Measurement of Ξ^- polarization and decay parameter β_Ξ in $\Xi^- \to \Lambda\pi^-$

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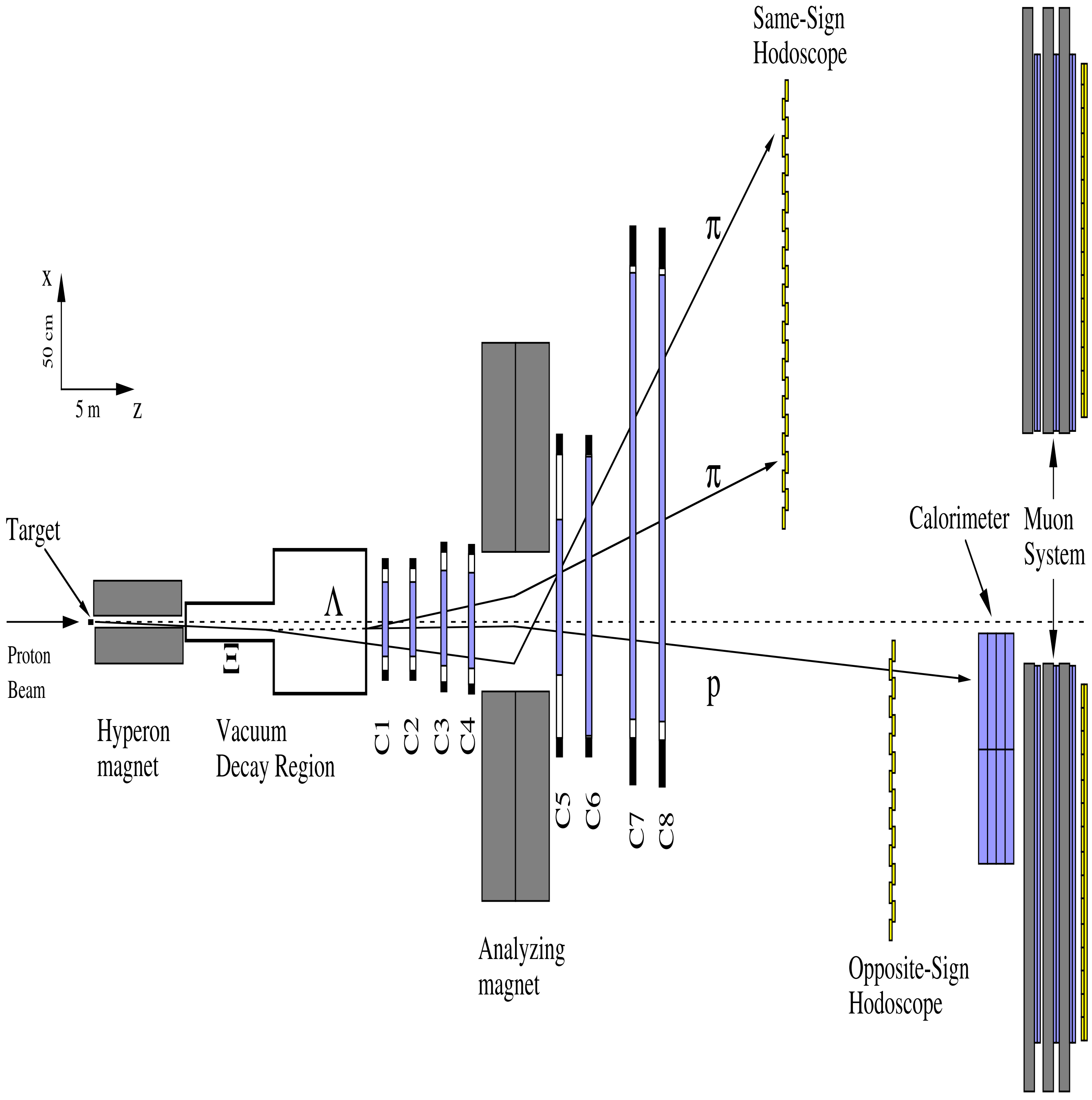


Same-Sign
Hodoscope
x
50 cm
5 m
z
π
π
Target
Λ
Ξ
p
Proton
Beam
Hyperon
magnet
Vacuum
Decay Region
C1
C2
C3
C4
C5
C6
C7
C8
Analyzing
magnet
Calorimeter
Muon
System
Opposite-Sign
Hodoscope

Purpose:

- The *HyperCP* experiment can measure the decay parameter β_Ξ with polarized data so as to allow us to estimate the $\Lambda\pi$ scattering strong phase shift difference :

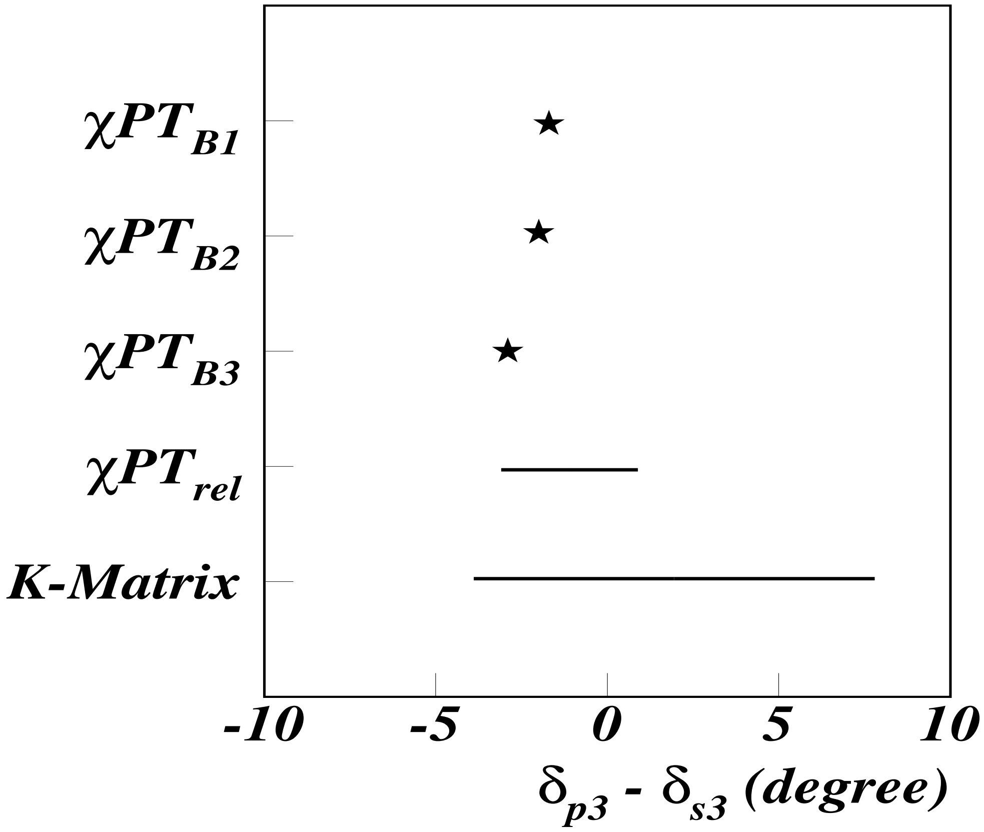
$$(\delta_{p3} - \delta_{s3})$$

- No direct way to measure $\Lambda\pi$ scattering
- Need to isolate the Λ and Ξ contribution to the CP-odd effect in the $\Xi - \Lambda$ decay sequence

$$A_{\Xi\Lambda} = \frac{\alpha_\Xi \alpha_\Lambda - \alpha_{\bar{\Xi}} \alpha_{\bar{\Lambda}}}{\alpha_\Xi \alpha_\Lambda + \alpha_{\bar{\Xi}} \alpha_{\bar{\Lambda}}} \approx A_\Xi + A_\Lambda$$

$$A_\Xi = -tan(\delta_{p3} - \delta_{s3}) sin(\phi_{p1} - \phi_{s1})$$

Theoretical Prediction of Strong phase shift difference



$\Longrightarrow$ Our measurement of β_{Ξ} would reduce the theoretical uncertainty in predicting the size of the *CP-odd* effect in the Ξ^- decay.

Physics:

In the decay sequence $\Xi^- \to \Lambda\pi^-$, $\Lambda \to p\pi^-$, the angular distribution of proton at Ξ^- rest frame is

$$\frac{d^2N}{d\Omega_\Lambda\, d\Omega_p} \propto (1 + \alpha_\Xi \vec{P}_\Xi \cdot \hat{\Lambda})(1 + \alpha_\Lambda \vec{P}_\Lambda \cdot \hat{p})$$

$\vec{P}_\Xi$: controlled by beam conditons
$\vec{P}_\Lambda$: aquired through the Ξ^- decay

where

$$\vec{P}_\Lambda = \frac{(\alpha_\Xi + \vec{P}_\Xi \cdot \hat{\Lambda})\hat{\Lambda} + \beta_\Xi \vec{P}_\Xi \times \hat{\Lambda} + \gamma_\Xi \hat{\Lambda} \times (\vec{P}_\Xi \times \hat{\Lambda})}{1 + \alpha_\Xi \vec{P}_\Xi \cdot \hat{\Lambda}}$$

$$\alpha_\Xi = \frac{2Re(s^*p)}{|s|^2 + |p|^2}, \quad \beta_\Xi = \frac{2Im(s^*p)}{|s|^2 + |p|^2}, \quad \gamma_\Xi = \frac{|s|^2 - |p|^2}{|s|^2 + |p|^2}$$

To measure β_Ξ :

$$\frac{dN}{d\cos\theta_p} \propto 1 + \frac{\pi}{4}\alpha_\Lambda \beta_\Xi P_\Xi \cos\theta_\beta \qquad \cos\theta_\beta = \hat{p} \cdot \frac{\vec{P}_\Xi \times \hat{\Lambda}}{|\vec{P}_\Xi \times \hat{\Lambda}|}$$

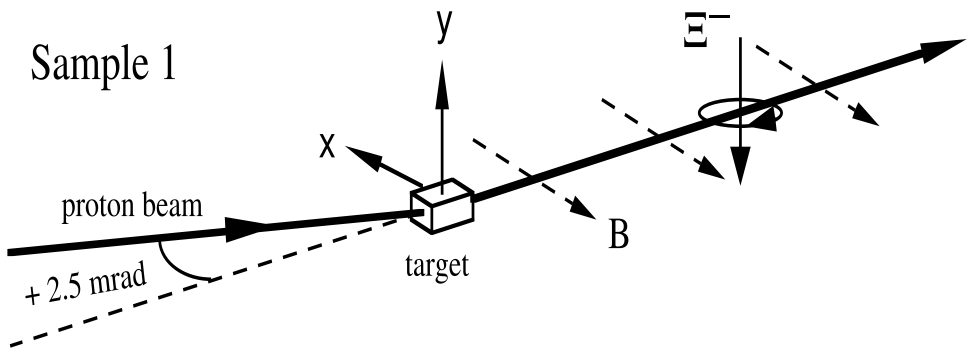
$\vec{P}_\Xi$ must be measured first :

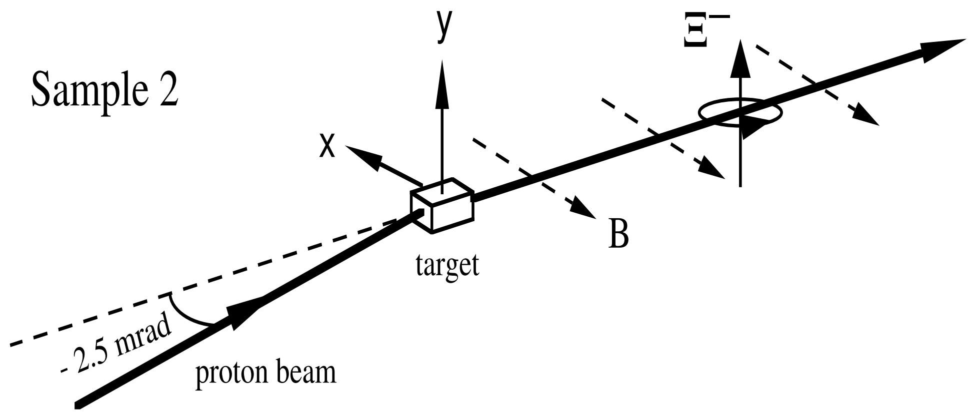
$$\frac{d^2N}{d\Omega_\Lambda d\cos\theta_p} \propto (1 + \alpha_\Xi \vec{P}_\Xi \cdot \hat{\Lambda}) + \alpha_\Lambda(\alpha_\Xi + \vec{P}_\Xi \cdot \hat{\Lambda}) \cos\theta_{p\Lambda}$$

$$\cos\theta_{p\Lambda} = \hat{p} \cdot \hat{\Lambda}$$

Production of Polarized Ξ^-

- The *HyperCP* experiment took polarized data at two different targetting angles.





Production of Polarized Ξ^- (continued)

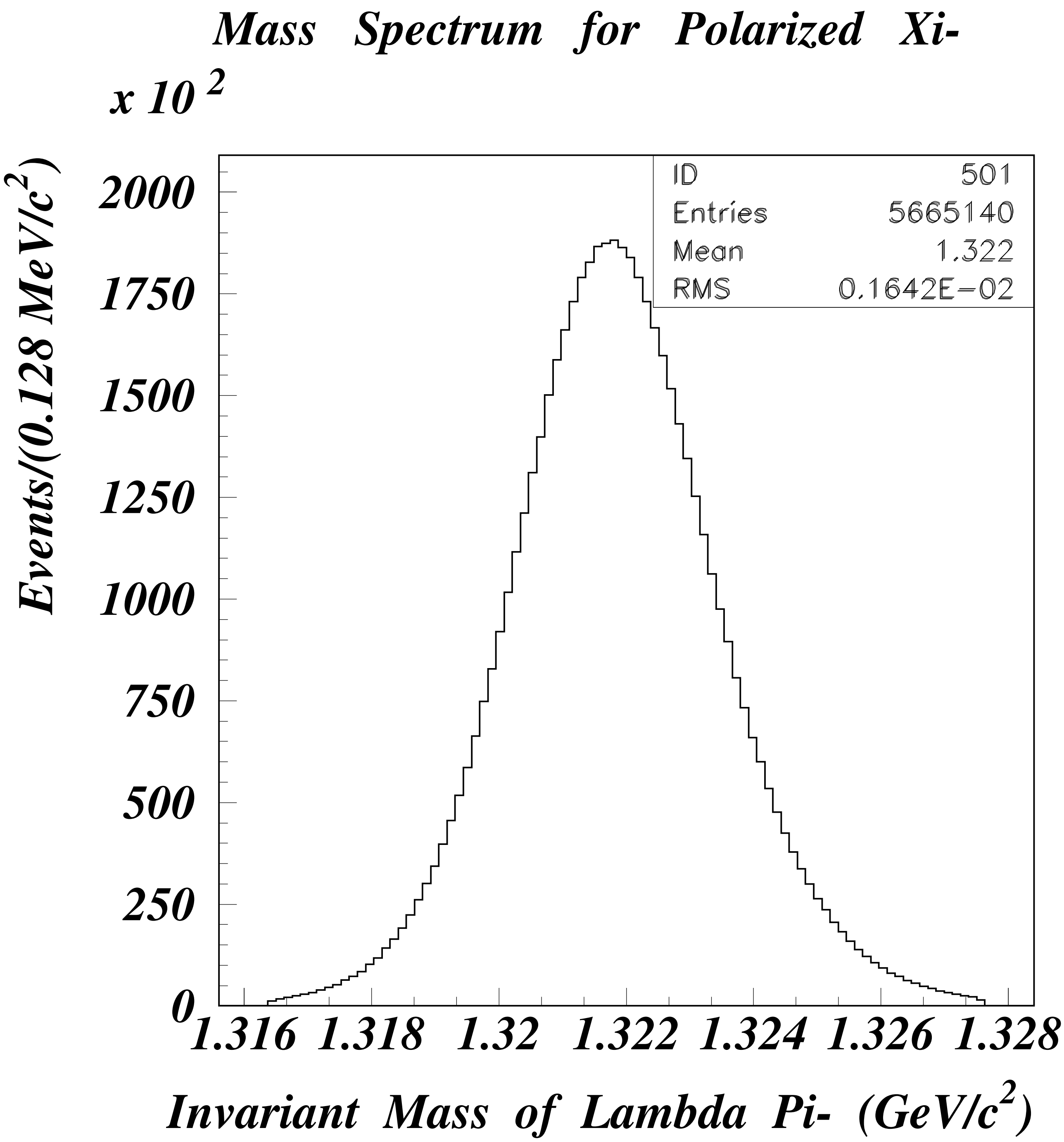
- The average momentum of polarized Ξ^- is

$$< p_\Xi >= 163\ GeV/c$$

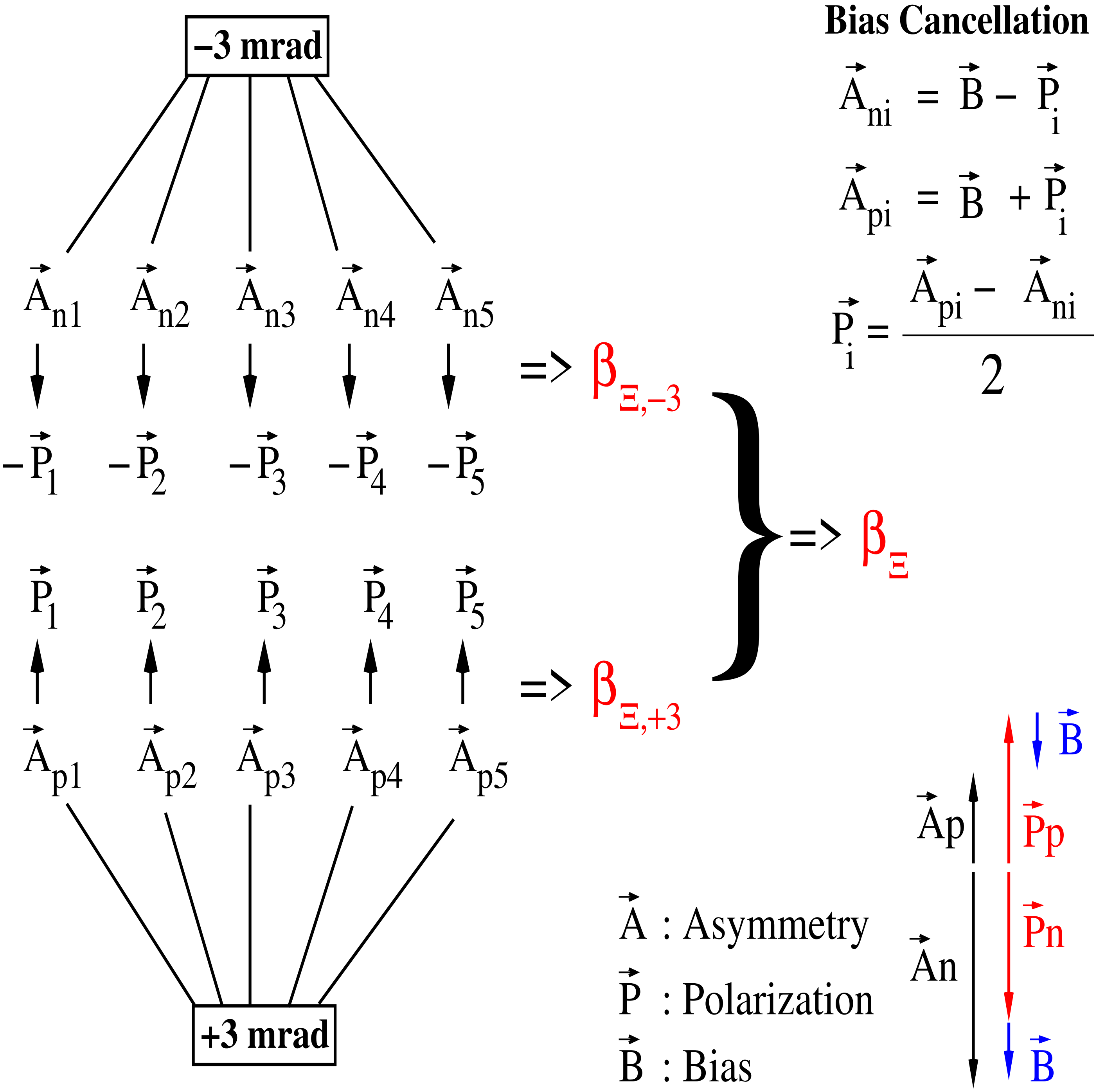
  The average P_t (transverse momentum) of polarized Ξ^- at ± 3 mrad is

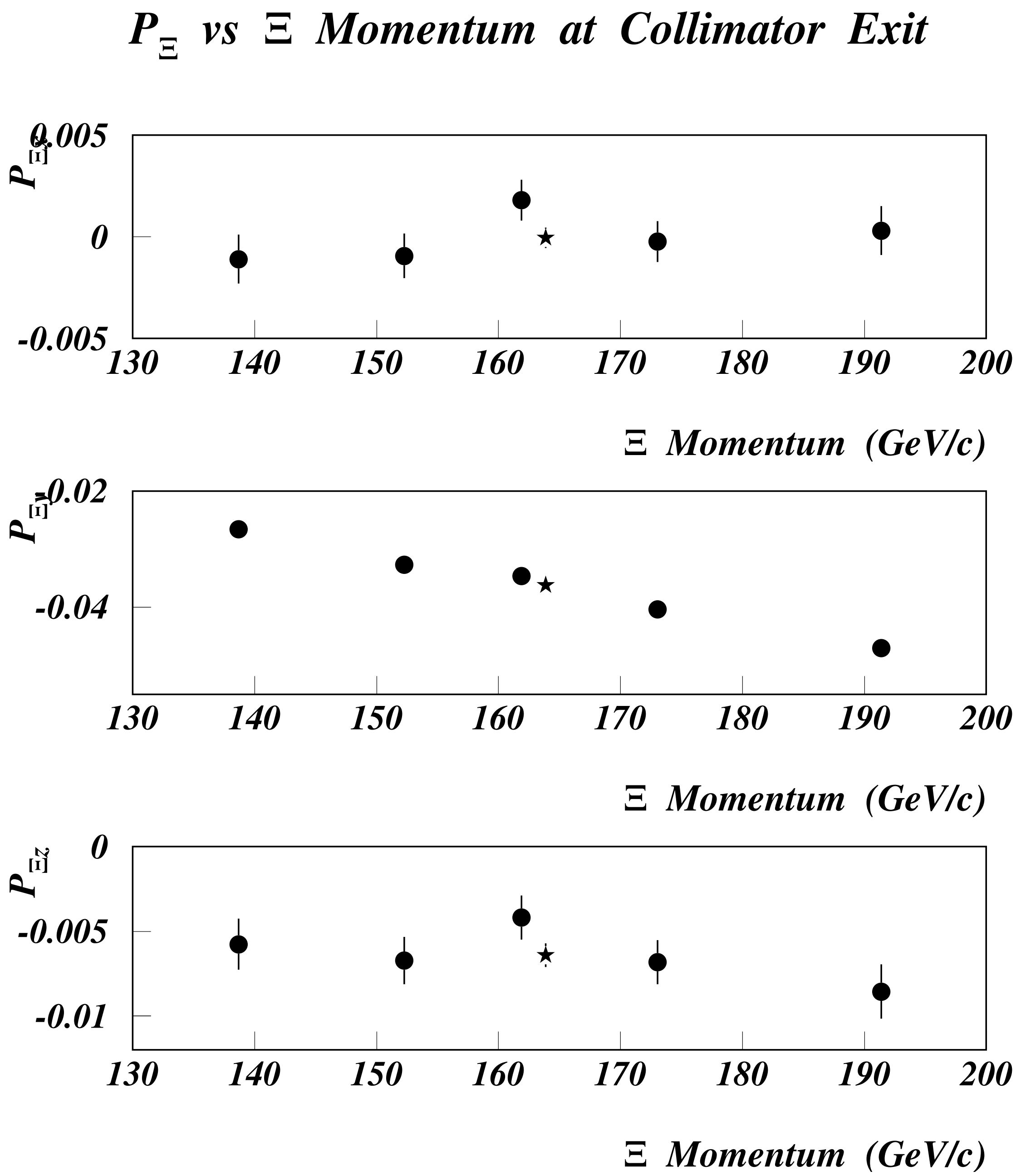
$$< P_t >= 0.456\ GeV/c$$

- After reconstruction and event selection,
  $\approx$ 60 million events of -3 mrad data, and
  $\approx$ 72 million events of +3 mrad data
  were used in the measurement of Ξ^- polarization and decay parameter β_Ξ

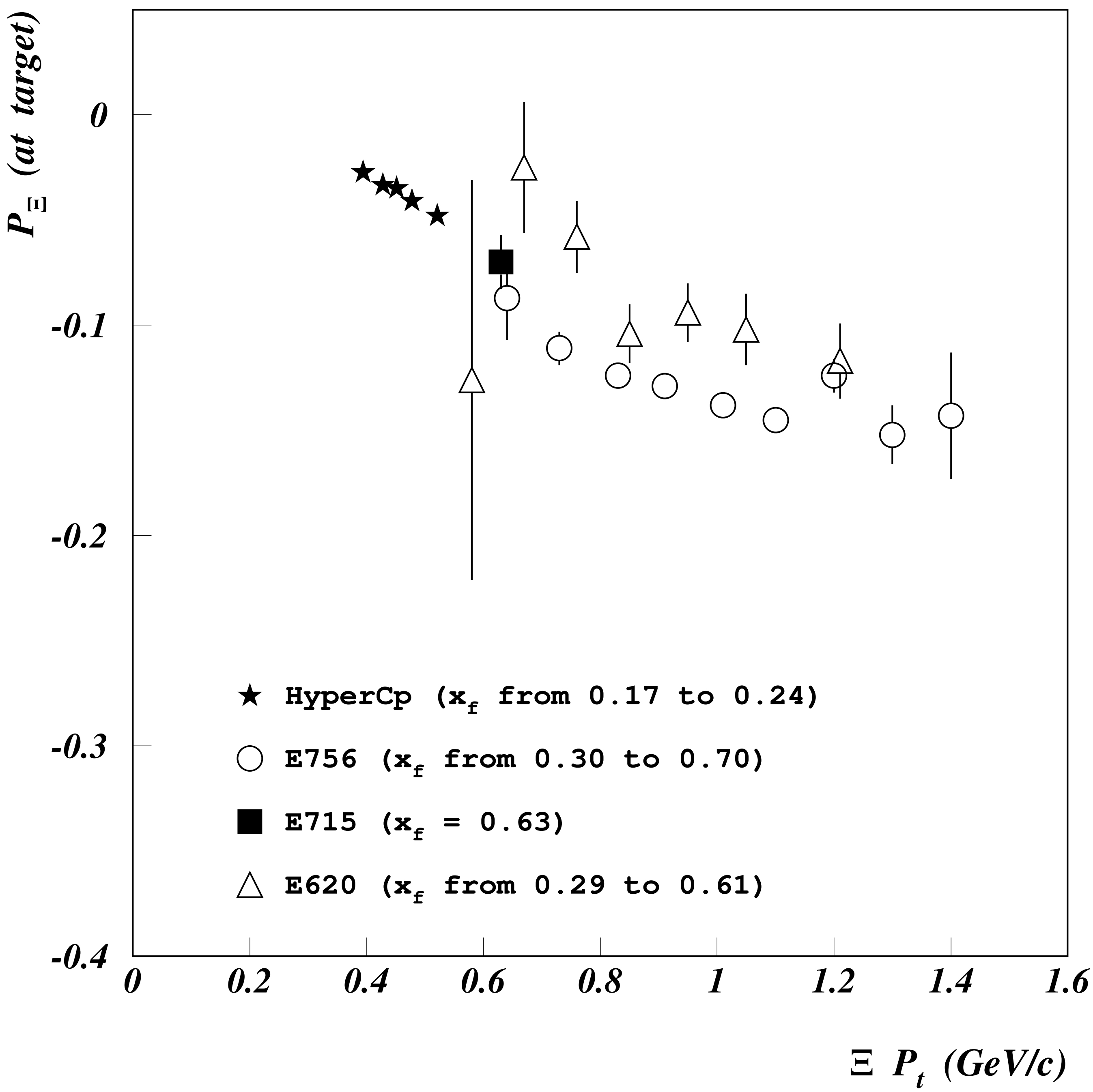

Mass Spectrum for Polarized Xi-
x 10 2
Events/(0.128 MeV/c2)
2000
1750
1500
1250
1000
750
500
250
0
ID 501
Entries 5665140
Mean 1.322
RMS 0.1642E-02
1.316 1.318 1.32 1.322 1.324 1.326 1.328
Invariant Mass of Lambda Pi- (GeV/c2)

Analysis Approach



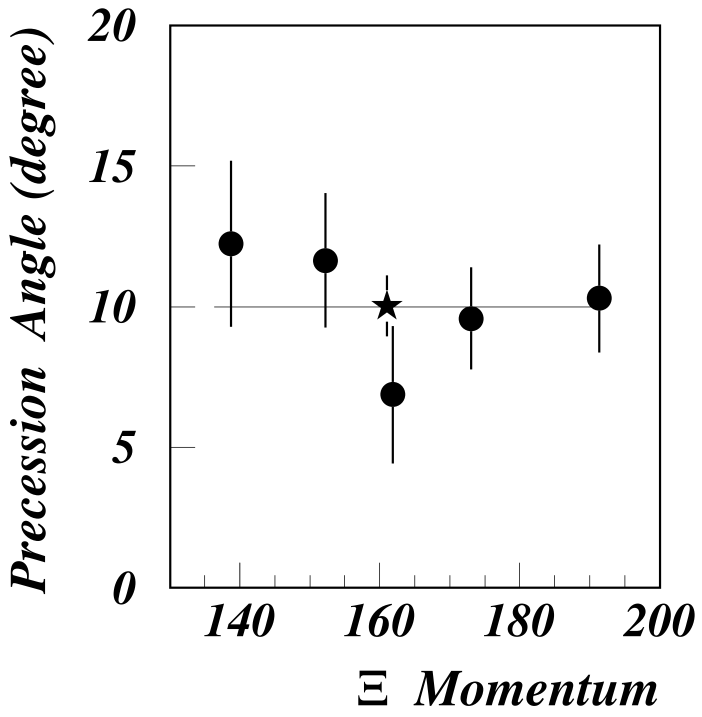


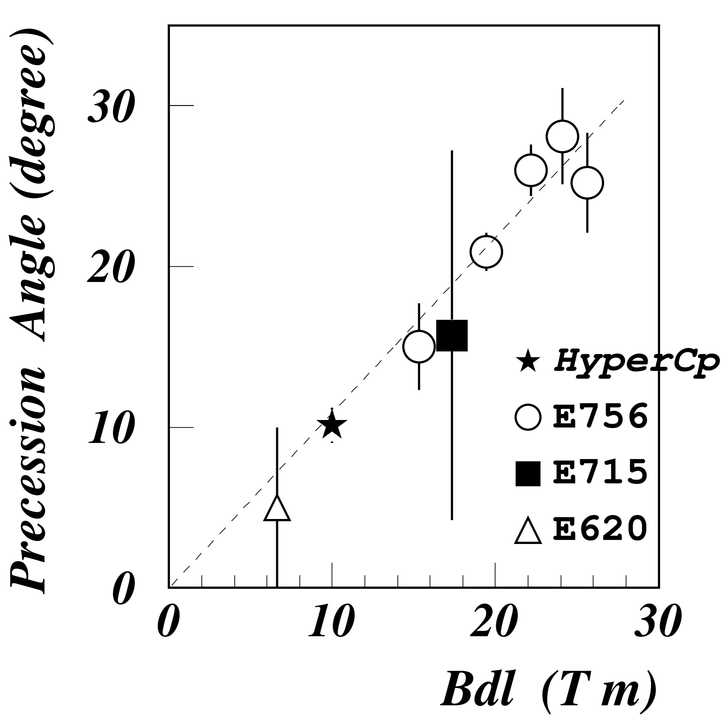
$$P_t \approx p_\Xi \times \theta_{prod}\ , \quad \theta_{prod} = 3\ mrad$$


P_Ξ (at target)
0
-0.1
-0.2
-0.3
-0.4
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
HyperCp (x_f from 0.17 to 0.24)
E756 (x_f from 0.30 to 0.70)
E715 (x_f = 0.63)
E620 (x_f from 0.29 to 0.61)
Ξ P_t (GeV/c)

Polarized Ξ^- precesses in the magnetic field of the collimator :

$$\Phi = tan^{-1}(P_{\Xi Z}/P_{\Xi Y}) \propto \oint Bdl$$





$$\Phi_{measure} = 10^o \pm 1^o \ (stat.)$$

at $\oint Bdl = 10 \ Tm$.

β_Ξ *Measurement* :

- A polarized Ξ^- data sample can allow us to measure β_Ξ :

$$\frac{dN}{d\cos\theta_p} \propto 1 + \frac{\pi}{4}\alpha_\Lambda \beta_\Xi P_\Xi \cos\theta_\beta$$

where

$$\cos\theta_\beta = \hat{p} \cdot \frac{\vec{P_\Xi} \times \hat{\Lambda}}{|\vec{P_\Xi} \times \hat{\Lambda}|}$$

- The measurement of β_Ξ is in progress

Conclusions:

With $\sim$ 130 million polarized Ξ^- events, we have **Preliminary results** :

1. the Ξ^-'s produced by 800 GeV/c protons at target were polarized with an average polarization of

$$P_\Xi = -0.0370 \pm 0.0005 \; (stat.)$$

$$\text{at} < P_t >= 0.456 \; GeV/c$$

2. The precession angle was determined as

$$\Phi = 10^o \pm 1^o \; (stat.)$$

$$\text{at} \oint Bdl = 10 \; Tm$$

3. - β_Ξ measurement
   - Study of systematic error

   in progress