PROSPECT

Precision Reactor Oscillation and SPECTrum Experiment

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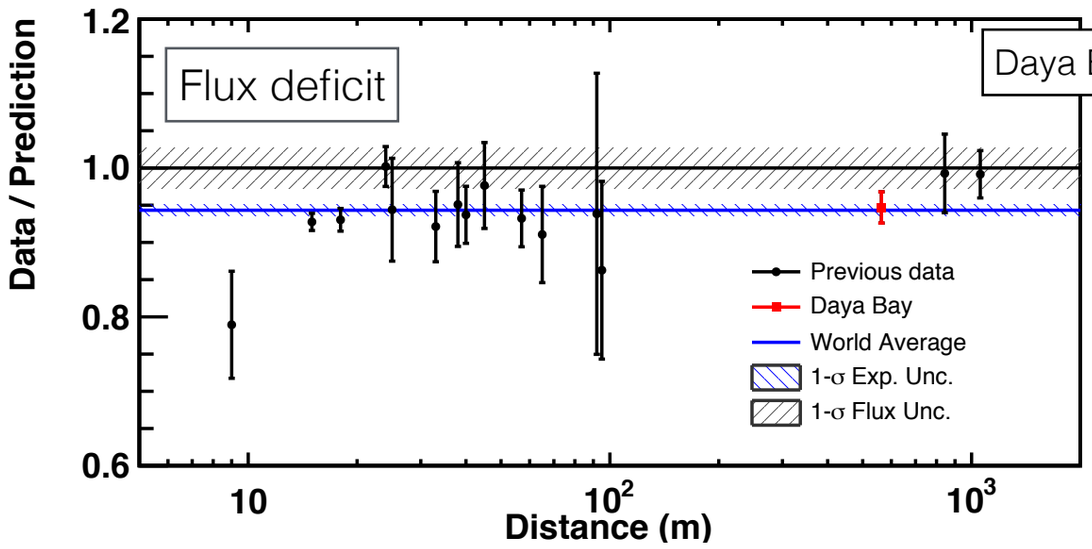
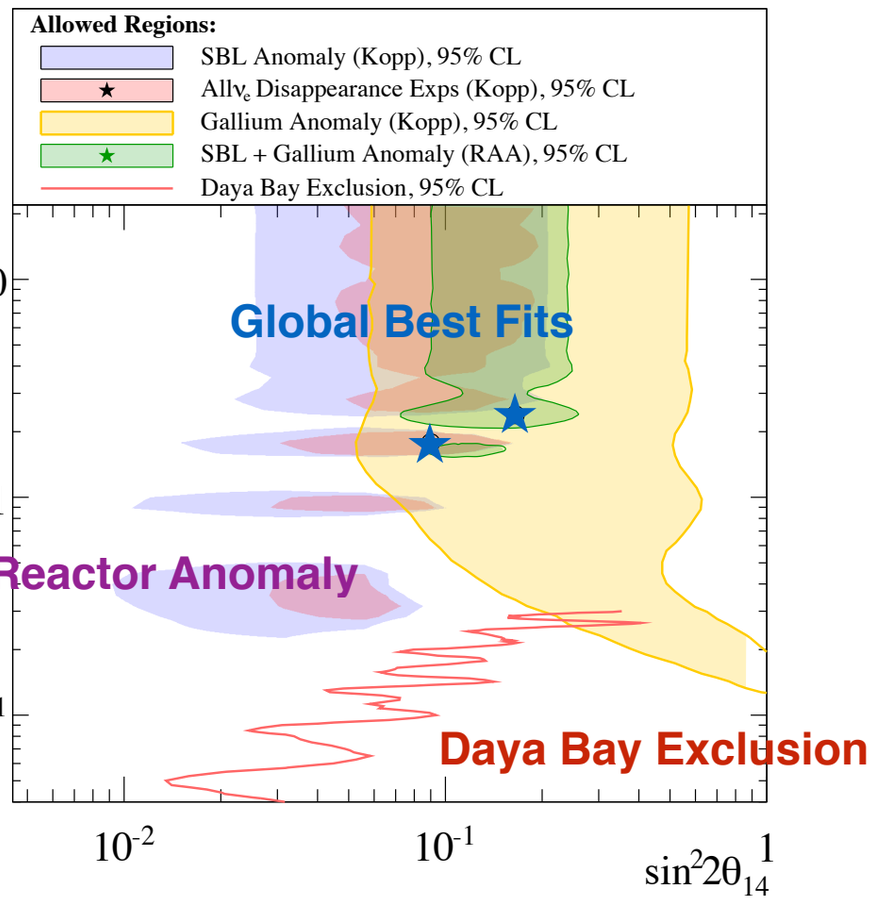
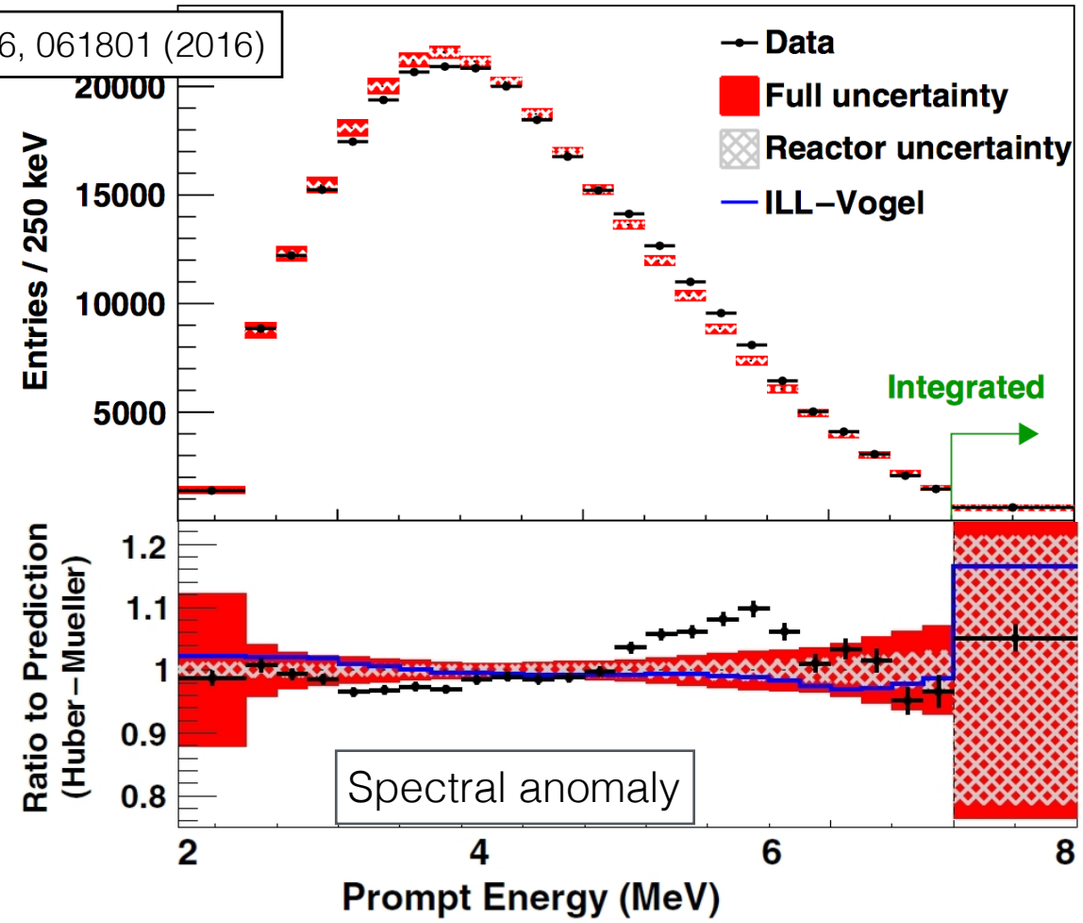
on behalf of the PROSPECT collaboration

Wright Laboratory Yale U.S. DEPARTMENT OF ENERGY Office of Science HEISING-SIMONS FOUNDATION

Reactor antineutrino anomalies







- reactor data does not agree with predictions
- flux deficit seen by most reactor experiments, is there a eV^2 sterile neutrino?
- spectral "bump" seen at by Θ_{13} experiments at LEU reactors, questions model validity

reactor neutrino experiments do not agree with predictions, could indicate new physics

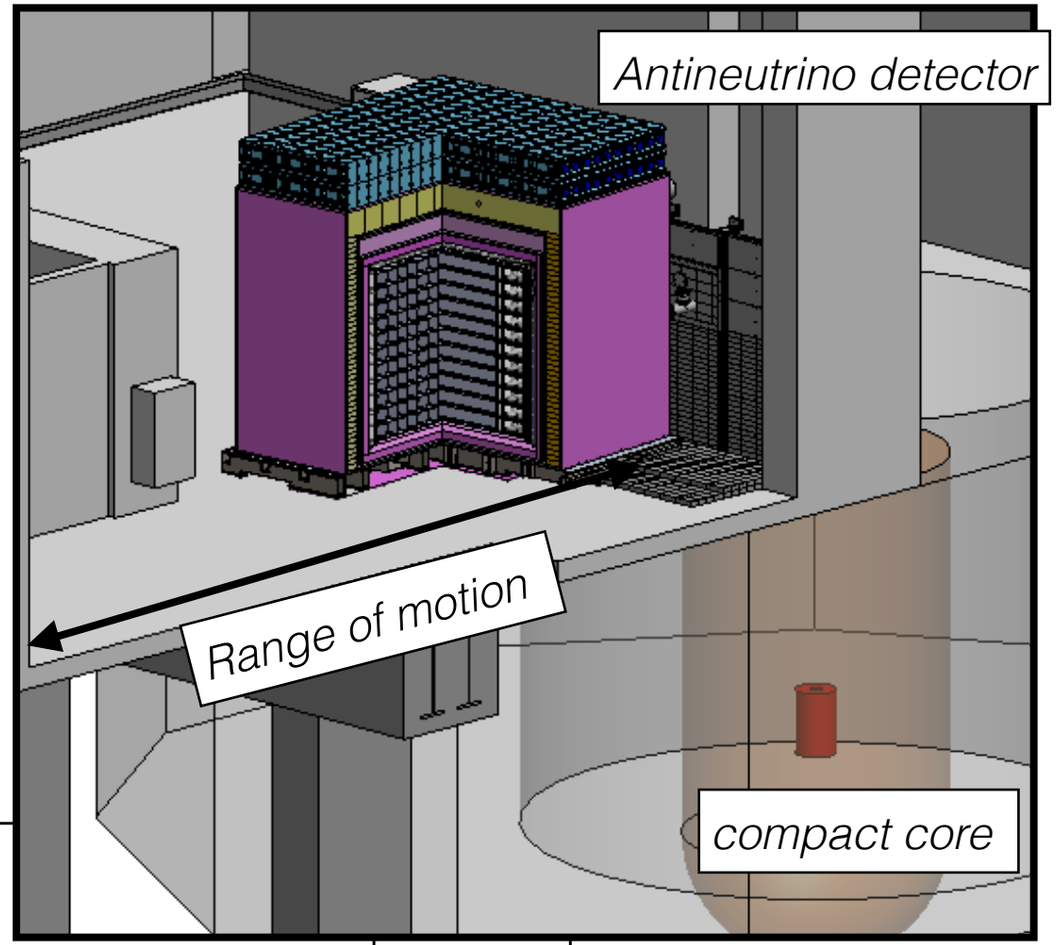
Precision Reactor Oscillation and SPECTrum experiment

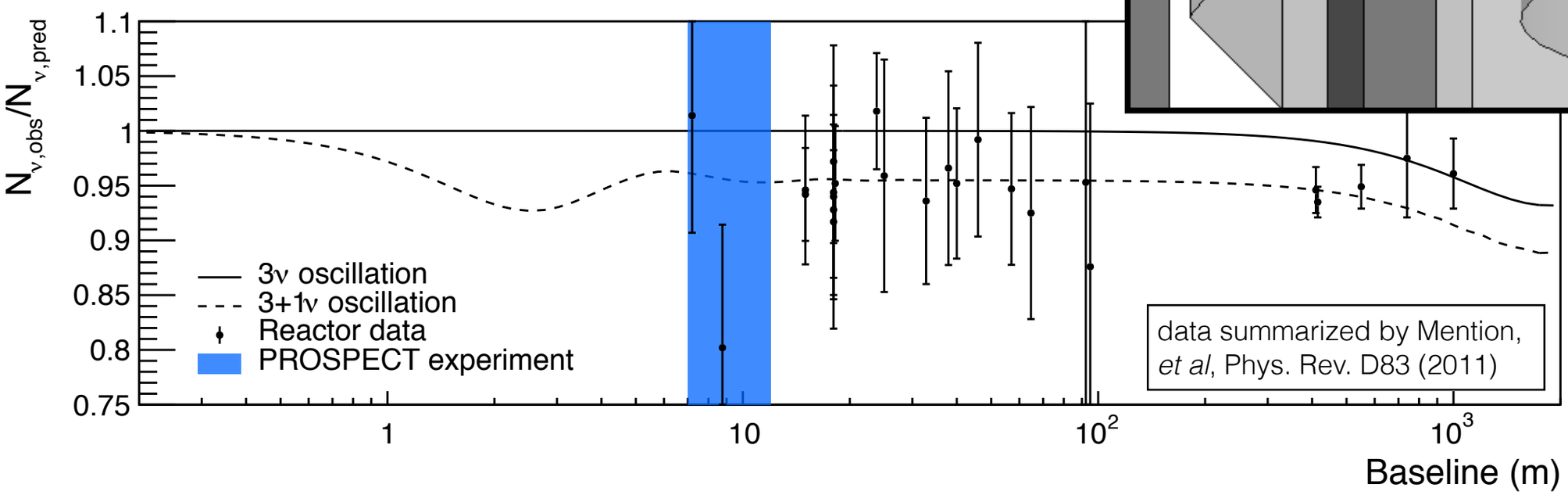
Goals:

1. model independent search for eV-scale sterile neutrinos at distances 7-12 m

2. perform a precision measurement of ^{235}U reactor antineutrino spectrum

@ High Flux Isotope Reactor (HFIR), Oak Ridge National Laboratory





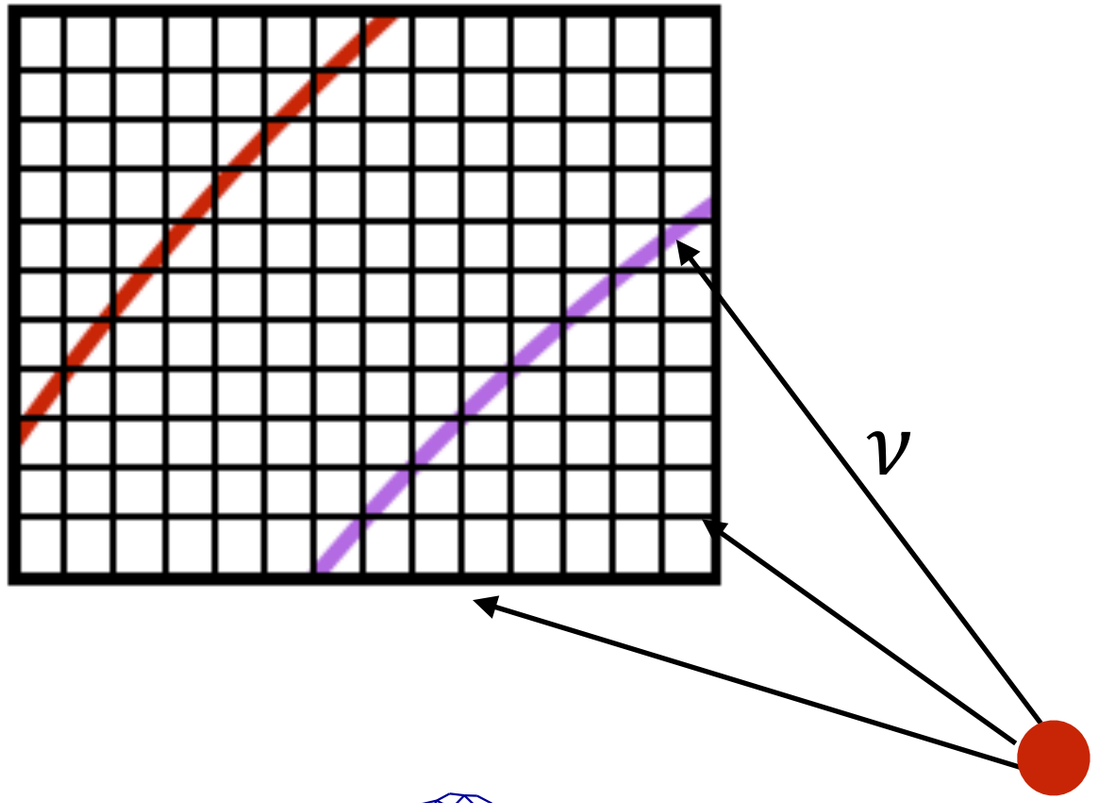
PROSPECT will probe unexplored baselines and measure neutrinos at a ^{235}U reactor

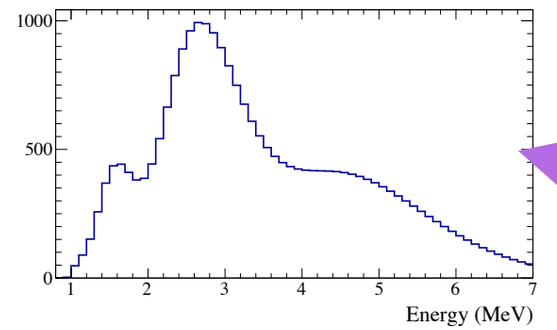
Segmented detector for model-independent oscillations

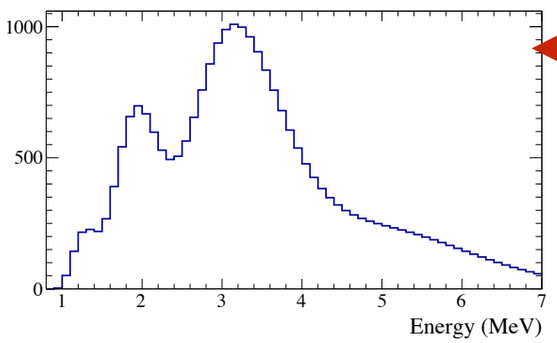
Challenge: detect inverse beta decays (IBDs) to search for sterile neutrinos without input from predictions

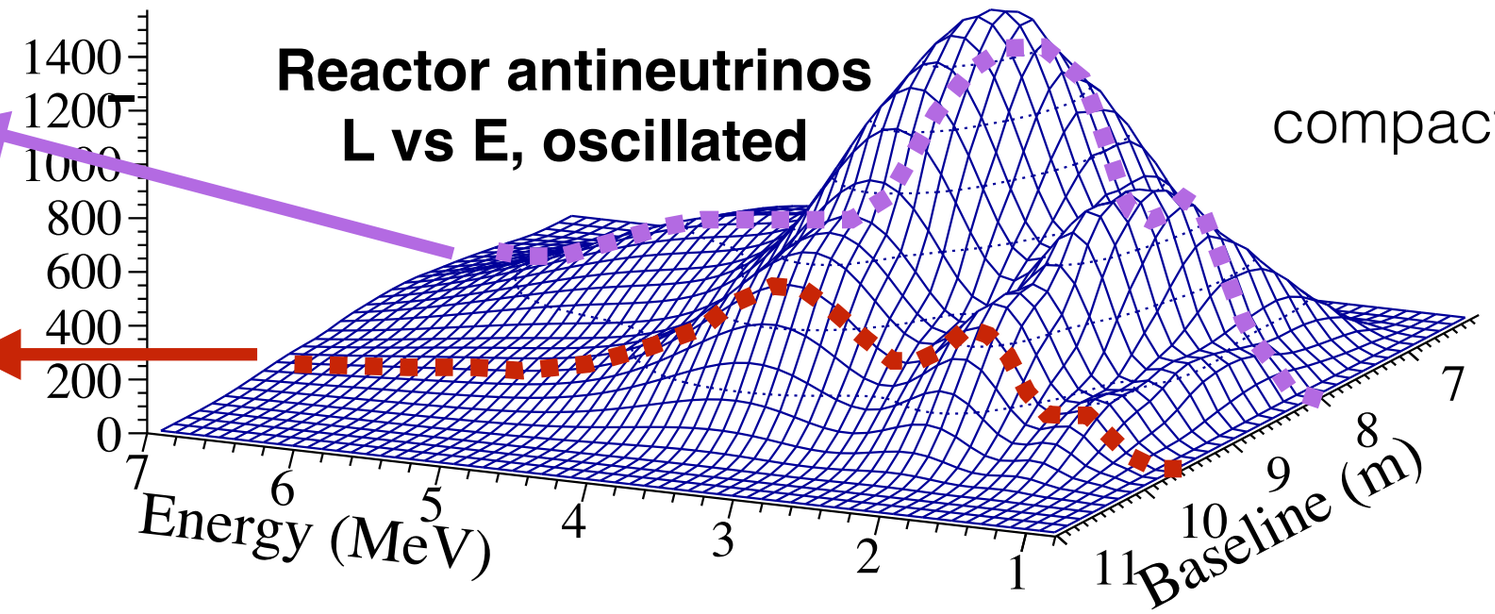
Solution: segmented detector

- 154 detector segments, multiple baselines
- each segment acts as separate detector
- measure energy spectrum at each radius, compare different baselines
- true oscillometry needed for confirmation









segmented detector allows for a model-independent sterile neutrino search

Segmented detector for backgrounds control

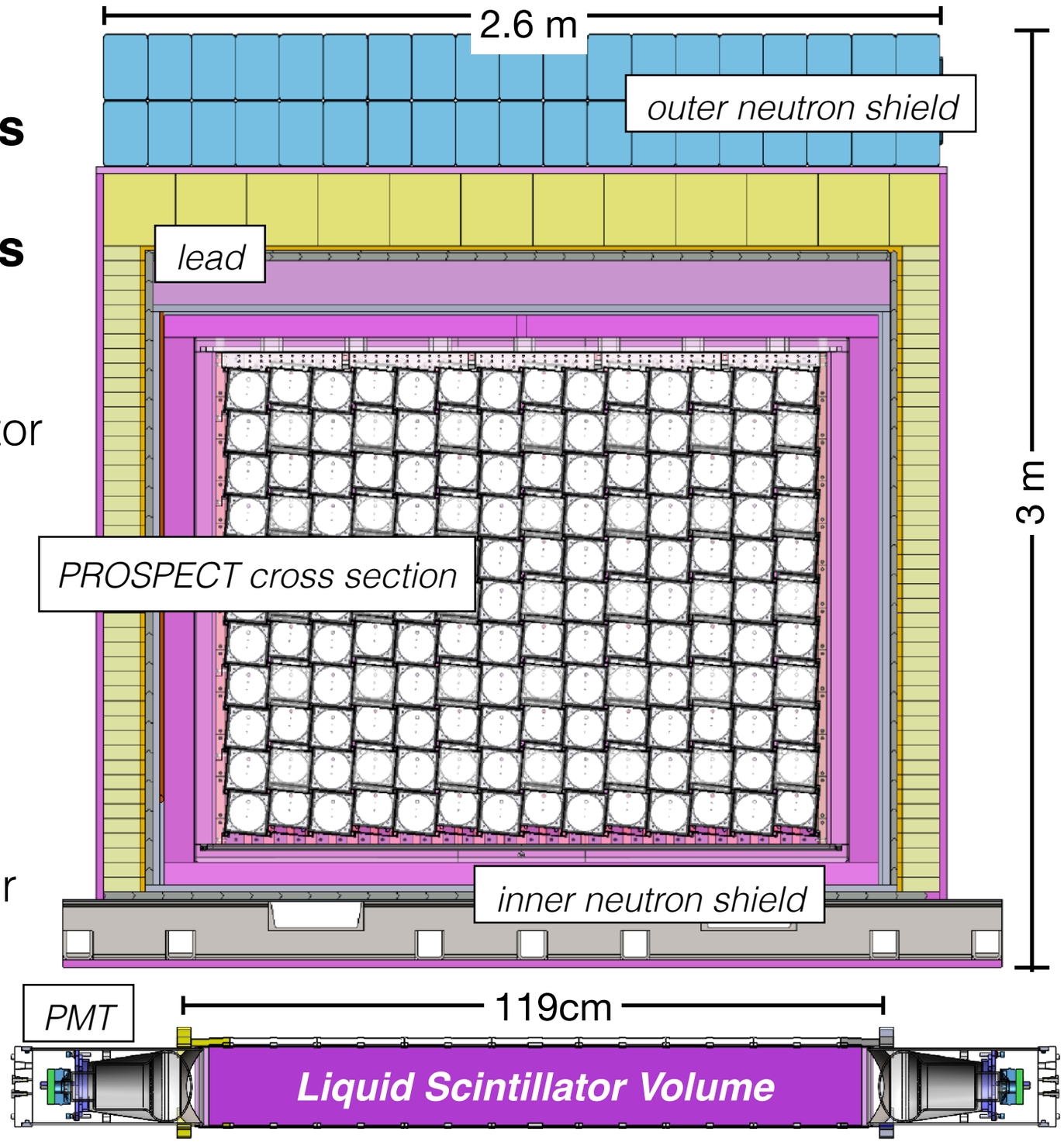
Challenge: detect inverse beta decays (IBDs) with minimal overburden, cosmogenic and reactor backgrounds

Solution: segmented detector

- ~4 ton ^{6}Li-loaded liquid scintillator detector
- 154 (25 liter) optical segments
- double-ended PMT readout
- calibration access between segments
- novel shield to reduce neutron spallation

with active background suppression

- energy resolution 4.5% @ 1MeV
- pulse shape discrimination (PSD) + ^{6}Li for particle identification
- segments = topology, fiducialization



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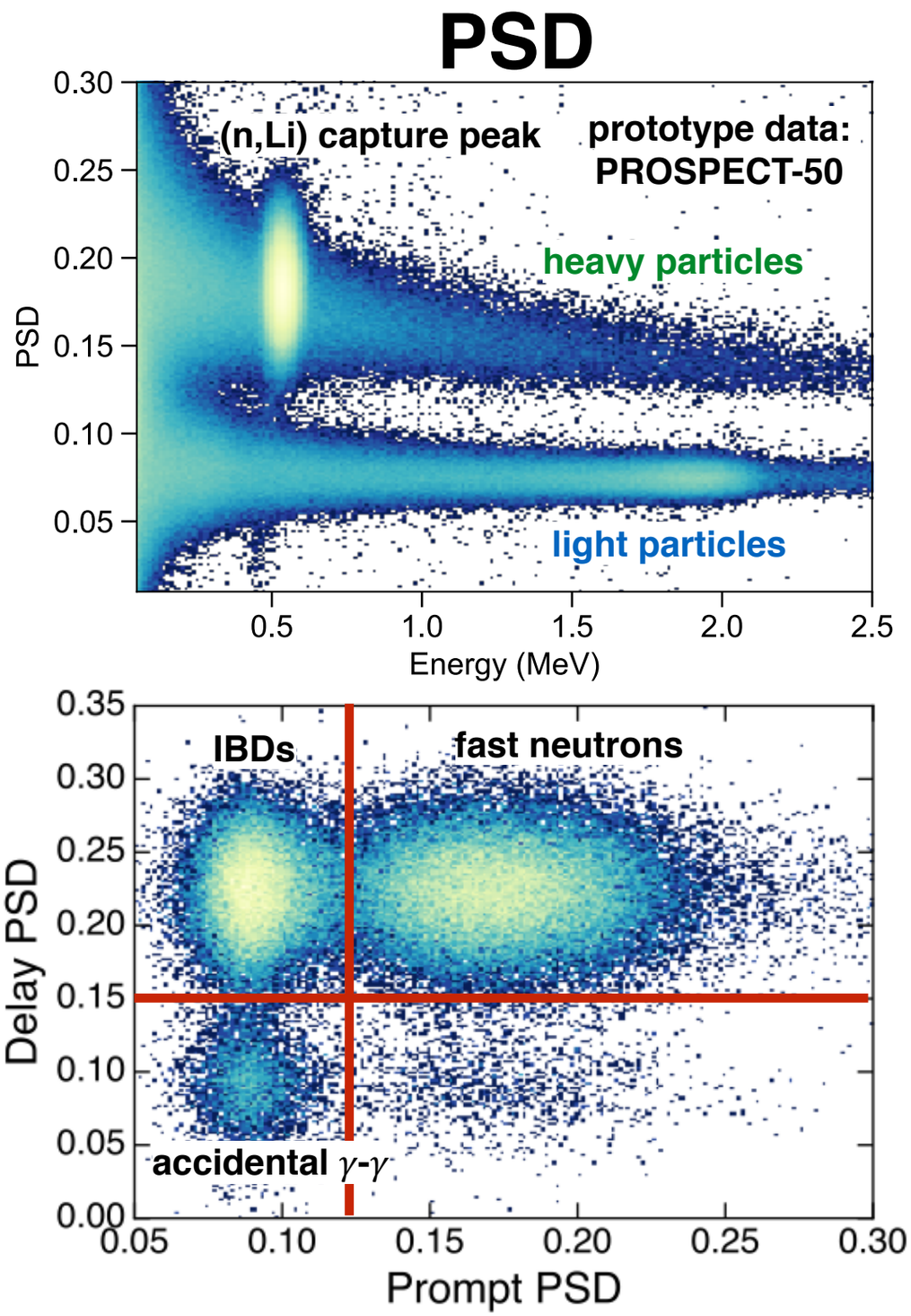

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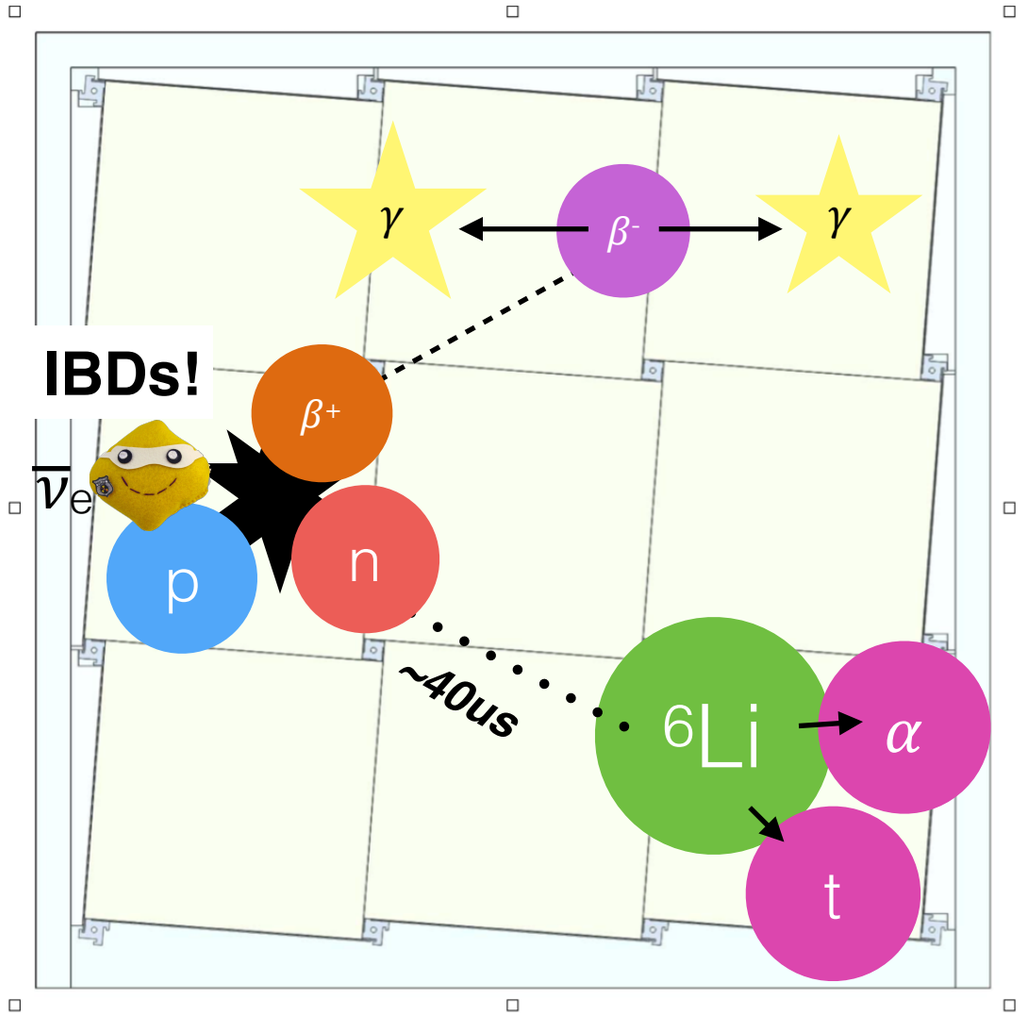
topology



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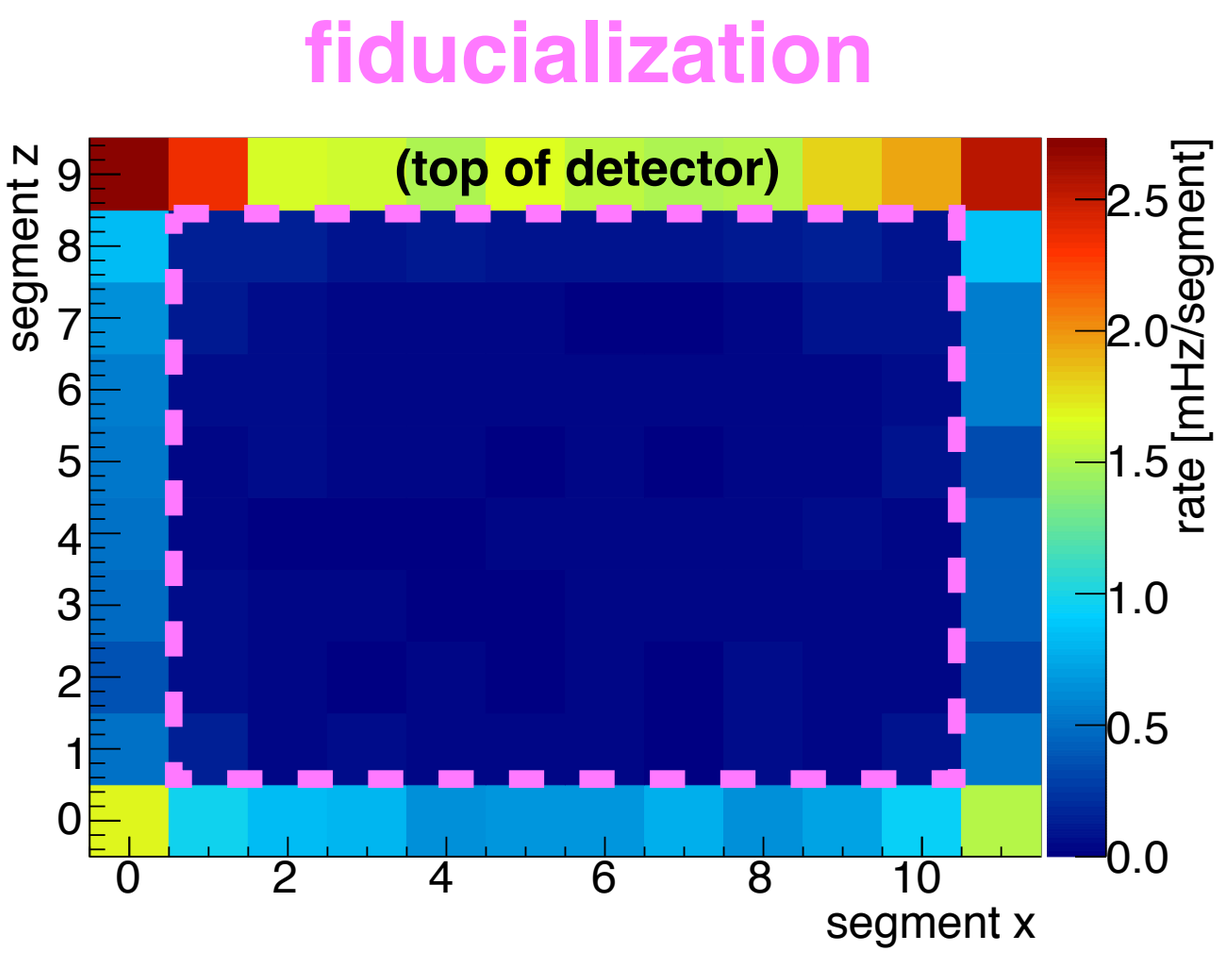
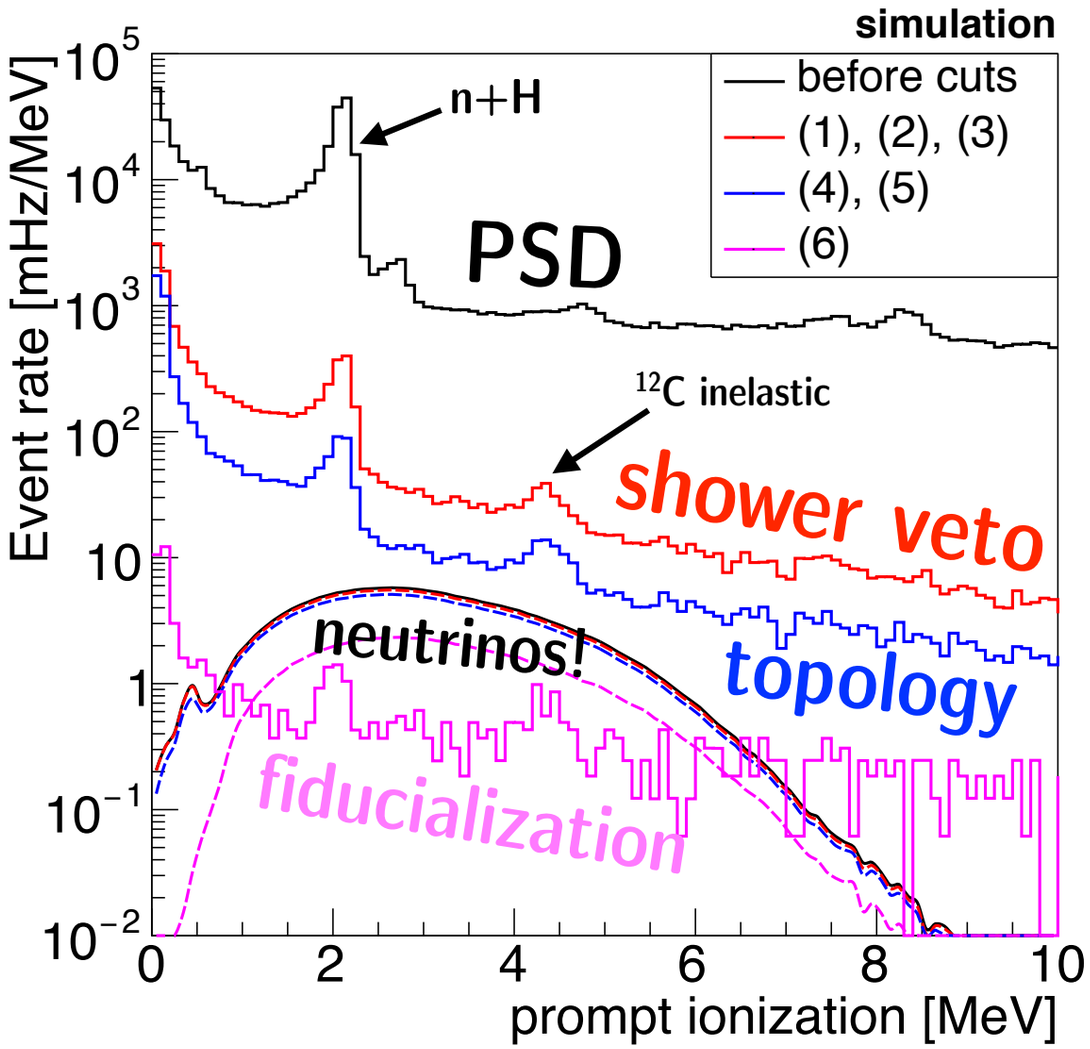
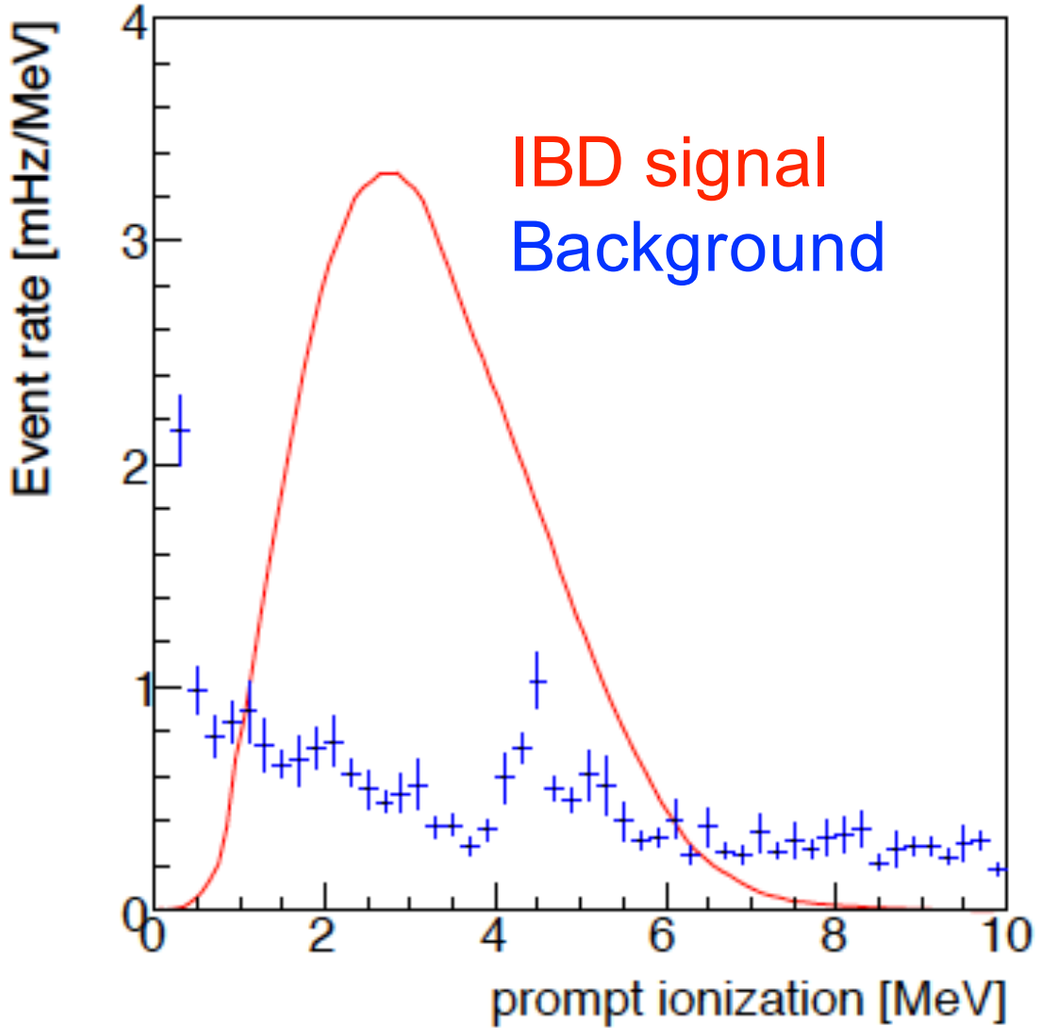


segmented detector allows for event identification for background reduction

All adds up: signal to background





- MC benchmarked by detector prototype data from HFIR site
- cosmogenic backgrounds (solid) and signal (dashed) per cut selection
- active background suppression >3 orders of magnitude, **expected S:B > 3:1**
- background will be measured when reactor off, subtracted with reactor on data

expected signal to background > 3:1 at near-surface detection location

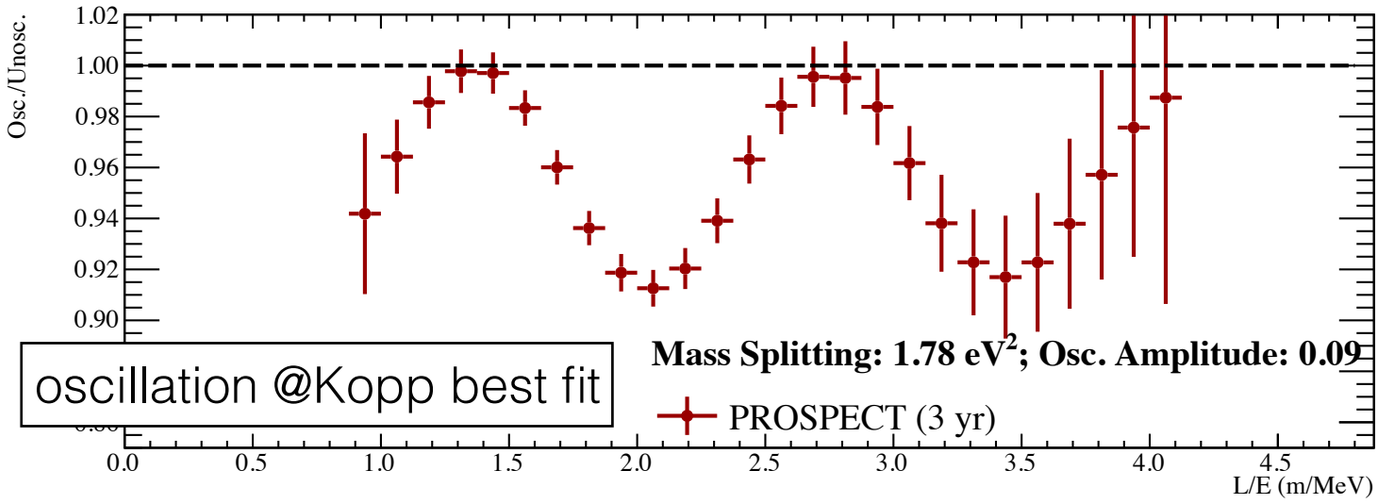
Construction of PROSPECT is complete!

top view of first layer

Assembling a layer in 30 seconds

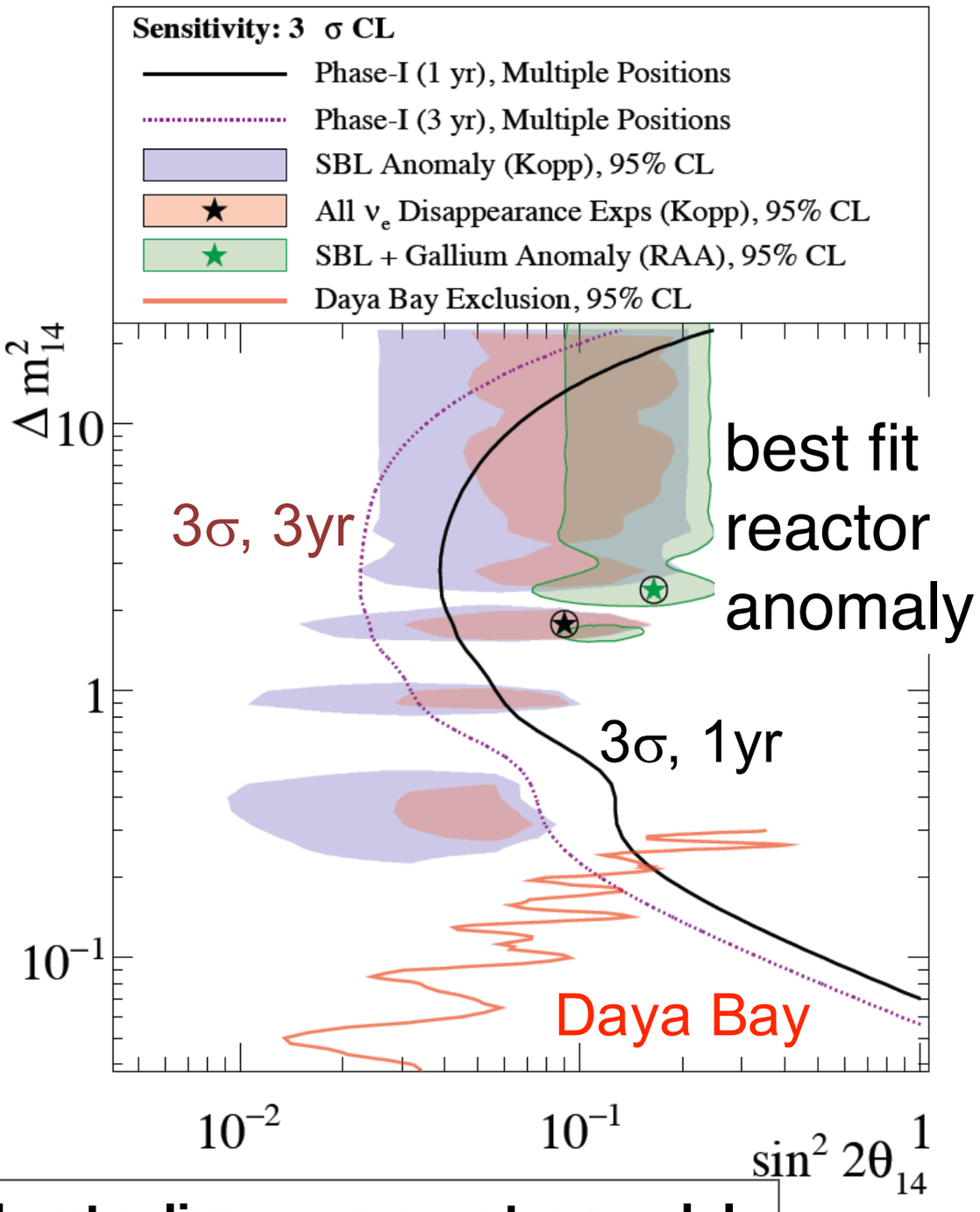
PROSPECT layer in 30 seconds

Model independent search for sterile neutrinos



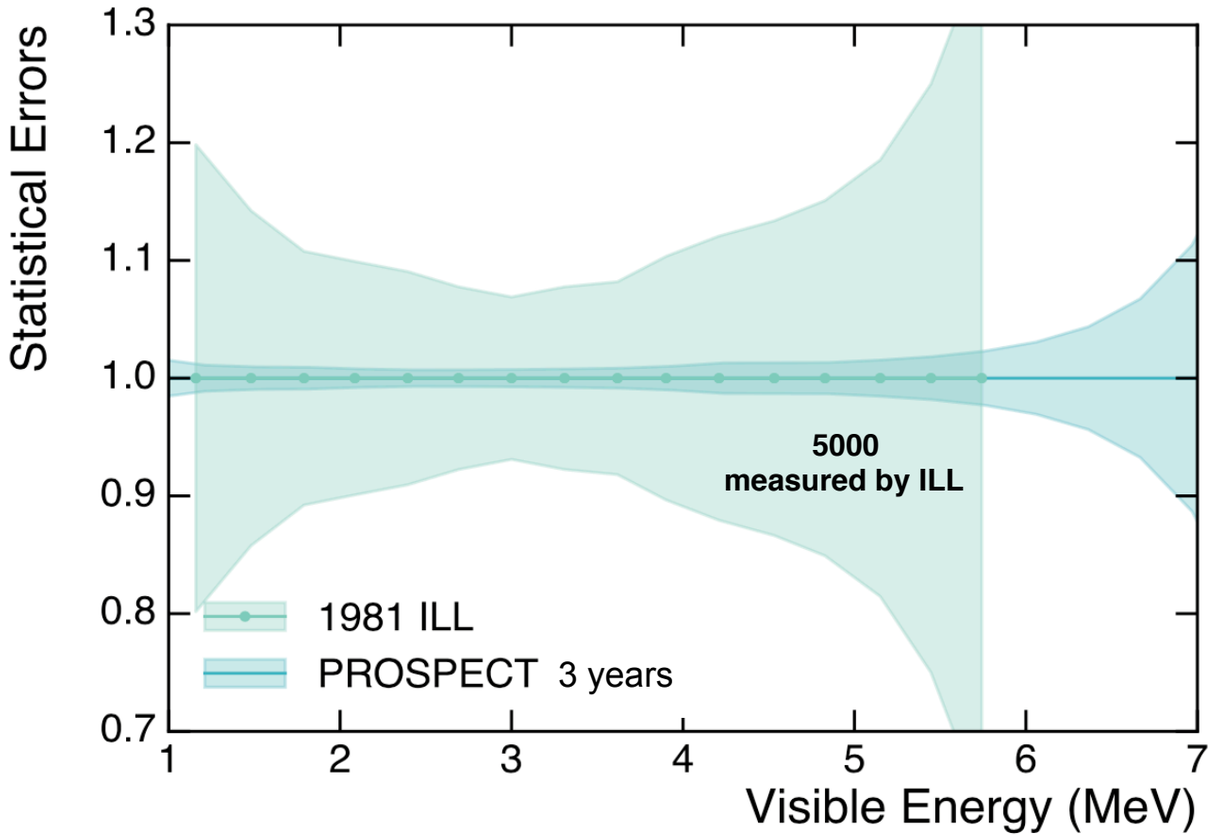
- compare L/E between segments (i.e. baselines)
- true oscillometry needed for confirmation of sterile neutrinos
- independent from reactor models
- probe best-fit point at 4σ in 1 year

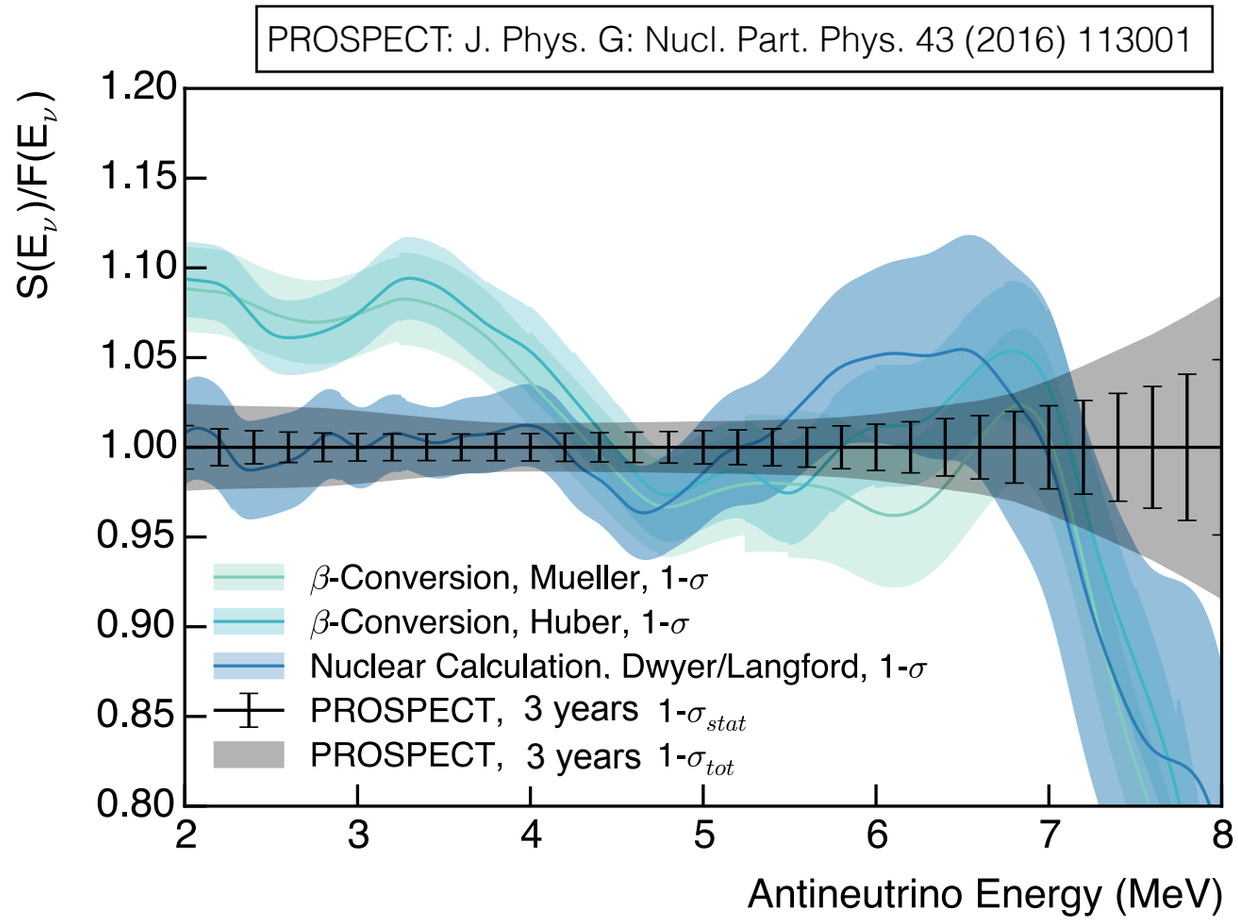
PROSPECT: J. Phys. G: Nucl. Part. Phys. 43 (2016) 113001



PROSPECT can search for sterile neutrinos without reliance on reactor models

Precision measurement of ^{235}U spectrum



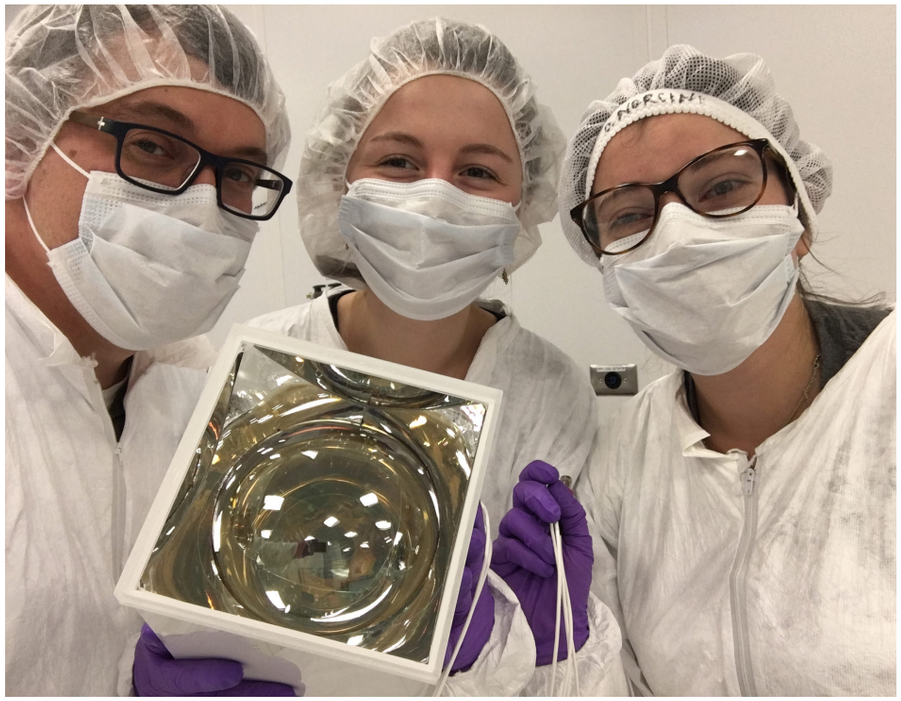


- ~1000 inverse beta decays detected per day, 160k/year
- best energy resolution of any reactor neutrino experiment (4.5%@1MeV), will be world's most precise ^{235}U measurement
- precision will surpass spectral model uncertainties: directly test reactor models, produce a benchmark spectrum for future reactor experiments

PROSPECT's ^{235}U antineutrino spectrum will be the world leading measurement

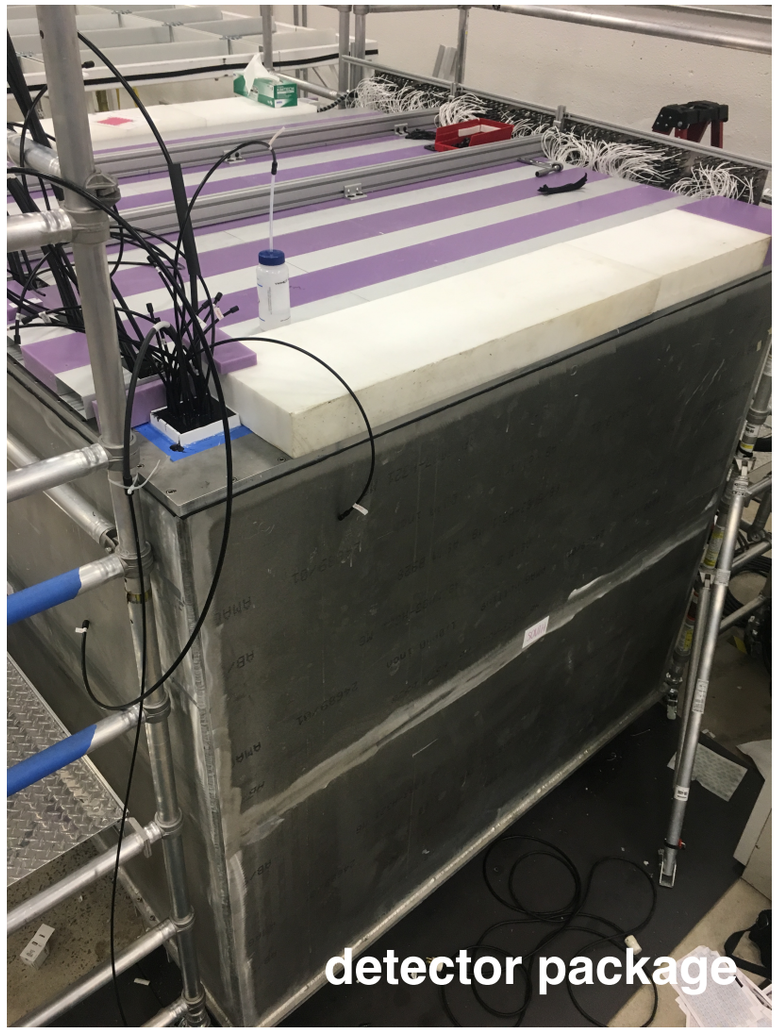
Stay tuned for PROSPECT

1. PROSPECT is a unique, segmented near-surface reactor neutrino detector.
2. Will perform a model-independent search for eV-scale sterile neutrinos.
3. Will measure the ^{235}U spectrum with the highest precision to date.
4. Detector construction complete, installation happening now at HFIR, and will be online soon!



first optical module!

inner detector



detector package


PROSPECT