νPRISM Status and Plans

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2nd νPRISM Workshop

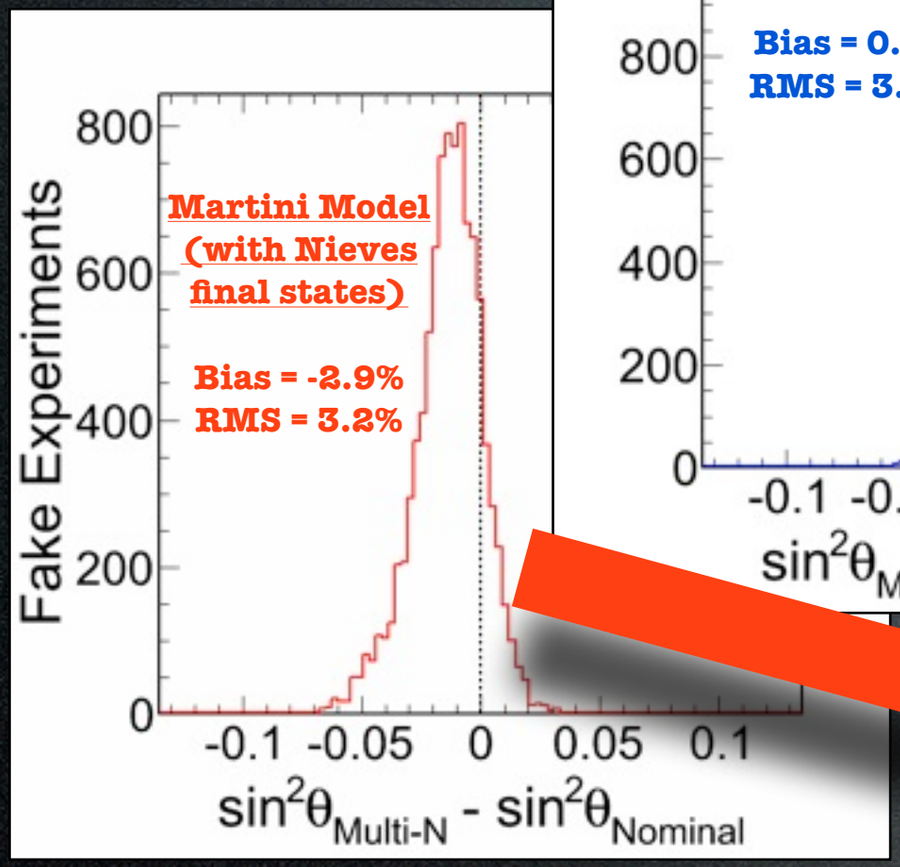
23-July-2014

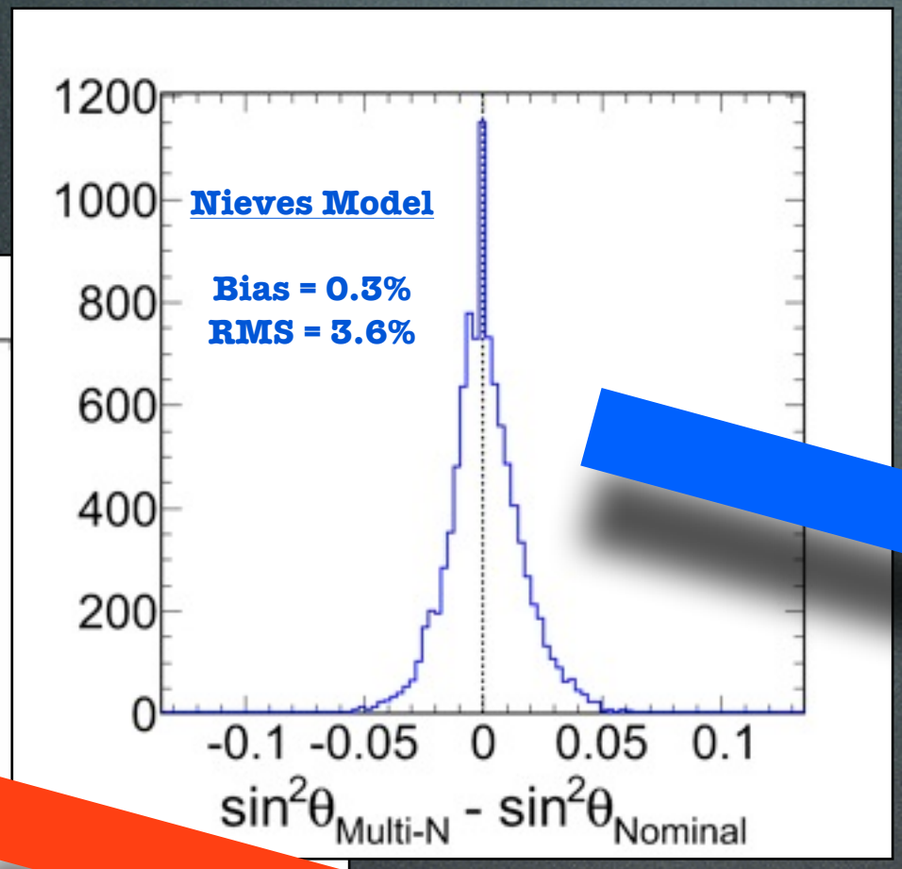
Goals from Previous Workshop

- Complete T2K ν_μ disappearance analysis
- Sterile neutrino sensitivities
- Detector simulation and reconstruction
- Preliminary detector design
  - PMTs, frame, electronics, calibration systems, scintillator panels, water system
- More information / bids on civil construction
- nuPRISM EOI for T2K

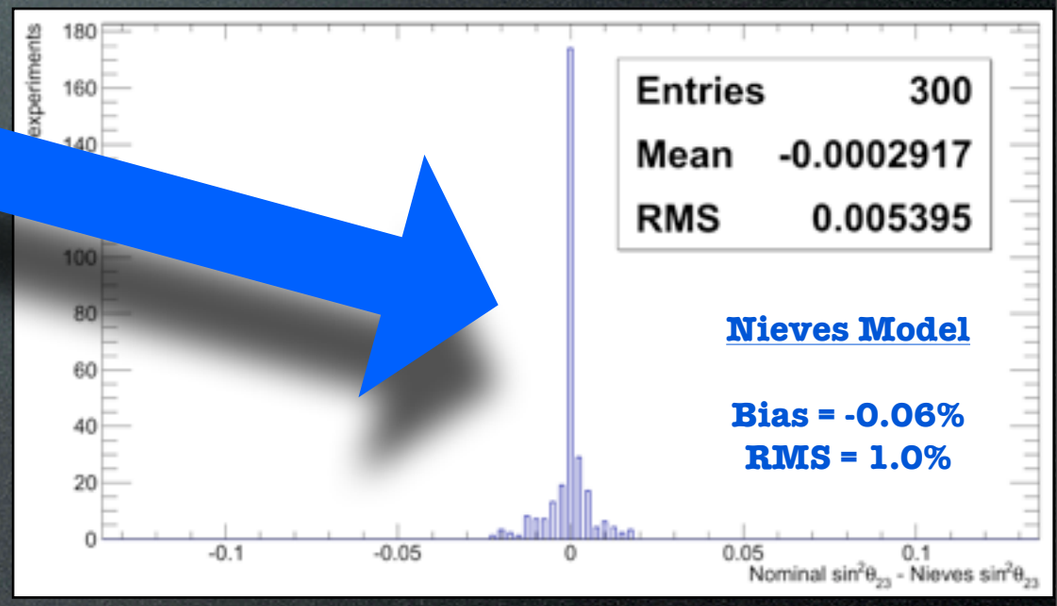
νPRISM ν_μ Disappearance Bias

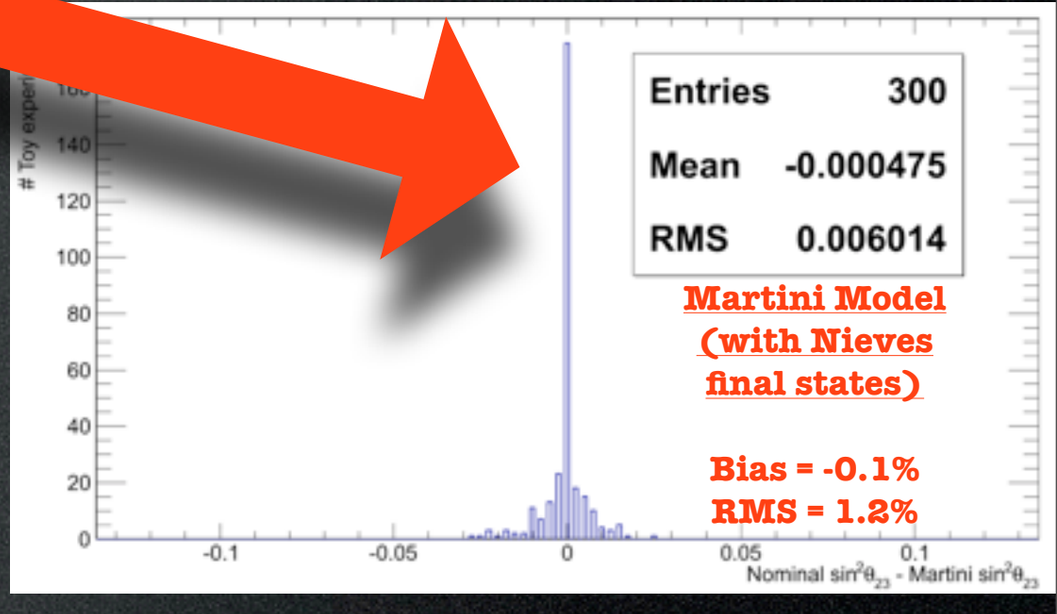
Standard T2K Analysis





νPRISM Analysis



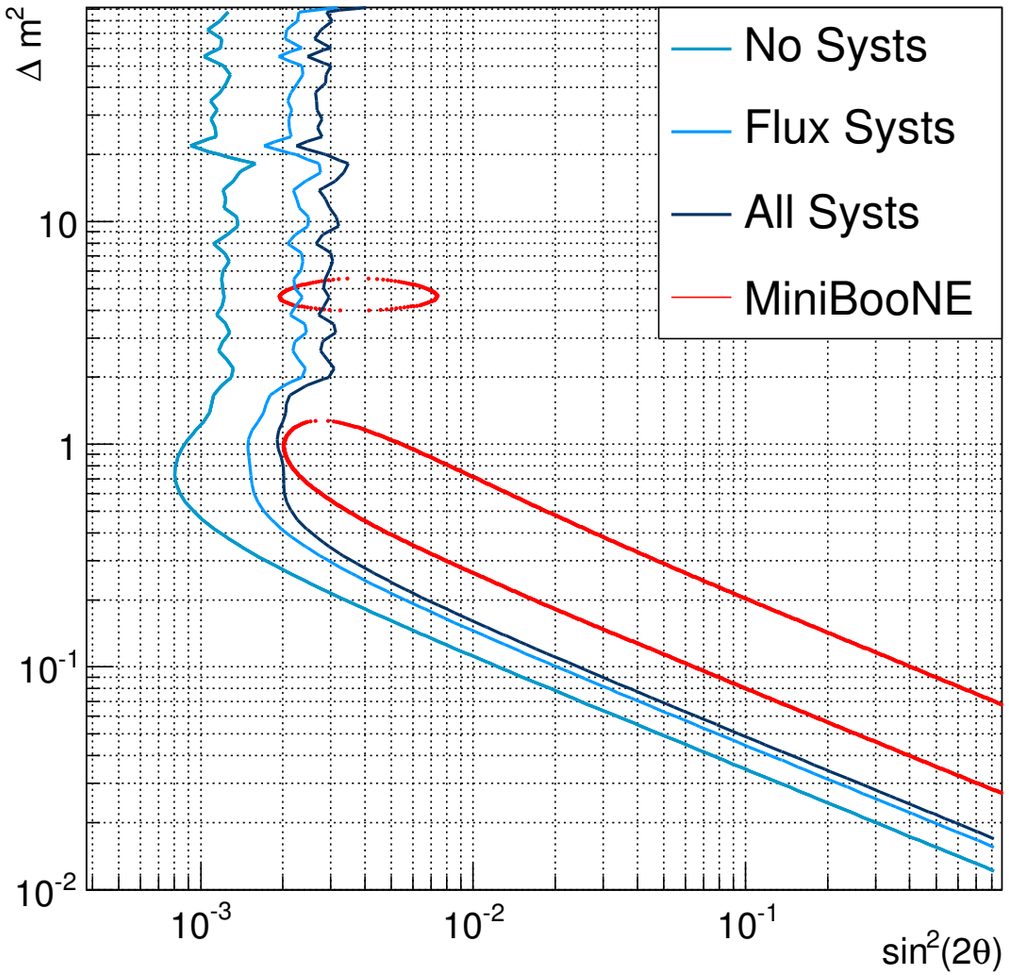


- nuPRISM works!
  - Using conservative systematics
  - Without using any information from ND280
- Next steps include realistic reconstruction, p/theta-only analysis, and incorporating a more sophisticated fitter

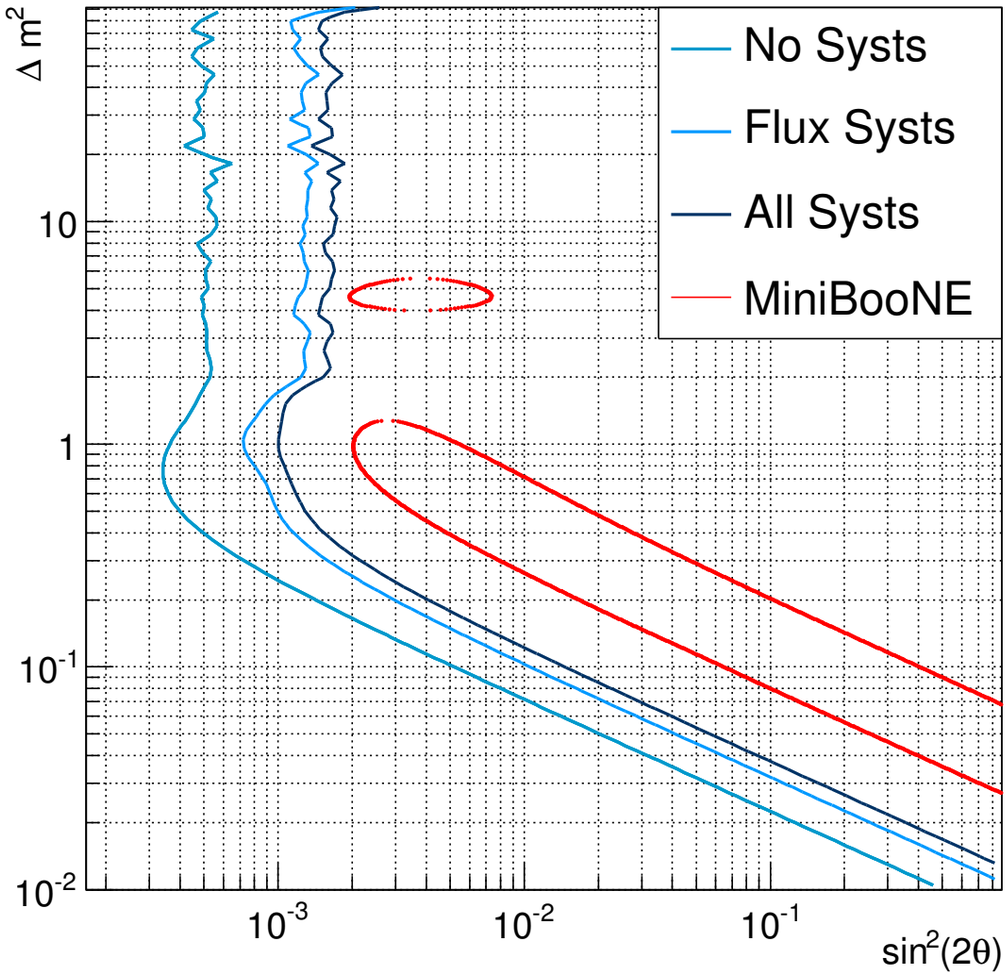
Sterile Neutrinos

- Based on half the total T2K statistics (expected after beam upgrade)
- Conservative estimates
  - MiniBooNE-style ν_e+ν_μ fit not yet used (strong flux correlations)
  - ND280 not yet used (2 detector fit can add significant sensitivity)
- Need to implement more information to make further improvements (see Stefania's talk)

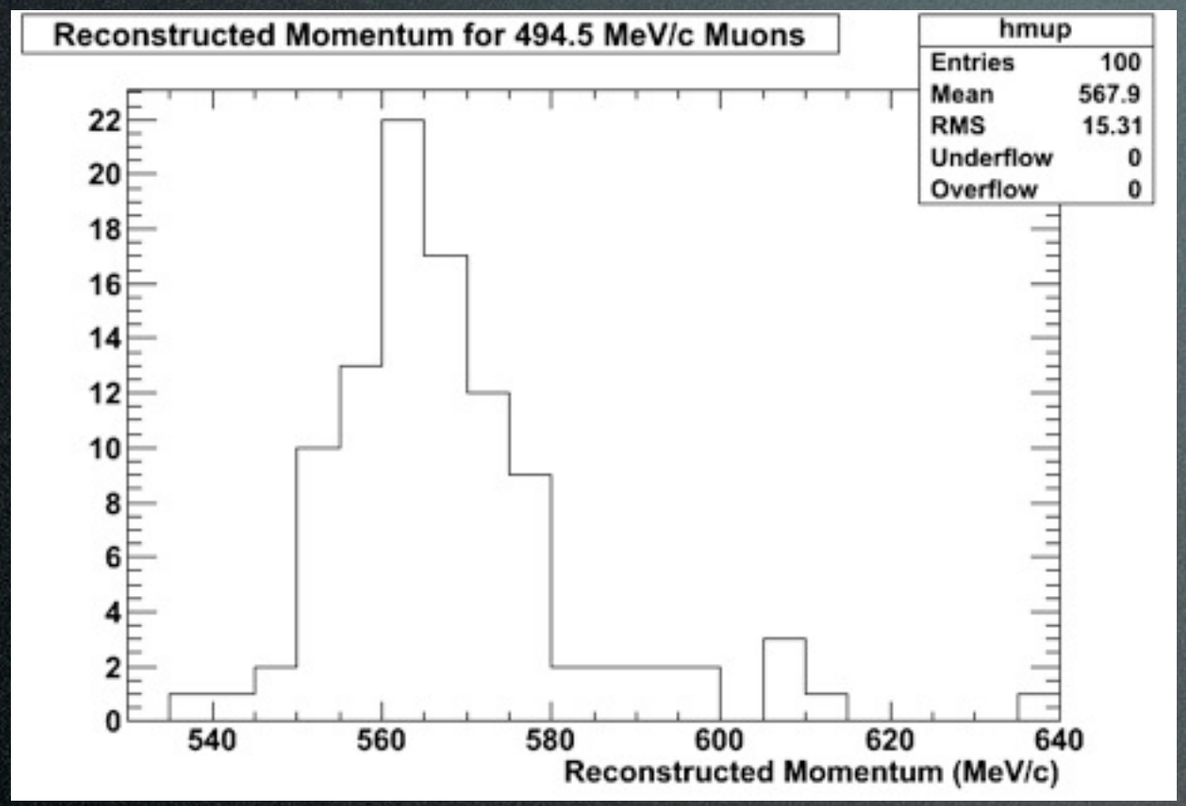
6m ID

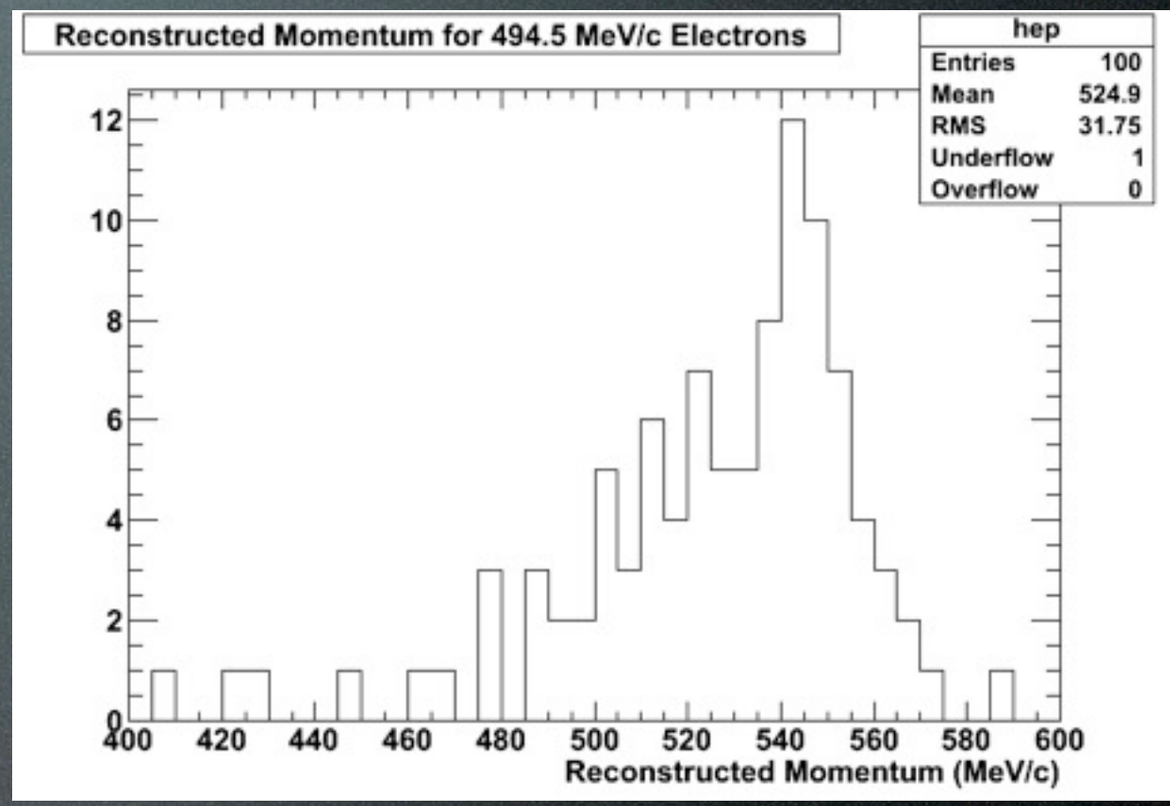


8m ID



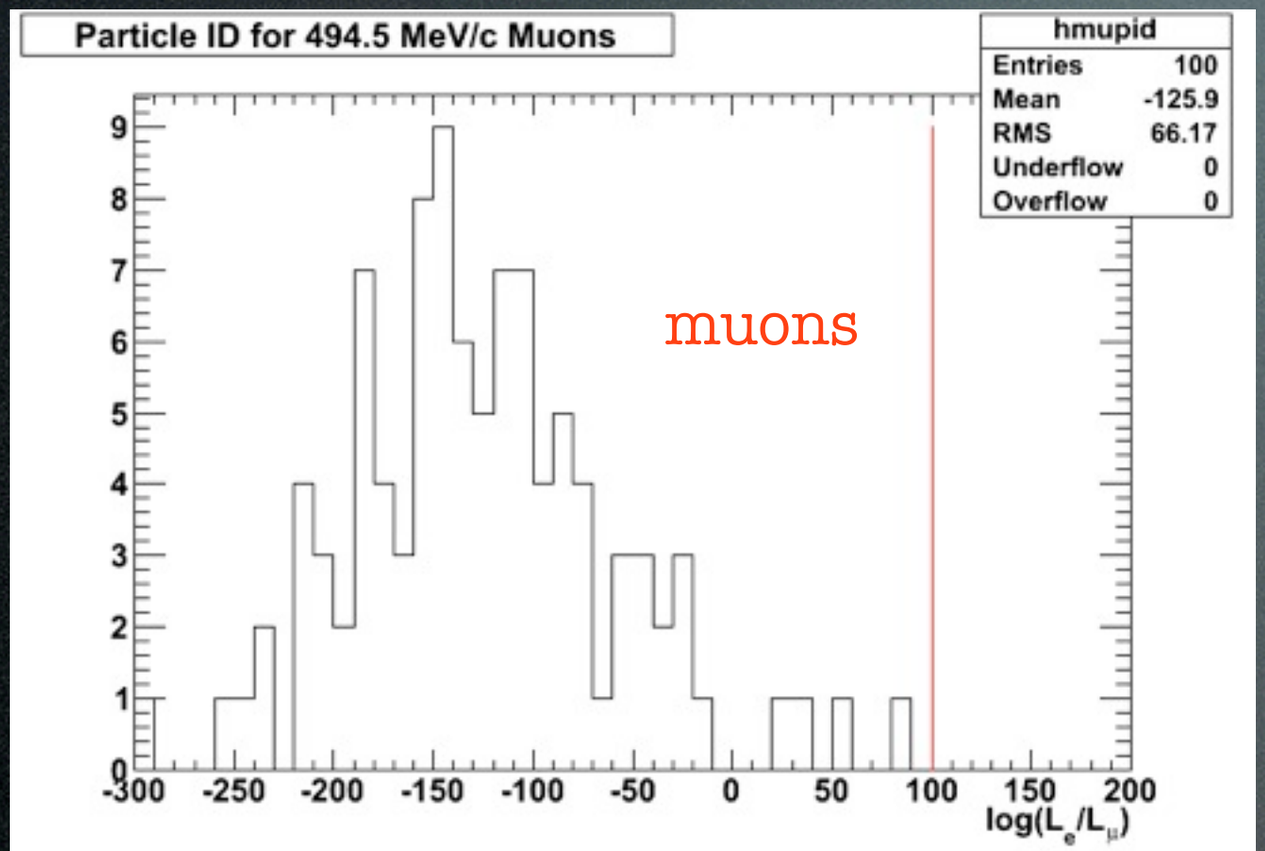
Detector Simulation and Reconstruction

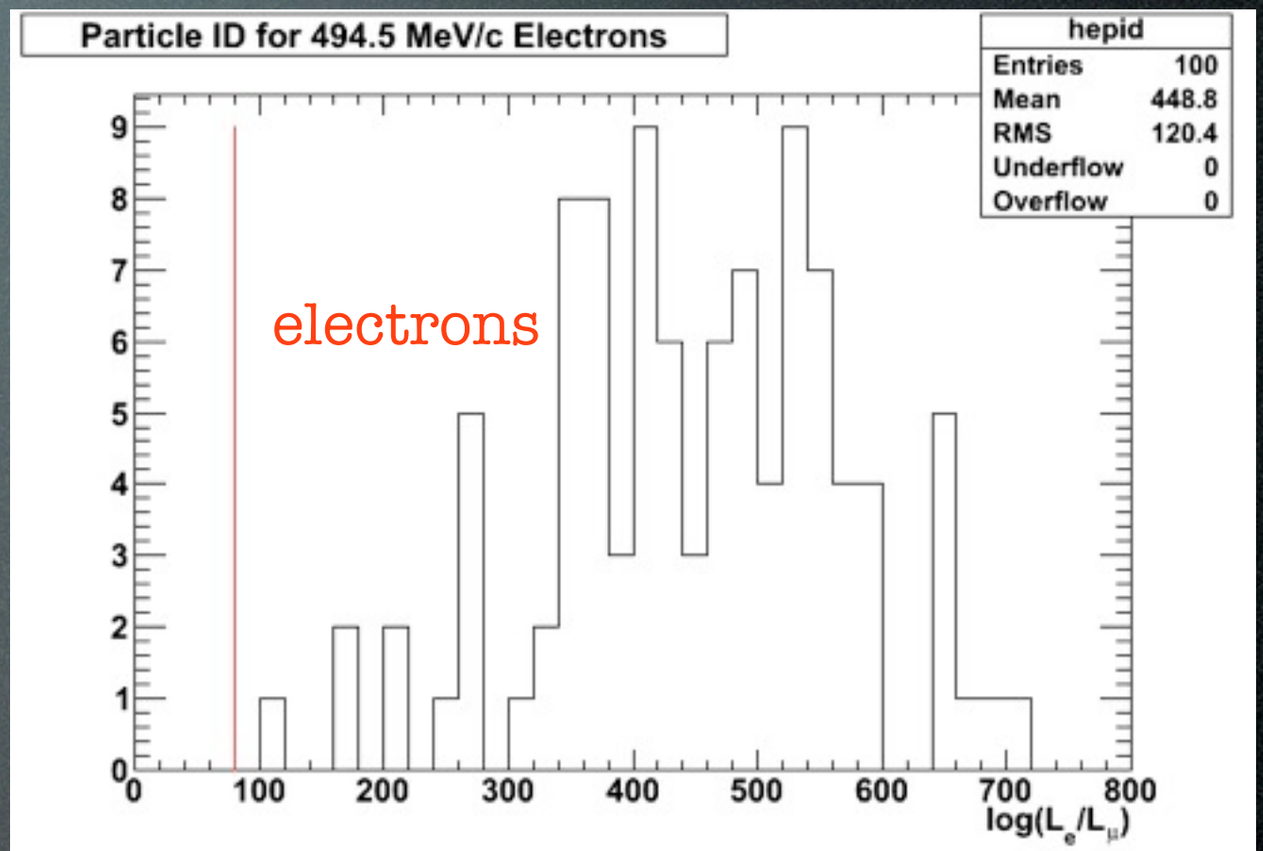




- Working set of code based on WCSim and fiTQun
- Some work still needed: clear biases seen in reconstructed momentum
  - ~13% for muons, ~10% for electrons
- Muon resolution is already at Super-K fiTQun levels
- fiTQun still needs to be tuned to WCSim optical model
  - Same issues seen in Hyper-K reconstruction
    - Work in progress at Winnipeg and Stony Brook; ~1 month until ready

Particle ID

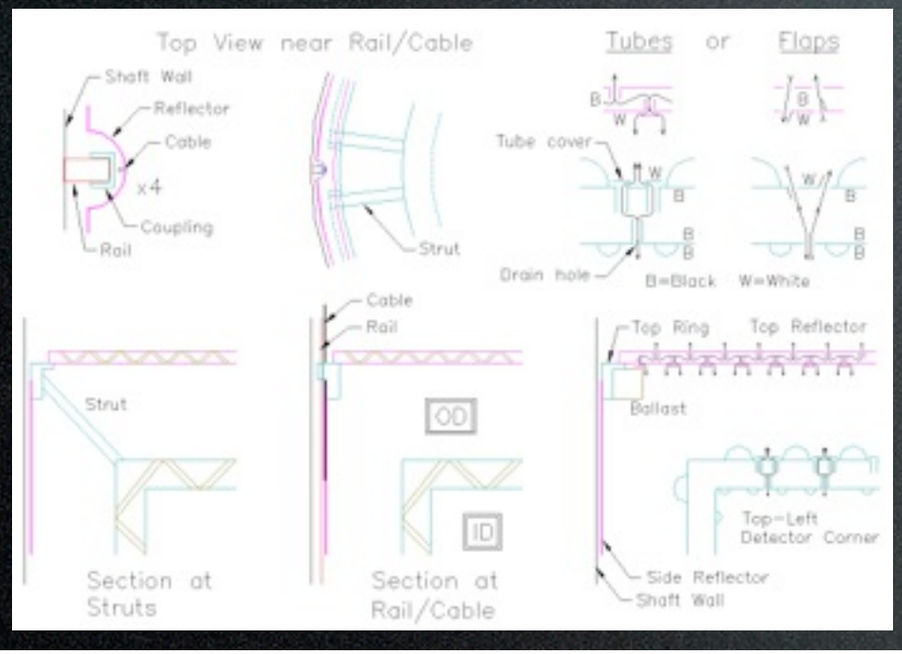


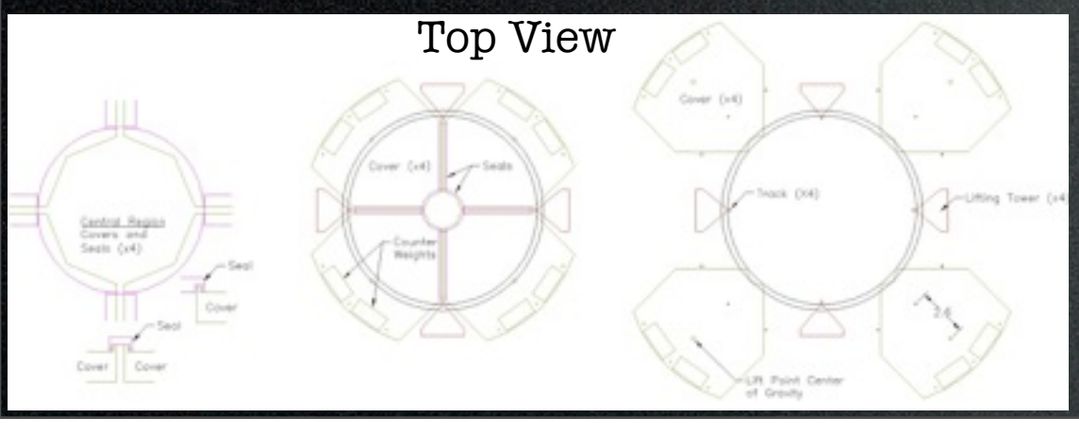


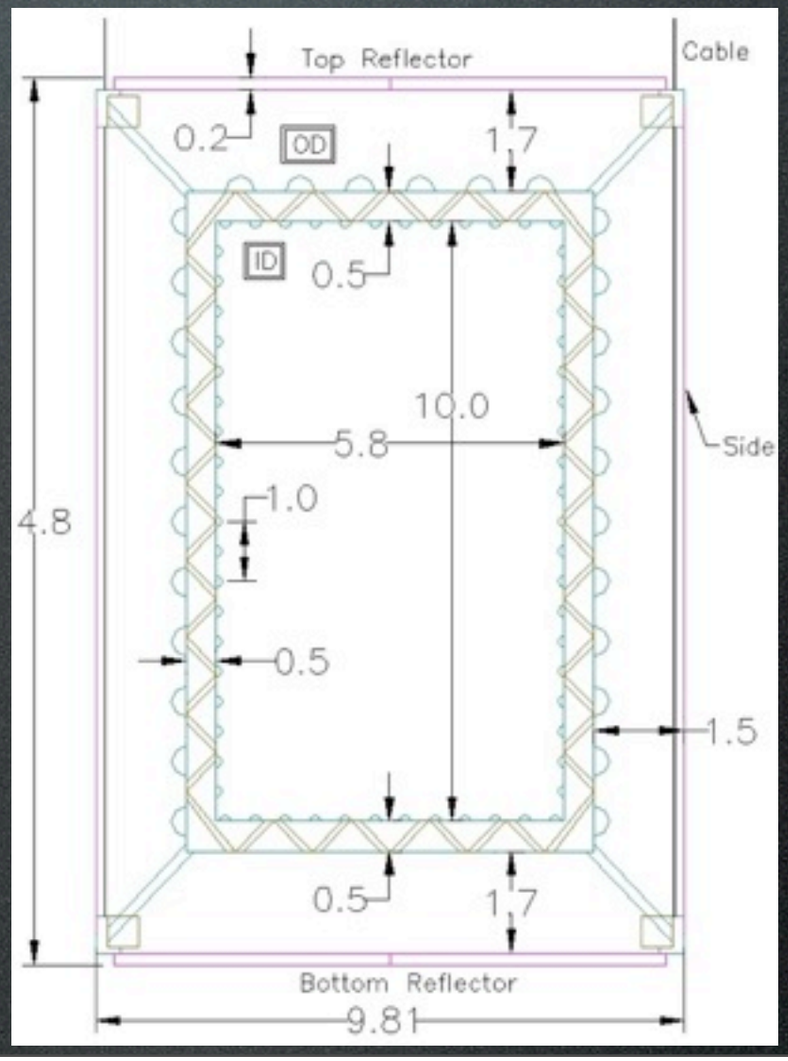
- PID works well out of the box
  - At 500 MeV/c, the standard fiTQun PID cut is at 100
- Some events are getting close to the cut line
  - Will be improved once momentum reconstruction is improved

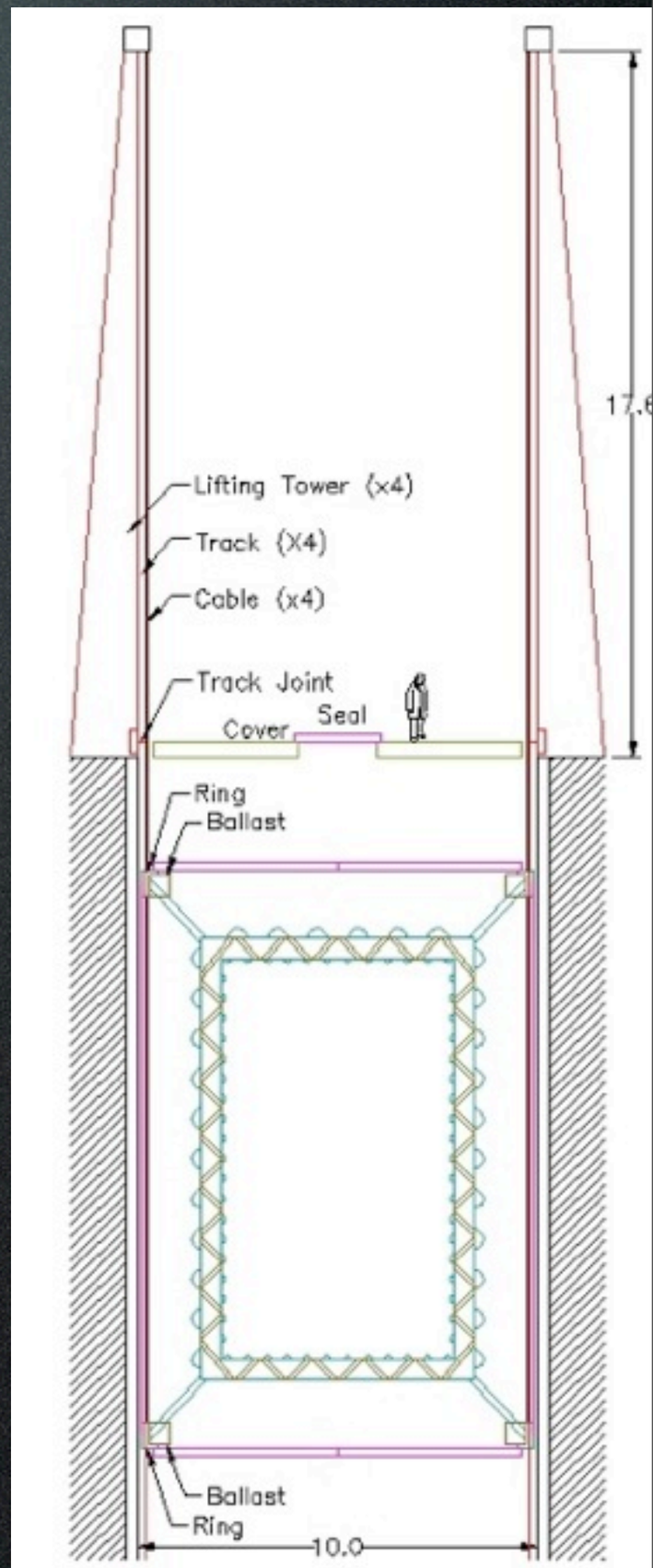
Detector Design

- Initial proposal for ID/OD frame and lifting mechanism has been produced
  - Careful consideration given to water flow rate while in motion
- Need to complete an initial design and incorporate scintillator panels









Civil Construction

- In total: 600百万円 ＝　6億円+alpha
- Assumption
  1. Soil condition is assumed to be the same as at 2km
  2. Hall size: 10m-Φ×50m-D, ILM+NATM
  3. Shotcrete (150mm) + (waterproof sheet) + Lining concrete (600mm) + **3mm HDPE lining** (maximum thickness in use) cf. spec at Hyper-K: 5~10mm
  4. …
- Company requests more information about the detector construction and related facilities. We need to expect +alpha
- 9 months of construction period in total.
  - 2 months for preparation + 7 months for construction

Slide from Ishida-san at T2K νPRISM premeeting

- Digging pit + liner may be much cheaper than or original estimates
- Need to firm up these estimates as best we can and incorporate this information into the proposal
  - Final cost estimate will require geological survey after the final decision is made on the detector location

The EOI Document

- Original goal was to release this at the previous T2K collaboration meeting
  - Results were not stable enough to provide a useful document
- Main results have now been ready for ~1 month
- New interesting and useful results have been added in the past few weeks
  - e.g. new flux fits to demonstrate how the nuPRISM technique can be used in ν_e and anti-ν analyses
- Proposal: freeze the document with the currently available results and release in the next week
  - Continue to update as necessary, and issue new versions, if required
- We will be working toward a full proposal this year, so frequent updates of the technote will not be necessary or desired

Toward a Full Proposal

- For reference, the original T2K 2 km proposal can be found here:
  - http://www.phy.duke.edu/~cwalter/nusag-members/
- 2 km proposal describes, in general terms, a water Cherenkov detector
  - Usefulness for T2K analyses is qualitatively assumed
- Our task is more difficult
  - νPRISM technique is more subtle, and its justification is to significantly reduce systematic errors
    - Quantitative demonstration that this detector will achieve such small uncertainties is required

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)
  - Anti-ν analyses (Leila's talk)
  - Sterile neutrino analysis (Stefania's talk)
  - Cross section physics (Kendall's talk)

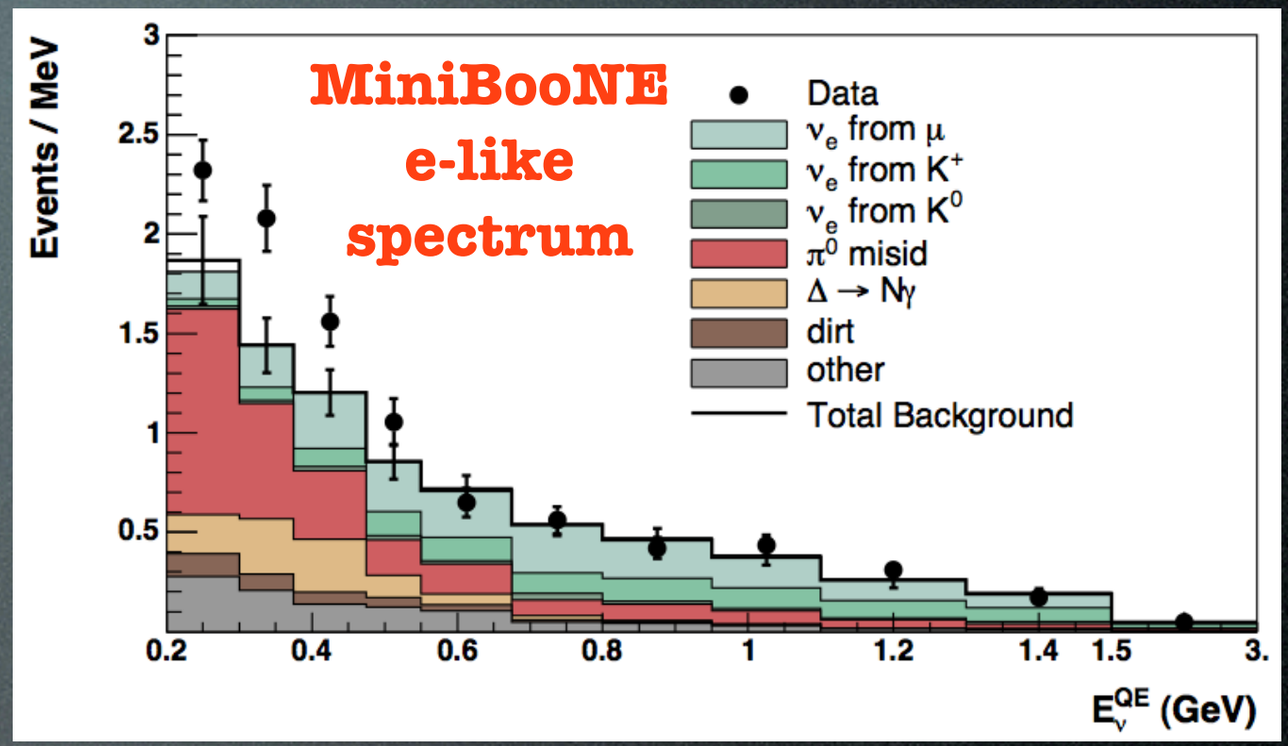
Carl's and Mark S.'s Talks

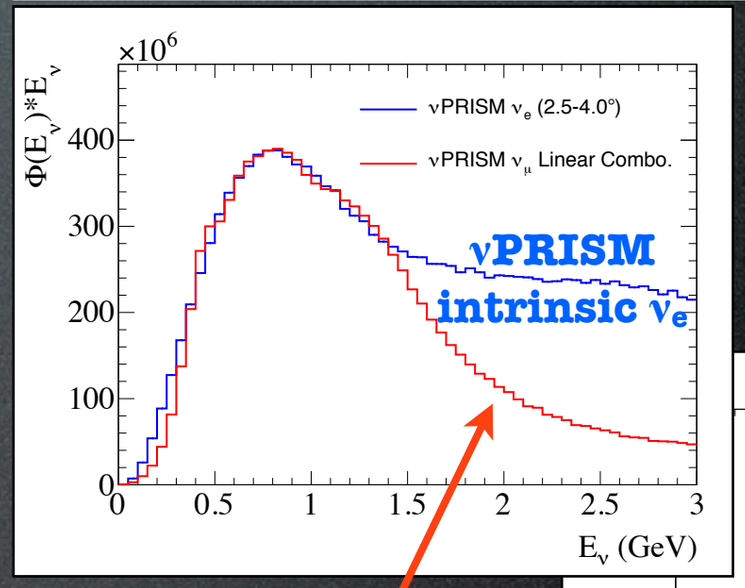
- **Requires realistic detector simulation/reconstruction, detector systematic errors, etc.**
- **Must decide on a plausible baseline detector design**
  - Tank size (length: off-axis angle range; width: electron and muon efficiency & purity)
  - PMT size and photocathode coverage
    - Will dictate 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

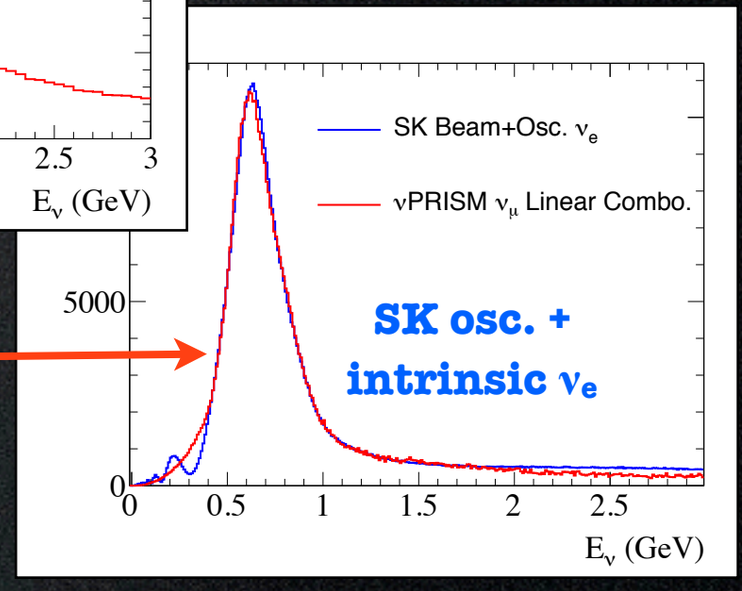
Electron-like Measurements

- MiniBooNE sees a large excess of electron-like events from?
  - NCπ^0
  - Single-γ production
  - External γ
  - Beam ν_e
  - muon misID
  - sterile neutrinos
- This must be understood for a precision CP violation measurement
- Linear combination of ν_μ fluxes can be used to reproduce **BOTH:**
  - The SK ν_e signal+background
    - Direct measurement of far detector ν_e response (excluding $\sigma(\nu_e)/\sigma(\nu_\mu)$ uncertainty)
  - The νPRISM ν_e flux
    - This will allow direct comparison of ν_μ and ν_e double-differential xsec



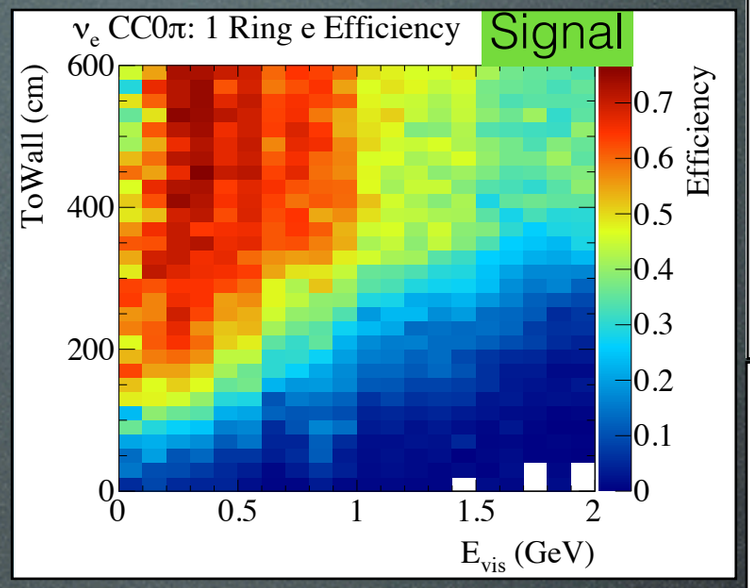


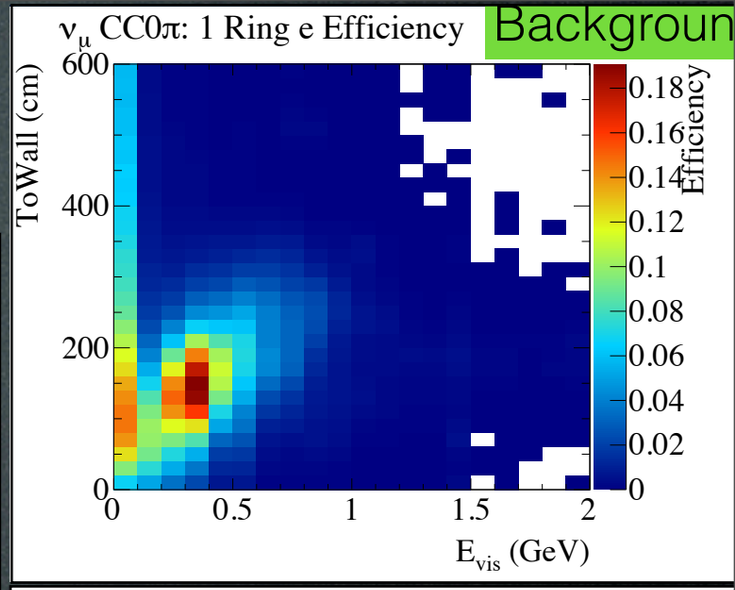
νPRISM
ν_μ Linear
Combinations

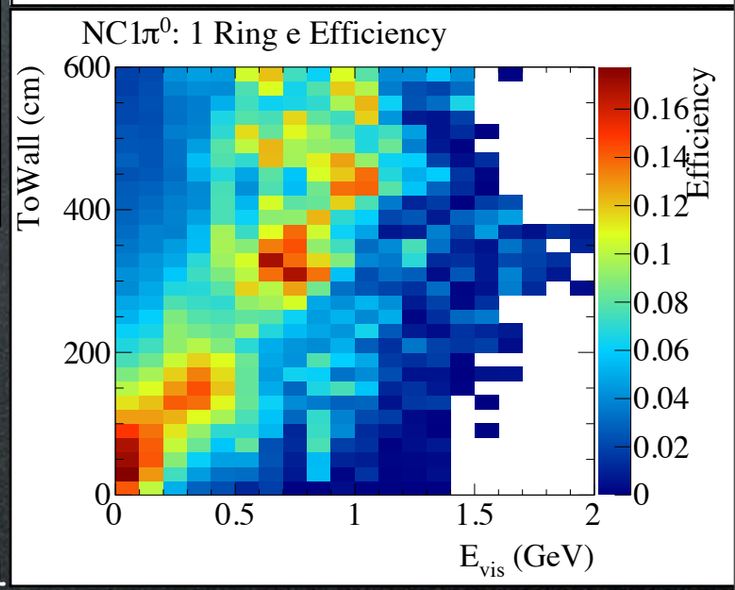


ν_e Event Selection

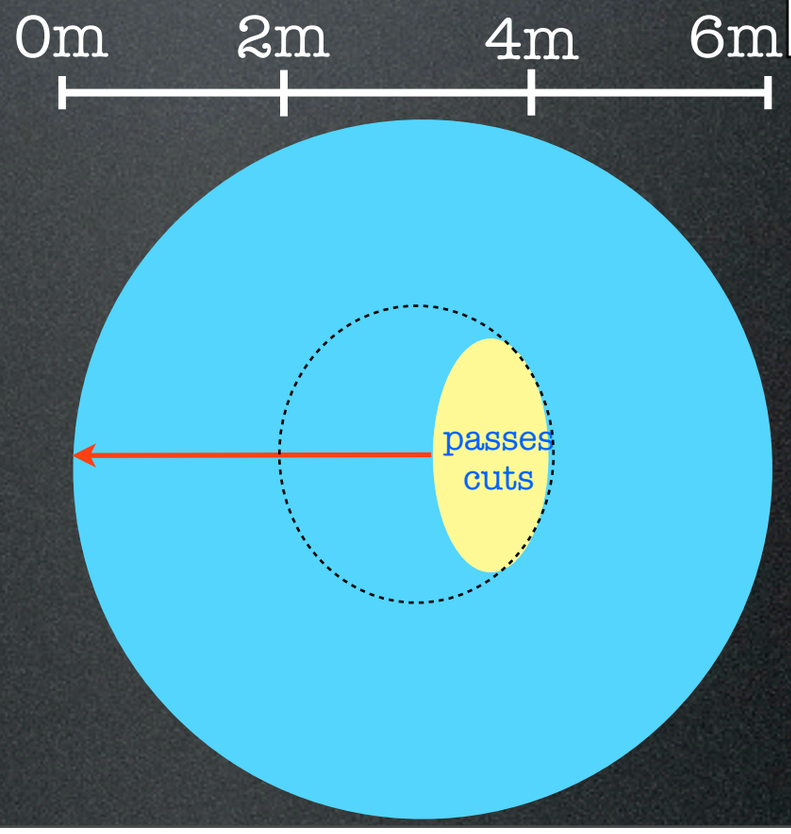
- ν_e's are more sensitive to the tank diameter than ν_μ's
- Large ν_μ background requires good PID
  - PID degrades as particles approach the tank wall
- 6m diameter may be too small
  - 8m diameter is also being investigated
  - (with 10m OD diameter kept fixed)







1 Ring e selection:
E_{vis}>200 MeV
DWall>200 cm
ToWall>320 cm



Tank Diameter Strongly Impacts ν_e Fiducial Volume

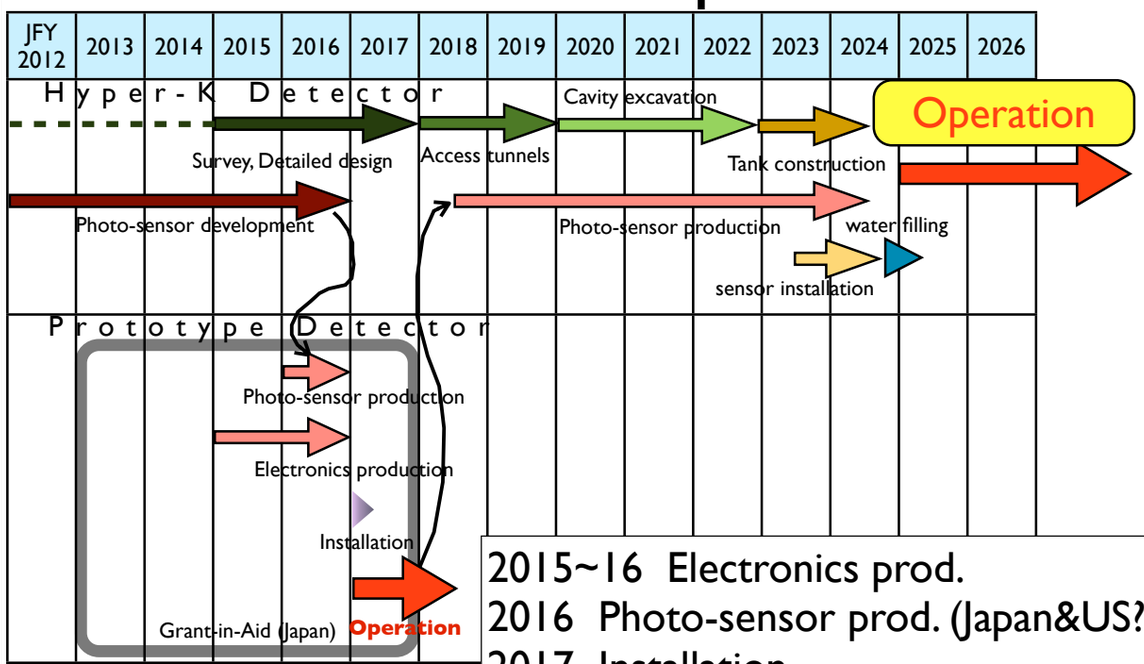
Hyper-K Prototype Detector

- Hyper-K will require a prototype detector
  - EGADs is small and is a currently running experiment
  - K2K 1kton detector needs significant refurbishment, and will not provide useful physics
  - nuPRISM-Lite mentioned as a possibility
- Current proposed timescale is too tight for prototype testing to begin in nuPRISM-Lite
  - Instead, we need a plan to relocate PMTs and electronics to nuPRISM once the detector is available
- Ultimately, nuPRISM-Lite will depend on J-PARC/KEK agreeing to the civil construction
  - Many other components can be acquired using existing HK R&D money
  - May be possible to reuse old PMTs from MiniBooNE or Daya Bay

Site

- I'd like to propose to use EGADS 200ton tank as a baseline option
  - we have to keep EGADS functionality; Improvements to the detector is welcomed as long as downtime is minimized
  - Case study talk by Yano-san today
- 1KT tank at KEK
  - may need inspection of the old facility, at least need refurbishment of the rusted tank, water system has been removed
- Interests in a near detector at ~1km in Tokai
  - near detector should be approved and budget should be secured in a timely manner

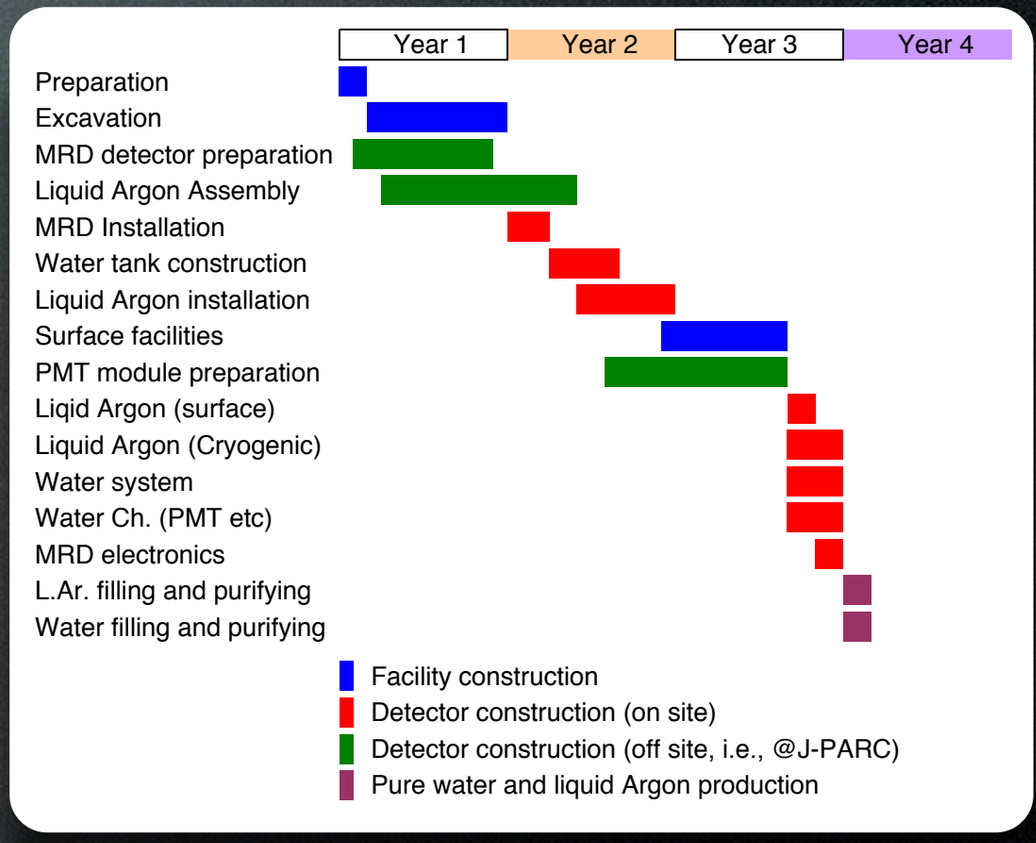
Timeline Proposal



2015~16 Electronics prod.
2016 Photo-sensor prod. (Japan&US?)
2017 Installation
2017~ Operation

Timescales

- If built for T2K, plans will need to be finalized quickly
  - Aim to begin data taking in 2019
    - To take significant data with upgraded T2K beam
    - Construction would begin in 2016
- Detailed detector design
  - Frame, moving mechanism
  - Field cancelation coils
  - Calibration systems
  - Water system
    - Circulation scheme, temperature control
  - Electronics prototyping
  - PMT production lead time
  - …
  - …



We will soon need our own project flow chart

Summary

- 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 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 fall!