Strange Particle Production and Λ Polarization

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Under Study in HERMES Experiment

in DIS regime

$$\vec{e} + A \Rightarrow e' + \vec{\Lambda}(\bar{\Lambda}, K_s) + X$$

in $Q^2 \simeq 0$ regime

$$\vec{e} + A \Rightarrow \vec{\Lambda}(\bar{\Lambda}, K_s) + X$$

A=H,D,^{3}He,^{14}N pol/unpol gas targets

- Unpolarized case.
  Comparison to LEPTO based Monte Carlo.

- Longitudinal Λ polarization in current fragmentation region.

- Transverse polarization of inclusively produced Λ and $\bar{\Lambda}$.

- Conclusion.

Conclusion

Semi-inclusive reactions

$$\vec{e} + A \Rightarrow e' + \vec{\Lambda}(\bar{\Lambda}, K_s) + X$$

have been studied **in DIS regime** with the HERMES spectrometer.

- Kinematic distributions for the detected by the spectrometer events show a good agreement wih LEPTO based Monte Carlo calculations

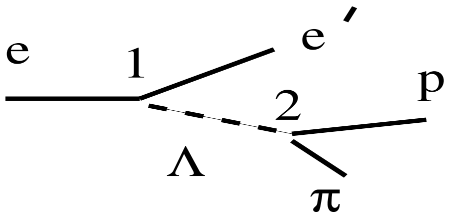
- Longitudinal Λ polarization measured in current fragmentation region is compatible with zero:

$$P_\Lambda = 0.03 \pm 0.06(stat) \pm 0.03(syst)$$

- Transverse polarization of inclusively produced Λ and $\bar{\Lambda}$ has been measured.It increases with $p_\Lambda t$. Averaged in $p_\Lambda t$ range upto 1.7 Gev/c preliminary

$$P_{n\Lambda} = (6.6 \pm 1.1 \pm 2.5)\% \quad P_{n\bar{\Lambda}} = (-6.6 \pm 3.7 \pm 2.5)\%$$

$\Lambda,\bar{\Lambda}$ and K_s event selection

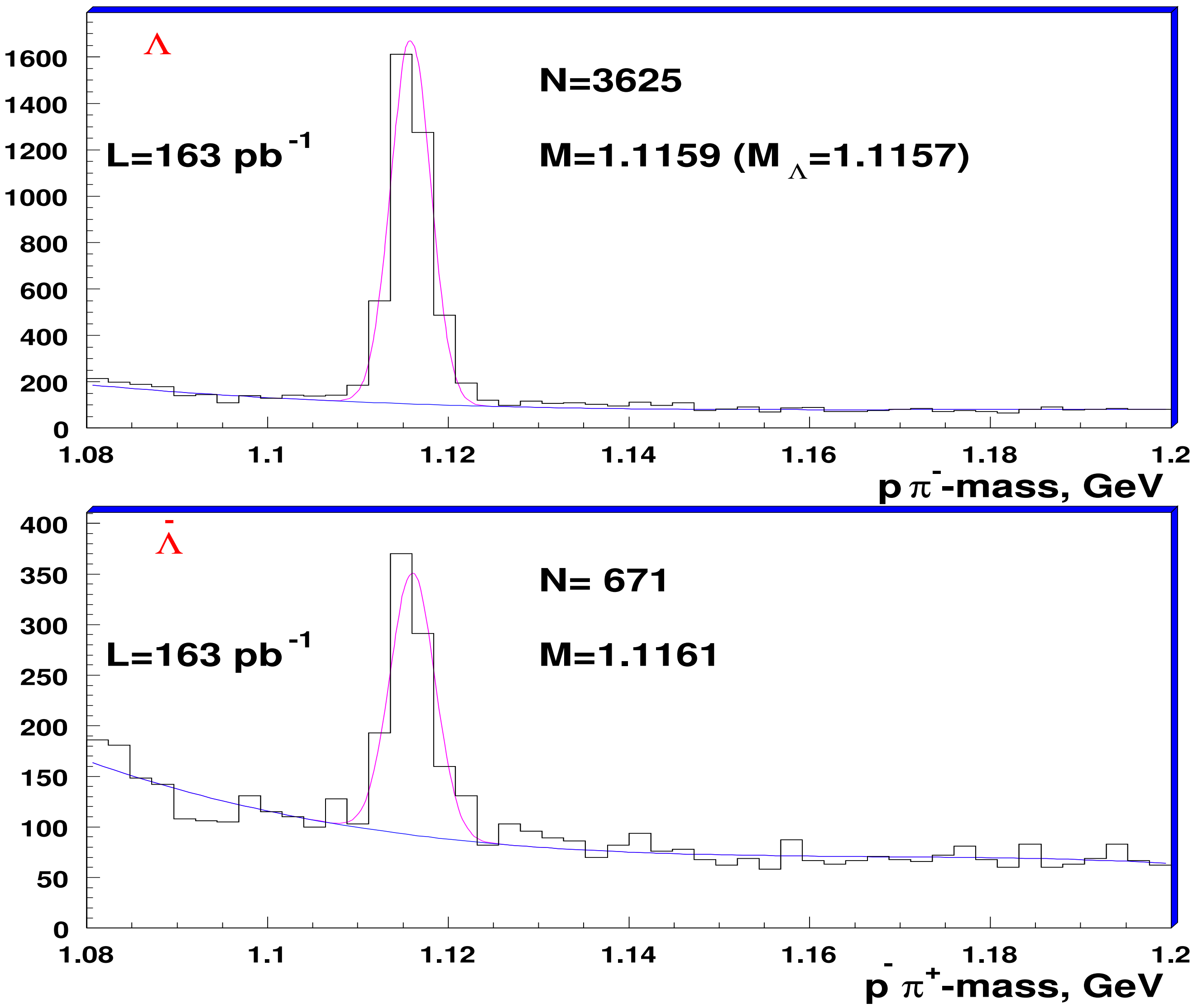


momenta of e ,p and π
measured

V1 and V2 reconstructed

main cuts z2-z1 >10cm

Cer<0.3



$\boxed{\text{Longitudinal } \Lambda \text{ polarization}}$

In QPM for a polarized beam and unpolarized target:

$$P_\Lambda = \tau D(y) P_B$$

where P_B is longitudinal beam polarization, $D(y) = \frac{y(2-y)}{1+(1-y^2)}$ depolarization factor,

$$D(y)P_B$$

polarization transfered to a quark,

and

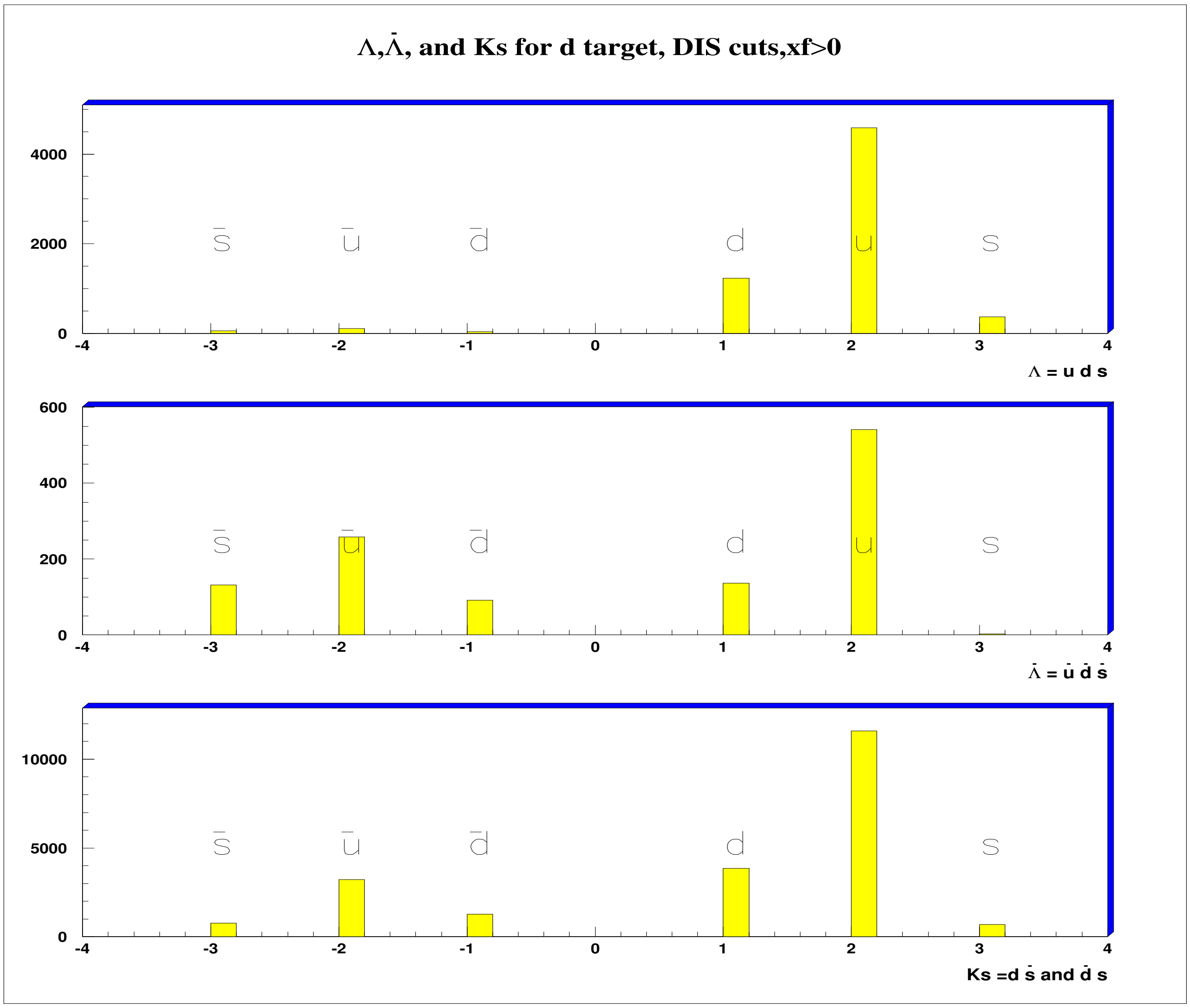
$$\tau = \frac{\sum_q e_q^2 q(x) \Delta D_q^\Lambda(z)}{\sum_q e_q^2 q(x) D_q^\Lambda(z)} = \sum_q \frac{\Delta D_q^\Lambda(z)}{D_q^\Lambda(z)} \omega_q^\Lambda(x)$$

with

$$\omega_q^\Lambda(x) = \frac{e_q^2(x) D_q^\Lambda(z)}{\sum_q e_q^2 q(x) D_q^\Lambda(z)}$$

Purity ($\omega_q^{\Lambda,\bar{\Lambda},K_s}$) distributions for $x_f > 0$

$$\omega_q = \int \omega_q(x)dx$$



P_Λ Expectation

From LEPTO based Monte Carlo for the accepted by the HERMES spectrometer events ($x_f > -0.2$)

$$\omega_u^\Lambda = 83\% \quad \omega_d^\Lambda = 12\% \quad \omega_s^\Lambda = 5\%$$

Estimations for $q \Rightarrow \Lambda$ polarization transfer $\frac{\Delta D_q^\Lambda}{D_q^\Lambda}$???

According to Jaffe

$$\frac{\Delta D_q^\Lambda(z)}{D_q^\Lambda(z)} \sim \frac{\Delta q_\Lambda}{q_\Lambda}.$$

This might be valid in the limit of $z \Rightarrow 1$

In realistic model of Λ

Quark	$\frac{\Delta q_\Lambda}{q_\Lambda}$
u	-0.2 ± 0.04
d	-0.2 ± 0.04
s	0.6 ± 0.04

Then $\tau = -0.16 \pm 0.05$,

and at HERMES kinematics with $\frac{y(2-y)}{1+(1-y^2)} = 0.69$

$$P_\Lambda \simeq -(0.16 \pm 0.05) \cdot 0.69 \cdot 0.52 = -0.057 \pm 0.02$$

Experimental result

Λ polarization is analysed through its decay $\Lambda \Rightarrow p + \pi$:

$$dN_{\Lambda} \sim (1 + \beta P_{\Lambda} \cos\theta) d \cos\theta$$

Here θ is angle between proton momentum and Λ polarization vector $\vec{P}_{\Lambda}$ in Λ rest frame, $\beta = 0.642$.
Unifying two data sets with opposite beam polarization $P_B = \pm 0.52$ the HERMES acceptance function cancels.
Then

$$P_{\Lambda} = (1/\beta) \frac{1/N_{\Lambda} \sum_{i=1}^{N_{\Lambda}} cos\theta_i}{1/N_{\Lambda} \sum_{i=1}^{N_{\Lambda}} cos^2\theta_i}.$$

In kinematic domain

$$x_f > 0, \quad Q^2_{mean} = 2.48 \, (Gev/c)^2, \quad z_{mean} = 0.45$$

we have obtained **preliminary**

$$P_{\Lambda} = 0.03 \pm 0.06(stat) \pm 0.03(syst)$$

$$\tau = 0.10 \pm 0.17(stat) \pm 0.09(syst)$$

To remind,expected $P_{\Lambda} \simeq -0.057 \pm 0.02$

Strange Particle Yields at HERMES

Most of the Λ,$\bar{\Lambda}$,K_s results comes from two sets of data obtained in a dedicated run of 1996 and 1997 with a high density unpolarized target Number of inclusive DIS detected by HERMES was $7.24{\cdot}10^6$ at integrated luminosity 163 pb^{-1}

Number of events from 1996+1997 year run.
After:
data quality cuts,
DIS cuts

$$(Q^2 > 1.\mathrm{GeV}^2, W^2 > 4.\mathrm{GeV}^2,\ y < 0.85, 0.02 < x_{Bj} < 0.8)$$

and background suppression cuts
we obtain

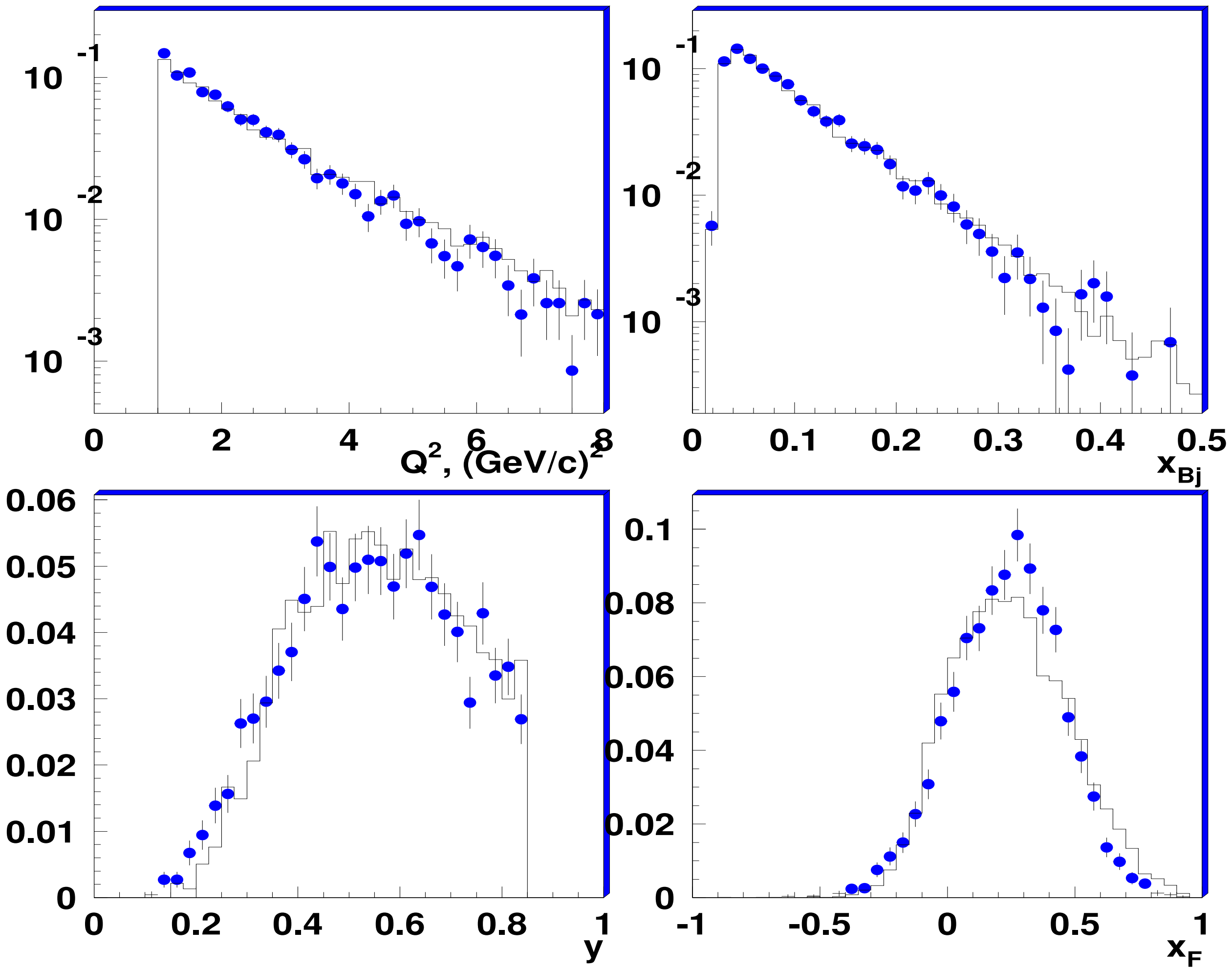
$$SIDIS\ \ \Lambda = 2800(\simeq 4800)\ \ \bar{\Lambda} = 320\ \ K_s = 8700$$

$$Incl.(Q^2 \simeq 0)\ \Lambda = 73 \cdot 10^3(\simeq 140 \cdot 10^3)\ \ \bar{\Lambda} = 18 \cdot 10^3$$

$$K_s = 110 \cdot 10^3$$

SIDIS Λ kinematics

Comparison to LEPTO based Monte Carlo
Accepted by the HERMES spectrometer events



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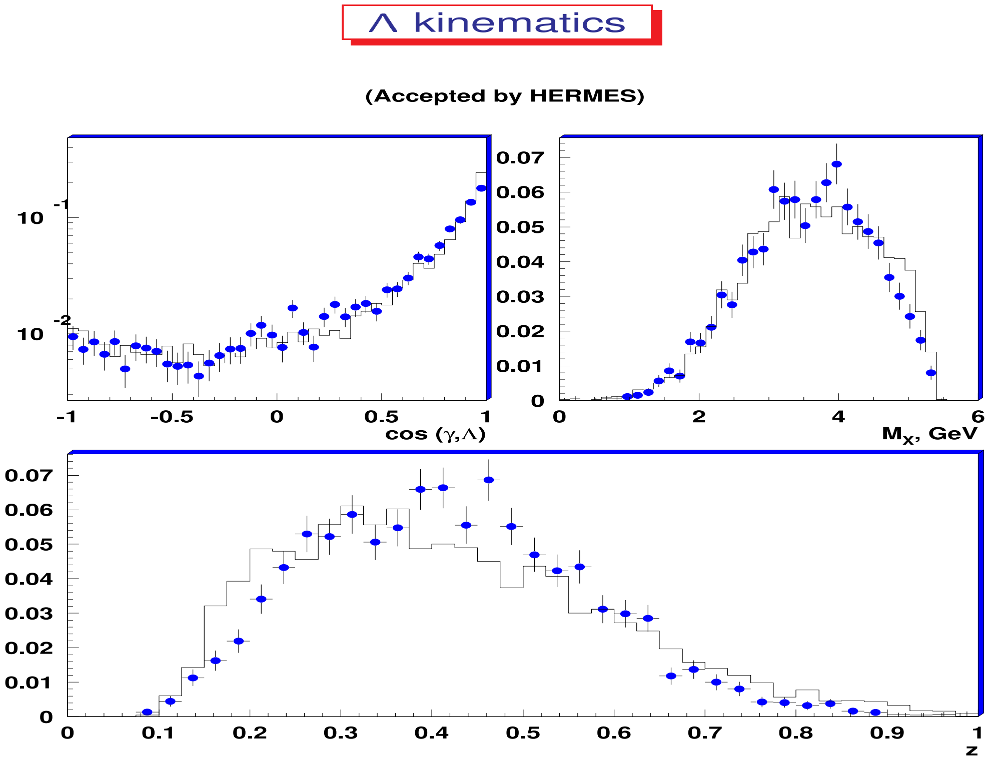

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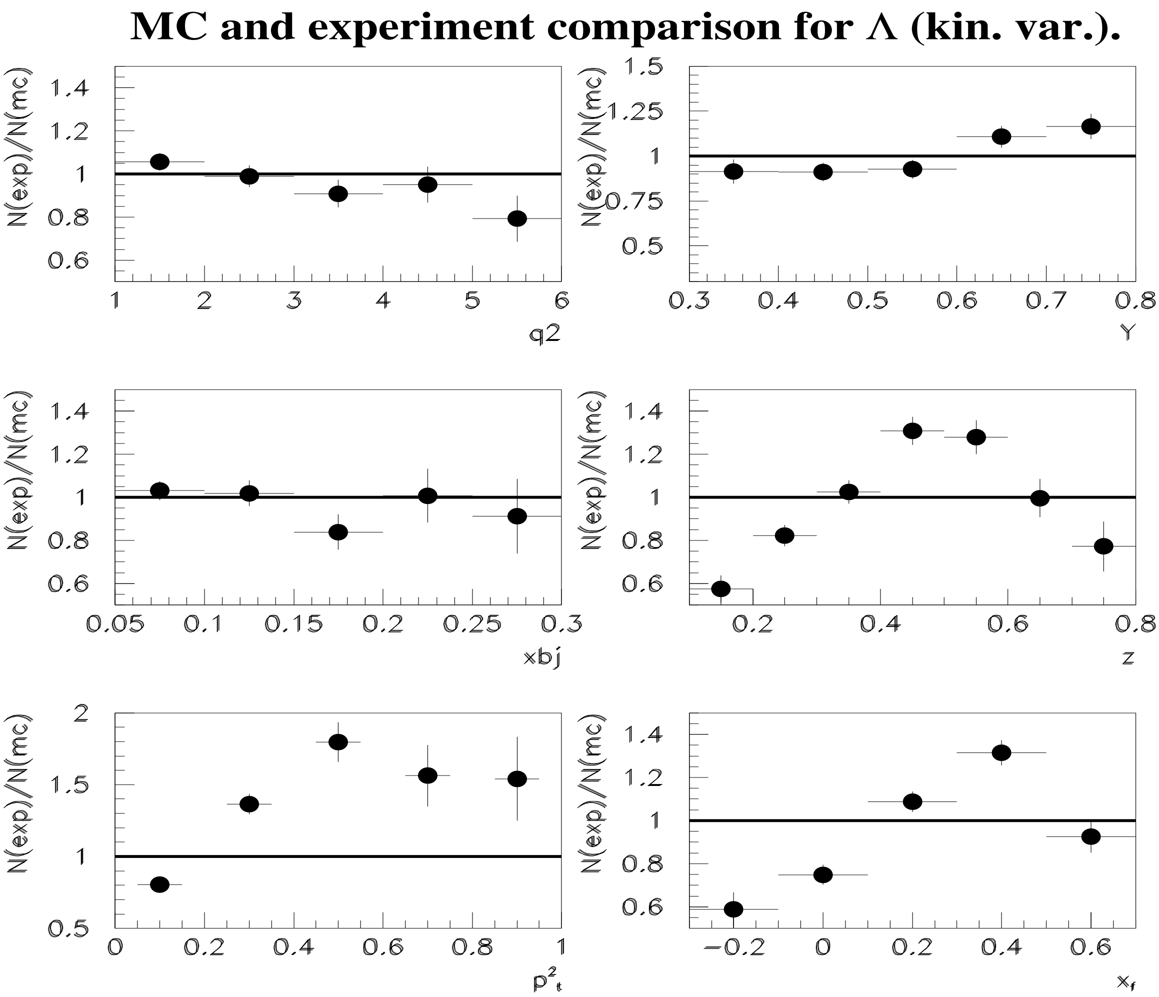
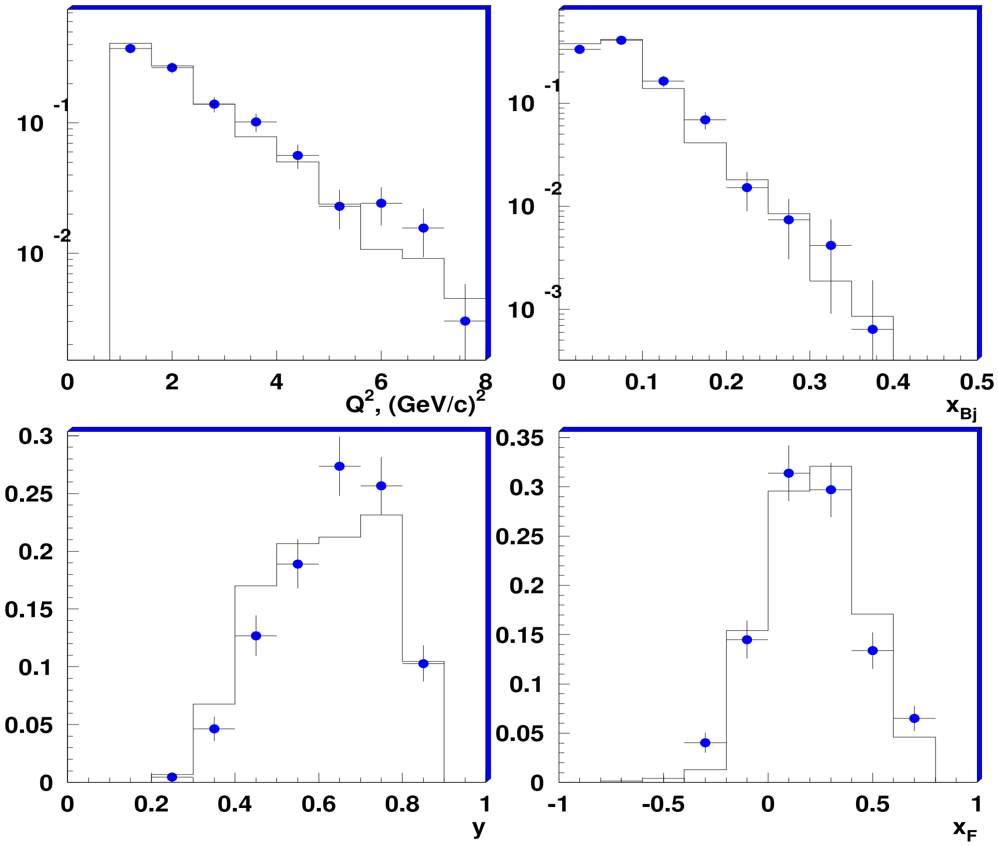


$\bar{\Lambda}$ kinematics

(Accepted by HERMES)



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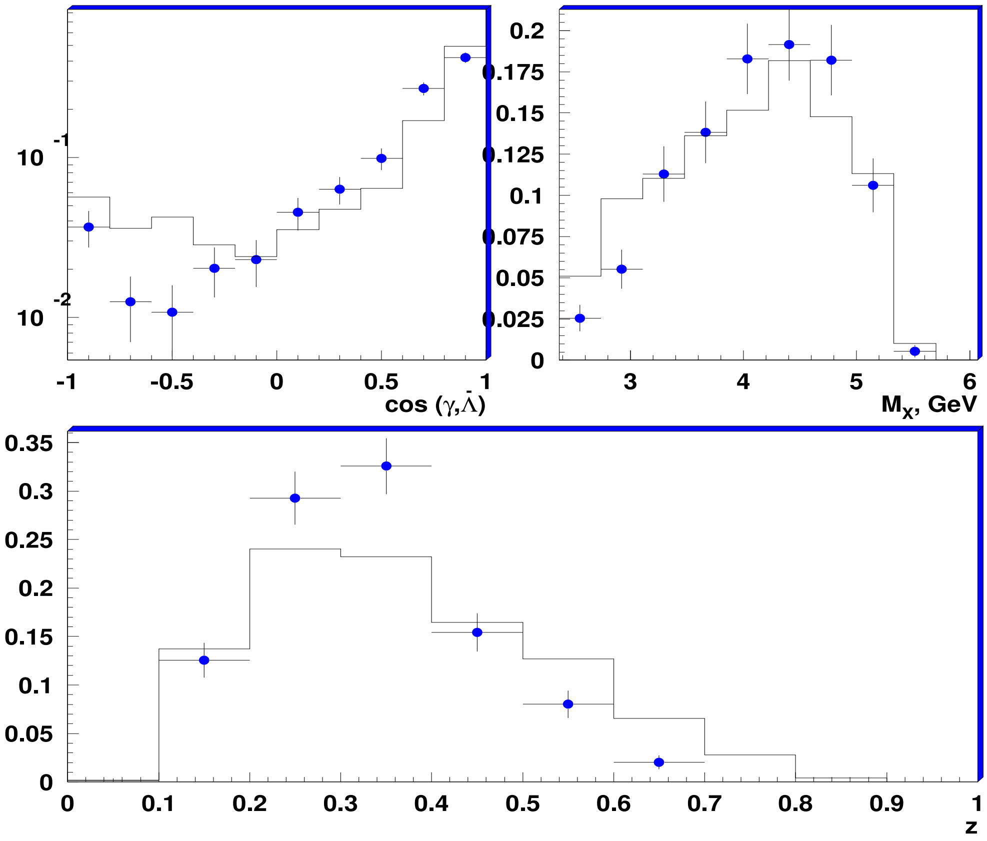
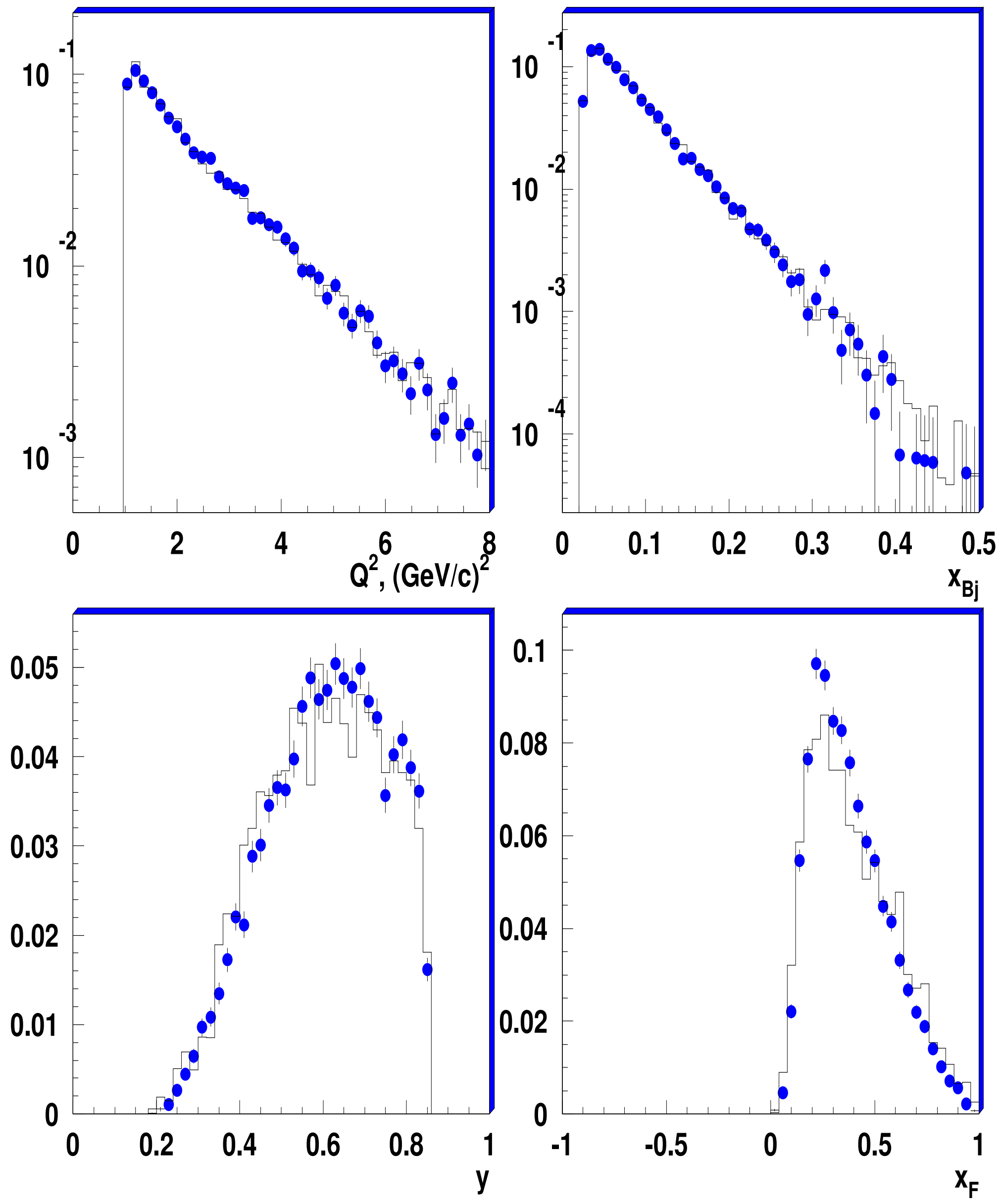


K_s kinematics

(Accepted by HERMES)



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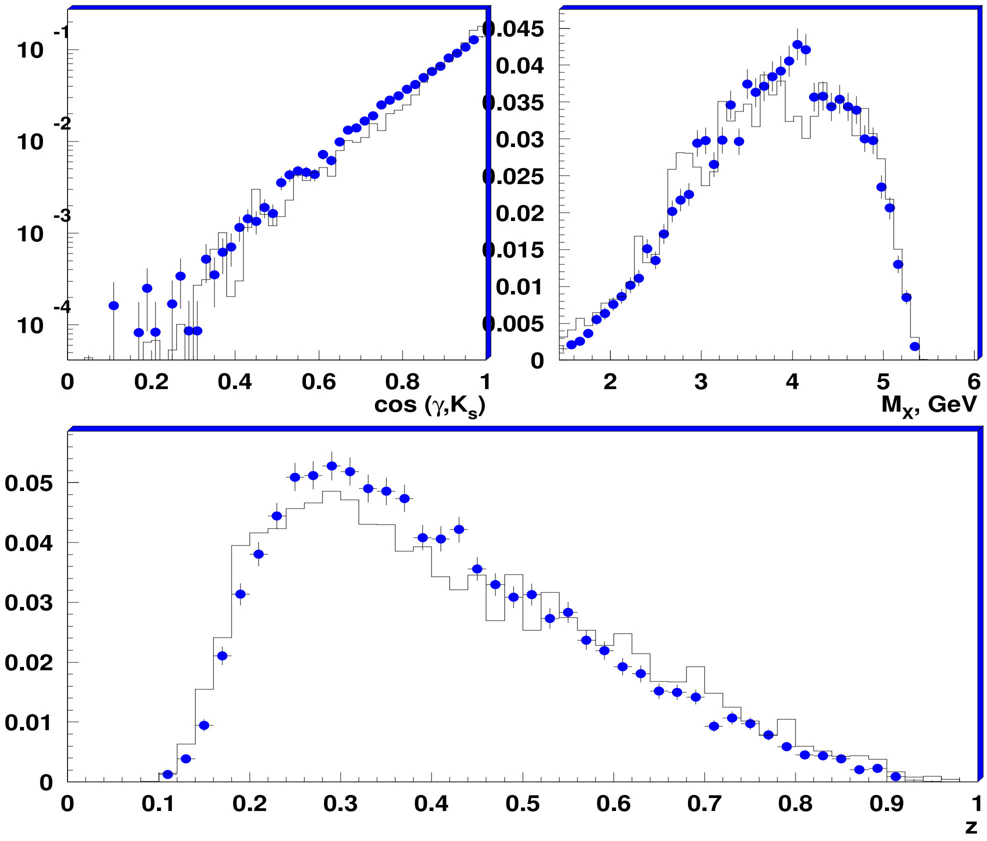
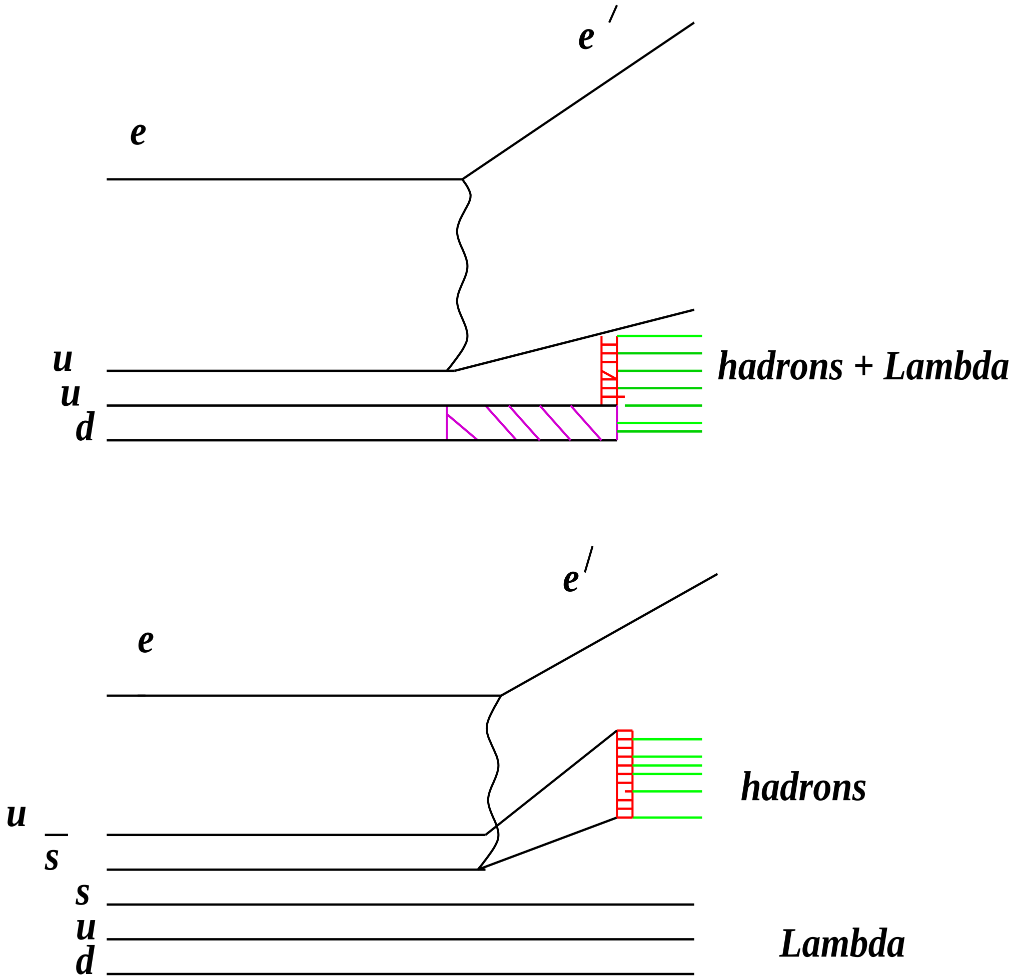


Lambda production mechanisms



Polarization extraction method

Due to up/down mirror symmetry of the HERMES spectrometer ($cos\theta_p^{up} = -cos\theta_p^{down}$) acceptance correction is negligible,and same (as for longitudinal case) formalism has been used. In the range of Λ transverse momenta

$$0 < p_t < 1.7 GeV/c$$

we have obtained preliminary

$$P_{n\Lambda} = (6.6 \pm 1.1 \pm 2.5)\%$$

$$P_{n\bar{\Lambda}} = (-6.6 \pm 3.7 \pm 2.5)\%$$

The systematic error estimation comes from additional study of acceptance function with the help of K_s and h^+h^- pairs. For false polarizations it has been found:

$$K_s(\pi^+\pi^-) \quad P_n = (1.7 \pm 0.8)\% \; P_n = (-1.2 \pm 0.8)\%$$

$$h^+h^- \quad P_n = (-0.7 \pm 1.5)\% \; P_n = (2.5 \pm 1.1)\%$$

Transverse Λ,$\bar{\Lambda}$ polarization

Transverse Λ polarization has been intensively studied in hadron collisions using different beams and targets.

It has been found that Λ's produced by unpolarized hadrons are usually strongly polarized:

$$h_1 + h_2 \Rightarrow \vec{\Lambda} + X$$

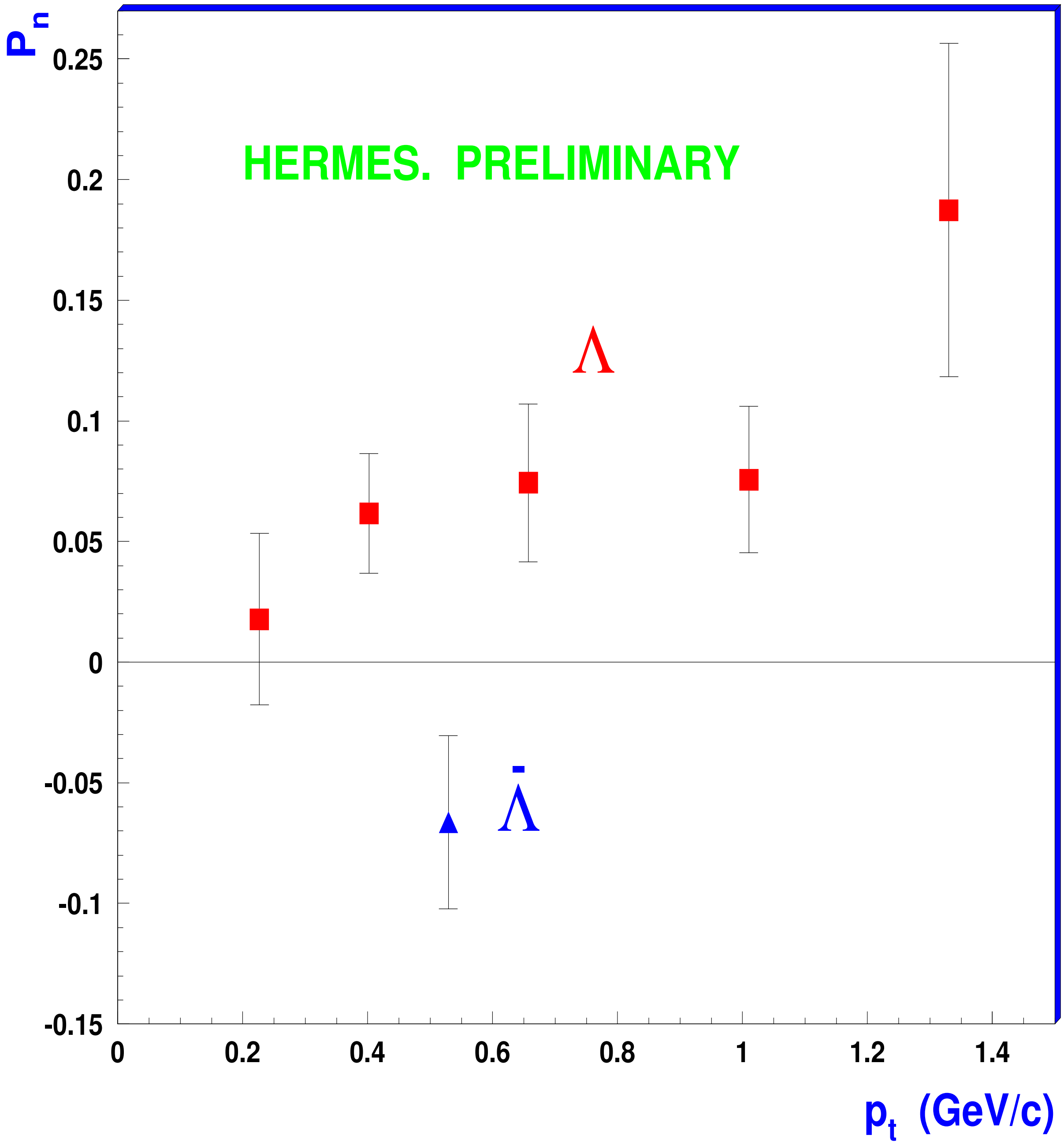
with polarization vector $\vec{P}_{n\Lambda}$ directed along the normal $\vec{n}$ to the Λ production plane:

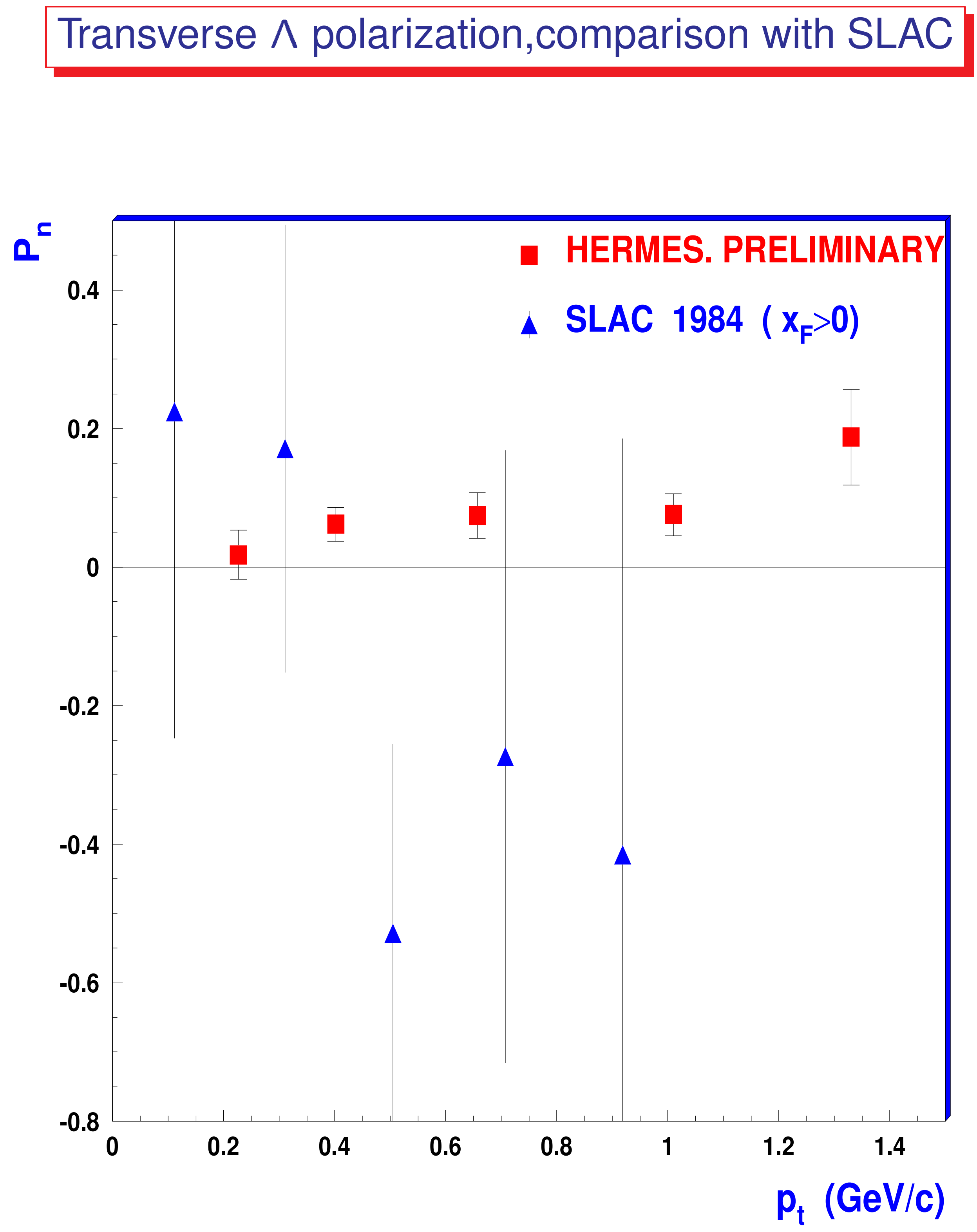
$$\vec{n} \sim [\vec{p}_{beam}, \vec{p}_{\Lambda}] = [\vec{p}_{beam}, \vec{p}_{\Lambda}t].$$

$P_{n\Lambda}$ increases by absolute value with transverse Λ momentum $p_{\Lambda}t$.
At $p_{\Lambda}t > 1$ Gev/c it shows no dependence on $p_{\Lambda}t$.

In case of lepto/photo produced Λ's transverse Λ polarization is poorly studied. There are only few experimental results (CERN,SLAC) available with statistics not sufficient for a solid conclusion.

Transverse Λ and $\bar{\Lambda}$ polarization




Transverse Λ polarization,comparison with SLAC
P_n
HERMES. PRELIMINARY
SLAC 1984 (x_F>0)
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
0.2
0.4
0.6
0.8
1
1.2
1.4
p_t (GeV/c)

Transverse Λ polarization,comparison with CERN