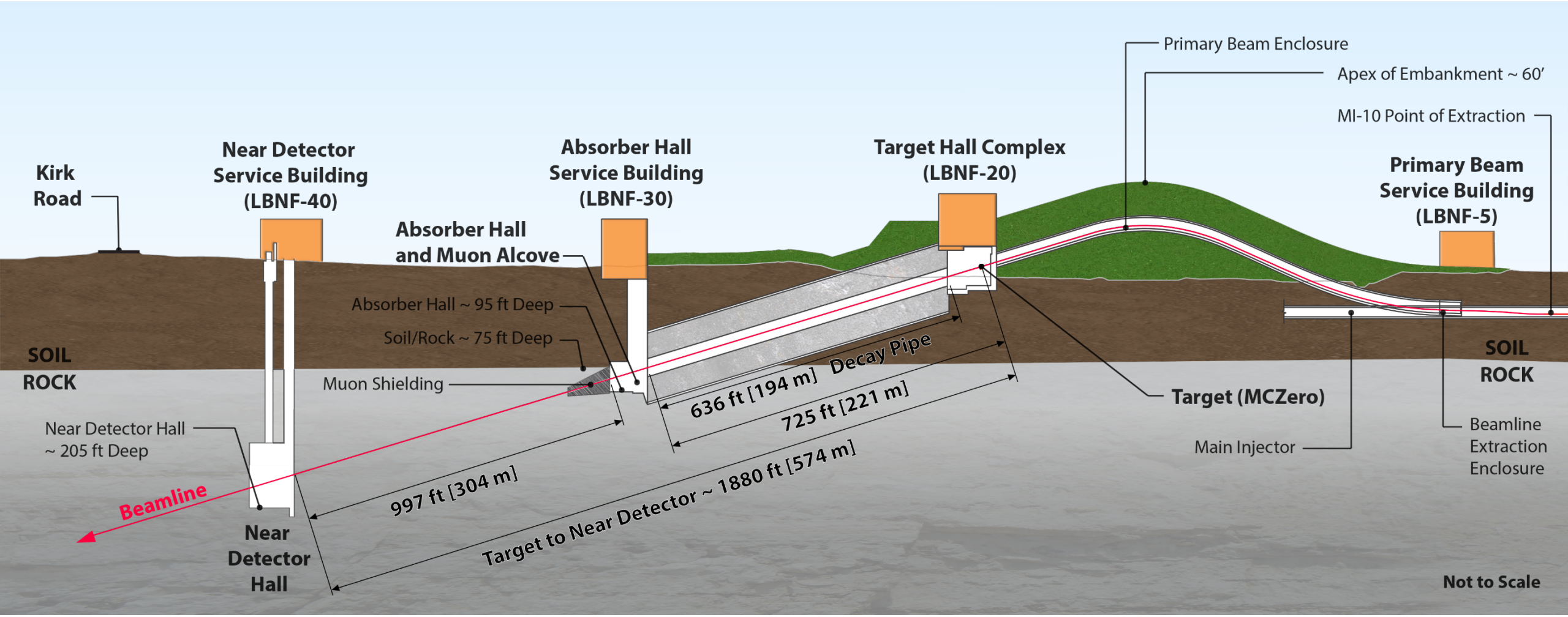
FAR DETECTOR nu SPECTRA EXTRAPOLATION STATUS

Oregon State University
Physics Department
October 1, 2015

DUNE Beamline with Near Detector



Beam Parameters

- Reference Beam
- Proton Beam Energy:80 GeV

- Optimized Beam(CP_run5_9116)
- Proton Beam Energy: 66 GeV

Parameters used for the Study

Parameters used for this study are:

- Geant4: geant4.9.6.p3
- Genie: 2.8.4
- G4lbne: v3r3p8

- Total POTS used: 1000X100000

Overview

Assumed 2 physics model (hadron production model):

FTFP_BERT: **True** model

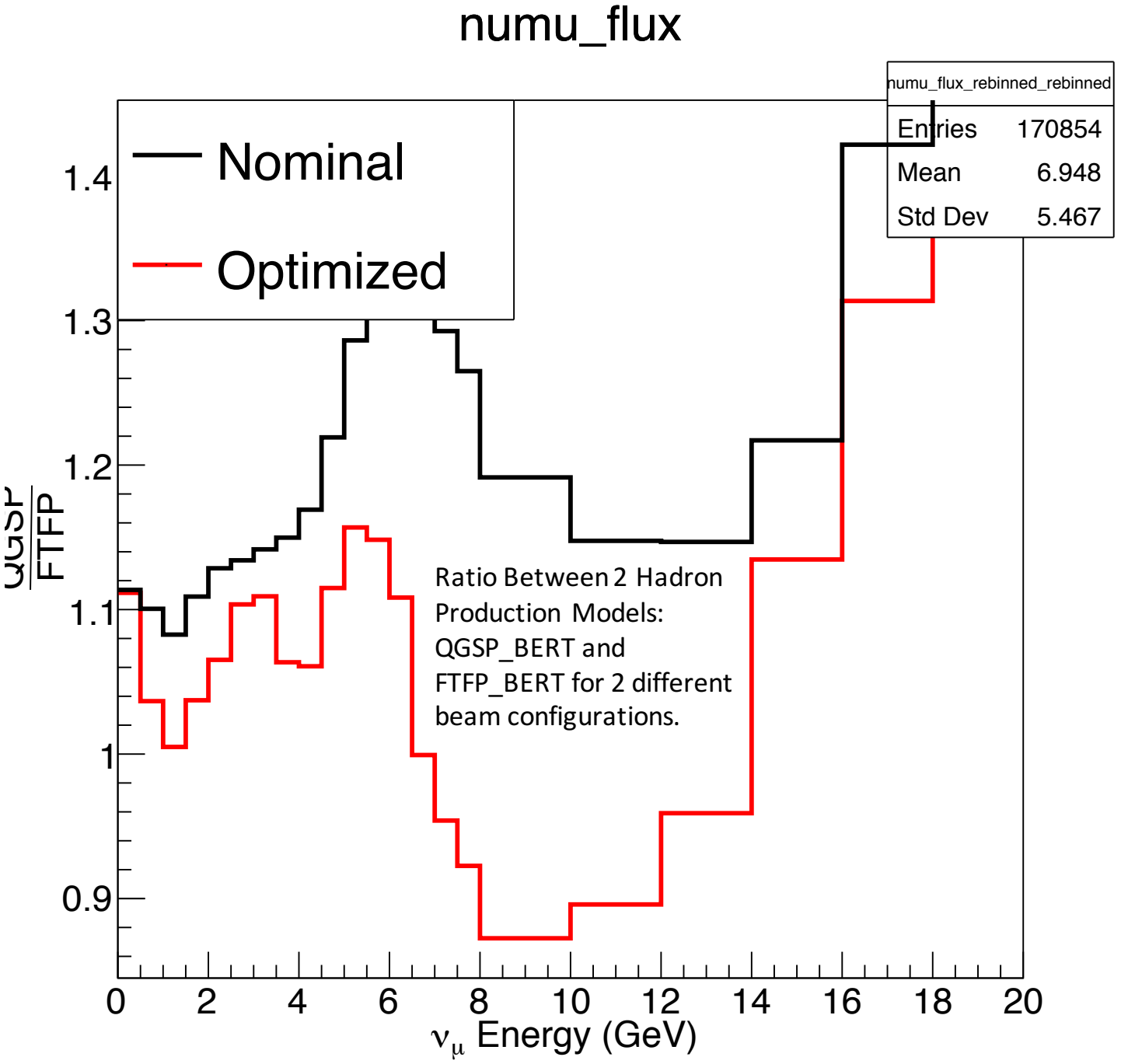
QGSP_BERT: **Simulation** model

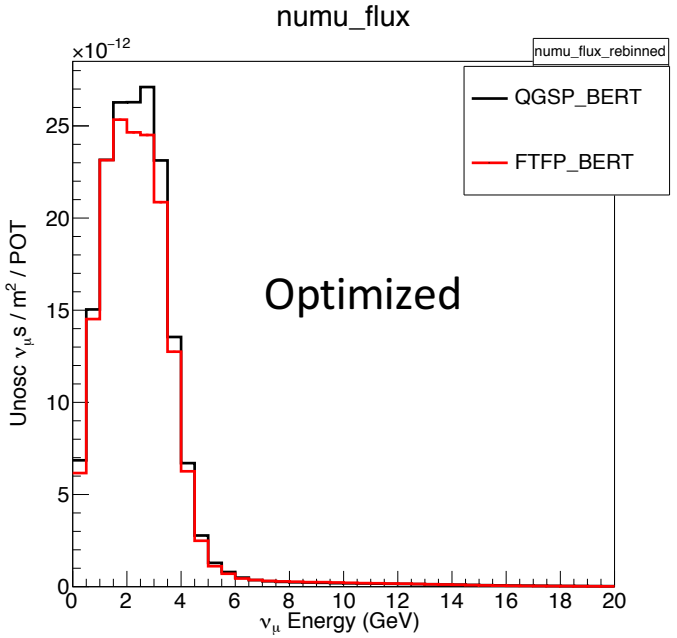
Use beam matrix/ ratio from QGSP_BERT to predict the FD flux of FTFP_BERT model

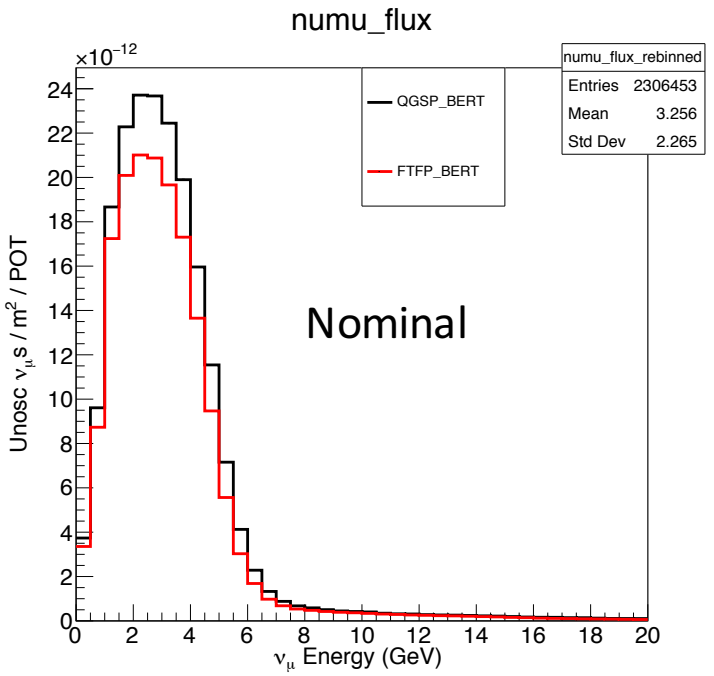
Closure test: Use beam matrix/ratio from FTFP_BERT FD flux of same model to get the FD flux.

Beam matrix and how it is done

- A near detector energy bin implies a far detector spectra over a range of bin.
- BeamMatrix = (i,j,$\frac{\emptyset Far[iXj]}{\emptyset near[i]}$) where Far(i,j) is the spectrum for a given near(i).
- Extrapolation simply includes the integration of flux over (i) for a given j and multiplying with near flux.


numu_flux
numu_flux_rebinned_rebinned
Entries 170854
Mean 6.948
Std Dev 5.467
Nominal
Optimized
QGSP / FTFP
Ratio Between 2 Hadron Production Models: QGSP_BERT and FTFP_BERT for 2 different beam configurations.
ν_μ Energy (GeV)


numu_flux
numu_flux_rebinned
QGSP_BERT
FTFP_BERT
Optimized
Unosc ν_μs / m^2 / POT
ν_μ Energy (GeV)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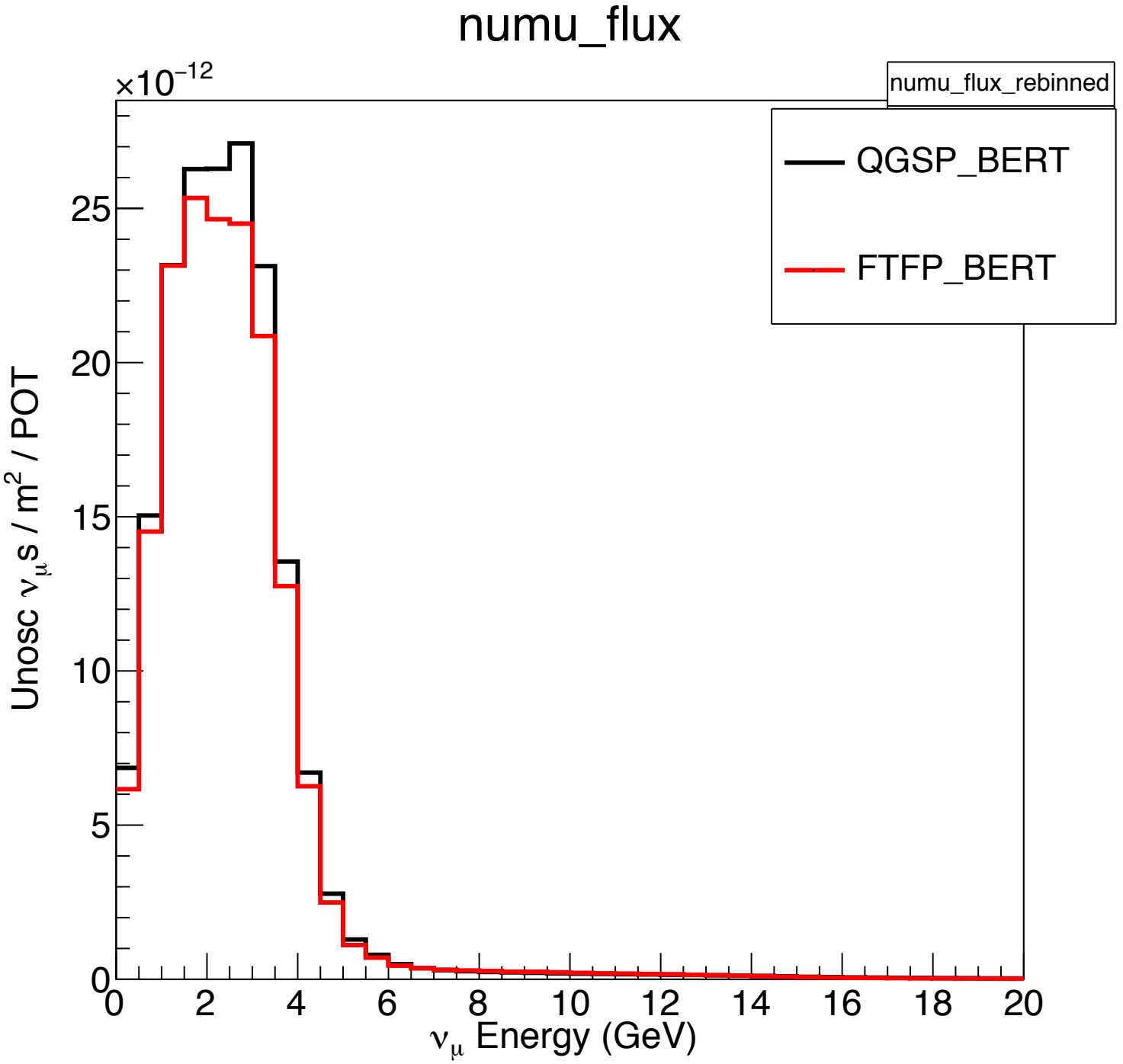
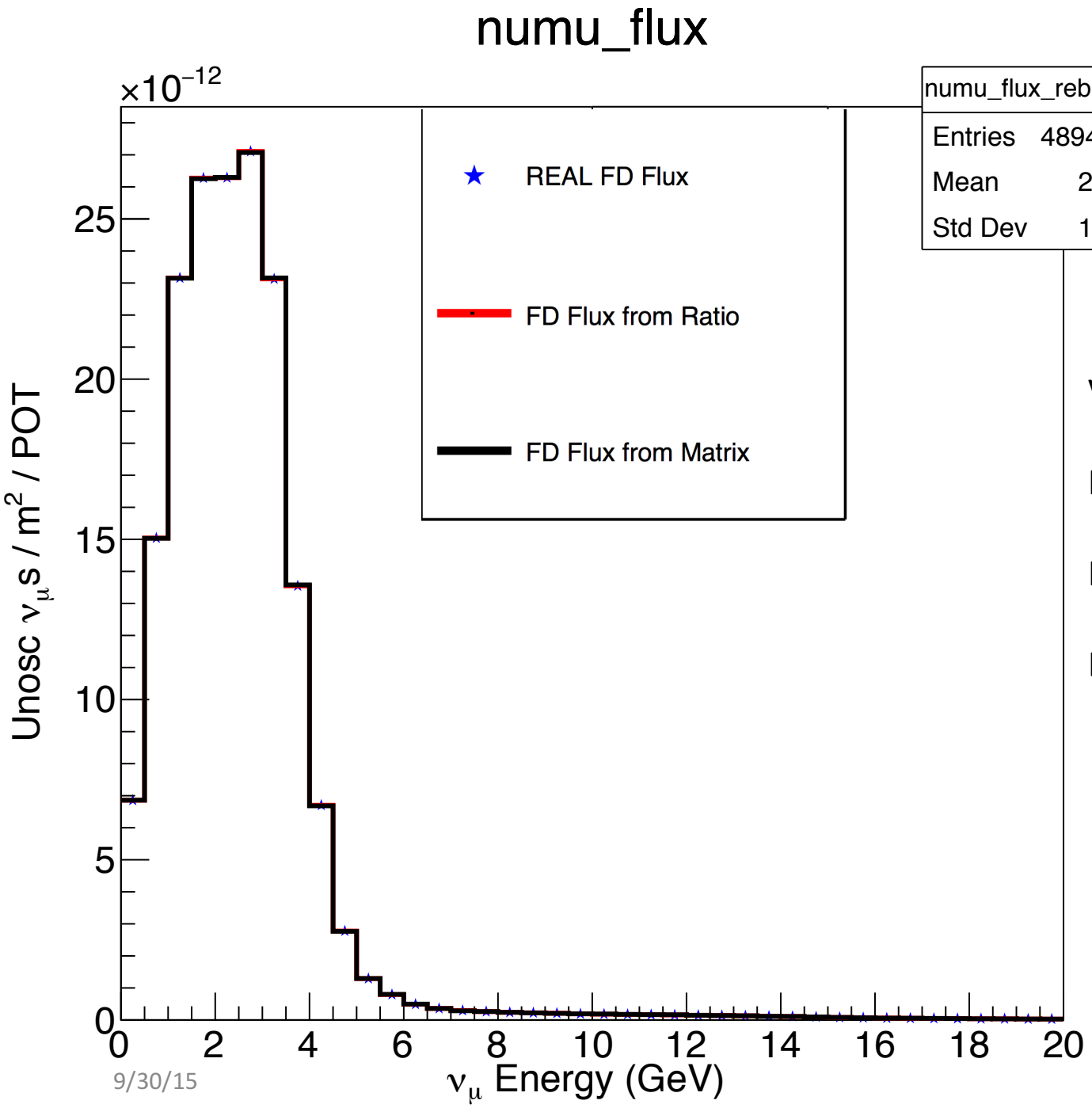
Entries 2306453
Mean 3.256
Std Dev 2.265
QGSP_BERT
FTFP_BERT
Nominal
Unosc ν_μs / m^2 / POT
ν_μ Energy (GeV)

OPTIMIZED FLUX FLUX

Optimized beam
Far Detector without ND extrapolation





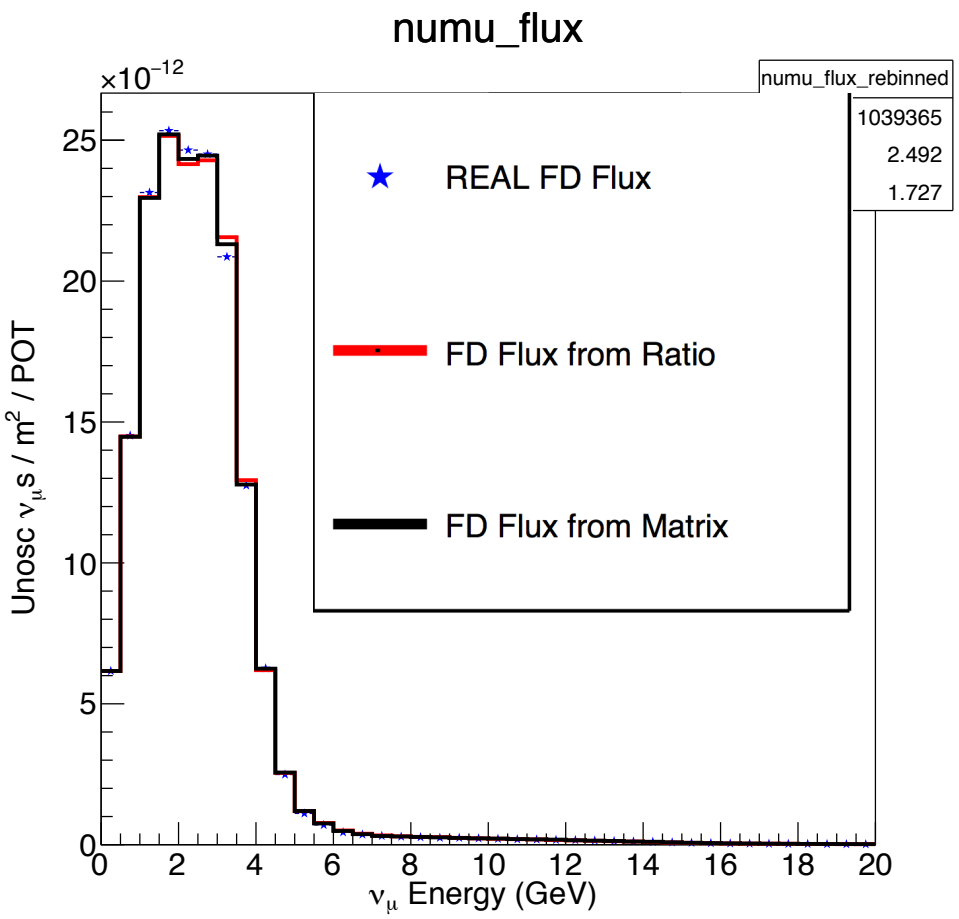
Verification: Optimized beam QGSP_BERT
Beam Matrix and Ratio extrapolation is correct.

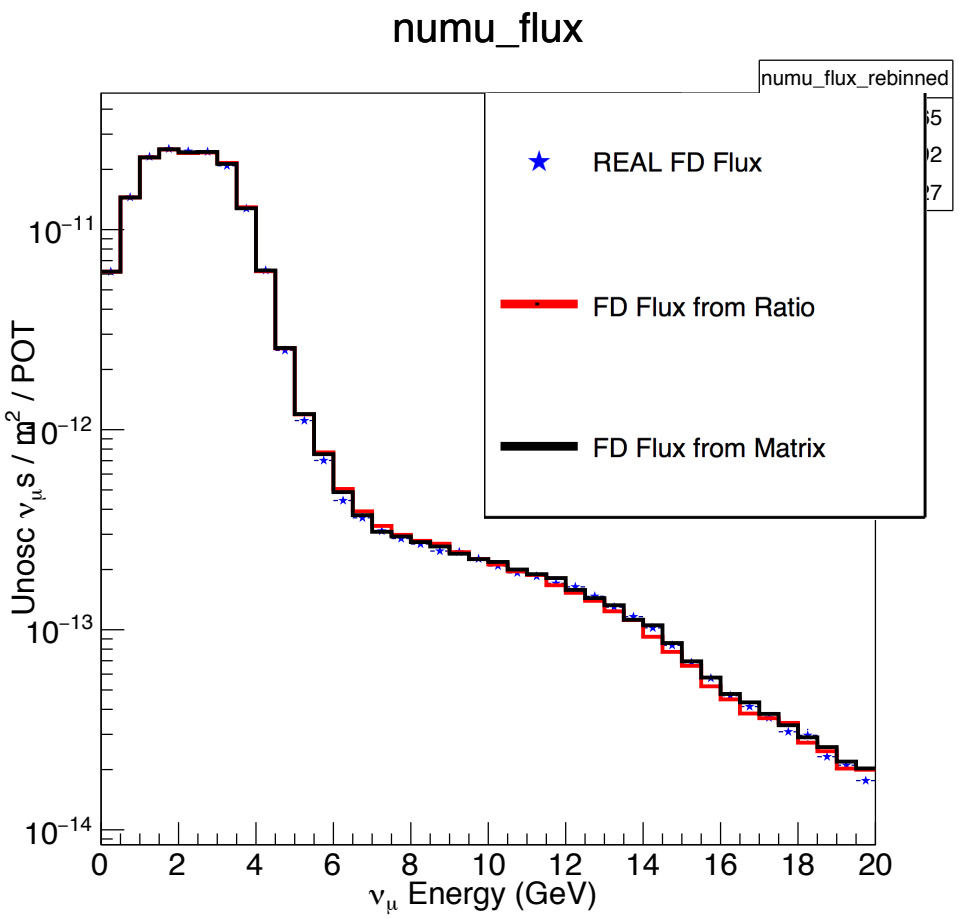
Verification Done by:

FD_(QGSP) = (Far/Near)_(QGSP) X ND_(QGSP)

FD_(QGSP) = (Beam Matrix)_(QGSP) X ND_(QGSP)

Exact match: The Methodology is correct!

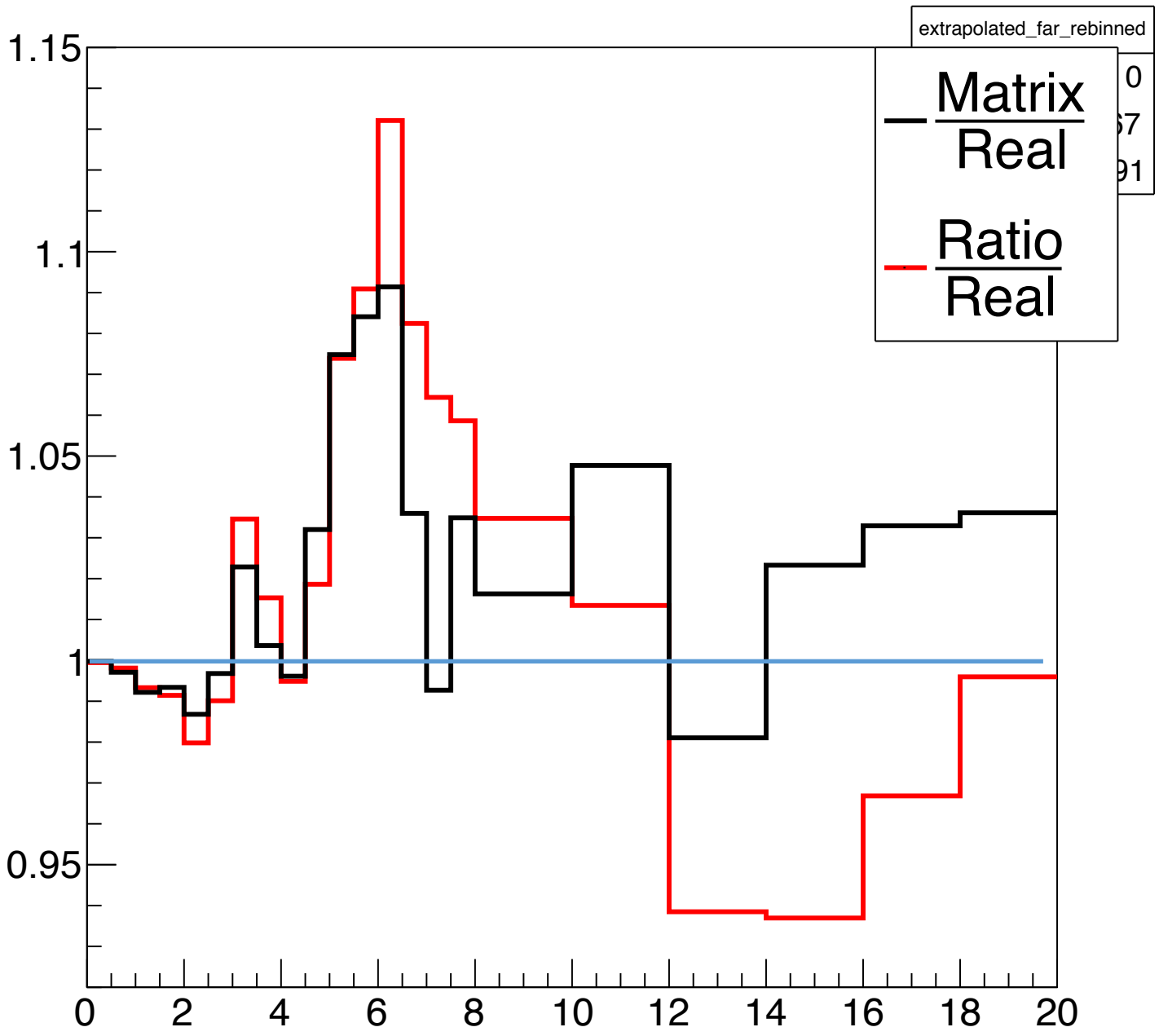




Extrapolated FD for the optimized beam
In overall, both methods have almost similar accuracy. Ratio plots shows a minimal better performance of matrix over ratio (not significant)

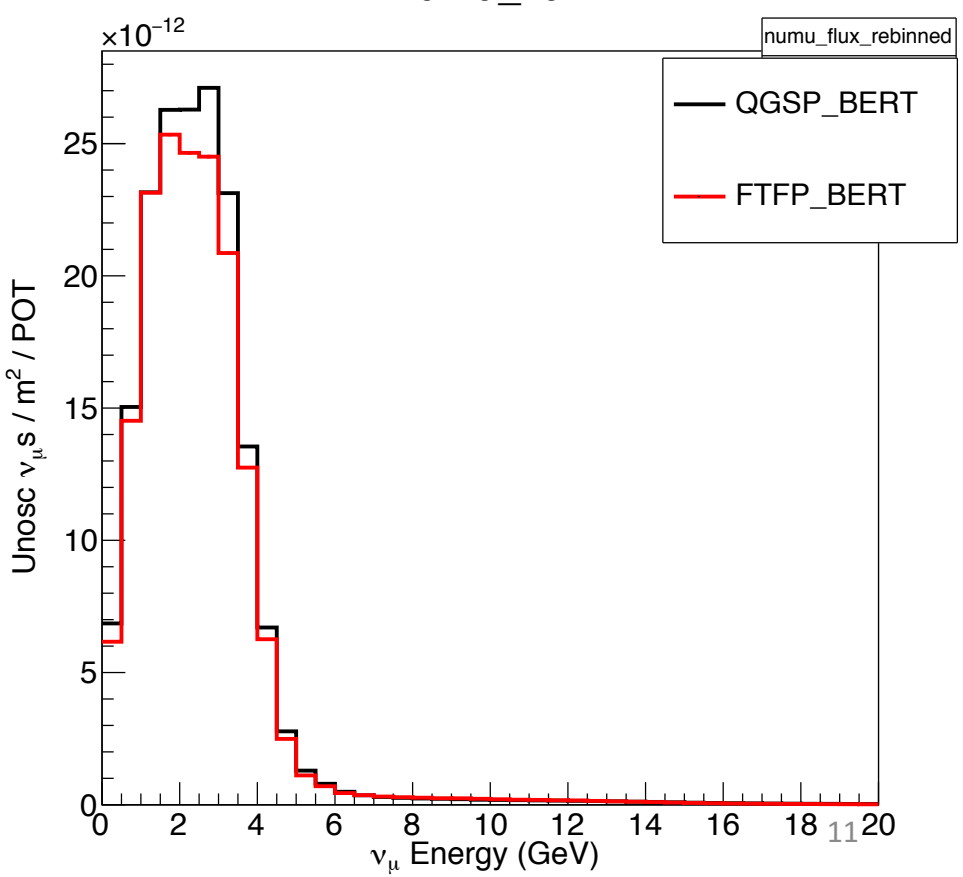
See Ratio in next slide.

Log scale

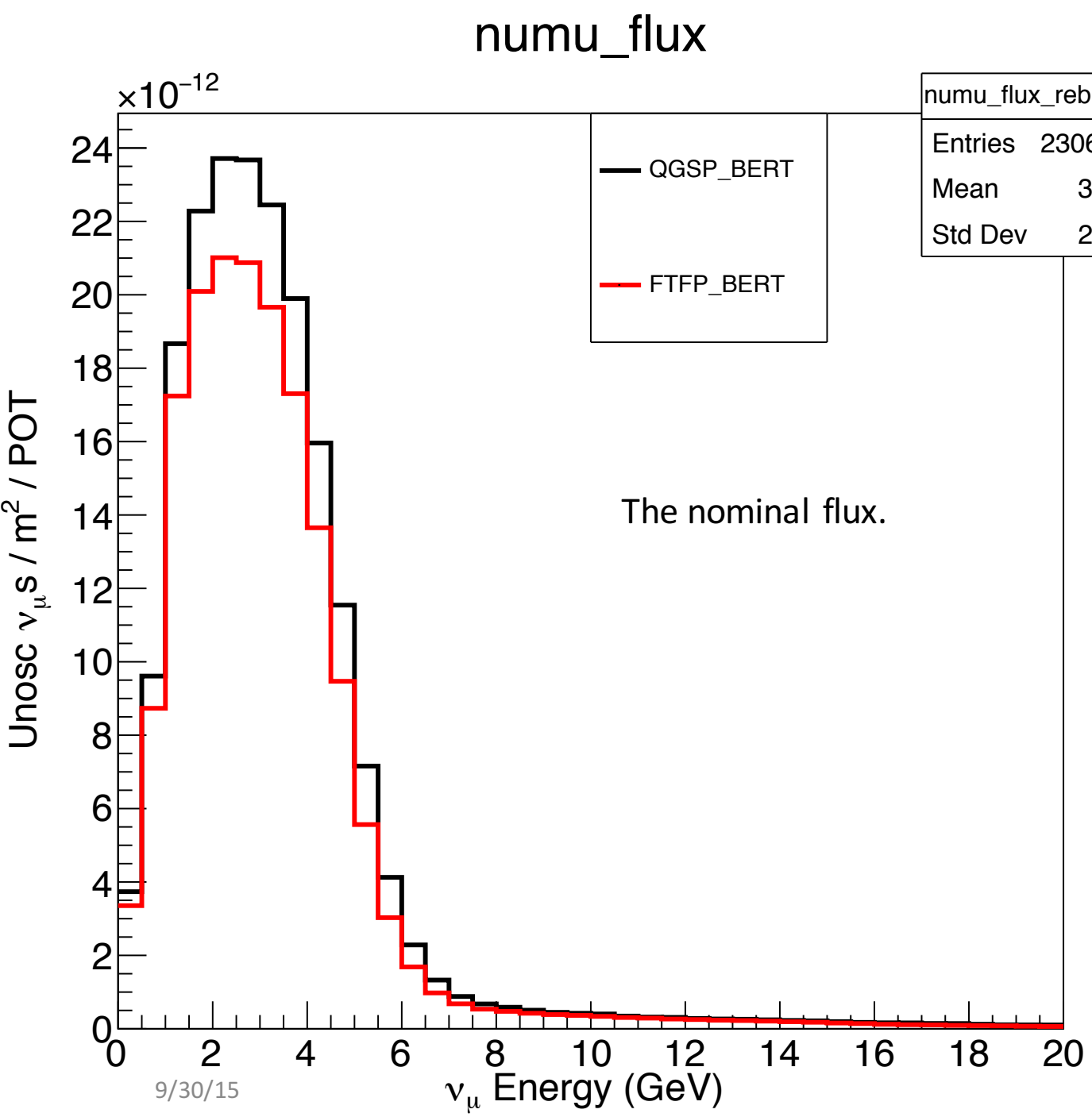


Relative comparison of extrapolated FD flux and "real" FD flux.

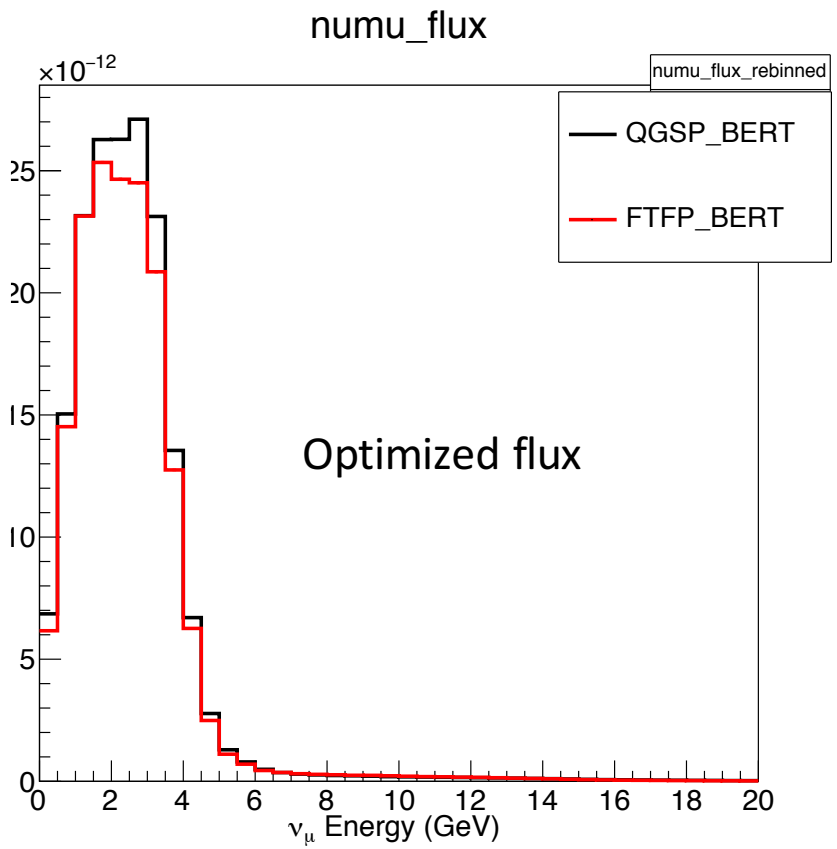
At all bins, the beam matrix seems to have relatively better prediction (although not so significant.)



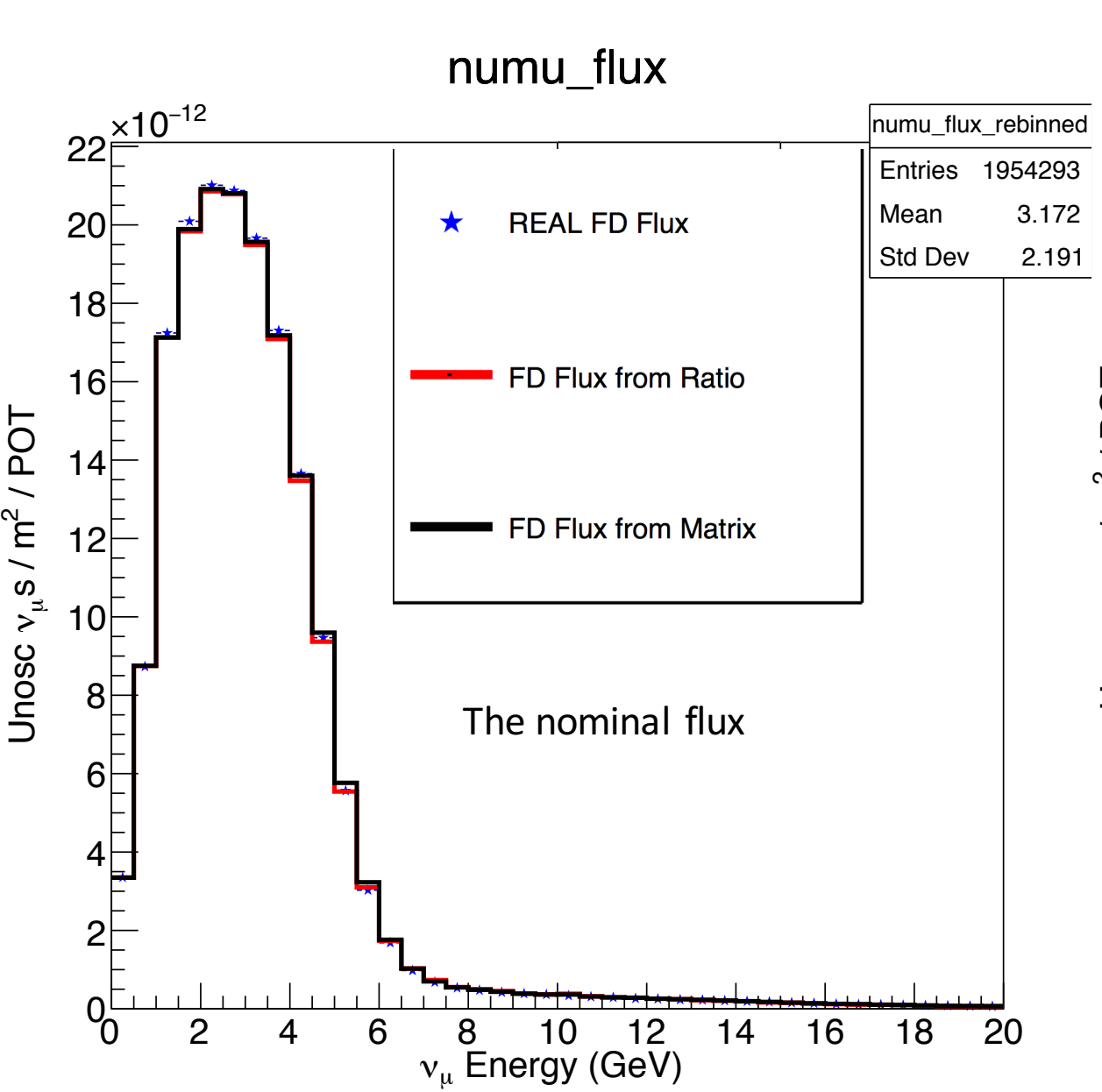
NOMINAL FLUX



The nominal flux.



Optimized flux


numu_flux
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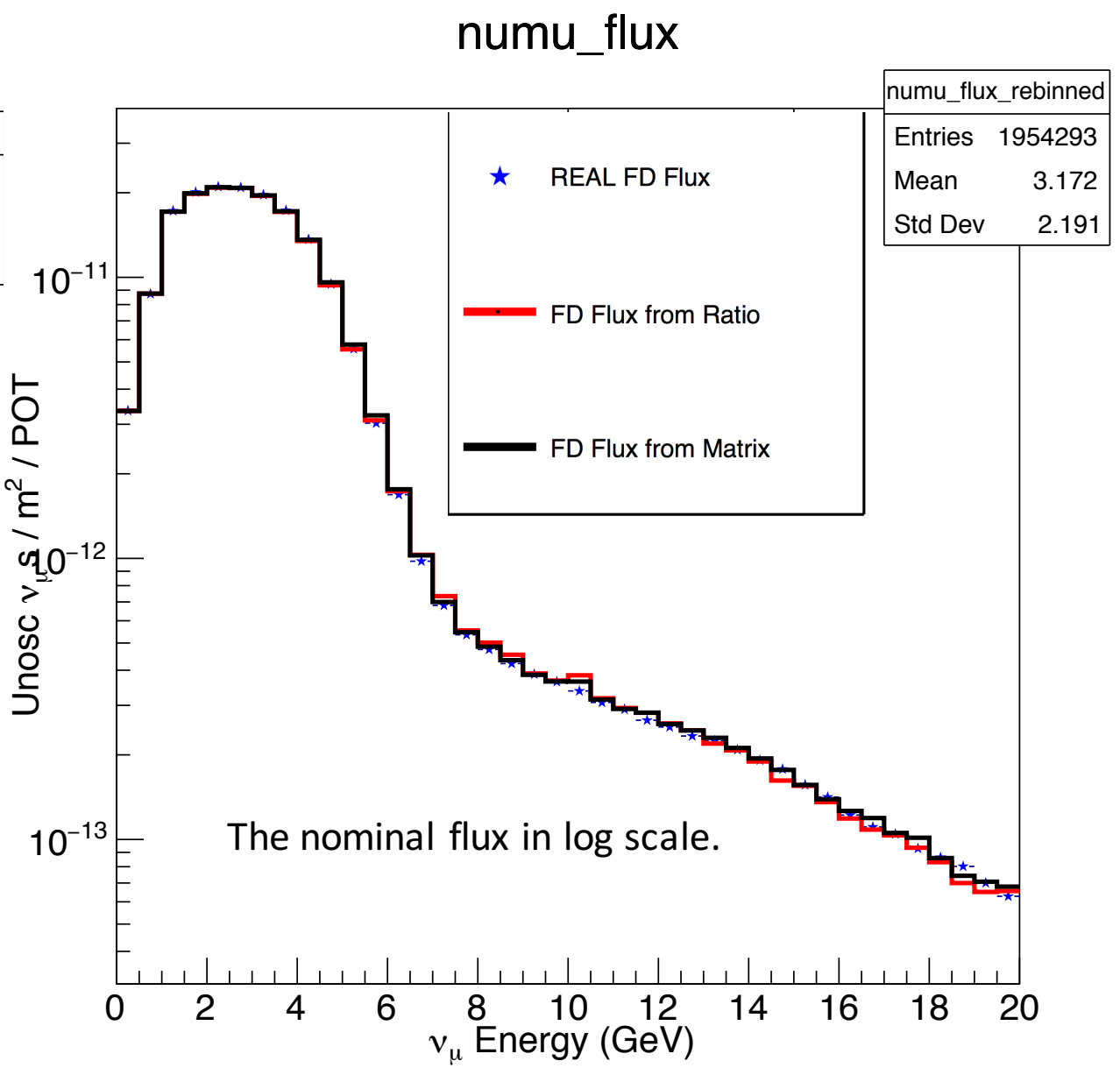
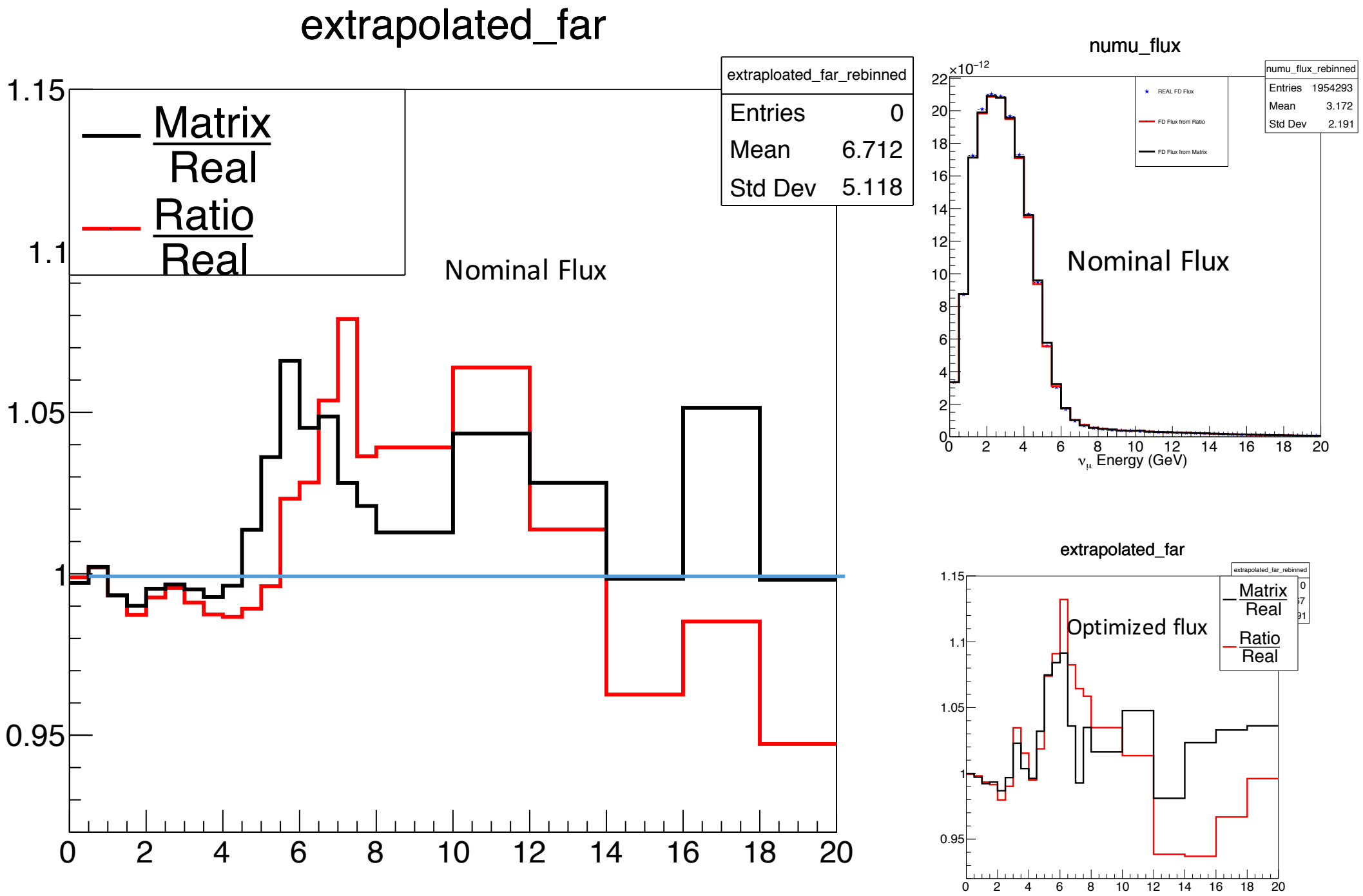
Entries 1954293
Mean 3.172
Std Dev 2.191
REAL FD Flux
FD Flux from Ratio
FD Flux from Matrix
The nominal flux
Unosc ν_μs / m^2 / POT
ν_μ Energy (GeV)


numu_flux
numu_flux_rebinned
Entries 1954293
Mean 3.172
Std Dev 2.191
REAL FD Flux
FD Flux from Ratio
FD Flux from Matrix
The nominal flux in log scale.
Unosc ν_μs / m^2 / POT
ν_μ Energy (GeV)

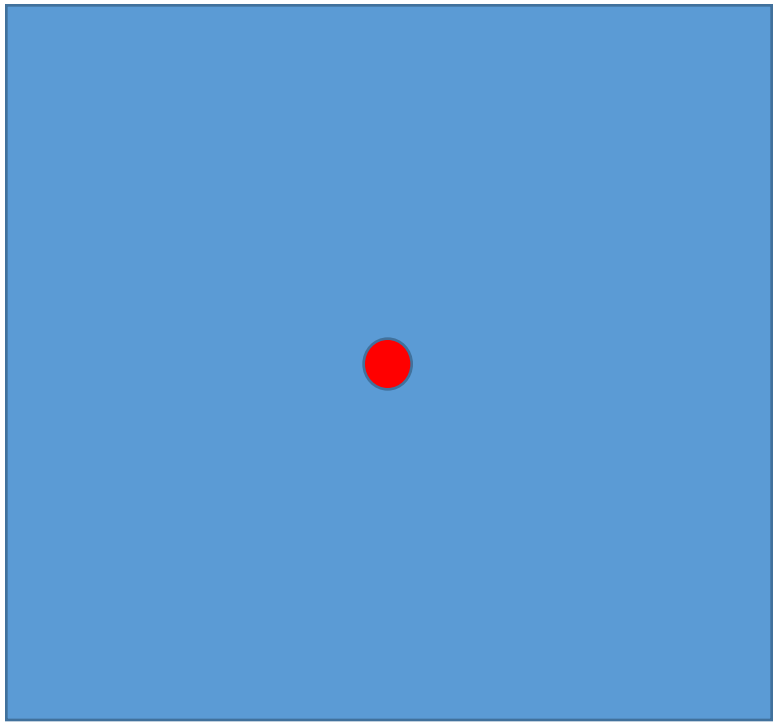

extrapolated_far
extraploated_far_rebinned
Entries 0
Mean 6.712
Std Dev 5.118
Matrix / Real
Ratio / Real
Nominal Flux
1.15
1.1
1.05
1
0.95
0 2 4 6 8 10 12 14 16 18 20
numu_flux
numu_flux_rebinned
Entries 1954293
Mean 3.172
Std Dev 2.191
REAL FD Flux
FD Flux from Ratio
FD Flux from Matrix
×10⁻¹²
Nominal Flux
νμ Energy (GeV)
extrapolated_far
Optimized flux
Matrix / Real
Ratio / Real

Comments/Future Works on Extrapolation

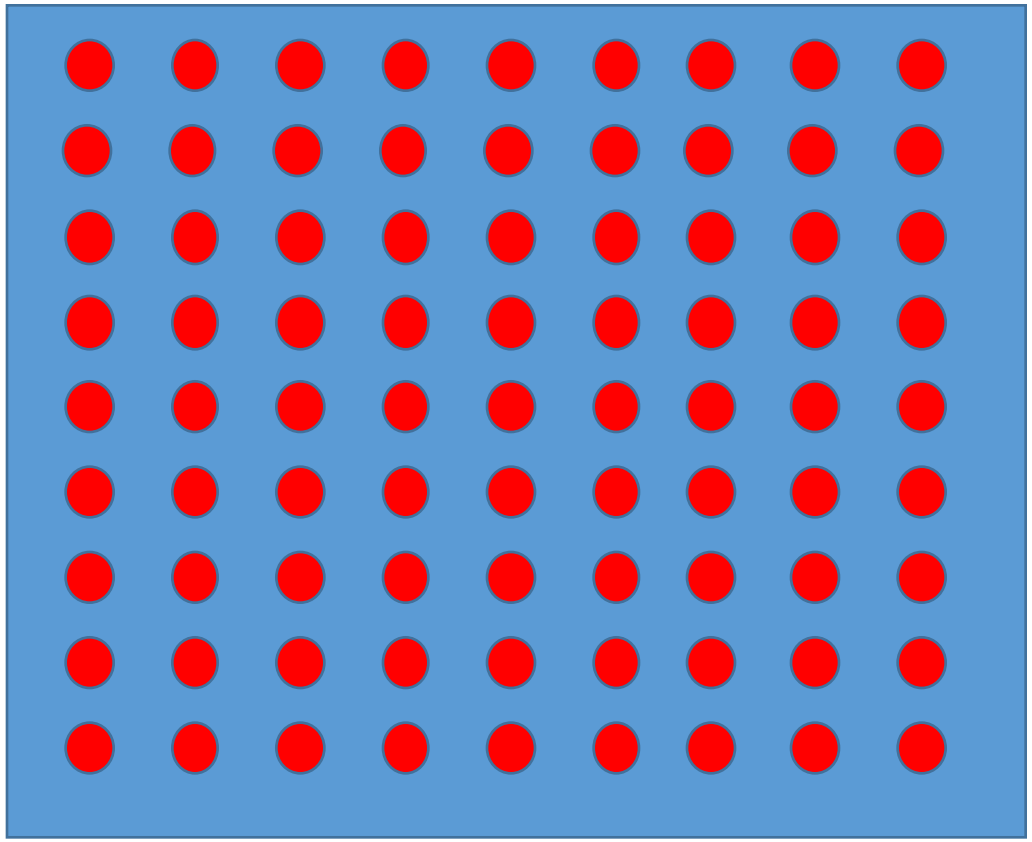
One method doesn't have significant advantage over another.

- At present, the ND and FD flux are calculated by "forcing" the neutrinos at the detector Z location (0,0,Z).
- The near detector is going to be 574 meters from the MC 0 point and with rough size of (300X300X600 cubic cm)→(Information from Laura who in turn got from ND group), flux needs to be calculated over the detector volume/area for more accurate prediction/extrapolation.

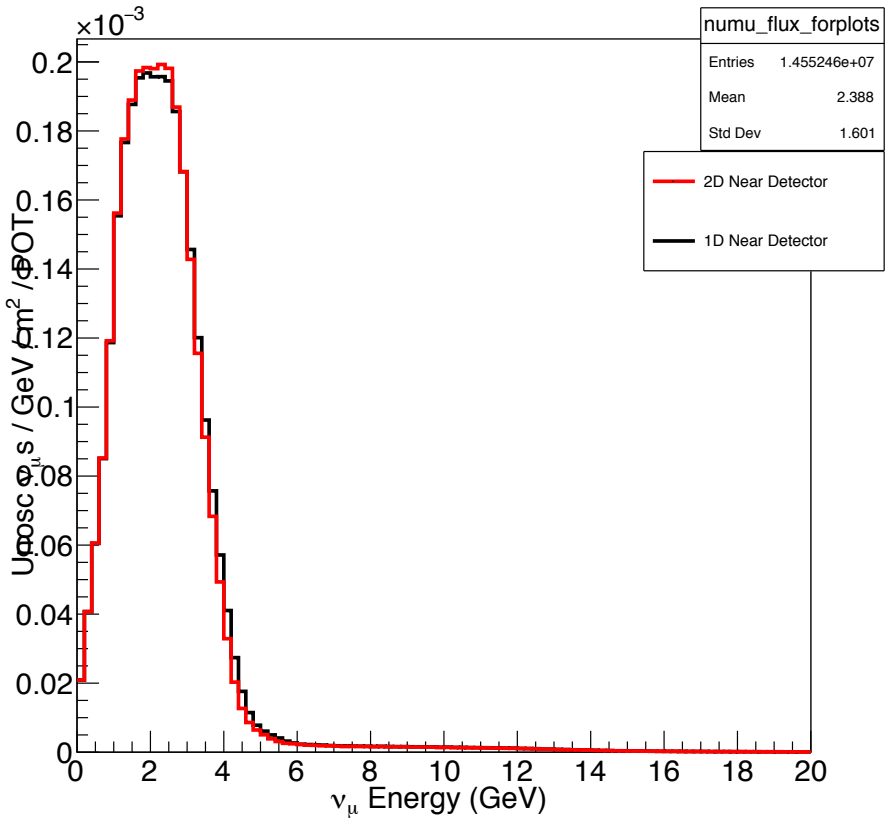
BACK UP

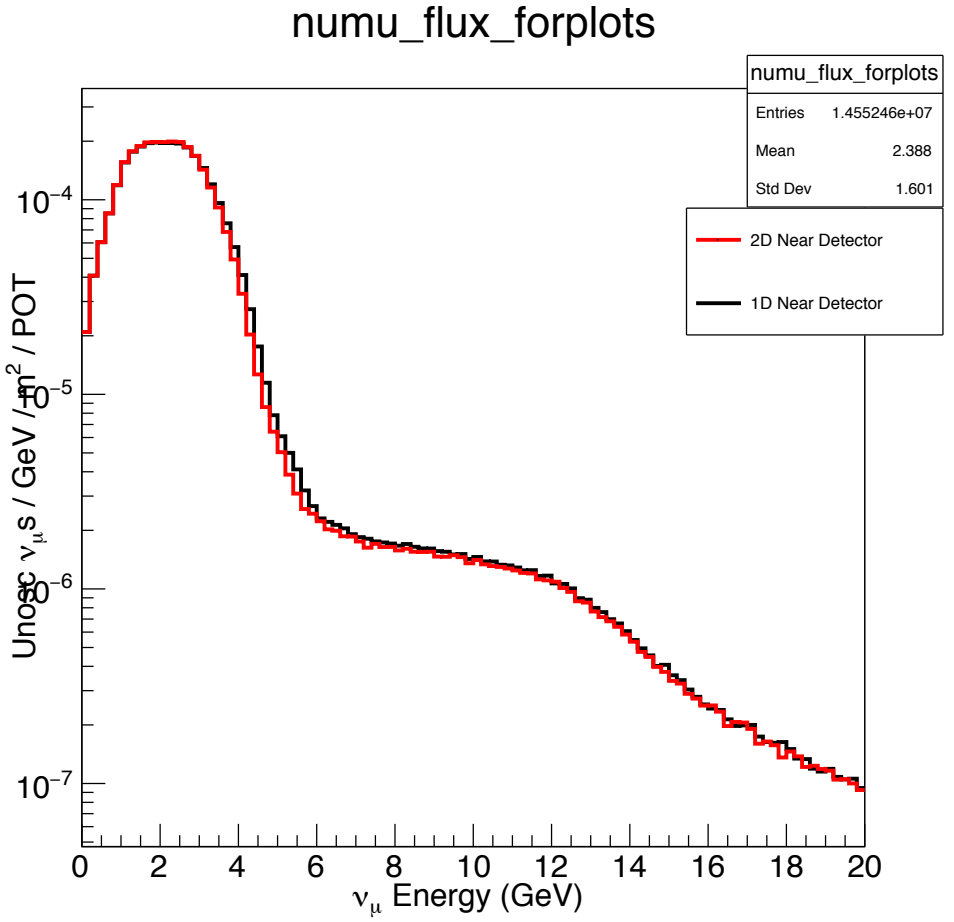


A neutrino event is projected at the center of the Near Detector Location and the weighted neutrino flux and energy is calculated



Each neutrino event is projected at several points equidistance from one another inside an area equal to that of ND and an average flux and energy of neutrino is calculated.


numu_flux_forplots
numu_flux_forplots
Entries 1.455246e+07
Mean 2.388
Std Dev 1.601
2D Near Detector
1D Near Detector
×10⁻³
Unosc ν_μs / GeV / m² / POT
ν_μ Energy (GeV)


numu_flux_forplots
numu_flux_forplots
Entries 1.455246e+07
Mean 2.388
Std Dev 1.601
2D Near Detector
1D Near Detector
Unosc ν_μs / GeV / m² / POT
ν_μ Energy (GeV)