Extraction Of Polarized Parton Distributions At Hermes

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On Behalf Of The Hermes Collaboration

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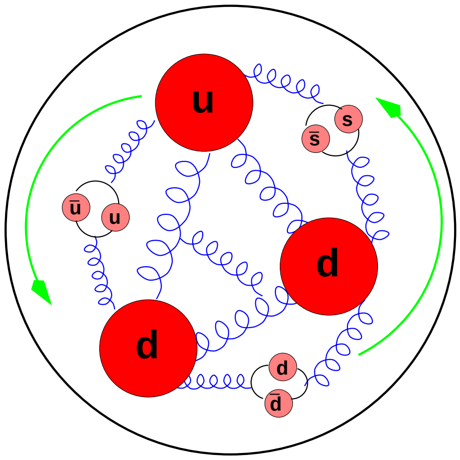
- Motivation
- Polarized Quark Distributions
- Spin Asymmetries In Photoproduction And $\Delta G/G$

results are based on the data taking periods 1995-1997 of the HERMES experiment at hera

Motivation

The spin structure of the proton:

$$S_z = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_z$$



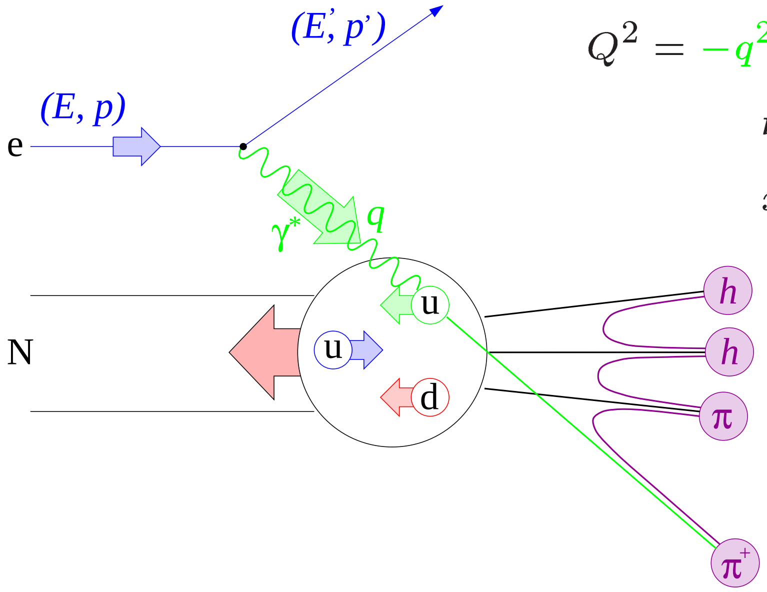
$\Delta\Sigma$ is found to be small in inclusive DIS experiments (EMC, SMC, SLAC, HERMES)

$$\Delta\Sigma = \sum_{i=1}^{n_{\text{flavors}}} (\Delta q_i + \Delta\bar{q}_i) \approx 0.2 \ldots 0.4$$

Possible contributions to S_z:

- strange sea polarization Δs is negative?
- gluon polarization ΔG is positive?
- orbital angular momentum L_z is positive?

Semi-Inclusive DIS at HERMES



$$Q^2 = -q^2 \overset{\text{lab}}{\approx} 4EE' \sin^2\theta/2$$

$$\nu \overset{\text{lab}}{=} E - E'$$

$$x \overset{\text{lab}}{=} Q^2/(2M\nu)$$

DETECT A HADRON h IN COINCIDENCE WITH THE SCATTERED CHARGED LEPTON (HERE e^+)

- DETERMINE KINEMATICS BY SCATTERED LEPTON: $0.02 < x < 0.8,\ Q^2 > 1\text{GeV}^2,\ \text{W} > 2\text{GeV}$
- SELECT HADRONS FRAGMENTED IN THE CURRENT REGION: $z \overset{\text{lab}}{=} E_h/\nu \approx E_\pi/\nu > 0.2$

$\rightarrow$ FLAVOR TAGGING (FAVORED $D_u^{\pi^+}$ > UNFAVORED $D_{\bar{u}}^{\pi^+}$)

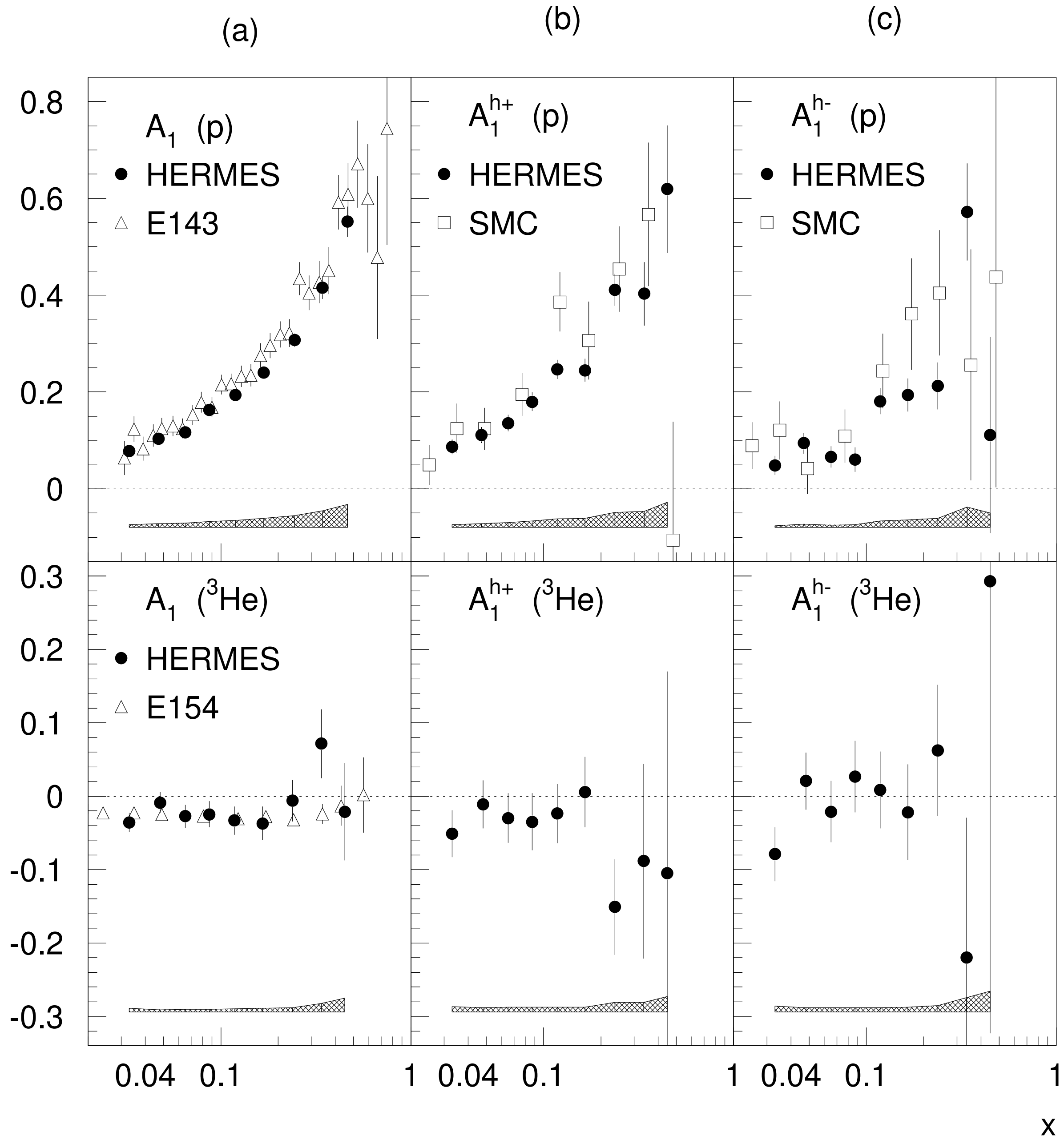
FORM SPIN ASYMMETRIES FOR THE PRODUCTION OF POSITIVE OR NEGATIVE CHARGED HADRONS:

$$A_{\|}^h = \frac{1}{< P_T P_B >} \frac{\left(N^h/L\right)^{\uparrow\Downarrow} - \left(N^h/L\right)^{\uparrow\Uparrow}}{\left(N^h/L\right)^{\uparrow\Downarrow} + \left(N^h/L\right)^{\uparrow\Uparrow}}$$

L :	DEADTIME CORRECTED LUMINOSITY
P_T, P_B :	TARGET AND BEAM POLARISATION
N^h :	NUMBER OF DIS EVENTS

$$A_1^h = \left(\frac{g_1}{F_1}\right)^h = \frac{A_{\|}^h}{D(1+\eta\gamma)} \qquad (g_2 = 0)$$

Semi-Inclusive Asymmetries



(a) inclusive asymmetries in comparison to SLAC

(b) semi-inclusive asymmetries for positively charged hadrons in comparison to SMC

(c) semi-inclusive asymmetries for negatively charged hadrons in comparison to SMC

data are given at mean Q^2 of each x bin
(published in hep-ex/9906035)

FLAVOR SEPARATION AND PURITIES

REWRITE PHOTON-NUCLEON ASYMMETRY ASSUMING FACTORIZATION, SPIN-INDEPENDENCE AND SCALING OF FRAGMENTATION FUNCTIONS $D_q^h(z)$

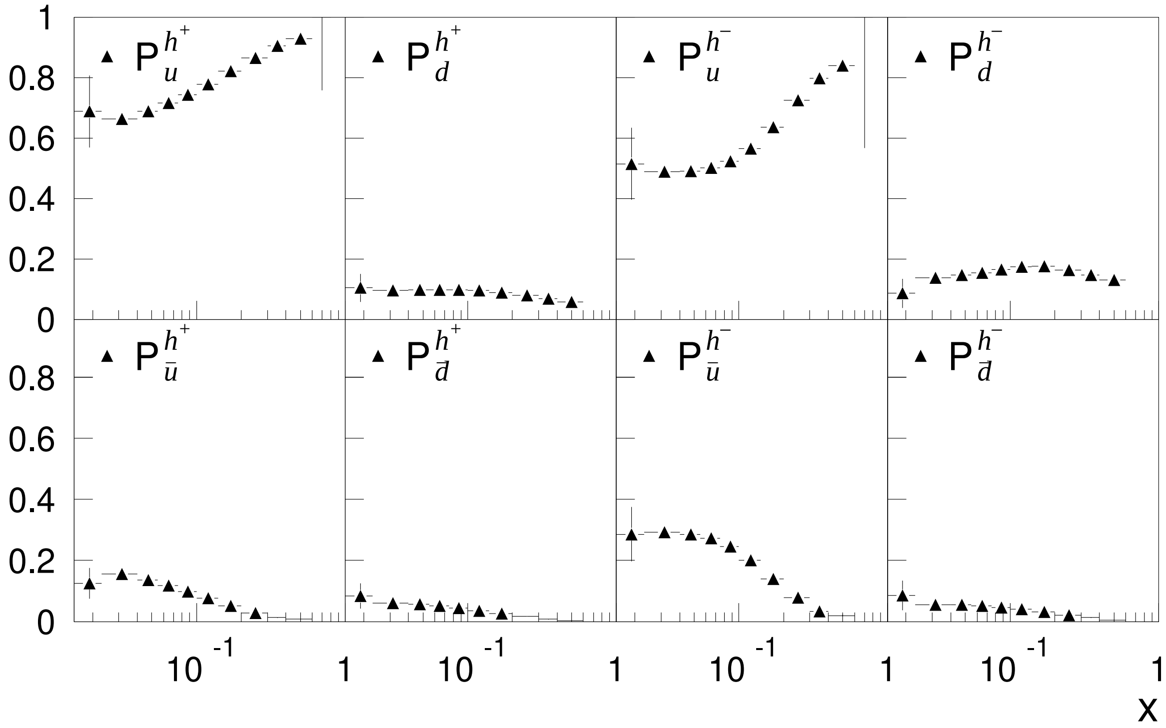
$$A_1^h(x) = \sum_q P_q^h(x) \cdot \frac{(1+R(x))}{(1+\gamma^2)} \cdot \frac{\Delta q(x)}{q(x)}$$

WITH

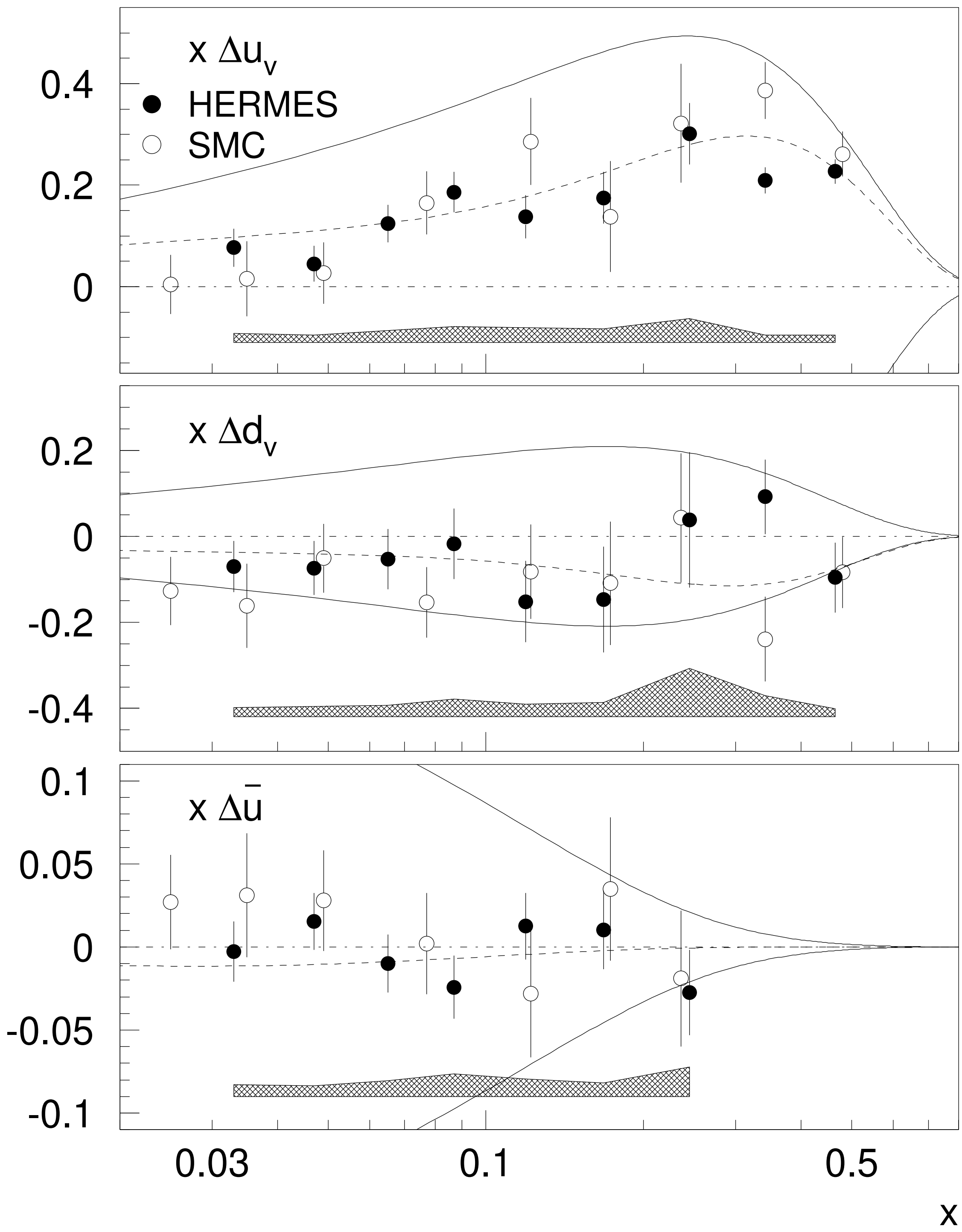
$$P_q^h(x) = \frac{e_q^2 q(x) \int_{0.2}^1 dz D_q^h(z)}{\sum_{q'} e_{q'}^2 q'(x) \int_{0.2}^1 dz' D_{q'}^h(z')}$$

PURITY $P_q^h(x)$ GIVES THE PROBABILITY THAT A QUARK q WAS STRUCK WHEN A HADRON h IS DETECTED

- CALCULATED BY MONTE CARLO (LO QCD)
- UNPOLARIZED QUANTITY
- EXAMPLE: z INTEGRATED PURITIES FOR A PROTON TARGET



Valence- And Sea Quark Distributions At $Q^2 = 2.5$ GeV^2



DASHED LINE: GS SET GLUON A (LO); SEA ASSUMPTIONS:

HERMES: $\frac{\Delta u_s}{u_s} = \frac{\Delta d_s}{d_s} = \frac{\Delta s}{s} = \frac{\Delta \bar{u}}{\bar{u}} = \frac{\Delta \bar{d}}{\bar{d}} = \frac{\Delta \bar{s}}{\bar{s}}$

SMC: $\Delta u_s = \Delta d_s = \Delta s = \Delta \bar{u} = \Delta \bar{d} = \Delta \bar{s}$

RESULTS ARE INSENSITIVE TO SEA ASSUMPTIONS

SPIN CONTRIBUTIONS AND $SU(3)_f$

COMPARISON OF THE HERMES INTEGRALS WITH SMC RESULTS AT $Q^2 = 2.5$ GeV^2 AND IN THE HERMES x-RANGE OF $0.023 < x < 0.6$.

	HERMES	SMC
Δu_v	$0.52 \pm 0.05 \pm 0.08$	$0.59 \pm 0.08 \pm 0.07$
Δd_v	$-0.19 \pm 0.11 \pm 0.13$	$-0.33 \pm 0.11 \pm 0.09$
$\Delta \bar{u}$	$-0.01 \pm 0.02 \pm 0.03$	$0.02 \pm 0.03 \pm 0.02$
$\Delta \bar{d}$	$-0.02 \pm 0.03 \pm 0.04$	$0.02 \pm 0.03 \pm 0.02$

$\longrightarrow$ AGREEMENT WITHIN $1\ \sigma$

HERMES FLAVOR DECOMPOSITION AT $Q^2 = 2.5$ GeV^2 (UNCERTAINTY FOR THE LOW x EXTRAPOLATION NOT INCLUDED)

TEST OF $SU(3)_f$ PREDICTIONS

	TOTAL INTEGRAL	$SU(3)_f$
$\Delta u + \Delta \bar{u}$	0.57 ± 0.04	0.66 ± 0.03
$\Delta d + \Delta \bar{d}$	-0.25 ± 0.07	-0.35 ± 0.03
$\Delta s + \Delta \bar{s}$	-0.01 ± 0.05	-0.08 ± 0.02

$\longrightarrow$ A DEFINITE STATEMENT WHETHER THE INTEGRATED POLARIZED QUARK DISTRIBUTIONS VIOLATE $SU(3)_f$ OR NOT IS NOT POSSIBLE YET

$\longrightarrow$ DIRECT MEASUREMENT OF STRANGE SEA IS REQUIRED (NOTE SEA ASSUMPTIONS!)

$A_{\parallel}$ In Photoproduction Of Pairs Of High p_T Hadrons

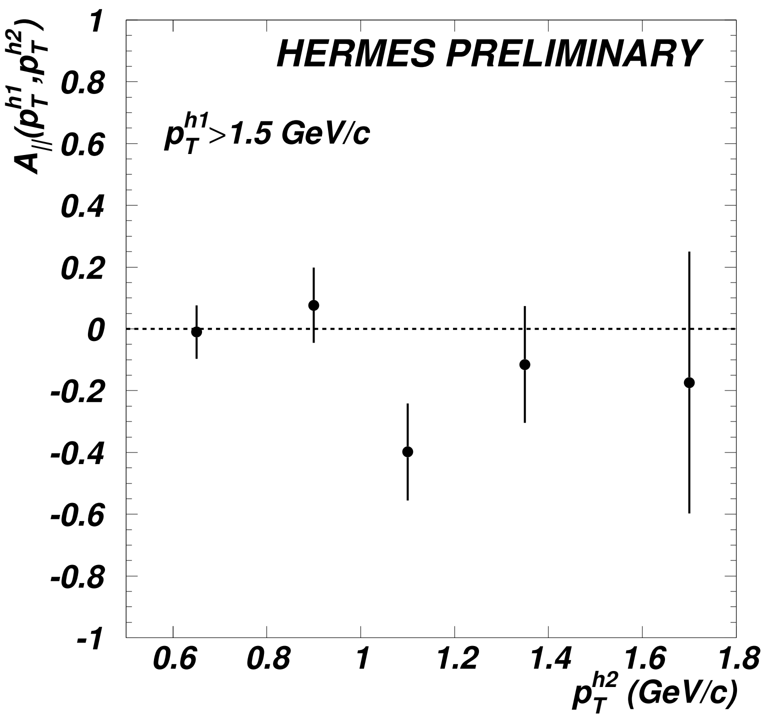
QUARK-GLUON DYNAMICS IS DESCRIBED IN THE FRAMEWORK OF PQCD BY THE DGLAP EVOLUTION EQUATIONS:

$\rightarrow$ ONLY INDIRECT ACCESS TO ΔG VIA THE SCALING VIOLATIONS OF THE SPIN STRUCTURE FUNCTION g_1

$\rightarrow$ ACCESS $\Delta G/G$ VIA PHOTON-GLUON FUSION (PGF) $(\gamma g \rightarrow q\bar{q})$

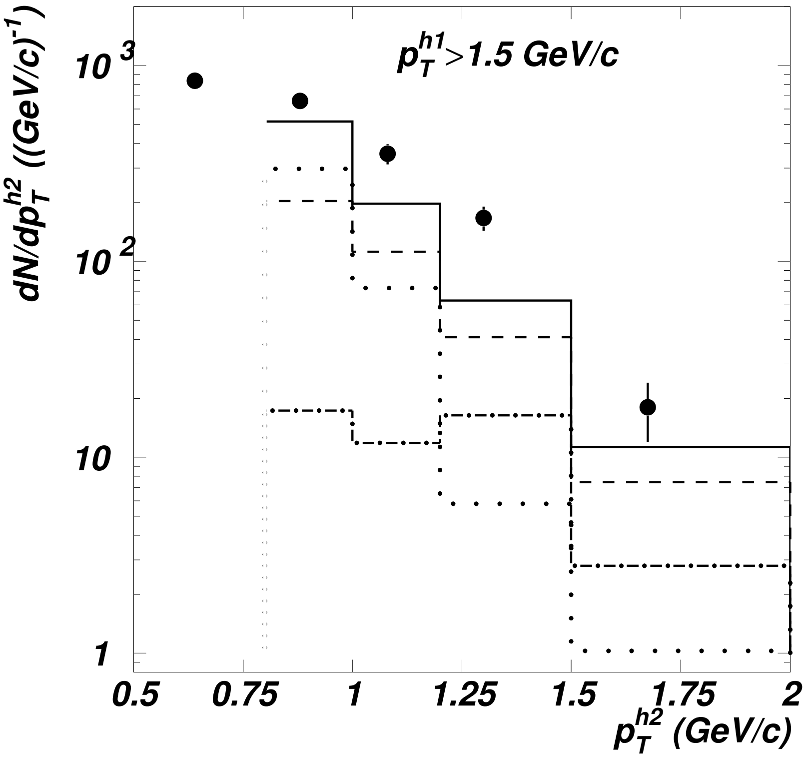
AT HERMES:

- TWO OPPOSITELY CHARGED HADRONS IN SPECTROMETER
- BOTH MUST HAVE HIGH TRANSVERSE MOMENTUM $p_T^{h_1(h_2)} > 1.5(0.5)$ GeV, AND $M(2\pi) > 1$ GeV
- NO REQUIREMENT OF THE SCATTERED POSITRON

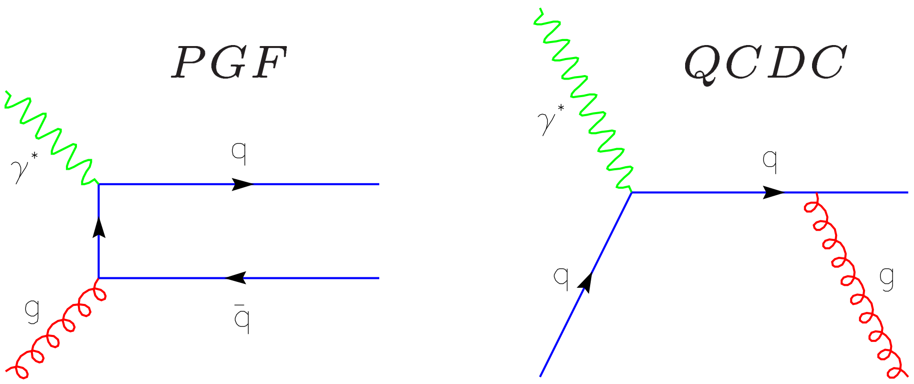


DATA-MC COMPARISONS

MODEL THE DATA WITH PYTHIA (LO QCD) FOR
$p_T > 0.8$ GeV $> \hat{p}_T^{min} \approx 0.5$ GeV



CONTRIBUTIONS: SOLID: TOTAL; DASHED: PGF; DOTTED: QCDC; DASHED-DOTTED: VMD



→ PHOTON-GLUON FUSION DOMINATES AT HIGH p_T

Model For $A_{\parallel}$ Interpretation

use Pythia (LO QCD) to determine the unpolarized fractions f_i of the assumed four cross section contributions $i =$ DIS, VMD, QCDC, and PGF: $A_{\parallel} = D \sum_{i=1}^{4} f_i \cdot A_i$

Note: contributions of hadronic component of the photon not known for HERMES energies and assumed to be zero

- calculated $f_{\mathrm{DIS}} \approx 0$ at $\langle Q^2 \rangle = 0.06\ \mathrm{GeV}^2$
- assume $A_{\mathrm{VMD}} \approx 0$
- calculated $\langle D(y) \rangle = 0.9$

$$A_{\parallel} \approx D(f_{\mathrm{QCDC}} A_{\mathrm{QCDC}} + f_{\mathrm{PGF}} A_{\mathrm{PGF}})$$

in small region of phase space one can write:

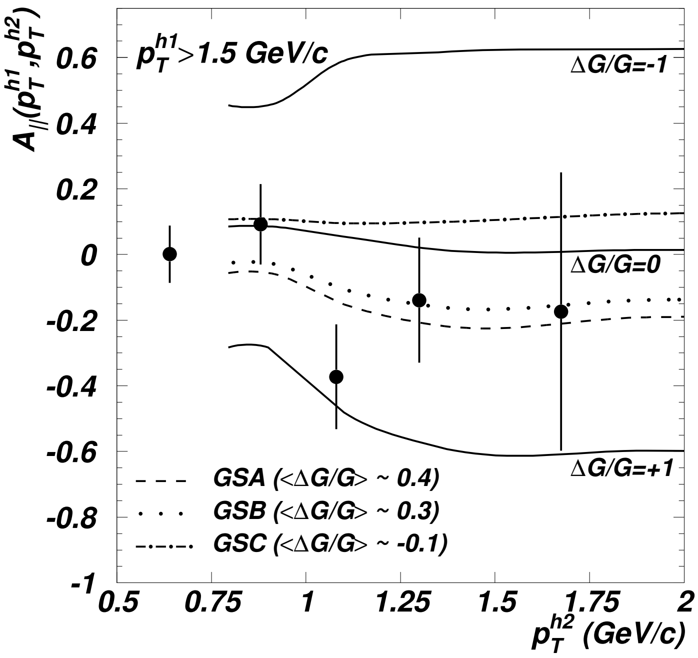
$$A_{\mathrm{PGF}} \approx \langle \hat{a}(\gamma g \to q\bar{q}) \rangle \langle \frac{\Delta G}{G} \rangle = \langle \hat{a}_{\mathrm{PGF}} \rangle \langle \frac{\Delta G}{G} \rangle$$
$$A_{\mathrm{QCDC}} \approx \langle \hat{a}(\gamma q \to q g) \rangle \langle \frac{\Delta q}{q} \rangle = \langle \hat{a}_{\mathrm{QCDC}} \rangle \langle \frac{\Delta q}{q} \rangle$$

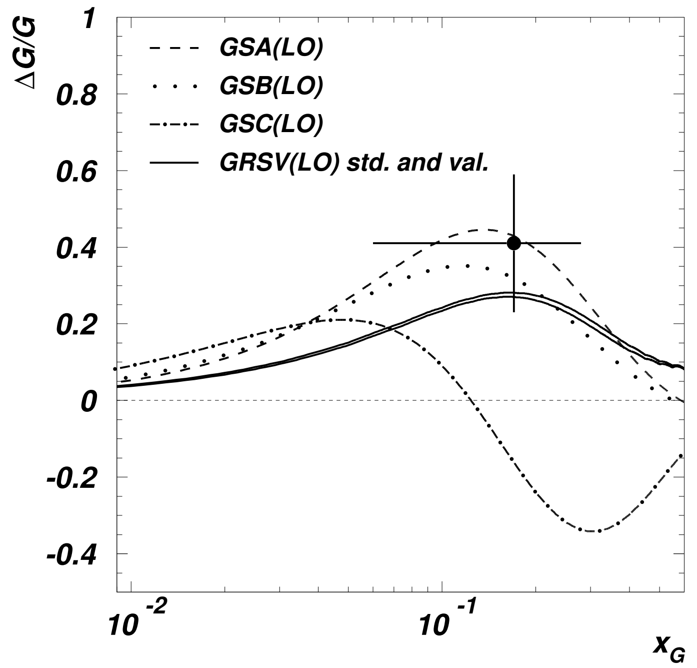
- calculated in LO QCD: $\langle \hat{a}_{\mathrm{PGF}} \rangle = -1$
  $\langle \hat{a}_{\mathrm{QCDC}} \rangle = +1/2$

Result Using Pythia Model

$$\langle \Delta G/G \rangle = 0.41 \pm 0.18(\text{stat.}) \pm 0.03(\text{exp. syst.})$$

AT $\langle x_G \rangle = 0.17$ AND $\langle \hat{p}_T^2 \rangle = 2.1\ \text{GeV}^2$





Summary

- QUARK POLARIZATION:
  - UP QUARKS: **positive**
  - DOWN QUARKS: **negative**
  - SEA QUARKS: COMPATIBLE WITH **zero**
- GLUON POLARIZATION:
  - INDICATION FOR **positive** $\Delta G/G$ AT $\langle x_G \rangle = 0.17$