Single Spin Asymmetry in electroproduction of exclusive π^+

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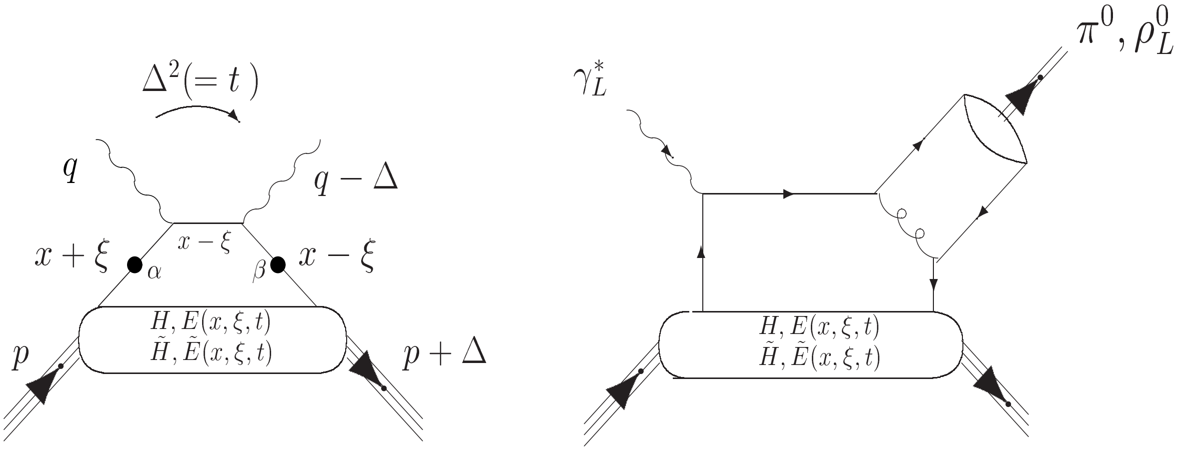
On behalf of HERMES collaboration

- ▷ Why?
- ▷ What?
- ▷ Conclusions

The SPD puzzle

Factorization has been demonstrated for hard exclusive production of photons and (longitudinal) mesons



Xi Ji Sum rule: $\int x dx(E+H) = L_q + J_q$

Quantum numbers of final states $\rightarrow$ select different SPD

- Vector mesons : $\rightarrow$ unpol. SPD E, H
- Pseudoscalar mesons : $\rightarrow$ pol. SPD $\tilde{E}, \tilde{H}$
- DVCS : $\rightarrow$ pol. and unpol. SPD, $E, H, \tilde{E}, \tilde{H}$

▷ Quadratic combination of SPD appear in the unpolarized cross section

▷ Polarization provide new observable

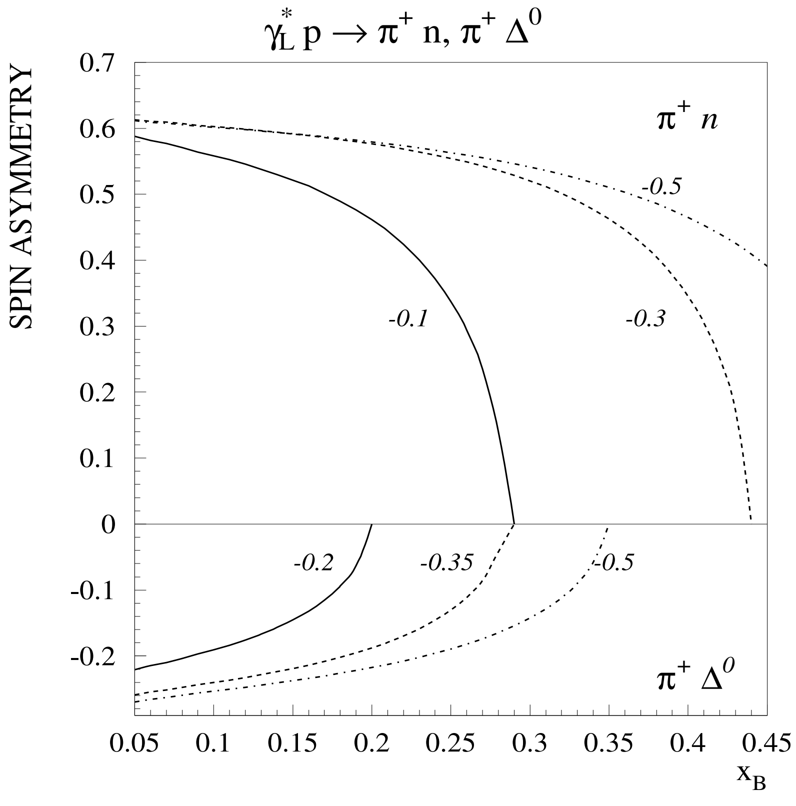
Exclusive π^+

Frankfurt, Pobylitsa, Polyakov, Strikman, Vanderheaghen:

Large SSA expected for transverse target:

$$\sigma \propto |S_\perp| \sin\phi \;\; \tilde{E} \cdot \tilde{H}$$

- $\tilde{E}$: π pole contribution $\rightarrow$ pi FF
- $\tilde{H}$: Forward limit: $\rightarrow \Delta q$
  $(\rightarrow (2\Delta u + \Delta\bar{u}) - (2\Delta d + \Delta\bar{d}))$

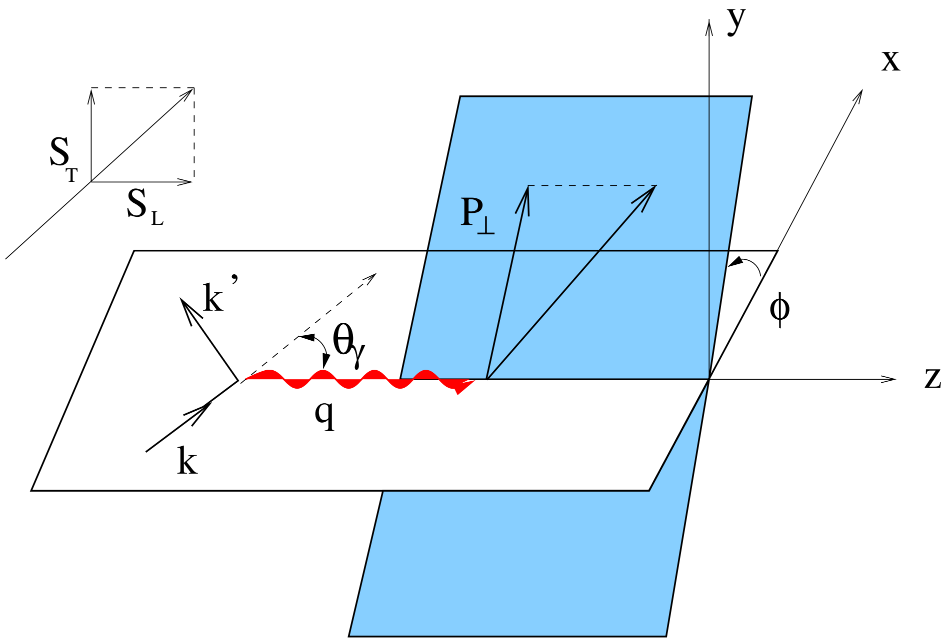


(PRD 60 (1999) 014010 and PRL 84 (2000) 2589)

HERMES: $S_\perp / |\vec{S}_\perp + \vec{S}_\parallel| \sim 0.17$

Kinematic

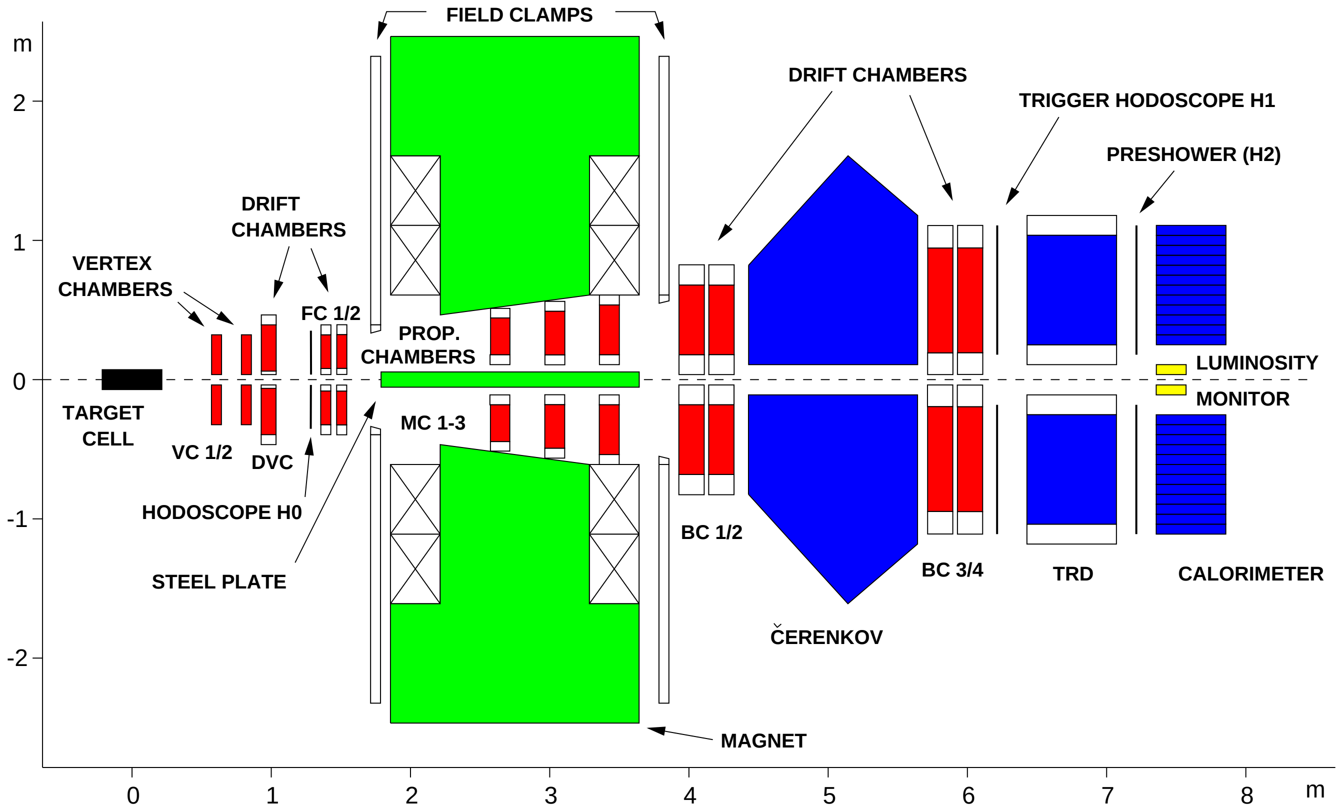
$$e\ P \to e'\ N\ \pi$$



e' and π detected

$$
\begin{aligned}
\phi &= \text{Azimuthal angle of } \pi^+ \text{ around } \gamma^* \text{ momentum} \\
M^2 &= (P + q - p_\pi)^2 \\
&= \text{Squared Missing Mass} \\
t &= (q - p_\pi)^2 = (P - N)^2 \\
&= \text{squared 4-momentum transfered to the nucl.}
\end{aligned}
$$

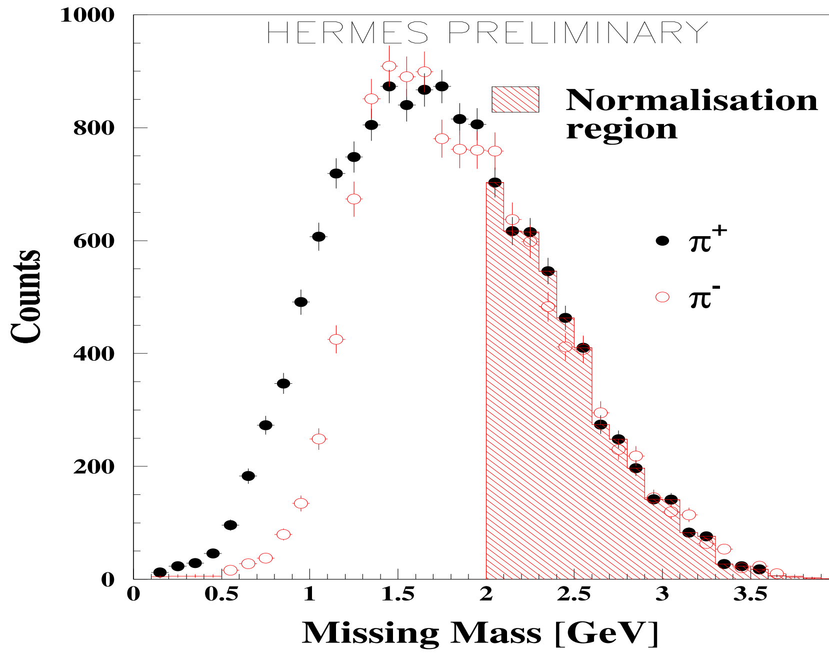
The HERMES Experiment (in 97)

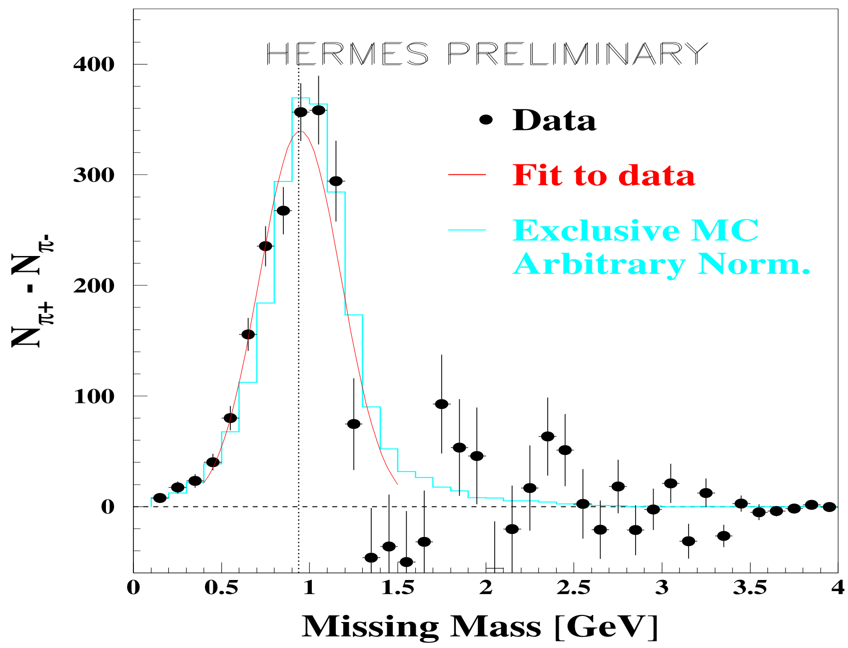


- **Beam** 27.5 GeV HERA e^+ beam
- **Target**: Longitudinal $P_{\vec{H}} \approx 88\%$, no dilution
- **kinematic:** $0.02 < x < 0.8$ for $Q^2 > 1$ and $W^2 > 4$
- **Tracking**: 57 tracking planes, $\delta P/P = (0.7 - 1.3)\%$, $\delta\theta < 0.6$ mrad

Data

Semi-inclusive π^+ and π^- ($|t| < 0.5\text{GeV}^2$)





Clear peak at Missing mass $\approx M_N$

Asymmetry

Cross section:

$$N^{\pm} = (\sigma^0 \pm \sigma^1 f(\phi)) \times \epsilon(\phi)$$

$$\sigma^0,\ \sigma^1 = \text{unpolarized, polarized cross section}$$

Cross section Asymmetry:

$$A(\phi) = \frac{1}{|P|}\frac{N^+ - N^-}{N^+ + N^-} = \frac{\sigma^1}{\sigma^0} f(\phi)$$

$\rightarrow$ Acceptance $\epsilon(\phi)$ cancel in the ratio

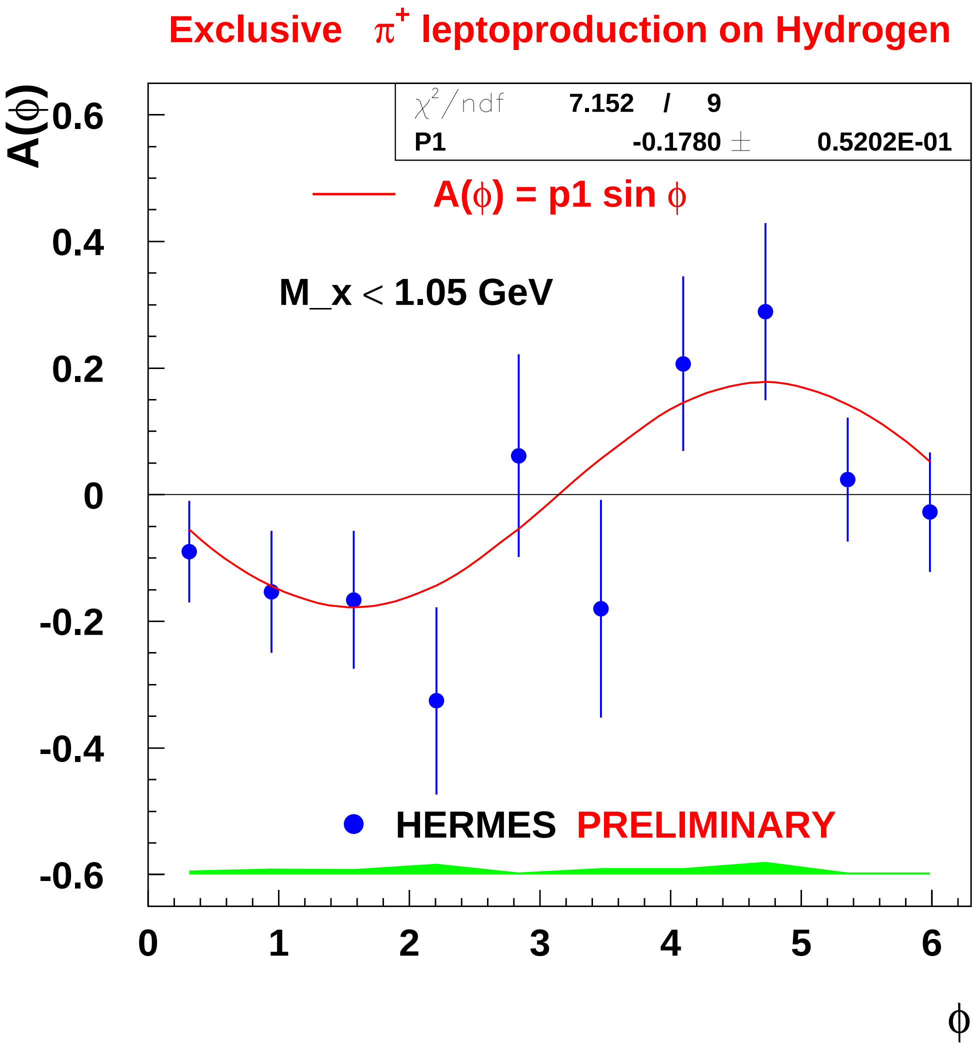
Background correction: (Signal/Background ~ 5)

$$A(\phi) = \frac{1}{|P|}\frac{N^+ - N^- \ - |P| A_{bg}(N^+_{bg} + N^-_{bg})}{N^+ + N^- - (N^+_{bg} + N^-_{bg})}$$

Only 2 parameters:

- Background yield $\rightarrow$ From π^- yield, $\pm 20\%$
- Background Asymmetry $\rightarrow$ Extrapolate from neighborhood region $A_{bg} = 2.5 \pm 2.5\%$

Cross section asymmetry

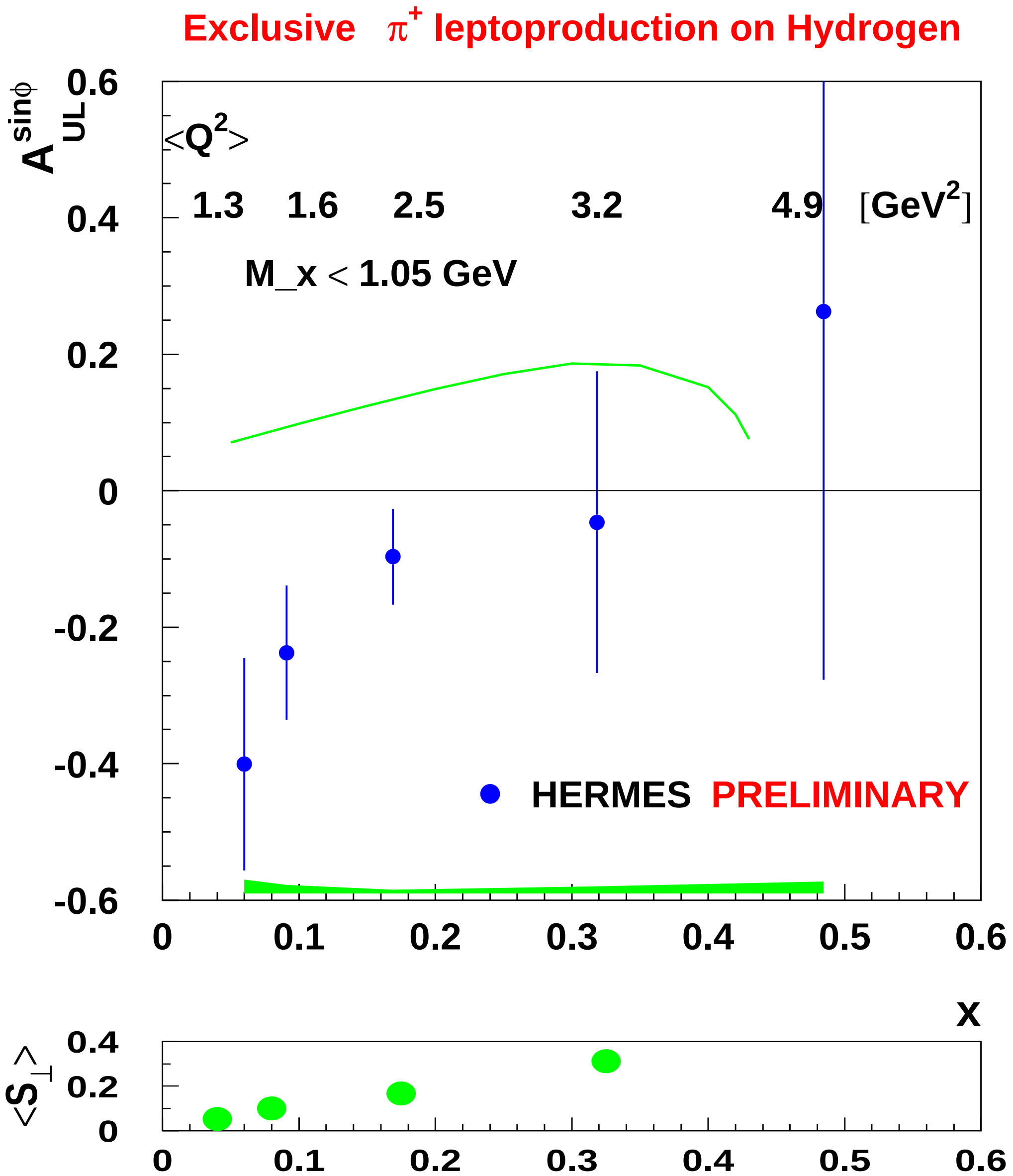


Systematic: Background, 5% on target polarization (dominant)

- ▷ Large asymmetry (>> SIDIS see Delia Hasch in the same session.)
- ▷ Asymmetry is Negative!

$A_{\mathrm{UL}}^{\sin\phi}$ vs x

Frankfurt et al Phys.Rev. D60 (1999) 014010)
Polyakov - Vanderheaghen, DIS00
LO prediction

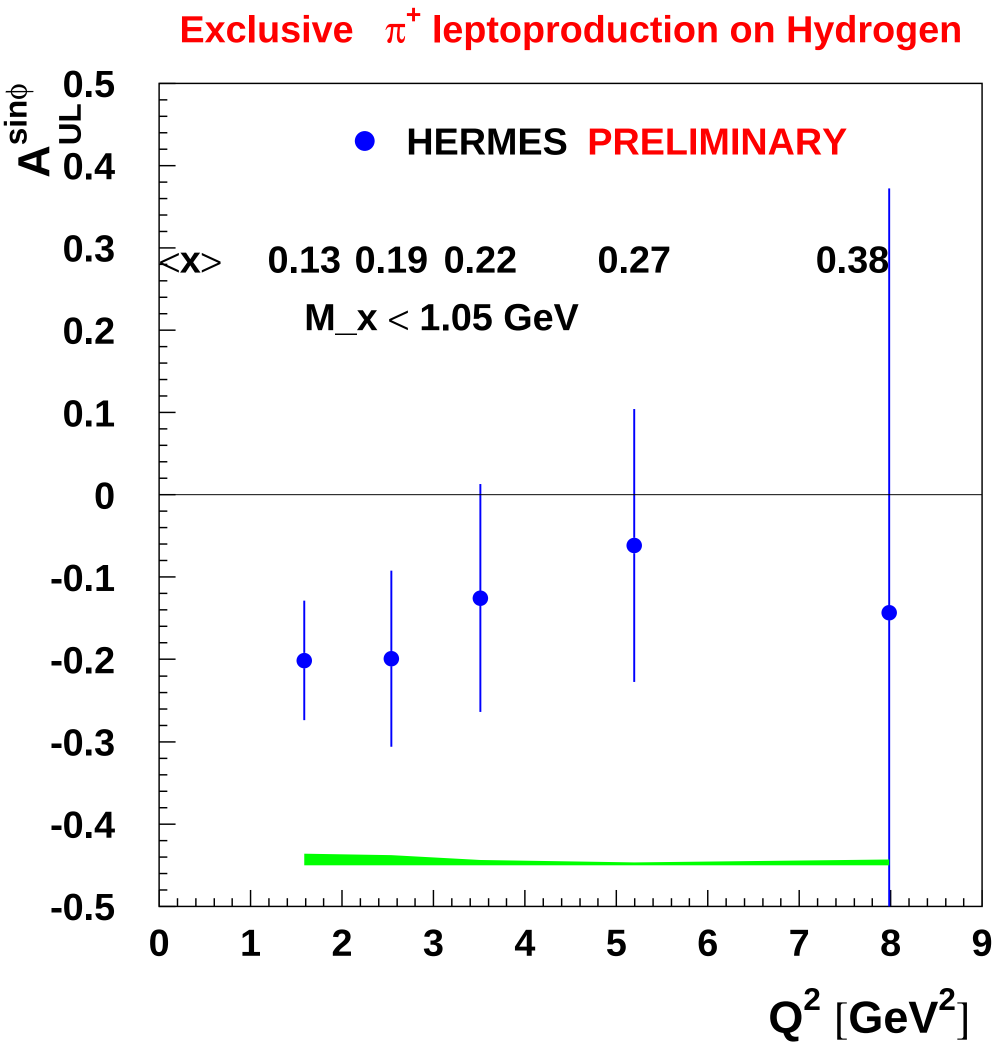


$$\sigma_P \sim [S_\perp \sigma_L + S_\parallel \sigma_{LT}]$$

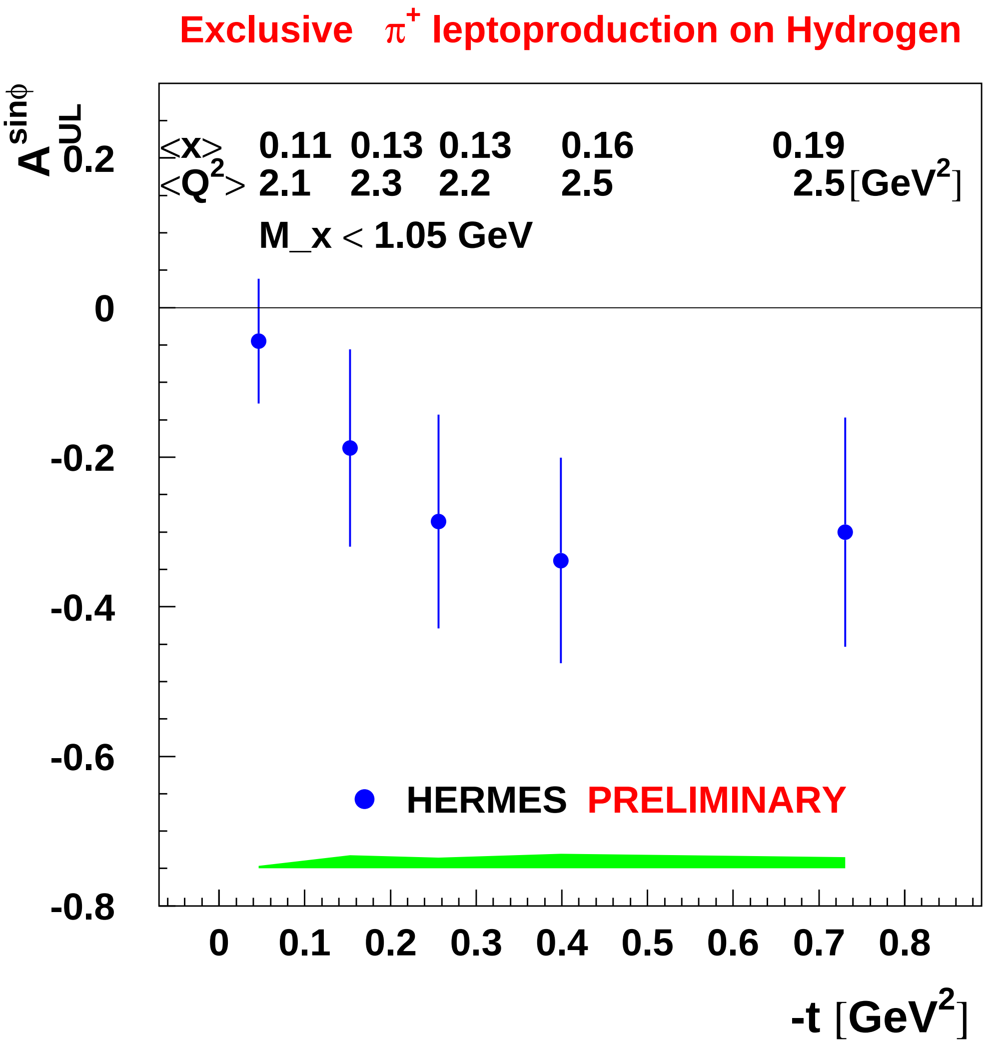
σ_{LT} suppressed by $1/Q \cdots$ but $S_\perp < S_\parallel$

Transverse target running in 2001-2!

$A_{UL}^{\sin\phi}$ vs Q^2



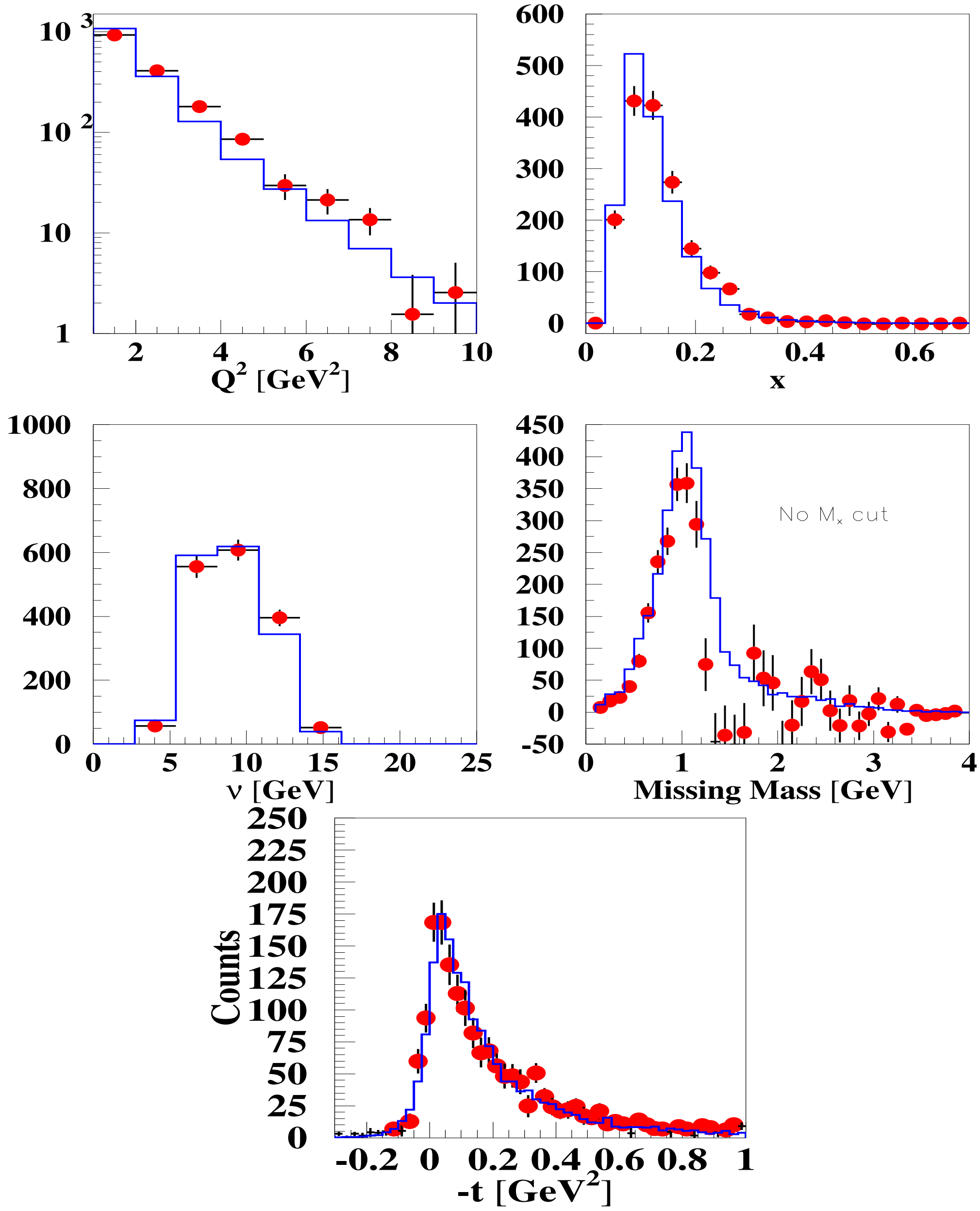
$A_{\mathrm{UL}}^{\sin\phi}$ vs t



▷ Asymmetry arise at $|t| > m_\pi^2$ (pion pole).

Unpolarized MC

Model by Mankiewicz, Piller and Radyushkin (Eur. Phys. J. C10 (1999) 307) - Arbitrary normalization.

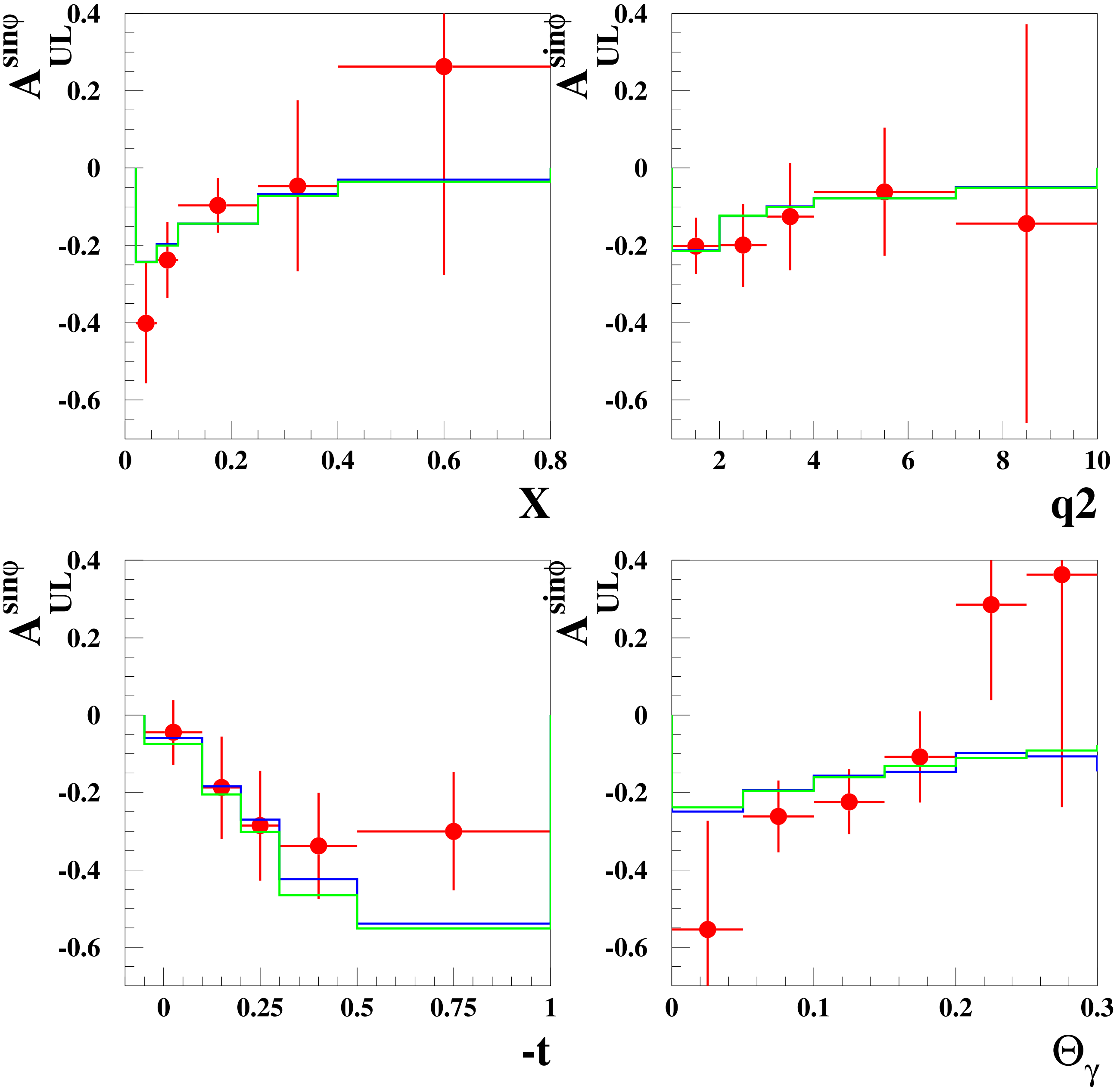


Good description of data.

ϕ-MC

Phenomenological ϕ dependence:

$$A_{\mathrm{UL}}^{\sin\phi} \propto \frac{(1-x)^4}{q}(1-\exp(t)) \cdot \sin\phi$$



Data Generated MC Reconstructed MC

No smearing correction to apply

Summary

- **First measurement of SSA in exclusive π^+ electroproduction**

- Large negative asymmetry, low x, high t.
- Sign is opposite to LO predictions.
- Estimates for $S_{\parallel}$?

- **Exciting HERMES transverse target running from 2001-2**