

Atmospheric Neutrino Flux Driver Repairs and Plans for Neutrino Flavor Classification Studies

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Event Generation Problems

1. When looking at reconstructed events we noticed a strange true energy spectrum. These events had been created using BARTOL Flux. (**Fixed**)
2. When looking at events created using Honda flux, we found a strange costheta distribution (of the incoming particles). (**In Progress**)

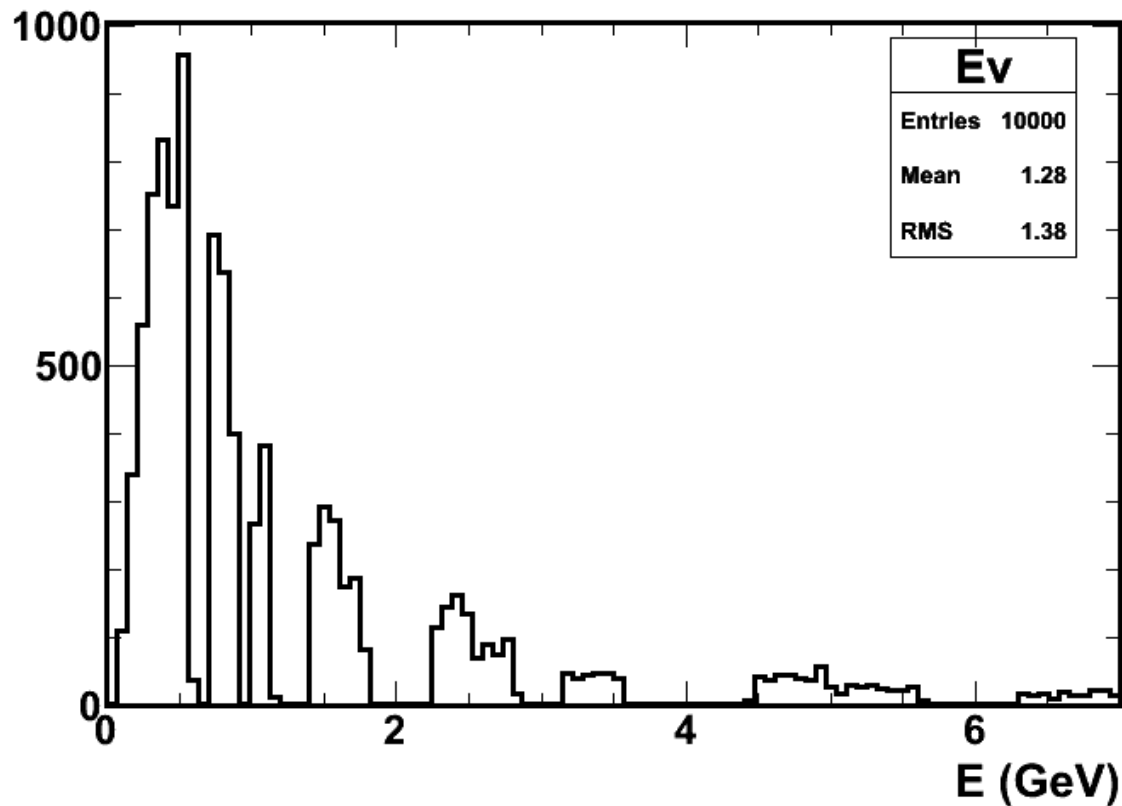
These were initially discussed in my previous talk:

<https://indico.fnal.gov/event/15272/contribution/3/material/slides/0.pdf>

BARTOL Energy Distribution Problem

Neutrino Energy

(fmax10_0401z.sou_num)



Events were generated using
gevgen_atmo in GENIE

The energy spectrum has
gaps where no events were
generated

Changes made to LarSoft

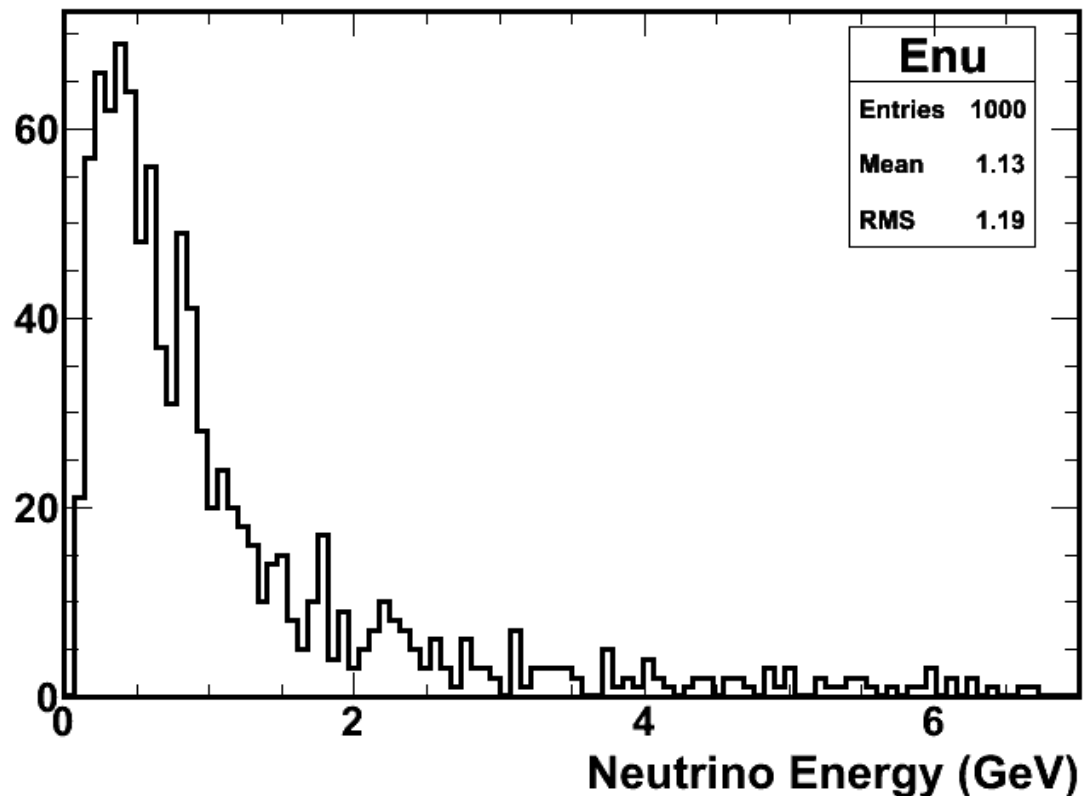
In version v06_54_00, I made the following changes (with guidance from Tingjun Yang)

In the file: `srcs/dunetpc/dune/EventGenerator/GENIE/genie_dune.fcl`

- `dune_fd_genie_atmo_max_flux.FluxType: "atmo_BARTOL"`
- `dune_fd_genie_atmo_max_flux.FluxSearchPaths: "/pnfs/dune/persistent/TaskForce_Flux/atmos/Bartol/"`
- `dune_fd_genie_atmo_max_flux.FluxFiles:`
`["fmax20_0401z.sou_nue", "fmax20_0401z.sou_num", "fmax20_0401z.sou_nbe", "fmax20_0401z.sou_nbm"]`

(And similar changes to the min flux section.)

Results of Changes

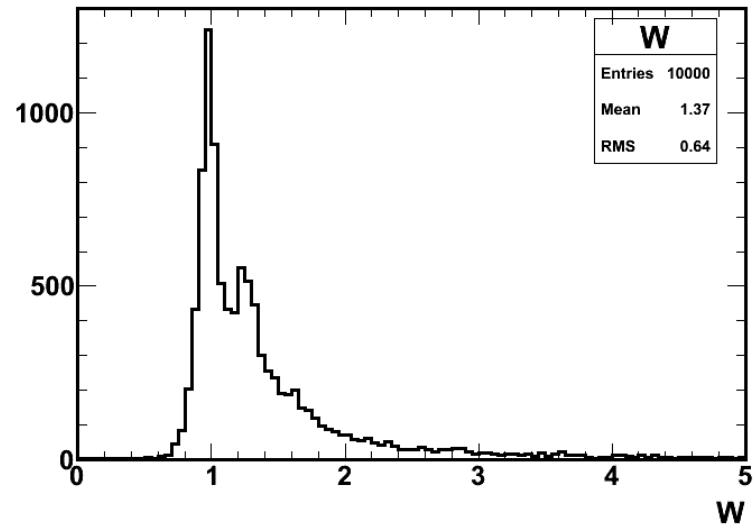
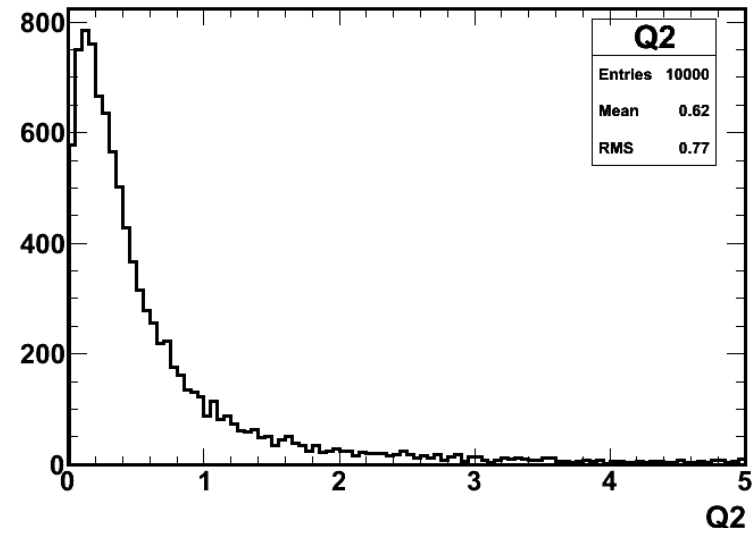
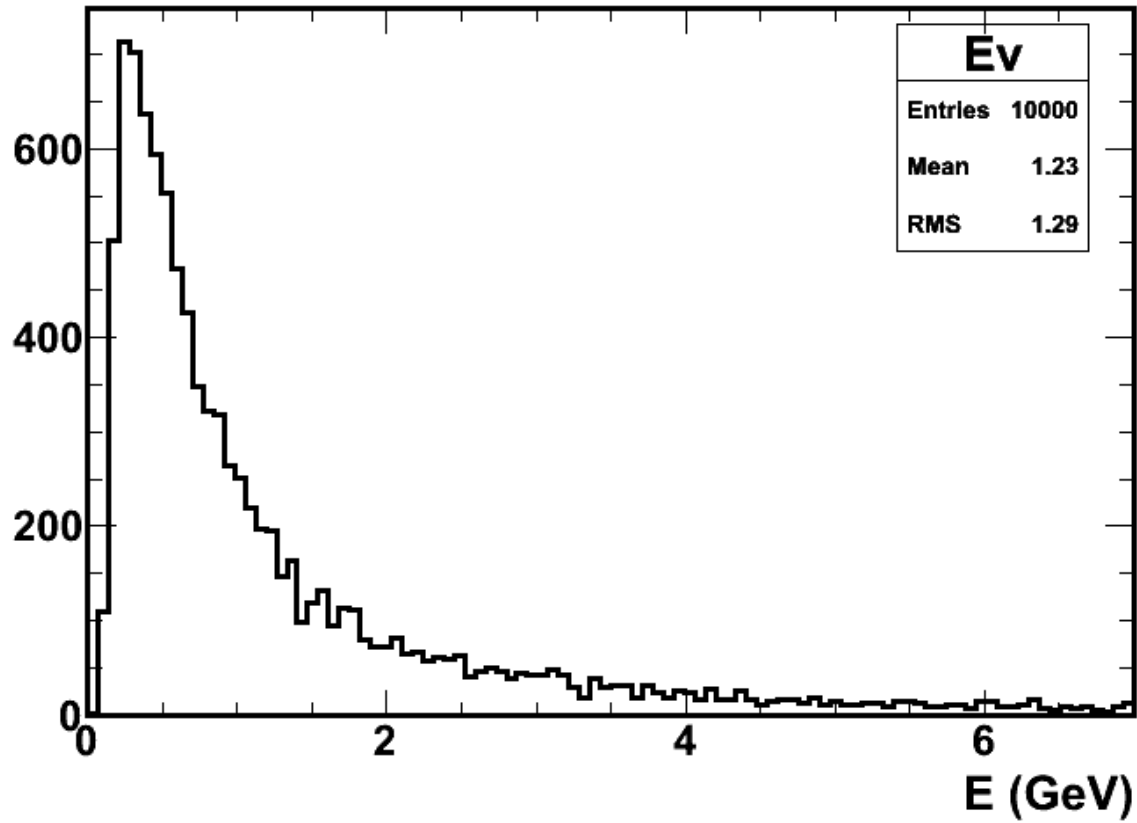


I created a 1000 event sample to verify that the changes made to Larsoft fixed the Energy distribution.

Tingjun has generated larger samples with the changes in place, which can be found at:

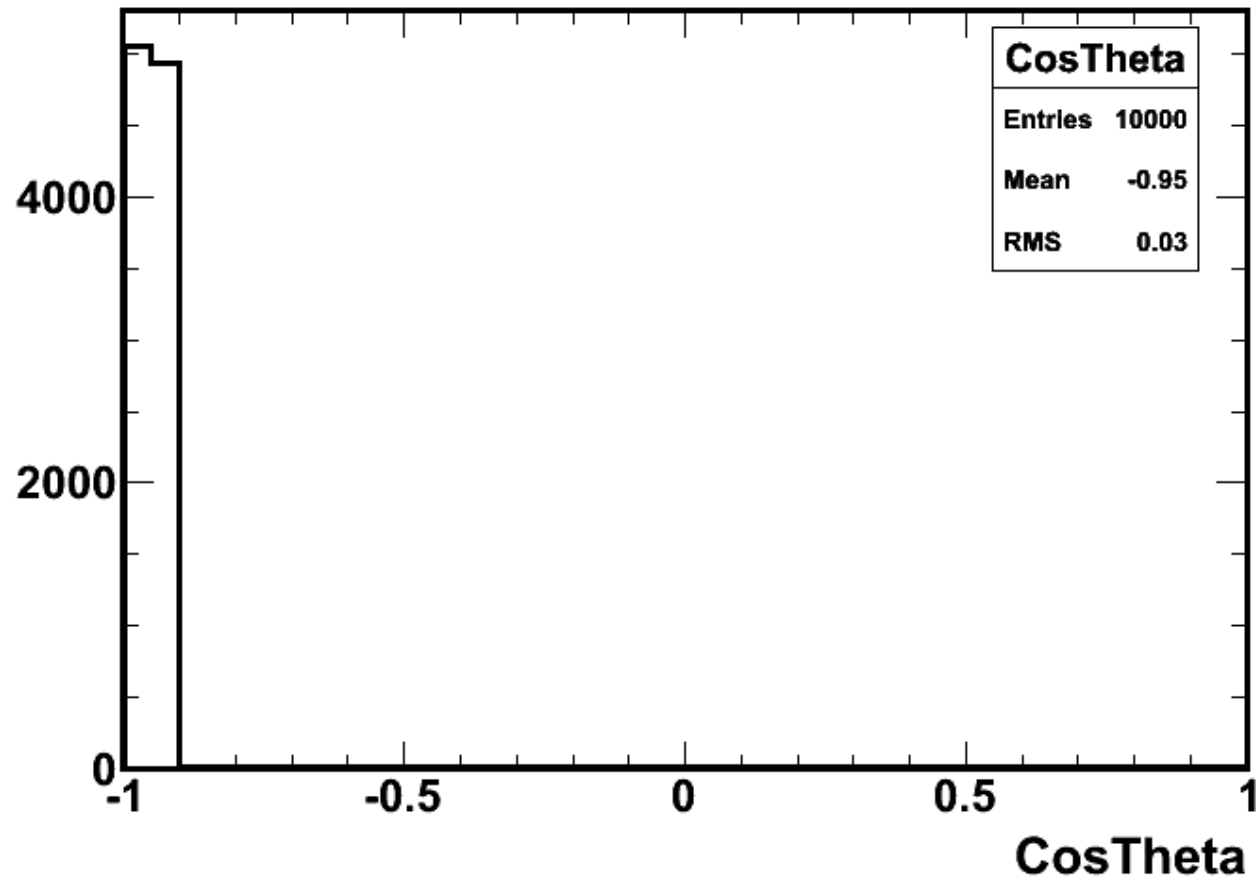
`/pnfs/dune/scratch/dunepro/v06_55_00/
mergeana/prodgenie_atmnu_max_dune10
kt_1x2x6/`

Neutrino Energy



CosTheta

HONDA



All events seem to be coming from directly overhead.

Currently: Looking into Honda

This seems to be a problem with the way GENIE is handling the HONDA Flux

Plan:

1. Look at the history of Genie changes to `gevgen_atmo` to see if anything could be causing this.
2. The problem may be coming from one of following two files in GENIE:
 - `GAtmoFlux.cxx`
 - `GHAKKMatmoFlux.cxx`

Next Step: Flavor Identification

We want to do a similar analysis with neutrino flavor identification to what we have started doing with vertex resolution (See Joshua Mills' talk).

Start by looking at how well Pandora reconstructs the neutrino flavor.

- We have started just looking at the out of the box results. It could be useful to work on improving and optimizing the Pandora analysis for atmospheric neutrinos

From there, it could be useful to try other methods, such as machine learning, for flavor identification.

Preliminary Results (Pandora)

| | Reconstructed : ν_e | Reconstructed : ν_u |
|--------------------|-------------------------|-------------------------|
| Truth : nc | 278 | 345 |
| Truth : cc ν_e | 877 | 259 |
| Truth : cc ν_u | 252 | 1797 |

Total number of events: 3808

Cuts:

Only events in the fiducial volume

Only events where Pandora found at least one vertex

True neutrinos and anti-neutrinos have been grouped together.

Conclusions

- We have applied the changes to Larsoft to fix the energy distribution for the Bartol flux files.
- In the future, it would be useful to create a standard DUNE validation package.
- The Honda Flux is currently giving a strange $\cos\theta$ when events are generated using GENIE
- Our next step is to look more closely at flavor identification, to see how well current methods do at reconstructing neutrino flavor.