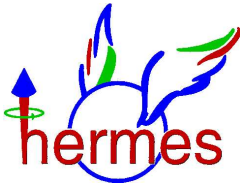
Exclusive Meson Production at HERMES

Particles and Nuclei International Conference, Santa Fe, US.

Jeroen Dreschler

on behalf of the HERMES collaboration

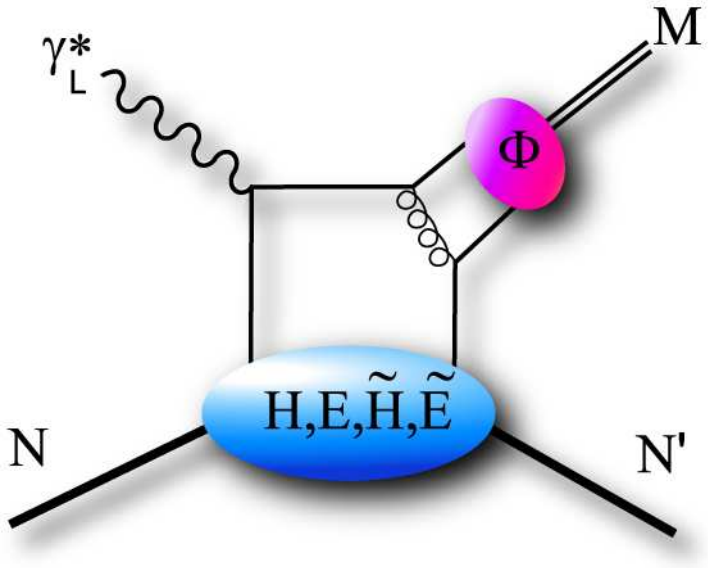


- Cross section of exclusive π^+ production
- Transverse target spin asymmetry in excl. ρ^0 production
- Spin Density Matrix Elements (SDMEs) for exclusive ρ^0 production

GPDs & Exclusive Meson Production

Factorization of Amplitudes

Proven for Mesons in case of
Longitudinal γ^* Polarization
(Collins, Frankfurt, Strikman:
Phys. Rev. D 56 (1997) 2982)

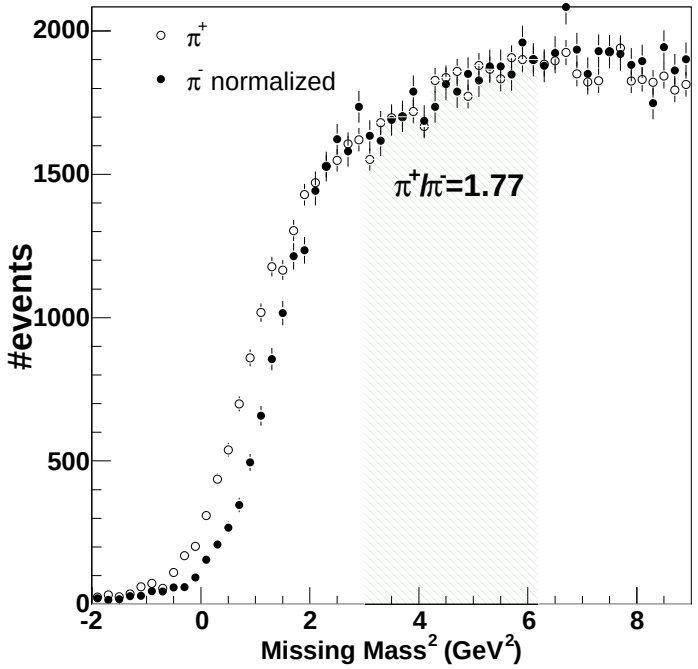


$\Rightarrow$ *Final state determines sensitivity to different GPDs*

$$\begin{cases} H, E: & \text{vector mesons } (\rho, \phi, \omega) \\ \tilde{H}, \tilde{E}: & \text{pseudoscalar mesons } (\pi, \eta) \end{cases}$$

Exclusive Events Selection

$\gamma^* p \rightarrow \pi^+ X$: Missing Mass

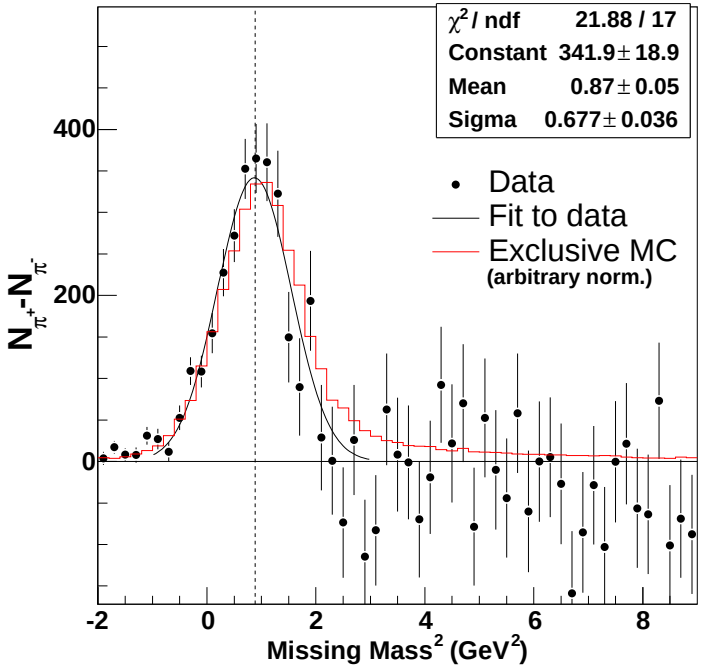


$$M_X^2 = (P_{\gamma^*} + P_p - P_{\pi^+})^2$$

- Non-exclusive background estimated with normalized π^- yields

Exclusive Events Selection

$\gamma^* p \rightarrow \pi^+ X$: Missing Mass



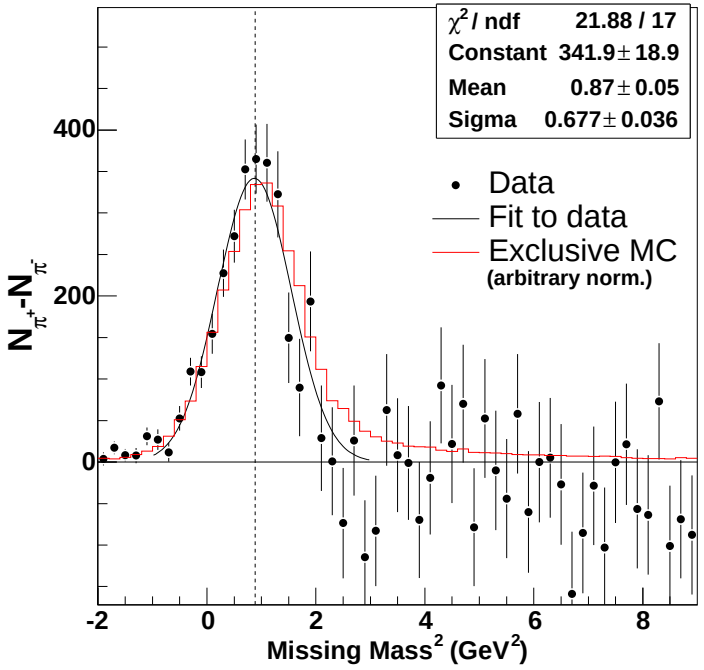
$$M_X^2 = (P_{\gamma^*} + P_p - P_{\pi^+})^2$$

- After background subtracktion:

  M_X *centered around* M_n

Exclusive Events Selection

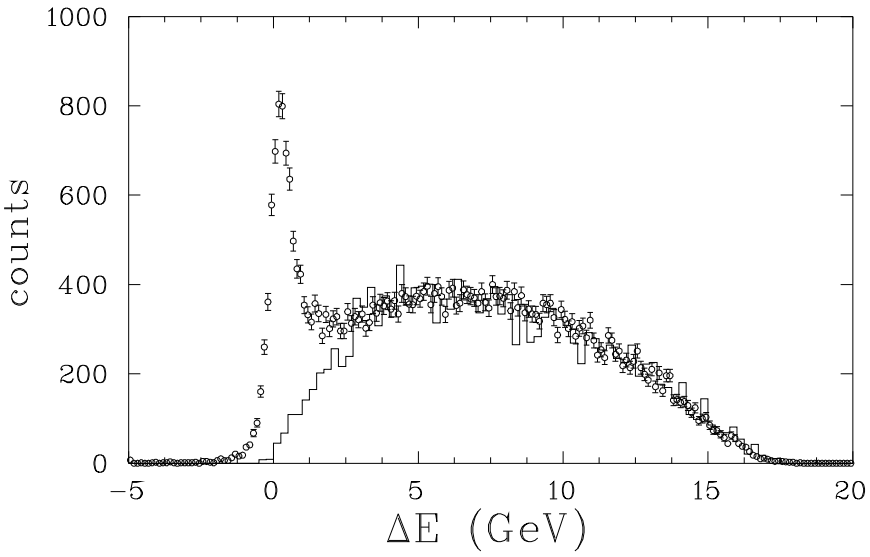
$\gamma^* p \to \pi^+ X$: Missing Mass



$$M_X^2 = (P_{\gamma^*} + P_p - P_{\pi^+})^2$$

- After background subtracktion:
  M_X *centered around* M_n

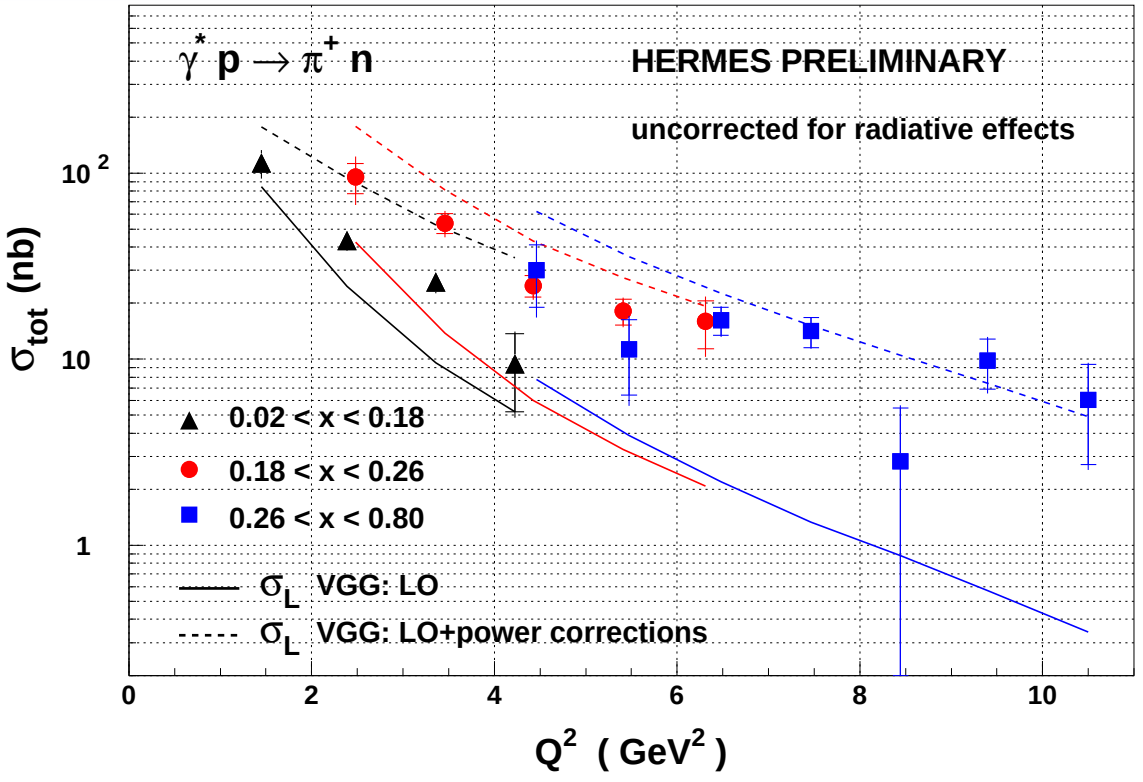
$\gamma^* p \to \rho^0 X$: Missing Energy



$$\Delta E = \frac{M_X^2 - M_p^2}{2M_p}$$

- Excl. ρ^0 data set:
  ΔE *around 0.0 GeV*

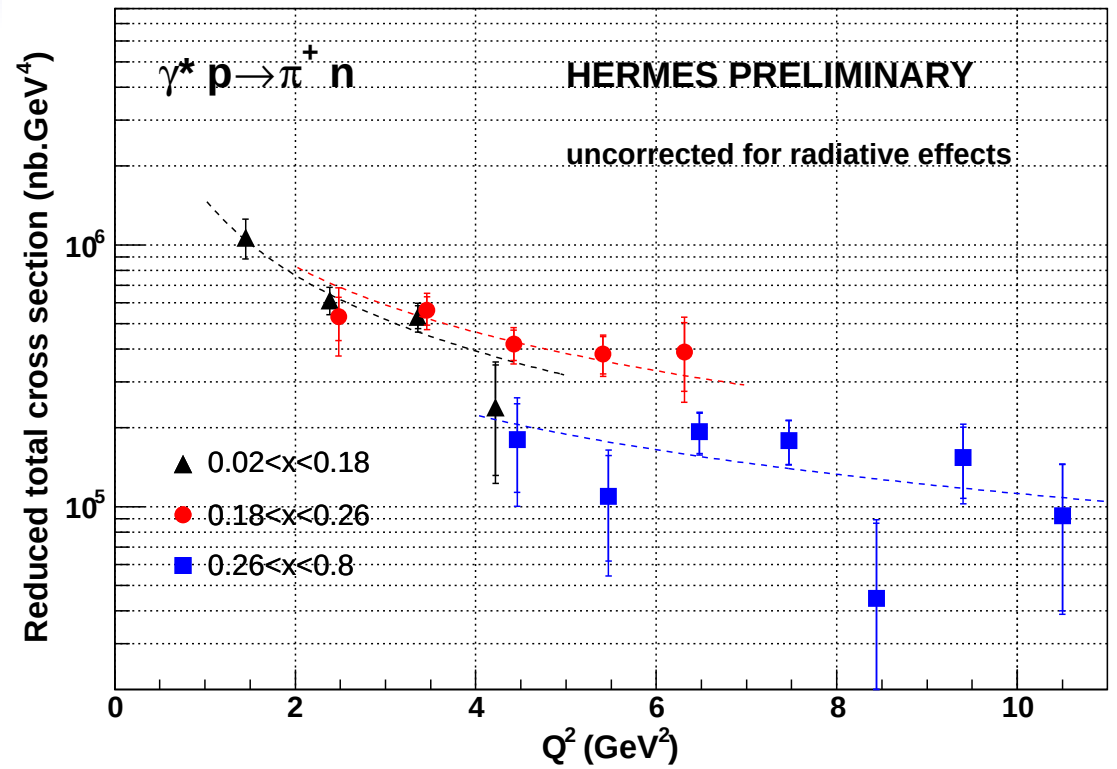
$\gamma^* p \to \pi^+ n$ Cross Section Measurements



- $\sigma_{tot} = \sigma_T + \epsilon\sigma_L$
- Regge model: dominance of σ_L over σ_T *(Laget: PRD 70 (2004) 054023)*
- Q^2 dependence agrees with GPD model calculations

  (Vanderhaegen, Guichon, Guidal: PRD 60 (1999) 094017)

Reduced Cross Section: Q^2 dependence



Fit of data with:

$\sigma_{\text{reduced}} \sim 1/Q^p$

- ▲ $p = 1.9 \pm 0.5$
- ● $p = 1.7 \pm 0.6$
- ■ $p = 1.5 \pm 1.0$

Definition: $\sigma_{\text{reduced}} = \sigma^{\gamma^* p \to n\pi^+} / \left(\frac{1}{16\pi} \frac{x^2}{1-x} \frac{1}{Q^4} \frac{1}{\sqrt{1+\frac{4mx^2}{Q^2}}} \right)$

Expectation: $\sigma_L \sim 1/Q^6 \quad \rightarrow \quad \sigma_{\text{reduced,L}} \sim 1/Q^2$

σ_T suppressed by $1/Q^2$

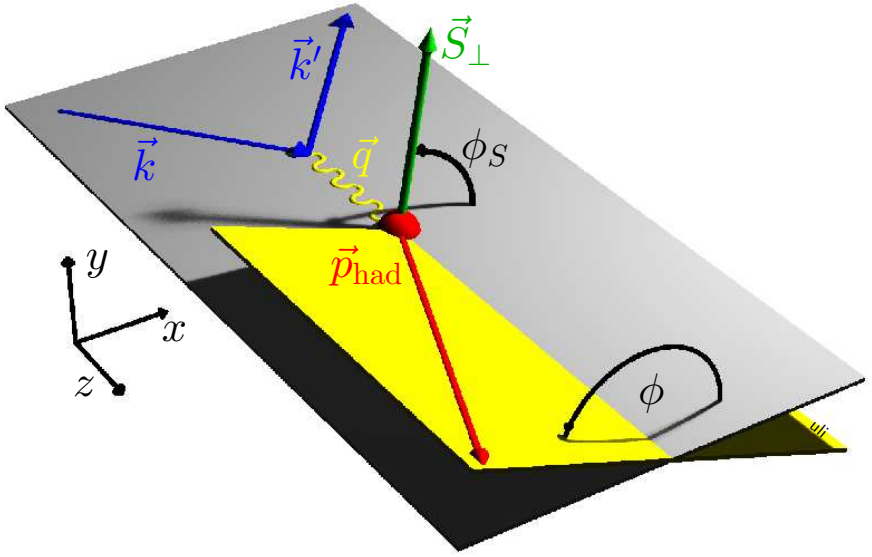
Transverse Target Spin Asymmetry in $\gamma^* p \to \rho^0 p$

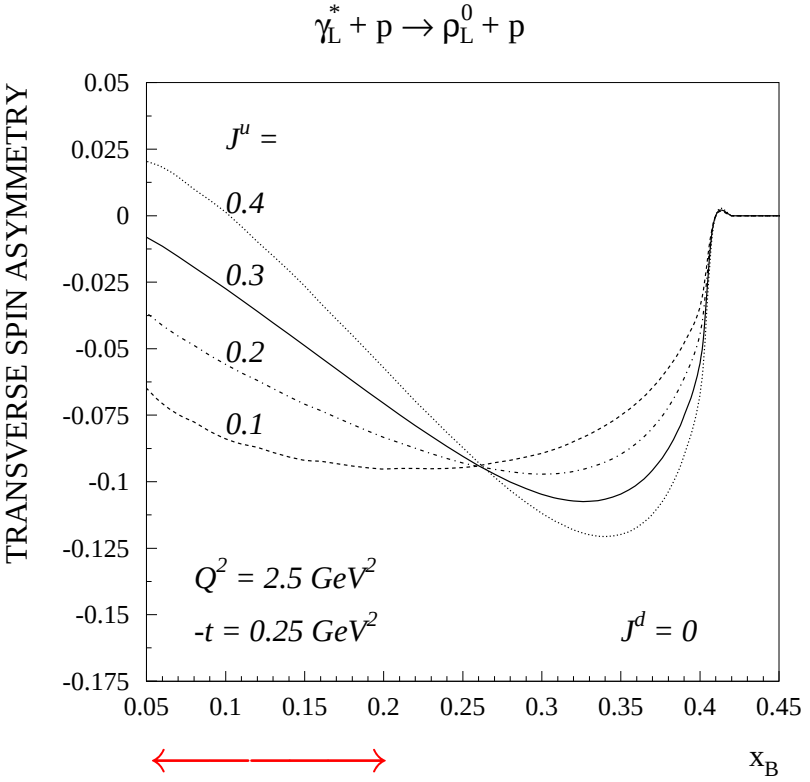
- Sensitive to EH interference term

$$A_{UT} \sim \sin(\phi - \phi_s) EH$$

$$A_{UT}(\phi, \phi_S) = \frac{1}{|P_t|} \frac{\sigma^{\uparrow}(\phi, \phi_S) - \sigma^{\downarrow}(\phi, \phi_S)}{\sigma^{\uparrow}(\phi, \phi_S) + \sigma^{\downarrow}(\phi, \phi_S)}$$

- Dependence on J^u $\Longrightarrow$

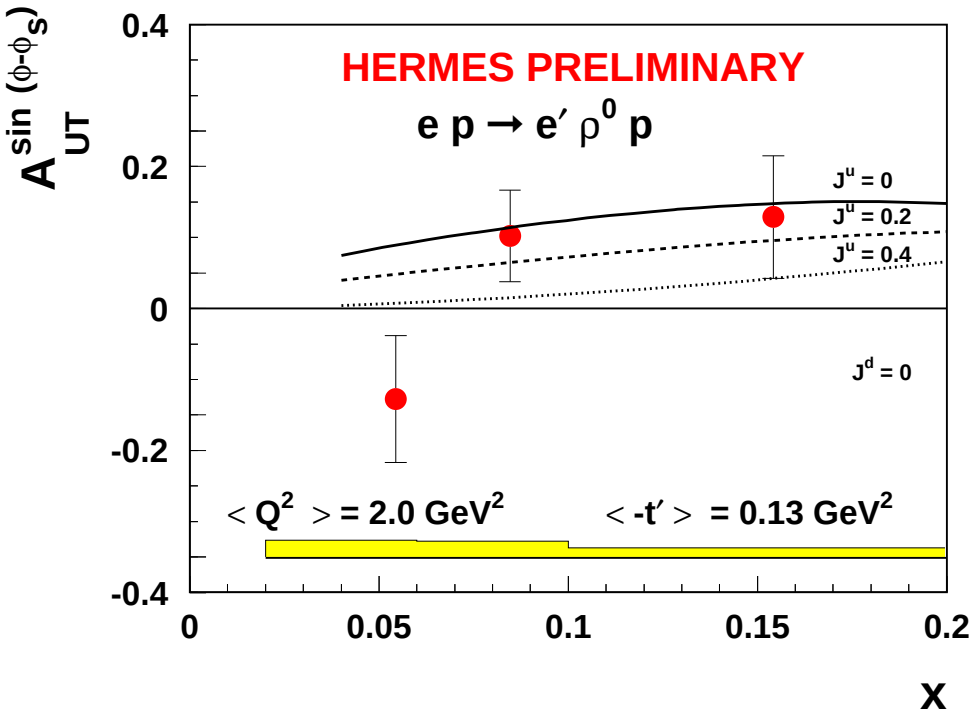




Goeke, Polyakov, Vanderhaeghen:
Prog. Part. Nucl. Phys. 47 (2001) 401

- $\mathcal{A}_{theory} \sim -A_{UT}^{\sin(\phi-\phi_s)} \sim EH$

Kinematic Dependence of $A_{UT}^{\sin(\phi-\phi_s)}$



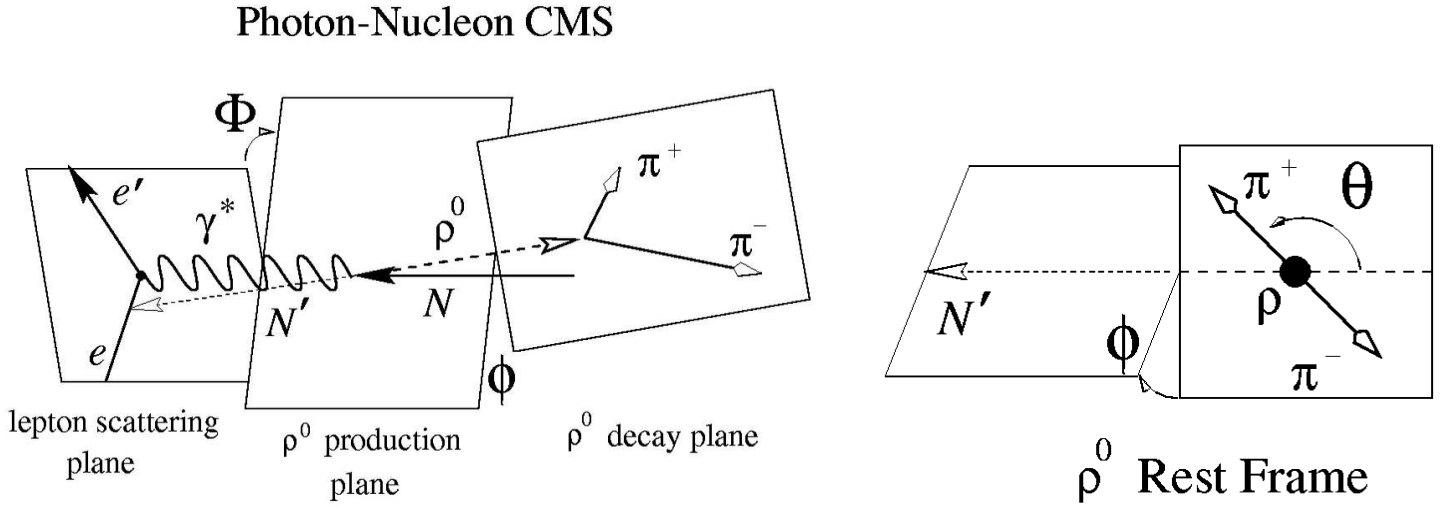
- Results consistent with GPD model calculations

  (Vinnikov: hep-ph / 0506264)

- To be done:
  - Include 2005 data (statistics increase by factor 2)
  - $\sigma_L - \sigma_T$ separation

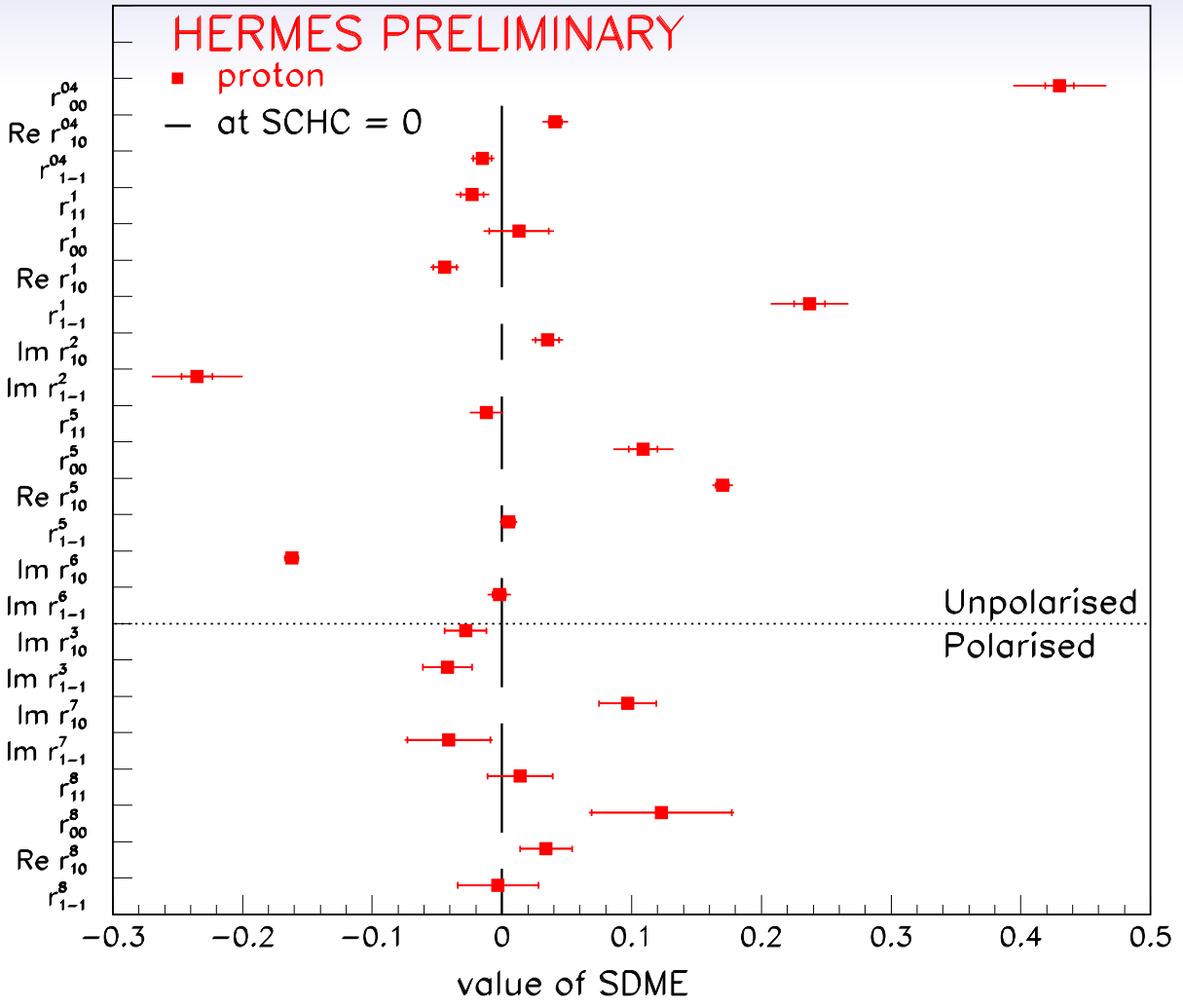
SDME Extraction for $\gamma^* N \to \rho^0 N$

- *SDMEs* extraction from angular distribution $W(\cos\theta, \phi, \Phi)$
  - Spin state of ρ^0 is reflected in orbital angular momentum of decay ($\pi^+\pi^-$) system $\to W(\cos\theta, \phi, \Phi)$



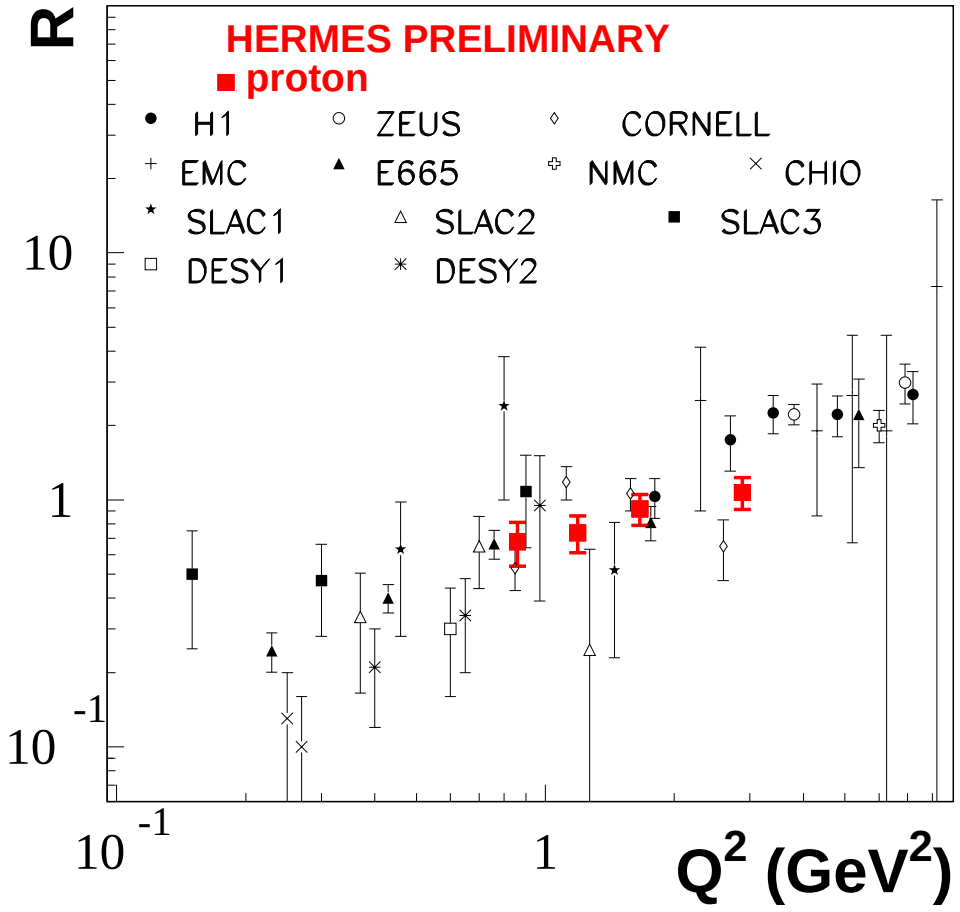
- Recent results for 23 SDMEs measured at HERMES:
  - 8 Polarized / 15 Unpolarized SDMEs
  - Used targets: Hydrogen / Deuterium

Extracted SDMEs (proton)



- SDMEs, obtained from a 3D maximum likelihood fit of $W(\cos\theta, \phi, \Phi)$
  - Dependences on kinematical variables x_B, Q^2, t' determined

$R = \sigma_L/\sigma_T$ for exclusive ρ^0 production



At HERMES:

Assuming s-channel helicity conservation:

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

$\sigma_L - \sigma_T$ separation:

- $\sigma_L = \frac{R}{1+\epsilon R}\sigma_{\gamma^* p \to \rho^0 p}$

Conclusion

Summary

- Cross section measured for exclusive π^+ production
  - Q^2 dependence in agreement GPD model calculations
- First results shown for A_{UT} in exclusive ρ^0 production
  - Sensitivity to GPD E and angular momentum J^u
- Recent results: SDMEs for ρ^0 production obtained using 3D maximum likelihood fit of angular distributions

Outlook

- More transversely polarized target data
- $\sigma_L - \sigma_T$ separation for A_{UT} in exclusive ρ^0 production
- Cross sections σ_{ρ^0}, $\sigma_\phi \rightarrow$ ratio $\sigma_\phi / \sigma_{\rho^0}$