INCLUSIVE SPIN-DEPENDENT ASYMMETRY A_1^D

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First preliminary results from the COMPASS experiment on the inclusive asymmetry A_1 and on the semi-inclusive asymmetries $A_1^{h^\pm}$ on deuterium obtained from 2002-2003 data are presented.

1. Introduction

COMPASS[1] is a fixed target experiment which is taking data since 2002. The main goal of COMPASS is the measurement of the polarized parton and gluon distributions in deep inelastic scattering (DIS) of longitudinally polarized muons on longitudinally polarized nucleons. One way to access the polarized quark distributions is the inclusive measurement of the photon-nucleon cross section asymmetry[a]

$$A_1 = \frac{\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow}}{\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow}} = \frac{\sum_q e_q^2 \left(q^{\uparrow\downarrow} - q^{\uparrow\uparrow} + \bar{q}^{\uparrow\downarrow} - \bar{q}^{\uparrow\uparrow}\right)}{\sum_q e_q^2 \left(q^{\uparrow\uparrow} + q^{\uparrow\downarrow} + \bar{q}^{\uparrow\uparrow} + \bar{q}^{\uparrow\downarrow}\right)} = \frac{\sum_q e_q^2 \left(\Delta q + \Delta \bar{q}\right)}{\sum_q e_q^2 \left(q + \bar{q}\right)}$$

(exact formulas for deuterium e.g. in [2]).The experimentally measurable quantity is the lepton-nucleon asymmetry A_{lN}, which is related to A_1 as:

$$A_{lN} \approx A_1 \cdot D = \frac{1}{P_t f P_b} \left(\frac{N_{\uparrow\downarrow} - N_{\uparrow\uparrow}}{N_{\uparrow\downarrow} + N_{\uparrow\uparrow}}\right).$$

Here P_b and P_t are the lepton and target polarizarion, f is the dilution factor, D is the kinematical variable known as the depolarization factor. $N_{\uparrow\downarrow}(N_{\uparrow\uparrow})$ are the numbers of scattering events for antiparallel and parallel lepton and nucleon polarizations, respectively.

This study can be extended by measuring not only the lepton but also at least 1 hadron in the final state (so-called semi-inclusive DIS). Then the

[a] $\sigma^{\uparrow\uparrow(\uparrow\downarrow)}$ and $q(\bar{q})^{\uparrow\uparrow(\uparrow\downarrow)}$ denote γ-nucleon cross sections and quark(antiquark) distributions in the nucleon for parallel(antiparallel) virtual photon and nucleon(quark) spin orientations.

measured asymmetries depend on the fragmentation functions $D^h_{q(\bar{q})}$ - i.e. on the probabilities for q or $\bar{q}$ fragment to the specified type of the hadron:

$$A_1^h = \frac{1}{P_t f P_b D}\left(\frac{N^h_{\uparrow\downarrow} - N^h_{\uparrow\uparrow}}{N^h_{\uparrow\downarrow} + N^h_{\uparrow\uparrow}}\right) = \frac{\sum_q e_q^2\left(\Delta q(x)\int D^h_q(z)dz + \Delta\bar{q}(x)\int D^h_{\bar{q}}(z)dz\right)}{\sum_q e_q^2\left(q(x)\int D^h_q(z)dz + \bar{q}(x)\int D^h_{\bar{q}}(z)dz\right)}$$

Measuring different types of hadrons and using both proton and deuteron targets the full flavour separation of Δq can be done. In the following we present preliminary results on A_1 and A_1^h obtained from measurements on the deuterium target in 2002 and 2003.

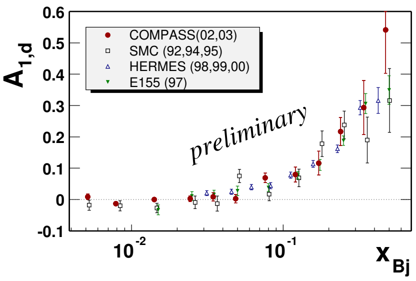
2. The Apparatus

In 2002-2004 COMPASS[3] took data on the muon beam line of the CERN SPS with a μ^+ intensity of $2 \cdot 10^8$ per spill of 4.8 sec. The nominal beam momentum was 160 GeV on average, with a momentum spread of $\delta P/P$ of 0.05 and a mean polarization of 76%. COMPASS target consists of 2 cylindrical cells, each 60 cm long and 3 cm in diameter, separated by 10 cm. They are filled with ^{6}LiD, which is used as a deuteron target material and are placed inside the solenoid to allow the material to be polarized by the dynamical nuclear polarization (DNP) technique[4]. The main advantage of the ^{6}LiD is its high dilution factor $f \approx 0.4$ which represents the fraction of scatterings on the deuterons (^{6}Li can be described by a core of α particle and deuteron).The cells are longitudinaly polarized in opposite directions. The typical polarization is above 50 %. In order to cancel out most of the systematic errors on the asymmetry measurements the polarization directions in target cells are reversed every 8 hours by rotating the magnetic field direction and at least once per data taking period by changing the DNP microwave frequency. The measured asymmetry is obtained from numbers of interactions observed for the two spin configurations (before and after polarization reversal) in upstream and downstream target cells. In such calculation beam fluxes and acceptances cancel out, provided that acceptance is the same before and after the polarization reversal.

3. The Inclusive Analysis

For the analysis we request that the primary vertex is inside one of the target cell, and that the incident muon has passed both target cells (to ensure the same muon flux for both cells). In addition, we apply the following kinematics cuts: 140 GeV$< E_\mu <$ 180 GeV, $Q^2 > 1$ GeV^2 and $0.1 < y < 0.9$. The total statistics of DIS events after these cuts is 34.5 million events.

Our data span a range of Bjorken variable $0.004 < x < 0.7$. In Figure 1, our results are compared to previous experiments. Below $x < 0.04$, only data from SMC[5] exist so far. Our preliminary results have smaller statistical errors owing to the increase in luminosity by a factor 5 and higher f with respect to the SMC experiment. This will help to better constrain the first moment of the spin dependent structure function g_1, and thus $\Delta\Sigma$. Known



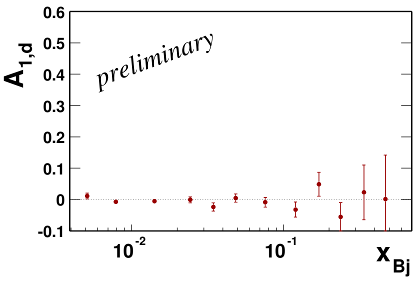


Figure 1. Measured asymmetry A_1 compared with other published experimental results (left). Fake configuration asymmetry (right). Within the statistical accuracy no asymmetry has been found.

sources of systematic errors are: $\sigma P_{target} = 5\%$, σP_{beam}=3 %, σf=5 % and $\sigma D < 5$ %. Systematic errors of other sources can be estimated

- by combining data with the same spin configuration, such that the measured asymmetry (fake configuration asymmetry) should be zero[b]. Our results obtained so far are compatible with zero within statistical error bars (see Figure 1);
- by using Monte Carlo simulation to study the effects of possible fluctuations in the detector efficiencies.

From the studies done so far, we estimate our systematic errors to be smaller than the statistical uncertainties.

4. Status of Semi-Inclusive Analysis

As described in the introduction the measurement of the semi-inclusive asymmetries allows to extract the contributions of the various quark flavours. At COMPASS we intend to measure six asymmetries $(A_1, A_1^{h^+}, A_1^{h^-}, A_1^{K^+}, A_1^{K^-}, A_1^{K_s^0})$. The upper index denotes which hadron

[b]time dependent changes in the spectrometer

type is detected in addition to the scattered muon. Figure 2 shows our preliminary result on the asymmetries $A_1^{h^\pm}$ obtained from our 2002-2003 data data compared to the SMC result.

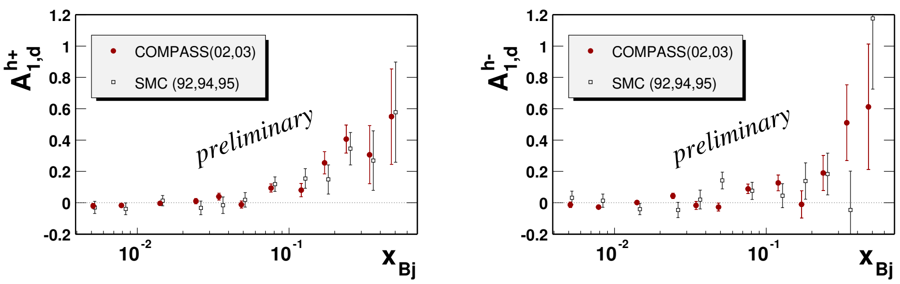


Figure 2. Measured semi-inclusive asymmetries $A_1^{h^+}$ (left panel) and $A_1^{h^-}$ (right panel) compared with SMC published result.

5. Conclusion

New preliminary results on both the inclusive, A_1, and semi-inclusive, $A_1^{h^\pm}$, spin dependent asymmetries on deuterium in the kinematic range $Q^2 > 1$ (GeV/c)^2 and $0.004 < x < 0.7$ have been obtained at COMPASS. Our results from 2002 and 2003 data are in good agreement with previous results from SMC, HERMES, SLAC experiments, and have already much improved statistical accuracy at low x compared to SMC, thanks to an increased beam flux and target dilution factor.

References

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