Measurement of gluon polarisation from high transverse momentum hadrons @ COMPASS

Luís Silva
LIP – Lisbon

lsilva@lip.pt

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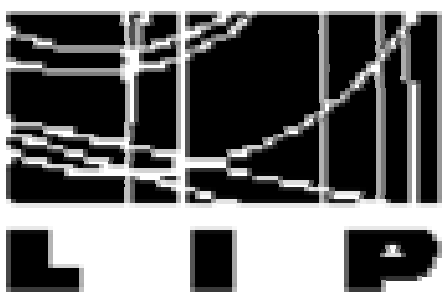
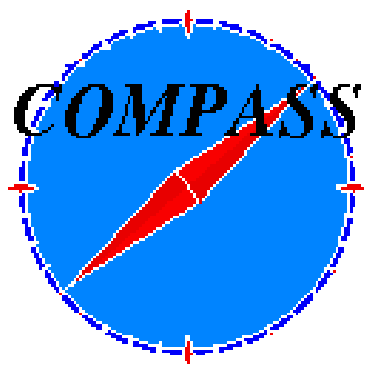
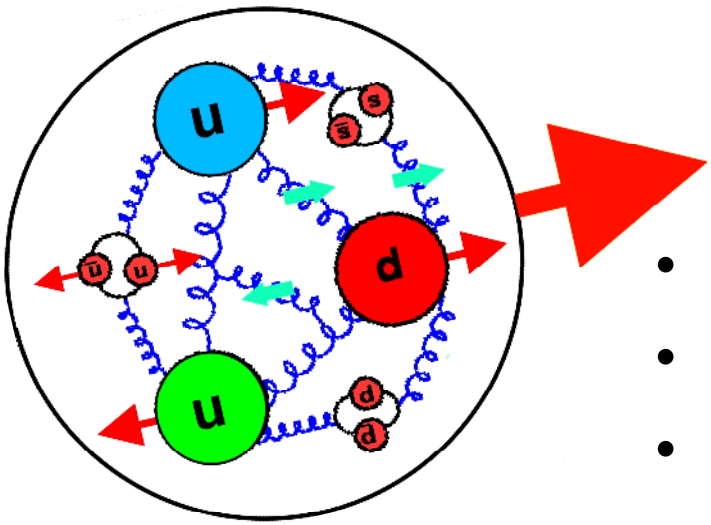




The Nucleon Spin



$$S_N = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_G$$

- Quarks: $\Delta\Sigma = \sum_q (\Delta q + \Delta\bar{q})$
- Gluons: ΔG
- Orbital angular momentum: $L_q + L_G$

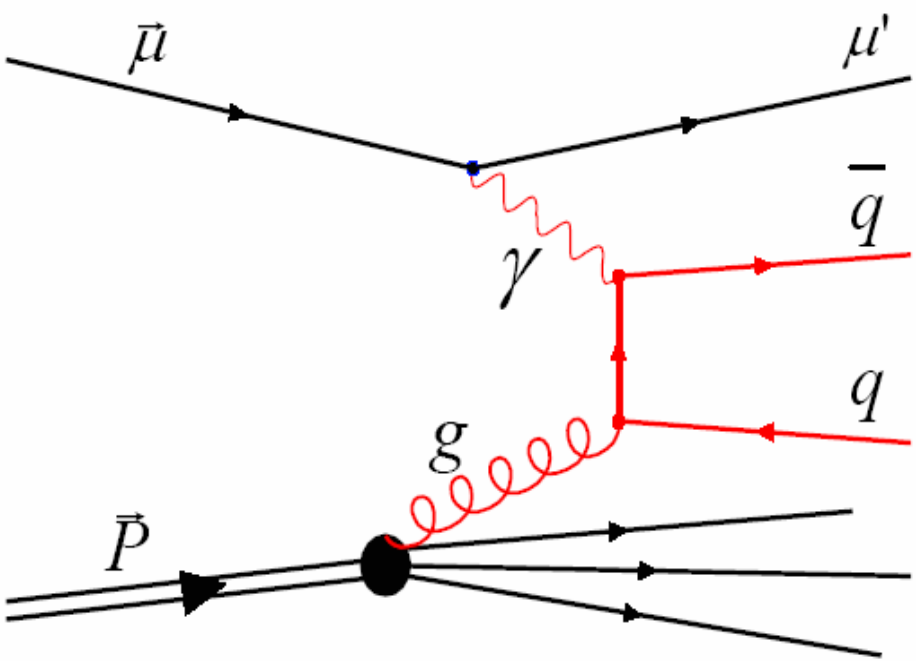
The spin sum rule

- Expectation (SU(3), Δs=0, Ellis/Jaffe): $\Delta\Sigma \approx 0.6$
- Experiments: $\Delta\Sigma \approx 0.2$ (EMC, SMC, SLAC and HERMES)

This puts the quark parton model into some questioning !

Direct measurement of ΔG/G

Photon-gluon fusion process (PGF)



COMPASS uses PGF processes

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

To tag this process there are two procedures concerning event selection :

- Open-charm hadrons
  - ☺ Provide the purest sample of PGF events without background asymmetry.
  - ☹ Low rate statistics, NLO corrections can be important.
- High transverse momentum hadrons $Q^2<1$ and $Q^2>1$ GeV^2
  - ☺ Much more statistics.
  - ☹ Physical background: strongly model dependent, requires a very good agreement between Data and MC.

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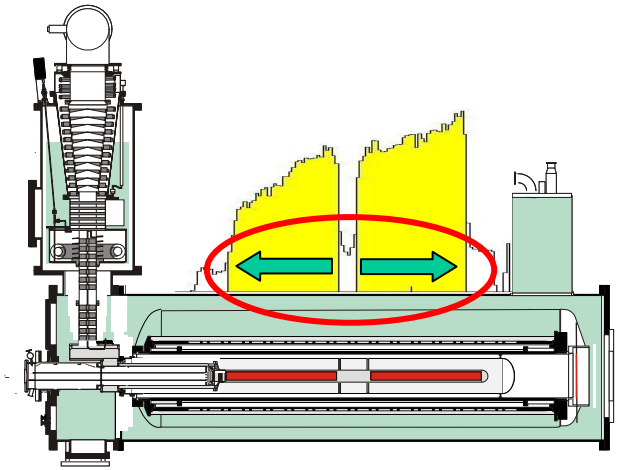
How is ΔG/G measured?

- Asymmetry

$$\frac{A_{LL}^{\mu N}}{D} = \frac{1}{P_T f P_b D} \frac{N^{\Leftarrow} - N^{\Leftarrow}}{N^{\Leftarrow} + N^{\Leftarrow}}$$

target polarisation $P_T \approx 0.50$
dilution factor $f \approx 0.40$
beam polarisation $P_b \approx 0.76$
depolarisation factor D



- ΔG/G

$$\frac{A_{LL}^{\mu N}}{D} = \frac{a_{LL}^{PGF}}{D} \frac{\Delta G}{G} \frac{\sigma^{PGF}}{\sigma^{tot}} + \frac{A_{LL}^{Background}}{D}$$

Different background contributions for the different channels

Determined from MC

$$a_{LL} = \frac{\Delta\sigma^{\mu g}}{\sigma^{\mu g}}$$

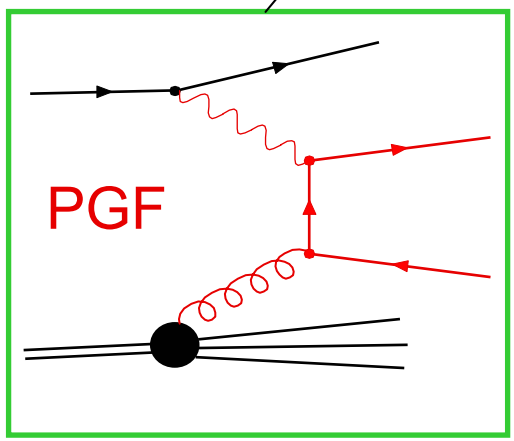
$$R^{PGF} = \frac{\sigma^{PGF}}{\sigma^{tot}}$$

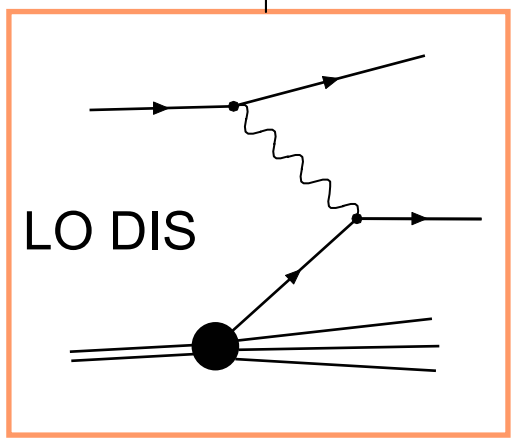
MC needs to be very well tuned

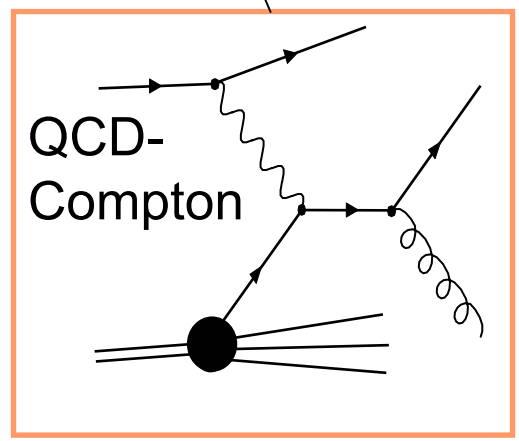
ΔG/G Measurement

Asymmetry: A_{LL}/D = - 0.015 ± 0.080 stat. ± 0.013 syst. (2002 + 2003)

$$\frac{A_{LL}}{D} \approx \frac{a_{LL}^{PGF}}{D}\frac{\Delta G}{G}\frac{\sigma^{PGF}}{\sigma^{tot}} + A_1\frac{a_{LL}^{LO}}{D}\frac{\sigma^{LO}}{\sigma^{tot}} + A_1\frac{a_{LL}^{QCD-C}}{D}\frac{\sigma^{QCD-C}}{\sigma^{tot}}$$







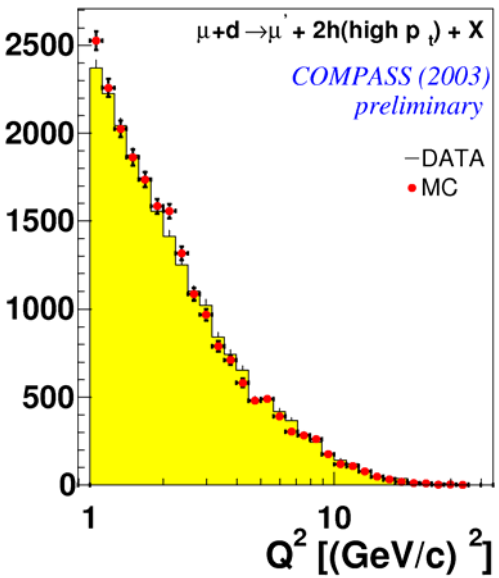
$\left\langle \hat{a}_{LL}^{PGF} / D \right\rangle \approx -0.75 \pm 0.05$

$A_1^d \approx 0$, $Q^2>1$

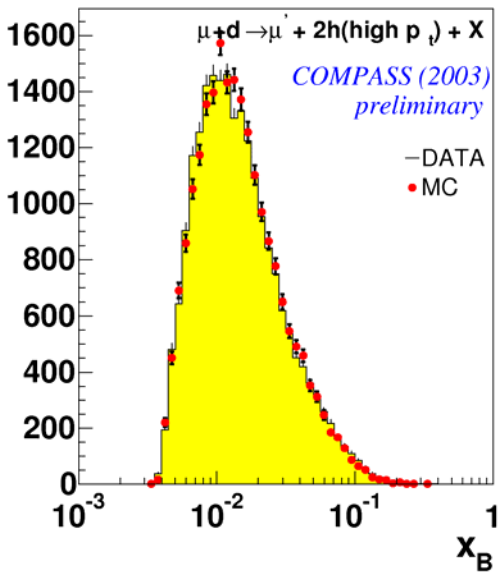
$\left\langle \hat{a}_{LL}^{Com} / D \right\rangle \left\langle \frac{\Delta q}{q} \right\rangle \approx 0$, $Q^2>1$ GeV ^{2}

Monte Carlo For Q^2>1 GeV^2

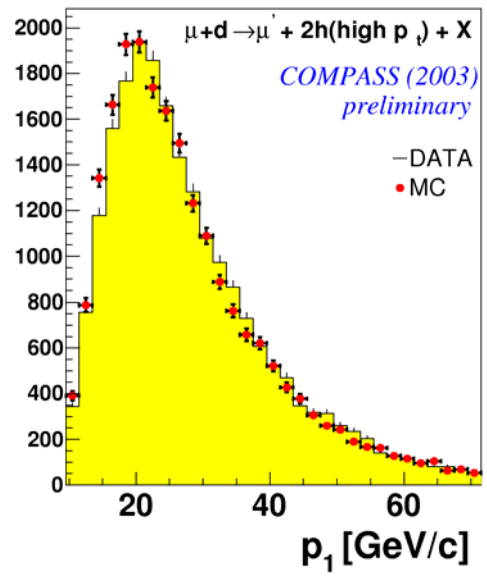
LEPTO (MC) was used as event generator



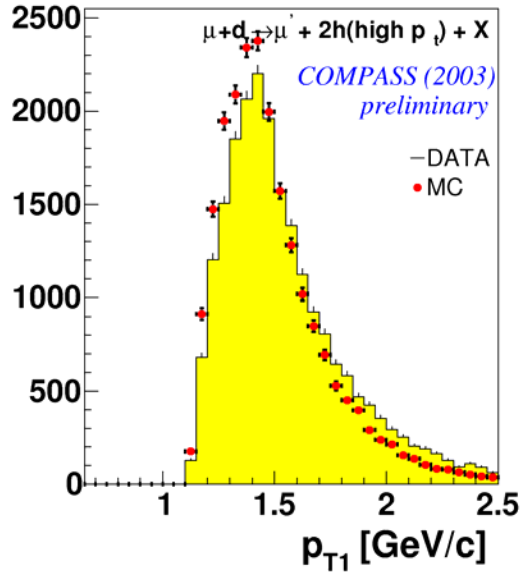
Q^2



X_B



p leading hadron



p_T leading hadron

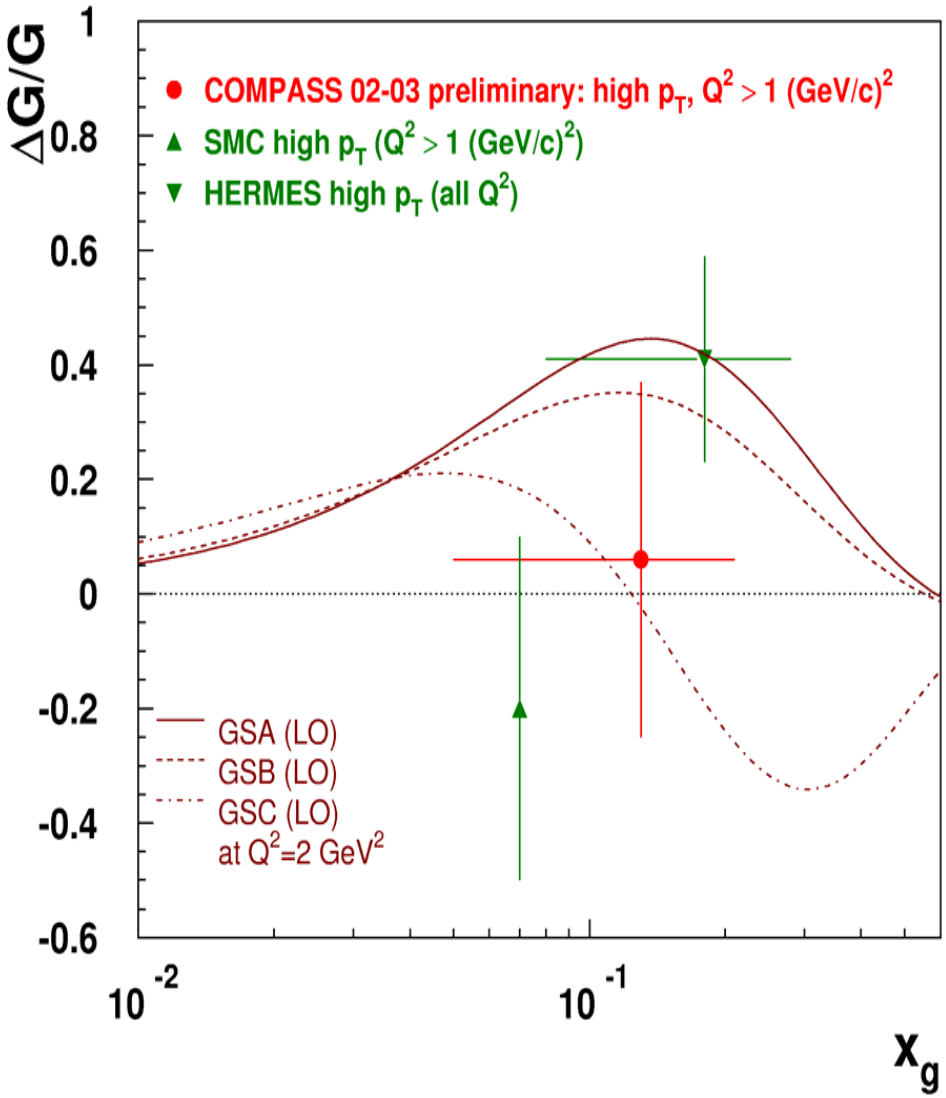
$$a_{LL}^{PGF} / D = -0.75 \pm 0.05$$

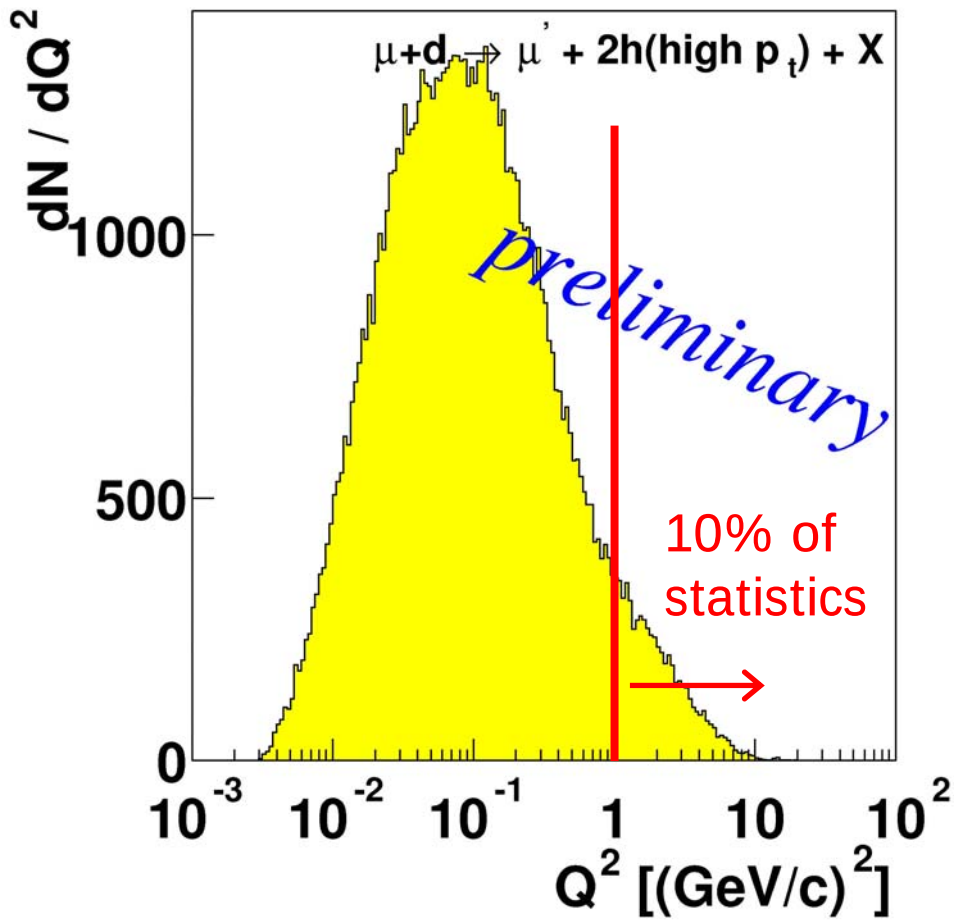
$$R^{PGF} = \frac{\sigma^{PGF}}{\sigma^{tot}} = 0.34 \pm 0.07$$

Gluon Polarisation, $Q^2 > 1$ GeV^2

at $\langle x_g \rangle = 0.13 \pm 0.08$

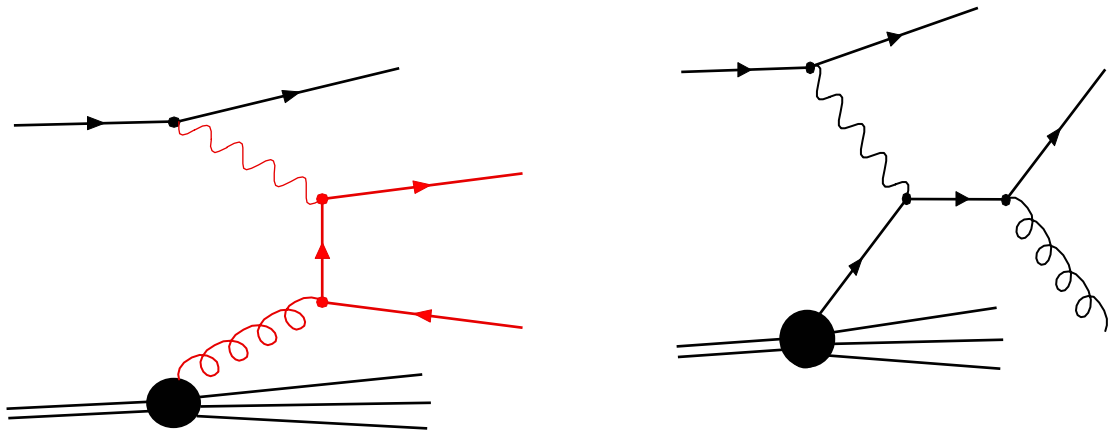
$$\frac{\Delta G}{G} = +0.06 \pm 0.31_{\text{stat.}} \pm 0.06_{\text{syst.}}$$





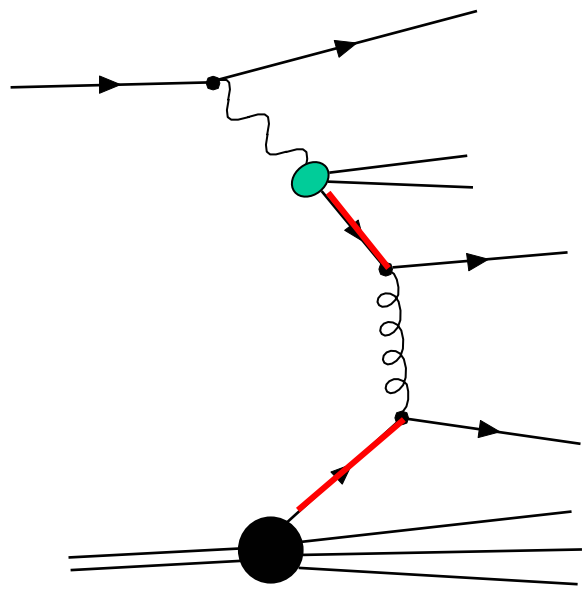
Asymmetry measurement, $Q^2<1$ GeV^2

$$A_{LL}^{\mu N} / D = R^{PGF} \; a_{LL}^{PGF} / D \; \Delta G / G + R^{QCD-C} \; a_{LL}^{QCD-C} / D \; A_1$$



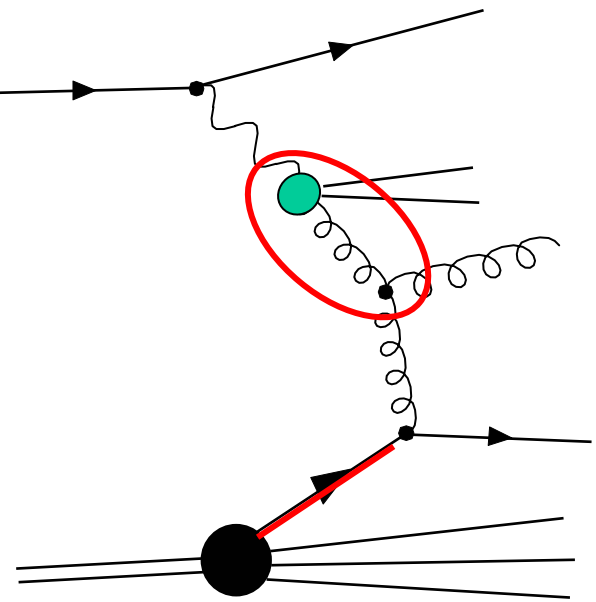
Asymmetry measurement, $Q^2<1$ GeV^2

$$A_{LL}^{\mu N}/D = R^{PGF}\ a_{LL}^{PGF}/D\ \ \Delta G/G + R^{QCD-C}\ a_{LL}^{QCD-C}/D\ A_1$$
$$+ R^{qq'}\ a_{LL}^{qq'}/D\ A_1\ A_1^{\gamma}$$



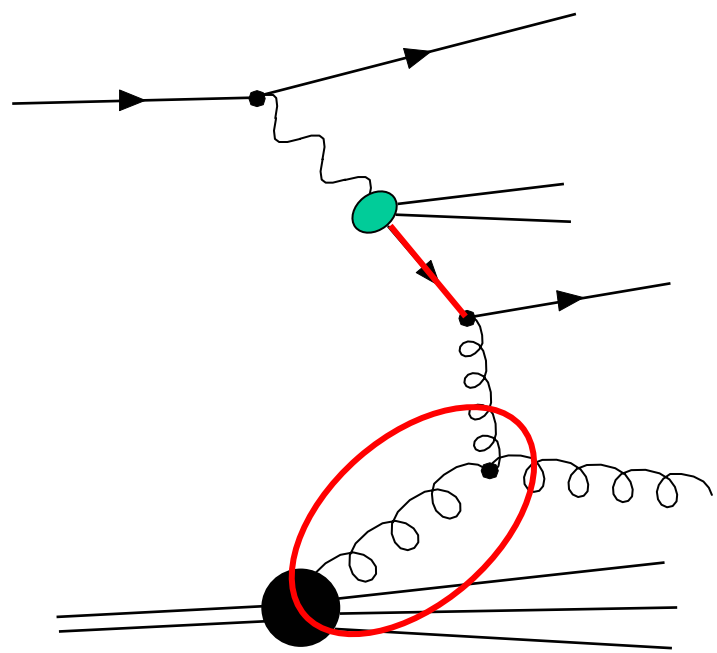
Asymmetry measurement, $Q^2<1$ GeV^2

$$A_{LL}^{\mu N}/D = R^{PGF}\ a_{LL}^{PGF}/D\ \ \Delta G/G + R^{QCD-C}\ a_{LL}^{QCD-C}/D\ A_1$$
$$+ R^{qq'}\ a_{LL}^{qq'}/D\ A_1\ A_1^{\gamma}$$
$$+ R^{qg}\ a_{LL}^{qg}/D\ A_1\ \left(\Delta G/G\right)^{\gamma}$$



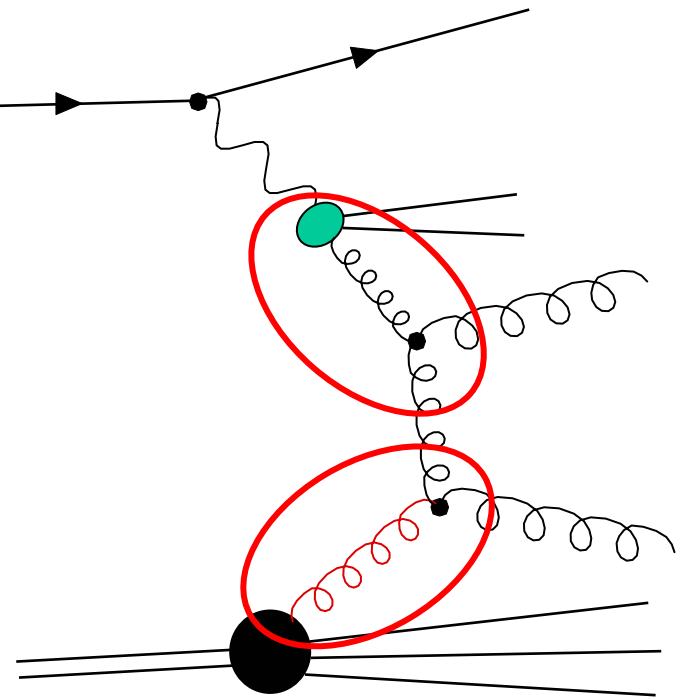
Asymmetry measurement, $Q^2<1$ GeV^2

$$A_{LL}^{\mu N}/D = R^{PGF}\ a_{LL}^{PGF}/D\ \ \Delta G/G + R^{QCD-C}\ a_{LL}^{QCD-C}/D\ A_1$$
$$+ R^{qq'}\ a_{LL}^{qq'}/D\ A_1\ A_1^{\gamma}$$
$$+ R^{qg}\ a_{LL}^{qg}/D\ A_1\ \left(\Delta G/G\right)^{\gamma}$$
$$+ R^{gq}\ a_{LL}^{gq}/D\ \Delta G/G\ A_1^{\gamma}$$



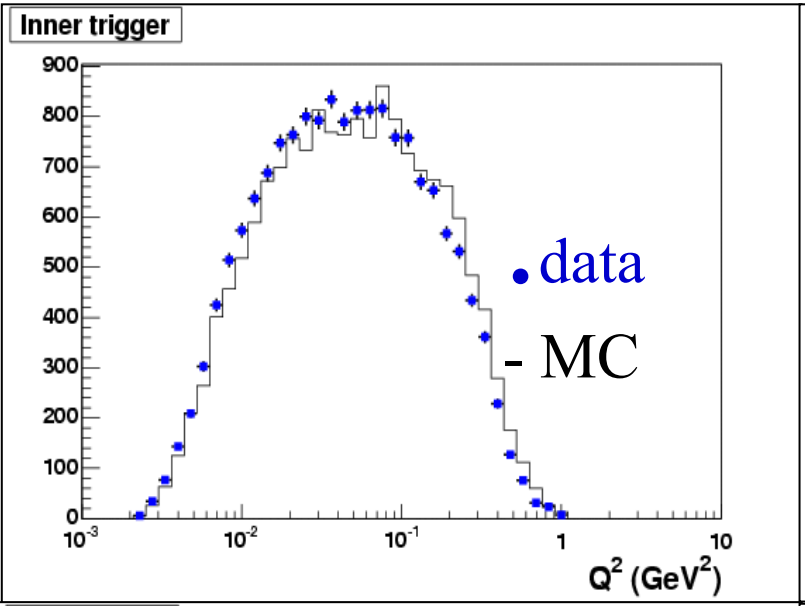
Asymmetry measurement, $Q^2<1$ GeV^2

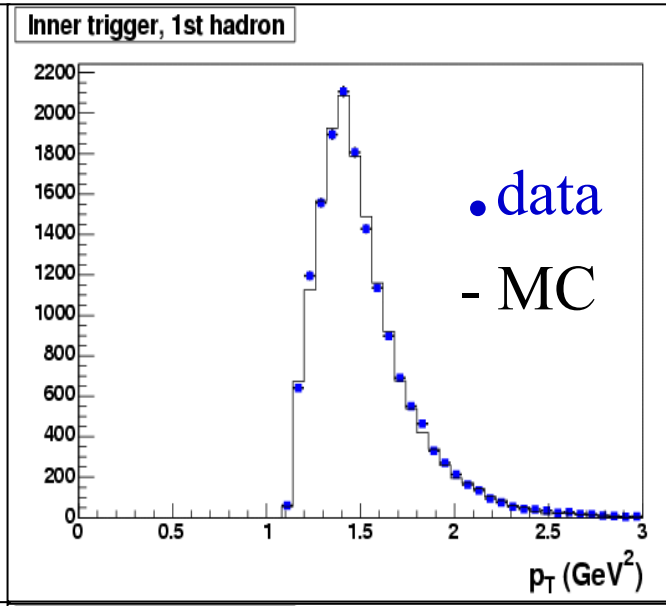
$$A_{LL}^{\mu N}/D = R^{PGF}\ a_{LL}^{PGF}/D\ \ \Delta G/G + R^{QCD-C}\ a_{LL}^{QCD-C}/D\ A_1$$
$$+ R^{qq'}\ a_{LL}^{qq'}/D\ A_1\ A_1^{\gamma}$$
$$+ R^{qg}\ a_{LL}^{qg}/D\ A_1\ \left(\Delta G/G\right)^{\gamma}$$
$$+ R^{gq}\ a_{LL}^{gq}/D\ \Delta G/G\ A_1^{\gamma}$$
$$+ R^{gg}\ a_{LL}^{gg}/D\ \Delta G/G\ \left(\Delta G/G\right)^{\gamma}$$

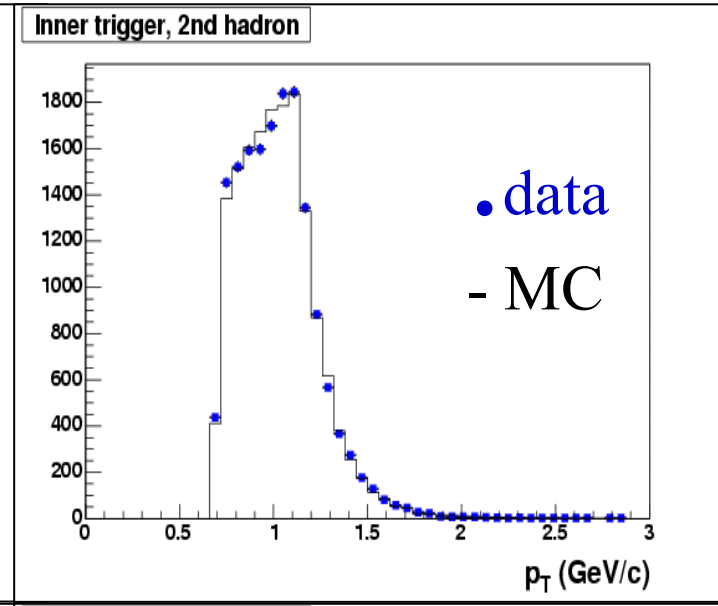


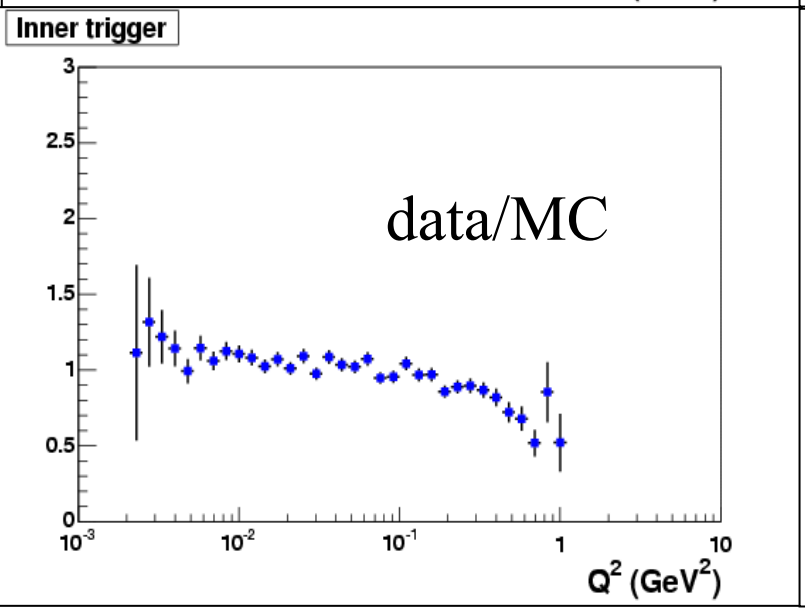
Data – Monte Carlo comparison, $Q^2<1$ GeV^2

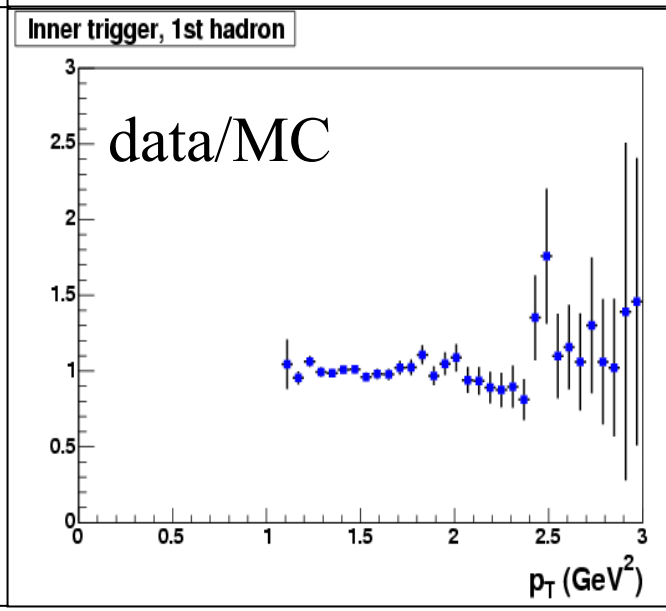
PYTHIA (MC) was used as event generator

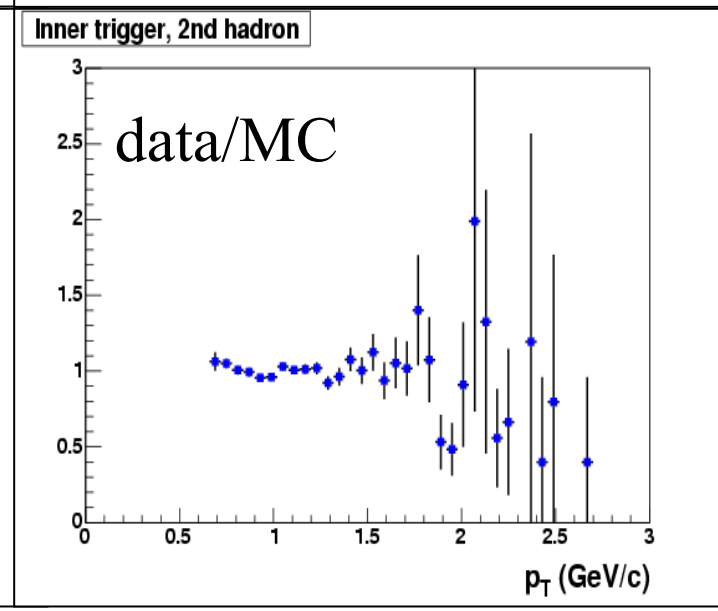










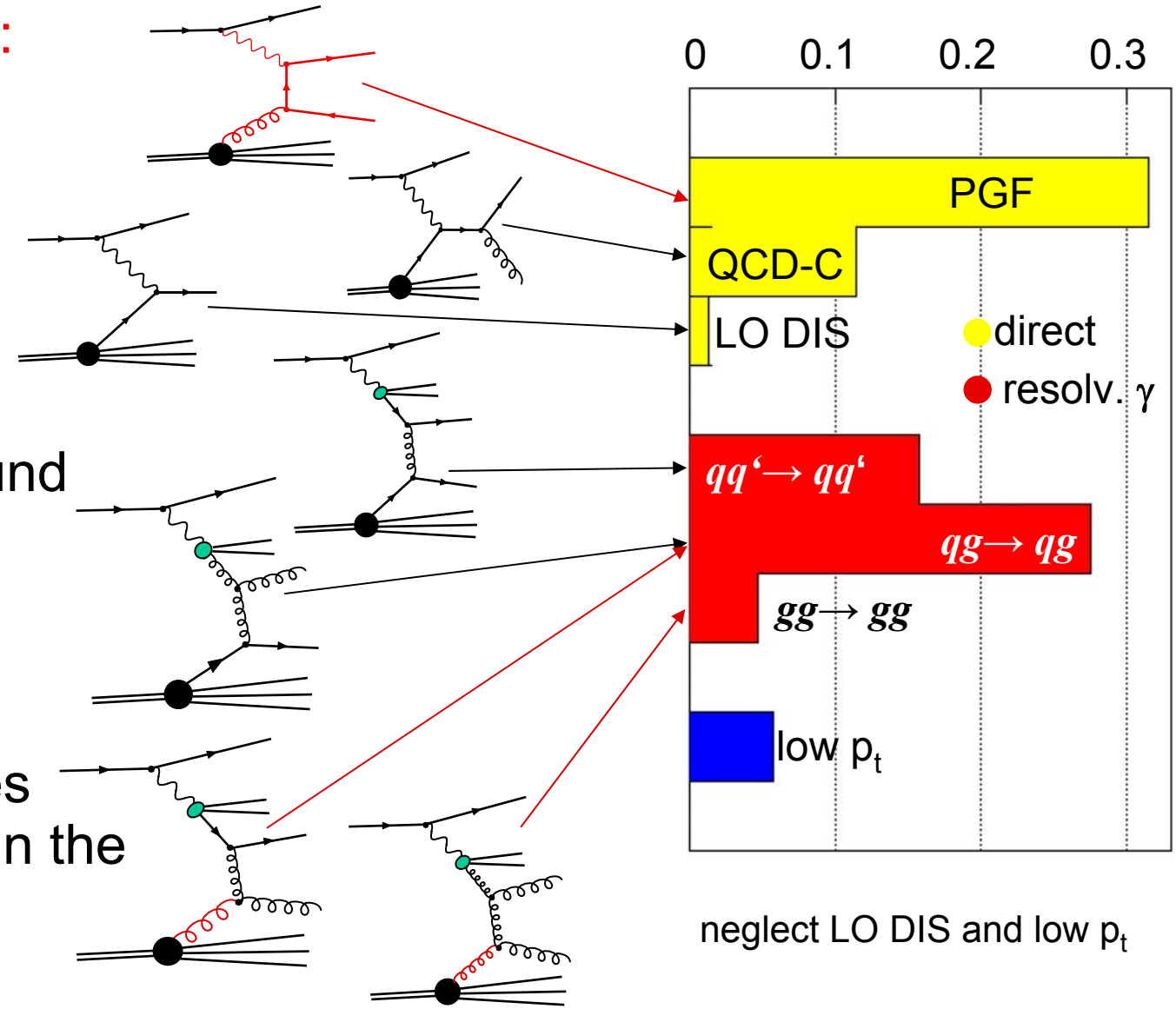


Luís Silva (lsilva@lip.pt)

PGF and Background events, $Q^2<1$ GeV^2

Results from PYTHIA :

- Background as for $Q^2 > 1$ GeV^2
- Additional background from resolved photon events
- Additional processes sensitive to gluons in the nucleon



New theoretical uncertainty

Contribution from resolved photons

- Problem: polarised PDF of the photon is not measured !

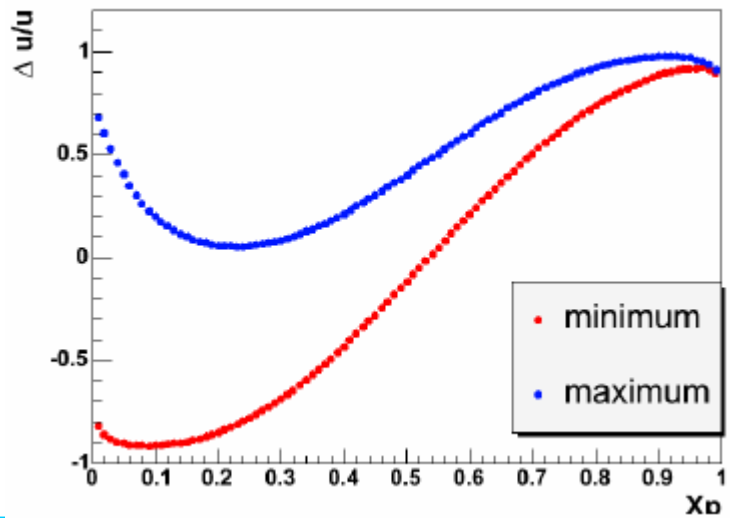
  → use unpolarised PDF to constrain polarised

$$-q^{\gamma}(x,Q^2) < \Delta q^{\gamma}(x,Q^2) < q^{\gamma}(x,Q^2)$$

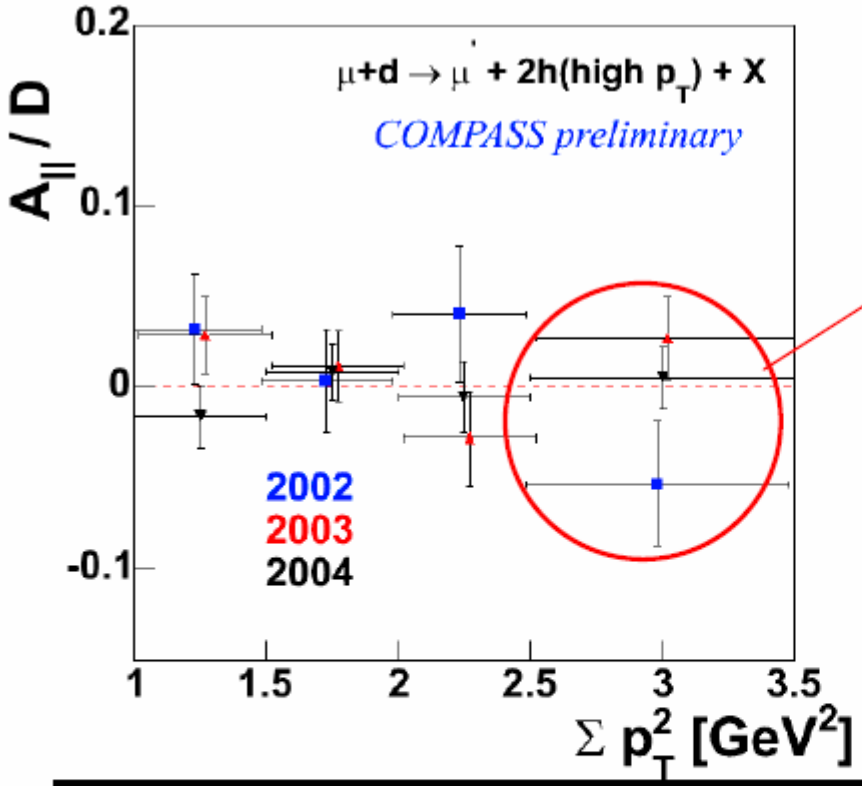
This lids us to 2 extreme (max & min) scenarios

additional uncertainty band.

Glück, Reya, Sieg, *Eur. Phys. J. C20* (2001) 271



Gluon Polarisation, $Q^2<1$ GeV^2



Values used for extraction of $\Delta G/G$

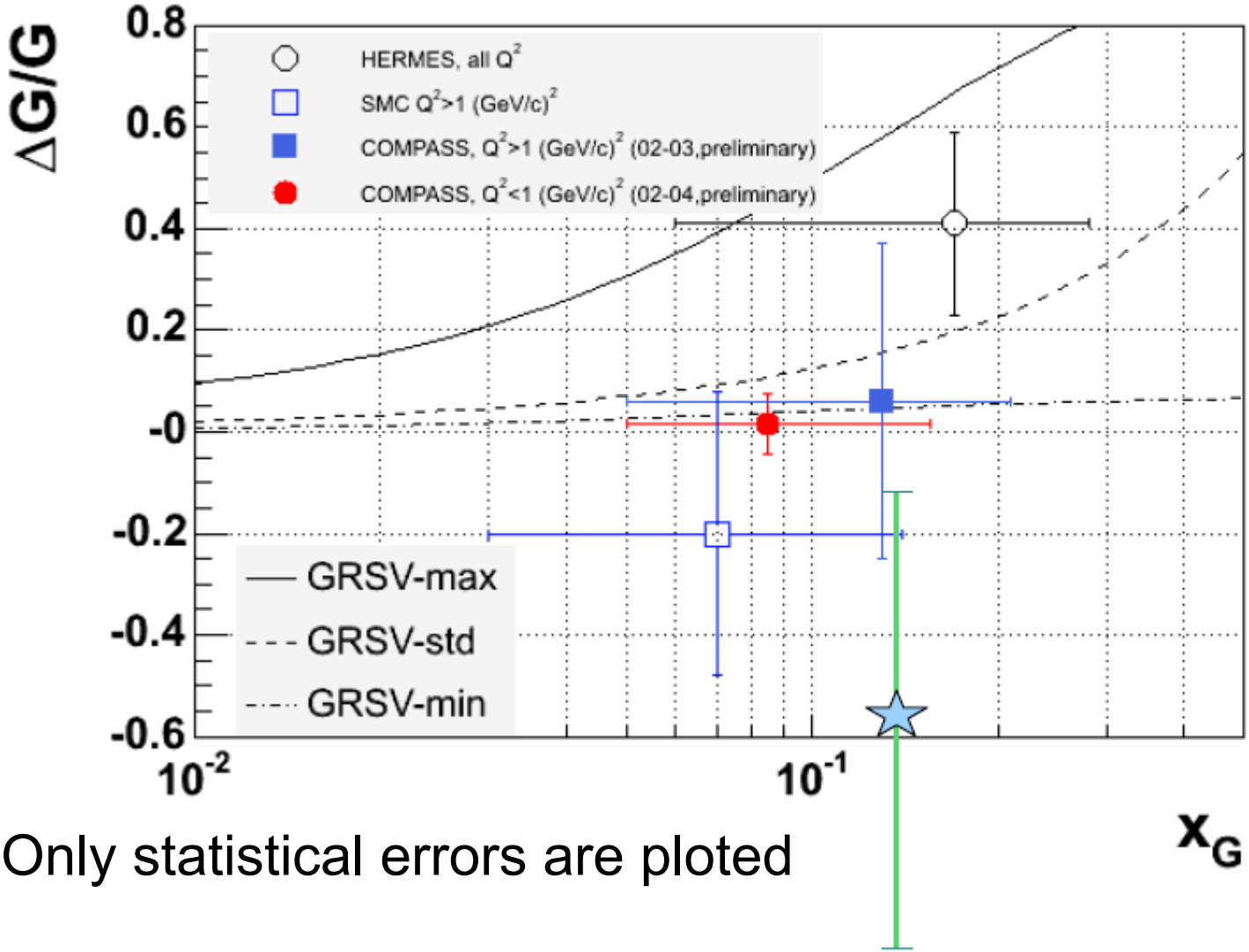
$$@\, x_g = 0.085^{+0.071}_{-0.035}$$

data	$(\Delta G/G)(x_g)$	stat	exp.syst	MC.syst	γ
02-03	0.024	0.089	0.014	0.052	0.018
02-04	0.016	0.058	0.014	0.052	0.013

hep-ex/0511028, CERN-PH-EP/2005-049, Phys. Lett. B 633 (2006) 25 - 32

High p_T Results

$$\int \Delta G(x) = 2.5$$



$$\int \Delta G(x) = 0.62$$

$$\int \Delta G(x) = 0.16$$

★ Open charm

Only statistical errors are ploted

Glück et al., *Phys. Rev. D63* (2001) 094005

Summary and conclusions

- The measurement gluon polarisation ΔG/G at COMPASS with high momentum hadrons has been presented.
- Small ΔG/G is preferred. Or has a node around 0.1
- Ellis-Jaffe sum rule seems to be violated if large ΔG is excluded.

➢ ΔG ≈ 0.4 is not excluded and scenario with orbital angular momentum small still possible.
➢ ΔG ≈ 0 indicates an important role of angular orbital momentum in nucleon spin decomposition described in the frame of the parton model and pQCD.

→ Q^2 >1 analysis of 2004 data coming soon !

→ 2006 run will bring more and new data.