Measurement of the Double Spin Asymmetries in the quasi-real Photo Production of High-p$_T$ Hadrons at HERMES

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on behalf of the
hermes Collaboration

1 Spin of the Nucleon

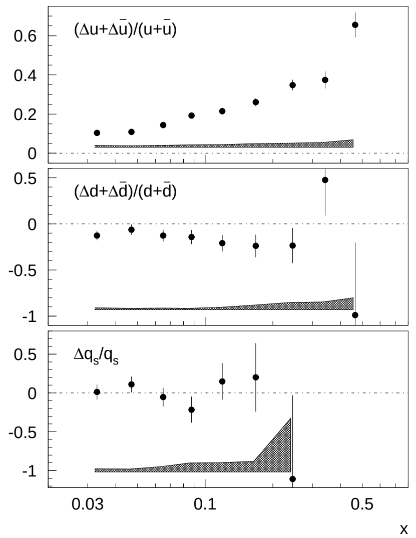
$$\frac{1}{2} = \frac{1}{2}\underbrace{(\Delta u + \Delta d + \Delta s)} + \Delta G + \underbrace{L_q + L_g}$$

$\downarrow$ $\downarrow$ $\downarrow$?

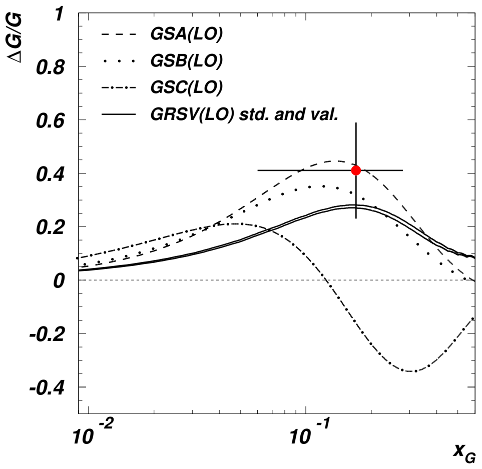
inclusive: g_p^1, g_n^1 $\rightarrow \Delta\Sigma$ — **PGF** — **exclusive:** π, γ

semi-incl.: flavor separation — **high-p$_t$ hadron pairs** — **Production**

Open Charm



hep-ex/9906035



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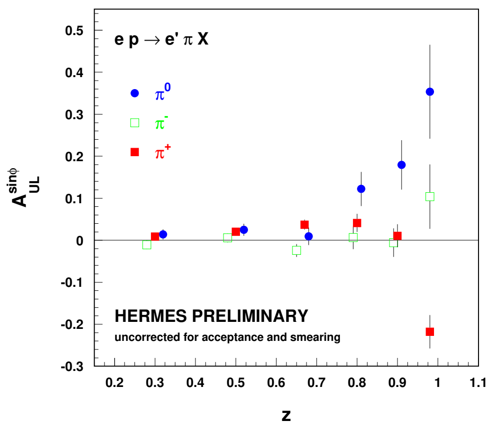
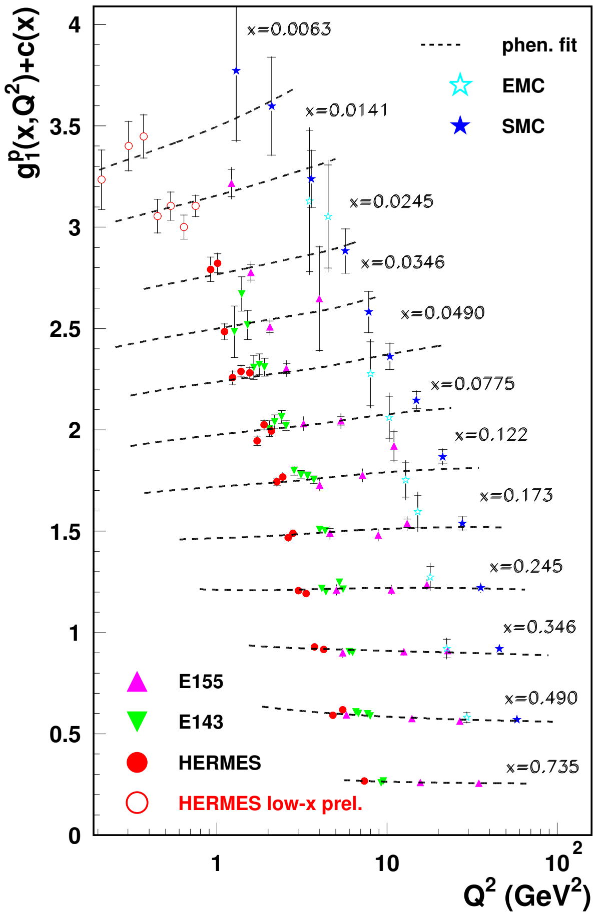


2 Indirect Measurement of ΔG

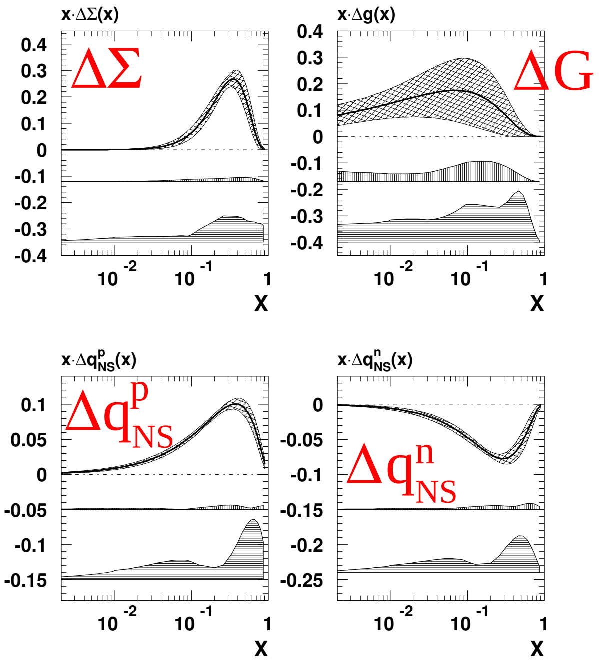
Scaling violation of g1



Fit by E155 using $Q^2 > 1$ GeV^2 world data:

$$g1/F1 = x^{0.7}(0.817 + 1.014x - 1.289x^2)(1 - 0.04/Q^2)$$

(hep-ph/0007248)



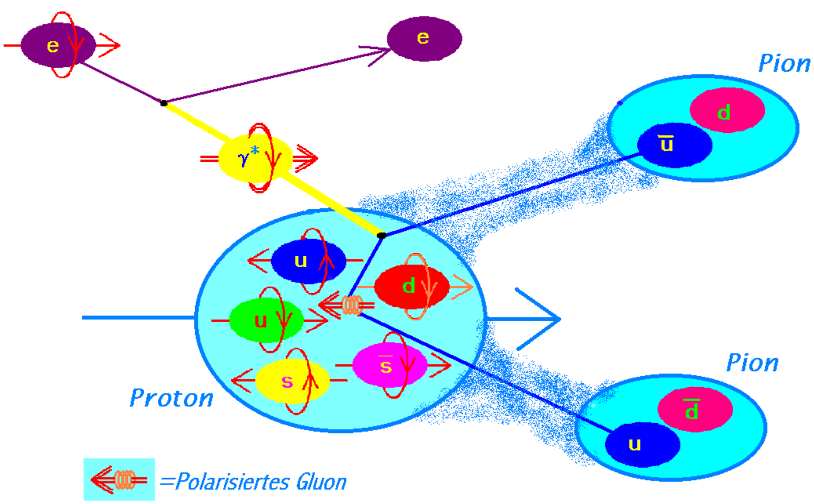
SMC, Phys.Rev. D58 (1998) 112002

Not a very accurate determination of ΔG

Scheme dependent extraction

3 Direct Measurements of ΔG

Isolate the photon-gluon fusion process (PGF)

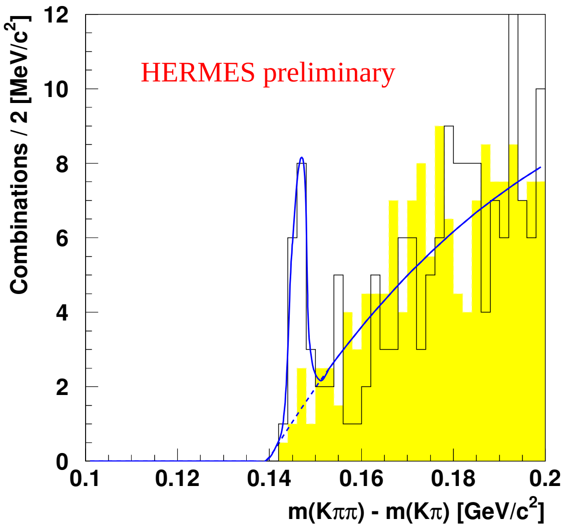


OPEN CHARM

reconstruct D^*, D^0

$$A_{||} = \frac{N^{\stackrel{\rightarrow}{\Leftarrow}}_{c\bar{c}} - N^{\stackrel{\rightarrow}{\Rightarrow}}_{c\bar{c}}}{N^{\stackrel{\rightarrow}{\Leftarrow}}_{c\bar{c}} + N^{\stackrel{\rightarrow}{\Rightarrow}}_{c\bar{c}}}$$

$$A^{\gamma p \to c\bar{c}} \sim \Delta G/G$$



$$D^* \to K + \pi + \pi_{slow}$$

currently anal. RICH data

HIGH-P_T

pairs of high-P_T hadrons

$$A_{||} = \frac{N^{\stackrel{\rightarrow}{\Leftarrow}}_{h\pm} - N^{\stackrel{\rightarrow}{\Rightarrow}}_{h\pm}}{N^{\stackrel{\rightarrow}{\Leftarrow}}_{h\pm} + N^{\stackrel{\rightarrow}{\Rightarrow}}_{h\pm}}$$

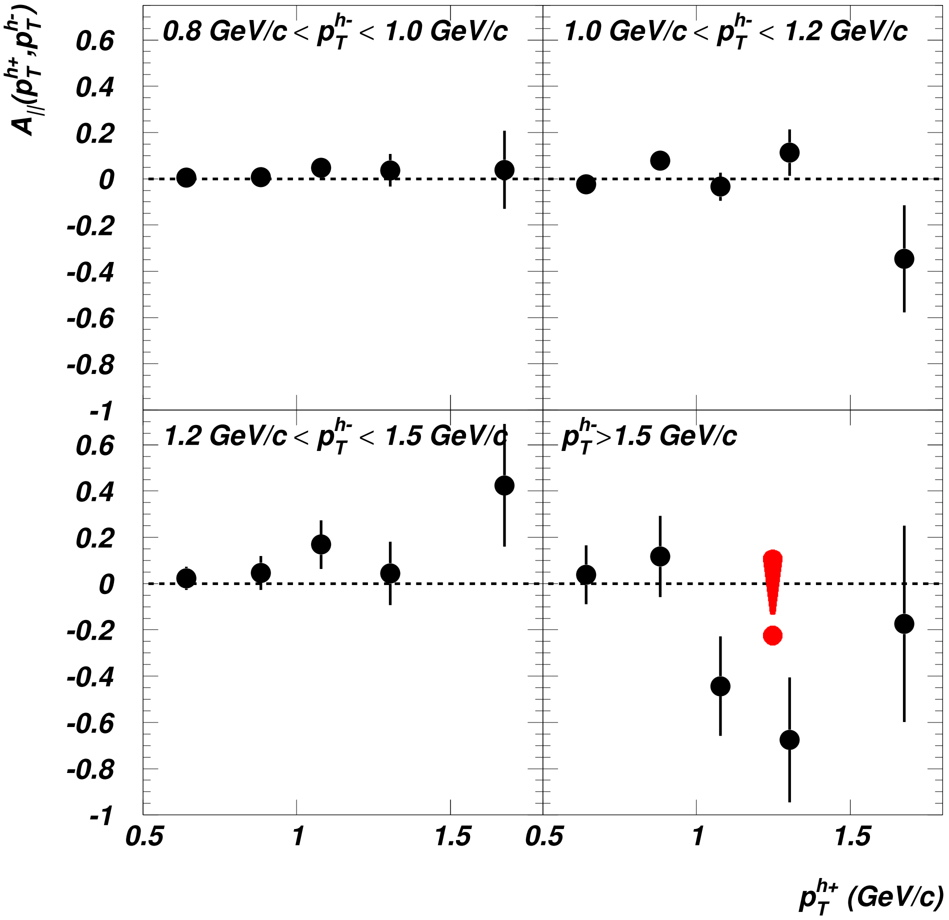
$$A^{\gamma p \to h^+ h^-} \sim \Delta G/G$$

A.Bravar Phys.Lett.B421 (1998) 349

4 The HERMES hunt for ΔG

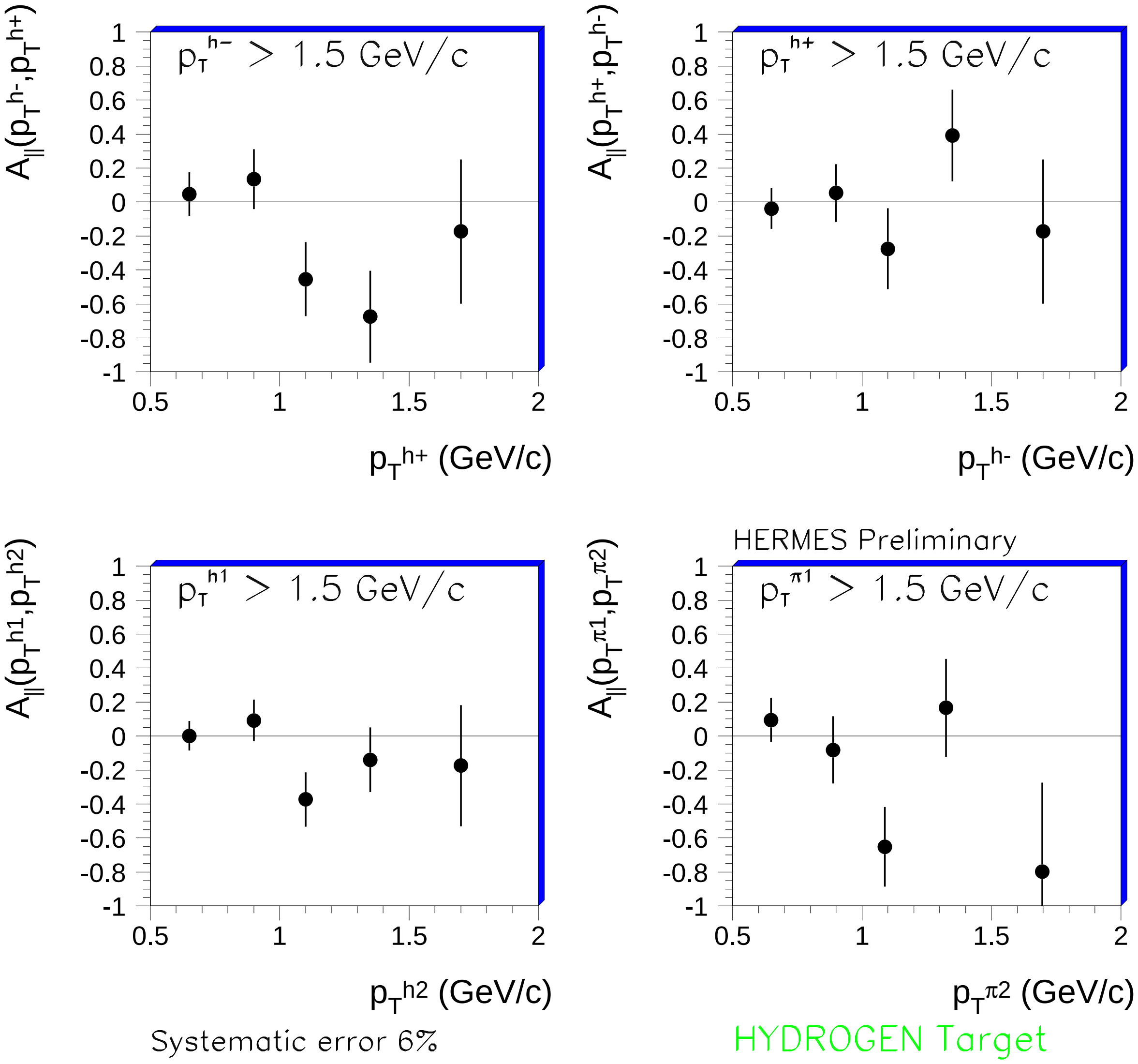
- select two oppositely charged hadrons h_1 & h_2
- low Q^2 range
  $\longrightarrow$ increase statistics
  $\longrightarrow$ scale of hard sub-processes defined by $\hat{p}_T^2$
- require $p_T(h_1,h_2) > 0.5$ GeV, $M(2\pi) > 1.0$ GeV
  $\longrightarrow$ removes resonances ρ and ϕ

$$A_{||} = \frac{N_{h\pm}^{\overset{\rightarrow}{\Leftarrow}} - N_{h\pm}^{\overset{\rightarrow}{\Rightarrow}}}{N_{h\pm}^{\overset{\rightarrow}{\Leftarrow}} + N_{h\pm}^{\overset{\rightarrow}{\Rightarrow}}} \text{ in dependence of } p_T(h_1)$$



Negative asymmetry in DIS unexpected

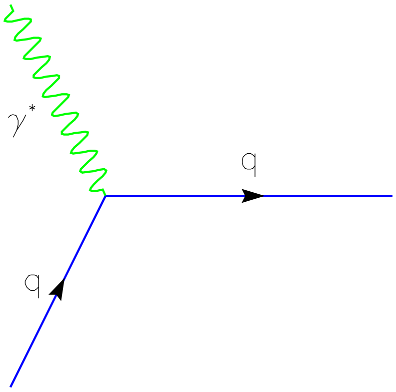
5 Results with a Hydrogen target

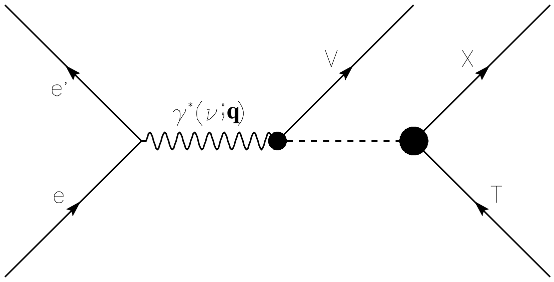


How can this asymmetry be interpreted ?

Interpretation

Assume four different processes may contribute (in LO QCD) to the high p_T h$^{\pm}$ pair production:



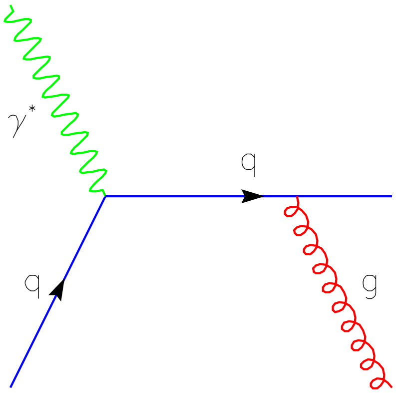


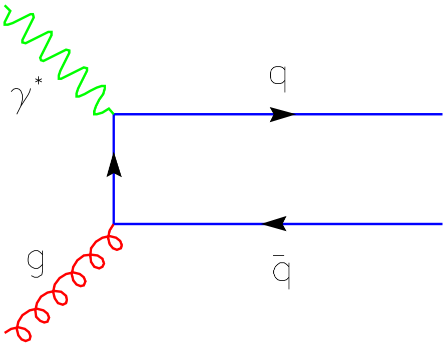
DIS

$A_{DIS} \sim \frac{\Delta q}{q}$

VMD

$\mathbf{A}_{VMD} = \mathbf{0}$





QCDC

$A_{QCDC} \sim \frac{\Delta q}{q}$

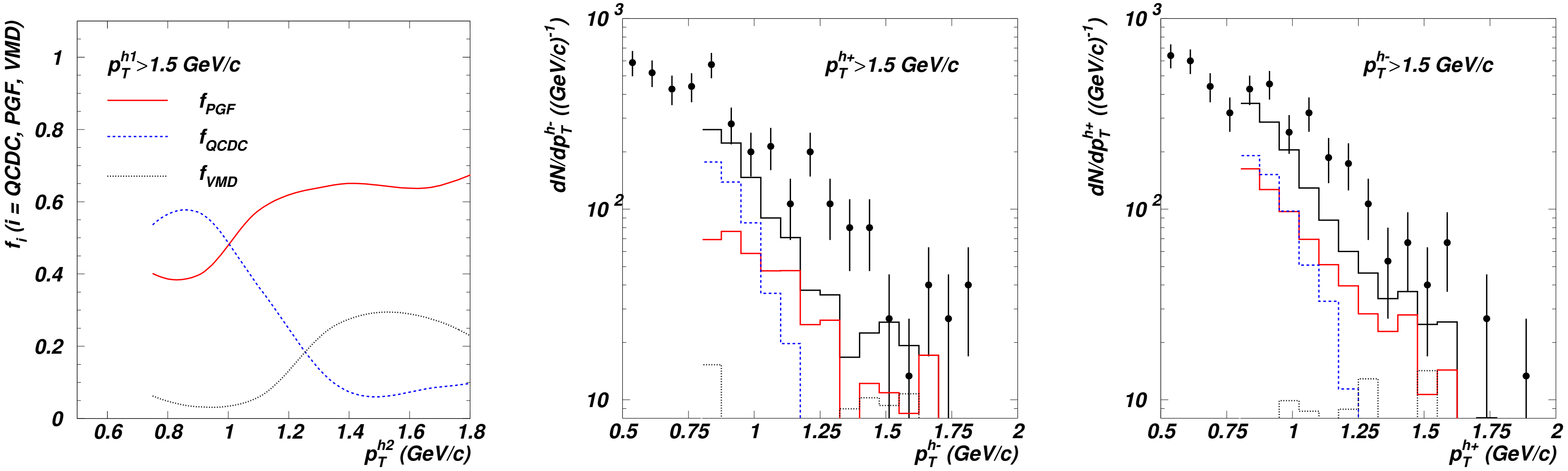
PGF

$A_{PGF} \sim \frac{\Delta G}{G}$

.. estimate their relative contributions using PYTHIA

$\rightarrow \Delta G/G$

6 Answer from PYTHIA 5



$$A_{\|} = D \sum_{i=1}^{4} f_i \cdot A_i \approx D(f_{\mathrm{QCDC}} A_{\mathrm{QCDC}} + f_{\mathrm{PGF}} A_{\mathrm{PGF}})$$

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

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

in LO QCD: $\langle \hat{a}_{\mathrm{PGF}} \rangle = -1$

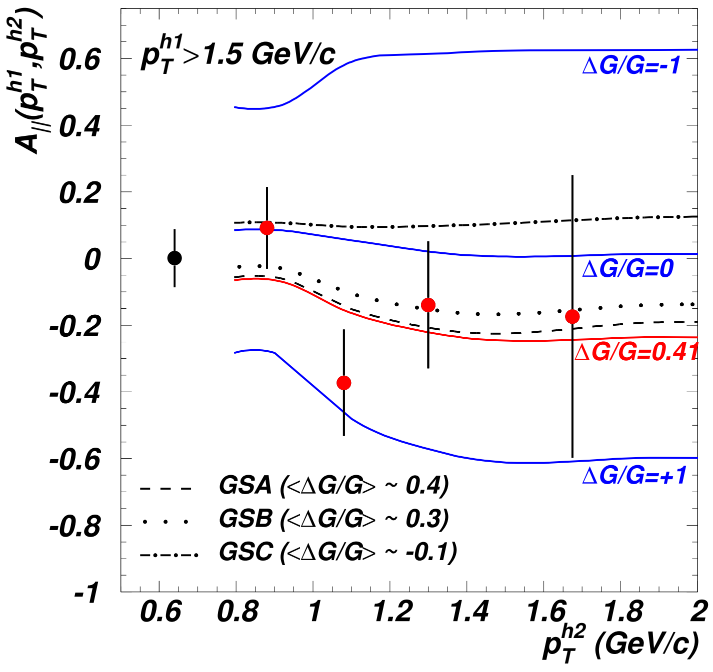
$\langle \hat{a}_{\mathrm{QCDC}} \rangle = +1/2$

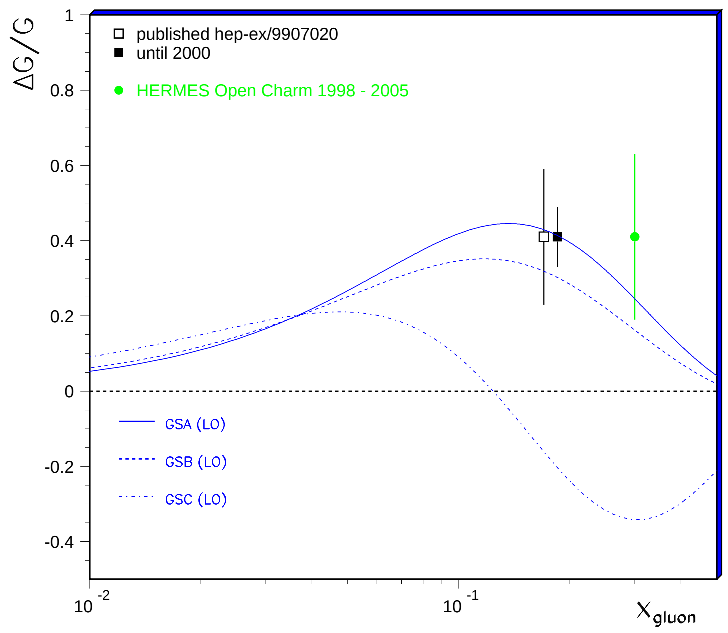
Result Using PYTHIA 5 Model

$\Delta G/G$ is positive

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

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



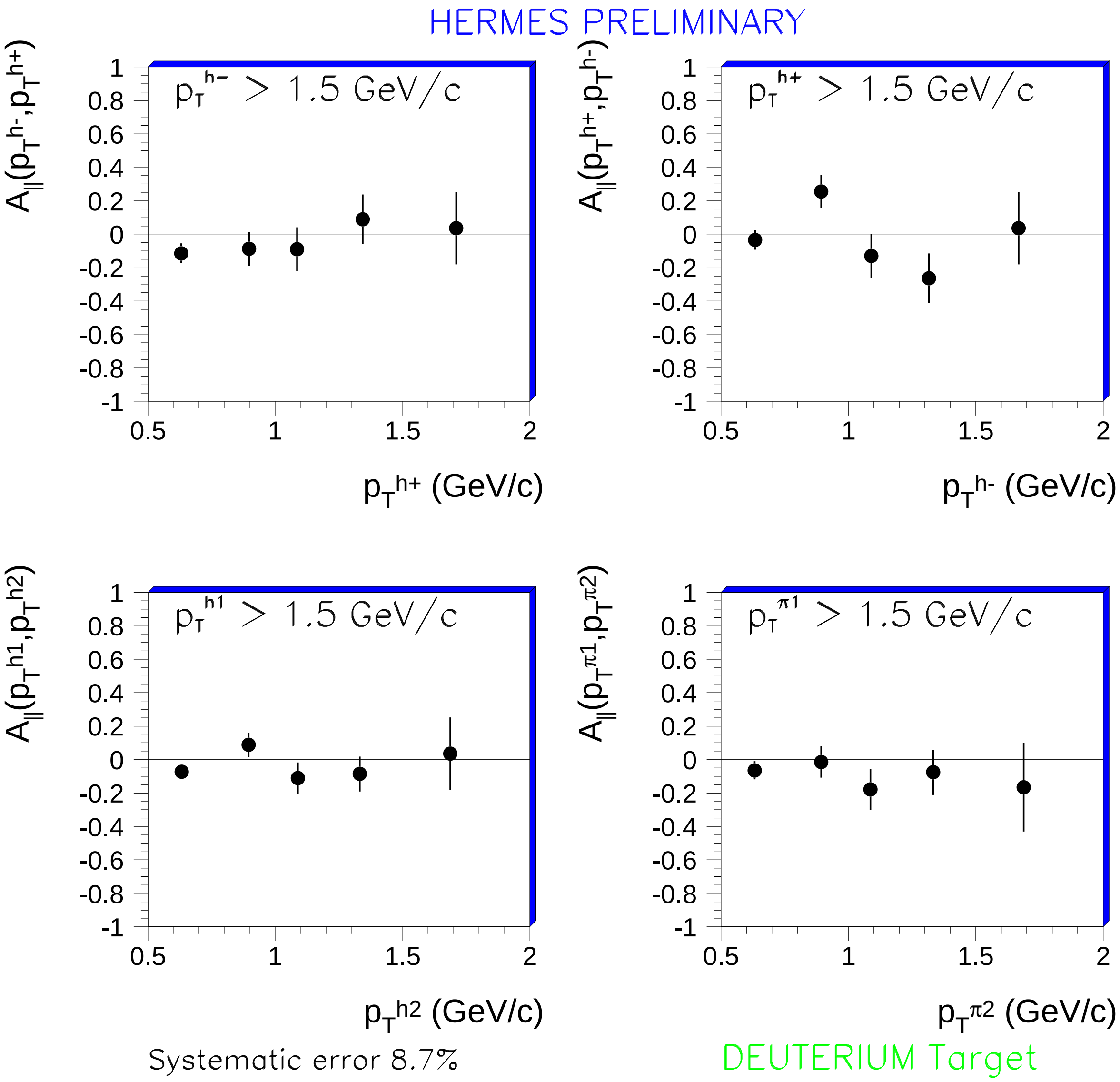


2 x smaller errors with 1998-2000 data

Extraction strongly Model dependent

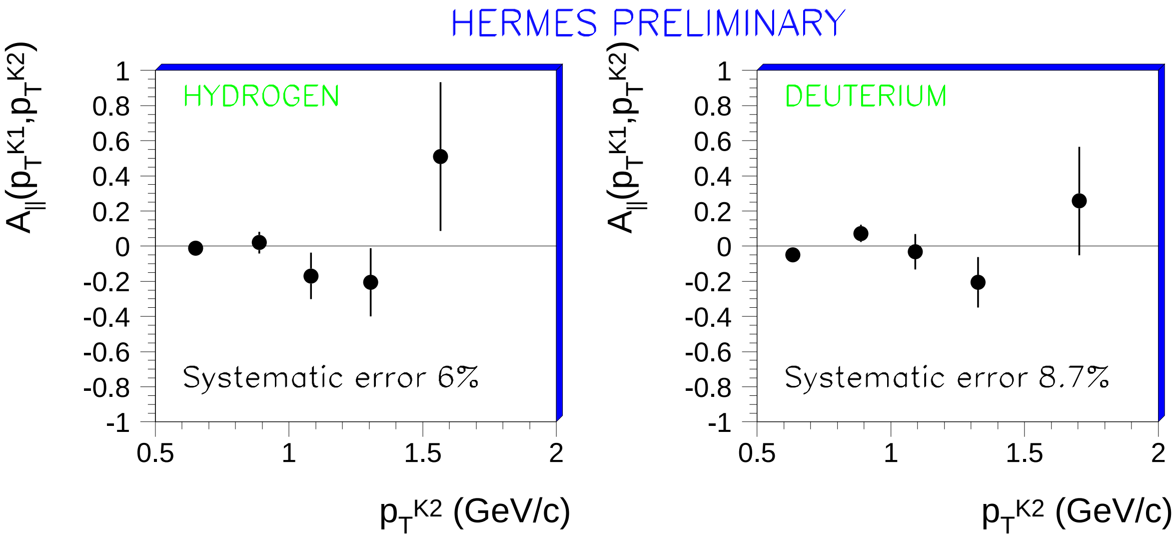
7 Results with a Deuterium target (I)

Included statistics corresponds to 8.9 $*10^6$ DIS (1998 - 2000)

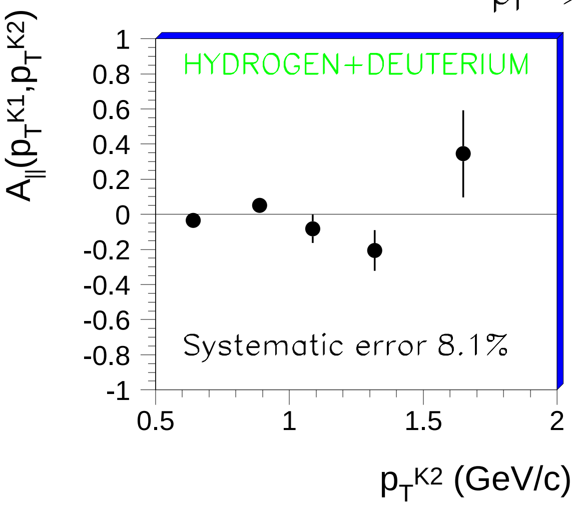


$\Delta G/G$ Extraction still under way

8 Results with a Deuterium target (II)



$p_T^{K1} > 1.0$ GeV/c



Hydrogen: Cerenkov
Contamination in Kaon−sample 30%

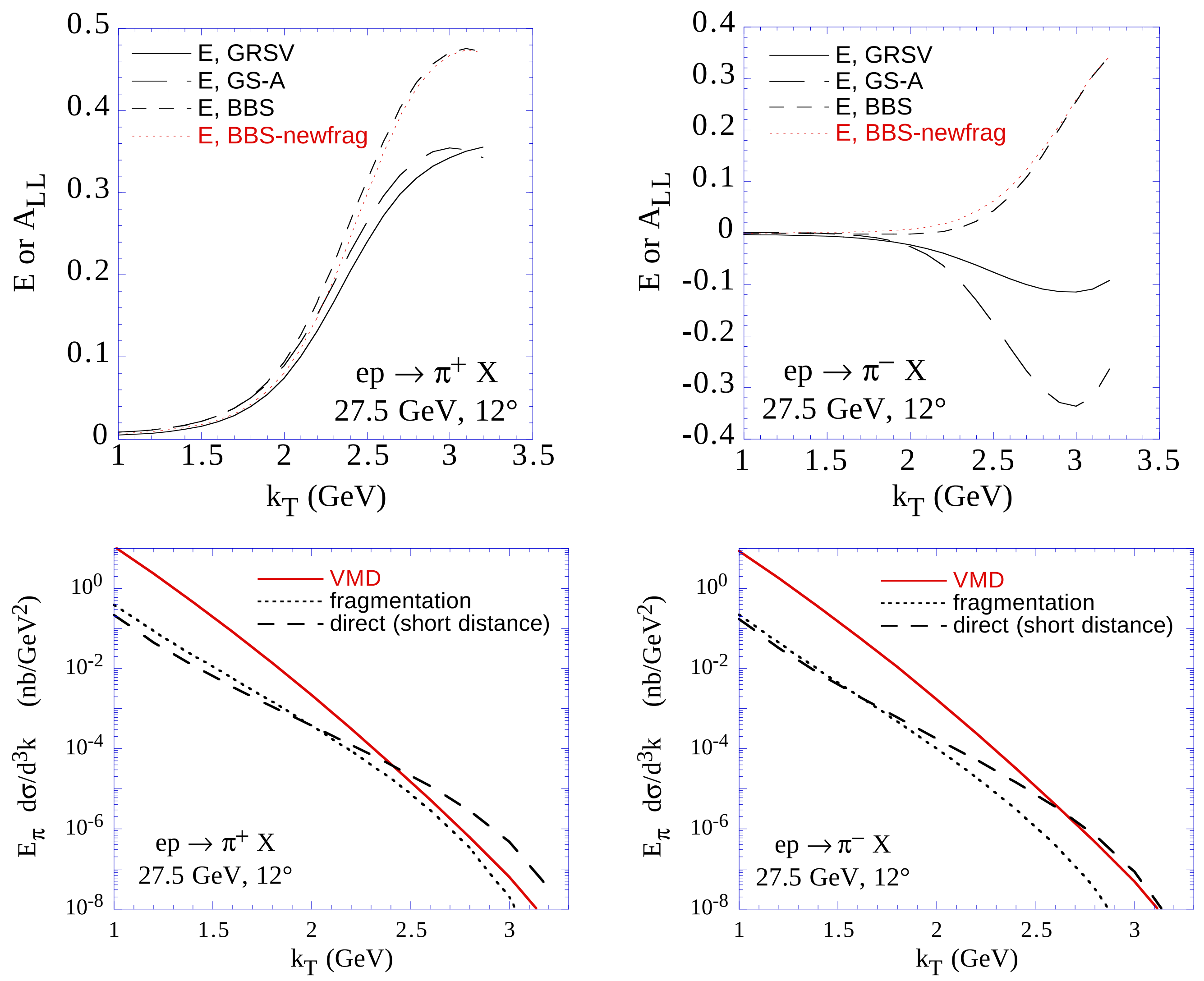
Deuterium: RICH
Contamination in Kaon−sample 5%

- **reduced $p_T(h1) > 1.5$GeV to $p_T(K1) > 1.0$GeV**
  $\longrightarrow$ more statistics
- **Advantage:**
  Production of strange hadrons in fragmentation is suppressed compared to non-strange hadrons
  $\longrightarrow$ cleaner sample

9 Another possible Channel ?

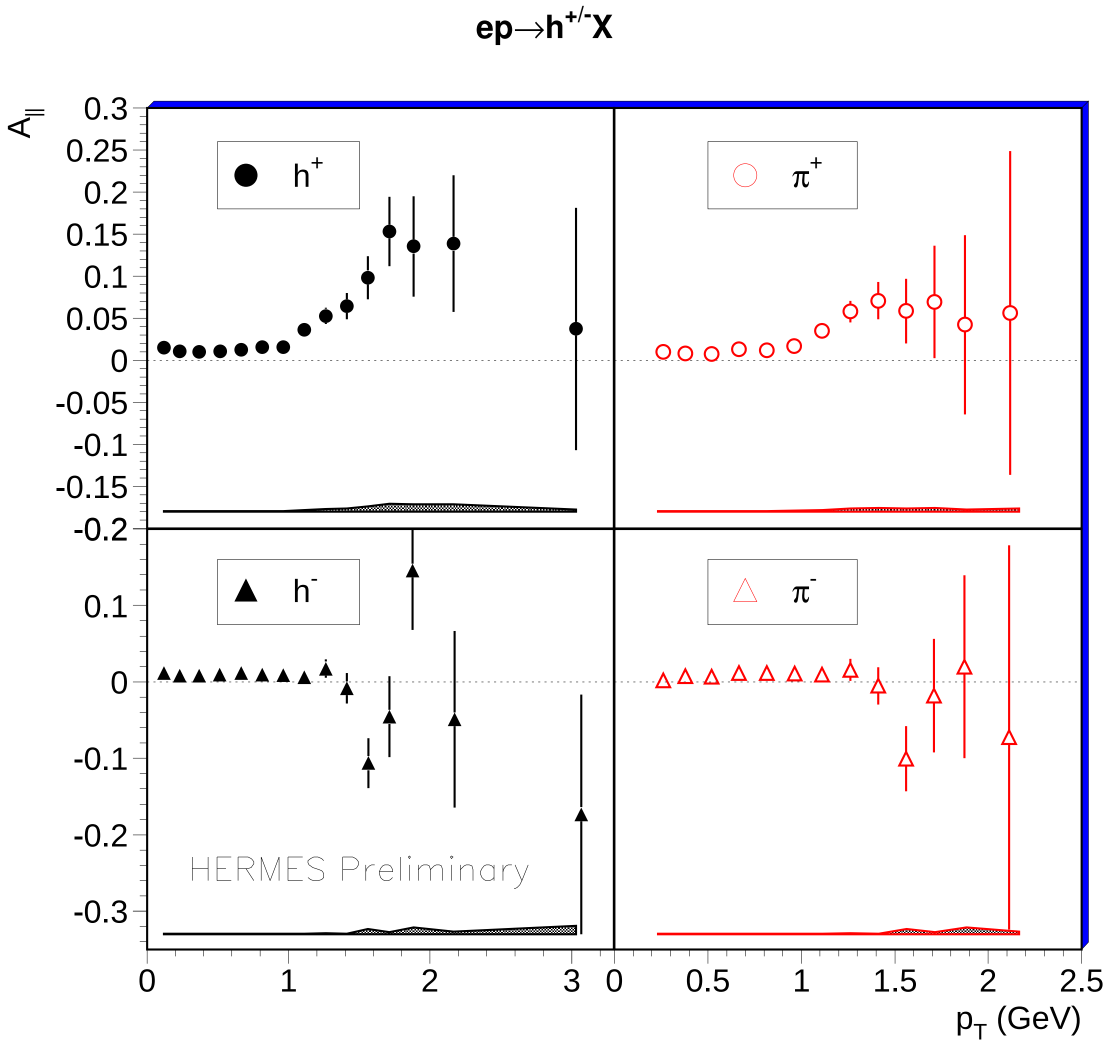
$$e + p \longrightarrow h^{\pm} + X$$

A. Afanasev et al. Phys.Rev.D58 (1998) 054007



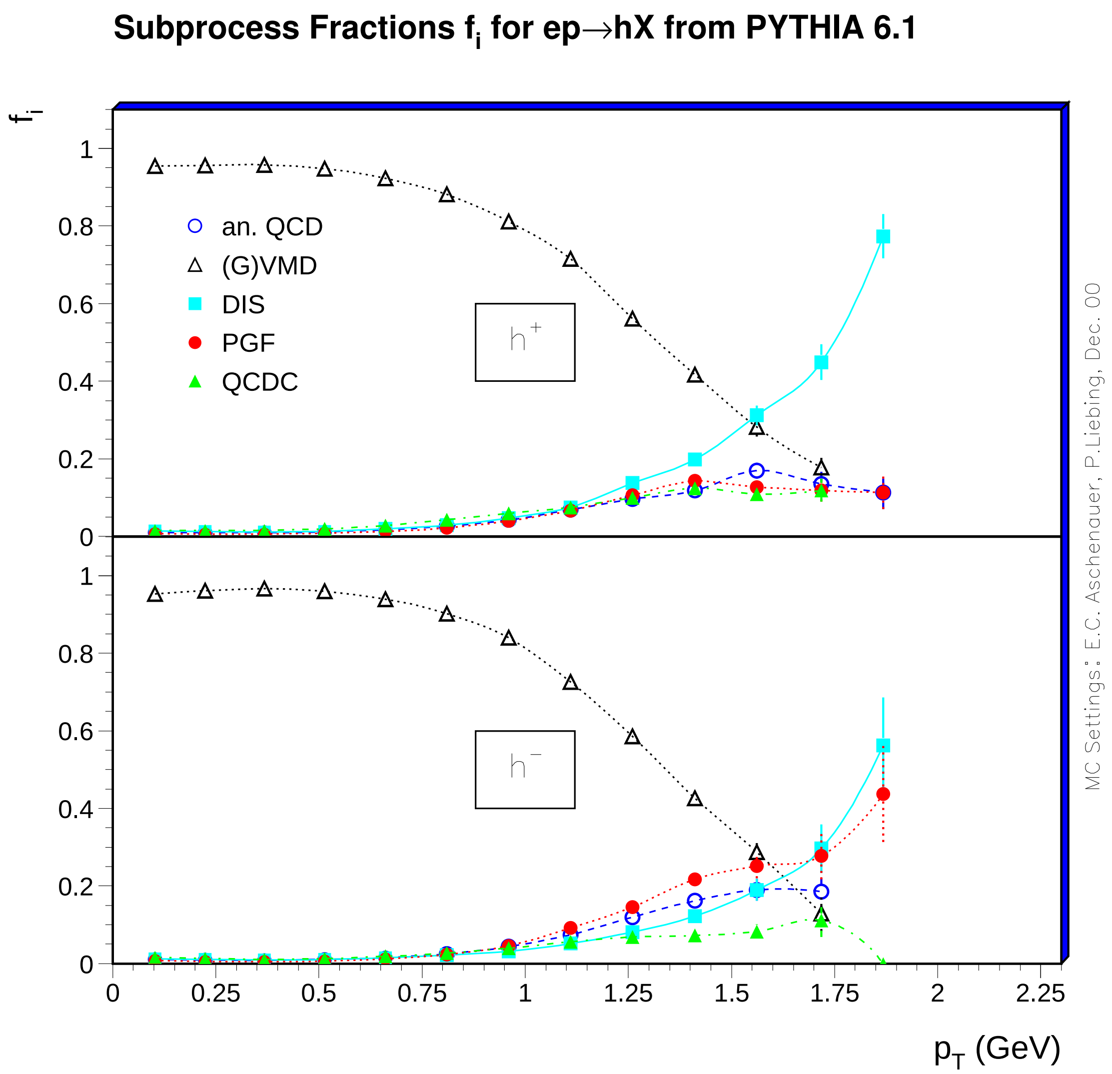
- **look for single high p_T hadrons**
- **Double Spin Asymmetry for h^+ or h^- vs. p_T**
  $\longrightarrow$ Different behavior for h^+ and h^-
- **Higher statistics as from pairs of high p_T hadrons**

10 First Results with a Hydrogen target



- **Hadrons: 2 GeV < p < 27.5 GeV**
  Pions: 4 GeV < p < 13.5 GeV (Cerenkov)
- **Deuterium Analysis still in Progress**
- **Similar result by SLAC (hep-ph9902412)**

11 First Steps to an Interpretation



Why PYTHIA 6?

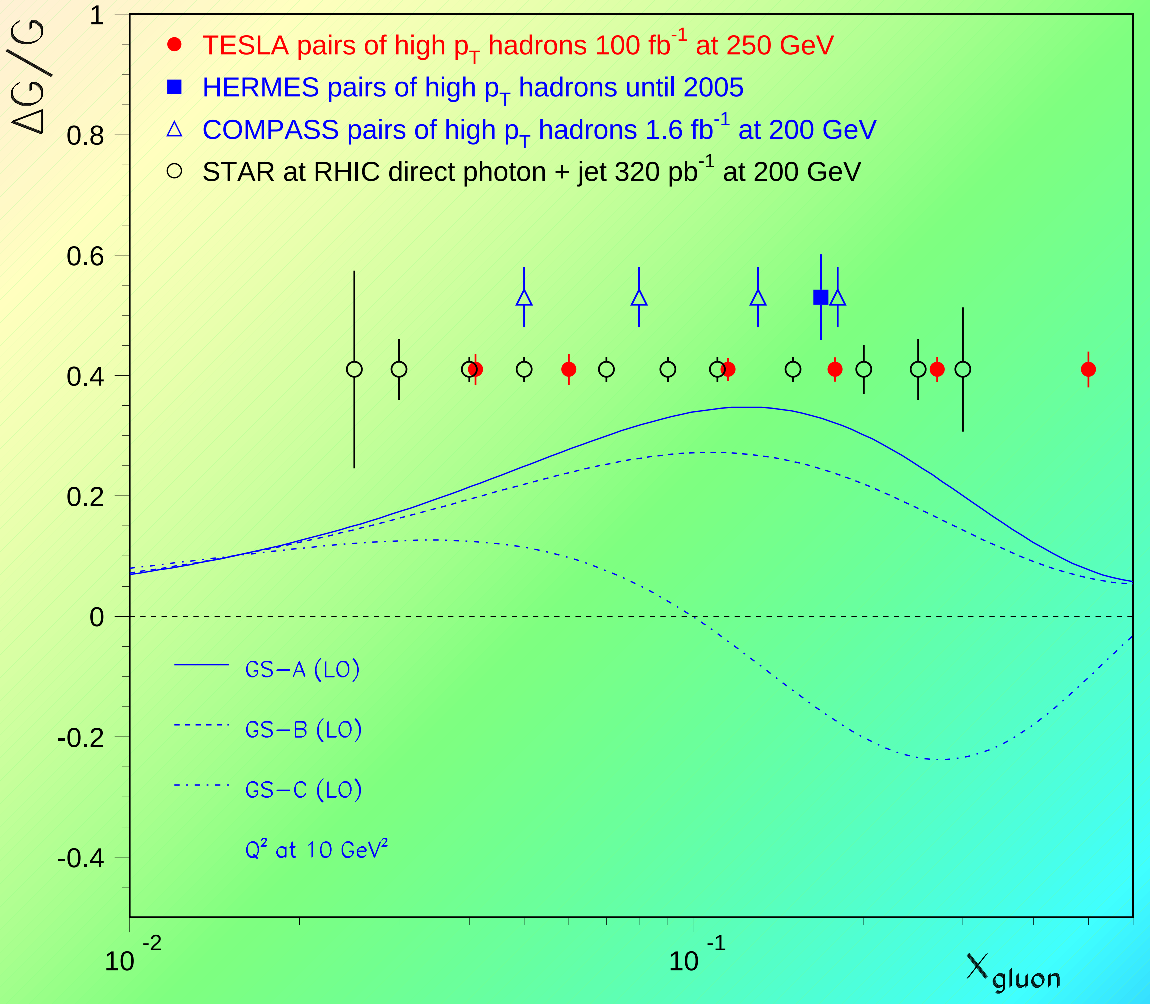
- Includes now virtual photons → DIS
  - ⟶ three scales Q^2, $k_\perp$ and $p_\perp$
  - ⟶ event sorting accordingly
  - ⟶ less double counting
- New optimization for HERMES needed

12 Conclusion

- **Observation of negative double spin asymmetry for hadrons, pions and kaons**
  $\longrightarrow$ Big statistics on Deuterium
  $\longrightarrow$ Data on Deuterium and Hydrogen
  $\longrightarrow$ much harder constraints on Monte Carlo possible
- **New data on double spin asymmetries for inclusive hadrons with high p_T in quasi real photo-production**
- **Ongoing interpretation using PYTHIA 6**
  $\longrightarrow$ need consistent explanation for single and pairs of high p_T hadrons
- **Problem PYTHIA 6 is "only" LO**

New $\Delta G/G$ extraction underway

$\Delta G/G$



in 2010