Updates on 1 GeV beam π^+-Ar inclusive cross section measurement

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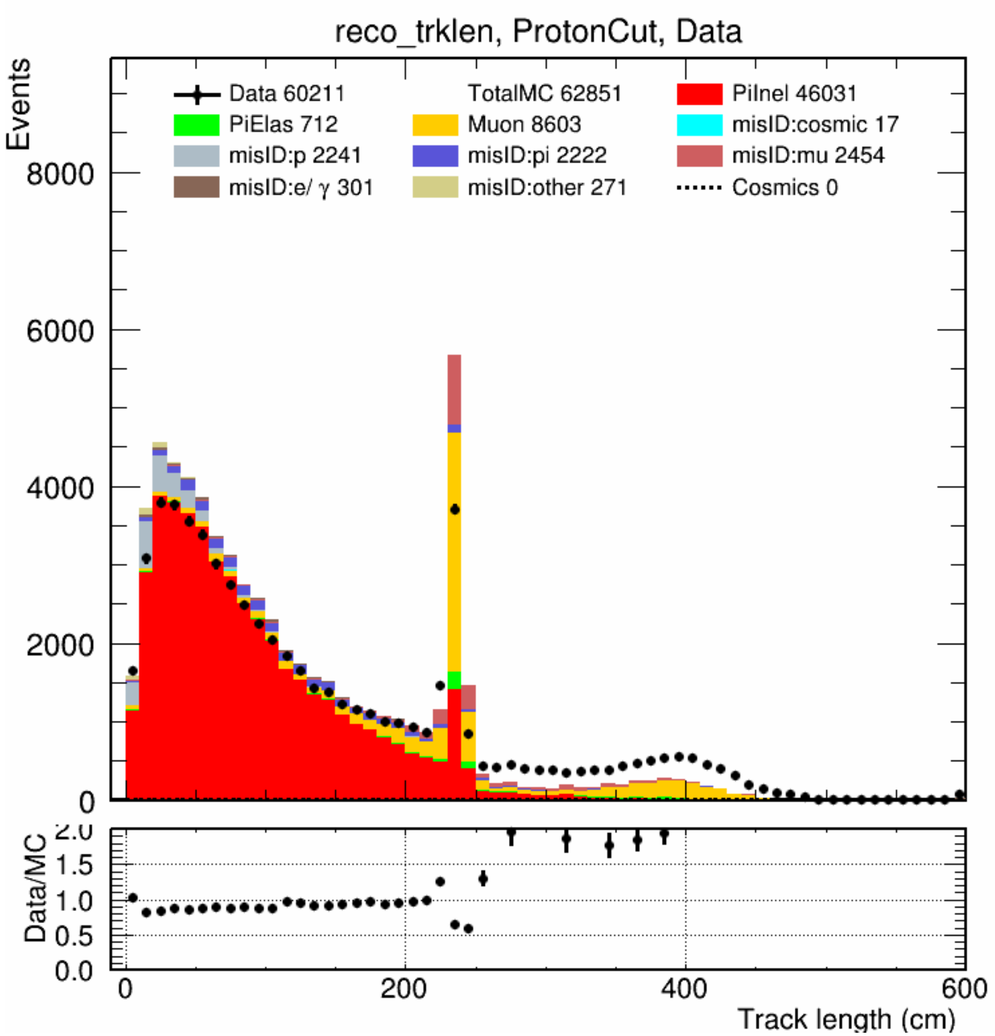
Heng-Ye's talk this morning on momentum reweight using proton

- Can I use the fit method provided by Sungbin to get a better reco KEff on pion?
  - Pion dE/dx is nearly a constant. Maybe hard to fit.
- Can I use the result from proton momentum?
  - Selections are different.

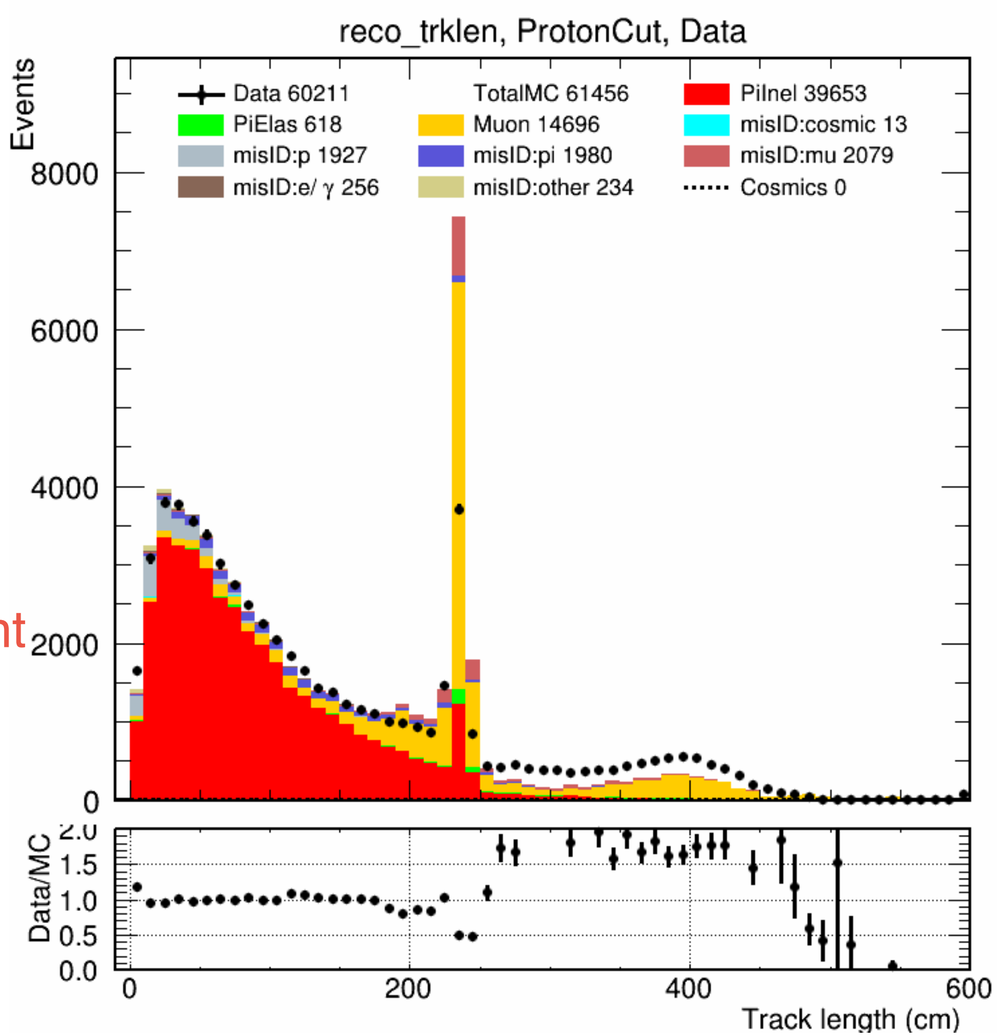
Reweight MC to better model data

- Muon bkg reweight
  - After all selections except muon cuts, perform chi2 fit in track length distribution.
- Beam momentum reweight
  - Using beam muon sample, perform chi2 fit in KEff from residue range.

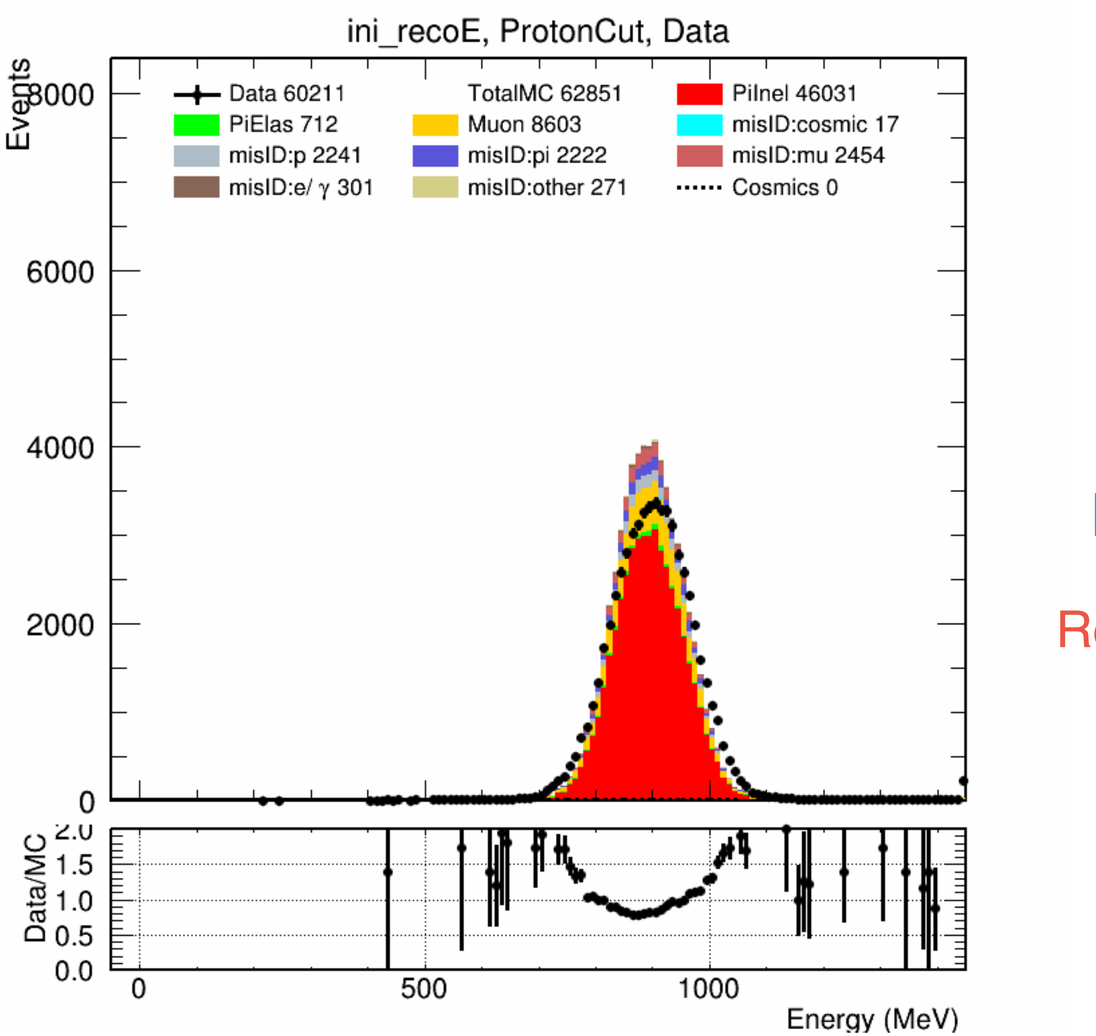
Track length distribution



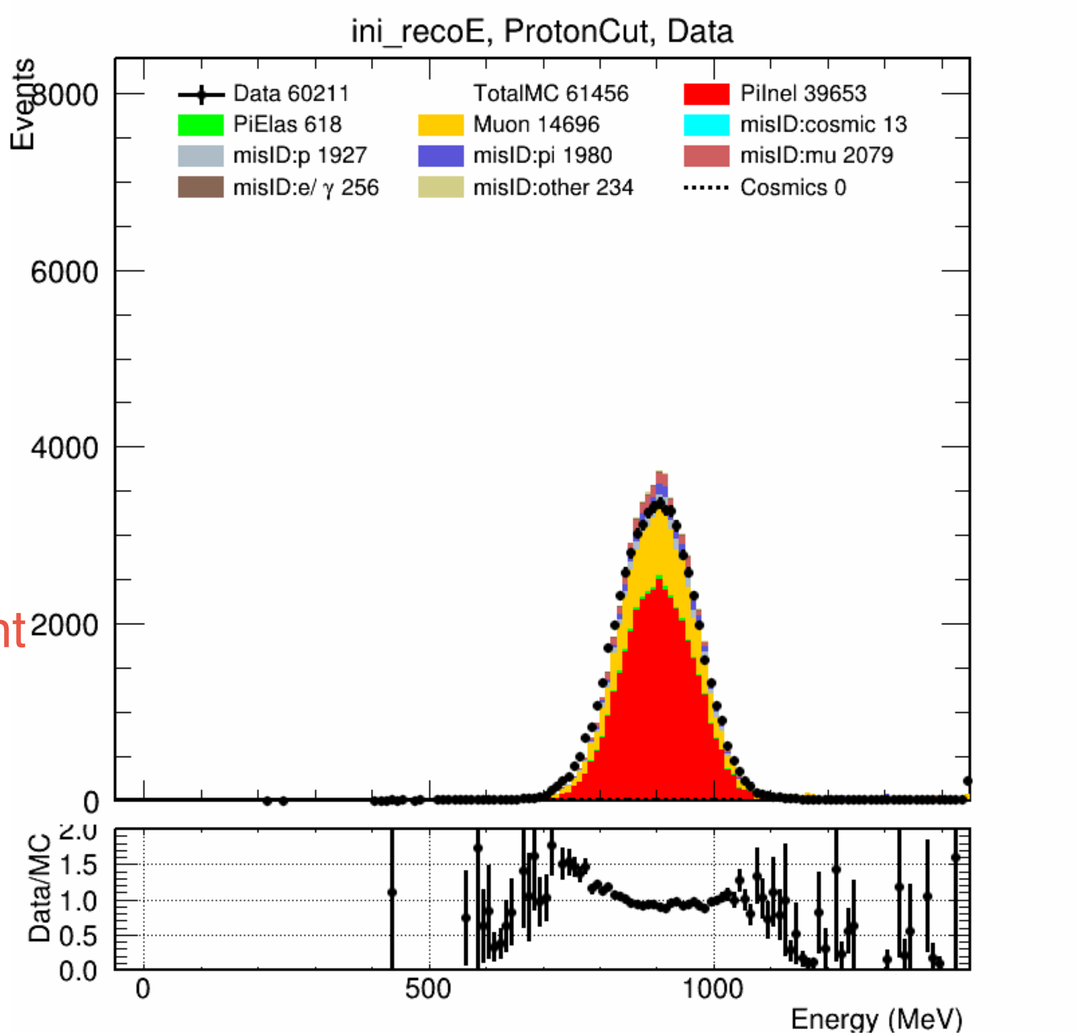
Reweight



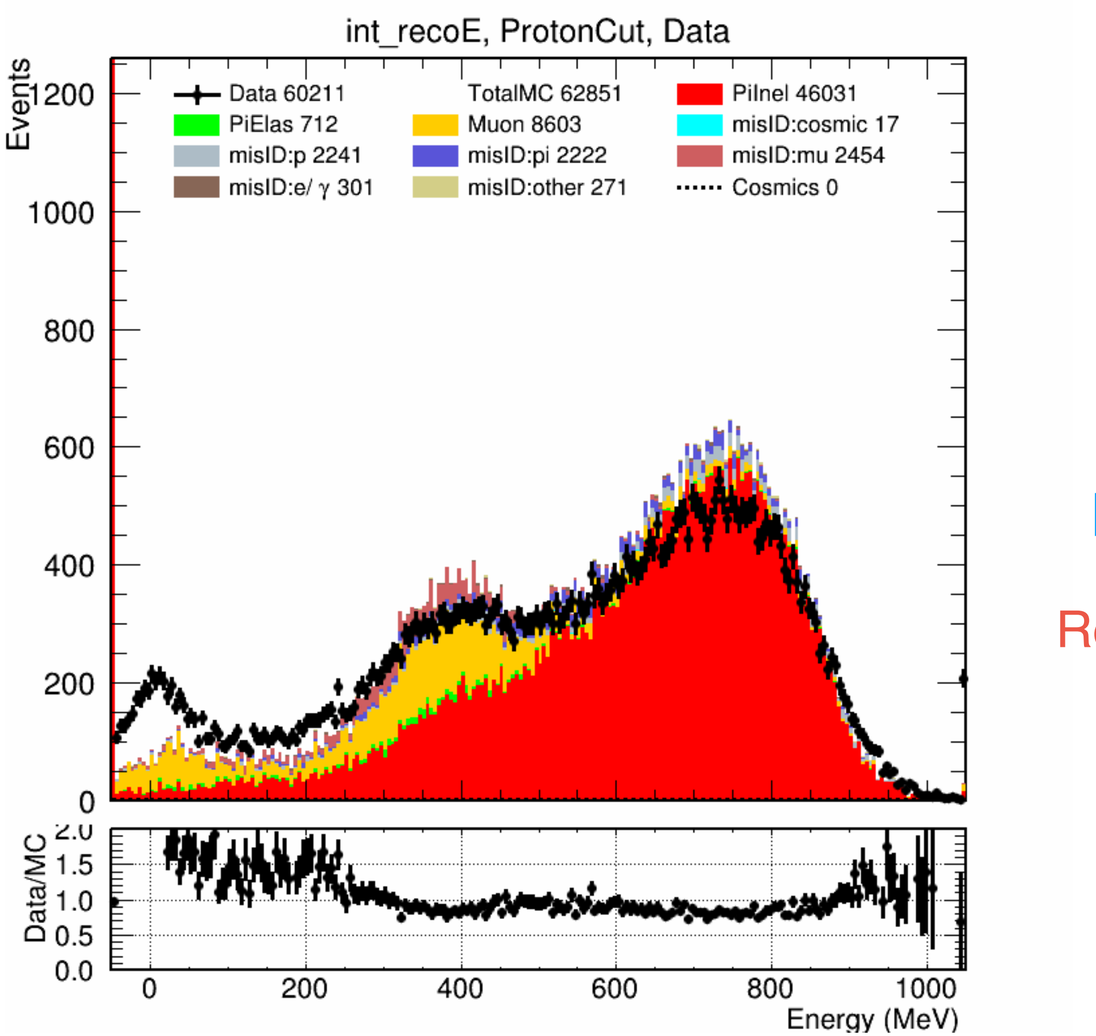
Front-face KE



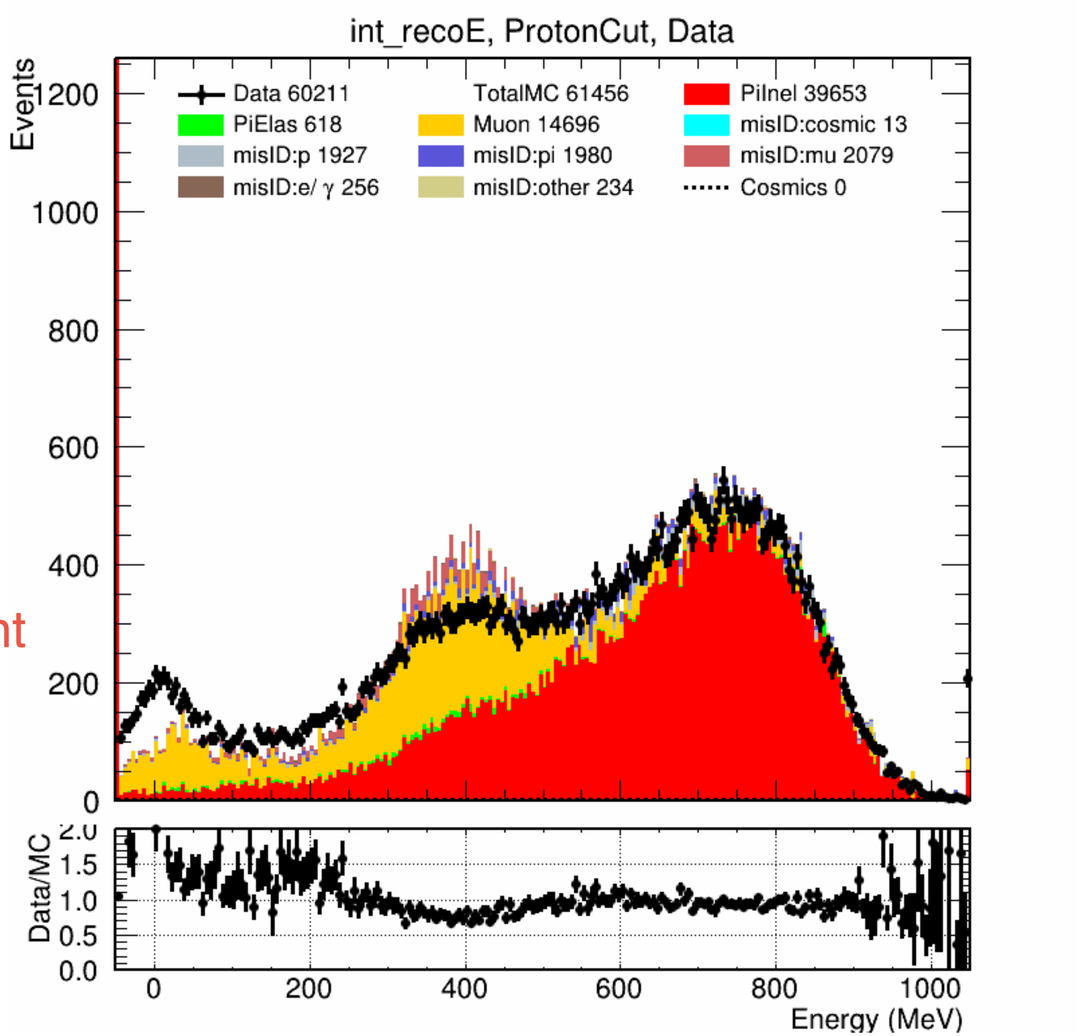
Reweight



Interaction KE



Reweight

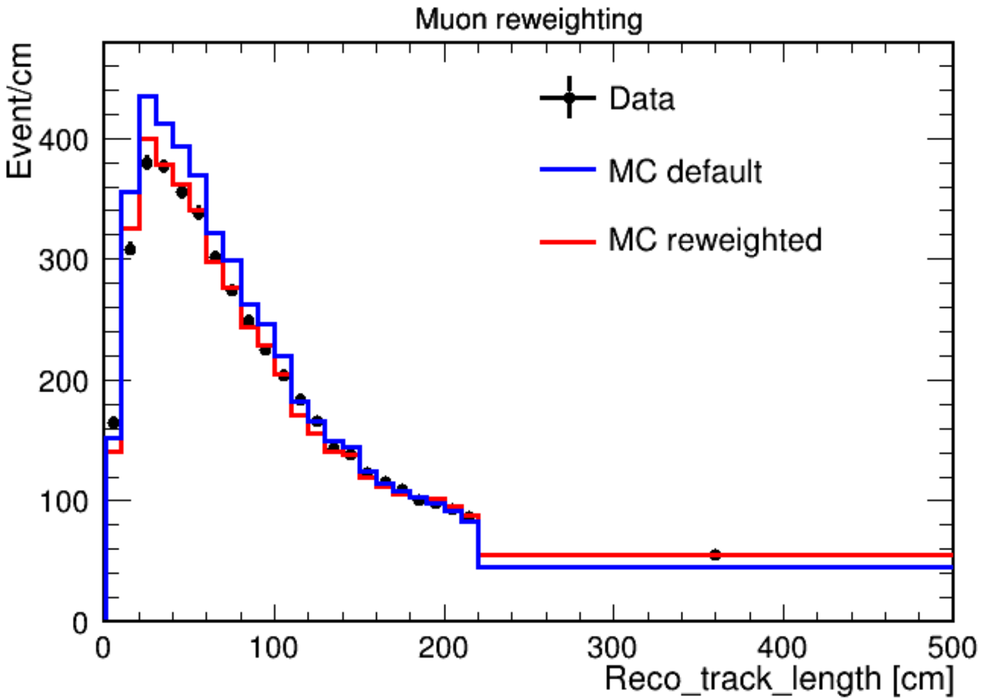


Muon bkg reweight

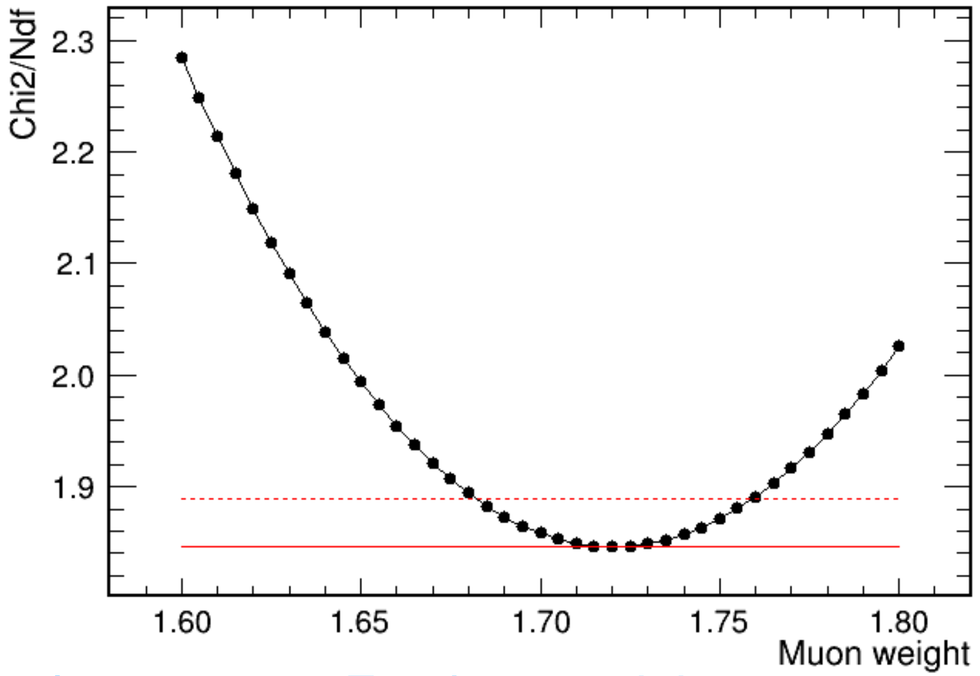
- After all selections except muon cuts, perform chi2 fit in track length distribution.

$$\chi^2/N_{\mathrm{df}} = \frac{1}{N-1}\sum_{\mathrm{bin}=1}^{N}\frac{(\mathrm{data}-\mathrm{weightedMC})^2}{\mathrm{data}+\mathrm{weightedMC}}$$

Poisson error

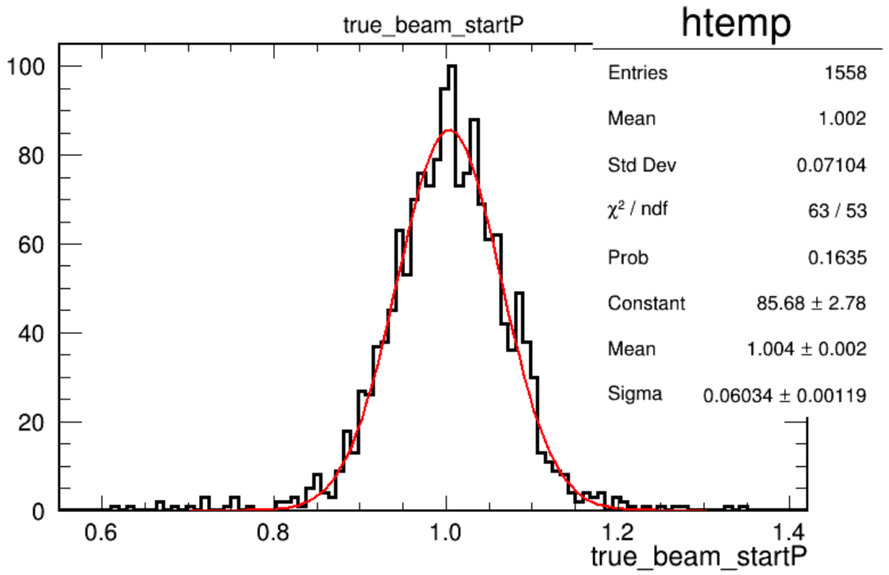


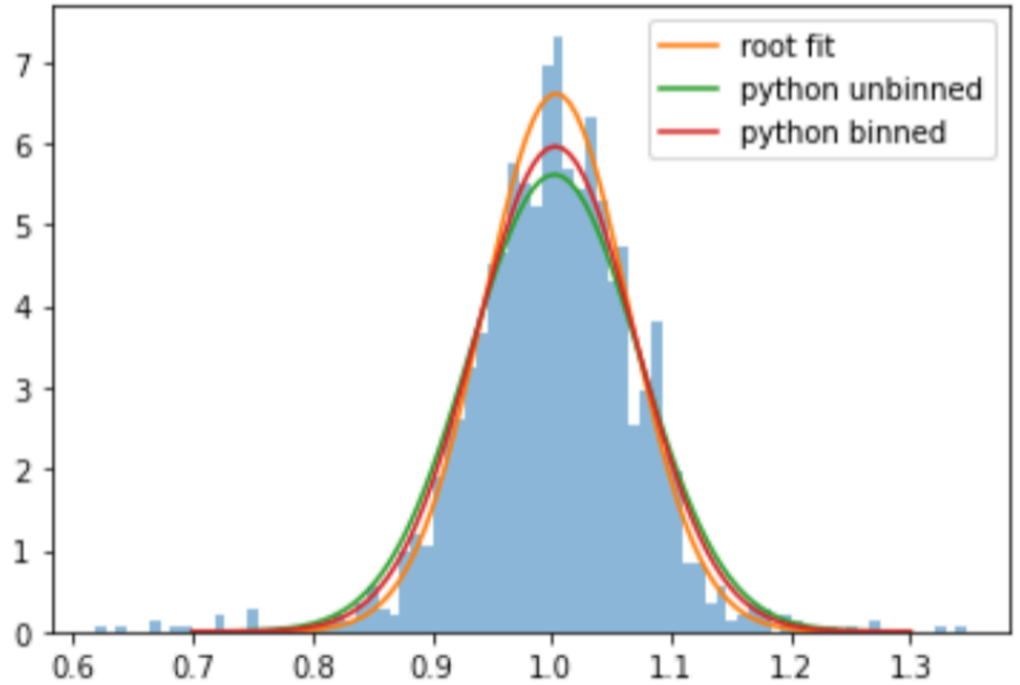
Weight = 1.72
FOM = 1.84585



This mainly correct for long muons. For the remaining muon, we still use Michel score distribution after APA3 cut for sideband fit.

Beam momentum reweight





- ROOT: $\mu = 1.0039 \pm 0.0016$; $\sigma = 0.0603 \pm 0.0012$
- Python unbinned: $\mu = 1.0024 \pm 0.0018$; $\sigma = 0.0710 \pm 0.0013$
- Python binned: $\mu = 1.0032 \pm 0.0013$; $\sigma = 0.0669 \pm 0.0009$

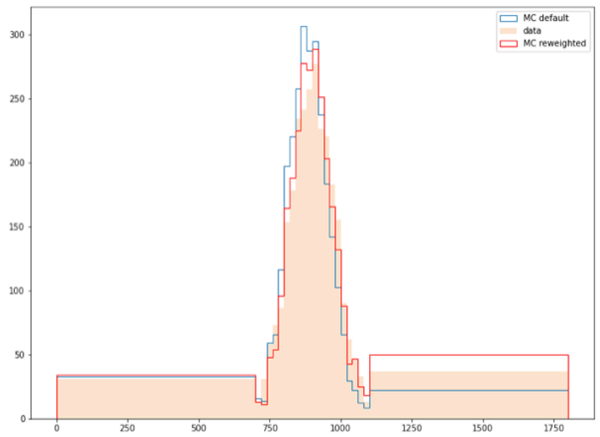
ROOT is extended likelihood fit?

Beam momentum reweight

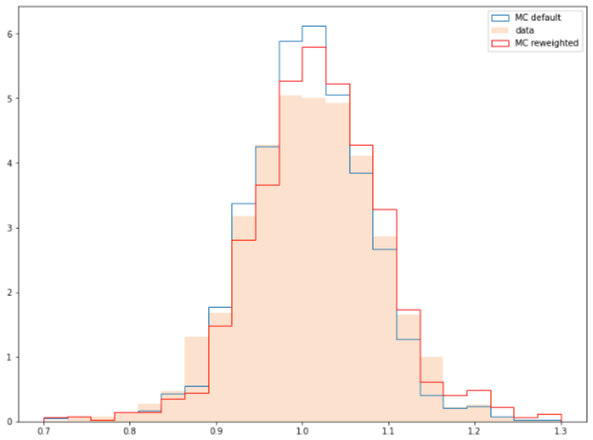
- A weight to each MC event

$$\frac{\frac{1}{\sigma}e^{-\frac{(p-\mu)^2}{2\sigma^2}}}{\frac{1}{\sigma_0}e^{-\frac{(p-\mu_0)^2}{2\sigma_0^2}}}$$

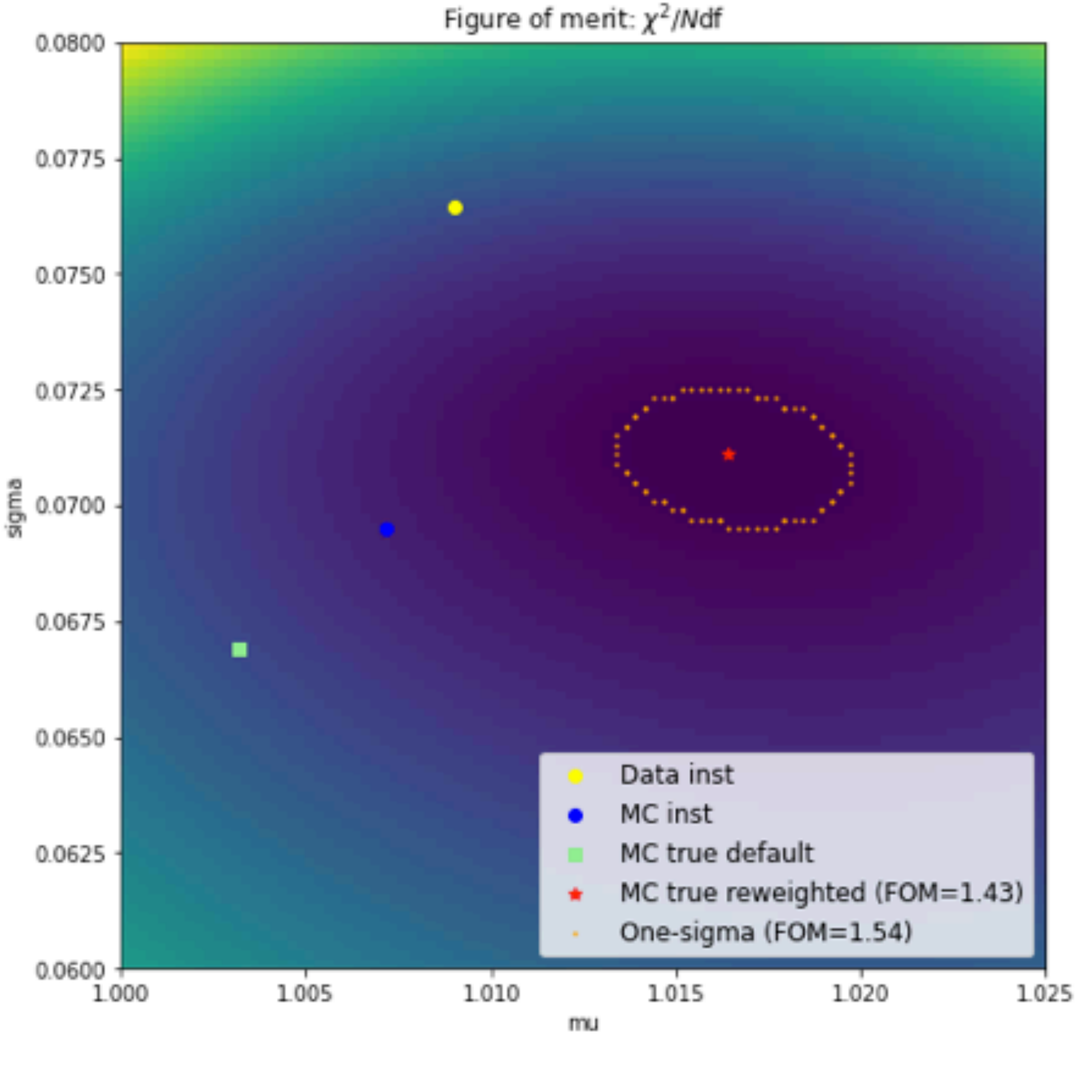
- p is the true momentum in each MC event
- μ_0 and σ_0 are fit to MC true momentum
- μ and σ are two **fit parameters**



Reconstructed front-face KE (MeV)



Beam instrumented momentum (GeV)

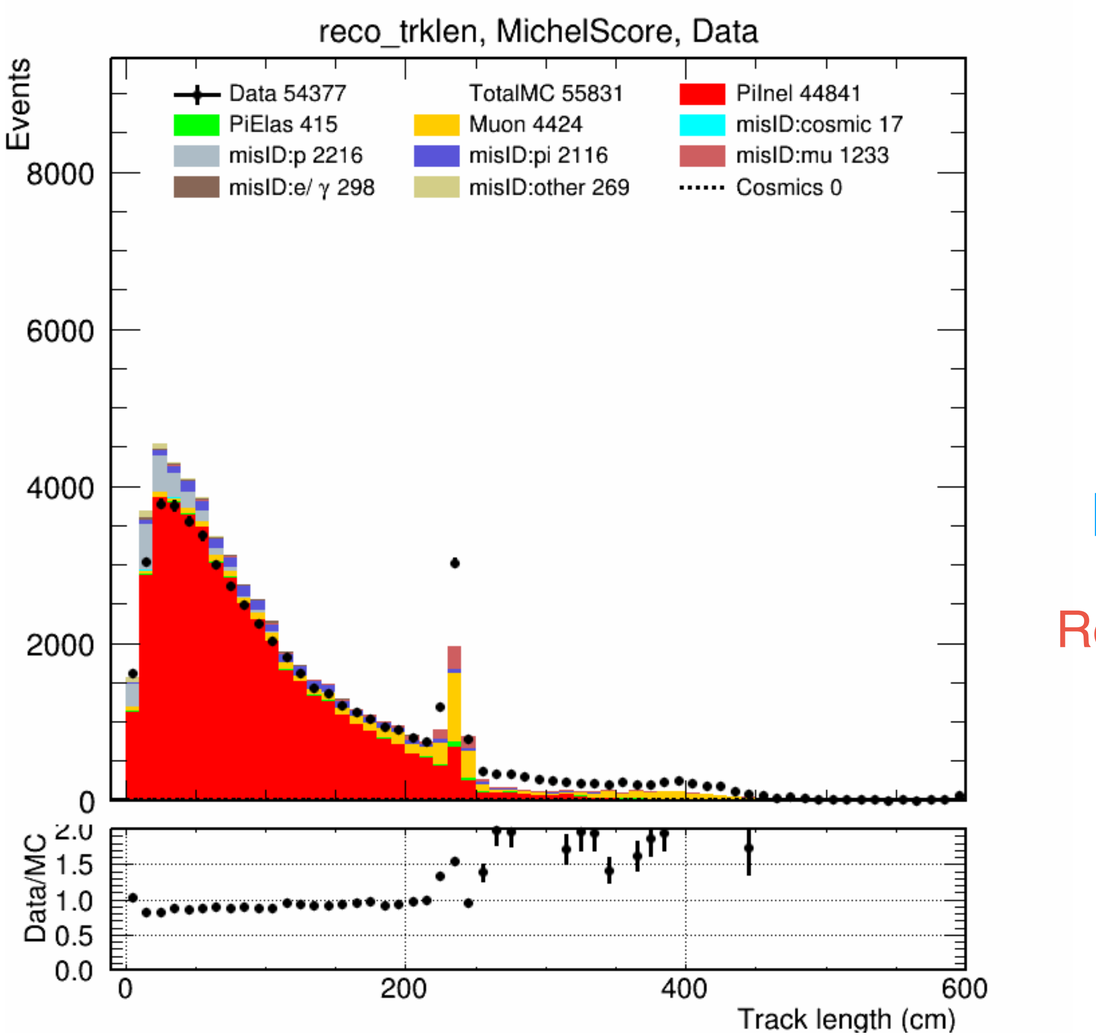


χ²/Ndf on 2D meshgrid of (μ, σ)

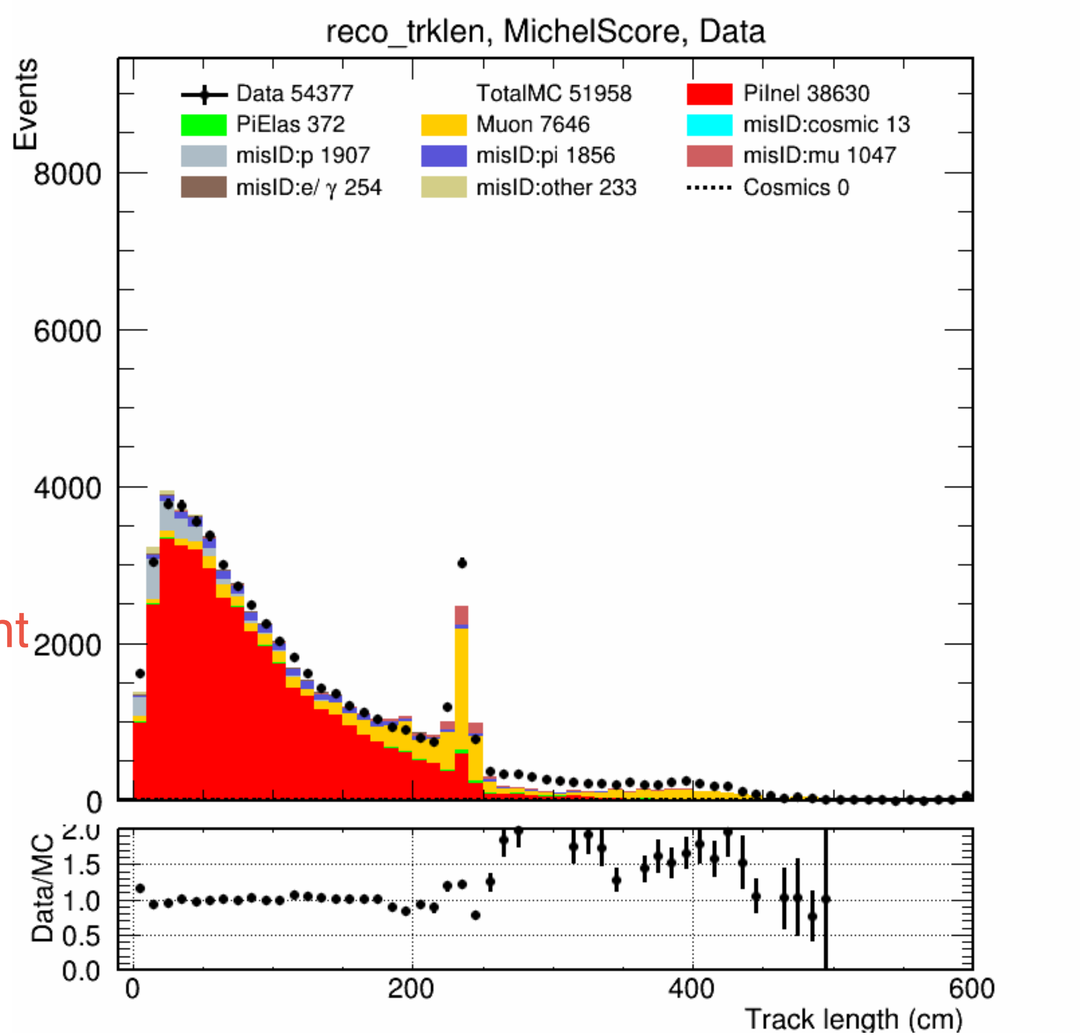
After reweighting

- Remaining differences
  - Long track (low KE) region
  - Short track (high KE) region

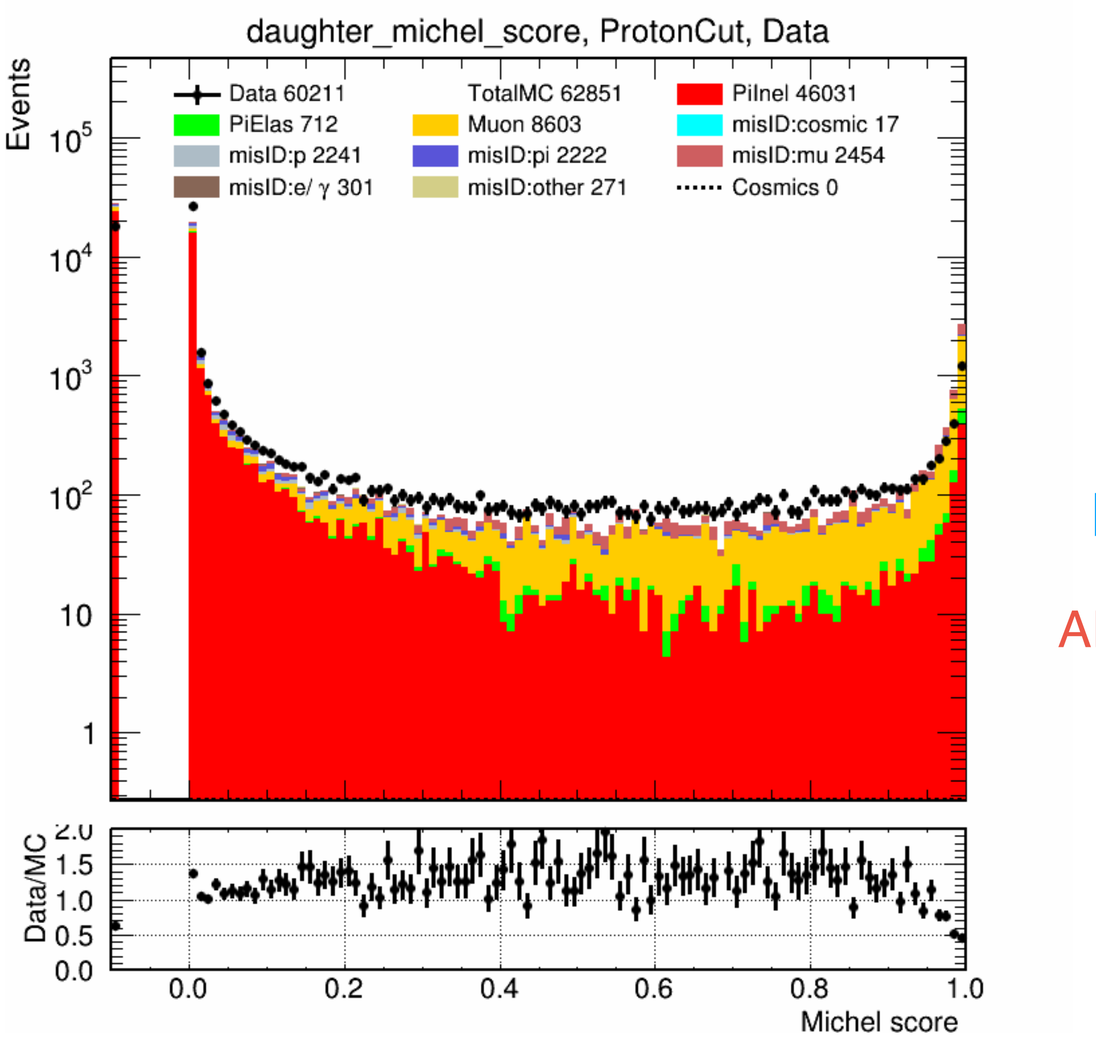
After Michel score cut



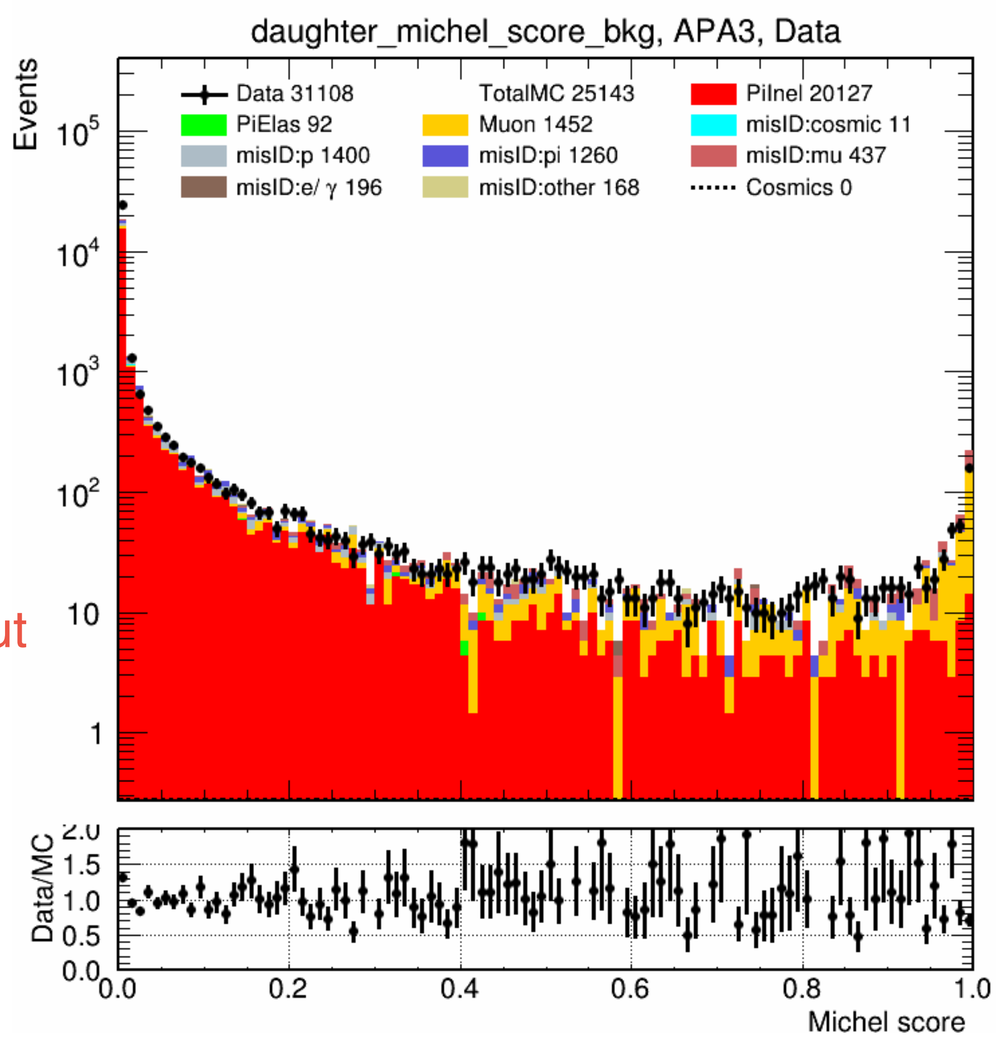
Reweight



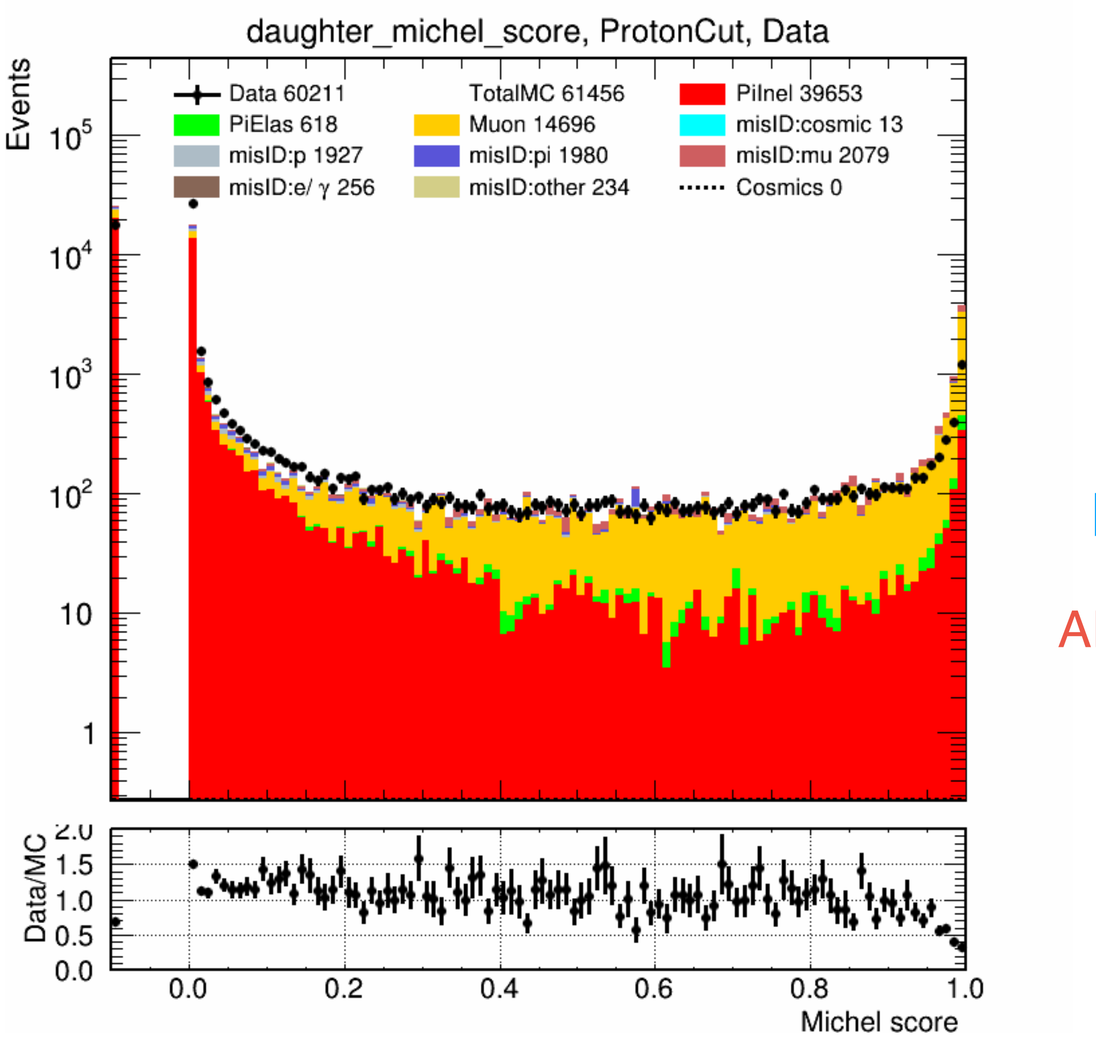
Michel score distribution (nominal)



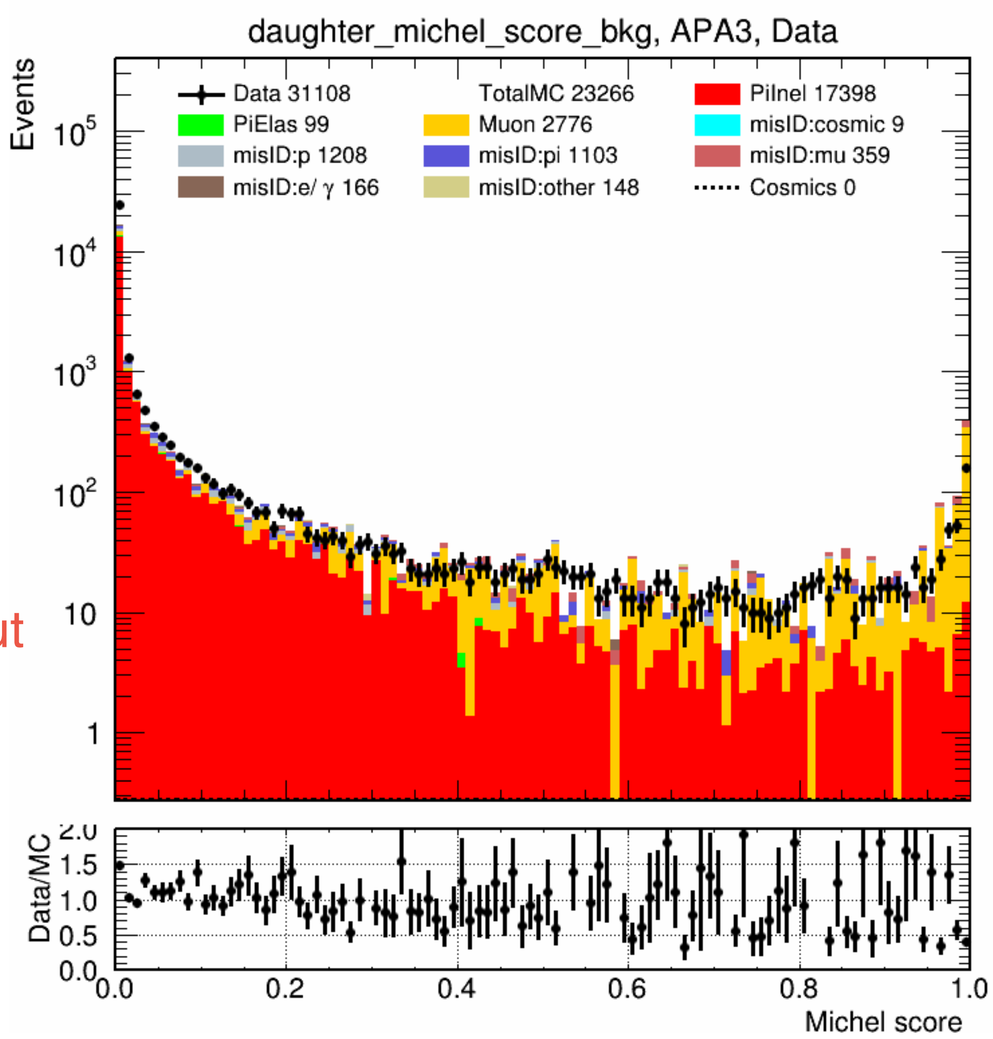
APA3 cut



Michel score distribution (after reweighting)



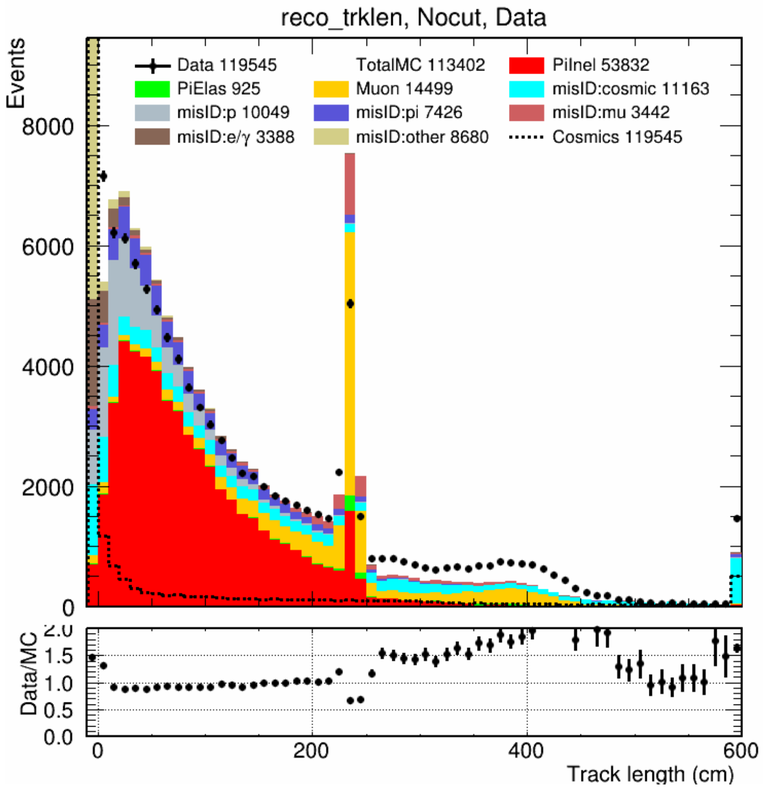
APA3 cut

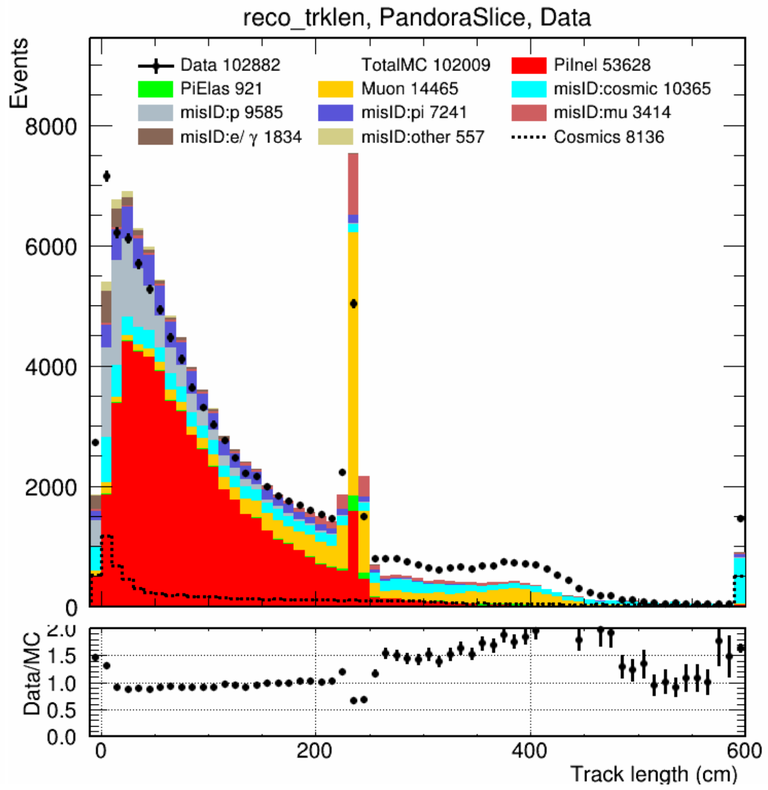


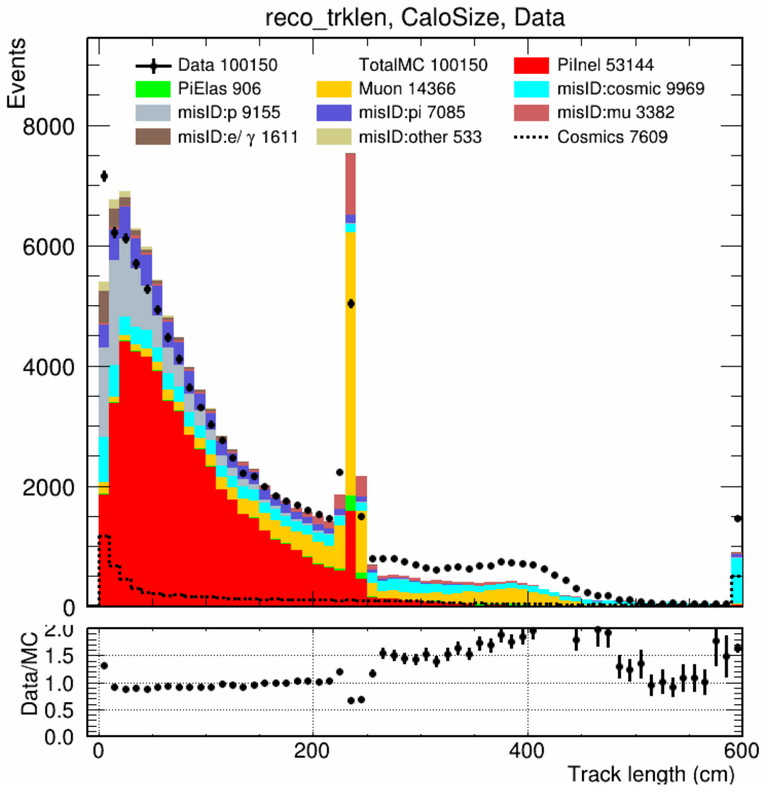
Long track (low KE) region

- The Michel score cut reduces more MC than data, maybe due to the fact there are more broken tracks in MC.
- It is better to combine Michel score cut and APA3 cut together as muon cut.

Cuts before beam quality cut

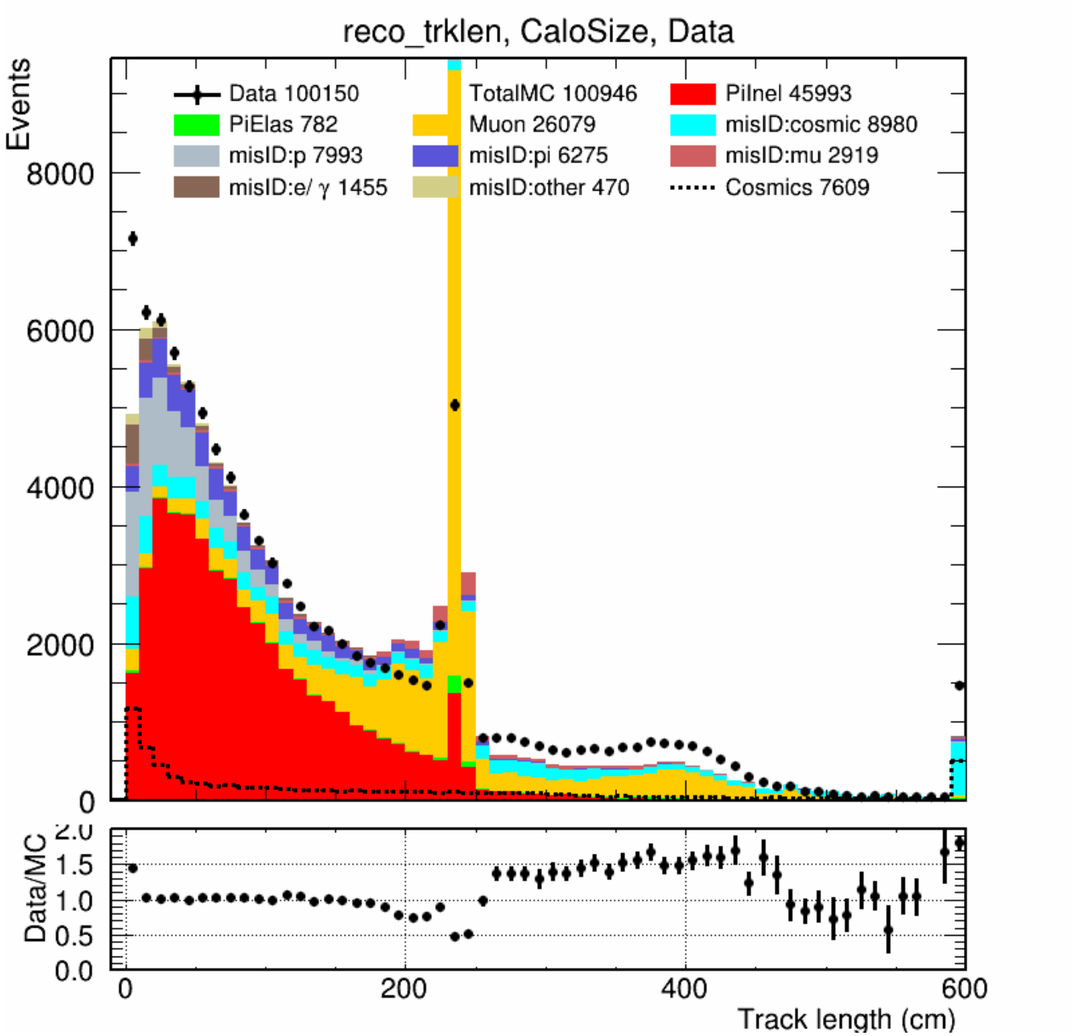




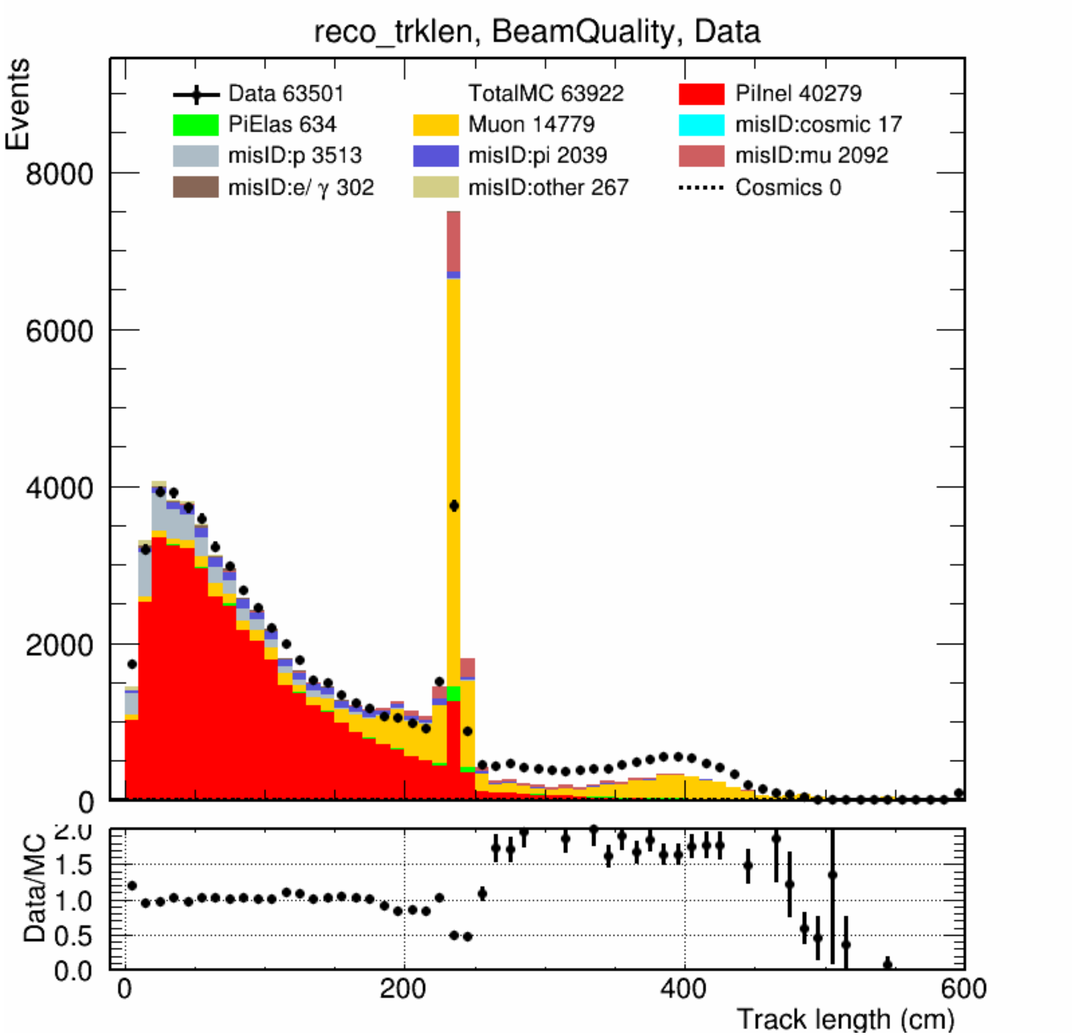


Only the underflow bin changes. More data than MC is removed.

Beam quality cut

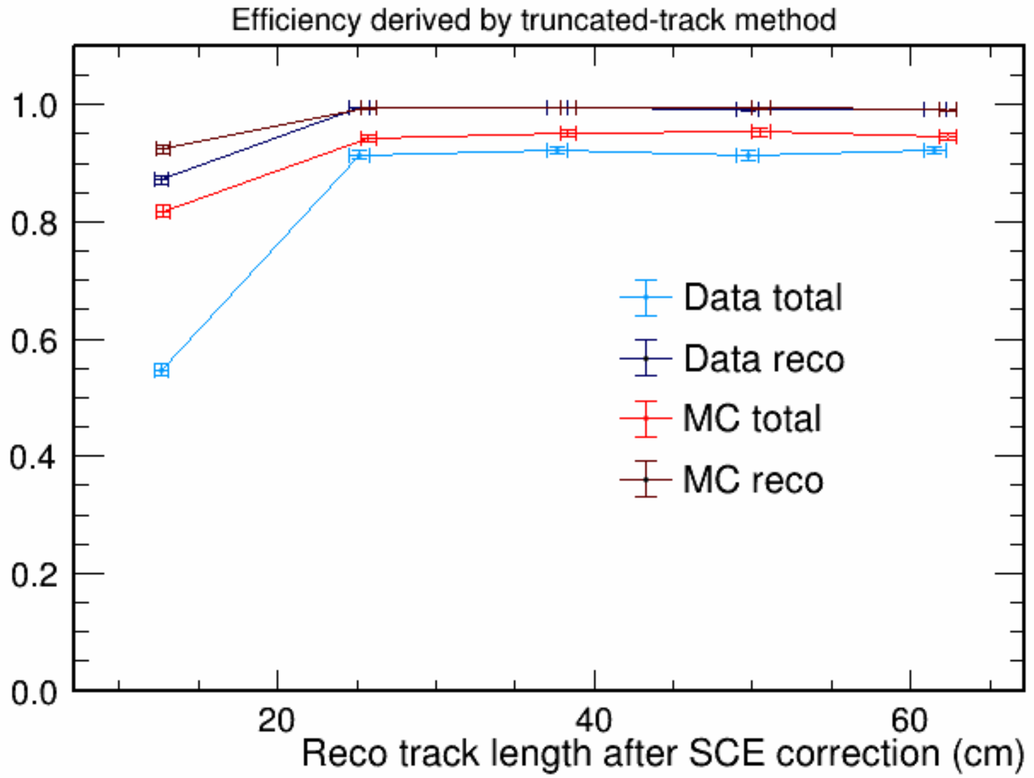


BQ cut



Short track (high KE) region

- It is possible the difference in short track region also due to efficiency.
- Maybe we should also study purity in addition to efficiency, since Nreco*purity=Ntrue*efficiency



LArIAT

- They reduce a fiducial volume
  - “consider only events whose matched track penetrates to at least 30 cm from the front face of the LArTPC. Any track which extends to more than 80 cm from the front face we label as “exiting”. Only the portions of the tracks within the **fiducial volume** (in the **30 cm** and **80 cm** range) are used in the analysis. This LArTPC fiducialization also carries the benefit of eliminating much of the electron content.”

- How should we cope with long tracks and short tracks?
- Should we add Michel score cut?

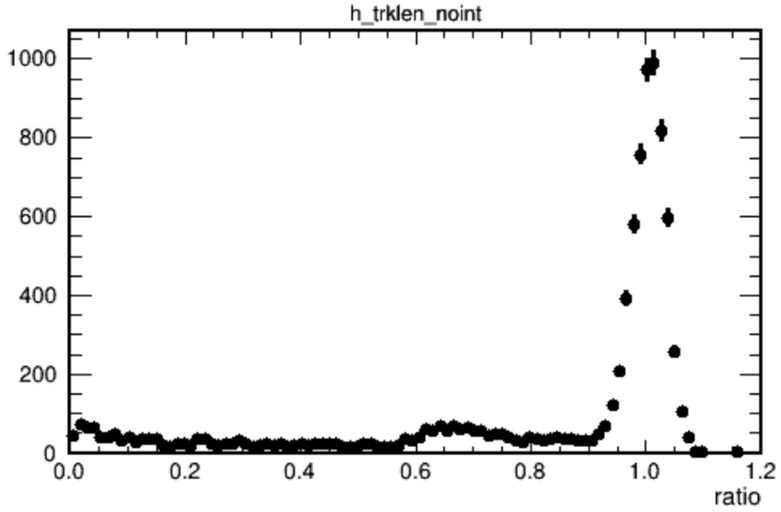
Next to-dos

- Reweight MC to match data
- Measured histograms after unfolding
- Uncertainties

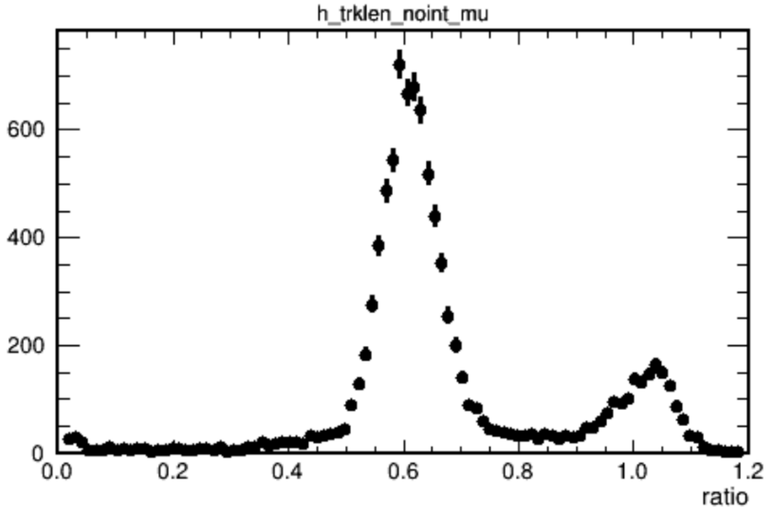
Back-ups

Stopping beam muon sample

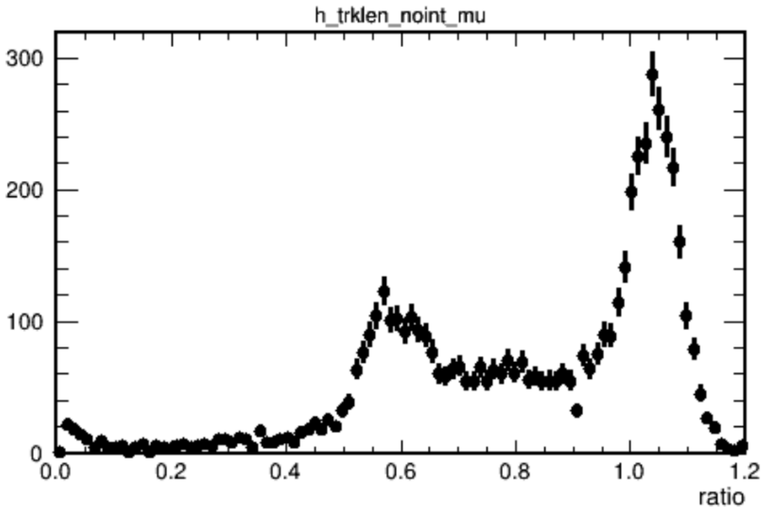
- BeamQualityCut && Michel_score > 0.6
- Ratio = trklen / RangeFromKE(Eff)



MC true



MC reco



Data reco

Select Ratio > 0.9 as stopping muon sample