Single-spin asymmetry in exclusive electroproduction of pseudoscalar and vector mesons at hermes

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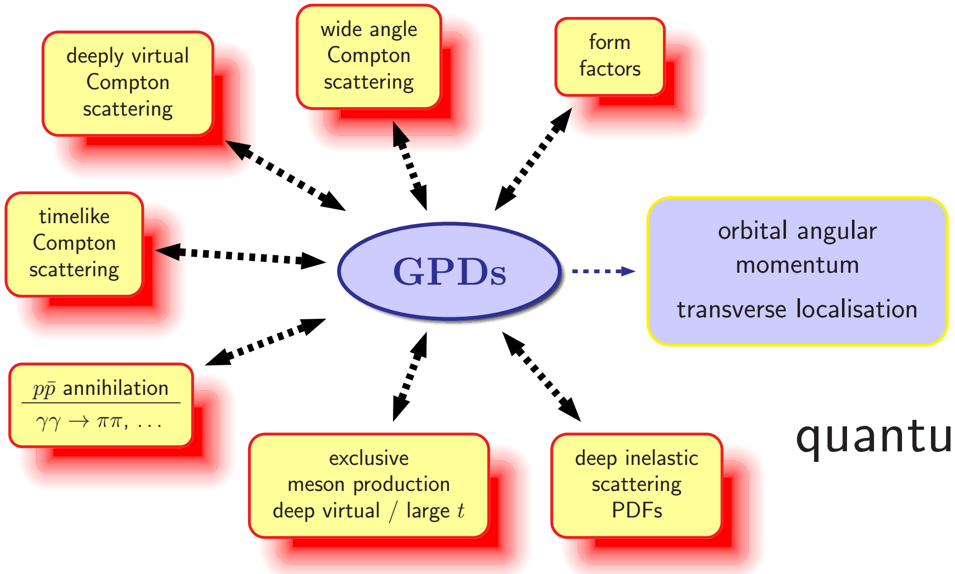
- GPDs and exclusive reactions
- exclusive reactions @ HERMES
- results on azimuthal single-spin asymmetries for π and ρ^0

new observables in hard exclusive processes:



Generalised Parton Distributions:

$\boxed{H, E}$ $\quad$ $\boxed{\tilde{H}, \tilde{E}}$

$\downarrow$ $\quad$ $\downarrow$

quantum number of final state selects different GPDs

$\rightarrow$ DVCS $\leftarrow$

$\downarrow$ $\quad$ $\downarrow$

vector mesons $\quad$ pseudoscalar mesons

quadratic combination of GPDs appear in unpolarised cross section

$\rightarrow$ **polarisation** provides **new observable**

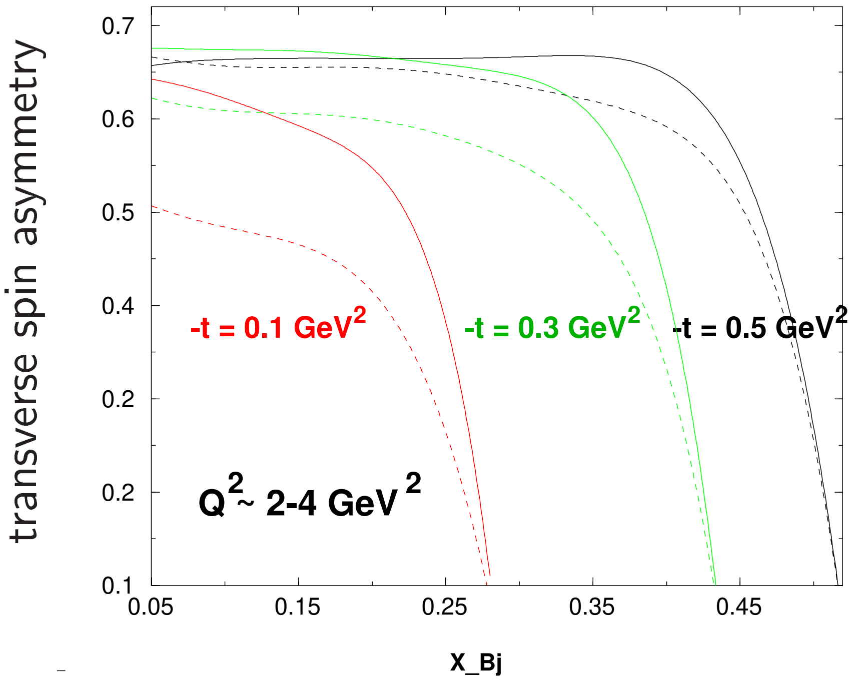
$\rightarrow$ large target-related single spin asymmetries predicted

GPDs predictions

interfererence between:

pole $\tilde{E}$ and non-pole $\tilde{H}$ amplitudes

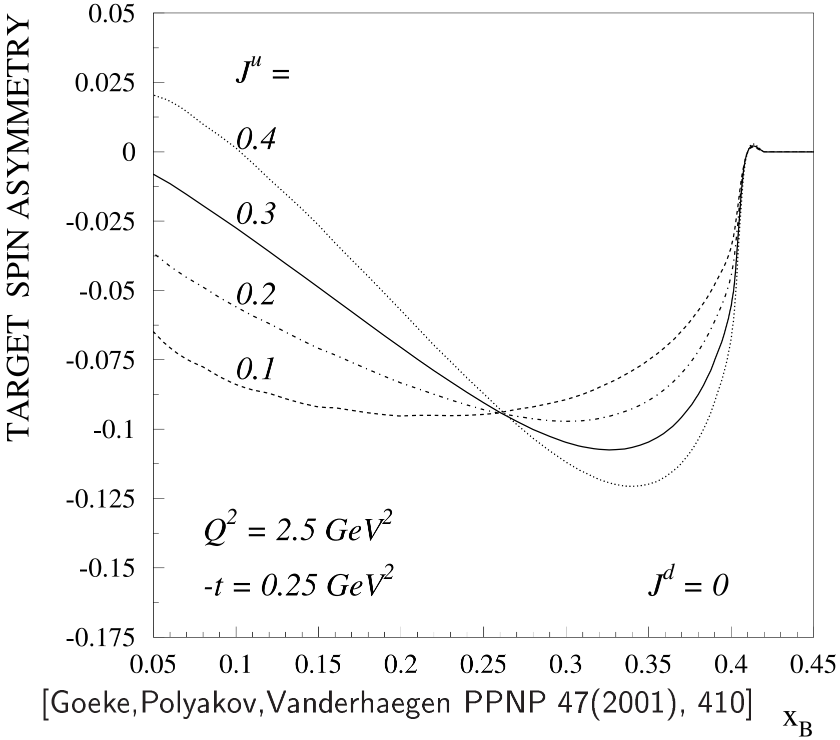
$\gamma_L^* + p \to \pi^+ + n$



[Frankfurt,Pobylitsa,Polyakov,Strikman PRD 60(1999), 014010]

H and $\to E \leftarrow$ amplitudes

$\gamma_L^* + p \to \rho_L^0 + p$

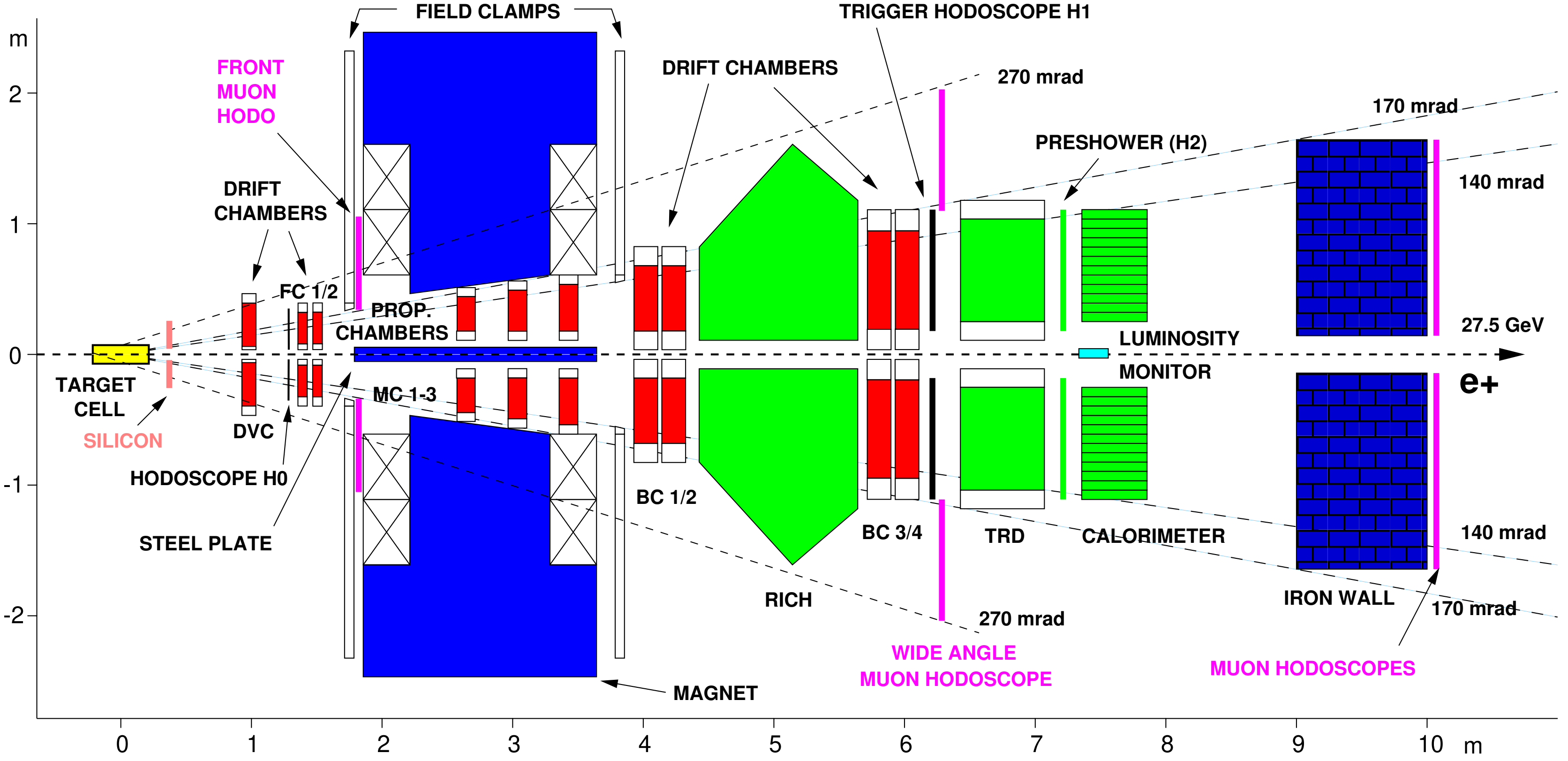


[Goeke,Polyakov,Vanderhaegen PPNP 47(2001), 410]

$\to$ scaling region reached at lower Q^2 than for absolute cross section

$\to$ NLO corrections cancel in asymmetry

HERMES experiment



tracking: 57 tracking planes $\Rightarrow \delta P/P = (0.7 - 1.3)\%$, $\delta\theta < 0.6$ mrad

particle ID: (cerenkov) RICH, TRD, preshower, calorimeter

$\Rightarrow$ ID for π: $\epsilon >$ (90) 98 % for $p > (5)\,1$ GeV

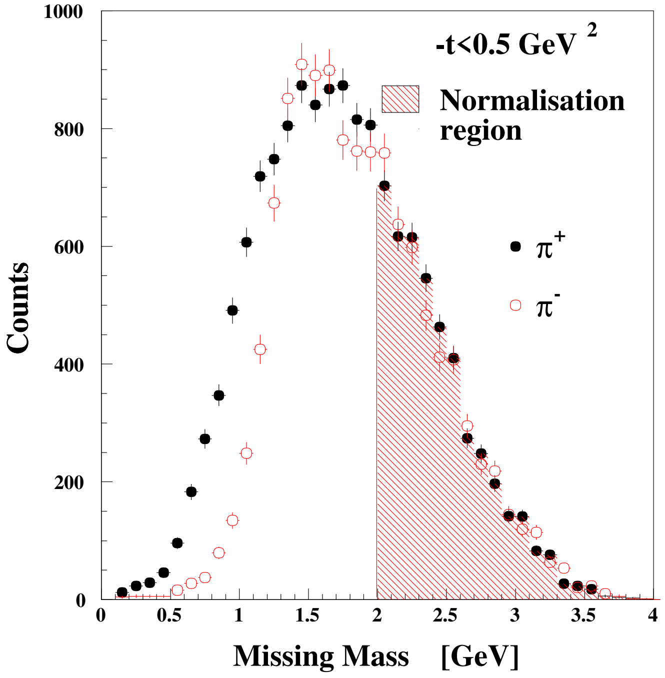
sidis kinematic: $0.02 < x < 0.5$ for $Q^2 > 1$ GeV^2 and $W^2 > 4$ GeV^2

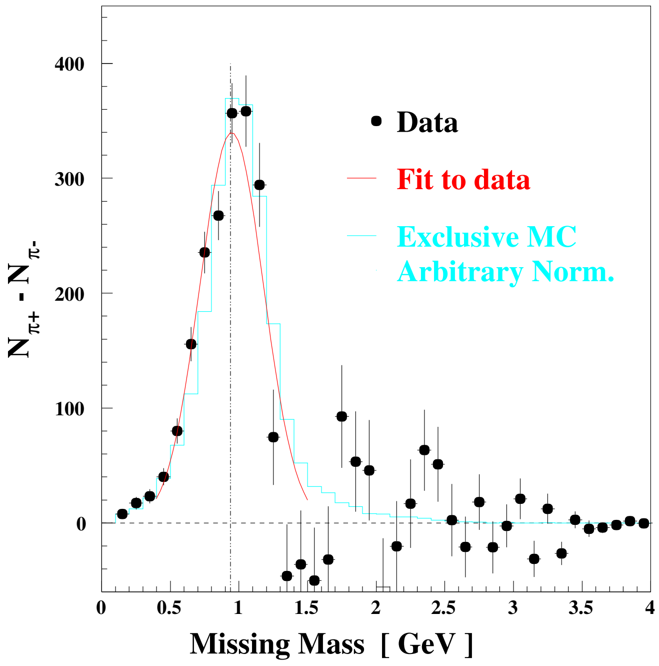
exclusive π^+ production

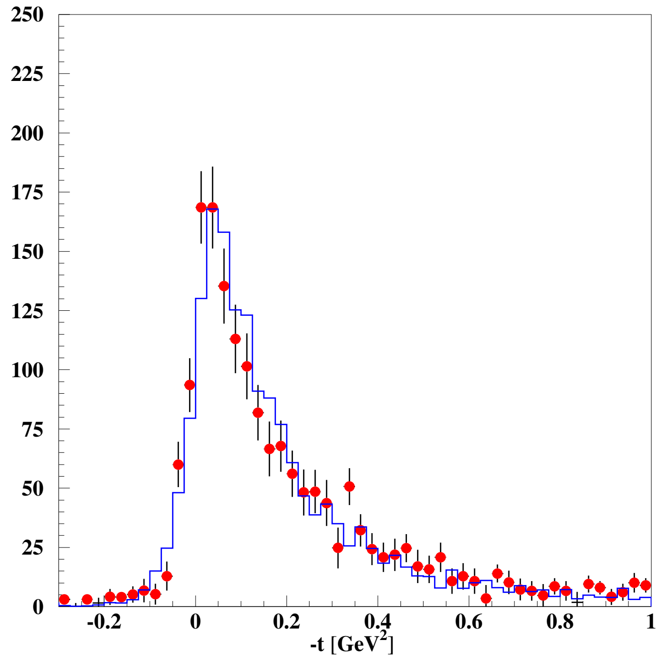
$e\,\vec{p} \rightarrow e'\,\pi\,X$

$e\,\vec{p} \rightarrow e'\,n\,\pi^+$

$\rightarrow t$ distribution







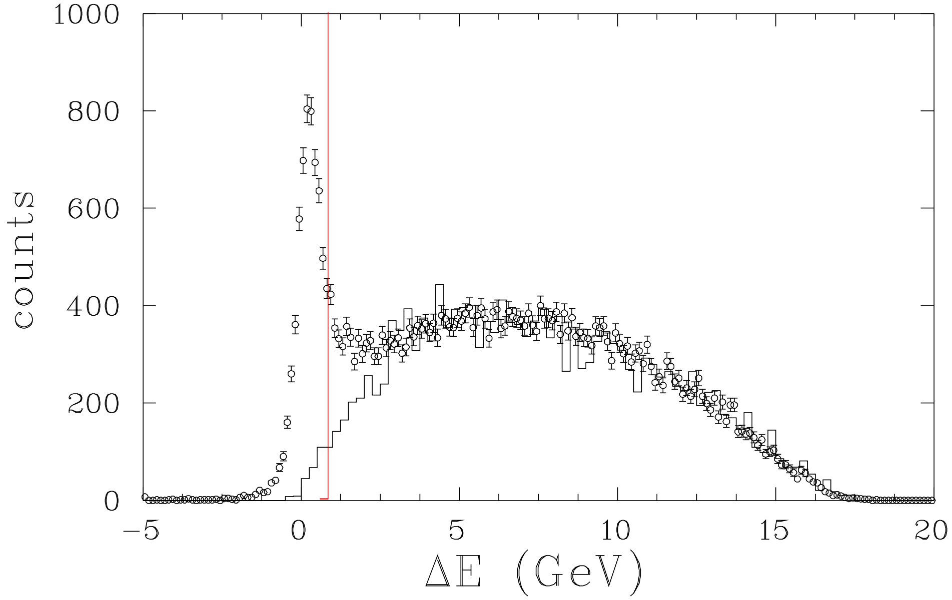
$\rightarrow$ clear peak at missing mass $\approx \mathrm{M_n}$

$\rightarrow$ t distribution well described Monte Carlo based on GPD model [Mankiewicz,Piller,Radyushkin, EPJC10(1999), 307]

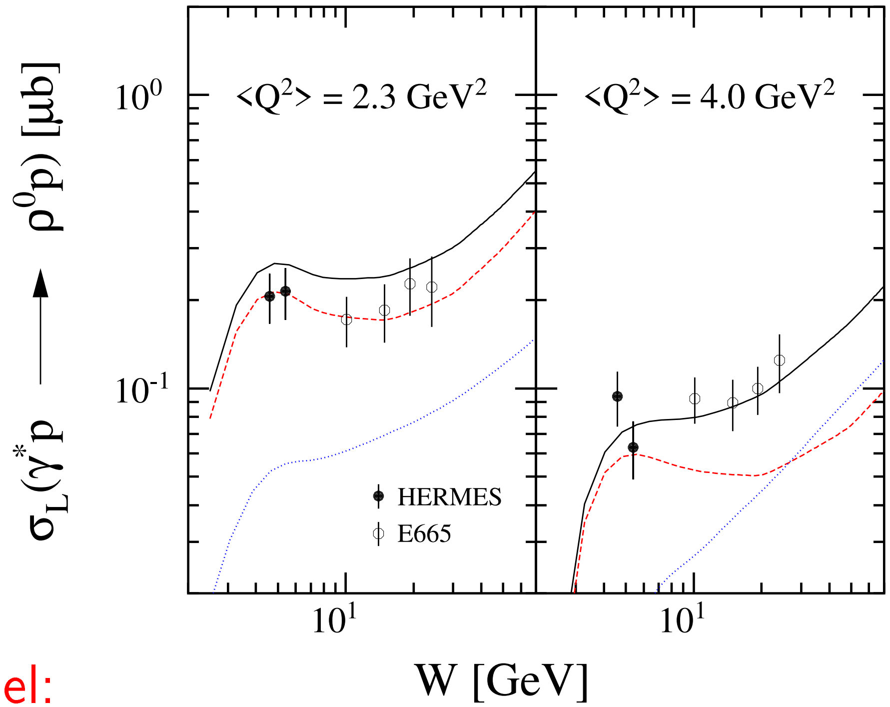
$\rightarrow$ no σ_L/σ_T (Rosenbluth) separation foreseen for the moment

exclusive ρ^0 production $\boxed{\sigma_L}$

$\boxed{e\ \vec{p} \rightarrow e'\ \rho^0\ X \rightarrow e'\ \pi^+\pi^-\ X}$



$\boxed{\gamma_L^*\ \vec{p} \rightarrow e'\ \rho^0\ p}$

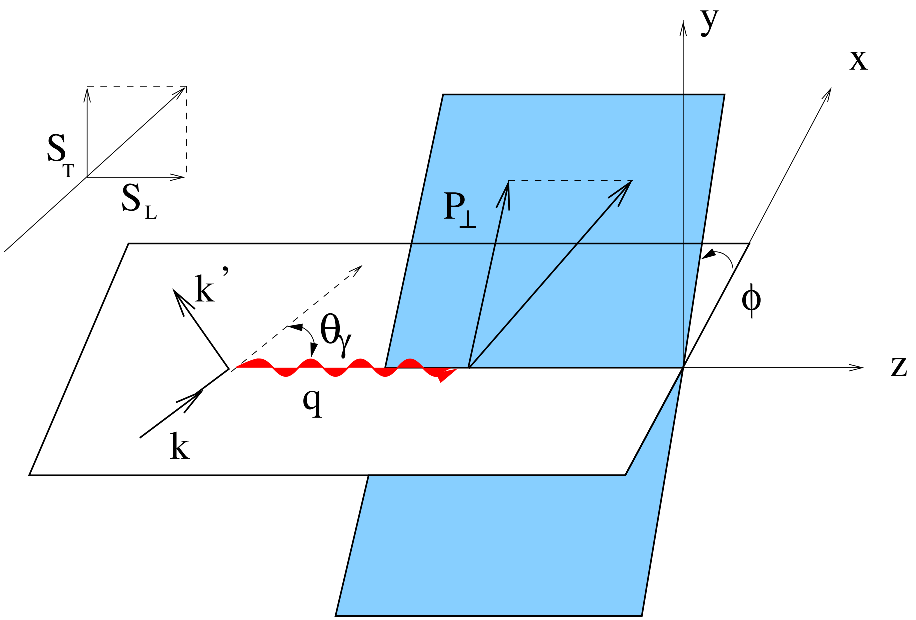


⇒ good determination of exclusive channel: $\Delta E < 0.6$ GeV

→ non-exclusive (DIS) background well described by Monte Carlo

GPD calculations:
quark exchange; 2-gluon exchange
mechanism dominates σ_L

single-spin azimuthal asymmetry (ssa)



$$\mathrm{A_{UL}}(\phi) = \frac{1}{\langle |P_t| \rangle} \cdot \frac{N^+(\phi) - N^-(\phi)}{N^+(\phi) + N^-(\phi)}$$

$\downarrow$

$\boxed{\text{fit}}$

$\downarrow$

$$\mathrm{A_{UL}^{\sin\phi}}(\phi) \cdot \sin\phi$$

transverse component in γ^* frame:

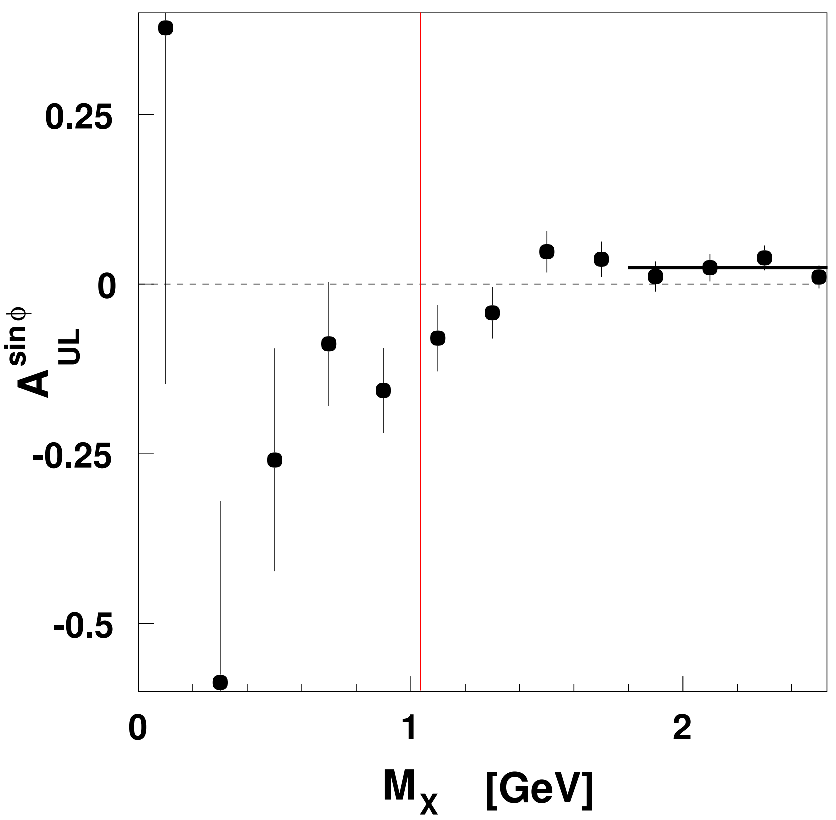
$\boxed{\sigma_\mathrm{S} \sim [S_\perp \sigma_\mathrm{L} + S_\| \sigma_\mathrm{LT}] \cdot \mathrm{A_{UL}^{\sin\phi}} \sin\phi}$ $\Rightarrow$ HERMES kinematics: $\boxed{S_\perp / S \sim 0.17}$

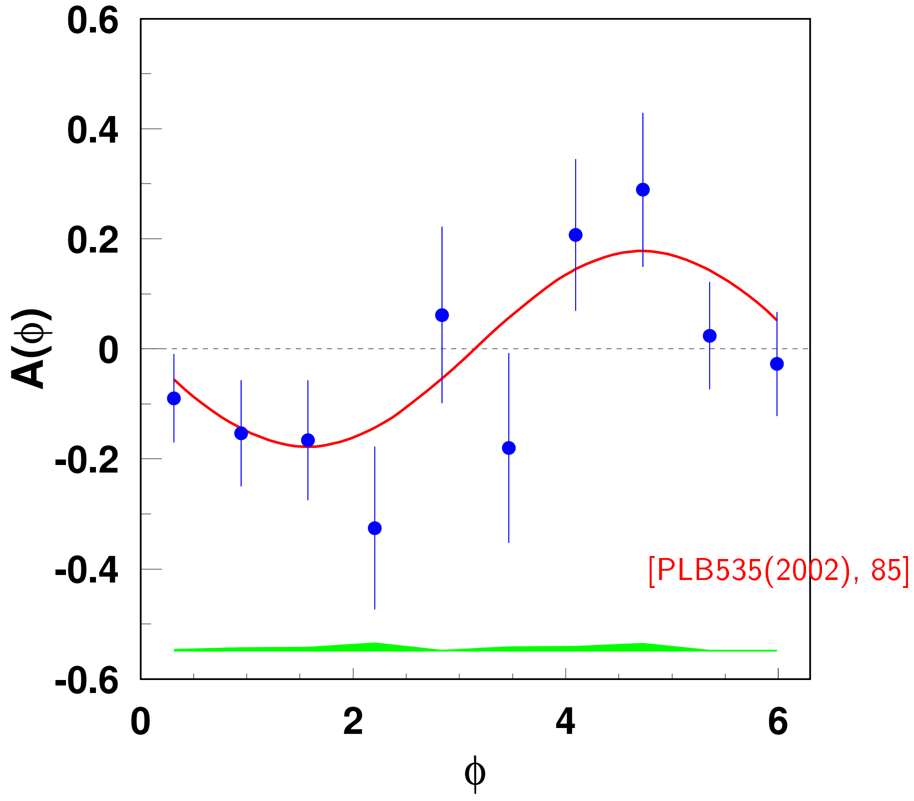
σ_LT suppressed by $1/Q \cdots$ but $S_\| > S_\perp = |S| \sin\theta_\gamma$

exclusive π^+ target - SSA

uncorrected for background $\rightarrow A_{\mathrm{UL}}(\phi) = \frac{1}{|P_t|} \cdot \frac{N^+(\phi) - N^-(\phi) - |P_t| A_{\mathrm{bg}}(\phi) N_{\mathrm{bg}}(\phi)}{N^+(\phi) + N^-(\phi) - N_{\mathrm{bg}}(\phi)}$

$\downarrow$

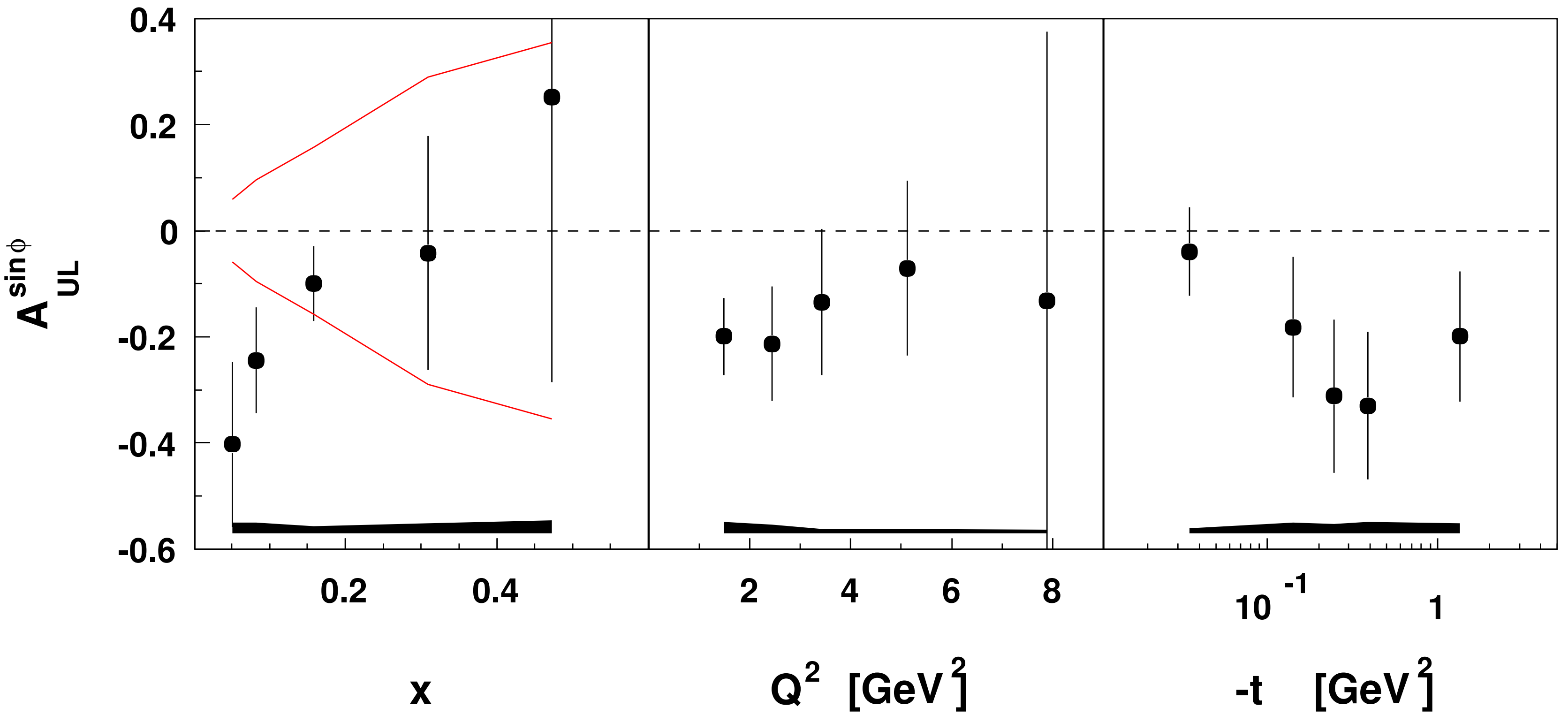




$\langle x \rangle = 0.15,\ \langle Q^2 \rangle = 2.2\ \mathrm{GeV}^2,\ \langle t \rangle = -0.46\ \mathrm{GeV}^2$

$A_{\mathrm{UL}}^{\sin\phi} = -0.18 \pm 0.05 \pm 0.02$

exclusive π^+ target - SSA

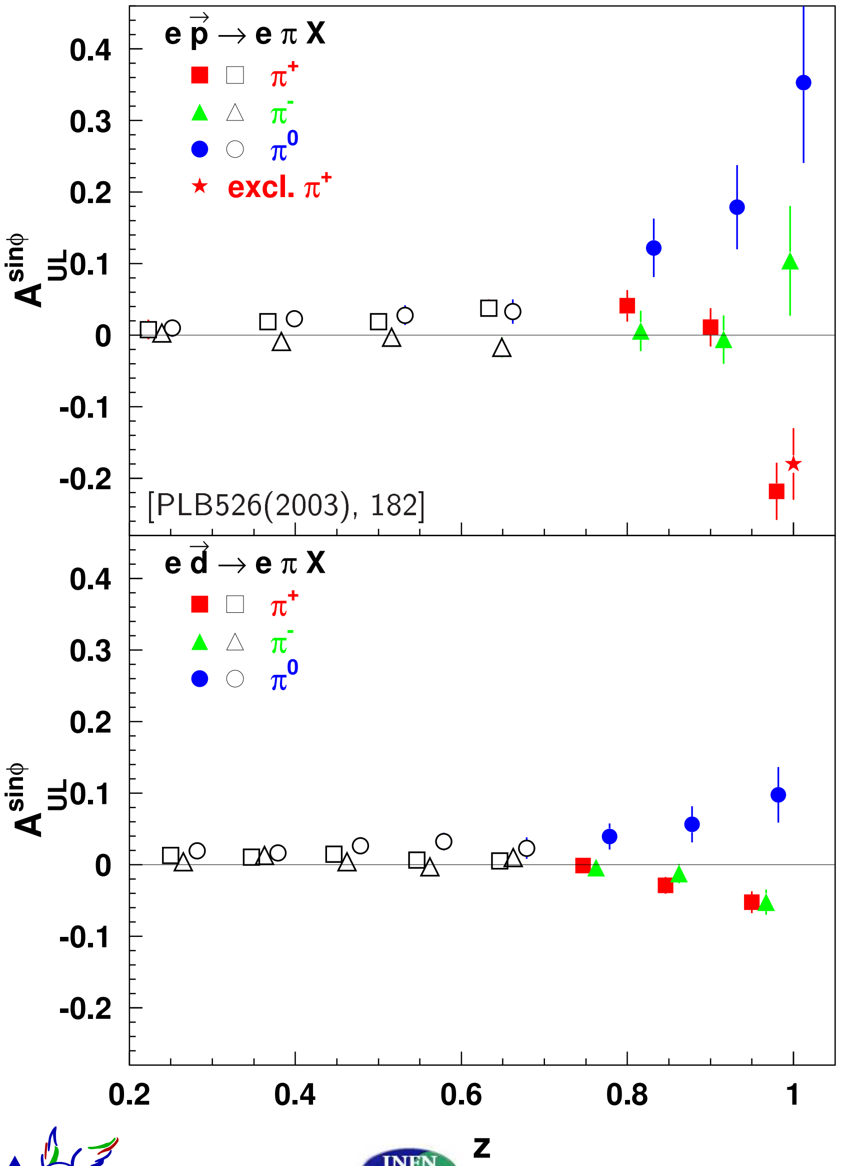


$$\boxed{S_\perp/|S| = \sin\theta_\gamma}$$

lines indicate limits for any asymmetry arising from *transverse* target component

$\Rightarrow$ asymmetry at low x arises from *longitudinal* target component $S_\parallel$ independently of any model

exclusive π^0, π^- ongoing analysis + future



exclusive production @ $z \rightarrow 1$

target-SSA for ep$\rightarrow$ e$'\pi^0$ p
ed$\rightarrow$ e$'\pi^0$ pn
ed$\rightarrow$ e$'\pi^+$d nn
ed$\rightarrow$ e$'\pi^-$d pp

pseudoscalar ratios:

ep $\rightarrow$ e$'\pi^+$ n / ep $\rightarrow$ e$'\pi^0$p

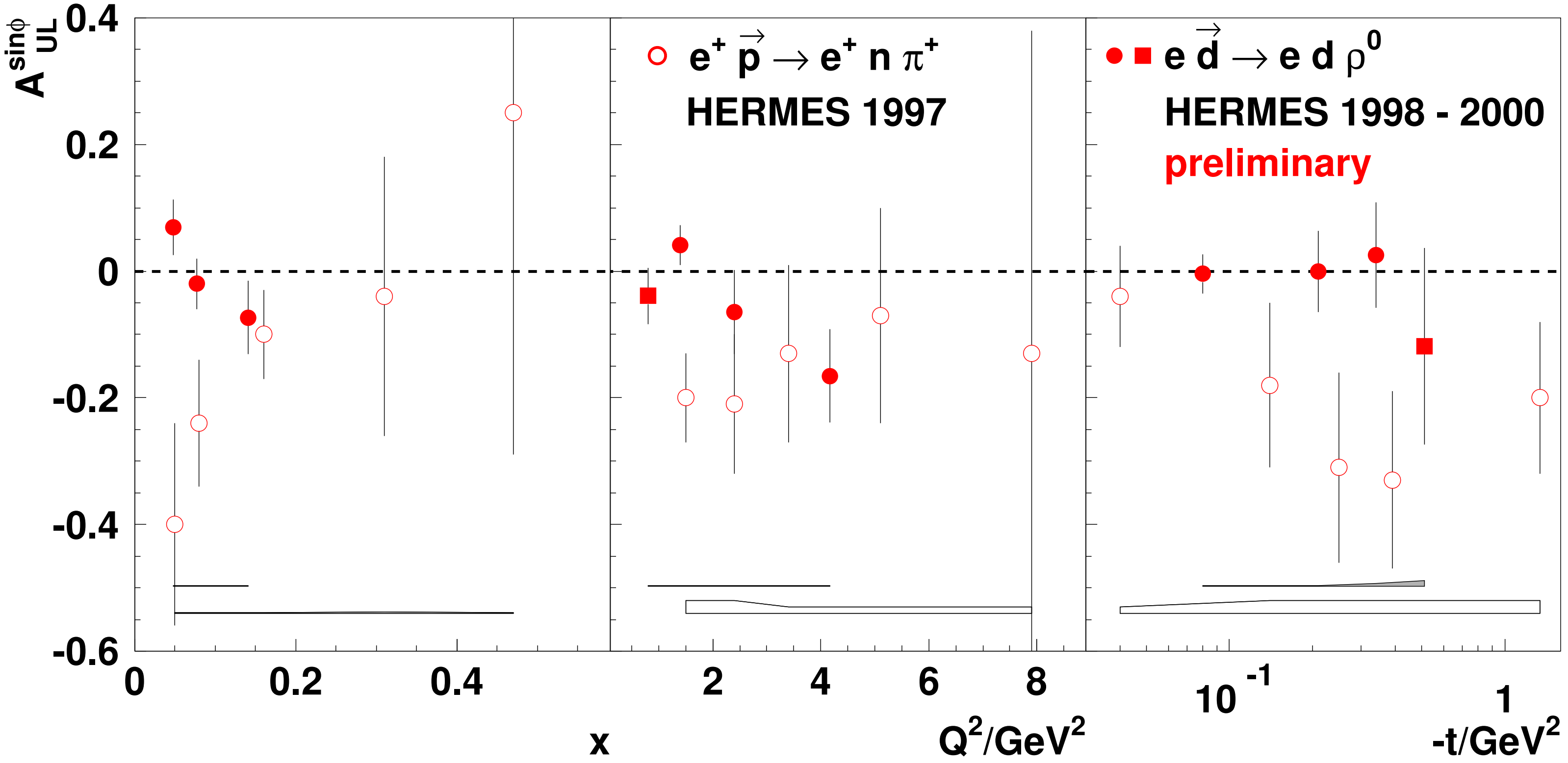
ep $\rightarrow$ e$'\eta$ p / ep $\rightarrow$ e$'\pi^0$p

ep $\rightarrow$ e$'\pi^0$p / en $\rightarrow$ e$'\pi^0$n

$\rightarrow$ detection of the recoiling proton
for years >= 2004

exclusive ρ^0 target - SSA $\boxed{\mathrm{e}\ \vec{\mathrm{d}} \rightarrow \mathrm{e}'\ \rho^0\ \mathrm{d}}$

$A_{\mathrm{UL}}^{\sin\phi} = -0.003 \pm 0.027 \pm 0.001$ $\langle x\rangle = 0.085$, $\langle Q^2\rangle = 2.0$ GeV^2, $\langle t'\rangle = -0.12$ GeV^2



$\rightarrow \sigma_L/\sigma_T$ separation from decay angular distribution under way

summary & **outlook**

→ GPDs can be probed by hard exclusive meson production

→ polarisation variables (target/beam) provide additional observables

→ large *transverse* single-target azimuthal asymmetries predicted for π^+ (ρ^0)

→ results for *longitudinal* target-spin asymmetries presented for π^+ and ρ^0

$\boxed{\pi^+}$ $A_{\mathrm{UL}}^{\sin\phi} = -0.18 \pm 0.05 \pm 0.02$ while $\boxed{\rho^0}$ compatible with zero

→ at low x the target-spin asymmetry of π^+ must arise from the longitudinal target polarisation component

→ results of data collected with a transversely polarised target will come soon