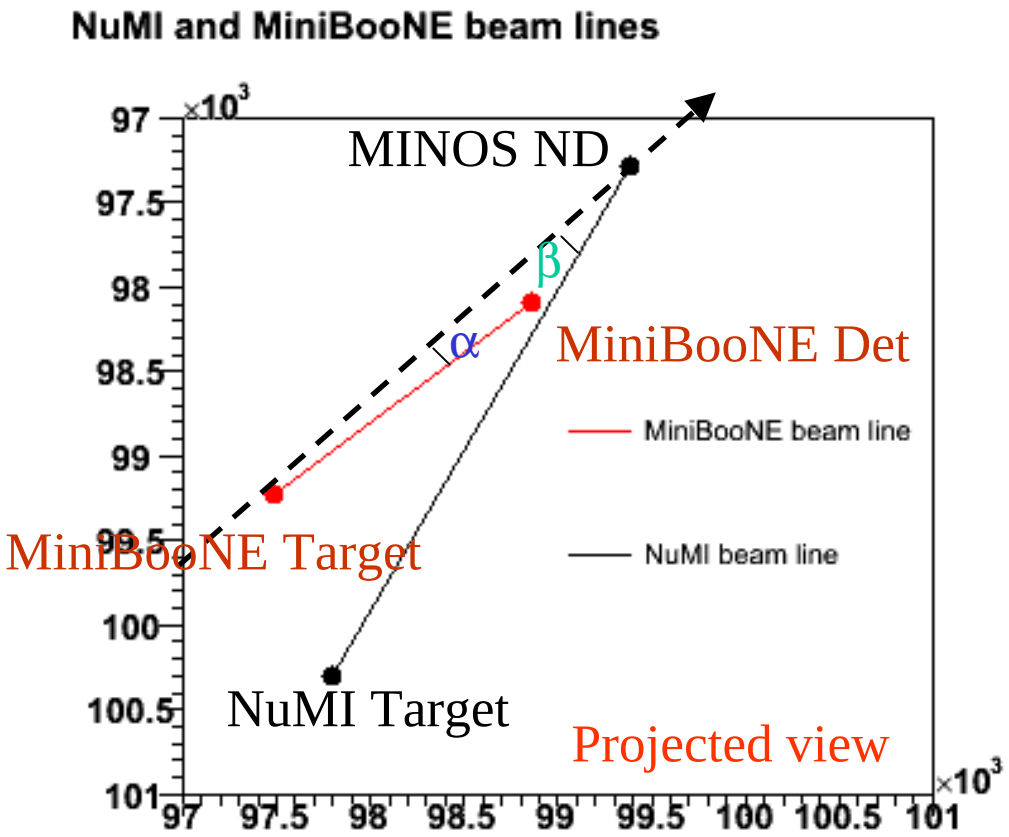
MiniBooNE Neutrinos at MINOS

Tingjun Yang
Work done with
H. J. Kang, S. Murgia, S. Wojcicki
Stanford University
D. Bogert, P. Shanahan, W. Smart
Fermilab

Minos Collaboration Meeting – Fermilab - April 2nd.

Outline:

- Review
- Data processing
- MC generation
- Data/MC comparison



α: off-axis angle to the MINOS detector = 9.13 deg

β: incident angle of MiniBooNE neutrinos on MINOS ND = 16.9 deg

Incoming direction of MB neutrinos:
zenith: 83.5 deg

azimuth: 172.8 deg

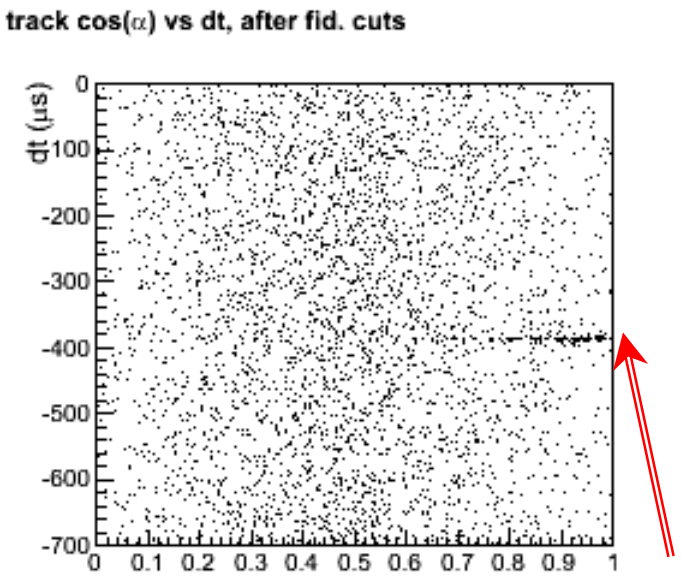
- **Highly monoenergetic ν beam:**
  - Determine the energy scale
  - Better signal/background discrimination for ν_e
  - Study cross sections for different interaction channels
  - Anomalous ν_e production

- Update since Oxford meeting
  - Data processing
  - Background reduction and estimation
  - Pot counting
  - MC simulation
  - Data/MC comparisons

Data processing

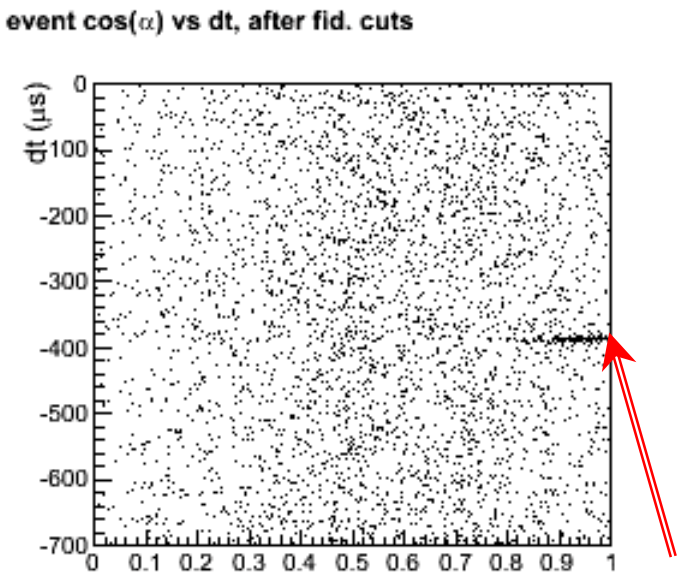
- To speed up processing, we filter only snarls within +-1 ms window around MB spill.
- Use R1.18.2 spill reconstruction:
  - Spill reco assumes neutrinos arrive into the near detector from the South, which is correct for MB neutrinos.
  - With cosmic reco, the direction could be assigned incorrectly.
- We have processed all ND data from March 2005 through February 2006. This includes MB runs with different horn currents (Nov05-Feb06) for their systematic studies.
- We will only show results with the nominal horn current (175kA) this time.

Correlation between timing and track/event direction



track direction

MB events



event direction

MB events

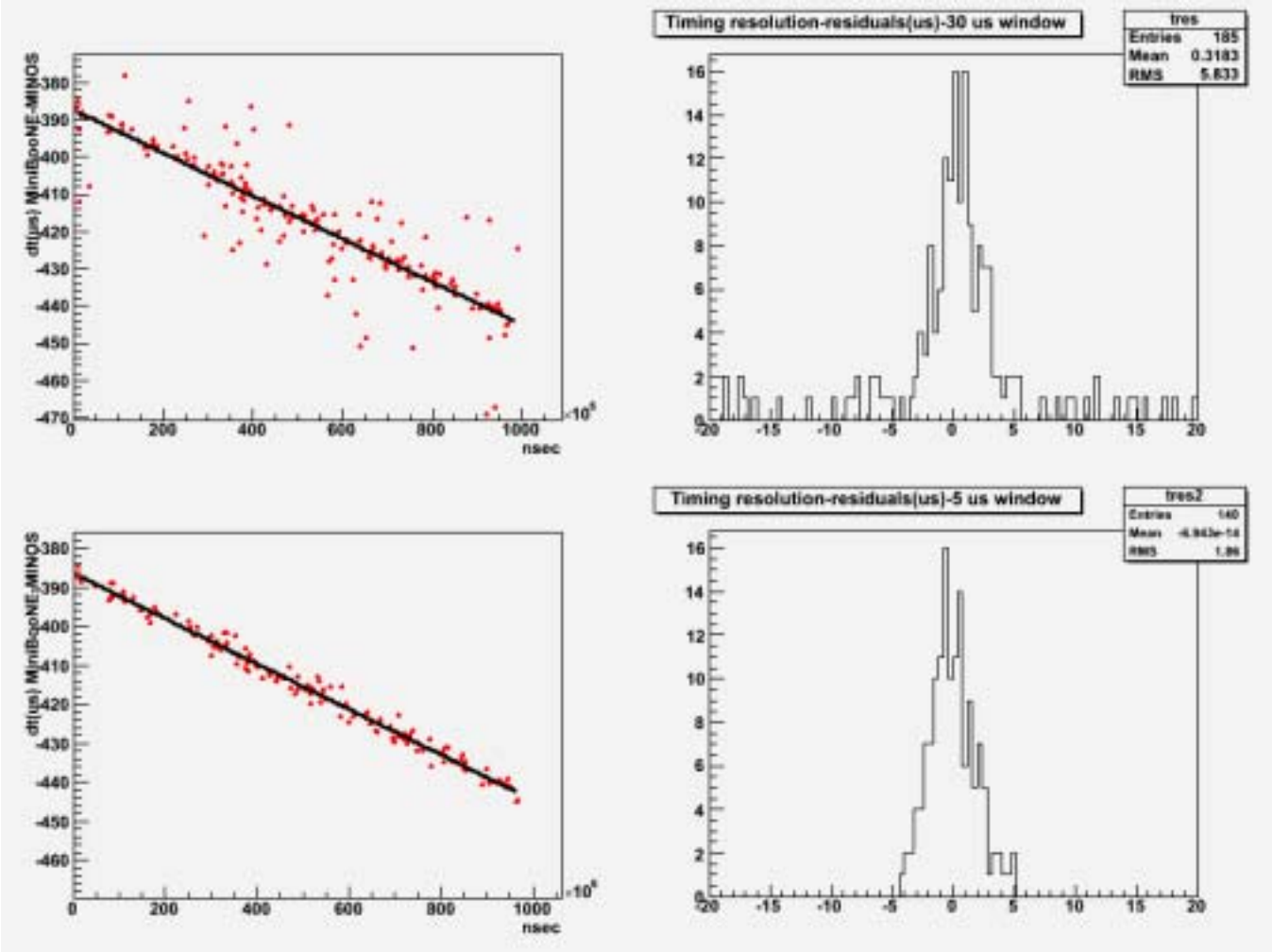
dt = Difference between MB spill and MINOS ND timestamp

α = angle between track/event and MB target to MINOS ND direction

Thanks to Steve Brice for providing the MiniBooNE spill timestamps (ACNET)

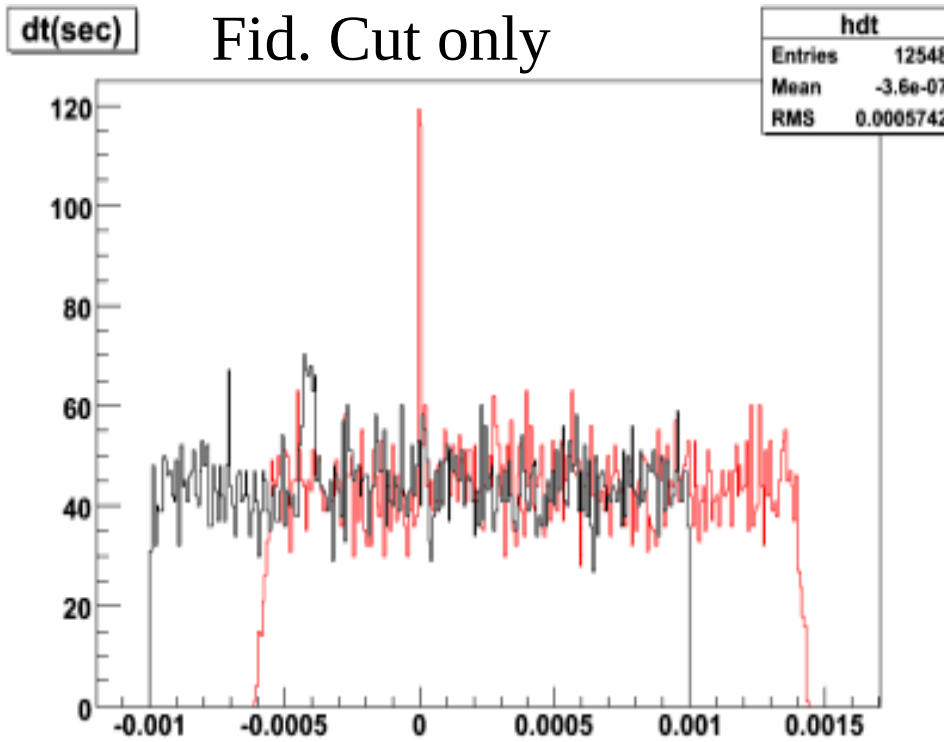
We are focusing on CC events: track_cos(alpha)>0.6

Timing correction – Timing difference vs nanosecond

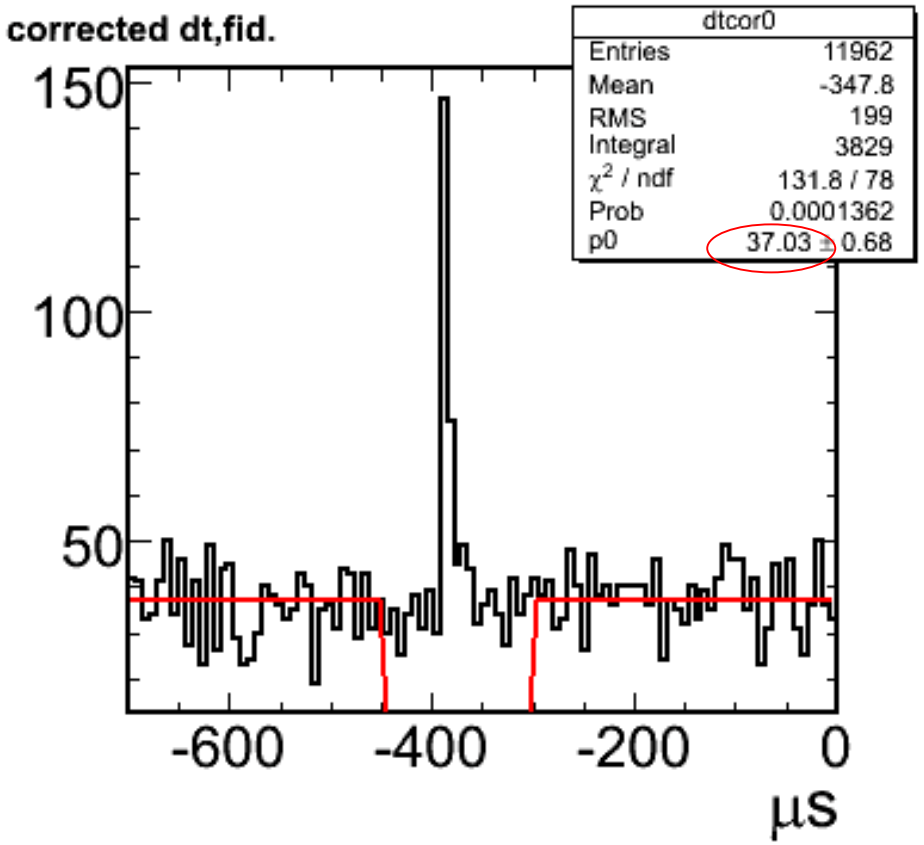


We plotted difference between MB spill and our timestamp as a function of the nanosecond: difference in the nanosec oscillators

Background estimation



Fid. Cut only



Black: before timing correction

Red: after timing correction

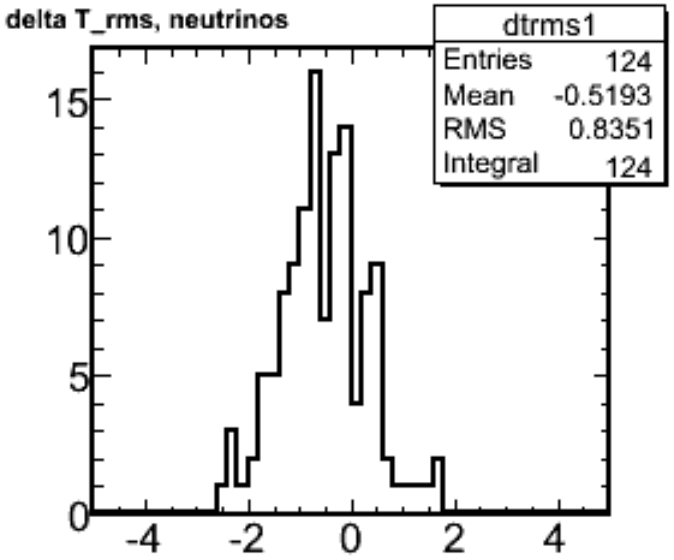
Peter Shanahan suggested the tail of dt distribution can be used to estimate our background.

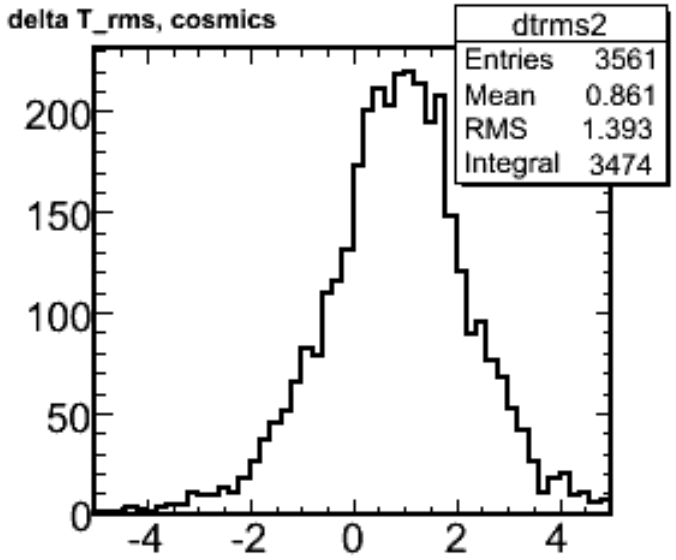
Background: 37.03 evt/7mus

Background reduction:

Most of the background should be cosmics with the wrong reconstructed direction. The first thing to look at is the track timing.

Fit ds vs dt of hits along track $\Delta t_{rms} = t_{rms}^{1/c} - t_{rms}^{-1/c}$





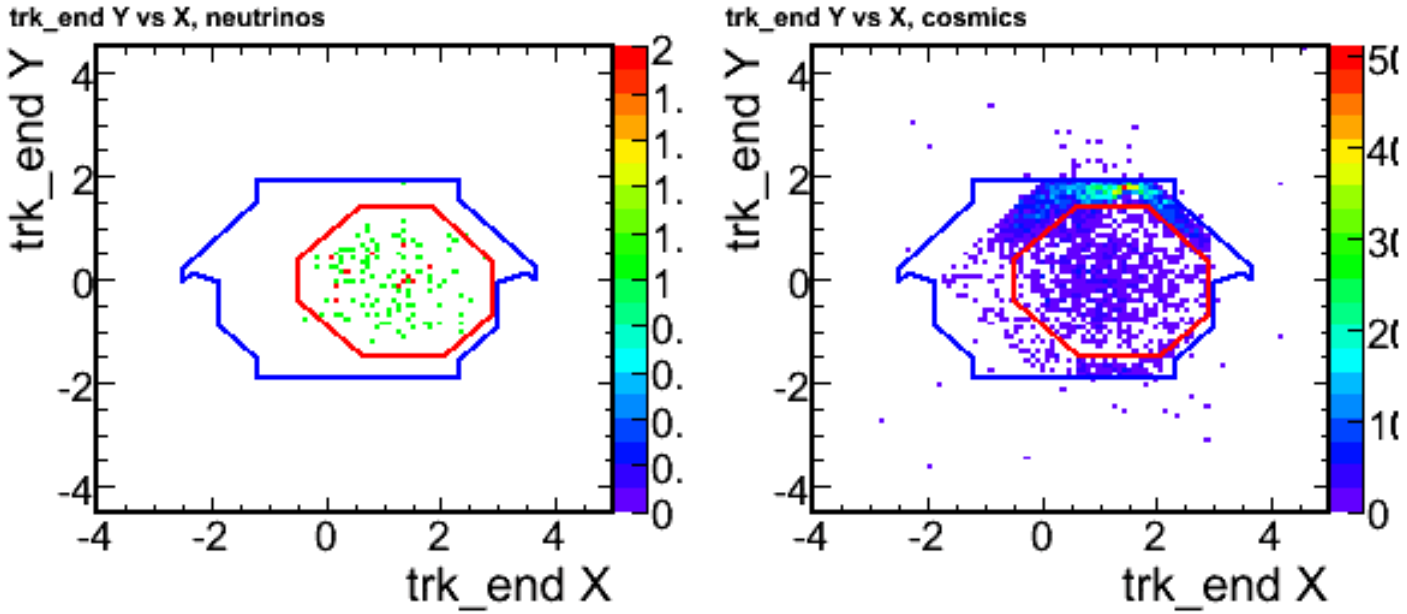
Events with |dt|<3mus good neutrinos

Events with |dt|>30mus,cosmics

Δt_{rms} <1.5ns

Background reduction:

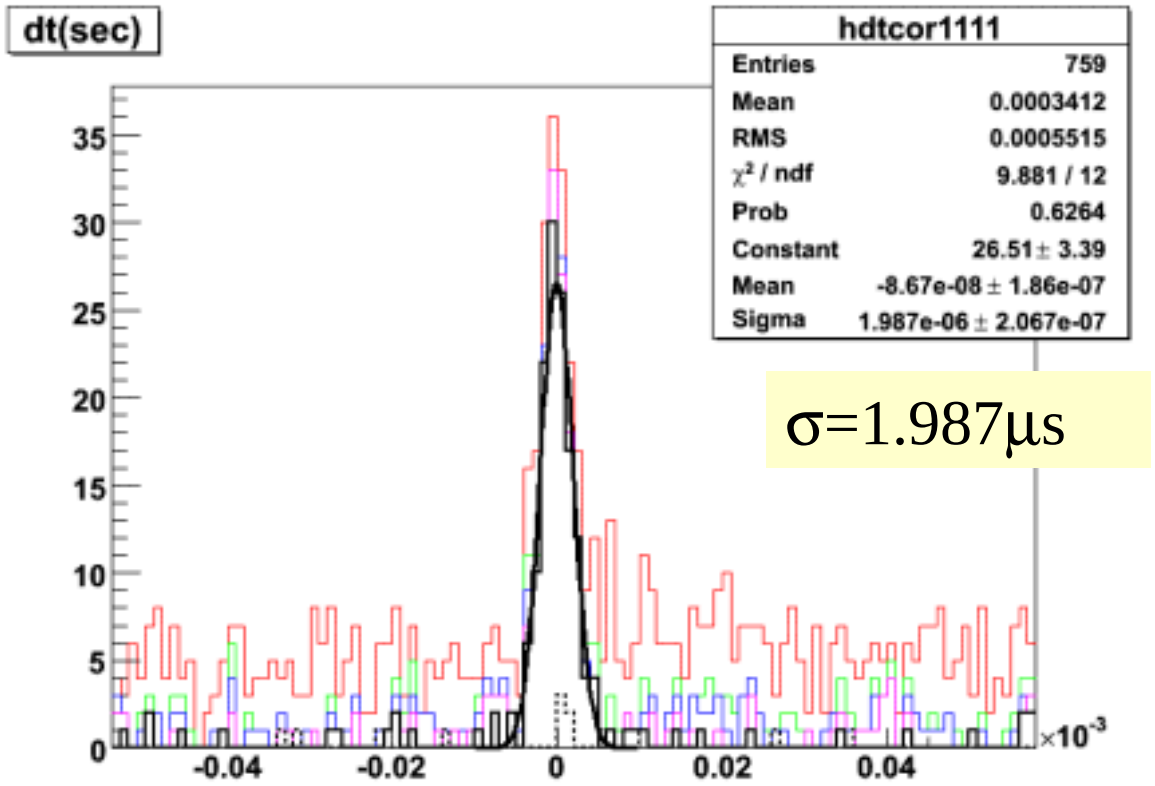
The background is mainly stopping muons. Look at the end of the track.



trk.end.x [-0.5,2.9] trk.end.u [-0.6,2.3]

trk.end.y [-1.5,1.4] trk.end.v [-2.5,0.6]

Background reduction (summary)



	Estimated background in +/- 10us time window
Fid.	105.8
cosα	32.6
Timing	20.8
Trk.end	7.4
others	2.9

Red: Fid. containment

Green: cos(alpha)>0.6

Blue: Timing cut (delta_trms<1.5ns)

Pink: end of track containement

a factor of 36 reduction

Black: 1 event + momentum < 4 GeV shower E < 4 GeV

Dashed Black: Same selection as above but reverse horn current

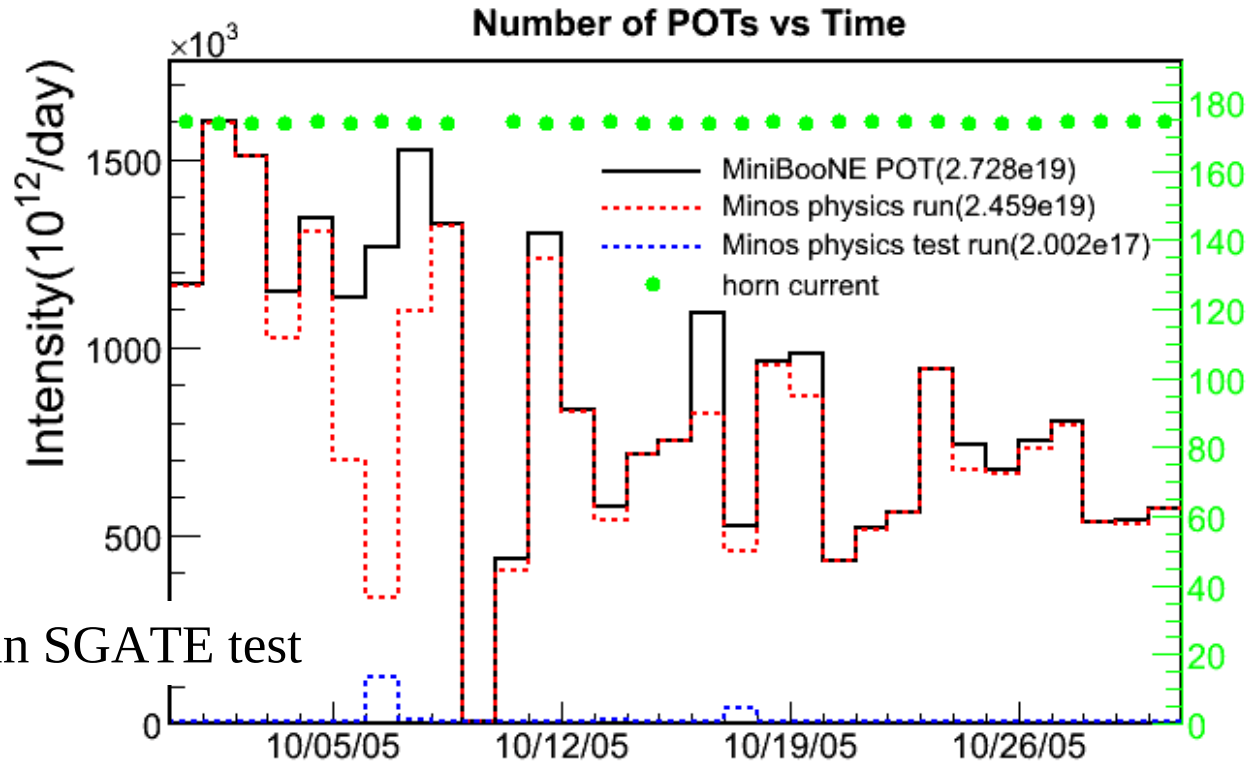
POT counting

Oct:

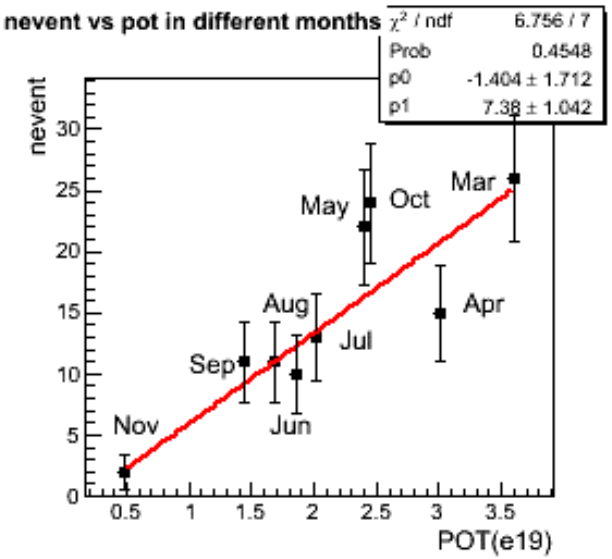
Tot pot: 2.728e19

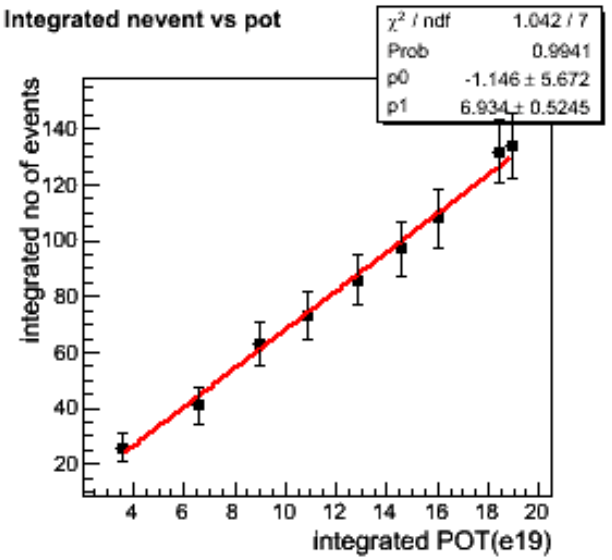
ND up time: 90.1%

From ACNET:
2.76e19



LI in SGATE test





Nominal horn current:

Total pot: 1.895e20

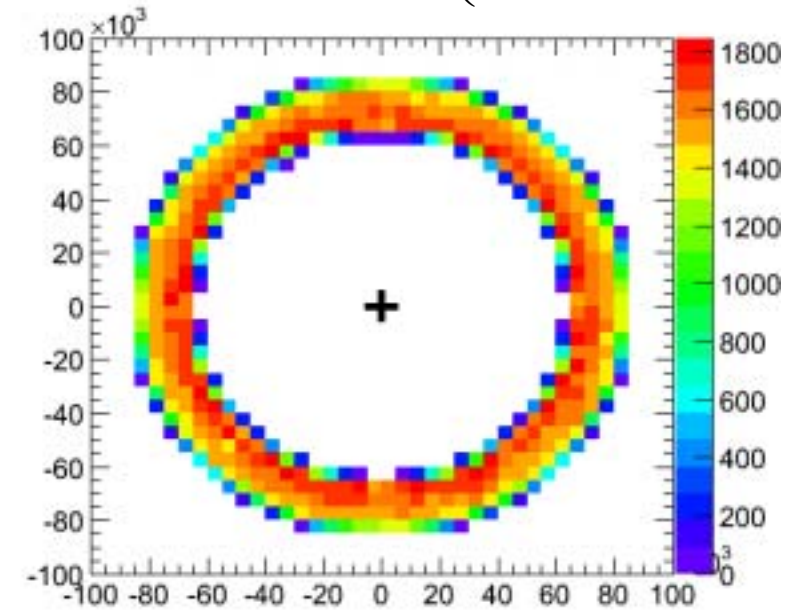
Total evt: 134

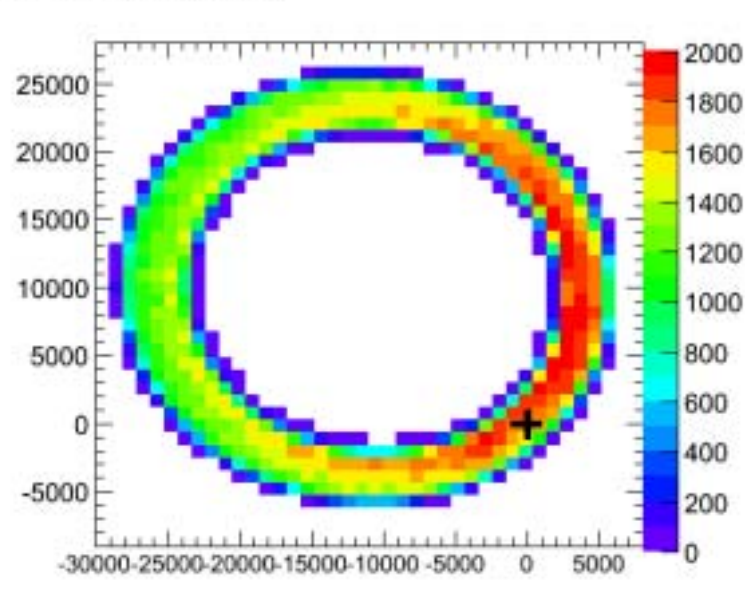
Background: 2.2%

Detector simulation with MiniBooNE MC

- Steve Brice run through MiniBooNE's latest beam MC output ntuples and gave us all those neutrinos that are emitted between 140 and 180 mrad from their beam axis – 50M POTs.
- We need to convert everything from MiniBooNE coordinate system to NuMI coordinate system. Coordinates from Wes.

$$\text{Rotation}_{\text{MB}->\text{NuMI}} = \begin{pmatrix} 0.921 & 0.001 & -0.389 \\ 0.023 & 0.998 & 0.057 \\ 0.388 & -0.061 & 0.919 \end{pmatrix} \qquad \text{Translation} = \begin{pmatrix} 23684.8 \\ 4761.4 \\ 24684.4 \end{pmatrix}$$



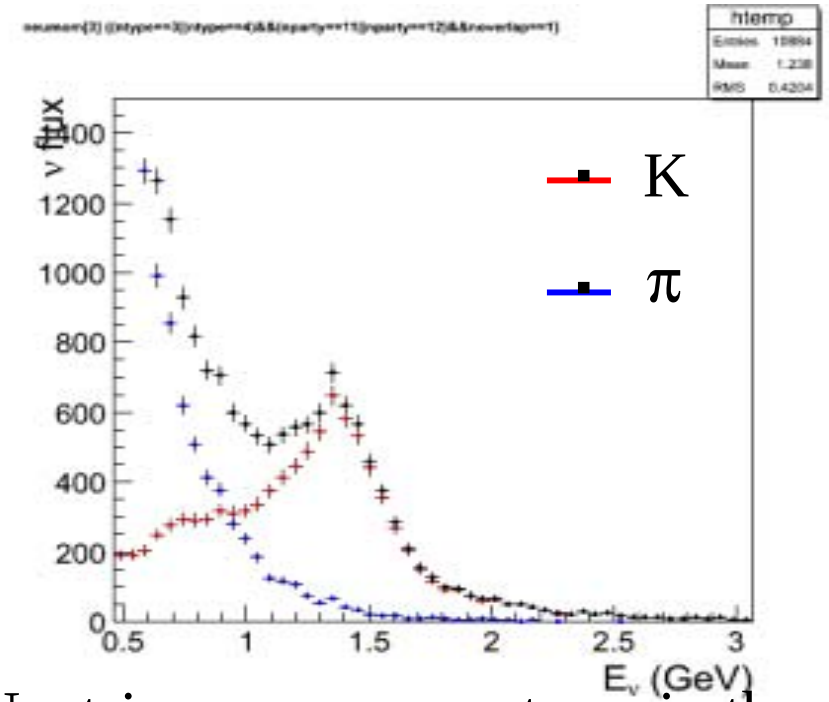


Projection of x,y in MB system

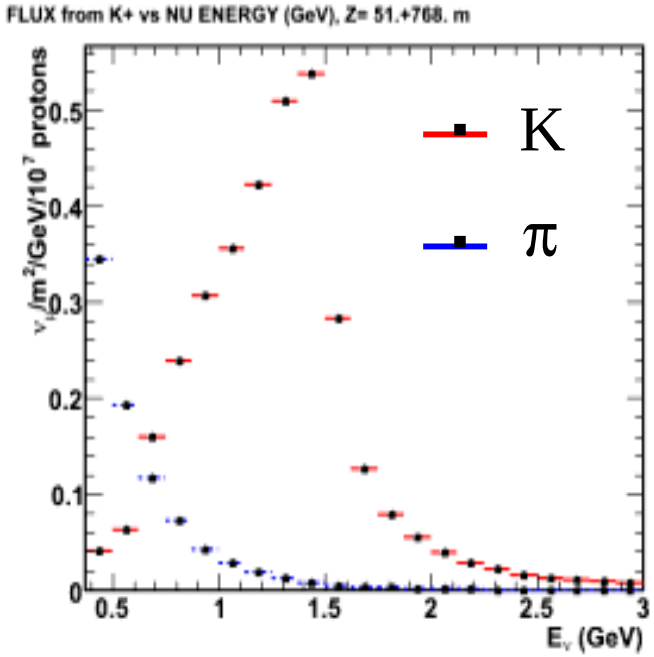
Projection of x,y in NuMI system

Detector simulation with MiniBooNE MC

We are suffering low statistics. One temporary solution is to divide the entire ring into 30 segments, then rotate each segment to cover our ND. Increase the statistics by a factor of 30.



Neutrino energy spectrum in the window |x|<10m |y|<10m

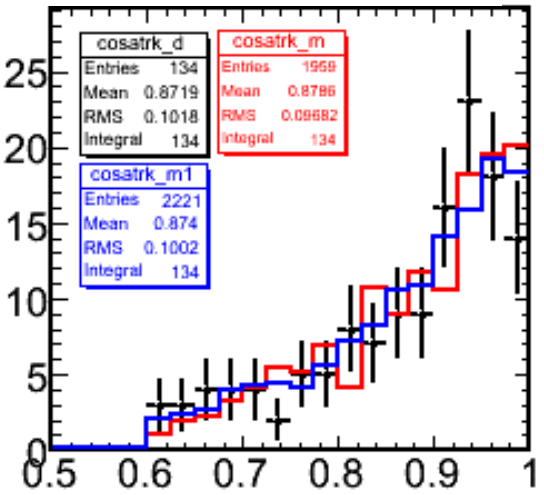


Pbeam simulation by Wes.

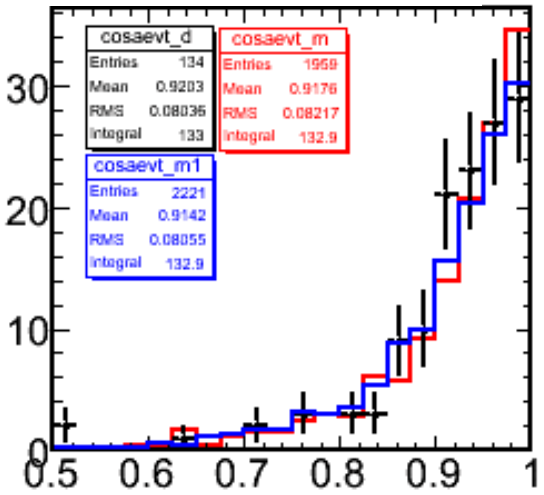
Kaon 3 body decay is not quite right in MB MC. Big difference in pion decay.

Data/MC comparison – normalized by no of events

trk cos(alpha)



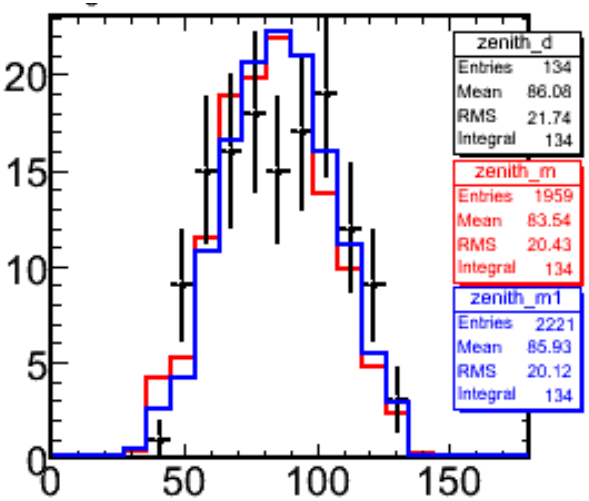
evt cos(alpha)



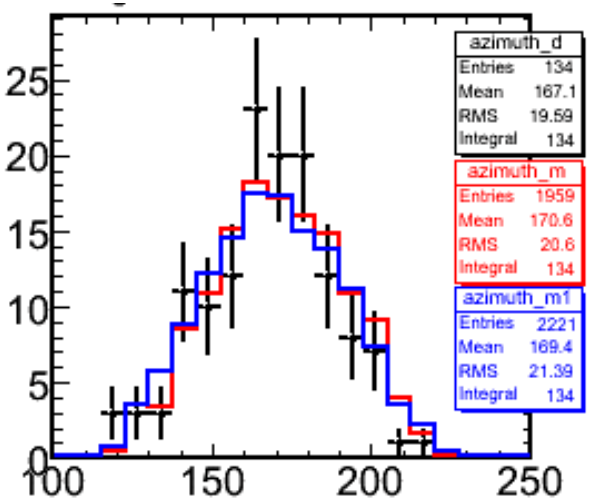
Red: pbeam MC

Blue: MB MC

zenith angle

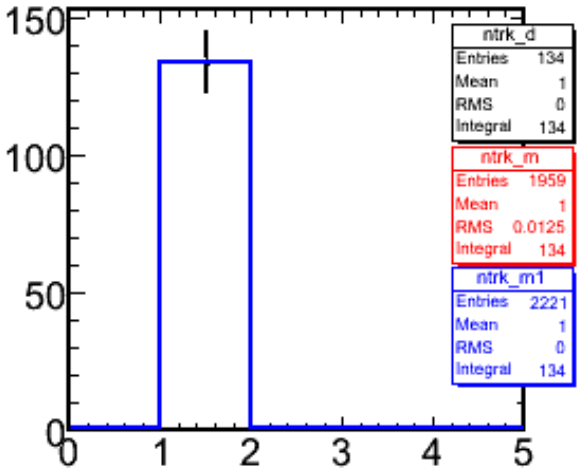


azimuth angle

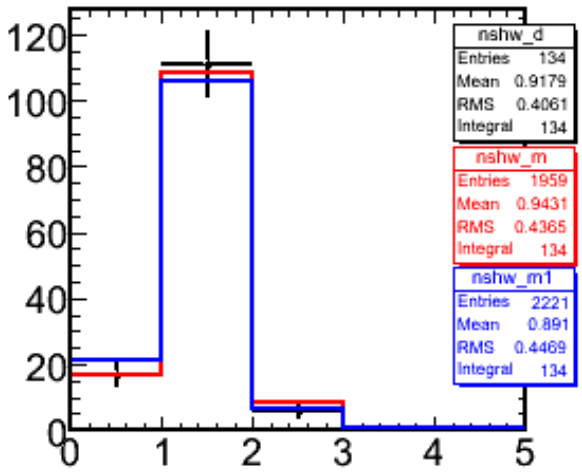


Data/MC comparison – normalized by no of events

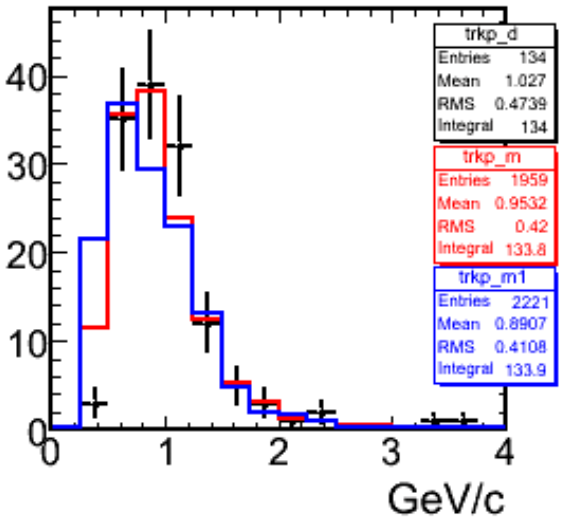
no. of tracks



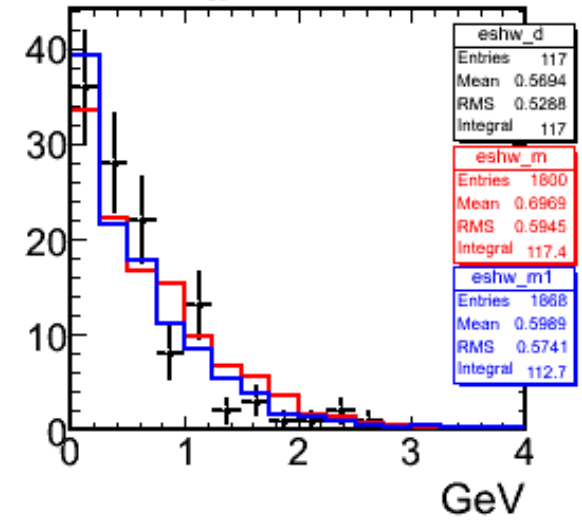
no. of showers



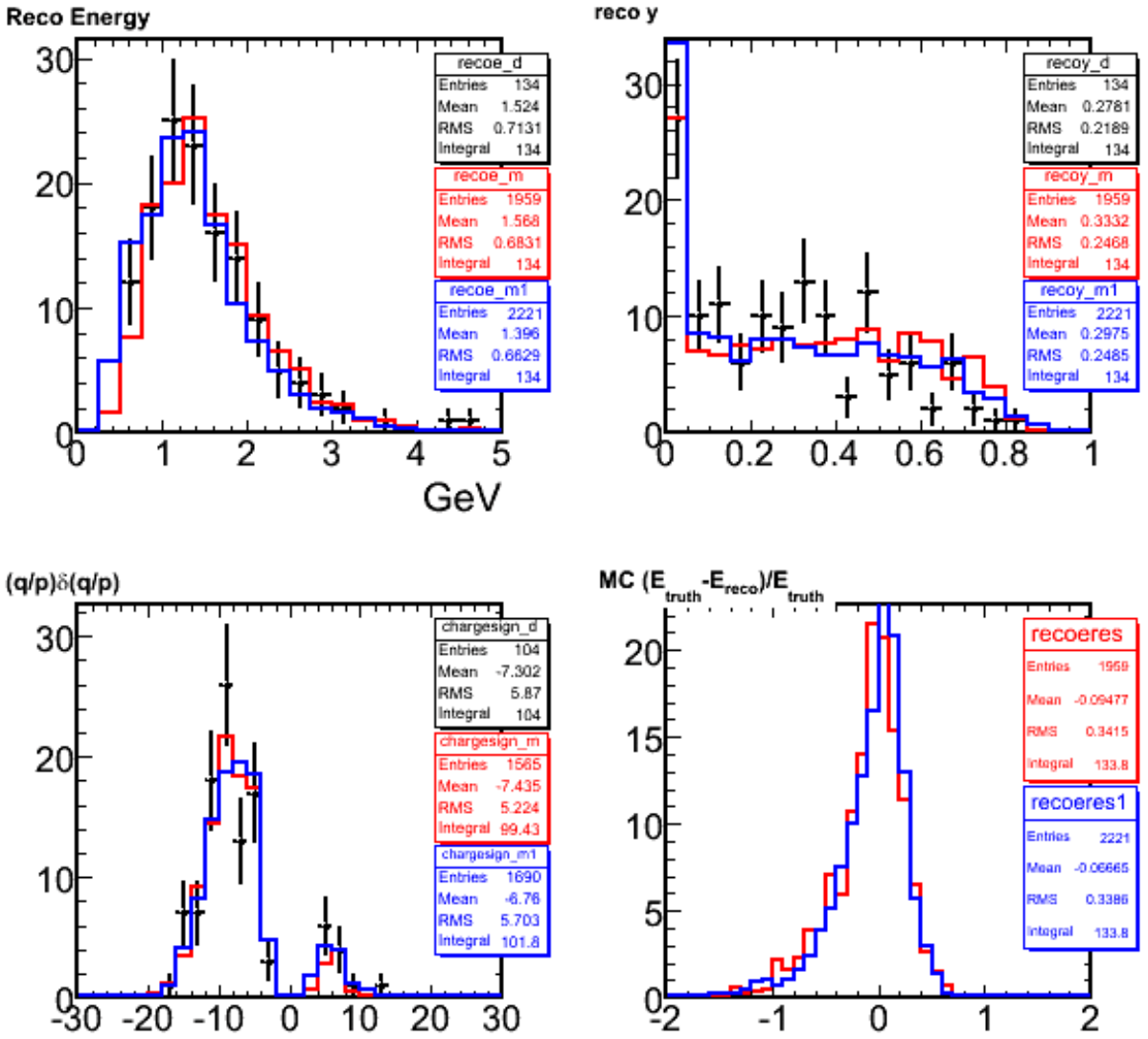
track momentum



shower energy



Data/MC comparison – normalized by no of events



Summary and future work

- We have processed almost all the available data.
- Background is highly reduced in the data sample.
- Fairly good data/mc agreement.
- Using more sophisticated methods to separate signal from background.
- Normalize MC by no. of POTs.