TMS Validation

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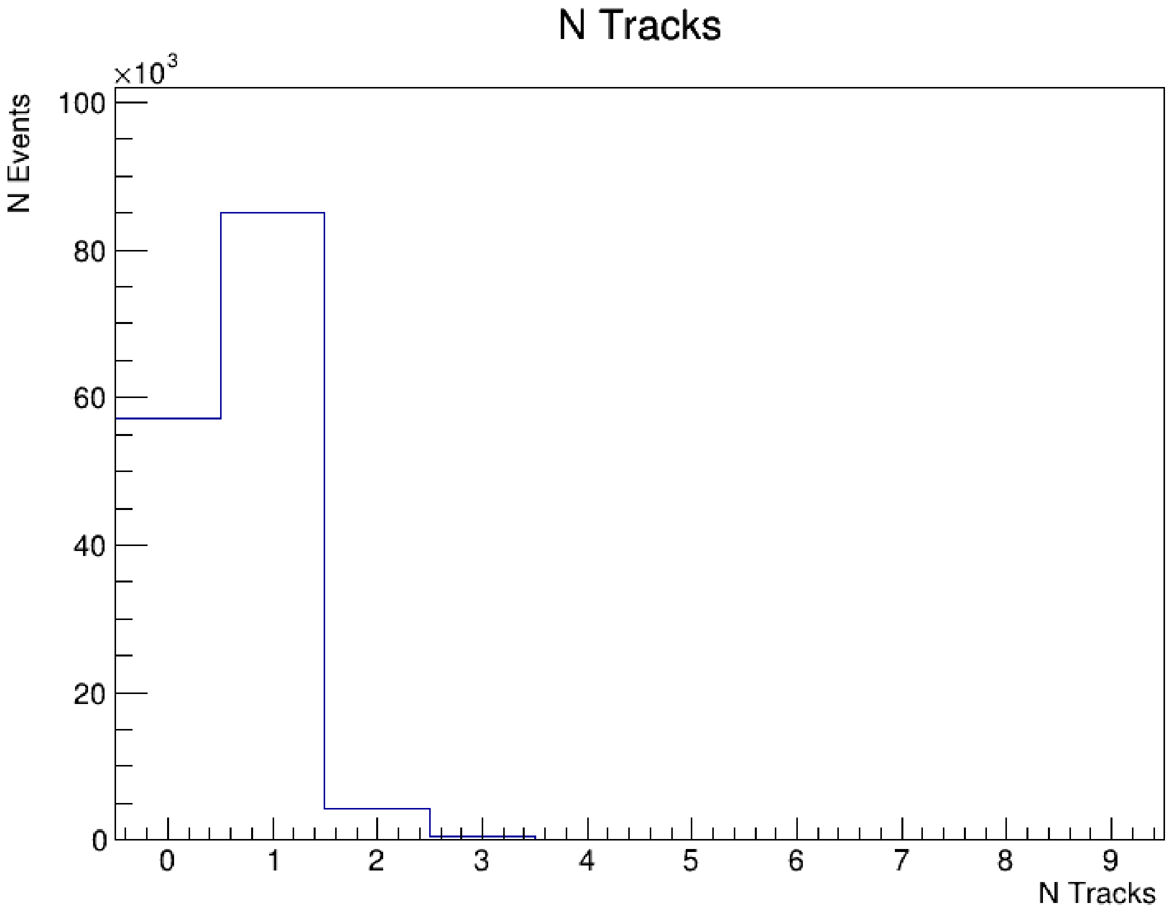
Sample Information

- Using new dune-tms v0.3.0 tag
  - with kalman filter turned off in config
- 125 MicroProdN1p2 edep sim files
  - /pnfs/dune/persistent/users/abooth/nd-production/MicroProdN1p2/output/run-spill-build/MicroProdN1p2_NDLAr_1E18_RHC.spill.nu/EDEPSIM_SPILLS/0000000
  - This is lar-starting events only, but using pileup
    - dune-tms is running the time slicer, so in most cases no resulting pileup
- Hadded output file here:
  - /exp/dune/data/users/kleykamp/dune-tms/2024-09-30_MicroProdN1p2_dune-tms0.3.0_no_kalman.tmsreco.root
  - 147232 time slices

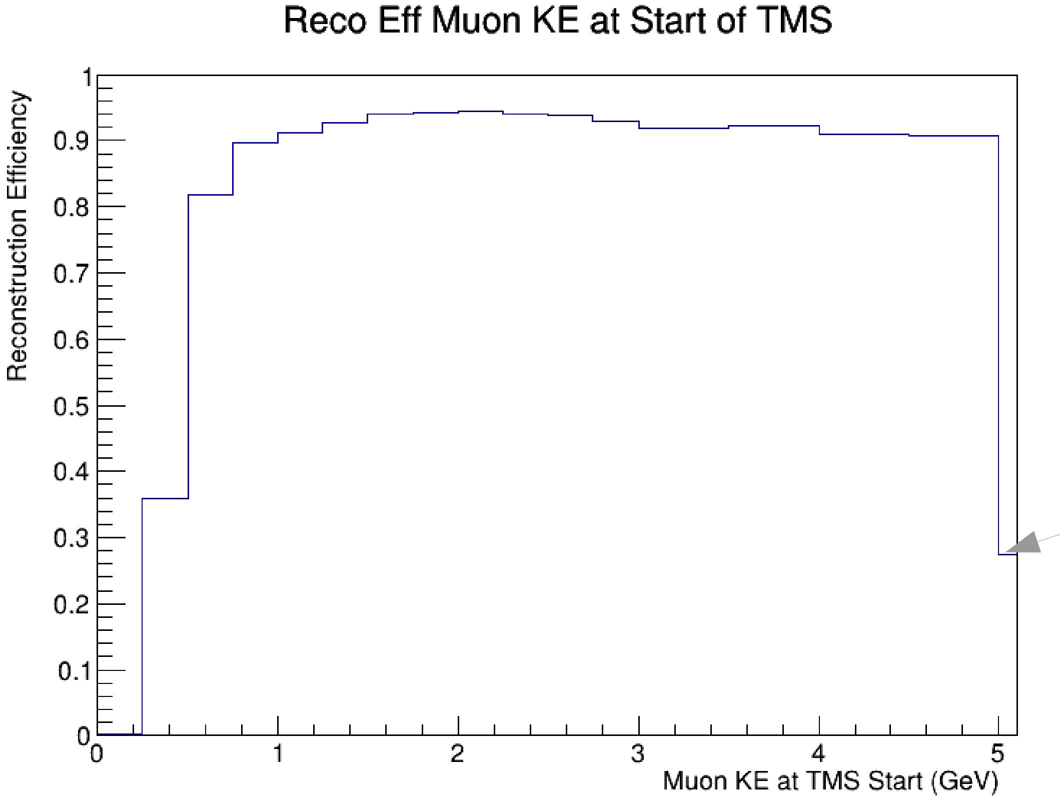
Validation

- Check basic variables
  - n tracks, n hits per track, etc
- Check intermediate variables and cuts
  - calculation inputs, nd physics sample cut inputs
- Check final variables
  - reco eff, energy resolution, charge id, lar-tms matching
- Ideally check against a baseline “good” sample
  - Right now trying to kill the bugs to get to this good state

Raw N reco tracks per time slice, no cuts



Reco Eff



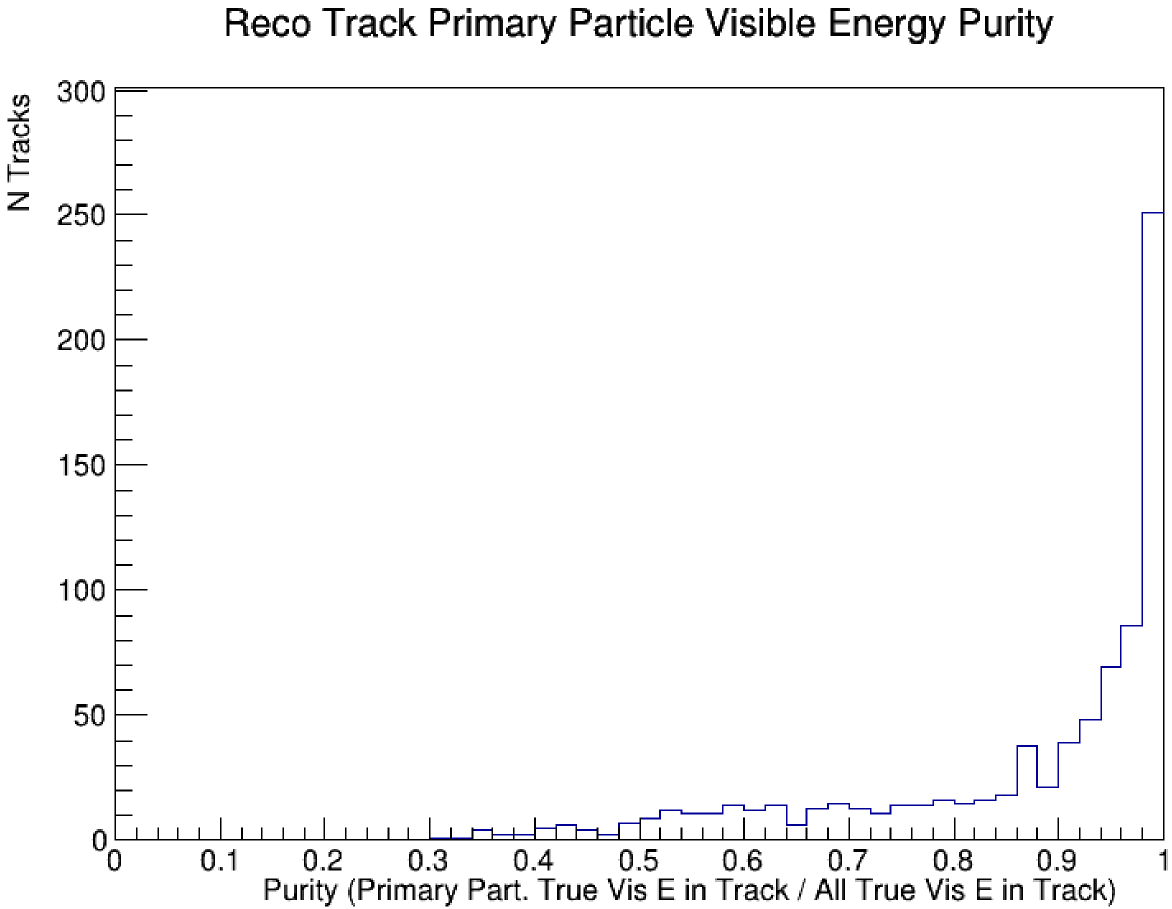
Overflow: any muon above 5 GeV

$$\text{eff} = \frac{\text{n true special muon reco'd so it became the primary true matched particle in reco track}}{\text{n true special muon}}$$

where true special muon = muon that starts in LAr and ends in TMS.

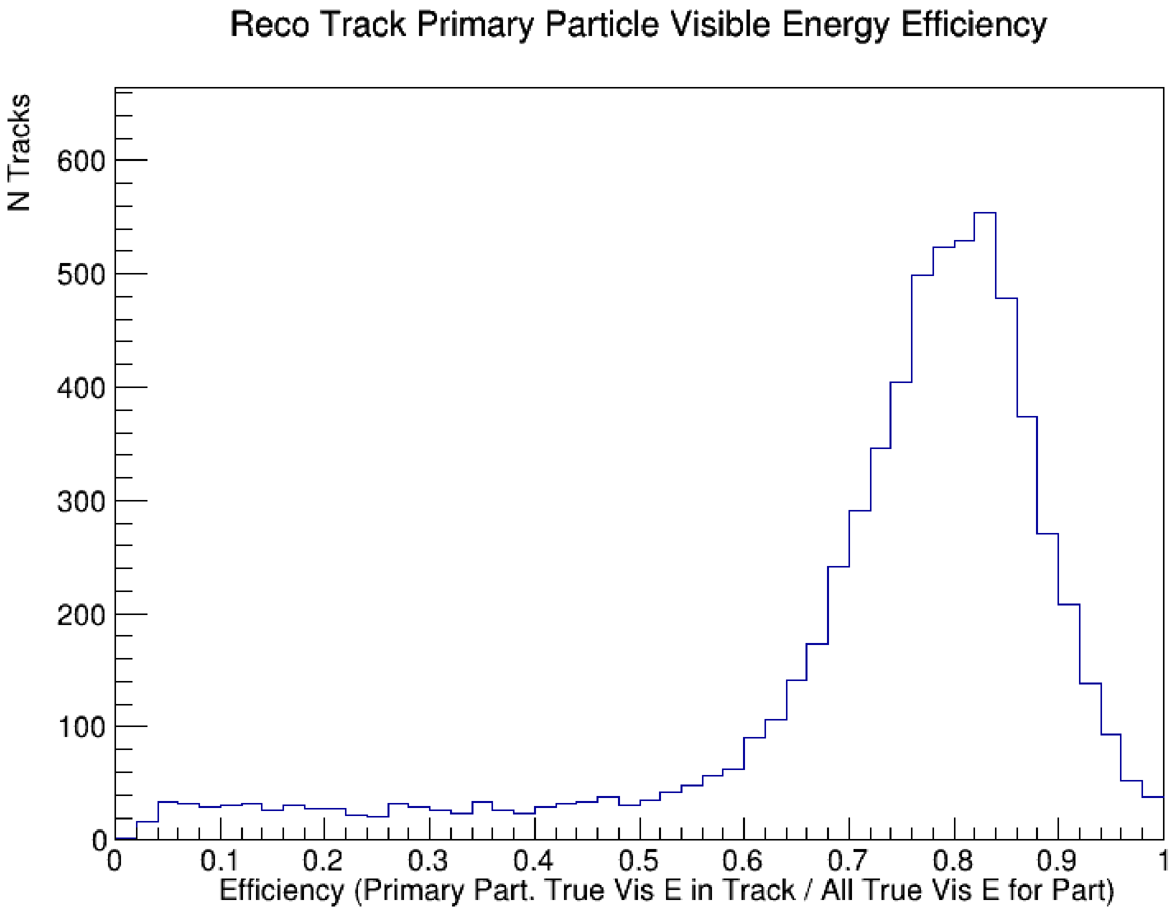
In the future, we want only well-reco’d muons that pass ND physics sample cuts.

Track Visible E Purity



Low purity = More track vis energy from other sources

Track Visible E Reco Eff

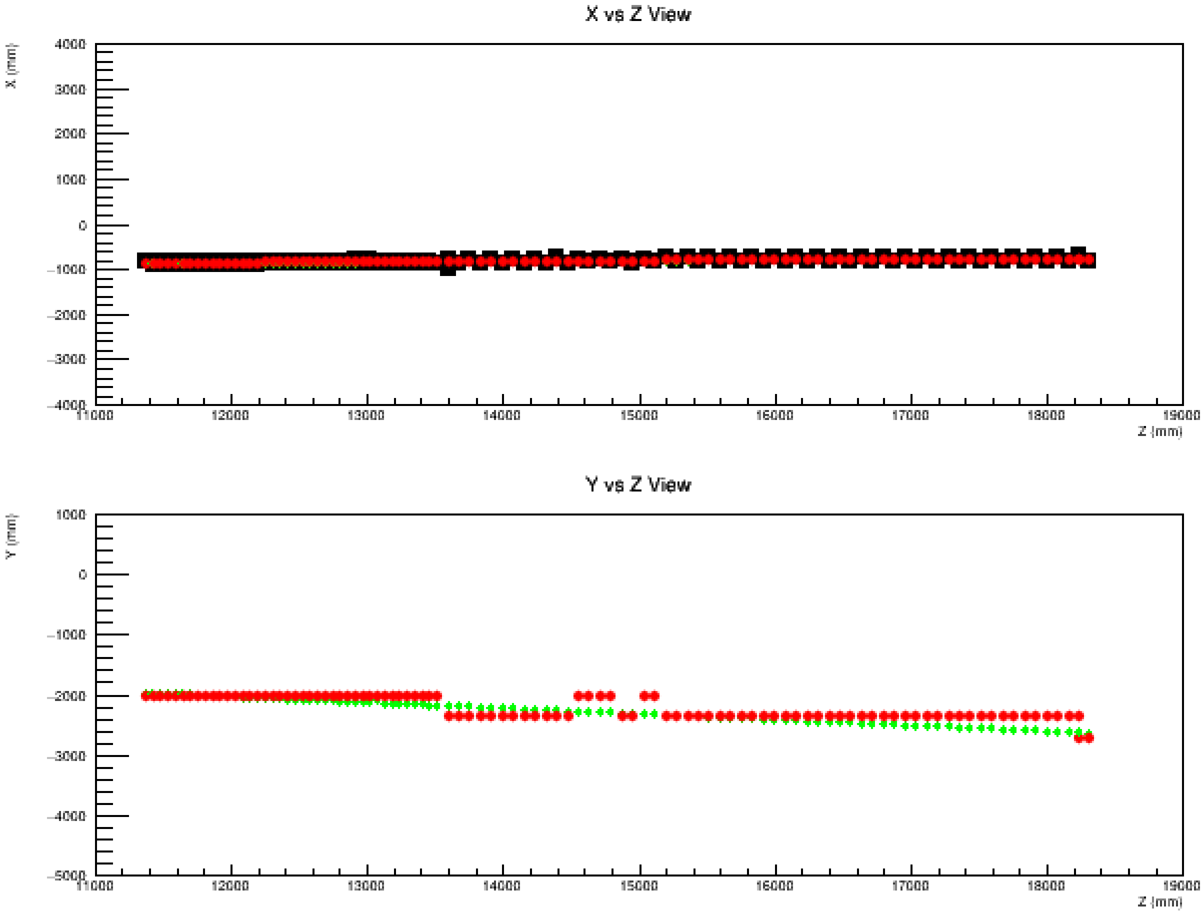


Avg ~ 0.8 Efficiency. Missing hits?

Event Displays

- Event displays are a great way to understand reco
- The goal was to have the validation code automatically spit out event displays under certain conditions
  - Like bad reco
  - Not yet implemented
- But here's a scan of some events

Good Reco Example



Key

Black square

– Reco Hits

Red dot

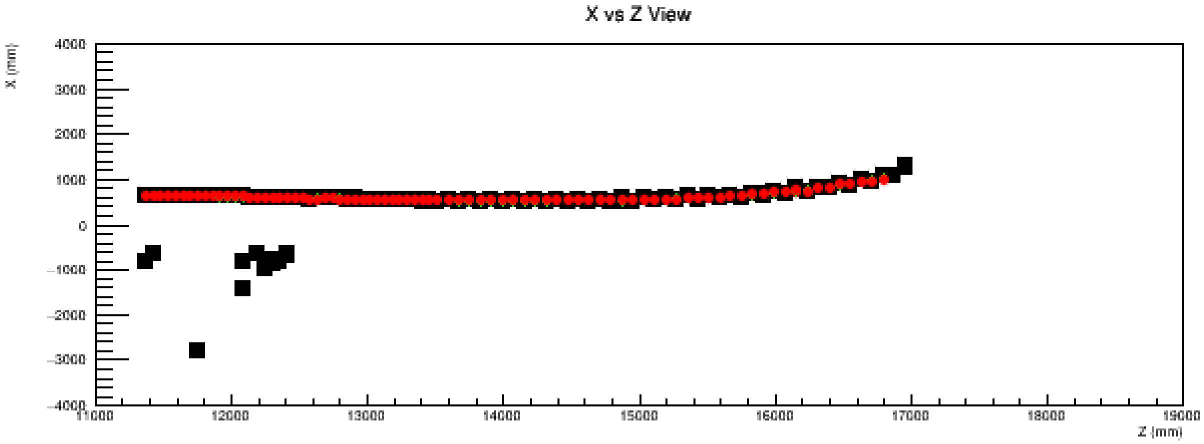
– Reco Track Hit Pos

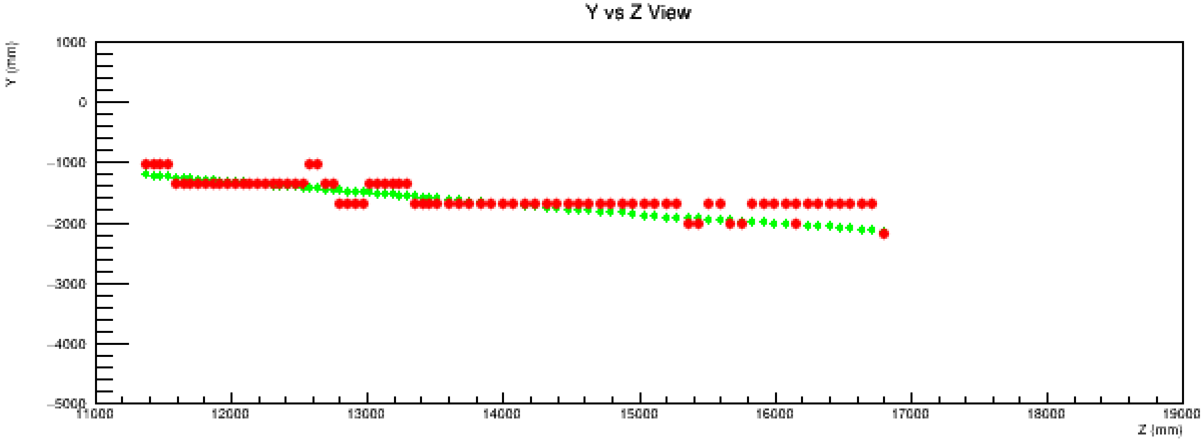
Green diamond

– True Hit pos

Note that true hit pos are only saved if reco hit pos exists. So won't show true particle endpoint

Missing Some of Endpoint





Key

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Green diamond

– True Hit pos

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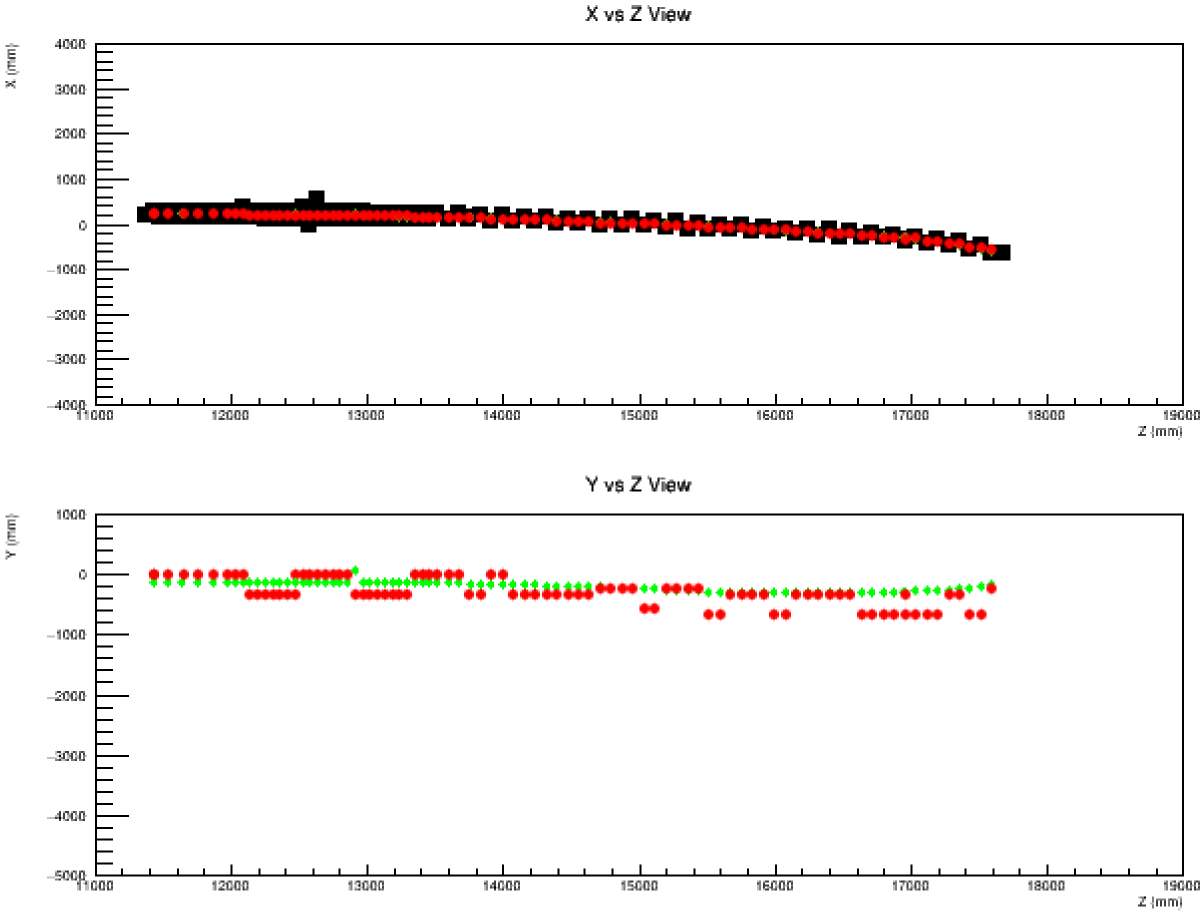
Only Only Reco in One View of Startpoint



Key

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– True Hit pos

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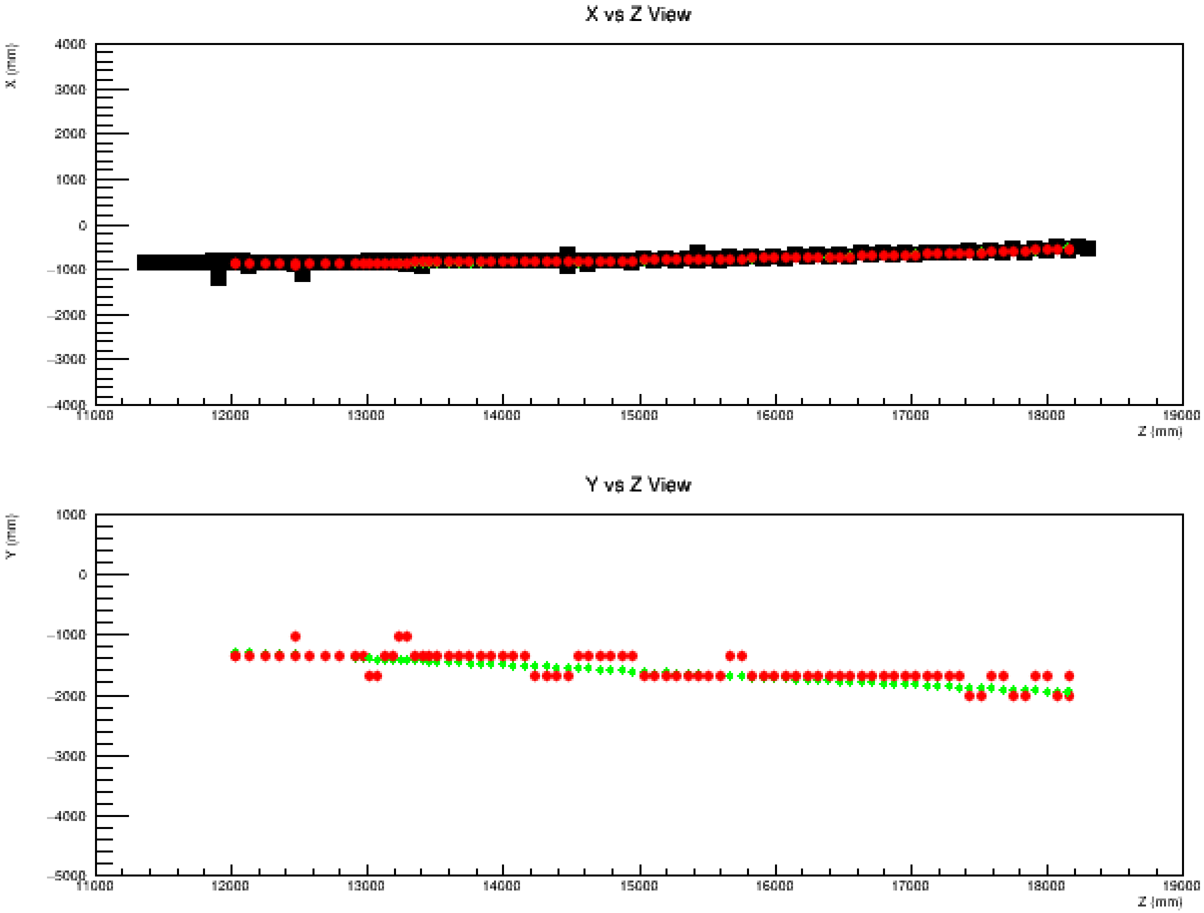
Track extrapolation issue? See issue #163 on github

Missing Startpoint



Key

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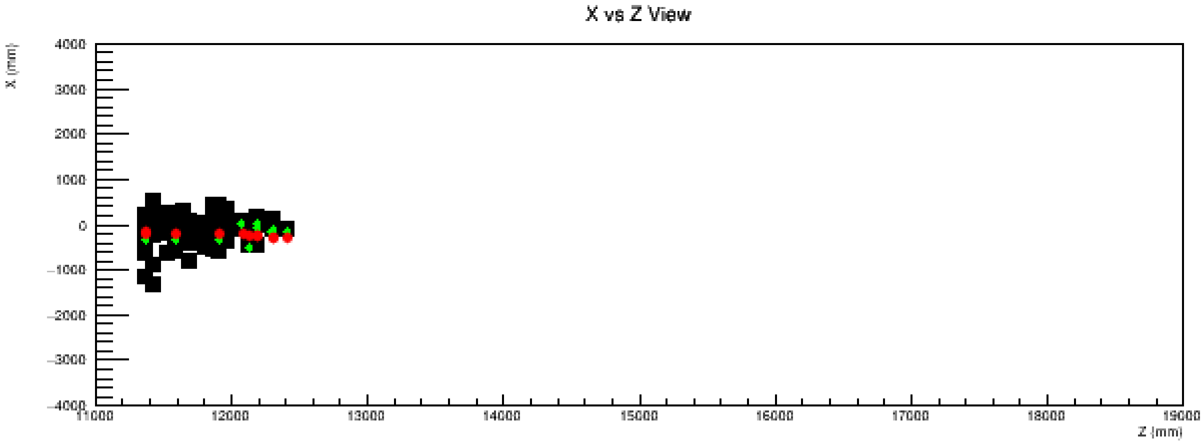
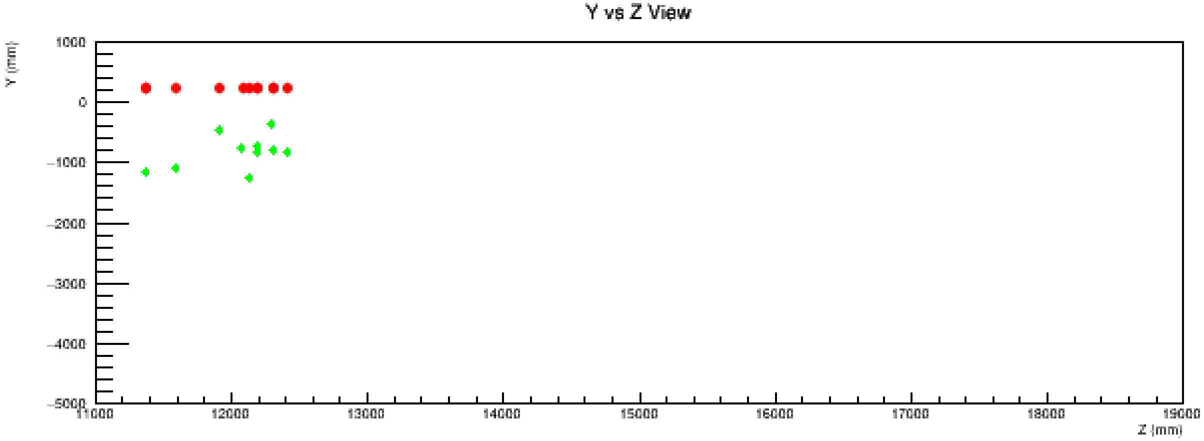
Made Track out of No Track





Key

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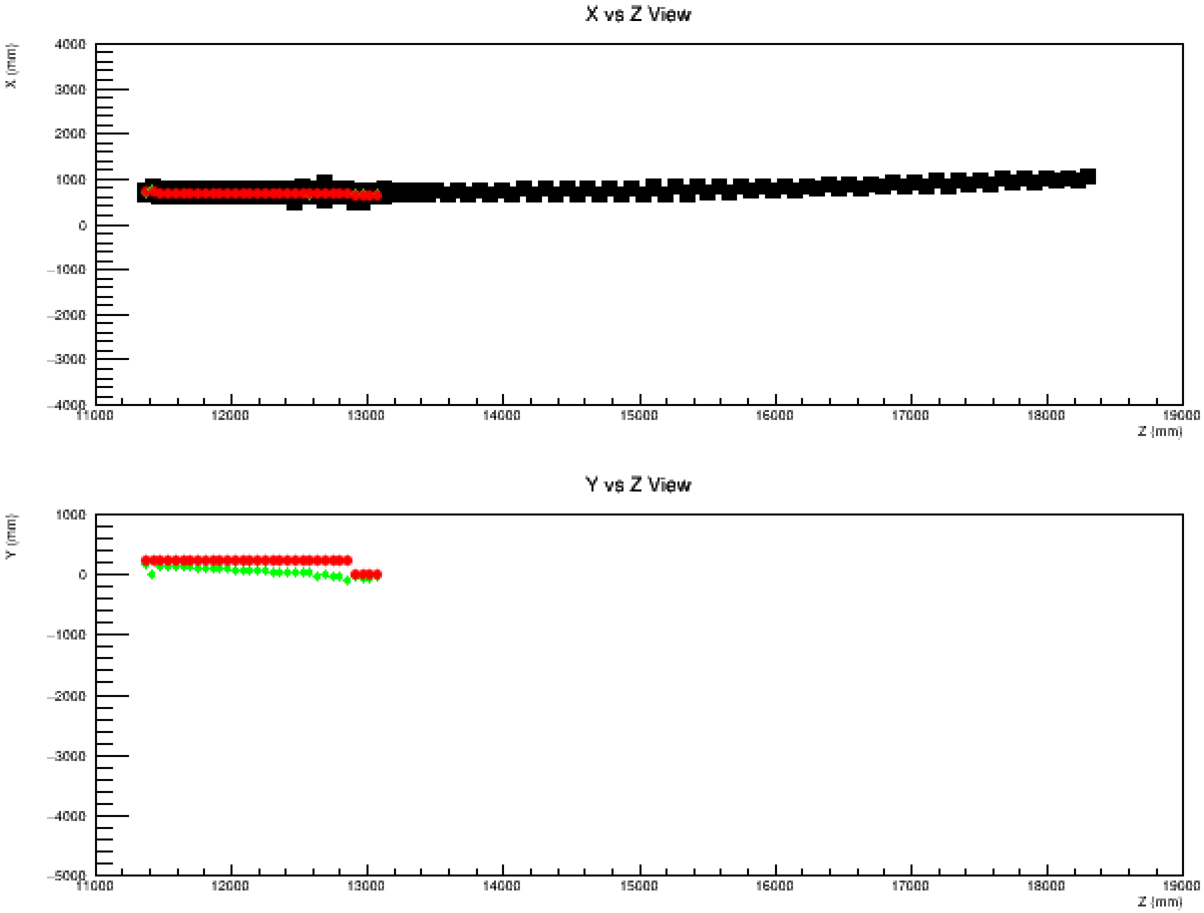
Missing Endpoint by a Lot



Key

Black square

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Red dot

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Green diamond

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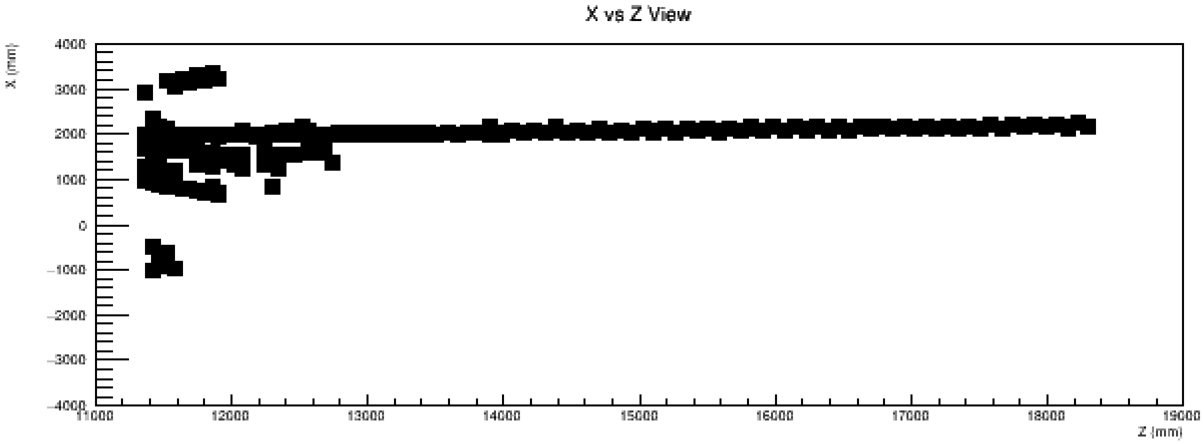
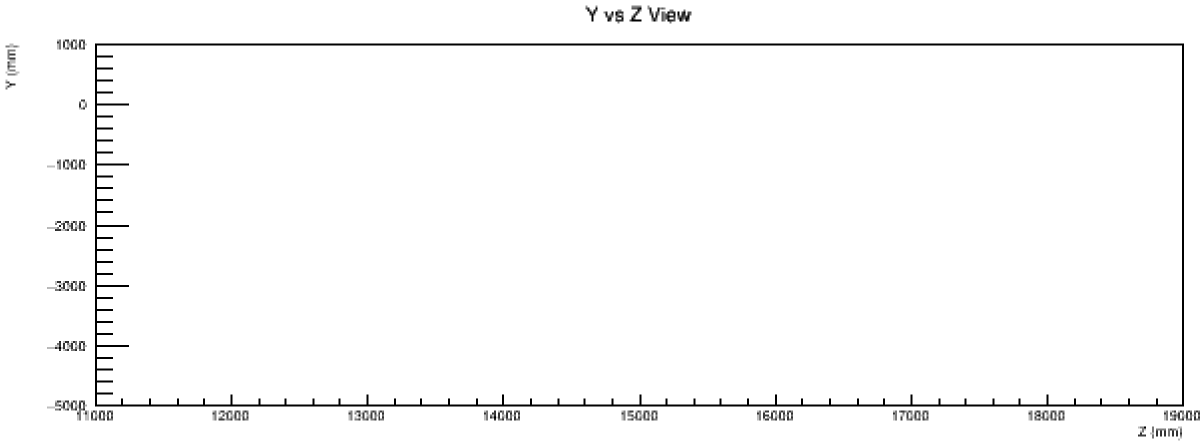
Reco Missing Completely





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Red dot
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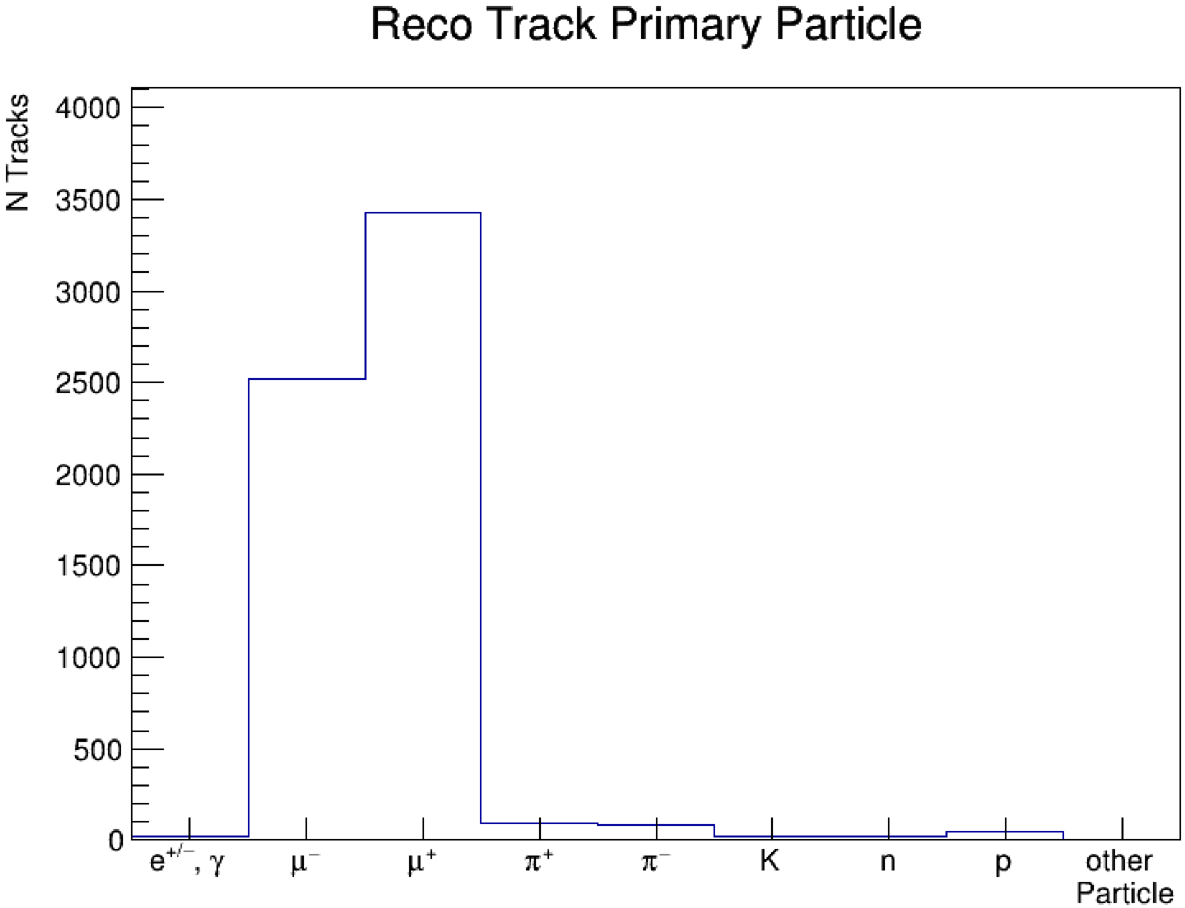
Green diamond
– True Hit pos

Note that true hit pos are only saved if reco hit pos exists. So won’t show true particle endpoint

Truth Matching

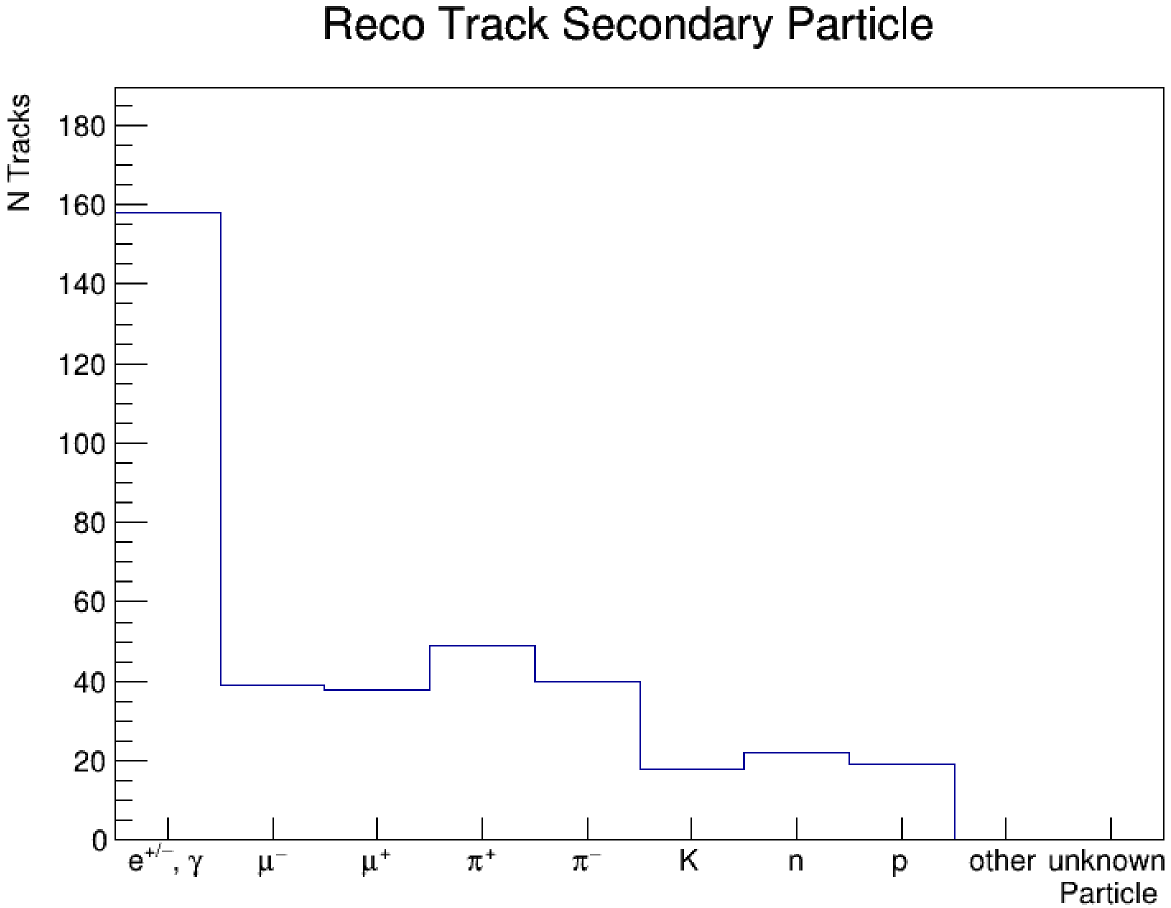
- For a given reco track, add up the total visible energy per true particle that is source of visible energy
    - Visible energy = energy deposited in TMS scintillator
- The truth matched primary particle is true particle that contributes most true visible energy to reco track
- Also saved the secondary particle in the ttree
    - could save more if needed

Reco Track Primary Particle (most vis E part)



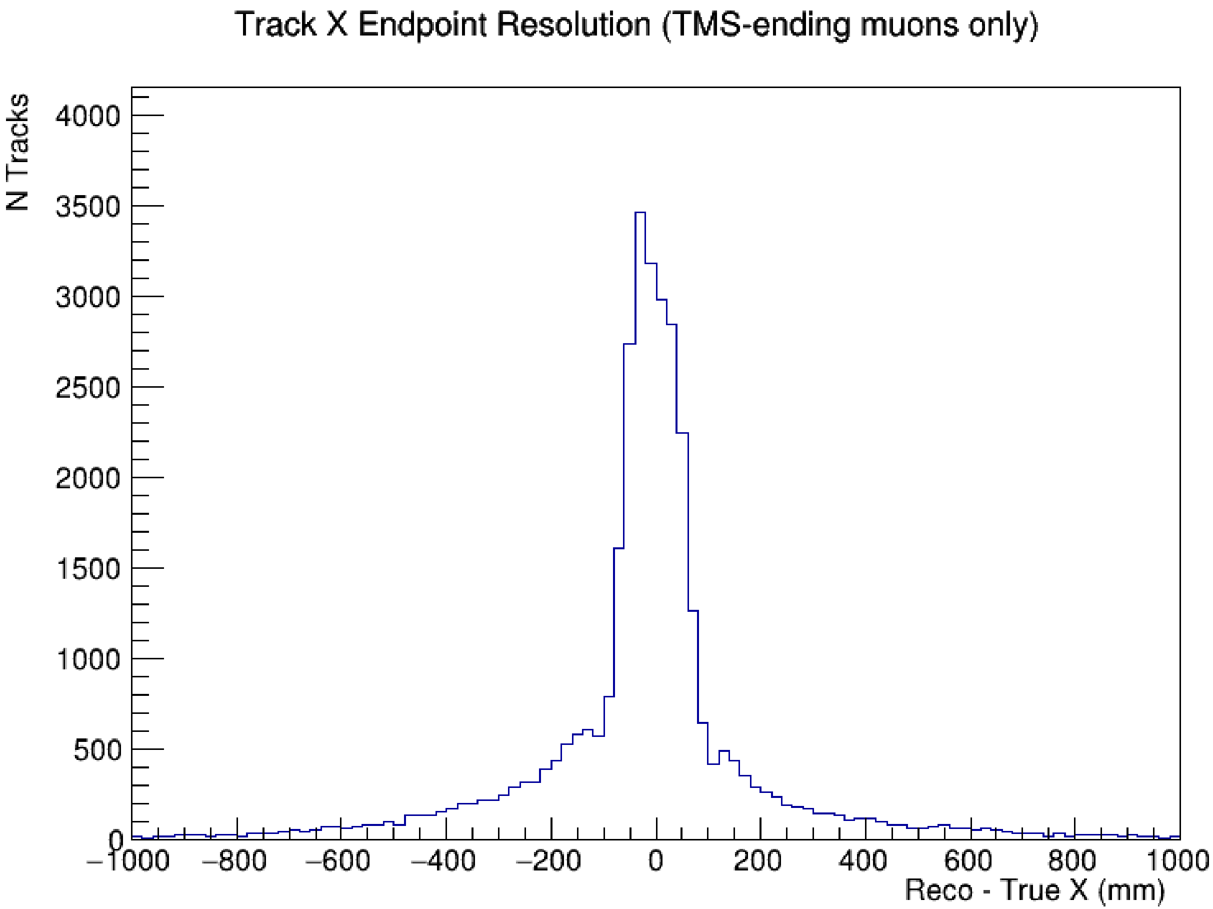
I’m a little suspicious of the truth matching. This is the current best estimate.
Filtered out some wrong cases if their true end position in front of TMS.
The raw truth matching has even more neutrons

Secondary Particle PDG (second-most vis E)



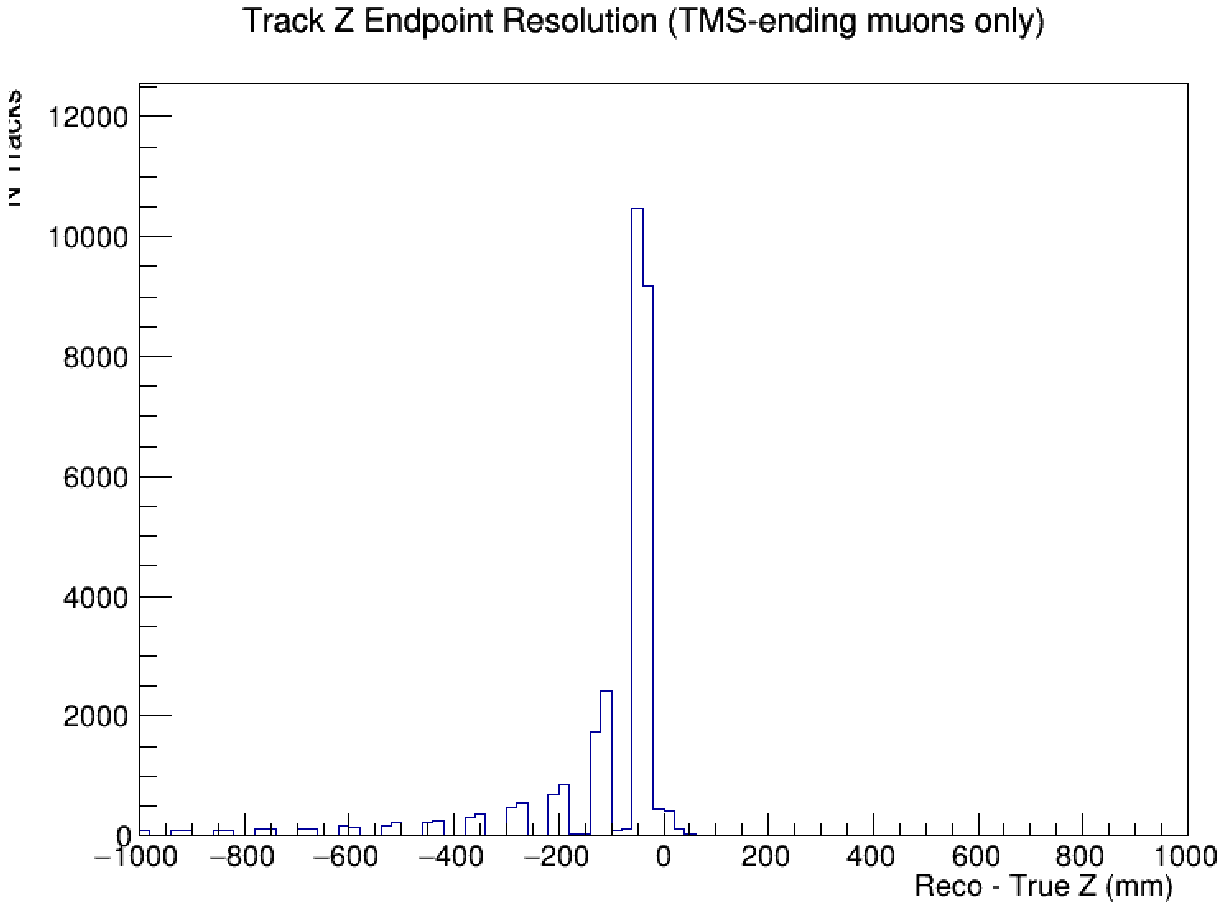
I’m a little suspicious of the truth matching. This is the current best estimate.
Filtered out some wrong cases if their true end position in front of TMS.
The raw truth matching has even more neutrons

Track X Resolution



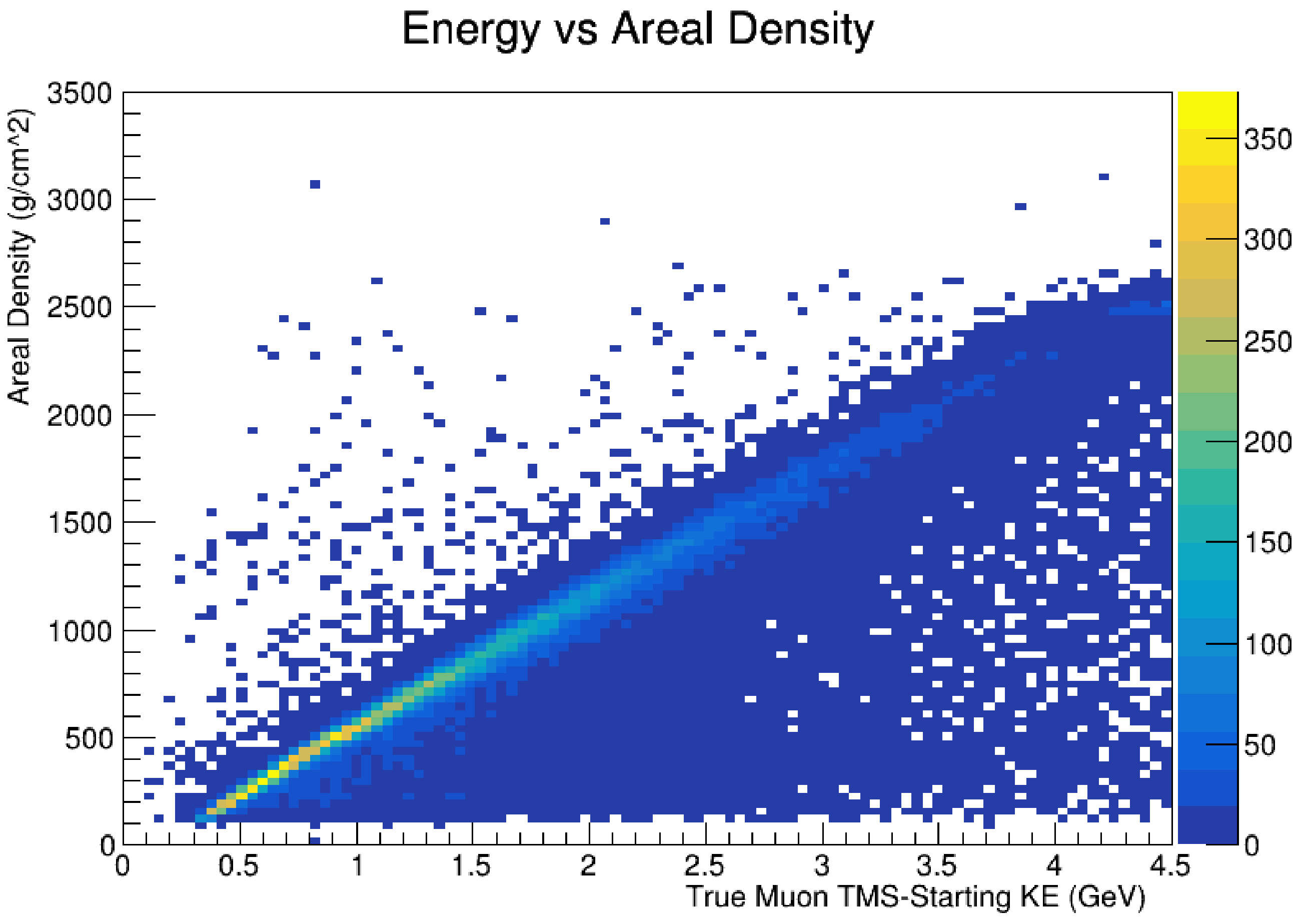
Where true position is true endpoint of primary particle

Track Z Resolution

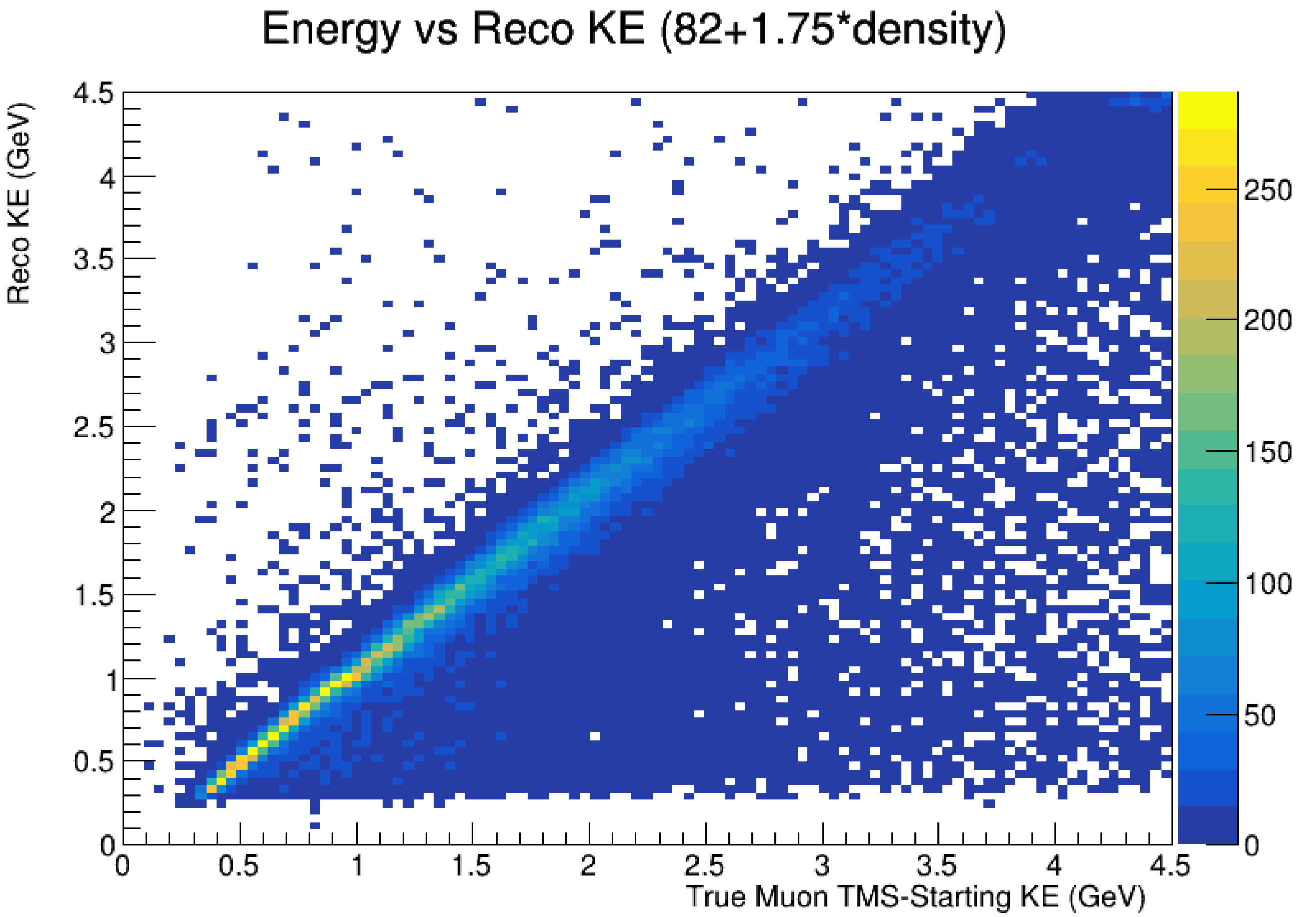


Where true position is true endpoint of primary particle

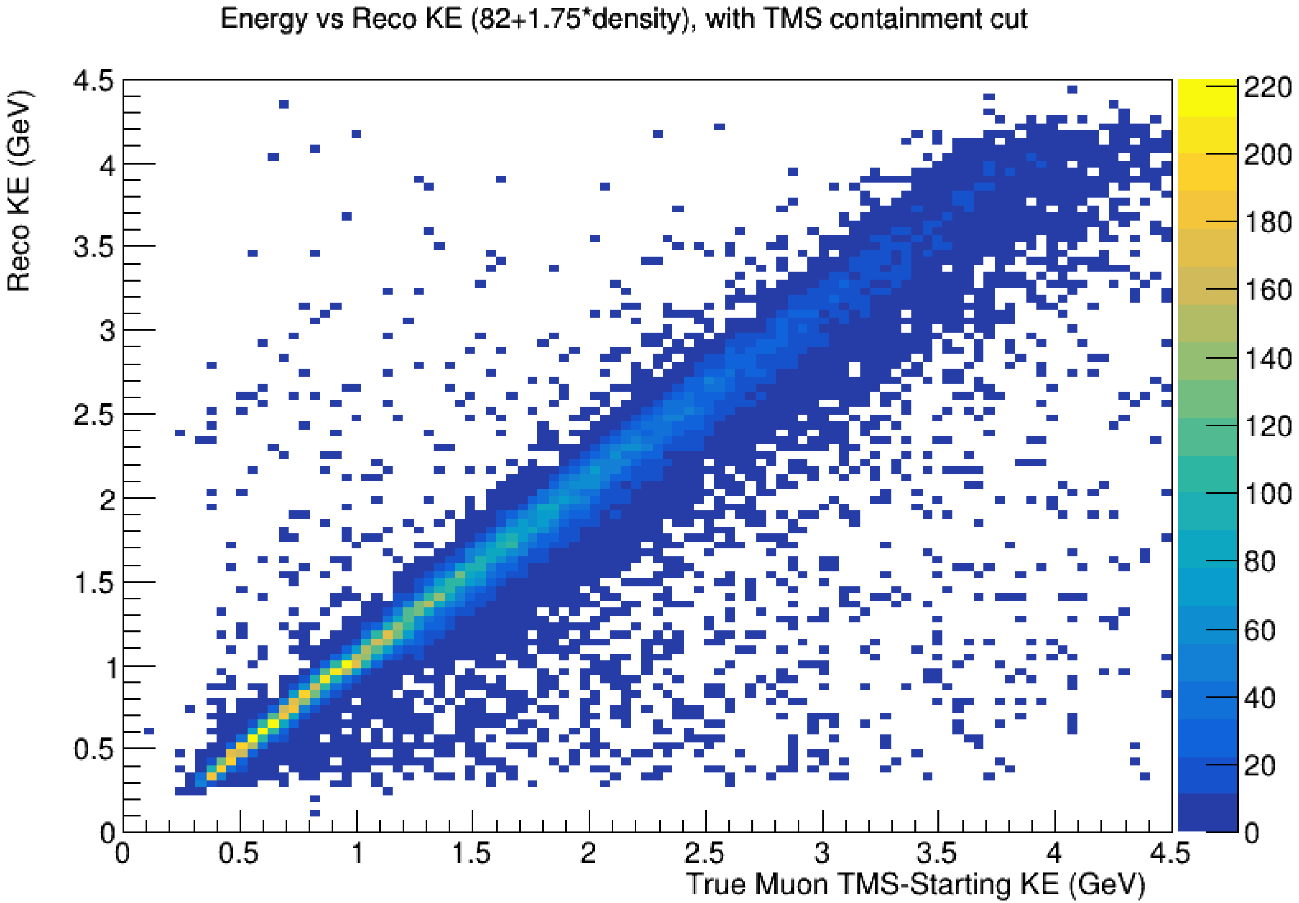
Energy Resolution, all true muons



Energy Resolution, all true muons



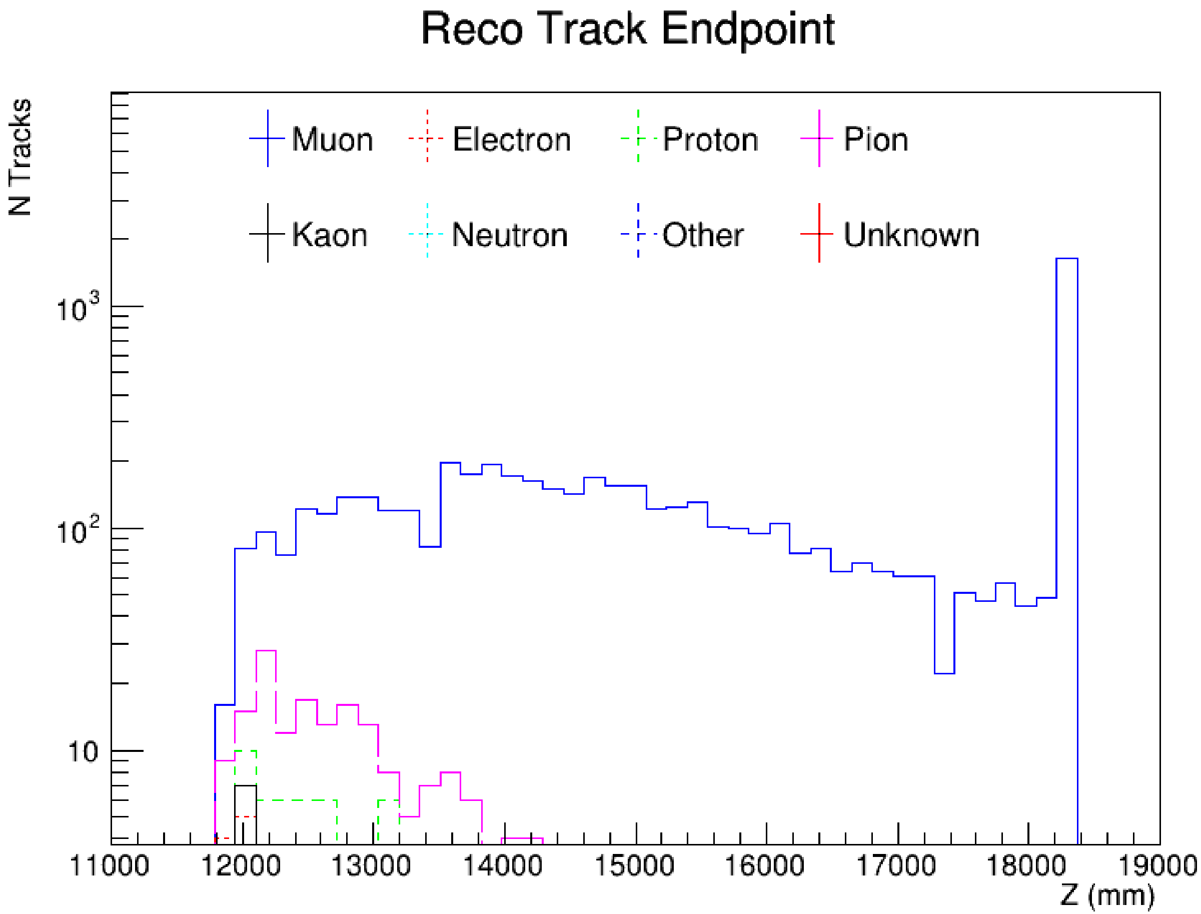
Energy Resolution, with Containment Cut



Containment cut: track in 1st two planes, Y < 30cm from edge, U/V pos within 1 bar of edge, Z within ~ 1 plane of end (I used like 3 planes, z < 17900mm)

See ND-physics sample wiki page

Particle Depth Based on Reco Endpoint



Caveat: not 100% sure on truth matching which makes this plot possible

Conclusion

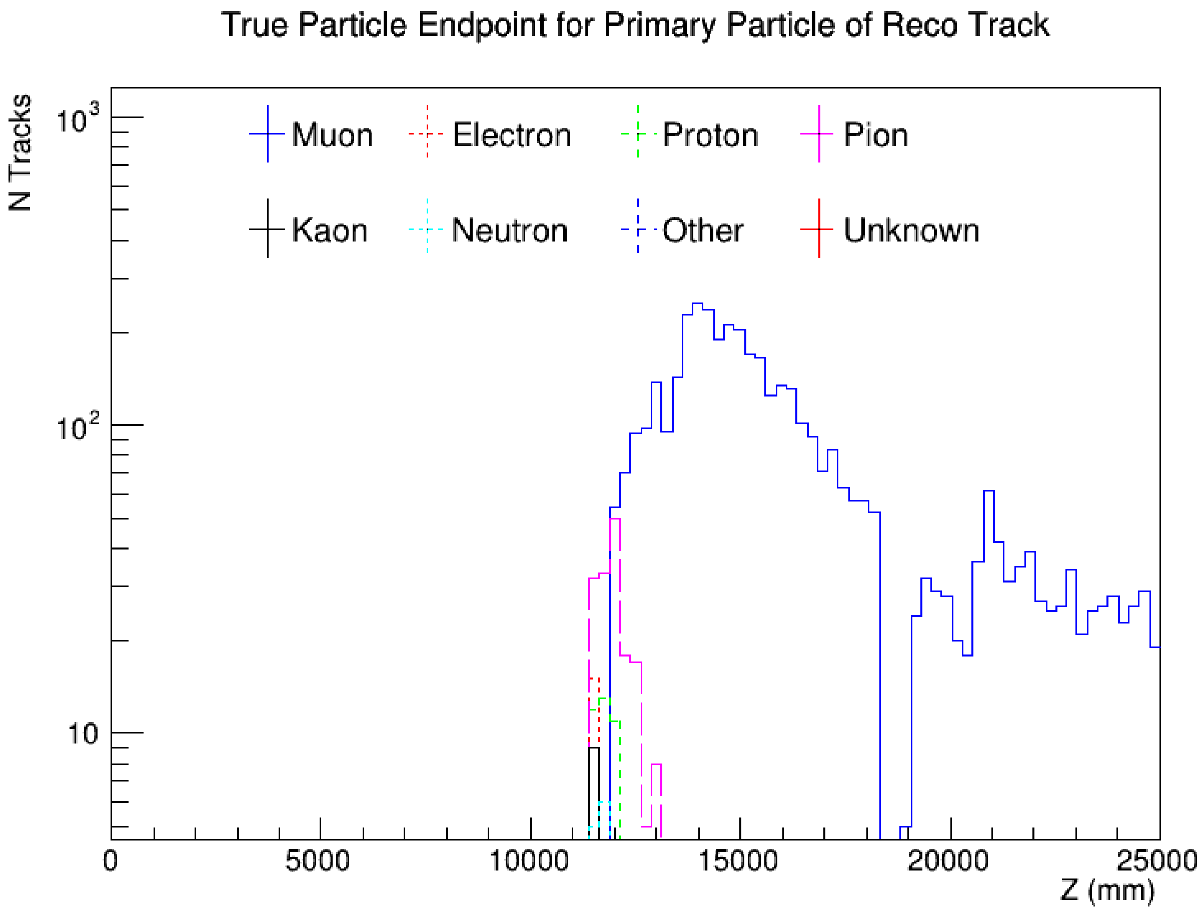
- Validation exercise itself has found issues
- Validation plots are coming along
  - See scripts/Validation/Tracking_Validation.cp on branch kleykamp_validation
  - Usage (please excuse the mess):

```
make
./Tracking_Validation /exp/dune/data/users/${USER}/dune-tms/2024-09-30_MicroProdN1p2_dune-tms0.3.0_no_kalman.tmsreco.root
python simply_draw_everything.py /exp/dune/data/users//${USER}/dune-tms/Validation/Tracking_Validation/2024-09-30_MicroProdN1p2_dune-tms0.3.0_no
```

  - Those of you interested in c++ versions of your python code, can use scripts in that dir as a starting point
    - Very fast, < 1min to run all 140k events
- Help me in various ways

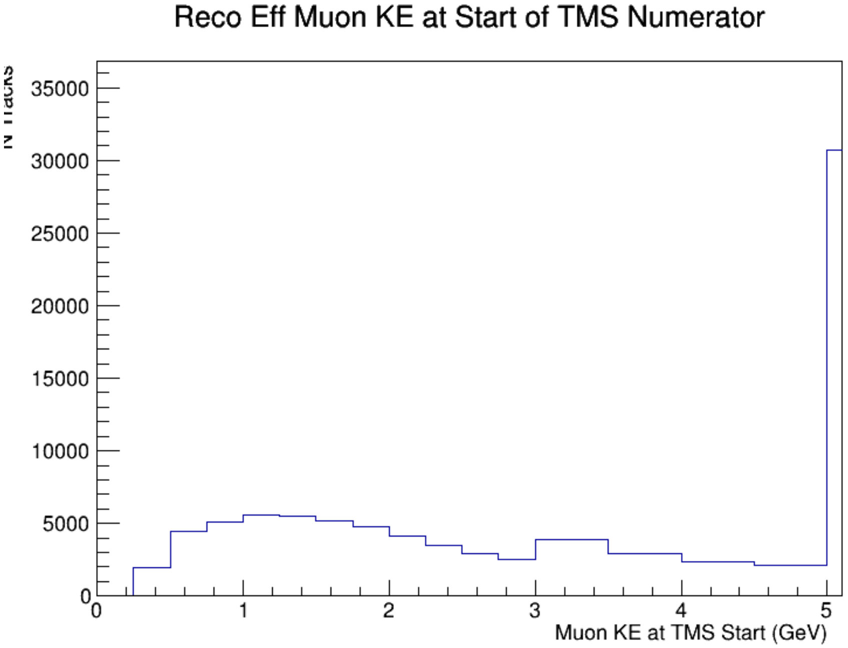
Backup

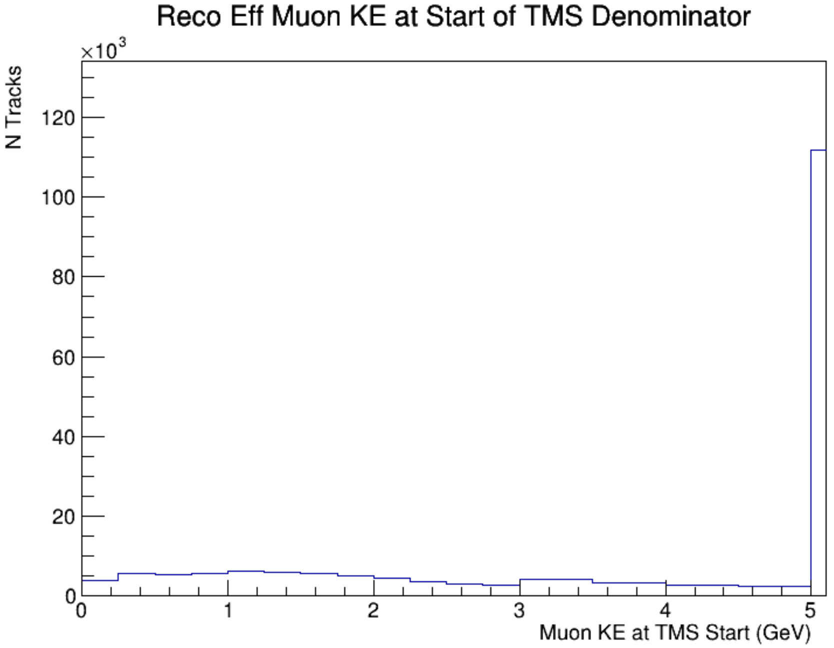
Particle Depth Based on True Endpoint



Caveat: not 100% sure on truth matching which makes this plot possible
Would have z < 11000 cases, but used z > 11000 has cut to remove “wrong” truth matching

Reco Eff Numerator and Denominator


Reco Eff Muon KE at Start of TMS Numerator
N Tracks
Muon KE at TMS Start (GeV)


Reco Eff Muon KE at Start of TMS Denominator
$\times 10^3$
N Tracks
Muon KE at TMS Start (GeV)