Final Search for Short-Baseline Neutrino Oscillations with the PROSPECT-I Detector at HFIR

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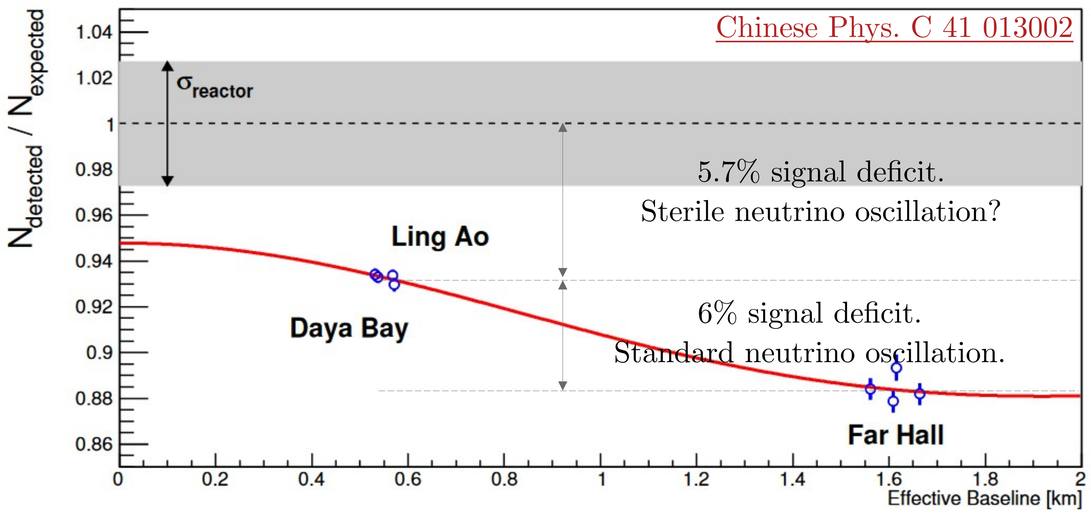
Sterile Neutrinos

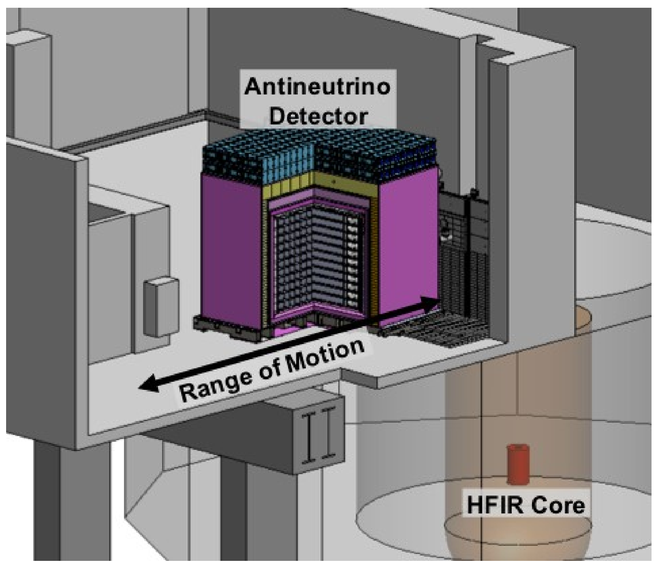


- Antineutrino flux deficit could be explained by the oscillation of active antineutrinos into sterile states.
  - Portal to Physics Beyond the Standard Model.
- Other anomalies point to the existence of sterile neutrino: LSND/MiniBoone, and the gallium anomaly.
- Recent result from the Neutrino-4 experiment claimed a non-zero oscillation. Phys. Rev. D 104, 032003 .

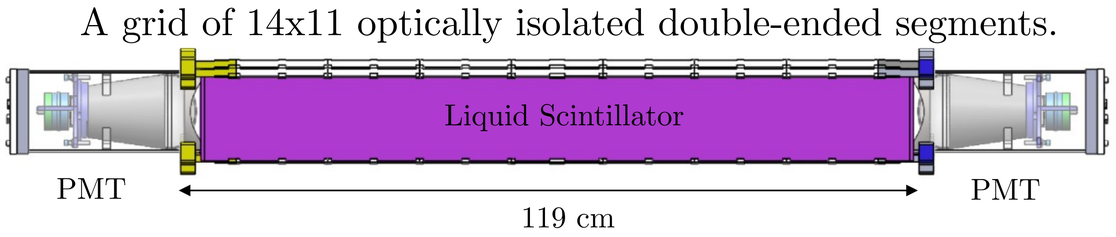
The PROSPECT Experiment

The Precision Reactor Oscillation and SPECTrum experiment is a reactor antineutrino experiment, designed to search for sterile neutrino oscillation and measure ^{235}U antineutrino spectrum.

- On-surface deployment with minimal overburden.
- 85 MW compact Higly Enriched Uranium reactor.
- Detector covers baseline of 7-9 m from the reactor core.
- Detector is filled with 4-ton of ^{6}Li-doped PSD-capable liquid scintillator.
- Antineutrino detection via Inverse Beta Decay (IBD).



A grid of 14x11 optically isolated double-ended segments.



The ingress of liquid scintillator into PMTs led to the failure of some PMTs, resulting previous results to be dominated by statistical uncertainty.

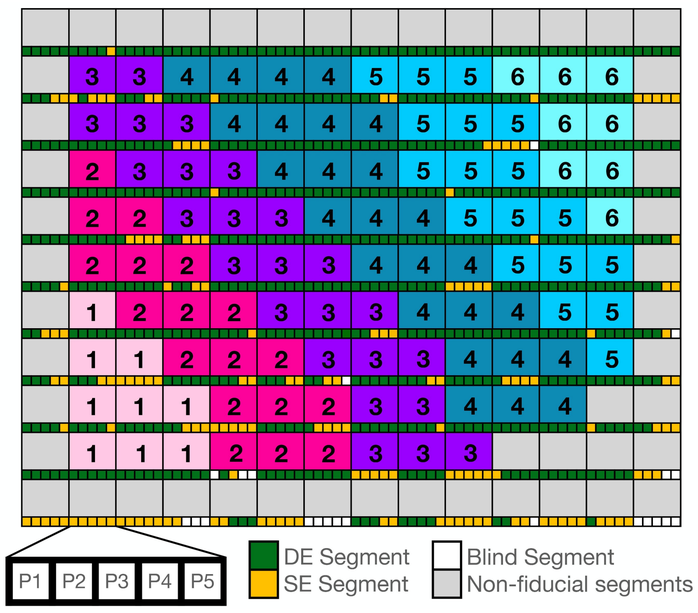
Multi-period analysis

- 96 days of data taking from March 5 to October 6, 2018.
- Split the data into 5 periods to recover IBD statistics:
  - Apply Single-Ended Event Reconstruction (SEER) to further reduce backgrounds.
- Total IBD count: 61,029 with 3.9 of S/B ratio.
- Used this optimized dataset for antineutrino spectrum measurement at PROSPECT, Phys. Rev. Lett. 131, 021802.

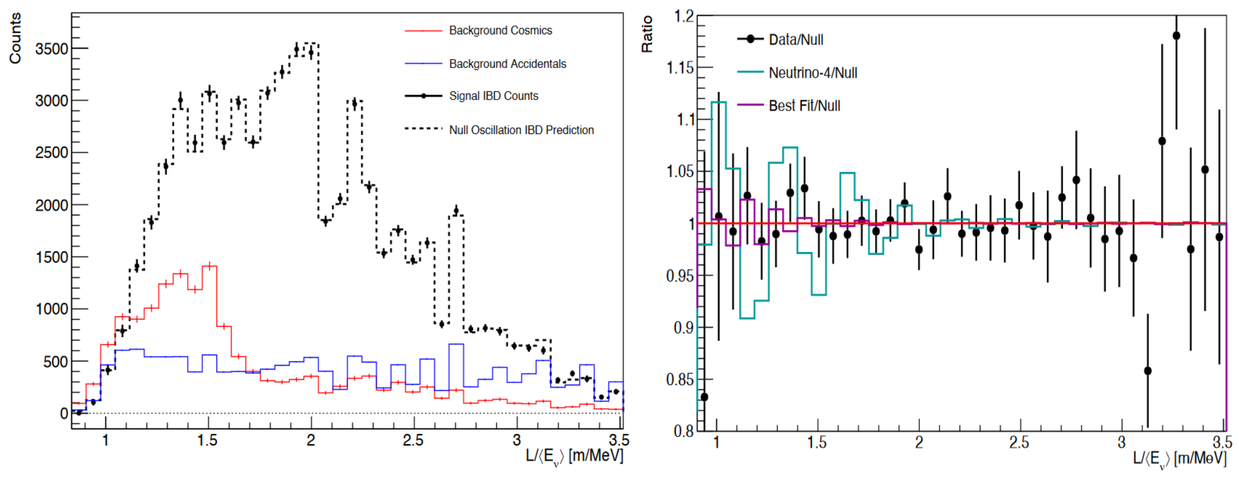
Data Set	Rx-On(Off) Days	N_{IBD}	N_{eff}	S:CB(AB)
Prev. Analysis	95.65(73.09)	50560 ± 406	18100	1.37(1.78)
This Analysis	95.62(72.69)	61029 ± 338	36204	3.90(4.31)
Period 1	9.54(14.58)	6357 ± 100	4328	4.03(6.21)
Period 2	22.83(15.71)	16546 ± 172	10259	4.35(4.64)
Period 3	23.20(16.40)	15094 ± 166	9050	4.04(4.44)
Period 4	22.29(16.79)	13486 ± 161	7742	3.72(3.39)
Period 5	17.76(9.21)	9546 ± 146	4825	3.38(2.88)

Analysis strategy

- Search for spectral distortion at each baseline of the detector.
- Perform a shape analysis which remove the reactor model dependency.
- Quantify the agreement between data and prediction with a χ^2 statistical test.
  - Combined Neyman-Pearson test to minimize bias from low statistics bins.

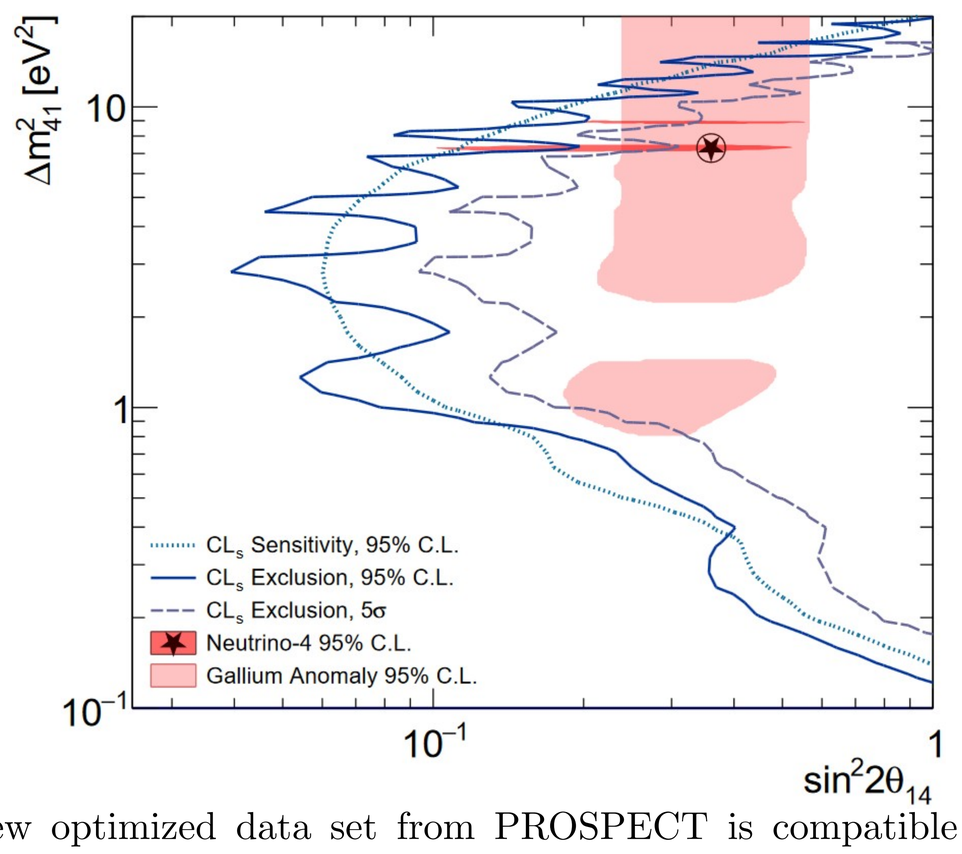


Data Visualization



- Short-baseline oscillation behavior in PROSECT 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.
- No obvious sign of short-baseline oscillation from PROSPECT IBD's dataset.

Result



- New optimized data set from PROSPECT is compatible with the absence of sterile neutrino oscillations.
- Claimed observation of short-baseline oscillation from the Neutrino-4 experiment is ruled out at more than 5σ.
- Exclude all phase-space for Δm^2 below 10 eV^2 suggested by the recently strengthened Gallium Anomaly.

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