Near to Far Extrapolation for ν_μ

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NOvA Collaboration Meeting @ Argonne

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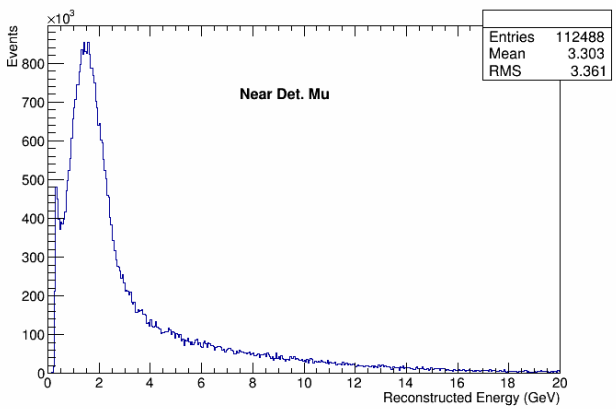
Outline

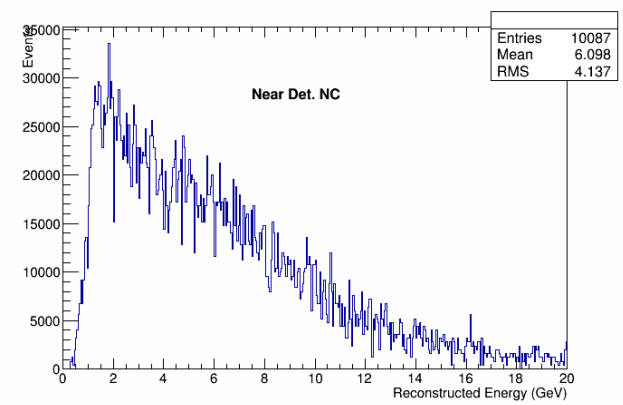
Update to NuMu Far to Near extrapolation. Updates to method:

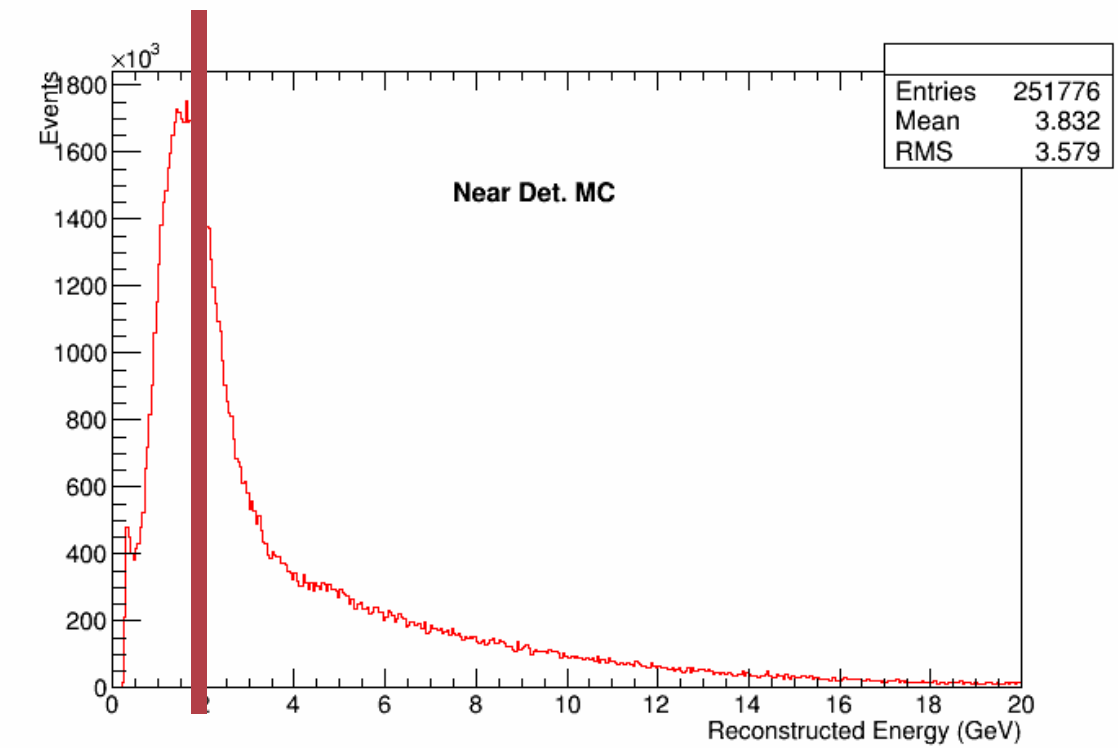
- Removal of dependence on MC truth for selection, only now used for determination of purity etc
- Near detector selection
  - For muons,
    - option for separate non QE and QE selection
    - very loose selection, 1 track < 200 GeV used
  - For electrons, standard ν_e preselection with energy requirement removed
- Far detector selection used here is a very loose muon selection, require only to be a track > 200 GeV
- Studied the far detector contribution that pass far detector selection per contribution (this does use MC truth)

Near detector data

- Peaking a little low
- Uncontained events and badly reco'ed tracks
- Using CaloE probably not best variable in long run but works for testing method





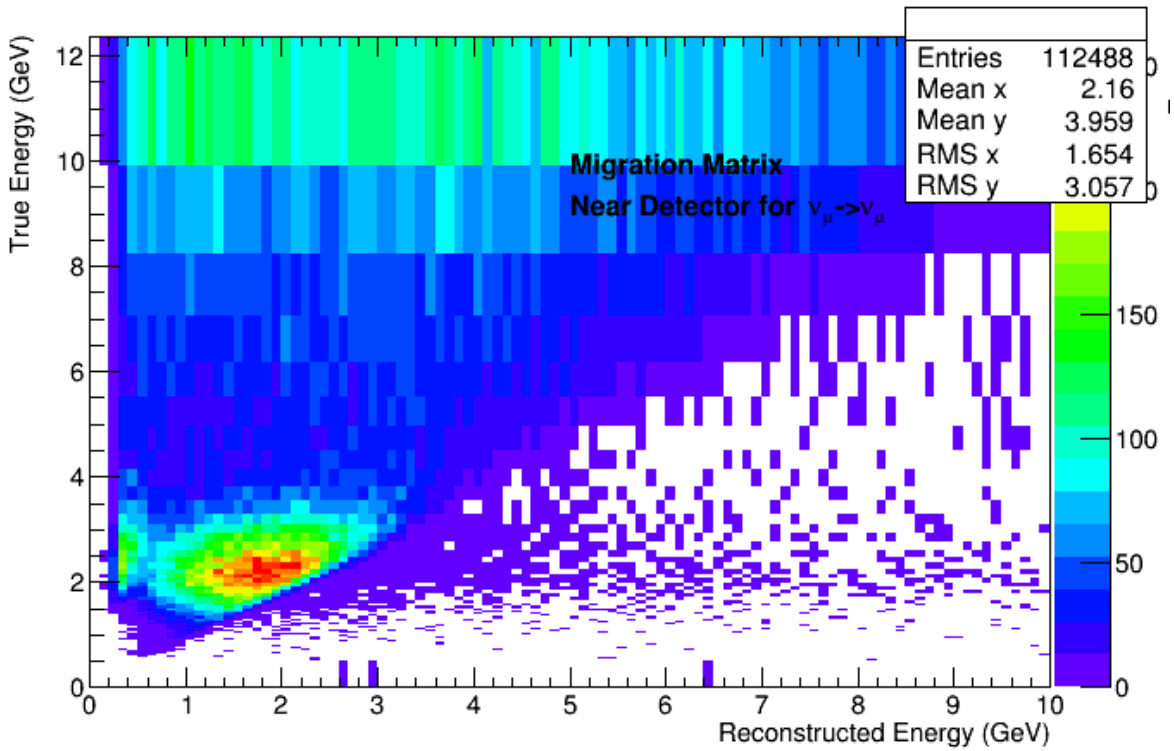


Disappearance

Disappearance of ν_μ events
Step 1: Unfold the reconstructed events

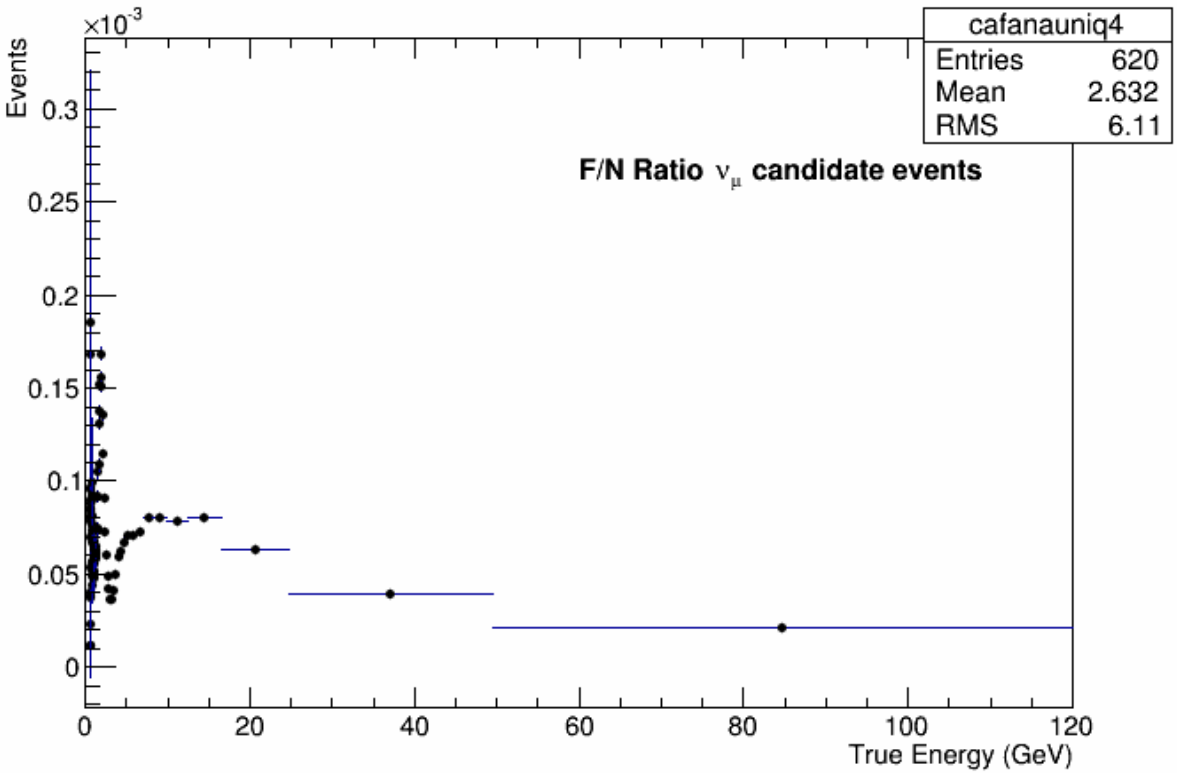
i.e. apply migration matrix to reconstructed events to determine the true energy distribution at the near detector

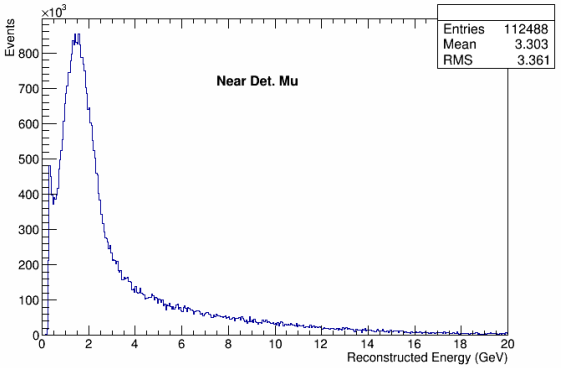
Need relationship between reconstructed and true events in near detector

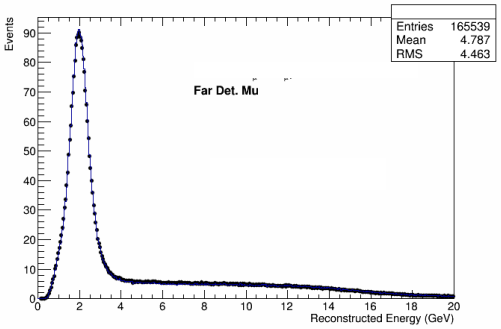


Disappearance of ν_μ events
Step 2: Apply the ratio of N(far)/N(near)

Apply ratio N(far)/N(near) which is determined as function of the true energy



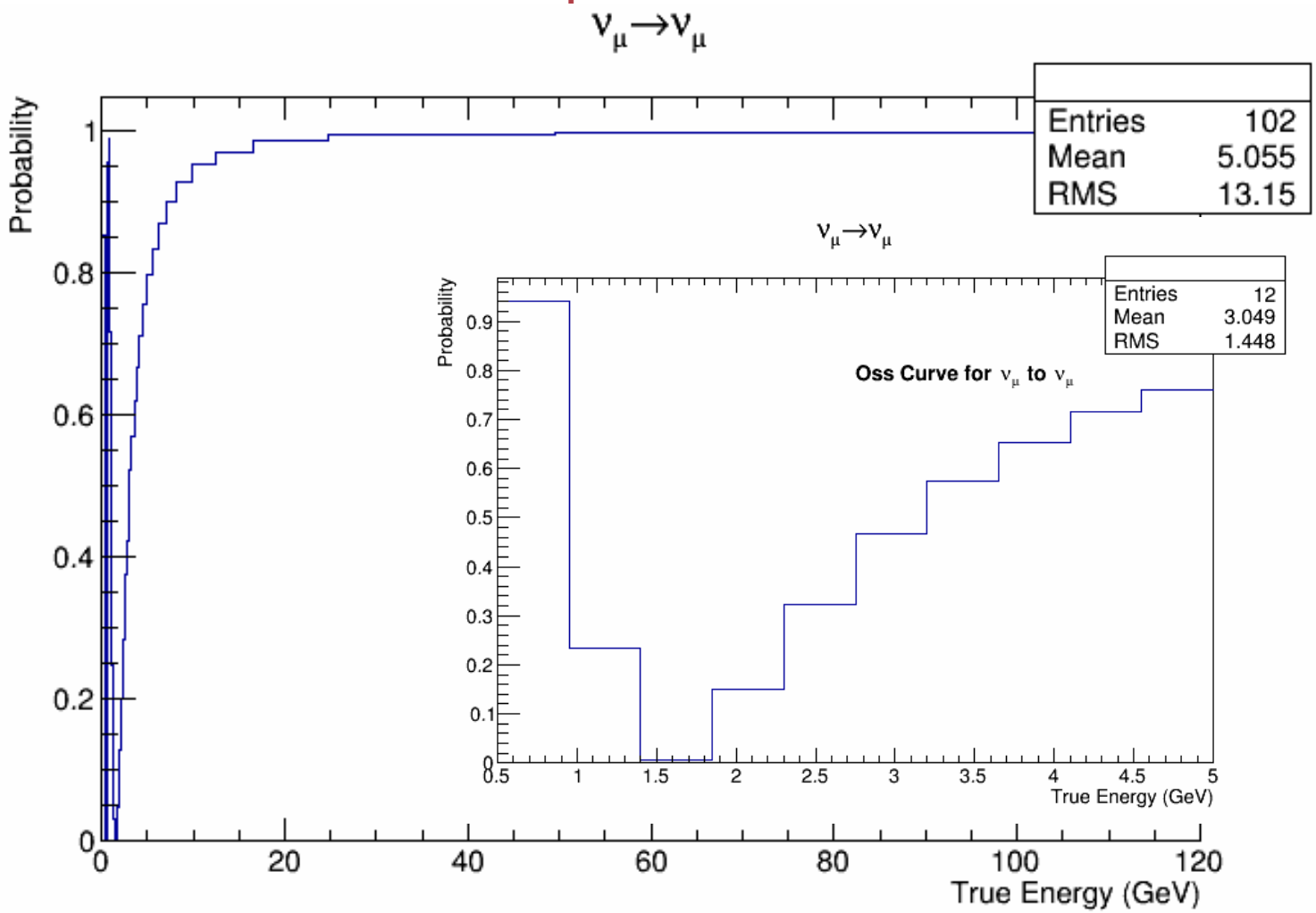




Variable bin widths

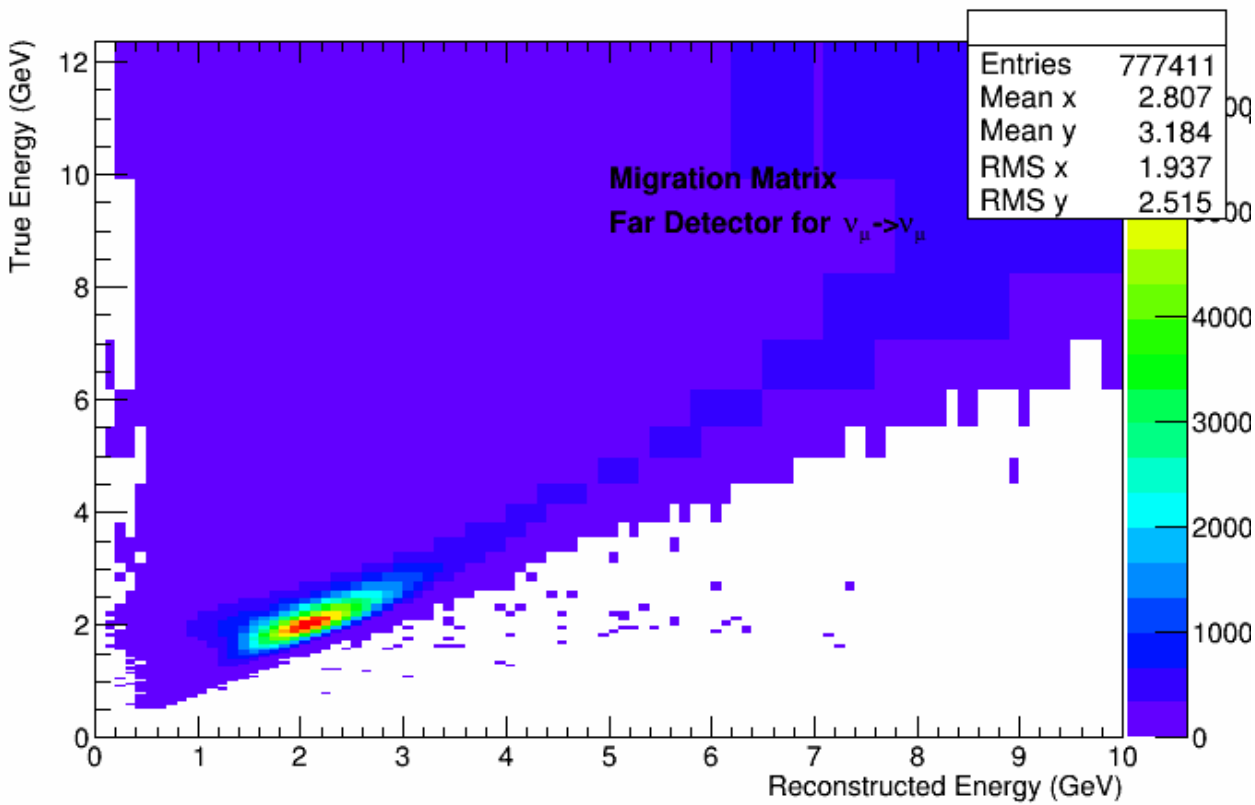
Disappearance of ν_μ events

Step 3: Oscillate the ν_μ



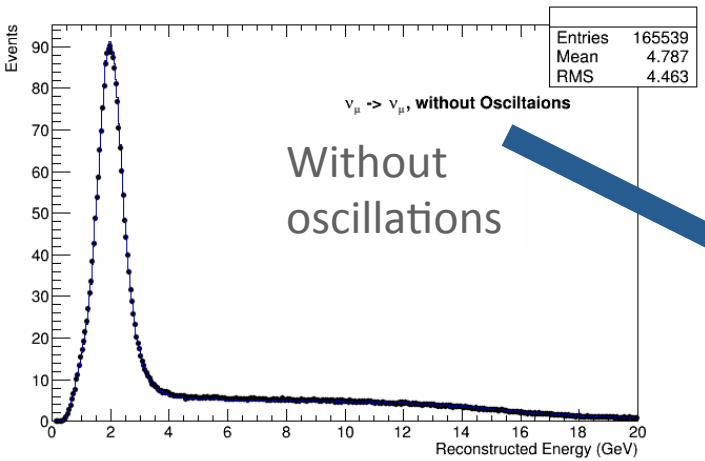
Disappearance of ν_μ events
Step 4: Fold the oscillated events

Apply migration matrix determined from ν_μ events at Far detector

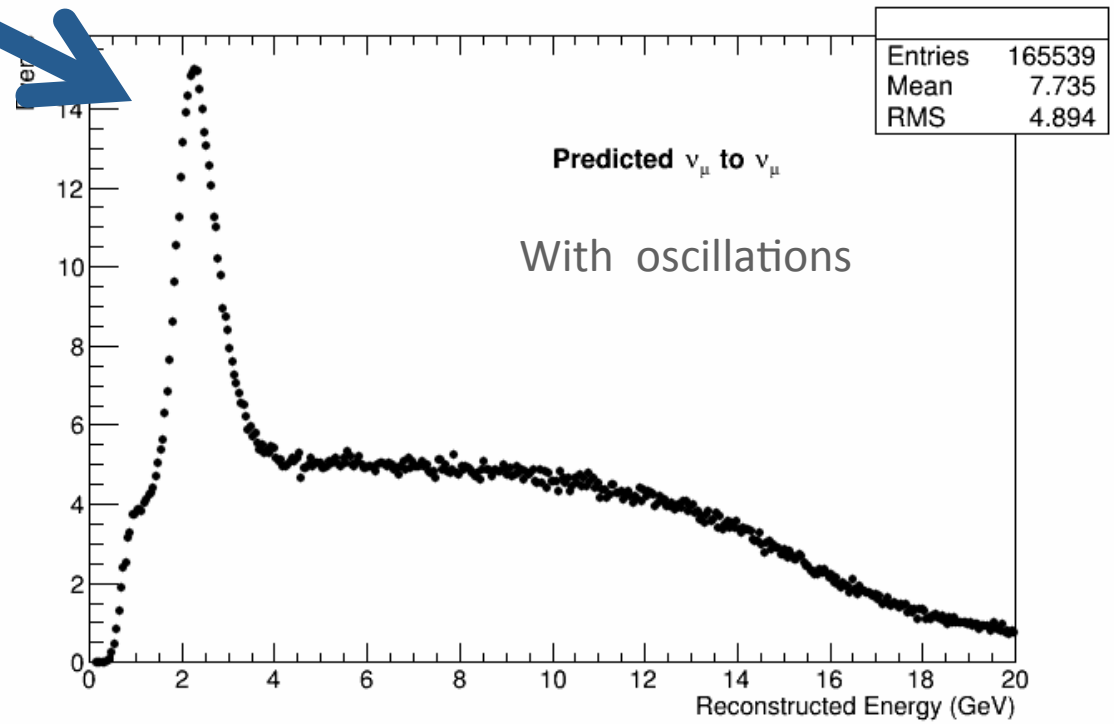


Disappearance of ν_μ events

Step 5: Compare distributions of oscillated and unoscillated ν_μ

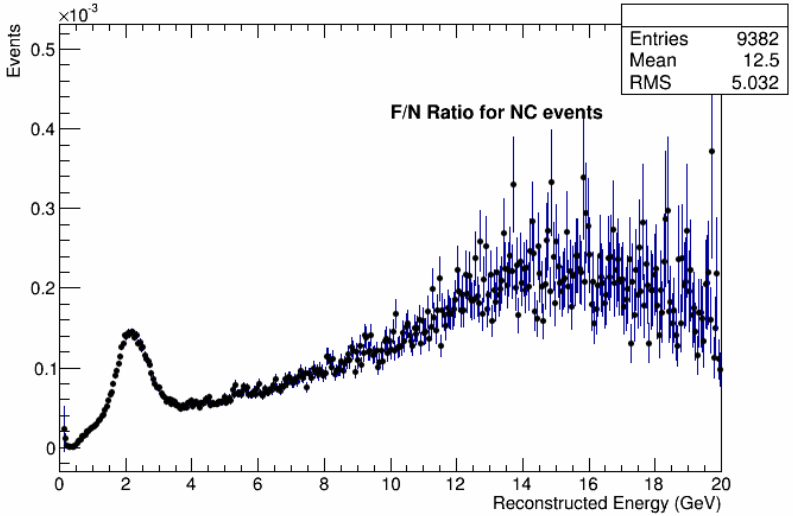


Without oscillations

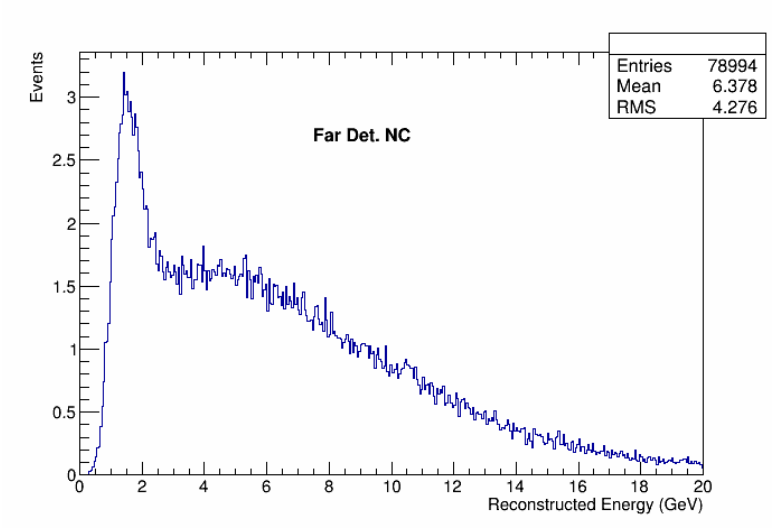


With oscillations

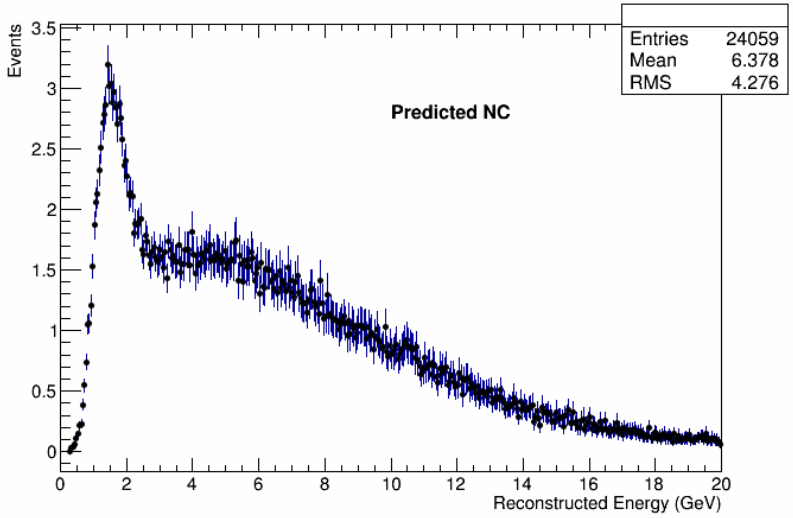
NC events
Extrapolated using F/N ratio



Far detector MC NC

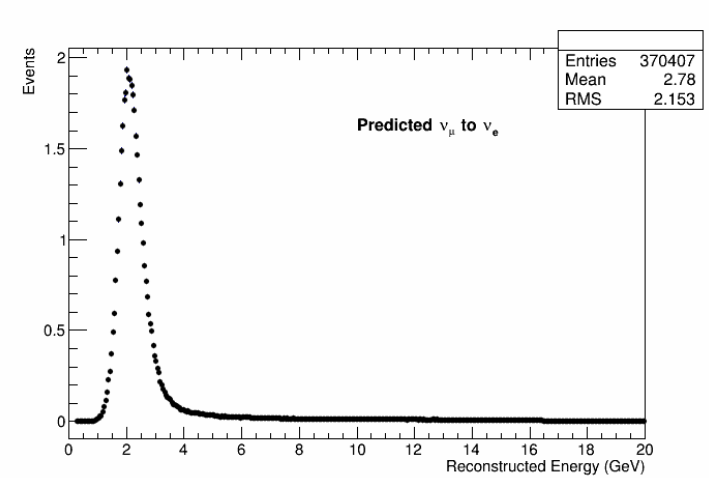


Extrapolated NC events

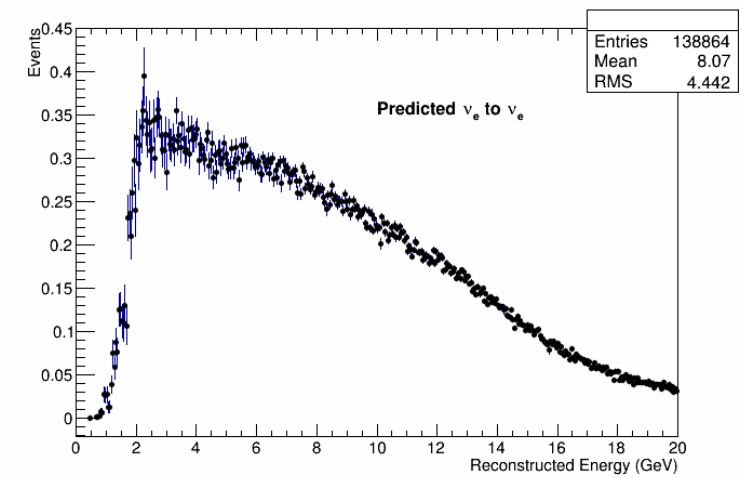


Appearance of ν_μ events
Other contributions through "fake" muons

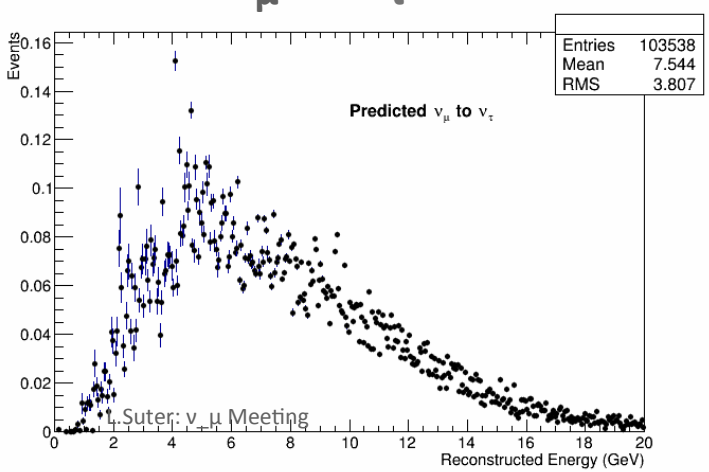
$\nu_\mu \rightarrow \nu_e$



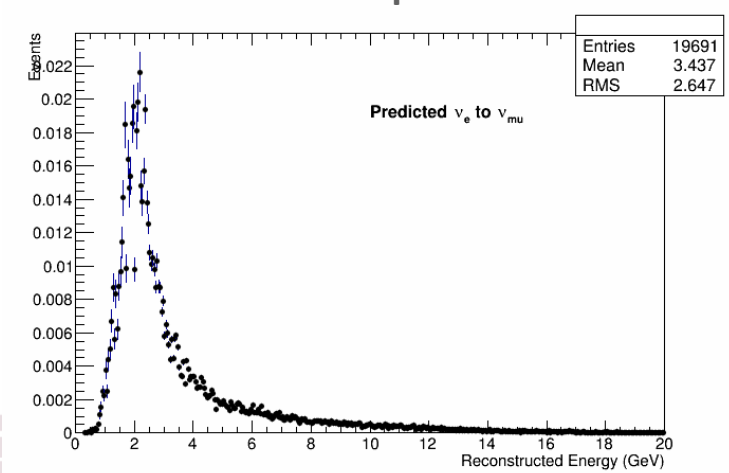
$\nu_e \rightarrow \nu_e$



$\nu_\mu \rightarrow \nu_\tau$

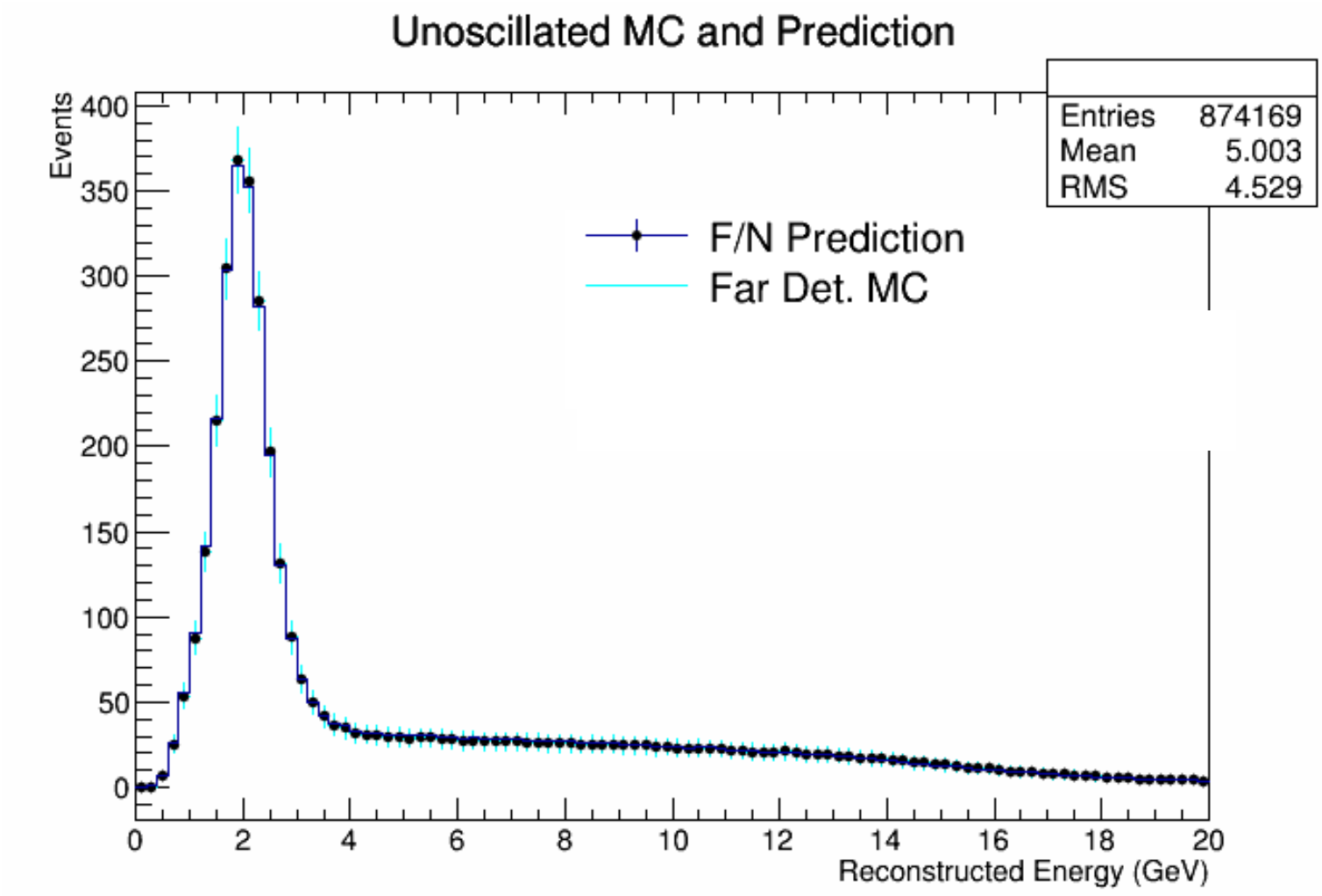


$\nu_e \rightarrow \nu_\mu$

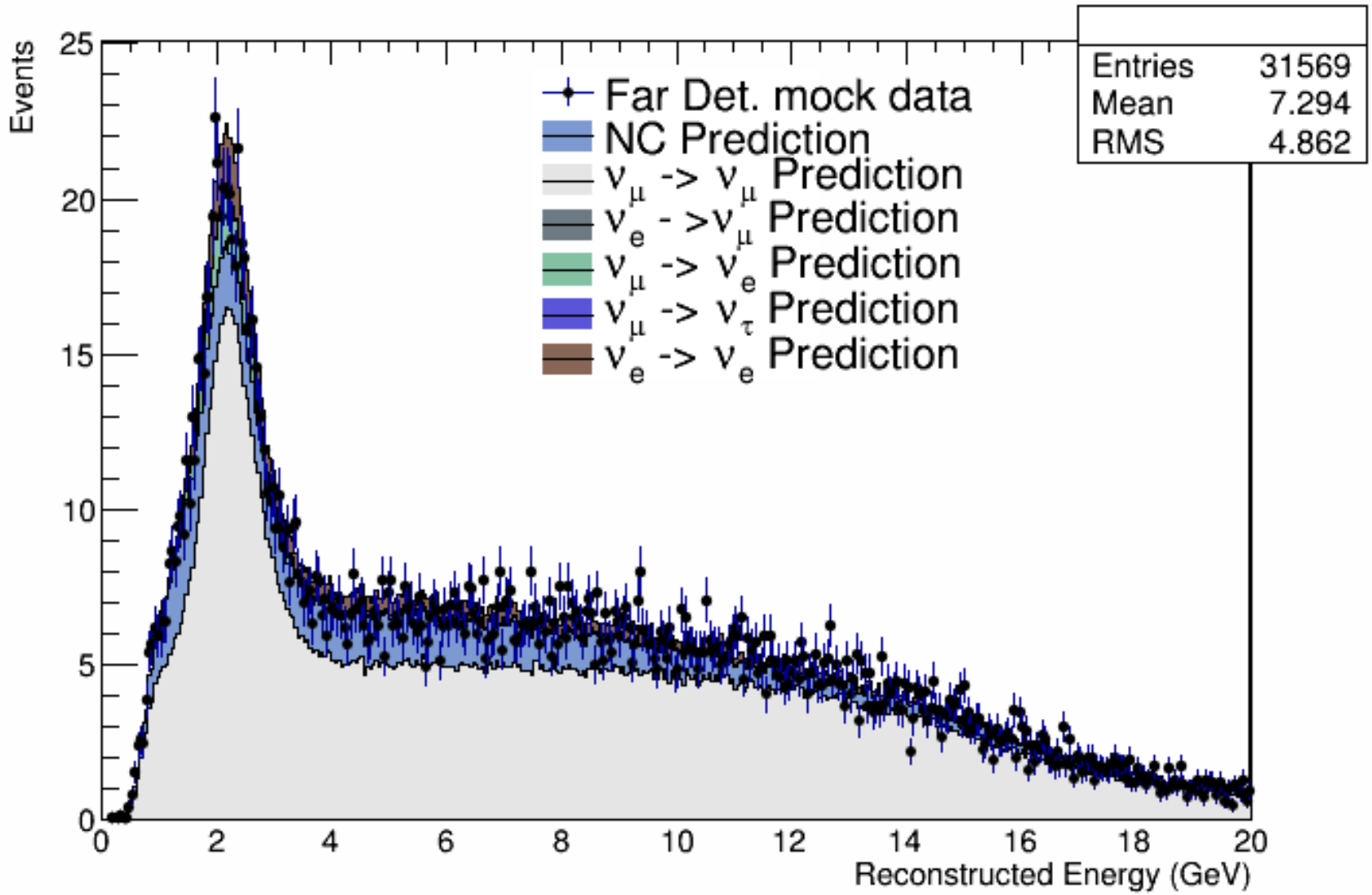


Comparison to mock data

Comparison no oscillation



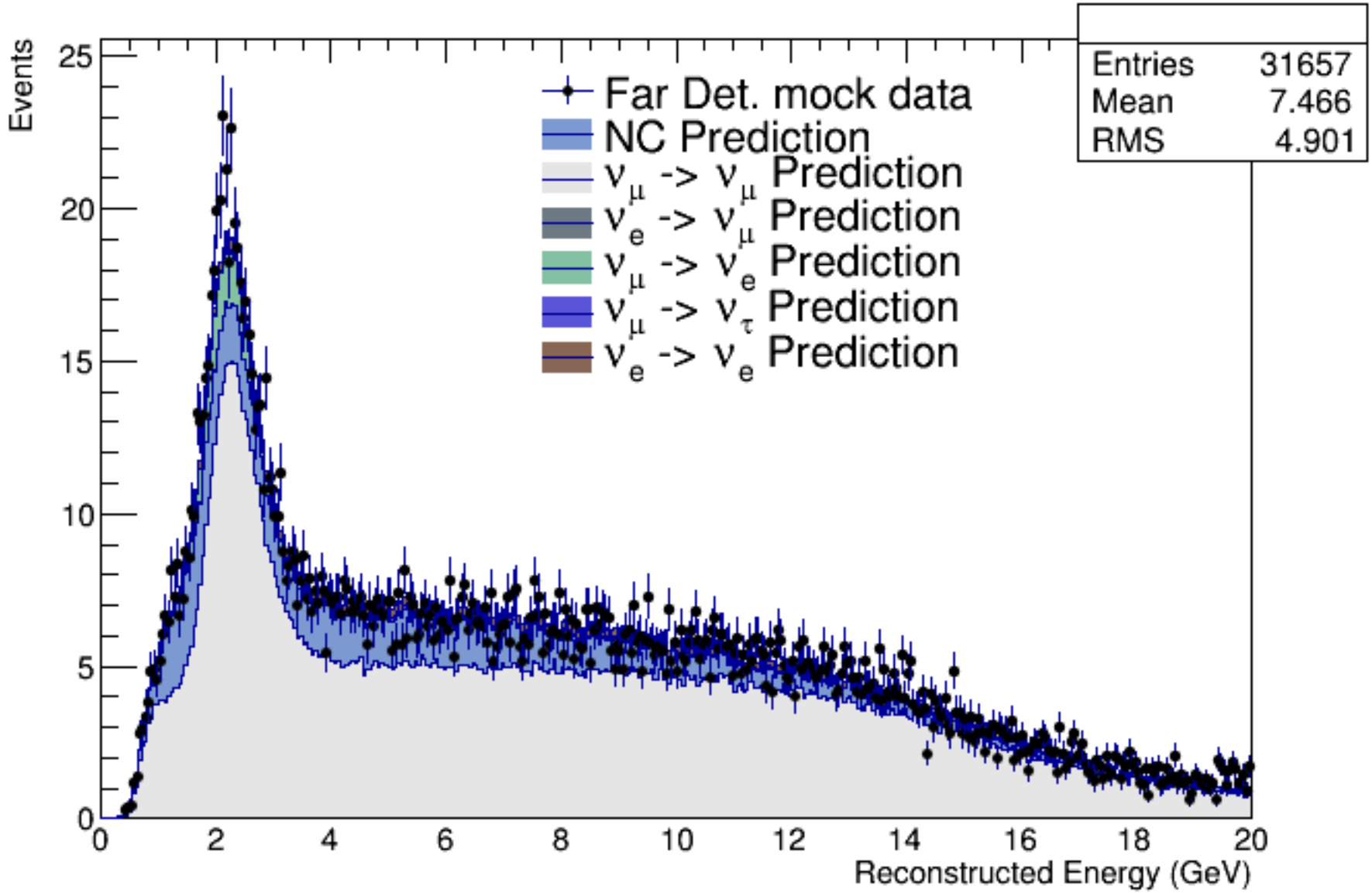
Mock data Osc1



Mock data Osc0

Sample	Events (normalised to POT 18e20)
NC	356.74 ± 3.25
$\nu_\mu \to \nu_\mu$	1723.63 ± 2.30
$\nu_\mu \to \nu_e$	0.73 ± 0.60
$\nu_\mu \to \nu_\tau$	15.47 ± 0.07
$\nu_e \to \nu_\mu$	43.37 ± 0.01
$\nu_e \to \nu_e$	71.75 ± 0.05
Total Events	2151.65 ± 0.19
Mock Data	2163.44 ± 46.51

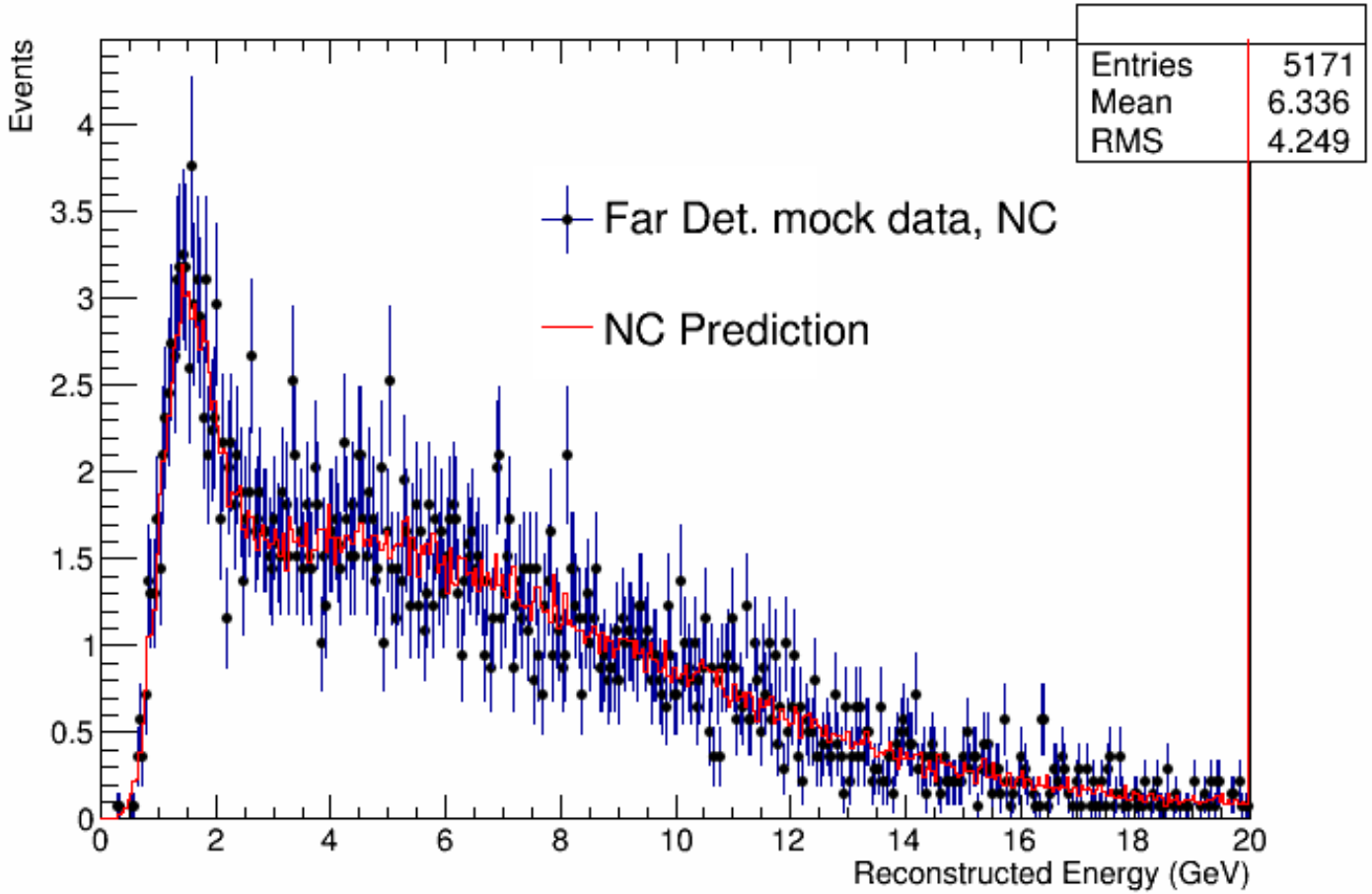
Mock data Osc1



Mock data Osc1

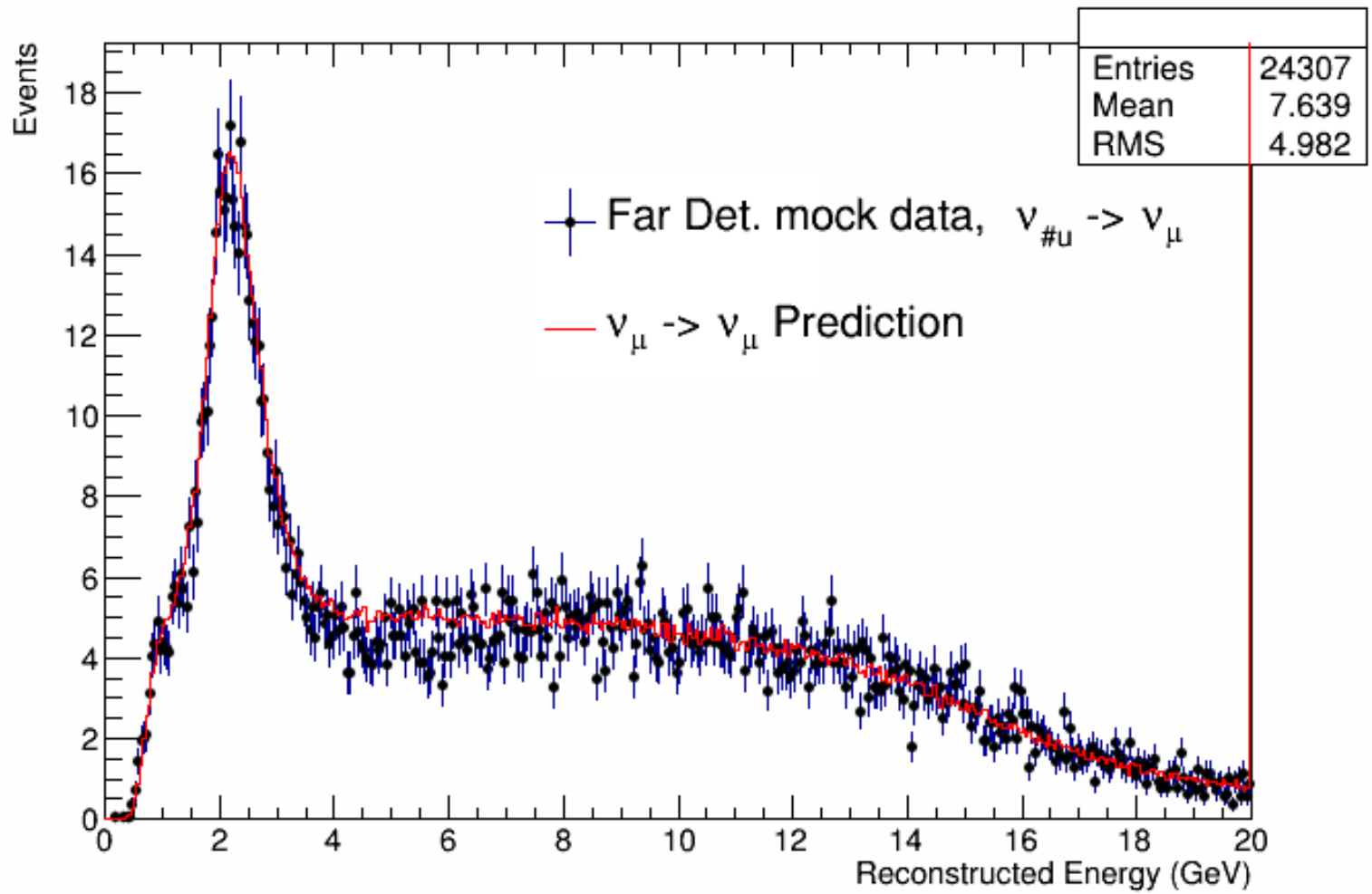
Sample	Events (normalised to POT 18e20)
NC	356.74 ± 12.43
$\nu_\mu \to \nu_\mu$	1723.63 ± 2.30
$\nu_\mu \to \nu_e$	0.89 ± 0.63
$\nu_\mu \to \nu_\tau$	15.60 ± 0.06
$\nu_e \to \nu_\mu$	39.26 ± 0.01
$\nu_e \to \nu_e$	126.44 ± 0.04
Total Events	2207.71 ± 0.20
Mock Data	2181.06 ± 46.70

Looking at individual components
NC

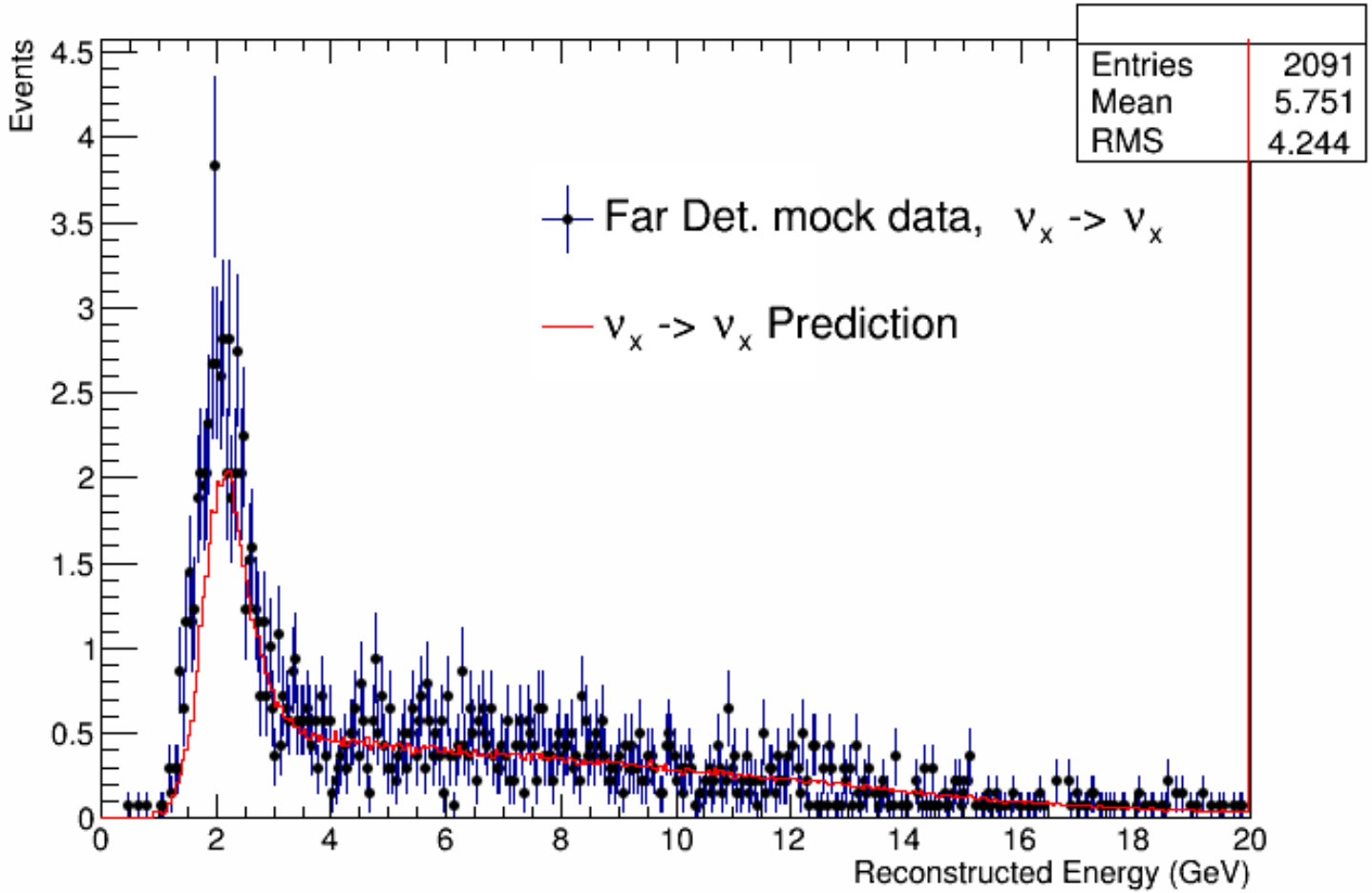


Looking at individual components

ν_μ to ν_μ



Looking at individual components
Everything else



Conclusions

- Far to near extrapolation is working for NuMu
- See reasonable agreement with mock data
- Excess at 2 GeV still being investigated
- Need to look in sensible near detector confinement and cuts