Exclusive π^+ production at HERMES

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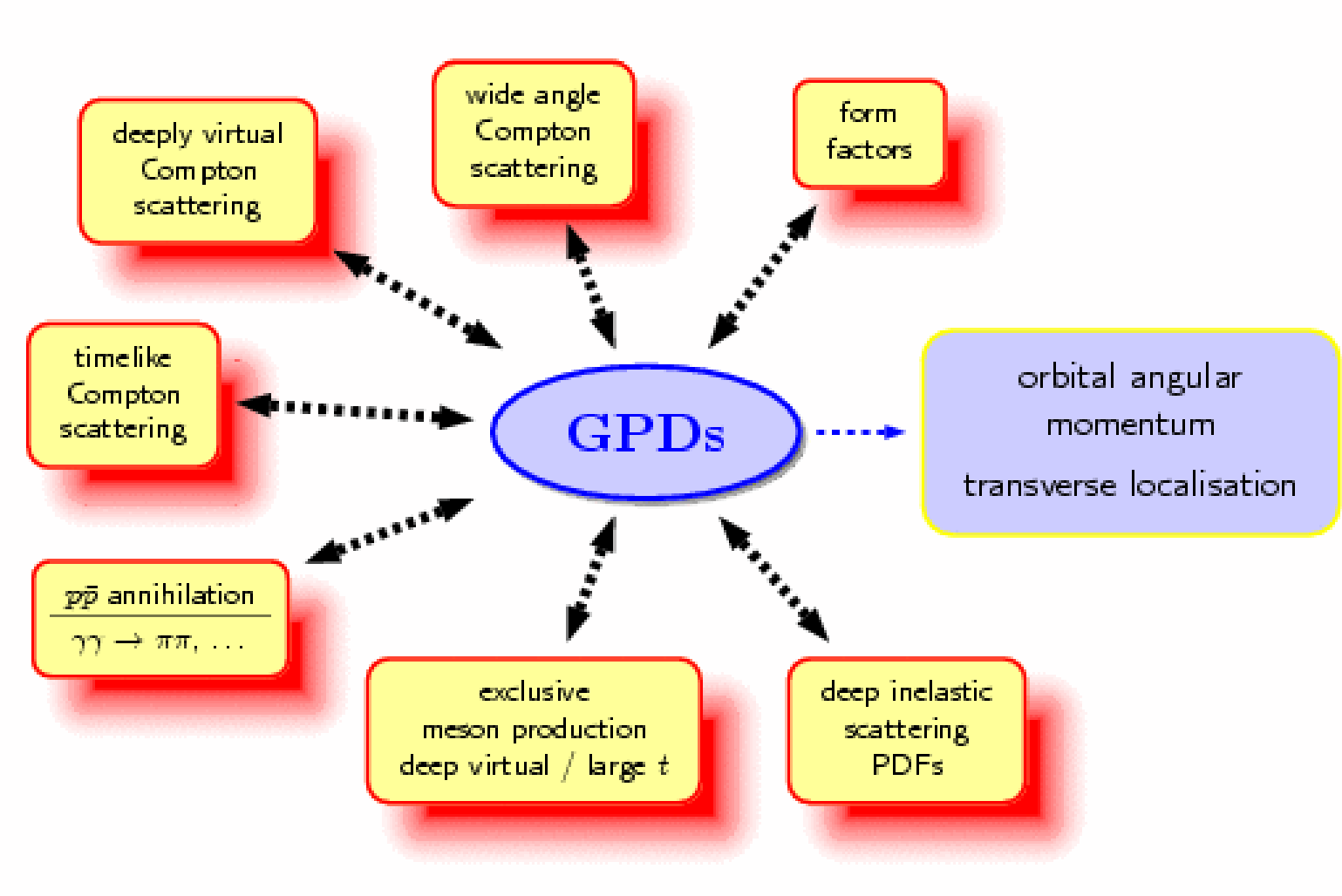
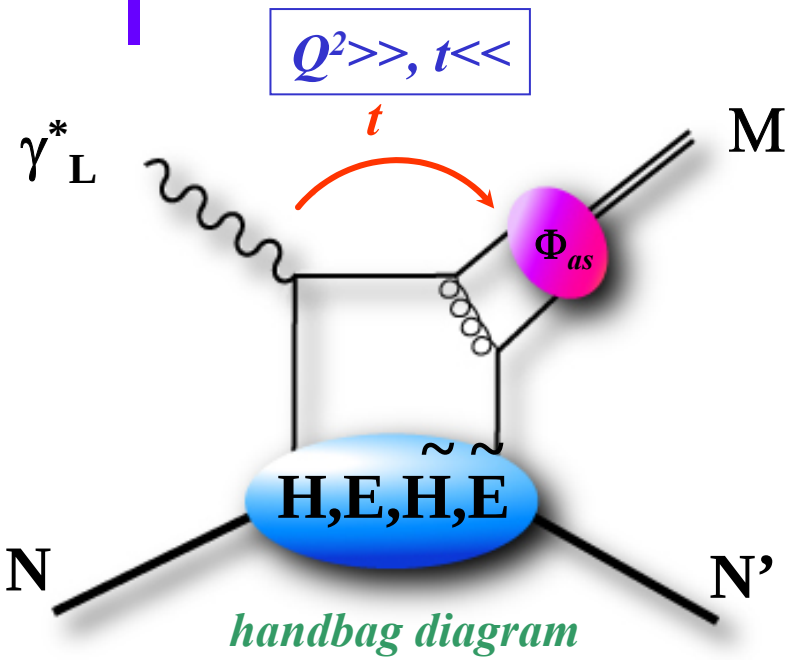
- ✓ Generalized Parton Distributions
- ✓ Exclusive π^+ production at HERMES
- ✓ Target spin asymmetry and cross section measurements

Generalized Parton Distributions (GPDs)



Factorization theorem for meson production



handbag diagram

- Müller (1994) -
- Ji & Radyushkin (1996) -
- Collins, Frankfurt & Strikman (1997) -

→ 4 **G**eneralized **P**arton **D**istributions (**GPDs**)

H $\tilde{H}$ conserve nucleon helicity

E $\tilde{E}$ flip nucleon helicity

H, E ↓ unpolarized; $\tilde{H}$, $\tilde{E}$ ↓ polarized

→ Quantum number of final state selects different GPDs

Vector mesons (ρ, ω, ϕ): unpolarized GPDs H E

Pseudoscalar mesons (π, η): polarized GPDs $\tilde{H}$ $\tilde{E}$ (pion pole)

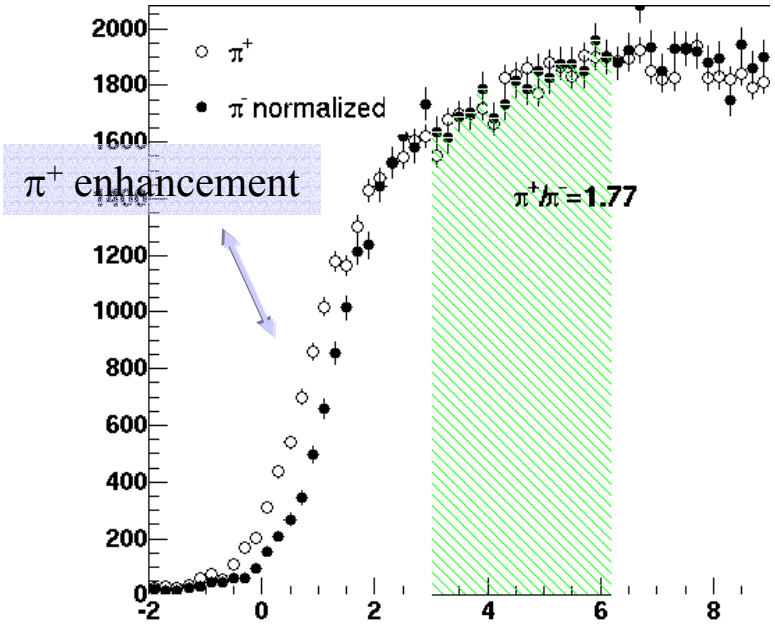
→ Factorization for longitudinal photons only

→ $\frac{d\sigma_L}{dt}$ *asymptotically* → *for fixed* x_B *and* t $\frac{1}{Q^6}$

Exclusivity for e p → e π^+(n)

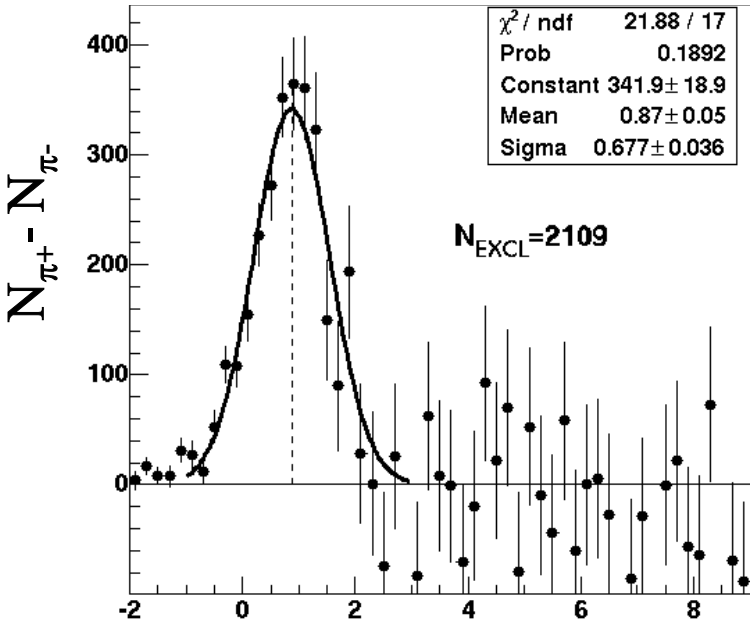
Detection: e, π^+ (recoil neutron)
Missing Mass technique: Missing Mass^2 = (e+p-e'-π^+)^2
Use of π^- yield to subtract the non exclusive background

e p → e π^+ **X**



Missing Mass ^{2} (GeV^2)

e p → e π^+ **n**

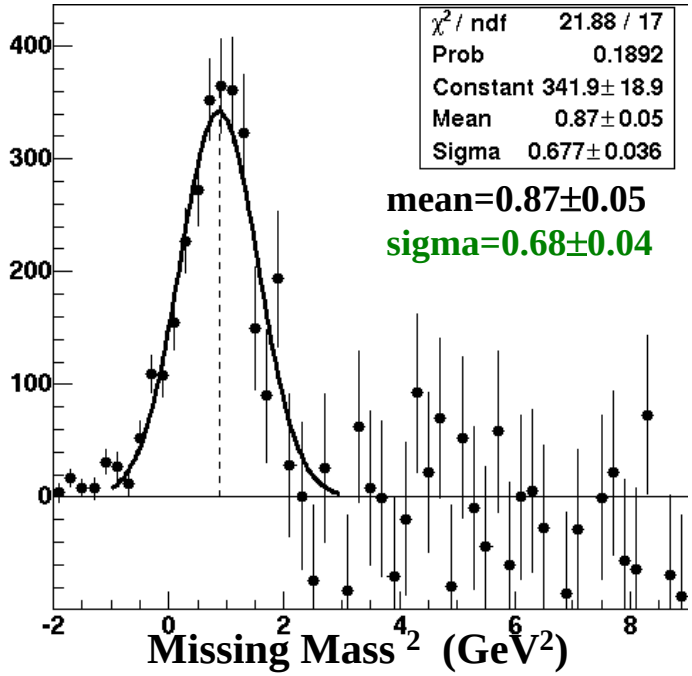


Missing Mass ^{2} (GeV^2)

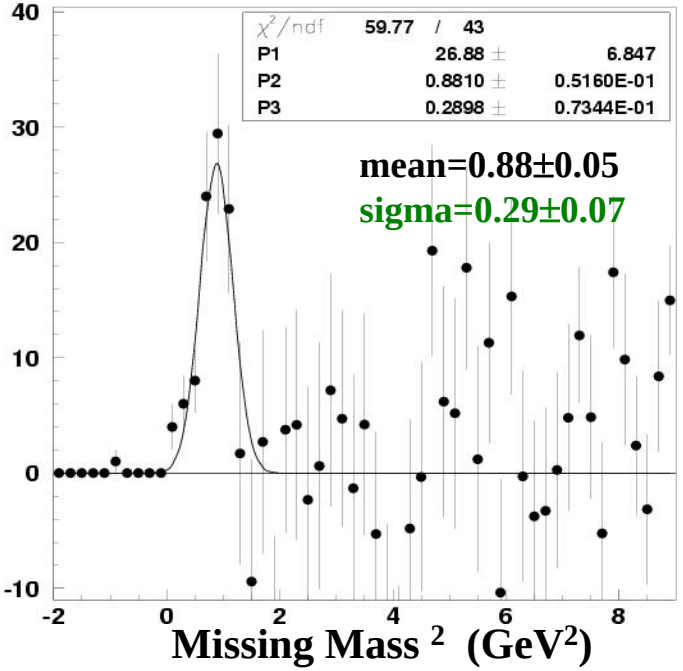
Exclusive peak clearly centered at the nucleon mass

Exclusivity for e p → e π^+(n)

E_e=27.5 GeV



E_e=12 GeV



→ For different beam energy, same exclusive peak at the nucleon mass

→ L/T separation not possible $\sigma_{tot} = \sigma_T + \varepsilon\, \sigma_L$

Hermes kinematics: $\varepsilon > 0.80$

σ_T suppressed by $1/Q^2$ → at large Q^2, σ_L dominates

Cross section determination

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

L	integrated luminosity
$\Delta x \Delta Q^2$	range in Q^2 and x
$\Gamma(x,Q^2)$	virtual photon flux factor

→ N^{excl} number of π^+ background subtracted

1996-2000: hydrogen target (unpolarized and polarized)

14.2 M DIS events - 3500 exclusive π^+

→ $\kappa(x,Q^2)$: detection probability

using 2 exclusive MC (different GPD parameterization)

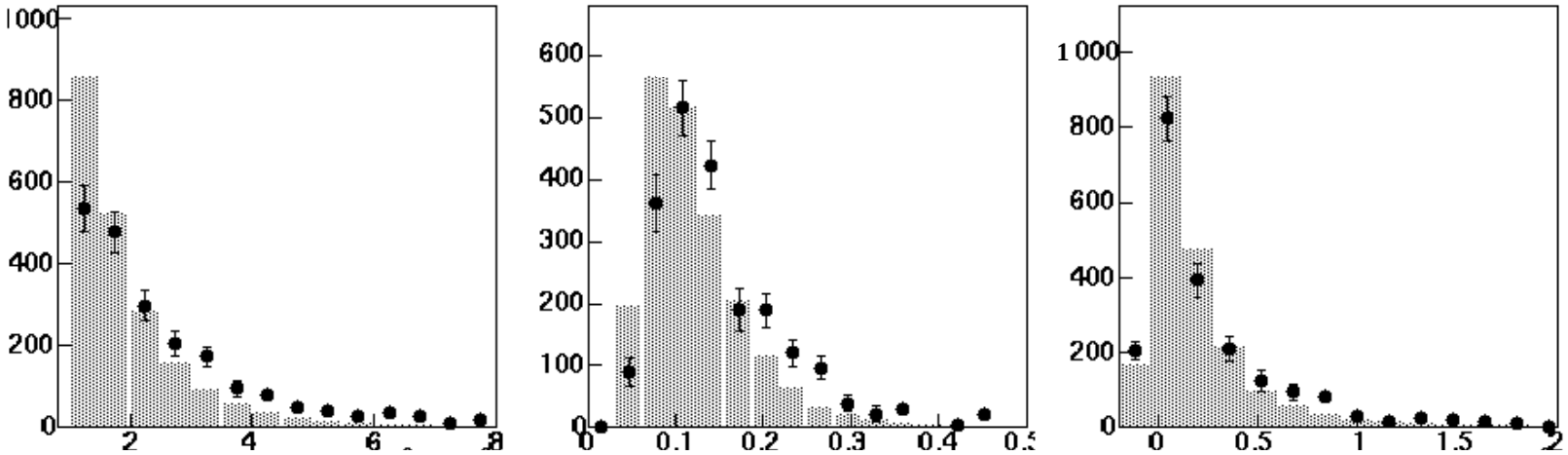
- Mankiewicz, Piller & Radyushkin (1999) -

- Vanderhaeghen, Guichon & Guidal (1999) -

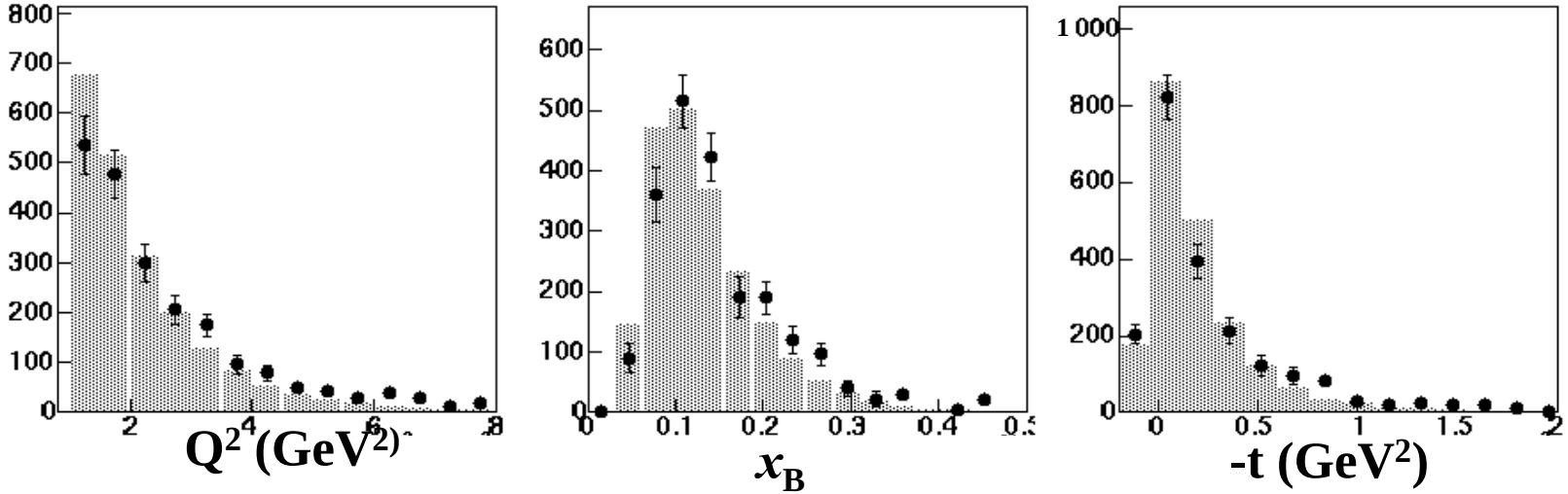
Monte Carlo

- Data distributions background subtracted
- Monte Carlo - arbitrary normalization

- Mankiewicz, Piller & Radyushkin (1999) -



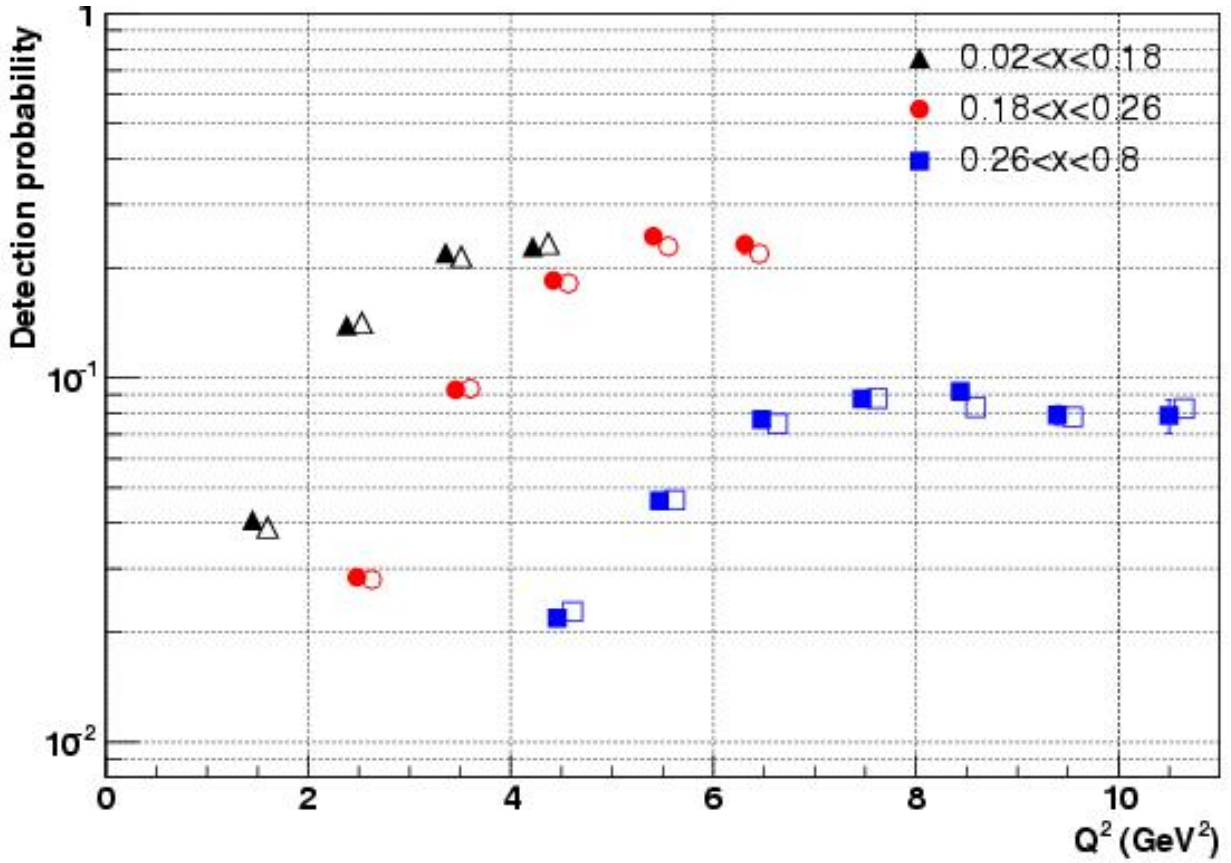
- Vanderhaeghen, Guichon & Guidal (1999) -



Detection probability

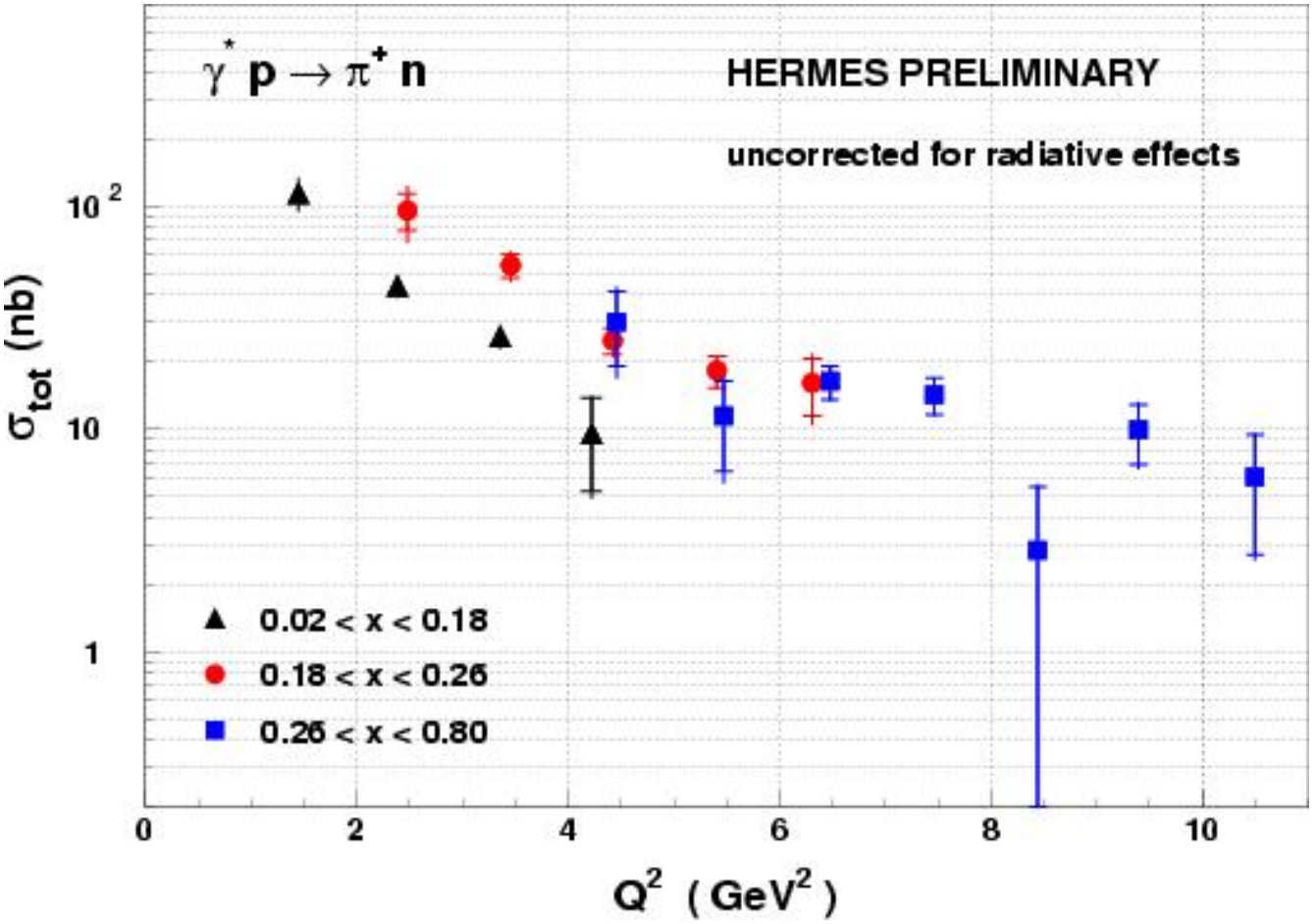
probability to detect e and π+ (generated in 4π) with the Hermes detector

- o *- Mankiewicz, Piller & Radyushkin (1999) -*
- ● *- Vanderhaeghen, Guichon & Guidal (1999) -*



→ Systematic error ~ 5% (< 10 %)

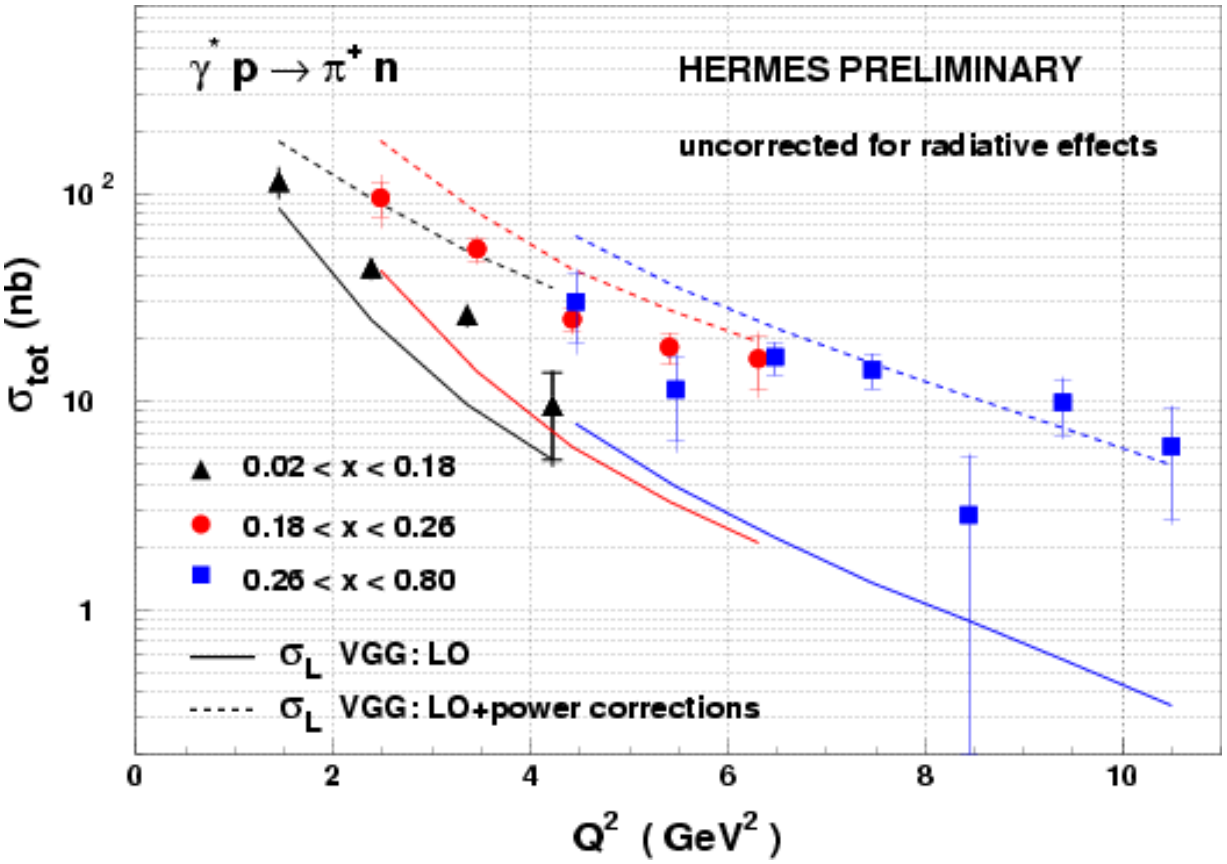
Cross section: Q^2 dependence @ fixed x



→ First measurements for Q^2 dependence at fixed x

Cross section: comparison with model

No L/T separation but σ_T suppressed by $1/Q^2$ and $\varepsilon > 0.8$



-Vanderhaeghen, Guichon & Guidal (1999) -

π production:

$\tilde{H}$ pseudovector contribution

$\tilde{E}$ pseudoscalar contribution

(pion pole related to F_π)

→ Q^2 dependence is in general agreement with the theoretical expectation

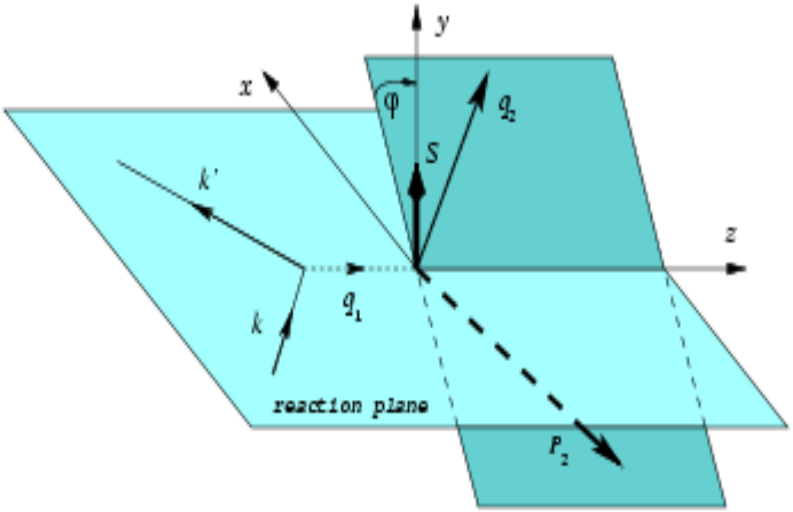
→ Power correction calculations overestimate the data

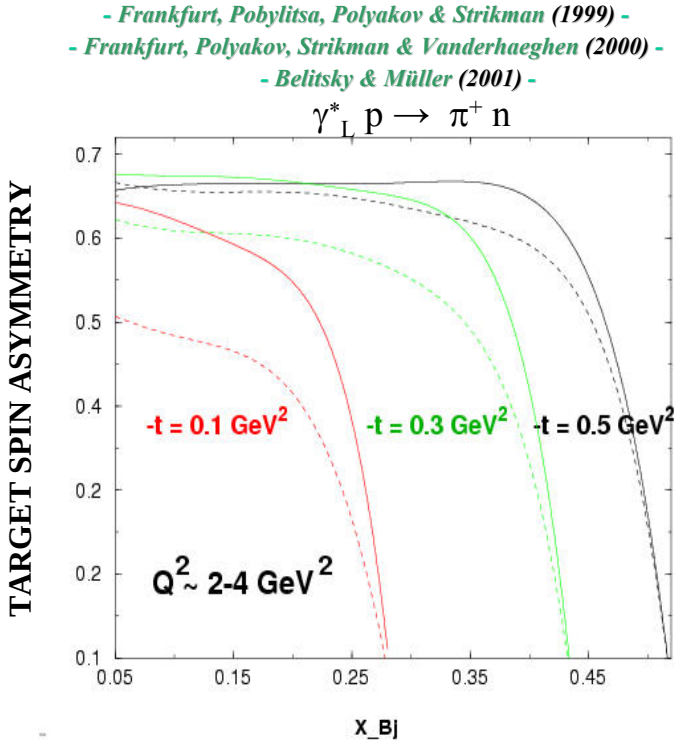
Asymmetry measurement for e p → e π^+ n

Transverse target spin asymmetry

interference between $\tilde{E}$ and $\tilde{H}$

σ_S: $|S_T| \sin\Phi \; \tilde{E} \; \tilde{H}$



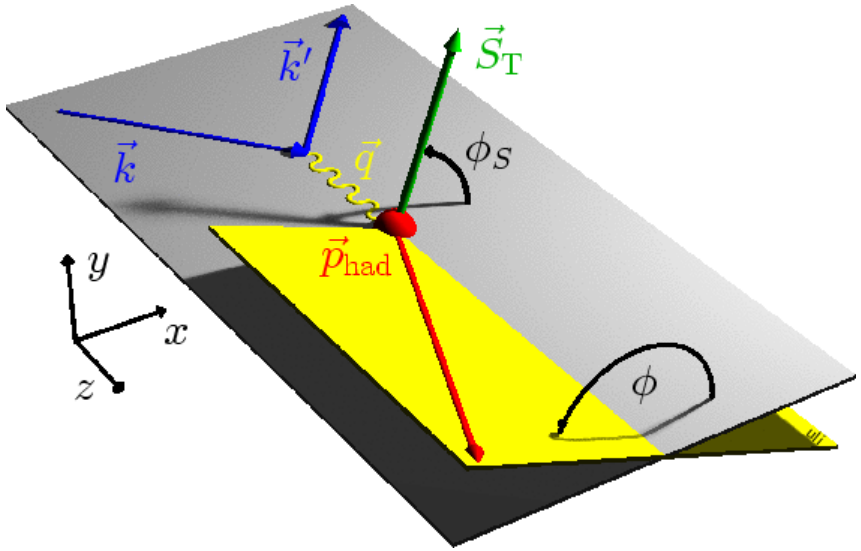


→ TSA linear dependence $\tilde{E}.\tilde{H}$ / cross section quadratic combination $(\tilde{E}+\tilde{H})^2$

→ TSA higher order corrections cancel: scaling region reached at lower Q^2

→ Constrain pole $\tilde{E}$ and non pole $\tilde{H}$ would help the π FF extraction

Transverse target spin asymmetry



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

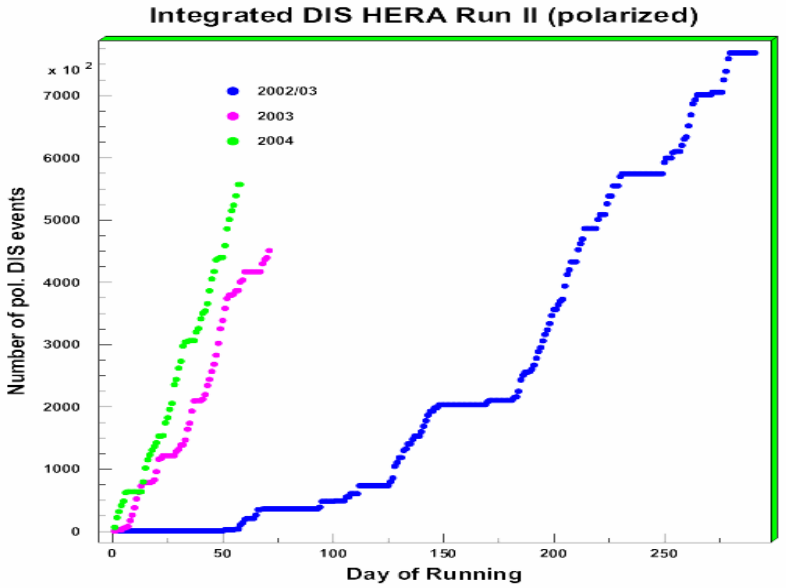
Φ

$\uparrow\downarrow$ proton target spin

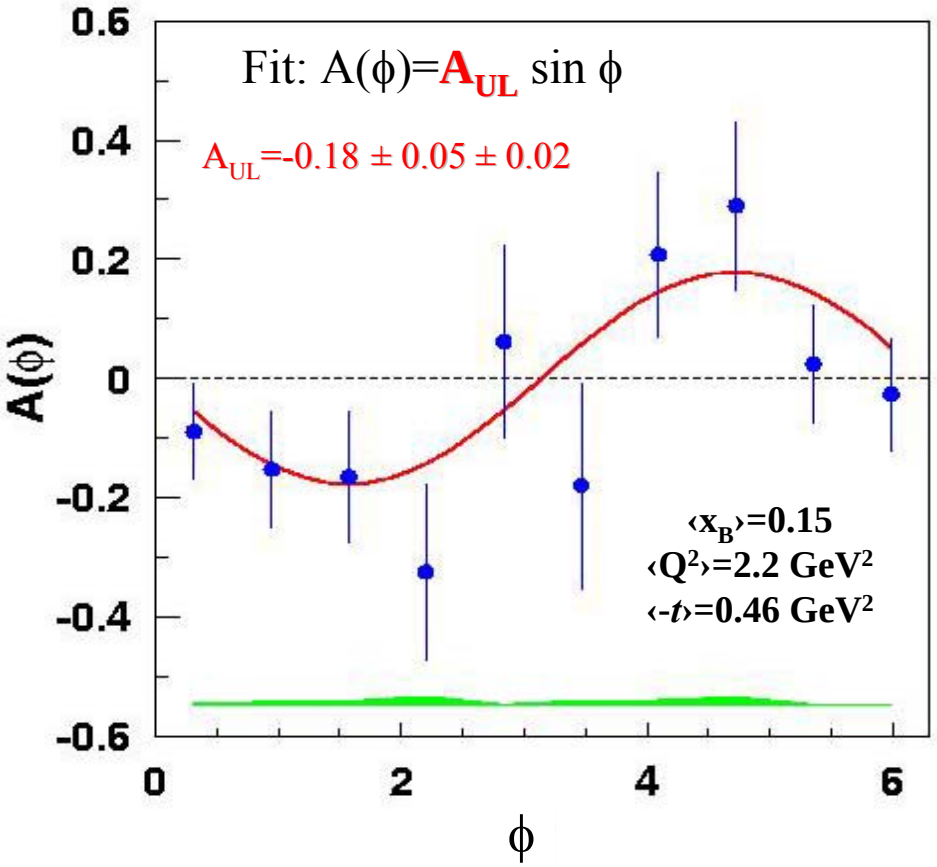
Fit: $A_{UT}(\phi-\phi_S) = \mathbf{A_{UT}} \sin(\phi-\phi_S)$

2002-2004: run with a transverse polarized target

$N_{excl} \sim 1000$



Longitudinal target spin asymmetry



Polarized cross section

$$\sigma_S = [S_T\,\sigma_L + S_L\,\sigma_{LT}]\,\mathbf{A_{UL}}\,\sin\phi$$

σ_{LT} suppressed by 1/Q
but $S_L > S_T = |S|\sin\theta_\gamma$

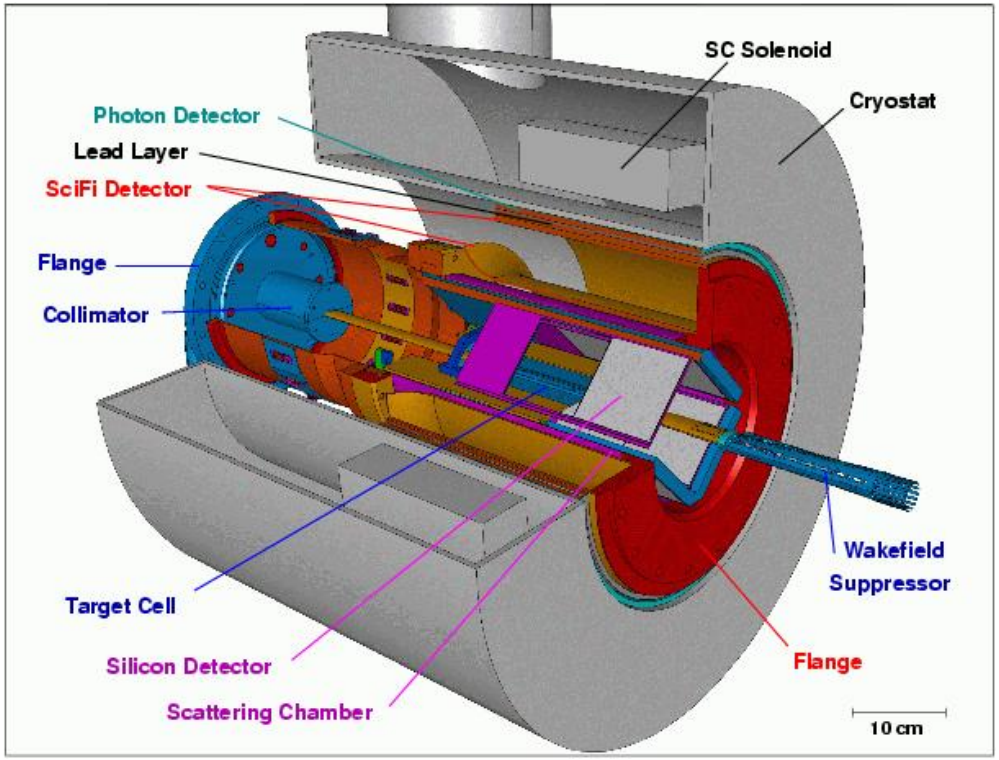
Hermes kinematics: $S_T/|S| \sim 0.17$

→ asymmetry arises from longitudinal target component S_L

→ S_L related to σ_{LT} (NLO): no theoretical interpretation yet

Exclusive reaction at Hermes: future analysis

Detection of the recoiling proton



Pseudoscalar ratios:

$e\,p \rightarrow e\,\pi^{+}\,n \;/\; e\,p \rightarrow e\,\pi^{0}\,p$

$e\,p \rightarrow e\,\eta\,p \;/\; e\,p \rightarrow e\,\pi^{0}\,p$

$e\,p \rightarrow e\,\pi^{0}\,p \;/\; e\,n \rightarrow e\,\pi^{0}\,n$

→ **2005**: (2 years with recoil detector)

Summary and outlook

- GPDs can be probed by hard exclusive meson production

- π^+ measurements at HERMES:

  Cross section: first measurements for Q^2 dependence at fixed *x*

  SSA: large longitudinal target spin asymmetry

- **2004:** end of transverse target runs: transverse spin asymmetry accessible for π^+

- **2005:** run with the recoil detector