Exclusive Electroproduction of Pions and Vector Mesons at HERMES

SPIN 2004,Trieste, Italy

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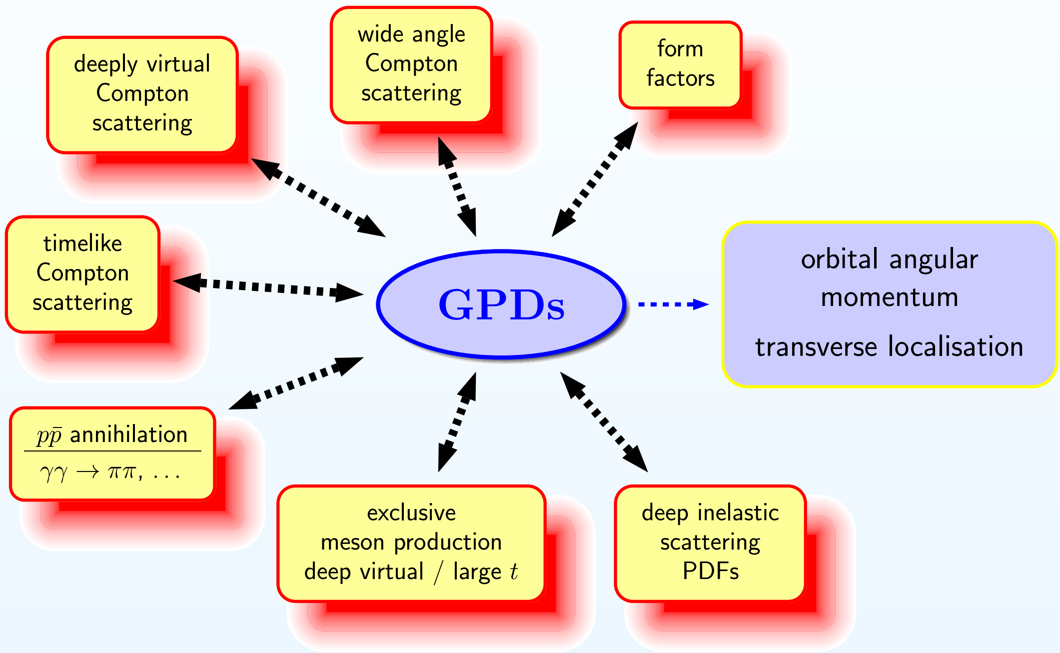
on behalf of the HERMES collaboration

(YerPhI/DESY)

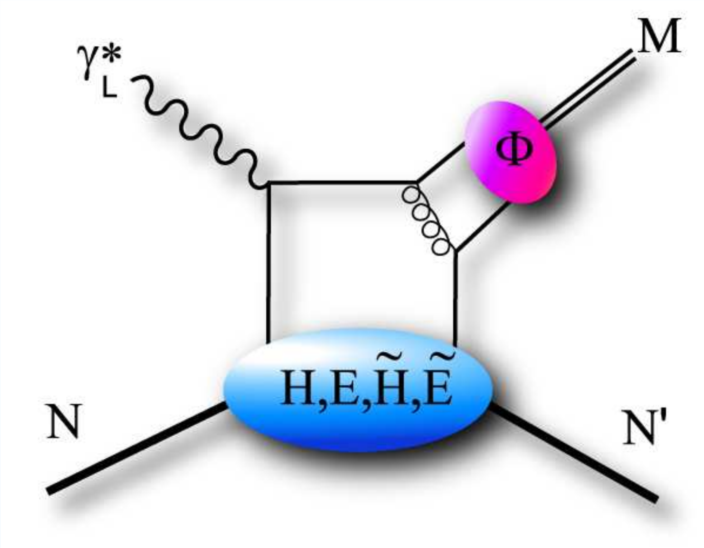
Generalized Parton Distributions (GPDs)



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

- parametrization of the *nucleon structure*
- description of *inclusive* and *hard exclusive* processes
- related to the sum of *quark spins* and *quark angular momenta*
- *transverse distribution* of quarks inside the nucleon

Factorization theorem for meson production



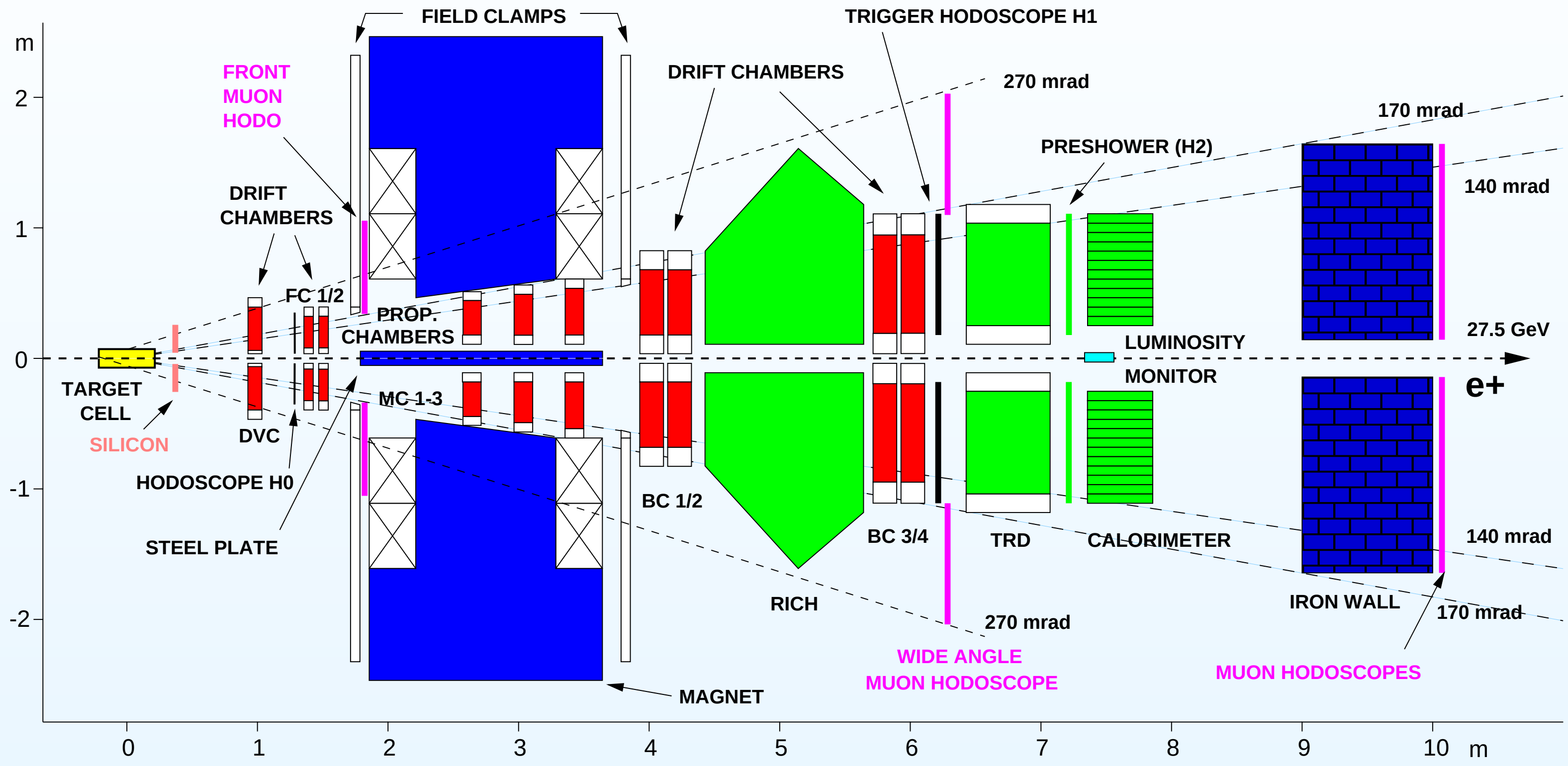
-Collins, Frankfurt, Strikman (1997)

$\longrightarrow$ 4 Generalized Parton Distributions

H	$\widetilde{H}$
E	$\widetilde{E}$
$\downarrow$	$\downarrow$
unpolarized	polarized

- Quantum numbers of final state selects different GPDs
  - vector mesons (ρ, ω, ϕ): unpolarized GPDs H E
  - pseudoscalar mesons (π, η): polarized GPDs $\widetilde{H}\,\widetilde{E}$
- Factorization for longitudinal photons only
- $\frac{d\sigma_L}{dt} \to \frac{1}{Q^6} \qquad \frac{\sigma_T}{\sigma_L} \sim \frac{1}{Q^2}$

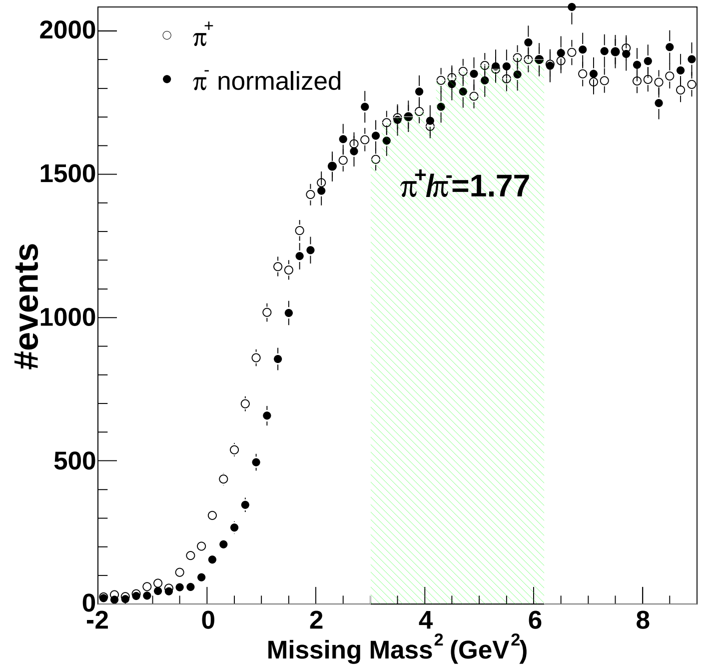
The spectrometer



- fixed target experiment
- forward spectrometer
- no recoil detection

Exclusivity for $ep \longrightarrow e'\pi^+(n)$

$ep \longrightarrow e\pi^+ X$



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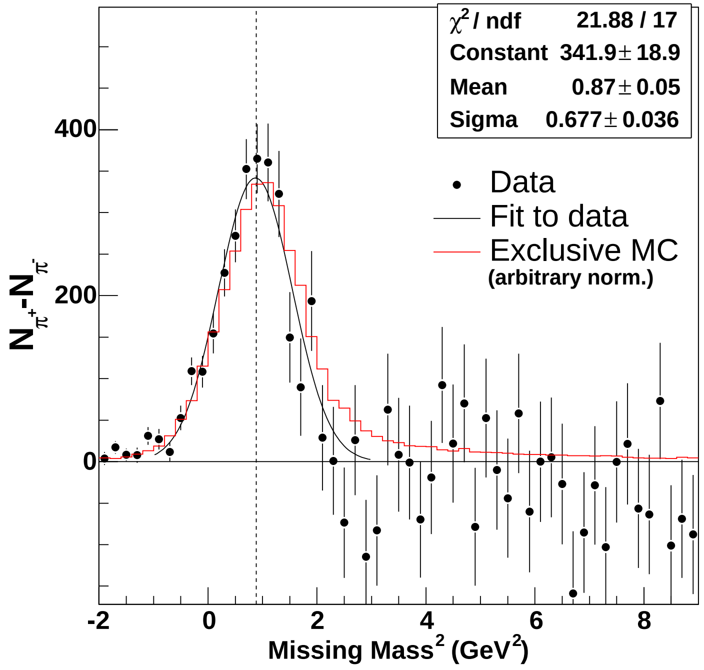

- π^- yield was used to subtract the non exclusive background

- exclusive peak centered at the nucleon mass
- MC is based on GPD model

Cross-section determination

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

$\rightarrow \kappa(x, Q^2)$:detection probability was calculated using VGG exclusive MC

-Vanderhaeghen,Guichon,Guidal (1999)-

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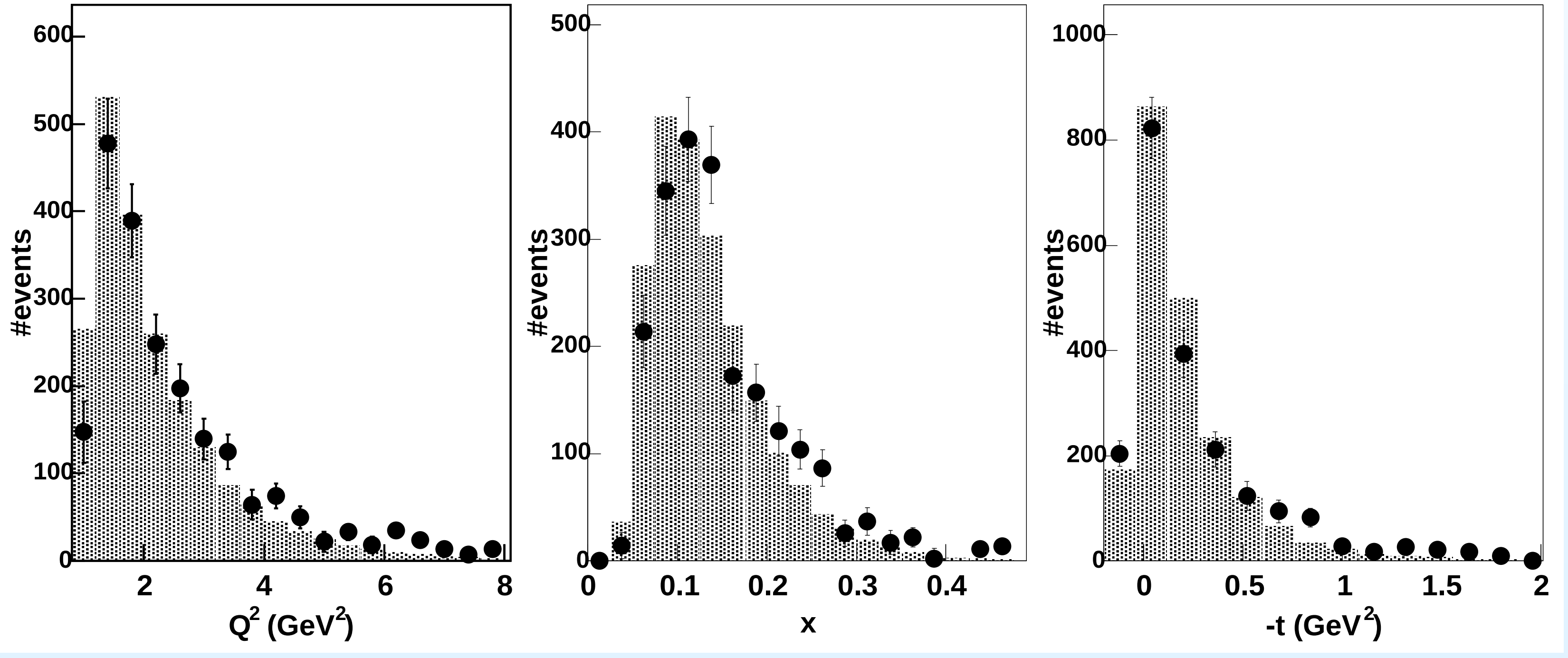

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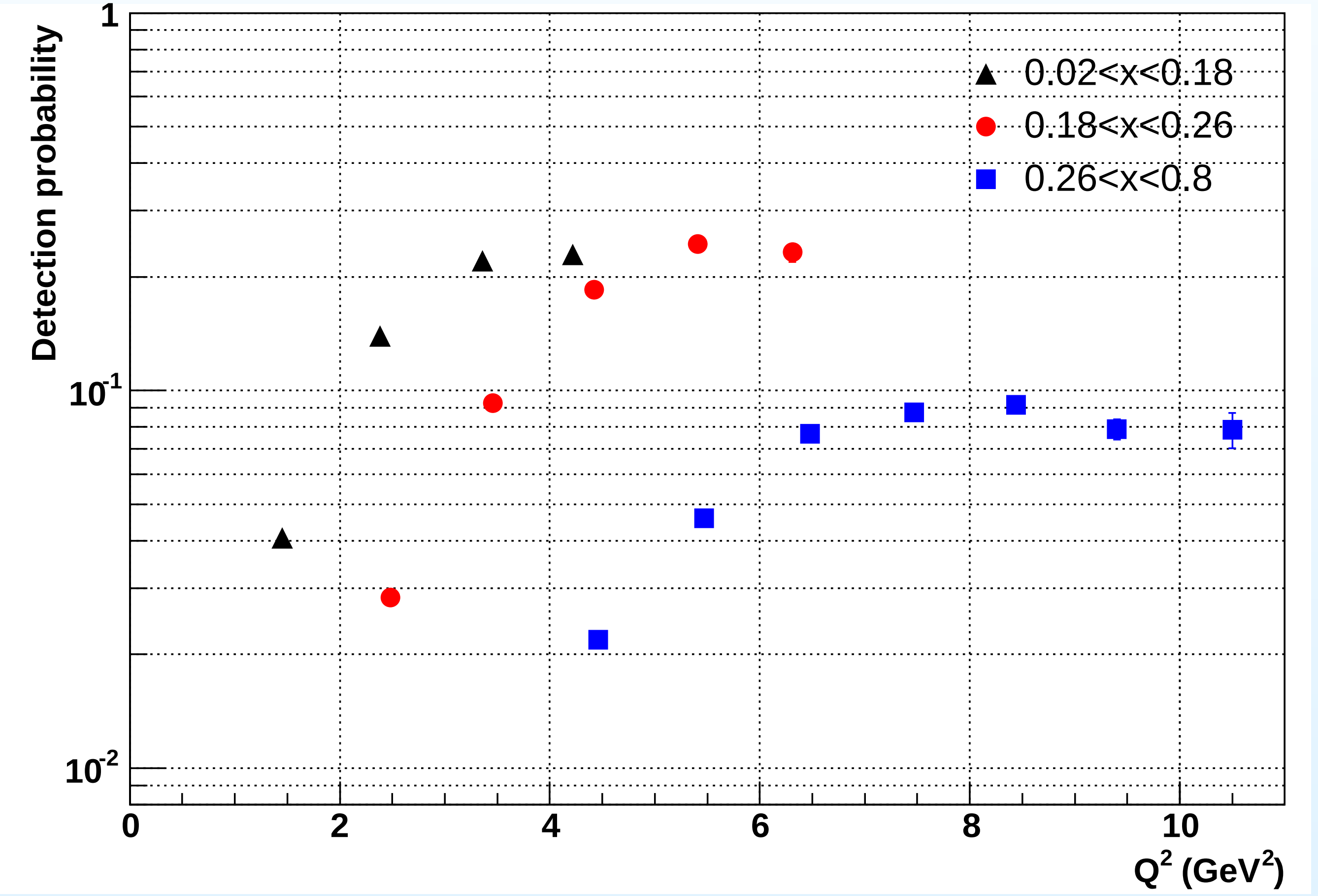
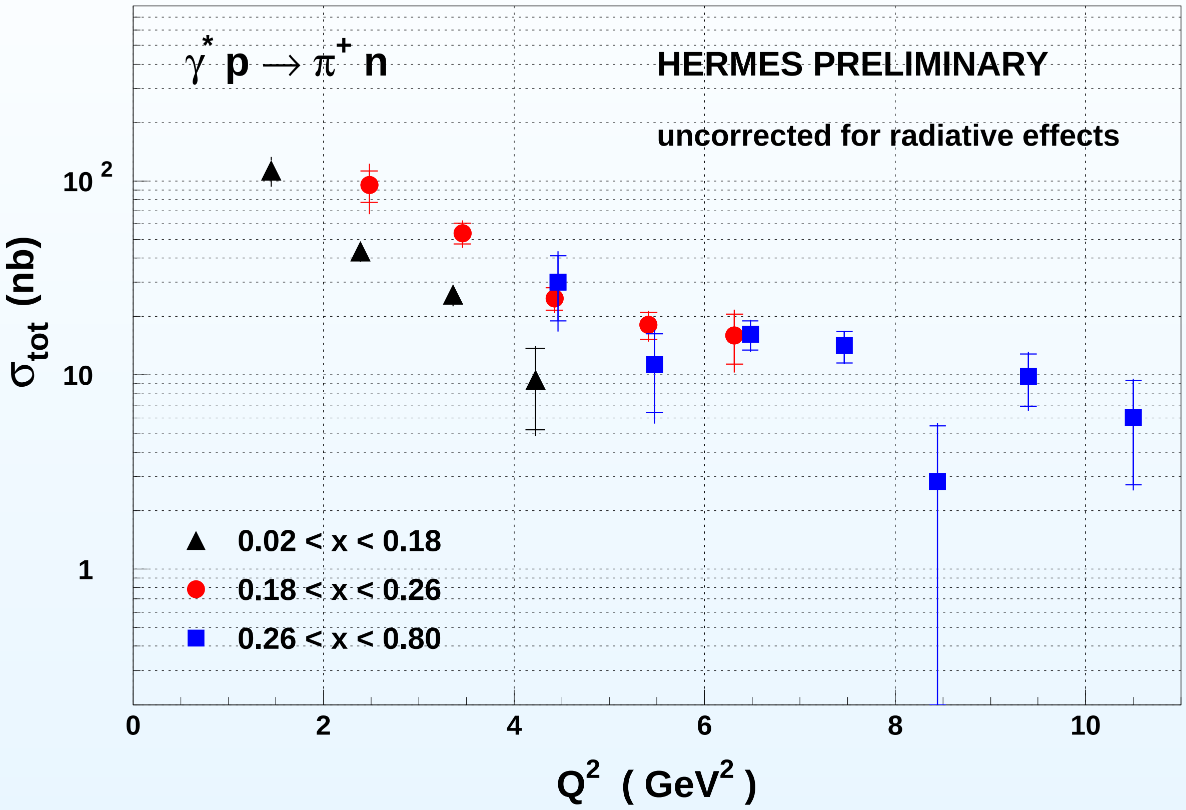


Cross-section: Q^2 dependence for different x ranges



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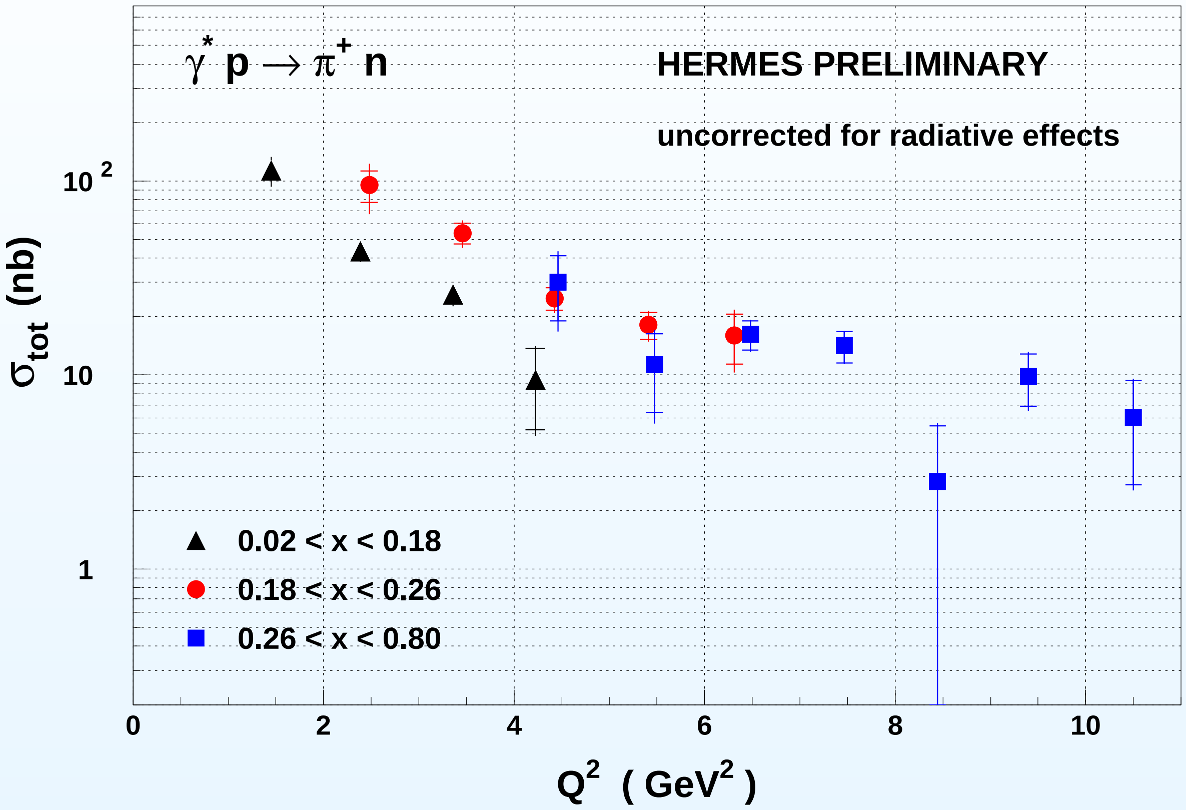

$$\sigma_{tot} = \sigma_T + \epsilon \sigma_L$$

- L/T separation not possible
- **BUT** σ_T suppressed by $1/Q^2$
- for HERMES kinematics: $0.80 < \epsilon < 0.96$

σ_L dominates at large Q^2

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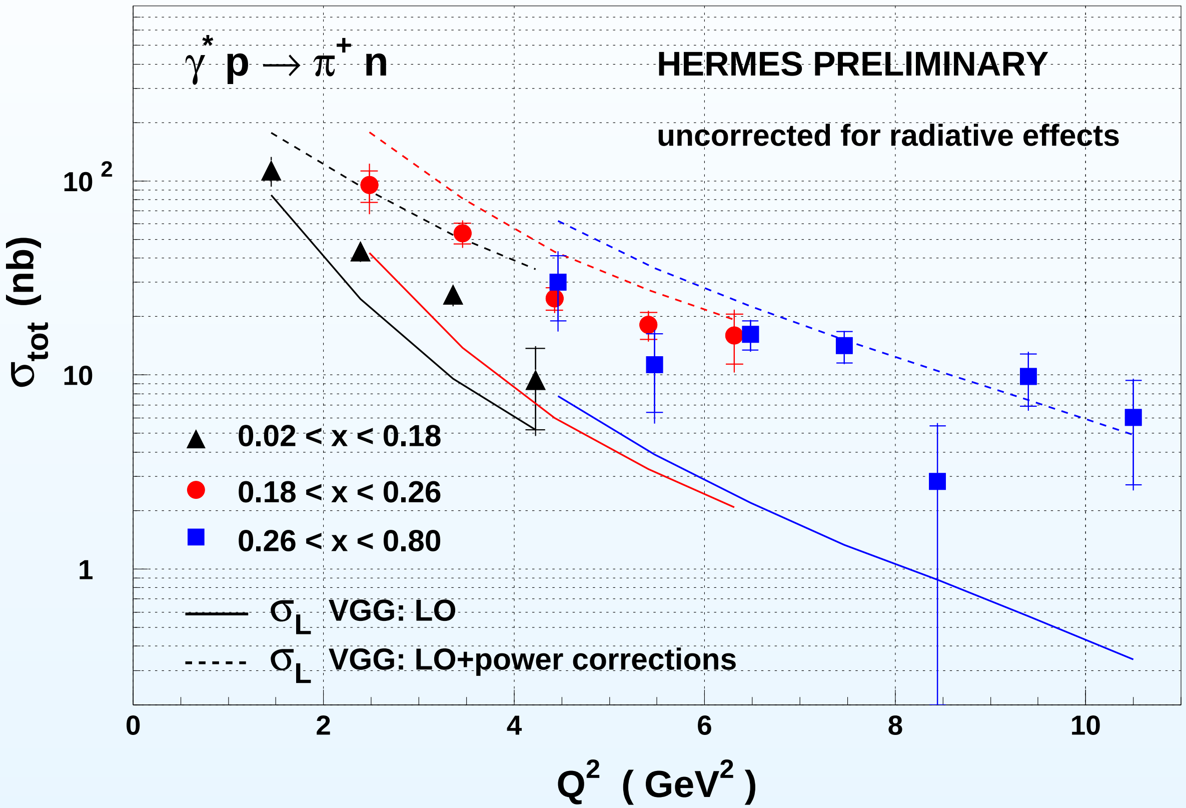

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$\Downarrow$

access to $\tilde{H}$ and $\tilde{E}$

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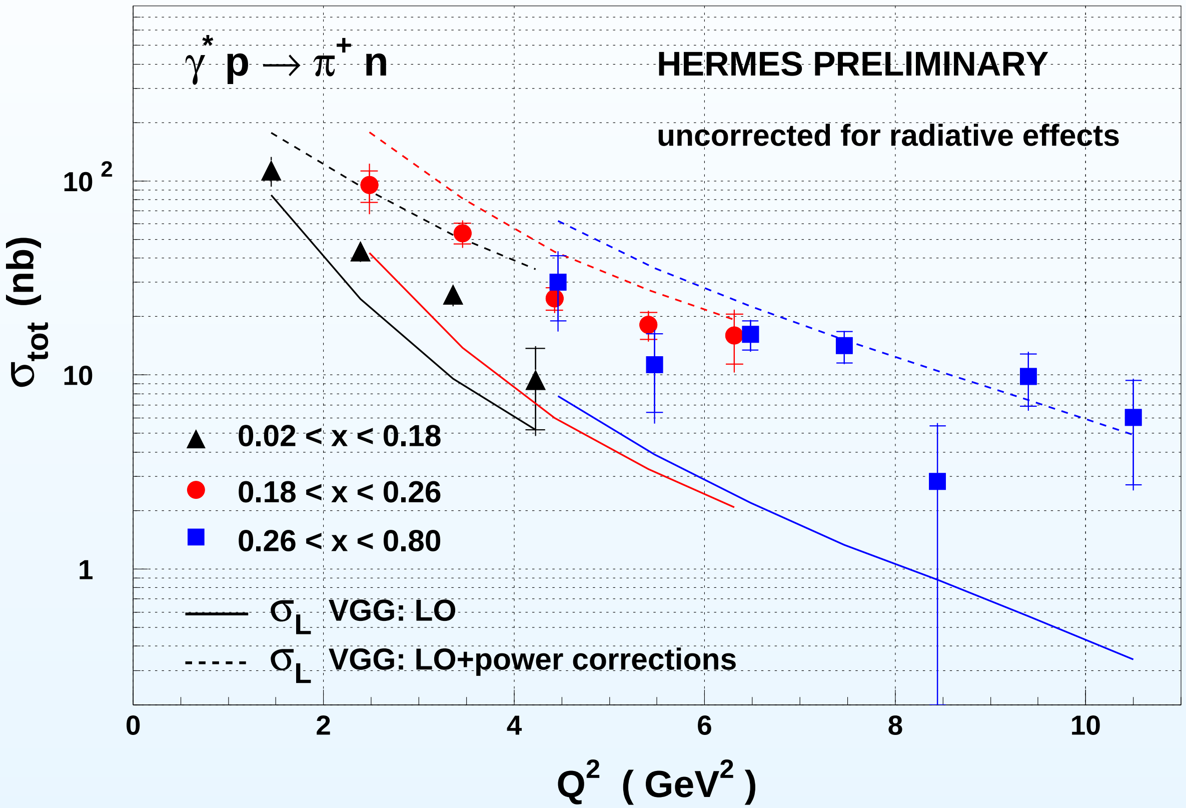

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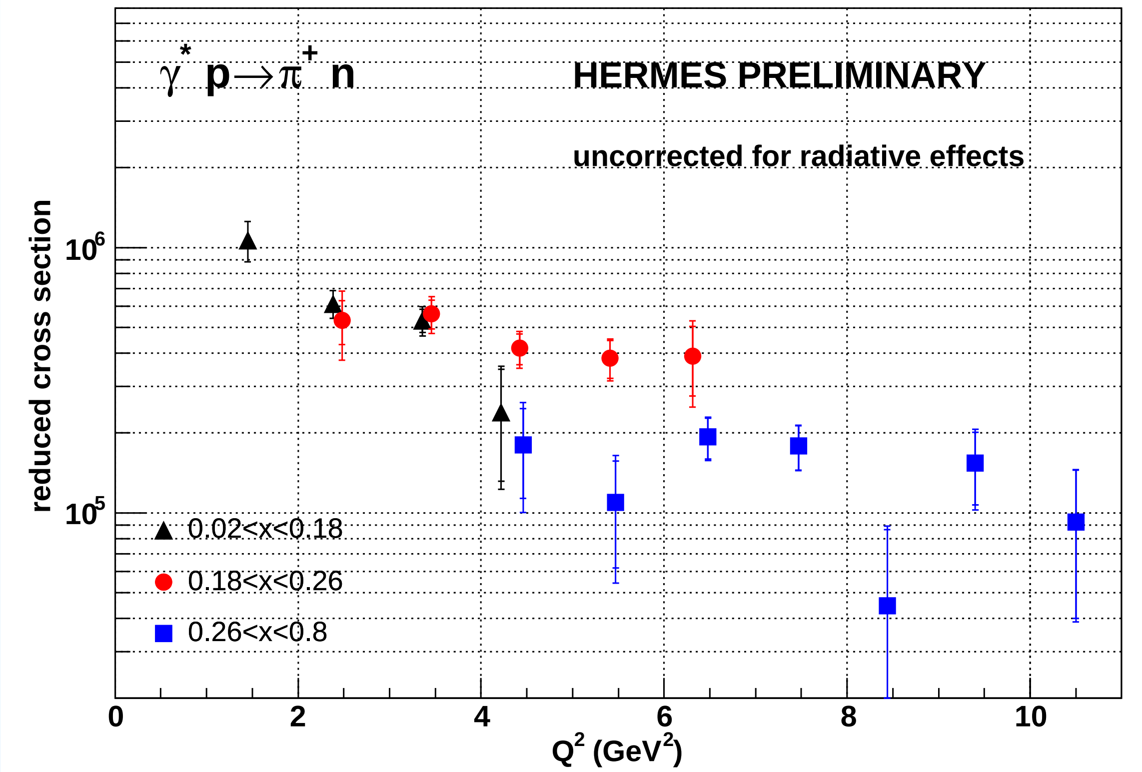
access to $\tilde{H}$ and $\tilde{E}$

$\Longrightarrow$ LO calculations underestimate the data

$\Longrightarrow$ Evaluation of the power correction appears too large

Q^2 dependence and theoretical expectations

Factorization theorem: $\sigma_L \rightarrow 1/Q^6$



$$\sigma_L = \text{Kin Factor} * \sum_{\text{spins}} |M|^2$$

$$\text{Kin Factor} \downarrow 1/Q^4 \qquad \sum_{\text{spins}} |M|^2 \downarrow 1/Q^2$$

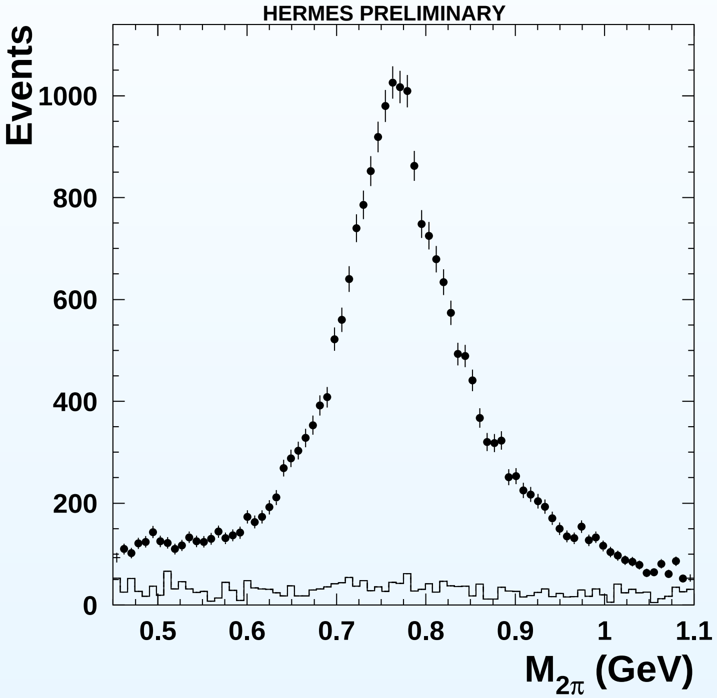
fit: $1/Q^p$

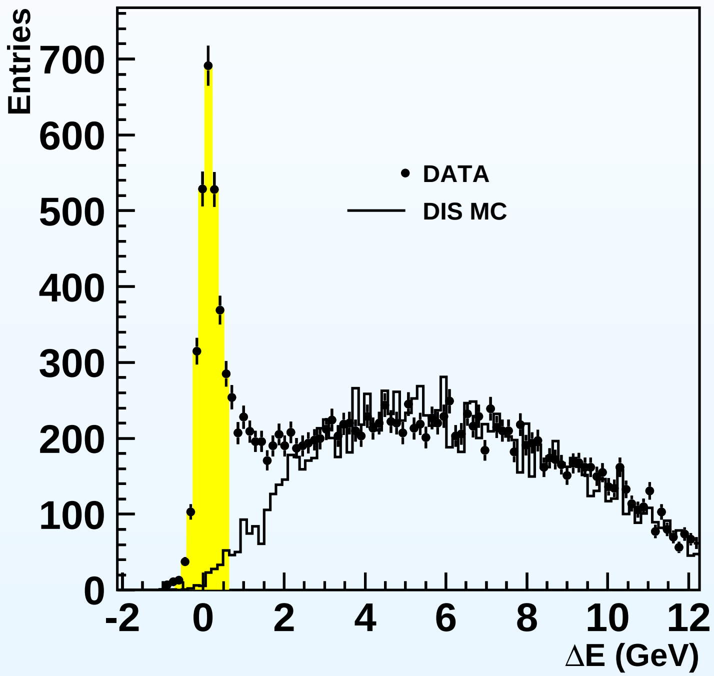
$$p = 1.9 \pm 0.5$$
$$p = 1.7 \pm 0.6$$
$$p = 1.5 \pm 1.0$$

$\rightarrow$ Q^2 dependence is in agreement with theoretical expectation

Kinematics

$\rho^0 \to \pi^+\pi^- \Longrightarrow$





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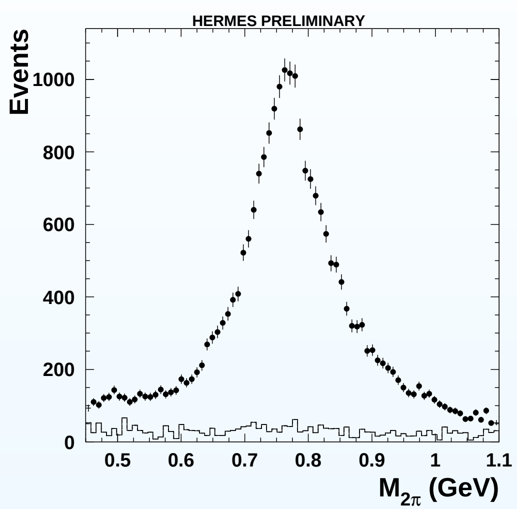
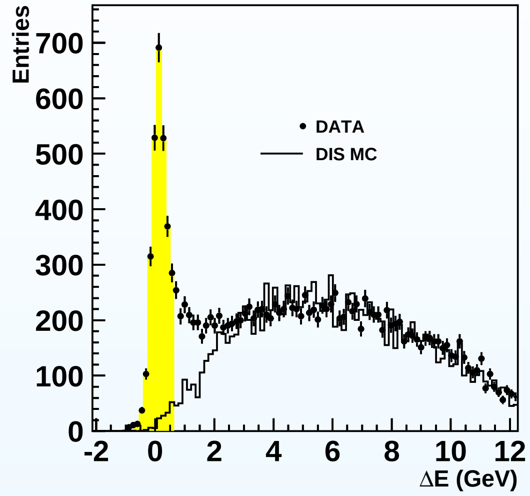
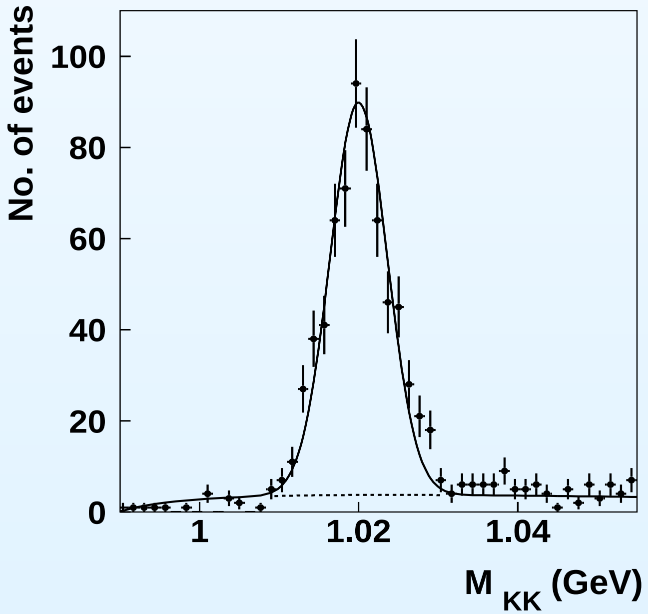
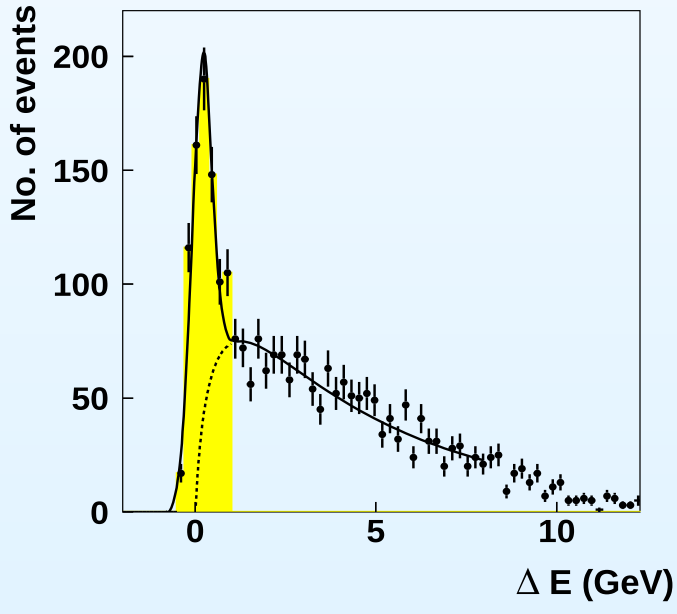




$\phi \to K^+K^- \Longrightarrow$





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

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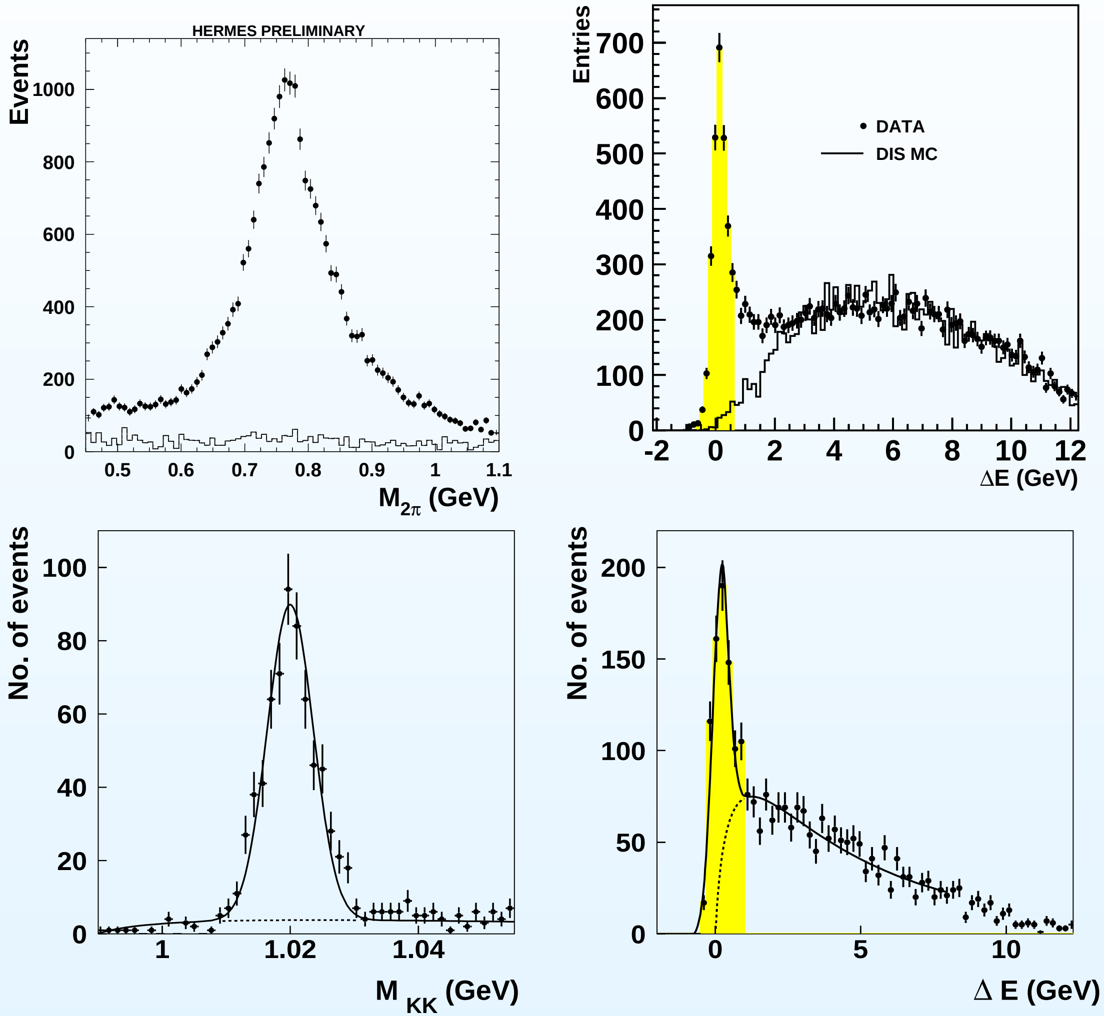

→ good determination of exclusive channels

→ background well described by Monte Carlo

σ_L/σ_T separation

- GPD calculations related to longitudinal component of cross section (σ_L).

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

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

ϵ – polarization of γ^*

- assuming SCHC

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

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

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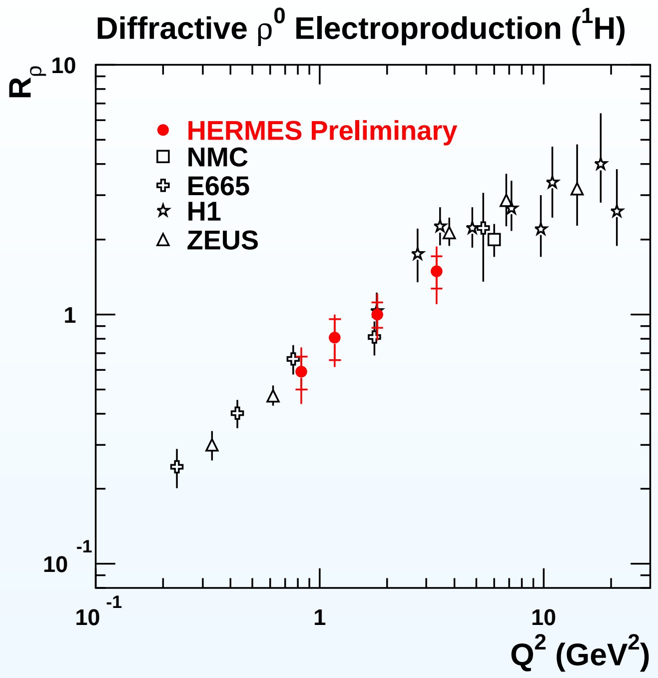

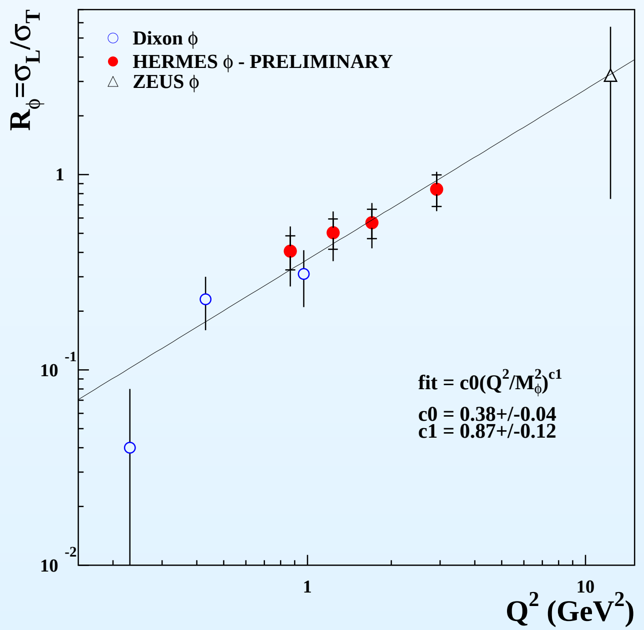

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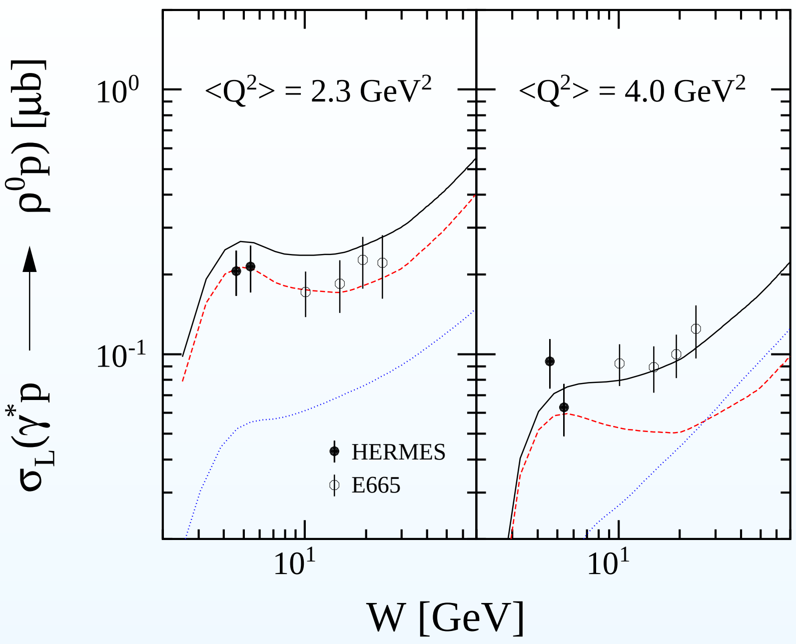
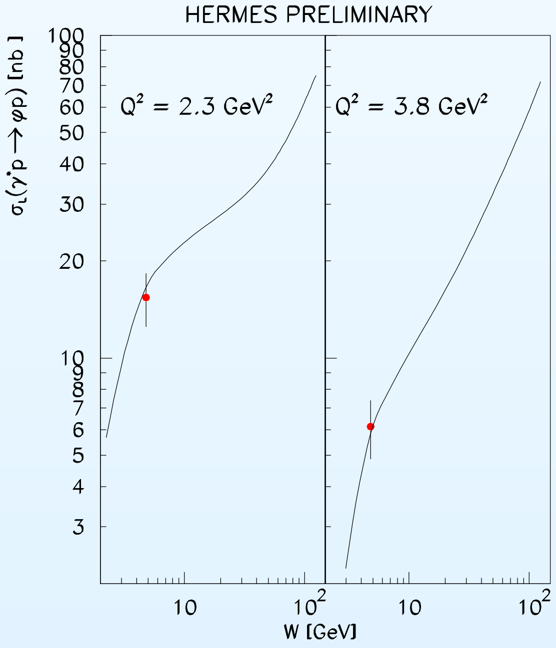
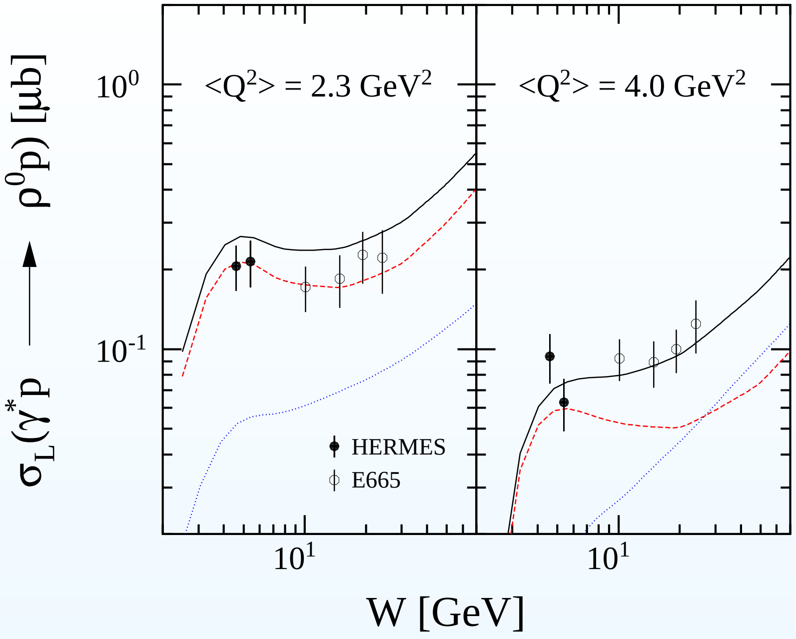


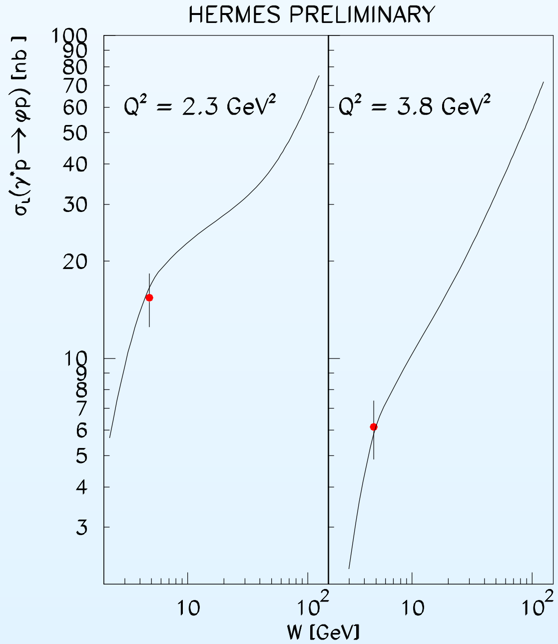


σ_L/σ_T separation

dominated by quark exchange ⟸

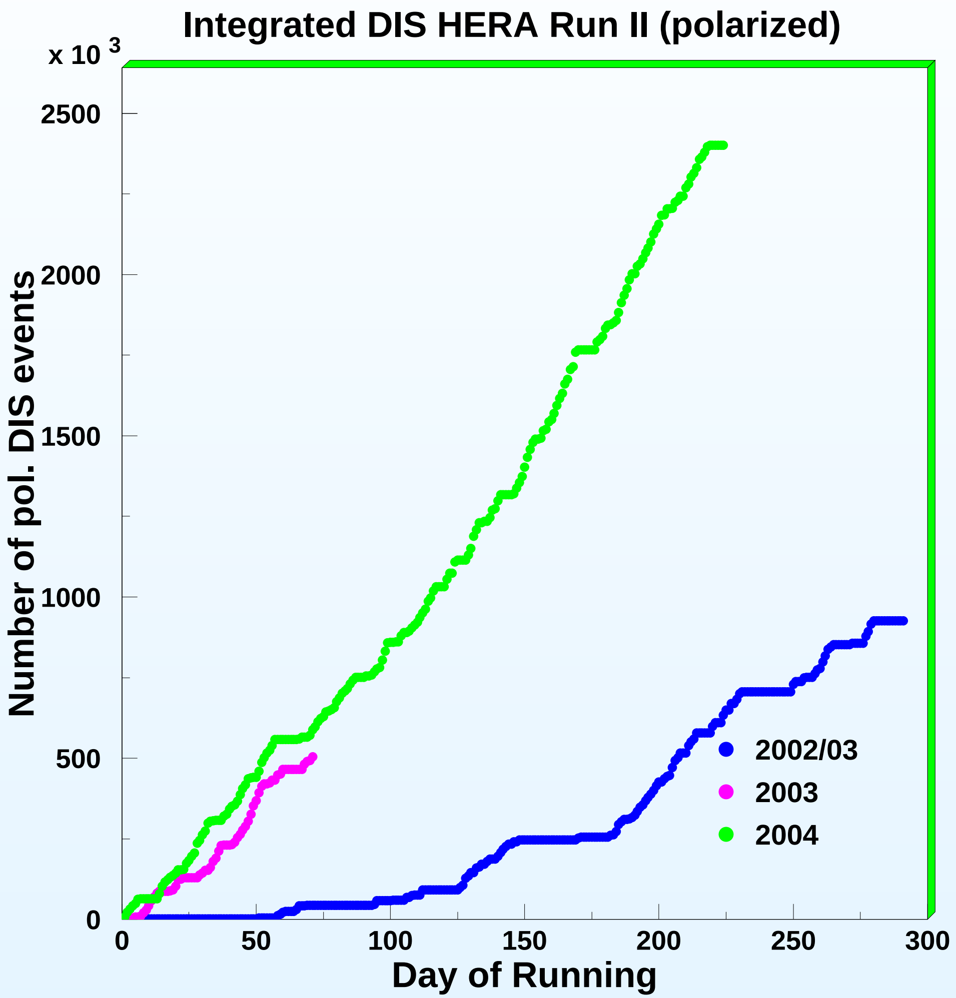


gluon exchange ⟸



-Vanderhaeghen,Guichon,Guidal (1999)-

Future...



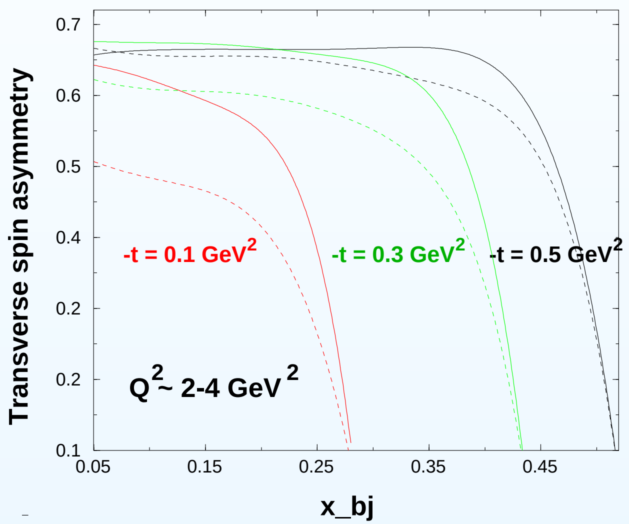
2002-2007: run with a transversely polarized target

2002-2004: we already have

$\mathbf{6}$M	DIS
$\mathbf{1.5}$k	exclusive π^+
$\mathbf{5}$k	exclusive ρ^0

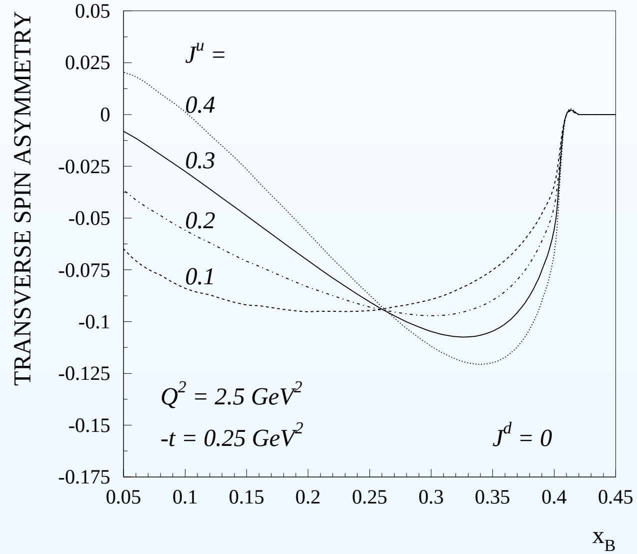
Transverse spin asymmetry of exclusive π^+ and ρ^0

$ep \longrightarrow e\pi^+ n$



-Frankfurt,Polyakov,Strikman,Vanderhaeghen (2000)-

$\gamma^*_L + p \rightarrow \rho^0_L + p$



-Goeke,Polyakov,Vanderhaeghen (2001)-

- $\sigma : |S_T| sin\Phi \widetilde{E}\widetilde{H}$
- $A_{UT} : E$
- $E \rightarrow 2J^u + J^d$

- the scaling region is reached at low Q^2
- not sensitive to NLO corrections

Outlook

- The cross section for exclusive π^+ and ρ^0 was extracted and compared to model calculations
- Future analysis:
  - ⊛ transverse target spin asymmetry of exclusive π^+ and ρ^0
- With recoil detector it will be possible to increase the statistics starting from 2005