Neutrino energy reconstruction in the DUNE far detector

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Updates

Will show updates for ν_μ CC events with contained tracks.

Looked at bias of reco energy as a function of true energy.

Also looked at low tails in plots of track momentum resolution.

Updates

Initially tried to use the same method that worked to correct bias as function of true energy for ν_e CC events: add one more bin to correction of reco hadronic energy at low true hadronic energy, then adjust fit ranges to obtain a better fit in lowest true hadronic energy bins.

Unfortunately this gave no improvement. Realised that the method works for ν_e CC events since there is almost no bias in reco shower energy compared with true electron energy.

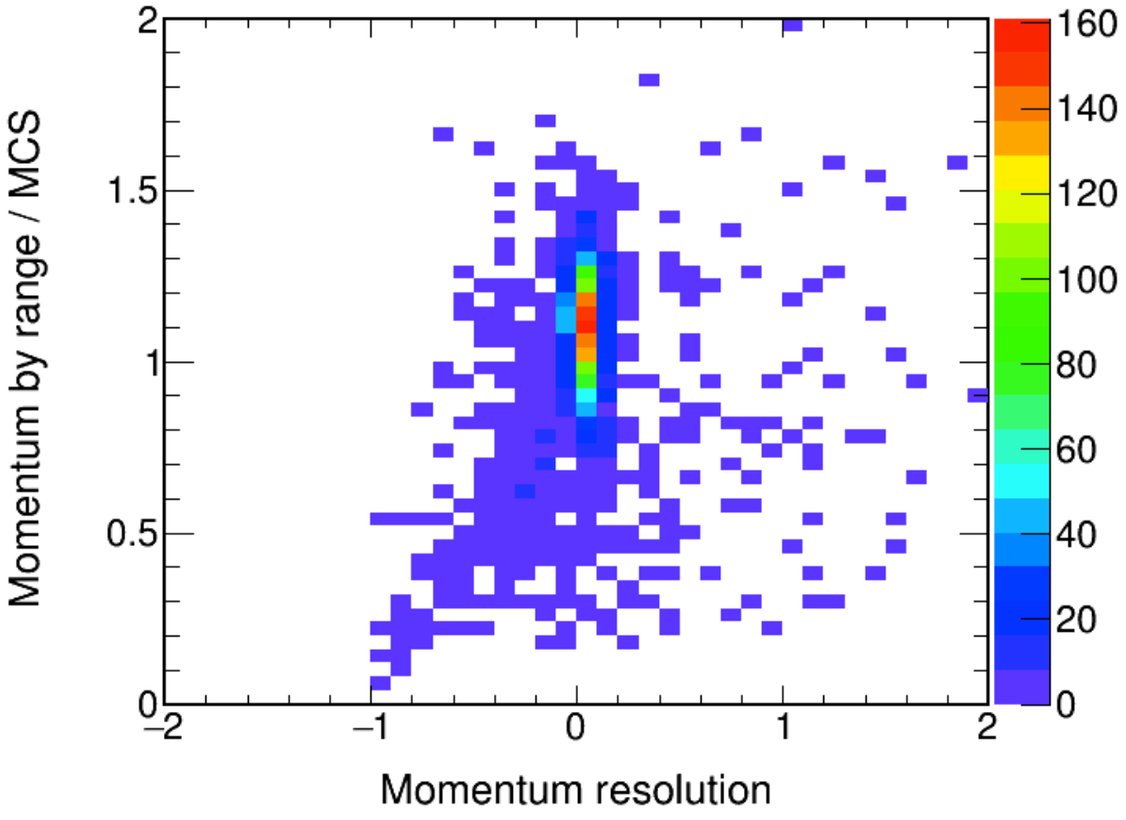
It does not work for ν_μ CC events as there are noticeable biases in reco track momentum compared with true muon momentum for both contained and exiting tracks.

Track momentum resolution by range

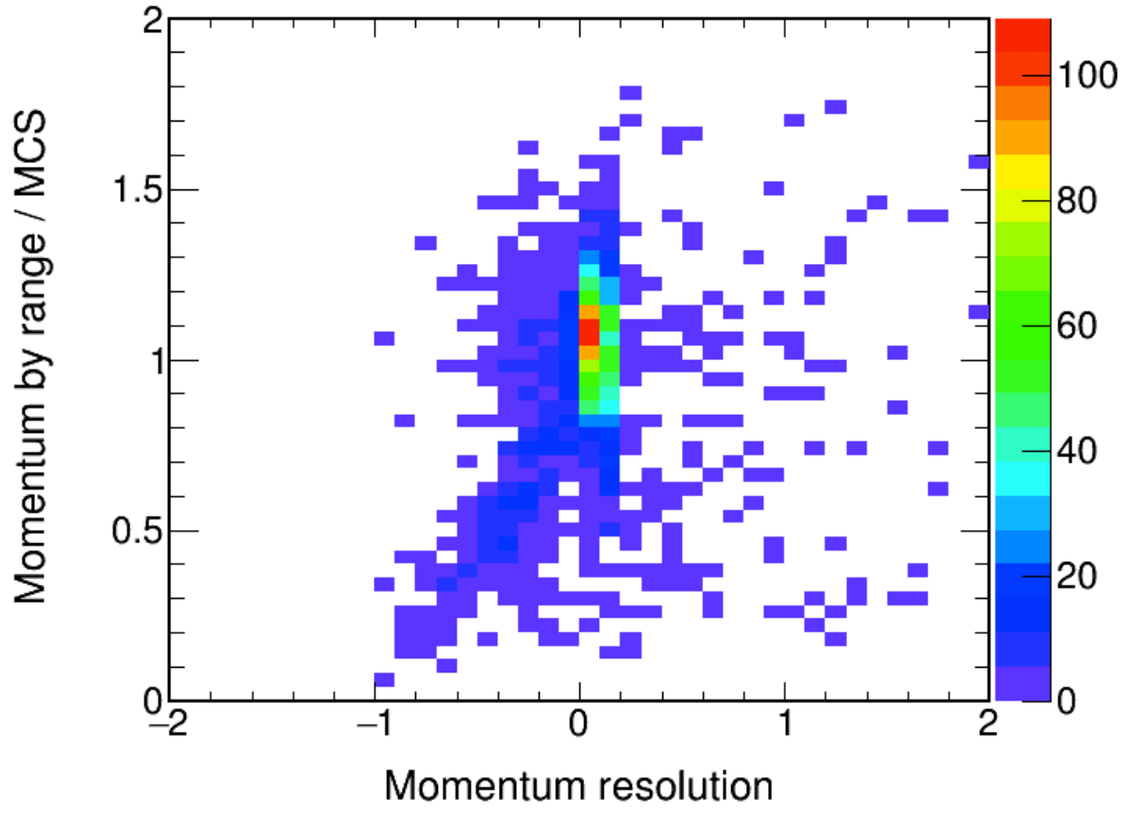
Investigate low tails by plotting resolution of momentum by range against ratio of momentum by range / MCS momentum

True CC events with contained track

PMTrack



Pandora



Please see also slide 11 in https://indico.fnal.gov/getFile.py/access?contribId=5&resId=0&materialId=slides&confId=13342

Track momentum resolution by range

Tracks in low tails of momentum by range resolution tend to have low values of ratio of momentum by range / MCS momentum (previous slide).

Use MCS momentum as a cross check of reconstruction of range.

In low tails, MCS momentum would be more accurate than momentum by range even though these tracks are contained. Use MCS instead of momentum by range if ratio < 0.7.

This does give some reduction in the low tails (next slide). Unfortunately, however, the effectiveness of this is reduced since some of the tracks in the low tails have reconstructed length < 100 cm. For these short tracks, it is not possible to split them into enough segments to calculate the MCS momentum.

Track momentum resolution by range

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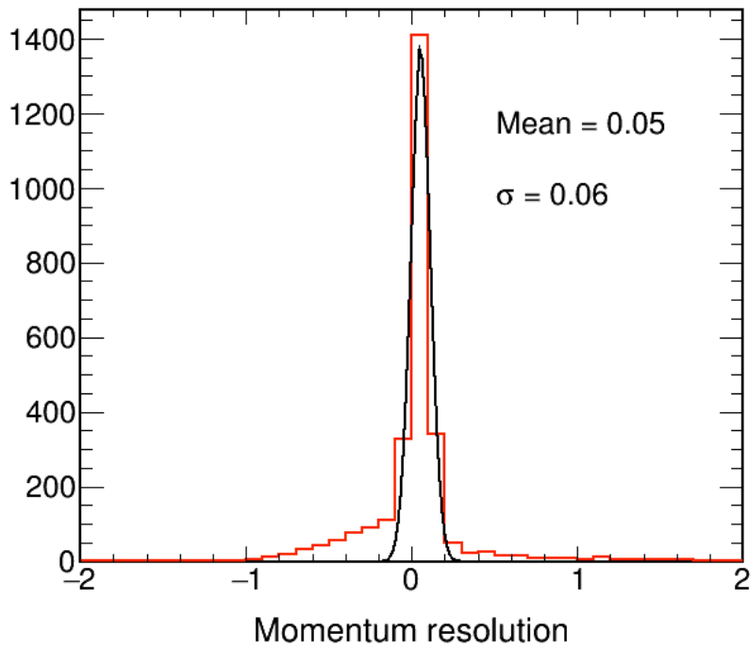
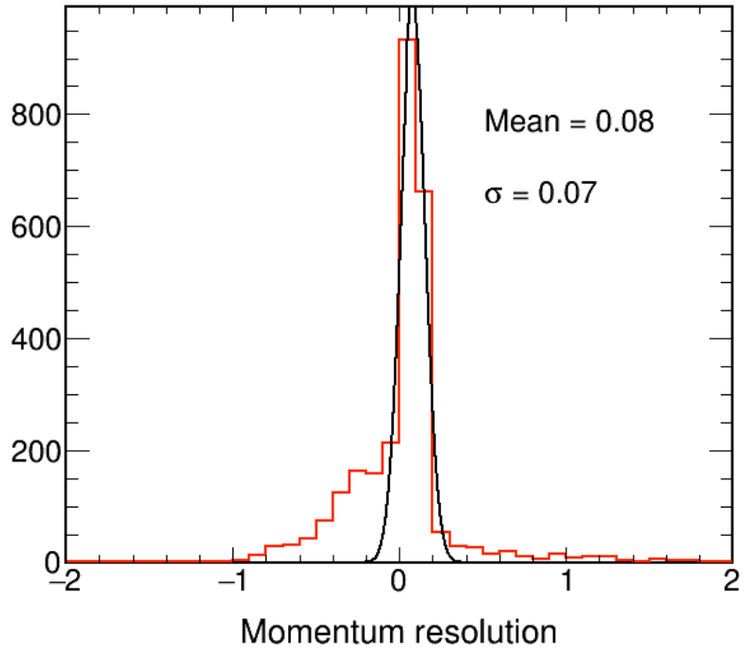
True CC events with contained track

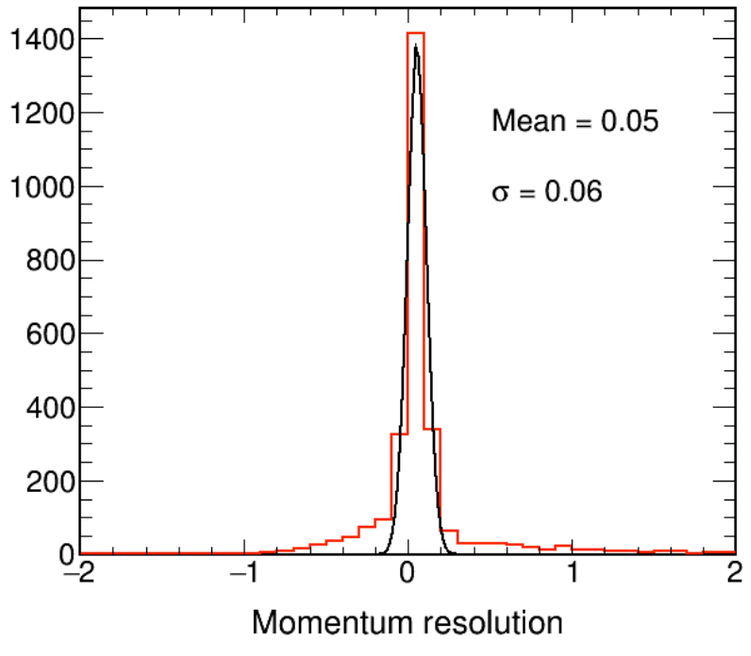
PMTrack

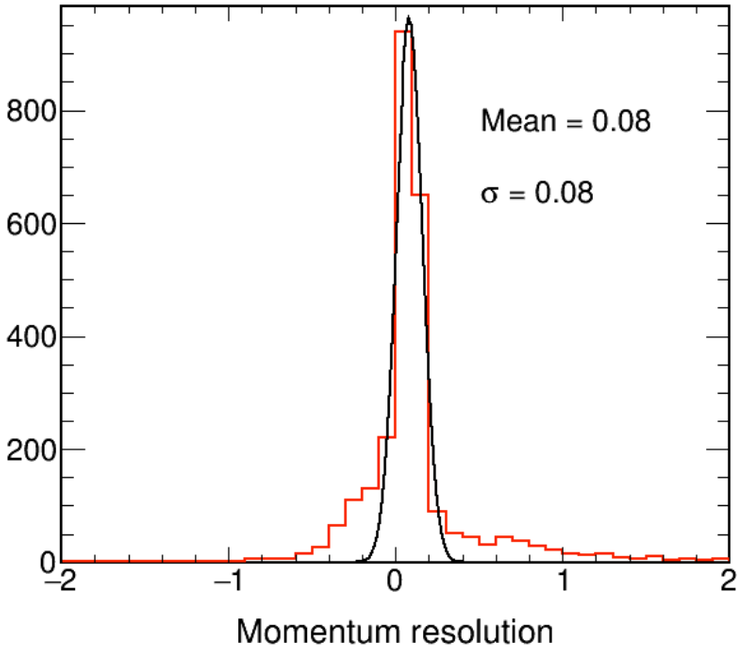


Pandora



Use range for all tracks





Use range if range / MCS > 0.7; otherwise use MCS

Track momentum resolution by range

Now try to improve track momentum resolution. Experiment with changing binning of calibration of track momentum by range using true muon momentum.

Track momentum resolution by range

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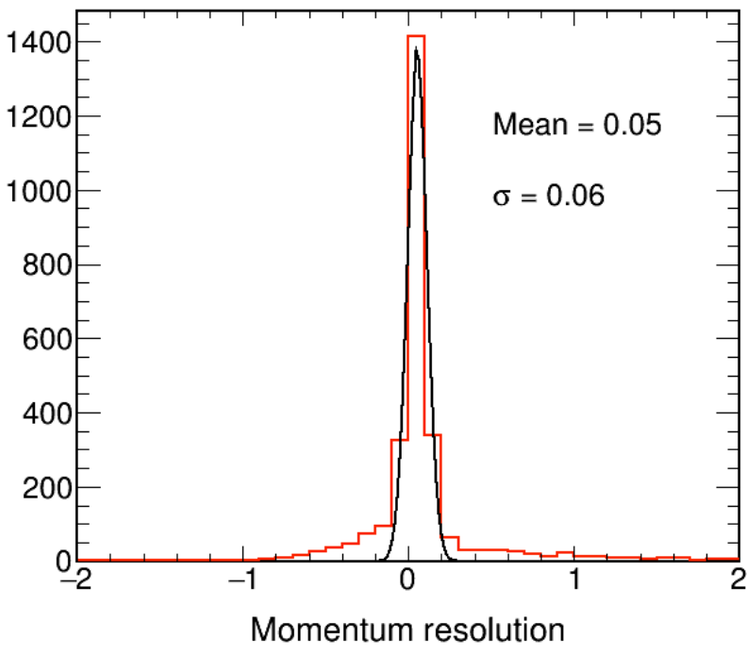
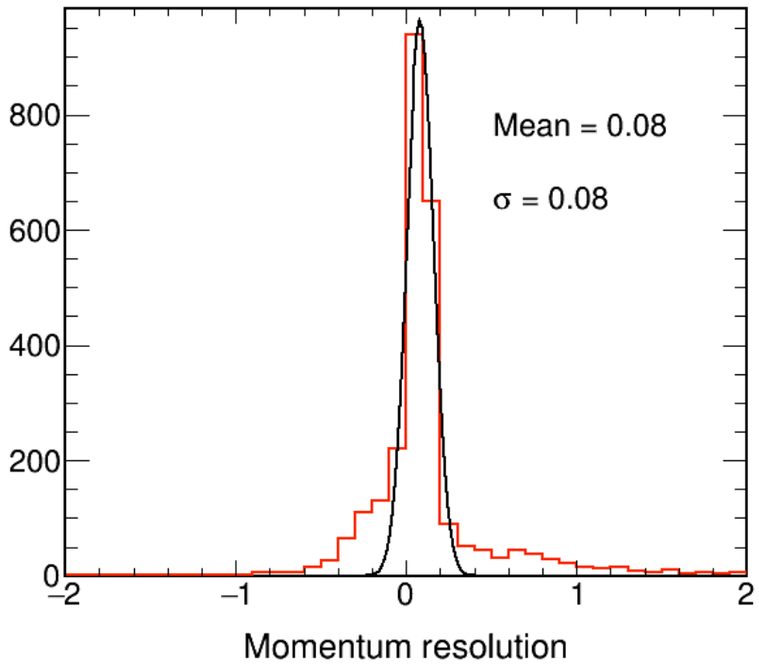
PMTrack

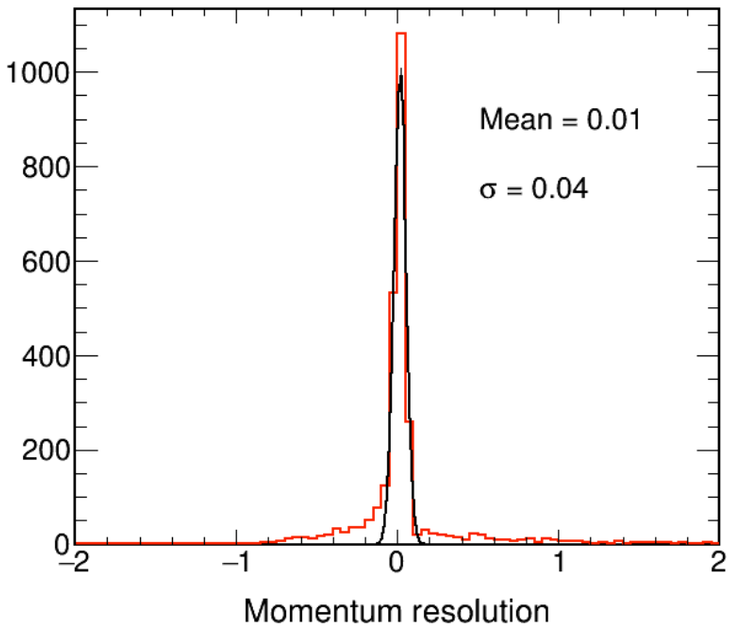


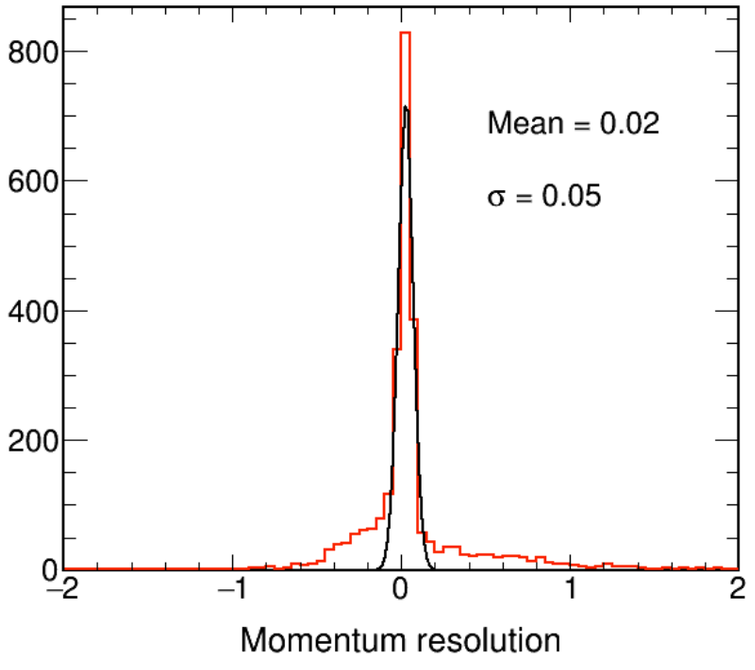
Pandora



True CC events with contained track

For calibration use 5 bins of true momentum from 0.5-3.0 GeV (width 0.5 GeV).





For calibration use 5 bins of true momentum from 0.2-1.7 GeV (width 0.3 GeV). Also double numbers of bins in resolution plots.

Track momentum resolution by range

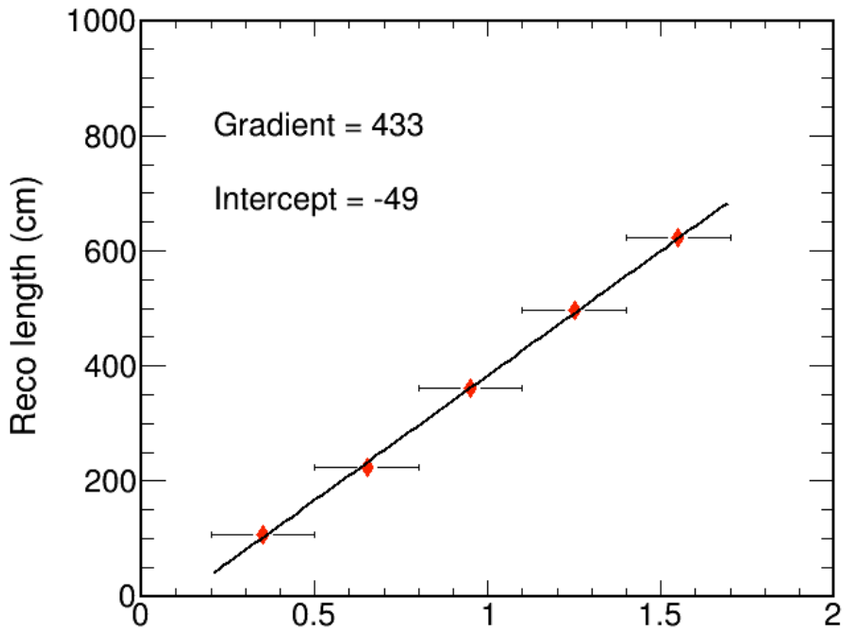
Following this change of binning, there is a clear reduction in both the bias and the width of the resolution of track momentum by range.

For PMTrack, the bias is reduced from 0.05 to 0.01 and the width from 0.06 to 0.04.

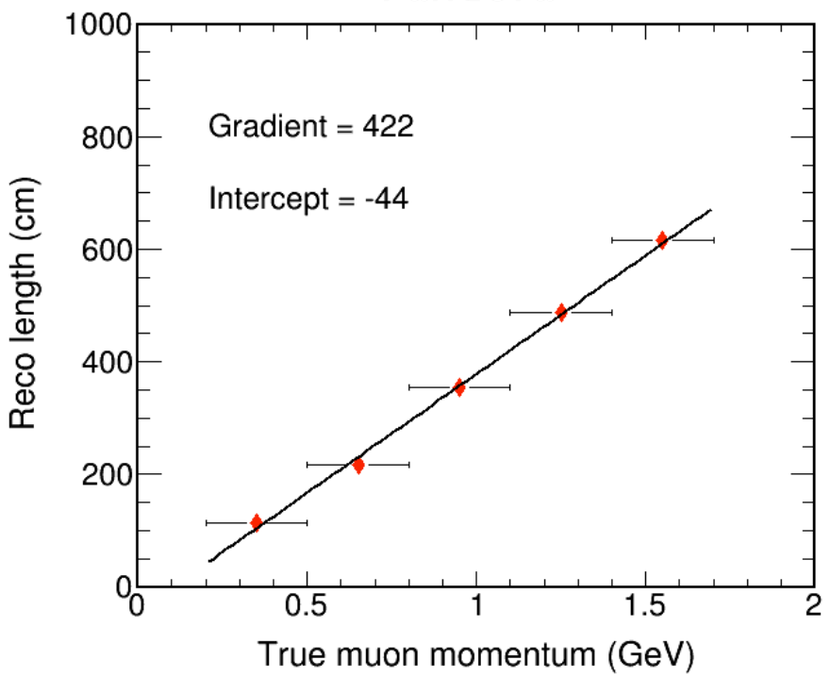
For Pandora, the bias is reduced from 0.08 to 0.02 and the width from 0.08 to 0.05.

Track momentum resolution by range

PMTrack



Pandora



Now try to remove remaining small biases in resolution of track momentum by range.

1. In calibration plots, tried using mean of true momentum distribution within each bin instead of centre of bin - this made no real difference.

2. In calibration plots, tried reversing axes and plotting true muon momentum in bins of reconstructed length - this gave a similar bias with a slightly larger width.

3. Try making ad hoc tweaks of gradients and intercepts of calibration plots - this gives some improvement (next 2 slides).

Track momentum resolution by range

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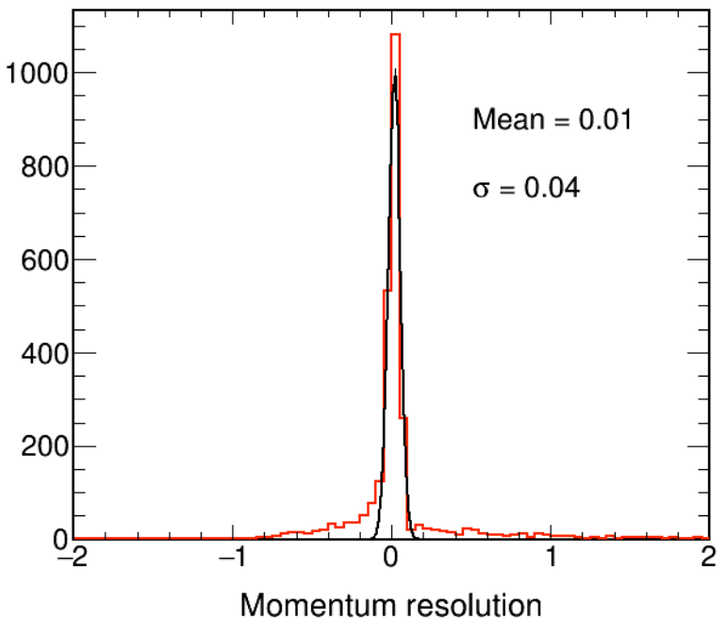
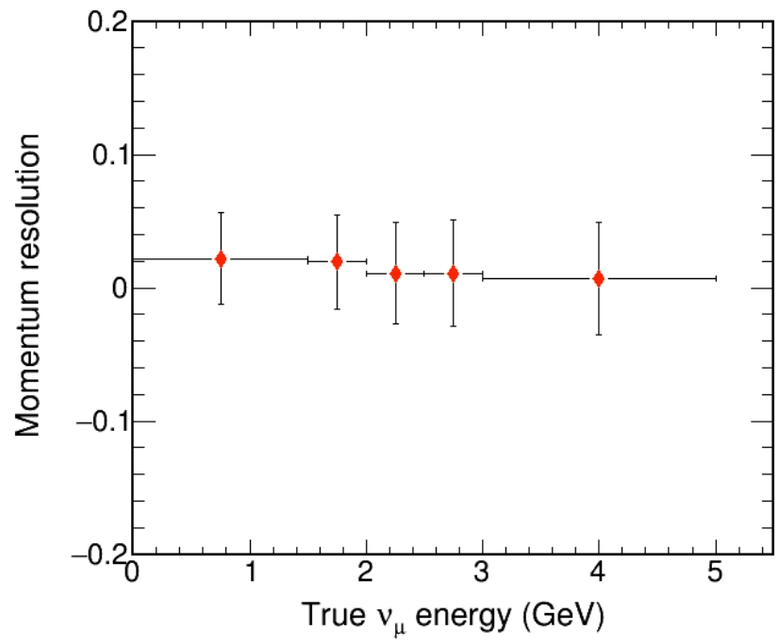
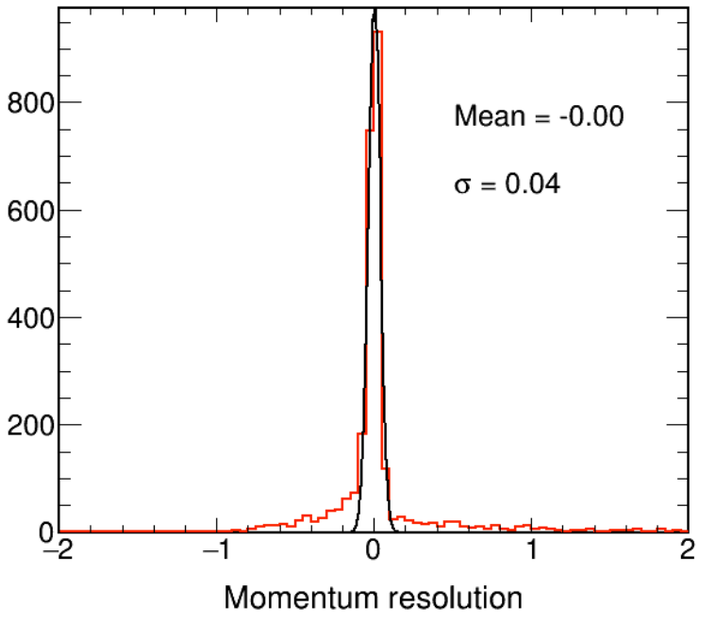
True CC events with contained track

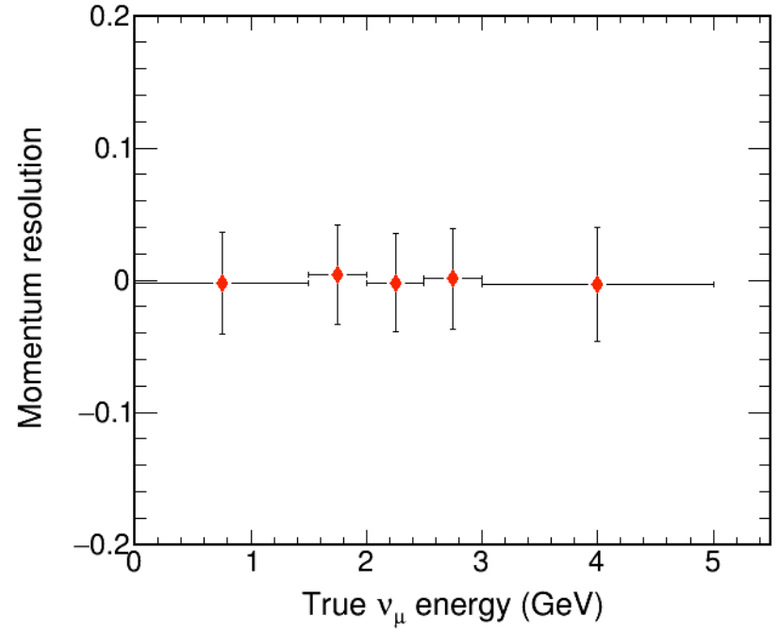
PMTrack





Gradient = 433
Intercept = -49
(as in calibration plot)





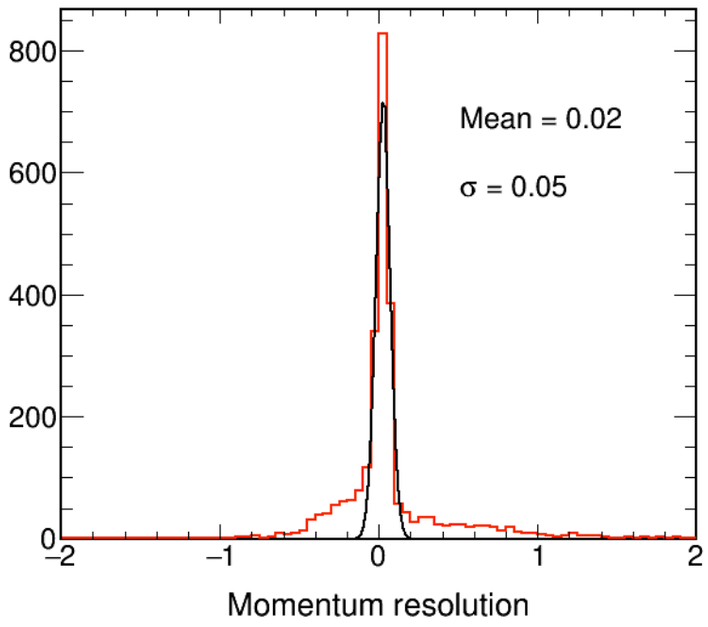
Keep gradient = 433, make ad hoc tweak of intercept to -54.

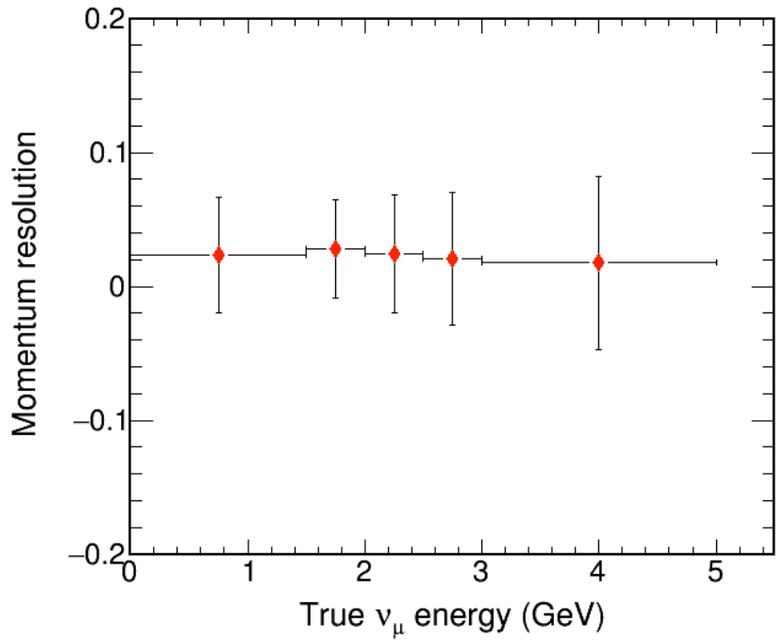
This corrects bias.

Track momentum resolution by range

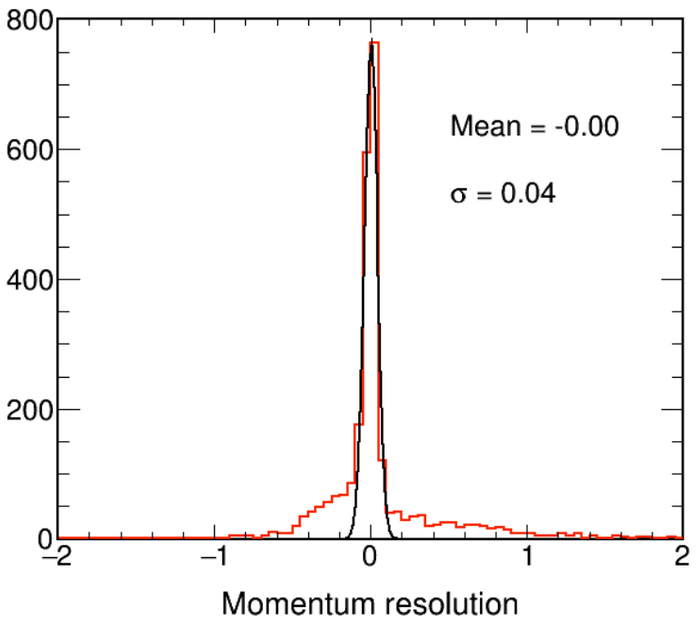
True CC events with contained track

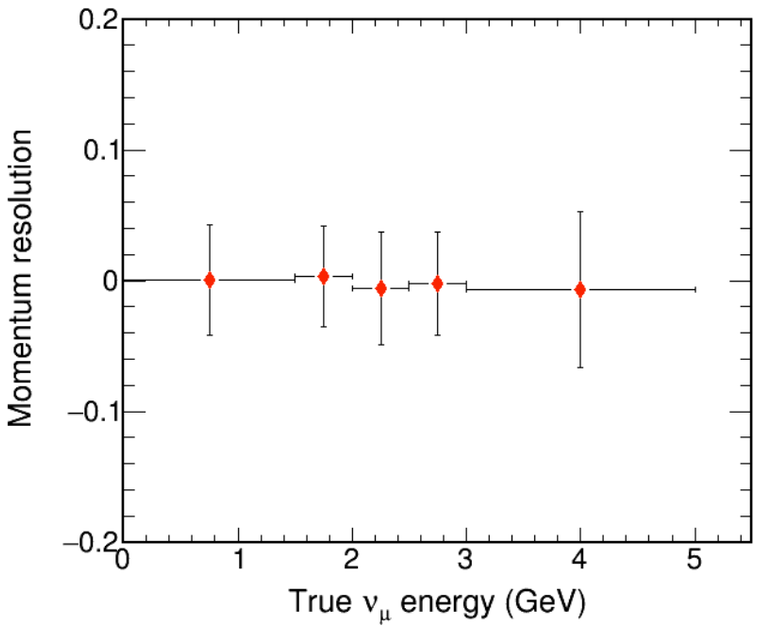
Pandora





Gradient = 422
Intercept = -44
(as in calibration plot)





Keep intercept = -44, make ad hoc tweak of gradient to 432.

This corrects bias and reduces width.

ν_μ energy resolution

Now check the effect of the improvement in resolution and bias of track momentum by range on ν_μ energy resolution as a function of true ν_μ energy for ν_μ CC events with contained tracks.

ν_μ energy resolution

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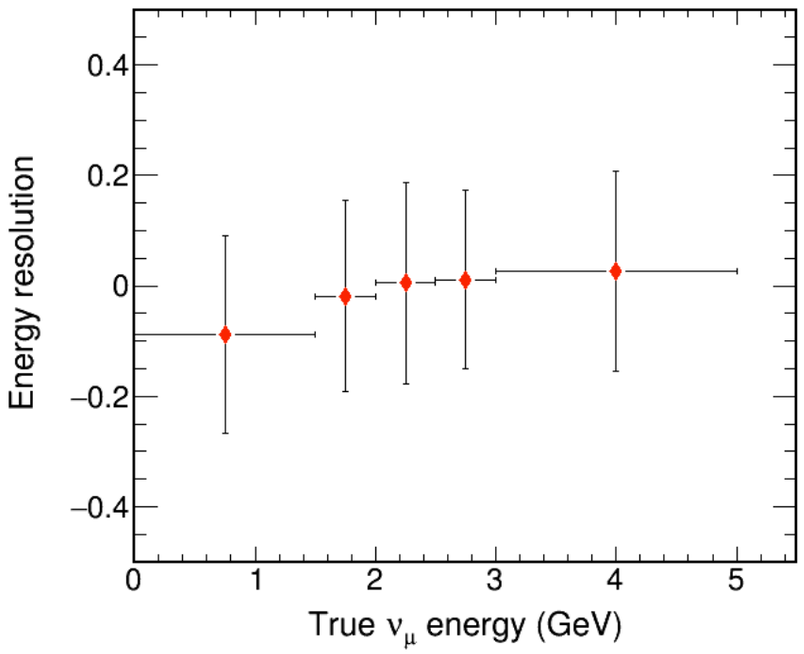
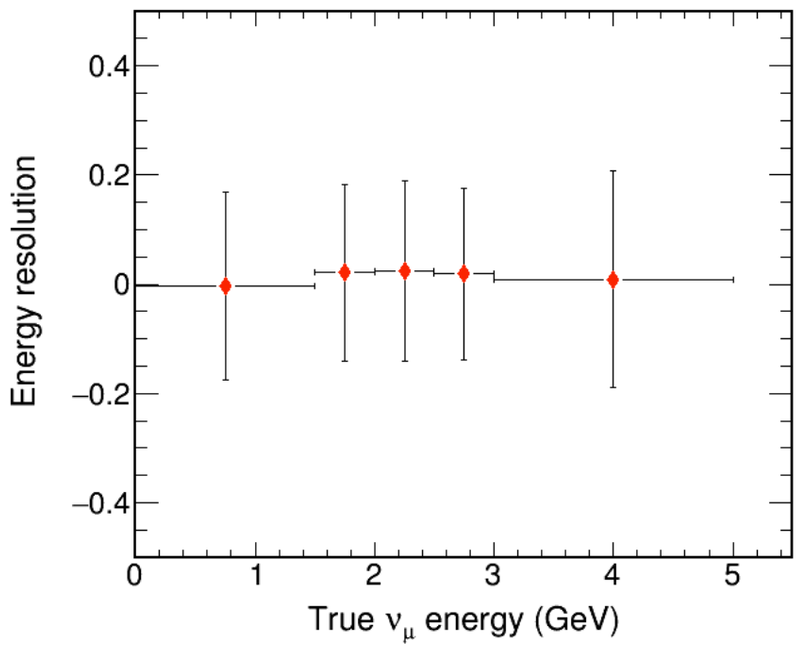
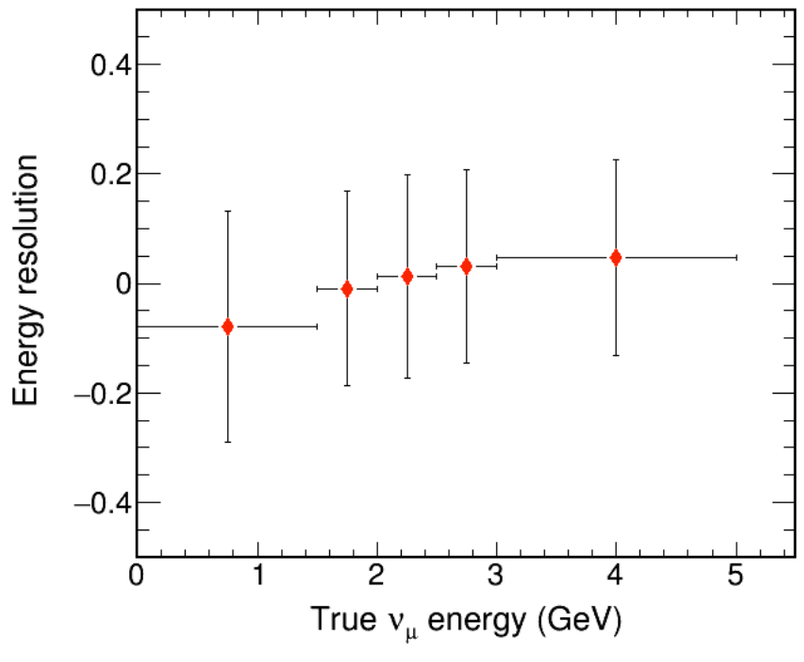
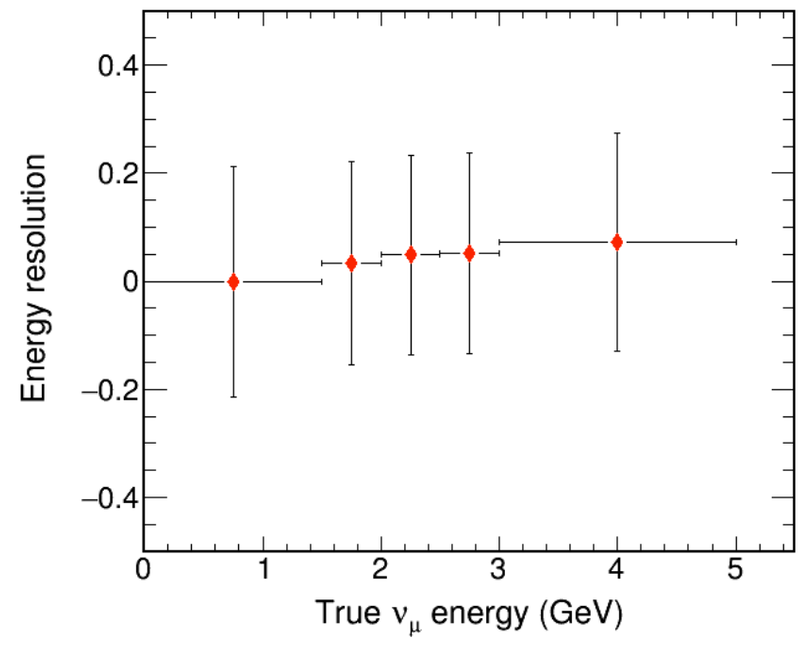
PMTrack



Pandora







True CC events with contained track

Before improvement of resolution of track momentum by range

After improvement of resolution of track momentum by range

No real improvement in bias of ν_μ energy resolution

ν_μ energy resolution

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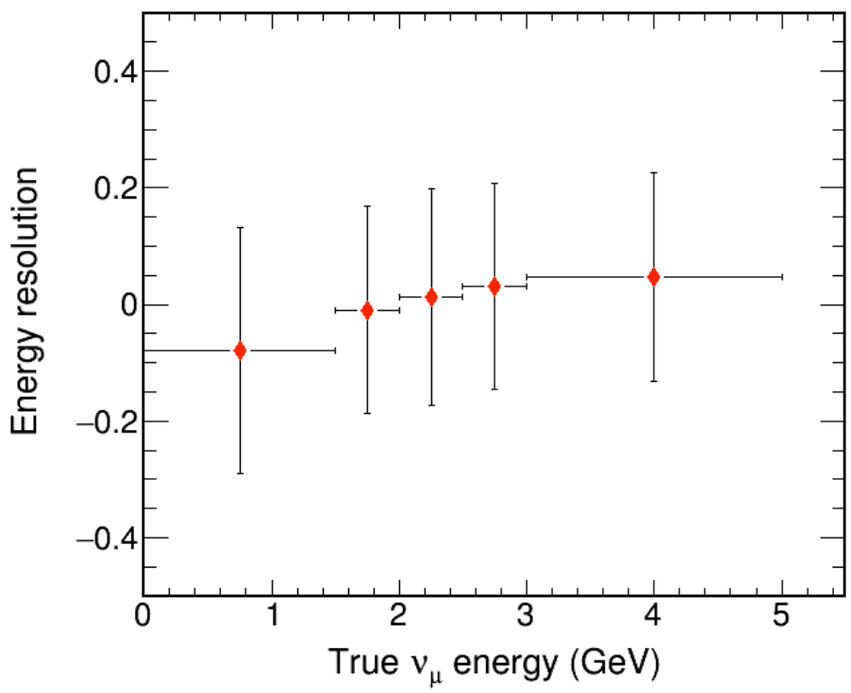
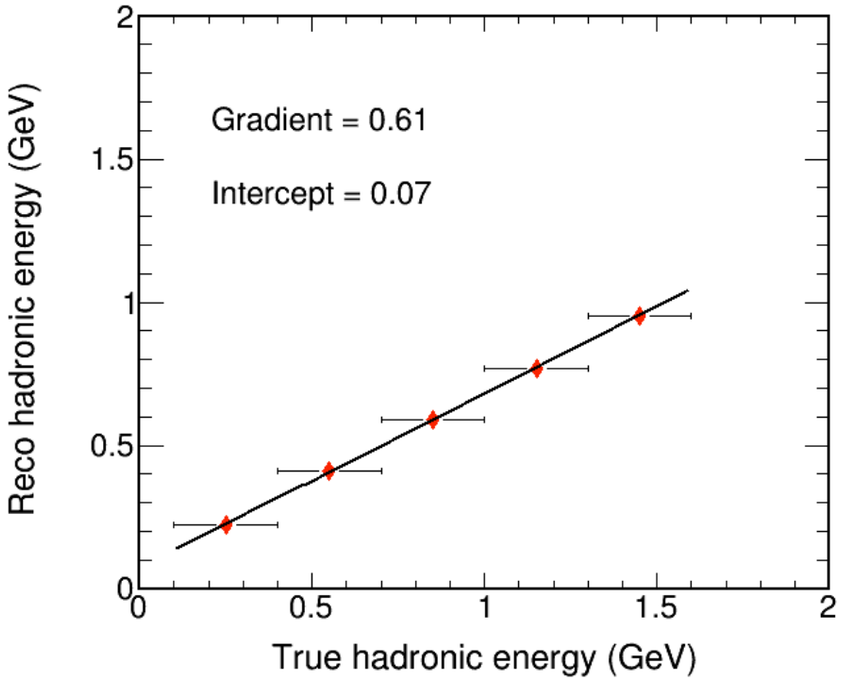
Now try ad hoc tweaks of gradient and intercept of correction of reco hadronic energy (bottom left plot). Use improved reco track momentum but without ad hoc tweaks.

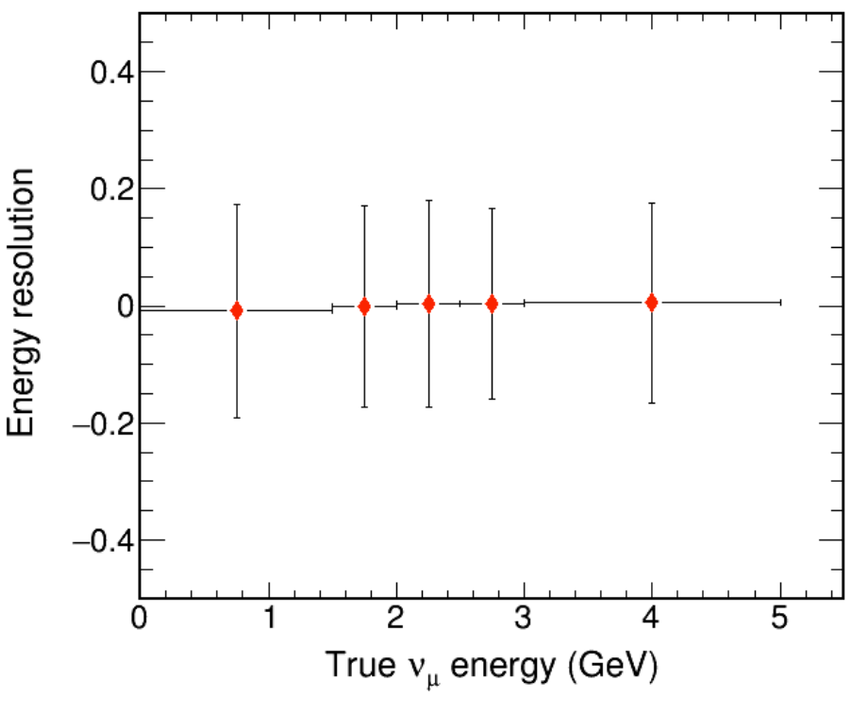
PMTrack



True CC events with contained track

Gradient = 0.61
Intercept = 0.07
(as in correction plot)



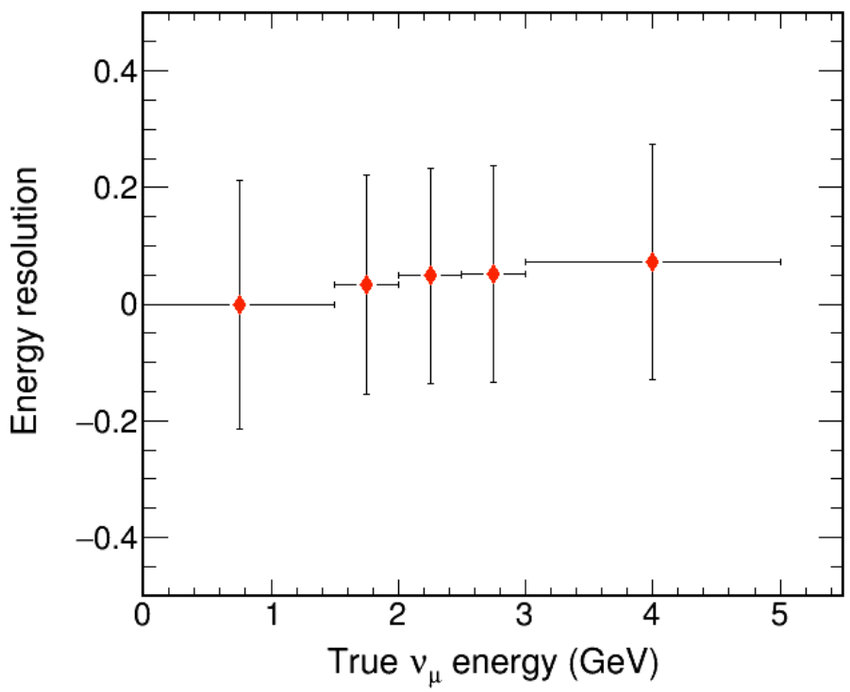


Make ad hoc tweaks to gradient = 0.68, intercept = 0.14.

This corrects bias. (Caveat: might need to retune for other datasets.)

ν_μ energy resolution

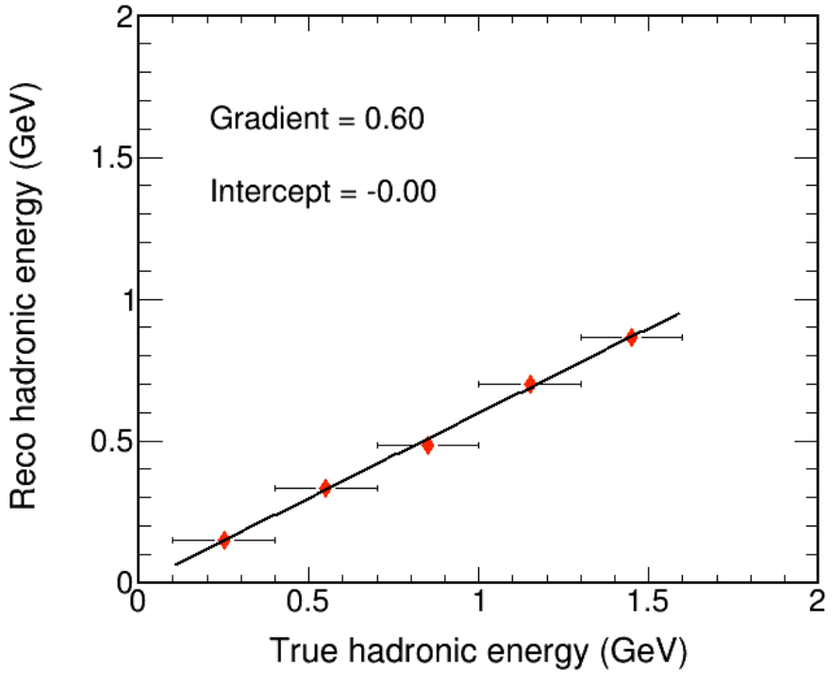
Pandora

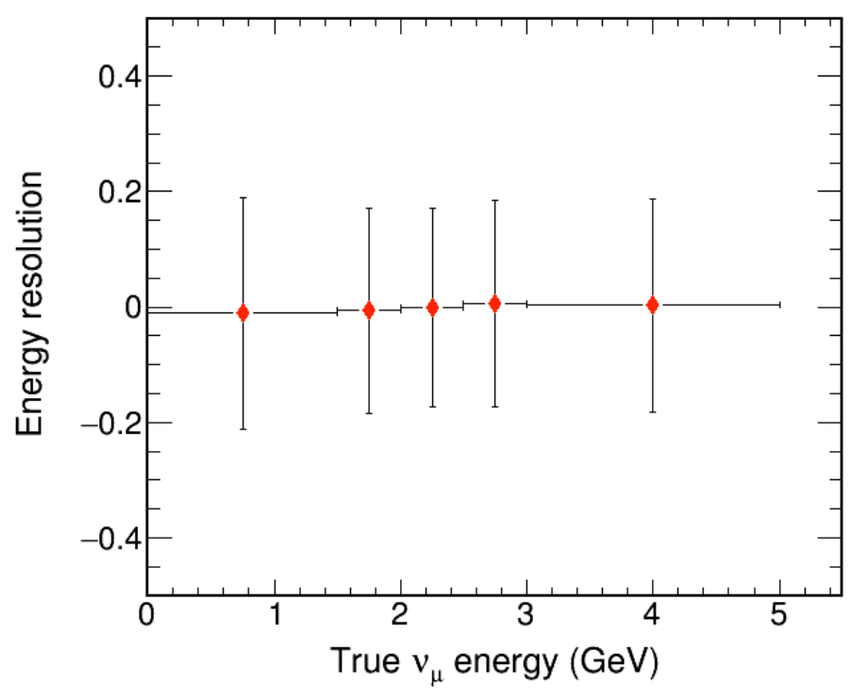


True CC events with contained track

Now try ad hoc tweaks of gradient and intercept of correction of reco hadronic energy (bottom left plot). Use improved reco track momentum but without ad hoc tweaks.

Gradient = 0.60
Intercept = 0.00
(as in correction plot)





Make ad hoc tweaks to gradient = 0.68, intercept = 0.025

This corrects bias. (Caveat: might need to retune for other datasets.)

ν_μ energy resolution

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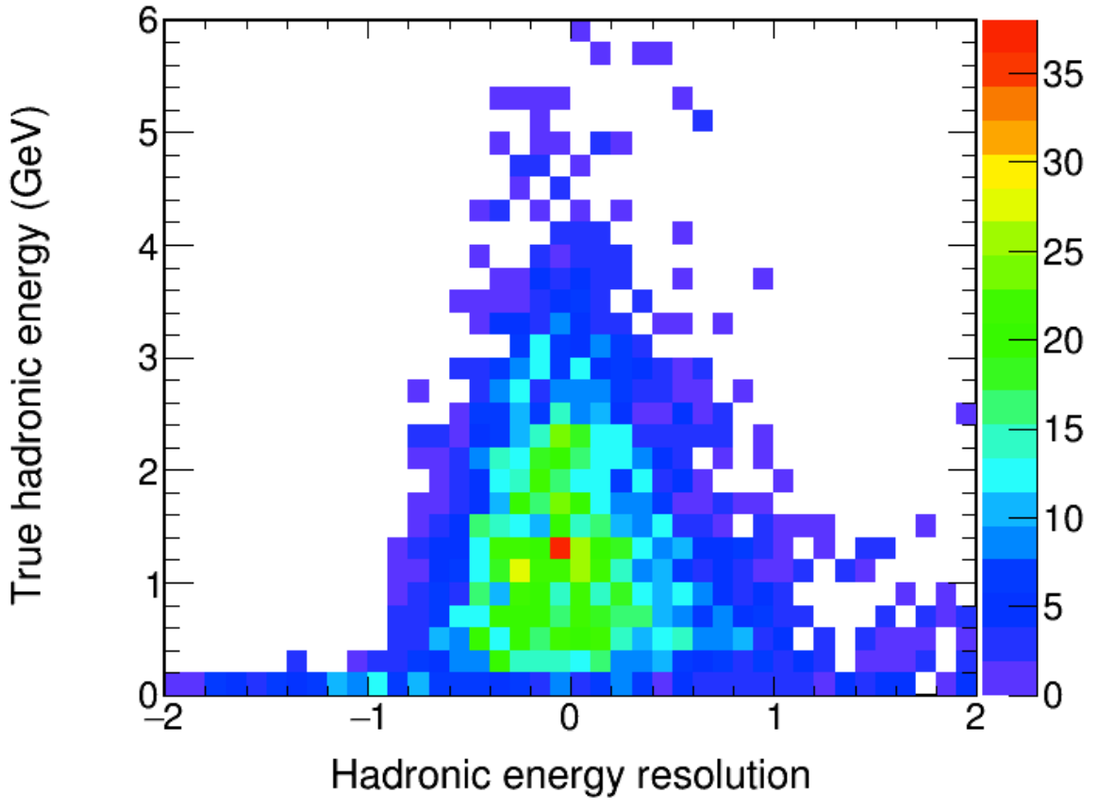
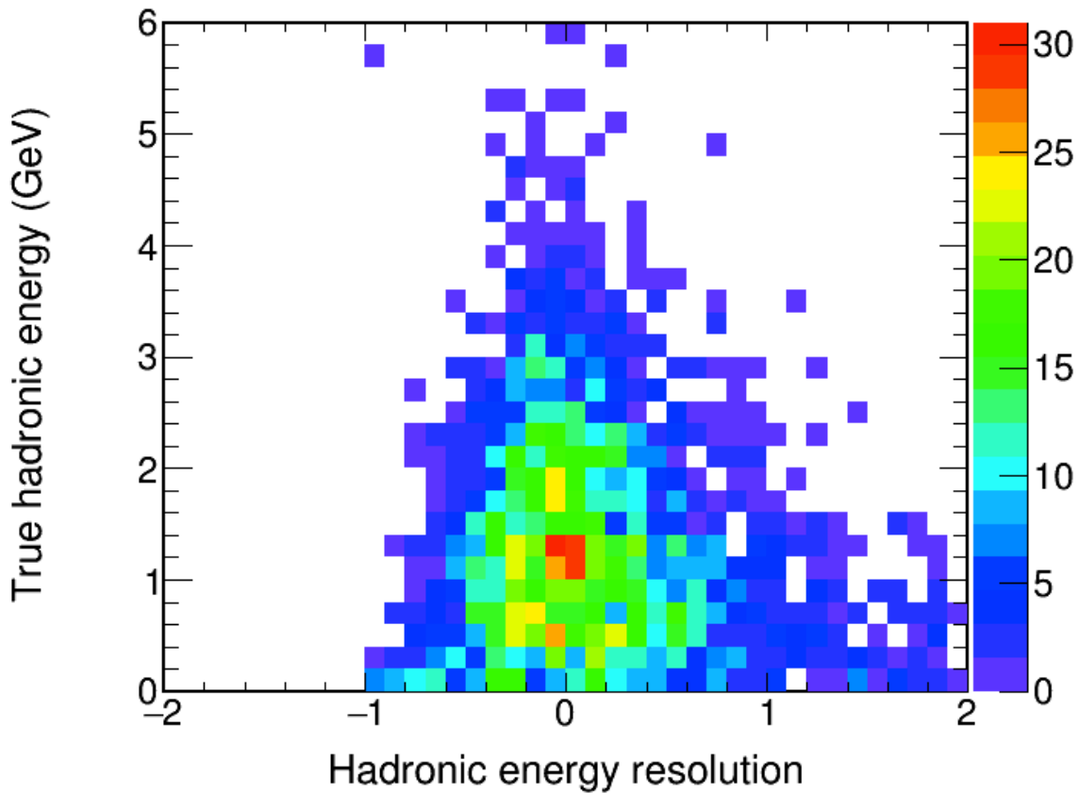
True CC events with contained track

With improvement of track momentum resolution, limiting factor in ν_μ energy resolution is the hadronic energy.
Resolution of this is worse at low true hadronic energy.

PMTrack



Pandora



BACKUP SLIDES