Longitudinal Λ^0 polarization measured at HERMES

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On behalf of HERMES collaboration

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Motivation

- Polarized DIS+SU$(3)_f$+axial currents:
  $\Delta u_p = 0.79 \;\; \Delta d_p = -0.45 \;\; \Delta s_p = -0.16$,
  where Δq_p is the fraction of the proton's spin carried by quarks of flavor q.
  $\Delta\Sigma \equiv \Delta u_p + \Delta d_p + \Delta s_p \approx 0.18$ - "spin crisis"
- SU$(3)_f$ $\Rightarrow$:
  $\Delta u_\Lambda = \Delta d_\Lambda = -0.20$, $\Delta s_\Lambda = 0.58$.
  Compare with NQM prediction
  $\Delta u_\Lambda = \Delta d_\Lambda = 0$, $\Delta s_\Lambda = 1$.
  Interesting to measure, but Λ target does not exist.
- Alternative to polarized DIS from Λ-polarized current fragmentation.

  Expectations:

  SU$(3)_f$ $\Rightarrow$ u, d fragmentation - Λ negatively polarized, spin transfer -0.2

  NQM $\Rightarrow$ u, d fragmentation - Λ unpolarized

Formalism of Λ polarization measurement

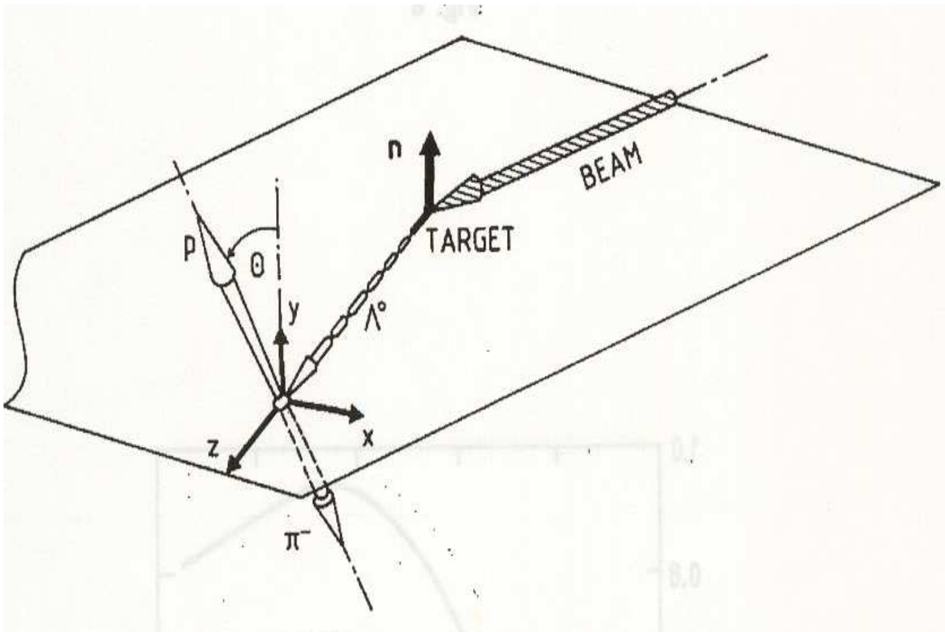
$$\Lambda \to p\pi^-$$

In Λ c.m. frame

$$\frac{1}{N}\frac{dN}{d\Omega} = \frac{1}{4\pi}\left[1 + \beta(\vec{P}_\Lambda, \vec{k})\right],$$

where $\beta = 0.642$ and $\vec{k}$ - the unit vector along the momentum of proton from Λ decay.

$$\vec{k} = \cos(x,p)\vec{e}_x + \cos(y,p)\vec{e}_y + \cos(z,p)\vec{e}_z = k^i\vec{e}_i$$



In case of 4π acceptance

$$\{k^i\} = \frac{\beta}{3}P^i_\Lambda, \qquad i = x, y, z.$$

$\{\cdots\}$ - an average over the experimental date set. Complications appear in case of restricted acceptance, when $\{k^i\} \neq 0$ even at $P^i_\Lambda = 0$.

Helicity balanced experiment

Actually we are interested in measuring of polarization transfer from the beam to Λ. For the beam with the polarization P_b the Λ polarization vector is equal to $\vec{P}_\Lambda = P_b \vec{\mathcal{D}}_\Lambda$. Let us suppose now that we perform measurements in a series of experiments with different beam polarizations $\{P_{bn}\}$, $n = 1, 2, \cdots, N$, but with the mean beam polarization over these experiments being equal to zero

$$\langle \mathbf{P_b} \rangle = \frac{\mathbf{1}}{\mathbf{N}} \sum_{\mathbf{n}} \mathbf{P_{bn}} = \mathbf{0}. \tag{1}$$

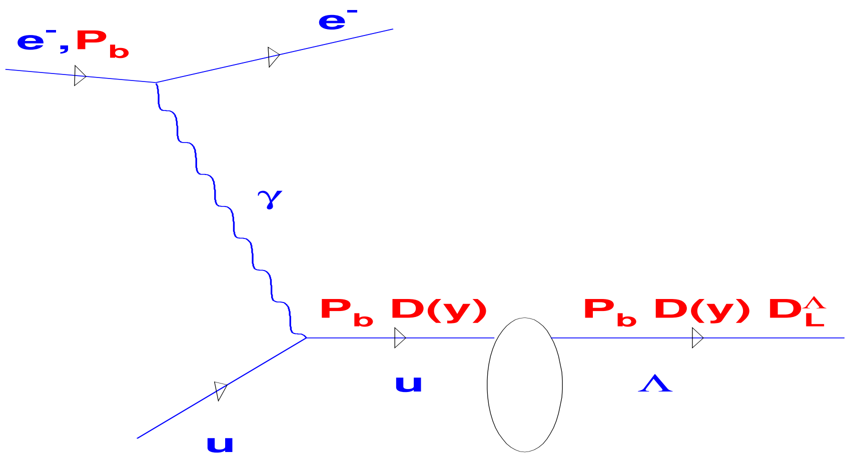
Then

$$\{k^i\} = \langle k^i \rangle, \qquad \{k^i k_j\} = \langle k^i k_j \rangle,$$

$\langle \cdots \rangle$ - average over unpolarized experiment set and

$$\boxed{\{P_b k^i\} = \beta < P_b^2 > \{k^i k_j\}\{\mathcal{D}^j_\Lambda\}.}$$

Polarization transfer from struck quark



In quark-parton model of DIS the longitudinally polarized positron polarizes the struck quark

$$P_{qs} = D(y)P_b, \qquad \vec{P}_\Lambda = D(y)P_b\vec{D}_L$$

where $y = (E - E')/E$ and

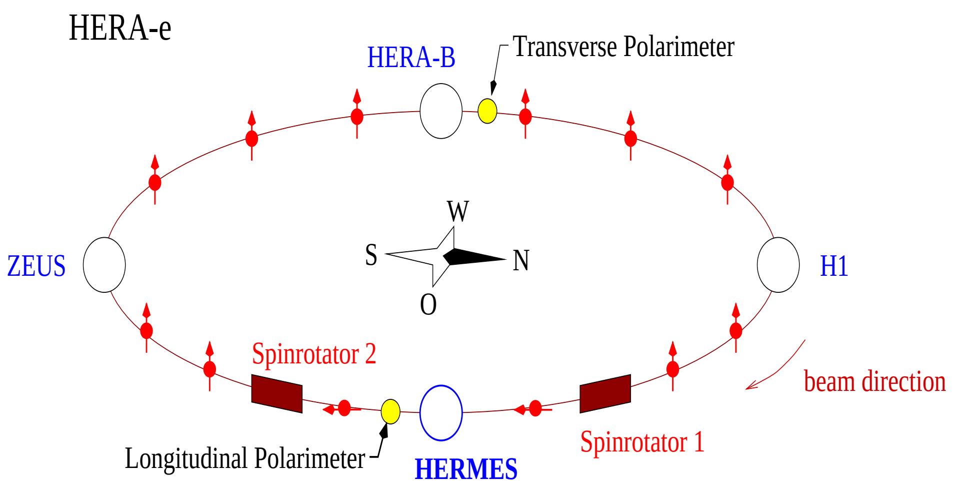
$$D(y) \simeq \frac{1-(1-y)^2}{1+(1-y)^2},$$

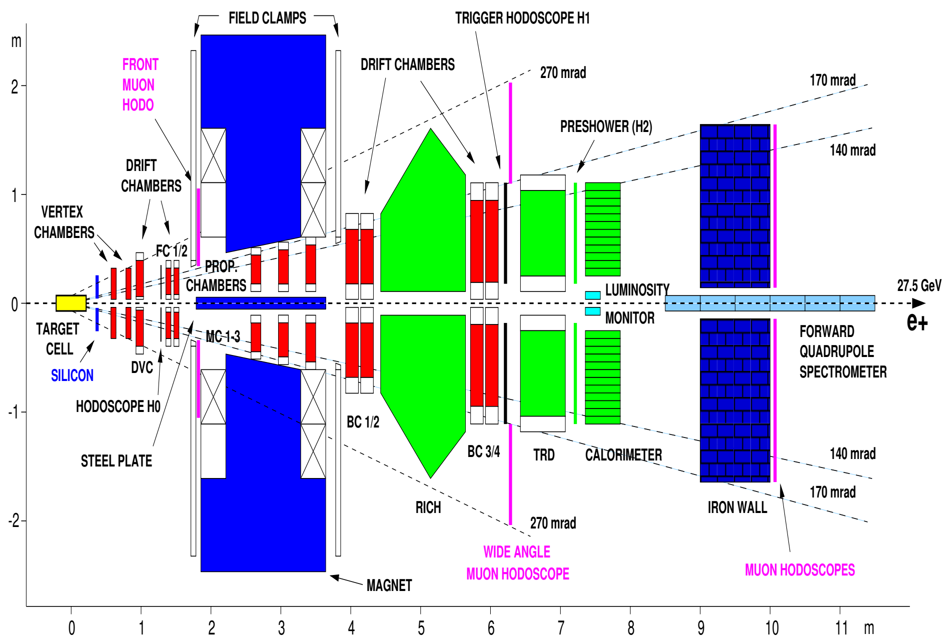
and it is natural to modify the formalism to extract the polarization transfer from struck quark to Λ

Then

$$\boxed{\{P_b k^i\} = \beta < P_b^2 > \{D(y)k^i k_j\}\{D_L^j\}.}$$

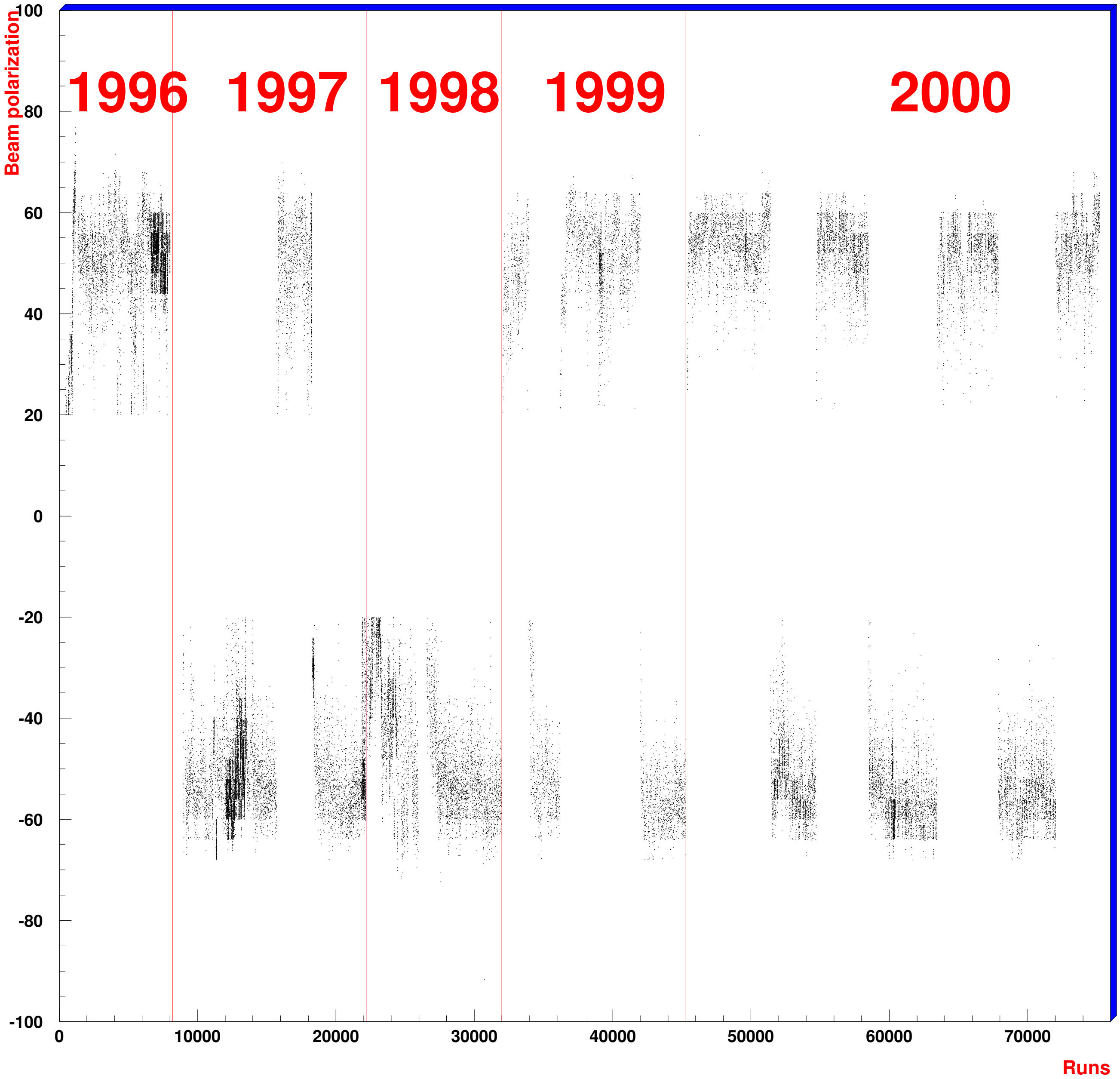
HERA+HERMES


HERA-e
HERA-B
Transverse Polarimeter
W
S
N
O
ZEUS
H1
Spinrotator 2
beam direction
Longitudinal Polarimeter
HERMES
Spinrotator 1


FIELD CLAMPS
TRIGGER HODOSCOPE H1
FRONT
MUON
HODO
DRIFT CHAMBERS
270 mrad
170 mrad
PRESHOWER (H2)
140 mrad
DRIFT
CHAMBERS
VERTEX
CHAMBERS
FC 1/2
PROP.
CHAMBERS
LUMINOSITY
MONITOR
27.5 GeV
e+
TARGET
CELL
SILICON
MC 1-3
DVC
FORWARD
QUADRUPOLE
SPECTROMETER
HODOSCOPE H0
BC 1/2
STEEL PLATE
BC 3/4
TRD
CALORIMETER
140 mrad
170 mrad
RICH
IRON WALL
270 mrad
WIDE ANGLE
MUON HODOSCOPE
MUON HODOSCOPES
MAGNET
m
2
1
0
-1
-2
0
1
2
3
4
5
6
7
8
9
10
11
m

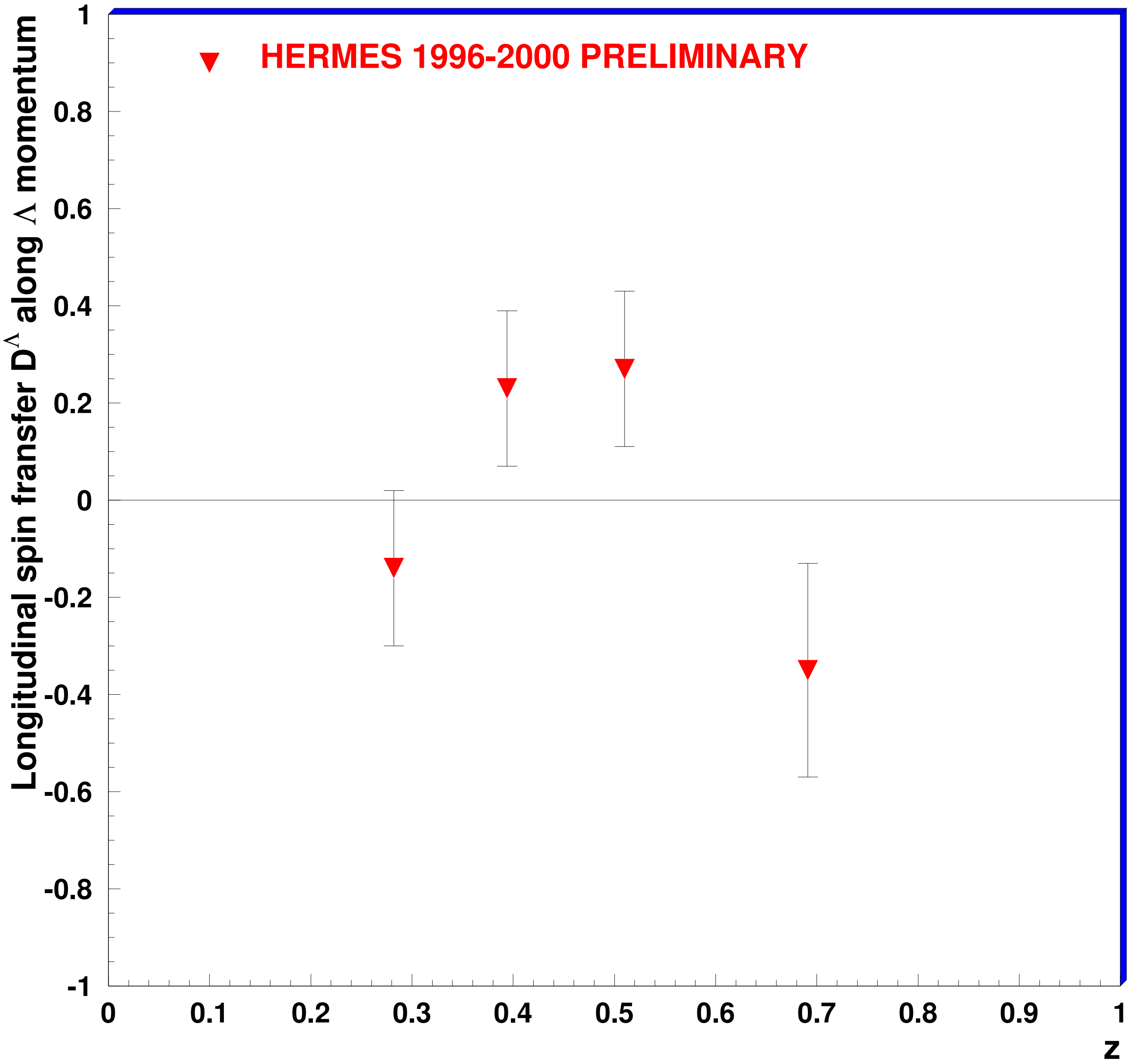
Beam polarization in 1996-2000 years

$$D^{\Lambda}_{L\,96-97} = 0.11 \pm 0.17(\text{stat}) \pm 0.03(\text{syst})$$



z-dependence of D_L along Λ.

$$z = \frac{E_\Lambda}{\nu}$$



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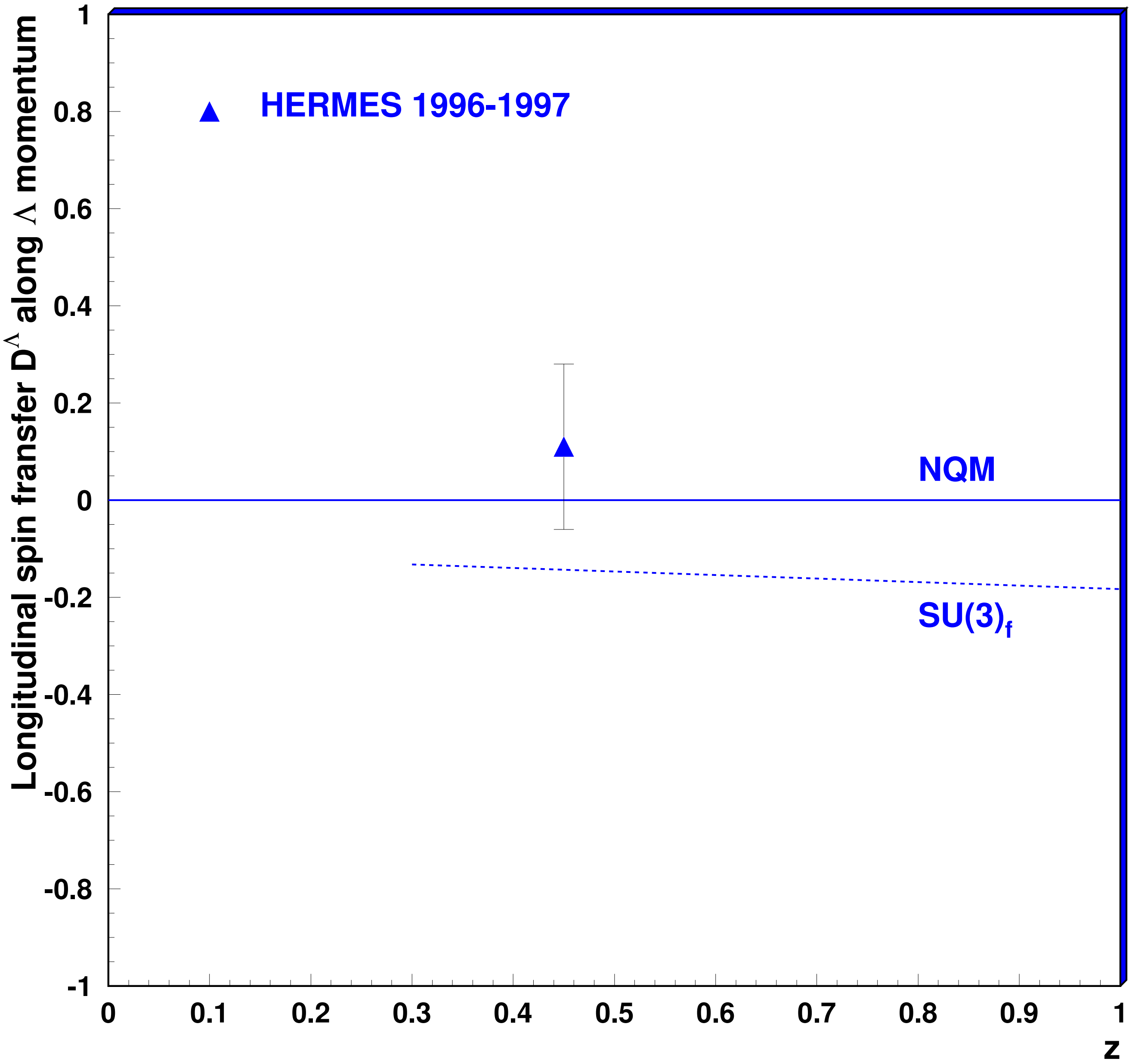
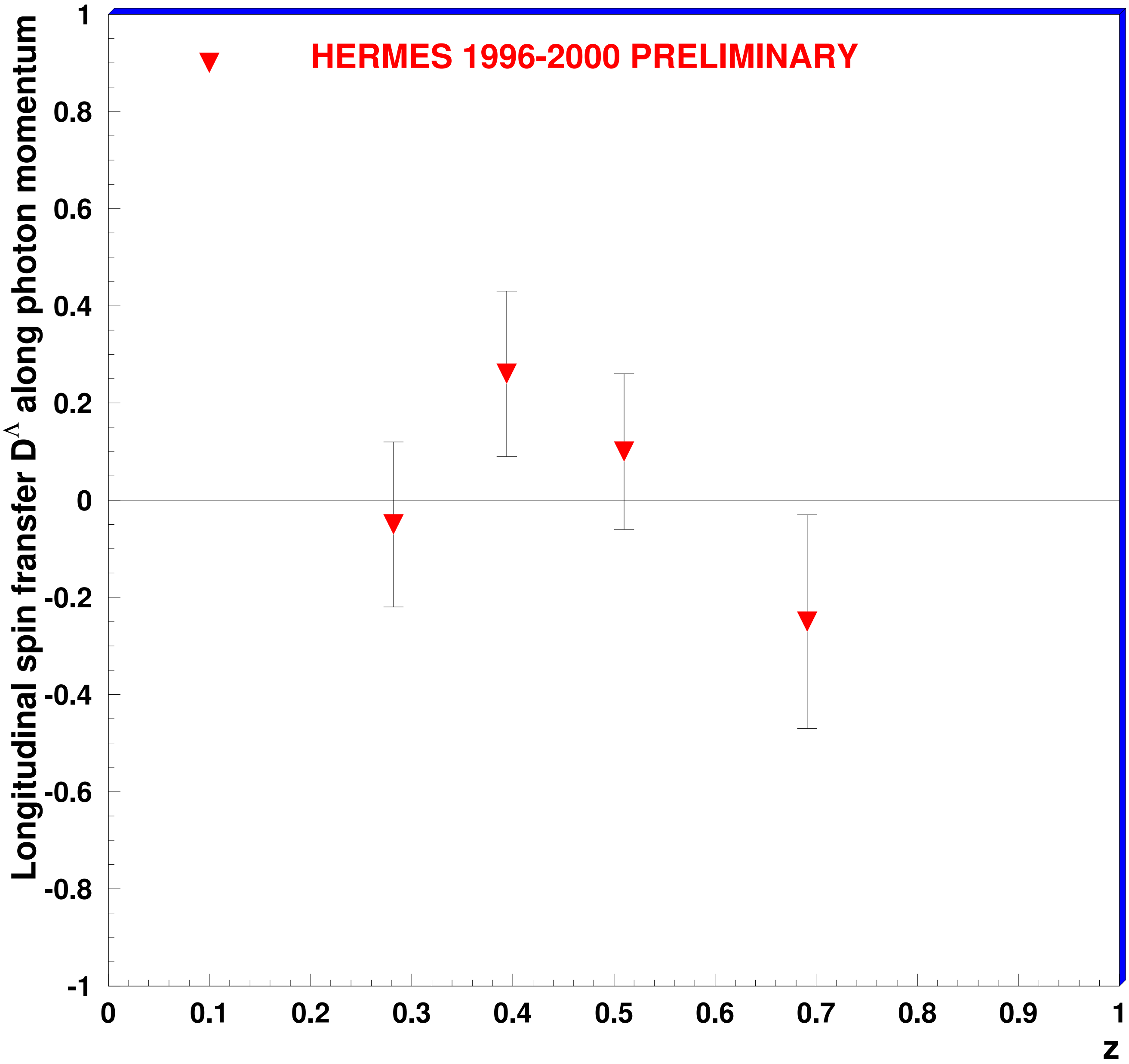
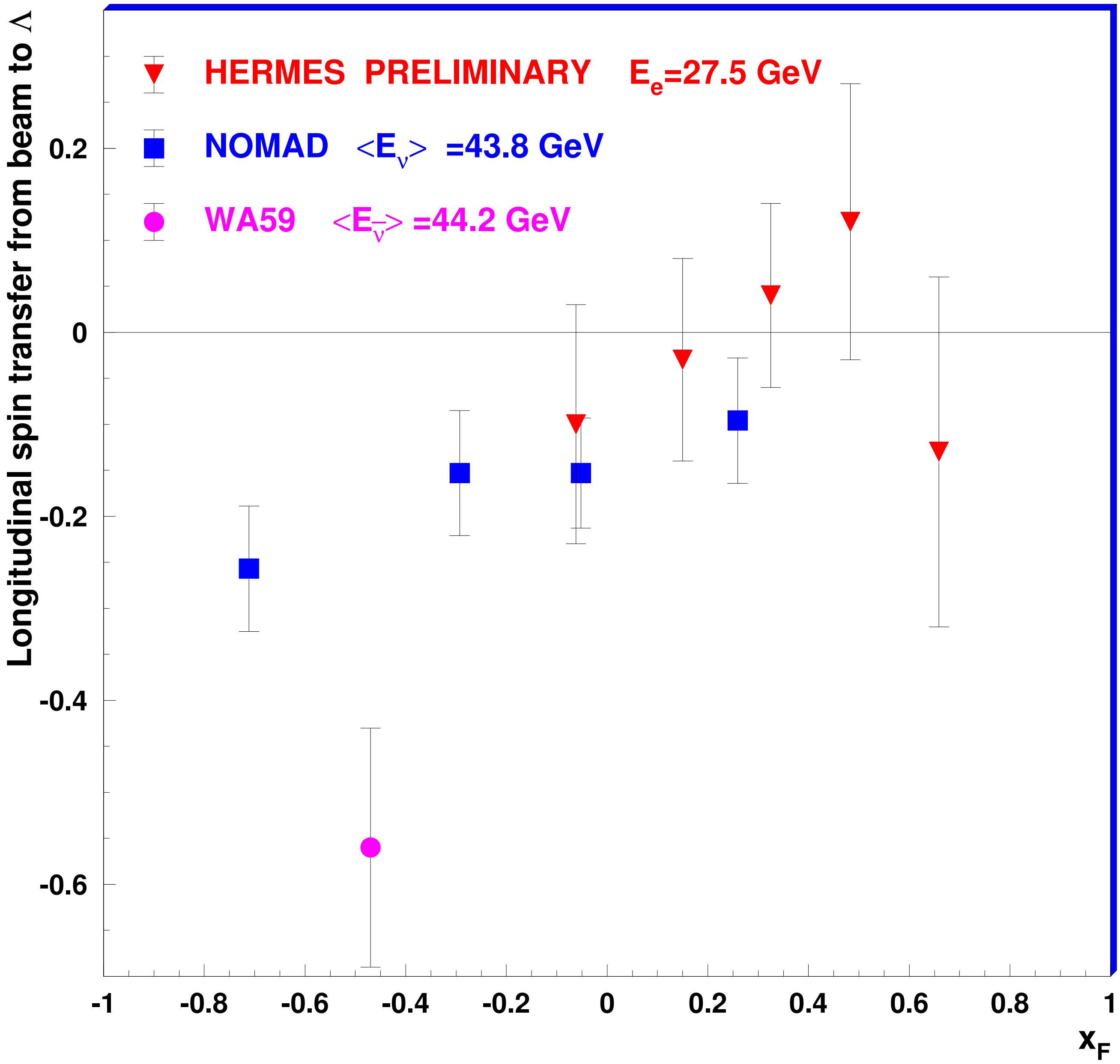


z-dependence of D_L along photon

$$z = \frac{E_\Lambda}{\nu}$$



x_F-dependence of spin transfer from beam



Summary

The substantial increasing of statistic in the combined analysis of 96-97-99-00 years data to compare with the previous analysis of HERMES 96-97 data was achieved. As result the statistical uncertainty in determination of longitudinal spin transfer from struck quark to Lambda has been decreased from 0.17 to 0.09. New data allow to follow the z- and x_F-dependences of Λ polarization.

As function of x_F the measured spin transfer from positron beam to Λ is compared to spin transfer from neutrino beam to Λ recently measured by NOMAD. At overlapping x_F these results are in agreement.

Outlook

In 2002 year we expect the further increasing of statistic and covering of the target fragmentation region by use of new silicon detector near the target cell - Lambda Wheels. The more long term project - Recoil Detector - will provide access to especially low x_F