Energy and Angle Resolutions of Primary Leptons

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Intro

- In this presentation, I will check whether assumptions on energy and angular resolutions from arxiv:1307.7335 (page 147 Table 4.12) are correct for the primary leptons in ν_μ and ν_e CC atmospheric events.

- To extract information about events I have used Aaron's NDKAna package.

- And I have used the following preselection for the primary leptons:
  - $E_{\text{true}} > 50$ MeV
 - True lepton trajectory must start and end within detector.

Expected Resolutions

Particle	Resolution
Angular Resolutions	
Electron	$1°$
Muon	$1°$
Hadronic System	$10°$
Energy Resolutions	
Stopping Muon	3%
Exiting Muon	15%
Electron	$1\%/\sqrt{E(GeV)} \oplus 1\%$
Hadronic System	$30\%/\sqrt{E(GeV)}$

01. Muon Energy Resolution

- According to `arxiv:1307.7335` page 147 Table 4.12, muon energy resolution is supposed to be around 3% for muons that have stopped inside of the detector

- To get a reco energy of the muon I have used momentum from range tables.

- Among all reco tracks in the event I have choosen one, that is closest by energy to the true track.

- And I have ignored events w/o reco tracks, or events with reco energy of 0.

01. Muon Energy Resolution, Range Tables

(track_Prange - true) / true. Range: 90.0 %. Cut: None
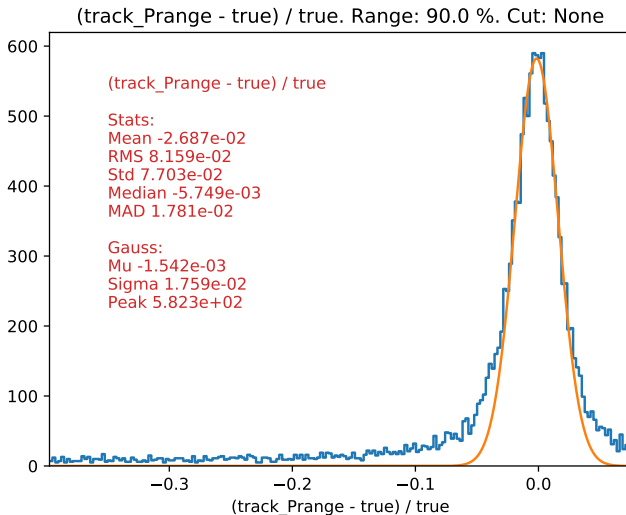
Using sigma of the gaussian fit as a metric, energy resolution is about 1.8% which is below 3.0%

02. Muon Angular Resolution

- According to `arxiv:1307.7335` page 147 Table 4.12, muon angular resolution is supposed to be around $1°$.

- As a true direction of the muon I have used true momentum.

- As a reco direction of the muon I have used track direction at the initial vertex.

- Among all reco tracks in the event I have choosen one, that is closest by direction to the true track.

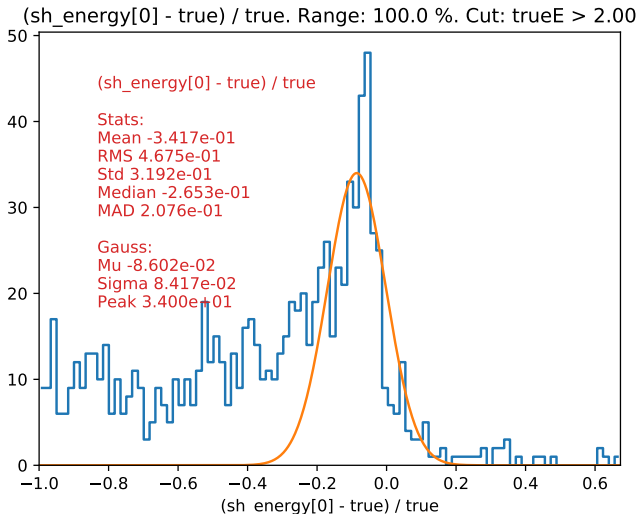true(start_momentum)_reco(vtxDir). Range: 80.0 %. Cut: None
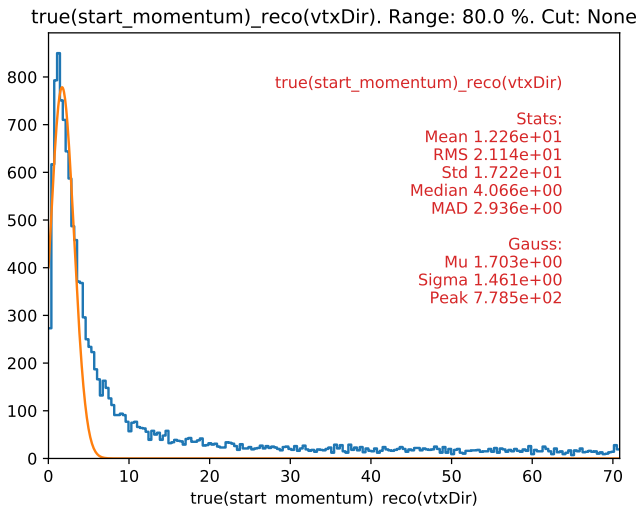
Distribution of difference between True and Reco tracks has peak around 2° and sigma of the peak of 2°

03. Electron Energy Resolution

- According to `arxiv:1307.7335` page 147 Table 4.12, electron energy resolution is supposed to be $1\%/\sqrt{E(GeV)} \oplus 1\%$.

- As a reco energy I have used calorimetric energy of the shower.

- Among all reco showers in the event I have choosen one, that is closest by energy to the true track.

- And I have ignored events w/o reco showers, or events with reco energy of 0.

03. Electron Energy Resolution, TrueE > 2 GeV

(sh_energy[0] - true) / true. Range: 100.0 %. Cut: trueE > 2.00

(sh_energy[0] - true) / true

Stats:
Mean -3.417e-01
RMS 4.675e-01
Std 3.192e-01
Median -2.653e-01
MAD 2.076e-01

Gauss:
Mu -8.602e-02
Sigma 8.417e-02
Peak 3.400e+01

For events with TrueE > 2 GeV, peak is around 9% and its sigma
is about 8% ≫ expected resolution of 1.2%

03. Electron Energy Resolution, $1 <$ TrueE < 2 GeV
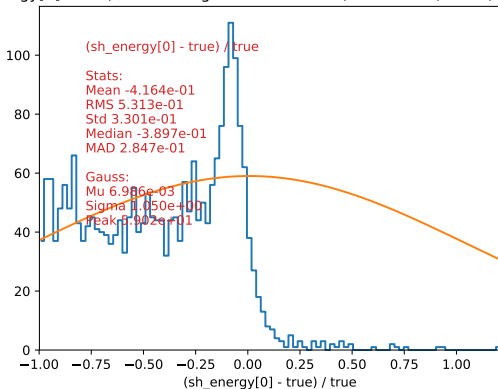

(sh_energy[0] - true) / true. Range: 100.0 %. Cut: (trueE > 1.00) and (trueE < 2.00)
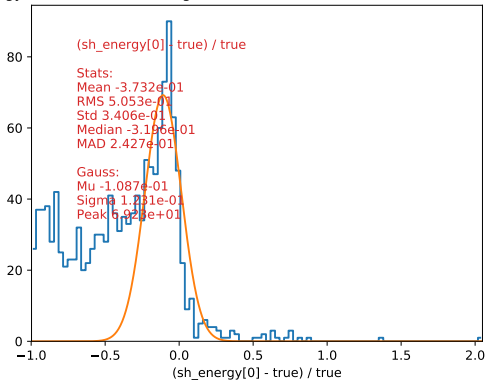
For events with $1 <$ TrueE < 2 GeV, peak is around 11% and its sigma is about 12% $\gg$ expected resolution of 1.4%

(sh_energy[0] - true) / true. Range: 100.0 %. Cut: (trueE > 0.5) and (trueE < 1.0)

For events with $0.5 <$ TrueE < 1.0 GeV, I have failed to produce gaussian fit, but the shape is quite similar to the previous case and actual energy resolution is above expected of 1.7%

04. Electron Angular Resolution

- According to `arxiv:1307.7335` page 147 Table 4.12, electron angular resolution is supposed to be $1°$.

- As a true direction of the electron I have used true momentum.

- As a reco direction of the electron I have used direction of the shower.

- Among all reco showers in the event I have choosen one, that is closest by direction to the true track.

04. Electron Angular Resolution, Angle True and Reco

true(start_momentum)_reco(sh_dir). Range: 80.0 %. Cut: None
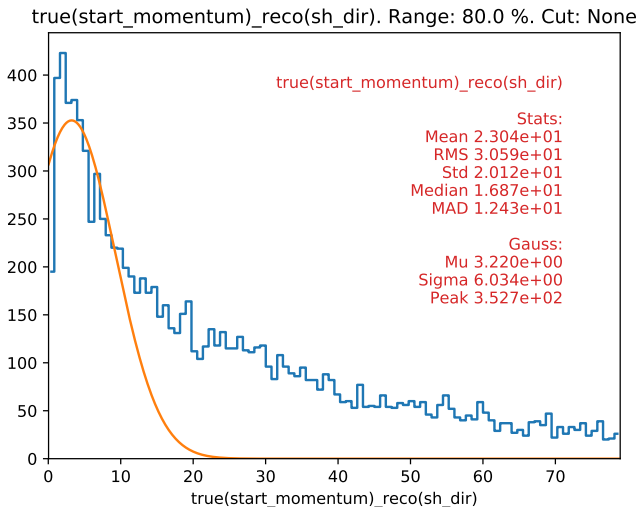
Distribution of difference between True and Reco tracks has peak
around $3°$ and sigma of the peak of $6°$ all $> 1°$

04. Electron Angular Resolution, Above 1 GeV

true(start_momentum)_reco(sh_dir). Range: 80.0 %. Cut: trueE > 1.00
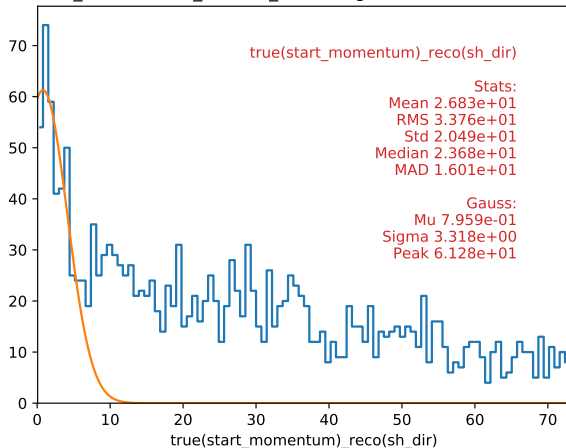
For events with TrueE > 1 GeV peak of the distribution is around $1°$ and sigma of the peak of $3°$

Summary

- Muon Energy Resolution of 1.8% is within expected of 3%.

- Muon Angular Resolution of $\sim 2^\circ$ is close to expected of 1°.

- Electron Energy Resolution is much greater than the expected one.

- Electron Angular Resolution of $\sim 6^\circ$ is above expected of 1°. But improves to $\sim 3^\circ$ for events with true energies above 1 GeV.

Backups

Setup

- **Data Files**:
  /pnfs/dune/persistent/dunepro/v06_55_00/detsim
        /prodgenie_atmnu_max_dune10kt_1x2x6/
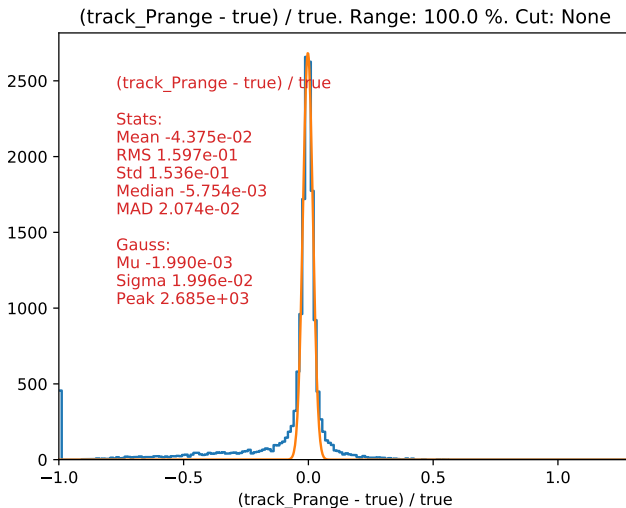
- **Reco**:
  `standard_reco_dune10kt_1x2x6.fcl`

- **LarSoft**:
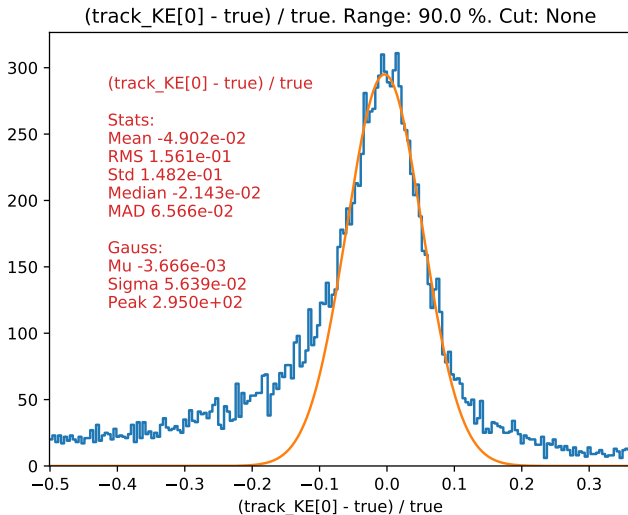 `v07_06_02 -q e17:prof`

01. Muon Energy Resolution, Range Tables, All Events

(track_Prange - true) / true. Range: 100.0 %. Cut: None

(track_Prange - true) / true

Stats:
Mean -4.375e-02
RMS 1.597e-01
Std 1.536e-01
Median -5.754e-03
MAD 2.074e-02

Gauss:
Mu -1.990e-03
Sigma 1.996e-02
Peak 2.685e+03
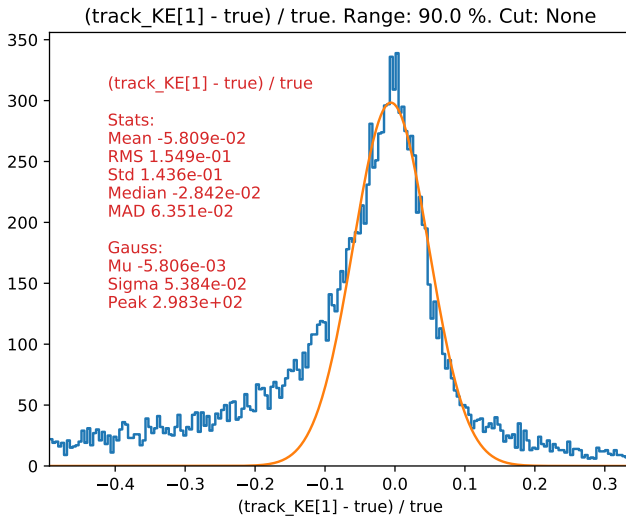
Using sigma of the gaussian fit as a metric, energy resolution is about 2.0%

01. Muon Energy Resolution, Calorimetric Energy, Plane 0

(track_KE[0] - true) / true. Range: 90.0 %. Cut: None

(track_KE[0] - true) / true

Stats:
Mean -4.902e-02
RMS 1.561e-01
Std 1.482e-01
Median -2.143e-02
MAD 6.566e-02

Gauss:
Mu -3.666e-03
Sigma 5.639e-02
Peak 2.950e+02

Using sigma of the gaussian fit as a metric, energy resolution is about 5.7%
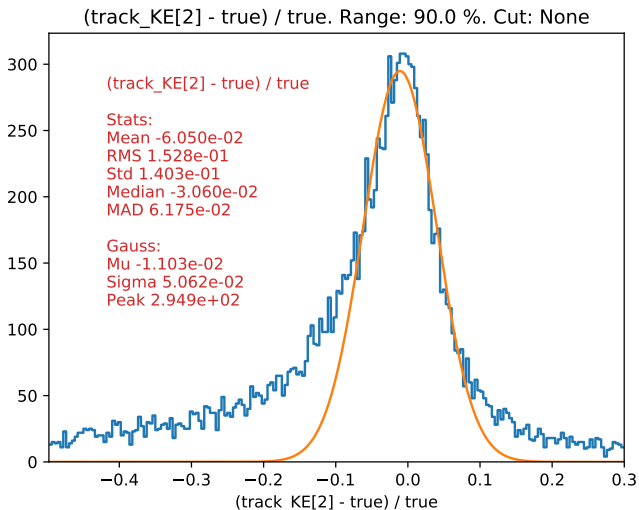
(track_KE[1] - true) / true. Range: 90.0 %. Cut: None

Using sigma of the gaussian fit as a metric, energy resolution is about 5.4%

01. Muon Energy Resolution, Calorimetric Energy, Plane 2

(track_KE[2] - true) / true. Range: 90.0 %. Cut: None

(track_KE[2] - true) / true

Stats:
Mean -6.050e-02
RMS 1.528e-01
Std 1.403e-01
Median -3.060e-02
MAD 6.175e-02

Gauss:
Mu -1.103e-02
Sigma 5.062e-02
Peak 2.949e+02

Using sigma of the gaussian fit as a metric, energy resolution is about 5.1%

true(diff_start_end_coords)_reco(diff_start_end_coords). Range: 60.0 %. Cut: None
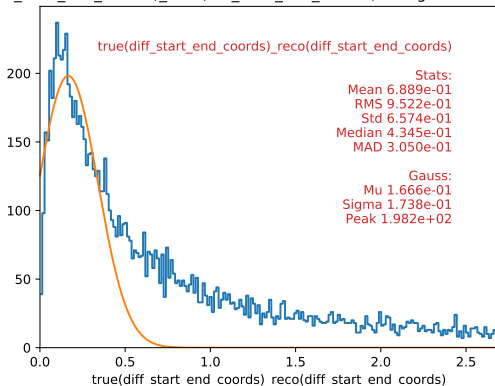
Distribution of difference between True and Reco tracks has peak around 0.2° and sigma of the peak of 0.2°