Nuclear medium dependence of transverse Λ polarisation in quasi-real photoproduction

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On behalf of the  collaboration

HERMES Experiment

27.5 GeV e^+/e^- beam of HERA

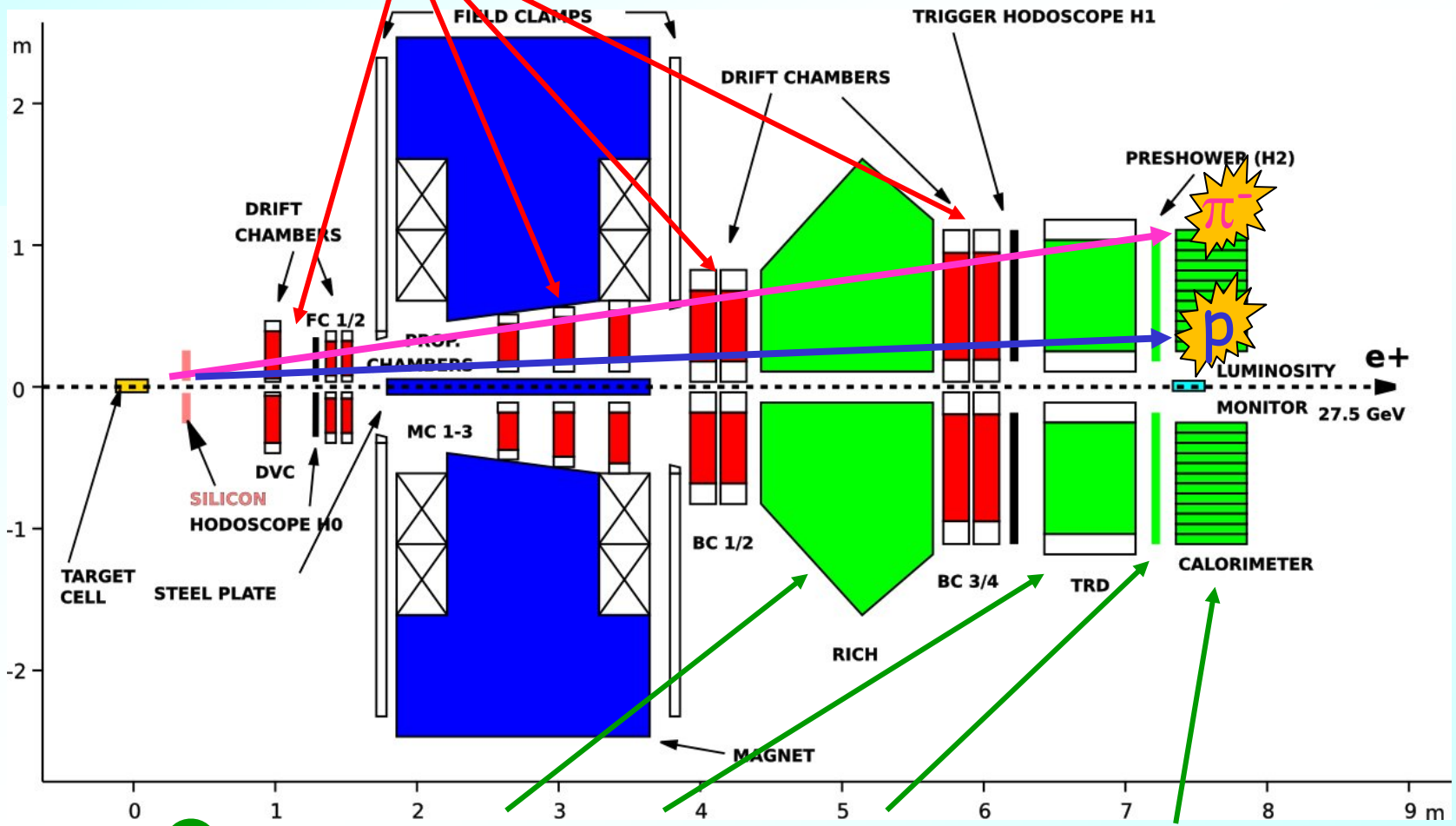
Internal gas targets

polarized : $\vec{}^{1}H, \vec{}^{1}H, \vec{}^{2}H, \vec{}^{3}He$

unpolarized: ^{1}H, ^{2}H, ^{3}He, ^{4}He, ^{14}N, ^{20}Ne, ^{84}Kr, ^{131}Xe

HERMES Spectrometer

- tracking: $\delta p/p \sim 2\%$, $\delta\Theta < 0.6$ mrad, 40-220 mrad

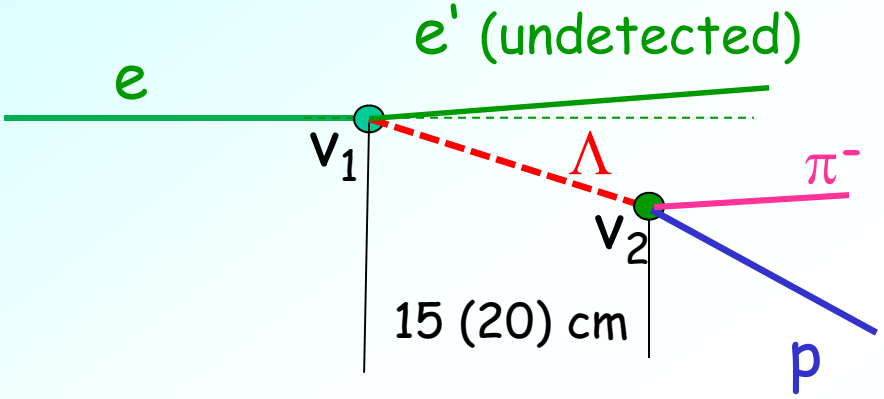


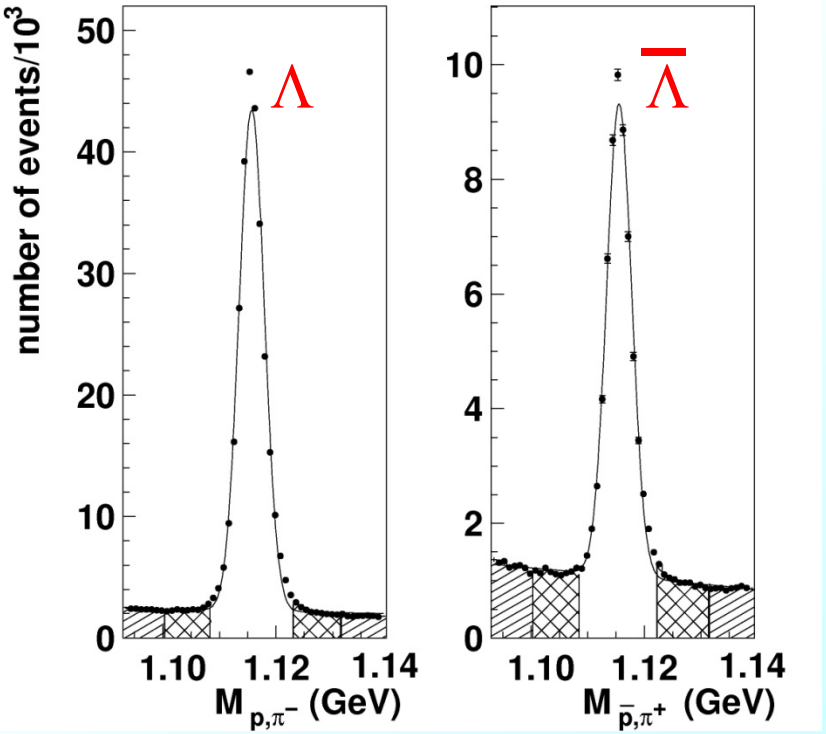
- PID: RICH, TRD, Preshower, Calorimeter
  lepton-hadron separation > 98%

Reconstruction of Λ events

$eN \rightarrow \Lambda^{\uparrow} X$

1995-2000 data
(all targets except Xe)





Background suppression:
Cherenkov information +
vertex cuts

$N_{\Lambda} \approx 250k$ $N_{\bar{\Lambda}} \approx 50k$

Longitudinal Λ Polarisation

Parity violating decay $\Lambda \to \pi^- p$: p preferentially emitted along Λ spin

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

$\alpha = 0.642 \pm 0.013$

$\gamma^* \vec{N} \to \vec{\Lambda} X$

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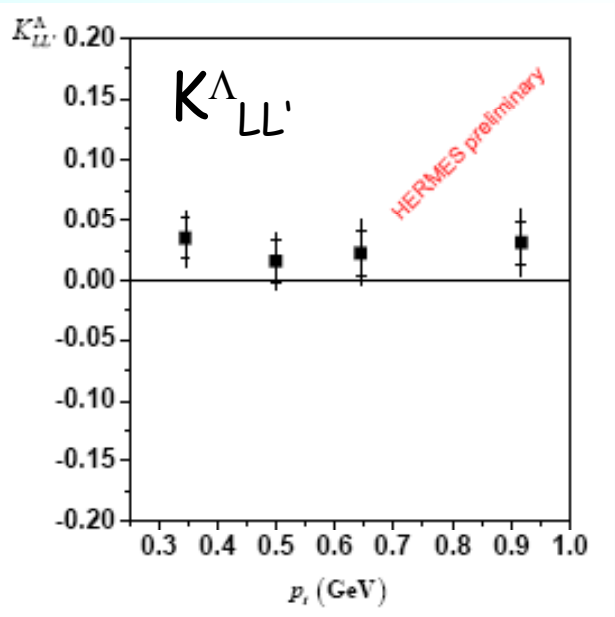
$D^{\Lambda}_{LL'} = 0.19 \pm 0.04$



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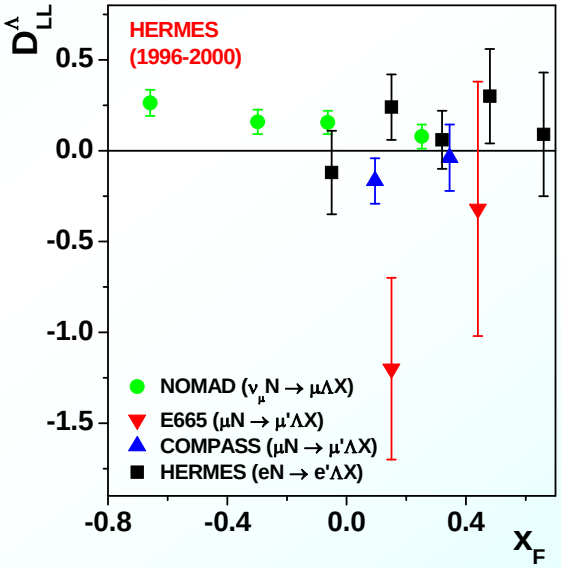
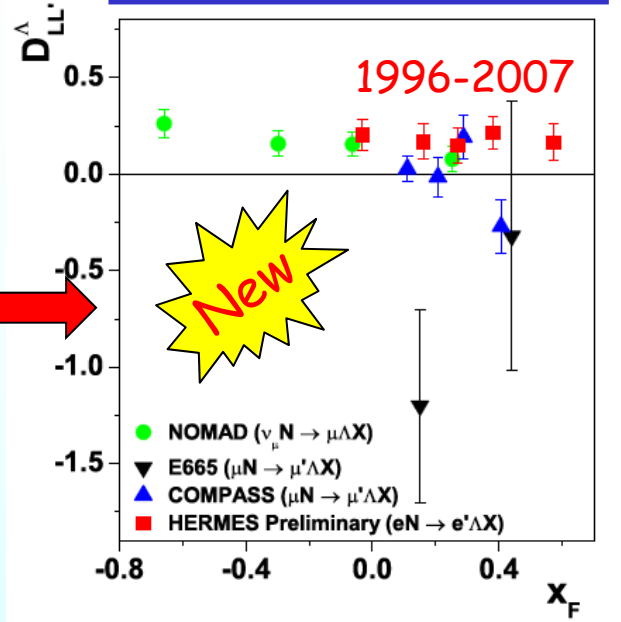




$N_\Lambda = 8200$

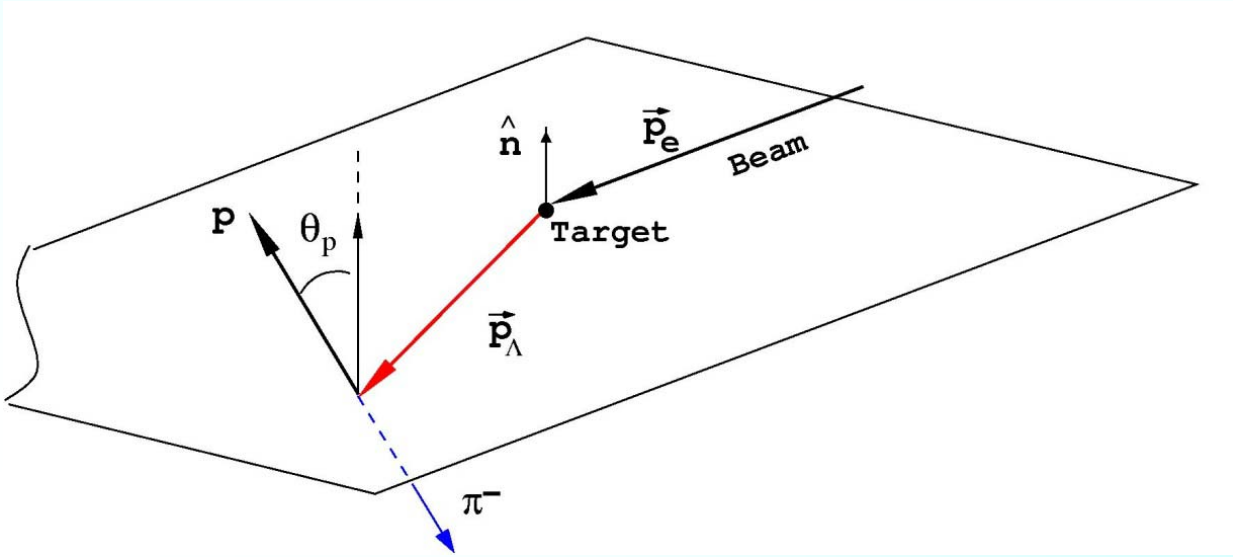
$N_\Lambda = 67000$

Transverse Λ polarisation

$eN \rightarrow \Lambda^{\uparrow} X$

- Quasi-real photoproduction: $Q^2 < 0.05\ GeV^2$, $< \nu >= 15.6\,GeV$ for 80% of events
- Unpolarised beam and target ($P_B P_T = 0.0000 \pm 0.0005$):

  Spontaneous polarisation is directed along $\hat{n}$



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

Extraction of Λ polarisation

Formalism (moments) is based on up/down mirror (geometrical) symmetry of the detector

$$< \cos\theta >_0^{up} = - < \cos\theta >_0^{down}$$

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

Kinematical dependences of P_Λ

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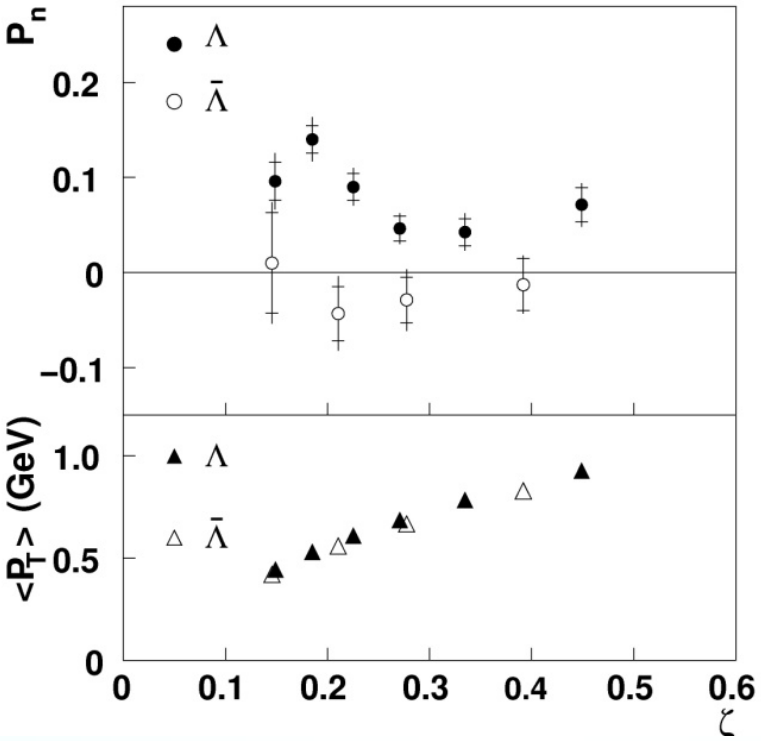
1995-2000 data (all targets except Xe)



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

ζ and x_F are correlated
$\zeta > 0.25 \leftrightarrow x_F > 0$

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

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

- $P_n(\Lambda)$ is positive
- Opposite sign compared to pion and proton beams
- Same sign as for K^- ($\bar{u}s$) and Σ^- (dds) beams
- Origin: *s*-quark content of γ ?

Kinematical dependences of P_Λ

1995-2000 data (all targets except Xe)

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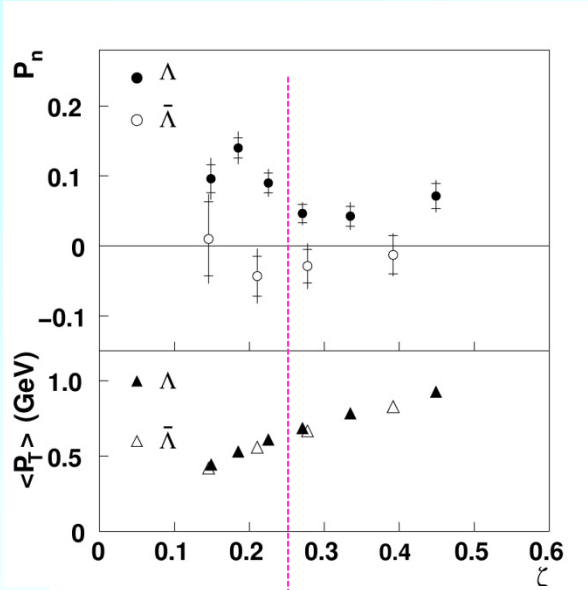
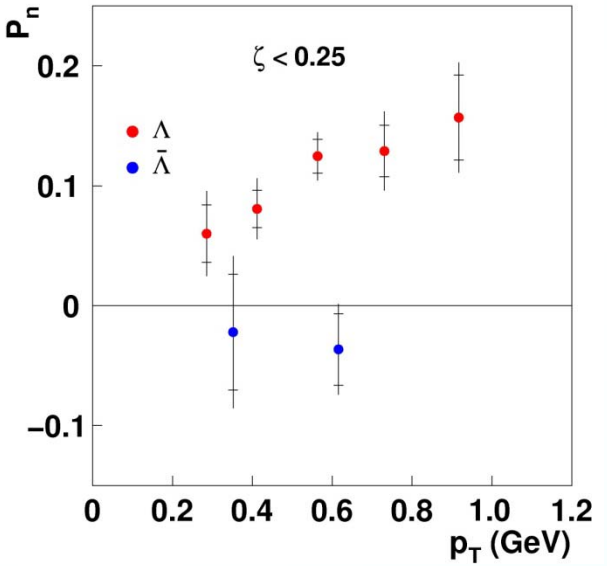
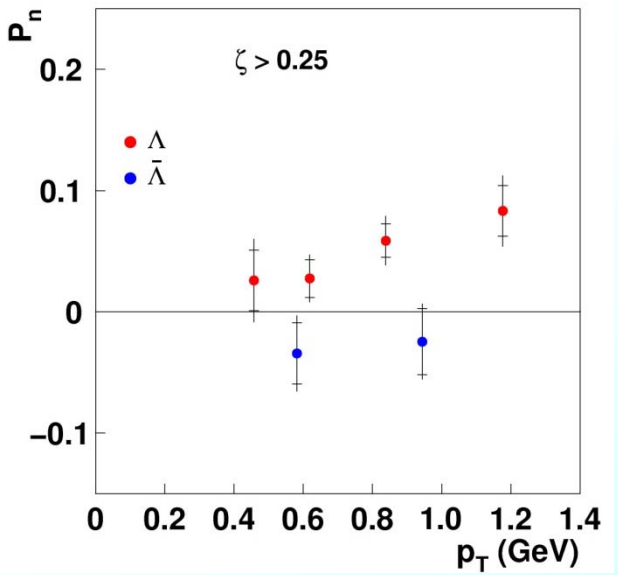
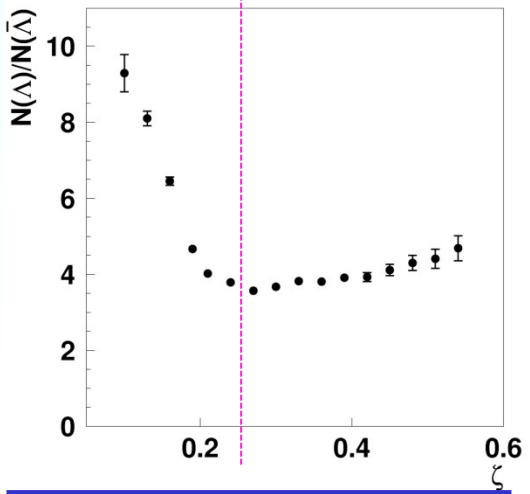








$\zeta = (E_\Lambda + p_{z\Lambda}) / (E_e + p_e)$

$P_n(\Lambda)$ increases with increasing p_T

$P_n(\Lambda)$ is larger for low ξ (target fragm.) than for high ξ (current fragmentation)

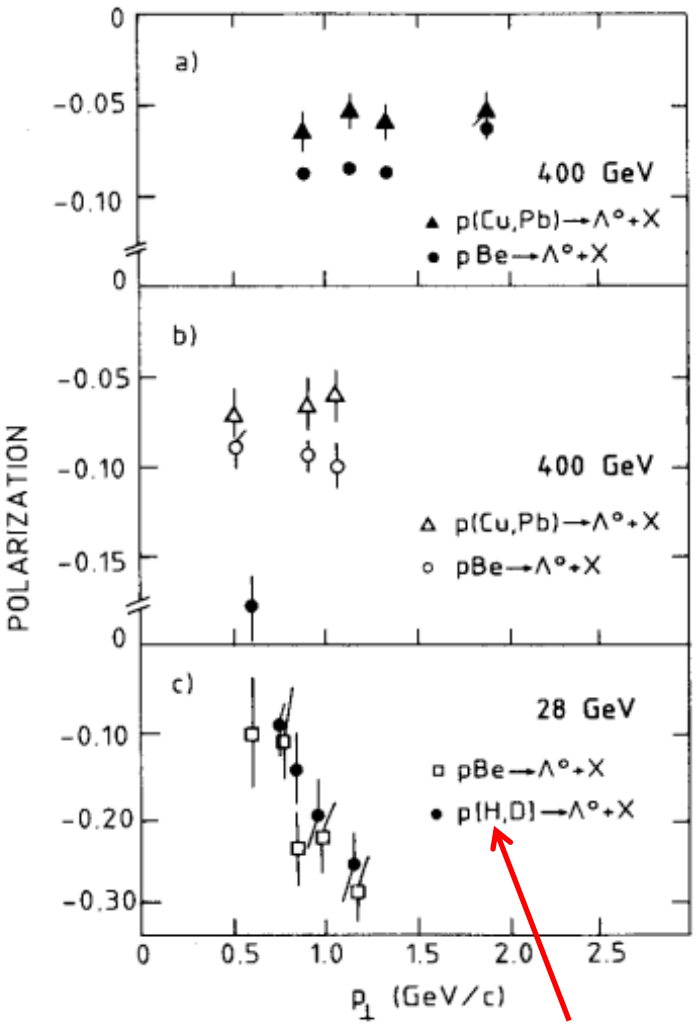
A dependence of P_Λ in pA collisions

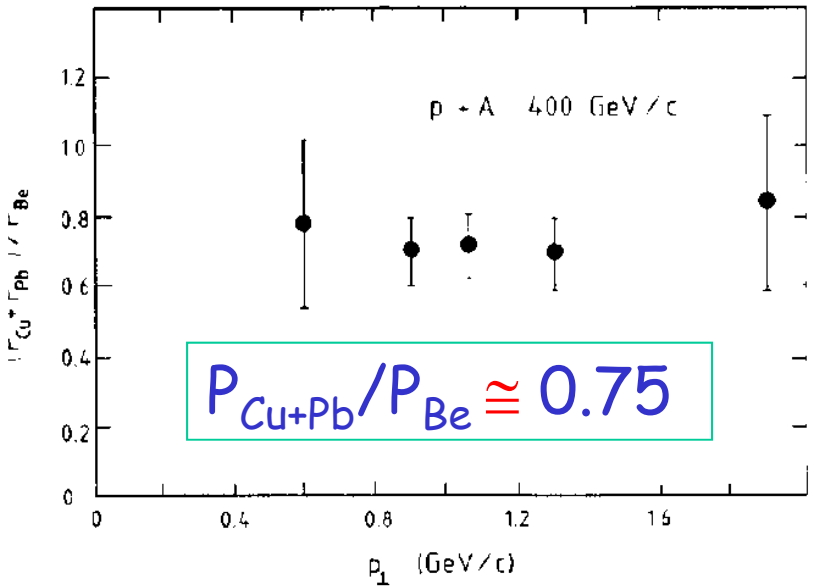
Experiment @ FNAL

$p\,A \rightarrow \Lambda^{\uparrow} X$

(targets Cu, Pb, Be)

p_{beam} = 400 GeV





$P_{Cu+Pb}/P_{Be} \cong 0.75$

Experiment @ BNL

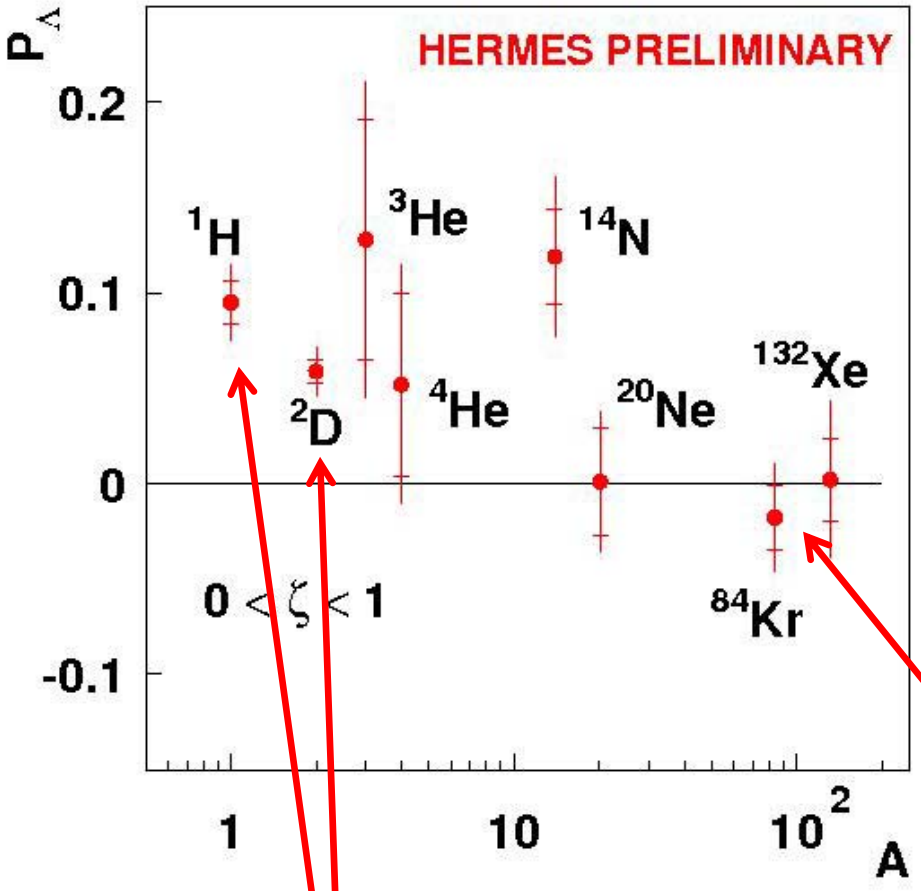
$p\,A \rightarrow \Lambda^{\uparrow} X$

(targets H, D, Be)

p_{beam} = 28 GeV

$P_\Lambda(^1H) \cong P_\Lambda(^2H)$

A dependence of Λ polarisation



1995-2005 data; $N_\Lambda \approx 385k$

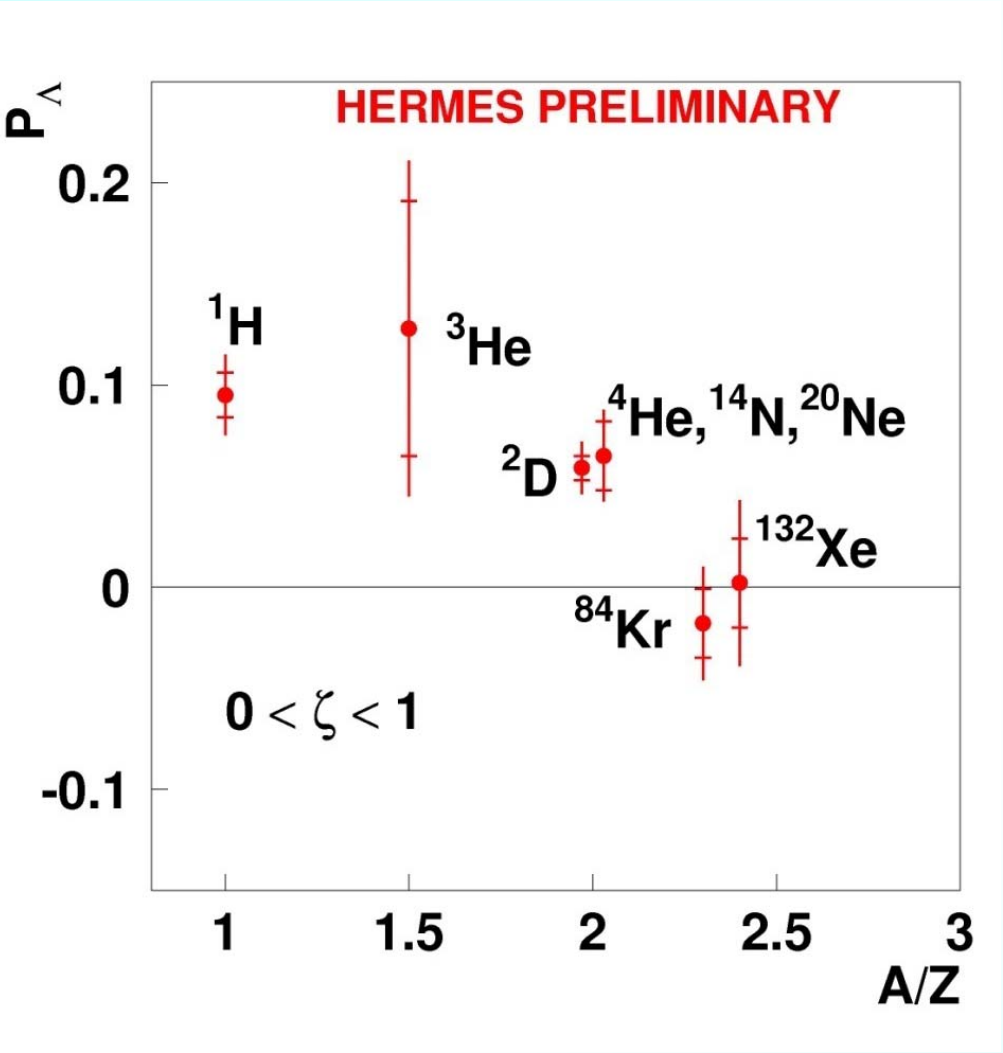
(50 % more D + 25k Kr, 17k Xe)

$P_\Lambda(^1H) \gg P_\Lambda(^2H)$

$P_\Lambda(n) \ll P_\Lambda(p)$?

P_Λ compatible with zero for large A

A/Z dependence of Λ polarisation



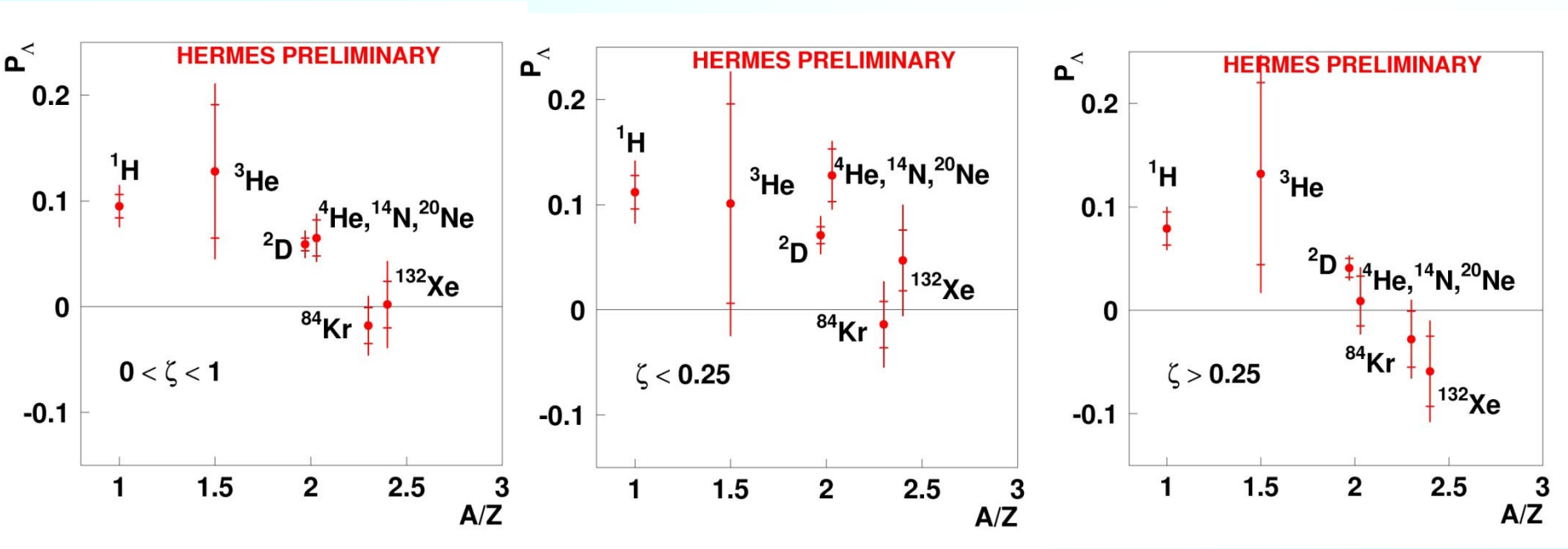
$P_\Lambda(n)$ << $P_\Lambda(p)$ not sufficient to explain vanishing P_Λ for large *A*

Additional nuclear medium effects required for explanation,
P_Λ destroyed by FSI ?

Summary

- Longitudinal spin transfer $D^{\Lambda}_{LL'}$ significantly different from zero at $x_F > 0$: $D^{\Lambda}_{LL'} = 0.19 \pm 0.04$
- Transverse Λ polarisation observed in quasi-real photoproduction
- $P_n(\Lambda)$ is positive. Same sign as for K^- (us) and Σ^- (dds) beams. Origin: s -quark content of γ ?
- $P_\Lambda(^1H) \gg P_\Lambda(^2H)$ ⇒ $P_n(\Lambda)$ for neutrons substantially smaller than for protons ?
- Nuclear medium effects:
  $P_n(\Lambda)$ appears to vanish for large A (A/Z)

A/Z dependence of Λ polarisation



A dependence of Λ polarisation