OVERVIEW OF THE COMPASS RESULTS

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on behalf of the COMPASS Collaboration

TWO CLASSES OF PHENOMENA

Longitudinal Spin case

Transverse Spin case

Longitudinal Spin case

from polarised lepton – polarised nucleon DIS $\quad d\sigma = d\bar{\sigma} \pm d\Delta\sigma$

$$\frac{d\Delta\sigma}{dx\,dy} = \frac{e^4}{4\pi^2 Q^2}\cdot\left\{\cos\alpha\cdot\left[\left(1-\frac{y}{2}-\frac{y^2}{4}\cdot\gamma^2\right)\cdot g_1 - \frac{9}{2}\cdot\gamma^2\cdot g_2\right] - \sin\alpha\cdot\cos\varphi\cdot\sqrt{1-\frac{y}{2}-\frac{y^2}{4}\cdot\gamma^2}\cdot\gamma\cdot\left(\frac{y}{2}\cdot g_1 + g_2\right)\right\}$$

with $\quad g_1(x) \approx \sum_q e_q^2 \cdot [\Delta q(x) + \Delta\bar{q}(x)]$ $\quad$ and $\quad \Delta q = \overleftrightarrow{q} - \overrightarrow{q}$

first moments: $\quad \Gamma_1 = \int g_1(x)\,dx \qquad \Delta q = \int \Delta q(x)\,dx$

from Γ_1^p measurement of EMC in 1988 and using complementary information from neutron and hyperon β–decay one obtained

$$\Delta\Sigma = \Delta u + \Delta d + \Delta s = 0.12 \pm 0.17$$

at variance with naïve expectation

since $\quad \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_{q,g}$

necessity for measuring Γ_1^n — *SMC, SLAC, HERMES*

Δq and $\Delta\bar{q}$ in SIDIS — SMC, HERMES, COMPASS

ΔG in SIDIS — HERMES, COMPASS

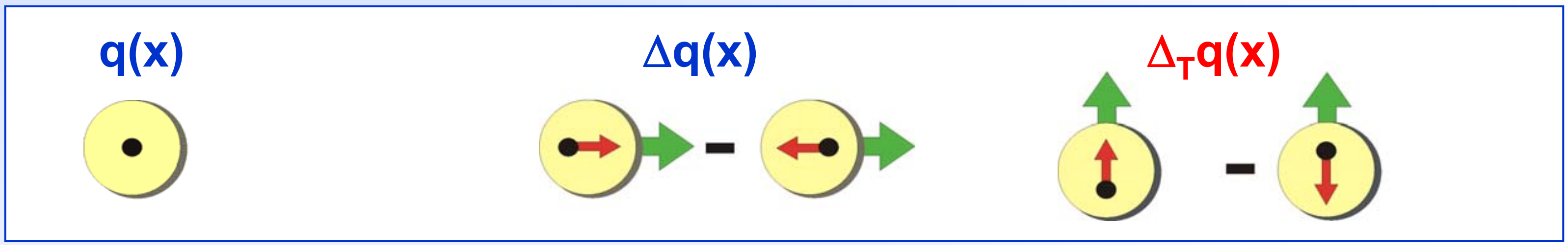
Transverse Spin case

Large effects observed in hadronic interactions

Theoretical developments:

at leading order a third PDF is necessary for a complete description of the structure of the nucleon

R.L. Jaffe and X. Ji, Phys. Rev. Lett. **67** (1991) 552



- $\Delta_T q(x)$ being chiral-odd, it can be measured only in conjunction with another chiral-odd partner:

DY $\Delta_T q \otimes \Delta_T \bar{q}$ SIDIS $\Delta_T q \otimes FF$ → **Collins function**

measurable in $e^+e^- \rightarrow$ hadrons

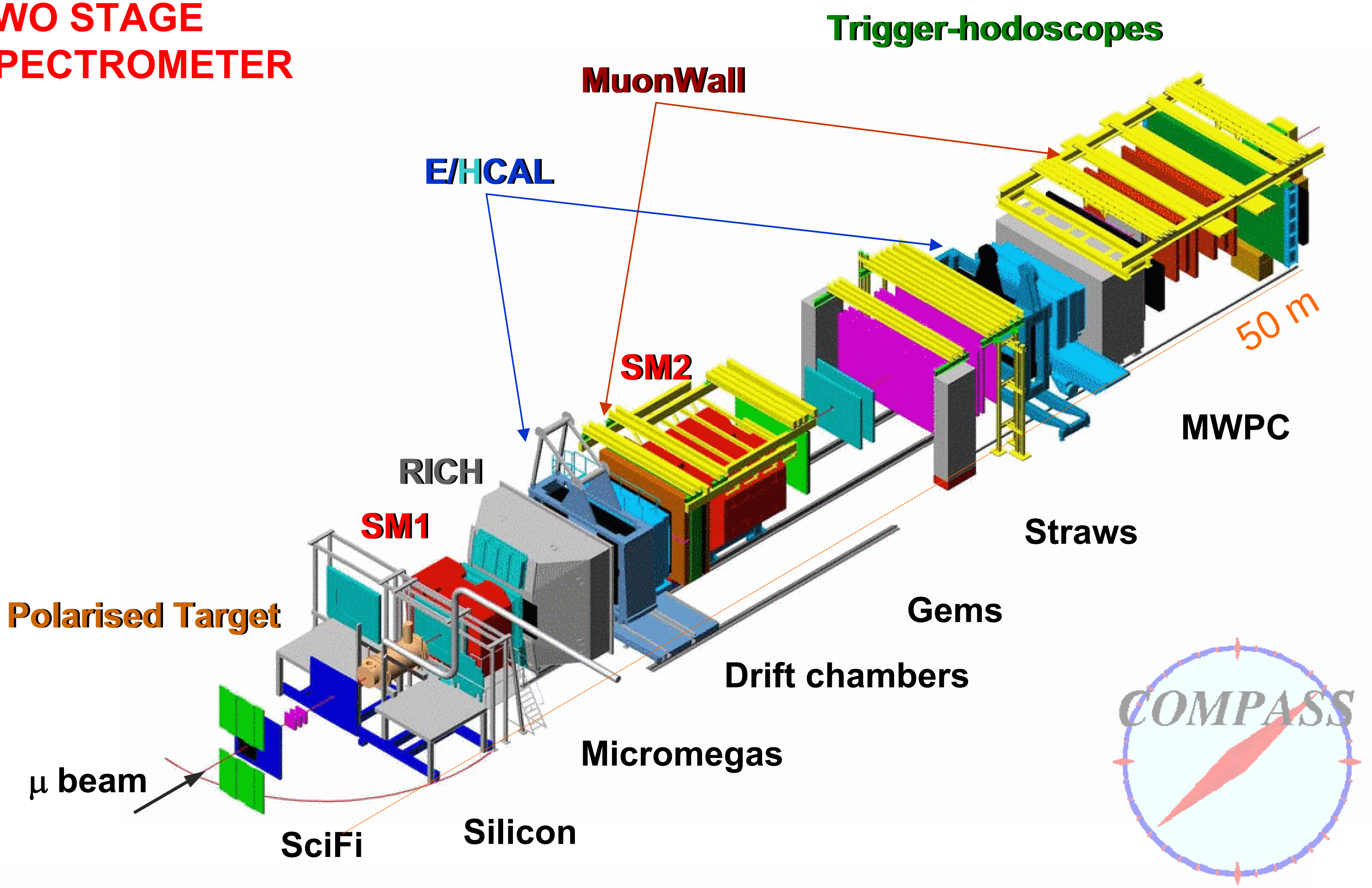
- relevance of transverse momentum dependent (TMD) PDF and FF → **Sivers function**

- longitudinally polarised muon beam
- longitudinally or transversely polarised deuteron (^{6}LiD) target
- momentum and calorimetry measurement
- particle identification

luminosity:	~5 · 10^{32} cm^{-2} s^{-1}
beam intensity:	2·10^{8} μ+/spill (4.8s/16.2s)
beam momentum:	160 GeV/*c*
target polarization:	*~50%*

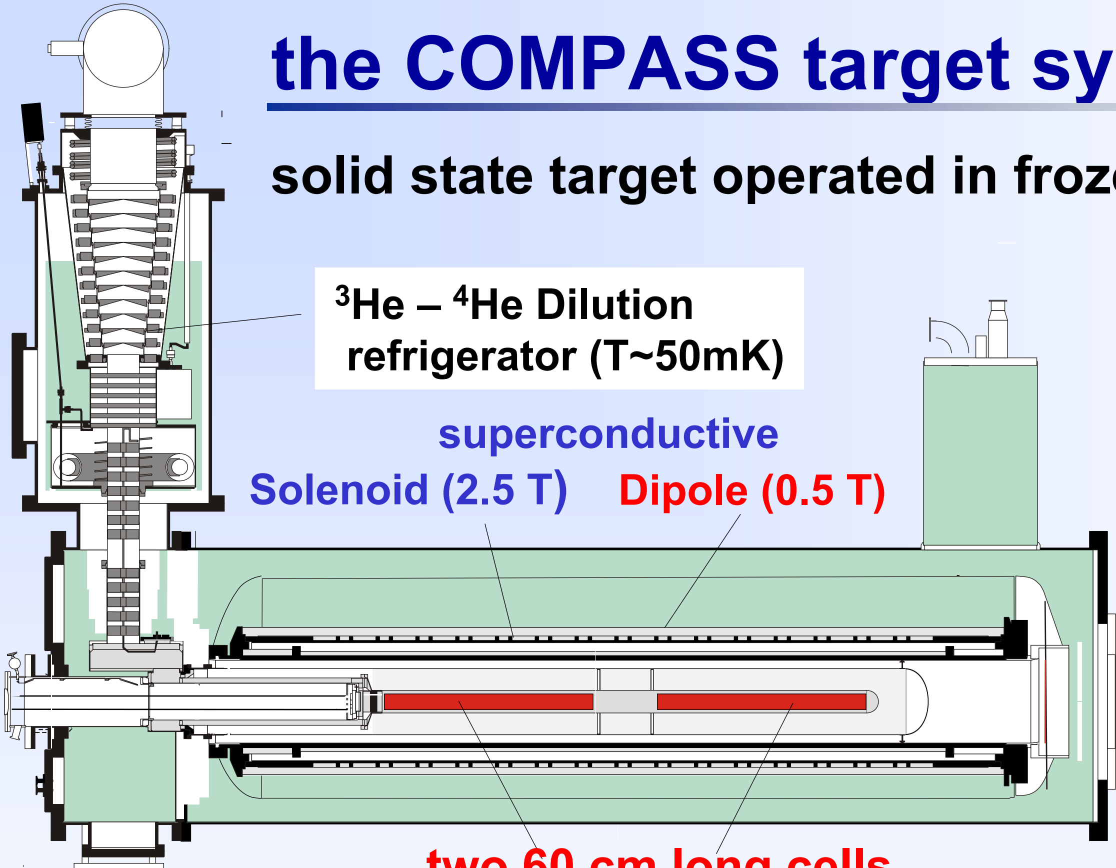
The COMPASS Spectrometer

TWO STAGE SPECTROMETER



the COMPASS target system (2002-2004)

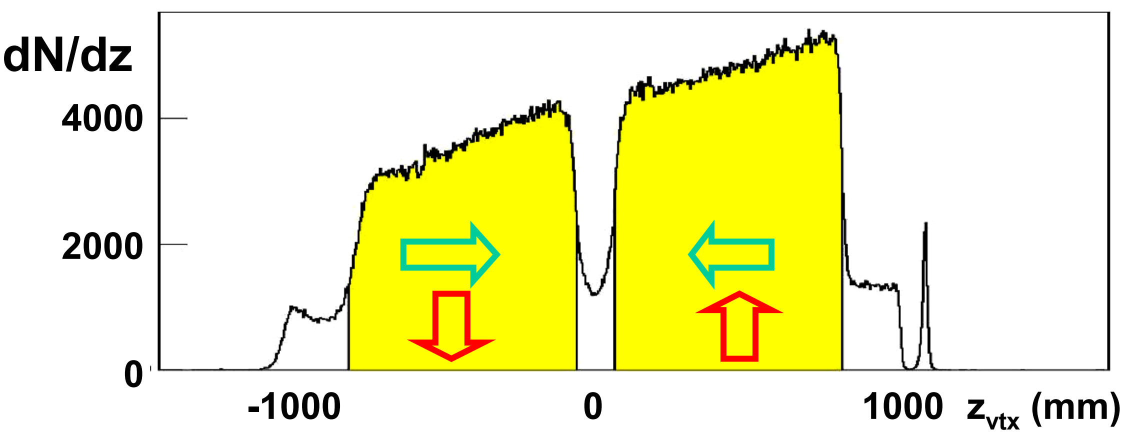
solid state target operated in frozen spin mode



two 60 cm long cells
with *opposite polarisation* (systematics)

2002-2004: ^{6}LiD
dilution factor f = 0.38
polarization P_T = 50%
~20% of the time transversely polarised

2006:
- **PTM replaced with the large acceptance COMPASS magnet**
- **2 ➔ 3 cells**

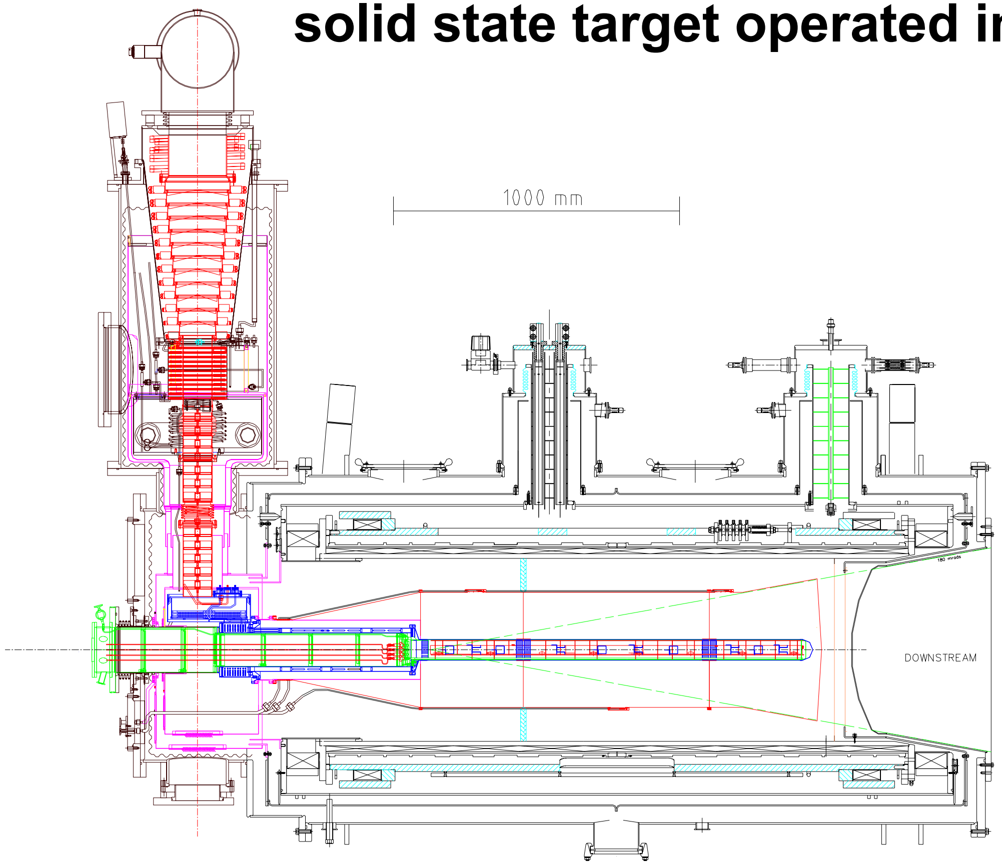


during data taking with transverse polarization
- **dipole field always ↑**
- **polarization reversal in the 2 cells after ~ 5 days**

F. Bradamante

COMPASS proton run 2007

solid state target operated in frozen spin mode

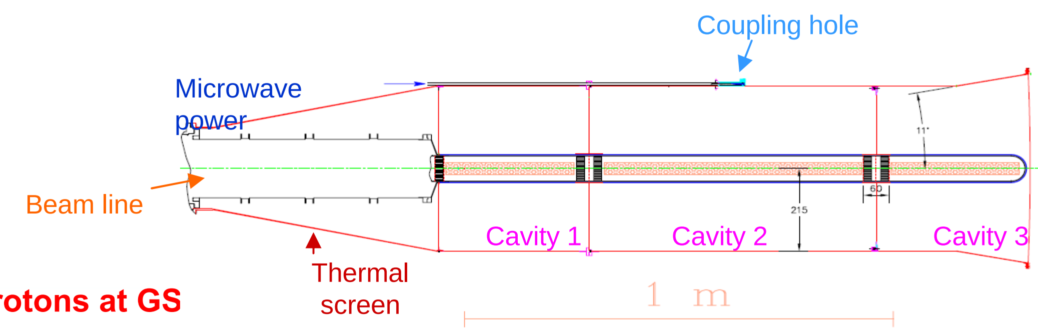


2007: NH_3

dilution factor f = 0.14

polarization P_T = 90%

2 ➔ 3 cells



LONGITUDINAL SPIN CASE

MEASUREMENT OF ΔG

COMPASS results

MEASUREMENTS OF THE GLUON POLARIZATION

FOUR LINES OF ATTACK:

1. Double spin asymmetry of the OPEN CHARM cross-section in high energy μD scattering

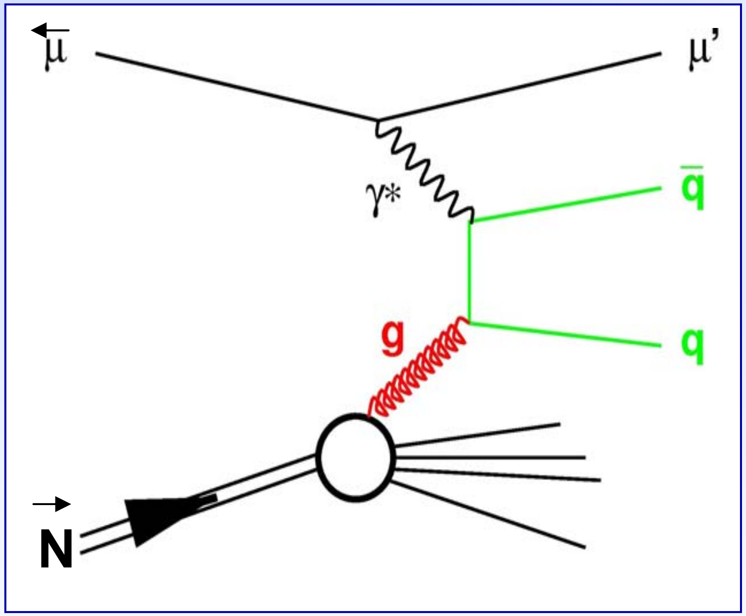
2. Double spin asymmetry of the HIGH-p_t HADRON PAIRS in high energy μD DIS ($Q^2 > 1$ GeV^2)

3. Double spin asymmetry of the high-p_t hadron pairs in high energy μD scattering ($Q^2 < 1$ GeV^2)

4. Measurement of g_1 of the deuteron and QCD fit of all the world data

Gluon Polarization

Photon-Gluon Fusion



q = c

"OPEN CHARM"

cross section difference in charmed meson production

→ *theory well understood*

→ *experiment challenging*

q = u,d,s

"HIGH p_T HADRON PAIRS"

cross section difference in 2+1 jet production in COMPASS: events with 2 hadrons with high p_T

→ *experiment "easy"*

→ *theory more difficult*

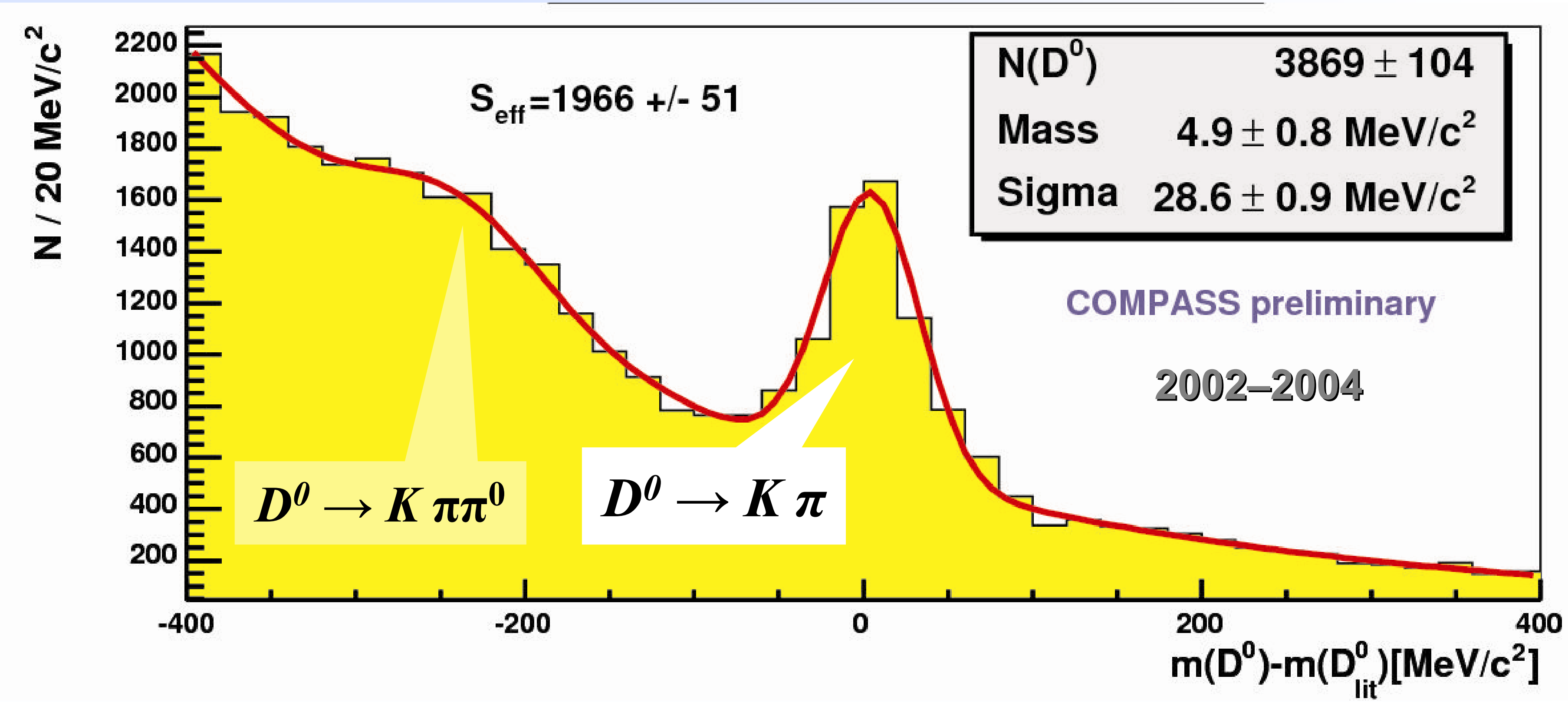
enrich photon-gluon fusion events with high-p_t cuts

$p_t > 0.7$ GeV/c	$p_{t1}^2 + p_{t2}^2 > 2.5\ (\mathrm{GeV/c})^2$
$x_F, z > 0.1$	$m(h_1,h_2) > 1.5\ \mathrm{GeV/c^2}$

Gluon Polarization

Open Charm: *D'*s from *D**'s

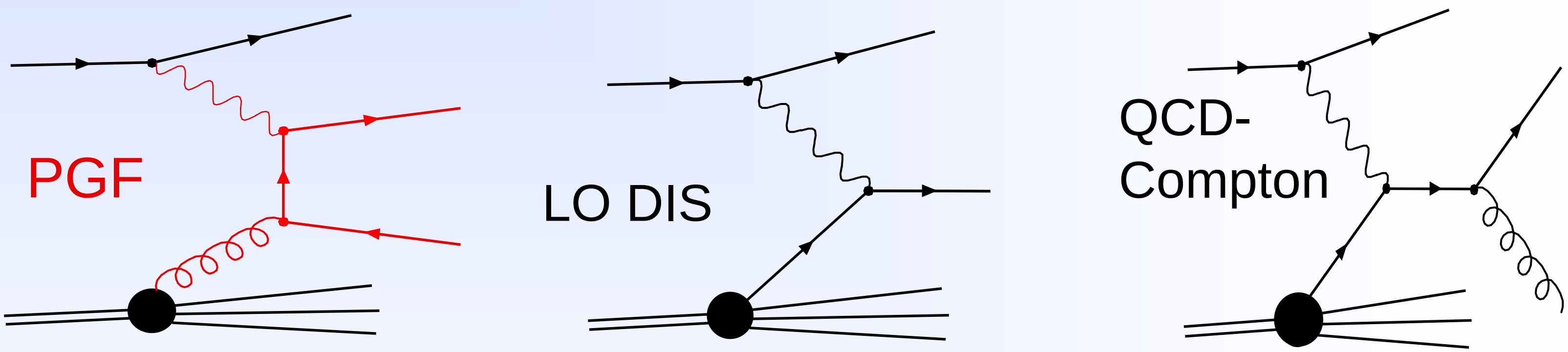
$D^* \to D\,\pi_s \to K\,\pi\,\pi_s$ **slow pion required**



Gluon Polarization

High-p_t Hadrons, $Q^2 > 1$ $(GeV/c)^2$

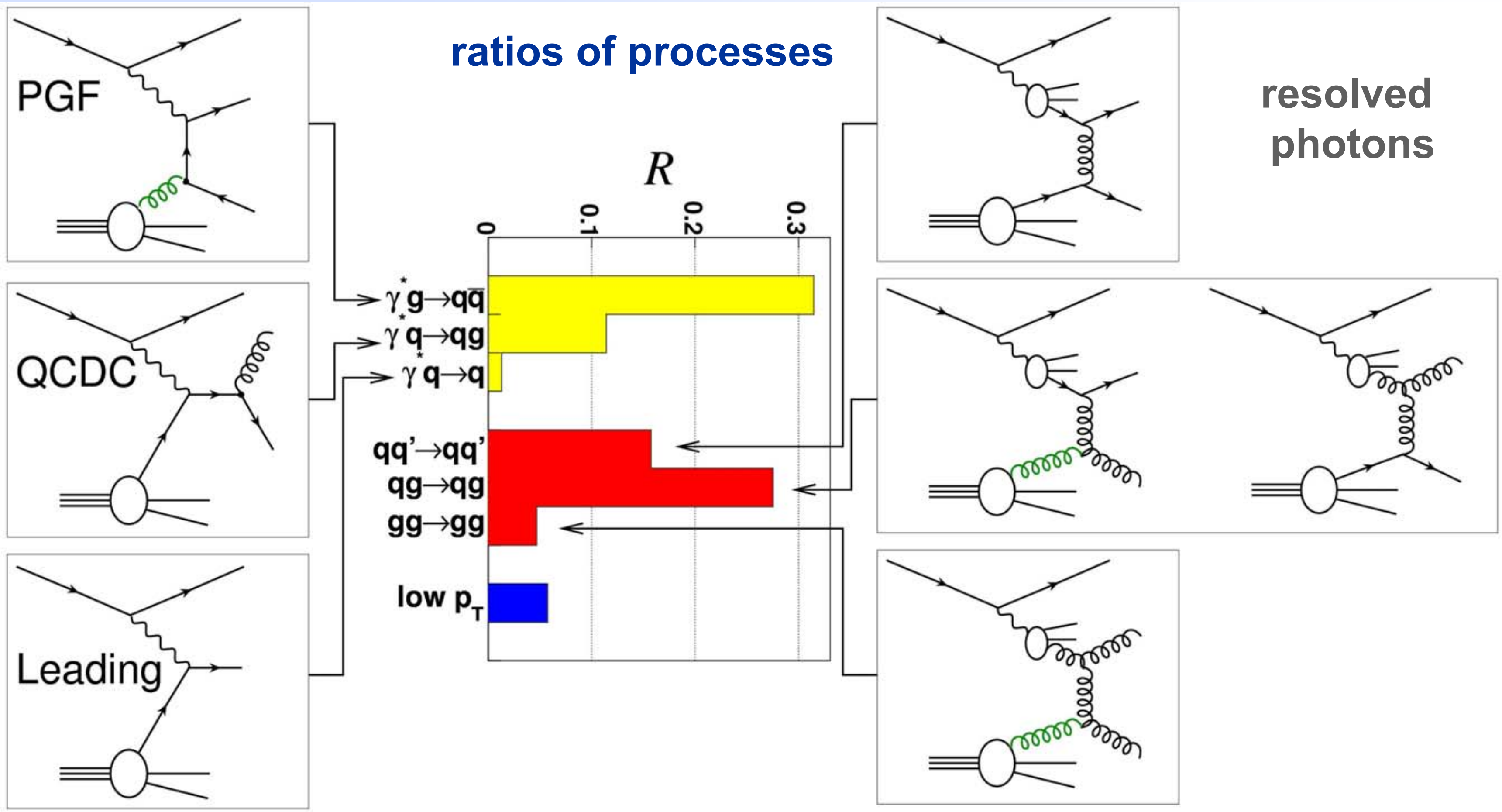
PGF **and** **background**



$$\frac{A_{LL}}{D} \approx \frac{a_{LL}^{PGF}}{D} \frac{\Delta G}{G} \frac{\sigma^{PGF}}{\sigma^{tot}} + A_1 \frac{a_{LL}^{LO}}{D} \frac{\sigma^{LO}}{\sigma^{tot}} + A_1 \frac{a_{LL}^{QCD-C}}{D} \frac{\sigma^{QCD-C}}{\sigma^{tot}}$$

Gluon Polarization

High-p_t Hadrons, $Q^2 < 1$ $(GeV/c)^2$



Gluon Polarization

COMPASS preliminary results

high-p_t pairs, Q^2>1GeV^2 : 2002–2003

$$\frac{\Delta G}{G} = 0.06 \pm 0.31(\text{stat.}) \pm 0.06(\text{syst.}) \qquad \langle x_g \rangle = 0.13$$

high-p_t pairs, Q^2< 1GeV^2 : 2002–2004

$$\frac{\Delta G}{G} = 0.016 \pm 0.058(\text{stat.}) \pm 0.055(\text{syst.})$$

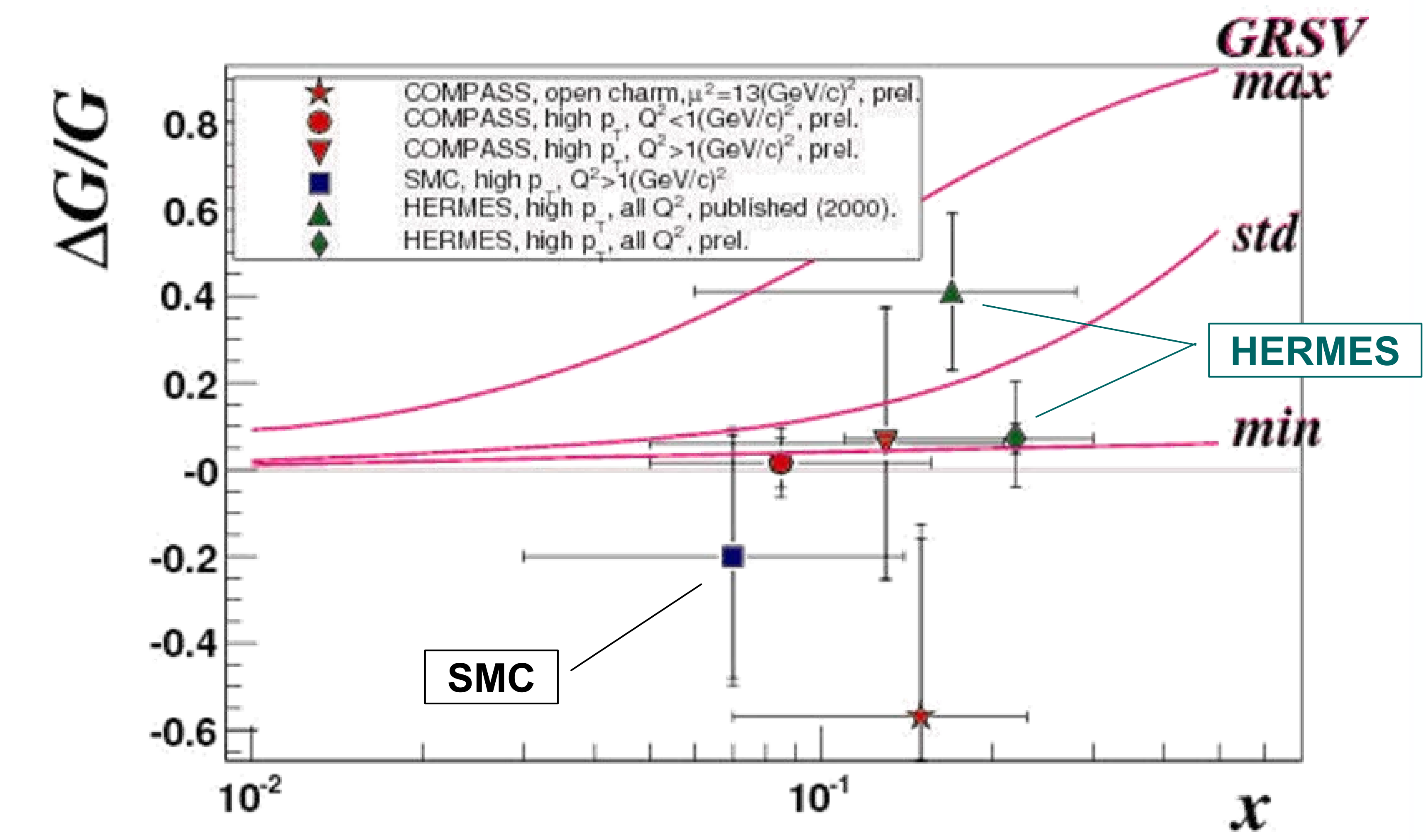
$$\langle x_g \rangle = 0.085 \qquad \langle \mu^2 \rangle = 3 \text{ GeV}^2$$

open charm: 2002–2004

$$\frac{\Delta G}{G} = -0.57 \pm 0.41(\text{stat.}) \pm 0.17(\text{syst.})$$

$$\langle x_g \rangle = 0.15 \quad \langle \mu^2 \rangle = 13 \text{ GeV}^2$$

ΔG/G COMPASS preliminary results

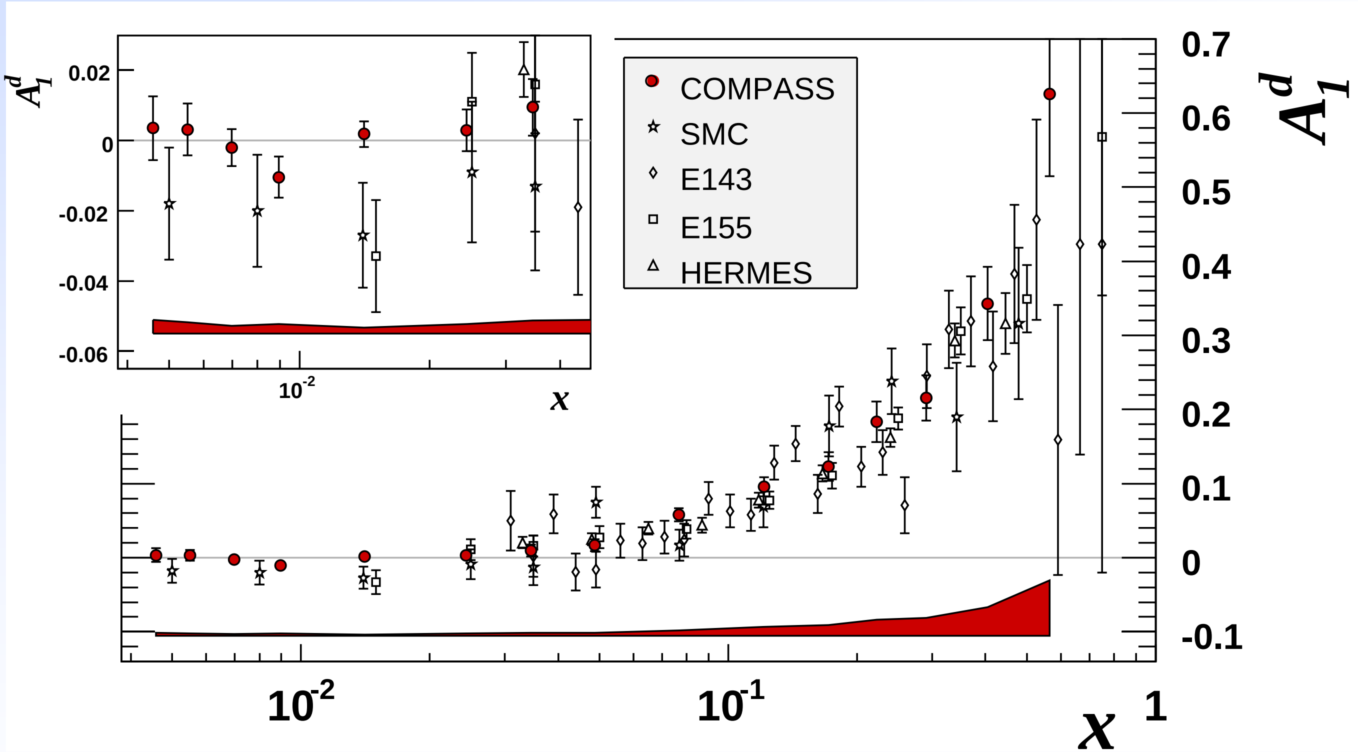


GRSV-max strongly disfavored

A_1^d and QCD fit

Inclusive DIS asymmetry $Q^2>1$ (GeV/c)^2

world results



COMPASS
PLB 647(2007)8

- good agreement with previous experiments
- significantly improved statistics at low x
- no tendency towards negative values at x<0.03

QCD fit

$$g_1(x,Q^2) = \frac{1}{2}\langle e^2\rangle \left[C_q^S \otimes \Delta\Sigma + C_q^{NS} \otimes \Delta q^{NS} + 2n_f\, C_G \otimes \Delta G \right]$$

$\Delta\Sigma = \Delta u + \Delta d + \Delta s$, $\Delta q_3 = \Delta u - \Delta d$, $\Delta q_8 = \Delta u + \Delta d - 2\Delta s$

DGLAP equations:

$$\frac{d}{dt}\Delta q^{NS} = \frac{\alpha_s(t)}{2\pi} P_{qq}^{NS} \otimes \Delta q^{NS}$$

$$\frac{d}{dt}\begin{pmatrix} \Delta\Sigma \\ \Delta G \end{pmatrix} = \frac{\alpha_s(t)}{2\pi}\begin{pmatrix} P_{qq}^S & 2n_f P_{qG}^S \\ P_{Gq}^S & P_{GG}^S \end{pmatrix} \otimes \begin{pmatrix} \Delta\Sigma \\ \Delta G \end{pmatrix}, \quad t = \log\left(\frac{Q^2}{\Lambda^2}\right)$$

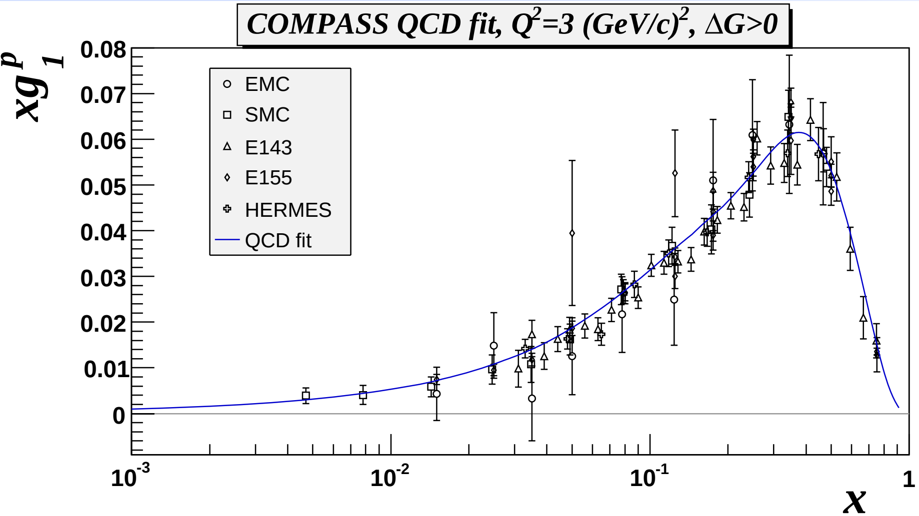
Input parameterisations (x–dependence at a fixed Q_0^2):

$$(\Delta\Sigma, \Delta q_3, \Delta q_8, \Delta G) = \eta \frac{x^\alpha (1-x)^\beta (1+\gamma x)}{\int_0^1 x^\alpha (1-x)^\beta (1+\gamma x)\,dx}$$

Minimization routine:

$$\chi^2 = \sum_{i=1}^{N} \frac{\left[g_1^{\mathrm{calc}}(x,Q^2) - g_1^{\mathrm{exp}}(x,Q^2)\right]^2}{\left[\sigma_{\mathrm{stat}}^{\mathrm{exp}}(x,Q^2)\right]^2}$$

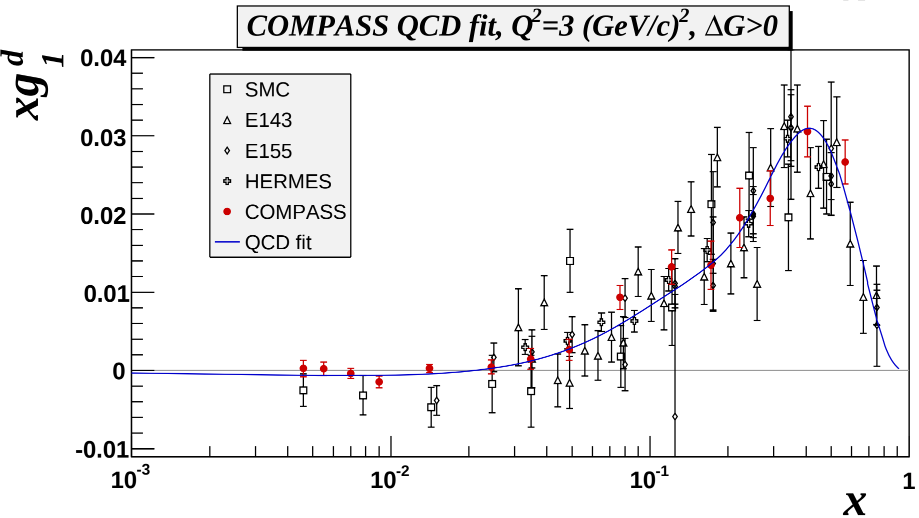
QCD fit

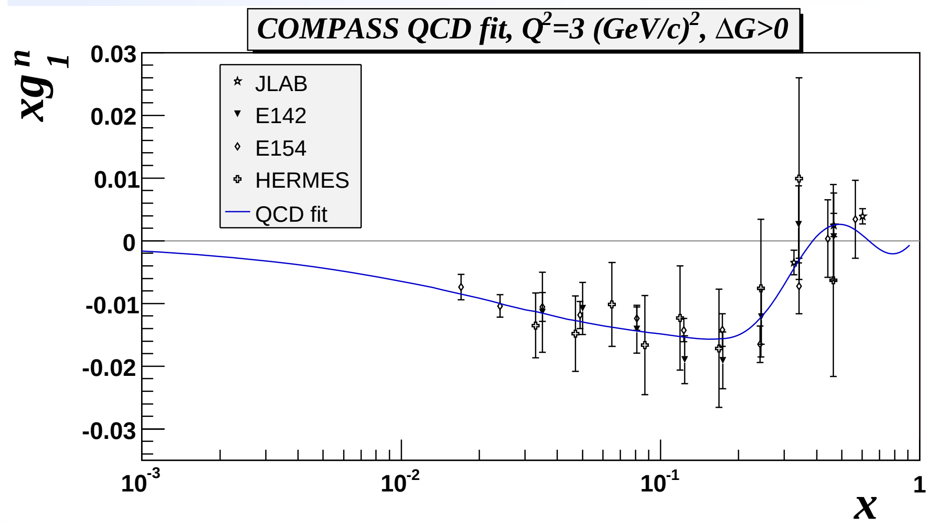


world data
at Q_0^2 = 3 GeV²

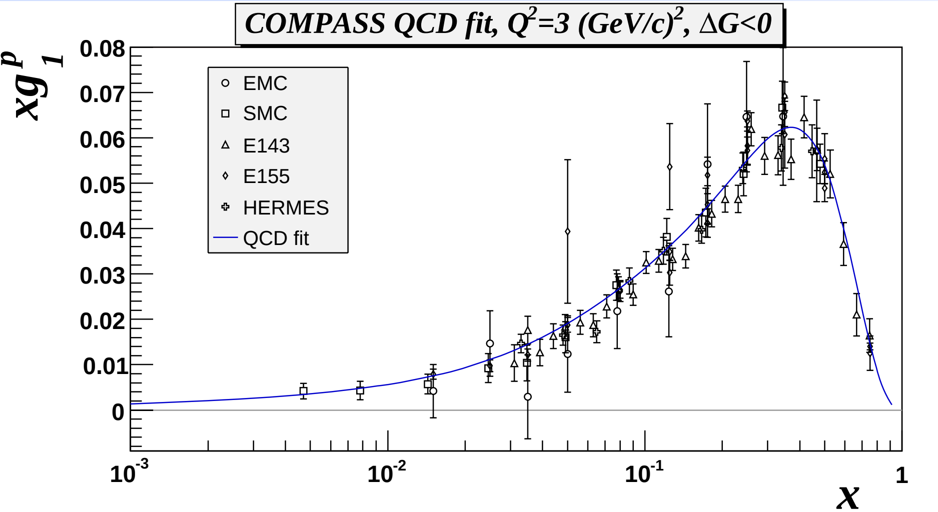
$$g_1(x,Q_0^2) = g_1(x,Q_i^2) + [g_1^{fit}(x,Q_0^2) - g_1^{fit}(x,Q_0^2)]$$

solutions with ΔG > 0



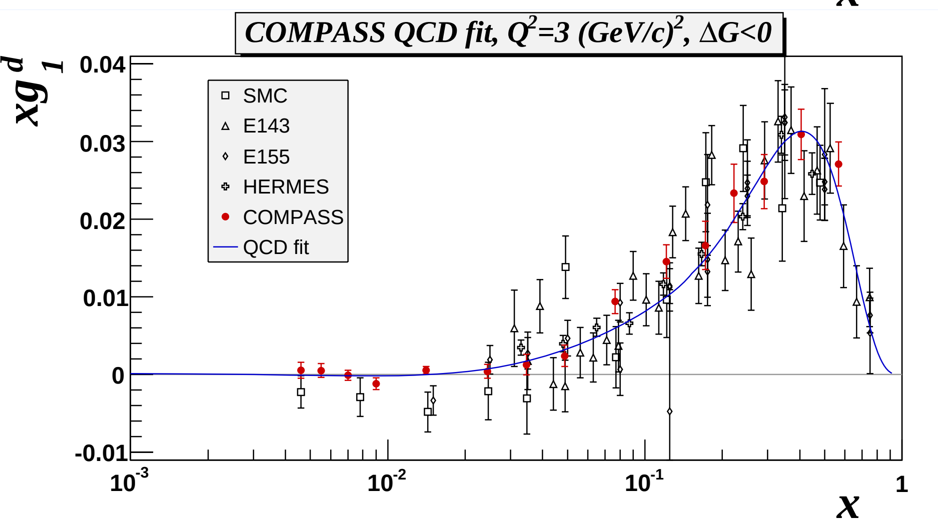


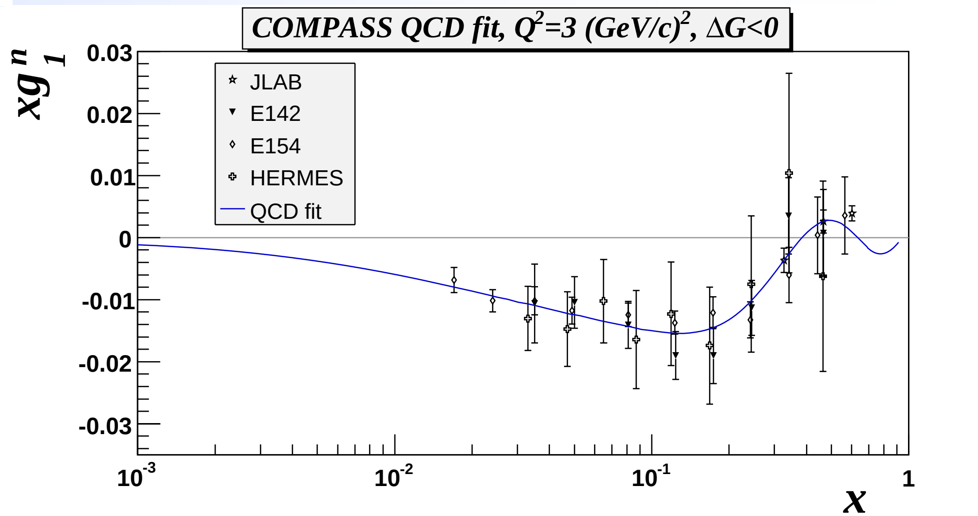
QCD fit



world data
at $Q_0^2 = 3\ GeV^2$

solutions with $\Delta G < 0$

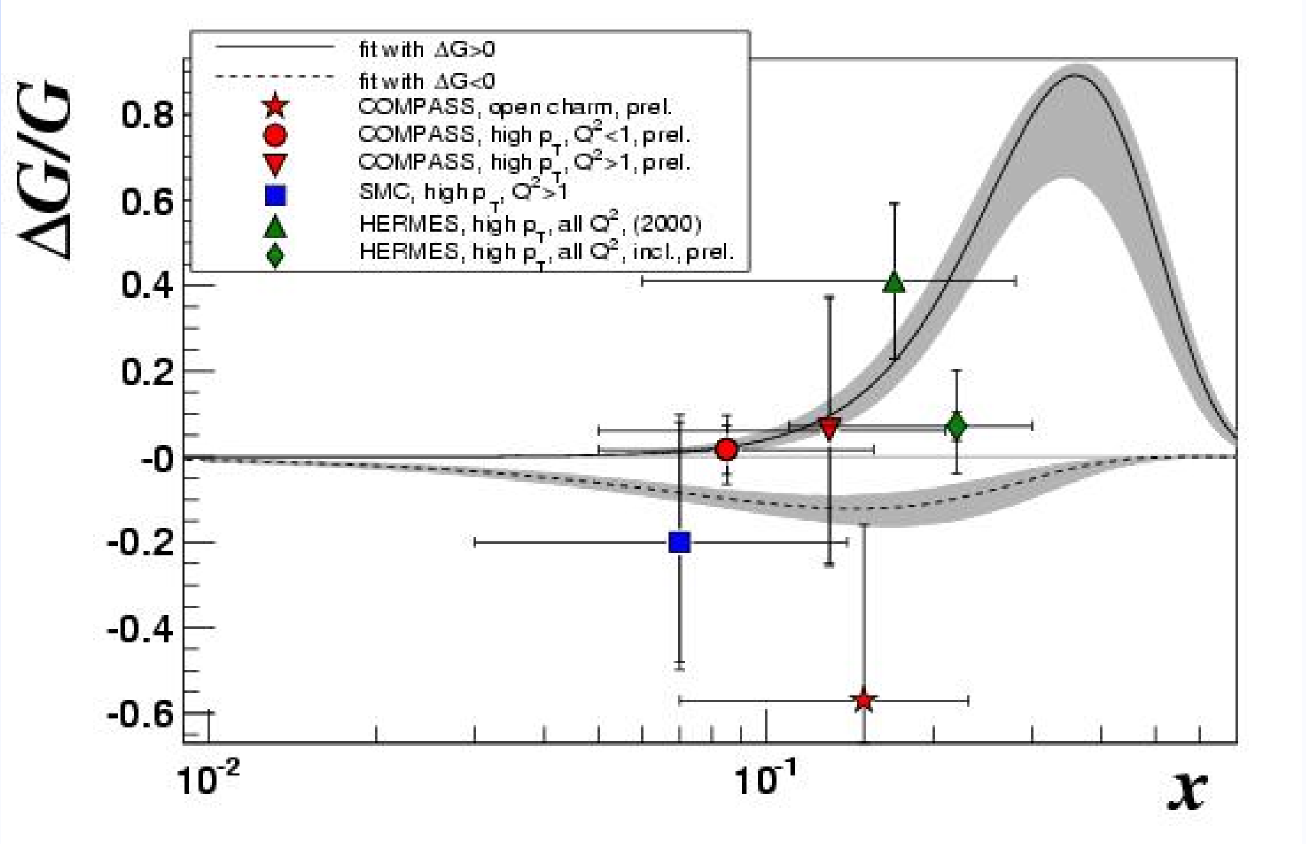




$$\eta_\Sigma = 0.30 \pm 0.01(\text{stat}) \pm 0.02(\text{evol})$$

$$|\eta_G| \approx 0.2 - 0.3$$

QCD fit



note: NLO fits, LO data

CONCLUSION from ΔG MEASUREMENTS:

ΔG SMALL

more precise measurements will come soon

COMPASS 2006

RHIC RUN6

....

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_{q,g}$$

interest in
orbital angular momentum

GPD's

Ji's SUM RULE $J^q(t) = \frac{1}{2}\int dx\, x\,(H^q + E^q)$

more on LONGITUDINAL SPIN CASE

MEASUREMENT OF VALENCE QUARK POLARISATION

COMPASS results

valence quark polarisation

hadron asymmetries

Semi-inclusive asymmetries

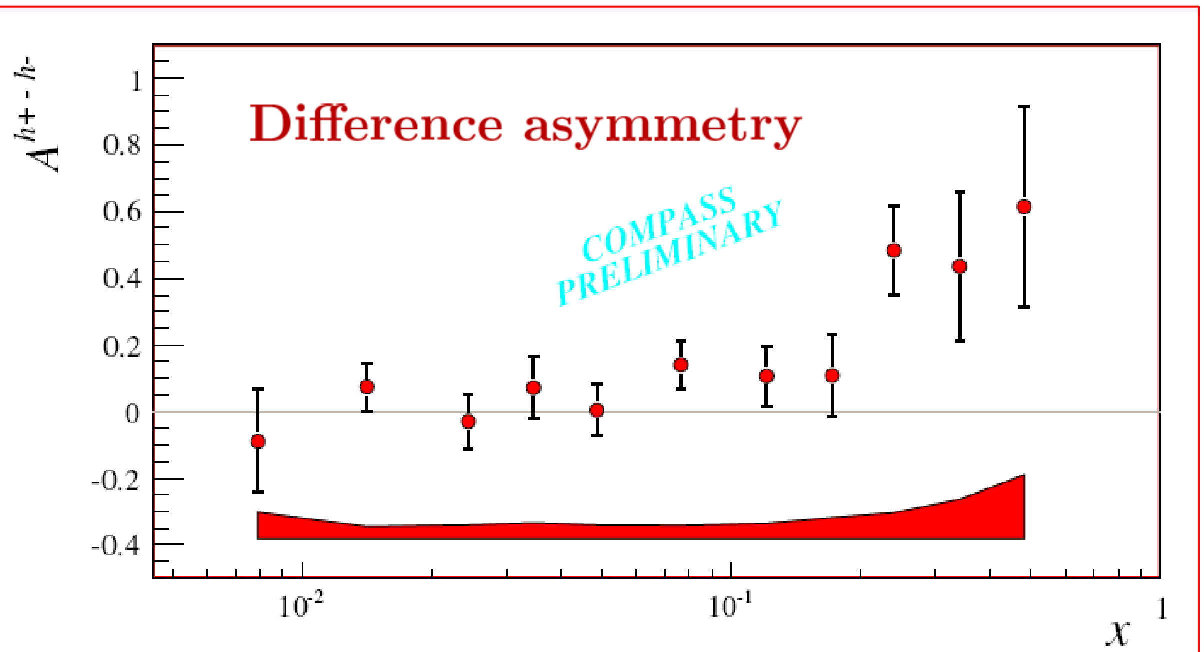
$$A^{+} = \frac{\sigma^{h+}_{\uparrow\downarrow} - \sigma^{h+}_{\uparrow\uparrow}}{\sigma^{h+}_{\uparrow\downarrow} + \sigma^{h+}_{\uparrow\uparrow}} \qquad A \;\; = \frac{\sigma^{h}_{\uparrow\downarrow} \;\; - \sigma^{h}_{\uparrow\uparrow}}{\sigma^{h-}_{\uparrow\downarrow} + \sigma^{h-}_{\uparrow\uparrow}}$$

$$A_1^h(x) = \frac{\sum_q e_q^2(\Delta q(x) D_q^h + \Delta \bar{q}(x) D_{\bar{q}}^h)}{\sum_q e_q^2(q(x) D_q^h + \bar{q}(x) D_{\bar{q}}^h)}$$

Difference asymmetry

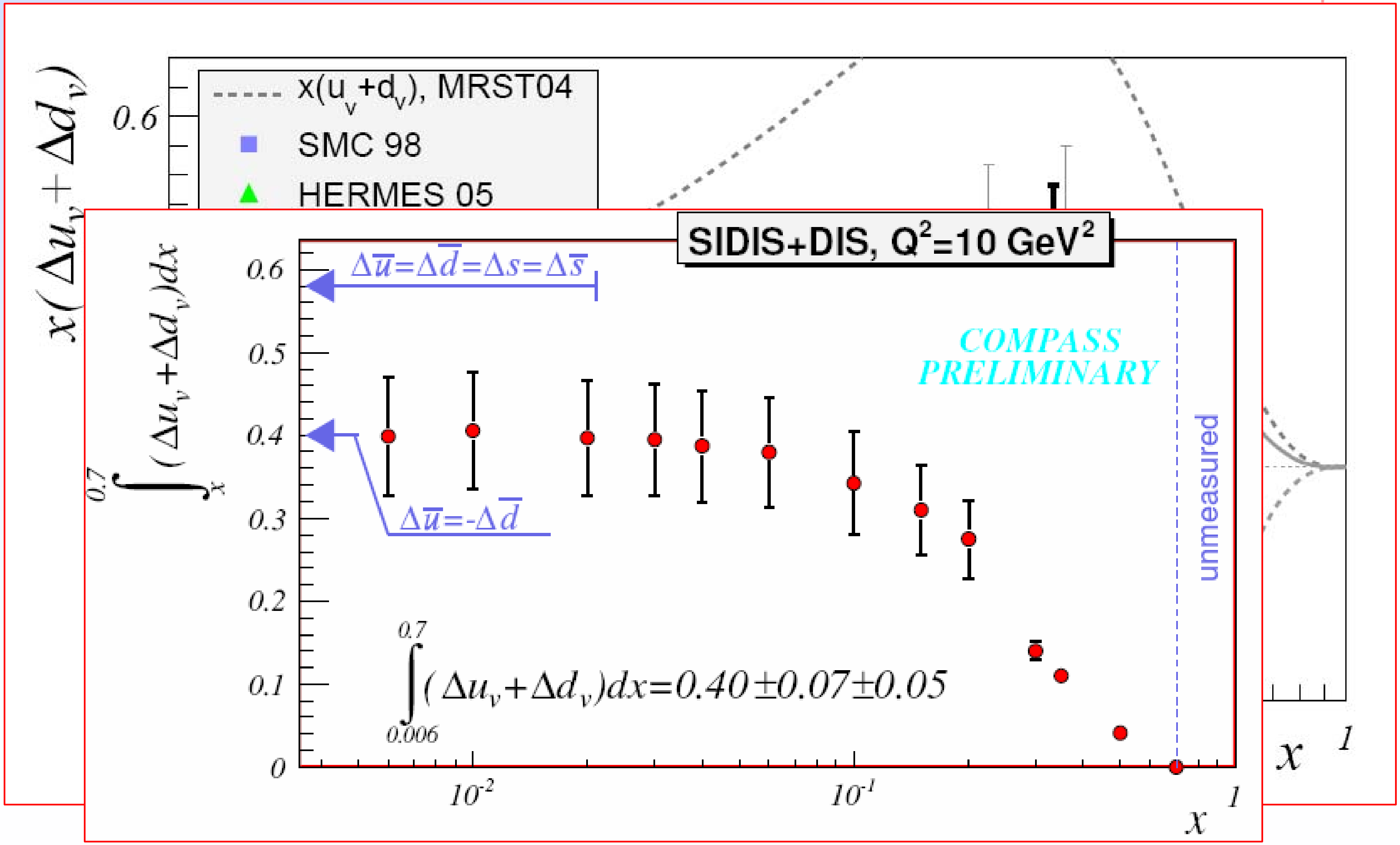
$$A^{+} \;\; = \frac{(\sigma^{h+}_{\uparrow\downarrow} - \sigma^{h}_{\uparrow\downarrow}\;) - (\sigma^{h+}_{\uparrow\uparrow} - \sigma^{h}_{\uparrow\uparrow}\;)}{(\sigma^{h+}_{\uparrow\downarrow} - \sigma^{h}_{\uparrow\downarrow}\;) + (\sigma^{h+}_{\uparrow\uparrow} - \sigma^{h}_{\uparrow\uparrow}\;)}$$

$$A_d^{\pi^+-\pi^-}(x) = A_d^{K^+-K^-}(x) = \frac{\Delta u_v(x) + \Delta d_v(x)}{u_v(x) + d_v(x)}$$



valence quark polarisation

comparison with other experiments



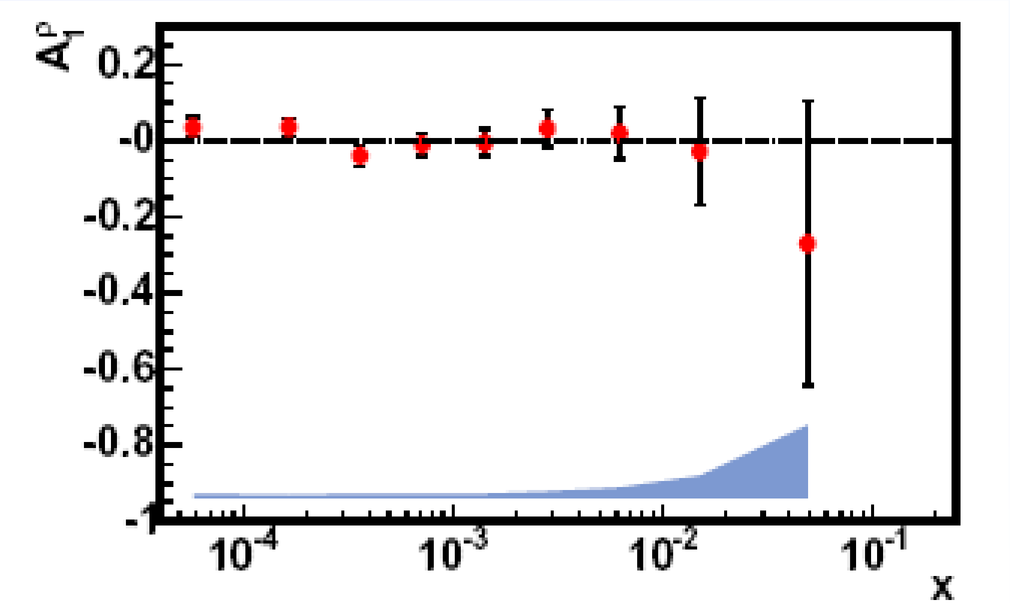
Asymmetries from SIDIS: rho

Longitudinal double-spin asymmetry A_1^{ρ} in exclusive incoherent ρ production

Related to spin-dependent, generalised parton distribution functions

$$\mu + N \rightarrow \mu' + \rho^0 + N'$$

hep-ex/0704.1863



TRANSVERSE SPIN CASE

Spectacular effects observed

SIDIS **COMPASS , HERMES**

p↑ p↑ **RHIC EXPERIMENTS**

BRAHMS
PHENIX
STAR

e^+e^- **BELLE**

TRANSVERSE SPIN CASE

Spectacular effects observed

SIDIS COMPASS , HERMES

Results on asymmetries

- **Transversity Distribution Function**
- **Sivers Distribution Function**
- **Other TMD Distribution Function**

Transversity DF: how to measure it

the Transversity DF is chiral-odd:

observable effects are given only by the product of $\Delta_T q\,(x)$ and an other chiral-odd function

can be measured in SIDIS on a transversely polarised target via "quark polarimetry"

$l\,N^{\uparrow} \rightarrow l'\,h\,X$ "Collins" asymmetry
"Collins" Fragmentation Function

$l\,N^{\uparrow} \rightarrow l'\,h\,h\,X$ two-hadron asymmetry
"Interference" Fragmentation Function

$l\,N^{\uparrow} \rightarrow l'\,\Lambda\,X$ Λ polarisation
Fragmentation Function of $q\uparrow \rightarrow \Lambda$

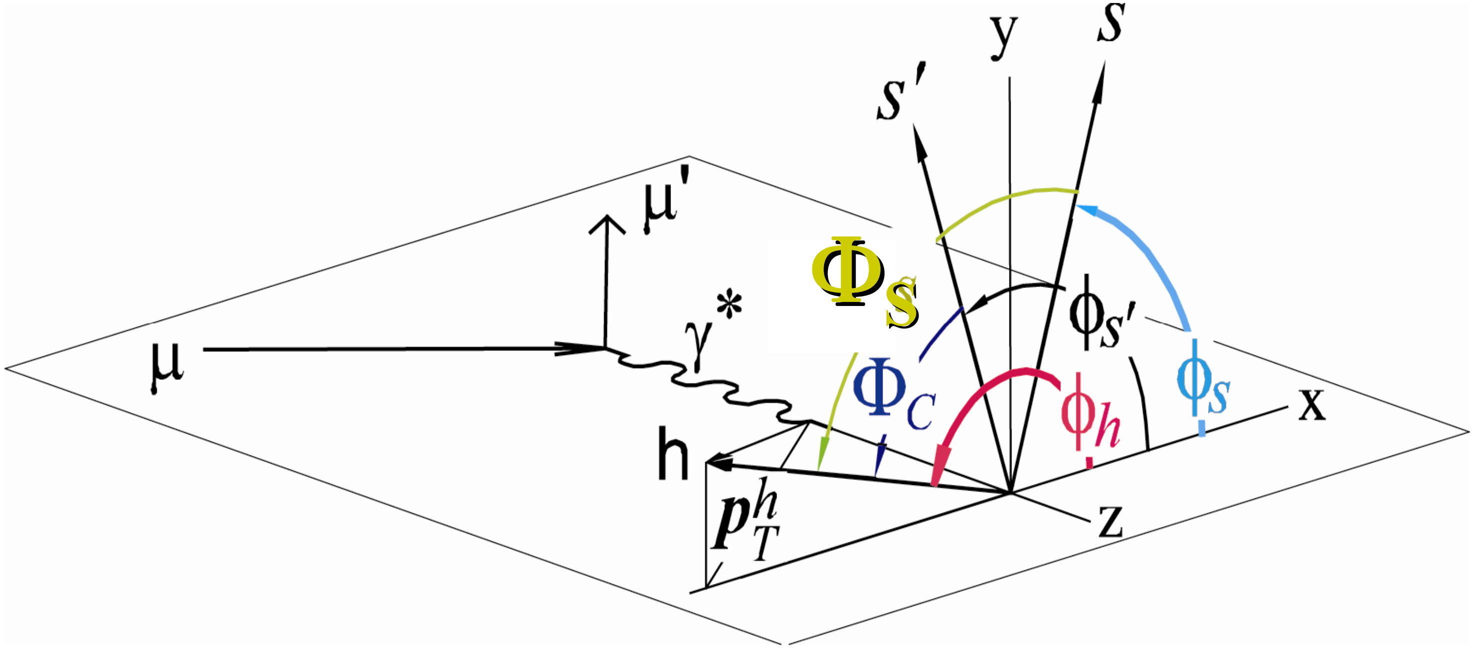
....

alternative way to access transversity independent on Transverse Momentum …
the favorite in some models (statistics)

"Collins" and "Sivers" effects in SIDIS

"Collins" angle $\Phi_C = \phi_h - \phi_{s'} = \phi_h + \phi_S - \pi$

"Sivers" angle $\Phi_S = \phi_h - \phi_S$



Collins and Sivers asymmetries

$$N_h^{\pm}(\Phi_C) = N_h^0 \cdot \left\{ 1 \pm A_C^h \cdot \sin\Phi_C \right\}$$

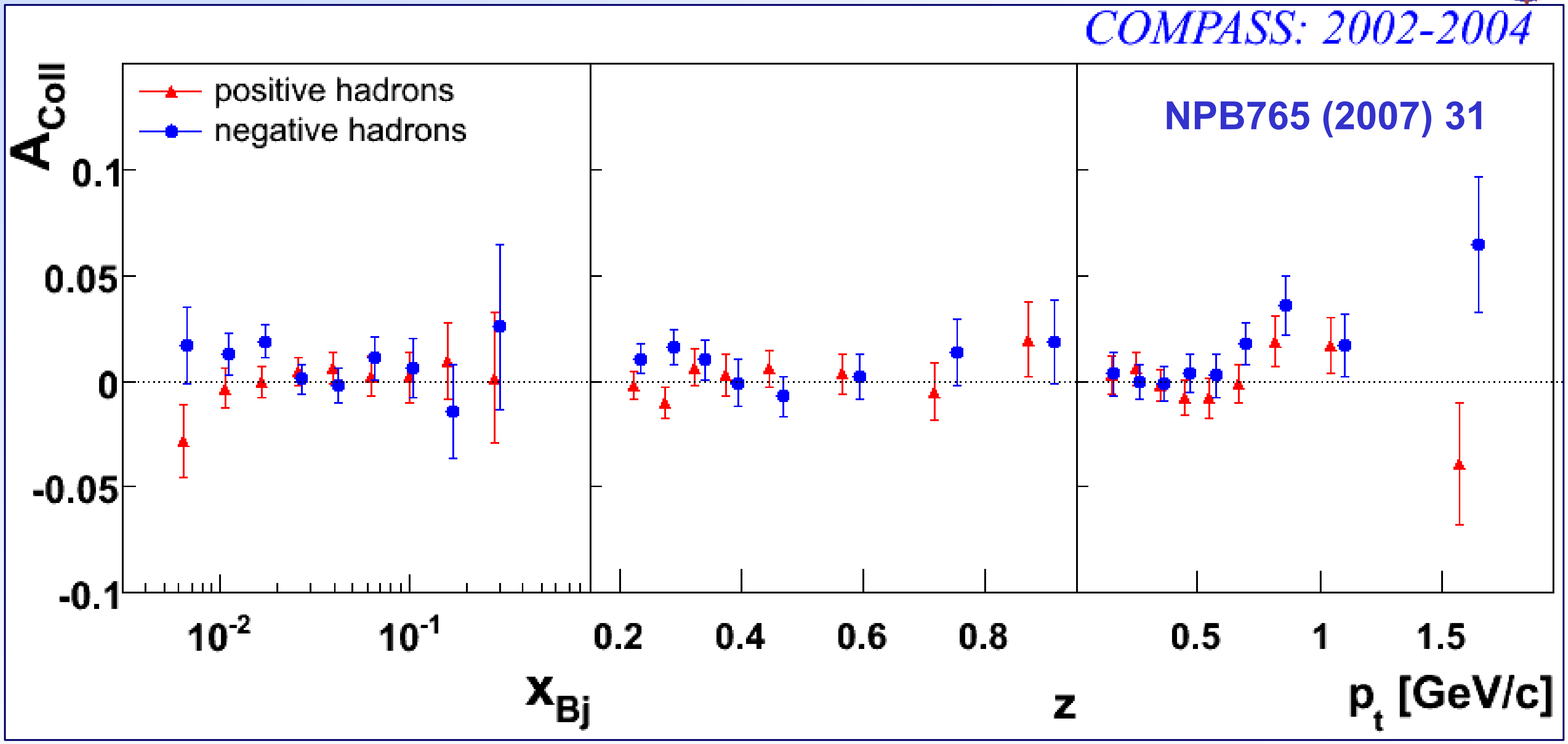
$$A_{Coll} = \frac{1}{f \cdot P_T \cdot D_{nn}} \cdot A_C^h = \frac{\sum_a e_a^2 \cdot \Delta_T q_a \cdot \Delta D_a^h}{\sum_a e_a^2 \cdot q_a \cdot D_a^h}$$

$$N_h^{\pm}(\Phi_S) = N_h^0 \cdot \left\{ 1 \pm A_S^h \cdot \sin\Phi_S \right\}$$

$$A_{Siv} = \frac{1}{f \cdot P_T} \cdot A_S^h = \frac{\sum_a e_a^2 \cdot \Delta_0^T q_a \cdot D_a^h}{\sum_a e_a^2 \cdot q_a \cdot D_a^h}$$

Can be measured simultaneously in SIDIS on a transversely polarized target

Collins Asymmetries 2002-2004



- small errors (~1%)
- small asymmetries
- cancellation between p and n

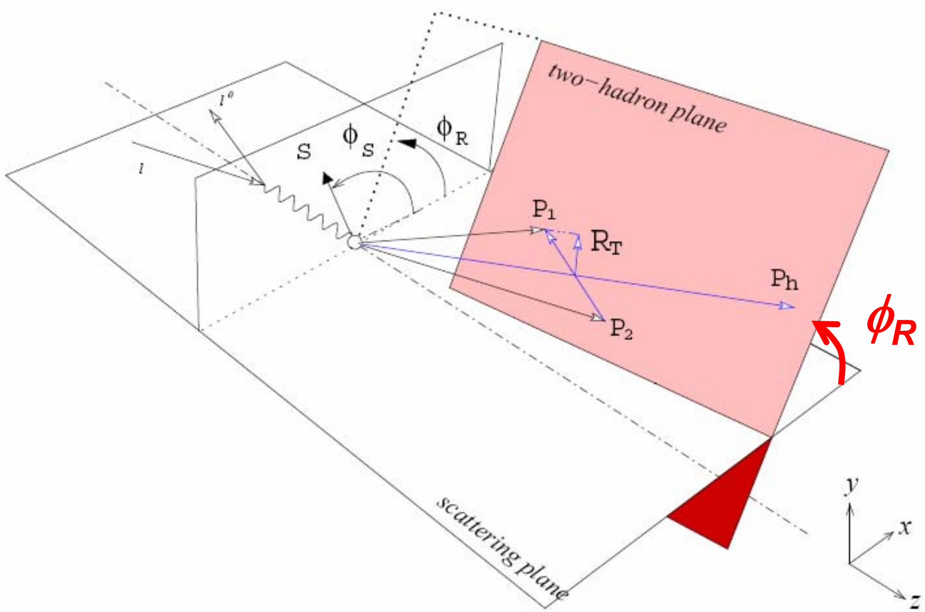
(lh and ah)

$$A^{\pi+}_{Coll,d} \approx (\Delta_T u + \Delta_T d) \cdot (4\Delta^0_T D^{\pi+}_u + \Delta^0_T D^{\pi+}_d)$$

$$A^{\pi-}_{Coll,d} \approx (\Delta_T u + \Delta_T d) \cdot (\Delta^0_T D^{\pi+}_u + 4\Delta^0_T D^{\pi+}_d)$$

Two Hadron Asymmetries

in inclusive production of hadron pairs, one can define the angle ϕ_R and measure an **azimuthal asymmetry** from the **modulation of the number of events in $\Phi_{RS} = \phi_R - \phi_S$,**



$$\vec{R} = \frac{z_1 \vec{P}_2 - z_2 \vec{P}_1}{z_1 + z_2}$$

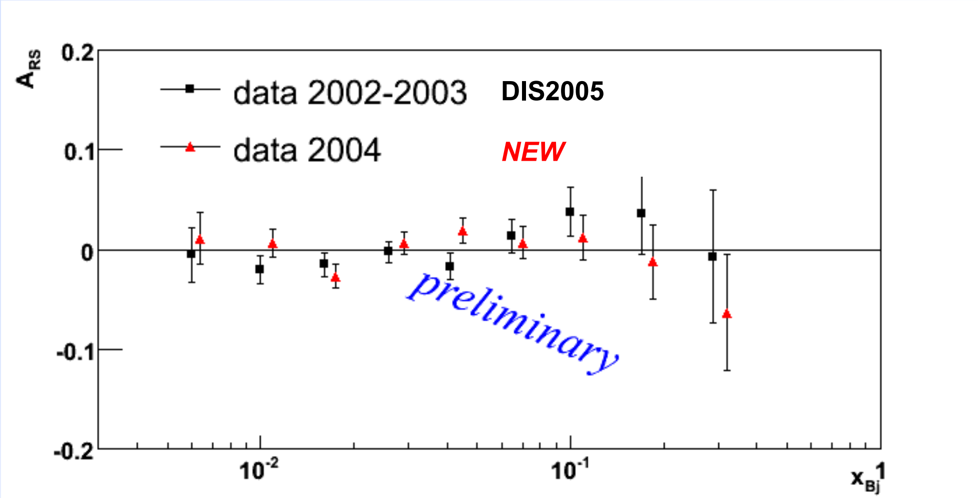
$$A_{RS} \propto \frac{\sum_q e_q^2 \cdot \Delta_T q \cdot H_1^{\angle}}{\sum_q e_q^2 \cdot q \cdot D_q}$$

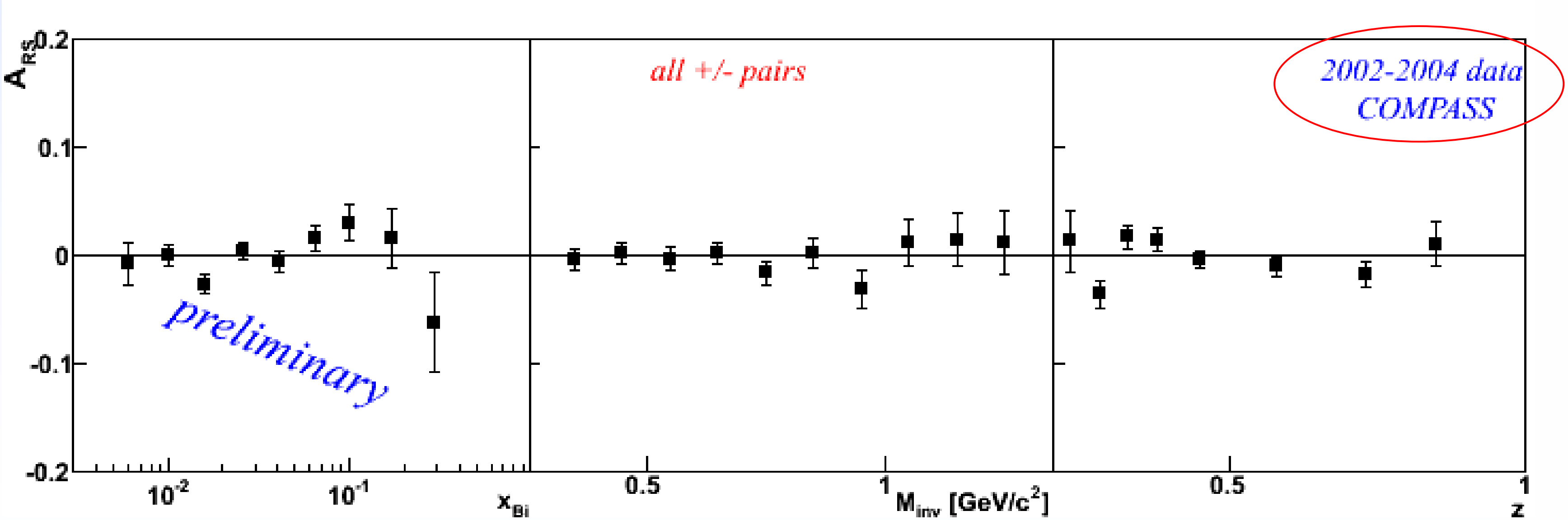
D_q, $H_1^{\angle}$ presently unknown being measured in e^+e^- (BELLE)

expected to depend on the hadron pair invariant mass

Two Hadron Asymmetries

all hadron pairs



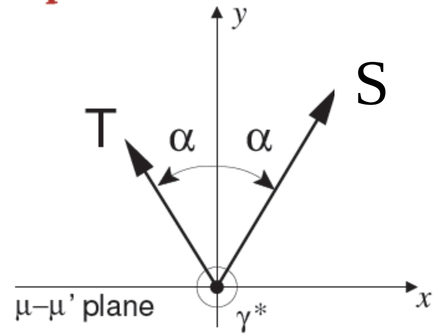


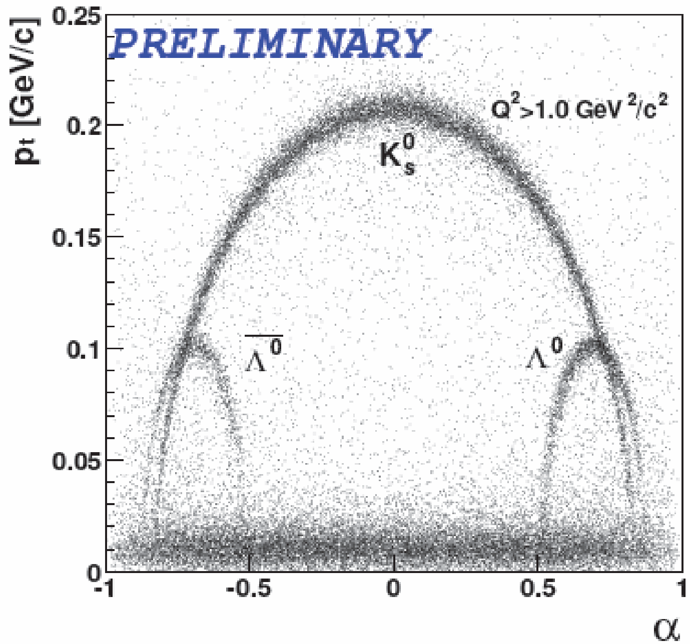
Λ polarimetry

$$P^{\Lambda}_{T,exp} = \frac{d\sigma^{\mu N^{\uparrow}\to\mu'\Lambda^{\uparrow}X} - d\sigma^{\mu N^{\downarrow}\to\mu'\Lambda^{\uparrow}X}}{d\sigma^{\mu N^{\uparrow}\to\mu'\Lambda^{\uparrow}X} + d\sigma^{\mu N^{\downarrow}\to\mu'\Lambda^{\uparrow}X}}$$

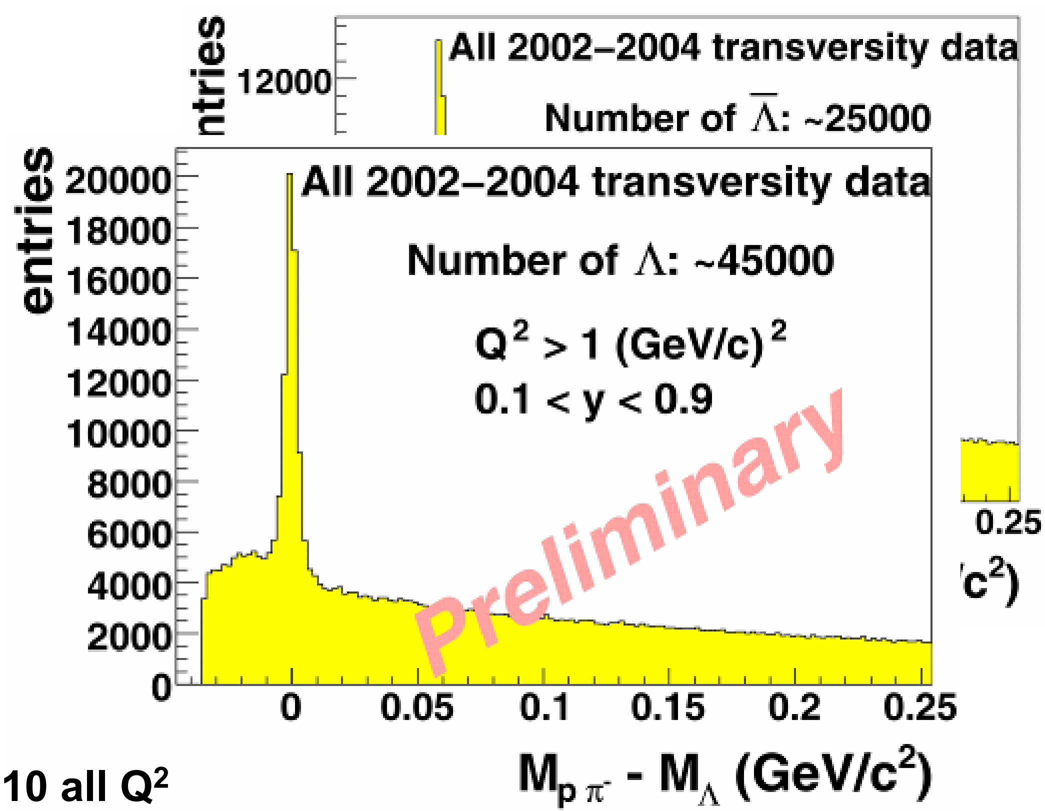
$$= f P_N D(y) \frac{\sum_q e_q^2 \Delta_T q(x) \Delta_T D_{\Lambda/q}(z)}{\sum_q e_q^2 q(x) D_{\Lambda/q}(z)}$$

Λ polarization axis

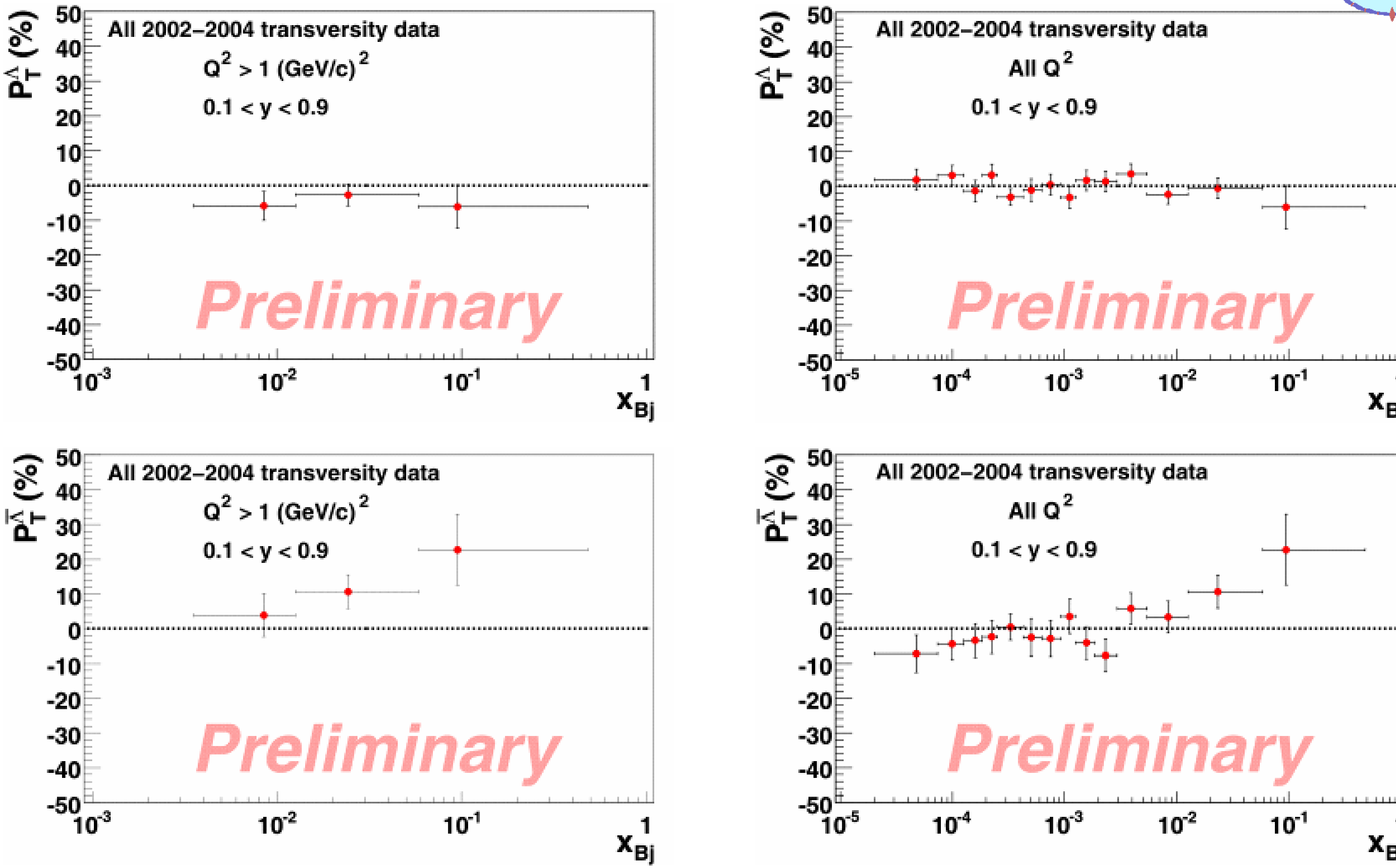




x 10 all Q^2



Λ polarimetry



systematic errors not larger than statistical errors

RICH ID not used yet; some other improvement in selection still foreseen

Collins asymmetries: SUMMARY

The facts:

- **HERMES has measured on a proton target non-zero Collins asymmetries for π^+ and π^-**
- **COMPASS has measured on a deuteron target Collins asymmetries compatible with zero**
- **BELLE has produced the first results on Collins FF**

Conclusion:

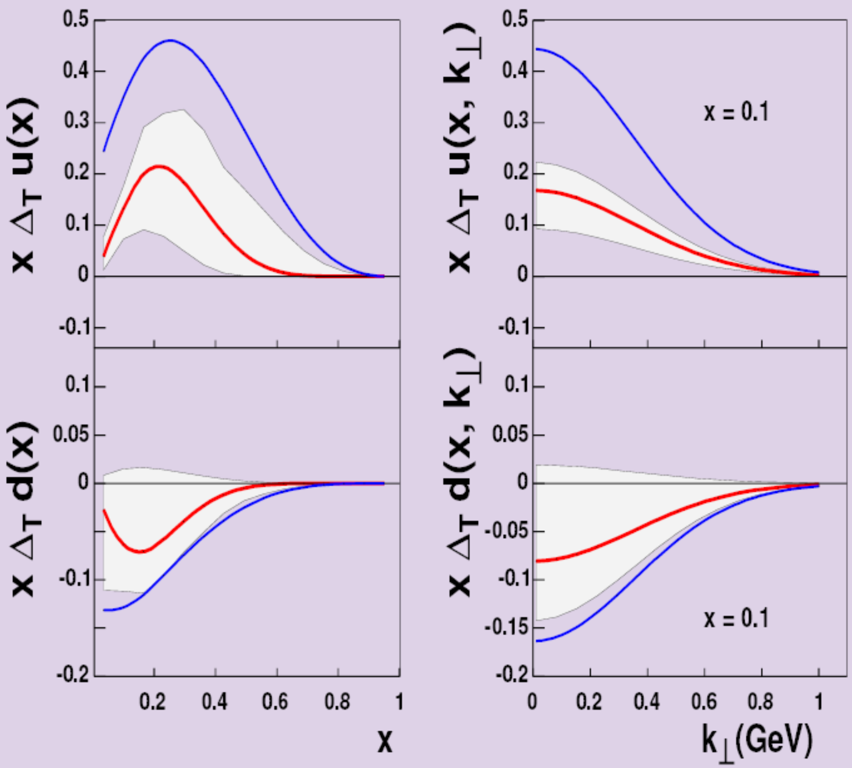
- **Collins mechanism is a real phenomenon**
- **universality of Collins FF**
- **transversity can be measured in SIDIS**

Present picture

- **Collins:** $\Delta_T u \sim - \Delta_T d$
  $\Delta_T{}^0 D(\text{fav.}) \sim - \Delta_T{}^0 D(\text{unfav})$

To extract TMD DF and FF GLOBAL ANALISYS are necessary

Transversity



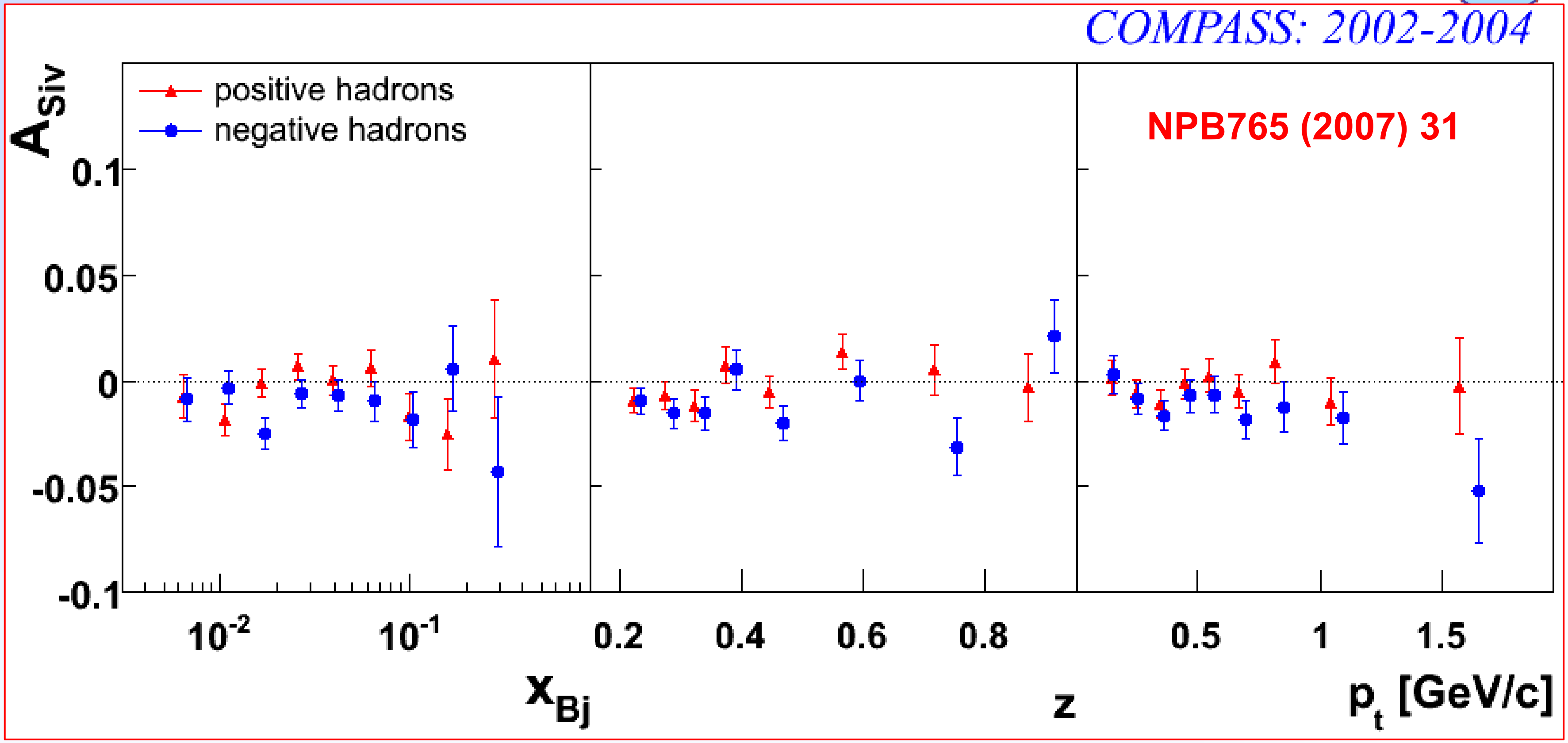
- This is the first extraction of transversity from experimental data.
- $\Delta_T u(x) > 0$ and $\Delta_T d(x) < 0$
- Both $\Delta_T u(x)$ and $\Delta_T d(x)$ do not saturate Soffer bound.
- HERMES data alone fixes well $\Delta_T u(x)$ while HERMES+COMPASS alows us to extract $\Delta_T d(x)$.

TRANSVERSE SPIN CASE

Results on asymmetries

- Transversity Distribution Function
- **Sivers Distribution Function**
- Other TMD Distribution Function

Sivers Asymmetries 2002-2004



- small errors (~1%)
- small asymmetries
- cancellation between p and n $A_{Siv,d} \approx \left(\Delta_0^T u + \Delta_0^T d\right) \cdot D$

(lh and ah)

Sivers asymmetries: SUMMARY

More facts:

- HERMES has measured on a proton target non-zero Sivers effect for π^+
- COMPASS has measured on a deuteron target ~ 0 Sivers asymmetries
  ► first and unique handle on $\Delta_T d$

Conclusion:

- **also Sivers mechanism is a real phenomenon**

Present picture

Sivers: $\Delta_0^T u \sim - \Delta_0^T d$ *work ongoing*

important theoretical work to connect

Sivers SSA with L_q and the E GPD

more about Sivers asymmetry

Evidence for the Absence of
Gluon Orbital Angular Momentum in the Nucleon

S.J. Brodsky, S. Gardner

SLAC-PUB-12062, Aug 2006. Subm. Phys.Lett.B, **hep-ph/0608219**

We note that a large SSA for π^+ production from a transversely polarized proton has been observed by the HERMES collaboration [14]; however, when an analogous observable is measured by the COMPASS collaboration from a deuterium target [26], the SSA is consistent with *zero*.

Due to the smallness of the anomalous magnetic moment of the deuteron the orbital motion of the quarks should not contribute to the Sivers SSA of the deuteron.

Thus

The approximate cancellation of the SSA measured on a deuterium target suggests that the gluon mechanism, and thus the orbital angular momentums carried by gluons in the nucleon, is small.

TRANSVERSE SPIN CASE

Results on asymmetries

- Transversity Distribution Function
- Sivers Distribution Function
- **Other TMD Distribution Function**

semi-inclusive cross-section

18 structure functions

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

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

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

$$+S_\parallel\left[\sqrt{2\varepsilon(1+\varepsilon)}\sin\phi_h F_{UL}^{\sin\phi_h}+\varepsilon\sin(2\phi_h)F_{UL}^{\sin 2\phi_h}\right]$$

$$+S_\parallel\lambda_e\left[\sqrt{1-\varepsilon^2}F_{LL}+\sqrt{2\varepsilon(1-\varepsilon)}\cos\phi_h F_{LL}^{\cos\phi_h}\right]$$

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

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

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

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

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

Cahn

Boer-Mulders

EMC
E665
ZEUS
CLAS
HERMES

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

semi-inclusive cross-section

8 tgt transverse spin dependent asymmetries, 4 LO

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

$$\frac{\alpha^2}{xyQ^2}\,\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Big\{\cdots\cdots\cdots$$

$f_{1T}^{\perp q} \otimes D_{1q}^{h}$ **Sivers**

$h_1^q \otimes H_{1q}^{\perp h}$ **transversity**

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

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

5

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

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

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

3

by now all measured by COMPASS on deuteron

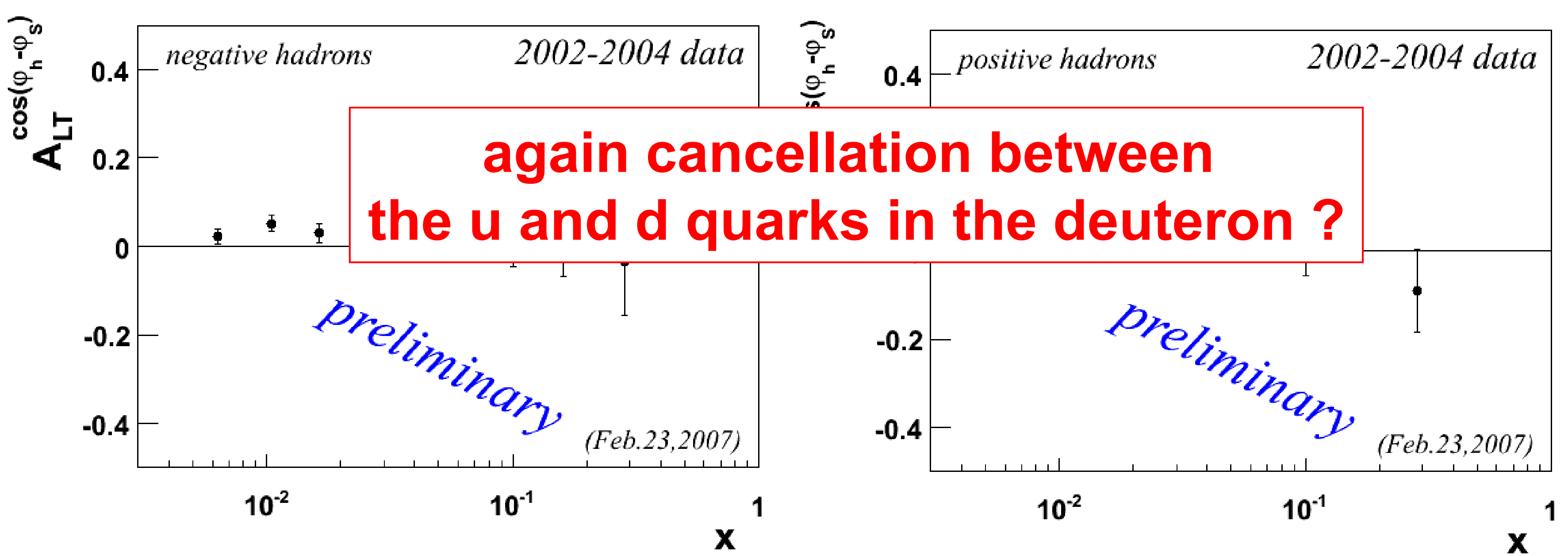
target transverse spin dependent asymmetries

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

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 ?

Conclusion

first results on transversity are available

global analysis ongoing

- first moments: tensor charge $\Delta_T q \equiv \int dx\, \Delta_T q(x)$
- sum rule for transverse spin in Parton Model framework $$\frac{1}{2} = \frac{1}{2}\sum \Delta_T q + L_q + L_g$$

Bakker, Leader, Trueman, PRD 70 (04)

PRECISION NEEDED

COMPASS has started measuring

with transversely polarized protons

CERN-SPSC-2007-002
SPSC-M-754

COMPASS Programme, 2007 to 2010

The COMPASS Collaboration - January 23, 2007

5 Longer term projects

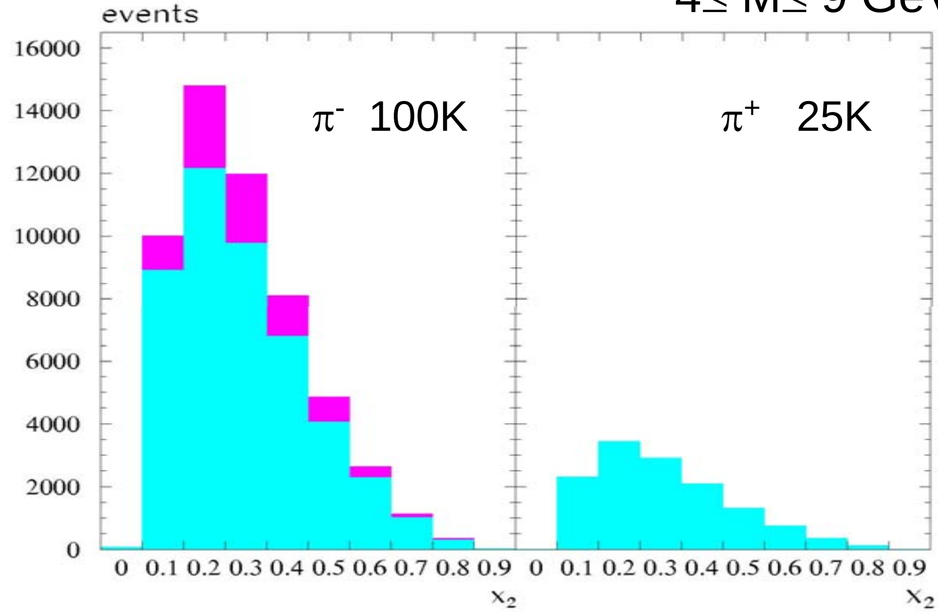
Other lines of research are presently under consideration as already mentioned in a document submitted January 15, 2006 to the CERN Council Strategy Group:

- The measurements of Generalised Parton Distribution functions with muon beams will, in particular, give access to the orbital momentum contribution to the nucleon spin, as described in the Expression Of Interest submitted (SPSC-2005-007, SPSC-EOI-005).
- The transverse spin effects were unveiled only recently and measurements are very preliminary. The next decade could cover systematic studies.
- The measurements of single spin observables in Drell–Yan processes with hadron beams will allow to check fundamental predictions of QCD. An EOI is being prepared.
- The double charm production with hadron beams will be accessible once a more refined vertex reconstruction is achieved.

$$\pi^{\pm} p^{\uparrow} \to \mu^{+}\mu^{-} X$$

100K events (before dilut.) E_{π}=100 GeV s=200 GeV^2

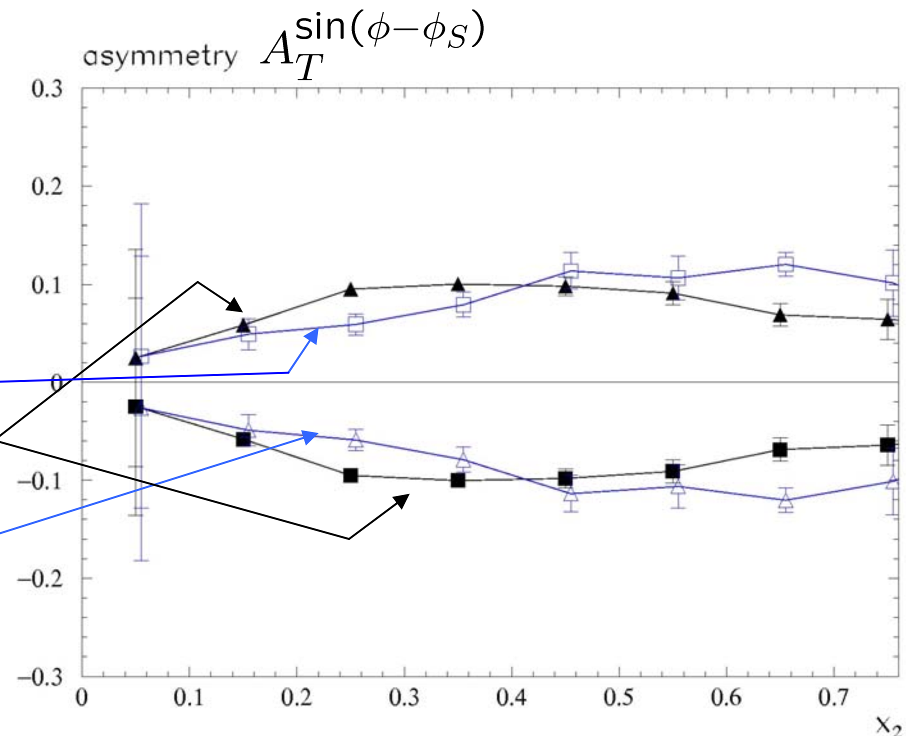
4≤ M≤ 9 GeV 0.5≤ q_T ≤ 2.5 GeV/c



$\sin(\phi - \phi_{S_p}) > 0$

$\sin(\phi - \phi_{S_p}) < 0$

Bianconi & Radici
P.R. D**73** (06) 114002



param. # 2

$$f_{1T}^{\perp q}\Big|_{SIDIS} = +f_{1T}^{\perp q}\Big|_{Drell-Yan}$$

π⁺ π⁻

$$f_{1T}^{\perp q}\Big|_{SIDIS} = -f_{1T}^{\perp q}\Big|_{Drell-Yan}$$

π⁻ π⁺

N_u = 0.7 N_d = -0.7

from M. Radici Talk in Freiburg, March 2007

THANK YOU