

Discussion of nuPRISM Analysis Tasks Towards the Proposal

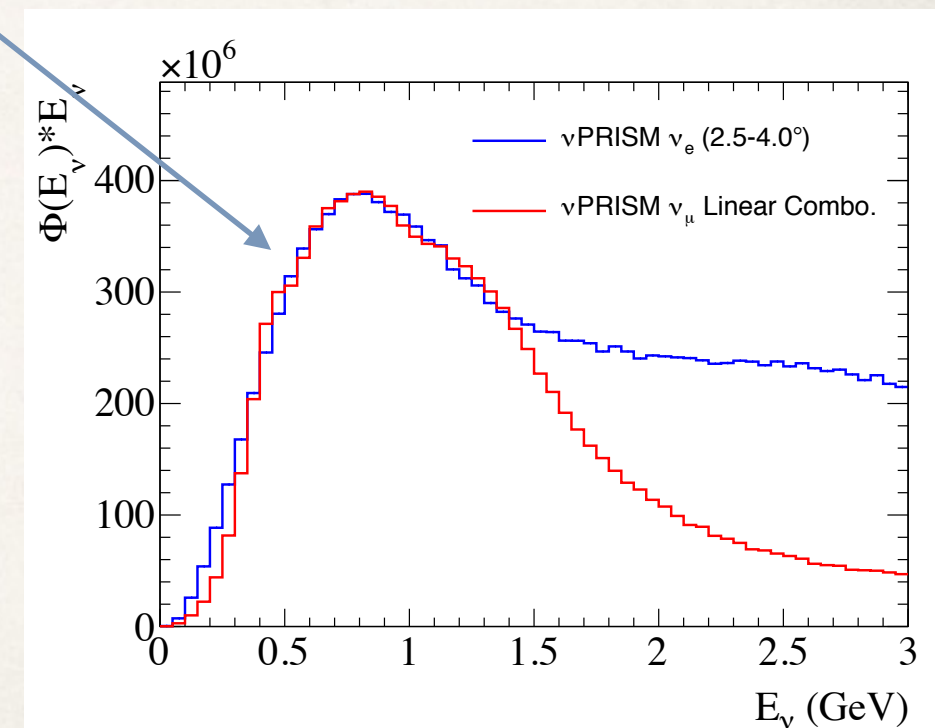
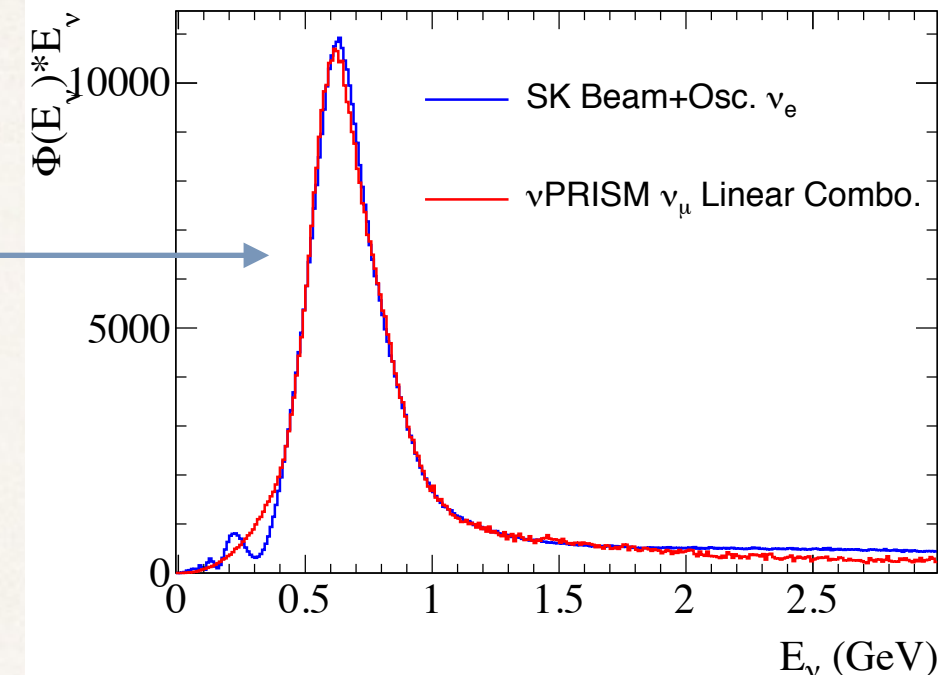
Mark Hartz

Status of the Analysis and Tools

- ❖ Using the analysis tools with table based efficiencies from fiTQun+SK:
 - ❖ Muon neutrino disappearance analysis (neutrinos only)
 - ❖ Short base-line $\bar{\nu}_e$ appearance analysis
 - ❖ Preliminary investigation into mono-chromatic beams
- ❖ Limitations of current tools
 - ❖ Using the efficiencies tables for 20 in SK PMTs leads to poor efficiency and purity in the $\bar{\nu}_e$ samples
 - ❖ Only reconstruction of lepton ring candidates is available
- ❖ Mark S. has talked about the status of the WCSim+fiTQun MC
 - ❖ Important for improving $\bar{\nu}_e$ based analyses and studying higher multiplicity measurements
- ❖ Will run through needed analysis work in the following slides

nuPRISM for CPV Measurement

- ❖ This analysis requires a two step approach
 - ❖ Use the usual linear combination method to reproduce the intrinsic ν_e +oscillated ν_e flux at the far detector using the ν_{μ} flux at nuPRISM
 - ❖ If electron and muon had the same mass, this would be sufficient
 - ❖ Use the linear combination method to reproduce the intrinsic ν_e flux at nuPRISM using the ν_{μ} flux at nuPRISM
 - ❖ Can measure the double differential ν_e / ν_{μ} cross section ratio with the same flux
 - ❖ Use this measurement to correct the prediction from the first step
 - ❖ Can also use nuPRISM to constrain the CC ν_{μ} and NC π^0 backgrounds from the nuPRISM ν_e measurement

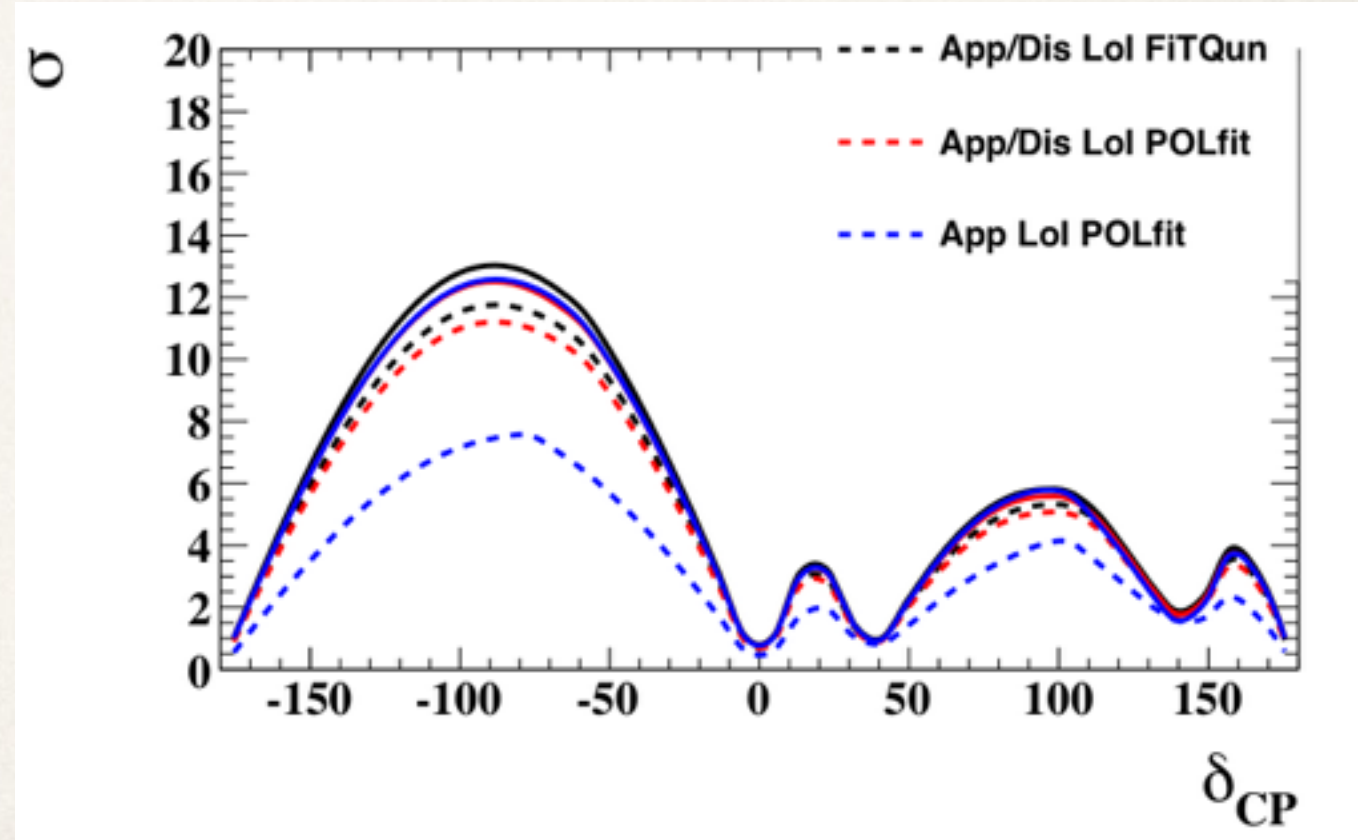


nuPRISM for CPV Measurement, Cont.

- ❖ We can start this analysis with the existing table-based reconstruction, but it should be significantly improved with the WCSim+fiTQun MC using smaller PMT sizes
- ❖ Treatment of the anti-nue prediction is also important and requires the additional step of subtracting the nuPRISM wrong sign background (more later)
- ❖ A. Kaboth had started looking into this analysis
 - ❖ Still available?
 - ❖ Is anyone else interested in helping with this analysis?

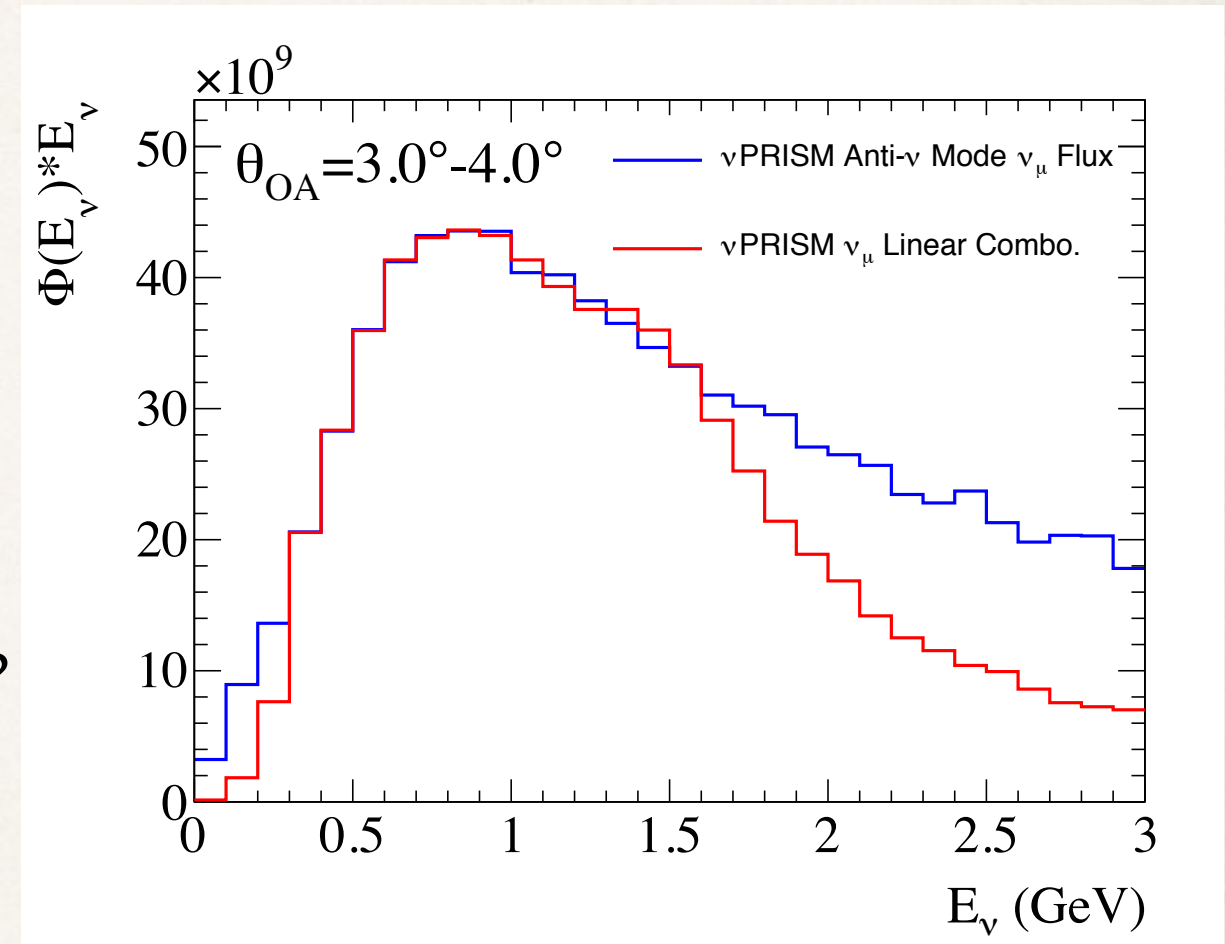
numu Disappearance Analysis Updates

- ❖ M. Scott is now producing full sensitivities for far detector exposures ranging T2K to T2HK
 - ❖ Should add a model for the nuPRISM detector uncertainties
 - ❖ For the HK era, is nuPRISM-lite sufficient, or do we need the full instrumentation
- ❖ How important is the measurement of θ_{23} for the CP violation measurement?
- ❖ Old study by L. Cremonesi showed a significant improvement with the inclusion of the disappearance sample.
- ❖ We should confirm this study and determine the importance of the θ_{23} precision
- ❖ May be able to get the HK-LBL group to study this



numu Disappearance Analysis Updates, Cont.

- ❖ Next major step for the disappearance sensitivity studies is the treatment of anti muon neutrinos
- ❖ Here we use the linear combination method to model the wrong sign numu background to numu-bar using the right sign numu events in positive focusing horn mode
- ❖ L. Haegel started to investigate this
 - ❖ Still available to work on it?
 - ❖ Are there any volunteers for this analysis?



nu μ e Appearance Sterile Analysis

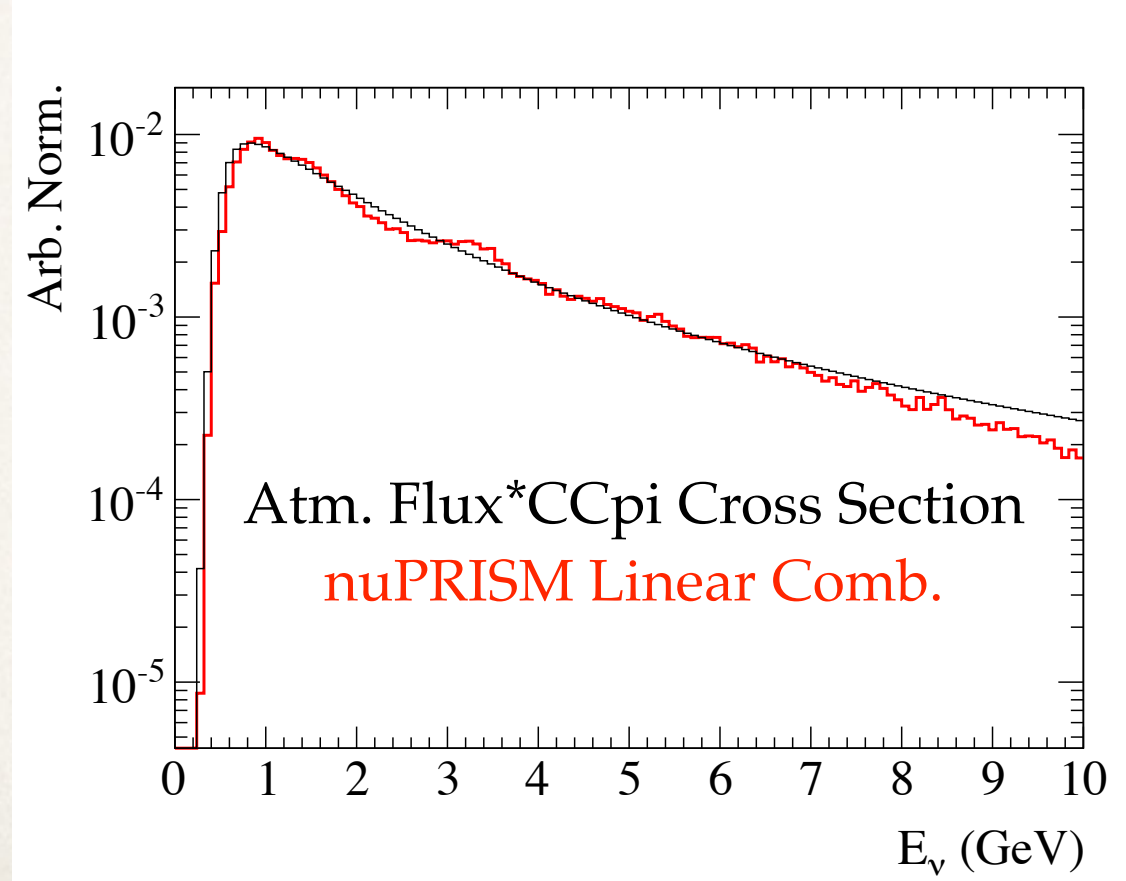
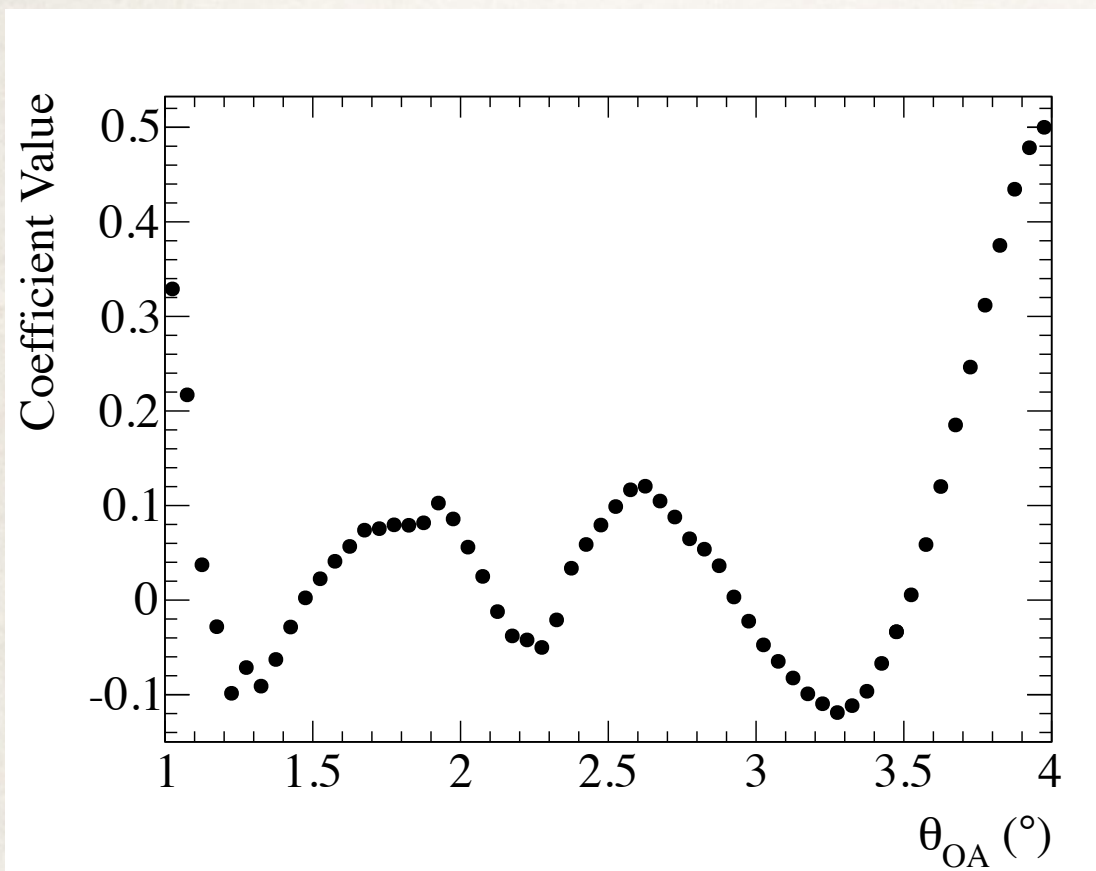
- ❖ Stefania has identified a number of areas for improvement
 - ❖ Combined $\nu\mu$ e- $\nu\mu$ candidate fit
 - ❖ Using the WCSim+fiTQun MC with better $\nu\mu$ e efficiency and purity
 - ❖ Combination with ND280 data
- ❖ Additionally, we can study the insensitivity to false positives that could be consistent with the excess observed at MiniBooNE
 - ❖ For example, an increased NC-gamma background, more feed-down from CC interactions or mis-modeling of the NC π^0 efficiency
- ❖ Should also include a nuPRISM detector systematic error model
- ❖ S. Bordini and J. Vo will work on the sterile analysis

Other physics capability studies

- ❖ Single lepton ring cross section measurements (mono-chromatic beams)
- ❖ The study of cross-sections with multi-ring candidates and background measurements (NC π^0 , CC1 π^+ , NC π^+ , CC multi- π , etc.)
 - ❖ These require the full reconstruction to produce samples with multi-ring final states
- ❖ Constraints for atmospheric neutrino measurements:
 - ❖ Angular distribution of 400-1000 MeV single ring events for CP violation (see Akira's talk at the HK Meeting) can be done with mono-chromatic beams
 - ❖ Measurements of 2-10 GeV multi-ring events for the mass hierarchy measurements (more on next slide)
 - ❖ Calibration of neutrino / antineutrino separation using neutron tagging with Gd in nuPRISM
- ❖ Any other ideas?

Measurements for Atmospheric Samples

- ❖ nuPRISM can also be used to constrain systematic uncertainties for atmospheric samples
- ❖ In the atmospheric data, events around 3-10 GeV are sensitive to the mass hierarchy
- ❖ In multi-ring events, the number of Michel electrons or non-leptonic part of the event are used to make a statistical separation of neutrinos and antineutrinos
 - ❖ These properties of the events can be constrained with nuPRISM
- ❖ The atmospheric flux*CCpi cross section can be reproduced at nuPRISM:



Conclusion

- ❖ There are a number of areas where we can improve or expand the nuPRISM physics potential studies
- ❖ The highest priorities are:
 - ❖ Applying nuPRISM to the CP violation measurement - people needed
 - ❖ Updating the numu disappearance measurement for antineutrinos - people needed
 - ❖ Improving the sterile measurement
- ❖ It is also important study the capabilities for neutrino cross-section measurements
- ❖ Please join the effort so we can make the nuPRISM experiment proposal as compelling as possible