

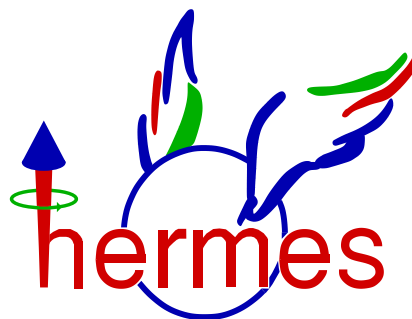
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# Beam Single Spin Azimuthal Asymmetries in Pion Electroproduction at HERMES

DIS 2004 Workshop, Štrbské Pleso, April 16

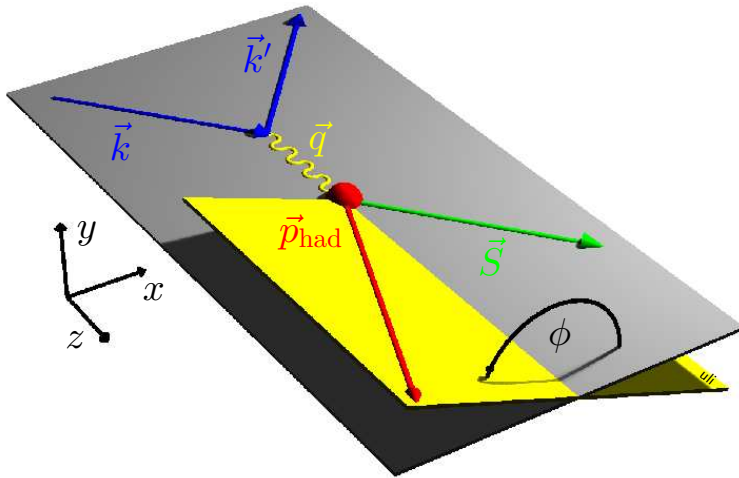
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# Semi Inclusive DIS:

$$\vec{e}p \rightarrow e'hX$$



$$Q^2 = 4EE' \sin^2\left(\frac{\theta}{2}\right)$$

$$\nu = E - E'$$

$$x = \frac{Q^2}{2m\nu}$$

$$y = \frac{\nu}{E} = \frac{p \cdot q}{p \cdot k}$$

$$z = \frac{E_h}{\nu}$$

$$\cos\phi = \frac{[\vec{q} \times \vec{k}][\vec{q} \times \vec{P}_h]}{|\vec{q} \times \vec{k}| |\vec{q} \times \vec{P}_h|}$$

$$\sigma(\phi) = A_0 + A_1 \sin\phi + B_1 \cos\phi + A_2 \sin 2\phi + B_2 \cos 2\phi \dots$$

$$\frac{d^3\sigma_{UU}}{dx dy dz d\phi} = \frac{1}{2} \left( \frac{d^3\sigma^+}{dx dy dz d\phi} + \frac{d^3\sigma^-}{dx dy dz d\phi} \right)$$

$$\frac{2}{P} \frac{d^3\sigma_{LU}}{dx dy dz d\phi} = \frac{1}{P^+} \frac{d^3\sigma^+}{dx dy dz d\phi} - \frac{1}{P^-} \frac{d^3\sigma^-}{dx dy dz d\phi}$$

# DFs and FFs:

$$\text{Factorization} \Rightarrow \sigma^{eH \rightarrow ehX} = \sum f^{H \rightarrow q} \otimes \sigma^{eq \rightarrow eq} \otimes D^{q \rightarrow h}$$

$\Downarrow$  **Distribution**
 $\Downarrow$  **Fragmentation**

$$\sigma_{unpol} \equiv \sigma_{UU} \propto (1 - y + y^2/2) \sum_{a, \bar{a}} e_a^2 x f_1^a(x) D_1^a(z) \quad \text{KNOWN!}$$

$$\sigma_{pol} = \{ \sigma_{UL}, \sigma_{LL}, \sigma_{UT}, \sigma_{LU}, \sigma_{LT} \}$$

$\swarrow \quad \searrow$   
**Beam Target polarization**

$$\sigma_{UL} \propto S_L \sin \phi (2 - y) \sqrt{1 - y} \frac{M}{Q} \sum_{a, \bar{a}} e_a^2 x^2 h_L^a(x) H_1^{\perp a}(z)$$

$$\sigma_{UT} \propto S_T (1 - y) \sin(\phi + \phi_s) \sum_{a, \bar{a}} e_a^2 x h_1^a(x) H_1^{\perp a}(z)$$

$$\sigma_{LU} \propto \lambda_e \sin \phi y \sqrt{1 - y} \frac{M}{Q} \sum_{a, \bar{a}} e_a^2 x^2 [e^a(x) H_1^{\perp a}(z) + h_1^{\perp a}(x) E^a(z)]$$

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# Asymmetries:

$$A_{LU} = \frac{d\sigma^+ - d\sigma^-}{d\sigma^+ + d\sigma^-} = \frac{d\sigma_{LU}}{d\sigma_{UU}}$$

$$A_{LU} \propto \frac{e(x)H_1^\perp(z) + h_1^\perp(x)E(z)}{f_1(x)D_1(z)}$$

	Distribution	Fragmentation
Twist-2	$h_1^\perp$	$H_1^\perp$
Twist-3	$e$	$E$

$$\left. \begin{aligned} f_1 &= \text{circle with black dot} \\ D_1 &= \text{circle with black dot} \end{aligned} \right\} \text{unpolarized functions}$$

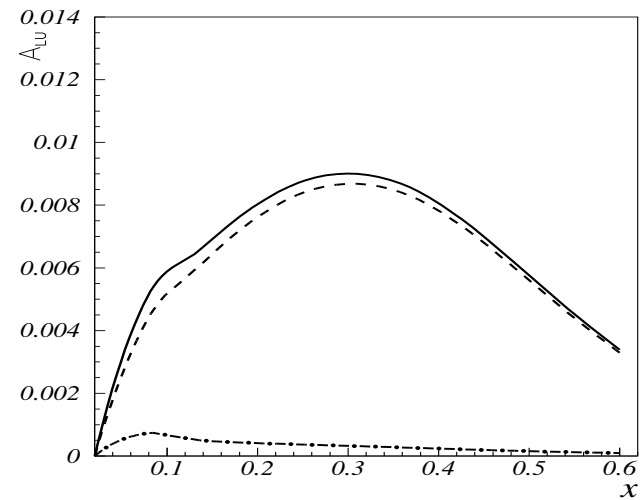
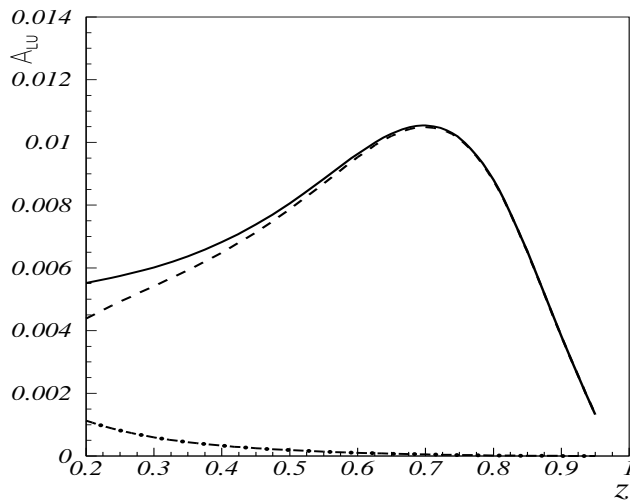
$$\left. \begin{aligned} h_1^\perp &= \text{circle with red dot and up arrow} - \text{circle with red dot and down arrow} \\ H_1^\perp &= \text{circle with green dot and up arrow} - \text{circle with green dot and down arrow} \end{aligned} \right\} \text{polarized functions}$$

# Asymmetries:

$$A_{LU} = \frac{d\sigma^+ - d\sigma^-}{d\sigma^+ + d\sigma^-} = \frac{d\sigma_{LU}}{d\sigma_{UU}}$$

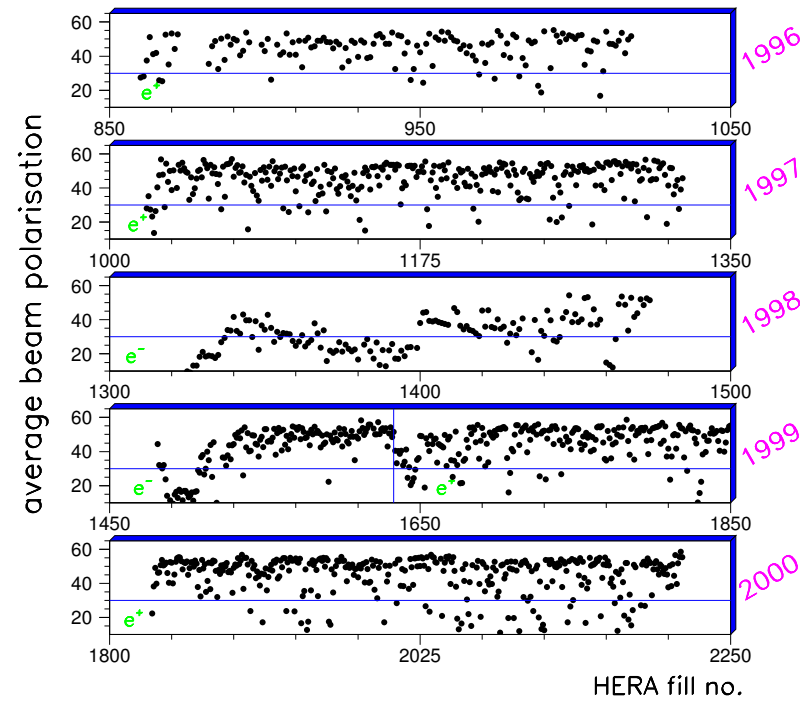
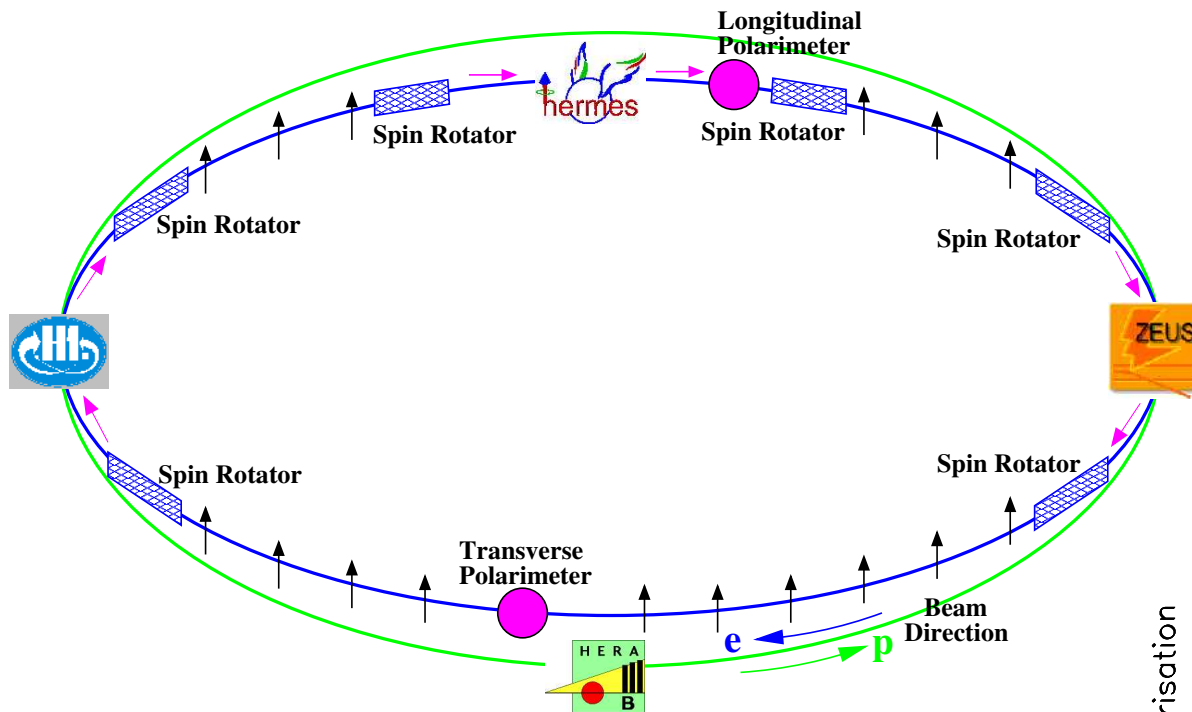
$$A_{LU} \propto \frac{e(x)H_1^\perp(z) + h_1^\perp(x)E(z)}{f_1(x)D_1(z)}$$

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Contributions of  $eH_1^\perp$  (dashed line) and  $h_1^\perp E$  (dotted line) terms in  $A_{LU}$  according to quark-diquark model (vs.  $z, x$ ).  $\Rightarrow h_1^\perp E$  is small

# HERA setup:



HERA-e beam self-polarized due to emission of synchrotron radiation

⇒ Sokolov-Ternov effect

$$\langle P_{\text{beam}} \rangle \simeq 55\%$$

# Beam SSA at HERMES

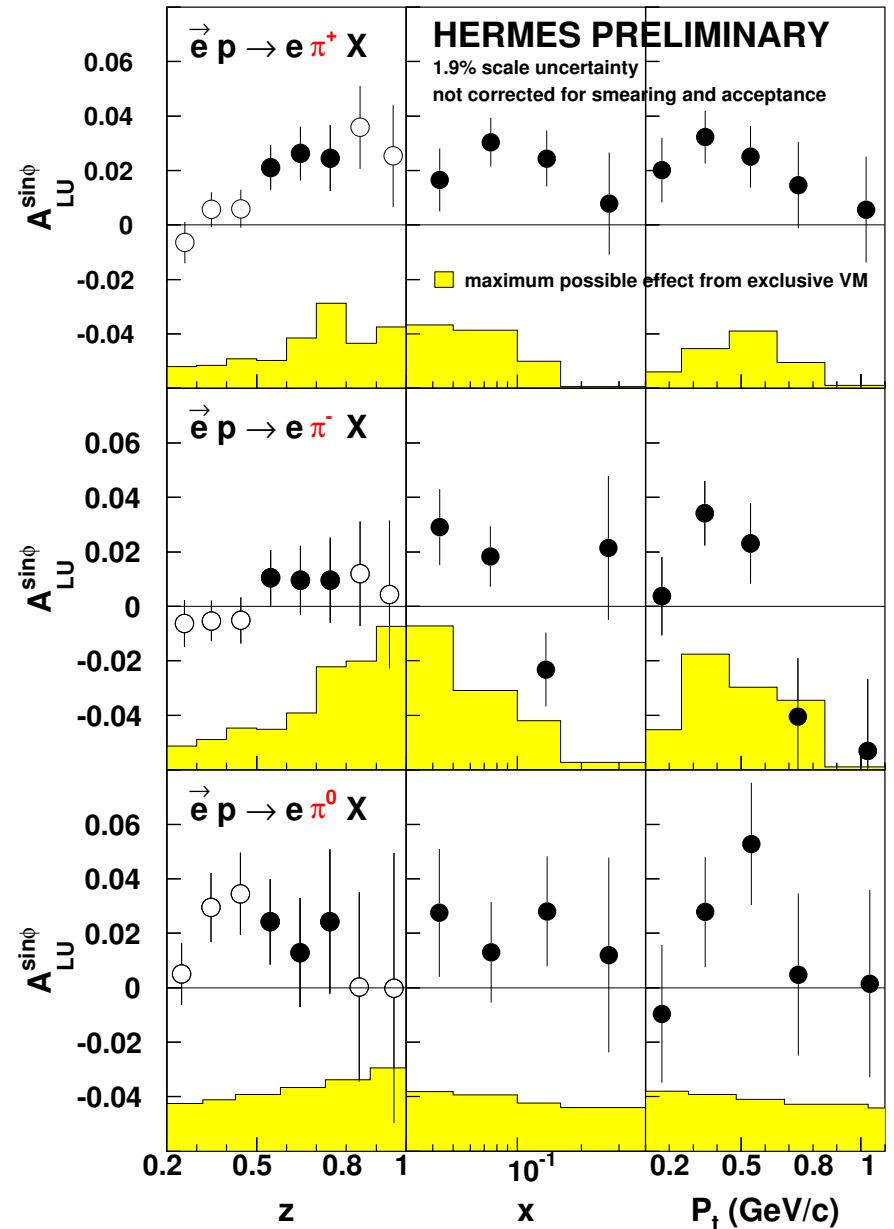
Fit method:

$$A(\phi) = \frac{N^+L^- - N^-L^+}{N^+L^-P^- + N^-L^+P^+}$$

Moments method:

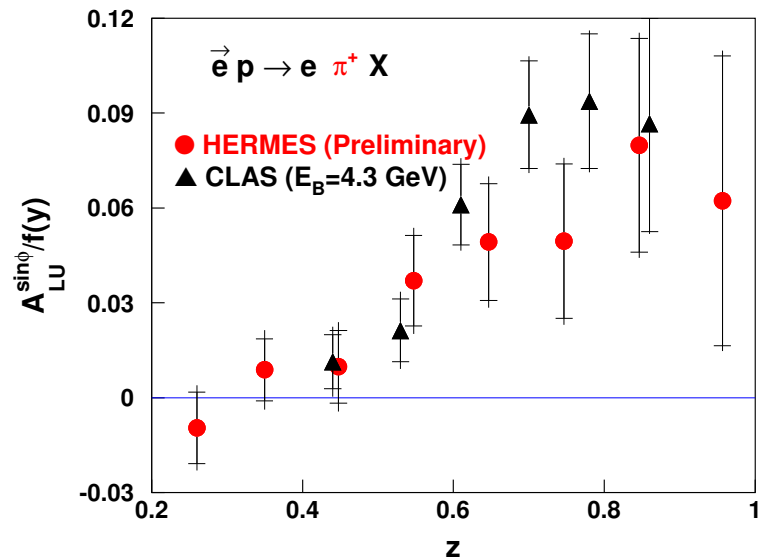
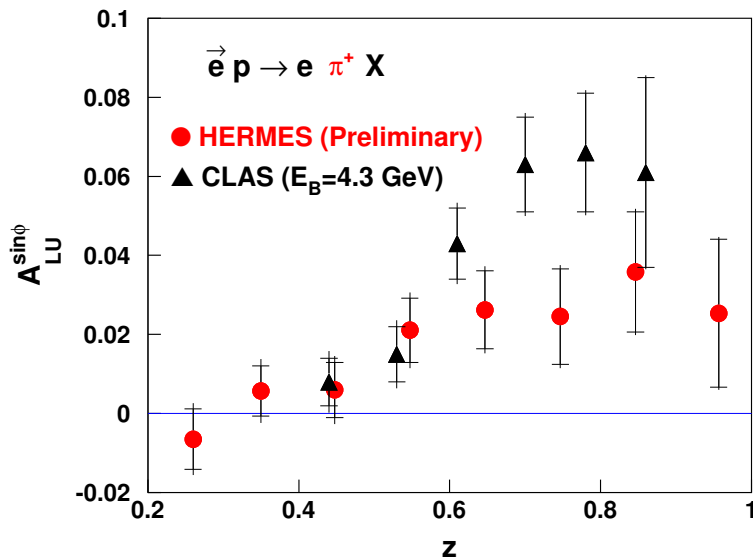
$$A_{LU}^{W\pm} = \frac{1}{P^\pm N^\pm} \sum_{i=1}^{N^\pm} W(\phi_i)$$

where  $W = \sin \phi$





# Comparison with CLAS:

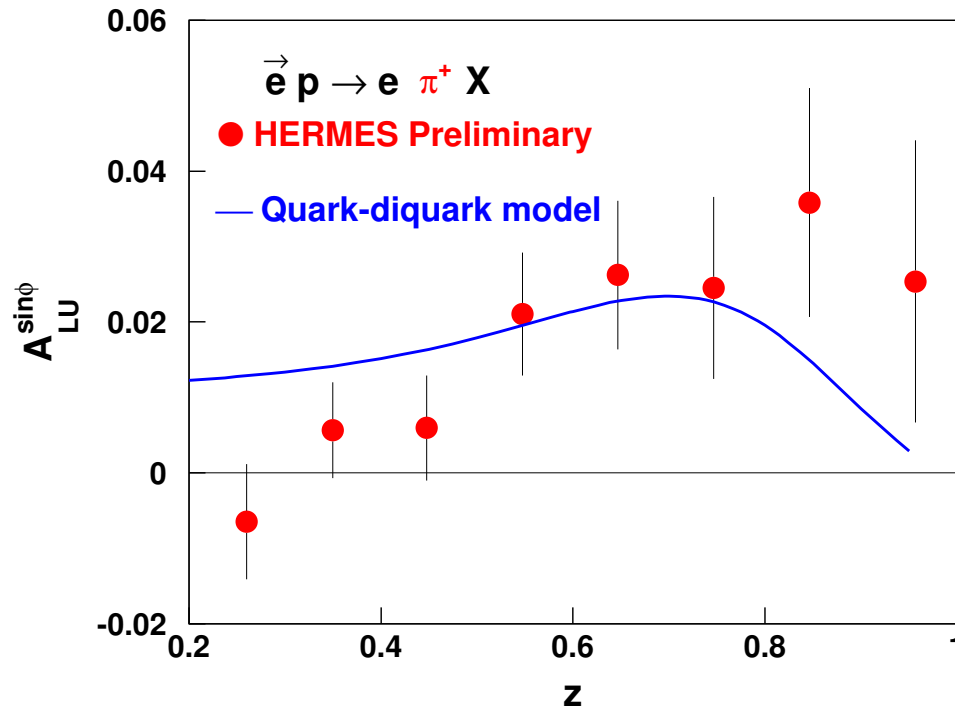


In leading order (neglecting  $\sigma_L/\sigma_T$ ):

$$f(y) = \frac{\sqrt{2(1-y)}}{1-y+y^2/2}$$

Strong kinematic suppression factor in HERMES ( $0.7 \rightarrow 0.35$  at higher  $z$ )  
roughly constant ( $f(y) \simeq 0.7$ ) in CLAS.

# Comparison with Theory:



Average kinematics:

$$\langle P_T \rangle = 0.45 \text{ GeV}$$

$$\langle Q^2 \rangle = 2.4 \text{ GeV}^2$$

L.Gamberg, D.Hwang, K.Oganessyan, hep-ph/0311221, Phys. Lett. B584 (2004) 276.

Quark-diquark spectator model prediction for  $A_{LU}$  at HERMES kinematics.

# Conclusions and future plans:

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- First measurement of beam-spin asymmetry for all pions
- Independent source of information about  $H_1^\perp$  Collins function
- Agreement with CLAS measurement of BSA for  $\pi^+$  (after kinematic range corrections)
- Agreement with theoretical model calculation

## Future plans:

- Measure BSA for pions and kaons on deuterium target