vPRISM Status and Plans

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2nd vPRISM Workshop
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Goals from Previous Workshop

- Complete T2K $\nu_\mu$ 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
nuPRISM \( \nu_\mu \) Disappearance Bias

Standard T2K Analysis

- **Martini Model** (with Nieves final states)
  - Bias = -2.9%
  - RMS = 3.2%

- **Nieves Model**
  - Bias = -0.06%
  - RMS = 1.0%

nuPRISM Analysis

- **Martini Model** (with Nieves final states)
  - Bias = -0.1%
  - RMS = 1.2%

- **Nieves Model**
  - Bias = 0.3%
  - RMS = 3.6%

- 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 $\nu_e + \nu_\mu$ 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)
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

- 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 $\nu_e$ and anti-$\nu$ 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**
  - $\nu_\mu$ disappearance analysis (Mark S.’s talk)
    - Initial version finished, but improvements are needed
  - $\nu_e$ appearance analysis (Asher’s talk)
  - Anti-$\nu$ analyses (Leila’s talk)
  - Sterile neutrino analysis (Stefania’s talk)
  - Cross section physics (Kendall’s talk)
  - 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

Carl’s and Mark S.’s Talks

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 σ(ν_e)/σ(ν_μ) uncertainty)
  - The νPRISM ν_e flux
  - This will allow direct comparison of ν_μ and ν_e double-differential xsec
**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)

**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

- JFY 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023
- 2024
- 2025
- 2026

Hyper-K Detector
- Survey, Detailed design
- Photo-sensor production
- Electronics production
- Installation

Prototype Detector
- Photo-sensor production
- Electronics production
- Installation

Operation
- 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 nuPRISIM technique in a T2K oscillation analysis
    • Data-driven nuPRISIM constraint works!
  • Many details regarding civil construction, detector design, electronics and PMTs are already available

• Timescales are tight for a nuPRISIM 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 nuPRISIM proposal
  • Need to completed all physics analysis studies

• Let’s complete the first nuPRISIM proposal this fall!