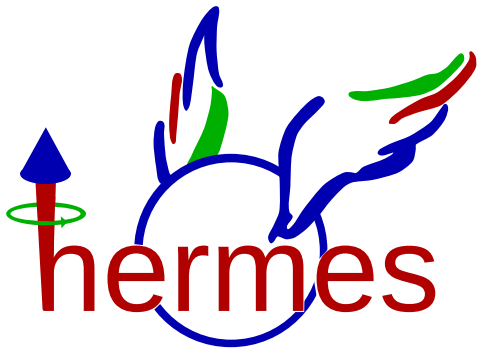
Azimuthal Single-Spin Asymmetries on a Transversely Polarized Hydrogen Target at HERMES

G. Schnell, H. Tanaka, H. Oshuga, T. Kobayashi, Y. Miyachi, T. Shibata

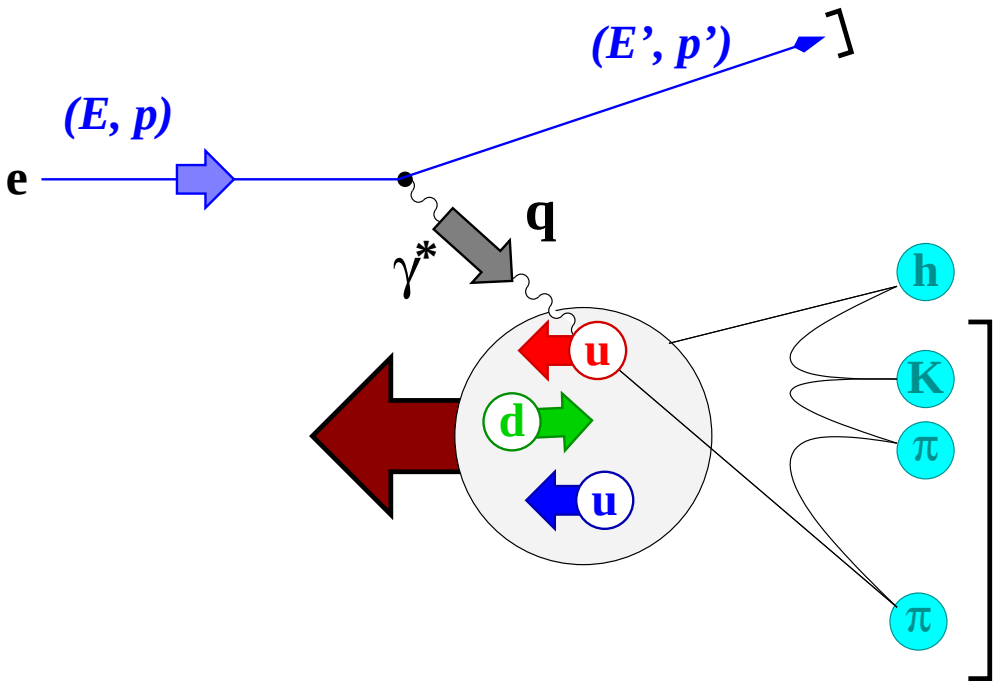
Tokyo Institute of Technology

gunar.schnell@desy.de

For the  Collaboration

Deep Inelastic Scattering

use well-known probe to study hadronic structure



$$Q^2 \overset{\text{lab}}{=} 4EE' \sin^2(\frac{\Theta}{2})$$

$$\nu \overset{\text{lab}}{=} E - E'$$

$$W^2 \overset{\text{lab}}{=} M^2 + 2M\nu - Q^2$$

$$y \overset{\text{lab}}{=} \frac{\nu}{E}$$

$$x \overset{\text{lab}}{=} \frac{Q^2}{2M\nu}$$

$$z \overset{\text{lab}}{=} \frac{E_h}{\nu}$$

Factorization $\Rightarrow \sigma^{ep\to ehX} = \sum_q DF^{p\to q} \otimes \sigma^{eq\to eq} \otimes FF^{q\to h}$

Azimuthal Single-Spin Asymmetries

$ep \longrightarrow e'\pi X$ – study azimuthal distribution of π's:

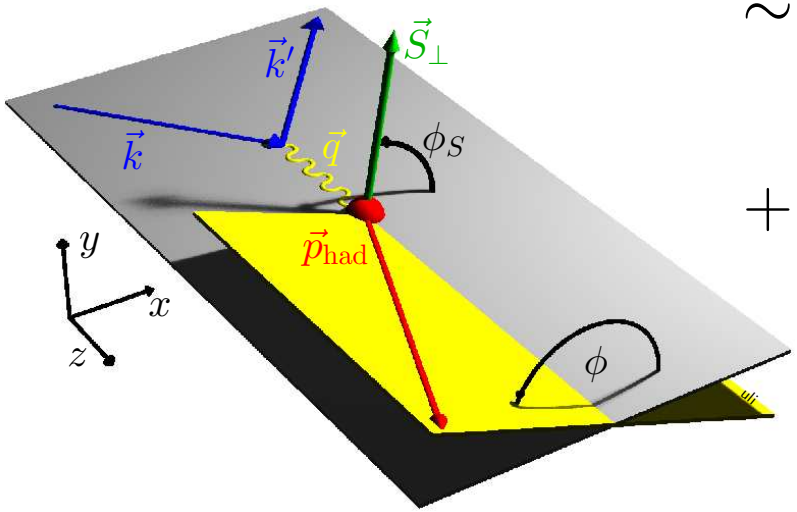
(Transversely polarized target & Unpolarized beam)

$$A_{UT}(\phi,\phi_S) = \frac{1}{\langle S_\perp \rangle} \cdot \frac{N^+(\phi,\phi_S) - N^-(\phi,\phi_S)}{N^+(\phi,\phi_S) + N^-(\phi,\phi_S)}$$

$$\sim \sin\Phi_C \cdot \sum_q e_q^2 \, \mathcal{I}\Big[h_1^q(x,p_T^2) \cdot H_1^{\perp,q}(z,k_T^2)\Big]$$

$$+ \sin\Phi_S \cdot \sum_q e_q^2 \, \mathcal{I}\Big[f_{1T}^{\perp,q}(x,q_T^2) \cdot D_1^q(z,k_T^2)\Big]$$

$$+ \ldots$$



$\Phi_C = \phi + \phi_S$ Collins angle

$\Phi_S = \phi - \phi_S$ Sivers angle

$\mathcal{I}[\ldots]$: convolution integral over initial (p_T) and final (k_T) quark transverse momenta

Resolving the Convolution Integral

A priori transverse momentum dependence not known
$\hookrightarrow$ can not resolve convolution without model assumptions

$\Rightarrow$ weight with transverse hadron momentum $P_{h\perp}$:

$$A_{UT}(\phi,\phi_S) = \frac{1}{\langle S_\perp \rangle} \cdot \frac{\sum_{i=1}^{N^+} P_{h\perp,i}(\phi,\phi_S) - \sum_{i=1}^{N^-} P_{h\perp,i}(\phi,\phi_S)}{N^+(\phi,\phi_S) + N^-(\phi,\phi_S)}$$

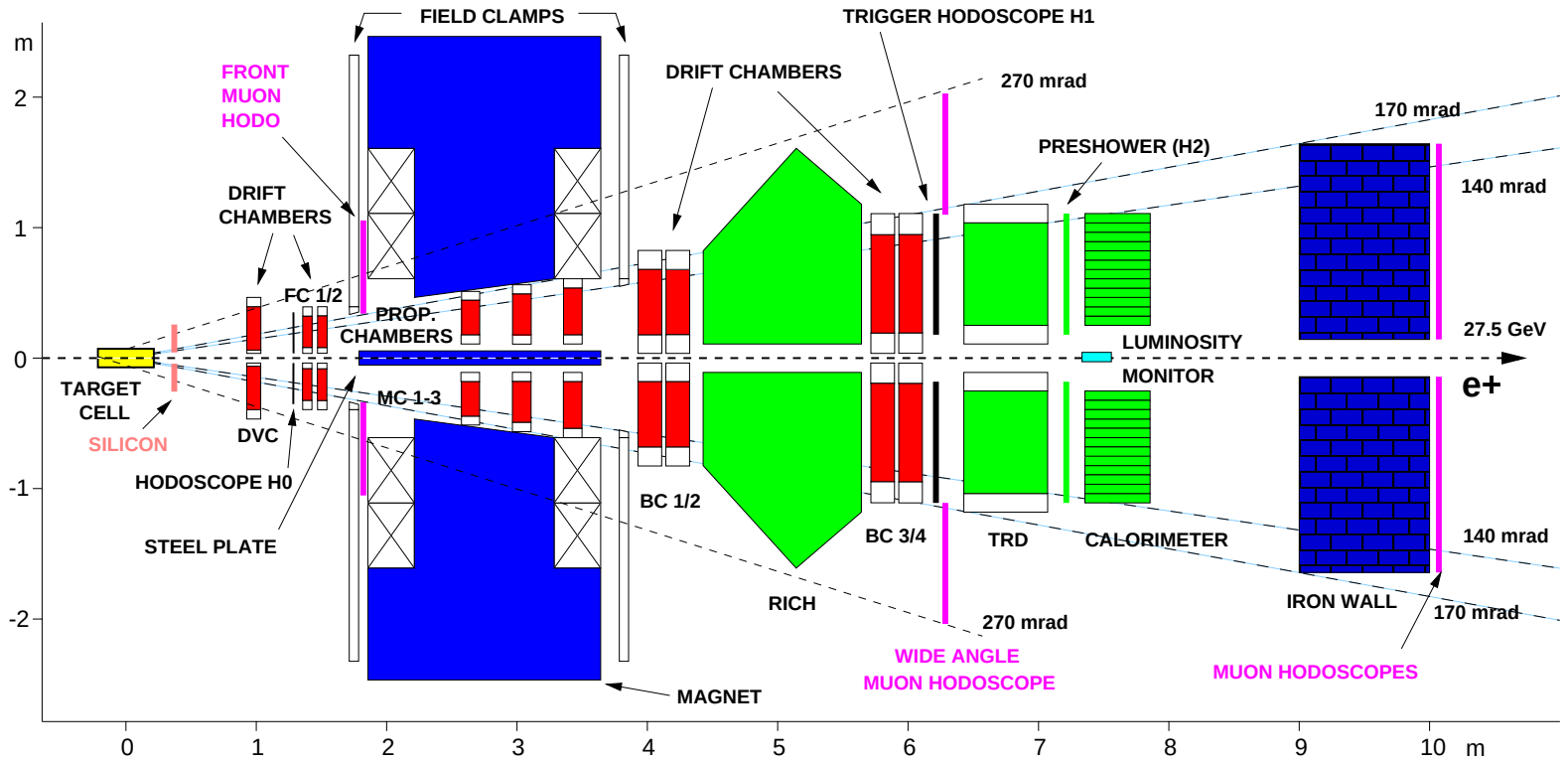
$$\sim \sin\Phi_C \cdot \sum_q e_q^2 \; h_1^q(x) \; H_1^{\perp(1),q}(z)$$

$$+ \sin\Phi_S \cdot \sum_q e_q^2 \; f_{1T}^{\perp(1),q}(x) \; D_1^q(z)$$

$$+ \ldots$$

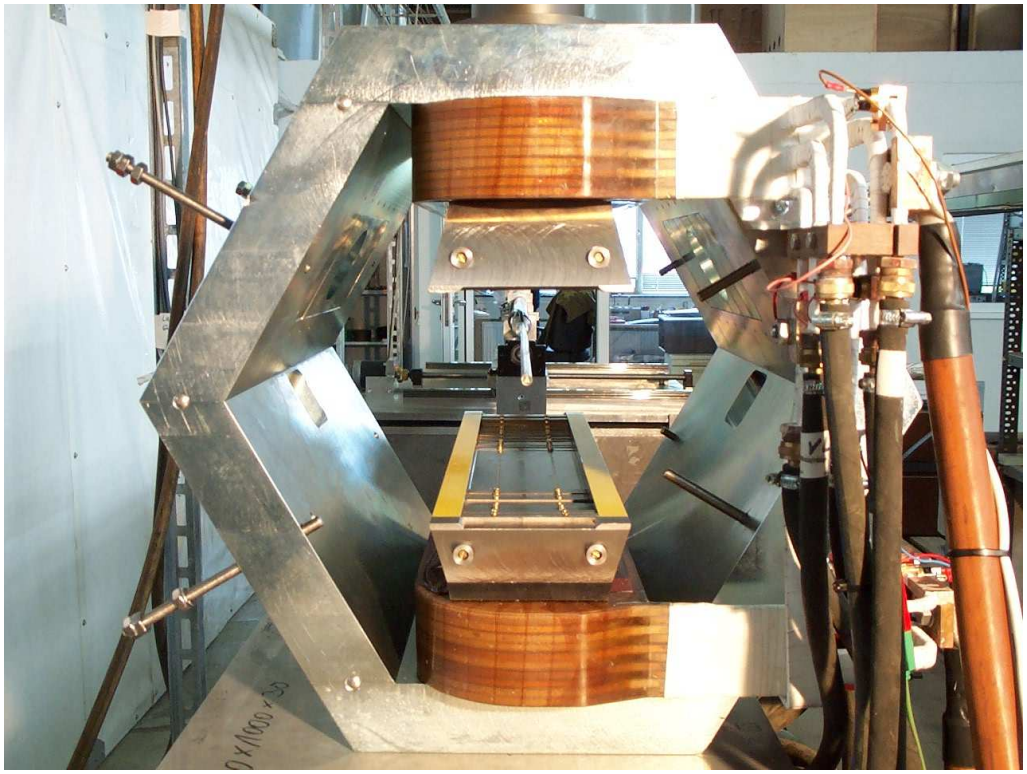
(1): p_T^2-/k_T^2-moment of distribution / fragmentation function

The HERMES Spectrometer



- Internal storage cell: pure gas target
- Forward acceptance spectrometer: $40\ \text{mrad} \leq \Theta \leq 220\ \text{mrad}$
- Tracking: 57 tracking planes: $\delta P/P = (0.7 - 1.3)\%$, $\delta\Theta \leq 0.6$ mrad
- PID: Cherenkov (RICH after 1997), TRD, Preshower, Calorimeter

Transverse Target HERMES



- **Transverse target magnet ($B = 0.295T$)**
- **High uniformity along beam direction: $\Delta B \leq 4.5 \cdot 10^{-5} T$**
- **Transversely polarized hydrogen**
- **Target polarization around 75%**

Effects of Transverse Target Magnet

- transverse target field deflects beam

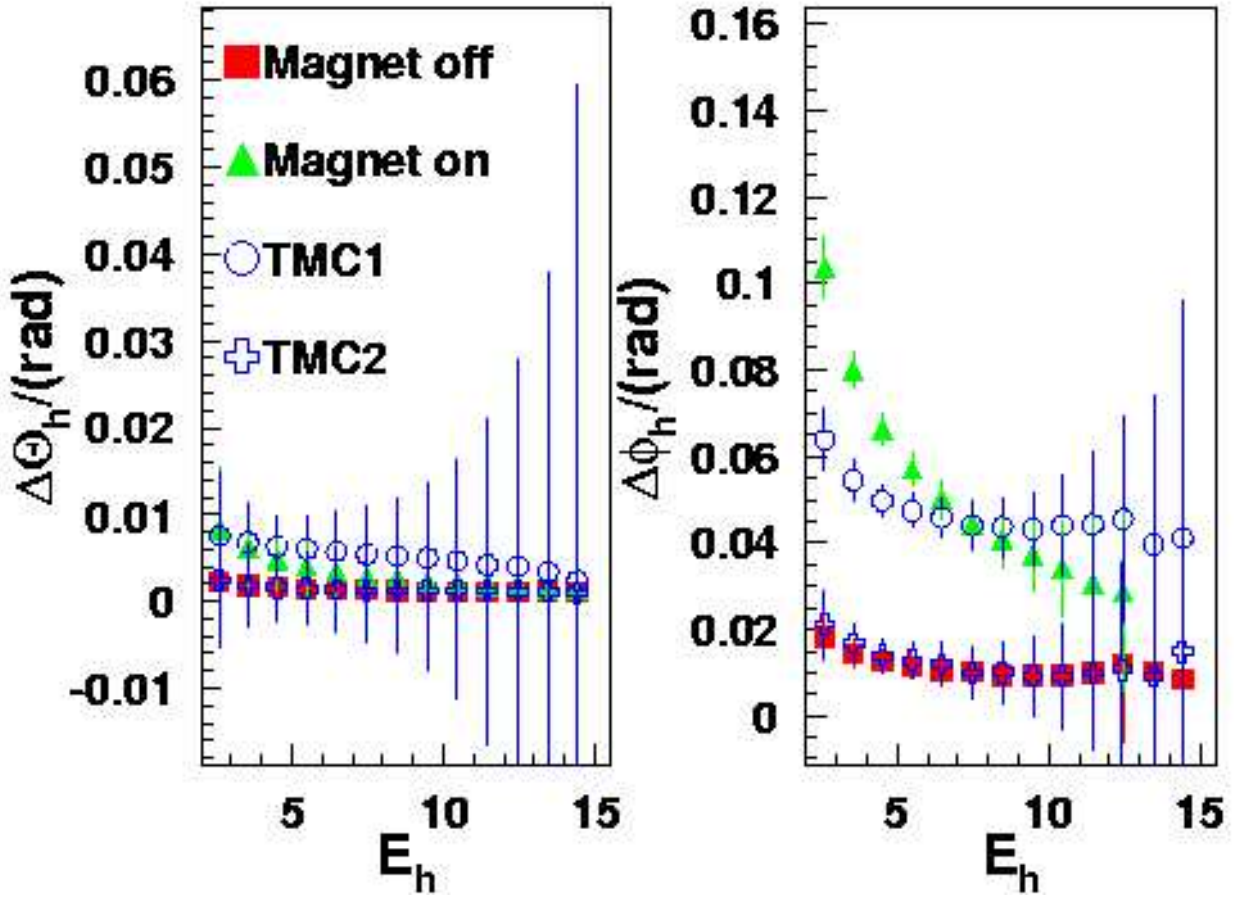
$\Rightarrow$ installed compensating magnets up- and downstream of target

- target field also deflects detected particles

$\Rightarrow$ reconstructed vertex kinematics change

$\Rightarrow$ implemented tracking correction

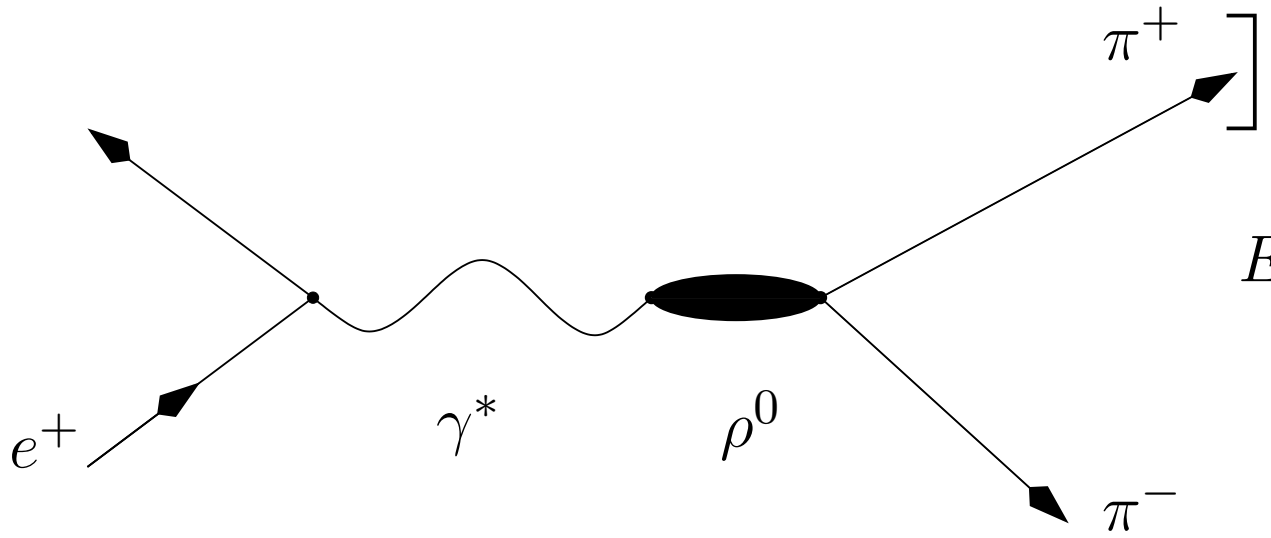
Track Correction (TMC2) at Work



no significant difference between resolutions with and without magnet (using TMC2)

Contribution from Exclusive Vector Meson Production

detection of π's from exclusively produced vector mesons:



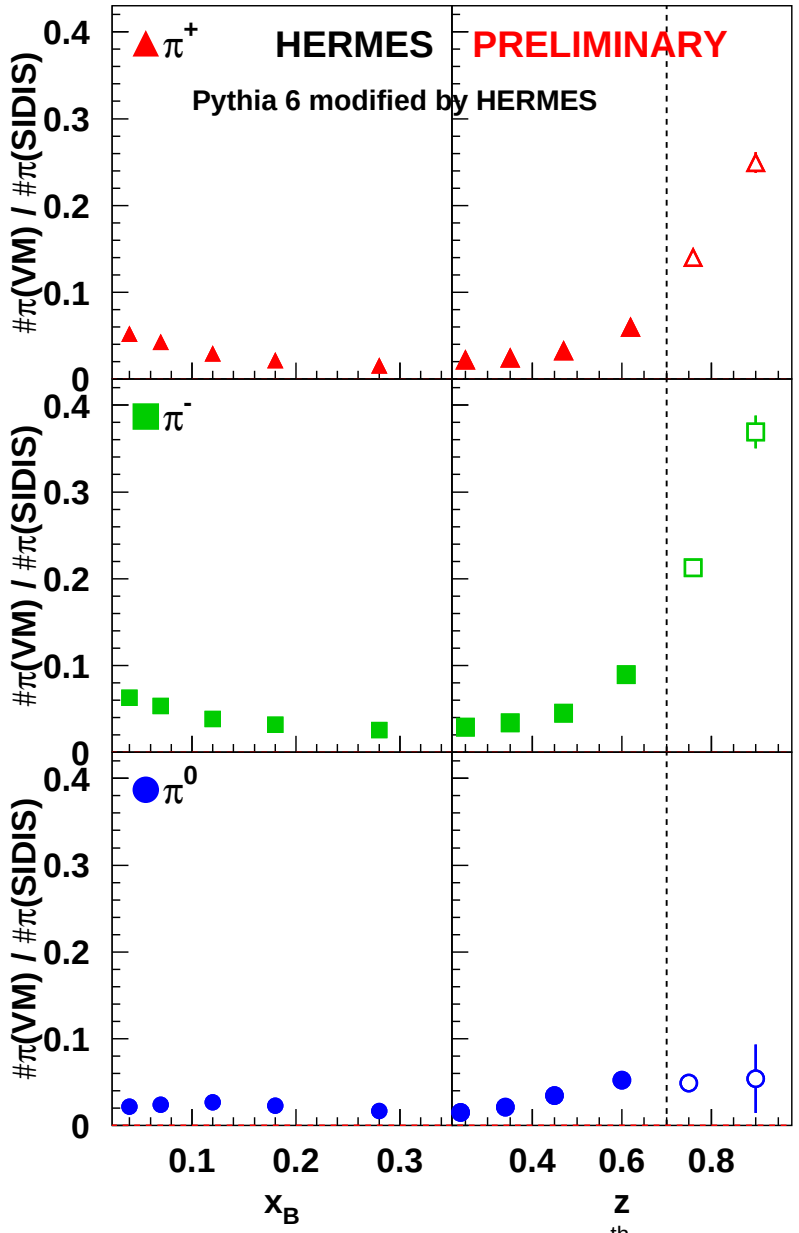
$$E_\pi < E_\rho = E_{\gamma^*}$$
$$\hookrightarrow z_\pi < 1$$

$$E_\rho = E_{\gamma^*}$$
$$\hookrightarrow z_\rho = 1$$

π's from exclusive VM misidentified as π's from fragmentation

Contamination of SIDIS Sample

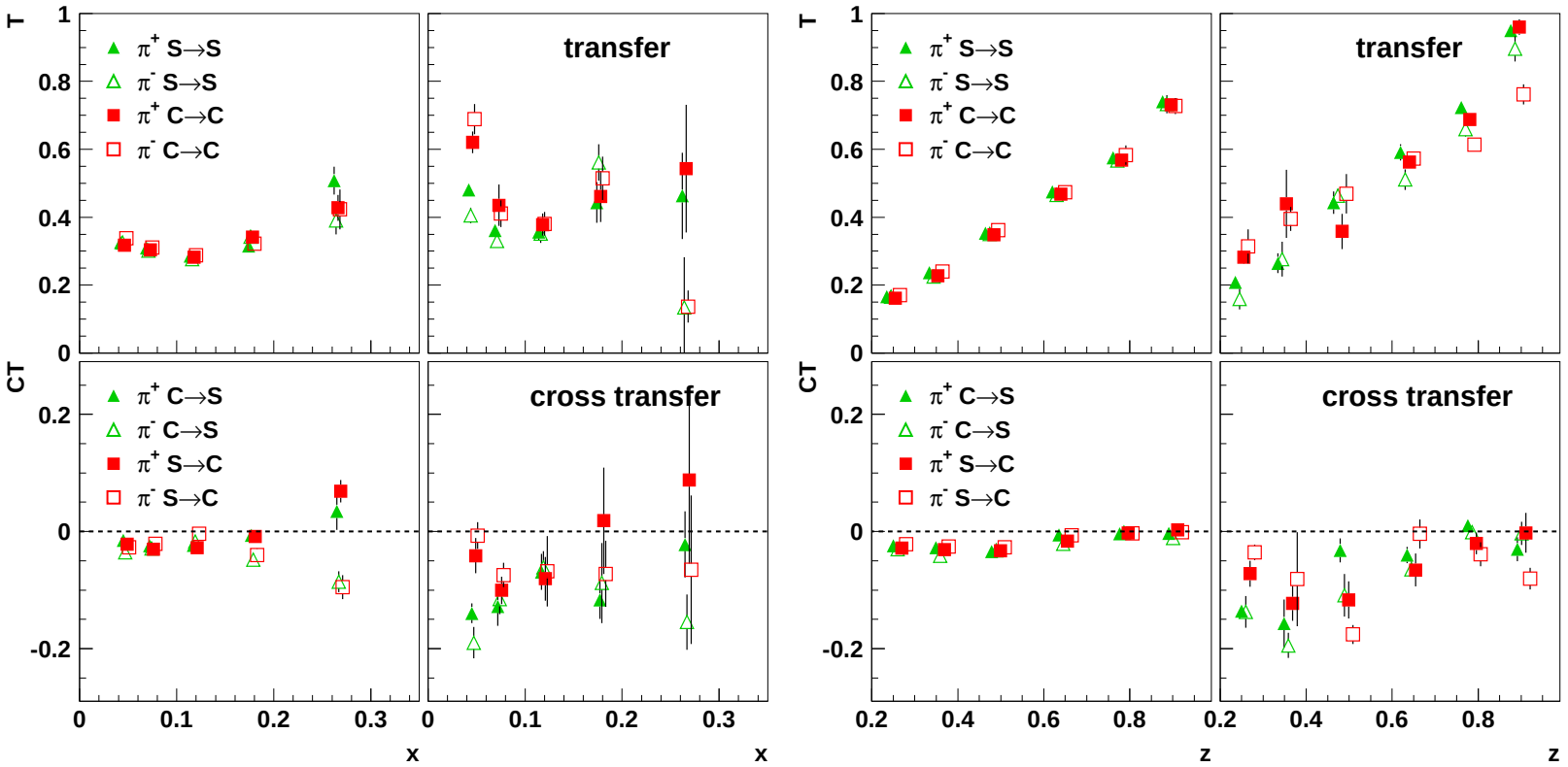
- GEANT based detector simulation
- PYTHIA physics generator tuned for HERMES
- radiative effects included
- identify π's from exclusive processes (ρ^0, ω)



small contribution for $z < 0.7$

Asymmetry Transfer from exclusive Vector Meson

π's can have similar azimuthal distribution as parent VM

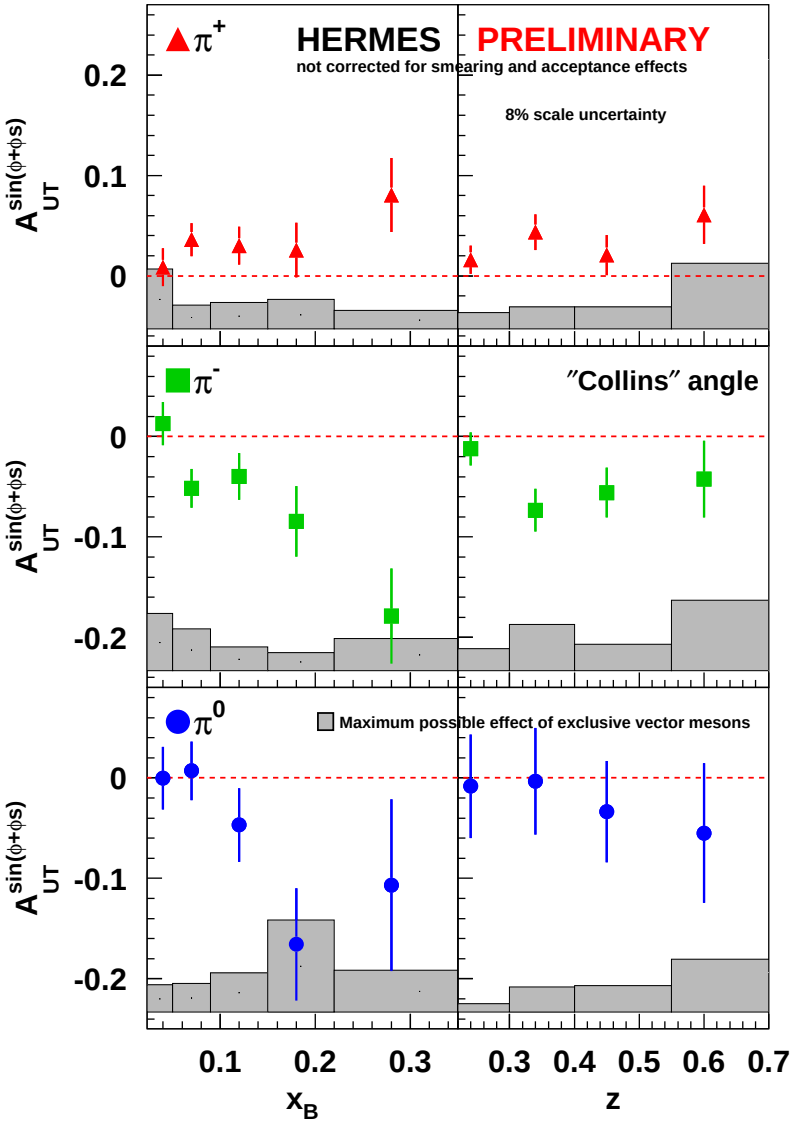


total contribution to measured asymmetry:

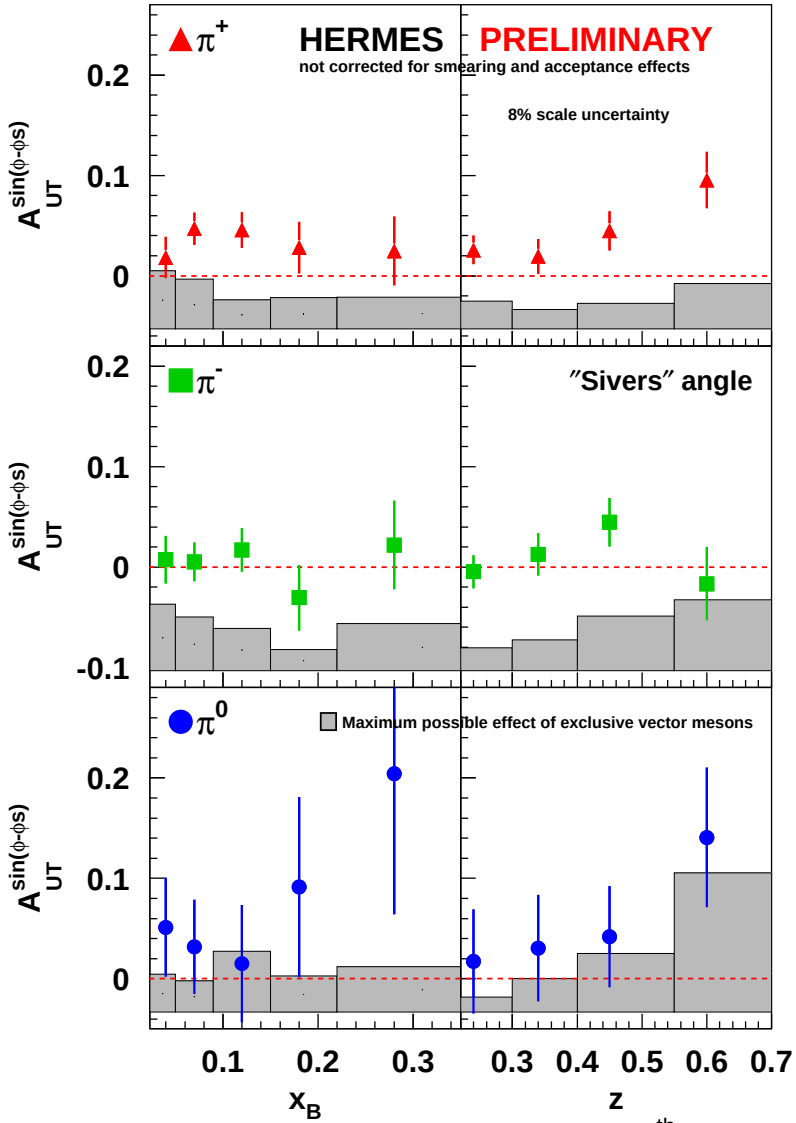
contamination $\otimes$ VM asymmetry $\otimes$ asymmetry transfer

Preliminary Results (unweighted)

$$A_{UT}^{\sin\Phi} \propto \mathcal{I}\left[h_1 \cdot H_1^{\perp}\right]$$

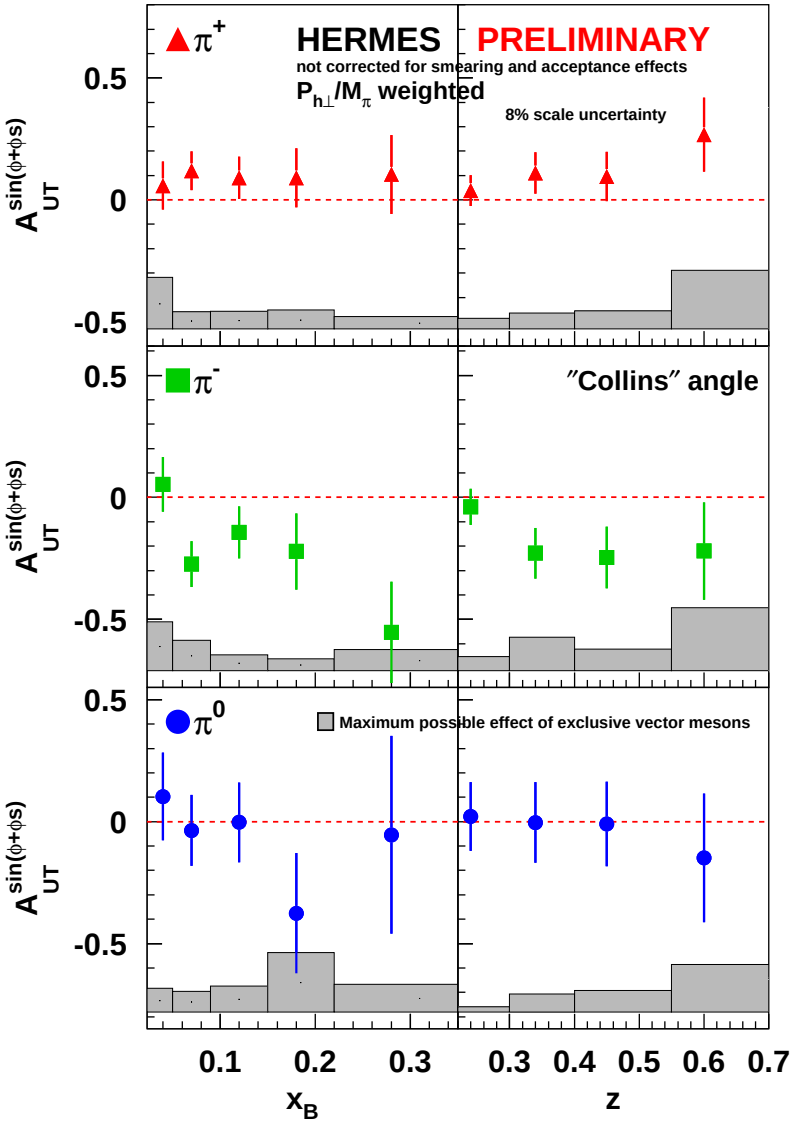


$$A_{UT}^{\sin\Phi} \propto \mathcal{I}\left[f_{1T}^{\perp} \cdot D_1\right]$$

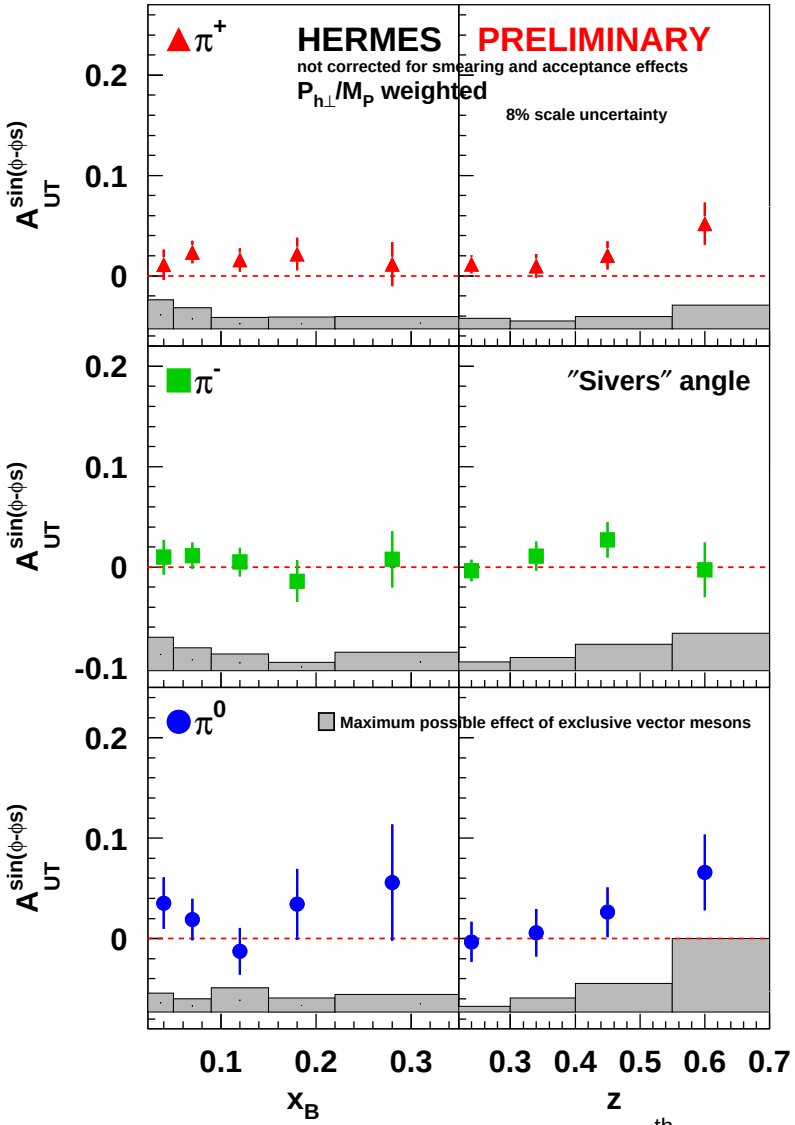


Preliminary Results ($P_{h\perp}$ weighted)

$$A_{UT}^{\sin\Phi} \propto h_1(x) \cdot H_1^{\perp(1)}(z)$$



$$A_{UT}^{\sin\Phi} \propto f_{1T}^{\perp(1)}(x) \cdot D_1(z)$$



Conclusion and Outlook

- First HERMES data with transversely polarized target
- Effects of Target Magnet on tracking under control
- Contribution of decay particles of exclusive VM have to be considered
- First measurement of Sivers asymmetry
- Collins asymmetry sizeable
- more data coming

Conclusion and Outlook

- First HERMES data with transversely polarized target
- Effects of Target Magnet on tracking under control
- Contribution of decay particles of exclusive VM have to be considered
- First measurement of Sivers asymmetry
- Collins asymmetry sizeable
- more data coming