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On behalf of the PROSPECT collaboration
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Related Talks:
G04.00006: Development of a magnetometer system to monitor stray magnetic fields near PROSPECT detector
Corey E Gilbert
G04.00007: Temperature Dependence studies of the 6Li-doped liquid scintillator used in PROSPECT
Brennan T Hackett
Outline

- Introduction to The Precision Reactor Oscillation and SPECTrum Experiment
- Backgrounds
- Recent results
- Conclusion
Motivation

PROSPECT physics goals:

- Model-independent search for oscillations into eV-scale sterile neutrino

\[ P_{\text{dis}} \simeq \sin^2 2\theta_{14} \sin^2 \left( 1.27 \Delta m^2_{14} (\text{eV}^2) \frac{L(m)}{E_\nu (\text{MeV})} \right) \]

- Precise measurement of \(^{235}\text{U}\) antineutrino spectrum

Spectral Shape Distortion

Reactor Antineutrino Anomaly (RAA)

Daya Bay: PRL 116, 061801 (2016)

~10% local excess

\[ \chi^2 \text{ contribution} \]

local p-value

prompt energy/MeV

1 MeV window
PROSPECT at HFIR

- High Flux Isotope Reactor (HFIR)
  - 85 MW research reactor
  - ~93% enriched $^{235}$U fuel
  - >99% of anti-neutrinos emitted by $^{235}$U fissions
  - Compact Core (h=0.5m d=0.4m)
  - close access
  - ~24 days reactor-on cycle
    - No $^{239}$Pu buildup(<0.5%)

~ 6 anti-neutrino/fission
Detector Overview

- ~4 ton $^6$Li-loaded liquid scintillator detector
- Optically segmented into 14x11 identical detectors
- Double ended PMT readout
- Low mass separator
- Access for in-situ calibration
- Energy resolution ~4.5% at 1 MeV
- ~100k anti-neutrinos detected/year, S:B ~ 3:1

Big Challenge: background suppression
**Inverse Beta Decay**

- **Prompt signal:** 1-10 MeV positron energy deposition

- **Delayed signal:** ~0.5 MeV from neutron capture on $^{6}$Li

**Pulse Shape Discrimination (PSD)**

Customized EJ-309-based $^{6}$LiLS gives excellent PSD performance, background suppression, and IBD pair event identification.
- Background anti-neutrino - accidentals

PROSPECT arXiv:1805.09245
Background Characterization

Identify hotspots from beam line underneath.

Sensitive to reactor operation such as fuel removal.

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Stray Magnetic Field Monitoring

- Stray magnetic field coming from neutron scattering experiments in nearby beam lines.
- PMTs are sensitive to surrounding magnetic field.
- Magnetometers have been incorporated into slow control system to monitor surrounding magnetic field.

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Cosmogenic Background

With PSD technique, shower veto, event topology and fiducialization, background noise can be greatly suppressed by order of magnitude of 4.

- Correlation between cosmogenic background and atmospheric pressure.
- Correct background subtraction for reactor-on.

PROSPECT plots are shown at Neutrino 2018

33 days of reactor on
28 days of reactor off
Average of 771 IBD/day

arXiv:1806.02784
Recent Results

- Data collection since March, 2018
- We see anti-neutrinos. $1/r^2$ trend
- Disfavors reactor antineutrino anomaly best fit point at $>95\% \ (2.2\sigma)$

First result presented at Neutrino 2018 at Heidelberg

First result paper arXiv:1806.02784
Recent Results

Prompt Energy Spectrum

More work is being done towards a final spectrum. Current measurement is statistics limited and will improve as we collect more data.

40.2 days reactor-on exposure
37.8 days reactor-off exposure
~ 31,000 IBD candidate events
Conclusion

- Powerful anti-neutrino detector has been installed and started data-taking since March 2018 at HFIR. IBD is used to detect anti-neutrinos.
- Having minimal overburden, backgrounds are thoroughly examined.
- Report the first high-statistics measurement of antineutrino spectrum.
Backup slides

Figure from B. Littlejohn
Baseline analysis

- Null-oscillation would yield a flat ratio for all baselines
- Direct ratio search for oscillations, reactor model independent
PSD performance

SINGLE SEGMENT
PRELIMINARY

FULL DETECTOR PSD

nLi

Nuclear Recoil

Electronic Recoil

PSD (Tail Fraction)

Energy (MeV)

PROSPECT
Energy Reconstruction

(a) Gamma Sources
- $^{137}$Cs
- $^{60}$Co
- Best fit MC

(b) $^{12}$B Spectrum

(c) $E/E_{\text{MC}}$ vs $E_{\text{rec}}$ [MeV]

(b) $^{22}$Na

(c) $E_{\text{rec}}$ vs Average $\gamma$ Energy [MeV]

(a) $E/E_{\text{Resolution Model}}$

Preliminary

PROSPECT, arXiv:1806.02784
Detector Uniformity

Relative Segment Energy Scale Factors

137Cs

Preliminary

\[
\begin{align*}
\frac{E_i}{E_0} &
\end{align*}
\]

212Bi \rightarrow 212Po \rightarrow 208Pb

Preliminary

Detector Maintenance Period

\[\begin{array}{c}
0.525 \\
0.53 \\
0.535 \\
0.54 \\
0.545 \\
0.55 \\
0.555
\end{array}\]