PROSPECT: Precision Reactor Oscillation SPECTrum Experiment

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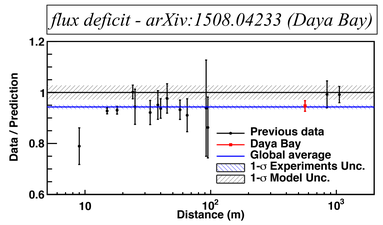
Reactor neutrino anomalies

Reactor experiments have a long, rich history in the study of neutrinos. However, recent reactor measurements show:

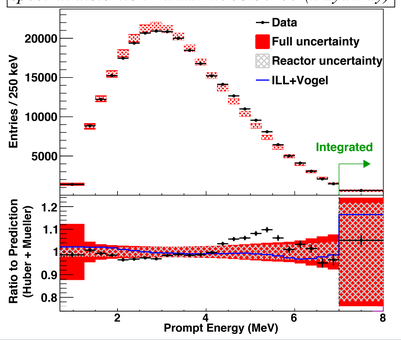
- 5% flux deficit of anti-ν_e compared to prediction
- 10% local spectral deviation

These observations may be hints of new physics, e.g. sterile neutrinos.

flux deficit - arXiv:1508.04233 (Daya Bay)



spectral distortion - arXiv:1508.04233 (Daya Bay)



PROSPECT physics goals

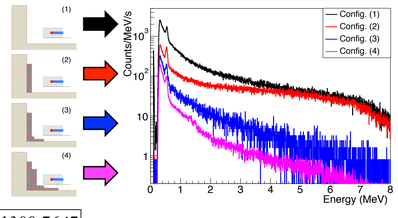
1. Directly address the sterile neutrino interpretation of the reactor flux deficit through a short-baseline oscillation search at a compact-core reactor.
2. Precisely measure the ^{235}U antineutrino spectrum from a highly enriched uranium (HEU) reactor to illuminate the recent spectral anomaly observed by the θ_{13} experiments.

Background studies at HFIR

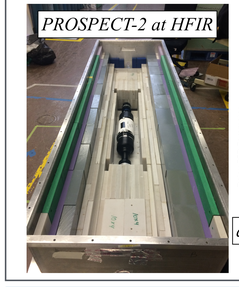
Short-baseline, near-surface reactor experiments face reactor-related (γ) and high cosmic (fast neutrons) backgrounds.

To characterize backgrounds in detail, we have deployed several test detectors to the PROSPECT site, the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory.

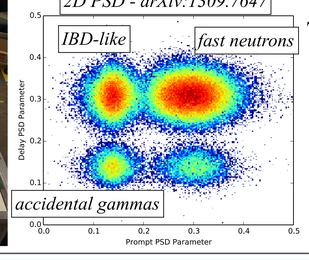
gamma rate - arXiv:1506.03547



PROSPECT-2 at HFIR



2D PSD - arXiv:1309.7647

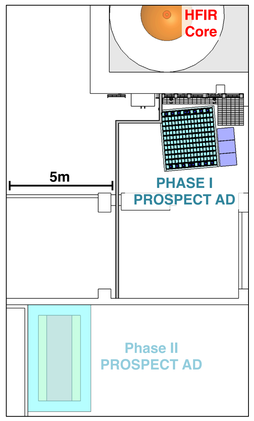


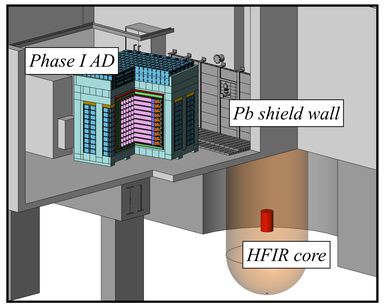
Test detectors:

- PROSPECT-0.1
  100 mL, EJ-309 LS cell
- PROSPECT-2
  1.75 L, LiLS test cell
- PROSPECT-20
  23 L, LiLS full segment

PROSPECT Phase I + II

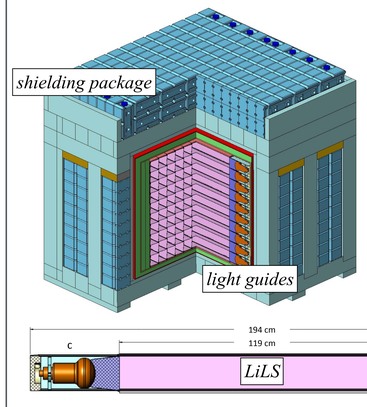
Detector layout at HFIR



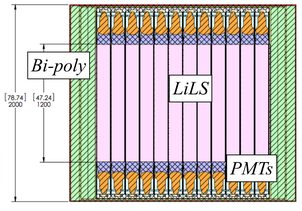


Phase I: 3 tons LiLS, L~7-12 m, 10x12 array
Phase II: ~10 tons LiLS, L~16-20 m

Antineutrino detector design

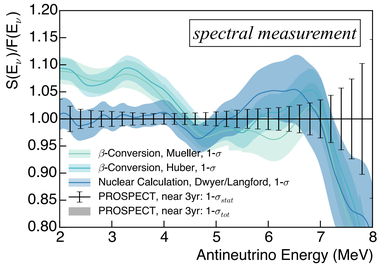


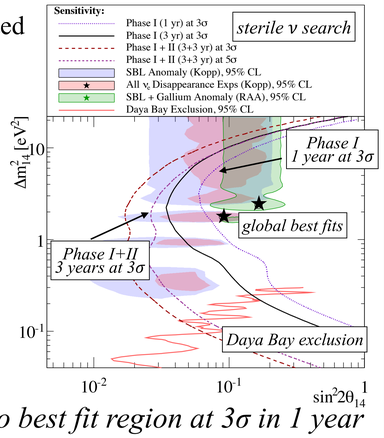
- ^{6}Li-loaded liquid scintillator (LiLS)
- double-ended PMT readout
- access tubes for source calibration
- installed inside shielding package
- light guides for PMT collection
- segment size: 119×15×15 cm^3



PROSPECT physics reach

- 1000 inverse beta decays/day detected
- L/E oscillations between segments
- energy resolution 4.5% at 1 MeV

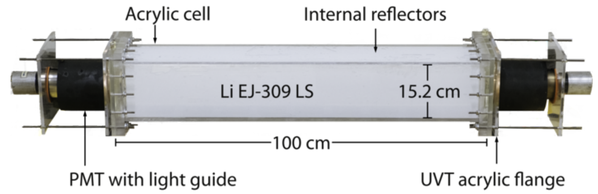


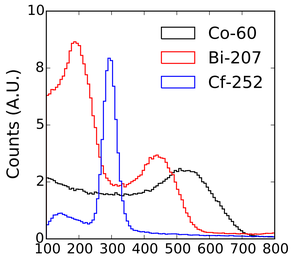


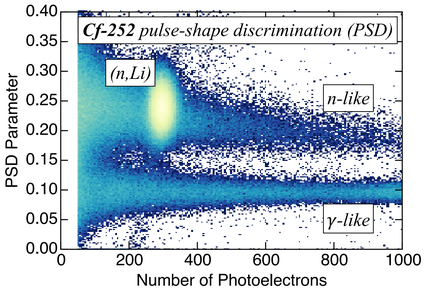
Phase I will probe sterile neutrino best fit region at 3σ in 1 year and surpass spectral model uncertainties.

PROSPECT-20 test segment

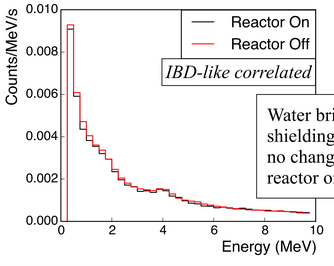
PROSPECT-20 is a full-scale acrylic test segment filled with ^{6}Li-loaded EJ-309 LS. It has dimensions of 100×15×15 cm^3 and equipped with 2 Hamamatsu R6594 5" PMTs.





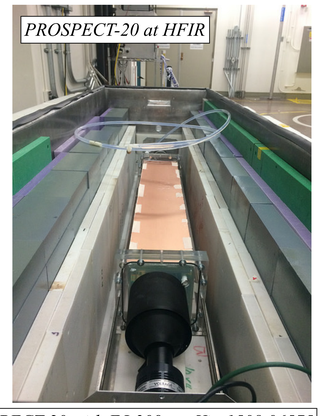


- LS performance in PROSPECT geometry
- demonstration of optical separators
- LiLS light collection 522±16 PE/MeV
- PSD figure-of-merit is 1.4 at (n,Li) peak
- uniform light collection with 2 PMTs



Water bricks, poly, Pb shielding is sufficient, no change in rate with reactor on!

PROSPECT-20 at HFIR



PROSPECT-20 with EJ-309 - arXiv:1508.06575

Collaboration

PROSPECT, HFIR, Brookhaven National Laboratory, NIST, Yale, University of Wisconsin, University of Waterloo, Le Moyne College, Drexel University, Oak Ridge National Laboratory, Lawrence Livermore National Laboratory, Temple University, William & Mary, University of Tennessee

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