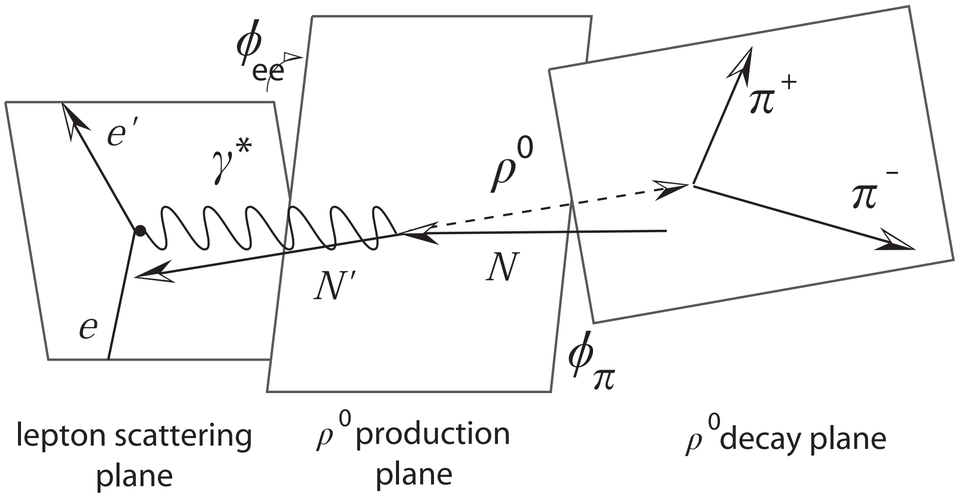
$$R = \frac{\sigma_L}{\sigma_T}$$

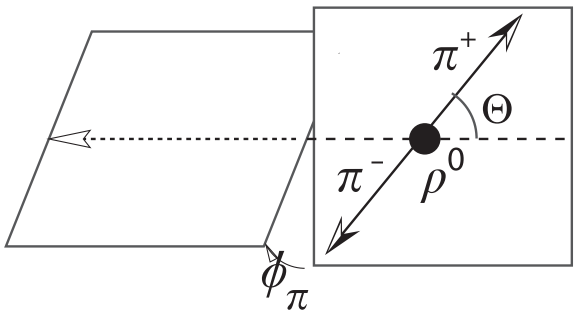
- assuming SCHC

$$R = \frac{1}{\epsilon}\frac{r^{04}_{00}}{1 - r^{04}_{00}}$$

$$r^{04}_{00} \rightarrow W(cos\theta)$$

Photon-Nucleon CMS





ρ^0 Rest Frame

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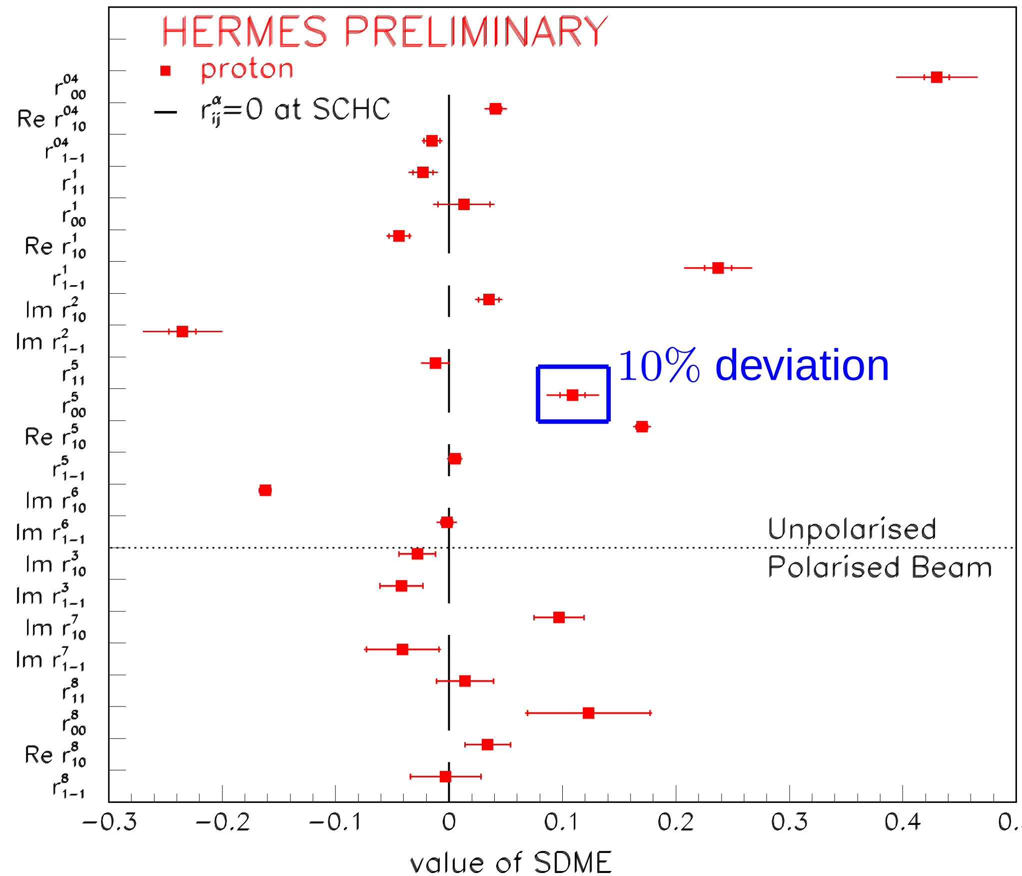

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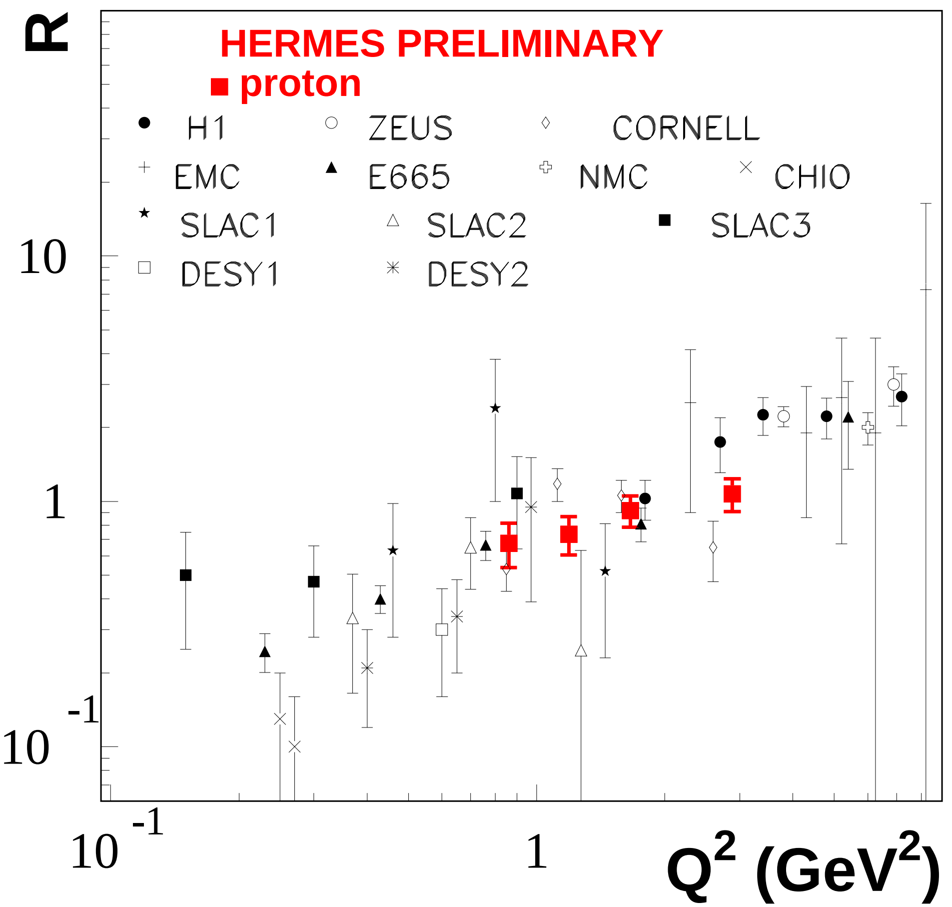

L/T separation of the $\gamma^* p$ X-section

$$Im(\sigma_{++}^{+-} + \epsilon \sigma_{00}^{+-})$$

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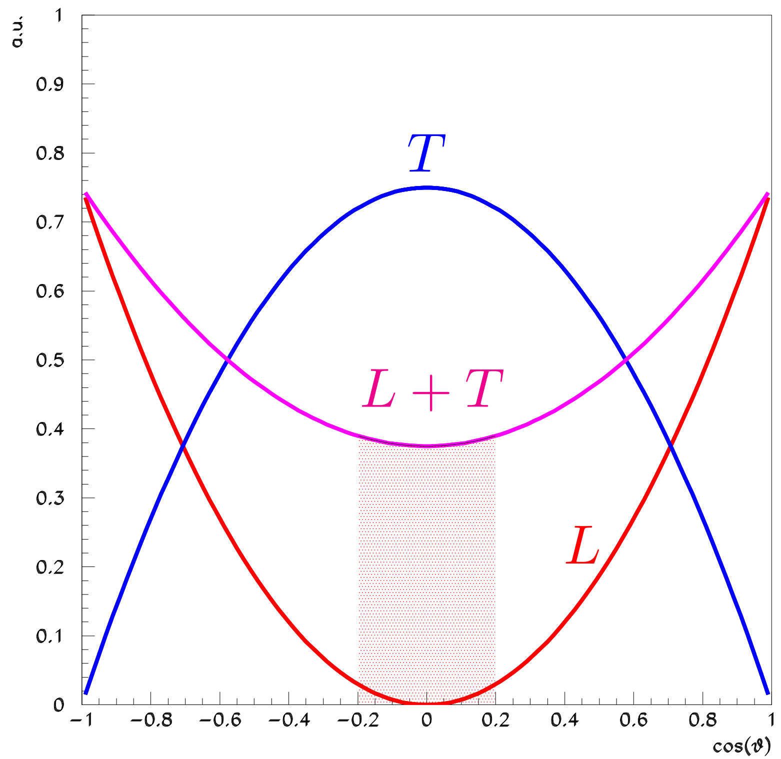
σ_{mn}^{ij}: different dependences on $\cos\theta$

$$\frac{d\sigma_{mn}^{ij}(\gamma^* p \to \pi^+\pi^- p)}{d(\cos\theta)} =$$

$$\frac{3\cos^2\theta}{2}\sigma_{mn}^{ij}(\gamma^* p \to \rho_L^0 p) \quad +$$

$$\frac{3\sin^2\theta}{4}\sigma_{mn}^{ij}(\gamma^* p \to \rho_T^0 p)$$



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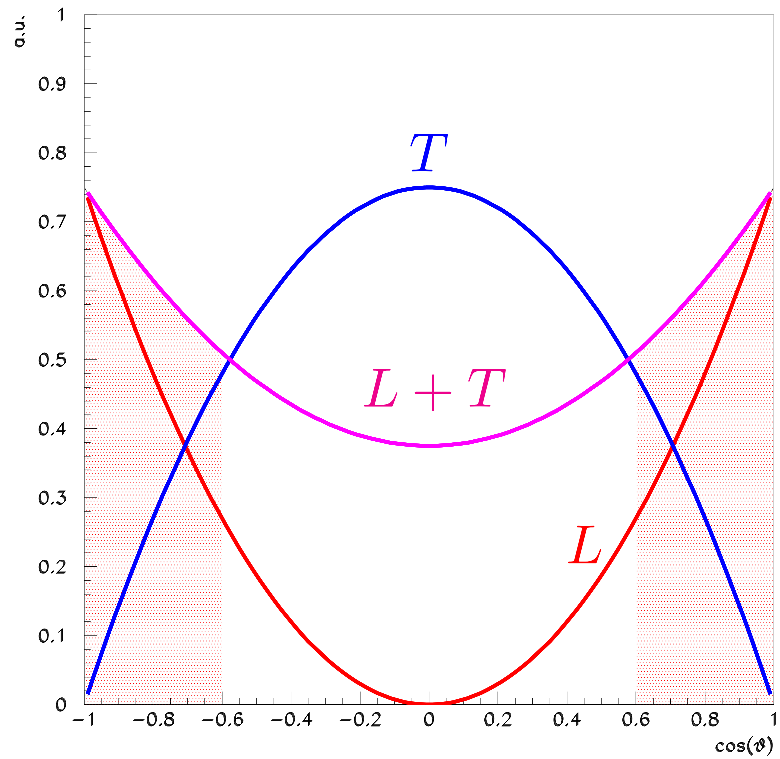

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$$\sigma_T + \epsilon\sigma_L$$

$$\Downarrow$$

assuming SCHC also for the transversely polarized target $\Rightarrow$ true?

$$\begin{aligned} d\sigma(\phi,\phi_s,\cos\theta) &= \frac{3\epsilon}{2}\sigma_L\Big(1 + A_L \sin(\phi-\phi_s)\Big)\cos^2\theta \\ &+ \frac{3}{4}\sigma_T\Big(1 + A_T \sin(\phi-\phi_s)\Big)(1-\cos^2\theta) \end{aligned}$$

$$A_L = -S_\perp \frac{Im(\sigma_{00}^{+-})}{\sigma_L} \qquad A_T = -S_\perp \frac{Im(\sigma_{++}^{+-})}{\sigma_T}$$

TTSA and L/T separation

- L+T

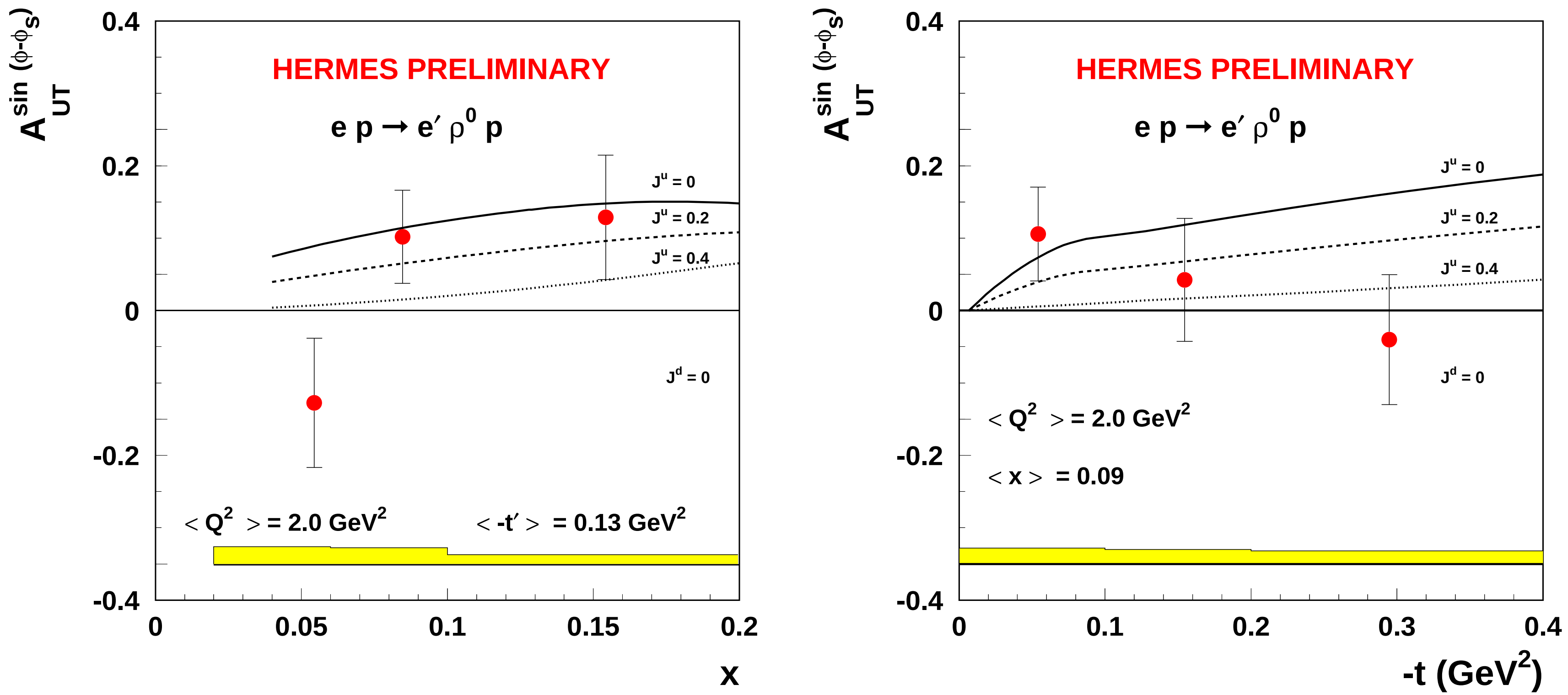
$$A_{UT}(\phi,\phi_s) = \frac{d\sigma(\phi,\phi_s) - d\sigma(\phi,\phi_s+\pi)}{d\sigma(\phi,\phi_s) + d\sigma(\phi,\phi_s+\pi)}$$
$$= A_{UT}^{\sin(\phi-\phi_S)} \cdot \sin(\phi-\phi_S) + \mathrm{constant}$$

- L/T

$$A_{UT}(\phi,\phi_s,\cos\theta) = \frac{d\sigma(\phi,\phi_s,\cos\theta) - d\sigma(\phi,\phi_s+\pi,\cos\theta)}{d\sigma(\phi,\phi_s,\cos\theta) + d\sigma(\phi,\phi_s+\pi,\cos\theta)}$$
$$= sin(\phi-\phi_s)\frac{2\epsilon R A_L \cos^2\theta + A_T(1-\cos^2\theta)}{2\epsilon R\cos^2\theta + (1-\cos^2\theta)}$$

Results

-Ellinghaus,Nowak,Vinnikov,Ye (2005)-



- L/T separation has not yet been done
- transverse component is suppressed at high Q^2
- within the statistical errors in agreement with theoretical calculations
- the statistics is not yet enough to make a statement about J^u

New results are coming soon