Longitudinal polarisation of Λ and $\bar{\Lambda}$ hyperons in deep-inelastic scattering at COMPASS.
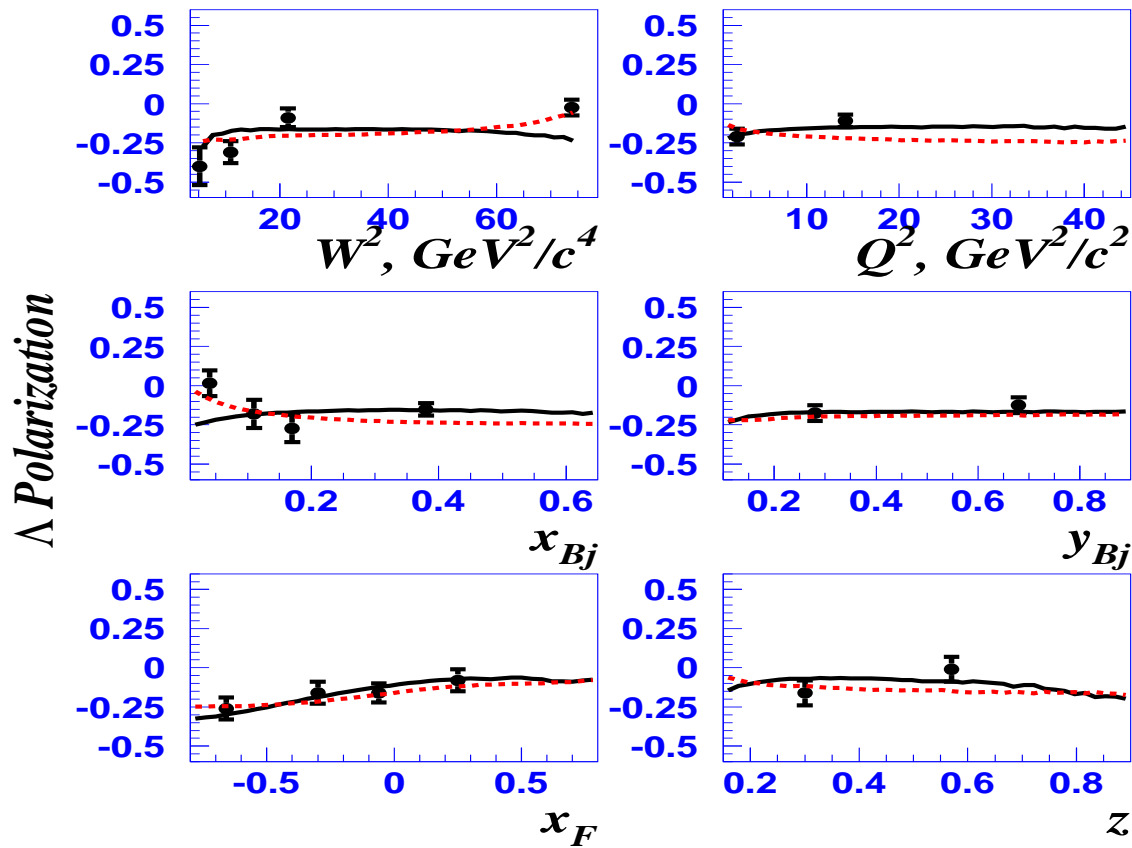
On behalf of the COMPASS Collaboration

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october 10_16 2004

spin

16th international spin physics symposium

Physics motivations

- Target fragmentation region (TFR) $x_F < 0$

  – Ellis, Kharzeev, Kotzinian (Z.Physik C69 (1996) 467) predict negative longitudinal polarisation of Λ hyperons (within polarised nucleon intrinsic strangeness model)

Ellis, Kotzinian, Naumov (Eur.Phys.J., C25 (2002) 603)


The predictions of polarised nucleon intrinsic strangeness model for the polarization of Λ hyperons produced in ν_μ charged-current DIS interactions off nuclei. The points with error bars are from NOMAD experiment.
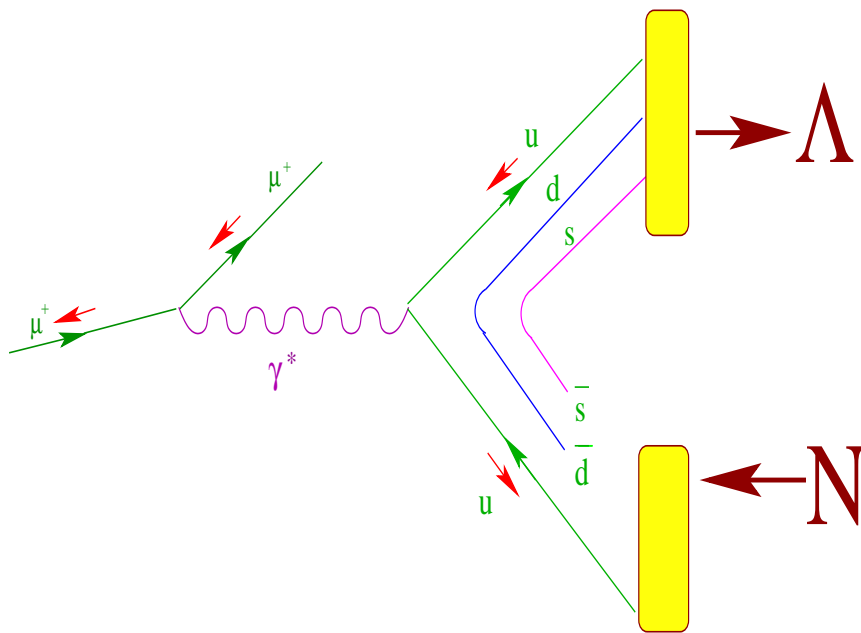
- Current fragmentation region (CFR) $x_F > 0$

  - Study of the quark to baryon spin transfer processes $q \to \Lambda$

  - Λ spin structure
    NQM: $\Delta u^\Lambda = \Delta d^\Lambda = 0, \Delta s^\Lambda = 1$
    Burkardt and Jaffe:
    $g_1^\Lambda \Rightarrow \Delta u^\Lambda = \Delta d^\Lambda = -0.23,$
    $\Delta s^\Lambda = 0.58$

  - Test of the strange quark-antiquark symmetry of the nucleon sea
    $s(x) \neq \bar{s}(x)$?
 $\Delta s(x) \neq \Delta \bar{s}(x)$?

Quark-Antiquark Asymmetry of the Nucleon Sea
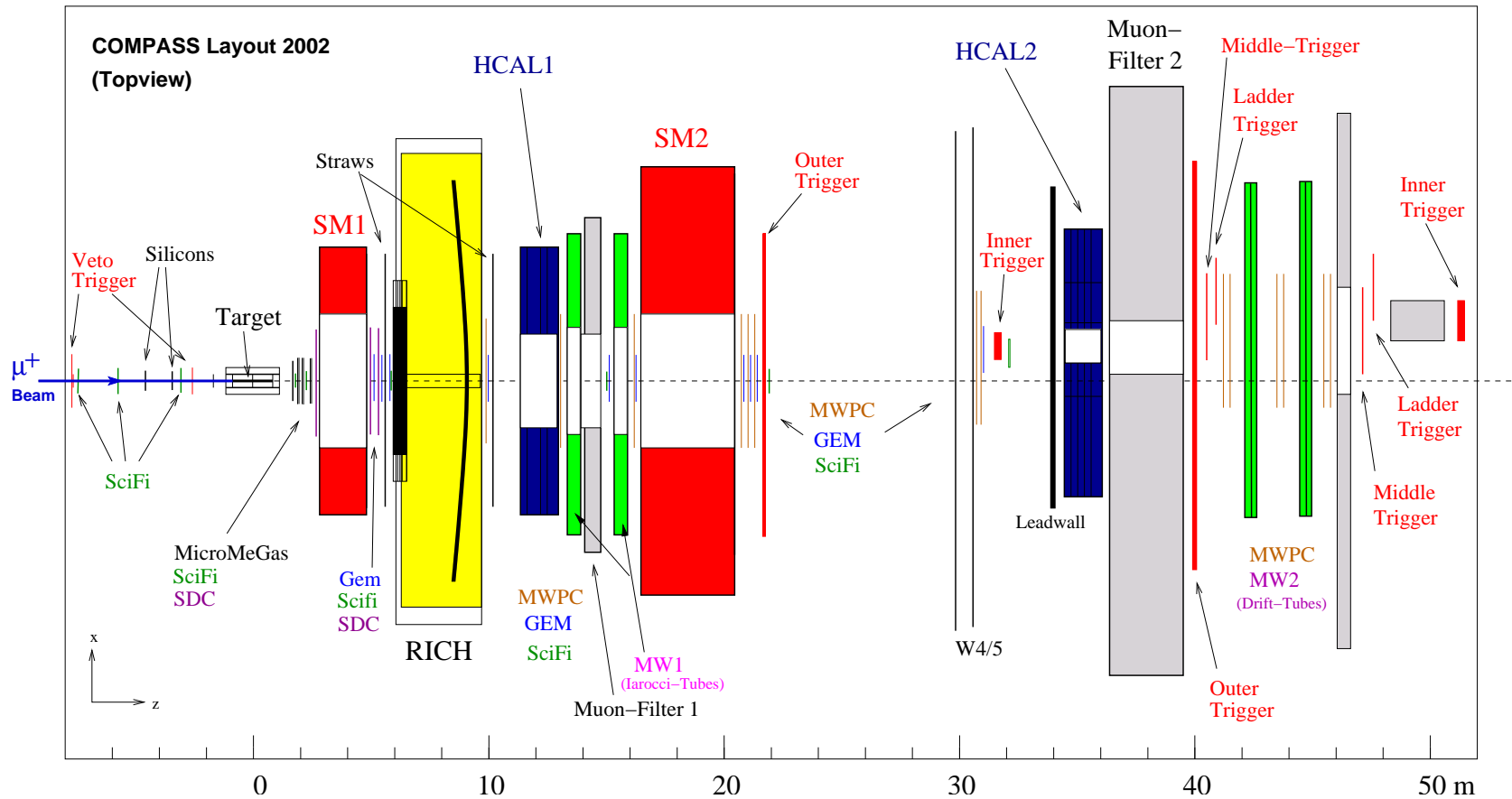
B.Q.Ma et al., Phys.Lett. B488 (2000) 254
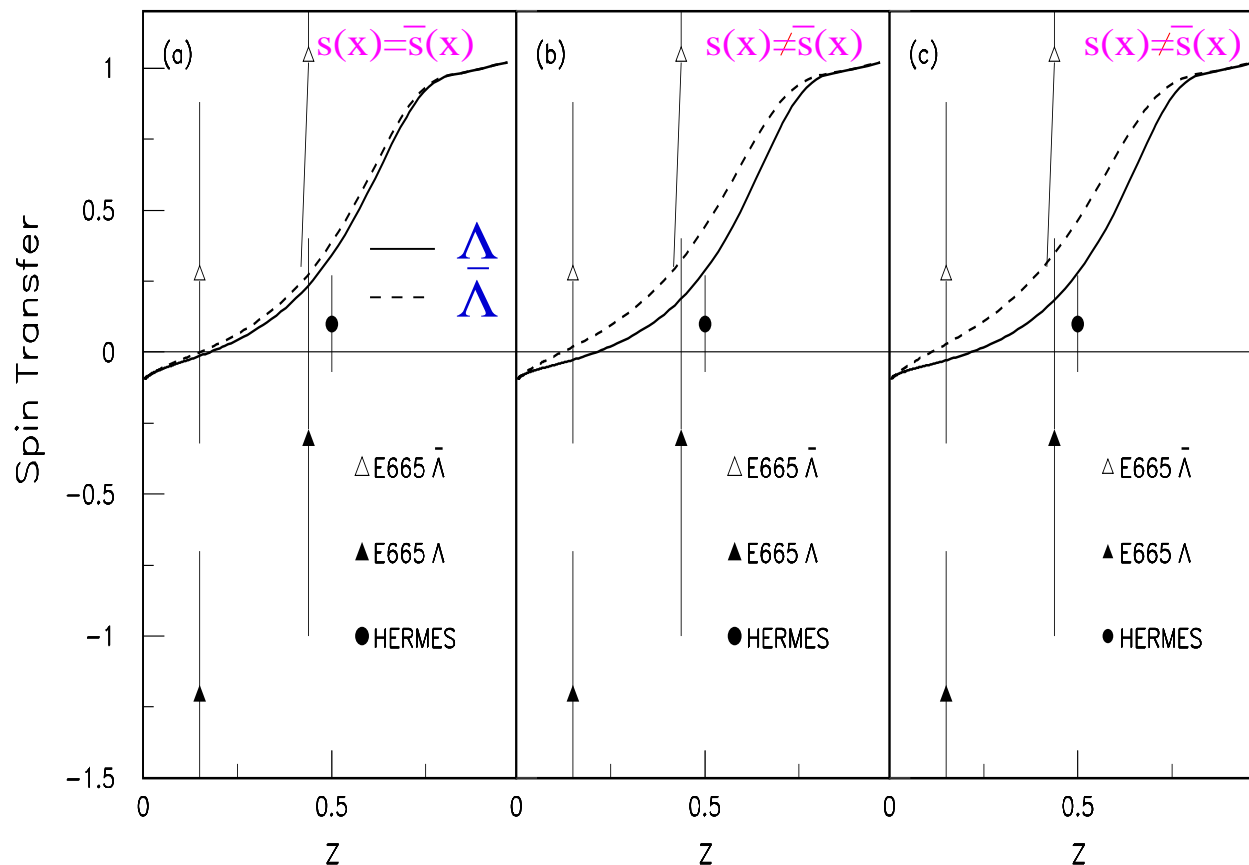
- The z-dependence of the Λ and $\bar{\Lambda}$ spin transfer in polarised charged lepton DIS on the nucleon.

- The solid and dashed curves correspond to the calculated results of Λ and $\bar{\Lambda}$ spin transfers with different parametrisations of quark distributions.

- Possibility of quark-antiquark asymmetries either in the quark to Λ fragmentation functions and/or in the quark and antiquark distributions of the target proton.

Difficulties in interpretation of experimental results due to:
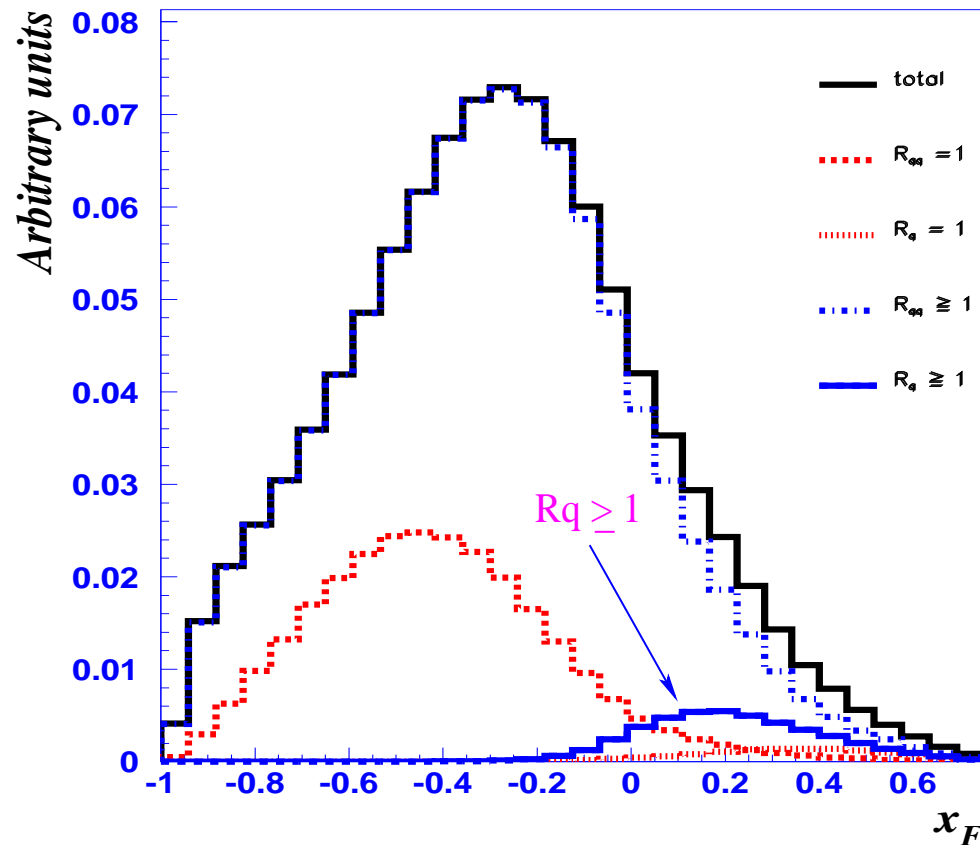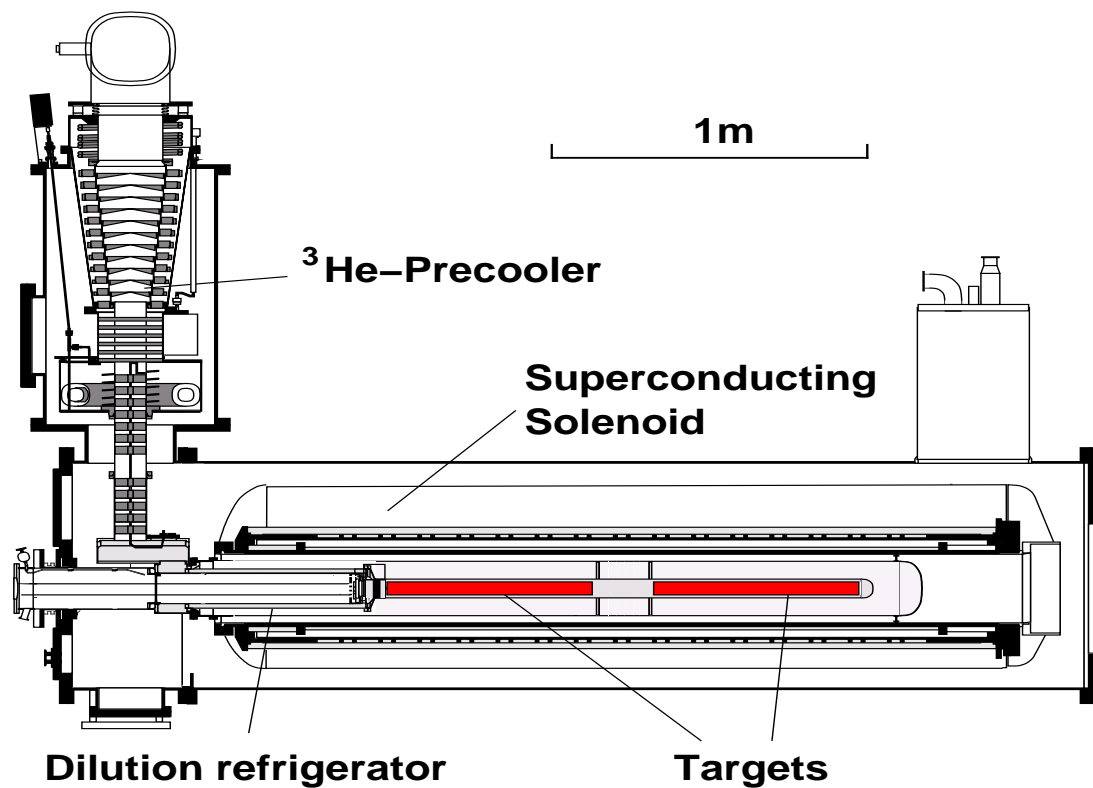

- large contribution from the diquark fragmentation (J. Ellis et al. Eur. Phys. J C25 (2002) 603) Rank counters R_{qq} and R_q corresond to particle rank from the diquark and quark ends of the string.

- significant fraction of Λ hyperons produced via decays of heavier strange particles

COMPASS experimental setup 2002

COMPASS Layout 2002
(Topview)

μ⁺ Beam

Veto Trigger — Silicons — SciFi

Target

MicroMeGas SciFi SDC

SM1

Gem Scifi SDC

Straws

RICH

HCAL1

MWPC GEM SciFi

Muon–Filter 1

MW1 (Iarocci–Tubes)

SM2

Outer Trigger

MWPC GEM SciFi

HCAL2

Inner Trigger

Leadwall

W4/5

Muon–Filter 2

Middle–Trigger

Ladder Trigger

Outer Trigger

MWPC MW2 (Drift–Tubes)

Inner Trigger

Ladder Trigger

Middle Trigger

x
z

0   10   20   30   40   50 m

Polarised target

^{3}He–Precooler

1m

Superconducting
Solenoid

Dilution refrigerator

Targets

- Solenoidal field 2.5T
- 2×60 cm long cells
- ^6LiD material
- $P_T \approx 50\%$
- $f = 0.5$
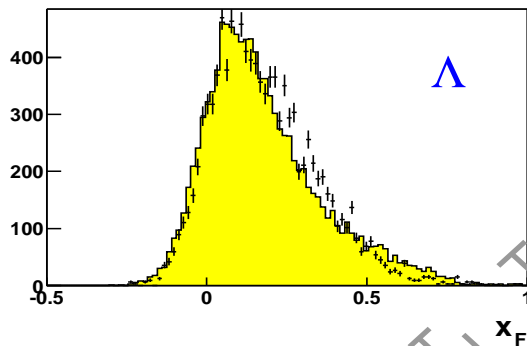- In this analysis data are averaged on target polarisation

Selection cuts

PRELIMINARY

$Q^2 > 1.0$ GeV^2/c^2

K^0_s

$\overline{\Lambda^0}$ Λ^0

p_t [GeV/c]

α
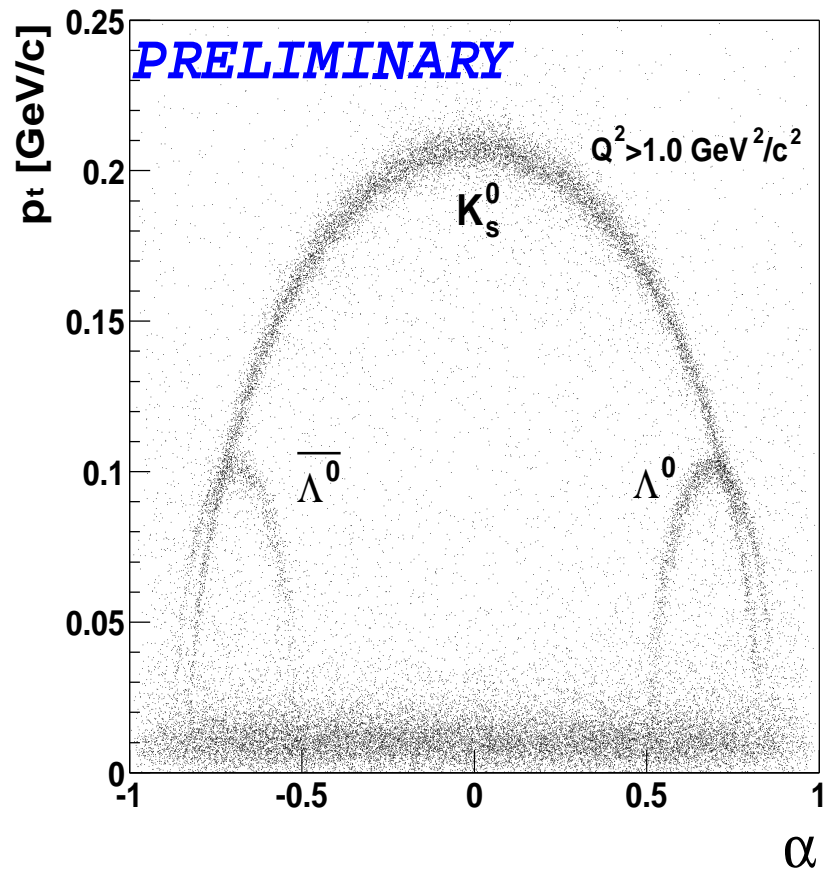
$$\alpha = \frac{p^+_L - p^-_L}{p^-_L + p^+_L}$$

- Decay vertex (V^0) must be outside of the target.

- The angle between vector of V^0 momentum and vector between primary and V^0 vertices should be $\theta_{col} < 0.01$ rad.

- $p_t > 23$ MeV/c.

- $Q^2 > 1 \; (GeV/c)^2$, $0.2 < y < 0.8$

Kinematical characteristics
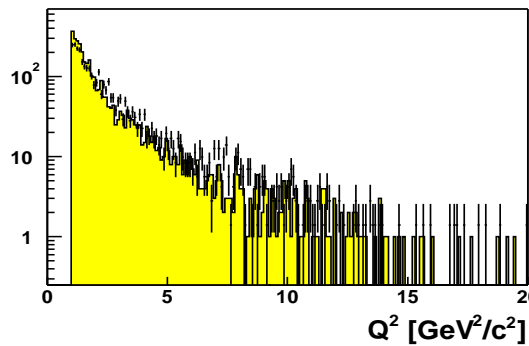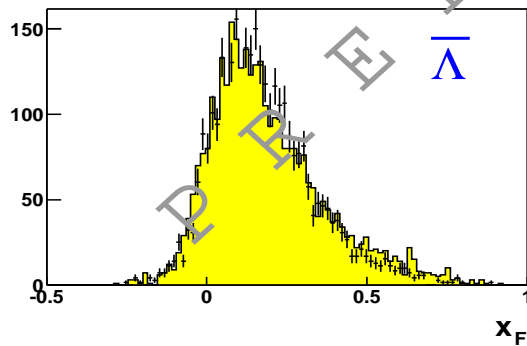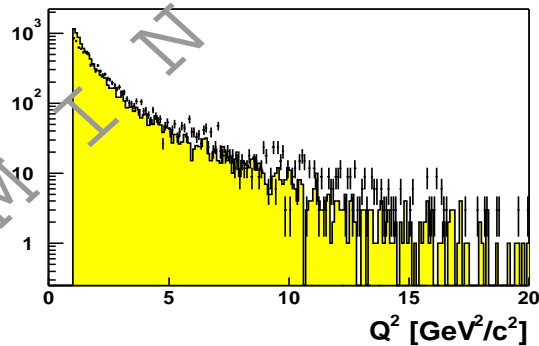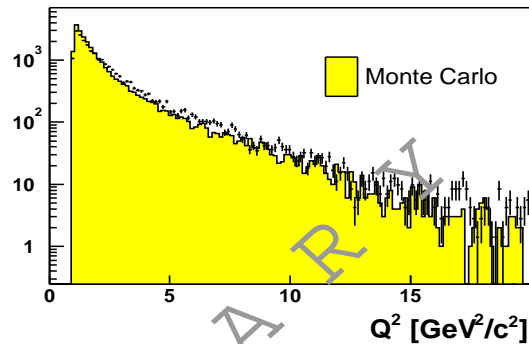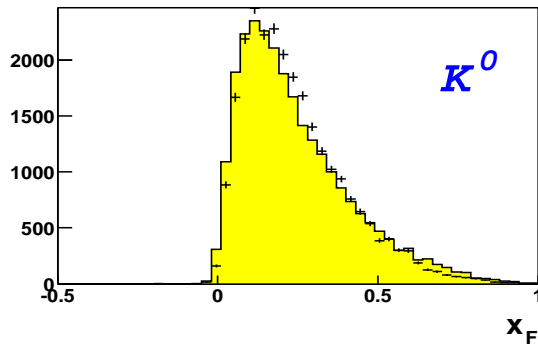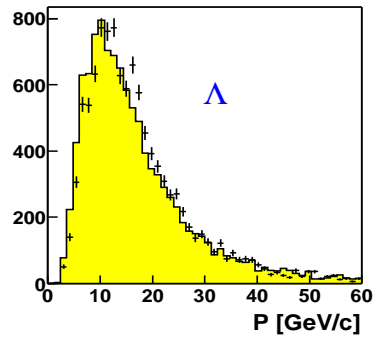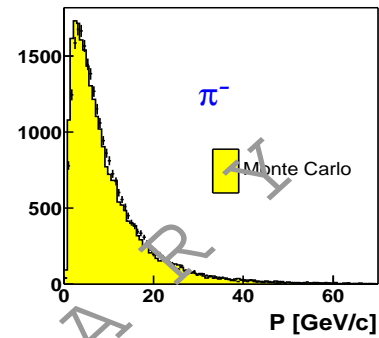

LEPTO 6.5.1 is used for event simulation.

$< x_F >= 0.2$

$< y >= 0.45$

$< x_{Bj} >= 0.02$

$< Q^2 >= 2.62 \ (GeV/c)^2$

Kinematical characteristics
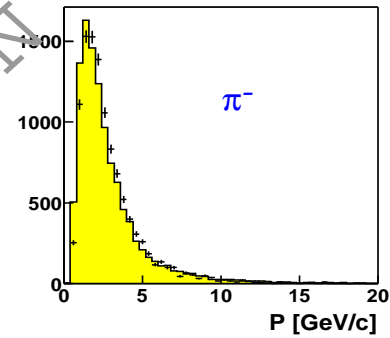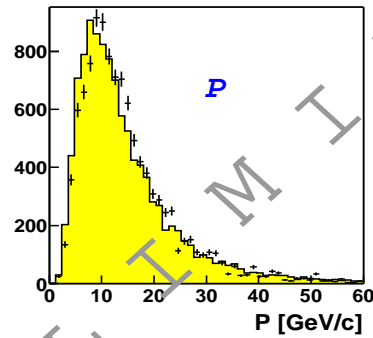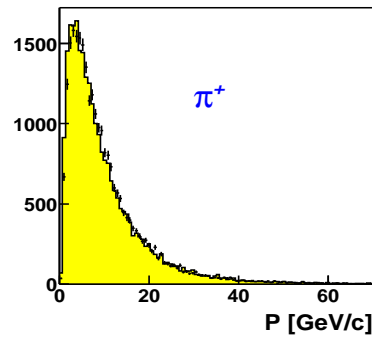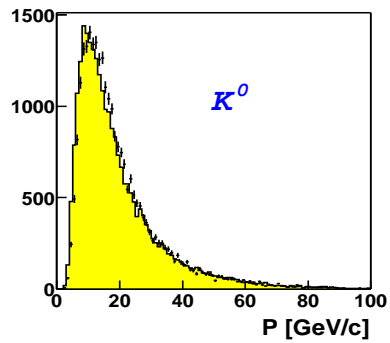
$< P_\Lambda > \approx 12 \ GeV/c$

$< P_\pi > \approx 2 \ GeV/c$
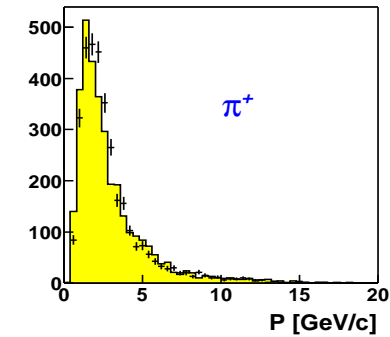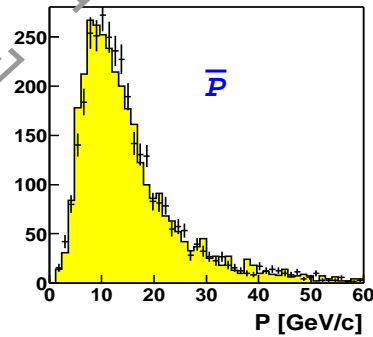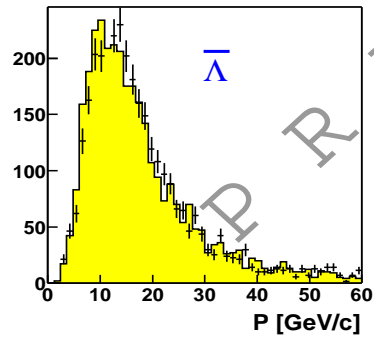
Experiments on Λ and $\bar\Lambda$ production in DIS

	N(Λ)	N($\bar\Lambda$)
E665	750	650
NOMAD	8087	649
HERMES, 1996-2000	10586	1687
COMPASS, 2002	7919	5062

Angular distributions
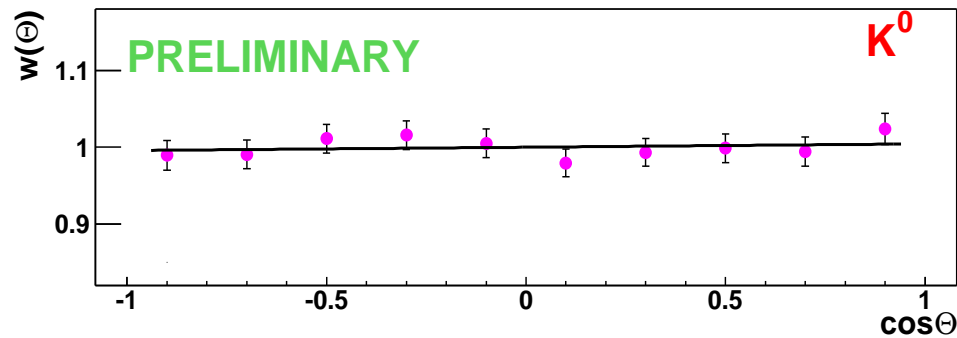
- $\Lambda(\bar{\Lambda})$ hyperon polarisation is measured via angular asymmetry of decay protons in $\Lambda \to p\pi^-$ $(\bar{\Lambda} \to \bar{p}\pi^+)$ decays.

- Determine X- axis along the direction of the virtual photon in the V^0 rest frame.

- The angular distribution in the $\Lambda(\bar{\Lambda})$ rest frame is

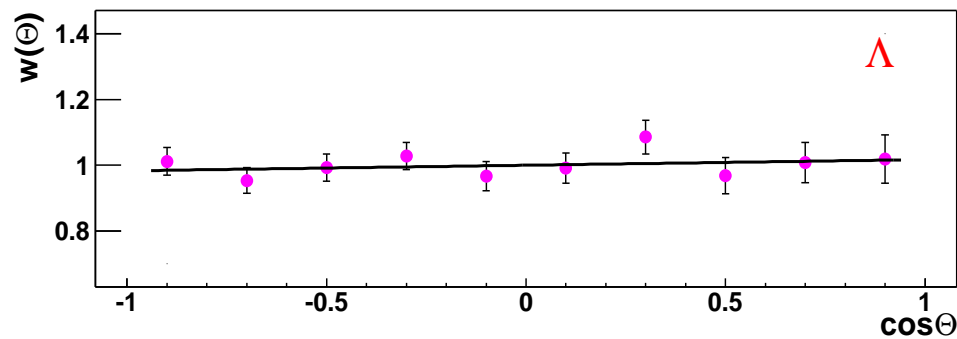$$\frac{dN}{d\cos\theta_X} = \frac{N_{tot}}{2}(1 + \alpha P \cos\theta_X) \tag{1}$$

  where N_{tot} is the total number of events, $\alpha = 0.642 \pm 0.013$ is Λ decay parameter, P is the projection of the polarisation vector at the corresponding axis, θ_X is the angle between the direction of the positive decay particle (proton for Λ, pion - for $\bar{\Lambda}$).

- Background subtraction using bin-by-bin fit of the invariant mass distributions of $(p\pi^-)$ in $\cos\theta$ bins.

- The acceptance correction $A(\cos\theta)$ was determined using unpolarised Monte Carlo simulation.
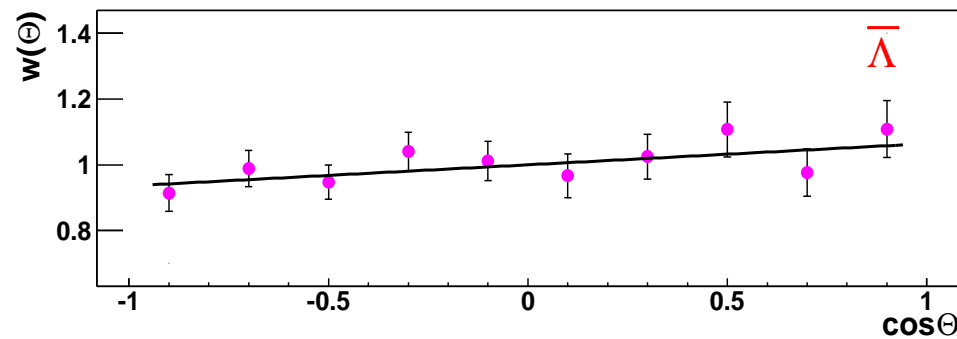
Corrected angular distributions
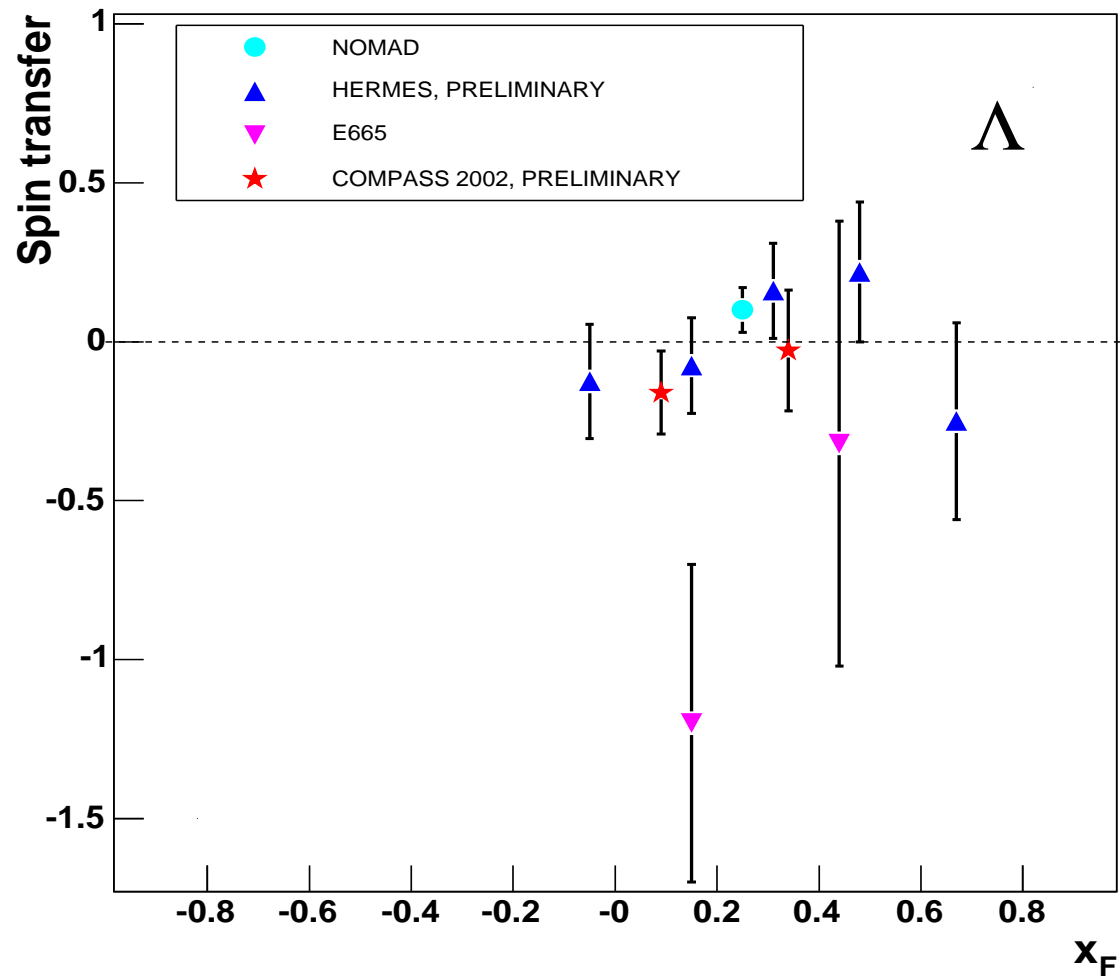

$$P_{K_s^0} = 0.007 \pm 0.017$$
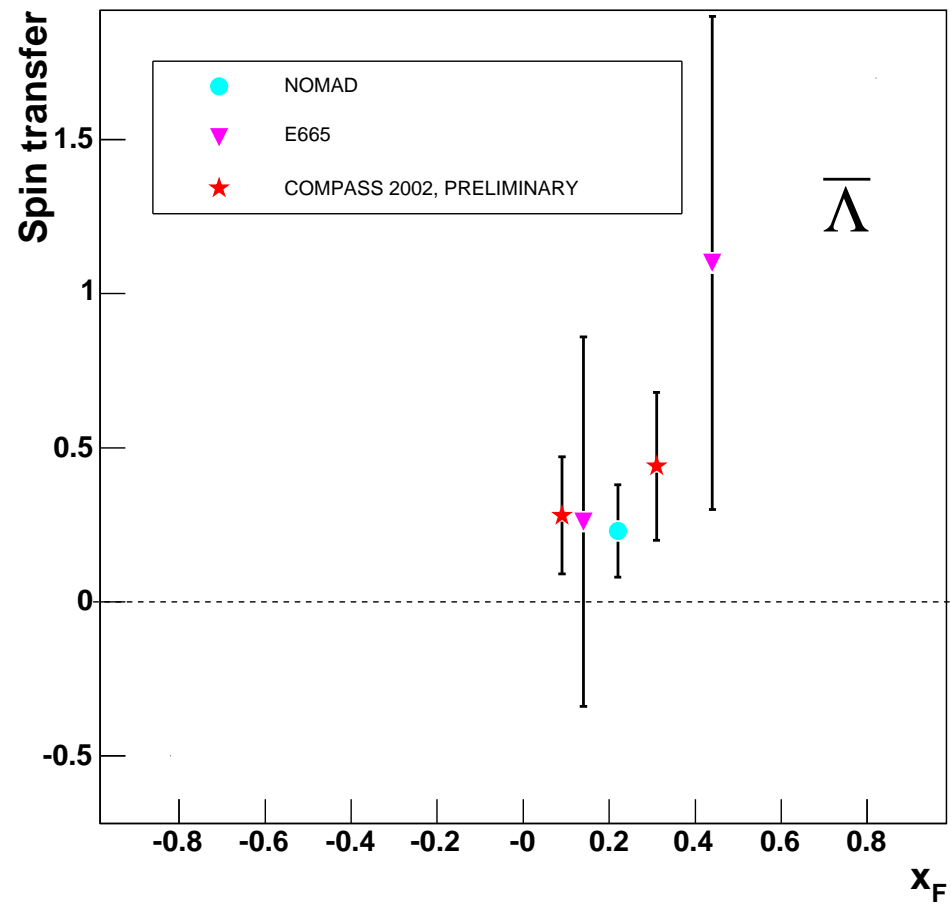
$$P_\Lambda = 0.03 \pm 0.04 \pm 0.04$$

$$P_{\bar{\Lambda}} = -0.11 \pm 0.06 \pm 0.05$$

Spin transfer to Λ

NOMAD
HERMES, PRELIMINARY
E665
COMPASS 2002, PRELIMINARY

Λ

$$S = \frac{P_\Lambda}{P_B D}$$

Spin transfer to $\bar{\Lambda}$

Conclusion

- 2002 data statistics is about 8000 Λ and 5000 $\bar{\Lambda}$ with background subtraction and with cuts on $Q^2 > 1 \ (GeV/c)^2$, $0.2 < y < 0.8$.

- 2002 data show good potential of COMPASS for Λ and $\bar{\Lambda}$ hyperons polarisation measurement.

- Data samples collected in 2003 and 2004 will significantly increase the statistics.