Hadronization studies at HERMES

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hermes

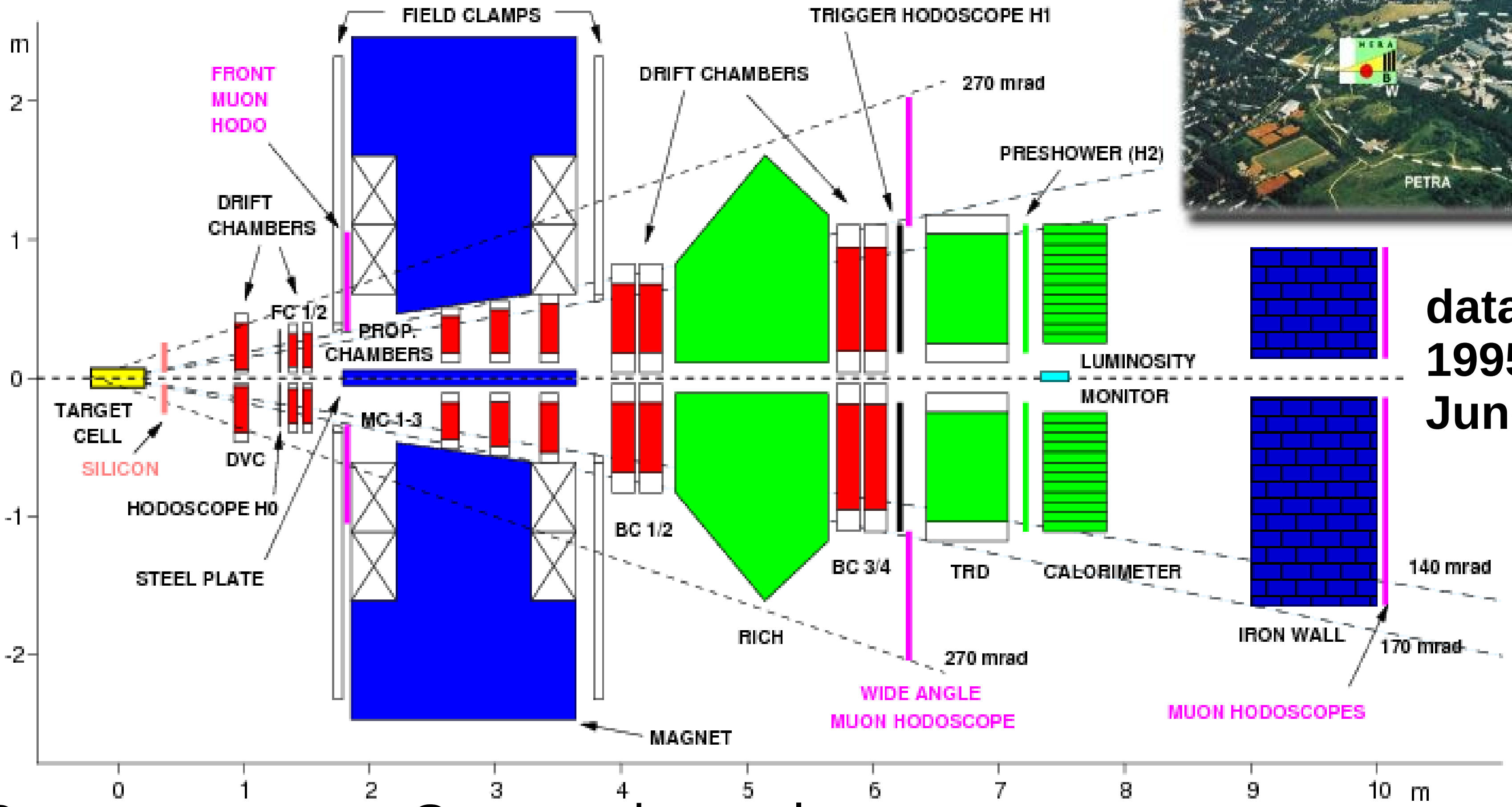
Outline

- the HERMES experiment
- $\pi^{\pm}$ and $K^{\pm}$ multiplicities on hydrogen and deuterium
- hadronization in nuclei
- Collins fragmentation function:

  - transversely polarized hydrogen target

  - unpolarized hydrogen/deuterium target
- dihadron fragmentation function

HERMES: HERA MEasurement of Spin



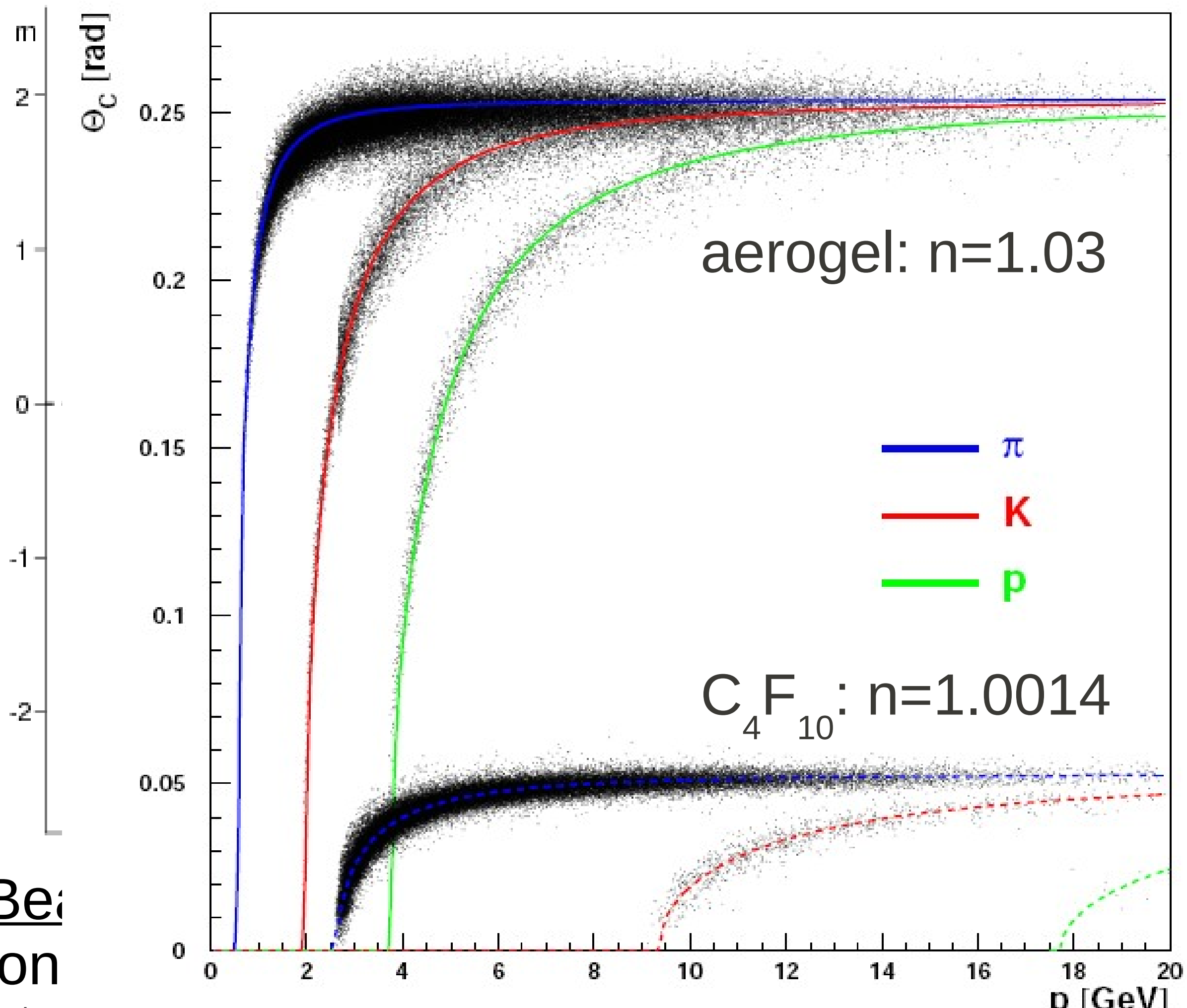
data taking from 1995 until June, 30 2007

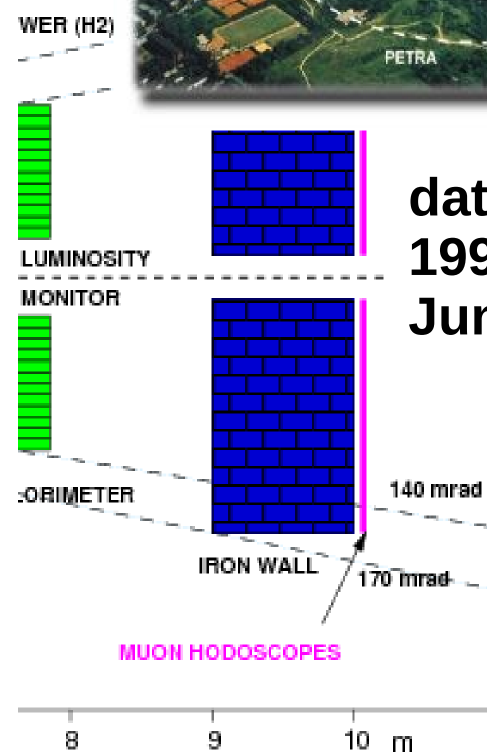
<u>Beam</u>
longitudinally pol.
e^+ & e^-
E= 27.6 GeV

<u>Gaseous internal target</u>
transversely pol. H (~75%)
unpol. H,D,He,Ne,Kr,Xe
longitudinally pol. H,D,He (~85%)

- **lepton-hadron PID: high efficiency (>98%) & low contamination (<1%)**
- **hadron PID: RICH 2-15 GeV**

HERMES: HERA MEasurement of Spin





data taking from 1995 until June, 30 2007

- lepton-hadron PID: high efficiency (>98%) & low contamination (<1%)
- hadron PID: RICH 2-15 GeV

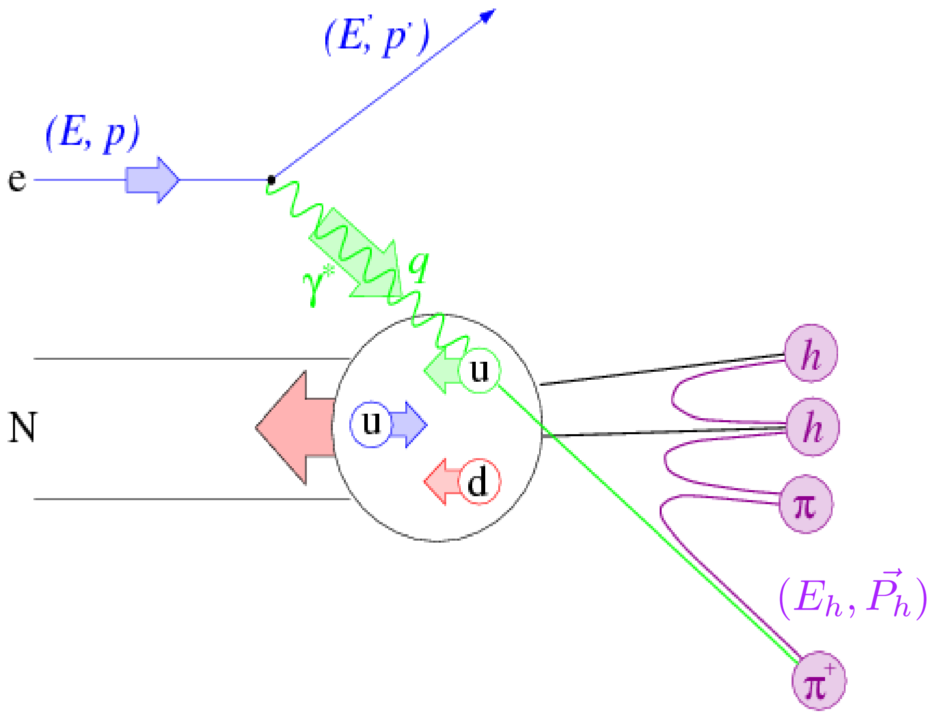
Bea

Ion

e^+ & e — unpol. H,D,He,Ne,Kr,Xe

E= 27.6 GeV — longitudinally pol. H,D,He (~85%)

Semi-inclusive deep-inelastic scattering



$$Q^2 = -q^2$$

$$\nu \stackrel{lab}{=} E - E'$$

$$W^2 = M_N^2 + 2M_N\nu - Q^2$$

$$y \stackrel{lab}{=} \frac{\nu}{E}$$

$$x_B \stackrel{lab}{=} \frac{Q^2}{2M_N\nu}$$

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

$$\sigma^{ep\to eh} = \sum_q \mathcal{I}[DF^{p\to q}(x_B, p_T^2, Q^2) \otimes \sigma^{eq\to eq} \otimes FF^{q\to h}(z, k_T^2, Q^2)]$$

Distribution Function (DF): distribution of quarks in nucleon

Fragmentation Function (FF): fragmentation of struck quark into final-state hadron

p_T/k_T: transverse momentum of struck/fragmenting quark

Access to spin-independent fragmentation functions

Hadron multiplicities and fragmentation functions

$$\mathrm{M}_n^h(x_B, Q^2, z, P_{h\perp}) = \frac{1}{d^2\, N^{DIS}(x_B, Q^2)} \frac{d^4\, N^h(x_B, Q^2, z, P_{h\perp})}{dz dP_{h\perp}}$$

$$= \frac{\sum_q e_q^2\, \mathcal{I}[f_1^q(x_B, p_T^2, Q^2) \otimes \mathcal{W}\, D_1^q(z, k_T^2, Q^2)]}{\sum_q e_q^2\, f_1^q(x_B, Q^2)}$$

collinear

QPM, leading twist, LO

$$M_n^h(x_B, Q^2, z) = \frac{\sum_q e_q^2\, f_1^q(x_B, Q^2)\, D_1^q(z, Q^2)}{\sum_q e_q^2\, f_1^q(x_B, Q^2)}$$

access to fragmentation function $\mathrm{D}_1^q(z, (k_T^2), Q^2)$:

- probe fragmentation function complementary to e^+e^- and $p\overset{(-)}{p}$
- disentangle favored (e.g. $\mathrm{u} \rightarrow \pi^+$) from unfavored fragmentation (e.g. $\bar{u} \rightarrow \pi^+$)

Extraction of multiplicities

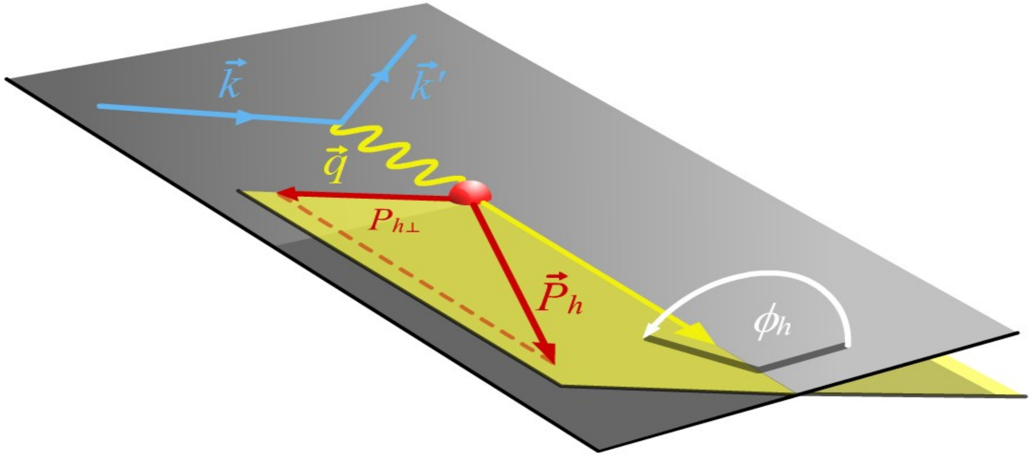
- charged pion and kaon multiplicities
- hydrogen and deuterium targets
- kinematic requirements:

$$Q^2 > 1 \text{ GeV}^2 \qquad 0.1 < y < 0.85$$

$$W^2 > 10 \text{ GeV}^2 \qquad 2 \text{ GeV} < P_h < 15 \text{ GeV}$$

$$0.2 < z < 0.8$$

- 3D binning: $(x_B, z, P_{h\perp})$ and $(Q^2, z, P_{h\perp})$



Extraction of Born multiplicities

$$M^h_{Born}(j) = \frac{1}{n^{DIS}_{Born}(j)} \sum_i \left[S_h^{-1}\right](j,i) \left[M^h_{meas}(i)\, N^{DIS}_{meas}(i) - n^h(i,0)\right]$$

smearing matrix from LEPTO+JETSET Monte-Carlo simulation

$$S_h(i,j) = \frac{n^h(i,j)}{n^h_{Born}(j)}$$

i → reconstructed

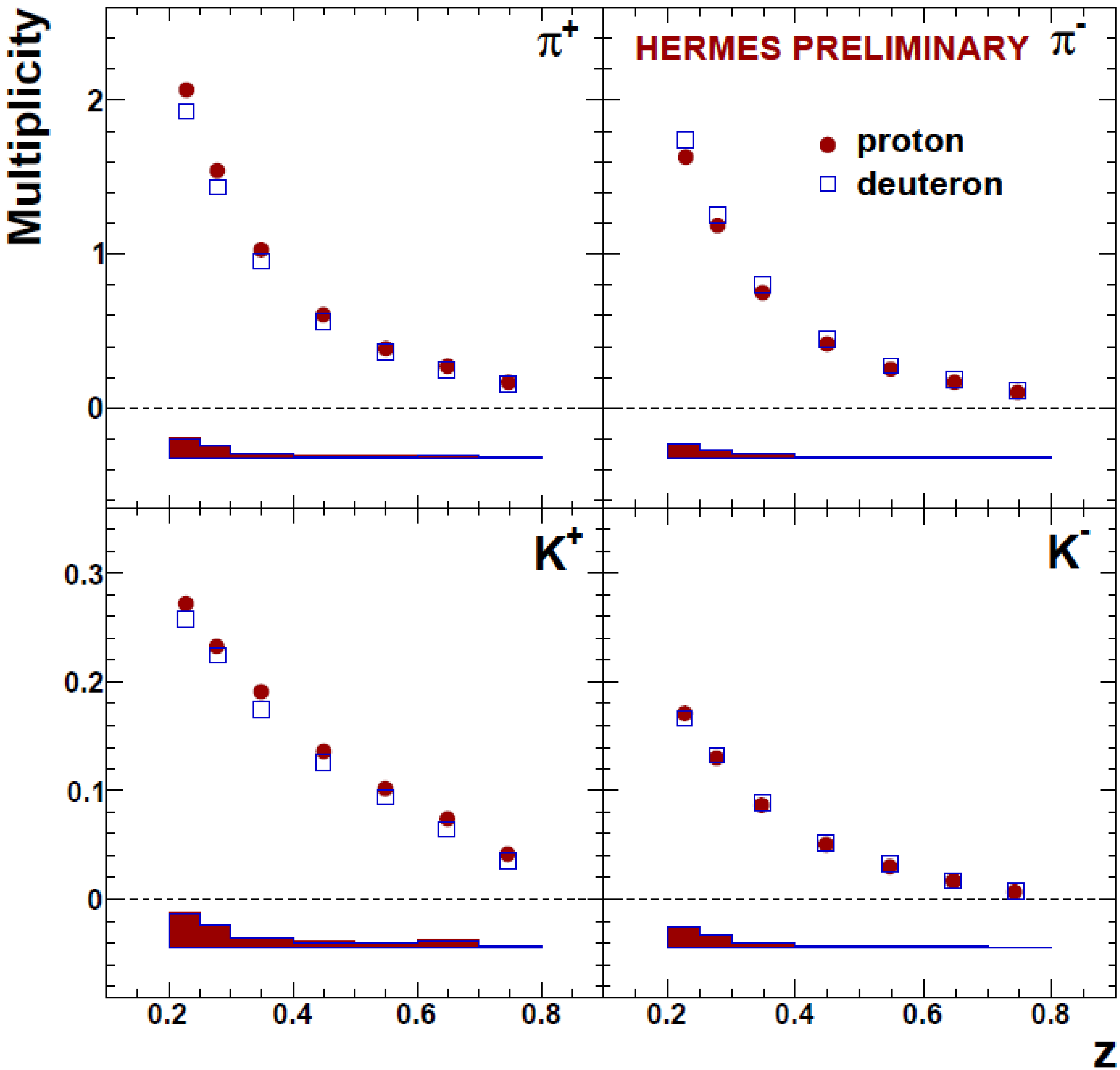
j → generated (Born)

accounts for

- QED radiative effects (RADGEN)
- limited geometric and kinematic acceptance of spectrometer
- detector resolution

$n^h(i,0)$ migration of events outside acceptance into acceptance

Results projected in z



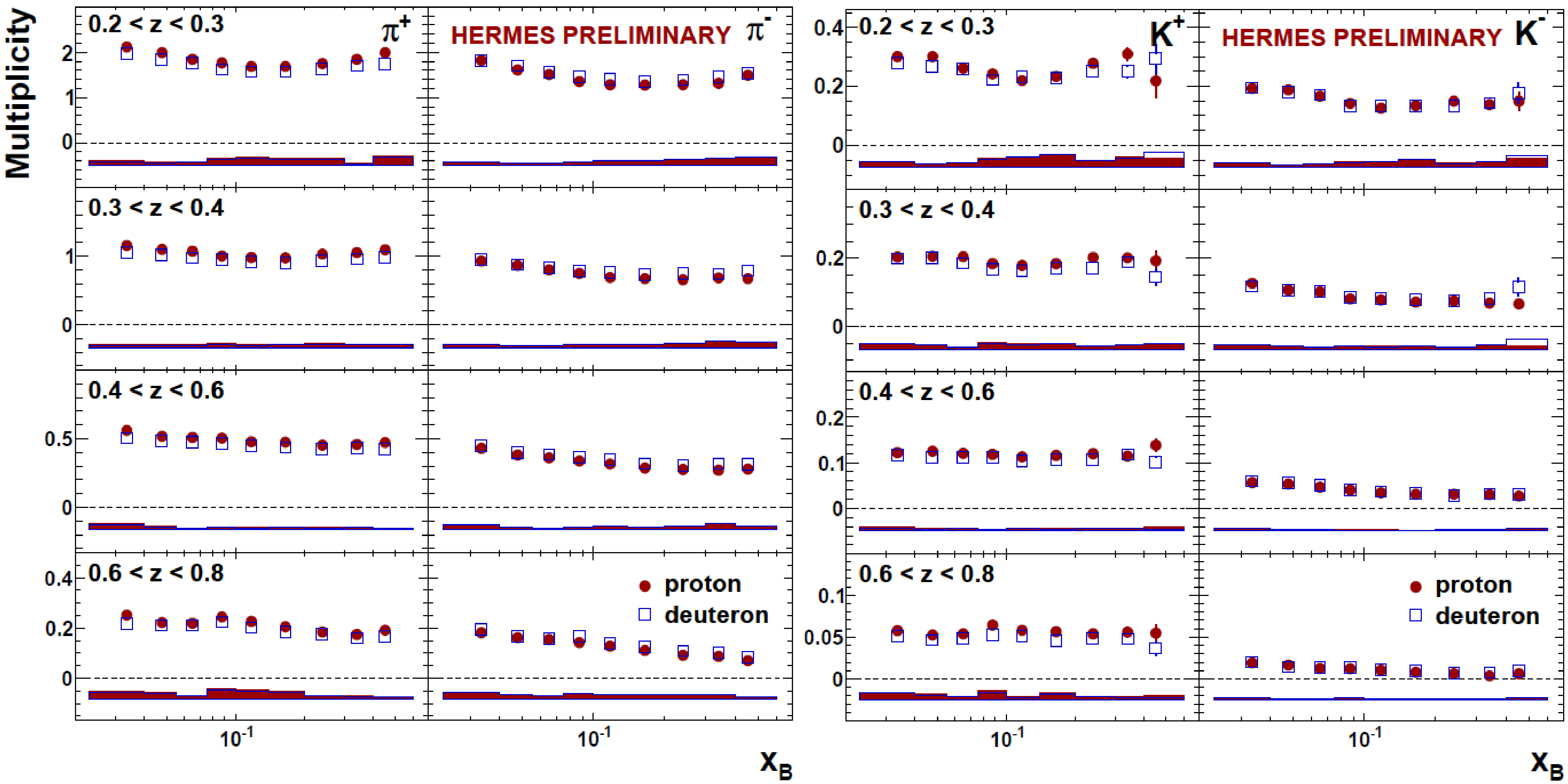
$$\frac{M^{\pi^+}_{p(d)}}{M^{\pi^-}_{p(d)}} = 1.2 - 2.6\,(1.1 - 1.8)$$

$$\frac{M^{K^+}_{p(d)}}{M^{K^-}_{p(d)}} = 1.5 - 5.7\,(1.3 - 4.6)$$

multiplicities reflect

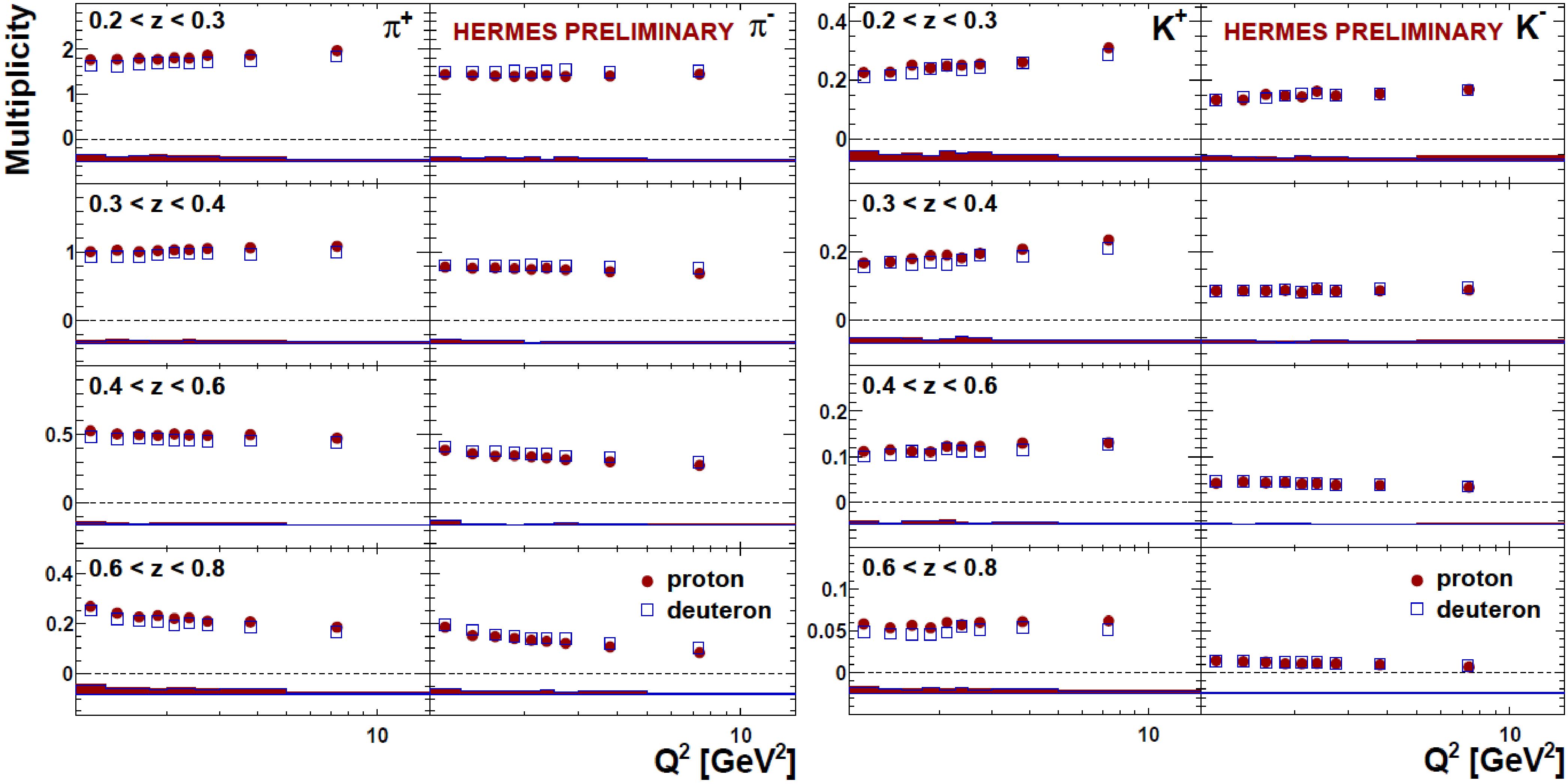
- nucleon valence-quark content (u-dominance)
- favored $\leftrightarrow$ unfavored fragmentation

Results projected in z and x_B



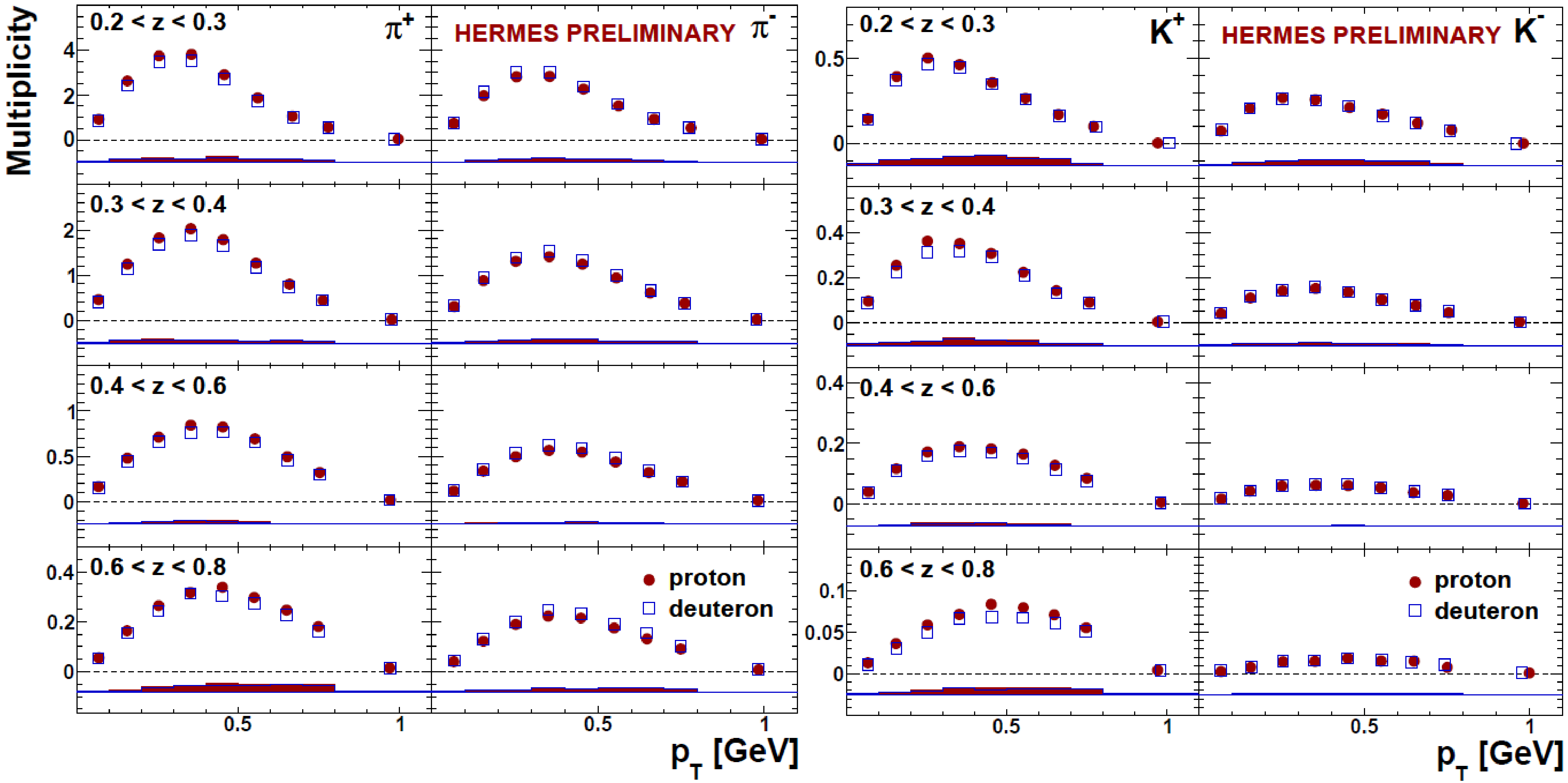
- no strong dependence on x_B

Results projected in z and Q^2



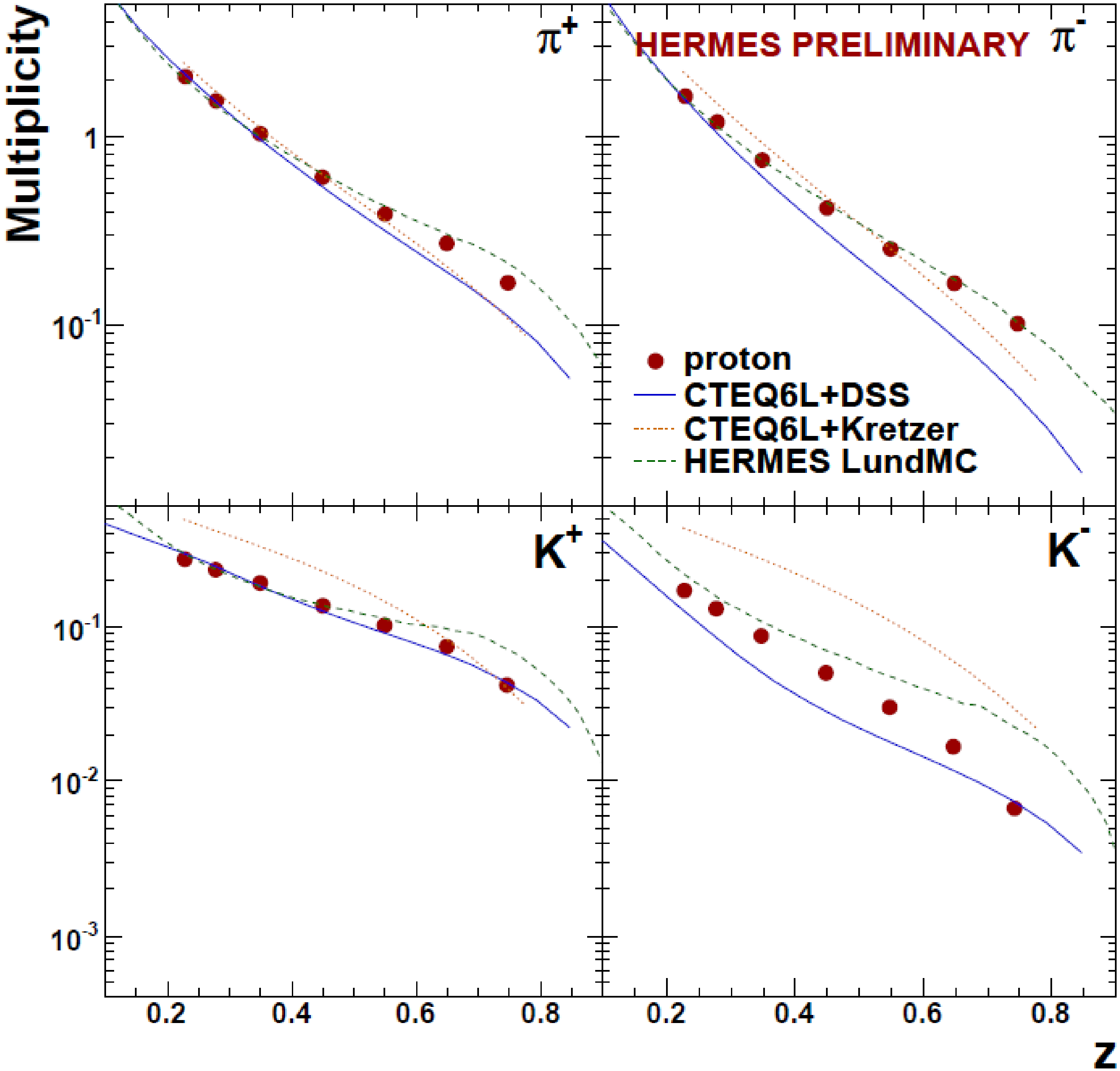
- strong correlation x_B and Q^2

Results projected in z and $P_{h\perp}$



- $P_{h\perp}$ (=p_T on figures): - transverse intrinsic struck-quark momentum
  - transverse momentum from fragmentation process
- K^-: broader distribution

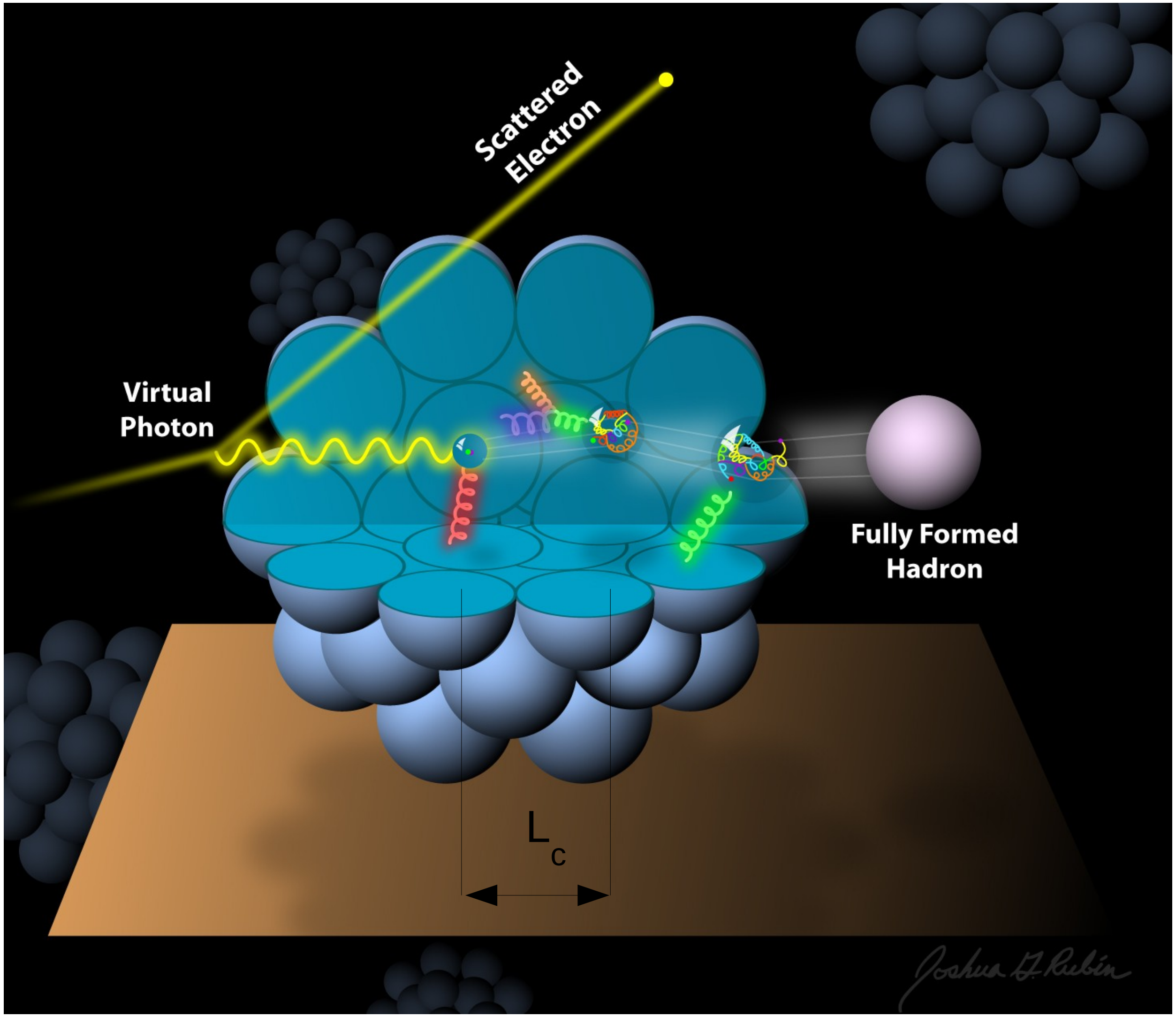
Comparison with models



- LO in α_S
- CTEQ6L PDFs
  JHEP **0602** (2006) 032
- DSS FFs
  Phys. Rev. D**75** (2007) 114010
- Kretzer FFs
  Phys. Rev. D**62** (2000) 054001

Hadronization in nuclei

Probing space-time evolution of hadronization



parton and nuclear medium:
- PDFs modified by nuclear medium
- gluon radiation and rescattering

(pre-)hadron and nuclear medium:
- rescattering
- absorption

- differences predicted for partonic and (pre-)hadronic interactions
- change from partonic to hadronic interactions=f(L_c/nucleon size)

hadron multiplicity ratios from heavier targets and deuterium → space-time evolution of hadron formation

Extraction of multiplicity ratios

- nuclear targets: Ne, Kr, Xe compared to D
- ratio $\Rightarrow$ approximate cancellation of

  - QED radiative effects (RADGEN)

  - limited geometric and kinematic acceptance of spectrometer

  - detector resolution
- multi-dimensional extraction:

  - ν for slices of z

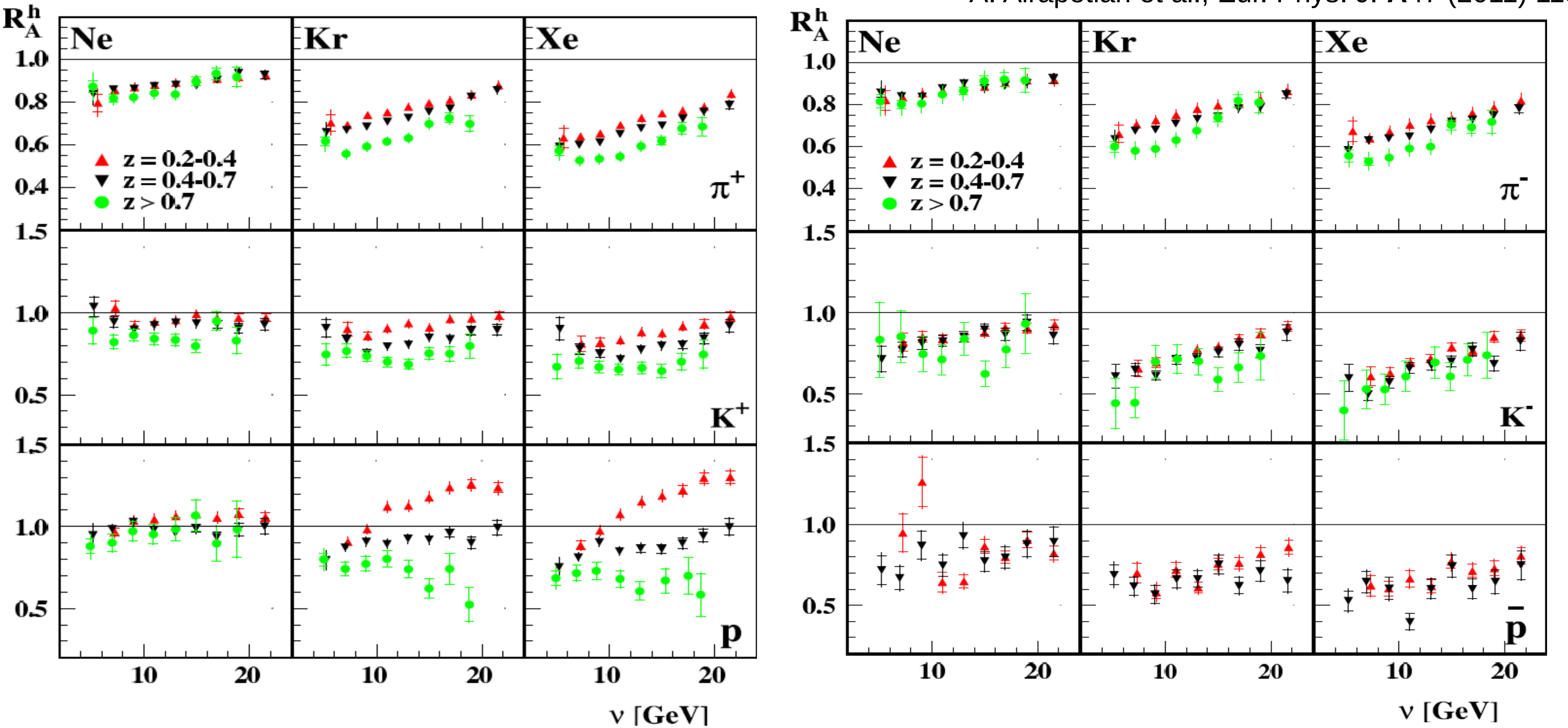
  - z for slices of ν

  - $P^2_{h\perp}$ for slices of z

  - z for slices of $P^2_{h\perp}$

Results in ν for slices of z

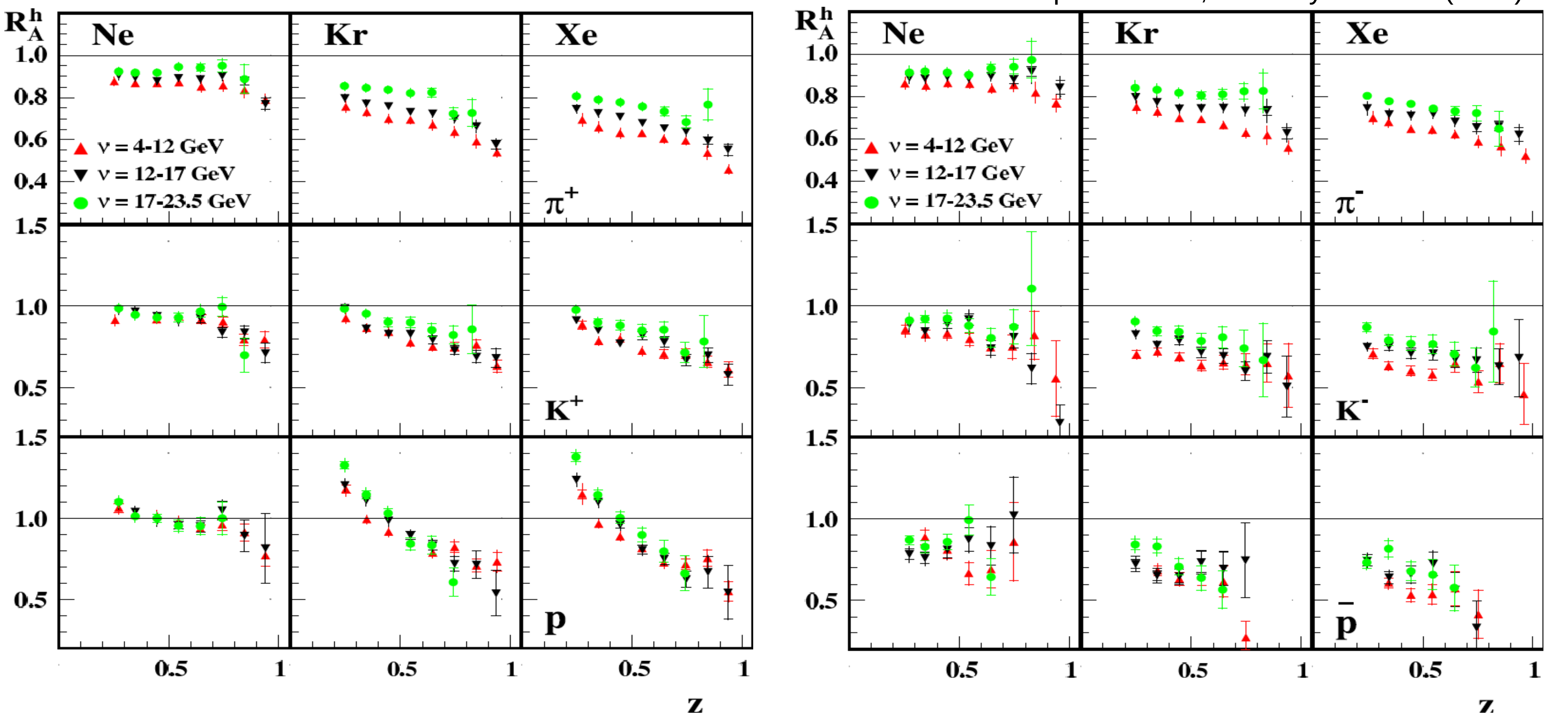
A. Airapetian et al., Eur. Phys. J. **A**47 (2011) 113



- R_A^h decreases with increasing A (except for protons)
- $\pi^\pm$ & K^-: R_A^h increases with increasing ν
- K^+: R_A^h increases with increasing ν, but different behavior
- p: R_A^h > 1 at low z

Results in z for slices of ν

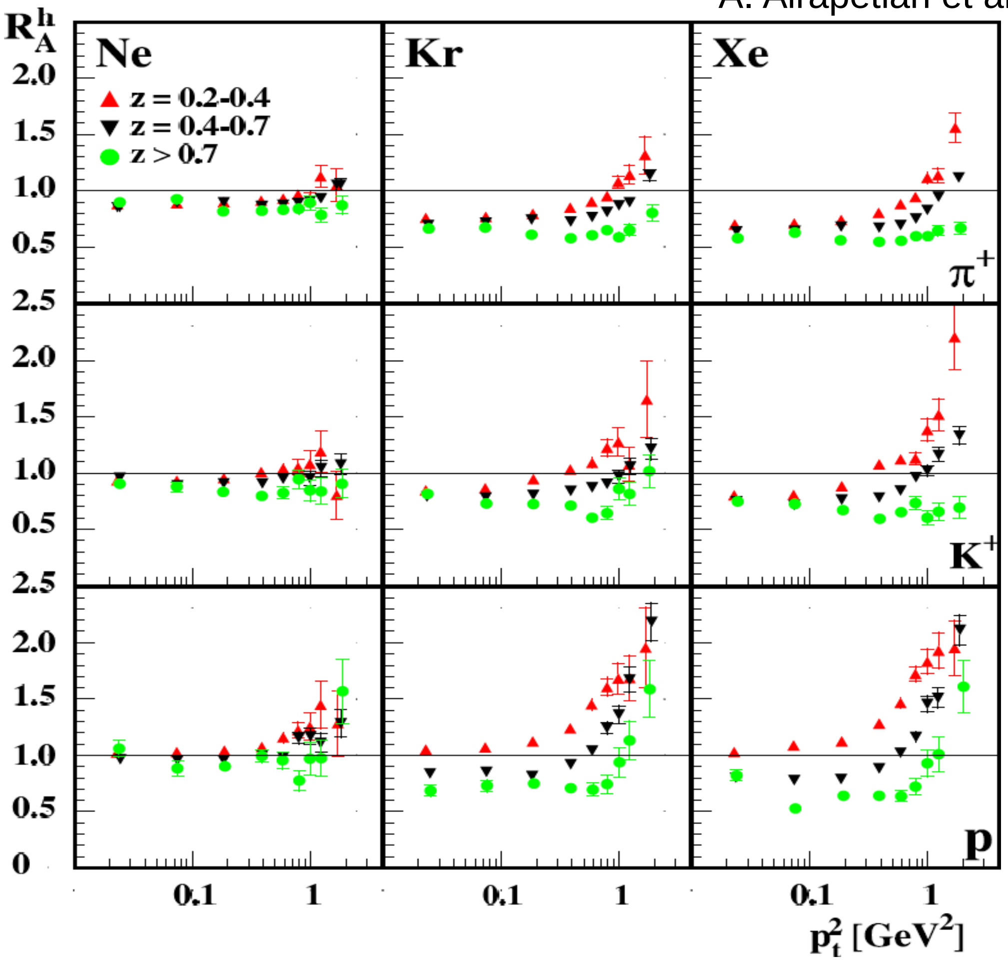
A. Airapetian et al., Eur. Phys. J. **A**47 (2011) 113



- R_A^h decreases with increasing z
- effect increases with increasing A
- p: $R_A^h > 1$ at low z
- K^+: $R_A^h \simeq 1$ at low z

Results in $P^2_{h\perp}$ for slices of z

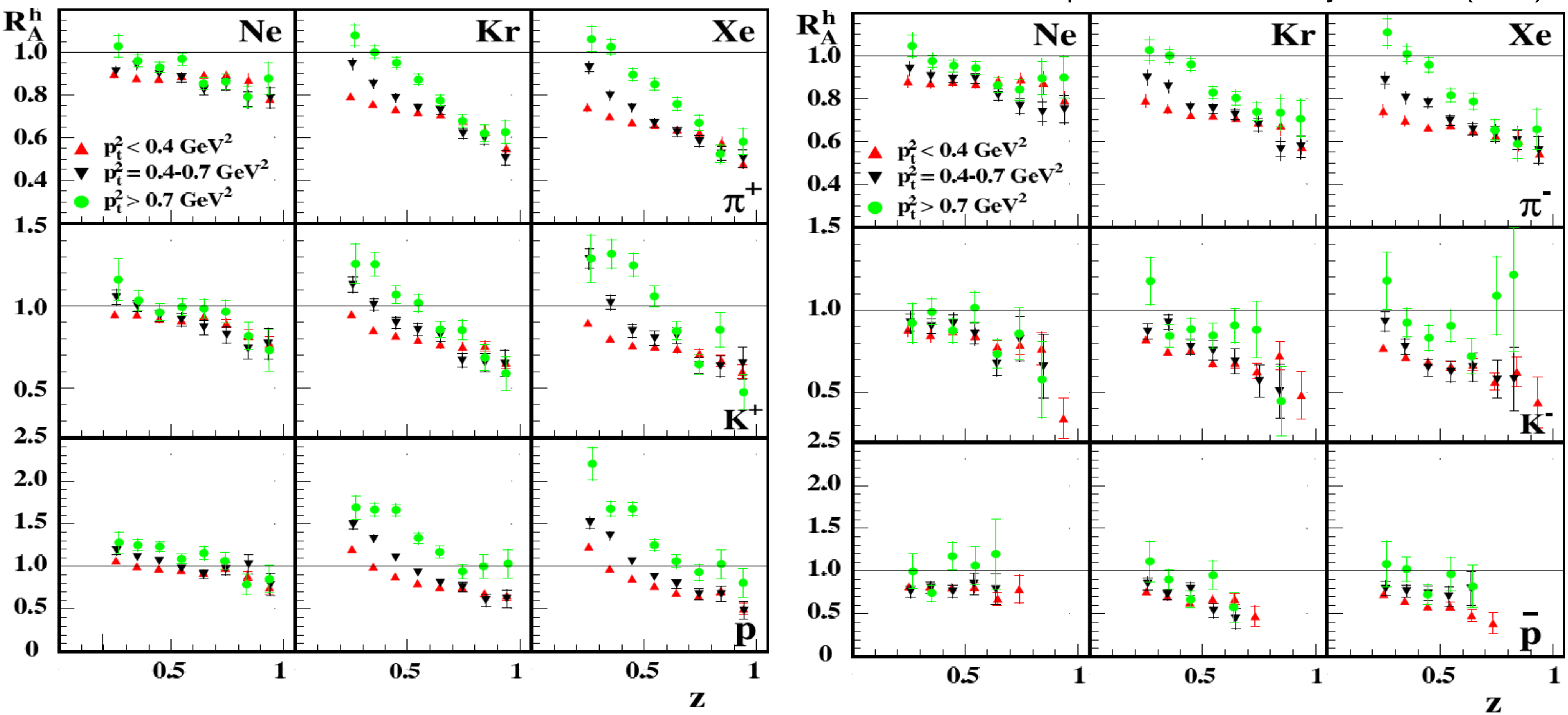
A. Airapetian et al., Eur. Phys. J. **A**47 (2011) 113



- R^h_A increases strongly with increasing $P^2_{h\perp}$ (Cronin effect)
- except at large z for π^+ and K^+

Results in z for slices of $P^2_{h\perp}$

A. Airapetian et al., Eur. Phys. J. **A**47 (2011) 113

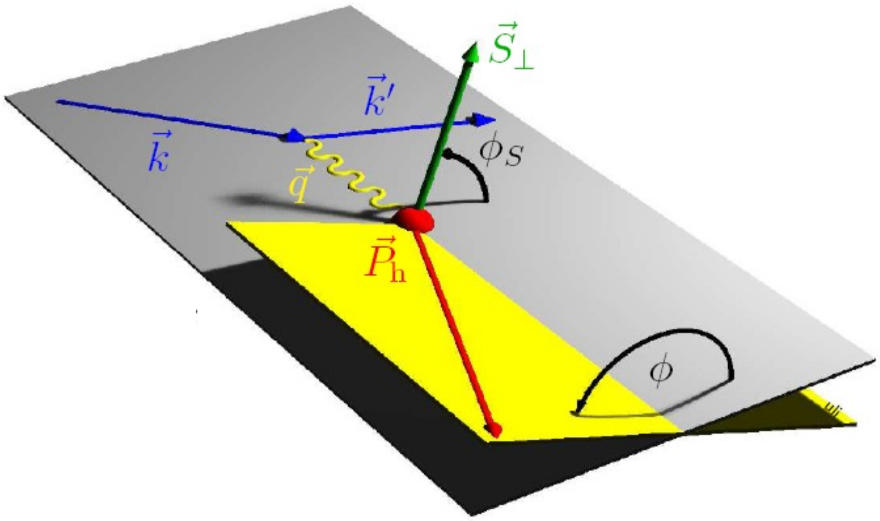


- decrease of R^h_A with increasing z stronger at large $P^2_{h\perp}$ and A
- no Cronin effect at large z
- p: R^h_A at low z larger for large $P^2_{h\perp}$

Access to Collins fragmentation function

Semi-inclusive deep-inelastic single-hadron production

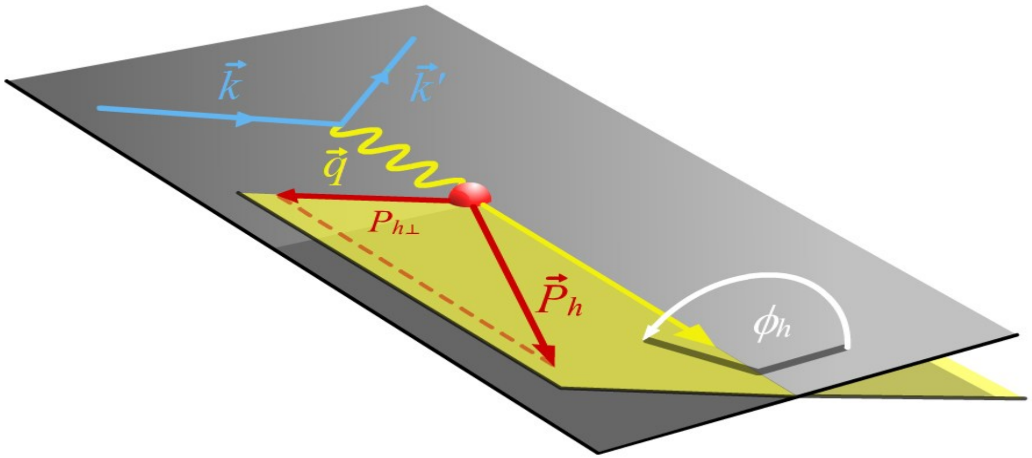
transverse target-spin asymmetry:



$$\sim \sin(\phi + \phi_S) \sum_q e_q^2 \, \mathcal{I}[h_{1T}^q \otimes \mathcal{W}_1 \, H_1^{\perp,q}]$$

$H_1^{\perp,q}$: Collins fragmentation function

spin-independent semi-inclusive cross section:

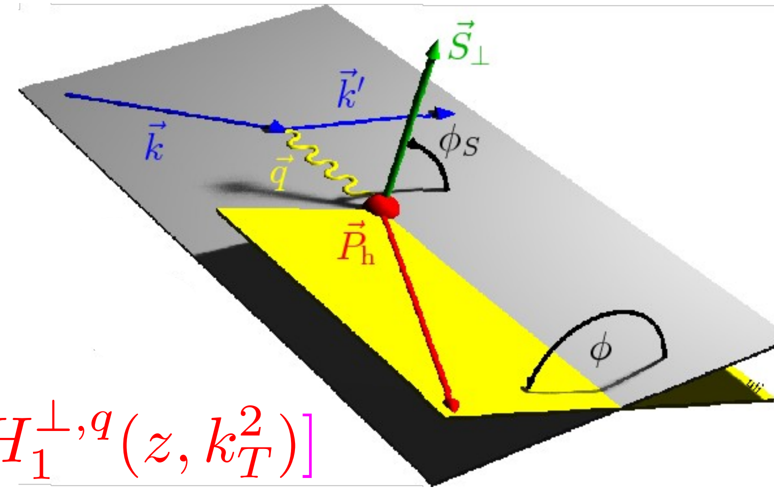


$$\sim \cos(2\phi_h) \sum_q e_q^2 \, \mathcal{I}[-h_1^{\perp,q} \otimes \mathcal{W}_2 \, H_1^{\perp,q}]$$

$$+ \cos(\phi_h) \sum_q e_q^2 \, \mathcal{I}[-f_1^q \otimes \mathcal{W}_3 \, D_1^q$$

$$-h_1^{\perp,q} \otimes \mathcal{W}_4 \, H_1^{\perp,q} + \ldots]$$

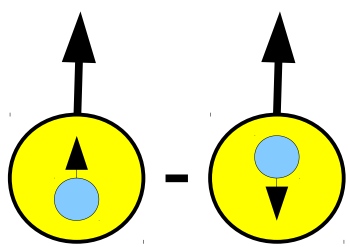
Single-Spin Asymmetry



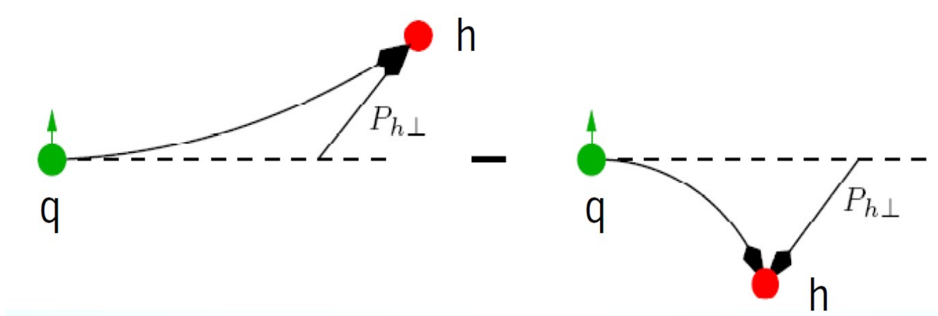
$$A_{UT} = \frac{1}{\langle |S_T| \rangle} \frac{N^{\uparrow}(\phi, \phi_S) - N^{\downarrow}(\phi, \phi_S)}{N^{\uparrow}(\phi, \phi_S) + N^{\downarrow}(\phi, \phi_S)}$$

$$\sim \sin(\phi + \phi_S) \sum_q e_q^2 \, \mathcal{I}\left[\frac{\vec{k}_T . \hat{P}_{h\perp}}{M_h} h_{1T}^q(x, p_T^2) \otimes H_1^{\perp,q}(z, k_T^2)\right]$$

$h_{1T}^q(x, p_T^2)$: transversity



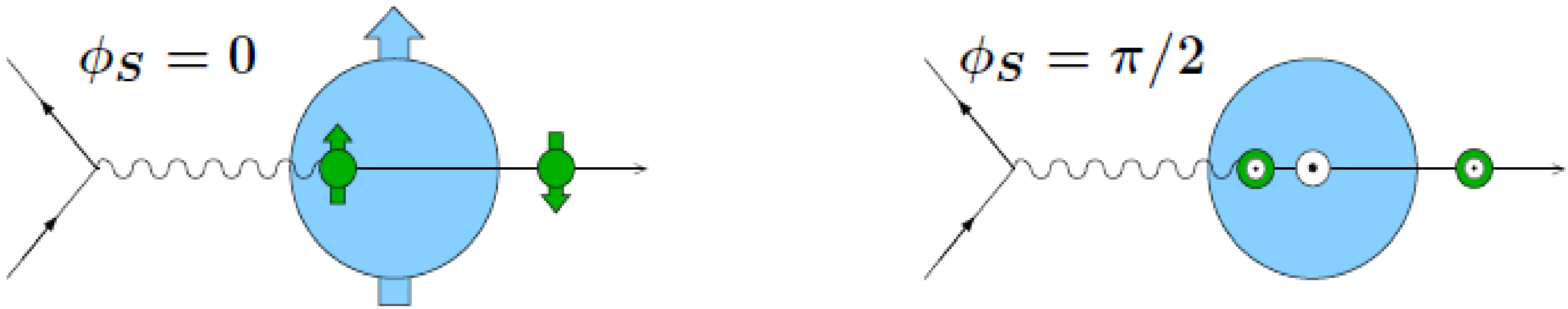
$H_1^{\perp,q}(z, k_T^2)$: Collins fragmentation function



Collins fragmentation function: Artru model

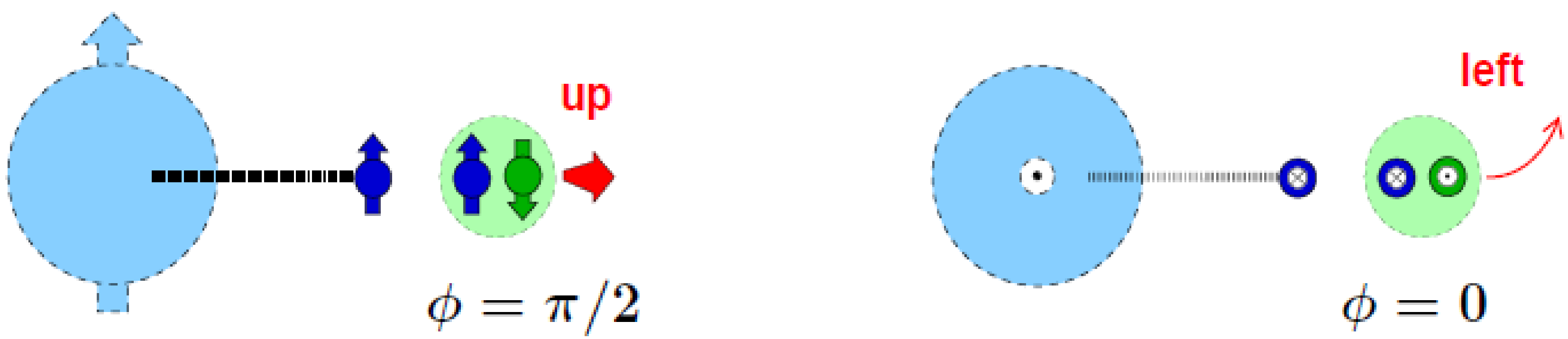
X. Artru et al. , Z. Phys. C**73** (1997) 527

polarisation component in lepton scattering plane reversed by photoabsorption:



string break, quark-antiquark pair with vacuum numbers:

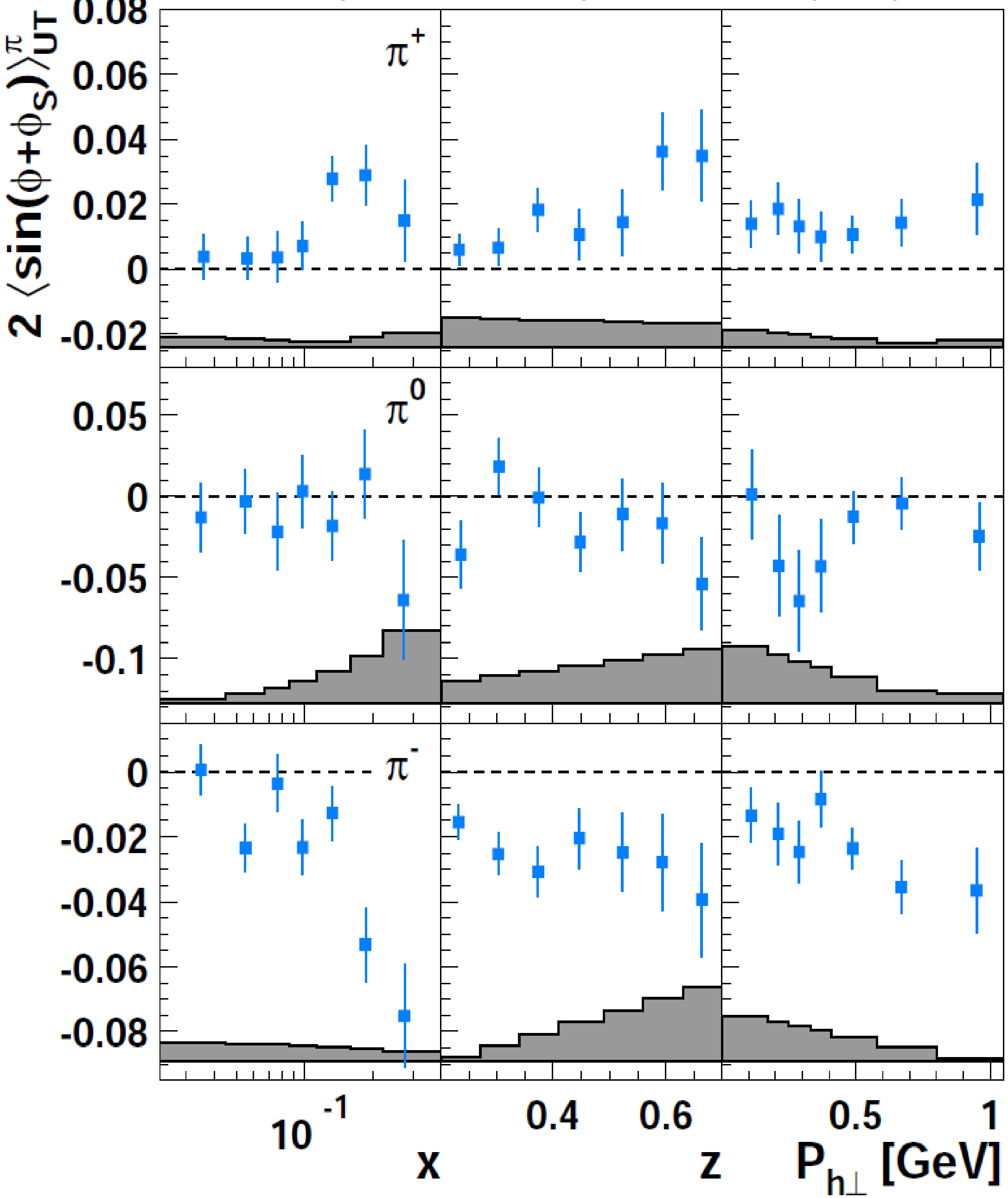
orbital angular momentum creates transverse momentum:



courtesy from U. Elschenbroich

Collins amplitudes for pions

A. Airapetian et al., Phys. Lett. B**693** (2010) 11-16



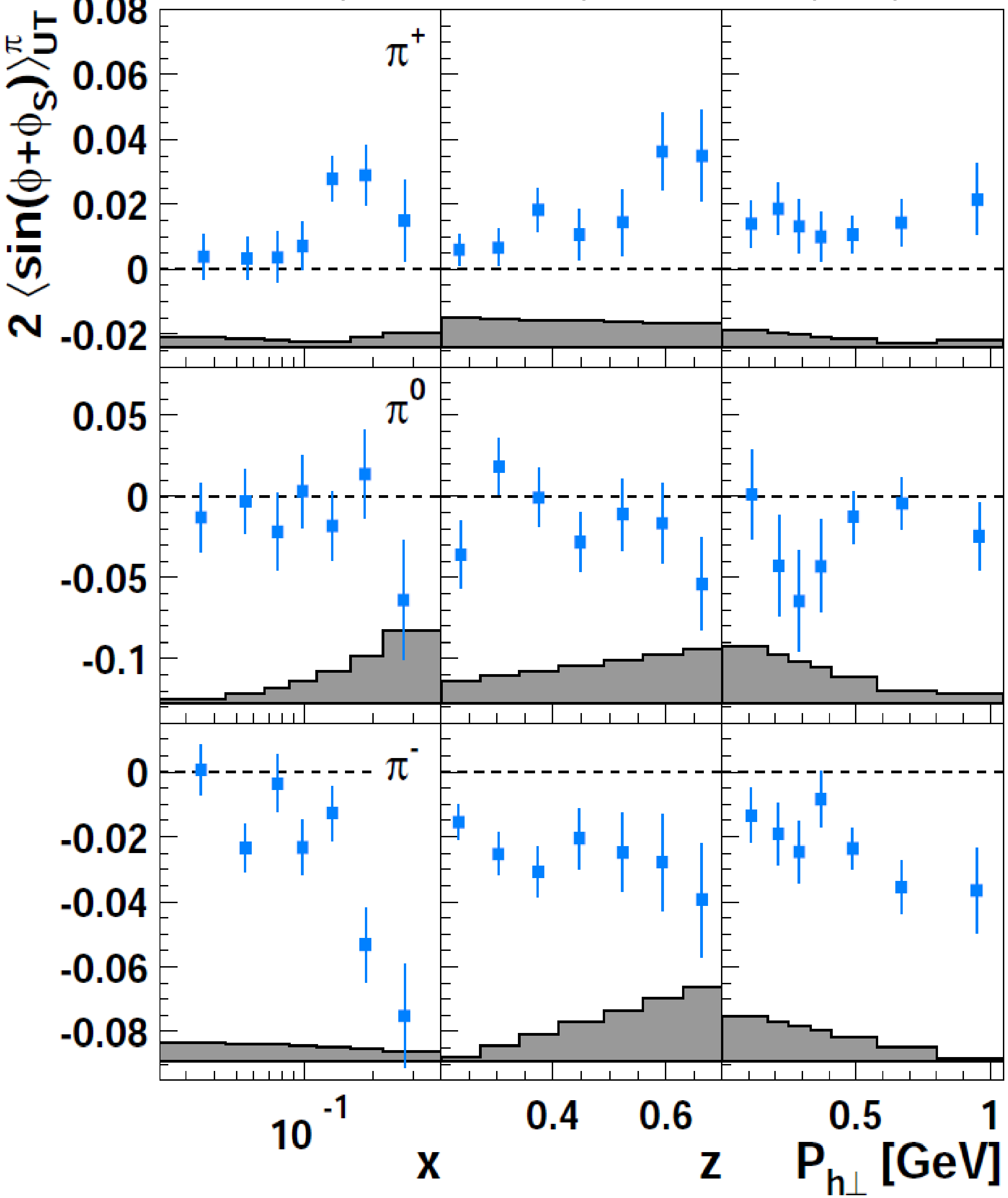
- $\pi^{\pm}$ increasing with z
- positive for π^+
- large & negative for π^-

$$H_1^{\perp,fav} \approx -H_1^{\perp,unfav}$$

- isospin symmetry fulfilled

Collins amplitudes for pions

A. Airapetian et al., Phys. Lett. B**693** (2010) 11-16

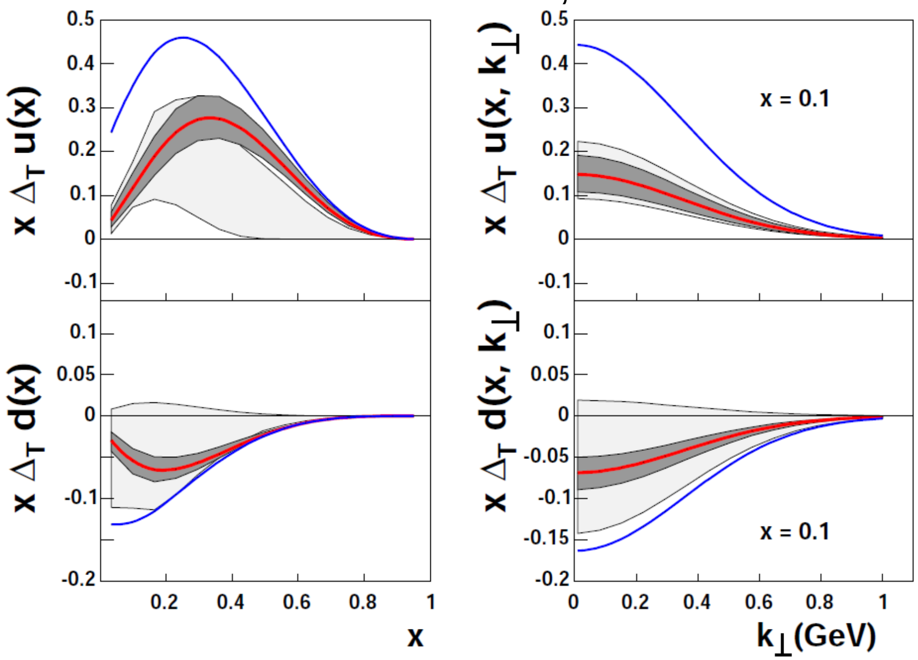


- $\pi^{\pm}$ increasing with z
- positive for π^+
- large & negative for π^-

$$H_1^{\perp,fav} \approx -H_1^{\perp,unfav}$$

- isospin symmetry fulfilled
- data from BELLE, COMPASS & HERMES $\longrightarrow$ extraction of h^q_{1T}

Anselmino et al., arXiv: 0807.0173



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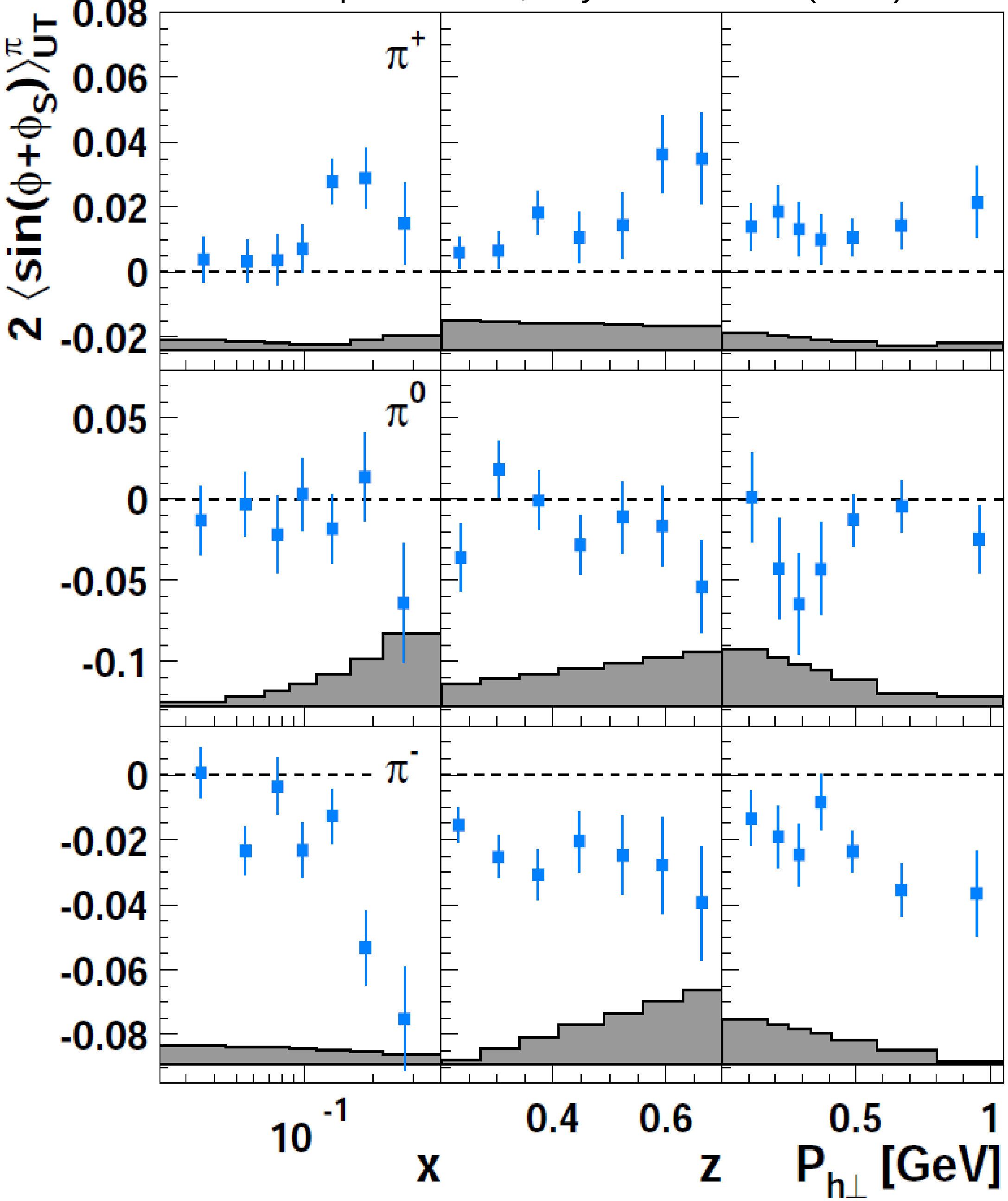
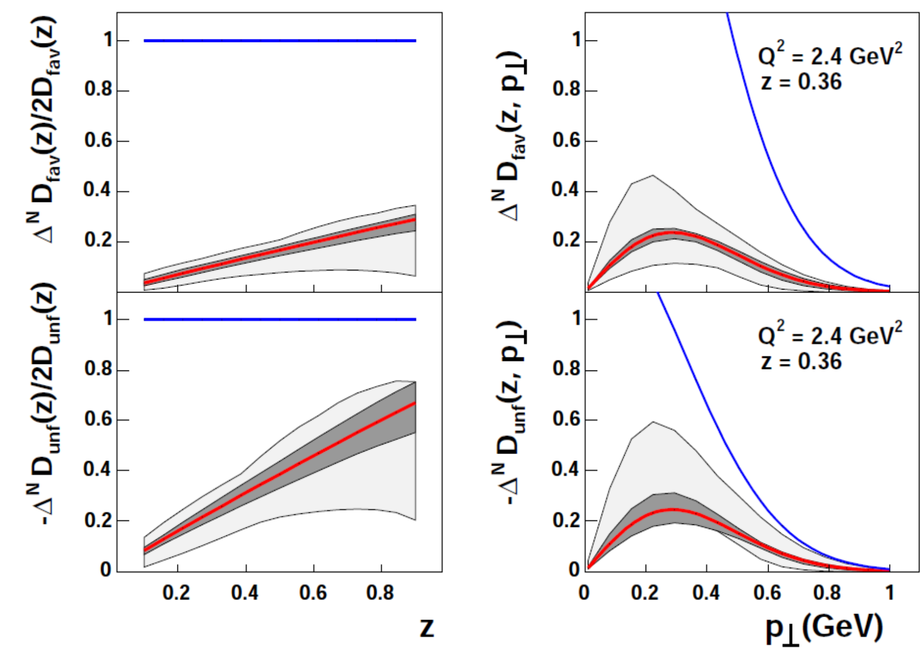


- $\pi^\pm$ increasing with z
- positive for π^+
- large & negative for π^-

$$H_1^{\perp,fav} \approx -H_1^{\perp,unfav}$$

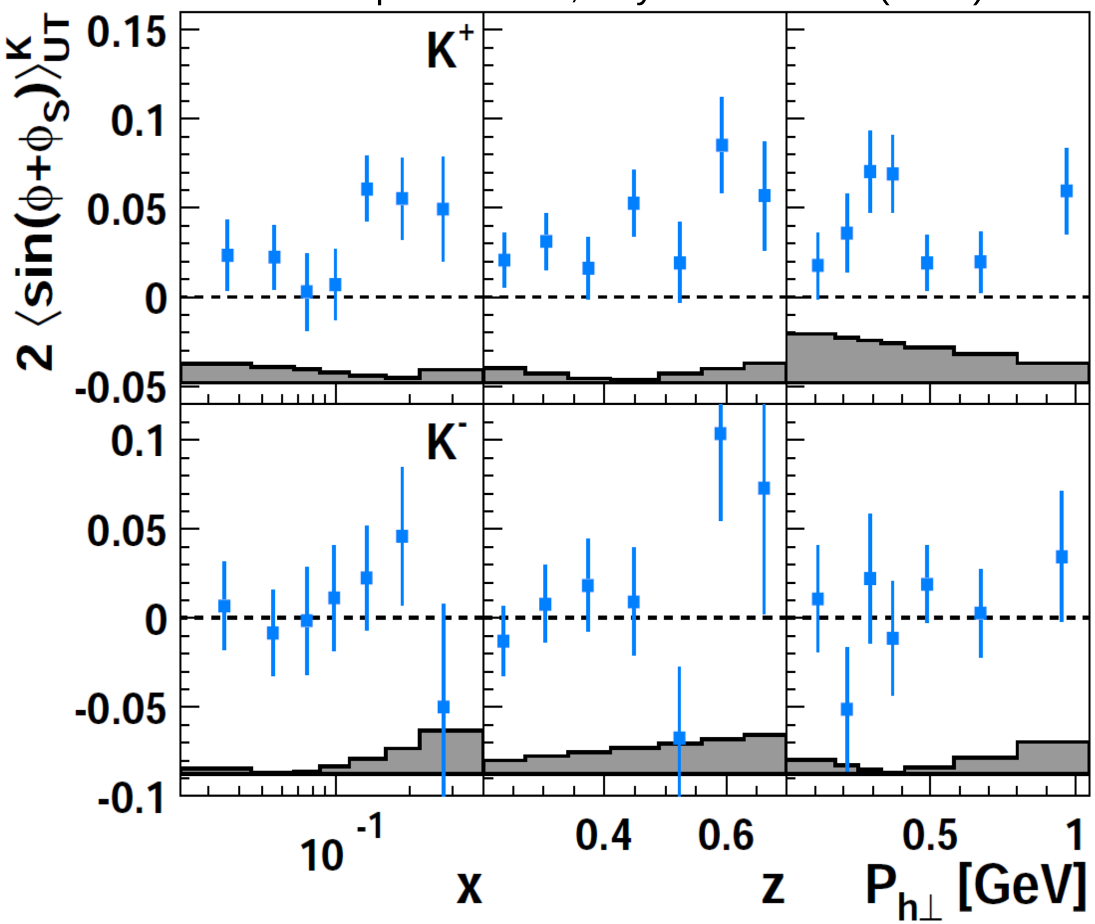
- isospin symmetry fulfilled
- data from BELLE, COMPASS & HERMES ⟶ extraction of $H_1^\perp$

Anselmino et al., arXiv: 0807.0173



Collins amplitudes for kaons

A. Airapetian et al., Phys. Lett. B**693** (2010) 11-16



- K$^+$: increasing with z
- positive for K$^+$ & larger than for π^+
  - role of s-quark
  - u-dominance $\xrightarrow{?}$

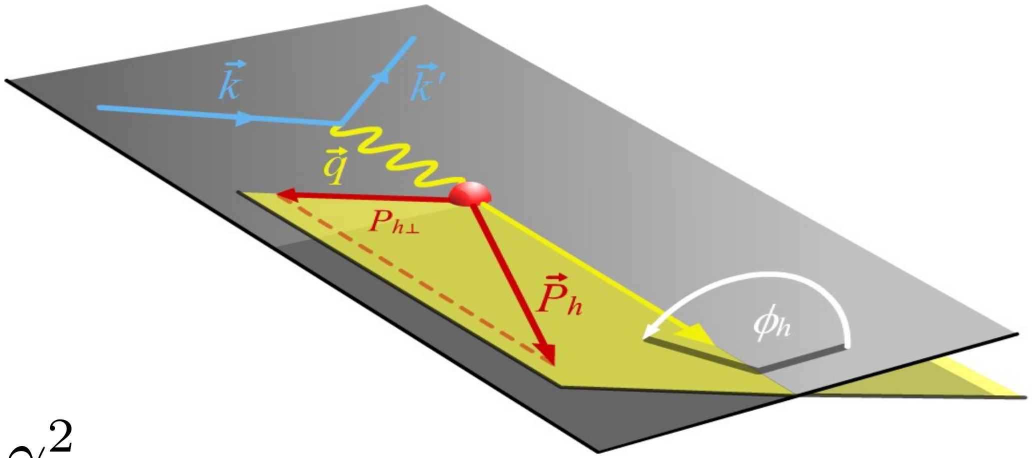
$$H_1^{\perp,u\to K^+} > H_1^{\perp,u\to\pi^+}$$

- K$^-$ ≈ 0, ≠ from π^-

  K$^-$ is pure sea object:

  sea-quark transversity expected to be small

Spin-independent semi-inclusive DIS cross section



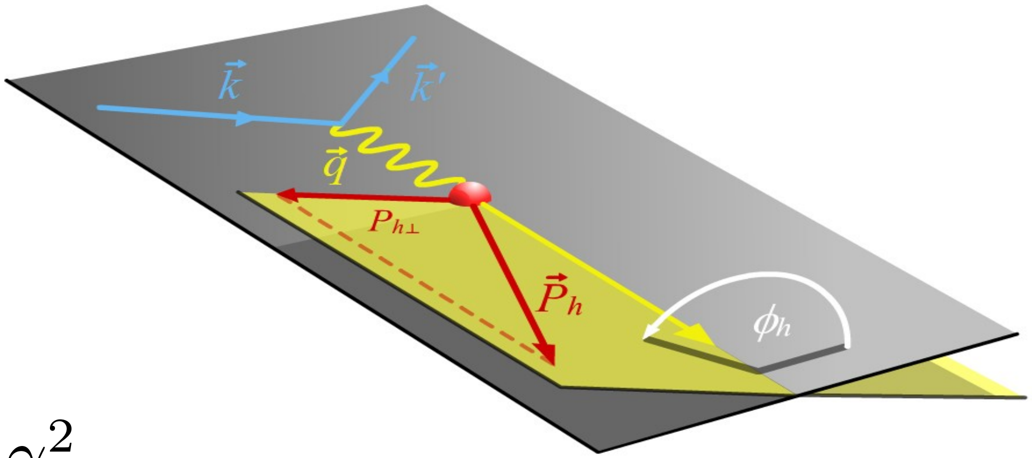
Non-collinear cross section

$$\frac{d\sigma}{dx\,dy\,dz\,dP_{h\perp}^2\,d\phi_h} = \frac{\alpha^2}{xyQ^2}\left(1+\frac{\gamma^2}{2x}\right)\{A(y)F_{UU,T} + B(y)F_{UU,L}$$

$$+C(y)\cos\phi_h F_{UU}^{\cos\phi_h} + B(y)\cos 2\phi_h F_{UU}^{\cos 2\phi_h}\}$$

$$\gamma = \frac{2Mx}{Q},\ F = F(x, Q, z, \vec{P_{h\perp}})$$

Spin-independent semi-inclusive DIS cross section



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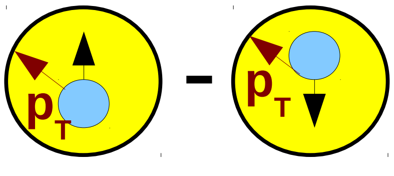
$$+C(y)\cos\phi_h F_{UU}^{\cos\phi_h} + B(y)\cos 2\phi_h F_{UU}^{\cos 2\phi_h}\}$$

$$\gamma = \frac{2Mx}{Q},\quad F = F(x, Q, z, \vec{P_{h\perp}})$$

leading twist

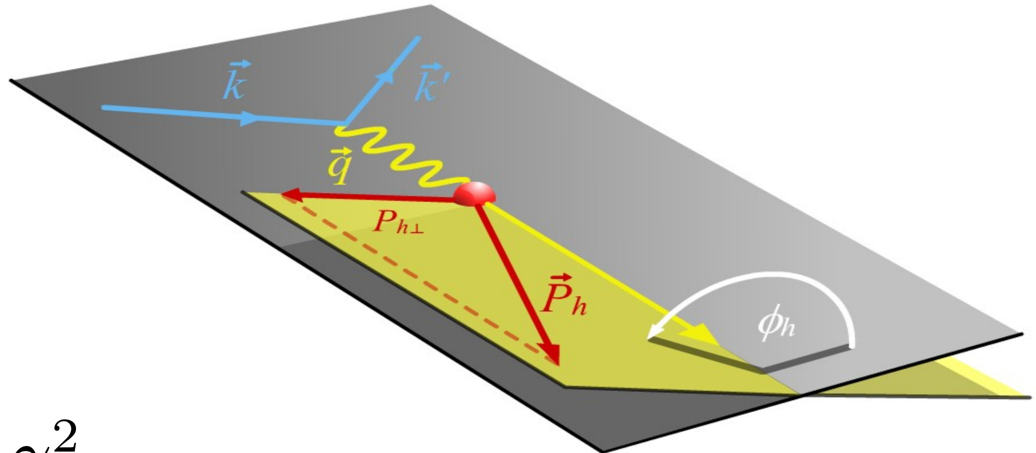
$$F_{UU}^{\cos 2\phi_h} = \mathcal{I}\left[-\frac{2(\hat{P}_{h\perp}.\vec{p}_T)(\hat{P}_{h\perp}.\vec{k}_T) - \vec{p}_T.\vec{k}_T}{M_h M} h_1^\perp H_1^\perp\right]$$



Boer-Mulders DF

Collins FF

Spin-independent semi-inclusive DIS cross section



Non-collinear cross section

$$\frac{d\sigma}{dx dy dz dP_{h\perp}^2 d\phi_h} = \frac{\alpha^2}{xyQ^2}(1+\frac{\gamma^2}{2x})\{A(y)F_{UU,T} + B(y)F_{UU,L}$$

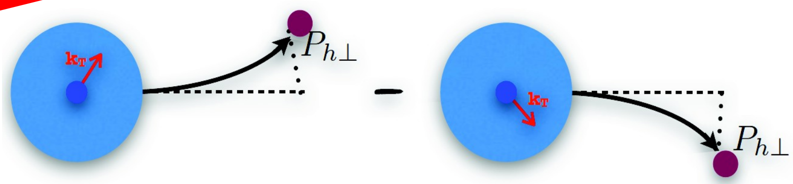
$$+C(y)\cos\phi_h F_{UU}^{\cos\phi_h} + B(y)\cos 2\phi_h F_{UU}^{\cos 2\phi_h}\}$$

$$\gamma = \frac{2Mx}{Q}, \;\; F = F(x, Q, z, \vec{P_{h\perp}})$$

sub-leading twist

$$F_{UU}^{\cos\phi_h} = \frac{2M}{Q}\mathcal{I}[-\frac{\hat{P}_{h\perp}.\vec{p}_T}{M} f_1 D_1 - \frac{\hat{P}_{h\perp}.\vec{k}_T}{M_h}\frac{p_T^2}{M^2} h_1^\perp H_1^\perp + \ldots]$$

Cahn effect



quark-gluon-quark correlations

Extraction of the cosine moments

$$\langle \cos(n\phi_h) \rangle \stackrel{th.}{=} \frac{\int d\phi_h \cos(n\phi_h) \sigma_{UU}(\omega, \phi_h)}{\int d\phi_h \sigma_{UU}(\omega, \phi_h)}$$

$$\omega = (x, y, z, P_{h\perp}^2)$$

$$\updownarrow$$

$$\langle \cos(n\phi_h) \rangle \stackrel{exp.}{=} \frac{\int d\phi_h \cos(n\phi_h) \epsilon_{acc}(\omega, \phi_h) \epsilon_{rad}(\omega, \phi_h) \sigma_{UU}(\omega, \phi_h)}{\int d\phi_h \epsilon_{acc}(\omega, \phi_h) \epsilon_{rad}(\omega, \phi_h) \sigma_{UU}(\omega, \phi_h)}$$

Extraction of the cosine moments

$$\langle\cos(n\phi_h)\rangle \stackrel{th.}{=} \frac{\int d\phi_h \cos(n\phi_h)\sigma_{UU}(\omega,\phi_h)}{\int d\phi_h \sigma_{UU}(\omega,\phi_h)}$$

$$\omega = (x, y, z, P_{h\perp}^2)$$

$$\updownarrow$$

$$\langle\cos(n\phi_h)\rangle \stackrel{exp.}{=} \frac{\int d\phi_h \cos(n\phi_h)\epsilon_{acc}(\omega,\phi_h)\epsilon_{rad}(\omega,\phi_h)\sigma_{UU}(\omega,\phi_h)}{\int d\phi_h \epsilon_{acc}(\omega,\phi_h)\epsilon_{rad}(\omega,\phi_h)\sigma_{UU}(\omega,\phi_h)}$$

extraction is challenging!
azimuthal modulations also possible due to
- detector geometrical acceptance
- higher-order QED effects

Extraction of the cosine moments

$$\langle \cos(n\phi_h) \rangle \overset{th.}{=} \frac{\int d\phi_h \cos(n\phi_h) \sigma_{UU}(\omega, \phi_h)}{\int d\phi_h \sigma_{UU}(\omega, \phi_h)}$$

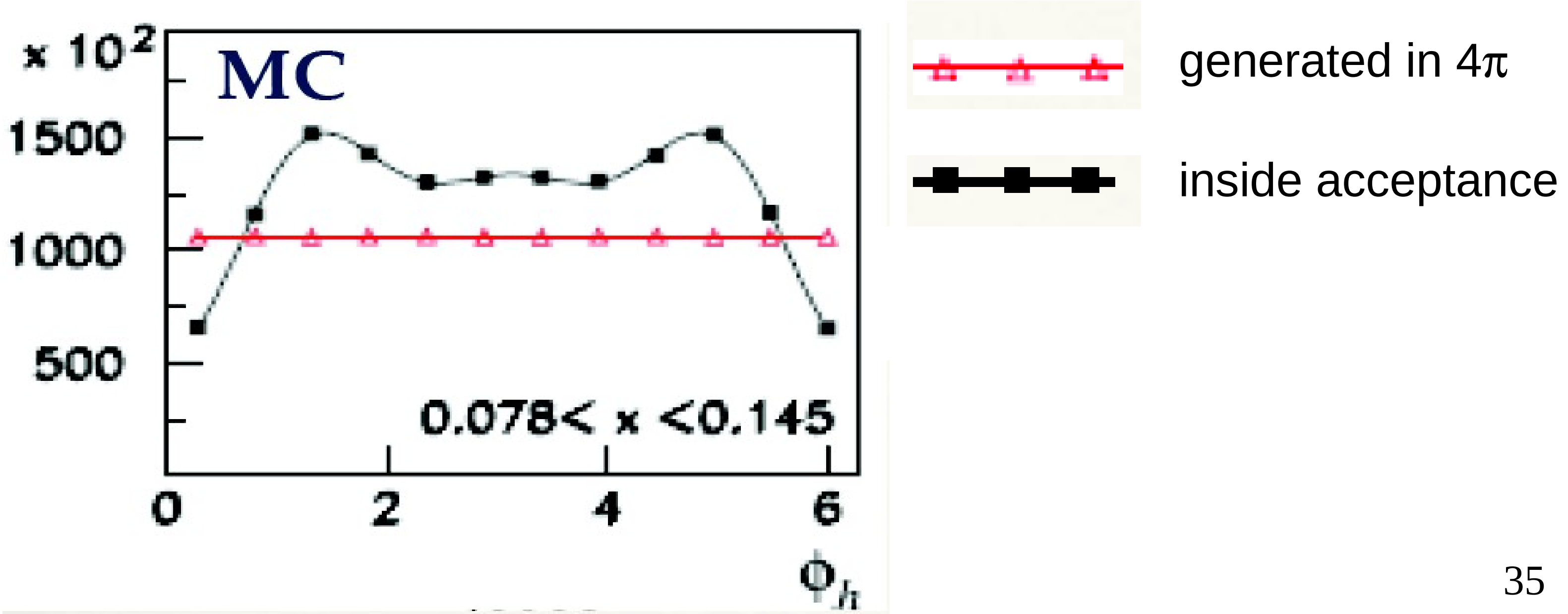
$$\omega = (x, y, z, P_{h\perp}^2)$$

$$\langle \cos(n\phi_h) \rangle \overset{exp.}{=} \frac{\int d\phi_h \cos(n\phi_h) \epsilon_{acc}(\omega, \phi_h) \epsilon_{rad}(\omega, \phi_h) \sigma_{UU}(\omega, \phi_h)}{\int d\phi_h \epsilon_{acc}(\omega, \phi_h) \epsilon_{rad}(\omega, \phi_h) \sigma_{UU}(\omega, \phi_h)}$$

extraction is challenging!

azimuthal modulations also possible due to

- detector geometrical acceptance
- higher-order QED effects



Extraction of the cosine moments

$$\langle\cos(n\phi_h)\rangle \stackrel{th.}{=} \frac{\int d\phi_h \cos(n\phi_h)\sigma_{UU}(\omega,\phi_h)}{\int d\phi_h \sigma_{UU}(\omega,\phi_h)}$$

$$\omega = (x, y, z, P_{h\perp}^2)$$

$$\updownarrow$$

$$\langle\cos(n\phi_h)\rangle \stackrel{exp.}{=} \frac{\int d\phi_h \cos(n\phi_h)\epsilon_{acc}(\omega,\phi_h)\epsilon_{rad}(\omega,\phi_h)\sigma_{UU}(\omega,\phi_h)}{\int d\phi_h \epsilon_{acc}(\omega,\phi_h)\epsilon_{rad}(\omega,\phi_h)\sigma_{UU}(\omega,\phi_h)}$$

extraction is challenging!
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fully differential analysis needed
unfolding procedure with 400 x 12 bins

BINNING 400 kinematic bins x 12 ϕ-bins							
Variable	Bin limits						#
x	0.023	0.042	0.078	0.145	0.27	1	5
y	0.3	0.45	0.6	0.7	0.85		4
z	0.2	0.3	0.45	0.6	0.75	1	5
P_{hT}	0.05	0.2	0.35	0.5	0.75		4

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extraction is challenging!
azimuthal modulations also possible due to
- detector geometrical acceptance
- higher-order QED effects

unfolding

fully differential analysis needed
unfolding procedure with 400 x 12 bins

$$\langle\cos(n\phi_h)\rangle\Big|_{\text{bin i}} \approx \frac{\int d\phi_h \cos(n\phi_h)\sigma_{UU}(\omega,\phi_h)}{\int d\phi_h \sigma_{UU}(\omega,\phi_h)}\Bigg|_{\text{bin i}}$$

BINNING 400 kinematic bins x 12 ϕ-bins							
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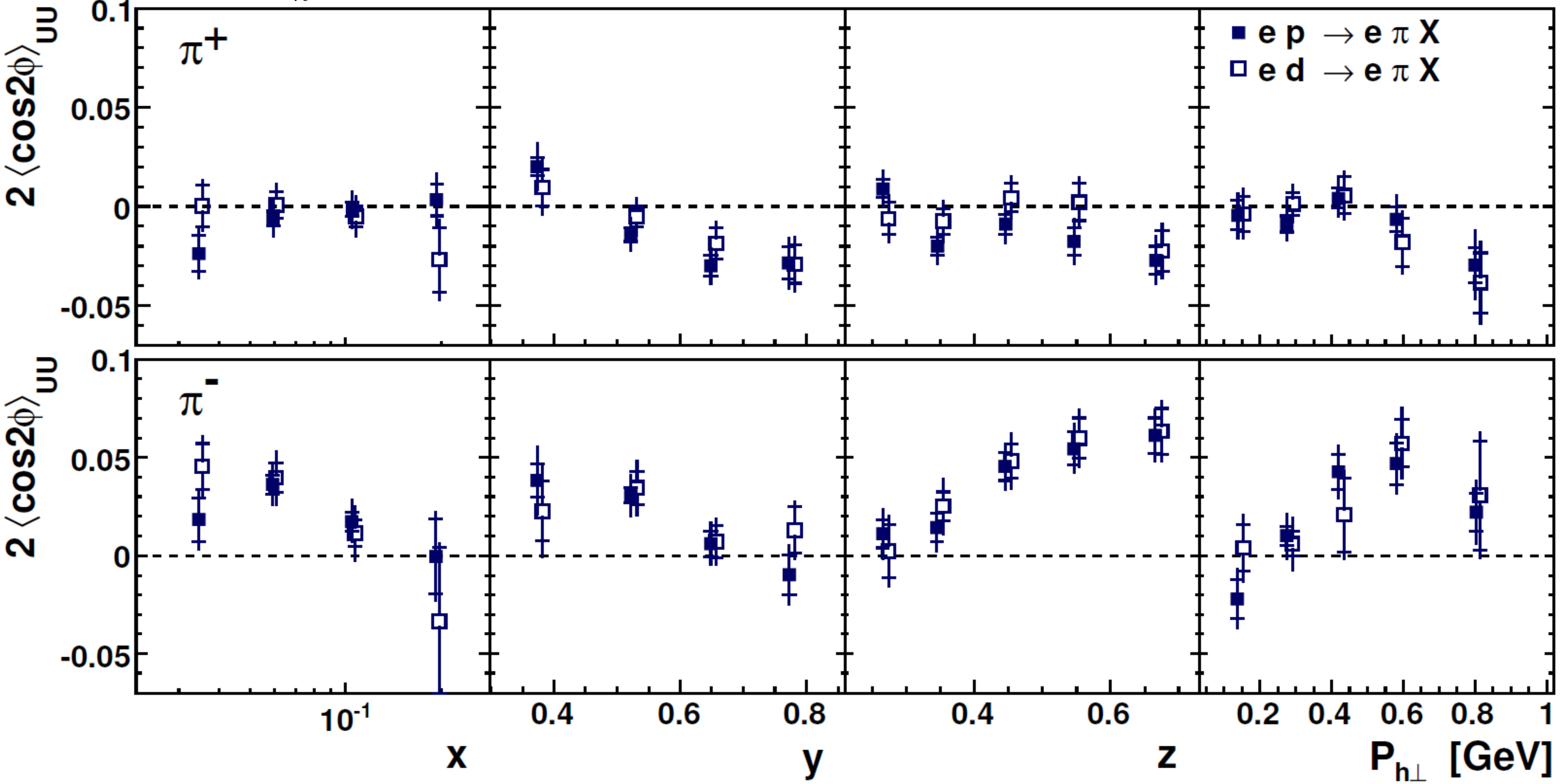
Results for <cos 2ϕ_h>: pions

$$\mathcal{I}[-\frac{2(\hat{P}_{h\perp}.\vec{p}_T)(\hat{P}_{h\perp}.\vec{k}_T)-\vec{p}_T.\vec{k}_T}{M_h M}h_1^\perp H_1^\perp]$$

A. Airapetian et al., arXiv:1204.4161

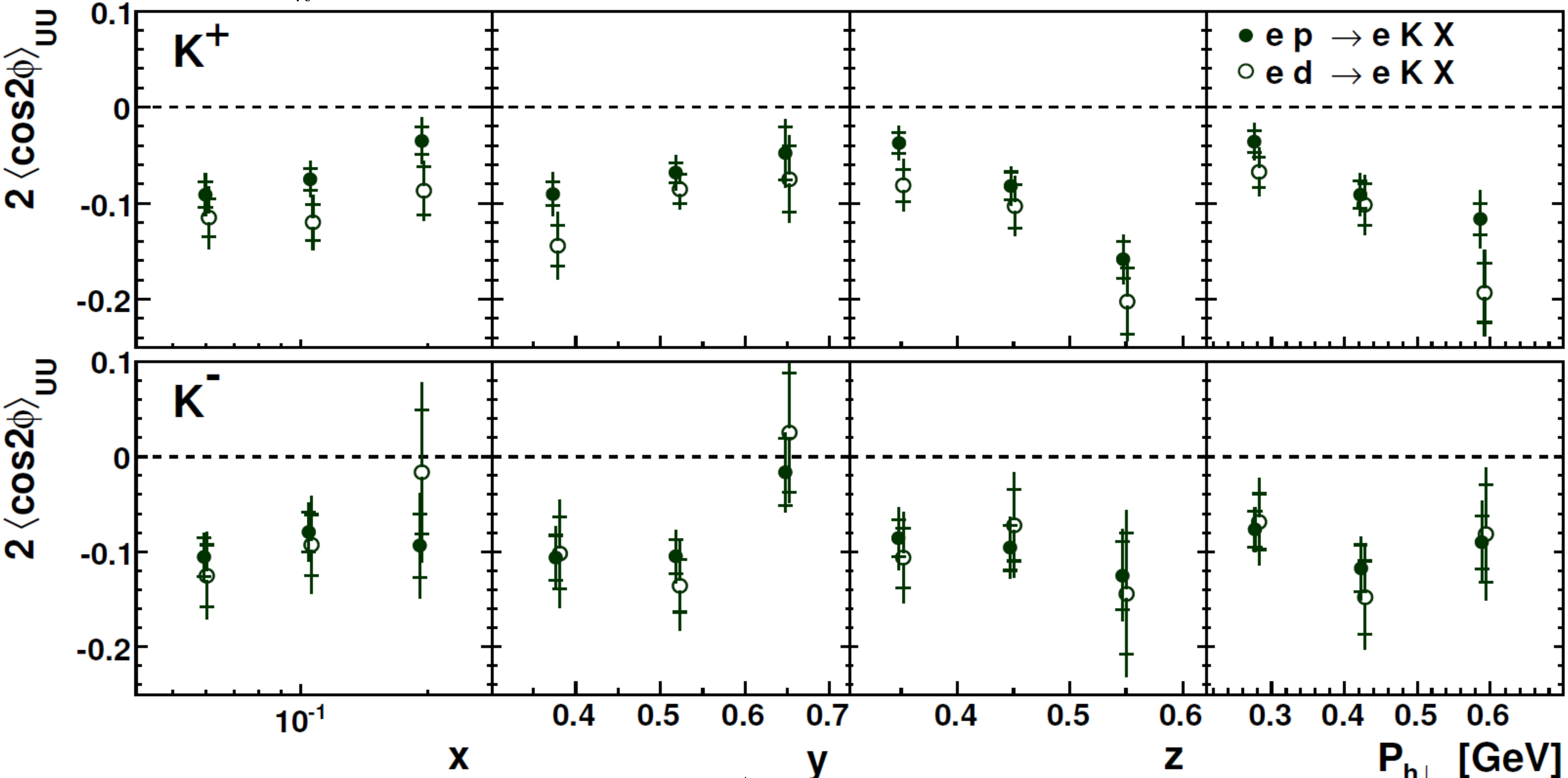


- H-D comparison: $h_1^{\perp,u} \approx h_1^{\perp,d}$
- π^- > 0 ◄──► $\pi^+ \leqslant$ 0: $H_1^{\perp,fav} \approx -H_1^{\perp,unfav}$

Results for <cos 2ϕ_h>: kaons

$$\mathcal{I}[-\frac{2(\hat{P}_{h\perp}.\vec{p}_T)(\hat{P}_{h\perp}.\vec{k}_T)-\vec{p}_T.\vec{k}_T}{M_h M} h_1^\perp H_1^\perp]$$

A. Airapetian et al., arXiv:1204.4161

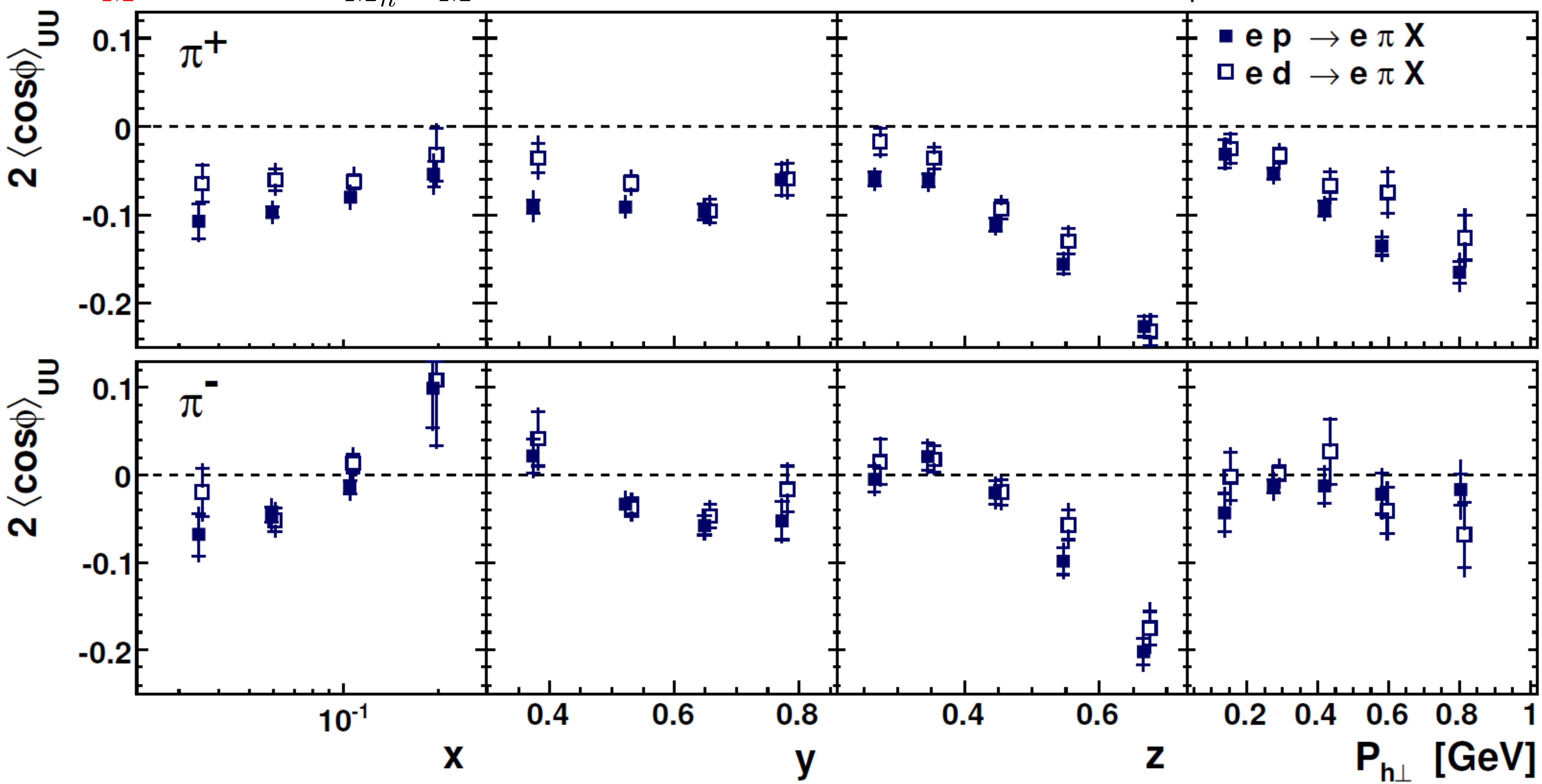


- $K^+<0$: - Artru model: sign $H_1^{\perp,u\to K^+}$ = sign $H_1^{\perp,u\to\pi^+}$
- $K^- \simeq K^+$: - u-dominance $\xrightarrow{?} H_1^{\perp,u\to K^+} \approx H_1^{\perp,u\to K^-}$
  - role of sea-quarks

Results for <cos ϕ_h>: pions

$$\mathcal{I}[-\frac{\hat{P}_{h\perp}.\vec{p}_T}{M} f_1 D_1 - \frac{\hat{P}_{h\perp}.\vec{k}_T}{M_h} \frac{p_T^2}{M^2} h_1^\perp H_1^\perp + ...]$$

A. Airapetian et al., arXiv:1204.4161

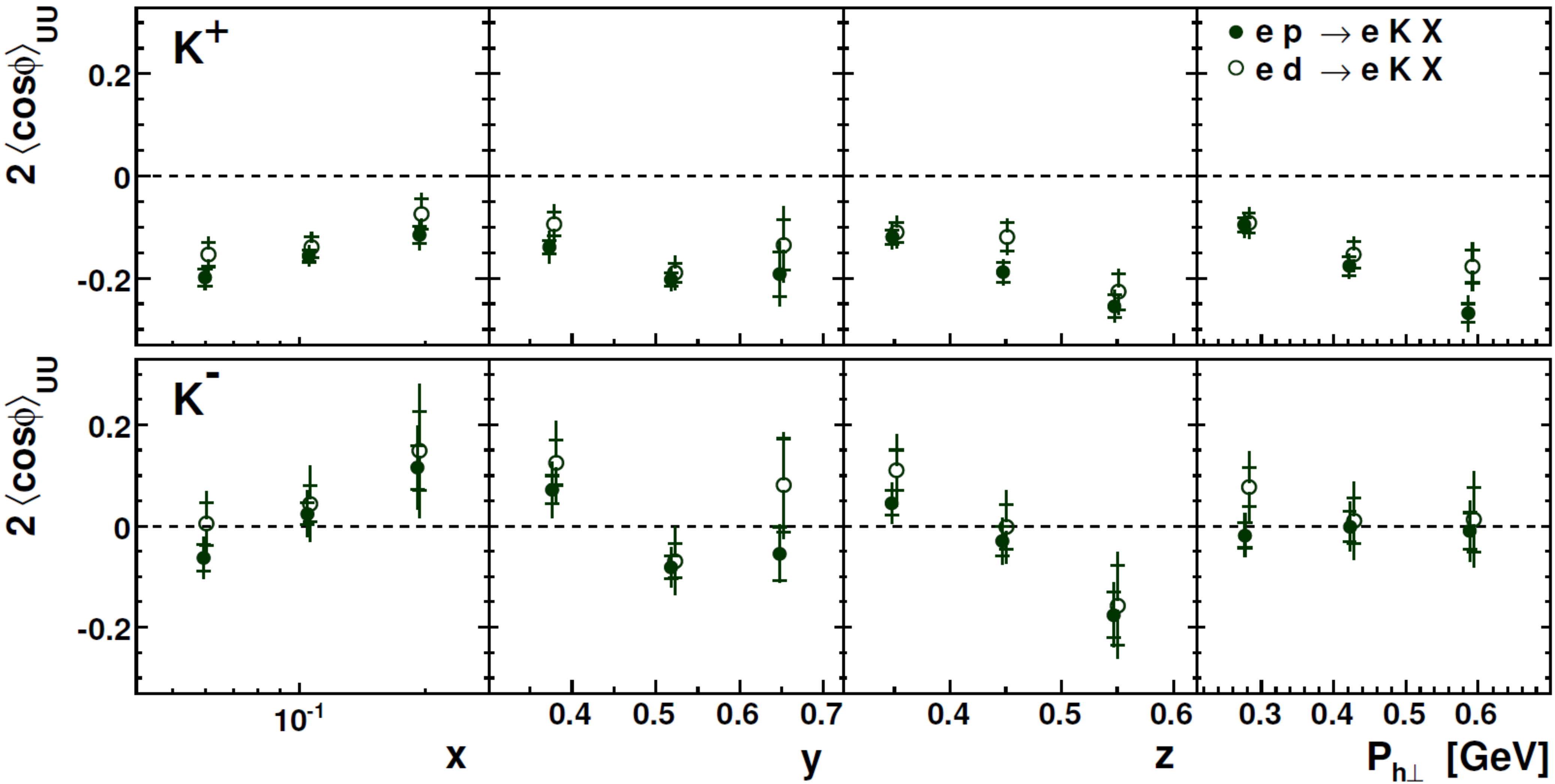


- H-D comparison: weak flavor dependence
- magnitude increases with z
- π^+: magnitude increases with $P_{h\perp}$

Results for <cos ϕ_h>: kaons

$$\mathcal{I}[-\frac{\hat{P}_{h\perp}.\vec{p}_T}{M} f_1 D_1 - \frac{\hat{P}_{h\perp}.\vec{k}_T}{M_h} \frac{p_T^2}{M^2} h_1^\perp H_1^\perp + ...]$$

A. Airapetian et al., arXiv:1204.4161

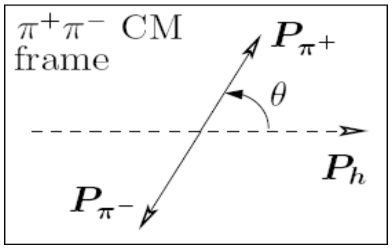


- $K^+<0$, larger in magnitude than π^+
- $K^- \simeq 0$

Access to dihadron fragmentation function

Single-spin asymmetry: $\pi^+\pi^-$ production

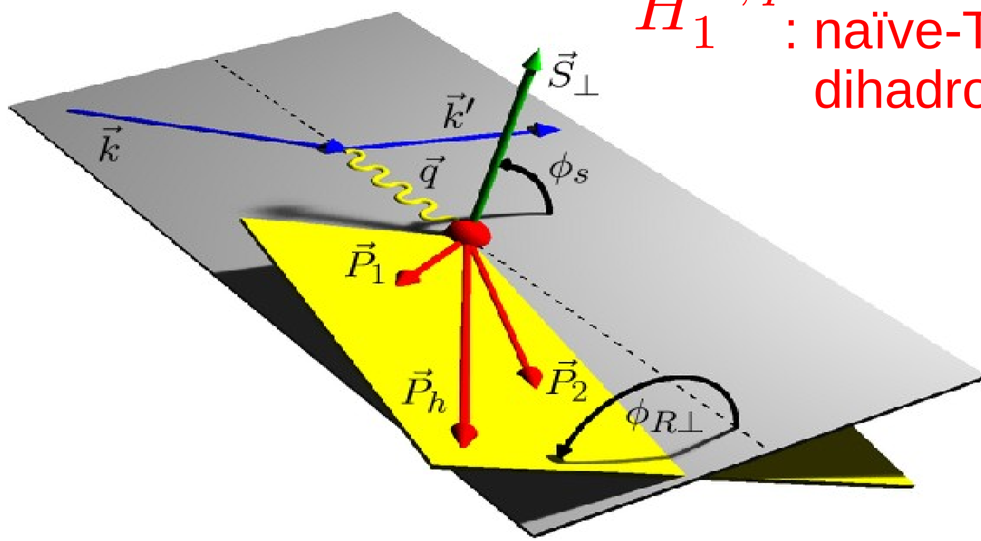
$$\sigma_{UT} \sim \sin(\phi_{R\perp} + \phi_S) \sum_q e_q^2 h_1^q(x) H_1^{\measuredangle,q}(z, M_{\pi\pi}, \theta)$$



$$\vec{R} = \frac{1}{2}(\vec{P}_1 - \vec{P}_2)$$

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

$$\vec{R}_T = \vec{R} - (\vec{R}.\hat{P}_h)\hat{P}_h$$



$H_1^{\measuredangle,q}$: naïve-T-odd and chiral-odd dihadron fragmentation function

- independent method to probe transversity: transverse spin of fragmenting quark transferred to relative orbital angular momentum of hadron pair
- integration over hadron momenta $\longrightarrow$ direct product

  but
- more complex cross section (9 variables)
- less statistics

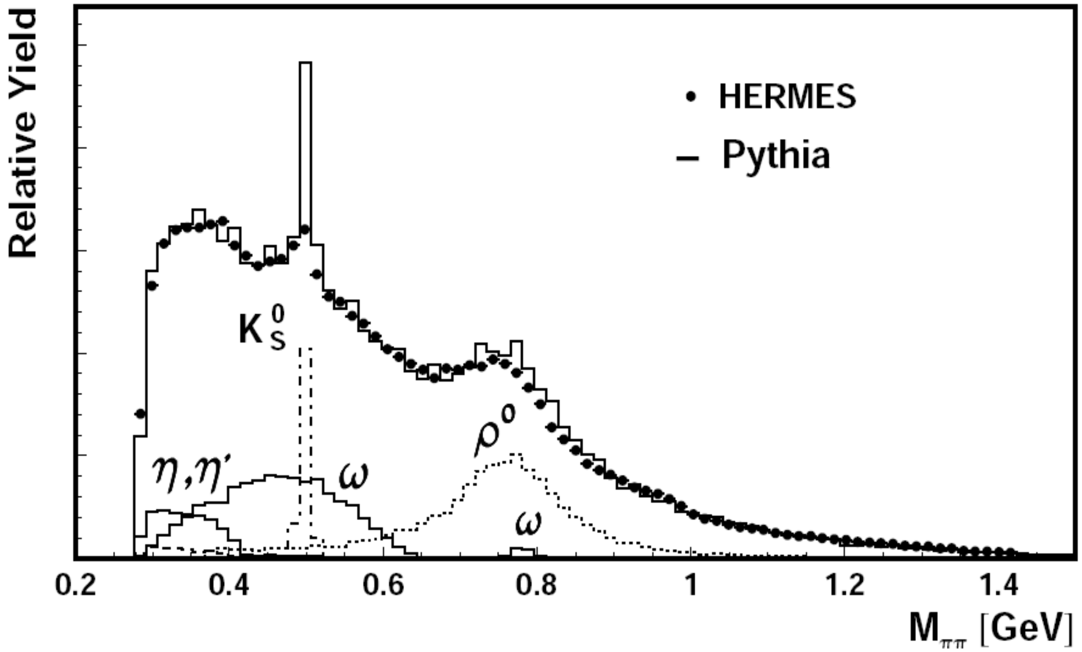
Extraction of $\pi^+\pi^-$ asymmetry

$$A_{UT} \sim \sin(\phi_{R\perp} + \phi_S)\sin\theta \frac{\sum_q e_q^2 h_{1T}^q(x) H_1^{\measuredangle,q}(z, M_{\pi\pi}, \cos\theta)}{\sum_q e_q^2 f_1^q(x) D_1^q(z, M_{\pi\pi}, \cos\theta)}$$

- Legendre expansion ($M_{\pi\pi}$<1.5 GeV):

$$H_1^{\measuredangle} = H_1^{\measuredangle,sp} + H_1^{\measuredangle,pp}\cos\theta$$

$$D_1 = D_1 + D_1^{sp}\cos\theta + D_1^{pp}\frac{1}{4}(3\cos^2\theta - 1)$$



Extraction of $\pi^+\pi^-$ asymmetry

- Legendre expansion ($M_{\pi\pi}$<1.5 GeV):

$$H_1^{\measuredangle} = H_1^{\measuredangle,sp} + H_1^{\measuredangle,pp}\cos\theta$$
$$D_1 = D_1 + D_1^{sp}\cos\theta + D_1^{pp}\frac{1}{4}(3\cos^2\theta - 1)$$

- symmetrization around θ = π/2

$\cancel{H_1^{\measuredangle,pp}}\cos\theta$ and $\cancel{D_1^{sp}}\cos\theta$

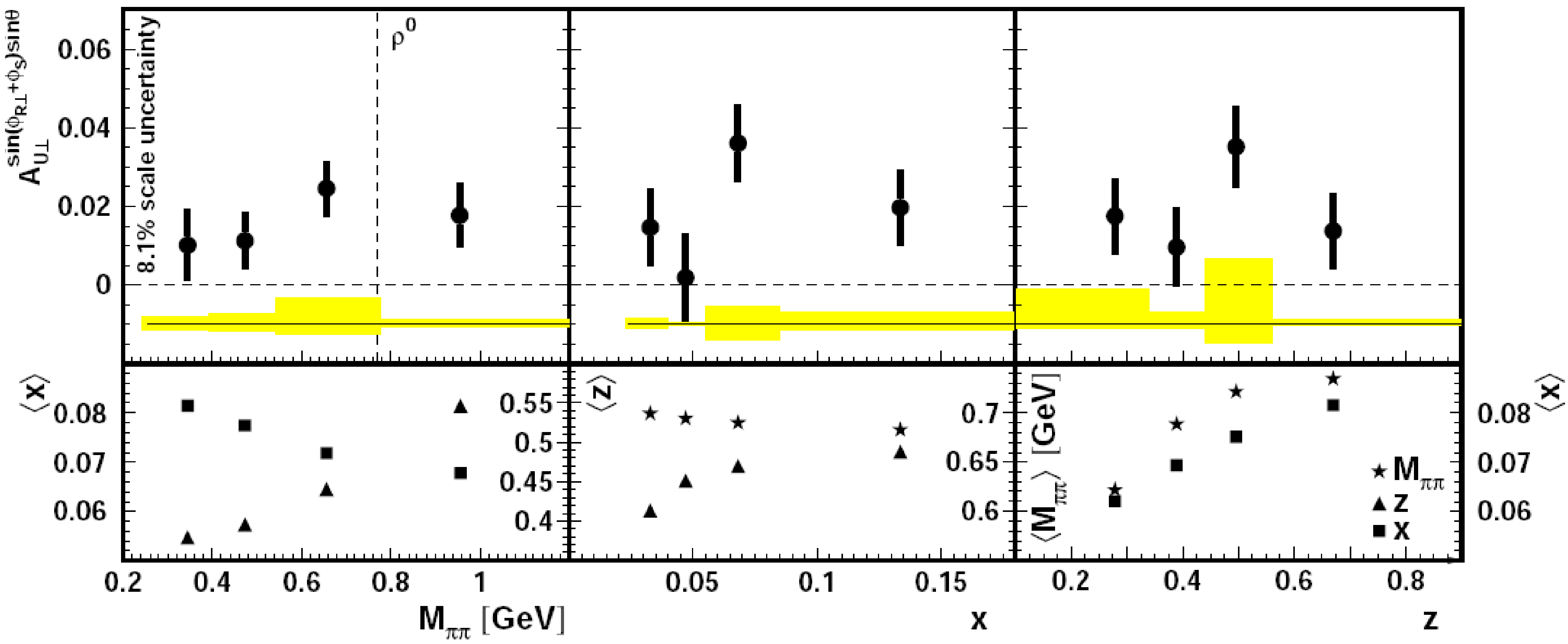
fit

$$\boxed{\frac{a}{1+\frac{b}{4}(3\cos^2\theta-1)}\sin(\phi_{R\perp}+\phi_S)\sin\theta}$$

$$a \equiv A_{U\perp}^{\sin(\phi_{R\perp}+\phi_S)\sin\theta} \sim \frac{\sum_q e_q^2 h_{1T}(x) H_1^{\measuredangle,sp}(z,M_{\pi\pi})}{\sum_q e_q^2 f_1(x) D_1(z,M_{\pi\pi})}$$

Final HERMES results

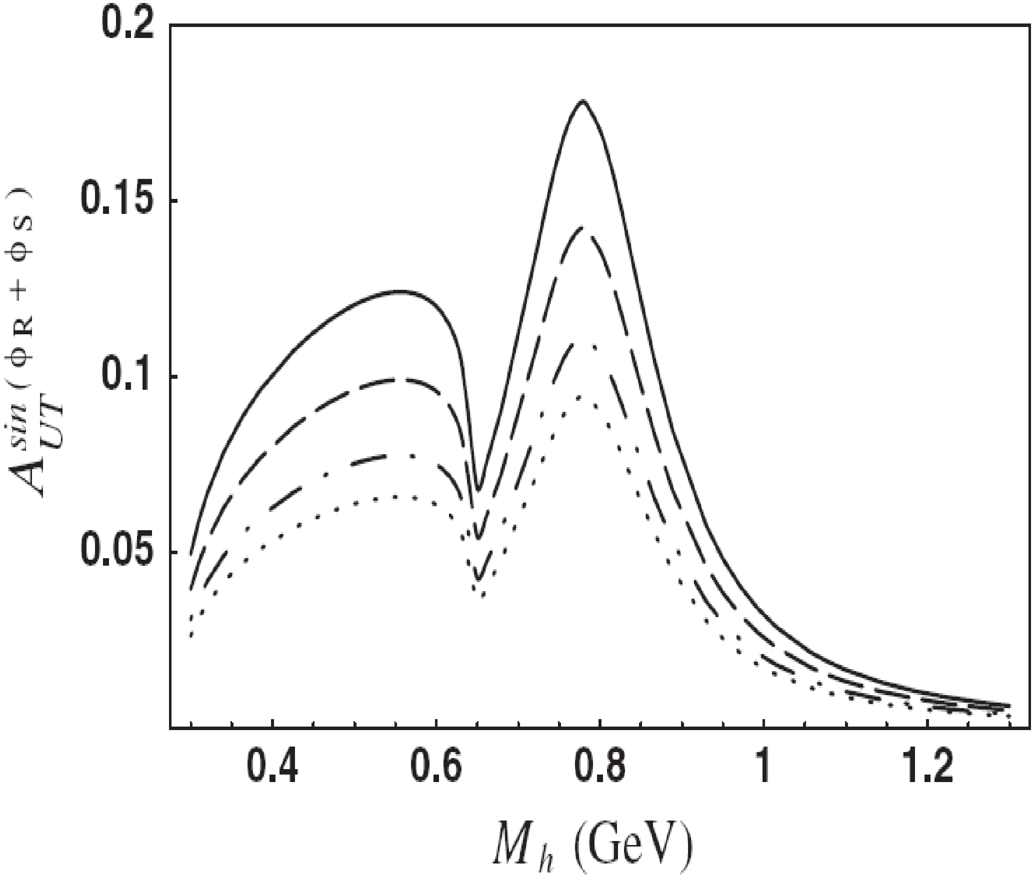
A. Airapetian et al., JHEP 0806 (2008) 017



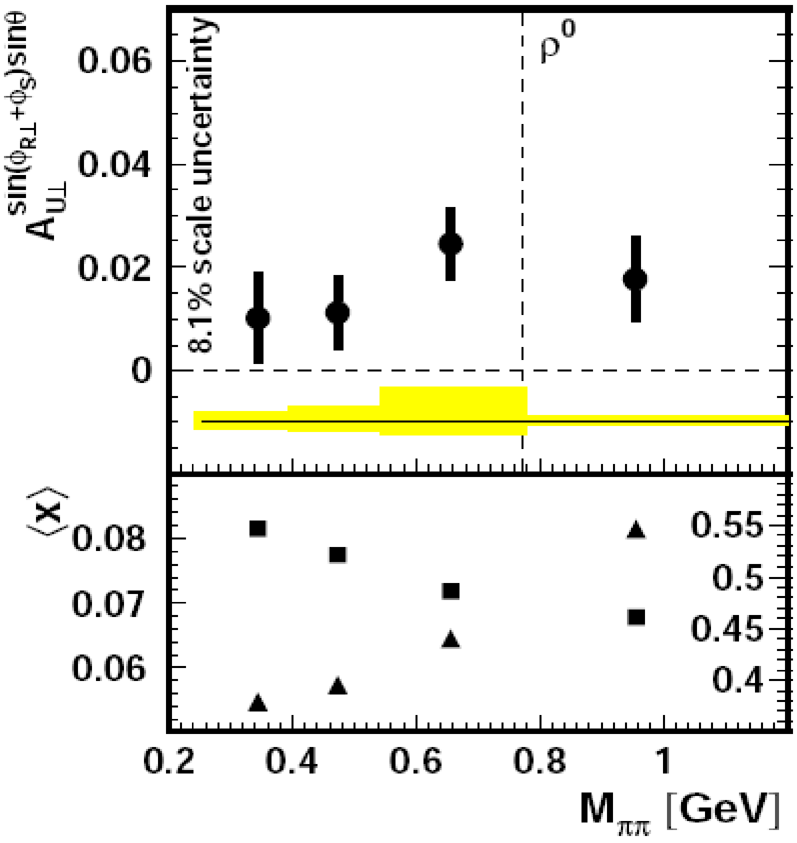
- first evidence for non-zero T-odd and chiral-odd dihadron fragmentation function

Comparison with model

A. Bacchetta, M. Radici, Phys. Rev. D**74** (2006) 114007



A. Airapetian et al., JHEP 0806 (2008) 017



- no sign change around ρ^0 mass (◄—► Jaffe model), confirmed by BELLE and COMPASS data

Summary

- $\pi^{\pm}$ and $K^{\pm}$ multiplicities on hydrogen and deuterium:

  - 3-dimensional extraction

  - support notion of favored fragmentation

- hadronization in nuclei:

  - 2-dimensional extraction

  - contribute to increased understanding of fragmentation process

- SIDIS single-hadron production on transv. pol. H and unpol. H and D:

  - pions: opposite sign for favored and unfavored u-quark Collins fragmentation function

  - kaons: large signal for single-spin asymmetry (K^+) and $\cos(2\phi)$ (K^+ and K^-)
    $\longrightarrow$ substantial s-quark Collins fragmentation function?

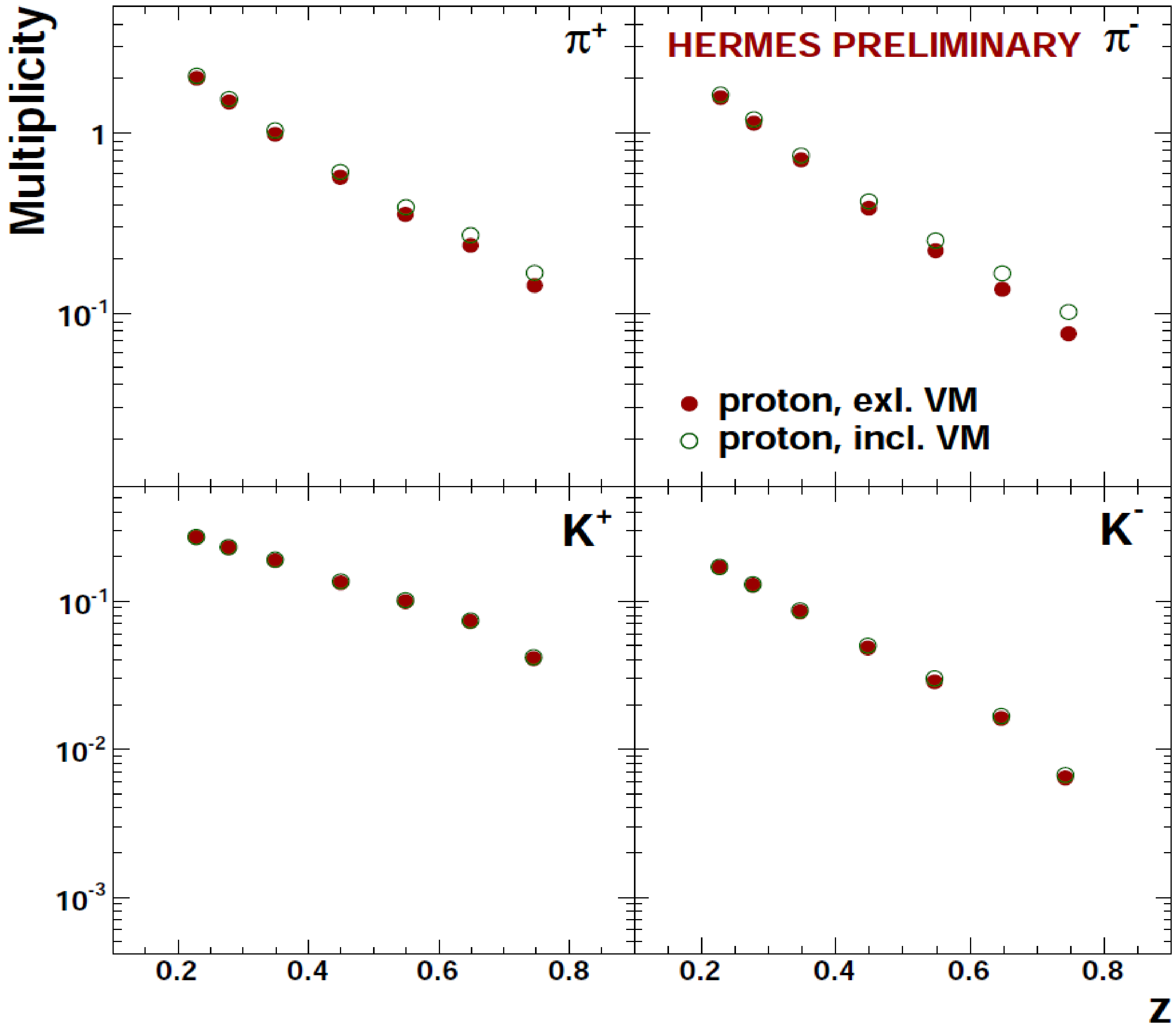
- dihadron fragmentation function:

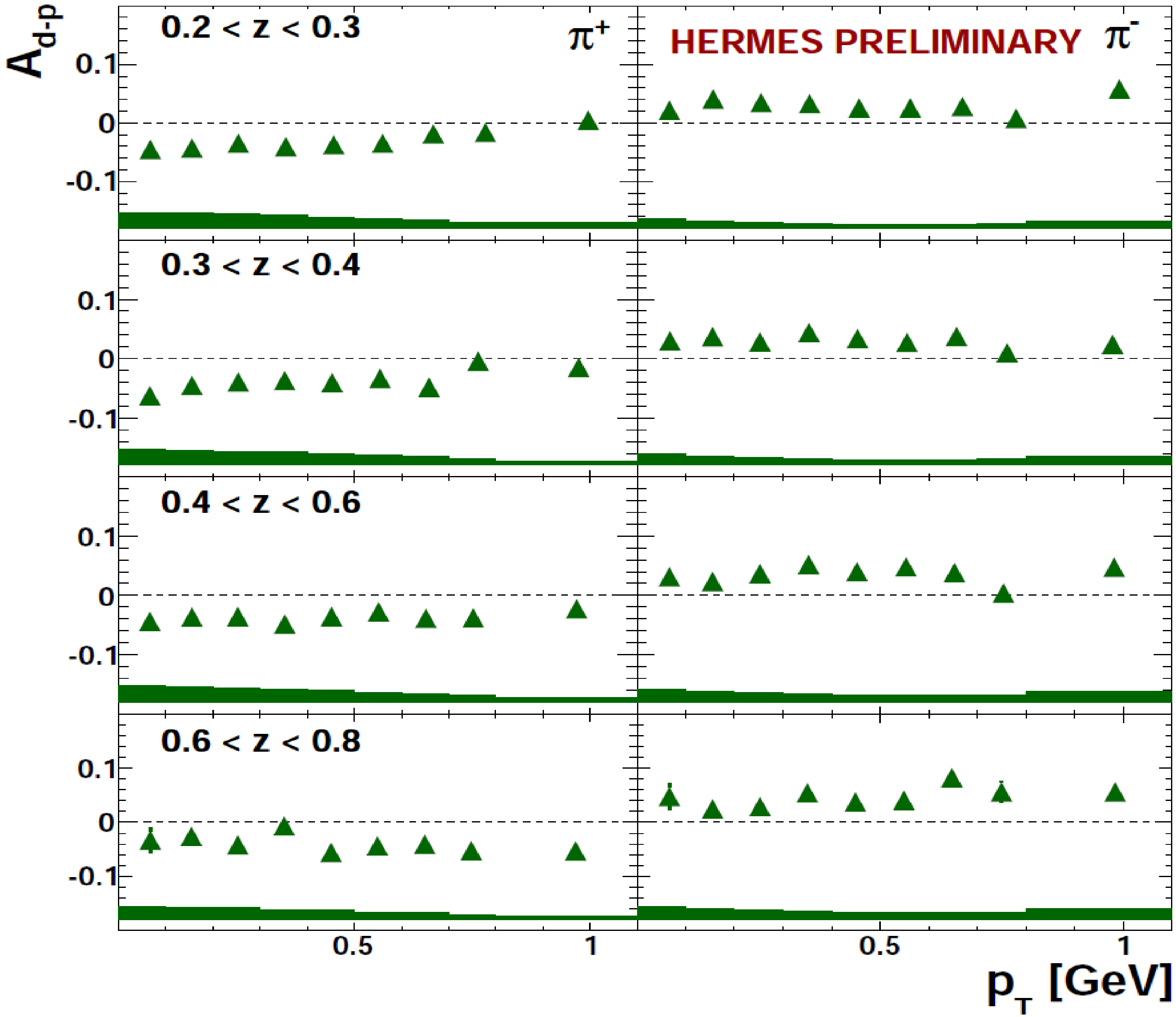
  - sizeable signal observed $\longrightarrow$

    contribute to increased understanding of transverse-spin effects

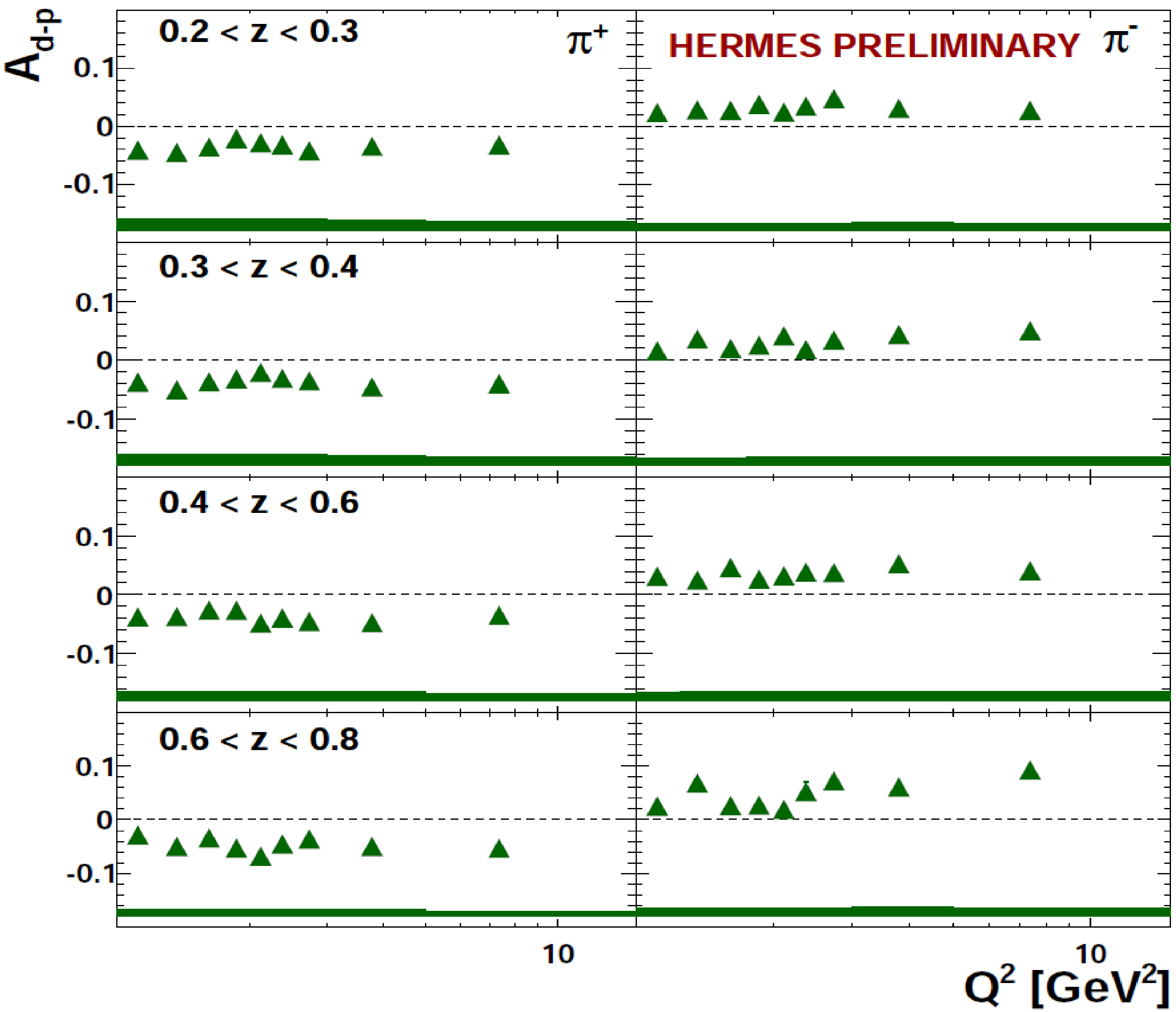
Backup

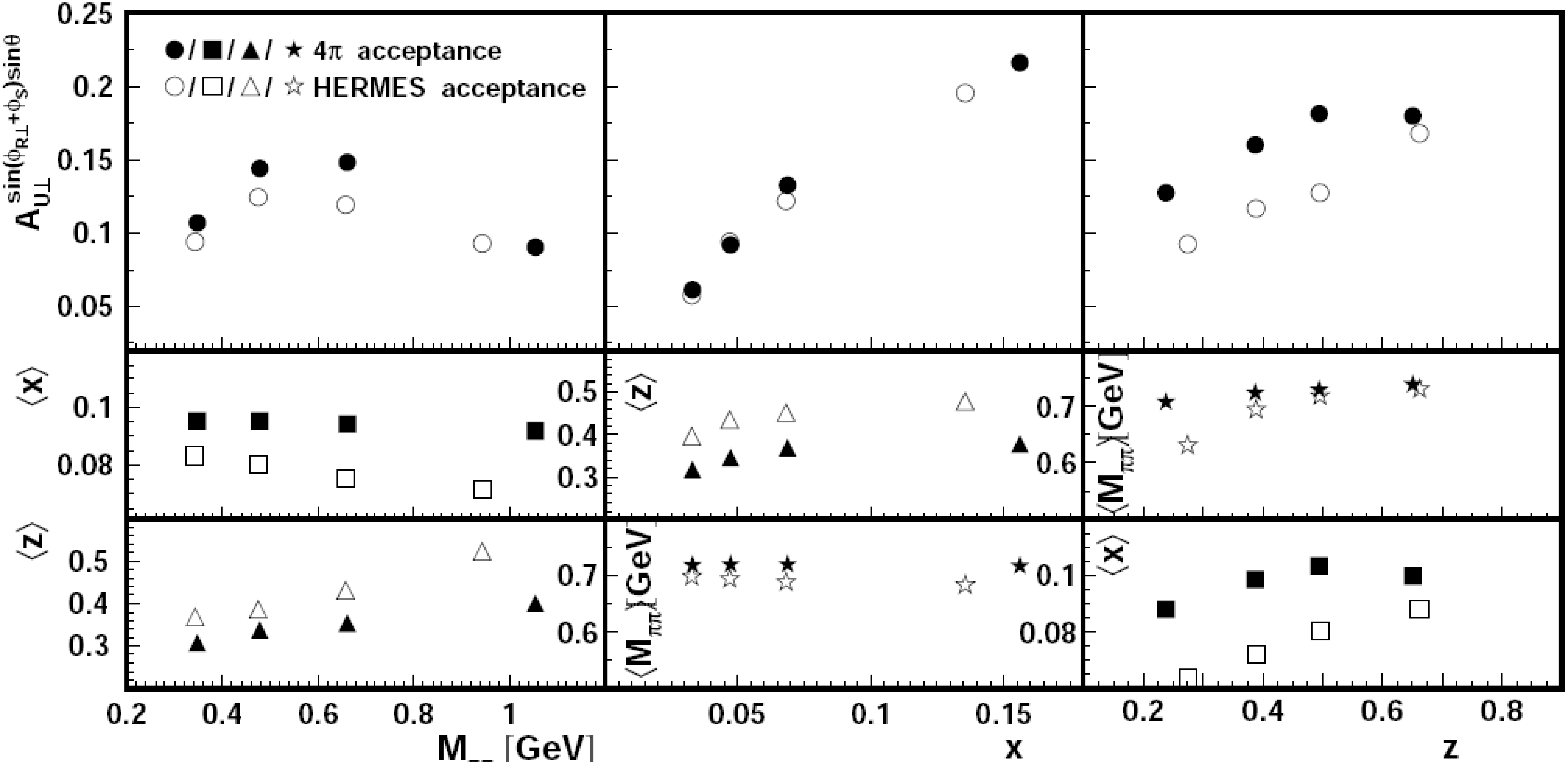
Multiplicities projected in z: VM contribution





A_{d-p}
0.2 < z < 0.3
0.3 < z < 0.4
0.4 < z < 0.6
0.6 < z < 0.8
π^+
HERMES PRELIMINARY
π^-
0.1
0
-0.1
0.5
1
p_T [GeV]


A_{d-p}
0.2 < z < 0.3
0.3 < z < 0.4
0.4 < z < 0.6
0.6 < z < 0.8
π+
π-
HERMES PRELIMINARY
0.1
0
-0.1
10
Q² [GeV²]



●/■/▲/ ★ 4π acceptance
○/□/△/ ☆ HERMES acceptance
$A_{U\perp}^{\sin(\phi_{R\perp}+\phi_S)\sin\theta}$
⟨x⟩
⟨z⟩
$\langle M_{\pi\pi}\rangle$ [GeV]
$M_{\pi\pi}$ [GeV]
x
z