Single-spin asymmetries

with 2 hadron fragmentation:

The Measurement

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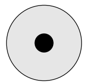
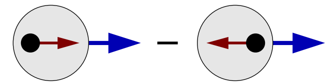
On behalf of the HERMES collaboration

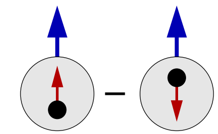
Layout:

- **Introduction**
- **Results**
- **Interpretation**

The holy grail

$f_1 =$ 

$g_1 =$ 

$h_1 =$ 

Characteristics of h_1:

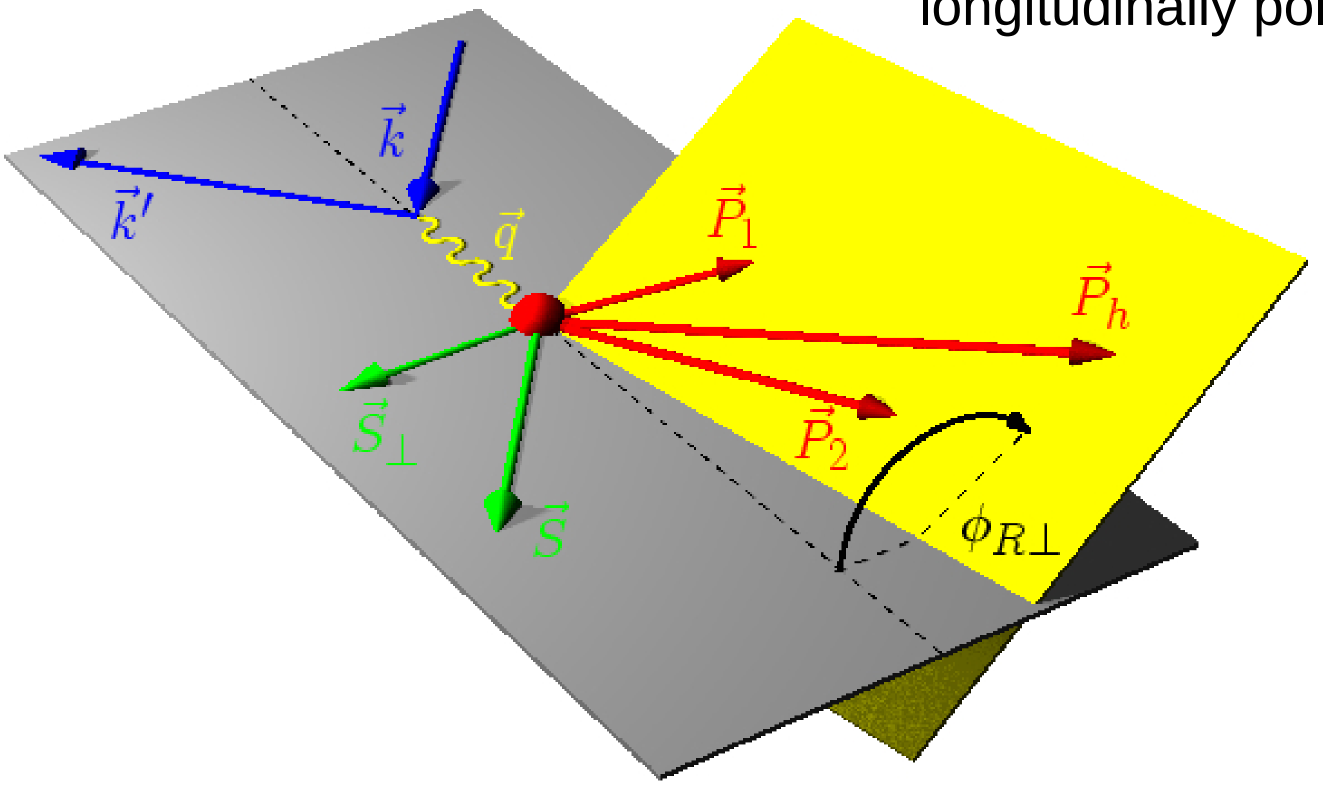
- leading twist -> on equal footing with f_1 and g_1
- chiral-odd -> can NOT be probed in inclusive DIS

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



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

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

h_1

Asymmetries -Theory

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

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

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

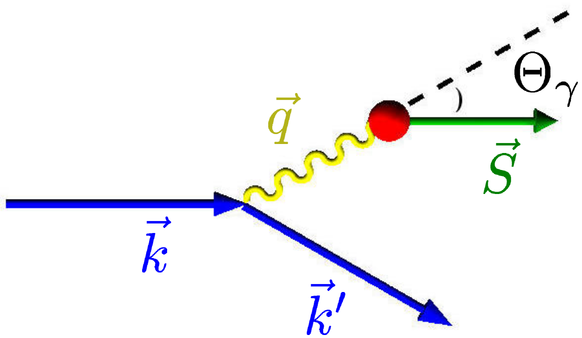
$T/L \Longrightarrow$ target spin defined w.r.t. virtual photon

Asymmetries - Experiment

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

target spin define d w.r.t. beam

target spin w.r.t. virtual photon



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

$$A_{UL} \sim V(y)\sin(\phi_{R\perp})\frac{M}{Q}(h_L H_1^{\sphericalangle} + g_1 \tilde{G}^{\sphericalangle}) + B'(y)\sin(\phi_{R\perp})\frac{M}{Q}h_1 H_1^{\sphericalangle}$$

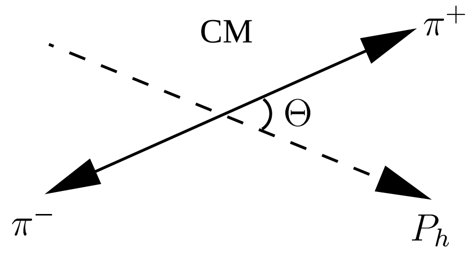
if $H_1^{\sphericalangle} \neq 0$:

$\Longrightarrow$ 2 hadron fragmentation can probe transversity!

h_1

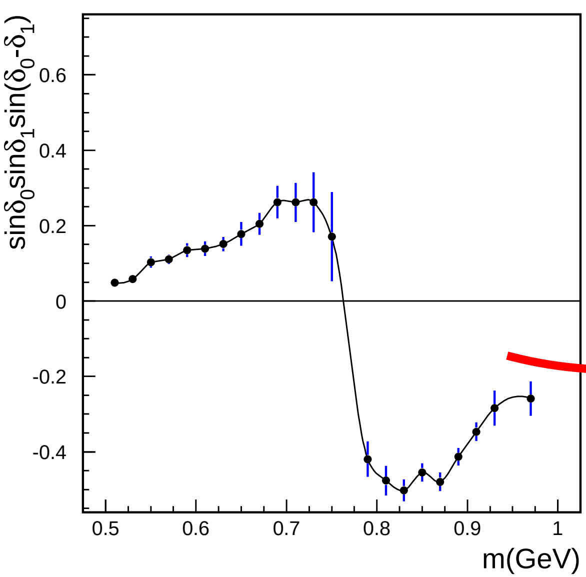
Interference FF

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



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

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



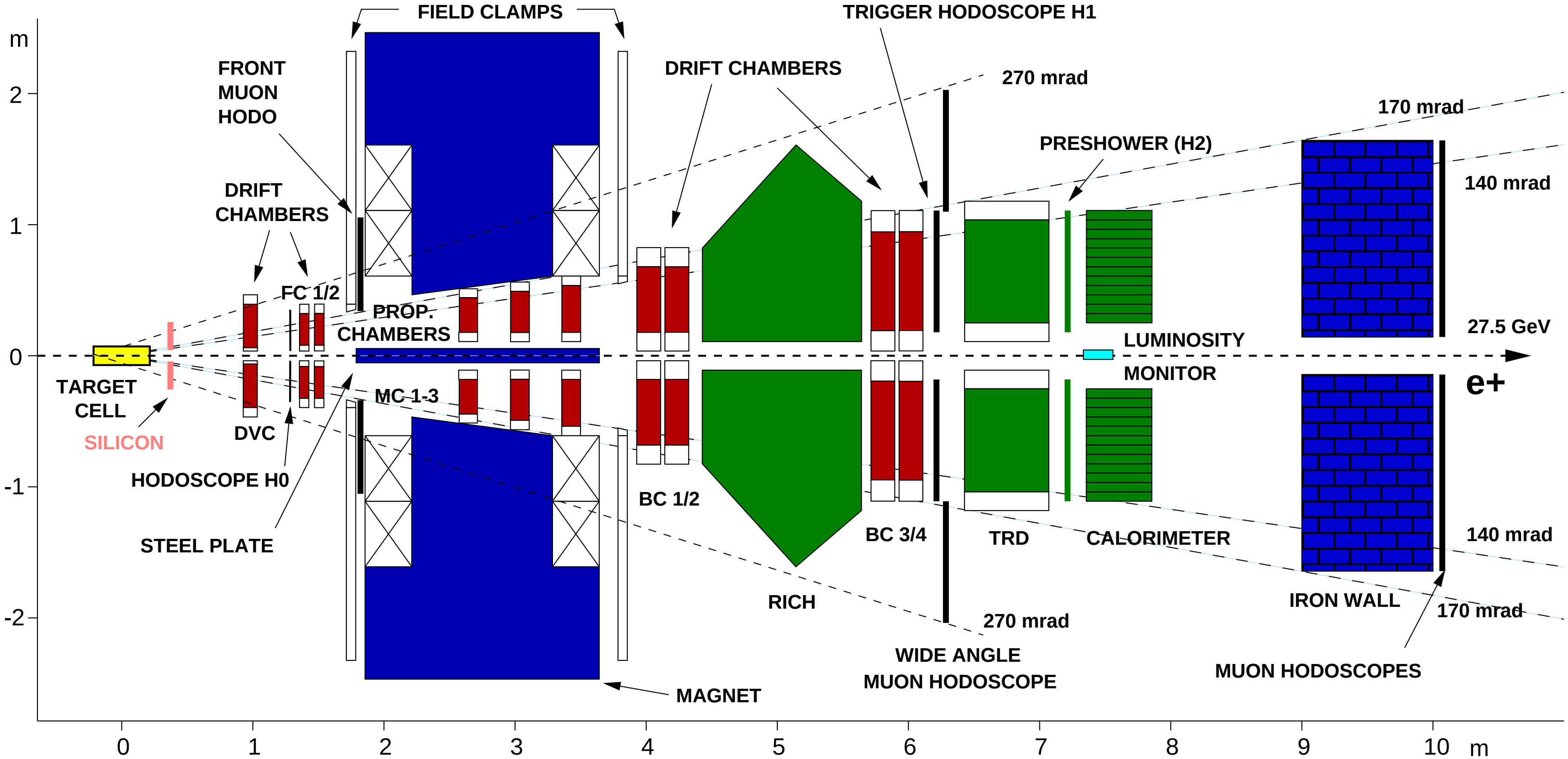
$$H_1^{\sphericalangle,sp}(z,M_{\pi\pi}^2) = \sin\delta_0 \sin\delta_1 \sin(\delta_0-\delta_1) H_1^{\sphericalangle,sp'}(z)$$

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

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

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

The HERMES Experiment



- Forward acceptance spectrometer: 40 mrad $\leq \Theta \leq 220$ mrad
- Tracking: 57 tracking planes: $\delta P/P = (0.7 - 1.3)\%$, $\delta\Theta \leq 0.6$ mrad

Analysis method

Fitting method:

$$A_{UL}(\phi) \sim \frac{N^{\leftarrow} - N^{\rightarrow}}{N^{\leftarrow} + N^{\rightarrow}}$$

fit with $\Longrightarrow$

$$f(\phi_{R\perp}) = a_0 + a_1 \sin\phi + b_1 \cos\phi + \ldots$$

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

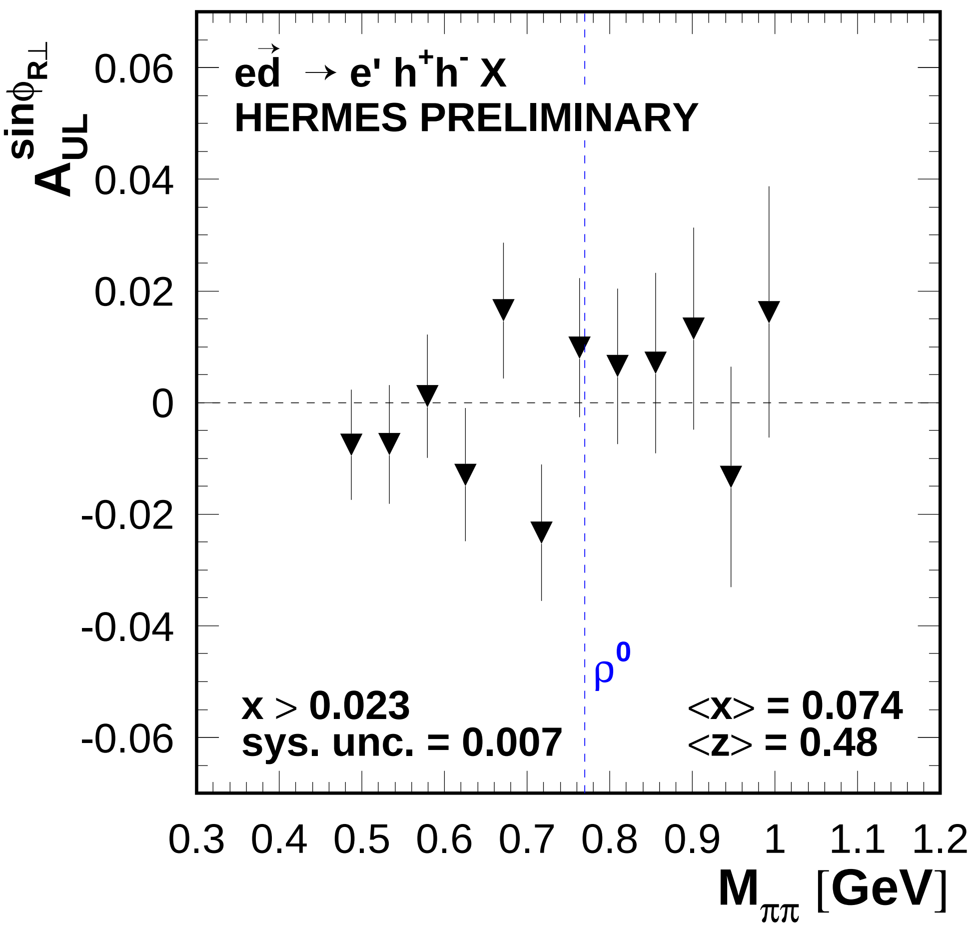
Weighting method:

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

Used fitting method for released results

$\Longrightarrow$ less sensitive to detector acceptance

Results



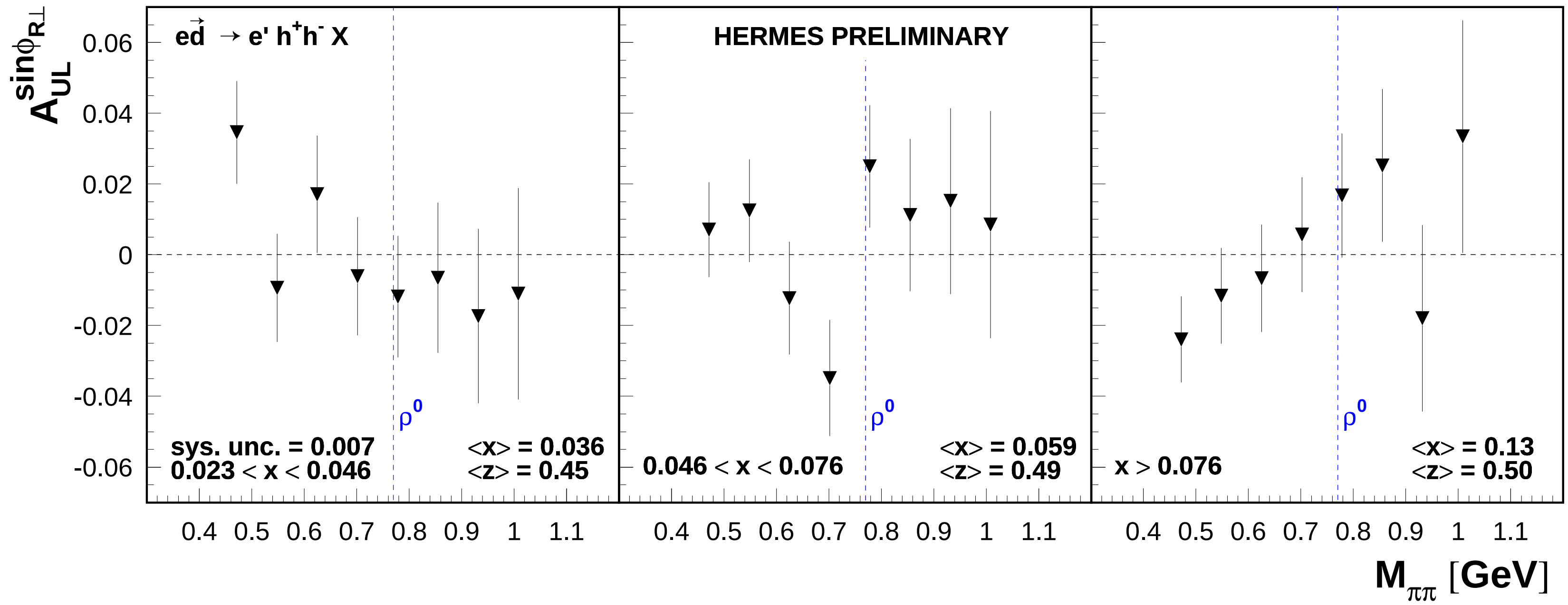
- first measurement ever of $A_{UL}^{\sin\phi_{R\perp}}$
- small asymmetries

h_1

x-dependence

Attempt to study x and z-dependence:

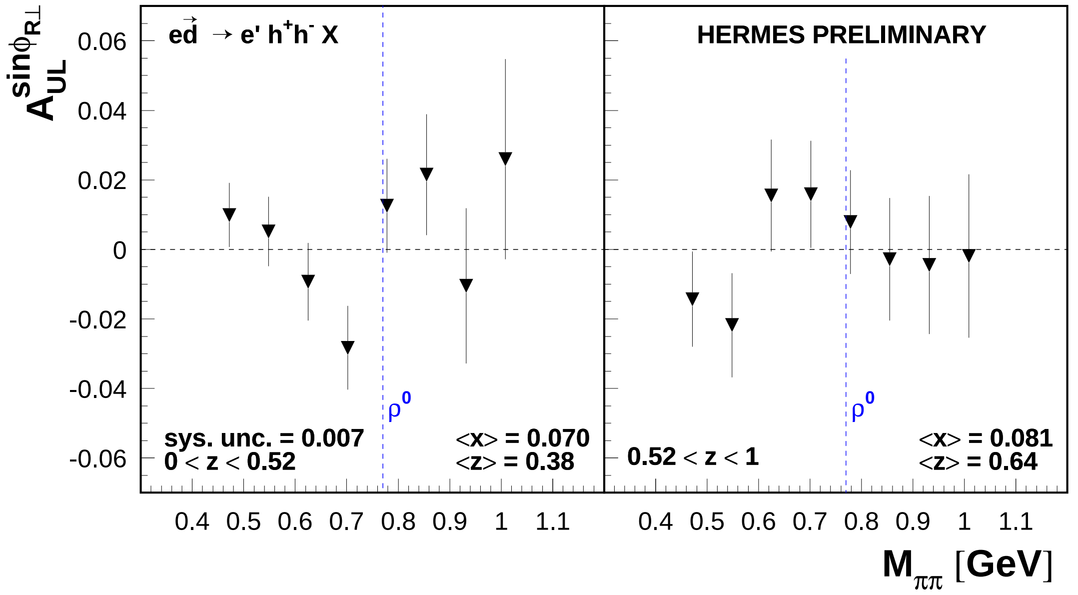
$$A_{UL}^{\sin\phi_{R\perp}} \propto h_1(x) H_1^{\sphericalangle,sp}(z, M_{\pi\pi}) + (\ldots)$$



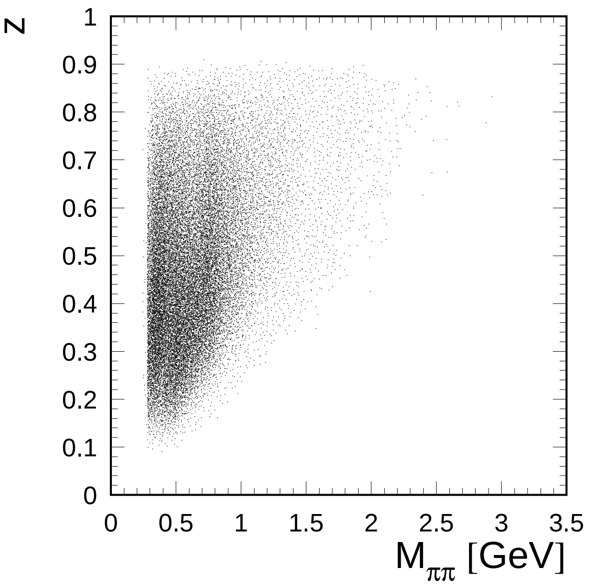
- no strong x-dependence observed
- statistics doesn't allow finer binning

h_1

z-dependence



$$z \equiv \frac{E_{\pi\pi}}{\nu}$$

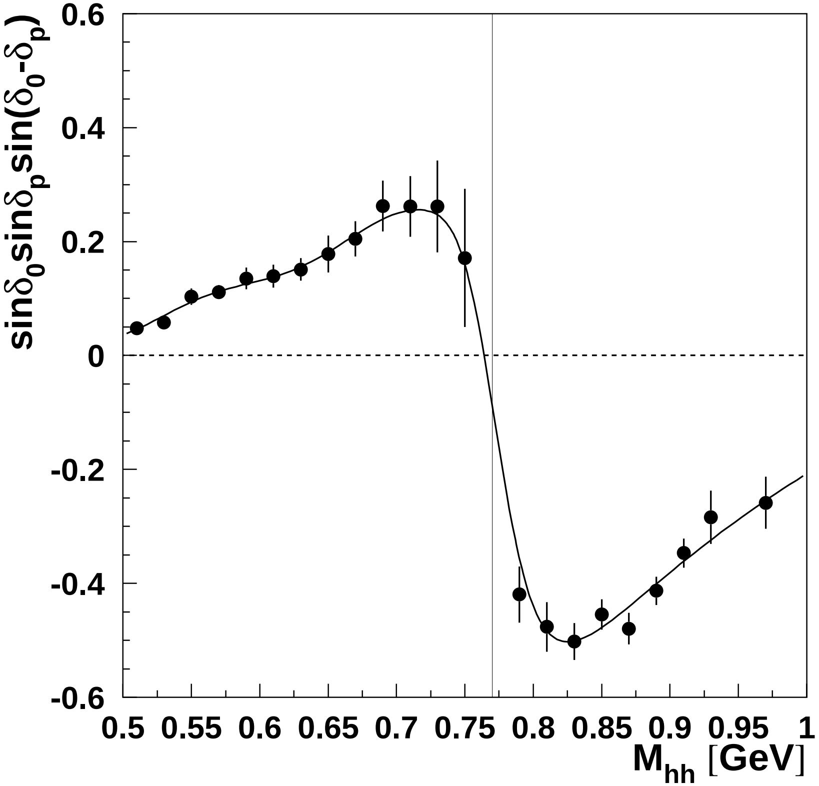


- no strong z-dependence observed
- no more than two bins possible

comparison to model prediction

Model by Jaffe et al.:

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

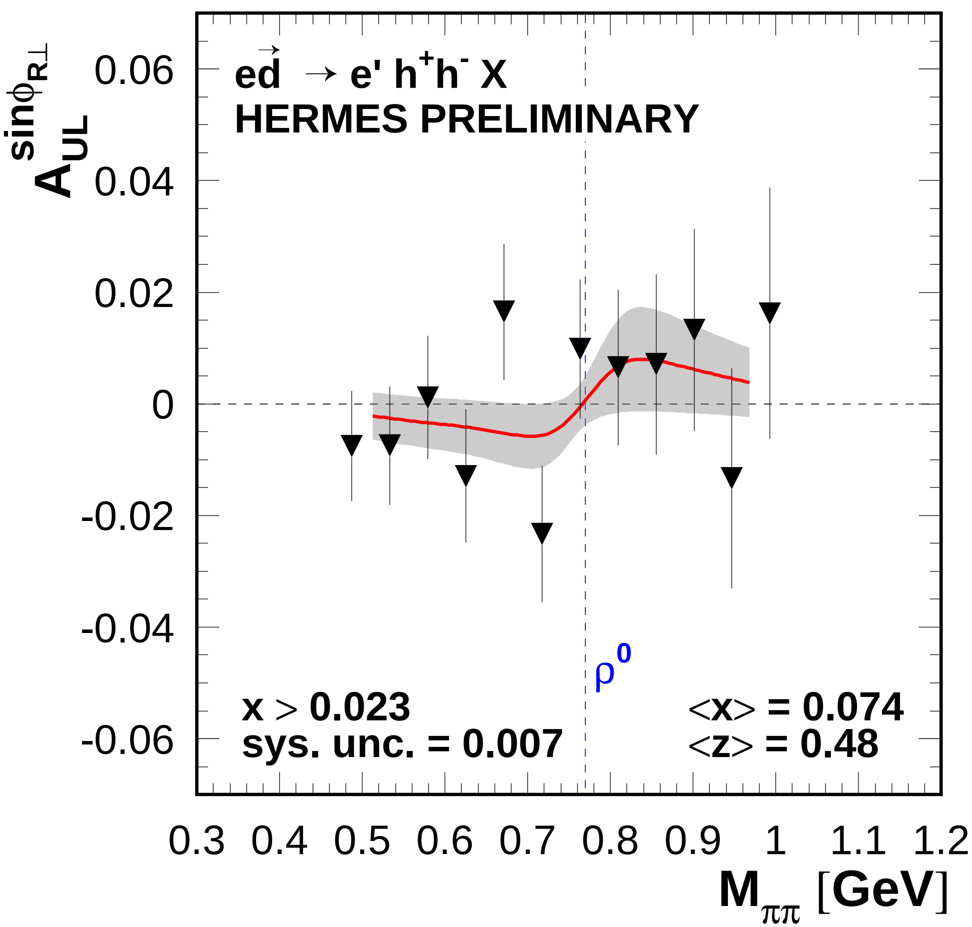


Fit data with:

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

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

comparison to model prediction



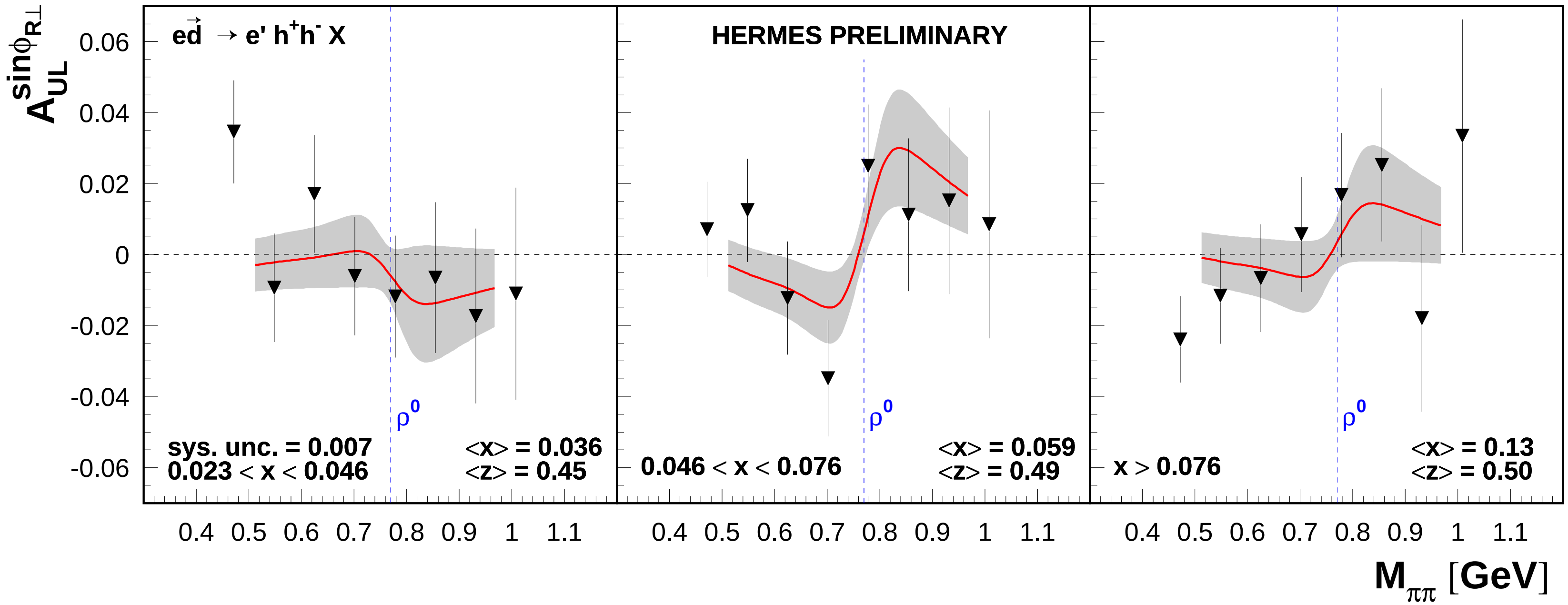
$$\begin{aligned} c_1 &= 0.040 \pm 0.036 \\ c_2 &= -0.001 \pm 0.004 \end{aligned}$$

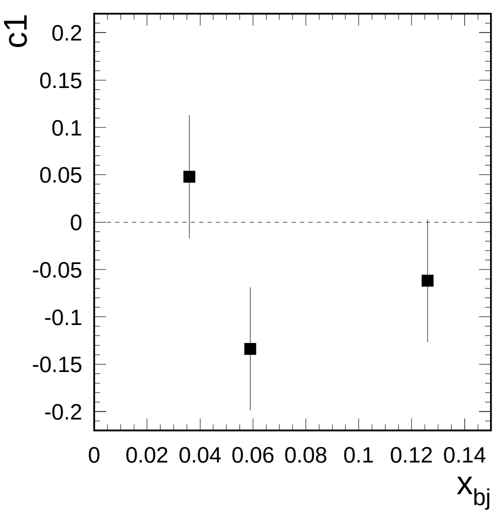
- hint of a sign change at the ρ^0 mass

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

h_1

x-dependence

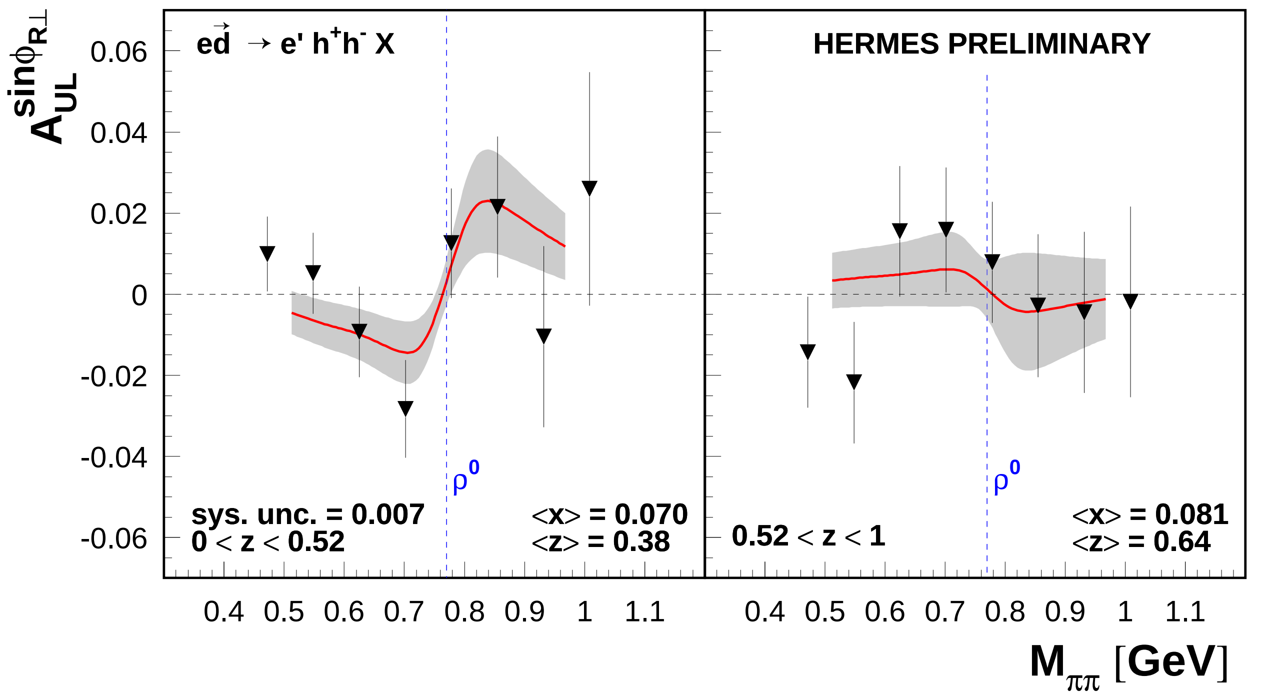


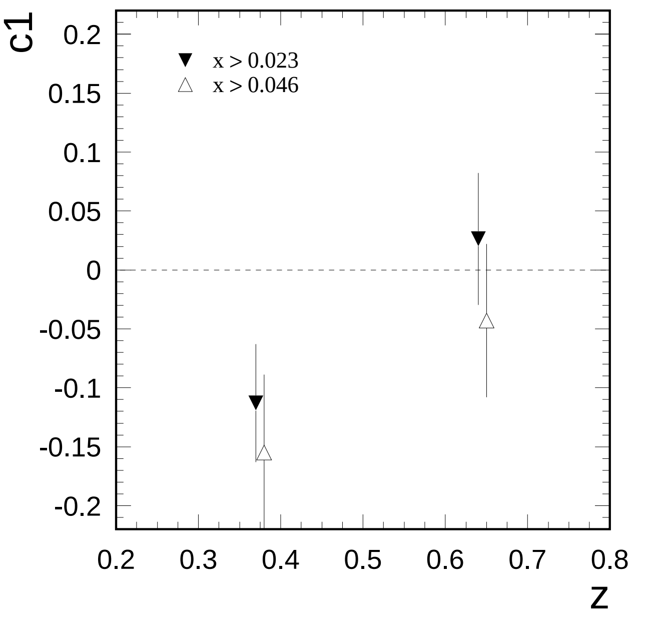


- higher x: hint of sign change at ρ^0 according to Jaffe's model
- $c_1(x) \propto h_1(x)$?

h_1

z-dependence





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

h₁

Conclusions & Outlook

Conclusions:

- Presented first measurement of $A_{UL}^{\sin\phi_{R\perp}}$
- Asymmetries of order $\sim 2\%$, but also consistent with zero
- $M_{\pi\pi}$-dependence consistent with model by Jaffe et al.
- Comparison with model prediction hints at x and z dependence
  $\Longrightarrow$ sensitive to $h_1(x) H_1^{\sphericalangle,sp}(z, M_{\pi\pi})$?

Outlook to $A_{UT}^{\sin\phi_{R\perp}}$:

- comparable uncertainty:
  - L polarized target $\rightarrow$ ~8M DIS events
    T polarized target $\rightarrow$ ~4M DIS events?
  - $\delta A \propto 1/\sqrt{N} \rightarrow \delta A$ dominated by statistical uncertainty
- much larger transverse target polarization $\rightarrow$ ~1/0.045 $= 22$ times bigger!