EINN 2009

Measurement of TMDs in Semi-Inclusive DIS at COMPASS

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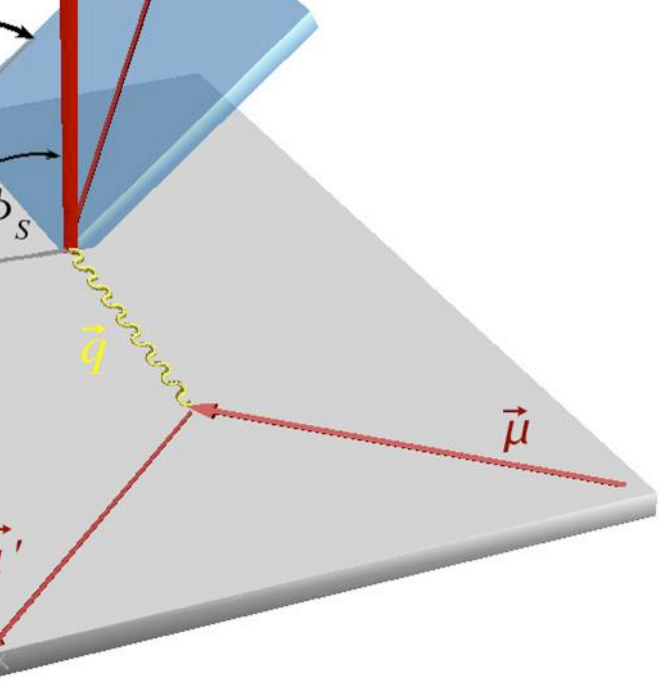
on behalf of the

COMPASS Collaboration

bmb+f - Förderschwerpunkt

COMPASS

Großgeräte der physikalischen Grundlagenforschung



ive of the talk

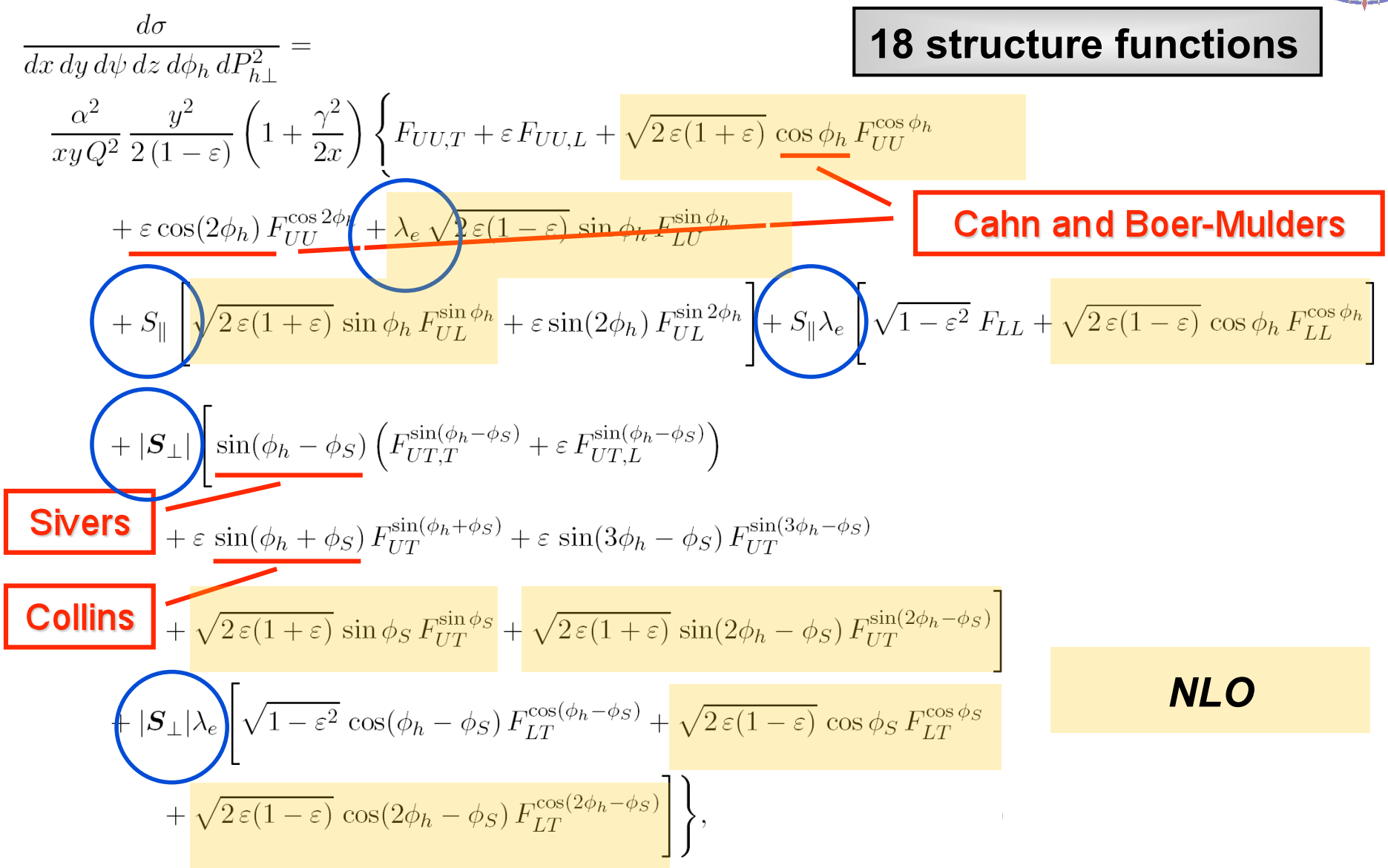
reactions in one photon exchange

$\delta\,\delta$

Skip intro

Full intro

Full SIDIS cross-section in NLO



$$\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_h\,dP_{h\perp}^2} =$$

$$\frac{\alpha^2}{xyQ^2}\,\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Big\{F_{UU,T}+\varepsilon F_{UU,L}+\sqrt{2\,\varepsilon(1+\varepsilon)}\,\cos\phi_h\,F_{UU}^{\cos\phi_h}$$

$$+\,\varepsilon\cos(2\phi_h)\,F_{UU}^{\cos 2\phi_h}+\lambda_e\sqrt{2\,\varepsilon(1-\varepsilon)}\,\sin\phi_h\,F_{LU}^{\sin\phi_h}$$

$$+\,S_\parallel\Big[\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_h\,F_{UL}^{\sin\phi_h}+\varepsilon\sin(2\phi_h)\,F_{UL}^{\sin 2\phi_h}\Big]+S_\parallel\lambda_e\Big[\sqrt{1-\varepsilon^2}\,F_{LL}+\sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_h\,F_{LL}^{\cos\phi_h}\Big]$$

$$+\,|\boldsymbol{S}_\perp|\Big[\sin(\phi_h-\phi_S)\left(F_{UT,T}^{\sin(\phi_h-\phi_S)}+\varepsilon\,F_{UT,L}^{\sin(\phi_h-\phi_S)}\right)$$

$$+\,\varepsilon\,\sin(\phi_h+\phi_S)\,F_{UT}^{\sin(\phi_h+\phi_S)}+\varepsilon\,\sin(3\phi_h-\phi_S)\,F_{UT}^{\sin(3\phi_h-\phi_S)}$$

$$+\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_S\,F_{UT}^{\sin\phi_S}+\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin(2\phi_h-\phi_S)\,F_{UT}^{\sin(2\phi_h-\phi_S)}\Big]$$

$$+\,|\boldsymbol{S}_\perp|\lambda_e\Big[\sqrt{1-\varepsilon^2}\,\cos(\phi_h-\phi_S)\,F_{LT}^{\cos(\phi_h-\phi_S)}+\sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_S\,F_{LT}^{\cos\phi_S}$$

$$+\sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos(2\phi_h-\phi_S)\,F_{LT}^{\cos(2\phi_h-\phi_S)}\Big]\Big\},$$

A Bacchetta, M Diehl, K Goeke, A Metz, P Mulders, M Schlegel (06)

SIDIS cross-section: PDFs and PFFs

Distribution Functions (x, k_T^2)			
N / q	U	L	T
U	f_1		$h_1^\perp$
L		g_1	$h_{1L}^\perp$
T	$f_{1T}^\perp$	$g_{1T}^\perp$	h_1, $h_{1T}^\perp$

Boer Mulders

$h_{1T}^\perp \otimes H_1^\perp$

Fragmentation Functions $(z, P_{h\perp}^2)$	
q/h	U
U	D_1
T	$H_1^\perp$

Collins

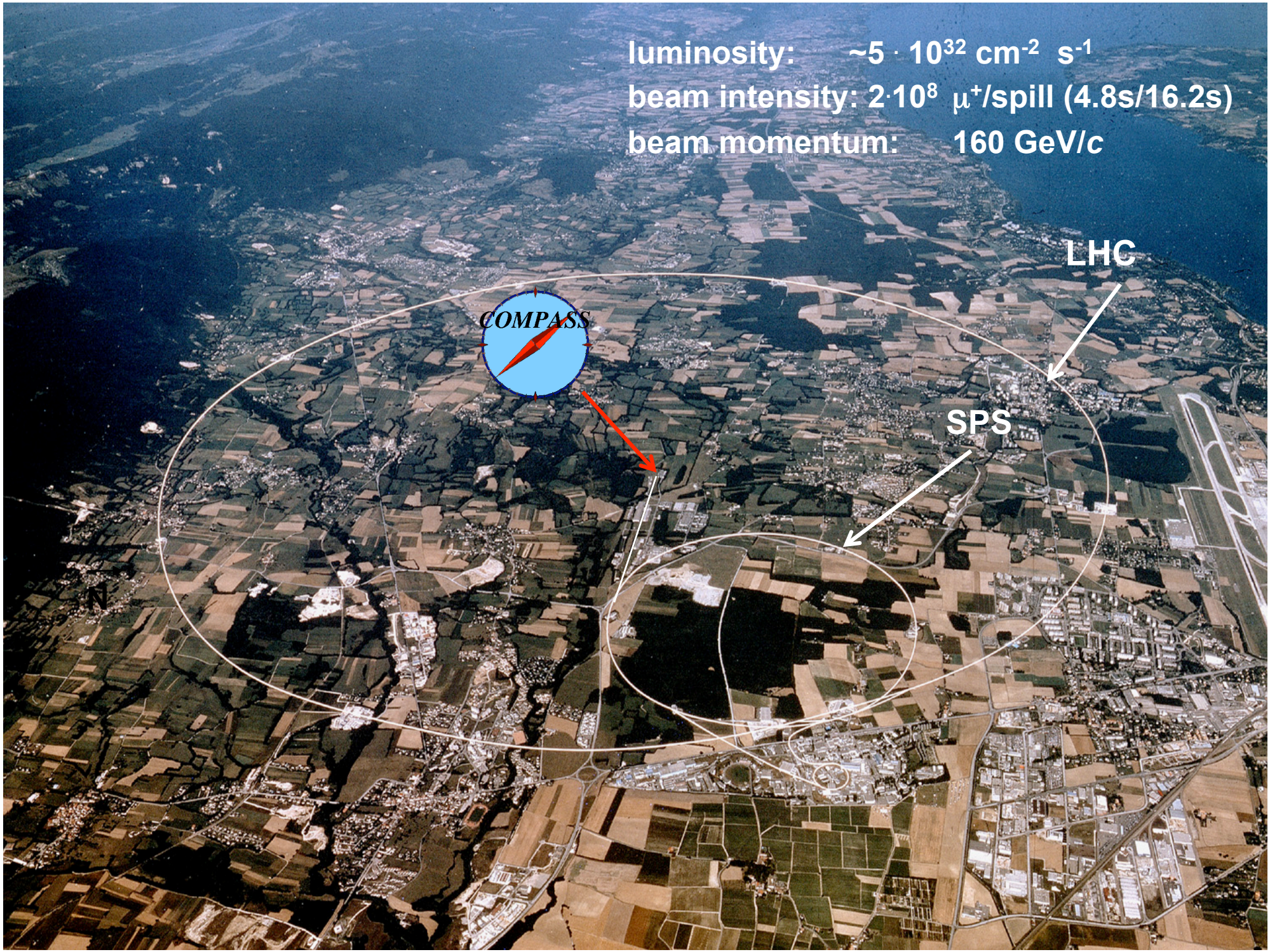
$h_1 \otimes H_1^\perp$

Sivers

$f_{1T}^\perp \otimes D_1$

"Pretzelosity"

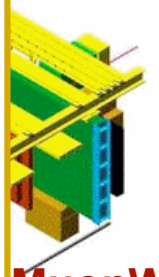
$h_{1T}^\perp \otimes H_1^\perp$


luminosity: ~5 · 10^32 cm^-2 s^-1
beam intensity: 2·10^8 μ+/spill (4.8s/16.2s)
beam momentum: 160 GeV/c
LHC
COMPASS
SPS
N

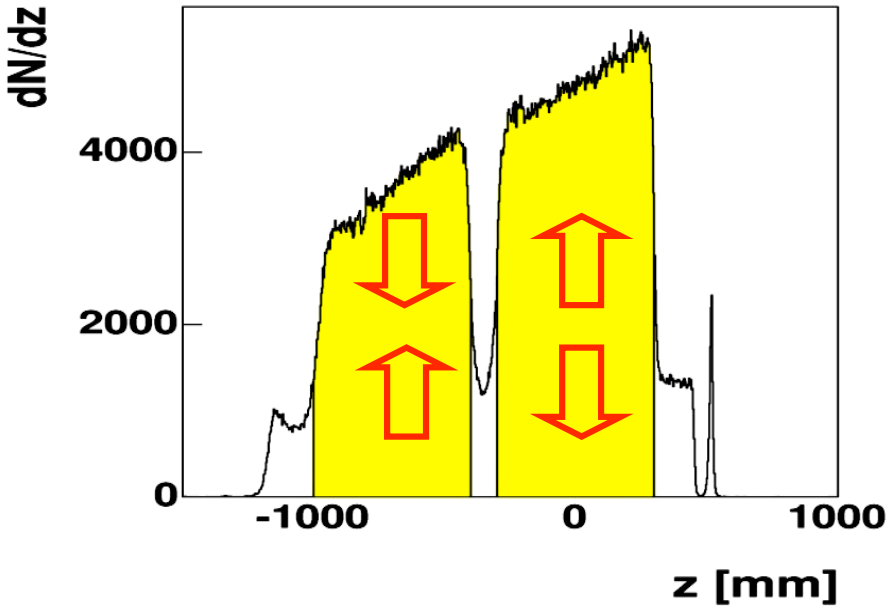
COMPASS

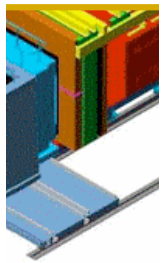
Polarized Target:

2002-2004: ^{6}LiD ($P_T \approx 50\%$, f = 0.38)
2007: NH_3 ($P_T \approx 90\%$, f = 0.14)
solid target cells
Polarization reversal: once a week



MuonWall





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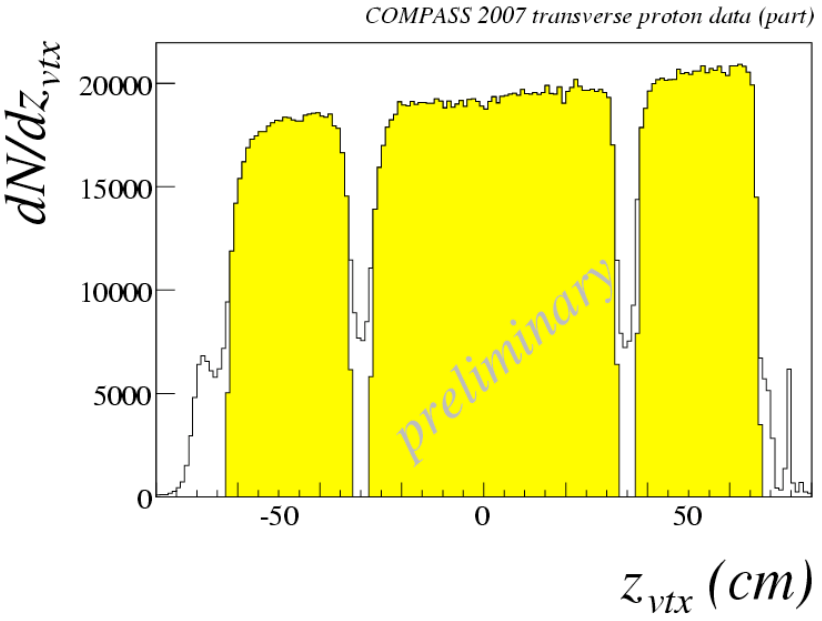
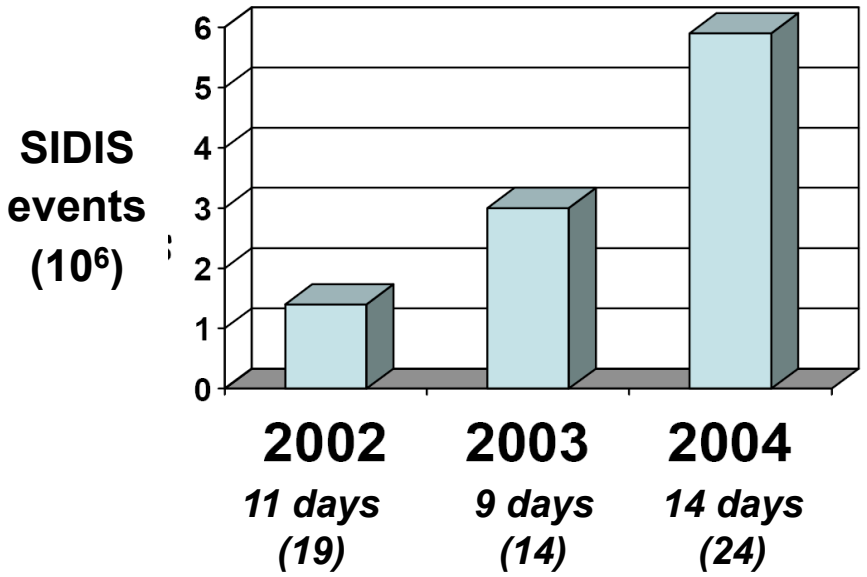


Transversely polarized target runs

2002-2004: ^{6}LiD only



	+ hadrons	- hadrons
Total statistics	8.5×10^6 h	7.0×10^6 h

2007: NH_3 target (protons)

First look:

$10\cdot10^6$ SIDIS events
(~20% of data)

	+ hadrons	- hadrons
Total statistics	5.7×10^6 h	4.5×10^6 h

New analysis:

	COLLINS	SIVERS
Total statistics	29×10^6 h	11×10^6 h

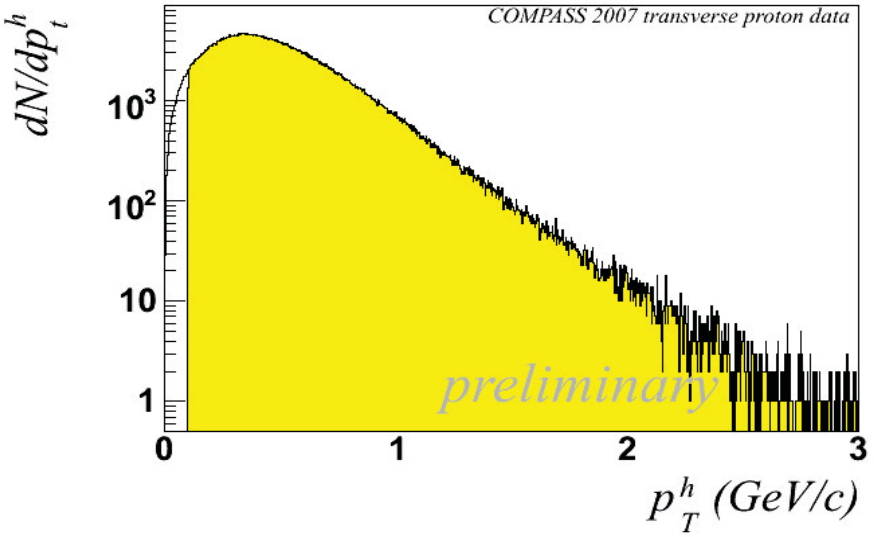
Event Selection

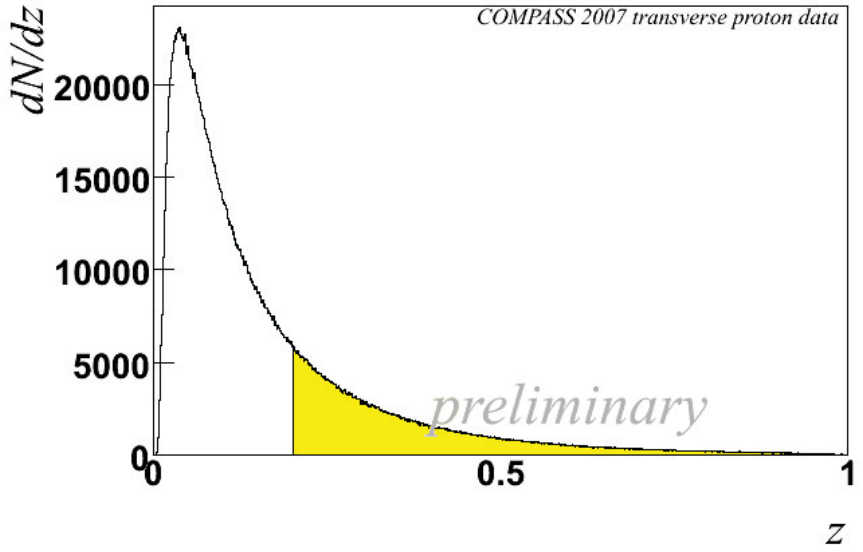
DIS cuts:

- $Q^2>1$ (GeV/c)^2
- $0.1<y<0.9$
- $W>5$ GeV/c^2

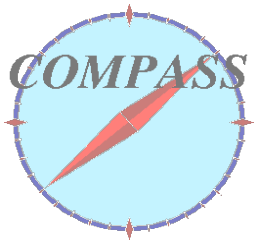
All hadrons

- Energy Deposit in HCALs>Thr. (4 GeV HCal1 and 5 GeV Hcal2)
- $p_T>0.1$ GeV/c
- $z>0.2$





Transversity



3 quark polarimeter in SIDIS:

- **Azimuthal asymmetries in one hadron production**
  (Collins effect)

- **Azimuthal asymmetries in hadron pair production**
  (Interference fragmentation function)

- **Transverse hyperon (Λ) polarization**

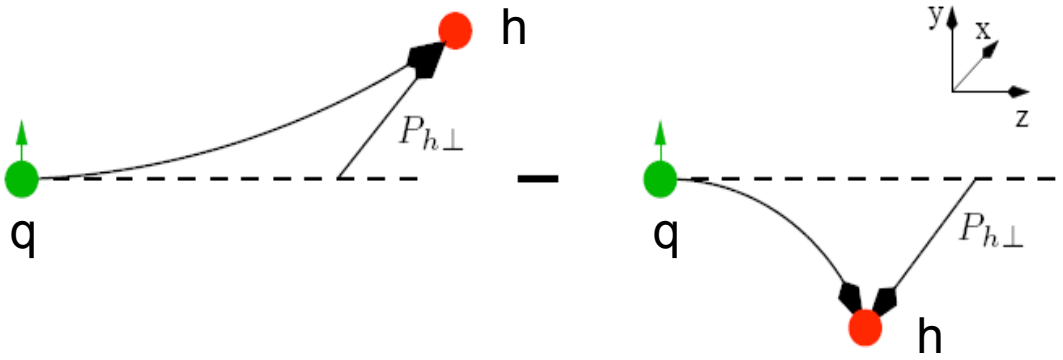
Collins-Effect

$$F_{UT}^{\sin(\phi_h - \phi_s)} \propto h_1 \otimes H_1^{\perp}$$

The Collins FF $H_1^{\perp q}(z, p_T)$: correlates the

transverse spin of the fragmenting quark and the

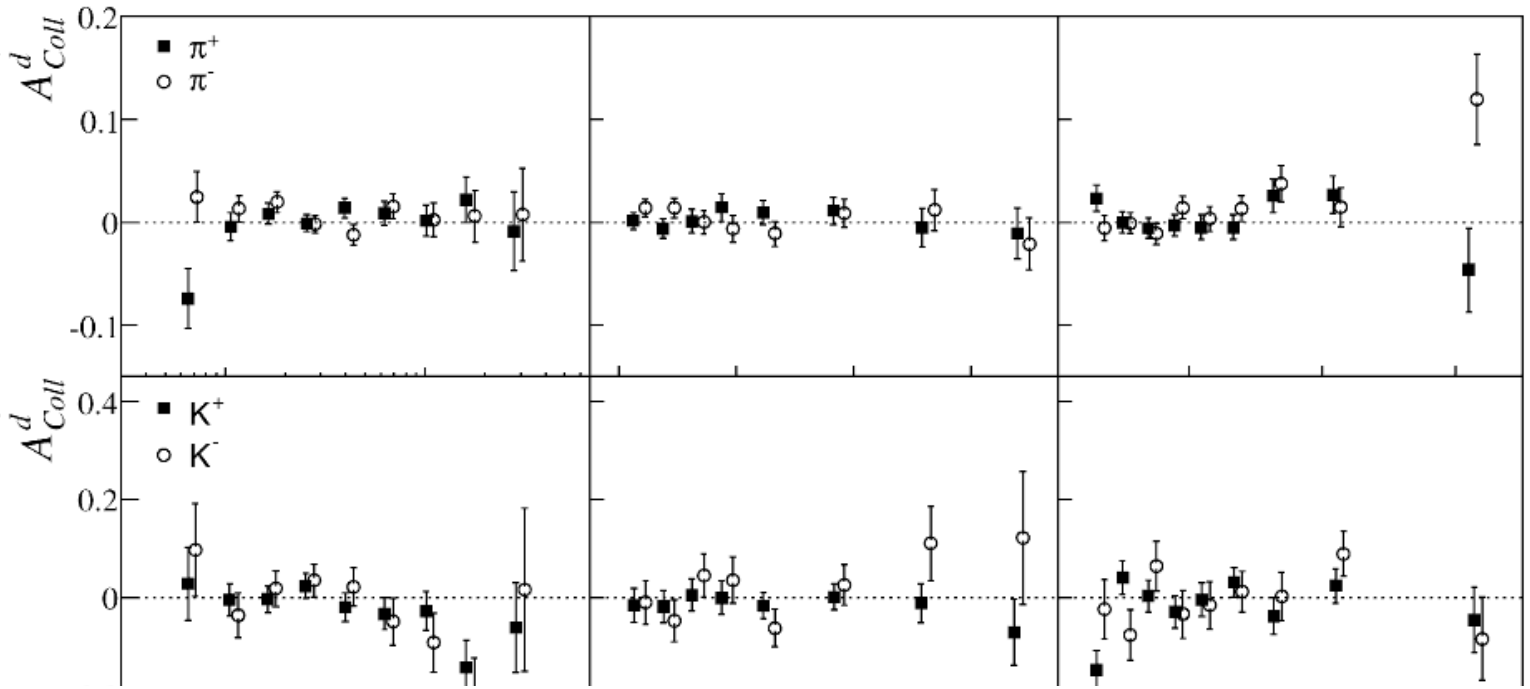
transverse momentum $P_{h\perp}$ of produced hadron h



The measured asymmetry A_{Coll} gives access to the transversity distribution times the Collins fragmentation function:

$$A_{Coll} \propto \frac{\sum_q e_q^2 \, h_1^q(x) \cdot H_1^{\perp q}(z, p_T)}{\sum_q e_q^2 \, f^q(x) \cdot D_q^h(z)}$$

Deuteron Results: Collins Effect



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Deuteron target

2002-2004

only statistical

Asymmetries compatible with 0 !

Indication of cancelation of u and d Quark contribution for a deuteron target

$$A_{\mathrm{Col}} \propto h_1^{\mathrm{u}} + h_1^{\mathrm{d}}$$

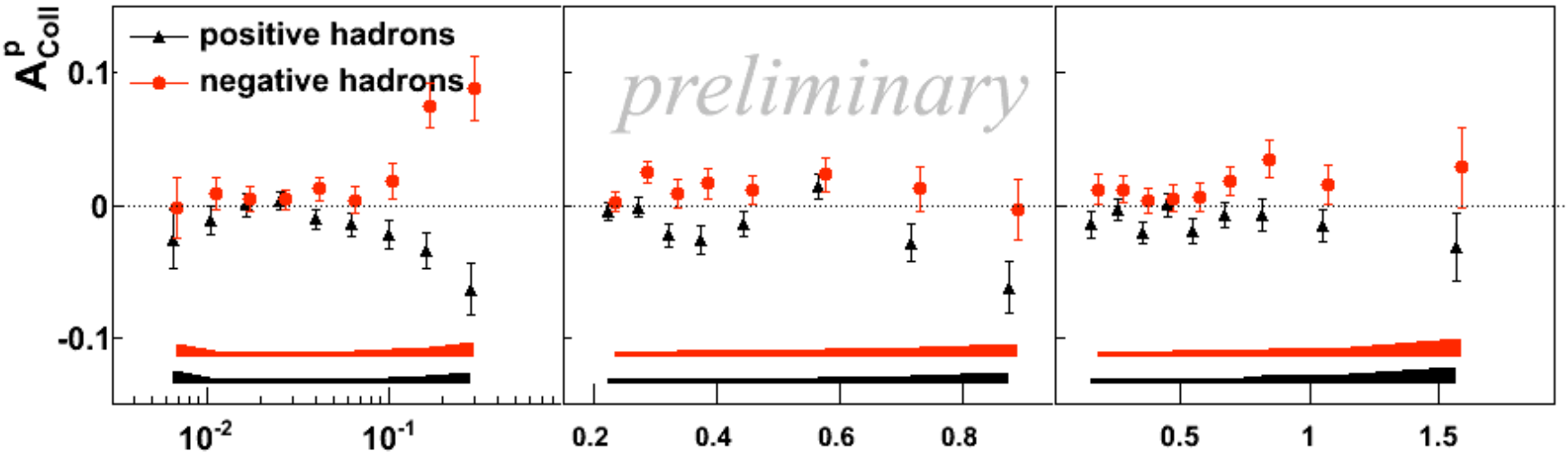
Access to d quark contribution in global fit

Collins asymmetry

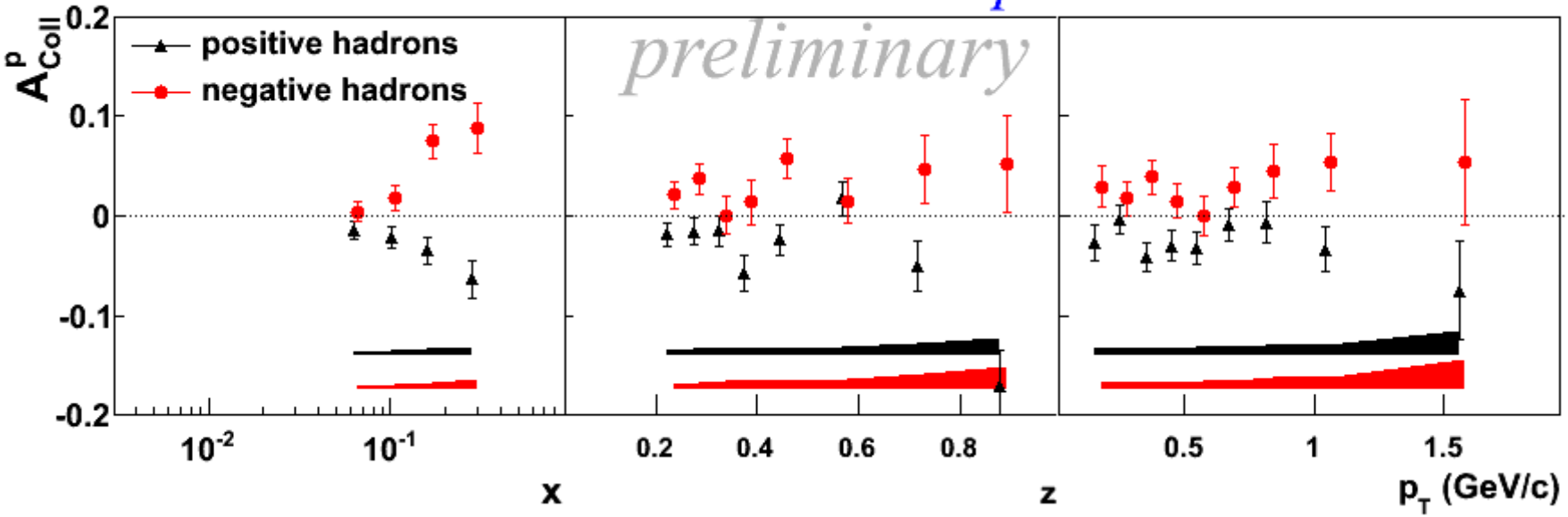
Proton target

Full 2007 statistics

COMPASS 2007 proton data



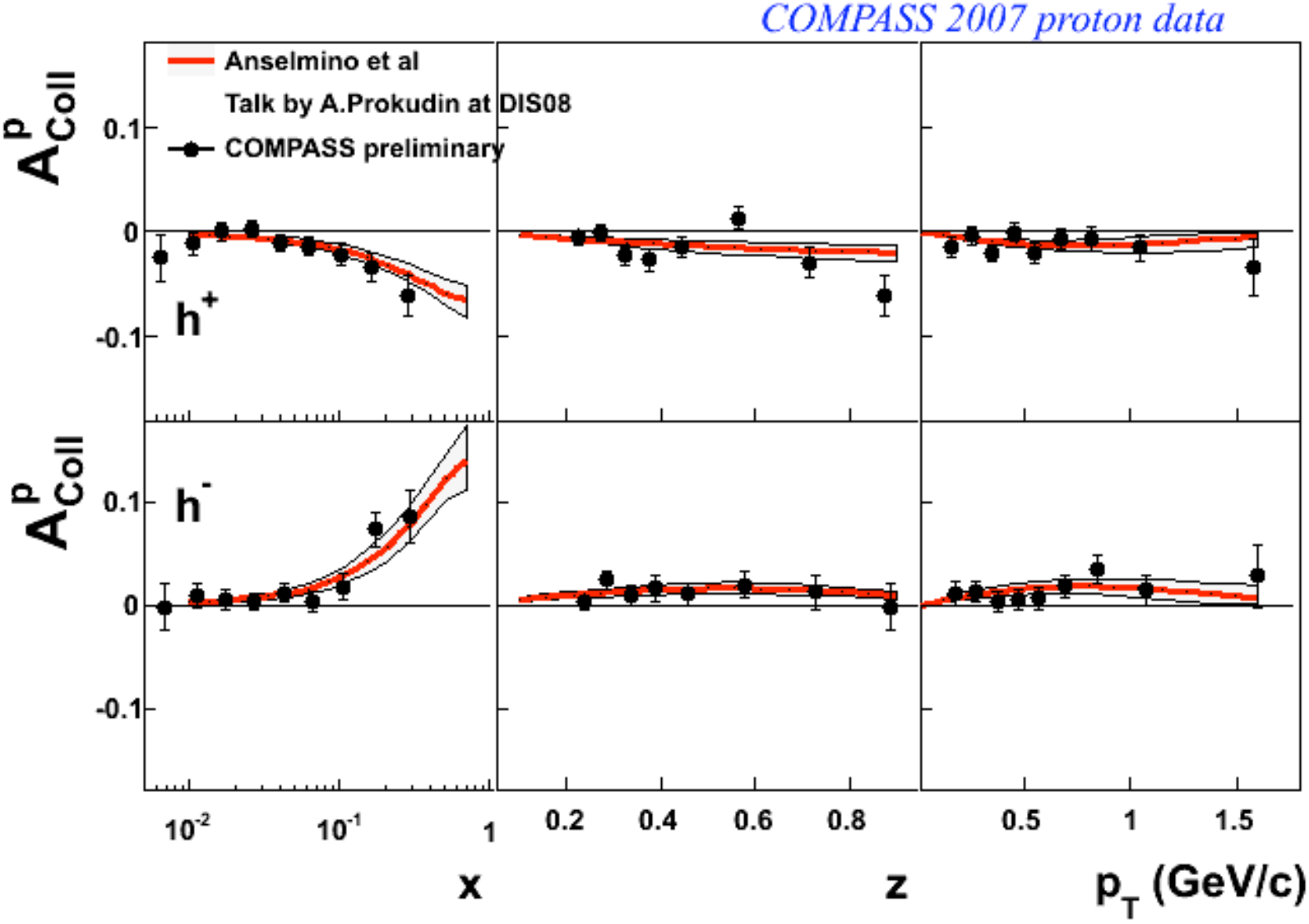
COMPASS 2007 proton data x>0.05



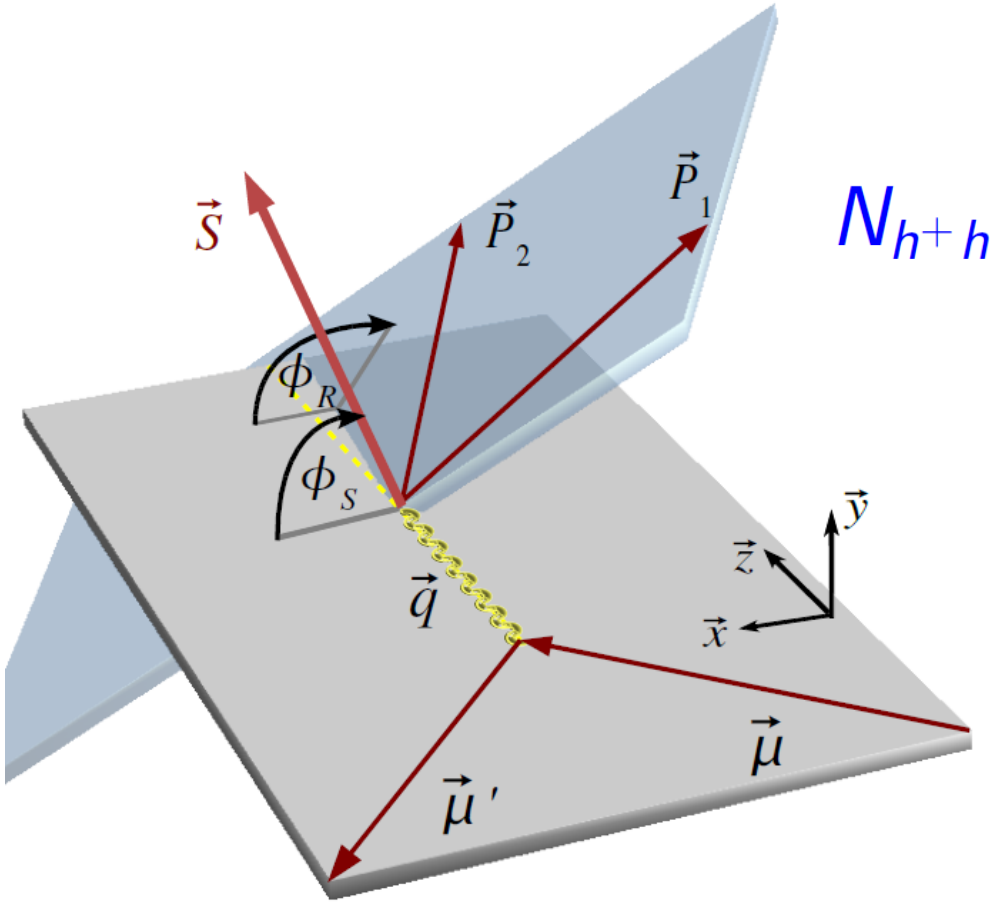
2009

Compass proton data

comparison with M. Anselmino et al. predictions

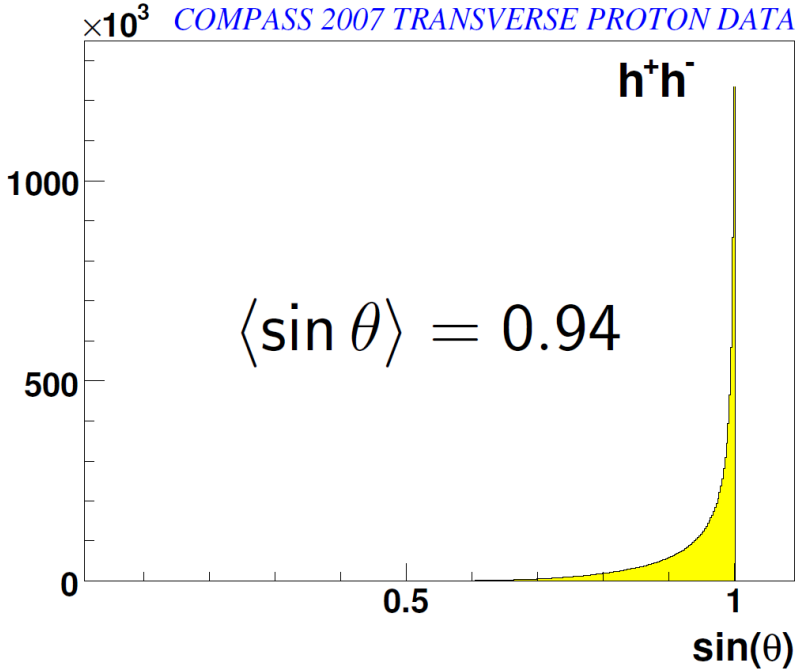


Transversity in 2-Hadron Production



$$N_{h^+h^-} \propto 1 \pm A \cdot \sin\phi_{RS} \cdot \sin\theta$$

$$\phi_{RS} = \phi_R + \phi_S - \pi$$



Transversity in 2-Hadron Production

The measured asymmetry A_{RS} is a product of transversity and the „Interference Fragmentation Function“ $H_1^{\sphericalangle}$

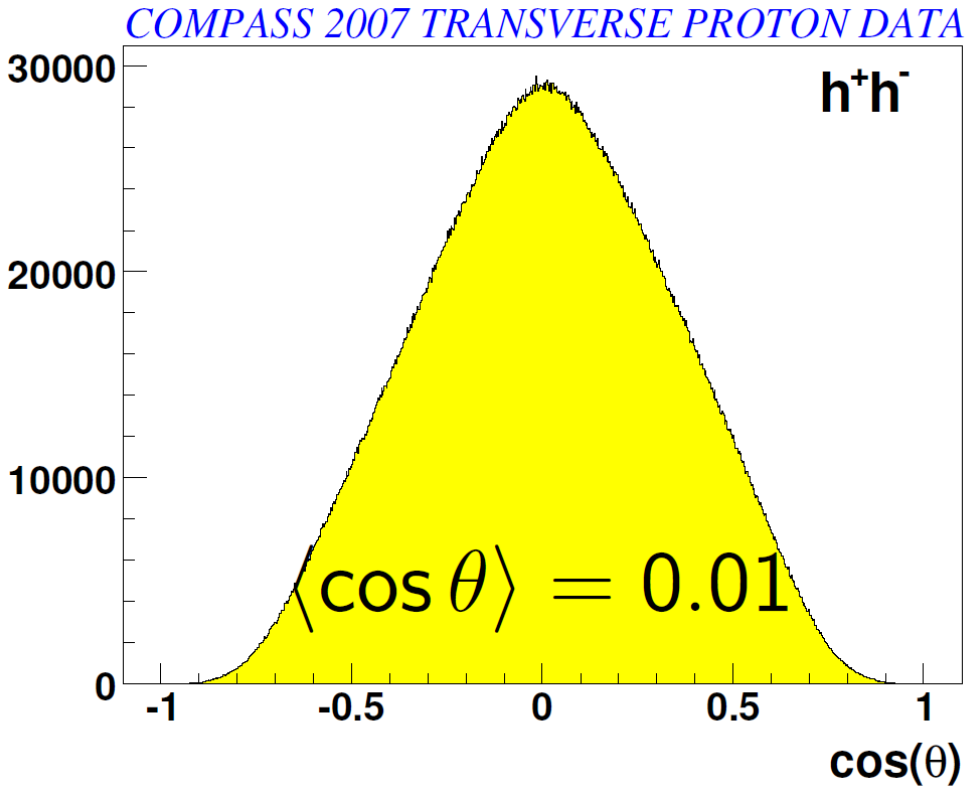
$$A_{RS} = \frac{A}{f\,P_T\,D_{nn}} = \frac{\sum_q e_q^2 \cdot h_1(x) \cdot H_1^{\sphericalangle}(z, M^2_{h^+h^-})}{\sum_q e_q^2 \cdot q(x) \cdot D_1(z, M^2_{h^+h^-})}$$

f target dilution factor

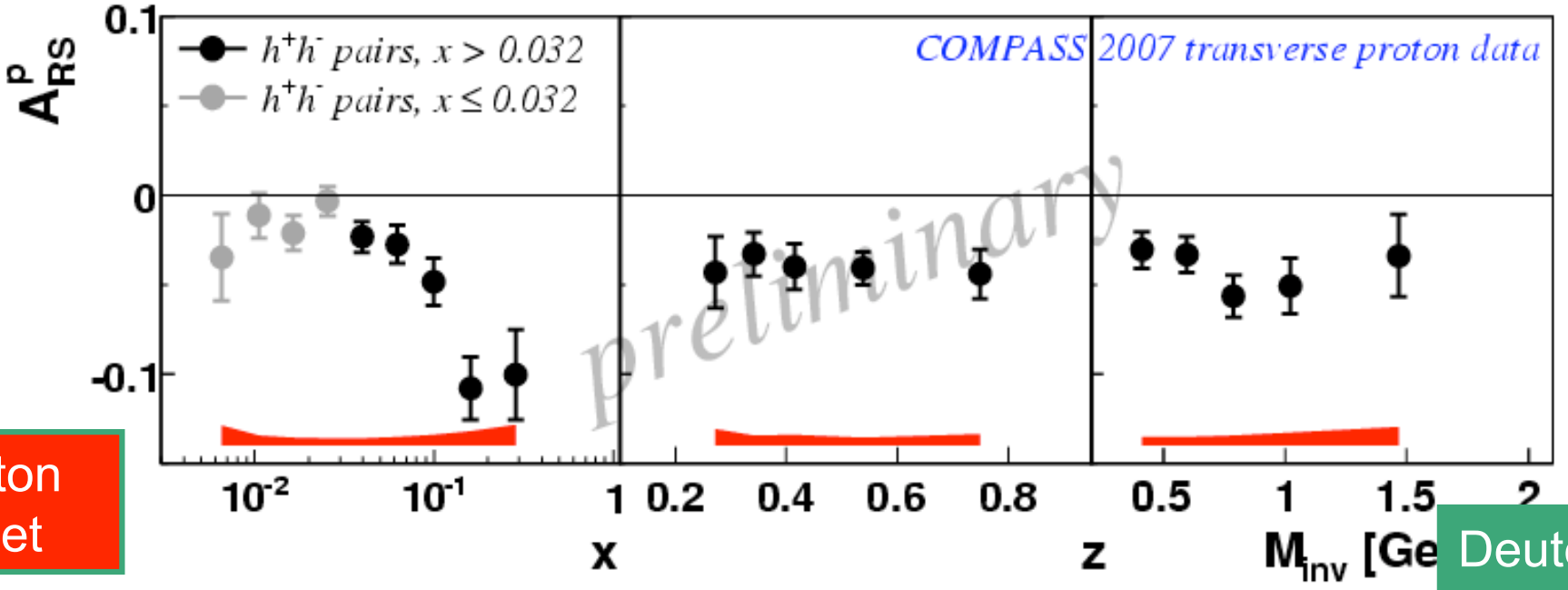
P_T target polarization

$D_{nn} = \frac{1-y}{1-y+y^2/2}$ depolarization factor

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

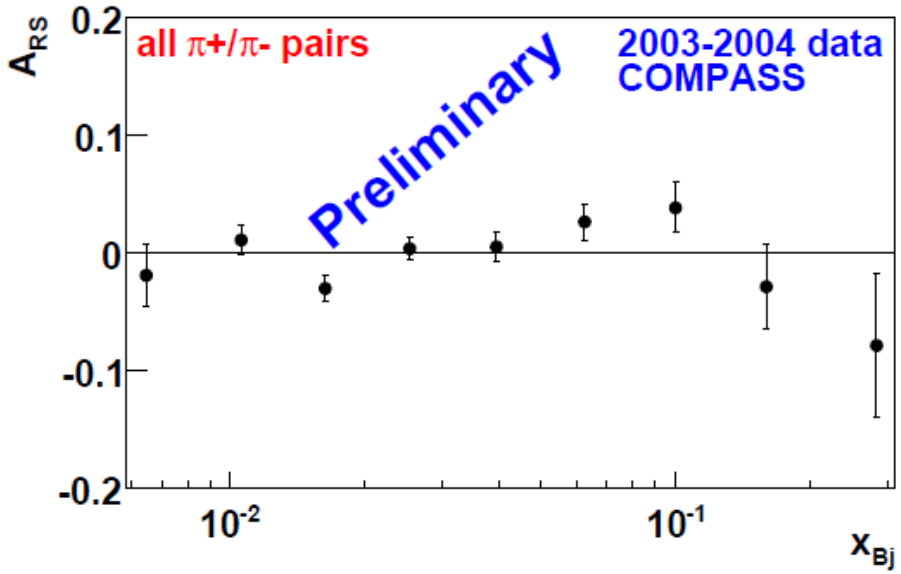


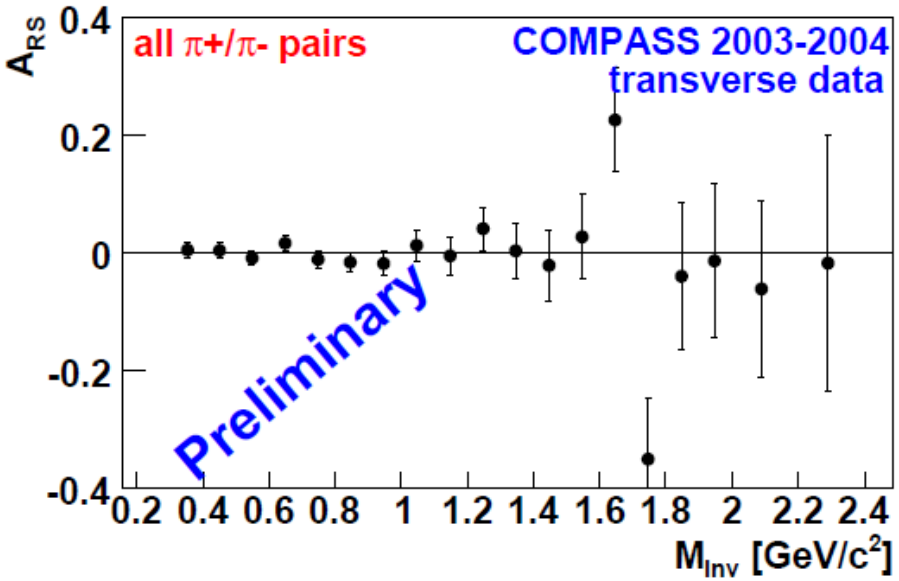
Transversity in 2-Hadron Production



Proton target

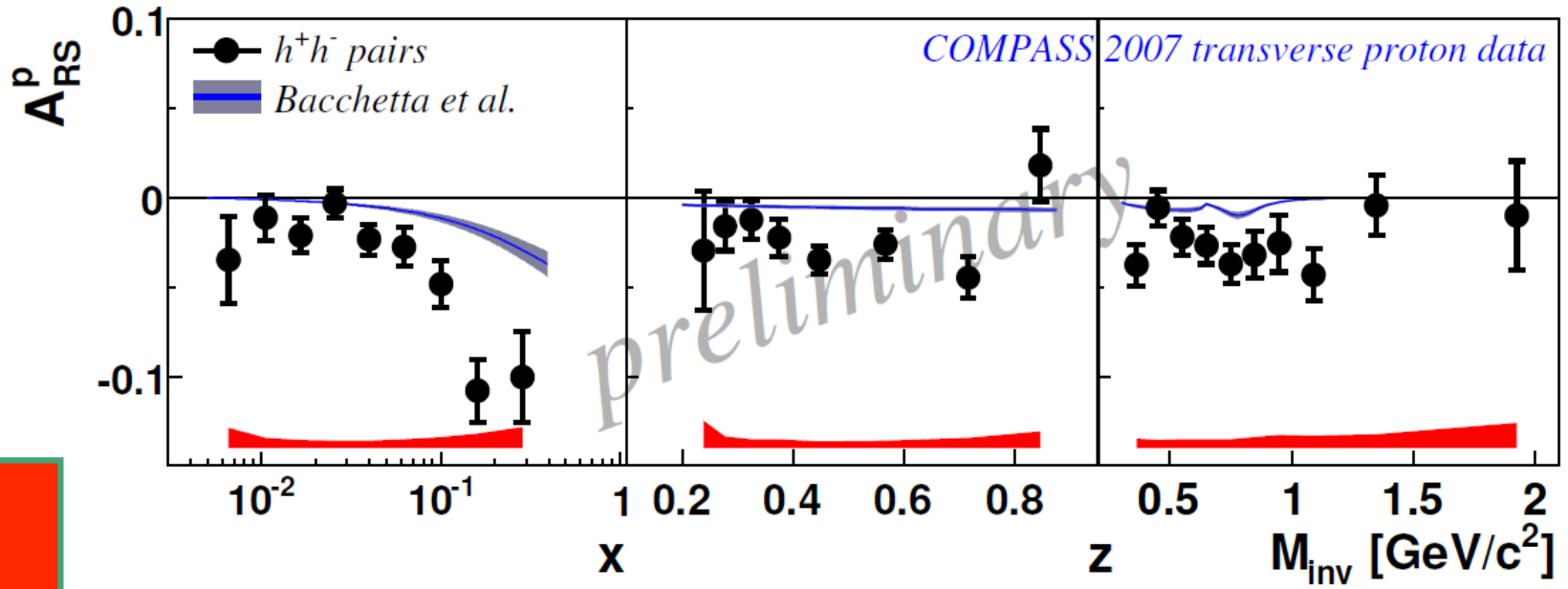
Deuteron target

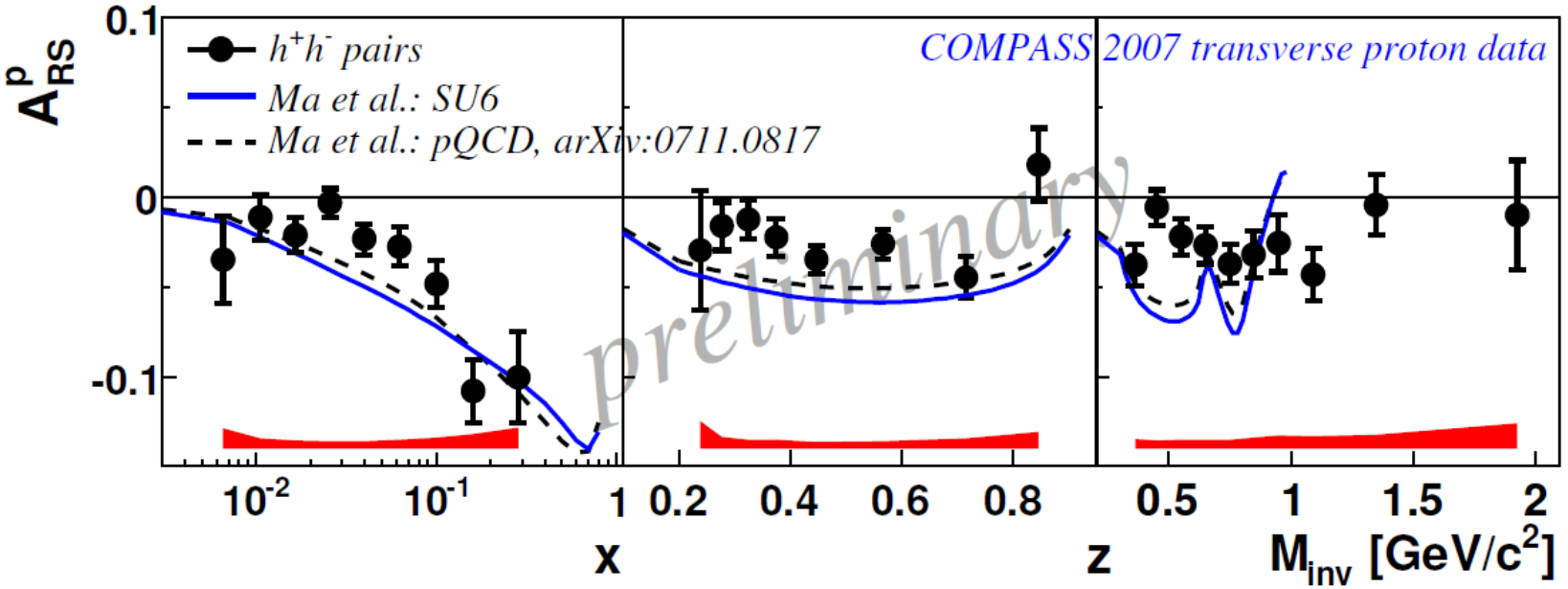




Transversity in 2-Hadron Production

Proton target





Transversity from Λ Production

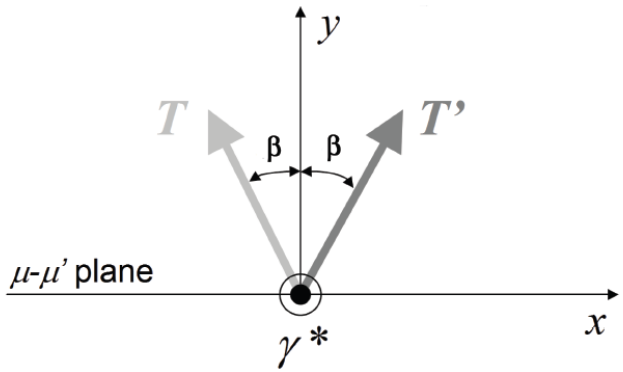
$$l p^{\uparrow} \rightarrow l' \Lambda^{\uparrow} X$$

$$P_{\Lambda}(x,z) = f P_T D_{NN}(y) \frac{\sum_q e_q^2 h_1^q(x) \Delta_T D_q^{\Lambda}(z)}{\sum_q e_q^2 f_1^q(x) D_q^{\Lambda}(z)}$$

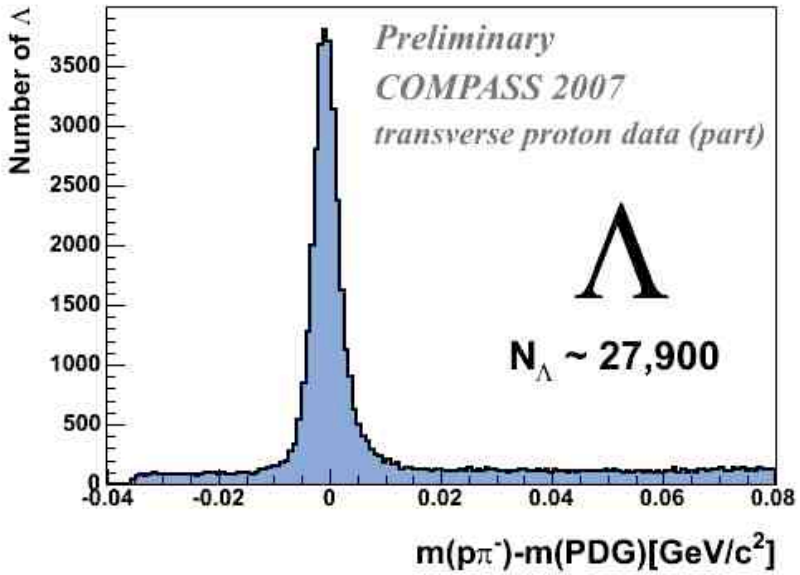
$$\Lambda \rightarrow p\,\pi \qquad BR \approx 64\,\%$$

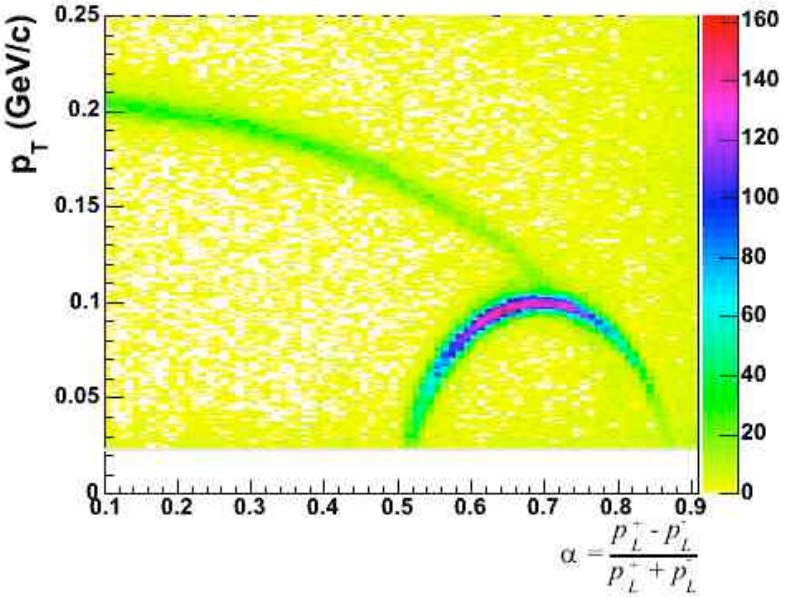
$$W(\Theta_{T'}) \propto 1 + \alpha P_T^{\Lambda} cos\Theta_{T'}$$

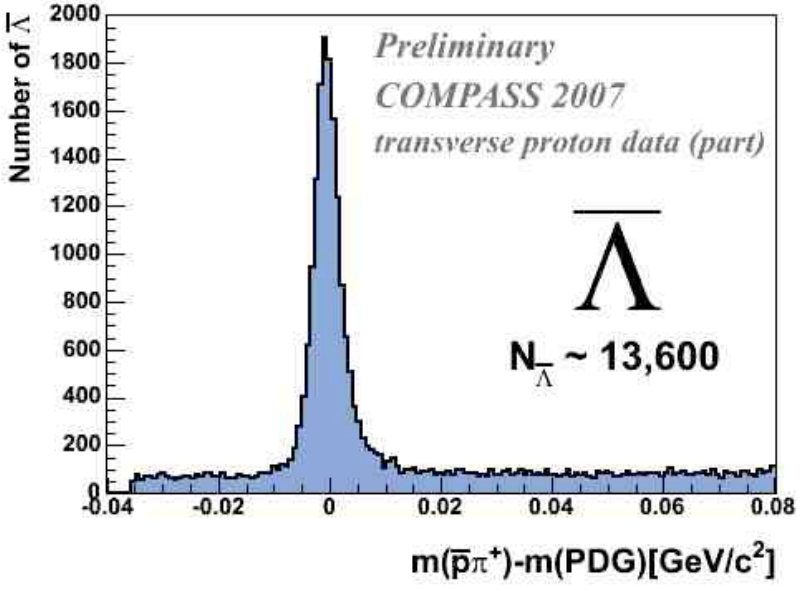
$$\alpha = \pm 0.642 \pm 0.013$$

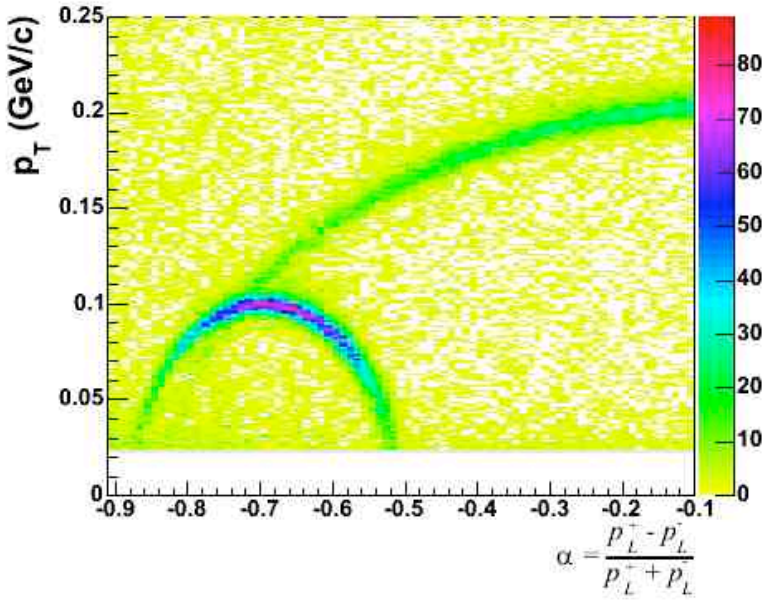


Data Selection



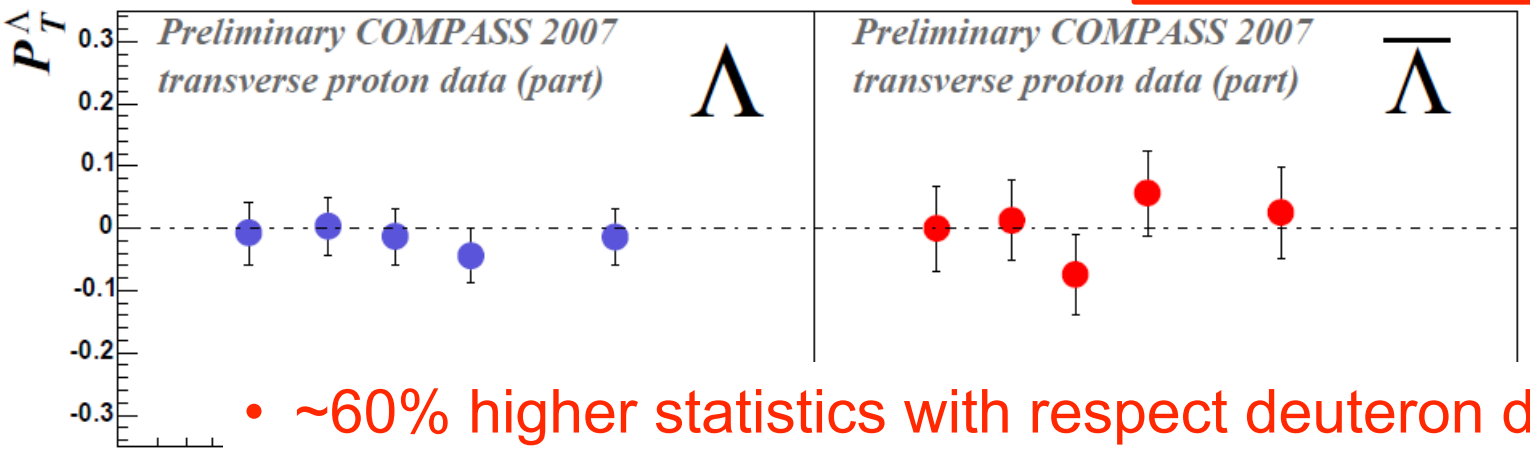






Results with proton target

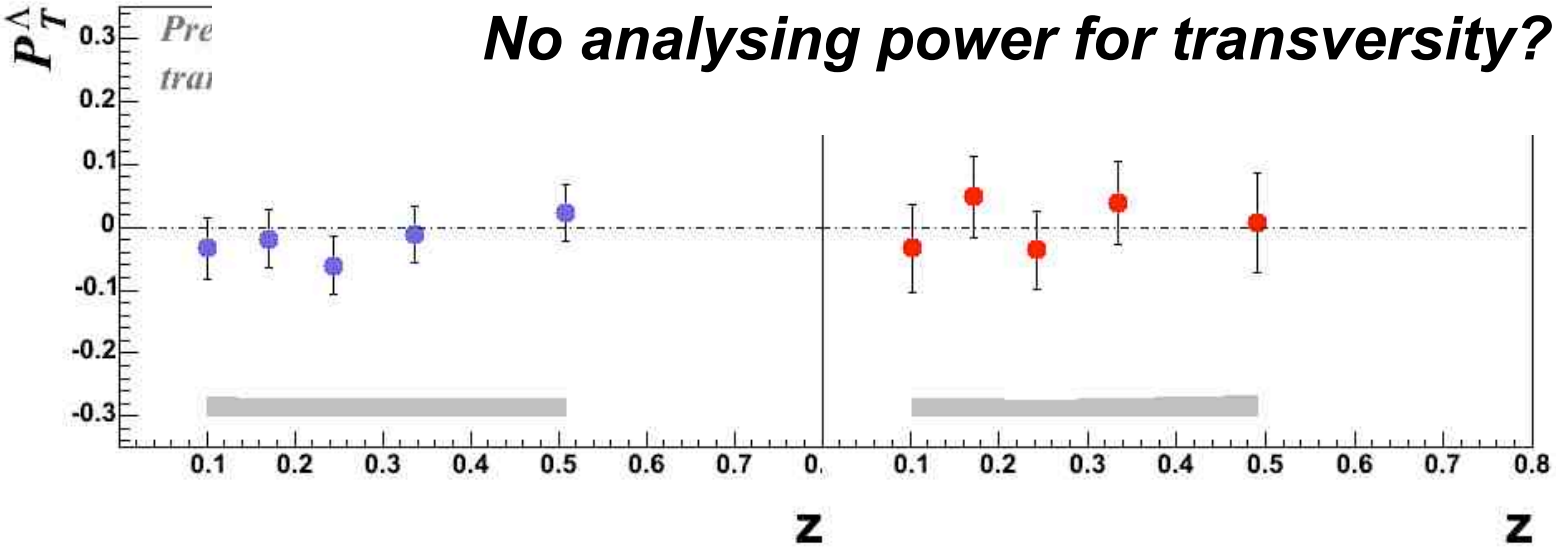
Full 2007 statistics



Proton target

- ~60% higher statistics with respect deuteron data
- Systematic errors have been estimated to be smaller than statistical errors from false polarization.
- No dependence on *x or z.*

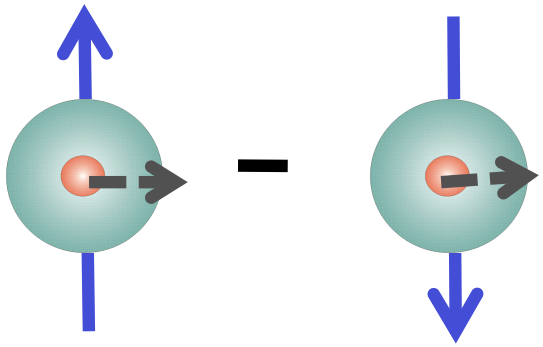
No analysing power for transversity?



Sivers Effect

$$F_{UT}^{\sin(\phi_h+\phi_s)} \propto f_{1T}^{\perp} \otimes D_1$$

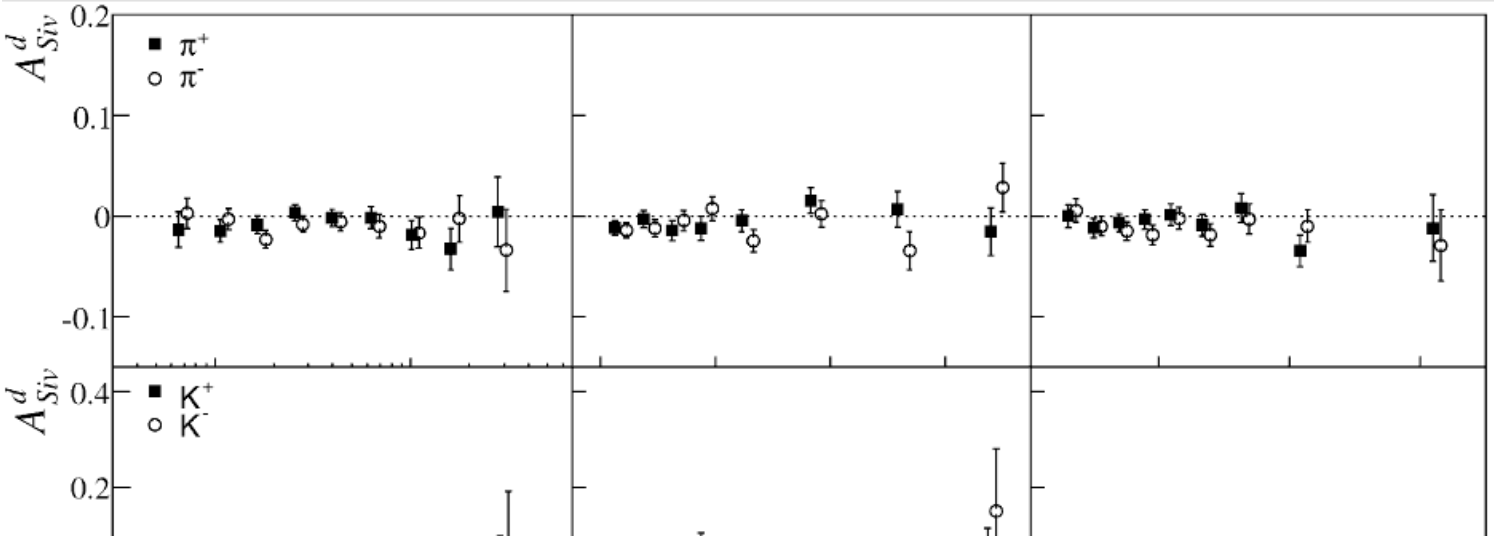
Distribution of unpolarized quarks with transverse momentum k_T in a transversely polarized nucleon



The Sivers asymmetry:

$$A_{Siv} \propto \frac{\sum_q e_q^2 \, f_{1T}^q(x,k_T) \cdot D_q^h(z)}{\sum_q e_q^2 \, f(x) \cdot D_q^h(z)}$$

Deuteron Results: Sivers Effect



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Deuteron Target

2002-2004

Data are compatible with 0 !

Strong indication of cancelation of u and d quark Sivers Functions in deuteron target

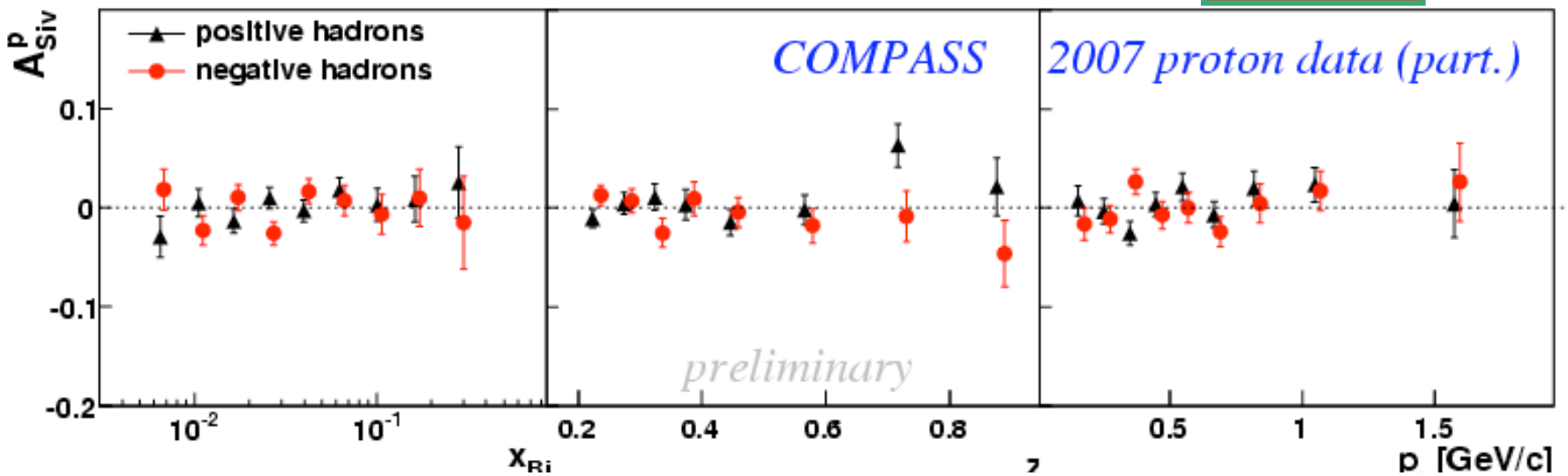
Constrains d quark contribution in global fit

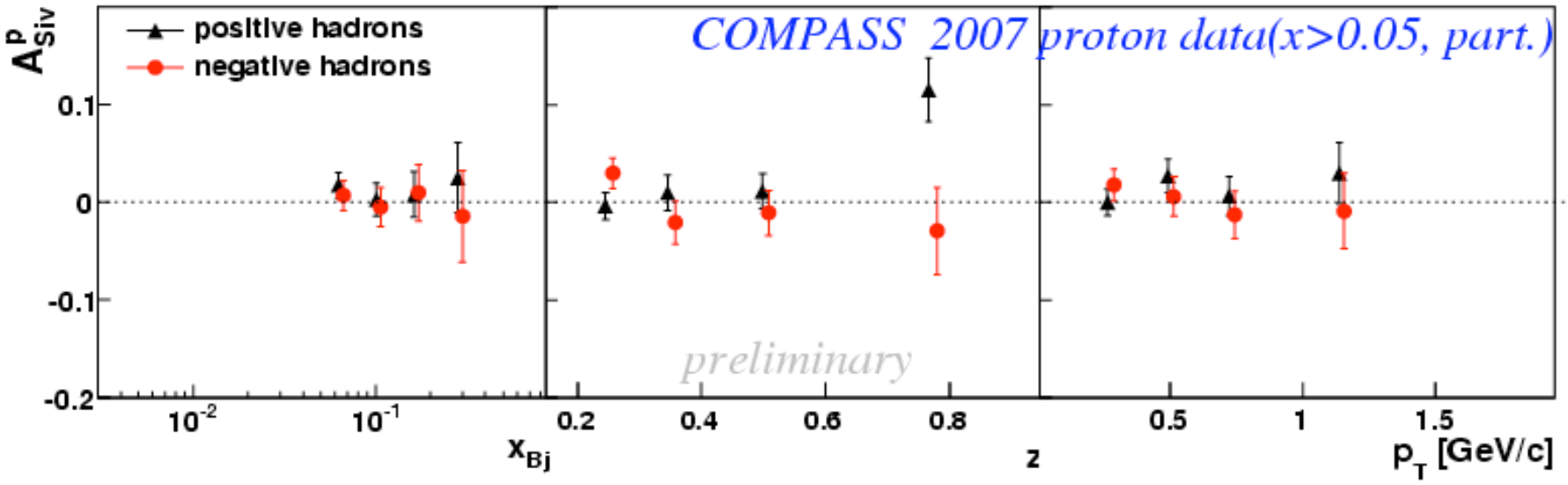
$$A_{\mathrm{Siv}} \propto f_{1\mathrm{T}}^{\perp \mathrm{u}} + f_{1\mathrm{T}}^{\perp \mathrm{d}}$$

Sivers asymmetry– proton data

Partial 2007 statistics

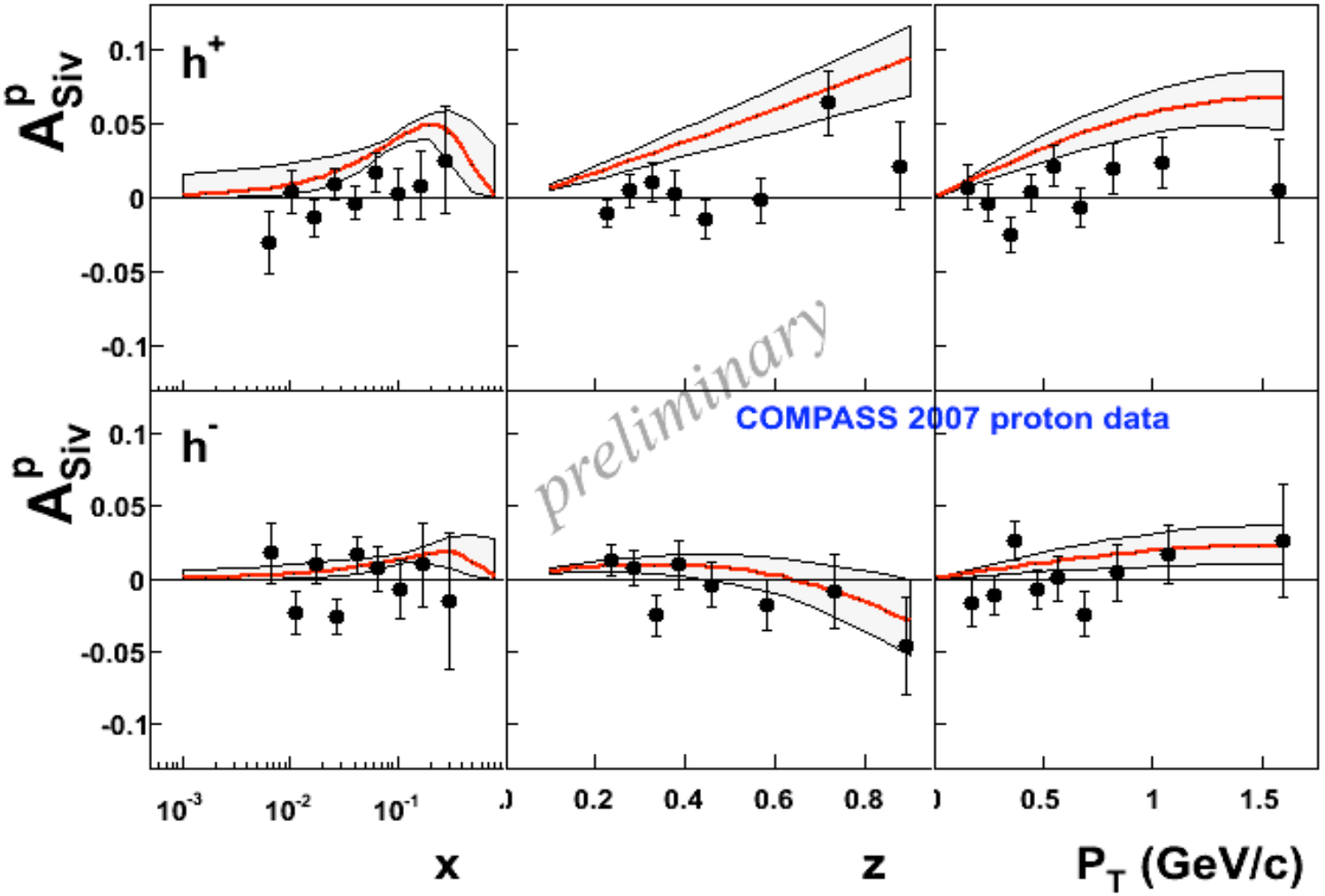
Proton target





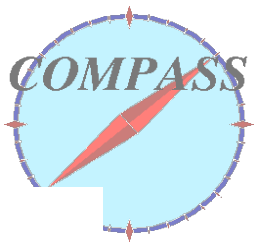
Sivers asymmetry– proton data

comparison with the most recent predictions from M. Anselmino et al.



arXiv:0805.2677

Unpolarised Target Cross-Section



$$\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_h\,dP_{h\perp}^2} =$$

$$\frac{\alpha^2}{xyQ^2}\,\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Big\{F_{UU,T}+\varepsilon F_{UU,L}+\sqrt{2\,\varepsilon(1+\varepsilon)}\cos\phi_h\,F_{UU}^{\cos\phi_h}$$

$$+\,\varepsilon\cos(2\phi_h)\,F_{UU}^{\cos 2\phi_h}+\lambda_e\sqrt{2\,\varepsilon(1-\varepsilon)}\sin\phi_h\,F_{LU}^{\sin\phi_h}$$

$$F_{LU}^{\sin\phi_h} = \frac{2M}{Q}\,\mathcal{C}\left[-\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_T}{M_h}\left(xe\,H_1^\perp+\frac{M_h}{M}\,f_1\frac{\tilde{G}^\perp}{z}\right)+\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{p}_T}{M}\left(xg^\perp D_1+\frac{M_h}{M}\,h_1^\perp\frac{\tilde{E}}{z}\right)\right]$$

$$F_{UU}^{\cos\phi} = \frac{2M}{Q}C\left[-\frac{\hat{h}\cdot\vec{p}_T}{M_h}\,x\;h_1^\perp H_1^\perp-\frac{\hat{h}\cdot\vec{k}_T}{M}\,x\;f_1D_1\right]$$

pQCD expected to be important at p_t > 1 GeV/c

here $\langle p_t\rangle \approx 0.5$ GeV/c

$$F_{UU}^{\cos 2\phi} = C\left[-\frac{2(\hat{h}\cdot\vec{k}_T)(\hat{h}\cdot\vec{p}_T)-\vec{k}_T\cdot\vec{p}_T}{MM_h}\,h_1^\perp H_1^\perp\right]$$

Boer- Mulders ⊗ Collins FF, Cahn effect and pQCD

Kinematical corrections: Cahn effect

Leading order QED with $k_T \neq 0$

R.N. Cahn PL B78 (1978) 269-273 …

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\phi_q} \propto x^2(1+(1-y)^2)\left(1 - 2\frac{k_t}{Q}D_{\cos\phi_h}(y)\cos(\phi_q) + \left(\frac{k_t}{Q}\right)^2 D_{\cos 2\phi_h}(y)\cos 2\phi_q\right)$$

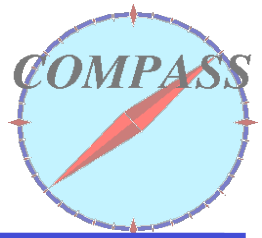
After fragmentation:

contributes to cos ϕ_h and cos $2\phi_h$ moments

$$\frac{d\sigma}{d\phi_h} \propto 1 - 4\frac{\langle k_t^2\rangle z P_t}{Q\langle P_t^2\rangle} D_{\cos\phi_h}(y)\cos\phi_h + \ldots$$

Access to $\langle k_T^2 \rangle$

Boer Mulders effect



Relation to transverse space

$$F_{UU}^{\cos\phi}, F_{UU}^{\cos 2\phi} \propto h_1^{\perp} \otimes H_1^{\perp}$$

Side view

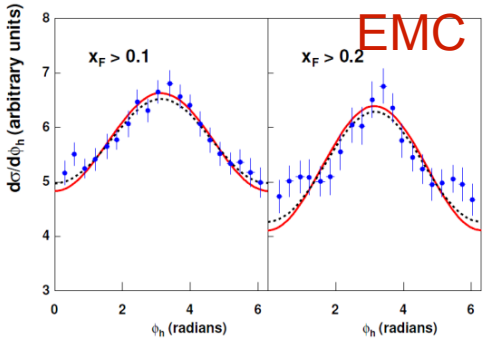
Front view

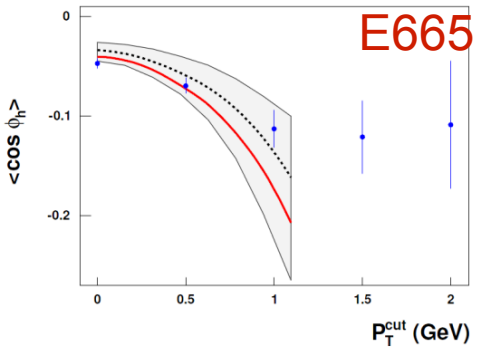
Convoluted with Collins function

Contributes to cos ϕ_h and cos $2\phi_h$ moments

Experimental status (up to 2008)

- Azimuthal modulations in lp→l'hX measured by
  - EMC
  - E665





- Large modulations up to 40% for cosϕ, while cos2ϕ ~ 5%

Since last year, new data from COMPASS and HERMES

Unpolarised Azimuthal Asymmetries

data sample:

- part of the 2004 data
- L and T target polarisation
- ONLY downstream target cell used
- each with both polarisation directions to cancel polarisation dependent effects

Event selection:

DIS events...

- $Q^2>1$ (GeV/c)^2
- $0.1<y<0.9$
- W>5 (GeV/c^2)

Hadrons

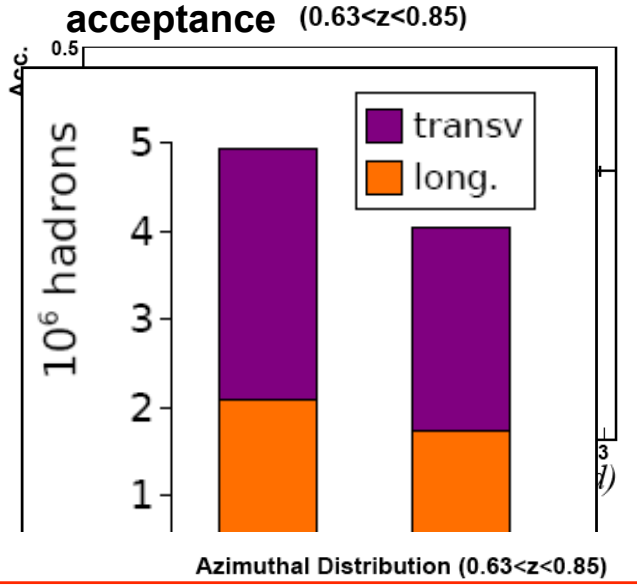
- $0.2< z < 0.85$
- $p_T^h > 0.1$ GeV/c

the azimuthal distributions have to be corrected by the apparatus acceptance

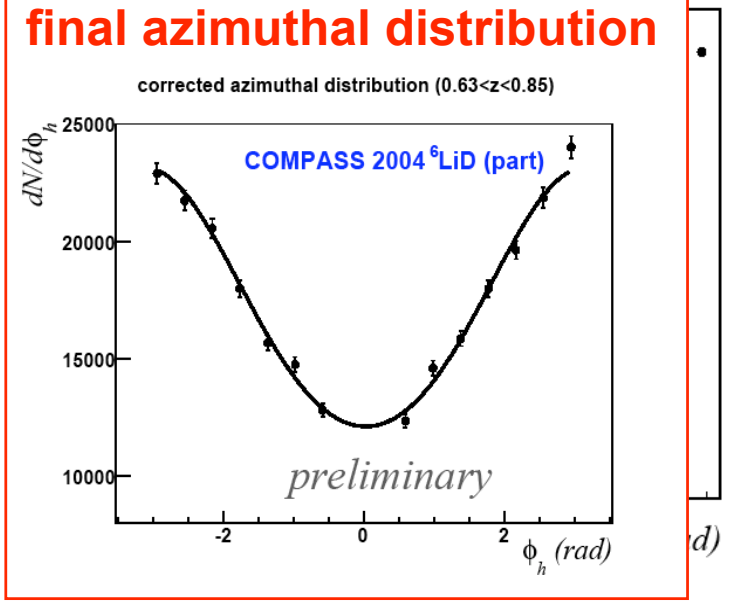
→ **dedicated MC simulations for L and T target polarisation data**

the corrected azimuthal distributions are fitted:

$$N_{corr}(\phi_h) = N_0 (1 + A_{\sin\phi_h} \sin\phi_h + A_{\cos\phi_h} \cos\phi_h + A_{\cos 2\phi_h} \cos 2\phi_h)$$



final azimuthal distribution



Results: sinϕ modulation

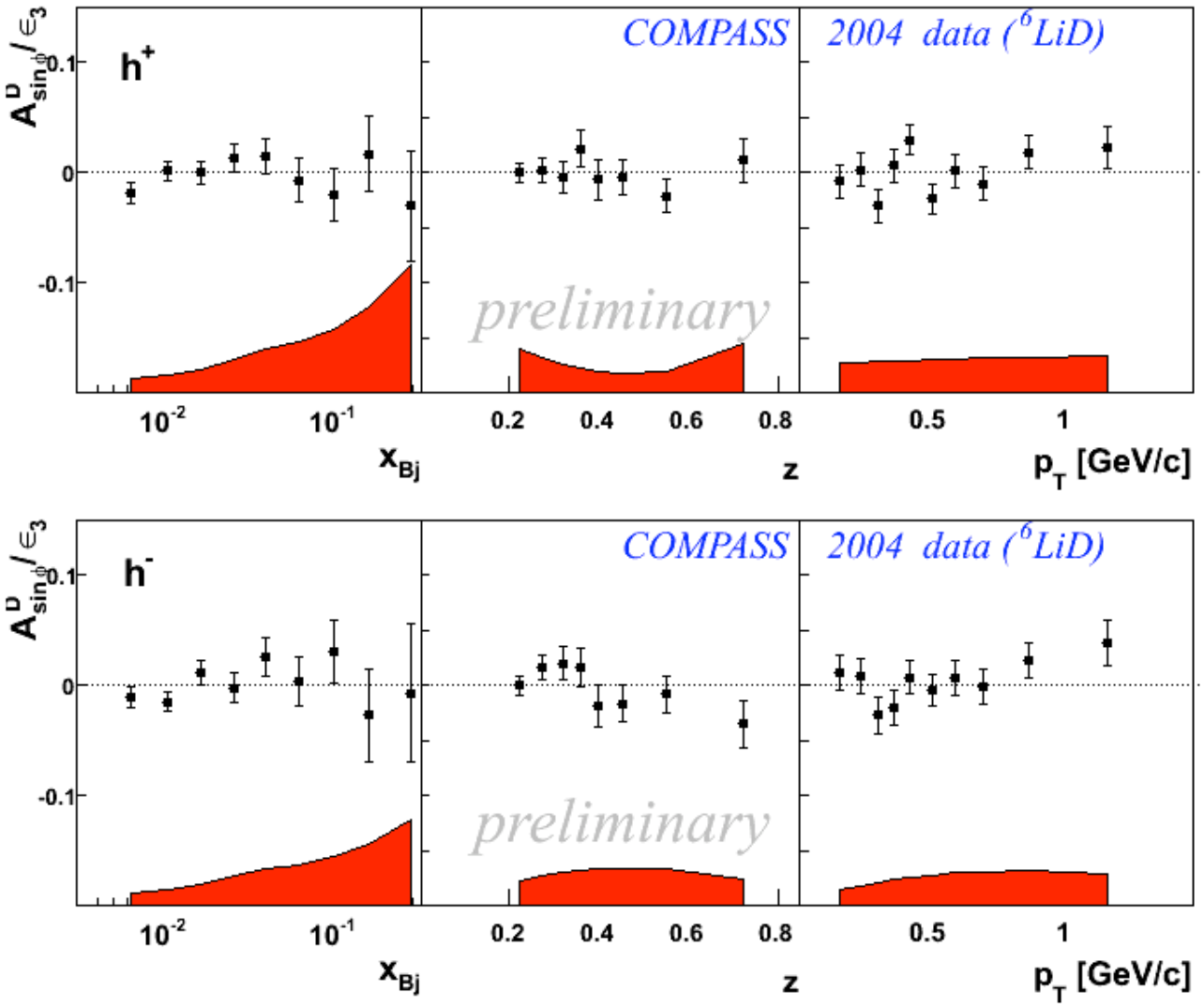
$$A_{\sin\phi} / \varepsilon_s$$

$$\varepsilon_s = \frac{2y\sqrt{1-y}}{1+(1-y)^2}$$

error bars:
statistical errors

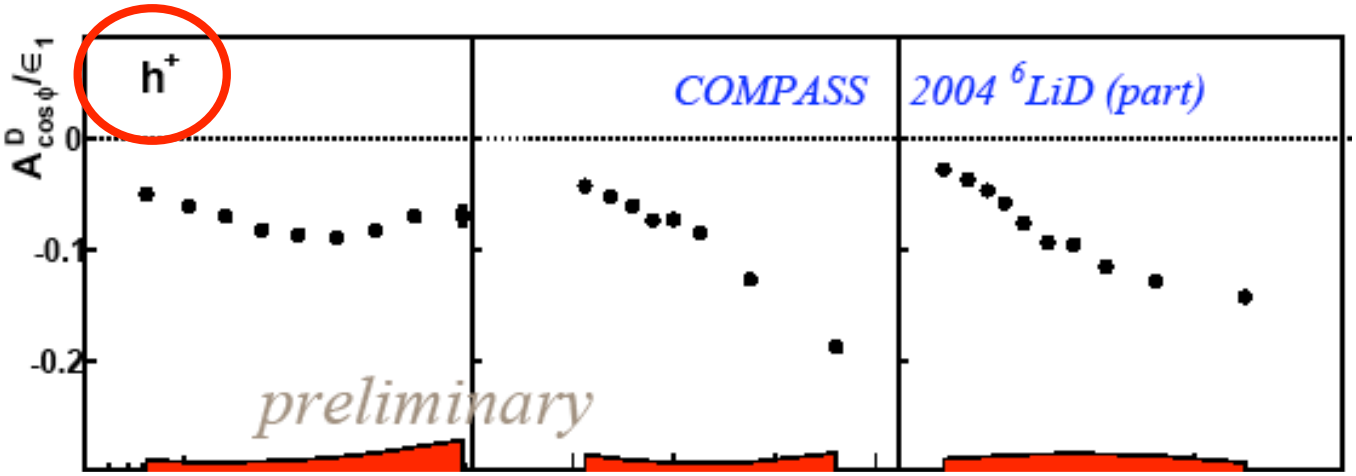
bands:
systematical errors

Deuteron target



Unpolarised Azimuthal Asymmetries

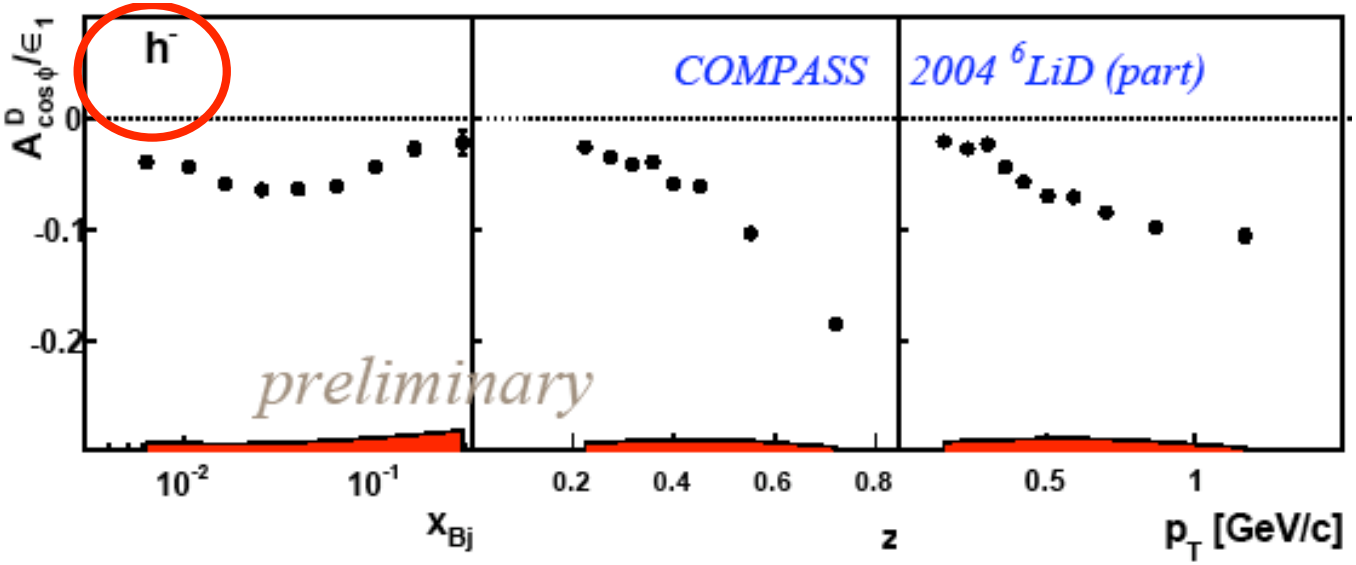
cosϕ modulation (Cahn + Boer-Mulders)



$$A_{\cos\phi} / \varepsilon_c$$

$$\varepsilon_c = \frac{2(2-y)\sqrt{1-y}}{1+(1-y)^2}$$

First determination of charge dependent cosϕ moments



error bars:
statistical errors

bands:
systematical errors

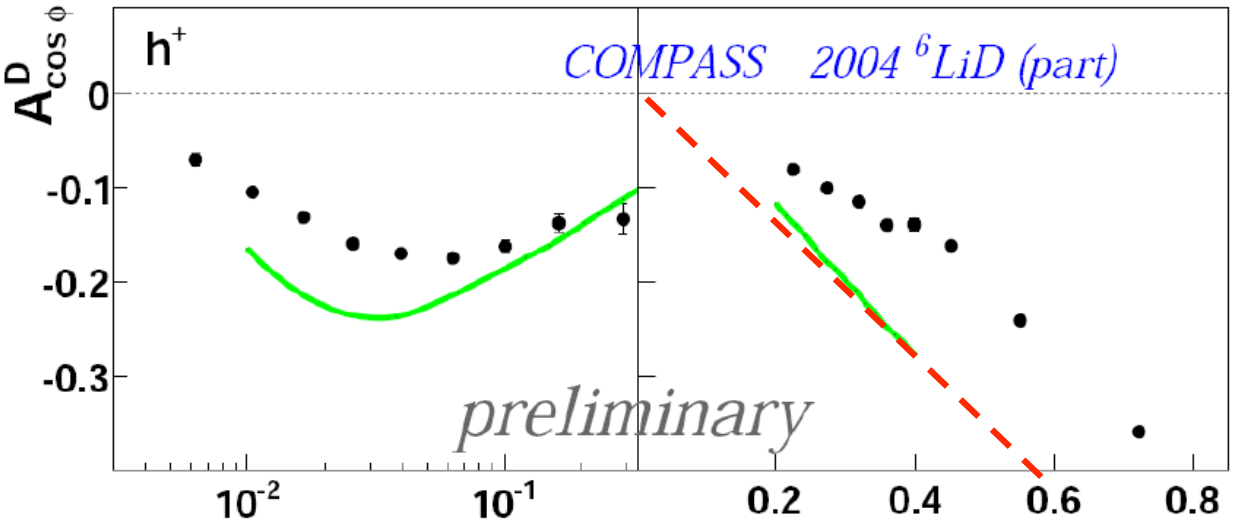
Deuteron target

Unpolarised Azimuthal Asymmetries

$\cos\phi$ modulation

comparison with theory

$$\frac{d\sigma}{d\phi_h} \propto 1 - 4\frac{\langle k_t^2 \rangle z P_t}{Q\langle P_t^2 \rangle} D_{\cos\phi_h}(y)\cos\phi_h + \ldots$$



Effect up to 40%

$\langle k_T^2 \rangle \approx 0.25$ GeV^2/c^2

Shape described by prediction

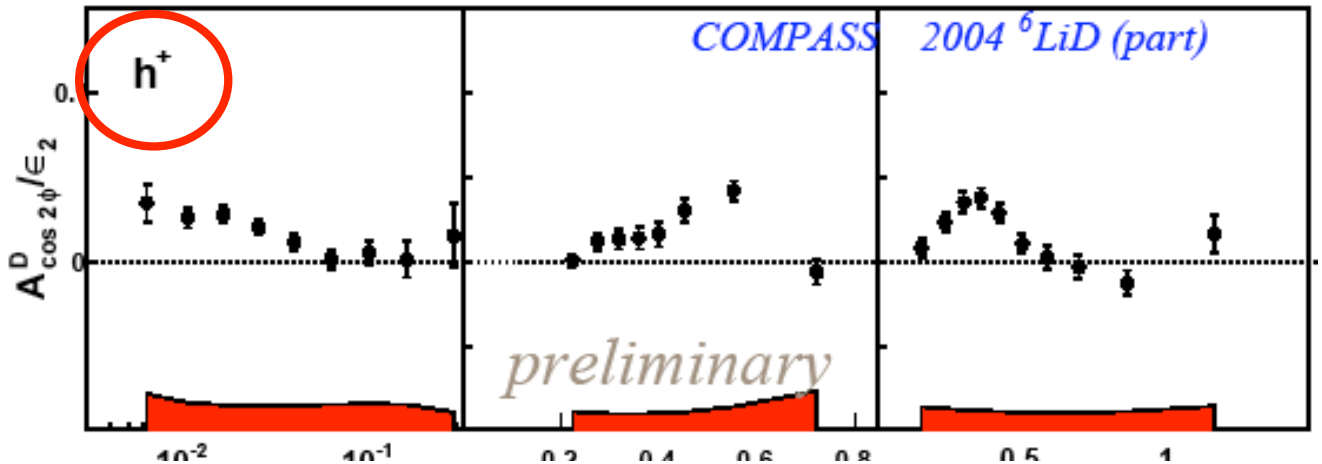
Size NOT in agreement with predictions

Unpolarised Azimuthal Asymmetries

cos2ϕ modulation (Cahn + Boer-Mulders)

$A_{\cos 2\phi} / \varepsilon_2$

$$\varepsilon_2 = \frac{2(2-y)}{1+(1-y)^2}$$

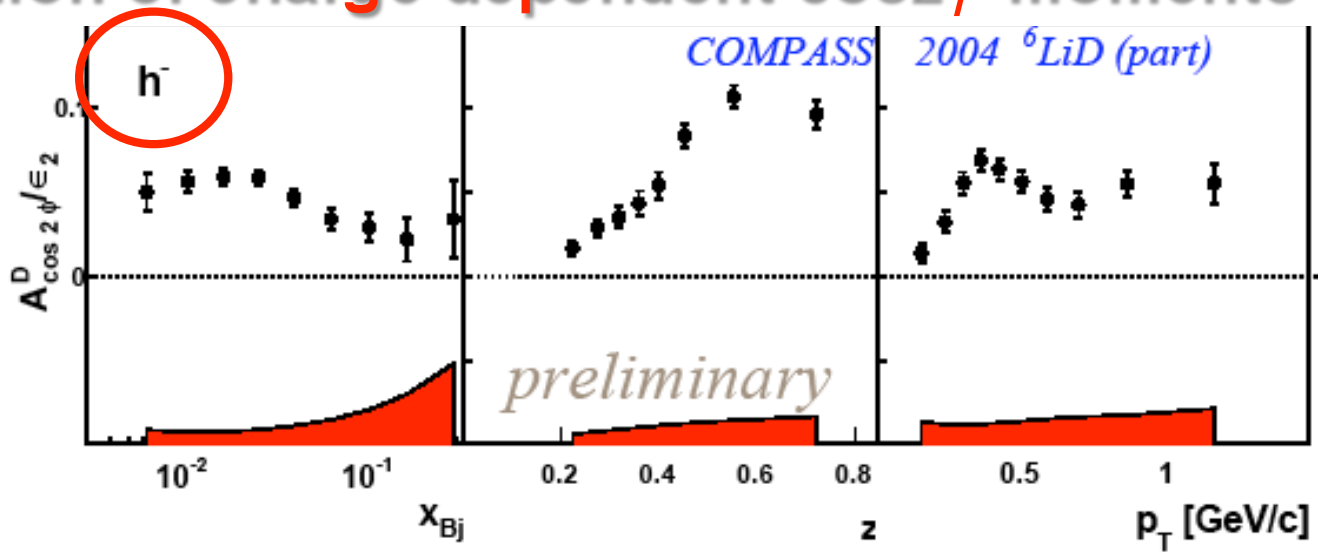


First determination of charge dependent cos2ϕ moments

statistical errors

bands:
systematical errors

Deuteron target

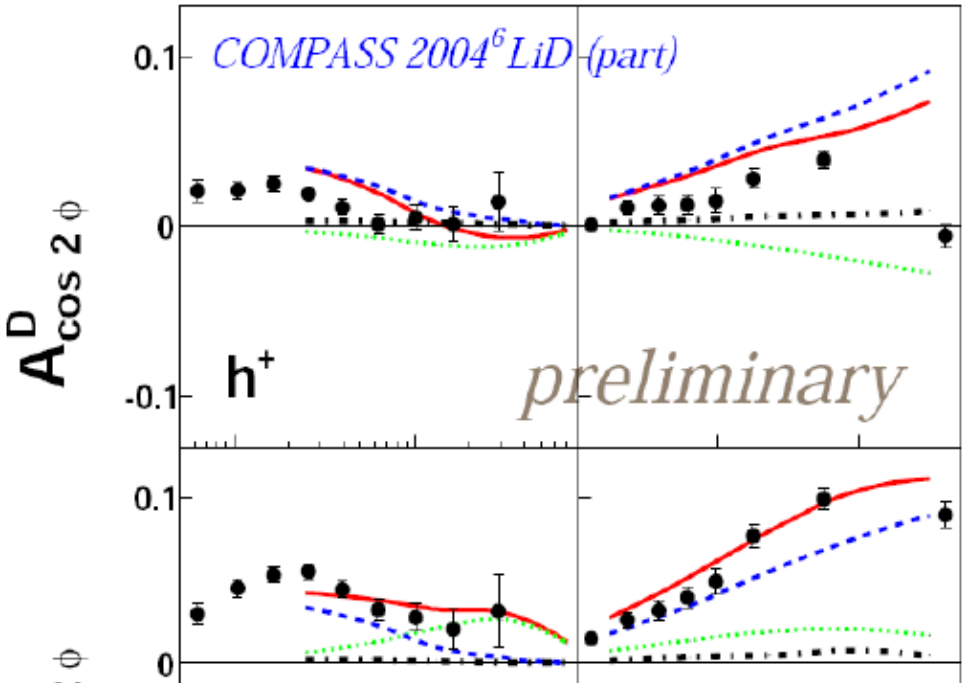


Unpolarised Azimuthal Asymmetries

$\cos 2\phi$ modulation

comparison with theory

- **pQCD** charge independent
- Cahn charge independent
  (if $k_T^u = k_T^d$)
- Boer–Mulders charge dependent



Effect up to 10%

Good agreement with predictions

Indication for non-vanishing Boer-Mulders function

Longitudinal target spin asymmetries

$$d\sigma = d\sigma_{00} + P_\mu d\sigma_{L0} + P_L\left(d\sigma_{0L} + P_\mu d\sigma_{LL}\right) + |P_T|\left(d\sigma_{0T} + P_\mu d\sigma_{LT}\right)$$

$$d\sigma_{0L} \propto \epsilon x h_{1L}^{\perp}(x) \otimes H_1^{\perp}(z)\sin(2\phi) + \sqrt{2\epsilon(1-\epsilon)}\frac{M}{Q}x^2\left(h_L(x) \otimes H_1^{\perp}(z) + f_L^{\perp}(x) \otimes D_1(z)\right)\sin(\phi),$$

$$d\sigma_{LL} \propto \sqrt{1-\epsilon^2}\, x g_{1L}(x) \otimes D_1(z) + \sqrt{2\epsilon(1-\epsilon)}\frac{M}{Q}x^2\left(g_L^{\perp}(x) \otimes D_1(z) + e_L(x) \otimes H_1^{\perp}(z)\right)\cos(\phi),$$

But caution: $|P_T| = P_{II}\sin(\theta_\gamma) \qquad \sin(\theta_\gamma) \approx 2\frac{M}{Q}x\sqrt{1-y}$

$$d\sigma_{0T} \propto \epsilon\{x h_1(x) \oplus H_1^{\perp}(z)\sin(\phi+\phi_S) + x h_{1T}^{\perp}(x) \otimes H_1^{\perp}(z)\sin(3\phi-\phi_S) - x f_{1T}^{\perp}(x) \otimes D_1(z)\sin(\phi-\phi_S)\},$$

$$d\sigma_{LT} \propto \sqrt{1-\epsilon^2}\, x g_{1T}(x) \otimes D_1(z)\cos(\phi-\phi_S),$$

Longitudinal target spin asymmetries

Full 2002 -2004 data sample on a longitudinally polarized LiD (deuteron) target:

~ 28 10^6 positive hadrons
~ 25 10^6 negative hadrons

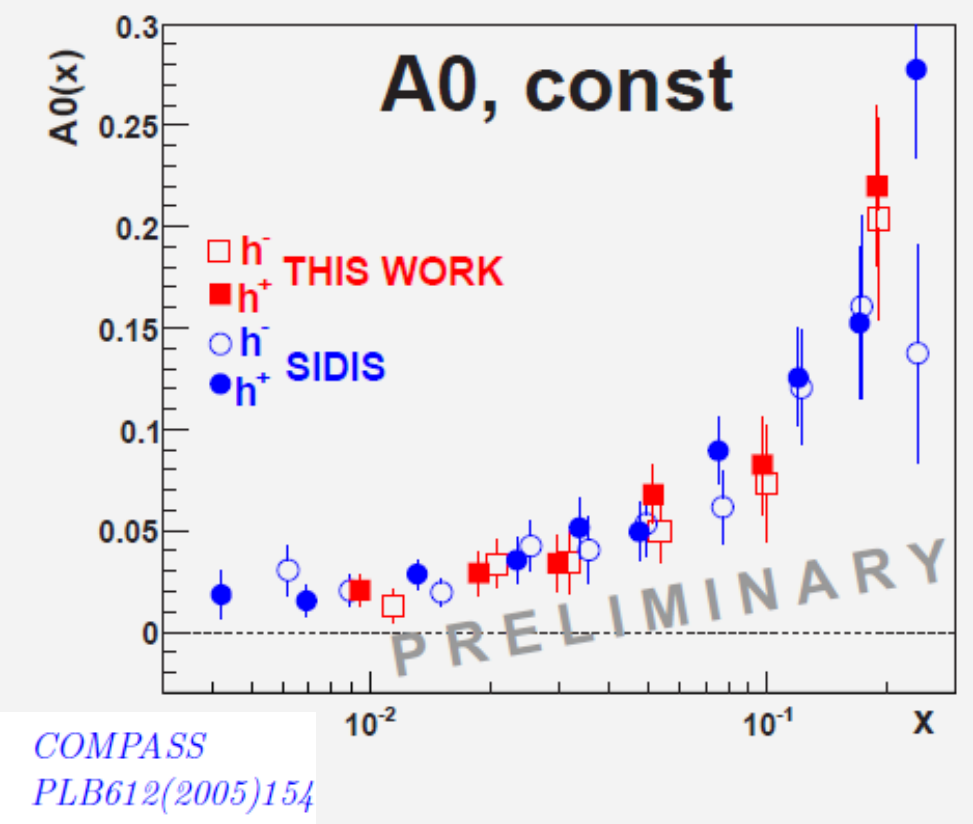
The double ratio

$$R_f(\phi) = \frac{N^U_{+f}(\phi)}{N^D_{-f}(\phi)} \cdot \frac{N^D_{+f}(\phi)}{N^U_{-f}(\phi)}$$

Is fitted by a 5 parameter fit:

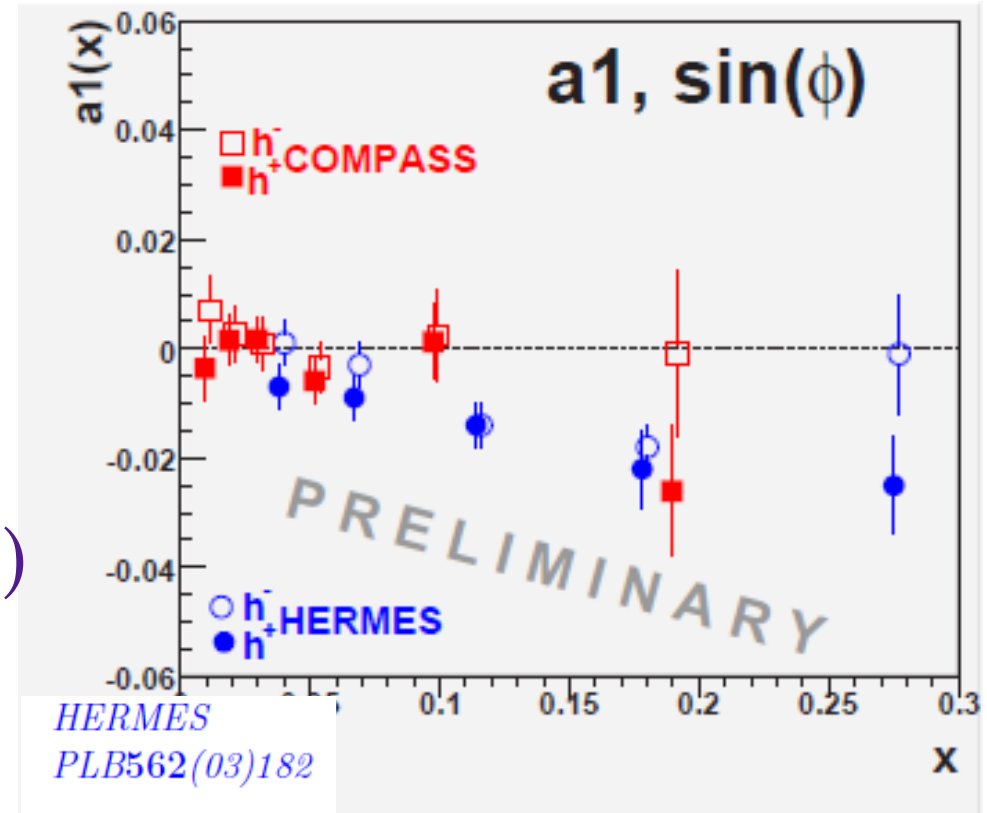
$$a_0 + a_1 \sin\phi + a_2 \sin 2\phi + a_3 \sin 3\phi + a_4 \cos\phi$$

Longitudinal target spin asymmetries



COMPASS
PLB612(2005)154

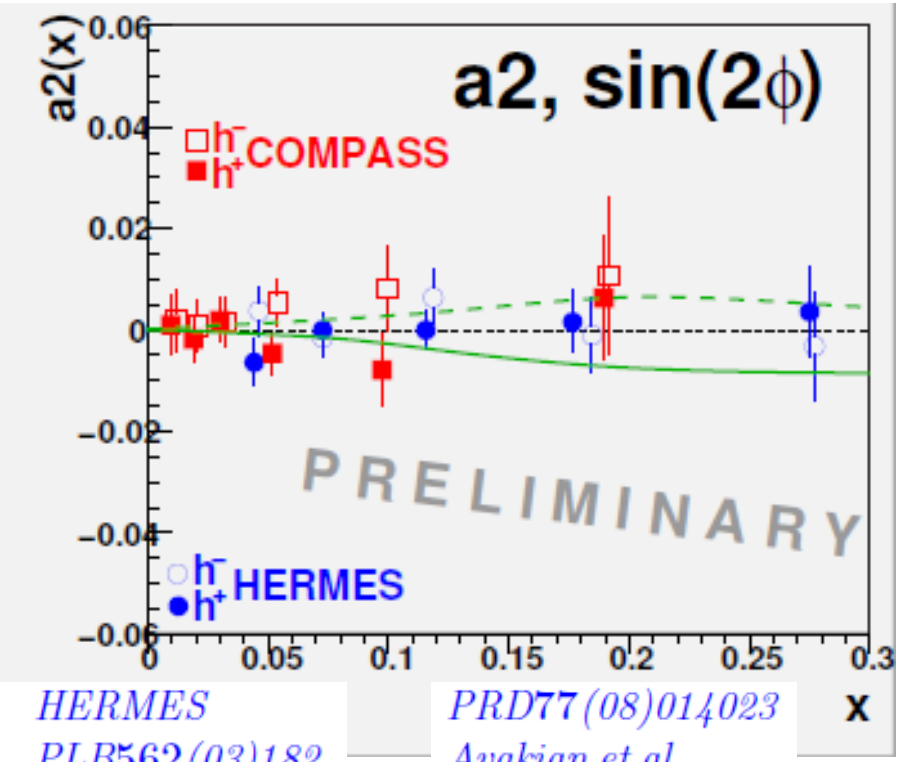
$$D_0 = P_\mu \cos(\theta_\gamma)\sqrt{1+\gamma^2}\left[\frac{y(2-y)}{2-2y+y^2(1+\frac{1}{2}\gamma^2)}\right]$$



HERMES
PLB562(03)182

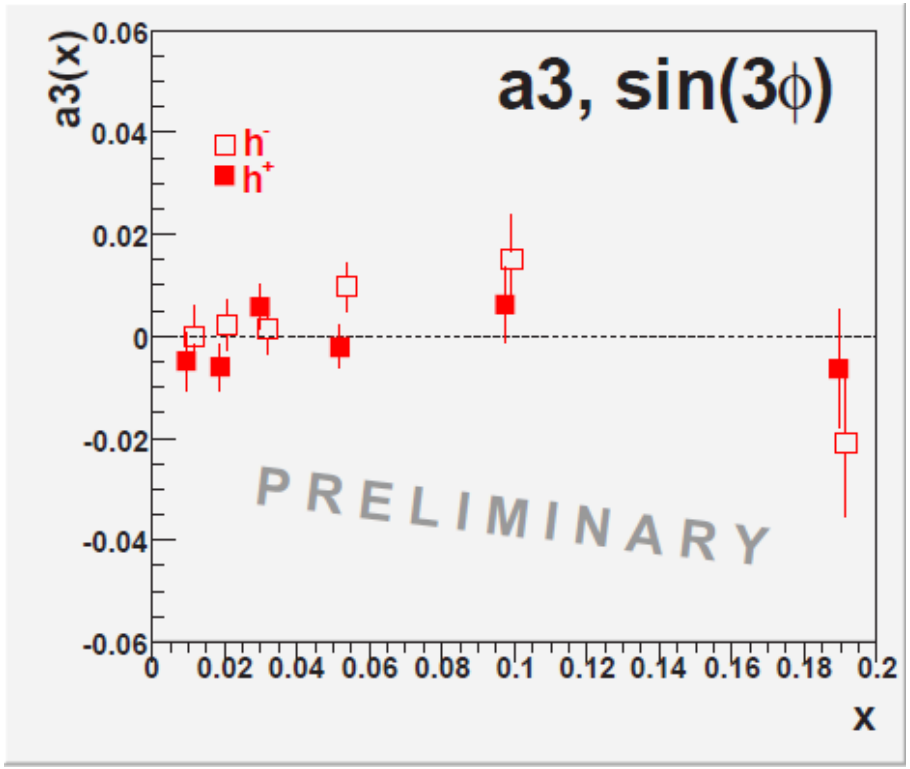
a₁ $\propto D_1 \otimes \frac{M}{Q}$ **and** **Collins and Sivers suppressed by** $\sin\theta_B \frac{M}{Q}$.

Longitudinal target spin asymmetries

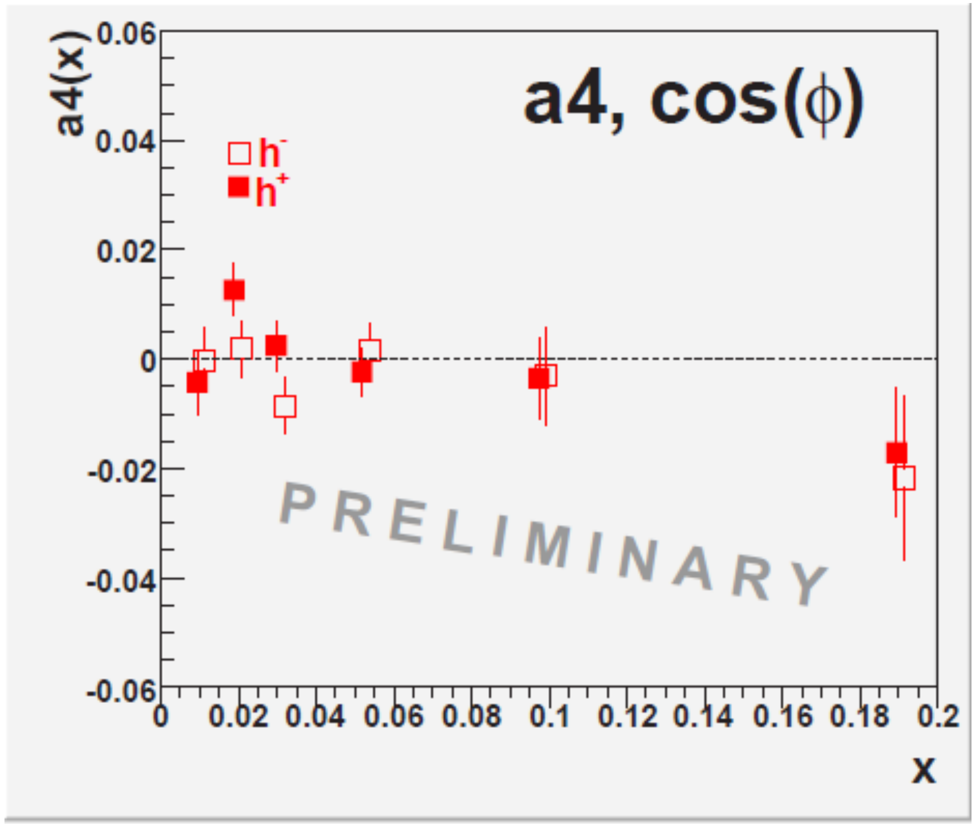


HERMES PLB562(03)182

PRD77(08)014023 Avakian et al.



Longitudinal target spin asymmetries



$$adxgx\Omega z_{414}\,\mathcal{D}_{LLL}\left(\frac{M}{Q}\right)^{2}\left(\vec{\ }()()\ldots\right)$$

and

$$F_{LT}^{\cos(\phi_h-\phi_s)} \propto g_{1T}^{q} \otimes D_{1q}^{h}$$

suppressed by $\sin N_B \;\frac{M}{Q}$.

LO target transverse spin asymmetries

8 Structure Functions for target transverse spin part, 4 LO

Sivers

$$A_{UT}^{\sin(\phi_h - \phi_s)} \propto D_{1T}^{\perp q} \otimes \delta_{11}^{q \to qh}$$

Collins

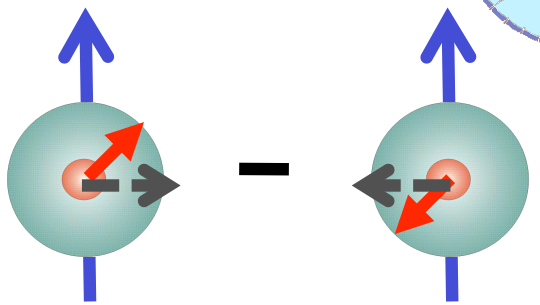
$$A_{UT}^{\sin(\phi_h + \phi_s)} \propto H_{1}^{\perp q} \otimes \delta_{11}^{q \to qh}$$

$$A_{LT}^{\cos(\phi_h - \phi_s)} \propto G_{1T}^{\perp q} \otimes \delta_{11}^{q \to qh}$$

$$A_{UT}^{\sin(3\phi_h - \phi_s)} \propto H_{1T}^{\perp q} \otimes \delta_{11}^{q \to qh}$$

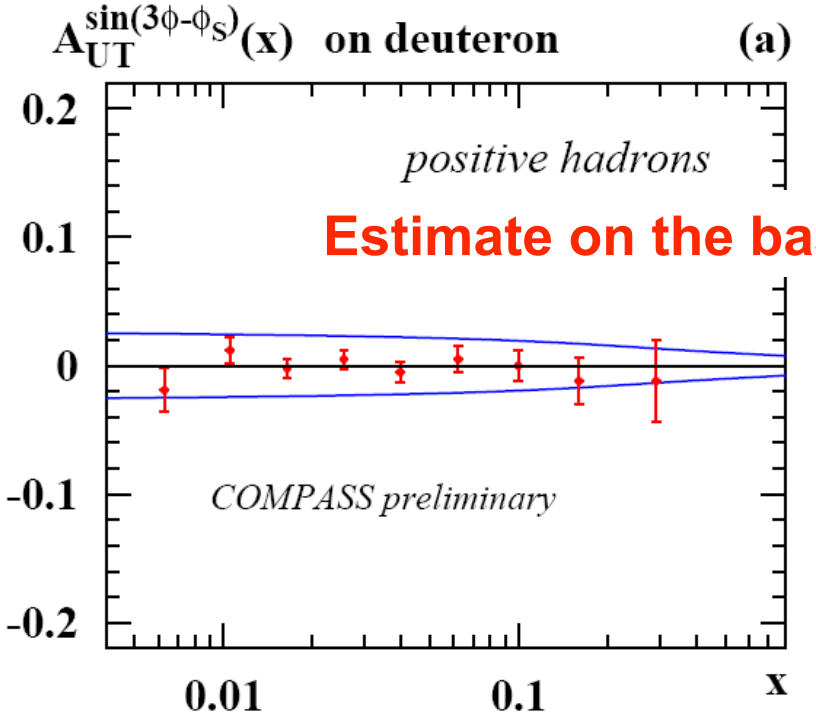
Pretzelosity

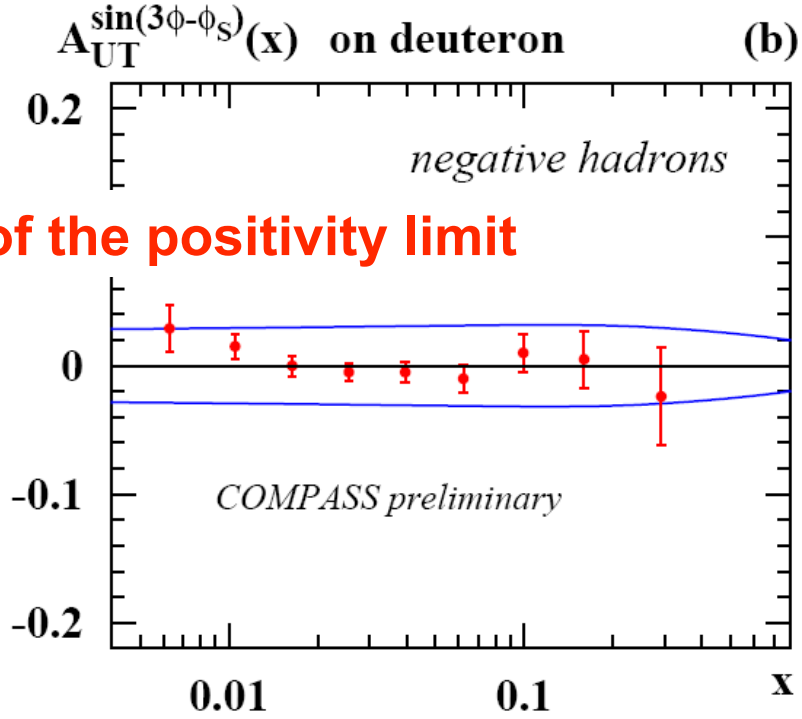
Target transverse spin results – (LO)



$$F_{UT}^{\sin(3\phi_h-\phi_s)} \propto h_{1T}^{\perp q} \otimes H_{1q}^{\perp h}$$

"Pretzelosity"



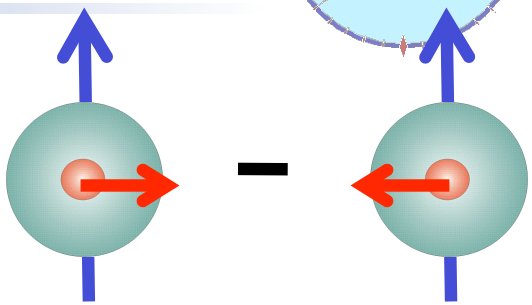


Estimate on the basis of the positivity limit

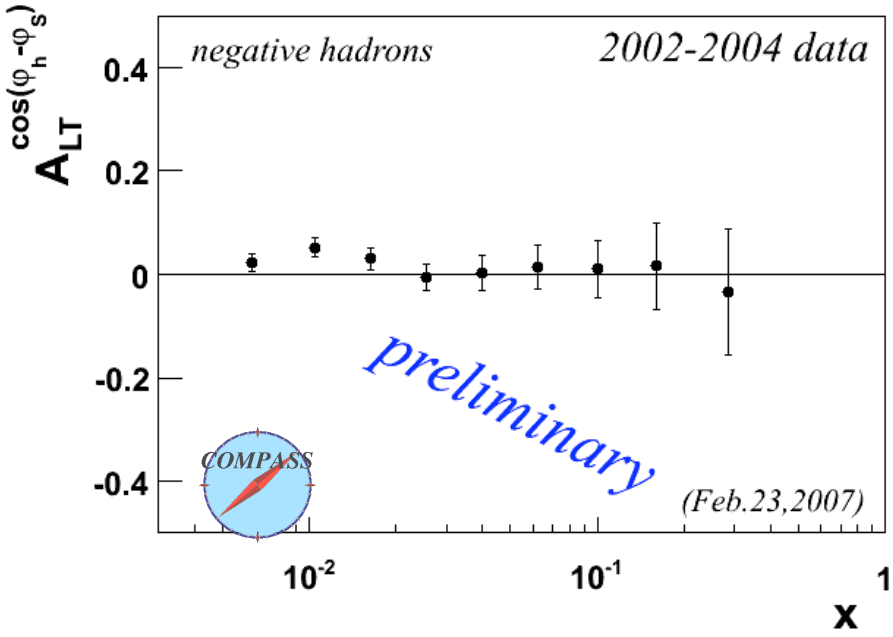
Avakian, Efremov, Schweitzer, Yuan, hep-ph/0808.3982

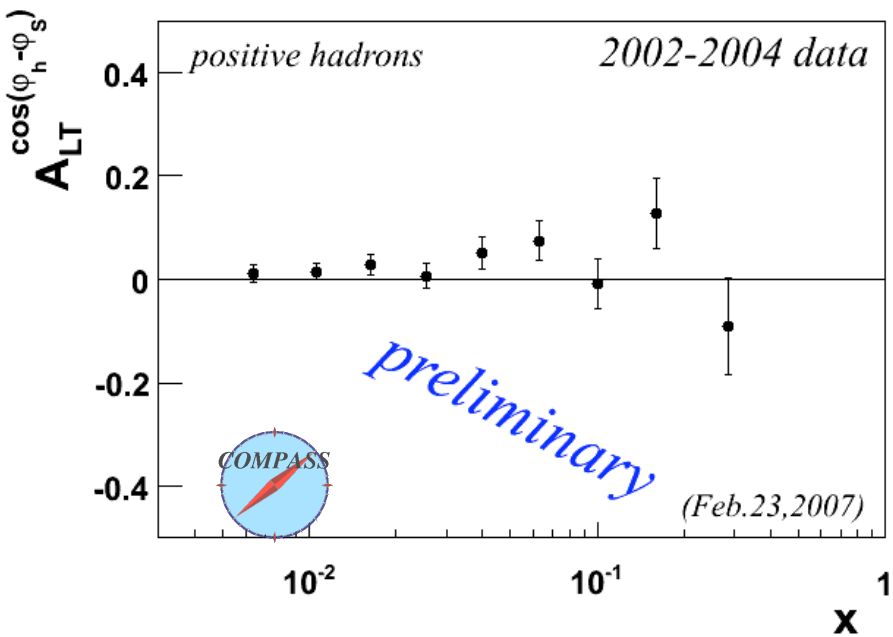
Target transverse spin results – (LO)

$$F_{LT}^{\cos(\phi_h-\phi_s)} \propto g_{1T}^{q} \otimes D_{1q}^{h}$$



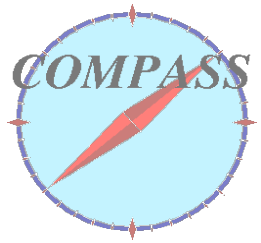
g_{1T} is the only parton DF which is
chiral-even, T-even, leading twist function
in addition to the unpolarised DF and to the helicity DF





again cancellation between
the u and d quarks in the deuteron ?

Summary I



- **Results on unpolarized asymmetries:**
  - First results obtained separately for + and - hadrons
  - sinϕ modulation compatible with 0
  - cosϕ modulation up to 20% (for large z or p_T) and the overall trend is reproduced by the predictions
  - cos2ϕ modulation smaller (10% at most). Overall good agreement with the predictions
  - There is a difference between +h and –h asymmetries on cosϕ/cos2ϕ

  Indication of non vanishing Boer-Mulders function !

- **Extraction of longitudinal target spin asymmetries**
  - sinϕ, sin2ϕ, sin3ϕ, modulations compatible with zero
  - cosϕ modulations very small but negative at high x compatible with zero in z and p_T

Summary II

- **Collins Asymmetry on Proton Target:**

  different from zero, comparable to HERMES

  agreement with predictions of Anselmino et al.

- **Sivers Asymmetry on Proton Target:**

  small and compatible with zero within the statistical errors

  Extraction of the Sivers asymmetry on the full 2007 run difficult due to instabilities

- **Hadron Pair-Production:**

  Asymmetry significantly different from zero

  - in agreement with predictions

  Two hadron Interference FF different from zero

- **Λ polarisation:**

  No signal visible, neither for deuteron, nor for proton target

  Fragmentation Function too small?

Outlook

Short term:

REQUEST TO CERN SPSC

(CERN-SPSC-2009-003 SPSC-I-238, 21 January 2009)

run one full year with transversely polarised proton target with the present muon beam and COMPASS spectrometer

(~9 10^{13} μ on tape, ~6 10^{18} p on T6)

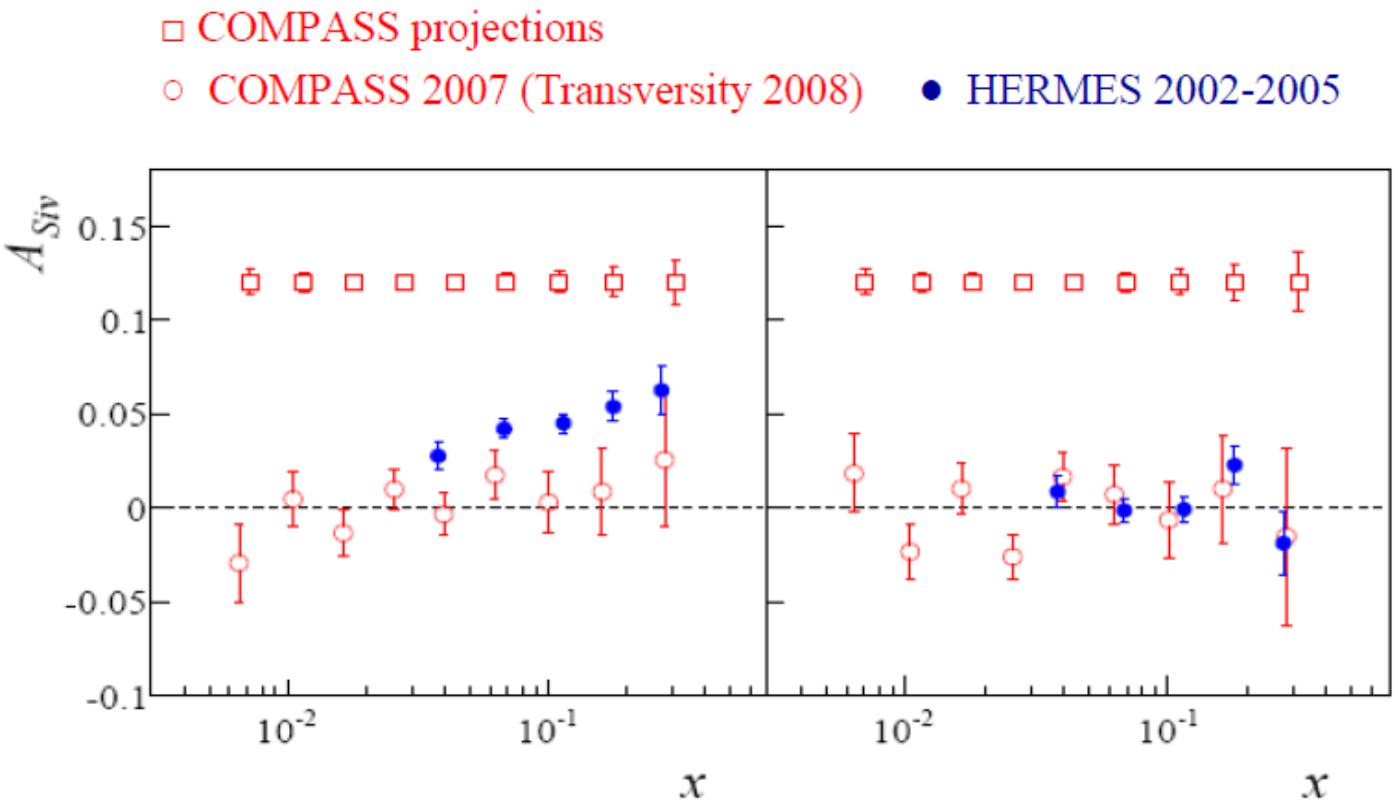
Medium and long term:

New COMPASS proposal

- **DVCS measurements to attack Generalised Parton Distributions**
  with muon beam and liquid hydrogen (or polarised proton) target
- **Drell-Yan measurements**
  with pion beam and polarised proton target

Outlook

Error projection on Sivers asymmetries:



projections for 1 year of data taking with NH_3 transversely polarized target

GOOD NEWS

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Dr. Sergio BERTOLUCCI
Director for Research and Computing
CERN
CH – 1211 GENEVA 23, Switzerland

Gerhard MALLOT

Telephone:
Direct + 41 22 767 1440
Secretariat
Telefax :
Direct
Electronic mail:

Our reference: C

Dear Dr. Mallot

I am happy to inform you that ' oard, in its meeting on September 2, has approved the Addendum ' oposal (SPSC-2009-025/M-769) which comprises two years of da' d target and a muon beam. The programme shall start already in 2'

Please extend to my best wishes for a fruitful run and a successful exploitatio' me.

I
September 2, h
769) which con
programme sha

Please extend to all the coll' run and a successful exploitation of the physi'

rs sincerely,

Sergio Bertolucci
Director for Research and Computing

Thank You !!