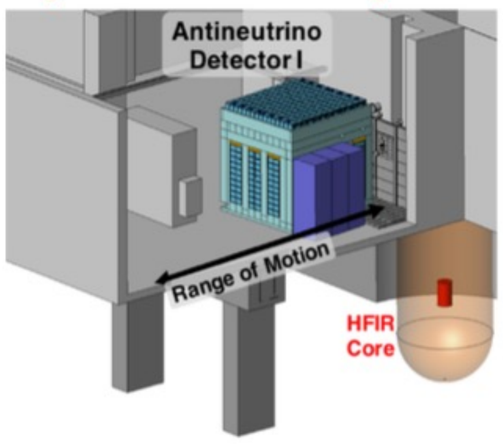
Final Results from the PROSPECT-I Data Set: Search for Short-Baseline Neutrino Oscillations at HFIR

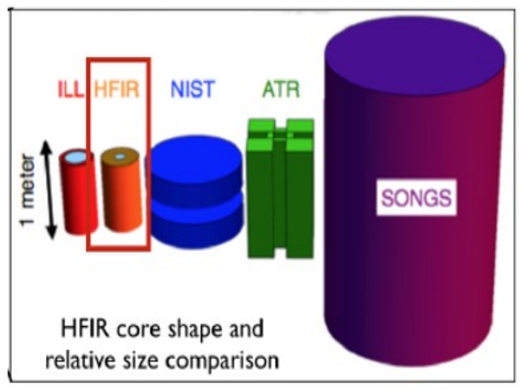
Diego Venegas Vargas[1,2]
[1]Department of Physics and Astronomy, University of Tennessee, Knoxville
[2]Physics Division, Oak Ridge National Laboratory
On Behalf of the PROSPECT Collaboration (prospect.yale.edu)

The PROSPECT Experiment and Motivation for a Final Analysis

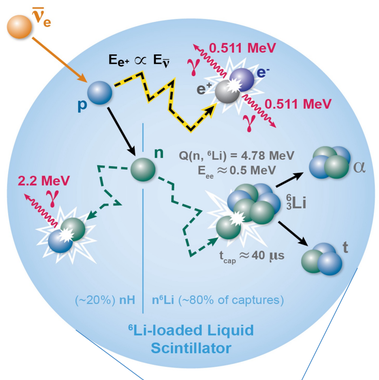
- The Precision Reactor Oscillation and Spectrum Experiment (PROSPECT) is a short-baseline above-ground antineutrino experiment located at the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL). This experiment's physics goals include searching for the existence of sterile neutrinos and precisely measuring the antineutrino energy spectrum from the fission of ^{235}U.

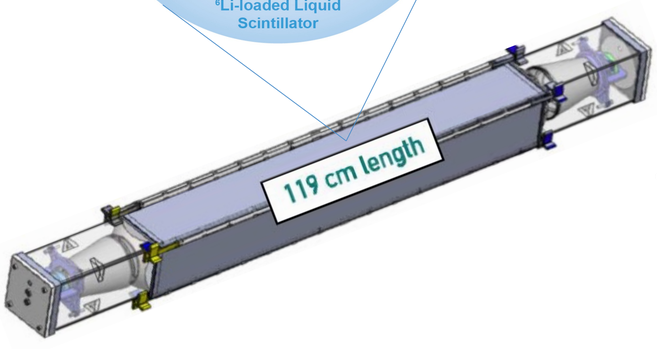


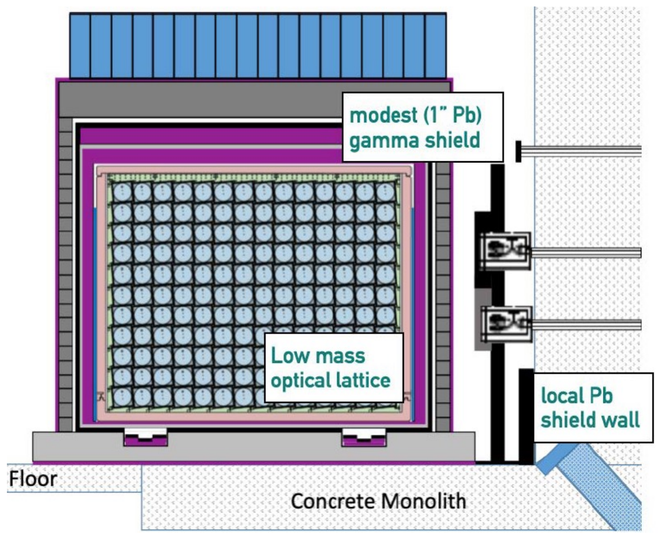
- 93% ^{235}U Fuel
- 85 MW thermal power
- Compact core
- Huge flux in the few MeV range
- ~50% duty cycle for BG measurements



- PROSPECT detects antineutrinos via the Inverse Beta Decay (IBD) process
- Prompt signal (e^+) provides a good energy estimate of incoming ν
- Localized delayed (n-^{6}Li) signal



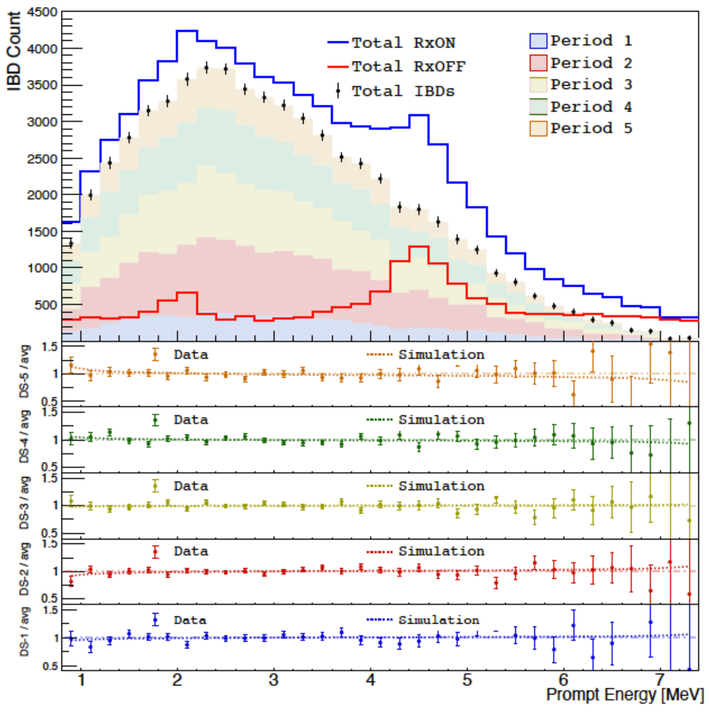




- 14 x 11 array of 6Li doped liquid scintillator for detecting reactor antineutrinos (6.7-9.2 m from compact highly enriched uranium reactor core)
- Statistics for previous results were affected by a gradual lost of photomultiplier tube bases throughout the data collection period.

M. Andriamirado et al. (PROSPECT Collaboration), Phys. Rev. D 103, 032001 (2021).

New Multi-Period Analysis



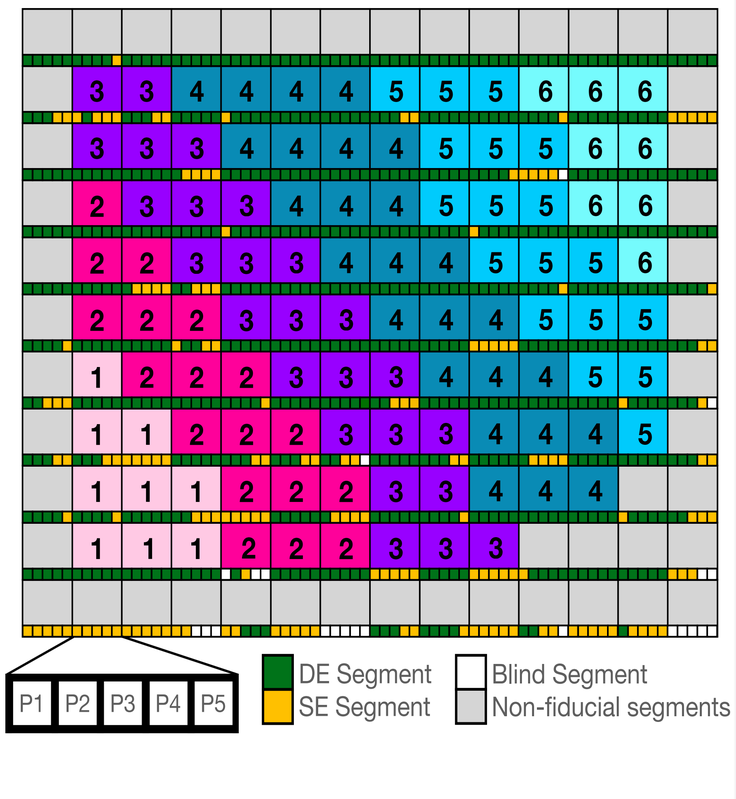
Measured absolute prompt energy spectra for all periods

Implementation of new analysis methods provided the following improvements:

- IBD counts: 50560 → **61029**
- IBD effective counts: 18100 → **36204**
- Signal to cosmogenic background (S/CB): 1.37 → **3.90**
- Signal to accidental background (S/AB): 1.78 → **4.31**

M. Andriamirado et al. (PROSPECT Collaboration), Phys. Rev. Lett. 131, 021802 (2023).

Operational status and baseline binning designation for each detector segment



Strategy for oscillation analysis

- Looking for IBD spectral distortion at each baseline/segment of the detector.
- Compare each baseline's measured spectrum to the absolute spectrum to remove reactor model dependency.
- Compare measured, predicted spectrum ratios for different (Δm^2_{41},$\sin^2(2\theta_{41})$)

CNP-Test to mitigate biases

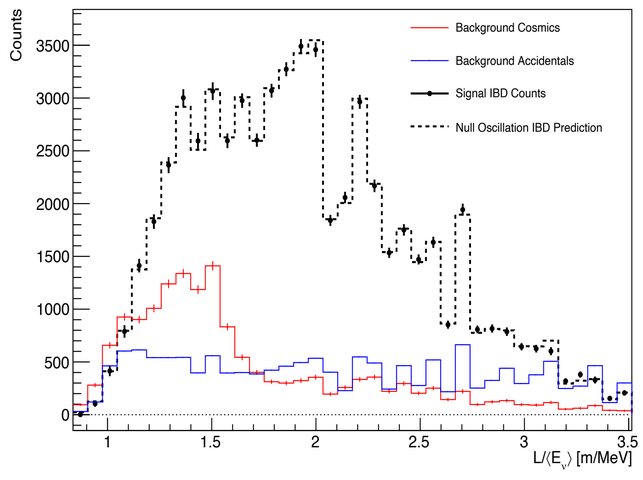
$$\chi^2_{rel} = \Delta^T V^{-1}_{rel} \Delta$$

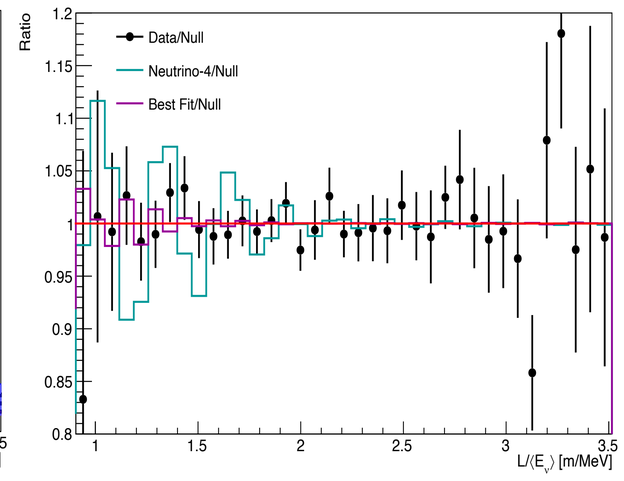
$$\Delta_{l,e} = M_{l,e} - P_{l,e}\frac{M_e}{P_e}$$

New Results

L/E_ν features between IBD signal and null oscillation prediction

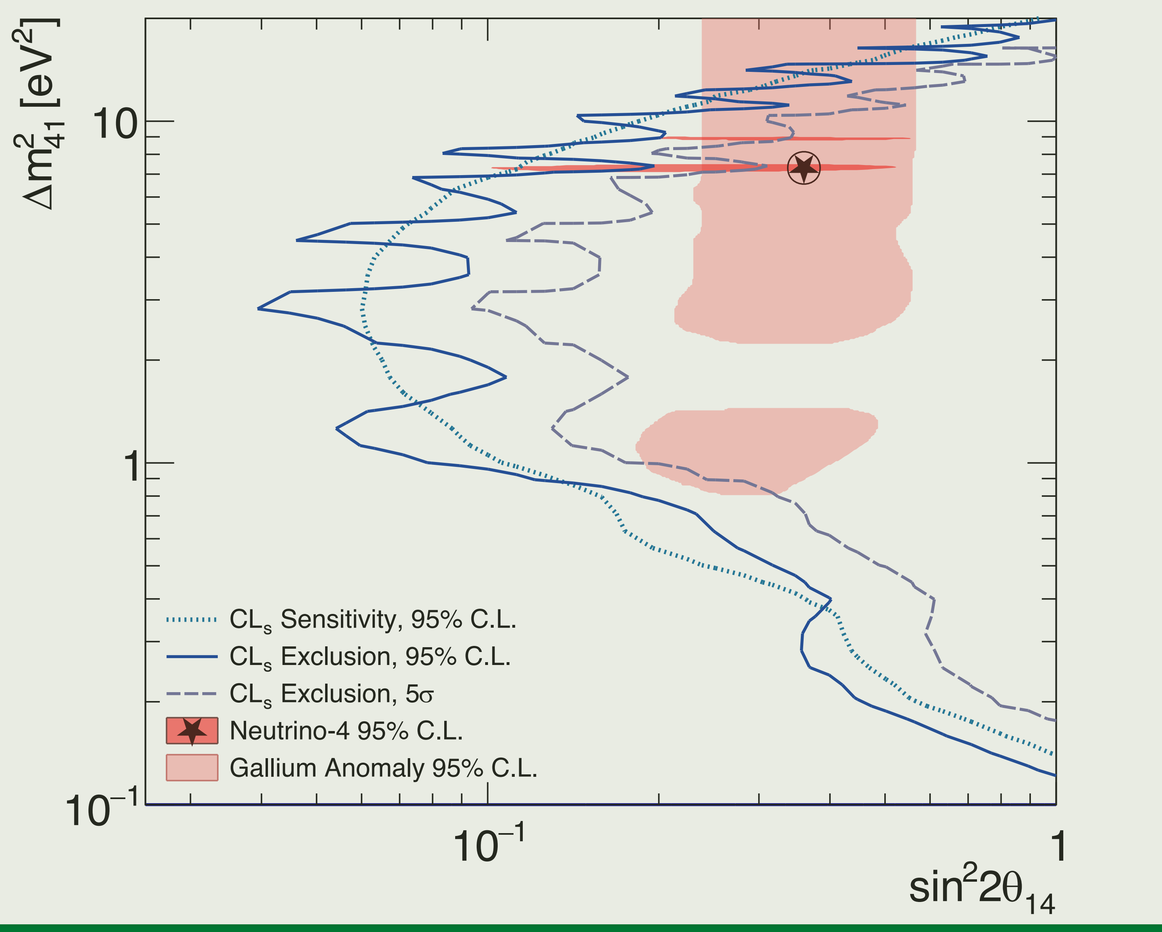
- Short-baseline oscillation behavior in PROSPECT can be visualized by grouping its IBD data into bins of common L/E_ν
- Ratios expected due to oscillations at the PROSPECT data and Neutrino-4 best-fit points are also depicted.
- PROSPECT-I's IBD data do not exhibit any obvious oscillatory behavior.



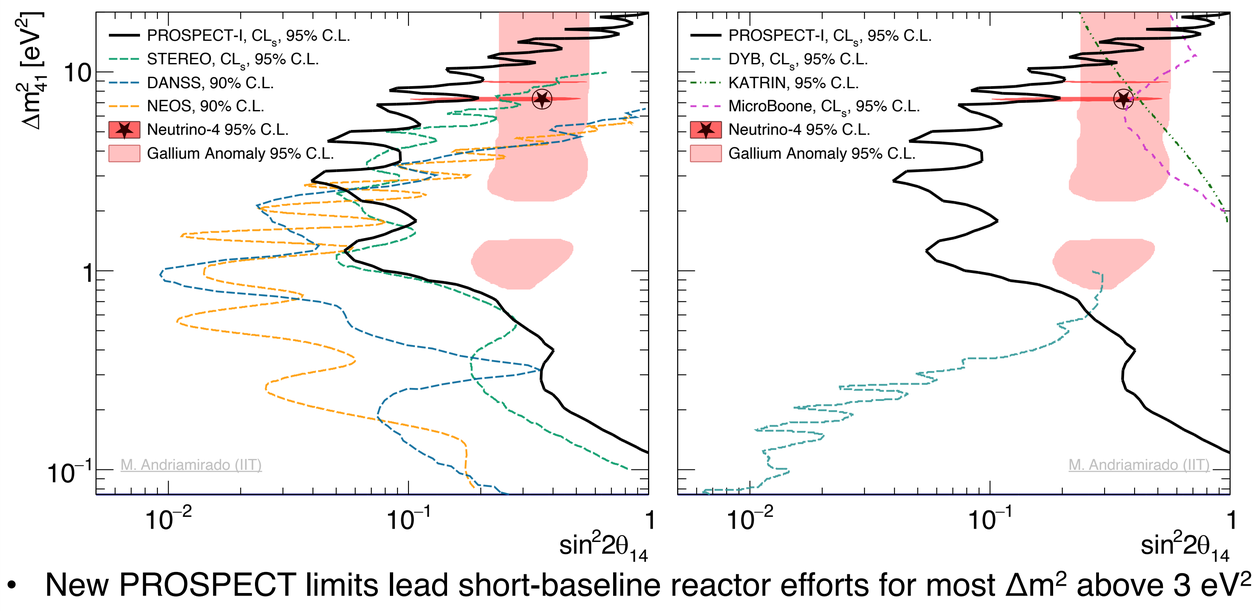


Phase space for 3+1 sterile neutrino oscillations excluded by the final PROSPECT-I dataset

- New PROSPECT data set is compatible with an absence of sterile neutrino oscillations.
- Best-fit point of the Neutrino-4 reactor experiment's claimed observation of short-baseline oscillation is ruled out at more than 5σ.
- Excluded all phase space for Δm^2 below 10 eV^2 suggested by the recently strengthened Gallium Anomaly



PROSPECT and Global Context



- New PROSPECT limits lead short-baseline reactor efforts for most Δm^2 above 3 eV^2
- **Reactor-based θ_{14} limits are much stronger than other experiment sectors over most of the pictured phase space**
- Additional sterile sensitivity unlocked by comparison of long (Daya Bay) and short (STEREO, PROSPECT) baseline energy spectra (*a la* NEOS/RENO)
  – New joint-oscillation analysis is underway!!!

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