The Transverse Single Spin Asymmetry A_N

in Inclusive Hadron Production $lp^{\uparrow} \rightarrow hX$ at HERMES

Florian Sanftl

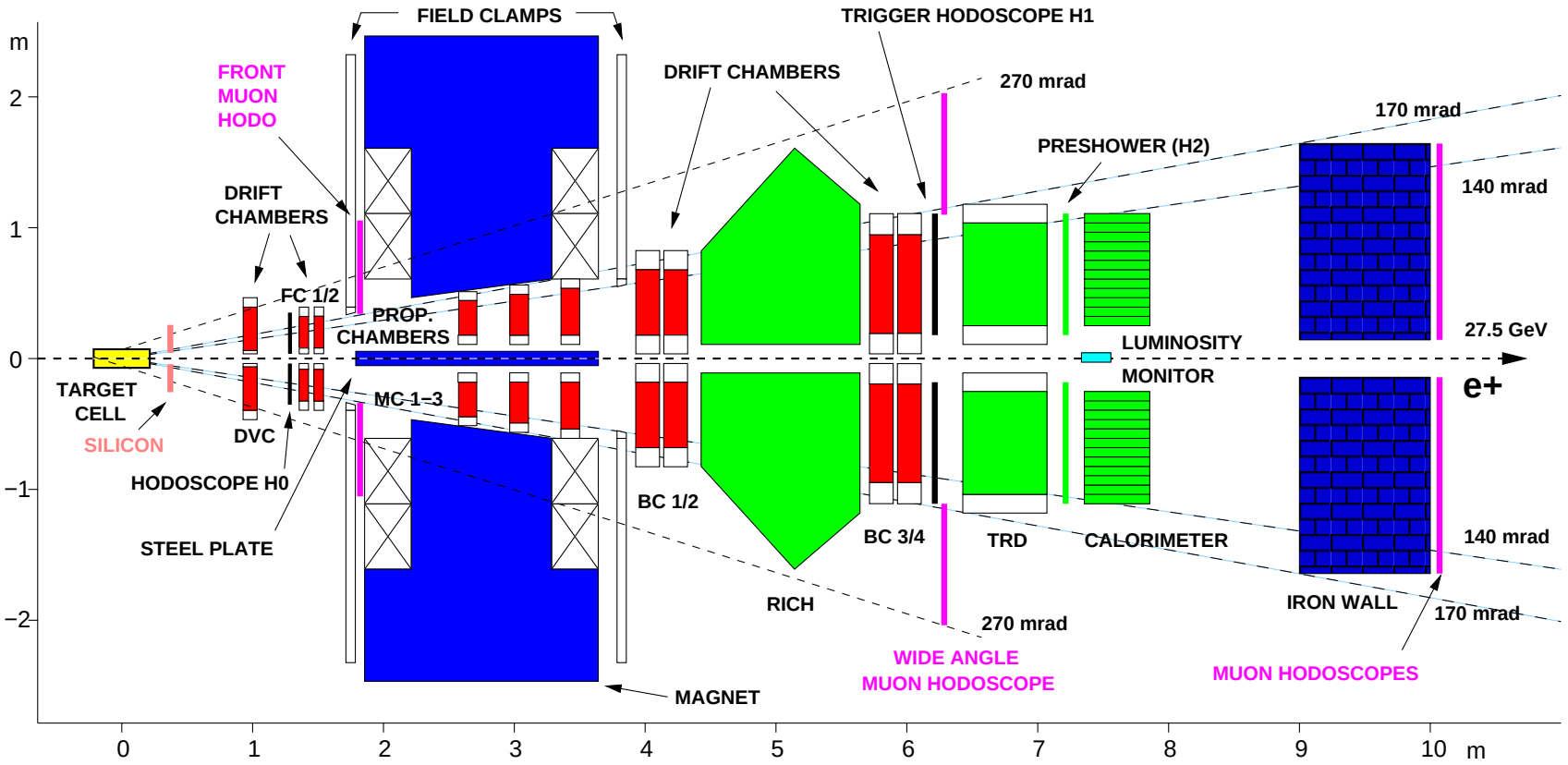
University of Regensburg

DPG-Meeting Bonn, March 2010

Overview

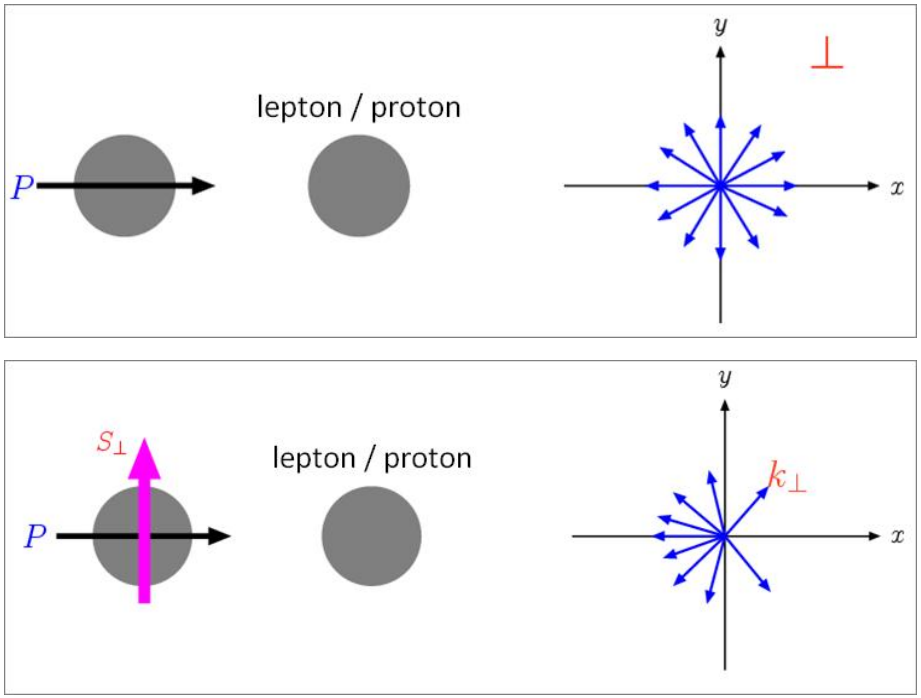
1. HERMES
   - The Spectrometer
2. Definition of A_N and Motivation
   - A_N in $pp^{\Uparrow} \rightarrow \pi^{\pm} X$
   - A_N in SIDIS ($lp^{\Uparrow} \rightarrow l\pi^{\pm} X$)
   - Motivation for A_N in $lp^{\uparrow} \rightarrow hX$
3. Inclusive Hadron Production (IH)
   - Effect on Kinematics
4. Results and Discussion
   - One-Dimensional Extraction
   - Two-Dimensional Extraction
   - Summary and Outlook

Detector and Experimental Facts



- 27.5GeV positron/lepton beam of HERA
- atomic beam source transversely provides polarized hydrogen with polarizations above $\sim 75\%$

But how is A_N defined?



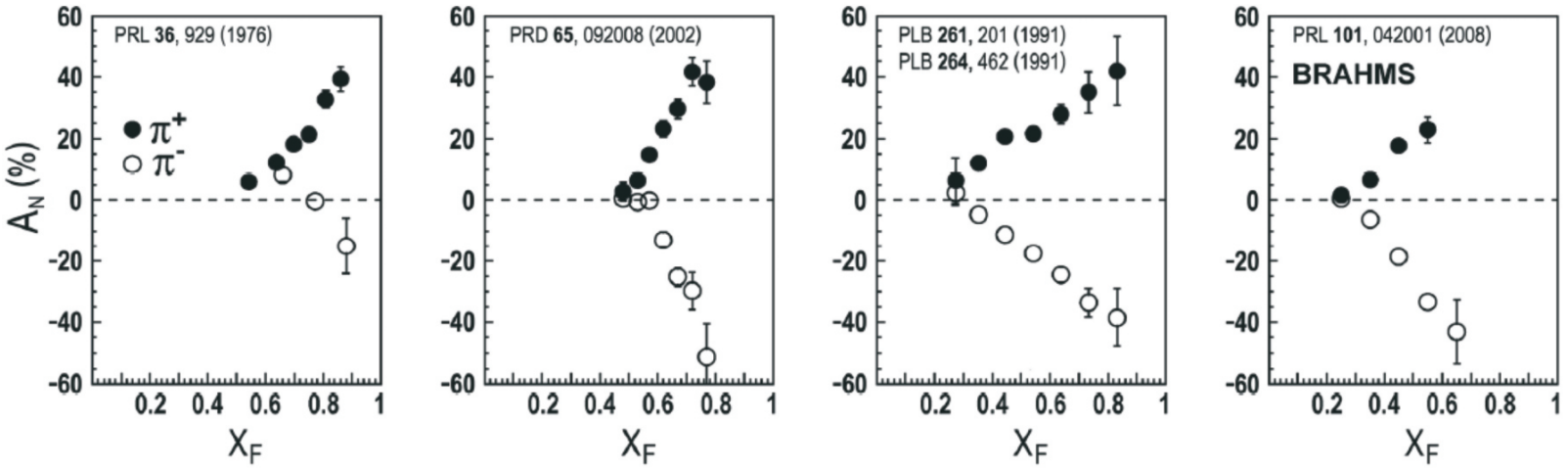
$\Rightarrow$ Final state particle is azimuthal symmetric

$d\sigma \propto \vec{S}_\perp \cdot (\vec{P}_{Beam} \times \vec{P}_{h\perp})$
$\Rightarrow$ Final state particle asymmetrically distributed in space

Experimental observable: A_N

- $A_N \equiv \frac{1}{|S_\perp|} \frac{\sigma^\uparrow - \sigma^\downarrow}{\sigma^\uparrow + \sigma^\downarrow} \equiv \frac{N_\uparrow(\phi) - N_\downarrow(\phi)}{N_\uparrow(\phi) + N_\downarrow(\phi)}$ ("Left-Right-Asymmetries")
- advantage: systematic effects cancel by using a ratio of yields

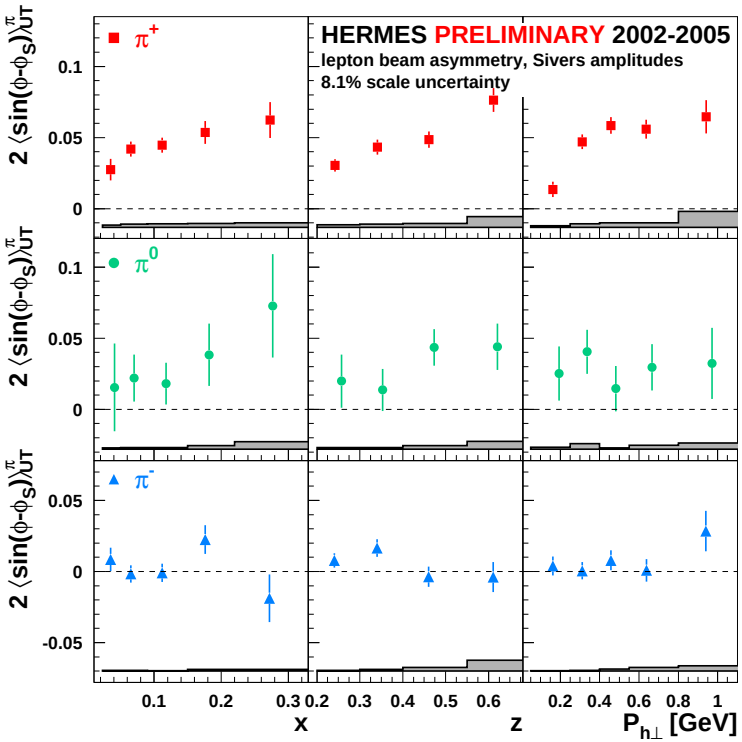
Short History I: A_N in $pp^{\Uparrow} \to \pi^{\pm} X$

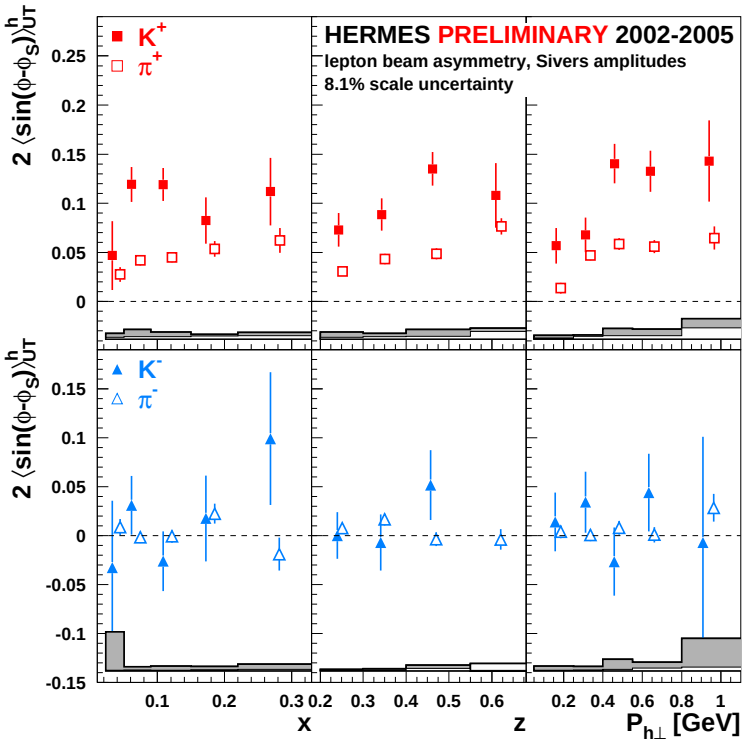


Main observations

- corresponds to $\sqrt{s}$: 4.9 GeV (ANL), 6.6 GeV (BNL), 19.4 GeV (FNAL), 62.4 GeV (RHIC)
- significant A_N-signal (already at low $\mathbf{P}_{h\perp} \approx 0.5$GeV!)
- mirror symmetric shapes of A_N dependent on particle charge
- How does this A_N look like in $ep^{\Uparrow} \to \pi^{\pm} X$-processes?

Short History II: A_N in $lp^{\Uparrow} \rightarrow l\pi^{\pm} X$





- π^+: positive, π^-: consistent with zero
- first evidence for non-zero Sivers fct.: $f_{1T}^{\perp u}(x, p_T^2) < 0$
- angular momentum of u-quarks has to be $L_z^u > 0$

How can A_N be caused?

Parametrization of the Cross-Section: Factorization Theorem

- in SIDIS ($lp^{\Uparrow} \rightarrow hX$) A_N can be written as:

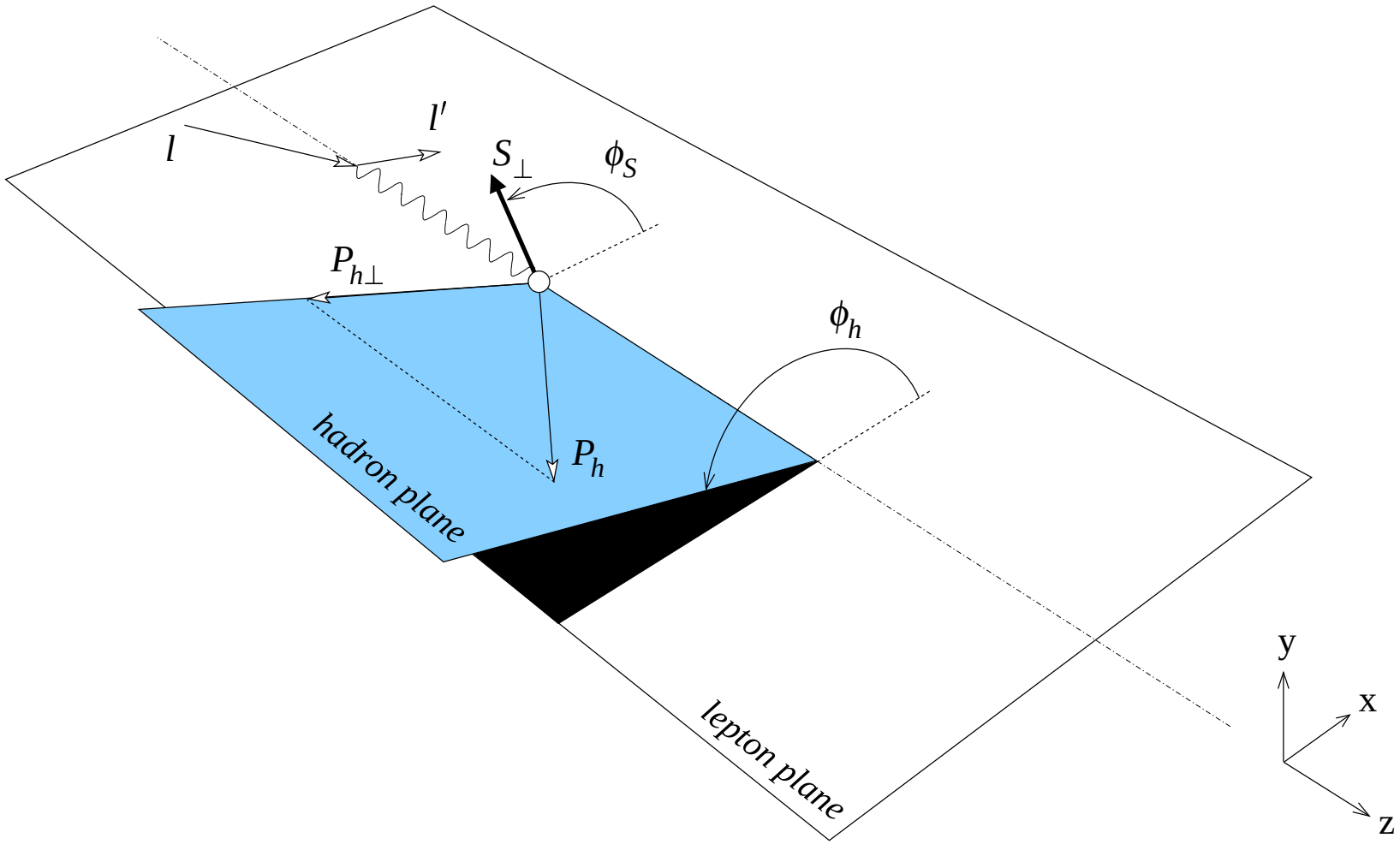
$$A_N(\phi, \phi_S) \propto \sin(\phi + \phi_S) \sum_{q,\bar{q}} e_q^2 \, \mathcal{I} \left[\frac{\vec{k}_T \cdot \vec{P}_{h\perp}}{m_h} \, \delta q(x, p_T^2) \, H_1^{\perp}(z, k_T^2) \right]$$
$$+ \sin(\phi - \phi_S) \sum_{q,\bar{q}} e_q^2 \, \mathcal{I} \left[\frac{\vec{p}_T \cdot \vec{P}_{h\perp}}{m_N} \, f_{1T}^{\perp q}(x, p_T^2) \, D_1^q(z, k_T^2) \right]$$

- with

$$\mathcal{I}[\mathcal{W} \cdot \mathcal{D} \cdot \mathcal{F}] \equiv \int d^2\vec{p}_T \, d^2\vec{k}_T \, \delta \left(\vec{p}_T - \frac{\vec{P}_{h\perp}}{z} - \vec{k}_T \right) \mathcal{W} \cdot \mathcal{D} \cdot \mathcal{F}$$

- so far only proven for SIDIS-Xsec when $P_{h\perp}^2 << Q^2$ (**Two** scales!)
- alternatives necessary to prove the theorem
- Note: Introduction of Transverse Momentum Dependent Distribution Functions

The Trento-Conventions

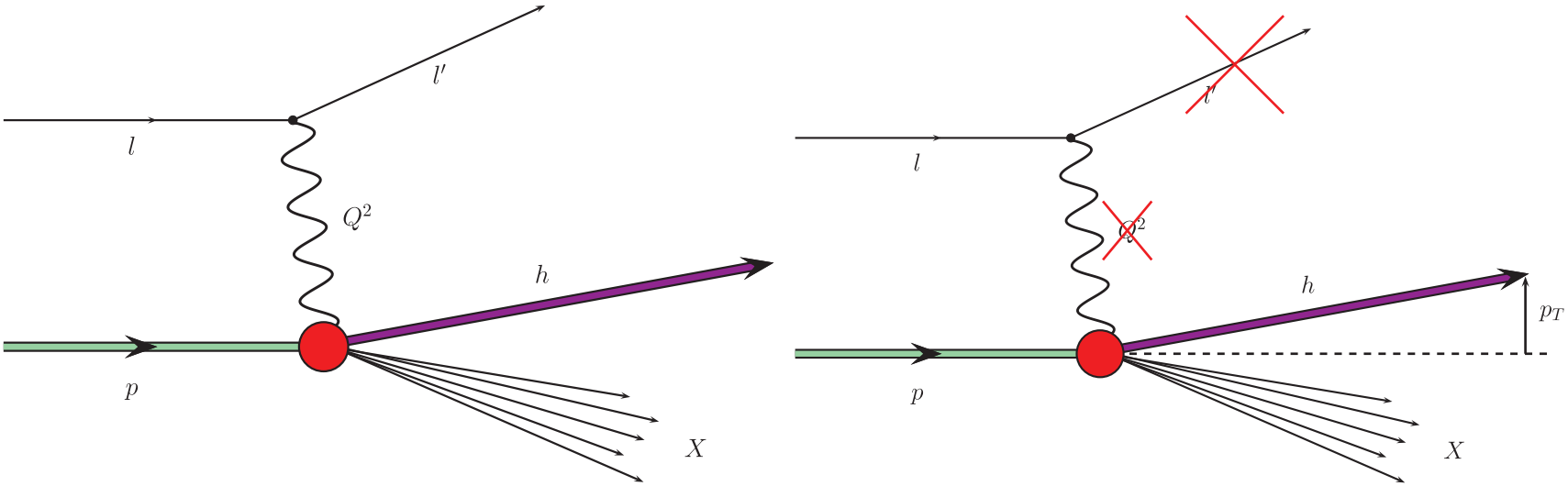


Why can be A_N in $lp^{\uparrow} \to hX$ interesting?

Brain Storming

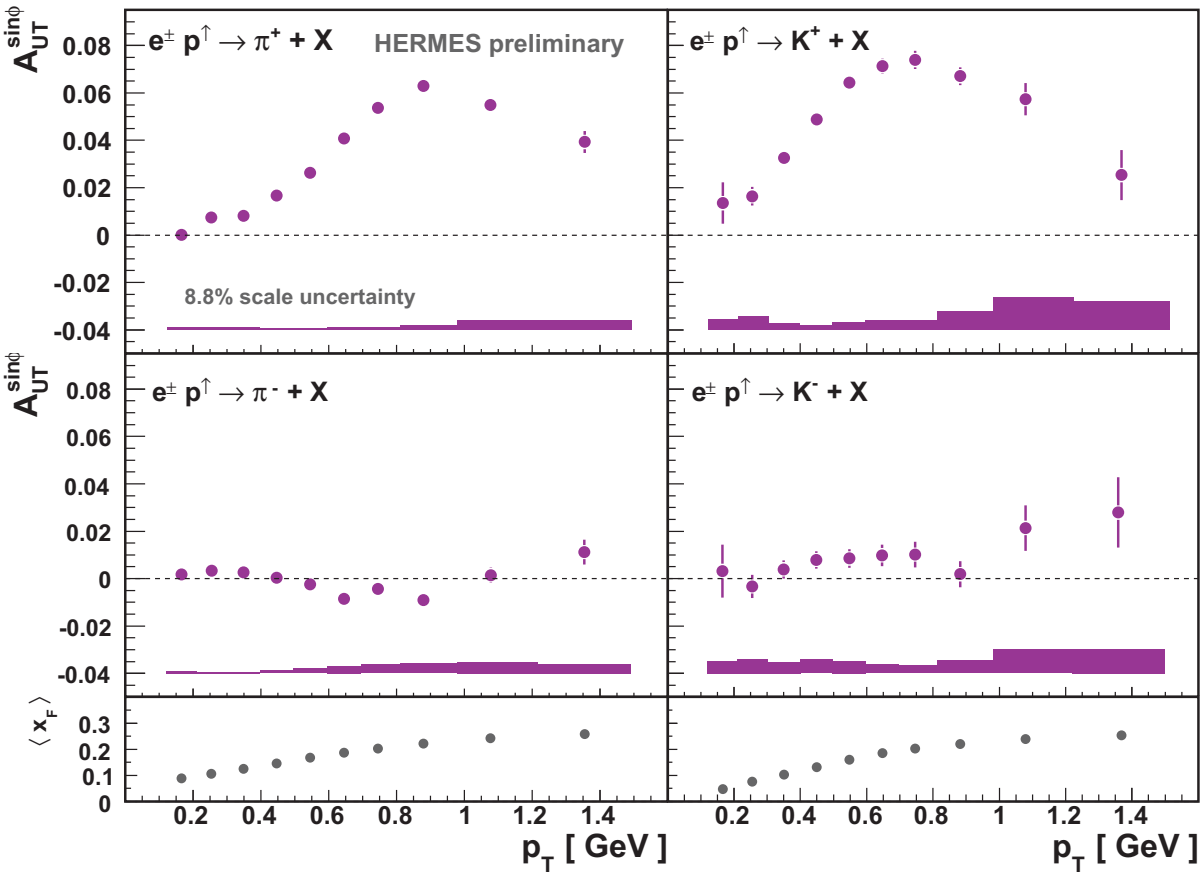
- Inclusive hadron production $lp^{\uparrow} \to hX$ is analogue of $pp^{\uparrow} \to hX$ process. Both have only one hard scale $P_{h\perp}$
- in $lp^{\uparrow} \to hX$ only one channel is present
- test for TMD-factorization formalism
- test for higher twist contributions to Sivers DF
- estimation of the magnitude of 'higher-twist-dilution'
- (eventual explanation for differences in COMPASS- and HERMES-results?!)

From SIDIS to Inclusive Hadrons (IH)

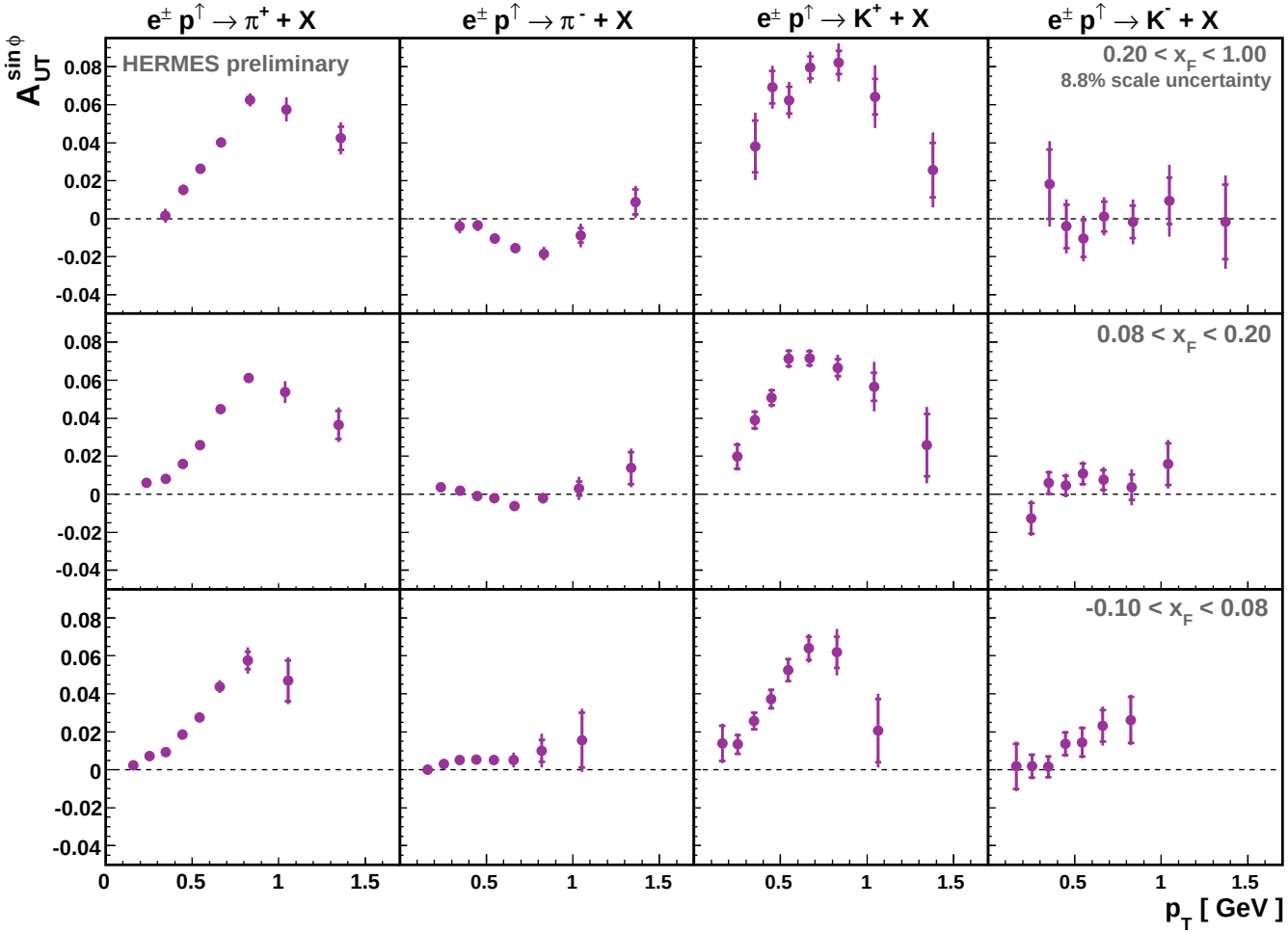


	SIDIS	IH-Case
Scale(s)	Q^2, $\mathbf{P}_{h\perp}$	$\mathbf{P}_{h\perp}$
Construction-frame of $\mathbf{P}_{h\perp}$	$\gamma^* p$	lp
Magnitude of Q^2	$Q^2 > 1\,\mathrm{GeV}^2$	$Q^2 \approx 0\,\mathrm{GeV}^2$
Magnitude of θ ($\sin^2(\frac{\theta}{2}) \overset{lab}{\propto} Q^2$)	full range	small
Scaling variables	x_F, x_B	"modified x_F" $= 2\frac{\mathbf{P}_{h,z}}{\sqrt{s}}$
Factorisation	$P_{h\perp}^2 << Q^2$	eventually valid for large $\mathbf{P}_{h\perp}$ (?)

$A_N(P_{h\perp})$ in $lp^\uparrow \to hX$



$A_N(x_F, P_{h\perp})$ in $lp^\uparrow \rightarrow hX$



Overview

Review

- Significant signal A_N for positively charged IH at HERMES
- sofar, most precise measurement of the inclusive analyzing power A_N at a DIS experiment
- Sivers- and Collins-Mechanism dominated by leading twist!?
- Higher twist effects do not seem to be negligible

Preview

- Extract A_N for neutral particles (check for Iso-Spin-Symmetry)
- Publish results ;-)