

NOvA ND Flux

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Fermilab

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- I will be focused on NovA ND ν_{μ} and ν_e HP corrected fluxes

calculated at the center of the front face:

$$(x,y,z) = (11.72, -3.32, 992.93) \text{ m} \sim 12.26 \text{ mrad.}$$

using thin target data for HP correction.

- I will not talk in detail about the NuMI beamline and all datasets or show all plots/results I have.

Introduction

MC Flux improvement

1. MC flux simulation

- Improved NuMI geometry implementation in g4numi: new horn model, longitudinal position in the target (LE), missing materials, etc.
- Modified Geant4 to include some variables not available to the users.
- Use dk2nu/dkmeta ntuple format.

MC Flux improvement

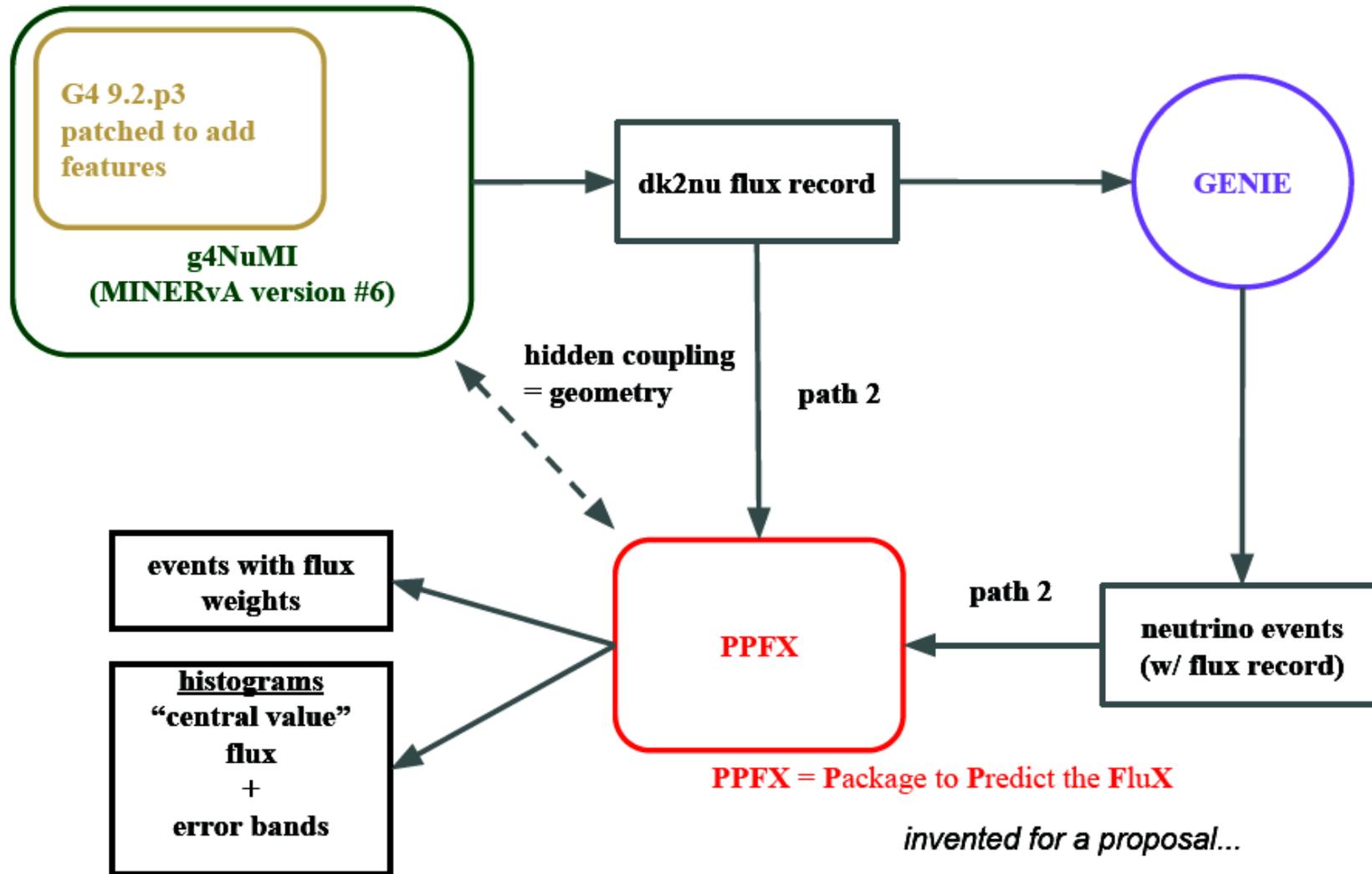
2. Data survey.

- Extensive survey of data sets: inelastic cross-sections, differential cross-sections, etc.
- Study and implementation of data systematic correlations.

3. PPFX

- Package to Predict the flux: calculates HP neutrino weights and handles the correlations.
- Switch modes: using thick target data as primary correction or only thin target data.

How it works



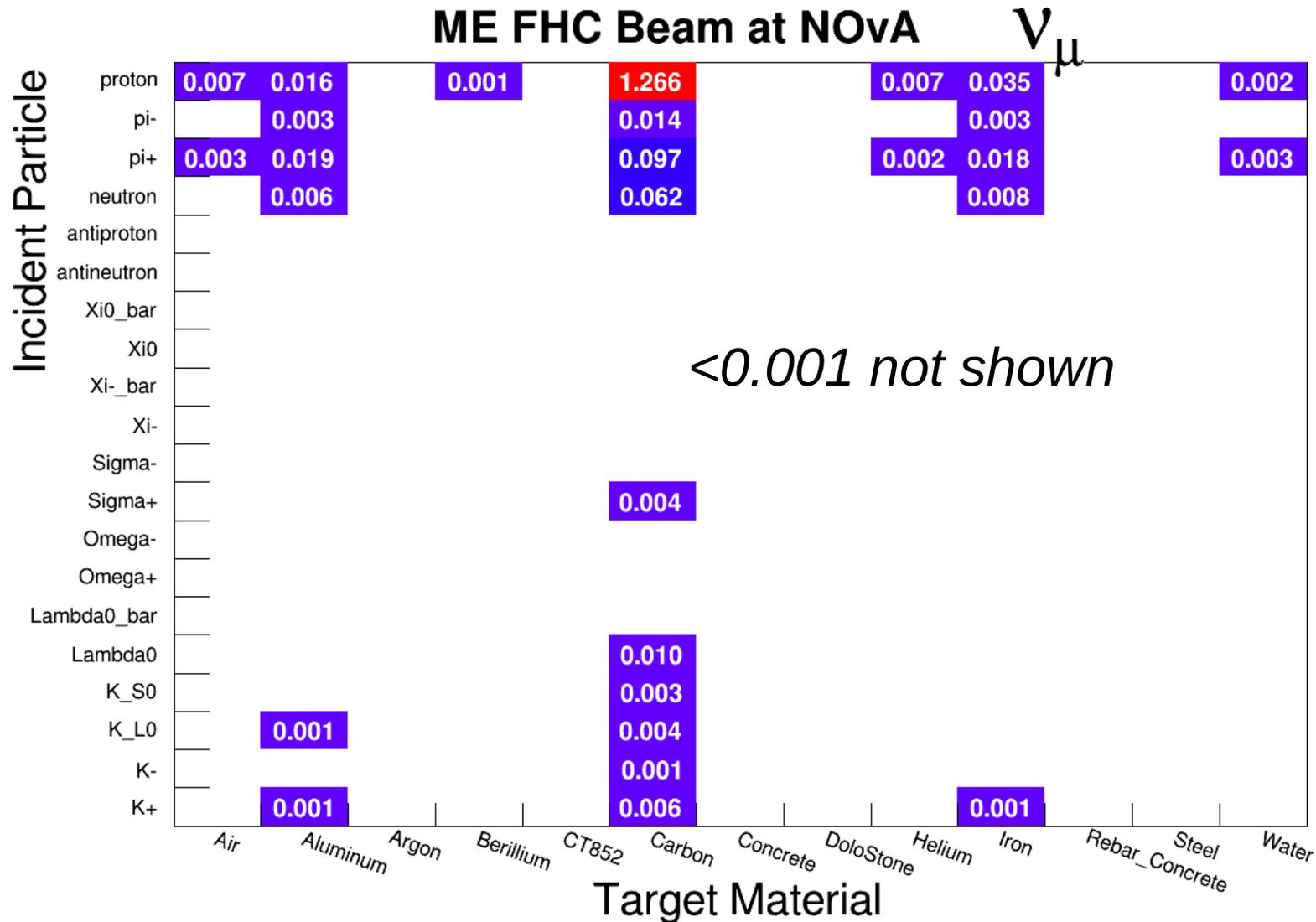
Output

- PPFX assigns a “central value” weight to each neutrino.
 - Based on its ancestry of interactions and how the MC cross-sections agree with data.
 - Filing a histogram with these weights gives you the best guess prediction.
- PPFX assigns N additional “multi-universe” weights to each neutrino
 - Each universe has underlying cross-sections shifted randomly according to joint covariance matrix.
 - Use to make error bands.

Neutrino ancestry

<# interactions> / ν_{μ} in NOvA ND

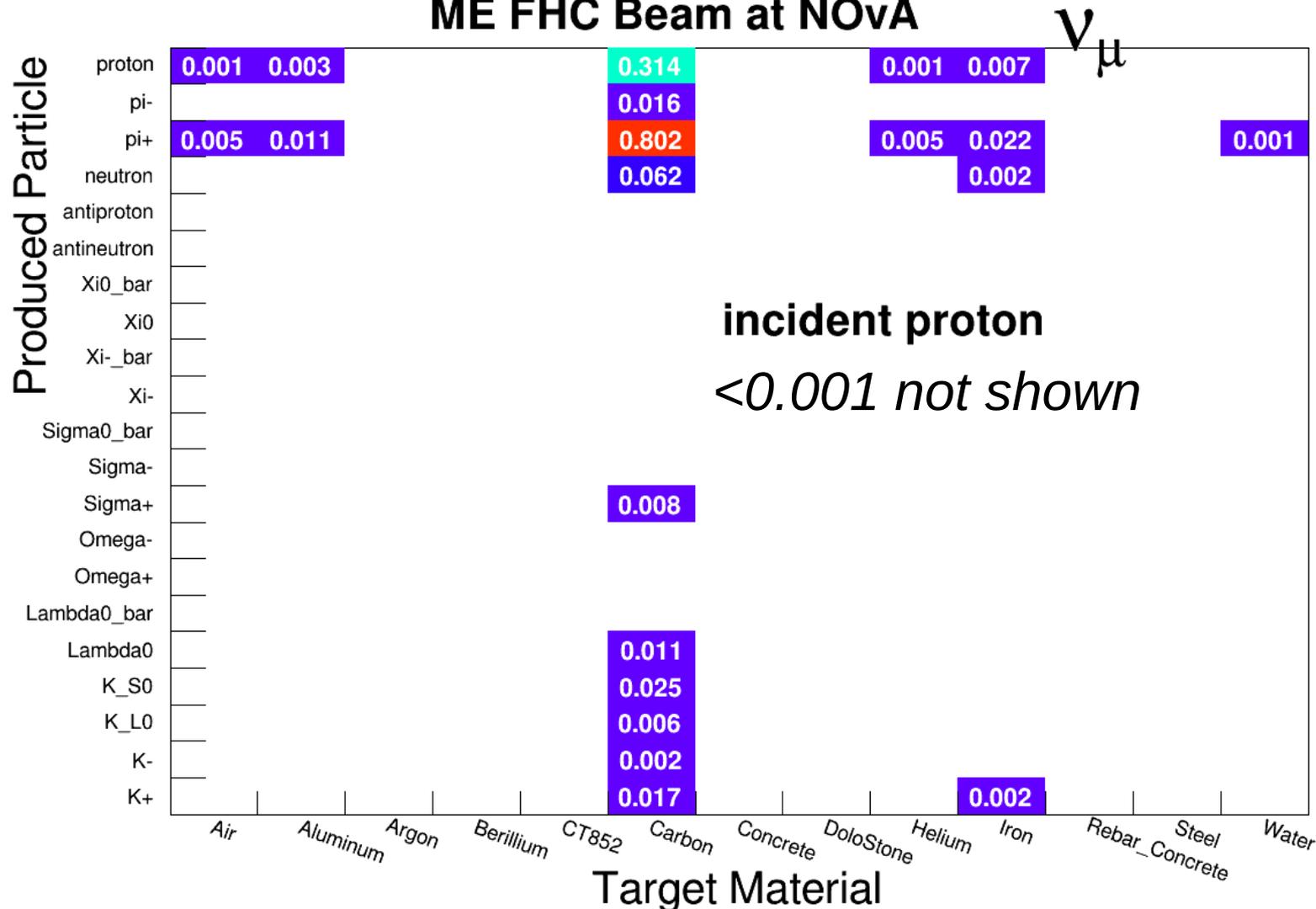
- Flux integrated in [0,20] GeV.



$\langle \# \text{ interactions} \rangle / \nu_{\mu}$ in NOvA ND

- Flux integrated in [0,20] GeV.

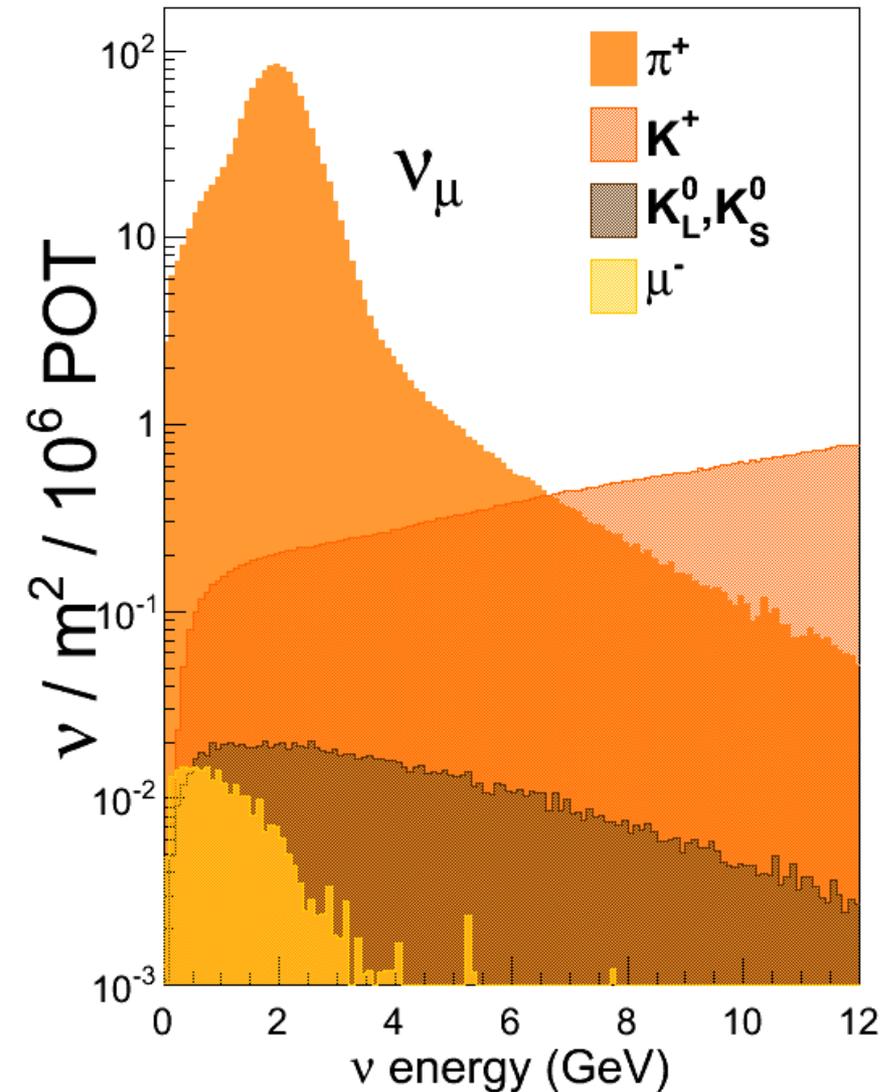
ME FHC Beam at NOvA



Neutrino Parent identity

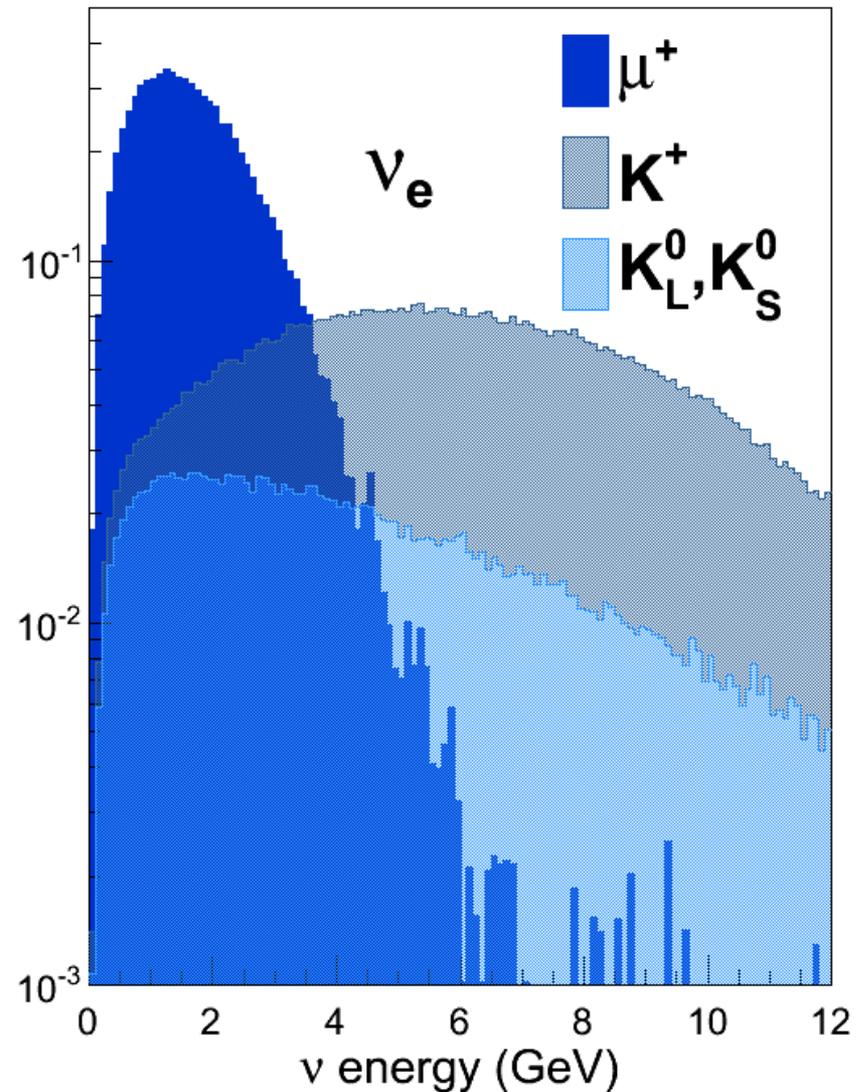
Muon neutrino

ME FHC at NOvA Near



Electron neutrino

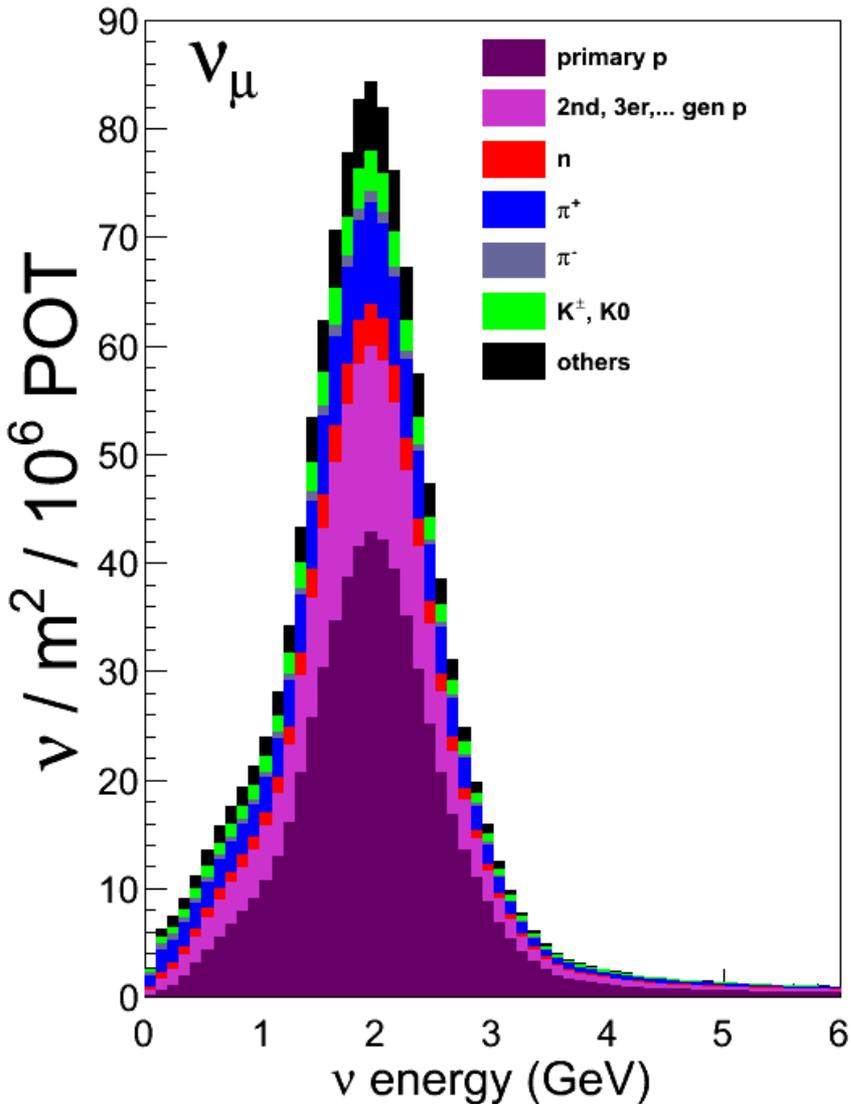
ME FHC at NOvA Near



Neutrino Grandparent identity

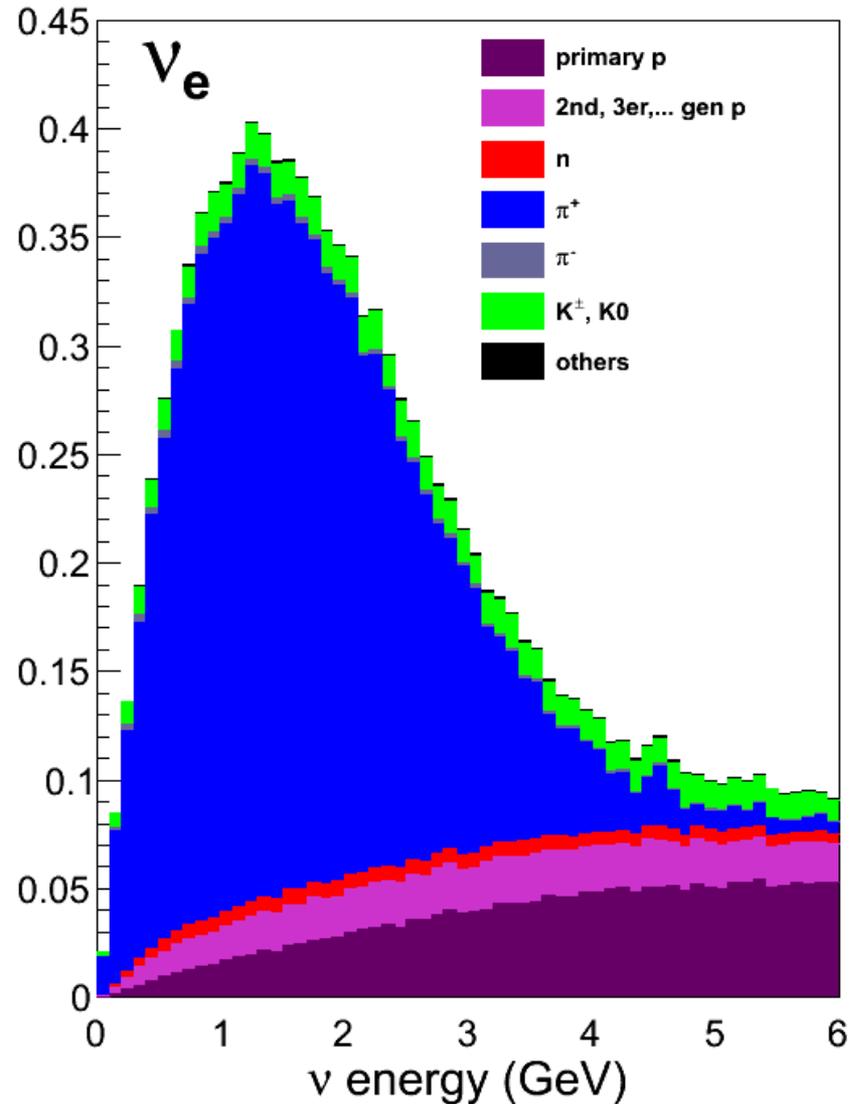
Muon neutrino

ME FHC at NOvA Near



Electron neutrino

ME FHC at NOvA Near



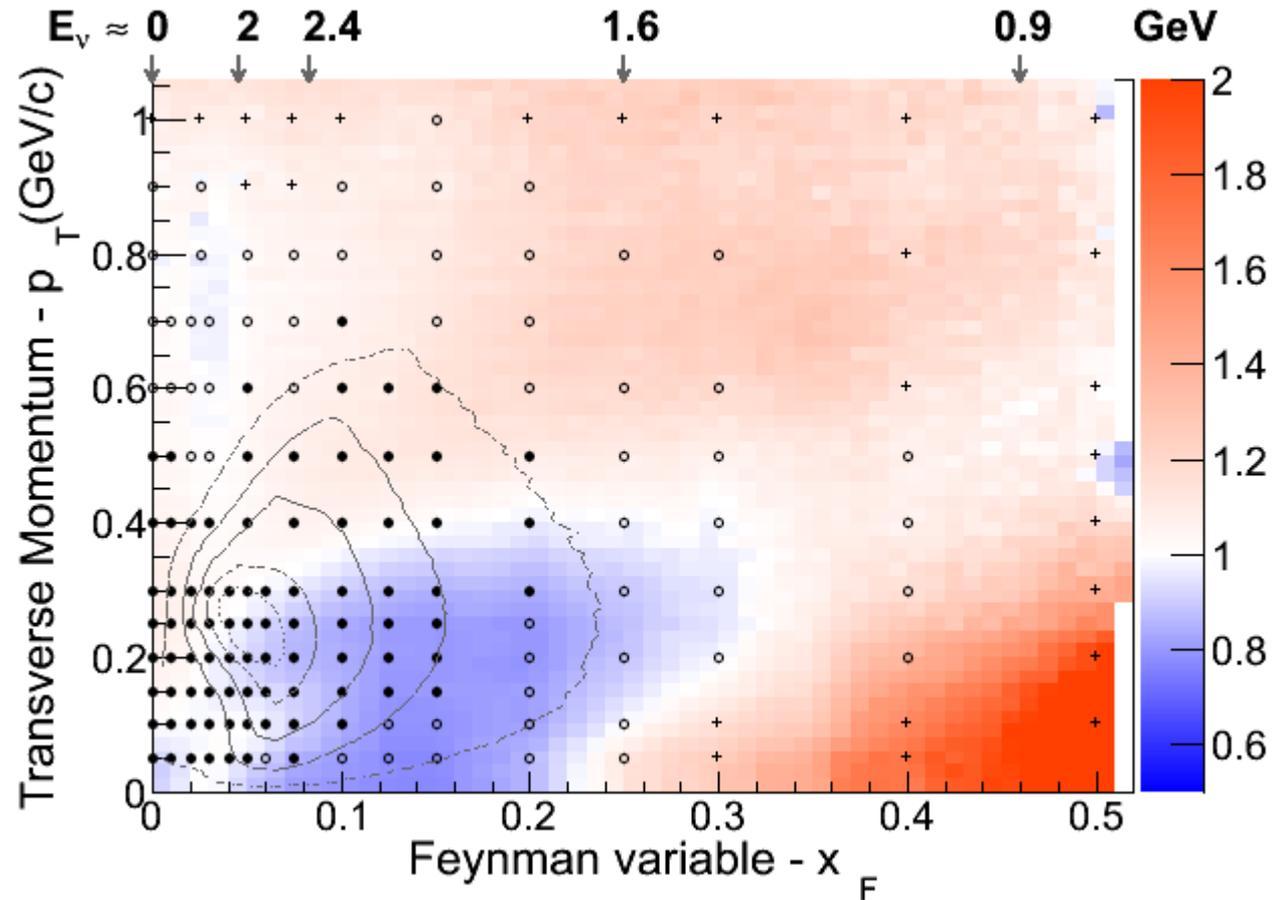
Results

NA49 $pC \rightarrow \pi^+ X$ Weights

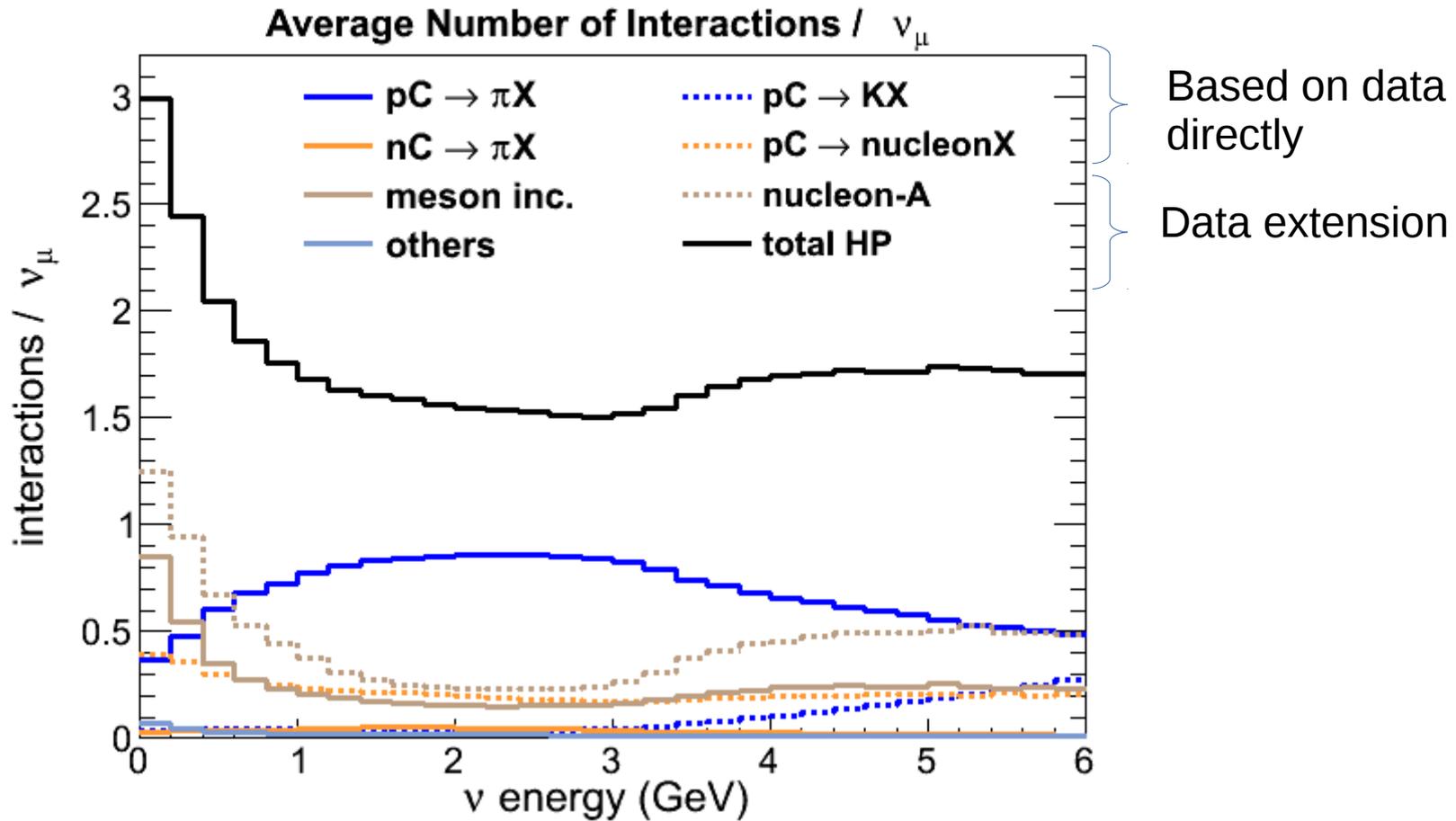
- NA49 Data/M comparison (Closed circles = statistical error < 2.5%, Open circles = 2.5-5.0% and Crosses > 5%)

- Systematic uncertainties = 3.8%.

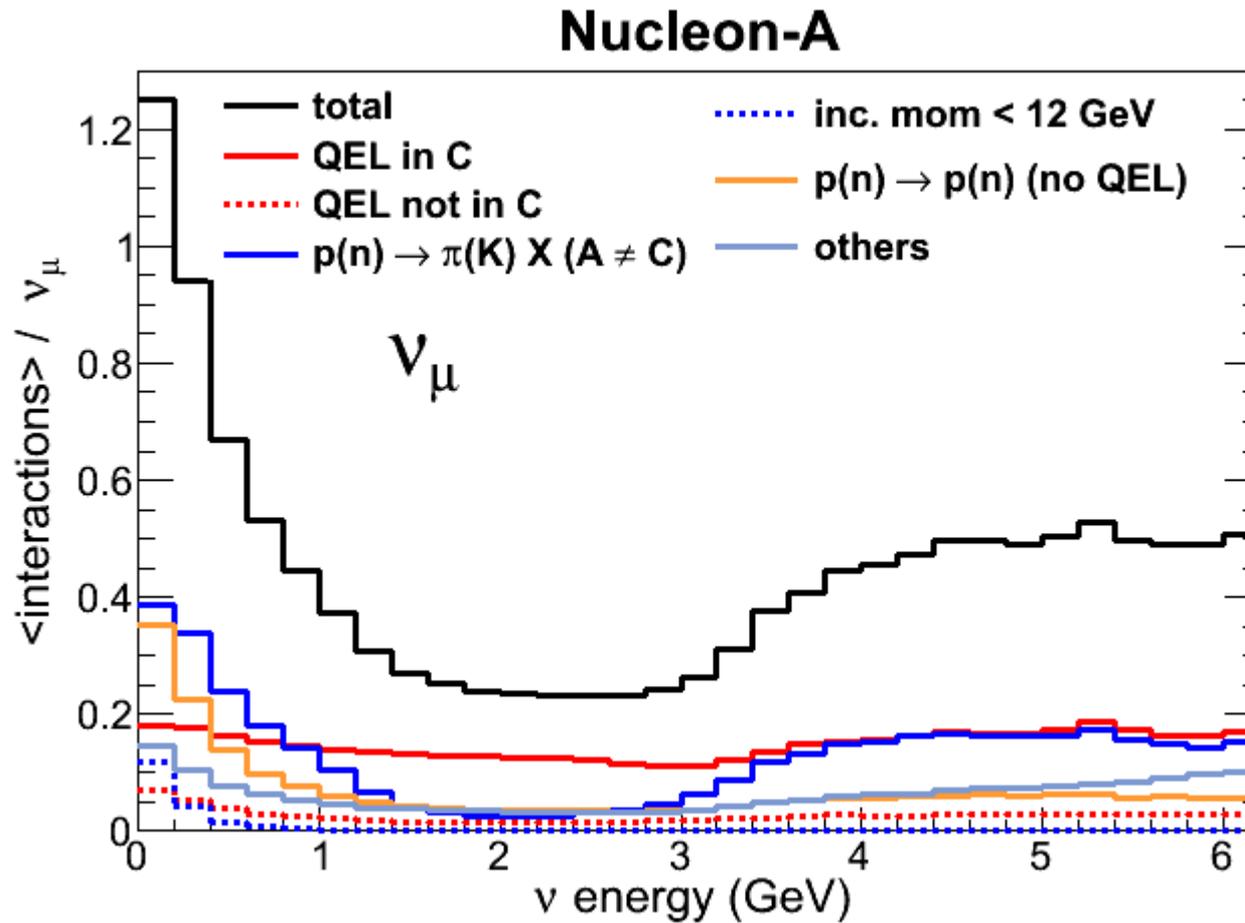
- Contours: 75%, 50%, 25%, 10%, 2.5%



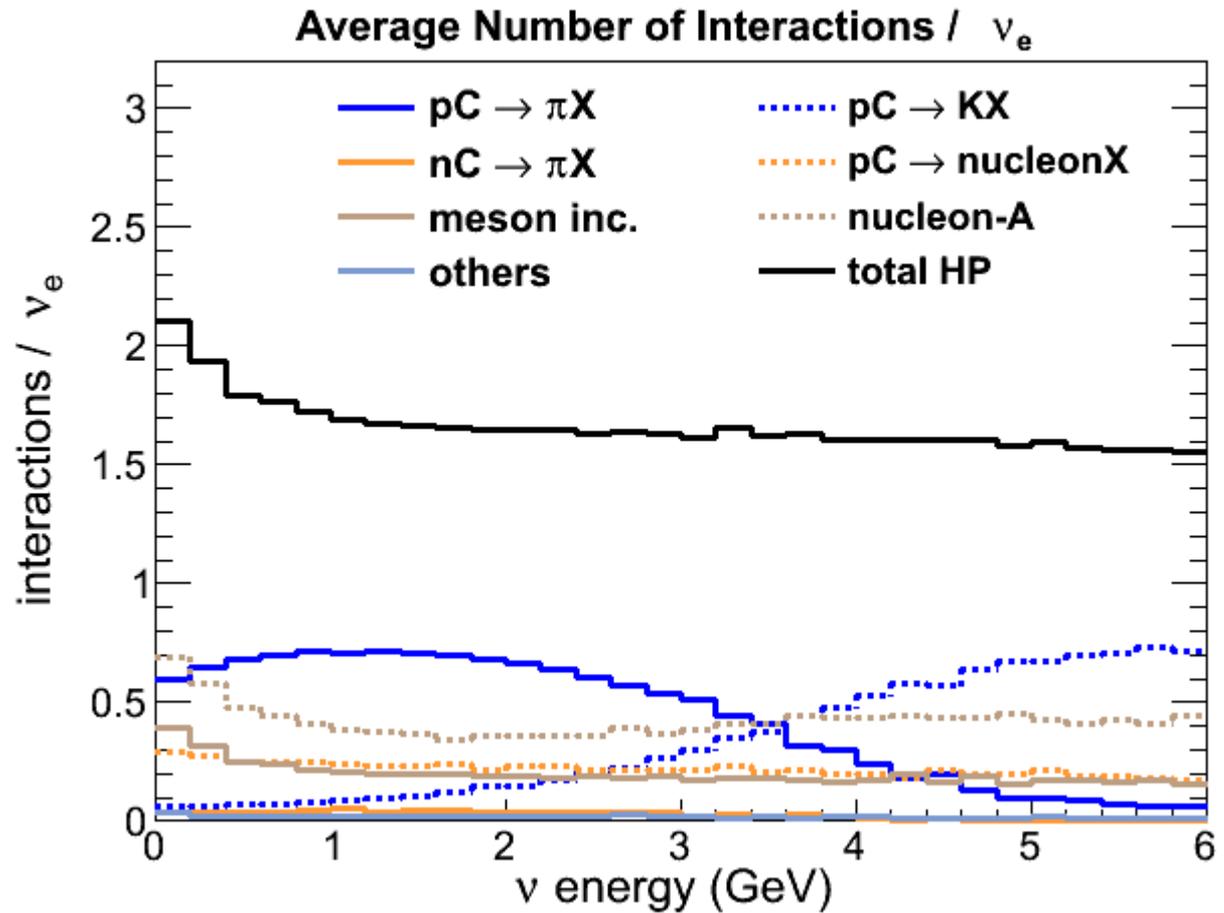
$\langle \# \text{ interactions} \rangle / \nu_{\mu}$ handled by every correction



$\langle \# \text{ interactions} \rangle / \nu_{\mu}$ handled by Nucleon – A correction

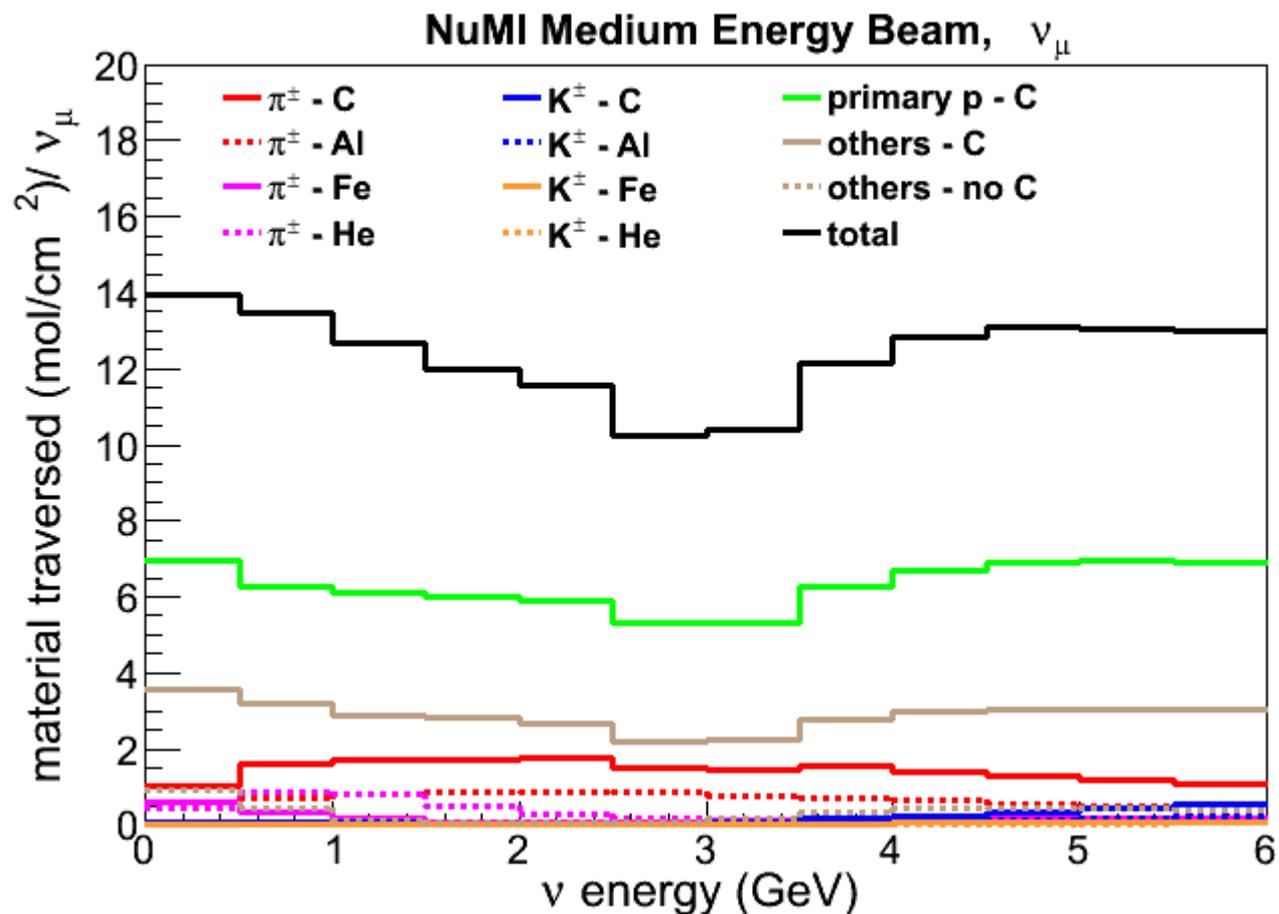


$\langle \# \text{ interactions} \rangle / \nu_e$ handled by every correction

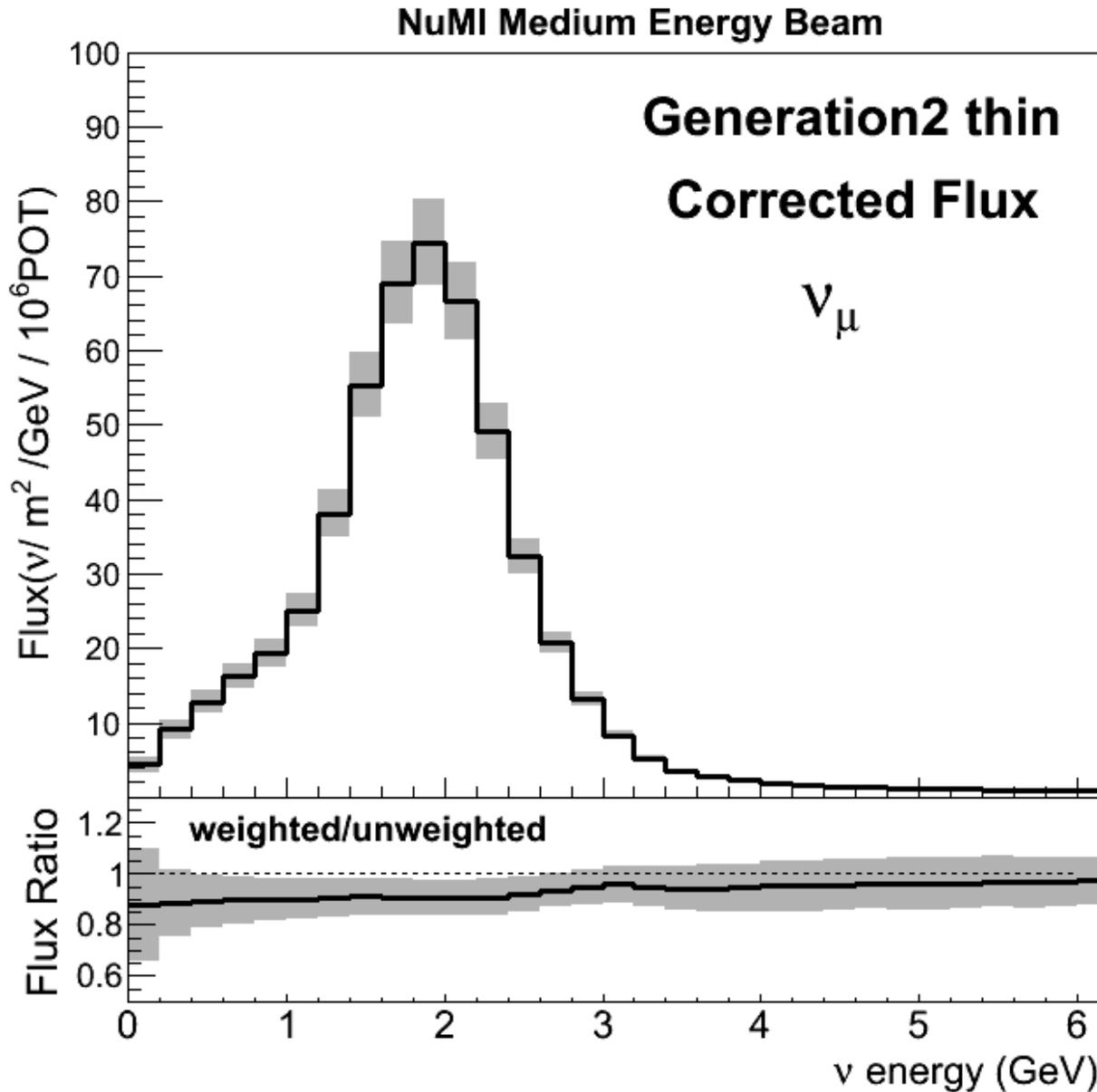


Material traversed in NuMI beamline

- 1 mol/cm² ~ 10 cm of Al ~ 500 m of He.
- 7 mol/cm² ~ 50 cm of C.



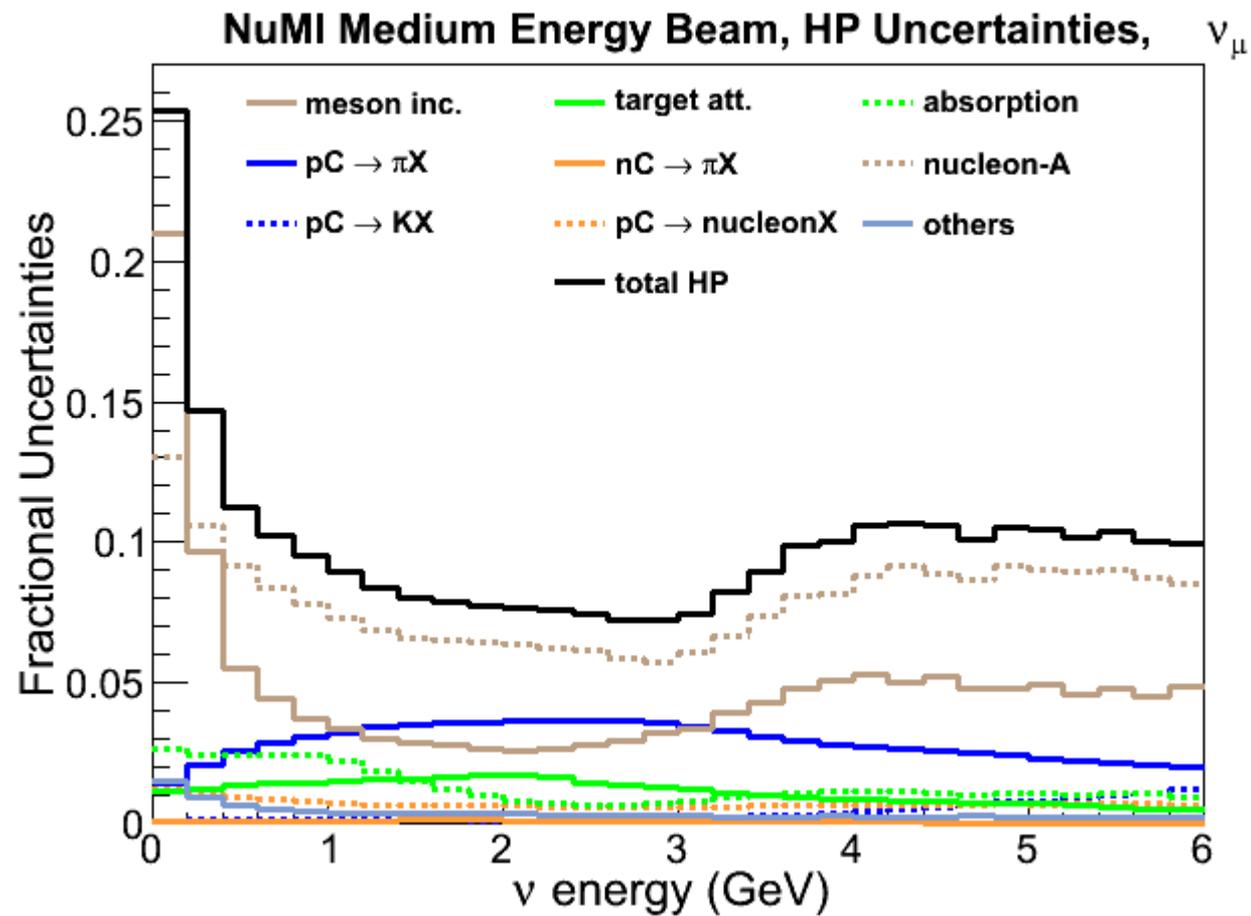
Muon neutrino flux



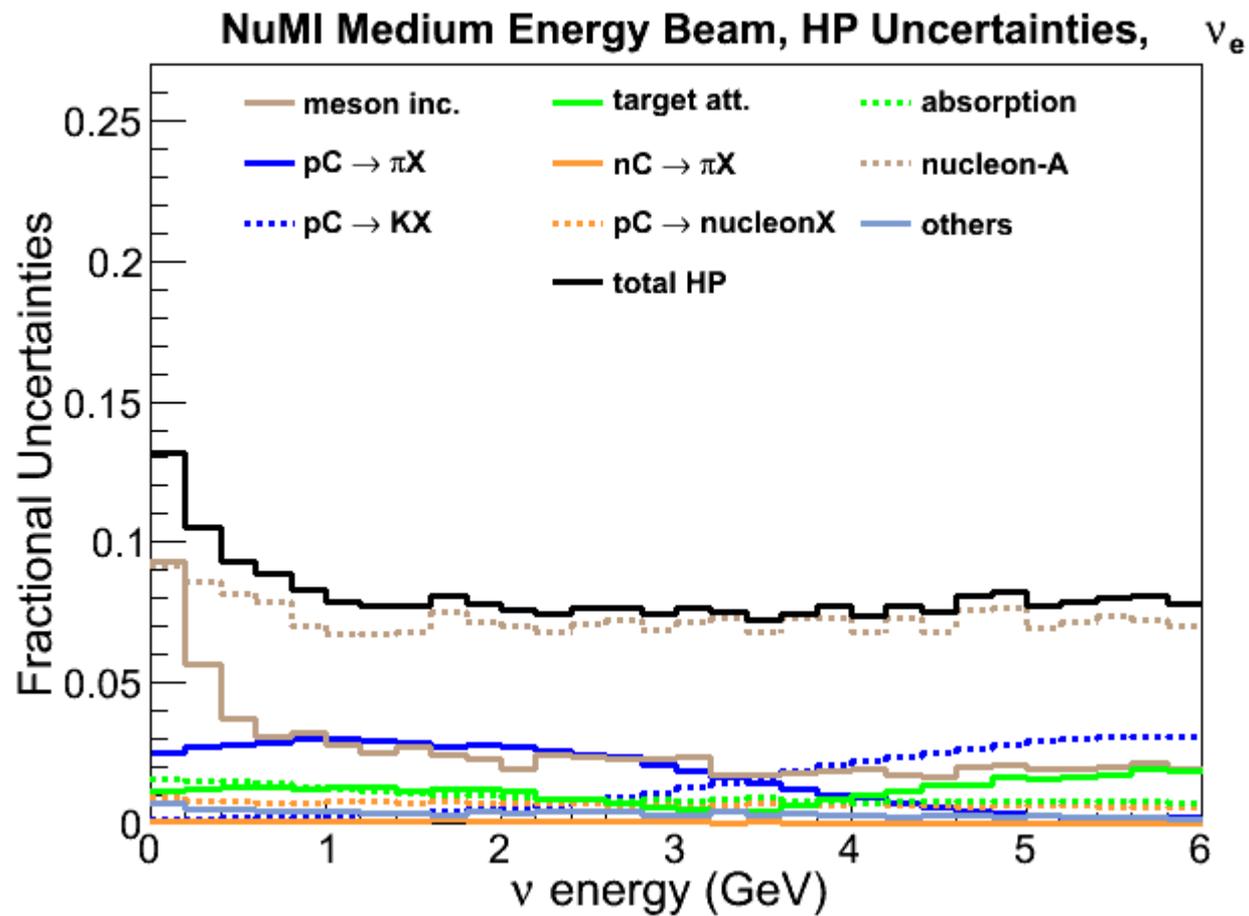
→ *Flux spectrum with HP error band.*

→ *Ratio respect to g4numi output.*

Muon neutrino flux HP fractional uncertainties



Electron neutrino flux HP fractional uncertainties



Implementation in NOvA

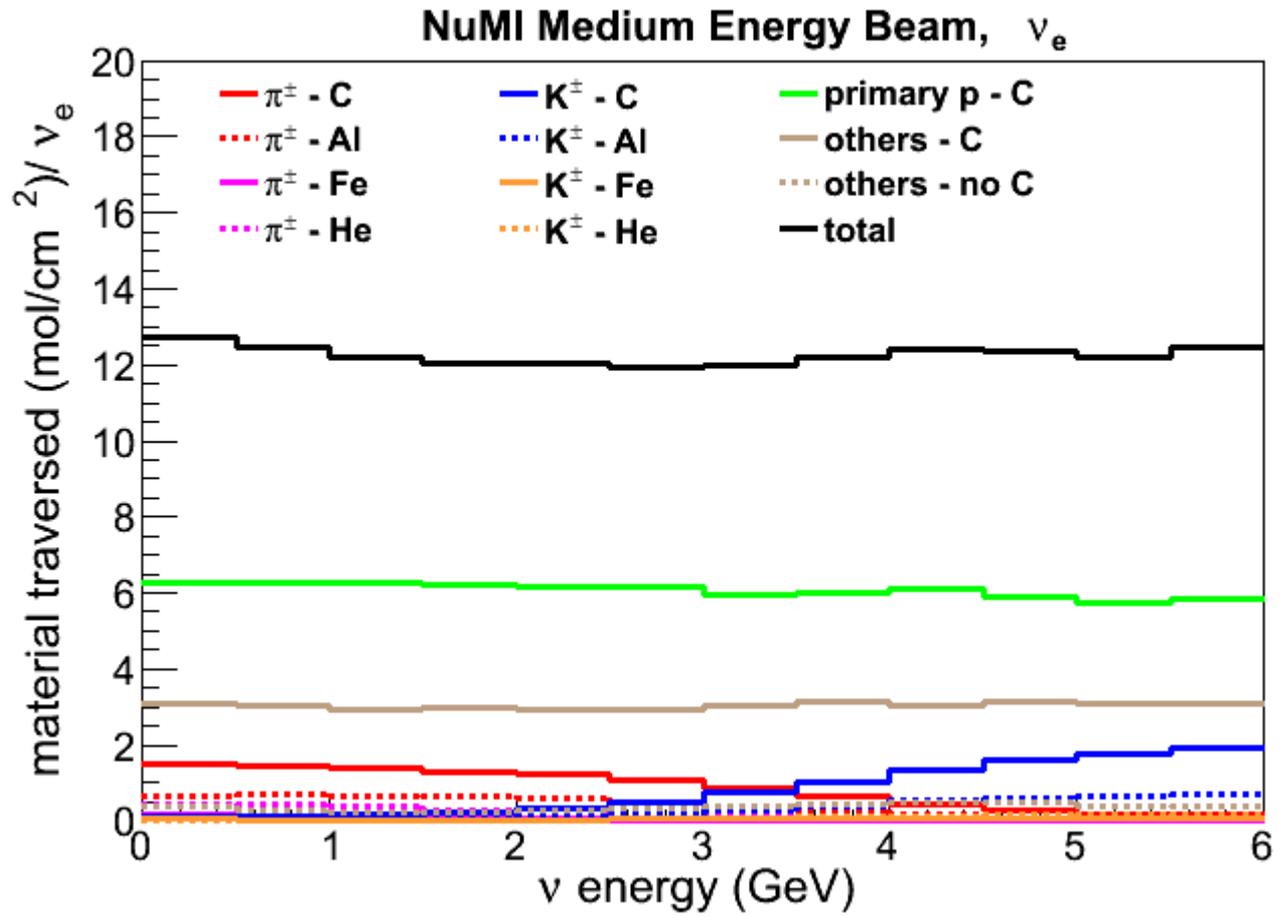
1. Short term

- NOvA is correcting the flugg central value to ppx central value, calculated in the center of the front face of the ND.
- To do: calculate the flux in other points of the ND.

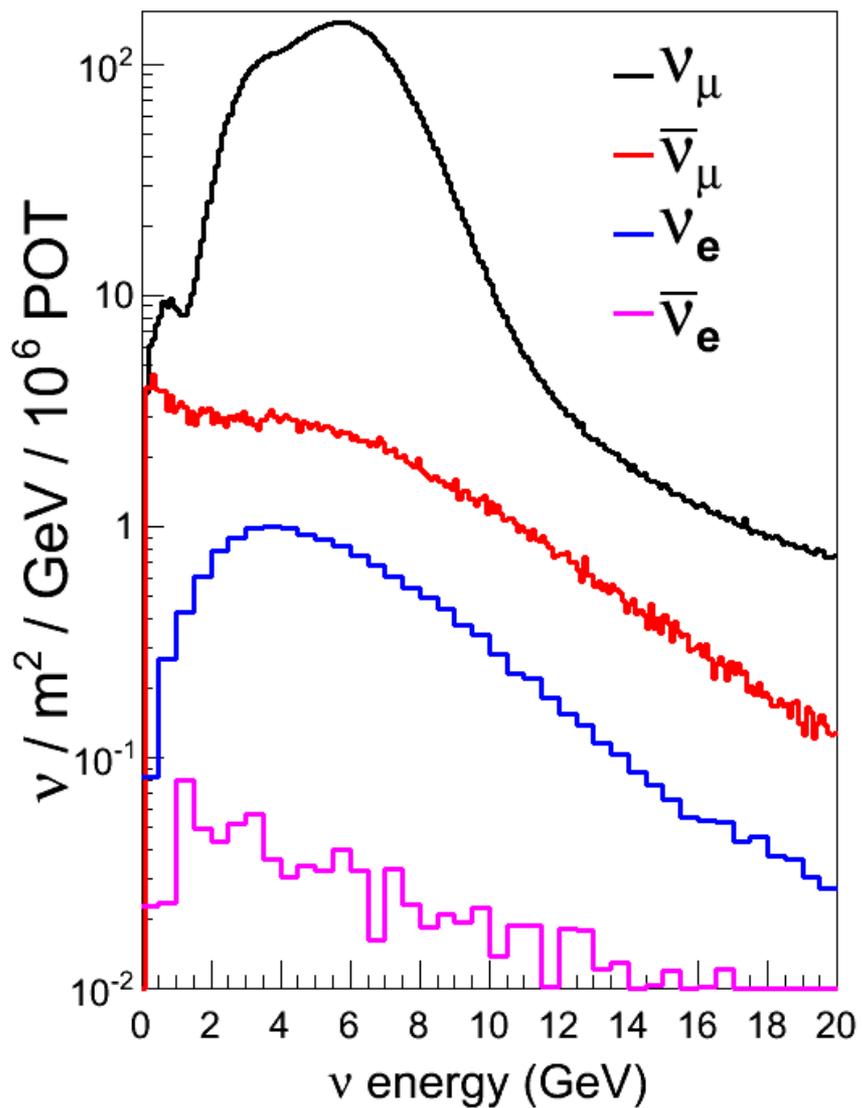
2. Long term

- Switch to g4numi?

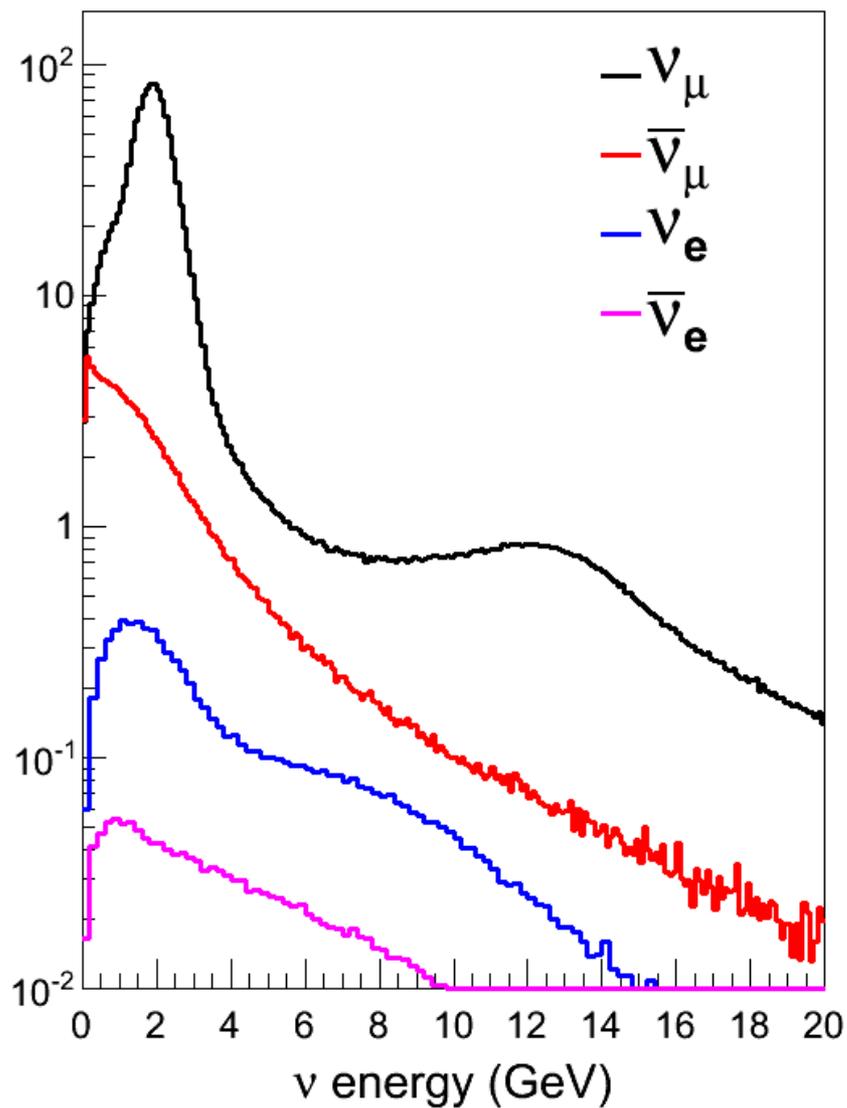
backup

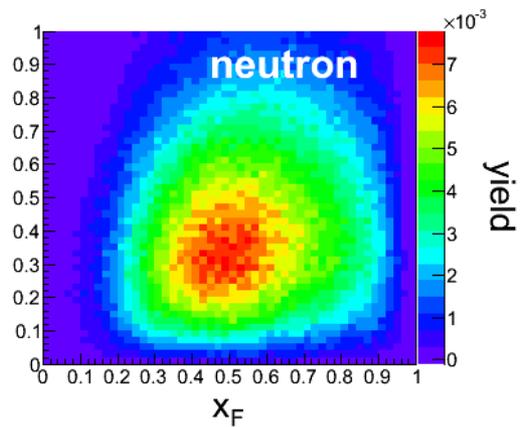
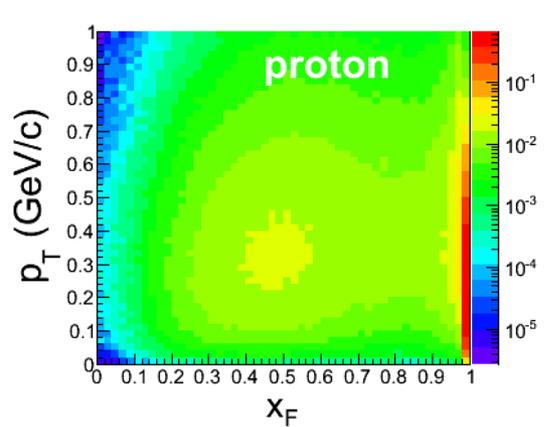
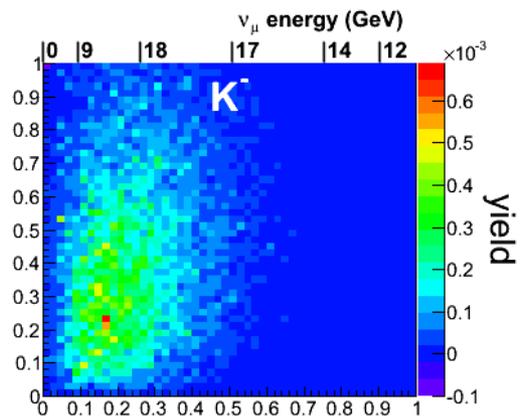
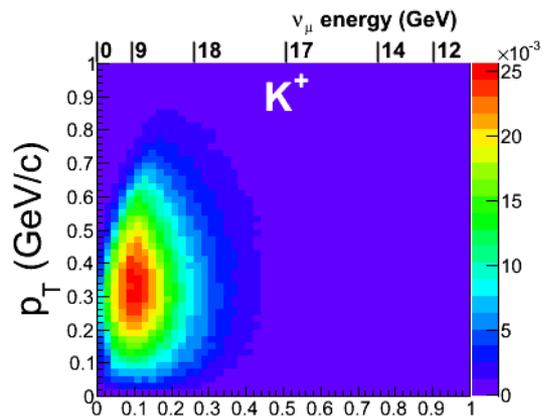
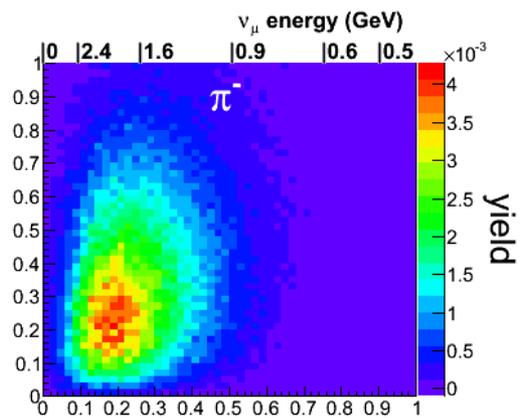
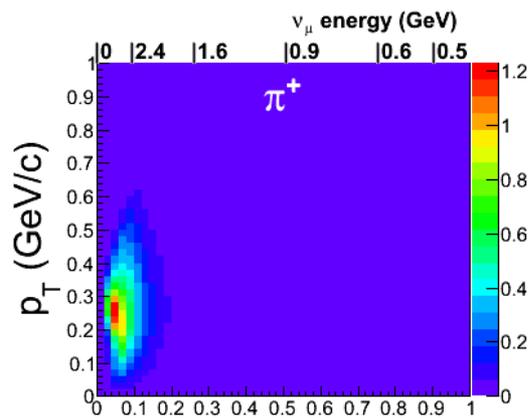


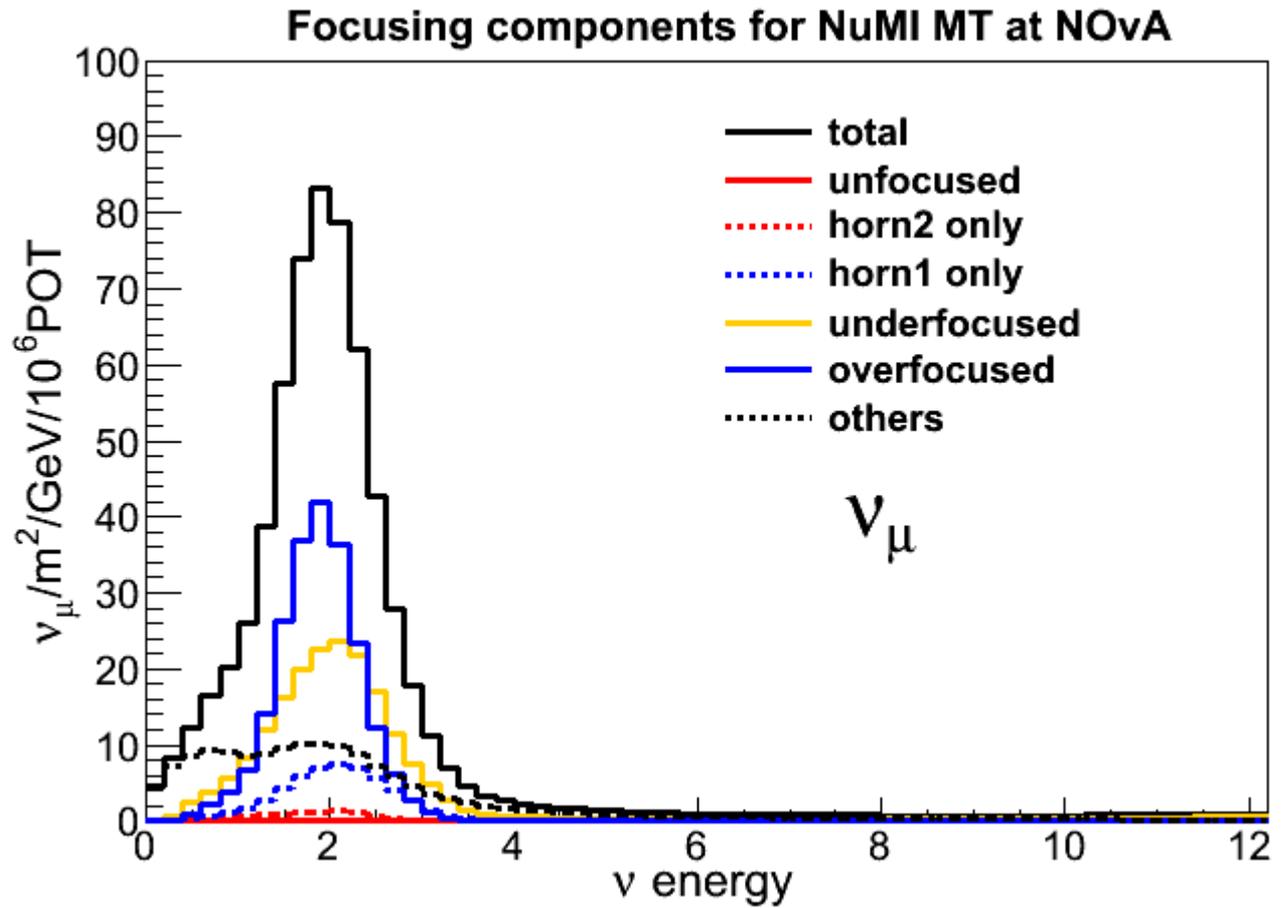
ME000z200i at MINERvA

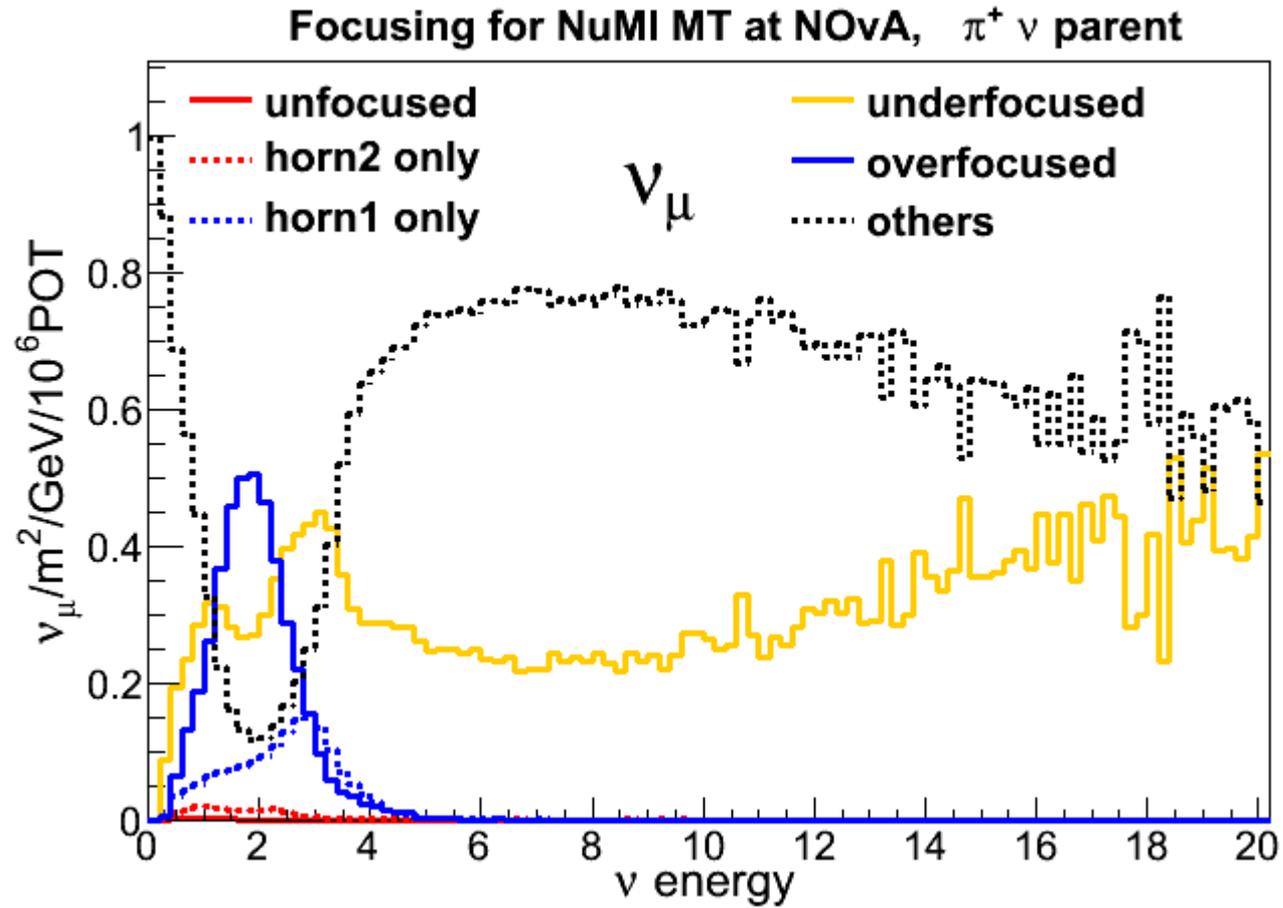


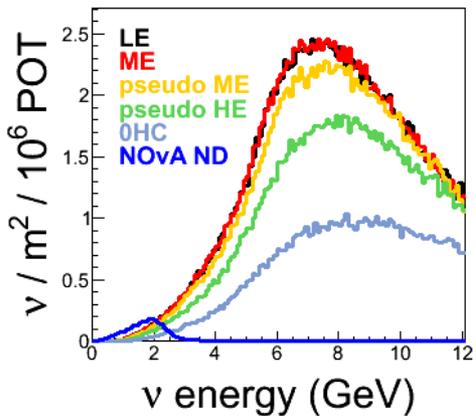
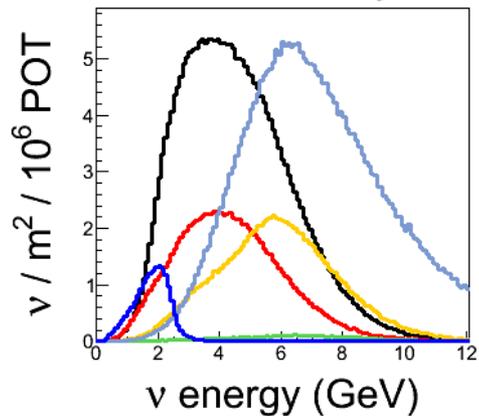
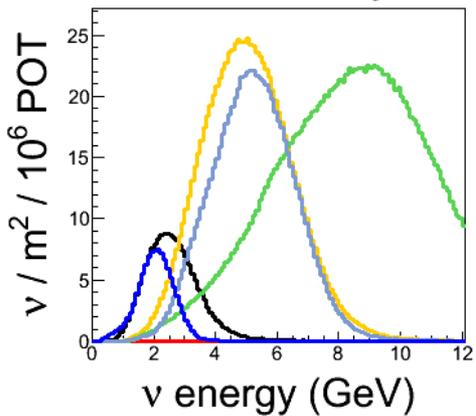
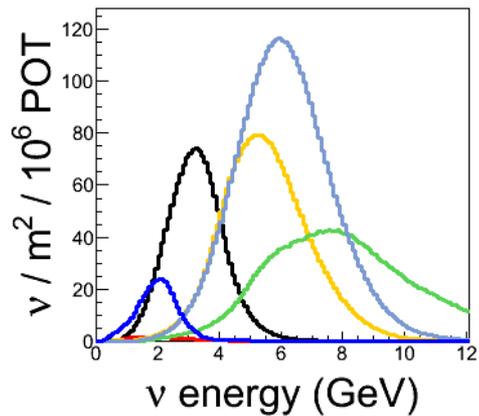
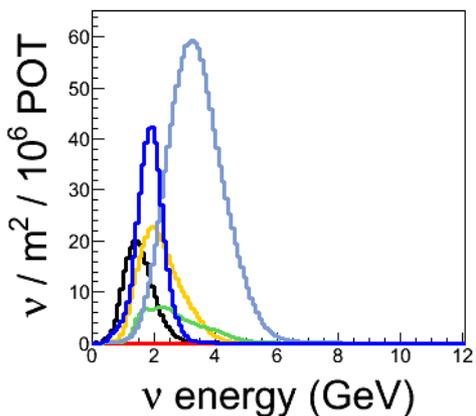
ME000z200i at NOvA ND









Unfocused**Horn2 only****Horn1 only****Underfocused****Overfocused****Others**