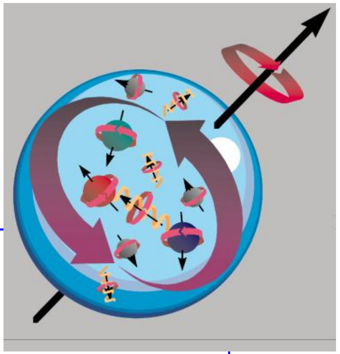
Overview of experimental results on Nucleon Spin Structure

F.Kunne - CEA Saclay, France



- Gluon and quark helicities
- Transverse spin &
  Transverse Momentum Dependent quark distributions
- Outlook

Baldin Seminar, Dubna, Russia, Oct.4-9 2010

How is the nucleon spin distributed among its constituents?

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

quark gluon orbital momentum

$\Delta q = \overrightarrow{q} - \overleftarrow{q}$ Parton spin parallel or anti parallel to nucleon spin

Theory : QCD, Ellis- Jaffe sum rule assuming $\Delta s = 0$, $\Delta\Sigma \sim 0.6$
Experiment: World data on polarized DIS g_1 + $SU_f(3)$ → $a_0 \sim 0.3$

QCD ($\overline{MS}$ scheme) $a_0 = \Delta\Sigma$

→ "Spin crisis" 1988, EMC measured $a_0 = 0.12 \pm 0.17$

QCD (AB scheme) $a_0 = \Delta\Sigma - n_f (\alpha_s/2\pi) \Delta G$

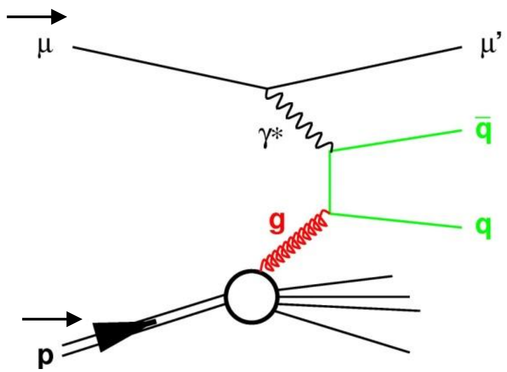
- For $a_0 \sim 0.3$, need $\Delta G \sim 2.5$ to restore $\Delta\Sigma \sim 0.6$. (Then $L_{q,g} \sim -2.3$)
- ΔG enters in the spin $\frac{1}{2}$ sum rule

→ motivated measurement of gluon polarization ΔG

Three ways to determine ΔG/G

1. $\vec{\text{Lepton}}$ $\vec{\text{Nucleon}}$

Photon Gluon Fusion

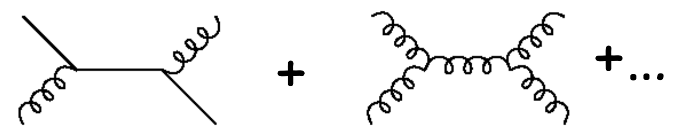


$\Delta G/G(x)$

SMC, HERMES, COMPASS

2. $\vec{\text{Proton}}$ $\vec{\text{Proton}}$ collisions

Gluon-Quark + Gluon-Gluon +...



$$\frac{\Delta G}{G} \times \frac{\Delta q}{q} + \frac{\Delta G}{G} \times \frac{\Delta G}{G} + \ldots$$

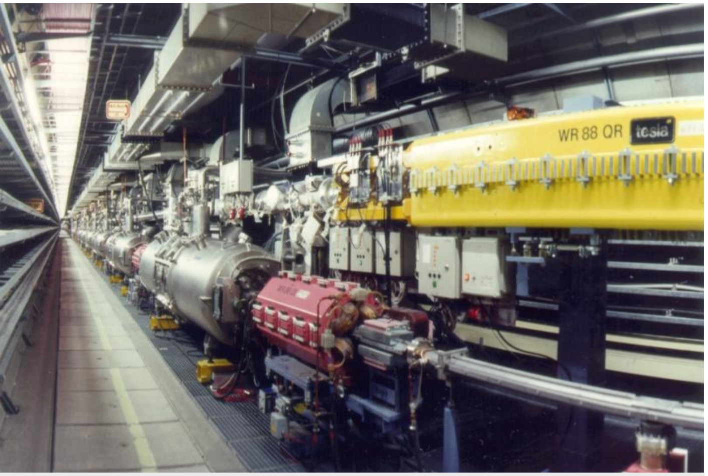
$A_{LL}(p_T)$

RHIC

3. QCD evolution of $g_1(x,Q^2)$:

Indirect determination assuming a functional form $\Delta G(x)$

HERMES at DESY

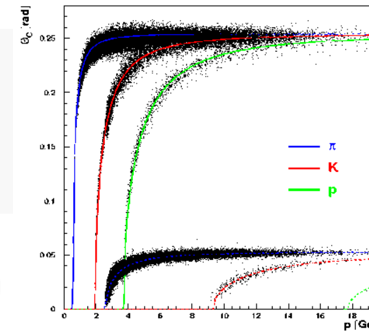


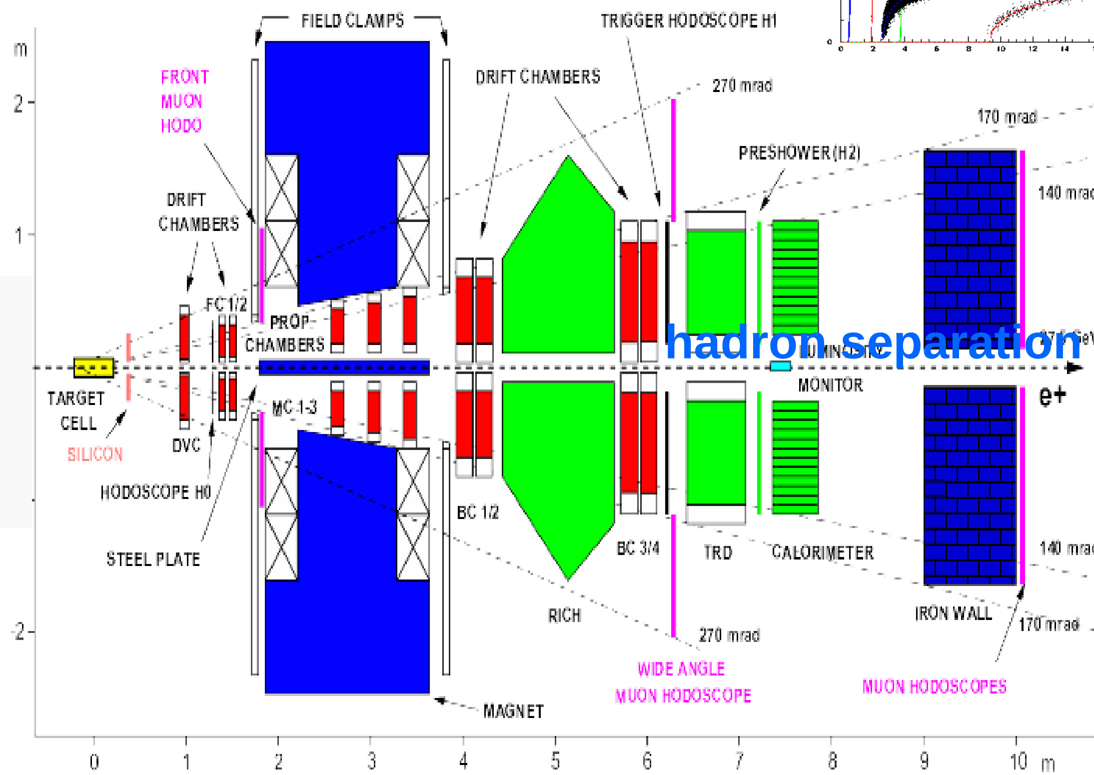
HERA e^+ & e^- 27 GeV

longitudinaly polarized ~ 54%

1995 to 2007

Spectrometer :
$\Delta p/p$~2%, $\Delta\Theta$<1 mrad
Excellent separation of π, K, p





hadron separation

Gaseous internal target

Longit. Polar. 85% H, D, He
Transv. Polar H
Unpol H, D, Ne, Kr

COMPASS at CERN

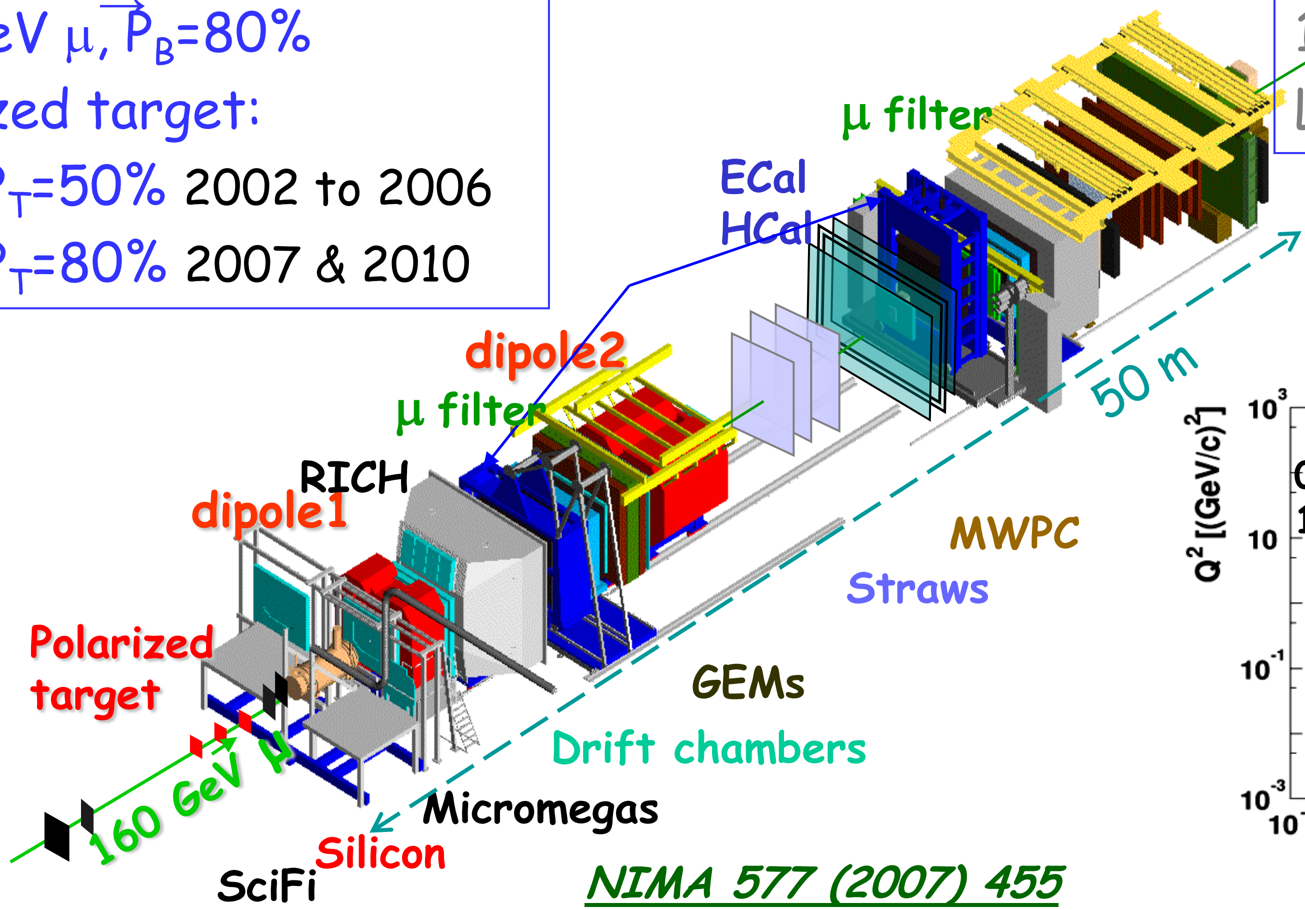
Fixed target
Secondary muon or hadron beams from SPS

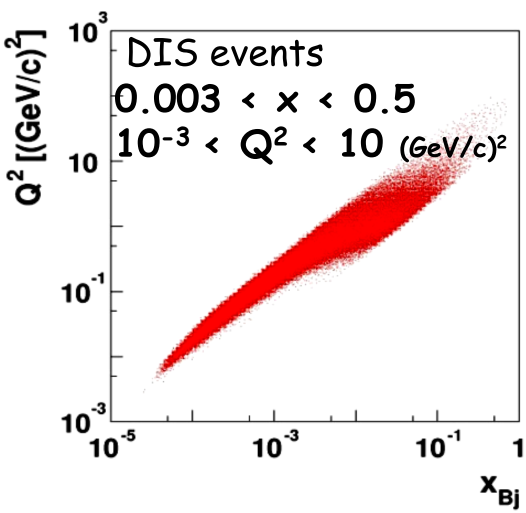
Nucleon spin structure

Polarized muon beam:
160 GeV μ, $\overrightarrow{P}_B$=80%
Polarized target:
^{6}LiD P_T=50% 2002 to 2006
NH_3 P_T=80% 2007 & 2010

Meson spectroscopy

Hadron beam :
190 GeV π / p
LH_2 2008-2009



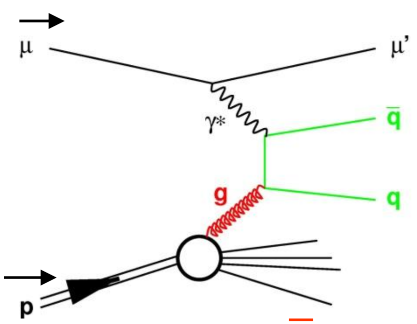


NIMA 577 (2007) 455

1. $\Delta G/G$ from Photon Gluon fusion (PGF)

- Need a process sensitive to gluon distribution : PGF
- Longitudinal spin asymmetry of cross sections

→ polarized lepton beam & polarized nucleon target.



$\gamma g \rightarrow q\bar{q}$

$A_{LL} = R_{PGF} \langle a_{LL} \rangle \langle \Delta G/G \rangle$

Two signatures for PGF:

- $q=c$ open charm $c \rightarrow D^0 \rightarrow K\,\pi$

Clean signature of PGF

pQCD scale $\mu^2 = 4\,(m_c^2 + p_T^2)$

Combinatorial background & limited statistics

→ Difficult experiment

COMPASS

- $q=u,d,s$ high p_T hadron pair $q\,q \rightarrow h\,\bar{h}$

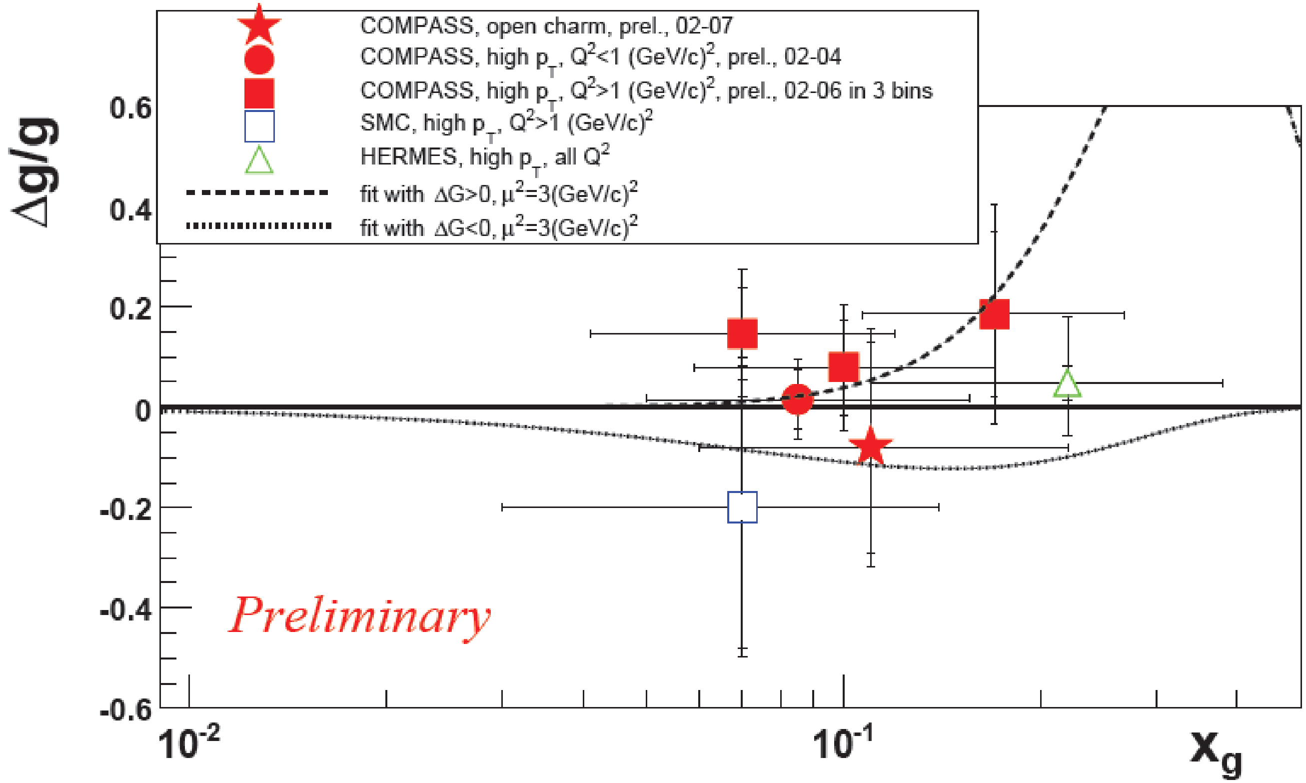
High statistics

pQCD scale Q^2 or Σp_T^2

Physical background, better described for high Q^2

HERMES, COMPASS

Results for $\Delta G/G$ direct measurements

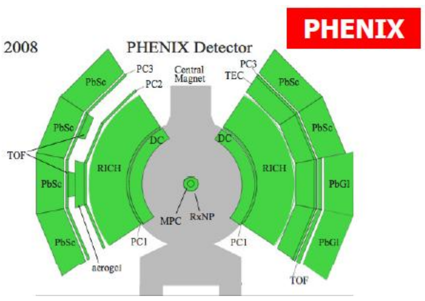


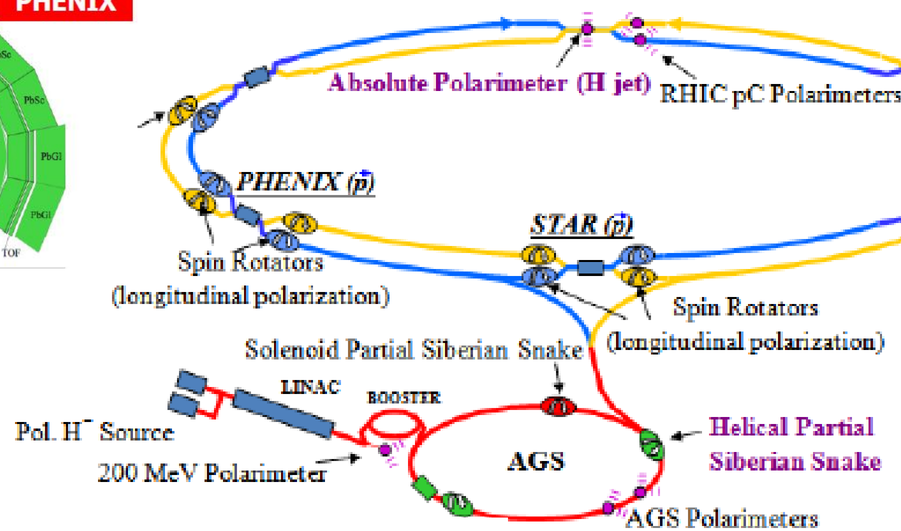
All measurements compatible with 0 for 0.04 < x < 0.2

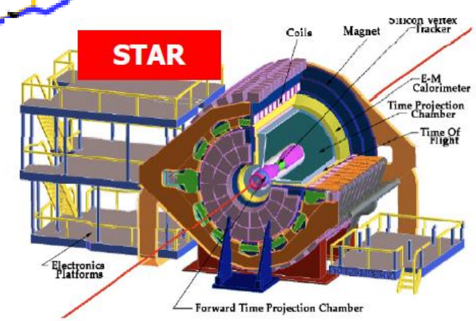
Direct measurements exclude values for the integral of ΔG as large as… ~ 0.5

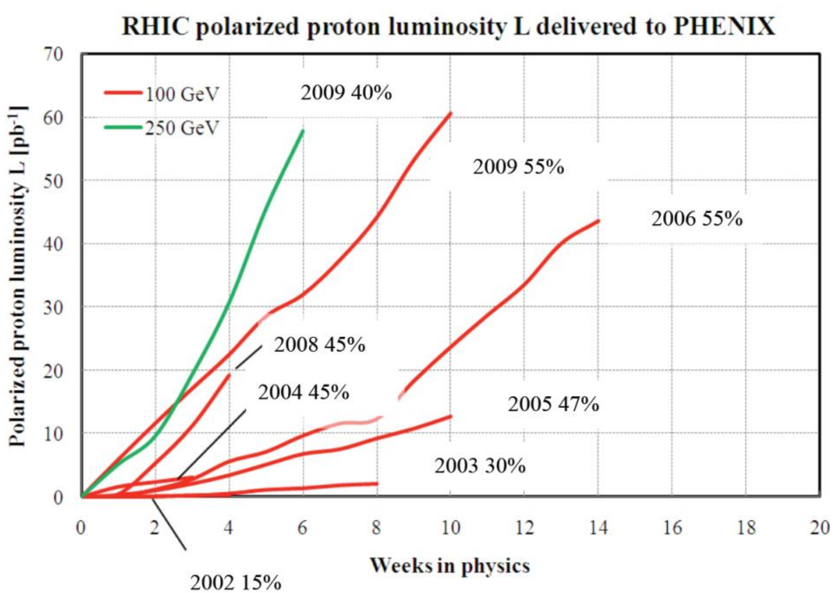
2. Polarized p p collisions at RHIC

$\sqrt{s}$ = 62, 200, 500 GeV







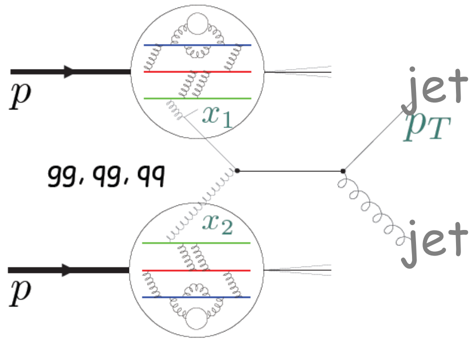


- Longitudinal spin asymmetries: sensitivity to $\langle \Delta G \rangle$, $\langle \Delta q \rangle$

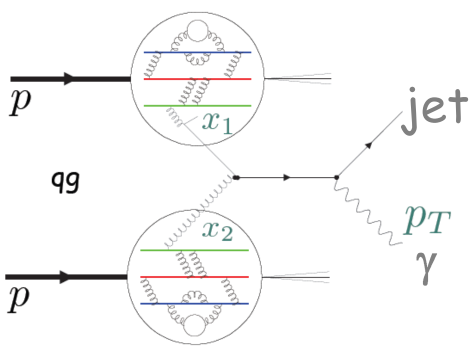
- Transverse spin

2. Polarized p p collisions at RHIC

Several channels sensitive to ΔG



Di-Jet production



Photon-Jet production

p p → π^0 X

More abundant channel

3 processes contribute

$\Delta G(x_1) . \Delta G(x_2)$

$\Delta G(x_1) . \Delta q(x_2)$

$\Delta q(x_1) . \Delta q(x_2)$

p p → jet X

p p → jet jet

p p → γ jet

1 process→ cleaner $\Delta G(x_1) . \Delta q(x_2)$

Full kinematics reconstructed

Low statistics

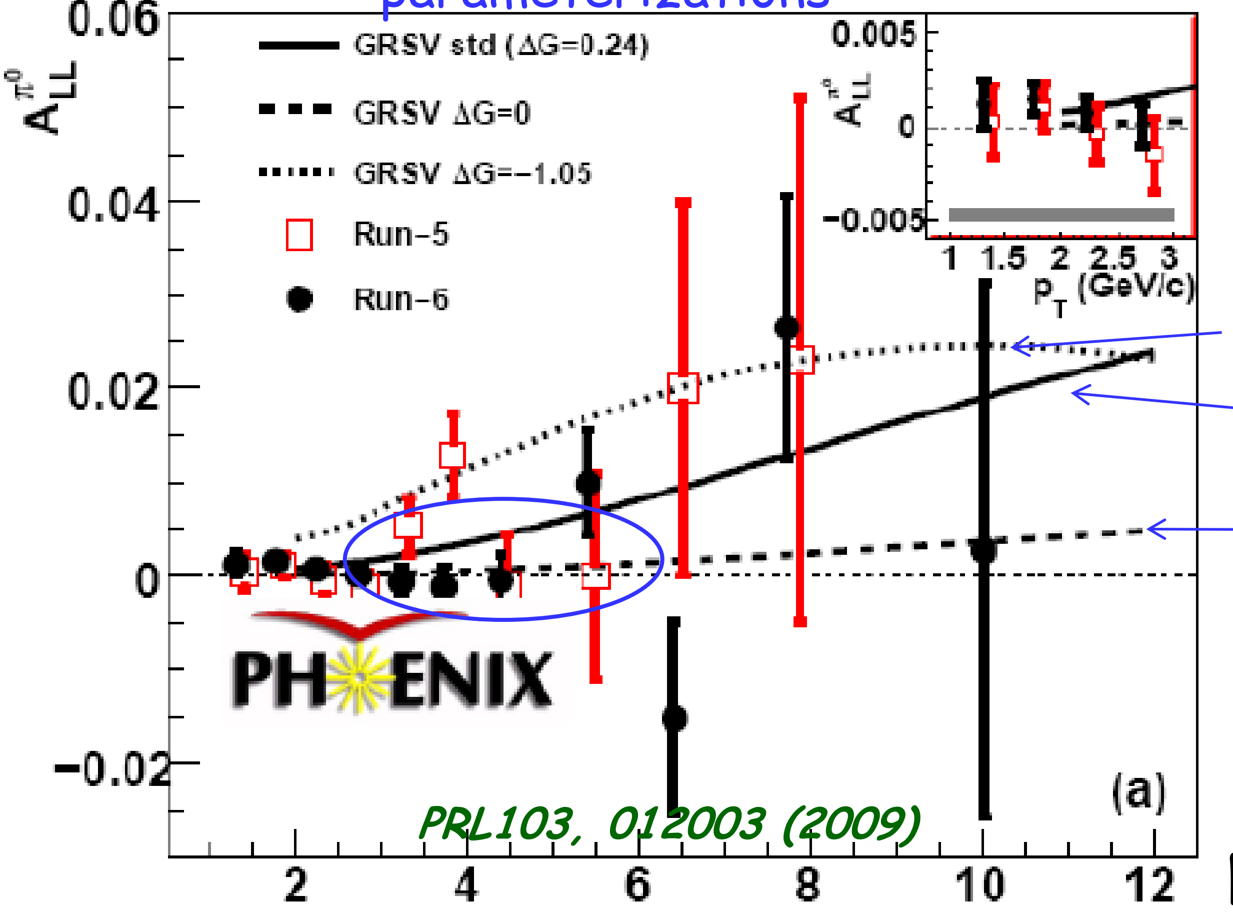
p p → γ X

…

A_{LL} spin asymmetry from pp collisions at RHIC

$p\,p \rightarrow \pi^0 X$

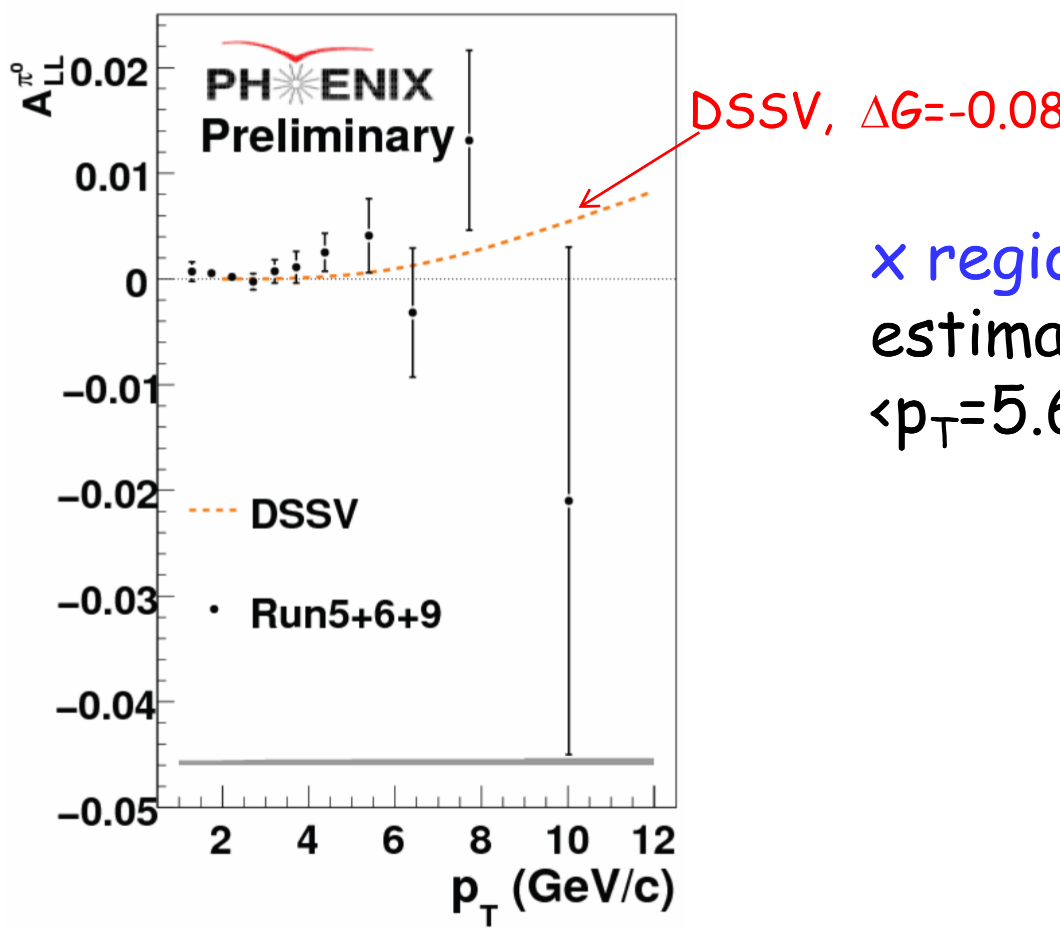
Compare $A_{LL}(p_T)$ data to GRSV fits with various $\Delta G(x)$ parameterizations



Constrains ⟨ΔG⟩ for $0.02 < x < 0.3$ in global QCD fits

New:

π^0 production with run9, 200 GeV



B. Surrow, SPIN2010

x region probed ?

estimated from MonteCarlo

$\langle p_T=5.6 \rangle \rightarrow 0.02 < x < 0.3$

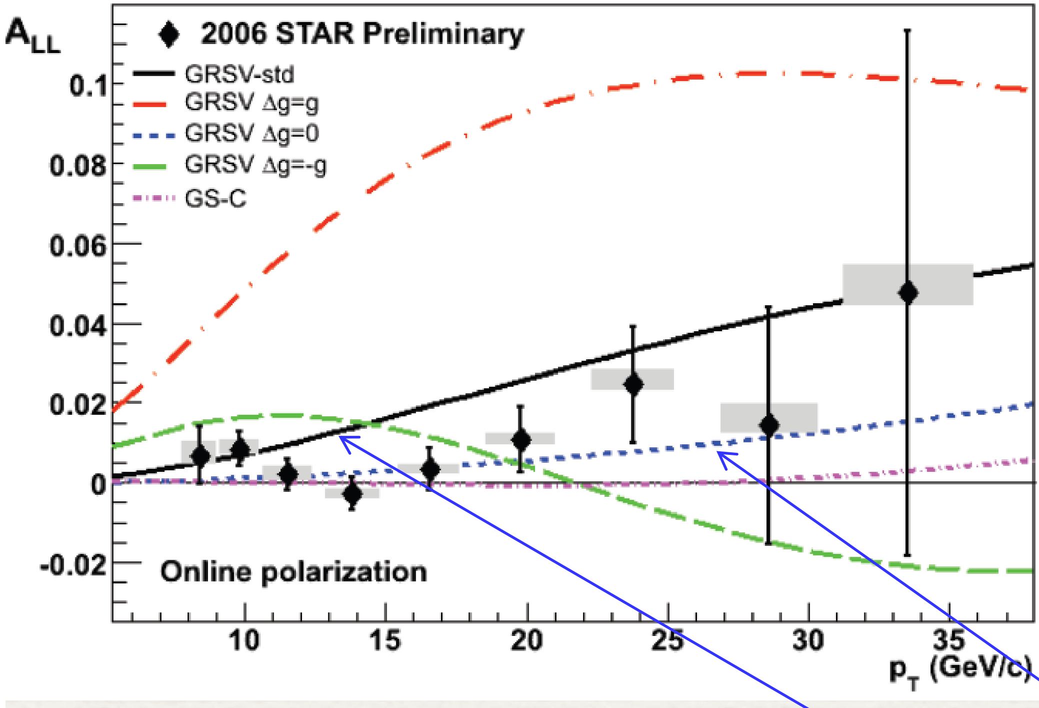
Will improve constrain on ΔG in QCD fits, for $0.02 < x < 0.3$

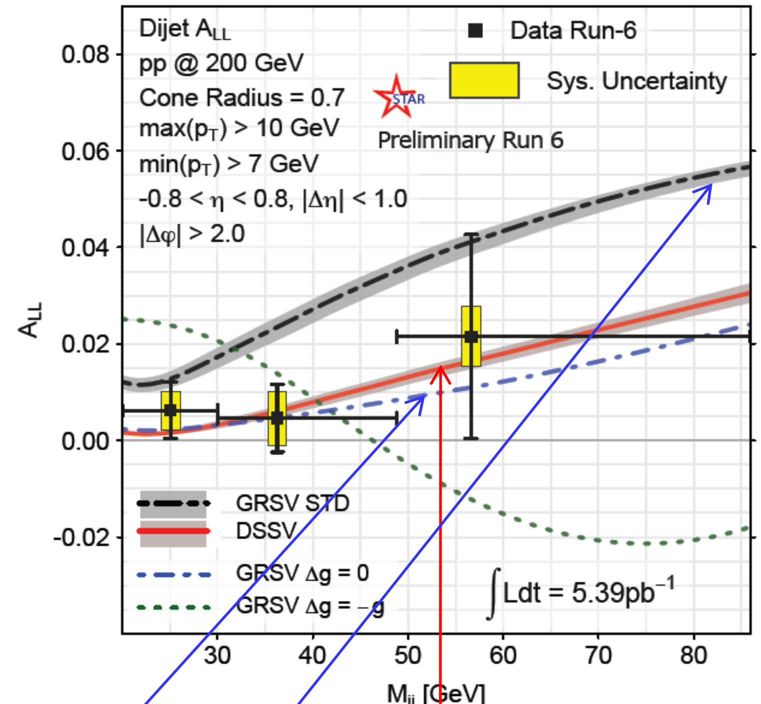
A_{LL} spin asymmetry from pp collisions at RHIC

STAR, jet +X

New: STAR jet+jet

M. Walker, SPIN2010





GRSV, ΔG=0

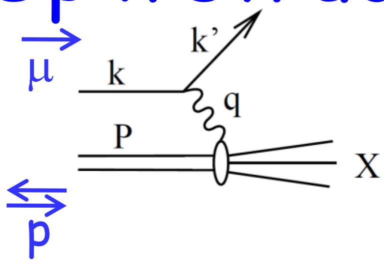
GRSV, ΔG std

DSSV, ΔG=-0.08

New data favour ΔG parameterizations with smaller integral, positive or negative

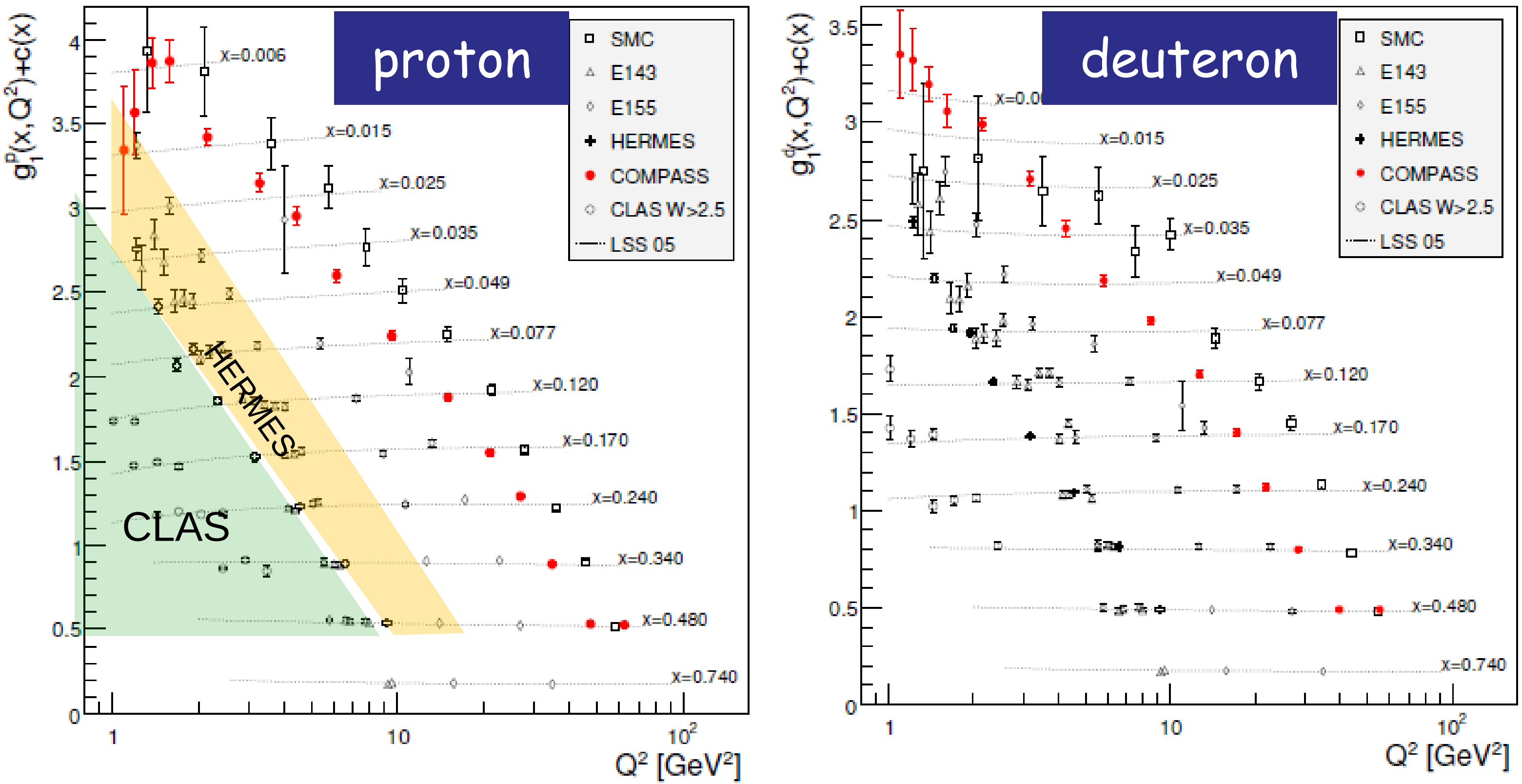
Spin structure functions - world data

Polarized DIS



$$\sigma_{DIS}^{inclusive} \propto g_1(x) \propto \frac{1}{2}\Sigma e_q^2 \left(\Delta q(x) + \Delta \bar{q}(x)\right)$$

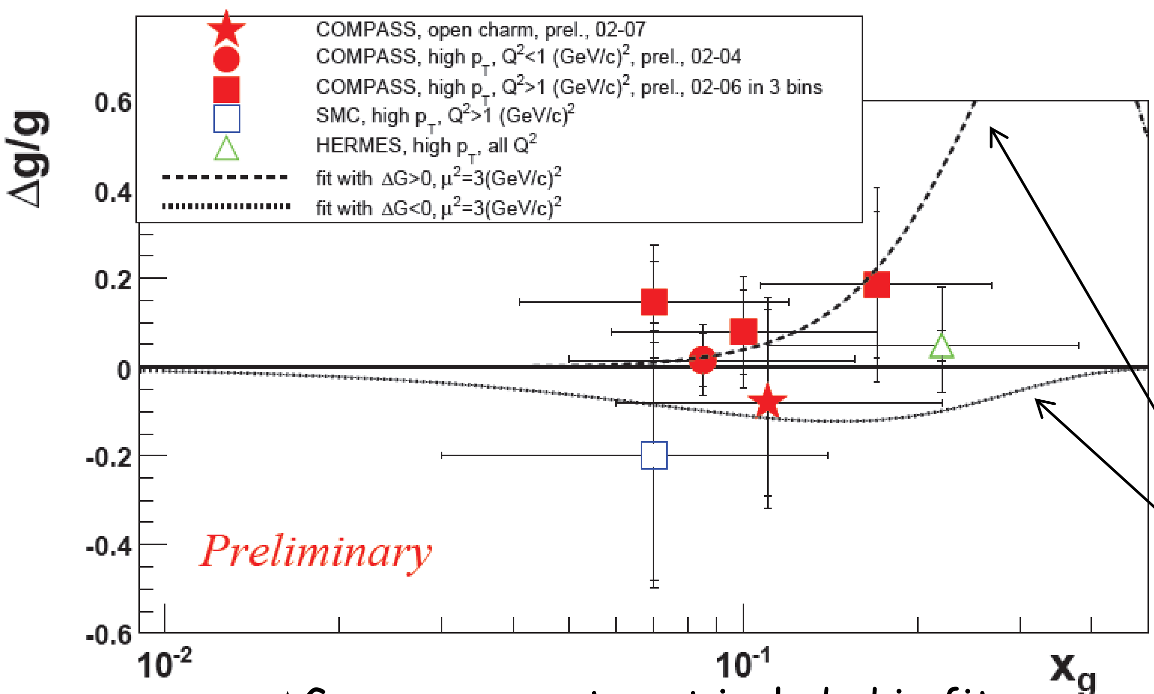
Polarized PDFs



Input to global QCD fits

→ Extract $\Delta q_f(x)$ and $\Delta G(x)$ through Q^2 evolution

3. $\Delta G(x)$ from global QCD fits of polarized DIS data $g_1(x,Q^2)$



ΔG measurements not included in fits

Use Q^2 evolution of spin dependent gluon and singlet quark distribution.

Lack of polarized data
Fits not so well constrained, however some results

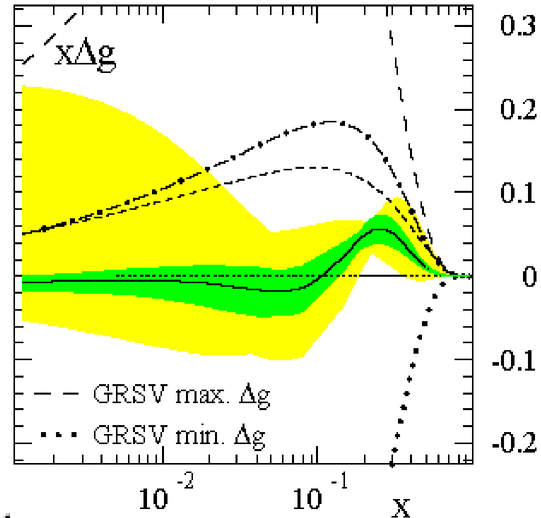
COMPASS NLO fit of g_1 data: 2 solutions with

$|\Delta G|=0.2\text{-}0.3$

3. $\Delta G(x)$ from global QCD fits, more results

DSSV
g_1 and $\vec{p}\,\vec{p}$ data

$\Delta G = -0.08$

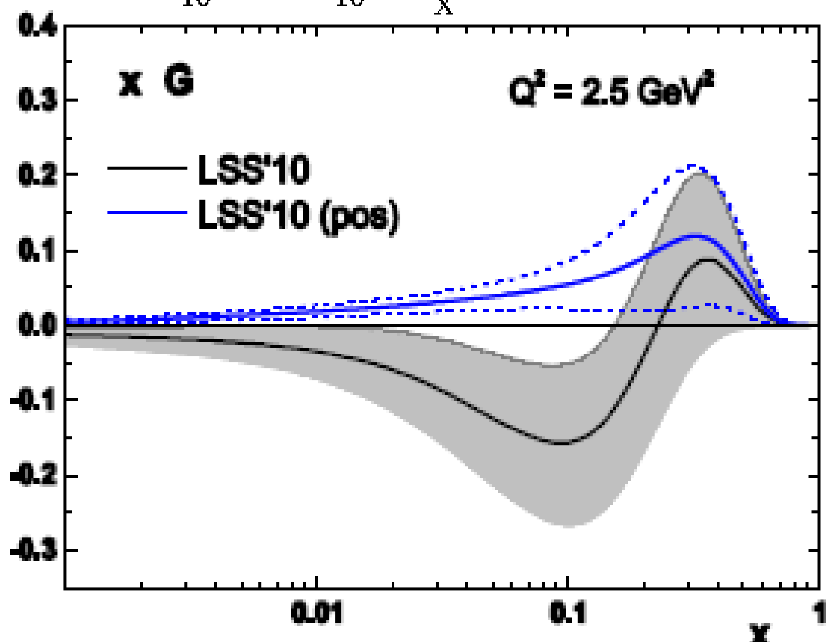


De Florian, Sassot, Stratmann, Vogelsang PRL101 (2008)072001

LSS '10
DIS(g_1) and SIDIS data

$\Delta G = 0.25 \pm 0.19$

$\Delta G = -0.40 \pm 0.43$



Leader, Sidorov, Stamenov,

$\Delta\Sigma$ from QCD fits

COMPASS $\Delta\Sigma = 0.30 \pm 0.01$ (stat) ± 0.02 (evol)

fit to $g_1^{p,n,d}$ world data, $\overline{MS}$ scheme, $Q^2=3$ $(GeV/c)^2$, PLB 647 (2007) 8

$\Delta s + \Delta\bar{s} = -0.08 \pm 0.01$ (stat) ± 0.02 (evol) COMPASS data only

HERMES $\Delta\Sigma = 0.33 \pm 0.011$ (stat) ± 0.025 (theo) ± 0.028 (evol)

HERMES g_1^d data, $\overline{MS}$ scheme, $Q^2=5$ $(GeV/c)^2$,
neglecting $x < 0.02$ contrib., PRD75 (2007)012007

$\Delta s + \Delta\bar{s} = -0.085 \pm 0.013$ (th) ± 0.008 (exp) ± 0.009 (evol)

DSSV $\Delta\Sigma = 0.24$ $Q^2=10$ $(GeV/c)^2$, arXiv:0804.0422

LSS '10

$\Delta\Sigma = 0.25 \pm 0.04$ ΔG with node $Q^2=10$ $(GeV/c)^2$,

$\Delta\Sigma = 0.21 \pm 0.03$ $\Delta G > 0$

Consequence for nucleon spin

- $\Delta G = \int \Delta g(x)dx$ not large, both from direct measurements (essentially PGF + RHIC) and g_1 QCD fit: $|\Delta G| < 0.35$

$$\Delta\Sigma = a_0 + \underbrace{(3\alpha_s/2\pi)\,\Delta G}_{\text{within}}$$

within 0.06 for ΔG within $\pm$ 0.35 at $Q^2=3$

$\rightarrow \Delta\Sigma \sim 0.30$ small ($\neq$ predictions)

$$\boxed{\tfrac{1}{2} = \tfrac{1}{2}\Delta\Sigma + \Delta G + L}$$

possible scenarios:

$$\begin{cases} \tfrac{1}{2}0.3 + 0.35 + 0.0 \\ \tfrac{1}{2}0.3 + 0.0 + 0.35 \\ \tfrac{1}{2}0.3 - 0.35 + 0.7 \end{cases}$$

Bjorken sum rule

Non-singlet combination : $g_1^p(x) - g_1^n(x)$

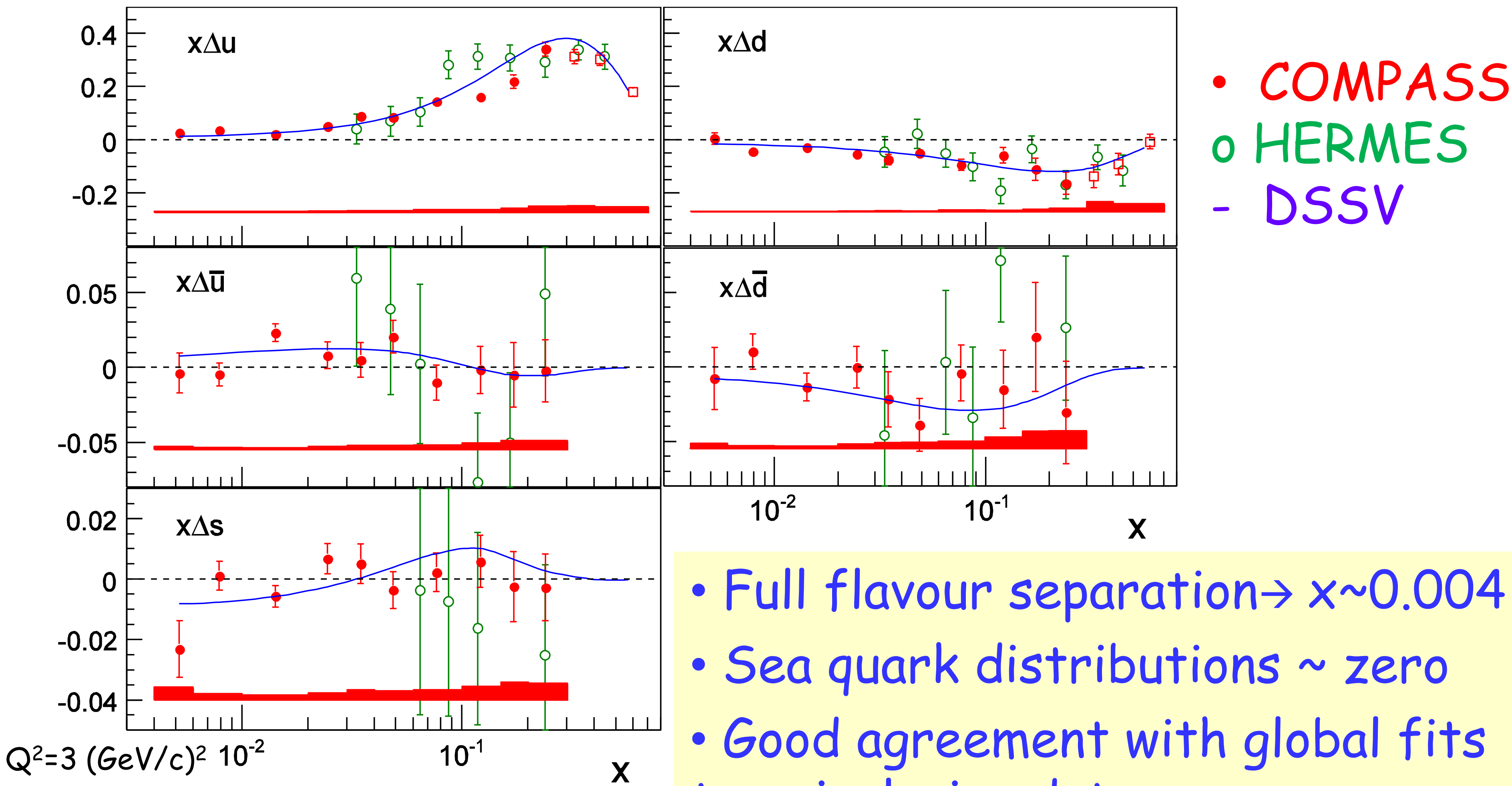
The first moment provides a test of the Bjorken sum rule, a fundamental result of QCD derived from current algebra

$$\int_0^1 g_1^{NS}(x)dx = \frac{1}{6}\left|\frac{g_A}{g_V}\right| C^{NS}$$

Fit to COMPASS data: g_A/g_V=
1.28 ±0.07(stat) ± 0.10(syst)

PDG value:
1.268 ±0.003

Quark helicities from SIDIS



- Full flavour separation→ x~0.004
- Sea quark distributions ~ zero
- Good agreement with global fits to g_1 inclusive data

Δs puzzle

Inclusive data (g_1^N & a_8 from hyperon decay +SU(3))
→ $\int \Delta s$ = - 0.08

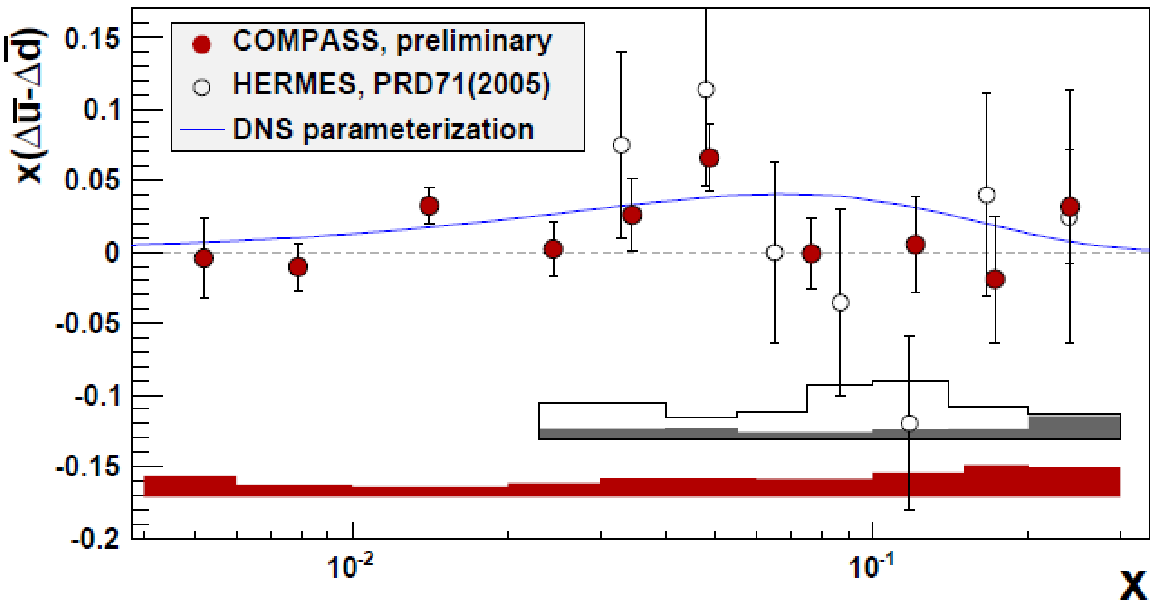
While semi inclusive data → $\Delta s(x) \approx 0$

- Uncertainty on quark fragmentation functions (s-quark to K)
  - would need a factor of ~2 from DSS value of FF
  - COMPASS will try to extract FF from kaon multiplicies in SIDIS
- Global fits (DSSV, LSS) suggest negative Δs at low x
  - reconciliates the two approaches
  - need data at lower x
- Assume SU(3) violation a_8 from0.58 to 0.42 → Δs=-0.02

Bass & Thomas, PLB684(2010) 216

Light sea quark polarized distributions, flavour asymmetry

$x(\Delta\bar{u}-\Delta\bar{d})$



- • COMPASS
- o HERMES

$$\int_{0.004}^{0.3}(\Delta\bar{u}-\Delta\bar{d})dx = 0.052 \pm 0.035(\text{stat.}) \pm 0.013(\text{syst.})$$

Sizable asymmetry in unpolarized case:

$$\int_0^1(\bar{u}-\bar{d})dx = 0.118 \pm 0.012$$

Quark helicities from W production in pp

RHIC short exploratory run :first collisions at 500 GeV

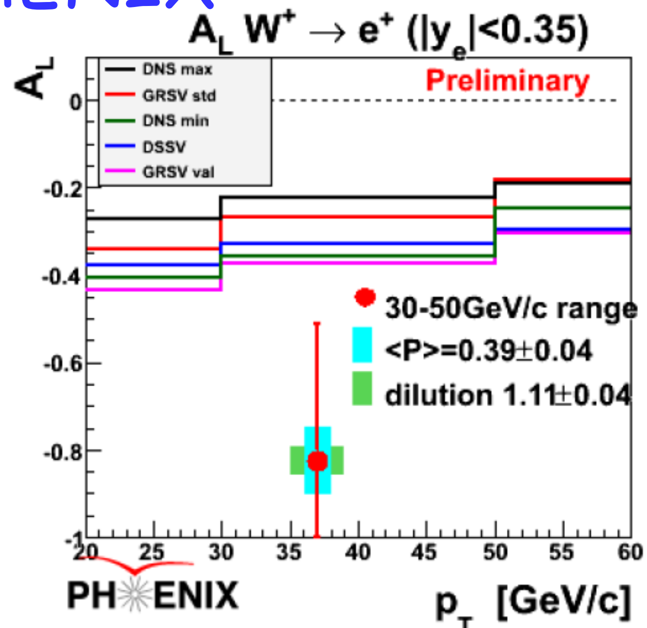
$$u + \bar{d} \rightarrow W^+ \rightarrow e^+ + \nu$$

$$\bar{u} + d \rightarrow W^- \rightarrow e^- + \bar{\nu}$$

$$\frac{\Delta \bar{d}}{\bar{d}} \quad \frac{\Delta u}{u}$$

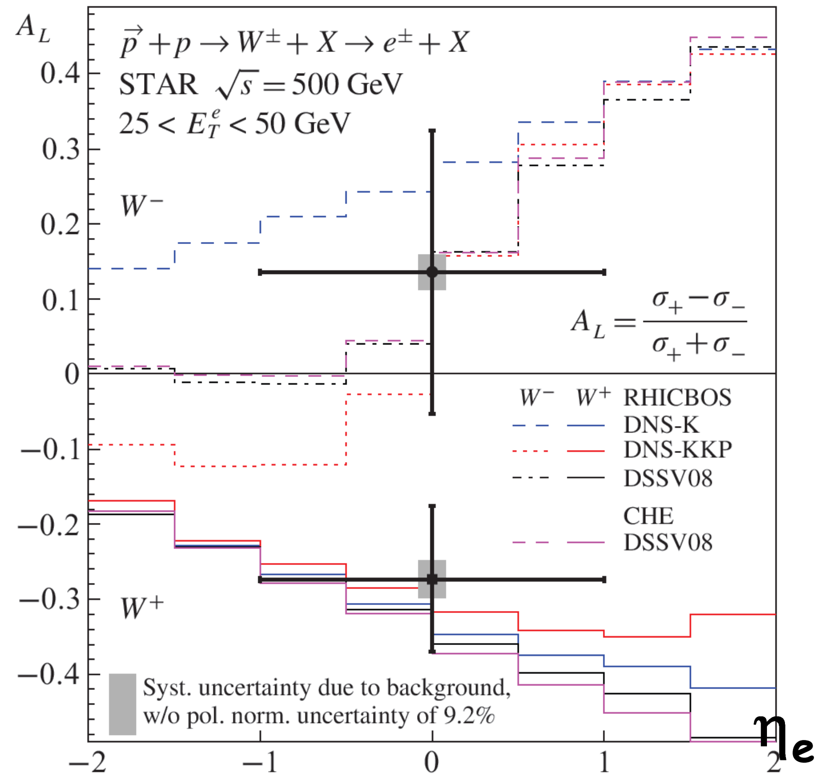
Parity violating, single spin asymmetry
No fragmentation function uncertainty

PHENIX



J. Haggerty ICHEP2010

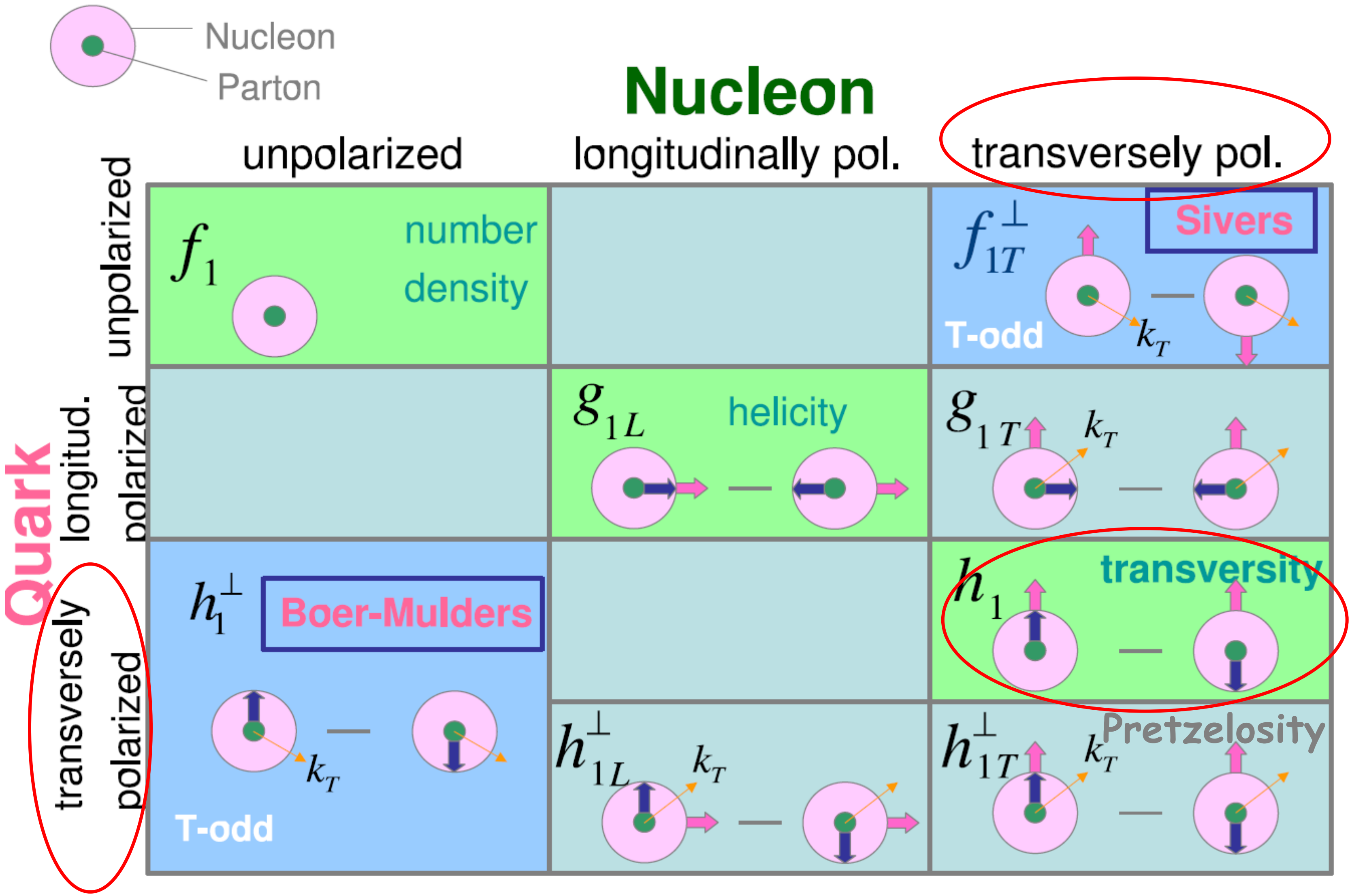
STAR



J. Seele, SPIN2010

Signs as expected from polarized PDFs
Promising channel

Nucleon Structure Functions



Collins and Sivers asymmetries

- Transversely polarized target $\mu\, p^{\uparrow} \rightarrow \mu\, p\, h^{+/-}$
- Measure simultaneously the two azimuthal asymmetries

Collins: Outgoing hadron direction & quark transverse spin

Sivers: Nucleon spin & quark transverse momentum

at LO:

Collins

q transverse spin distr.

$$A_{Coll} = \frac{\sum_q e_q^2 \cdot \Delta_T q \cdot \Delta_T^{\circ} D_q^h}{\sum_q e_q^2 \cdot q \cdot D_q^h}$$

Collins fragmentation function, depends on spin

Sivers

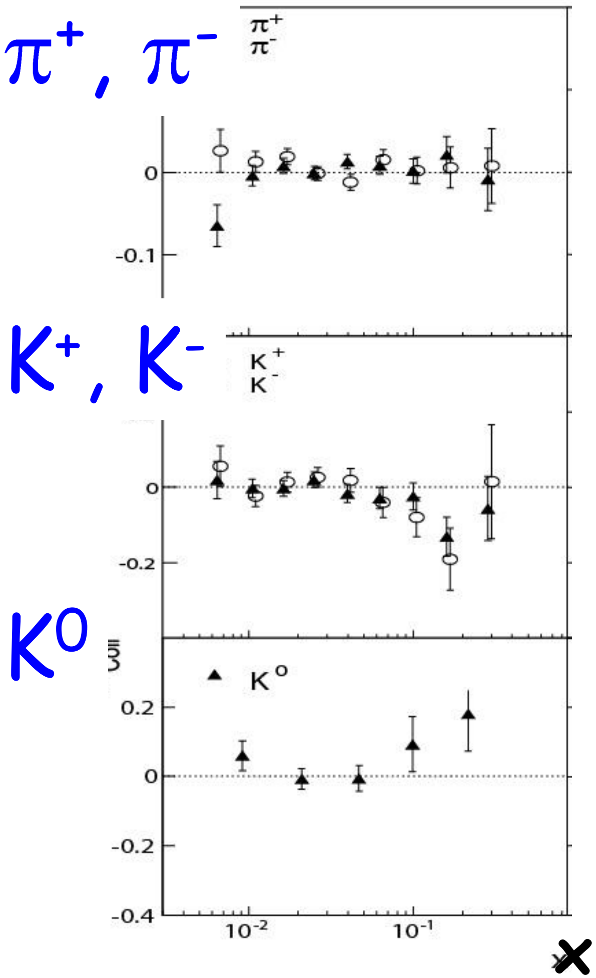
$$A_{Siv} = \frac{\sum_q e_q^2 \cdot f_{1Tq}^{\perp} \cdot D_q^h}{\sum_q e_q^2 \cdot q \cdot D_q^h}$$

Usual quark fragmentation function

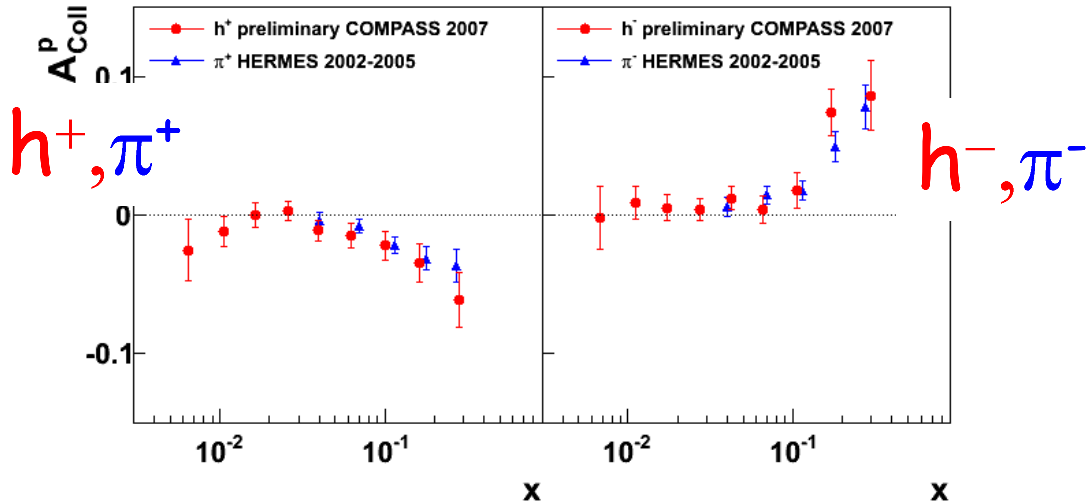
note: $\Delta_T q$ also measured using
- "Two hadron" fragm. fct.
- lambda Transverse. Polarization

Transversity : Collins Asymmetry

deuteron COMPASS



proton COMPASS & proton HERMES



- Large signals in valence region

→both transverse quark distribution $\Delta_T q(x)$ and Collins FF non zero

- Opposite for + and –hadrons:

→opposite u and d Collins FF

- HERMES and COMPASS similar:

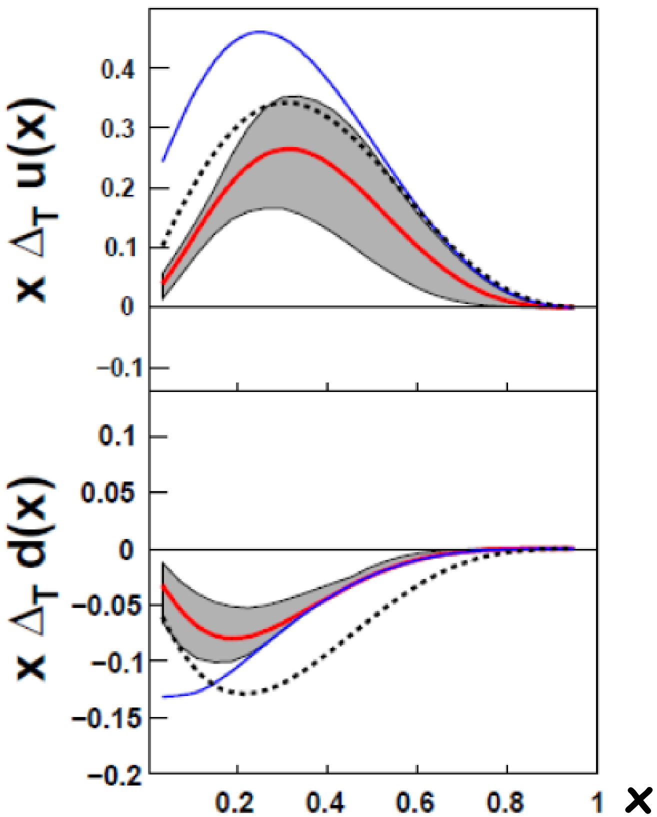
→data support assumption of weak Q^2 dependence in this energy range

Compatible with zero:

→ $\Delta_T u + \Delta_T d$ opposite

Transversity : Collins Asymmetry

Several combined analyses of
HERMES-p, COMPASS-d data, and BELLE FF.



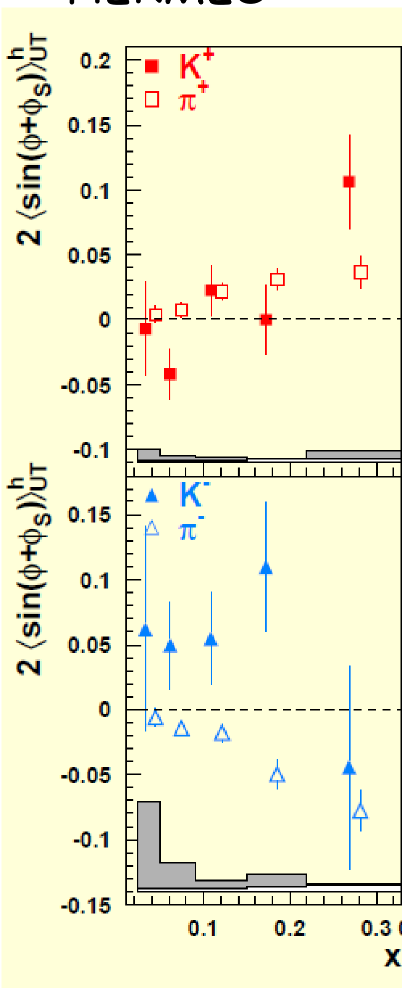
Ex: M. Anselmino et al. arXiv:0812.4366

- $\Delta_T u > 0$ and $\Delta_T d < 0$
- Do not saturate Soffer bound
- Smaller than helicity

Transversity : Collins Asymmetry on proton

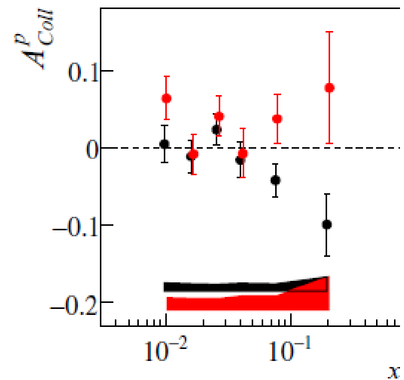
Identifying outgoing hadron: kaons and pions (HERMES-p and COMPASS-p)

HERMES

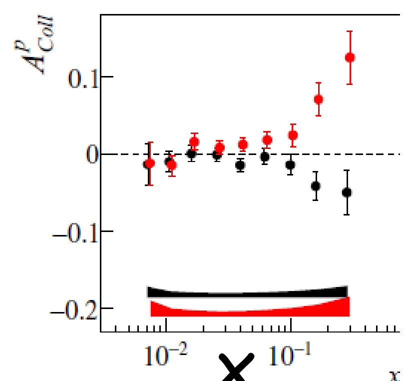


COMPASS

K^+ K^-



π^+ π^-



X

- K^+ & $\pi+$: similar (u dominance)
- K^- & π^- opposite, however still low statistics on K-

(K^-= $\overline{u}s$ sea quark dominance)

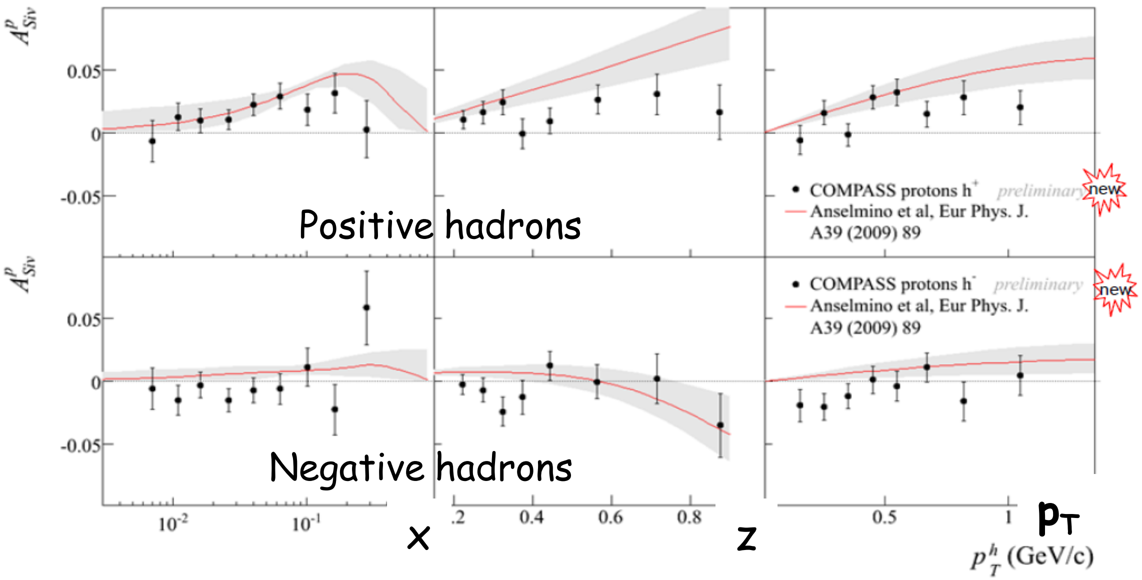
→ Progress in flavour separation

Sivers Asymmetry- proton

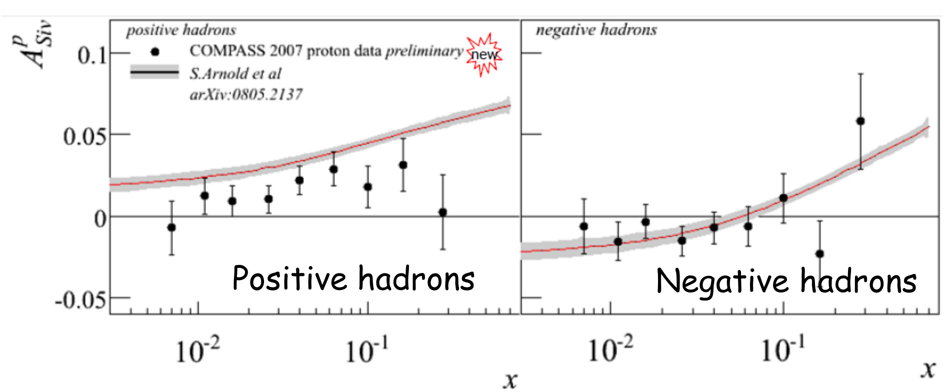
Comparison with predictions from Anselmino *et al.*, based on fit of Hermes-p and Compass-d data

Present data not in fit

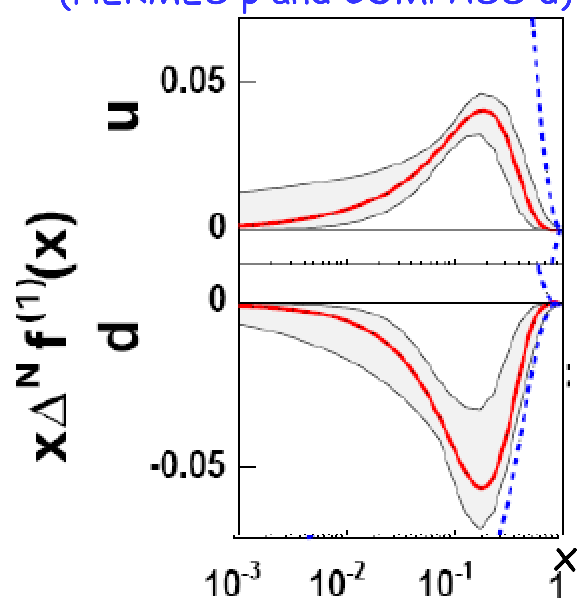
- COMPASS signal < HERMES signal
- Possible W dependence



Comparison with calculations of Arnold,Efremov *et al.*, which are in agreement with Hermes-p data.

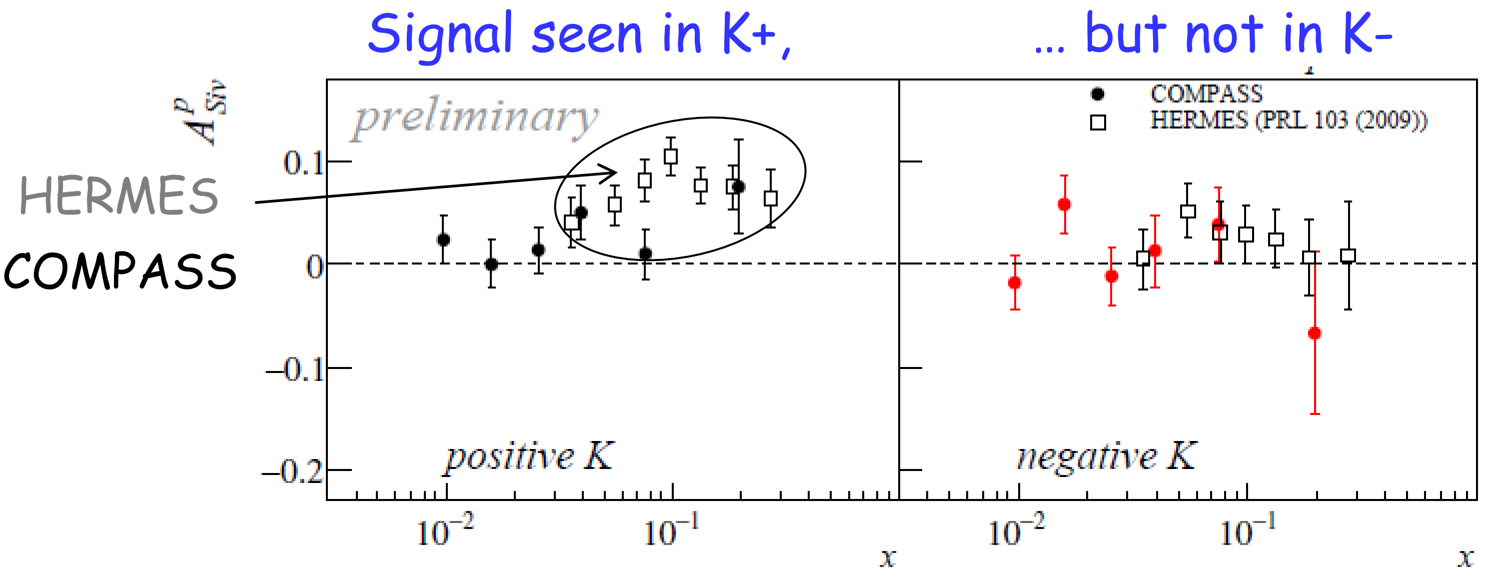


Extraction of Sivers fct (HERMES p and COMPASS d)



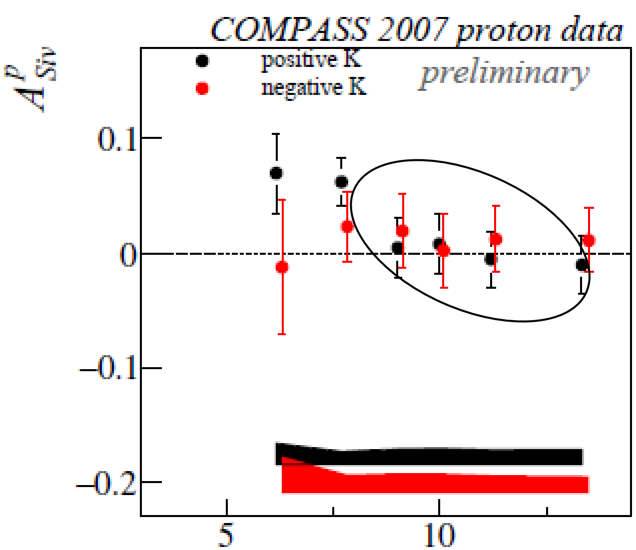
Ex: M. Anselmino et al. arXiv:0812.4366

Sivers Asymmetry on proton



Other observation in HERMES and COMPASS: K⁺ signal larger than π^+

→ Much progress in flavour separation (sea quarks)

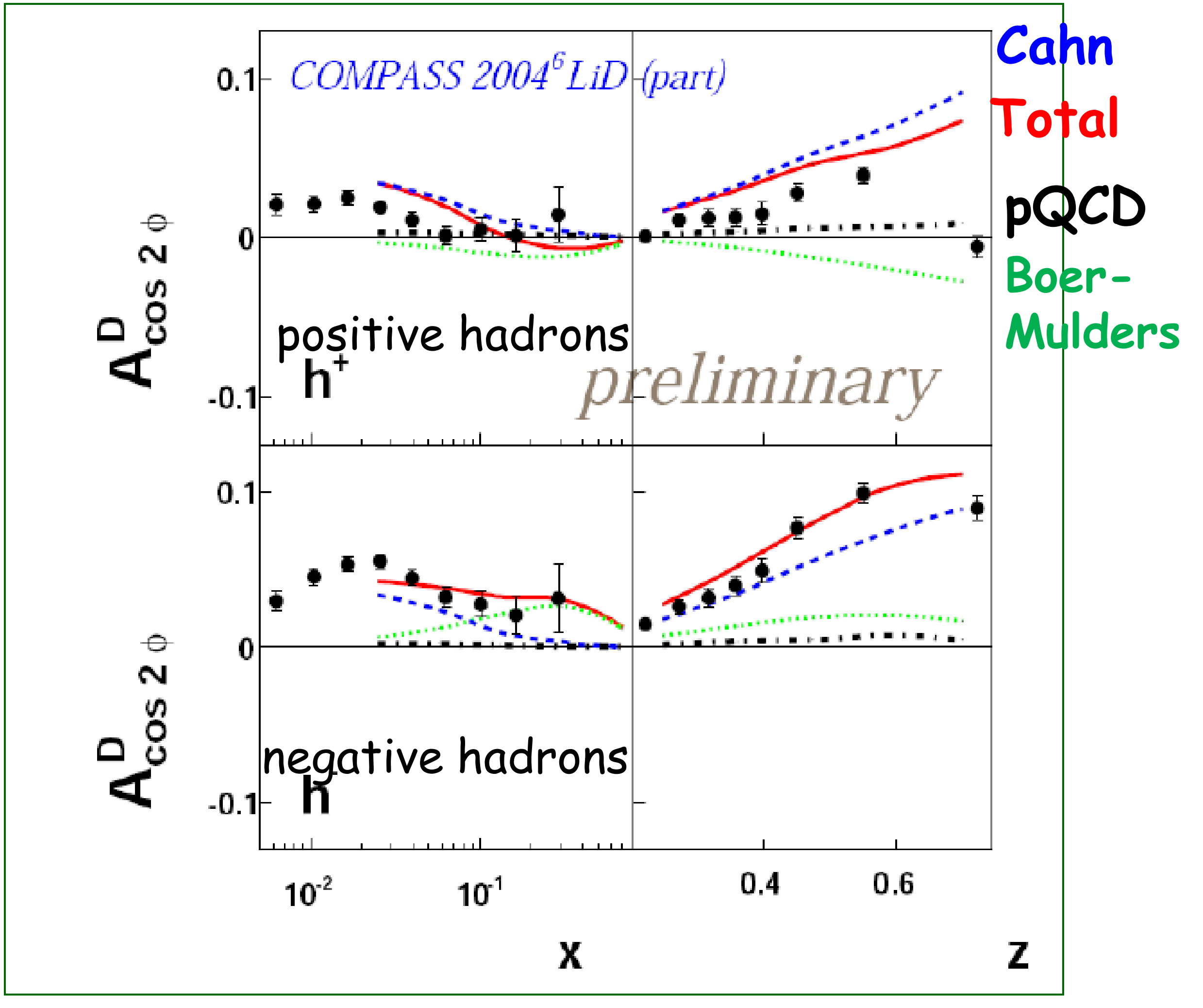


Possible unexpected dependence on W:
Higher signal in HERMES (low W) and in low W part of COMPASS data

Example of one azimuthal asymmetry

Unpolarized target.

cos(2ϕ) modulation comparison with theory



total — Boer Mulders
Cahn — pQCD

V.Barone, A.Prokudin, B.Q.Ma
arXiv:0804.3024 [hep-ph]

Sensitivity to Transverse Momentum Distributions

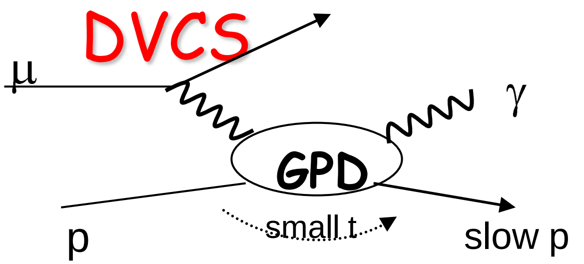
Future: COMPASS II

New

approved by CERN SPSC for initial period 2013-1015

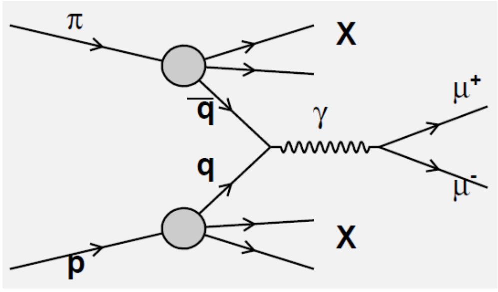
- GPD (Generalized Parton Distributions) $\mu p \rightarrow \mu p \gamma$

by exclusive reactions DVCS (Deep Virtual ComptonScattering)
and DVMP (Meson production),
2 year 'beam charge and spin asymmetry' measurement



- Polarized Drell-Yan $\pi p^{\uparrow} \rightarrow \mu^{+}\mu^{-}X$

Sivers & Boer-Mulders
Transverse Momentum Dependent distributions
2 years with transversely polarised proton target
Test of factorization approach :
Comparison SIDIS/ Drell-Yan



Summary

- Gluon polarization

at LO, $\Delta G/G$ ~ 0 at x ~ 0.1   7 independent points (5 from COMPASS)
Confirmed by $A_{LL}(p_T)$ at RHIC
$\int\Delta G$ could still account for a substantial part of the nucleon spin

- Quark helicity : extraction at LO for all flavours

$\Delta s(x) \sim 0$ from SIDIS in measured region, and $\int \Delta s < 0$ from DIS

- Transversity:

Collins and Sivers deuteron, compatible ~ 0
Collins proton: Signal in valence region, for pos. and neg. hadrons
Extract $\Delta_T u > 0$ and $\Delta_T d < 0$
Sivers proton: Signal for positive hadrons, especially kaons
Extract Sivers u and d, and possible k_T dependence

And exciting future programs in preparation

COMPASS II, RHIC-spin and Jlab-12 GeV

Spares

Table II. First moments (total polarizations) Δf of polarized NLO parton densities $\delta f(x, Q^2)$ and $g_1^{p,n}(x, Q^2)$, defined in (1.3) and (1.4), as obtained in the 'standard' scenario. The marginal differences between $\Delta\bar{u}$ and $\Delta\bar{d}$ at $Q^2 > \mu^2$, generated dynamically by the NLO evolution, are not displayed.

Q^2 (GeV^2)	Δu	Δd	$\Delta\bar{q}$	Δg	$\Delta\Sigma$	Γ_1^p	Γ_1^n
μ^2_{NLO}	0.863	-0.404	-0.062	0.240	0.211	0.119	-0.054
1	0.861	-0.405	-0.063	0.420	0.204	0.127	-0.058
5	0.859	-0.406	-0.064	0.708	0.197	0.132	-0.062
10	0.859	-0.406	-0.064	0.828	0.197	0.133	-0.063

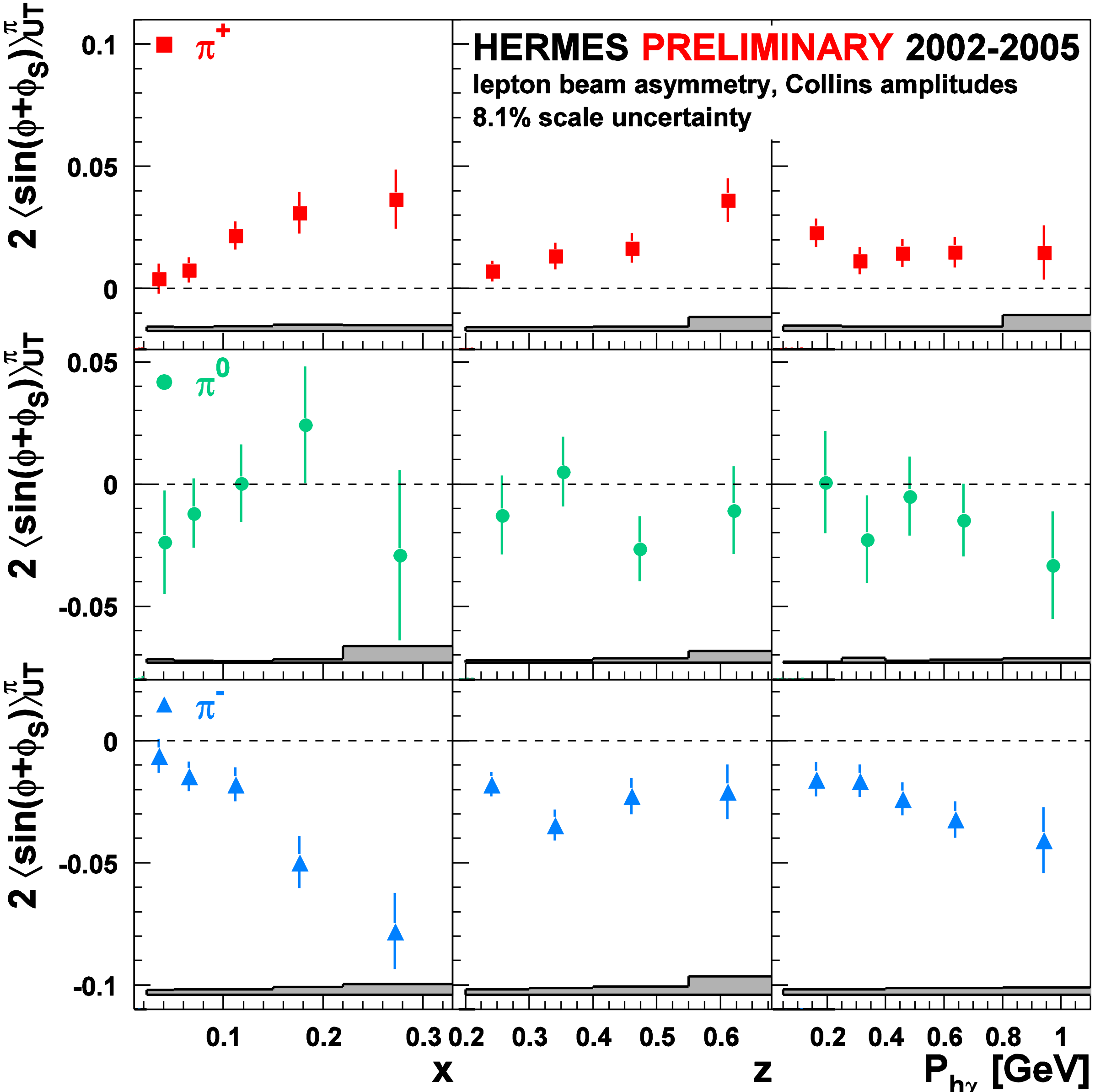
Table IV. First moments (total polarizations) Δf of polarized parton densities $\delta f(x, Q^2)$ and $g_1^{p,n}(x, Q^2)$, defined in (1.3) and (1.4), as obtained in the fully flavor–broken 'valence' scenario. The marginal finite $\Delta s = \Delta\bar{s}(Q^2 > \mu^2_{\rm NLO})$ are generated dynamically by the NLO evolution.

GRSV-std

Q^2 (GeV^2)	Δu	Δd	$\Delta\bar{u}$	$\Delta\bar{d}$	$\Delta s = \Delta\bar{s}$	Δg	$\Delta\Sigma$	Γ_1^p	Γ_1^n
μ^2_{NLO}	0.693	-0.255	0.087	-0.232	0	0.330	0.293	0.119	-0.053
1	0.691	-0.257	0.086	-0.234	-1.95×10^{-3}	0.579	0.282	0.127	-0.058
5	0.689	-0.258	0.085	-0.235	-3.31×10^{-3}	0.974	0.273	0.132	-0.062
10	0.688	-0.258	0.085	-0.236	-3.64×10^{-3}	1.140	0.272	0.133	-0.062

Transversity : Collins Asymmetry on proton

HERMES pions



- Both transversity & Collins fragm.function ≠0
- Opposite results for π+ & π- suggest opposite u & d Collins fragm.function

SIDIS, transverse case

$\mu\ p^{\uparrow} \rightarrow \mu\ p\ h^{+/-}$

From A. Bacchetta et al., JHEP 0702:093,2007. e-Print: hep-ph/0611265

$$\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_h\,dP_{h\perp}^2} = \frac{\alpha^2}{xyQ^2}\,\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Big\{ \;\ldots$$

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

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

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

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

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

Sivers

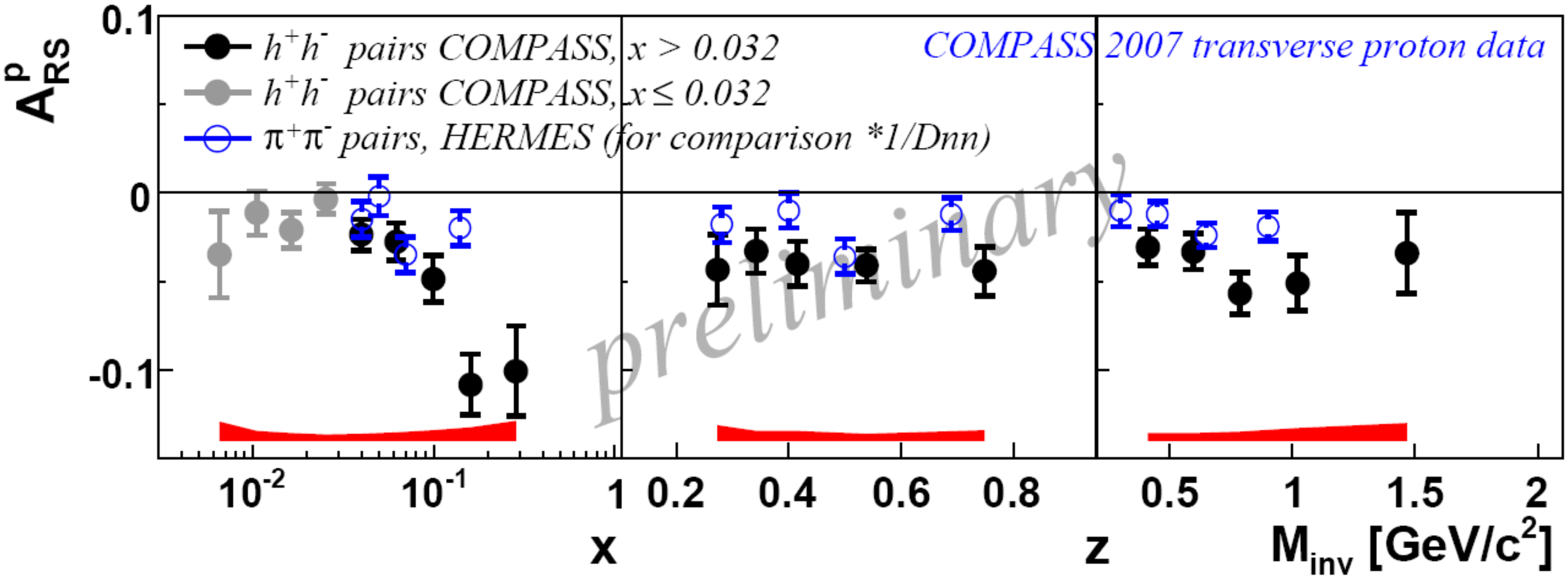
Collins

6 other modulations

8 azimuthal asymmetries extracted at once

Transversity via "two hadron"

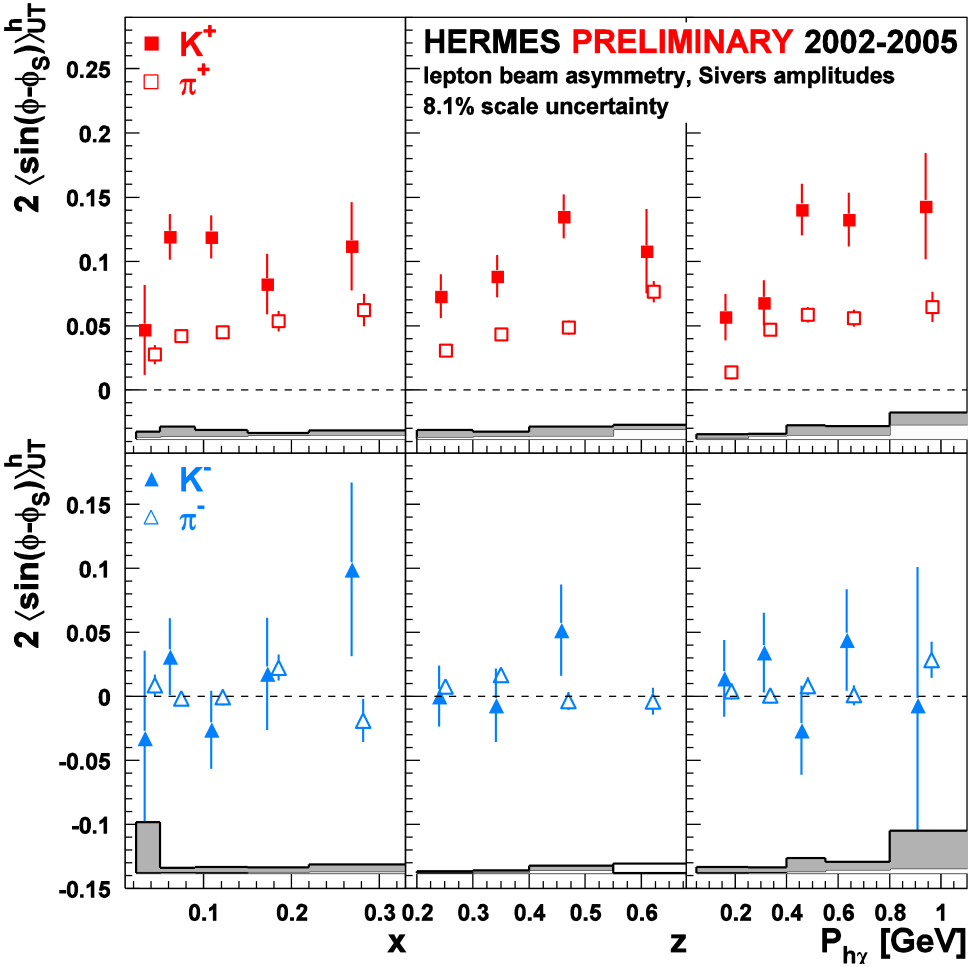
as an alternative for $\Delta_T u$ and $\Delta_T d$, no FF needed



- Confirms non zero effect at large x; larger than Collins asym.

- Smaller signal seen in HERMES in different phase space, but difficult to describe both simultaneously *A.Bacchetta et al., Mah et al.*

Sivers Asymmetry on proton



HERMES K/ π comparison

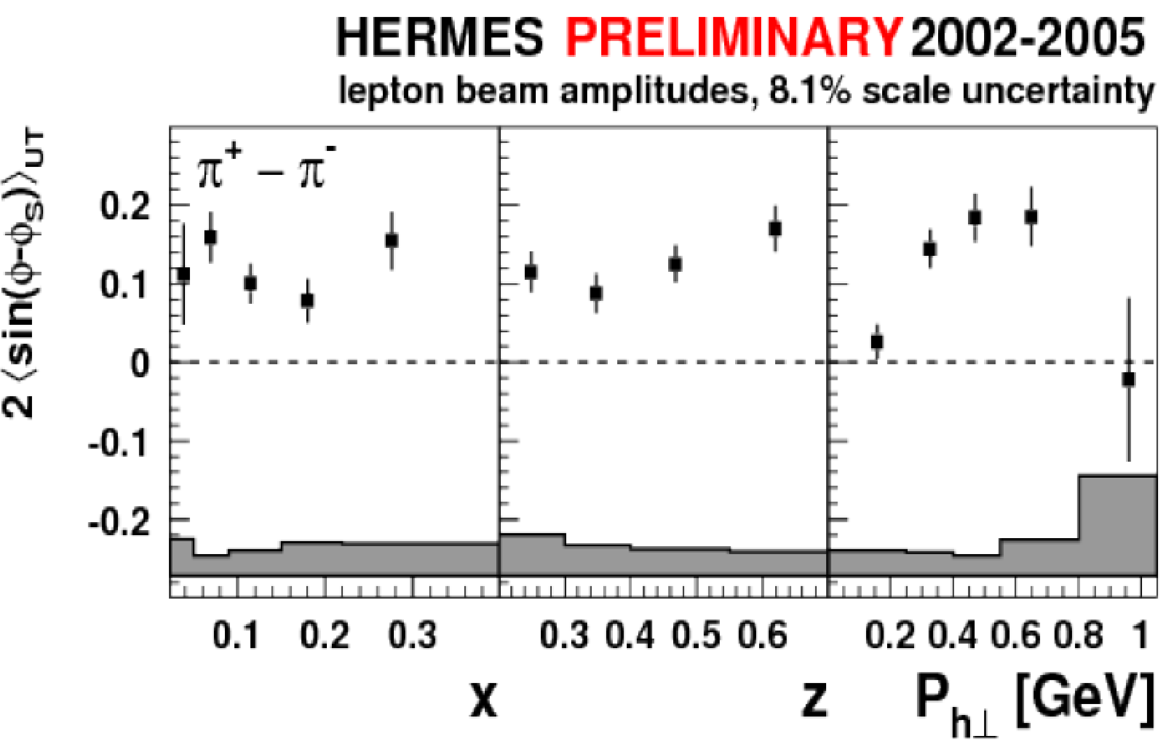
- K^+ twice bigger than π^+

Sivers function for the sea quarks $\bar{s}$ and $\bar{d}$?

- K^- and π^- ~ 0

$\bar{u}s$ $\bar{u}d$

Sivers Asymmetry ($\pi^+ - \pi^-$)

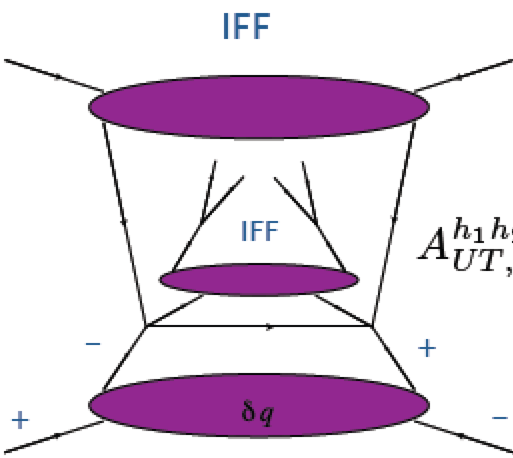


- Sivers $d_{valence}$ >> $u_{valence}$
  OR
- Sivers $u_{valence}$ large <0 (more likely)

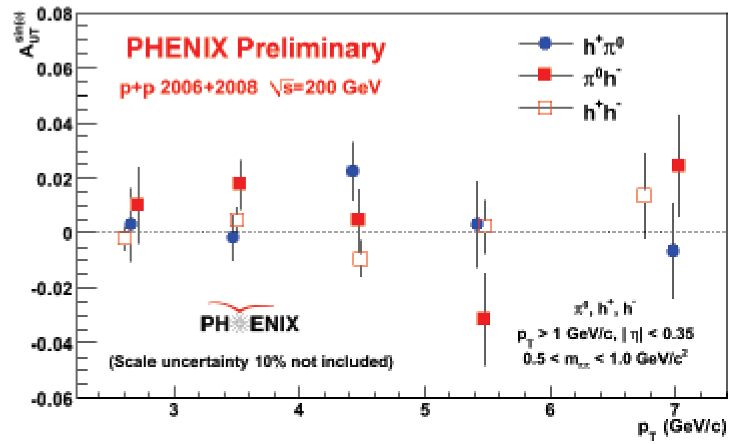
From Ch. Van Hulse, Bochum 2009

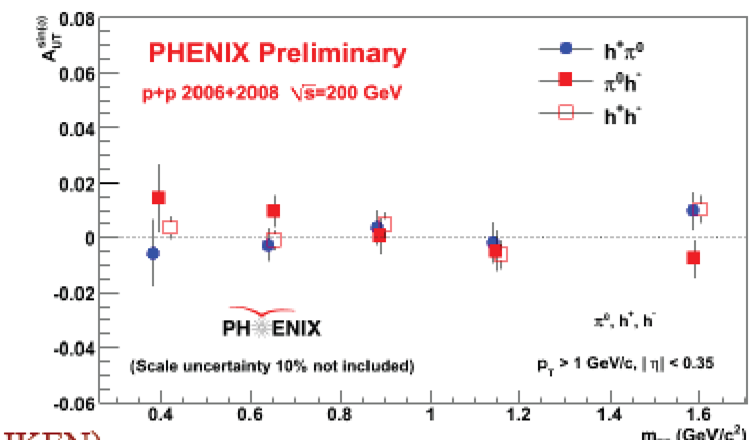
Recent results - Transverse spin program

- PHENIX: IFF measurements



$$A_{UT,\phi}^{h_1 h_2} = \frac{\sigma_\phi^\uparrow - \sigma_\phi^\downarrow}{\sigma_\phi^\uparrow + \sigma_\phi^\downarrow}$$





- Measure transversity ⊗ IFF
- No significant asymmetry seen at mid-rapidity
- IFF measurements from BELLE

R. Seidl (RIKEN)

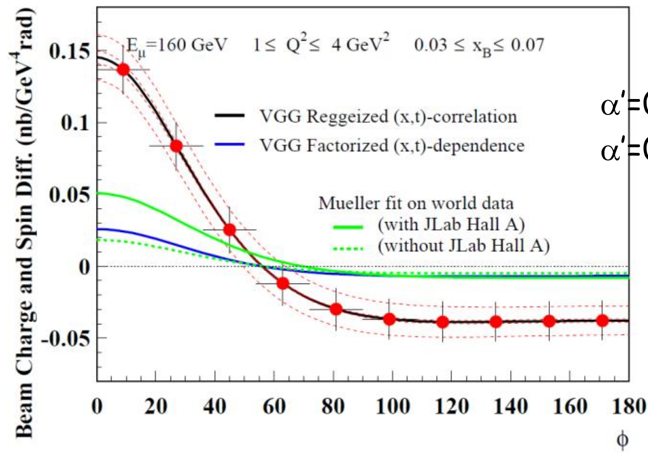
Generalized Parton Distributions

- Unified description of form factors and parton distribution functions
- Transverse imaging = nucleon tomography

and (in far future) sensitivity to the quark angular momentum

Kinematic domain : intermediate between HERA and JLab $10^{-2} < x_B < 10^{-1}$

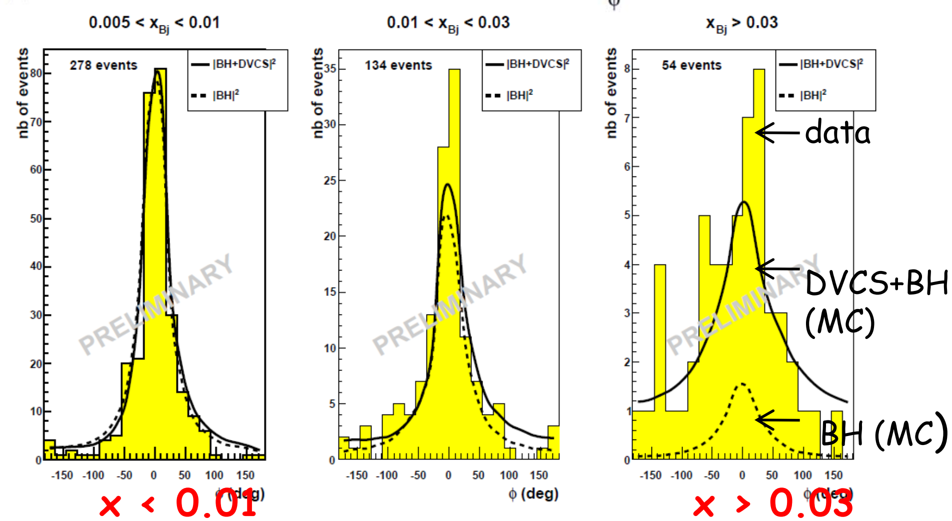
Ex: Beam charge & spin asymmetry in DVCS process (interfering with BH):



α'=0.8
α'=0.05

COMPASS proj. 2years

First signal of DVCS&BH from 2009 short test run, compared to simulations

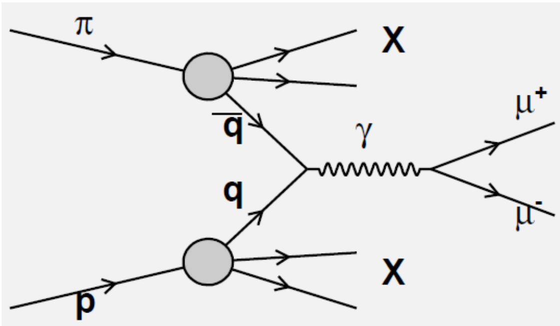


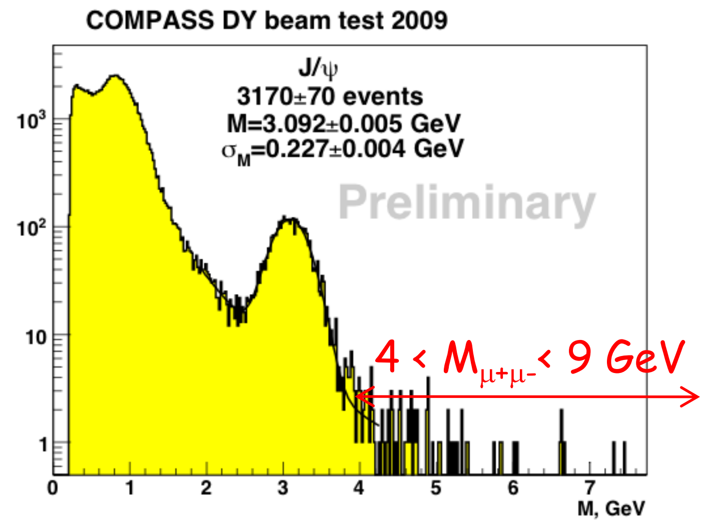
$x < 0.01$ BH dominates

$x > 0.03$ DVCS dominates

Polarized Drell-Yan $\pi^- p^\uparrow \rightarrow \mu^+\mu^- X$

transversely polarised NH_3 target

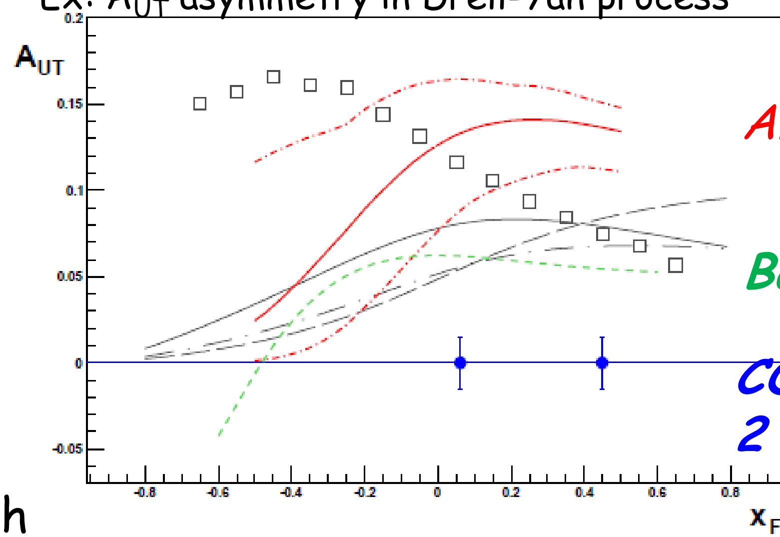




$$\sigma^{DY} \propto f_{\bar{u}|\pi^-} \otimes f'_{u|p}$$

→ Transverse Momentum Dependent (TMD) parton distribution functions

Ex: A_{UT} asymmetry in Drell-Yan process



Sivers and Boer Mulders fct will be measured :

- in Drell-Yan process
- in μp SIDIS process

Expect opposite sign

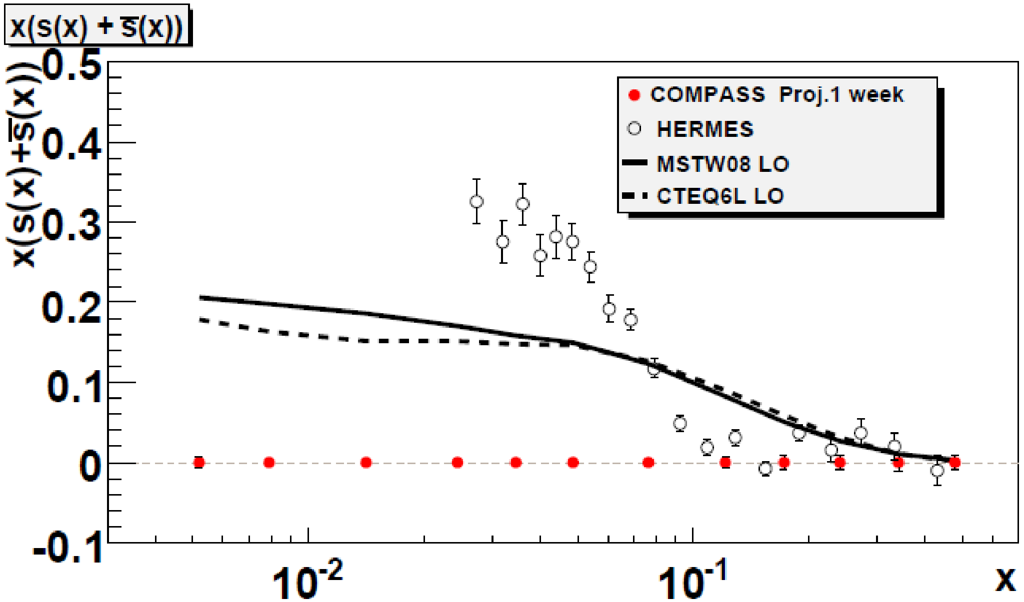
→ Test of factorization approach

Measurement of unpolarized PDFs

• In parallel to the DVCS/DVMP program, get (for free) SIDIS data on LH_2 target

• Extract strange quark PDF s(x) as well as quark fragmentation functions from kaon multiplicities

Short term goal: LO analysis from COMPASS data alone integrated over z



Longer term goal : provide p and K multiplicities as fct of x, z for global QCD analyses