Status and Perspectives of Spin Physics

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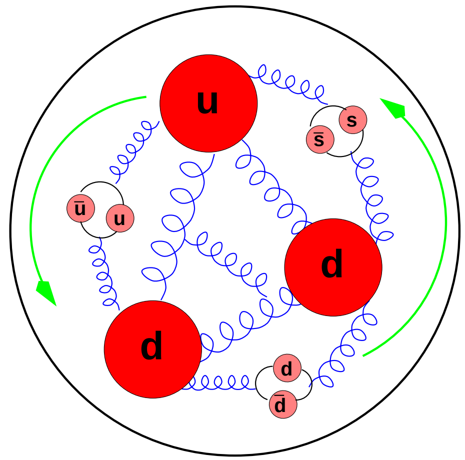
Motivation

the spin structure of the nucleon:



$$\langle S_z^{\mathrm{N}} \rangle = \frac{1}{2} = J_q + J_g$$
$$= \frac{1}{2}\Delta\Sigma + L_q + \Delta G + L_g$$

$\Delta\Sigma$ is found to be small in inclusive DIS experiments

- $\sim$1980: SLAC: connection of nucleon spin with quarks
- 1988: EMC: *"spin crisis"* $\Delta\Sigma = 0.12 \pm 0.17 \approx 0\,?\ \ll \Delta\Sigma_{\mathrm{QPM}} = 1$
- 1988–2000: SLAC, CERN, DESY: $\Delta\Sigma \approx 0.2 \ldots 0.4 > 0$

possible contributions to $\langle S_z \rangle$ still unknown

- strange sea polarization $\Delta s < 0$? $\rightsquigarrow$ semi-inclusive DSA
- gluon polarization $\Delta G > 0$? $\rightsquigarrow$ high p_T hadron pairs, open charm, direct γ
- orbital angular momentum $L_{q,g}$? $\rightsquigarrow$ exclusive γ, π production

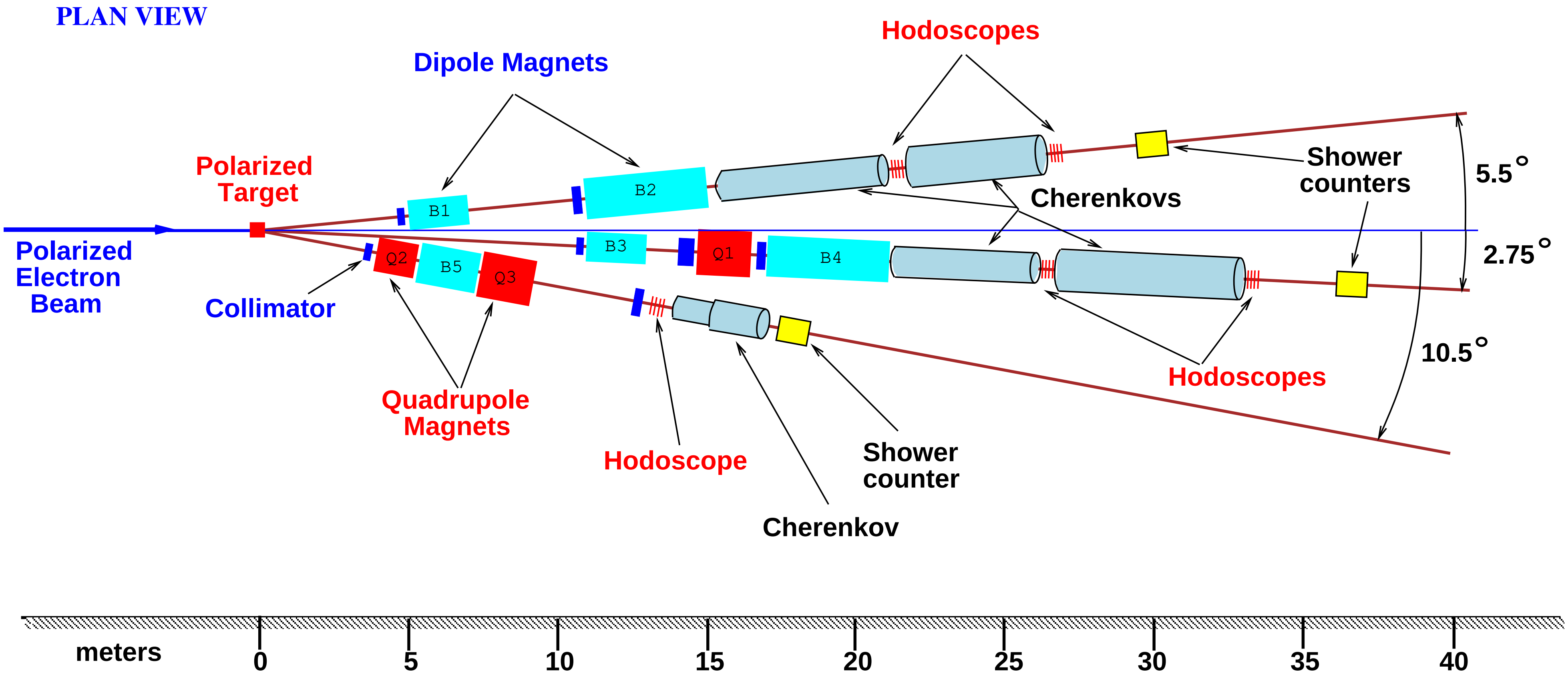
Outline

- Experiments
- Asymmetries and Structure Functions $g_{1,2}$
- QCD and Gluon Polarization ΔG
- Flavour Separation of Polarized Parton Distributions
- Exclusive Spin Physics
- Prospects of Current Experiments
- Conclusion

Deep Inelastic lp and pp Spin Experiments

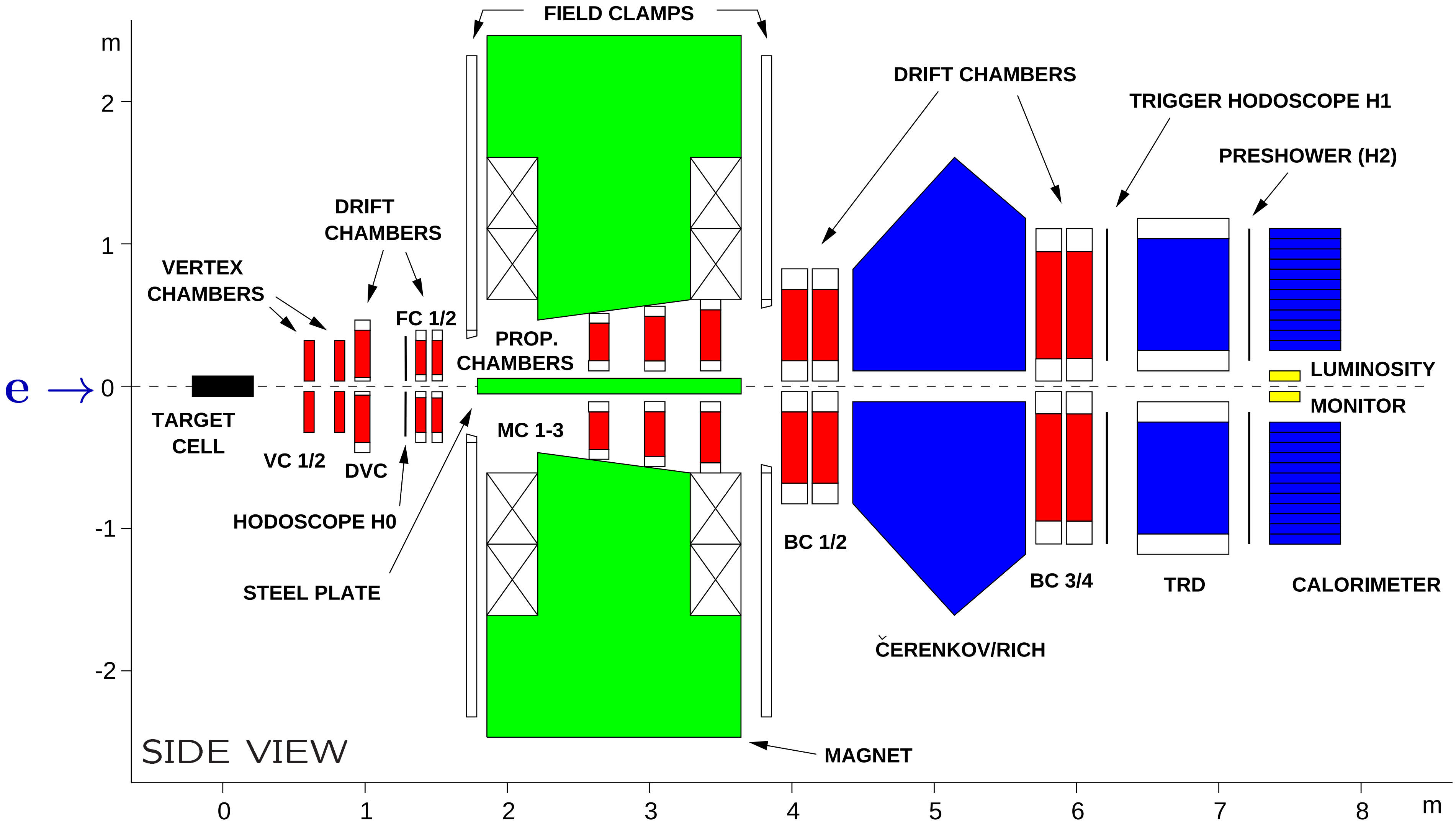
Lab	Exp.	Year	Beam	P %	Target	P %	f
SLAC	E80	75	10-16 GeV e^-	85	H-butanol	50	0.13
	E130	80	16-23 GeV e^-	81	H-butanol	58	0.15
	E142	92	19-26 GeV e^-	39	^{3}He	35	0.35
	E143	93	10-29 GeV e^-	85	NH_3	70	0.15
					ND_3	25	0.24
	E154	95	48 GeV e^-	83	^{3}He	33	0.55
	E155	97	48 GeV e^-	81	NH_3	90	0.15
					LiD	22	0.36
	E155X	99	30 GeV e^-	83	NH_3	70	0.16
					LiD	22	0.36
CERN	EMC	85	200 GeV μ^+	79	NH_3	78	0.16
	SMC	92	100 GeV μ^+	82	D-butanol	35	0.19
		93	190 GeV μ^+	80	H-butanol	86	0.12
		94/95		81	D-butanol	50	0.20
		96		77	NH_3	89	0.16
DESY	HERMES	95	28 GeV e^+	55	^{3}He	46	1.0
		96/97		55	H	88	1.0
		98	28 GeV e^-	55	D	85	1.0
		99/00	28 GeV e^+	55	D	85	1.0
DESY	HERMES	01	28 GeV e^+	55	H	85	1.0
CERN	COMPASS	01	160 GeV μ^+	80	NH_3	90	0.16
					LiD	50	0.50
BNL	RHIC	01	200 GeV p	70	200 GeV p	70	1.0

E155 Spectrometers

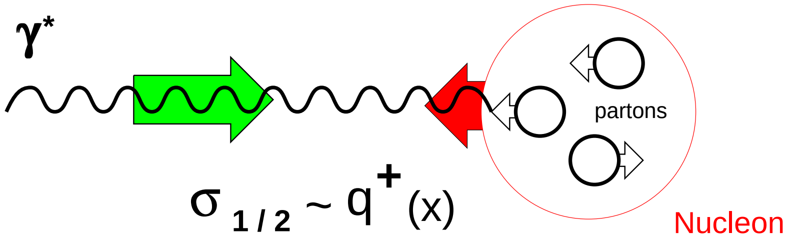


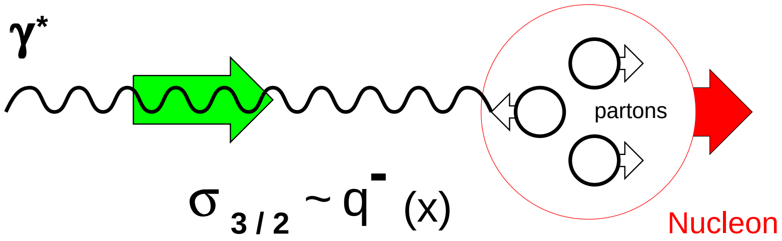
The HERMES Experiment at DESY

forward spectrometer (0.04 < |Θ| < 0.22 mrad)



Spin Structure Functions - Partonic Interpretation





QPM:

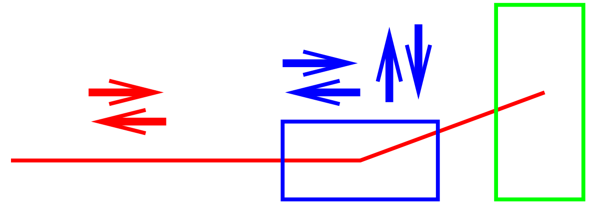
$$
\begin{aligned}
q(x) &= q^{+}(x) + q^{-}(x) \\
F_1(x) &= \frac{1}{2}\sum_f e_f^2 q_f(x) \\
F_2 &= 2xF_1 \\
\Delta q(x) &= q^{+}(x) - q^{-}(x) \\
g_1(x) &= \frac{1}{2}\sum_f e_f^2 \Delta q_f(x) \\
g_2 &= 0
\end{aligned}
$$

simple physical interpretation of g_1 in terms of quark helicity distributions $\Delta q_f(x)$

BUT no simple partonic picture for g_2

Spin Structure Functions - Measurement

form cross section asymmetries w.r.t. orientations of beam and target spins



measured asymmetries:

$$A_{||} = \frac{\sigma^{\overset{\rightarrow}{\Leftarrow}} - \sigma^{\overset{\rightarrow}{\Rightarrow}}}{\sigma^{\overset{\rightarrow}{\Leftarrow}} + \sigma^{\overset{\rightarrow}{\Rightarrow}}} \qquad A_{\perp} = \frac{\sigma^{\Downarrow\rightarrow} - \sigma^{\Uparrow\rightarrow}}{\sigma^{\Downarrow\rightarrow} + \sigma^{\Uparrow\rightarrow}}$$

relation to virtual photon asymmetries A_1 and A_2:

$$A_{||} = D(A_1 + \eta A_2) \qquad A_{\perp} = d(\zeta A_1 + A_2)$$

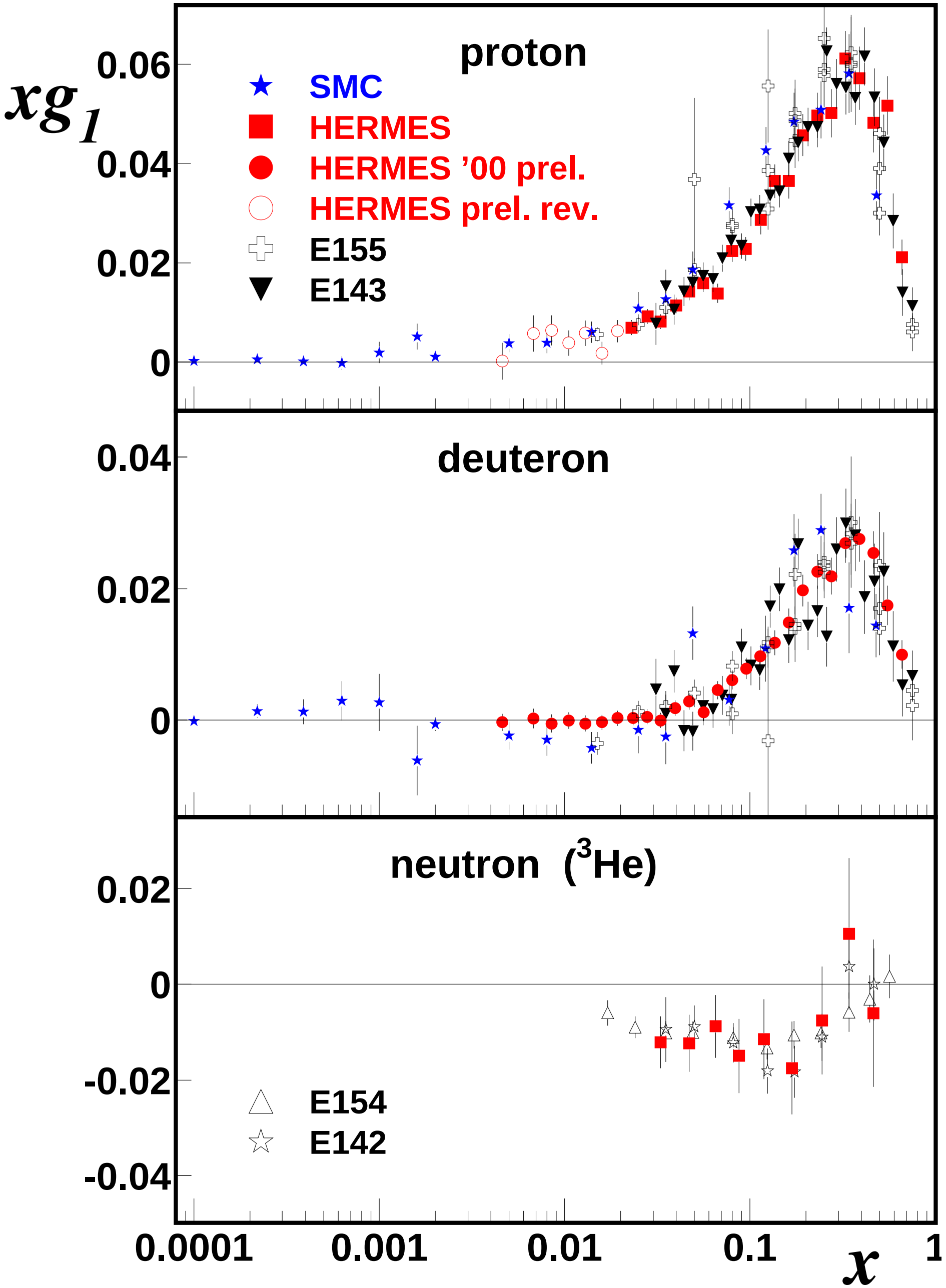
relation to spin structure functions g_1 and g_2:

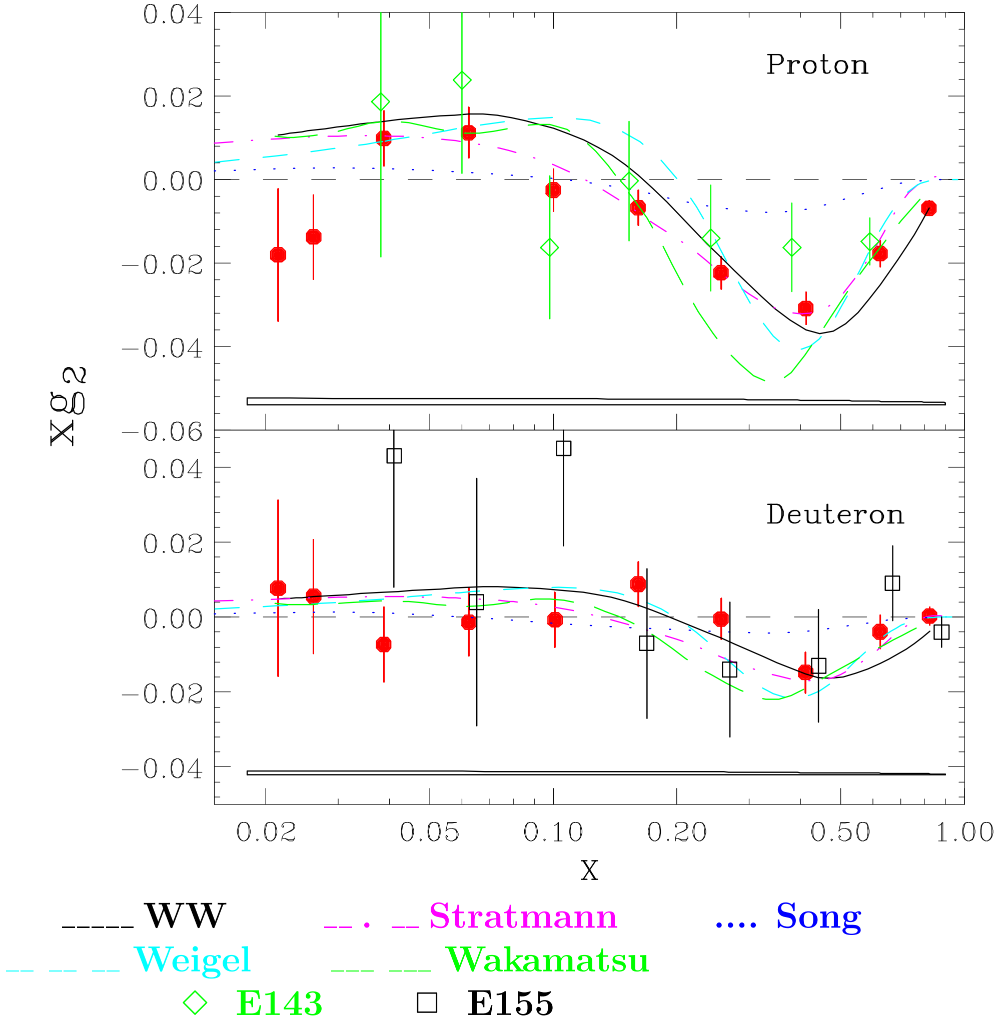
$$A_1 = \frac{(g_1 - \gamma^2 g_2)}{F_1} \approx \frac{g_1}{F_1} \qquad A_2 = \gamma \frac{(g_1 + g_2)}{F_1}$$

D, d : photon depolarization factors ($D \approx y$)

η, γ, ζ : kinematic factors ($\eta \approx \gamma \xrightarrow{Q^2 \gg M^2} 0$)

Recent Data on xg_1 and xg_2



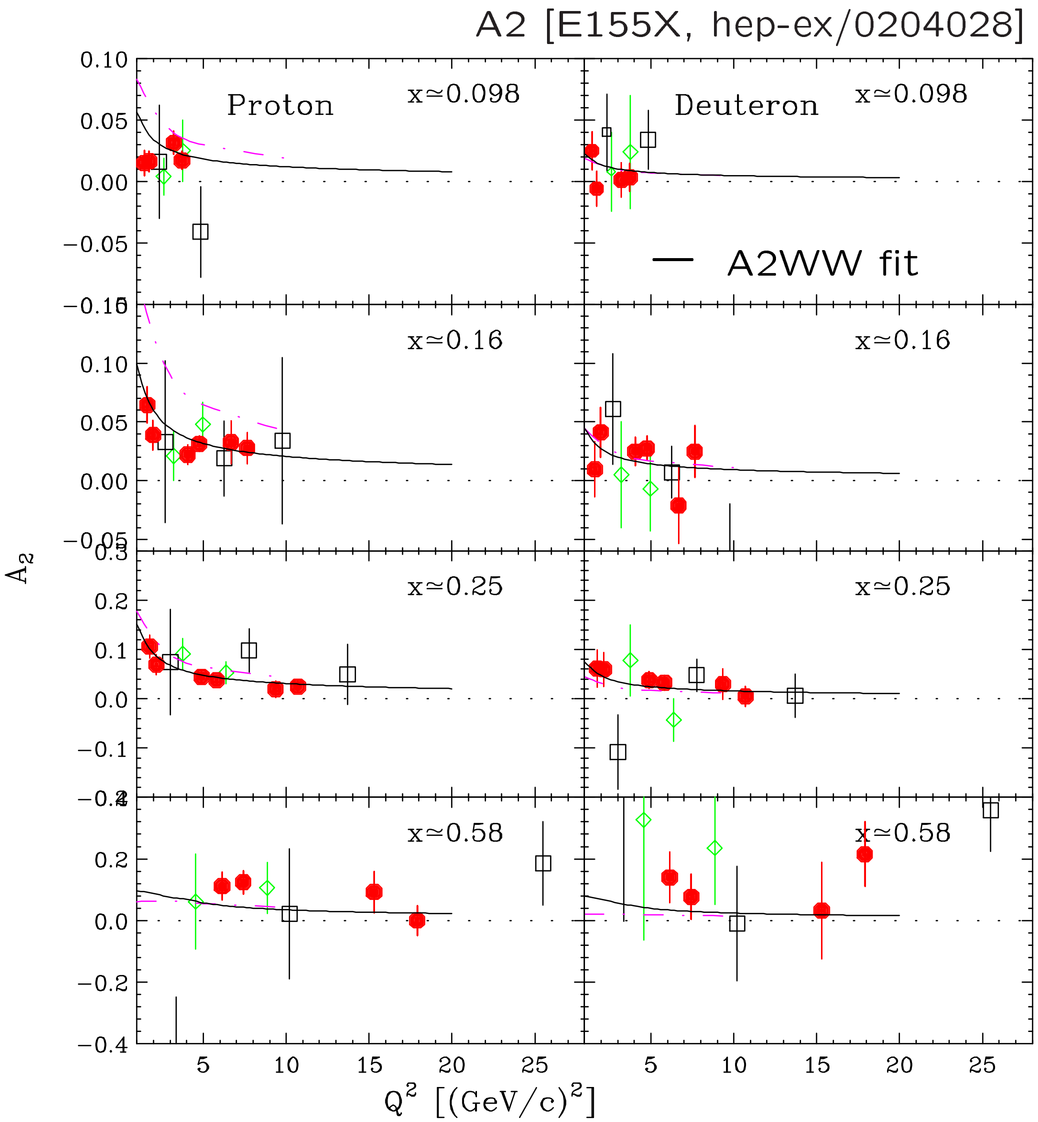


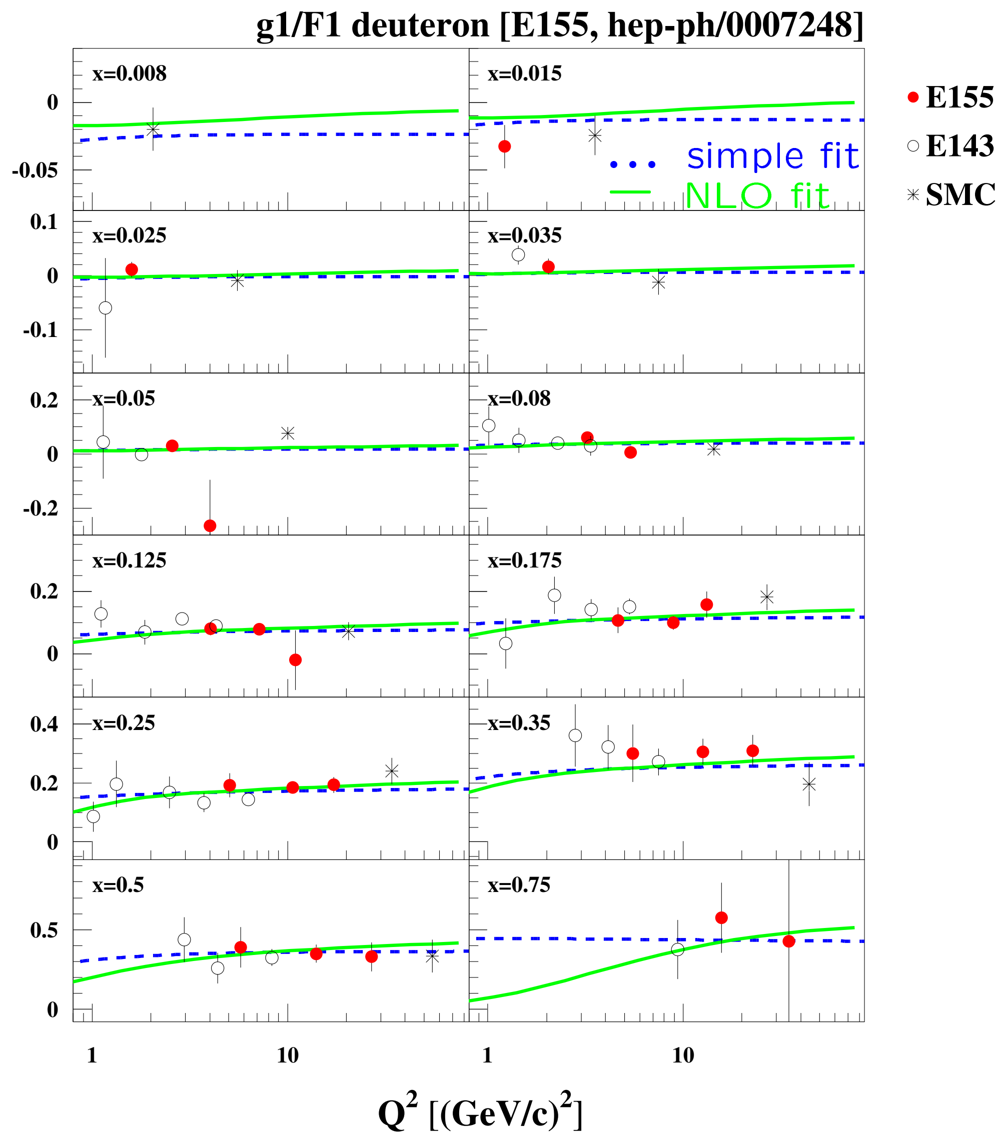
NEW E155X [hep-ex/0204028]

HERMES prelim. ('00)

data given at measured $\langle Q^2 \rangle$: 0.02-58 GeV^2

Q^2 Dependence of A_2 and $A_1 \approx g_1/F_1$



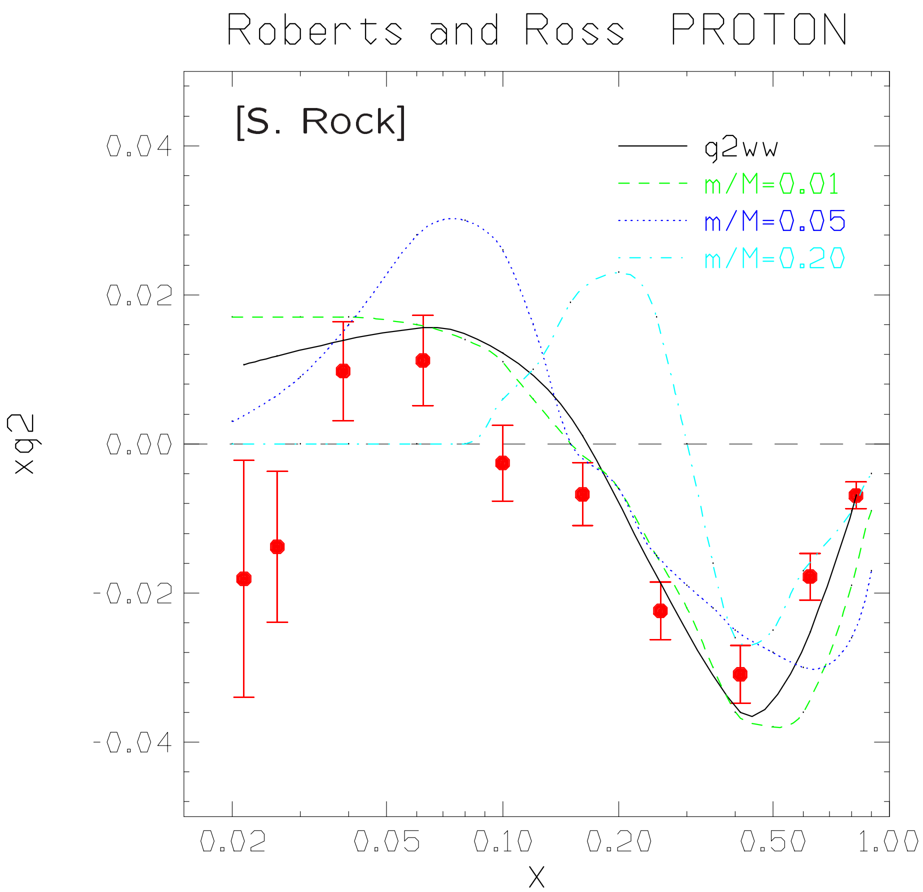


⤳ weak Q^2 dependence of A_2 and A_1 in DIS region within current uncertainties

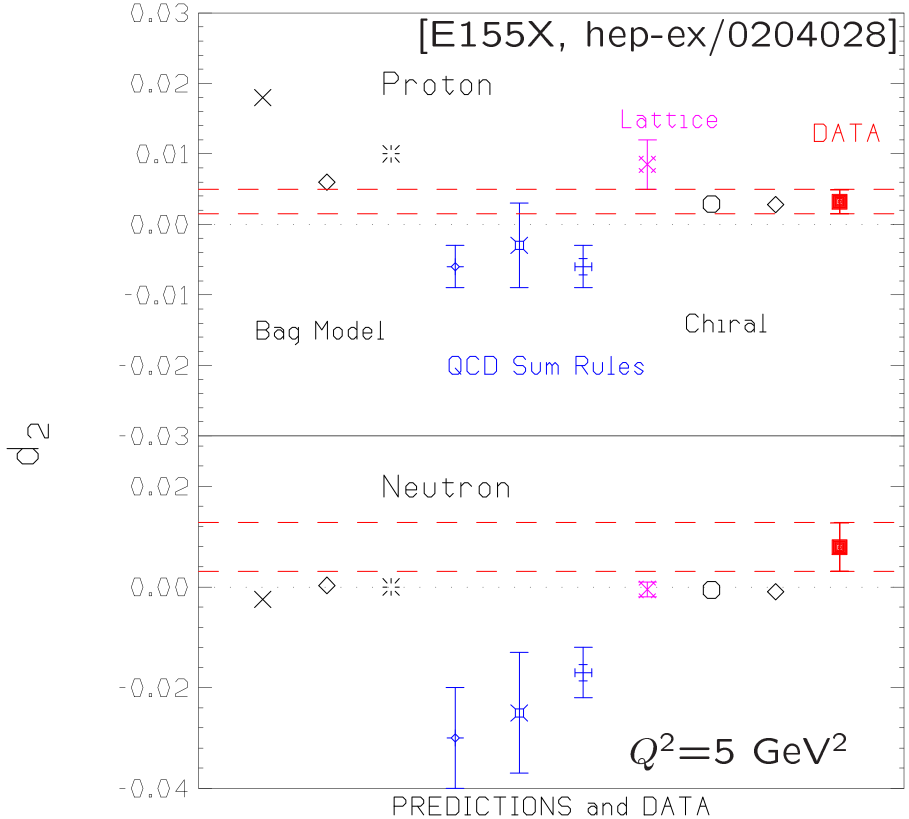
Interpretations of g_2

$$g_2(x,Q^2) = g_2^{WW}(x,Q^2) + \overline{g_2}(x,Q^2)$$

- twist-2 contribution: $g_2^{WW}(x,Q^2) = -g_1(x,Q^2) + \int_x^1 \frac{dy}{y} g_1(y,Q^2)$
- $\overline{g_2}$ includes quark-gluon correlations $\rightsquigarrow$ twist-3 matrix element d_2



sensitive to m_q/M

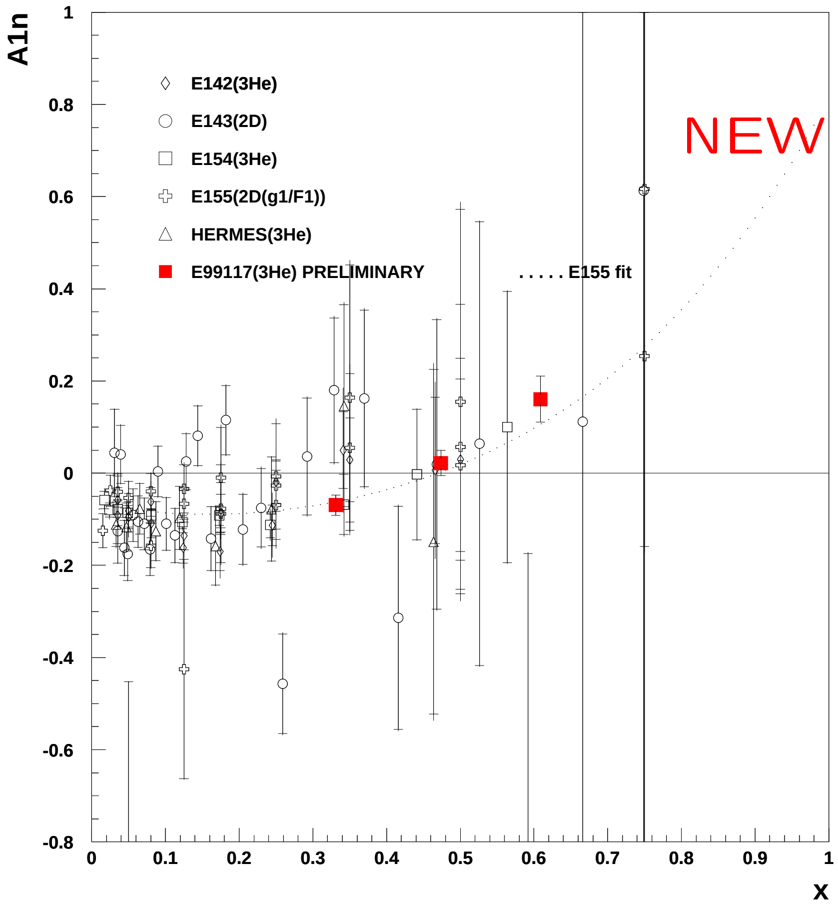


d_2: 0.0032 ± 0.0017 (p)
d_2: 0.0079 ± 0.0048 (n)

Precision Measurements of A_1 and A_2 at Low W

JLAB: polarized electron beam 0.8-5.7 GeV ($P \sim 70-80\%$) and polarized targets $NH_3 \rightsquigarrow$ p, $ND_3 \rightsquigarrow$ d, ^{3}He $\rightsquigarrow$ n

transition from DIS to Low $Q^2 \lesssim 1$ GeV^2 and to resonance region $W \lesssim 2$ GeV



JLAB: E99-117

polarized electron beam 5.7 GeV ($P \sim 81\%$) and polarized ^{3}He target ($P \sim 40\%$), L $\sim 10^{36}$ cm^{-2} s^{-1}

$\rightsquigarrow$ first precise data of A_1^n at $x > 0.3$: A_1^n POSITIVE at high $x \sim 0.6$ ($Q^2 \sim 5$ GeV^2, $W^2 \sim 4$ GeV^2)

$\rightsquigarrow$ distinguish models for $A_1(x \to 1)$

$\rightsquigarrow$ JLAB@12 GeV

Spin Physics at Low Q^2

higher twist effects $\rightsquigarrow$ quark-gluon correlations (e.g. g_2)

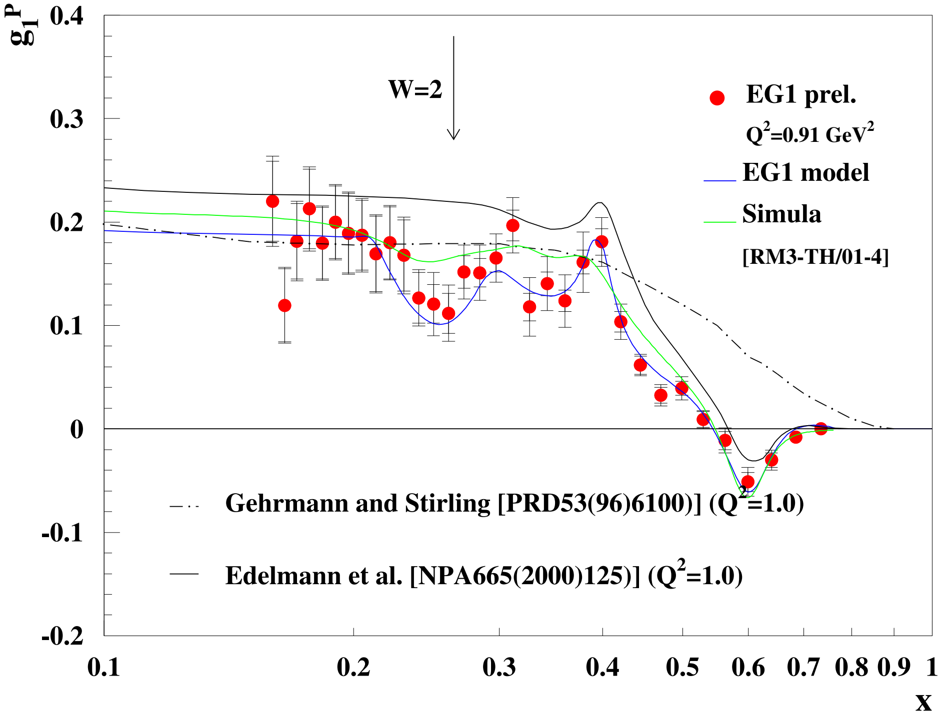
relate spin properties at $Q^2 = 0$ (low-energy theorems) to those at $Q^2 \to \infty$ (pQCD) $\rightsquigarrow$ test of Gerasimov-Drell-Hearn Integral at

MAMI, ELSA, JLAB, HERMES $\rightsquigarrow$ parallel session

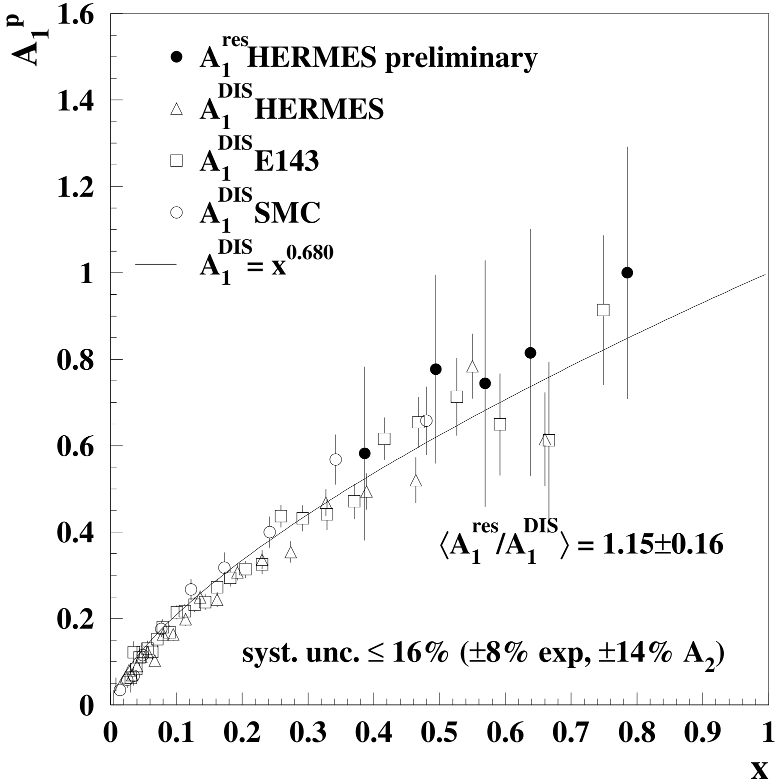
test of Quark-Hadron Duality in the spin sector at low W (low Q) at

JLAB, HERMES

JLAB EG1 NEW



HERMES NEW



$Q^2 \geq 1$ GeV^2 : Interpretation of g_1 in NLO pQCD

g_1 well described in QCD improved QPM (NLO)

$$g_1^{\mathrm{p(n)}} = \frac{1}{9}\left\{\Delta C_{NS} \otimes \left[\pm\frac{3}{4}\mathbf{\Delta q_3} + \frac{1}{4}\mathbf{\Delta q_8}\right] + \Delta C_S \otimes \mathbf{\Delta\Sigma} + 2N_f \Delta C_G \otimes \mathbf{\Delta G}\right\}$$

with usual notations ($N_f = 3$):

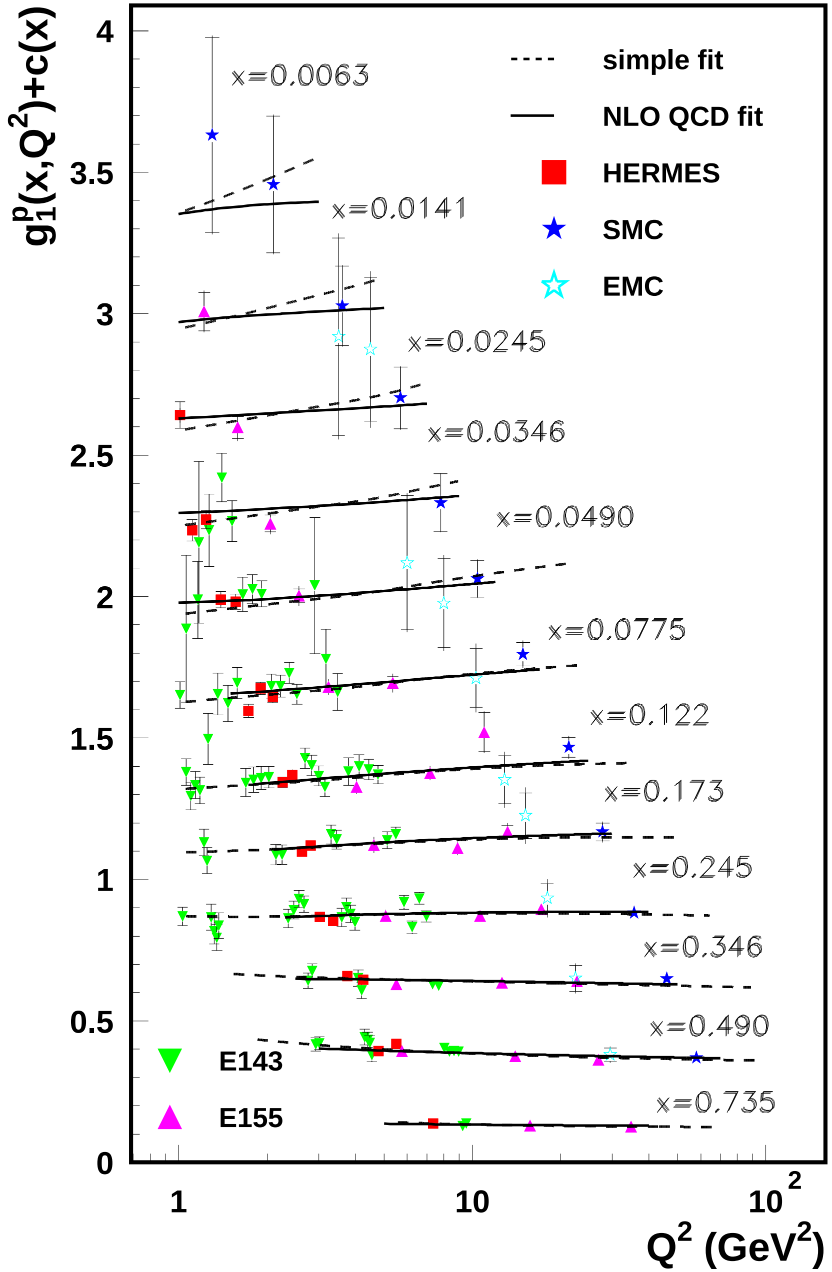
$$\begin{aligned}
\Delta\Sigma(x,Q^2) &= (\Delta u + \Delta\bar{u}) + (\Delta d + \Delta\bar{d}) + (\Delta s + \Delta\bar{s}) \\
\Delta q_3(x,Q^2) &= (\Delta u + \Delta\bar{u}) - (\Delta d + \Delta\bar{d}) = 6(g_1^p - g_1^n) \\
\Delta q_8(x,Q^2) &= (\Delta u + \Delta\bar{u}) + (\Delta d + \Delta\bar{d}) - 2(\Delta s + \Delta\bar{s}) \\
\Delta G(x,Q^2) & \quad \text{in NLO only; } \Delta C_G^0 = 0 \text{ in LO}
\end{aligned}$$

in principle linear combinations of polarized PDF's and ΔG can be determined due to their different Q^2 evolution

BUT at NLO mixing of $\Delta\Sigma$ and ΔG $\rightsquigarrow$ factorization scheme dependence :
$\Rightarrow$ $\overline{\mathrm{MS}}$ scheme: $\Delta\Sigma$ not conserved
$\Rightarrow$ AB or JET scheme: $\Delta\Sigma$ conserved

$$\Delta\Sigma(Q^2)_{\overline{\mathrm{MS}}} = \Delta\Sigma_{\mathrm{AB(JET)}} - N_f \frac{\alpha_s(Q^2)}{2\pi}\Delta G(Q^2)$$
$$\Delta G(Q^2)_{\overline{\mathrm{MS}}} = \Delta G(Q^2)_{\mathrm{AB(JET)}}$$

Q^2 Dependence of g_1^p



$\rightsquigarrow$ Q^2 dependence of g_1^p similar to the Q^2 dependence of F_1^p

NLO pQCD fit of $g_1^{p,d,n}$ data with $Q^2 > 1$ GeV^2

Fits to $g_1(x,Q^2)$ in NLO pQCD using SU(3)$_f$

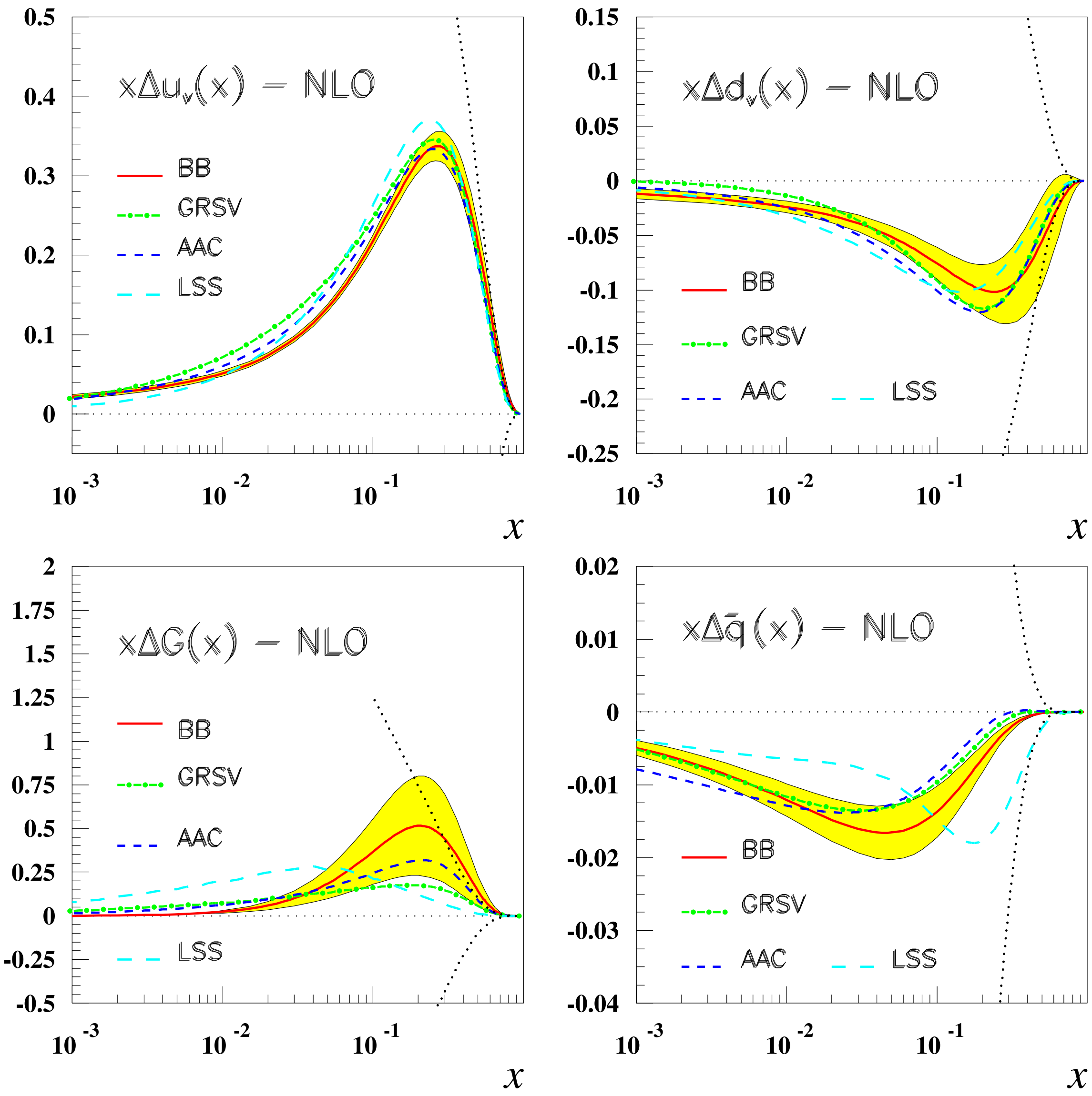
updated NLO QCD ($\overline{\text{MS}}$) fits at $Q^2 = 4$ GeV^2
propagated statistical uncertainties (yellow bands - BB 2002) $\rightsquigarrow$

$\Delta s(\bar{q})$ = -0.07 ± 0.02 (stat) < 0

ΔG = 1.03 ± 0.55 (stat) > 0

BUT SU(3)$_f$ symmetry breaking, e.g. [LSS, hep-ph/0004106] ?

BB: Blümlein, Böttcher, hep-ph/0203155
LSS: Leader et al., hep-ph/0111267
GRSV: Glück et al., hep-ph/0011215
AAC: Goto et al., hep-ph/0001046



$\rightsquigarrow$ more direct probes needed for ΔG and Δs

HERMES : ΔG from Photon-Gluon Fusion (LO)

$\gamma g \rightarrow q\bar{q}$: select h^+h^- pairs with large $p_T^{h_1}$ >1.5 GeV, $p_T^{h_2} > 0.5$ GeV

$\rightsquigarrow$ negative asymmetry $A_{||}$ interpreted in terms of $\Delta G/G$ (PGF) and $\Delta q/q$ (QCDC) contributions using PYTHIA model

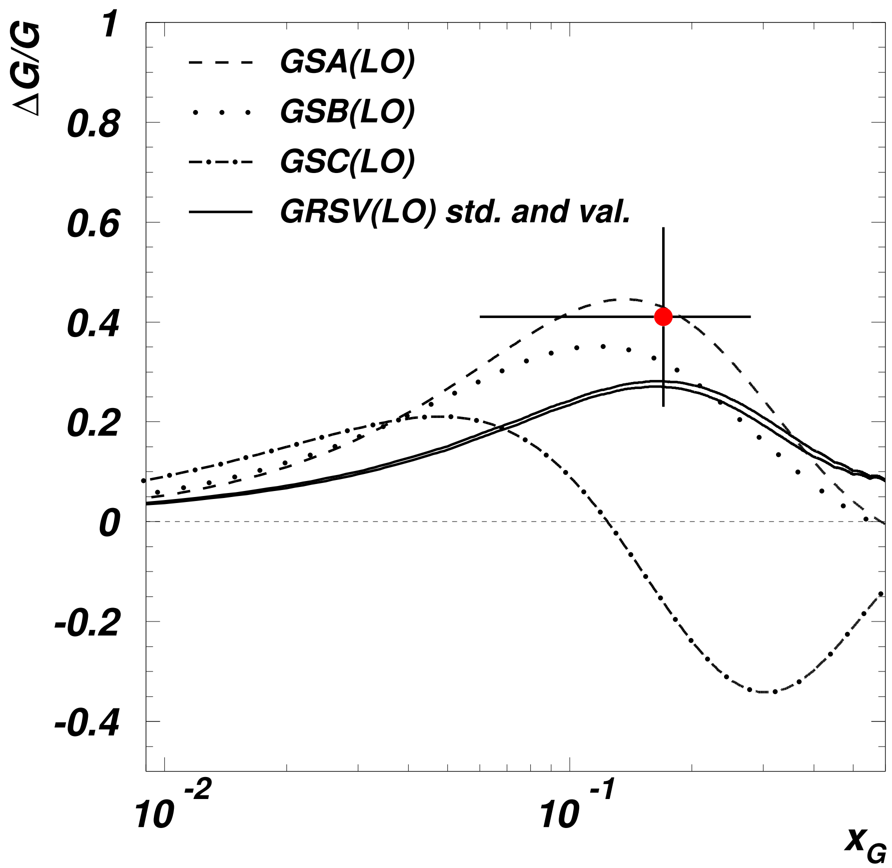
$\rightsquigarrow$ $\Delta G/G$ positive at $\langle x_{\rm g} \rangle = 0.17$ and $\langle p_T^2 \rangle = 2.1$ GeV^2

$\Delta G/G = 0.41 \pm 0.18(stat.) \pm 0.03(exp.syst.)$

[HERMES, PRL84(2000)2584]

ongoing: $\Delta G/G$ analysis based on high statistics deuteron data of HERMES run periods 1998-2000

expected: $\Delta G/G$ from COMPASS

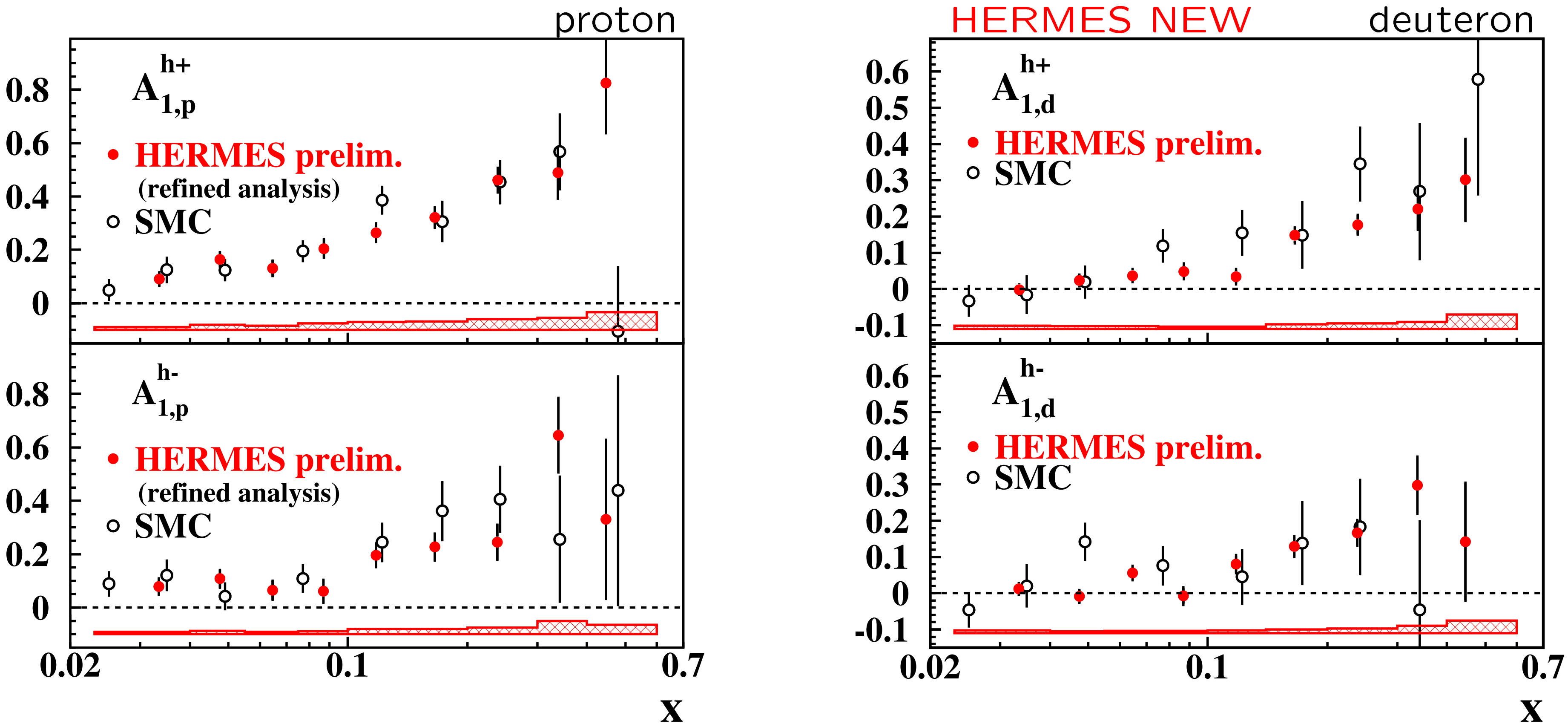


GS: Gehrmann, Stirling, PRD53(1996)6100

Semi-Inclusive Asymmetries

$$A_1^h \approx \frac{g_1^h}{F_1^h}(x,Q^2) = \frac{\int_{z_{min}}^{z_{max}} dz \sum_q e_q^2 \Delta q(x,Q^2) \cdot D_q^h(z,Q^2)}{\int_{z_{min}}^{z_{max}} dz \sum_q e_q^2 q(x,Q^2) \cdot D_q^h(z,Q^2)} \quad \text{(LO pQCD)}$$

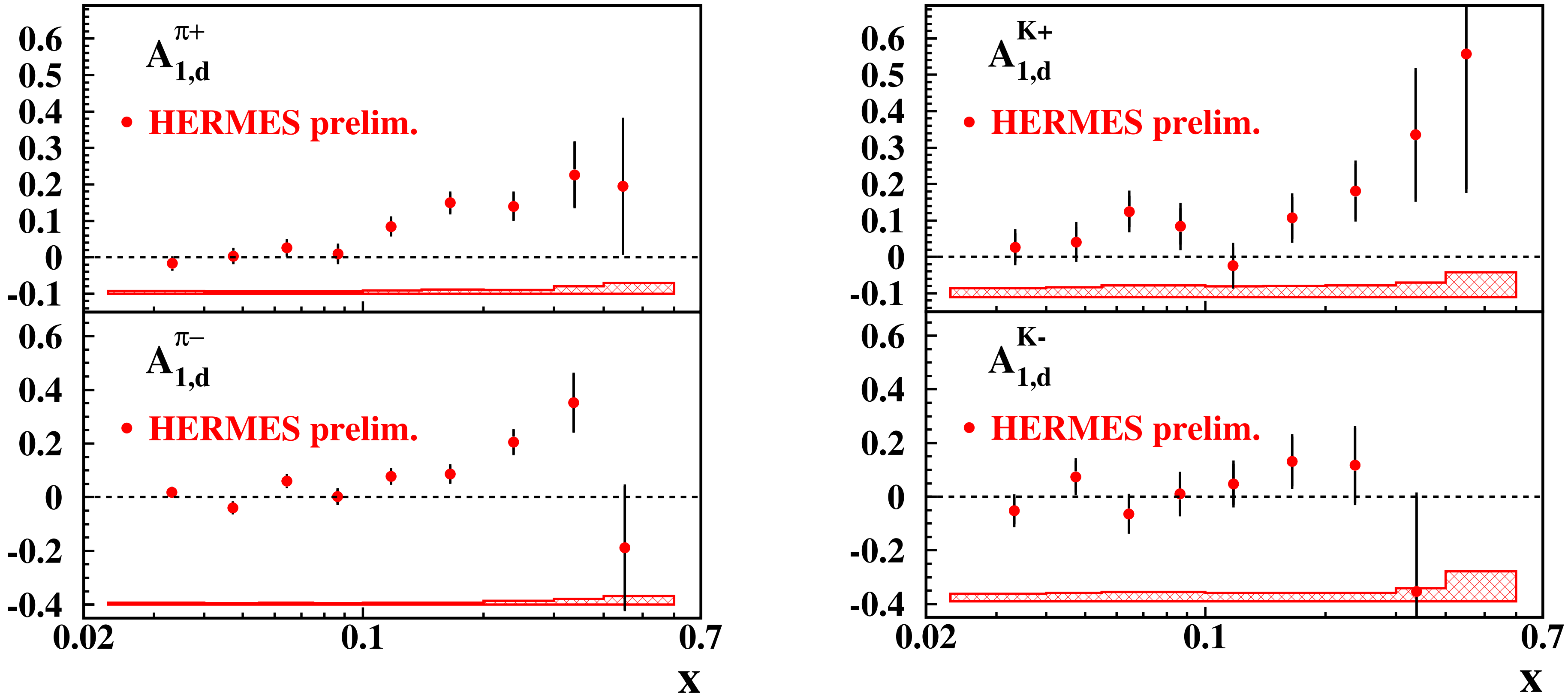
$D_q^h(z,Q^2)$: correlation between hadron h and struck quark flavor q
$\rightsquigarrow$ flavor tagging in current fragmentation region



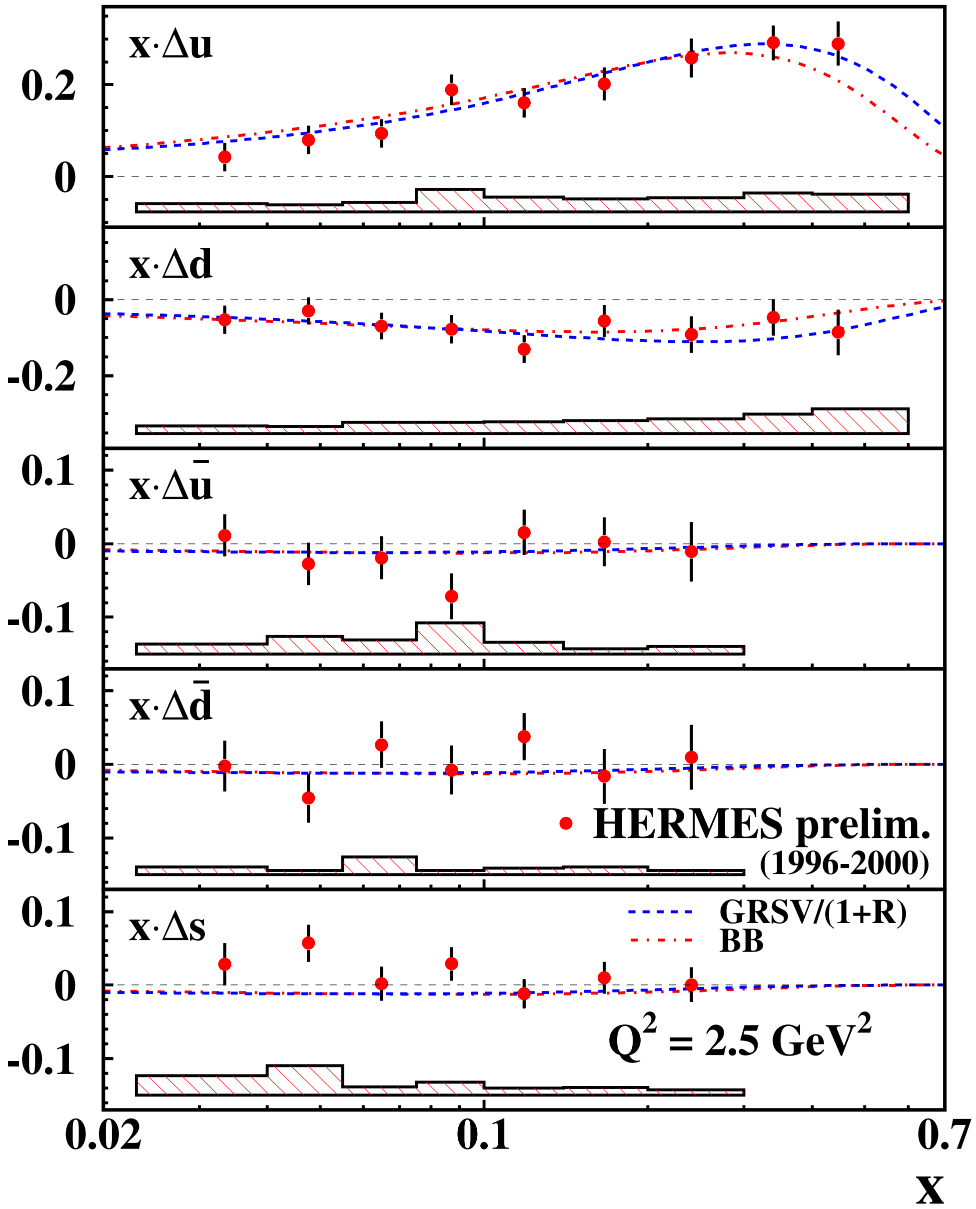
Semi-Inclusive Asymmetries for pions and kaons

HERMES RICH detector allows excellent particle identification of charged pions and kaons for 2 GeV $< p <$ 15 GeV

NEW HERMES results for deuterium target (1998-2000)



Flavor Separated Polarized Quark Distributions (LO)



NEW HERMES extraction of $\frac{\Delta u}{u}$, $\frac{\Delta d}{d}$, $\frac{\Delta \bar{u}}{\bar{u}}$, $\frac{\Delta \bar{d}}{\bar{d}}$, $\frac{\Delta s + \Delta \bar{s}}{s + \bar{s}}$ polarized quark sea separated

$A_1(h^\pm)$ on proton dominated by $\Delta u(x)$

$A_1(h^\pm)$ on neutron dominated by $\Delta d(x)$

sensitivity on the sea polarizations at $0.02 < x < 0.2$:

$A_1(h^+)$ p, n: $\Delta\bar{u}$ and $\Delta\bar{d}$ $\sim$ 5...10%

$A_1(h^-)$ p(n): $\Delta\bar{u}$ ($\Delta\bar{d}$) $\sim$ 10...30%

$A_1(K^+)$ p, n: $\Delta\bar{s} \lesssim$ 10%

$A_1(K^-)$ p, n: $\Delta s \lesssim$ 10%

systematics: limited knowledge of fragmentation functions and unpol. PDFs

Broken SU(3)$_f$ Symmetry of Polarized Light Sea - Models

Various models for the $\bar{u} \neq \bar{d}$ asymmetry in the nucleon
$\rightsquigarrow$ predictions for polarized sea in the proton:
$\Delta\bar{u} > 0 > \Delta\bar{s} > \Delta\bar{d}$ and $\Delta\bar{u} - \Delta\bar{d} > \bar{d} - \bar{u} > 0$

e.g.

Chiral Quark-Soliton-Model (χQSM)

[Dressler et al., EPJC14(2000)147]

statistical model for polarized and unpolarized structure functions and PDFs

[Bhalerao, hep-ph/0003075]

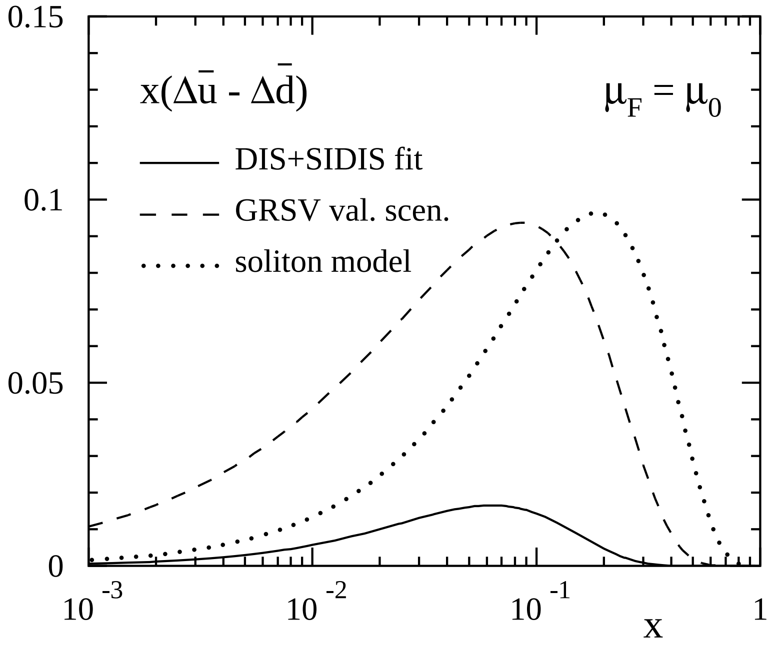
[Borrely et al., hep-ph/0109160]

pQCD analyses with flavor-asymmetric light sea densities (Pauli-blocking ansatz)

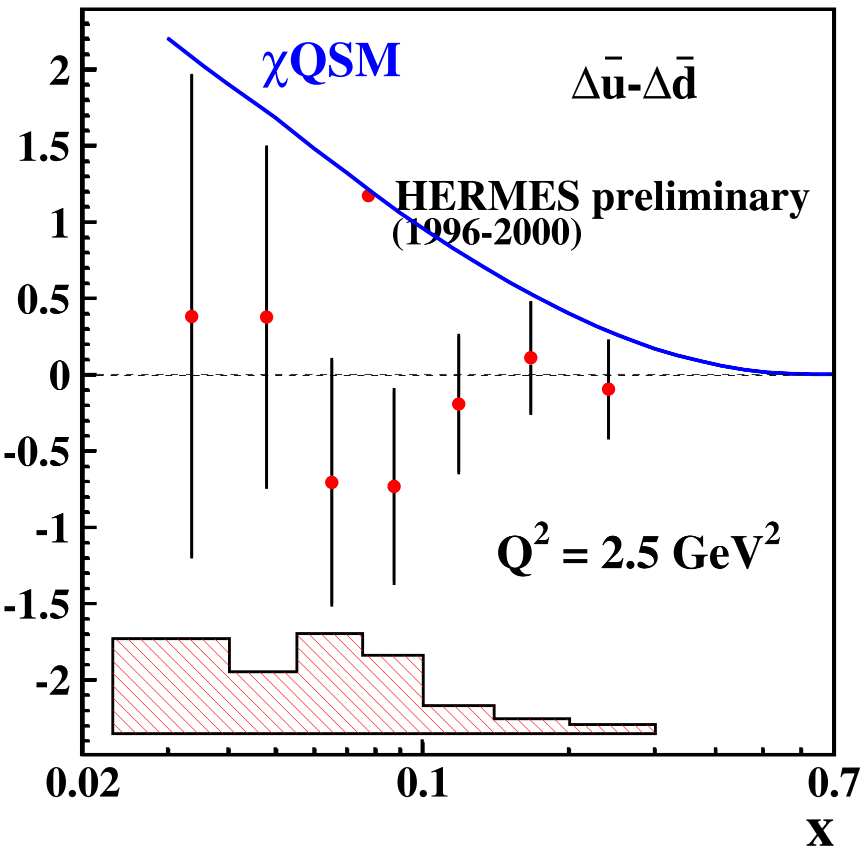
[Glück et al., PRD63(2001)094005]

pQCD analyses including SIDIS data

[Stratmann, Vogelsang, hep-ph/0107064]



First Measurement of Symmetry of Polarized Light Sea

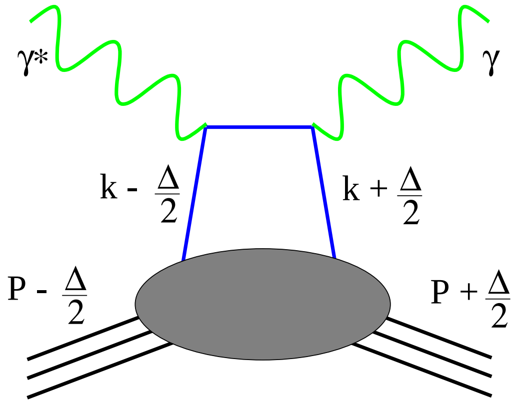


no breaking of the flavor symmetry in the light sea observed beyond the accuracy of the data

$\leadsto$ predictions from e.g. the χQSM are not favored by Hermes data on $\Delta\bar{u}(x) - \Delta\bar{d}(x)$

$\leadsto$ more and precise data needed $\rightarrow$ RHIC

Spin Structure and DVCS



new observables in hard exclusive processes

Generalized Parton Distributions $(H, E, \tilde{H}, \tilde{E})$

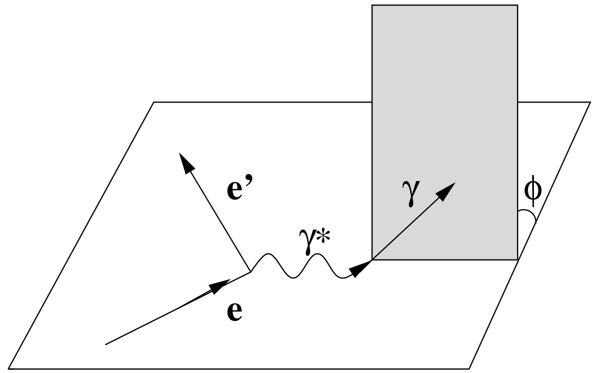
related to DIS structure functions, elastic form factors and angular momentum

$J_q = \frac{1}{2}\Delta\Sigma + L_q = \frac{1}{2}\sum_q \int_{-1}^{1} x\,\mathrm{d}x(H^q + E^q)$

[in forward limit $\Delta^2 = -t = 0$]

hard exclusive photon-production cross section:

$$d\sigma \propto |\tau_{\mathrm{DVCS}}|^2 + |\tau_{\mathrm{BH}}|^2$$
$$+(\tau^*_{\mathrm{DVCS}}\tau_{\mathrm{BH}} + \tau_{\mathrm{DVCS}}\tau^*_{\mathrm{BH}})$$



ϕ: azimuth between γ γ^* and e scattering planes

real and imaginary parts of the DVCS amplitudes can be expressed in terms of GPDs

$\rightsquigarrow$ ϕ dependencies of single spin asymmetries associated with DVCS

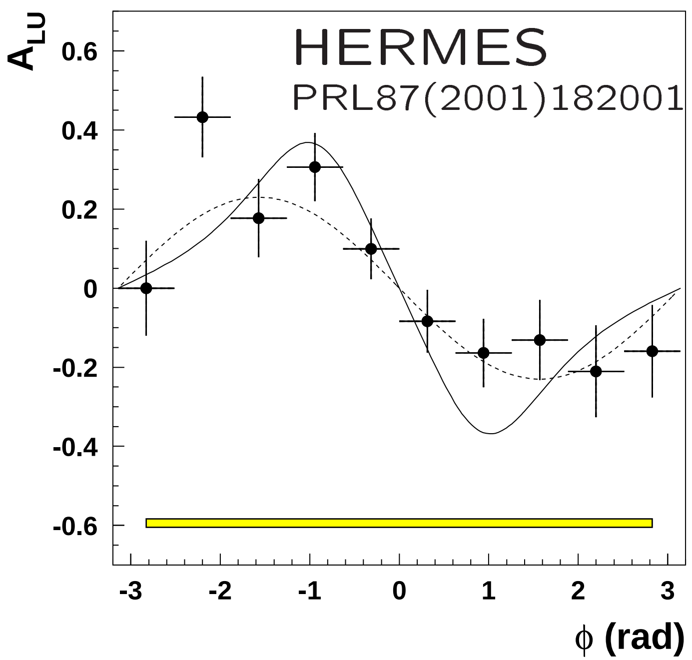
DVCS: Beam-Spin Asymmetry

imaginary part of the BH-DVCS interference term can be accessed via beam-spin asymmetry using longitudinally polarized beam and unpolarized target

$$d\sigma(\overrightarrow{e^+}p - d\sigma(\overleftarrow{e^+}p) \sim \mathrm{Im}(\tau_{\mathrm{DVCS}}\tau_{\mathrm{BH}})$$

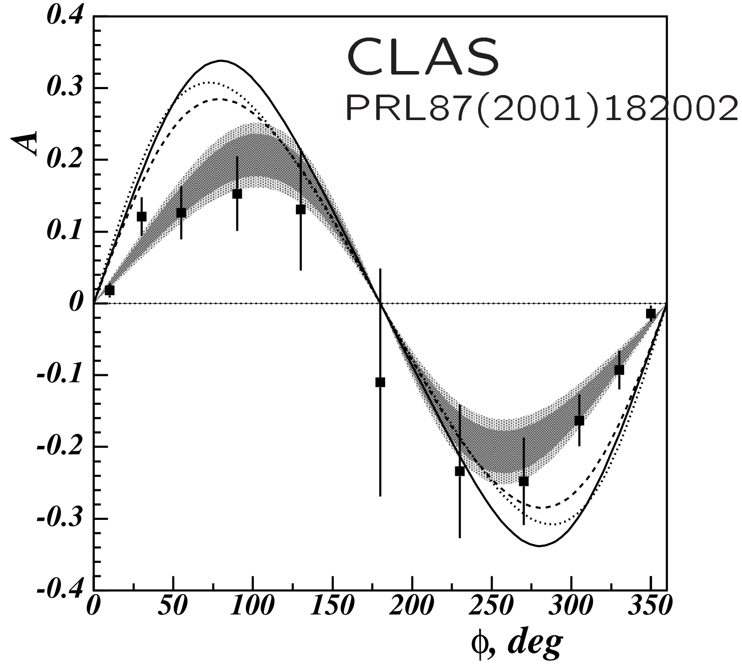
$\rightsquigarrow$ sin(ϕ) dependence in LO leading twist: $A(\phi) = -\alpha\,\mathrm{sign(e)}\,\sin(\phi)$

$\mathbf{e^+}$: $\alpha = \mathbf{-0.23 \pm 0.04^{stat} \pm 0.03^{sys}}$



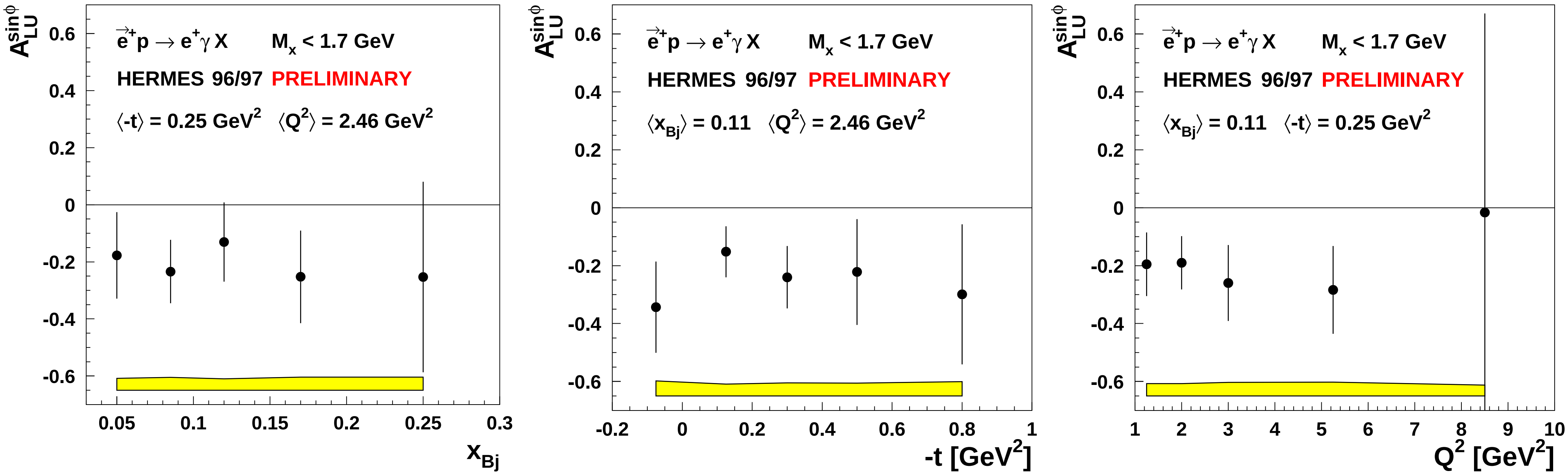
NEW

$\mathbf{e^-}$: $\alpha = \mathbf{0.202 \pm 0.021^{stat} \pm 0.009^{sys}}$



– GPD model including twist-3

DVCS: Kinematic Dependencies of Beam-Spin Asymmetry



$\rightsquigarrow$ no significant dependencies on kinematic variables x, t, Q^2
$\rightsquigarrow$ HERMES results limited by t resolution $\Rightarrow$ recoil detector upgrade (2005-2006) $\rightsquigarrow$ parallel session

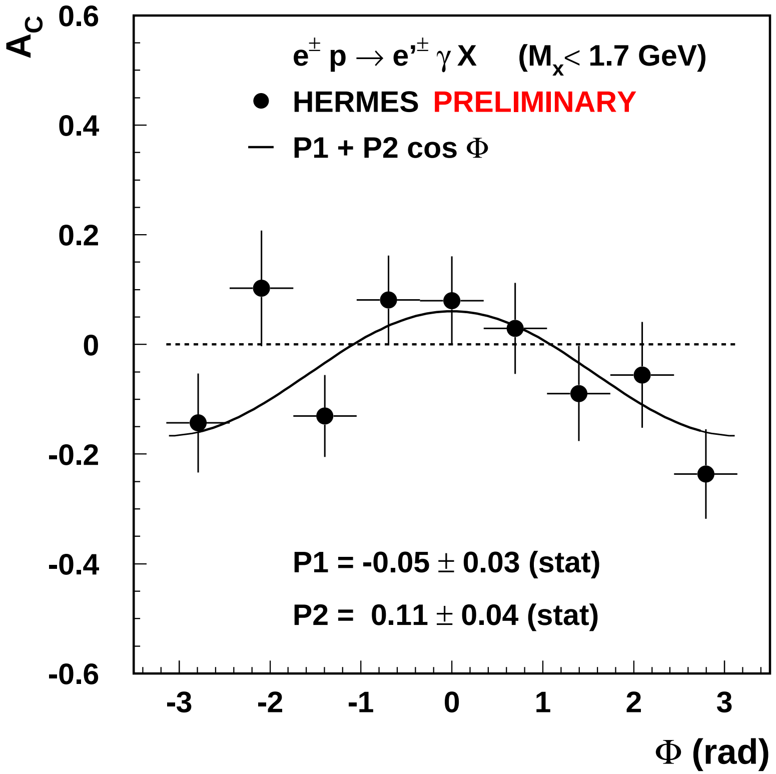
DVCS: Beam-Charge Asymmetry

real part of the BH-DVCS interference term can be accessed via beam-charge asymmetry using unpolarized beam and target

$$d\sigma(e^+p) - d\sigma(e^-p) \sim \mathrm{Re}(\tau_{\mathrm{DVCS}}\tau_{\mathrm{BH}})$$

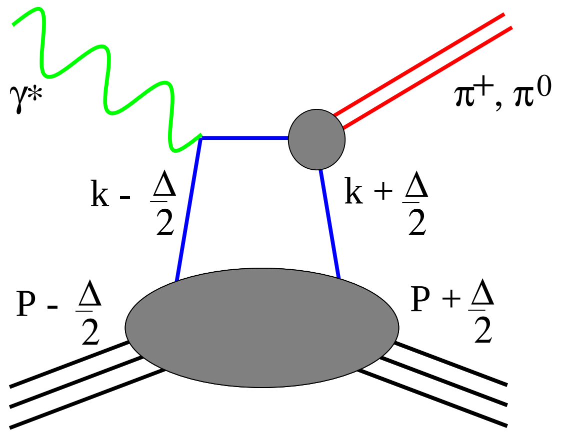
$\rightsquigarrow$ $\cos(\phi)$ dependence in LO leading twist: $A(\phi) = \alpha\cos(\phi)$

$$\alpha = A_{\mathrm{C}}|_{\mathrm{M}_X<1.7\mathrm{GeV}} = 0.11 \pm 0.04(\mathrm{stat}) \pm 0.03(\mathrm{syst})$$



HERMES NEW

Hard exclusive Pion Production



pseudoscalar mesons $\rightsquigarrow$ pol. GPD's $\tilde{E}$, $\tilde{H}$

reversal of transverse target spins:

$d\sigma_{\Downarrow} - d\sigma_{\Uparrow} \sim \sin(\phi)\,\tilde{E}\,\tilde{H}$

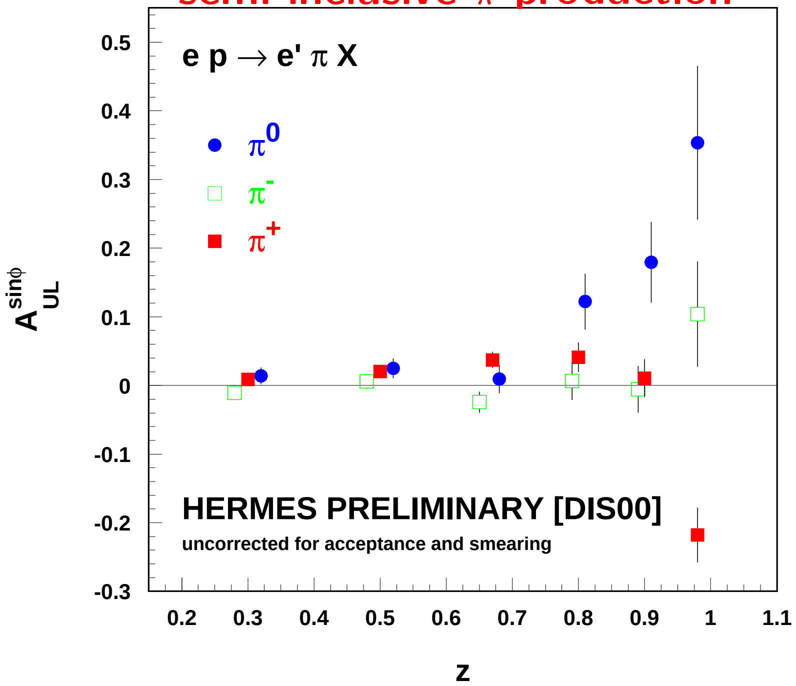
$\tilde{E}$: pion fragmentation function

$\tilde{H}$: $\rightarrow \Delta q$ in forward limit ($\Delta^2 = 0$)

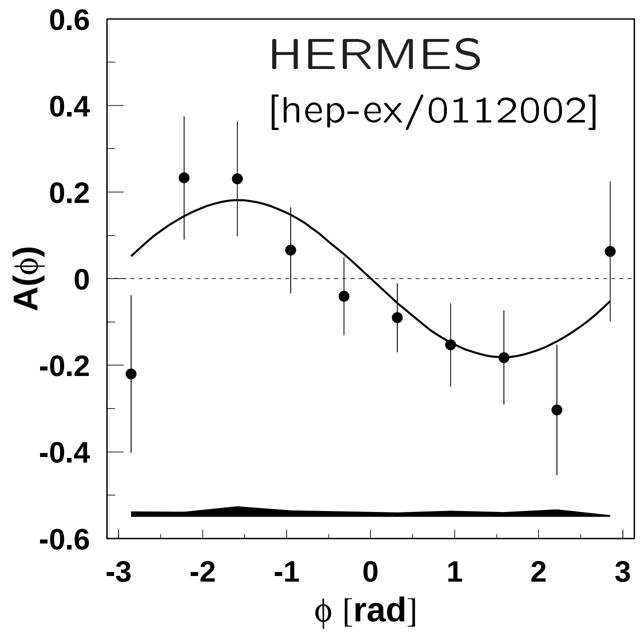
$\rightsquigarrow$ large single-spin asymmetry

HERMES: long. target but transv. component w.r.t. γ^* about 20%

semi-inclusive π production



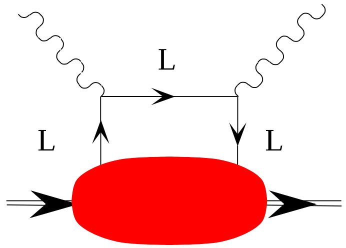
exclusive π^+ production $M_X < 1.05$ GeV



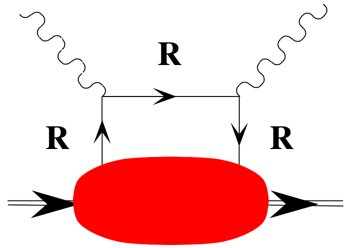
eN : HERMES RUN II $\geq$ 2001

focus: leading twist distribution $h_1(x) = \delta q(x) =$ quark transverse polarization in a transversely polarized nucleon $\rightsquigarrow$ unmeasured yet

$f_1\,(g_1) = \frac{1}{2}$

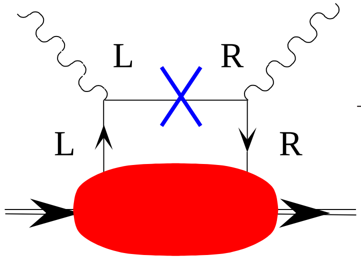


$+\,(-)$



$\rightarrow$ chiral even

$h_1 = \frac{1}{2}$



$\frac{\delta m}{\sqrt{Q^2}}$

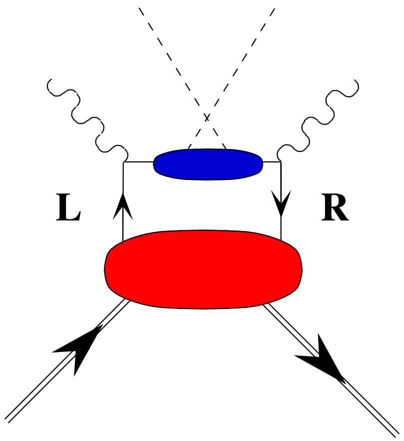
$\rightarrow$ **chiral odd** [suppressed in DIS]

h_1 must couple to another chiral-odd function

$\rightsquigarrow$ Collins fragmentation function $H_1^{\perp}$

[J. Collins, Nucl.Phys. B396(1993), 161]

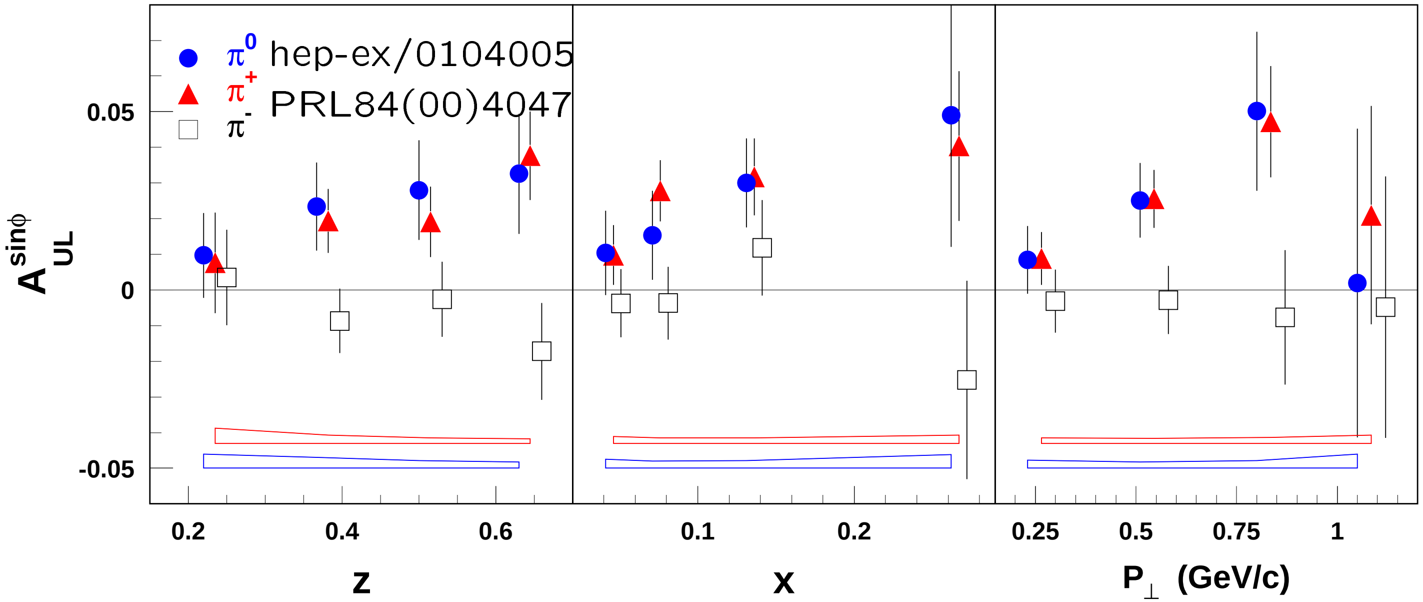
$\Longrightarrow$



$H_1^{\perp}$ filter to transversity distribution $\rightsquigarrow$ experimentally observable asymmetry in semi-inclusive DIS

eN : HERMES RUN II $\geq$ 2001 ...cont'd

HERMES observations: single-spin azimuthal asymmetries in $e\overrightarrow{p} \to e'\pi X$ and in $e\overrightarrow{d} \to e'\pi X$ (NEW $\rightsquigarrow$ parallel session) favour non-zero transversity and fragmentation functions, $A_{\mathrm{UL}}^{\sin\phi} \sim \sum_f e_f^2 h_1^f H_1^f$



$\rightsquigarrow$ future measurements of δu with transversely polarized $H^{\uparrow}$ target (2002-2003)

furthermore:

improved measurements of ΔG, Δq, hard exclusive processes ...

μN : COMPASS $\geq$ 2001

100-200 GeV $\vec{\mu}^{\pm}$ on $N\vec{H}_3$ and $^6\vec{L}i\vec{D}$ targets, 2 fb^{-1}/y (5 $\times$ SMC)

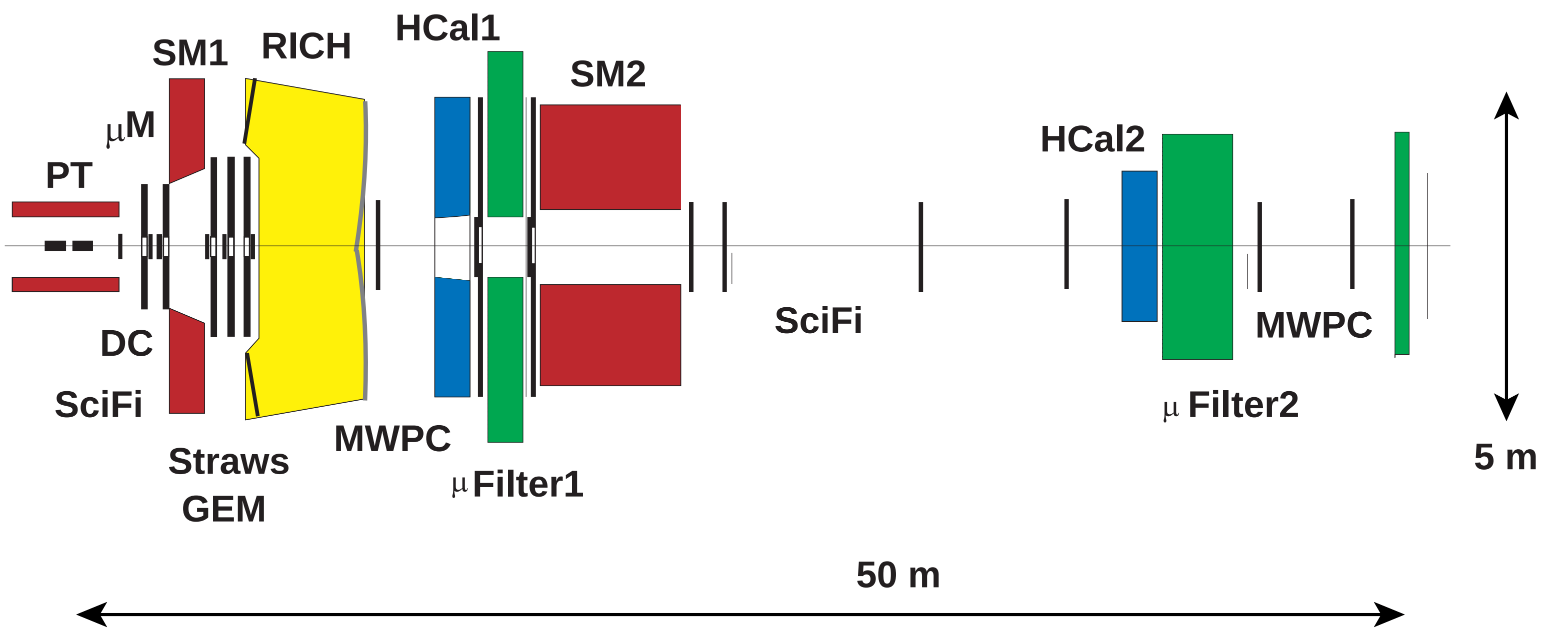
new magnetic spectrometer for hadron and spin physics

2001 run (Jul-Oct): 160 GeV $\vec{\mu}^{\pm}$: setting up period (e.g. RICH fully equipped) and 2 weeks 'smooth data taking' $\rightsquigarrow$ 2002 run (May-Sep)

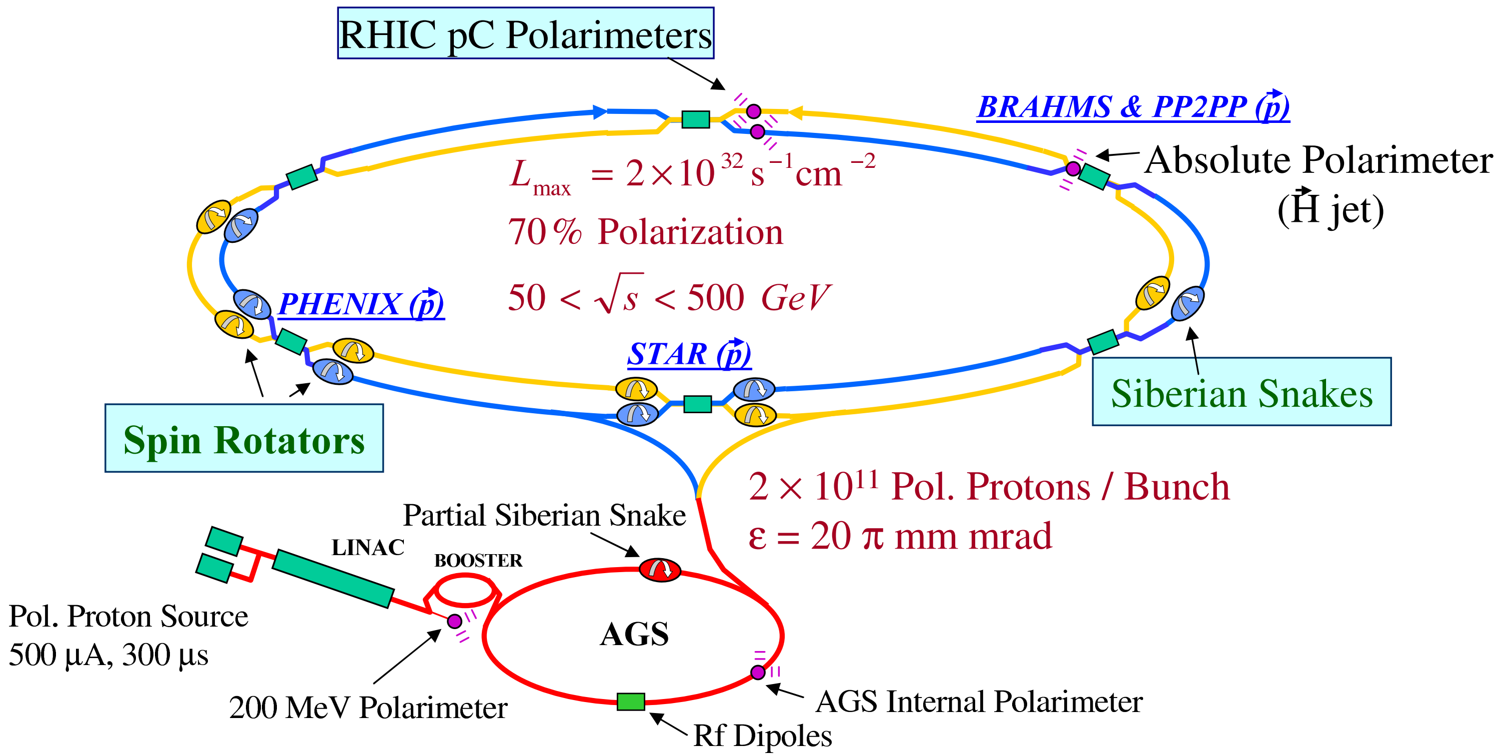
use of SMC solenoid currently limits acceptance (180 mrad $\rightarrow$ 70 mrad)

primary goal: $\Delta G/G$ with $\sim$ 0.1 accuracy using open charm or pairs of high-p_T hadrons: $0.04 < x_g < 0.3$

furthermore: measurements of Δq, g_1, h_1 ... at low x



pp : Spin at RHIC $\geq$ 2001



startup: first RHIC Spin run (Dec 2001 - Jan 2002):

$\sqrt{s} = 200$ GeV, luminosity $\simeq 10^{30}$ cm^{-2} s^{-1} (0.16 pb^{-1}),

polarization 14-17% [20% achieved in initial test (9/2000)]

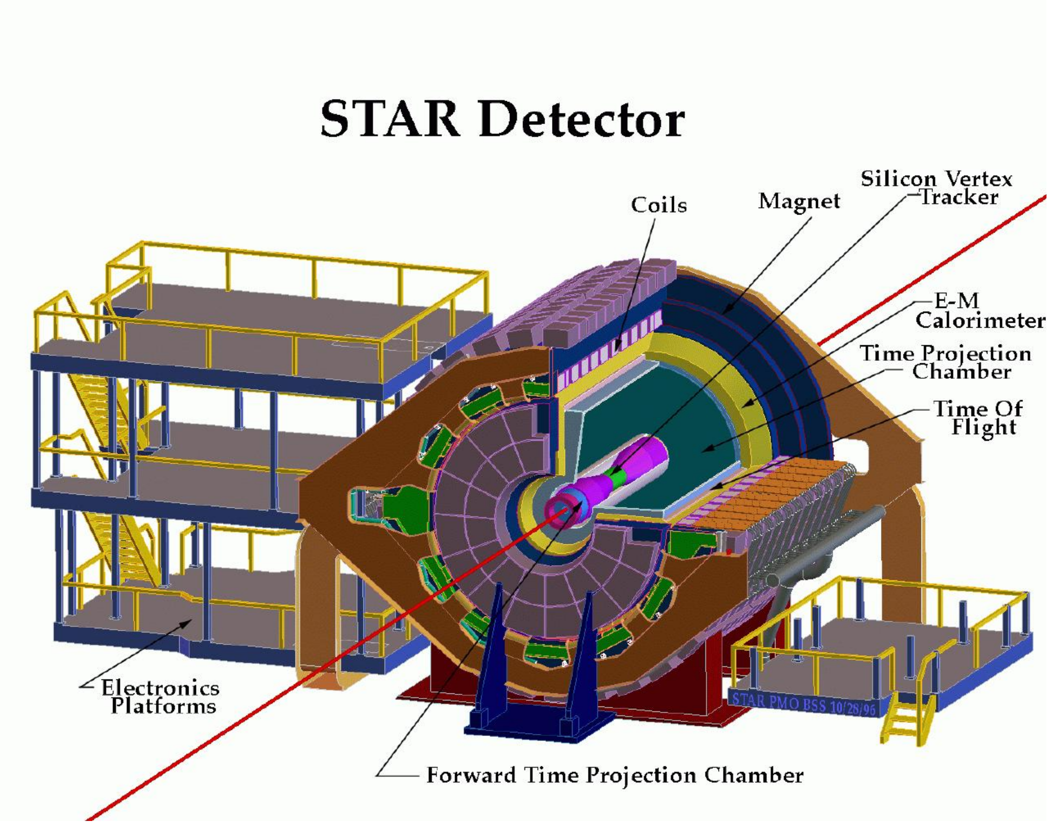
$\rightsquigarrow$ siberian snakes work $\rightsquigarrow$ physics with transverse spin

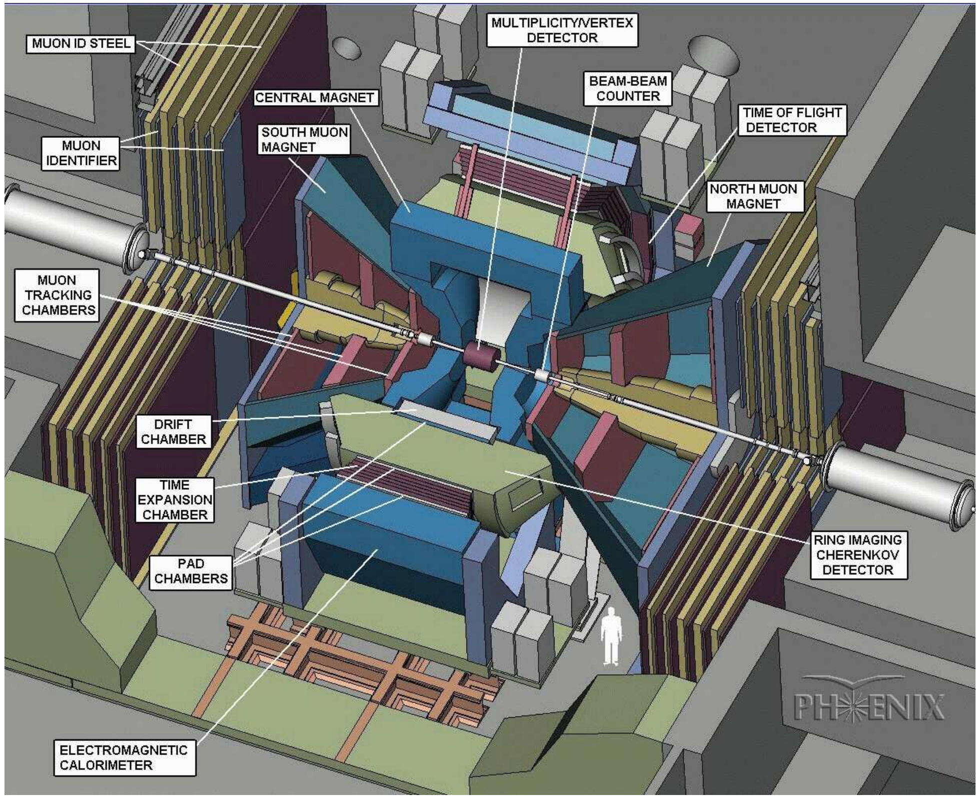
$\rightsquigarrow$ spin rotators are being installed

pp : STAR and PHENIX at RHIC $\geq$ 2001

STAR and PHENIX fully operational, except PHENIX north muon arm (2002) and STAR EMC (2002-2004)

next run planned: 8 weeks pp within Nov 2002 - April 2003





pp : STAR and PHENIX at RHIC $\geq$ 2001

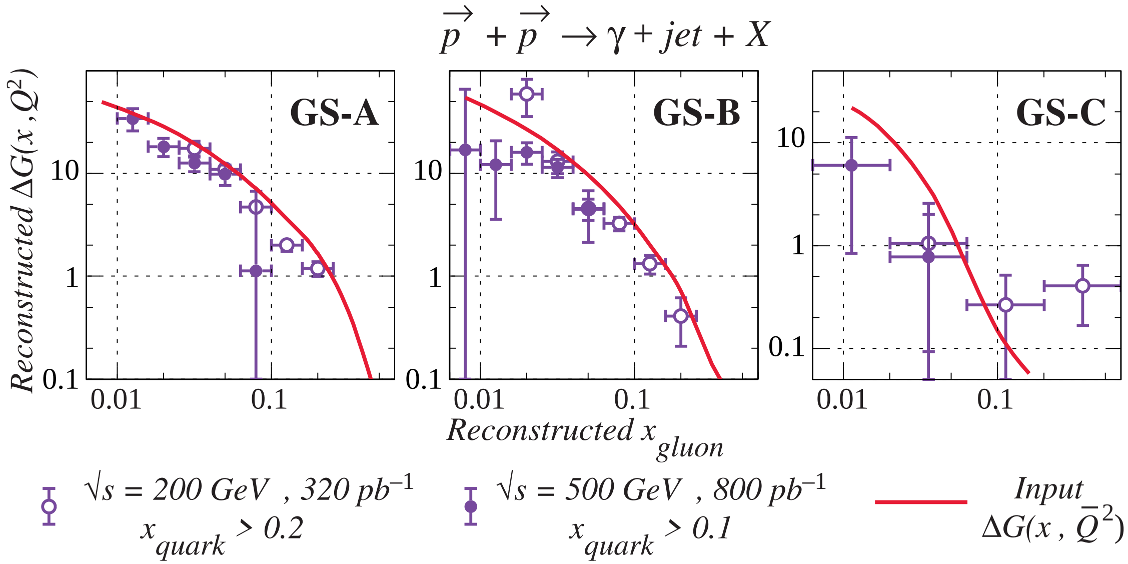
general focus:

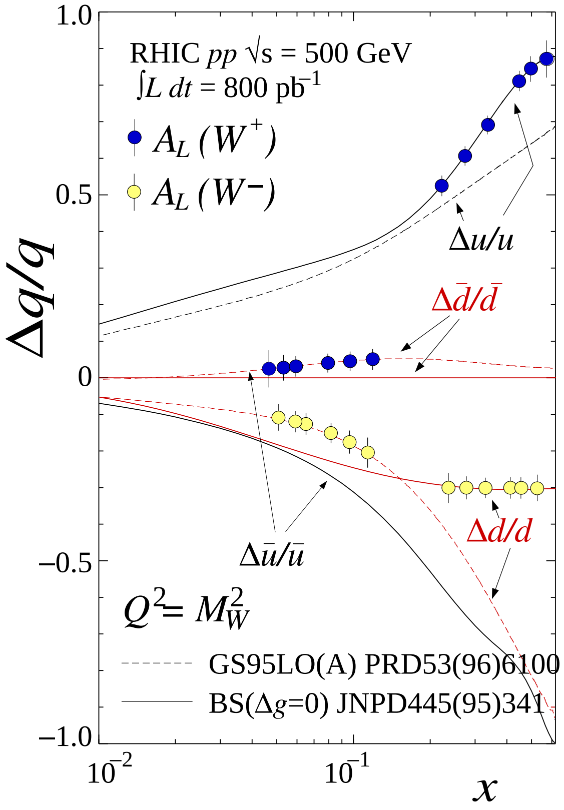
ΔG from direct photons

$qg \to \gamma q$: $0.02 < x_g < 0.3$

$\rightsquigarrow$ simulation for STAR

[Bland, hep-ex/9907058]





sea quark polarizations from $W\pm$ production asymmetries in $\vec{p}(1)p(2)$:

$$u\bar{d} \to W^+ \to l^+\nu \qquad d\bar{u} \to W^- \to l^-\nu$$

$$\sim \Delta u(x_1)/u(x_1) \qquad \sim \Delta d(x_1)/d(x_1) \qquad \text{if } x_1 \gg x_2$$

$$\sim \Delta\bar{d}(x_1)/\bar{d}(x_1) \qquad \sim \Delta\bar{u}(x_1)/\bar{u}(x_1) \qquad \text{if } x_1 \ll x_2$$

$\rightsquigarrow$ simulation for PHENIX muons

[Bunce et al., hep-ph/0007218]

Conclusion

- spin physics is an exciting and a rapidly developing field
- new data from DESY, JLAB, SLAC on g_1^d, $g_2^{p,d}$, A_1^n ..., flavor separated quark distributions and hard exclusive processes support remarkably the QCD picture of the spin structure of the nucleon $\leadsto$ GPD's and hard exclusive processes open a window to access $L_{q,g}$ for the first time
- new and more precise data will be soon available
  $\Rightarrow$ Δq, $\Delta\bar{q}$, ΔG, δq, $\delta\bar{q}$, hard exclusive processes
  $\geq$ 2001 high luminosity experiments:
  COMPASS, HERMES, JLAB, RHIC-Spin, [SLAC-E161]
- future ($\geq$ 2006?)
  GPD's and hard exclusive processes $\leftrightarrow$ $L_{q,g}$:
  eN fixed target: *CEBAF@12 GeV, ELFE/TESLA-N ...*
  ΔG, Δq, g_5... at low x, high Q^2:
  eN collider: *eRHIC/EIC, pol. HERA ...*