Λ polarization at HERMES. Study of Longitudinal spin transfer.

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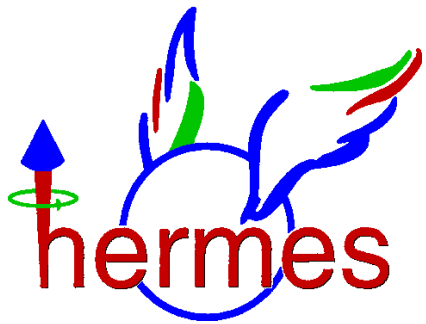
On behalf of the HERMES collaboration



Polarized Λ decay (Λ rest frame)

Λ^0 is "self analyzing" particle due to its parity violation decay:

$$\Lambda^0 \rightarrow p + \pi^-$$

Angular distribution of proton from Λ^0 decay is:

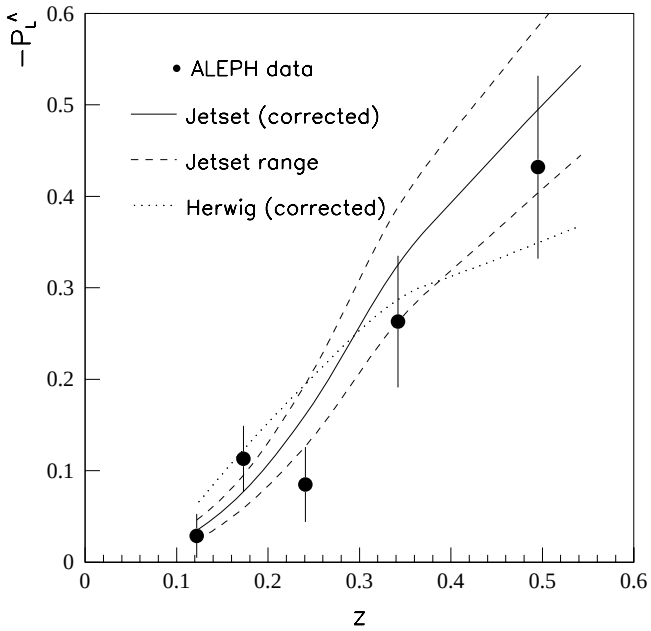
$$\frac{dN}{d\Omega_p} = \frac{dN_0}{d\Omega_p}(1 + \alpha P_\Lambda \cos\theta_p)$$

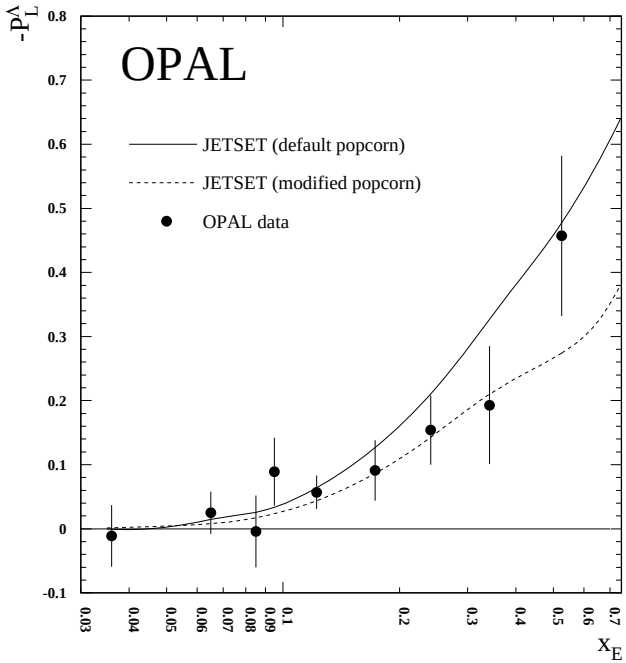
$$\alpha = 0.642 \text{ for } \Lambda$$

$$\alpha = -0.642 \text{ for } \overline{\Lambda}$$

θ_p is the angle between proton momentum in the Λ rest frame and the Λ polarization

Λ polarization in e⁺e⁻ : $e^+e^- \to Z \to \vec{q}\vec{\bar{q}} \to \vec{\Lambda}$

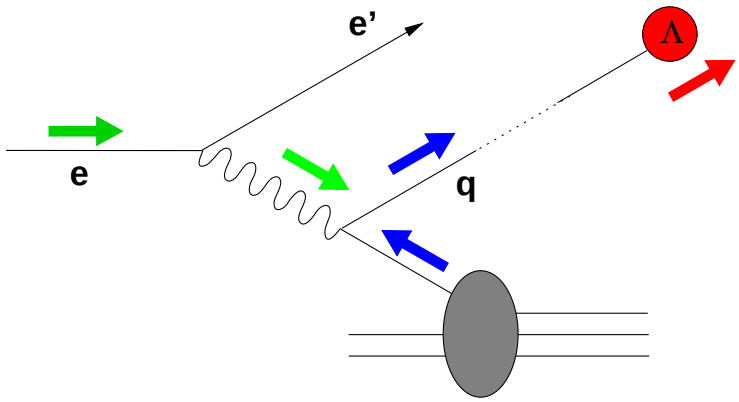




ALEPH and OPAL data well described by the Monte-Carlo based model

s-quark is dominating in Λ production in e+e- experiments

Models of Λ polarization



Λ spin structure

- According to Naïve Constituent Quark Model Λ polarization is determined by s- quark
  $\Delta u = \Delta d = 0, \Delta s = 1$
- Burkardt-Jaffe model for current fragmentation based on $SU_f(3)$ symmetry for baryon octet and experimental data:
  $\Delta u = \Delta d = -0.17, \quad \Delta s = 0.63$

Spin transfer to Λ

- QCD and quark-diquark models B.-Q.Ma, J.-J.Yang, I.Schmidt
- SU(3) model B.-Q.Ma, I.Schmidt, J. Soffer and J.- J.Yang
- SU(3) model C. Boros, J.T. Londergan, A.W.Thomas

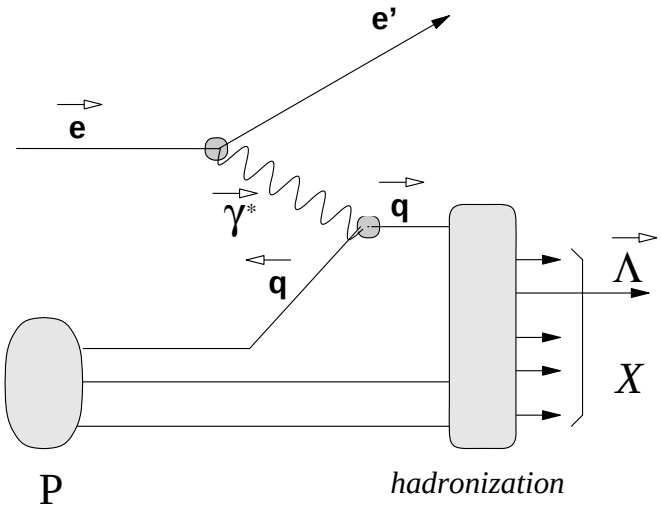
Longitudinal spin transfer $D_{LL'}^{\Lambda}$

$$\vec{e} + N \rightarrow e' + \vec{\Lambda} + X$$

$$Q^2, \quad \nu = E - E', \qquad y = \frac{\nu}{E} \qquad x_{bj} = \frac{Q^2}{2M\nu}$$

$$z = \frac{E_h}{\nu} \qquad x_f = \frac{p_{\parallel}}{p_{\max}}$$

kinematical limits are:
Q^2 >0.8 GeV^2, y<0.85
0<z<1, -1<x_F<1



In the case of polarized beam and unpolarized target struck quark polarization is: $P_q = P_b \cdot D(y)$ **and Λ polarization is:**

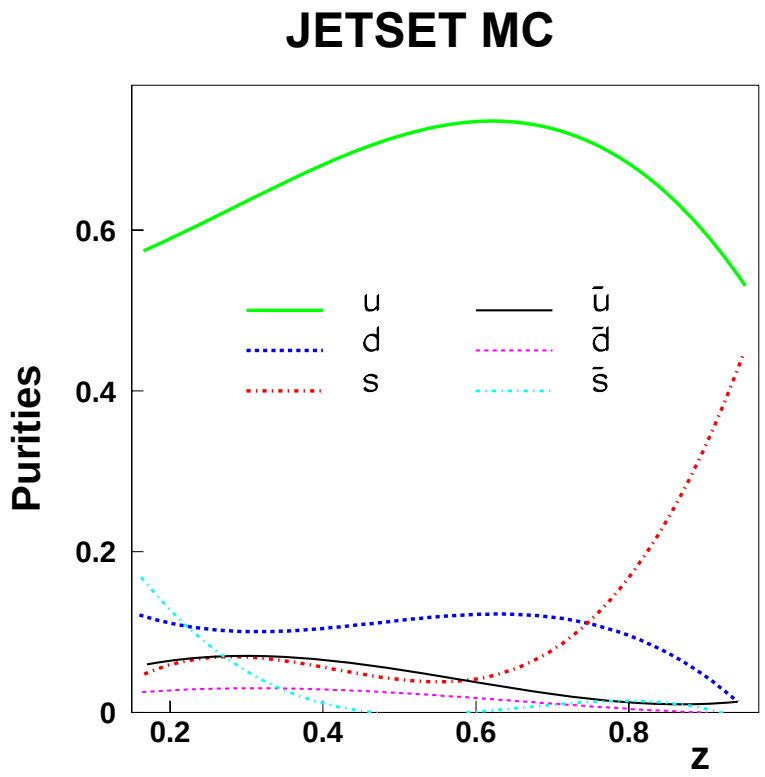
$$P_{L'}^{\Lambda} = P_b \cdot D(y) D_{LL'}^{\Lambda}, \; < P_b >_{run\ I} \approx 55\%, \; < D(y) > \approx 0.7$$

Struck quark: *u-quark* dominance

$$D_{LL'}^{\Lambda}(z) = \sum_f D_{LL'}^{\Lambda,f}(z) \cdot \omega_f^{\Lambda}(z)$$

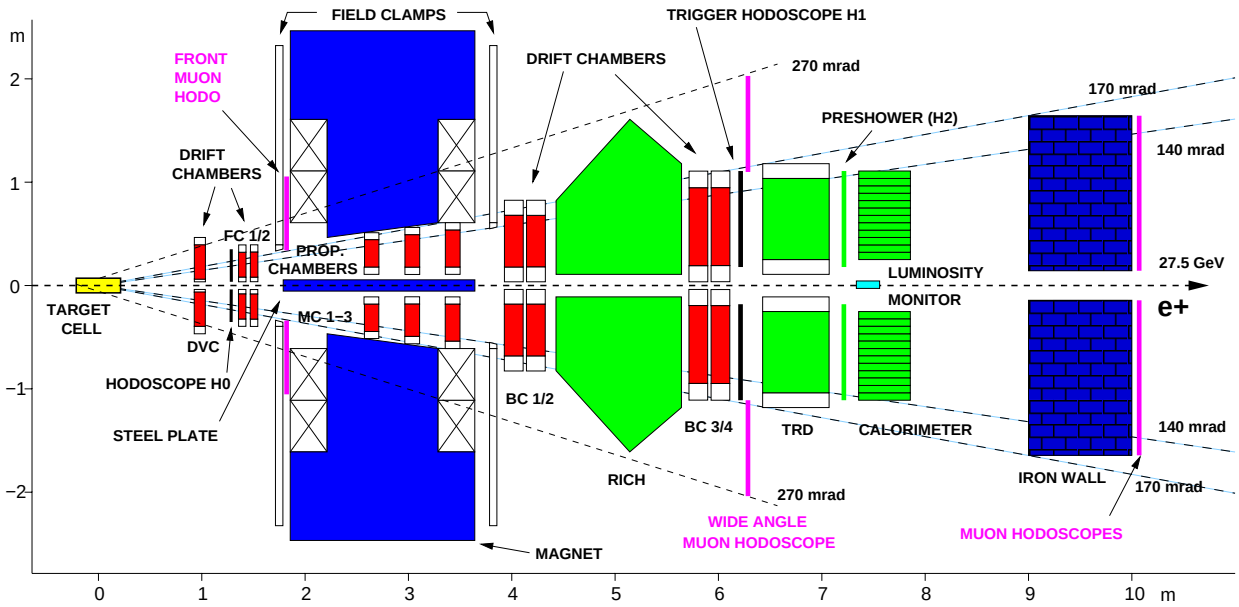
$$\sum_f \omega_f^{\Lambda}(z) = 1$$

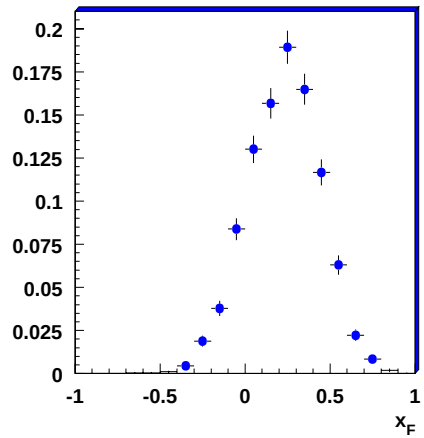
$$D_{LL',f}^{\Lambda}(z) = \frac{\Delta D_f^{\Lambda}(z)}{D_f^{\Lambda}(z)}$$



Λ production in DIS is dominating by knocking out of *u* and *d* quark

Experiment HERMES





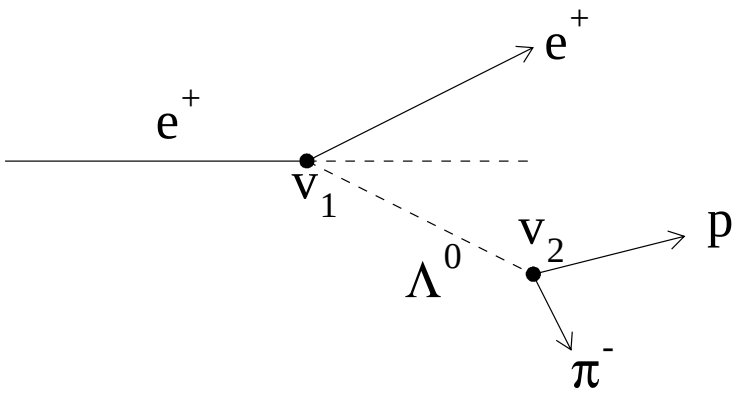
E_e = 27.5 GeV, average beam polarization P_b=55%

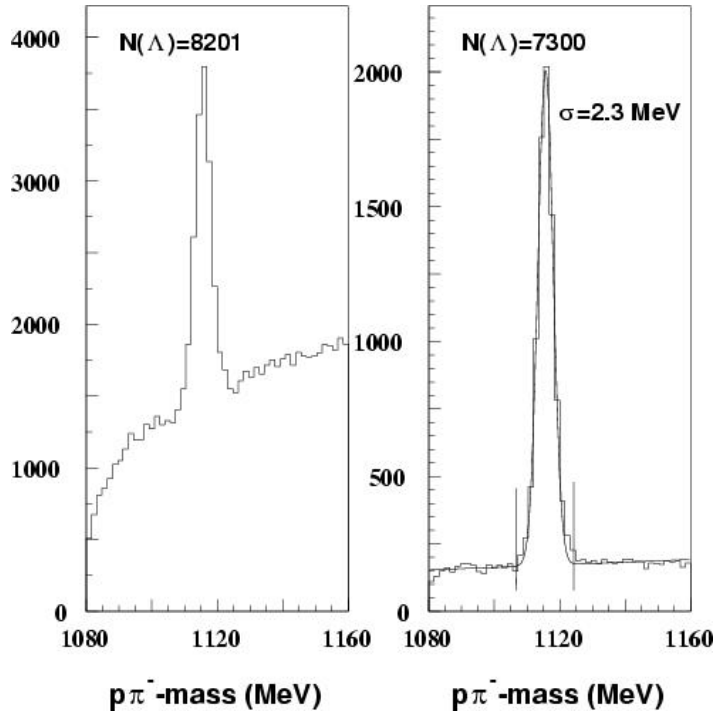
<u>beam polarization is changed about monthly</u>

polarized and unpolarized internal gas targets

GOOD RICH PID for hadron separation*: π / K / p*

Reconstructed Λ mass peaks





Background is ***h⁺ h⁻*** **pairs from fragmentation well suppressed by vertex separation cut** ***z_z-z_1>10 cm***
Cherenkov **1996-1997 and**
RICH **1999-2000**

left – **without** background suppression,
right – **with** background suppression

Longitudinal spin transfer $D_{LL'}^{\Lambda}$ $x_F > 0$

There are two typical choices of longitudinal Λ polarization axis:
along the direction of Λ momentum or along
virtual photon γ* **momentum in the Λ rest fame**

Due to possibility of flipping beam polarization no Monte-Carlo simulation of the spectrometer acceptance is nesessary to extract $D_{LL'}^{\Lambda}$

spin transfer along Λ *momentum* based on the data collected in 1996-2000 years is:

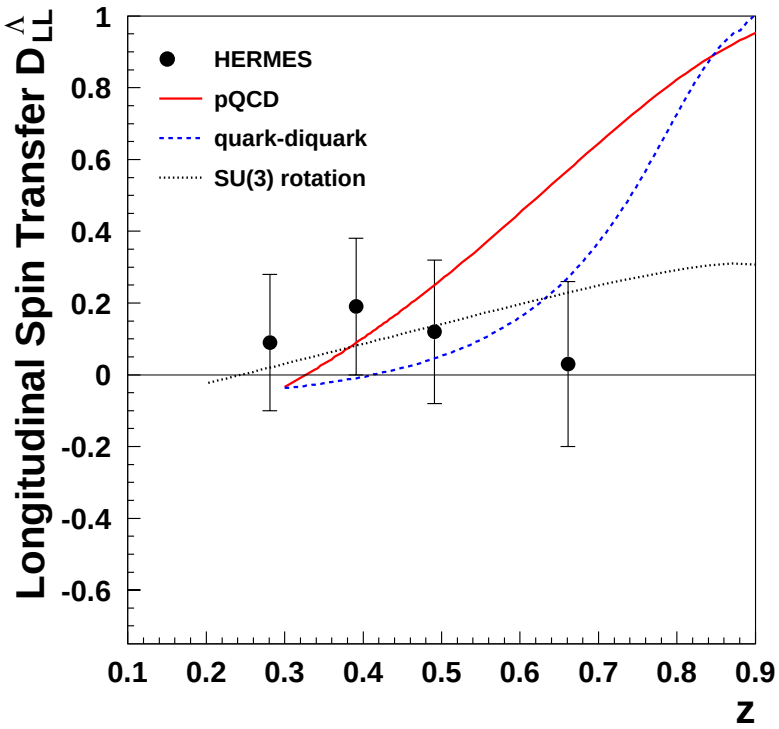
$$D_{LL'}^{\Lambda} = 0.11 \pm 0.10(stat) \pm 0.03(sys)$$

at $\langle Q^2 \rangle = 2.4$ GeV^2, $\langle x_{bj} \rangle = 0.088$, $\langle z \rangle = 0.45$
Experimental results shows no significant difference between two axis choices

Longitudinal spin transfer $D_{LL'}^{\Lambda}$ vs z, $x_F > 0$

pQCD and quark-diquark model
B.-Q.Ma, J.-J.Yang, I.Schmidt
Phys.Lett.B477:107-113,2000

SU(3) model
B.-Q.Ma, I.Schmidt, J. Soffer and J.-J.Yang
Phys.Rev.D65: 034004,2002

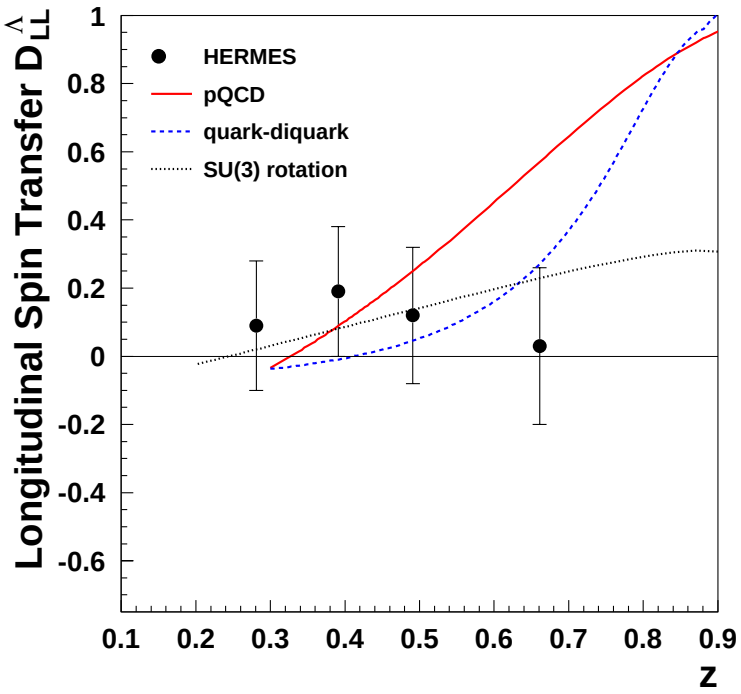


All models are assumed that:

- **Λ contain struck quark**
- **helicity conservation in fragmentation**

- **MC calculation shows that only *10%* of Λ contain struck quark**
- **Significant contribution from heavier hyperon decays (40-60%)**

Longitudinal spin transfer $D_{LL'}^{\Lambda}$ vs z, $x_F > 0$



$$\Sigma^* \sim 35\%,\ \Delta u_{\Sigma^*} = \Delta d_{\Sigma^*} = \Delta s_{\Sigma^*} = 1$$

$$\Sigma^0 \sim 20\%,\ \Delta u_{\Sigma^0} = \Delta d_{\Sigma^0} = +2/3,\ \Delta s_{\Sigma^0} = -1/3$$

$$\Xi^0 \sim 5\%,\quad \Delta u_{\Xi^0} = -1/3,\ \Delta d_{\Xi^0} = 0,\ \Delta s_{\Xi^0} = +4/3$$

$$p_q(\Lambda\, direct) = \frac{\Delta q_\Lambda}{q_\Lambda}$$

$$p_q^\Lambda(\Sigma^* \to \Lambda) = \frac{5}{9}\frac{\Delta q_{\Sigma^*}}{q_{\Sigma^*}}$$

$$p_q^\Lambda(\Sigma^0 \to \Lambda) = -\frac{1}{3}\frac{\Delta q_{\Sigma^0}}{q_{\Sigma^0}}$$

$$p_q^\Lambda(\Xi^0 \to \Lambda) = \frac{\Delta q_{\Xi^0}}{q_{\Xi^0}}$$

- **MC calculation shows that only *10%* of Λ contain struck quark**
- **Significant contribution from heavier hyperon decays (40-60%)**

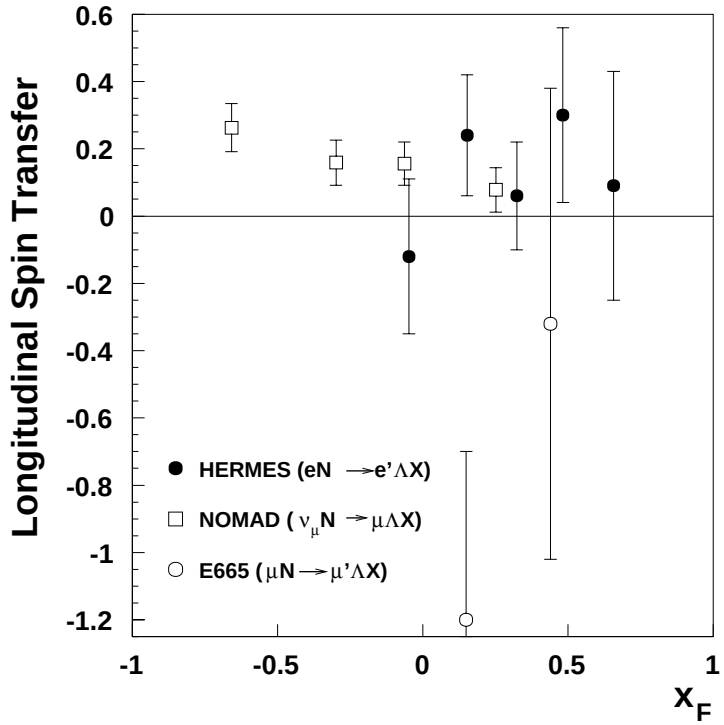
Compilation of longitudinal spin transfer data

HERMES:
E=27.57 GeV
Average beam polarization is 55%,

$x_F > 0,\ D_{LL'}^{\Lambda} = 0.11 \pm 0.10(stat) \pm 0.03(sys)$

NOMAD:
E=43.8 GeV
Beam polarization = 100%

$x_F > 0,\ D_{LL'}^{\Lambda} = 0.09 \pm 0.06(stat) \pm 0.03(sys)$



Conclusion and Outlook

- Longitudinal spin transfer at $x_F > 0$, $\langle z \rangle = 0.45$ is compatible with *"0"* and found to be:

$$D_{LL'}^{\Lambda} = 0.11 \pm 0.10(stat) \pm 0.03(sys)$$

- No z or x_F dependence of $D_{LL'}^{\Lambda}$ was found
- HERMES results consistent with the data obtained by NOMAD collaboration

- Data collected in 2002-2005 will increase the statistics for spin transfer analysis up to 1.5 times
- Spin transfer $D_{LL'}^{\bar{\Lambda}}$ for anti – Lambda
- Spin transfer from the polarized target under study
- Use Monte-Carlo for complex $D_{LL'}^{\bar{\Lambda}}$ simulation taking into account spin structure of heavy resonances decaying to Λ

Λ polarization in DIS: very complex production mechanism