SSA in inclusive hadron production at HERMES

Alejandro López Ruiz
Department of physics and astronomy
Universiteit Gent
DIS'10 Florence

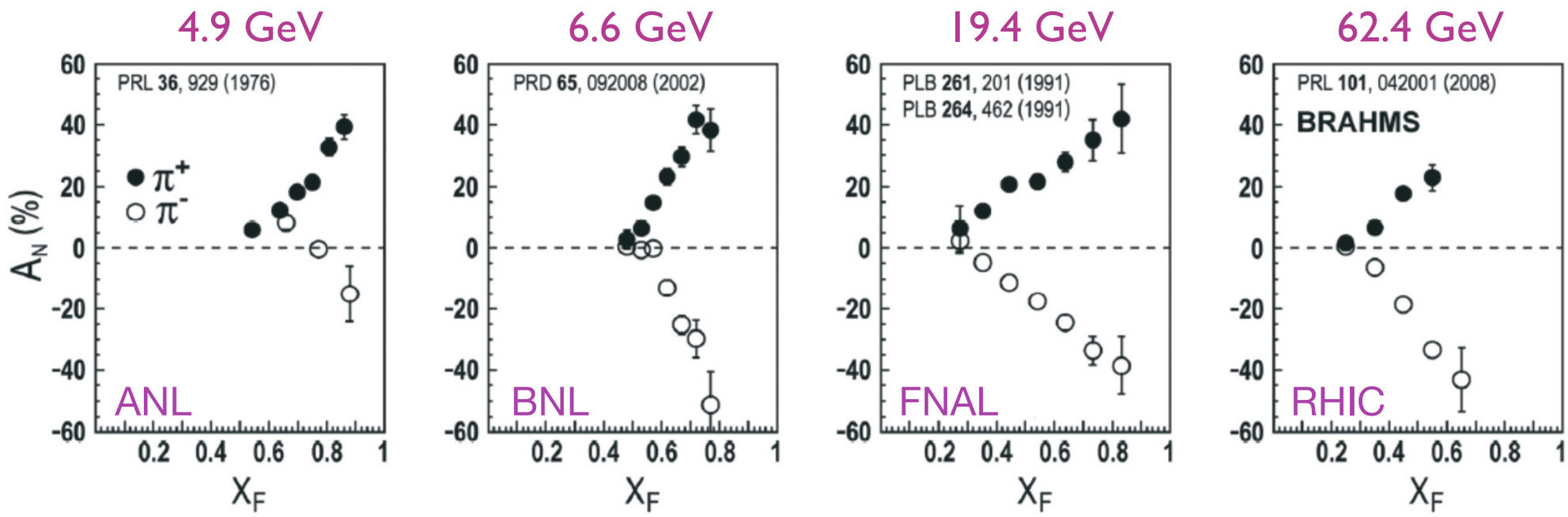
OUTLOOK

- MOTIVATION
- HERMES
- METHOD
- RESULTS
- CONCLUSIONS

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

MOTIVATION

- Measurement of A_N in $p^{\uparrow}p$-scattering for different **center of mass** energies:



- Only two models consistently describing the data:
  * TMDs (Transverse Momentum Dependent) distributions
  * high-twist correlations
- Interpretation not yet completely satisfactory
- All available models predict A_N goes to zero at high p_T values.
- **BUT**: not yet DATA at such kinematic region
- all available data coming from $p^{\uparrow}p$ scattering

$$A_N = \frac{N_R - N_L}{N_R + N_L}$$

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

MOTIVATION

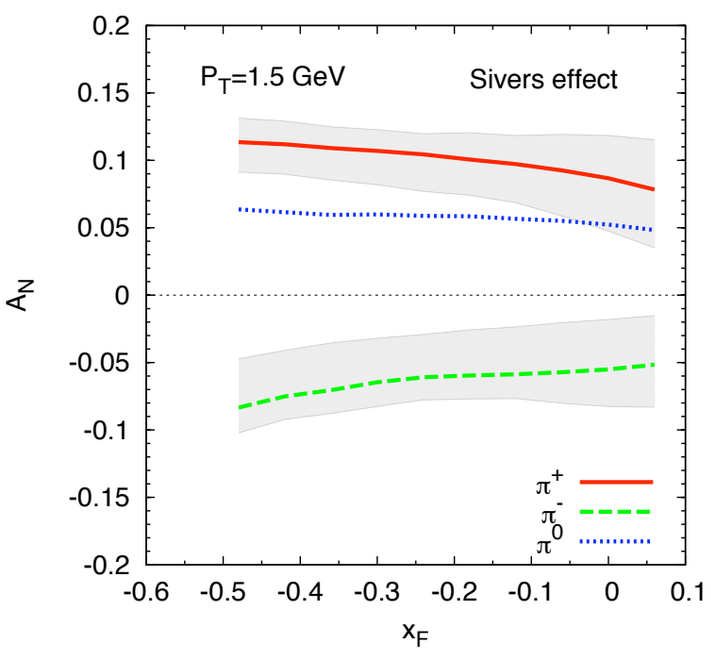
A_N in inclusive hadron production:

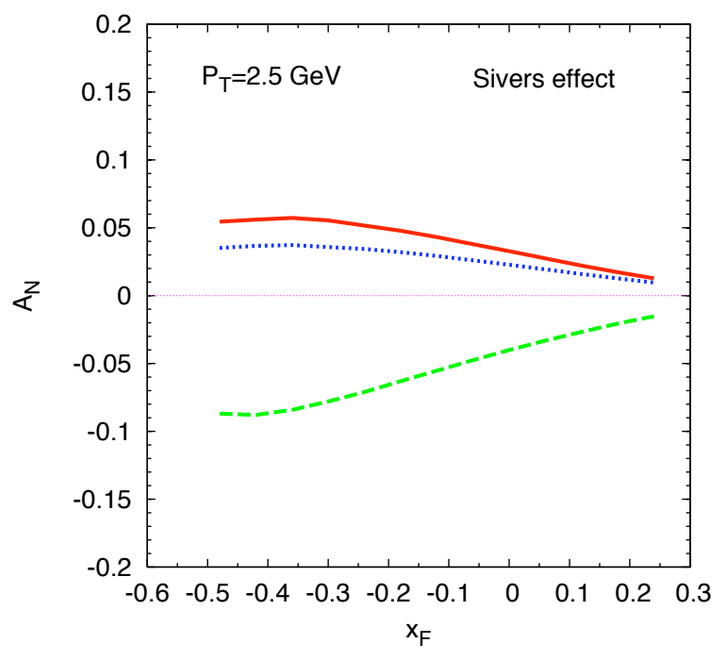
- one can also measure the A_N in $ep^\uparrow$ scattering
- it's a much cleaner process involving only one quark channel
- equivalent to $pp^\uparrow$ scattering

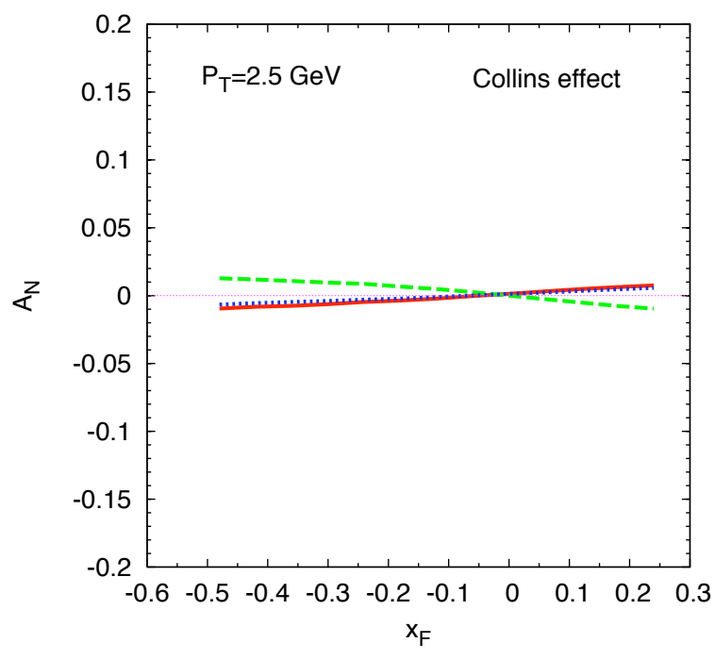
- hard scale of the process given by p_T
- it's a clean test of **TMD** formalism
- DATA already exist
- and **HERMES** has a LOT of them!

Estimates from the Torino group (Anselmino et al.):

from arXiv: 0911.1744







- extracted from **SIDIS** data
  for the $p^\uparrow e \rightarrow \text{pi } X$ process at **HERMES** kinematics

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

MOTIVATION

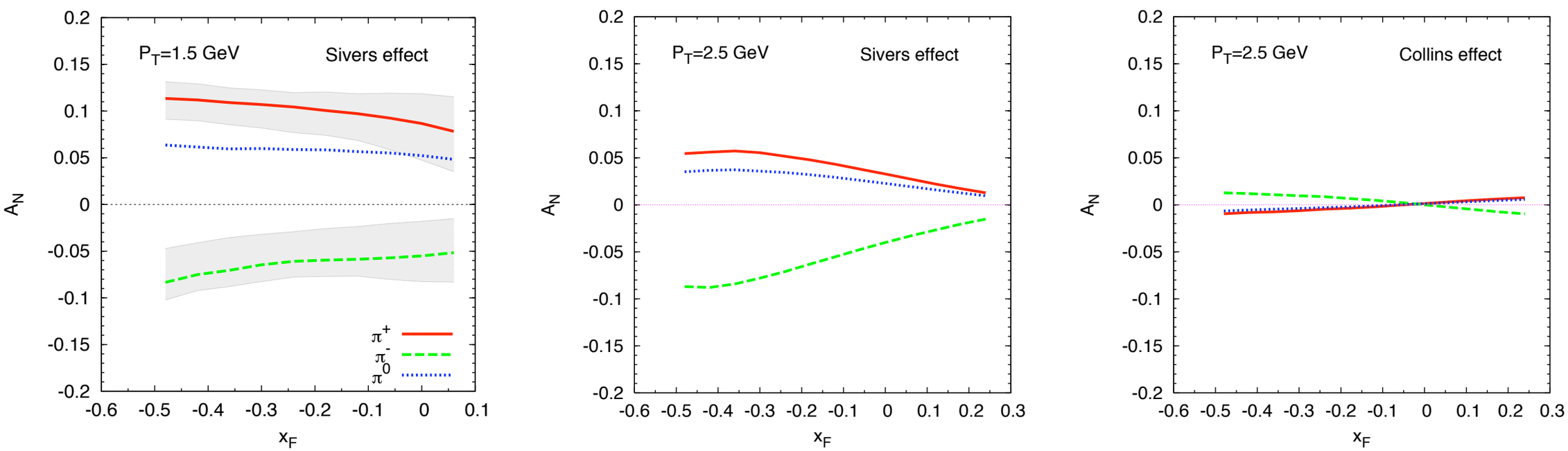
A_N in inclusive hadron production:

- one can also measure the A_N in $ep^\uparrow$ scattering
- it's a much cleaner process involving only one quark channel
- equivalent to $pp^\uparrow$ scattering

- hard scale of the process given by p_T
- it's a clean test of **TMD** formalism
- DATA already exist
- and **HERMES** has a LOT of them!

Estimates from the Torino group (Anselmino et al.):

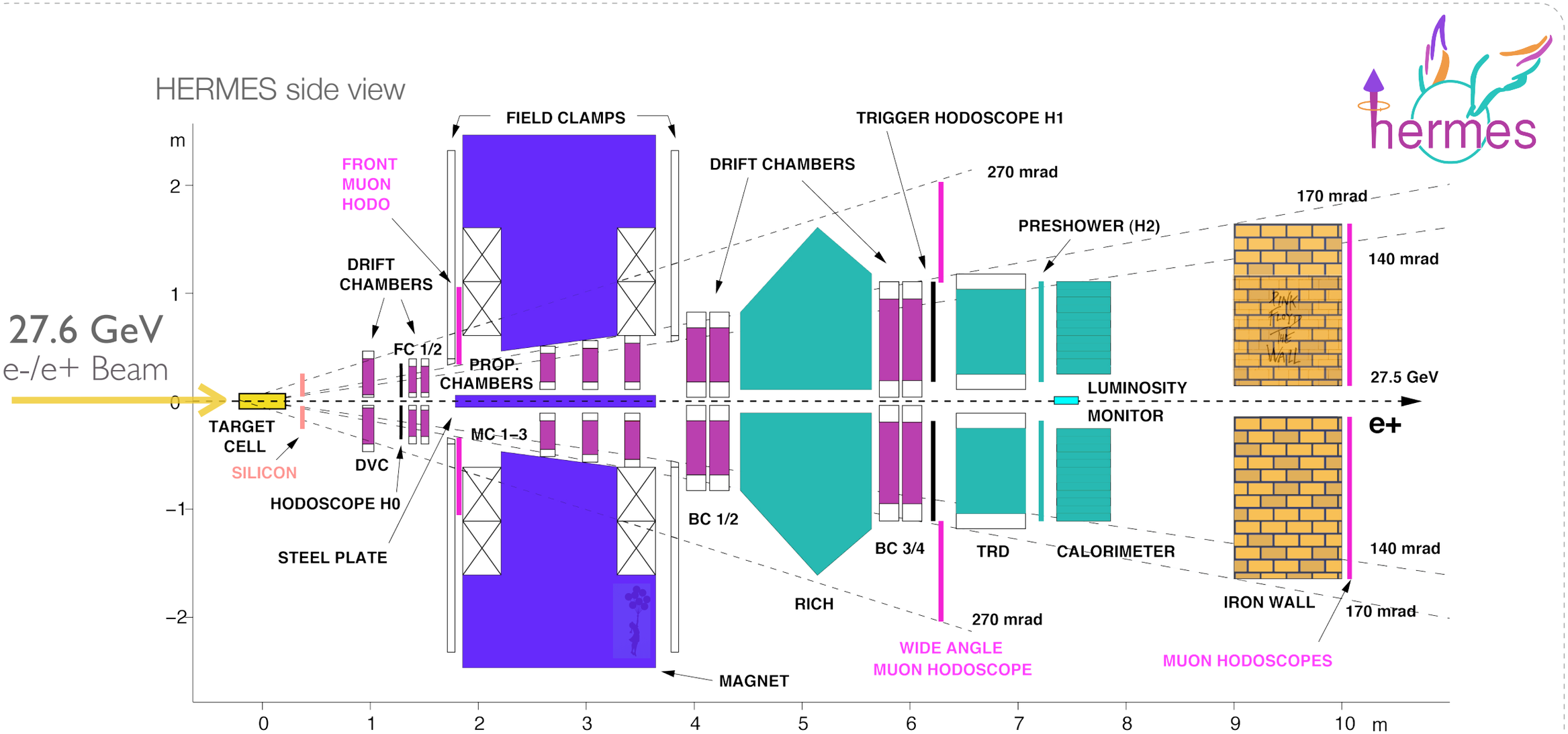
from arXiv: 0911.1744



> “ The measurement of these predicted asymmetries allows a test of the validity of the TMD factorization, largely accepted for SIDIS processes with two scales (small P_T and large Q), but still much debated for processes with only one large scale (P_T), like the one we are considering here. A test of TMD factorization in such processes is of great importance for a consistent understanding of the large SSAs measured in the single inclusive production of large P_T hadrons in proton-proton collisions. ”

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

the HERMES spectrometer

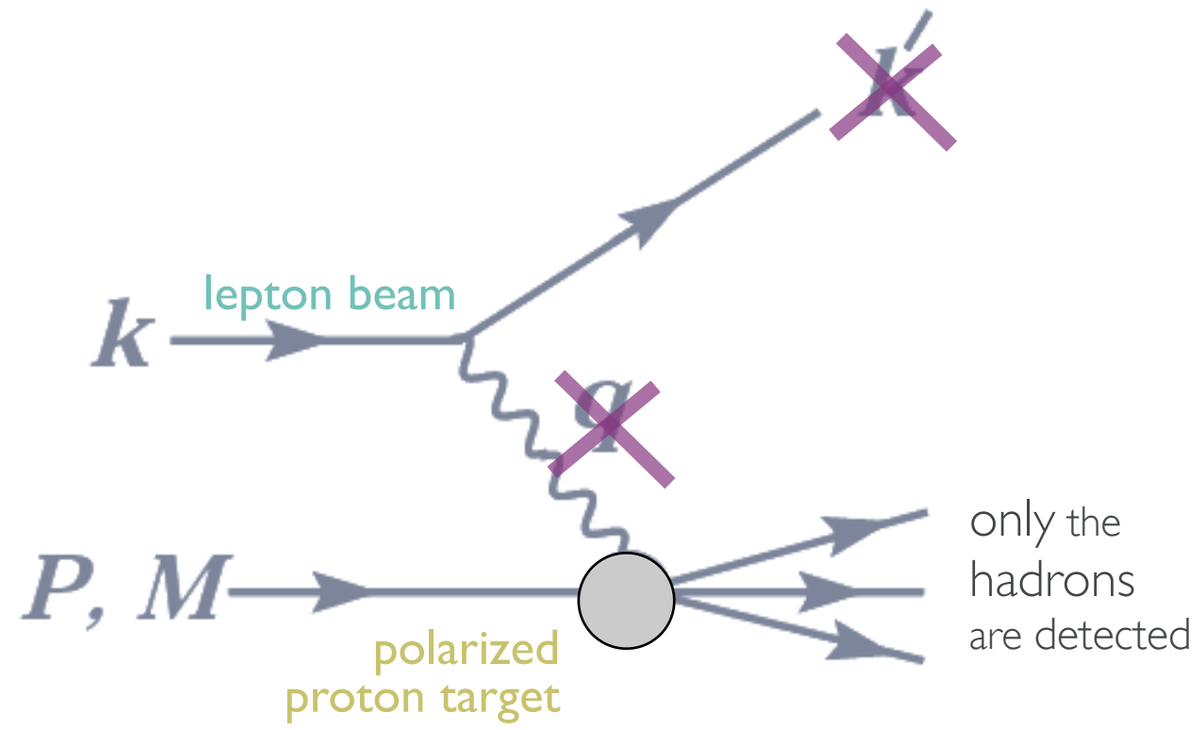


- forward spectrometer
- fixed gas target, transversely polarized H
- target spin direction reversed every 1-3 min
- **Particle ID:** RICH + TRD + CALO + hodoscope

HERA accelerator
Hamburg

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

inclusive HADRON production at HERMES



inclusive measurement

$ep^{\uparrow} \rightarrow hX$

DIS variables:

$Q^2 = -(k-k')^2$

$x_B = Q^2 / 2M(E-E')$

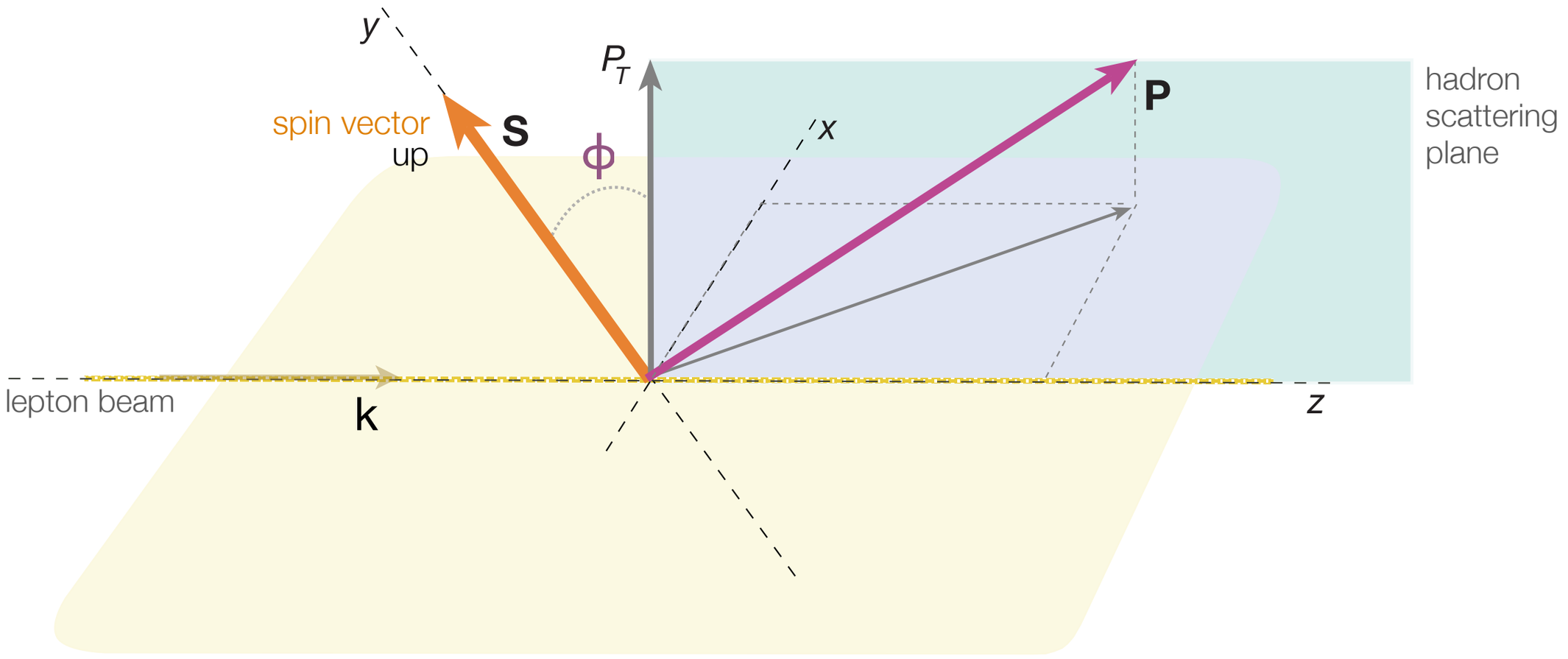
inclusive hadrons:

$x_F = 2p_L / \sqrt{s}$

$p_T = p \cos\theta$

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

inclusive HADRON production
at HERMES



spin dependent part of the cross section

$$\sigma = \sigma_{UU} + \sigma_{UT}$$

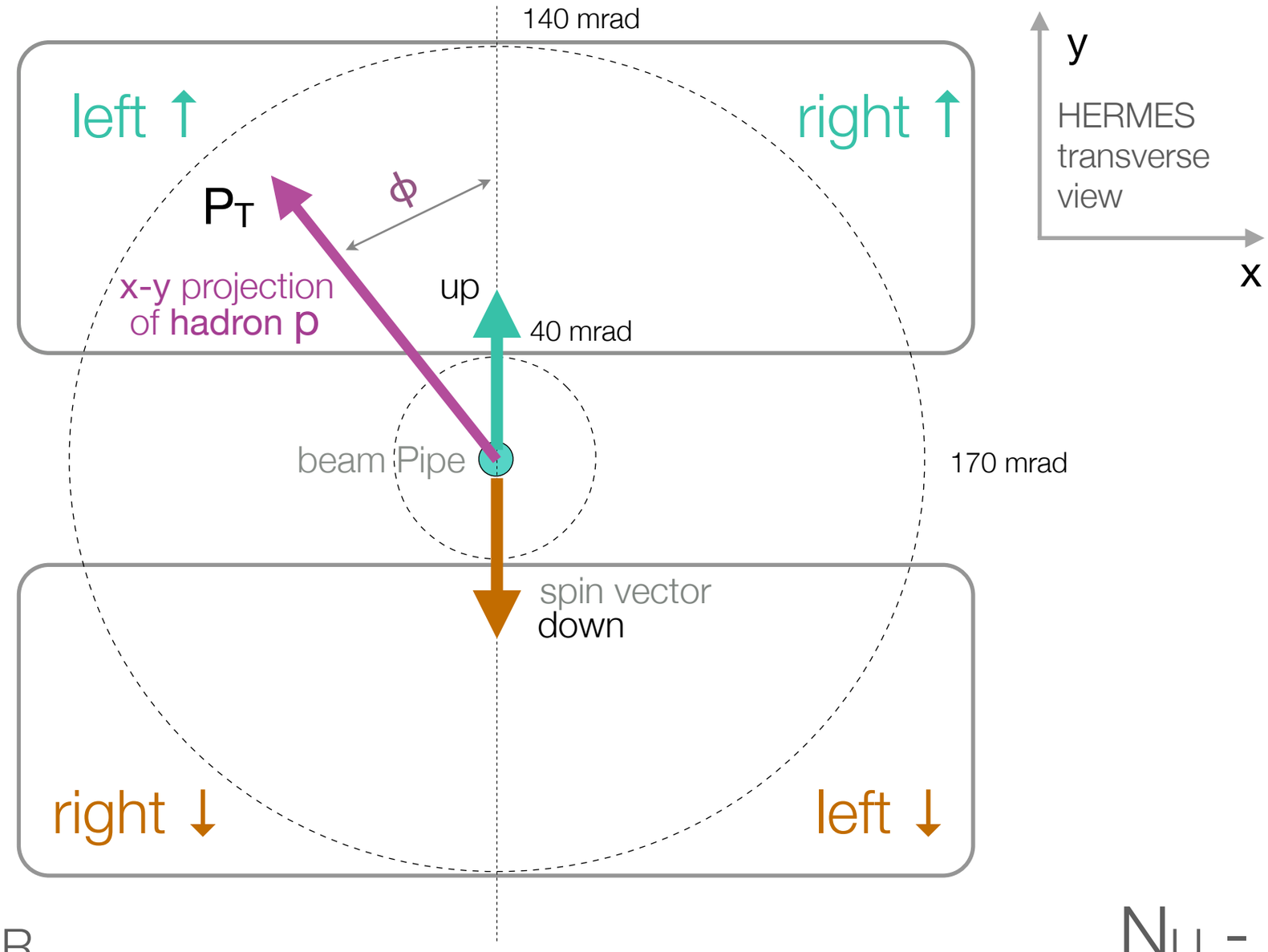
$$\propto \vec{S} \cdot (\vec{k} \times \vec{P}) \sim \sin\phi$$

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

AT HERMES

a note about acceptance

the highest sensitivity to a LR asymmetry is around the beam pipe. Since the HERMES acceptance doesn't cover this region, the asymmetry should be corrected for it



$$A_N = \frac{N_L - N_R}{N_L + N_R}$$
left-right

the up-down asymmetry is completely equivalent to the left-right, but free of acceptance effects.

$$A_{UT} = \frac{N_U - N_D}{N_U + N_D}$$
up-down

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

single spin Asymmetry

sinPhi moments

collected hadrons with → target spin UP
target spin DOWN

$$A_{UT} = \frac{N_U - N_D}{N_U + N_D}$$

transversely polarized target
unpolarized beam

1. more specifically:

$$A_{UT}(p_T, x_F, \phi) = \frac{\mathrm{d}^3\sigma_{UT}}{\mathrm{d}^3\sigma_{UU}}$$

2. from the sinPhi dependence:

$$\mathrm{d}^3\sigma_{UT} = \mathrm{d}^3\sigma_{UU}\, A_{UT}^{\sin\phi}(p_T, x_F)\sin\phi$$

$\mathrm{d}^3\sigma_{UU}$ → unpolarized xSection
$A_{UT}^{\sin\phi}$ → sinPhi amplitude

relation to the left-right asymmetry:

$$A_N = \frac{\int_0^\pi d\phi\, \sigma_{UT}\sin\phi}{\int_0^\pi d\phi\, \sigma_{UU}} = \frac{2}{\pi}\cdot A_{UT}^{\sin\phi}$$

all together:

$$A_{UT}(p_T, x_F, \phi) = A_{UT}^{\sin\phi}(p_T, x_F)\sin\phi$$

$A_{UT}^{\sin\phi}$ → this is what we measure!

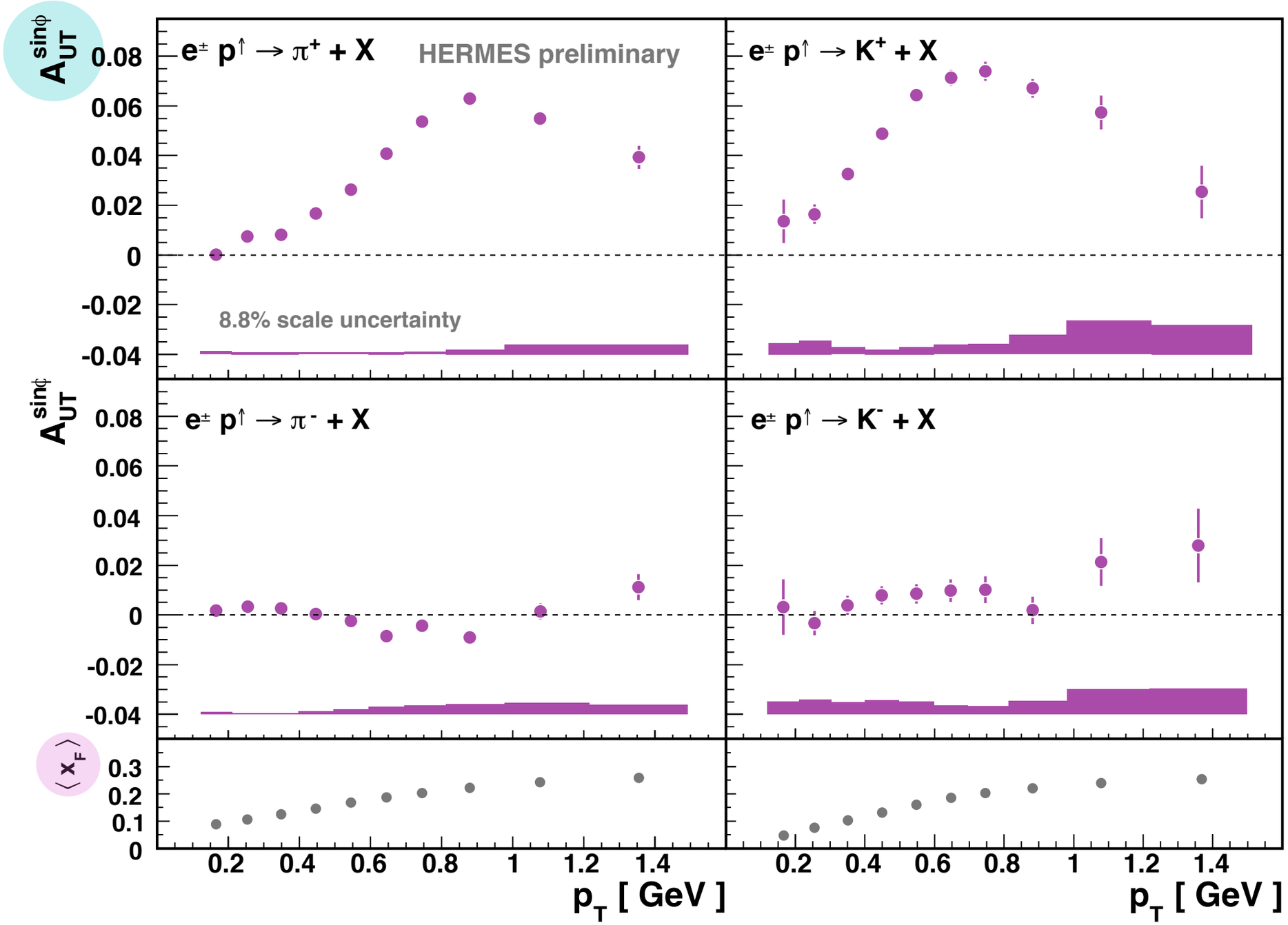
Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

RESULTS

oneDim binning

$A_{UT}^{\sin\phi}$

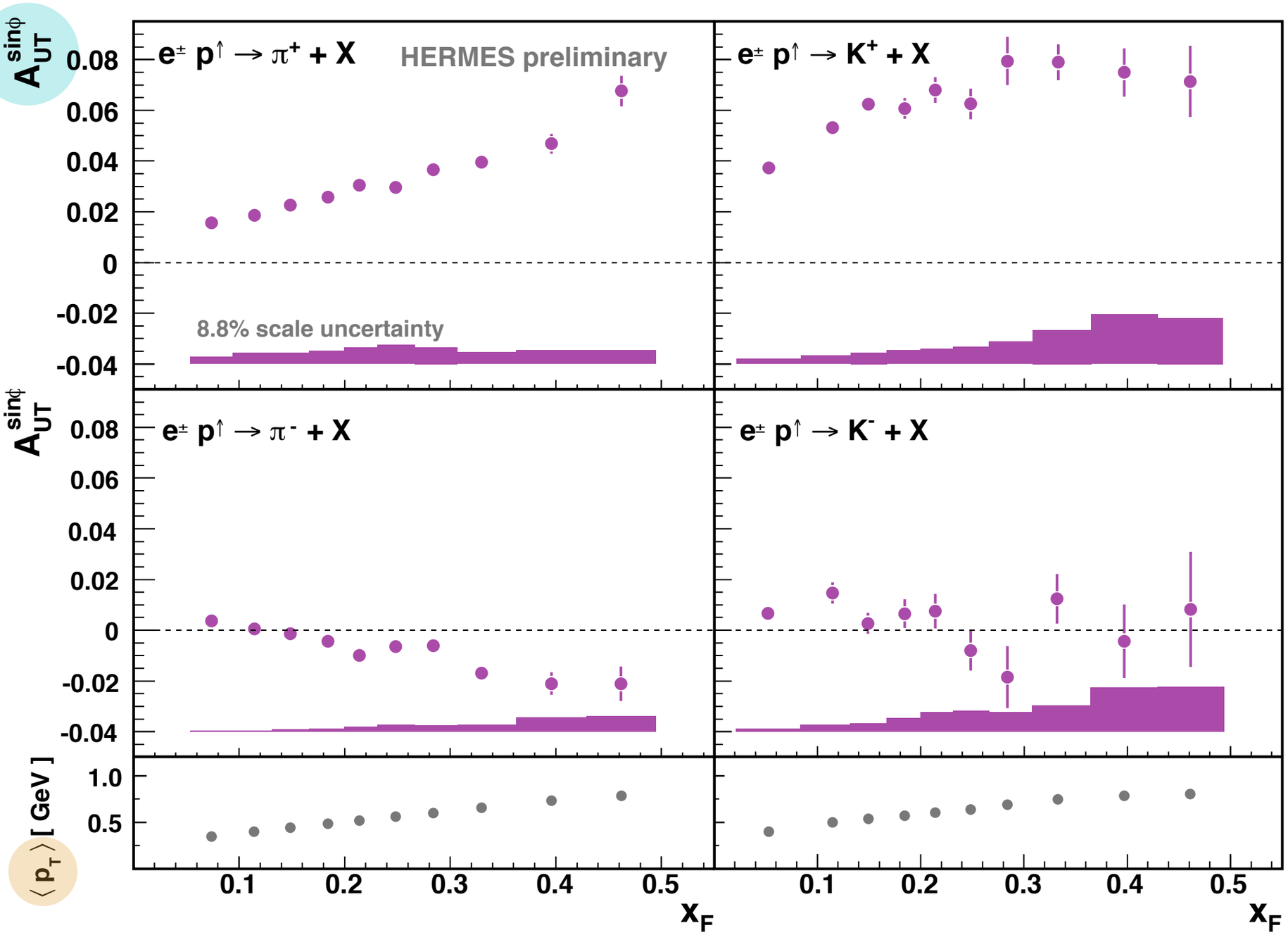
P_T



Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

RESULTS

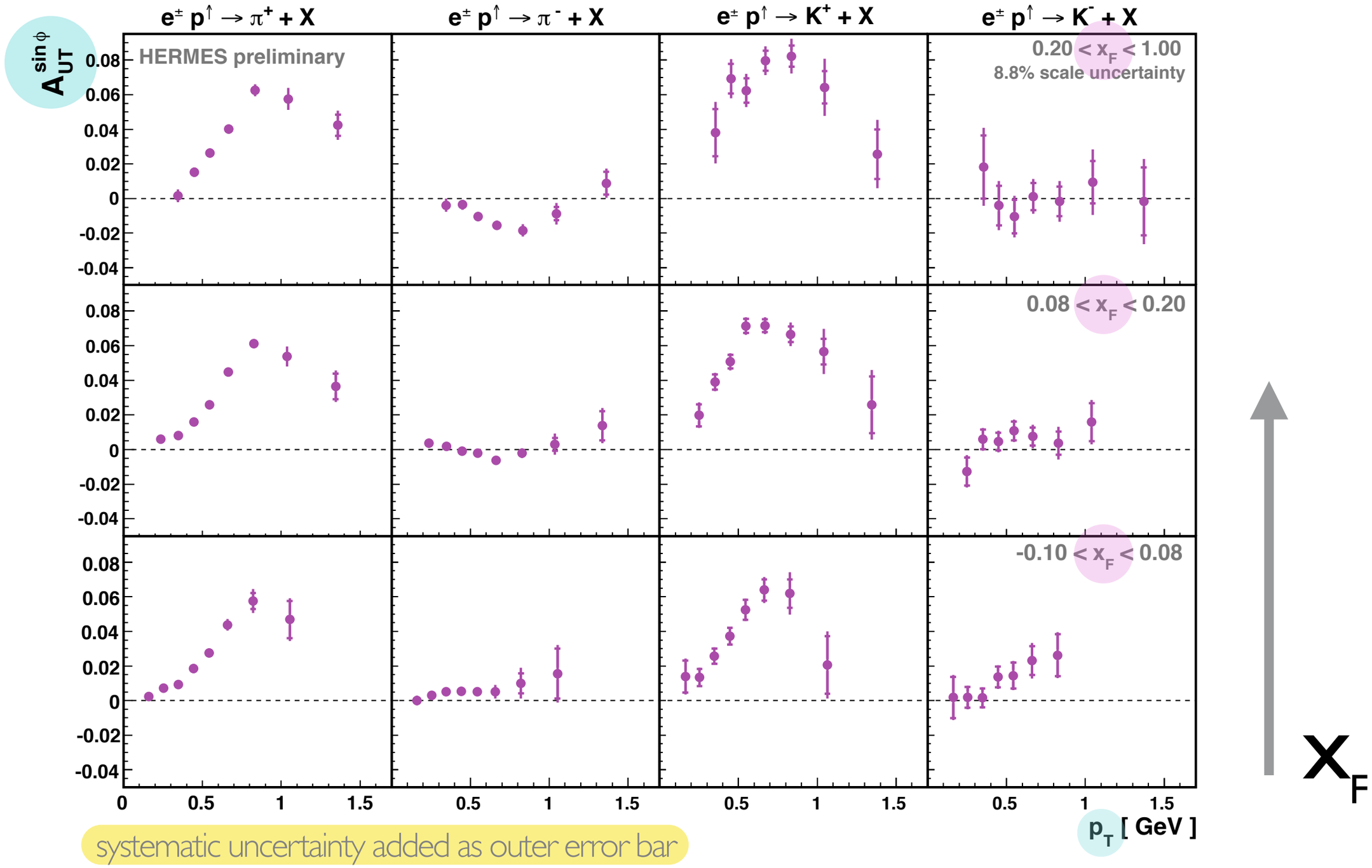
oneDim binning



Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

RESULTS

twoDim binning



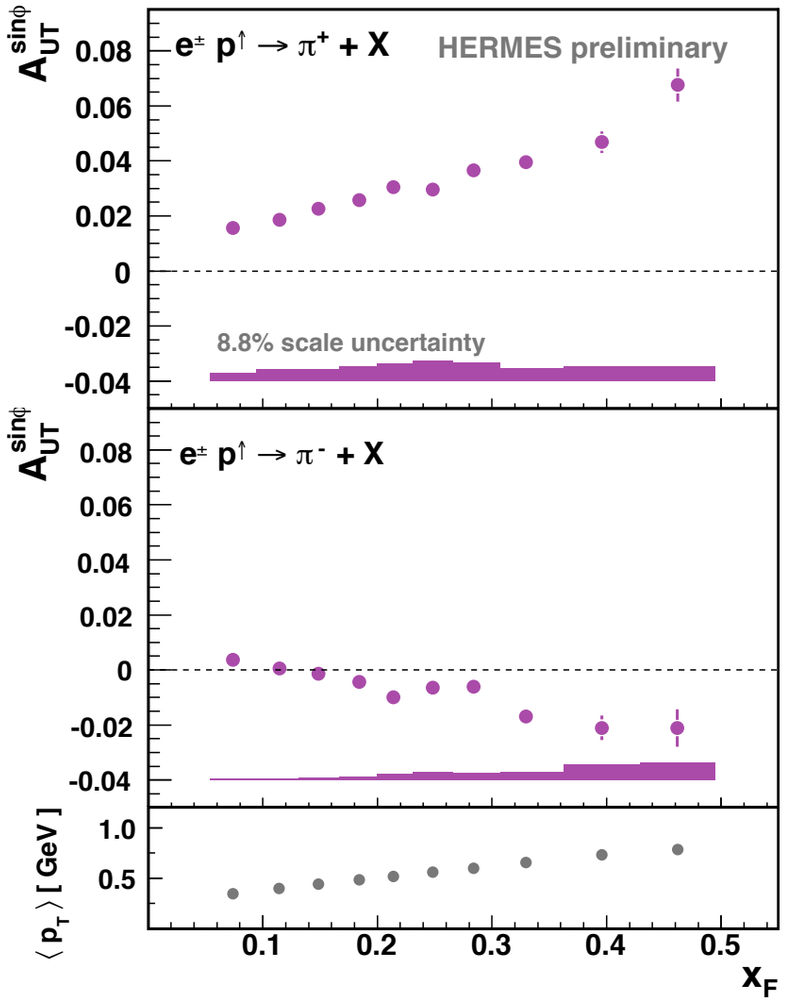
systematic uncertainty added as outer error bar

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

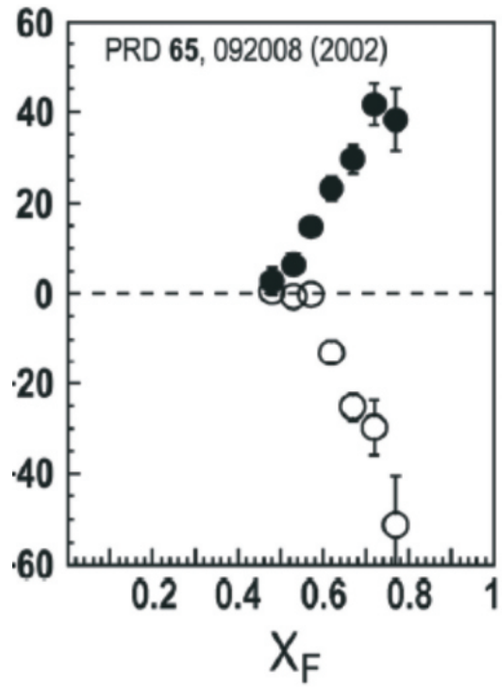
CONCLUSIONS

previous measurements

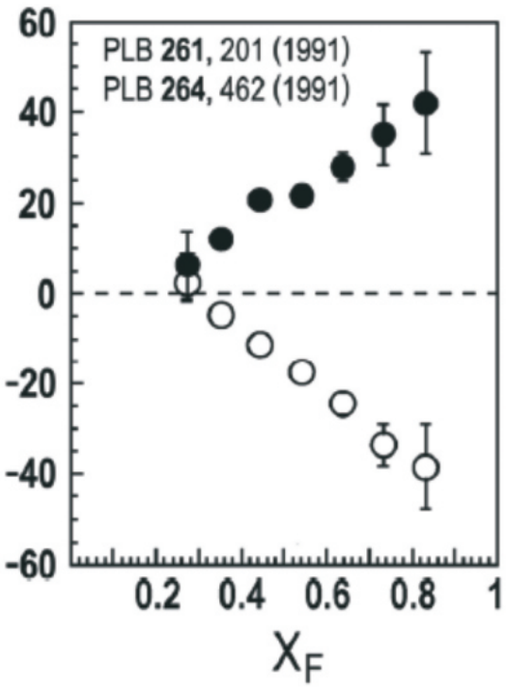
7 GeV



6.6 GeV



19.4 GeV



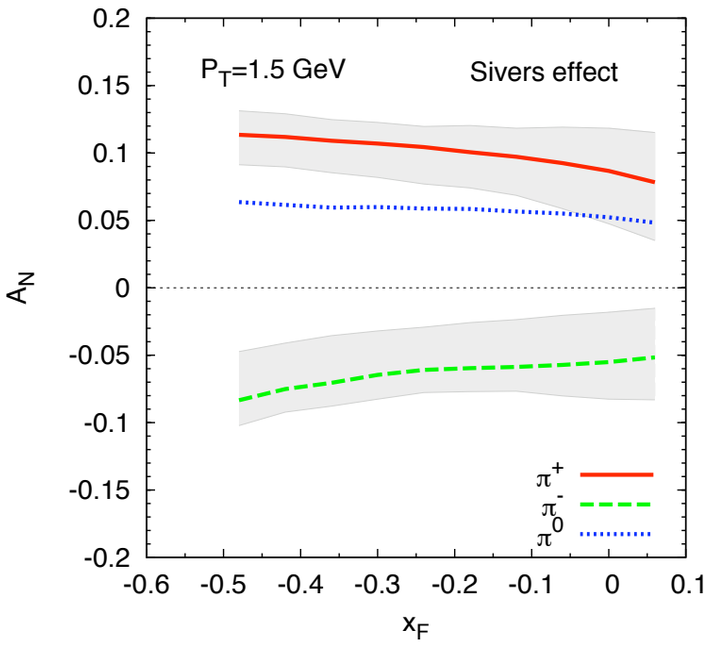
- A_N in **p↑p** scattering bigger than in **ep↑** scattering
- **u-quark** dominance in **ep↑** scattering explains the smaller size of **pi-** asymmetry.

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

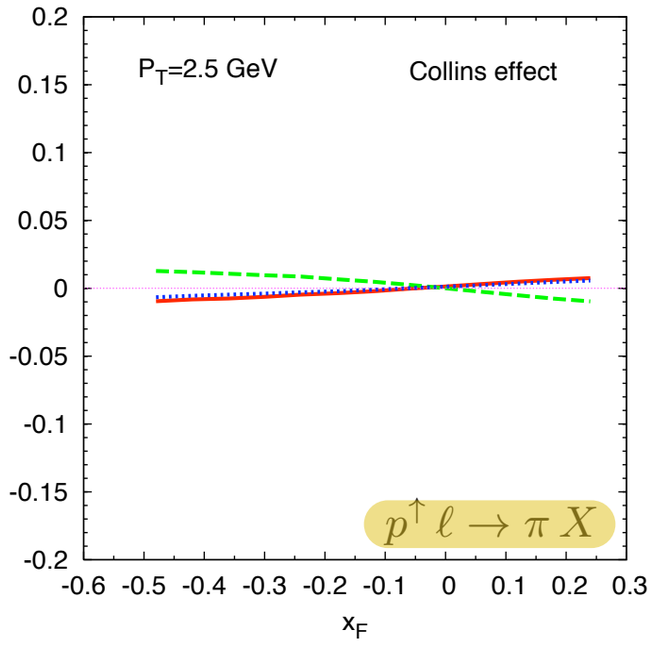
CONCLUSIONS

theory

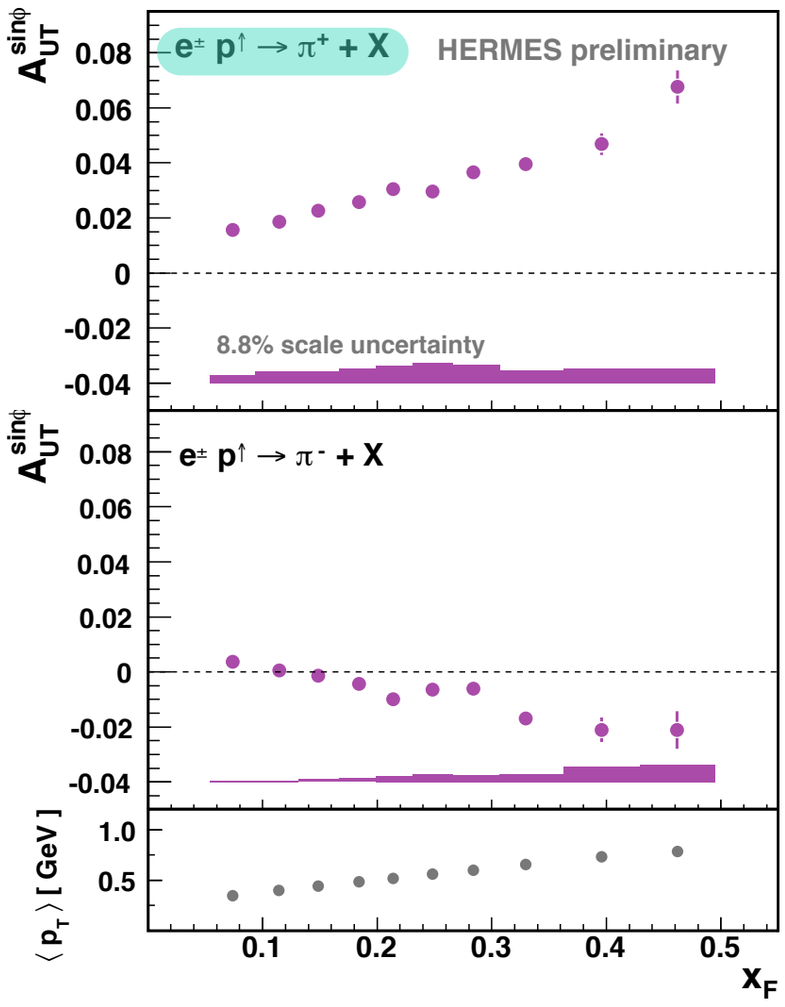
Sivers



Collins



inclusive Hadrons



- note different kinematical configuration :

$$A_N^{\ell p^\uparrow \to h(\text{jet})+X}(x_F, \boldsymbol{P}_T) = -A_N^{p^\uparrow \ell \to h(\text{jet})+X}(-x_F, \boldsymbol{P}_T)$$

electrons moving along the positive Z direction

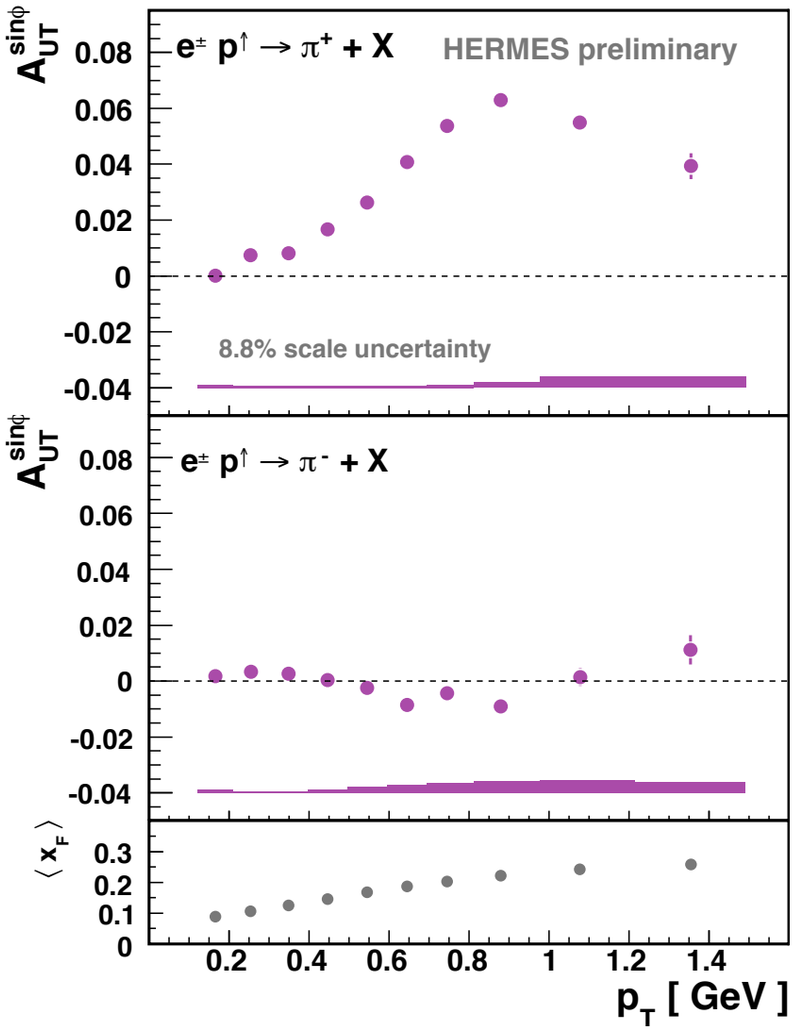
protons moving along the positive Z direction

Alejandro López Ruiz
Universiteit Gent
Florence/DIS 10

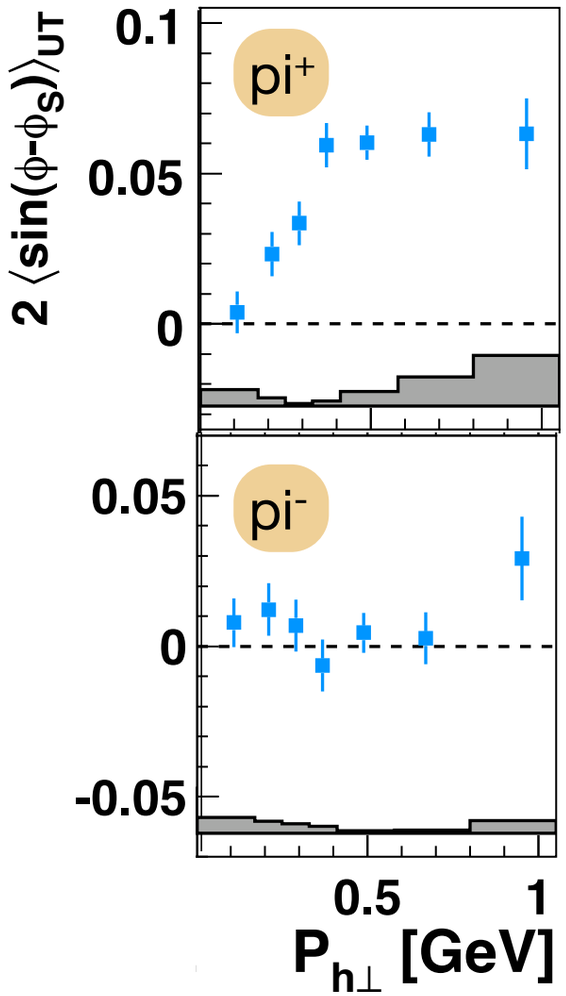
CONCLUSIONS

comparison to SIDIS

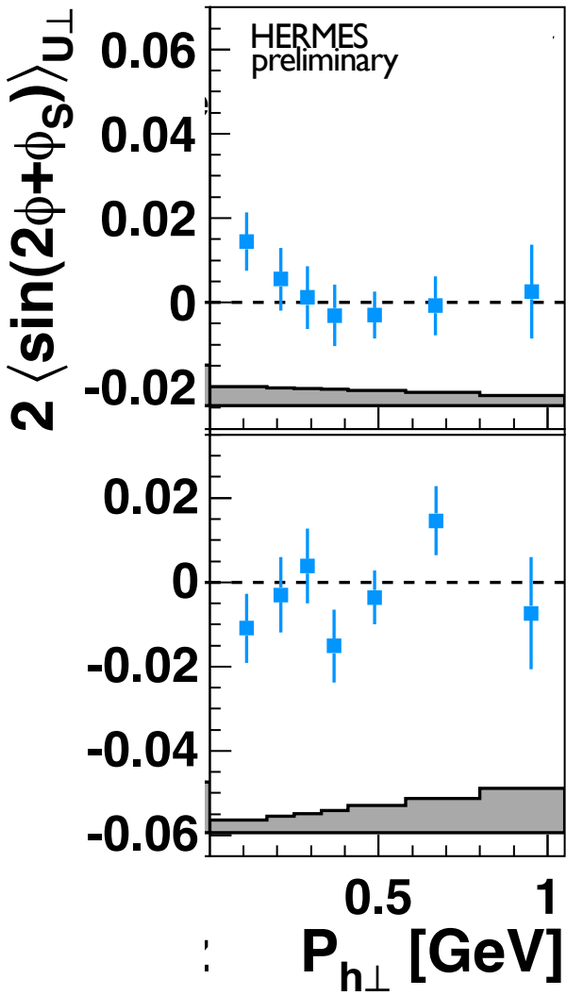
inclusive Hadrons



Sivers



Collins



- A_N resembles SIVERS effect

thanks!