Measurement of the Gluon Polarization at COMPASS

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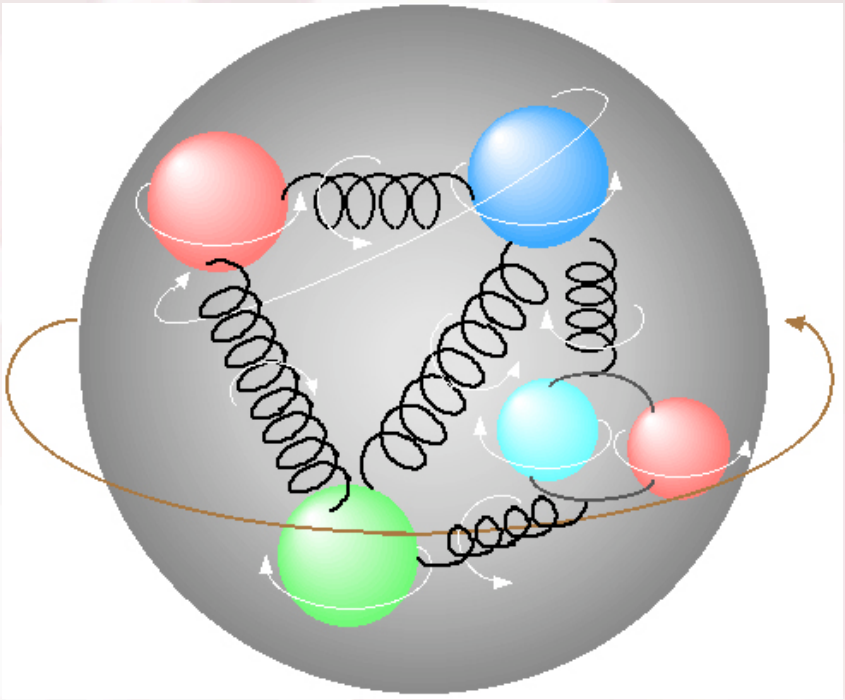
Outline

- Introduction
- The COMPASS experiment
- Direct measurements of ΔG

  3 measurements with 2 processes
- The 2006 run
- Analysis improvement
- Summary

Introduction



Nucleon spin

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

$\Delta\Sigma$: Quarks spin

ΔG : Gluons spin

Lq, Lg : Orbital angular momentum

$\Delta\Sigma \approx 0.3$

smaller than predicted

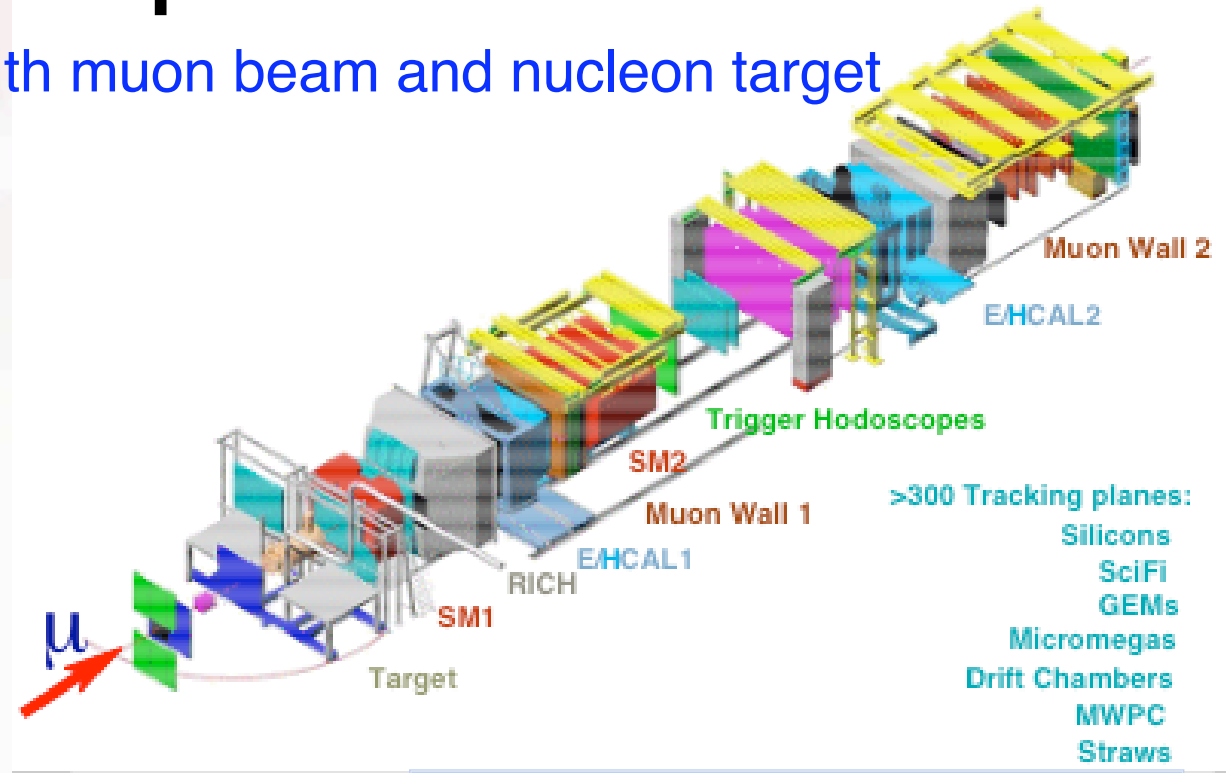
→ ΔG ??

The COMPASS experiment

Spin dependent DIS with muon beam and nucleon target

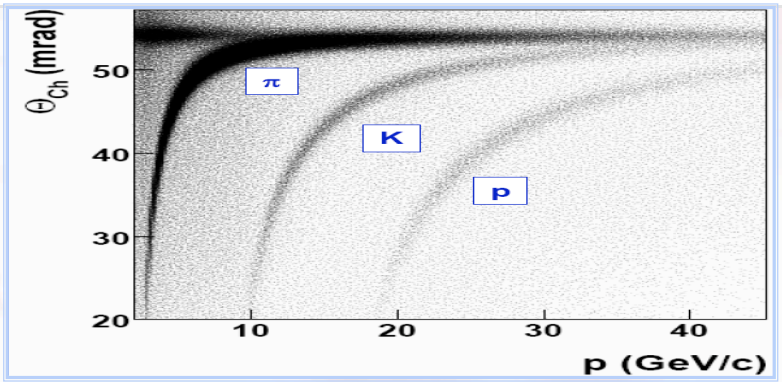
Muon beam

- 2 x 10^8 muons/spill
- 160 GeV/c
- ~80% polarization

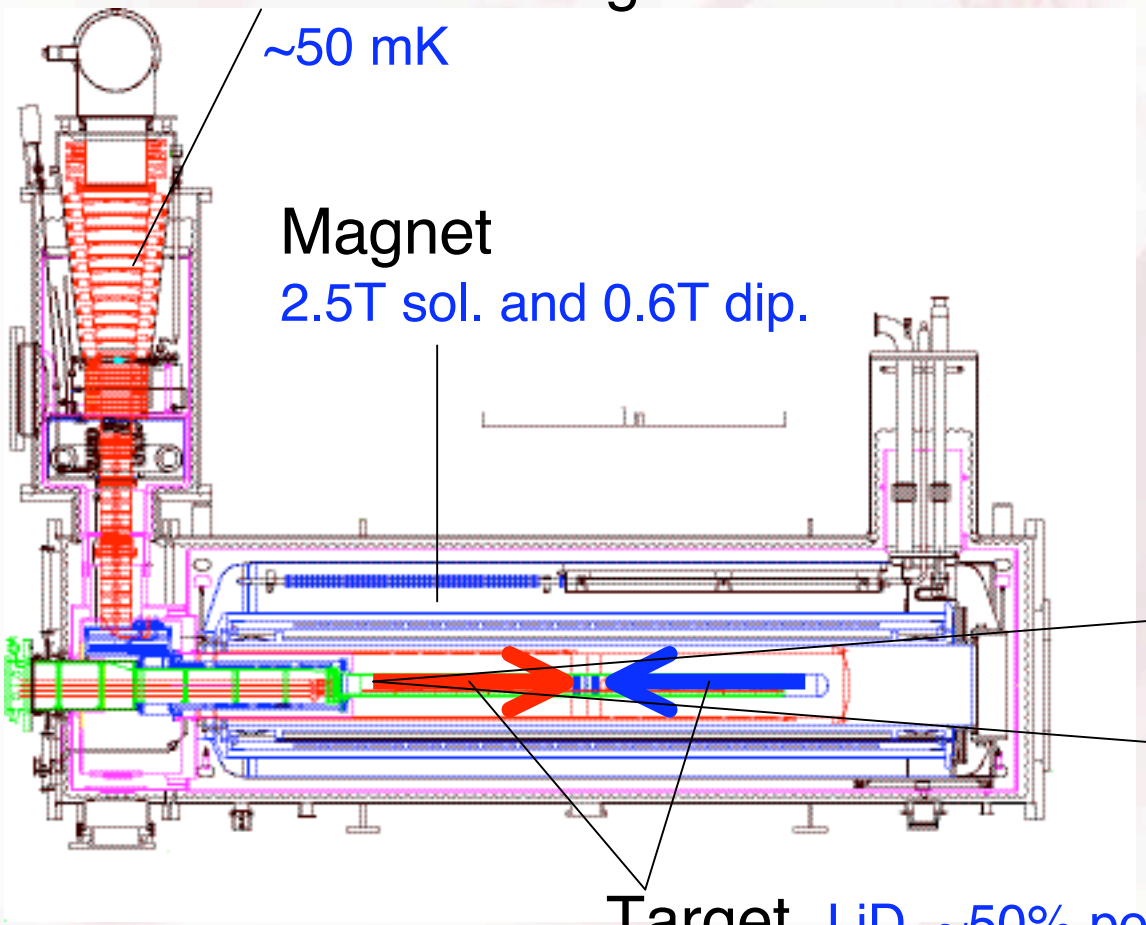


RICH

- K π separation up to about 50 GeV/c



Polarized target
(2002-2004)



Direct measurements of ΔG

Experimental asymmetry

$$A_{exp} = \frac{N^{\Rightarrow}_{\leftarrow} - N^{\Rightarrow}_{\leftarrow}}{N^{\Rightarrow}_{\leftarrow} + N^{\Rightarrow}_{\leftarrow}} = P_B P_T f A_{II}$$

$\leftarrow$: Direction of beam polarization

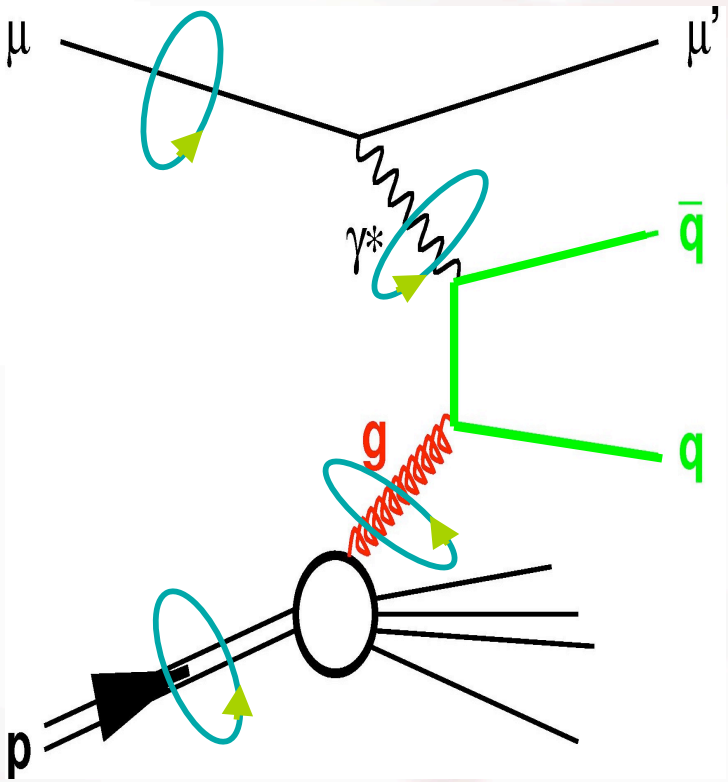
$\Leftarrow$: Direction of target polarization

ΔG : Photon-Gluon-Fusion process

$$A_{II}^{PGF} \sim \langle a_{LL} \rangle \frac{\Delta G}{G}$$

- Open Charm
- High P_T hadron pairs $Q^2 < 1$ $(GeV/c)^2$
- High P_T hadron pairs $Q^2 > 1$ $(GeV/c)^2$

Photon-Gluon-Fusion



Open charm

$$\gamma^* g \rightarrow c\bar{c} \rightarrow D^0 X \rightarrow (K\pi)X$$

- Clean channel
- Low statistics
- K identification by RICH

High p_T hadron pairs

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

- Large statistics
- Physical background

Open charm

$D^* \rightarrow D^0 \pi_{soft}$

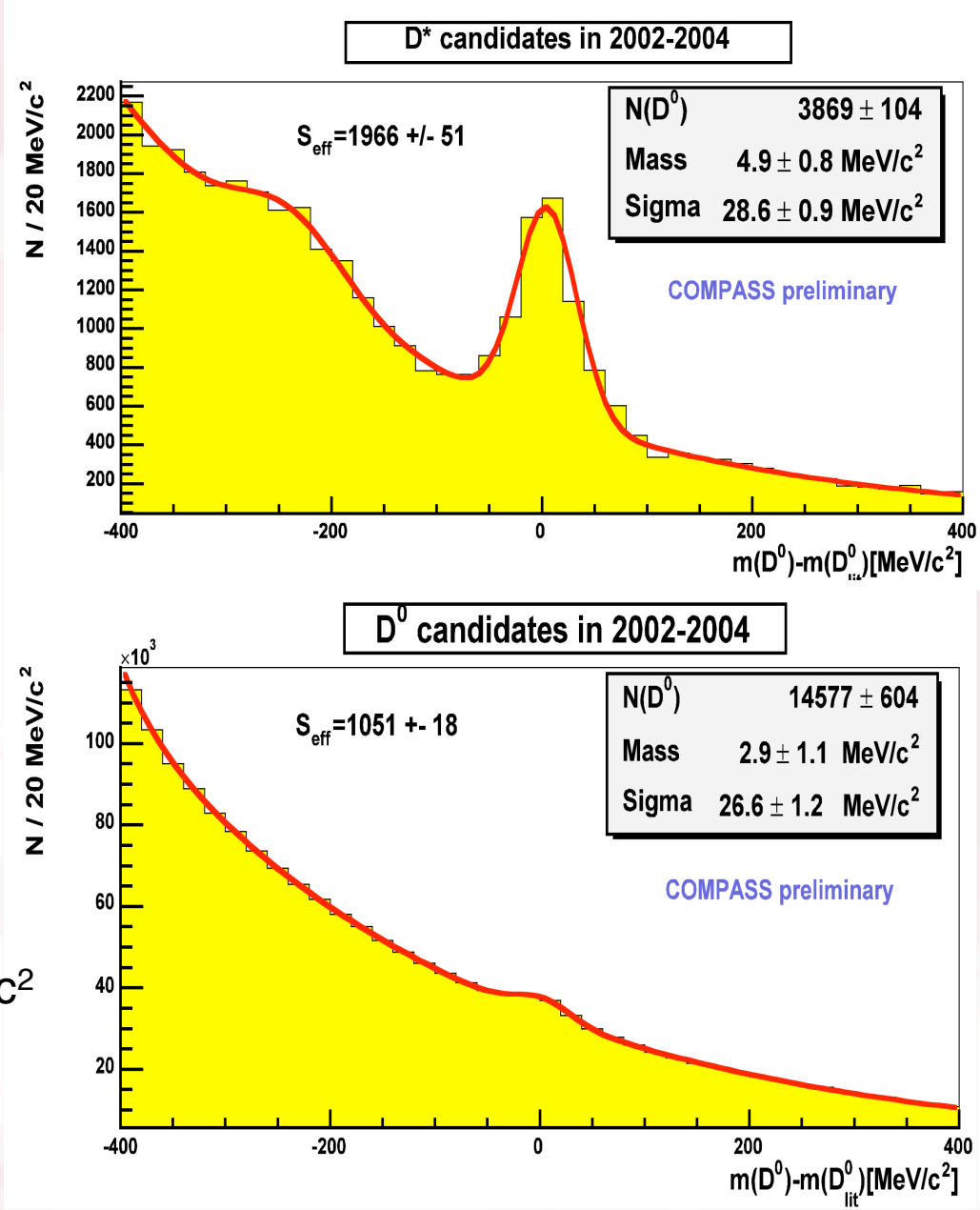
(BR ≈ 68%)

$D^0 \rightarrow K\pi$

(BR ≈ 4%)

Selection

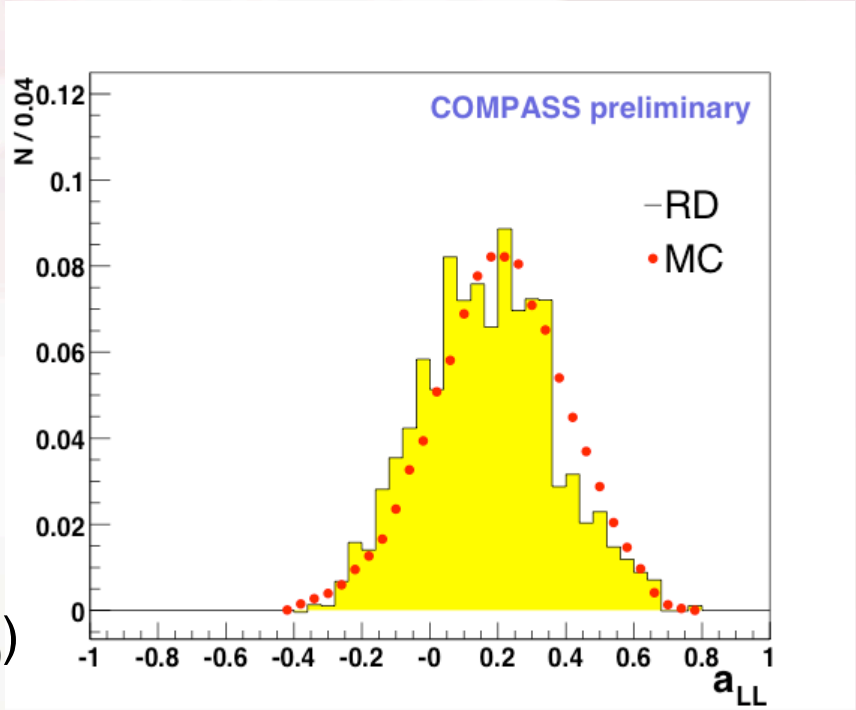
- D^0 kinematics
  mom. fraction $Z_{D0} > 0.2$ (0.25)
  decay angle $|\cos\theta^*|<0.85$ (0.5)
- D* tag : mass difference δm
  3.1 MeV/c^2 < (δm-mπ) < 9.1 MeV/c^2



Results of Open charm (2002-2004)

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

- $\sigma^{PGF}/\sigma_{tot} = S/(S+B)$: determined by the fit
- a_{LL} calculated by MC using AROMA parametrisation with (y, Q^2, Z_{D0}, $P_T{}^{\gamma}{}_{D0}$)

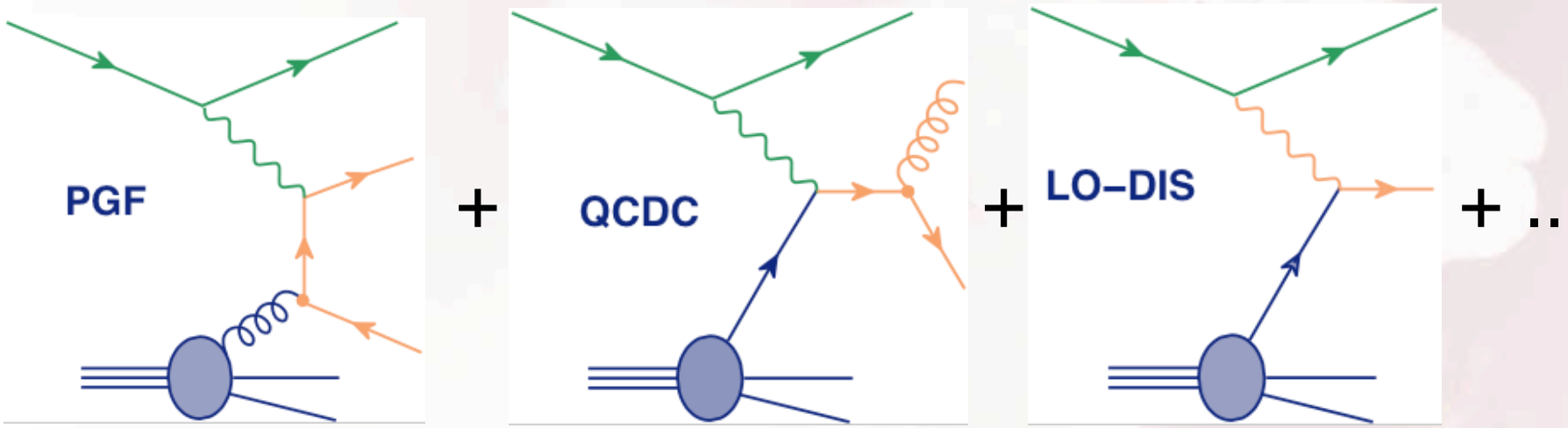


Preliminary result $\frac{\Delta G}{G} = -0.57 \pm 0.41(\text{stat.}) \pm 0.17(\text{syst.})$ New

main sources ⇒ 0.10 : false asymmetry
0.09 : fitting
0.07 : background asym.

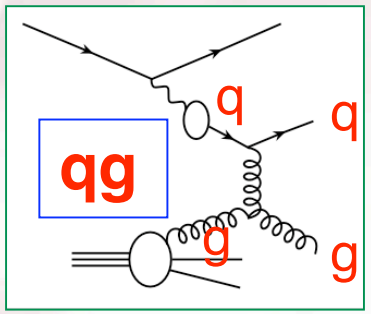
$\mu^2(\text{scale}) \sim 13(\text{GeV/c})^2$
$\langle x_G \rangle \sim 0.15$

High p_T hadron pairs



$$A_{ll} = R_{PGF} \langle a_{LL}^{PGF} \rangle \frac{\Delta G}{G} + R_{QCDC} \langle a_{LL}^{QCDC} \rangle \frac{\Delta q}{q} + R_{LO} \langle a_{LL}^{LO} \rangle \frac{\Delta q}{q} +$$ resolved photons processes for lowQ^2

- Several possible contributions to the measured asymmetry
- MC needed to determine R and a_{LL}



High p_T event selection

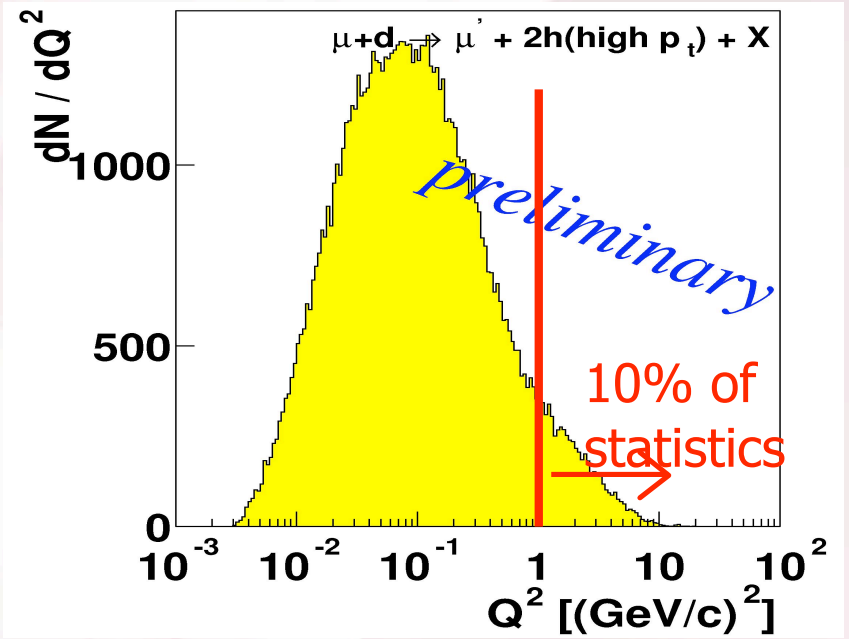
For PGF contribution enhancement

$p_T > 0.7$ GeV/c

$p_{T1}^2 + p_{T2}^2 > 2.5$ (GeV/c)^2

$x_F > 0.1$, $z > 0.1$

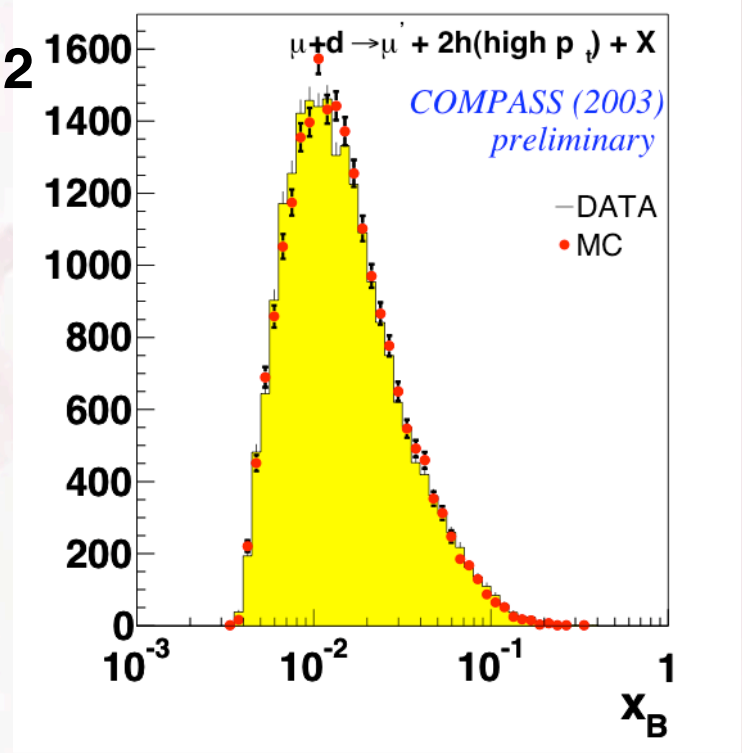
$m(h_1,h_2) > 1.5$ GeV/c^2



analysis	$Q^2 < 1$ (GeV/c)^2	$Q^2 > 1$ (GeV/c)^2
statistics	90%	10%
background	QCDC, LO Resolved photons	QCDC, LO
MC generator	PYTHIA	LEPTO

Results from $Q^2>1$ (GeV/c)^2
(2002,2003(28k events))

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



LEPTO Monte Carlo

- $\langle a_{LL}/D \rangle = -0.75 +/- 0.05$
- $R_{PGF} = 0.34 +/- 0.07$

Contributions of LO and QCDC can be neglected at $x_B < 0.05$. ($A_1 \approx 0$)

Preliminary result

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

main sources ⇒ False asymmetry

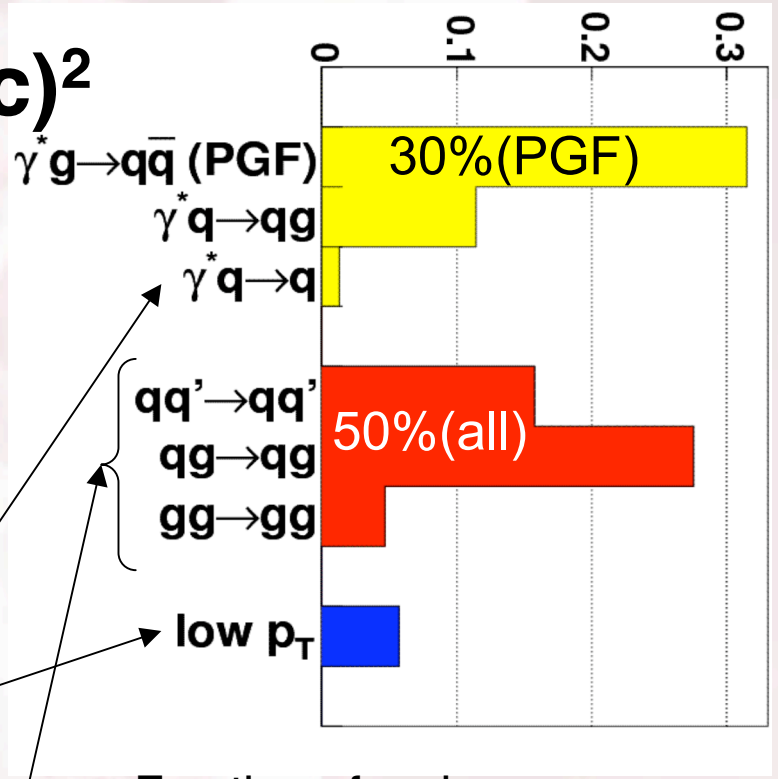
$\mu^2(\text{scale}) \sim 3(\text{GeV/c})^2$

$\langle x_G \rangle \sim 0.13$

Results from $Q^2<1$ (GeV/c)^2 (2002-2004)

MC $A_{ll}/D = R_{PGF}\ \Delta G/G\ a_{LL}^{PGF} + R_{QCDC}\ \Delta q/q\ a_{LL}^{QCDC}$

resolved photons $+ R_{qq}\ \Delta q/q\ a_{LL}^{qq}\ (\Delta G/G)^{\gamma} + R_{qg}\ \Delta G/G\ a_{LL}^{qg}\ (\Delta q/q)^{\gamma} + \ldots$



Fraction of various processes

- Negligible： LO-DIS and Low-P_T
- Main background : resolved photons

Preliminary result $\frac{\Delta G}{G} = +0.016 \pm 0.058(\text{stat.}) \pm 0.055(\text{syst.})$

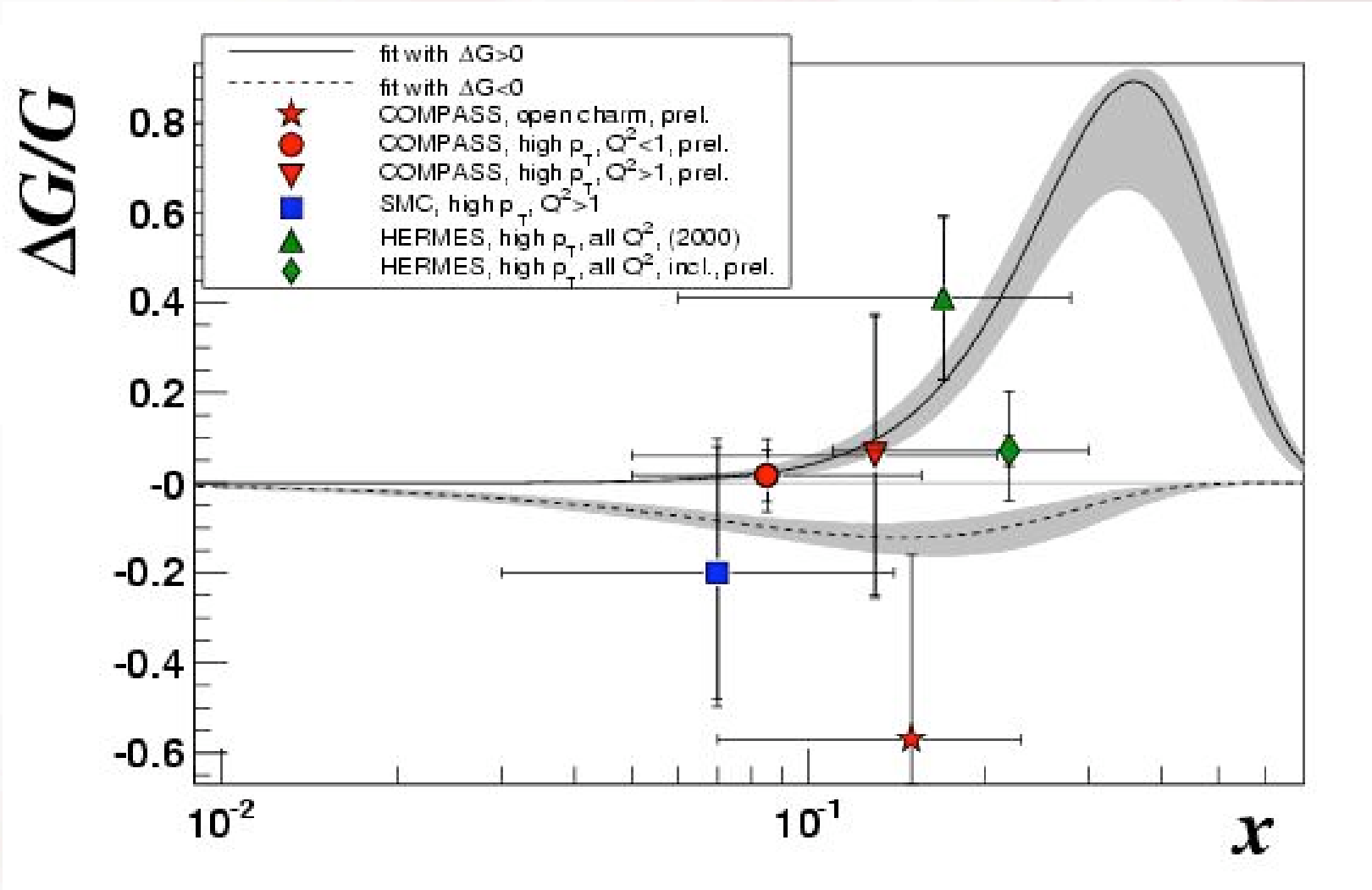
$\mu^2(\text{scale}) \sim 3(\text{GeV/c})^2$

$\langle x_G \rangle \sim 0.085$

0.052 : Monte Carlo
0.014 : false asymmetry
0.013 : resolved photons

VMD term of the polarized PDFs of photon (Δf_{VMD}^{γ}) is not known.
possible range: $-f_{VMD}^{\gamma} < \Delta f_{VMD}^{\gamma} < f_{VMD}^{\gamma}$

ΔG/G results of all processes



Improvement in 2006 run

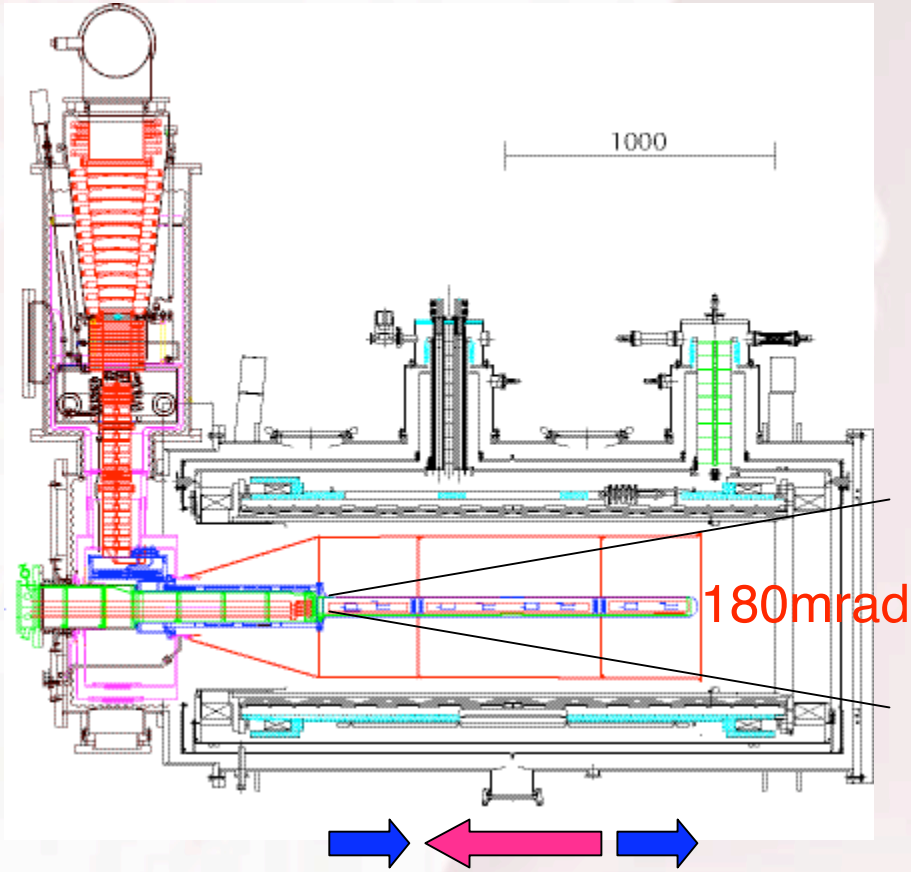
New target system

New magnet and μwave cavity

- larger acceptance
- good magnetic field homogeneity
- good μwave distribution

New 3 target cells

- reduce false asymmetry

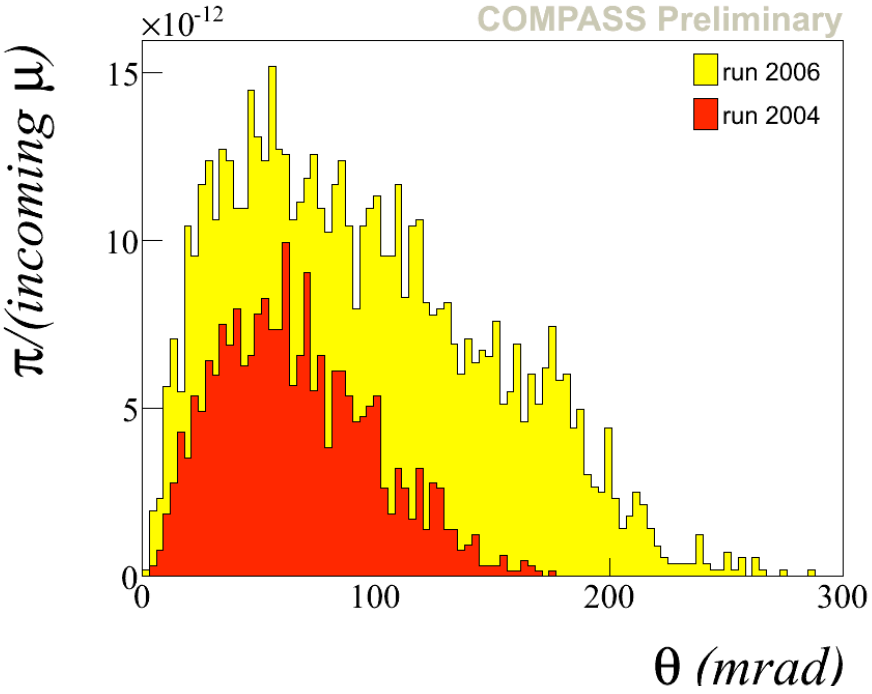


RICH upgrade

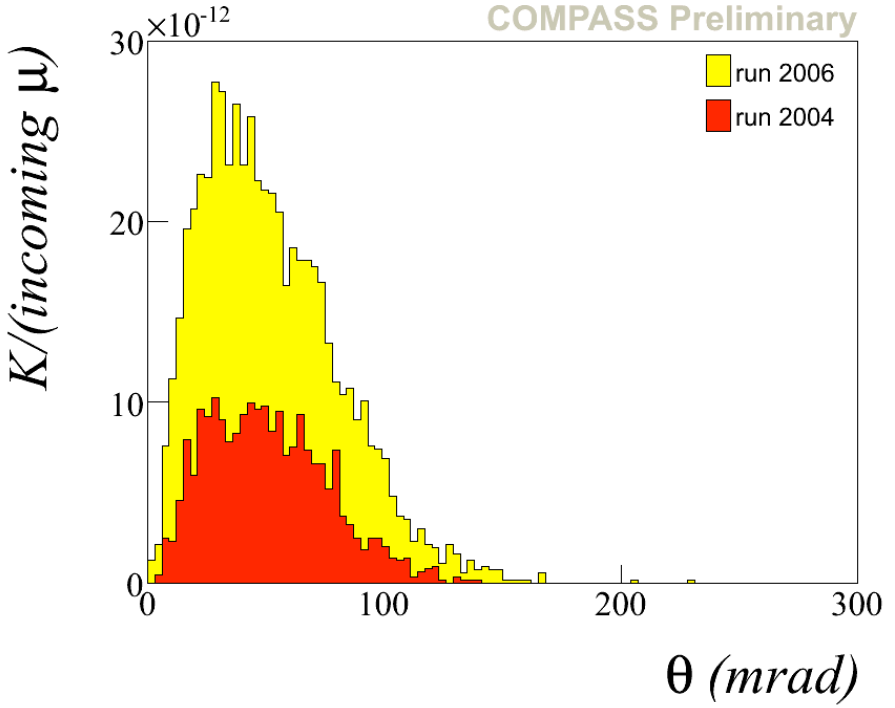
MAPMTs in the central area

- Significant increase in number of photons

Acceptance and event gains in 2006
(preliminary)



Larger magnet acceptance



RICH upgrade

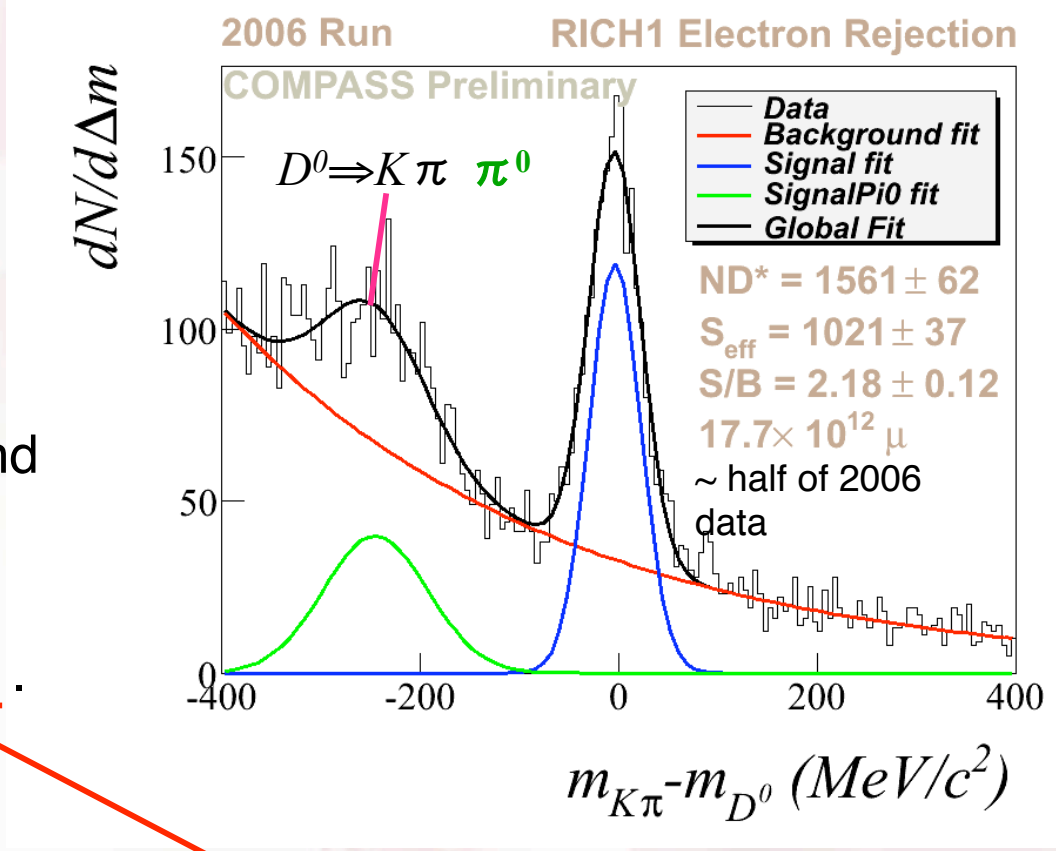
D* sample

Effective signal

$$S_{eff} = \frac{S^2}{S+B} \propto \delta^2 \frac{\Delta G}{G}$$

- large ***light lepton*** background found in π_s sample
- rejected by RICH

⇨ S_{eff} increases by 25 % .



$S_{eff}(D^*)_{2006} / S_{eff}(D^*)_{2004} = 1.8 \times 1.25 = 2.25$

Normalized by the beam flux

- New magnet
- RICH upgrade
- Improvements in the reconstruction

ΔG/G analysis improvement

Working on analysis of 2006 data

Open charm

- Simultaneous determination of the signal and background
- $D^0 \Rightarrow K\pi\,\pi^0$ channel
- Plan for NLO extraction

High p_T (large Q^2)

- Lowering the sum P_T^2 cut

  considerable gain in statistics while R_{PGF} is still reasonable
- Working on the analysis to include 2004/2006

High p_T (low Q^2)

- Plan to divide x_g into 2 bins

Summary

- Direct measurements results indicate small ΔG around $x_g \approx 0.1$.
- Direct measurements can not discriminate between $\Delta G>0$ and $\Delta G<0$ solutions of QCD analysis.
- The statistical errors will be reduced by the 2006 data.
- The analysis improvements are going on.