Measurement of Transverse Lambda Polarization in quasi-real photoproduction at HERMES

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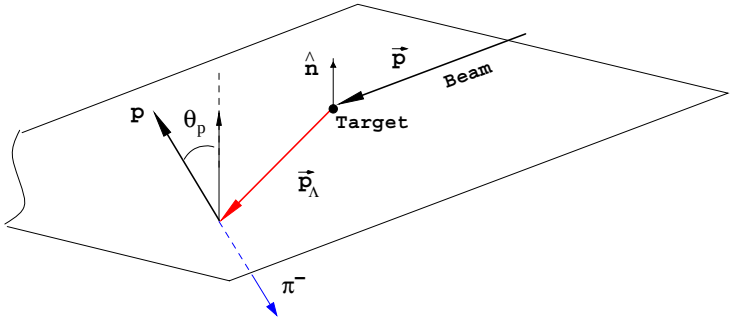
On behalf of the HERMES collaboration

Introduction

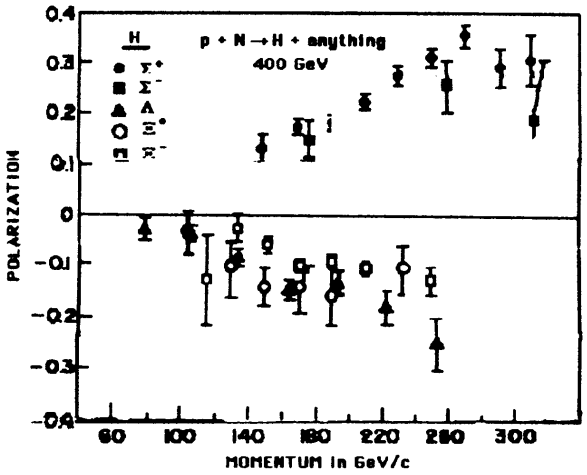
World data shows that Λ is polarized perpendicular to the reaction plane even when neither beam nor target is polarized $\Rightarrow$ spontaneous polarization

$$\overrightarrow{P_\Lambda} = P_\Lambda \cdot \vec{n}, \quad \vec{n} = \frac{\vec{p}_e \times \vec{p}_\Lambda}{|\vec{p}_e \times \vec{p}_\Lambda|}$$

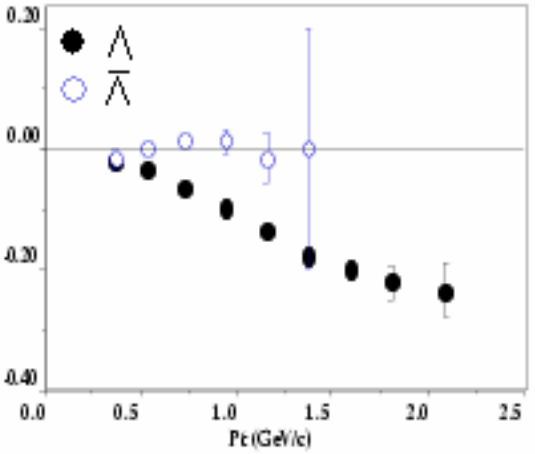


In hadron-hadron collisions Λ has a large polarization

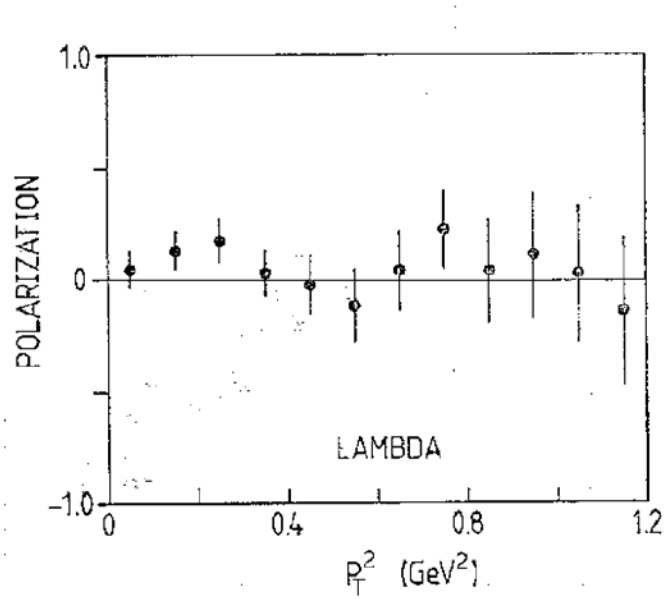
$p + N \to Y\uparrow + X$



$p + Be \to \Lambda(\overline{\Lambda}) + X$, *FNAL E440*



In lepto/photoproduction (SLAC, CERN) Λ polarization suffer from lack of statistics

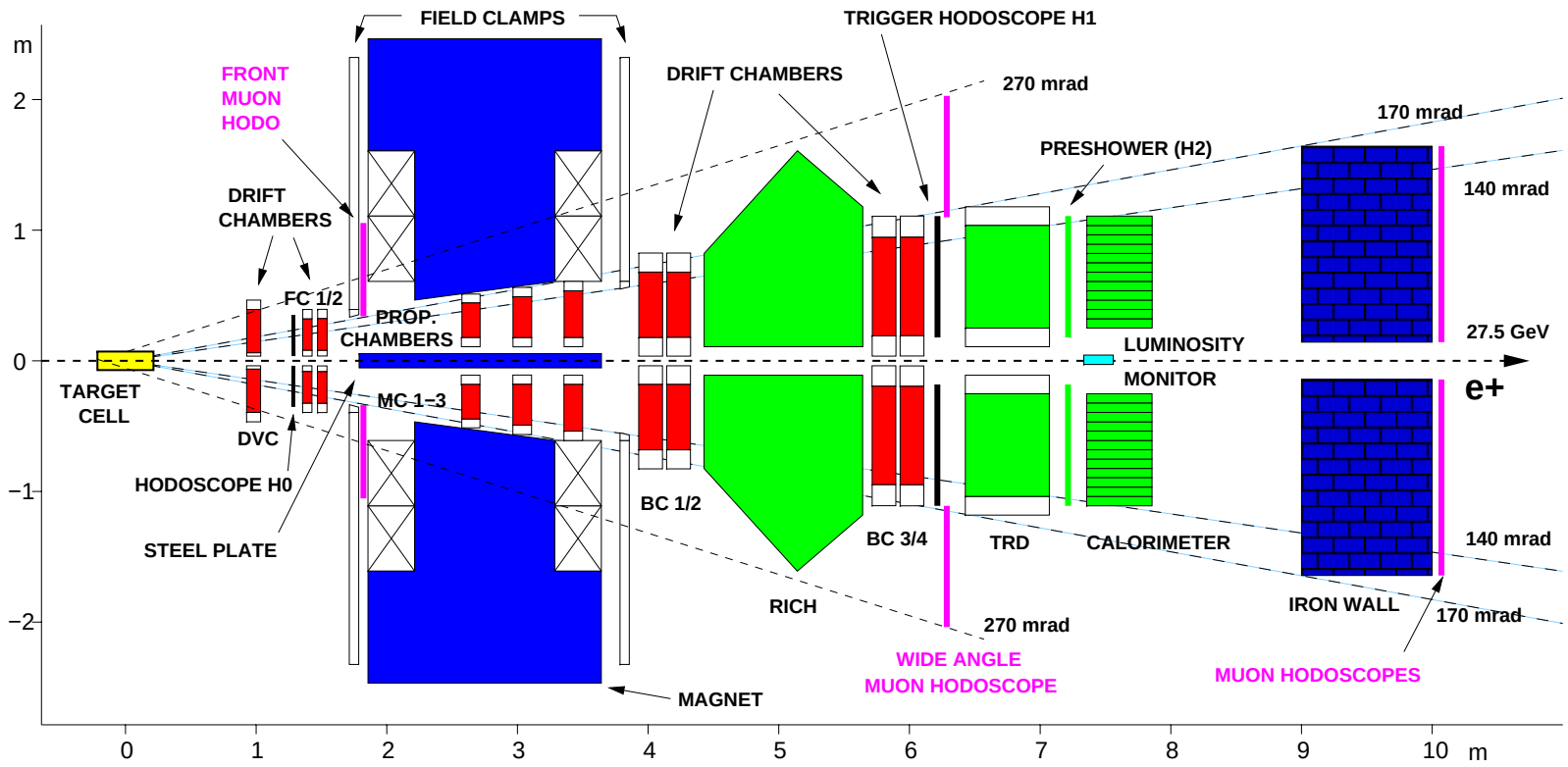


$$CERN,\ \gamma p \to \Lambda X,$$
$$E_\gamma = 25 - 70\ GeV$$

HERMES gives a good opportunity to study transverse Λ polarization. When lepton is not detected most of the events are in the region of the quasi-real photo-production $(Q^2 \approx 0)$

$$E_e = 27.57\,GeV, \qquad \langle \nu \rangle \approx 15.6\,GeV$$

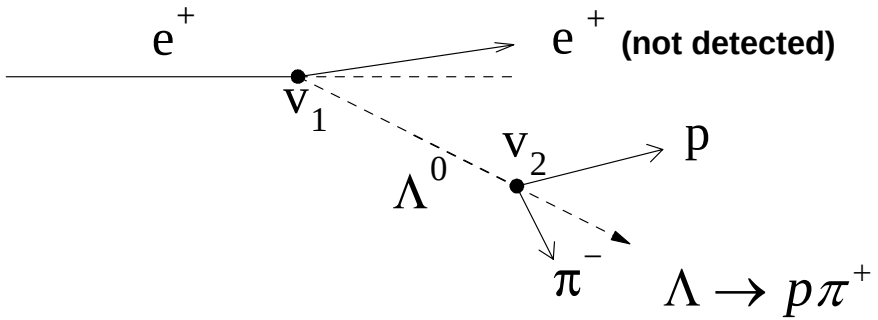
Experiment HERMES



polarized positron beam E_e = 27.5 GeV,
polarized and unpolarized internal gas targets H, D, He, Ne, N, Kr
GOOD RICH PID for hadron separation*: π / K / p*
detector is up/down symmetric

Reconstruction of Λ events

Quasi-real photoproduction, $\langle Q^2 \rangle < 0.05\ GeV^2$ ***for 80% of the events***



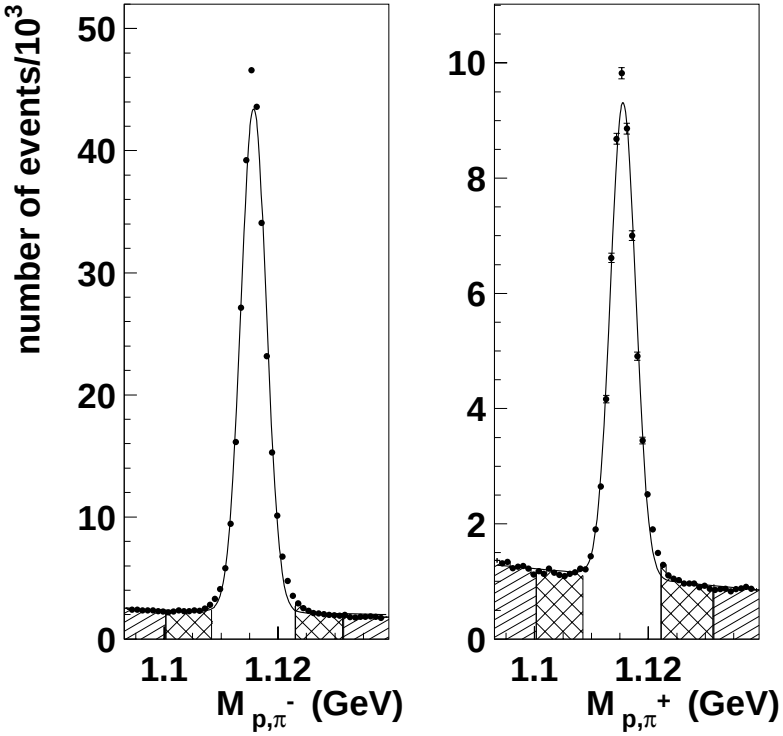
***Background suppression cuts*:**

Threshold Cherenkov det. **1996-1997**

Ring imaging Cherenkov det. **1999-2000**

$z_2 - z_1 > 15\,cm$ *for* Λ

$z_2 - z_1 > 20\,cm$ *for* $\overline{\Lambda}$



$N(\Lambda) = 259 \cdot 10^3,\ N(\overline{\Lambda}) = 51 \cdot 10^3$

$L = 852\,pb^{-1}$ ***(H, D, He, Ne, N, Kr)***

Transverse Λ polarization

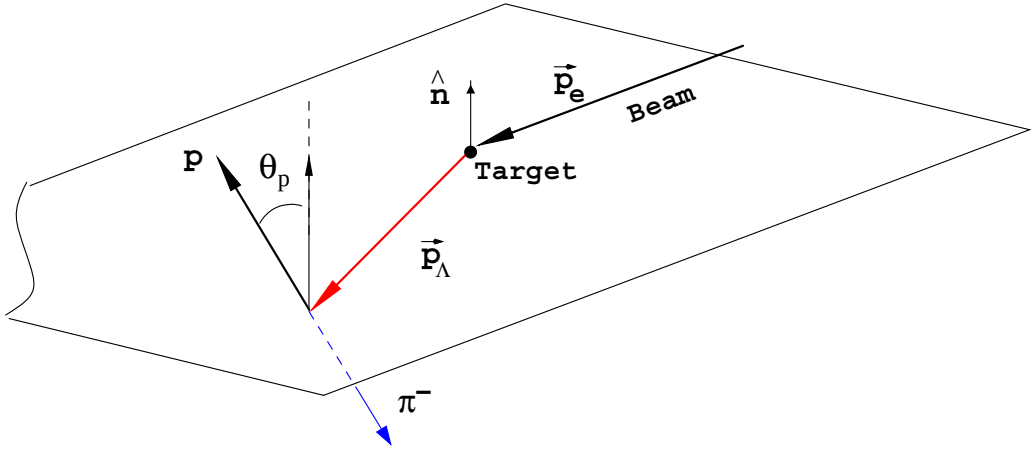
$$\Lambda \rightarrow p\pi^{+}$$

Polarized Λ decay
Λ rest frame

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

$\alpha = 0.642$ for Λ $\quad$ $\alpha = -0.642$ for $\overline{\Lambda}$

$$\overrightarrow{P_\Lambda} = P_\Lambda \cdot \vec{n}, \quad \vec{n} = \frac{\vec{p}_e \times \vec{p}_\Lambda}{\left|\vec{p}_e \times \vec{p}_\Lambda\right|}$$



Extraction of the polarization

The scheme of the polarization extraction is based on the moment method
acceptance is limited $\Rightarrow$ we should correct for that

$$\langle \cos\theta_p \rangle = \frac{\langle \cos\theta_p \rangle_0 + \alpha P_n^{\Lambda} \langle \cos^2\theta_p \rangle_0}{1 + \alpha P_n^{\Lambda} \langle \cos\theta_p \rangle_0}$$

where:

$$\langle \cos^n\theta_p \rangle = \frac{1}{N_\Lambda} \sum_{i=1}^{N_\Lambda} \cos^n\theta_{p,i}$$

in the case of up / down symmetry

$\Downarrow$

$$\alpha P_n^{\Lambda} = \frac{c_+ / \langle \cos^2\theta_p \rangle}{1 - \langle \cos\theta_p \rangle_0^{top} c_- / \langle \cos^2\theta_p \rangle}$$

$\Rightarrow$

$$P_n^{\Lambda} \approx \frac{\langle \cos\theta_p \rangle}{\alpha \langle \cos^2\theta_p \rangle}$$

$$\langle \cos\theta_p \rangle_0^{top} = \frac{c_-}{1 - c_+ \alpha P_n^{\Lambda}}$$

where:

$$c_+ = \langle \cos\theta_p \rangle^{top} + \langle \cos\theta_p \rangle^{bot} \qquad c_- = \langle \cos\theta_p \rangle^{top} - \langle \cos\theta_p \rangle^{bot}$$

Results averaged over the kinematics

$$\langle p_T \rangle = 0.625\,GeV$$

$$\langle \nu \rangle = 15.6\,GeV\ (Monte-Carlo)$$

For Λ

$$P_{\Lambda} = 0.078 \pm 0.006(stat) \pm 0.012(syst)$$

Positive and statistically significant

For $\overline{\Lambda}$

$$P_{\overline{\Lambda}} = -0.025 \pm 0.015(stat) \pm 0.018(syst)$$

consistent with zero

Systematic error determination: false polarization is studied using h^+h^- pairs and K_s data sample

Λ *case* $(leading\ \pi^+, h^+)$

$$P_{K_s} = 0.012 \pm 0.004$$

$$P_{h^+h^-} = 0.012 \pm 0.002$$

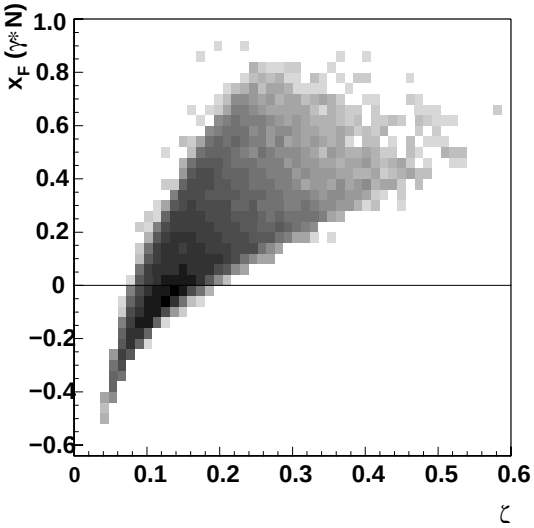
$\overline{\Lambda}$ *case* $(leading\ \pi^-, h^-)$

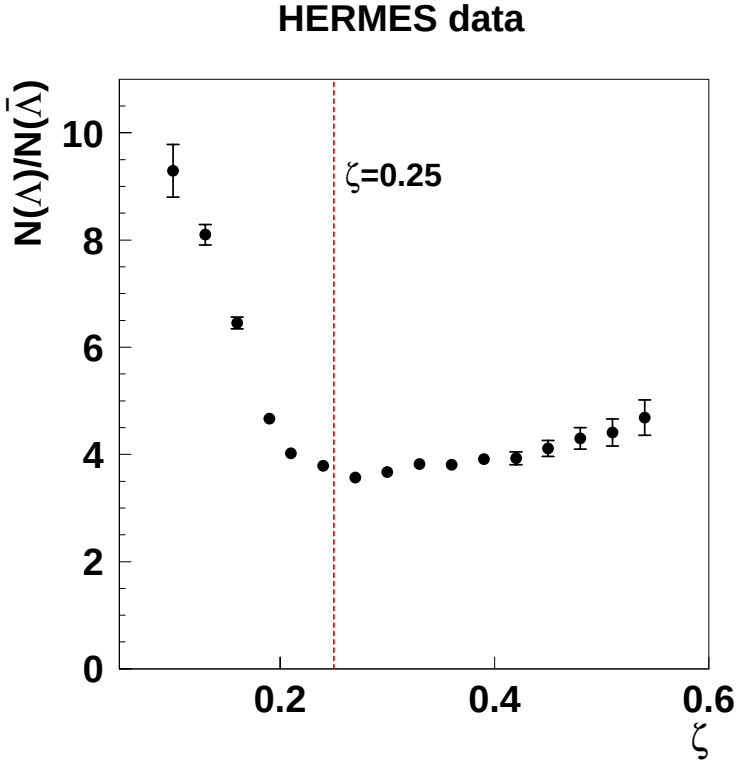
$$P_{K_s} = 0.002 \pm 0.004$$

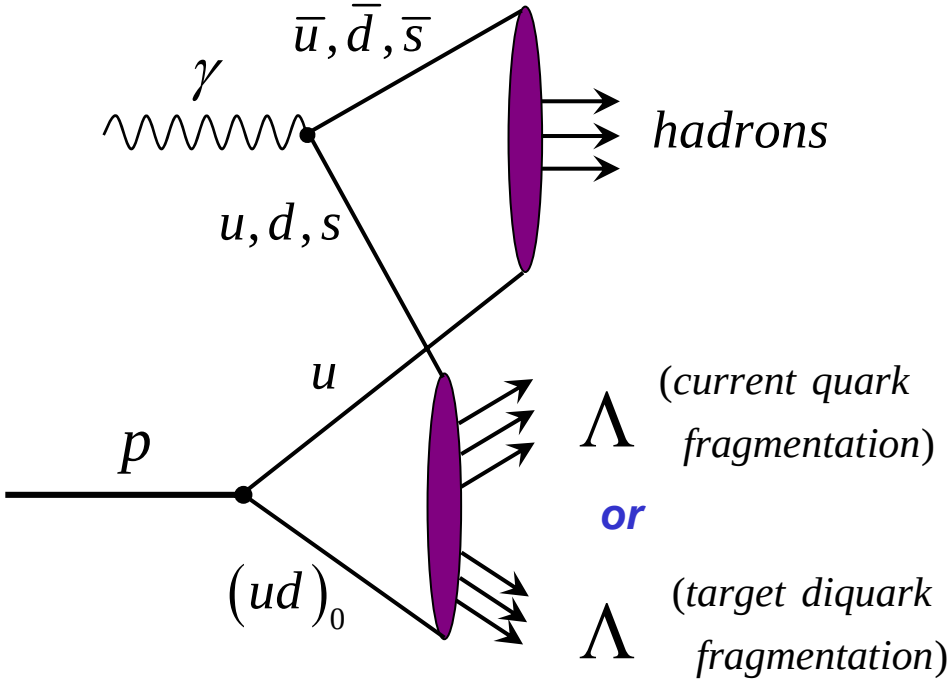
$$P_{h^+h^-} = 0.018 \pm 0.002$$

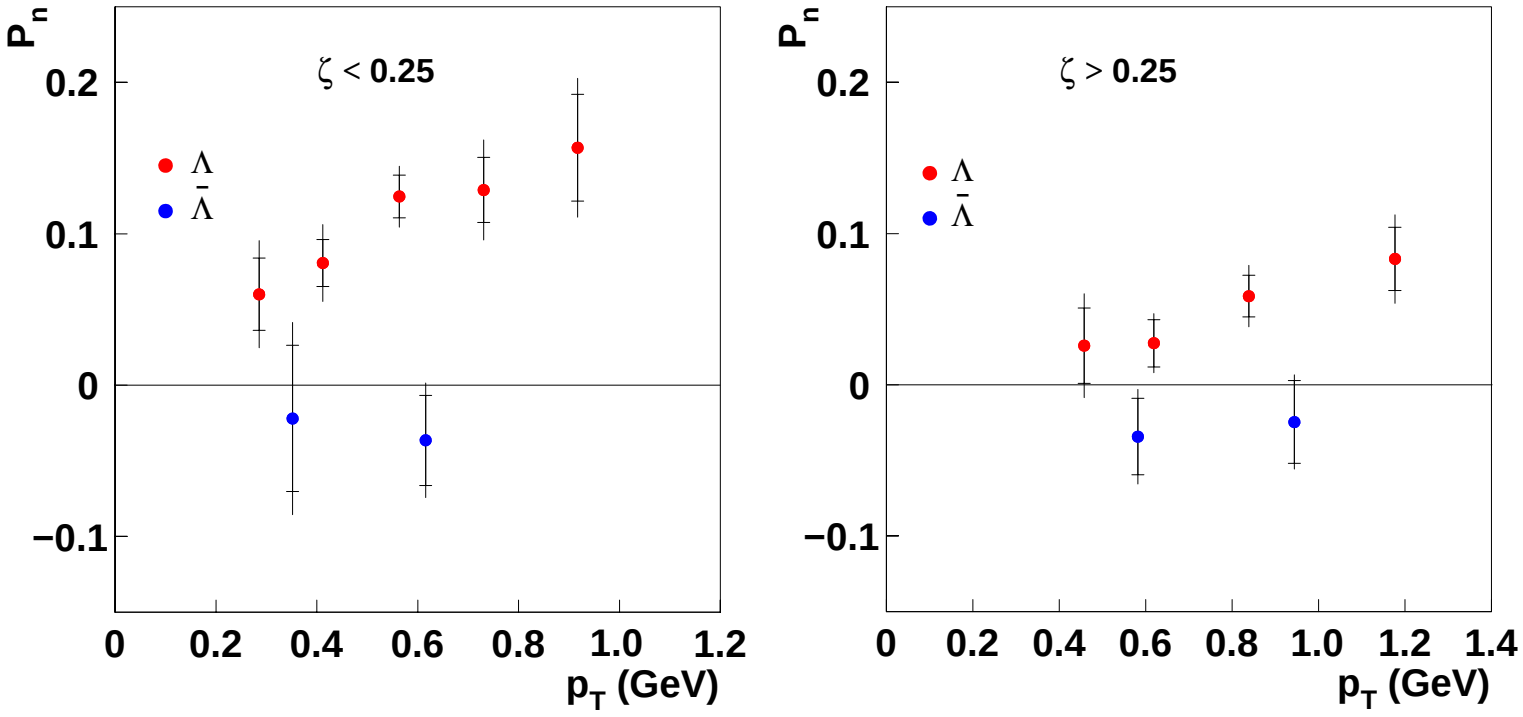
Kinematic regimes

$$x_F = \frac{p_{\parallel}}{p_{\parallel \max}} \Rightarrow \zeta = \frac{E_\Lambda + p_{\Lambda,z}}{E_e + p_{e,z}}$$



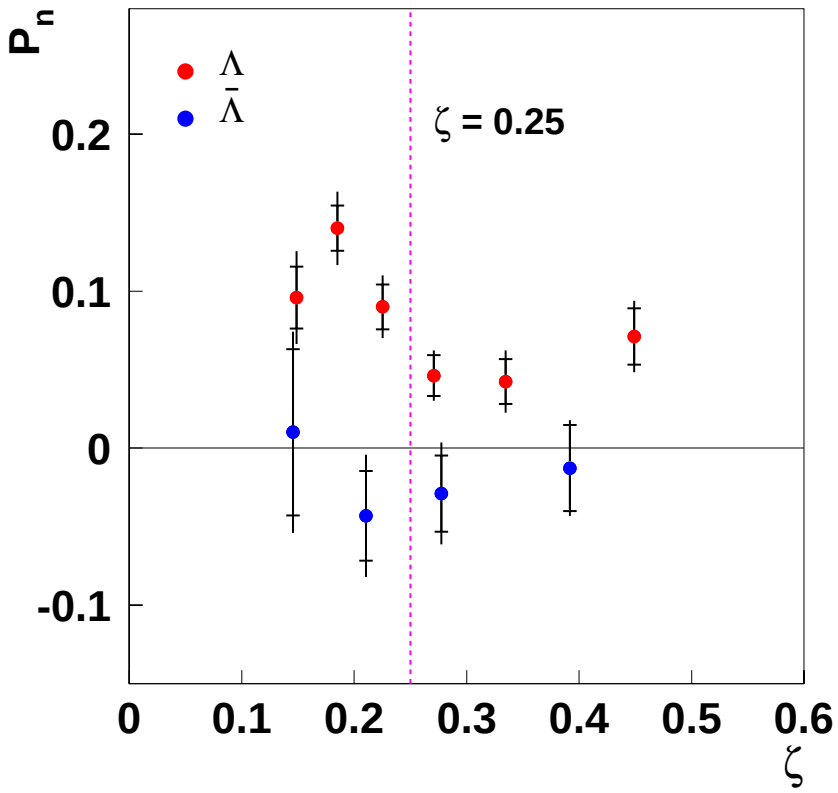






The measured Λ polarization rises linearly with p_T in both regions, but the effect is more pronounced at ζ<0.25

The measured $\bar{\Lambda}$ polarization does not depend from p_T and compatible with zero



Transverse Λ polarization is large in the region ζ<0.25 where Λ production from di-quark fragmentation is the dominant mechanism.

Conclusion

- *Transverse Λ polarization is found to be **positive** in quasi-real photoproduction*

$$P_{\Lambda} = 0.078 \pm 0.006(stat) \pm 0.012(syst)$$

- *First statistically significant measurement in photoproduction*
- *The measured Λ polarization rises linearly with p_T*
- *The polarization is large for ζ<0.25 where diquark fragmentation dominates*
- *Transverse $\overline{\Lambda}$ polarization is compatible with zero*

$$P_{\overline{\Lambda}} = -0.025 \pm 0.015(stat) \pm 0.018(syst)$$

- *Paper is ready for submission to PRD!*