New COMPASS results on semi-inclusive polarised DIS

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Abstract

A main topic of investigation at the COMPASS experiment is the spin structure of the nucleon. This article reports on the experimental procedure to measure the spin-dependent structures functions of the valence, non-strange and strange quarks in polarised deep inelastic scattering. The dependence of the results for the strange quark polarisation on the fragmentation functions is discussed.

Key words: Nucleon Spin; DIS; A_1^d Asymmetries; Polarised PDF; Strange Quark Polarisation;
PACS: 13.60.Hb; 13.88.+e; 24.85.+p

COMPASS makes use of the CERN–SPS facilities, impinging a high intensity 160 GeV muon beam on a ^{6}LiD polarised target. The detailed description of the spectrometer can be found at Ref. [1]. Data presented in this article have been collected in the years 2002, 2003, 2004 and 2006.

In order to access the spin-dependent structure functions, the longitudinal photon-deuteron asymmetries, A_1^d and $A_{1,d}^h$, are measured. Events are selected by cuts on the four-momentum transfer squared, $Q^2 > 1\,(\mathrm{GeV}/c)^2$, and the fractional energy of the virtual photon, $0.1 < y < 0.9$. The Bjorken scaling variable interval is $0.004 < x < 0.3$. The fraction of the photon energy carried out by the hadrons, z, lies between 0.2 and 0.85. The momentum range of the hadrons is 10 – 50 GeV/c.

Fig. 1 shows the inclusive and charged hadron asymmetries A_1^d, $A_{1,d}^{\pi^\pm}$ and $A_{1,d}^{K^\pm}$ as a function of x, as measured by COMPASS. The results of HERMES [2] are also shown. The asymmetry is 0 for $x < 0.05$ and gets larger as x increases, with exception for $A_{1,d}^{K-}$. The statistical errors of COMPASS are similar to HERMES ones, but COMPASS has one order of magnitude larger phase space. The solid band corresponds to the systematic errors of the COMPASS measurements. The sources are the uncertainties of the beam and the target polarisations (5% each), the dilution factor (2%) and the depolarisation

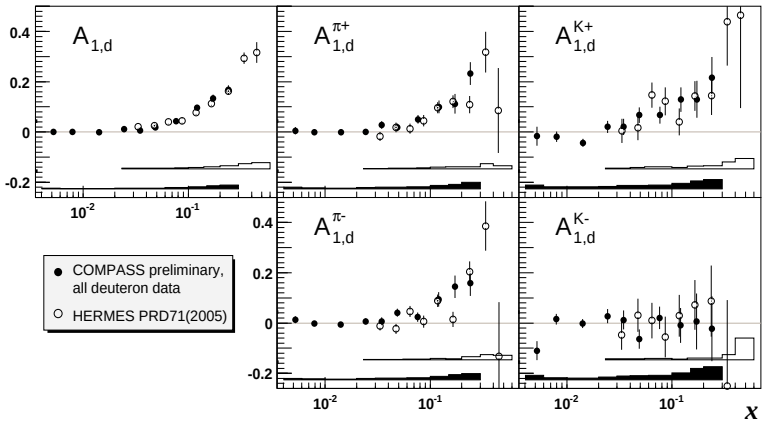

Fig. 1. *The asymmetries $A_1^d(x)$, $A_{1,d}^{\pi^\pm}(x)$ and $A_{1,d}^{K^\pm}(x)$ as measured by the COMPASS and the HERMES experiments. The error bars are the statistical ones. The bands show the COMPASS systematic errors.*

factor (2-3%). Radiative corrections are found to have a small effect. The upper limit for the systematic error due to false asymmetries is 40% of the statistical one.

The spin asymmetries shown above are used to determine the polarised parton density functions, $\Delta q(x, Q^2)$:

$$A_1^h(x, Q^2, z) = \frac{\sum_q e_q^2(\Delta q(x, Q^2) D_q^h(z, Q^2))}{\sum_q e_q^2(q(x, Q^2) D_q^h(z, Q^2))}, \quad (1)$$

where e_q is the quark charge. For the unpolarised distributions, $q(x, Q^2)$, LO MRST04 [3] are used. The two sets of fragmentation functions, $D_q^h(z, Q^2)$, are considered from the DSS [4] group and the EMC [5] measurements of the u quark fragmentation into π and K. The main difference between the two sets is the enhanced $s(\bar{s})$ quark contribution to the production of $K^-(K^+)$ in DSS, thus only the results on the strange quark polarisation are visibly affected. The fitted polarised PDFs are shown in Fig. 2. The lines are the LO DNS [6] fit to SMC [7] and HERMES [2] data, only. Indeed, the DNS parameterisation predicts successfully our result. The first moments of valence and non-strange quark polarisations, truncated to the measured x range and obtained with DSS FF, are $\Delta u_v + \Delta d_v = 0.28 \pm 0.06 \pm 0.03$ and $\Delta\bar{u} + \Delta\bar{d} = -0.03 \pm 0.03 \pm 0.01$. These values are well in agreement with the ones measured with the difference asymmetry approach [8]. A different scenario concerns the contribution of the strange quark ($\Delta s(SIDIS) = -0.01 \pm 0.01 \pm 0.01$, from the measured x range) to the nucleon spin, as this SIDIS measurement is not confirmed in inclusive DIS [9] ($\Delta s(DIS) = -0.05 \pm 0.01 \pm 0.01$, in the full x range). A similar disagreement is obtained by HERMES [10].

In order to study the dependence of Δs on the fragmentation functions, a different approach is used. In such, Δs is related to inclusive and charged kaon asymmetries and to the ratios of strange to favoured, $R_{SF} = \int D_{\bar{s}}^{K+} / \int D_u^{K+}$, and unfavoured to favoured, $R_{UF} = \int D_{\bar{d}}^{K+} / \int D_u^{K+}$, fragmentation functions. This approach leads to a very similar result on Δs, as can be seen on the left panel of Fig. 3. The right panel shows the strong dependence of Δs on the R_{SF}. R_{UF} is fixed to 0.14 from the DSS FF, but large changes of this ratio do not change significantly the result of Δs. If $R_{SF} > 5$ Δs from SIDIS measurements becomes larger than Δs obtained in DIS, which implies that Δs must be

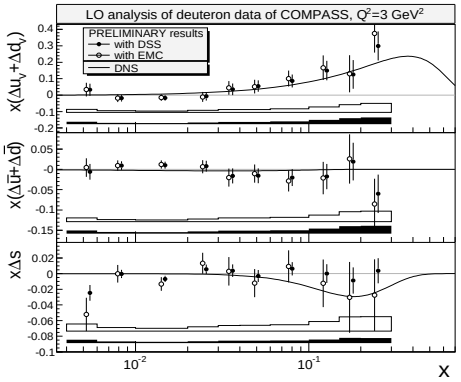

Fig. 2. *The polarised PDFs for valence, non-strange and strange quarks for two sets of fragmentation functions, evaluated at* $Q_0^2 = 3GeV^2$*. The error bars are the statistical ones. The bands represent the systematic uncertainties. The curves are the DNS fit which do not include the present COMPASS data.*

negative in the unmeasured low x range. However, the difference never exceeds 2σ.

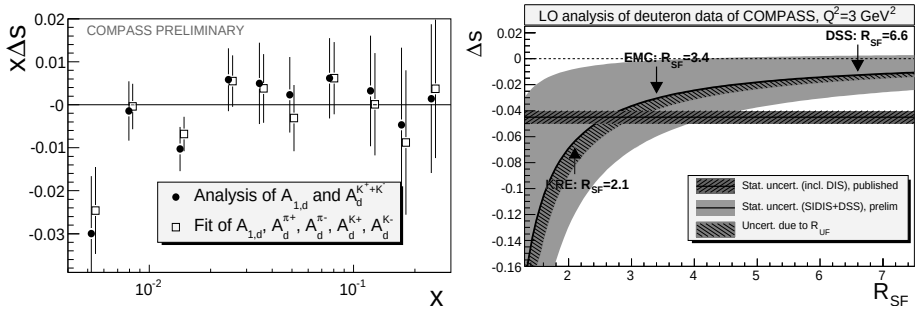

Fig. 3. *Left: The strange quark helicity distributions derived from inclusive and charged kaon asymmetries compared to the result of the least square fit. Right: Integral of* Δs *as a function of* R_{SF} *for* R_{UF} *fixed to 0.14 (thick solid curve). The light grey area is the statistical uncertainty and the hatched band is the statistical uncertainty due to* R_{UF}*. The horizontal band is the full moment of* Δs *derived from COMPASS measurement at DIS. The arrows indicate the values of* R_{SF} *corresponding to DSS [4], EMC [5] and KRE [11] parameterisations of fragmentation functions.*

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