Development of the PROSPECT Source Calibration System

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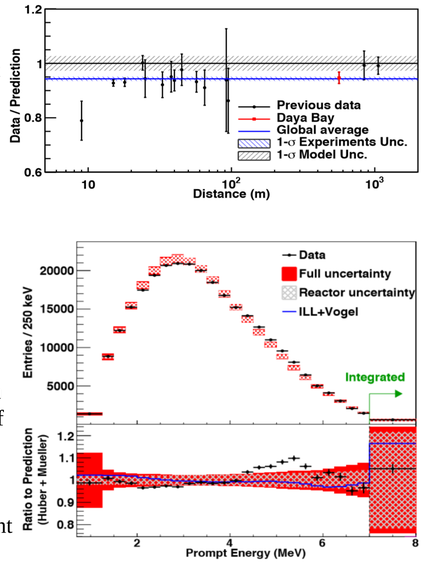
Reactor Anomalies and Physics Goals

The Flux Deficit
Previous reactor experiments observed 6% flux deficit when compared to reactor models.

PROSPECT Physics Goal 1:
Search for short-baseline oscillations and conclusively address the sterile neutrino hypothesis of the reactor flux anomaly.

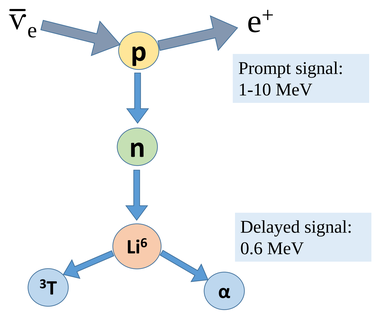
The Spectral Deviation
Daya Bay and other θ_{13} experiments observed bump in 4-6 MeV region, a deviation of ~10%.

PROSPECT Physics Goal 2:
To make a precise measurement of the antineutrino spectrum from a HEU reactor (mainly U^{235}).



Figures: F.P. An et al, Daya Bay Collaboration, Phys. Rev. Lett. 113, 141802

Detecting Neutrinos



Inverse Beta Decay (IBD)

Electron antineutrino signature:
- Prompt positron
- ~40μs delay
- Neutron capture

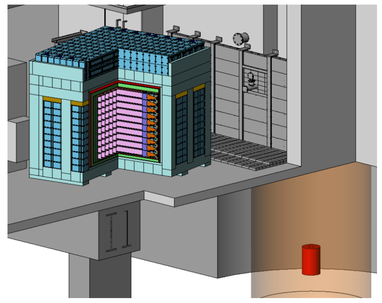
Sign of the sterile neutrino: An oscillation in rate and spectrum of IBD events at 7-12m baseline.

PROSPECT at DNP 2016

- **"PROSPECT: The Precision Reactor Oscillation and Spectrum Experiment"** – Thomas Langford, Sat Oct 15, 2:36pm
- **"Development and Characterization of ^{6}Li-doped Liquid Scintillator Detectors for PROSPECT"** – Jeremy Gaison, Sat Oct 15, 2:48pm
- **"PROSPECT: Optical Calibration System"** – Ken Trinh, CEU Poster

Also go to prospect.yale.edu for more information!

PROSPECT Detector Design

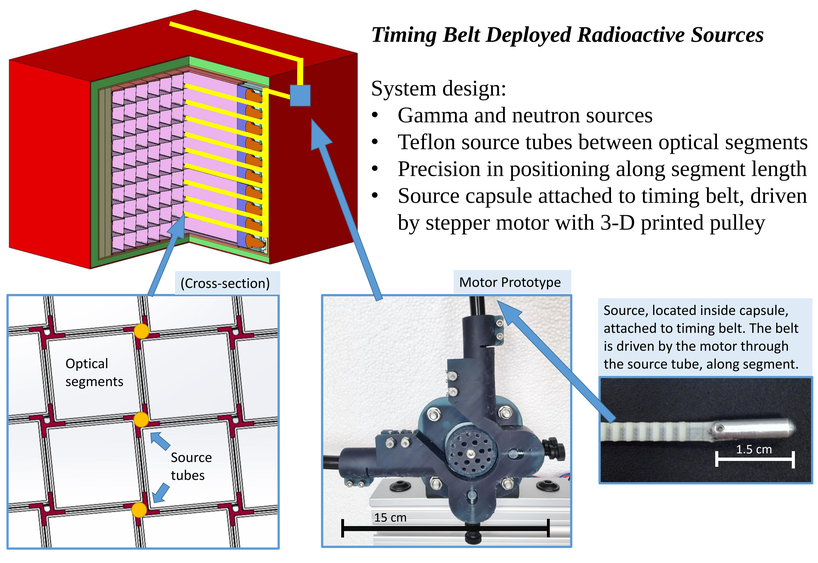


PROSPECT: The Precision Reactor Oscillation and Spectrum Experiment

PROSPECT will be commissioned at Oak Ridge National Laboratory's High Flux Isotope Reactor (HFIR), a highly enriched ^{235}U core.
- 10x12 array of optical segments, ~3 ton
- Double-ended photomultiplier readout
- Movable baseline at 7-12 m from reactor
- Polyethylene, lead, and water brick shielding
- Construction currently underway

LiLS – Lithium-loaded Liquid Scintillator
The active volume of PROSPECT is filled with ^{6}Li-loaded EJ309 liquid scintillator.
- Light collection of >550 PE/MeV
- Excellent pulse-shape discrimination (PSD) for neutron capture events.

Calibration Source Deployment System



Timing Belt Deployed Radioactive Sources

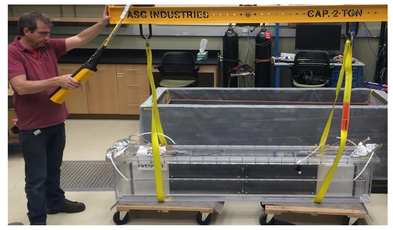
System design:
- Gamma and neutron sources
- Teflon source tubes between optical segments
- Precision in positioning along segment length
- Source capsule attached to timing belt, driven by stepper motor with 3-D printed pulley

Results and Status

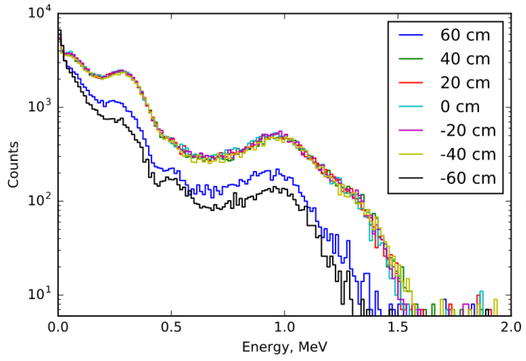
- Developed and tested prototype system that can be scaled to 30+ units
- Attained precise positioning of sources along segment lengths
- Operated calibration system tests with PROSPECT-50 prototype detector
- Currently optimizing calibration procedure with PROSPECT-50 studies
- Integrating timing belt system with full PROSPECT detector

PROSPECT-50 Prototype Detector

PROSPECT-50 (P50) operating since March 2016.
- 50L, 2 optical segments
- Ambient background analysis
- Detector characterization
- Design/assembly experience
- Na-22 and Cs-137 internal calibrations

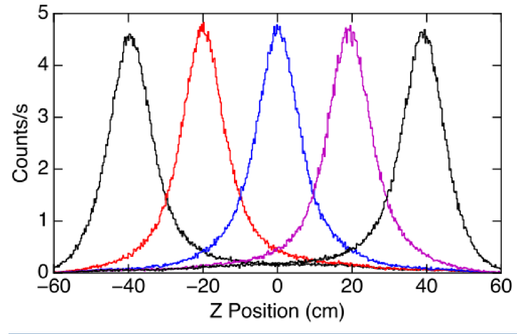


Calibration Studies with P50



Energy Spectra of Na-22 internal source calibration

Measurements taken along segment length. (0cm = center)



Position Reconstruction of Na-22 internal source calibration

Energy range: 900-1300keV
Positioning obtained by timing difference of photomultiplier tubes.

Collaboration

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