Transverse and longitudinal lambda polarization at HERMES

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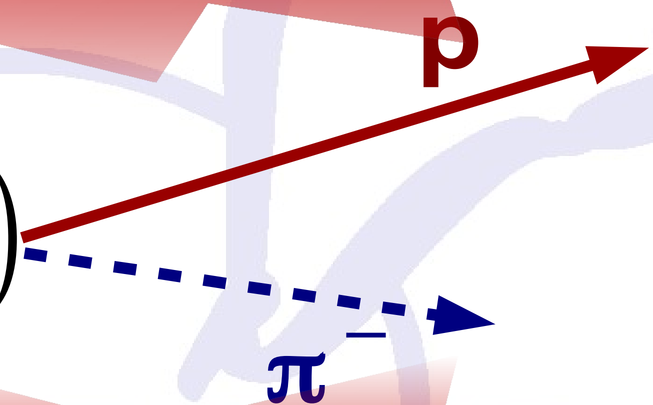
Why Λ polarization is important

Self-analyzing power through the parity-violating weak decay

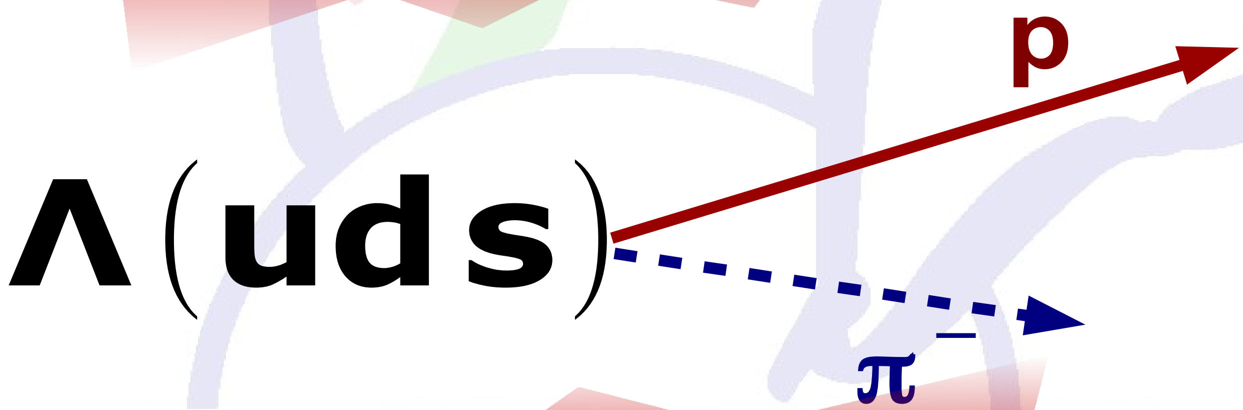
$\Lambda(uds)$



Spin structure of the lightest hyperon

Why Λ polarization is important

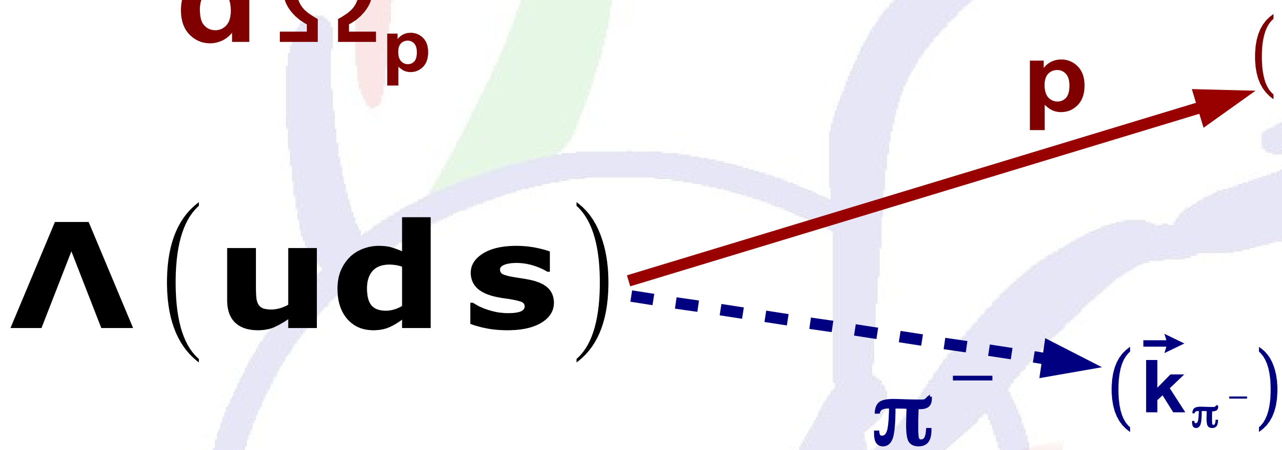
Sensitivity to the strange quark polarization



Access to the quarks transverse spin distribution

How to access Λ polarization

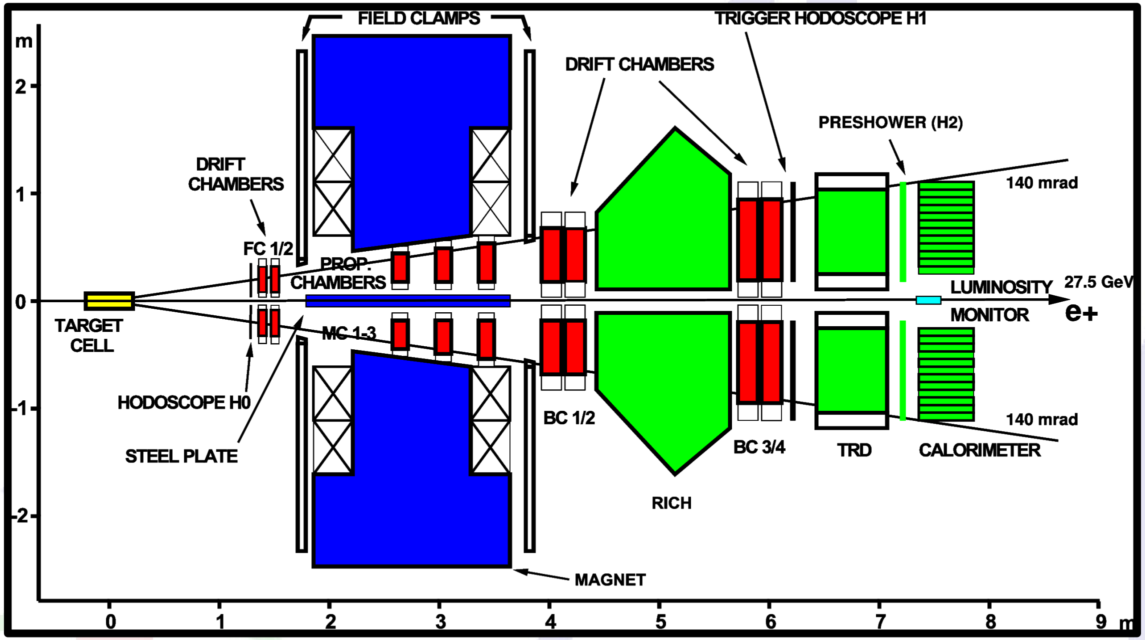
$$\frac{dN}{d\Omega_p} \simeq 1 + \alpha \vec{P}_\Lambda \cdot \hat{k}_p$$

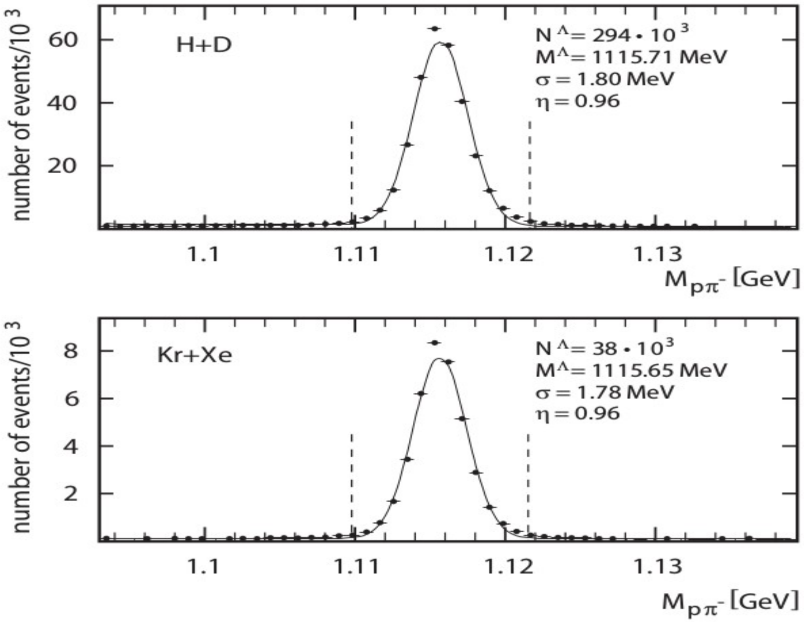


$$\hat{k}_p = \frac{\vec{k}_p}{|\vec{k}_p|}$$

Decay protons prefer to follow the spin direction of Λ

Experiment





Beam : e^-/e^+ 27.6 GeV

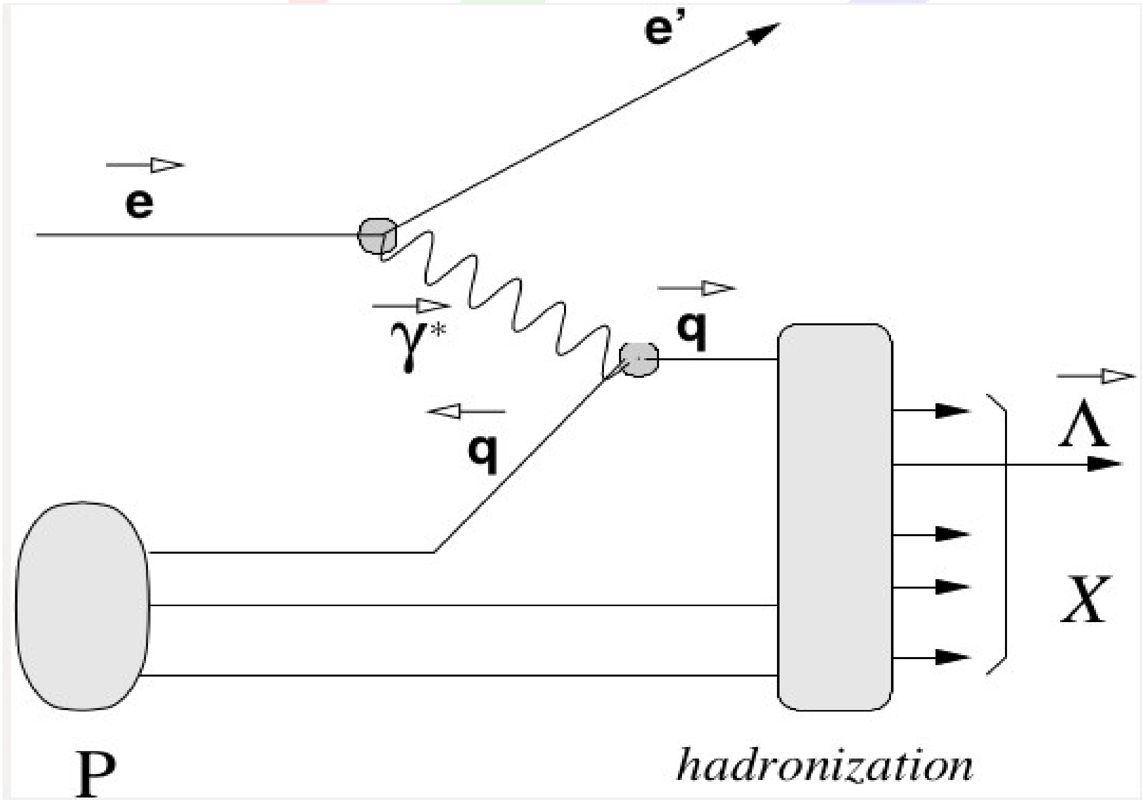
Target : H, D, He^3, Ne, Kr, Xe pure gaseous

Good momentum resolution : $\frac{\delta p}{p} < 2\ \%$

Excellent particle identification

Longitudinal Λ polarization

$$e + N \rightarrow e + \Lambda + X$$

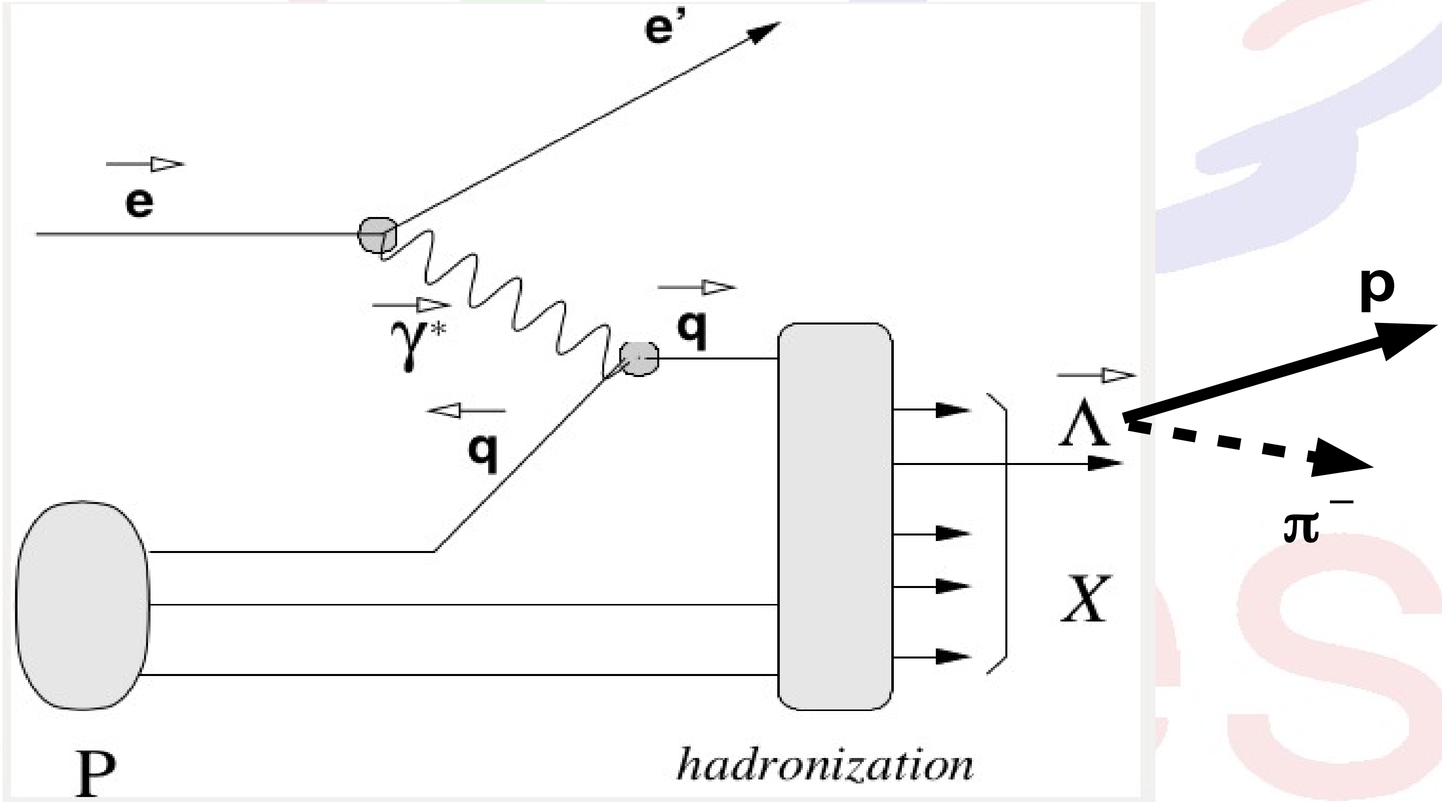


Longitudinal Λ polarization

$\vec{e} + N \longrightarrow e + \vec{\Lambda} + X$

Longitudinally polarized

Unpolarized



Longitudinal Λ polarization

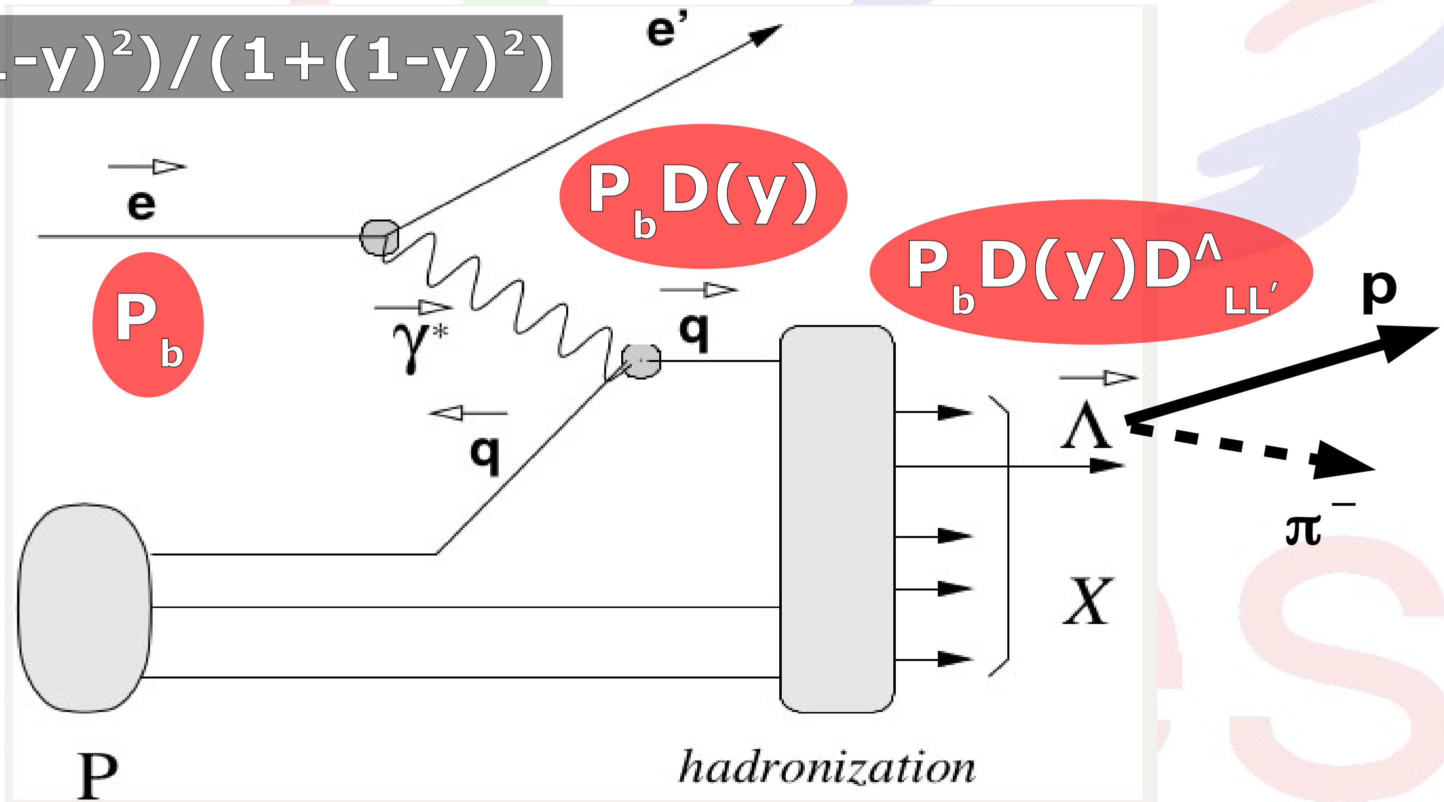
$$\vec{e} + N \rightarrow e + \vec{\Lambda} + X$$

Longitudinally polarized

Unpolarized

$D(y) \approx (1-(1-y)^2)/(1+(1-y)^2)$

$y = \nu/E_b$



Longitudinal Λ polarization

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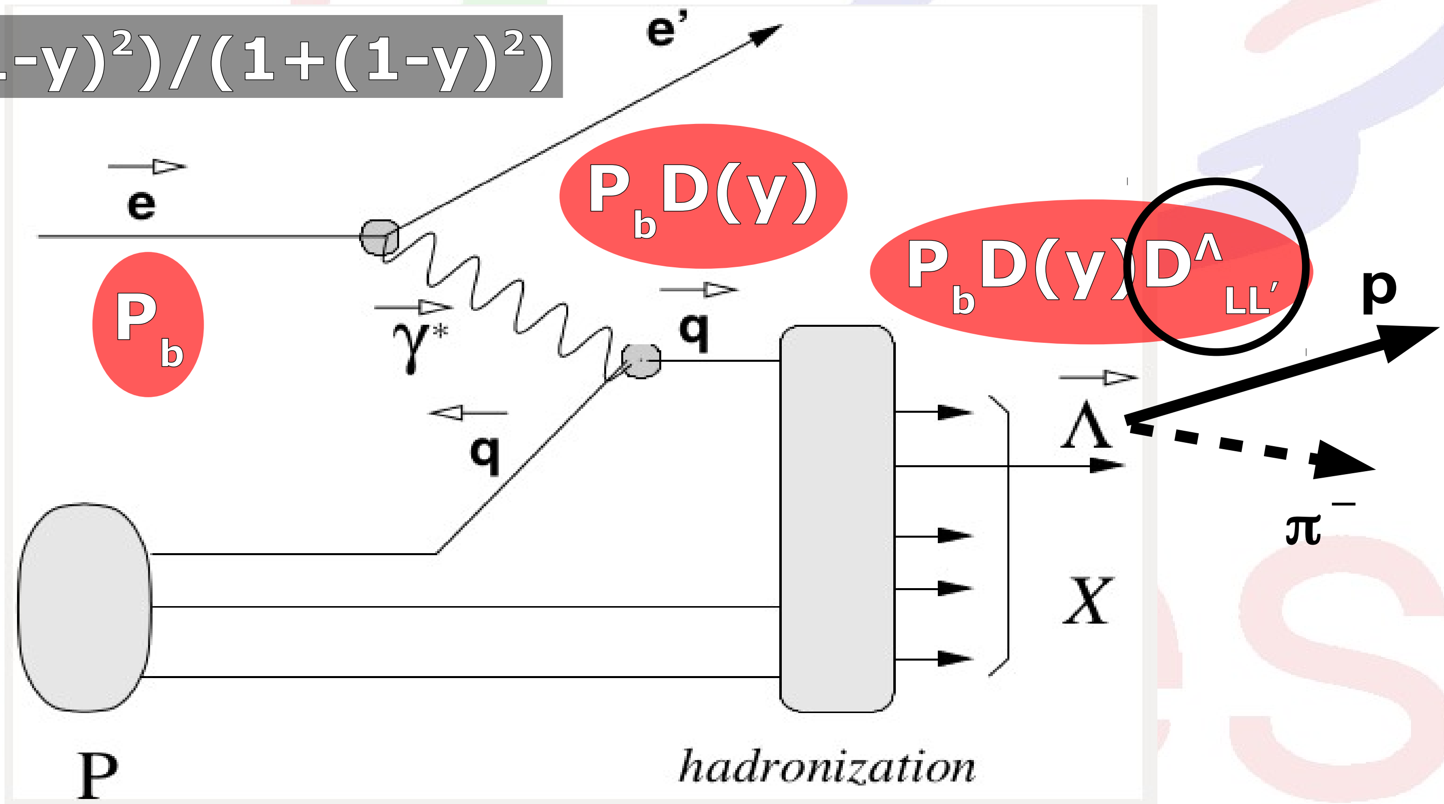
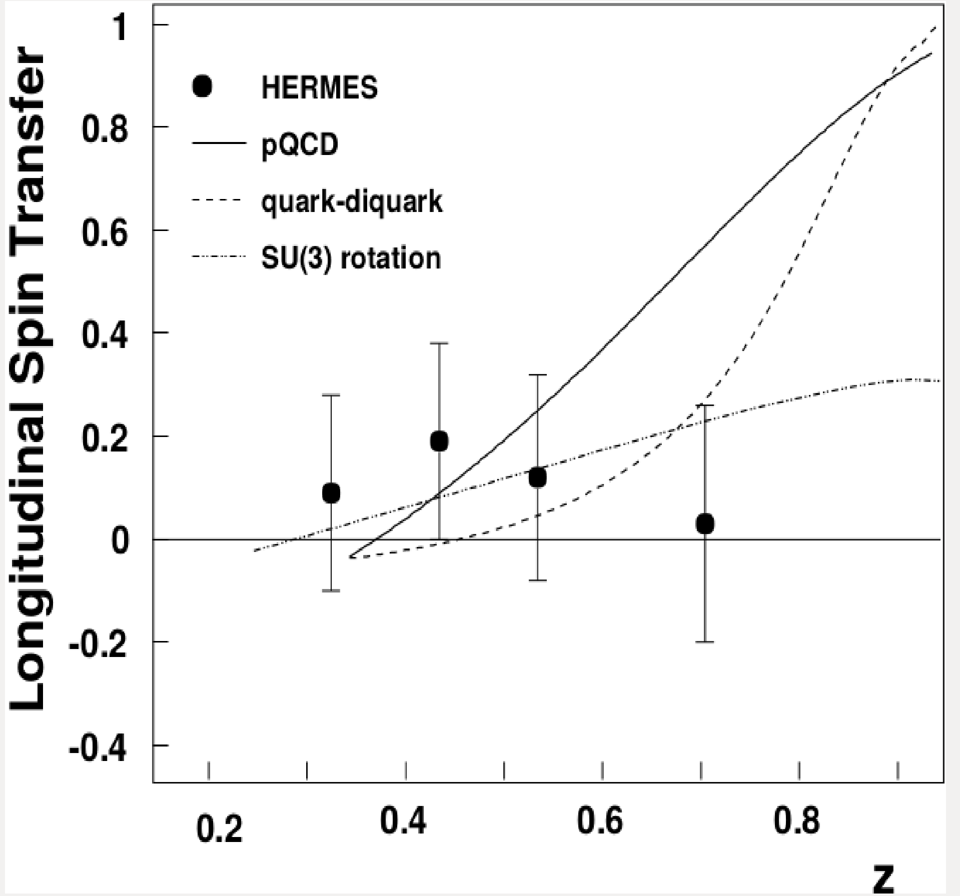


Longitudinal Λ polarization

Phys. Rev. D74 (2006) 072004 (all targets except Xe)



$D_{LL'} = 0.11 \pm 0.10 \pm 0.03$

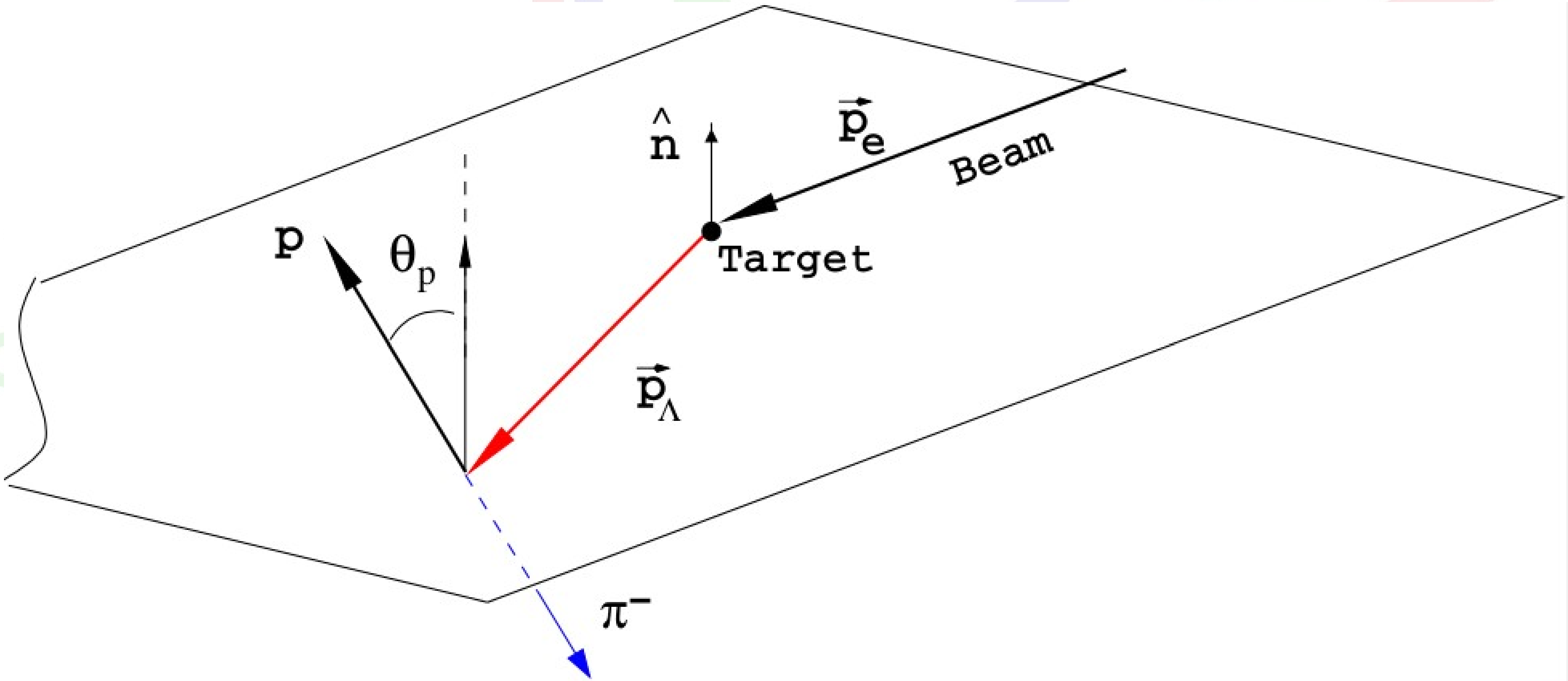
Small value for $D_{LL'}$ is observed.

Dominance of scattering from u and d quarks.

Strong rise at high z in models: polarized **s** ⟶ **Λ** (no hyperon decay in these models).

Transverse Λ polarization

$e + N \rightarrow \Lambda + X$ (quasi-real photo-production)



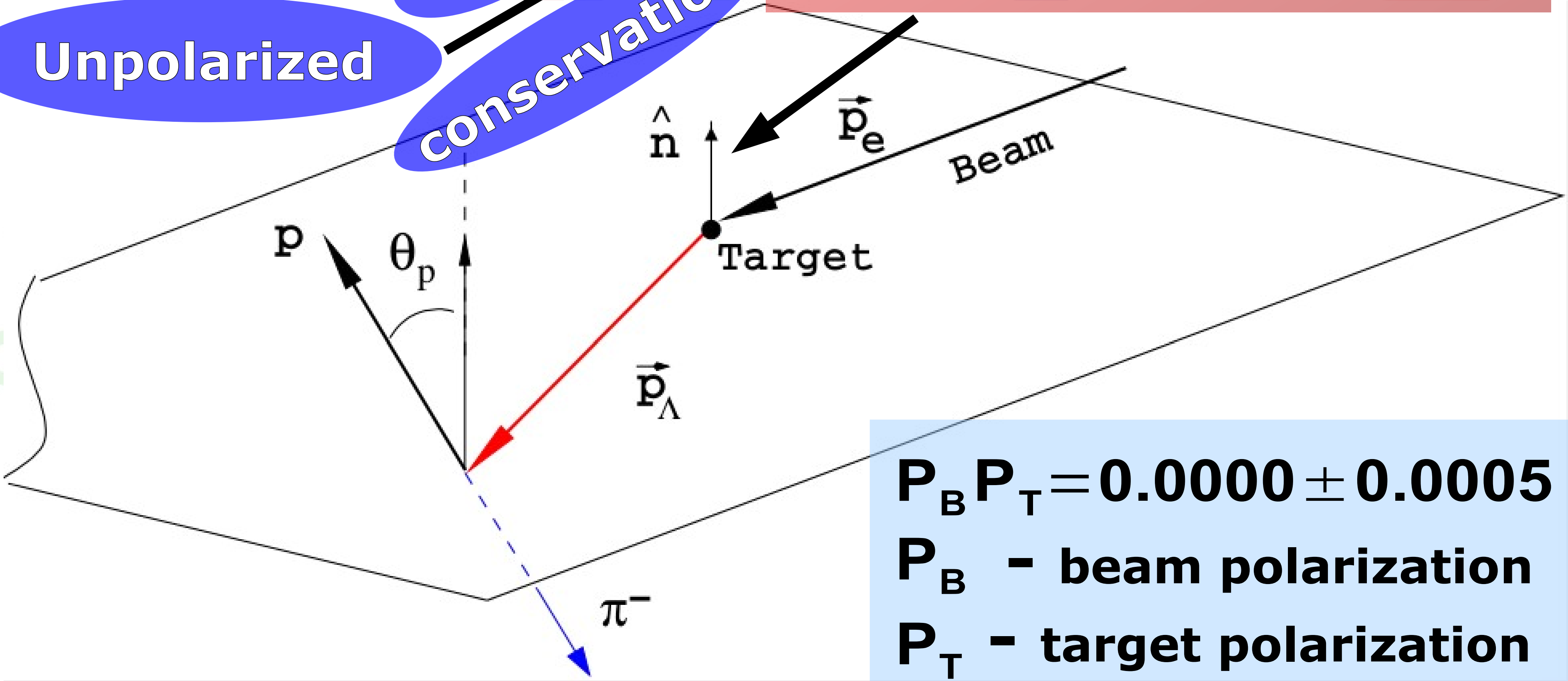
Transverse Λ polarization

$e + N \to \Lambda + X$

Unpolarized

Parity conservation

direction of spontaneous polarization



$P_B P_T = 0.0000 \pm 0.0005$

P_B - beam polarization

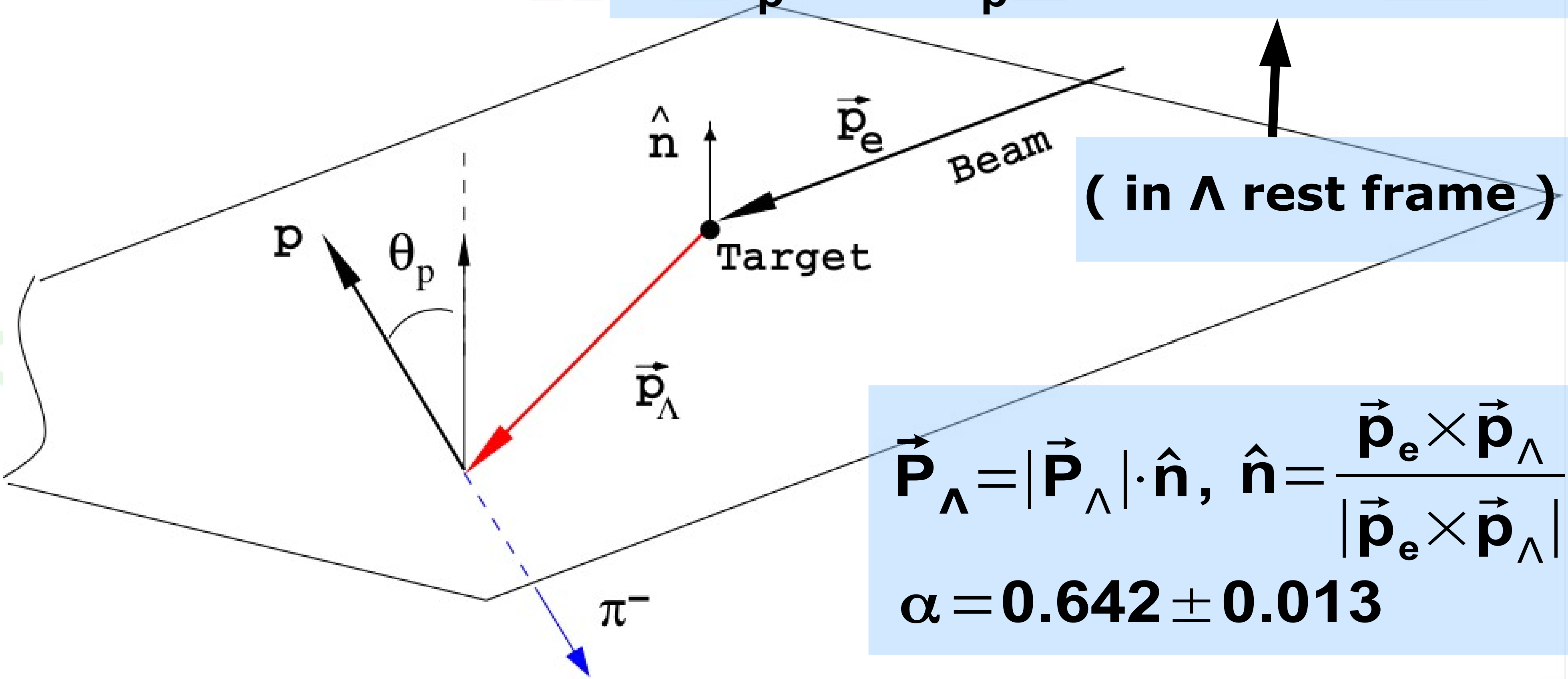
P_T - target polarization

Transverse Λ polarization

$$e+N \rightarrow \Lambda + X$$

$$\frac{dN}{d\Omega_p} = \frac{dN_0}{d\Omega_p}\left(1+\alpha|\vec{P}_\Lambda|\cos\theta_p\right)$$

(in Λ rest frame)

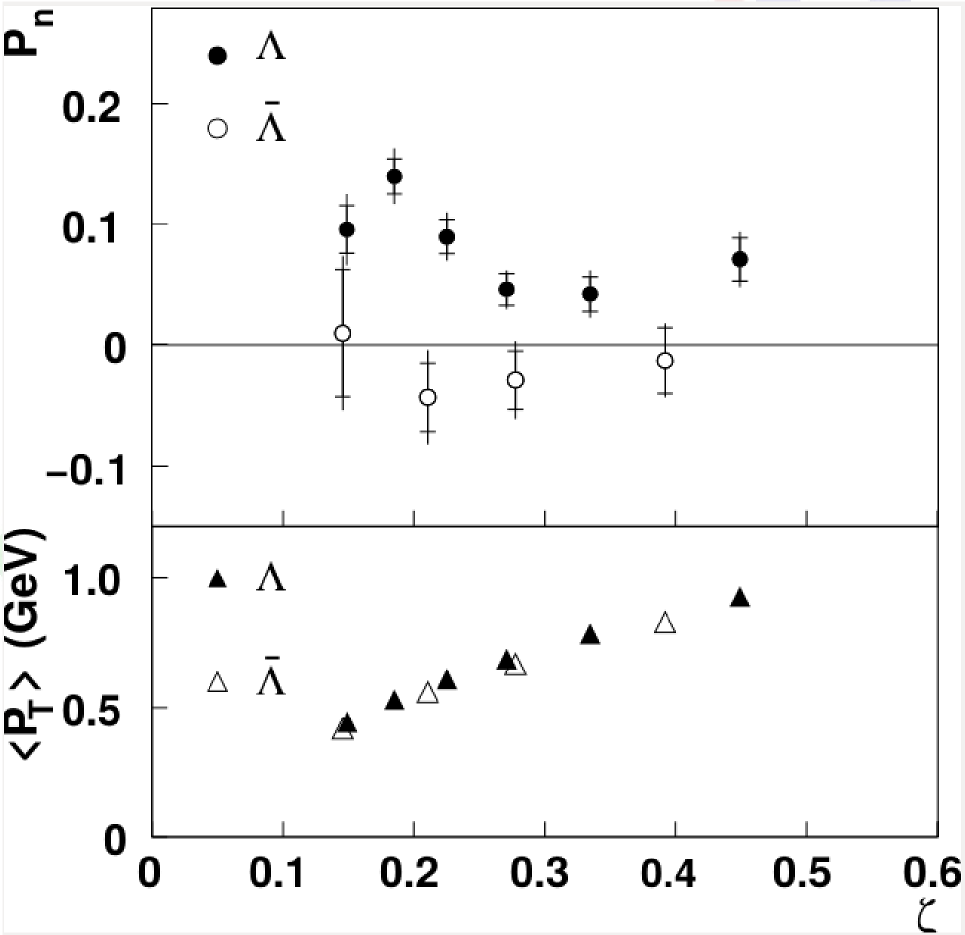


$$\vec{P}_\Lambda = |\vec{P}_\Lambda|\cdot\hat{n},\ \hat{n} = \frac{\vec{p}_e\times\vec{p}_\Lambda}{|\vec{p}_e\times\vec{p}_\Lambda|}$$

$$\alpha = 0.642 \pm 0.013$$

Transverse Λ polarization

Phys. Rev. D76 (2007) 092008 **(all targets except Xe)**



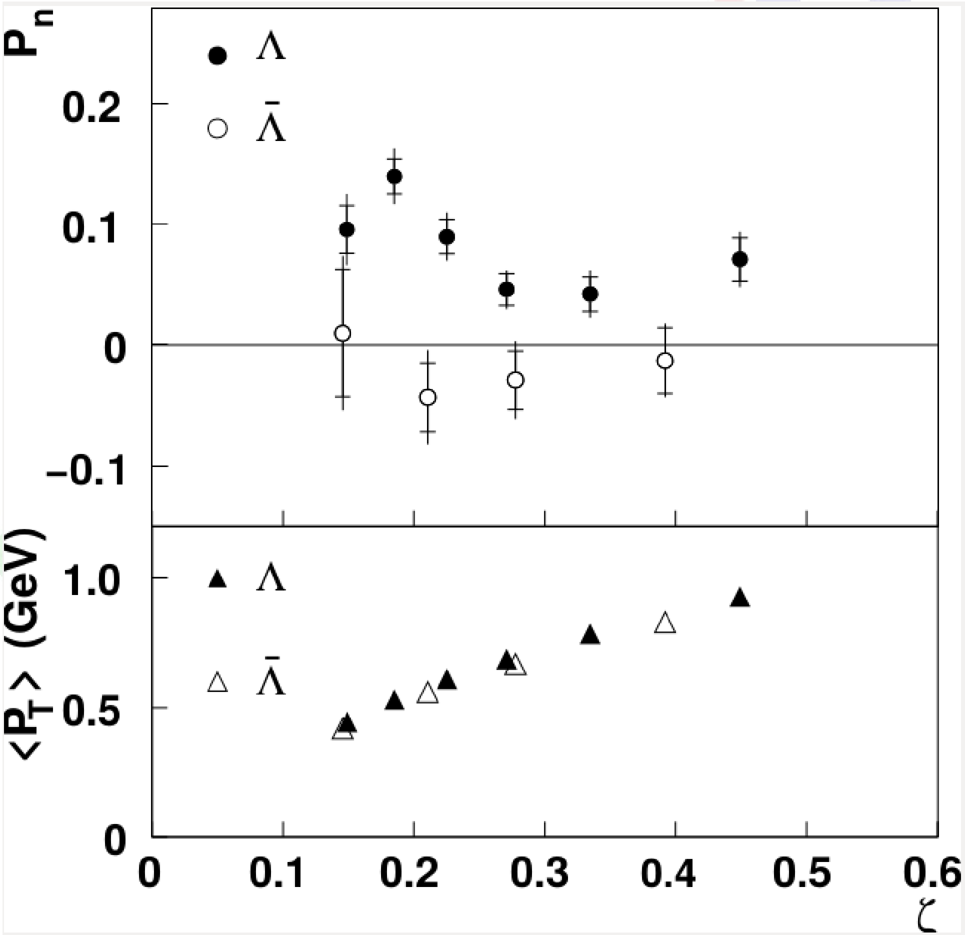
$P_n^{\Lambda} = 0.078 \pm 0.006 \pm 0.012$

$P_n^{\bar{\Lambda}} = -0.025 \pm 0.015 \pm 0.018$

Λ polarization is found to be positive (opposite sign compared to pion and proton beam data).

Transverse Λ polarization

Phys. Rev. D76 (2007) 092008 (all targets except Xe)



$$P_n^{\Lambda} = 0.078 \pm 0.006 \pm 0.012$$

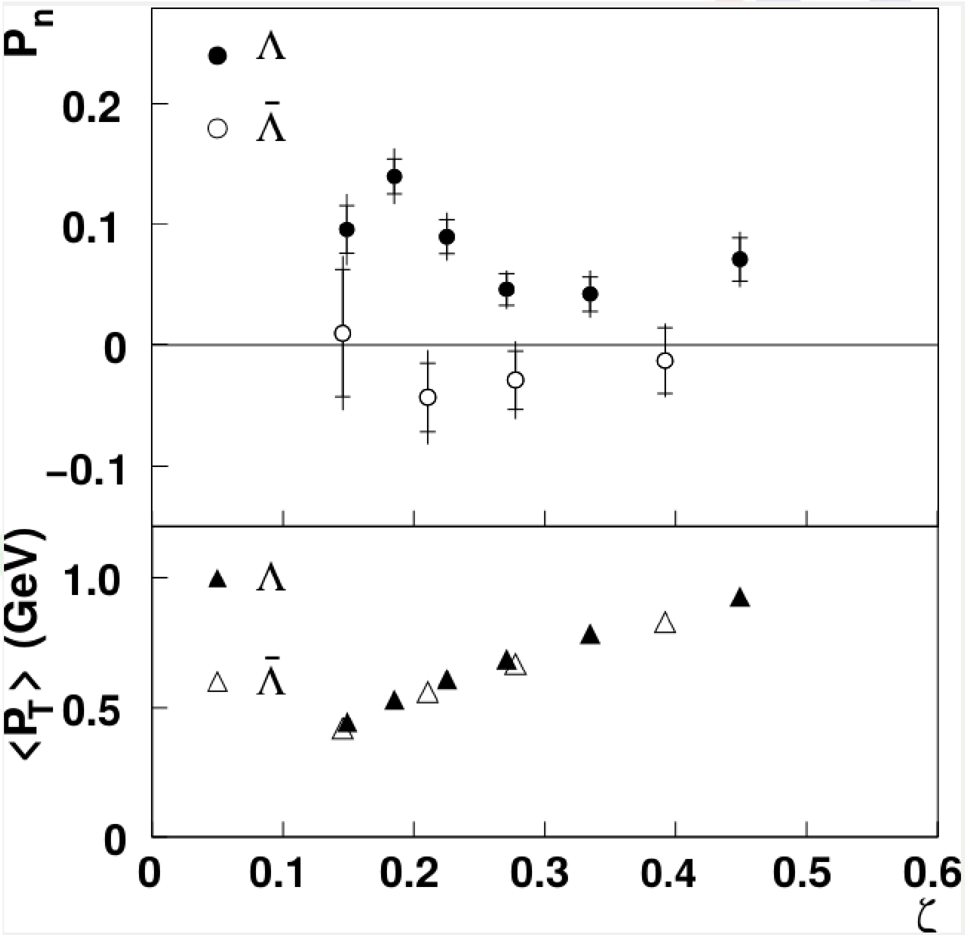
$$P_n^{\bar{\Lambda}} = -0.025 \pm 0.015 \pm 0.018$$

$$\zeta = \frac{(E_\Lambda + p_{z\Lambda})}{E_e + p_e}$$

correlated with x_F

Transverse Λ polarization

Phys. Rev. D76 (2007) 092008 **(all targets except Xe)**



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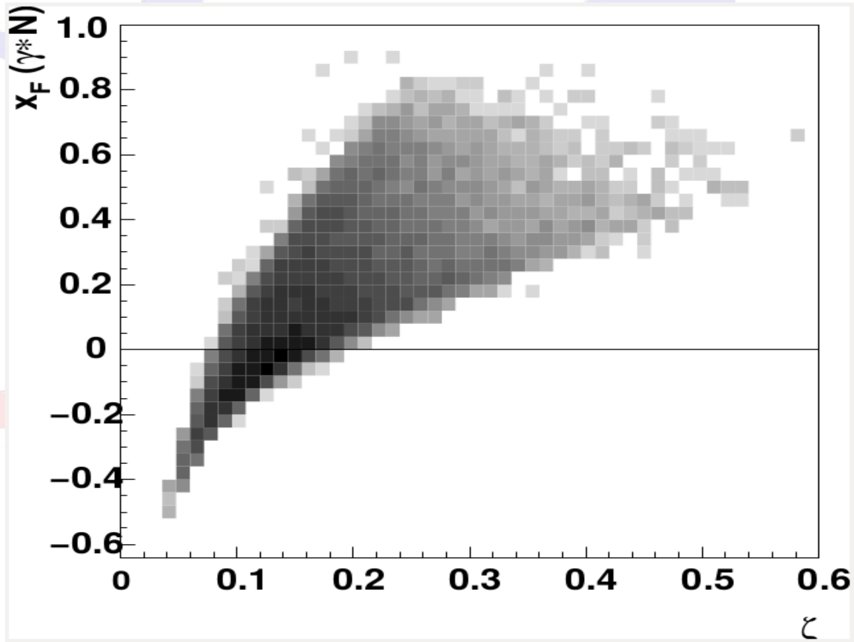
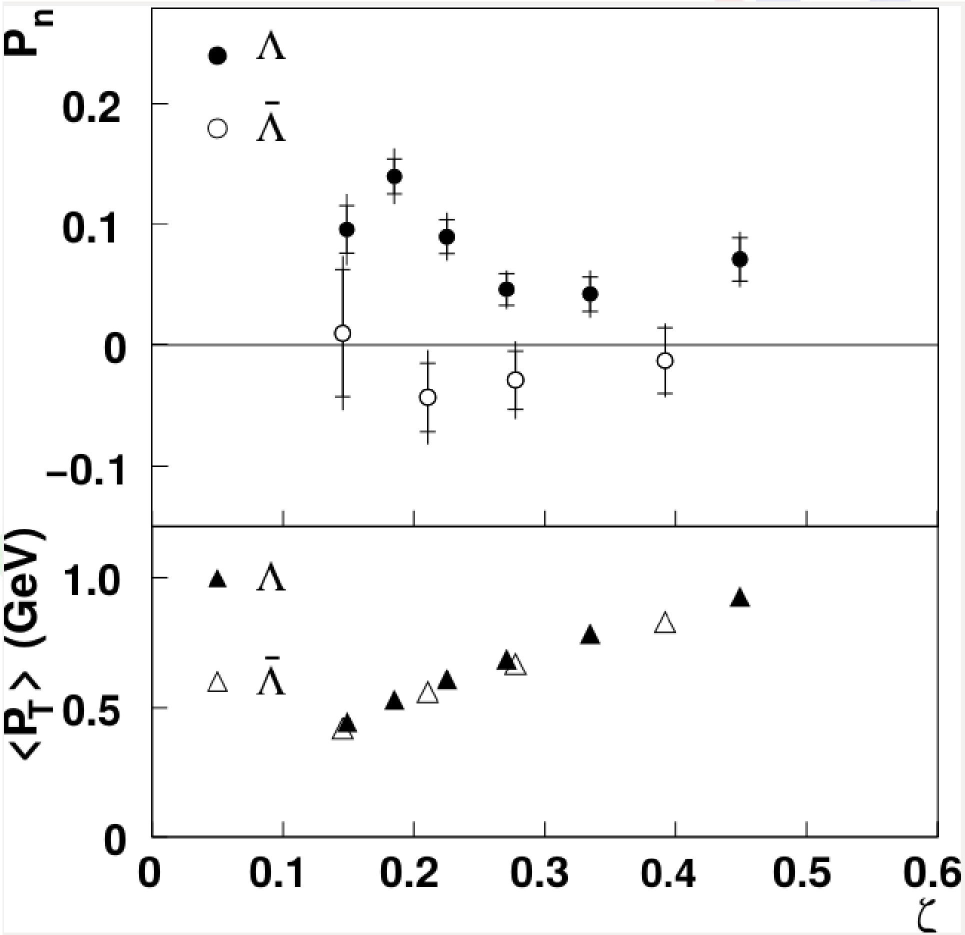


Transverse Λ polarization

Phys. Rev. D76 (2007) 092008 (all targets except Xe)



$P_n^{\Lambda} = 0.078 \pm 0.006 \pm 0.012$

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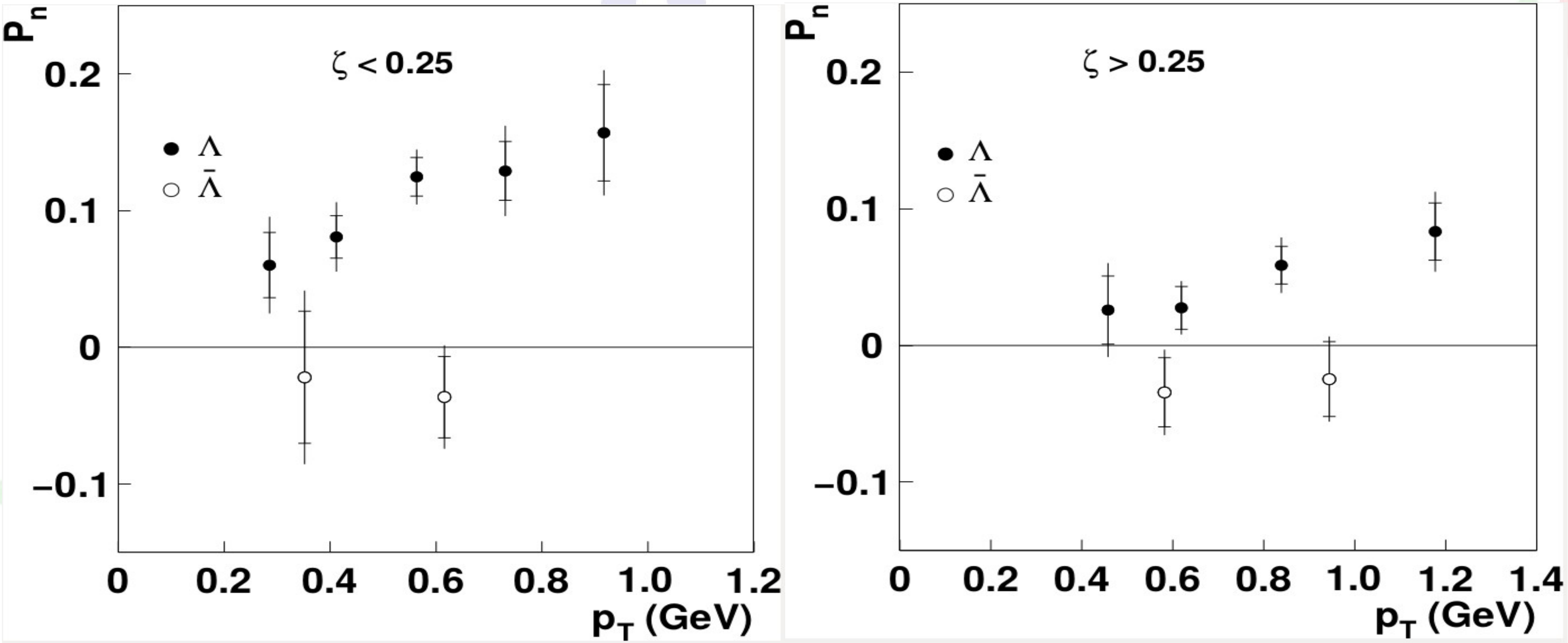
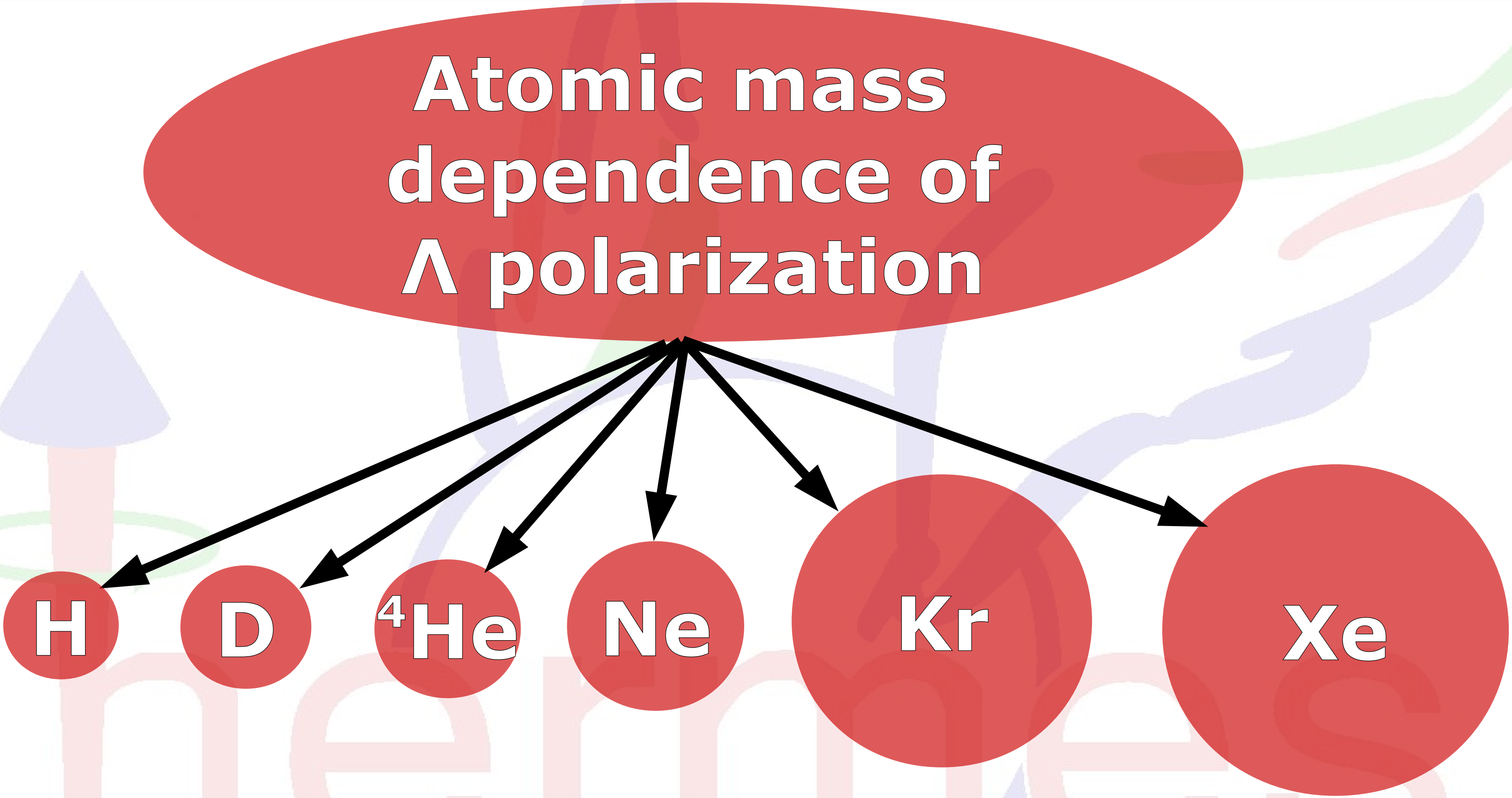
Different magnitudes for Λ polarization in the "backward" (ζ<0.25) and "forward" (ζ>0.25) kimenatic regions.

Transverse Λ polarization



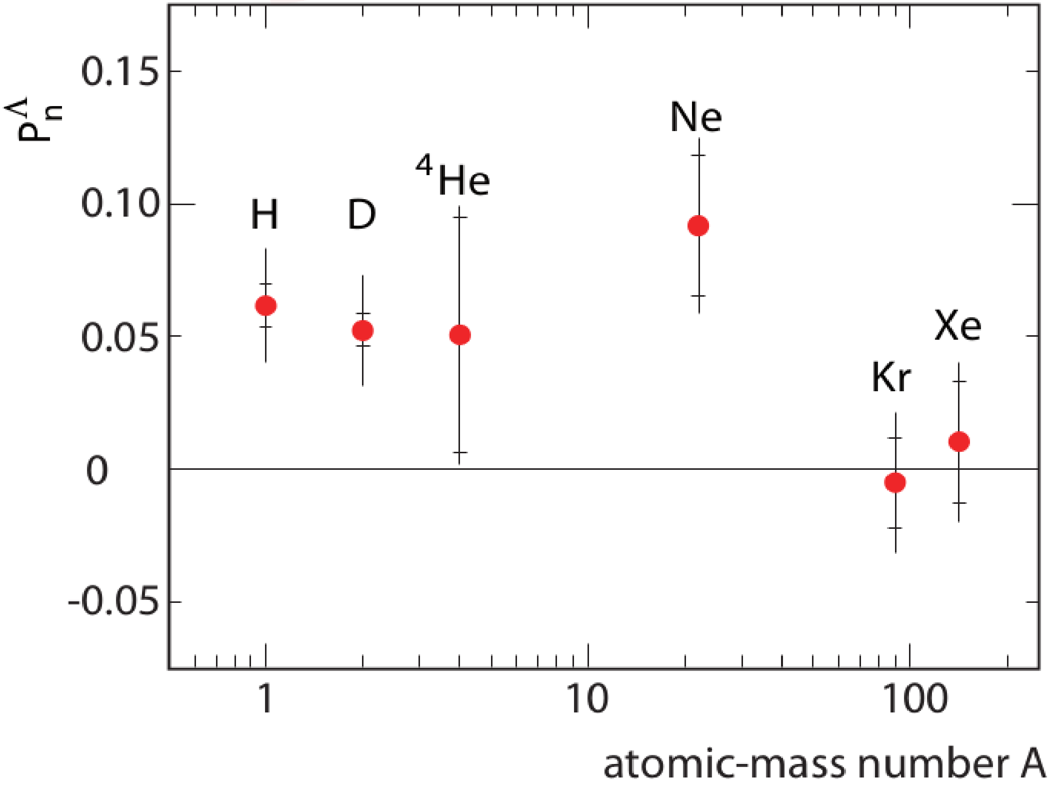
Λ polarization rises linearly with p_T in both kinematic regions.

Transverse Λ polarization on nuclei



Transverse Λ polarization on nuclei

Phys. Rev. D90 (2014) 072007

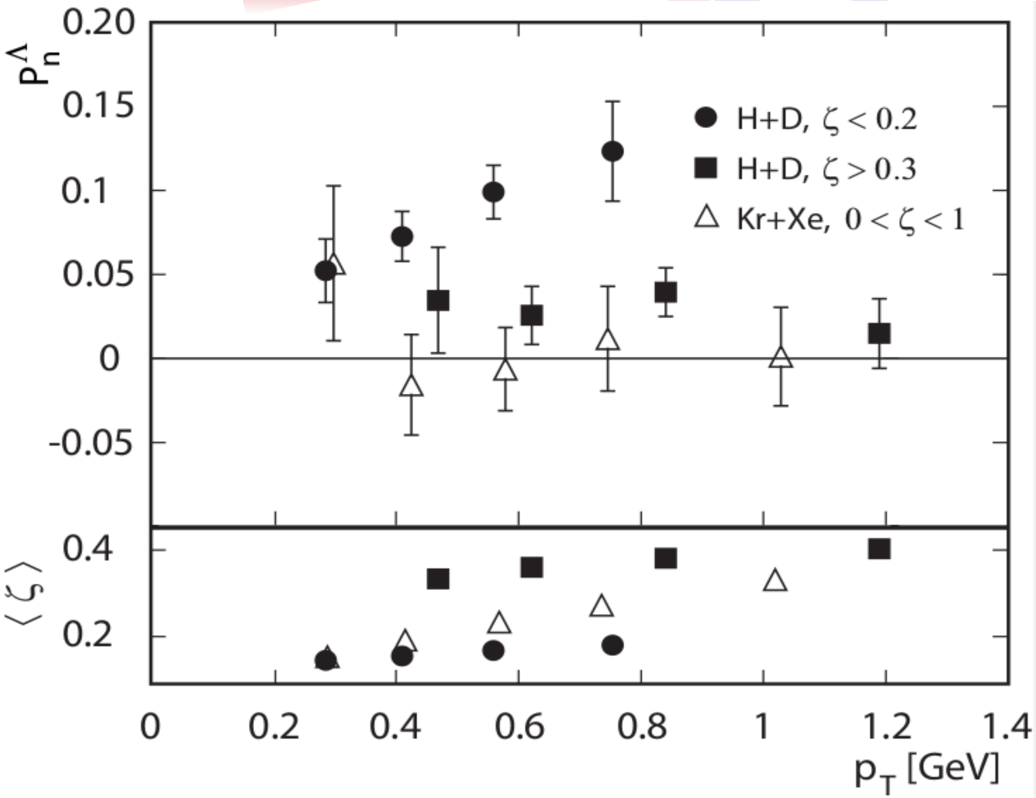


Positive polarization for light nuclei.

Compatible with zero polarization for heavy nuclei.

Transverse Λ polarization on nuclei

Phys. Rev. D90 (2014) 072007



H+D data : polarization increases linearly with p_T at small ζ (backward region).

H+D data : polarization is substantially smaller in forward region (ζ>0.3) with very little dependence on p_T.

Kr+Xe data : polarization is compatible with zero within experimental uncertainties.

Summary

- Small polarization transfer from a polarized beam to the lambda.
- Positive sign for the lambda transverse polarization.
- Different transverse polarizations for the lambda in "backward" and "forward" regions.
- Linear rise for the lambda transverse polarization with its transverse momentum.
- Positive transverse polarization for light nuclei and compatible with zero polarization for heavy nuclei.