XIV WORKSHOP ON HIGH ENERGY SPIN PHYSICS
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Measurement of
Two Hadron Asymmetries
at COMPASS

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Outline

- *Theoretical motivation*
- *The Compass experiment*
- *Data selection*
- *Results*
- *Conclusions*

Theoretical motivations

Theoretical motivations

Three distribution functions are necessary to describe the structure of the nucleon at LO in the collinear case:

quark

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

Distribution functions

$f_1(x)$
unpolarized distribution functions
gives the probability of finding a quark with a fraction x of the longitudinal momentum of parent nucleon

$g_1(x)$
helicity distribution functions
gives the probability density of finding a quark with a momentum fraction x and spin parallel to that of the parent nucleon in a longitudinally polarized nucleon

$h_1(x)$
transversity distribution functions
gives the probability of finding a quark with a momentum fraction x and spin parallel to that of the parent nucleon in a transversely polarized nucleon.

Theoretical motivations

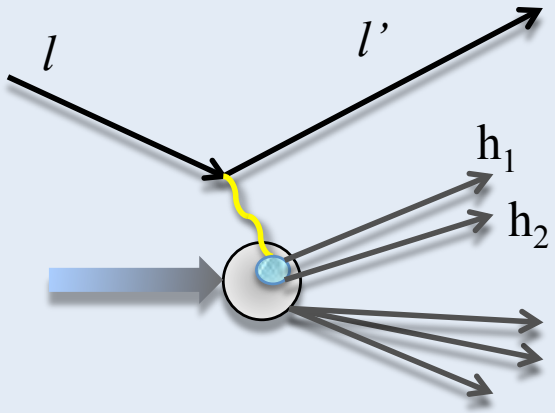
$h_1(x)$ is chiral-odd, not measurable in DIS but can be measure in SIDIS coupled with an other chiral-odd function. In COMPASS we measure:

$l\ N^{\uparrow} \rightarrow l'\,hX$ (**Collins asymmetry**: transversity PDF is coupled with Collins Fragmentation Function) (see Christoph Adolph talk!)

$l\ N^{\uparrow} \rightarrow l'\,\Lambda X$ (**Λ polarization**: transversity PDF is coupled with Fragmentation Function of q↑ in Λ)

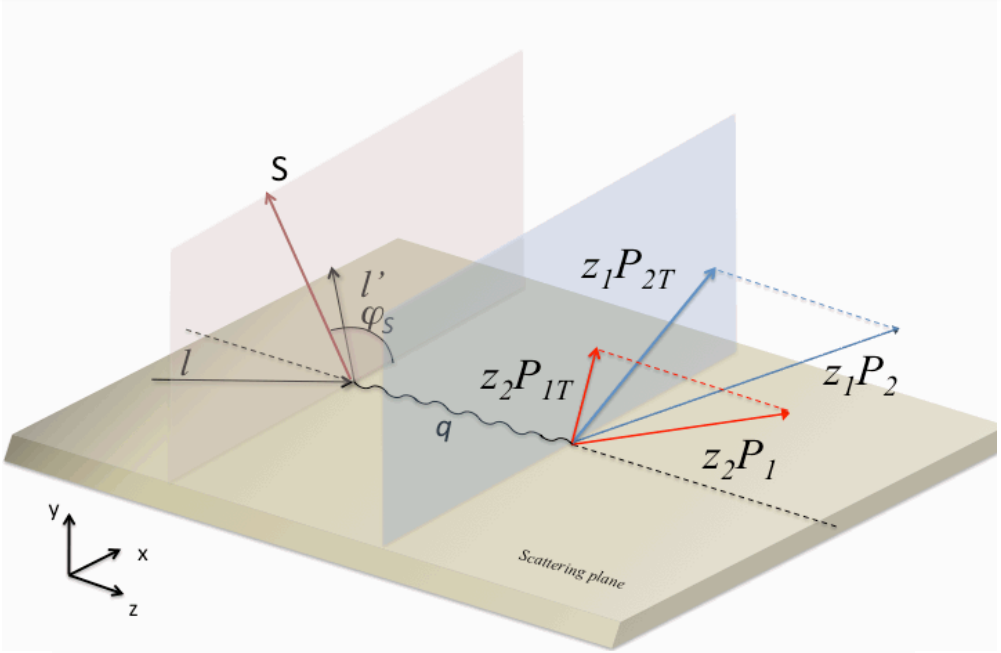
$l\ N^{\uparrow} \rightarrow l'\,h_1 h_2 X$ (**Two-hadron asymmetry**: transversity PDF is coupled with Di-hadron Fragmentation Function)

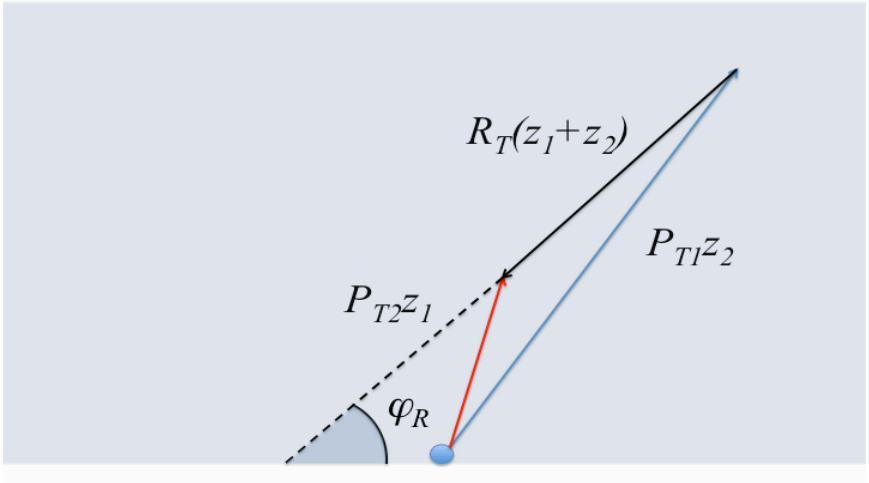
Di-hadron Fragmentation Function (*Di FF*)



describes the correlation between the transverse polarization of the fragmenting quark and the azimuthal arientation of the plain containing the momenta of the detected hadron pair

Theoretical motivations





Definitions

$$z_i = \frac{E_i}{E_{Tot}}$$

$$z = z_1 + z_2$$

$$\xi = \frac{z_1}{z}$$

$$R_T = \frac{z_1 P_{2T} - z_2 P_{1T}}{z_1 + z_2}$$

φ_S = azimuthal angle of the spin of the nucleon

φ_R = azimuthal angle of R_T

$$\varphi_{RS} = \varphi_R + \varphi_S - \pi$$

Theoretical motivations

Cross section

$$\frac{d^7\sigma}{d\xi dM_h d\varphi_{RS} dz dx dy} = \frac{2\alpha^2}{4\pi s x y^2} \sum_q e_q^2 \Big\{ A(y) f_1^q(x) D_1^{q\to h^+h^-}(z,\xi,M_h^2) + B(y)|S_\perp| \frac{|R_T|}{M_h} h_1^q(x) H_1^{\sphericalangle q\to h^+h^-}(z,\xi,M_h^2)\sin(\varphi_{RS}) \Big\}$$

Access Transversity

$$A_{2h} = \frac{\sum_q e_q^2 \frac{|R_T|}{M_h} h_1^q(x) H_1^{\sphericalangle q\to h^+h^-}(z,\xi,M_h^2)}{\sum_q e_q^2 f_1^q(x) D_1^{q\to h^+h^-}(z,\xi,M_h^2)}$$

Spin dependent Di-hadron FF

Pair production

$$N_{2h}^{\pm}(\varphi_{RS}) \propto (1 \pm |S_\perp| D_{NN} A_{2h} \sin\varphi_{RS})$$

- ± *nucleon spin orientation*
- $S_T = f P_T$

  P_T *nucleon polarization and* f *the fraction of polarized material in the target*
- $D_{NN} = B(y)/A(y) = (1-y)/(1-y+y^2/2)$

  (spin transfer coefficient from the initial to the struck quark)

The Compass experiment

The COMPASS experiment

- *Theoretical motivation*
- *The Compass experiment*
- *Data selection*
- *Results*
- *Conclusions*

The COMPASS experiment

COMPASS data taking

2002
2003
2004 — Polarized *deuteron* target — longitudinal 75%, transverse 25%

2005 — *CERN shutdown*

2006 — Longitudinal polarized *deuteron* target

2007 — Polarized *proton* target — longitudinal 50%, transverse 50%

2008/2009 spectroscopy

2010 — Trasversely polarized *proton* target

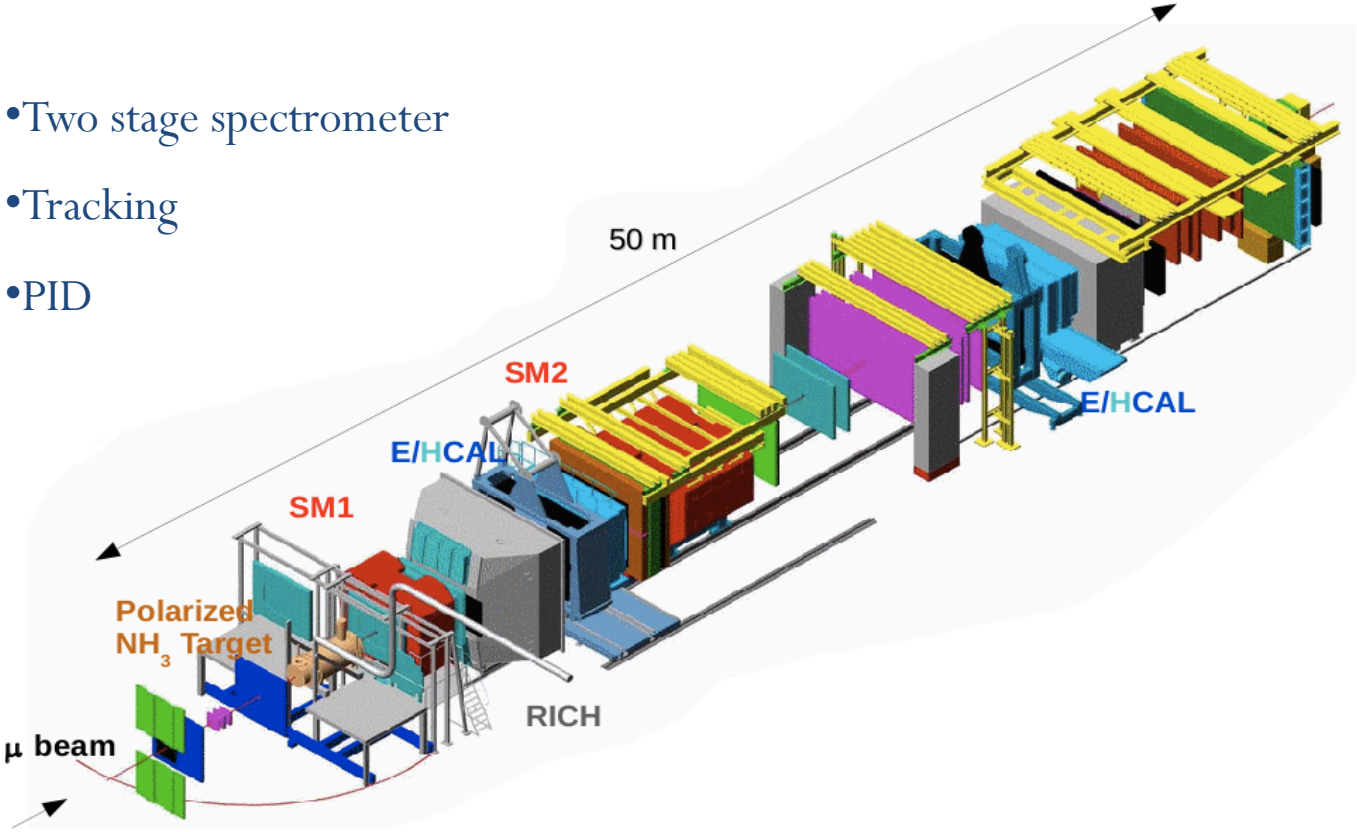
2011 — Longitudinal polarized *proton* target

The COMPASS experiment

•Two stage spectrometer

•Tracking

•PID



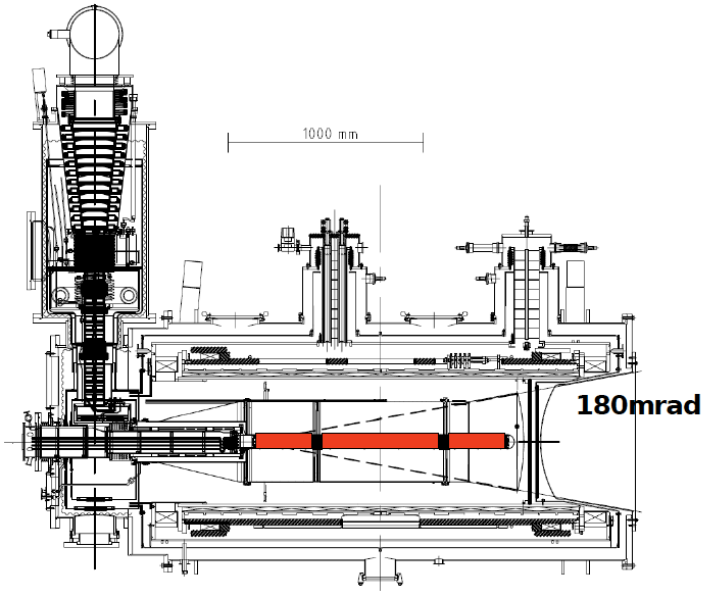
For the study of the spin structure of the nucleon

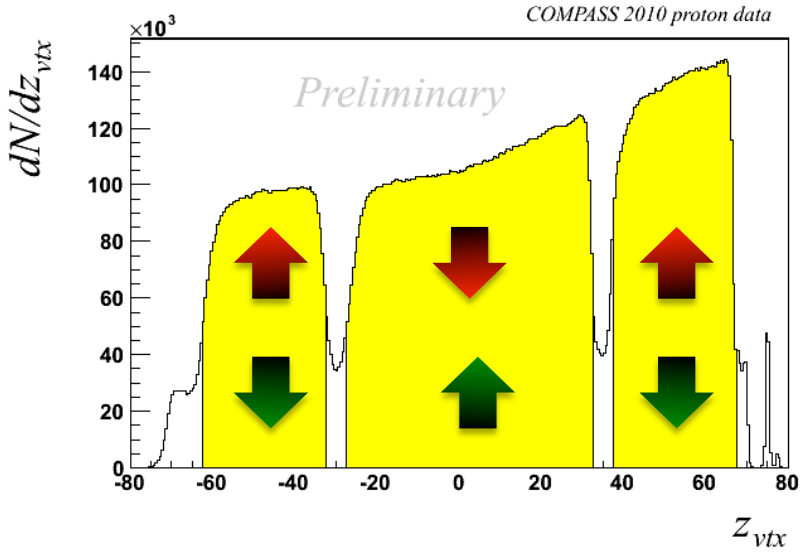
•Longitudinal polarized μ^+ beam with momentum 160 Gev/c

•Intensity 2×10^8 μ^+/spill Luminosity $5\times10^{32}cm^{-2}\ s^{-1}$

•400 TB of data per year

The COMPASS experiment





- ± 180 mrad geometrical acceptance
- Three cells with opposite polarization
- Transverse polarization reversed every week

○ ^{6}LiD (deuteron)

- *polarization ≈ 48%*
- *diluition factor ≈0.38*

○ NH_3 (proton)

- *polarization ≈90%*
- *diluition factor ≈0.15*

Data selection

Data selection

DIS cuts:

$Q^2 > 1 GeV/c^2$

$0.1 < y < 0.9$

$W > 5\ GeV/c^2$

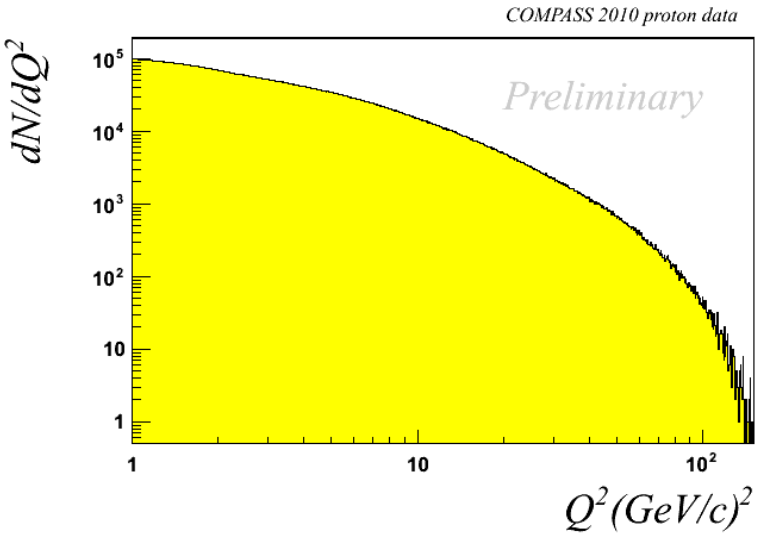
hadron pair selection:

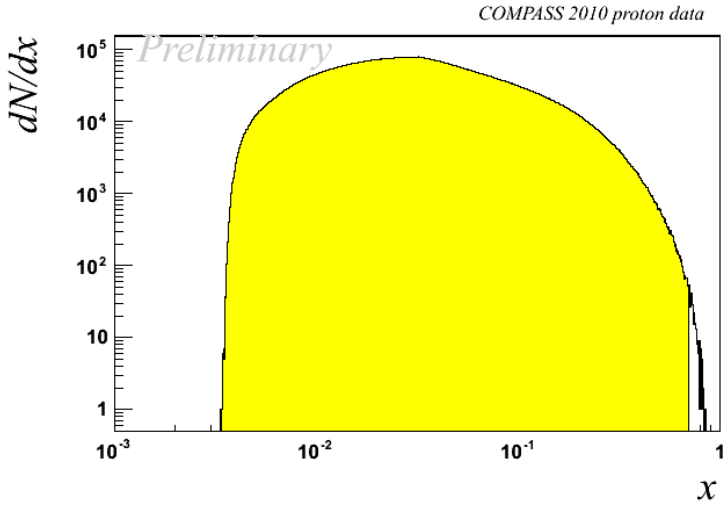
$z_i > 0.1$

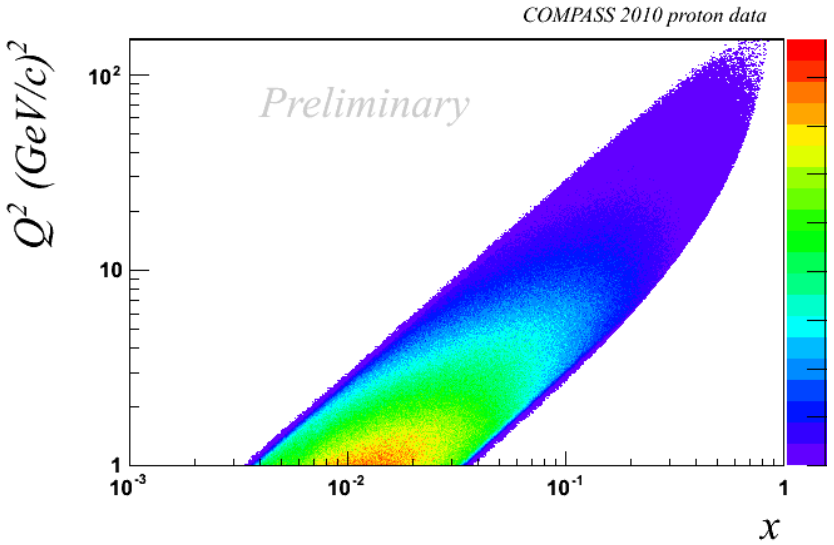
$x_{iF} > 0.1$

$R_T > 0.07\ GeV$

$E_{miss} > 3\ GeV$







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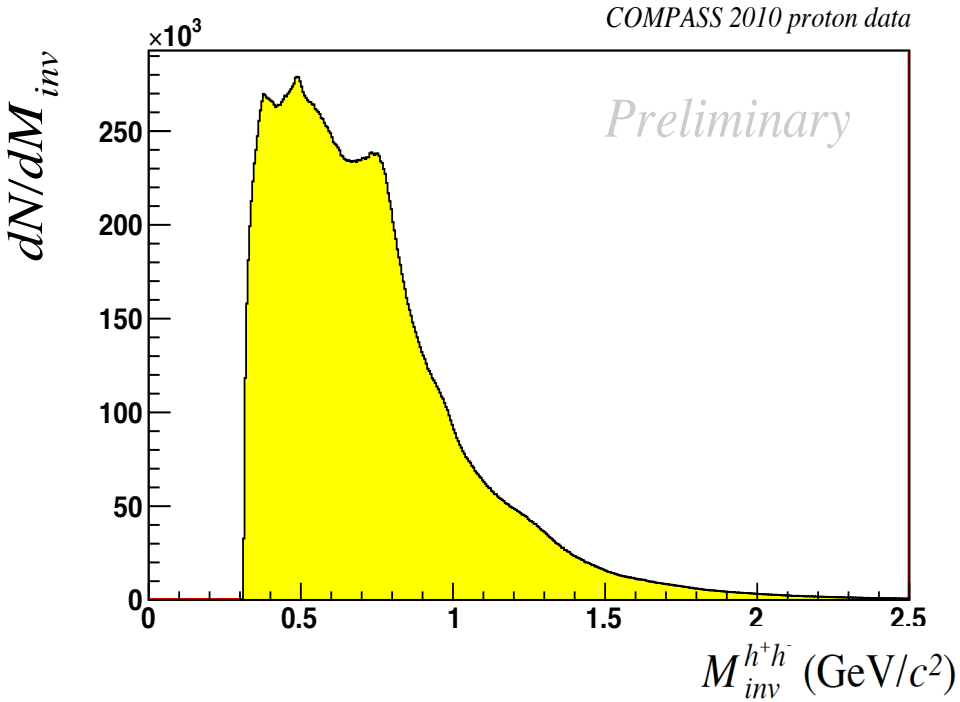
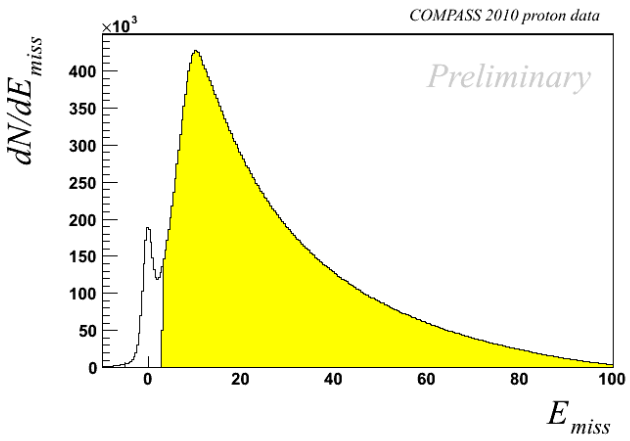
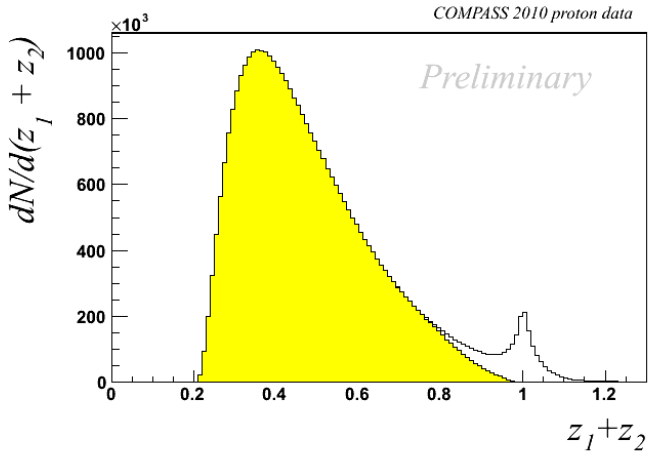


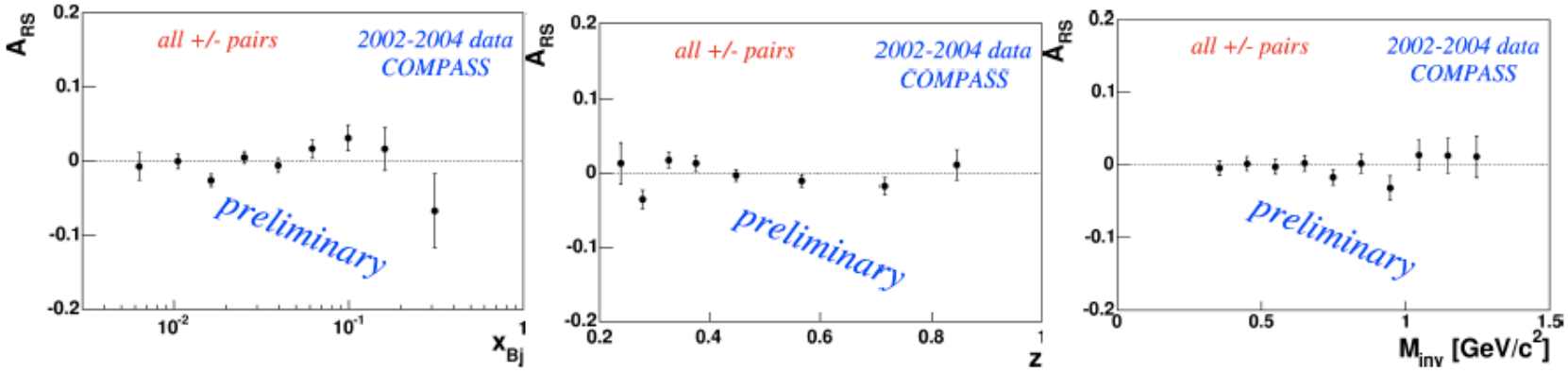




Results

Results : 2002-2004 deuteron data

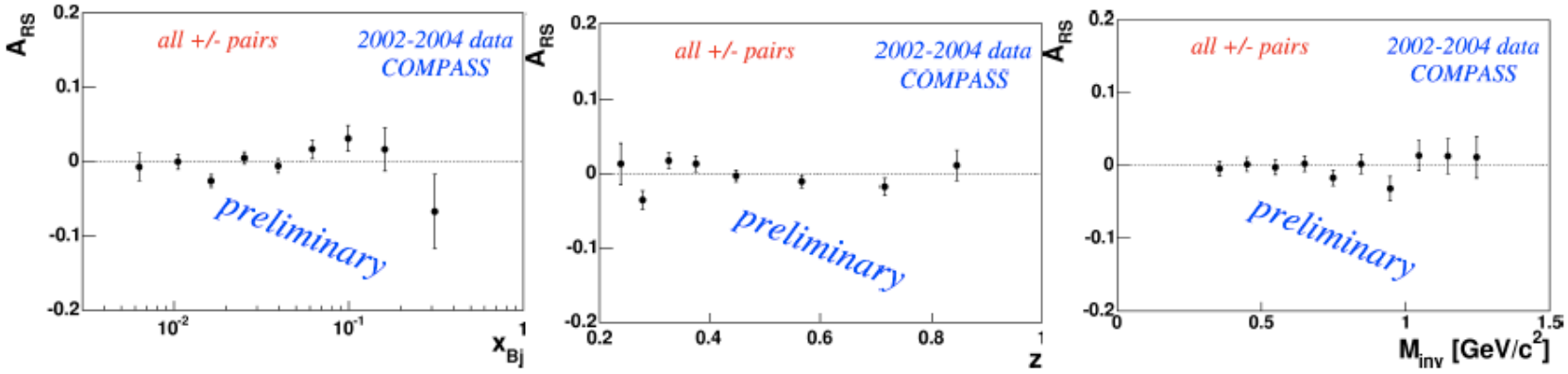
Asymmetries for h^+h^- pairs on 2002-2004 deuteron data



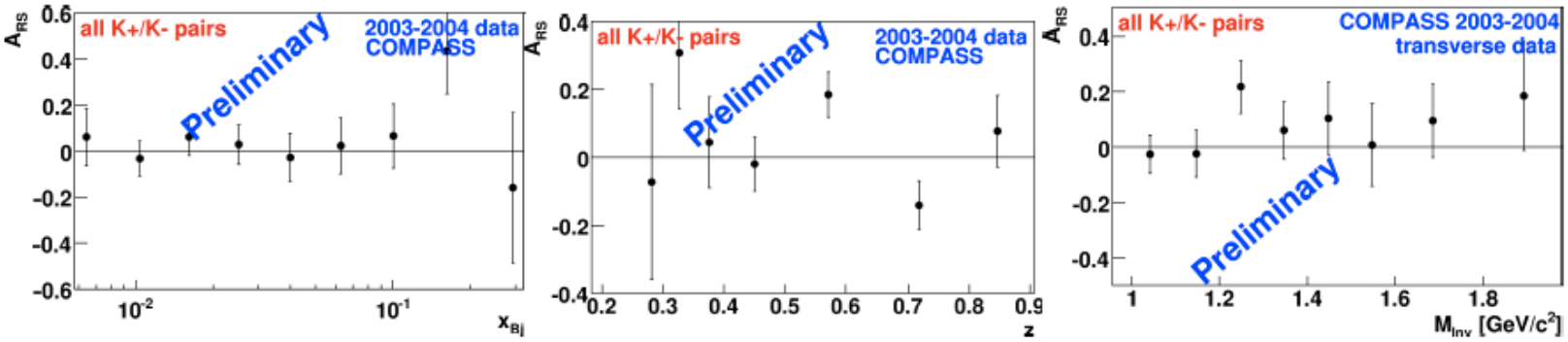
All the asymmetries are compatible with zero

Results : 2002-2004 deuteron data

Asymmetries for h^+h^- pairs on 2002-2004 deuteron data

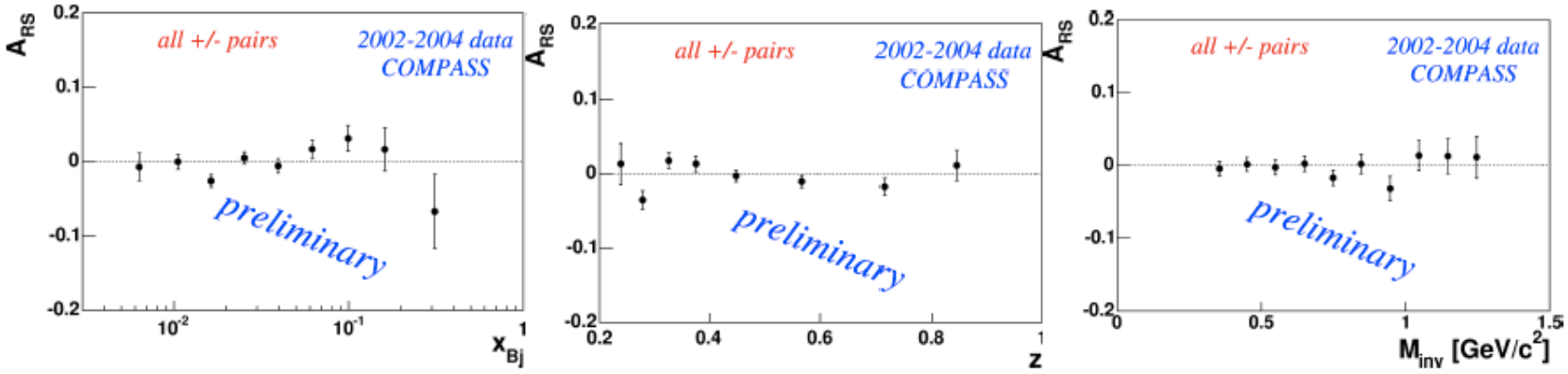


Asymmetries for K^+K^- pairs on 2003-2004 deuteron data

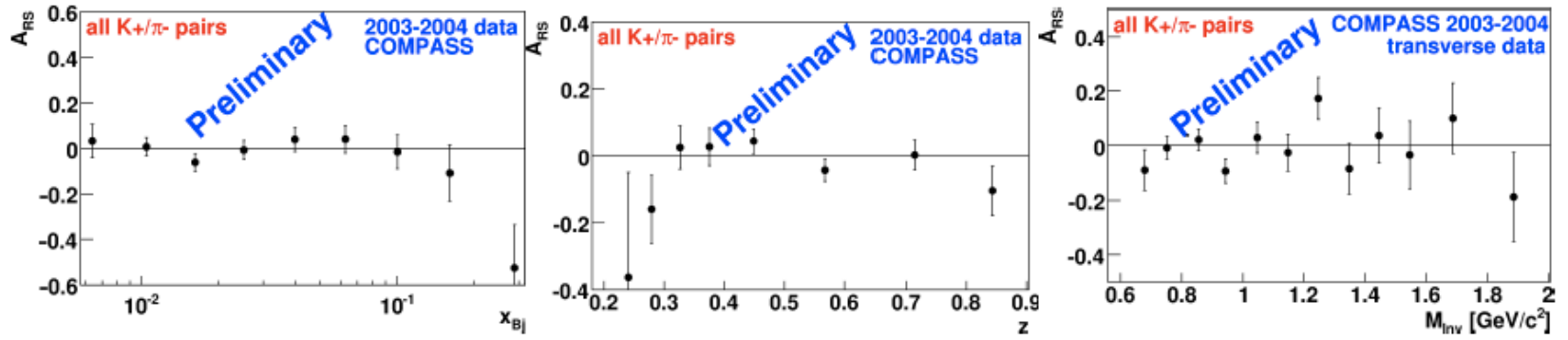


Results : 2002-2004 deuteron data

Asymmetries for h^+h^- pairs on 2002-2004 deuteron data

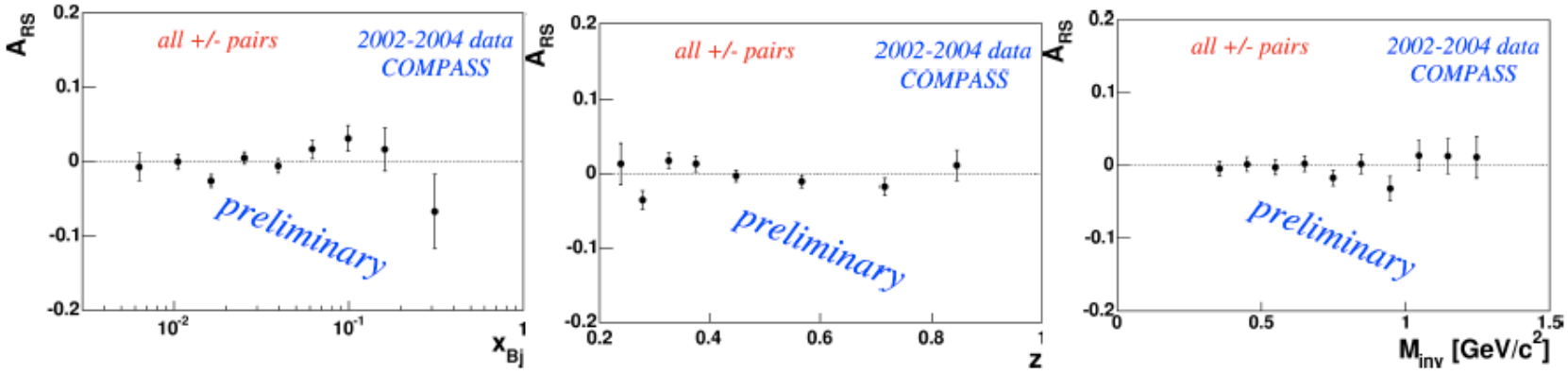


Asymmetries for $K^+\pi^-$ pairs on 2003-2004 deuteron data

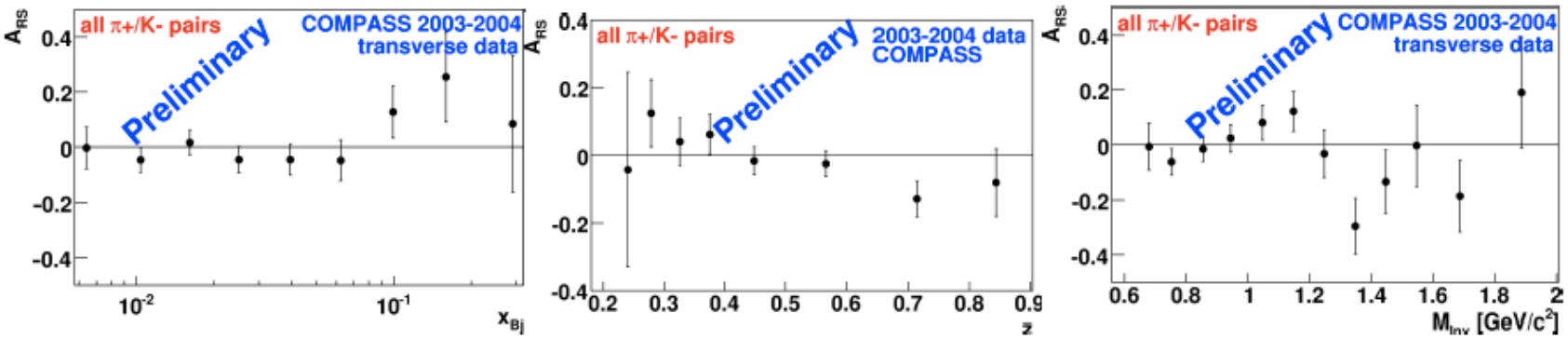


Results : 2002-2004 deuteron data

Asymmetries for h^+h^- pairs on 2002-2004 deuteron data

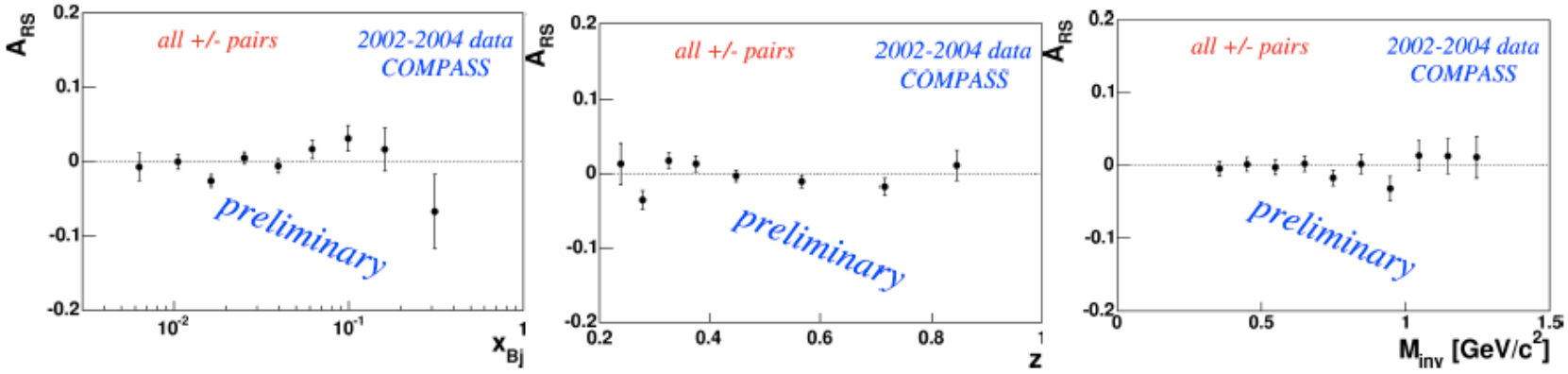


Asymmetries for π^+K^- pairs on 2003-2004 deuteron data

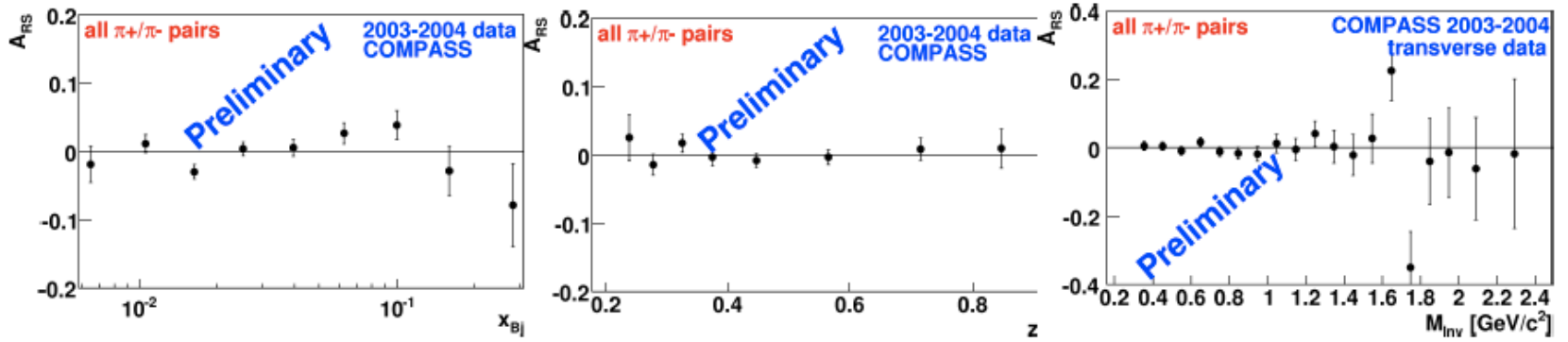


Results : 2002-2004 deuteron data

Asymmetries for h^+h^- pairs on 2002-2004 deuteron data

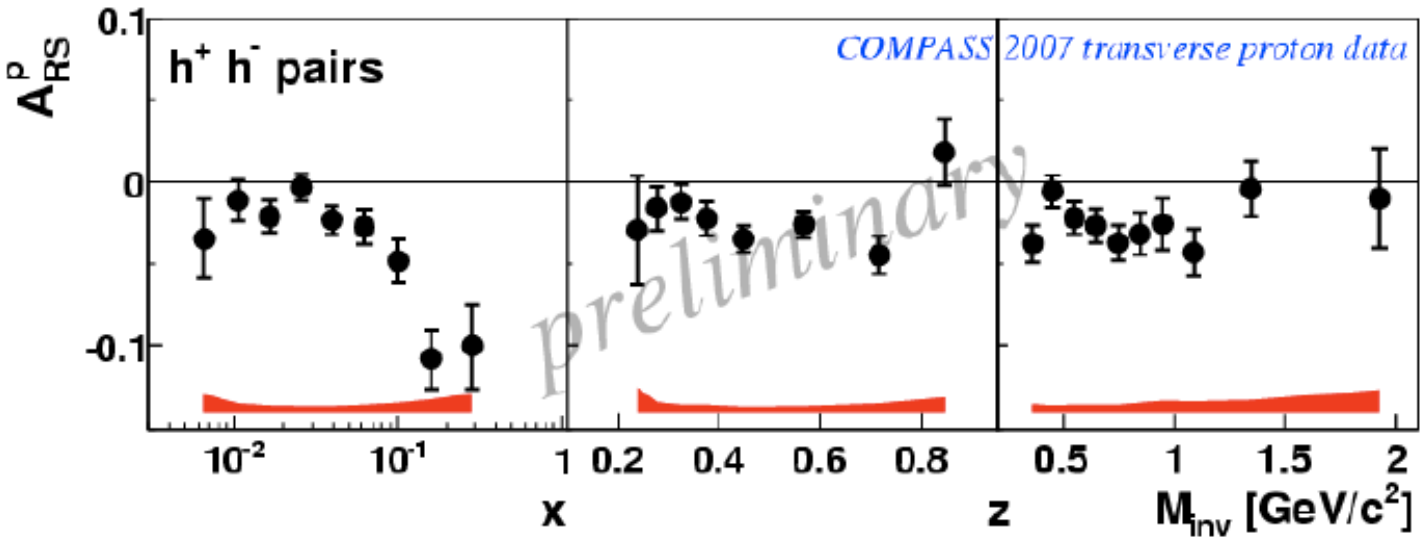


Asymmetries for $\pi^+\pi^-$ pairs on 2003-2004 deuteron data



Results : 2007 proton data

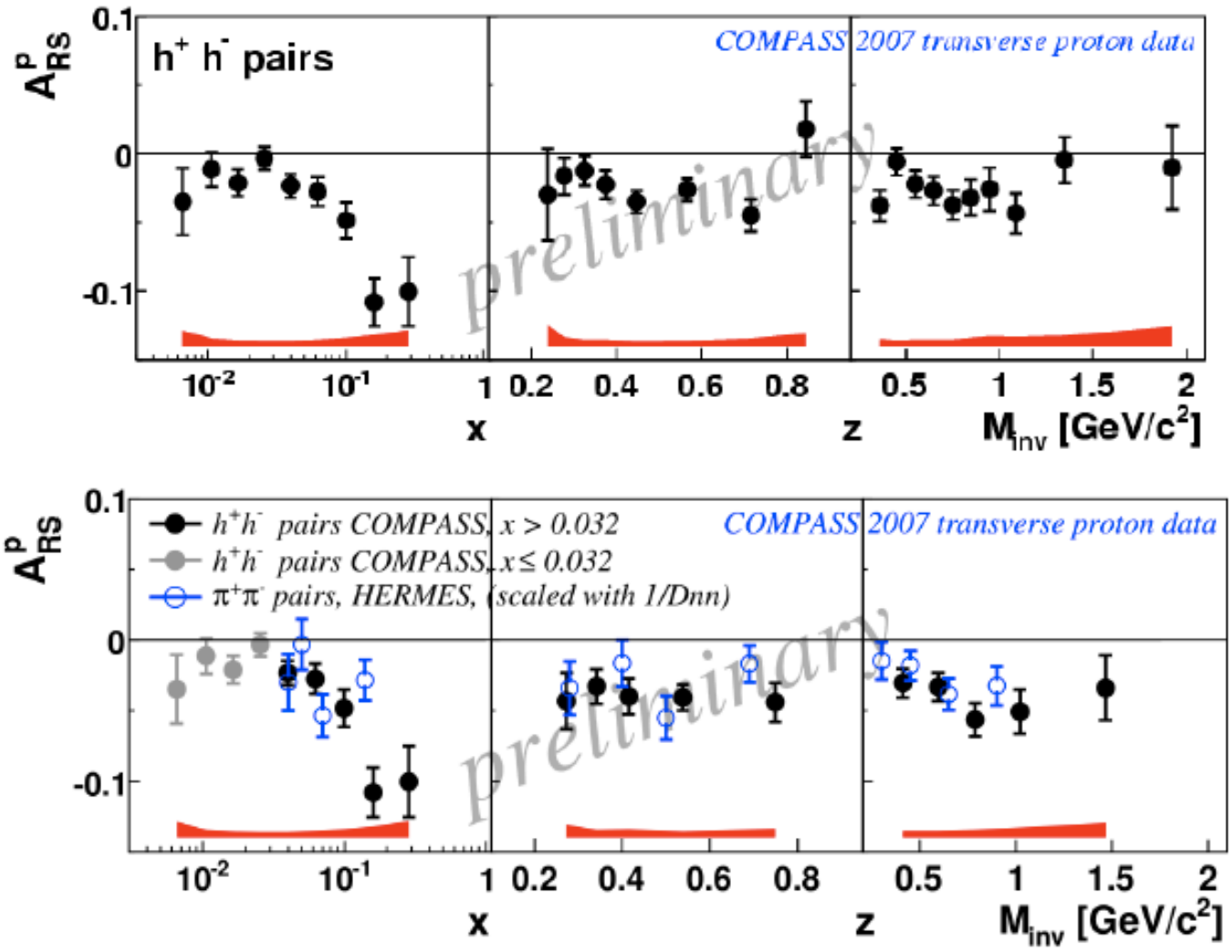
Asymmetries for h^+h^- pairs on 2007 proton data



Large signal up to 5-10 % in the valence region

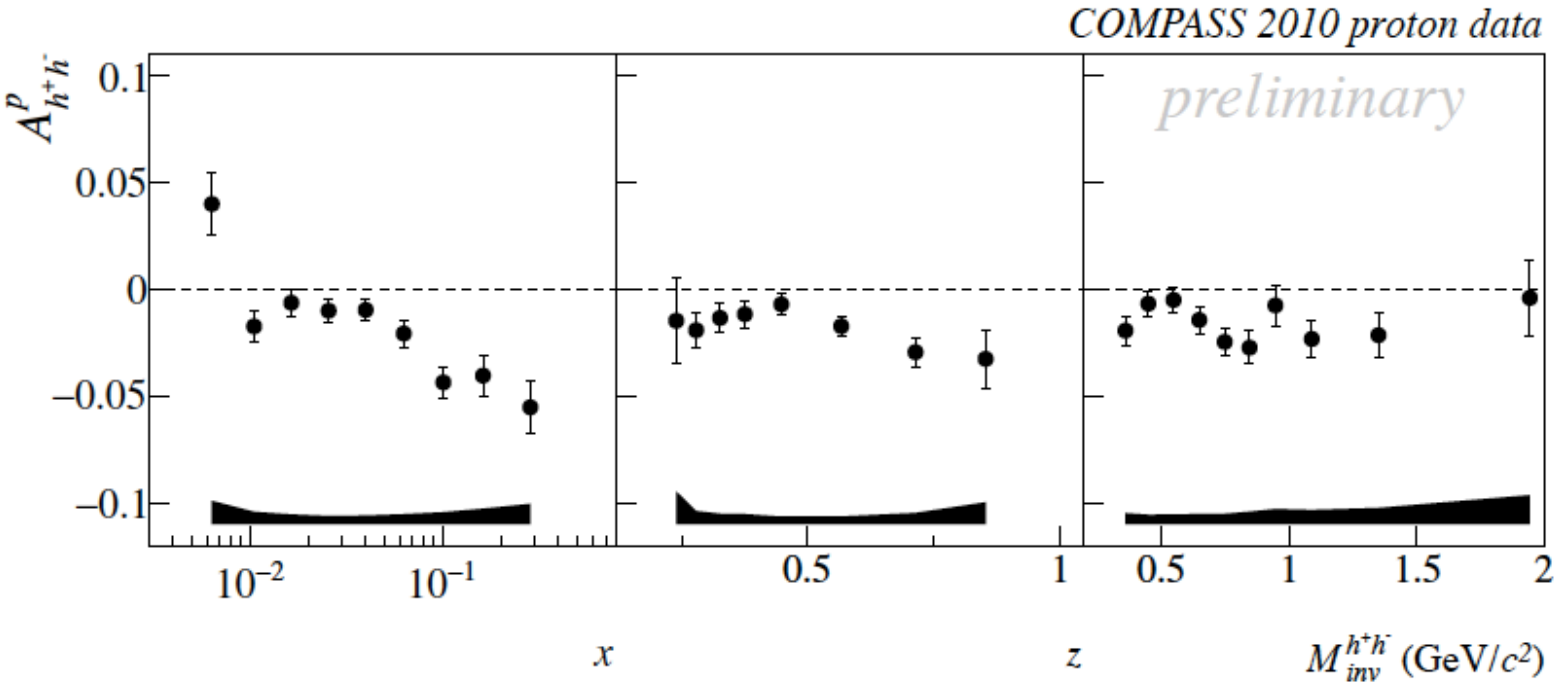
Results : 2007 proton data

2007 proton data : comparison with Hermes results



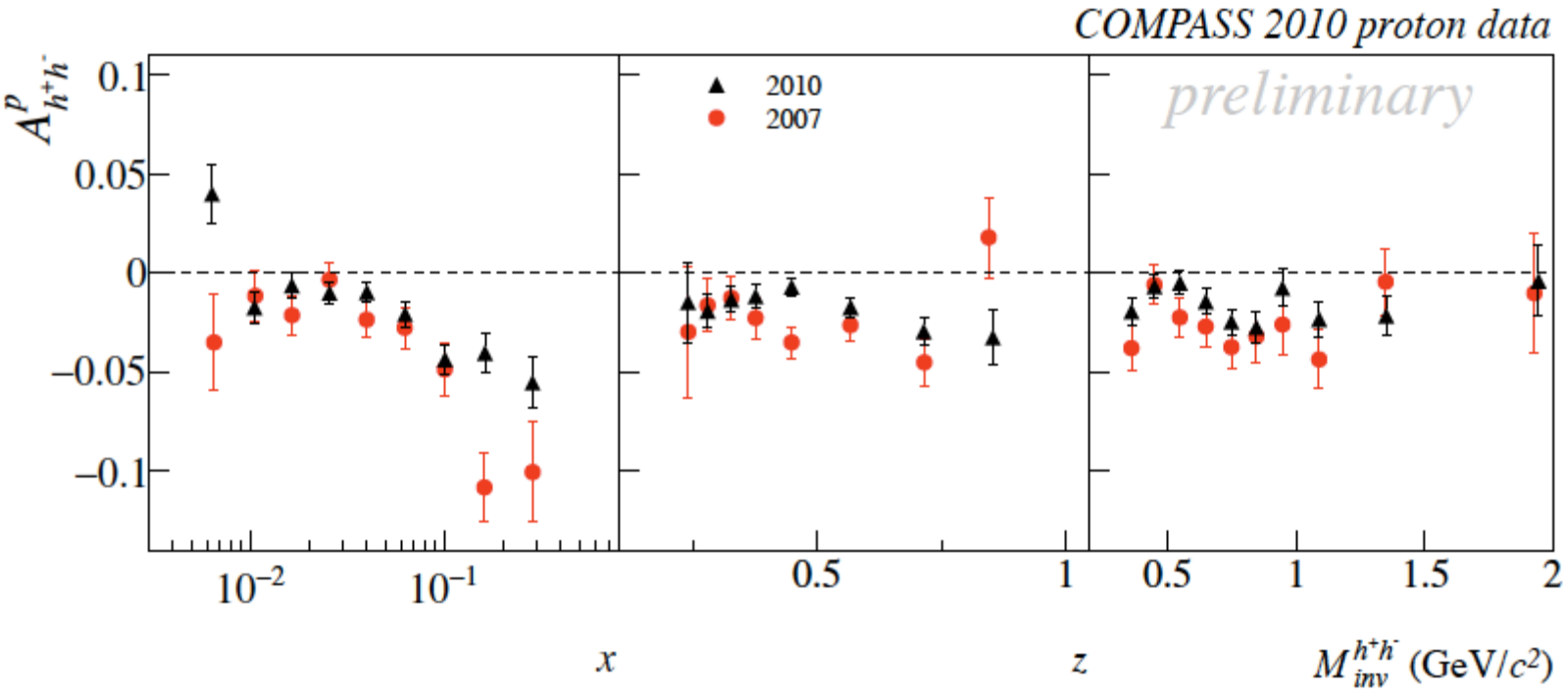
Results : 2010 proton data

Asymmetries for h^+h^- pairs on 2010 proton data first time presented at *Transversity 2011* conference



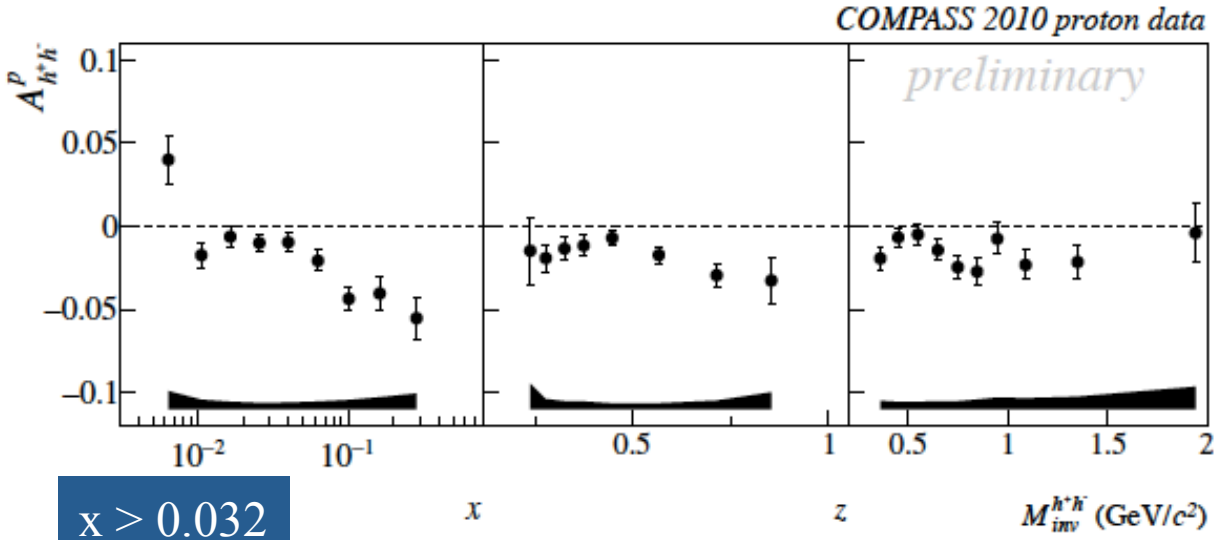
Results : 2010 proton data

2010 proton data : comparison with 2007 results

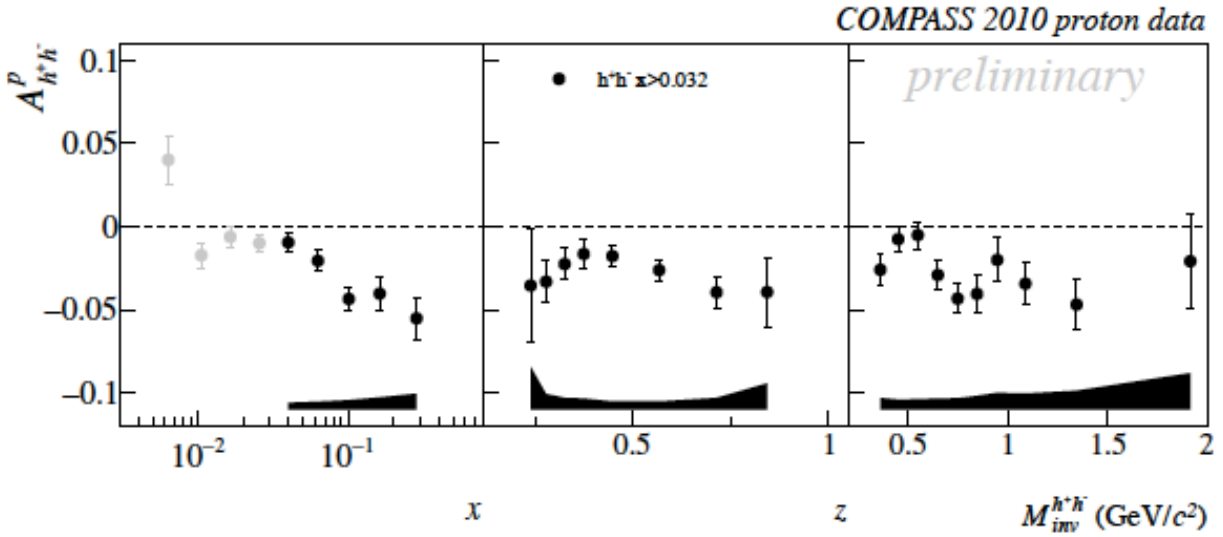


Good agreement between the results

Results : 2010 proton data



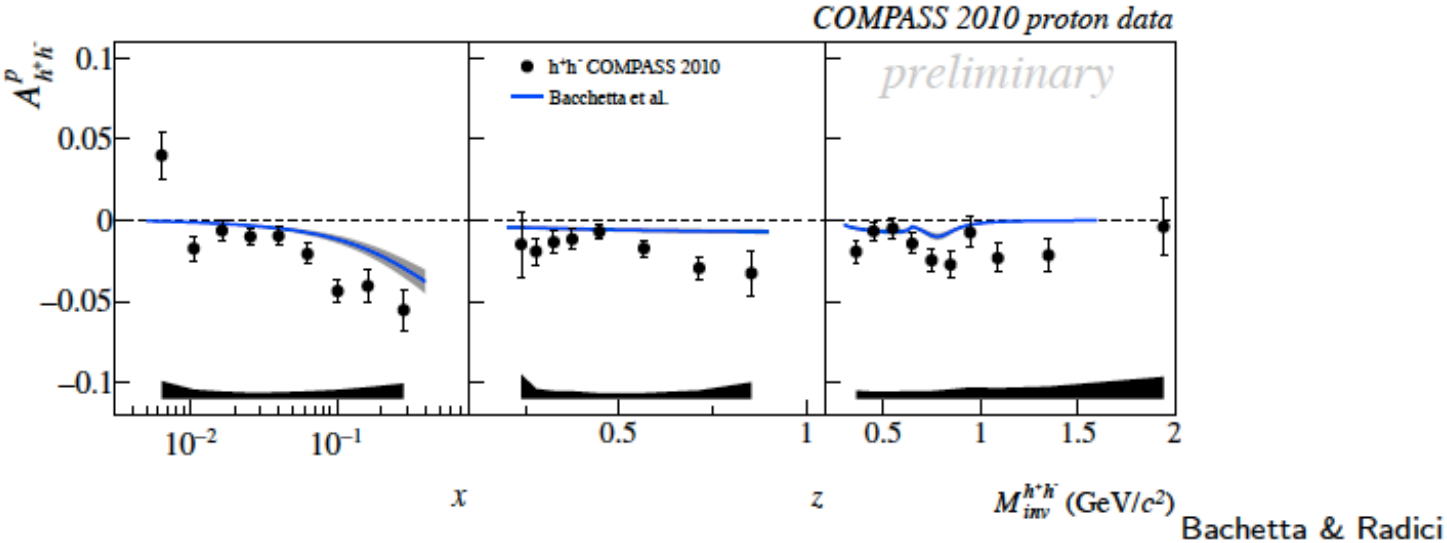
x > 0.032



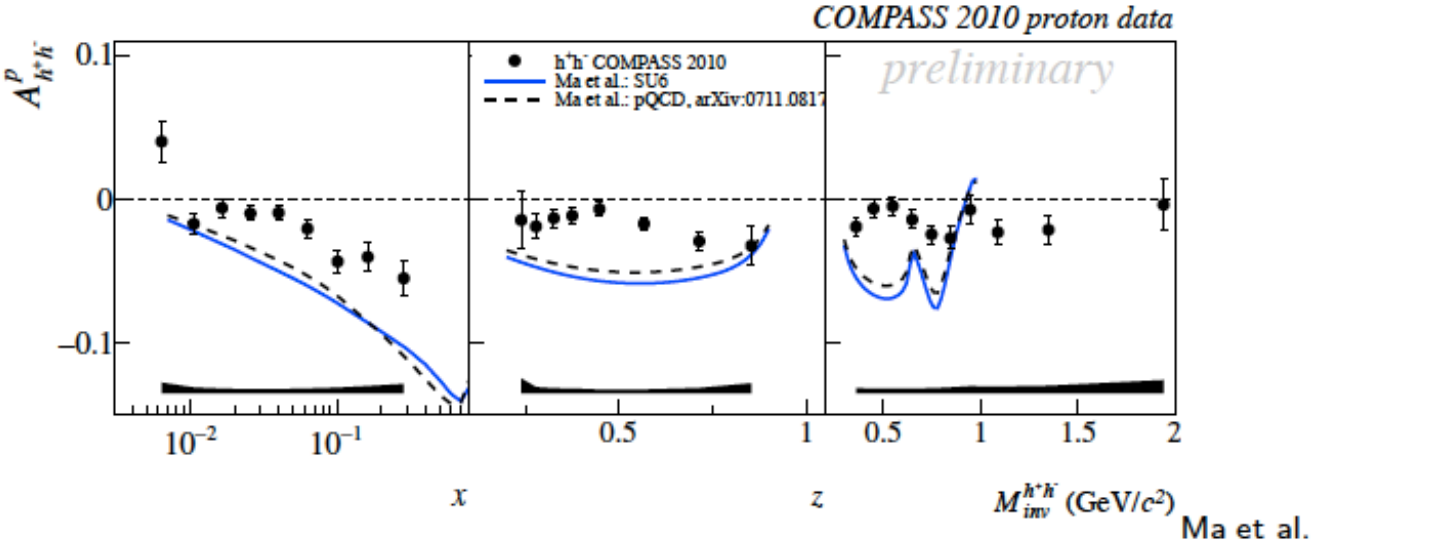
this selection makes the M_{inv} dependence more clear

Results : 2010 proton data

2010 proton data : comparison with model predictions

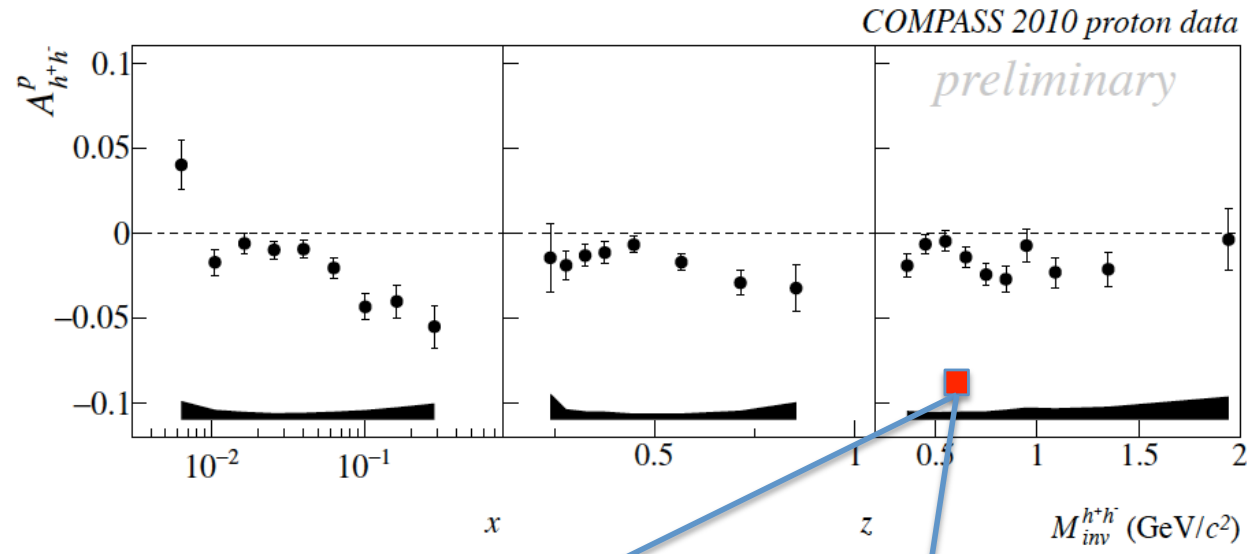


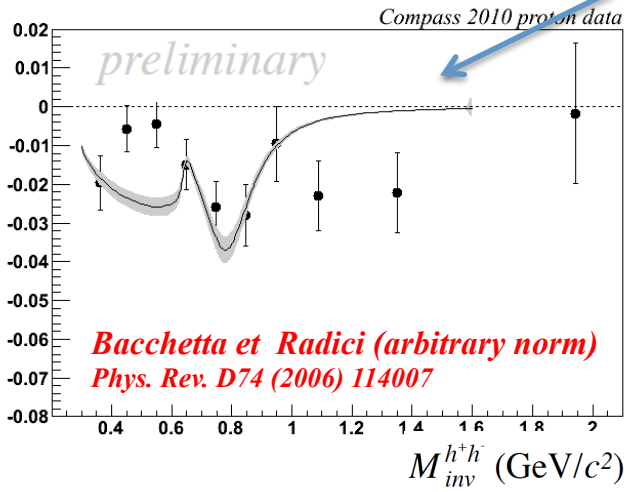
Bachetta & Radici

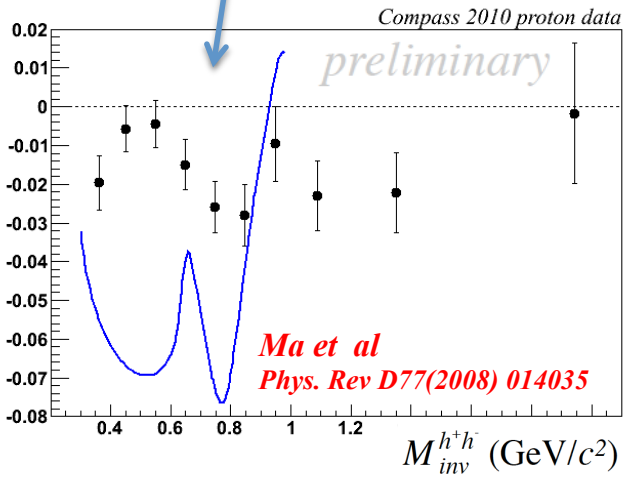


Ma et al.

Results : 2010 proton data







Not a very good agreement

Conclusions and Outlook

Summarizing COMPASS results

- All asymmetries on deuteron compatible with zero

- Asymmetries on proton for h^+h^- from the 2007 data

  clear signal in the valence region as large as Collins asymmetry on p

- Asymmetries on proton for h^+h^- from the 2010 data

  in agreement with the 2007 results and with better statistics

  interesting dependence on the Invariant Mass

coming soon...

two hadron asymmetries for identified particles

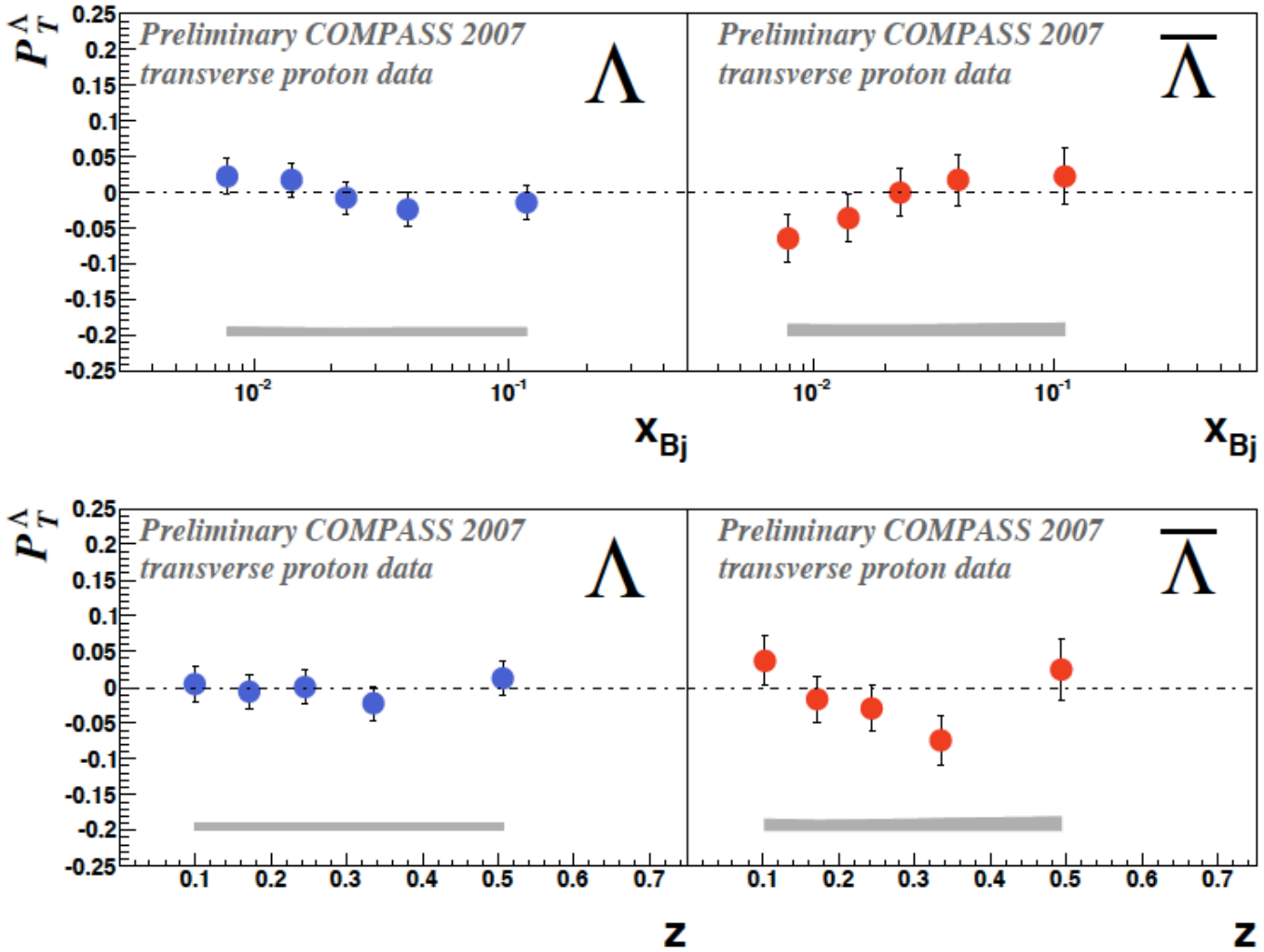
Also thanks to the large statistic collected in 2010 further studies on kinematical dependece can be performed

Conclusions and Outlook

Thank you for the attention !

Back up

Transverse Λ and $\overline{\Lambda}$ polarizations as a function of x_{Bj} and z in the 2007 data.



Missing Energy definition

$$P^{\mu} = proton\ \ 4-vector$$

$$Q^{\mu} = photon\ \ 4-vector$$

$$D^{\mu} = Di-hadron\ \ 4-vector\ \ (P^{\mu}_{h_1} + P^{\mu}_{h_{21}})$$

$$E_{miss} = \frac{(P^{\mu} + Q^{\mu} - D^{\mu})^2 - M_P^2}{2M_P}$$