Design of the PROSPECT Experiment

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Abstract

PROSPECT is a multi-phased reactor antineutrino experiment with primary goals of making a precise measurement of $^{3}ar{\nu}_U$ reactor antineutrino spectrum and performing a search for sterile neutrinos. The detectors will be deployed at short baselines 7-19m from the High Flux Isotope Reactor at Oak Ridge National Laboratory. In addition to being optimally located to search for oscillations arising from $\nu_e$ and $\bar{\nu}_e$, the detectors will also allow direct measurements of reactor antineutrino spectrum and perform a search for sterile neutrinos.

Physics Goals

- Highly enriched uranium (HEU) research reactor
- Operating at 85 MW
- Core shape is cylindrical, 0.5m high and 0.4m wide
- Doped Li target with $^{6}\text{Li}$ loading

Antineutrino Source: High Flux Isotope Reactor at ORNL

- Highly enriched uranium (HEU) research reactor
- Operating at 85 MW
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Detector Layout

- Phased approach
- Units movable covering 7-12m baseline range
- Phase-II extends coverage to 19 m
- Oscillation by relative spectral comparison between baselines
- High antineutrino flux (115k/year for Phase-I)

Antineutrino Detector Design: Segmentation

- Segmented design
- Oscillation analysis with single detector
- Inherent position reconstruction
- Background rejection by fiducialization and topology cuts
- Double-ended readout

Detector Calibration

- Neutron Sources
- $^{6}\text{Li}$ calibration
- Detection efficiency of neutrons
- Gamma Sources
- Absolute energy scale
- Scintillator non-linearity

Shielding Design

- Cosmogenic backgrounds are the primary source of backgrounds for PROSPECT
- Passive shielding package design aimed at reducing these backgrounds
- Double-ended readout
- Position reconstruction along the segment
- Excellent and uniform light collection
- Better pulse shape discrimination (PSD)
- 3D printed pinwheel to join optical separators and support the optical structure

Antineutrino Target: $^{6}\text{Li}$-loaded Liquid Scintillator

- Doping of $^{6}\text{Li}$ in liquid scintillant:
  - Excellent background rejection
  - High IBD detection efficiency
  - Spatial and temporal dense energy deposition

References

1. http://prospect.yale.edu
2. PROSPECT, arXiv:hep-ex[1506.03547]