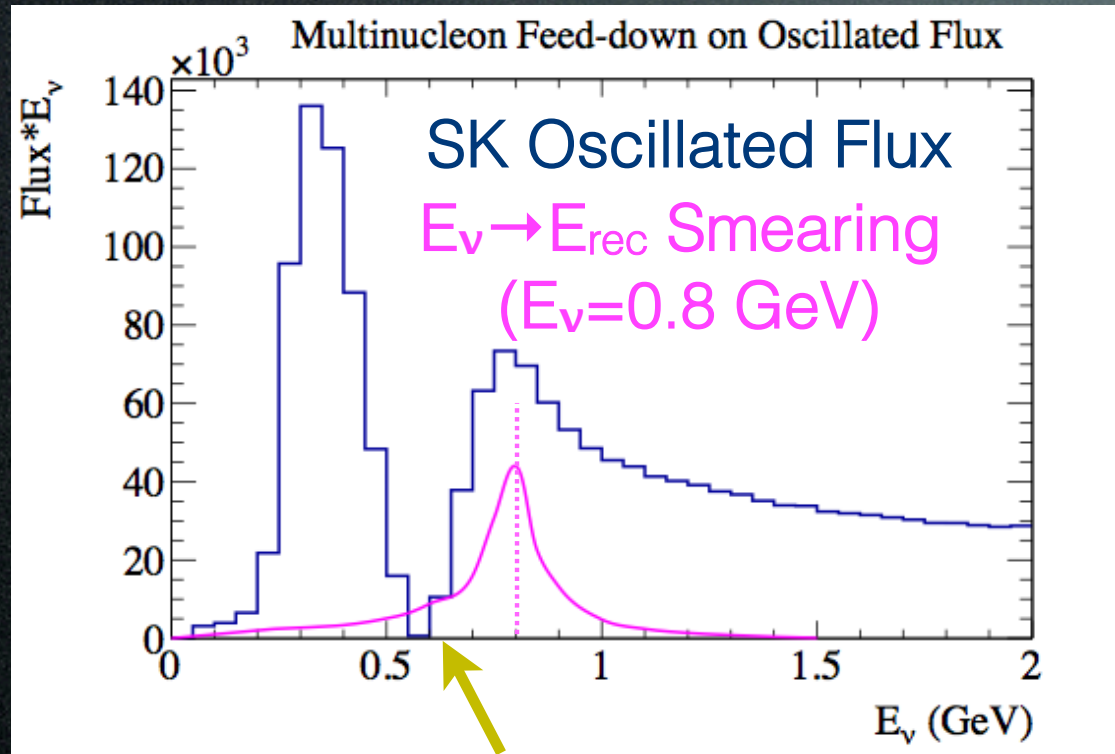# vPRISM Discussion/ Next Steps

Mike Wilking
2nd vPRISM Workshop
24-July-2014

Proposal Goals
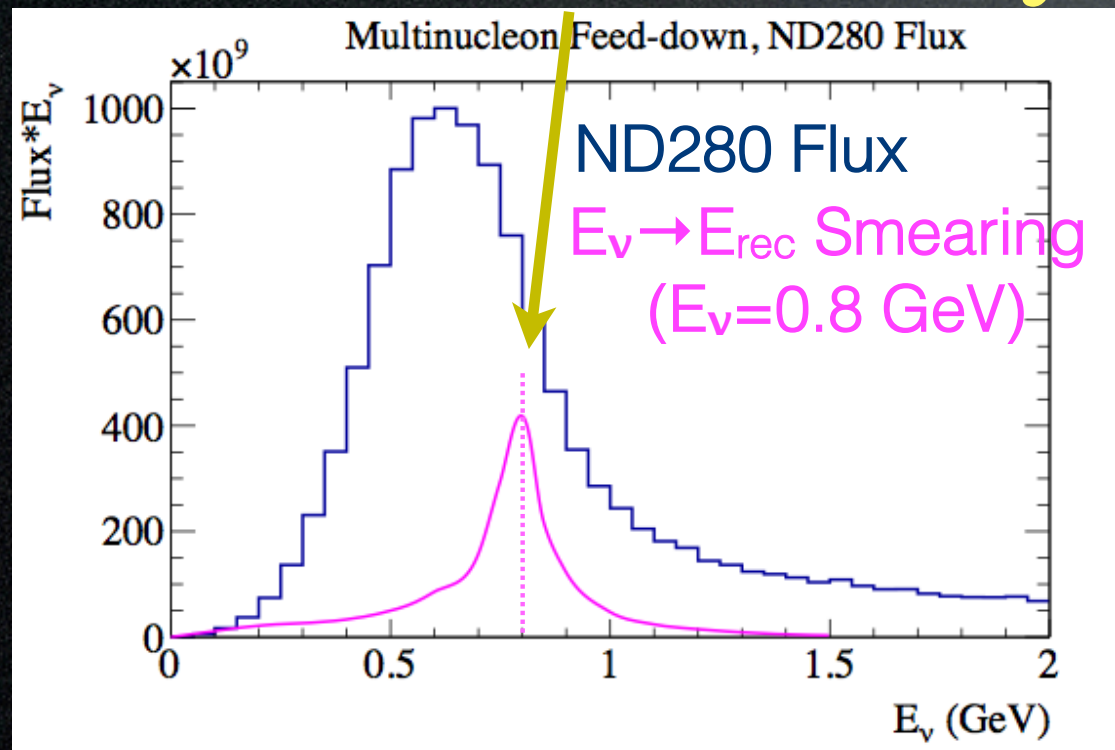
- **nuPRISM is driven by measurement capabilities, so complete analyses are required**

    - ν_μ disappearance analysis (Mark S.'s talk)

        - Initial version finished, but improvements are needed

    - ν_e appearance analysis (Asher's talk; initial studies underway; electron purity is important)

    - Anti-ν analyses (Leila's talk; just starting)

    - Sterile neutrino analysis (Stefania's talk; now quite mature; next steps to include ND280?)

    - Cross section physics (Kendall's talk; just finished discussing this)
      Carl's and Mark S.'s Talks

    - **Requires realistic detector simulation/reconstruction, detector systematic errors, etc.**

- **Must decide on a plausible baseline detector design**

    - Tank size (length: off-axis angle range; width: electron and muon efficiency & purity)

    - PMT size and photocathode coverage

        - Will dictate the required/allowed electronics (Thomas' and Marcin's talks)

            - Must maintain synergy with Hyper-K R&D, if possible

    - Integration of all detector systems (e.g. including scintillator panels as an OD reflector)

    - **Detector calibration requirements, and corresponding systems, are essential!**

- **As much information regarding civil construction as possible (without yet acquiring site)**
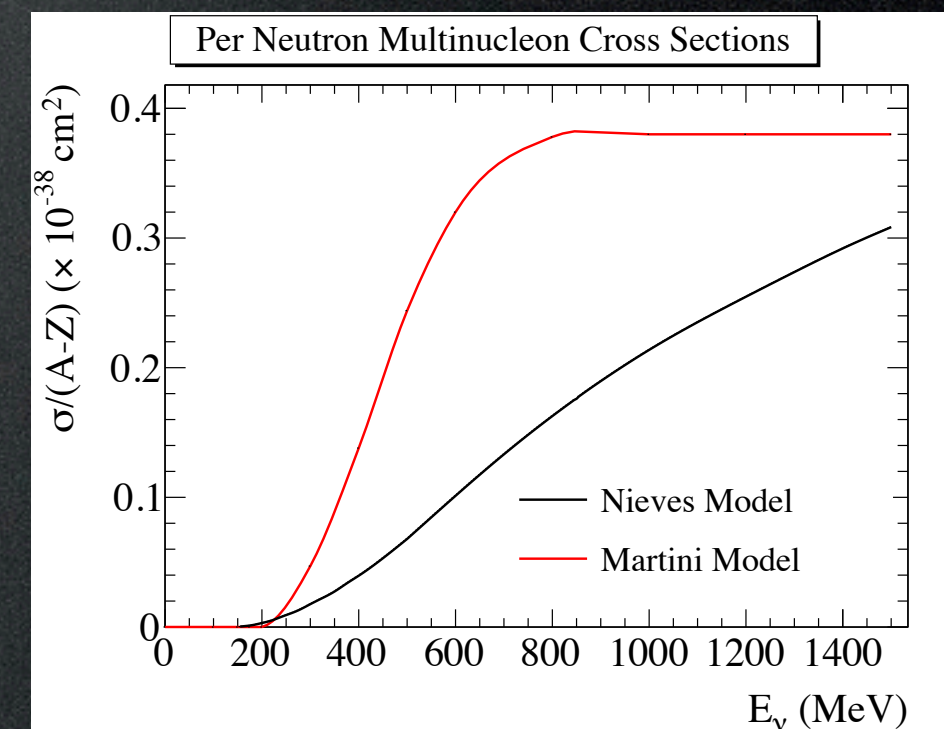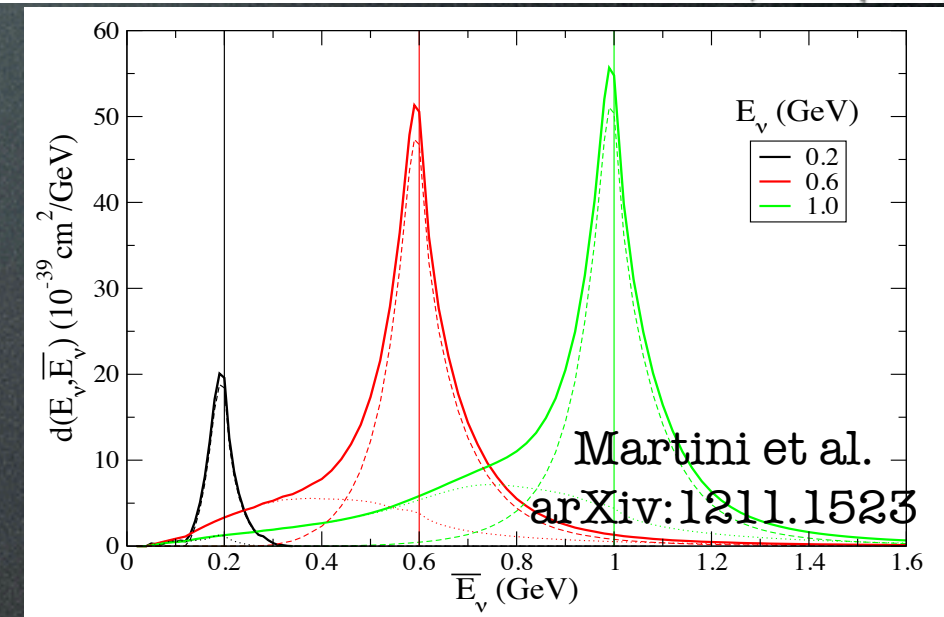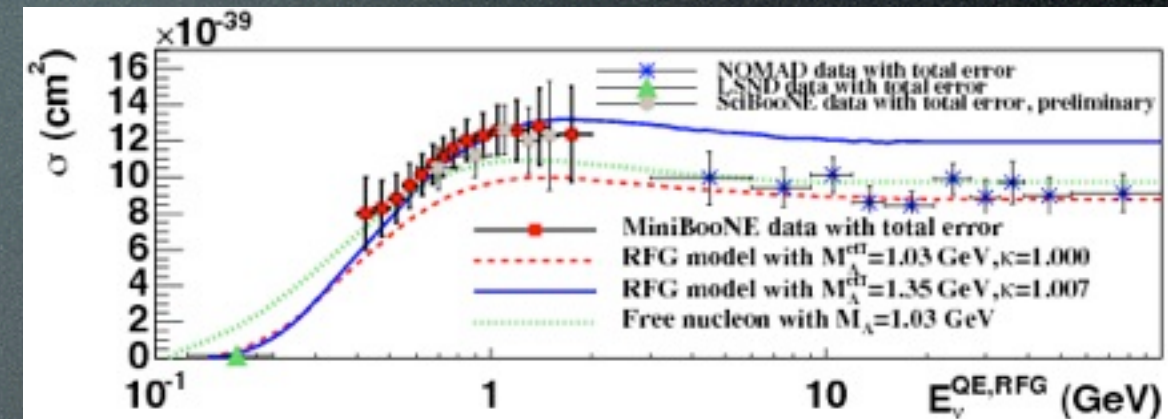 Ishida-san's Talk

More Motivation?

Multinucleon Feed-down on Oscillated Flux

SK Oscillated Flux
$E_\nu \rightarrow E_{rec}$ Smearing
(E_ν=0.8 GeV)

Mixing Angle Bias!

Near detectors lack sensitivity

Multinucleon Feed-down, ND280 Flux

ND280 Flux
$E_\nu \rightarrow E_{rec}$ Smearing
(E_ν=0.8 GeV)

Need more than this for the proposal?

More models? GiBUU? GENIE?

NOMAD data with total error
LSND data with total error
SciBooNE data with total error, preliminary
MiniBooNE data with total error
RFG model with M_A^{eff}=1.03 GeV, κ=1.000
RFG model with M_A^{eff}=1.35 GeV, κ=1.007
Free nucleon with M_A=1.03 GeV

E_ν (GeV)
0.2
0.6
1.0

Martini et al.
arXiv:1211.1523

Per Neutron Multinucleon Cross Sections

Nieves Model
Martini Model

3

Detector Simulation and Reconstruction
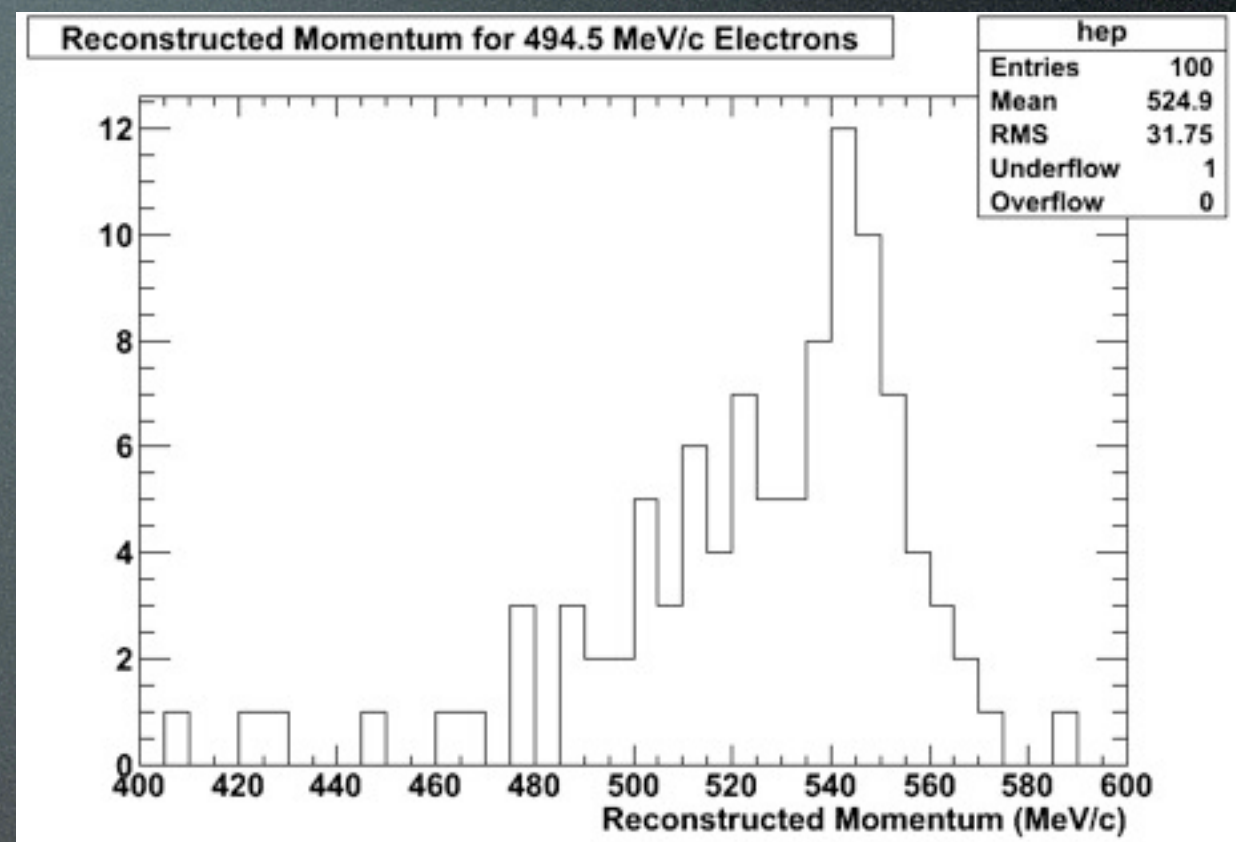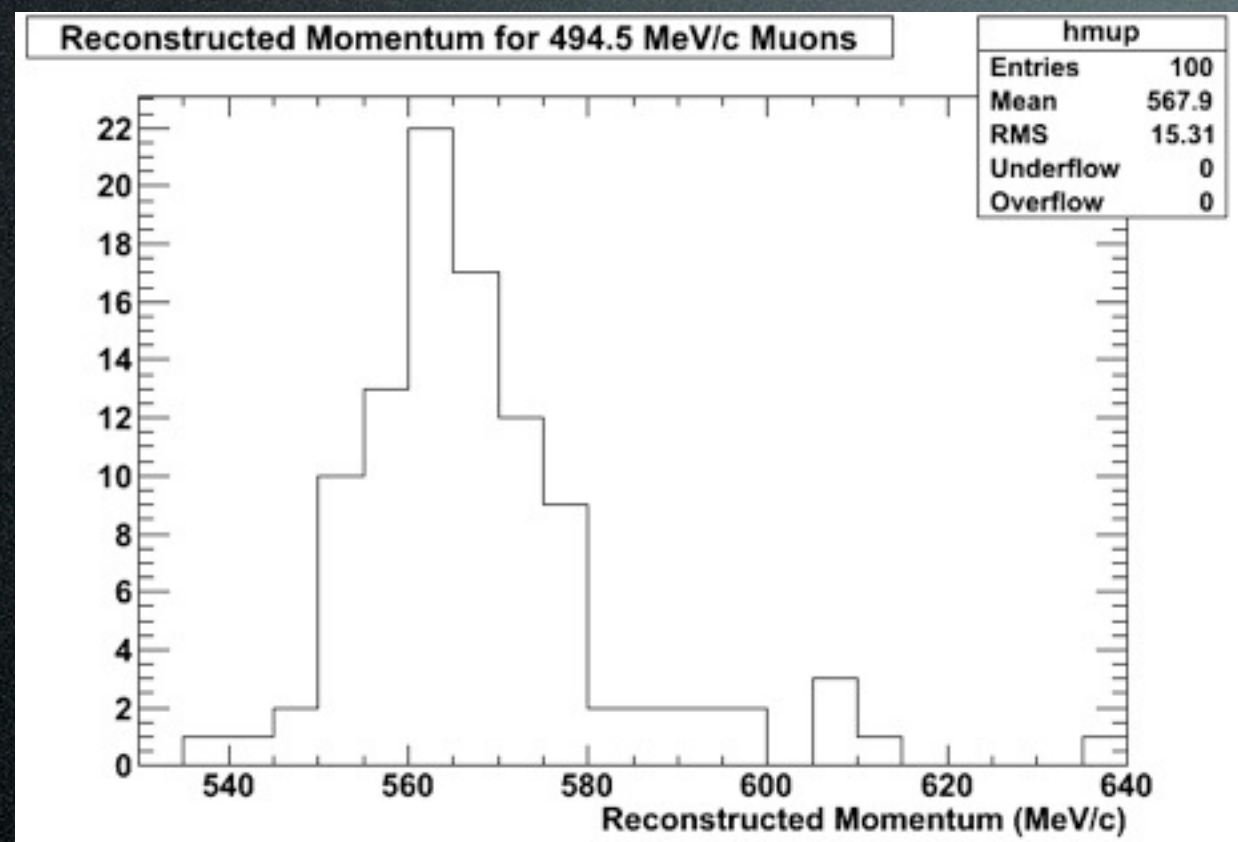
- Now becoming critical for all nuPRISM stuies (and Hyper-K)

- Working set of code based on WCSim and fiTQun

- fiTQun still needs to be tuned to WCSim optical model

  - Same issues seen in Hyper-K reconstruction

    - Work in progress at Winnipeg and Stony Brook; ~1 month until ready

Detector Systematics

- Just started to explore this, and can be important

- Need to define requirements for the calibration

- Linear momentum bias as a function of depth:
  - Nominal momentum at top, 93% of measured value at bottom

Momentum bias applied

Nominal νPRISM prediction

E_{Rec} (GeV)
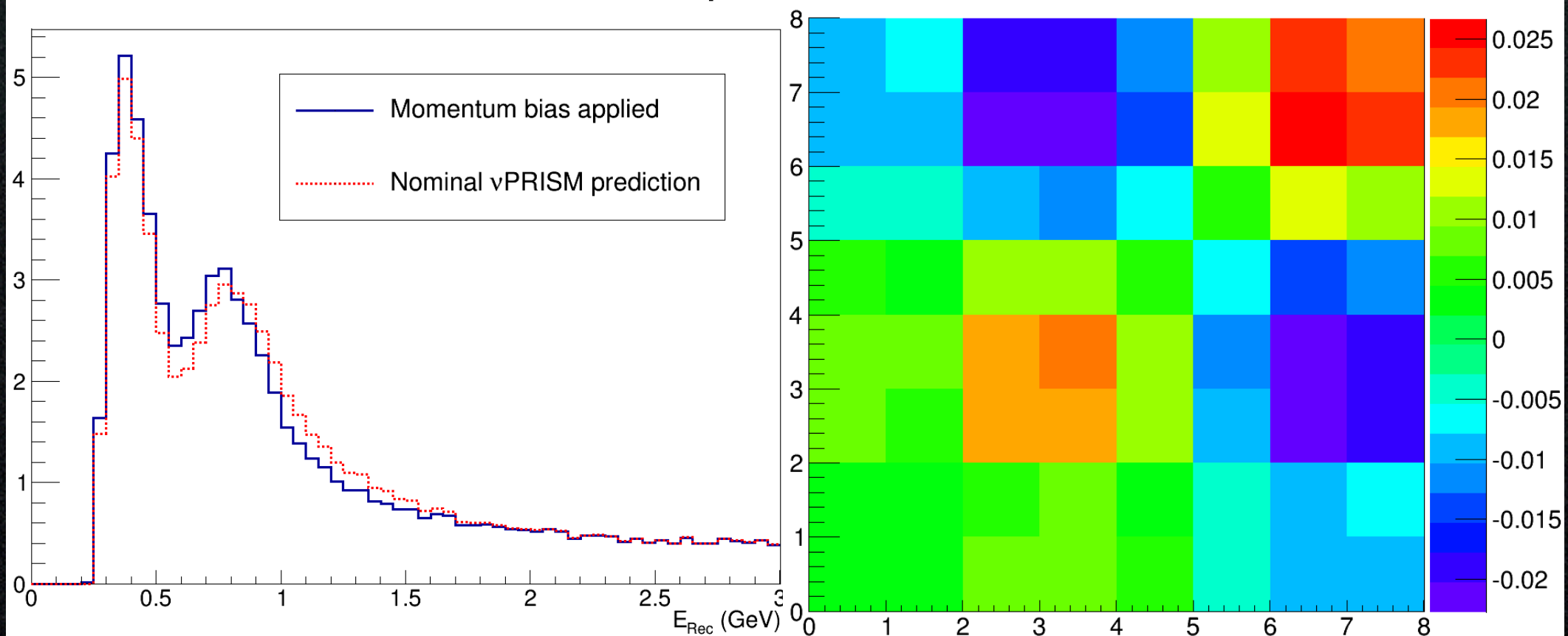
- Big effect, ~15% maximum uncertainty and anti-correlations in energy bins

Calibration

Environmental control (monitoring)

- PMT gain/efficiency
  - Voltage/current (power supply) monitoring
  - Temperature, B-field sensors
- Light scattering
  - Water quality monitoring: sampling
  - Surface condition of PMT/sheets: ccd camera?
- Geometry
  - PMT position/tilt: laser tracker, ccd camera
- Accidental rate monitoring for pile ups
  - light leaks, electric noise monitoring
  - event rate monitoring

- PMT gain/efficiency and timing
  - Ni ball, Xe-scint. ball
  - Manipulation system to deploy at different positions:
    - attached to the nuPRISM-lite and automatic deployment
  - ex-situ characterization of PMT response
    - angular response
    - HV/temperature/B-field dependence
- Reflection: water/surface quality changes
  - laser/LED calibration, Rayleigh scattering device
  - ex-situ characterization of water, blacksheet, etc.
- Geometry (change due to movement)
  - laser tracker, ccd camera
- Electronics calibration

- Michel electrons from stopping cosmic rays
  - scintillator box (miniBooNE)
- Through-going muons (beam, cosmic rays)
- π^0 mass
- Characteristic neutrino interaction processes
- Beam tests of small scale detector:
  - e.g. TRIUMF M11 beam
  - tagged neutron beam at RCNP

- Need to explore options, understand feasibility cost, etc.

- Ensure that all our calibration needs are met (with redundancy)

Toward a Full Proposal

- Much has been accomplished in a very short time!

  - Only 4 months since the last workshop

  - Complete demonstration of nuPRISM technique in a T2K oscillation analysis

    - Data-driven nuPRISM constraint works!

  - Many details regarding civil construction, detector design, electronics and PMTs are already available

- Timescales are tight for a nuPRISM upgrade for T2K

  - Still a possibility if we can gain approval in the next 1-2 years

  - Regardless, these studies will be useful for building a nuPRISM for future oscillation experiments

- Next step is a full nuPRISM proposal

  - Need to completed all physics analysis studies

- Let's complete the first nuPRISM proposal this year!