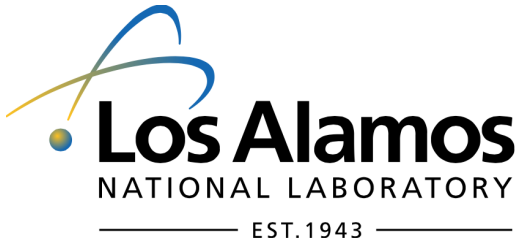
NuMI Neutrinos in MicroBooNE

Douglas Davis [†], **Žarko Pavlović** [‡]

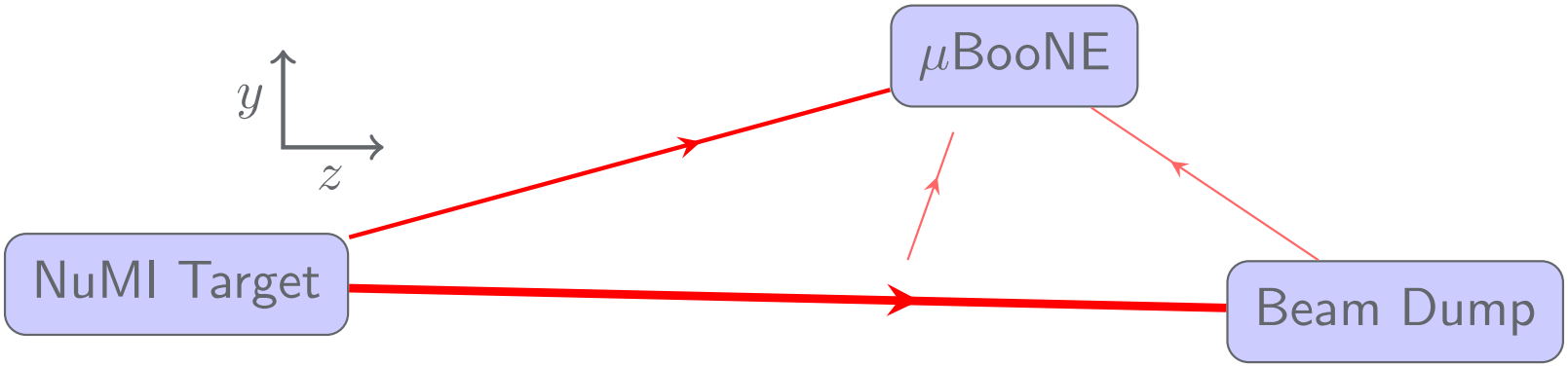
[†] *The University of Texas at Austin*
[‡] *Los Alamos National Laboratory*



August 6, 2013

Simple Introduction

NuMI ν's in a Booster beam line experiment – MiniBooNE saw neutrino events from NuMI; $\therefore$ so will MicroBooNE. Rough sketch:

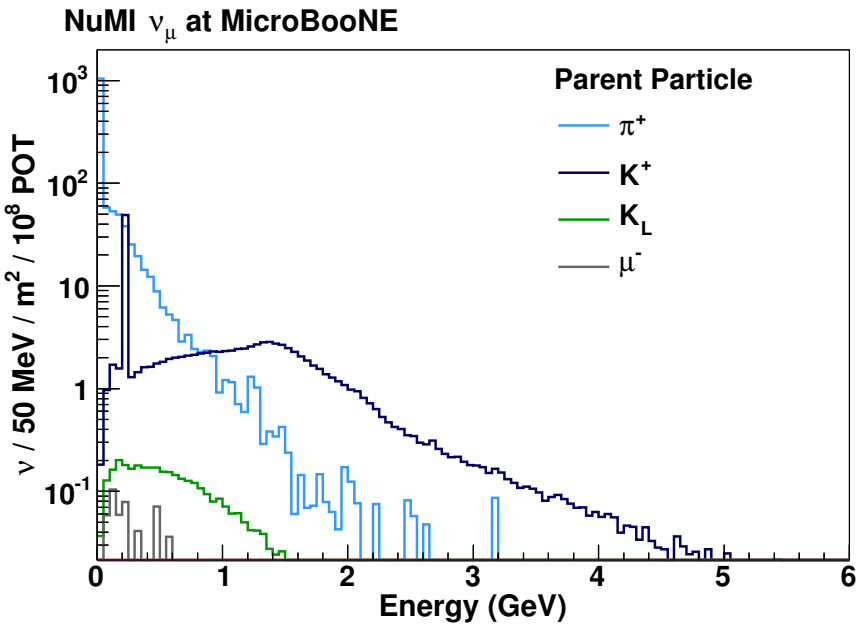


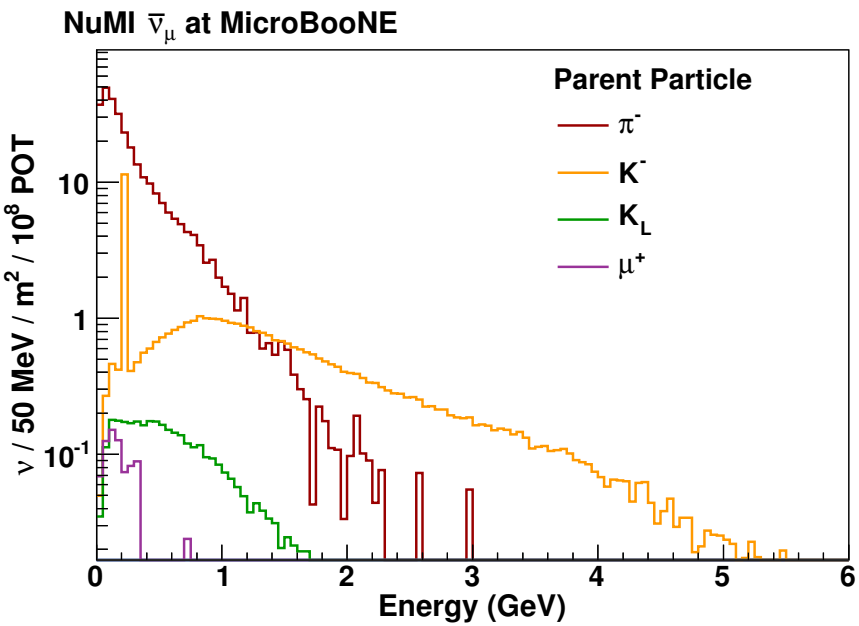
Very rough, not to scale, side-view diagram, the MicroBooNE detector does not share the x coordinate with the NuMI target either.

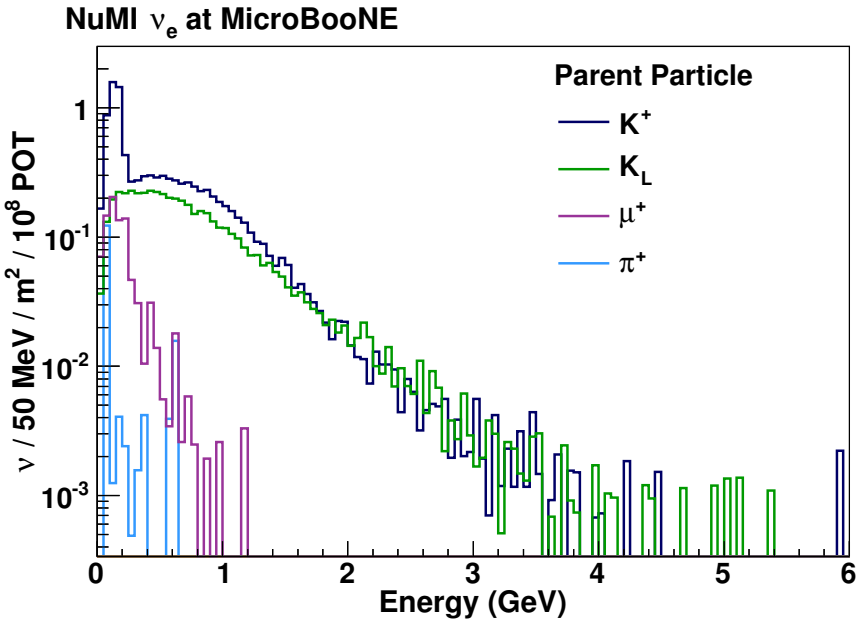
- Understanding NuMI ν's in μBooNE will be helpful for all NuMI fed experiments.
- Some hadron decay in the beam dump are particularly interesting because daughter neutrinos are traveling at $-z$ and monoenergetic, Ex. $\mathrm{BR}(K^+ \to \mu^+ \nu_\mu) = 0.635$ (PDG).

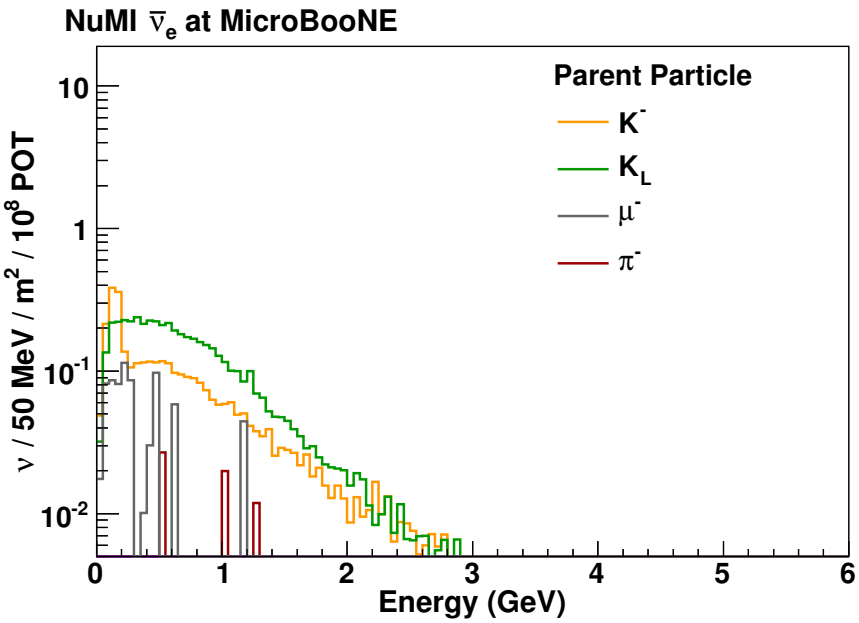
$$P_{\text{osc}} \propto \sin^2\left(\frac{1.267\Delta m^2 L}{E}\right) \quad E_{\nu_\mu} \simeq \sqrt{\frac{\frac{1}{4}\left(\mathcal{M}^2 - m_\mu^2\right)^2}{\mathcal{M}^2}} \simeq 236 \text{ MeV}$$

Raw NuMI flux in the MicroBooNE detector

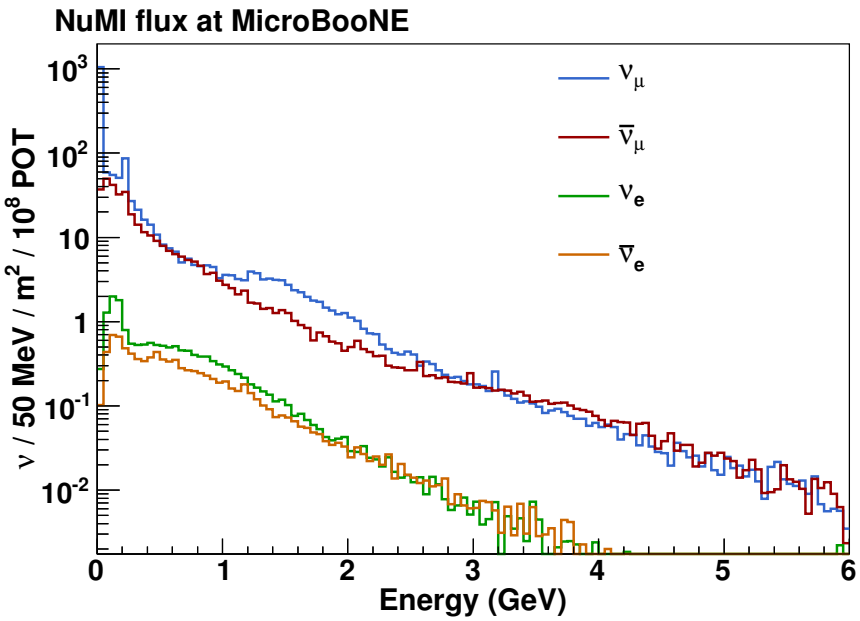


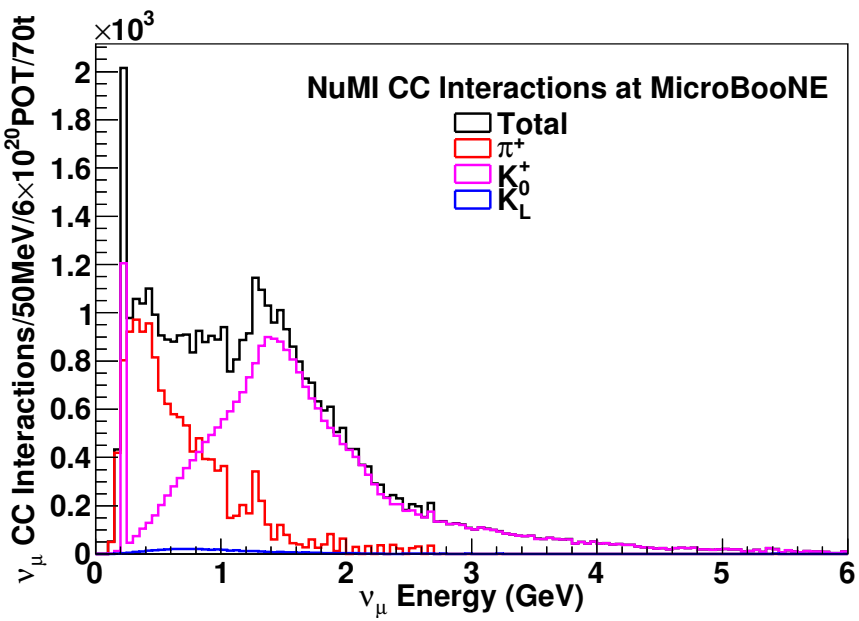






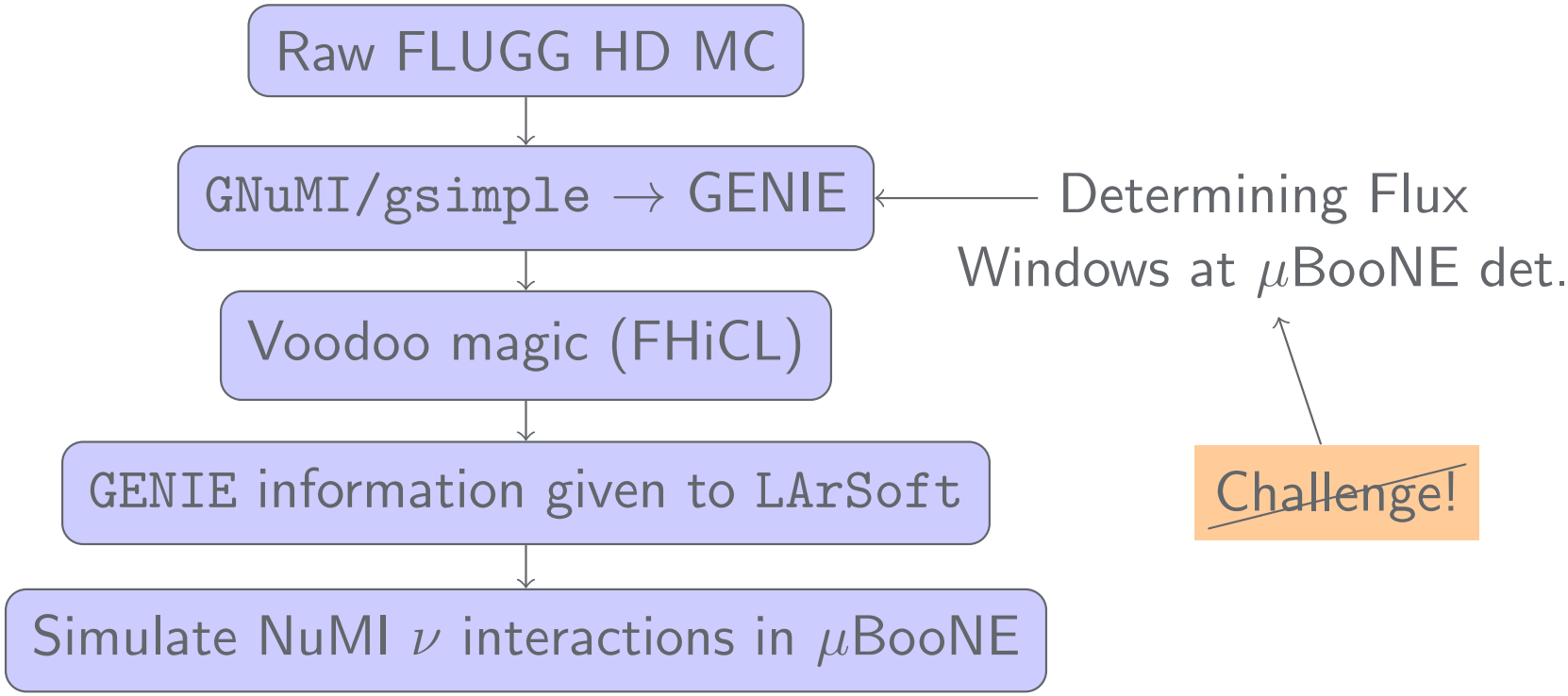
Raw NuMI flux cont.



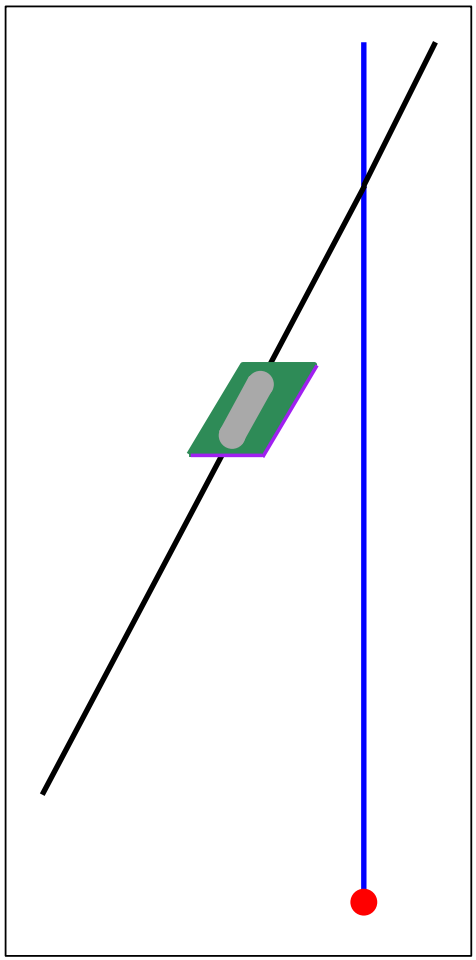


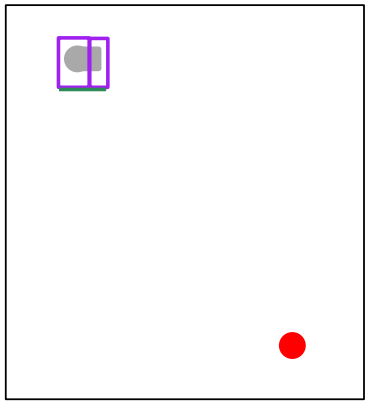
Generating NuMI GENIE files for LArSoft

To simulate NuMI ν's in the detector, we generate flux files using Robert Hatcher's gsimple framework. It takes raw FLUGG NuMI Monte Carlo and returns flux information at specified locations through specified windows in GENIE format. Zarko provided the proper location of μBooNE according to NuMI coordinate system and the required rotation matrices to transform into NuMI coordinates. Simplified flow:



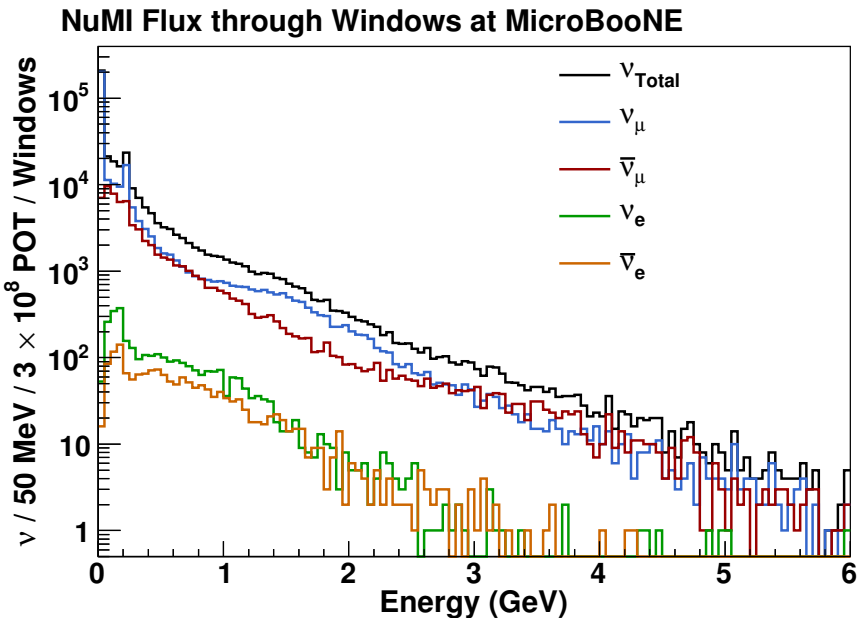
Establishing Flux Windows

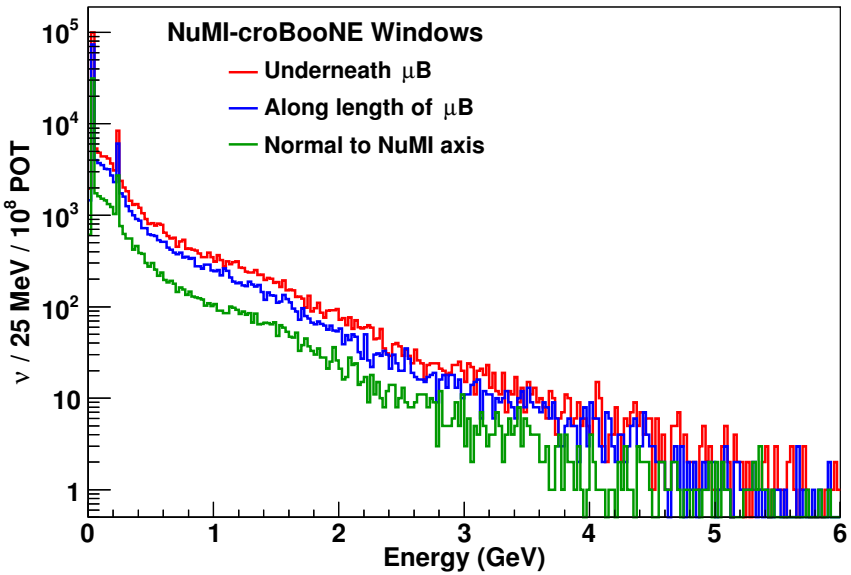




- Red dot: Target
- Left: Birds eye. Blue is NuMI, Black is BNB, Window on the underside (green). Purple lines are windows coming out of page.
- Right: NuMI beam goes into the page. Window in front of cryostat normal to NuMI beam (purple). Window along the length of the crystat (purple). Green window is the underside window.

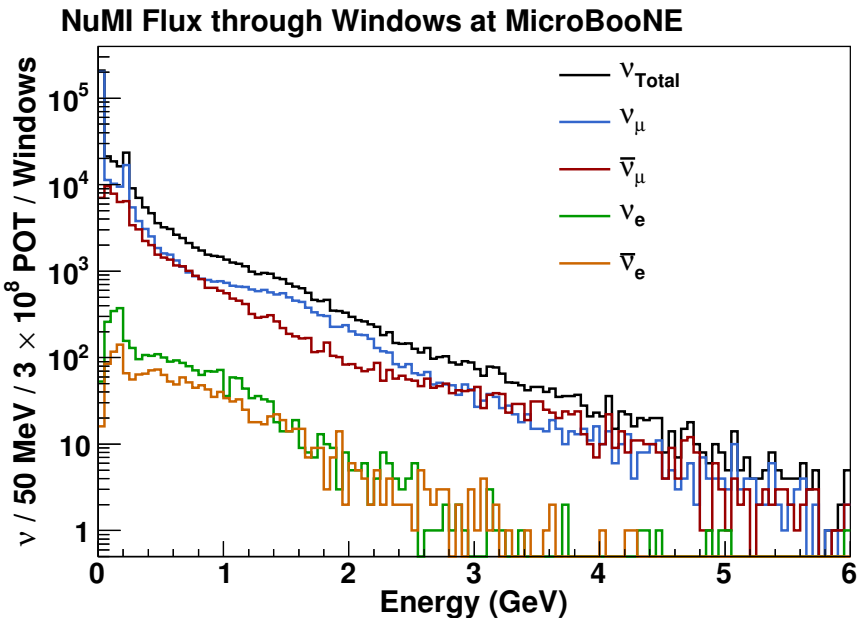
From `gsimple` Run

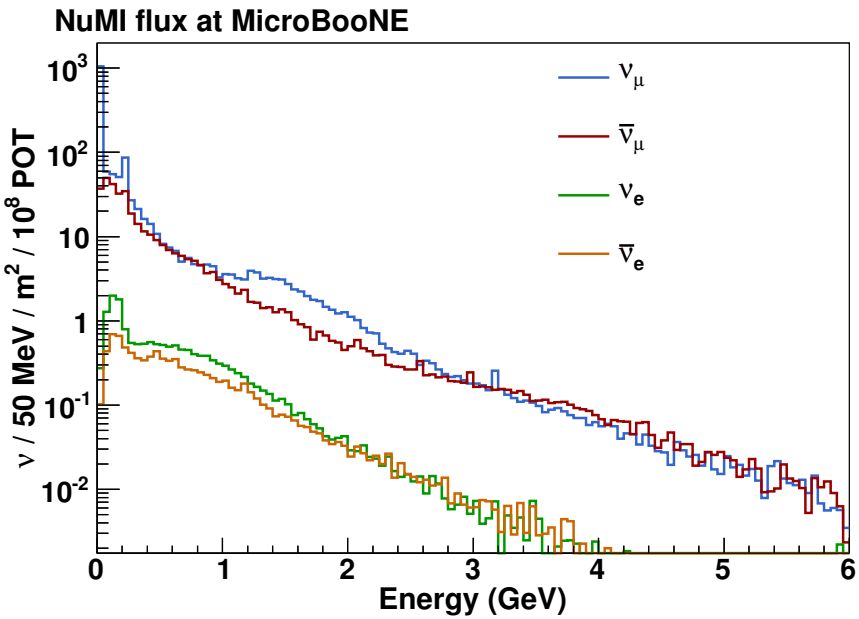




- Top plot, distribution of energy for respective neutrinos. 3 Flux files for each window (10^8 POT per file).
- Bottom plot. Distrubution of all neutrinos for each window.
  - Window underneath MicroBooNE, $\sim 175,000$ $\nu/10^8$ POT.
  - Window along the length of MicroBooNE, $\sim 125,000$ $\nu/10^8$ POT.
  - Window Normal to z of NuMI shifted up 3^o, $\sim 55,000$ $\nu/10^8$ POT.

First Cross Check

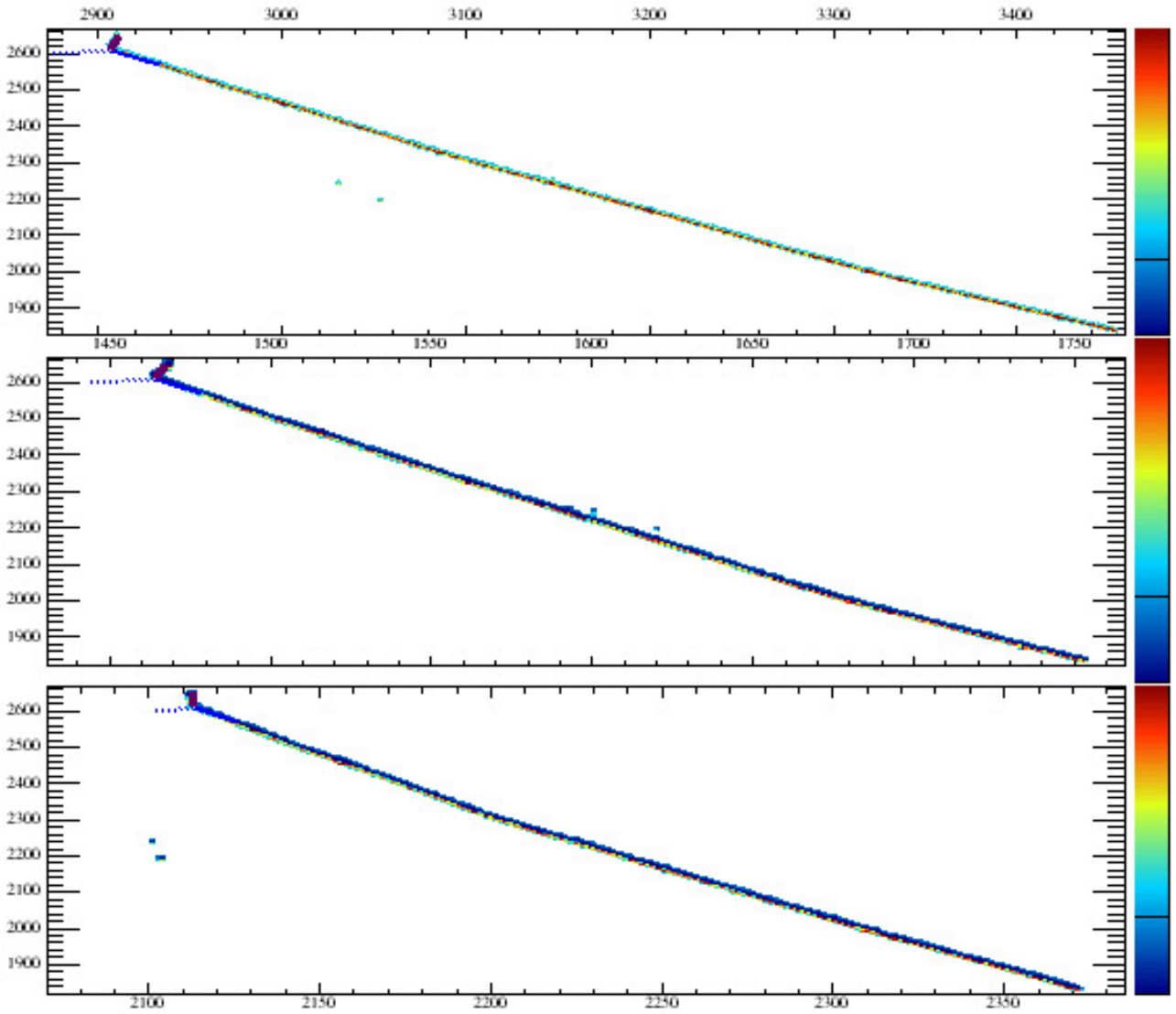




- We plan to start cross checking using the truth momentum of simulated CC ν_μ interactions in `LArSoft`.
- *But*, first step towards validation is checking the flux distribution through windows against the raw flux distribution.

Propogating through LArSoft

$$\nu_\mu \, N_{^{40}\mathrm{Ar}} \rightarrow \mu^+ \, p$$



Summary

- Method to generate `GENIE` flux files from raw hadron decay Monte Carlo is `gsimple`
- We needed the MicroBooNE coordinates according to NuMI ✓
- ~~Current~~ Completed challenges:
  - Solving `GENIE`'s problem with the MicroBooNE detector z coordinate (according to NuMI system) being less than total NuMI decay pipe length. ✓
  - Determining windows at the MicroBooNE detector to generate flux files with. ✓
- ~~Future~~ Current:
  - Testing in `LArSoft`. (Need more experienced users!)
  - Generate `gsimple` files from all 1,000 `FLUGG` files.