Exclusive Meson Production at HERMES

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Gent University, Belgium
On behalf of the HERMES Collaboration

XIII International Workshop on Deep Inelastic Scattering
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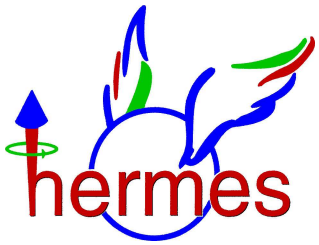
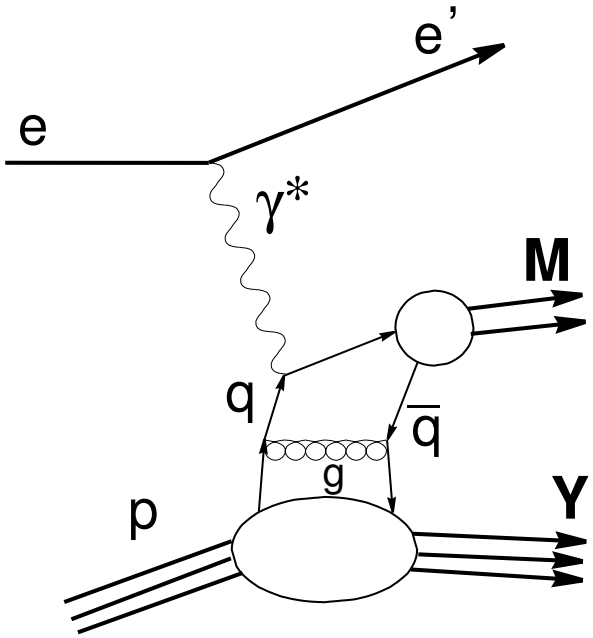


Outline

Exclusive Leptoproduction of Mesons

- Collins, hep-ph/9907513 -
- Collins, Frankfurt, Strikman, hep-ph/9709336 -

- In the case of large Q^2 and for γ_L^* a Factorization can be applied for exclusive processes:
  - a hard part
  - a meson wave function
  - a soft part providing information about the nucleon in terms of Generalized Parton Distributions



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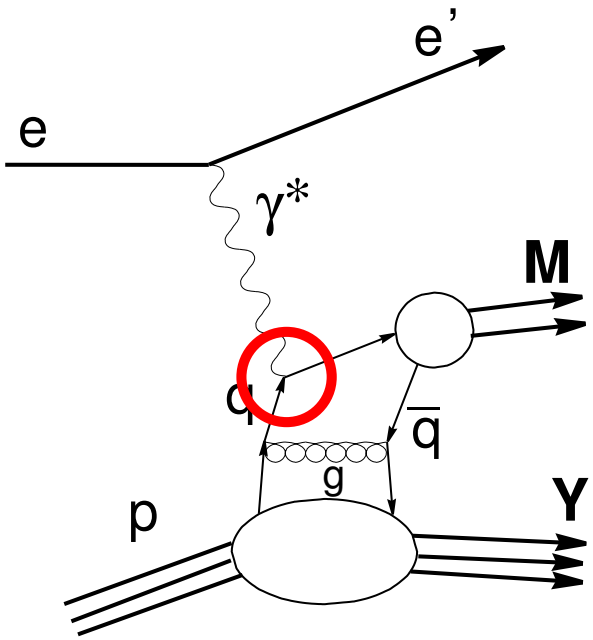

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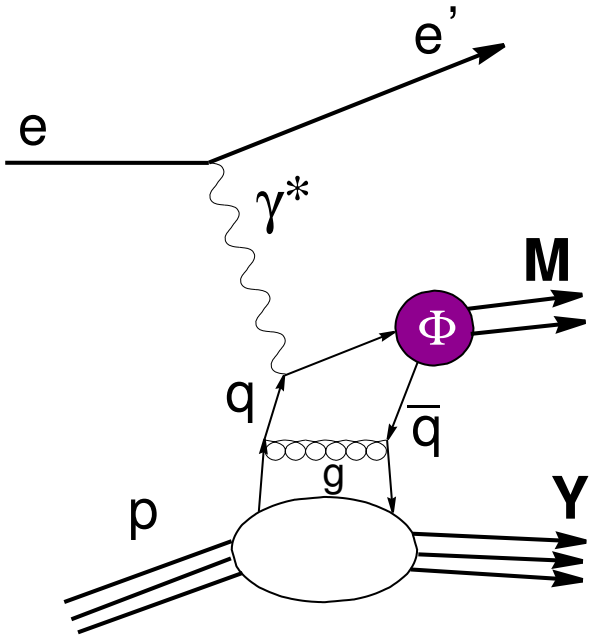

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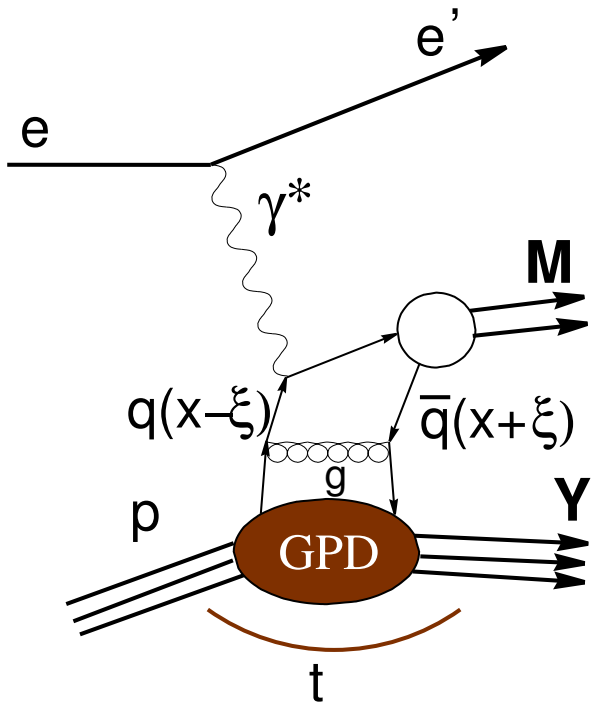

GPD(x,ξ,t)

Generalized Parton Distributions

- $\tilde{H}^q$, $\tilde{E}^q$ accessible via pseudoscalar meson production, $\tilde{E}^q$ is the pseudoscalar contribution, related to the pion pole
  - σ_{π^+}, A_{UT}, A_{UL}
- H^q, E^q accessible through vector meson production:
  - $\frac{\sigma_\rho}{\sigma_\phi}$, A_{UT}, A_{UL}
- Both different mesons and different observables select different combinations of GPD's
- $\sigma_L - \sigma_T$ separation:
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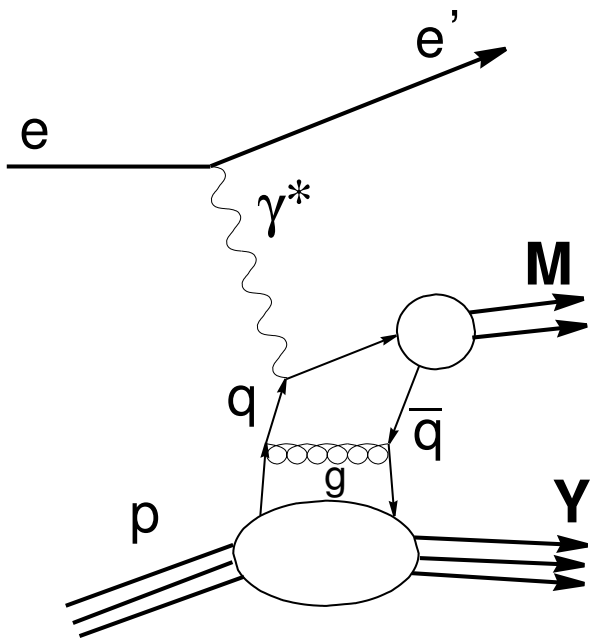
Exclusive processes

- Initial and Final State *fully* known
- Scattered Lepton and produced meson in Hermes acceptance
- Select Exclusive reactions by putting *constraints* to the missing mass, or missing energy



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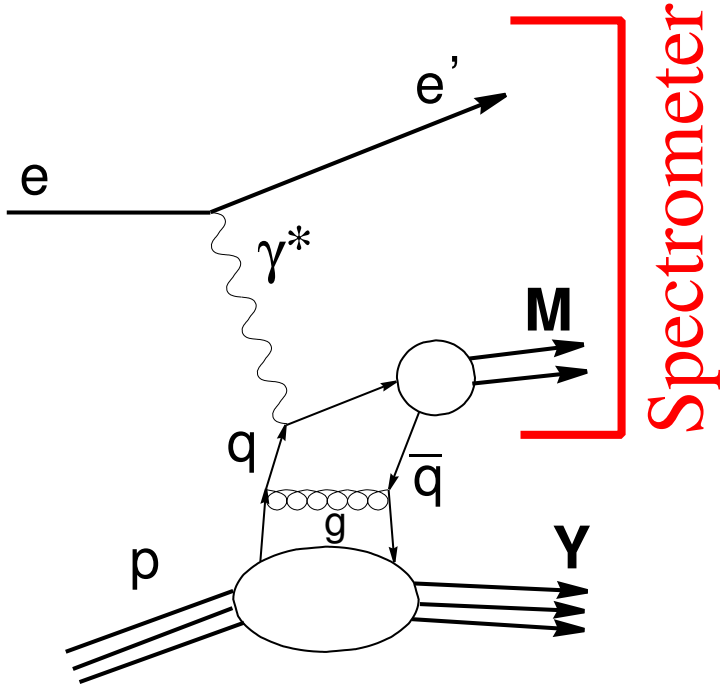

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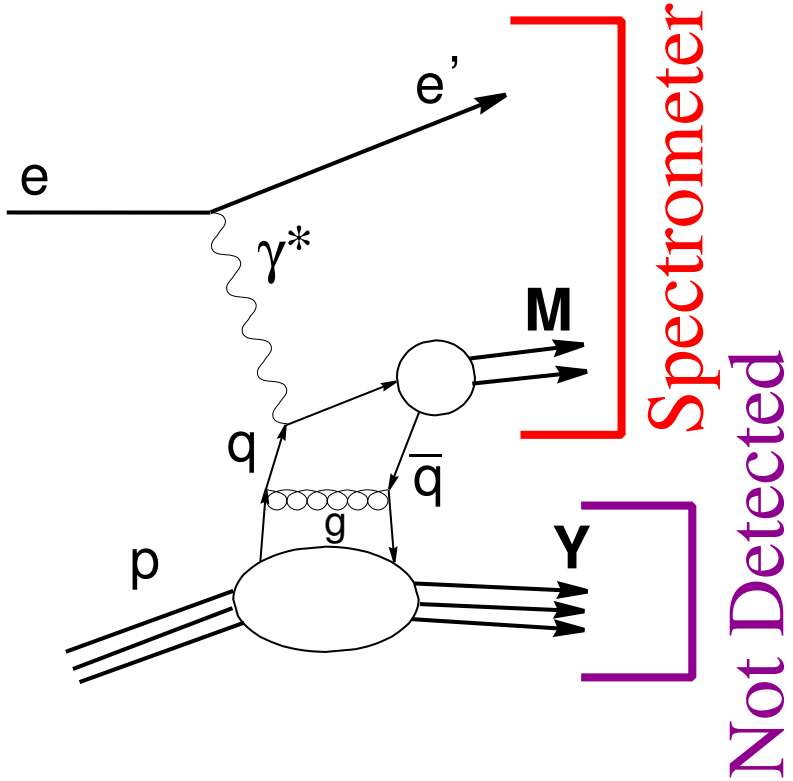

Pseudoscalar Mesons

$\Rightarrow$ *Probe* $\tilde{E}$ *and* $\tilde{H}$

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

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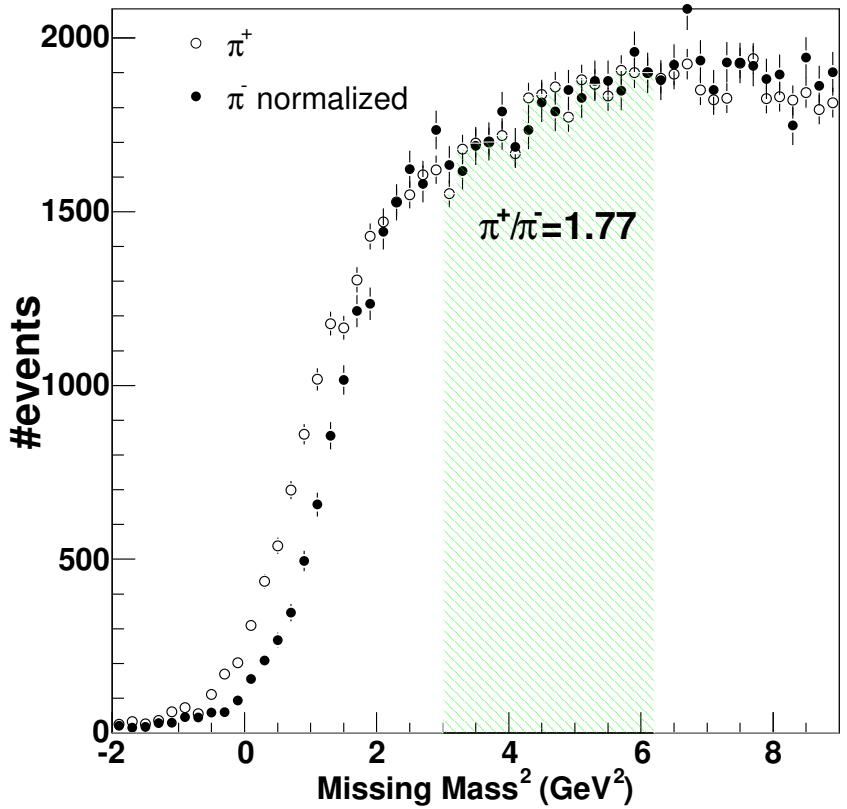

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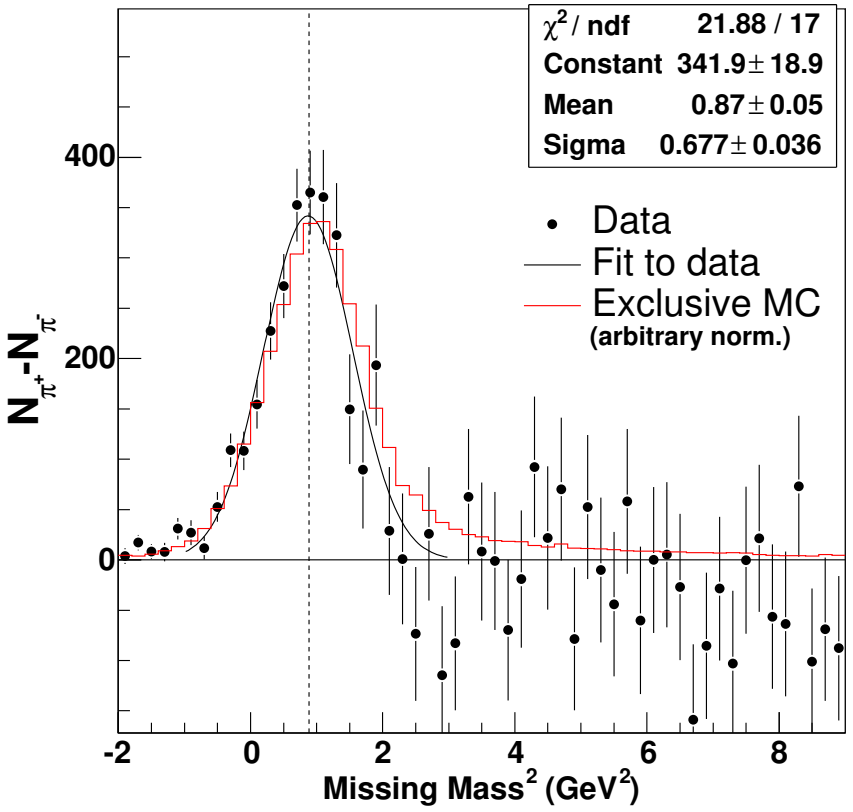
- Exclusive Peak at nucleon mass, mean and width like exclusive Monte Carlo, based on a GPD model



Cross Section: $\sim (\tilde{H} + \tilde{E})^2$

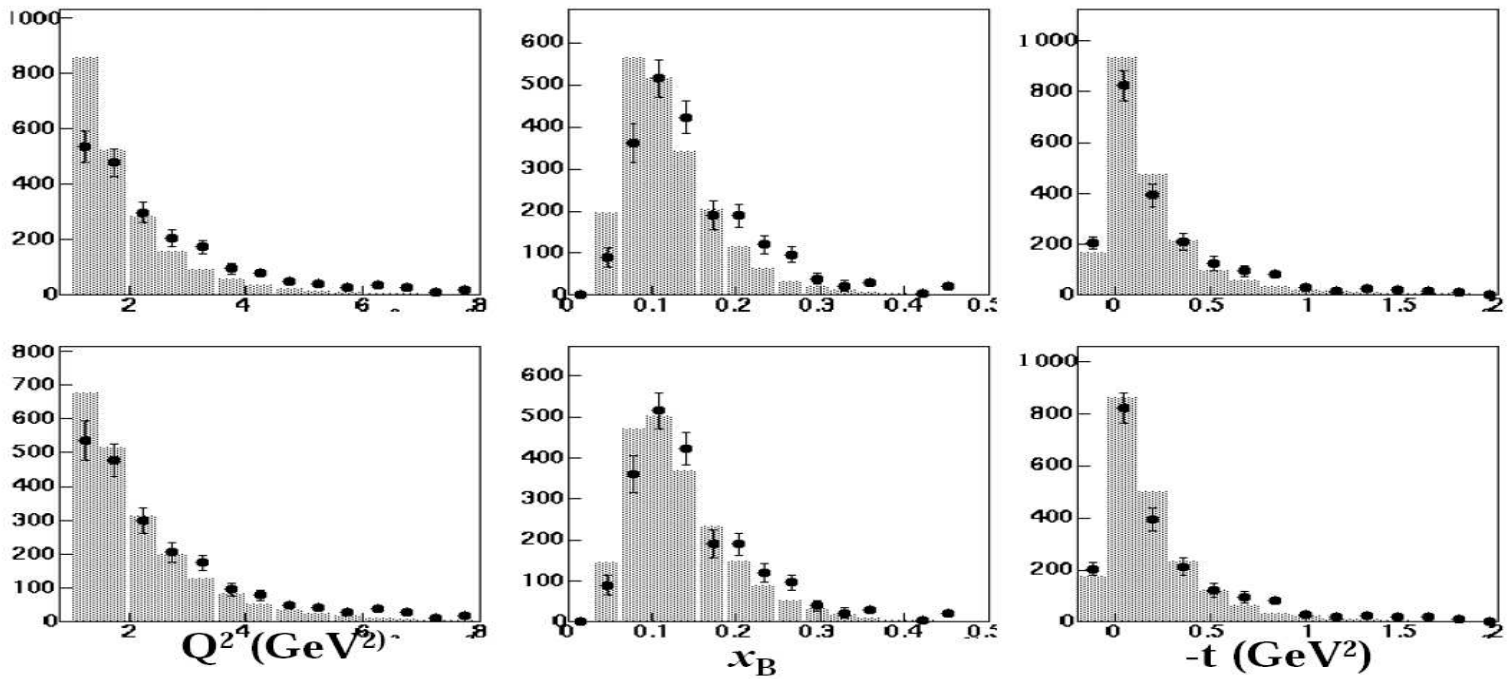
Cross Section:

$$\sigma^{\gamma^* p \to n + \pi^+}(x, Q^2) = \frac{N^{\pi^+}_{\text{excl}}}{L \cdot \Delta x \Delta Q^2 \cdot \kappa(x, Q^2) \cdot \Gamma(< x >, < Q^2 >)}$$

- L: Integrated luminosity 1996-2000 : 283 pb^{-1}
- $\kappa(x, Q^2)$: Detection probability (from MC)
- $\Gamma(< x >, < Q^2 >)$: virtual photon flux factor

Extracting a Cross Section

- Acceptance correction is strongly model dependent, therefore a comparison with 2 different models was made:
  - Mankiewicz, Piller & Radyushkin (1999)
  - Vanderhaeghen, Guichon & Guidal (1999)



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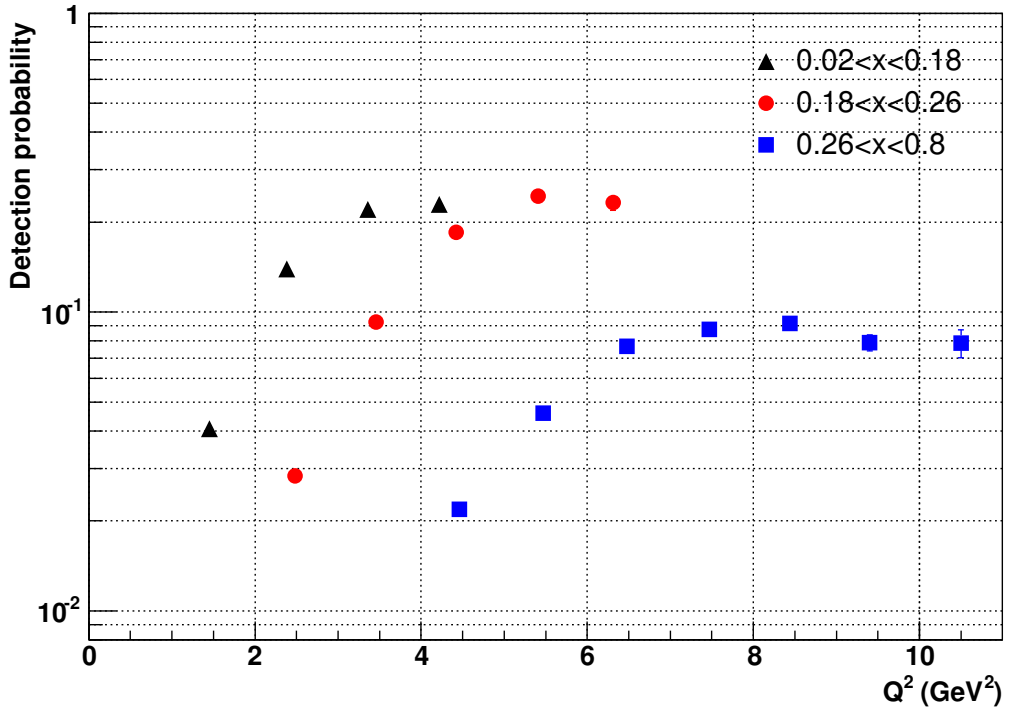
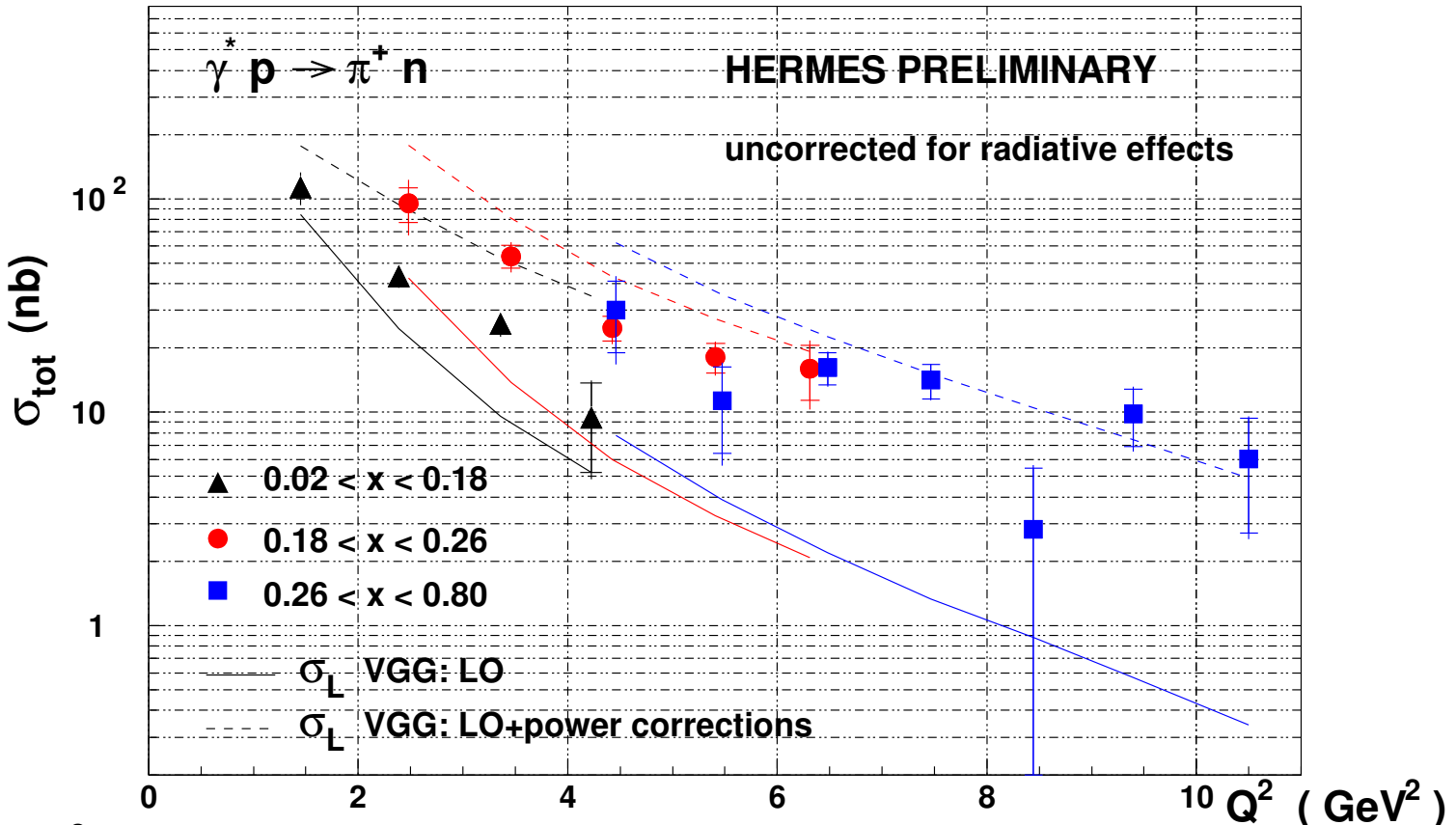


$\sigma_{\rm tot}$: Q^2 dependence in x bins: $\sim (\tilde{H} + \tilde{E})^2$

- Q^2 behavior with respect to $\sigma_L - \sigma_T$



- Q^2 dependence is consistent with LO expectations, however Vanderhaeghen, Guidal, Guichon model too small
- Power corrections (k_T, soft overlap) overestimate data

Towards an x independent form: σ_{reduced}

- Factorization theorem predicts a $\frac{1}{Q^6}$ dependence for σ_L at fixed x and t
- Cross Section can be writen as

$$\mathrm{d}\sigma = \frac{1}{16\pi}\frac{x^2}{1-x}\frac{1}{Q^4}\frac{1}{\sqrt{1+\frac{4m^2x^2}{Q^2}}}\sum_{\text{spin}}|\mathcal{A}(\gamma^* p \to pM)|^2$$

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pure γ_L^* + LO $\Rightarrow$ d$\sigma_{\text{red}} \sim \frac{1}{Q^2}$

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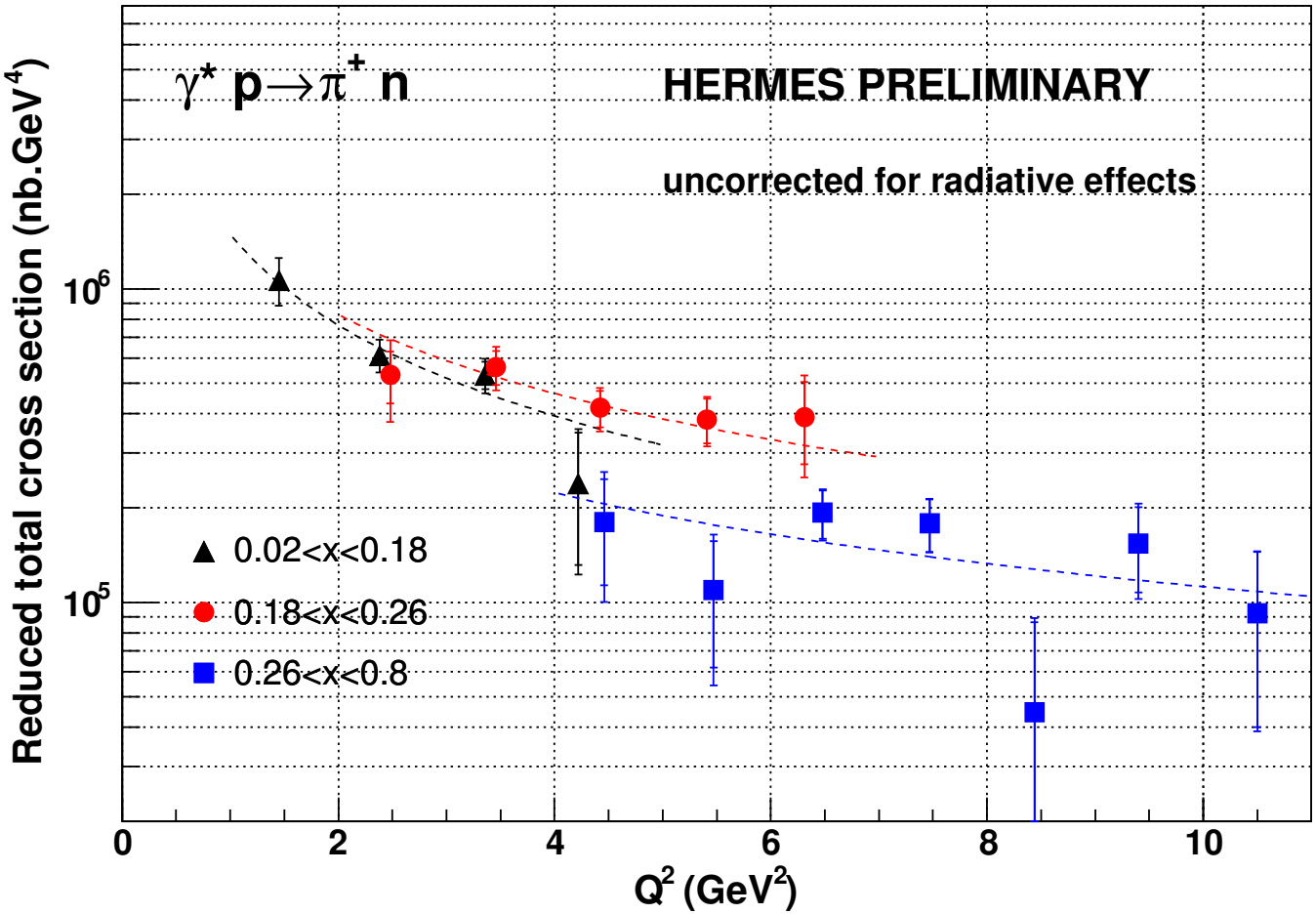

Fit To data of a $\frac{1}{Q^p}$ function:

$p = 1.9 \pm 0.5$ $p = 1.7 \pm 0.6$ $p = 1.5 \pm 1.0$

Asymmetries

- Target Related Single Spin Asymmetry $\sim \tilde{E} \cdot \tilde{H}$
- Theoretical expectation for asymmetries: Scaling region reached at lower Q^2

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Transverse Spin Asymetry:

$$\sigma^{U\uparrow} - \sigma^{U\downarrow} \sim |S_\perp| \sin\phi \cdot A_{UT} \sim |S_\perp| \sin\phi \cdot \tilde{E} \cdot \tilde{H}$$

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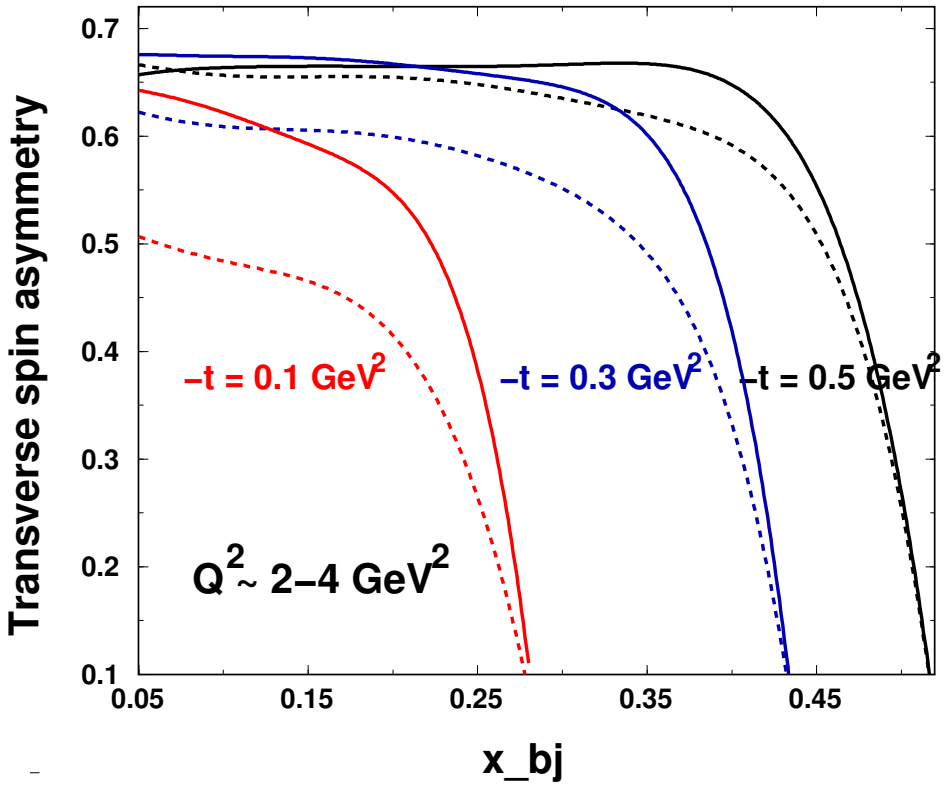
- 2002-2005: HERMES run with transversely polarized target
- Analysis ongoing !

Asymmetries

- Theoretical prediction – Frankfurt et Al., Phys. Rev. D60 (1999), 2 models with different pion form factor



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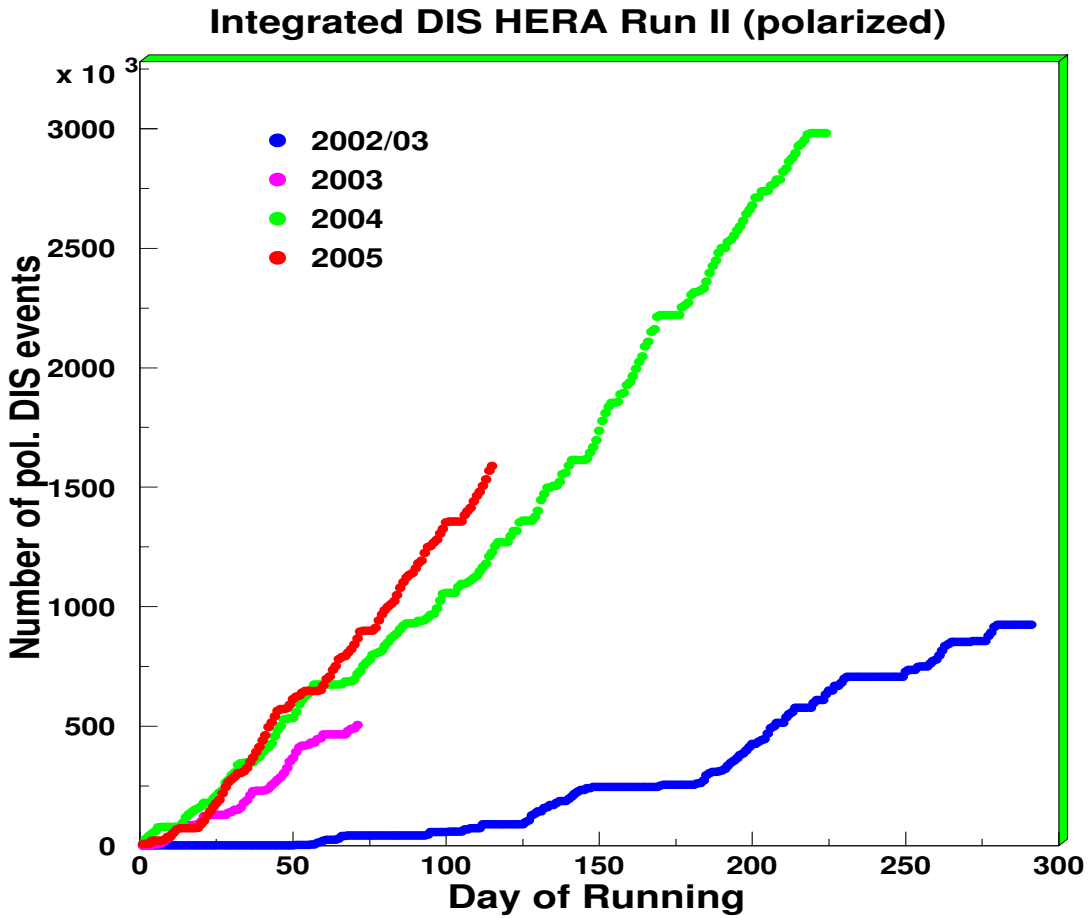

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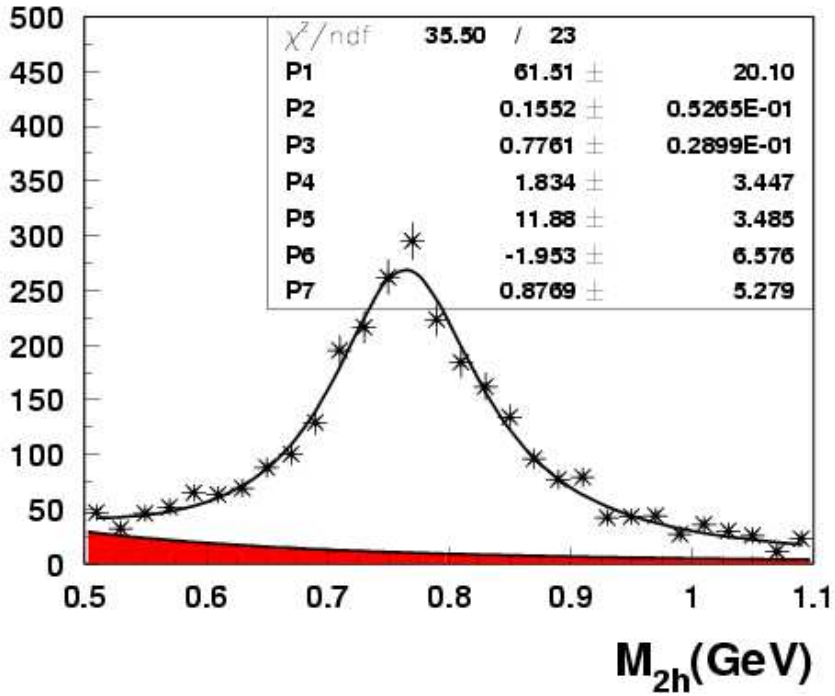
Vector Mesons

$\Rightarrow$ *Probe E and H*

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

- ρ^0 reconstructed from h^+h^- pairs
- Exclusivity constraints by requiring *Missing Energy* ΔE to be 0, describe background shape by MC
- Evidence of exclusive ρ^0 production



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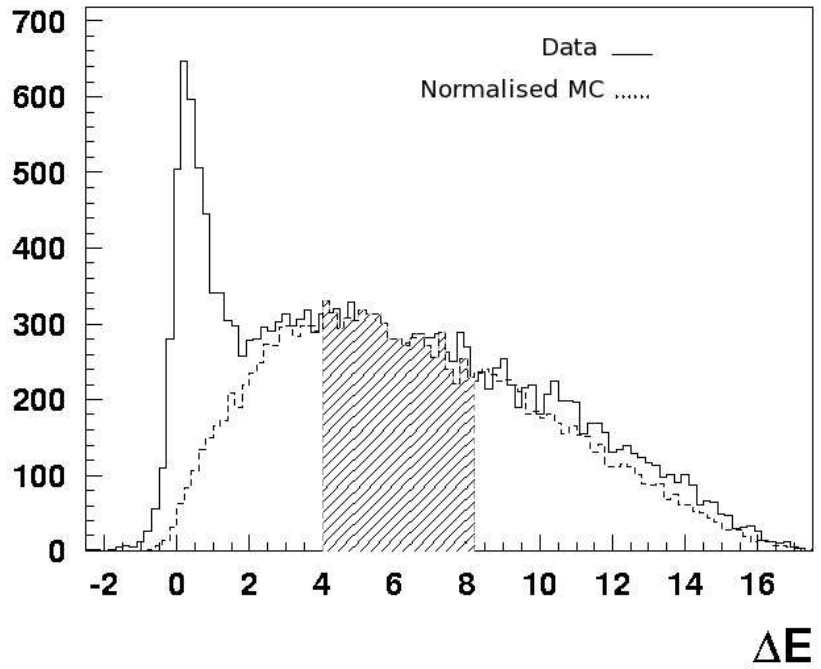

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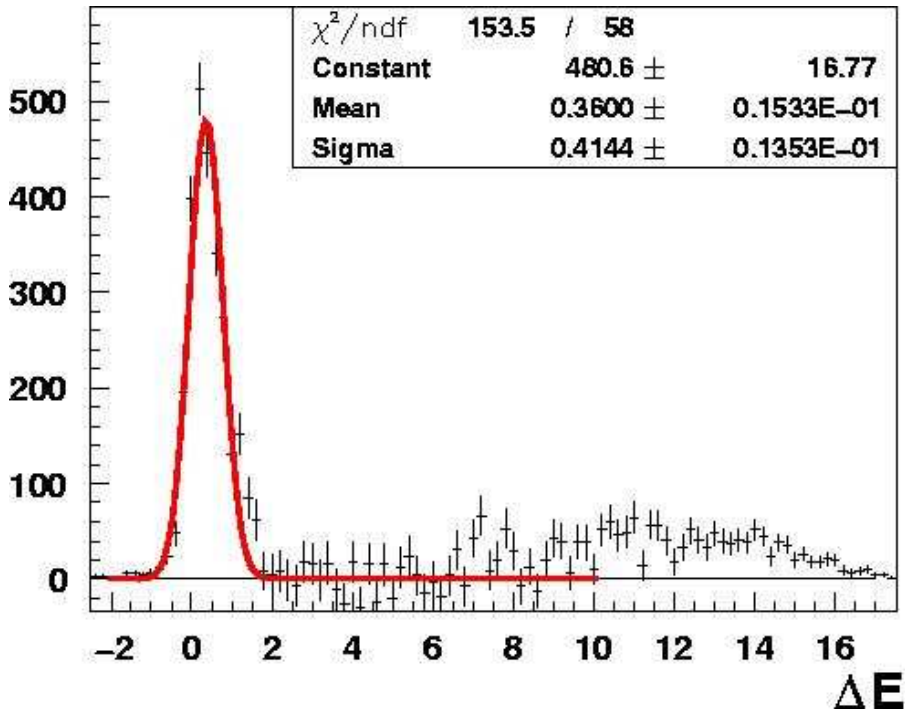
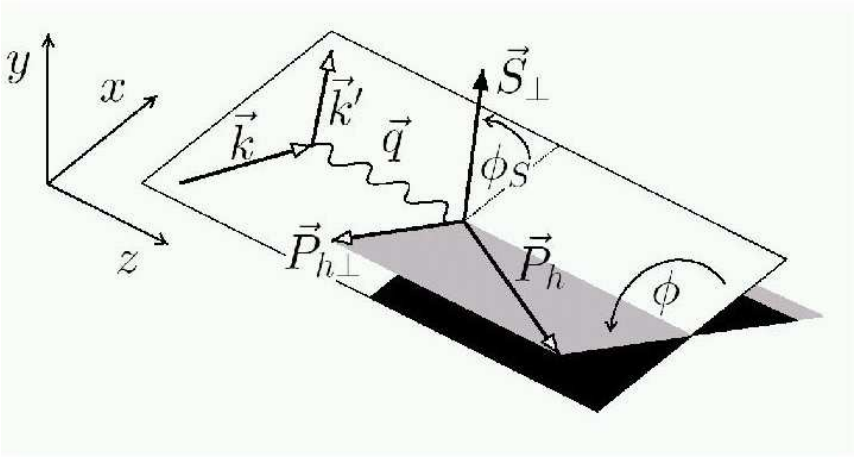


Target Spin Asymmetry A_{UT}

- Experimentally:

$$A_{UT}(\phi-\phi_S) = \frac{1}{|P|}\frac{N^{\uparrow} - N^{\downarrow}}{N^{\uparrow} + N^{\downarrow}}$$

- $A_{UT} \sim$ GPD E



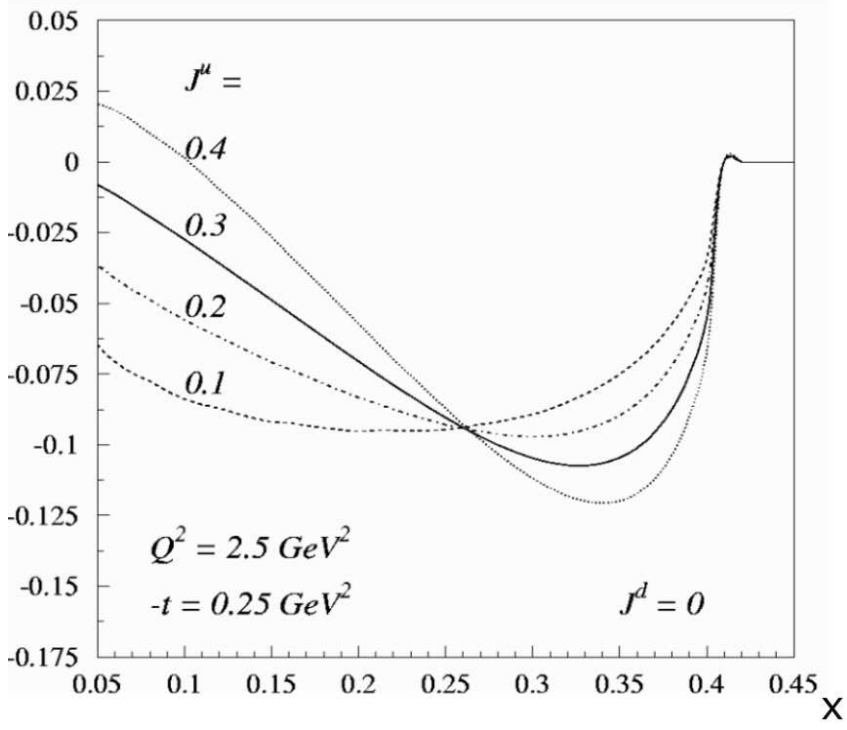
$\sin(\phi - \phi_S)$ amplitude of asymmetry: $A_{UT}^{\sin(\phi-\phi_S)}$

Target Spin Asymmetry A_{UT}

$$\mathcal{A} = \frac{1}{|S_\perp|} \frac{\int_0^\pi \sigma(\beta)\mathrm{d}\beta - \int_\pi^{2\pi} \sigma(\beta)\mathrm{d}\beta}{\int_0^{2\pi} \sigma(\beta)\mathrm{d}\beta}$$

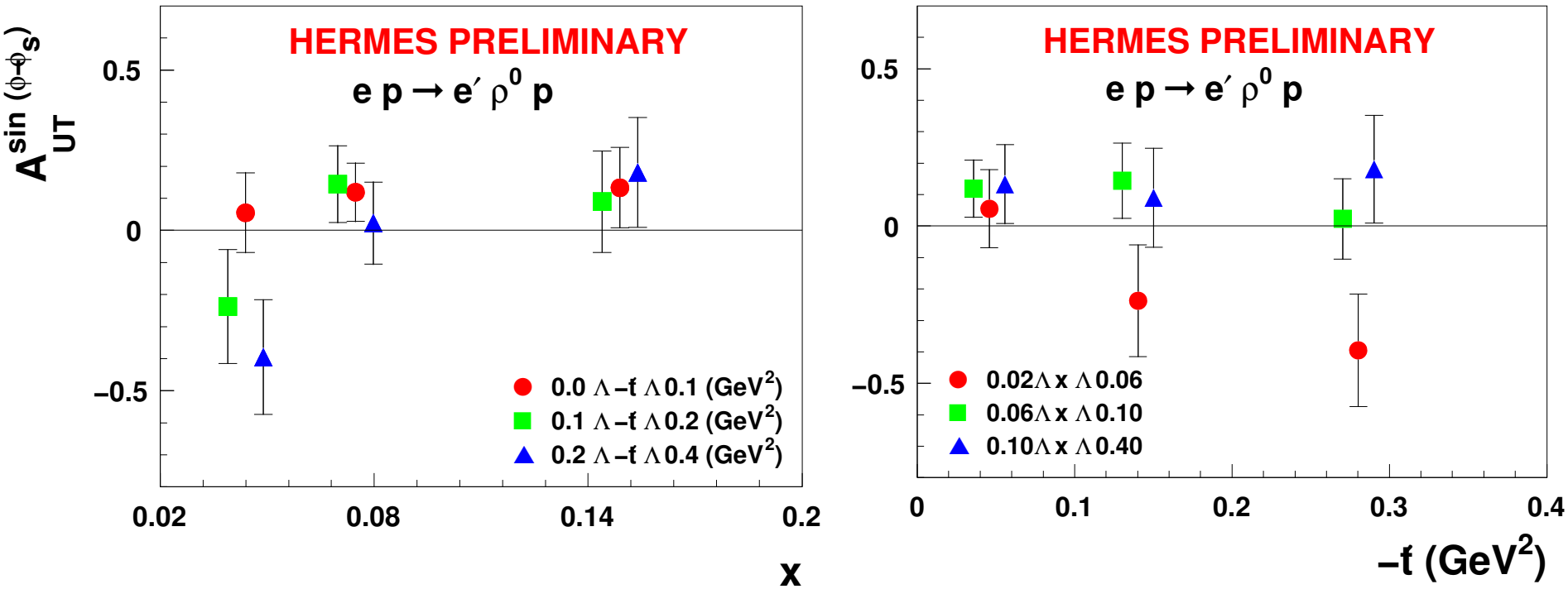
- Sensitivity to J^u
- At Hermes asymmetry slope is positive

Goeke et al., Prog. Part. Nucl. Phys. 47 (2001)



$\sin(\phi - \phi_S)$ amplitude of asymmetry $A_{UT}^{\sin(\phi-\phi_S)} \sim -\mathcal{A}$

A_{UT} for exclusive ρ^0 production

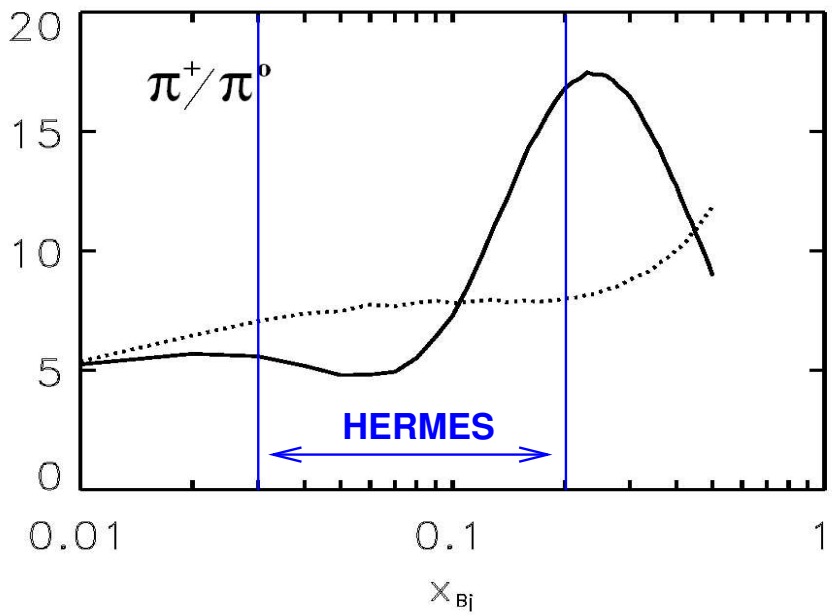


- Data consistent with theory predictions
- Increasing statistics by including all transverse data will allow for an $\sigma_L - \sigma_T$ separation

Stay Tuned !

- Exclusive π^0 production analysis ongoing
  - no pion-pole contribution
  - information about pseudovector $\tilde{H}$ only

Mankiewicz et. al.
Eur. Phys. J. C10 (1999)



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  - information about pseudovector $\tilde{H}$ only
- This fall a Recoil Detector will be installed around the target cell

Summary

1. Factorization theorem for hard exclusive processes allows GPD's to be probed
2. Cross Section for exclusive π^+ production
   - Comparison with GPD based model
   - Q^2 dependence in agreement with theory
3. First measurement of A_{UT} for exclusive ρ^0 production
4. Ongoing Analysis: A_{UT} for π^+, ratio π^+/π^0

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