Transverse Polarization of Λ and $\bar{\Lambda}$ produced inclusively in eN scattering at HERMES.

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On behalf of HERMES collaboration

- Introduction
- Event selection
- Extraction of the transverse polarization
- Results
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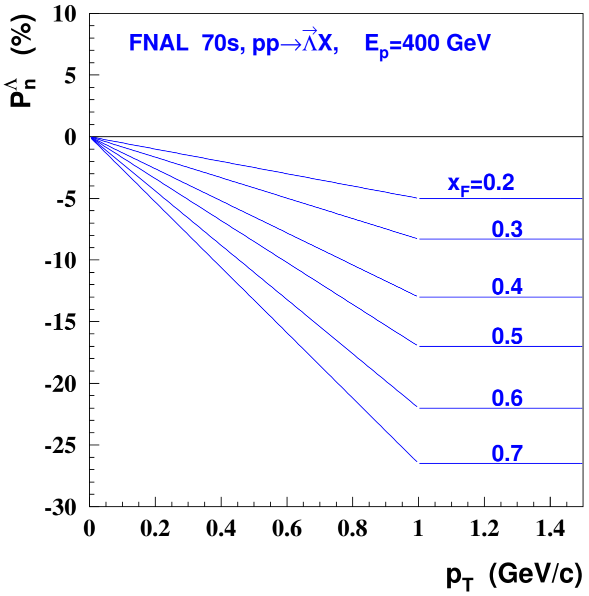
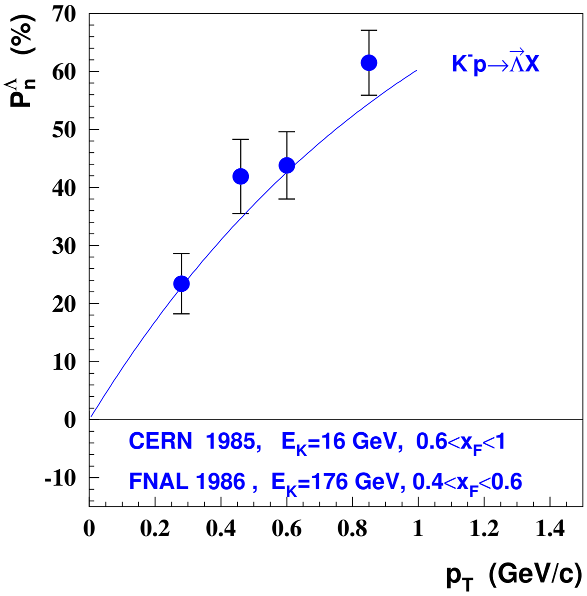
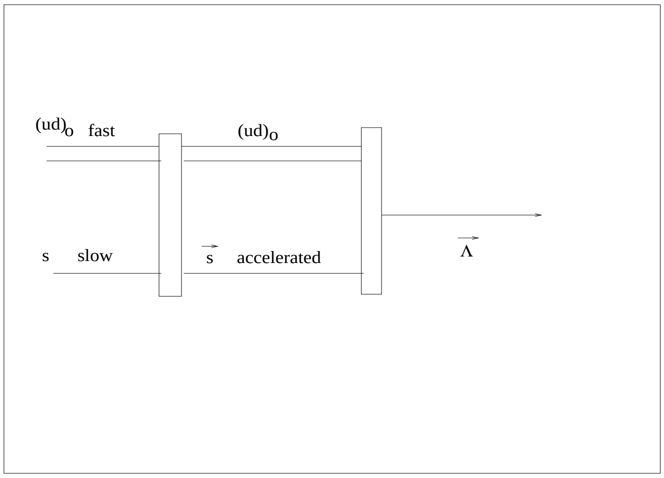
Introduction. $hp \to \vec{\Lambda} X$.

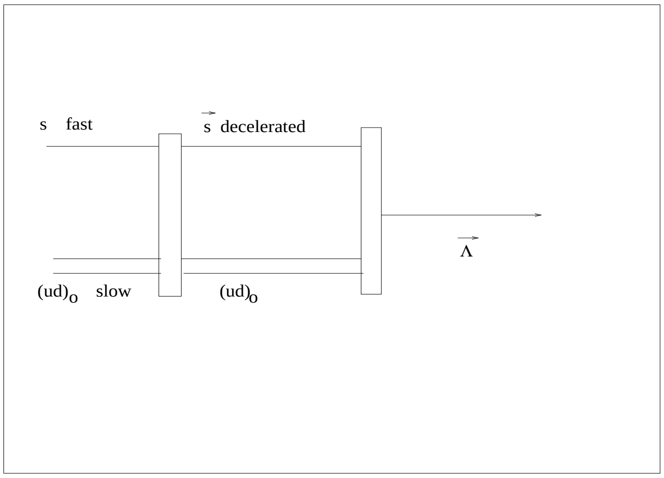
$$\vec{P}^{\Lambda} = P_n^{\Lambda}\vec{n}, \qquad \vec{n} = \frac{\vec{p}_{beam} \times \vec{p}_{\Lambda}}{|\vec{p}_{beam} \times \vec{p}_{\Lambda}|}.$$





DeGrand & Miettinen

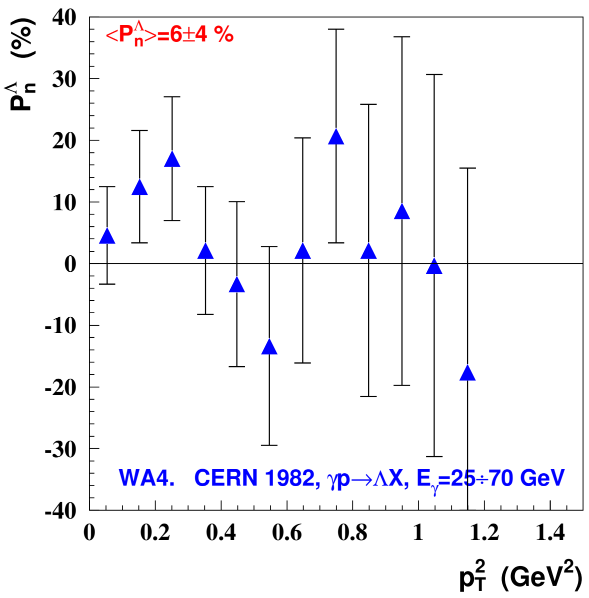


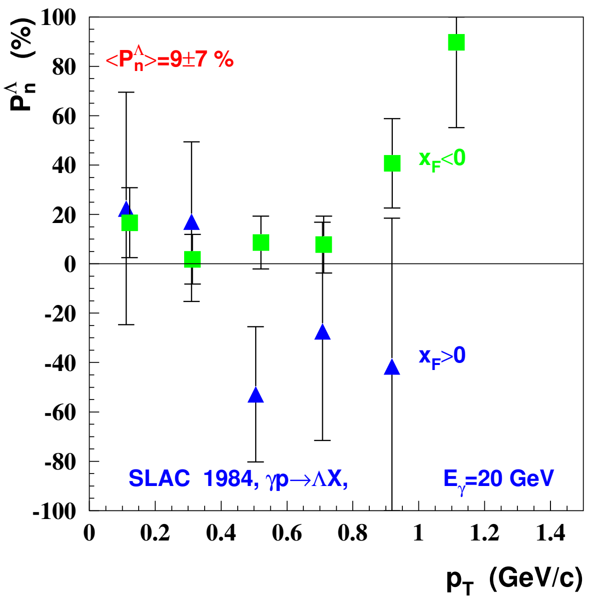


Introduction. $\gamma p \rightarrow \vec{\Lambda} X$.

It is natural to expect non-vanishing polarization also in the Λ photo-production since it is well known that the real photon has the structure : $\gamma \rightarrow q\bar{q}$.

$$\vec{P}^{\Lambda} = P_n^{\Lambda}\vec{n}, \qquad \vec{n} = \frac{\vec{p}_{beam} \times \vec{p}_{\Lambda}}{|\vec{p}_{beam} \times \vec{p}_{\Lambda}|}.$$





Introduction

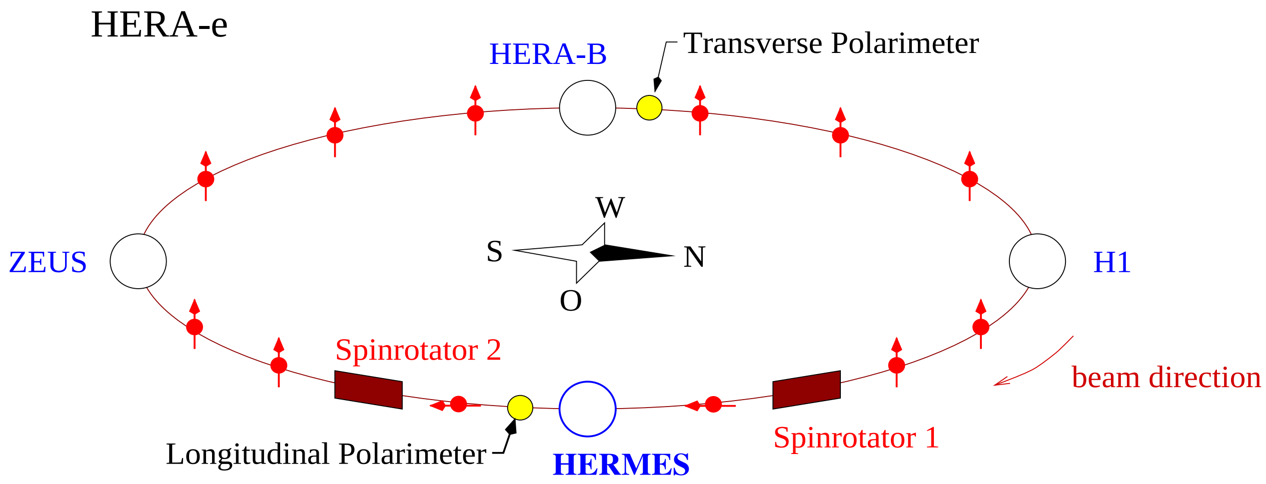
The HERMES experiment offers an opportunity to measure the transverse polarization of Λ and $\bar{\Lambda}$ hyperons produced in SIDIS

$$eN \to e'\vec{\Lambda}X, \qquad eN \to e'\vec{\bar{\Lambda}}X, \qquad Q^2 \gtrsim 0.6$$

and in inclusive reactions

$$\boxed{eN \to \vec{\Lambda}X, \qquad eN \to \vec{\bar{\Lambda}}X, \qquad Q^2 \approx 0\ .}$$

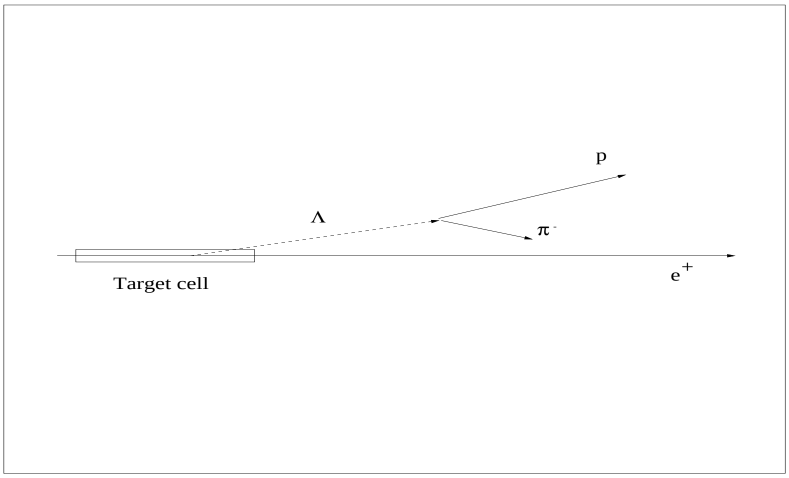
using 27.5 GeV positron beam of HERA collider and the internal gas target with a storage cell.

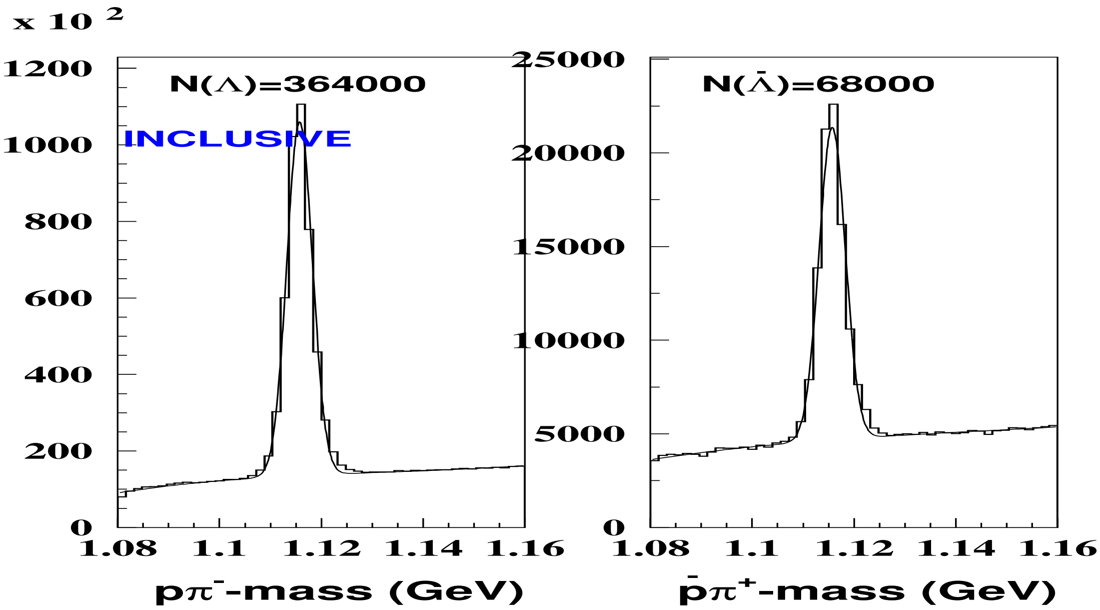


Event selection

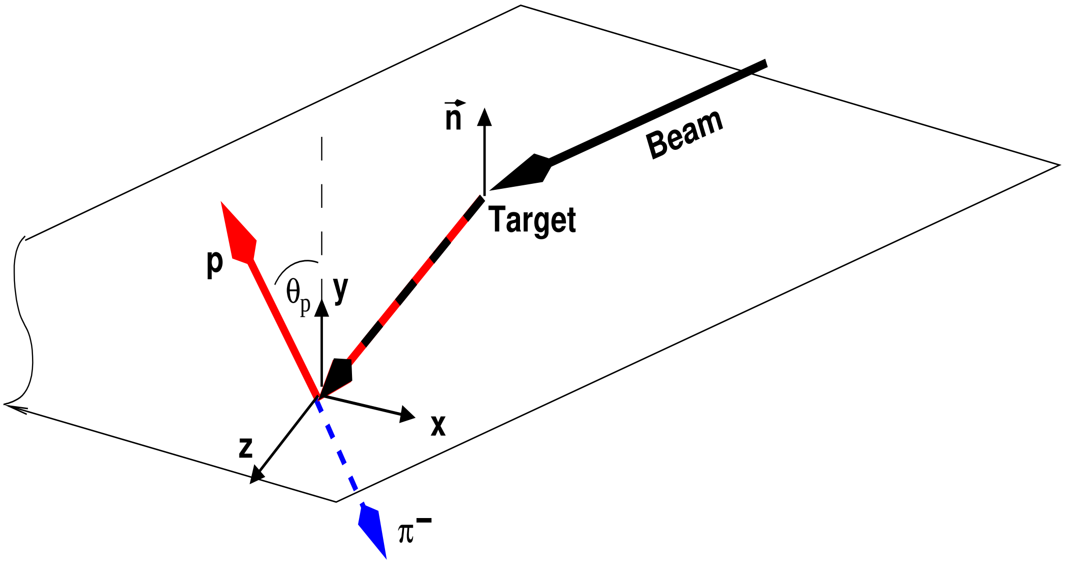
Data collected at HERMES in the years 1996-2000 have been combined in this analysis. The integrated luminosity of the full data sample with positron beam was

$$L \approx 1000 \text{ pb}^{-1}.$$





Extraction of the polarization



4π acceptance :

$$\frac{dN}{d\Omega} \propto 1 + \alpha P_n^{\Lambda} \cos\theta_p \rightarrow P_n^{\Lambda} = \frac{\{cos\theta_p\}}{\alpha\{\cos^2\theta_p\}} = \frac{3\{\cos\theta_p\}}{\alpha}$$

Restricted up/down symmetric acceptance:

$$P_n^{\Lambda} \approx \frac{\{cos\theta_p\}^{top} + \{cos\theta_p\}^{bot}}{2\alpha\{cos^2\theta_p\}}.$$

Decay parameter α is equal to 0.642 for Λ and to -0.642 for $\bar{\Lambda}$ hyperons.

Average Transverse Polarizations

Averaged over the full kinematic range the transverse polarization of Λ and $\bar{\Lambda}$ hyperons was measured to be

$$P_n^{\Lambda} = 5.4 \pm 0.5(\text{stat}) \pm 1.5(\text{syst})\%$$

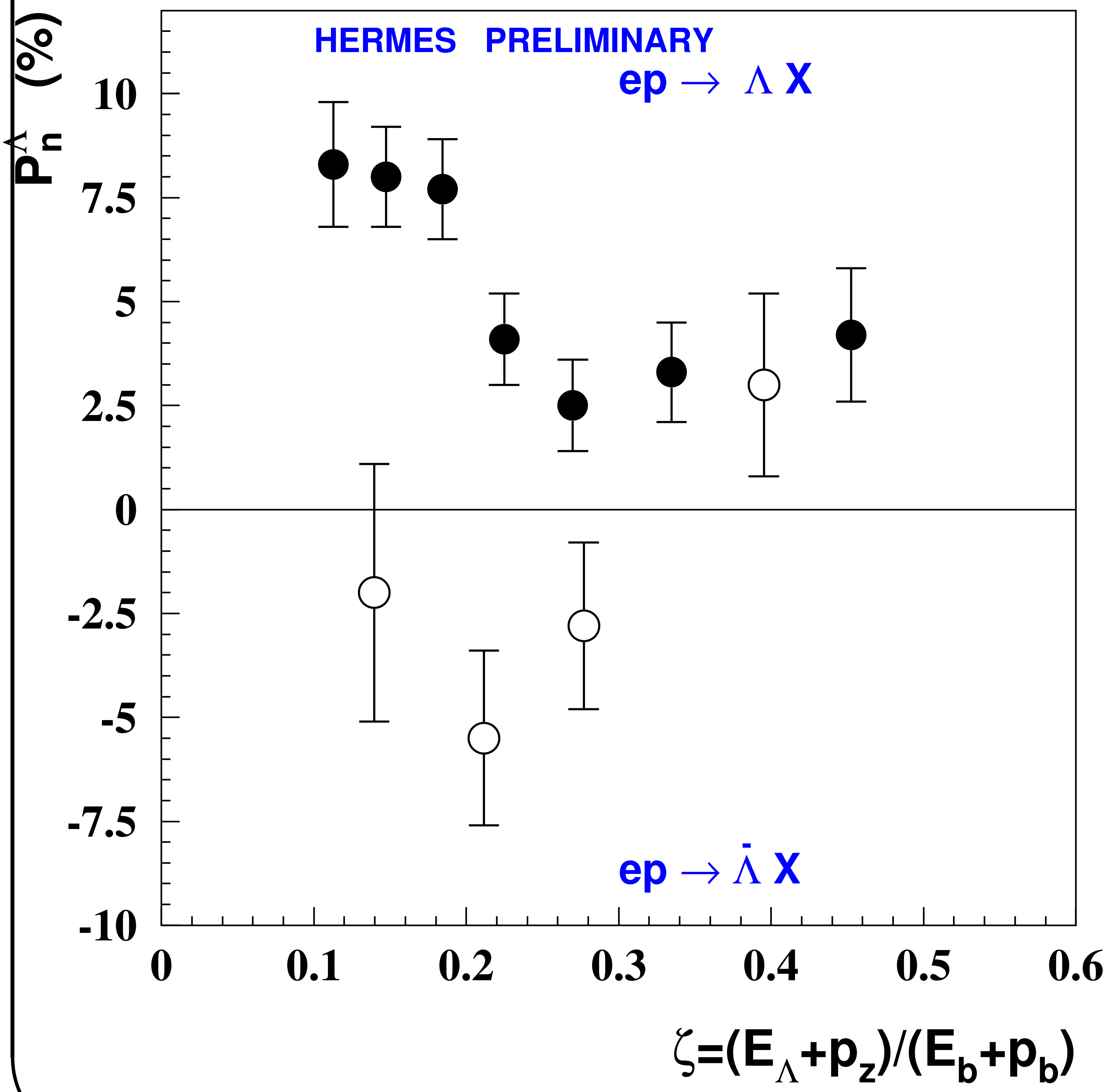
$$P_n^{\bar{\Lambda}} = -4.0 \pm 1.3(\text{stat}) \pm 1.2(\text{syst})\%$$

Systematic uncertainty is estimated using $K_s \to \pi^+\pi^-$ decay and h^+h^- pairs from the target, which do not contain $\Lambda/\bar{\Lambda}$ events.

Statistic allows the dependence of the polarization on the kinematic variables to be studied. But no kinematic variables related to γN system are available
(no intermediate photon tagging !
PYTHIA: $Q^2 \lesssim 0.06$ GeV^2, $\langle \nu \rangle = 16$ GeV) . Hence:

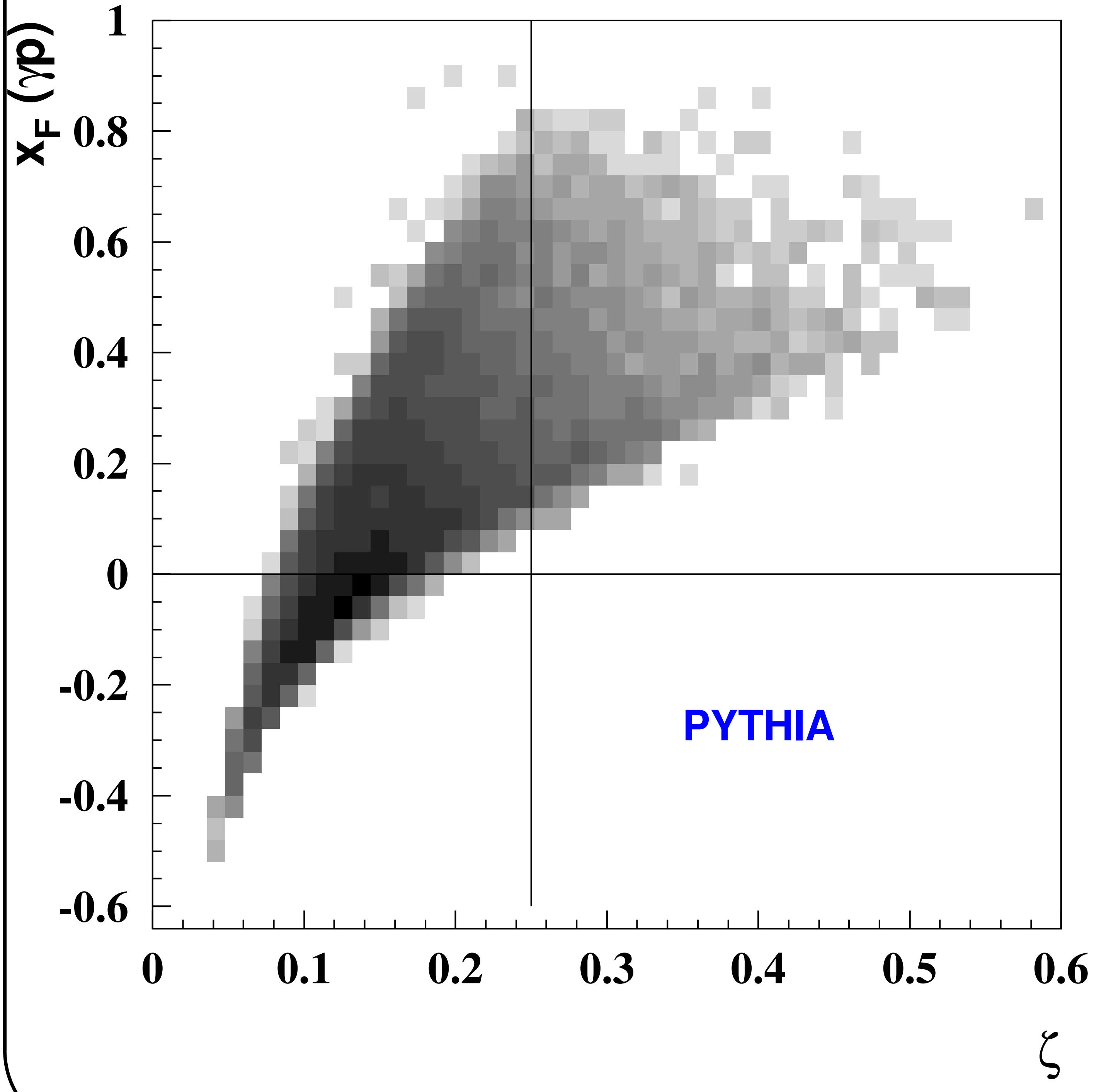
$$\zeta = \frac{E_\Lambda + p_z}{E_b + p_b} \simeq \frac{p_z}{p_b}, \qquad p_T.$$

Results

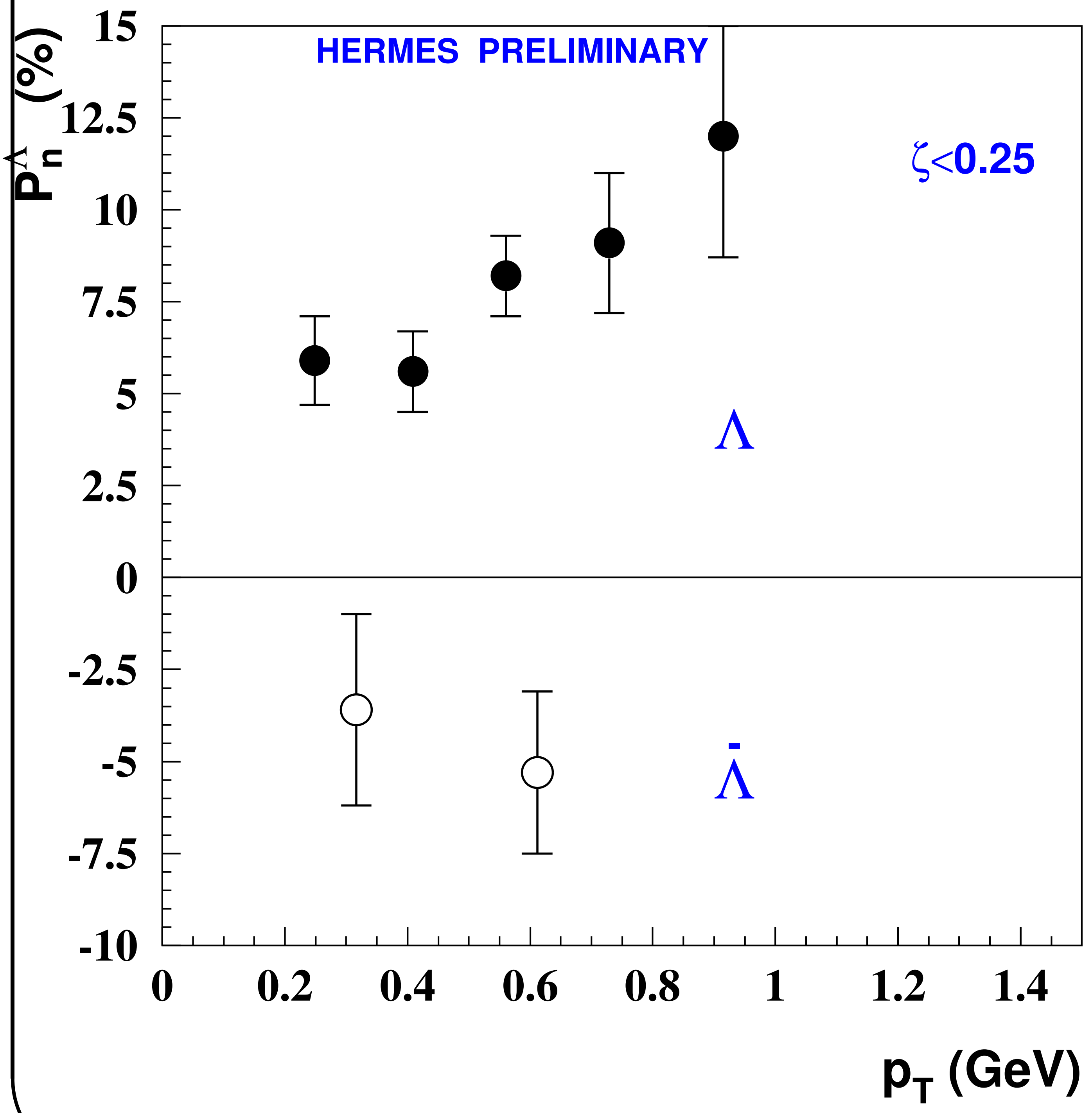


HERMES PRELIMINARY
$ep \to \Lambda X$
$ep \to \bar{\Lambda} X$
P_n^Λ (%)
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
0
0.1
0.2
0.3
0.4
0.5
0.6
$\zeta=(E_\Lambda+p_z)/(E_b+p_b)$

Low and high energy separation

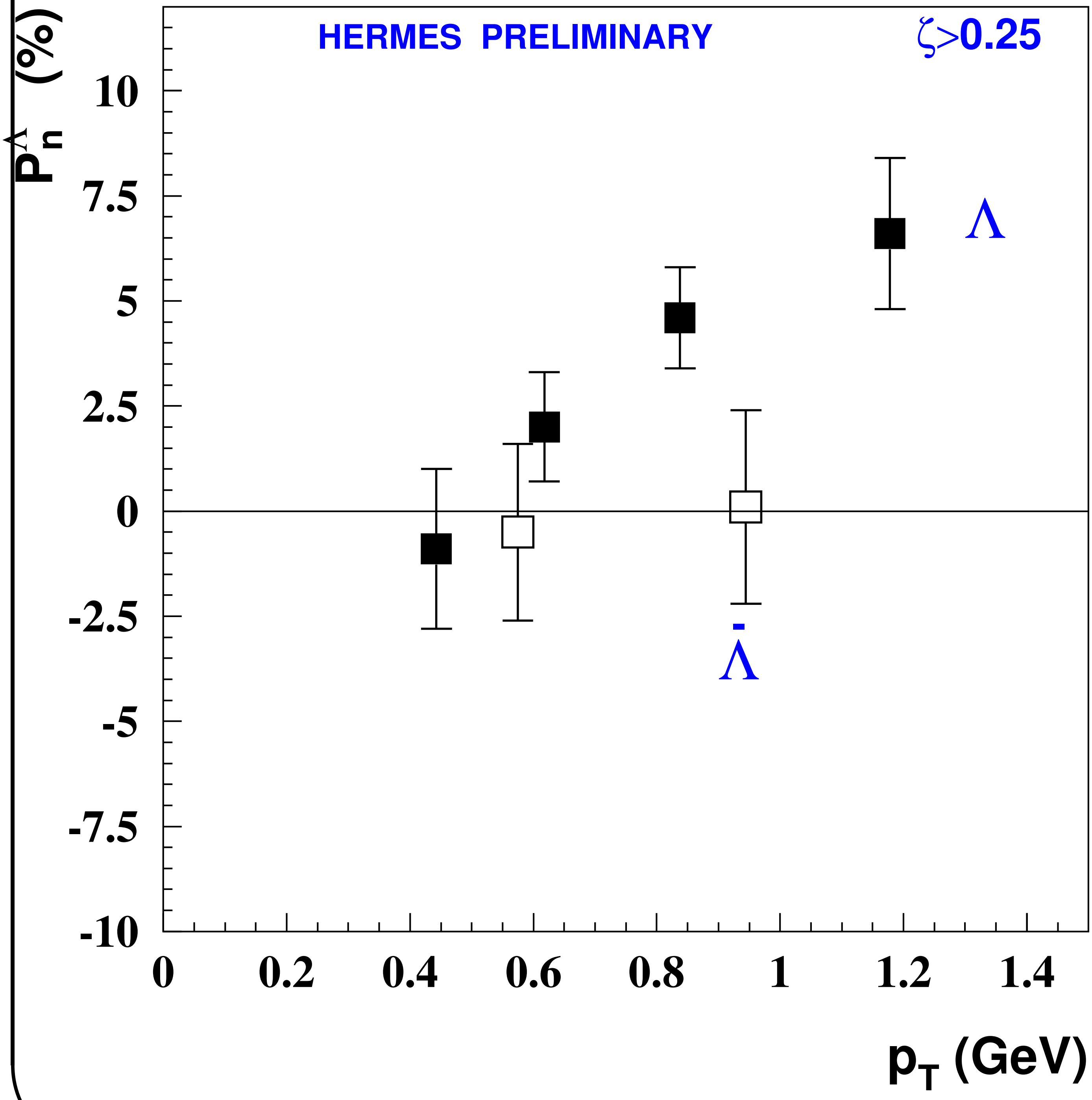


Results



HERMES PRELIMINARY
P_n^Λ (%)
15
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
ζ<0.25
Λ
$\bar{\Lambda}$
0
0.2
0.4
0.6
0.8
1
1.2
1.4
p_T (GeV)

Results


HERMES PRELIMINARY
ζ>0.25
P_n^{Λ} (%)
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
Λ
$\bar{\Lambda}$
0
0.2
0.4
0.6
0.8
1
1.2
1.4
p_T (GeV)

Discussion

Few theoretical models of Λ and $\bar{\Lambda}$ polarization in photo- and electro-production are available for comparison with the data.

Physical photon :

$$|\gamma\rangle = \underbrace{\overbrace{\sqrt{Z_3}|\gamma_B\rangle}^{\text{direct events}} + \overbrace{\frac{e}{f_{q\bar{q}}}|q\bar{q}\rangle}^{\text{anom}}}_{\text{hight } p_T\text{, pQCD+fragm.}} + \underbrace{\overbrace{\sum_{\rho^0,\omega,\phi}\frac{e}{f_V}|V\rangle}^{\text{VMD}}}_{\text{low } p_T\text{, QRM}}$$

Since the VMD part corresponds to about 80 % of the total γp cross section one might assume that substantial part of the Λ and $\bar{\Lambda}$ hyperons is produced in the interaction of the target with the ρ^0, ω and ϕ mesons.

In particular the Λ transverse polarization measured at some kinematic in HERMES is likely to be related to the one measured in the reactions:

$$K^{\pm} + p \rightarrow \Lambda + X,$$

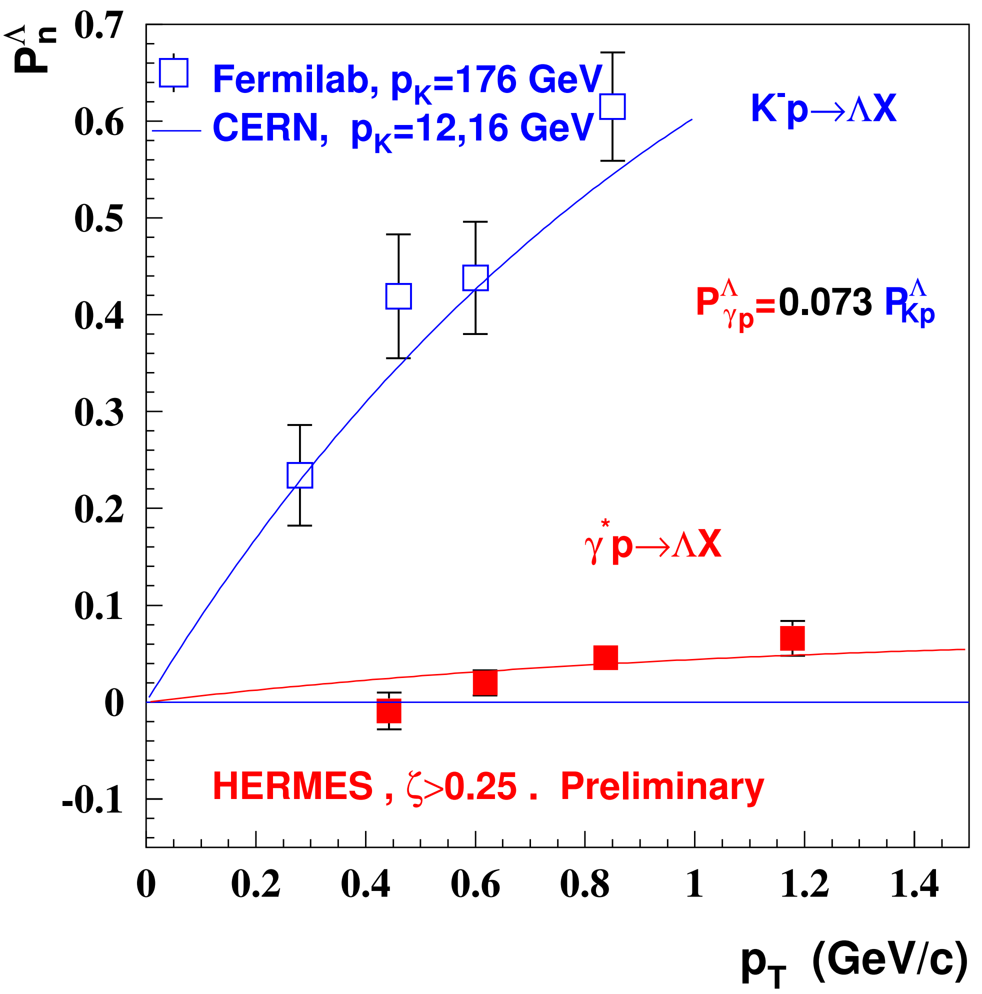
$$\pi^{\pm} + p \rightarrow \Lambda + X.$$

Discussion

Among these reactions only the Λ production in K^- fragmentation sees a clear positive polarization;

$$P_{\gamma^* p} = \alpha P_{\pi^+ p} + \beta P_{\pi^- p} + \gamma P_{K^+ p} + \epsilon P_{K^- p} \approx \epsilon P_{K^- p}$$

$$\epsilon = 0.073$$



Quark Recombination Model

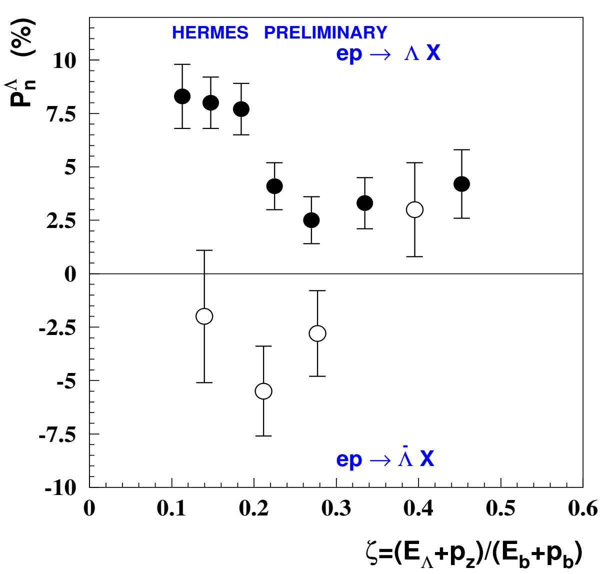
Assumption: the initial s and $\bar{s}$ quarks from the beam due to the $\gamma \to \phi \to K^+K^-$ or the direct $\gamma \to s\bar{s}$ fluctuation acquires polarization in the recombination process:

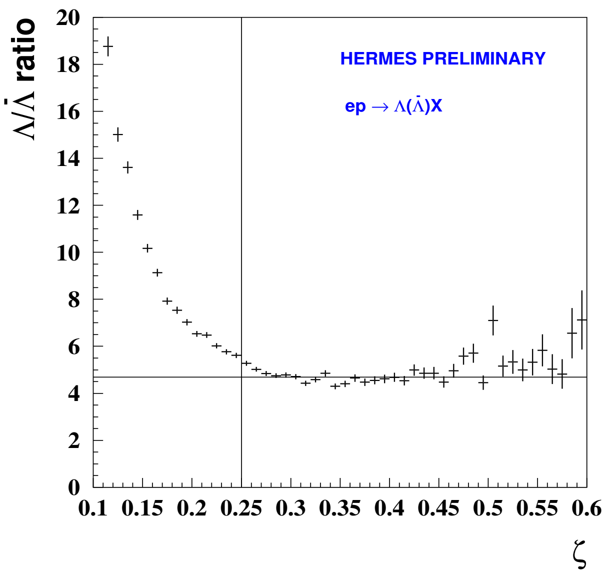
$$s + (ud)_0 \to \vec{s} + (ud)_0 \to \vec{\Lambda},$$
$$\bar{s} + (\bar{u}\bar{d})_0 \to \vec{\bar{s}} + (\bar{u}\bar{d})_0 \to \vec{\bar{\Lambda}}.$$

QRM model predicts the conjugate relation $P(h \to \Lambda) = P(\bar{h} \to \bar{\Lambda})$, which has been confirmed experimentally, and hence one might expect the approximate equation

$$P(\gamma \to \Lambda) \approx P(\gamma \to \bar{\Lambda}),$$

which looks like to be confirmed by HERMES at $\zeta > 0.3$





Summary

- The results presented here, a first measurement of non-zero transverse polarization in $eN \to \vec{\Lambda} X$ and $eN \to \vec{\bar{\Lambda}} X$ reactions at $Q^2 \approx 0$, adds an interesting new piece to the long-standing mystery of hyperon polarization at high energies.
- The transverse polarization of inclusively produced Λ and $\bar{\Lambda}$ hyperons has been measured to be
  $P_n^{\Lambda} = 5.4 \pm 0.5(\text{stat}) \pm 1.5(\text{syst})\%$ and
  $P_n^{\bar{\Lambda}} = -4.0 \pm 1.3(\text{stat}) \pm 1.2(\text{syst})\%$.
- The difference in Λ and $\bar{\Lambda}$ polarizations appears to arise principally from the data in the "backward-production" region $\zeta = \frac{E_\Lambda + p_z}{E_b + p_b} < 0.3$ with the complex and poorly understood mechanism of the target fragmentation.
- In contrast, in the "forward" direction ($\zeta > 0.3$) the Λ and $\bar{\Lambda}$ polarizations are rather close. In this region the data support qualitatively the expectation of Vector Meson Dominance picture, in which the quasi-real photon beam provides a source of s and $\bar{s}$ quarks on an equal footing, which enter then as valence quarks into the Λ and $\bar{\Lambda}$ hyperons.