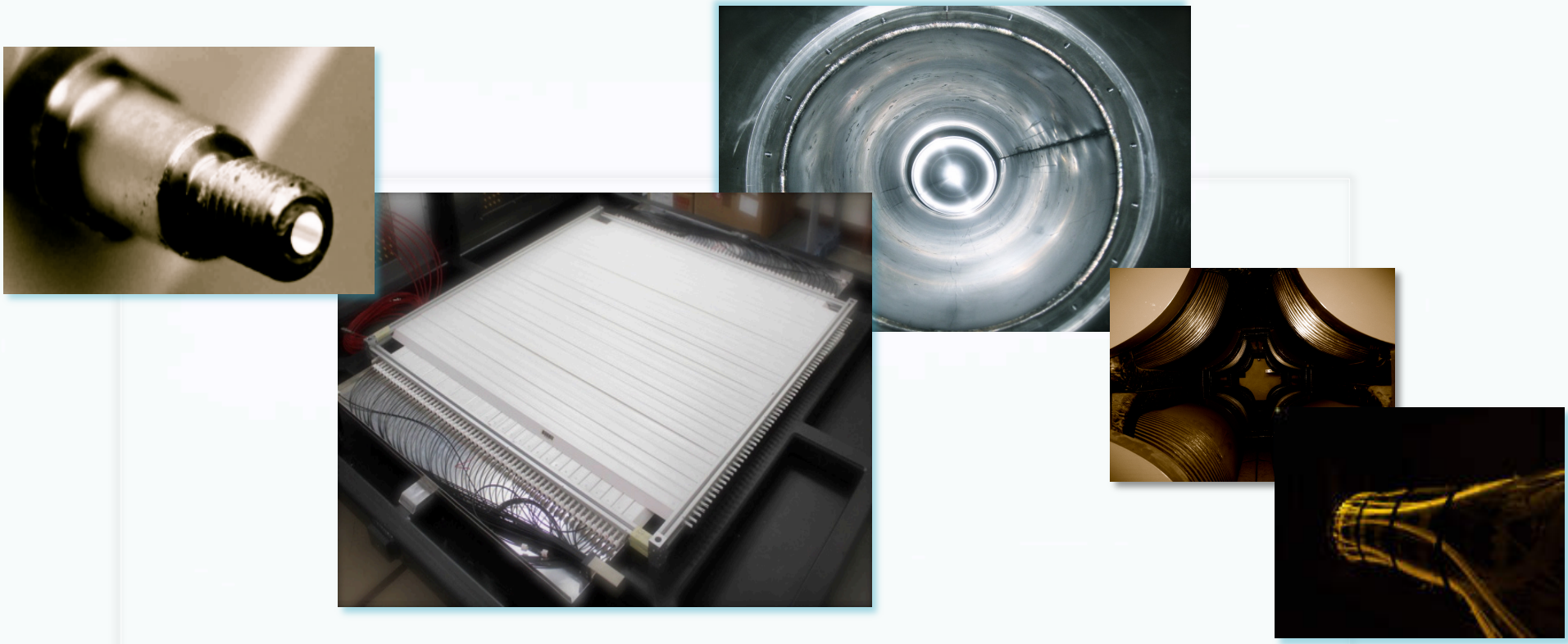


Beam Polarization in MICE

By Sophie Charlotte Middleton

Imperial College London

MICE Collaboration Meeting 23/06/2015-Plenary Session

Outline

- Introduction:
  - Motivations For Study
  - Fitting to positron tracks
- Analysis:
  - How accurate is the reconstruction method?:
    - Resolution/Residuals
    - Bias?
    - Reconstruction Efficiency
  - Polarization Results
- Conclusions

Introduction

Motivations & Method

Beam Polarization

Can we tell the difference between a forward polarized and backward polarized muon beam at the EMR?

- When muon decays the resulting electrons have an angular distribution integrated over momentum space of:

$$\frac{d\Gamma}{d(cos(\theta))} = 1 \pm \frac{1}{3} P_\mu cos(\theta)$$

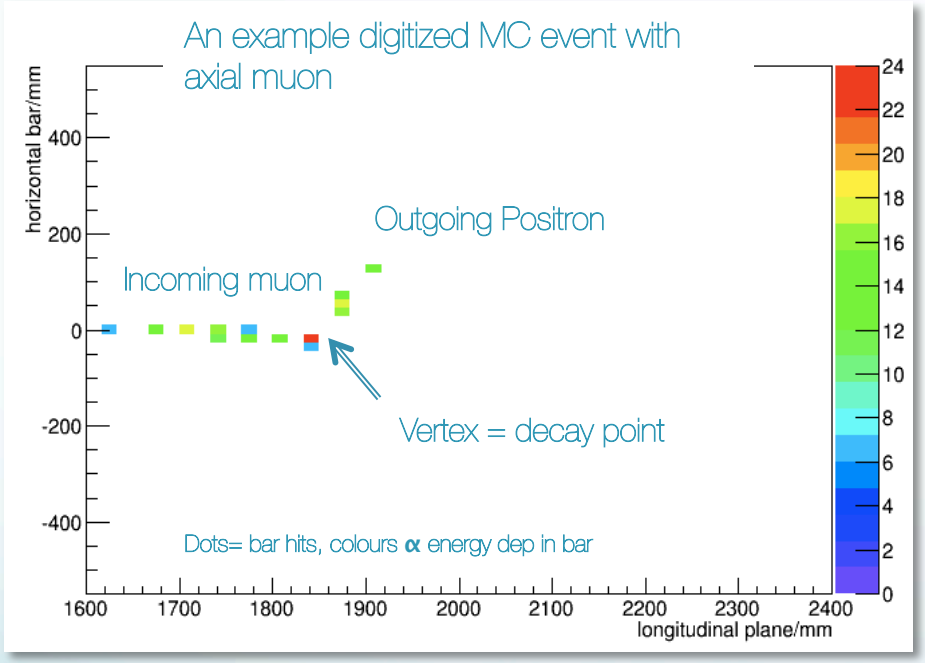
- P_M = +1 (forward), -1 (backward) or 0 (flat)

- Θ = *the angle between the muon momentum and the electron direction….this is what I'm looking to measure*

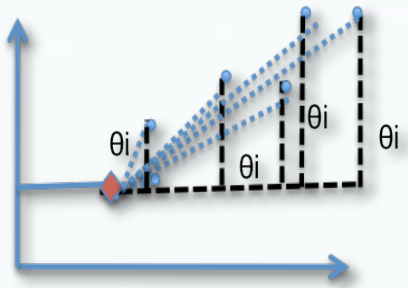
- Method: Derive cos (Θ) → plot 1D Histogram → fit Y=MX+C → M = P

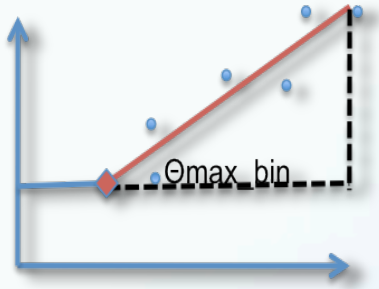
A Muon Decay

Decay positron leaves vertex at some angle relative to initial muon direction → want to measure this angle!



Fitting Method:



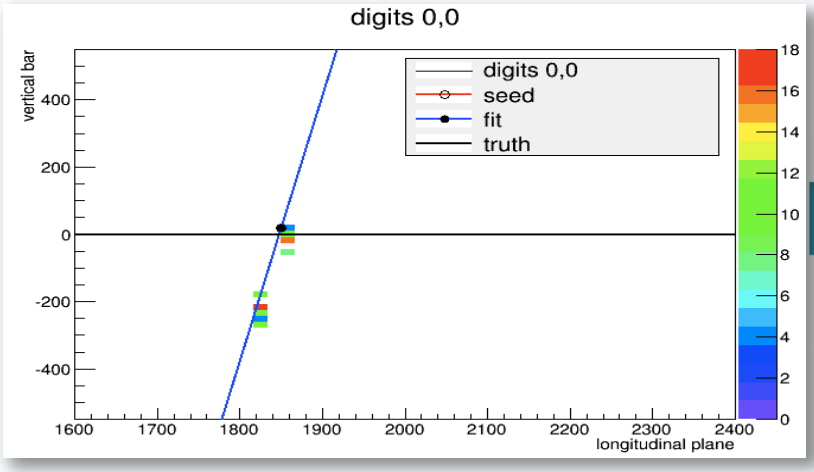


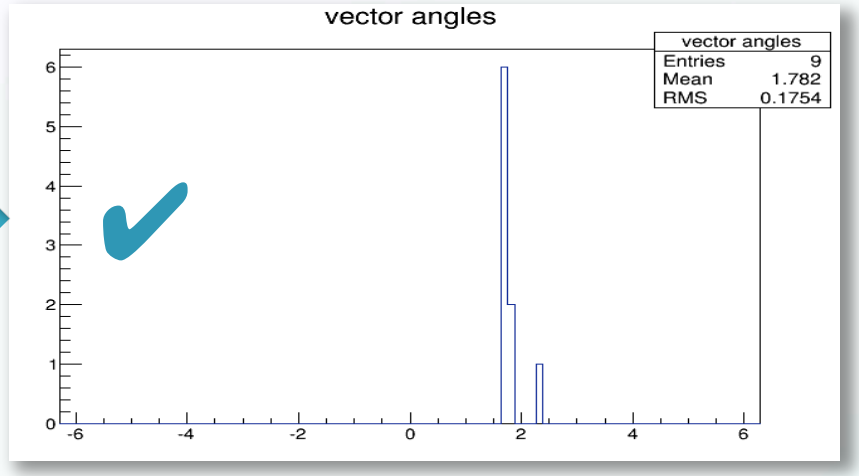
$$\theta_i = arctan\left(\frac{x_i - x_0}{y_i - y_0}\right)$$

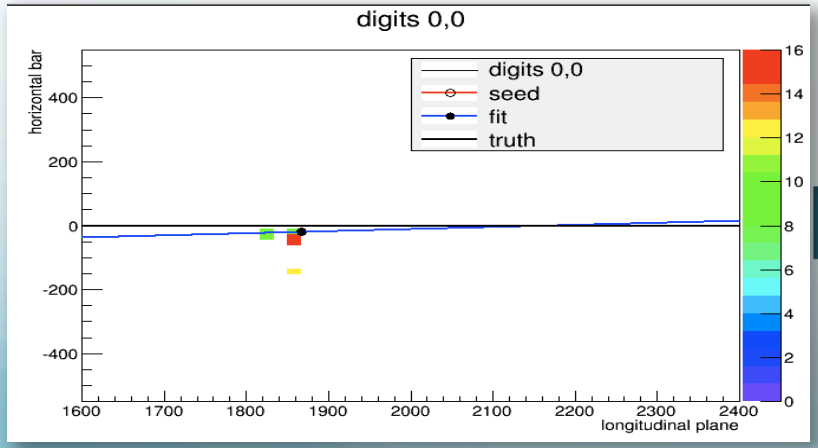
* Tried fitting in Minuit in both Cartesians and polars → both encountered infinities

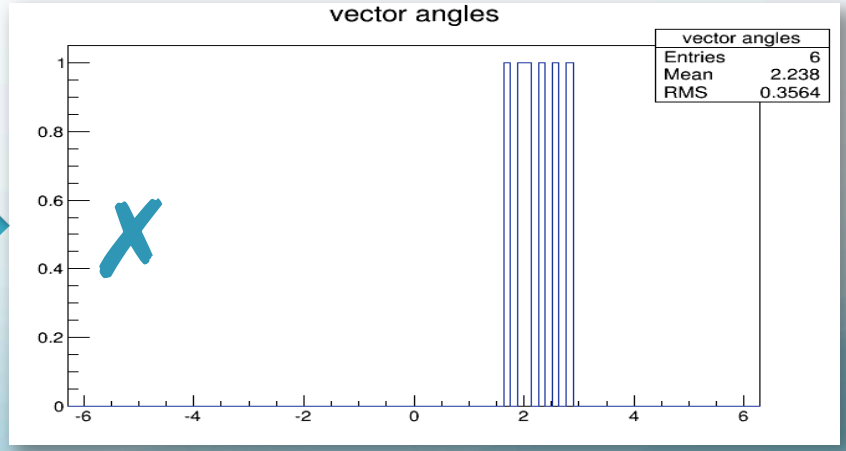
"Window" Cut

A chi-squared style cut ensures 50% of hits are within +/- 2 bins of peak









"Digit" Cut

Want to make sure method can accurately reconstruct event given information on the positron track at the EMR

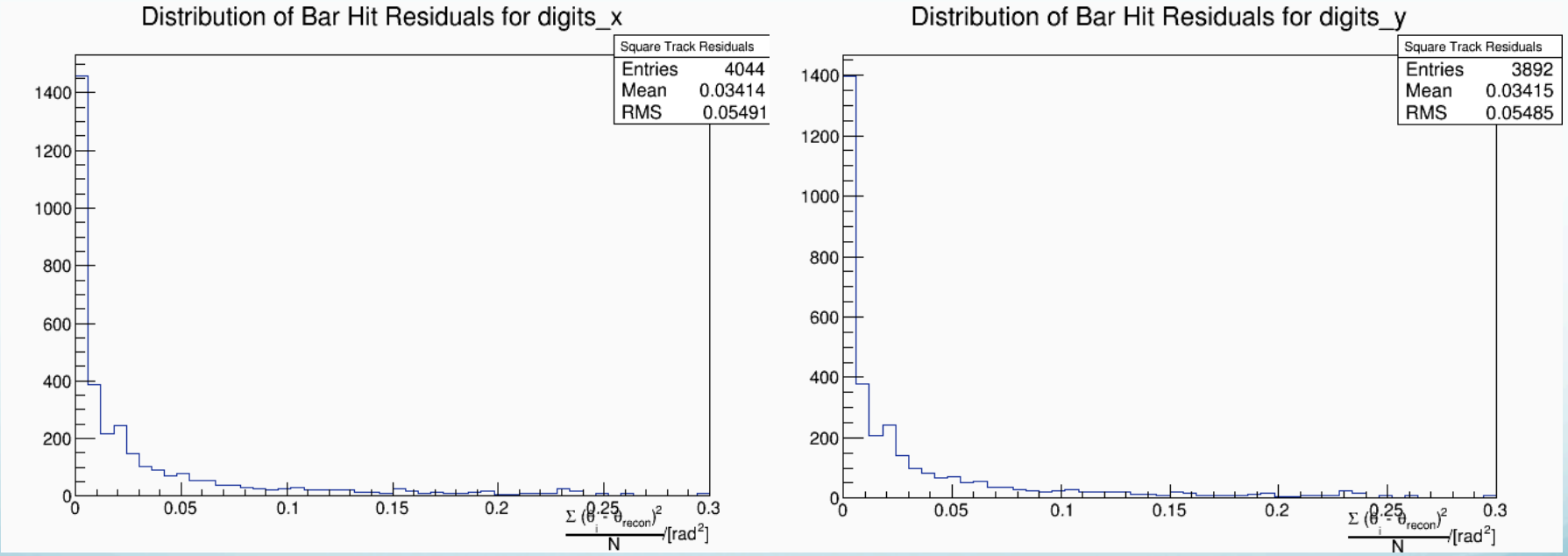
- Always require at least 1 digit in x and y
- After this a "digit cut" on minimum number of digits had little effect on the accuracy of the method (judging by looking at the RMS of the resolution of the fit – ($\Theta_{RECON} - \Theta_{TRUE}$) and average reconstruction efficiency)

Minimum Number of Digits	RMS or resolution/ [rad]	Efficiency/ [%]
1	0.2692	88.0
2	0.2549	85.87
5	0.2585	83.3
10	0.2542	81.24

Bar Hit Residuals

How spread out are the hits from the derived average?

* RMS ~0.05 rad^2 → suggests that tracks are relatively straight with only small deviations probably due to detector geometry



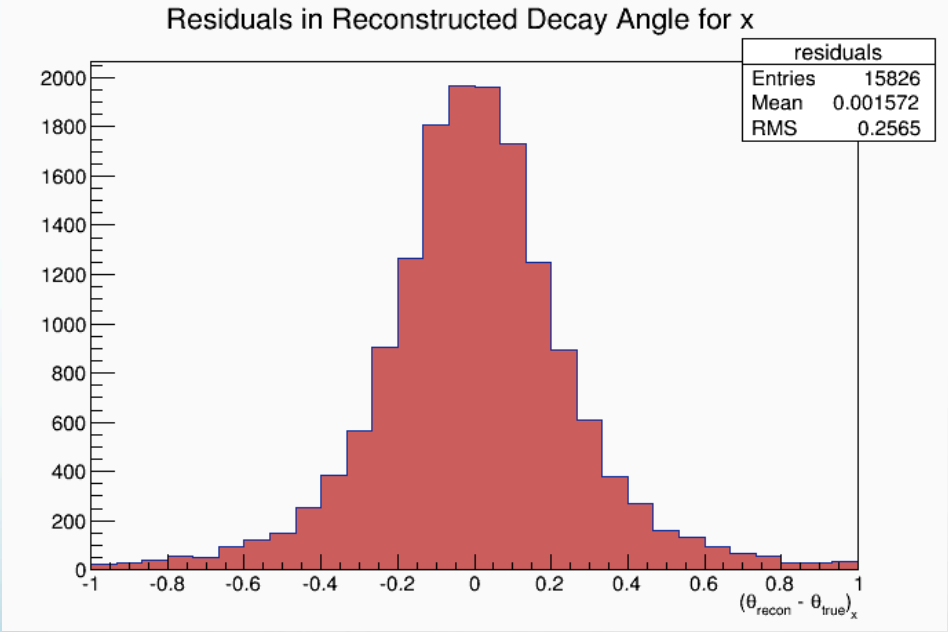
Analysis

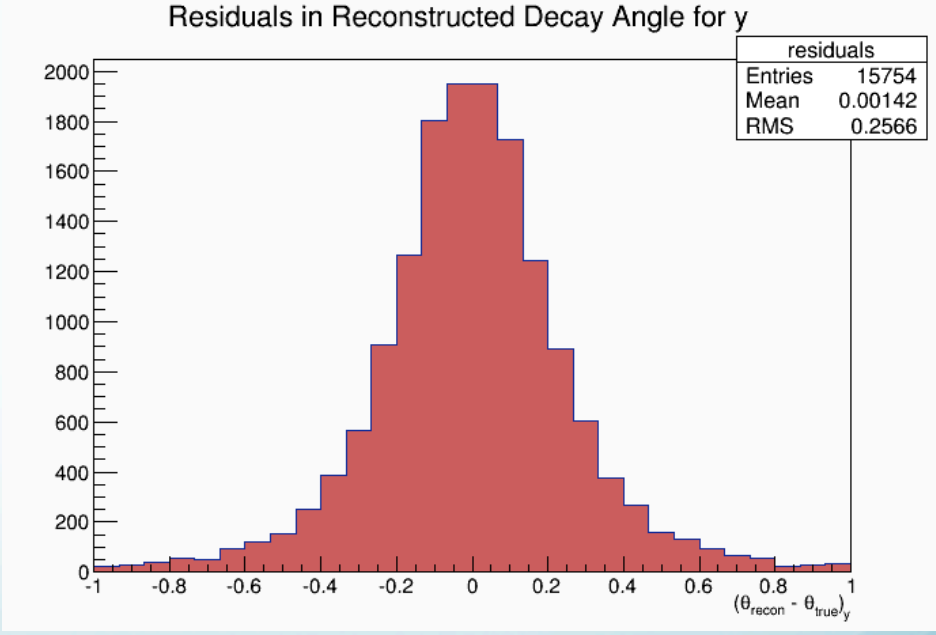
Results & Discussion

Resolution

How well can the method reconstruct digitized MC?

* Distribution of difference in reconstructed angle from digitized MC and MC truth has RMS ~0.25 radians for both horizontal and vertical going positron tracks



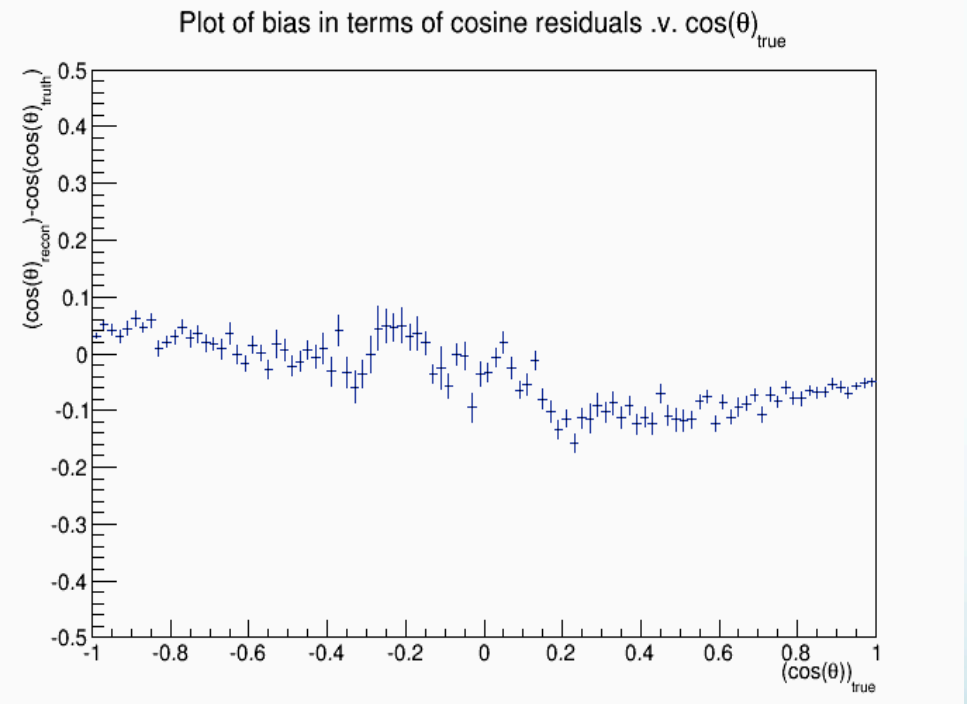


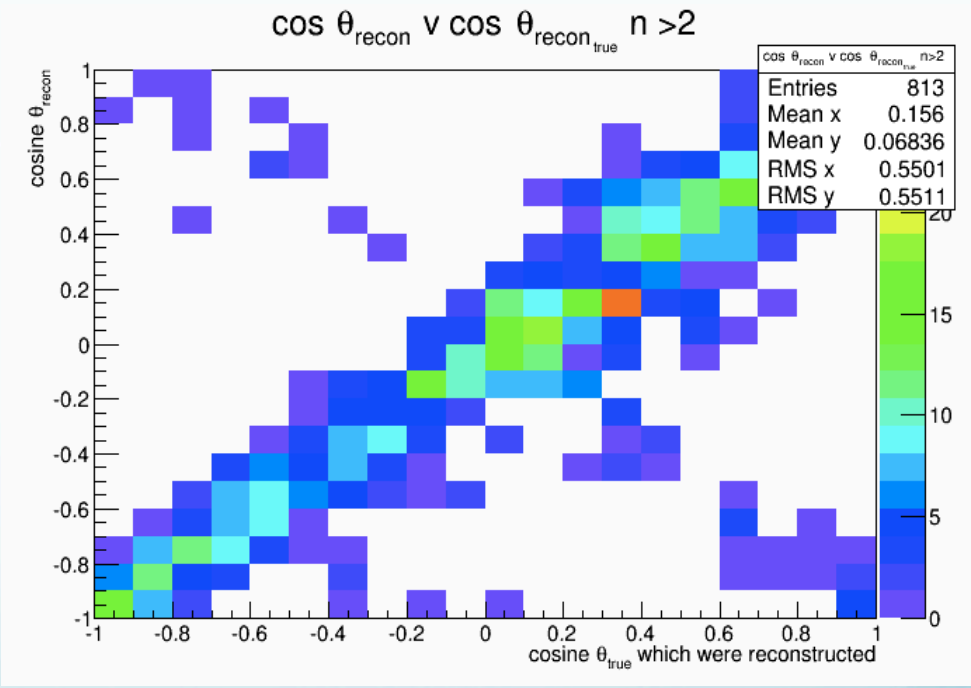
* *This is sufficient given detector limits!*

Checking For Bias

Is the reconstruction method biased?

* Plot of cosine of the true angle .v. cosine of the reconstructed angle

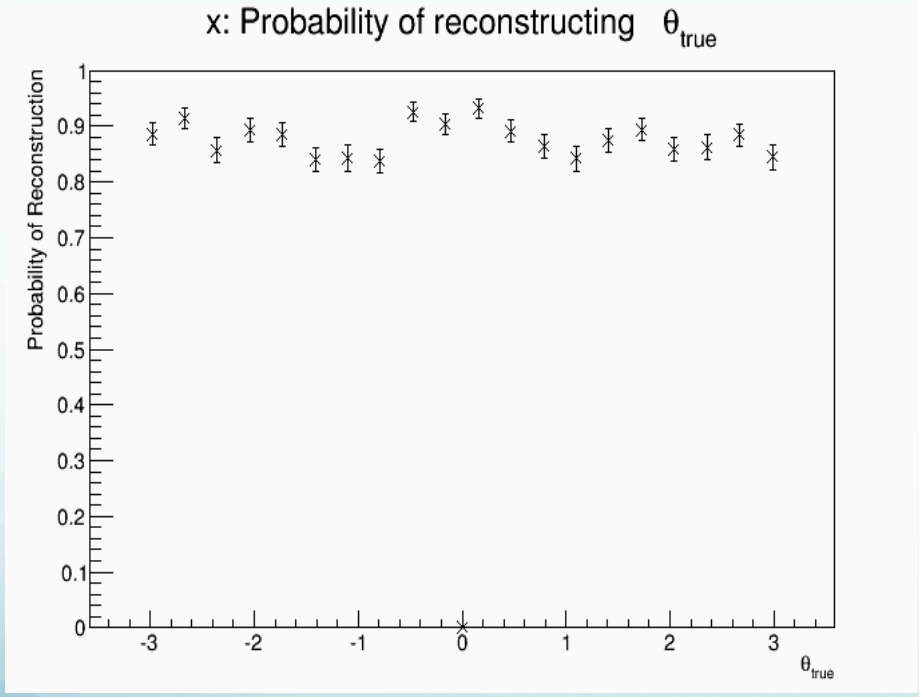


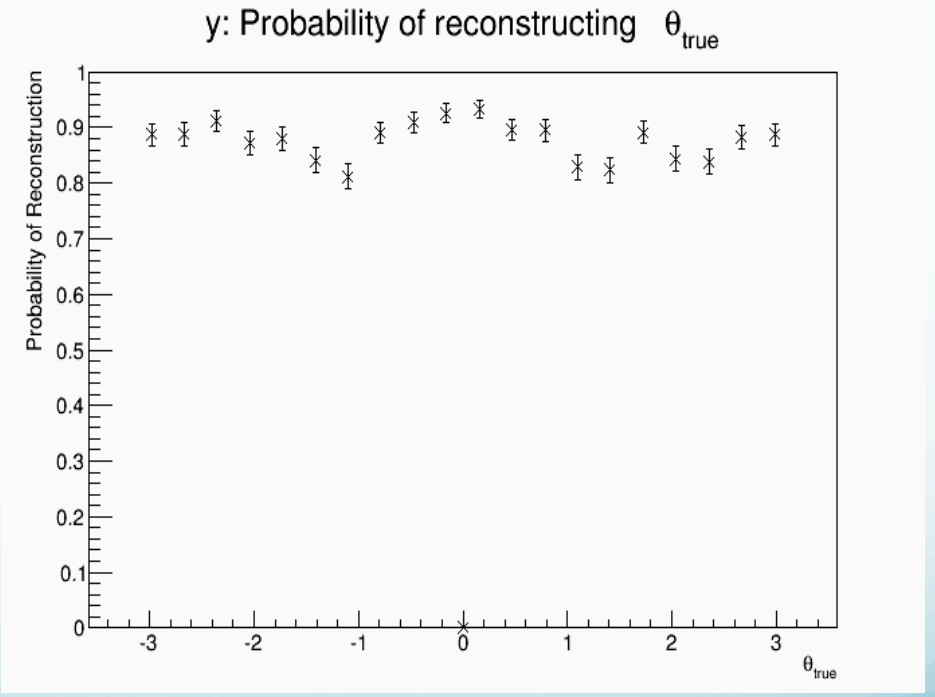


EFFICIENCY

HOW EFFICIENT IS THE CODE AT RECONSTRUCTING TRACKS AT A GIVEN ANGLE?

* THE PROBABILITY OF CORRECTLY RECONSTRUCTING AN ANGLE Θ FIND EFFICIENCY ~80-90 % FOR BOTH X AND Y TRACKS

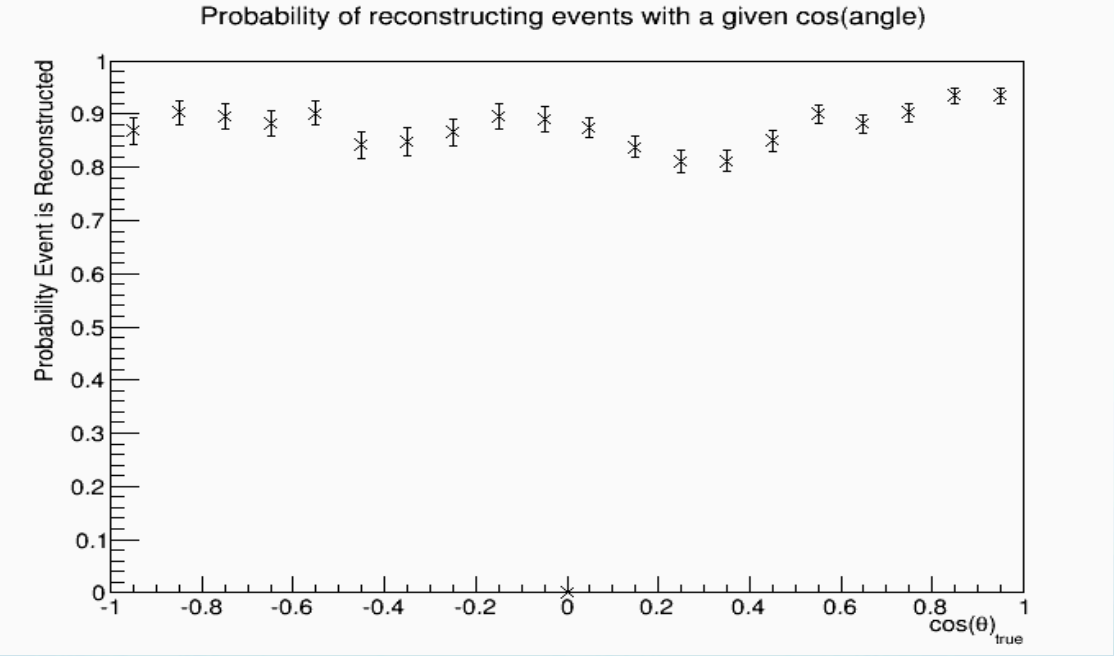




EFFICIENCY

HOW EFFICIENT IS THE CODE AT RECONSTRUCTING TRACKS AT A GIVEN ANGLE?

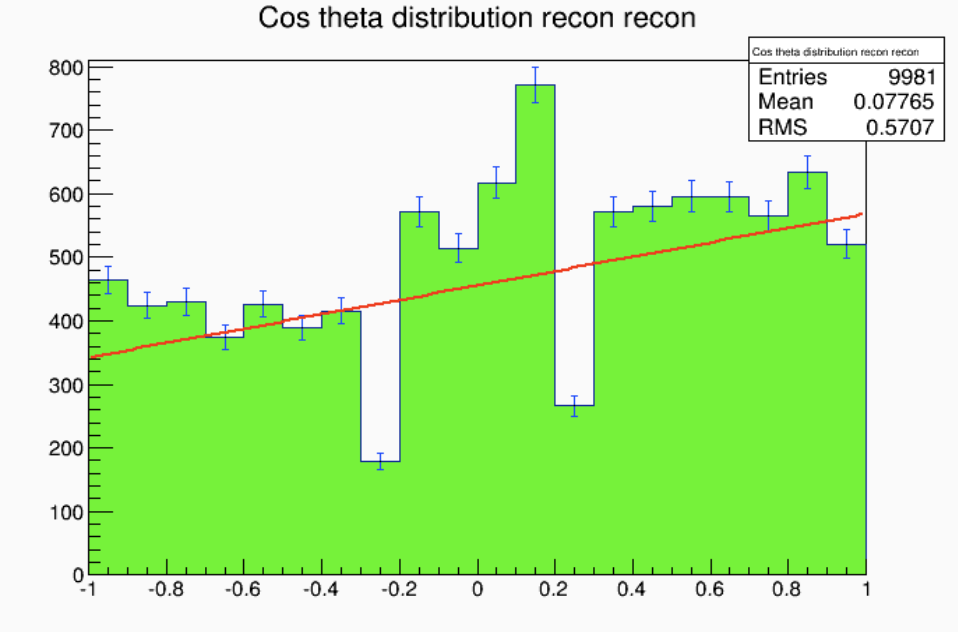
* FOR A COMBINED COS(Θ) FOUND USING THE DOT PRODUCT BETWEEN INITIAL MUON DIRECTION AND ELECTRON TRACK- FIND EFFICIENCY ALSO ~80-90 %



Polarization: MC

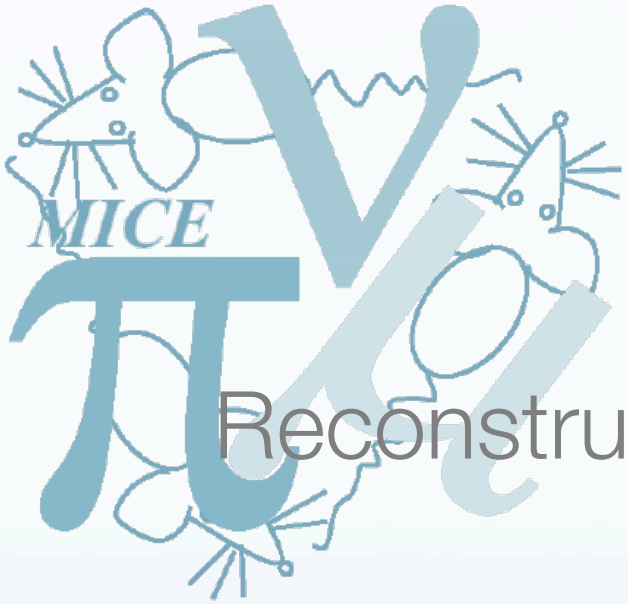
Can the method correctly reconstruct the polarization?

- Beam in MC was initially forward polarized (P=+1)- so gradient of mx +c line fit to cosine distribution should have m = +1/3



$$\frac{d\Gamma}{d(cos(\theta))} = 1 \pm \frac{1}{3} P_\mu cos(\theta)$$

- Straight Line fit gives: 0.25 ± 0.03(stat)



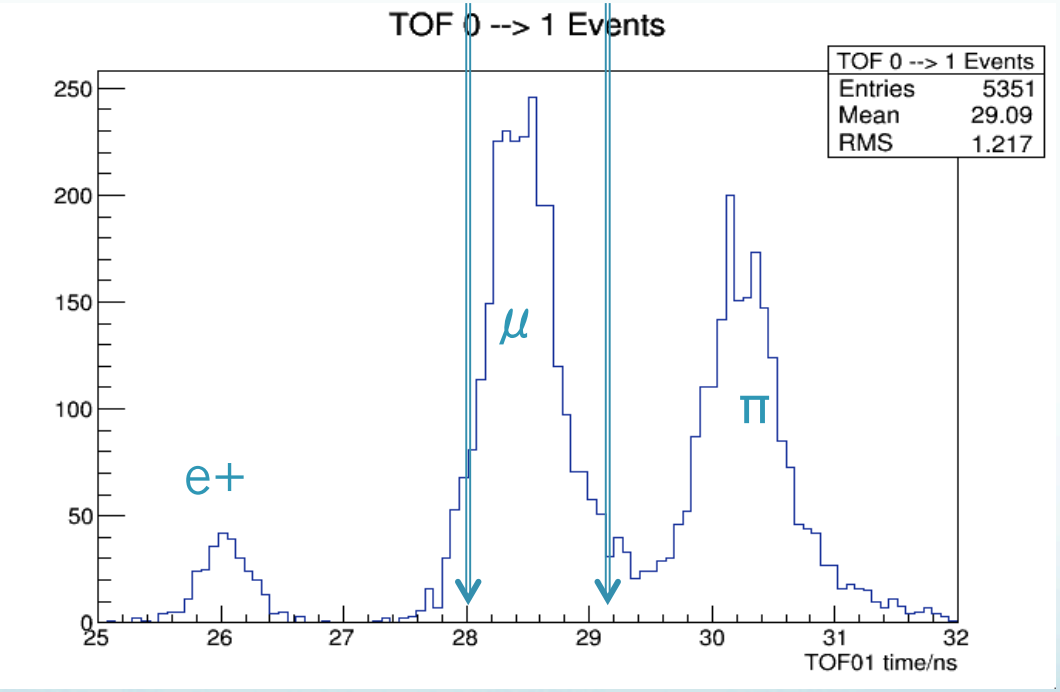
Analyzing Data

Reconstructing Data: Results

Time-of-Flight Cut

Need to remove pions from data

* Can use the time of flight between TOF 0 and TOF 1 to remove pions and positrons from contaminating the muon primary data



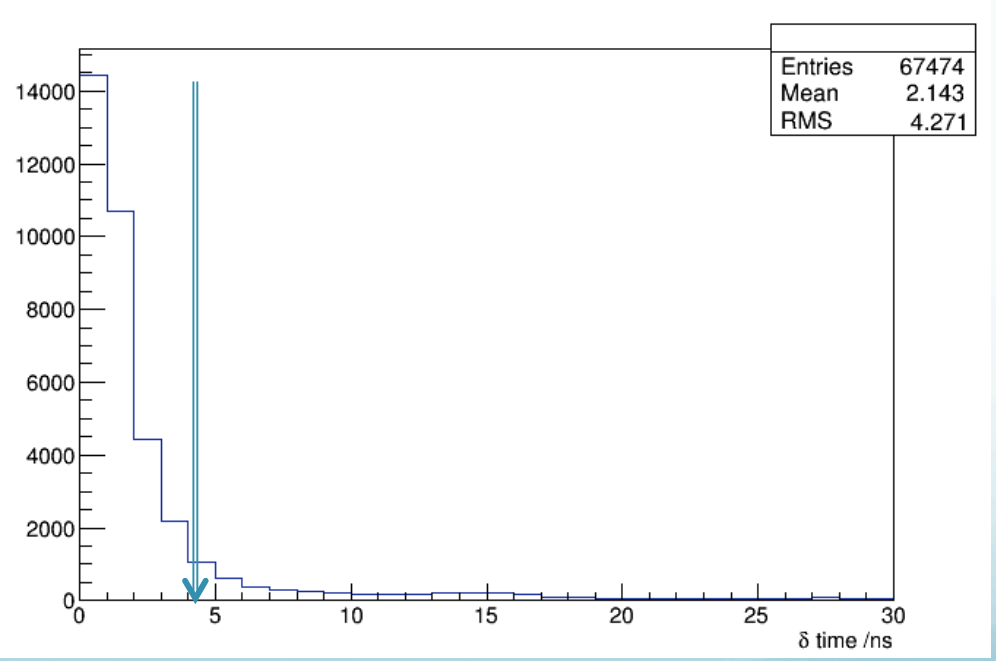
* Chose TOF01 time = 28 ns < T < 29 ns

Time Difference Cut

Need to reduce noise in EMR data

* A cut on the time between consecutive bar hits (digits) helps remove noise

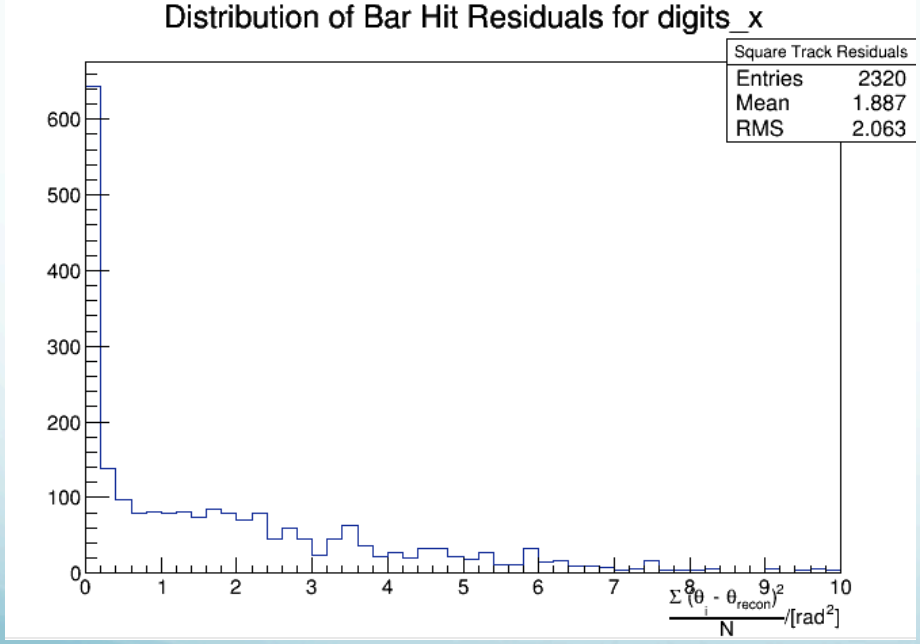
* Ensure that the time between consecutive hits is < 4 ns

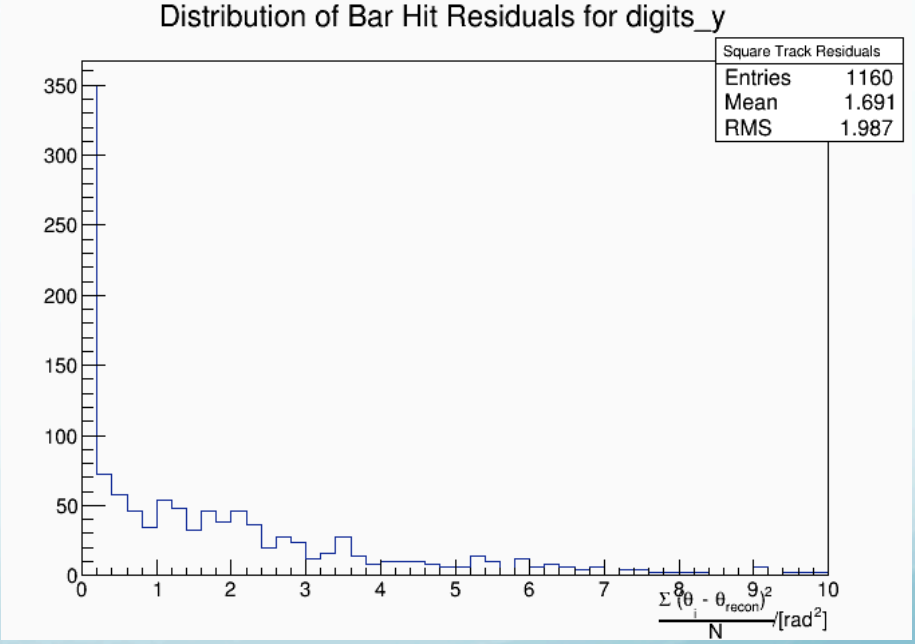


Bar Hit Residuals

How Spread Out Is Data From Average?

- Bar Hits are much more spread out than if track were straight → Noise
- RMS is ~ 40x the MC RMS → Need to improve noise rejection!!!





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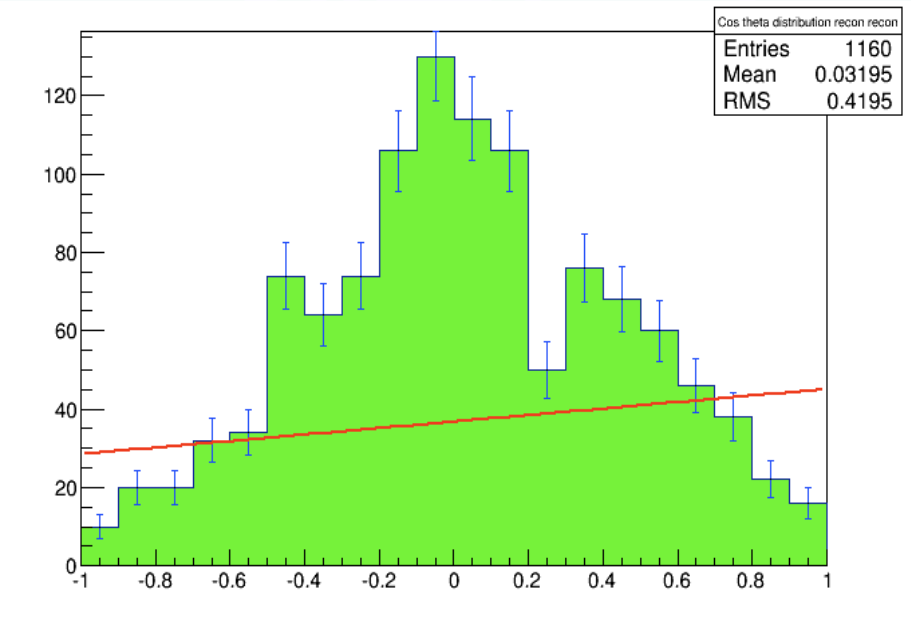

$$\frac{d\Gamma}{d(cos(\theta))} = 1 \pm \frac{1}{3} P_\mu cos(\theta)$$

- Straight Line fit gives: 0.15 ± 0.031(stat) ± 0…(sys)

Summary

- Analysis is working:
  - Good resolution
  - Good Recon. Efficiencies
  - No indication of a significant bias
- Need estimate of systematic errors
- All that is now needed is to reconstruct for more data sets
- *Thanks to Francois Drielsma for help with debugging*

Thank You For Listening

Any Questions?