Extraction of TMDs with global fits

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In collaboration with
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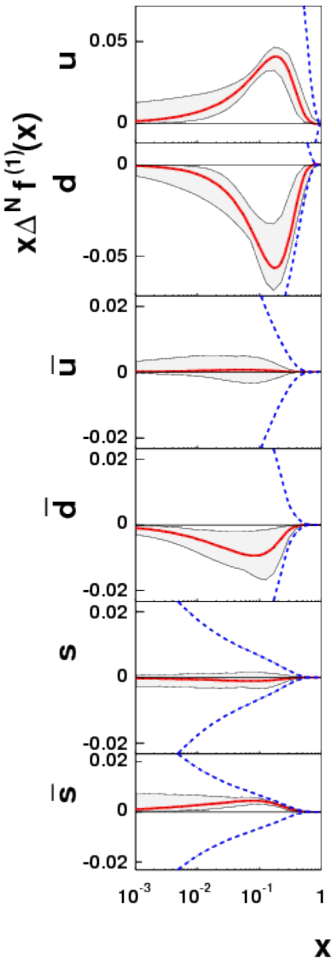
The Sivers Functions from SIDIS data

Extracted Sivers Functions

- Anselmino et al. Eur. Phys. J. A39,89 (2009)
  - HERMES DATA 2002-2005 (proton target)
  - COMPASS 2003-2004 (deuteron target)

Extracted Sivers Functions



✔ Valence quarks

- $\Delta^N f_{u/p^\uparrow} > 0 \Rightarrow f_{1T}^{\perp u} < 0$
- $\Delta^N f_{d/p^\uparrow} < 0 \Rightarrow f_{1T}^{\perp d} > 0$

✔ Sea quarks

- $\Delta^N f_{\bar{s}/p^\uparrow} > 0 \Rightarrow f_{1T}^{\perp \bar{s}} < 0$

✔ $\Delta^N f_{q/p^\uparrow}(x, k_\perp) = 2\,\mathcal{N}_q(x)\,h(k_\perp)\,f_{q/p}(x, k_\perp)$

✔ $\mathcal{N}_q(x) = N_q\,x^{\alpha_q}(1-x)^{\beta_q}\,\frac{(\alpha_q+\beta_q)^{(\alpha_q+\beta_q)}}{\alpha_q^{\alpha_q}\,\beta_q^{\beta_q}}$

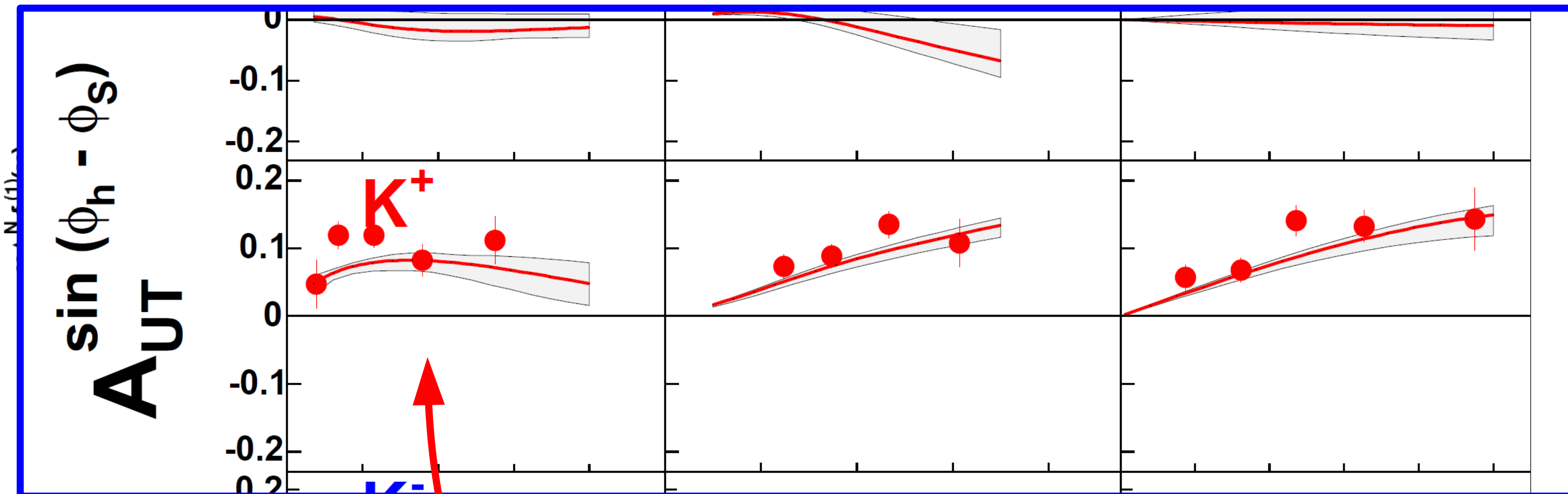
✔ $h(k_\perp) = \sqrt{2e}\,\frac{k_\perp}{M_1}\,e^{-k_\perp^2/M_1^2}$

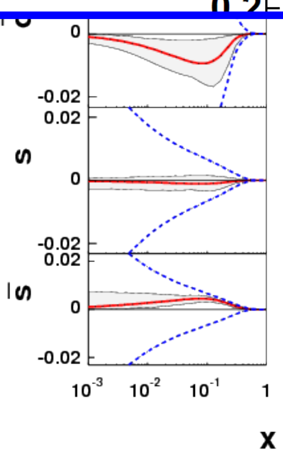
$\chi^2/d.o.f = 1$		
$N_u = 0.35^{+0.078}_{-0.079}$	$N_d = -0.9^{+0.43}_{-0.098}$	$N_s = -0.24^{+0.62}_{-0.5}$
$N_{\bar{u}} = 0.037^{+0.22}_{-0.24}$	$N_{\bar{d}} = -0.4^{+0.33}_{-0.44}$	$N_{\bar{s}} = 1^{+0}_{-0.0001}$
$\alpha_u = 0.73^{+0.72}_{-0.58}$	$\alpha_d = 1.1^{+0.82}_{-0.65}$	$\alpha_{sea} = 0.79^{+0.56}_{-0.47}$
$\beta = 3.5^{+4.9}_{-2.9}$	$M_1^2 = 0.34^{+0.3}_{-0.16}$ GeV^2	

→ $\Delta^N f_q^{(1)}(x) \equiv \int d^2\boldsymbol{k}_\perp\,\frac{k_\perp}{4m_p}\,\Delta^N f_{q/p^\uparrow}(x, k_\perp) = -f_{1T}^{\perp(1)q}(x)$

Extracted Sivers Functions

HERMES 2002-5





✔Sea quarks

- $\Delta^N f_{\bar{s}/p^\uparrow} > 0 \quad \Rightarrow f_{1T}^{\perp \bar{s}} < 0$

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$\chi^2/d.o.f = 1$		
$N_u = 0.35^{+0.078}_{-0.079}$ $N_{\bar{u}} = 0.037^{+0.22}_{-0.24}$ $\alpha_u = 0.73^{+0.72}_{-0.58}$ $\beta = 3.5^{+4.9}_{-2.9}$	$N_d = -0.9^{+0.43}_{-0.098}$ $N_{\bar{d}} = -0.4^{+0.33}_{-0.44}$ $\alpha_d = 1.1^{+0.82}_{-0.65}$ $M_1^2 = 0.34^{+0.3}_{-0.16}$ GeV^2	$N_s = -0.24^{+0.62}_{-0.5}$ $N_{\bar{s}} = 1^{+0}_{-0.0001}$ $\alpha_{sea} = 0.79^{+0.56}_{-0.47}$

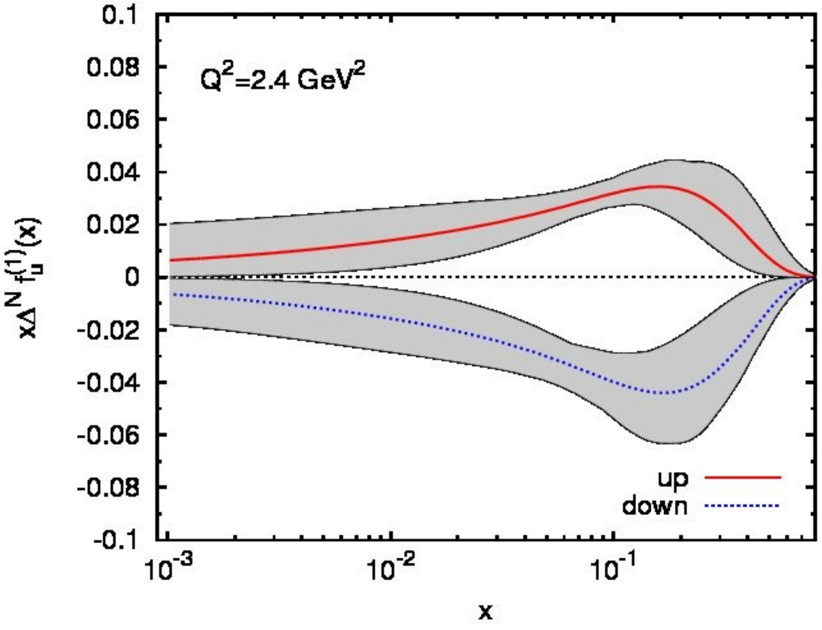
New data-new fit

- Smaller K^+ asymmetries from HERMES
  - Do we need sea quarks?

- u and d flavours only (7 parameters)
- HERMES DATA(2009) π^+ π^- π^0 K^+ K^-
- COMPASS DATA Deuteron π^+ π^- π^0 K^+ K^-

New data-new fit

FIT u & d only



	$\chi^2_{dof} = 1.06$	
$N_u = 0.4$ $N_d = -0.97$	$\alpha_u = 0.35$ $\alpha_d = 0.44$ $M_1^2 = 0.19\ \mathrm{GeV}^2$	$\beta_u = 0.26$ $\beta_d = 0.90$

✔ $\Delta^N f_{q/p^\uparrow}(x, k_\perp) = 2\,\mathcal{N}_q(x)\, h(k_\perp)\, f_{q/p}(x, k_\perp)$

✔ $\mathcal{N}_q(x) = N_q\, x^{\alpha_q}(1-x)^{\beta_q}\, \frac{(\alpha_q+\beta_q)^{(\alpha_q+\beta_q)}}{\alpha_q^{\alpha_q}\, \beta_q^{\beta_q}}$

✔ $h(k_\perp) = \sqrt{2e}\, \frac{k_\perp}{M_1}\, e^{-k_\perp^2/M_1^2}$

New data-new fit

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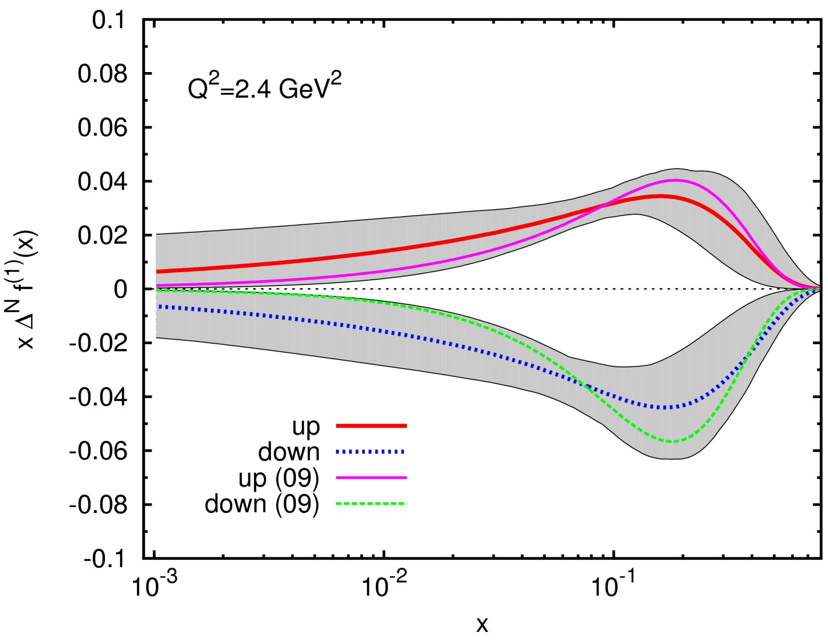

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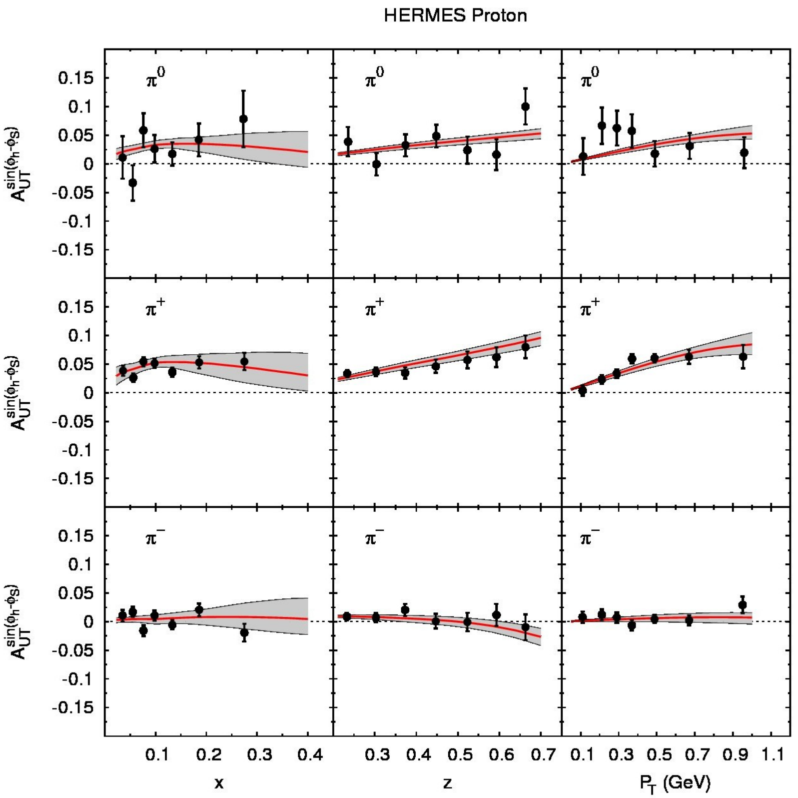
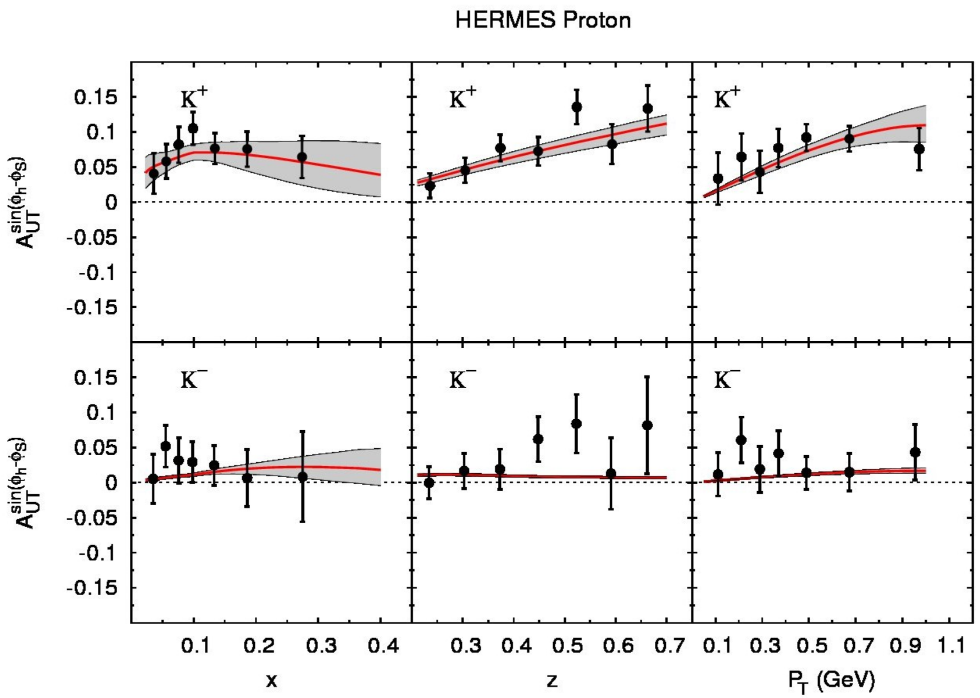
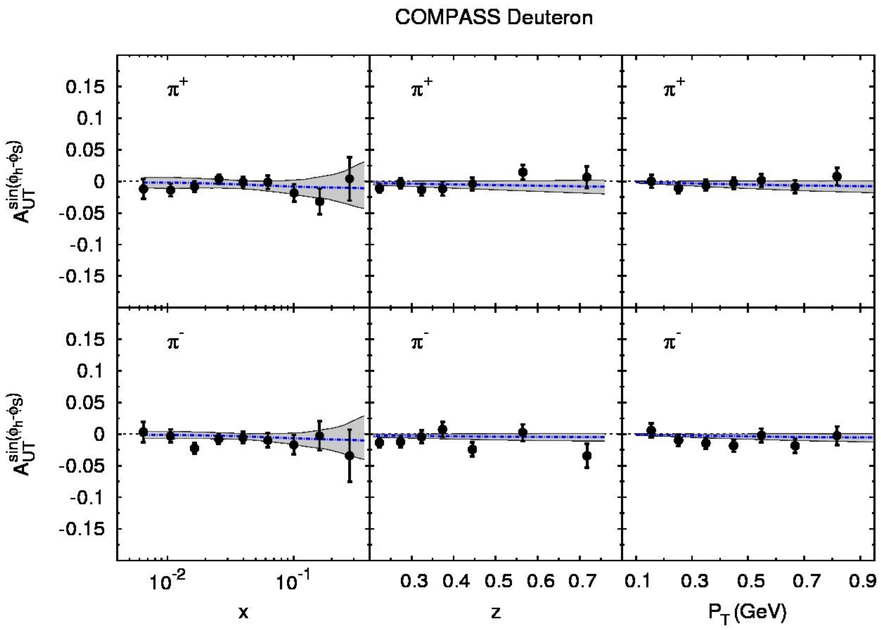
FIT u & d only

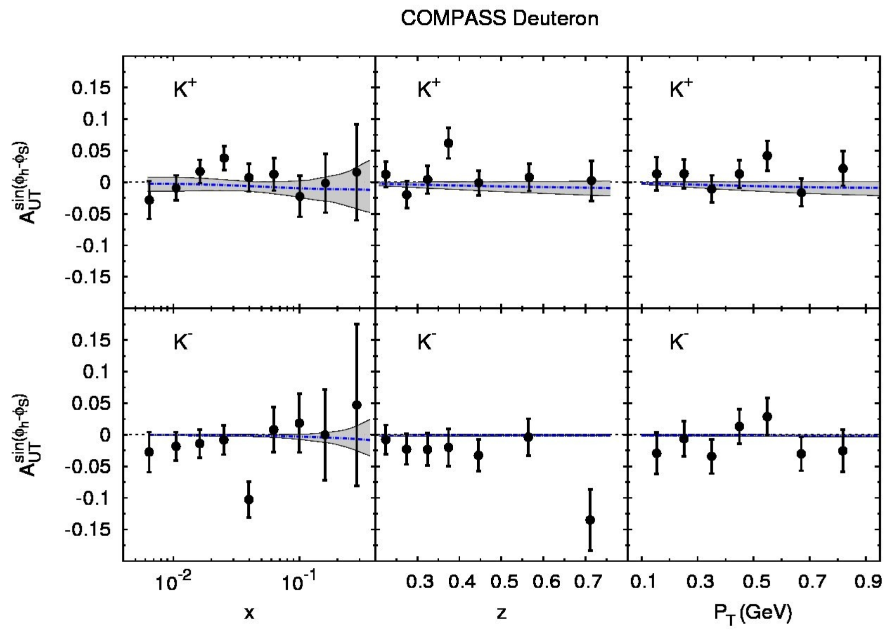




New data-new fit

FIT u & d only

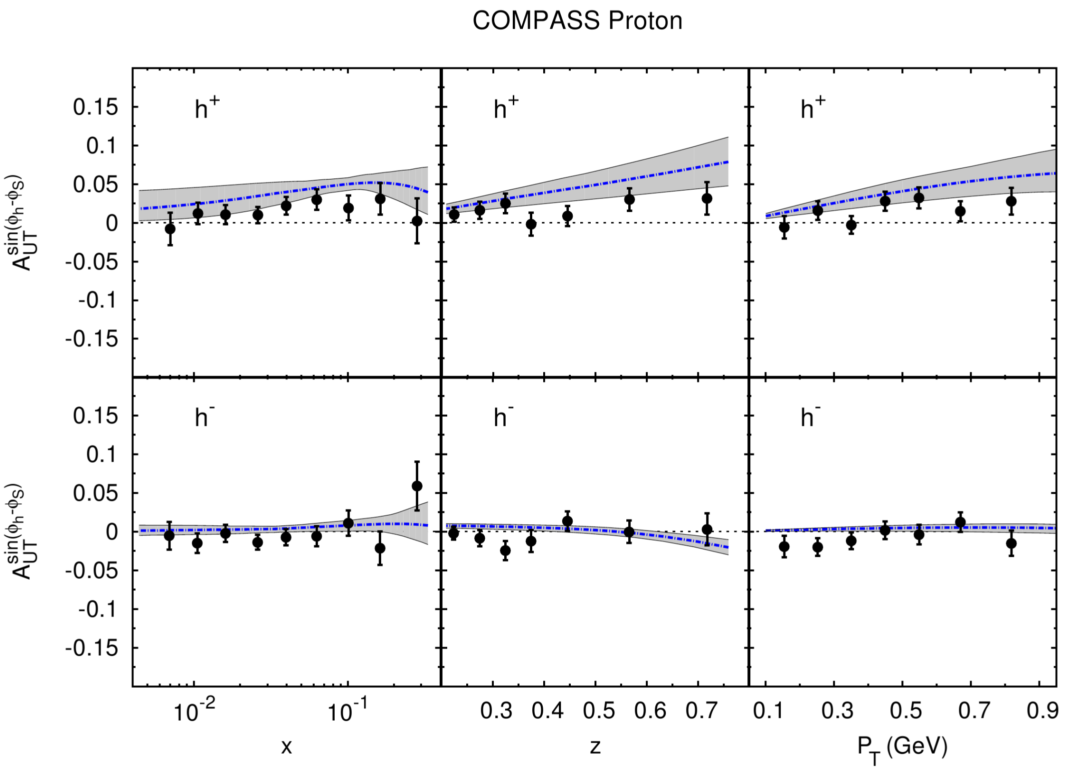




New data-new fit

FIT u & d only

COMPASS



Conclusions I

- A large anti-strange contribution is no more required
- The "sizes" of the Sivers functions are well constrained in the available kinematical regions
- The behavior of the Sivers functions is not constrained by data in the full x range : JLAB, EIC

Polarized SIDIS& e+e- data:

Extraction of Collins function & Transversity

Anselmino et. al arXiv: 0812.4366v1

Extraction of the transversity and the Collins function

- Azimuthal asymmetry in polarized SIDIS

$$\mathrm{d}\sigma^{\uparrow} - \mathrm{d}\sigma^{\downarrow} = \sum_q h_{1q}(x, \boldsymbol{k}_\perp) \otimes \mathrm{d}\Delta\hat{\sigma}(y, \boldsymbol{k}_\perp) \otimes \Delta^N D_{h/q^{\uparrow}}(z, \boldsymbol{p}_\perp)$$

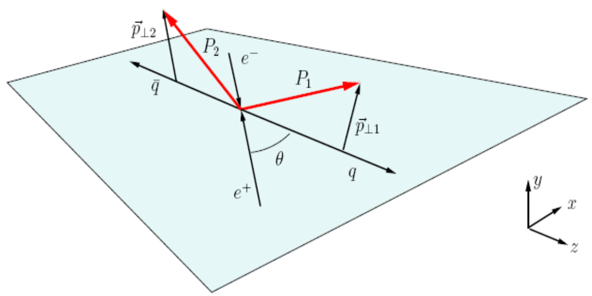
Transversity — $h_{1q}(x, \boldsymbol{k}_\perp)$

Collins function — $\Delta^N D_{h/q^{\uparrow}}(z, \boldsymbol{p}_\perp)$

$$A_{UT}^{\sin(\phi+\phi_S)} \equiv 2\,\frac{\int \mathrm{d}\phi\,\mathrm{d}\phi_S\,[\mathrm{d}\sigma^{\uparrow} - \mathrm{d}\sigma^{\downarrow}]\,\sin(\phi+\phi_S)}{\int \mathrm{d}\phi\,\mathrm{d}\phi_S\,[\mathrm{d}\sigma^{\uparrow} + \mathrm{d}\sigma^{\downarrow}]}$$

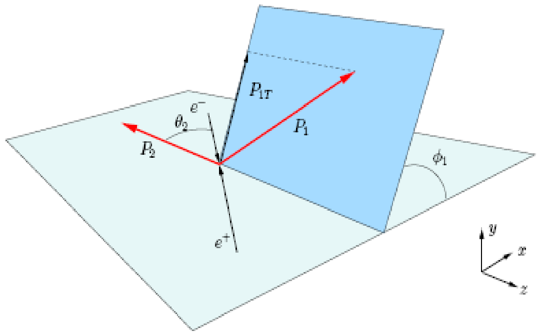
Extraction of the transversity and the Collins function

- e^+e^- -> h_1 h_2 X BELLE Data



$$A(z_1, z_2, \theta, \varphi_1+\varphi_2) \equiv \frac{1}{\langle d\sigma \rangle} \frac{d\sigma^{e^+e^-\to h_1 h_2 X}}{dz_1\, dz_2\, d\cos\theta\, d(\varphi_1+\varphi_2)}$$

$$= 1 + \frac{1}{8} \frac{\sin^2\theta}{1+\cos^2\theta} \cos(\varphi_1+\varphi_2) \frac{\sum_q e_q^2 \Delta^N D_{h_1/q^\uparrow}(z_1)\, \Delta^N D_{h_2/\bar{q}^\uparrow}(z_2)}{\sum_q e_q^2 D_{h_1/q}(z_1)\, D_{h_2/\bar{q}}(z_2)}$$



$$A(z_1, z_2, \theta_2, \phi_1) = 1 + \frac{1}{\pi} \frac{z_1 z_2}{z_1^2+z_2^2} \frac{\sin^2\theta_2}{1+\cos^2\theta_2} \cos(2\phi_1) \frac{\sum_q e_q^2 \Delta^N D_{h_1/q^\uparrow}(z_1)\, \Delta^N D_{h_2/\bar{q}^\uparrow}(z_2)}{\sum_q e_q^2 D_{h_1/q}(z_1)\, D_{h_2/\bar{q}}(z_2)}$$

Extraction of the transversity and the Collins function

➢Parametrization of Transversity function:

$$\Delta_T q(x, k_\perp) = \frac{1}{2}\mathcal{N}_q^T(x)[f_{q/p}(x) + \Delta q(x)]\,\frac{1}{\pi\langle k_\perp^2\rangle}\,e^{-k_\perp^2/\langle k_\perp^2\rangle}$$

Unpolarized PDF

Helicity PDF

$$\mathcal{N}_q^T(x) = N_q^T\, x^{\alpha_q}(1-x)^{\beta_q}\,\frac{(\alpha_q+\beta_q)^{(\alpha_q+\beta_q)}}{\alpha_q^{\alpha_q}\,\beta_q^{\beta_q}}$$

N_q^T, α, β free parameters

Extraction of the transversity and the Collins function

- Parametrization of the Collins function:

$$\Delta^N D_{\pi/q^\uparrow}(z,p_\perp) = 2\mathcal{N}_q^C(z)\, h(p_\perp)\, D_{\pi/q}(z,p_\perp)$$

- $\mathcal{N}_q^C(z) = N_q^C\, z^\gamma (1-z)^\delta \dfrac{(\gamma+\delta)^{(\gamma+\delta)}}{\gamma^\gamma \delta^\delta}$

- $h(p_\perp) = \sqrt{2e}\,\dfrac{p_\perp}{M_h}\, e^{-p_\perp^2/M_h^2}$

Unpolarized FF

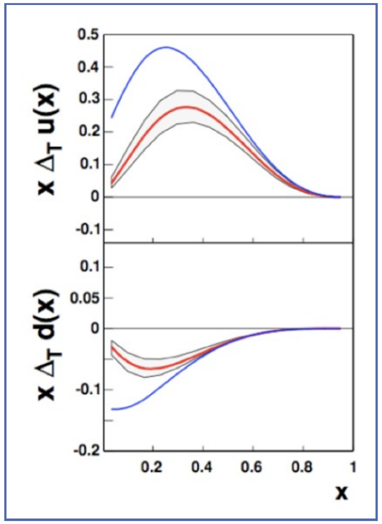
N_q^C, γ, δ, M_h free parameters

> ✔ Bound:
>
> $$\Delta^N D_{\pi/q^\uparrow}(z,p_\perp) = \frac{2p_\perp}{zM} H_1^\perp(z,p_\perp)$$
>
> ✔ Torino vs Amsterdam notation
>
> $$\Delta^N D_{\pi/q^\uparrow}(z,p_\perp) = \frac{2p_\perp}{zM} H_1^\perp(z,p_\perp)$$

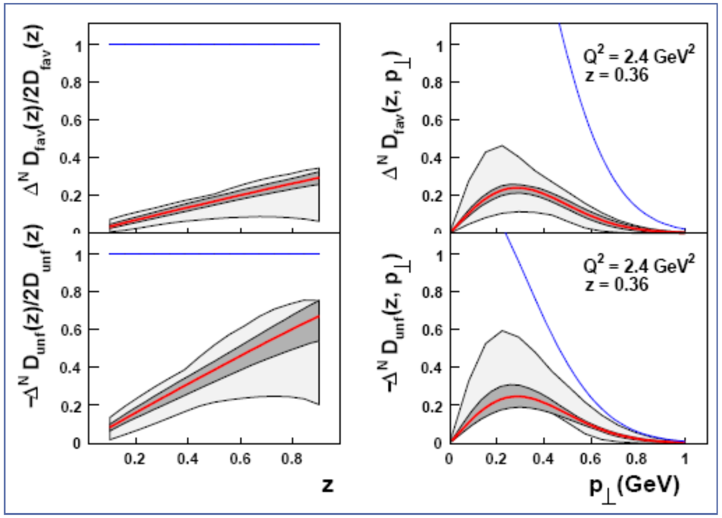
Extraction of the transversity and the Collins function

- Simultaneous fit of HERMES, COMPASS and BELLE data

χ^2_{dof}=1.3



Transversity



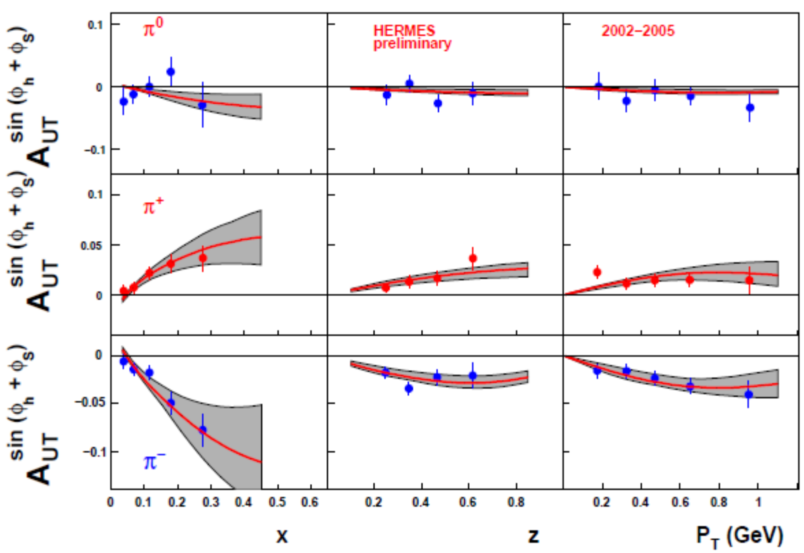
Collins functions

$N_u^T = 0.64 \pm 0.34$	$N_d^T = -1.00 \pm 0.02$
$\alpha = 0.73 \pm 0.51$	$\beta = 0.84 \pm 2.30$
$N_{fav}^C = 0.44 \pm 0.07$	$N_{unf}^C = -1.00 \pm 0.06$
$\gamma = 0.96 \pm 0.08$	$\delta = 0.01 \pm 0.05$
$M_h^2 = 0.91 \pm 0.52$ GeV^2	

- Anselmino et. al arXiv: 0812.4366v1

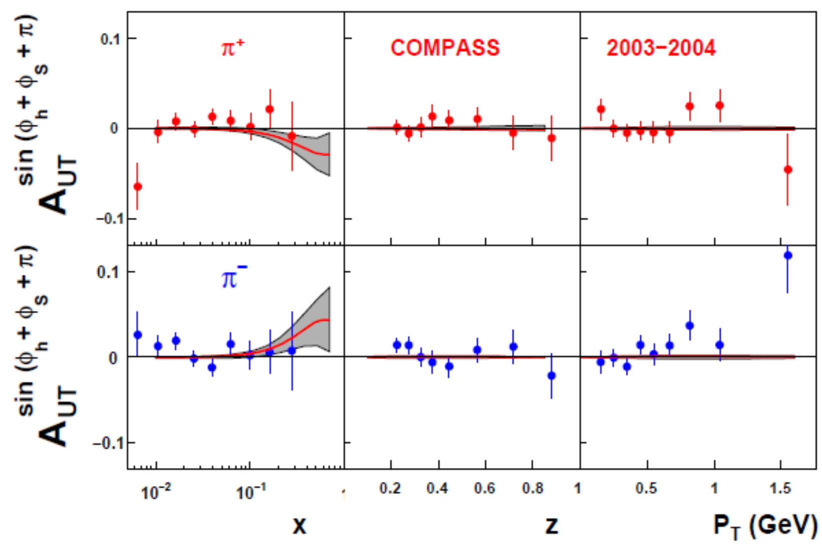
Extraction of the transversity and the Collins function

HERMES



◇ M. Diefenthaler, (2007),arXiv:0706.2242

COMPASS

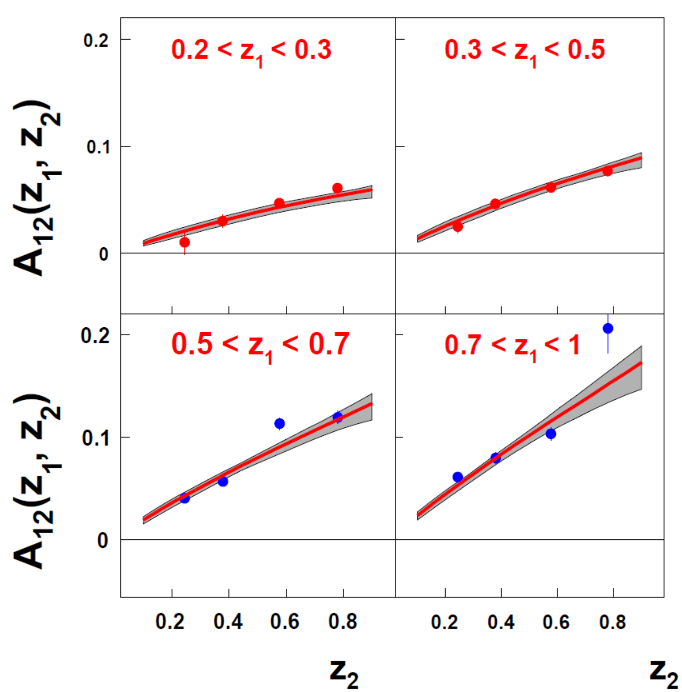


◇ M. Alekseev et al., (2008), arXiv:0802.2160

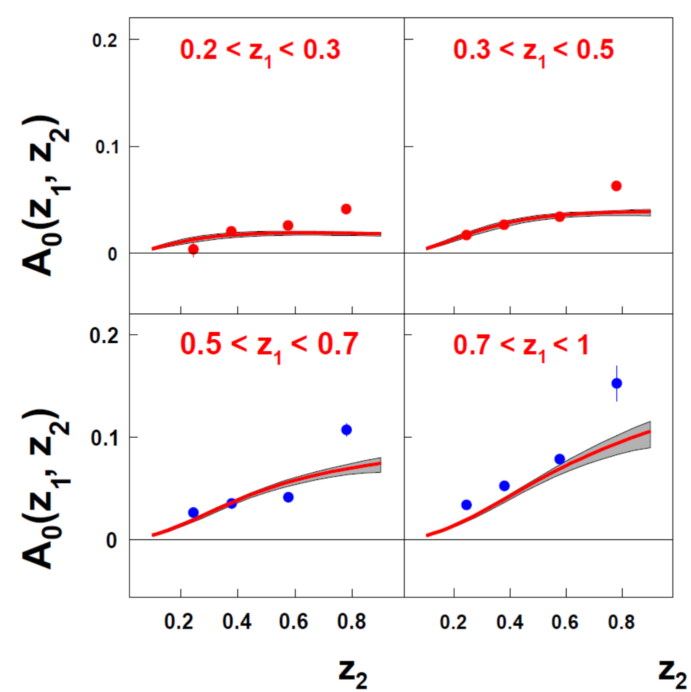
- Anselmino et. al arXiv: 0812.4366v1

Extraction of the transversity and the Collins function

BELLE A_{12} (FIT)



BELLE A_0 (Predicted)



◇ R. Seidl et al., Phys. Rev. D78

- Anselmino et. al arXiv: 0812.4366v1

Conclusions II

- u and d transversity functions are opposite in signs
- Favored and unfavored are opposite in signs
- BELLE data sets are not symmetric in z_1 <-> z_2 exchange

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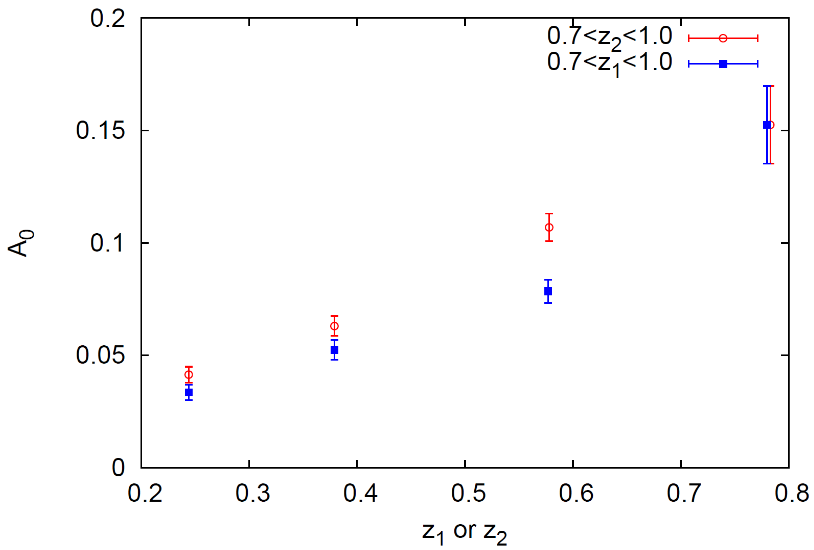

Unpolarized SIDIS data:

Extraction of the Boer-Mulders function

Barone, Melis, Prokudin
Phys. Rev. D 81,224026 (2010)

Extraction of the Boer-Mulders function

- The angular distribution in the unpolarized SIDIS can be written as

$$d\sigma = A + B\cos\phi + C\cos 2\phi$$

- $A = \propto f_1 \otimes D_1$ is the usual ϕ-independent contribution
- $C \propto h_1^{\perp} \otimes H_1^{\perp} + \frac{1}{Q^2} f_1 \otimes D_1$ BM effect+Twist-4 Cahn effect

$$A^{\cos 2\phi} = 2\frac{\int d\sigma \cos 2\phi}{\int d\sigma} = \frac{C}{A}$$

Extraction of the Boer-Mulders function

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Unpolarized PDF&FF gaussian as in Anselmino et al. [1]

[1] Anselmino et. Phys. ReV D71, 074006 (2005)

Extraction of the Boer-Mulders function

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Collins function as in Anselmino et. al arXiv: 0812.4366v1

Extraction of the Boer-Mulders function

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BM that we want to extract from the fit of $A^{\cos 2\phi}$ data

Extraction of the Boer-Mulders function

- Simple parametrization of the Boer-Mulders functions:

  - $h_1^{\perp q}(x, k_\perp) = \lambda_q \, f_{1T}^{\perp q}(x, k_\perp)$ for valence quarks
  - $h_1^{\perp q}(x, k_\perp) = -|f_{1T}^{\perp q}(x, k_\perp)|$ for sea quarks

- Inspired by models:

$$h_1^{\perp q}(x, k_\perp) = \frac{\mathcal{K}_T^q}{\mathcal{K}^q} f_{1T}^{\perp q}(x, k_\perp)$$

Tensor magnetic moment ($\mathcal{K}_T^q$)

Anomalous magnetic moment ($\mathcal{K}^q$)

Burkardt, Phys. Rev. D72, 094020 (2005)

Gockeler, Phys.Rev.Lett.98:222001,2007.

Extraction of the Boer-Mulders function

- $h_1^{\perp q}(x, k_\perp) = \lambda_q \, f_{1T}^{\perp q}(x, k_\perp)$ for valence quarks
- $h_1^{\perp q}(x, k_\perp) = -|f_{1T}^{\perp q}(x, k_\perp)|$ for sea quarks

➢ Models inspired:

$$h_1^{\perp q}(x, k_\perp) = \frac{\mathcal{K}_T^q}{\mathcal{K}^q} f_{1T}^{\perp q}(x, k_\perp)$$

- $h_1^{\perp u}(x, k_\perp) \simeq 1.80 f_{1T}^{\perp u}(x, k_\perp) < 0$
- $h_1^{\perp d}(x, k_\perp) \simeq -0.94 f_{1T}^{\perp d}(x, k_\perp) < 0$

Extraction of the Boer-Mulders function

FIT I

- HERMES proton and deuteron target (x,z,P_T) charged hadrons

- COMPASS deuteron target (x,z) charged hadrons

- 2 free parameters:

  λ_u λ_d

✔GRV98 PDF

✔DSS FF

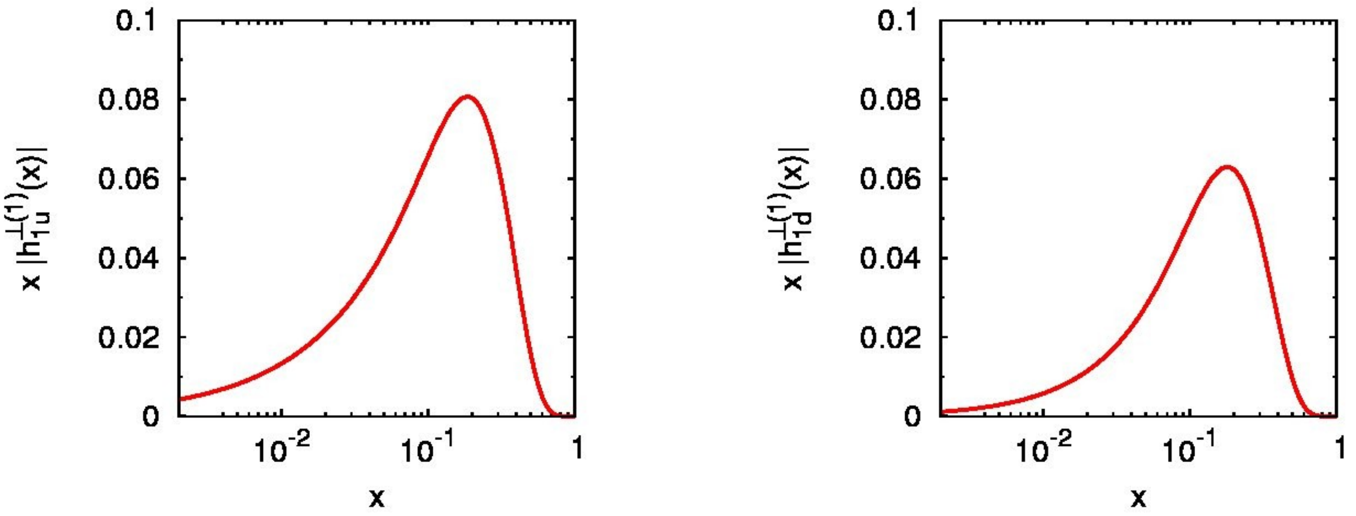
✔Gaussians: $\langle k_\perp^2 \rangle = 0.25\ (GeV/c)^2$
$\langle p_\perp^2 \rangle = 0.20\ (GeV/c)^2$
(from Cahn effect)

✔$h_1^{\perp q}(x,k_\perp) = \lambda_q\, f_{1T}^{\perp q}(x,k_\perp)$

✔$h_1^{\perp q}(x,k_\perp) = -|f_{1T}^{\perp q}(x,k_\perp)|$

Sivers functions from Anselmino et al. Eur. Phys. J. A39,89

Extraction of the Boer-Mulders function

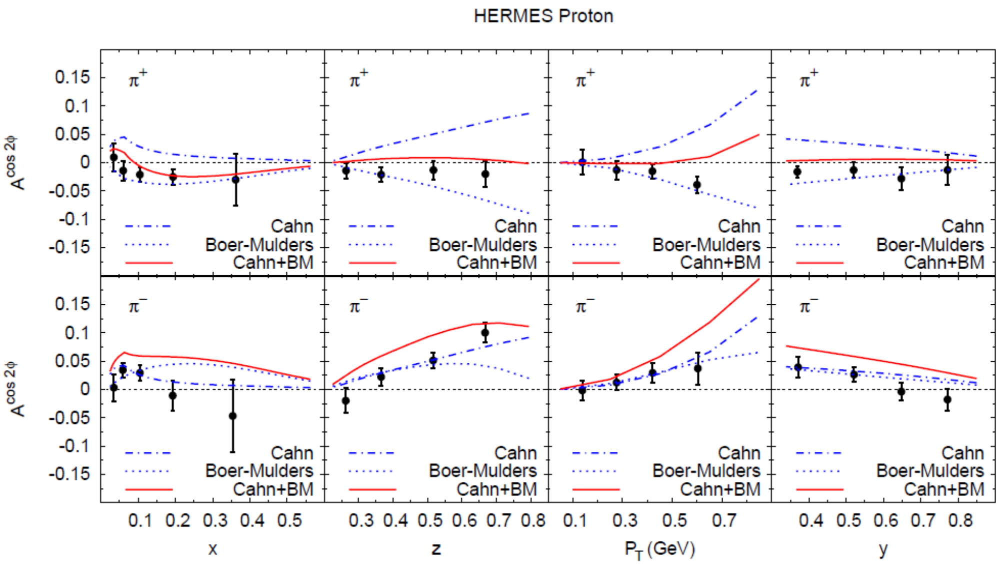


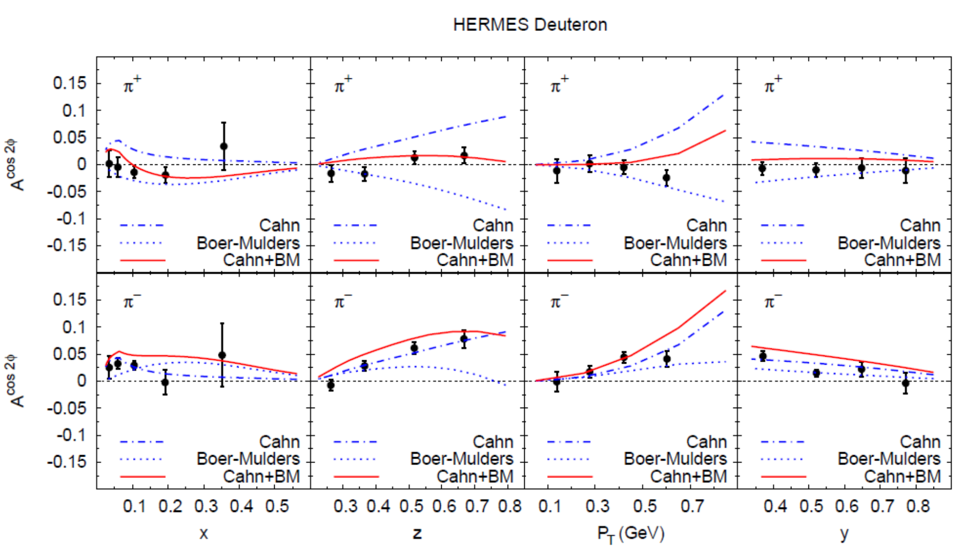
- ◇ $\chi^2/d.o.f. = 3.73$
- • $\lambda_u = 2.0 \pm 0.1$
- • $\lambda_d = -1.11^{+0.00}_{-0.02}$

$\Rightarrow$ $h_1^{\perp d}$ and $h_1^{\perp u}$ both negative

Compatible with models predictions

Extraction of the Boer-Mulders function

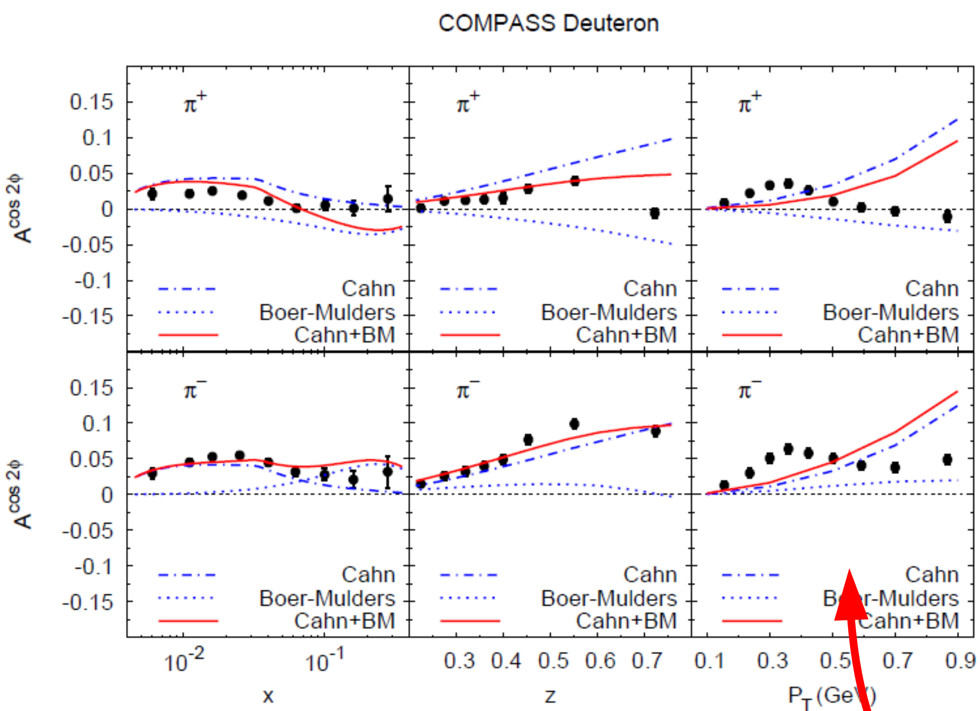




- ✔Cahn effect (Twist-4)comparable to BM effect
- ✔Same sign of Cahn contribution for positive and negative pions
- ✔BM contribution opposite in sign for positive and negative pions

HERMES, Giordano:arXiv:0901.2438

Extraction of the Boer-Mulders function



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- ✔Same sign of Cahn contribution for positive and negative pions
- ✔BM contribution opposite in sign for positive and negative pions

COMPASS, Kafer: arXiv 0808.0114

Data in p_T not included in the fit

Extraction of the Boer-Mulders function

- The Cahn effect is a crucial ingredient

✔Gaussians: $\langle k_\perp^2 \rangle = 0.25\ (GeV/c)^2$
$\langle p_\perp^2 \rangle = 0.20\ (GeV/c)^2$ } From Ref.[*]: analysis of Cahn $\cos\phi$ effect form EMC data

COMPASS	HERMES
$\langle k_\perp^2 \rangle = 0.25\ (GeV/c)^2$	$\langle k_\perp^2 \rangle = 0.18\ (GeV/c)^2$
$\langle p_\perp^2 \rangle = 0.20\ (GeV/c)^2$	$\langle p_\perp^2 \rangle = 0.20\ (GeV/c)^2$
~EMC	~HERMES MC

[*] Anselmino et al. Phys. Rev. D71 074006 (2005)

Extraction of the Boer-Mulders function

- FIT II

COMPASS

$\langle k_\perp^2 \rangle = 0.25\ (GeV/c)^2$

$\langle p_\perp^2 \rangle = 0.20\ (GeV/c)^2$

~EMC

HERMES

$\langle k_\perp^2 \rangle = 0.18\ (GeV/c)^2$

$\langle p_\perp^2 \rangle = 0.20\ (GeV/c)^2$

~HERMES MC

FIT II

$\diamond \chi^2/d.o.f. = 2.41$

$\bullet \lambda_u = 2.1 \pm 0.1$

$\bullet \lambda_d = -1.11^{+0.00}_{-0.02}$

Better description of HERMES but the BM is unchanged

Conclusions III

- u and d BM functions have the same sign. They are compatible with models
- Twist-4 Cahn effect cannot be neglected at HERMES and COMPASS.
- Different average transverse momenta for different experiments?

Intrisic parton motion in unpolarized SIDIS...

Boglione, Melis, Prokudin
Phys. Rev. D 84, 034033 (2011)

Why such a large Cahn effect?

- The Cahn effect is suppressed by powers of Q:

$$d\sigma = A + B\cos\phi + C\cos 2\phi$$

- $A = \propto f_1 \otimes D_1$ is the usual ϕ-independent contribution
- $B \propto \frac{1}{Q}\left(f_1 \otimes D_1 + h_1^{\perp} \otimes H_1^{\perp}\right)$ subleading Cahn+Boer-Mulders effect
- $C \propto h_1^{\perp} \otimes H_1^{\perp} + \frac{1}{Q^2} f_1 \otimes D_1$ BM effect+Twist-4 Cahn effect

$$\frac{k_\perp}{Q} \ll 1 \text{ ??}$$

Why such a large Cahn effect?

- HERMES and COMPASS: $\langle Q^2 \rangle \simeq 2\ \mathrm{GeV}^2$

$$Q^2 > 1\ \mathrm{GeV}^2$$

- Analytical integration of the transverse momenta

$$f_{q/p}(x, k_\perp) = f(x)\frac{e^{-k_\perp^2/\langle k_\perp^2 \rangle}}{\pi \langle k_\perp^2 \rangle}$$

$$\langle k_\perp^2 \rangle \simeq 0.25\ (\mathrm{GeV}/c)^2$$

$$\int d^2\boldsymbol{k}_\perp \Rightarrow \int_0^{2\pi} d\varphi \int_0^\infty dk_\perp\, k_\perp$$

Bounds on the intrinic transverse momenta

- ✔ The integration from 0 to infinity can be a crude assumption
- ✔ The parton model provides kinematical limits on the transverse momentum size

  - ➢ By requiring the energy of the parton to be smaller than the energy of its parent hadron, we have

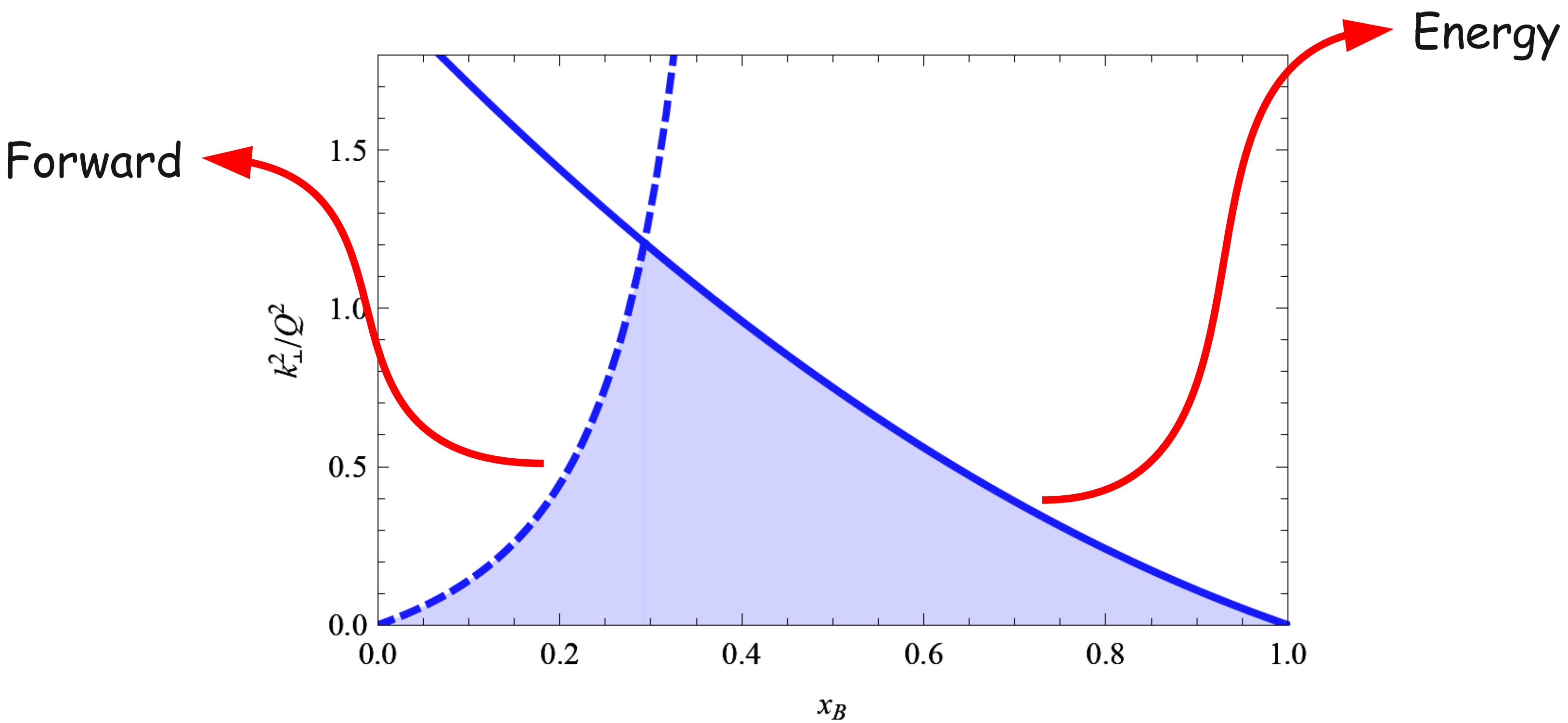
$$k_\perp^2 \leq (2 - x_B)(1 - x_B)Q^2 \quad , \quad 0 < x_B < 1$$

  - ➢ By requiring the parton not to move backward with respect to its parent hadron, we find

$$k_\perp^2 \leq \frac{x_B(1 - x_B)}{(1 - 2x_B)^2} Q^2 \quad , \quad x_B < 0.5$$

Bounds on the intrinic transverse momenta

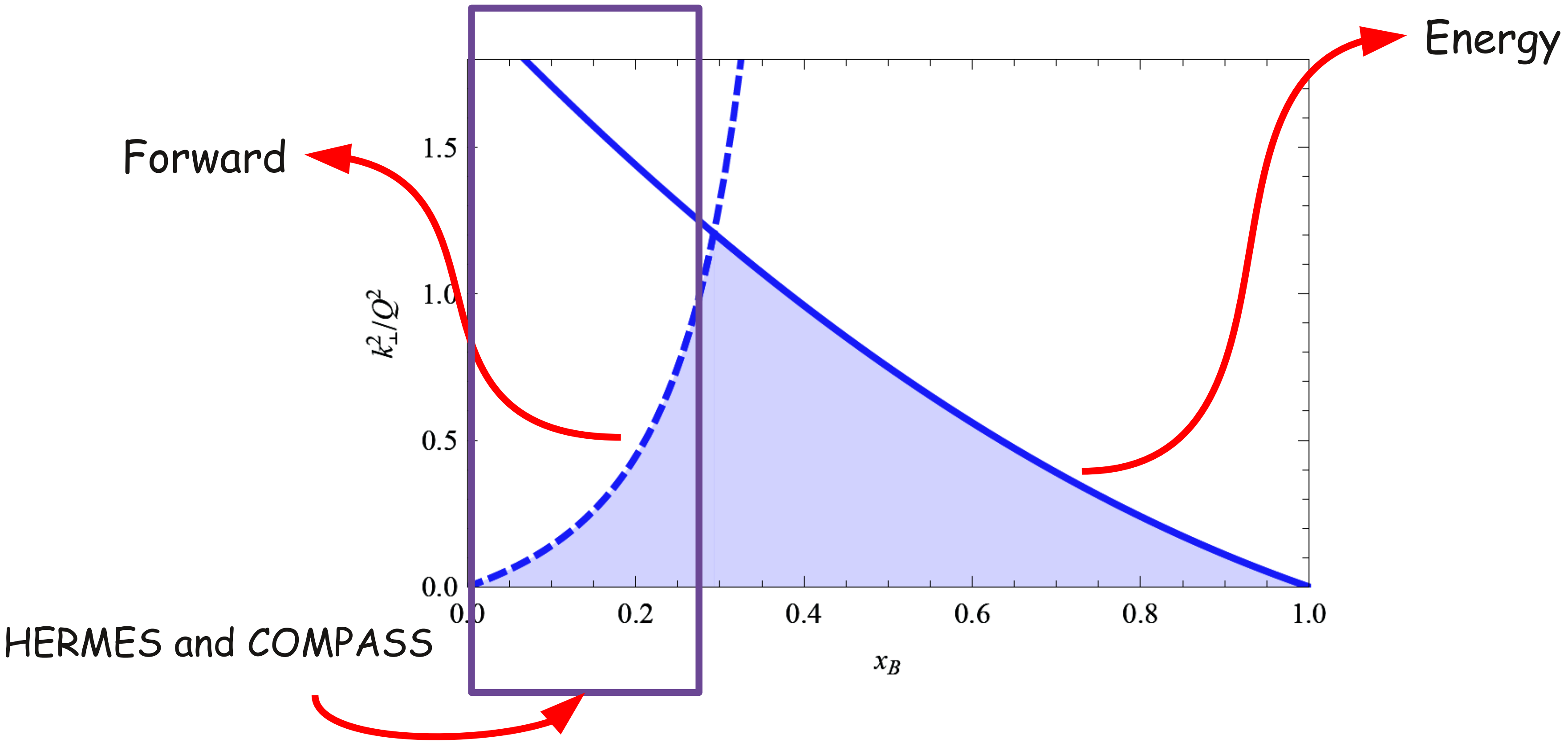
- ✔The integration from 0 to infinity can be a crude assumption
- ✔The parton model provides kinematical limits on the transverse momentum size



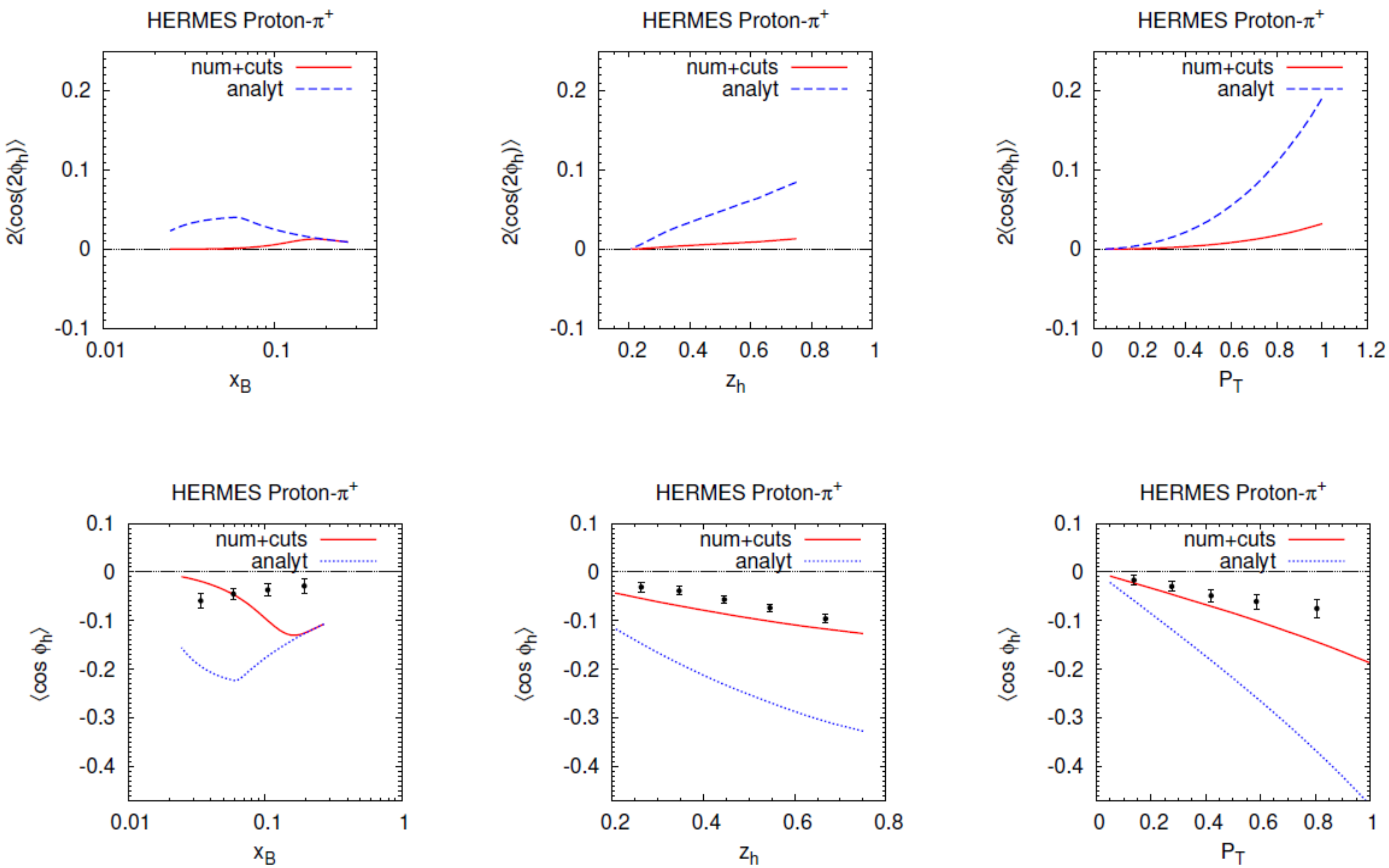
Bounds on the intrinic transverse momenta

✔The integration from 0 to infinity can be a crude assumption

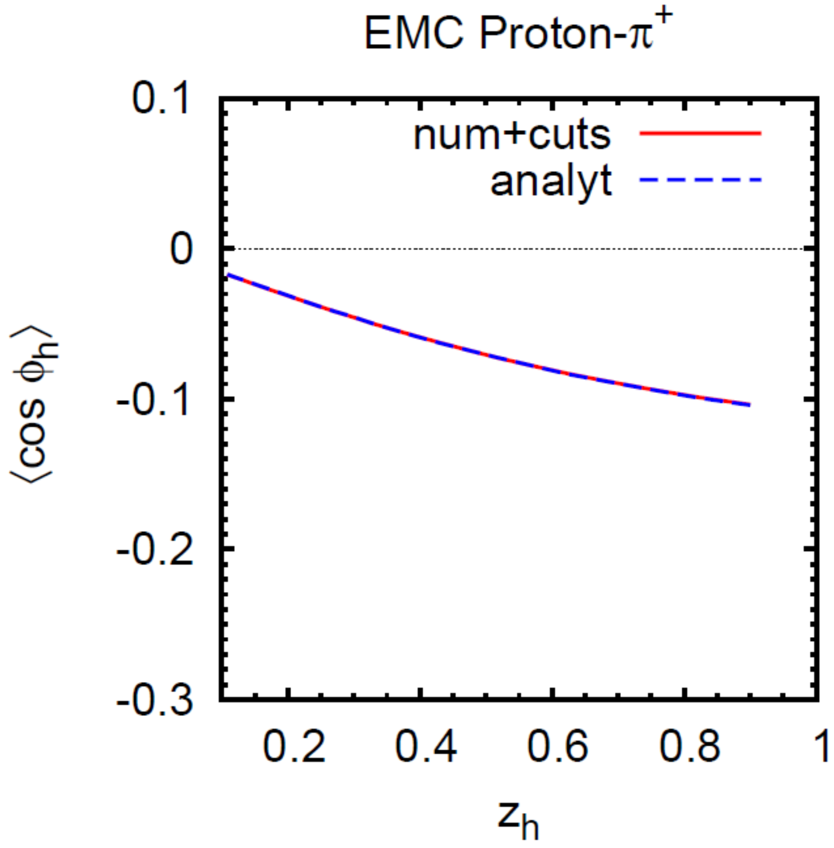
✔The parton model provides kinematical limits on the transverse momentum size



Smaller Cahn effect...



No effects in “true” DIS regime...



EMC like kinematics:

$$Q^2 \geq 5 \ \mathrm{GeV}^2$$

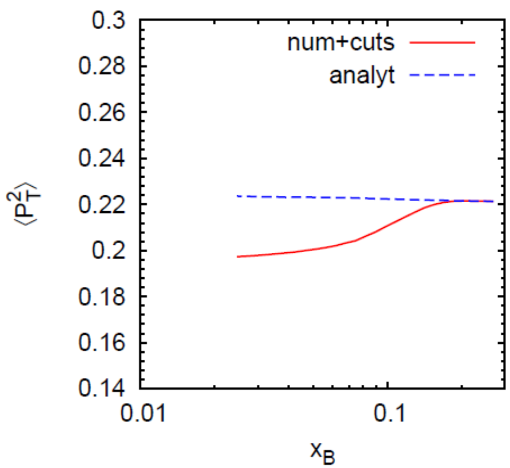
Conclusions IV

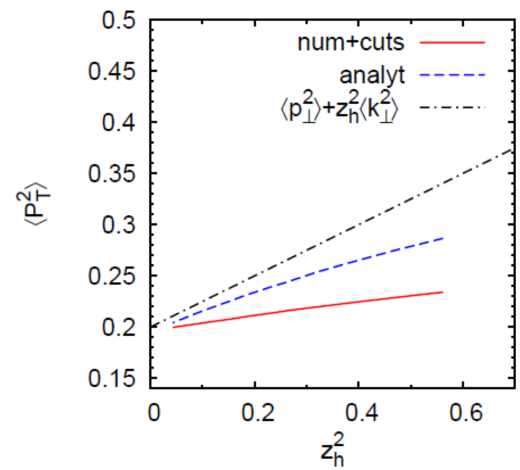
- In some kinematical region $k_{\perp}/Q \sim 1$
- A large Cahn effect is a consequence of that
- The parton model provides constraints on the intrinsic transverse momenta
- Better description of $\langle \cos\varphi \rangle$ and $\langle \cos 2\varphi \rangle$ data
- Impact in the calculation of $\langle P_T^2 \rangle$

UNP

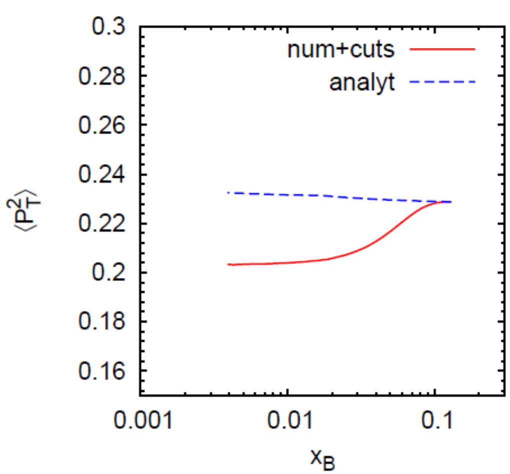
$\langle P_T^2 \rangle$

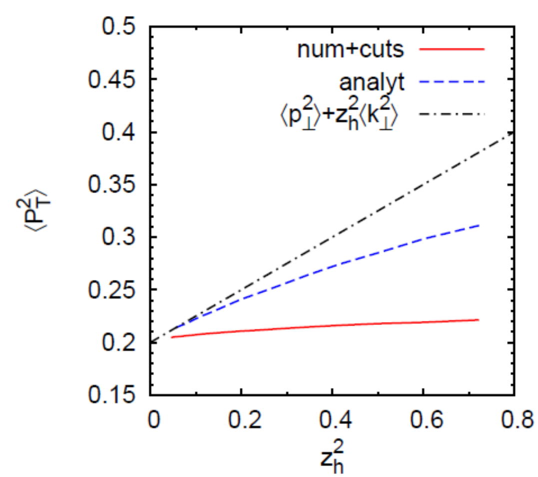
HERMES Proton-π^+



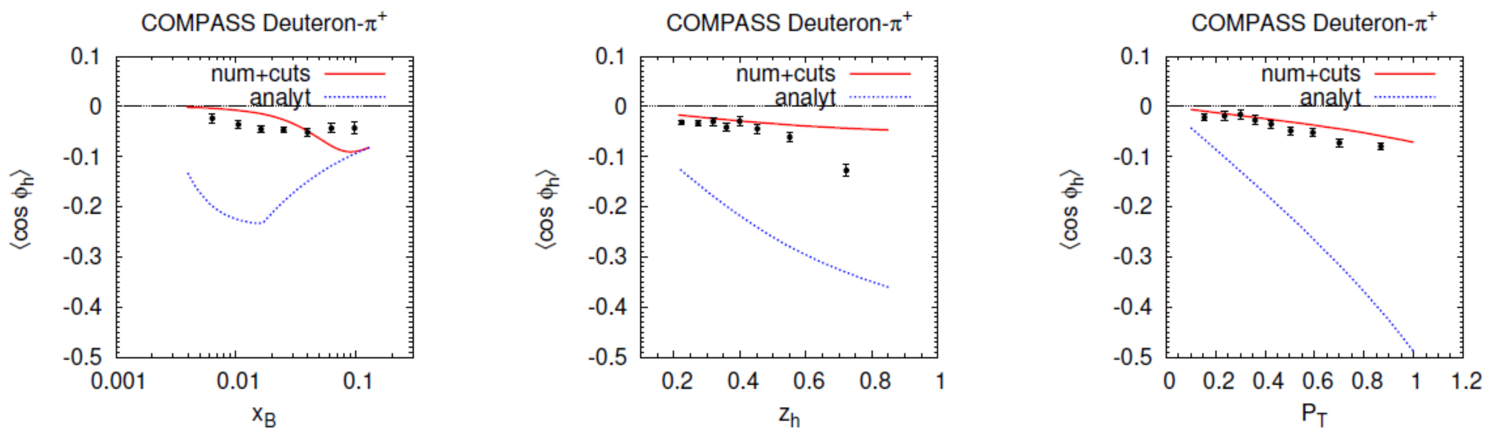


COMPASS Proton-π^+





COMPASS



COMPASS Deuteron-π+
num+cuts
analyt
⟨cos φh⟩
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0.001
0.01
0.1
xB
COMPASS Deuteron-π+
num+cuts
analyt
⟨cos φh⟩
0.2
0.4
0.6
0.8
1
zh
COMPASS Deuteron-π+
num+cuts
analyt
⟨cos φh⟩
0
0.2
0.4
0.6
0.8
1
1.2
PT

Intrisic parton motion in unpolarized SIDIS...

Unpolarized PDF $$f_{q/p}(x,k_\perp) = f(x)\frac{e^{-k_\perp^2/\langle k_\perp^2\rangle}}{\pi\langle k_\perp^2\rangle}$$

Unpolarized FF $$D_{h/q}(z,p_\perp) = D_{h/q}(z)\,\frac{1}{\pi\langle p_\perp^2\rangle}\,e^{-p_\perp^2/\langle p_\perp^2\rangle}$$

$$\int_0^{2\pi} d\varphi \int_0^{\infty} dk_\perp\, k_\perp\, f_{q/p}(x,k_\perp) = f_{q/p}(x)$$

Intrisic parton motion in unpolarized SIDIS...

$$\frac{d\sigma^{\ell+p\to\ell' hX}}{dx_B\, dy\, dz_h\, d^2\boldsymbol{P}_T} = \frac{4\pi\,\alpha^2}{x_B\, s y^2}\left\{\frac{1+(1-y)^2}{2} F_{UU} + (2-y)\sqrt{1-y}\,\cos\phi_h\, F_{UU}^{\cos\phi_h} + (1-y)\,\cos 2\phi_h\, F_{UU}^{\cos 2\phi_h}\right\}$$

$$F_{UU} = \sum_q e_q^2 \int d^2\boldsymbol{k}_\perp\, f_{q/p}(x, k_\perp)\, D_{h/q}(z, p_\perp)$$

$$\int d^2\boldsymbol{k}_\perp \Rightarrow \int_0^{2\pi} d\varphi \int_0^{\infty} dk_\perp\, k_\perp$$

$$F_{UU} = \sum_q e_q^2\, f_{q/p}(x_B)\, D_{h/q}(z_h) \frac{e^{-P_T^2/\langle P_T^2\rangle_G}}{\pi\langle P_T^2\rangle_G}$$

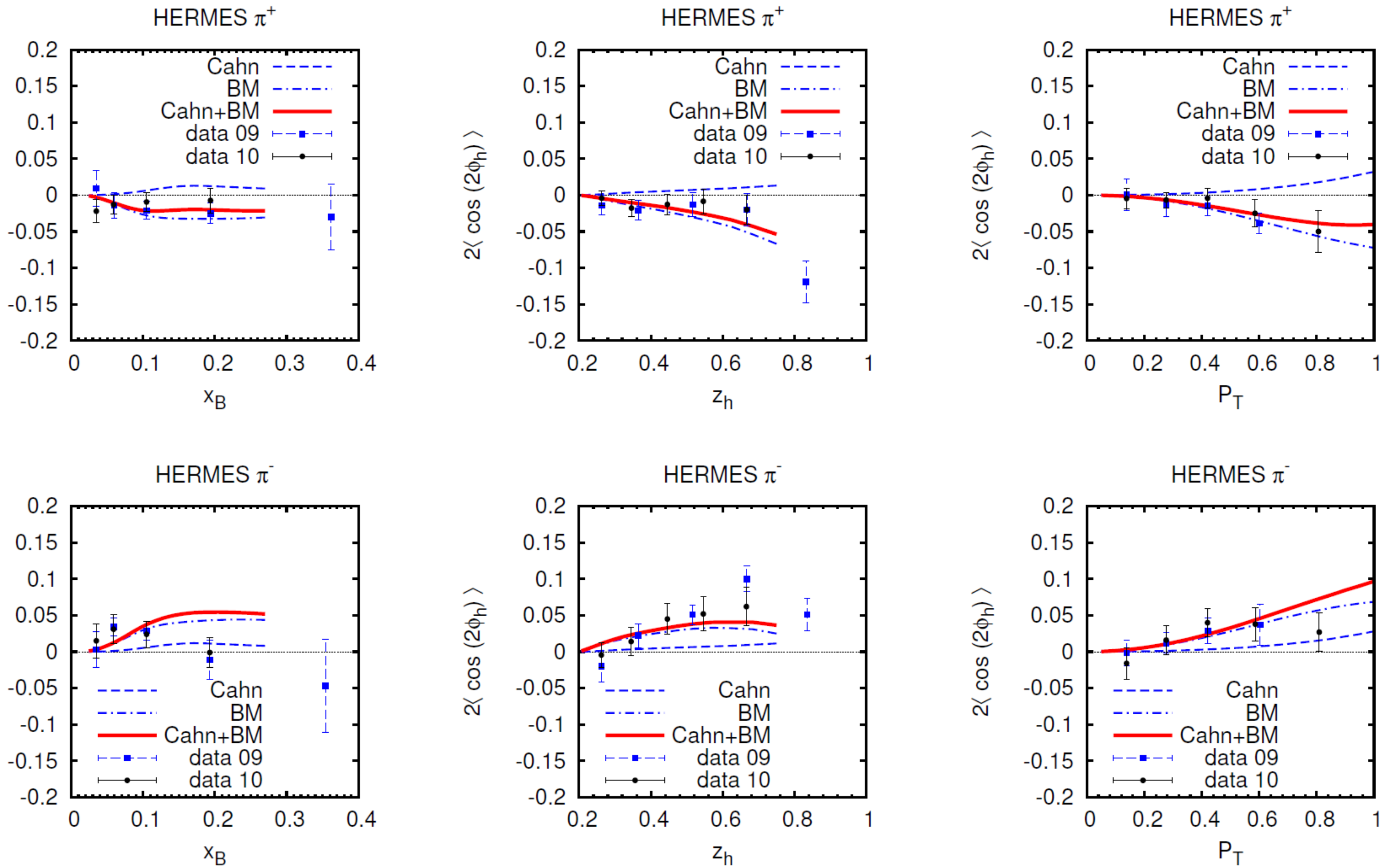
$$\langle P_T^2\rangle_G = \langle p_\perp^2\rangle + z_h^2\langle k_\perp^2\rangle$$

Intrisic parton motion in unpolarized SIDIS...

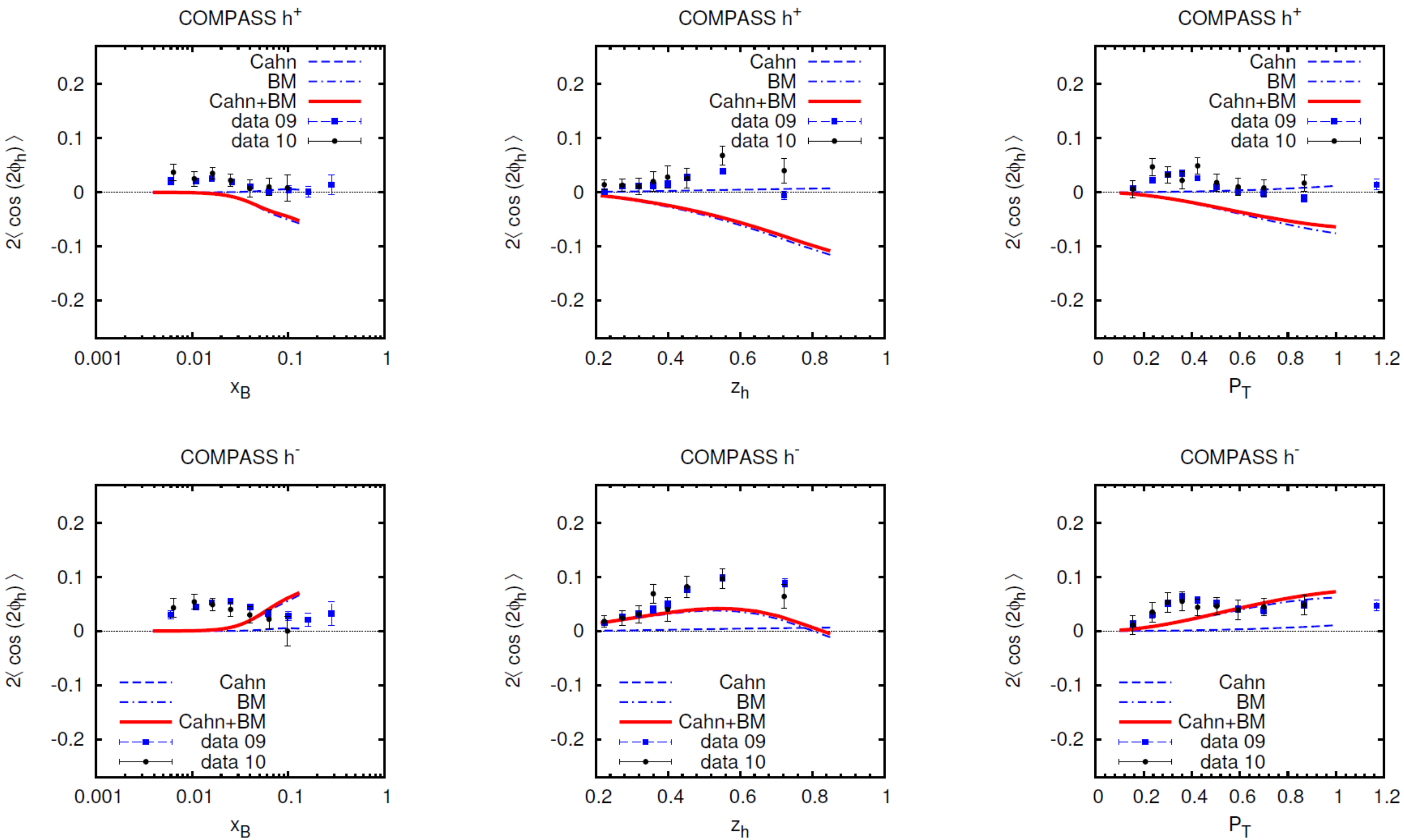
$$f_{q/p}(x,k_\perp) = f_{q/p}(x)\,\frac{1}{1-e^{-(k_\perp^{\rm max})^2/\langle k_\perp^2\rangle}}\,\frac{e^{-k_\perp^2/\langle k_\perp^2\rangle}}{\pi\langle k_\perp^2\rangle}$$

$$f_{q/p}(x) = \int_0^{2\pi} d\varphi \int_0^{k_\perp^{\rm max}} k_\perp\, dk_\perp\, f_{q/p}(x,k_\perp)$$

C2PHI

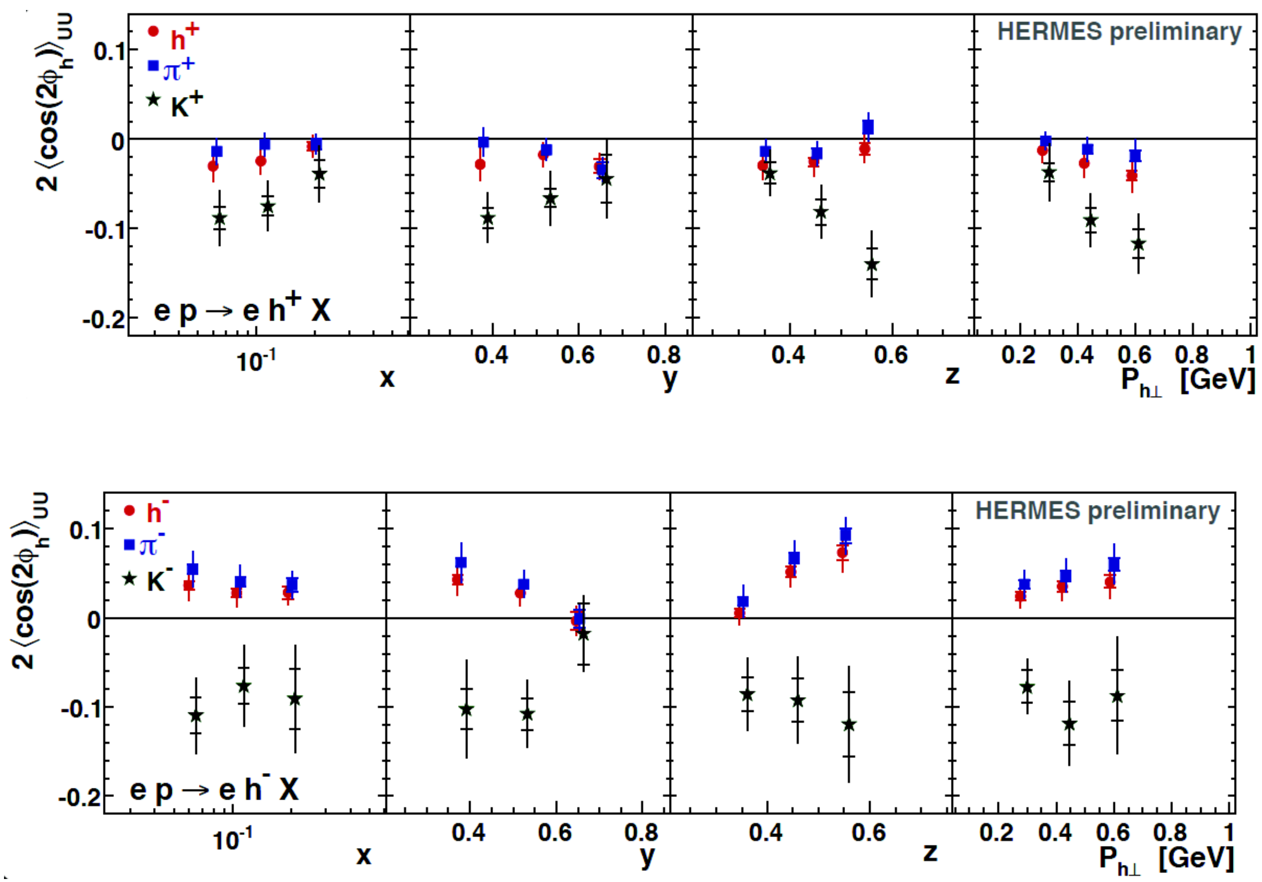

HERMES π+
HERMES π+
HERMES π+
HERMES π-
HERMES π-
HERMES π-
Cahn
BM
Cahn+BM
data 09
data 10
2⟨ cos (2φh) ⟩
xB
zh
PT

C2PHI


COMPASS h+
COMPASS h+
COMPASS h+
COMPASS h-
COMPASS h-
COMPASS h-
Cahn
BM
Cahn+BM
data 09
data 10
2⟨ cos (2ϕh) ⟩
xB
zh
PT
0.2
0.1
0
-0.1
-0.2
0.001
0.01
0.1
1
0.4
0.6
0.8
1.2

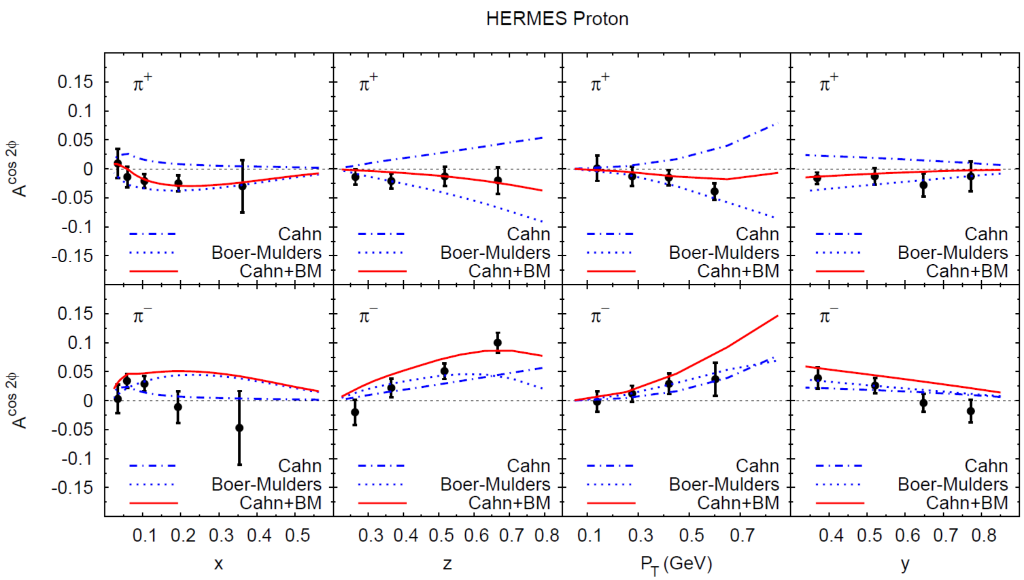
BM

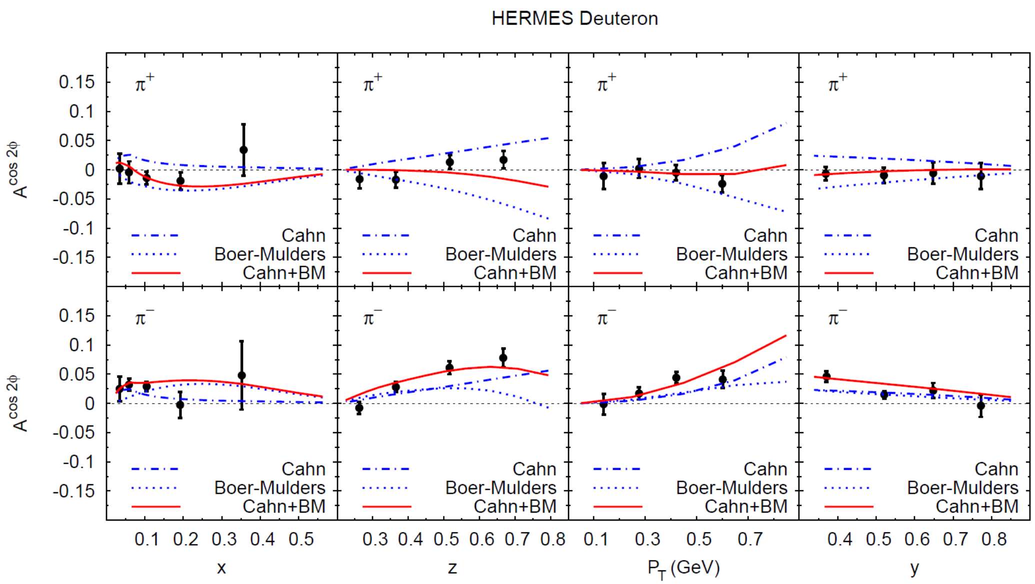
Extraction of the Boer-Mulders Function
Kaons!



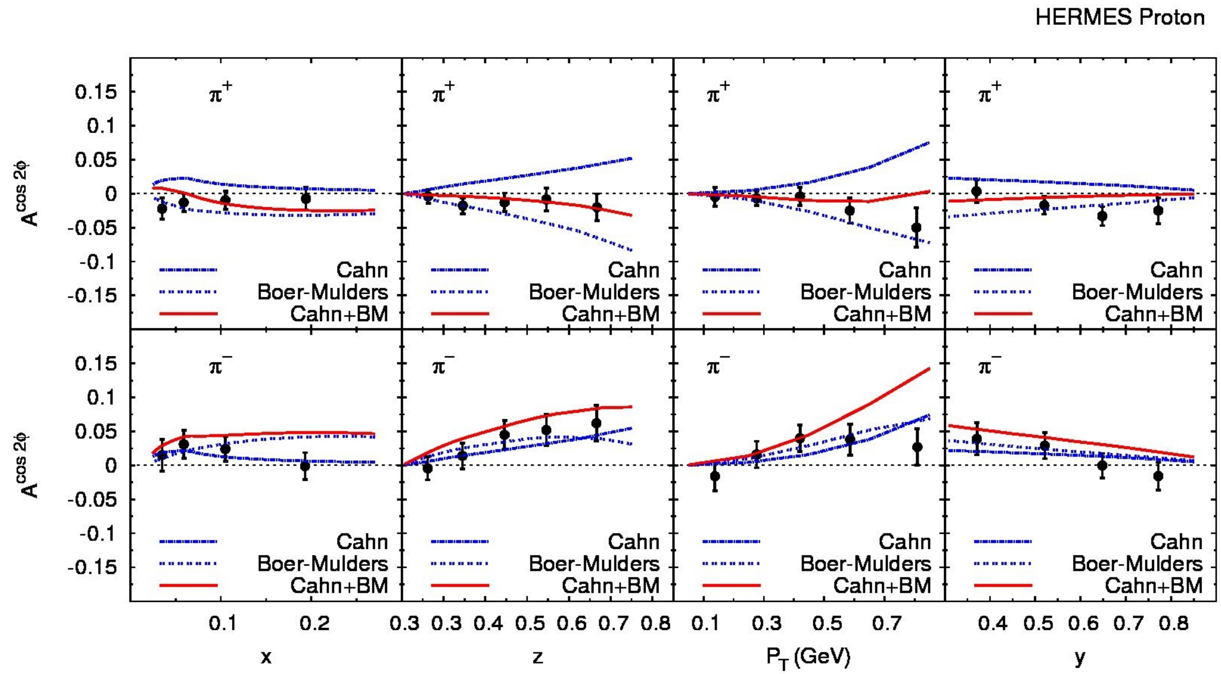
- Kaons production mainly driven by u quark fragmentation
- Favored & Unfavored kaon Collins functions both positive

Extraction of the Boer-Mulders function



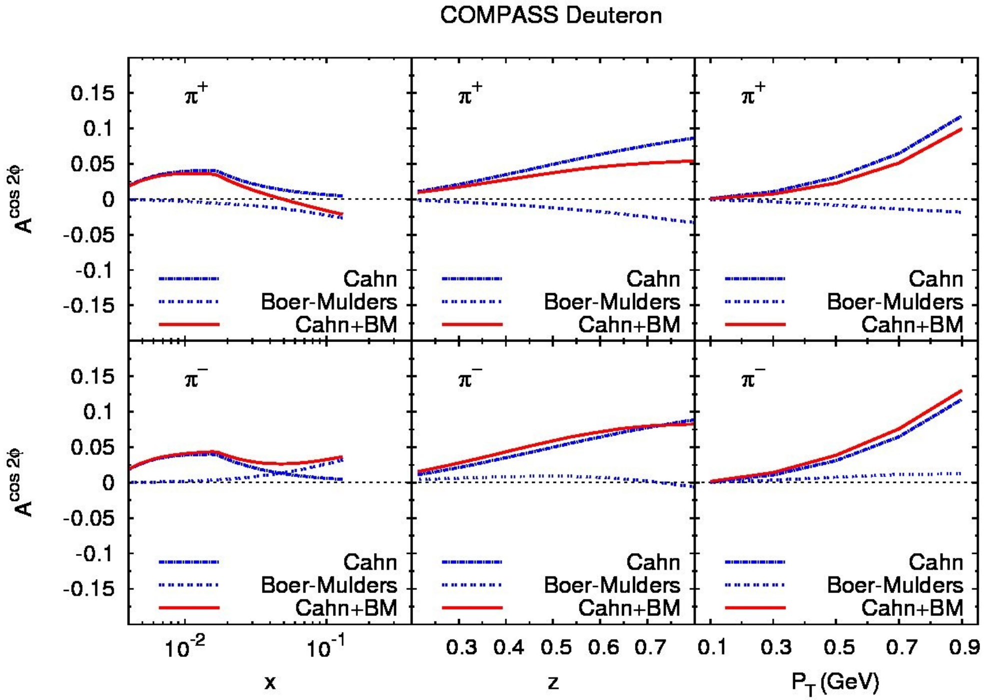


Extraction of the Boer-Mulders function



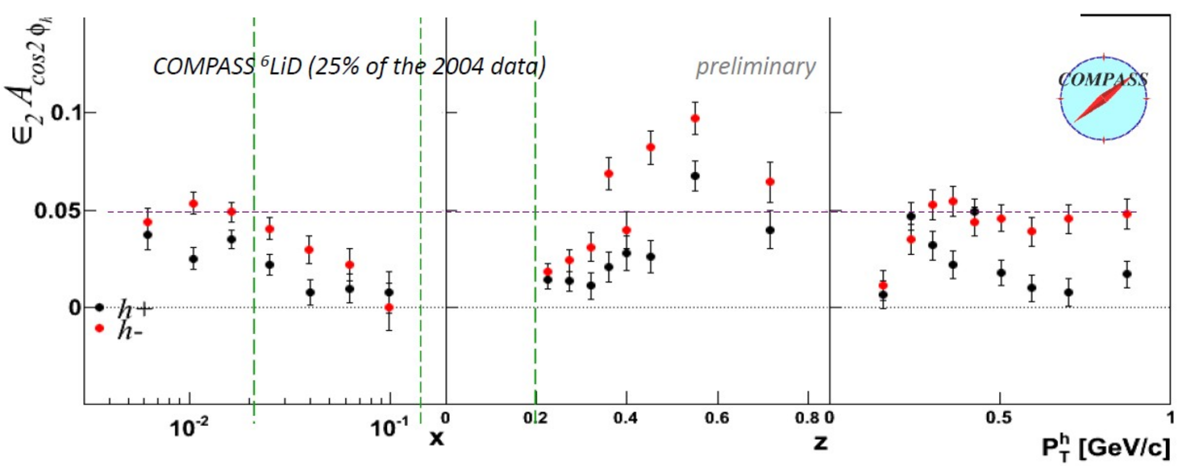
New HERMES data. Presented at SPIN2010

Extraction of the Boer-Mulders function



New COMPASS data!

Presented at SPIN2010 (Sbrizzai)



Extracted Sivers Functions

- Simple parametrization of the Sivers function

$$\Delta^N f_{q/p^\uparrow}(x, k_\perp) = 2\,\mathcal{N}_q(x)\, h(k_\perp)\, f_{q/p}(x, k_\perp)$$

Unpolarized PDF $$f_{q/p}(x, k_\perp) = f(x)\,\frac{e^{-k_\perp^2/\langle k_\perp^2\rangle}}{\pi\langle k_\perp^2\rangle}$$

✔ Torino vs Amsterdam notation

$$\frac{1}{2}\Delta^N f_{q/p^\uparrow}(x, k_\perp) = -\frac{k_\perp}{m_p} f_{1T}^{\perp q}(x, k_\perp)$$

Extracted Sivers Functions

- Simple parametrization of the Sivers function

$$\Delta^N f_{q/p^\uparrow}(x,k_\perp) = 2\,\mathcal{N}_q(x)\,h(k_\perp)\,f_{q/p}(x,k_\perp)$$

$$\mathcal{N}_q(x) = N_q\,x^{\alpha_q}(1-x)^{\beta_q}\,\frac{(\alpha_q+\beta_q)^{(\alpha_q+\beta_q)}}{\alpha_q^{\alpha_q}\,\beta_q^{\beta_q}} \le 1$$

$$h(k_\perp) = \sqrt{2e}\,\frac{k_\perp}{M_1}\,e^{-k_\perp^2/M_1^2} \le 1$$

N_q, α_q, β_q & M_1 free parameters