New Results on $\Delta g/g$ from COMPASS Experiment at CERN

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Abstract

The gluon polarisation, $\Delta g/g$, is determined from photon-gluon fusion (PGF) events produced in scattering of 160 GeV polarised muons off polarised deuterons. Two independent methods based on LO QCD are used to extract PGF events: selection of D or D^* mesons or a pair of high p_t hadrons. In the former we use the data collected in 2002-2004 and 2006 and apply a new method of the signal strength parametrisation. In the latter we select $Q^2 > 1\,\mathrm{GeV}^2$ region from 2002-2004 data and apply a new method of accounting for background processes.

Key words: keyword Deep inelastic scattering, Spin structure of nucleon, Gluon polarisation
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1. Introduction

Experiments on the spin structure of the nucleon consistently determine the contribution of the spin of quarks to the nucleon spin to be around 30%. The missing fraction is expected to come from the spin of gluons and from the orbital angular momentum of quarks and gluons. The contribution from the spin of gluons can be determined in polarised deep inelastic scattering using events produced by the process of PGF, $\gamma^* g \to q\overline{q}$. The asymmetry of the cross sections for the PGF is directly related to the gluon polarisation: $A_{LL} = a_{LL}\frac{\Delta g}{g}$, where a_{LL} is the analysing power.
In the COMPASS experiment the muon beam polarisation is -75% and gluons come from deuterons in ^{6}LiD which are polarised either parallel (+53%) or antiparallel (-50%) to the beam direction.
In the experiment the asymmetry of the counting rates is determined: $A_{exp} = \frac{N^{\downarrow\Downarrow} - N^{\downarrow\Uparrow}}{N^{\downarrow\Downarrow} + N^{\downarrow\Uparrow}}$.

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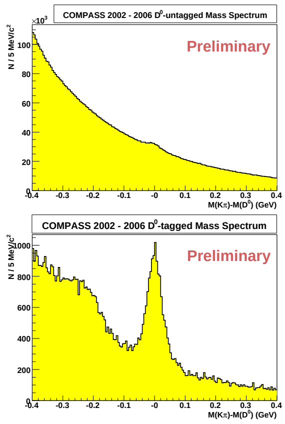

Fig. 1. Invariant mass distribution of D^0 (up) and D^* (down) mesons.

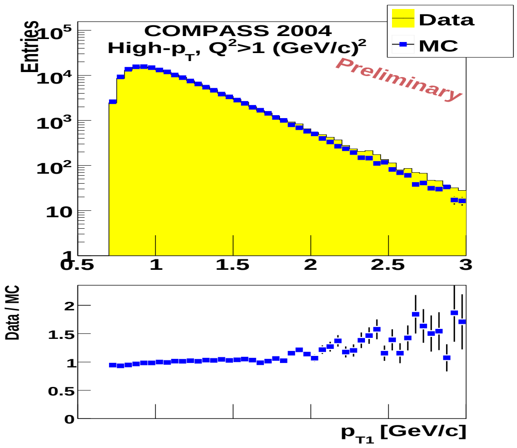

Fig. 2. Distribution of the transverse momentum of the leading hadrons in data and in Monte Carlo (up) and their ratio (down).

Here N is number of events from a given target cell and the arrows indicate the beam ($\downarrow$) and target ($\Downarrow\Uparrow$) polarisations. This asymmetry is related to the cross section asymmetry by $A_{exp} = A_{LL} P_B P_T f$, where $P_{B(T)}$ are beam and target polarisations and $f = 0.4$ is target dilution factor. A detailed description of the experiment can be found in Ref. [1].

2. $\Delta g/g$ from Open Charm Events

PGF events can be conveniently tagged by charmed mesons which come from the fragmentation of charm quarks produced in the fusion: $c\bar{c} \to D^{0(*)}X$. The QCD scale for this process is set by $2m_c$. These events have neglegible contributions from other processes. Charmed mesons are identified by their decays: $D^0 \to K\pi$ and $D^{*+(-)} \to D^0\pi$. In the COMPASS experiment the decay vertex is not determined due to long polarised solid state targets (60 cm cells) and only the invariant mass is used to select events. Identification of K in the RICH Cerenkov detector is most important. Further suppression of the combinatorial background is achieved by cuts on z_{D^0} and on the D^0 decay angle. Finally, an important suppression of the combinatorial background in the D^* is obtained by a cut on $m_{K\pi\pi} - m_{K\pi}$. The selected sample has 37.4k D^0 events and 8.7k D^* events. The gluon polarisation is determined independently for the two decay channels.
The experimental asymmetry can be written as $A_{exp} = \frac{\Delta g}{g} P_T P_B a_{LL} f \frac{S}{S+B} + A_{BG}$, where $S(B)$ is number of signal (background) events in the invariant mass window and A_{BG} is the asymmetry of the background. The analysing power a_{LL} is reconstructed using a parametrisation obtained from Neural Networks trained on the AROMA Monte-Carlo. Since a_{LL} and $\frac{S}{S+B}$ have a large dispersion, each event was assigned a weight $w = P_B a_{LL} f \frac{S}{S+B}$. The invariant mass distributions of mesons are shown in Fig.1. The values of $\Delta g/g$ obtained from D^0 and D^* samples are combined and give the preliminary result:

$\Delta g/g = -0.46 \pm 0.27(stat.) \pm 0.11(sys.)$, where $x_g = 0.11^{+0.11}_{-0.05}$ and the scale $\mu^2 \simeq 13\,\mathrm{GeV}^2$.

3. $\Delta g/g$ from Events with High-p_t Hadrons

In the COMPASS analysis PGF events are also tagged by hadrons coming from the fragmentation of light quarks. The advantage is a relatively larger number of events. Contributions from leading order (LO) and QCD-Compton (C) processes are suppressed by a cut on the large transverse momentum p_t of hadrons but have to be accounted for by the Monte Carlo. We use LEPTO with MRST2004LO PDF and JETSET fragmentation. For this analysis the scale is given by the $Q^2 > 1\,\mathrm{GeV}^2$ cut.
The selected events are required to have two hadrons of $p_t > 0.7\,\mathrm{GeV}$ and $x_F > 0$ relative to the virtual photon direction. In the analysis we determine A_{LL}^{2h} and we use also existing data on the inclusive asymmetry A_{LL}^{inc} to determine $\Delta g/g$ by solving the two equations:

$$A_{LL}^{2h}(x_{Bj}) = R_{PGF} a_{LL}^{PGF} \frac{\Delta G}{G}(x_G) + R_{LO} D A_1^{LO}(x_{Bj}) + R_C a_{LL}^C A_1^{LO}(x_C) \tag{1}$$

$$A_{LL}^{inc}(x_{Bj}) = R_{PGF}^{inc} a_{LL}^{inc,PGF} \frac{\Delta G}{G}(x\prime_G) + R_{LO}^{inc} D A_1^{LO}(x_{Bj}) + R_C^{inc} a_{LL}^{inc,C} A_1^{LO}(x\prime_C) \tag{2}$$

where a_{LL} are analysing powers, R are fractions of PGF, C and LO processes and D is the virtual photon depolarisation factor determined from the event kinematics. Arguments in the paratheses indicate that in the three processes partons of different lightcone momenta are involved. The solution of these equations is:

$$\frac{\Delta g}{g}(\overline{x_G}) = \frac{1}{\beta}(A_{LL}^{2h}(x_{Bj}) + A^{corr}), \tag{3}$$

where β and A^{corr} are functions of variables in Eq. (1-2). Unmeasured variables are determined using Monte Carlo simulations and are parametrised using Neural Networks as functions of the measured kinamatic variables. For each event we determine the weight $w = fDP_B\beta$ and A^{corr}, where f, D and P_B is determined from the data.
This method strongly relies on Monte Carlo and therefore it is very important that simulations agree with the data. Satisfactory agreement is seen on Fig. 2. The average values of a_{LL}^{PGF} and R^{PGF} in the analysed sample are -0.36 and 0.31 respectively.
The preliminary value of $\Delta g/g$ is:
$\Delta g/g = 0.08 \pm 0.10(stat.) \pm 0.05(sys.)$, where $x_g = 0.082$ and the scale $\mu^2 \simeq 3\,\mathrm{GeV}^2$.

4. Conclusions

COMPASS presented two new, preliminary results on $\Delta g/g(x \simeq 0.1)$ at scale $3\,\mathrm{GeV}^2$ and $13\,\mathrm{GeV}^2$. Both results indicate small, consistent with zero, value of the gluon polarisation.

References

[1] COMPASS; P. Abbon *et al.* Nucl. Instr. Meth. A **577**, 455 (2007).