Possibility of Measurement of the Longitudinal Spin Transfer to Λ and $\bar{\Lambda}$ Hyperons in Semi-Inclusive DIS at HERA

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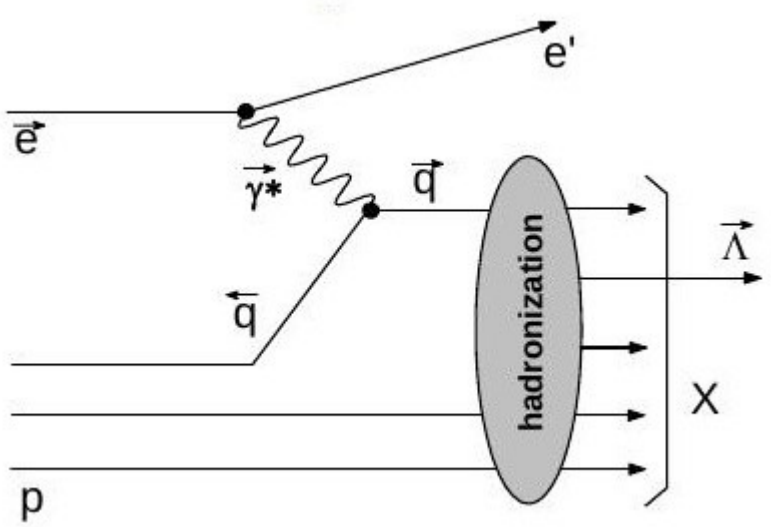
- Motivation
- Data sample
- Method
- Results
- Summary

Motivation

The study important for:

- The understanding of the nucleon structure;
- The mechanism of hyperon production;
- The hyperon spin structure.



A longitudinally polarized electron or positron emits a polarized virtual photon γ^* which is absorbed by a quark of opposite spin direction in the target proton.

At the HERA energy the target remnant and quark fragmentation mechanisms may be distinguished unambiguously.

DIS variables:

$Q^2 = -(k-k')^2 \quad \nu = E-E' \quad y = \frac{\nu}{E} \quad x = \frac{\Theta^2}{2M\nu} \quad z = \frac{E_\Lambda}{\nu}$

Method

The polarization of final-state Λ hyperon can be measured using the week decay channel $\Lambda^0 \to p\pi^-$ by asymmetry of proton emission in respect to the Λ polarization vector in the Λ rest frame.

Angular distribution of protons *(in Λ rest frame)*

$$\frac{dN}{d\Omega_p} = \frac{dN_0}{d\Omega_p}\left(1 + \alpha\, P_{L'}^{\Lambda} \cos\theta_{pL'}\right)$$

- Unpolarized distribution
- decay constant, 0.642
- angle between proton momentum and Λ spin in Λ rest frame

The component of the polarization transferred Along the direction L' from the virtual photon to the produced Λ:

$$P_{L'}^{\Lambda} = D_{LL'}^{\Lambda} P_b D(y)$$

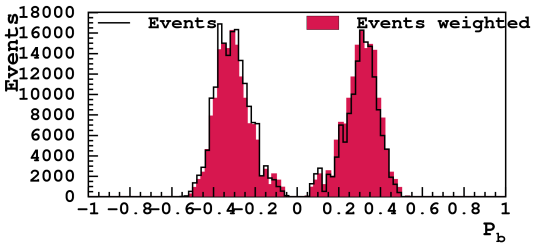
where

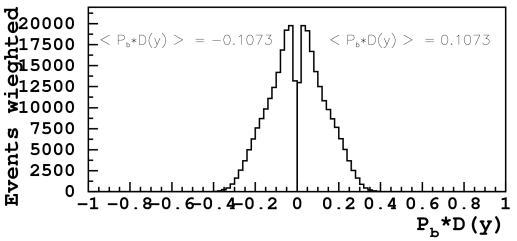
$D(y) = (1-(1-y)^2)/(1+(1-y)^2)$

is the virtual photon depolarization,

$D^{\Lambda}_{LL'}$ is the spin transfer coefficient describing the probability that the polarization of the struck quark is transferred to the Λ along a secondary quantization axis L'.

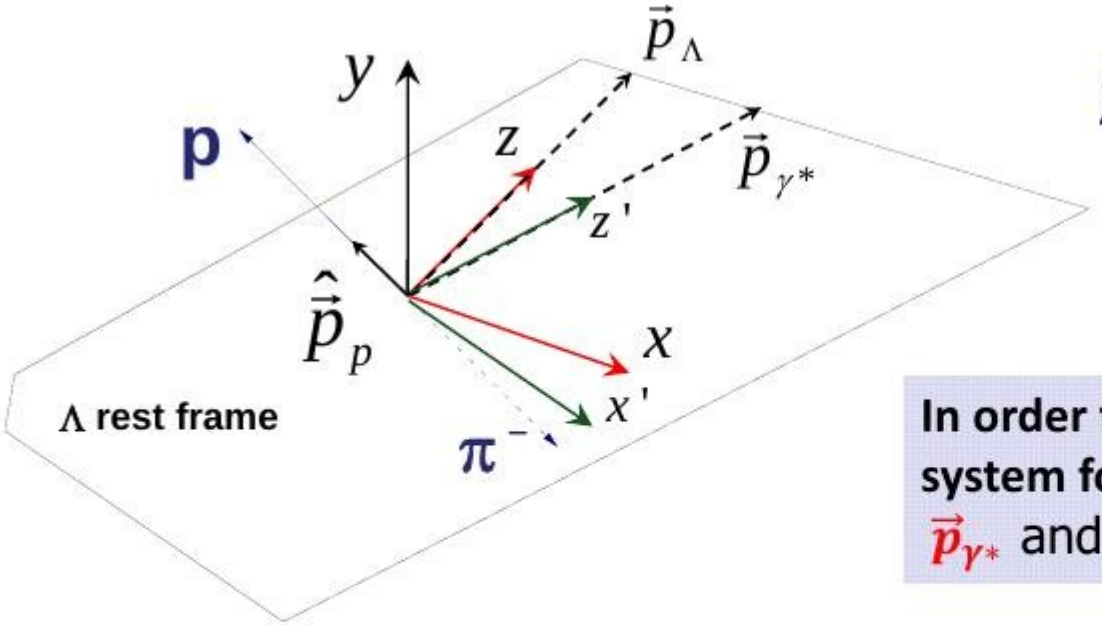
Longitudinally polarized beam from HERA
Beam spin flipped very few months.





Unpolarised distribution ≡helicity balanced sample obtained by weighting events:

Method



$$\vec{\gamma}^* + p \rightarrow \vec{\Lambda} + X$$

In order to build coordinate system for Λ at rest two vectors: $\vec{p}_{\gamma^*}$ and $\vec{p}_\Lambda$ are used

2 variants of system

$$\vec{k}_z = \hat{\vec{p}}_\Lambda, \quad \vec{k}_y = \hat{\vec{p}}_\Lambda \times \hat{\vec{p}}_{\gamma^*}, \quad \vec{k}_x = \vec{k}_y \times \vec{k}_z$$

$$\vec{k}_z = \hat{\vec{p}}_{\gamma^*}, \quad \vec{k}_y = \hat{\vec{p}}_\Lambda \times \hat{\vec{p}}_{\gamma^*}, \quad \vec{k}_x = \vec{k}_y \times \vec{k}_z$$

DATA sample

Event selection for presented results

Data : ZTT tracks
after Grand Reprocessing
Global ntuples -V06a
(06-07) 142 pb^{-1} +(05) 148 pb^{-1}

Kinematics:
$Q^2 > 5\ GeV^2$
$E_e > 10$ GeV
$y_{JB} > 0.04$, $y_e < 0.95$
$35 < E - P_z < 60$ GeV
$-50\ cm < Z_{vtx} < 50\ cm$
box cut : 24 X 12 cm

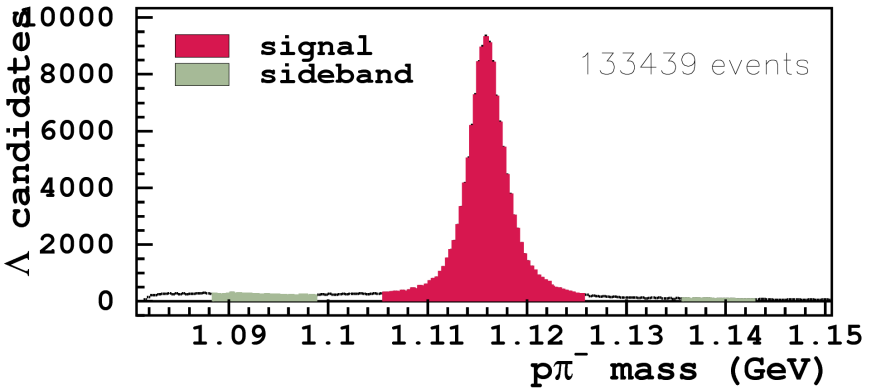
V^0 reconstruction

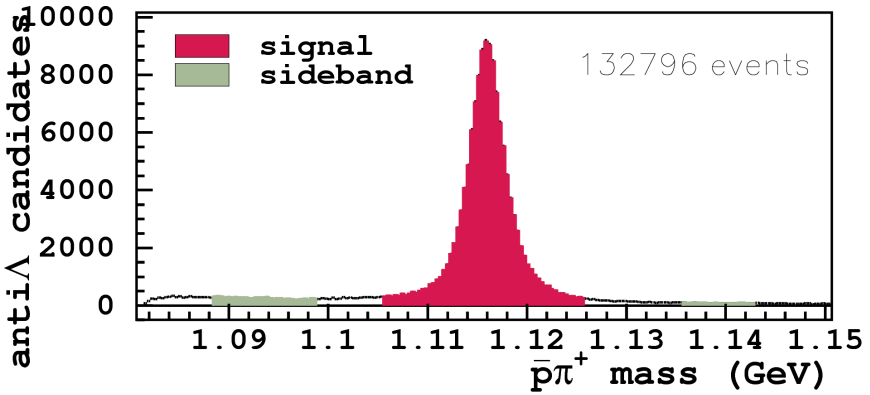
Orange block: V0lite (ZTT tracks)

Secondary vertex:
Λ - decay channel to p and π, tracks should pass throught more than 3 CTD superlayers

Criteria to accept the candiate Λ:

m_{eff}	$m_\Lambda \pm 0.01$ (GeV)	L_{min}	1 cm
collin3	< 0.040	collin2	< 0.030
$c\tau$	< 20 cm		

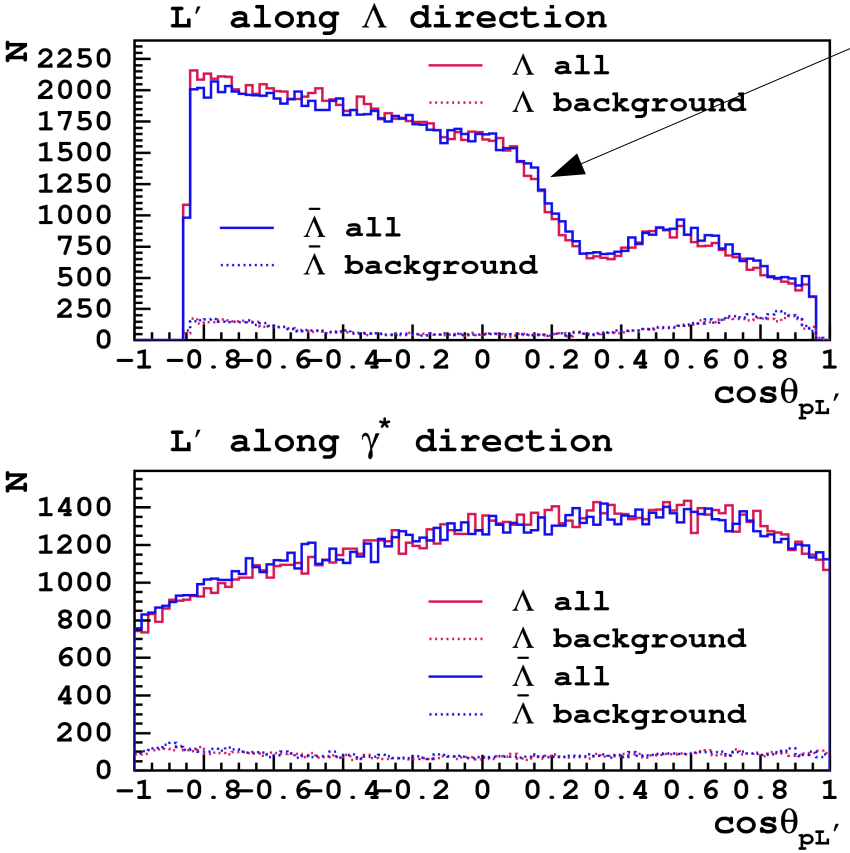




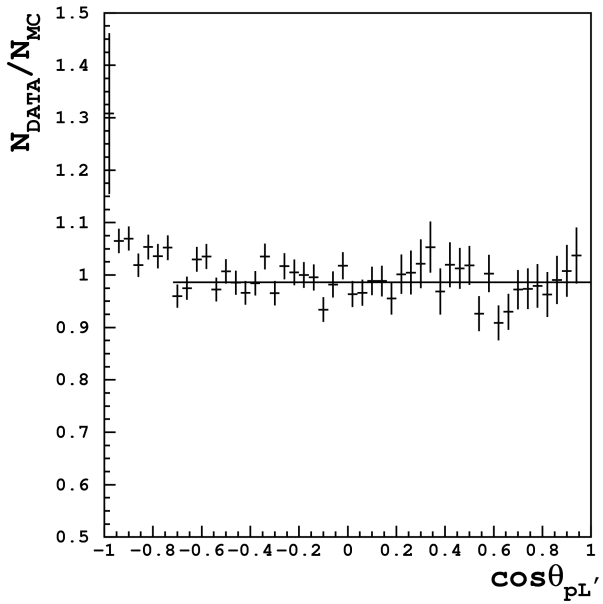
Background is taken into account by side band method.

DATA sample

L' direction of Λ polarisation:
- Along Λ
- Along γ^*

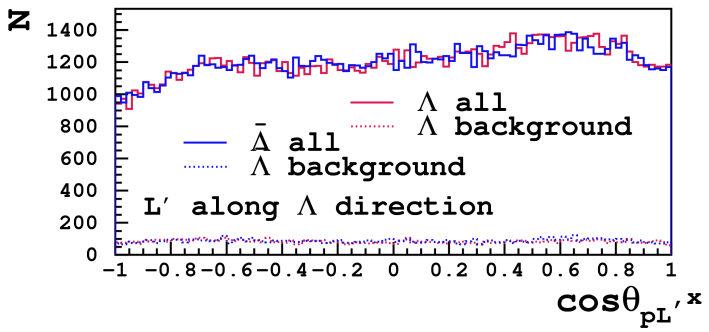


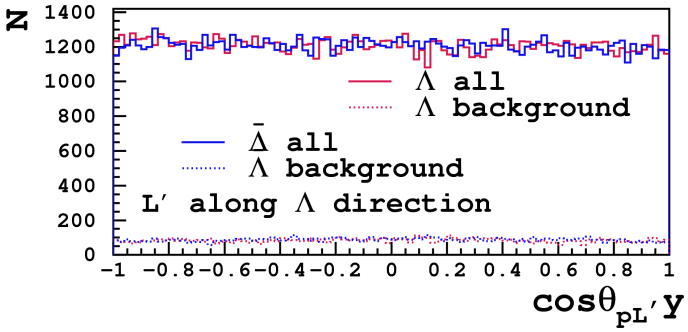
True distribution of $cos\theta_{pL}$ is flat.
The shape of the experimental distributions reflects the acceptance of the detector.
It is well reproduced by MC however uncertainty of MC simulation is of order of the effects which are investigated.

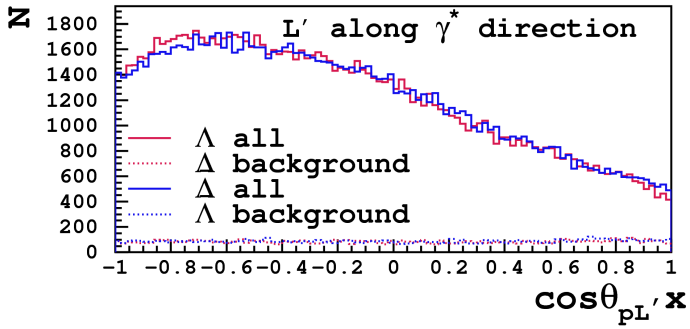


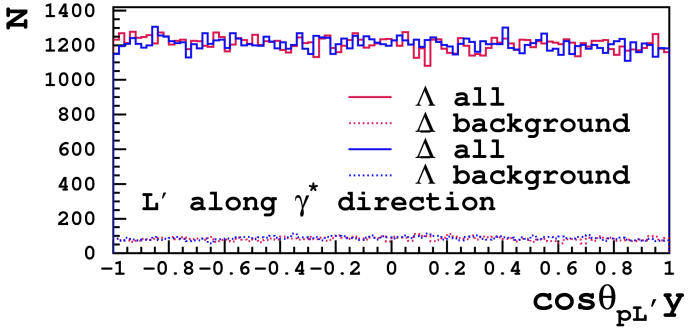
DATA sample

Transverse directions:





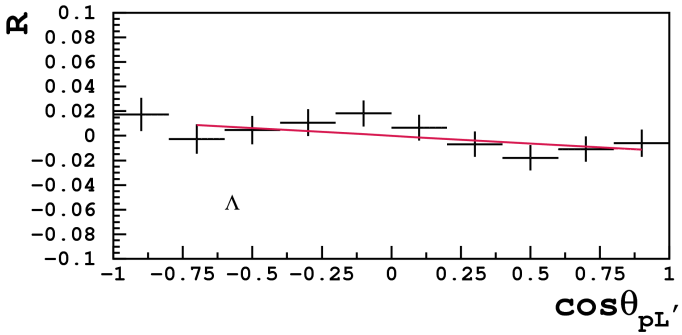


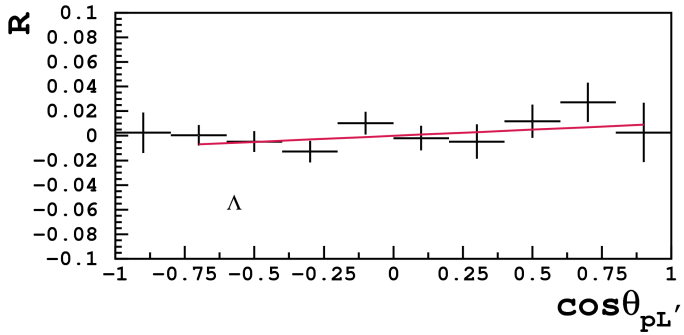


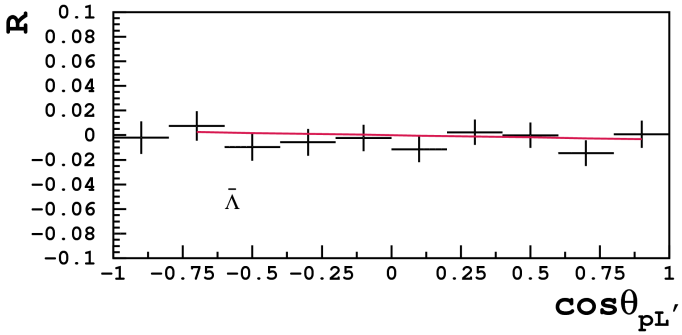
Results

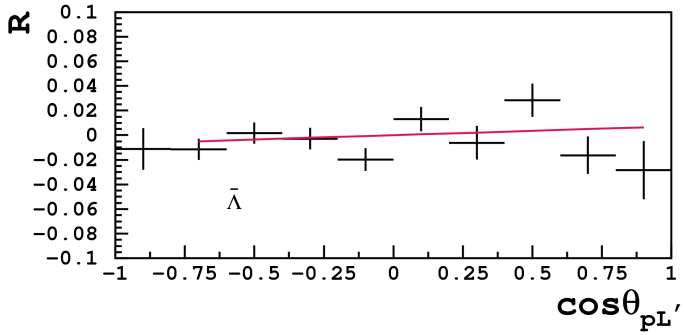
$$R = \frac{dN/d(cos\theta_{pL'})^{P_b>0} - dN/d(cos\theta_{pL'})^{P_b<0}}{dN/d(cos\theta_{pL'})^{P_b=0}}$$

The difference between the distributions for data with opposite beam polarization divided by the distribution obtained with helicity balanced data set.









$R = b*\cos\theta_{pL}/2$

b fitted,

Spin transfer:

$D_{LL'} = b/\langle P_b D(y)\rangle$

L' along γ^* $D_{LL'}^{\Lambda} = -0.177 \pm 0.081$

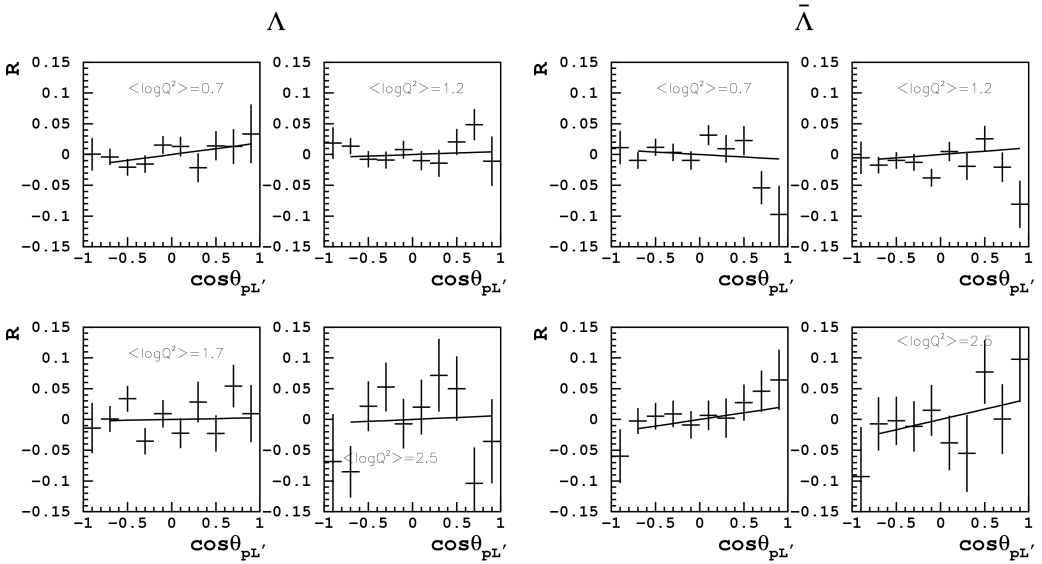
$D_{LL'}^{\bar{\Lambda}} = -0.014 \pm 0.080$

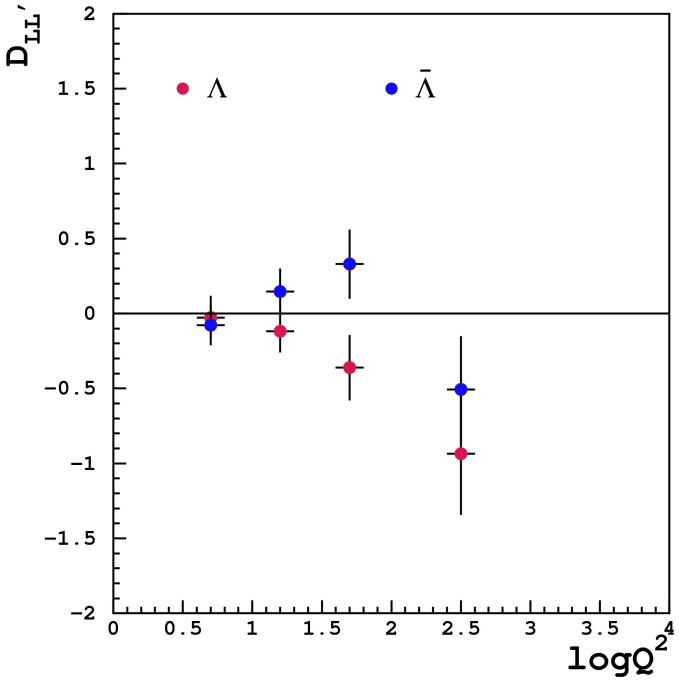
L' along Λ $D_{LL'}^{\Lambda} = 0.103 \pm 0.091$

$D_{LL'}^{\bar{\Lambda}} = -0.085 \pm 0.089$

Results

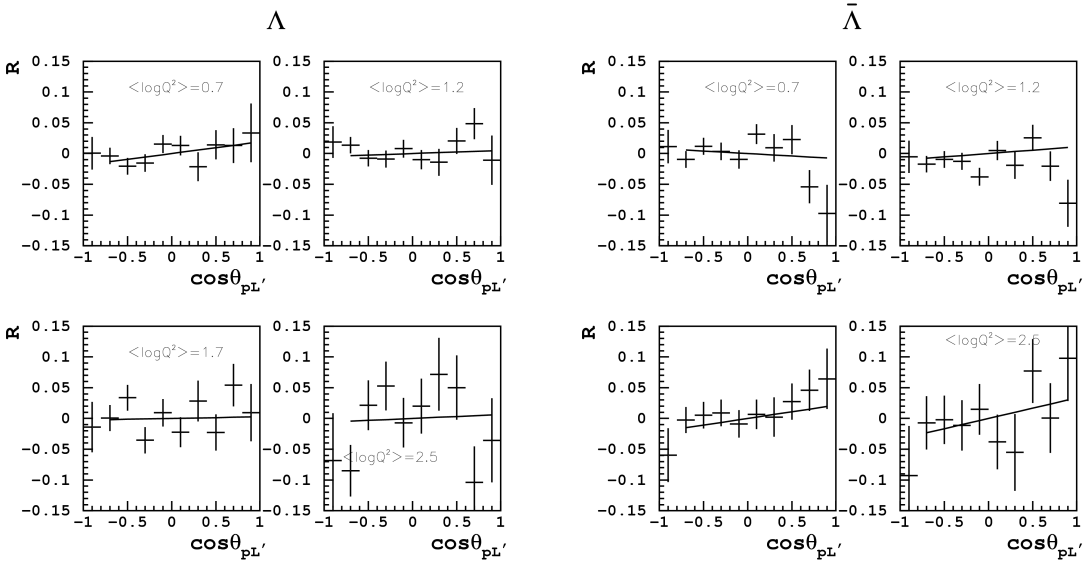
L' along γ^* , $D_{LL'}$ dependence on Q^2

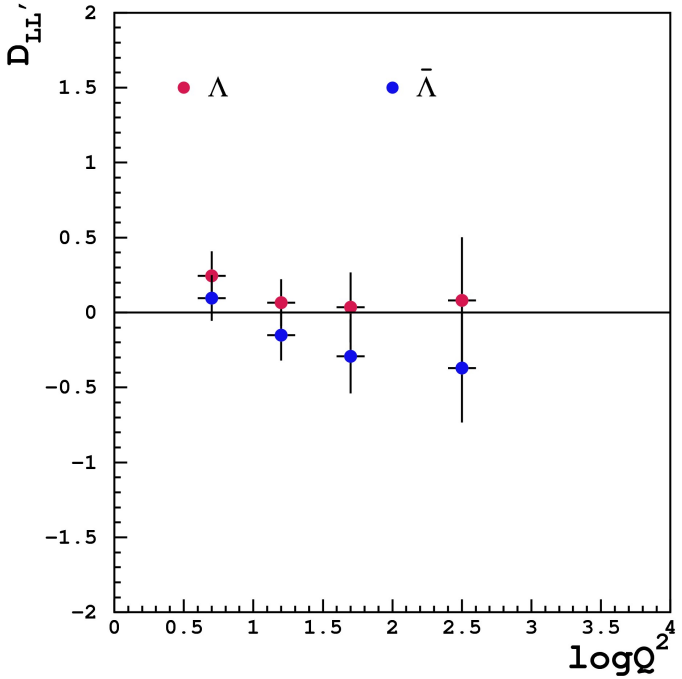




Results

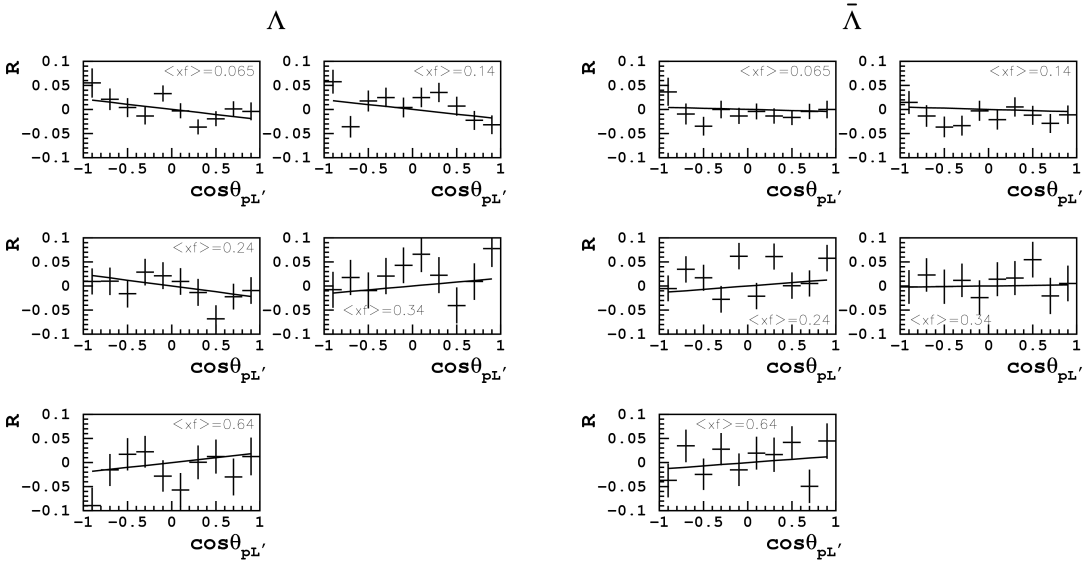
L' along Λ , $D_{LL'}$ dependence on Q^2



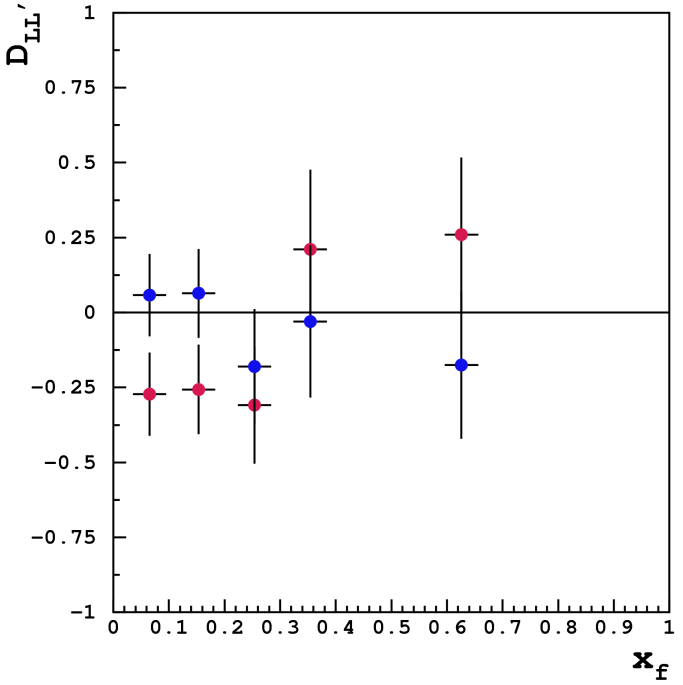


Results

L' along γ^* , $D_{LL'}$ dependence on x_f

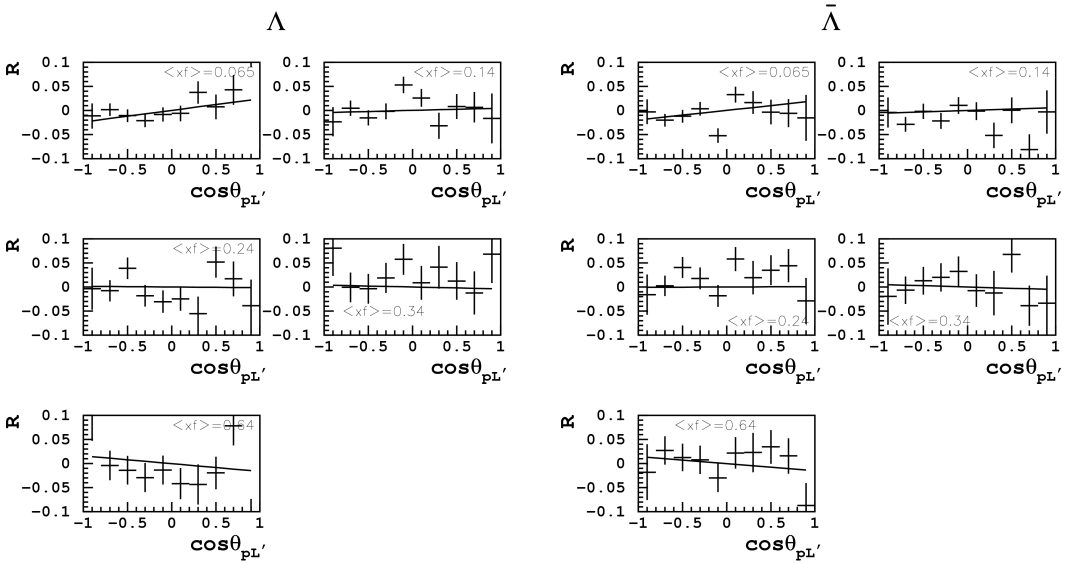


$x_f = 2P^*_L/W$,
P^*_L is particle longitudinal momentum in HCM.



Results

L' along Λ , $D_{LL'}$ dependence on x_f



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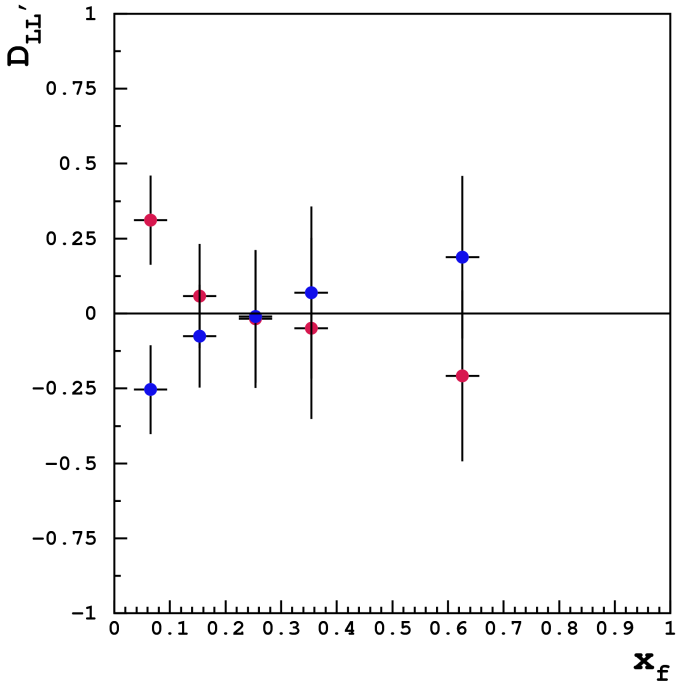
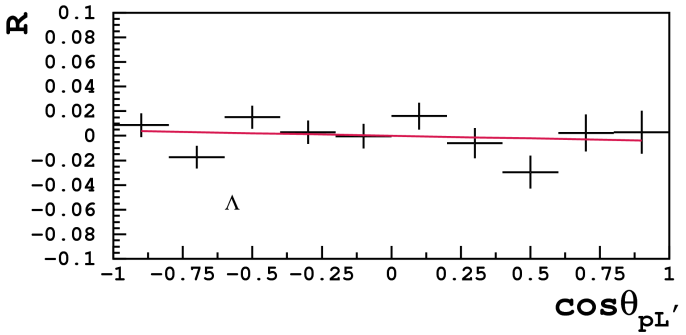
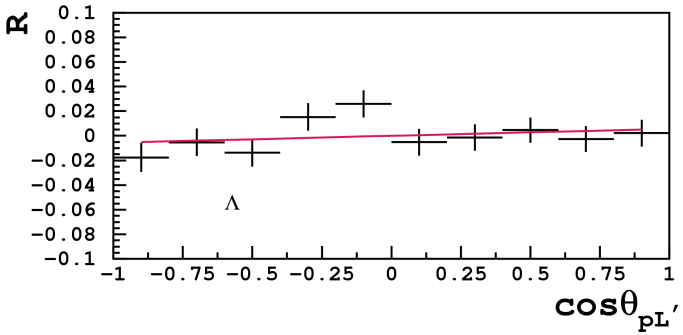
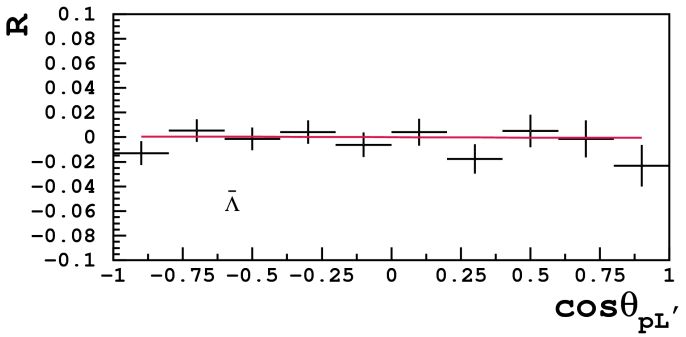


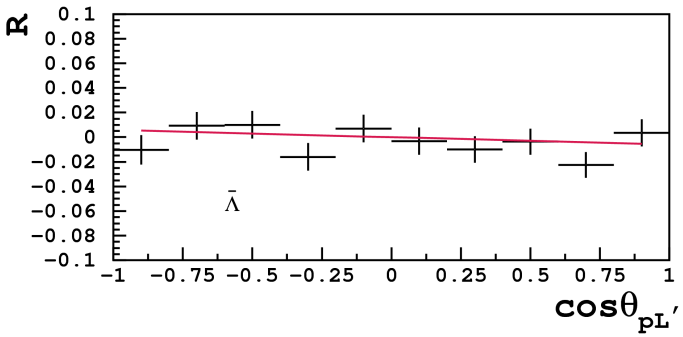
Results

Transverse direction x









L' along Υ^*

L' along Λ

$D_{Lx}^{\Lambda} = -0.053 \pm 0.081$

$D_{Lz}^{\bar{\Lambda}} = 0.083 \pm 0.080$

$D_{Lx}^{\Lambda} = 0.071 \pm 0.078$

$D_{Lx}^{\bar{\Lambda}} = 0.075 \pm 0.079$

Summary

- All three components of spin transfer $D_{LL'}$ have been measured. Two coordinate systems have been used.
  - Z axis along γ^*
  - Z axis along Λ
- In spite of huge sample of Λ and $\overline{\Lambda}$ (~250000) the significance of the measurement of $D_{LL'}$ is small.
- Nevertheless Q^2 and x_f dependence of $D_{LL'}$ has been investigated.

To continue

- Systematic errors should be calculated however they are expected to be small (uncertainty of beam polarization).
- Dependence of $D_{LL'}$ on other variables (x, z) may be investigated.
- Photo-production data may be analyzed.

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