NuMI Neutrinos in MicroBooNE

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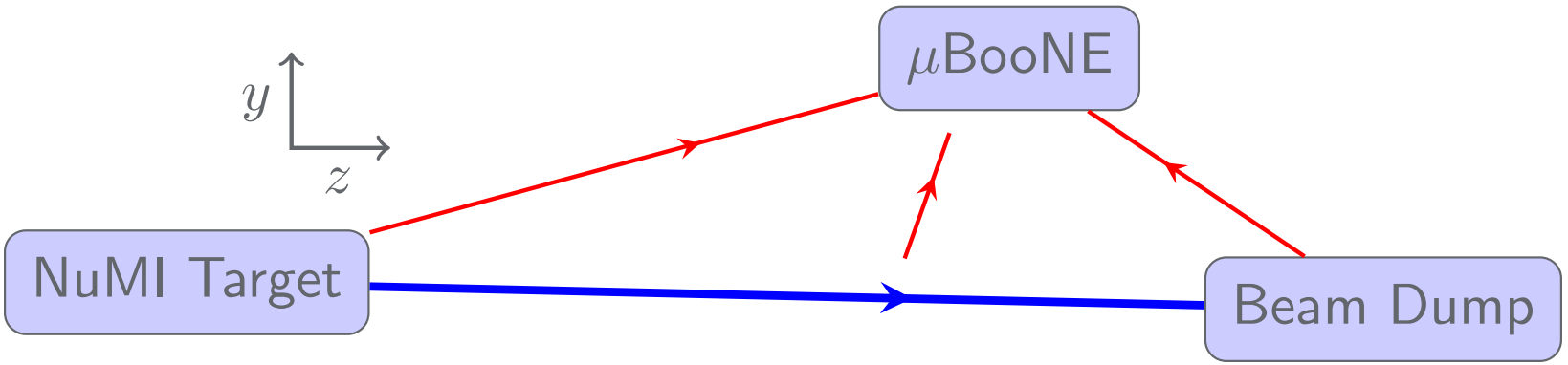
Outline

1. Quick Introduction
2. Raw NuMI Flux @ MicroBooNE
3. Generating `gsimple` NuMI Flux Files
4. Establishing Flux Windows
5. Current Status & Cross Checking
6. First Events in `LArSoft` and Summary

Simple Introduction



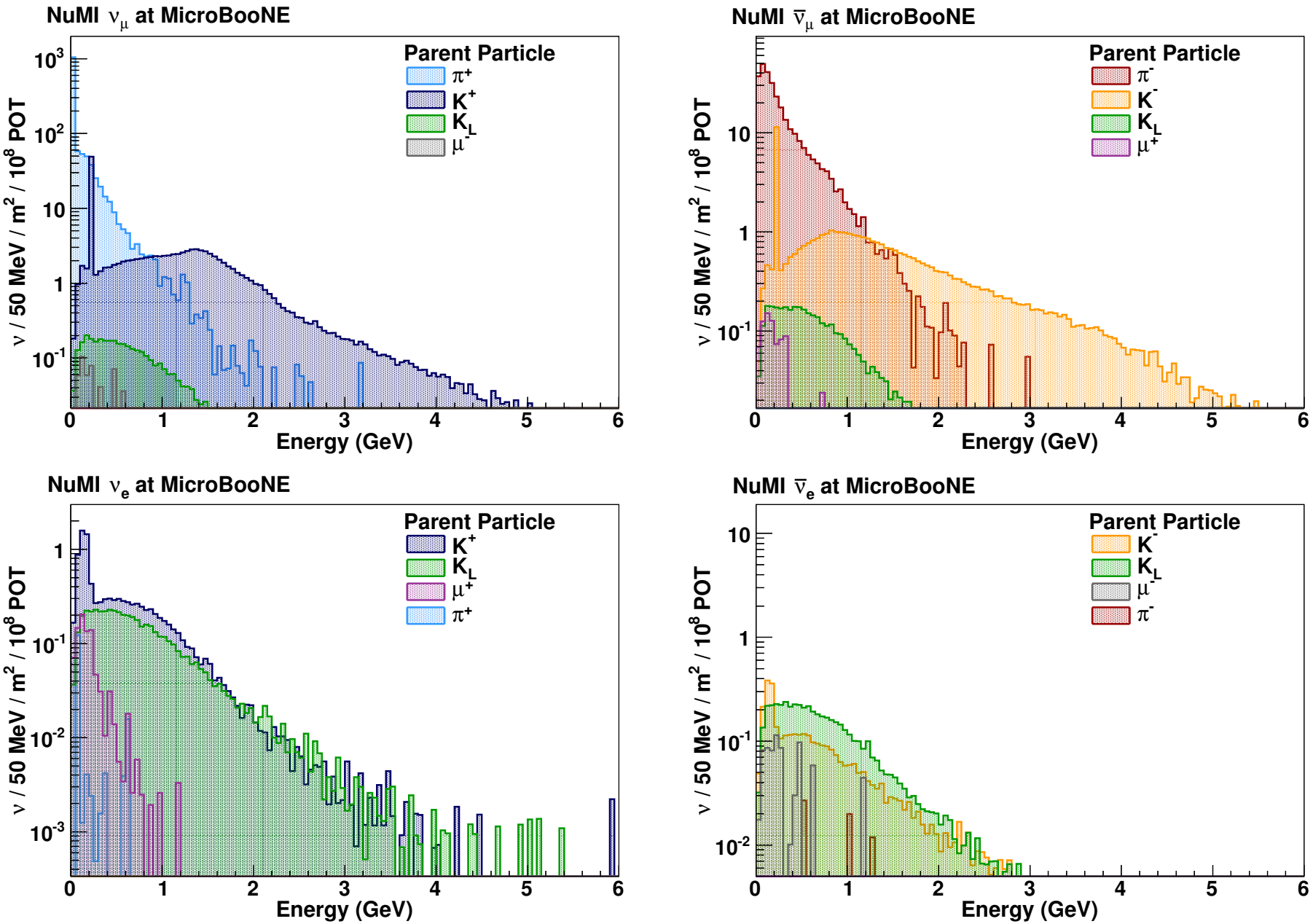
Events	BNB	NuMI
Total	145k	60k
ν_μ CCQE	68k	25k
NC π^0	8k	3k
ν_e CCQE	0.4k	1.2k
POT	6×10^{20}	8×20^{20}

2–3 years of running.

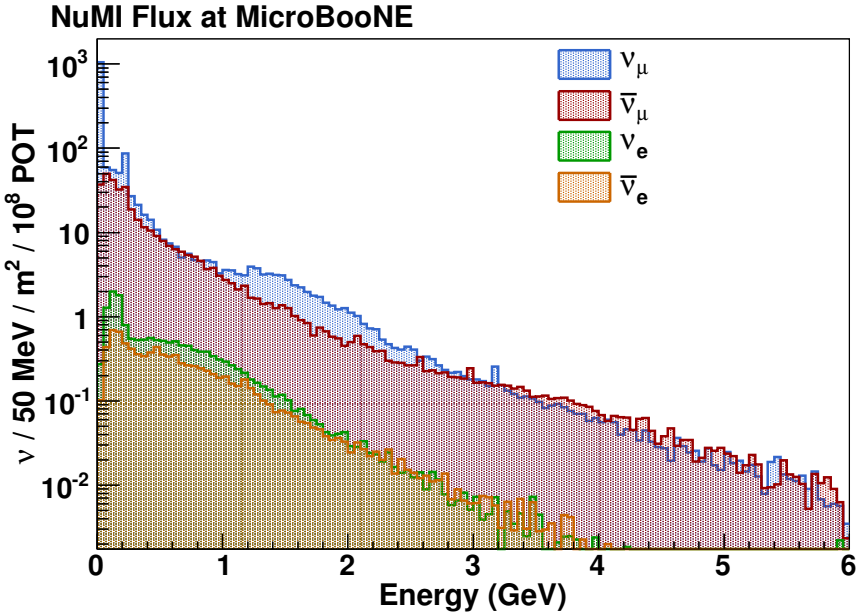
- Lots of neutrinos from NuMI in MicroBooNE.
- NuMI in MicroBooNE will be helpful to all NuMI fed experiments.
- Stopped hadron decay in the dump is of interest.

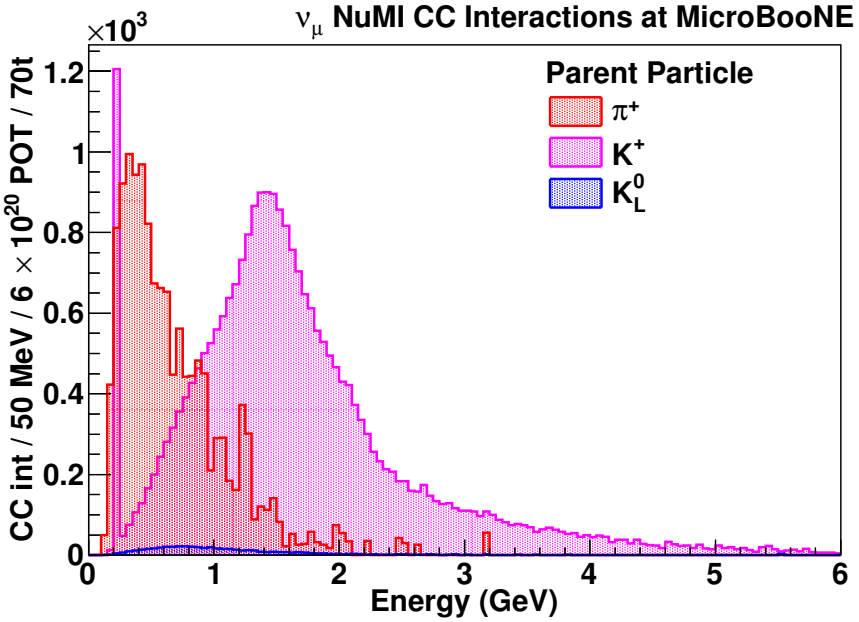
See Ben's Thursday night talk on Aug. 22 for more on beam dump!

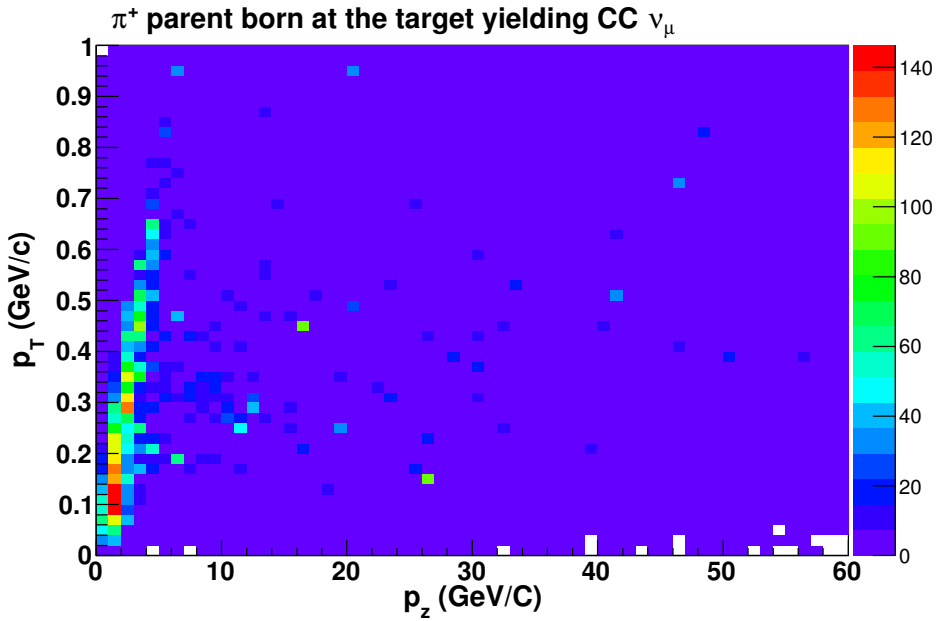
Raw NuMI flux in the MicroBooNE detector

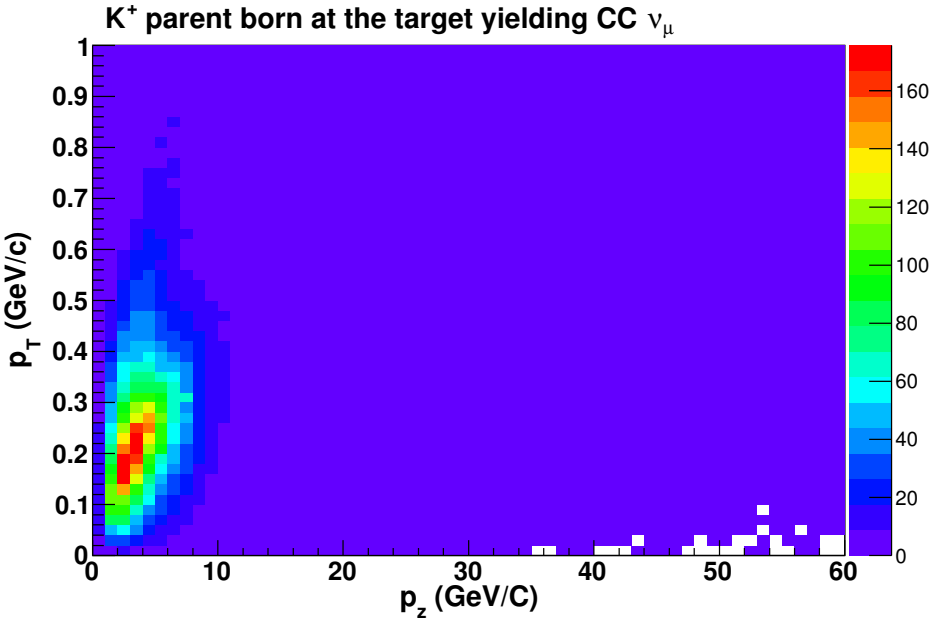


Raw cont.


NuMI Flux at MicroBooNE
ν_μ
$\bar{\nu}_\mu$
ν_e
$\bar{\nu}_e$
ν / 50 MeV / m^2 / 10^8 POT
Energy (GeV)

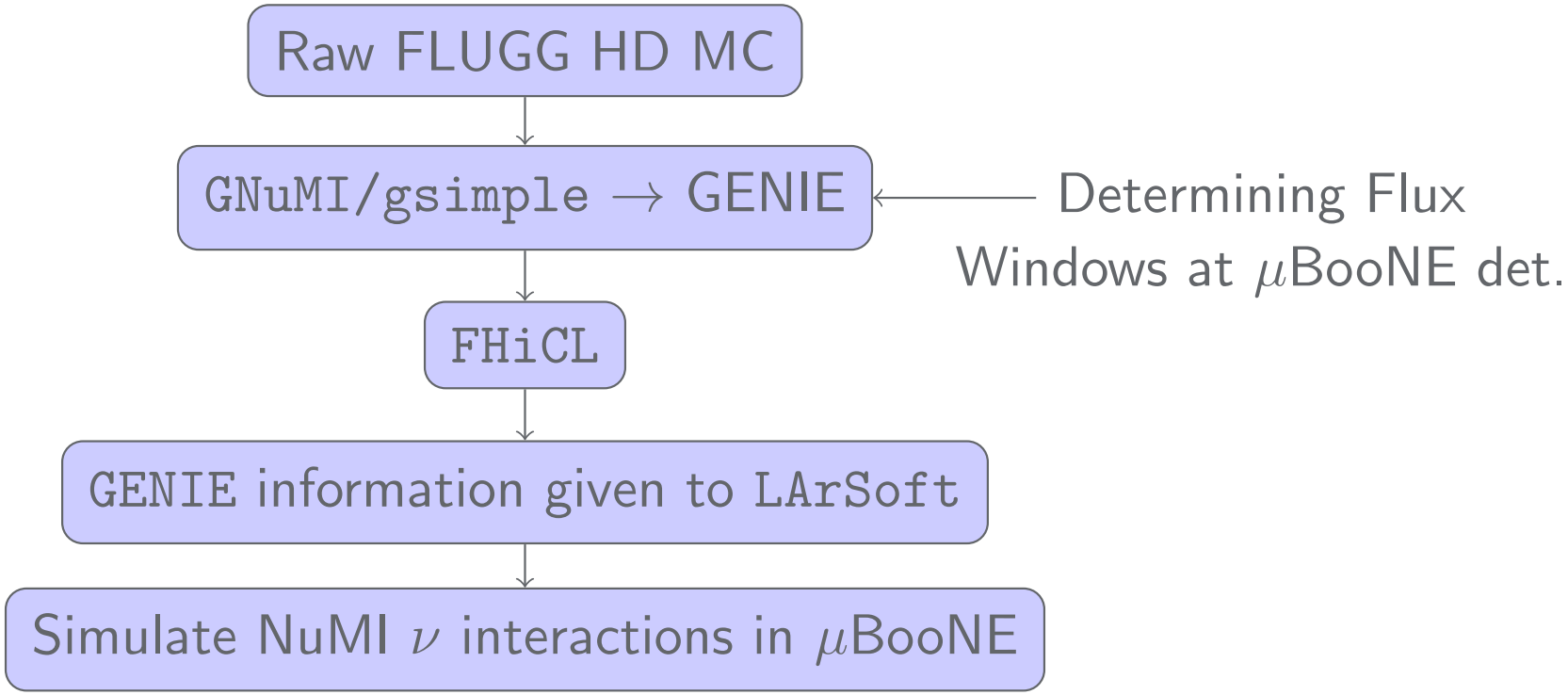

ν_μ NuMI CC Interactions at MicroBooNE
$\times 10^3$
Parent Particle
π^+
K^+
K_L^0
CC int / 50 MeV / 6 $\times 10^{20}$ POT / 70t
Energy (GeV)


π^+ parent born at the target yielding CC ν_μ
p_T (GeV/c)
p_z (GeV/C)

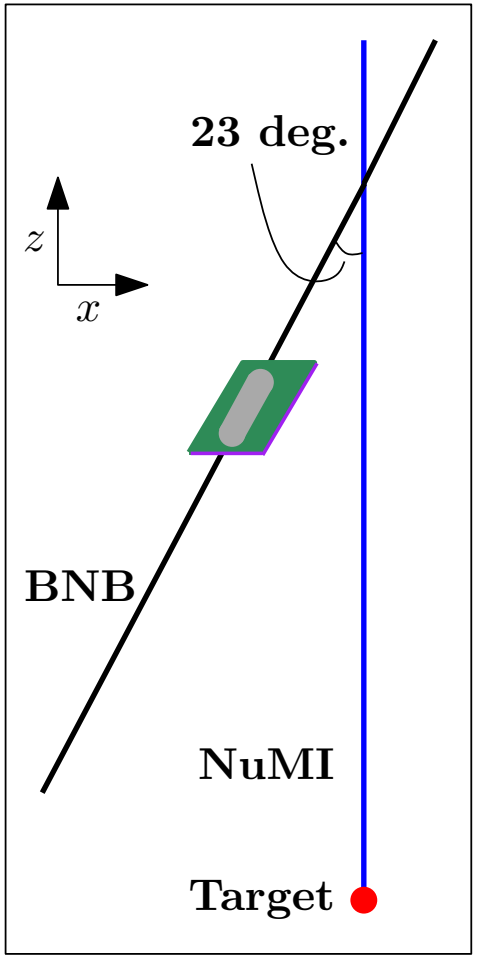

K^+ parent born at the target yielding CC ν_μ
p_T (GeV/c)
p_z (GeV/C)

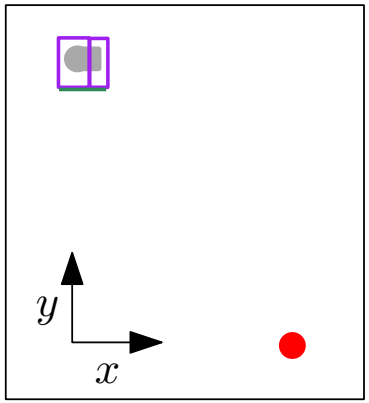
Generating NuMI GENIE files for LArSoft

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:



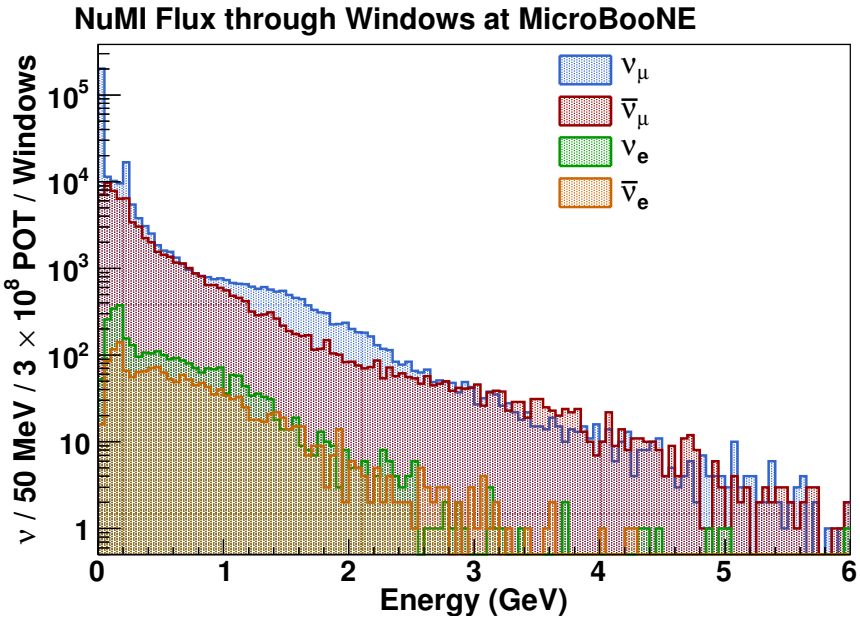
Establishing Flux Windows

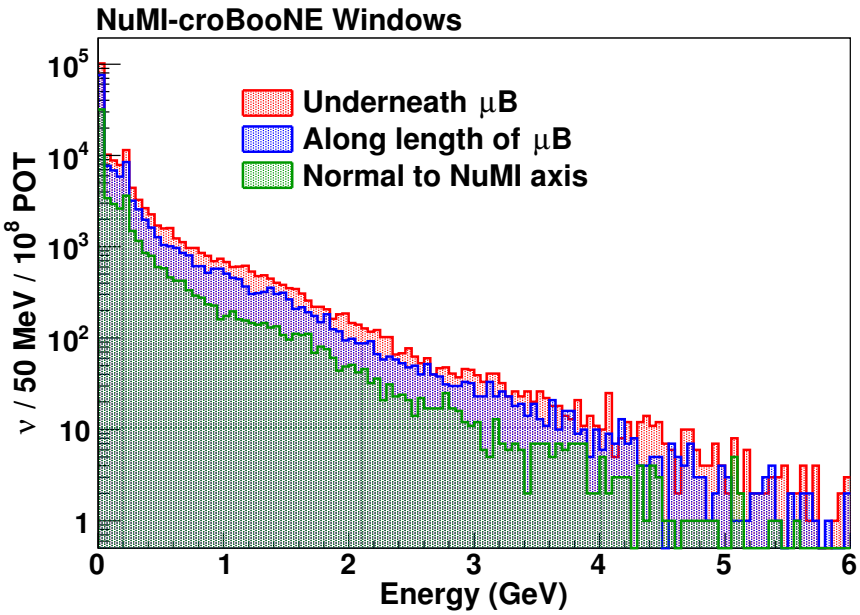




- Red dot: Target
- Left: Birds eye. Blue is NuMI, Black is BNB, Window on the underside (green). Purple lines are windows coming out of page.
- Right: NuMI beam goes into the page. Window in front of cryostat normal to NuMI beam (purple). Window along the length of the cryostat (purple). Green window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

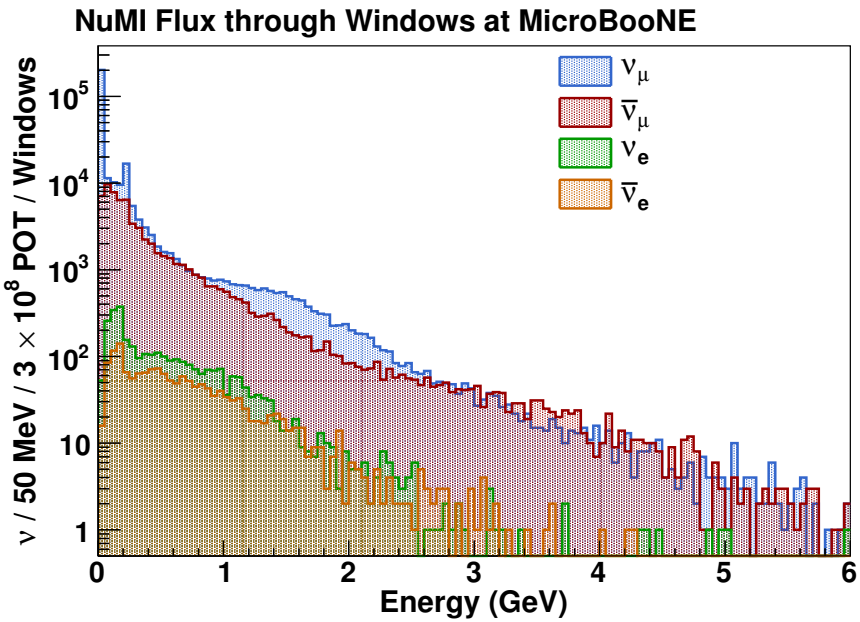
From gsimple Run

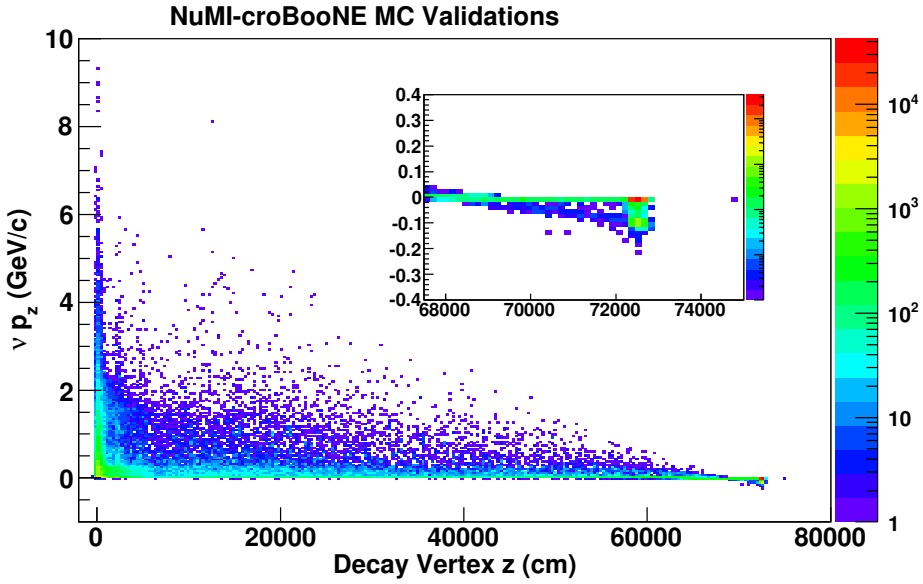


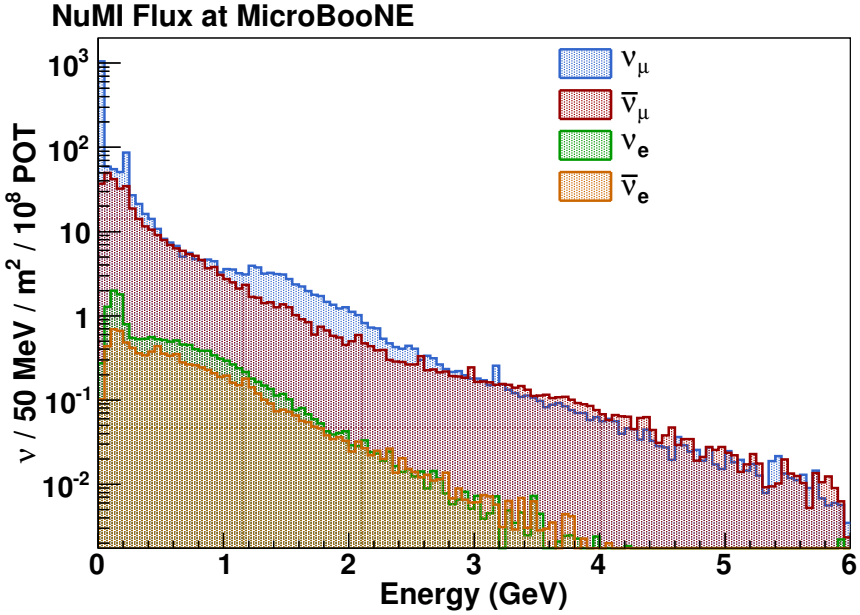


- Top plot, distribution of energy for respective neutrinos. 3 Flux files for each window (10^8 POT per file).
- Bottom plot. Distrubution of all neutrinos for each window.
  - Window underneath MicroBooNE, $\sim 175,000\ \nu/10^8$ POT.
  - Window along the length of MicroBooNE, $\sim 125,000\ \nu/10^8$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

Starting Validation



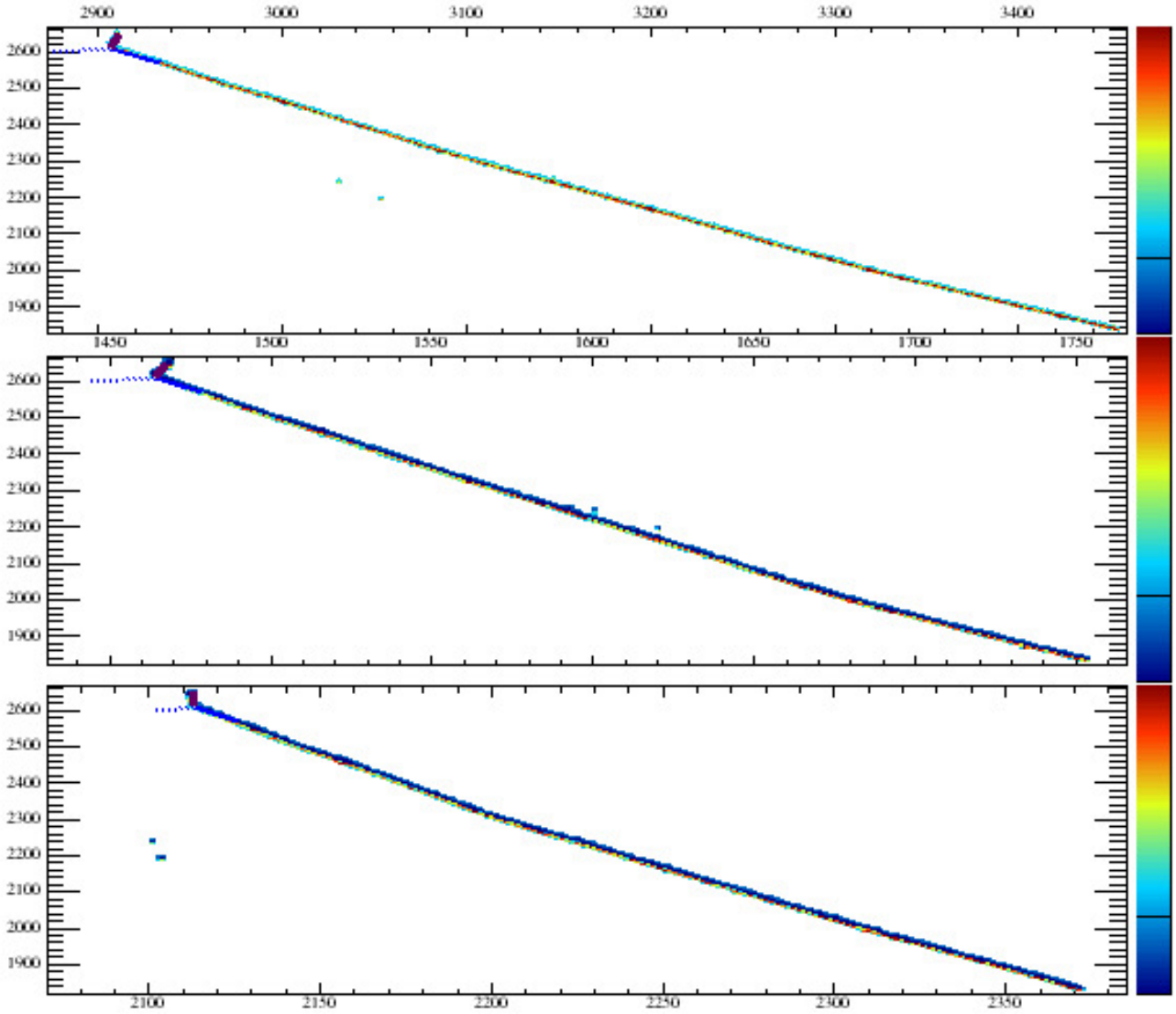




- Current quick: check window flux vs. raw FLUGG; also looking for expected behavior
- Near future: more set in stone validation (MC truth information; looking at muons from CC ν_μ).

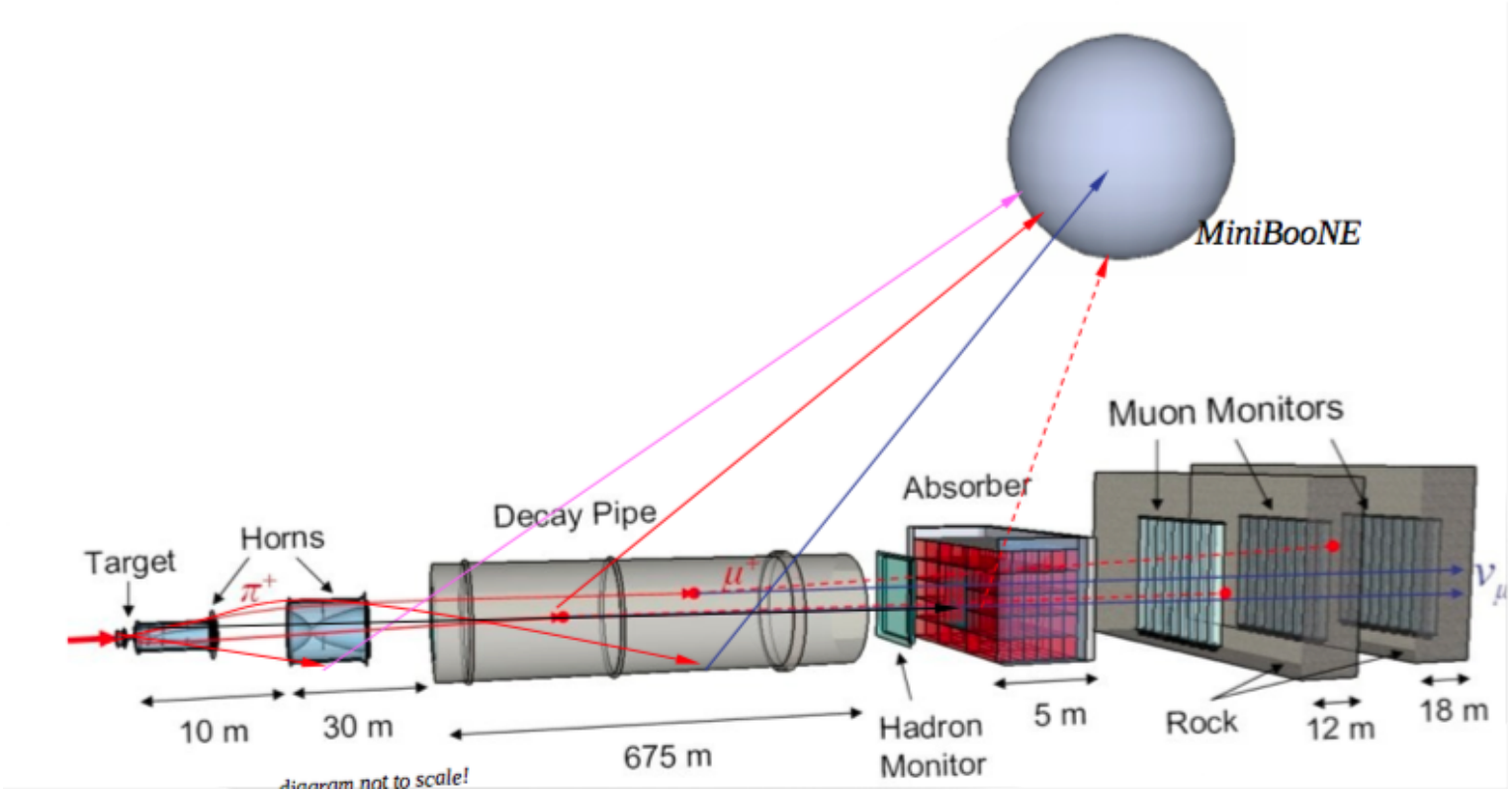
Propogating through LArSoft

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



Summary

- MicroBooNE supply many neutrinos to MicroBooNE.
- Method to generate `GENIE` flux files from raw hadron decay Monte Carlo is `gsimple`
- Completed:
  - MicroBooNE location & rotation matrix wrt NuMI determined
  - Determined flux windows to shadow MicroBooNE detector
  - Generated `gsimple` flux files
  - Starting validation of neutrino rays
  - Starting progagating through `LArSoft`

Backup

MicroBooNE is in front of MiniBooNE wrt BNB axis. Therefore in this diagram MicroBooNE is to the left of MiniBooNE in front of the absorber