Measurement of the nuclear-mass dependence of spontaneous (transverse) Λ polarisation in quasi-real photoproduction at HERMES

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On behalf of the HERMES collaboration

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Introduction

Reaction under study $\gamma^* + A \Rightarrow \Lambda^{\uparrow} + X$

A: ^{1}H, ^{2}H, ^{3}He, ^{4}He, ^{14}N, ^{20}Ne, ^{84}Kr, ^{132}Xe

Spontaneous (transverse) Λ polarization does not depend on beam or target polarizations and directed along $\hat{n}$:

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

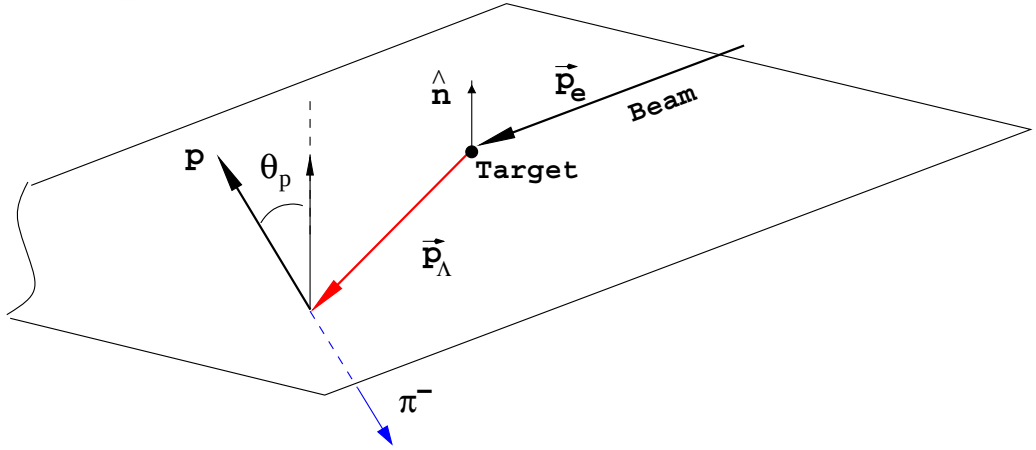
Polarized Λ decay in Λ rest frame

$$\Lambda \rightarrow p\pi^-$$

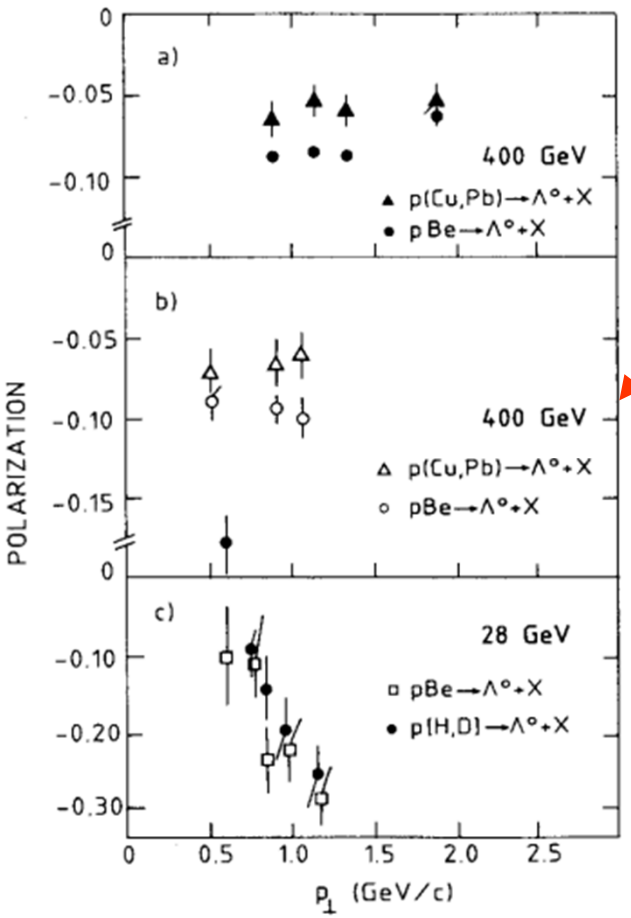
$$\frac{dN}{d\Omega_p} = \frac{dN_0}{d\Omega_p}(1 + \alpha P_\Lambda \cos\theta_p)$$

$$\alpha = 0.642 \pm 0.013 \text{ for } \Lambda,$$

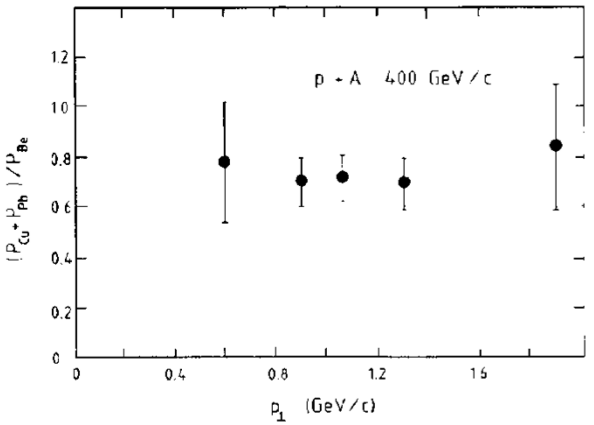
$$\alpha = -0.642 \pm 0.013 \text{ for } \bar{\Lambda}$$



A-dependence in pA collisions

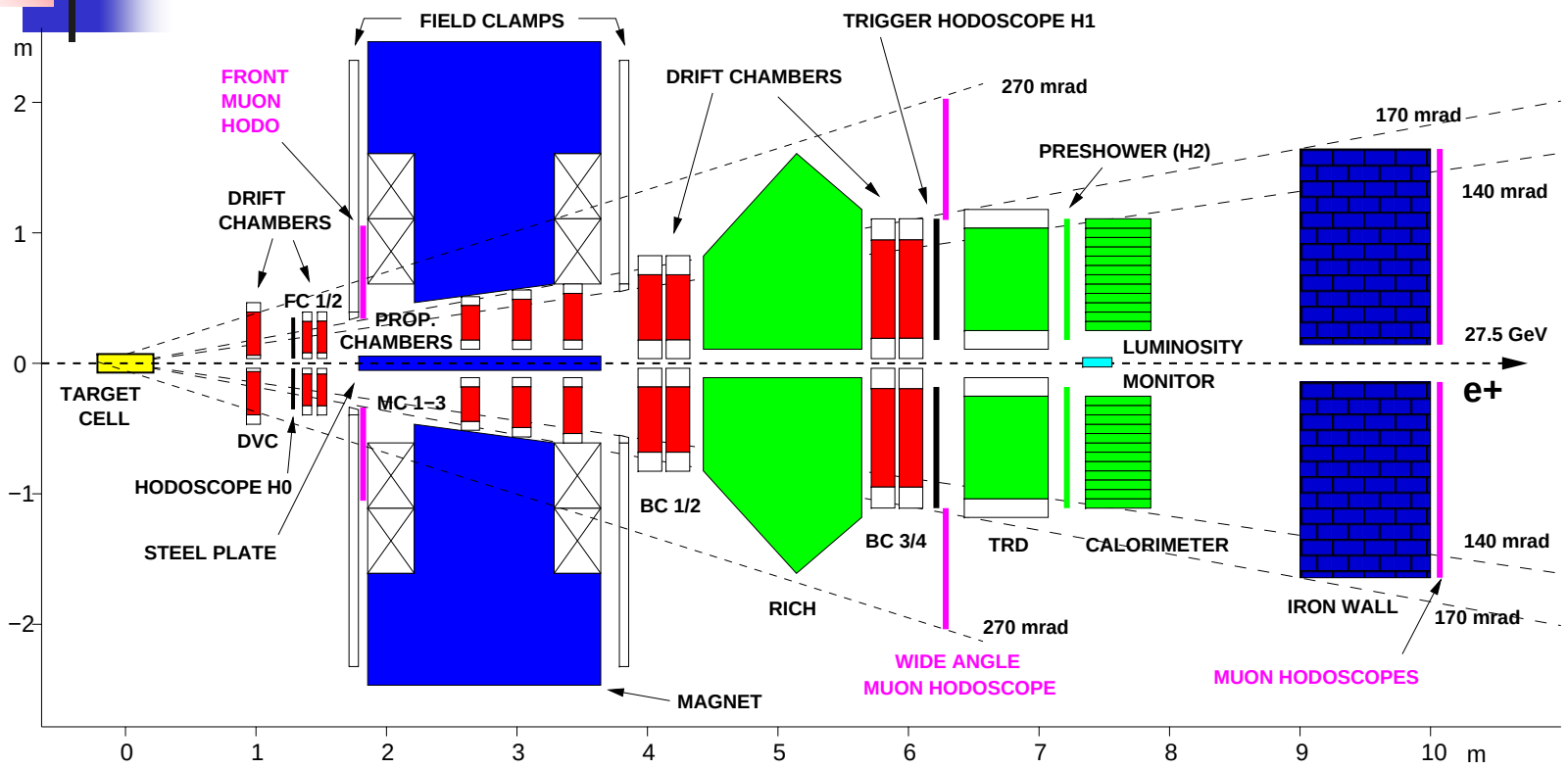


Experiment @ FNAL
p A → Λ X
(targets Cu, Pb, Be)
$p_{beam} = 400$ *GeV*



Experiment @ BNL
p A → Λ X
(targets H, D, Be)
$p_{beam} = 28$ *GeV*

HERMES spectrometer



- *polarized positron (and electron) beam E_e = 27.5 GeV,*
- *average beam polarization $P_b \sim \pm 45\%$*
- *polarized and unpolarized internal gas targets:*
  $(\vec{H}, \vec{D})$, ^1H, ^2H, ^3He, ^4He, ^{14}N, ^{20}Ne, ^{84}Kr, ^{132}Xe
- *up/down mirror symmetric (important for extraction of transverse Λ polarization)*

Extraction of Λ polarization

Formalism of Λ polarization extraction is based on up/down mirror (geometrical) symmetry of the detector and moment method

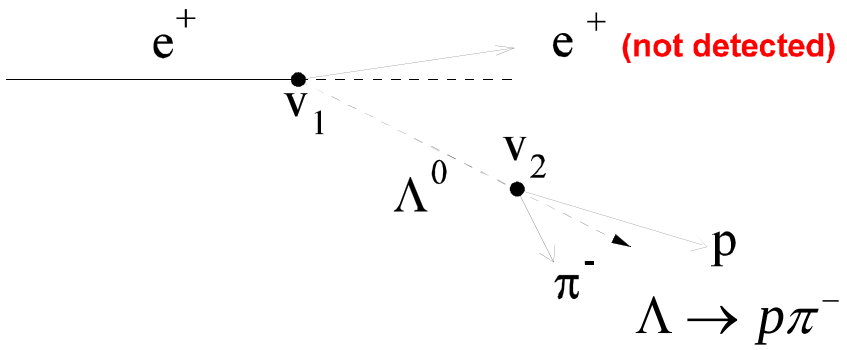
$$P_\Lambda = \frac{\langle \cos\theta_p \rangle}{\alpha \langle \cos^2\theta_p \rangle} = \frac{\frac{1}{N_\Lambda}\sum_{i=1}^{N_\Lambda} \cos\theta_p}{\alpha \frac{1}{N_\Lambda}\sum_{i=1}^{N_\Lambda} \cos^2\theta_p}$$

No Monte-Carlo simulations of the spectrometer acceptance is involved!

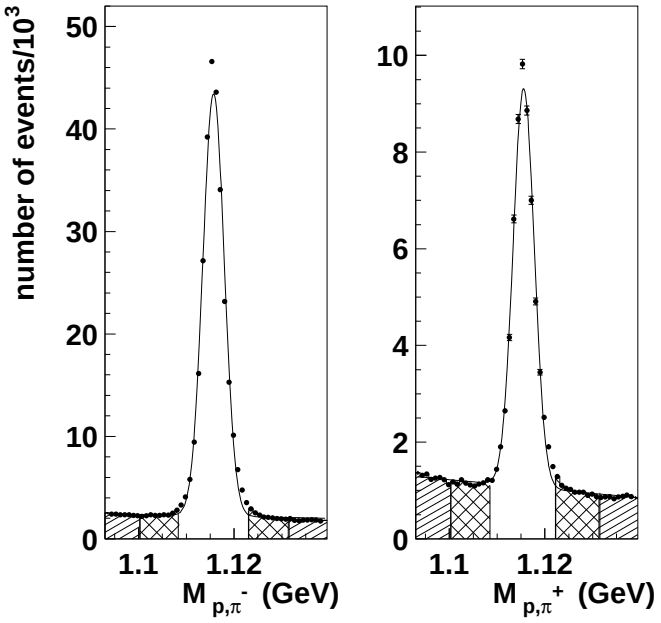
Reconstruction of Λ events

Quasi-real photoproduction, Q^2 <0.05 GeV^2 for 80% of the events (MC)

$\langle E_\gamma \rangle$ =15.6 GeV



1996-2000



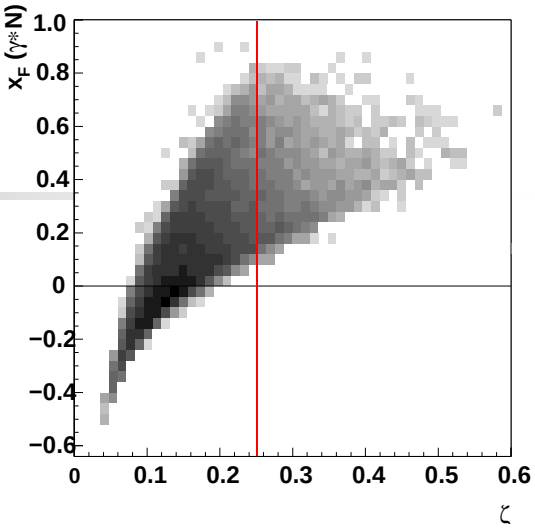
***Background suppression cuts*:**

- *Threshold Cherenkov / Ring imaging Cherenkov detector*
- $z_2 - z_1 > 15\,cm$ *for* Λ

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

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

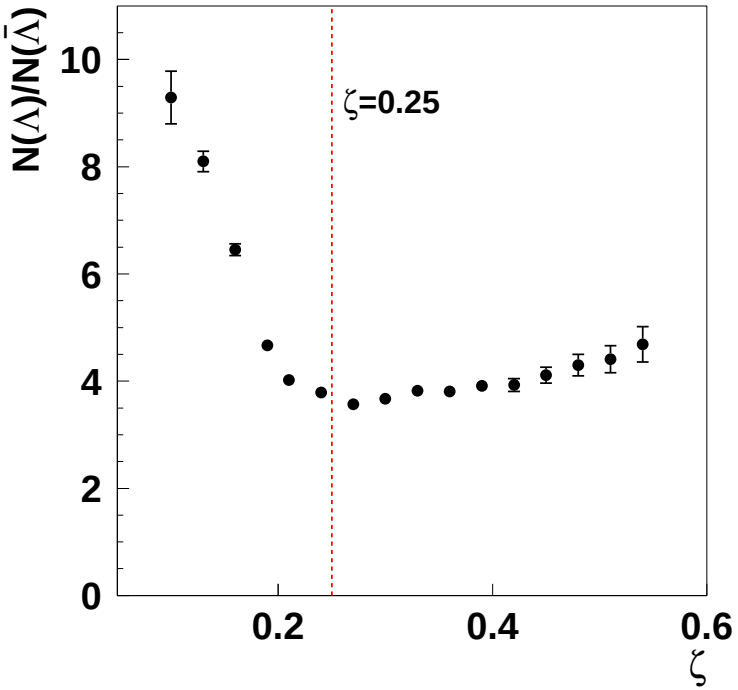
Kinematic regimes

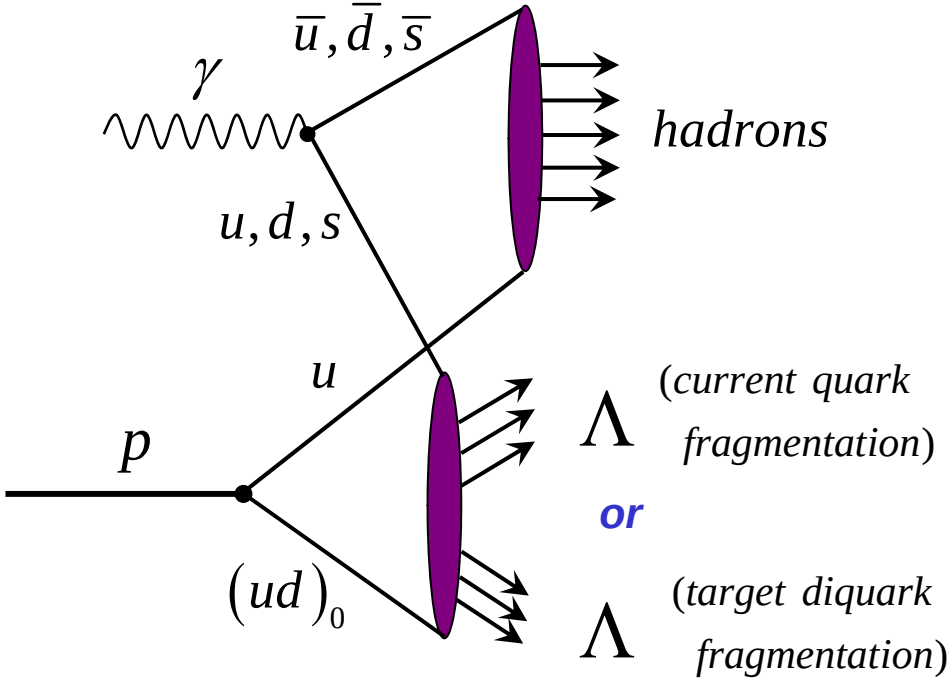


Light cone variable

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

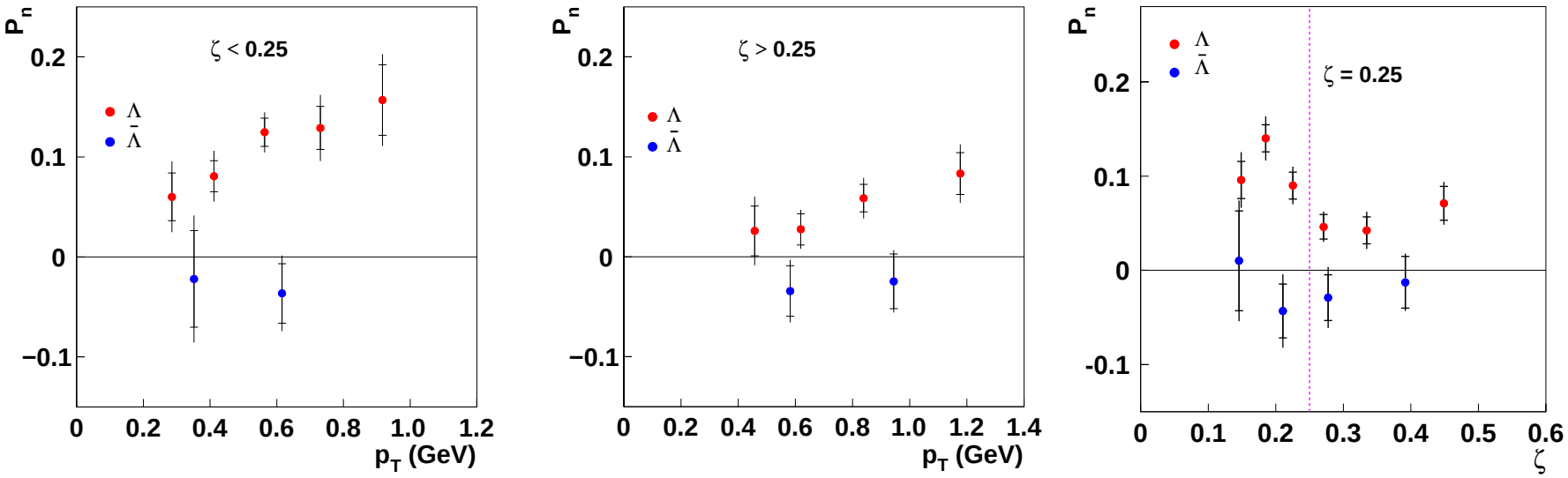
HERMES data





LUND mechanisms

Kinematical dependences of the transverse Λ polarization, 1996-2000 data



For Λ

$$P_{\Lambda} = 0.078 \pm 0.006_{stat.} \pm 0.012_{syst.}$$

For $\overline{\Lambda}$

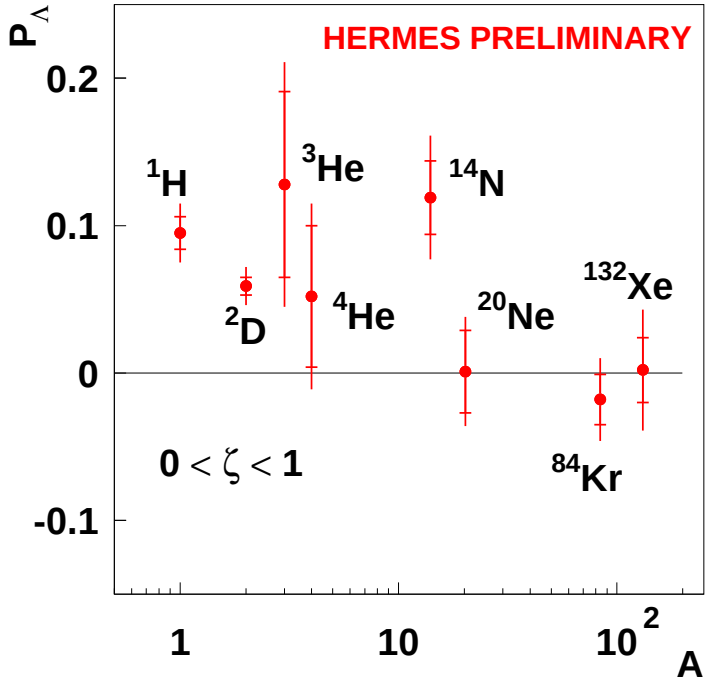
$$P_{\overline{\Lambda}} = -0.025 \pm 0.015_{stat.} \pm 0.018_{syst.}$$

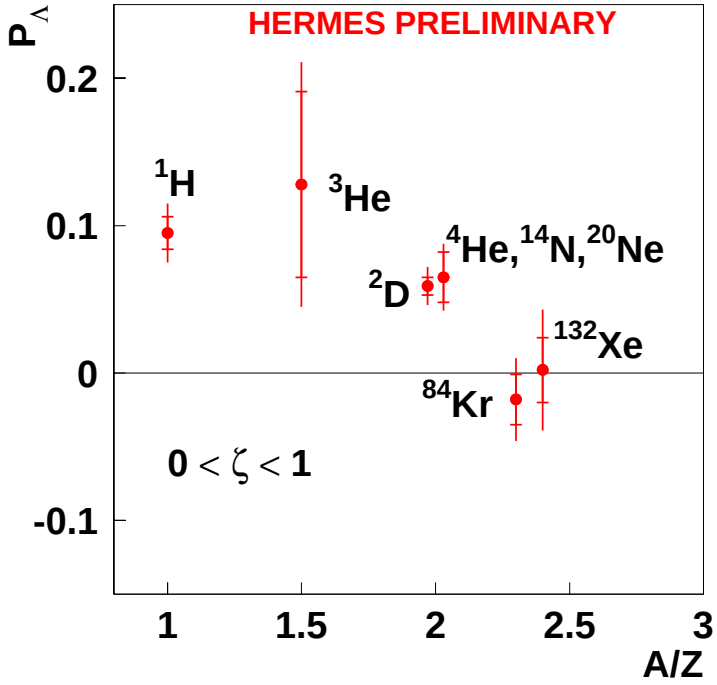
light targets are dominating
$N_{\Lambda}(^1H+^2H) \sim 85\%$

False polarization is studied using h^+h^- pairs and K_s data sample

A. Airapetian et al., Phys.Rev.D76:092008,2007

Nuclear effects: A, A/Z-dependence of Λ polarization





$$N(\Lambda) = 385 \cdot 10^3 \quad (1996 - 2005)$$

$$\langle p_T \rangle \approx 0.25\,GeV, \ \langle \zeta \rangle \approx 0.63$$

Conclusion

- *Spontaneous polarization in quasi-real photoproduction regime (Q2 <0.05 GeV2 for 80% and $\langle E_\gamma \rangle$ =15.6 GeV) obtained mainly on H,D is found to be:*

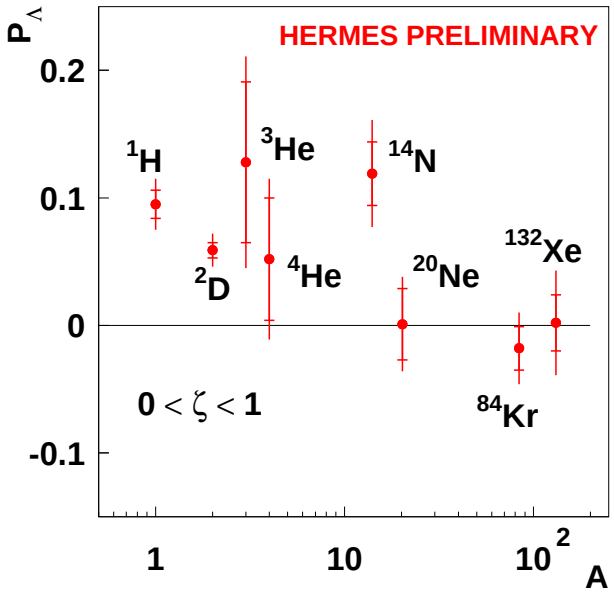
  for Λ $P_n = 0.078 \pm 0.006_{stat.} \pm 0.012_{syst.}$

  and $\bar{\Lambda}$-bar $P_n = -0.025 \pm 0.015_{stat.} \pm 0.018_{syst.}$

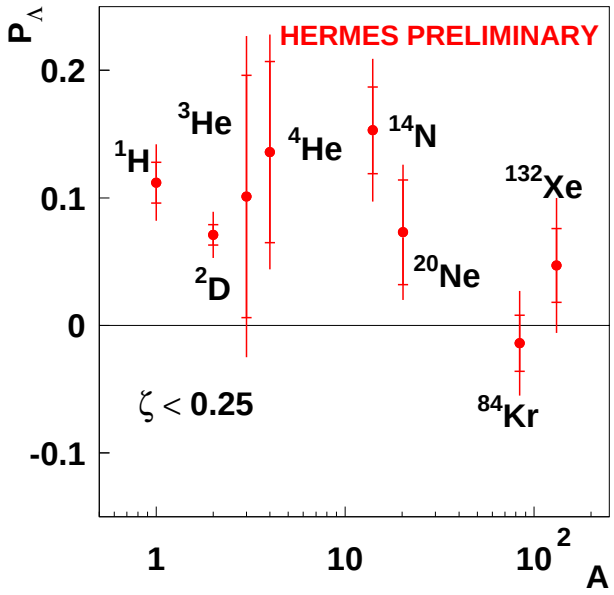
- *A (A/Z) - dependence of P_n is observed. Unlike case of hadron collisions for light nuclei P_n is positive while for heavy nuclei P_n is compatible with zero.*

Backup slides

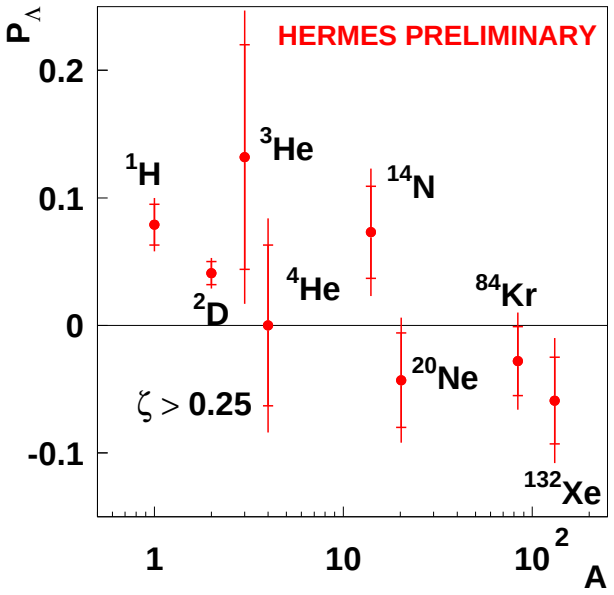
A-dependence of the polarization



$0<\zeta<1$

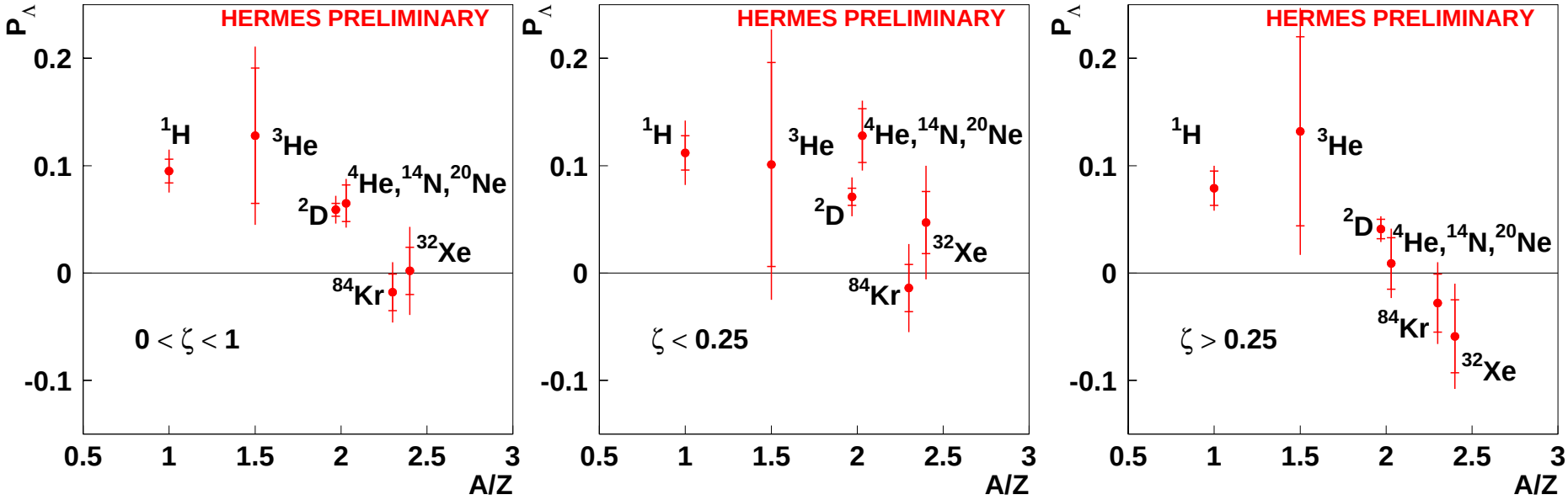


$\zeta<0.25$



$\zeta>0.25$

A/Z-dependence of the polarization



$0<\zeta<1$ $\zeta<0.25$ $\zeta>0.25$