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Simulations of $\bar{\mathrm{p}}\mathrm{p} \to \bar{\Lambda}\Lambda$

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Outline

1. Reconstruction of Λ polarisation in $\bar{\mathrm{p}}\mathrm{p} \rightarrow \bar{\Lambda}\Lambda \rightarrow \bar{\mathrm{p}}\pi^{+}\mathrm{p}\pi^{-}$
2. Simulations at 1.64 GeV
3. Conclusions
4. Outlook

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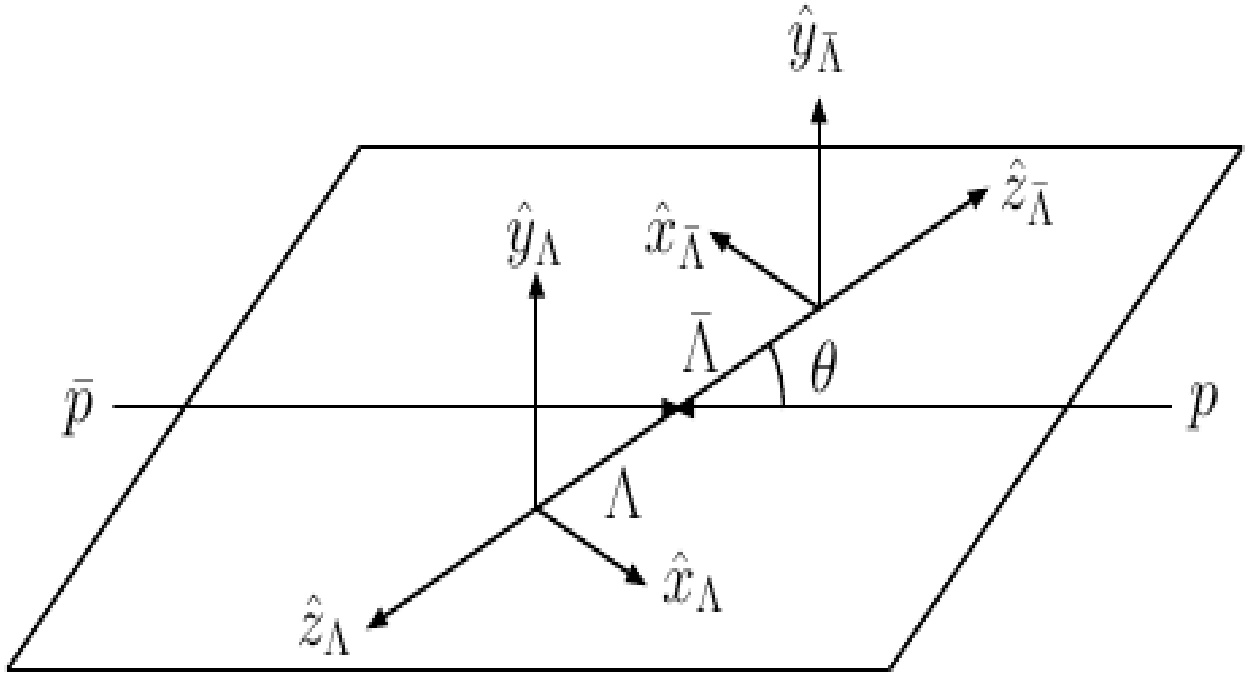
Reconstruction of Λ polarisation in $\bar{\mathrm{p}}\mathrm{p} \to \bar{\Lambda}\Lambda \to \bar{\mathrm{p}}\pi^{+}\mathrm{p}\pi^{-}$

- $\Lambda \to p\pi^{-}$
- weak decay $\to$ parity violation

$$I(\theta_{\mathrm{p}}) = \frac{1}{4\pi}\left(1 + \alpha P \cos\theta_{\mathrm{p}}\right) \tag{1}$$

  where $\alpha = 0.64$ for Λ (and $\alpha = -0.64$ for $\bar{\Lambda}$)
- $p\bar{p} \to \Lambda\bar{\Lambda}$
- unpolarised beam and target $\to$ Λ polarisation can only be measured in the direction transverse to the production plane

Definition of the $\Lambda/\bar{\Lambda}$ rest frame



$$\begin{aligned} \hat{x} &= \hat{y} \times \hat{z} \\ \hat{y} &= \frac{\bar{k}_i \times \bar{k}_\Lambda}{|\bar{k}_i \times \bar{k}_\Lambda|} \\ \hat{z} &= \hat{k}_j \end{aligned} \tag{2}$$

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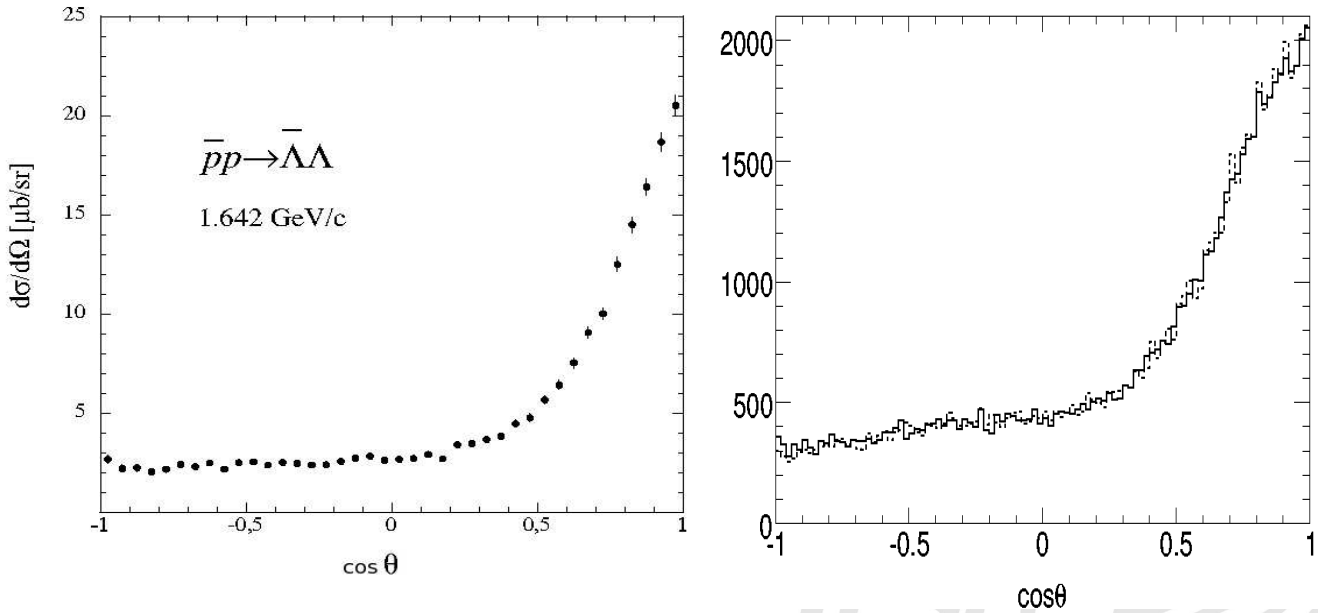
Simulations at 1.64 GeV

- Release 0.13.1
- Subdetectors used for reconstruction: MVD, STT, two MDC in target spectrometer and six MDC in forward spectrometer
- Events produced by modified generator, originally used at the PS185 experiment
- 100% polarisation
- Angular distribution of Λ from PS185 experiment

$\bar{\Lambda}$ angular distribution

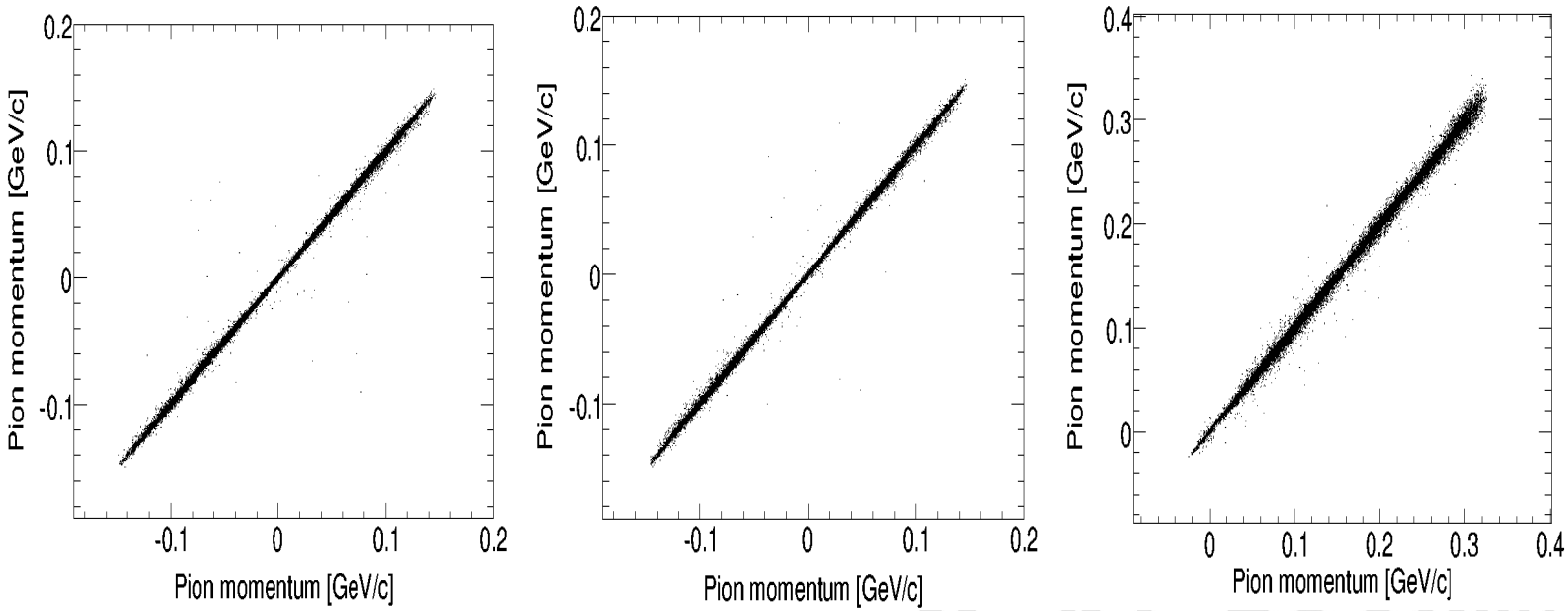
$1.10 < m_\Lambda < 1.13$, $P(\chi^2) > 0.001$
Efficiency 35%, Background 0.6%



Angular distribution of $\bar{\Lambda}$ from the PS185 experiment and from the simulation.

Reconstruction of π^+ momentum

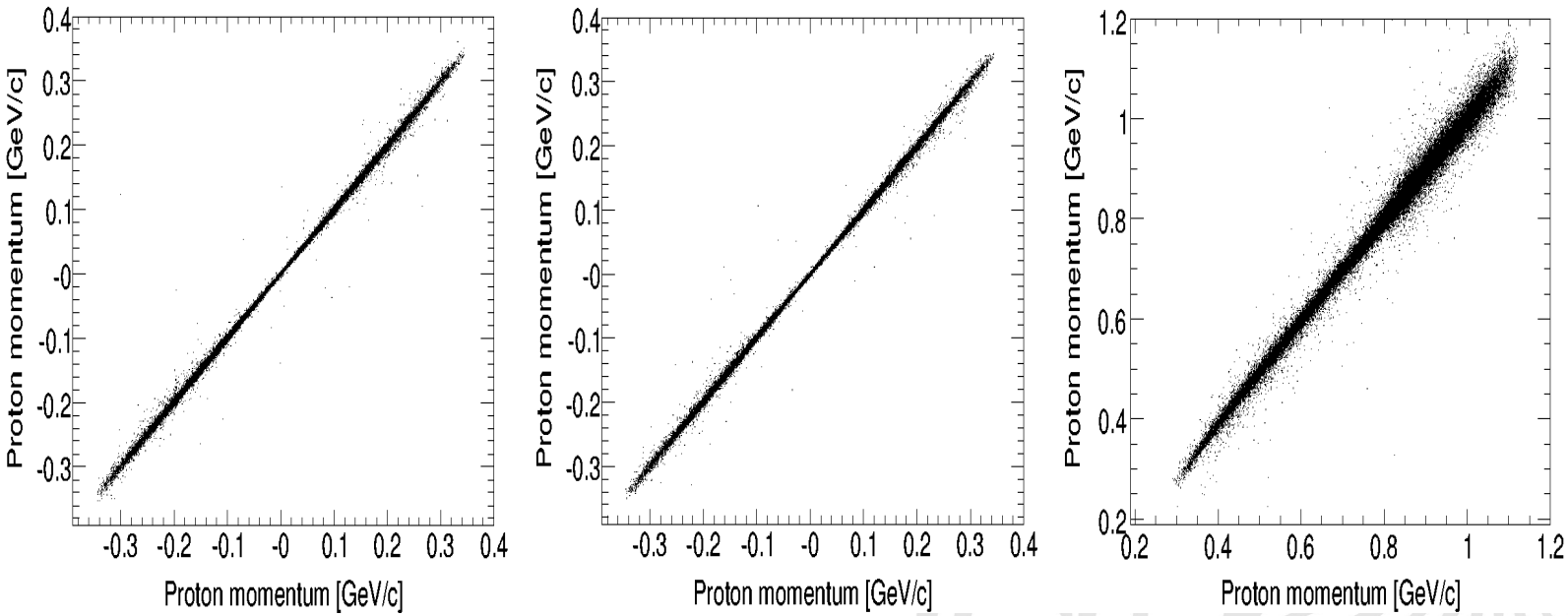
$\sigma \approx 1$ MeV/c $\sigma \approx 1$ MeV/c $\sigma \approx 2$ MeV/c



Reconstructed π^+ momentum vs MC π^+ momentum in x-, y- and z-direction.

Reconstruction of $\bar{p}$ momentum

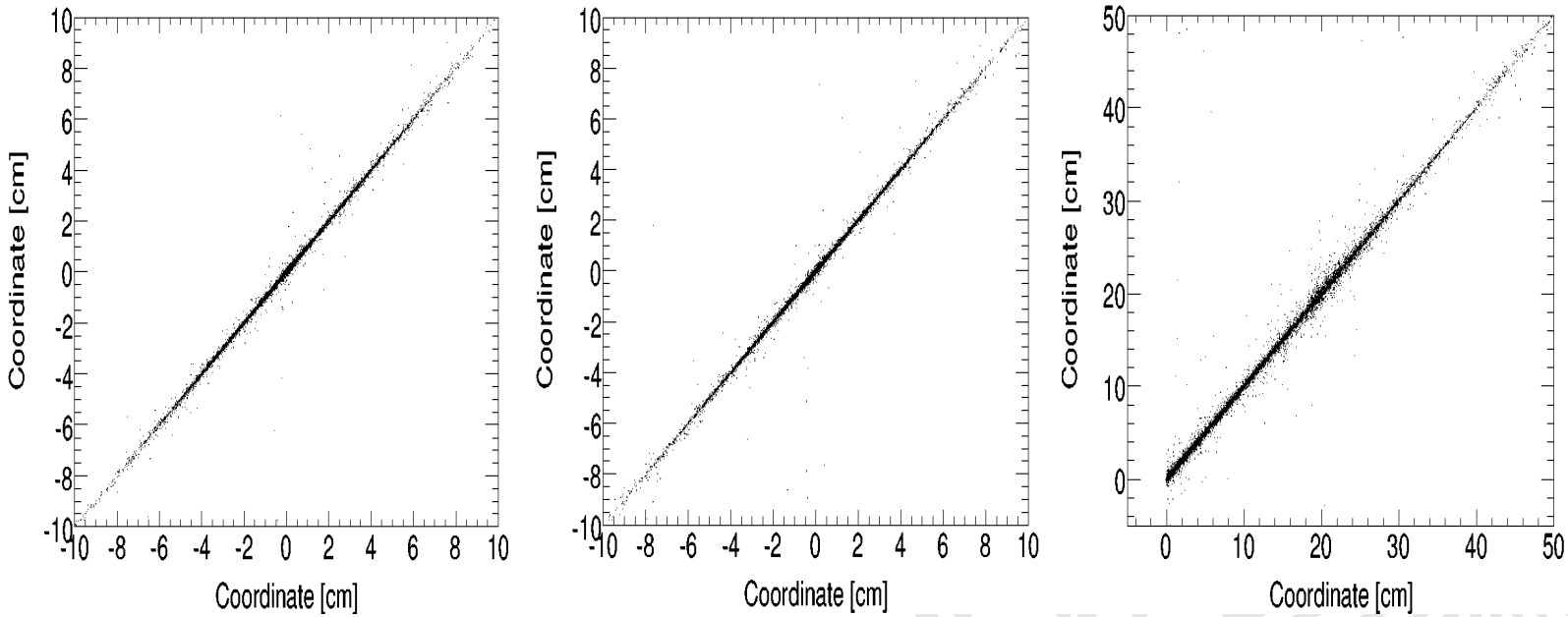
$\sigma \approx 2$ MeV/c $\sigma \approx 2$ MeV/c $\sigma \approx 15$ MeV/c



Reconstructed $\bar{p}$ momentum vs MC $\bar{p}$ momentum in x-, y- and z-direction.

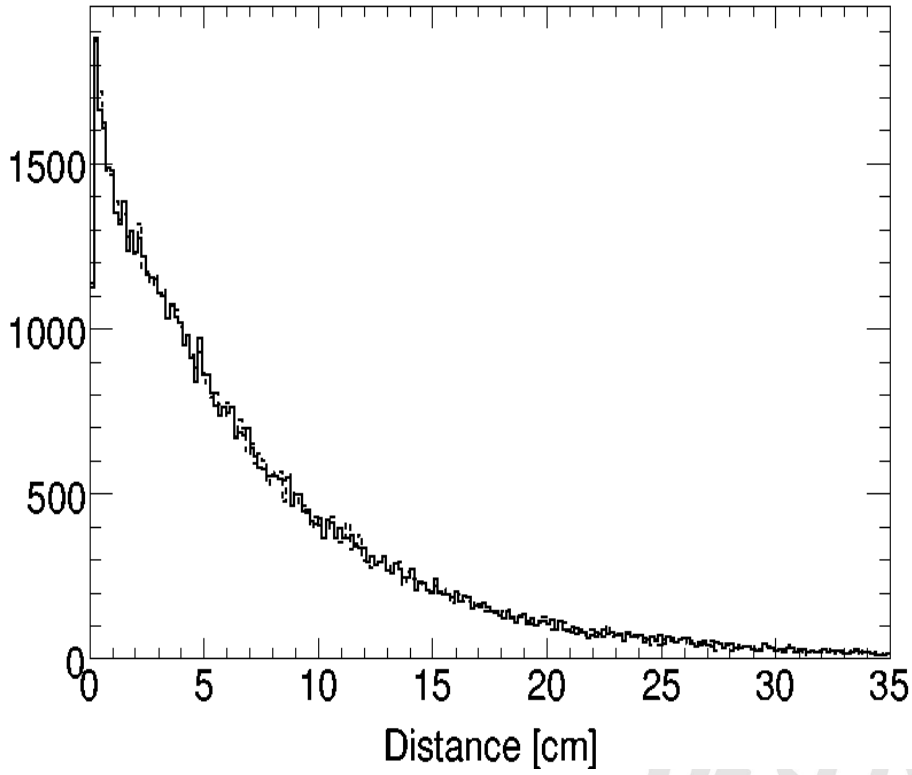
Reconstruction of $\bar{\Lambda}$ decay vertex

$\sigma \approx 0.1$ mm $\sigma \approx 0.1$ mm $\sigma \approx 1$ mm



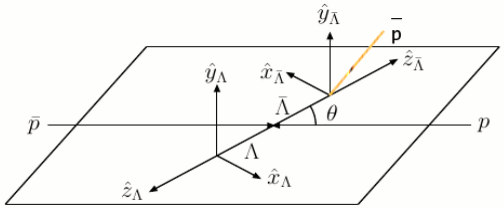
Reconstructed $\bar{\Lambda}$ decay vertex vs MC $\bar{\Lambda}$ decay vertex in x-, y- and z-direction.

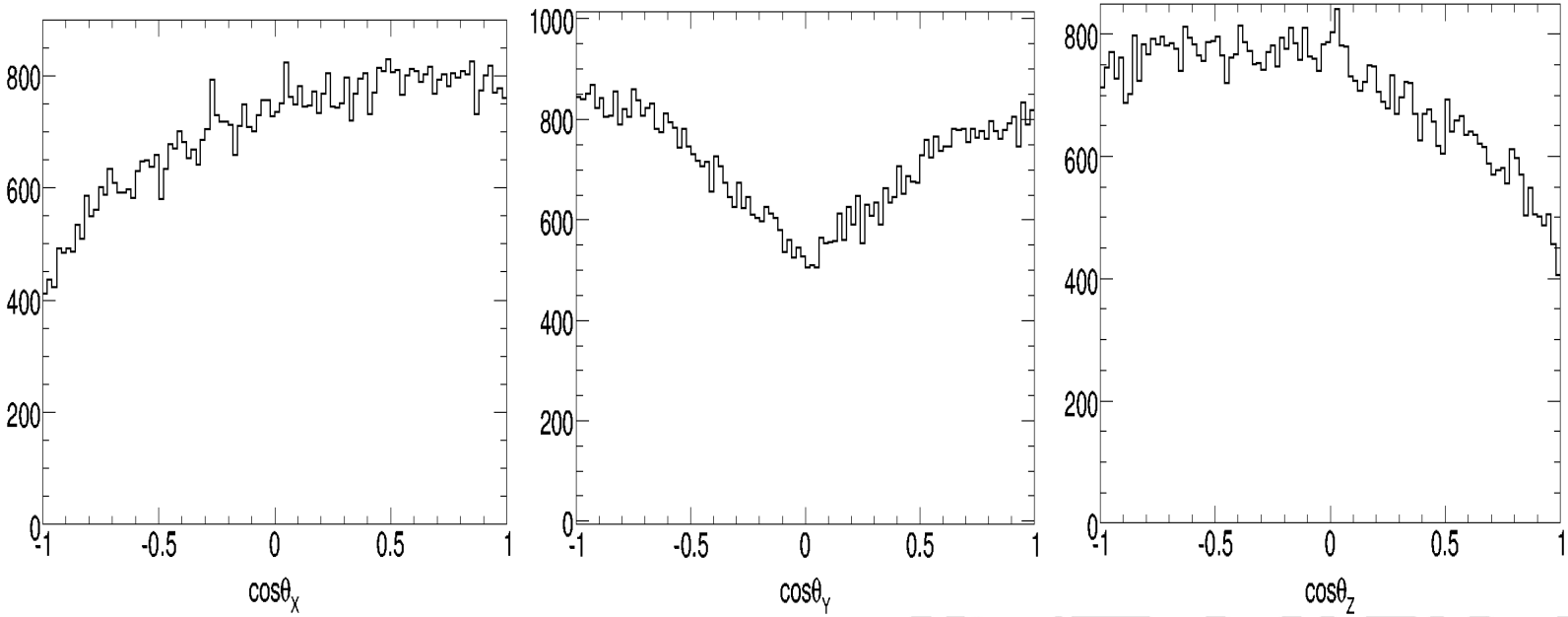
Reconstruction of the $\bar{\Lambda}$ lifetime



Reconstructed $c\tau = 7.45 \pm 0.021$ cm. The measured experimental value is 7.89 cm. The deviation is to be investigated.

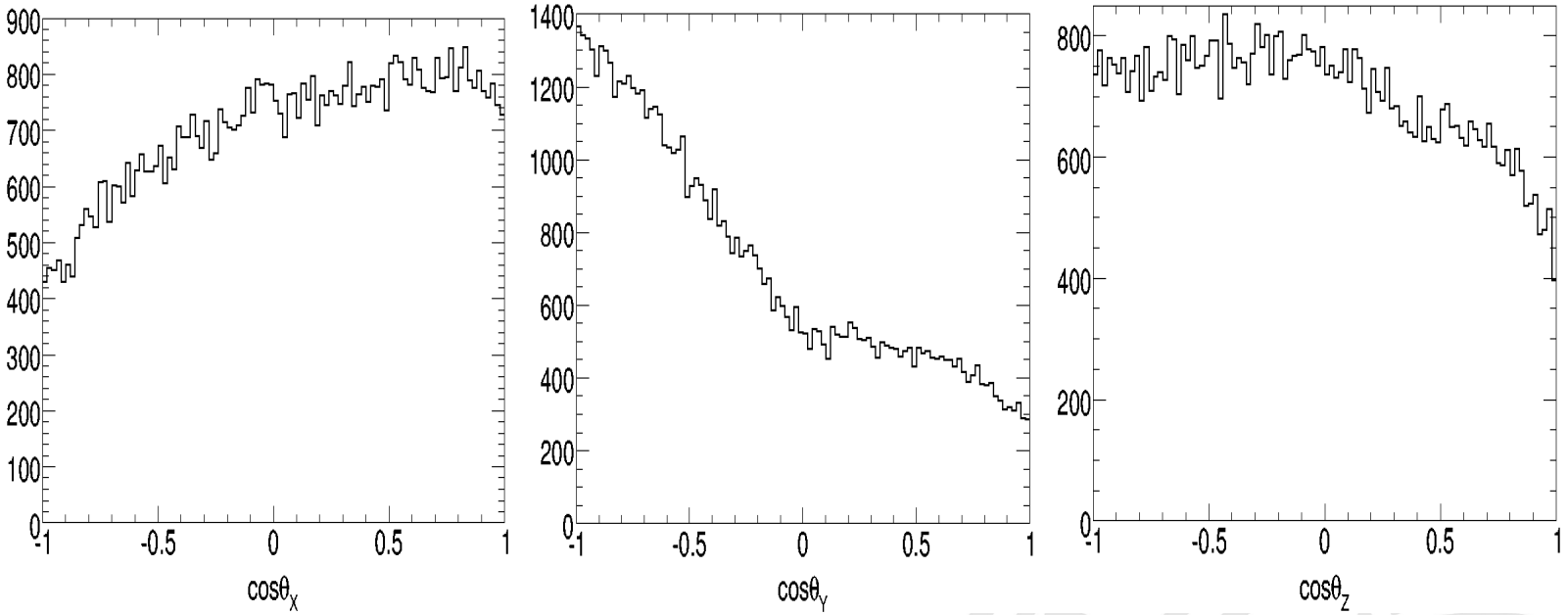
$\cos\Theta_{\bar{p}}$ in $\bar{\Lambda}$ rest frame for unpolarised events





The distributions are not flat due to different detector efficiency for different angles, since events with slow pions are not reconstructed.

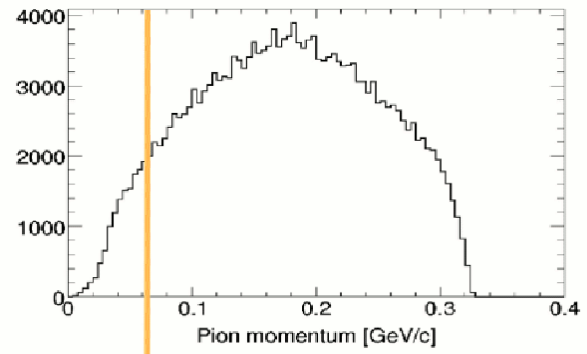
$\cos\Theta_{\bar{p}}$ in $\bar{\Lambda}$ rest frame for polarised events

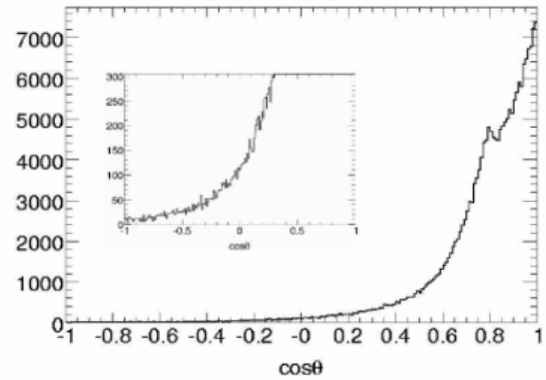


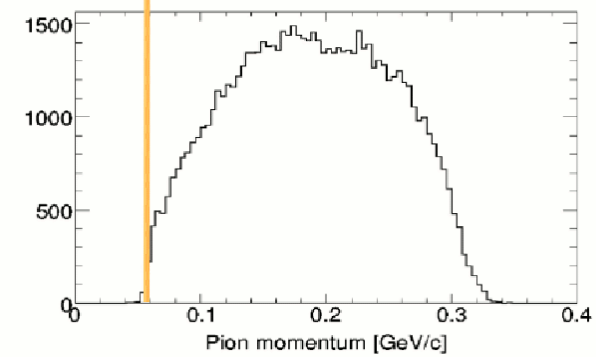
The polarisation is calculated using the method of moments.

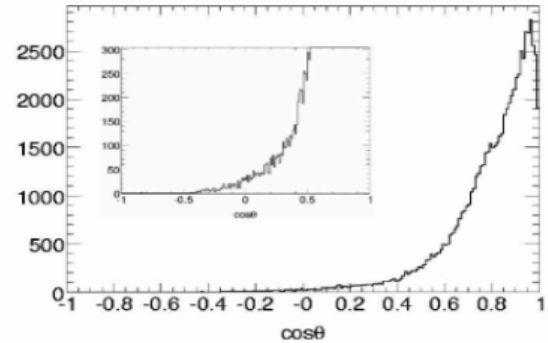
	x-direction	y-direction	z-direction
100% pol	-0.35±0.010	1.2±0.01	0.25±0.010
0% pol	-0.34±0.010	-0.066±0.01	0.28±0.010

Events with slow and backwards pions are not reconstructed









Slow pions are not reconstructed since they will spiral in the detector due to the solenoid field. It could be interesting to use 1 T magnetic field instead of 2 T.

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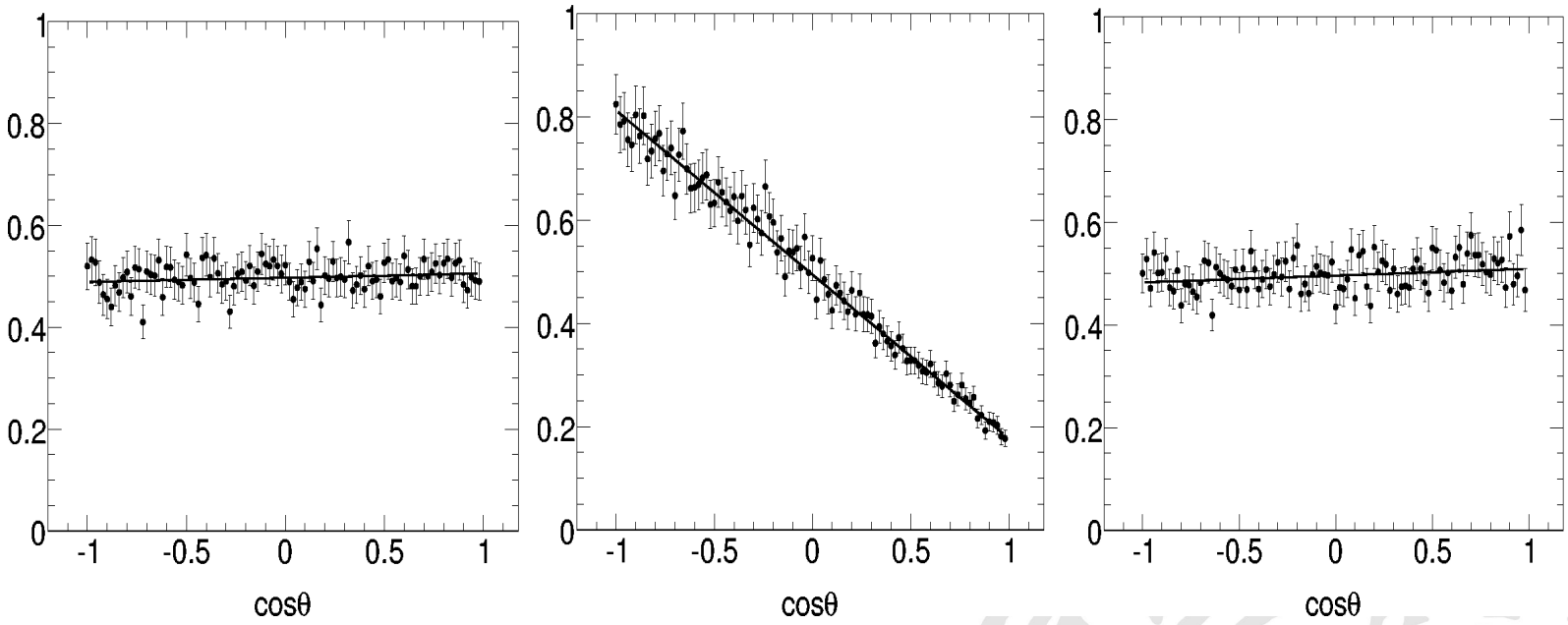
Efficiency calibration

Since the MC truth for the unpolarised events have flat $\cos\Theta_p$ distributions, they can be used to compensate for detector efficiency. The efficiency calibration is done by dividing the bin contents of the polarised events by the bin contents of the unpolarised events.

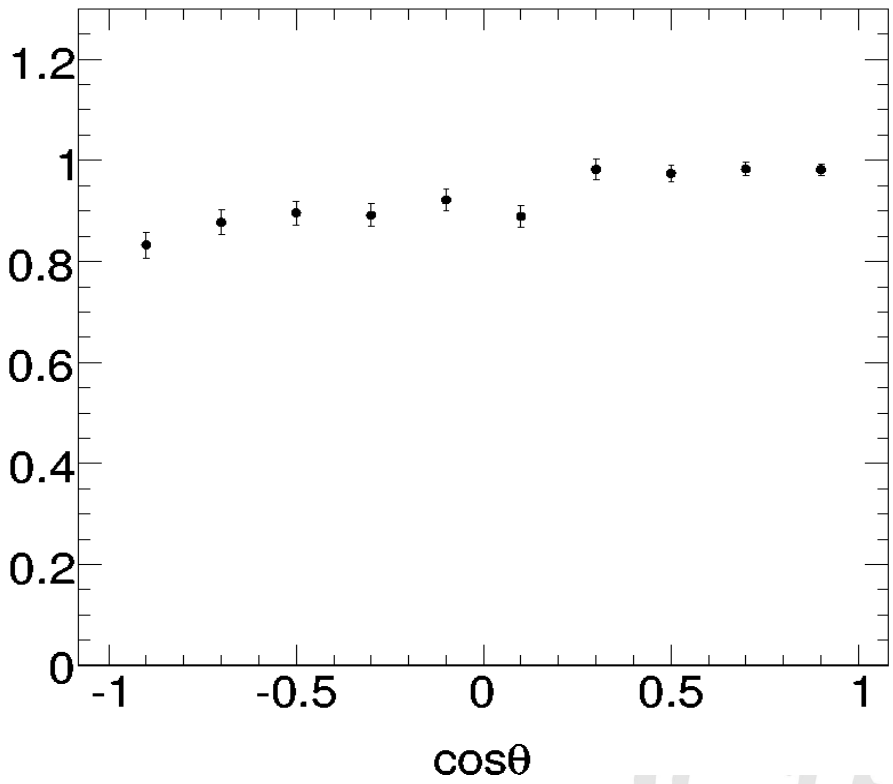
Efficiency calibrated polarisation



Slope, x-direction	Slope, y-direction	Slope, z-direction
0.0084±0.0066	-0.32±0.0058	0.013±0.0067

$$f(\theta_p) = \frac{1}{2}(1 + \alpha P \cos\theta_p,) \qquad \alpha = -0.64 \qquad (3)$$

Efficiency calibrated polarisation as a function of $\cos\Theta_{\bar{\Lambda}}$



Small deviation for $\cos\Theta_{\bar{\Lambda}} < 0$ yet to be investigated.

Conclusions

- Efficiency 35%, Background 0.6%
- Events with slow pions are not reconstructed
- This affects the polarisation calculated from angular distribution of the decay proton
- When the unpolarised events are used to calibrate for the detector efficiency, the polaristion can be reconstructed
- Still minor details to be investigated

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Outlook

- Simulations at 15 Gev
- 1 T magnetic field
- More realistic polarisation as a function of Θ_Λ
- Other hyperons (Ξ^+, Ξ^-, ...)