MEASUREMENT OF THE FLUX AND FLUX RATIOS OF NEUTRINOS IN THE LBNF BEAMLINE

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GOAL

- To compute the LBNF and NuMI beamline flux, flux ratios, and their uncertainties for ν_μ, ν_e, $\overline{\nu_e}$, and $\overline{\nu_\mu}$

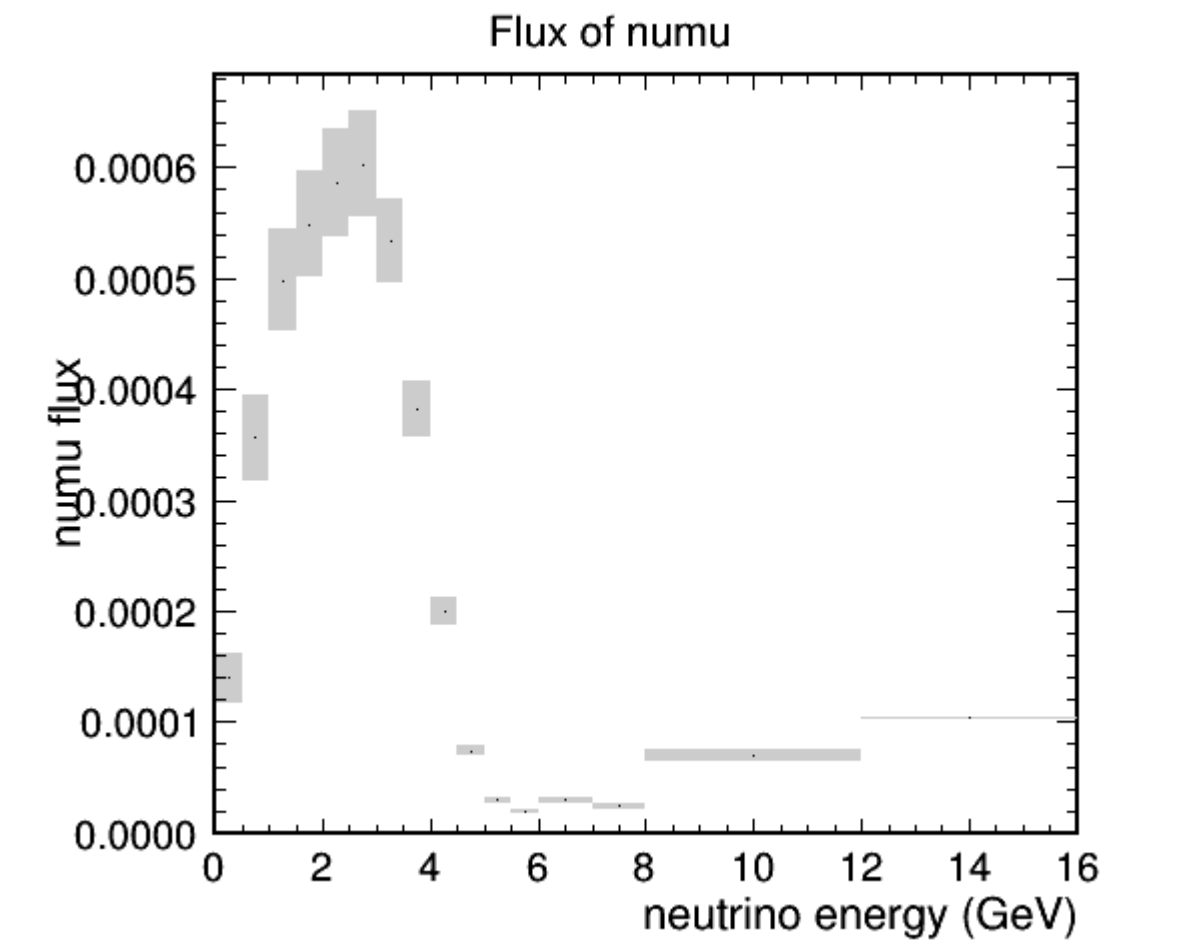
WHY?

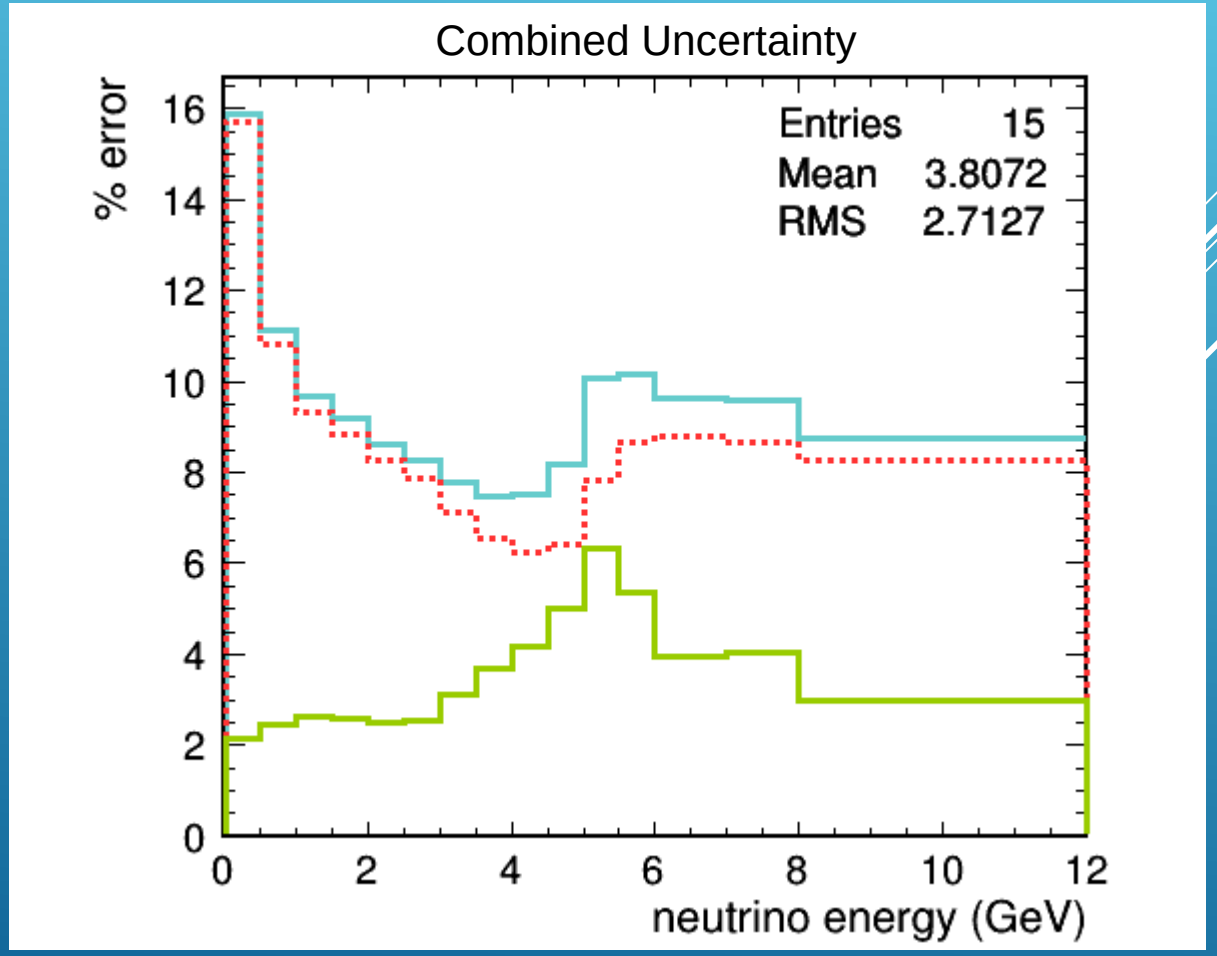
- We want to measure the oscillation of ν_μ to ν_e
- How many ν_e appear as a function of oscillation parameters?
  - Requires knowledge of the unoscillated ν_μ flux and the ν_e cross section
  - How many beam ν_e are there?
- How well is the beam $\frac{\nu_e}{\nu_\mu}$ flux ratio predicted?
- If well known, the event ratio at the ND gives the cross-section ratio
- We will also be measuring the ν_μ cross sections and fluxes

METHOD

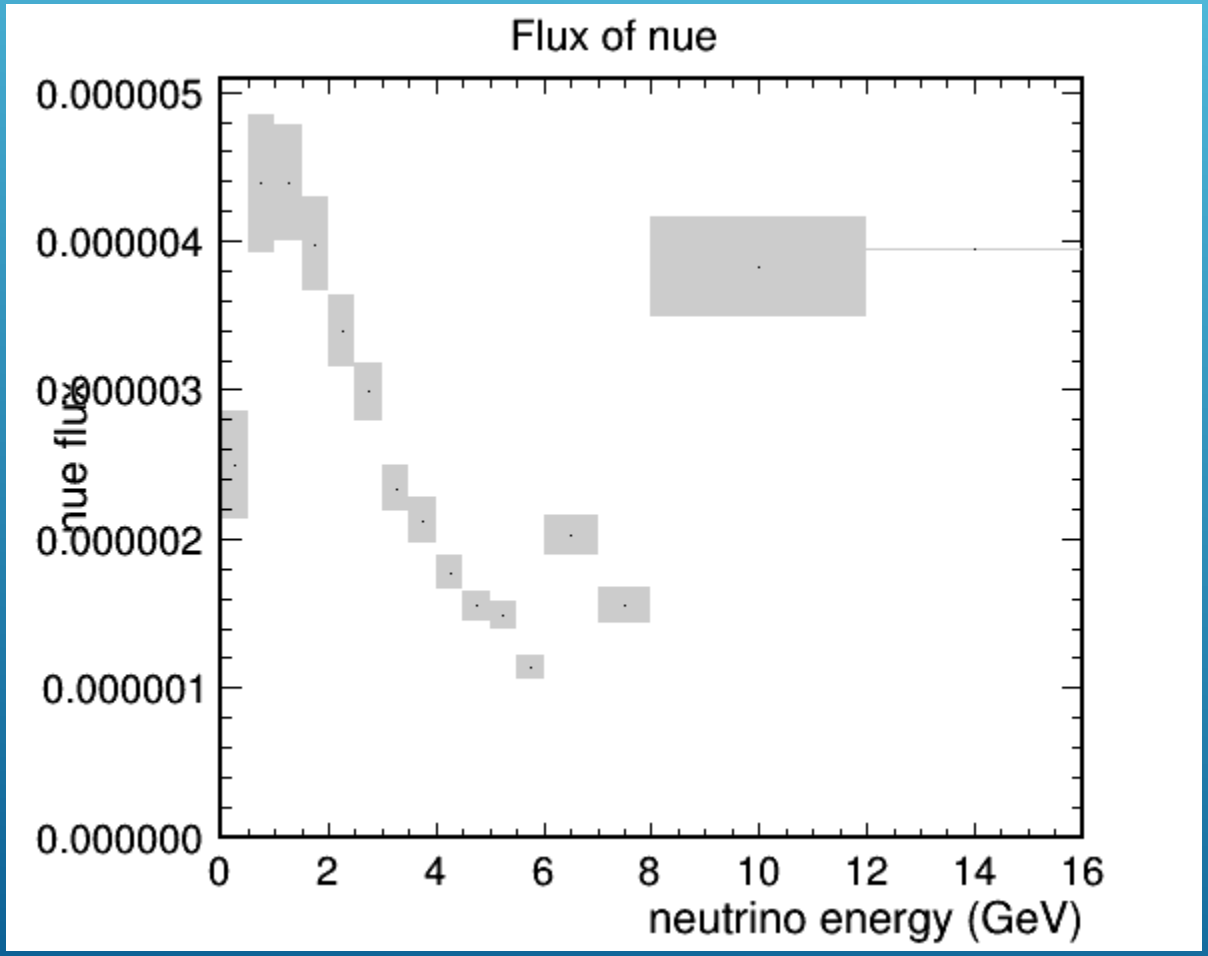
- NuMI flux histograms and uncertainties used to make sure we could repeat previous work
- Used histos_g4lbne_v3r5p4_beta_QGSP_BERT_OptimizedEngineeredSept2017Review_18_neutrino_LBNFFD_ppfx.root, forwarded by Amit Bashyal
  - Disclaimer: The file uses FD universes
  - Located in /pnfs/dune/persistent/users/bashyal8/v3r5p4/OptimizedEngineeredSept2017_18/ppfx/ in the dunegpvm machine
- Also used the sigma1 shift histograms from Laura Fields
- New universes were made using the simulated universes and random scalings of the sigma1 shift histograms
- Correlation and covariance matrices were then built up, along with the flux and flux uncertainty histograms

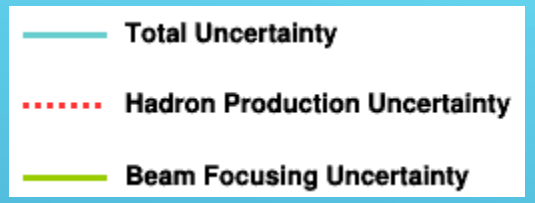
ν_μ

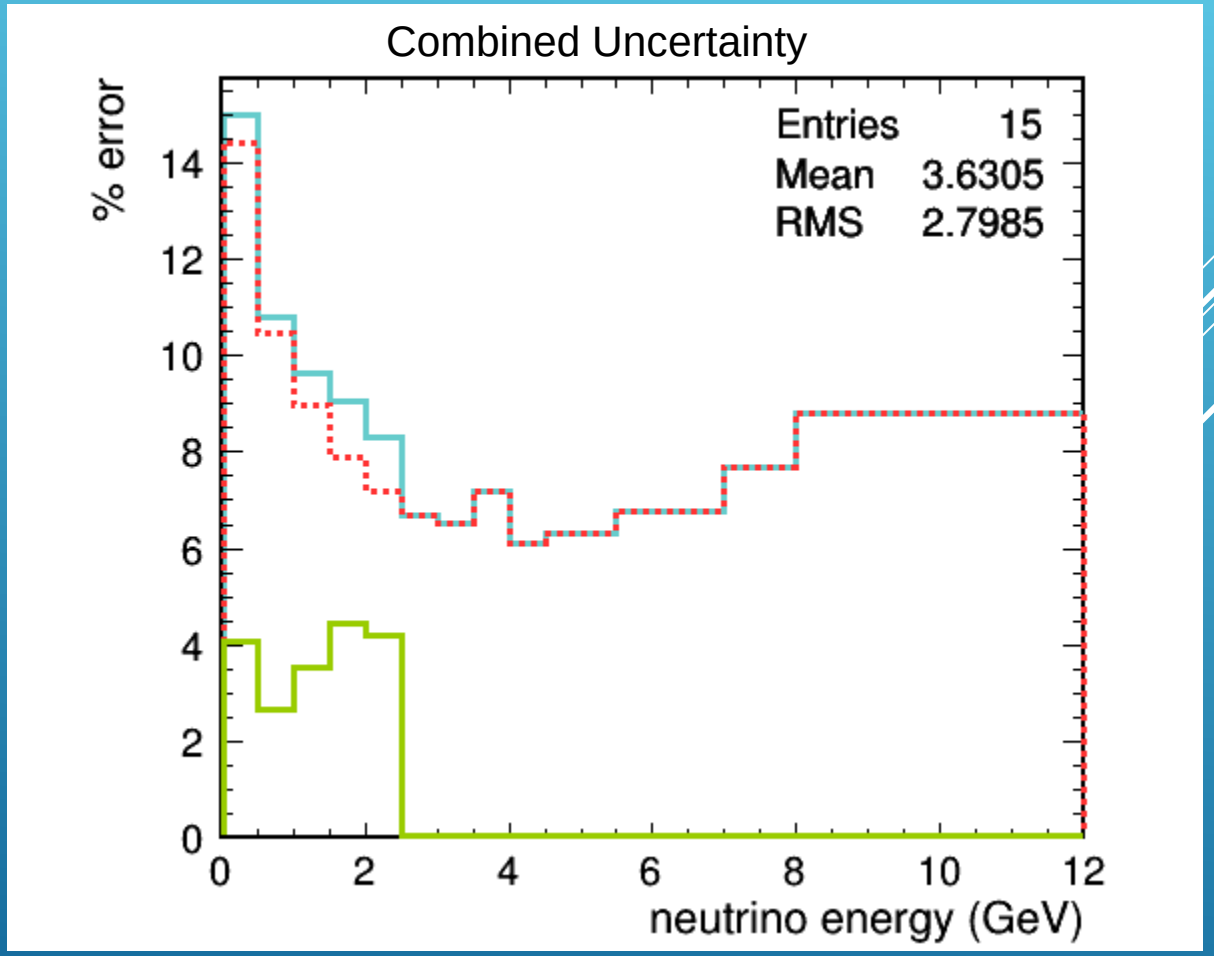

Flux of numu
numu flux
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
0
2
4
6
8
10
12
14
16
neutrino energy (GeV)


Total Uncertainty
Hadron Production Uncertainty
Beam Focusing Uncertainty
Combined Uncertainty
% error
Entries 15
Mean 3.8072
RMS 2.7127
0
2
4
6
8
10
12
14
16
neutrino energy (GeV)

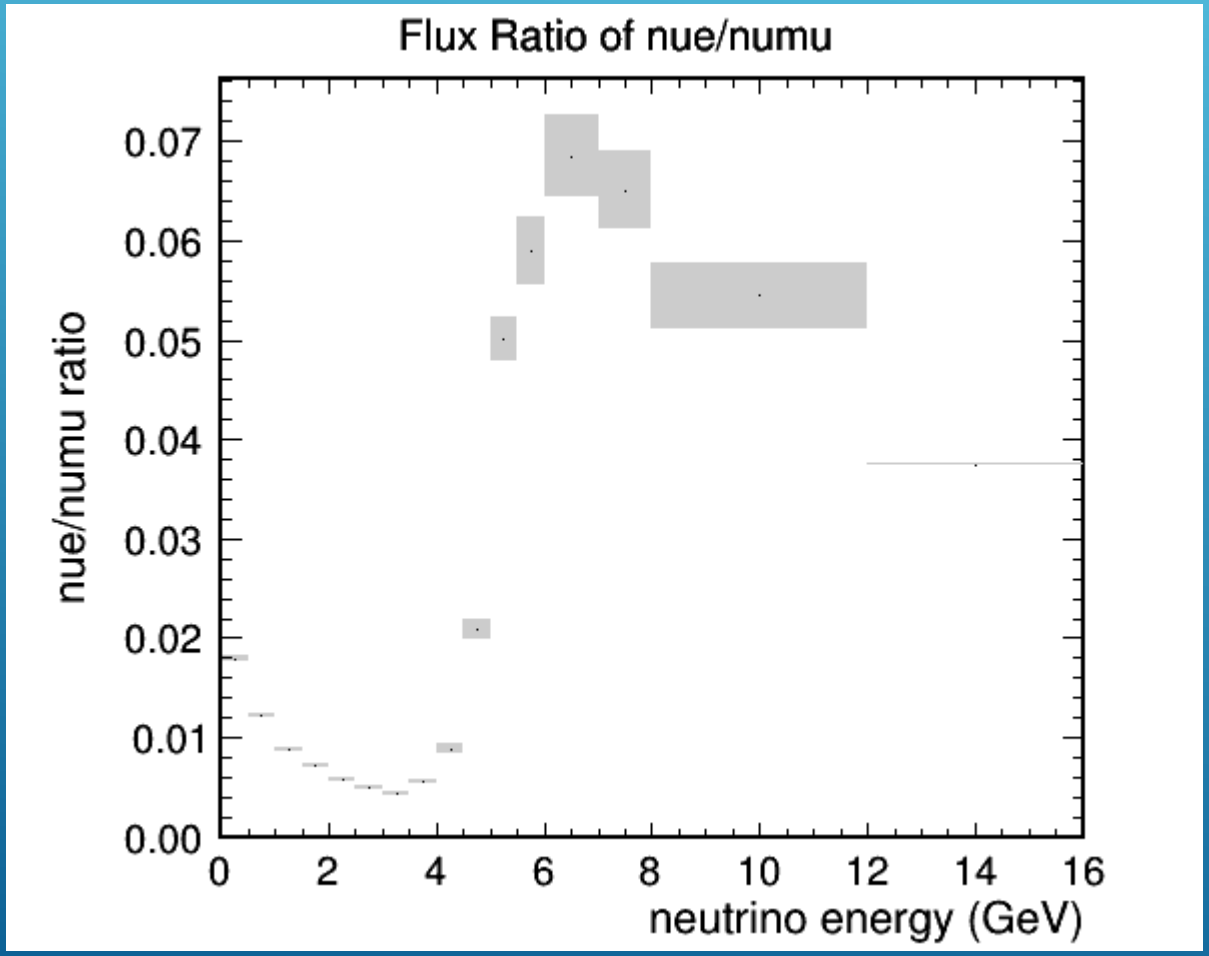
ν_e

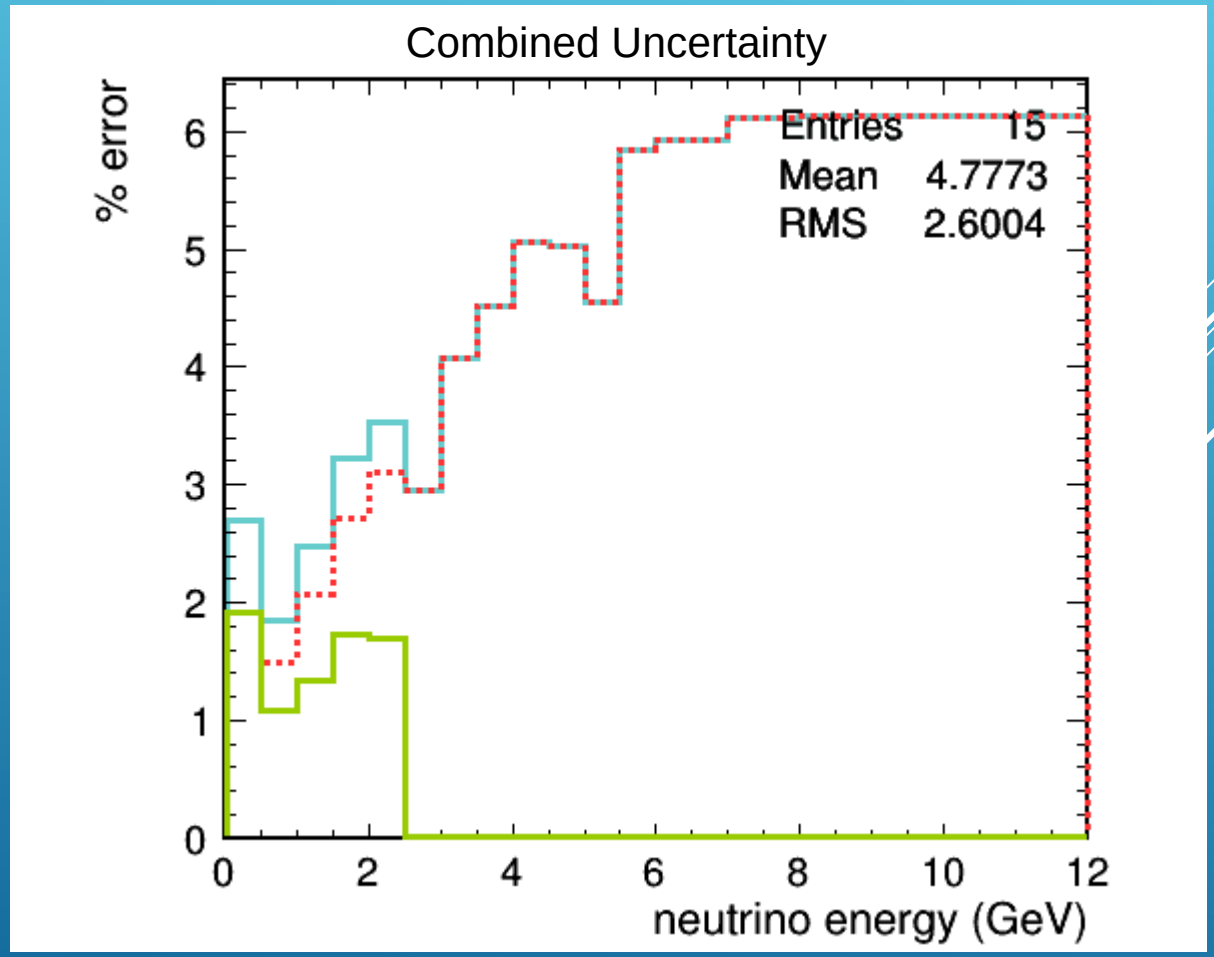

Flux of nue
0.000005
0.000004
0.000003
0.000002
0.000001
0.000000
nue flux
0
2
4
6
8
10
12
14
16
neutrino energy (GeV)


Total Uncertainty
Hadron Production Uncertainty
Beam Focusing Uncertainty

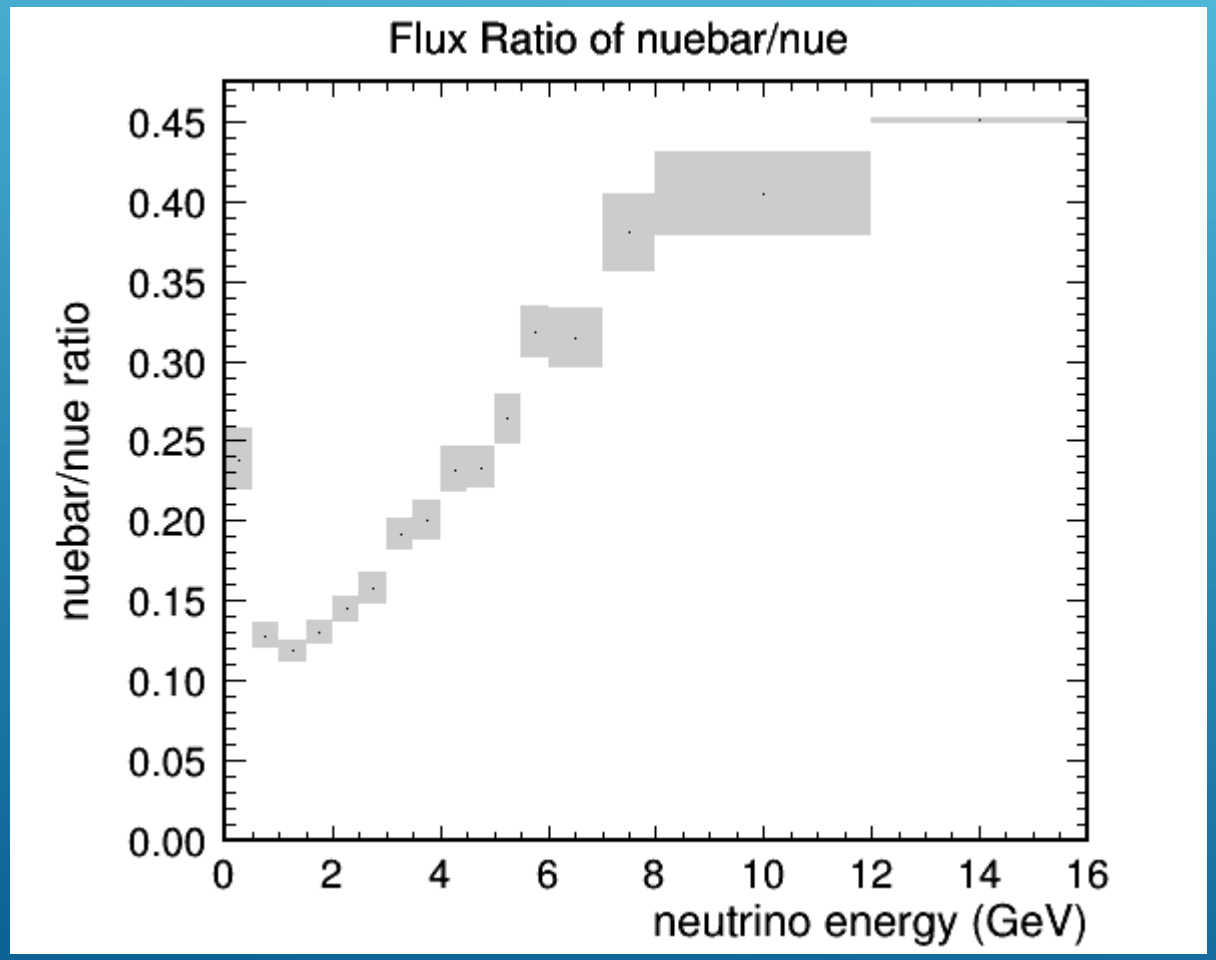

Combined Uncertainty
% error
Entries 15
Mean 3.6305
RMS 2.7985
0
2
4
6
8
10
12
14
0
2
4
6
8
10
12
neutrino energy (GeV)

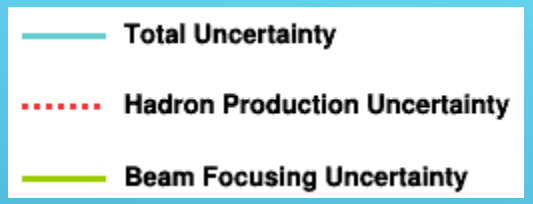
$$\frac{\nu_e}{\nu_\mu}$$

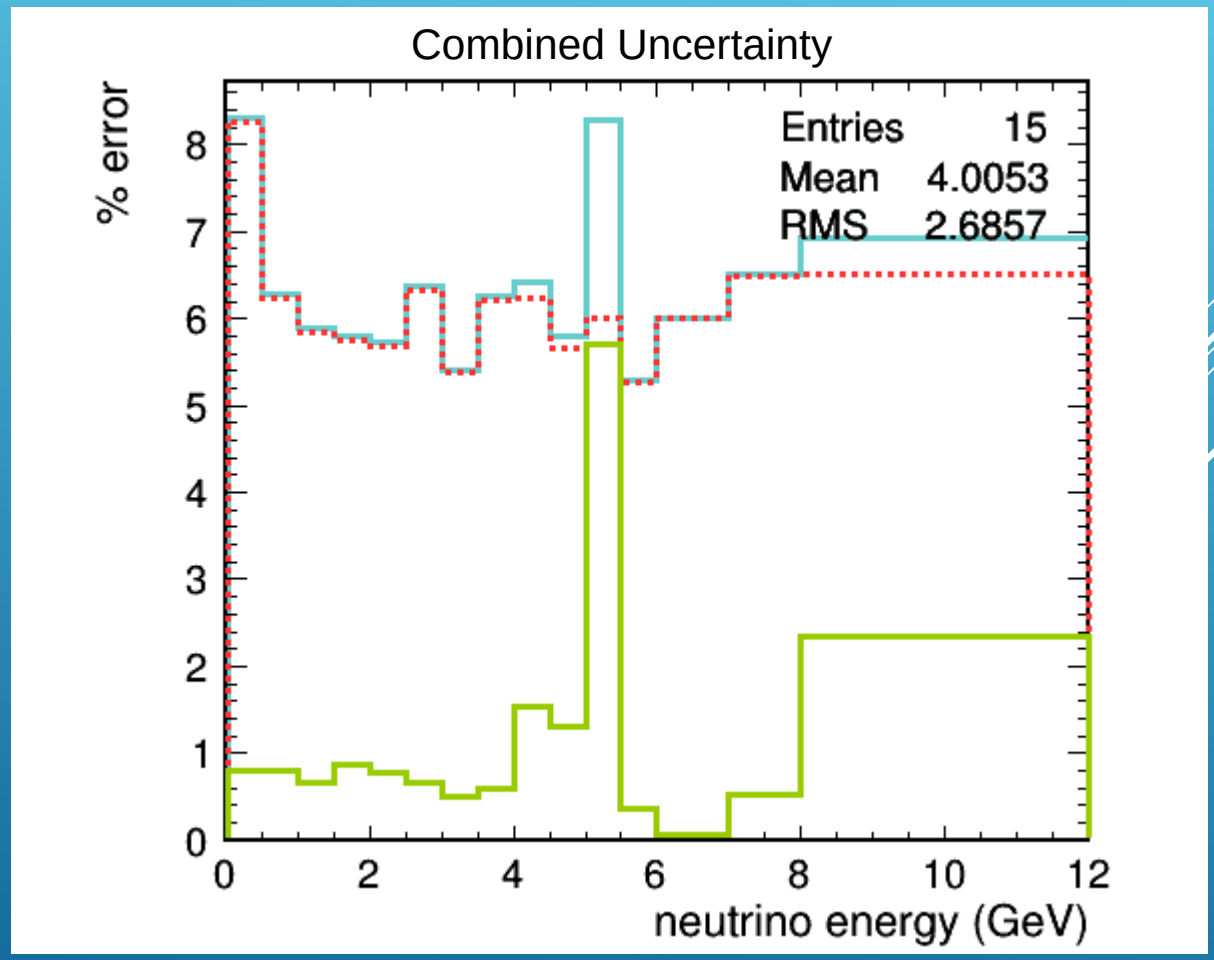




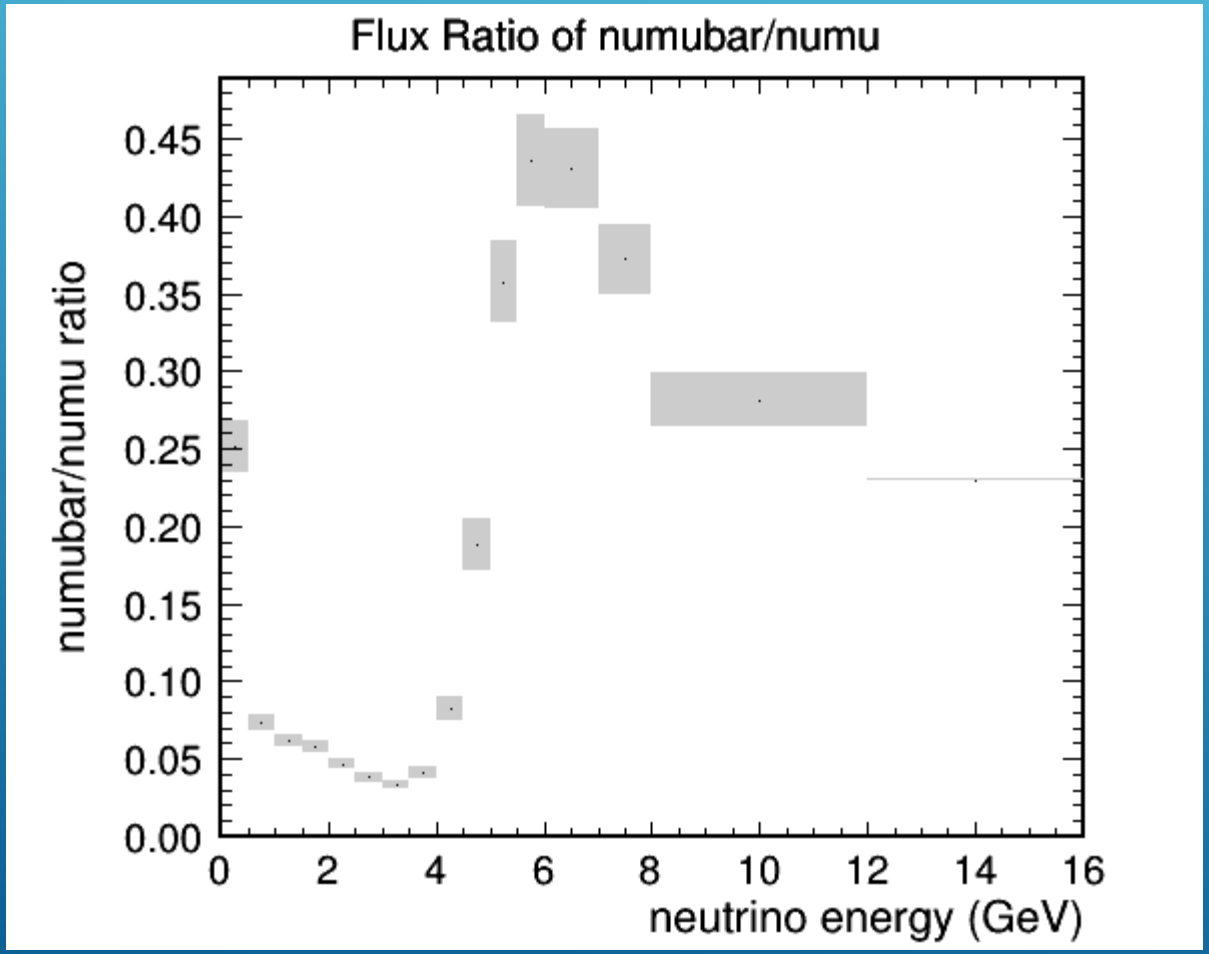
$$\frac{\bar{\nu}_e}{\nu_e}$$

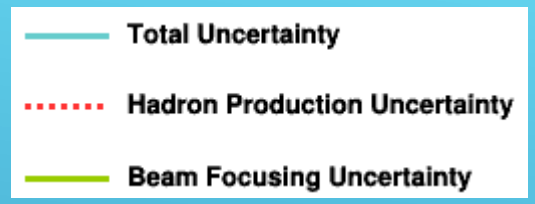


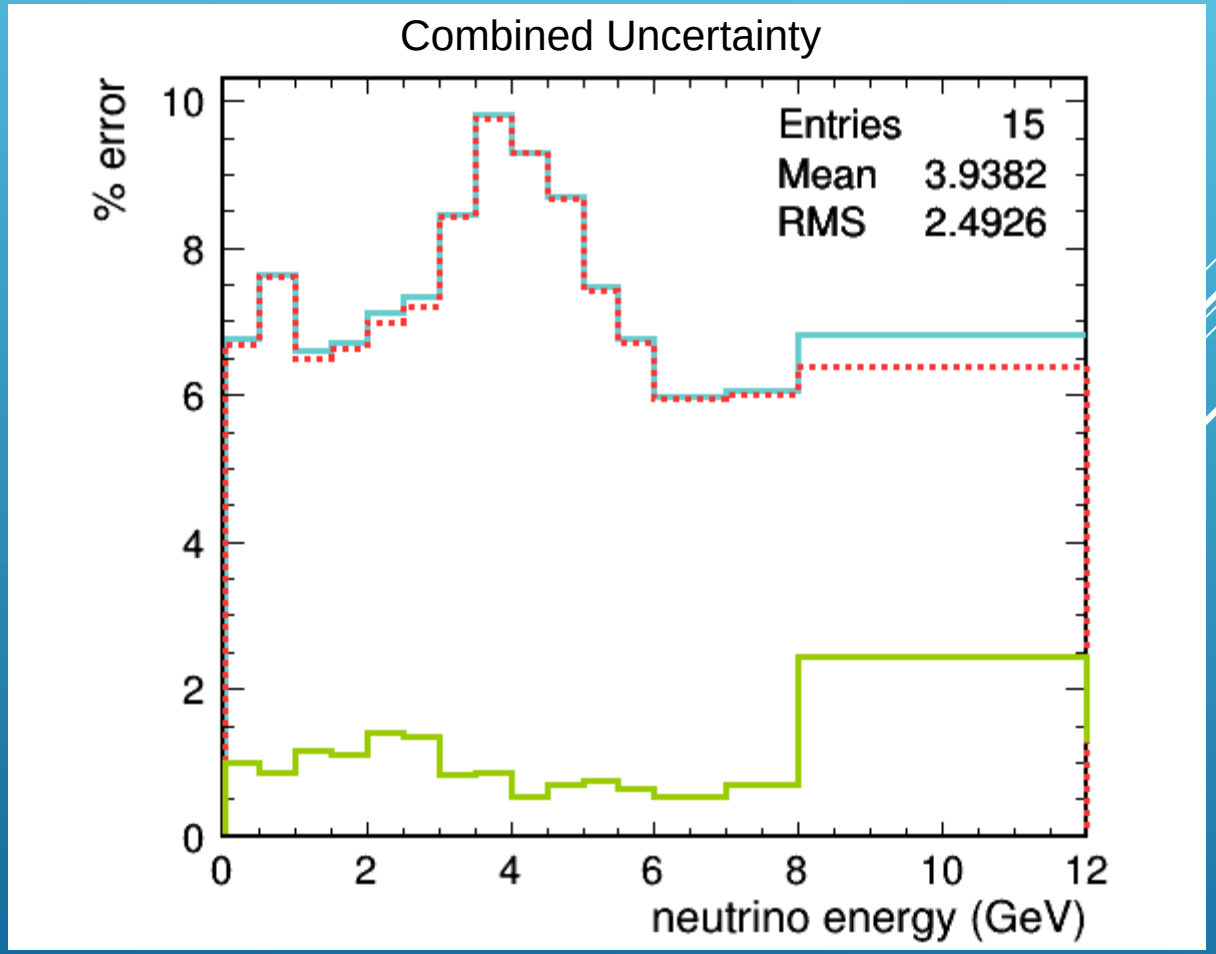




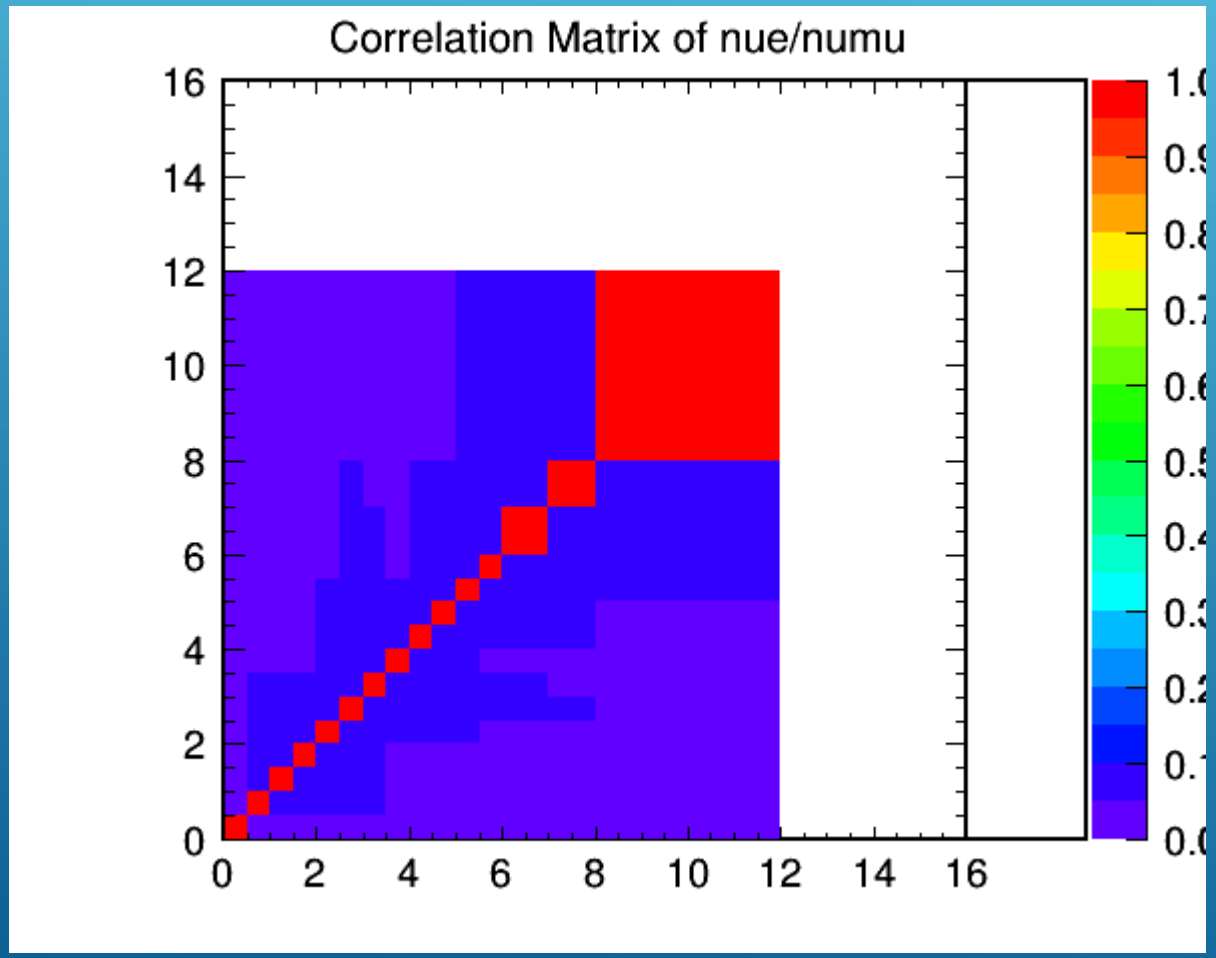
$$\frac{\overline{\nu_\mu}}{\nu_\mu}$$

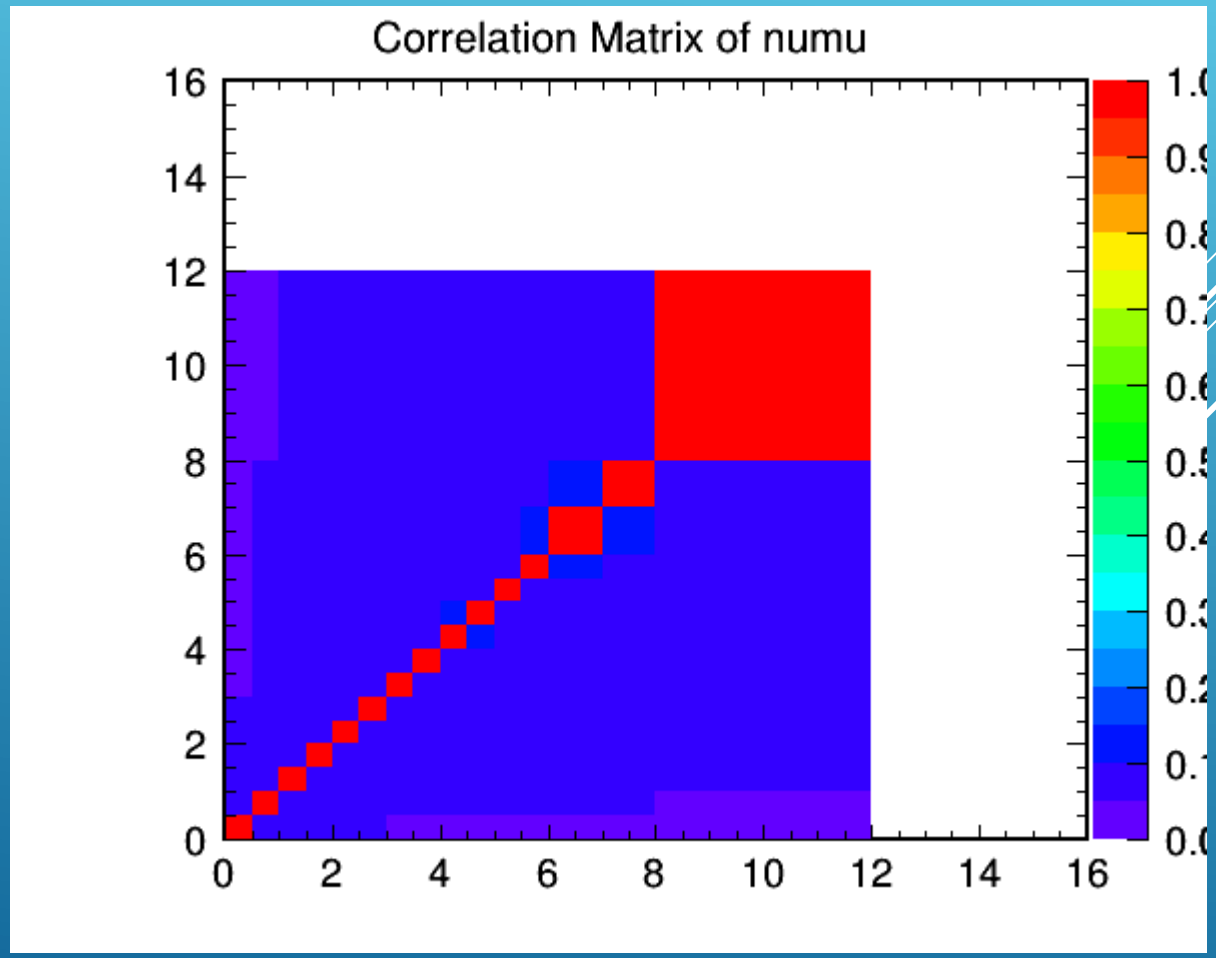






CORRELATION MATRICES





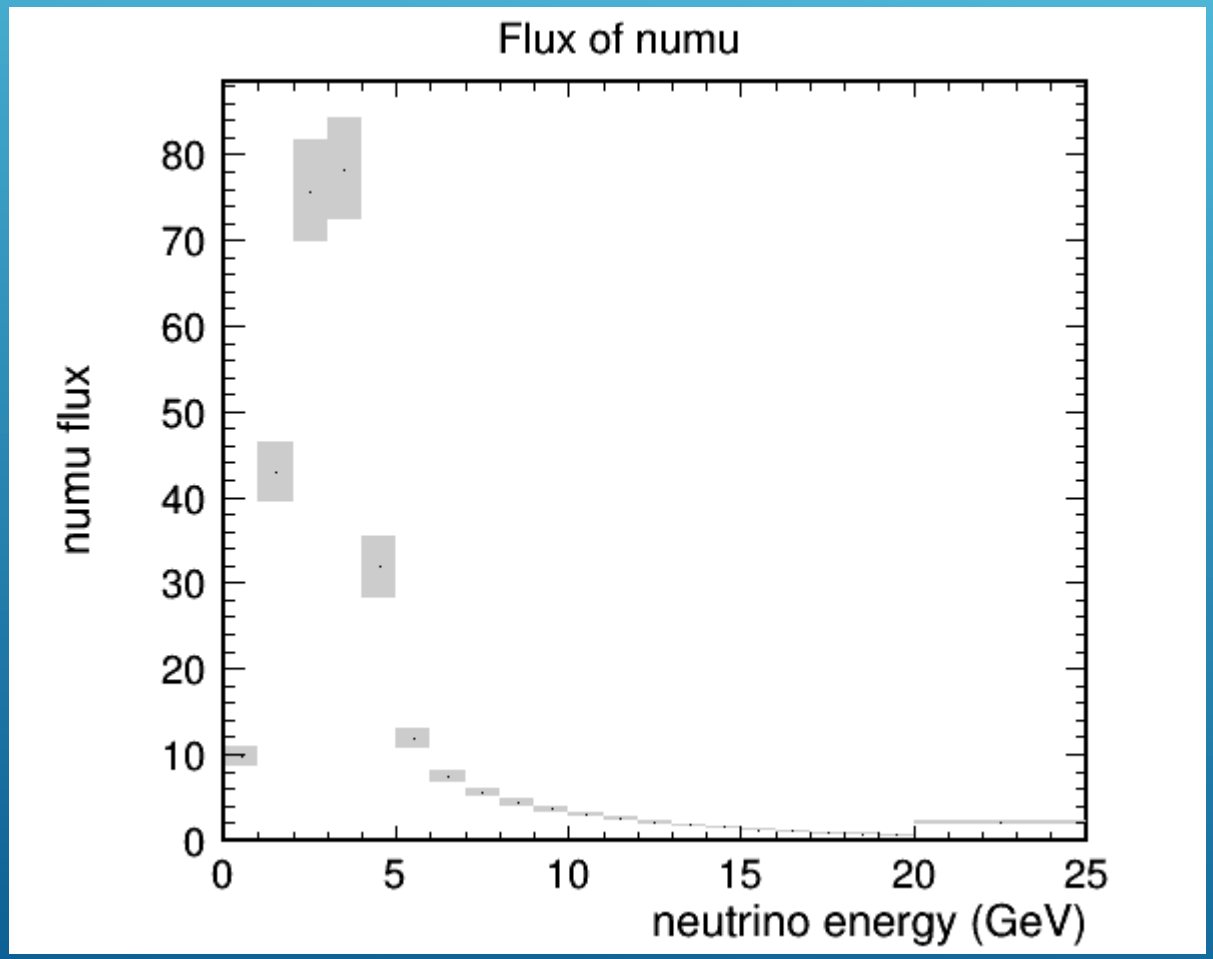
CONCLUSIONS

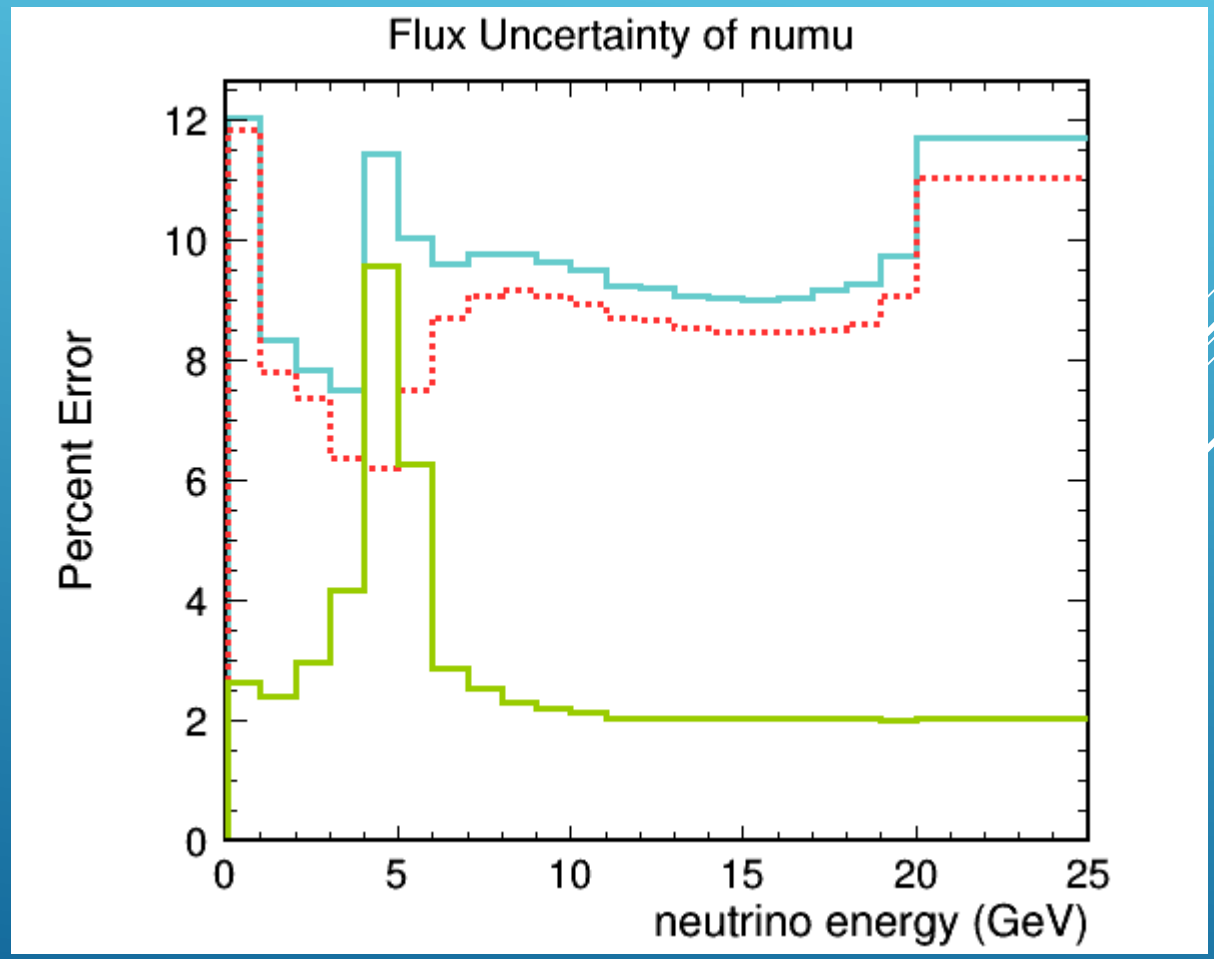
- The ν_e background is smaller than that of the NuMI beamline – this is known
- Level of $\frac{\nu_e}{\nu_\mu}$ uncertainty is small in the focusing peak due to the pion decay chain
- $\frac{\overline{\nu_e}}{\nu_e}$ has low statistics
- $\frac{\overline{\nu_\mu}}{\nu_\mu}$ not well-correlated

FURTHER WORK

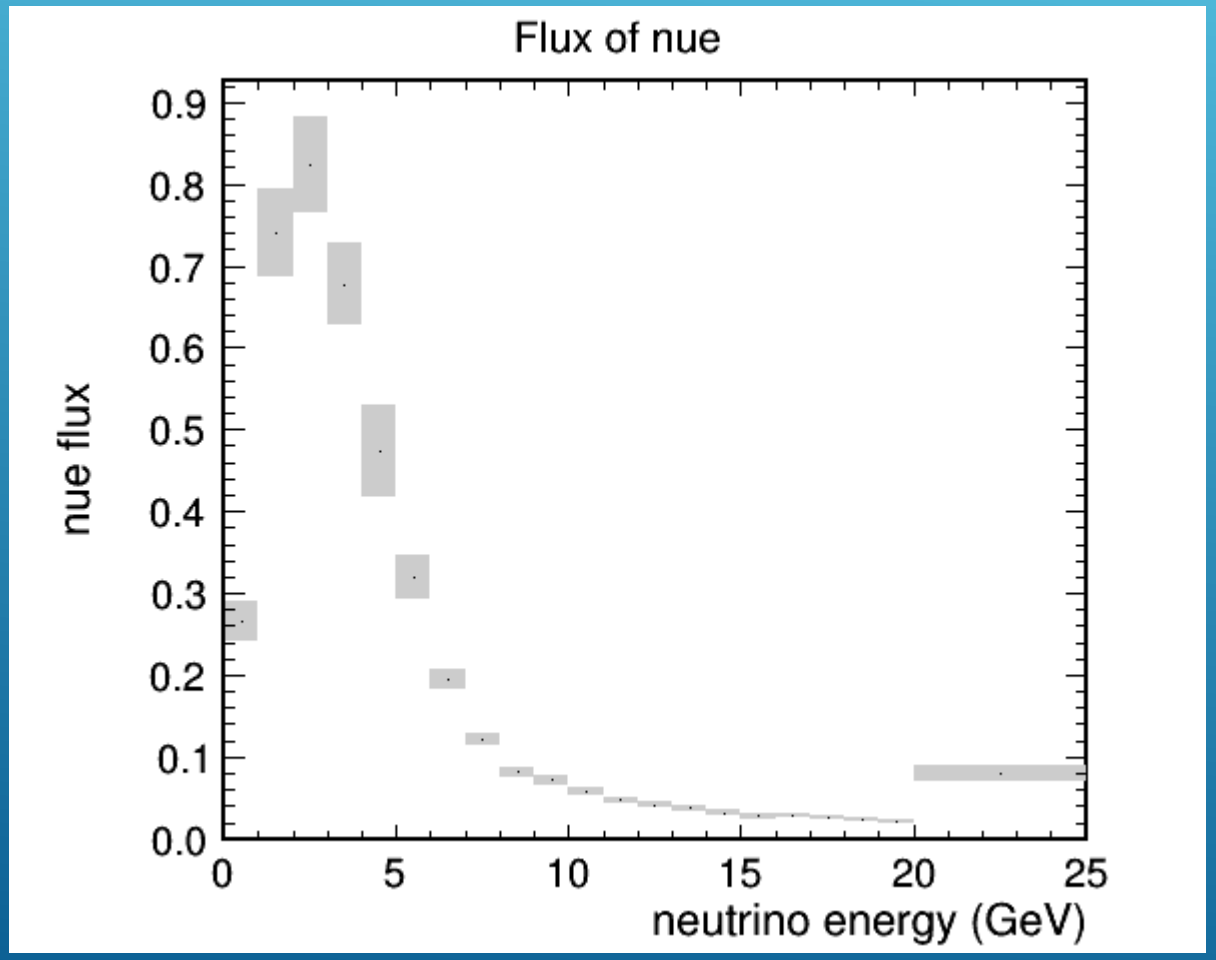
- Obtain the ND ppfx universes to rerun
- Normalize the ν_e and ν_μ fluxes
- Provide a tarball of the plots once this is done

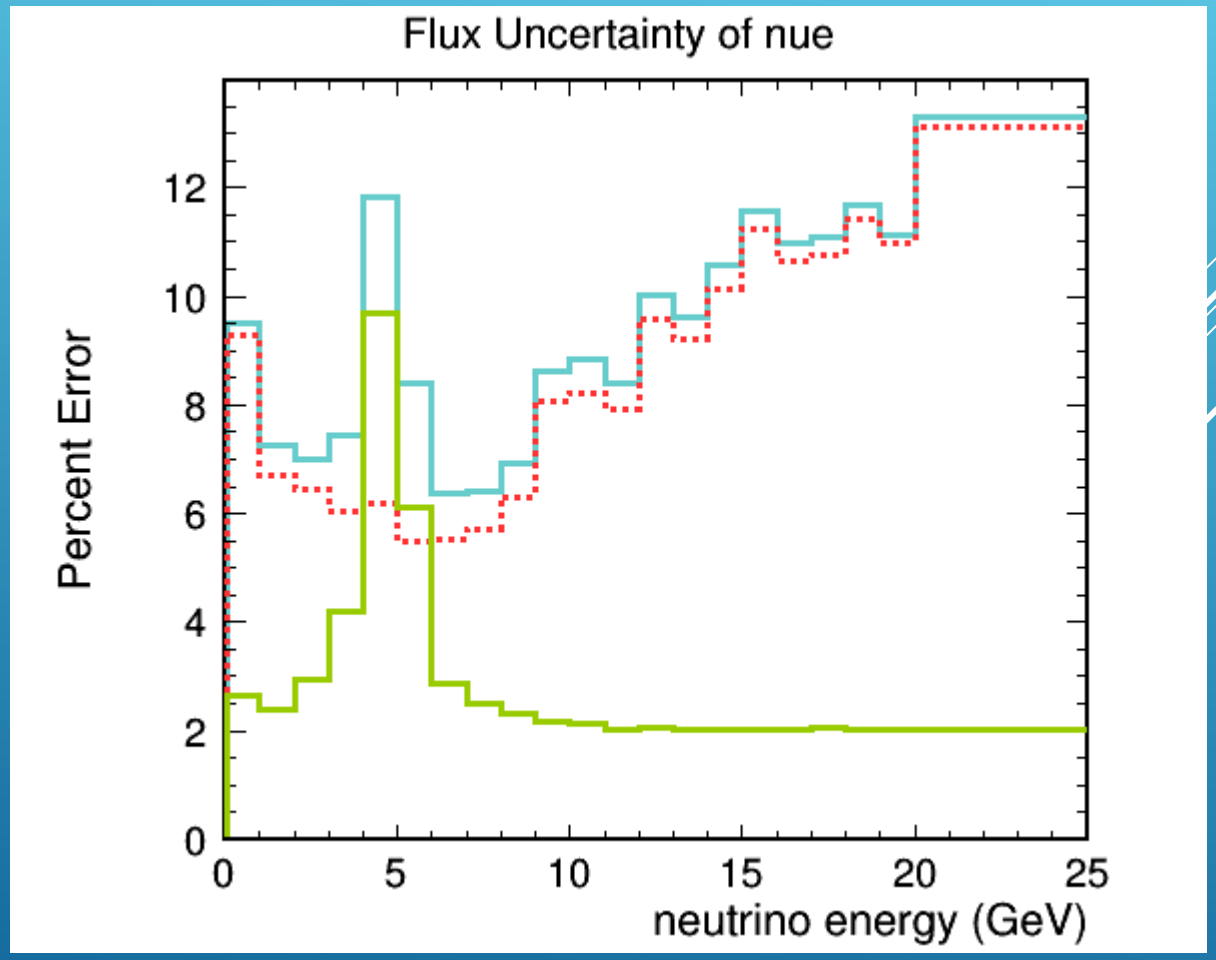
NUMI ν_μ


Flux of numu
numu flux
neutrino energy (GeV)
0
10
20
30
40
50
60
70
80
0
5
10
15
20
25

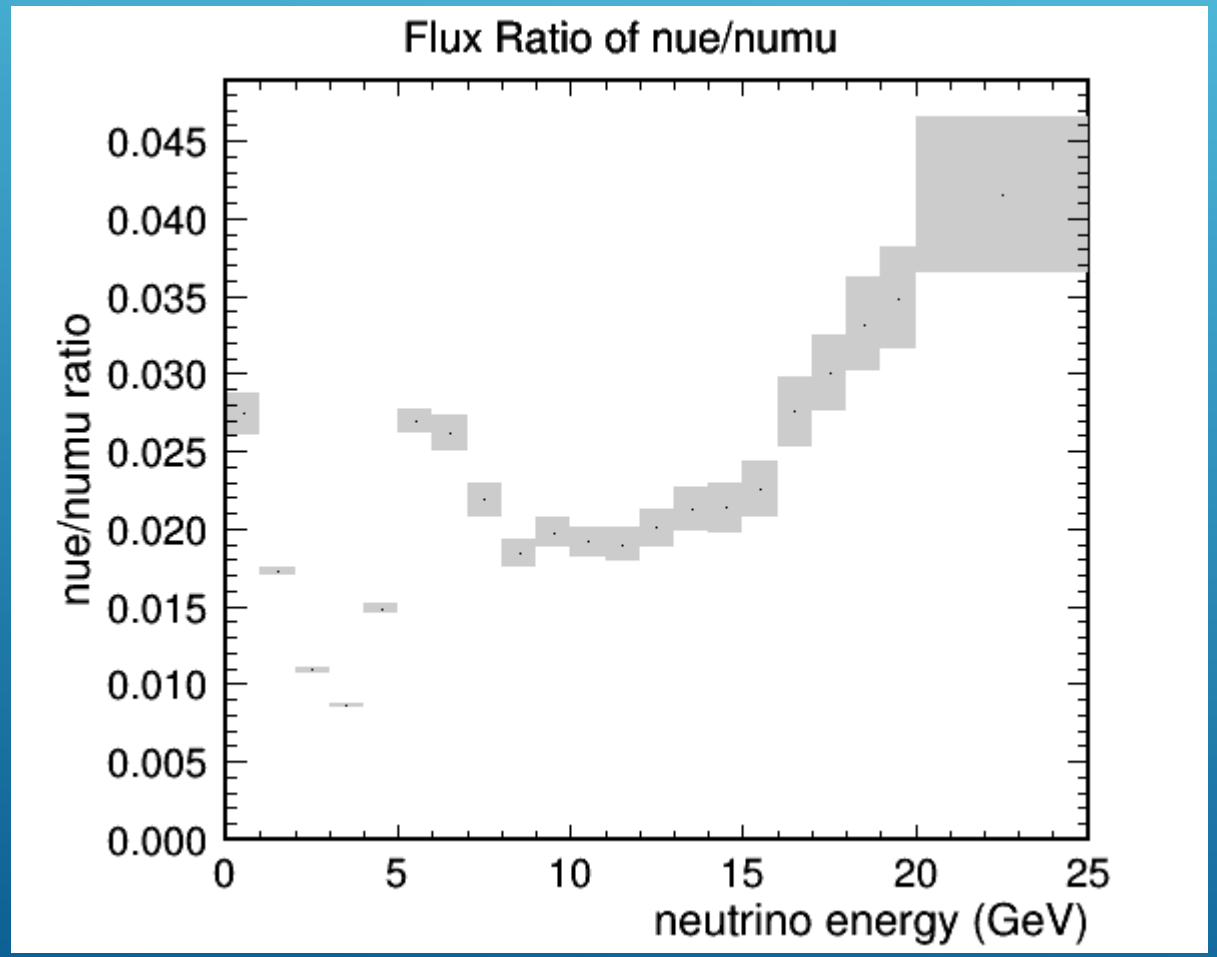

Total Uncertainty
Hadron Production Uncertainty
Beam Focusing Uncertainty
Flux Uncertainty of numu
Percent Error
neutrino energy (GeV)
0
2
4
6
8
10
12
0
5
10
15
20
25

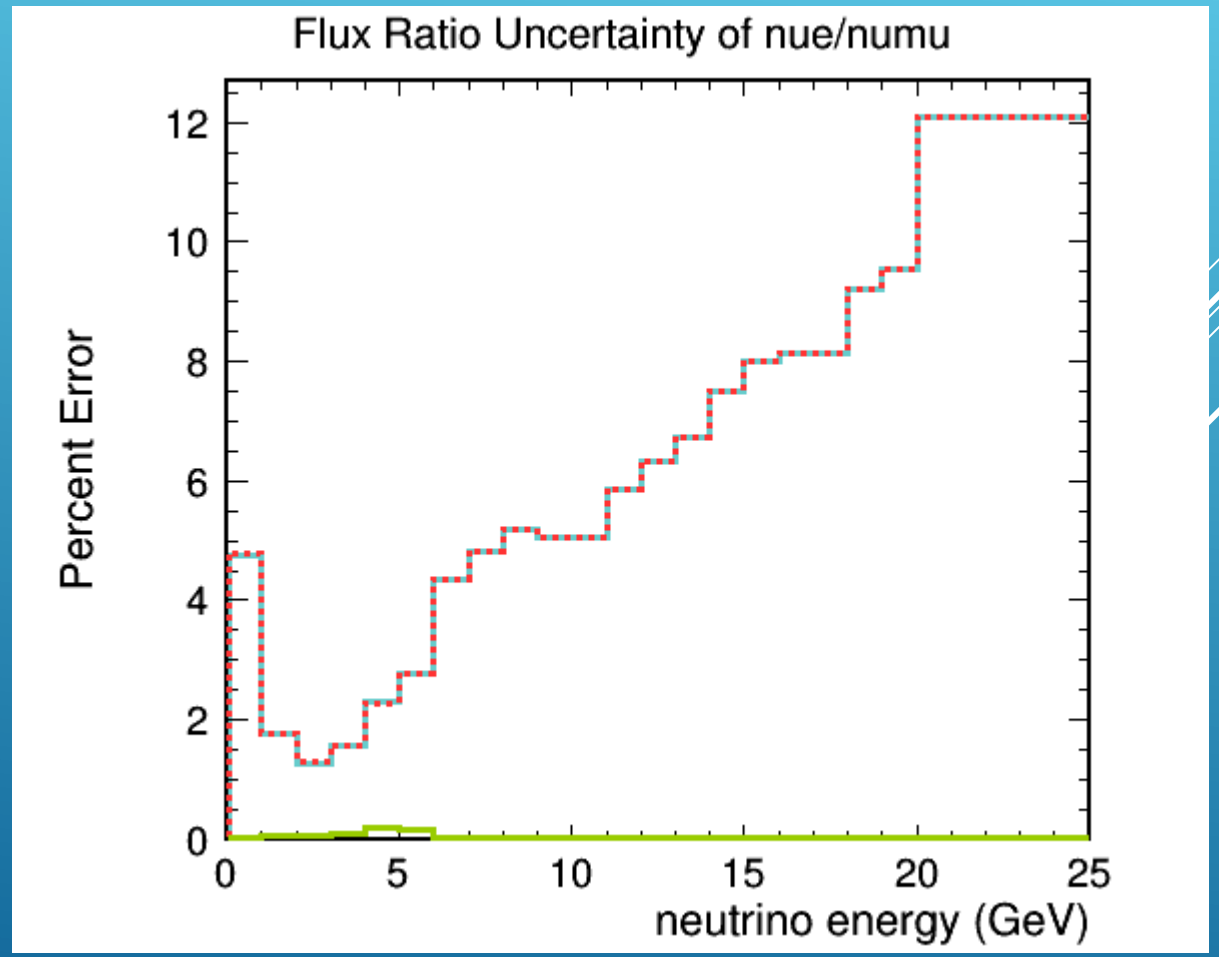
NUMI ν_e


Flux of nue
nue flux
neutrino energy (GeV)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
5
10
15
20
25

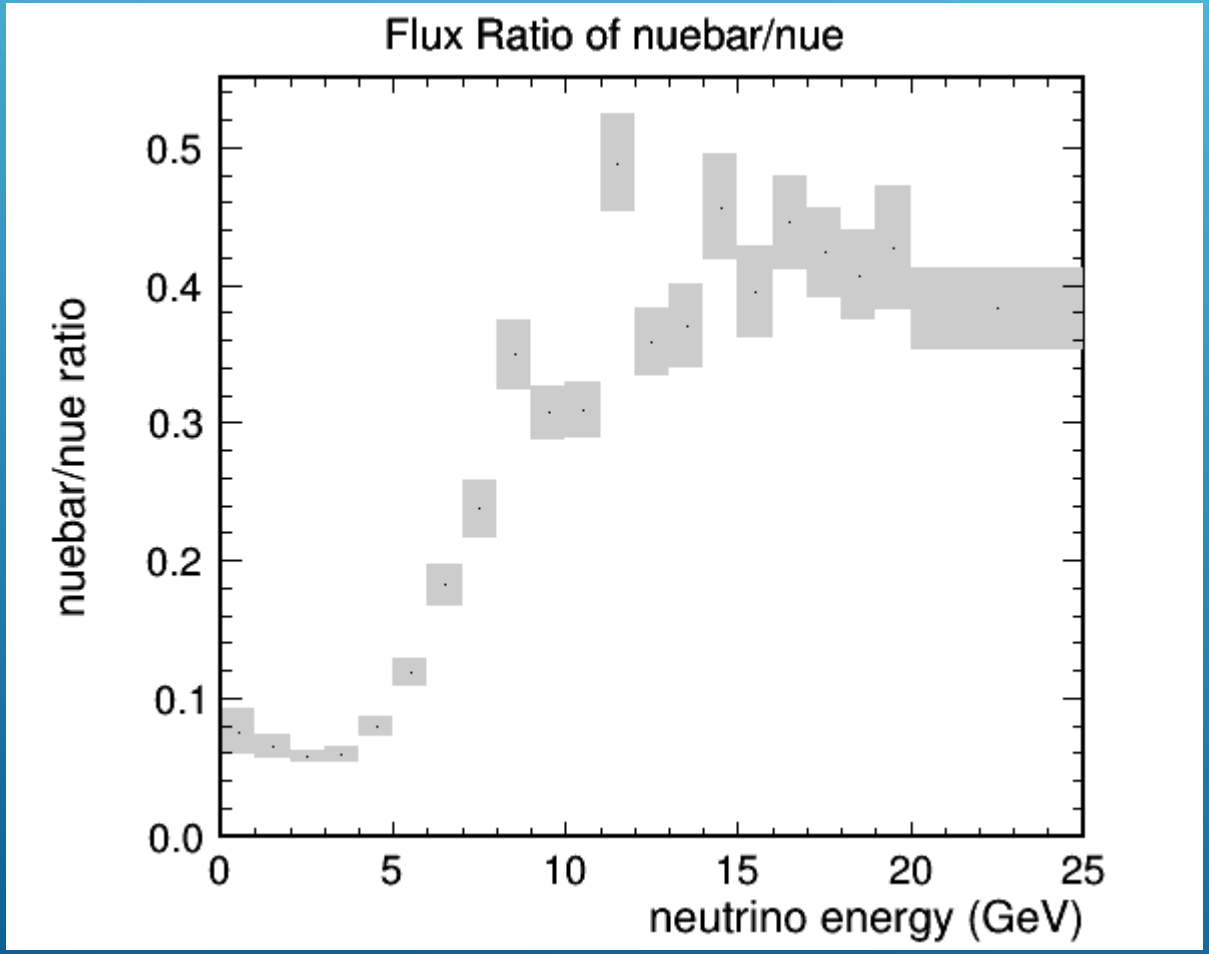

Total Uncertainty
Hadron Production Uncertainty
Beam Focusing Uncertainty
Flux Uncertainty of nue
Percent Error
neutrino energy (GeV)
0
2
4
6
8
10
12
0
5
10
15
20
25

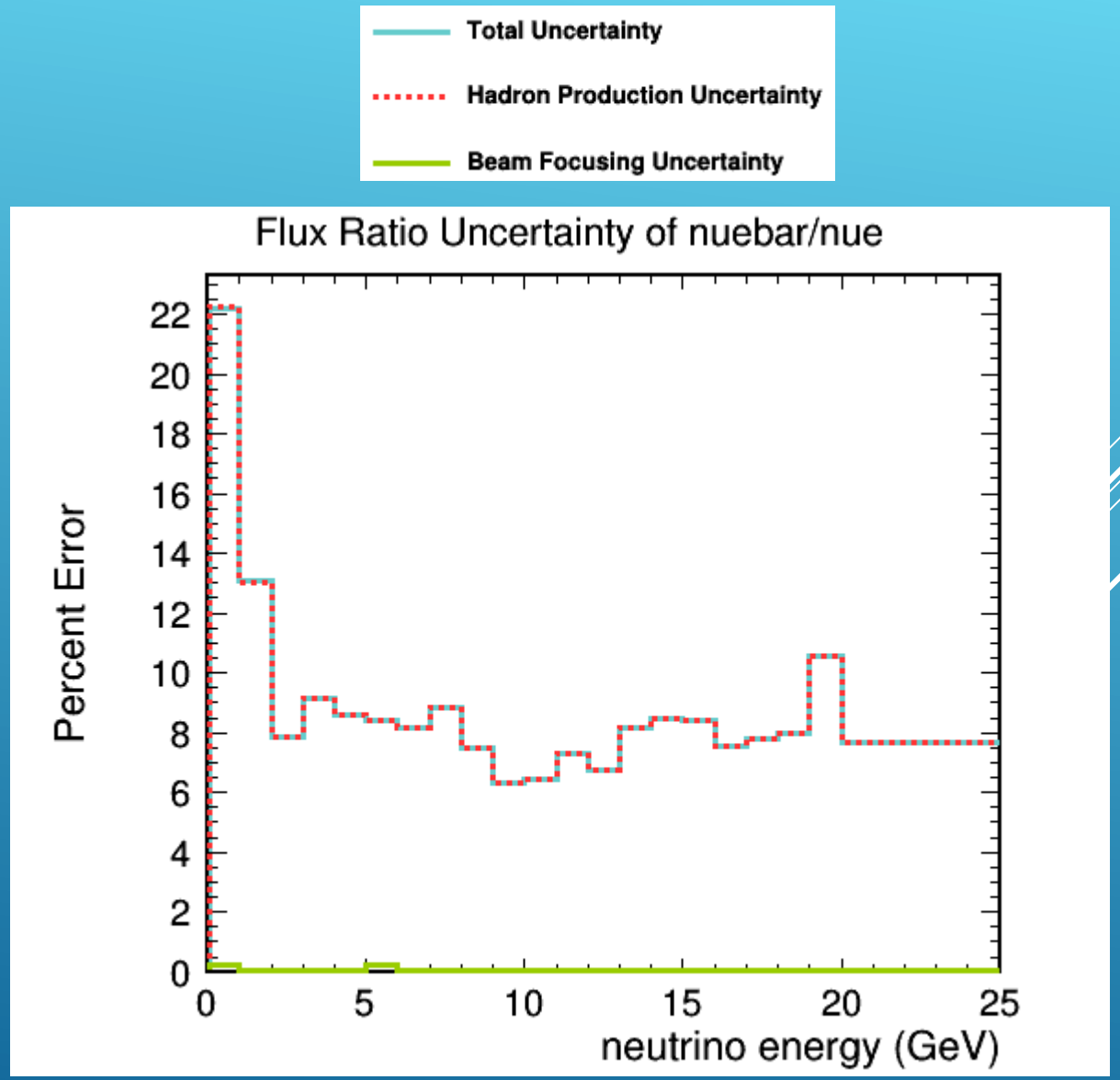
NUMI $\frac{\nu_e}{\nu_\mu}$



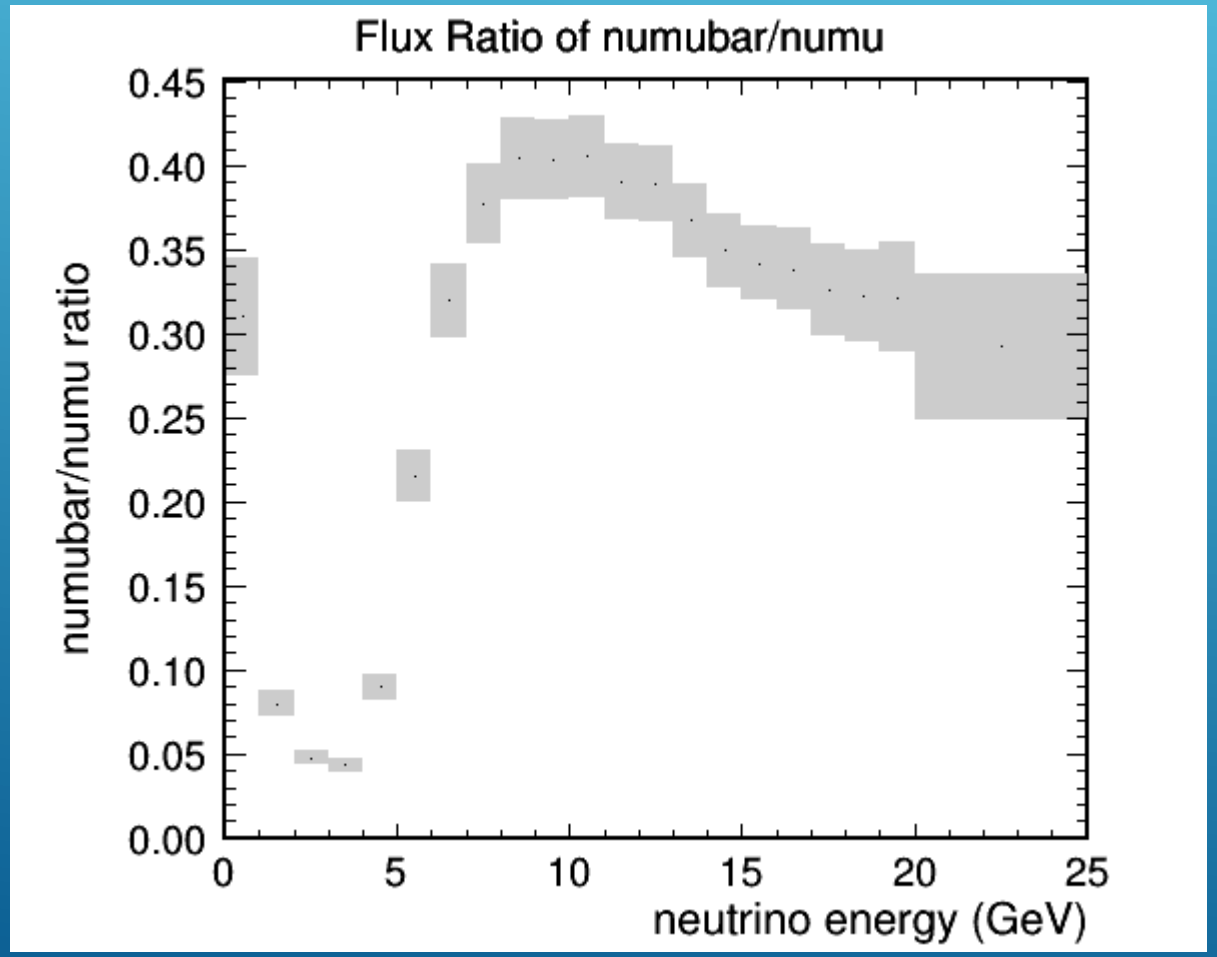


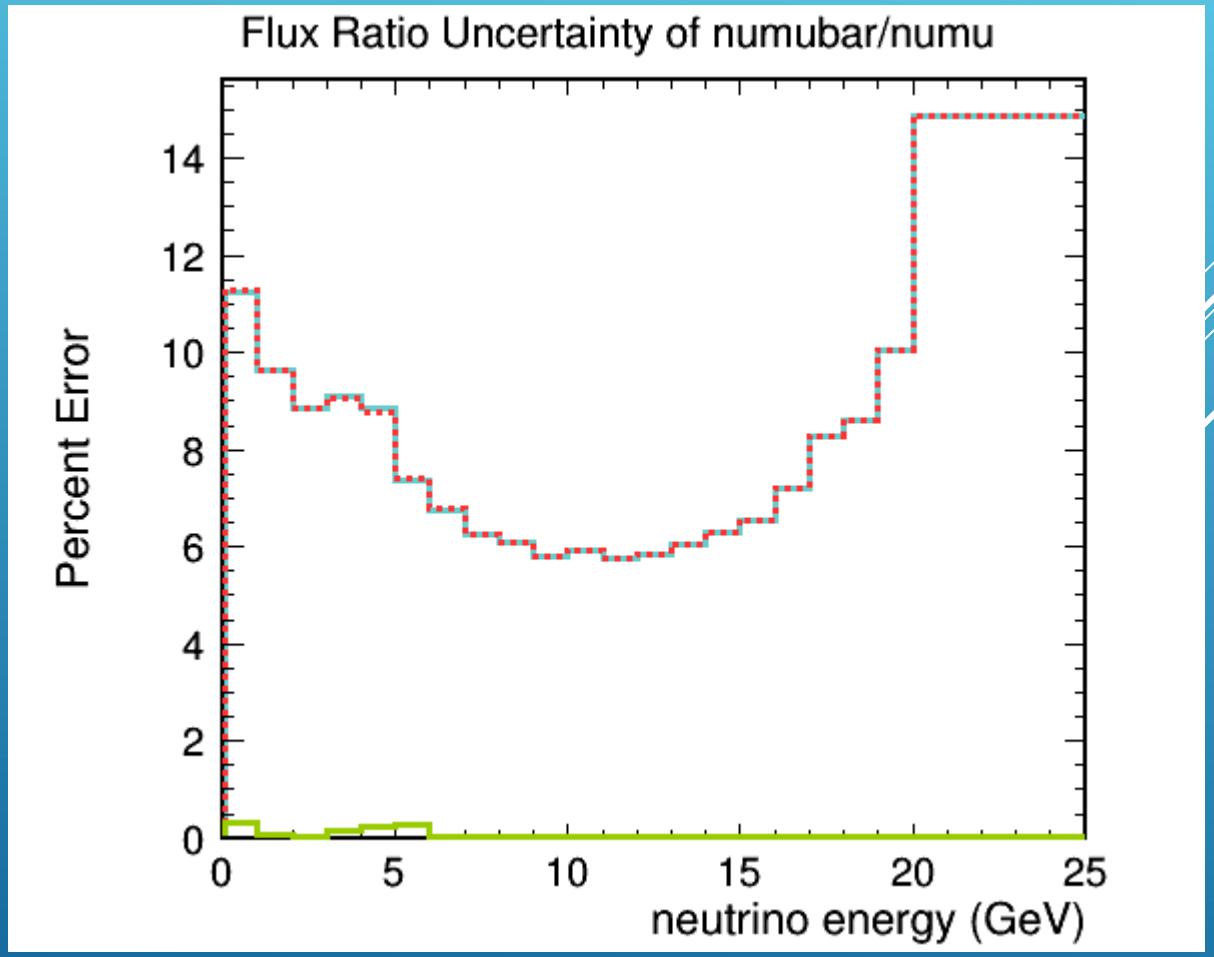
NUMI $\frac{\overline{\nu_e}}{\nu_e}$



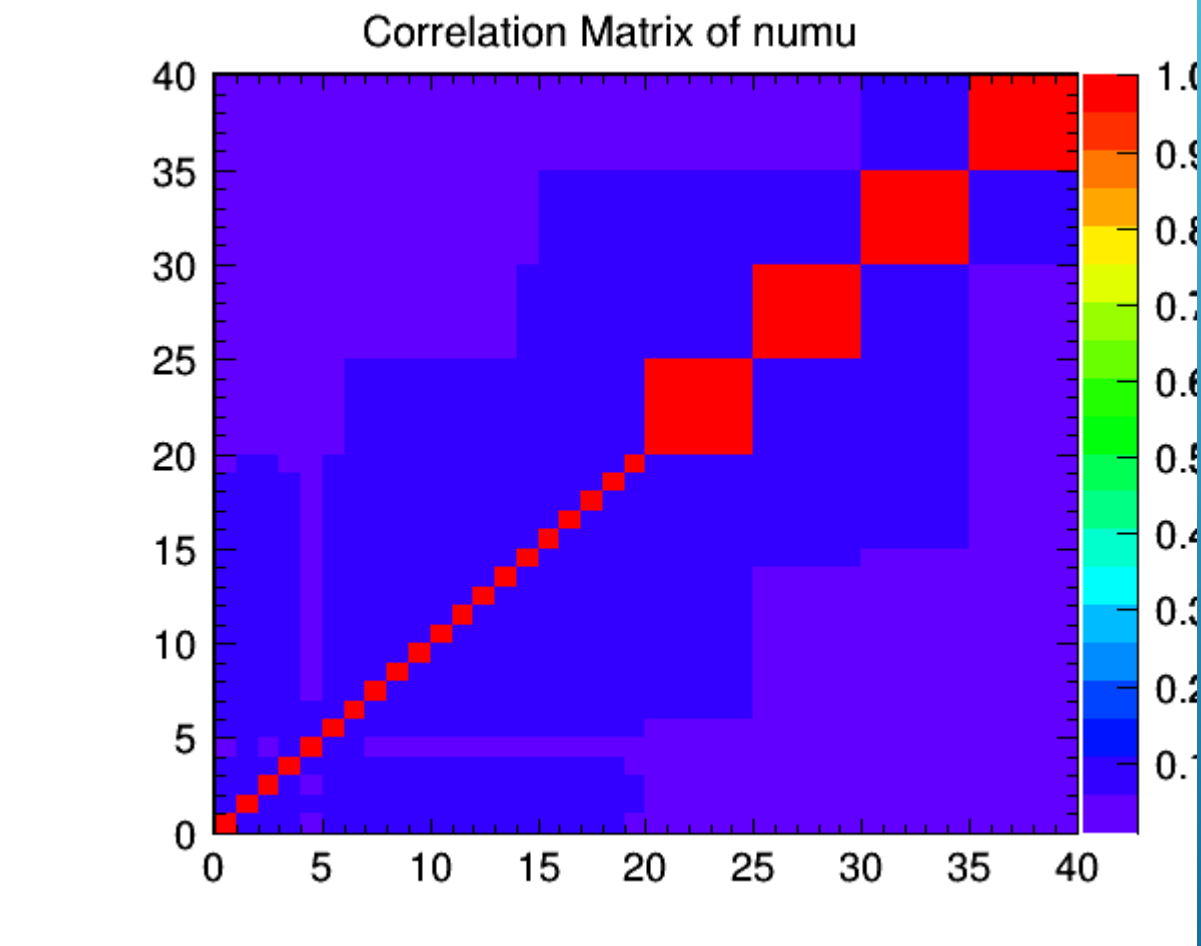


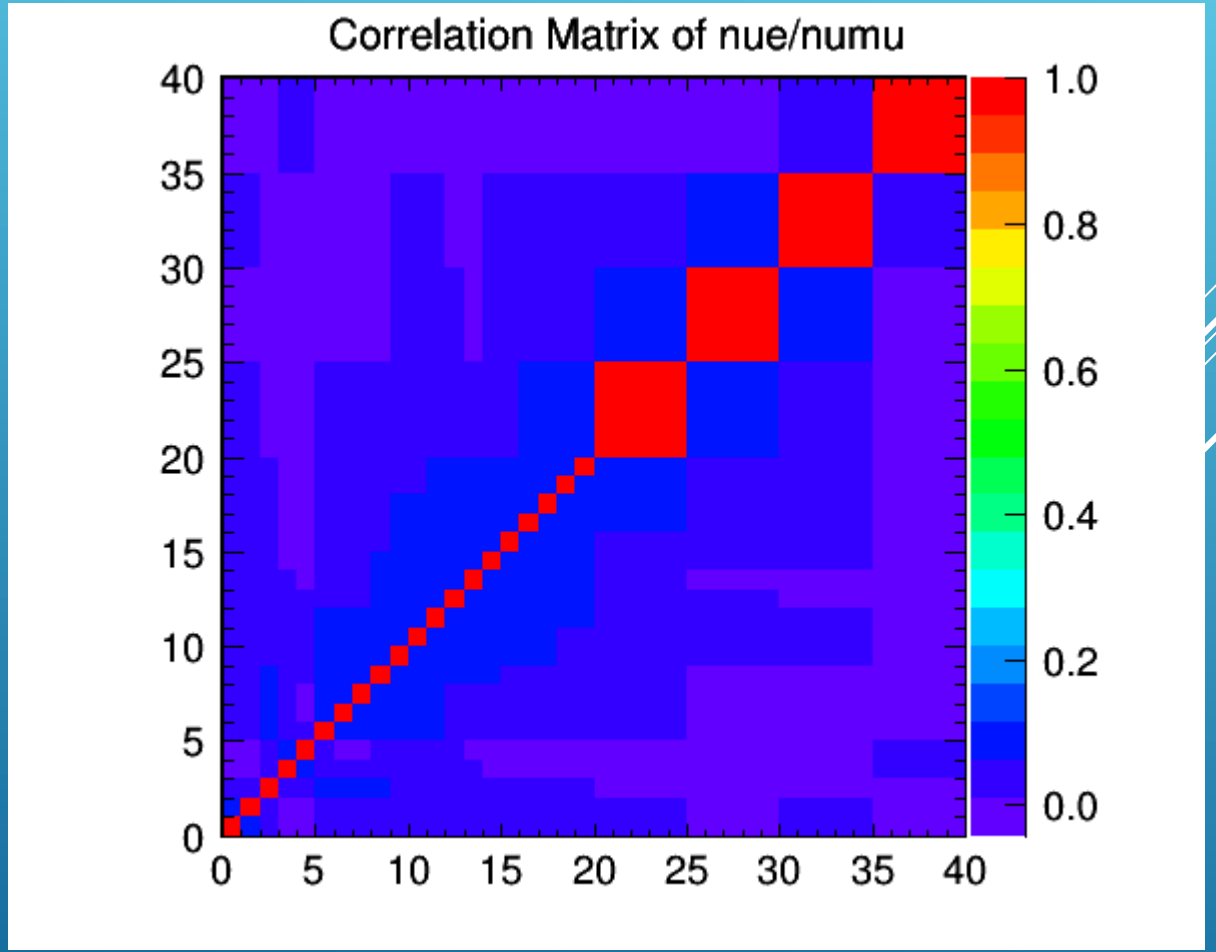
NUMI $\frac{\overline{\nu_\mu}}{\nu_\mu}$



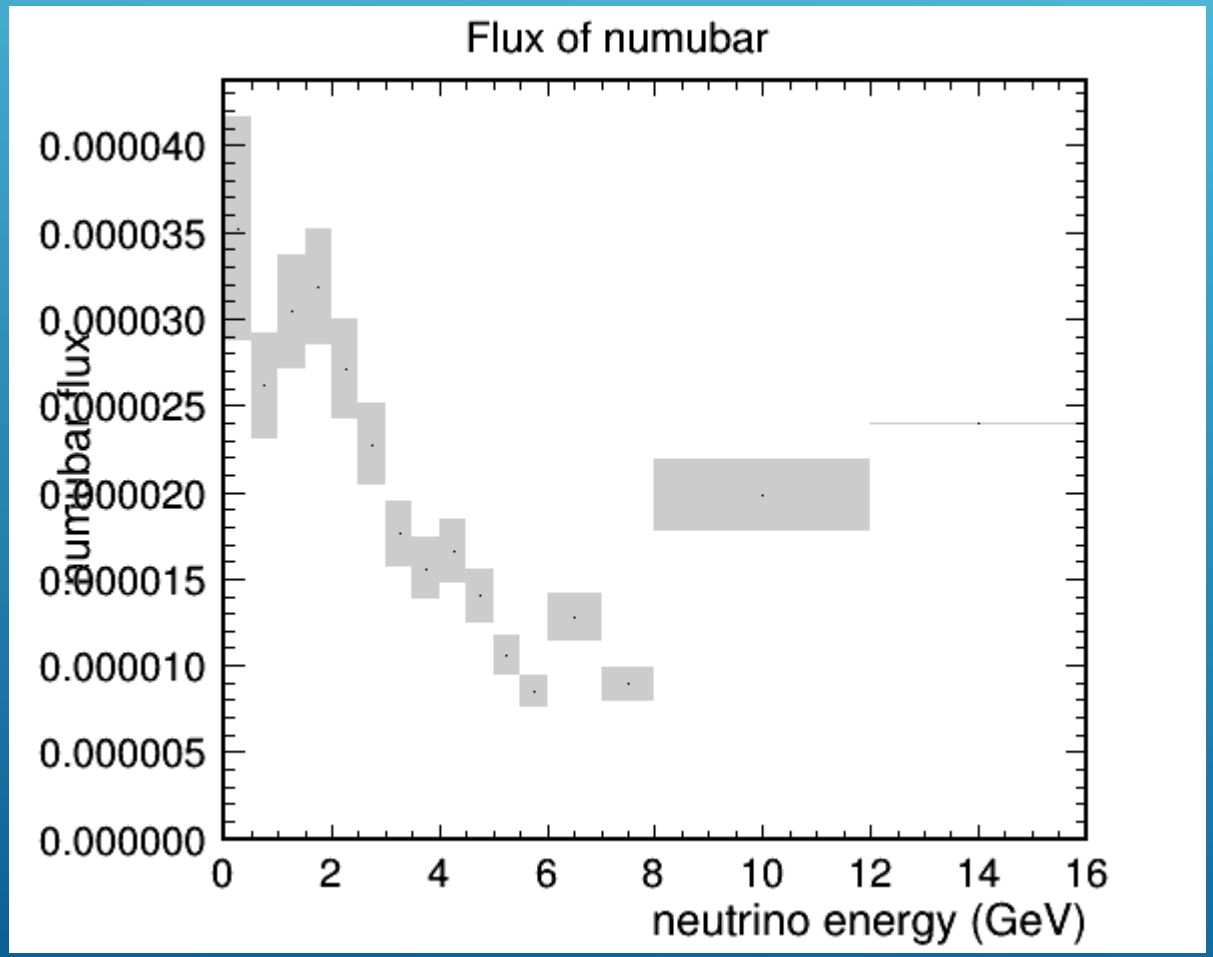


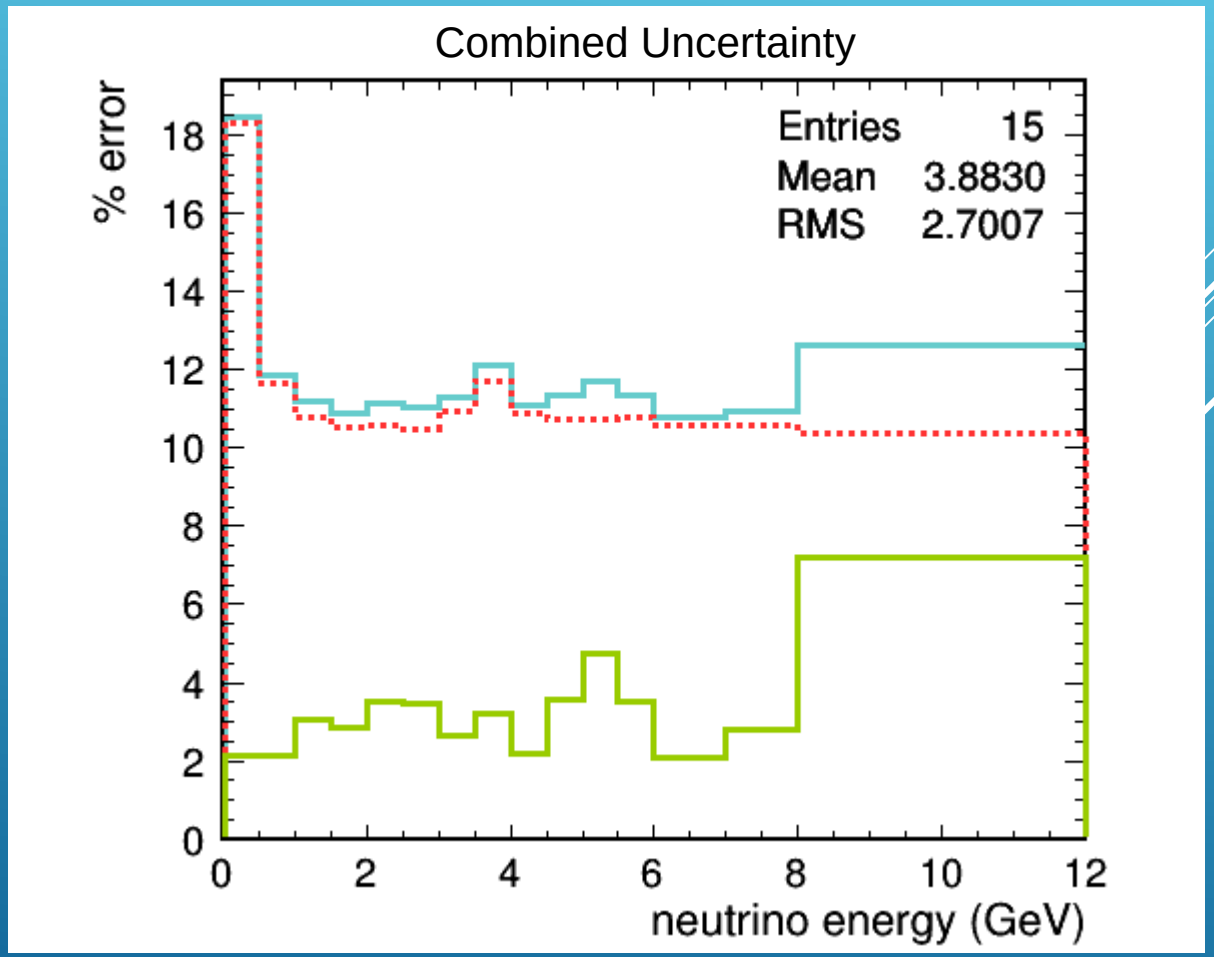
NUMI CORRELATION MATRICES





$\overline{\nu_\mu}$





$\overline{\nu}_e$