Studying the use of e^- data and resonant interactions for DUNE energy reconstruction

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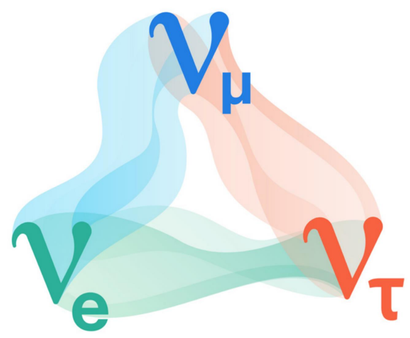
Introduction

DUNE requires reconstruction of neutrino energies to measure oscillation parameters. We study the calorimetric method on QE events and use electron data to constrain the reconstruction. In order to study resonant events later, we compare electron and neutrino scattering in that regime.



Highlights

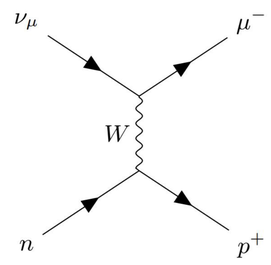
- The use of electron data to constrain neutrino energy reconstruction looks promising.
- Electron and neutrino scattering are similar in the resonant channel.

Energy reconstruction for QE events

In this study, we look at QE DUNE events. Performed 0pi and QE cuts on simulated data: no pions produced, Q2 > 0.5 GeV, proton momentum > 0.3 GeV, W < 2.0 GeV.

Calorimetric reconstruction (conserving energy):

$$E_{\nu\,rec} = E_\ell + K_p + E_b$$

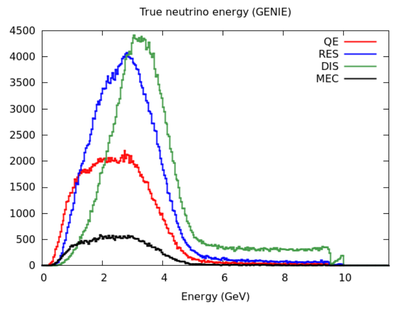


We apply 0pi and kinematic cuts, so the events used resemble this.

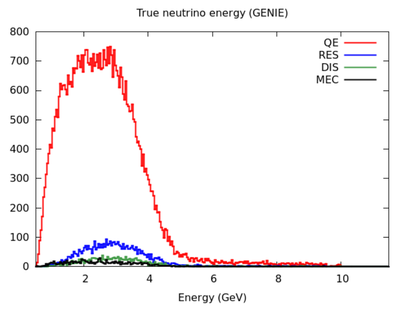
Methods

Neutrino and electron events in all interaction channels were generated with GENIE MC v3.0.4 at 2.2 GeV and 0-10 GeV, with carbon-12 and argon-40 targets.

Using DUNE neutrino flux to simulate events

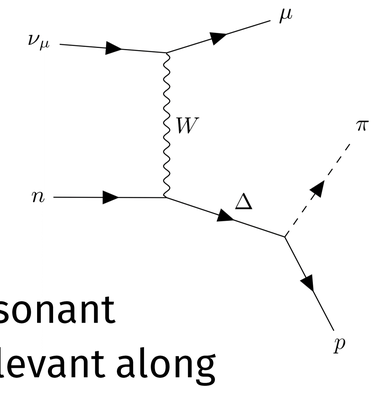


Neutrino events were generated at energies between 0 and 10 GeV using an argon-40 target.



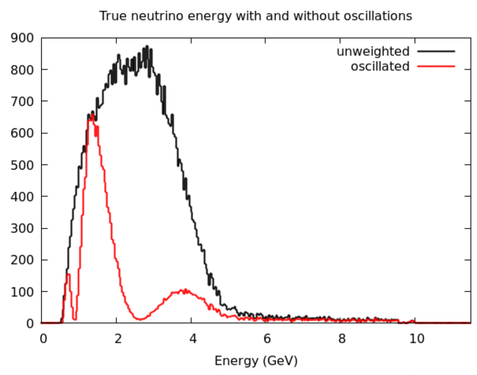
Applying cuts and the CCQE selection from electron scattering gives us a pure QE sample.

Resonant interactions

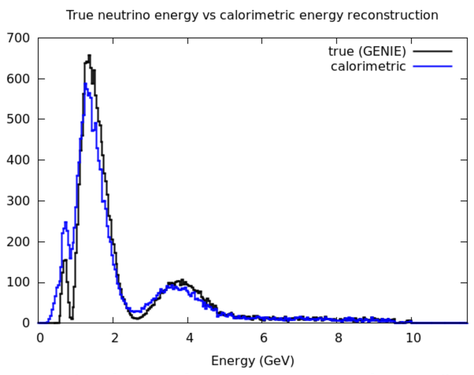


Electron and neutrino scattering are similar in the resonant channel, which is relevant along with the QE and DIS channels for DUNE's operating energy range.

Adding oscillations and reconstructing energies



NuFIT 4.0 values were used to add oscillation weights.



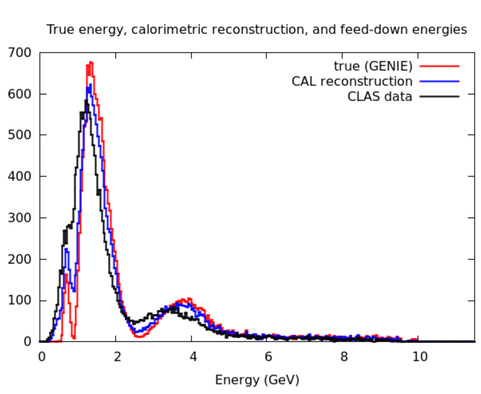
Calorimetric reconstruction of oscillated neutrino energy.

NuFIT 4.0 parameters (normal ordering, no SK atmospheric data) for DUNE far detector.

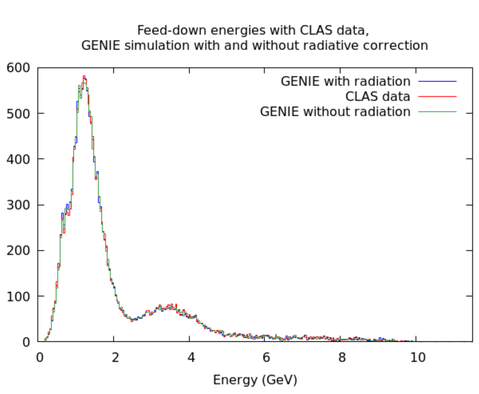
$\sin^2\vartheta_{12}$	0.310
$\sin^2\vartheta_{23}$	0.580
$\sin^2\vartheta_{13}$	0.02241
Δm^2_{21}	7.39 x 10^{-5} eV^2
Δm^2_{atm}	2.525 x 10^{-3} eV^2
δ_{CP}	0
beam dip angle	5.8°

Comparing reconstructions: Ecal and electron data

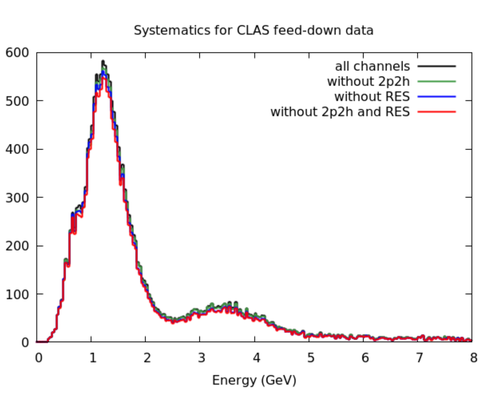
There is an effect on the reconstruction when we constrain the reconstruction using CLAS electron data or electron simulations, as compared to the Ecal method.



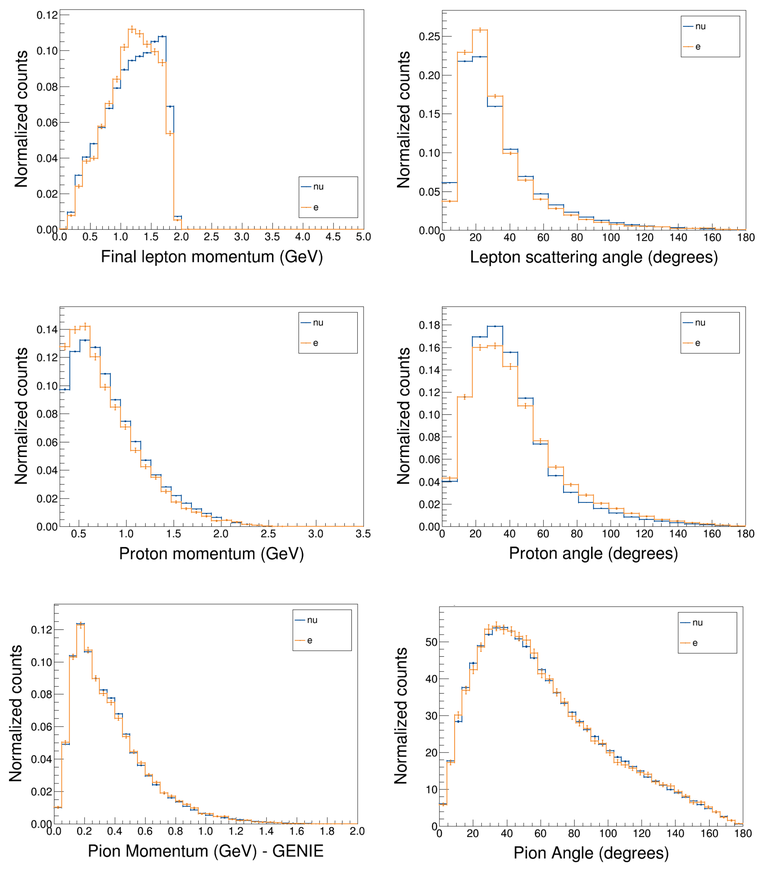
Feed-down result, Ecal, and true energy for carbon-12.



CLAS data compared to simulations with and without corrections.



Systematics for feed-down result with CLAS data.



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