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Status of the COMPASS experiment at CERN

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Abstract. Status of the COMPASS experiment at CERN is given.

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1 Introduction

The COMPASS (or NA58) is a two-phase experiment, situated at the M2 muon beam from the CERN SPS [1]. In its present, muon beam phase the experiment is designed to access the gluon polarisation ΔG/G in the nucleon, longitudinal (Δq) and transverse ($\Delta_{\rm T}$q) spin dependent parton distributions in the nucleon, nucleon structure function g_1 at low- and moderate x, Λ hyperon polarisation and spin transfer in the fragmentation, (ΔD_q^Λ) and finaly the vector meson production and decay. In this paper a short account of the status of COMPASS after the 2002 run will be given.

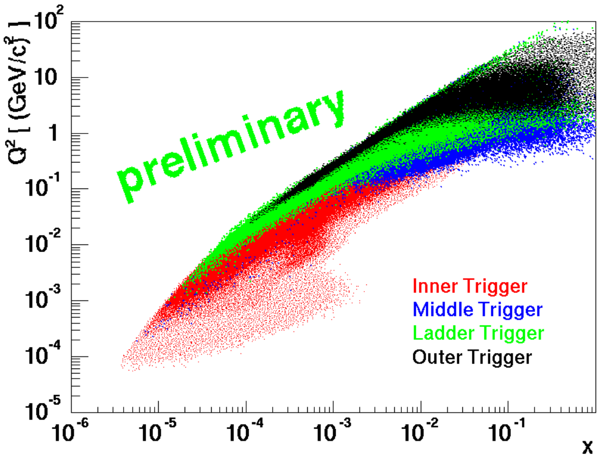

Fig. 1. COMPASS kinematic acceptance.

2 Setup

The first physics data were taken in 2002, using the positive muon beam of 160 GeV arriving in 4.8 s long spills every 16.2 seconds. The muon flux was 2.8×10^8 per spill. The beam was about 76% polarised, 3% momentum spread and emittance larger than 6 mm×mrad. It was incident on a ^{6}LiD polarised solid-state target, consisting of two cells, oppositely polarised up to 57% by the dynamical nuclear polarisation and of angular acceptance for produced particles about 70 mrad. Both longitudinal and transverse target polarisations were used.

The detector is a two-stage spectrometer; the large- and small-angle spectrometers cover ±180 mrad and ±30 mrad acceptance respectively and each comprises tracking and particle identification detectors as well as a conventional dipole magnet of bending powers 1 and 4.4 Tm. Spectrometer performance in 2002 is described in detail in [2]. All the results shown here come from the 2002 run.

3 Acceptance and data flow

A total amount of 260 TBytes of data were collected. For the longitudinal target polarisation this corresponded to 3 800 ×10^6 events, out of which about 570×10^6 events contained incident and scattered muons and 29 ×10^6 events also corresponding to Q^2 >1 GeV^2. Integrated luminosity was 1.2 fm^{-1} and 0.3 fm^{-1}, respectively for the longitudinal and transverse polarisation. The kinematic acceptance covered by the data is shown in Fig.1. Very small values of Q^2 (and x) are accessed; this was a goal since the charm production cross section is high there. It will also permit to test the Regge predictions for g_1 since at low Q^2 the covered interval in x is wide, cf. [3].

4 Gluon polarisation, ΔG/G

The gluon polarisation in the nucleon, ΔG/G, will be accessed through measurements of the spin cross section

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asymmetries in the photon–gluon fusion process ($g\gamma^\star \to q\bar{q}$) tagged either by a charmed $D^0(\overline{D^0})$ meson or by the high transverse momentum hadron pair in the final state. The former reaction is very clean due to the charmed meson decay in the $K\pi$ channel with the cross section high at low Q^2; the RICH identification of kaons is essential here. The latter is very abundant but flooded by the background of the QCD Compton scattering and of the leading order processes. Estimated statistical accuracy of the $\Delta G/G$ measurement via the high–p_T hadron pairs and based on 2002 data is about 0.3 (0.1) for Q^2 >1 GeV^2 (no Q^2 cut) sample. For the open charm production no accuracy estimates can be given at present.

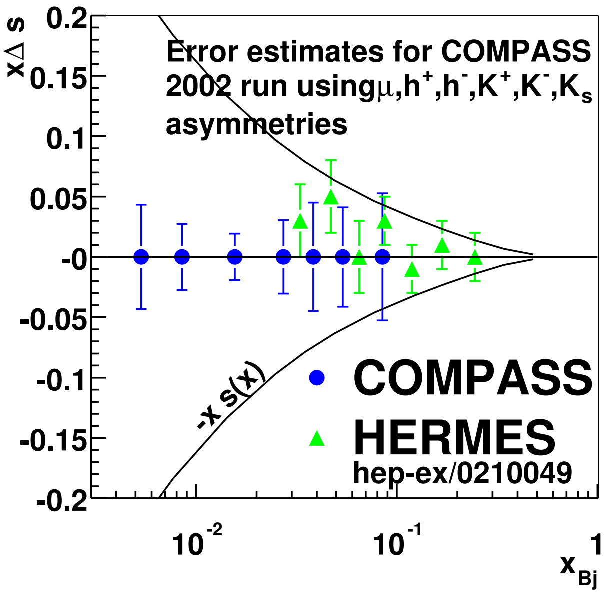

Fig. 2. Expected statistical error on the $x\Delta s$ part of the quark contribution to the nucleon spin.

5 Spin dependent parton distributions, Δq

Large statistics of the semi–inclusive processes at $Q^2 > 1$ GeV^2 together with a good identification of the final state hadrons will permit the flavour decomposition of the quark contribution to the nucleon spin. In Fig.2 an example of the statistical error estimate for the $x\Delta s$ for the 2002 COMPASS data combined with those of the SMC is shown, together with measurements of HERMES. The lower limit in x for the COMPASS data will be an order of magnitude smaller than the one for HERMES.

6 Transverse spin dependent parton distributions, $\Delta_T q$

Semi–inclusive deep inelastic scattering off a transversely polarised target permits to measure the transverse spin dependent parton distributions, complementing the spin averaged and longitudinal spin dependent distributions in the full (leading twist) description of the nucleon. These distributions correspond to the quark polarisation along the nucleon spin direction when the nucleon is polarised transversely to the virtual photon. Non-relativistically they are identical with Δq but in a relativistic picture of the nucleon they may differ due to the fact that longitudinal and transverse operators do not commute. Two types of polarimeters may be used in the measurements: mesonic ones ($\Delta_T q$ extraction *via* the azimuthal dependence of a leading hadron in the Collins effect) and baryonic ones ($\Delta_T q$ extraction from the transverse polarisation of the produced hyperon Λ). In 2002 about 10^7 events were collected with the transversely polarised ^{6}LiD target and in the $Q^2 > 1$ GeV^2 region. Corresponding statistical accuracy of the Collins asymmetry for events with positive leading hadron and additional cuts: $0.1 < y < 0.9$, $z^h > 0.25$ and $p_T^h > 0.1$ GeV is shown in Fig.3. More details about the transversity analysis is given in [4].

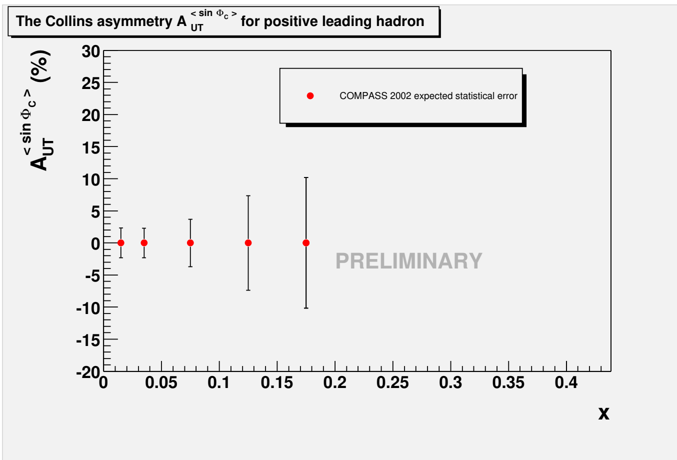

Fig. 3. Expected statistical accuracy for the Collins asymmtery for positive leading hadron. See text for details.

7 Longitudinal polarisation of the Λ^0 hyperon

Longitudinal polarisation of the Λ hyperon in the current fragmentation region (x_F >0) provides a possibility to measure the spin transfer in the fragmentation, ΔD_q^Λ, as well as to test the strange sea symmetry in the nucleon. The Λ^0 ($\overline{\Lambda^0}$) hyperons are clearly identified in the data, Fig. 4. Their polarisation was measured *via* the angular asymmetry of their positive decay product. In the Λ cms (with an x axis along virtual photon, $\gamma^\star$ and y perpendicular to $\gamma^\star$ and the target nucleon momenta) the angular distribution, $dN/d\cos\theta_i$, of that positive particle is given by $(1+\alpha P_i \cos\theta_i)/2$ where $i = x, y, z$, $\overline{P}$ is the polarisation vector and α=0.642±0.013 is the hyperon decay parameter. In Fig.4 ratios of the measured to simulated values of $\cos\theta_i$ are shown for the K^0 meson and Λ^0 ($\overline{\Lambda^0}$) hyperons.

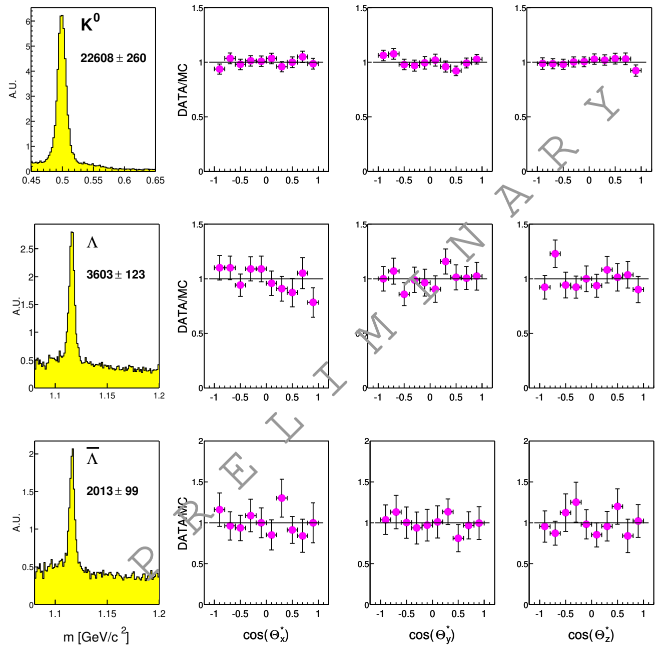

Fig. 4. Angular distributions of K^0 mesons and Λ hyperons normalised to the (unpolarised) Monte Carlo calculations. Errors are statistical. The first column shows the K^0 and Λ ($\bar{\Lambda}$) signals.

The data correspond to about 1/6 of the 2002 statistics. Cuts: $Q^2 > 1$ GeV^2, $0.2 < y < 0.9$ and the decay vertex situated outside the target were imposed. All the distributions for the K^0 meson (which is spinless) and cosθ_z for the hyperons should be flat. Deviations from flateness in all other distributions point towards longitudinal (cosθ_x) or transverse (cosθ_y) polarisation of hyperons. There is a hint of a small P_x polarisation of the Λ. The analysis is described in more detail in [5]. The data demonstrate a very good COMPASS potential for the Λ hyperon polarisation measurement.

8 Vector meson production and decay

A very clear signal of the hadronic ($\pi\pi$ and KK) decay channels of the ρ^0 and ϕ mesons is seen in the data. Statistics is large in the whole range of measured Q^2 values, from the (quasi–real) photoproduction up to the deep inelastic region. This permits a high precision investigations of the $\gamma^\star N \rightarrow VN$ reaction, known to be diffractive even at large Q^2 and important in the studies of pomeron/multigluon exchanges. Among the goals one should also mention the extraction of the density matrix elements and tests of the s channel helicity conservation (SCHC), measurements of the double spin asymmetry (possibly related to $\Delta G/G$ at high Q^2), and exploratory studies of generalised parton distributions at large Q^2.

One dimensional projections of the ρ^0 decay distributions are shown in Fig.5. They are based on 1/6 of the 2002 statistics, are acceptance uncorrected and comprise the following cuts: scattered muon energy > 20 GeV, muon energy transfer > 30 GeV, $Q^2 > 0.05$ GeV^2, modulus of the four-momentum transfer to the target corrected by its minimal kinematically allowed value is smaller than 0.5 GeV^2 and $-2 < (M_x^2 - M_{proton}^2)/2M_{proton} < 2.5$ GeV (M_x is the missing mass of undetected final state particles), see [6] for details. The data show that the fraction of longitudinally polarised ρ mesons seems to be close to zero at small Q^2 and growing with Q^2. The azimuthal distributions are consistent with an approximate SCHC.

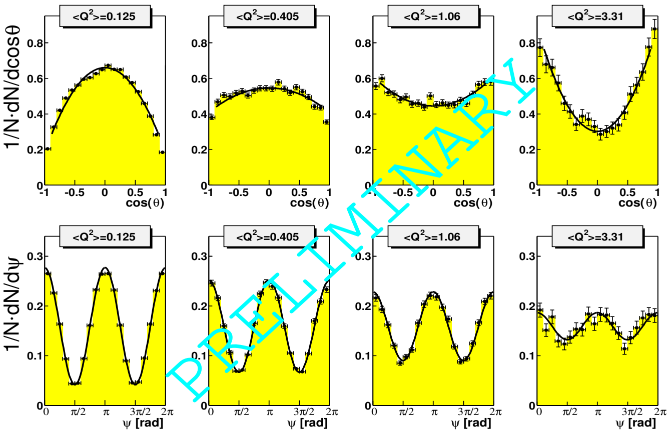

Fig. 5. Angular distributions in the ρ^0 decay for four bins of Q^2. Errors are statistical. Angle θ is measured in the ρ^0 rest frame, $\Psi = \phi - \Phi$ if the s channel helicity is conserved and ϕ and Φ are angles between ρ^0 production and decay planes and production and scattering planes respectively.

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