

Resolution of Pandora's Neutrino Selection

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What's Being Done

- Pandora has a scoring method to determine which vertex is most likely to be the neutrino vertex for a given event. I am determining the neutrino vertex resolution by comparing the location of this reconstructed vertex with that of the true neutrino interaction vertex.
- The reconstructed neutrino vertex is stored in variables: `nuvtxx`, `nuvtxy`, `nuvtxz`,
- This is a continuation of work I've done on atmospheric neutrino vertex resolution, my last talk is available: <https://indico.fnal.gov/event/15272/contribution/2>
- Cuts are made to only include only reconstructions of charged current muon events in the fiducial volume with at least one vertex placed, and in the case of the longest track method, only events with >0 tracks

*Some events label 2 vertices as both being neutrinos, not sure why at this time.

Files Used:

```
-- standard_ana_dune10kt_1x2x6.fcl (Edited flag to save Neutrino label, should be standard in next release)
-- /pnfs/dune/tape_backed/dunepro/mc/dune/full-
reconstructed/01/55/07/70/prodgenie_atmnu_max_dune10kt_1x2x6__20161213T031412_merged0.root
```

Pandora's Neutrino Vertex Scoring

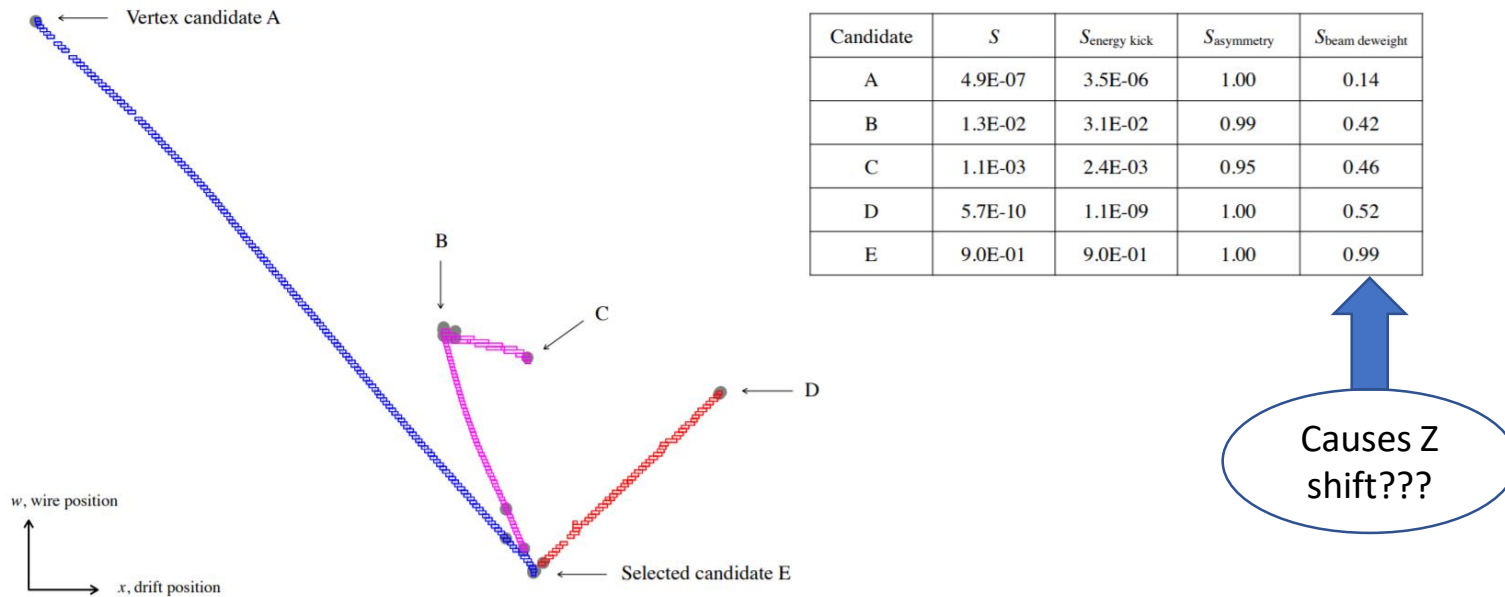
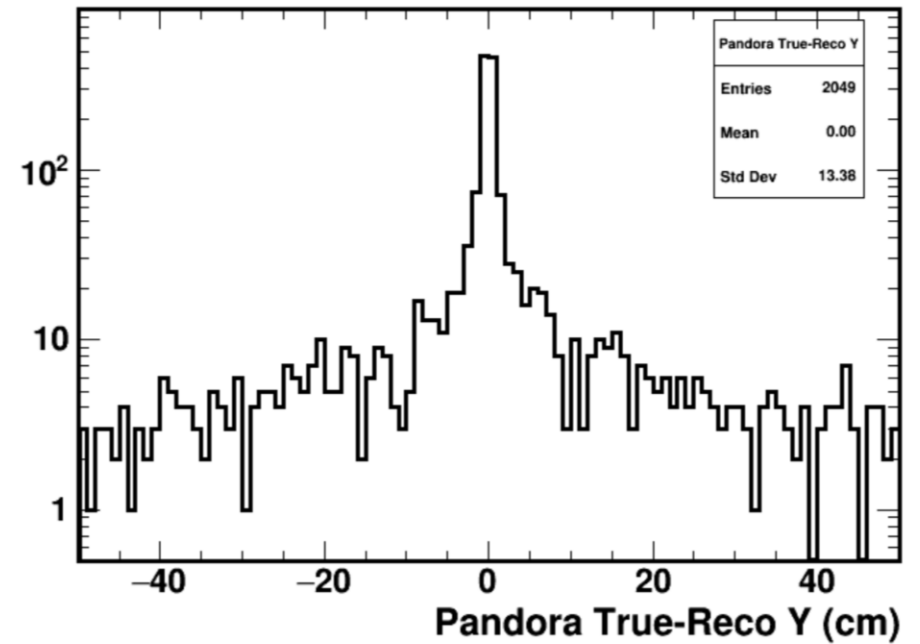
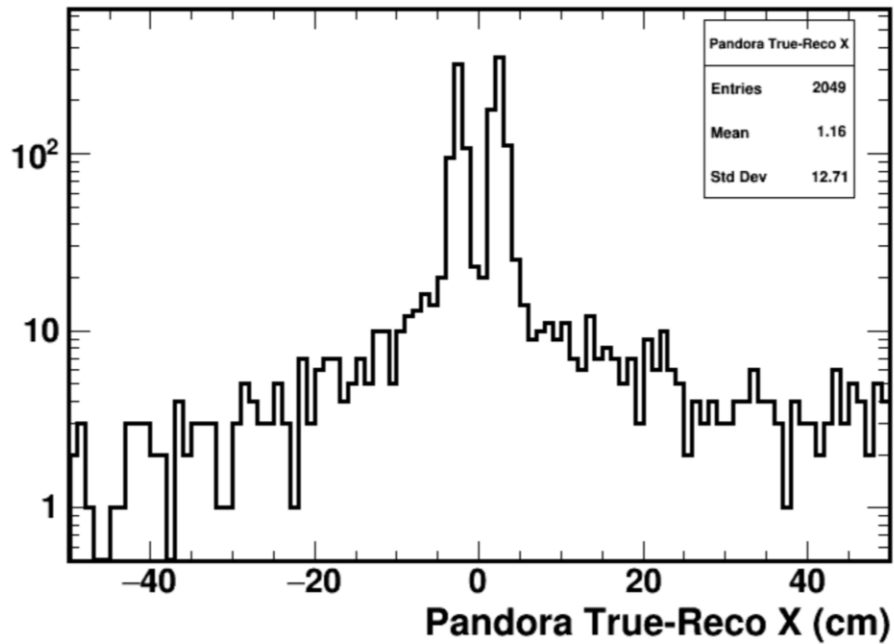


Fig. 5: The positions of 3D neutrino interaction vertex candidates, as projected into the w view. A comprehensive list of candidates is produced for each event, identifying all the key features in the event topology. To select the neutrino interaction vertex, each candidate is assigned a score. The scores are indicated for a number of candidates and a breakdown of each score into its component parts is provided.

From Taritree's Pandora Microboone Paper
[arXiv:1708.03135](https://arxiv.org/abs/1708.03135)

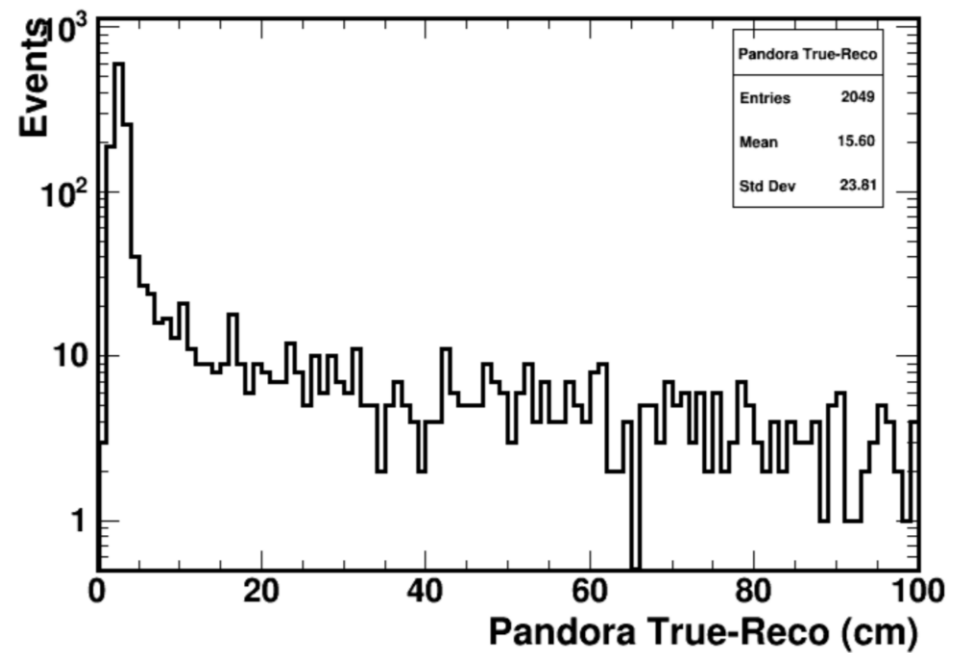
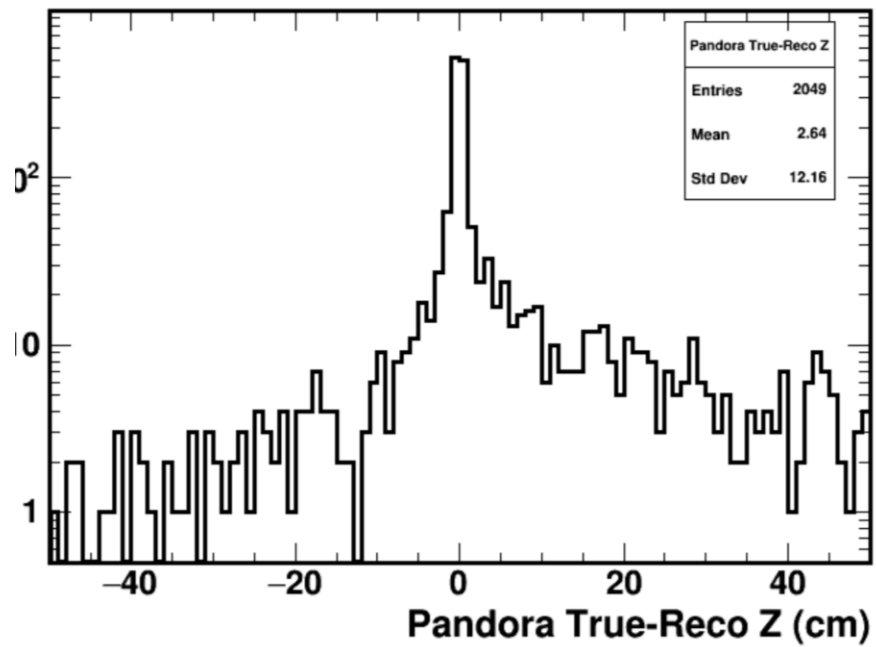
NuVertex Resolution



11/15/2017

4

More Plots



A Quick Review of Methods

I have used three different methods have been used to select a vertex method thus far:

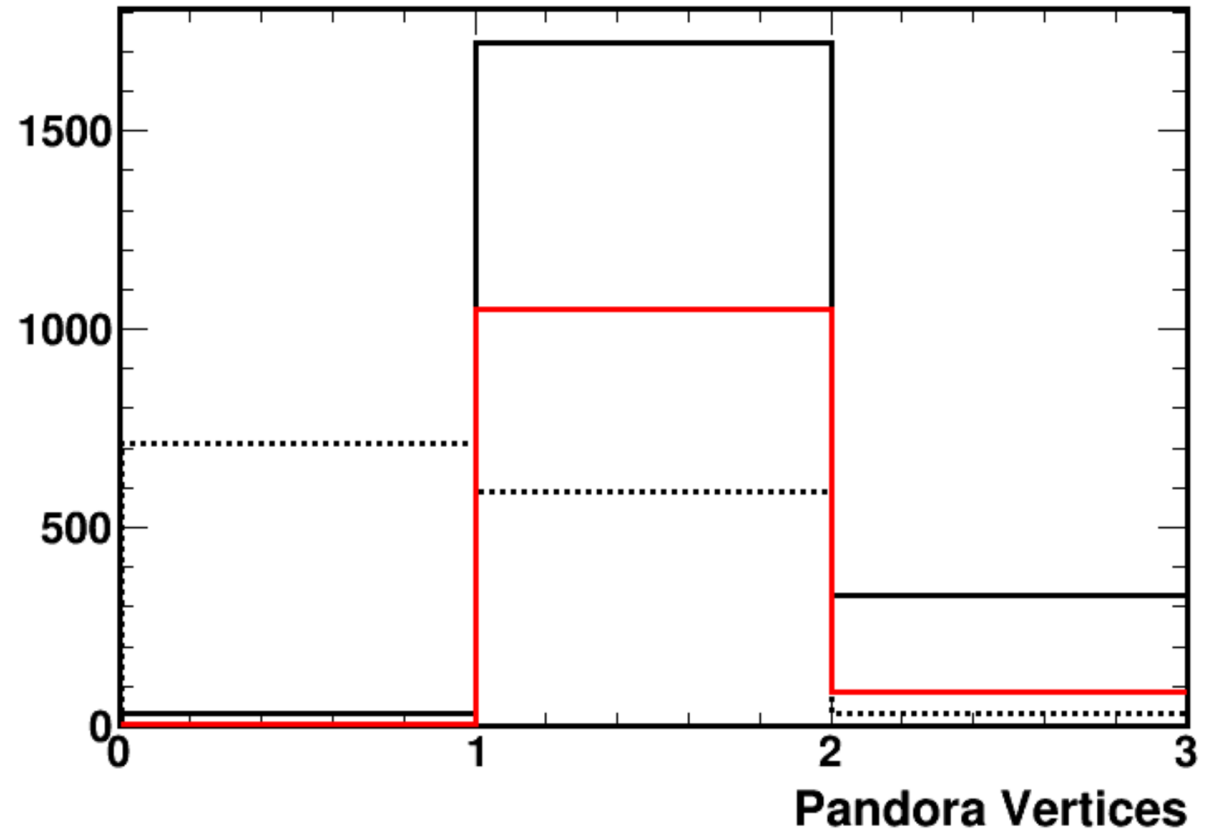
1. The “Cheat Method” which runs through every vertex pandora notices in an event, and then selects the one closest geometrically to the true neutrino vertex position to be labeled as the neutrino. (This is cheating because with actual data there is no truth information)
2. The Longest Track Method which runs through every vertex pandora notices in an event, and then selects the one that is closest to either end of the longest track pandora has reconstructed in the event.
3. The Neutrino Scoring Method which relies on Pandora’s internal vertex scoring framework described earlier. This is not optimized for Atmospheric Neutrinos, and it is unclear how much improvement removing the beam weighting would have.

A Summary of Results

	Reconstruction Method	nEvents After Cuts	nEvents within 5 cm (3D)	Avg nVertices Reconstructed
Cheat Method	Pandora	2049	1296 (63%)	3.91
Longest Track	Pandora	1910	982 (51%)	3.91
Neutrino Scoring	Pandora	2049	1081 (53%)	3.91

Number of Vertices

In both plots:
Black = numuCC
Dashed = Neutral Current
Red = nueCC



11/15/2017

8

Conclusions

- Using the Neutrino labeled vertex instead of the cheat method cuts the number of events resolved within 5cm by 14%
- Need to find out why sometimes 2 vertices are labeled neutrinos.
- Twin Peaks present in my data, but this was caused by a timing bug that should be fixed in the latest release, and Monte Carlo Generation (still needs to be verified)
- Vertex Z-coordinate still weighted toward the positive end, due to Pandora Scoring method

Future Plans:

1. Develop a pandora reconstruction method optimized for atmospheric neutrinos (Would require collaboration with core pandora developers)

Or

2. Try a deep learning approach to vertex finding (similar to work done by Aaron Higuera found here: <https://indico.fnal.gov/event/15363/contribution/1/material/slides/0.pdf>)