Results on Δg/g from COMPASS

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Abstract. Experiment is using a 160 GeV beam of polarized muons and longitudinally polarized deuterium in a ^{6}LiD double-cell target. The gluon polarization, Δg/g, is determined from the double-spin cross section asymmetries for the events selected by tagging the photon-gluon fusion process. We obtain three independent results at $x_g \approx 0.1$.

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In the QCD the nucleon spin can be decomposed into the contributions from the total spin of quarks (ΔΣ) and gluons (ΔG) and their orbital angular momenta (L_q, L_g). Whereas ΔΣ can be determined from the QCD fits to the structure functions g_1, this method gives a large uncertainty of ΔG [1]. The gluon polarization Δg/g ($x_g \approx 0.1$–0.2) has been determined by HERMES [2] and SMC [3] from the photon-gluon fusion (PGF) process, tagged by hadrons with large p_t, using events at $Q^2 \approx 0$ and $Q^2 > 1$ GeV^2, respectively. Here we report on the results obtained using the COMPASS data in the region $Q^2 < 1$ GeV^2 and $Q^2 > 1$ GeV^2. We also present the results obtained by tagging the PGF process by charmed mesons. Results are obtained from the data collected in 2002 and 2003 with the longitudinal target polarization, corresponding to the total integrated luminosity of 1.25 fb^{-1}. Description of the experiment is given in ref. [4].

The asymmetry $A_\parallel$ can be obtained from the number of events in the upstream and downstream target cells, before and after field rotation:

$$A_\parallel = \frac{1}{2\,|P_b P_t f|}\left(\frac{N_u^{\uparrow\Downarrow} - N_d^{\uparrow\Uparrow}}{N_u^{\uparrow\Downarrow} + N_d^{\uparrow\Uparrow}} + \frac{N_d^{\uparrow\Downarrow} - N_u^{\uparrow\Uparrow}}{N_d^{\uparrow\Downarrow} + N_u^{\uparrow\Uparrow}}\right)$$

where the two terms correspond to opposite orientations of the target magnetic field and arrows indicate the relative beam ($\langle P_b \rangle = -0.76$) and target polarizations ($P_t = \pm 0.50$). The target dilution factor is $f \approx 0.40$. In order to minimize the statistical error on the asymmetry we use event weighting described in ref. [4].

Δg/g from Charmed Meson Production

Charmed meson production is an unambiguous signature of the PGF process in the kinematics region covered by the COMPASS data.

D^0 and $D^{*\pm}$ meson signal was searched for in the invariant mass distribution of charged hadrons originating from the decays (and their charged conjugate modes): $D^{*+} \rightarrow D^0 \pi^+ \rightarrow K^+\pi^- \pi^+$ ("D^* tagging") and $D^0 \rightarrow K^+\pi^-$, where identification of $K^\pm$ with RICH detector was required. The D^0 decay vertex is not accessible in our extended target. The best S/B (signal/background) ratio was obtained with "D^* tagging", by selecting the signal visible in the difference of the invariant masses $M(K\pi\pi) - M(K\pi)$, close to the limit of the phase space. Events not contributing to $D^{*\pm}$ signal were searched for a D^0 signal visible in the invariant mass $M(K\pi)$ ("without tagging").

The asymmetry has been calculated separately for events with and without "D^* tagging" and the results were merged. For weights we used $w = fP_b a_{LL,PGF} S/(S+B)$, where $a_{LL,PGF}$ is the helicity asymmetry in the hard lepton-gluon scattering, which has been parameterized in terms of y and D^0 variables using Monte Carlo AROMA [5]. Our preliminary result is: $\Delta g/g = -1.08\pm0.73(\text{stat})$ at $\langle x_g \rangle = 0.15\pm0.08(\text{rms})$.

Δg/g from Hadron Production at Large Transverse Momentum

Two hadrons at large transverse momentum were required in order to enhance the contribution from the PGF: $p_{t1(2)} > 0.7$ GeV^2 and $p_{t1}^2 + p_{t2}^2 > 2.5$ GeV^2. The resonance region was excluded by a cut on the invariant mass of two hadrons, $M_{1,2} > 1.2$ GeV^2, and the target fragmentation region was suppressed by requiring $x_F > 0.1$. In the selected sample the asymmetry has been determined using event weight $w = fDP_b$, where the average value of the polarization transfer from the beam to the virtual photon is $\langle D \rangle = 0.6$. After the cuts, the relative contribution from the PGF process in the data was estimated from Monte Carlo models, which have been tuned to reproduce well the distributions of muonic and hadronic variables.

In the analysis, the leading order (LO) pQCD approach has been consistently used in Particle Distribution Functions, expressions for $a_{LL,PGF}$ and in the Monte Carlo (JETSET) [6], where the parton showers were switched off.

Events with $Q^2 > 1$GeV^2

We use the cut $0.1 < y < 0.9$. The contributions to the asymmetry from LO and QCD Compton (QCDC) processes are proportional to the semi-inclusive asymmetry A_1^d which is consistent with zero at small x and we use the cut $x < 0.05$ which renders them negligible. Therefore only PGF contributes to the asymmetry in the selected events: $\langle A_{\|}/D \rangle = -0.015\pm0.089(\text{stat})\pm0.013(\text{syst})$.

We use LEPTO [7] as a model to determine the corresponding event fraction $R_{PGF} = 0.34\pm0.07$, the value of $\langle a_{LL,PGF}/D \rangle = -0.75\pm0.15$ and obtain the preliminary result: $\Delta g/g = 0.06\pm0.31(\text{stat})\pm0.06(\text{syst})$ at $\langle x_g \rangle = 0.13\pm0.08(\text{rms})$.

Events with $Q^2 < 1$GeV^2

For events with $0.35 < y < 0.9$ the asymmetry is:
$\langle A_{\|}/D \rangle = 0.002\pm0.019(\text{stat})\pm0.003(\text{syst})$.

From PYTHIA [6] we determined the event fraction for QCDC, PGF and Resolved Photon (RP) processes and also a fraction of LO and "low-p_t processes", which constitute 7% of events and make a small contribution to the asymmetry. The fraction of PGF events in our sample is about 30% and the value $\langle a_{LL,PGF}/D \rangle = -0.93$. The parton from RP interacts with a quark or a gluon from the nucleon for which we use polarized [8] and unpolarized parton distributions [9]. For the polarizations of quarks and gluons in the virtual photon we used the so-called minimum and maximum scenarios [10]. The average value of the gluon polarization is [4]:
$\Delta g/g = 0.024 \pm 0.089(\text{stat}) \pm 0.057(\text{syst})$ at $\langle x_g \rangle = 0.095^{+0.08}_{-0.04}(\text{rms})$.

The three independent COMPASS results are shown in Fig. 1 together with previous measurements from HERMES and the SMC.

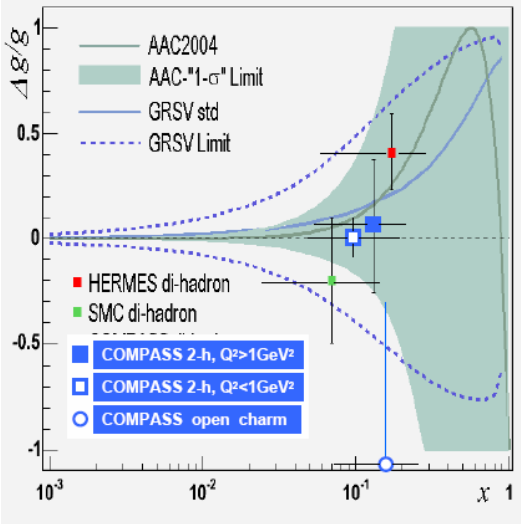

FIGURE 1. The results for $\Delta g/g$ from COMPASS, HERMES and the SMC. Horizontal bar on the points represents the range in x_g. AAC04 is the result obtained from NLO QCD fit to the world data on g_1 [1]. GRSV is the parameterization from ref. [8].

COMPASS results indicate that $\Delta g/g$ is close to zero at $x_g \approx 0.1$. The statistical errors will be reduced by about 30% after including 2004 data. Further improvements are expected from the 2006 data collected with an upgraded experimental setup.

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