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Longitudinal polarization of Λ and $\bar{\Lambda}$ in DIS at COMPASS

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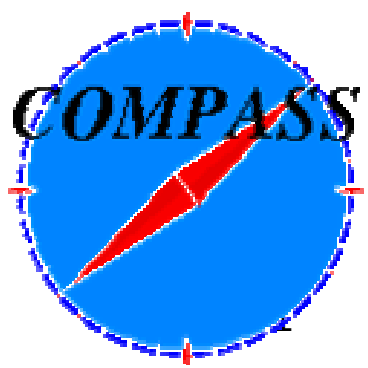
On behalf of the COMPASS Collaboration



Slide 1

a1 a; 25.09.2008

Physical motivation

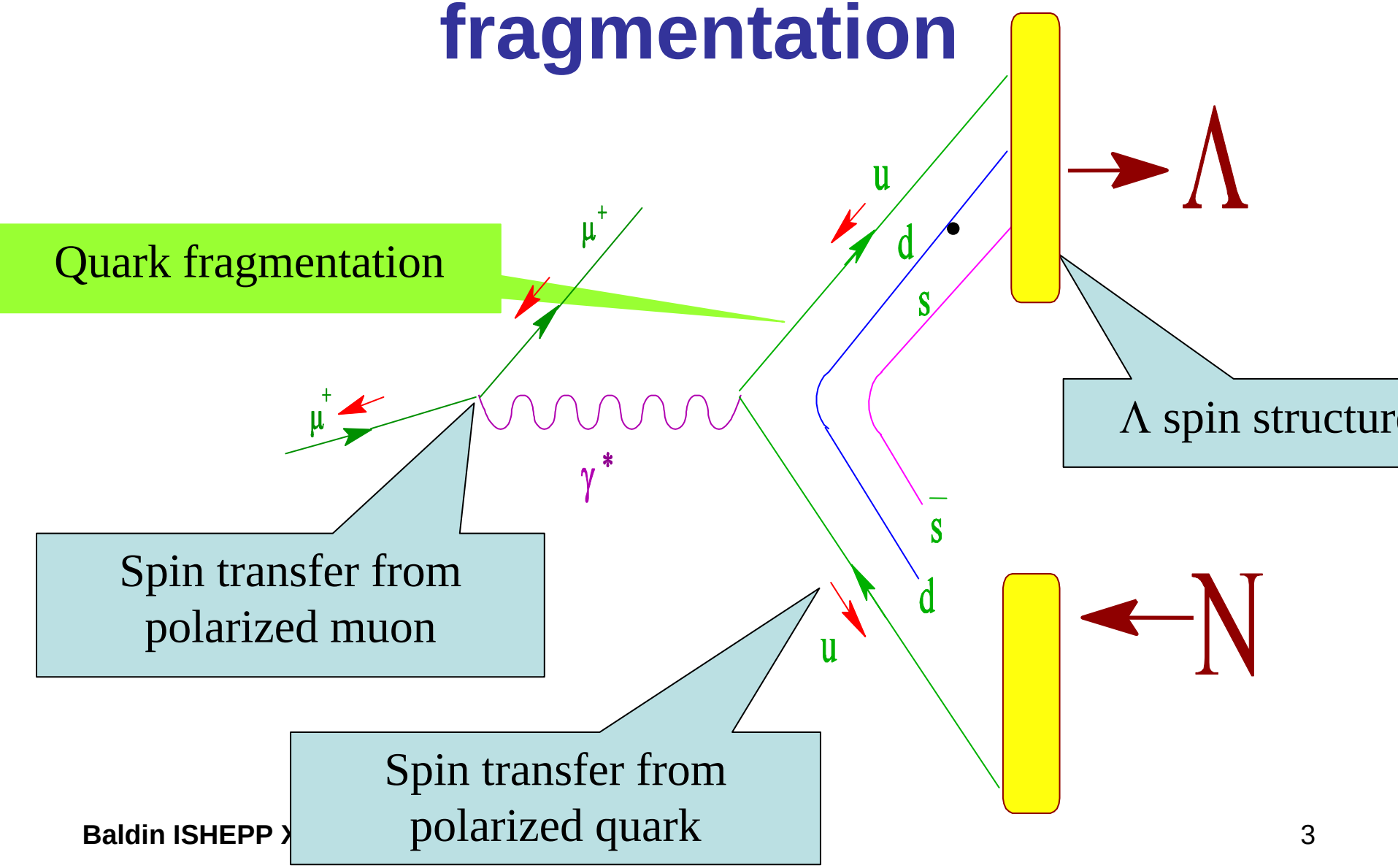
Longitudinal polarization of Λ and $\bar{\Lambda}$ in DIS is sensitive to:

- s(x), $\bar{s}$(x)
- polarization of strange quarks Δs

$$\Delta s = \int dx[s_{\uparrow}(x) - s_{\downarrow}(x) + \bar{s}_{\uparrow}(x) - \bar{s}_{\downarrow}(x)]$$

- Λ spin structure

Λ production in DIS, quark fragmentation



Polarization of Λ from quark fragmentation

Spin transfer from polarized muon

Spin transfer from polarized quark

$$P_\Lambda = \frac{\Sigma_q e_q^2 [P_b D(y) q\,(x) + P_T \Delta q\,(x)] \Delta D_q^\Lambda(z)}{\Sigma_q e_q^2 [q\,(x) + P_b P_T D(y) \Delta q\,(x)] D_q^\Lambda(z)}$$

Λ spin structure

- **SU(6) quark model:** $\Delta s_\Lambda = 1, \Delta u_\Lambda = \Delta d_\Lambda = 0$

  100% polarization to **u** or **d** quarks has no influence on polarization of Λ (and of Lambda-bar)

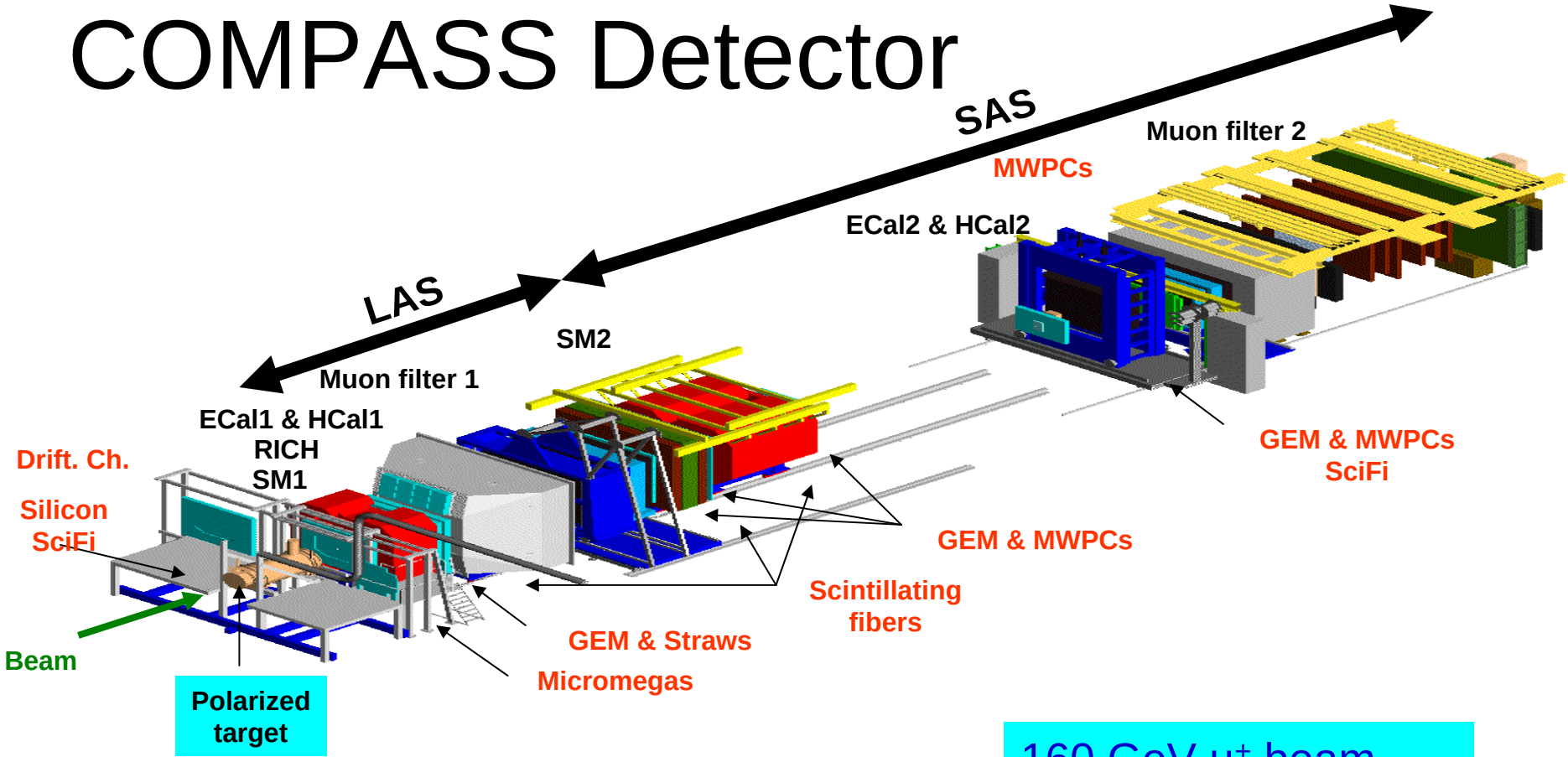
  P(Λ) - 0 (for u –quarks dominance)
- **Burkardt-Jaffe:** $\Delta u_\Lambda = \Delta d_\Lambda = -0.23$

  P(Λ) – negative
- **B.Q.Ma et al.:** $\Delta u_\Lambda = \Delta d_\Lambda = \Delta s_\Lambda$

  P(Λ) – positive
- **Lattice calculations:** $\Delta u_\Lambda = \Delta d_\Lambda \sim 0, \Delta s_\Lambda = 0.68$

  P(Λ) ~ 0

COMPASS Detector



160 GeV μ^+ beam

$2.8 \cdot 10^8$ μ/spill (4.8 s)

$P_b = -0.76 \pm 0.04$ - 2003

$P_b = -0.80 \pm 0.04$ - 2004

Production of $\Lambda(\bar{\Lambda})$

$$\vec{\mu} + N \rightarrow \mu + \Lambda + X$$

$$\Lambda \rightarrow p + \pi^-$$

No PID used

$$\vec{\mu} + N \rightarrow \mu + \bar{\Lambda} + X$$

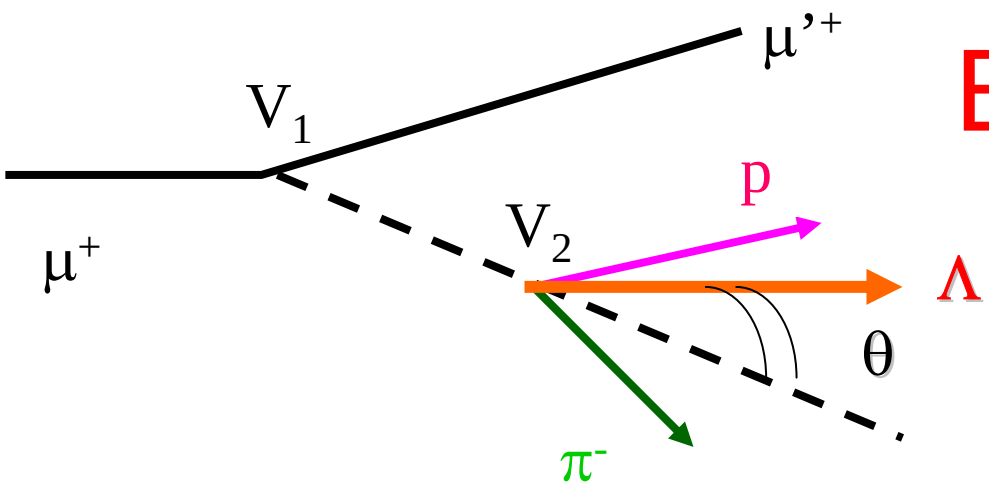
$$\bar{\Lambda} \rightarrow \bar{p} + \pi^+$$

The present results are averaged over target polarization

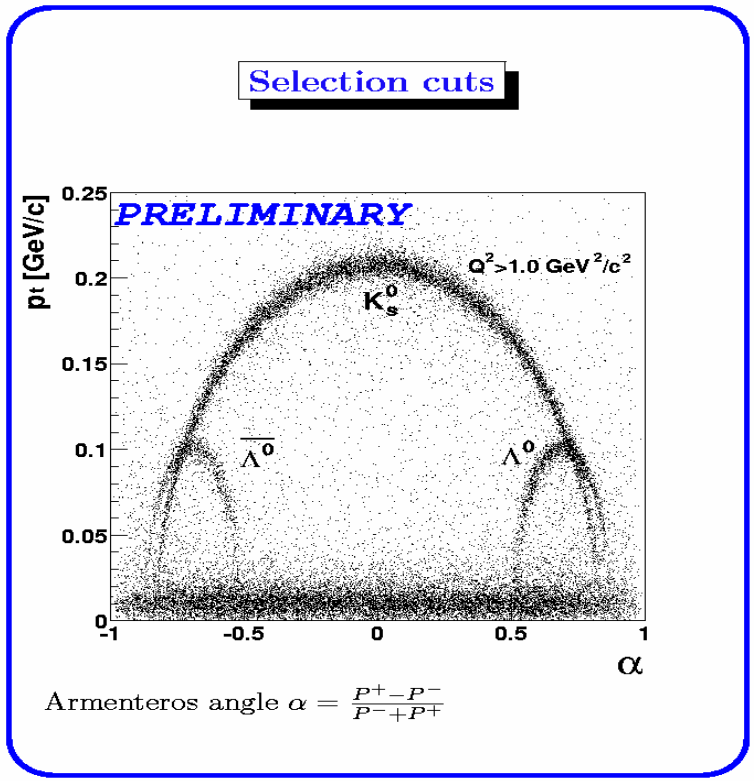
$$\vec{\mu} + N \rightarrow \mu + K_S + X$$

$$K_S \rightarrow \pi^+ + \pi^-$$

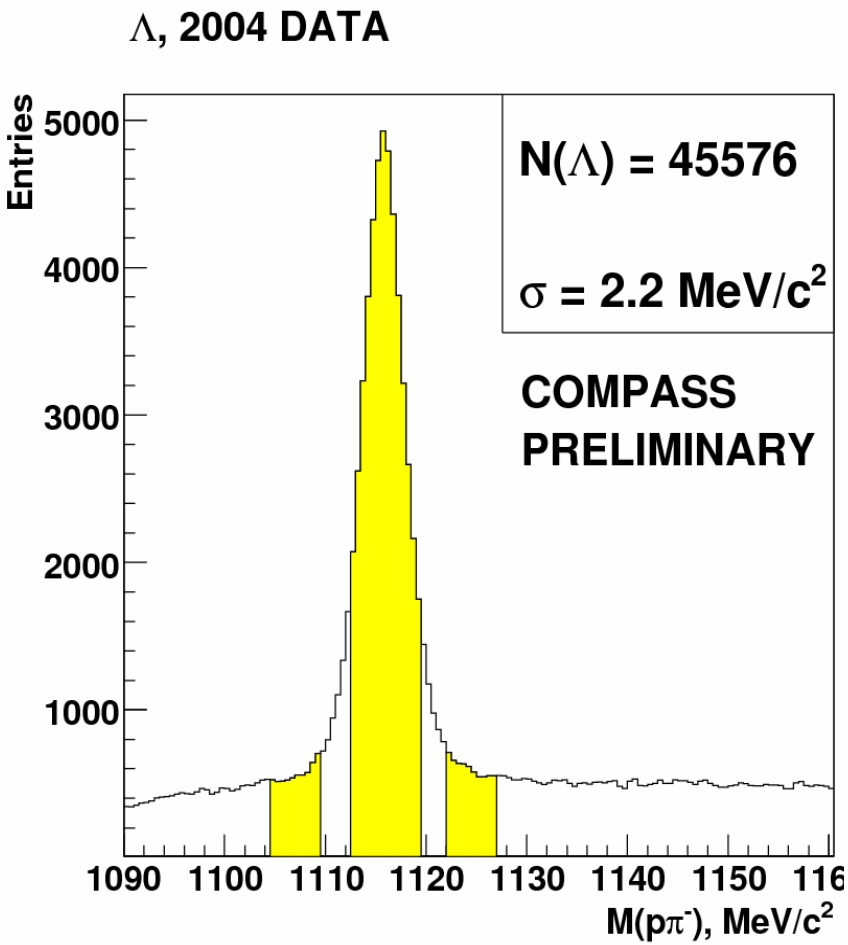
Event selection

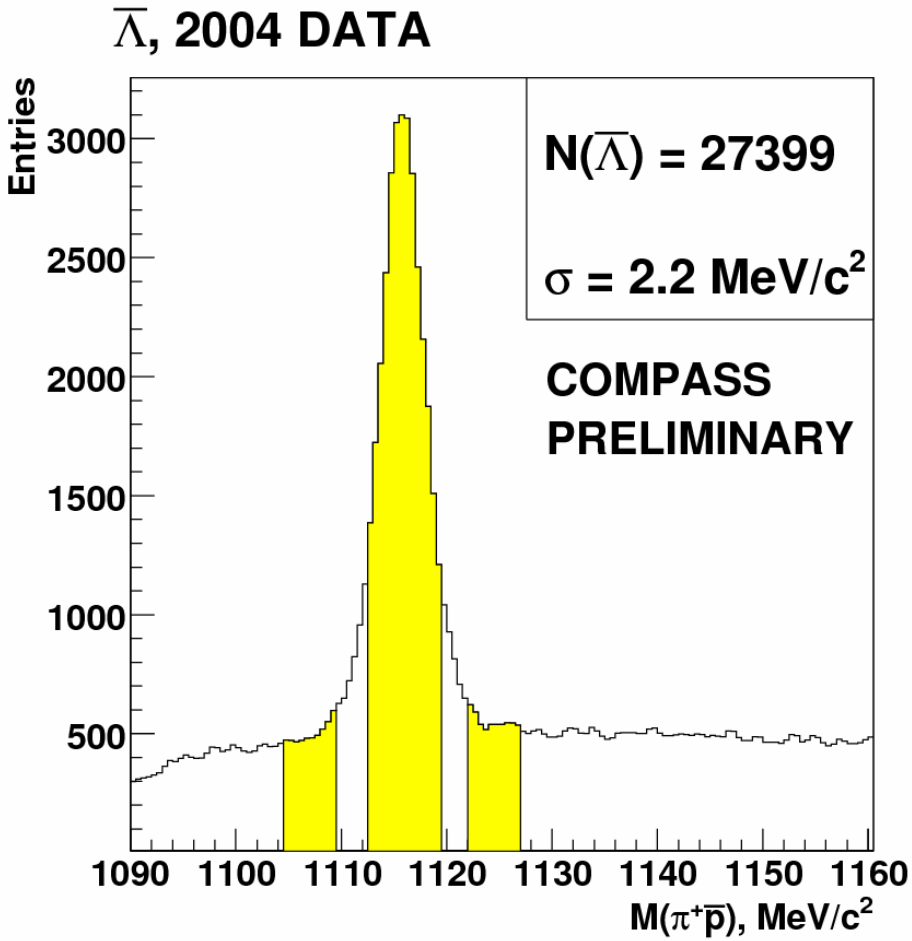


- **Primary vertex: in the target**
- **Secondary vertex: 5 cm downstream the target**
- **p_T > 23 MeV/c**
- **θ < 0.01 rad**
- **Q^2 >1 $(GeV/c)^2$**
- **0.2<y<0.9**



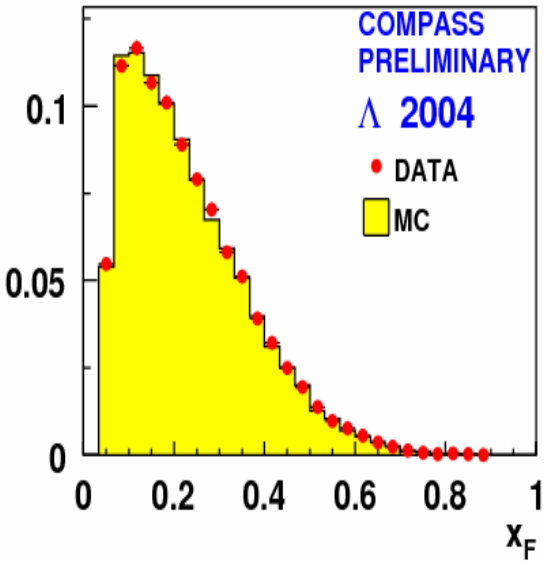
Invariant mass distribution: Λ / $\overline{\Lambda}$

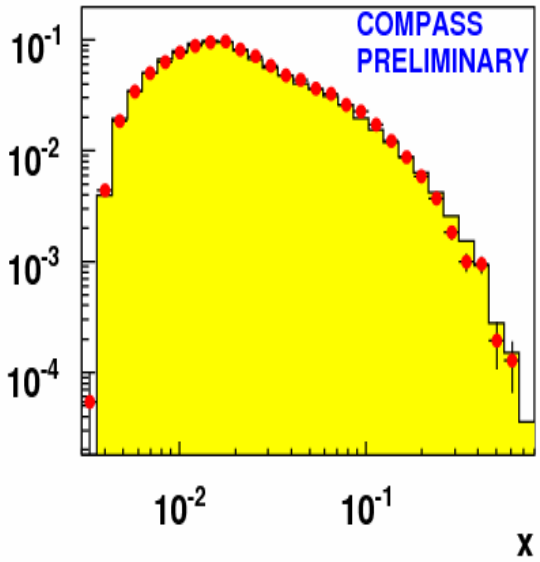


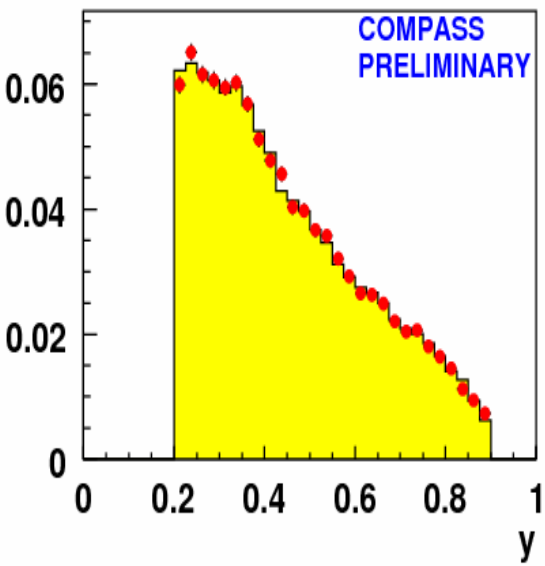


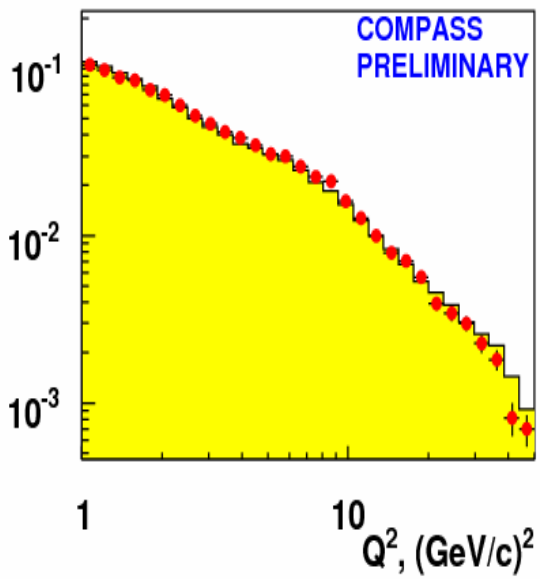
Comparison with other experiments

	N(Λ)	N($\bar{\Lambda}$)
E665	750	650
NOMAD	8 087	649
HERMES, 1996-2000	7 300	1 687
RHIC	30 000	24 000
COMPASS, 2003,2004	70 000	42 000









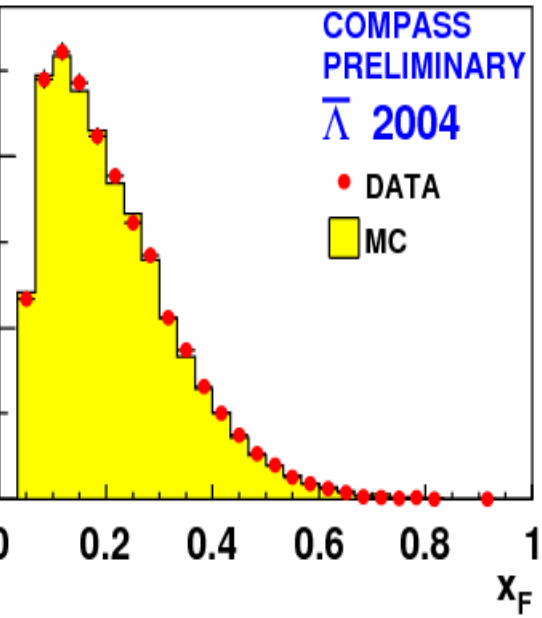
- Λ

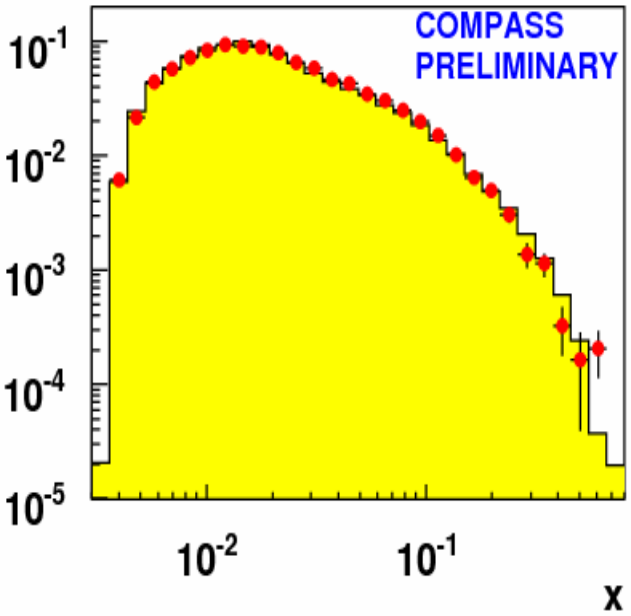
$\langle x_{Bj} \rangle = 0.05$

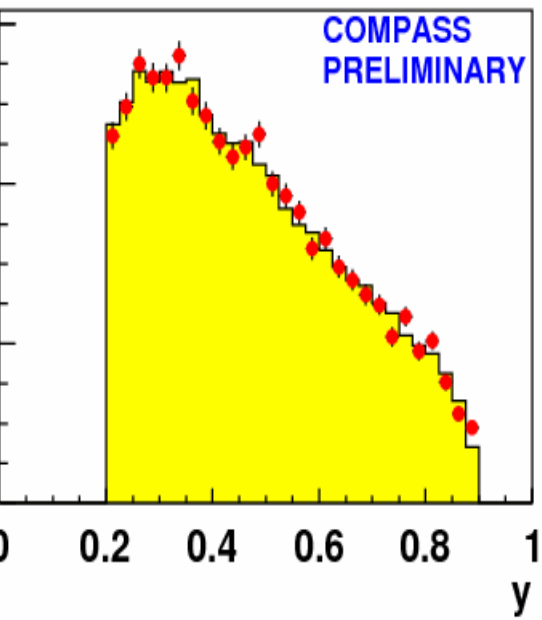
$\langle x_F \rangle = 0.23$

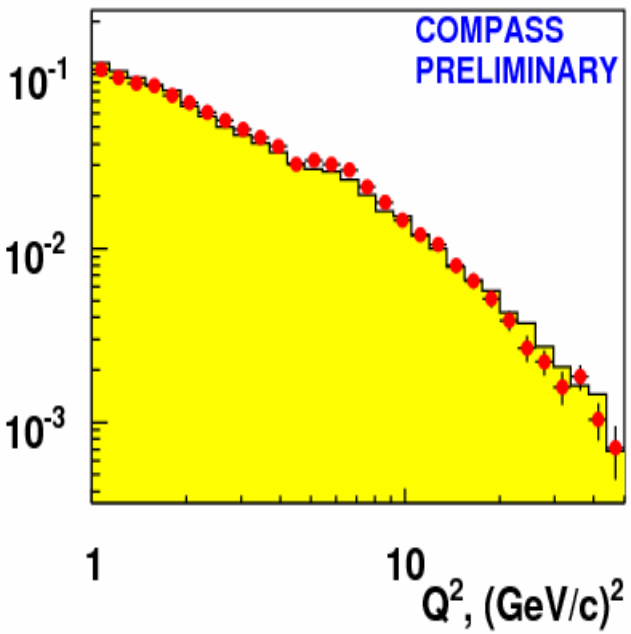
$\langle y \rangle = 0.46$

$\langle Q^2 \rangle = 3.31\ GeV^2$









- $\overline{\Lambda}$

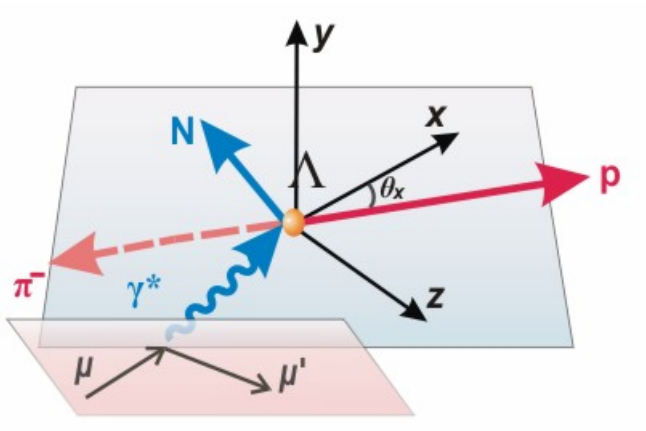
$\langle x_{Bj} \rangle = 0.050$

$\langle x_F \rangle = 0.22$

$\langle y \rangle = 0.48$

$\langle Q^2 \rangle = 3.27\ GeV^2$

Longitudinal polarization P_X



$$\frac{dN}{d\Omega} = \frac{N_{tot}}{4\pi}(1+\alpha\vec{P}\vec{k})$$

α=+(-)0.642 ±0.013 - Λ($\bar{\Lambda}$) decay parameter, *P* - polarization vector, *k* - unit vector along the decay proton momentum, X-axis - along the momentum of virtual photon.

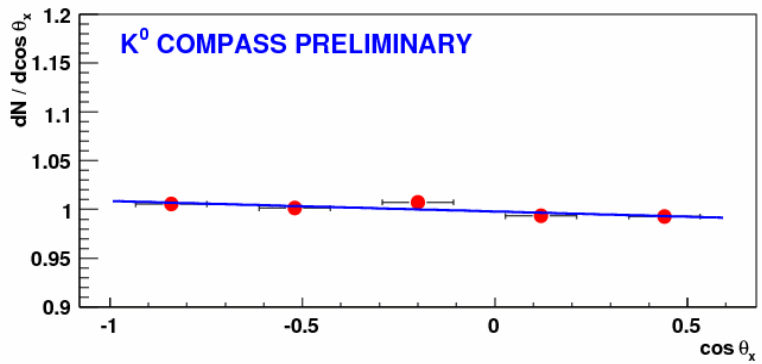
$$\frac{1}{N_{tot}^{obs}}\frac{dN^{obs}}{d\cos\theta_X} = \frac{1}{2}(1+\alpha\cdot P_X\cdot\cos\theta_X)A(\cos\theta_X)$$

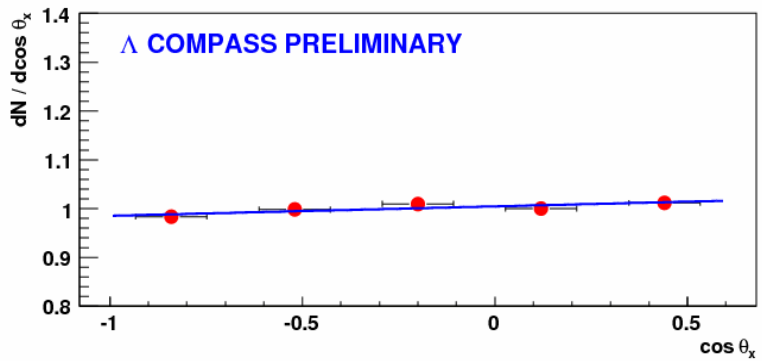
Longitudinal spin transfer S_X

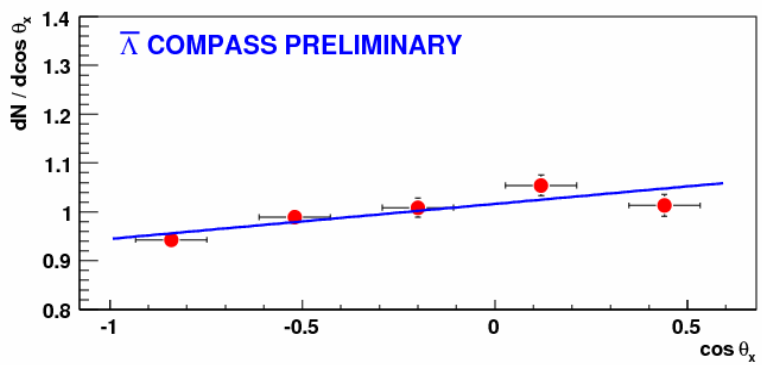
$$P_X = S_X P_b D(y)$$

P_b – beam polarization, D(y) – depolarization factor

$$D(y) = \frac{1-(1-y)^2}{1+(1-y)^2}$$

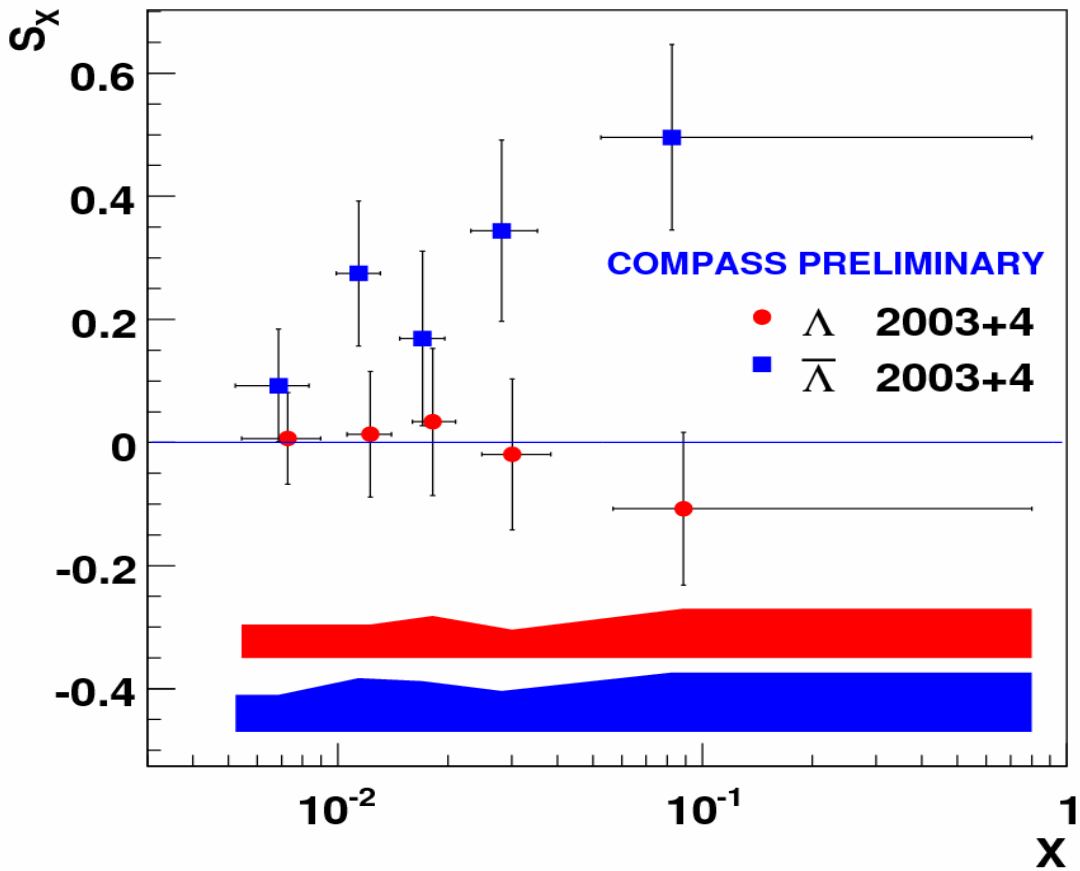






- **angular distributions of K^0 , Λ and $\bar{\Lambda}$**
- **2004 run**
- **$P(K^0)=0.011\pm0.005$**

Comparison of Λ and $\bar{\Lambda}$: x

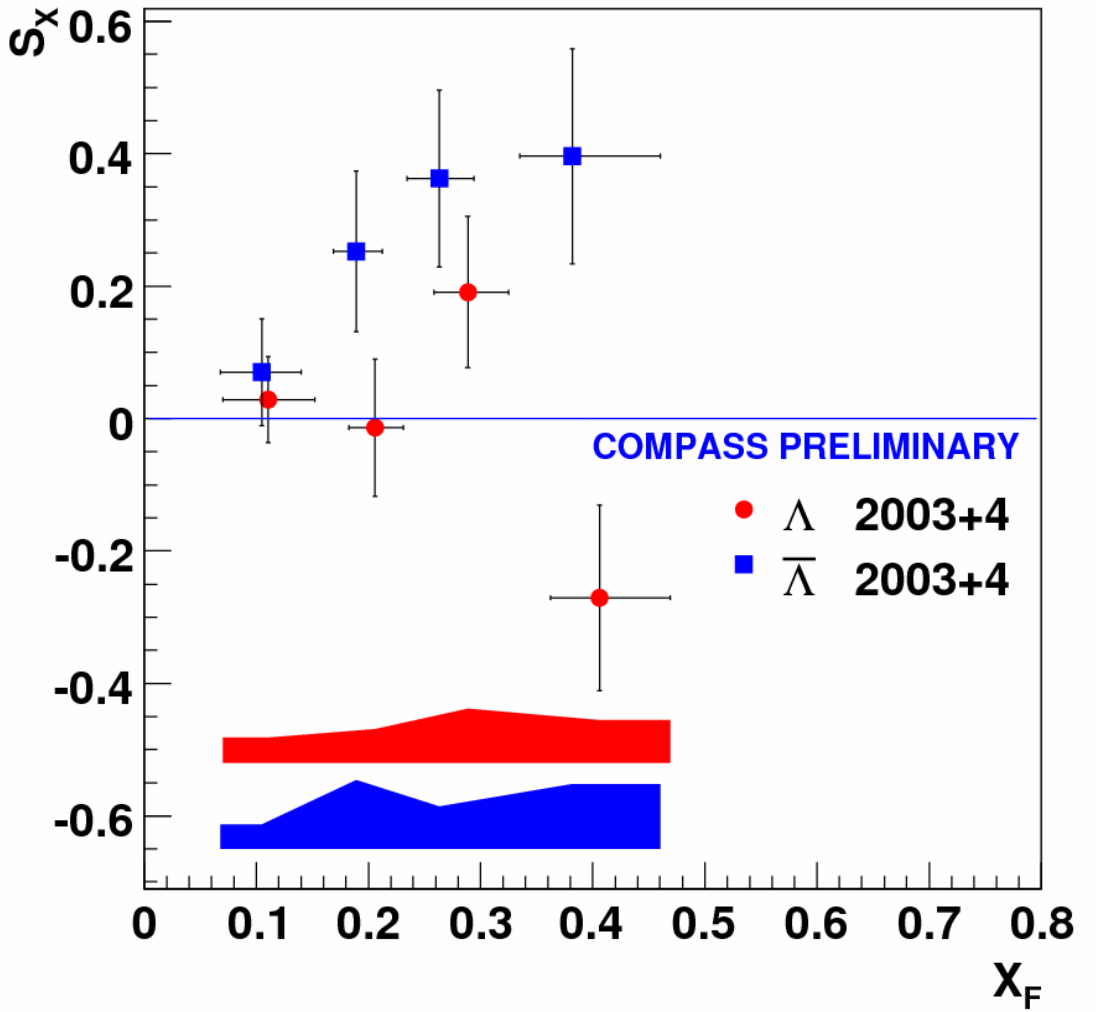


$S_X(\Lambda) \neq S_X(\bar{\Lambda})$

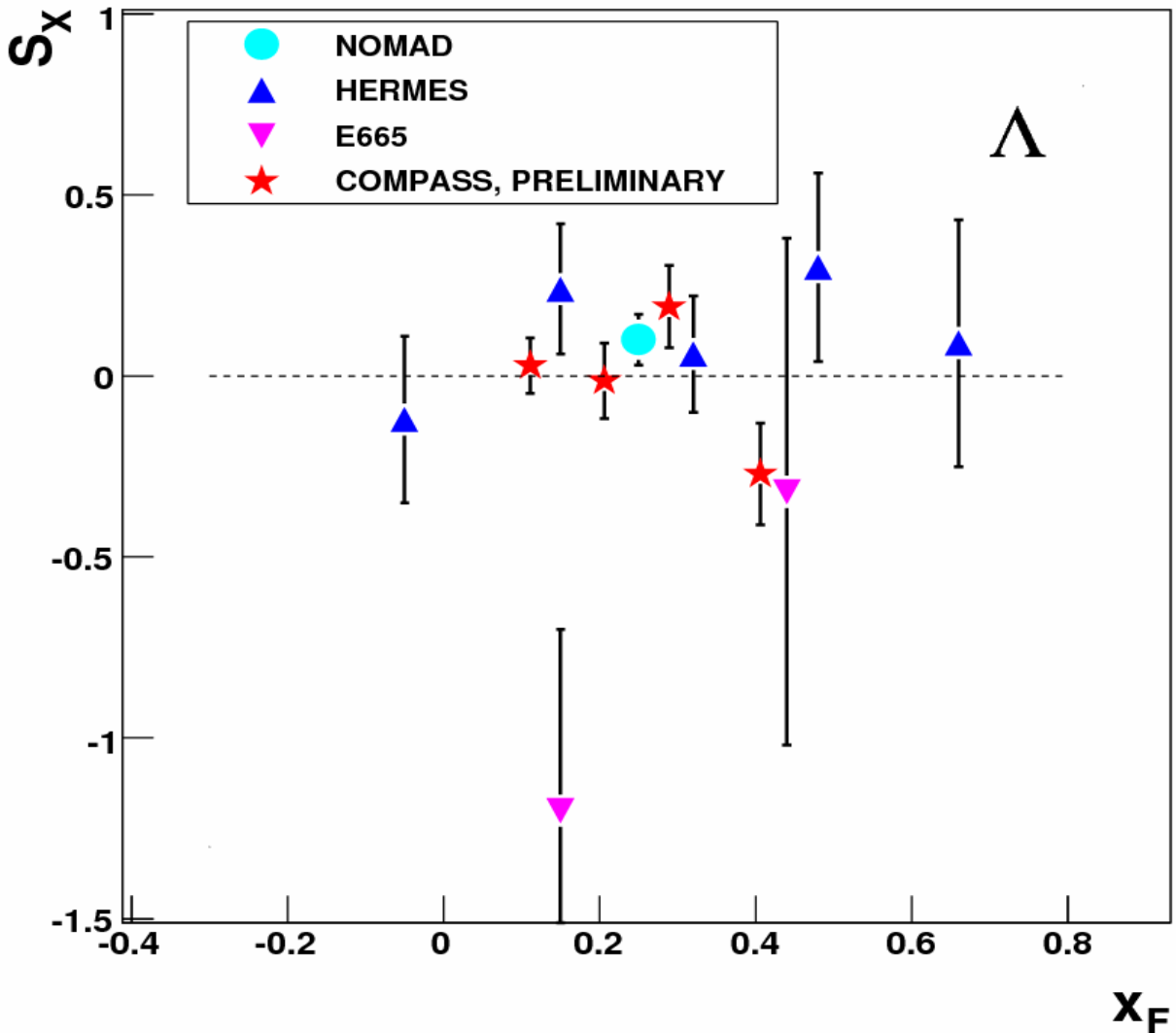
$S_X(\Lambda) = -0.012 \pm 0.047 \pm 0.024$

$S_X(\bar{\Lambda}) = 0.249 \pm 0.056 \pm 0.049$

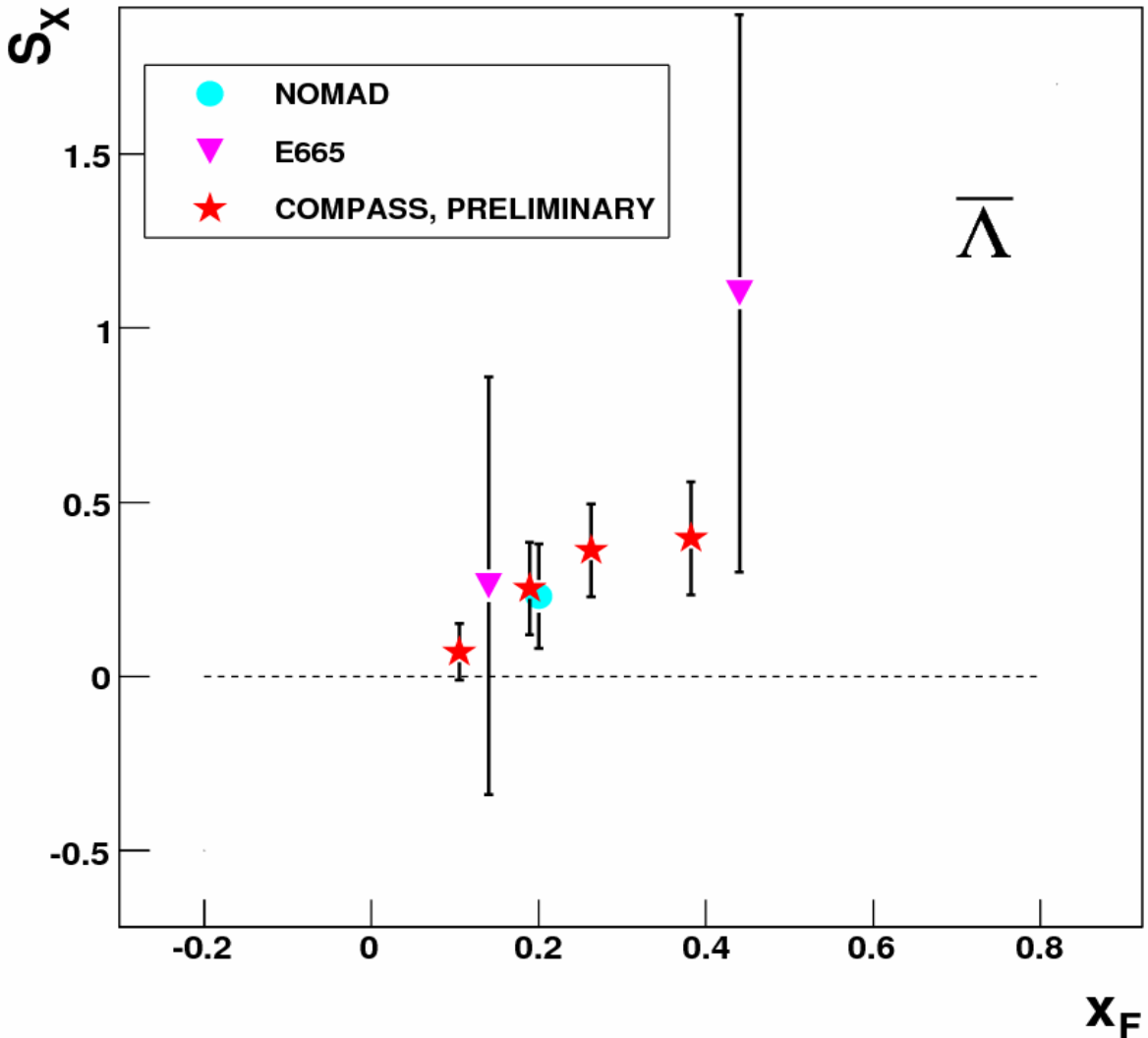
Comparison of Λ and $\overline{\Lambda}$: x_F



Comparison with other experiments : Λ

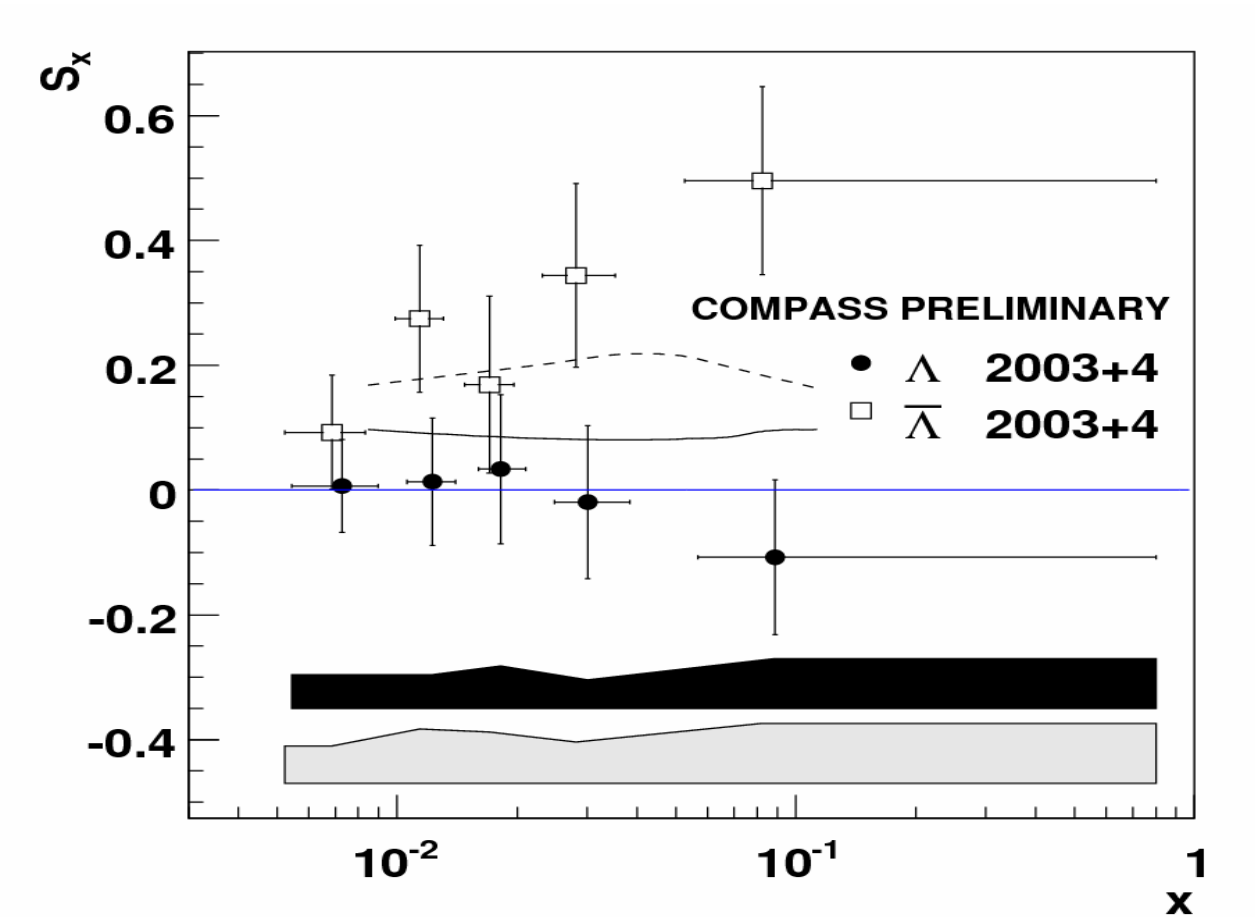


Comparison with other experiments : $\overline{\Lambda}$

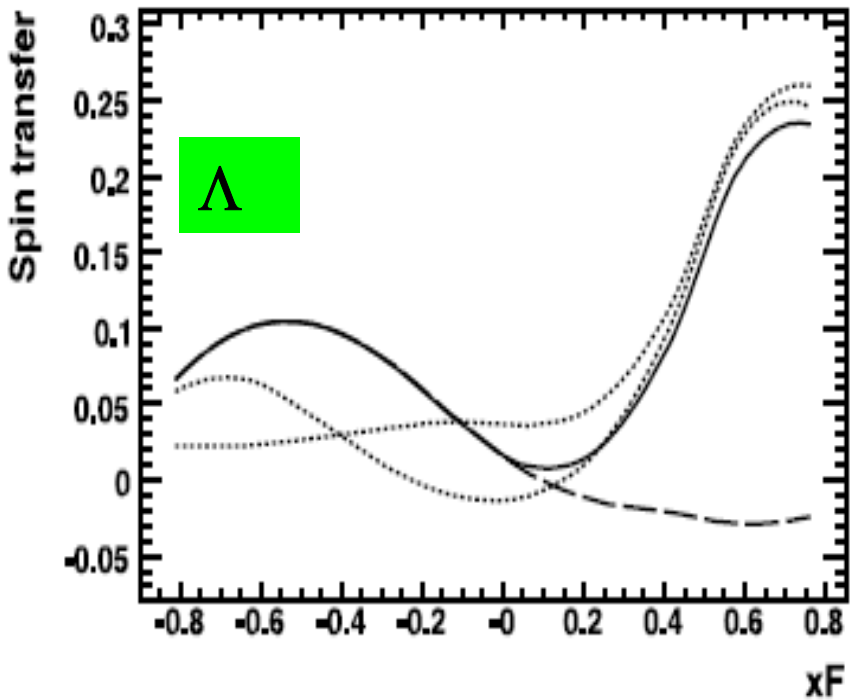


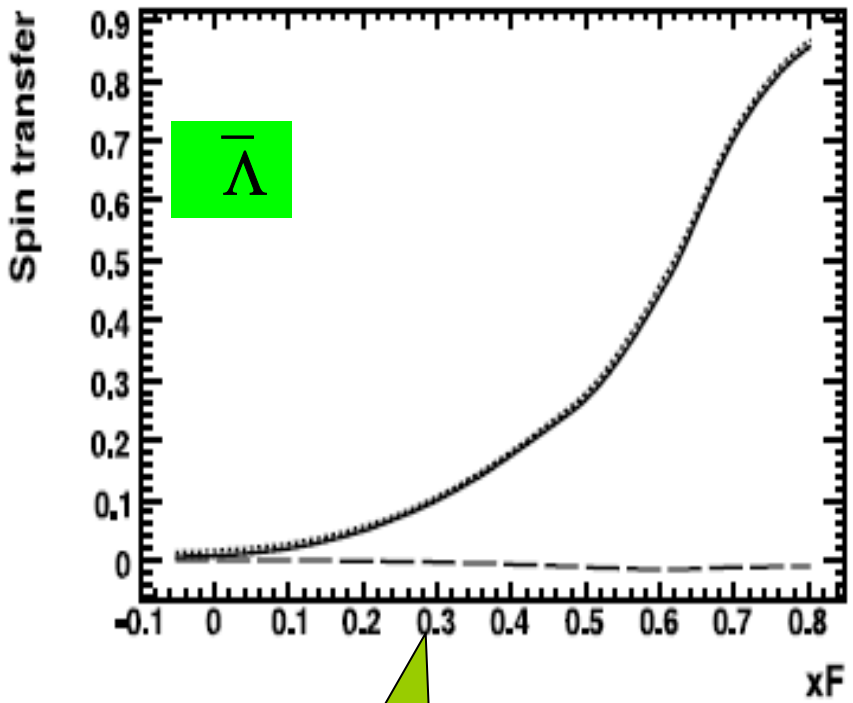
Theory predictions for Λ/ $\overline{\Lambda}$

- **J.Ellis et al., *Eur.Phys.J. C52 (2007) 603***



Theory predictions for Λ/ $\bar{\Lambda}$





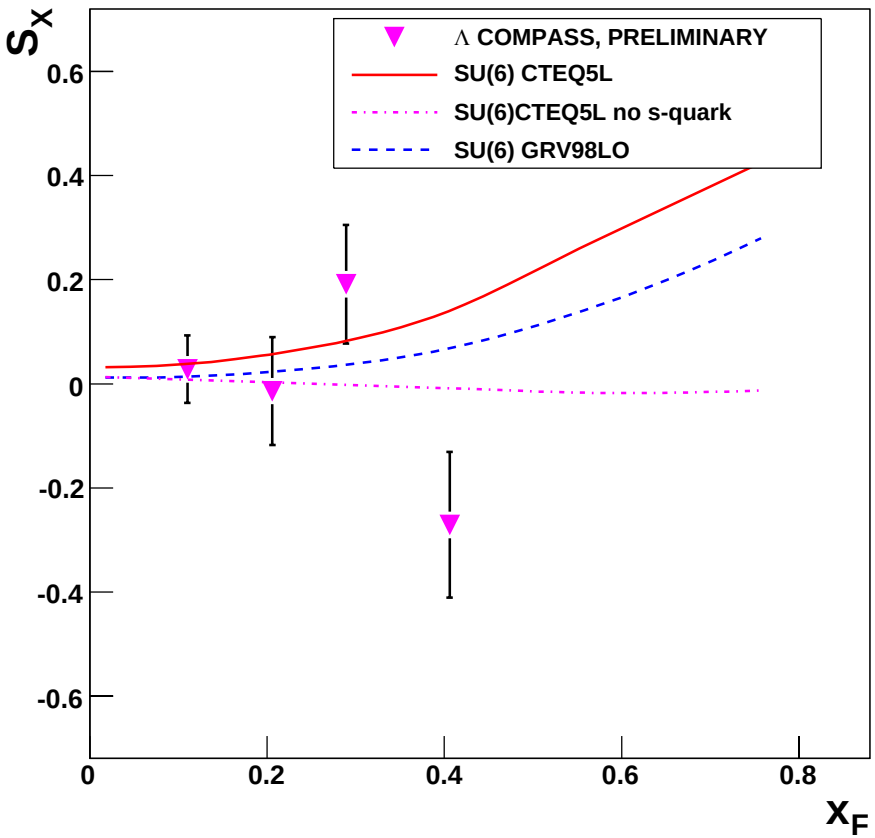
J.Ellis et al., *Eur.Phys.J. C52 (2007) 603*

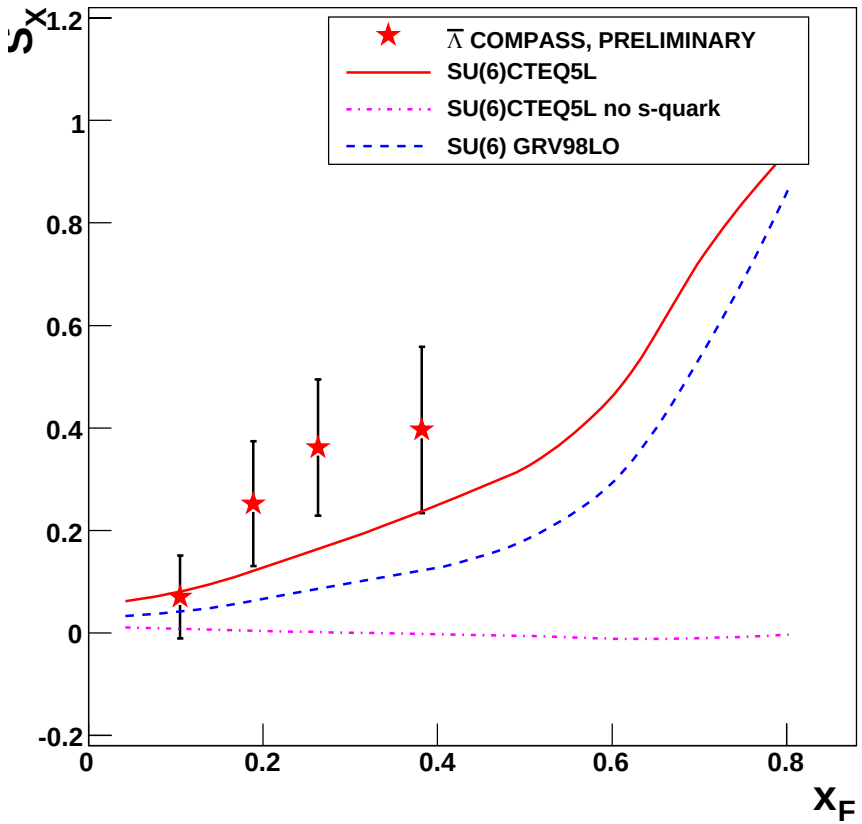
S($\bar{\Lambda}$) > S(Λ)

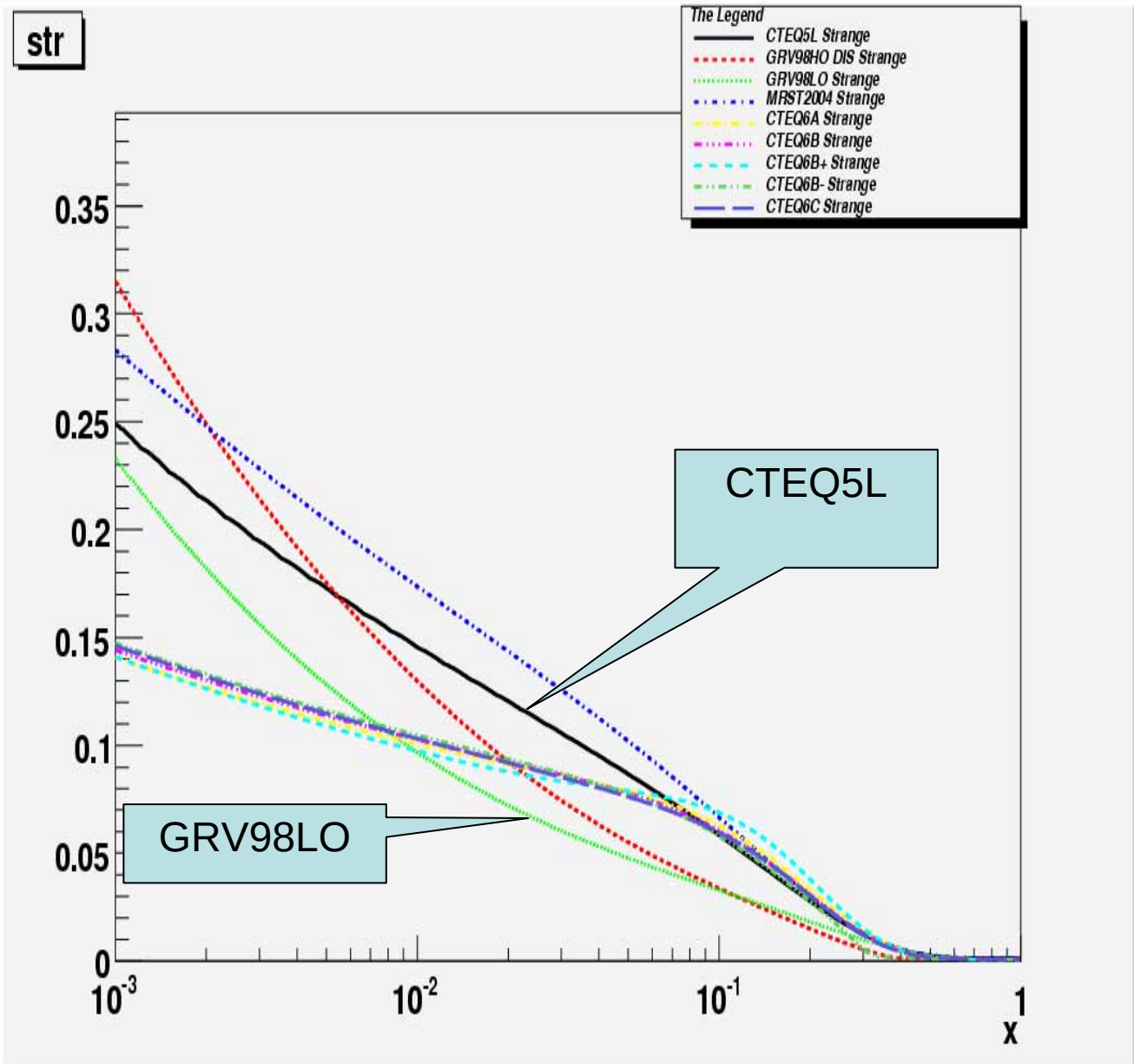
S($\bar{\Lambda}$) is due to $\bar{s}$ quarks

Spin transfer from the s-quarks is switched off

Comparison with theory: pdf







- Influence to different PDF's
- $Q^2 = 4$ GeV^2

Conclusions

- Preliminary results on Λ and $\bar{\Lambda}$ spin transfer in DIS are obtained on statistics 70000 Λ and 42000 $\bar{\Lambda}$
- $S_X(\Lambda) \neq S_X(\bar{\Lambda})$
- $S_X(\Lambda) \sim 0$
- $S_X(\bar{\Lambda})$ may be as large as 0.4-0.5
- Comparison with theory:
  - data need more s(x) than the GRV98
  - present statistics is not enough to distinguish between SU(6) and BJ variants of the Λ spin function.

The End

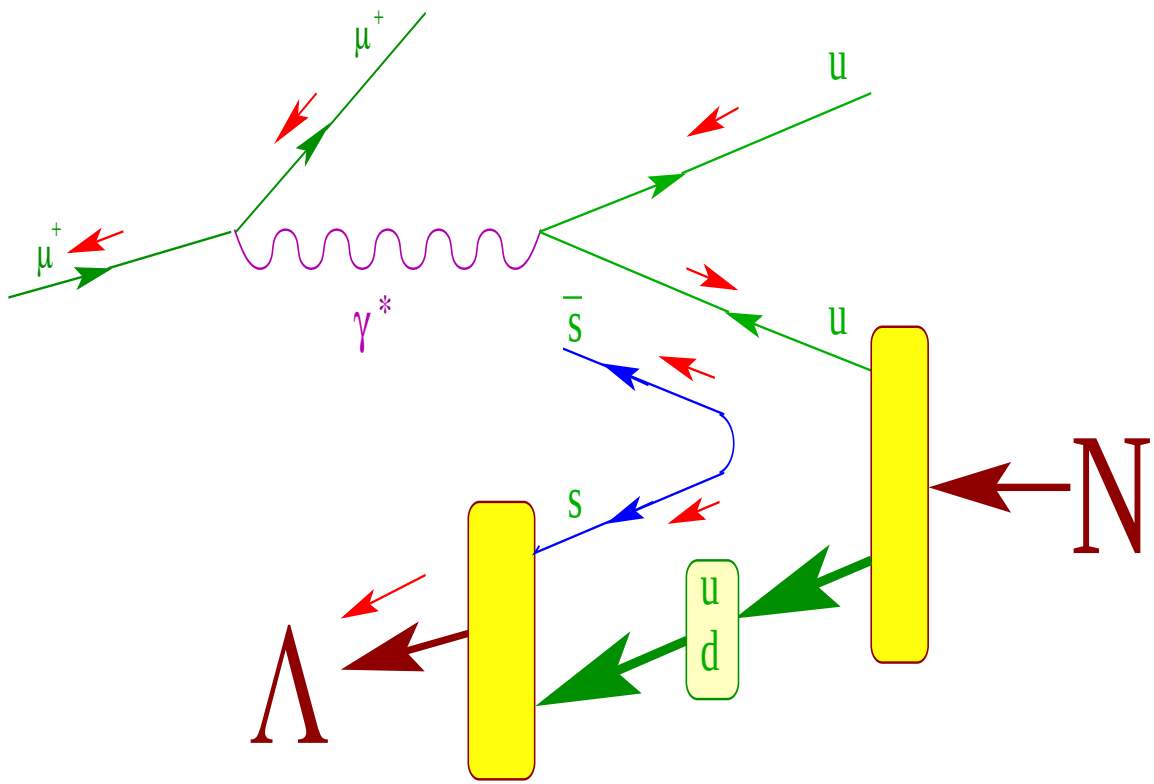
Future programme:

1. **Longitudinal polarization of $\bar{\Lambda}/\Lambda$ for different target polarizations**
   $\bar{\Lambda}$ (Λ) asymmetry ($\Delta \bar{s}$ ~ -0.08, Δs ~0 , J.Ellis)
2. **Correlation analysis of ΛK and $\Lambda \bar{\Lambda}$ pairs**
3. **Determination of all components of $\bar{\Lambda}/\Lambda$ polarization vector P_X, P_Y, P_z**
4. **Q^2 dependence of the polarization ($Q^2 > 0.5$ GeV^2)**

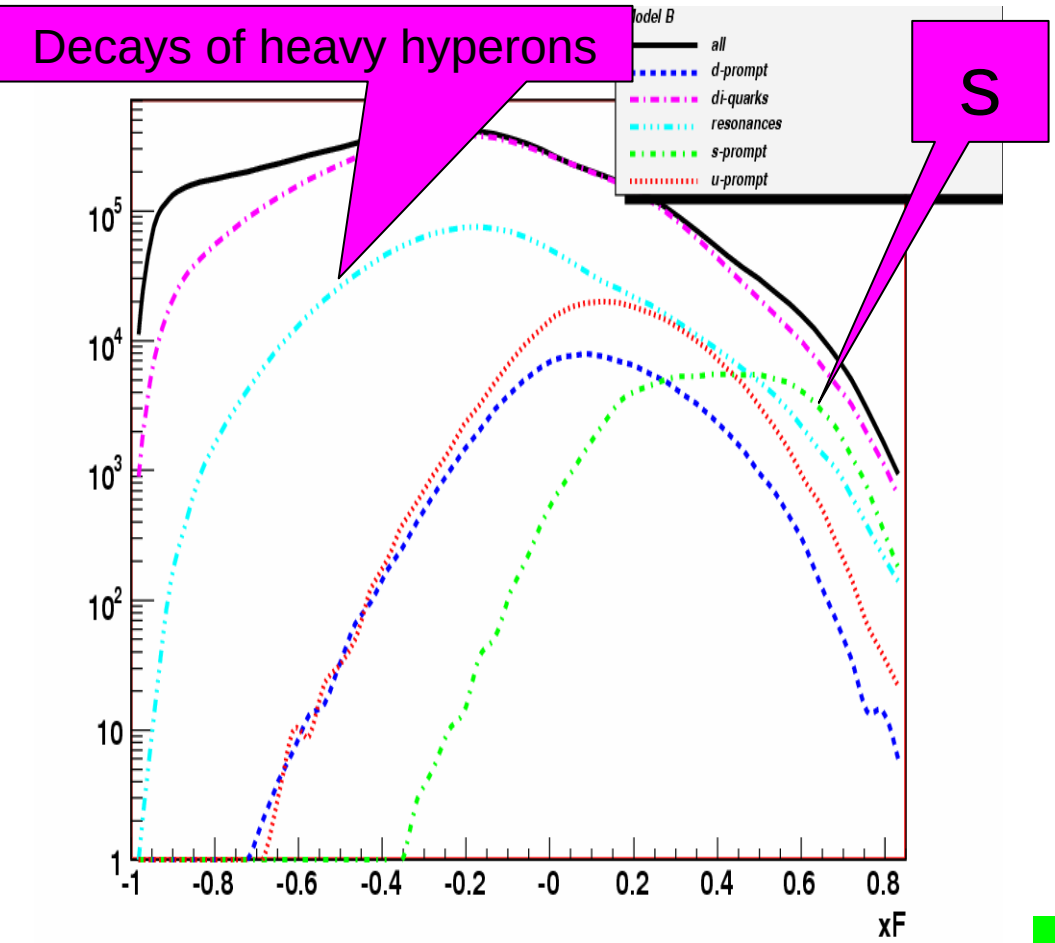
All - for 2006-2007 data

Backup slides

Λ production in DIS, diquark fragmentation



Flavour dependence, Λ

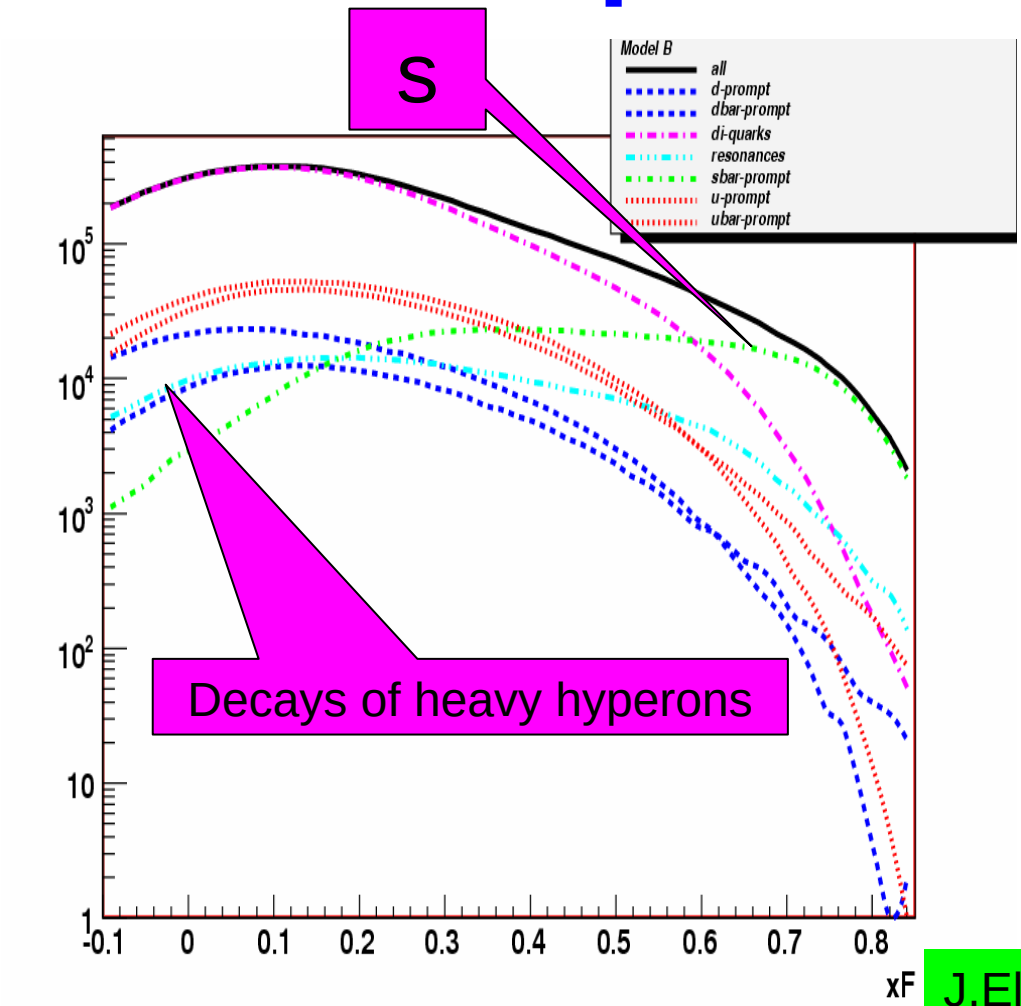


Λ production in DIS at COMPASS energies

- production from the diquark fragmentation is dominated
- production on s-quarks is important for x_F >0.5

J.Ellis, A.Kotzinian, D.Naumov, M.S.

Flavour dependence, $\bar{\Lambda}$



- production on $\bar{s}$-quarks is dominated at x_F >0.4-0.5
- contribution from heavy antihyperon decays is negligible at COMPASS energies

J.Ellis, A.Kotzinian, D.Naumov, M.S.

Transverse polarization P_Y

First analysis on 2002 data, all Q^2

- 160,000 Λs and 85,000 $\overline{\Lambda}$s
- Small positive Λ polarization:
  $P_T^{\Lambda} = +2.7 \pm 0.9(\text{stat.}) \pm 1.1(\text{sys.})$ %
  - Sign opposite to Λ polarization in p and π^- beams
  - Same sign as in K^- beam
  - Much lower absolute value
- $\overline{\Lambda}$ unpolarized: $P_T^{\overline{\Lambda}} = -0.3 \pm 1.4(\text{stat.}) \pm 1.8(\text{sys.})$ %

Polarization of indirect Λ

D.Ashery, H.Lipkin,Phys. Lett.