Measurement of the Spin Asymmetry in the Photoproduction of High-p_T Hadron Pairs at

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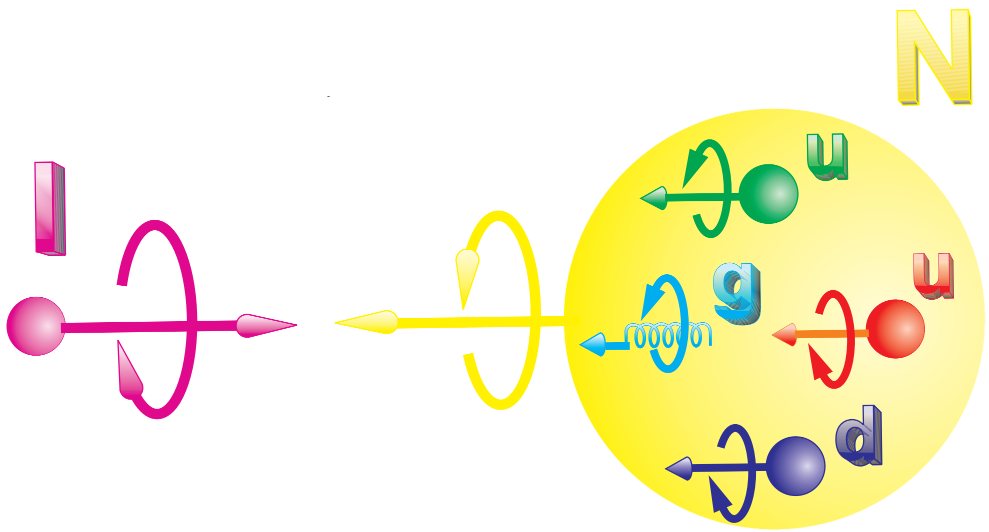
Outline

- Introduction and Motivation
- The HERMES Experiment
- Analysis
- Interpretation
- $\Delta G/G$

Motivation to Study High-p_T hadrons



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

$\Delta\Sigma$ is found to be small in polarized DIS experiments
possible explanations:

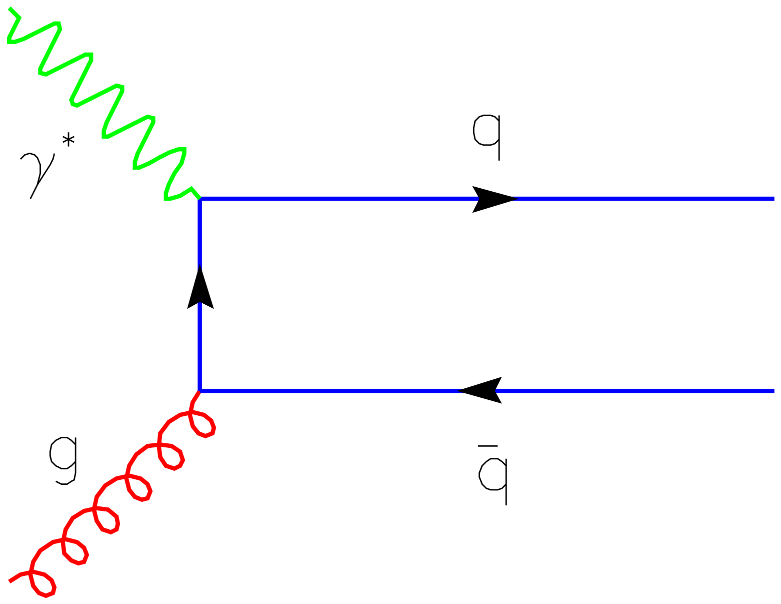
- ΔG is large and positive
- Δs is negative
- L_z is positive

$\rightarrow$ Let's measure ΔG!

How?

- x_{Bj} scaling violation for the polarized structure functions. Q^2 evolution is due to gluons.
- direct measurement via isolation of the photon gluon fusion (PGF) LO QCD diagram.

PGF via kinematical cuts on hadrons

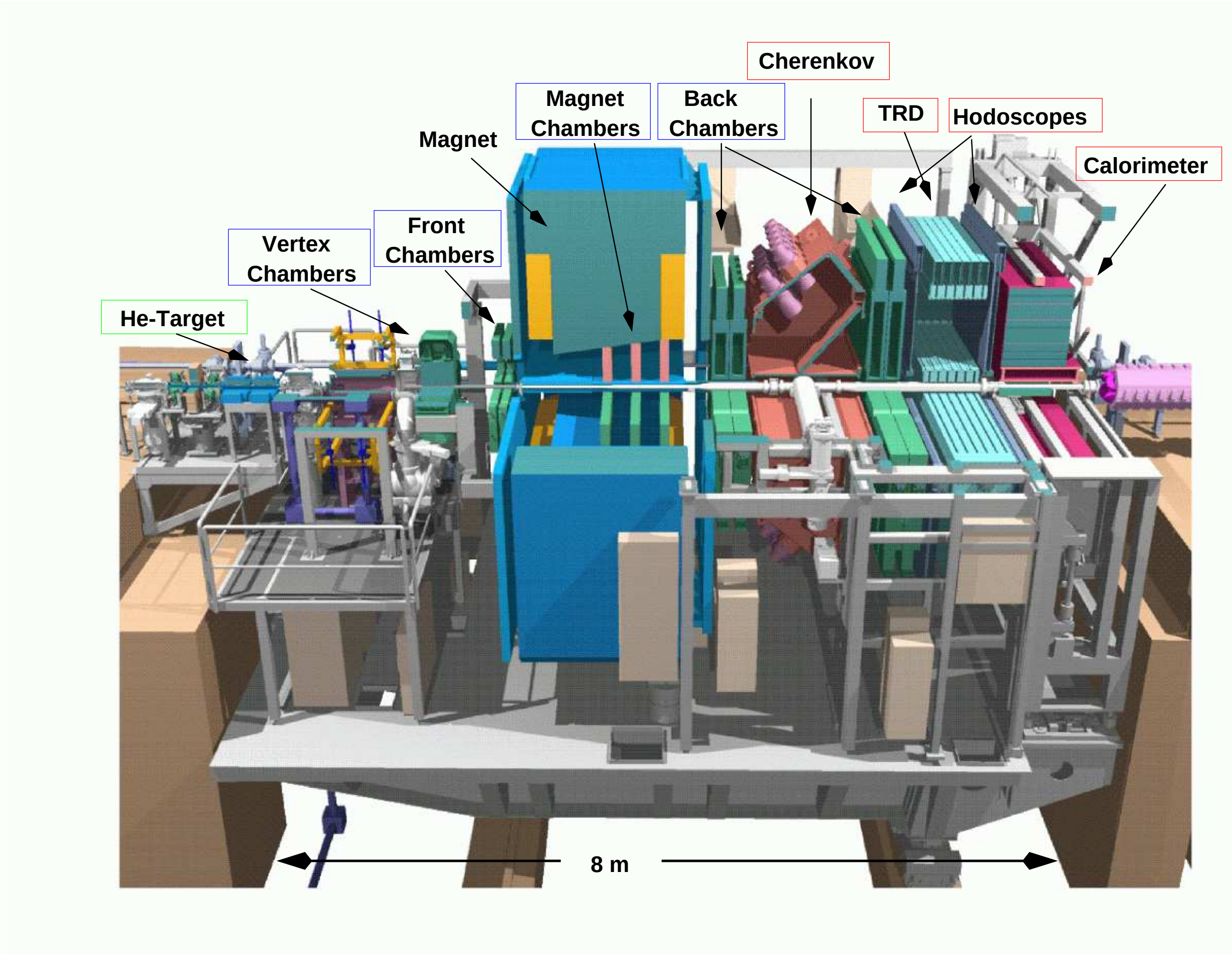


- PGF is isolated at collider experiments via $e + p \to e'$+ 2 jets + target fragments. (see e.g. H1, NPB**75**(1995)539 $G(x)$ from dijet production)

- HERMES does not have jets, can use high-p_T hadrons instead. (see e.g. study for COMPASS Bravar et al, Phys. Lett. B**421**(1998)349, study for SLAC E154, E155 Afanasev et al, Phys. Rev. D**58**(1998)054007)

- The cross-section is maximal at $Q^2 = 0$. Thus, include statistics from quasi-real photoproduction.

The HERMES Experiment



- use HERA 27.5 GeV $\vec{e}$ ring. $P_{\mathrm{beam}} \approx 0.55$.
- internal $^1\vec{\mathrm{H}}$ ABS target. $P_{\mathrm{target}} \approx 0.88$.
- forward spectrometer (40 mrad $< \theta_{\mathrm{lab.}} <$ 220 mrad). momentum resolution $\delta p/p \approx 1\%$.
- PID accomplished using four detectors: calorimeter, preshower, TRD, threshold Č. probability of e/h misidentification $\approx 0.2\%$.

Experimental Technique

Measure the cross section asymmetry:

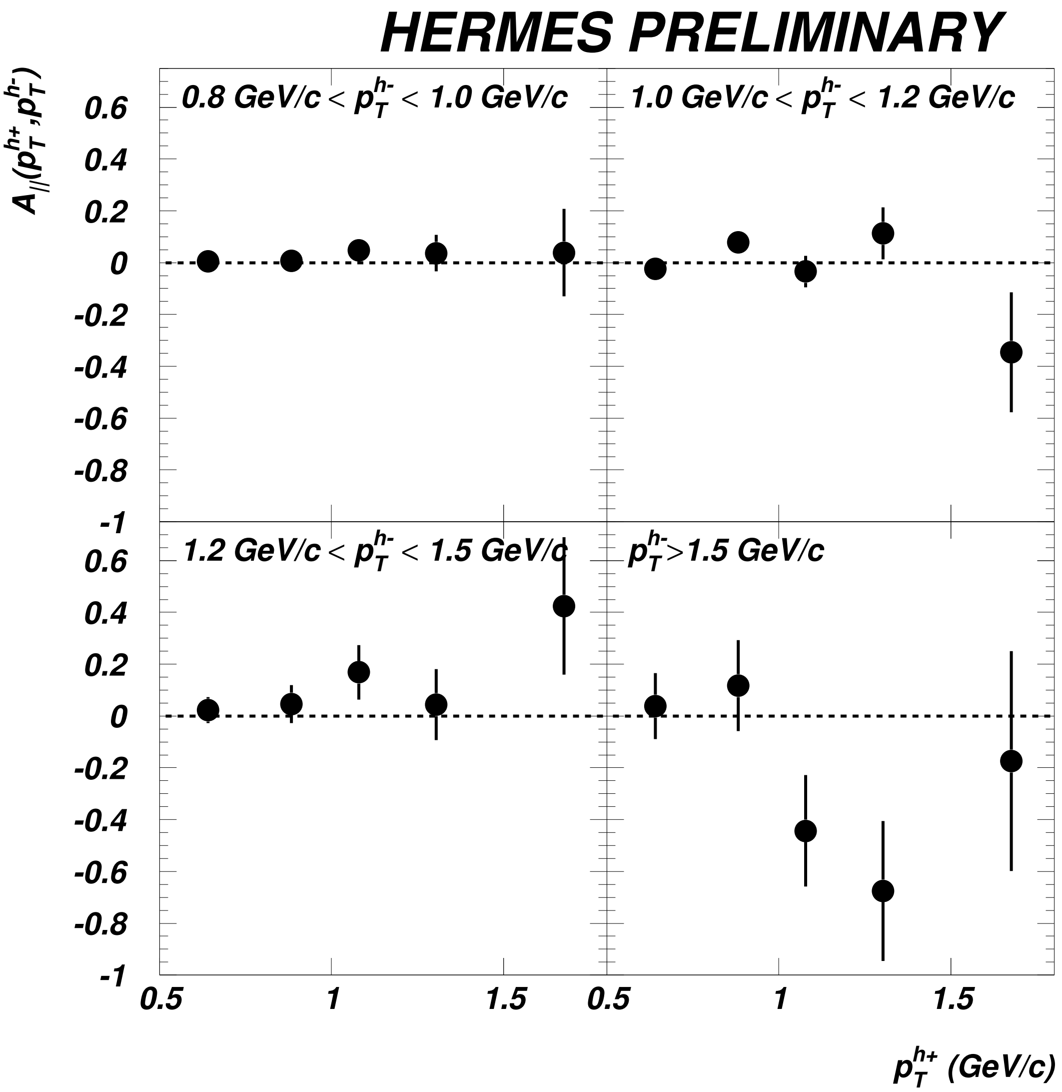
$$A_{||} = \frac{N^- L^+ - N^+ L^-}{N^- L_P^+ + N^+ L_P^-}$$

where $N^+ (N^-)$ is the number of hadron pairs observed for target spin parallel (anti-parallel) to the beam spin orientation. $L^{\pm}$ and $L_P^{\pm}$ are luminosity and polarization weighted luminosity, respectively.

Require:

- at least two hadrons in spectrometer: one h^+ and one h^-.
- both must be high momentum (>4.5 GeV/c) and high p_T (>0.5 GeV/c).
- $M(2\pi) > 1.0$ GeV/c^2, to remove ρ and ϕ resonances.
- quasi-real photoproduction: do not force scattered e^+ in spectrometer.

Measured Asymmetry $A_{||}(p_T^{h^+}, p_T^{h^-})$

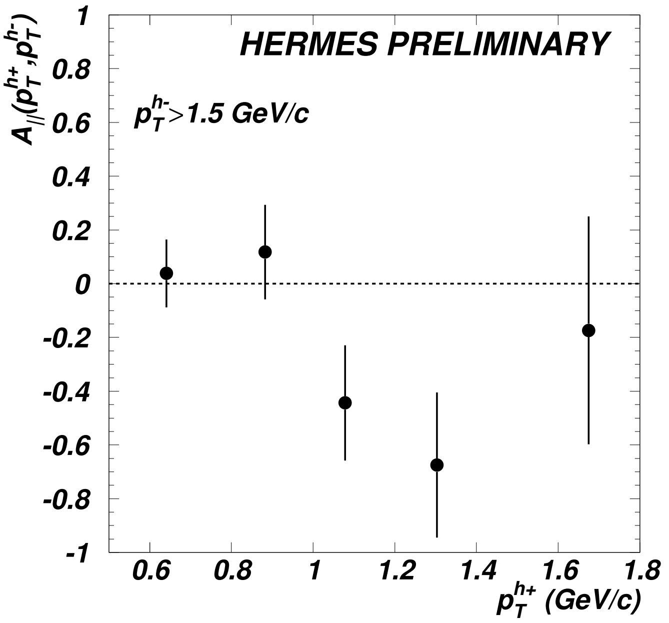


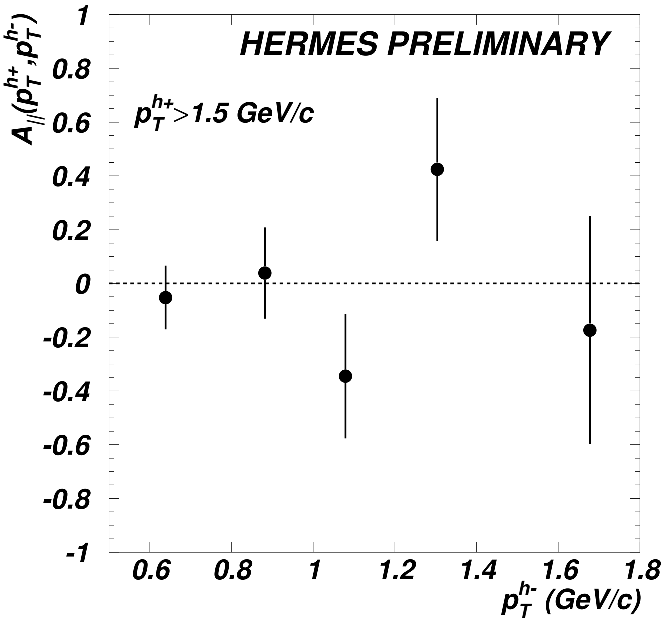
systematic error $\approx$ 8 % of measurement

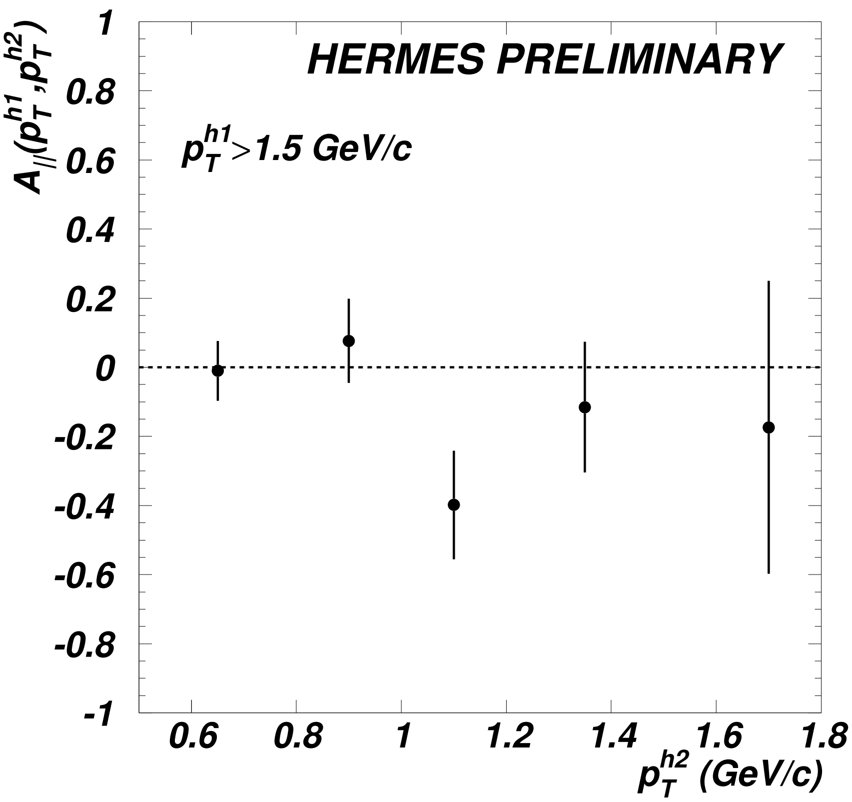
checks that have been performed on the data:

- $e^+ - h^+$ misidentification.
- particle identification cut variation.
- momentum ($\sim z$) cut variation.
- consistent result obtained using identified pions only.

Region of interest



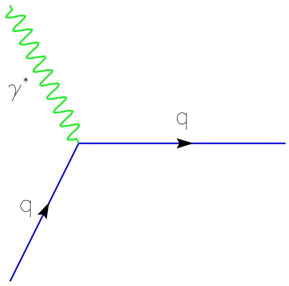




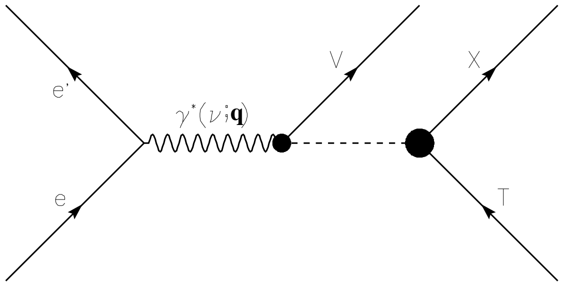
systematic error ≈ 8 % of measurement

Interpretation

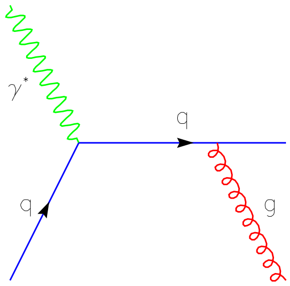
Assume four different processes may contribute:



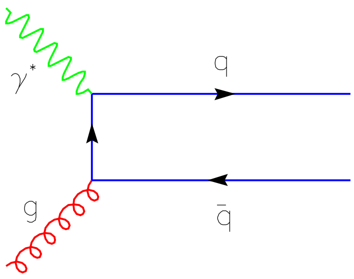
DIS



VMD



QCDC



PGF

...and estimate their relative contributions.

The spin asymmetries each contribute to the measured asymmetry:

$$
\begin{aligned}
A_{||} &= A_{\rm QCDC} f_{\rm QCDC} + A_{\rm PGF} f_{\rm PGF} + A_{\rm DIS} f_{\rm DIS} + A_{\rm VMD} f_{\rm VMD} \\
&\approx A_{\rm QCDC} f_{\rm QCDC} + A_{\rm PGF} f_{\rm PGF}
\end{aligned}
$$

f_i is unpolarized fraction of events for subprocess i =QCDC, PGF, DIS, VMD.

Modeling the data

In small region of phase space take (in LO QCD):

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

$$A_{\mathrm{QCDC}} \approx \langle \hat{a}(\gamma q \rightarrow qG)\rangle \langle \frac{\Delta q}{q} \rangle = \langle \hat{a}_{\mathrm{QCDC}} \rangle \frac{\Delta q}{q}$$

where $\hat{a}_{\mathrm{PGF}} = -1$ and $\hat{a}_{\mathrm{QCDC}} \approx 0.5$ are subprocess asymmetries directly calculable in LO QCD.

Invert to extract $\Delta G/G$:

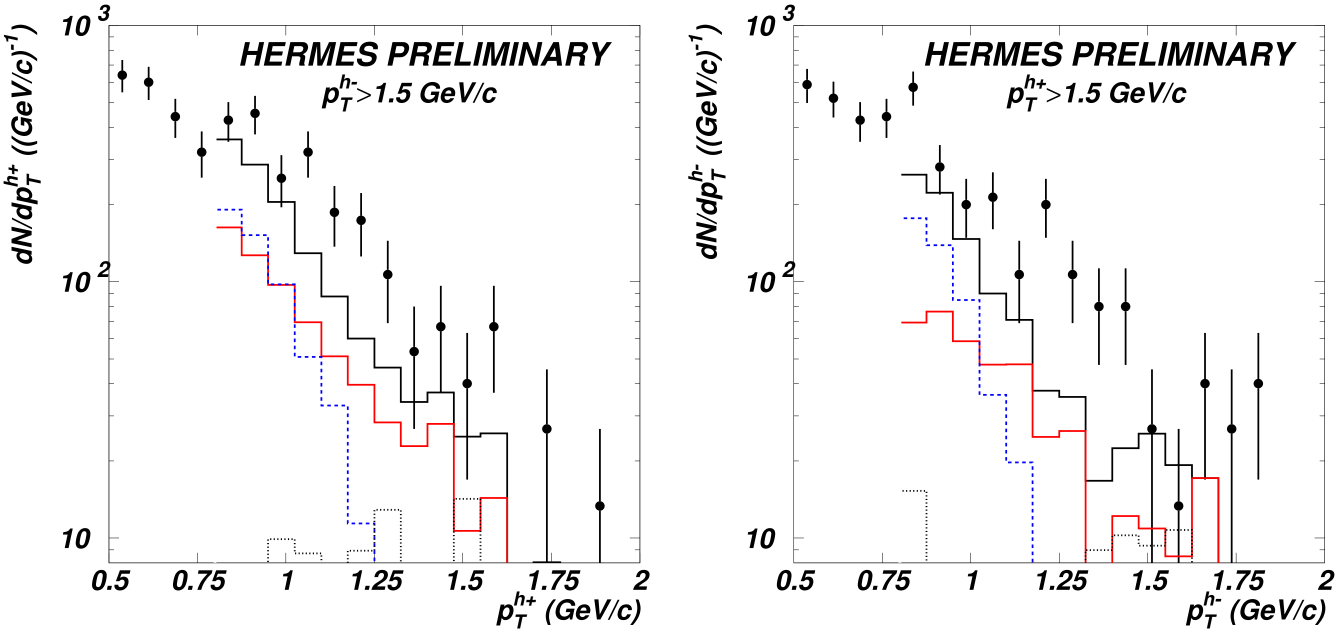
$$\frac{\Delta G}{G} \approx \frac{A_{\mathrm{measured}} - \langle \hat{a}_{\mathrm{QCDC}} \rangle \frac{\Delta q}{q} f_{\mathrm{QCDC}} \langle D(y) \rangle}{\langle \hat{a}_{\mathrm{PGF}} \rangle f_{\mathrm{PGF}} \langle D(y) \rangle}$$

Quantity	Value
$\langle D(y)\hat{a}_{\mathrm{QCDC}}\frac{\Delta q}{q}\rangle$	0.15
$\langle \hat{a}_{\mathrm{PGF}} \rangle$	-1
$\langle D(y) \rangle$	0.9
A_{VMD}	0*
$f_{\mathrm{PGF}}, f_{\mathrm{QCDC}}, f_{\mathrm{VMD}}$	see plot
$\langle x_G \rangle$	0.17
$\langle \hat{p}_T^2 \rangle$	2.1 GeV^2
$\langle Q^2 \rangle$	0.06 GeV^2

* Unknown spin asymmetry of VMD photon. Assume zero spin asymmetry.

MC-Data Comparisons

Comparisons of measured cross sections with predictions of model implemented in PYTHIA.



solid black = total,
solid red = PGF,
dashed blue = QCDC,
dotted black = soft VMD

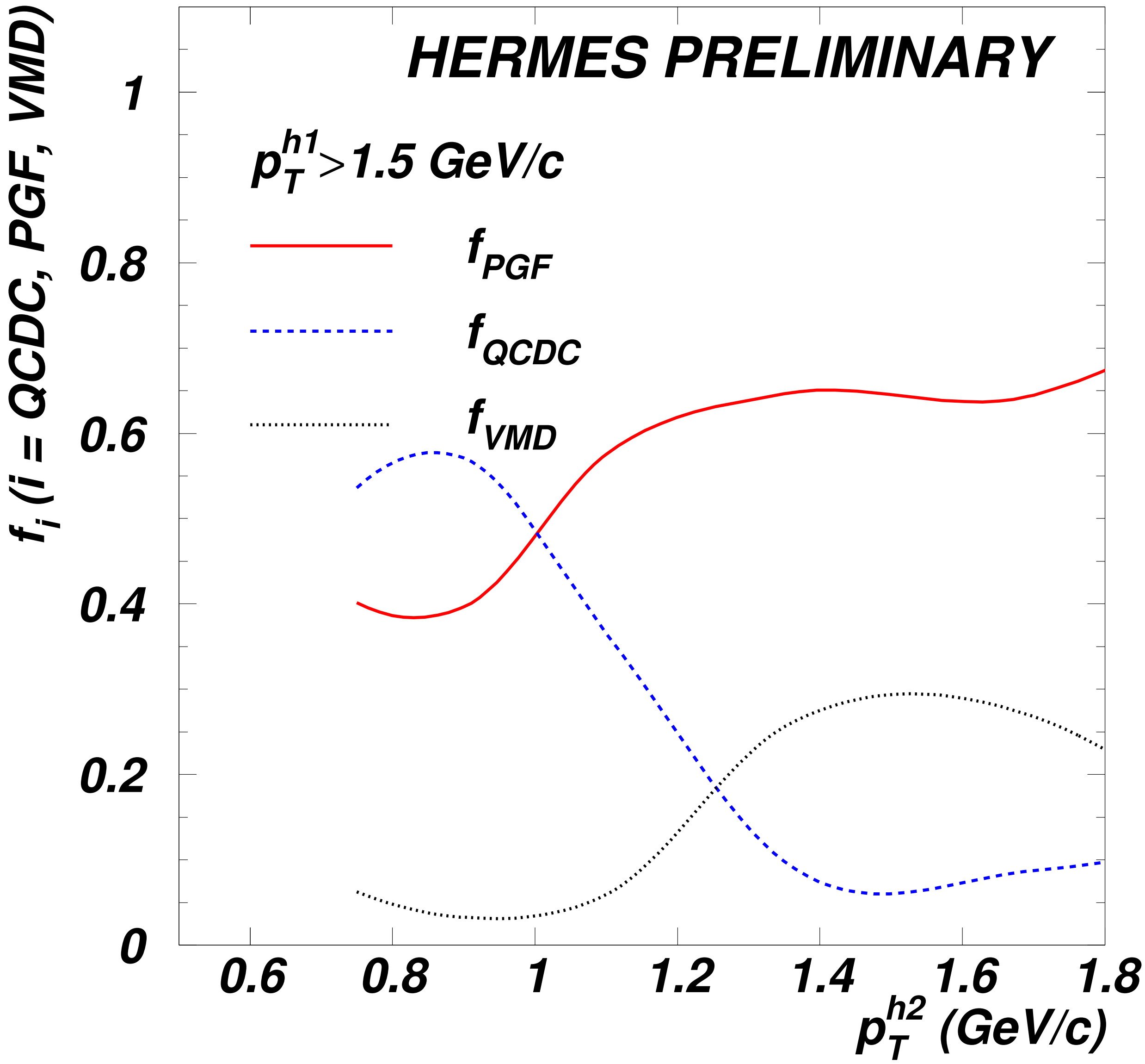
data are compared in a region where PYTHIA model is independent of $\hat{p}_T^{\min}$ cut-off parameter.

Other comparisons:

- other distributions: e.g. $\Delta\phi$
- other regions of phase space: e.g. in regions dominated by soft VMD.

Extracted subprocess fractions

The unpolarized model of the data is used to extract the unpolarized f_i's:



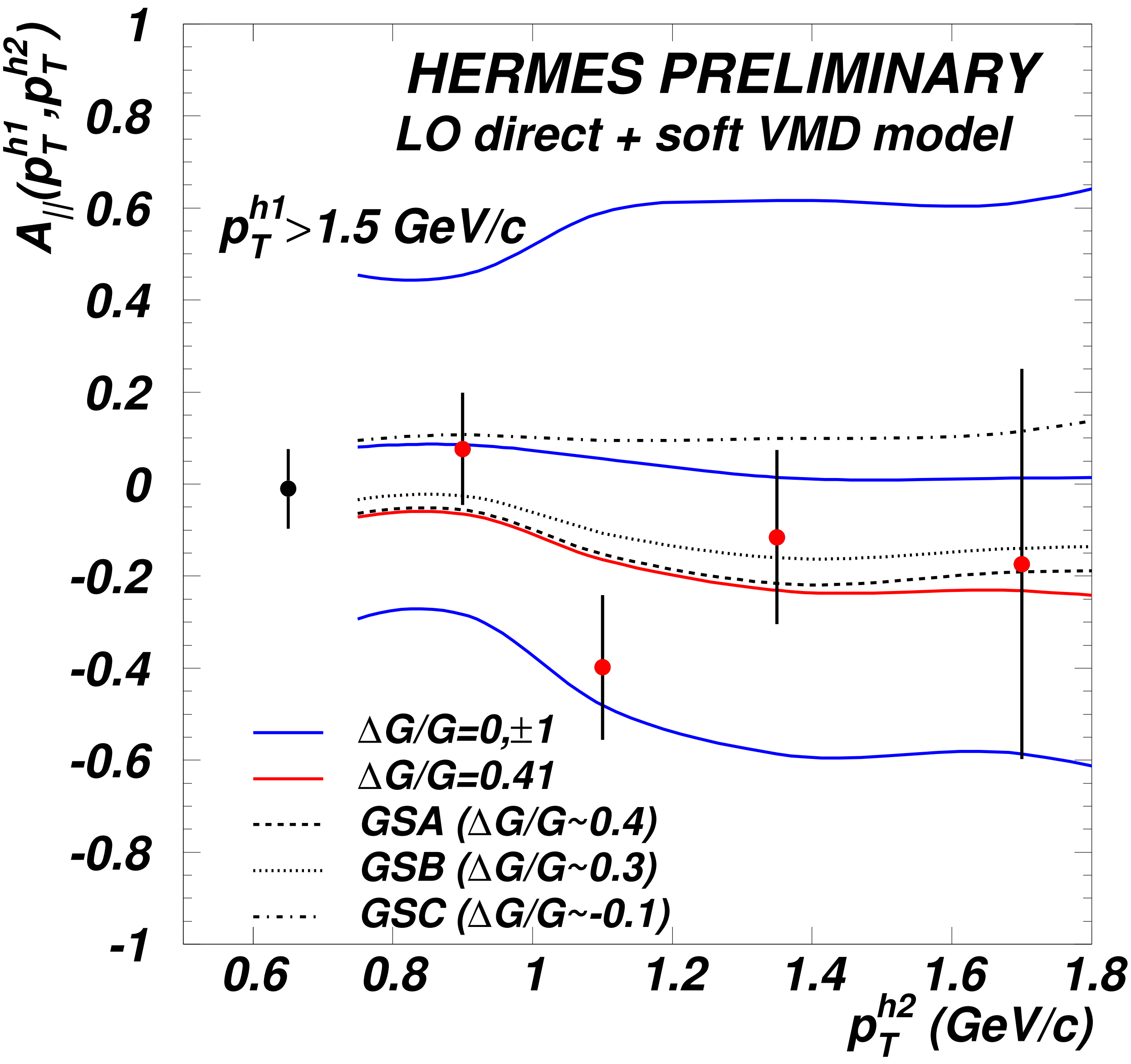
The negative asymmetry is observed where PGF is expected to dominate.

Significant uncertainty from contribution due to hadronic structure of the photon.

Result Using PYTHIA Model

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

at $\langle x_G \rangle = 0.17$ and $\langle \hat{p}_T^2 \rangle = 2.1$ GeV^2



Large uncertainty from contribution and unknown spin asymmetry of hadronic photon. If only a dilution, value of $\Delta G/G$ will increase but significance will not change.

Conclusion

hermes

- Negative asymmetry at high p_T (particularly for $p_T^{h_1} > 1.5$ GeV/c, $p_T^{h_2} > 1.0$ GeV/c).

- Cross-section in reasonably good agreement with PYTHIA model

- With stated assumptions, preliminary result for $\Delta G/G = 0.41 \pm 0.18\ (\mathrm{stat.}) \pm 0.03\ (\mathrm{exp.syst.})$ at $\langle x_G \rangle = 0.17$ and scale $\langle \hat{p}_T^2 \rangle = 2.1$ GeV^2.

- This is a LO QCD direct (+ soft VMD) model. Possible contributions from e.g. hadronic structure of photon, NLO corrections, etc. have been ignored.

- Indicates a positive contribution to the nucleon spin from the gluon polarization.