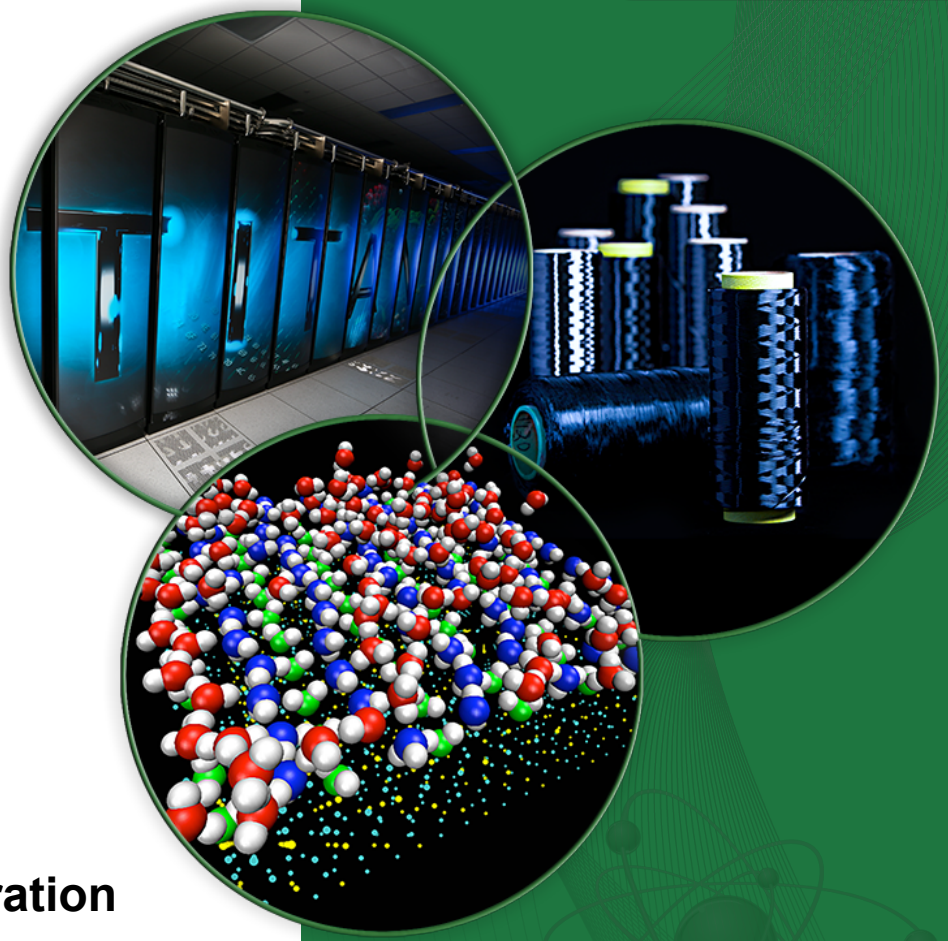

Jeremy Lu

On behalf of the PROSPECT collaboration

Nov 9, 2018

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

ORNL is managed by UT-Battelle for the US Department of Energy

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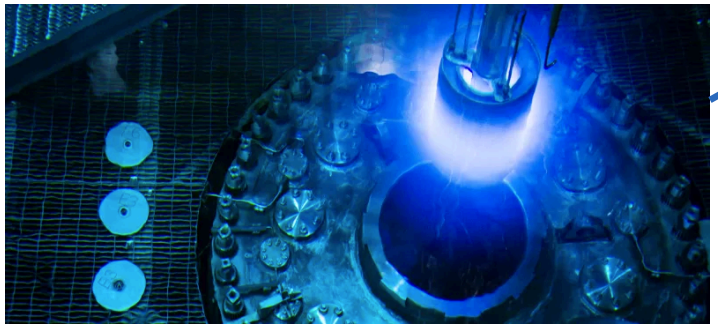
Outline

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



MeV electron anti-neutrino

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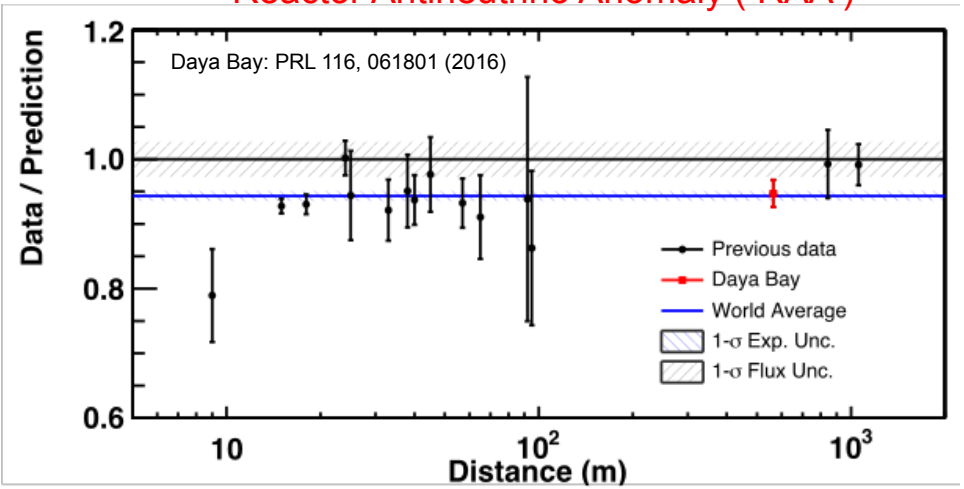
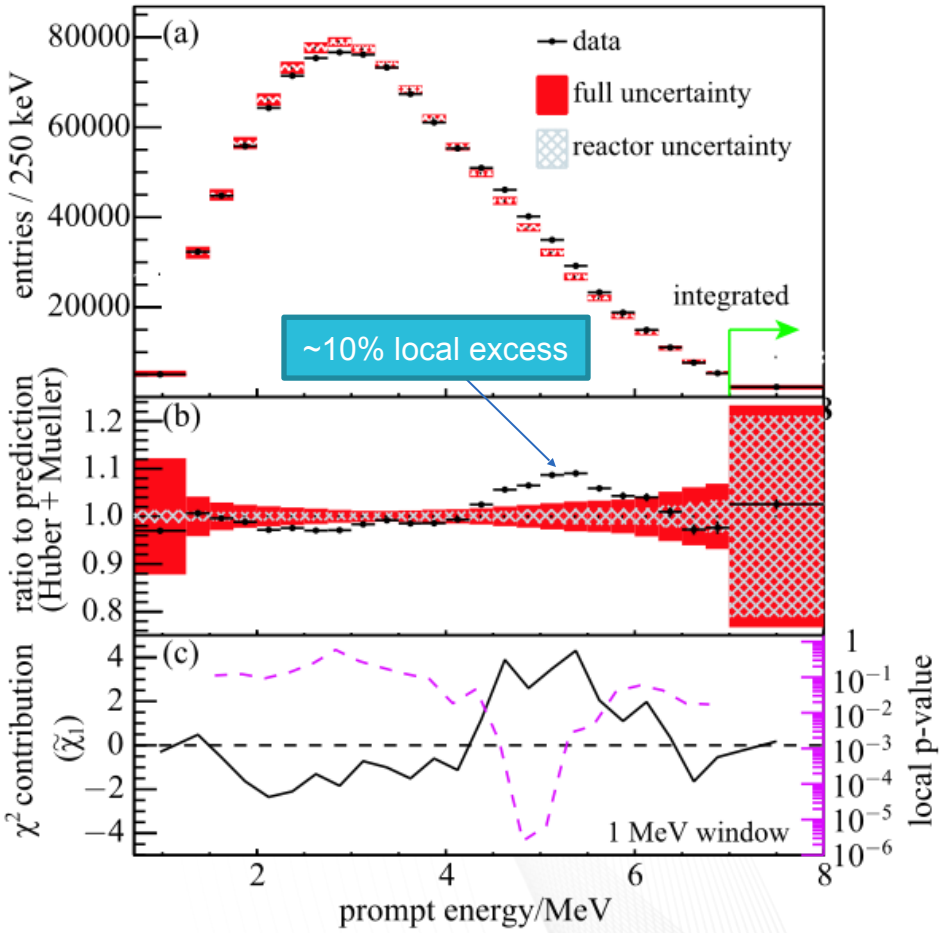
Motivation

Reactor Antineutrino Anomaly (RAA)



Spectral Shape Distortion



PROSPECT physics goals:

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

$$P_{dis} \backsimeq \sin^2 2\theta_{14} \sin^2 \left(1.27 \Delta m^2_{14}(\mathrm{eV}^2) \frac{L(\mathrm{m})}{E_\nu(\mathrm{MeV})} \right)$$

- Precise measurement of ^{235}U anitneutrino spectrum

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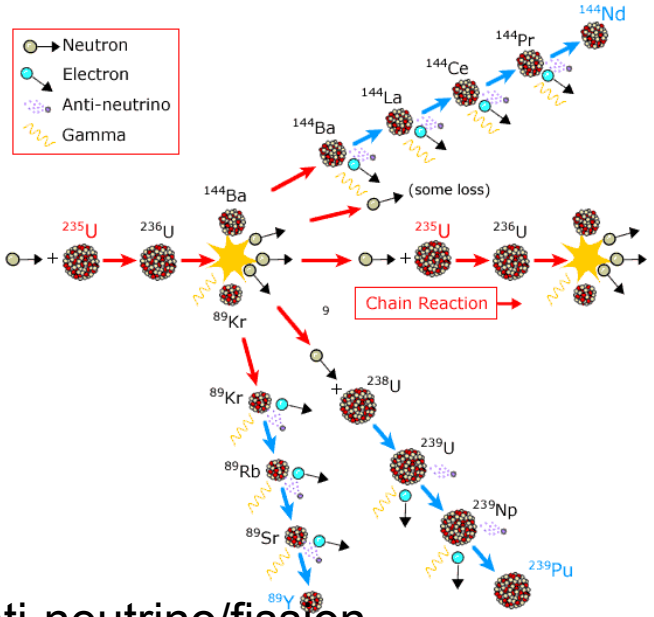
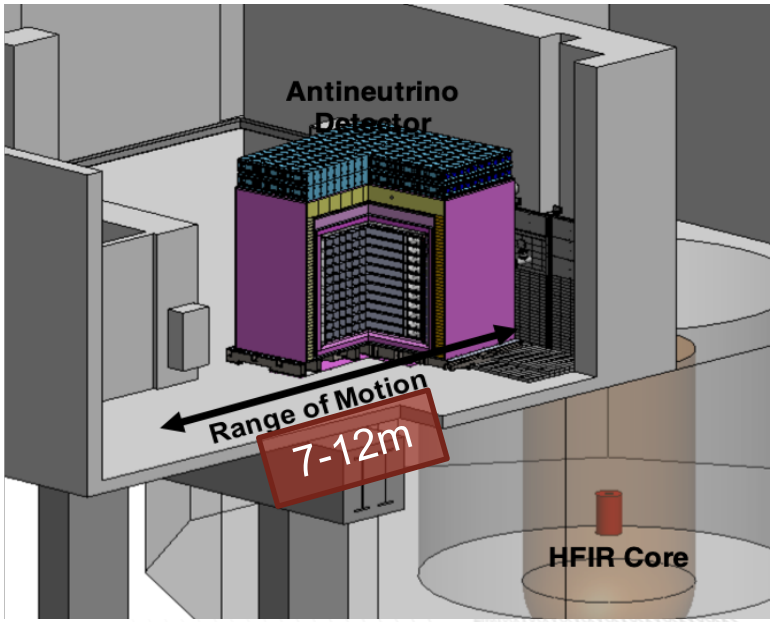
PROSPECT at HFIR

- 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



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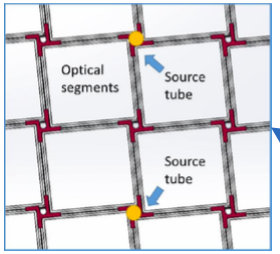
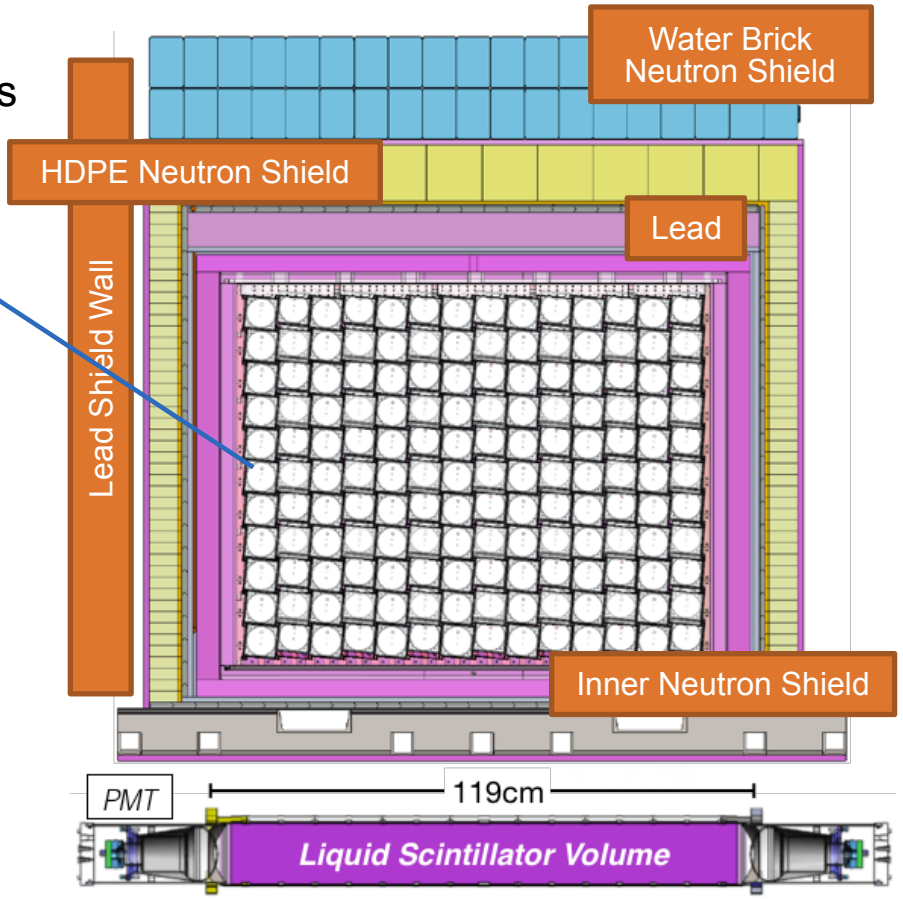
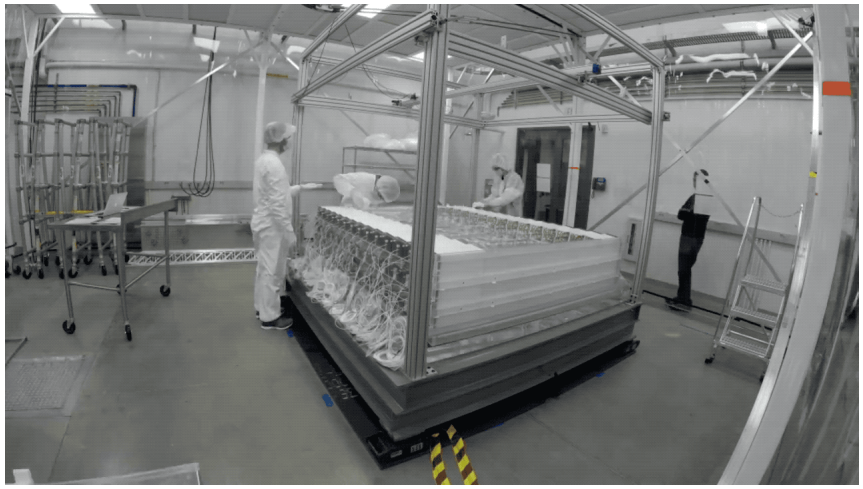
Detector Overview

- ~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

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The PROSPECT Reactor Antineutrino Experiment: arXiv:1808.00097

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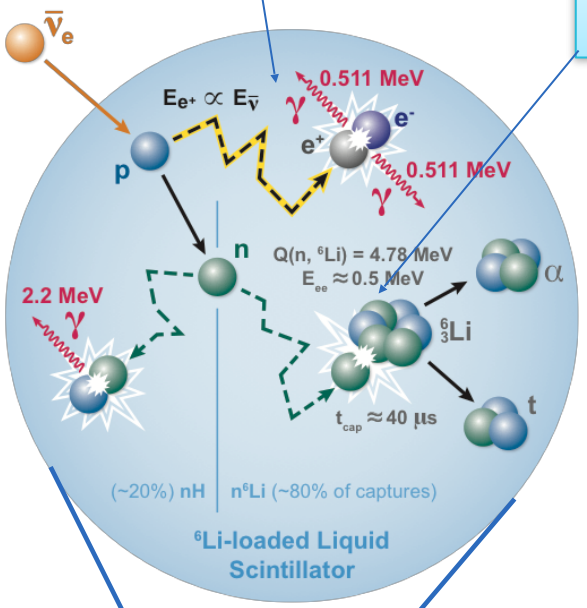
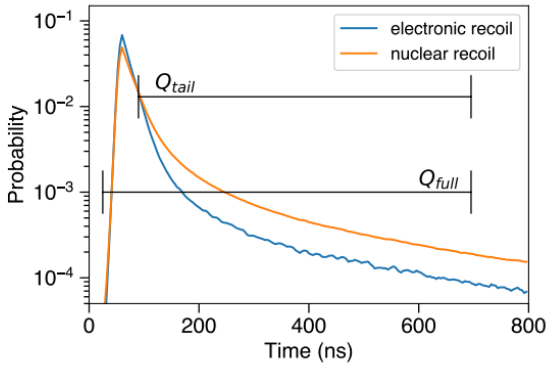
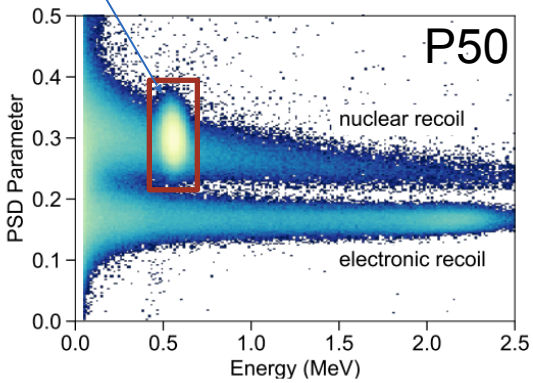
Inverse Beta Decay

- Prompt signal: 1-10 MeV positron energy deposition
- Delayed signal: ~0.5 MeV from neutron capture on ^{6}Li

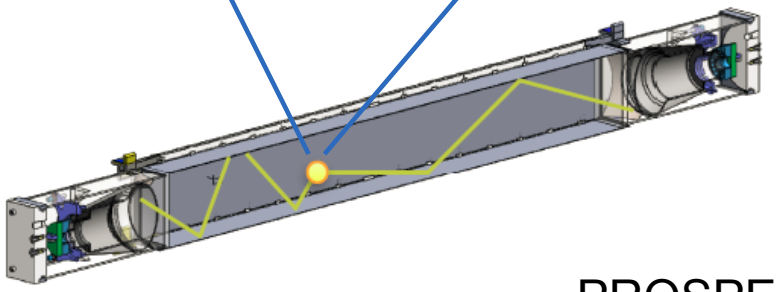






Pulse Shape Discrimination (PSD)

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

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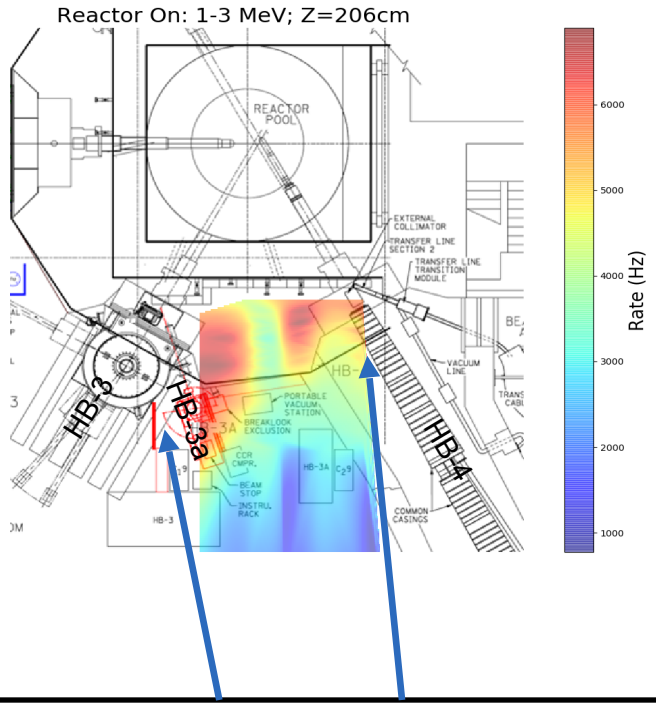
Background Characterization

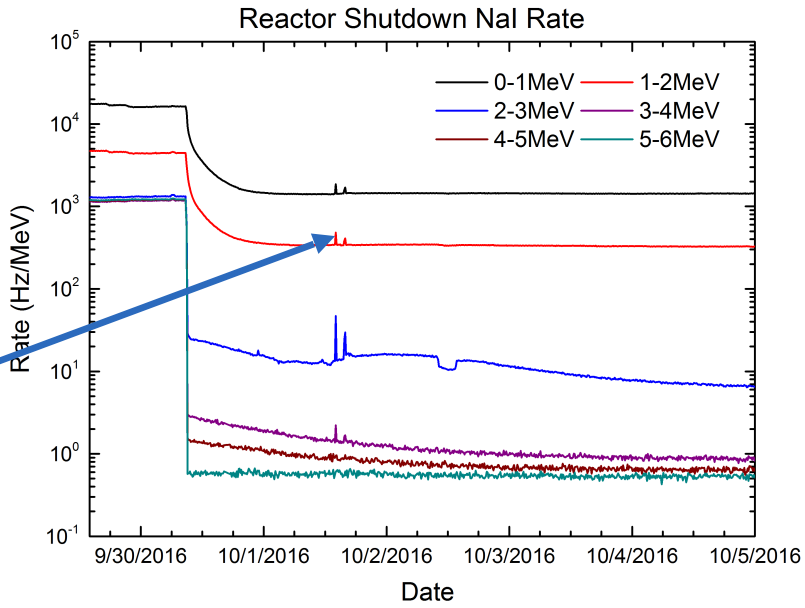


DANG

Figure 3.3: DANG: Detector Array for Neutron and Gamma detection.

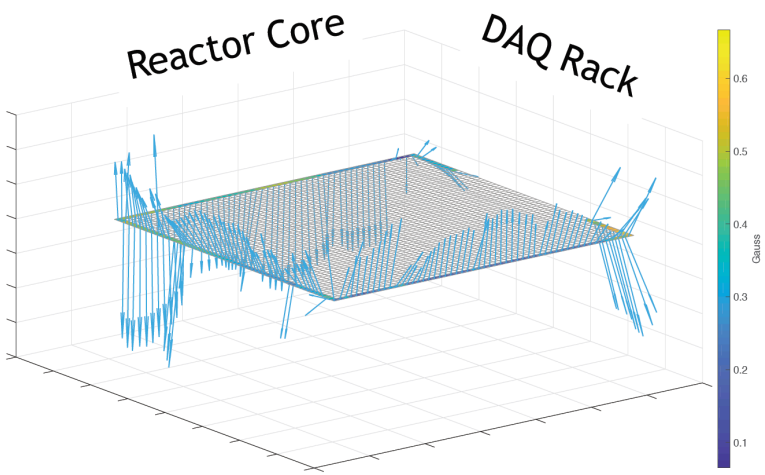
Identify hotspots from beam line underneath.

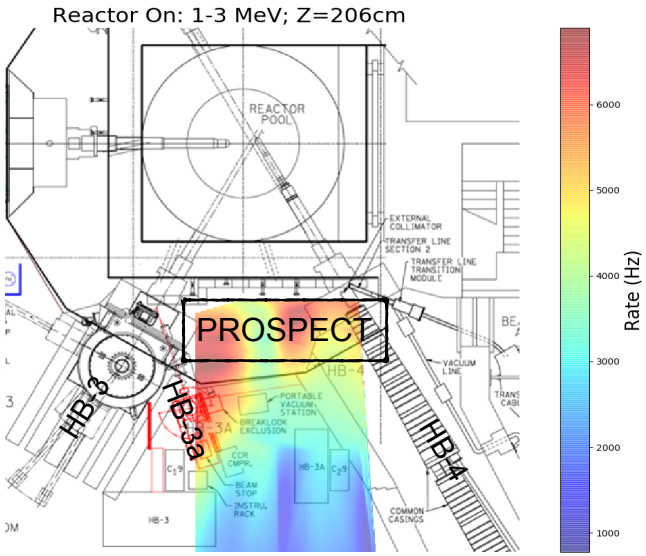
Sensitive to reactor operation such as fuel removal.

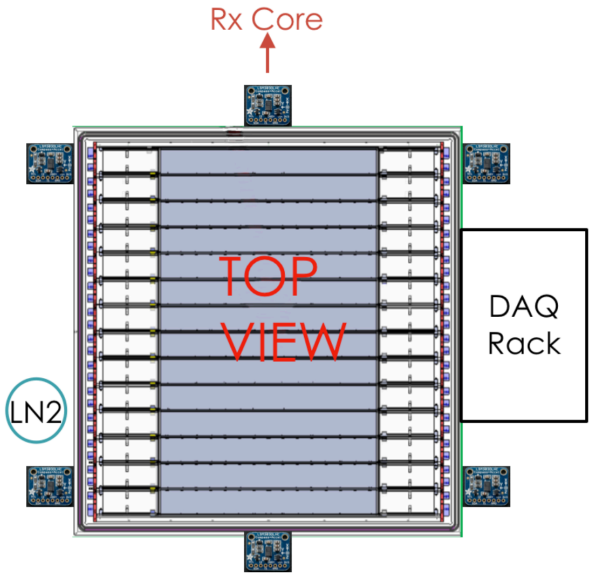


G04.00007: Temperature Dependence studies of the 6Li-doped liquid scintillator used in PROSPECT
Brennan T Hackett

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.

G04.00006: Development of a magnetometer system to monitor stray magnetic fields near PROSPECT detector
Corey E Gilbert

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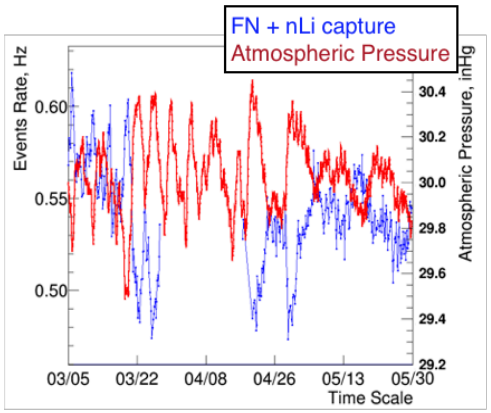
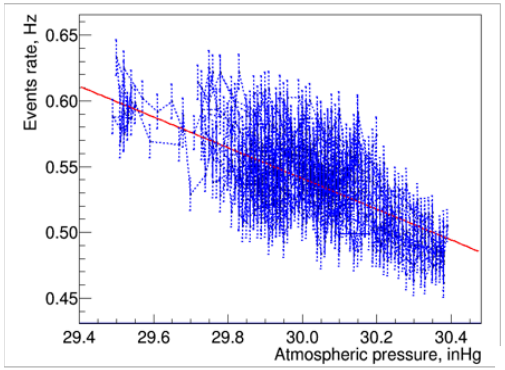
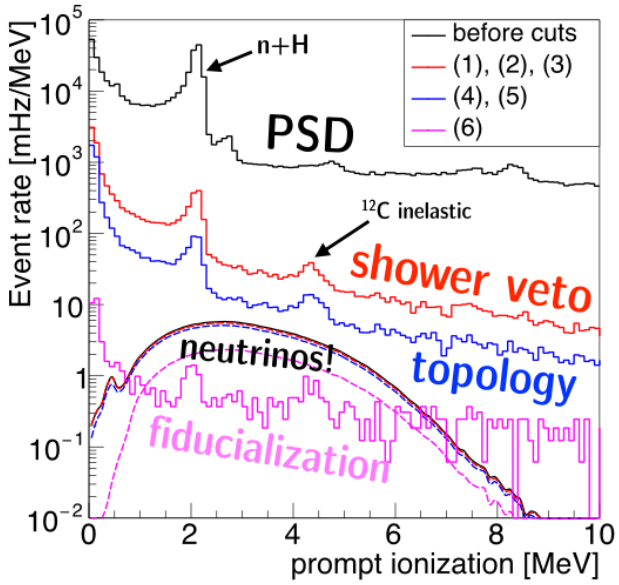
Cosmogenic Background

PROSPECT J. Phys. G: 43 (2016)

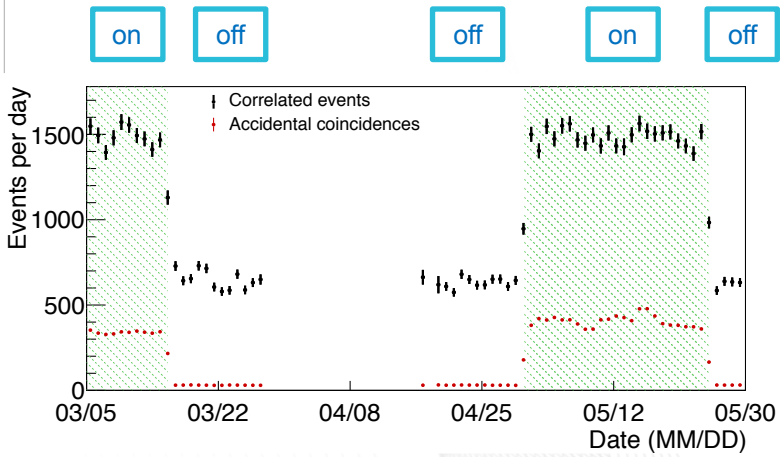
With PSD technique, shower veto, event topology and fiducialization, background noise can be greatly suppressed by order of magnitude of 4.







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



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

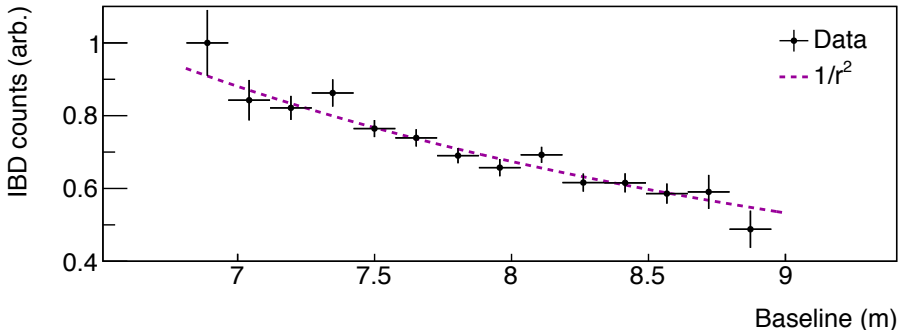
arXiv:1806.02784

PROSPECT plots are shown at Neutrino 2018

Recent Results

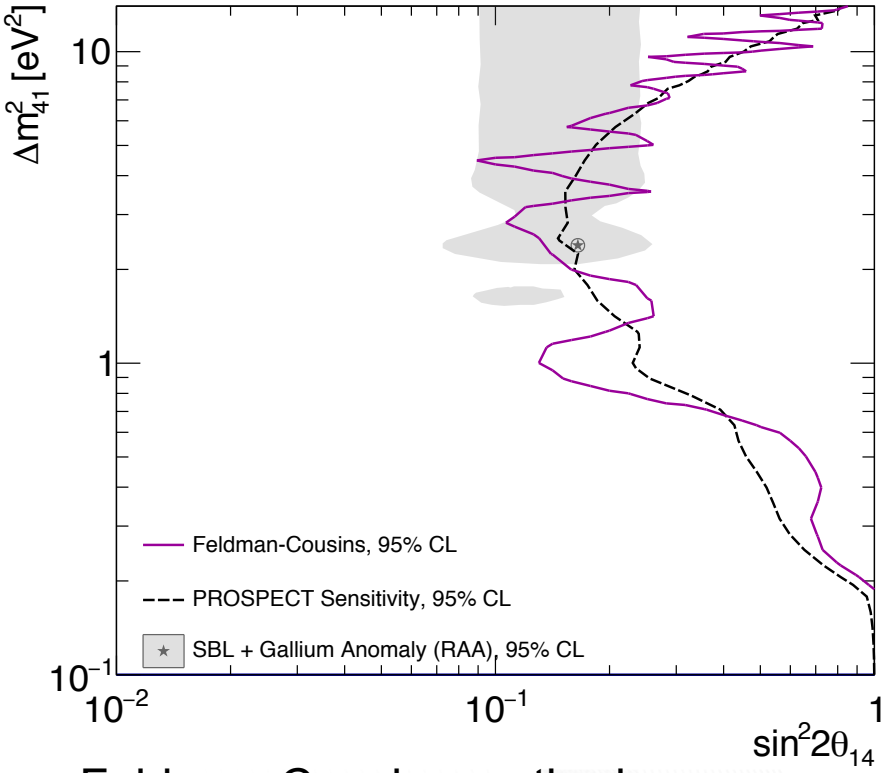
- Data collection since March, 2018
- We see anti-neutrinos. $1/r^2$ trend
- Disfavors reactor antineutrino anomaly best fit point at >95% (2.2σ)

Segmentation allowing for different baselines coverage even with detector in fixed position



IBD rate shows $1/r^2$

5σ statistical significance within two hours of on-surface reactor-on data-taking



Feldman Cousins method
Covariance matrix for each uncertainty

First result paper **arXiv:1806.02784**

[First result presented at Neutrino 2018 at Heidelberg]

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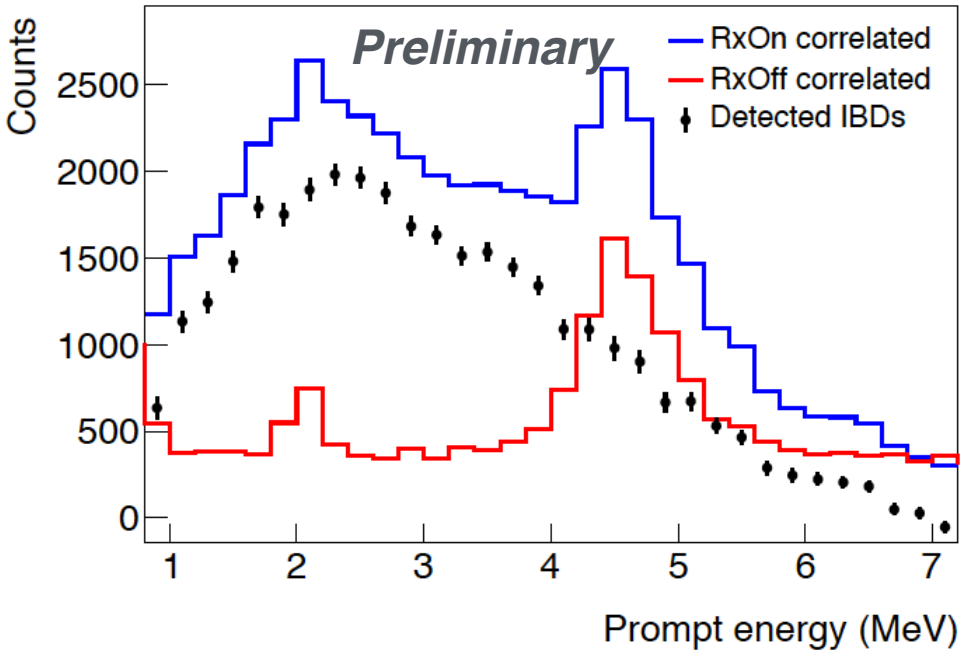
Recent Results

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

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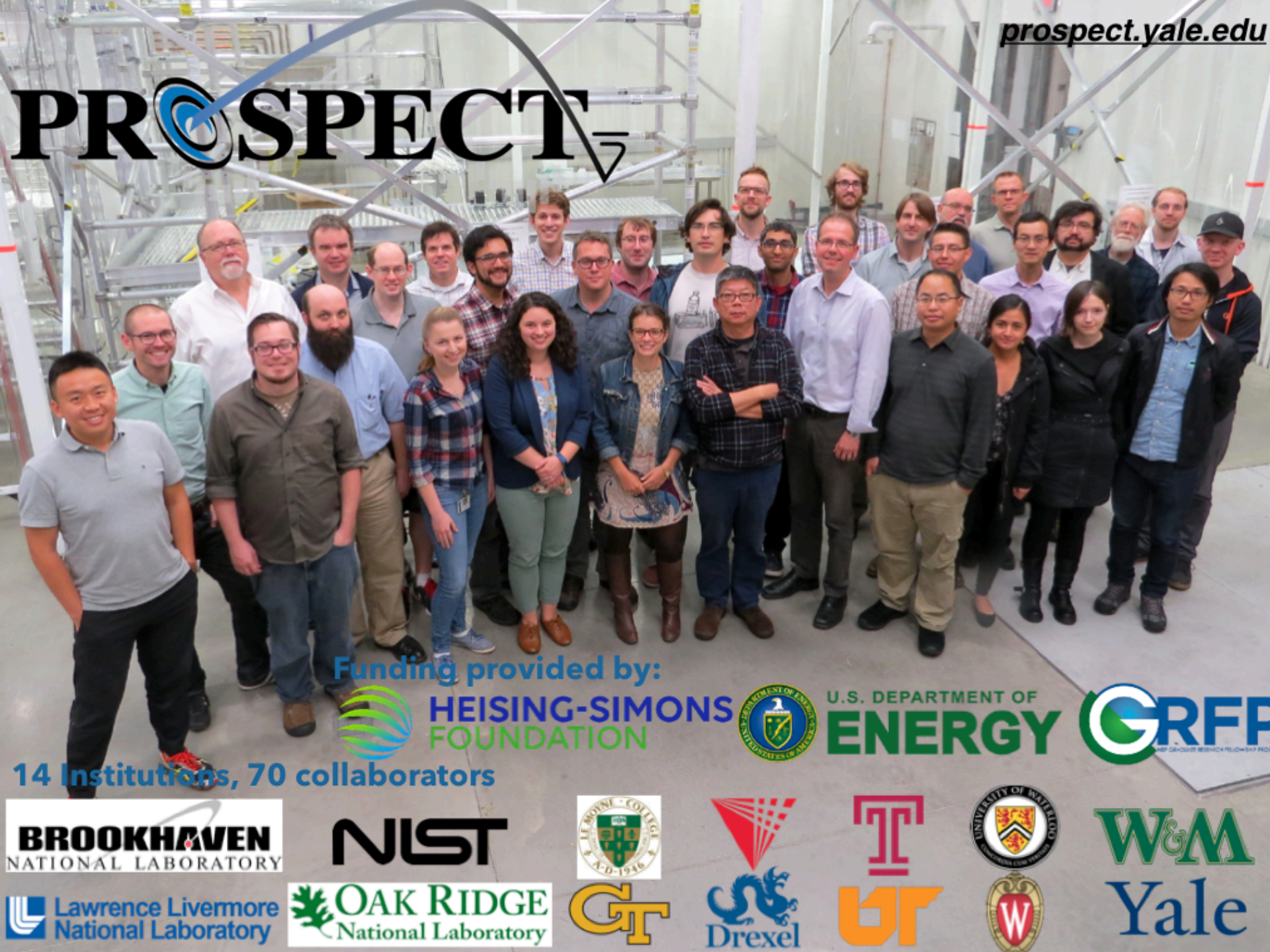
Conclusion

- 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.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U.S. DEPARTMENT OF ENERGY
GRFP
14 Institutions, 70 collaborators
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Lawrence Livermore National Laboratory
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Backup slides

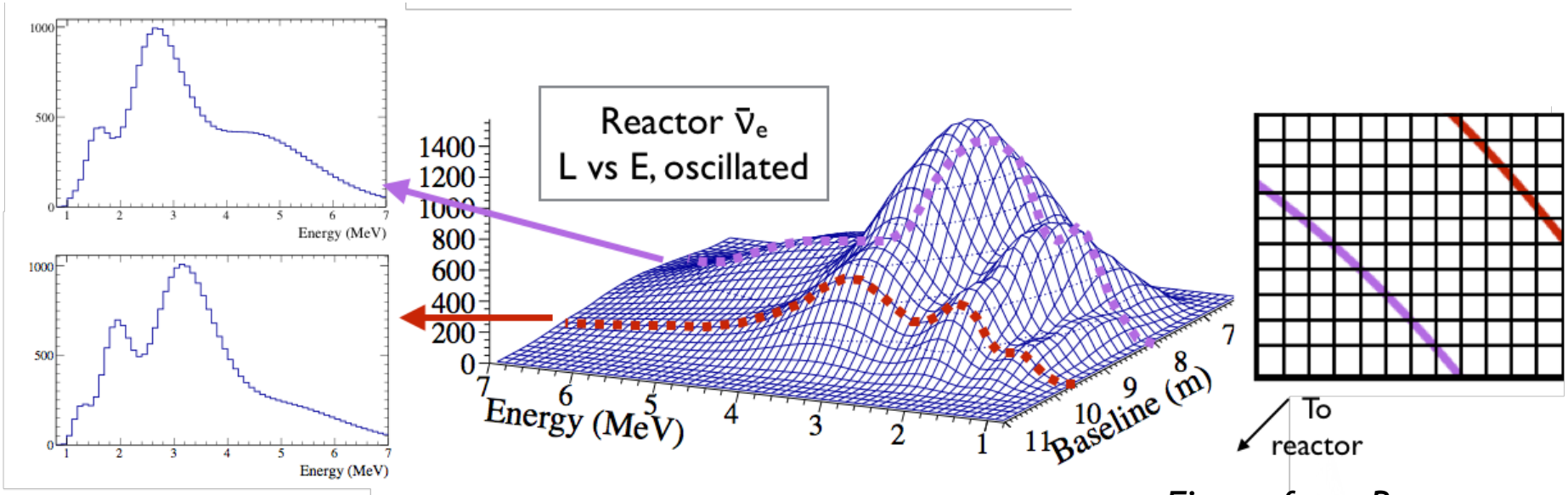
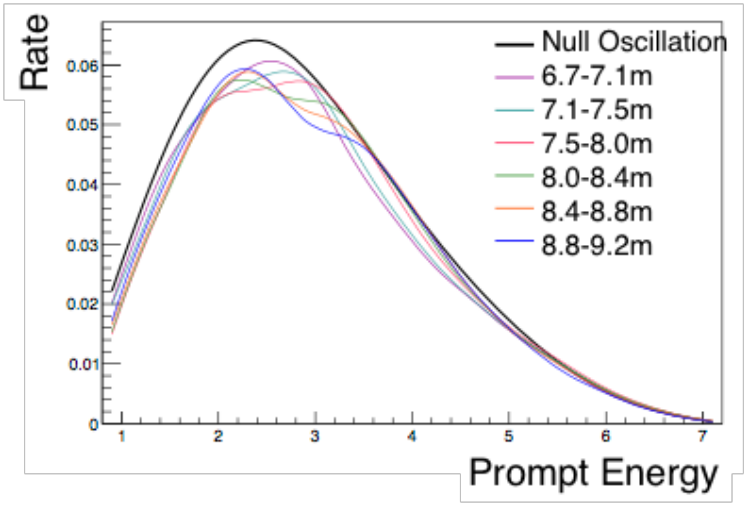
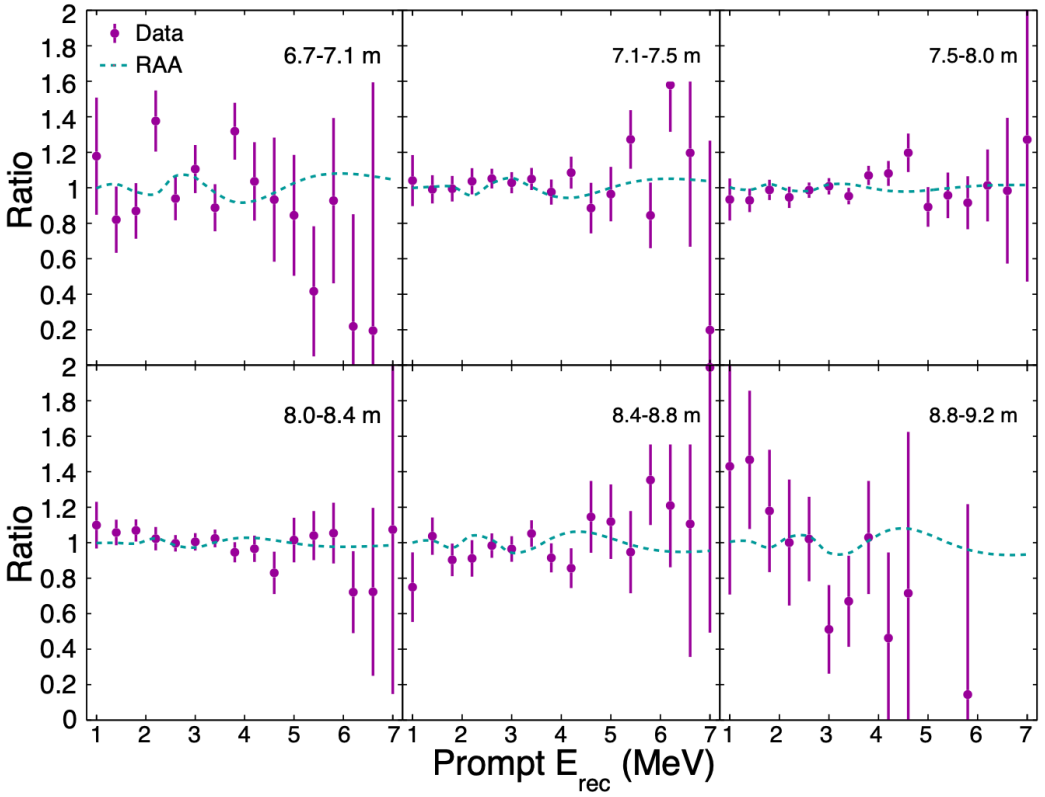


Figure from B. Littlejohn

Baseline analysis





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

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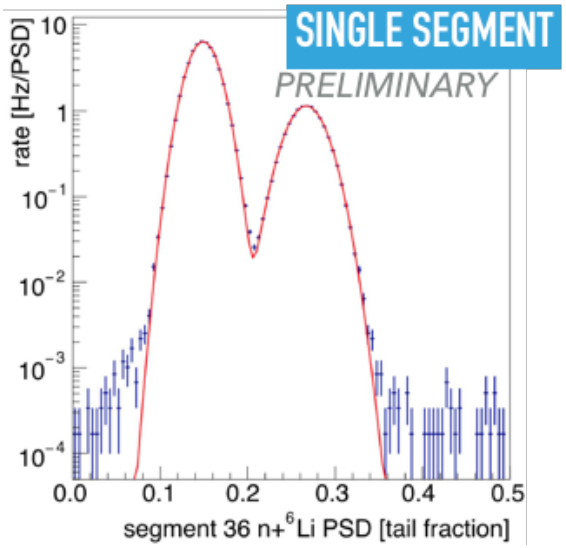
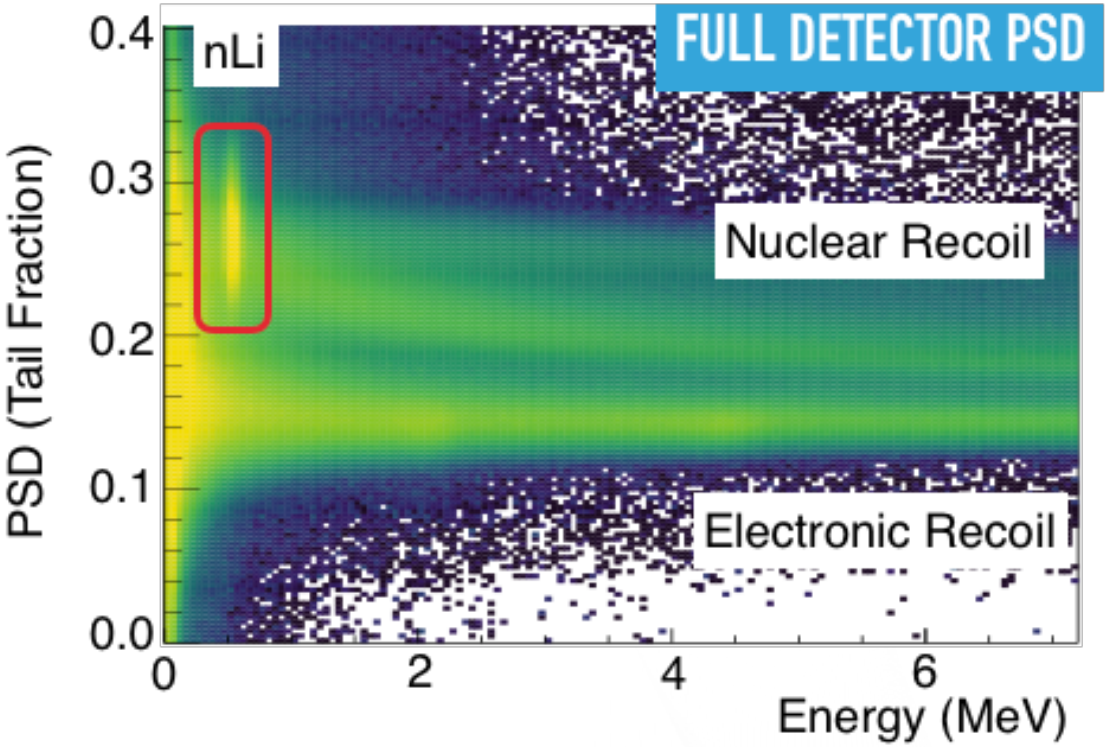
PSD performance





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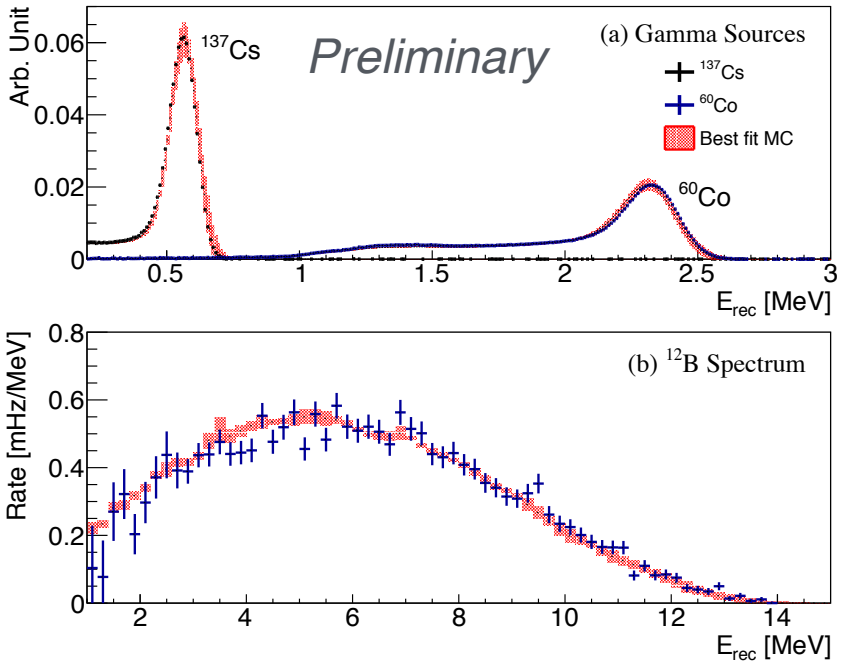
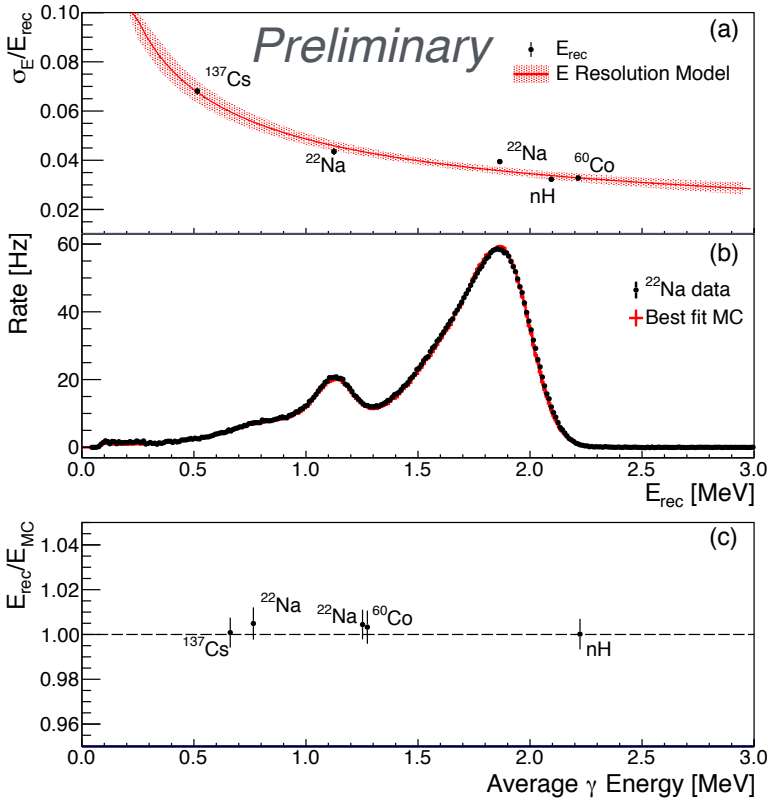
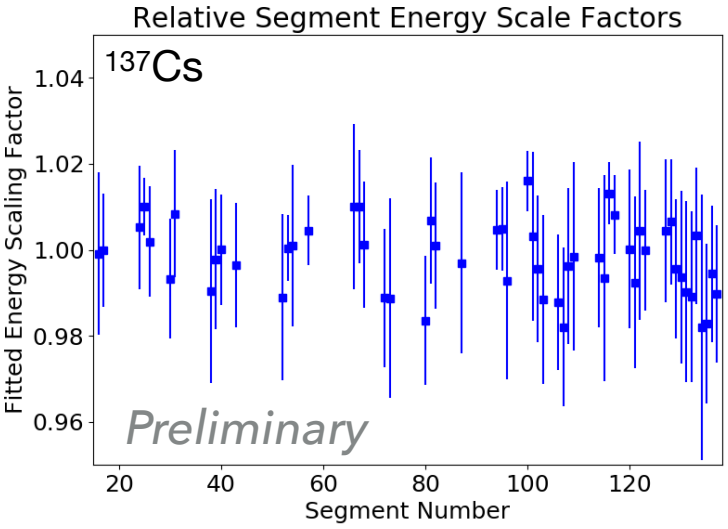
Energy Reconstruction

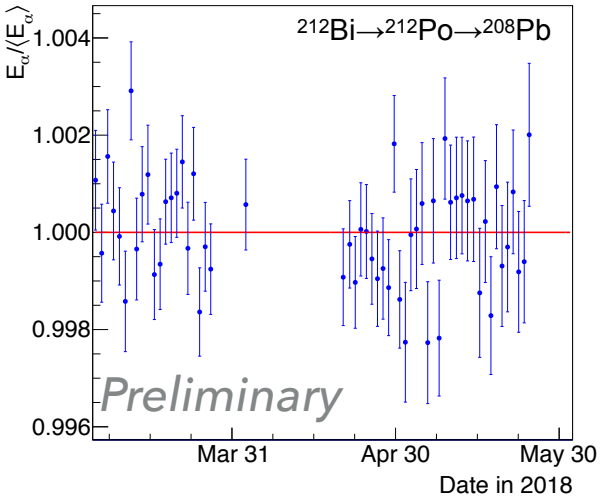


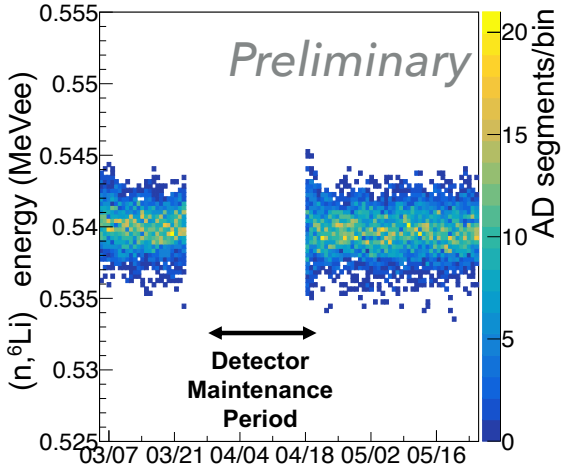


PROSPECT,arXiv:1806.02784

Detector Uniformity







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