Initial Performance of the PROSPECT Antineutrino Detector

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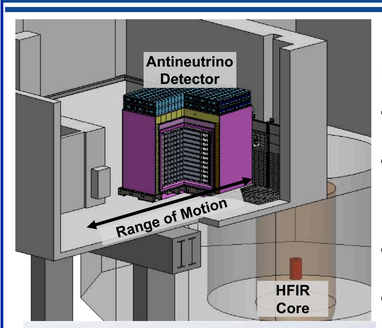
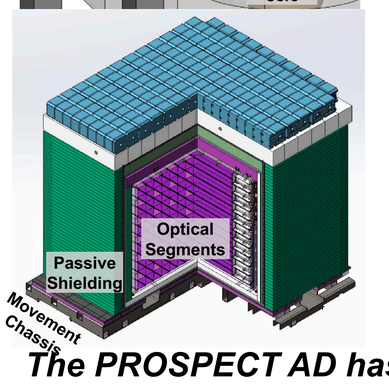
See also posters 139, 146, 188, 194; Talk Friday 12.15pm

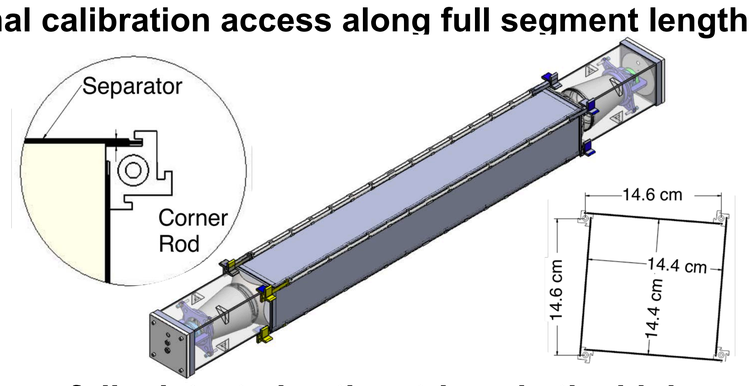
PROSPECT Segmented ^{6}Li-Loaded Antineutrino Detector Design



The PROSPECT antineutrino detector (AD) in now operating 7-9m from a research reactor core:

- 4 ton ^{6}Li-loaded liquid scintillator (^{6}LiLS) target
- Low mass optical separators provide 154 optical segments, 117.5x14.6x14.6cm^3
- Double-ended PMT readout
- Internal calibration access along full segment length





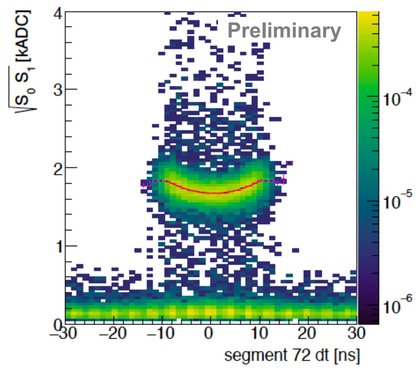
The PROSPECT AD has successfully detected antineutrinos in the high background environment close to a reactor core and on the Earth's surface

Antineutrino Detector Self-Calibration

Segmented PROSPECT AD design and Li-6 and Ac-227 doping provide a wealth of data for position, timing, and response calibrations for all segments and axial positions

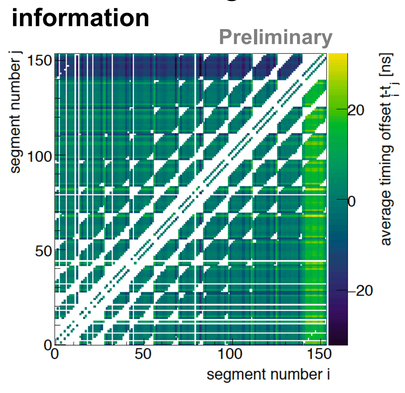
Response Calibration

^{6}Li neutron capture gives fixed energy events distributed throughout entire AD – track system response in time and measure variation along segments

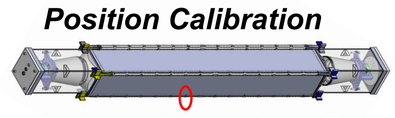


Timing Calibration

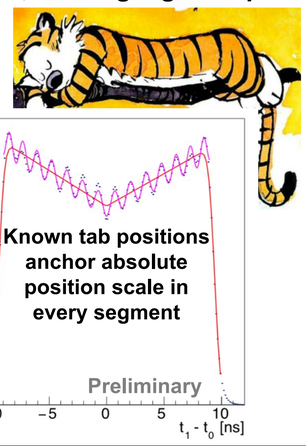
Muon tracks traversing multiple segments provide coincident events to extract segment-to-segment and PMT-to-PMT timing information



Position Calibration



Pinwheel tabs alter local light transport, causing 'tiger stripes'

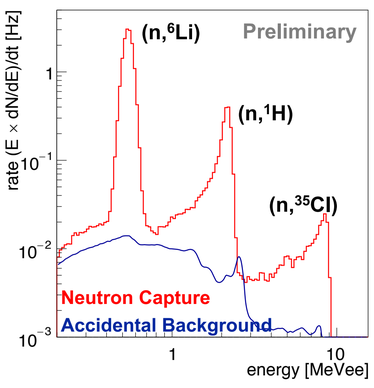


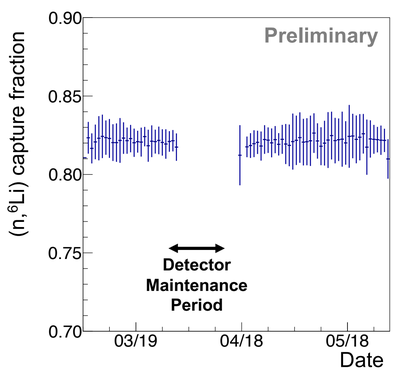
Stability of Antineutrino Detector Response

In addition to calibration sources, AD data can be used to measure system stability, validating our calibration procedures

Time stability of neutron capture efficiency

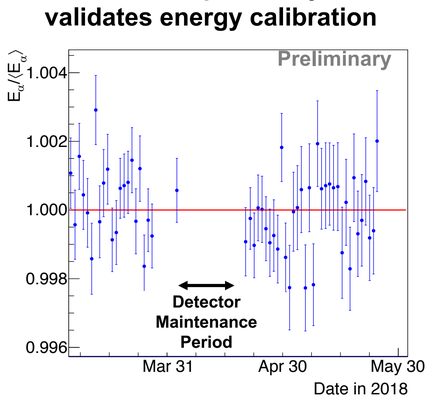
The LiLS contains three species with non-negligible capture cross sections: ^{6}Li, ^{1}H, and ^{35}Cl. Tracking relative capture fractions demonstrates stable efficiency of the ^{6}Li capture reaction used for antineutrino detection





Time stability of energy reconstruction

Tracking reconstructed energy of BiPo events distributed uniformly throughout the detector independently validates energy calibration

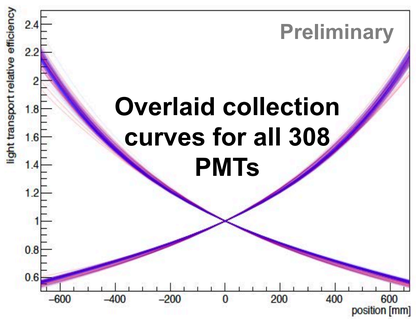


Uniformity of Antineutrino Detector Response

Background events provide a myriad of ways to measure segments performance – observed segment-to-segment variation is small

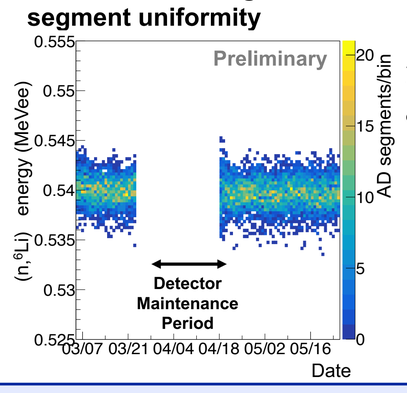
Optical collection along segment length

Axial variation in single PMT light collection is almost exponential and has minor variation amongst PMTs



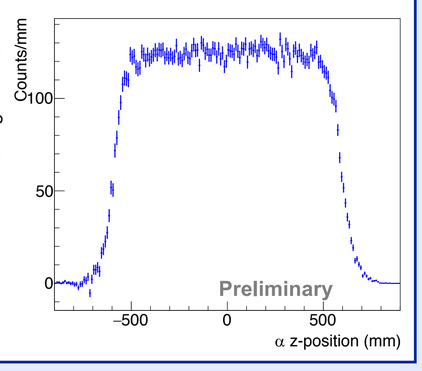
Relative energy scale between segments

Tracking ^{6}Li neutron capture feature in time demonstrates effectiveness of running calibration and segment-to-segment uniformity



Axial position reconstruction

BiPo events provide a uniformly distributed event sample with which to validate axial position reconstruction

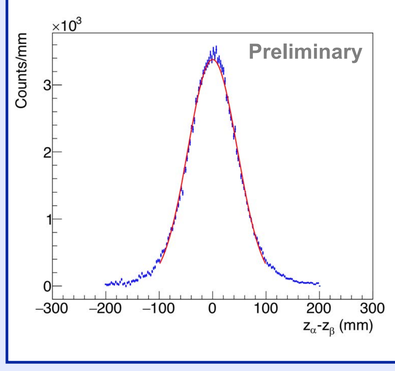


Antineutrino Detector Performance

The AD light yield & PSD performance are very good (poster 146), as is axial position resolution. Other performance parameters are assessed via a combination of measurements and simulation.

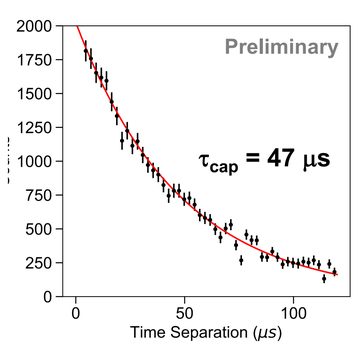
Axial Position Resolution

^{212}Po decays produce β–α correlated events in the same location - provide direct measure of AD position resolution



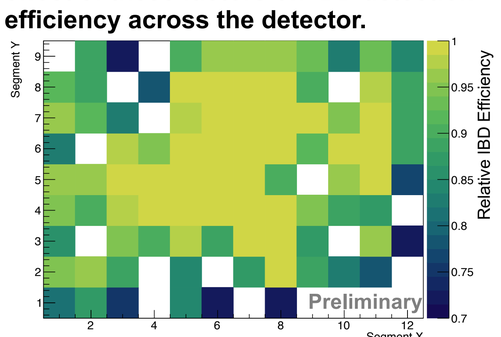
Neutron Capture Time

The prompt-delayed event separation time for IBD candidates exhibits the expected exponential behaviour



Antineutrino detection efficiency

Antineutrino selection cuts preferentially reject cosmogenic backgrounds. Some PMTs have exhibited anomalous current behavior, with these segments being excluded from analysis for now. Simulation is used to understand the effect of these factors on IBD detection efficiency across the detector.



Signal and Background Characteristics

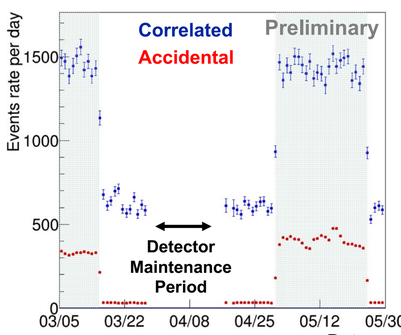
Prospect has begun to study the characteristics of IBD signal and cosmogenic background events

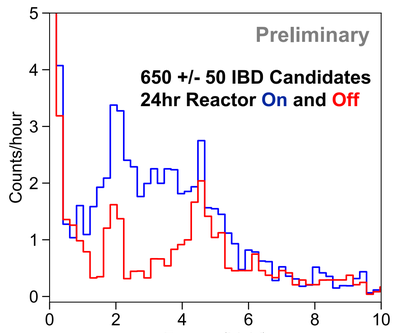
Observation of reactor antineutrinos at the Earth's surface

Accidental backgrounds vary due to γ-rays background from nearby neutron scattering experiments. Cosmogenic correlated backgrounds are measured during Reactor Off periods.

Preliminary selection cuts that emphasize statistical precision yield a Signal-to-Correlated Background ratio of 1.3.

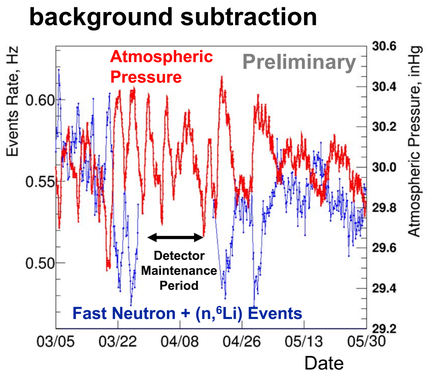
A 5σ observation at the surface is achieved with ~4 hours of Reactor On & Off data





Time variation of cosmogenic backgrounds

Several cosmogenic background event classes are observed to vary with the depth of the atmospheric column. This ~1% effect is corrected for in background subtraction



Conclusions

- **The recently commissioned PROSPECT AD is performing very well**
- **Detector design features provide multiple observables to calibrate and track system stability and uniformity**
- **Energy resolution, position resolution and detection efficiency meet expectations**
- **Antineutrinos have been detected in the high background environment close to a research reactor core and on the Earth's surface**

PROSPECT Publications
arXiv: 1506.03547, 1508.06575, 1512.02202, 1805.09245
http://prospect.yale.edu

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