Recent gluon polarization results from COMPASS

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on behalf of the COMPASS Collaboration

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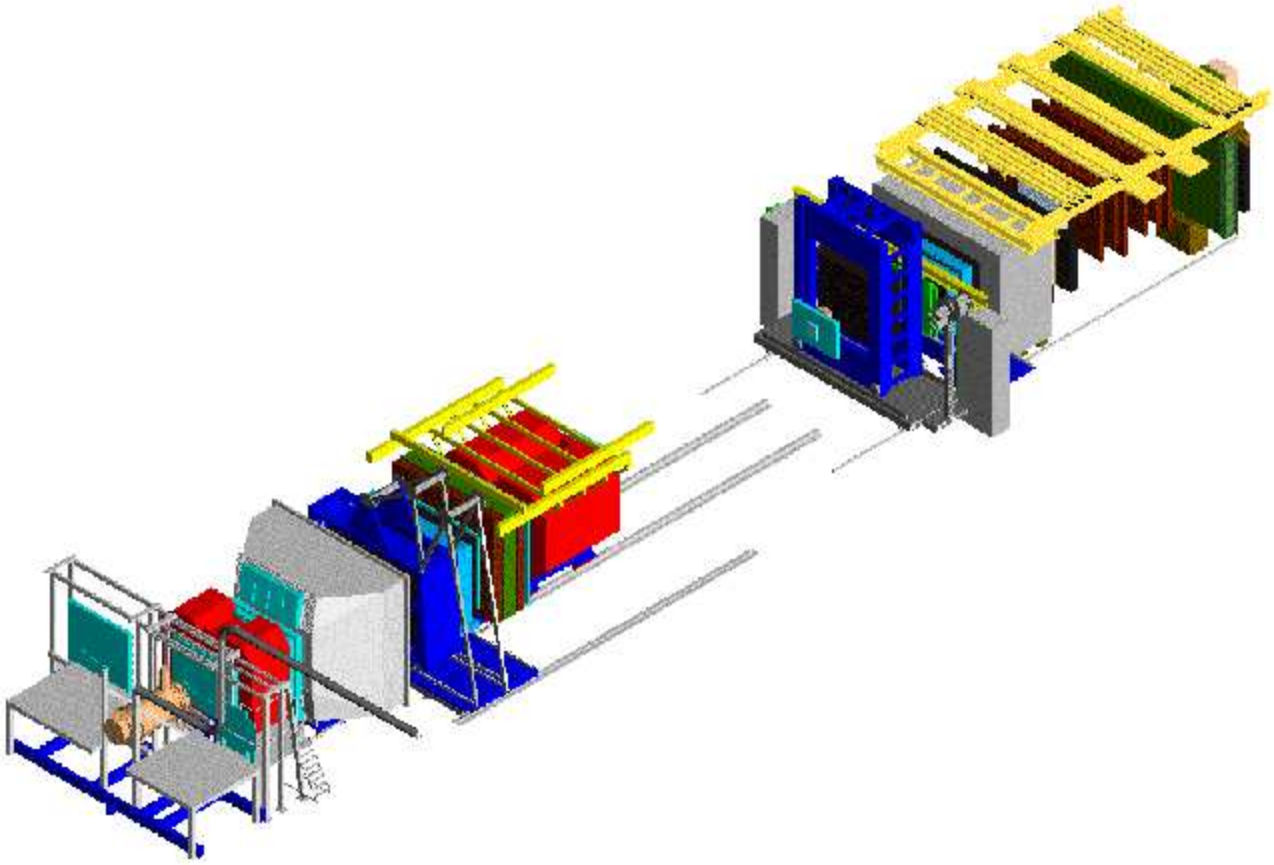
- The COMPASS experiment
- How to measure asymmetries in DIS
- Extract $\Delta G/G$ from PGF events:
  - ⋆ Analysis of open charm events
  - ⋆ Analysis of high p_T hadron pairs, at $Q^2 > 1$ GeV^2
  - ⋆ Analysis of high p_T hadron pairs, at $Q^2 < 1$ GeV^2
- Summary and conclusions

The COMPASS Experiment at CERN



Naturally polarized μ^+ beam at 160 GeV/c ($P_B \approx -76\%$)

Beam intensity: 2×10^8 μ^+/spill (4.8/16.2 s)

Longitudinally polarized ^6LiD target ($P_T \approx 50\%$)

The spin content of the nucleon

$$\textbf{Nucleon Spin: } \tfrac{1}{2} = \tfrac{1}{2}\,\Delta\Sigma + \Delta G + \langle\, L_z \,\rangle$$

quarks spin — gluons spin — orbital ang. mom.

- From a naive partons model, including relativistic corrections, one would expect: $\Delta\Sigma = 0.6$
- But, in 1988, EMC measured: $\Delta\Sigma = 0.12 \pm 0.09 \pm 0.14$

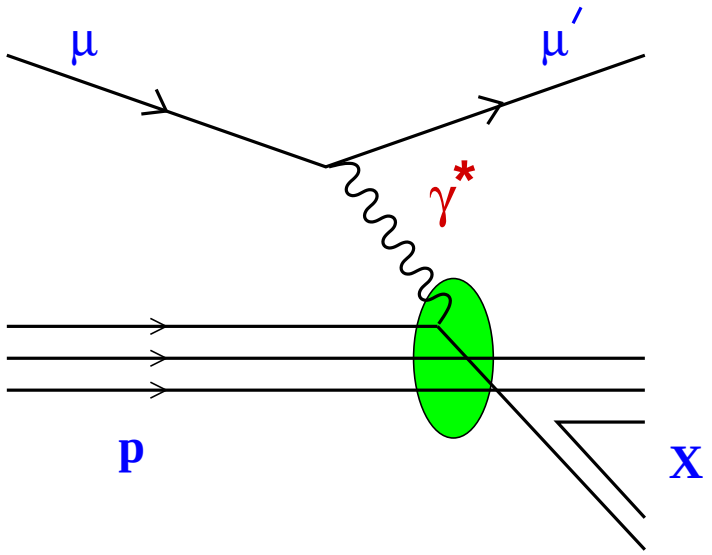
⇓

A measurement of ΔG is needed

Measuring asymmetries in DIS

After event selection, we measure the asymmetry between the 2 target cells with oposite polarisations:

$$\frac{A_{\parallel}}{D} = \frac{1}{f P_T P_B D} \left(\frac{N^{\Rightarrow} - N^{\Leftarrow}}{N^{\Rightarrow} + N^{\Leftarrow}} \right)$$



P_T and P_B: target and beam average polarizations

D: γ^* depolarization factor

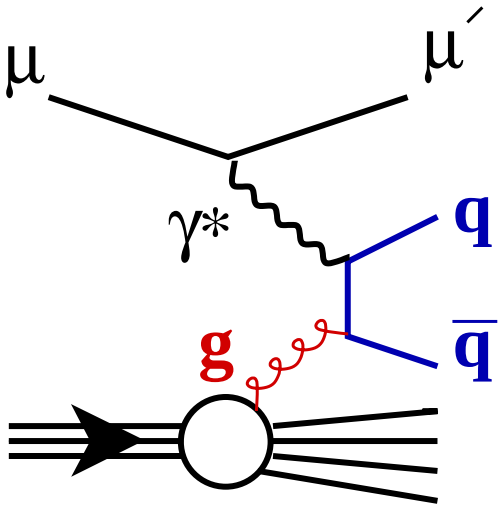
$\langle D \rangle \approx 0.6$

f: target dilution factor

$\langle f \rangle = 0.4$

$\Delta G/G$ from PGF

The gluon polarization in the nucleon, $\Delta G/G$, can be accessed via the **photon-gluon fusion** process.



$$A_{\gamma N}^{PGF} = \frac{\int d\hat{s}\, \Delta\sigma^{PGF}(\hat{s})\, \Delta G(x_g, \hat{s})}{\int d\hat{s}\, \sigma^{PGF}(\hat{s})\, G(x_g, \hat{s})}$$

$$\approx \langle a_{LL}^{PGF} \rangle \frac{\Delta G}{G}$$

$\langle a_{LL}^{PGF} \rangle$: analysing power

The percentage of PGF events in the sample is increased by selecting:

- hadron pairs with high p_T: **q=u,d,s**
- open-charm production: D^0 and D^* events: $\mathbf{q = c}$

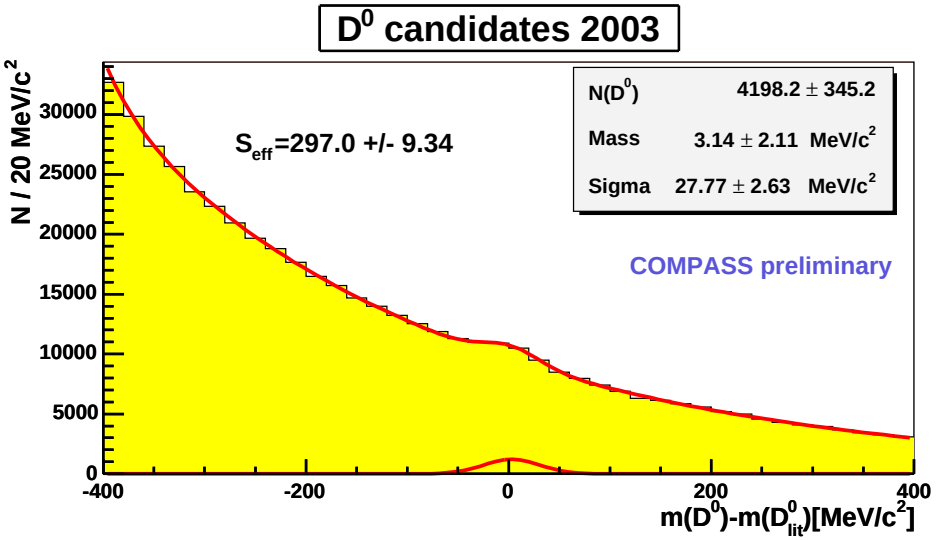
PGF in open charm events

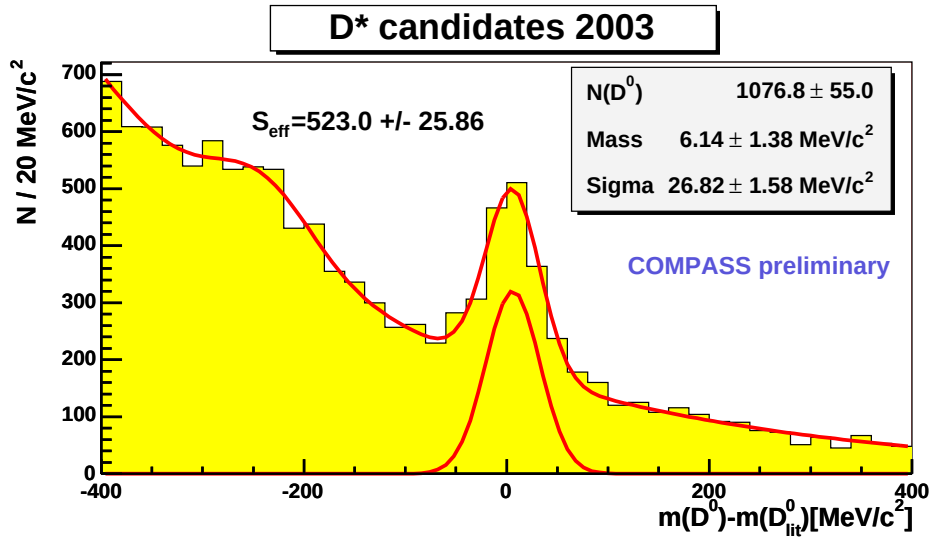
$$D^{*\pm} \to D^0 \pi^{\pm}_{soft} \quad (BR\,68\%)$$

$$D^0 \to K^- \pi^+ \quad (BR\,4\%)$$

Event selection:

- RICH is used for particle identification.
- **Raw asymmetries** are calculated from events in a mass window around the peaks.

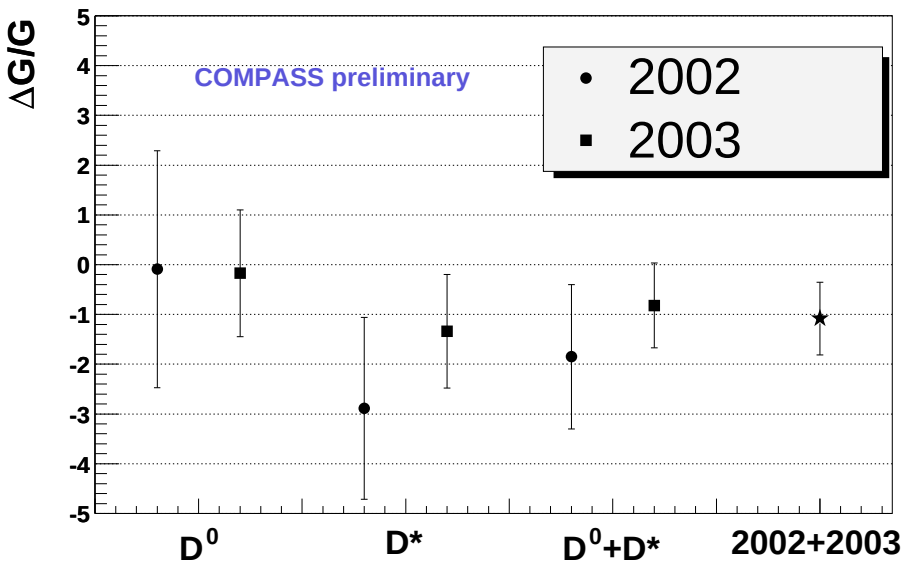




$$A_{Raw} = f P_B a_{LL} P_T \frac{S}{S+B} \frac{\Delta G}{G}$$

$\Delta G/G$ from open charm 2002+2003 data

- ★ no physics background
- ★ ...but low statistics



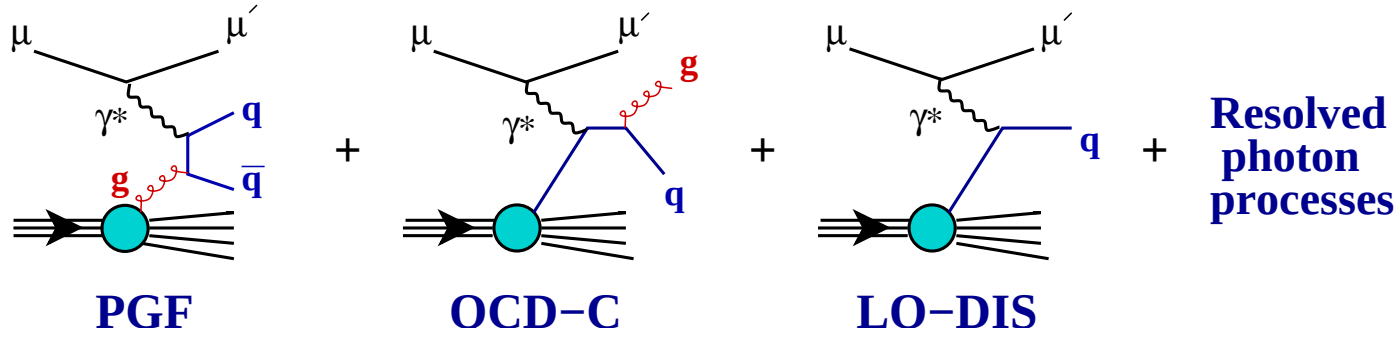
- ♦ $\langle a_{LL} \rangle$ calculated from MC (AROMA generator)
- ♦ Good description of data kinematics (p_T, z_D and y) by MC

$$\langle \Delta G/G \rangle = -1.08 \pm 0.73(stat.)$$

$\hookrightarrow$ at $\langle x_g \rangle = 0.15$ (RMS 0.08)

PGF in high p_T hadron pairs

The measured cross-section asymmetry $A_{\parallel}/D$ results from the sum of all **physics contributions**:



$Q^2 > 1$ GeV^2 : LEPTO (10% of the data)

$Q^2 < 1$ GeV^2 : PYTHIA (90% of the data)

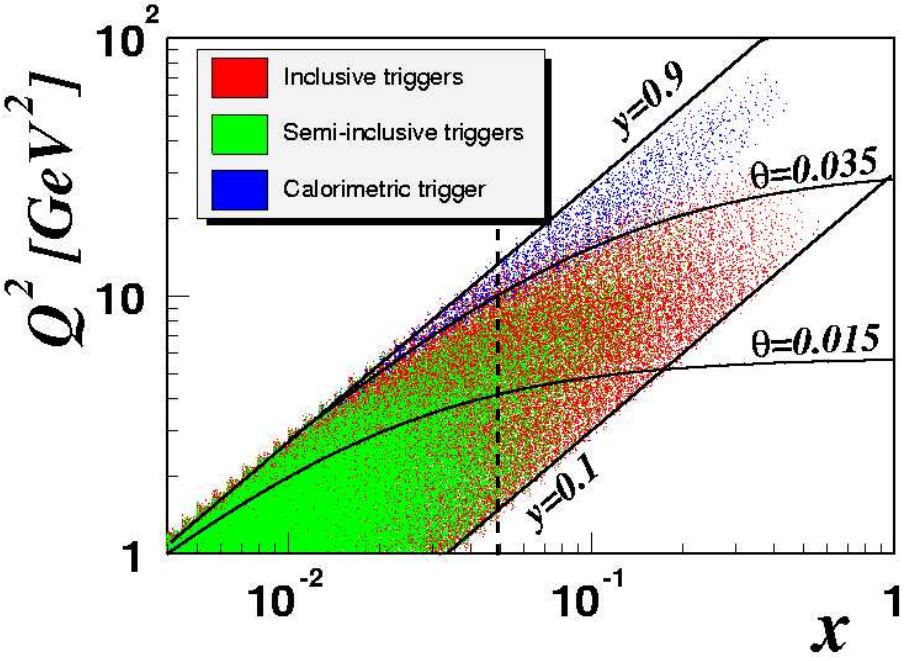
$$\frac{A_{\parallel}}{D} = R_{PGF} \left\langle \frac{a_{LL}^{PGF}}{D} \right\rangle \frac{\Delta G}{G} + \text{Background asymmetry}$$

R_{PGF} and a_{LL}^{PGF}/D are extracted from MC

$$R_{PGF} = \frac{\sigma_{PGF}}{\sigma_{tot}}$$

High p_T hadron pairs

$Q^2 > 1$ GeV^2



z: fraction of energy from γ^* taken by the hadron

y: fraction of energy lost by the incident muon

Selection of events with 2 hadrons

- $p_{T,1} > 0.7$ GeV/c
  $p_{T,2} > 0.7$ GeV/c
- $p_{T,1}^2 + p_{T,2}^2 > 2.5$ (GeV/c)^2
- $z > 0.1$ and $x_F > 0.1$

And kinematical cuts:

- $0.1 < y < 0.9$
- $x < 0.05$:
  in this region, because $A_1^d \approx 0$, QCD-C and LO-DIS can be neglected.

$\Delta G/G$ for $Q^2 > 1$ GeV^2

2002+2003 data

The analysis of the 28K events gives:

$$\frac{A_\parallel}{D} = -0.015 \pm 0.080(stat.) \pm 0.013(syst.)$$

- The MC sample obtained compares well with data

$$\Downarrow$$

$$\langle a_{LL}/D \rangle = -0.75 \pm 0.05$$

$$R_{PGF} = 0.33 \pm 0.07$$

$$\hookrightarrow \Delta G/G = 0.06 \pm 0.31(stat.) \pm 0.06(syst.)$$

at an average gluon momentum fraction $\langle x_g \rangle = 0.13$ (RMS 0.08)

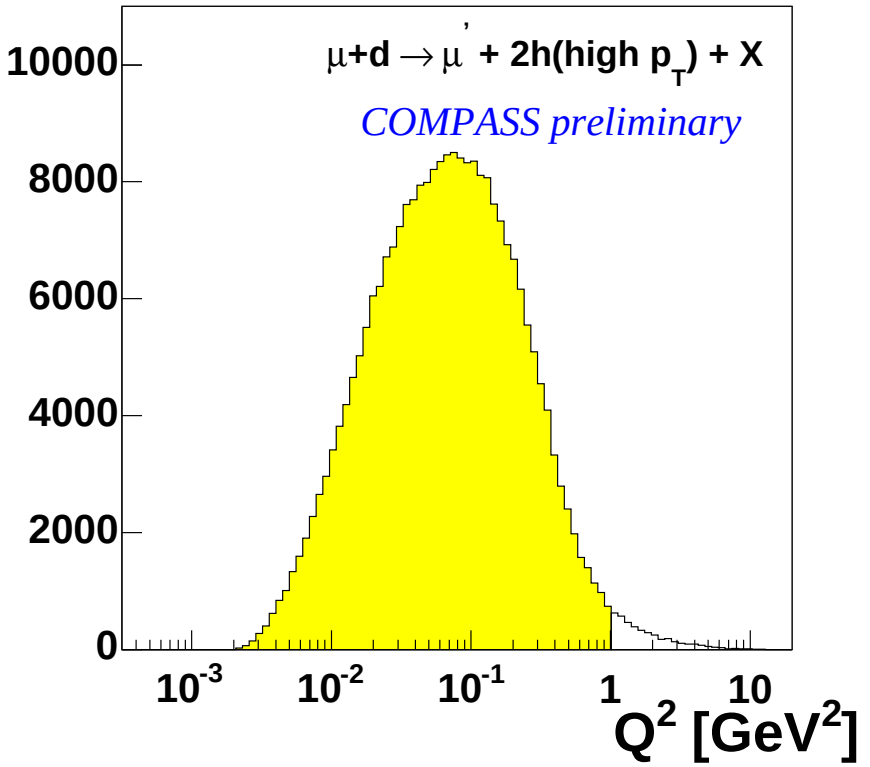
High p_T hadron pairs

$Q^2 < 1$ GeV^2

- The high p_T selection is the same as previously.

The analysis of the 252K events (2002+2003 data) gives:

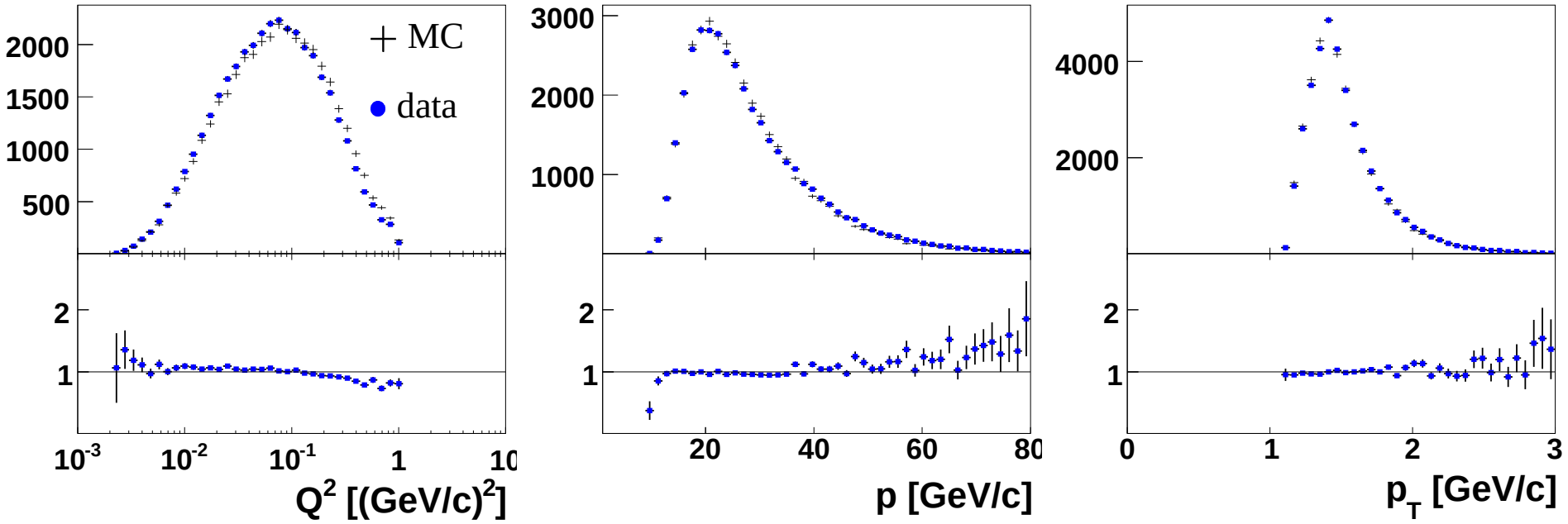
$$A_{\parallel}/D = 0.002 \pm 0.019(stat.) \pm \\ \pm 0.003(exp.syst.)$$



$$\frac{A_{\parallel}}{D} = R_{PGF} \left\langle \frac{a_{LL}^{PGF}}{D} \right\rangle \frac{\Delta G}{G} + \\ + \text{Background asymmetry}$$

- Since this is an analysis with high statistics, the knowledge of the background contributions, from MC, is crucial.

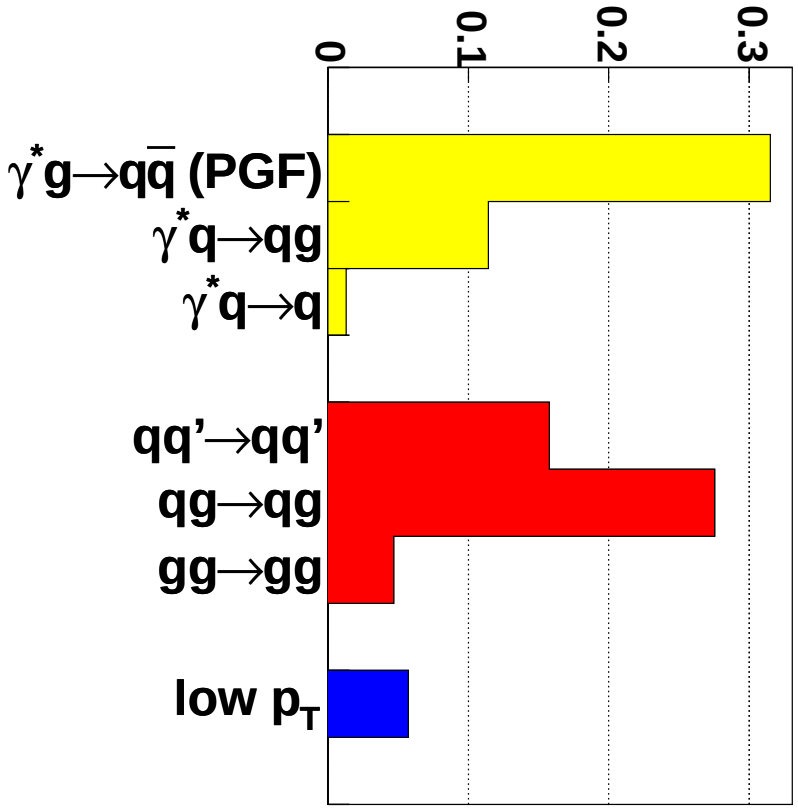
MC compared to data



- MC is well under control and shows good agreement with experimental data

Extracting $\Delta G/G$ for $Q^2 < 1$ GeV^2

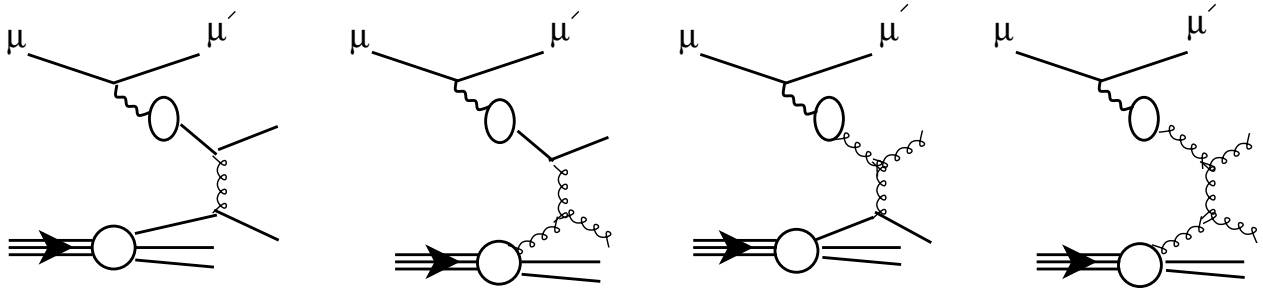
Use **PYTHIA** event generator



- Low p_T scattering and LO-DIS processes are neglected.
- Resolved photon processes: need to know the polarization of quark flavours in the deuteron and in the photon.

● direct ● resolved photon ● low p_T scattering

Resolved photon processes



- The polarized PDFs of the photon are a sum of a non-perturbative term (VMD - the photon fluctuates into a vector-meson) and a perturbative (point-like) term [Ref: Glück, Reya & Schienbein]
- The polarized VMD part is not calculable. But theory defines a **minimal** and a **maximal scenario**:

$$-q^{\gamma}_{VMD} < \Delta q^{\gamma}_{VMD} < q^{\gamma}_{VMD}$$

which we can use to obtain limits on the contribution of resolved photon processes to the measured asymmetry.

$\Delta G/G$ for $Q^2 < 1$ GeV^2

2002+2003 data

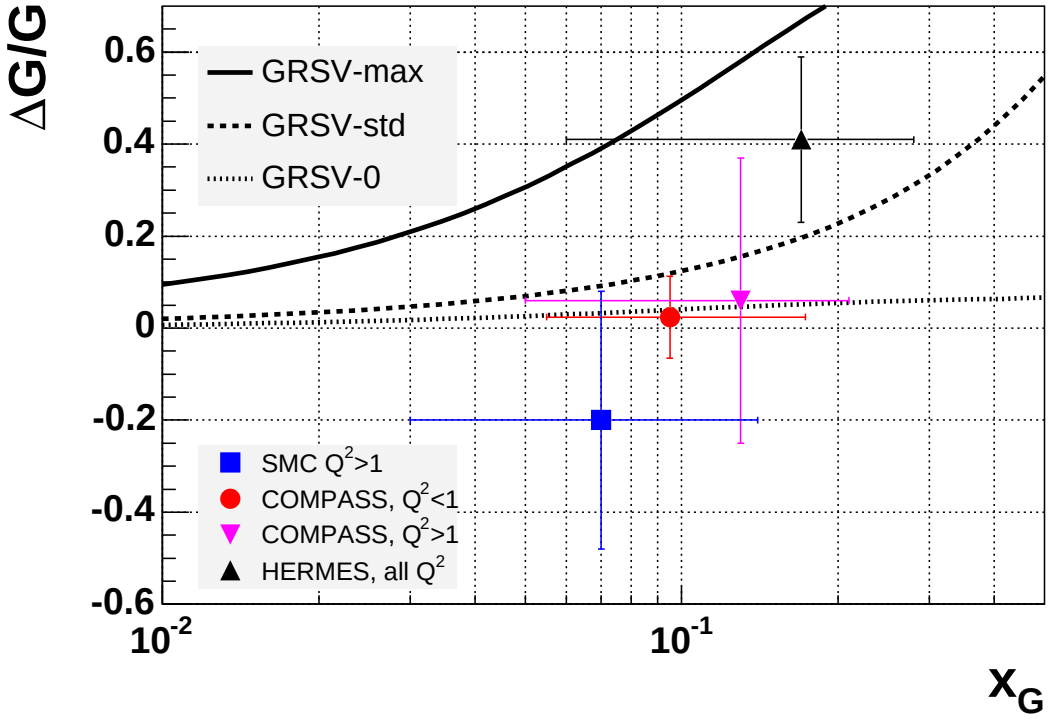
$$(\frac{\Delta G}{G})_{min} = 0.016 \pm 0.068(stat.) \pm 0.011(exp.syst.) \pm 0.018(MC\ syst.)$$

$$(\frac{\Delta G}{G})_{max} = 0.031 \pm 0.089(stat.) \pm 0.014(exp.syst.) \pm 0.052(MC\ syst.)$$

$\Downarrow$

$$\frac{\Delta G}{G} = 0.024 \pm 0.089(stat.) \pm 0.057(syst.)$$

$\hookrightarrow$ at $\langle x_g \rangle = 0.095^{+0.08}_{-0.04}$



[Ref: Glück, Reya, Stratmann & Vogelsang]

Summary (I)

- From the analysis of open charm events, with low statistics, but without physics background:
  $\Delta G/G_{(x_g=0.15)} = -1.08 \pm 0.73(stat.)$
  with systematic error (mostly from false asymmetries) negligible w.r.t. the statistical one.
- From the analysis of high p_T hadron pairs, with $Q^2 > 1GeV^2$, we get (2002+2003):
  $\Delta G/G_{(x_g=0.13)} = 0.06 \pm 0.31(stat.) \pm 0.06(syst.)$
- From the analysis of high p_T hadron pairs with $Q^2 < 1GeV^2$, with much more statistics:
  $\Delta G/G_{(x_g=0.095)} = 0.024 \pm 0.089(stat.) \pm 0.057(syst.)$
- This means that
  - ⋆ either $\Delta G/G$ is small
  - ⋆ or $\Delta G/G$ has to cross 0 around $x_g = 0.1$

Summary (II)

- 2004 Run statistics is as much as (2002+2003).

  Besides this increase in statistics, there will also be D^0's from other physics channels.

  $\hookrightarrow$ Data is now being analysed.

- COMPASS will continue to take data from 2006 on.