Beam Polarization in MICE

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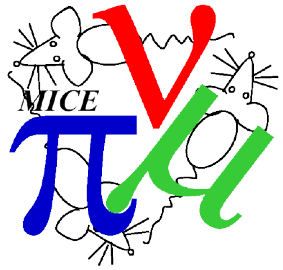

Introduction

QUESTION:- Can we tell the difference between forward polarized and backward polarized muons by their decay electrons energy spectrum in the EMR?

- Decay electrons tend to spoil the cooling measurement by introducing an apparent emittance increase in the beam.

- The number of decay electrons in the beam is dependent on beam polarization.

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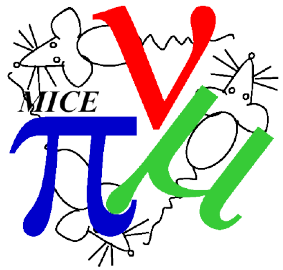


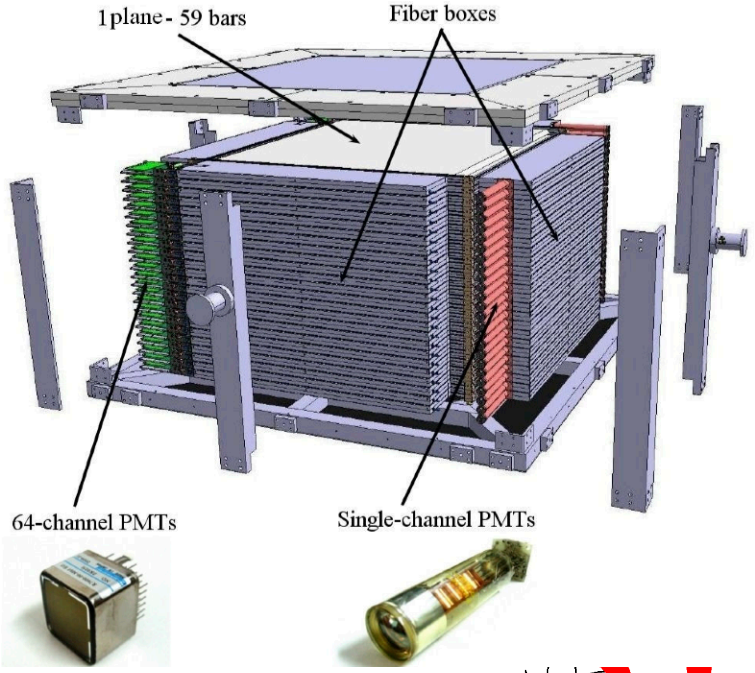
The Electron-Muon Ranger

- **Aims to measure range of muons and reject those which decayed within channel**

- Overview:
  - 48 Planes
  - 59 Bars Per Plane

- The Planes :
  - Total Plane Area = 1.21 m^2
  - Alternate Horizontal/Vertical

- The Bars :
  - Contain WLS fiber
  - Triangular in shape:
    - Base = 3.3 cm
    - Height = 1.7 cm
    - Length = 1.1 m



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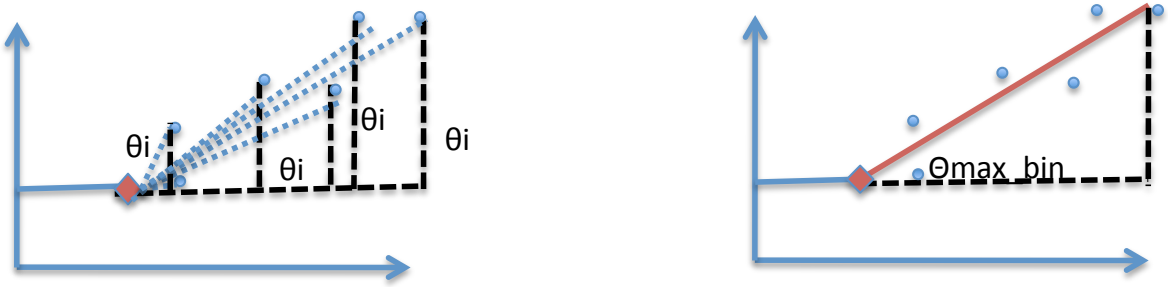
Fitting Positron Tracks

- ***Need to accurately calculate angle between initial muon track and decay positron track***
- Simple **"Vector Fit"**:



Find $\theta_{reco} = arctan(\frac{x_i - x_0}{y_i - y_0})$ [1]

Histogram this for each event → Take the angle of the track to be the central value of the maximum bin

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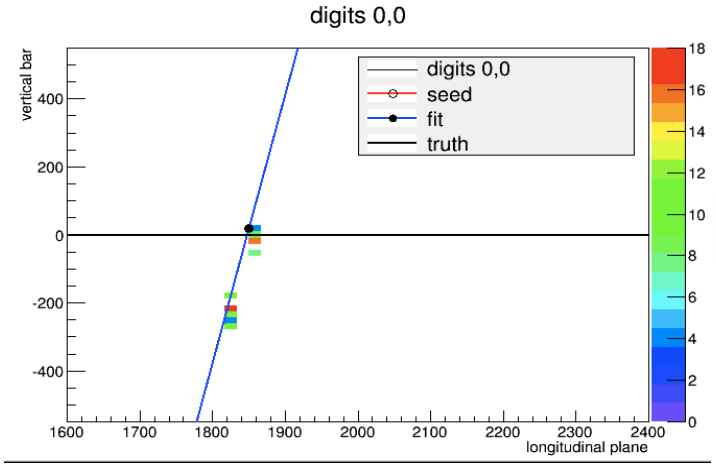
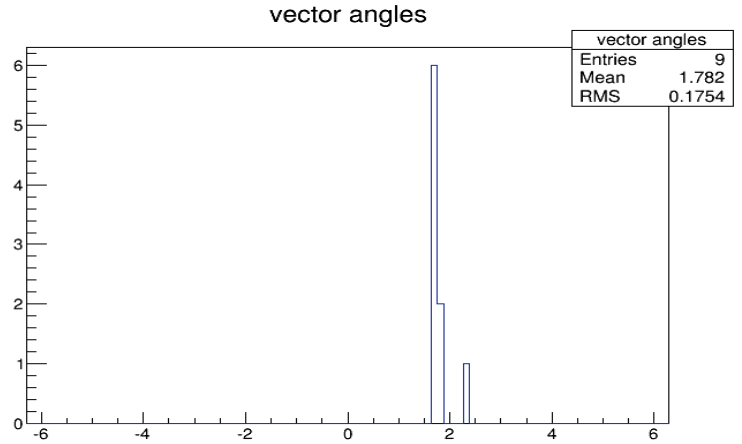
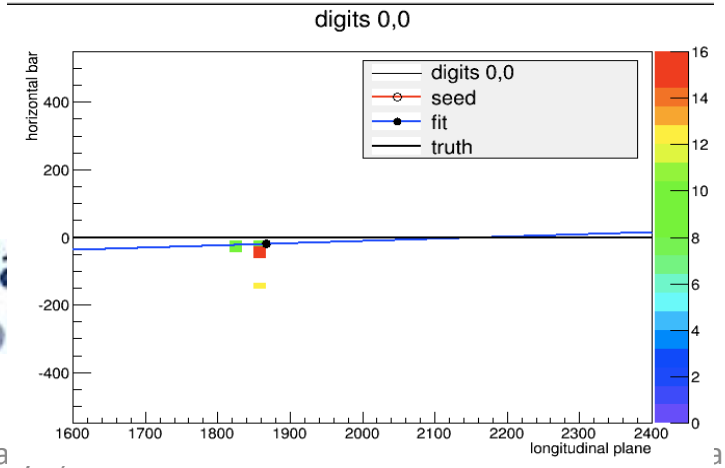
Fitting Positron Tracks

- Use chi-squared type **"window cut"** to reject tracks with a large spread of hit angles → makes sure that 50% of the events are within ±2bins of peak bin

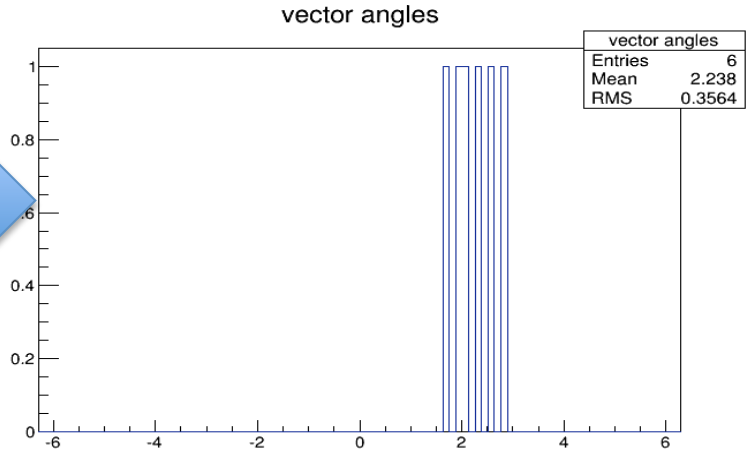


Accepted





Rejected



Vertex Finding

- ***Need to accurately find the point where the muon decays…***

- This is done by separating events in to muons and decay electrons :
  - Done using simple **time cut** muon (muon has time < 50ns, positron has time >100ns) [See slides from CM39 for plot]

  - Find the bar and plane number of last hit which fits muon criteria Assume this is vertex

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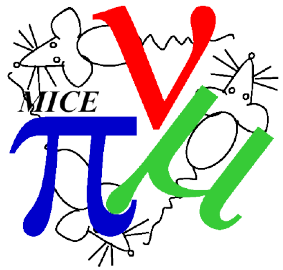

Cuts and Cross-checks

- Must have **> 2 digits** in event to avoid bad fitting
- Check that there is "positron data" -> **time cut**
- Have transferred the "digits" from bar/plane numbers to **EMR co-ordinates** (mm)

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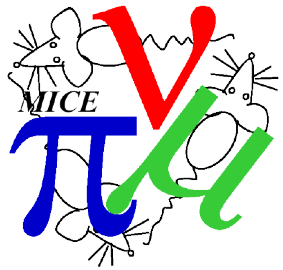
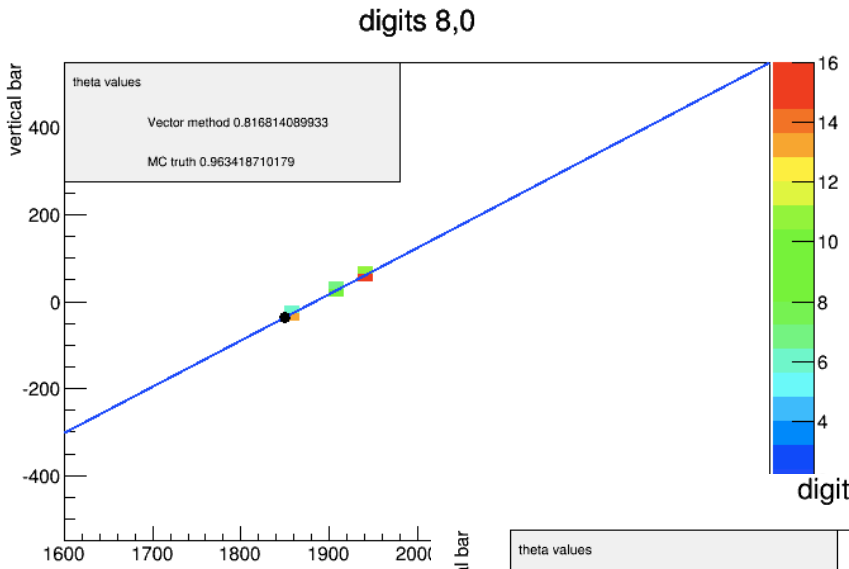
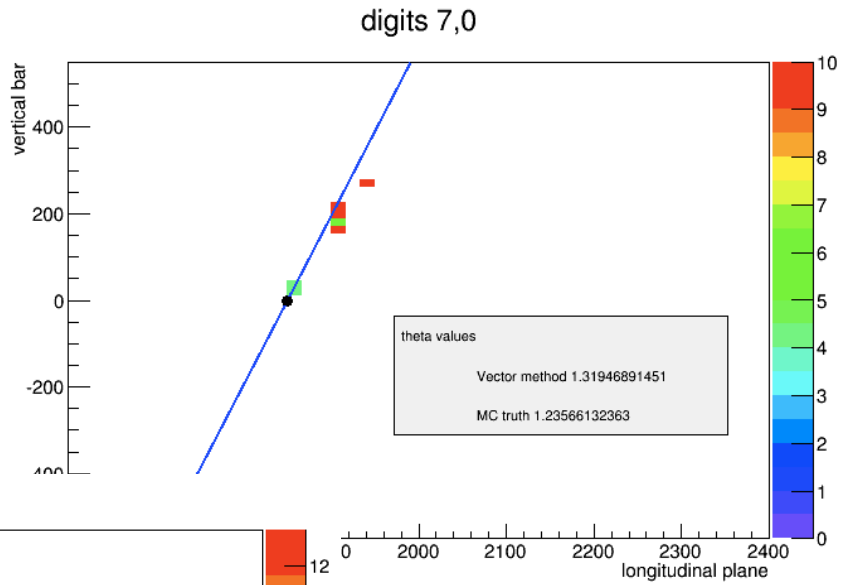
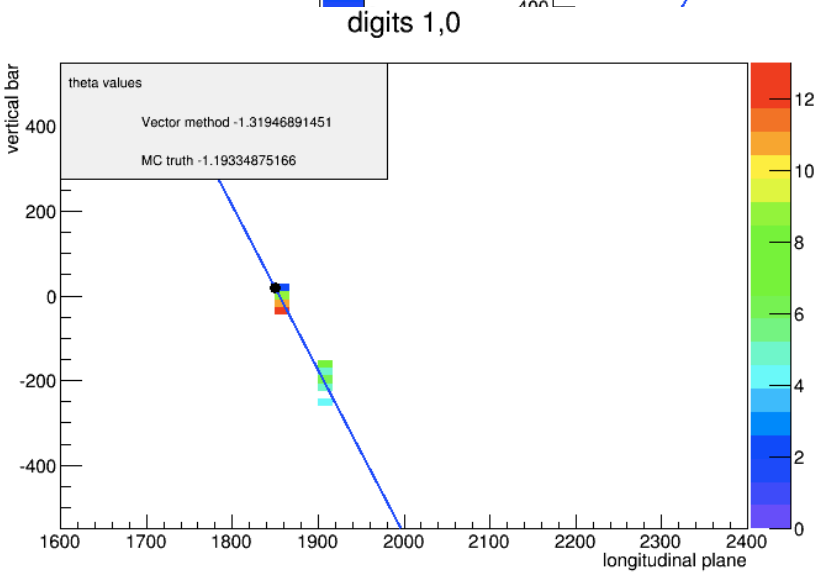


Examples Fitted Track (MC Digits)







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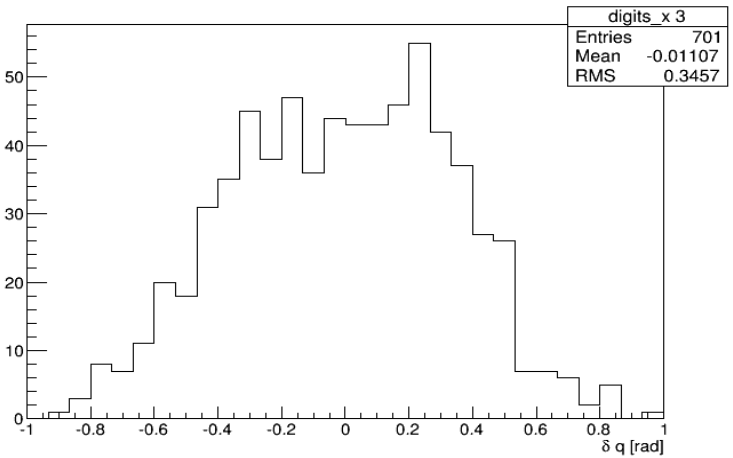
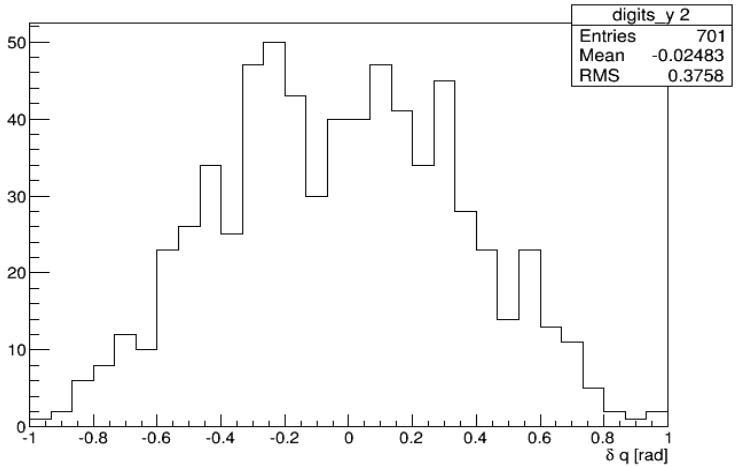
Residuals

Difference between reconstructed decay angle and true decay angle (as taken from MC)





- RMS varies from **0.3-0.4 rad** for horizontal and vertical. - **sufficient for the study**

- **From detector limits: with a track length of ~10 bar widths then tan(theta) = 1/10 → theta ~0.1 rad → I think 0.3 rad is ok**

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Checking for Bias in method

- **We need to make sure we understand whether the method introduces bias into our measurements**

- Need to quantify, or at least understand, if where a particle decays determines how well we can reconstruct it – geometrical effects?

- Look at how residuals, number of hits in EMR and Energy Deposited in EMR vary with reconstructed angle

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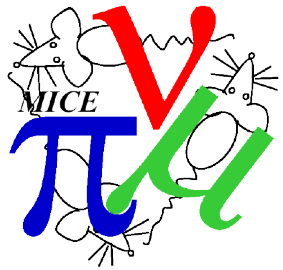
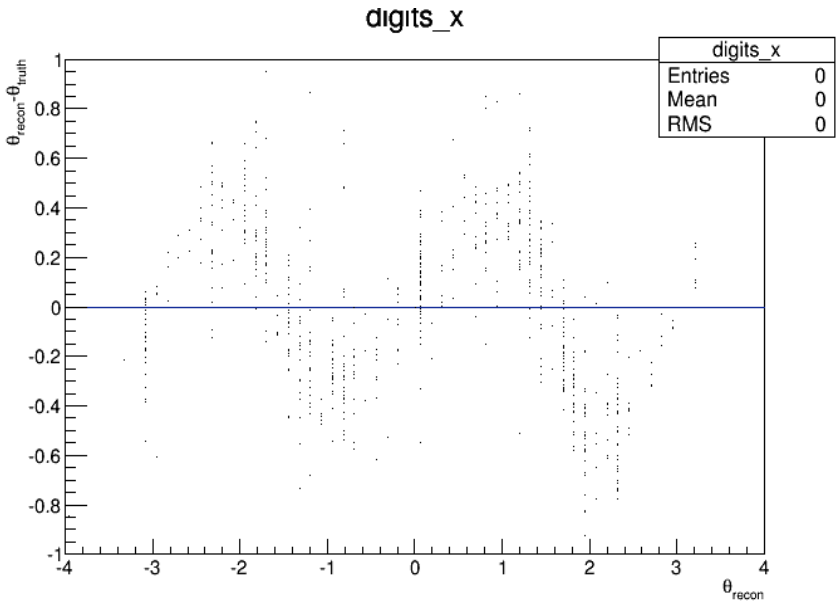
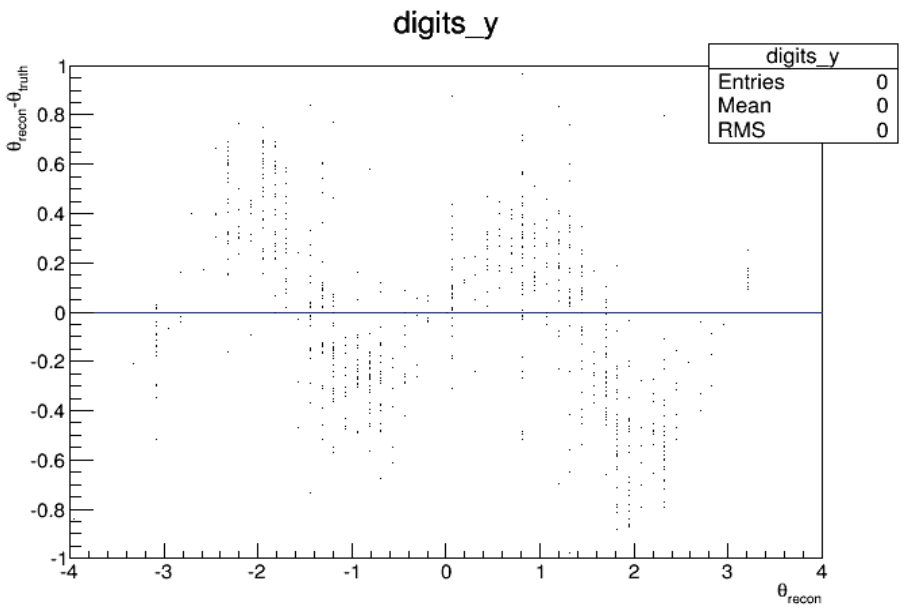


How do residuals vary with reconstructed angle?





- Obvious residuals ~0.8sin(reco_angle)→ what is causing this bias?!

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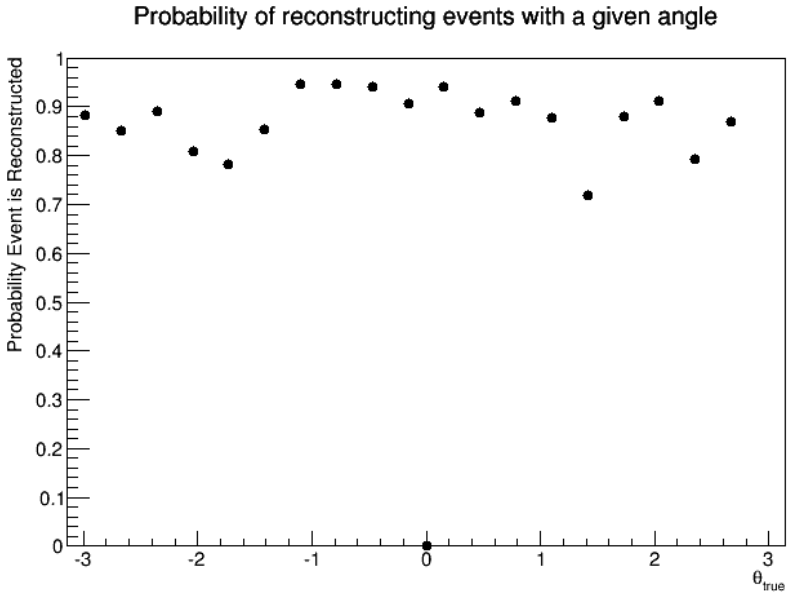
Reconstruction Efficiency

- **How efficient is the code at reconstructing the MC digits?**

- Plot shows reasonable efficiency- **all >70% with most 80-90%** of been reconstructed for given theta value



Are the deviations significant? Assuming Gaussian stats with p ~0.9 and number of events per bin ~ 50 then the error ~ 0.9/√50 ~0.13 ➔ **Uniform**

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EMR Data analysis

- Run Conditions:
  - Needed a good analyzable run from 2013 EMR data taking
  - + polarity
  - Beamline species: pions
  - Momentum at D2 = 265.98 MeV/c

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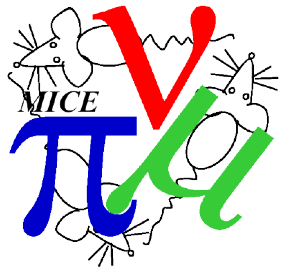
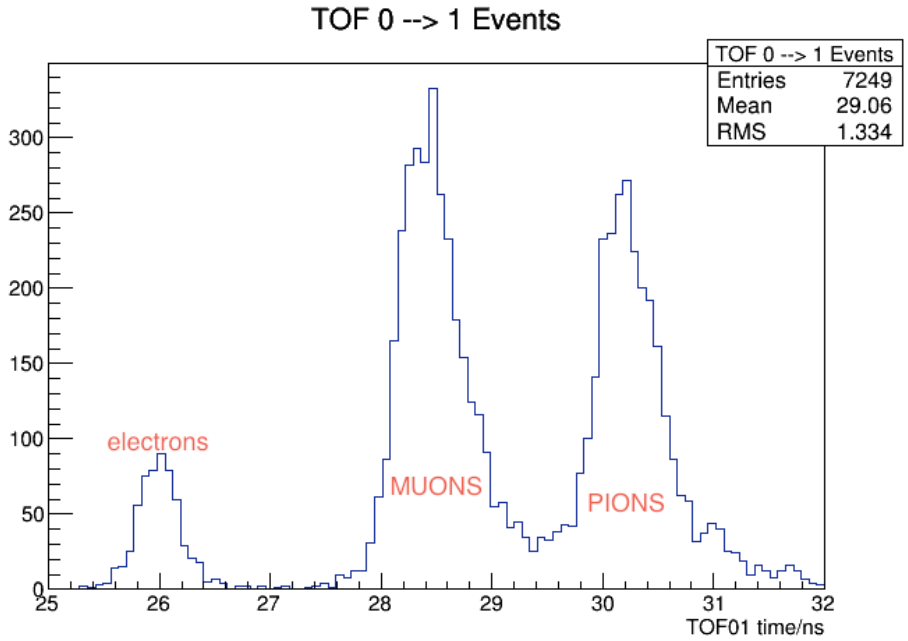


PID TOF Selection

- **Need to efficiently distinguish muon tracks from pions etc.**
- We initially looked at TOF02 time for PID but the efficiency was poor
- **Instead used T0F0 and TOF1** -> Will need to look into how good **pion rejection** will be



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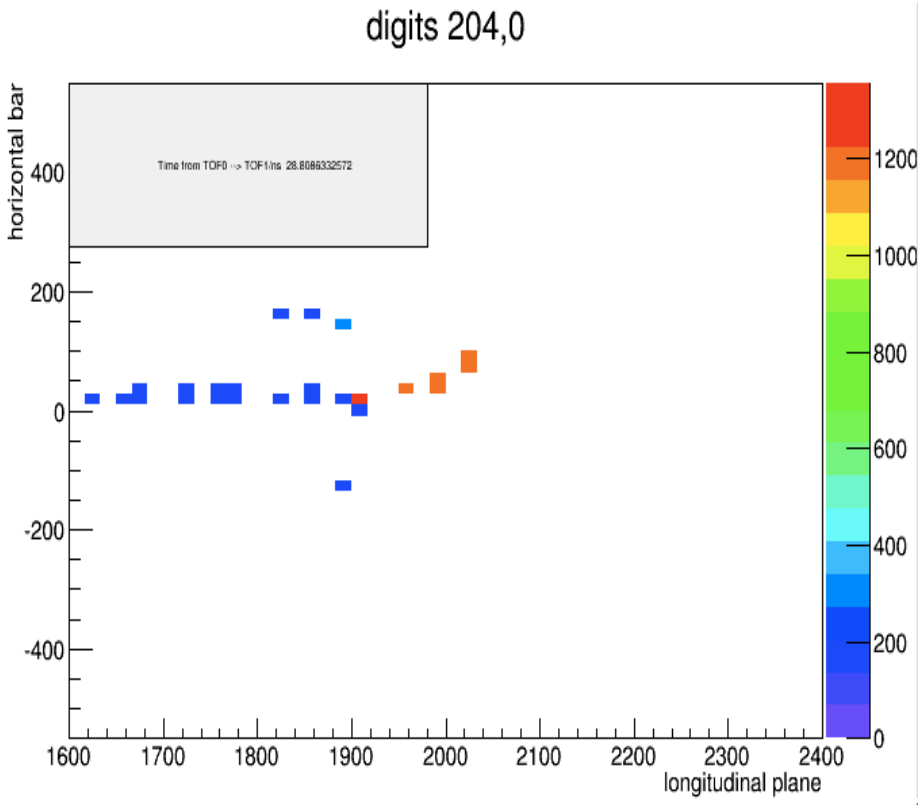
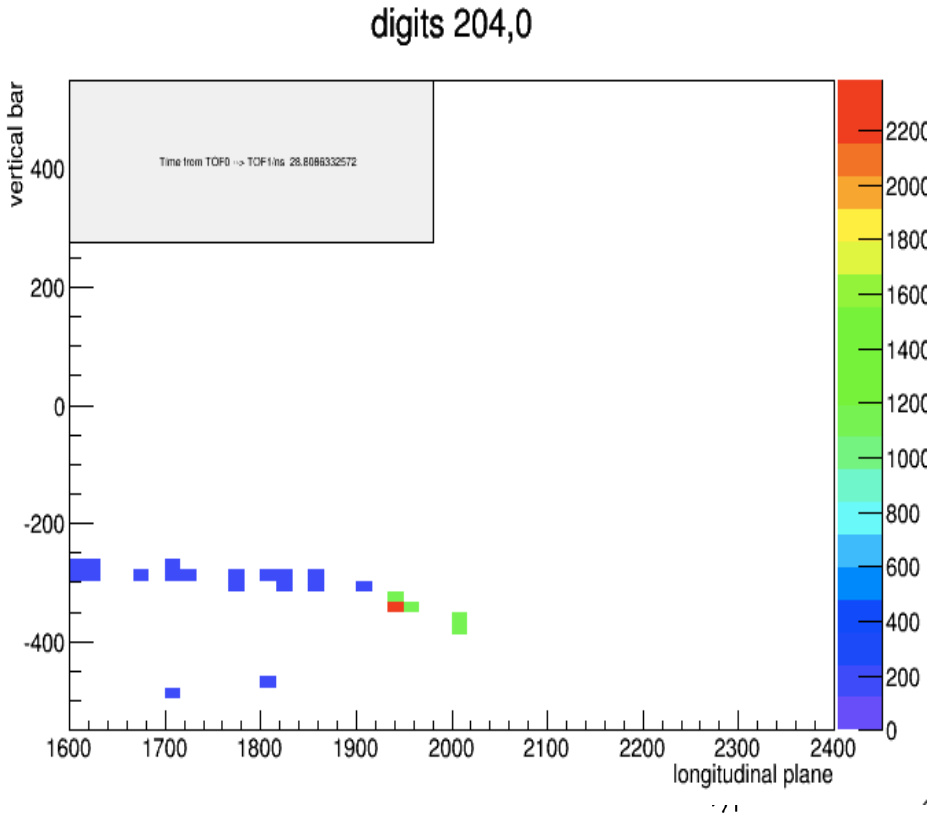
Example Secondary Track

- Using TOF01 between 28-29ns is where most of our muons lie (this is a small window-may switch to using TOF02)

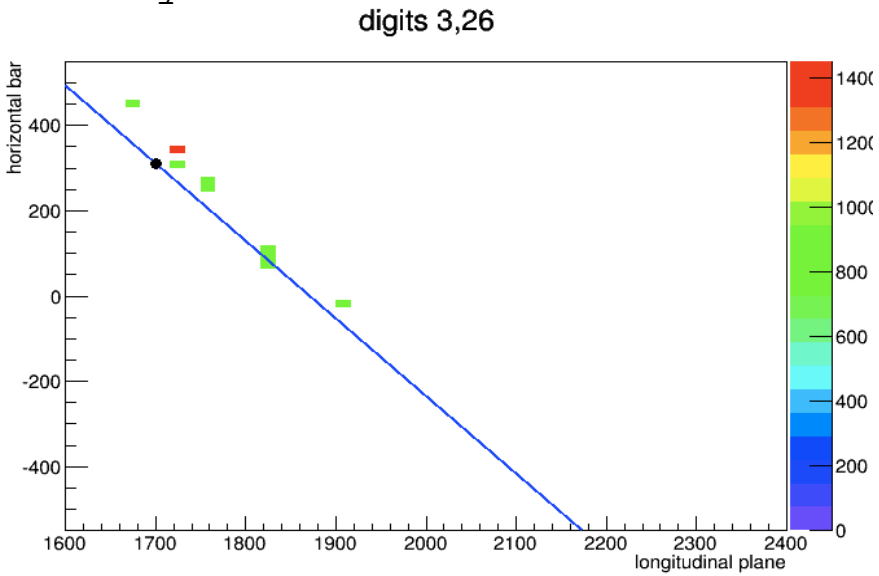
- Examples of some events in this window → muon decays:

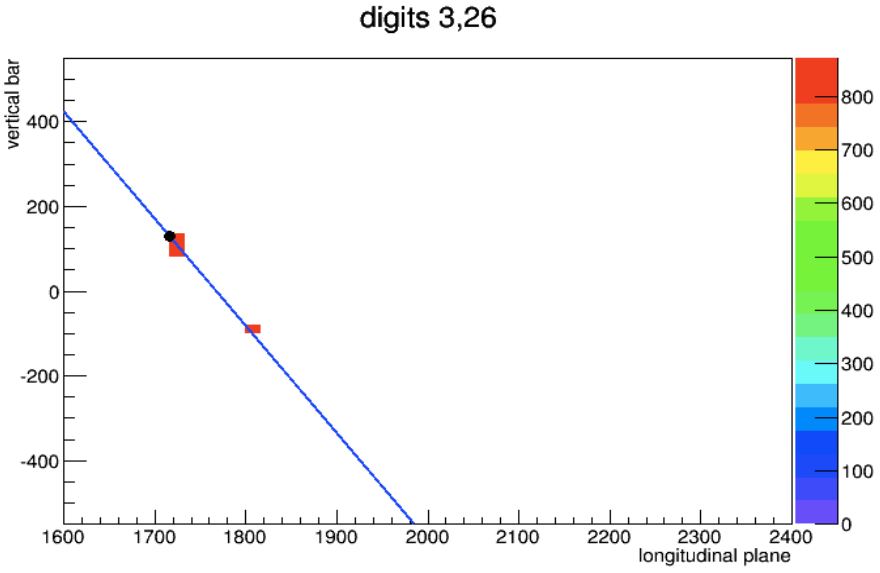




Fitted Decay Electron Tracks

- A few examples of some of the selected reconstructed decay electron tracks





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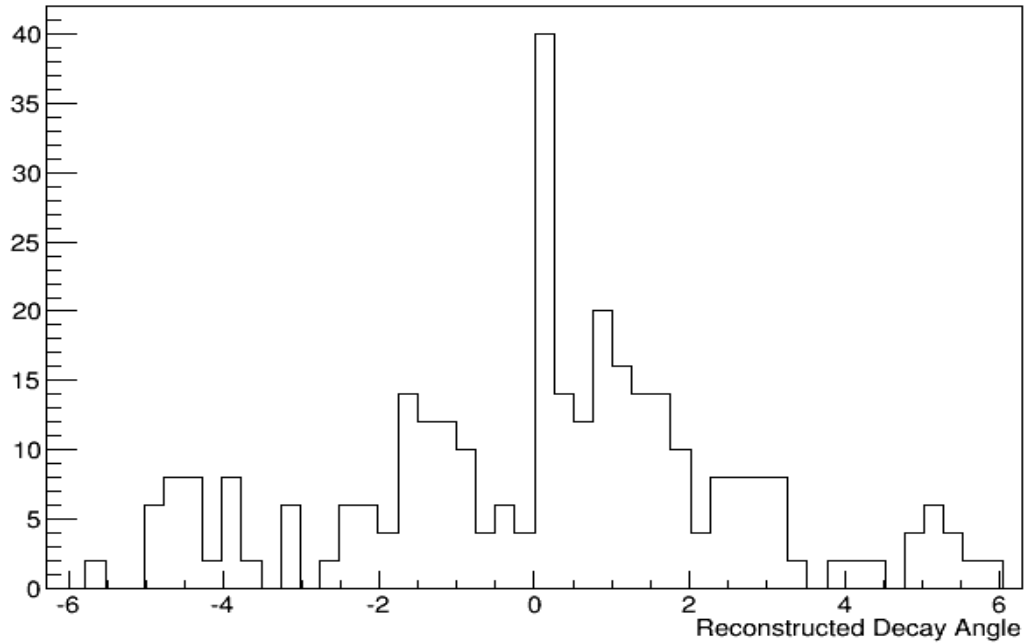
Angular Distribution of Decay Electrons



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What's Next?

- Now have a working end-to-end analysis!
- Need to make plots of cos(θ) instead of just decay angle

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