Optimization of detector design of NuPRISM, a new water-Cherenkov neutrino near detector

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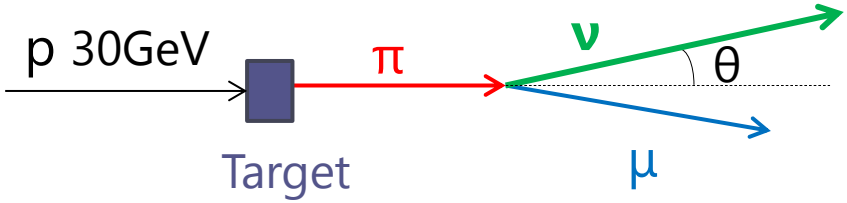
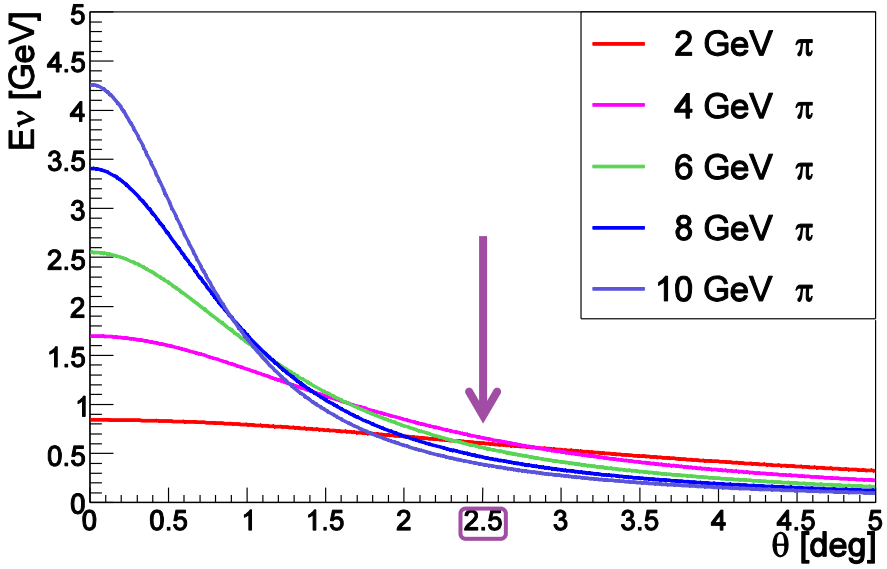
J-PARC Off-Axis beam

- The J-PARC neutrino beam is directed 2.5° away from the far detector. (Off-Axis beam)
- Neutrino energy peaks at 0.6 GeV oscillation maximum, and narrowly distributed.

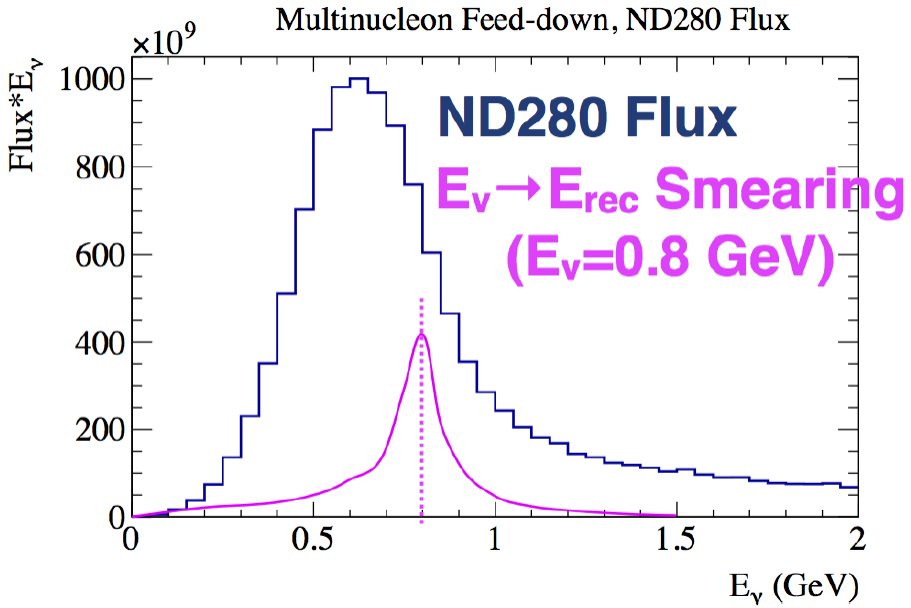


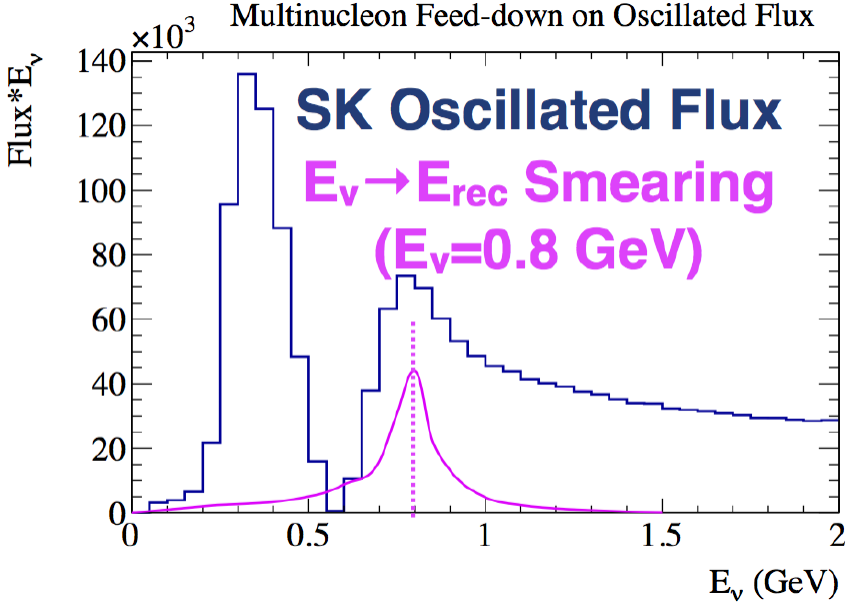
$$E_\nu = \frac{m_\pi^2 - m_\mu^2}{2E_\pi} \frac{1}{1-\beta_\pi \cos\theta}$$



Neutrino spectra at far and near detector

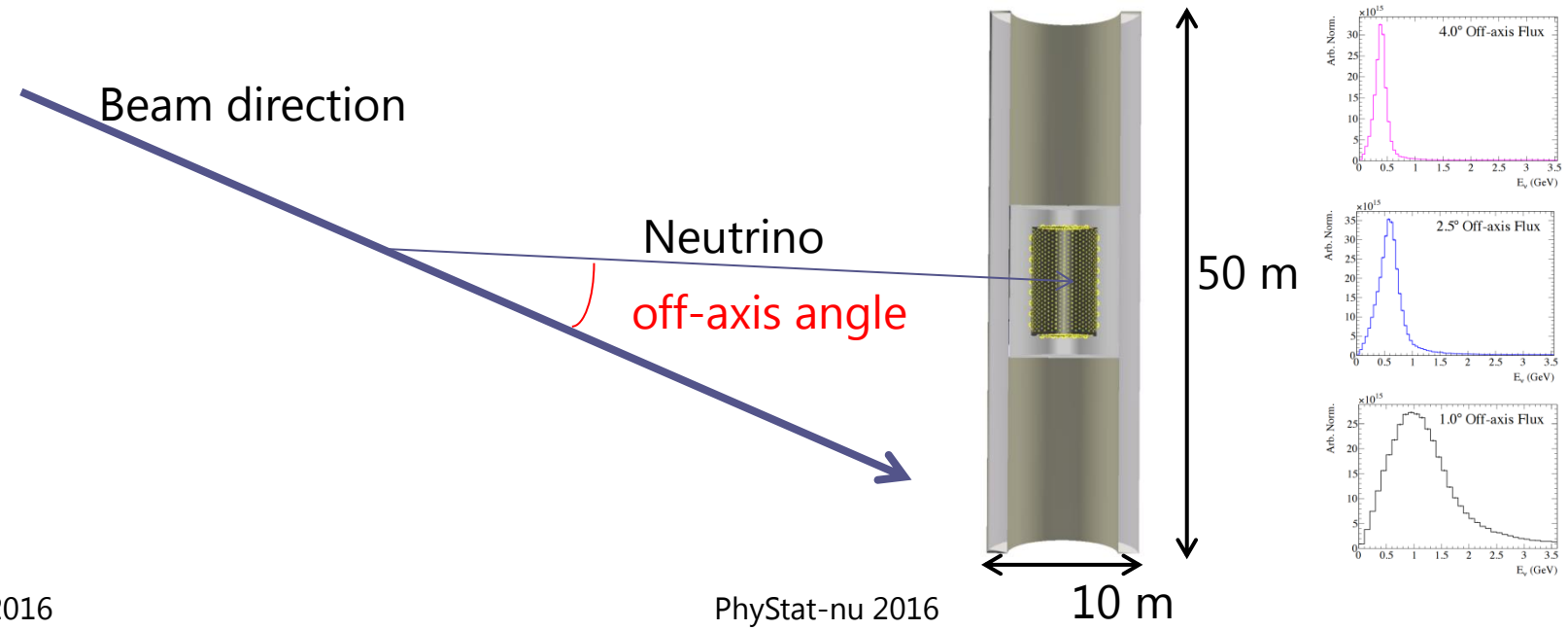
- Neutrino oscillation results in different neutrino energy spectra at near and far detectors.
- Energy smearing may have large effect in oscillation analysis at far detector, if it could not be measured enough at near detector.





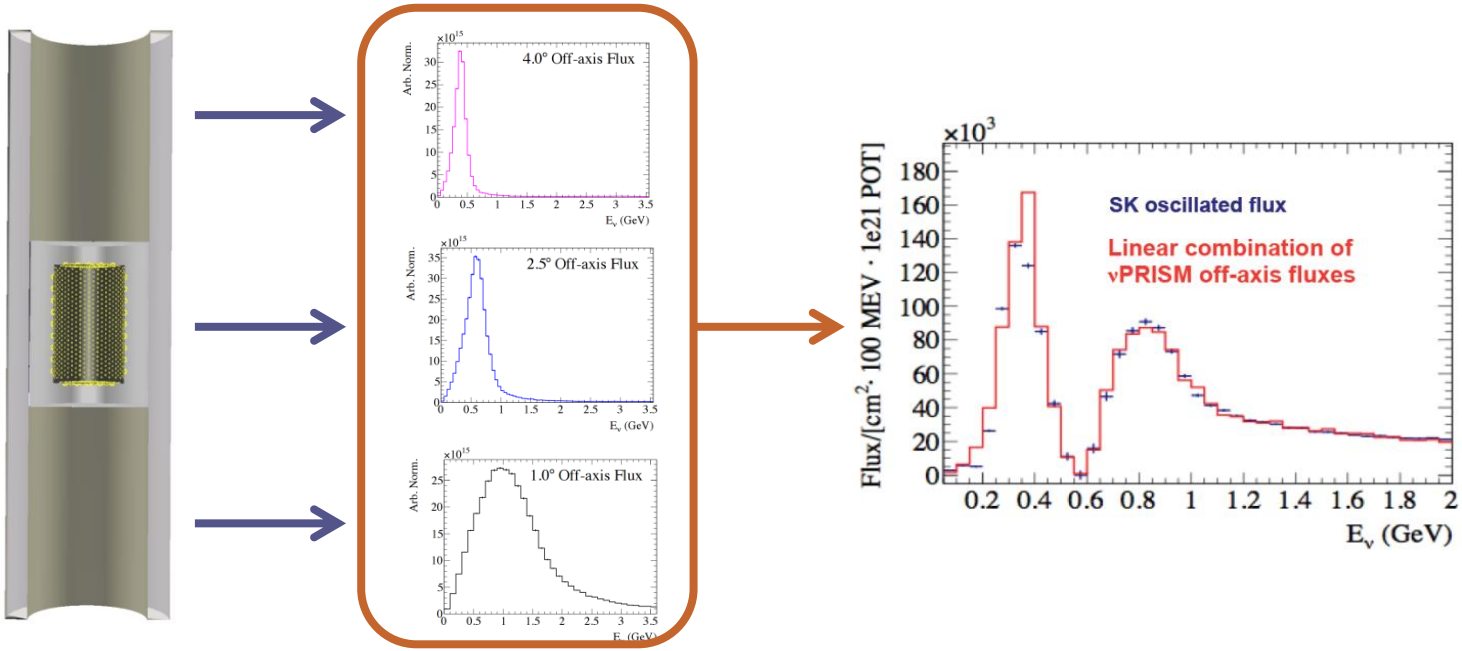
NuPRISM Detector

- A proposed water Cherenkov detector in the J-PARC neutrino beam at 1~2 km baseline.
- NuPRISM measures neutrino interactions over off-axis angles 1~4° to study neutrino-nucleus interactions and cross section.



NuPRISM off-axis measurements

- By taking linear combination of each off-axis bin, the oscillated neutrino spectrum is reproduced.
- Predict lepton kinematic distribution at far detector.



- Extract information about the cross section

NuPRISM detector optimization

- O(100) times as many ν_μ events as ν_e events are expected at NuPRISM detector.
  → PMT configuration should be optimized to select **pure ν_e samples** for ν_e cross section measurements and short baseline oscillation search.

- Event reconstruction performance between some configurations with different PMTs are compared using detector simulation.