Transversity in Two-Pion Semi-Inclusive Deep-Inelastic Scattering

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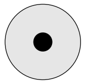
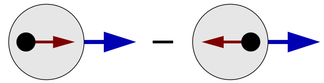
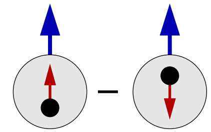
Introduction

- Transversity: $h_1(x)$ is the distribution of transversely polarized quarks inside a transversely polarized nucleon
- Tensor charge: $\delta q = \int h_1(x) dx$
- Completely new information on nucleon structure
- Lattice and model calculations show that δq is not small
- Interference fragmentation functions offer one of the most promising ways to measure $h_1(x)$
- JLab can do this

The h_1 Structure Function

$\boldsymbol{f_1} =$  $\boldsymbol{g_1} =$  $\boldsymbol{h_1} =$ 

Characteristics of $\boldsymbol{h_1}$:

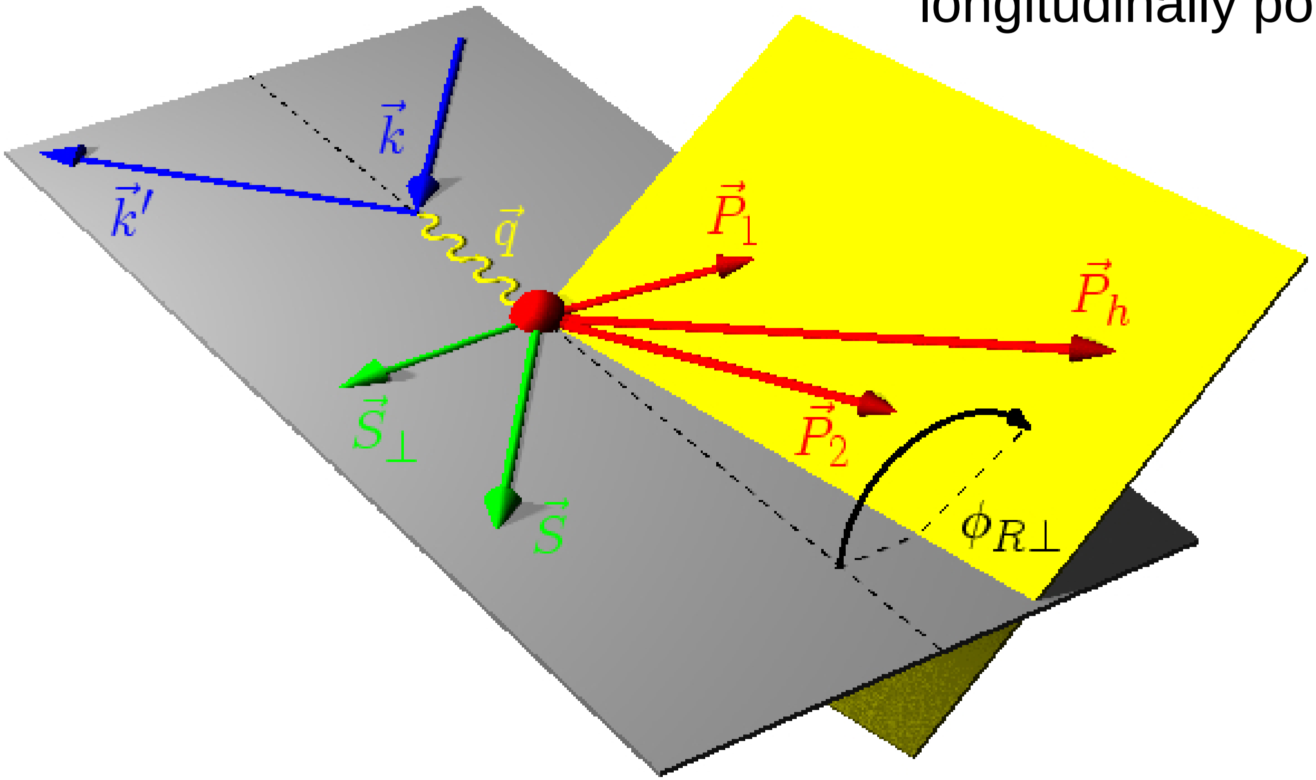
- leading twist -> on equal footing with f_1 and g_1
- chiral-odd -> can NOT be probed in inclusive DIS

Solution: couple h_1 to chiral-odd fragmentation function

Two options: 1 or 2 particle semi-inclusive DIS

Single Spin Asymmetry

longitudinally polarized deuterium target



$$\vec{P}_h \equiv \vec{P}_1 + \vec{P}_2$$

$$A_{UL}(\phi_{R\perp}) = \frac{1}{|P_T|} \frac{N^{\rightarrow}(\phi_{R\perp})/L^{\rightarrow} - N^{\leftarrow}(\phi_{R\perp})/L^{\leftarrow}}{N^{\rightarrow}(\phi_{R\perp})/L^{\rightarrow} + N^{\leftarrow}(\phi_{R\perp})/L^{\leftarrow}}$$

Asymmetries -Theory

A. Bacchetta, M. Radici, PRD 69, 0740XX (2004)

$$A'_{UT} \sim B(y)\sin(\phi_{R\perp}+\phi_S)h_1 H_1^{\sphericalangle} + V(y)\sin(\phi_S)\frac{M}{Q}(\cdots)$$

$$A'_{UL} \sim V(y)\sin(\phi_{R\perp})\frac{M}{Q}(h_L H_1^{\sphericalangle} + g_1 \tilde{G}^{\sphericalangle})$$

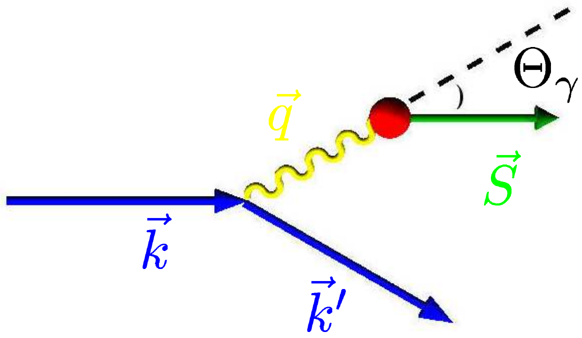
$T/L \Longrightarrow$ target spin defined w.r.t. virtual photon

Asymmetries - Experiment

$$A_{UL} \simeq A'_{UL} - \sin\Theta_\gamma A'_{UT}$$

target spin defined w.r.t. beam

target spin w.r.t. virtual photon



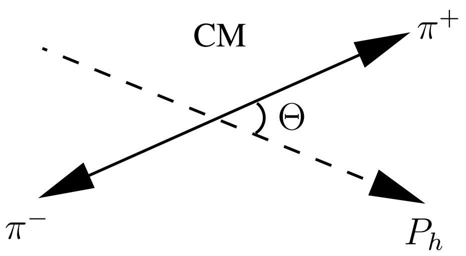
$$\langle \sin\Theta_\gamma \rangle = \langle \frac{2Mx}{Q}\sqrt{1-y} \rangle \simeq 0.045$$

if $H_1^{\sphericalangle} \neq 0$:

$\Longrightarrow$ 2 hadron fragmentation can probe transversity!

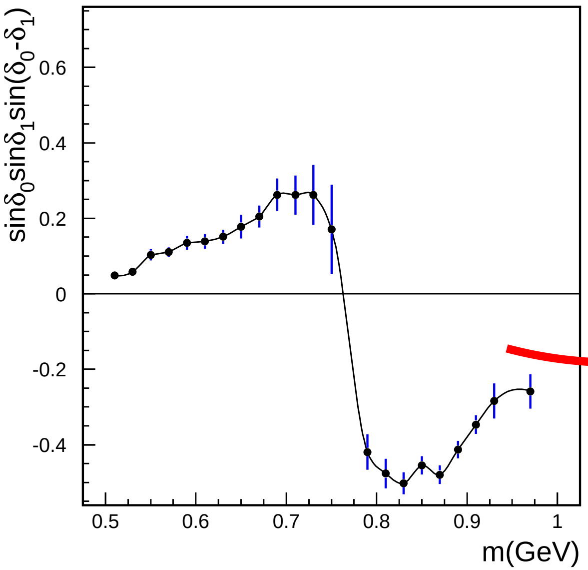
Interference FF

$$H_1^{\sphericalangle}(z, \cos\Theta, M_{\pi\pi}^2) = H_1^{\sphericalangle,sp}(z, M_{\pi\pi}^2) + \cos\Theta H_1^{\sphericalangle,pp}(z, M_{\pi\pi}^2)$$



$\langle\cos\Theta\rangle \approx 0 \implies H_1^{\sphericalangle,pp}$ drops out!

Jaffe et al. [**hep-ph/9709322**]:



$$H_1^{\sphericalangle,sp}(z, M_{\pi\pi}^2) = \sin\delta_0 \sin\delta_1 \sin(\delta_0 - \delta_1) H_1^{\sphericalangle,sp'}(z$$

δ_0 (δ_1) $\to$ S(P)-wave phase shifts

$$= \mathcal{P}(M_{\pi\pi}^2) H_1^{\sphericalangle,sp'}(z)$$

$\implies A_{UL}$ might depend stongly on $M_{\pi\pi}$

Analysis method

Fitting method:

$$A_{UL}(\phi) \sim \frac{N^{\rightarrow} - N^{\leftarrow}}{N^{\rightarrow} + N^{\leftarrow}} \quad \overset{\text{fit with}}{\Longleftarrow} \quad f(\phi_{R\perp}) = a_0 + a_1 \sin\phi + b_1 \cos\phi + \ldots$$

$$a_1 \rightarrow A_{UL}^{\sin\phi}$$

Weighting method:

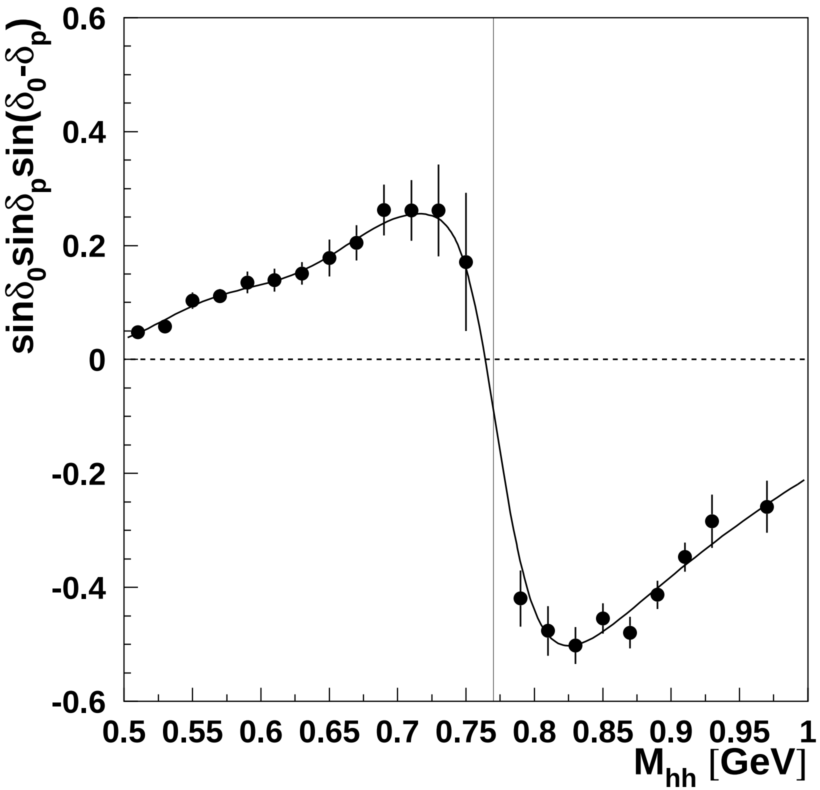
$$A_{UL}^{\sin\phi} \sim \frac{\sum_{i=1}^{N^{\rightarrow}} \sin\phi_i - \sum_{i=1}^{N^{\leftarrow}} \sin\phi_i}{\frac{1}{2}(N^{\rightarrow} + N^{\leftarrow})}$$

$\Longleftarrow$ weighting is sensitive to detector acceptance

comparison to model prediction

Model by Jaffe et al.:

- predicts mass dependence
- NO statements on size/sign of the asymmetry

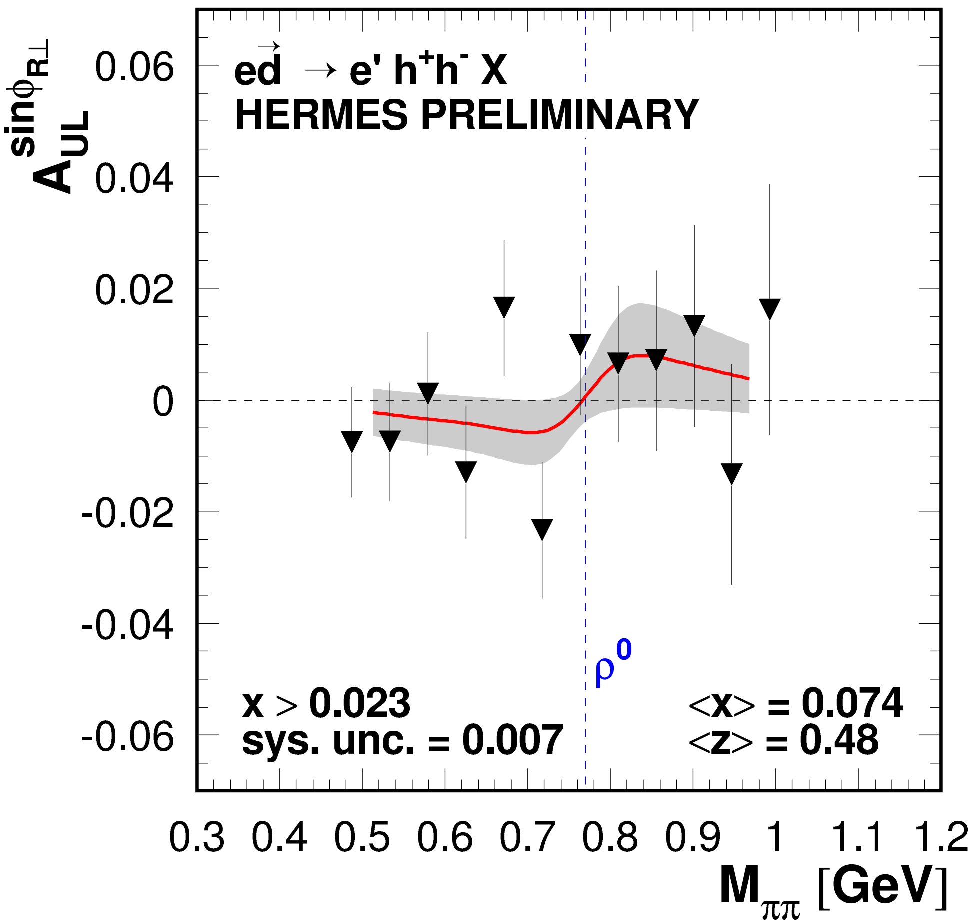


Fit data with:

$$g(M^2_{\pi\pi}) \simeq c_1 \mathcal{P}(M^2_{\pi\pi}) + c_2$$

by extracting c_1 & c_2 a qualitative comparison can be made to the model prediction

comparison to model prediction

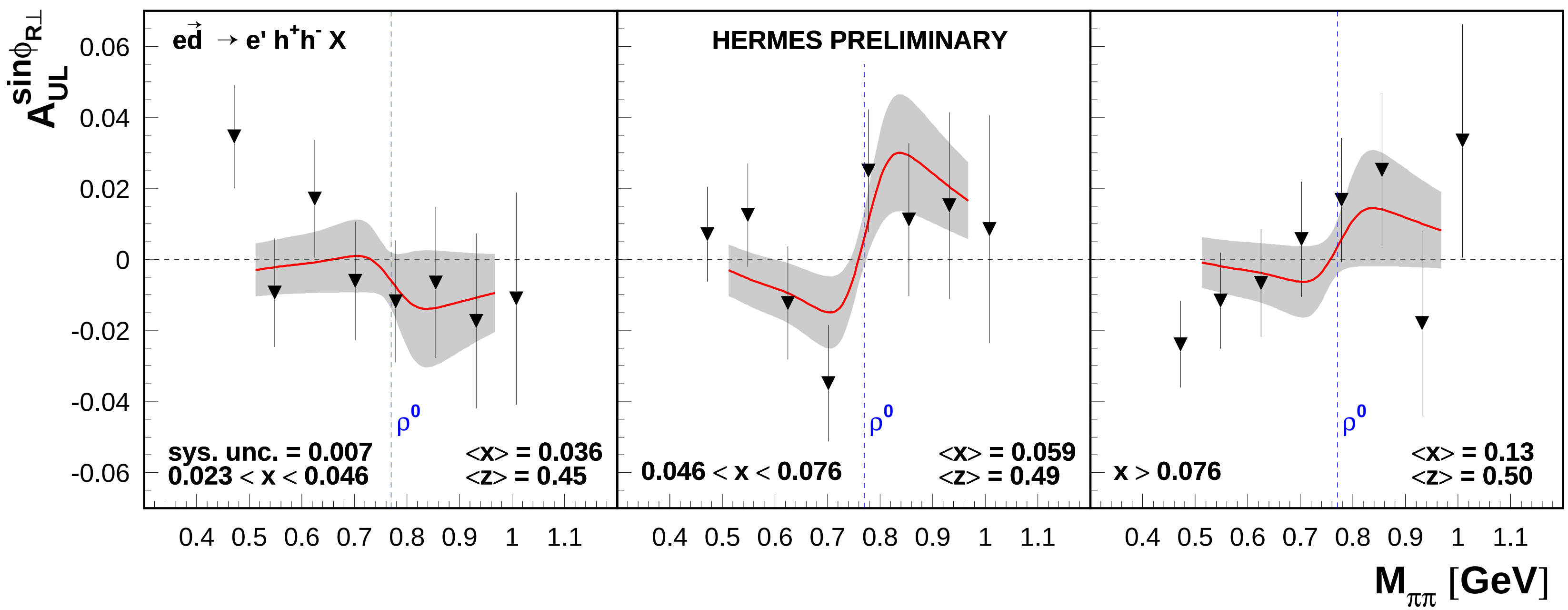


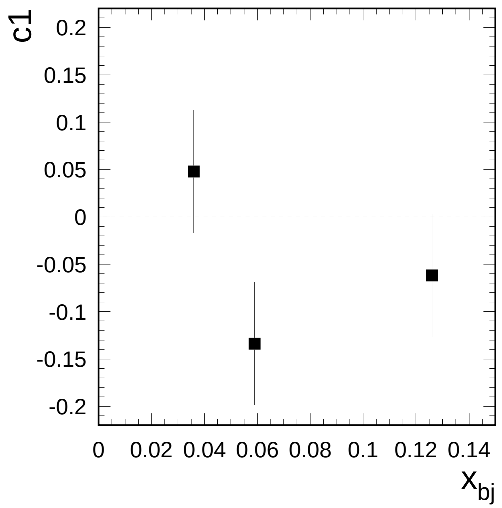
$$c_1 = \quad 0.040 \pm 0.036$$
$$c_2 = -0.001 \pm 0.004$$

- hint of a sign change at the ρ^0 mass

$$g(M_{\pi\pi}^2) \simeq c_1 \mathcal{P}(M_{\pi\pi}^2) + c_2$$

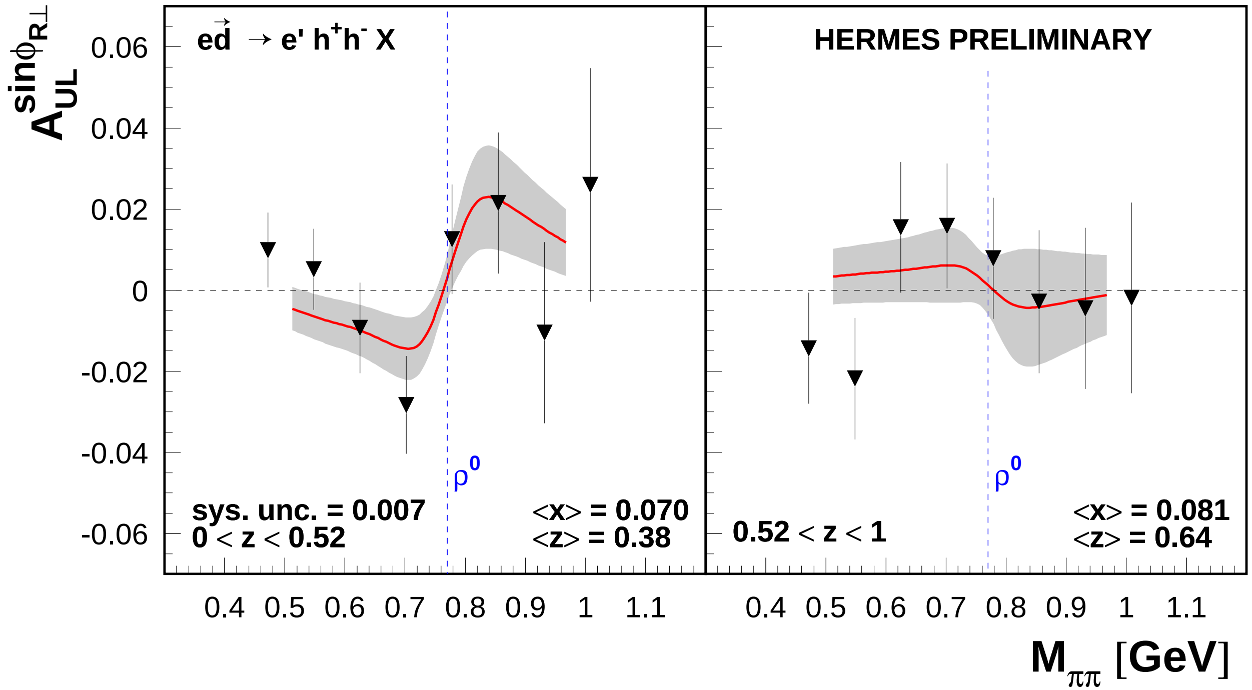
x-dependence



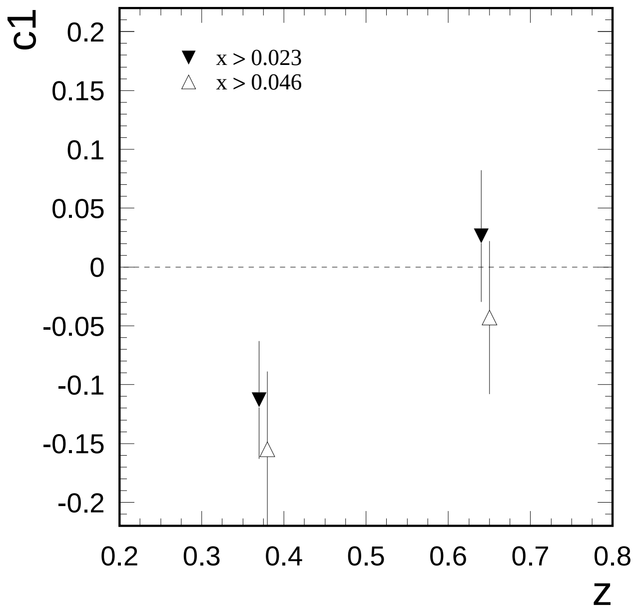


- higher x: hint of sign change at ρ^0 according to Jaffe's model
- $c_1(x) \propto h_1(x)$?

z-dependence



- sign change at ρ^0 according to Jaffe's model for low z
- $c_1(z) \propto H_1^{\sphericalangle,sp}(z, M_{\pi\pi})$?



Conclusions

- Initial HERMES measurements with a longitudinal target polarization show very interesting results.
- A similar analysis is underway with CLAS EG2000 data
- Since no single experiment is self-sufficient, JLab at 12 GeV can play a big role in determining h_1 through 2-hadron fragmentation functions, provided there is a multi-particle detector in its future.