

1-Hadron transverse target spin asymmetries at COMPASS

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on behalf of the COMPASS collaboration

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**Friedrich-Alexander-Universität
Erlangen-Nürnberg**



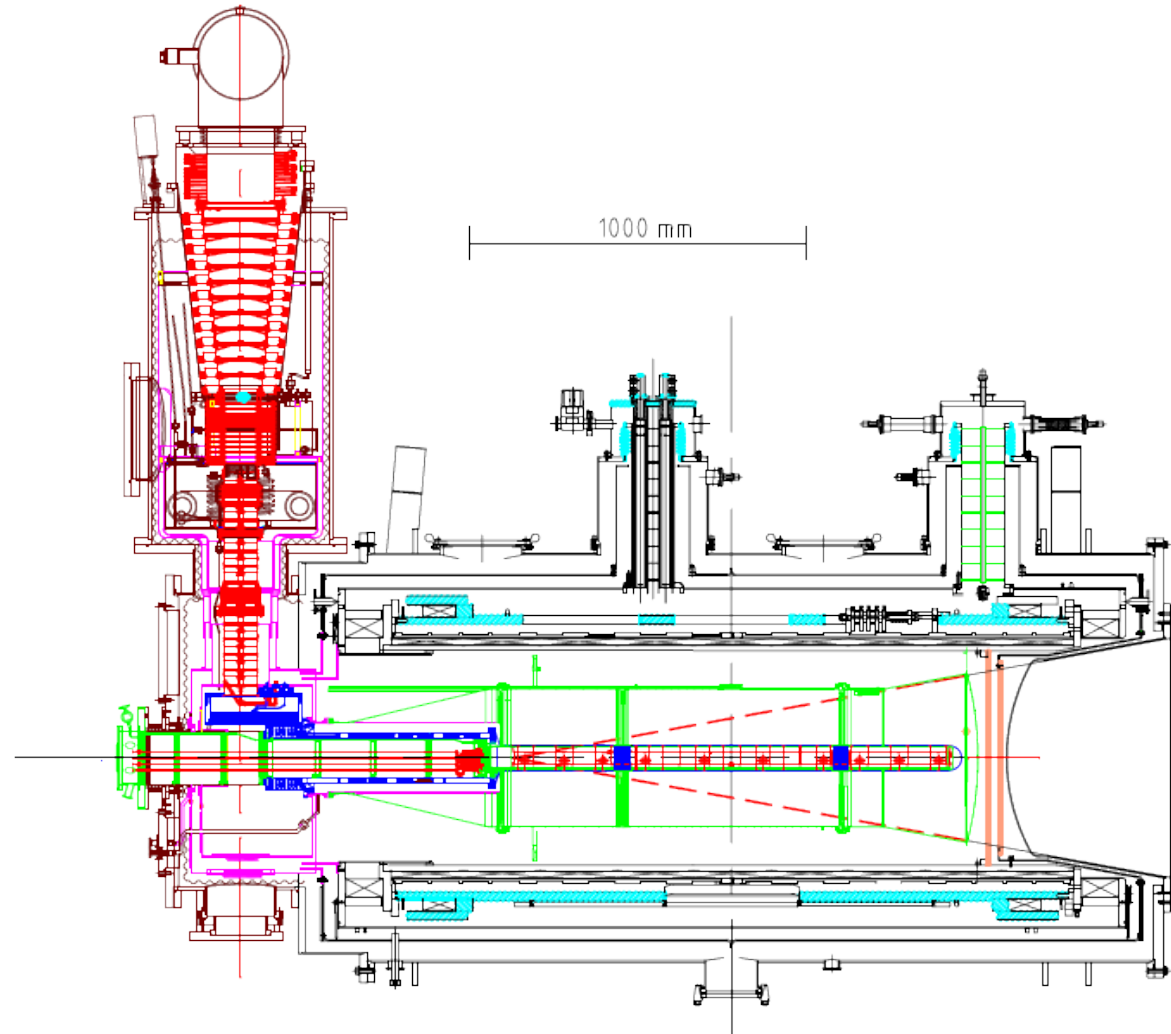
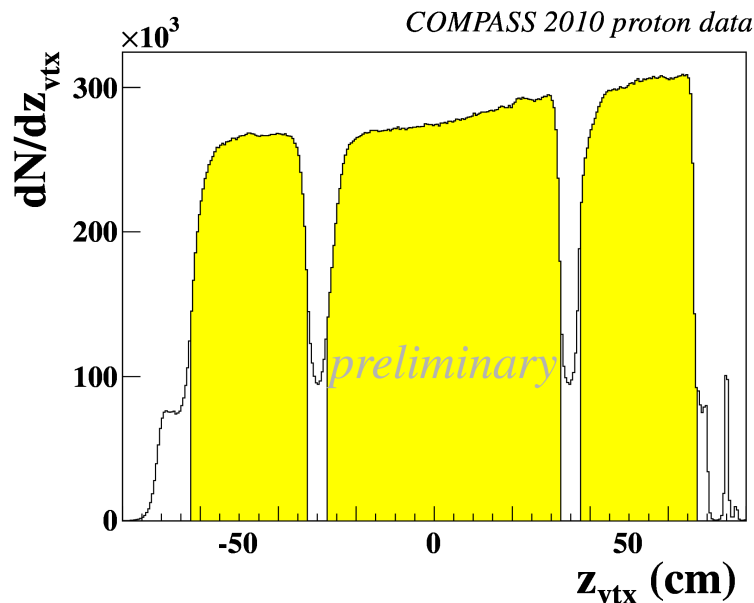
bmb+f - Förderschwerpunkt

COMPASS

Großgeräte der physikalischen
Grundlagenforschung

The COMPASS polarized target system



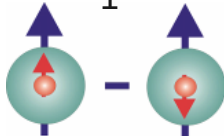
- Upgrade of target system in 2005
- Three cells with opposite polarisation (2002-04 two cells)
- 180mrad geometrical acceptance
- NH_3 :
 - polarization: $\sim 90\%$
 - dilution factor: ~ 0.15
- Transverse polarization reversed every week via microwave



Spin structure → Transversity

Three distribution functions are necessary to describe the spin structure of the nucleon in LO:

quark

		U	L	T
nucleon	U	$f_1(x)$ 		
	L		$g_1(x)$ 	
	T			$h_1(x)$ 

Quark distribution
 $f_1(x) = q^+(x) + q^-(x)$

Helicity distribution
 $g_1(x) = q^+(x) - q^-(x)$



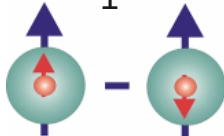
Transversity distribution
 $h_1(x) = q^{\uparrow\uparrow}(x) - q^{\uparrow\downarrow}(x)$

$lN^\uparrow \rightarrow l' hX$ Collins FF
 $lN^\uparrow \rightarrow l' hhX$ Interference FF
 $lN^\uparrow \rightarrow l' \Lambda X$ FF of $q^\uparrow \rightarrow \Lambda$

Spin structure \rightarrow Transversity

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The Collins modulation

For measuring Transversity quark spin must flip:

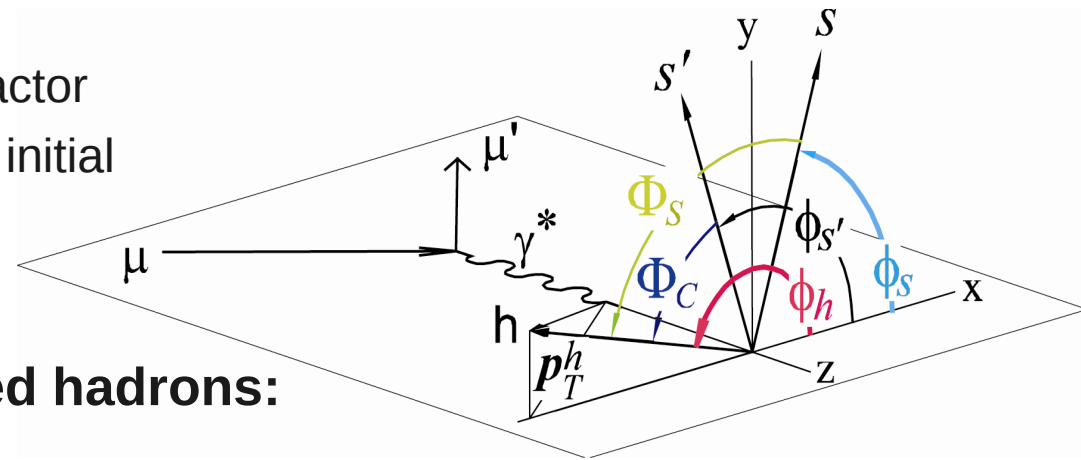
—► $h_1(x)$ decouples from inclusive DIS

Product of $h_1(x)$ and another chiral-odd function needed: Collins FF H_{1q}^h

—► $h_1(x)$ can be extracted via SIDIS on a transversely polarized target.

$$A_{Coll} = \frac{A_C^h}{f \cdot P_T \cdot D_{nn}} = \frac{\sum_q e_q^2 \cdot h_1 \cdot H_{1q}^h}{\sum_q e_q^2 \cdot f_1 \cdot D_q^h}$$

with P_T the target polarization, f the dilution factor and D_{NN} the spin transfer coefficient from the initial to the struck quark



Azimuthal distribution of the produced hadrons:

$$N_h^\pm(\Phi_C) = N_h^0(1 \pm A_C^h \sin(\Phi_C))$$

$$\text{with } \Phi_C = \phi_h - \phi_{s'} = \phi_h + \phi_S - \pi$$

SIDIS event selection

Standard cuts like in 2007:

DIS cuts: $Q^2 > 1 \text{ (GeV/c)}^2$

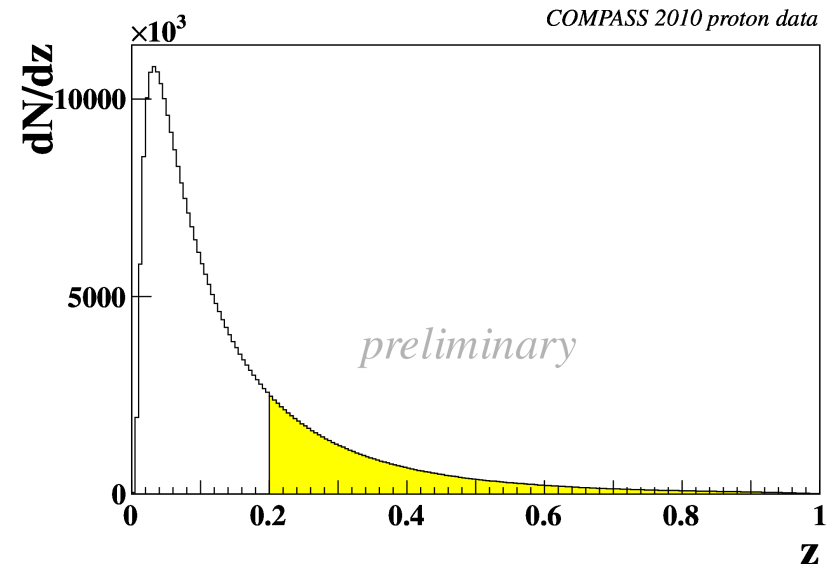
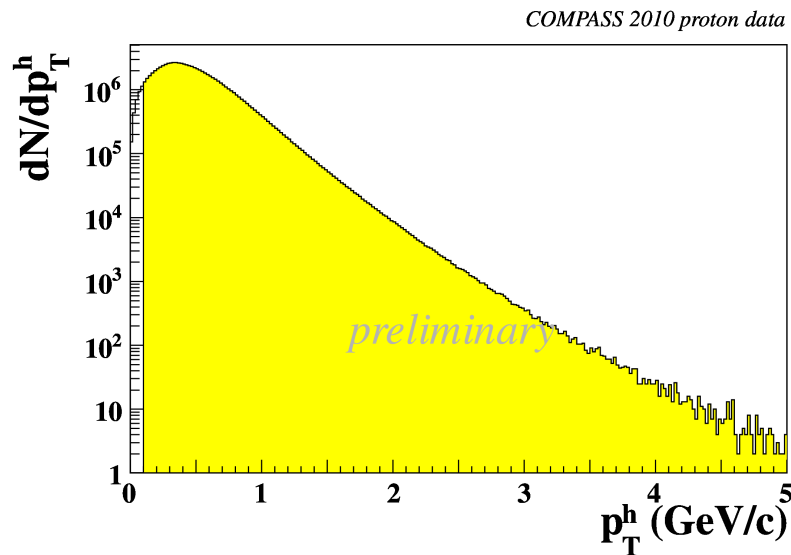
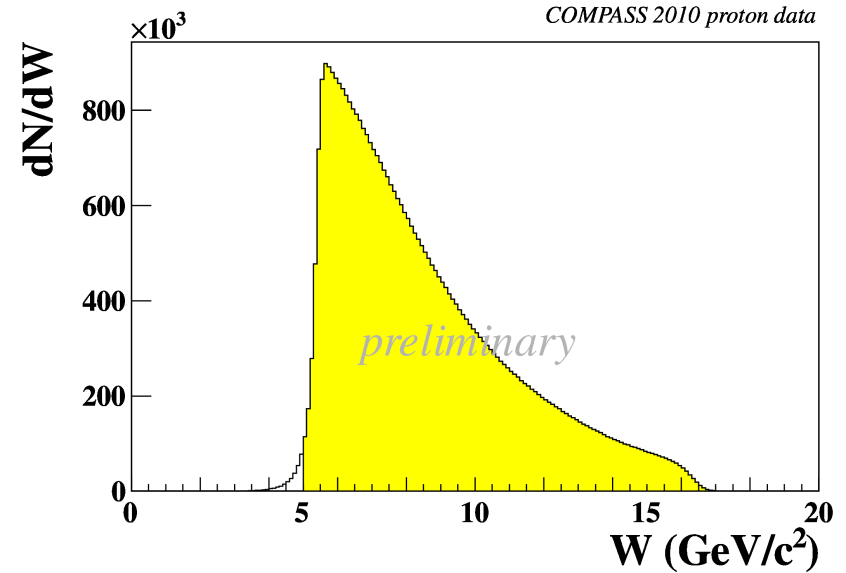
$0.1 < y < 0.9$

$W > 5 \text{ GeV/c}^2$

Hadron selection:

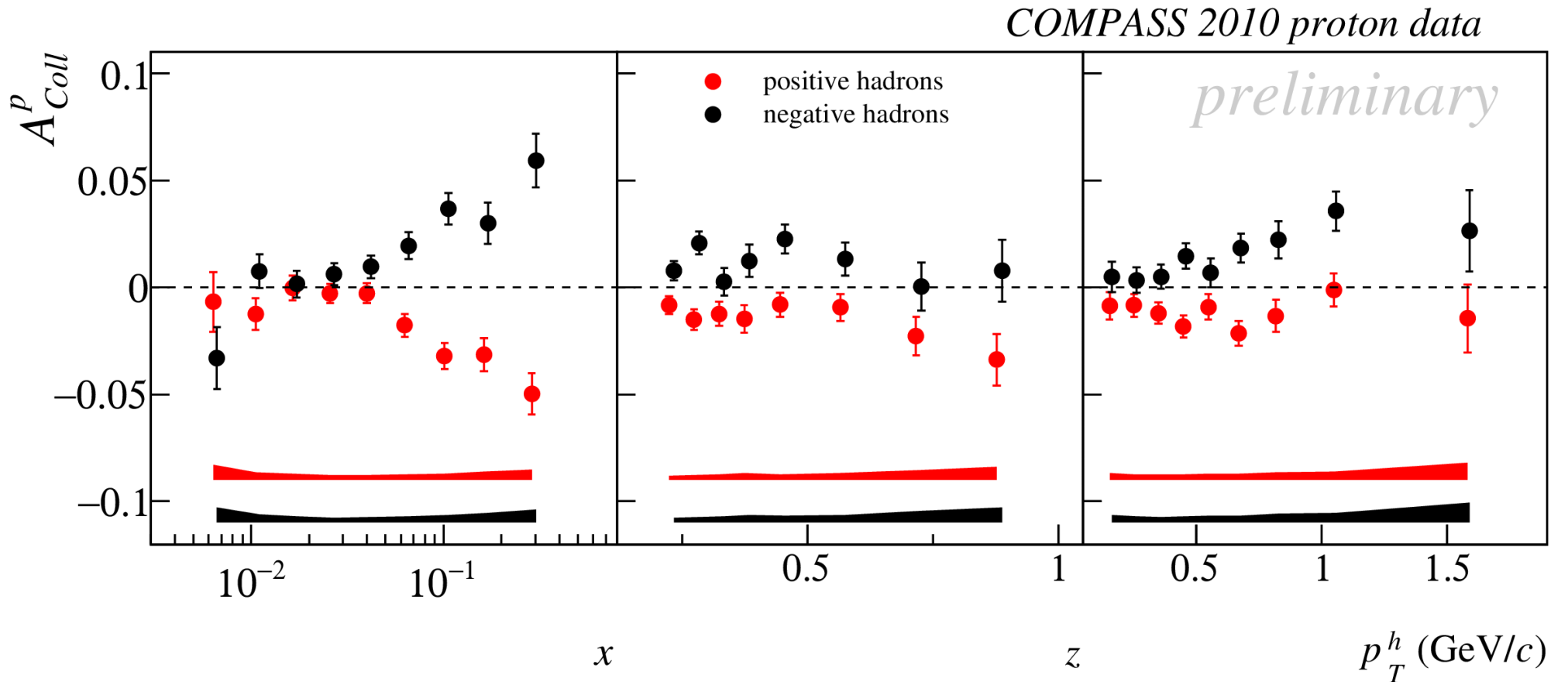
$P_t^h > 0.1 \text{ GeV/c}$

$z > 0.2$



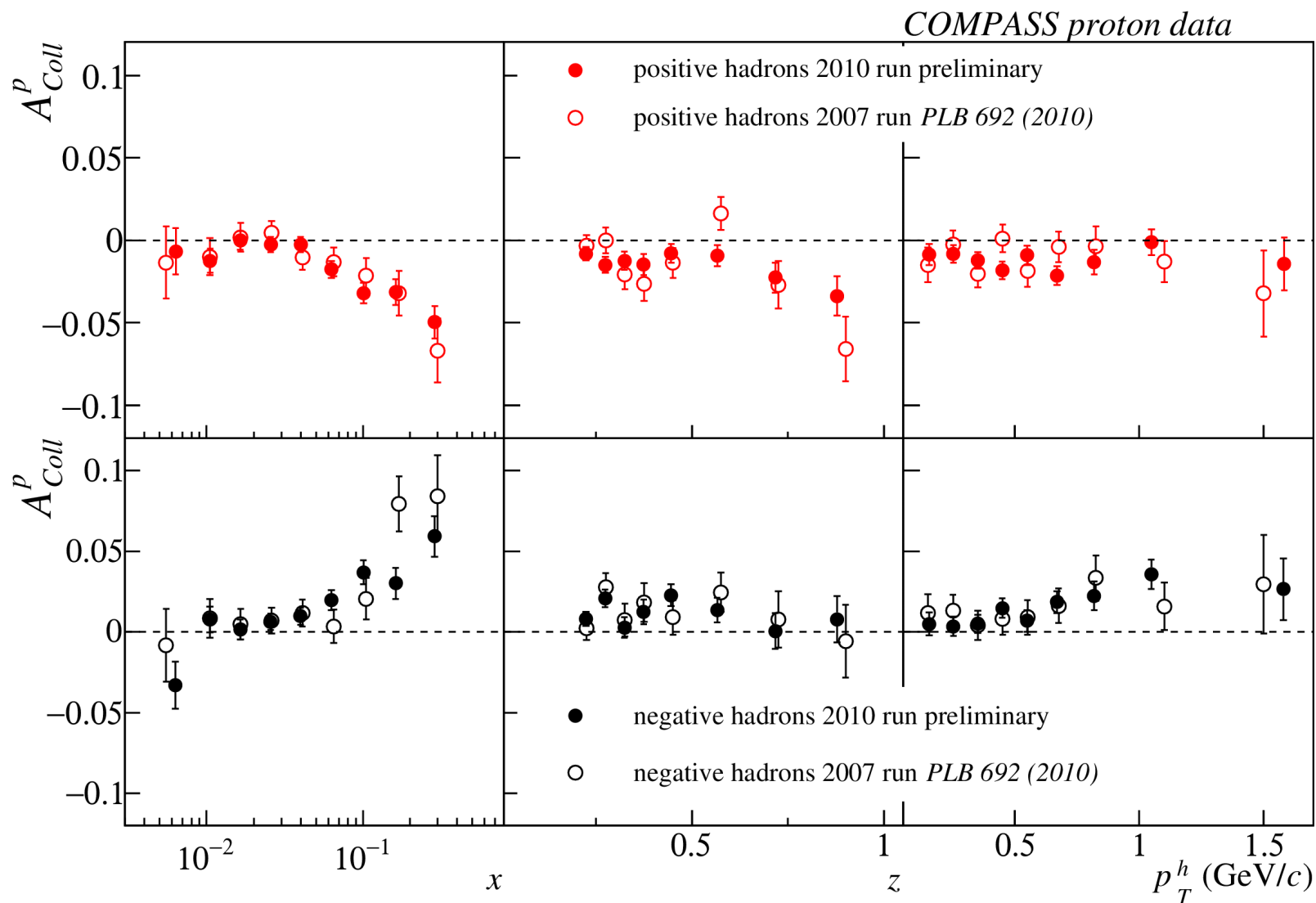
The Collins modulation – 2010 data

- at small x asymmetries are compatible with zero
- Large signal in the valence region of opposite sign for positive and negative hadrons



$$\sigma_{\text{syst}} \sim 0.5 \sigma_{\text{stat}}$$

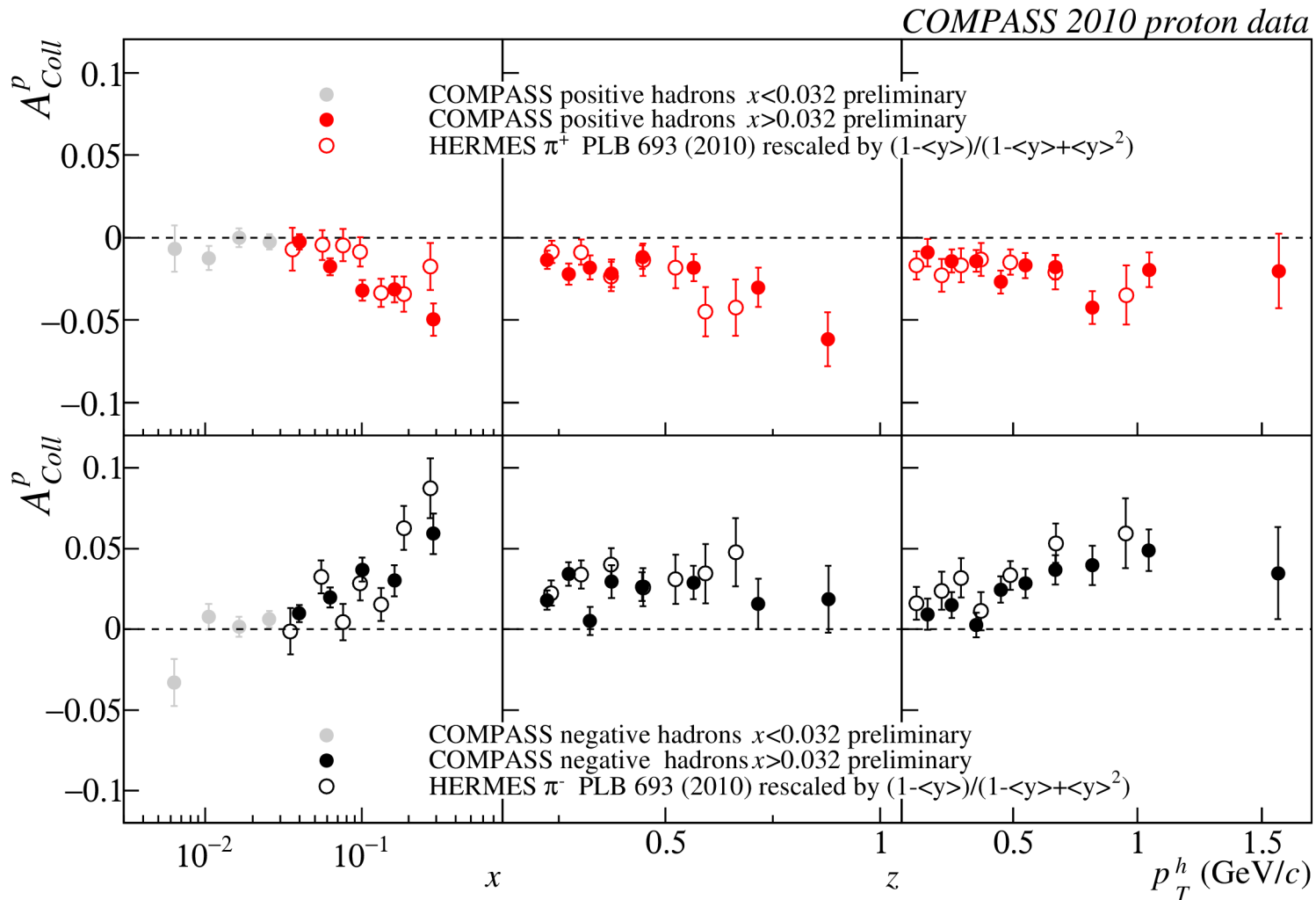
The Collins modulation 2010 ↔ 2007



confirmation of 2007 results with increased statistics

The Collins modulation

Comparison to HERMES data for $x > 0.032$

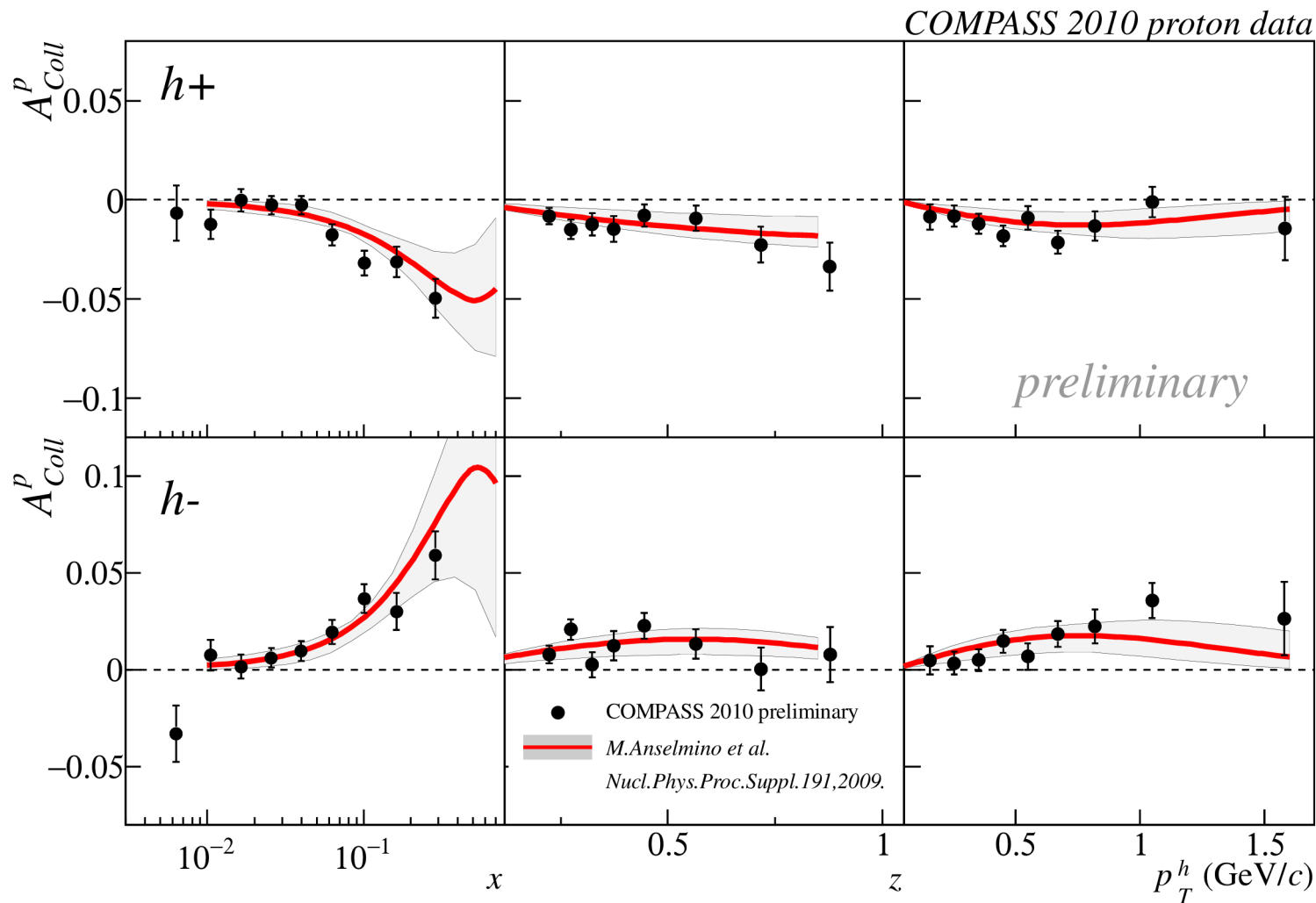


nice agreement between COMPASS and HERMES

The Collins modulation



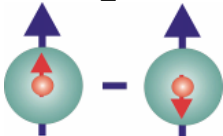
Comparison to model predictions

Comparison with the predictions from the fit to the COMPASS deuteron data, HERMES proton SIDIS data and BELLE e+e- data (Anselmino et al.):



Transverse spin physics

Taking into account the transverse momentum k_T of the quarks:

		quark		
		U	L	T
nucleon	U	$f_1(x)$ 		
	L		$g_1(x)$ 	
	T			$h_1(x)$ 

Transverse spin physics: TMDs

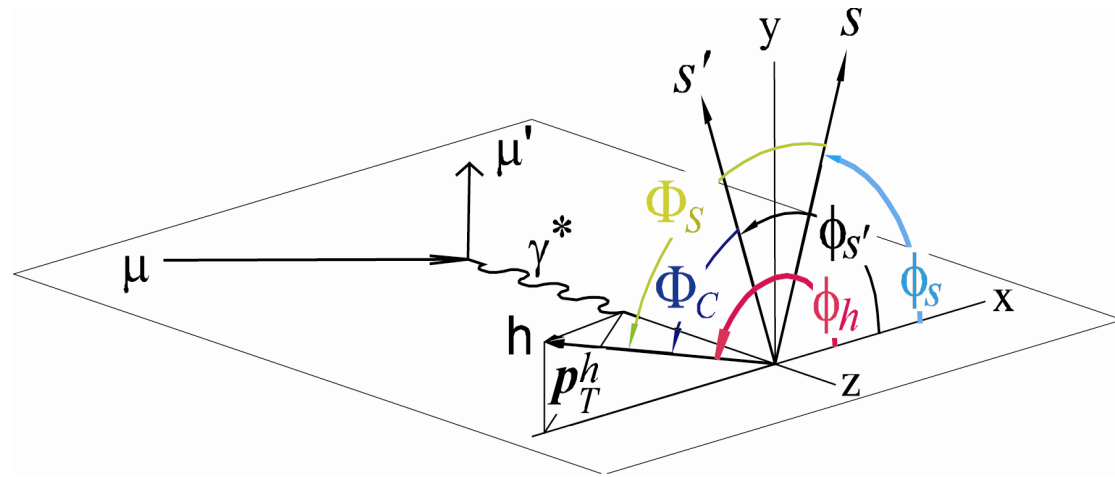
Taking into account the transverse momentum k_T of the quarks:

		quark		
		U	L	T
nucleon	U	$f_1(x, k_T)$		$h_1^\perp(x, k_T)$ Boer-Mulders
	L		$g_1(x, k_T)$	$h_{1L}(x, k_T)$ Worm-gear 1
	T	$f_{1T}^\perp(x, k_T)$ Sivers	$g_{1T}(x, k_T)$ Worm-gear 2	$h_{1T}(x, k_T)$ Transversity $h_{1T}^\perp(x, k_T)$ Pretzelosity

The Sivers modulation

Sivers function $f_{1T}^\perp(x, k_\perp)$: Correlation between the transverse spin of a nucleon and the intrinsic transverse momentum of unpolarized quarks

$$A_{Siv} = \frac{A_S^h}{f \cdot P_T} = \frac{\sum_q e_q^2 \cdot f_{1Tq}^\perp D_q^h}{\sum_q e_q^2 \cdot f_{1q} \cdot D_q^h}$$

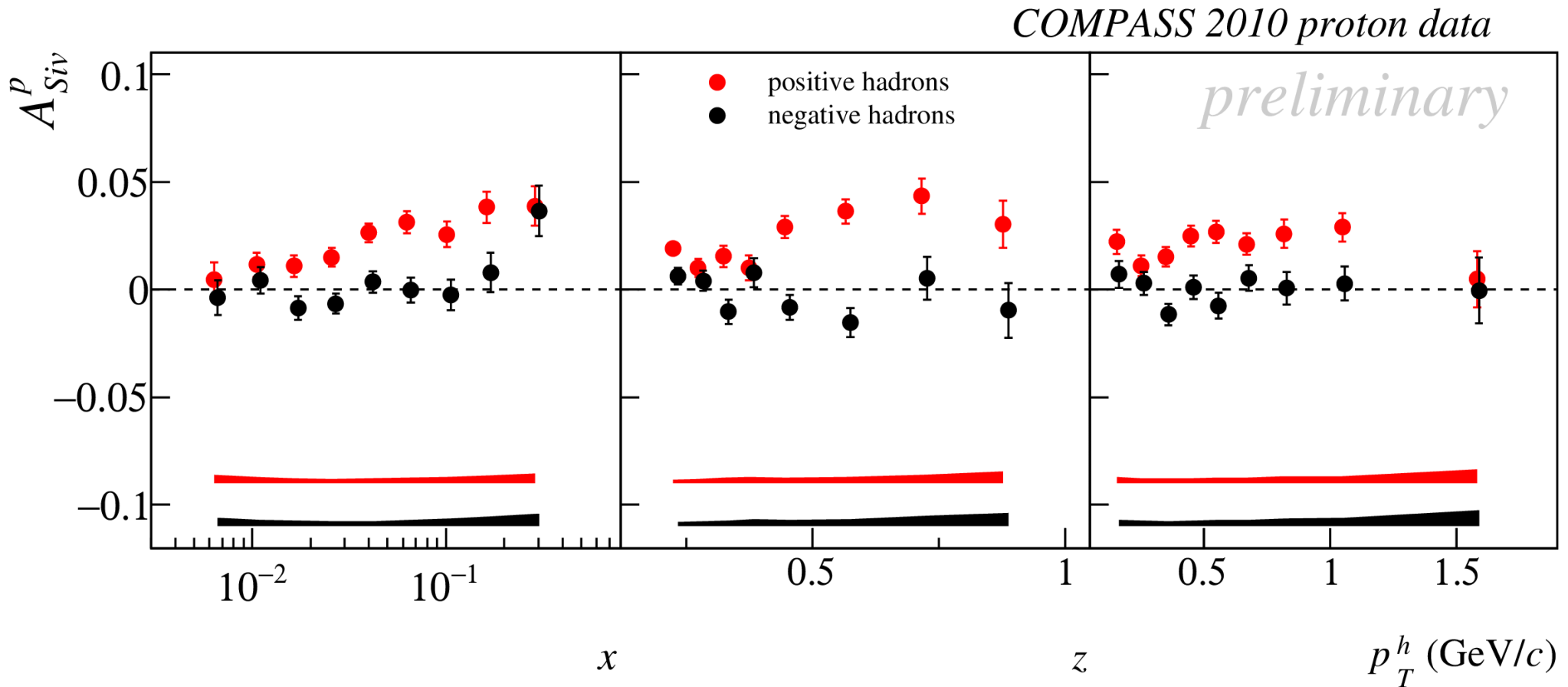


Azimuthal distribution of the produced hadrons:

$$N_h^\pm(\Phi_C) = N_h^0(1 \pm A_S^h \sin(\Phi_S))$$

$$\text{with } \Phi_S = \phi_h - \phi_S$$

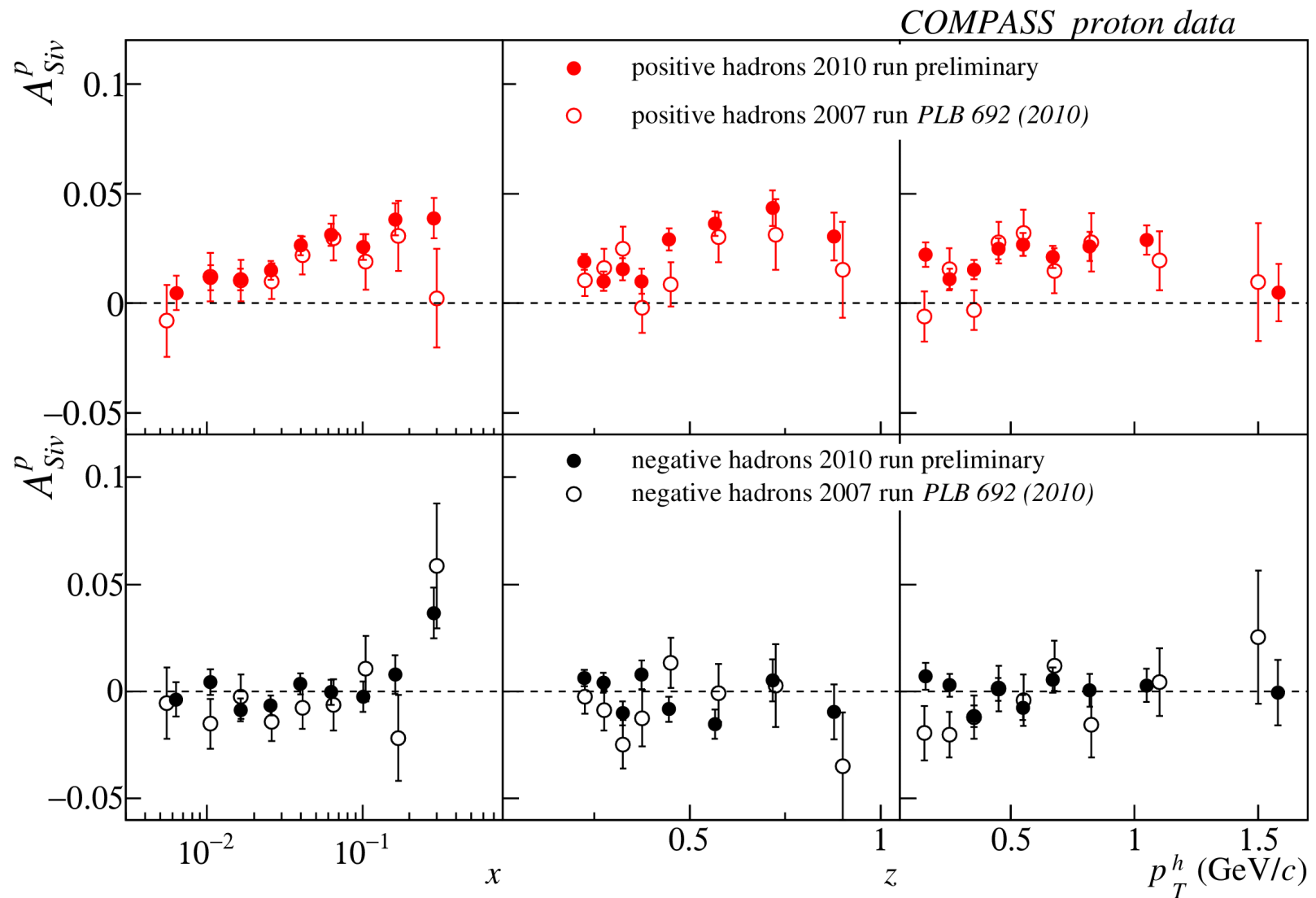
The Sivers modulation – 2010 data



- positive signal for positive hadrons
- h^- asymmetry compatible with zero

$$\sigma_{\text{syst}} \sim 0.5 \sigma_{\text{stat}}$$

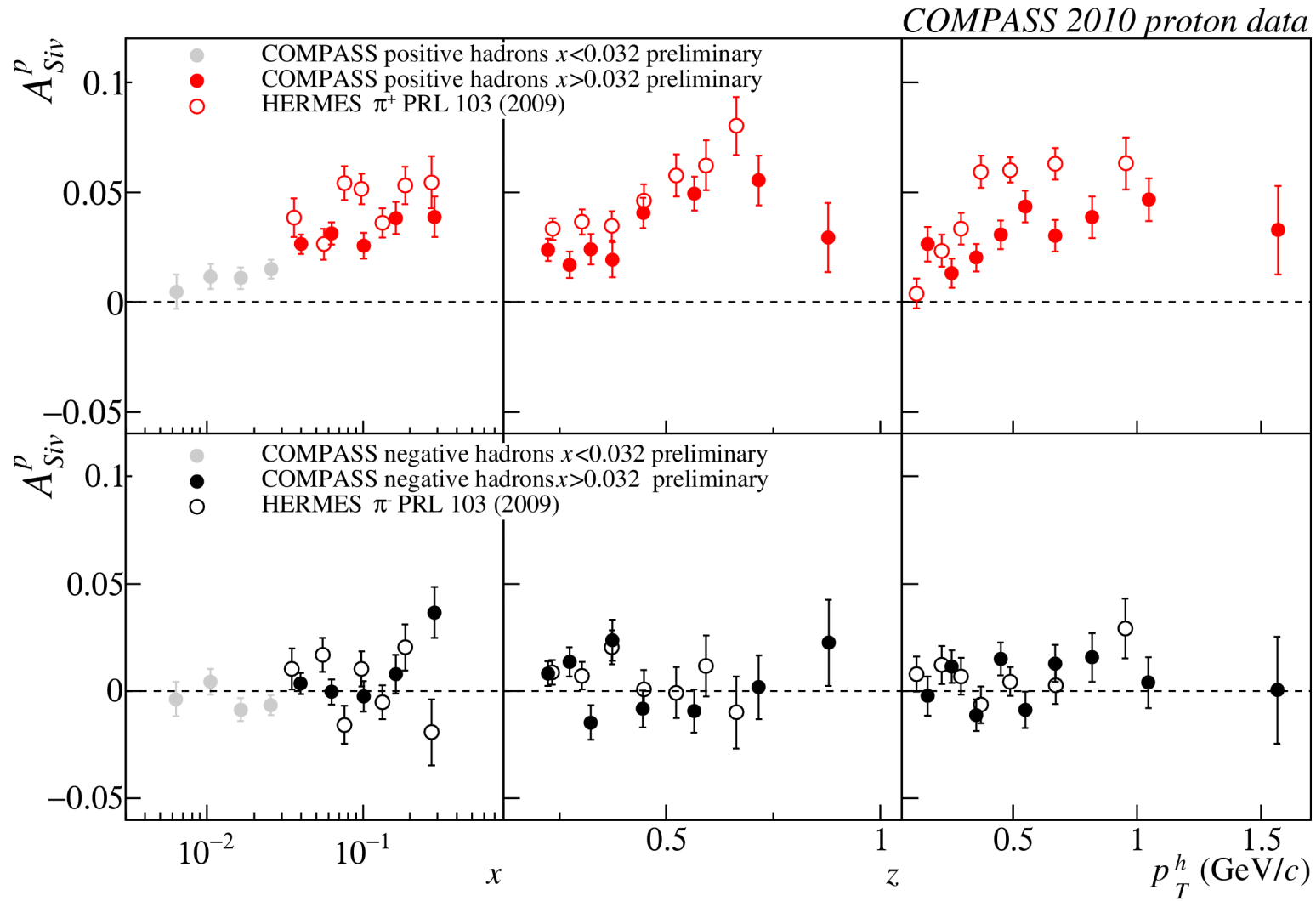
The Sivers modulation 2010 ↔ 2007



good agreement with 2007 published results, but with smaller errors

The Siverts modulation

Comparison to Hermes data for $x > 0.032$

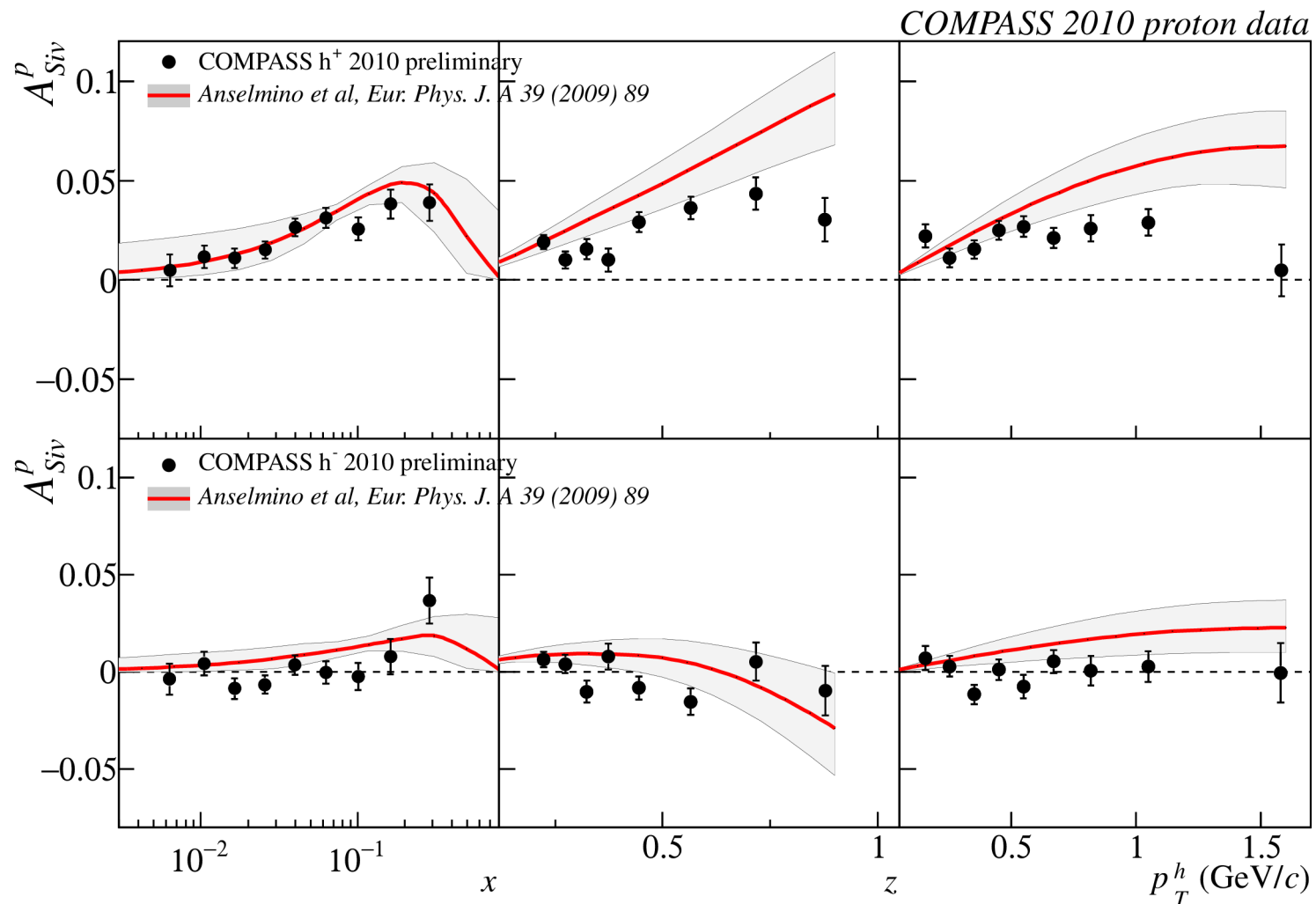


difference between COMPASS and HERMES results, but same trend

The Siverts modulation

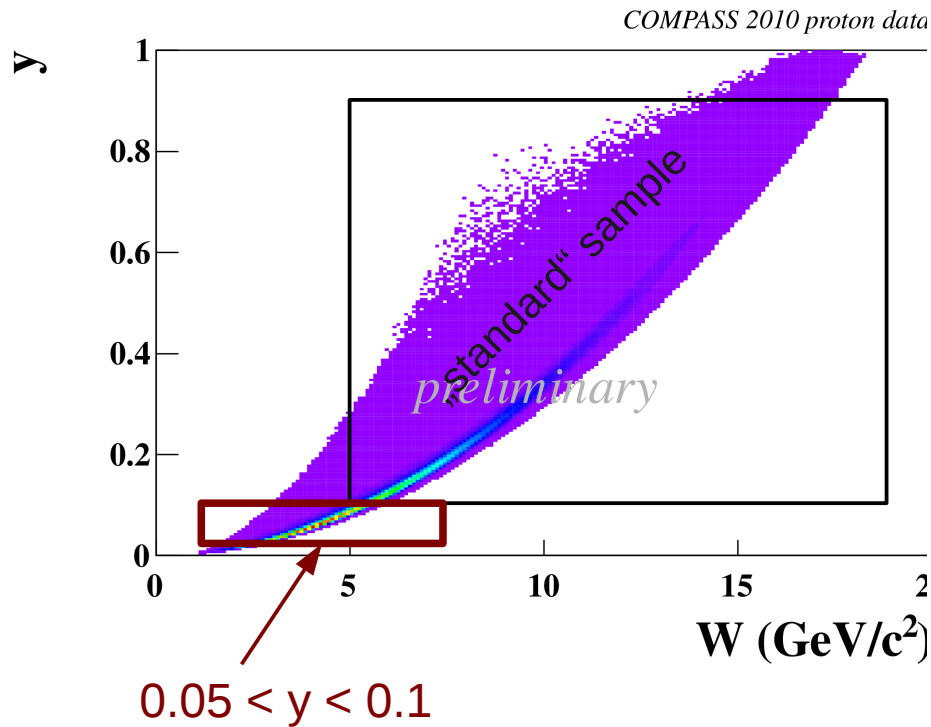
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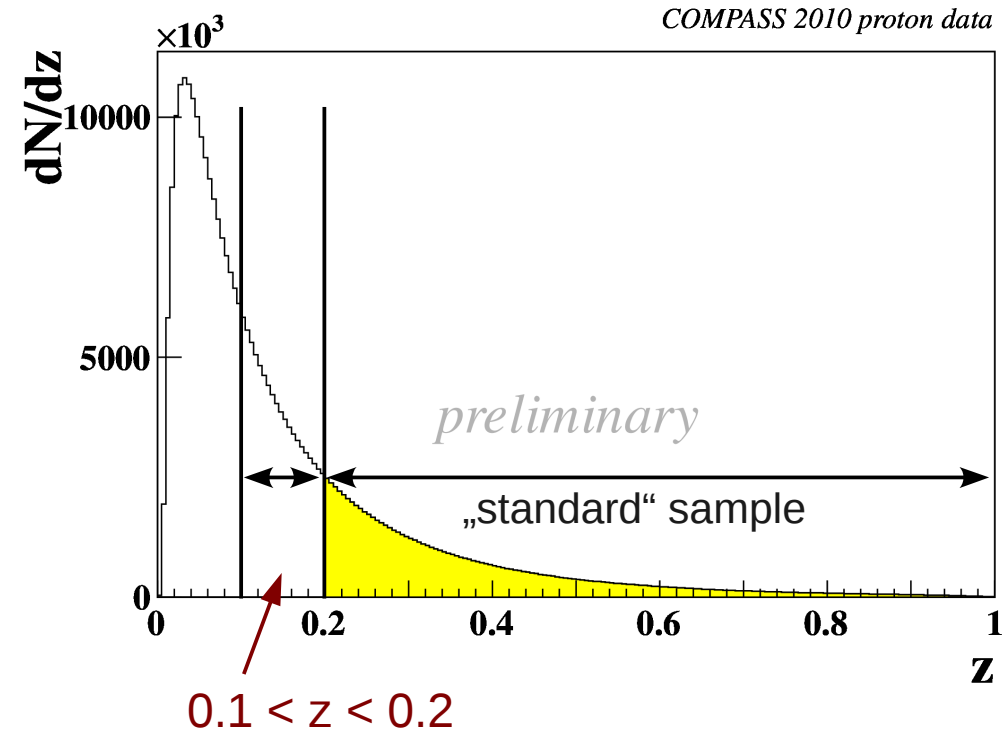


Exploration of different kinematic regions

low y : $0.05 < y < 0.1$

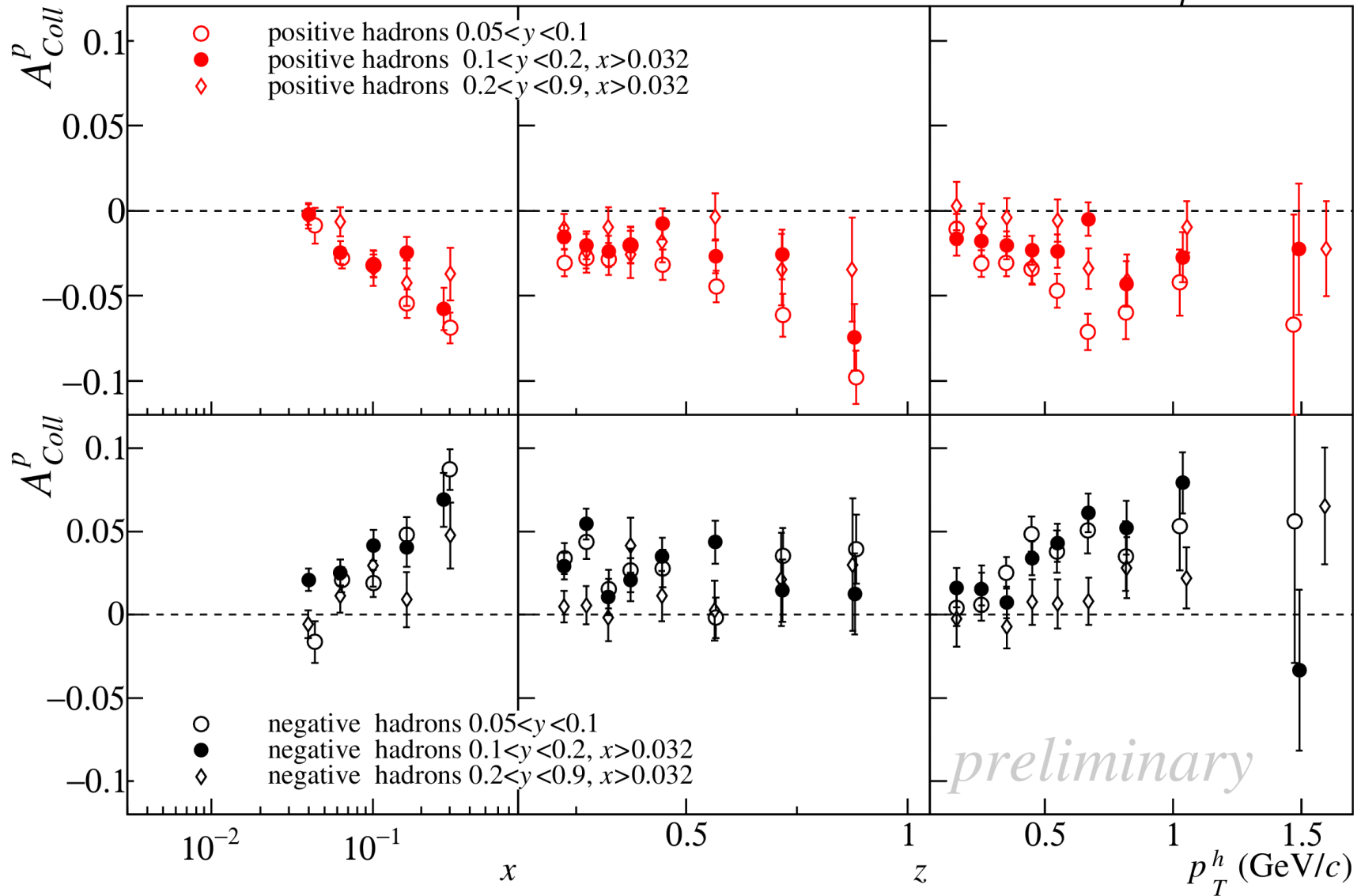


low z : $0.1 < z < 0.2$



3 y ranges – Collins asymmetry

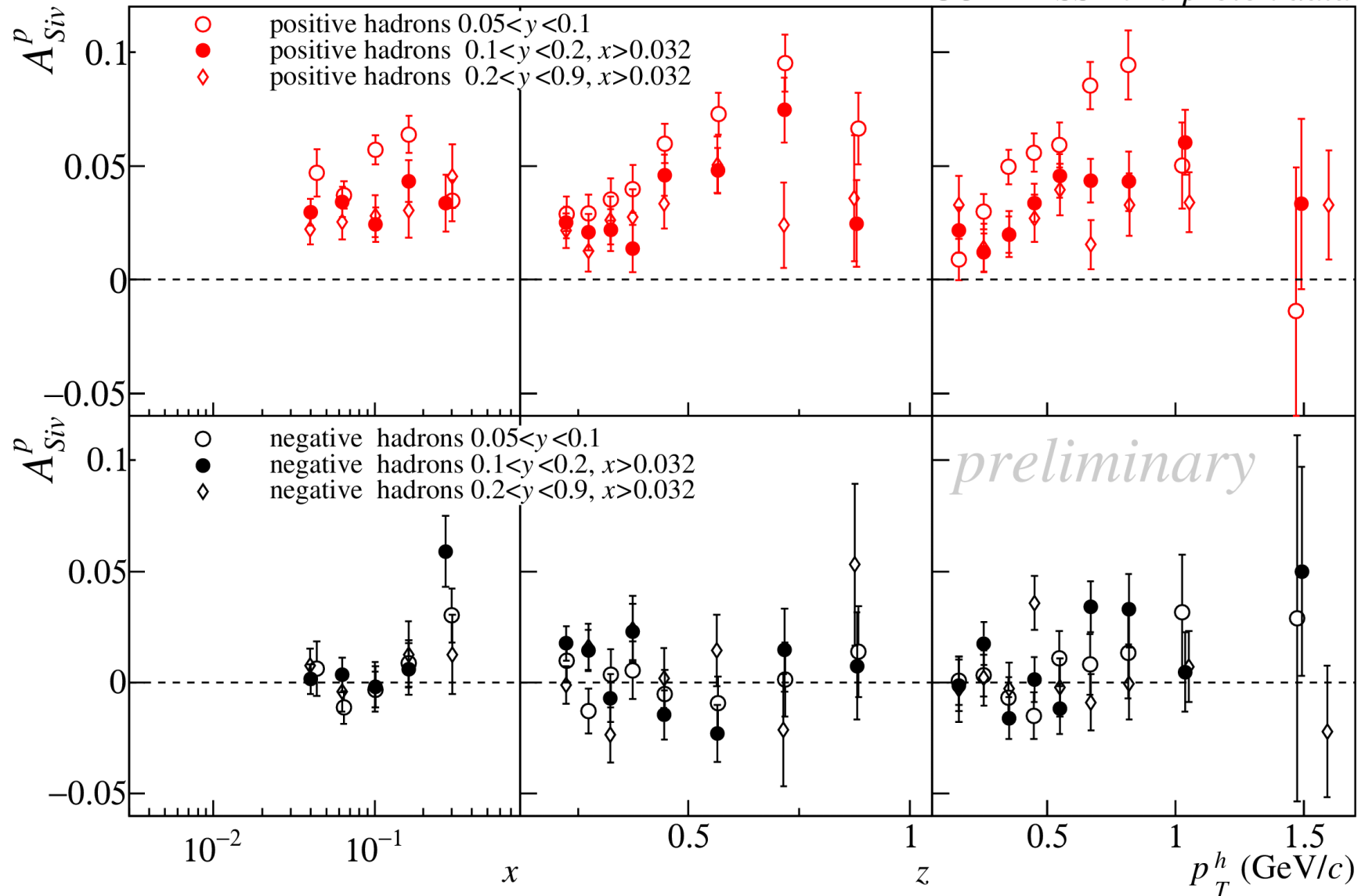
COMPASS 2010 proton data



small effect for positive hadrons

3 y ranges – Sivers asymmetry

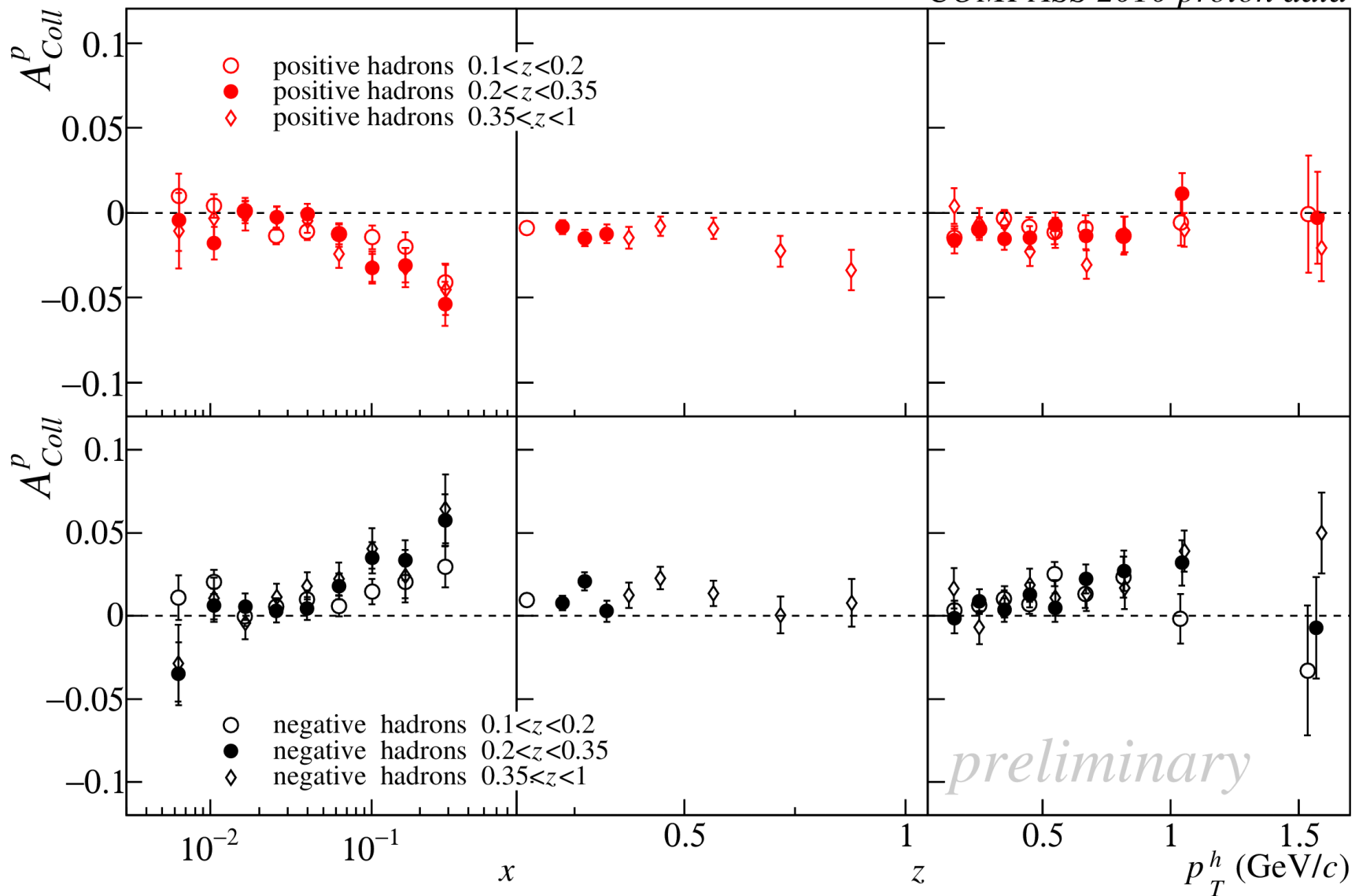
COMPASS 2010 proton data



clear increase of Sivers asymmetries for positive hadrons at low y

z in 3 ranges – Collins asymmetry

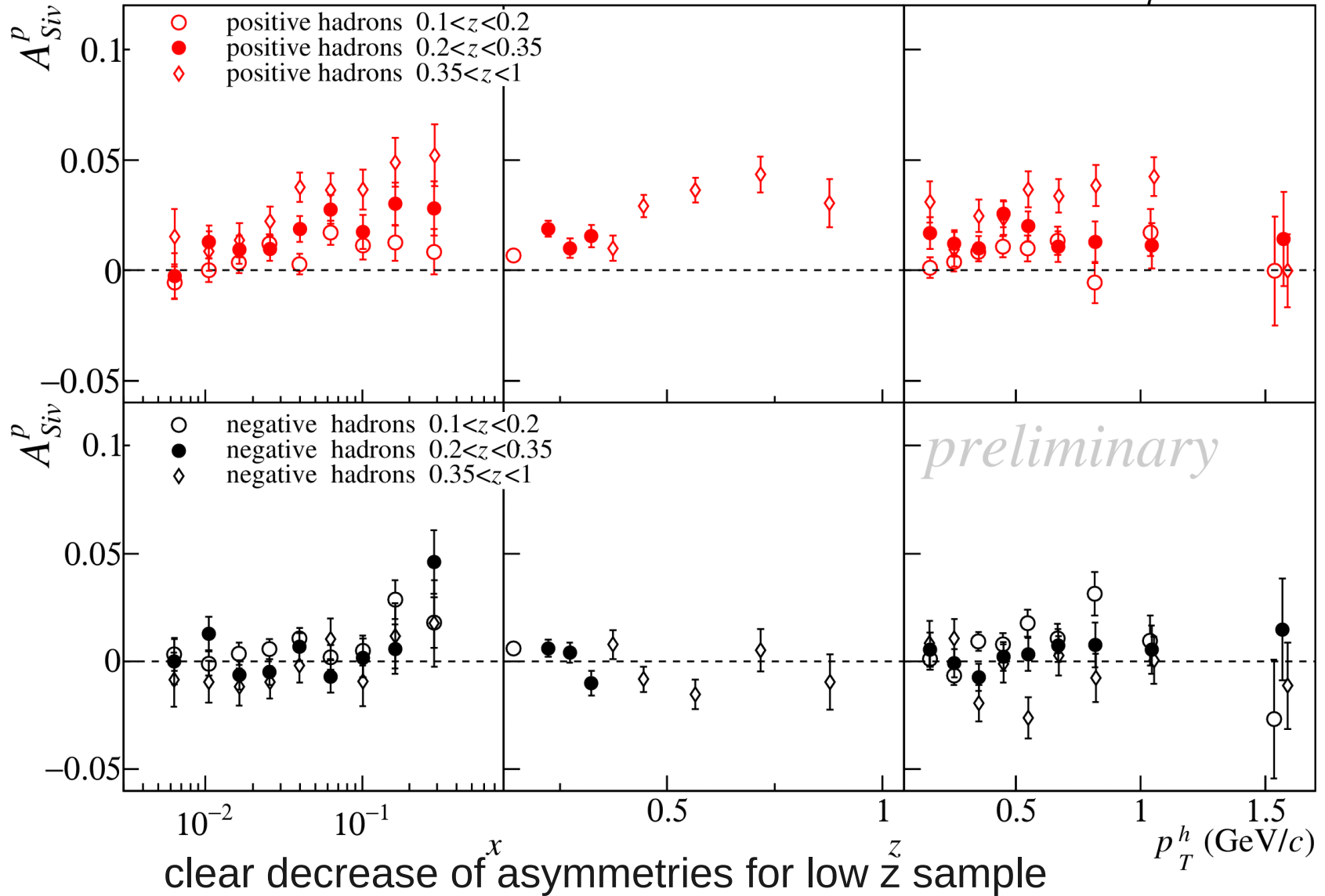
COMPASS 2010 proton data



small decrease of asymmetries for low z sample

z in 3 ranges – Sivers asymmetry

COMPASS 2010 proton data



Conclusions

2010: one year of data taking on a transversely polarized proton target

- higher statistics and smaller systematical errors
- confirmation of 2007 results
- both Collins and Sivers asymmetries are different from zero
- new investigation of z and y dependence with interesting results

- next: asymmetries for identified hadrons (pions, kaons)
extraction of the other 6 asymmetries

SPARES

Hadron statistics

2007

Charged hadrons

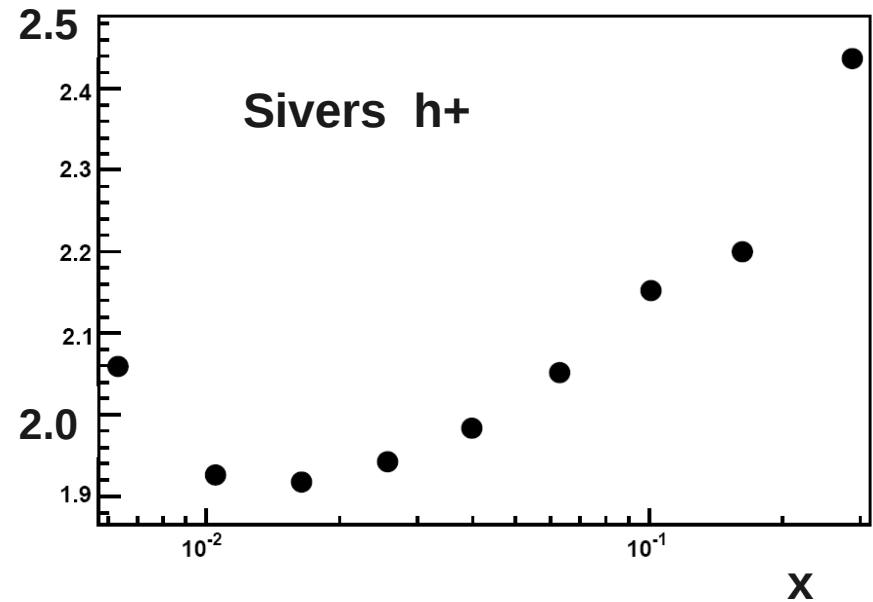
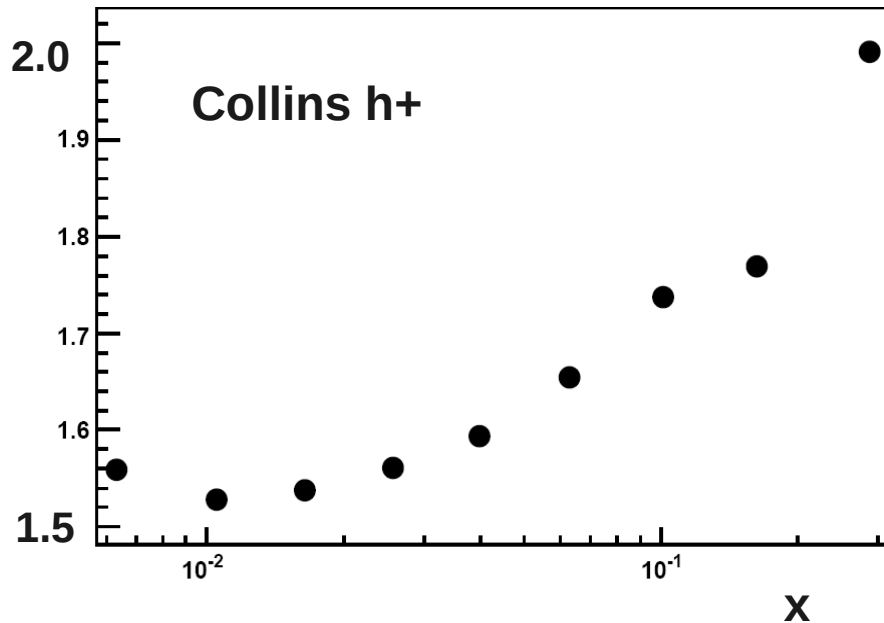
	h+	h-
Collins	15.1M	12.0M
Sivers	10.2M	8.1M

2010

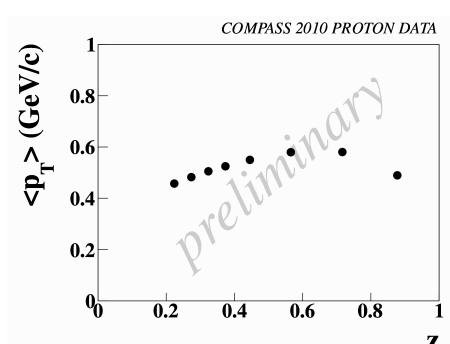
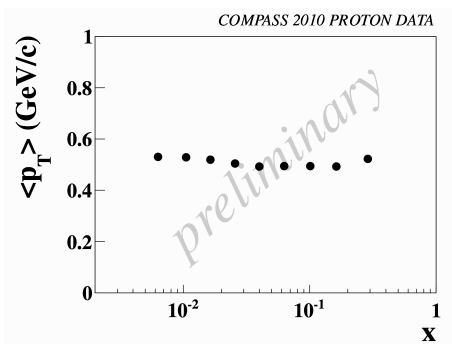
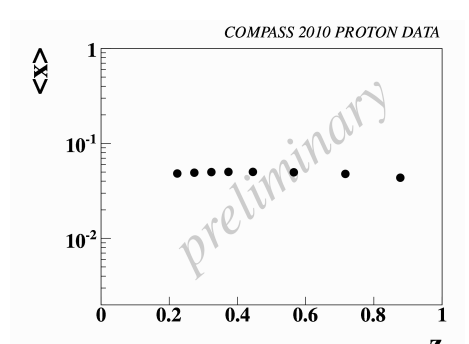
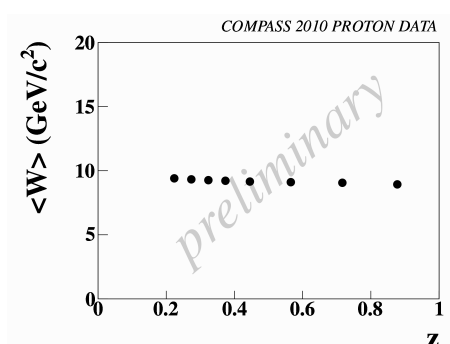
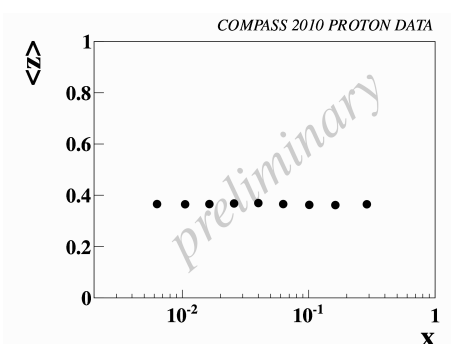
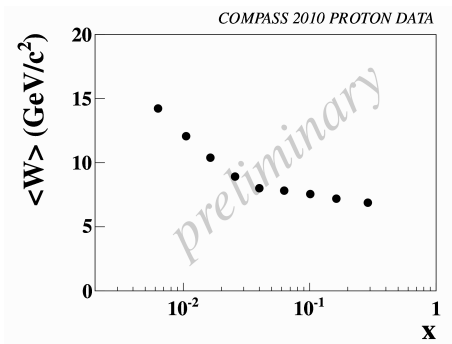
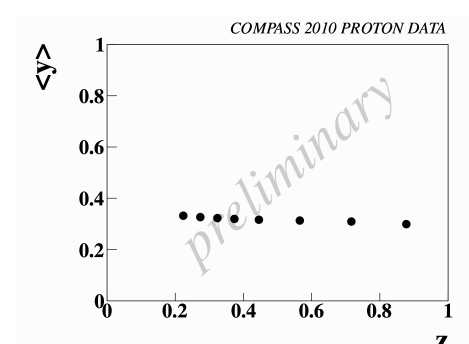
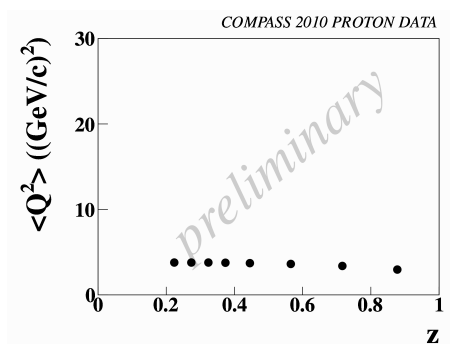
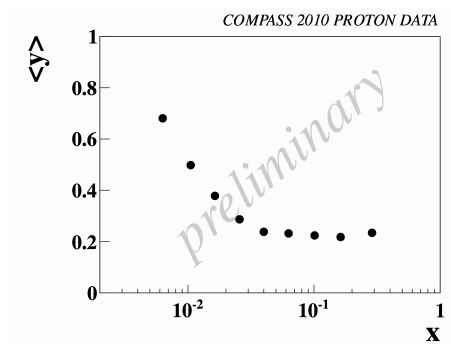
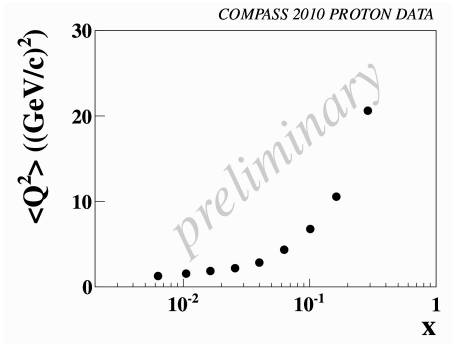
Charged hadrons

h+	h-
43M	34M

ratio of statistical errors: 2007 / 2010



mean variables in different bins



mean variables in different bins

