

Yale

PROSPECTS FOR AN IMPROVED  
PROSPECT-II

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*DNP2021 - Boston MA*



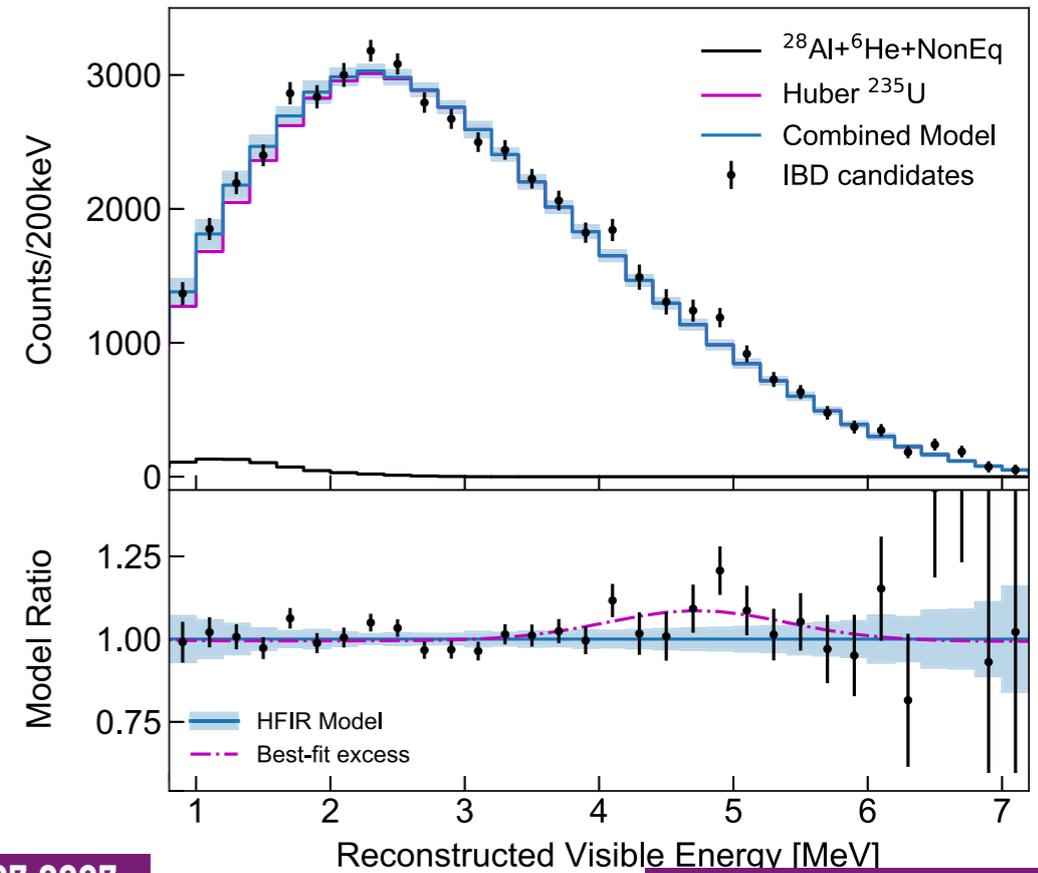
Wright  
Laboratory

# RECENT PROSPECT-I RESULTS

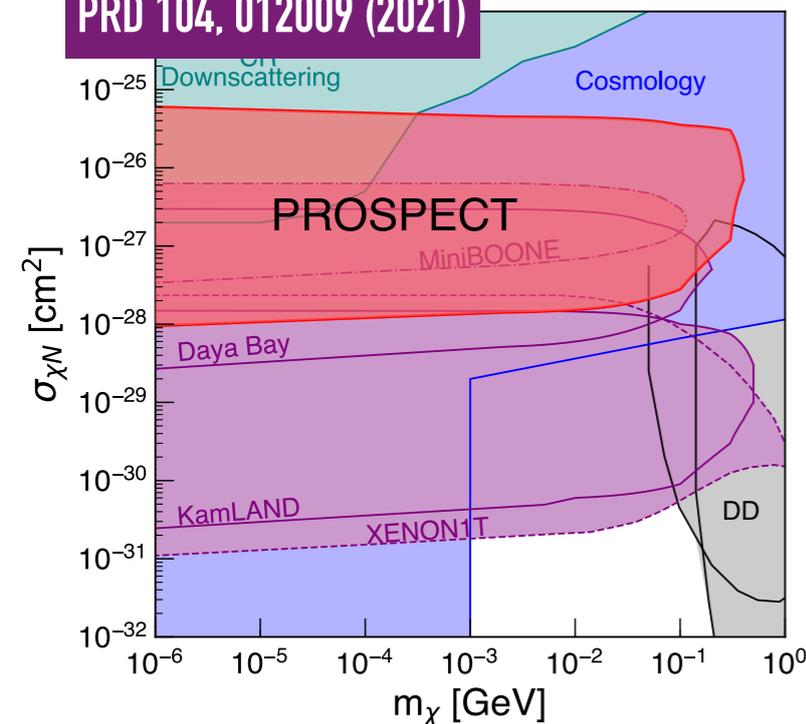
## PROSPECT achieved its main physics goals

- ▶ 50k IBDs detected at ~8m from HFIR, with S:B > 1
- ▶ Search for short baseline oscillations excludes the RAA best-fit at  $2.5\sigma$
- ▶ 5MeV spectral distortion best-fit amplitude of  $0.84 \pm 0.39$  relative to Daya Bay, excludes "all- $^{235}\text{U}$ " and "no- $^{235}\text{U}$ " bump hypotheses at  $>2\sigma$

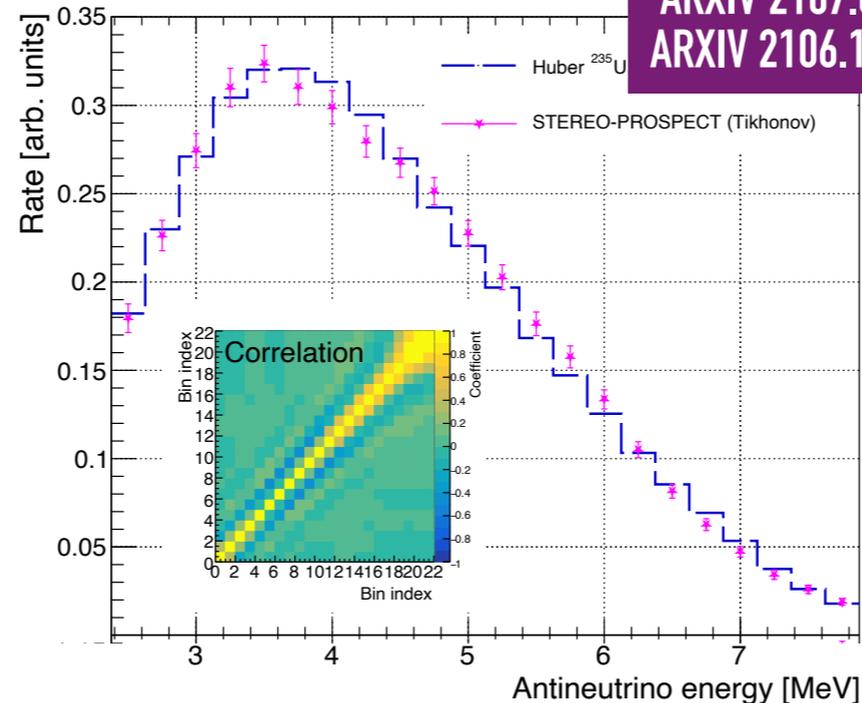
*Extended physics impact through joint analyses and search for boosted dark matter*



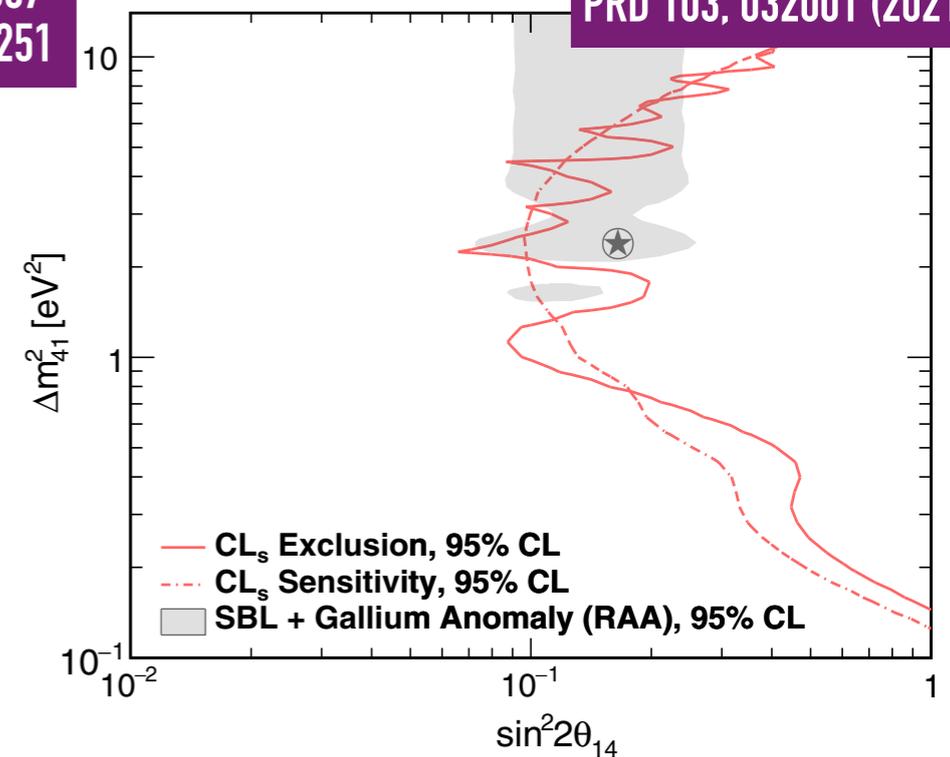
PRD 104, 012009 (2021)



ARXIV 2107.0337  
ARXIV 2106.12251



PRD 103, 032001 (2021)



## Inspired by PROSPECT's success, there are new and expanded physics questions within reach

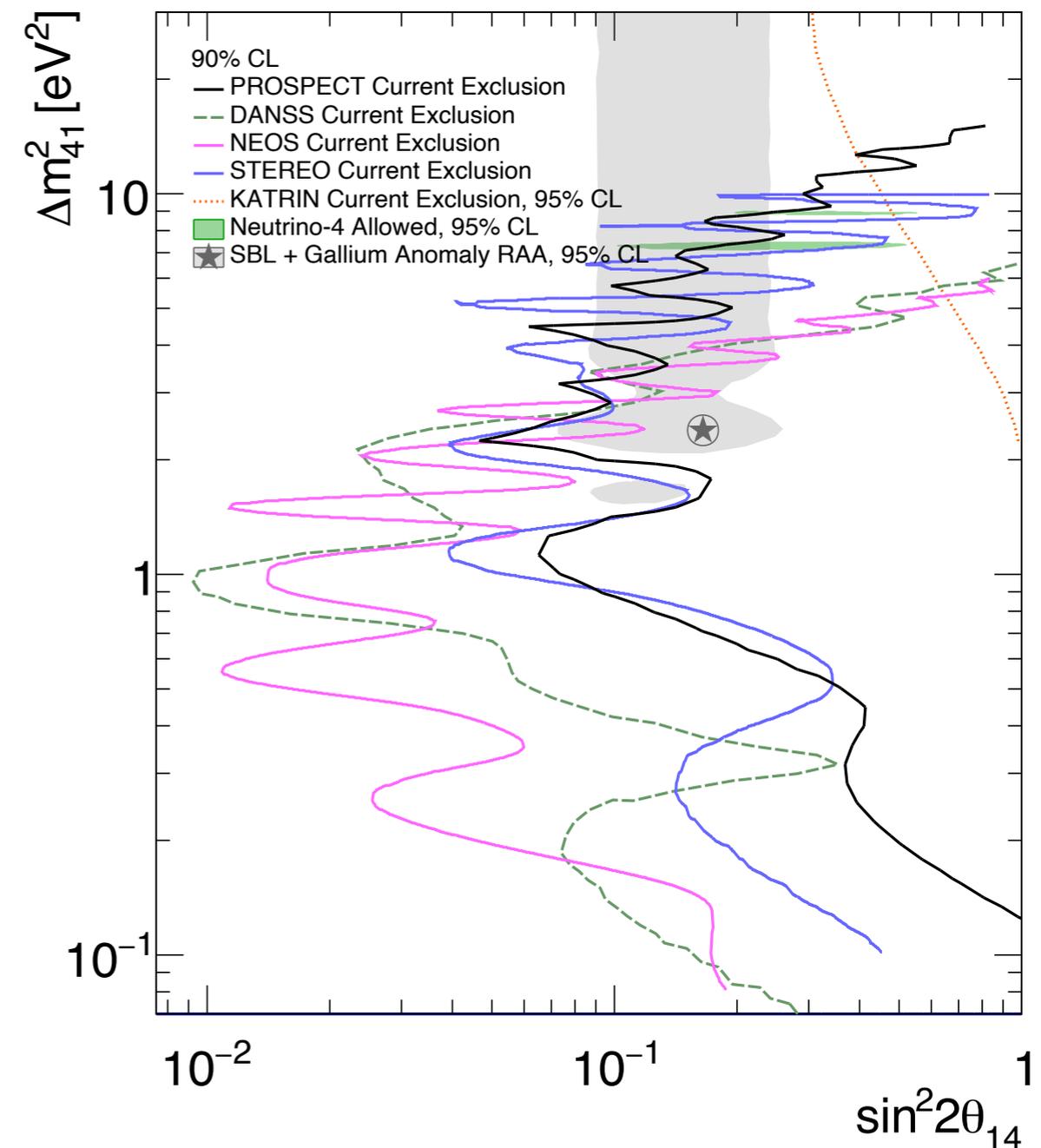
- ▶ Could there be sterile neutrinos hiding in the last remaining RAA allowed region?
- ▶ Are there sterile neutrinos beyond the RAA that could challenge the interpretation of DUNE and LBL experiments?
- ▶ What is the isotopic dependence of the spectral distortion?
- ▶ What is the absolute flux of neutrinos from  $^{235}\text{U}$ ?

*The PROSPECT collaboration has developed a refined detector design and run-plan to go after these questions*

*Detailed Physics paper on arXiv ([2107.03934](https://arxiv.org/abs/2107.03934)) and submitted to J Phys G*

- ▶ Many experiments have probed various parts of the RAA favored region
  - ▶ Strong rejection of the best-fit point
  - ▶ Remaining parameter space at high- $\Delta m^2$
- ▶ Wide range of parameter space beyond RAA that is significant to interpretation of LBL oscillation experiments
- ▶ We have a technology that can probe this parameter space, we should go do it!

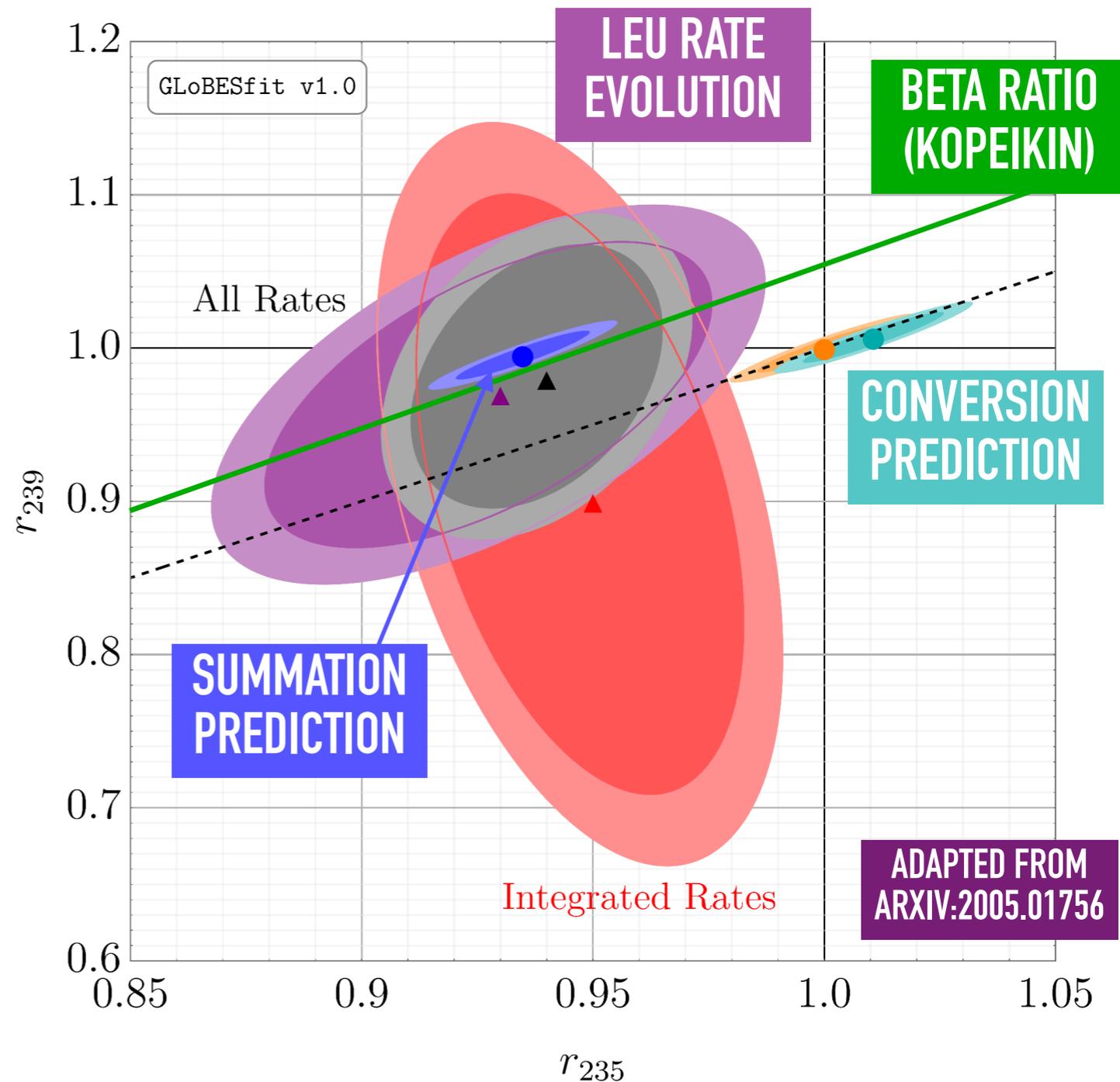
PROSPECT-II PHYSICS PAPER  
[2107.03934](#)



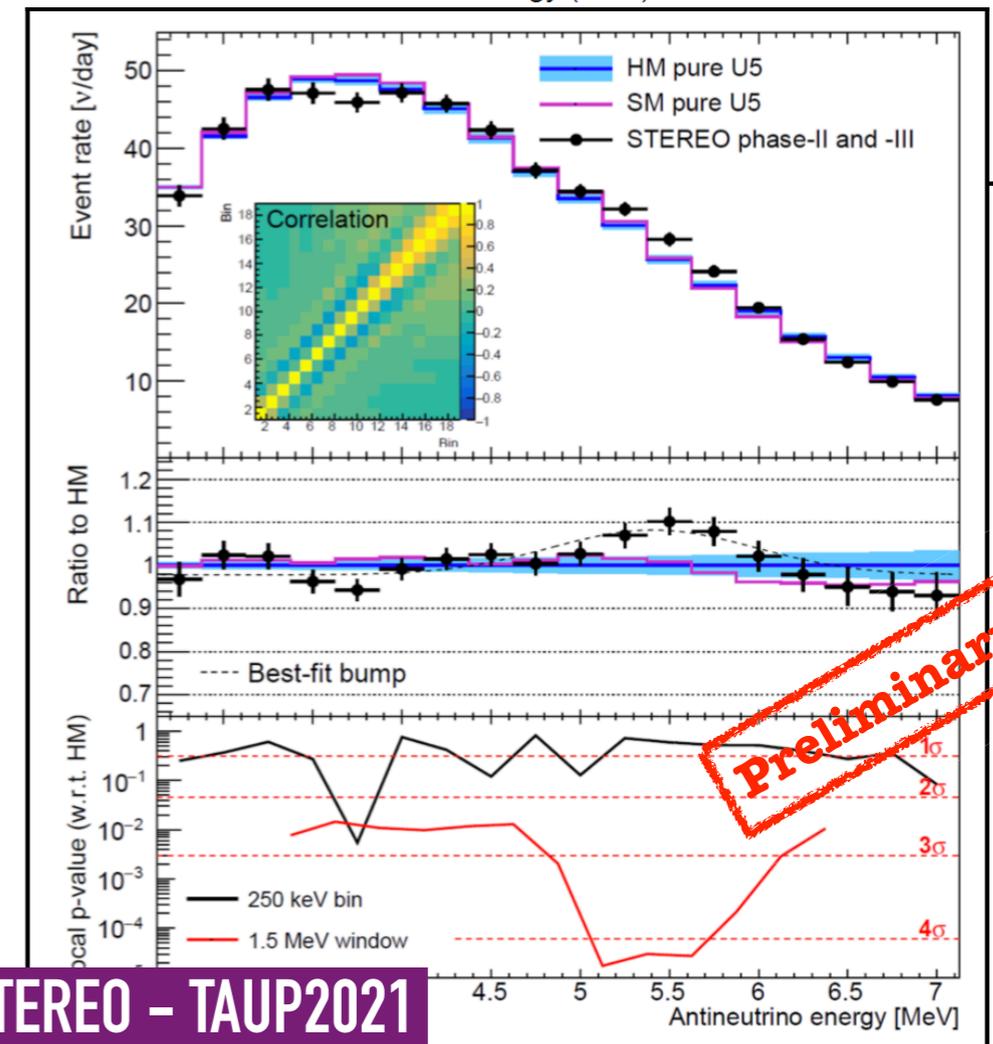
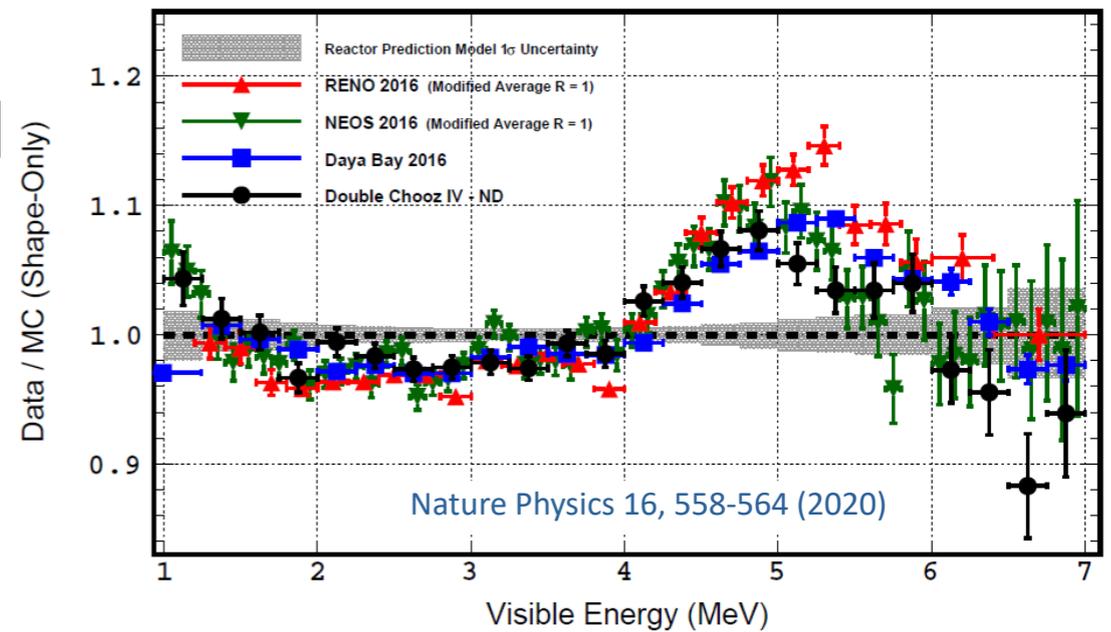
## Global picture forming points to problems with $^{235}\text{U}$ flux prediction

- ▶ HEU measurement from STEREO
- ▶ Time-evolution of LEU measurements from Daya Bay/RENO
- ▶ Recent beta measurements of  $^{239}\text{Pu}/^{235}\text{U}$  ratio (Kopeikin et al)
- ▶ New *ab-initio* summation predictions of reactor flux with improved decay data

*Doesn't rule out sterile neutrinos, but decreases RAA significance*



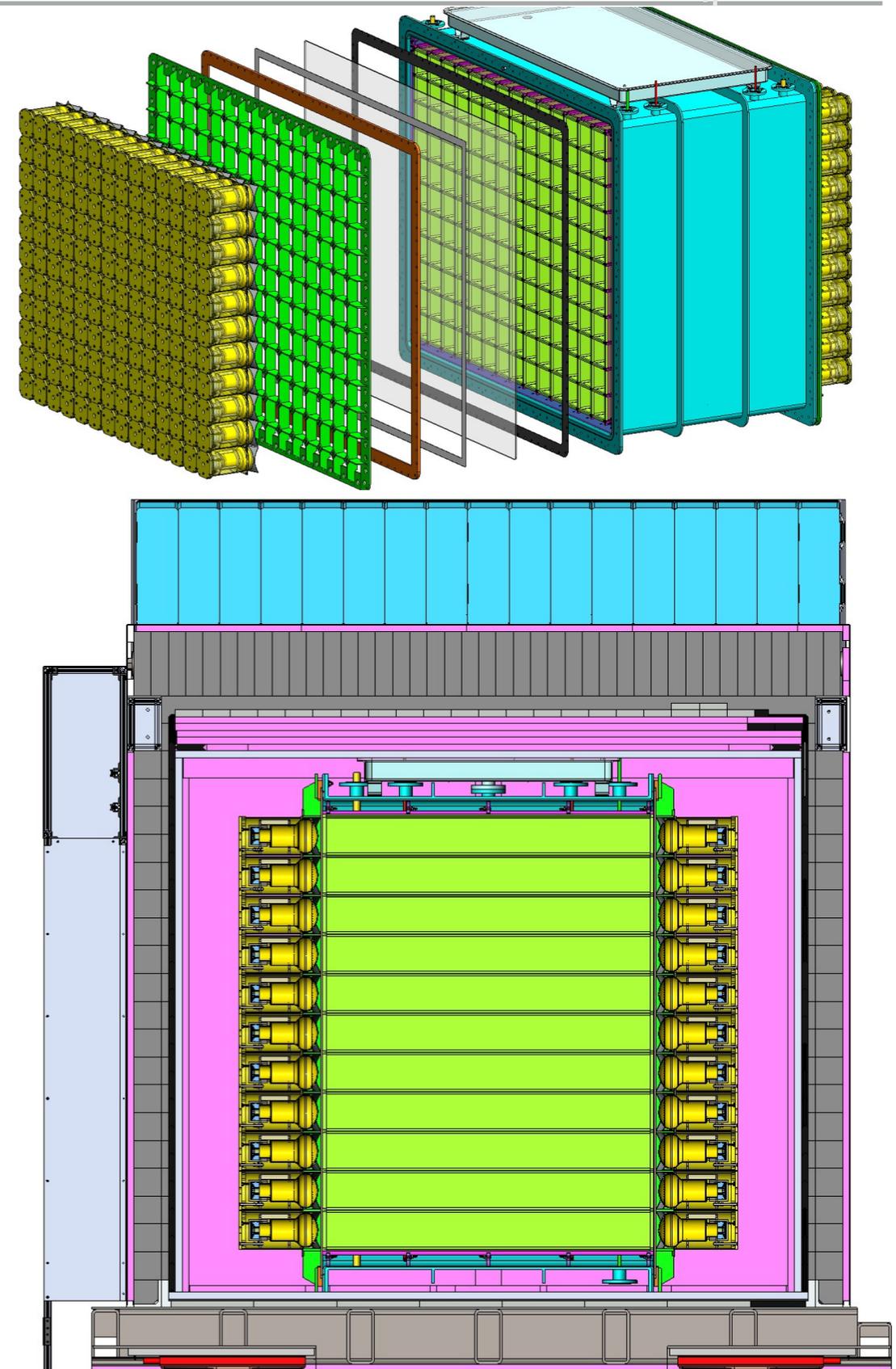
- ▶ Evidence from multiple experiments and reactor types that multiple isotopes are responsible for the spectral deviation
- ▶ Current experiments are limited in statistics or resolution to probe further than a Gaussian fit
- ▶ Isotopic dependence of the spectral deviation may illuminate which fission daughters are mis-modeled or have unexpected shape corrections
- ▶ Increased statistics and energy resolution can look for fine structure from individual beta-decays



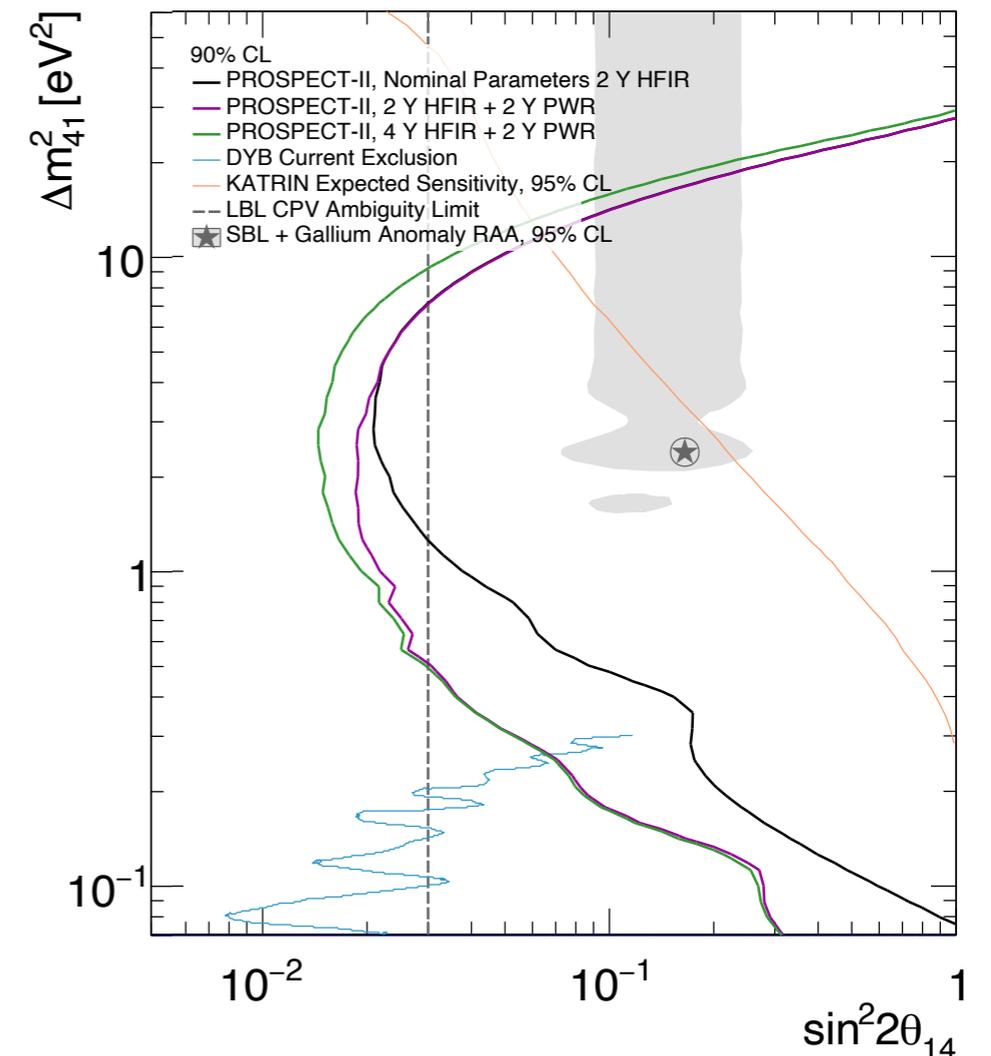
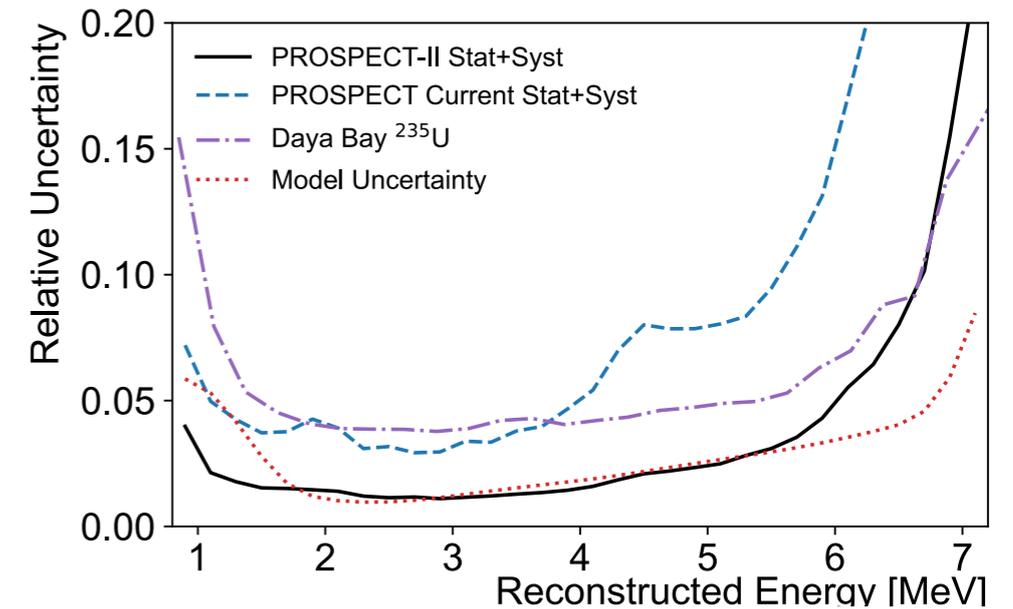
STEREO - TAUP2021

Preliminary

- ▶ PROSPECT-I demonstrated the power of a segmented PSD-capable LiLS detector
  - ▶ Excellent S:B, energy reconstruction, detection efficiency
- ▶ PROSPECT-II is designing a ruggedized detector to increase longevity and enable a multi-site deployment
  - ▶ Simplified internal structure
  - ▶ Increasingly hermetically sealed LS volume
  - ▶ Teflon-lined aluminum inner tank for increased strength
  - ▶ PMTs submerged in single MO volume
- ▶ *Mature design and in communication with vendors for key subsystems*



- ▶ **Oscillation:** Extend sensitivity to beyond the 'LBL CPV ambiguity limit'
- ▶ **Spectrum:** Surpass the model uncertainties for the majority of the antineutrino spectrum
- ▶ **Flux:** measure  $^{235}\text{U}$  flux from HFIR to  $\sim 2.5\%$
- ▶ **Primary run of two years operation at HFIR (10-14 cycles)**
  - ▶ 200k+ IBD events 7.9m from reactor core, S:B = 4
- ▶ **Move to LEU reactor, two additional years operation**
  - ▶ 200k+ IBD events 25m from reactor core, S:B  $\sim 20$
- ▶ Combined analysis enhances both primary physics goals
  - ▶ Oscillation sensitivity extended to lower  $\text{dm}^2$  from longer baseline
  - ▶ Spectrum measurement at different reactor gives powerful probe of spectral isotopic dependence
  - ▶ Flux measurements at both reactors yield unambiguous measure of the isotopic antineutrino yield



- ▶ PROSPECT was a pathfinder experiment that successfully demonstrated surface-based reactor physics
- ▶ Delivered on primary and side analyses in a rapid timescale
- ▶ This success opens the door to an expanded physics program for oscillation, spectrum, and an absolute flux measurement
- ▶ PROSPECT-II's mature detector design builds upon these lessons to increase robustness and enable multiple site deployments
- ▶ Detailed PROSPECT-II paper on arXiv ([2107.03934](https://arxiv.org/abs/2107.03934))



### Funding provided by:



16 Institutions, 73 collaborators

