Spin Physics with COMPASS

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1. Introduction: The Nucleon Spin

In an intuitive picture the spin of the nucleon is carried by its valence quarks. The analysis of axial matrix elements of weak baryon decays shows, that this contribution is reduced to about 60% if the sea quarks are assumed to be unpolarised. But then deep inelastic scattering (DIS) experiments (EMC/SMC, SLAC, HERMES) revealed that the contribution of the quarks to the nucleon spin is even smaller and only 30%, with a strange quark contribution consistent with zero [1]. However the interpretation of DIS results is not without ambiguity if the helicity contribution of the gluons to the nucleon spin is sizable. Therefore the measurement of the gluon polarisation, $\Delta G/G$, as a function of the Bjorken scaling variable $x = Q^2/2M(E-E')$ is of basic interest and this measurement is presently the main goal of the COMPASS experiment [2].

2. The COMPASS Experiment

COMPASS is a fixed-target experiment located at the muon beam-line M2 of the CERN-SPS accelerator. The muon beam energy is currently 160 GeV (could be up to 200 GeV). The beam intensity is about 2×10^8 muons per spill of 5 s every 15 s with a polarization of about 76%. The target is a two-cell solid-state ^{6}LiD target polarised by Dynamic Nuclear Polarisation up to 54%.

COMPASS uses a two-stage forward spectrometer, shown in Fig. 1. Both stages consist of a bending magnet with tracking stations in front and behind it, particle identification provided by an electromagnetic and a hadronic calorimeter, a Ring Imaging Cherenkov Counter (RICH) in the first stage, and an iron absorber to identify muons. The magnets have a bending power of 1.1 Tm and 6.2 Tm. The RICH provides a $K-\pi$ separation in the momentum range 3 to 50 GeV/c. The overall acceptance of the spectrometer is 70 mrad in polar angle, full acceptance in azimuth. Tracking is provided by different types of detectors. The beam region is covered by scintillating fibre hodoscopes and silicon detectors. Small angle tracking is provided by Micromeagas, Gas Electron Multipliers (GEMs) and MWPCs. For large angle tracking, drift chambers with a size up to 320×240 cm^2 (straws) are used.

After an engineering run in 2001, COMPASS had its first physics run in 2002. Out of the 100 days of beam time, 76 days could be used to take physics data. The other 24 days were needed for setup and tuning. In total 260 TByte of data were collected.

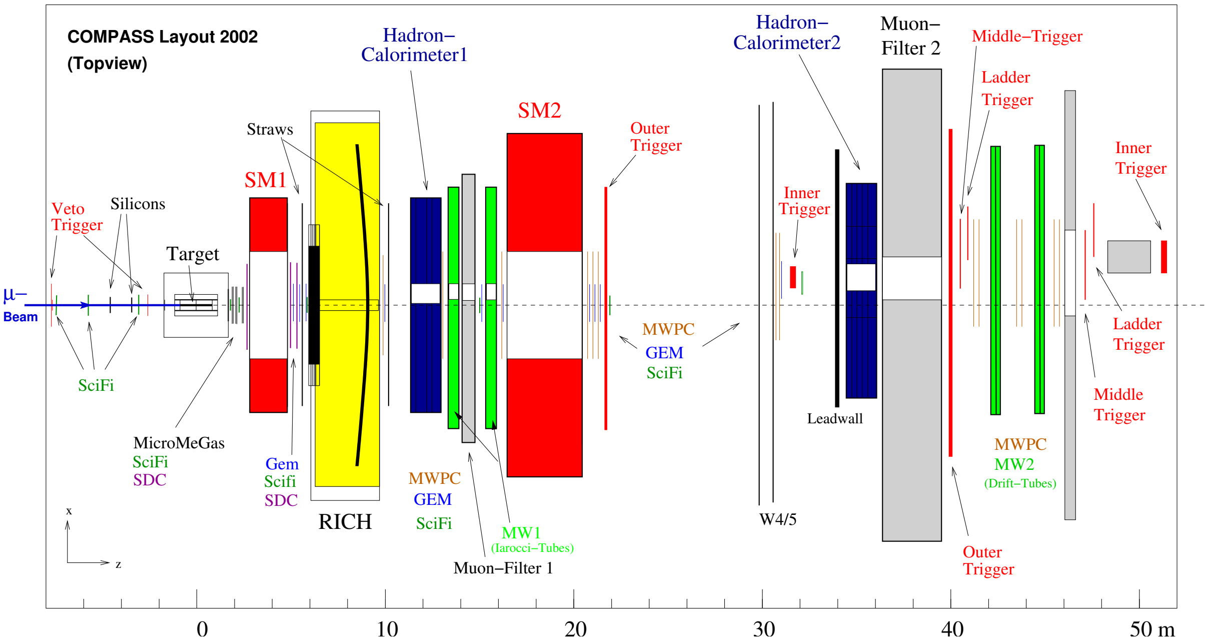

Figure 1. Schematic view of the COMPASS experiment

Of the physics data (4.75×10^9 trigger) 80% were taken with a longitudinally polarised target, the rest with a transversely polarised target. For the longitudinal data we reconstructed 570×10^6 events with an incoming and a scattered muon, covering more than 5 orders of magnitudes in x and Q^2 (Fig. 2). The reconstructed sample contains 29×10^6 inclusive events with $Q^2 > 1\mathrm{GeV}^2$.

3. COMPASS Physics Programme: Nucleon Spin Structure

The main goal of the COMPASS experiment at present is the measurement of the gluon polarisation $\Delta G/G$. In addition to this we have a broad spectrum of measurements using the muon beam: transversity, reconstruction of Λ and $\bar{\Lambda}$, diffractive vector meson production, flavour separation Δq, $\Delta\bar{q}$, and spin dependant fragmentation functions ΔD_q^λ.

3.1. Measurement of $\Delta G/G$

Up to now most of the experiments focused on *inclusive* deep inelastic scattering where only the scattered lepton is observed in the final state ($l + N \to l' + X$). Common to all measurements mentioned above is the observation of part of the hadronic final state: $l + N \to l' + hadrons + X$. This so called semi-inclusive process allows a deeper insight into the structure of the nucleon, since it is the parton that participates in the deep-inelastic scattering process. Also a gluon can participate in a deep-inelastic process via the photon-gluon fusion ($\gamma^* + g \to q + \bar{q}$), which can be identified by its hadronic final state.

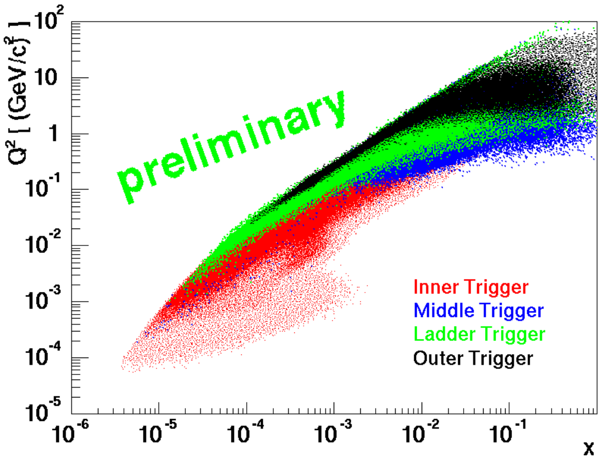

Figure 2. Kinematic range of COMPASS

$\delta(\Delta G/G)$	Q^2 range
0.31	≤ 1 GeV^2
≈ 0.1	all

Table 1. Error estimates for $\Delta G/G$ from the high-p$_T$ data from 2002

In the case the produced quarks are charm quarks the process can be tagged by the observation of charmed hadrons. Since there is no intrinsic charm quark in the proton and the production of charm quarks in the fragmentation process is suppressed, the observation of a charmed hadron clearly tags the photon gluon fusion process. On average 1.2 D^0 or $\bar{D}^0$ are produced in the fragmentation of the photon-gluon fusion process. The D^0 can be detected via several decay channels. The most promising one is $D^0 \rightarrow K^- + \pi^+$.

In case the produced quarks are light quarks, the process can be tagged by a pair of hadrons with large transverse momenta. This high-p_T method is less clean due to concurrent background like the QCD compton processes $(\gamma^* + q \rightarrow q + g)$ which also leads to the creation of hadrons with large transverse momenta.

To measure the gluon polarisation $\Delta G/G$ one has to measure the double spin asymmetry of PGF events with nucleon and lepton spin parallel and anti-parallel. The statistical errors we anticipate from the year 2002 data taking are shown in table 1.

4. Outlook

For the years 2003 and 2004 we will continue with the nucleon spin structure measurements using the muon beam and collect more data. In 2005 COMPASS will be upgraded and modified, due to the start of the additional hadron spectroscopy programm in 2006. This programm will use π-, K- and p-beams. Objectives of these measurements will be Primakoff reactions (polarisibility of π, K), generalised parton distributions, glueballs, hybrid- and charmed hadrons.

REFERENCES

1. K.Ackerstaff et all., Phys. Lett. B **464** (1999) 123
2. COMPASS proposal, CERN/SPSLC 96-14, SPSLC/P297, 1996