Muon Removal Update

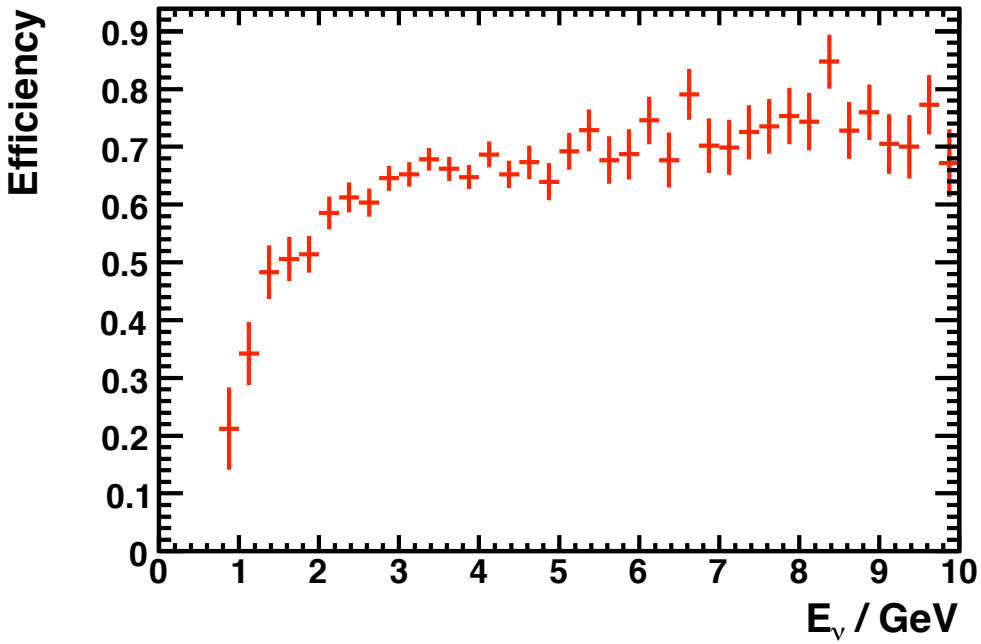
Caius Howcroft

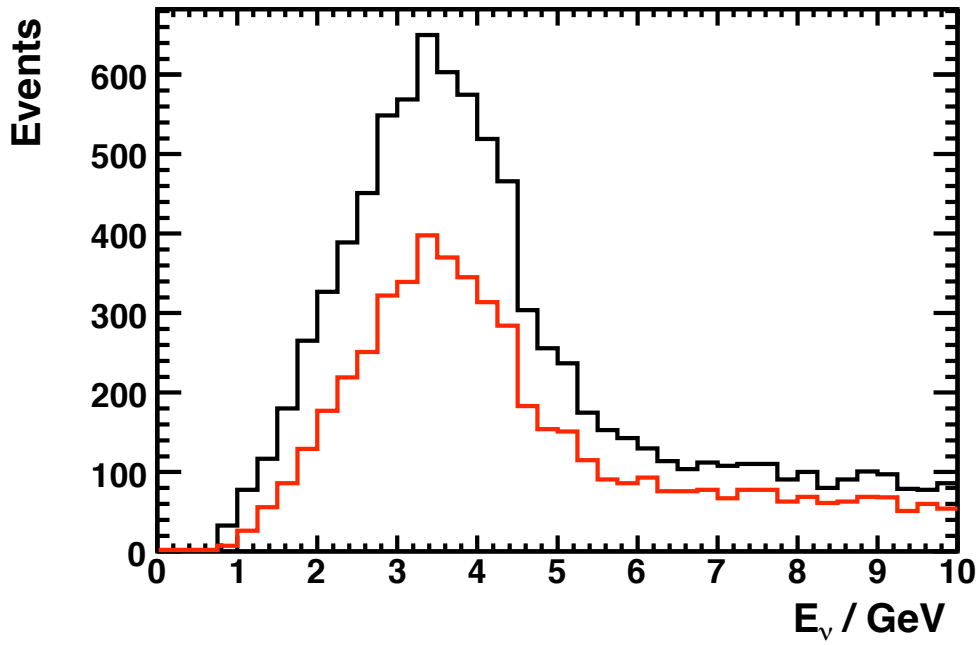


Input Events Selection

- Want a sample of "golden" NuMu CC events
- Require:
  - 1 or more track reco'ed + fitted, with ≥15 planes
  - Vertex contained
  - Tagged as a real spill (Data)
  - Not a cosmic (dcosZ<0.5)
  - LI stripping.
- Input data:
  - Spill stripped raw data Sept/Oct, LI stripped, 1,422,741 spills
  - Carrot 'beam' fardet MC (1002-1009)

Selection Purity/Efficiency





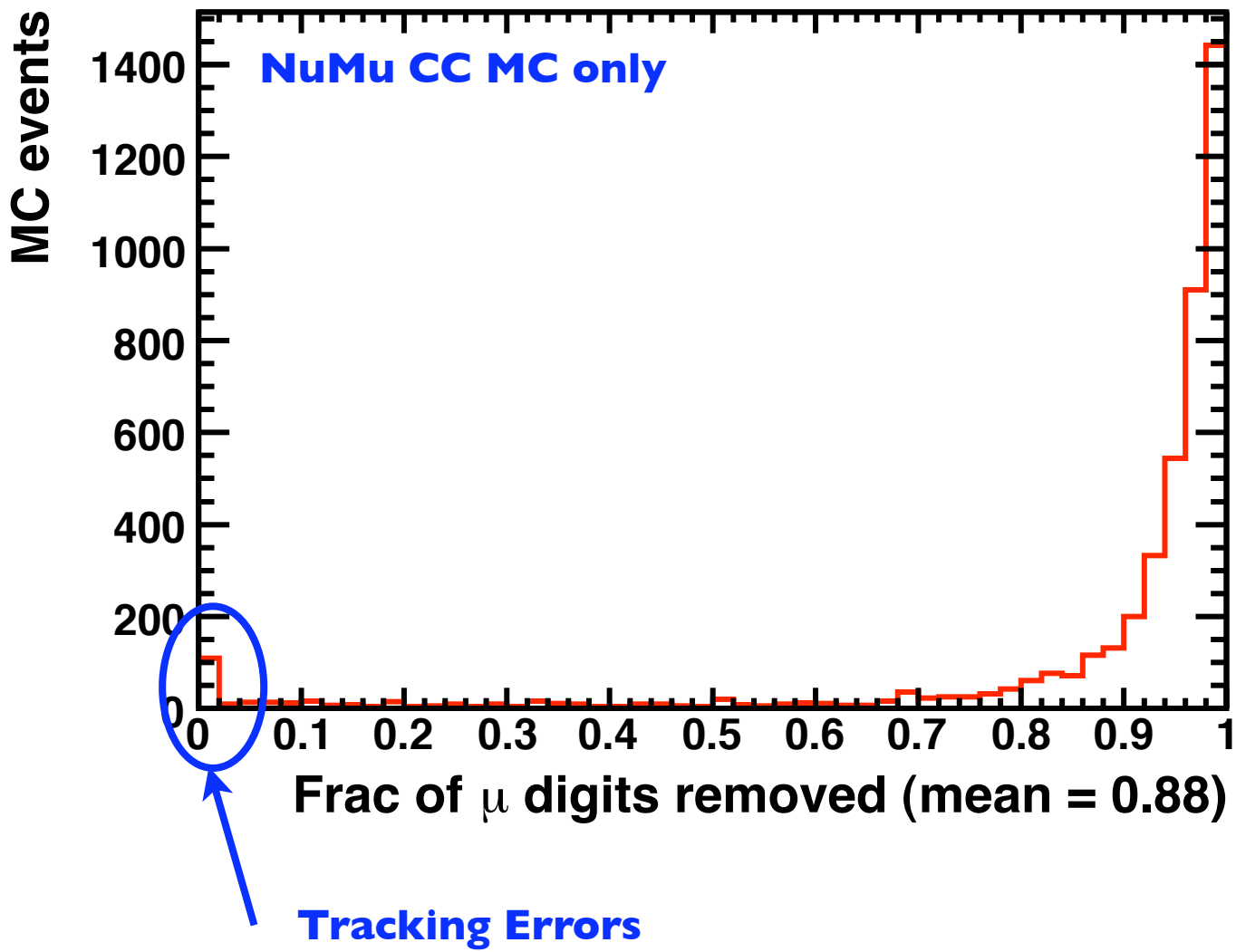
	Fraction of selected
NuMu CC	91.3±0.3 %
NuE CC	0.7±0.1 %
NC	8.0±0.3 %

Method Muon Removal Method

- Use Cand files from farm.
- Take reco'ed track and look for the Max Shower Plane:
  - work from vertex count 5 'track like planes', the 6th is the 'max shower plane'
    - 'trk like plane', >80% PE's in track and total PE's in plane >3
  - Kill all digits after 'max shower plane'
- Follow back into shower, and remove all track hits <2MIPS
- For track hits >2MIPs look in adjacent strips, if >3PE keep, else remove.
- Write out new CandDigitList without the muon hits.
- Kill all other Candidates.

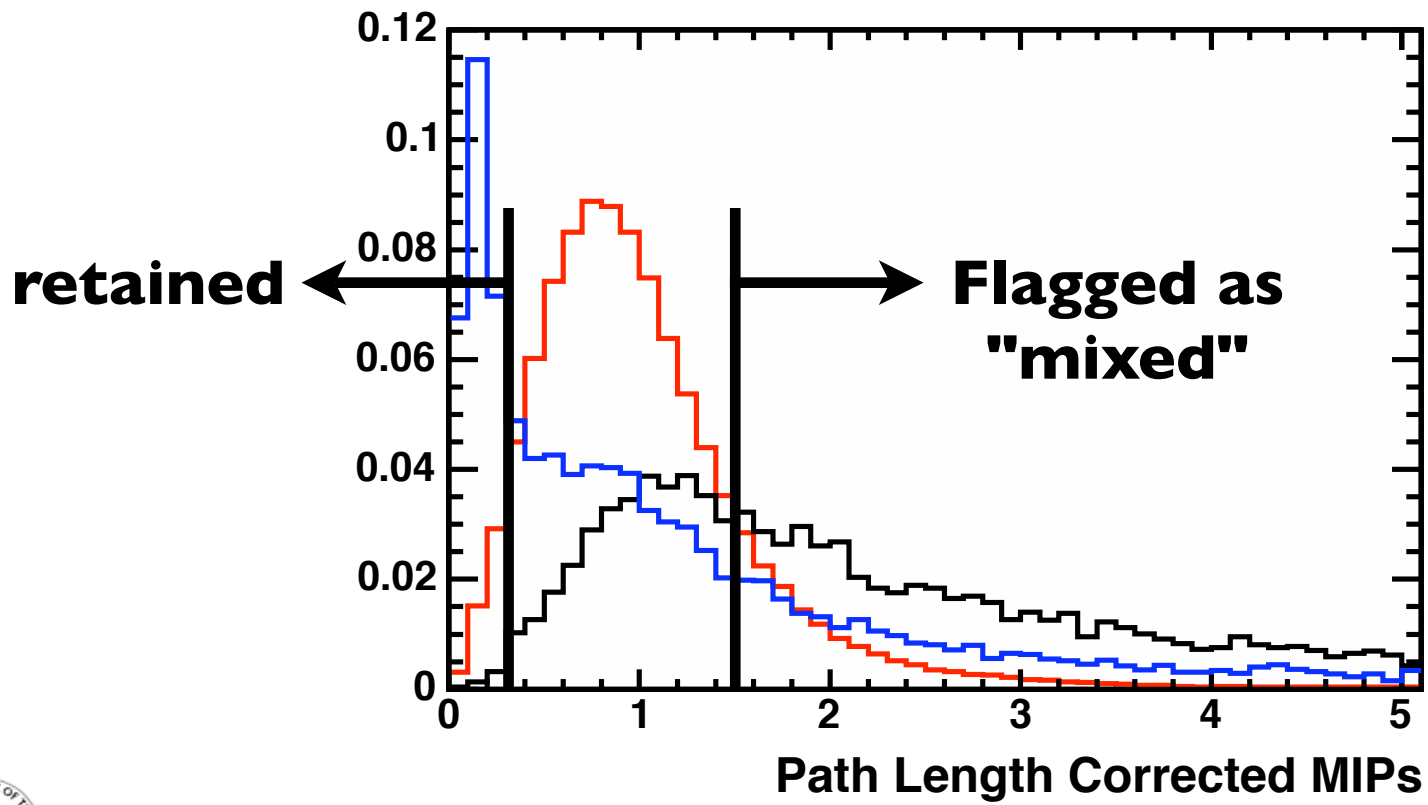
Muon Removal Efficiency

- Fraction of digits that are truly muons (have a muon component) that are removed.



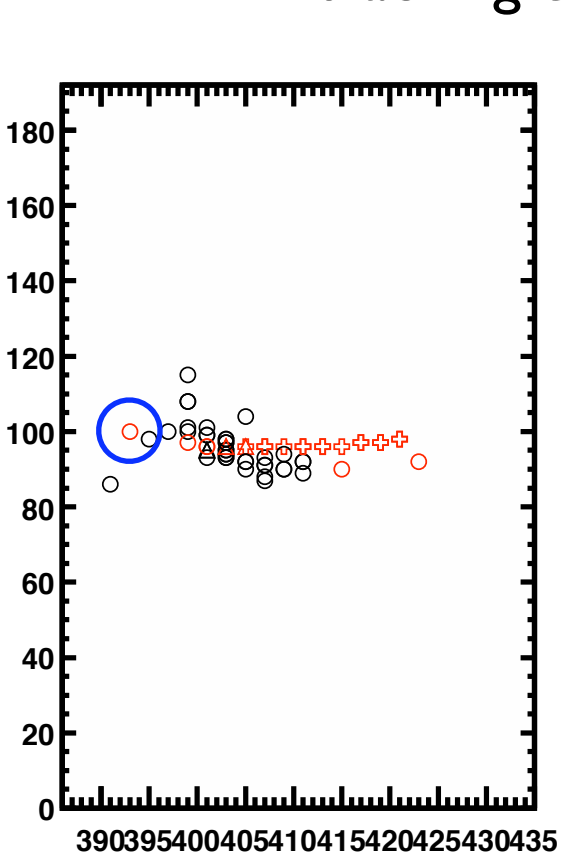
Tracked Hits

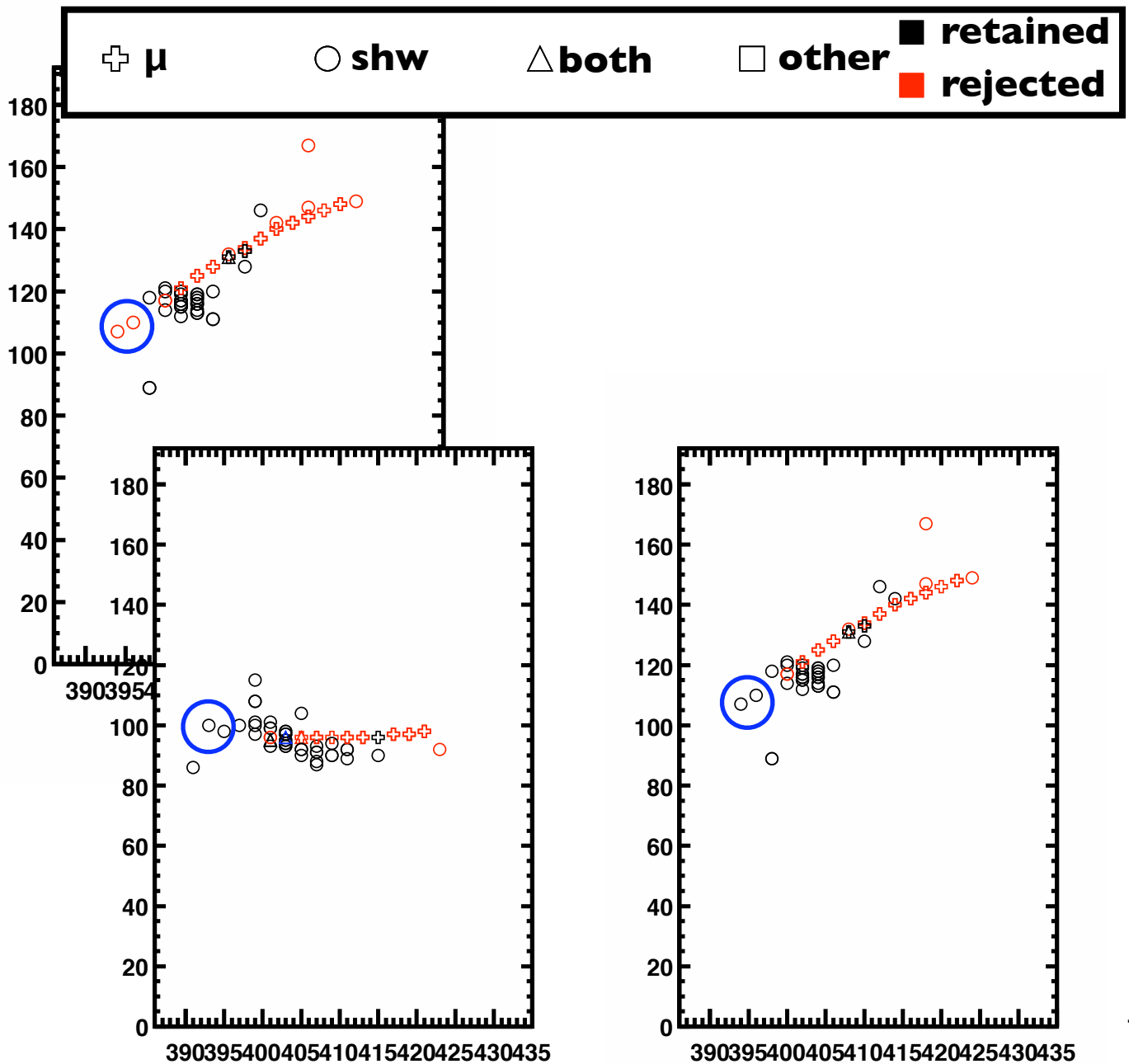
- Plot the path corrected MIPs deposited per a plane in a track for:
  - Pure muon planes
  - Mixed muon and shower planes
  - Shower only planes (i.e. tracking errors)



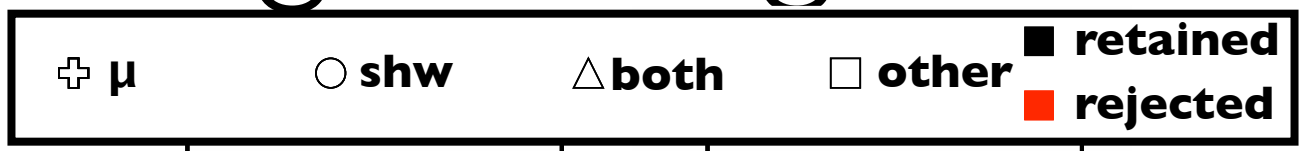
Low Charge Hits

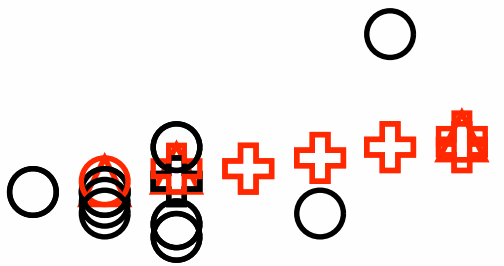
- <<1 MIP deposition good indication that there was a tracking error. Often these are near the start of the track.

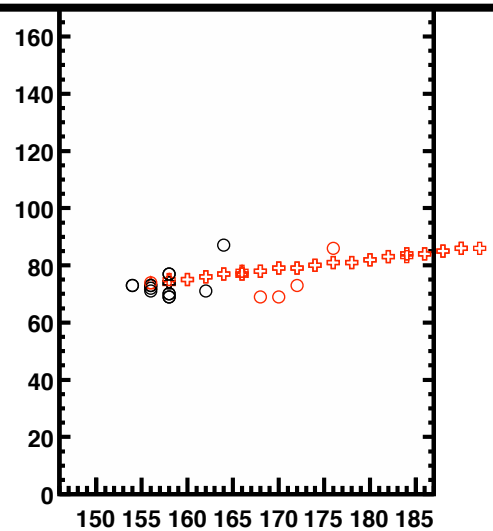


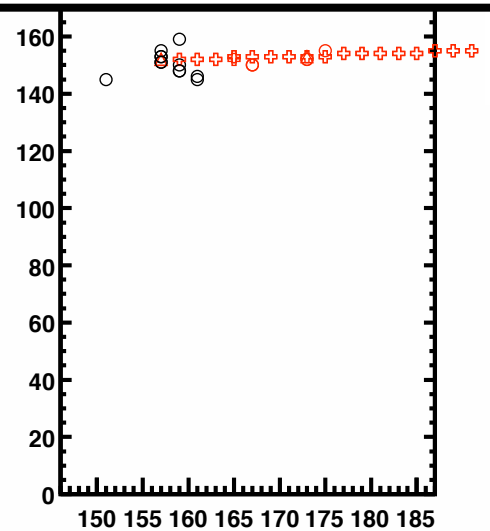


High Charge Hits

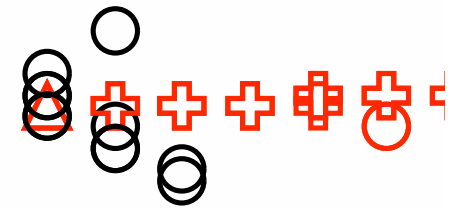


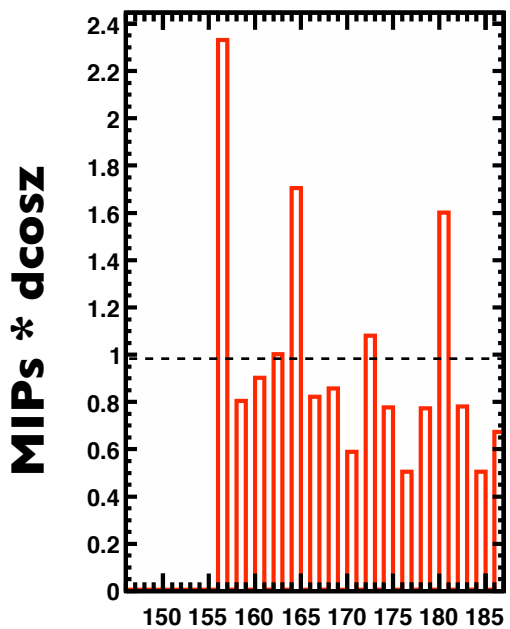


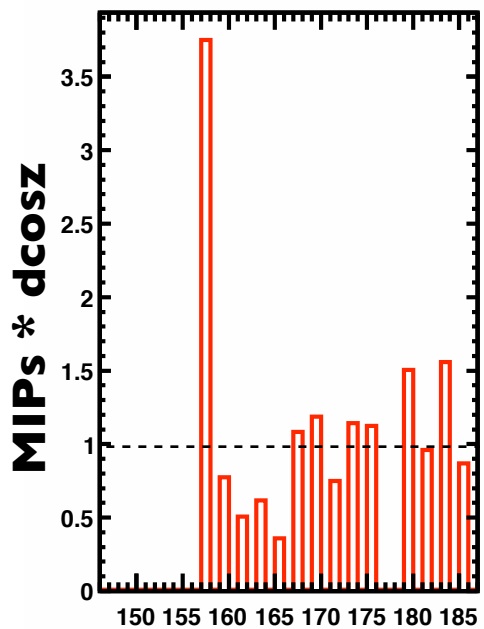




Plane

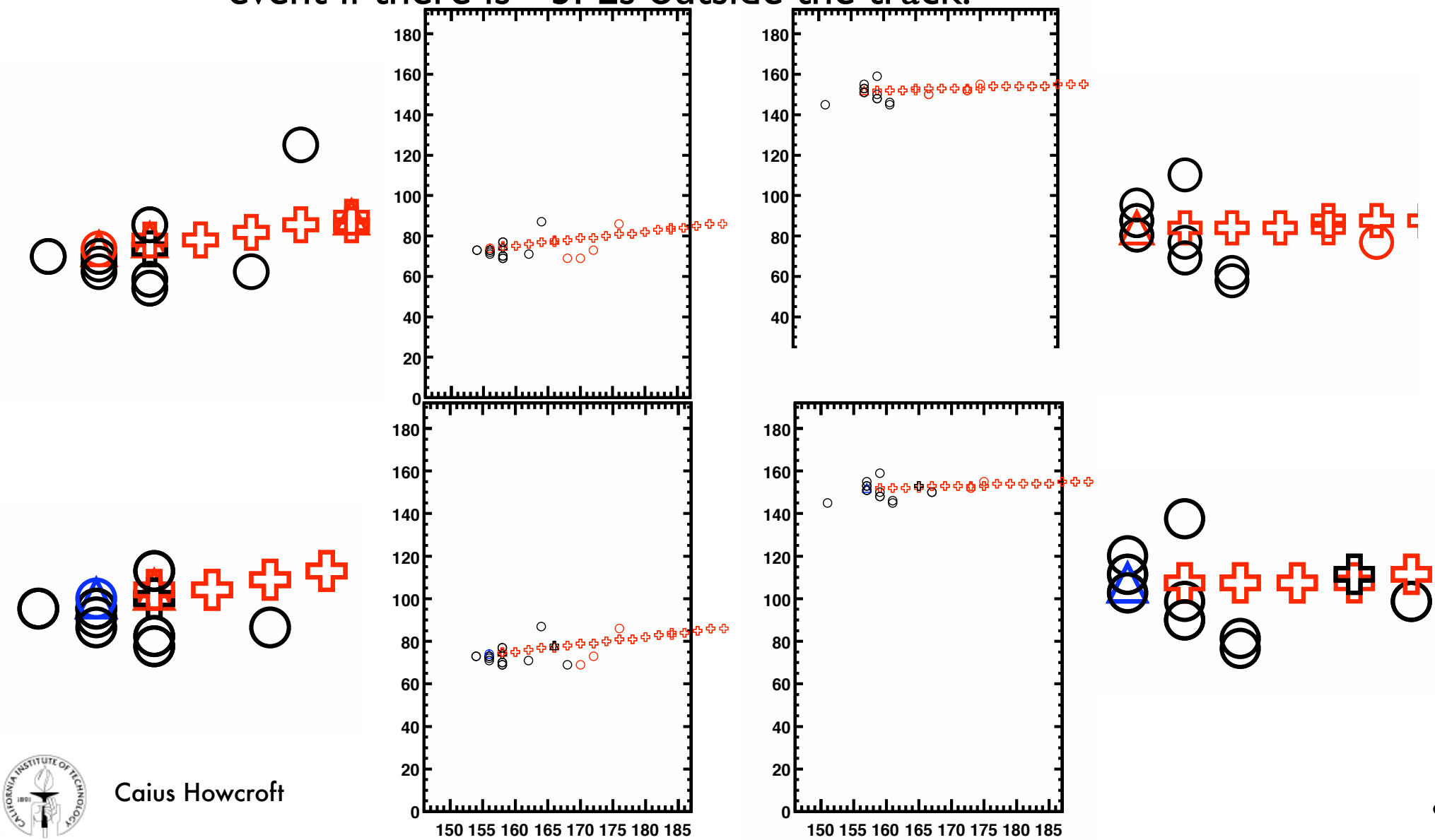




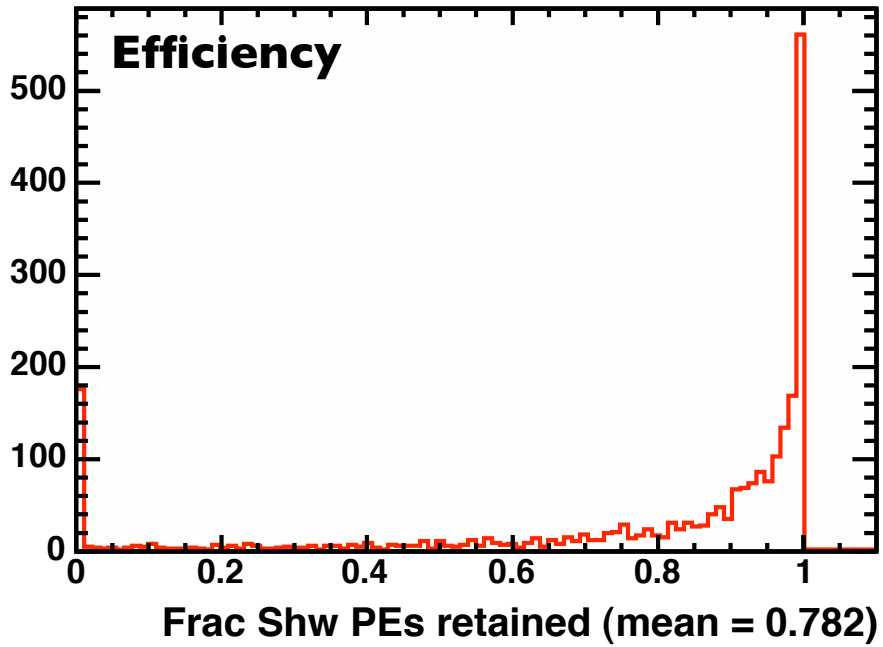


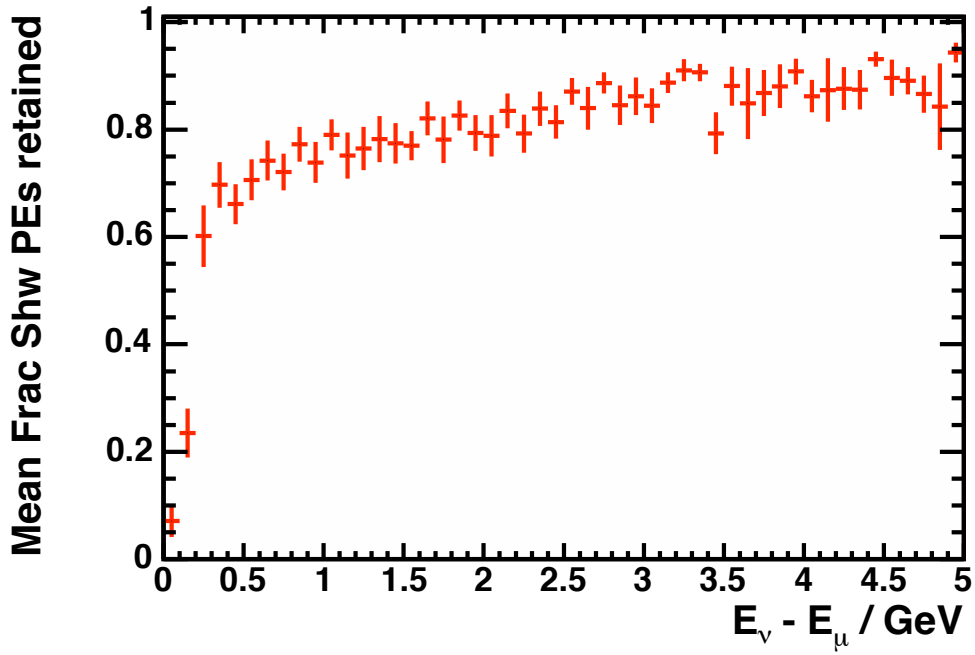
High Charge Hits (2)

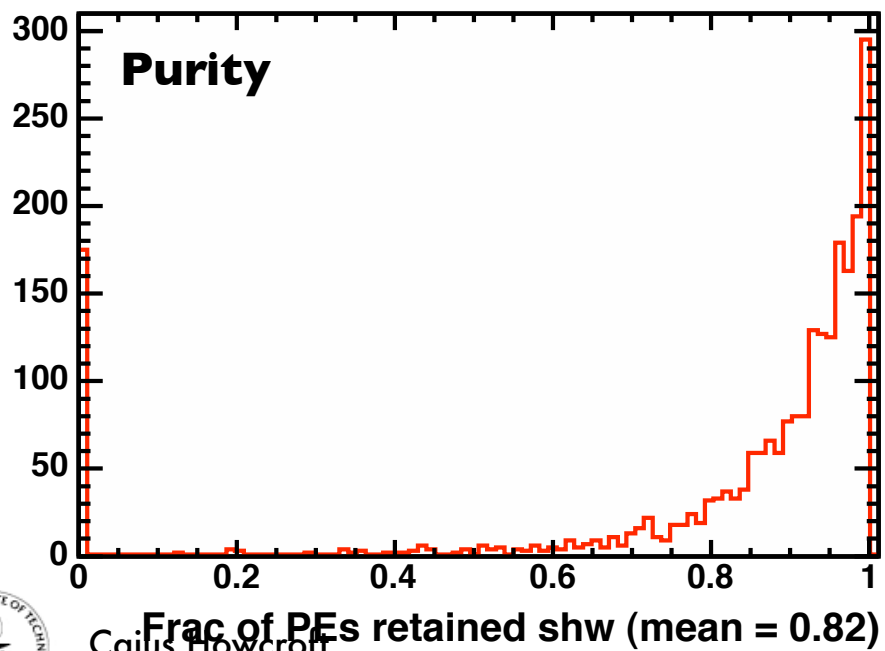
- Take planes with MIPs*dcosz>1.2, flag as "mixed" and rescaled to remove 1/dcosz MIPs and added back into the event if there is >3PEs outside the track.

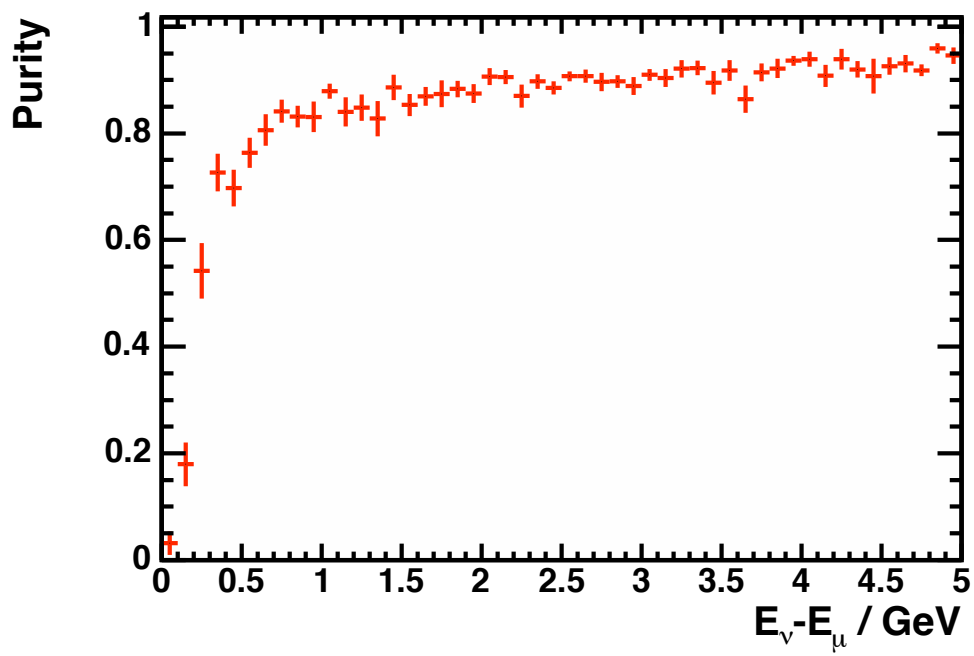


Efficiency & Purity



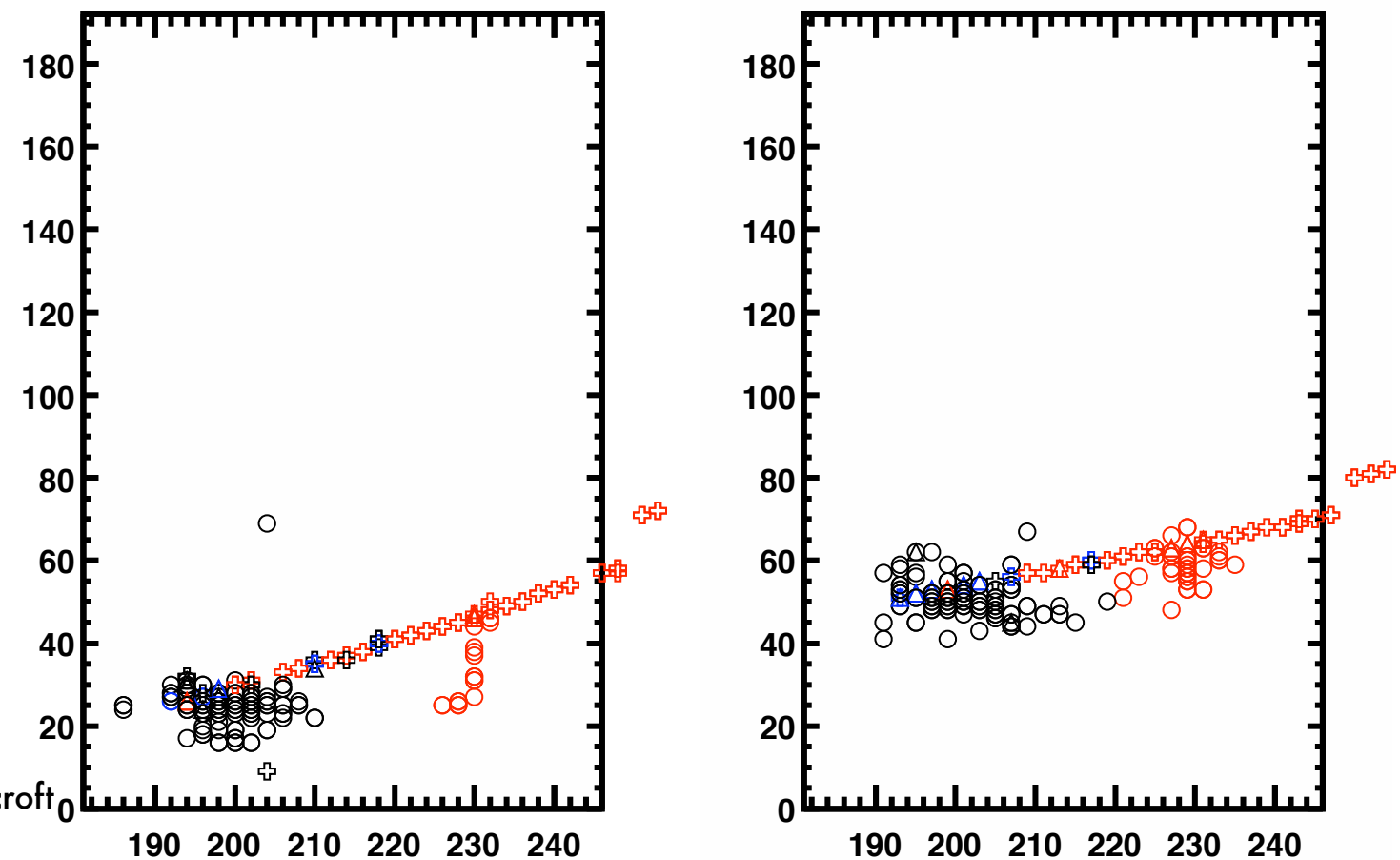






Purity Limitations

	Fraction of Rejected Shw Digits
Out of Vertex Area	45 %
Tracked && !Muon	35 %
Mixed Muon and Shw	25 %
Reco'ed XTalk	8 %

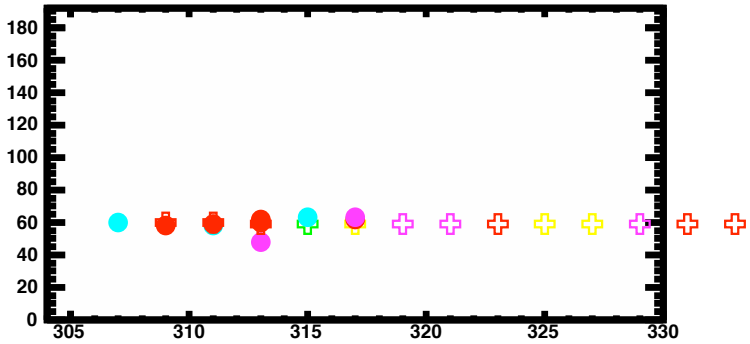


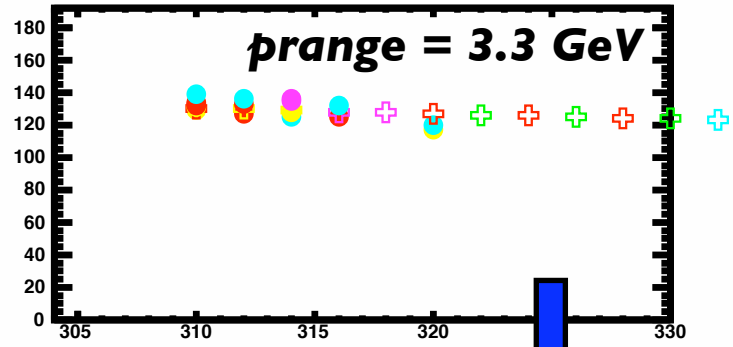
Event Merging

- Take muon parameters, dcosx,dcosy,dcosz and P (from fit or range depending on end containment)
- Give parameters to Chris to generate electrons with same input true parameters.
- Write out digits in text files.
- Read back into framework and combine stripped digit list with the digits from the electrons
  - Read in digits
  - Combine with current data digits:
    - build pixel maps
    - align digits in time (TDCs) using muon TDC's
    - recalculate timewalk
    - recalculate the trigger times
    - remultiplex event
- Write out a 'merged' cand digit list
- Run this digit list through regular reconstruction.

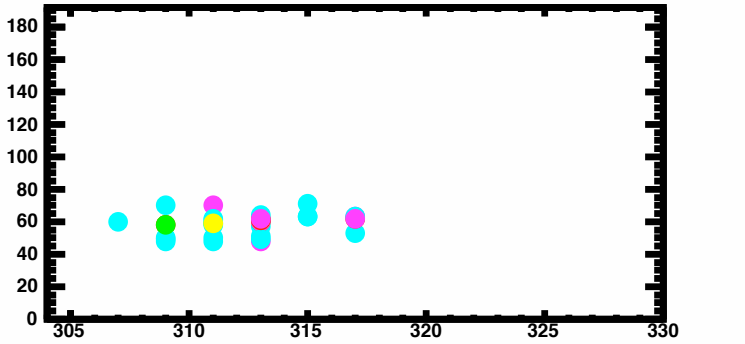
MC Example 1

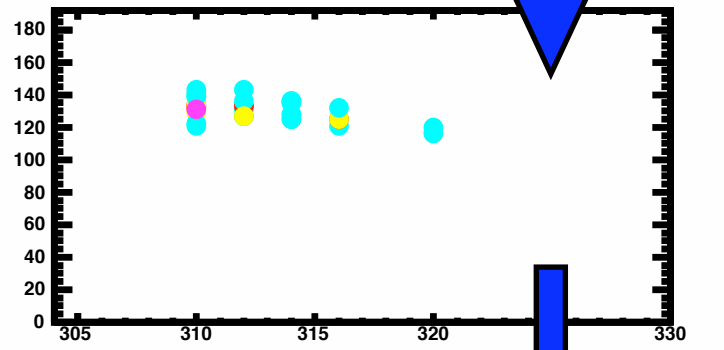
Original Event



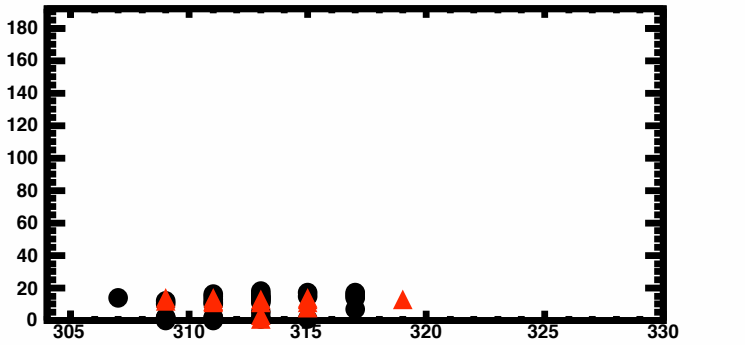


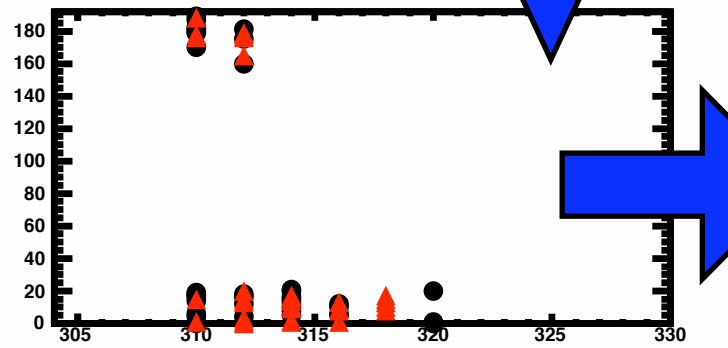
Muon removed





Electron Added + remultiplexed





Std. Reco.

Example 1 (b)

Run: 21001002, Snarl: 0, Slice: 1(/1), Event 1(/1)

Reco

#Trks: 0

#Shws: 1

q/p: 0.000 +/- 0.000, p/q: 0.000

TrkRangeEnergy: 0.000 RecoShwEnergy: 6.013

Vtx: 0.00, 0.00, 0.00

Truth

N/A

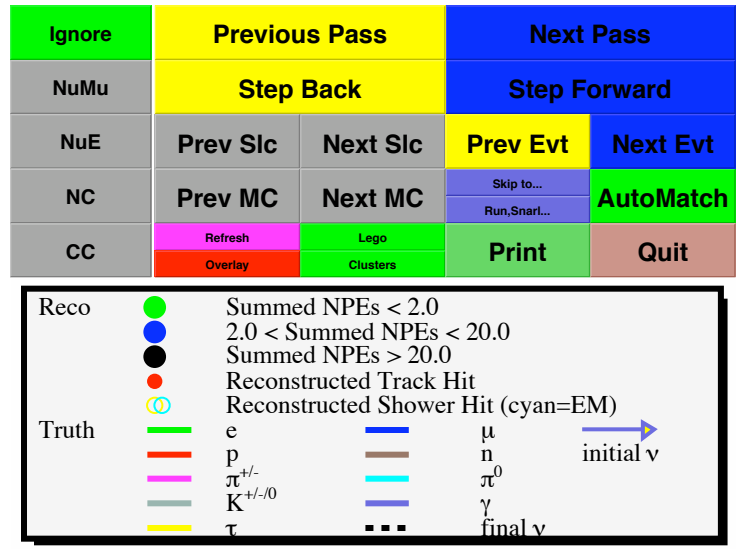
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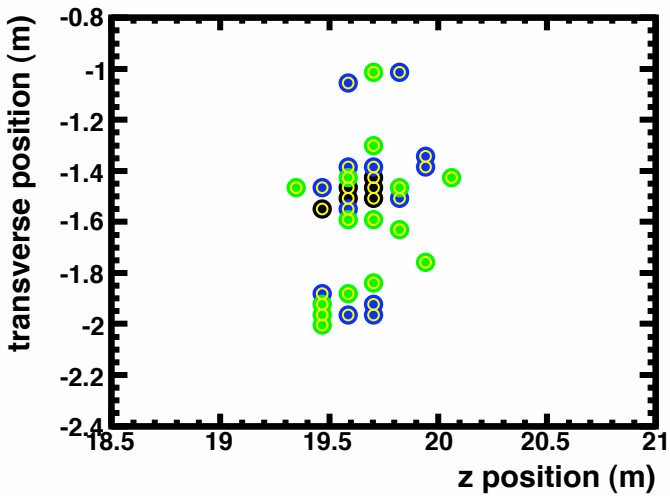
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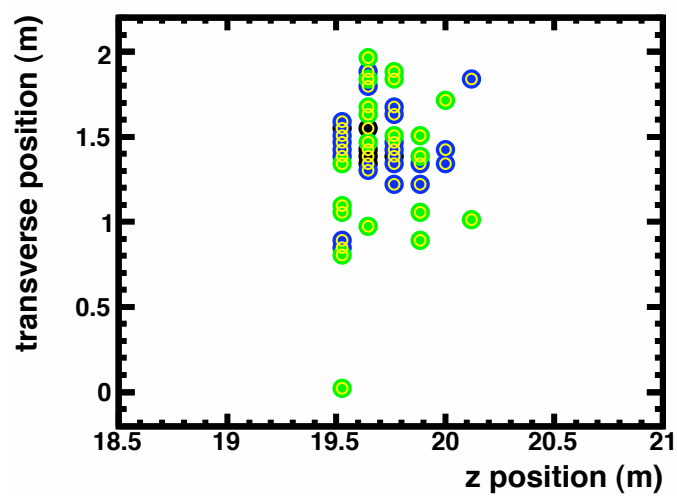
N/A

N/A

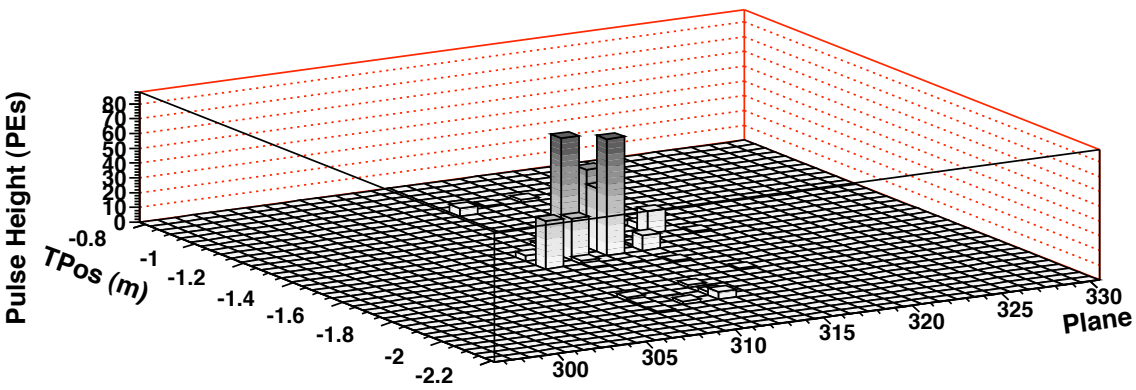
N/A

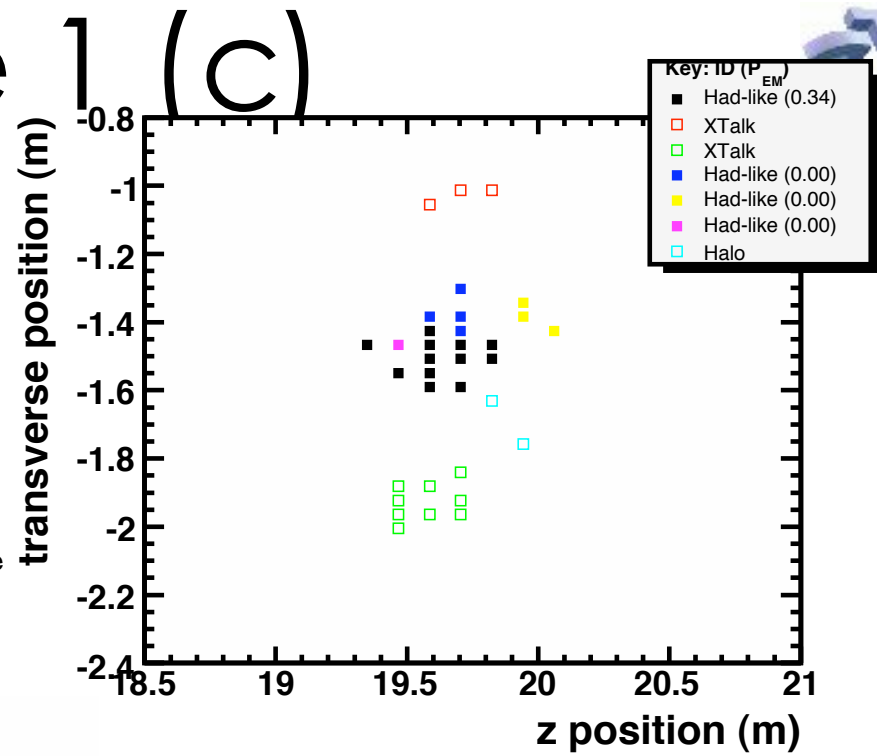


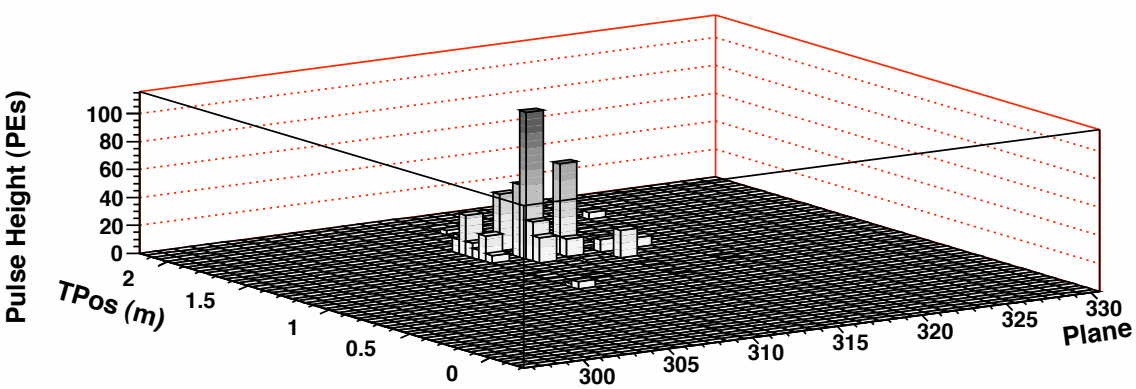


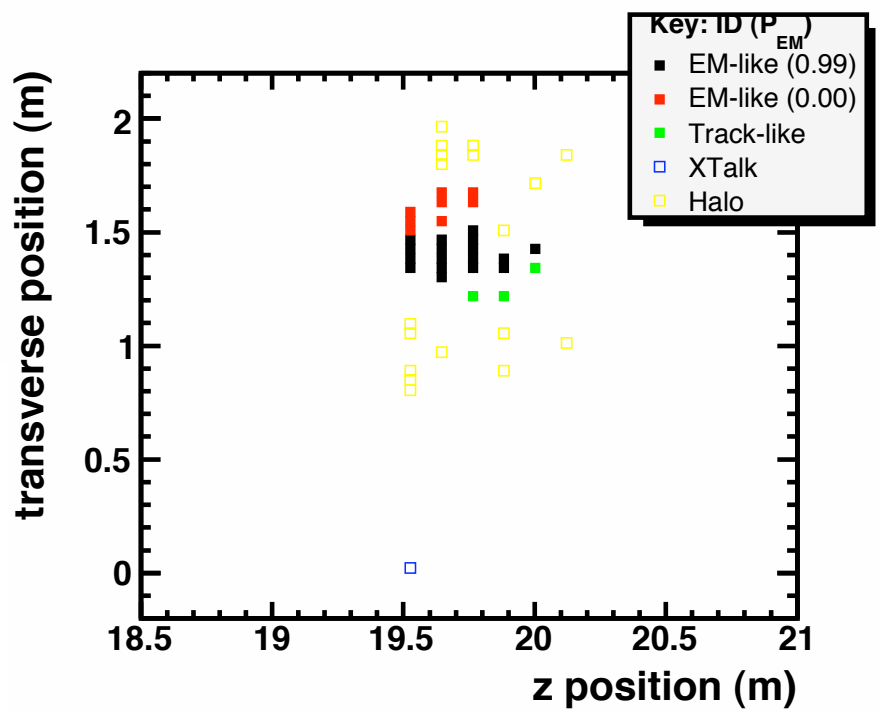


Example 1 (c)


Pulse Height (PEs)
TPos (m)
Plane

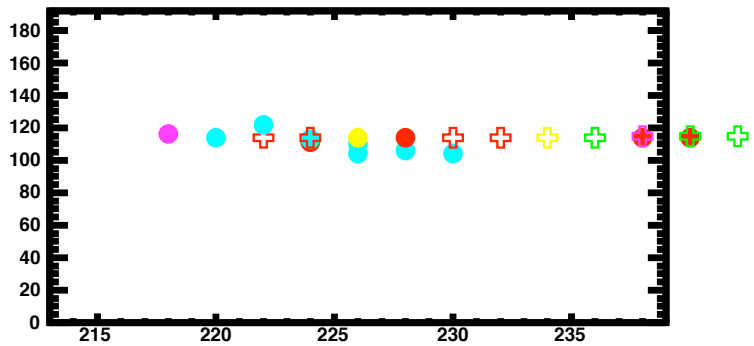

Key: ID (P_EM)
Had-like (0.34)
XTalk
XTalk
Had-like (0.00)
Had-like (0.00)
Had-like (0.00)
Halo
transverse position (m)
z position (m)

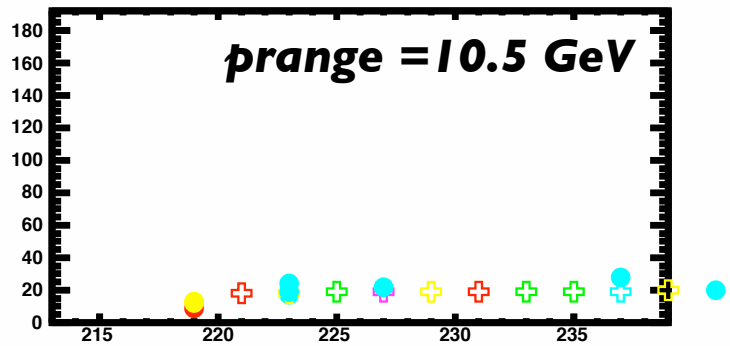

Pulse Height (PEs)
TPos (m)
Plane


Key: ID (P_EM)
EM-like (0.99)
EM-like (0.00)
Track-like
XTalk
Halo
transverse position (m)
z position (m)

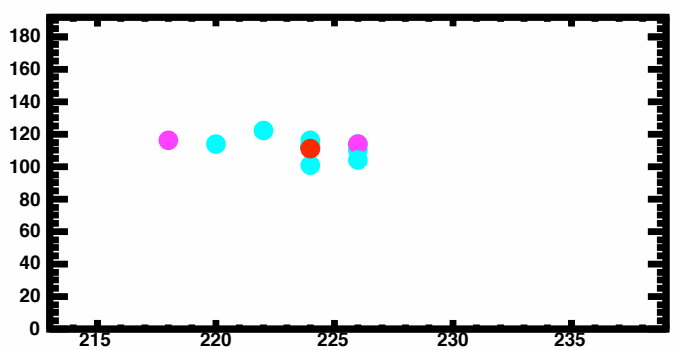
MC Example (a)

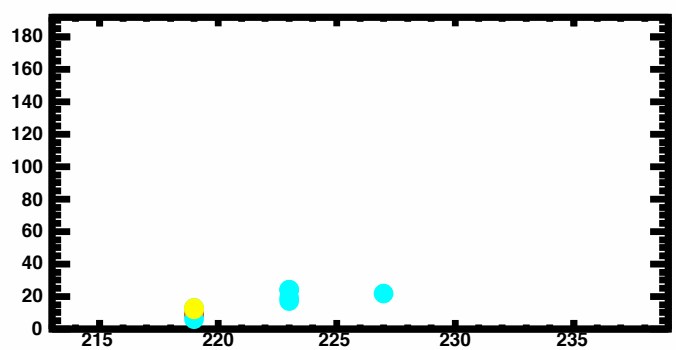
Original Event



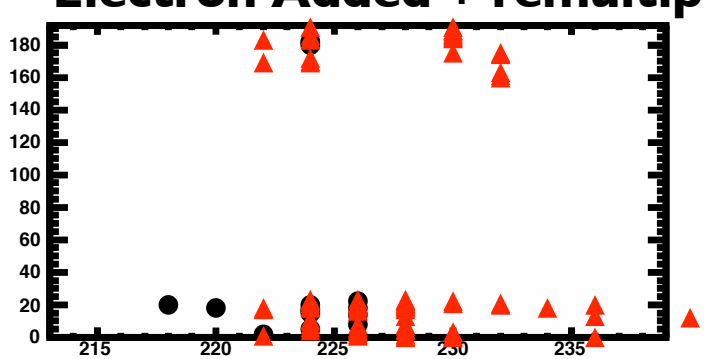


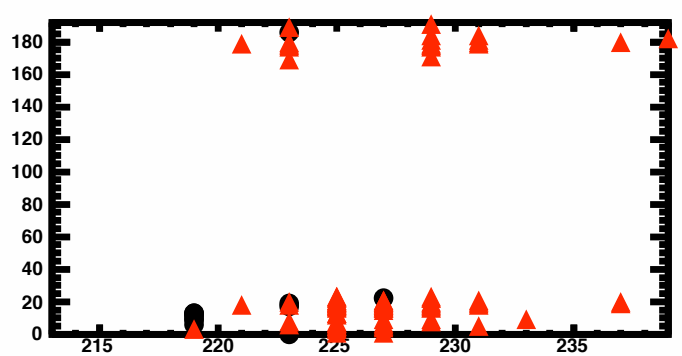
Muon removed





Electron Added + remultiplexed





MC Example 2 (b)

Run: 21001002, Snarl: 3, Slice: 1(/1), Event 1(/1)

Reco

#Trks: 0

#Shws: 1

q/p: 0.000 +/- 0.000, p/q: 0.000

TrkRangeEnergy: 0.000 RecoShwEnergy: 12.317

Vtx: 0.00, 0.00, 0.00

Truth

N/A

N/A

N/A

N/A

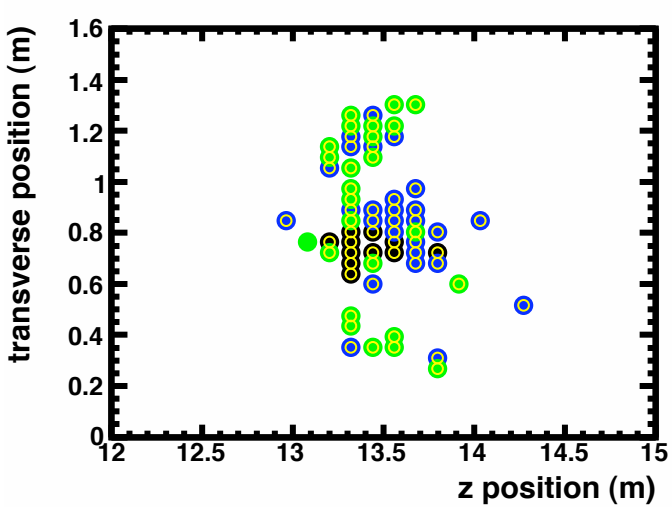
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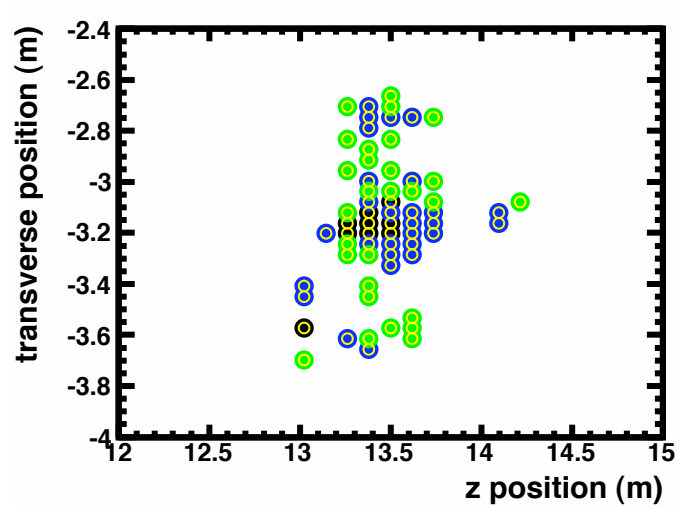
N/A

Ignore	Previous Pass		Next Pass	
NuMu	Step Back		Step Forward	
NuE	Prev Slc	Next Slc	Prev Evt	Next Evt
NC	Prev MC	Next MC	Skip to... / Run,Snarl...	AutoMatch
CC	Refresh / Overlay	Lego / Clusters	Print	Quit

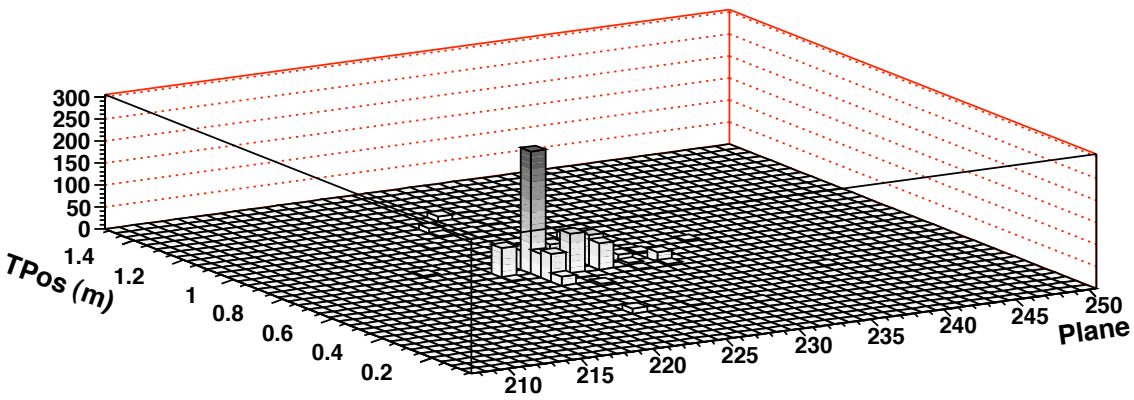
Reco
- Summed NPEs < 2.0
- 2.0 < Summed NPEs < 20.0
- Summed NPEs > 20.0
- Reconstructed Track Hit
- Reconstructed Shower Hit (cyan=EM)

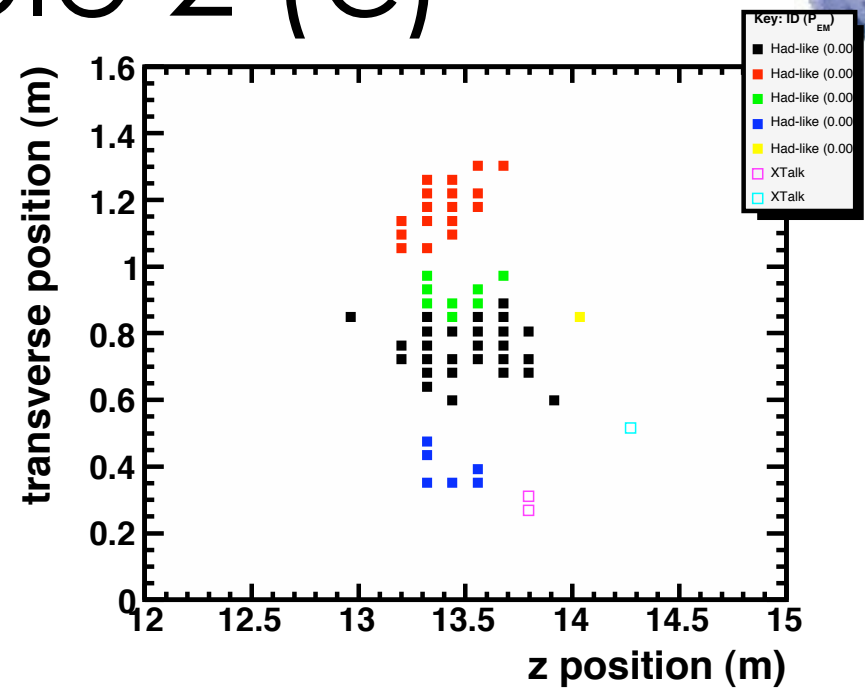
Truth
- e, μ, initial ν
- p, n
- $\pi^{+/-}$, π^0
- $K^{+/-/0}$, γ
- τ, final ν

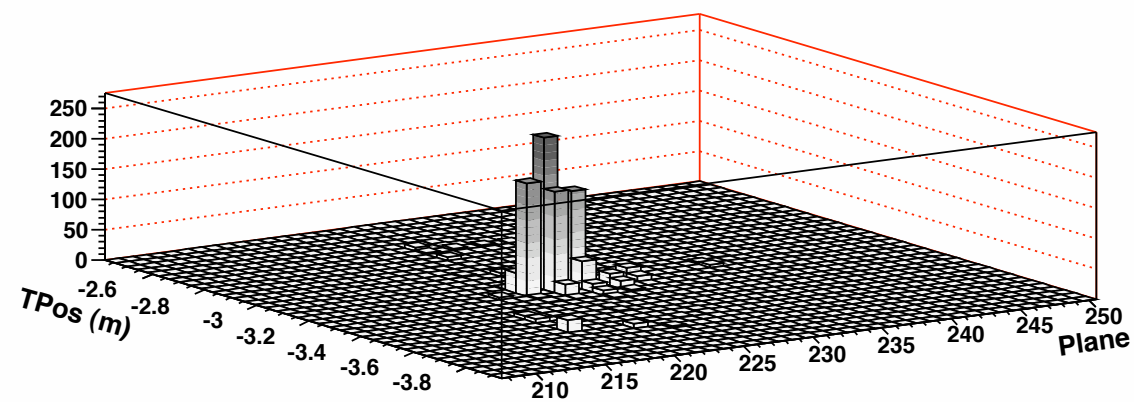


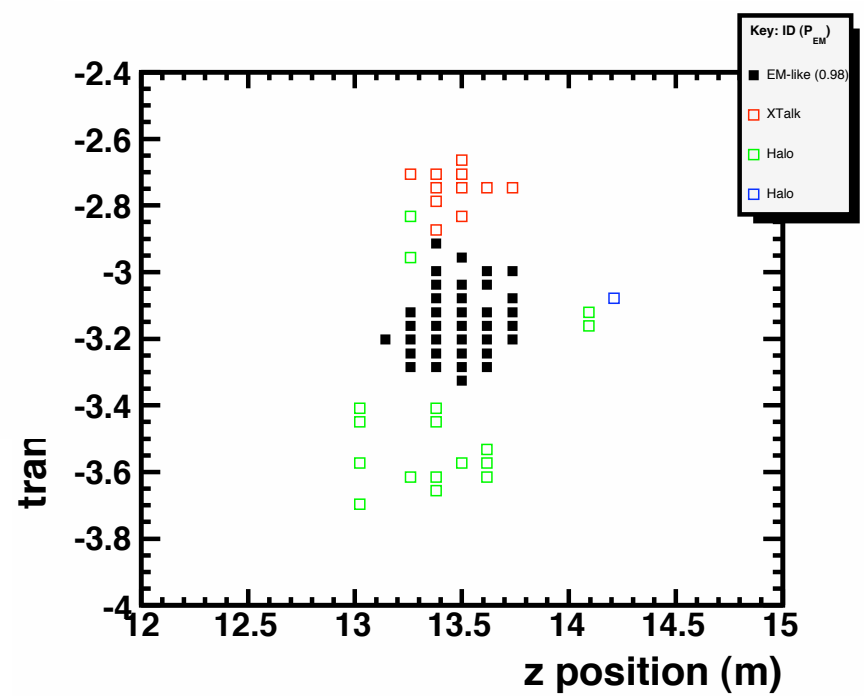


MC Example 2 (c)









Current limitations (TO DO)

- XTalk from track digits on planes with shower energy no removed.
- 2/36 is not correctly applied (and never can be with this method)
- No attempt made to evaluate how good input parameters are.
- Event timing still needs some work
- Mixed calibration for data and MC not correctly handled.



Summary



- 10% improvement on shower energy efficiency
- Code is a little faster, still very clunky to run.
- Correctly handles mixed track+shower hits (can be used in the actual tracker)
- Need experienced "nue-eyes" to start looking at some of the events.
- Have small sample of "data" NC and "semi-data" eCC FD data events.