

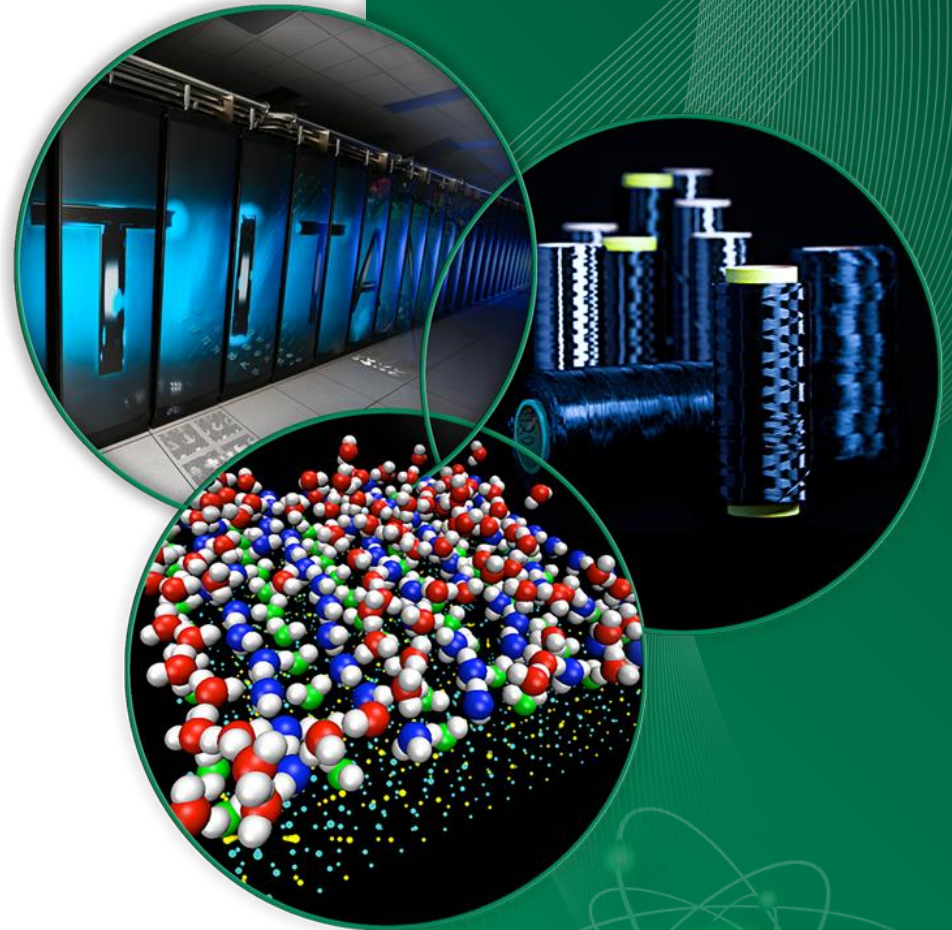
PROSPECT

The **P**recision **R**eactor **O**scillation and **SPECT**rum Experiment

James T. Matta

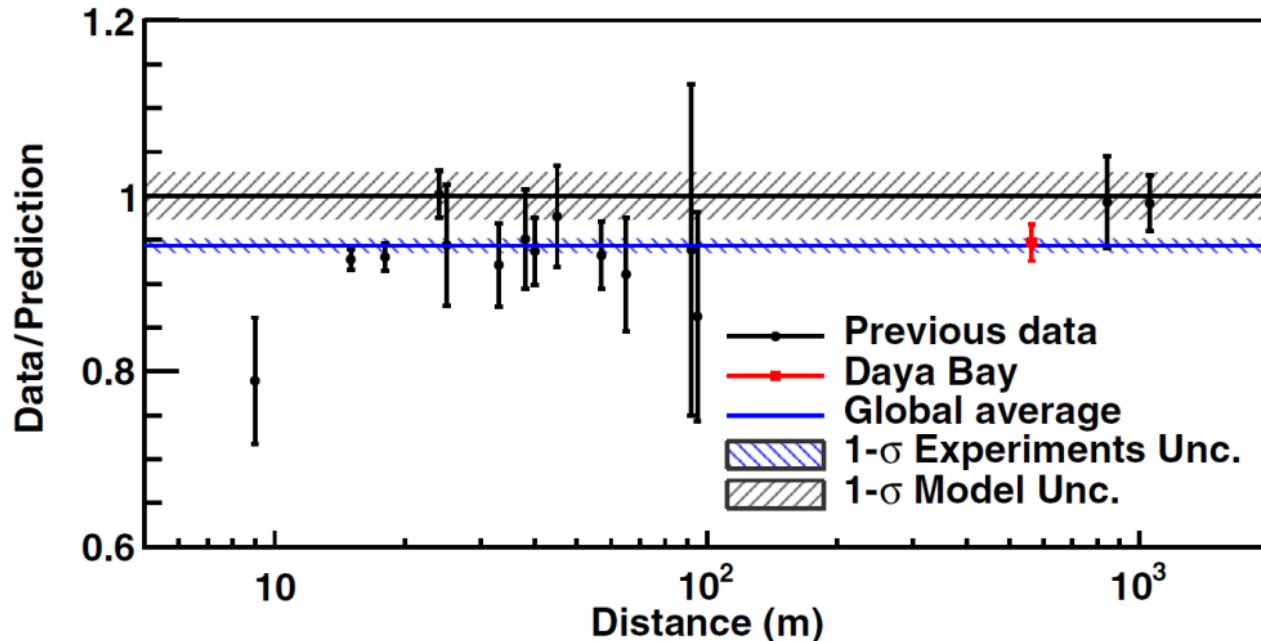
Oak Ridge National Laboratory

On behalf of the PROSPECT Collaboration



The Reactor $\bar{\nu}_e$ Flux Anomaly

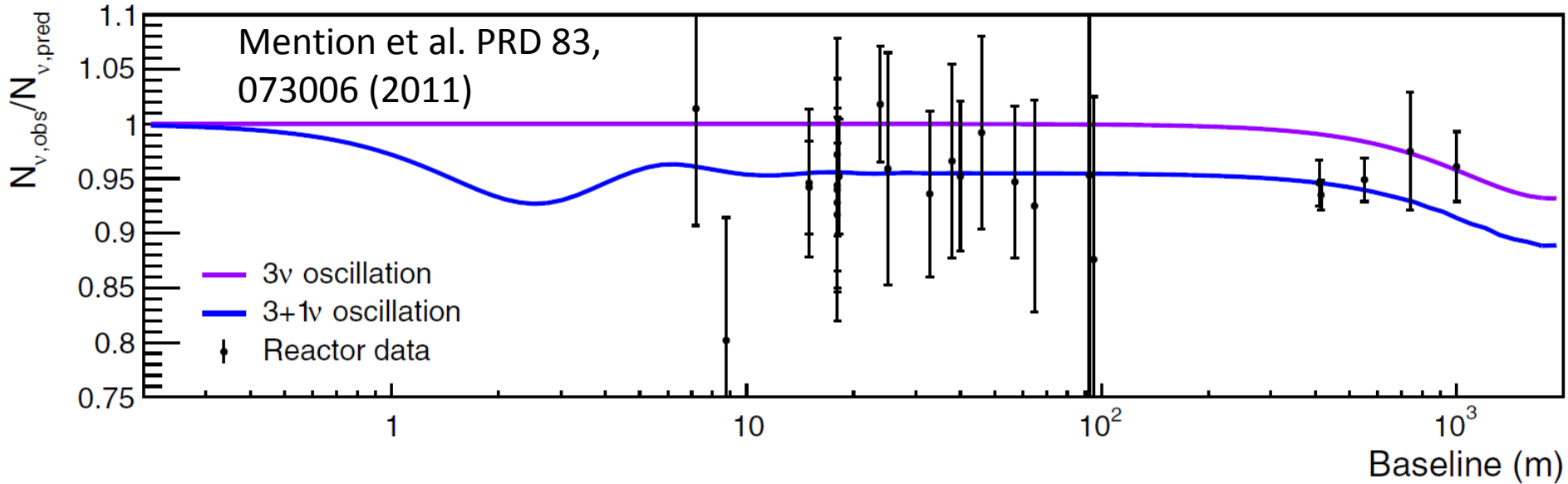
Evidence For A Sterile Neutrino?



- Reactor measurements previously agreed with $\bar{\nu}_e$ flux models
- Re-evaluation of the flux model by Mueller/Huber showed them to be consistently low
- The deficit is suggested to be evidence for is evidence for a sterile neutrino flavor

The Reactor $\bar{\nu}_e$ Flux Anomaly

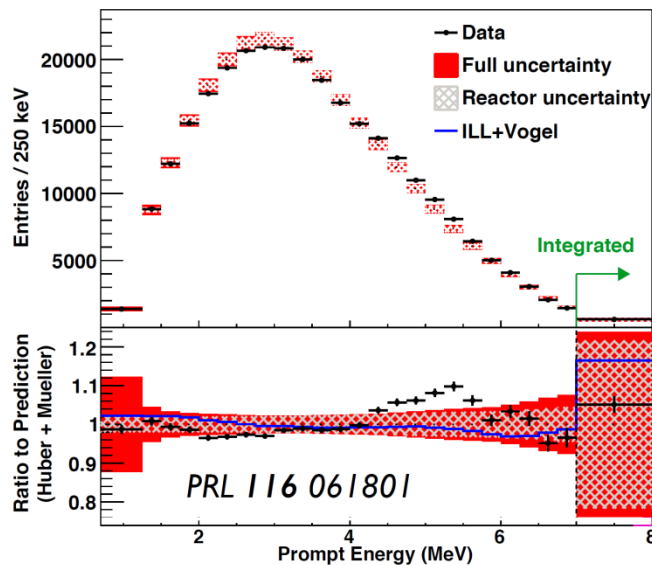
Evidence For A Sterile Neutrino?



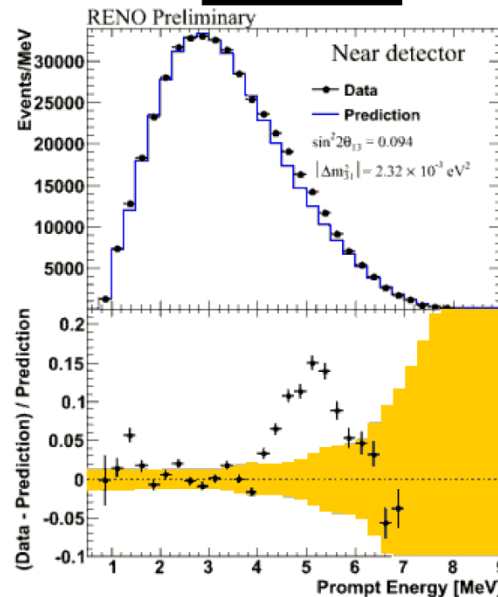
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Reactor $\bar{\nu}_e$ Spectral Anomaly “The Bump”

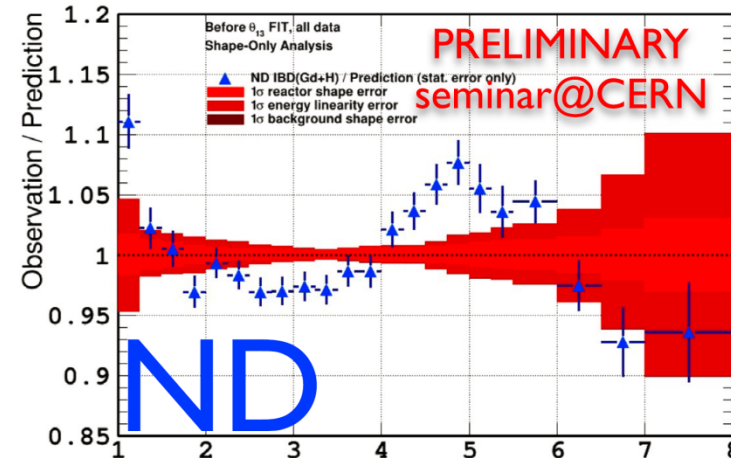
Daya Bay



RENO



Double Chooz

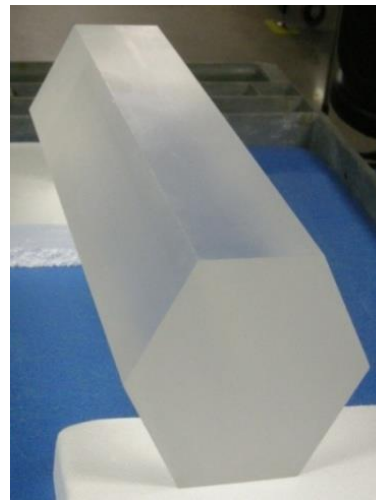
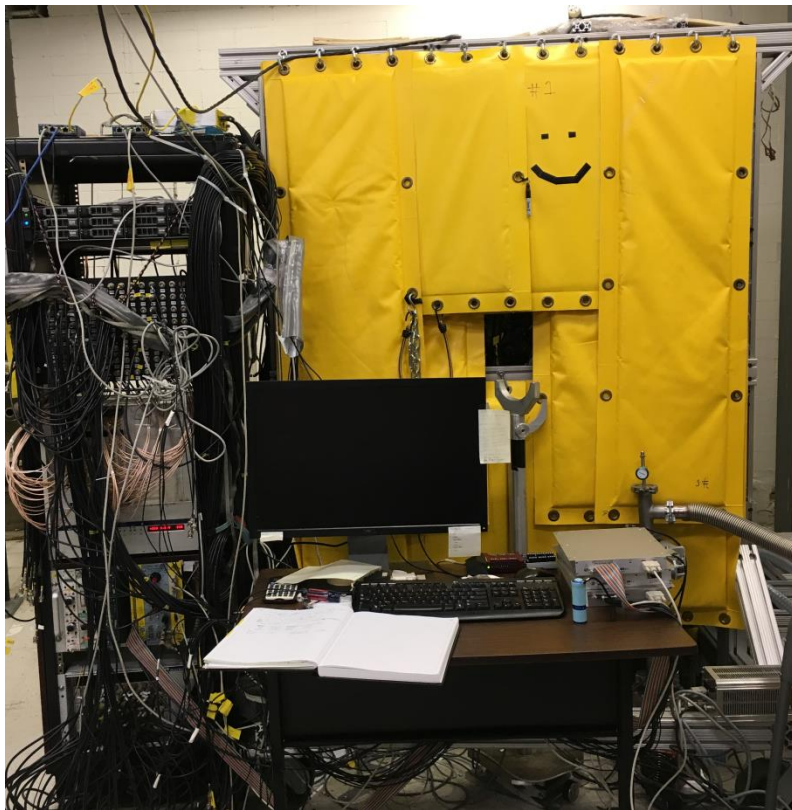
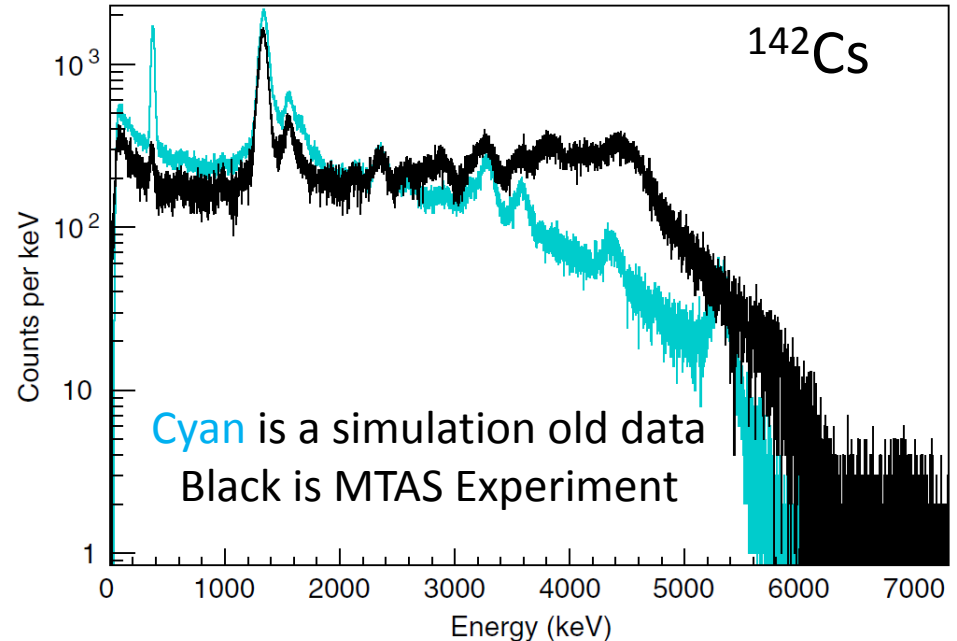


- Recent θ_{13} experiments at LEU reactors observe an excess between 4-6 MeV
 - Problems with one fissile isotope? Multiple isotopes?

A Sterile Neutrino or Erroneous Models?

ORNL Efforts to Revise β^- Decay Data

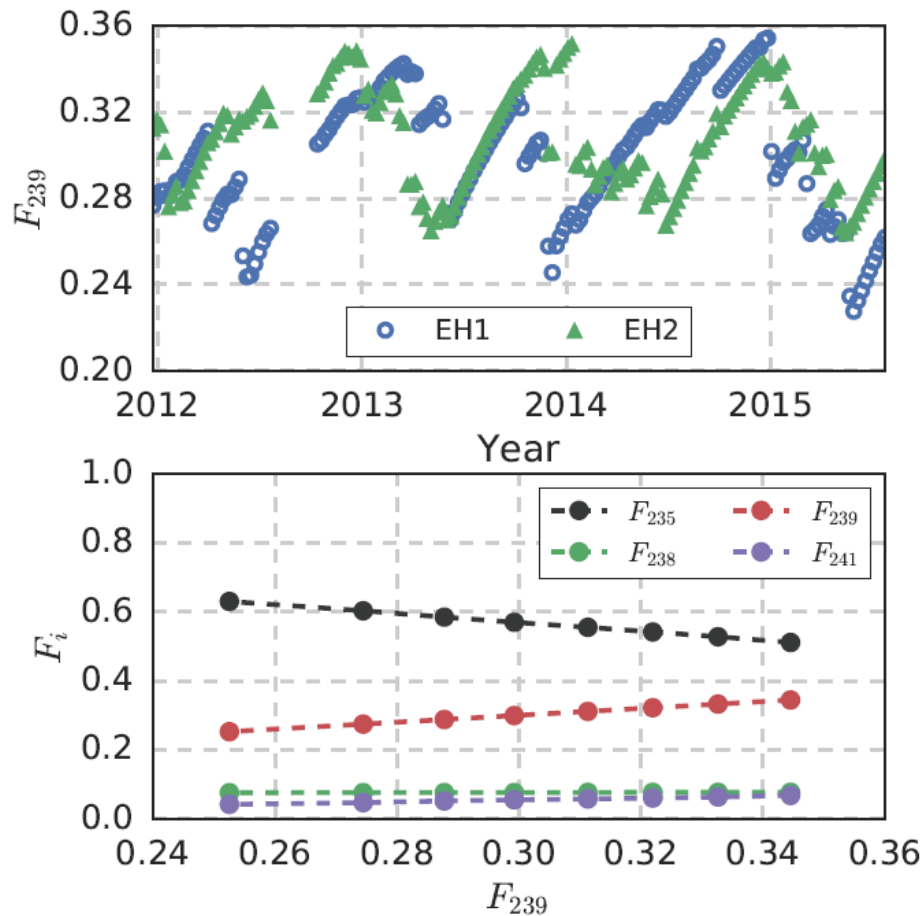
Recently the nuclear physics community has been revisiting the β^- decay branching ratios of the top $\bar{\nu}_e$ spectrum contributors.



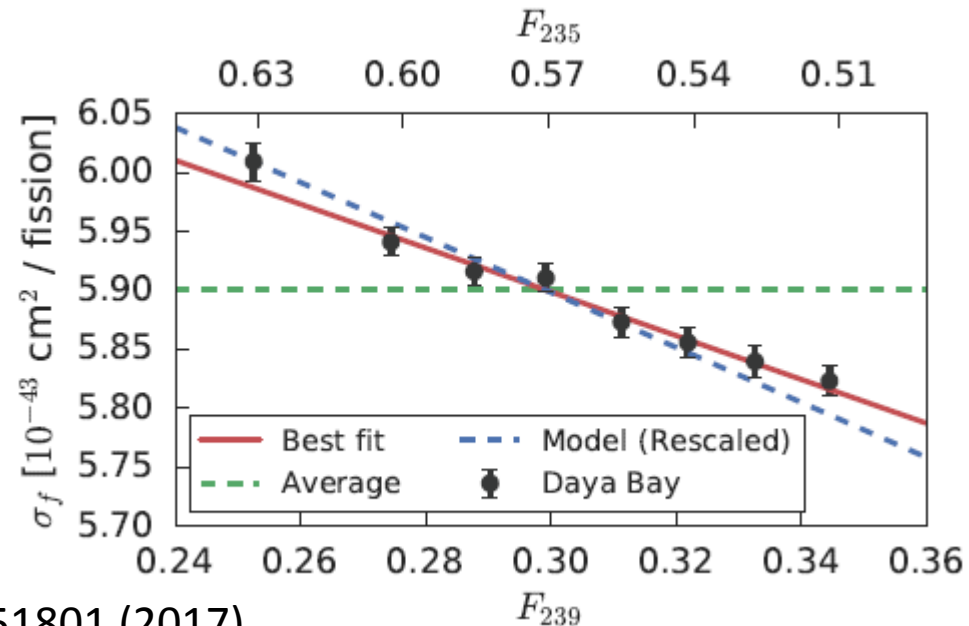
B.C. Rasco et al. PRL **117**,
(2016) 092501

A Sterile Neutrino or Erroneous Models?

Flux Anomaly Depends On Fuel Composition



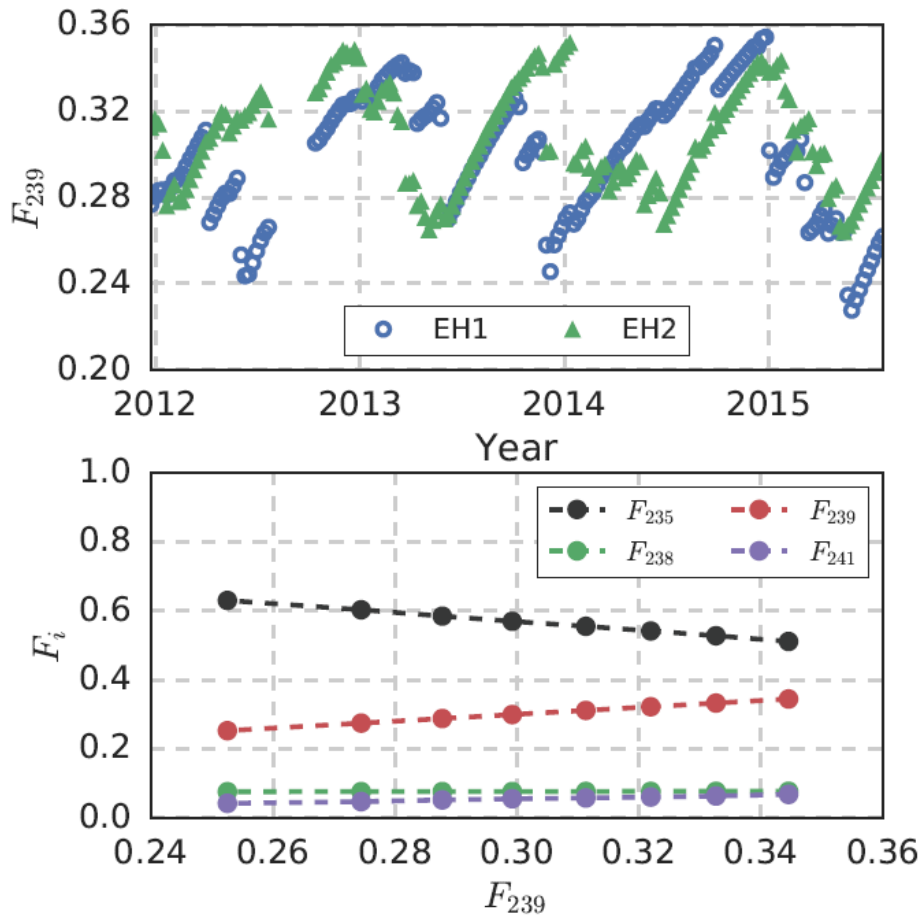
Daya Bay has **not** shown that neutrino oscillations don't play a role. Disagreements could be a combination of effects: issues with the $\bar{\nu}_e$ yield from ^{235}U **and** new physics



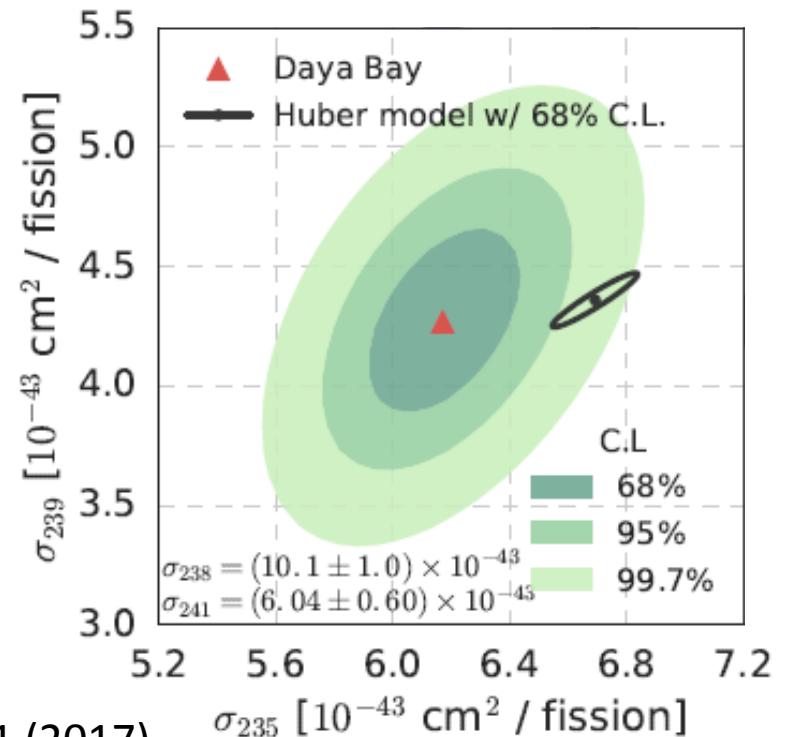
Daya Bay Collaboration Phys. Rev. Lett. **118**, 251801 (2017)

A Sterile Neutrino or Erroneous Models?

Flux Anomaly Depends On Fuel Composition



Daya Bay has **not** shown that neutrino oscillations don't play a role. Disagreements could be a combination of effects: issues with the $\bar{\nu}_e$ yield from ^{235}U **and** new physics

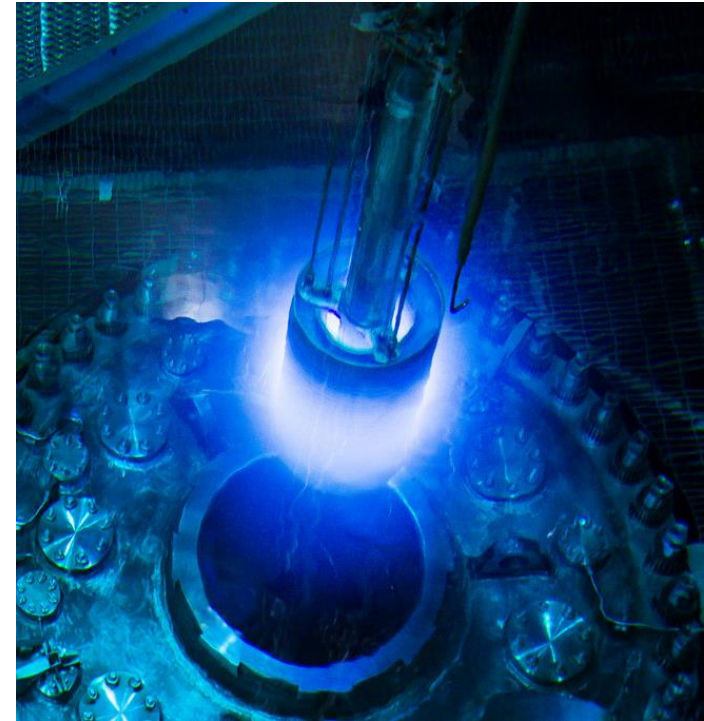
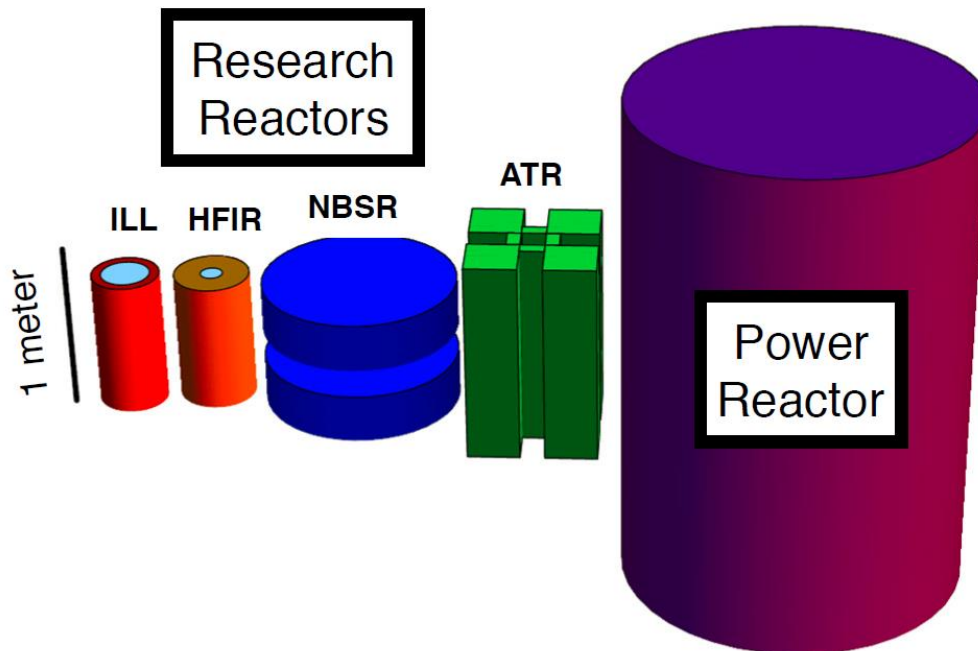


Daya Bay Collaboration Phys. Rev. Lett. **118**, 251801 (2017)

The High Flux Isotope Reactor

HFIR

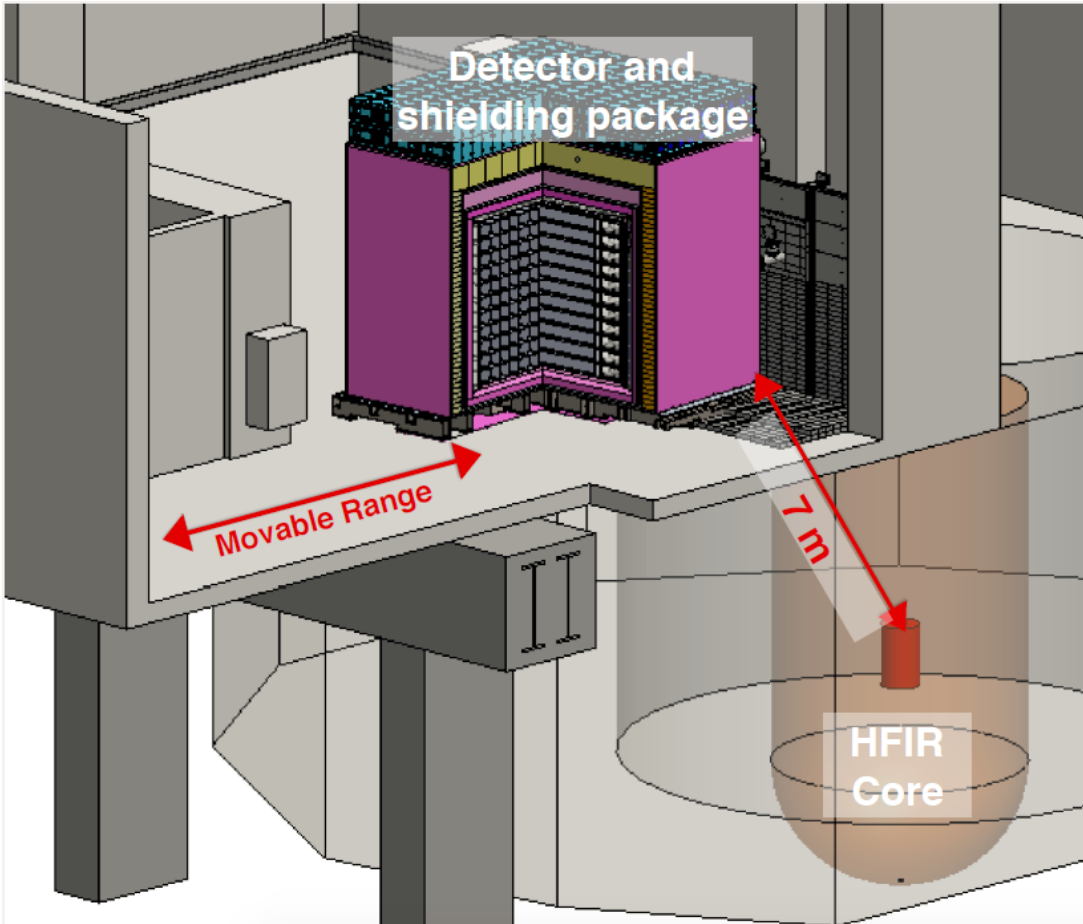
- 85 MW Thermal Power Research Reactor
- ~93% enriched ^{235}U fuel
- Very compact core (h=0.6m d=0.4m)
- Very near access available
- 24 day cycle means no ^{239}Pu buildup (<0.5%)
- ~50% duty cycle allows good background char



PROSPECT



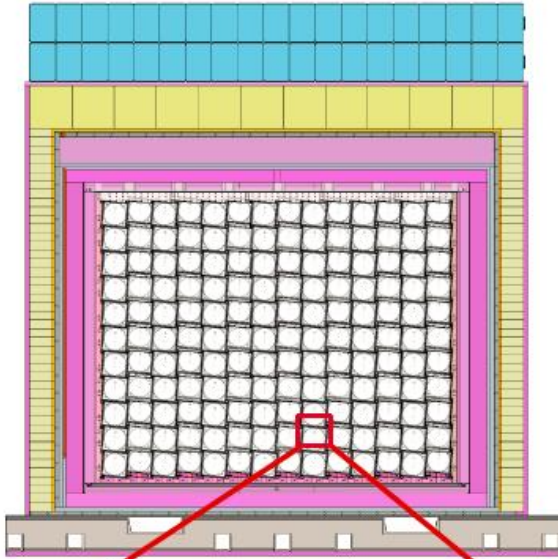
- Model independent search for neutrino oscillations into eV-scale sterile states
- Precision measurement of an HEU reactor spectrum with the best energy resolution to date



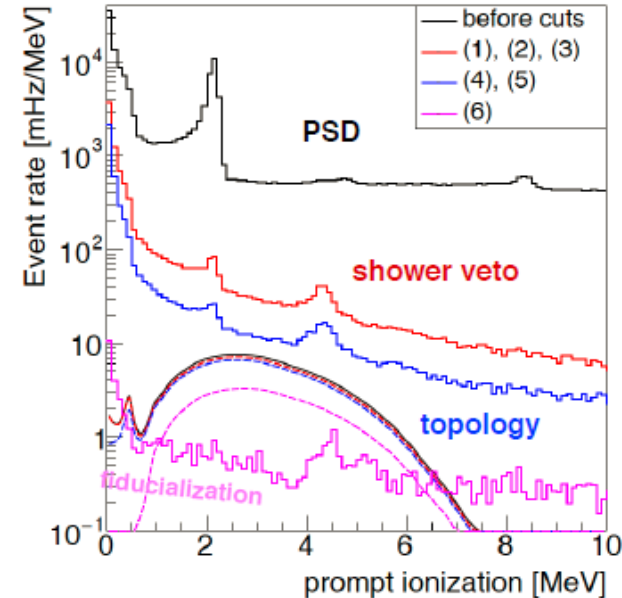
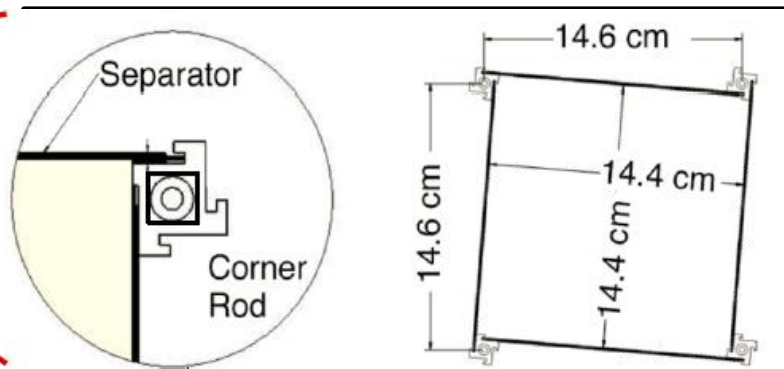
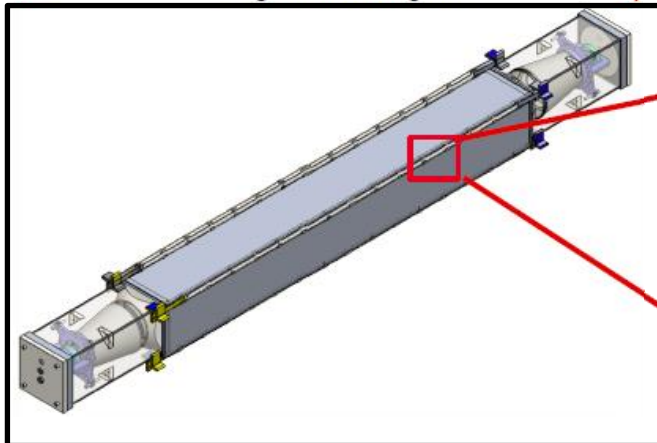
- Complement existing LEU reactor measurements
- We also hope to:
 - Measure total absolute reactor flux
 - Observe $\bar{\nu}_e$ from spent nuclear fuel
- ~ 160 k IBD/year
- Resolution $4.5\%/\sqrt{E}$
- S/B of 3:1
- Most precise ^{235}U spectrum measurement
- Compare reactor $\bar{\nu}_e$ spectrum models
- Provide a benchmark for future reactor $\bar{\nu}_e$ experiments

Detector Design

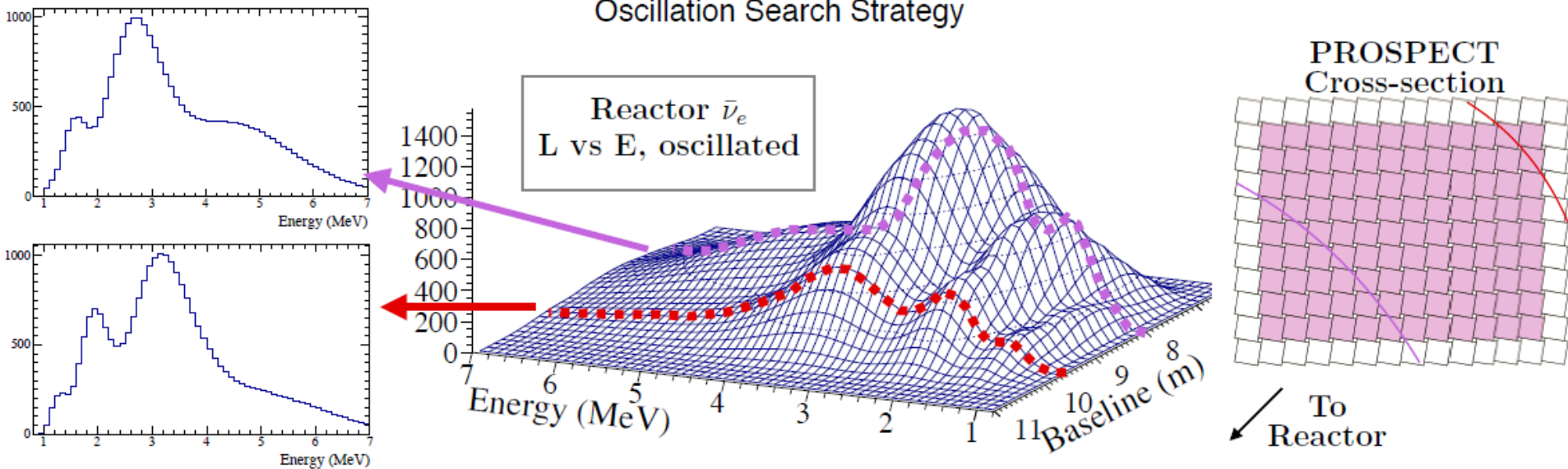
- ~4ton ${}^6\text{Li}$ -loaded liquid scintillator detector
- Optically divided into 14x11 identical segments
 - *i.e.* 154 detectors
- Low mass optical separators
 - Minimal dead material
- Double-ended readout
- Access for calibration *in-situ*



Single detector segment



Oscillation Search



- Relative spectrum measurement between independent detectors
- Segmentation gives clear baseline dependency
- Independent of reactor flux and spectrum models
- Relative measurement and movement minimize systematic errors

R&D Progression

PROSPECT-0.1

Aug 2014
Spring 2015



5cm
0.1 liter
LS cell



PROSPECT-2

Dec 2014
Feb 2015



12.5cm
1.7 liter
LS cell



PROSPECT-20

March 2015

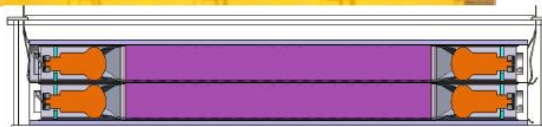


1m
23 liter
LS cell



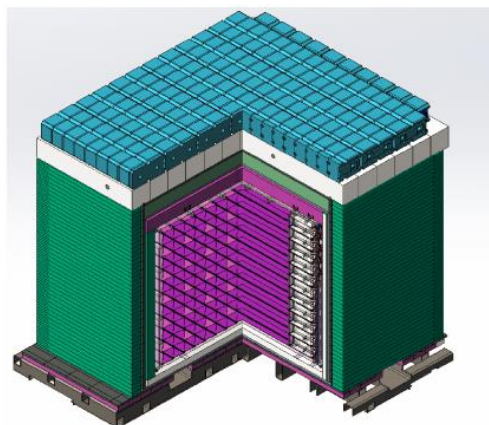
PROSPECT-50

February 2016

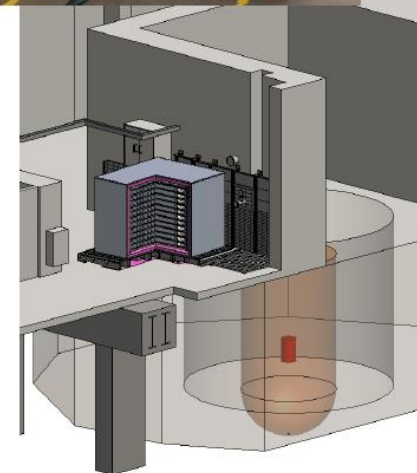


1.2m
2x25 liter
LS segments

PROSPECT Phase I 2017*



154x25 liter
LS segments
15x15x120cm



*under assembly

Construction

- Construction of components is progressing quickly
- Deployment to occur in 2017



Separator Panel
Production

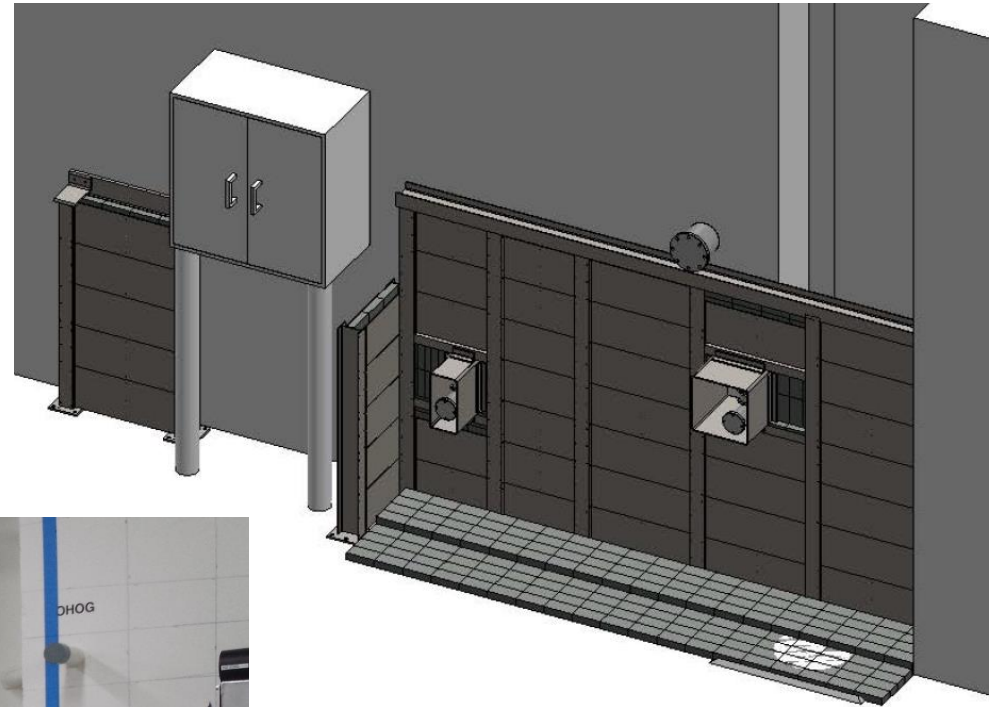
Liquid Scintillator
Accumulation



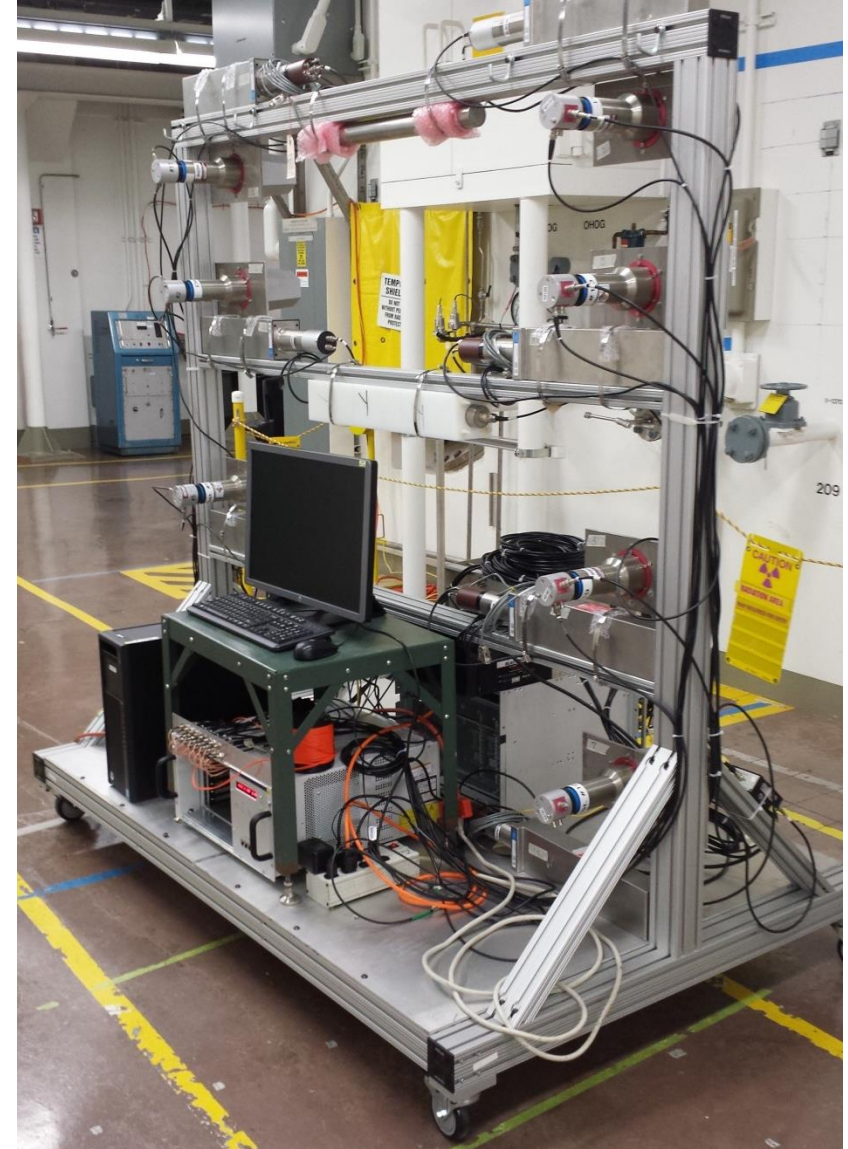
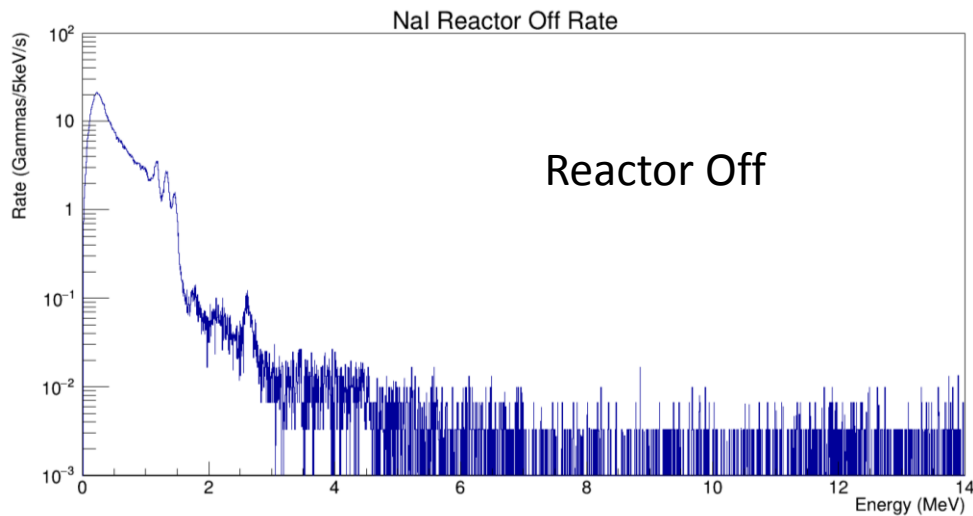
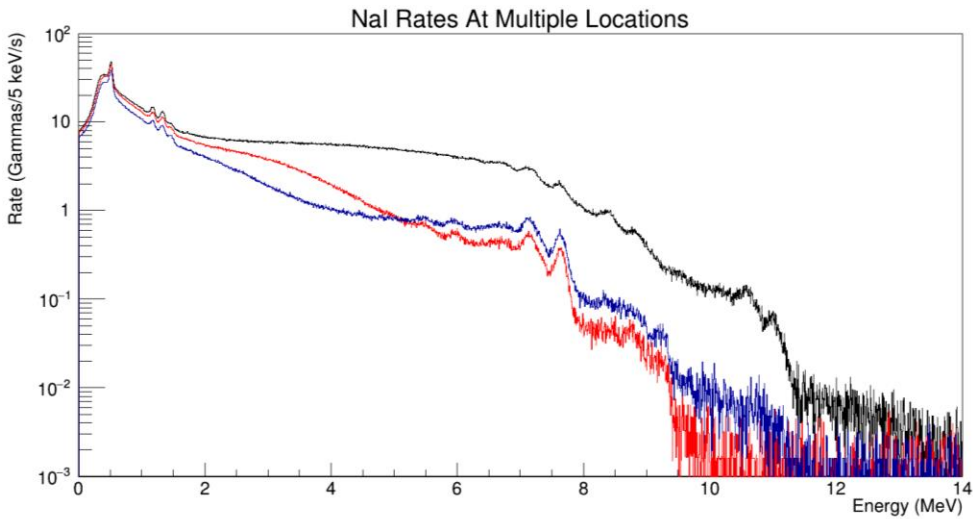
PMT Housing
Production Progress

Site Preparation

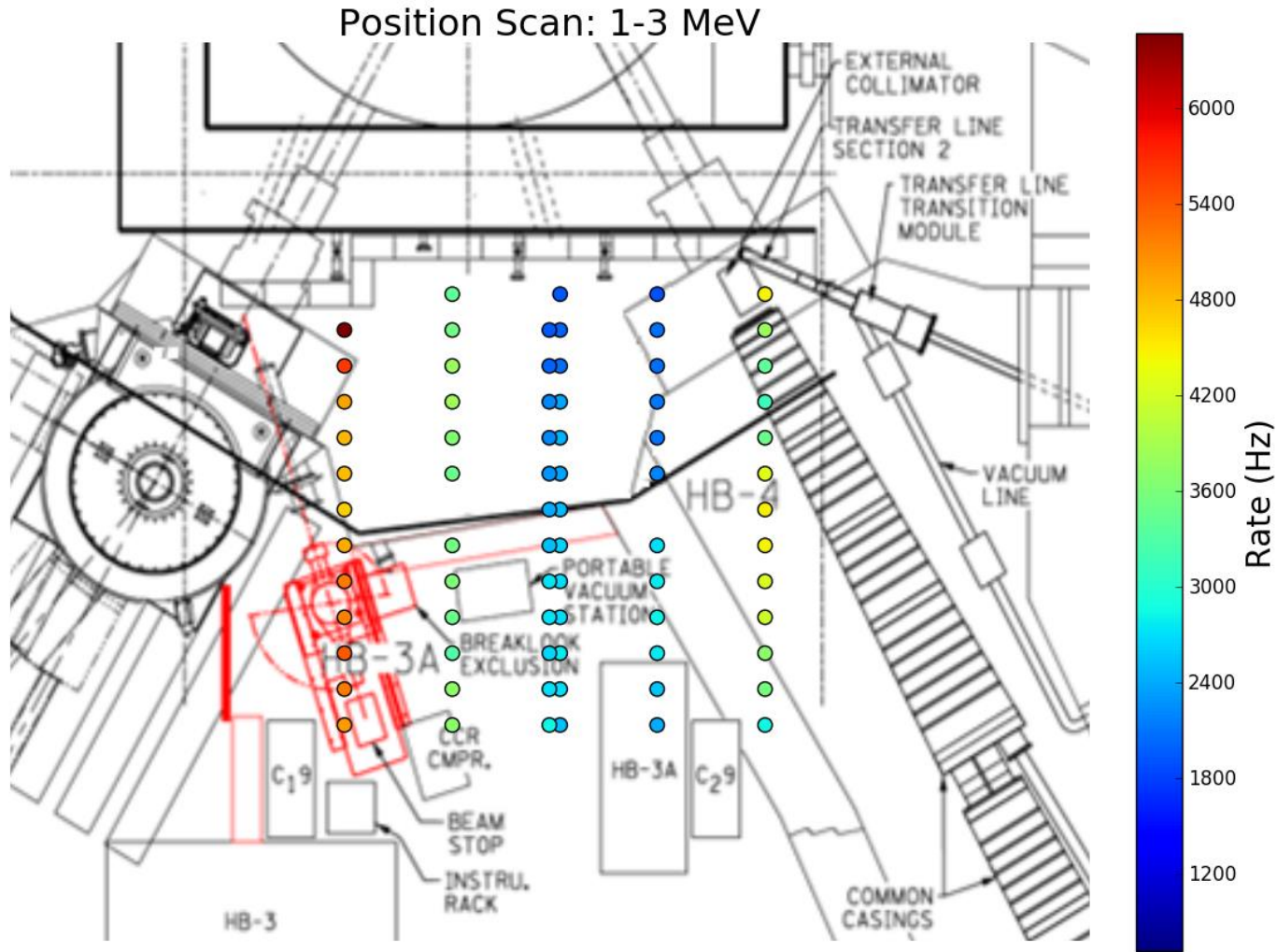
- Installation of shield wall for background reduction
- Leveling of floor for detector movement system



Background Characterization

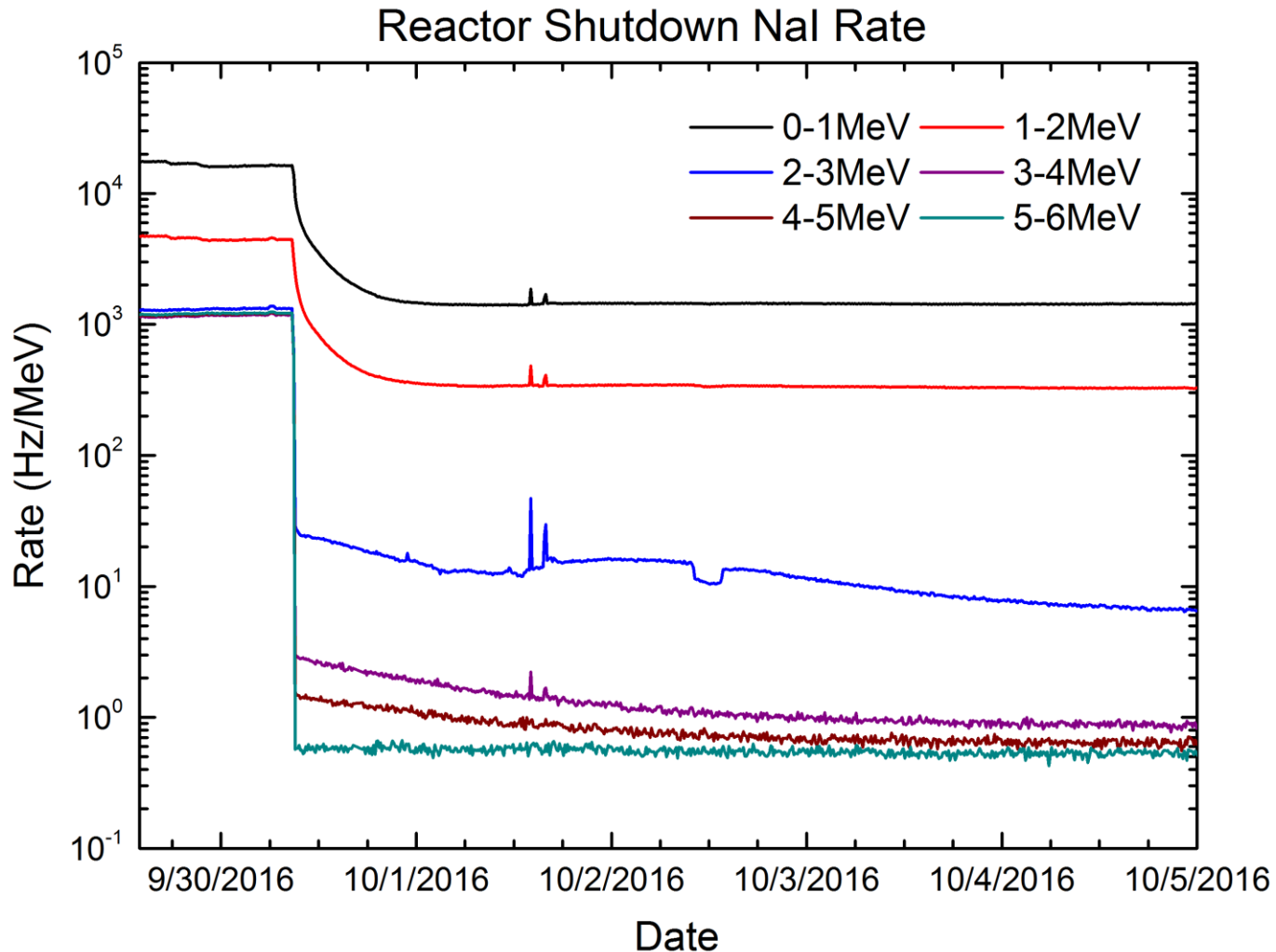


Background Characterization



Background Characterization

Time Variations



Summary

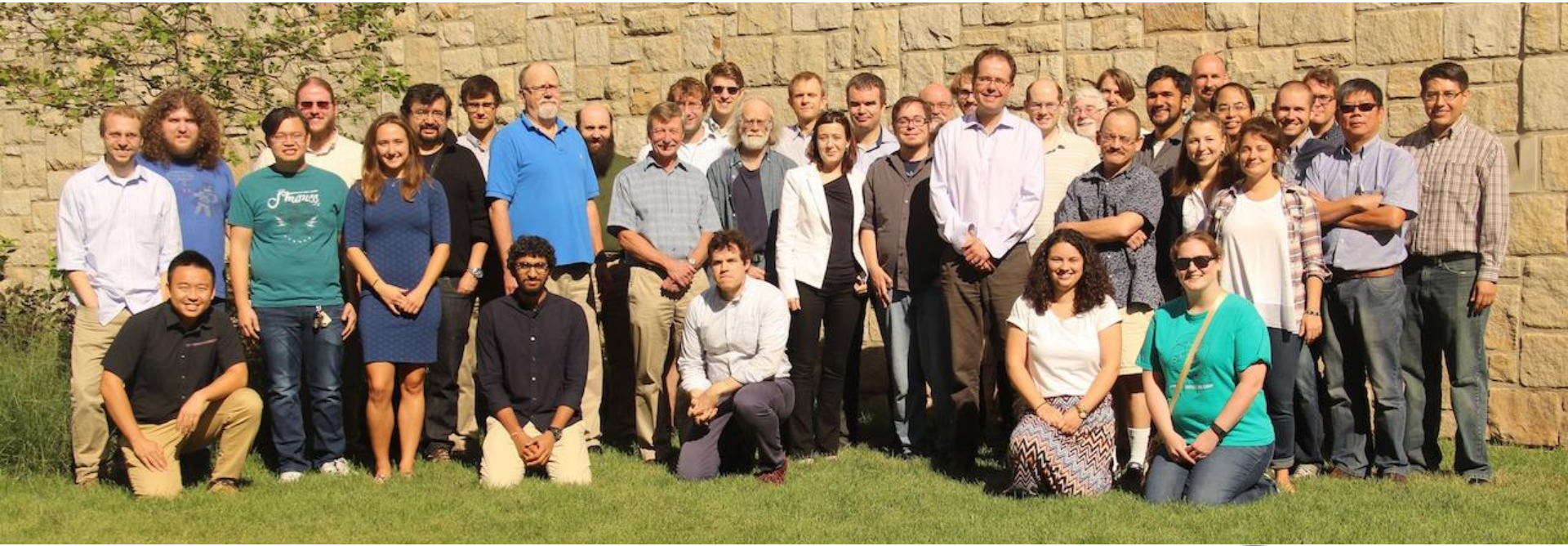


- PROSPECT will:
 - Make a precision ^{235}U spectrum measurement, complementing LEU measurements.
 - Make a model independent search that will cover the sterile neutrino oscillation best-fit point at better than 3σ in one calendar year
 - Cover favored regions at 3σ in 3 years
 - Test ^{235}U as the source of the 4-6MeV “bump”
- Detector construction is proceeding, deployment and first data taking will begin before the end of 2017
- Preparations for deployment are in full swing
- Backgrounds, reactor on and off, have been characterized

The PROSPECT Collaboration



4 National Labs 10 Universities 68 Collaborators



Supported by:

prospect.yale.edu



U.S. DEPARTMENT OF
ENERGY

Office of
Science



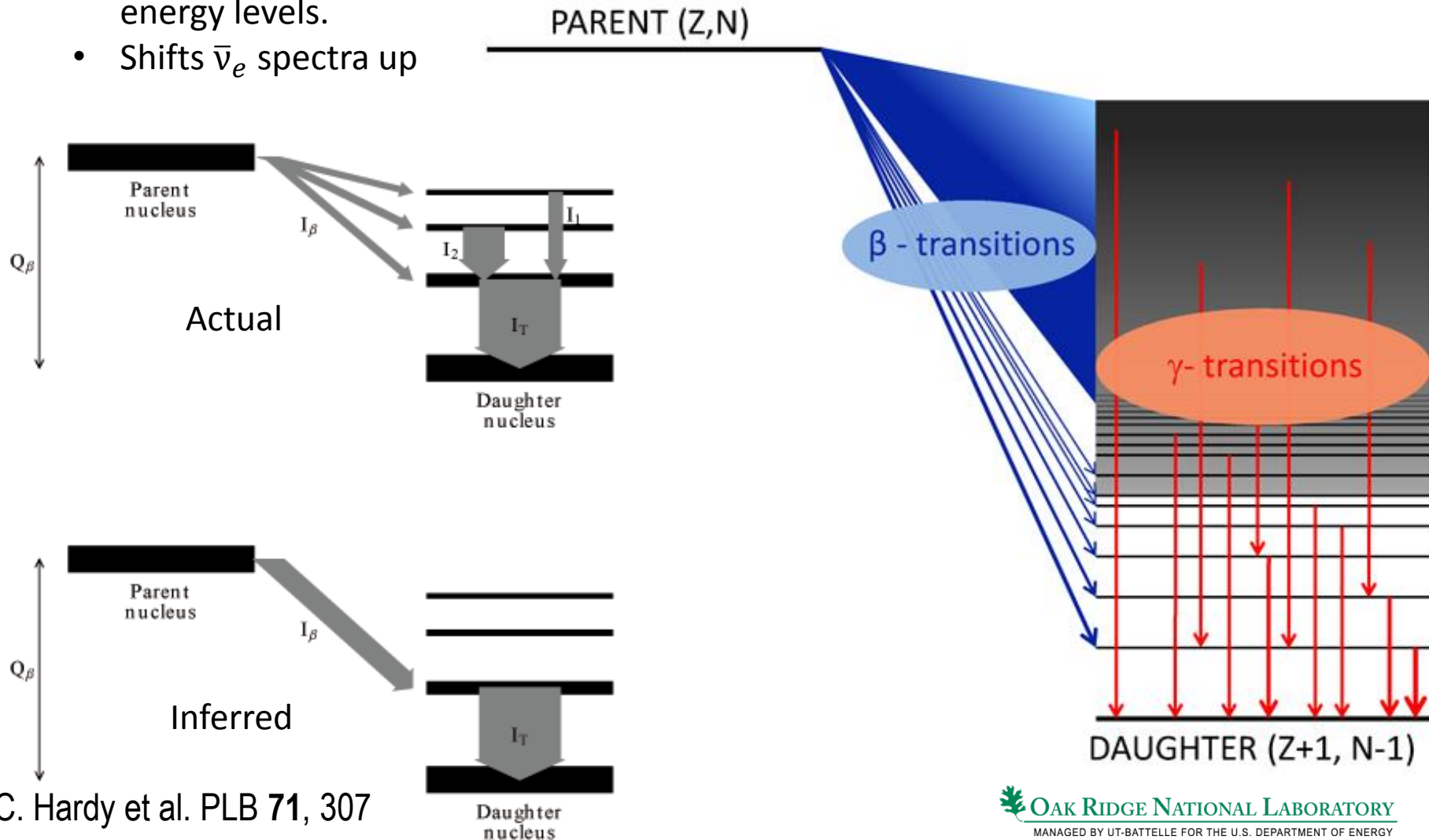
**HEISING-SIMONS
FOUNDATION**

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE U.S. DEPARTMENT OF ENERGY

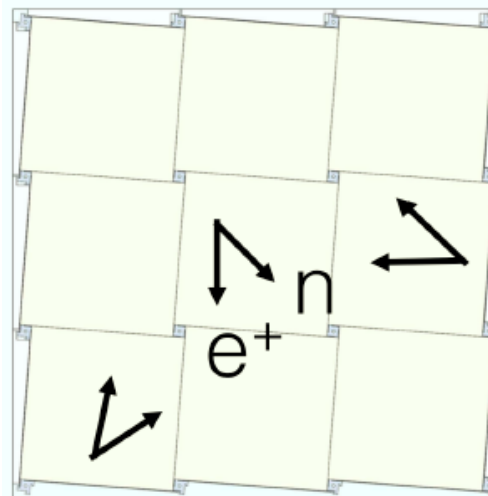
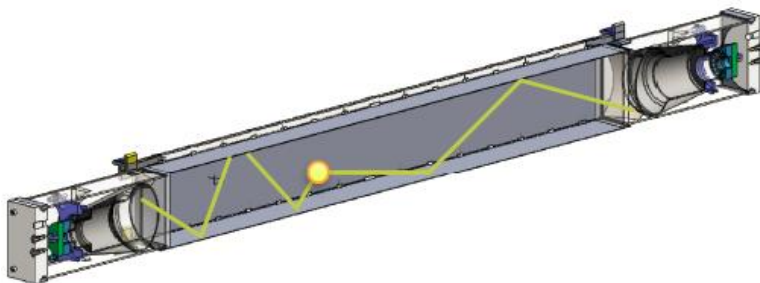
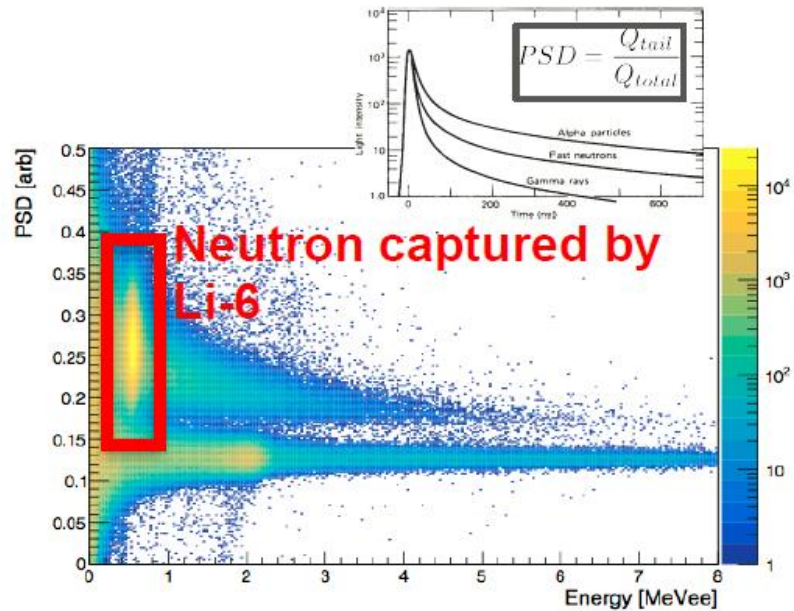
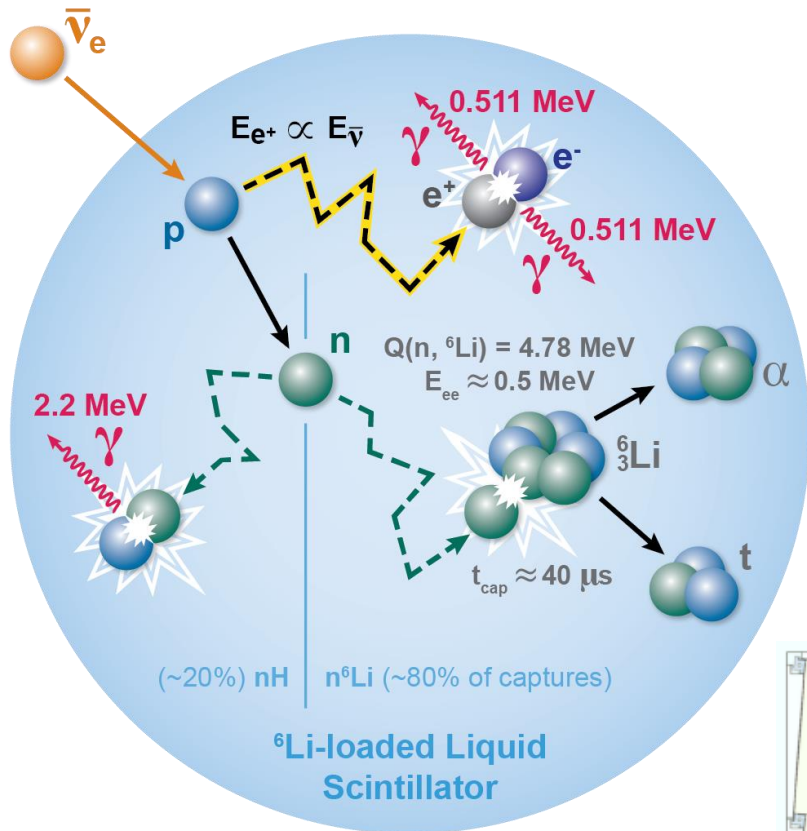
BACKUP

The Pandemonium Effect

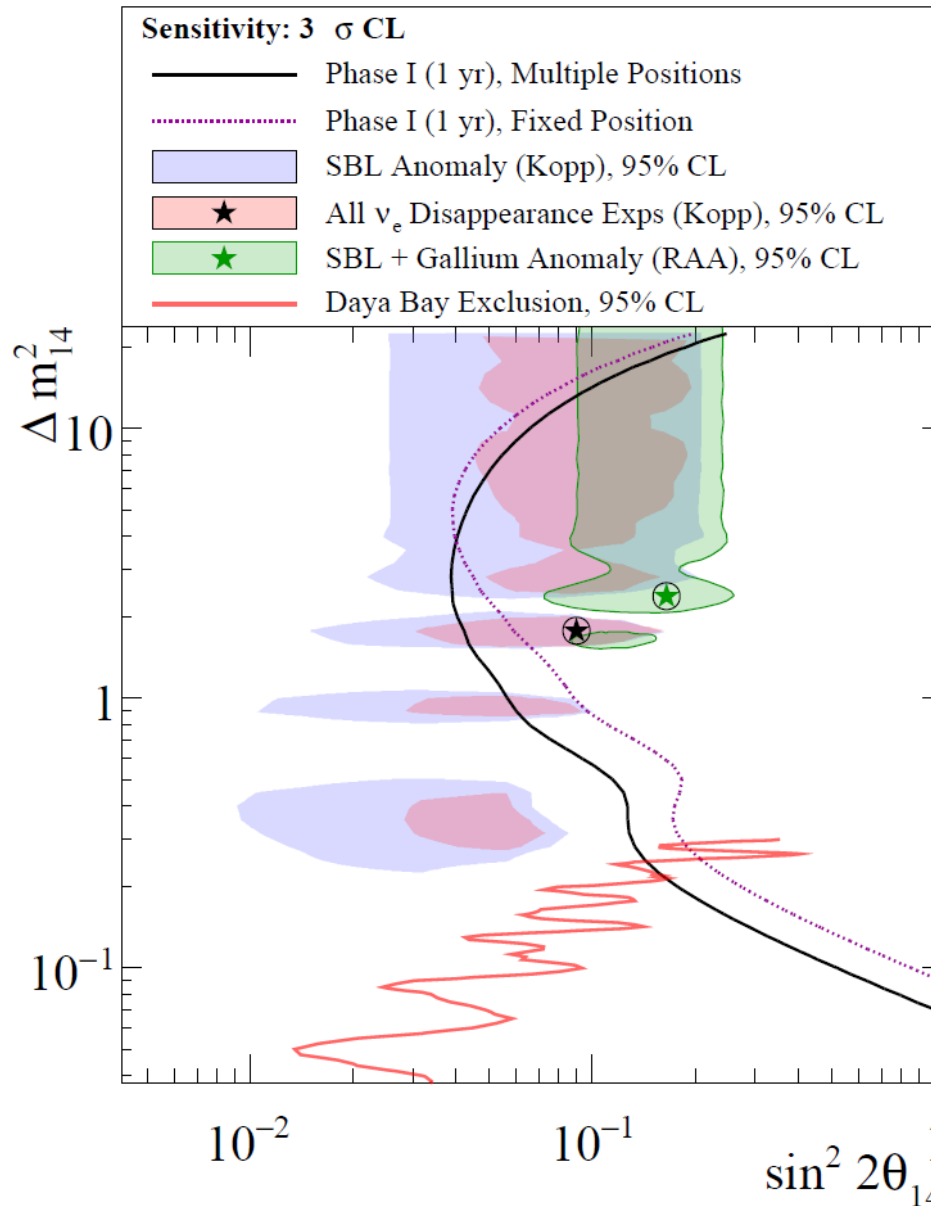
- Fragmentation of decay strength at high excitation energy due to high level density.
 - Low efficiency high resolution experiments overestimate the branching to low energy levels.
 - Shifts $\bar{\nu}_e$ spectra up



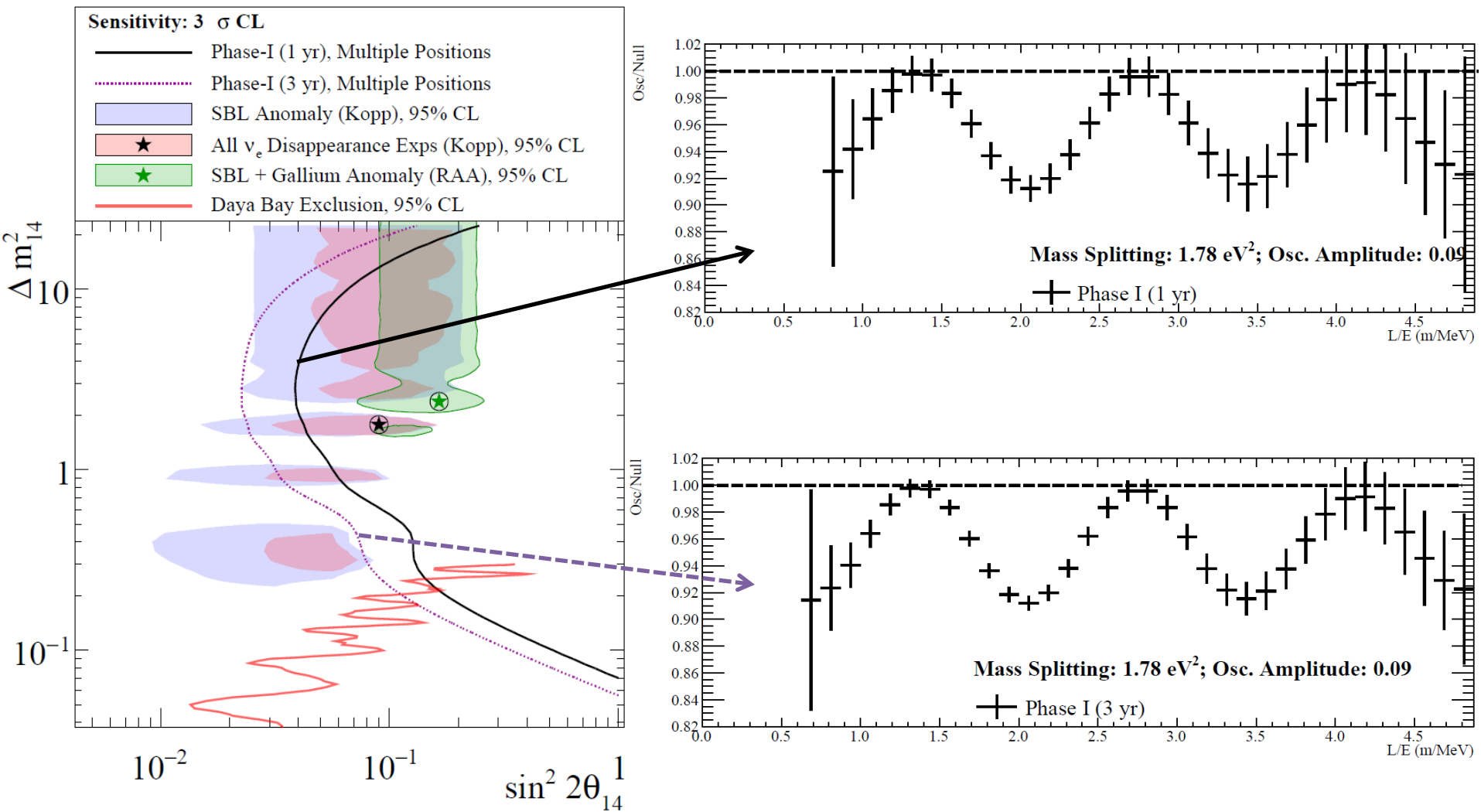
Detector Design: Detection



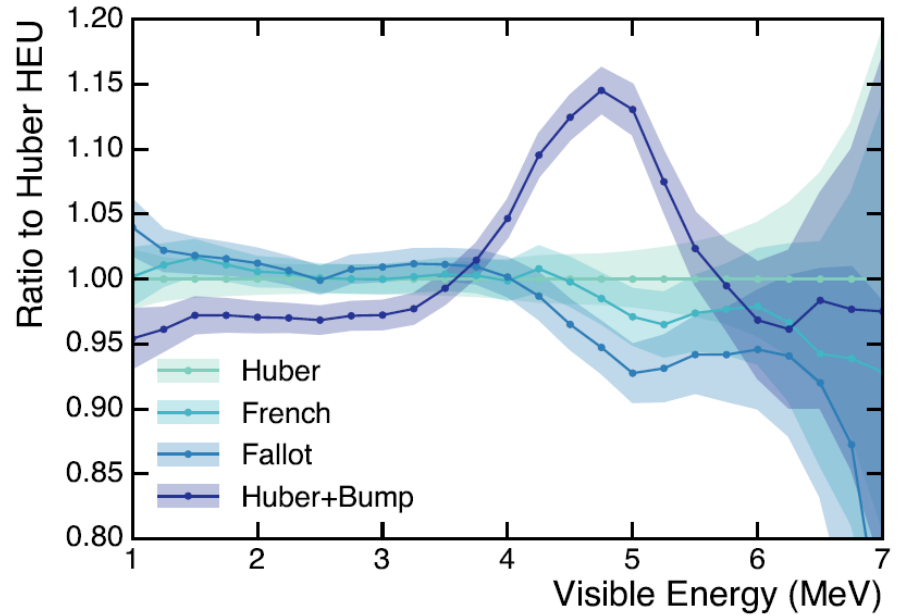
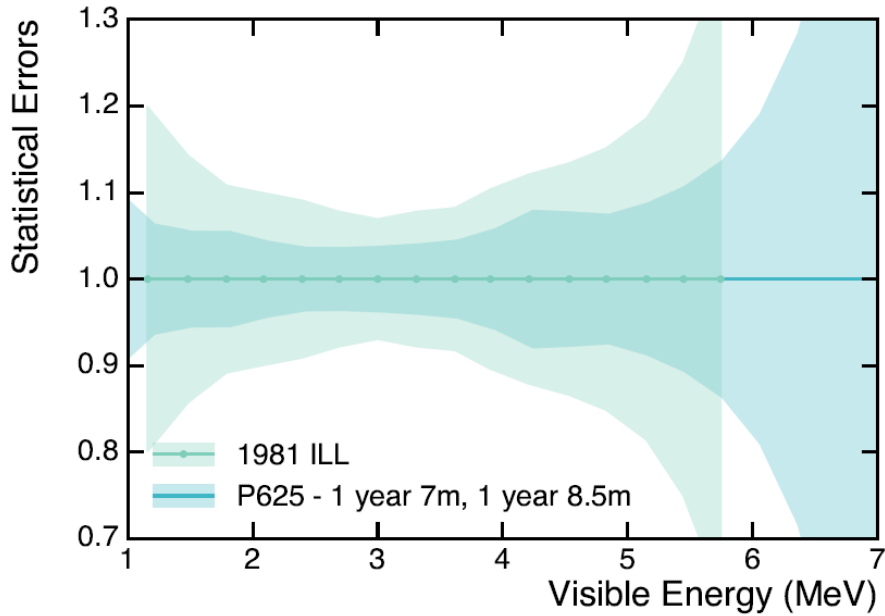
Why a Movable Detector?



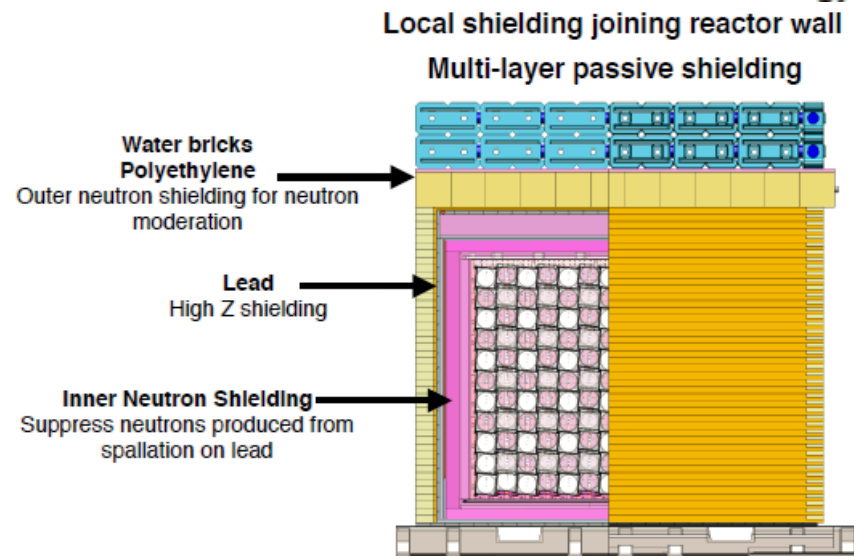
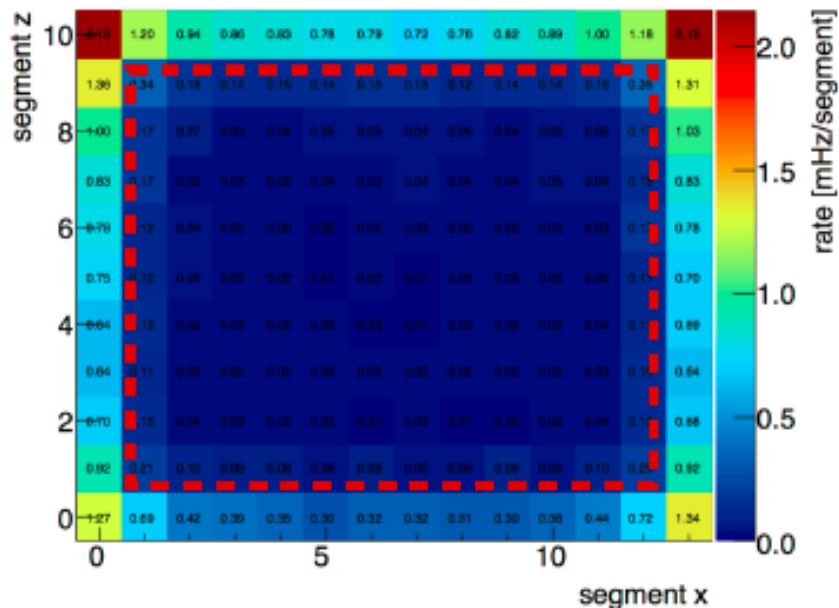
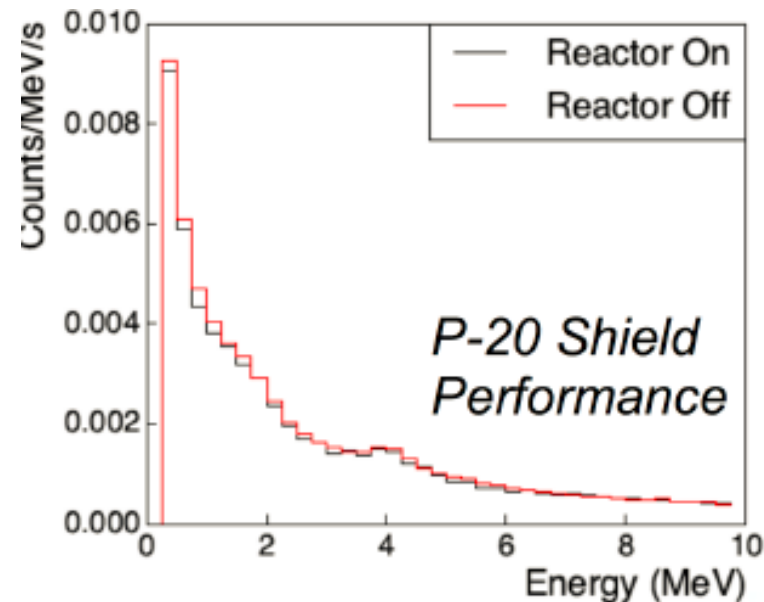
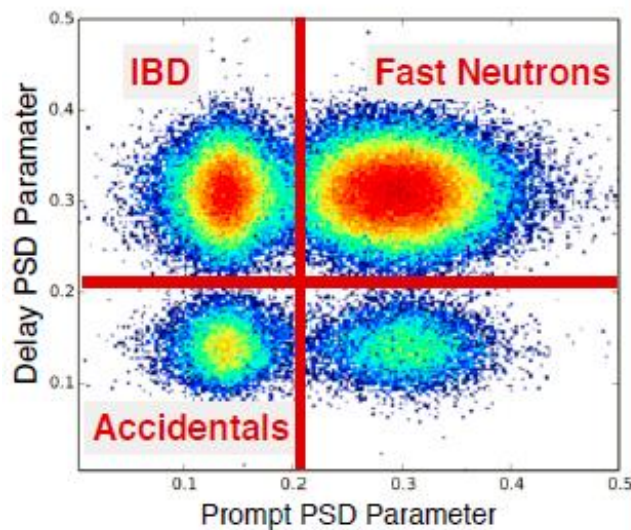
Oscillation Search



Spectrum Measurement



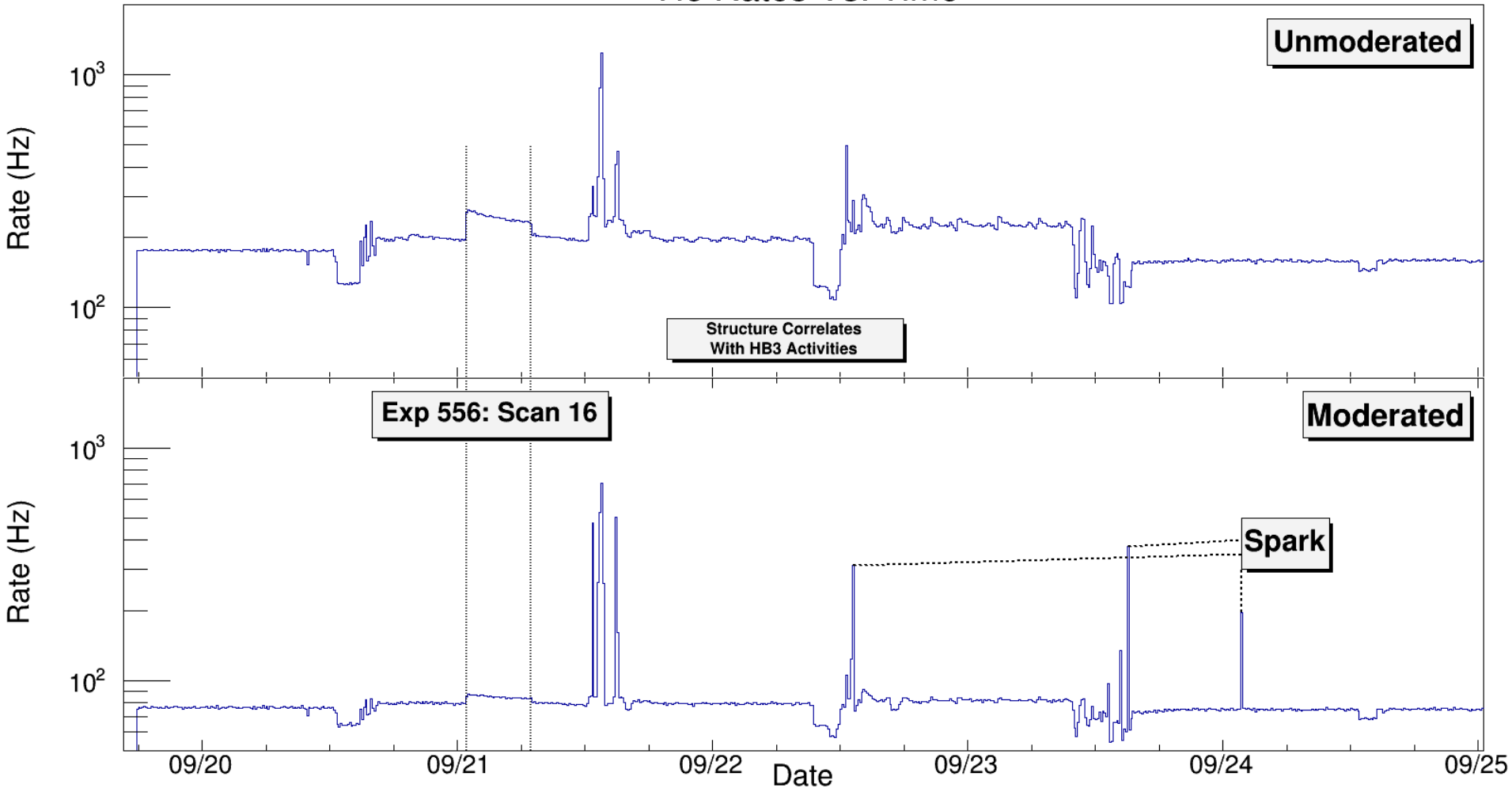
Background Reduction



Background Characterization

Time Variations

^3He Rates Vs. Time



Background Characterization

Time Variations

