Neutrino energy reconstruction in the DUNE far detector

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Introduction

In last talk, showed that tweaking the binning of the correction plots and the gradients and intercepts could reduce the bias in reco neutrino energy as a function of true energy.

Tingjun ran over some MCC7 numu files using the tune of gradients/intercepts from that talk. He found that the energy resolution was reasonably good but there was some negative bias. We agreed that there should be a new tune for MCC7.

One reason that a new tune is needed for each dataset is the correction of hadronic energy. Only ~60% of true hadronic energy is reconstructed, which means that this is a large correction, especially at low true energy.

Updates

Added a module (NuEnergyReco_module.cc) to FDSensOpt. This writes quantities relevant for neutrino energy reconstruction to a TTree.

Also added macros to FDSensOpt:

CorrRecoEnNumu.C: use TTree to plot reco against true muon momentum in bins of true momentum, and reco against true hadronic energy in true energy bins. Fit a straight line to each of these graphs and find gradients and intercepts.

PlotEnergyResNumu.C: use TTree and gradients and intercepts to make resolution plots.

There are equivalent macros for nue events called CorrRecoEnNue.C and PlotEnergyResNue.C.

Tingjun ran the module over MCC7, and the macros were used to obtain results for nue events.

Method

For ν_e CC events, use reco shower with highest total hit charge. Apply lifetime correction and an average recombination correction of 1/0.63 to this charge. Convert to reco energy using

Energy (GeV) = Corrected ADC * 23.6×10^{-9} / 4.966×10^{-3}

Estimate hadronic energy from (total hit charge - shower hit charge) using same corrections and conversion.

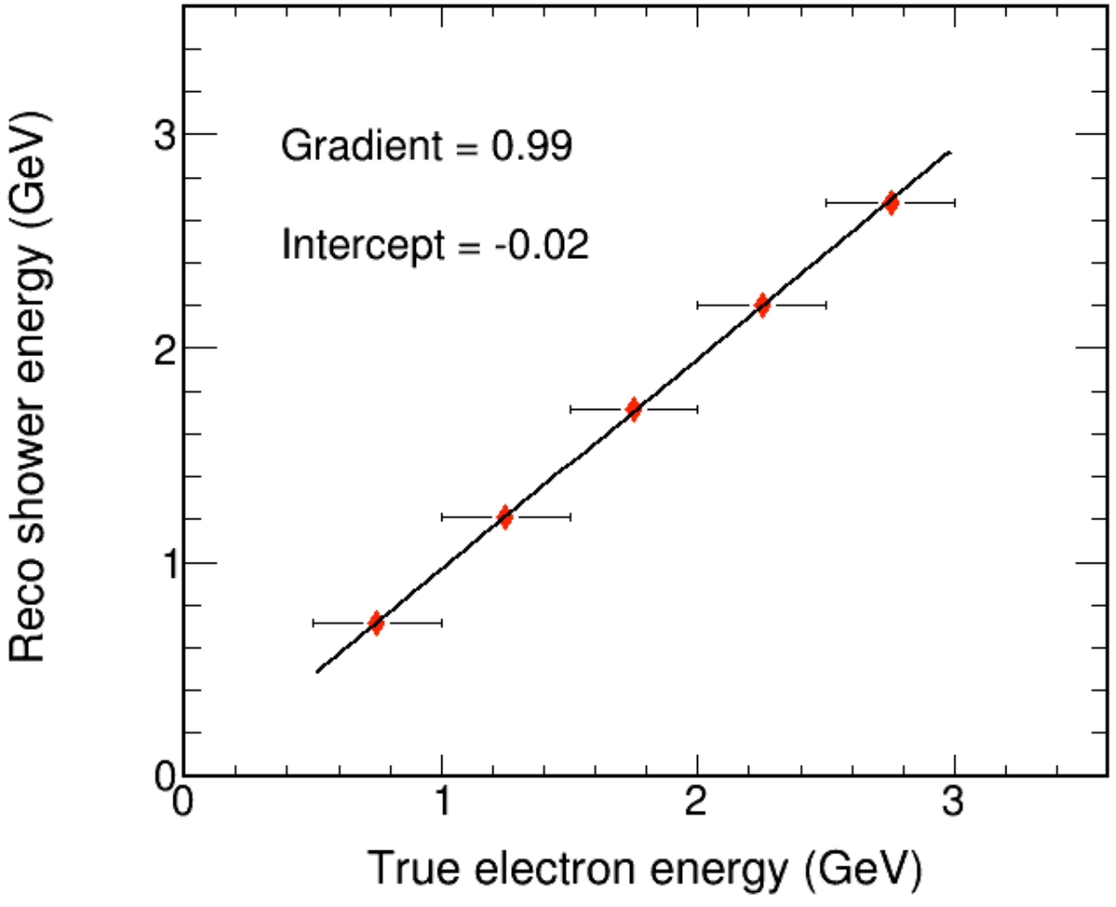
Reco ν_e energy = reco shower energy + reco hadronic energy.

Define a fiducial volume as |x|<=310, |y|<=550, 50<=z<=1250 cm, and include only events with true vertices within this fiducial volume.

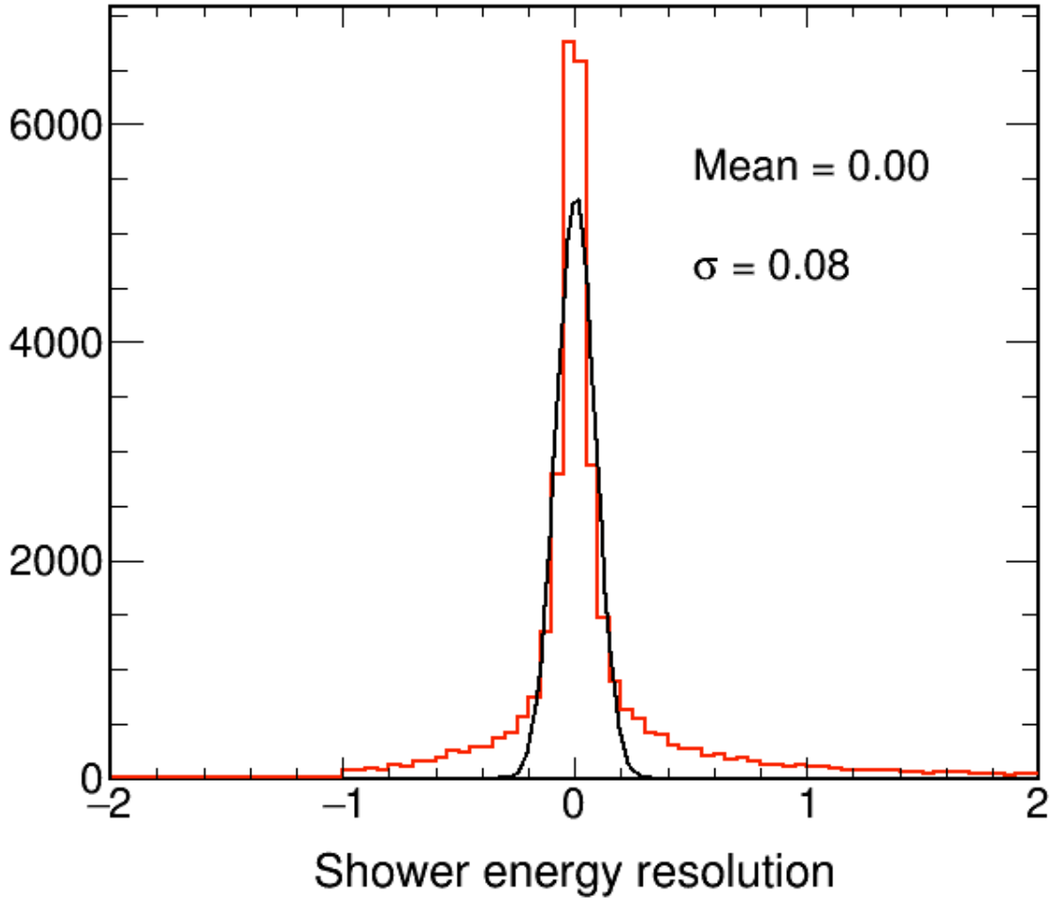
Shower energy

For each bin of true electron energy, plot 1D histogram of reco shower energy and fit Gaussian to it. On correction plot, x values of points are centres of bins, y values are means of Gaussian fits.

Shower energy correction

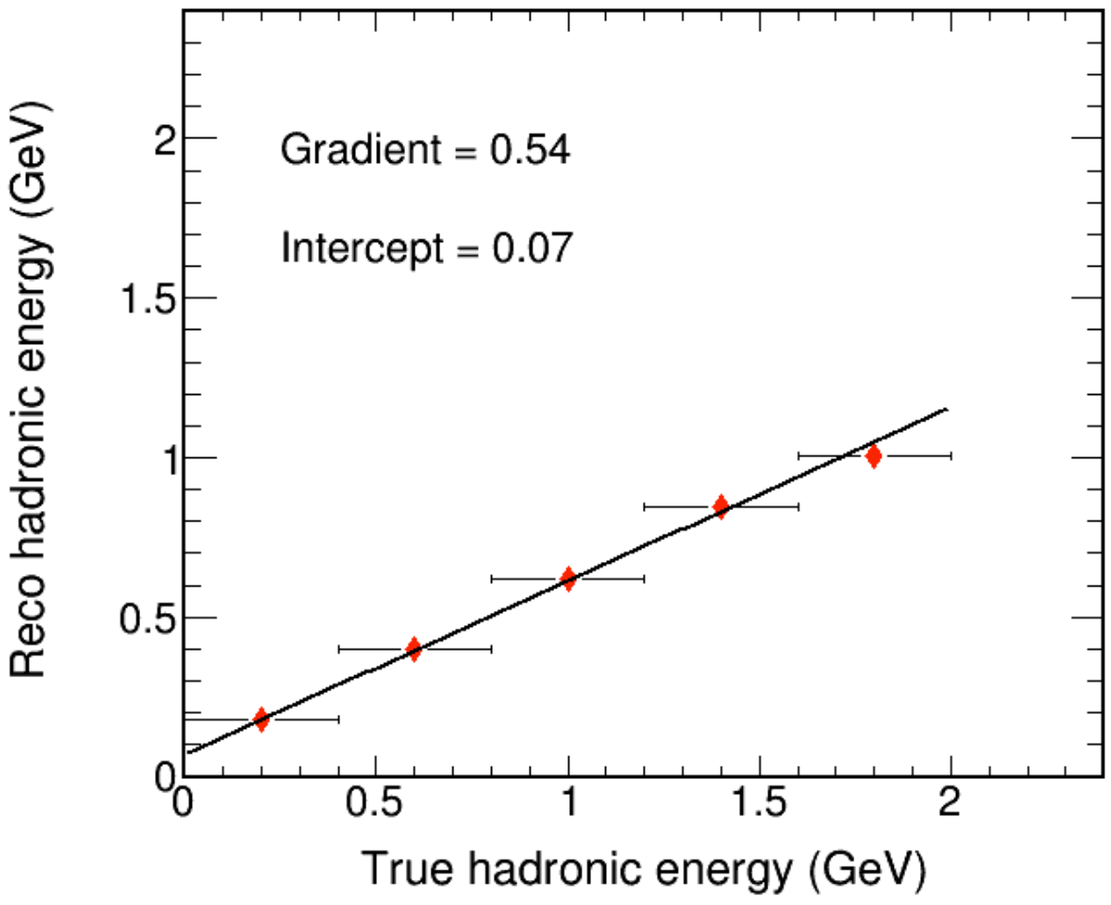


Shower energy resolution

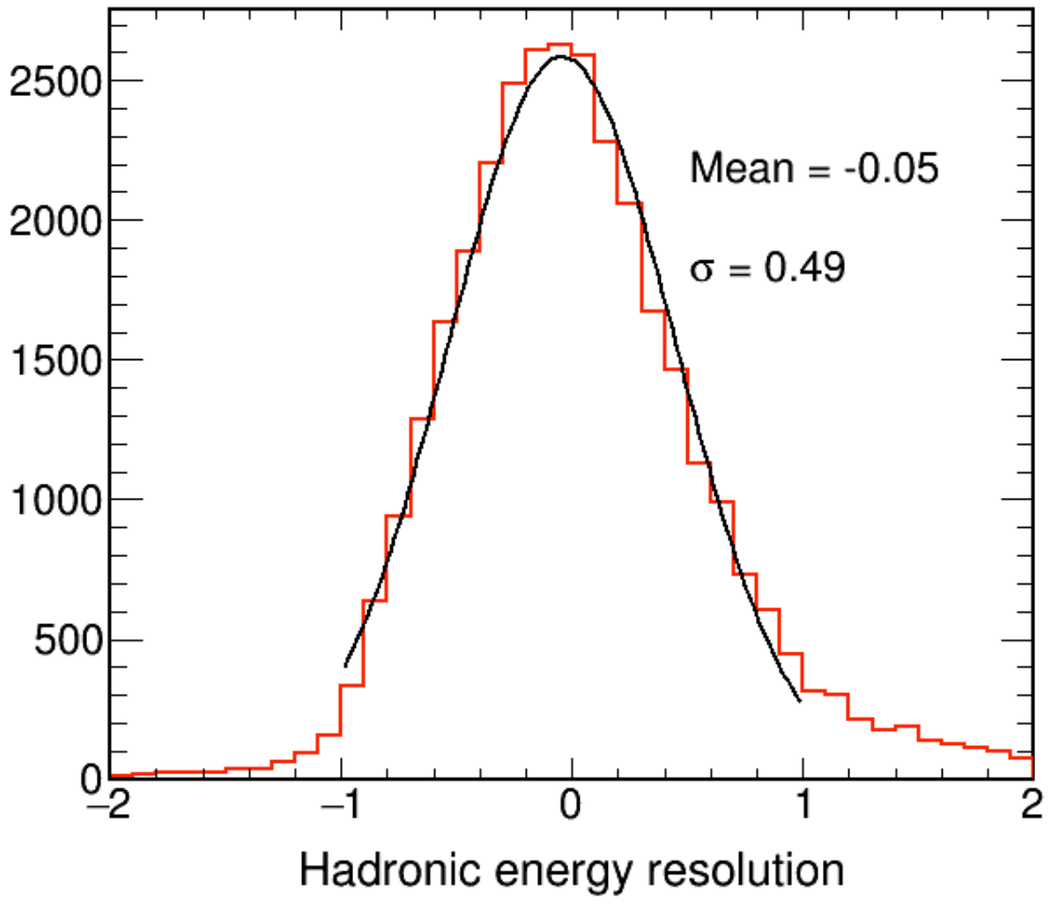


Hadronic energy

Hadronic energy correction

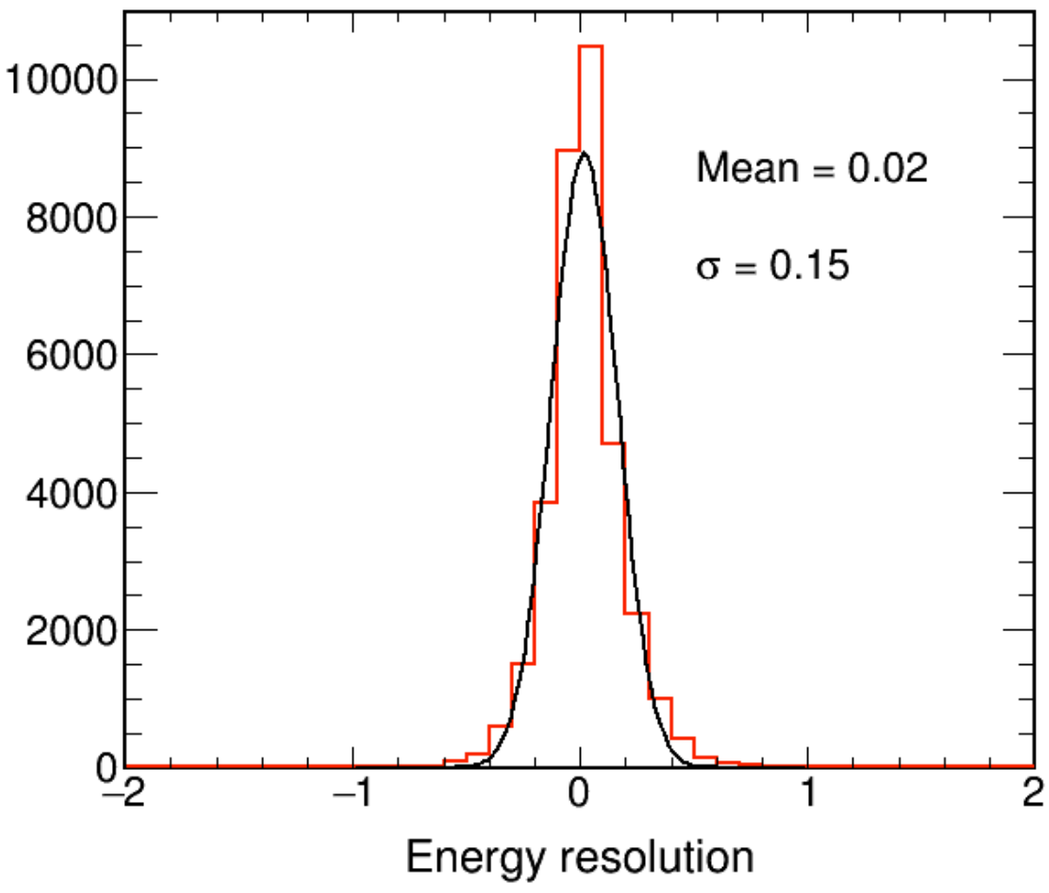


Hadronic energy resolution

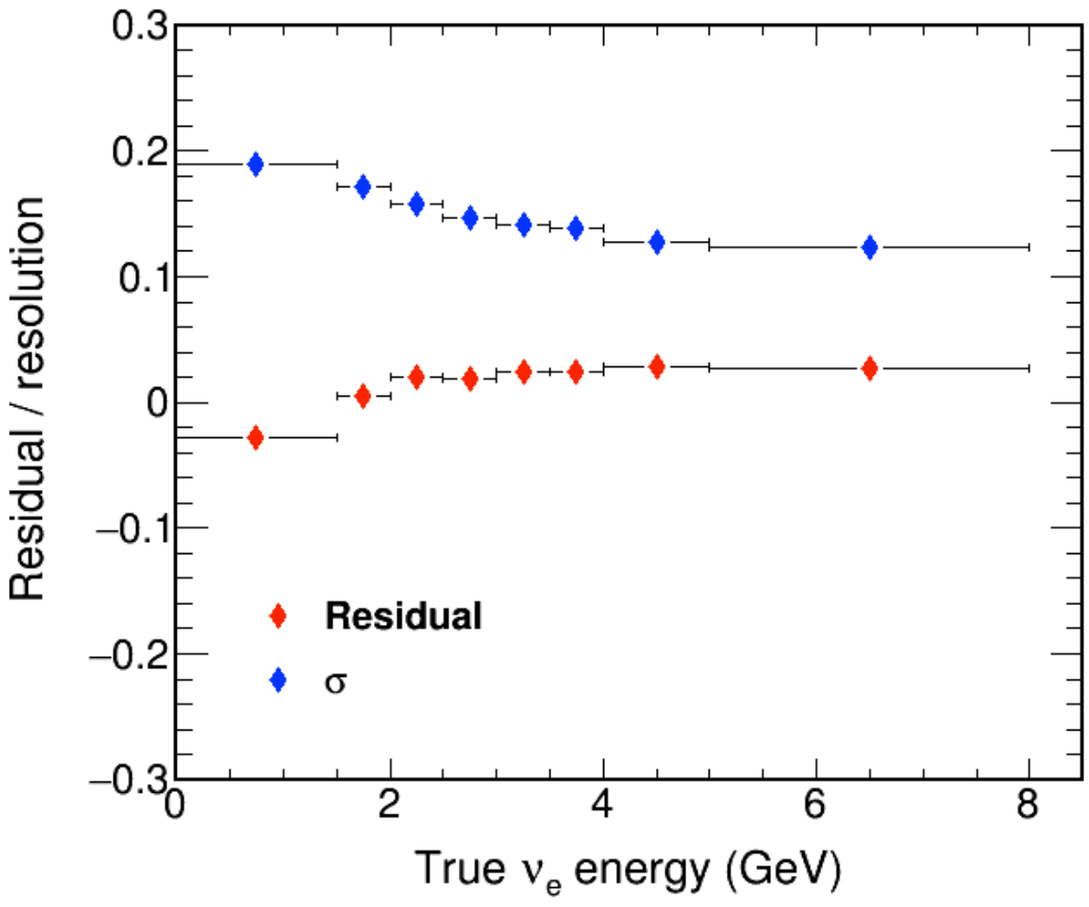


ν_e energy resolution

Overall ν_e energy resolution



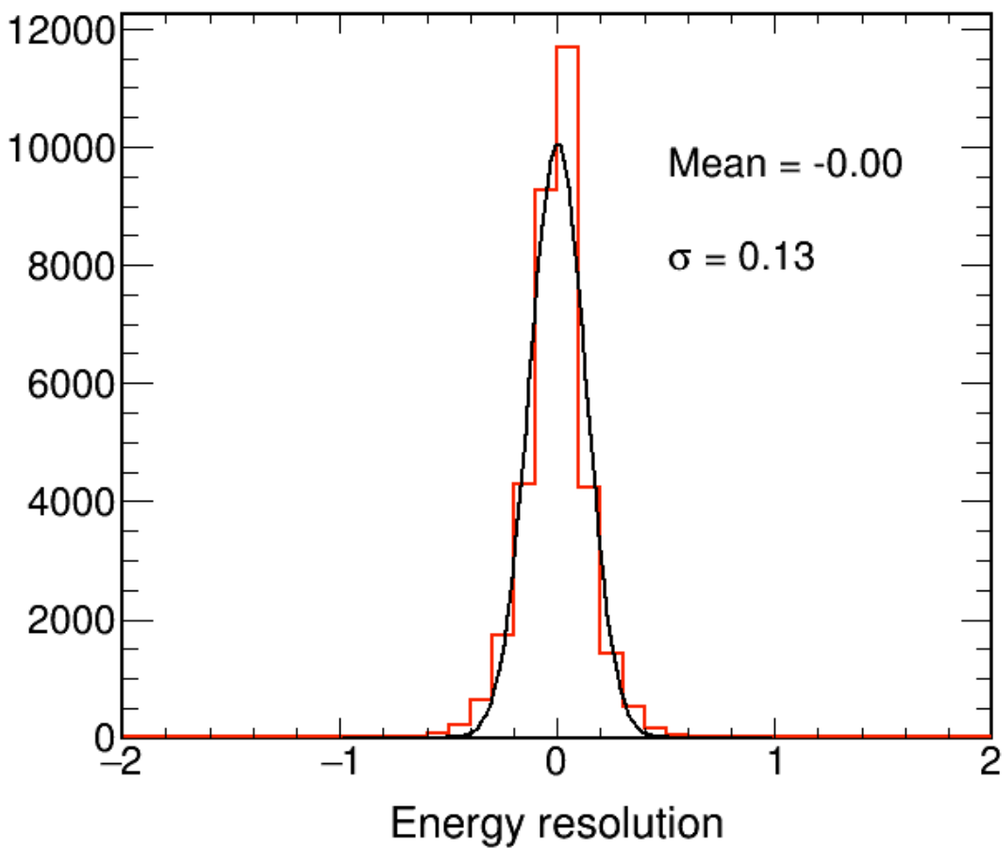
ν_e energy resolution as function of true energy



ν_e energy resolution

Make ad hoc tweaks of correction of hadronic energy.
Change gradient from 0.54 to 0.62 and intercept from 0.07 to 0.02.

Overall ν_e energy resolution



ν_e energy resolution as function of true energy