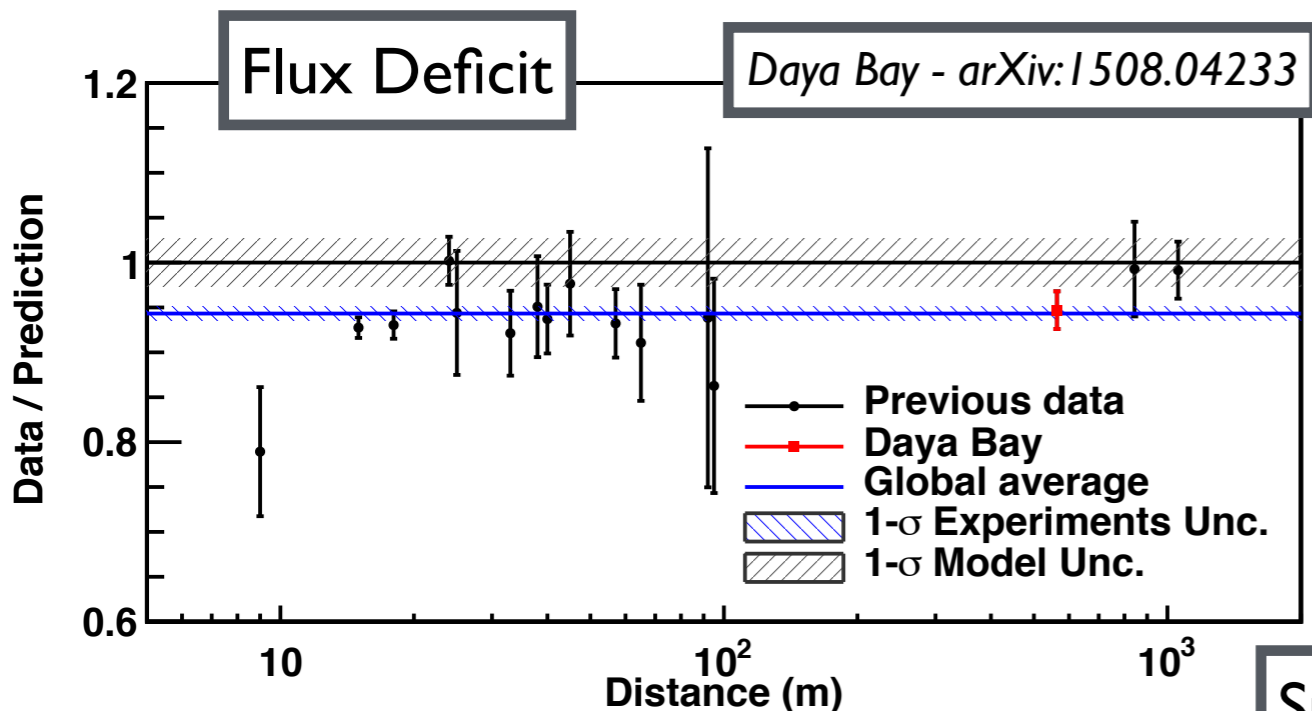


PROSPECT: The Precision Reactor Oscillation and Spectrum Experiment

TJ Langford
Yale University
October 31, 2015

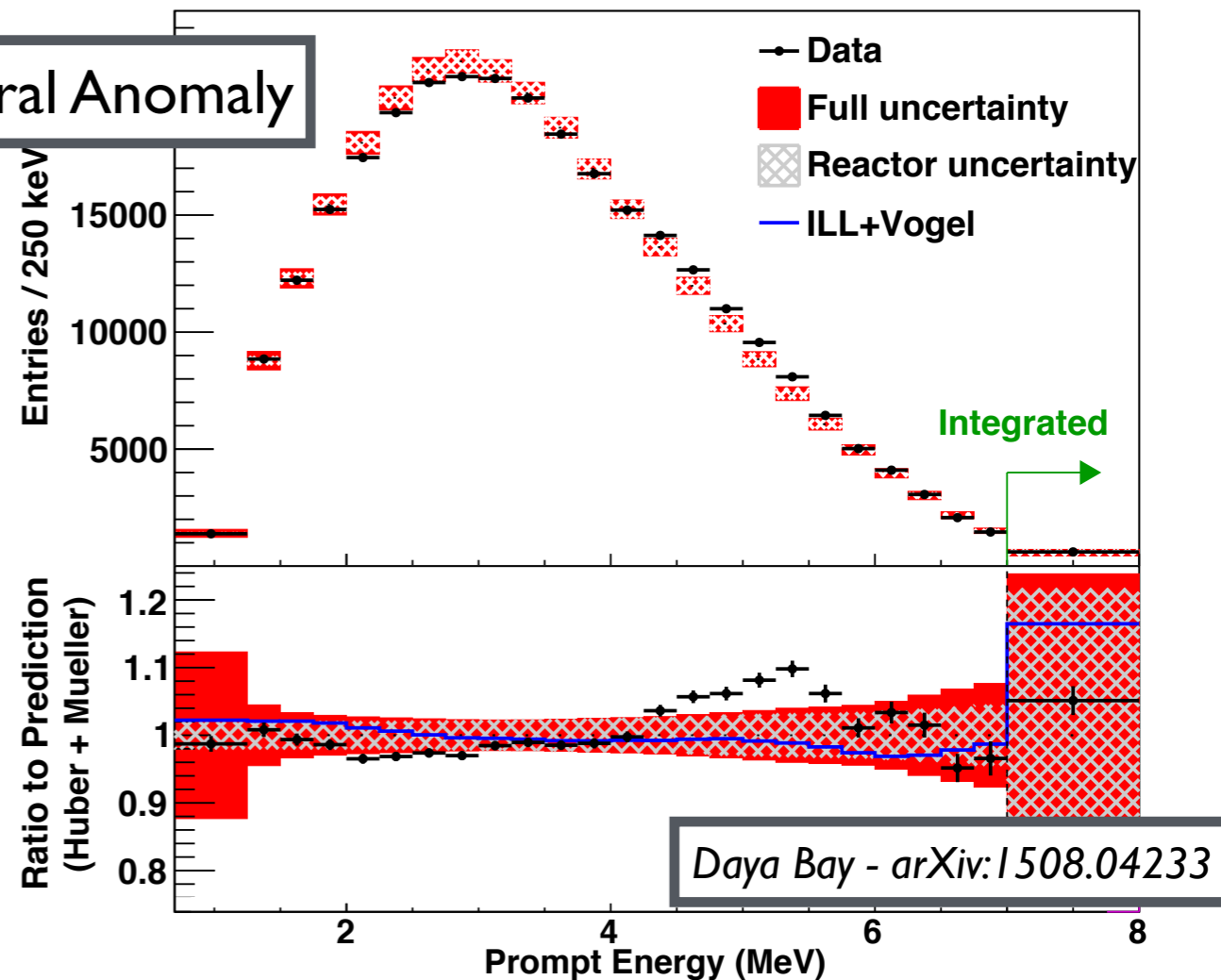




Recent anomalous results in the measured flux and spectrum exist

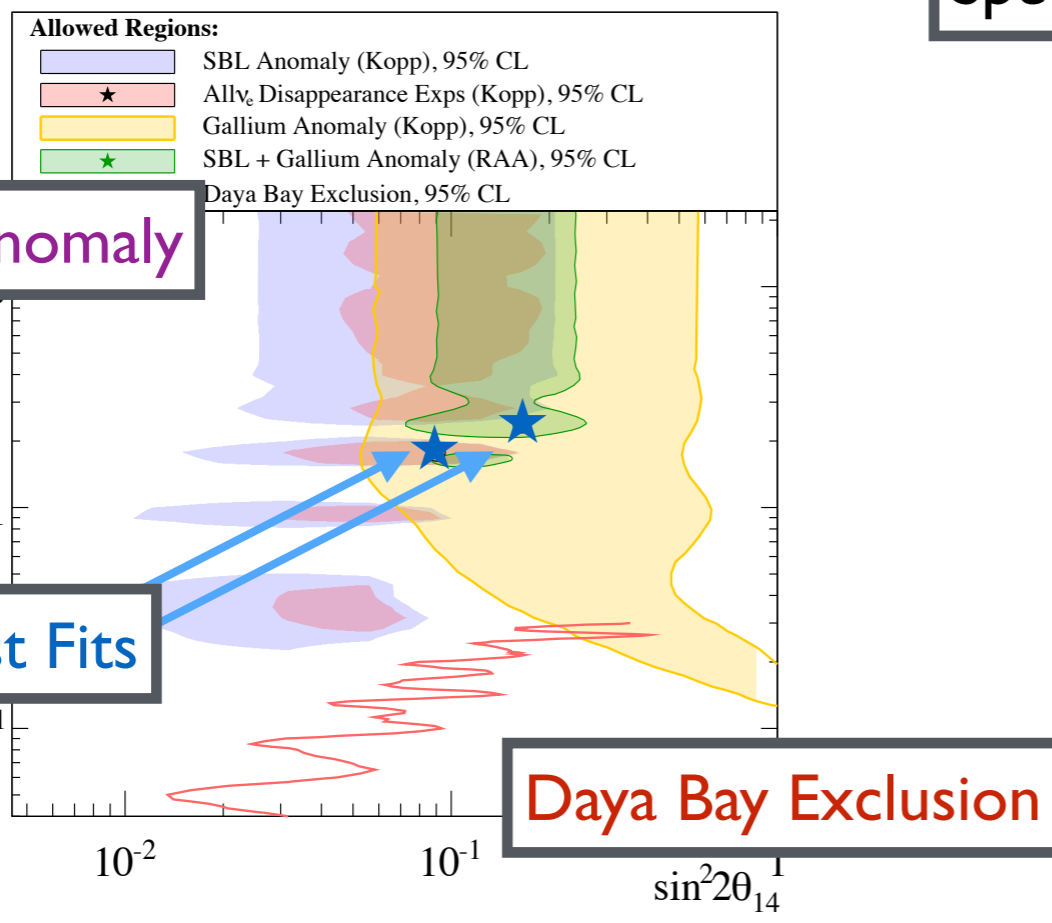
- 5% flux deficit
- Bump: 10% local spectral deviation
- **Indication of new physics?**

Spectral Anomaly



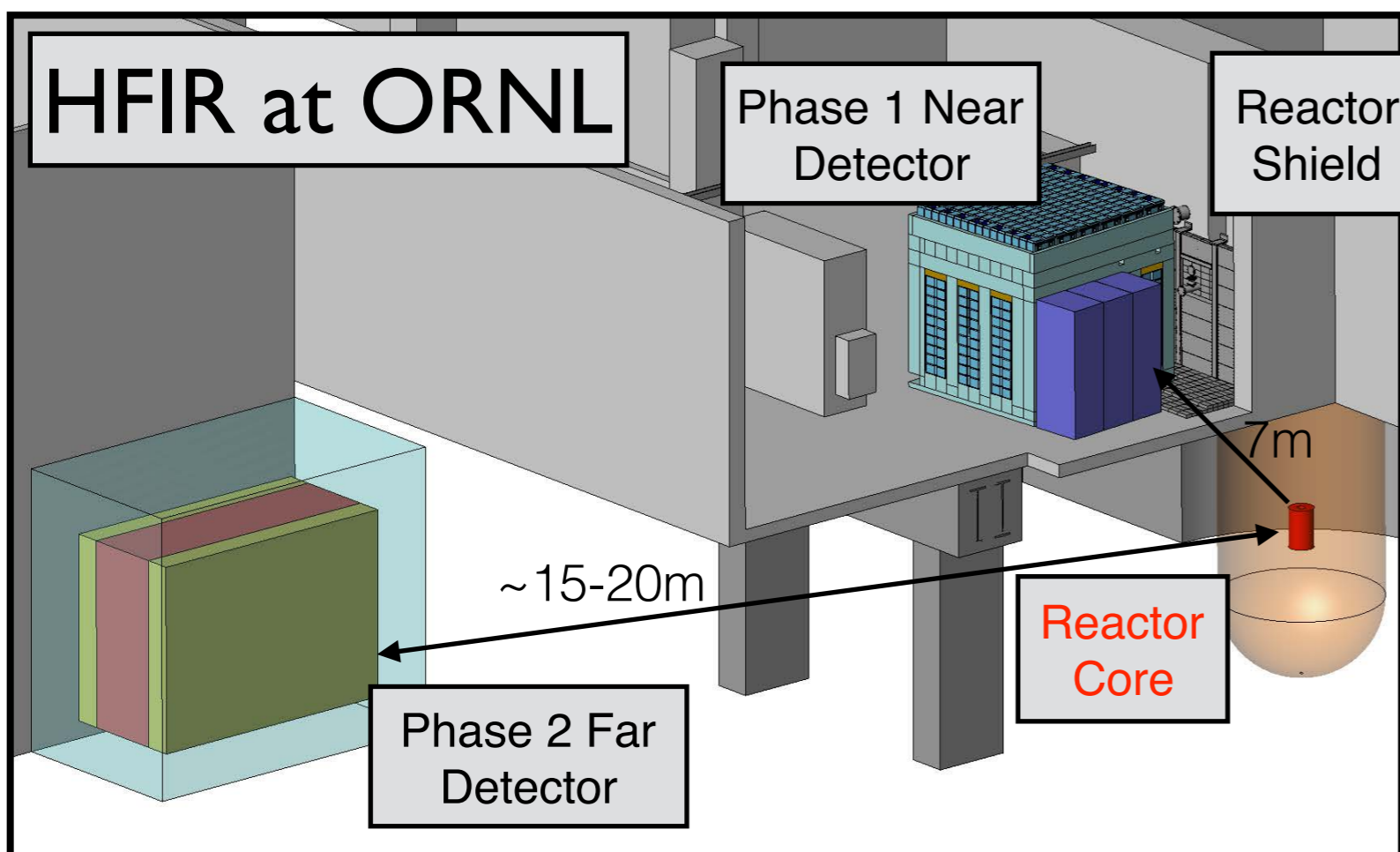
Reactor Anomaly

Global Best Fits



Physics Goals:

- Search for short baseline ν_e oscillations using detector segmentation
 - Distortions in energy spectrum that vary with baseline
- Measure ^{235}U antineutrino spectrum to illuminate the “Bump”



Experimental Strategy:

- **Phase 1:**
 - Sterile neutrino search, cover best fit region at 3σ in 1 year
 - Measure ^{235}U spectrum with 100k events/year
- **Phase 2:** World-leading short baseline sensitivity

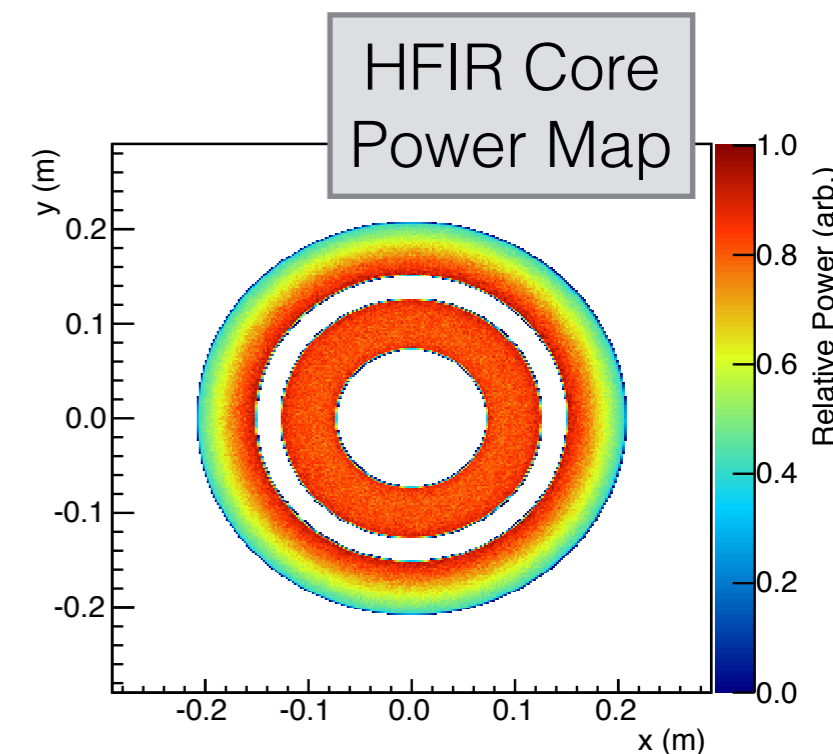
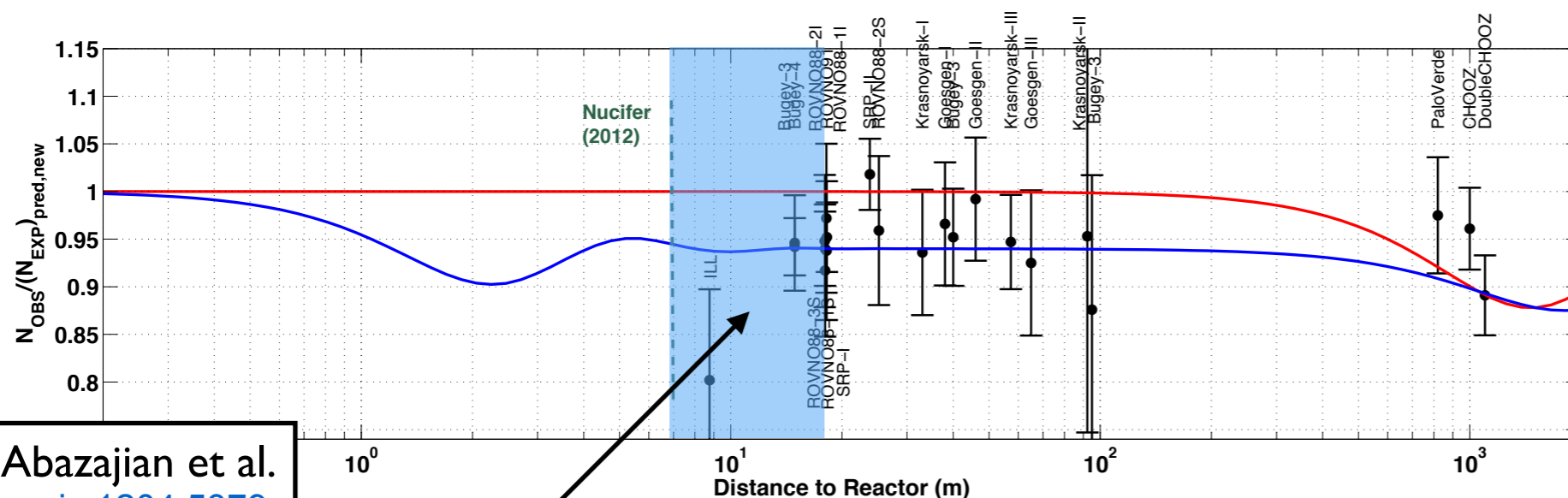
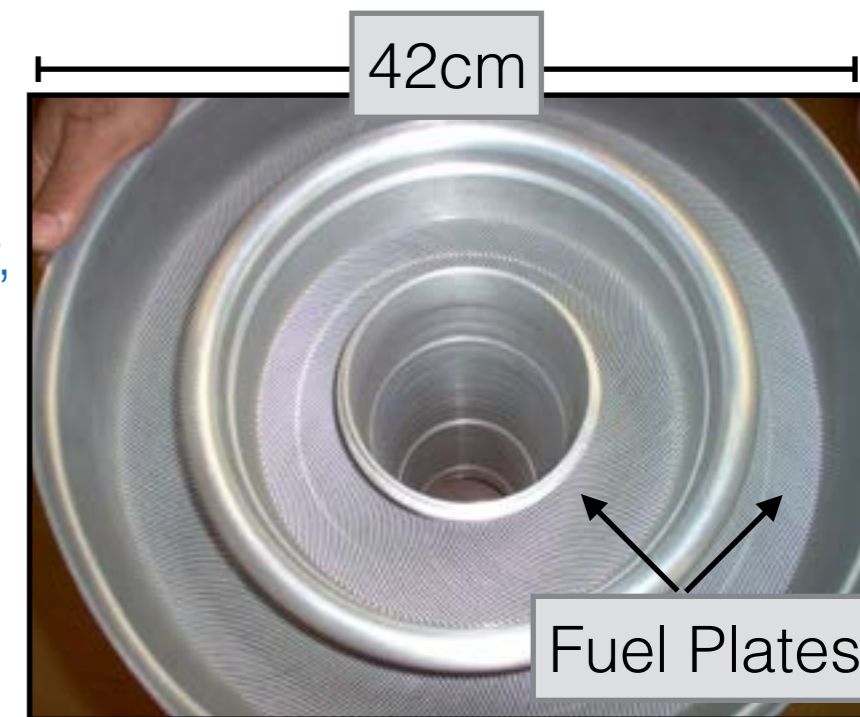
Challenges:

- Minimal overburden, cosmogenic backgrounds
- Reactor-related backgrounds
 - High energy ($\approx 10\text{MeV}$) gammas

HFIR Research Reactor



- High Flux Isotope Reactor at Oak Ridge National Lab
- 85MW HEU compact-core reactor, 42% uptime
- PROSPECT activity for past 2 yrs
- Backgrounds fully characterized (arXiv:1506.03547)
- Unique location for a short baseline experiment



Abazajian et al.
[arxiv:1204.5379](https://arxiv.org/abs/1204.5379)

HFIR Baselines

Phased Detector Development



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

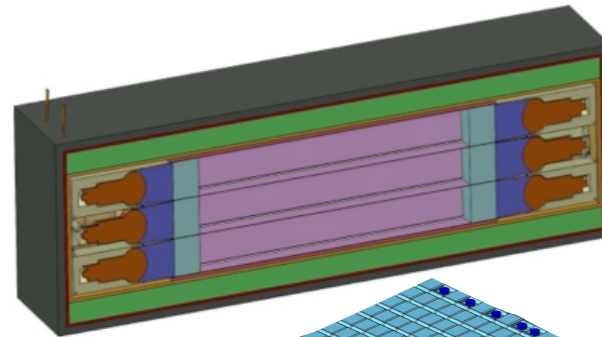


1m
23 liter
LS cell

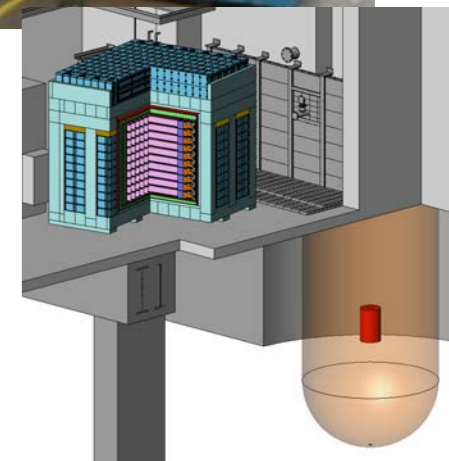


PROSPECT-Nx30

Early 2016*



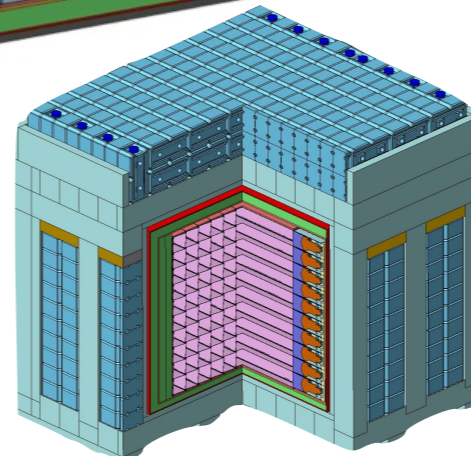
1.19m long
Nx30 liter
LS segments



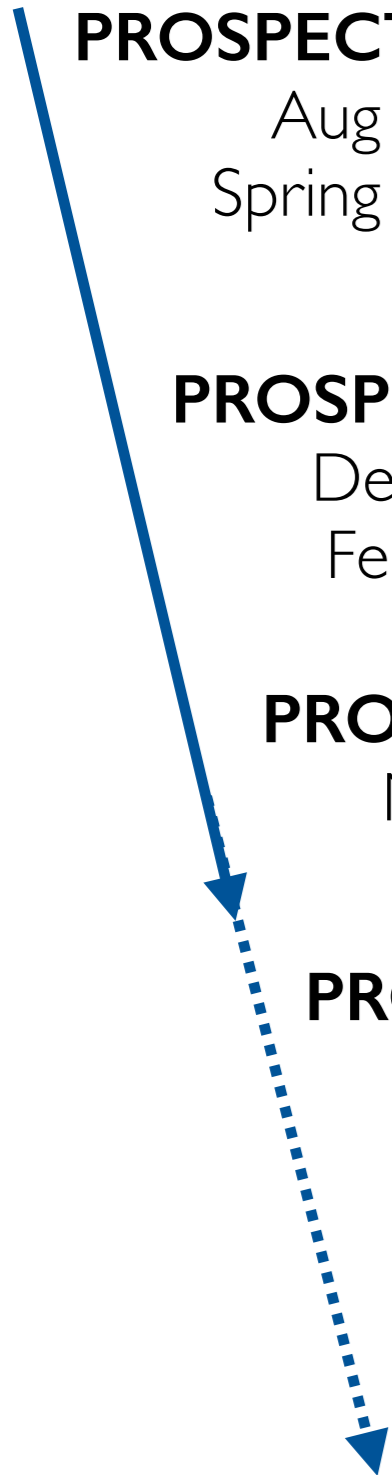
PROSPECT

Phase I

Late 2016*

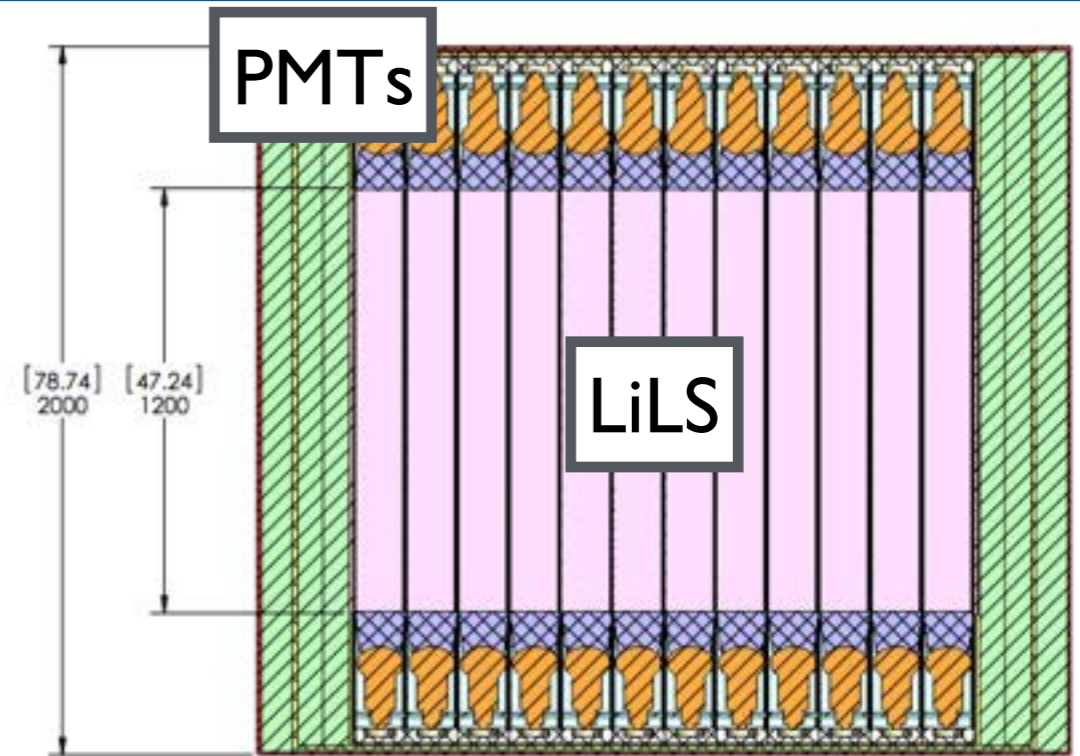
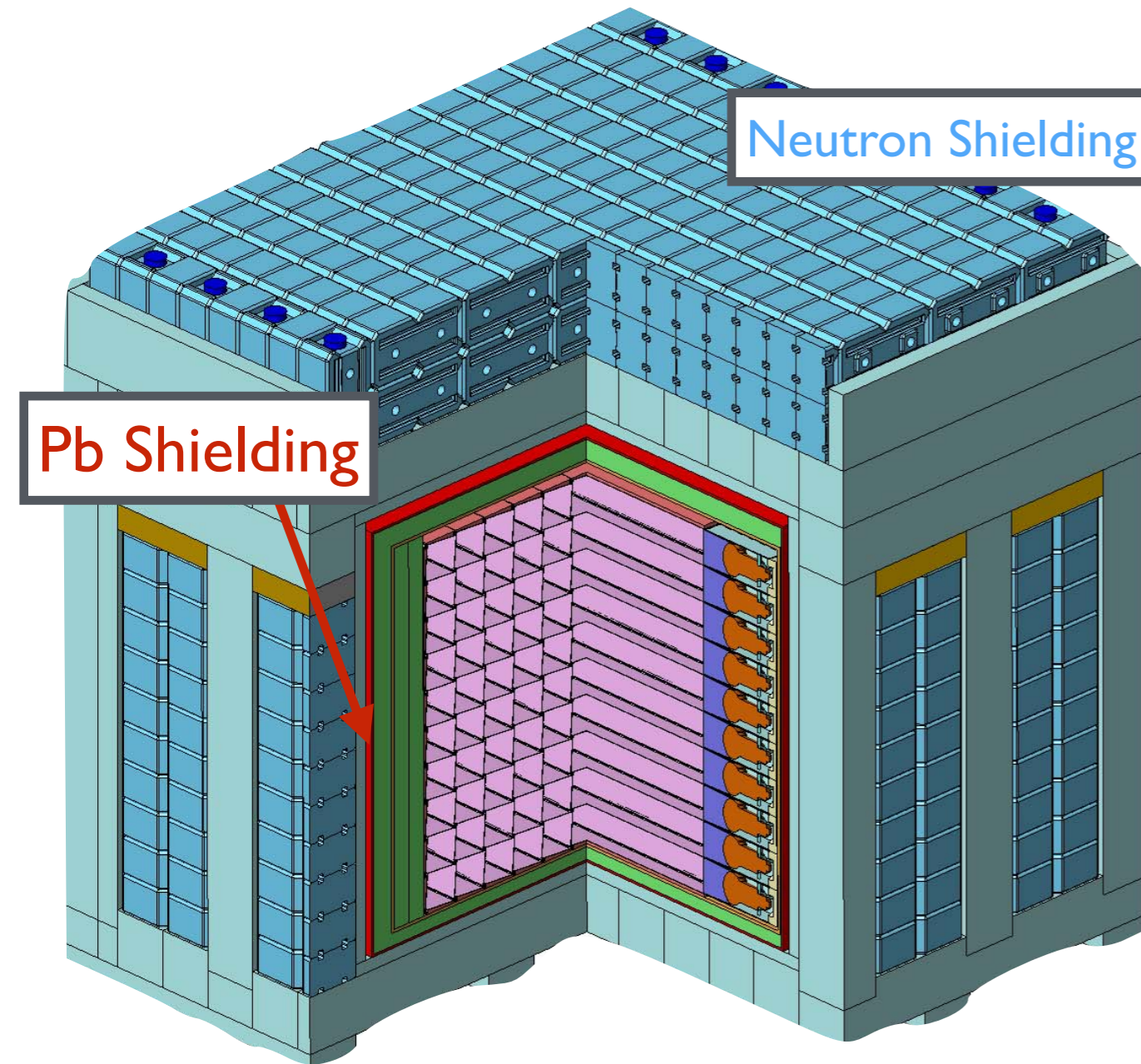


120x30 liter
LS segments
15x15x119cm

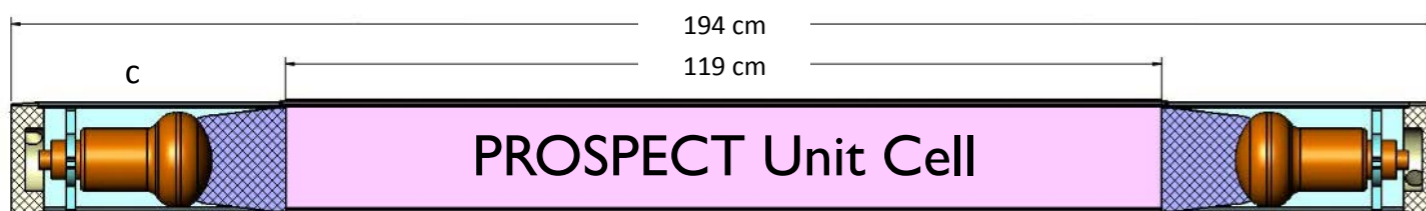


*technically driven schedule

Segmented Antineutrino Detector



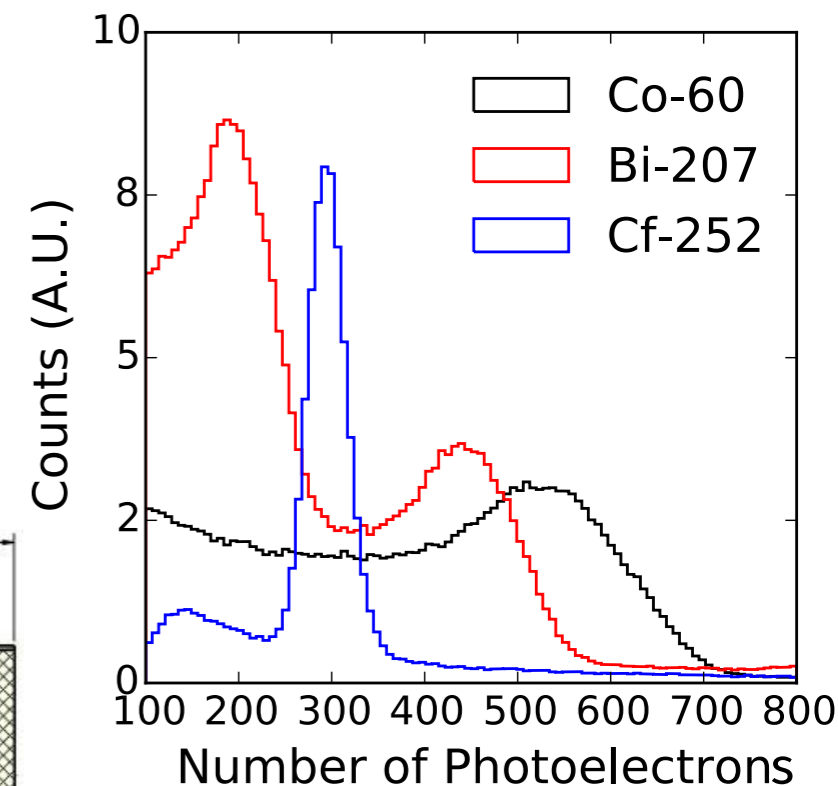
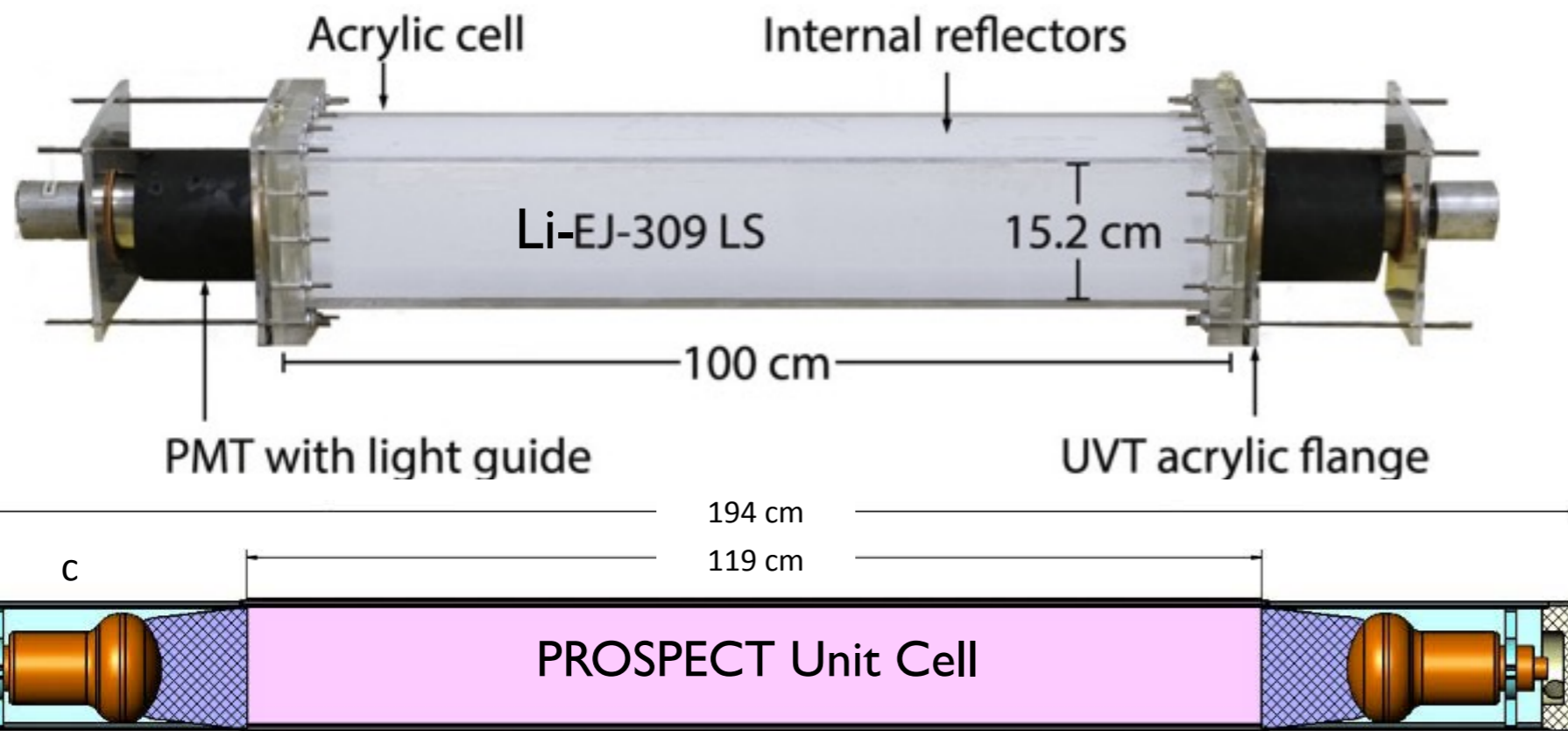
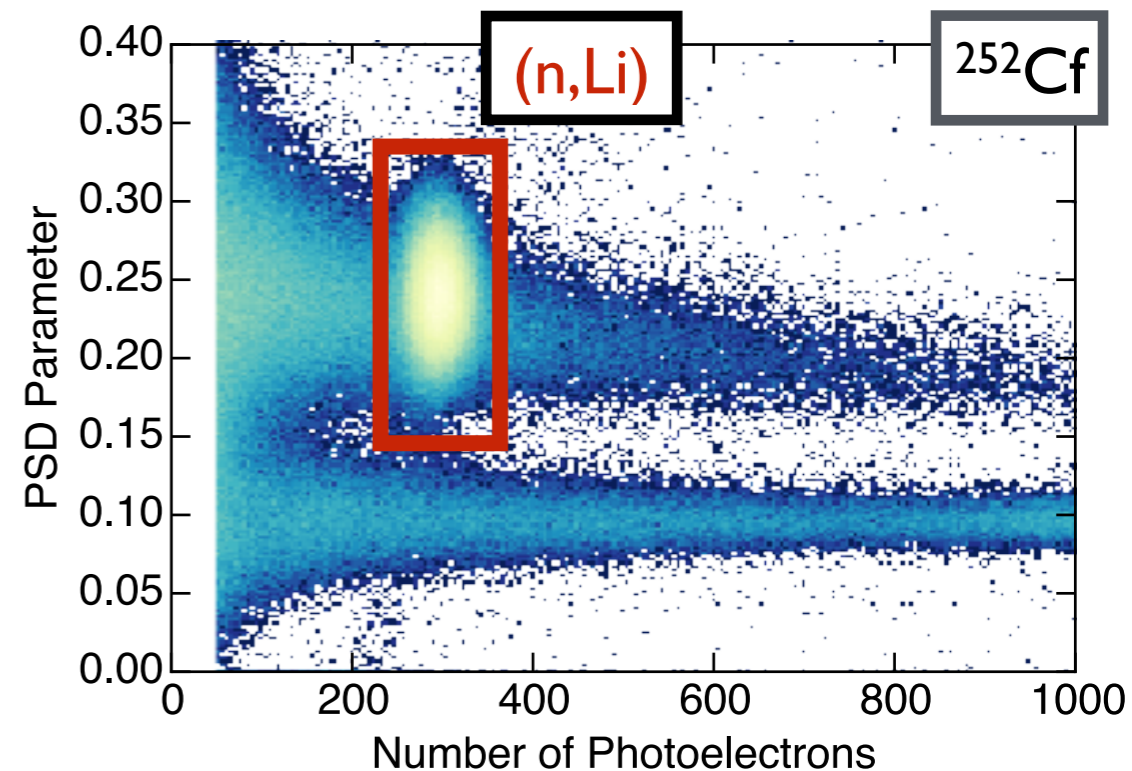
- 3ton LiLS detector
- 120 optical segments
 - 119x15x15cm³ each
- Double-ended PMT readout
- Access for calibration sources between every cell
- Shielding package designed for surface backgrounds



Full-scale Test Detector

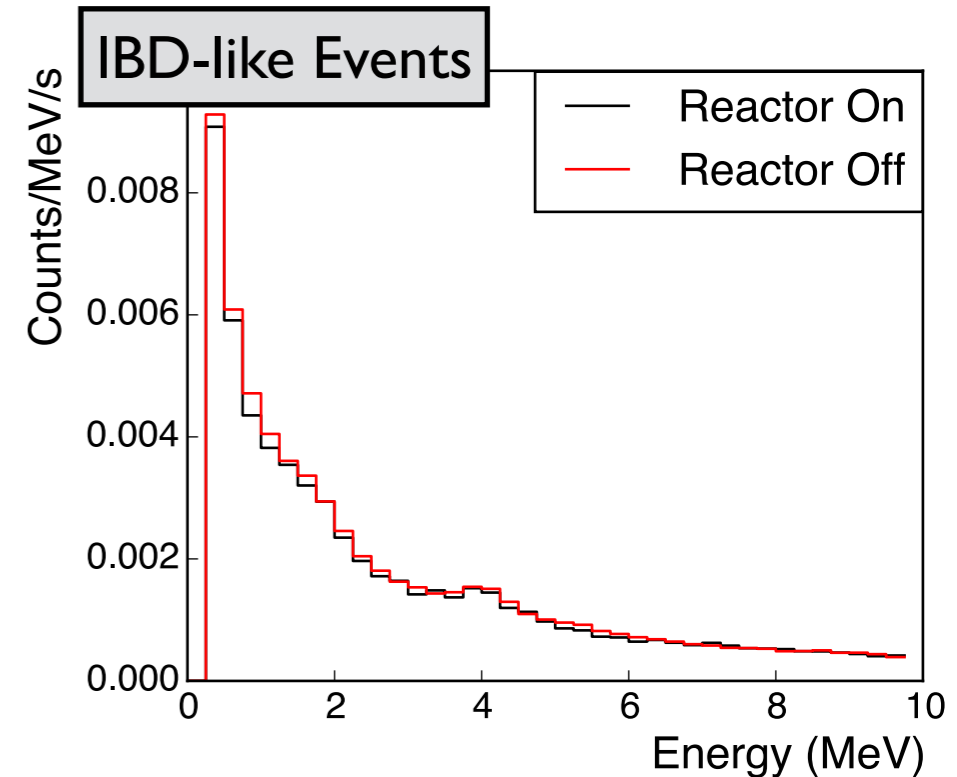
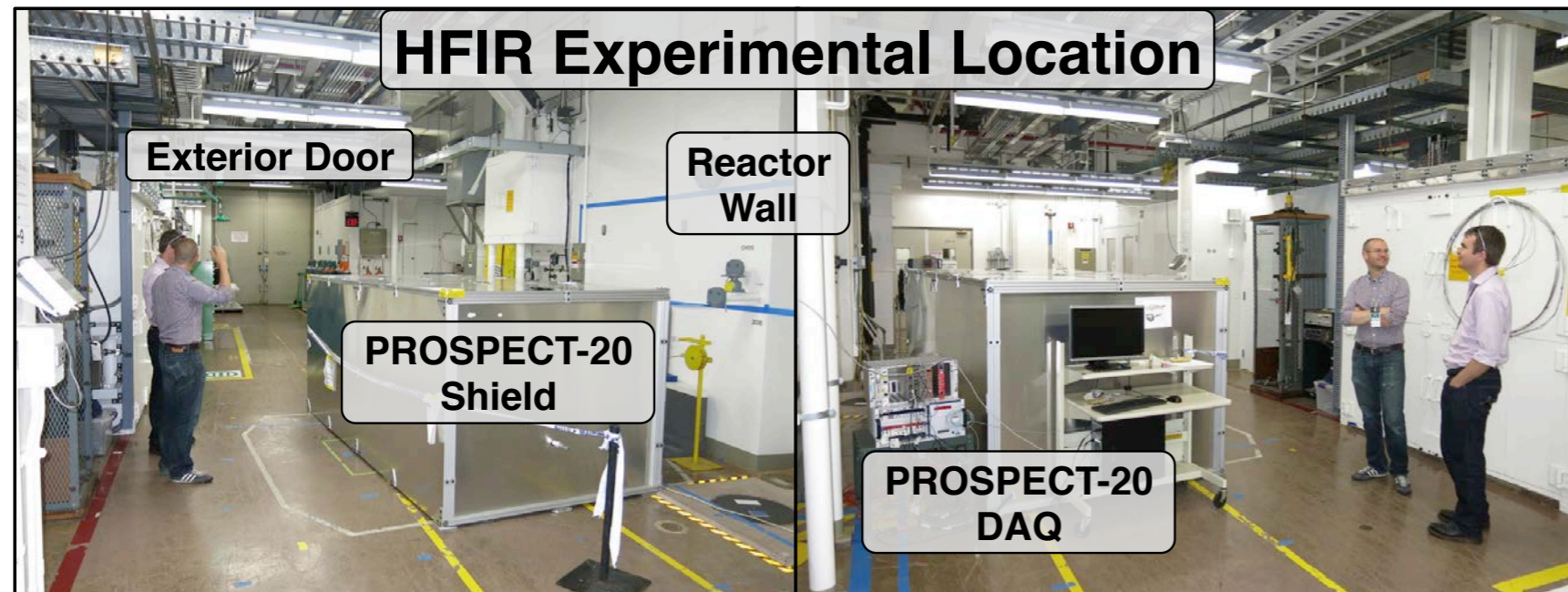


- PROSPECT-20
 - 23L test cell of 6Li-loaded Liquid Scintillator
 - 15x15x100cm³ detector
 - Measured Light collection: **530PE/MeV**
 - **4.5% @ 1MeV energy resolution**
 - Measured PSD Figure of Merit: **1.4 at (n,Li) capture**
 - **>99.9% background rejection**
 - Double-ended readout
 - uniform light collection and position reconstruction

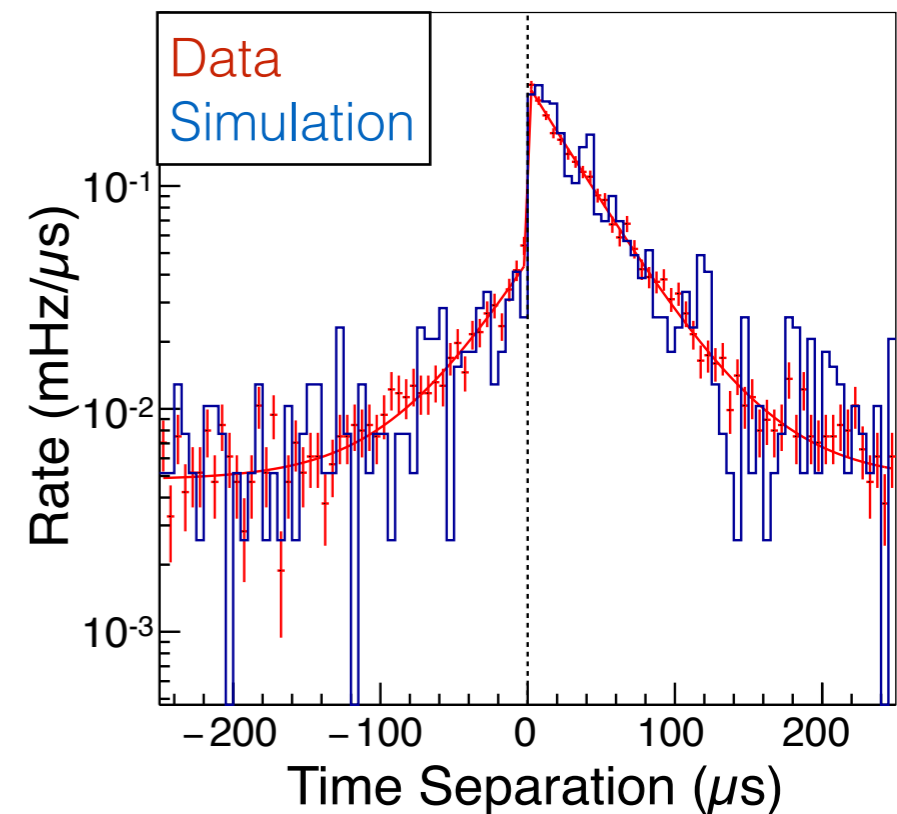


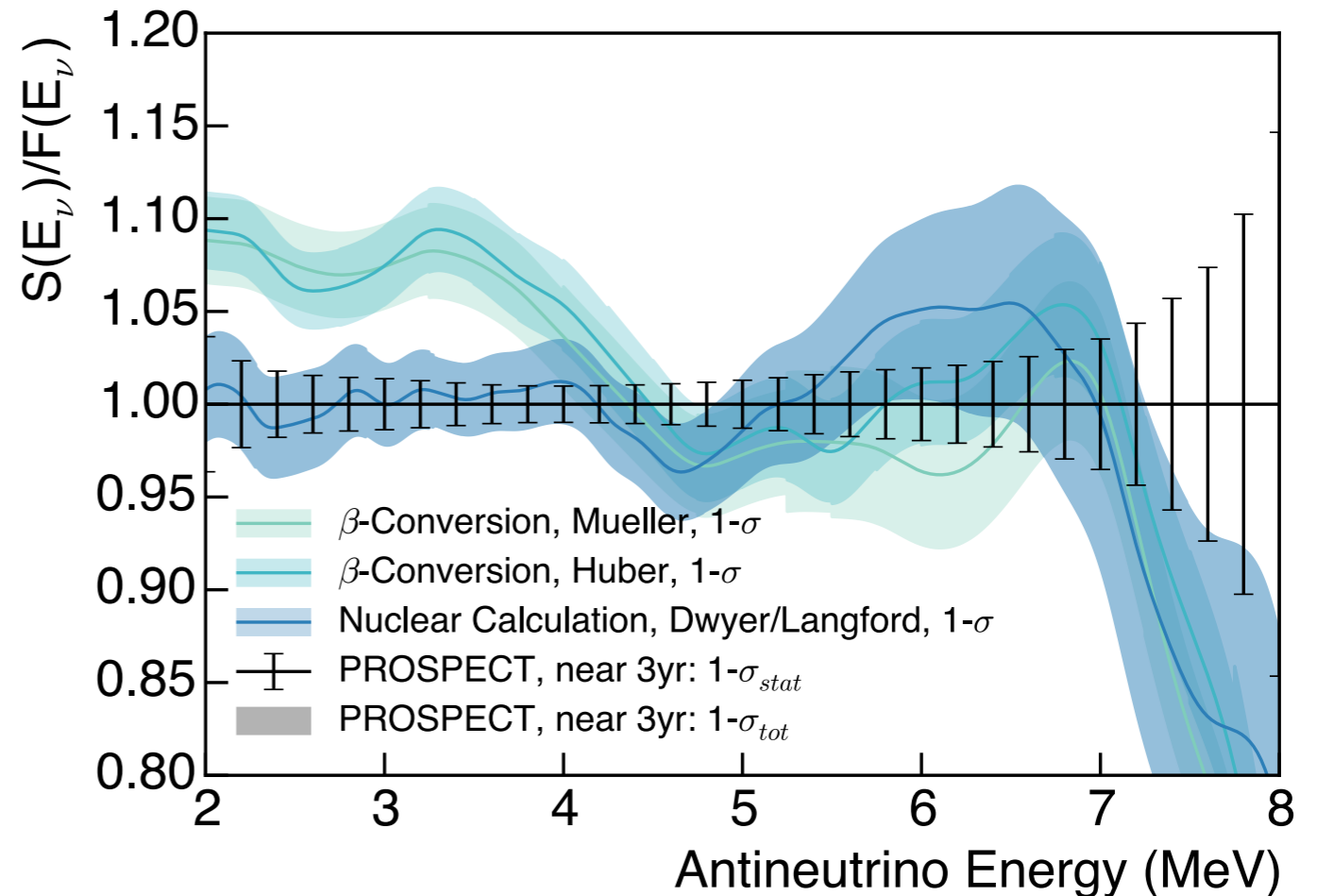
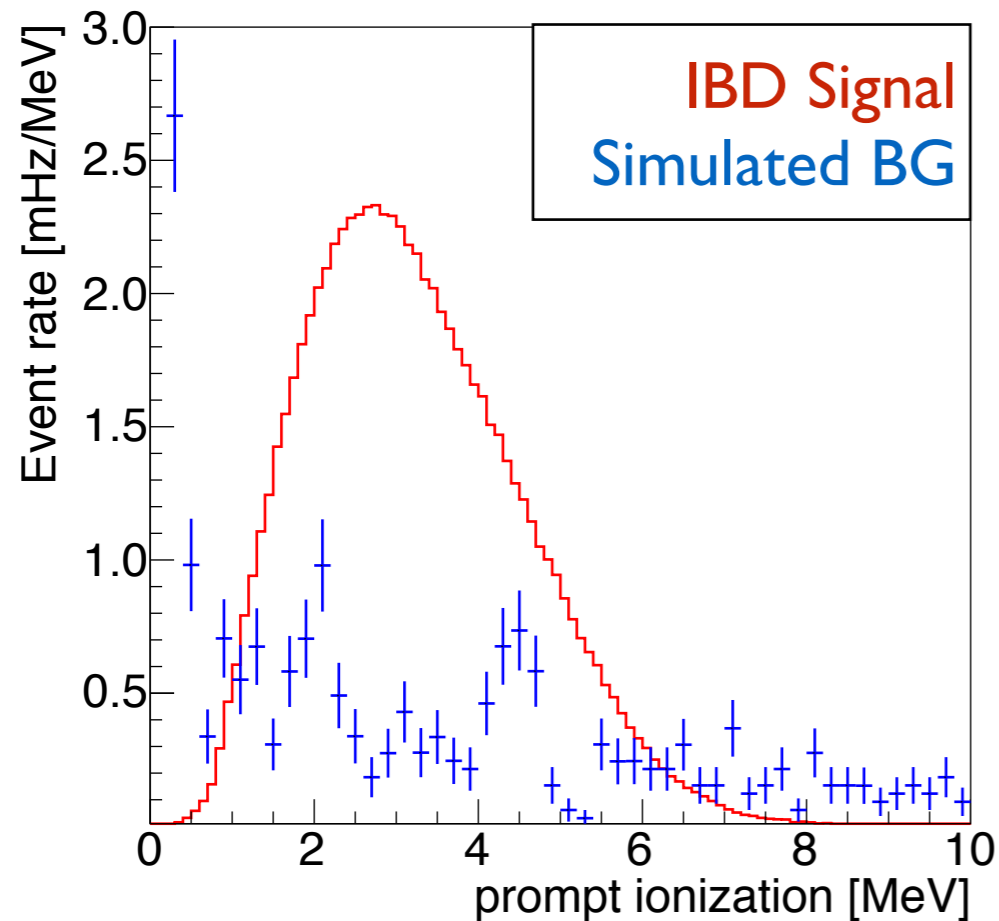
PROSPECT-20 Paper arXiv:1508.06575

Operation of PROSPECT-20 at HFIR



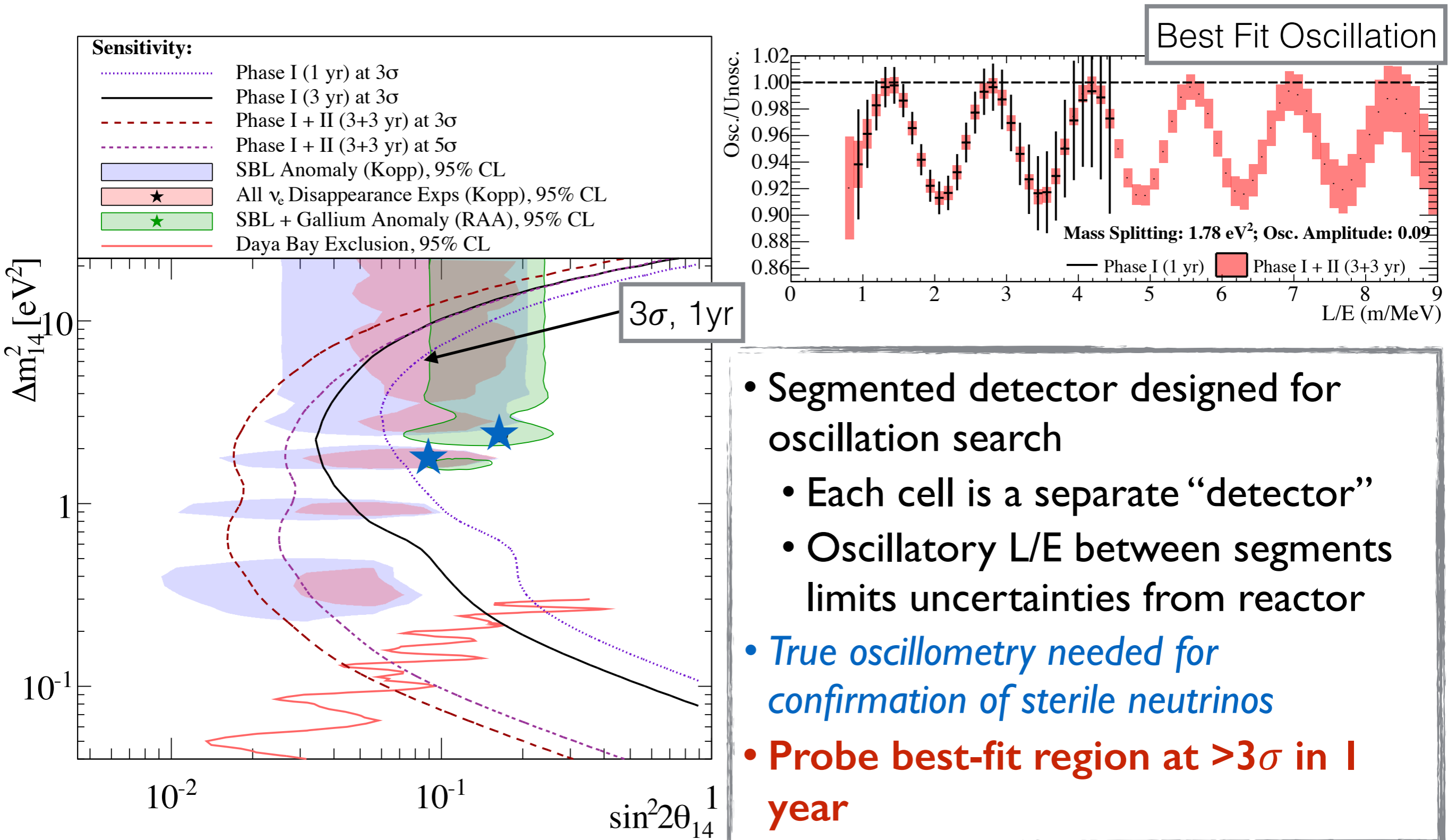
- Operated for four months at HFIR
 - Two HFIR cycles
- Shielding package roughly 25% mass of full shield
- **Reactor-related backgrounds mitigated**
 - Targeted local shielding
 - Active background rejection with LiLS
- **Validation of background simulations for full PROSPECT detector**





- Simulated Signal/Background > 1 , validated by PROSPECT-20 at HFIR
- ~ 1000 inverse beta decays detected per day, 100k/year
- Best energy resolution of any reactor neutrino experiment (4.5% @ 1 MeV)
- **Phase-I precision will surpass spectral model uncertainties**
 - Directly test reactor neutrino models
 - Produce a benchmark spectrum for future reactor experiments

Short Baseline Oscillation Search PROSPECT



- Segmented detector designed for oscillation search
 - Each cell is a separate “detector”
 - Oscillatory L/E between segments limits uncertainties from reactor
- *True oscillometry needed for confirmation of sterile neutrinos*
- **Probe best-fit region at $>3\sigma$ in 1 year**

- PROSPECT is designed to probe new physics at short-baselines
- Backgrounds have been characterized and test cells deployed at HFIR
- Design light collection and PSD performance validated by full-scale test cell
- **PROSPECT will cover the sterile neutrino best fit region at 3σ within its first calendar year**
- **PROSPECT will measure the ^{235}U spectrum with the highest precision to-date**

Yale W&M



HIGH FLUX ISOTOPE REACTOR



ILLINOIS INSTITUTE OF TECHNOLOGY



Publications: arXiv: 1309.7647, 1506.03547, 1508.06575

<http://prospect.yale.edu>