

# COHERENT: An Update

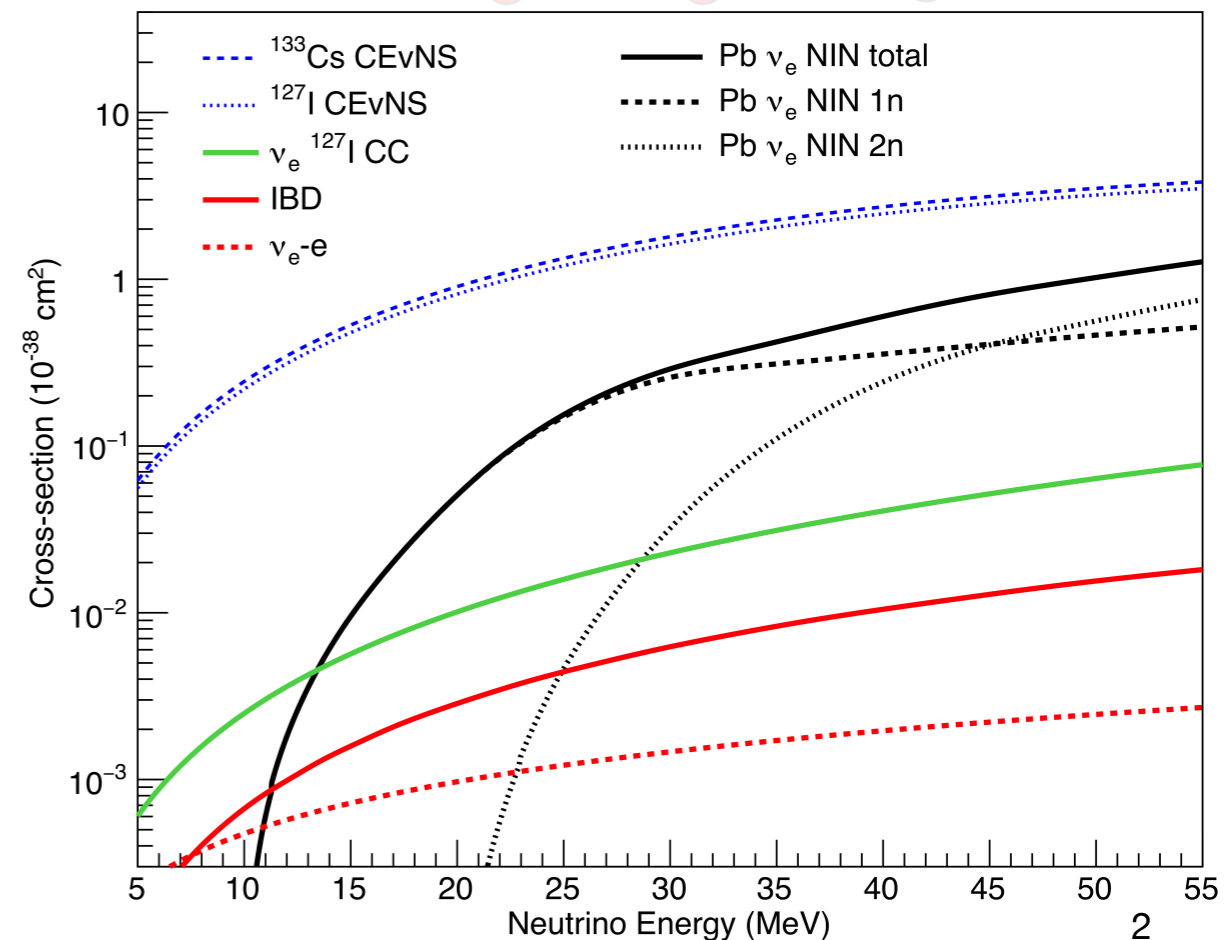
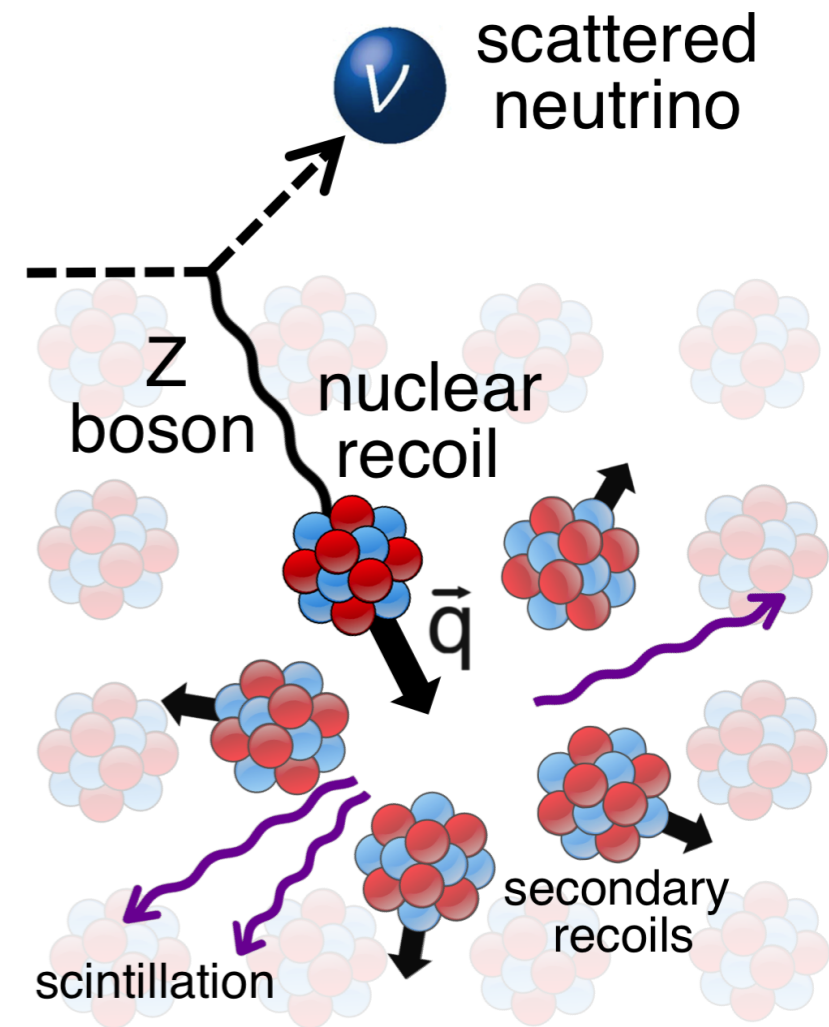


Phil Barbeau  
(he/him/his)

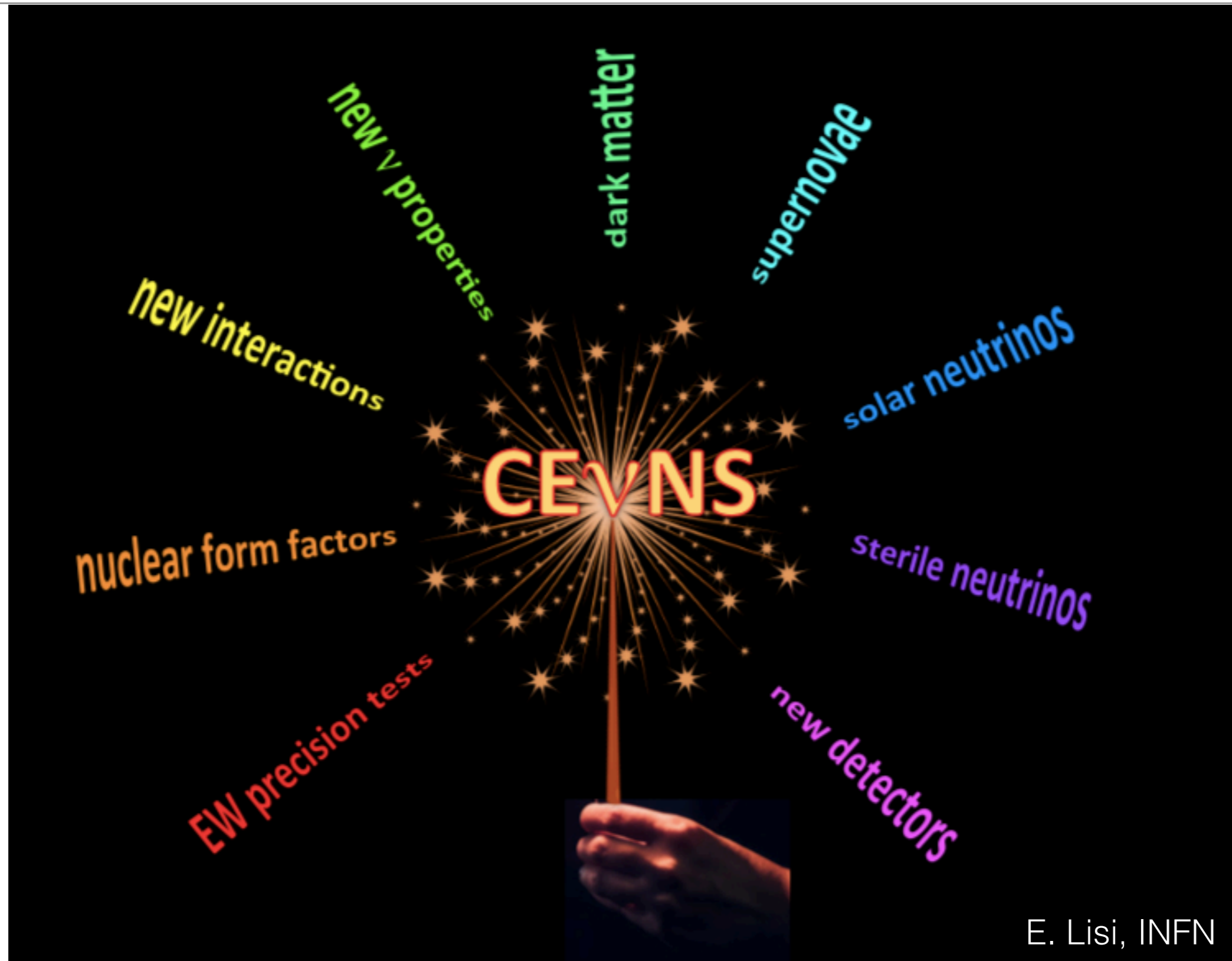


# Coherent $\nu$ -Nucleus Scattering

- 46 years ago, Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) was predicted with the realization of the neutral weak current. D. Z. Freedman, PRD 9 (5) 1974
- Neutrino scatters coherently off all Nucleons  $\rightarrow$  cross section enhancement:  
 $\sigma \propto N^2$
- Initial and final states must be identical:  
Neutral Current elastic scattering
- Nucleons must recoil in phase  $\rightarrow$  low momentum transfer  $qR < 1 \rightarrow$  very low energy nuclear recoil



# The Global CEvNS (“sevens”) Research Program

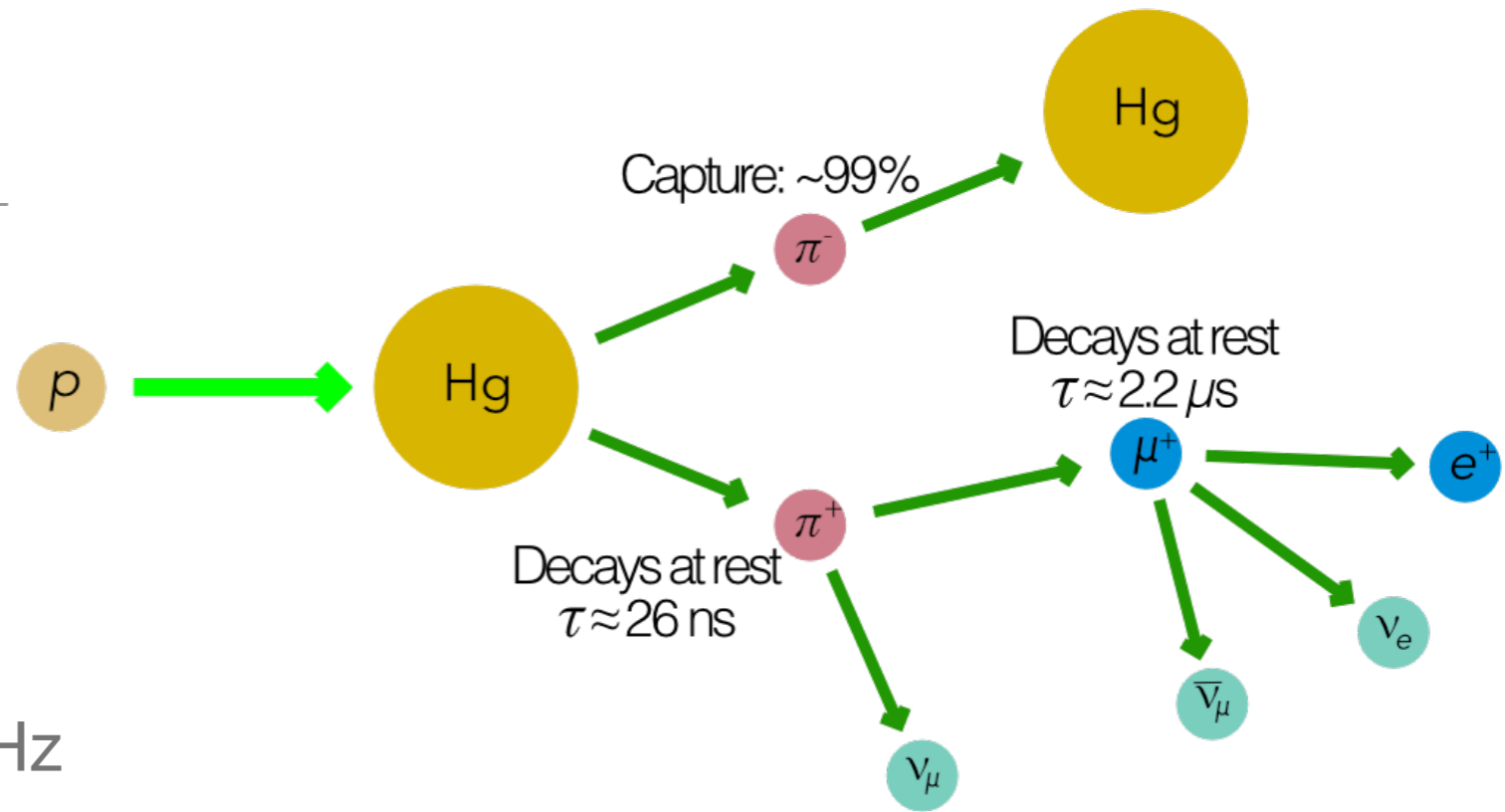


# The HERENT Collaboration



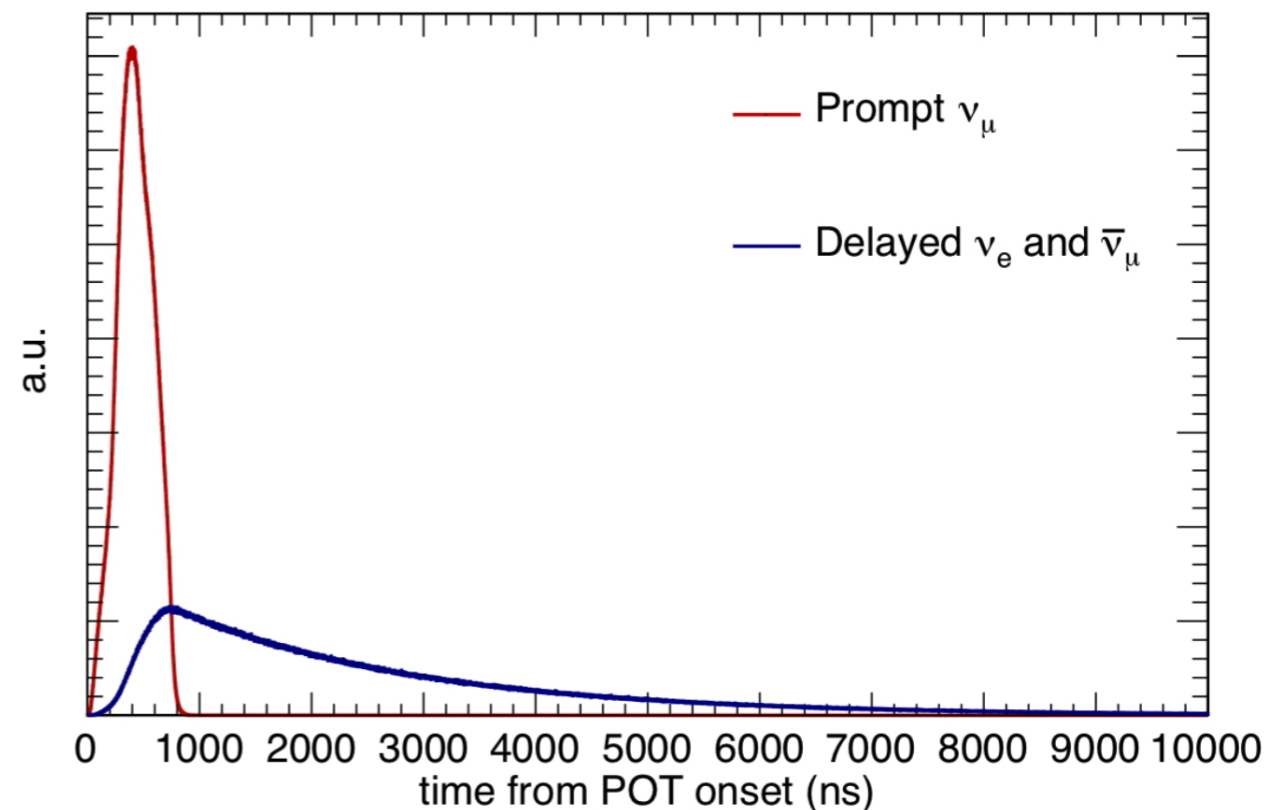
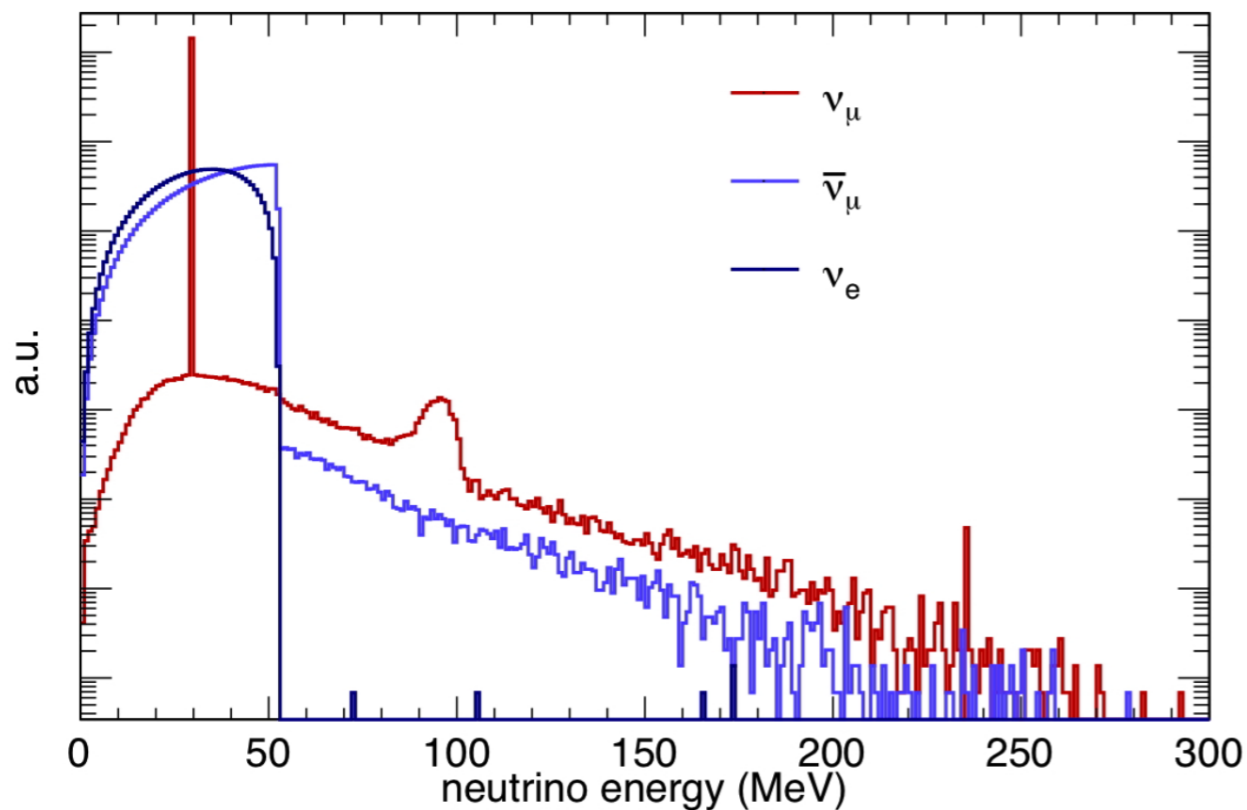
# The Spallation Neutron Source

- Pion Decay-at-Rest Neutrino Source
- $\nu$  flux  $4.3 \times 10^7 \nu \text{ cm}^{-2} \text{ s}^{-1}$  at 20 m
- Pulsed: 800 ns full-width at 60 Hz

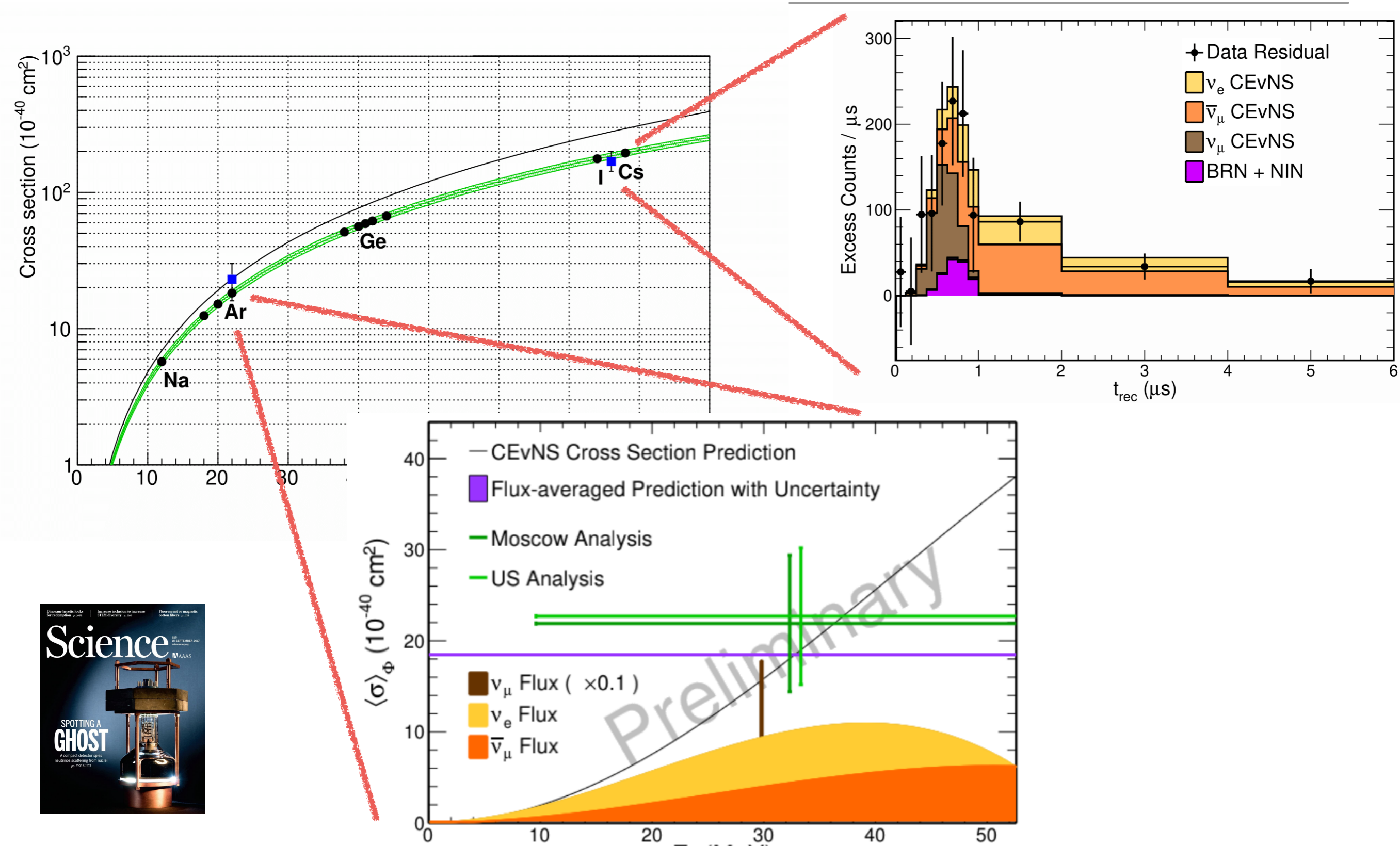


**<1% contamination from non-CEvNS scatters**

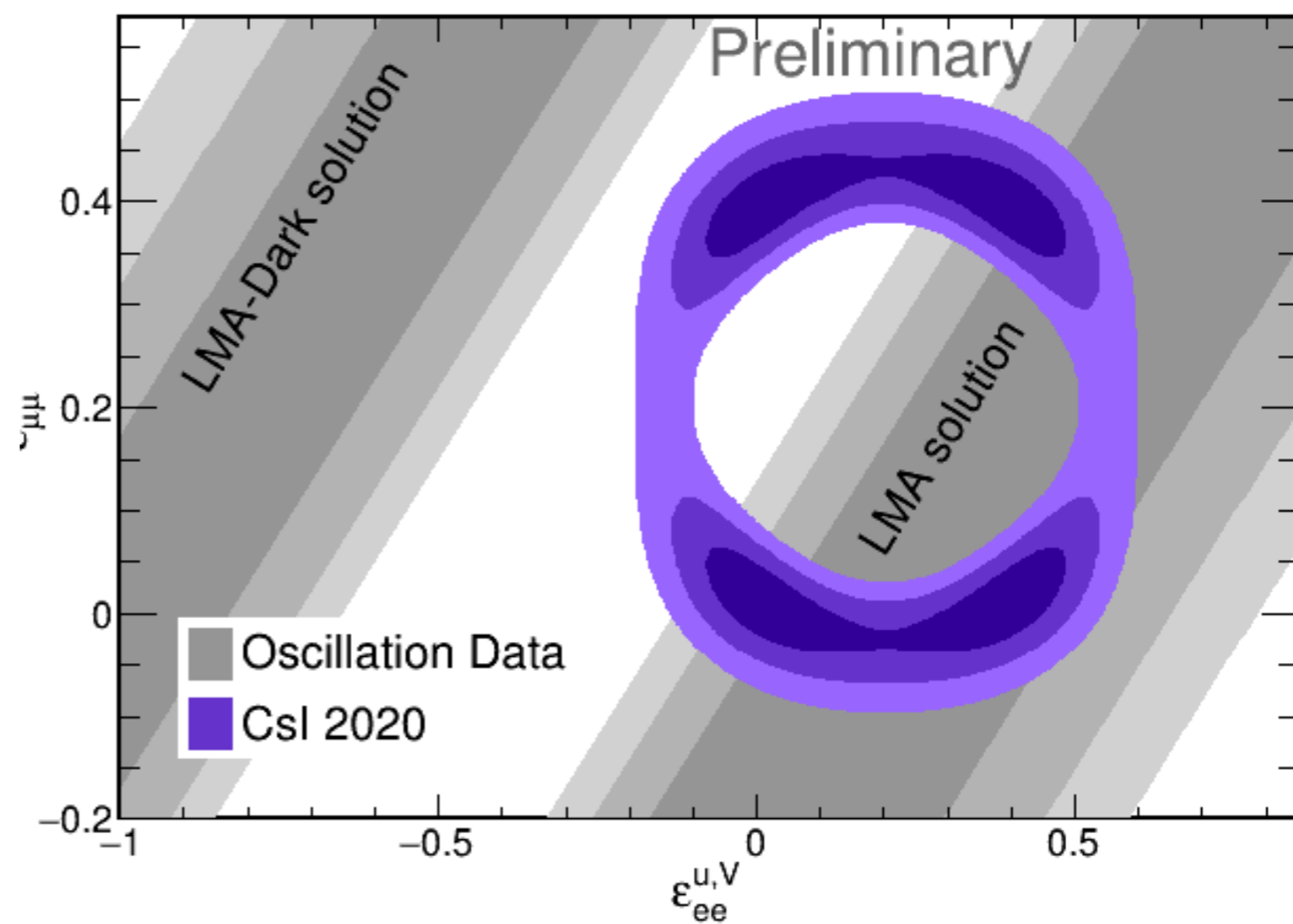
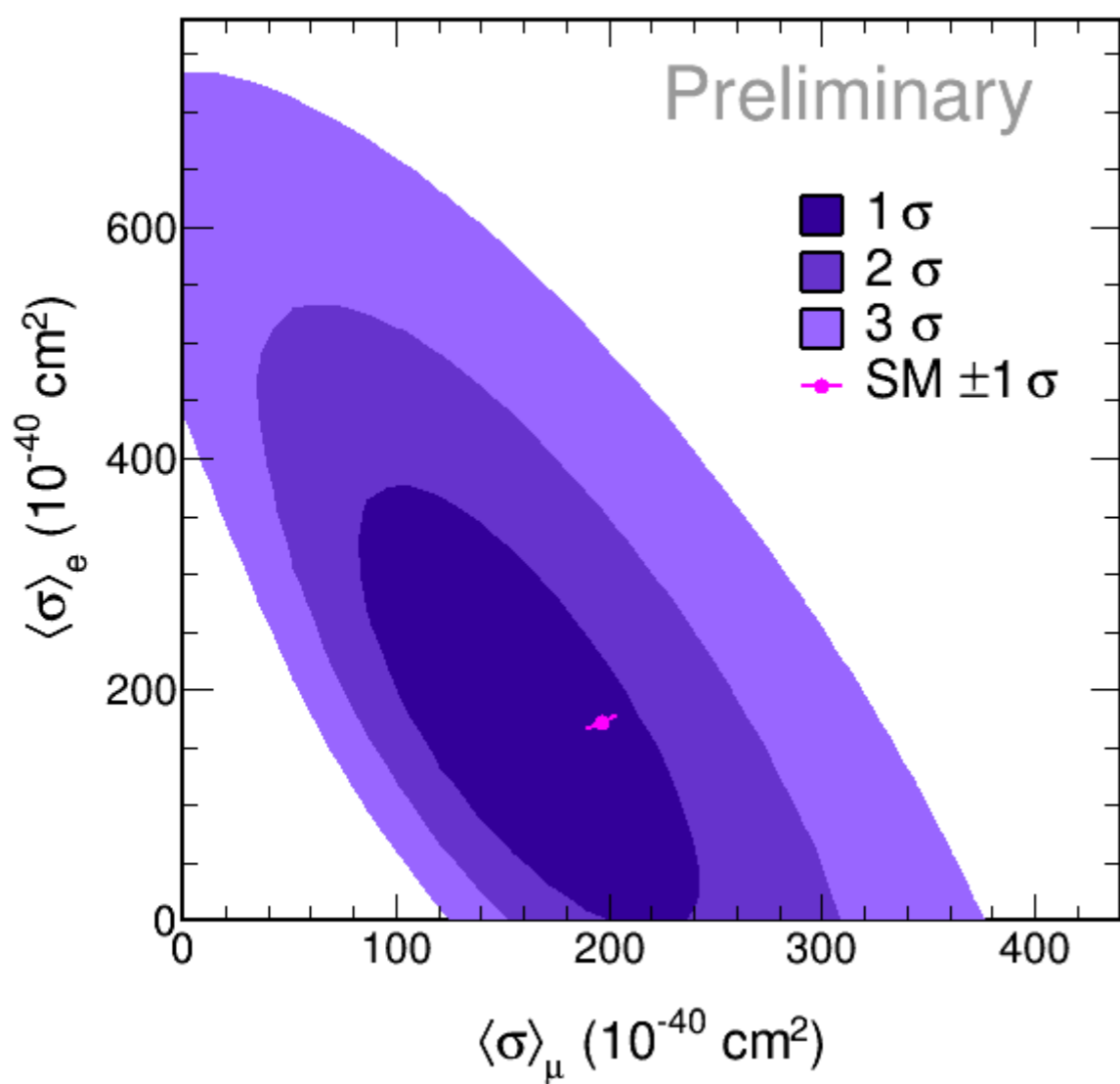
**$\sim 4 \times 10^{-5}$  background reduction**



# COHERENT CEvNS Measurements So Far



# Improved NSI



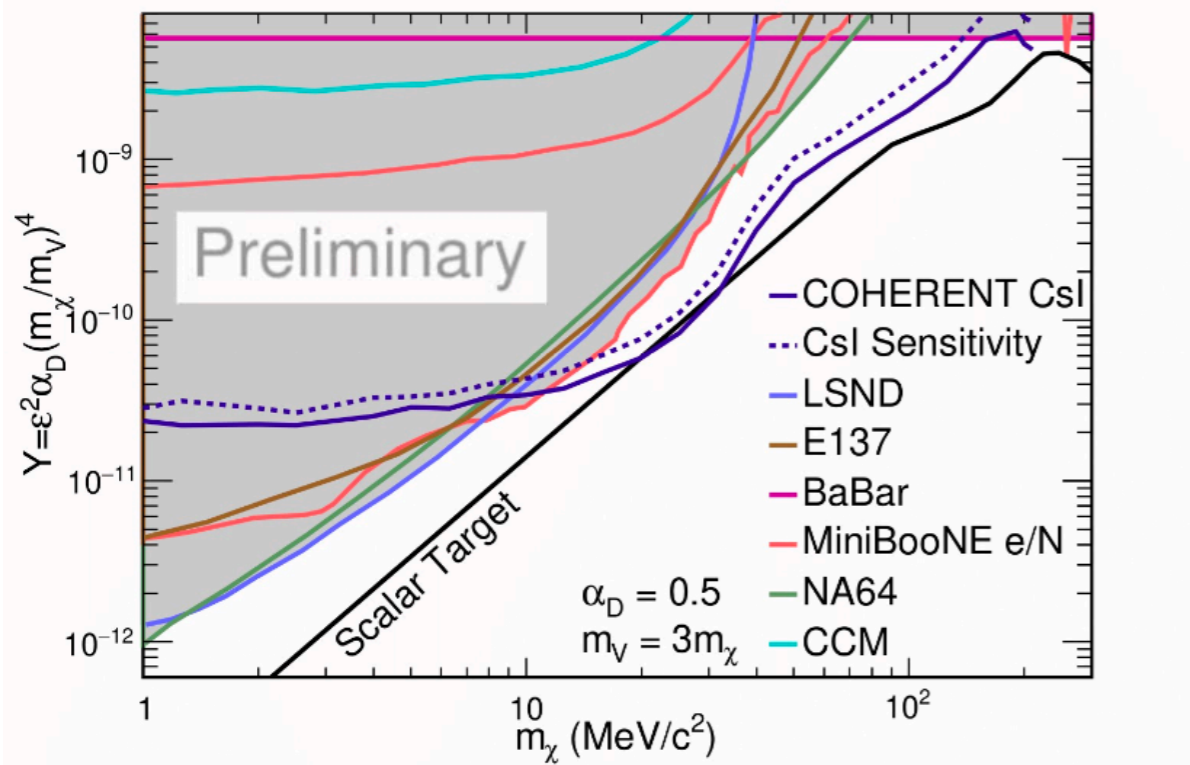
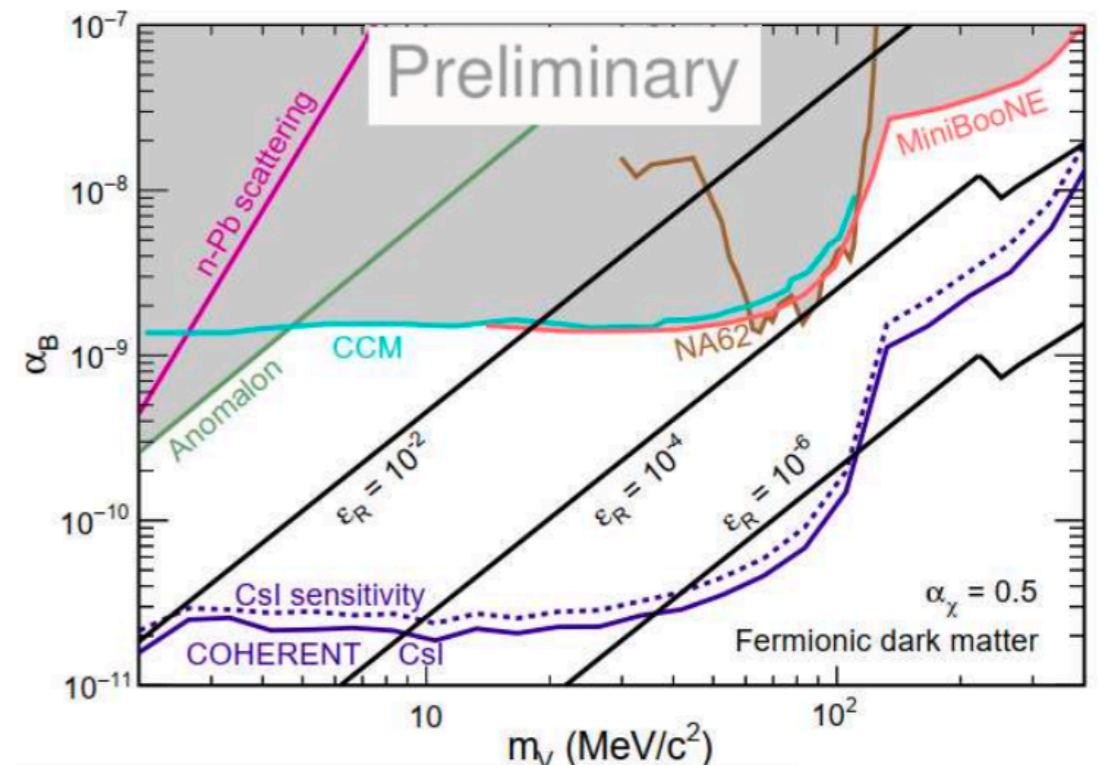
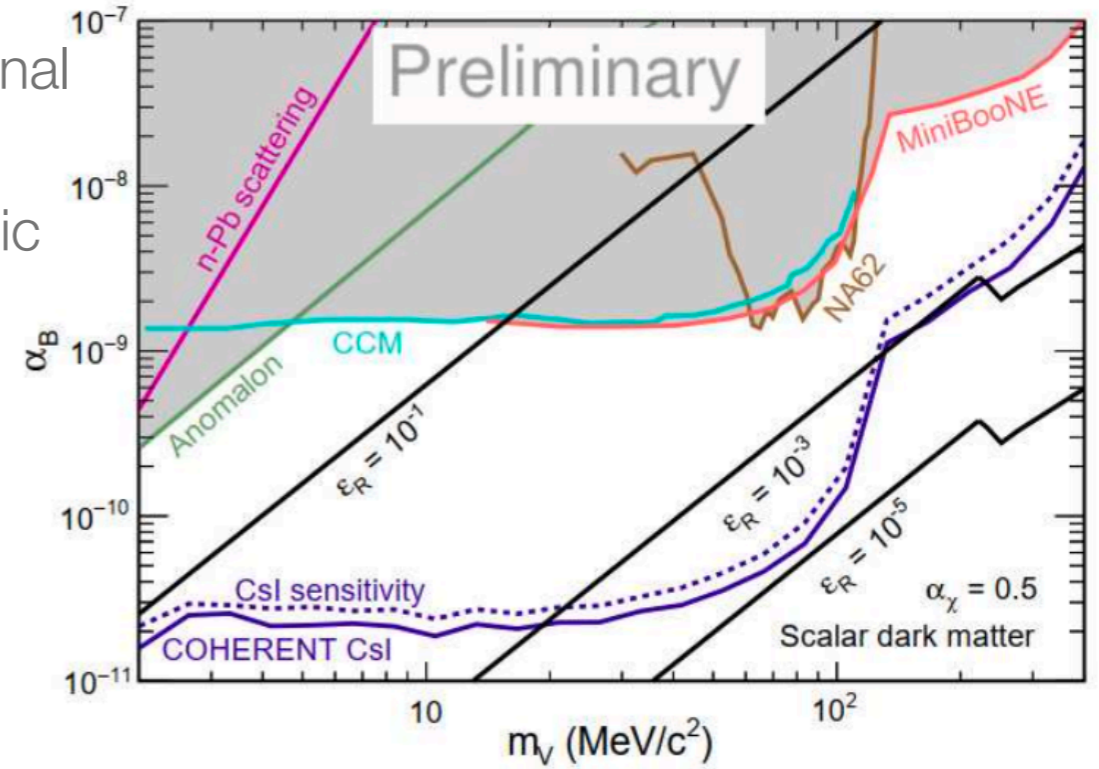
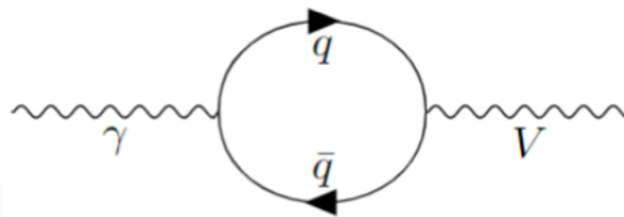
# Constraints on Sub-GeV Dark Matter

- Searching for DM in the SNS beam on top of CEvNS signal
- First probe beyond the scalar target that matches the relic abundance
- Also searches for Leptophobic Dark Matter

General kinetic mixing:

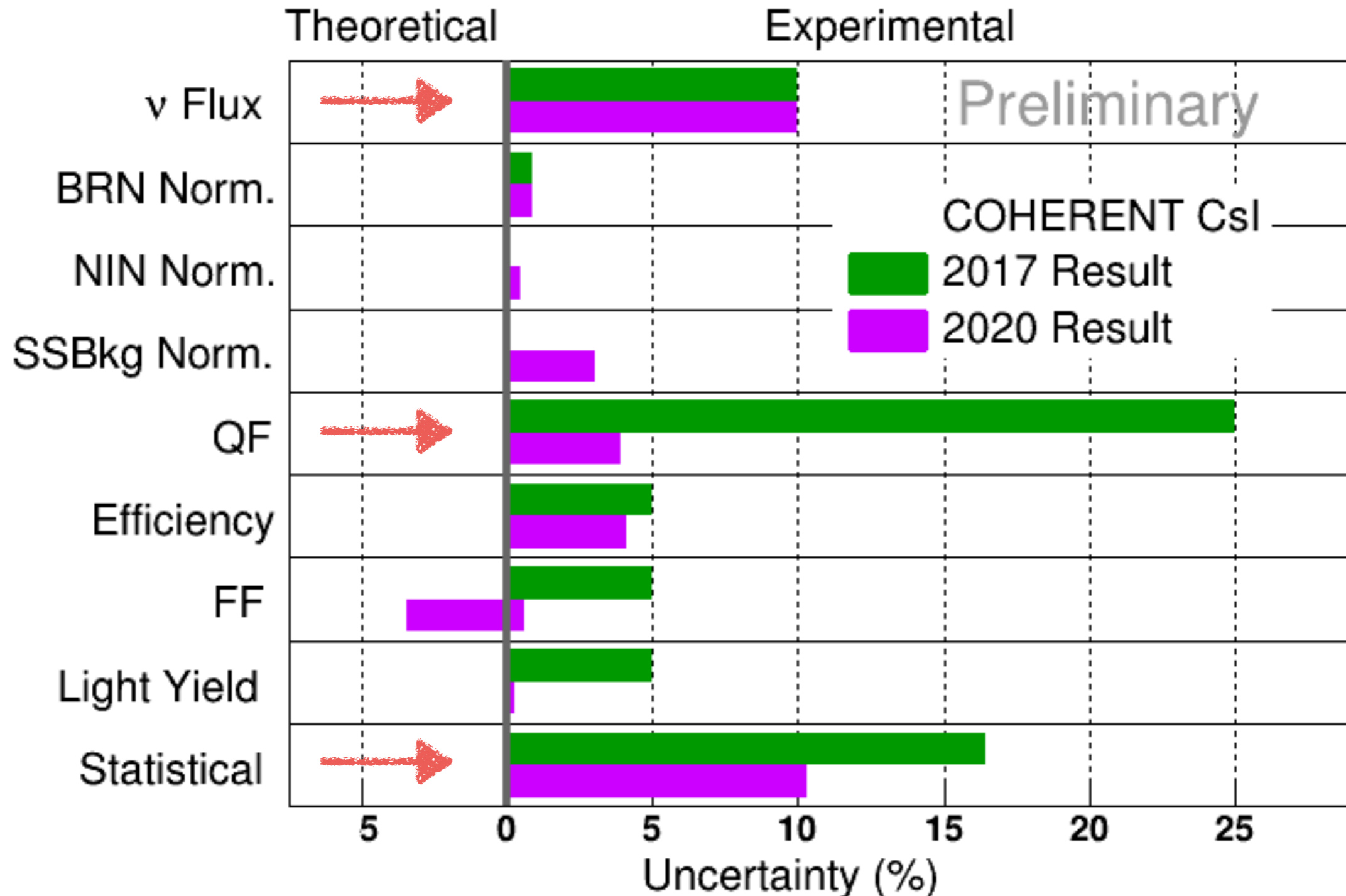


Leptophobic dark matter:

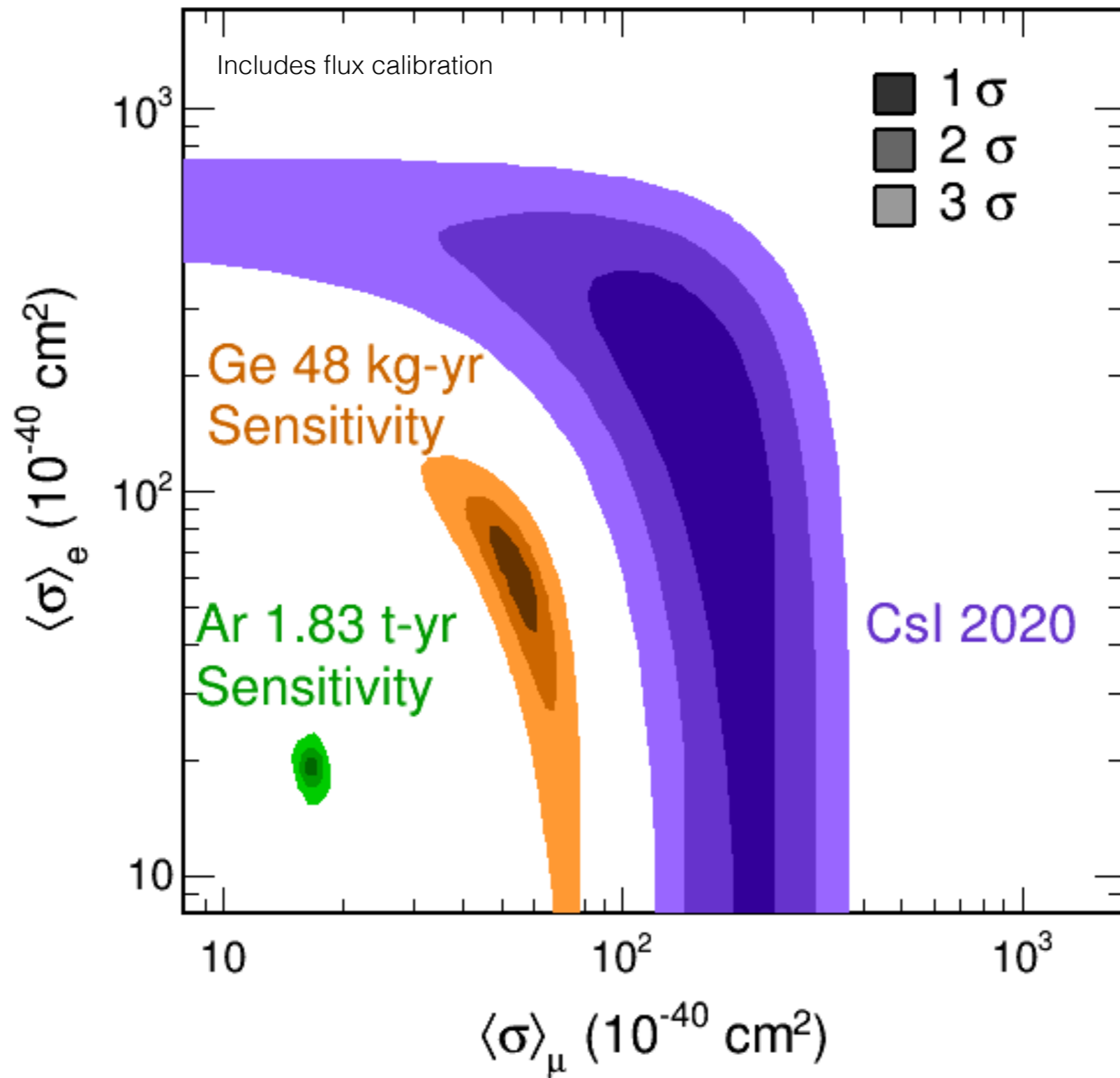




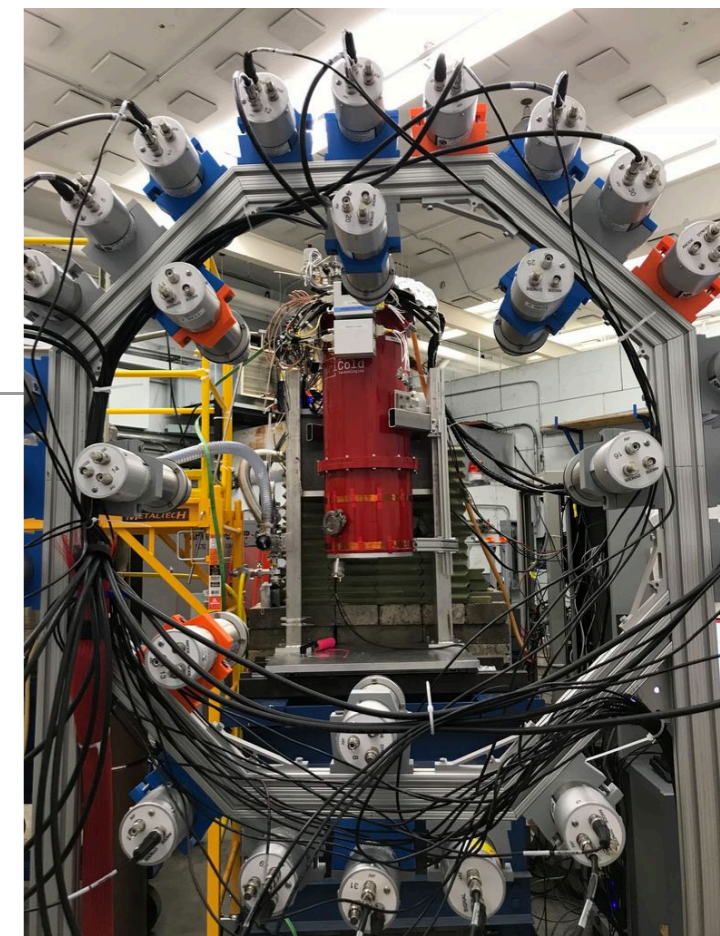
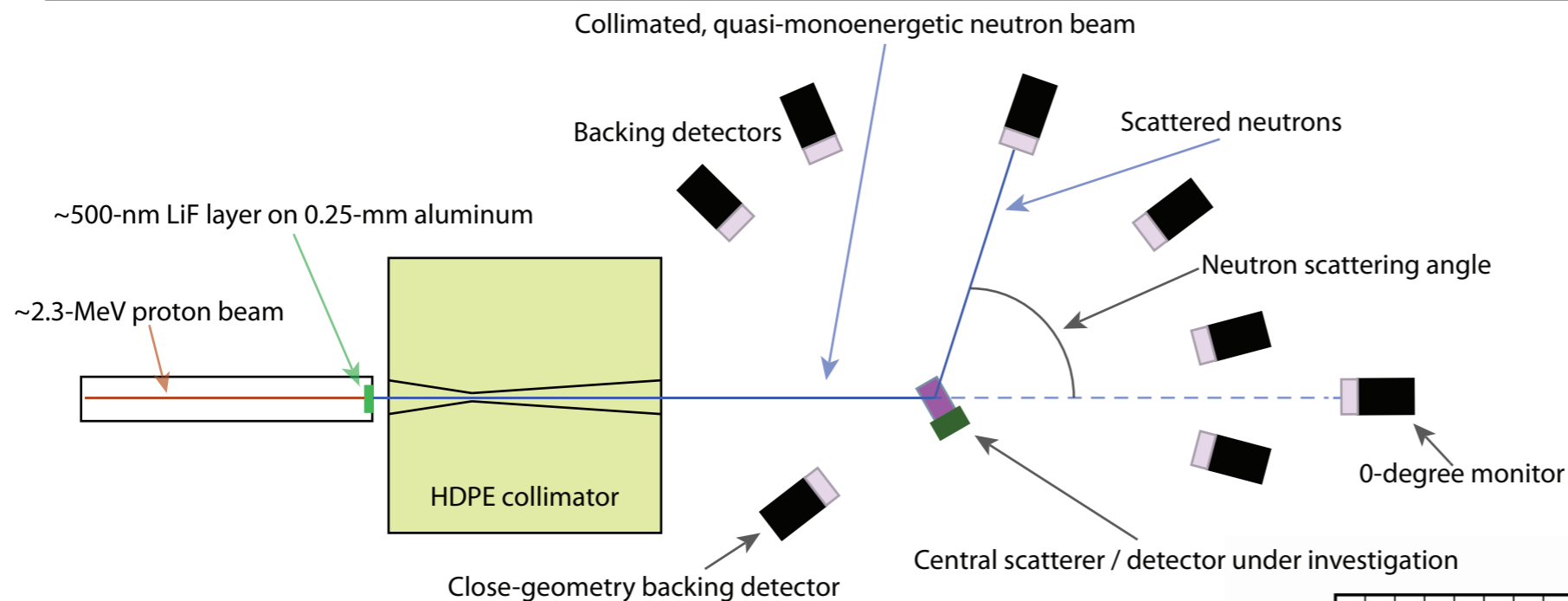
# New CsI[Na] Analysis — Error Budget



# Improving the Precision: Future Sensitivity



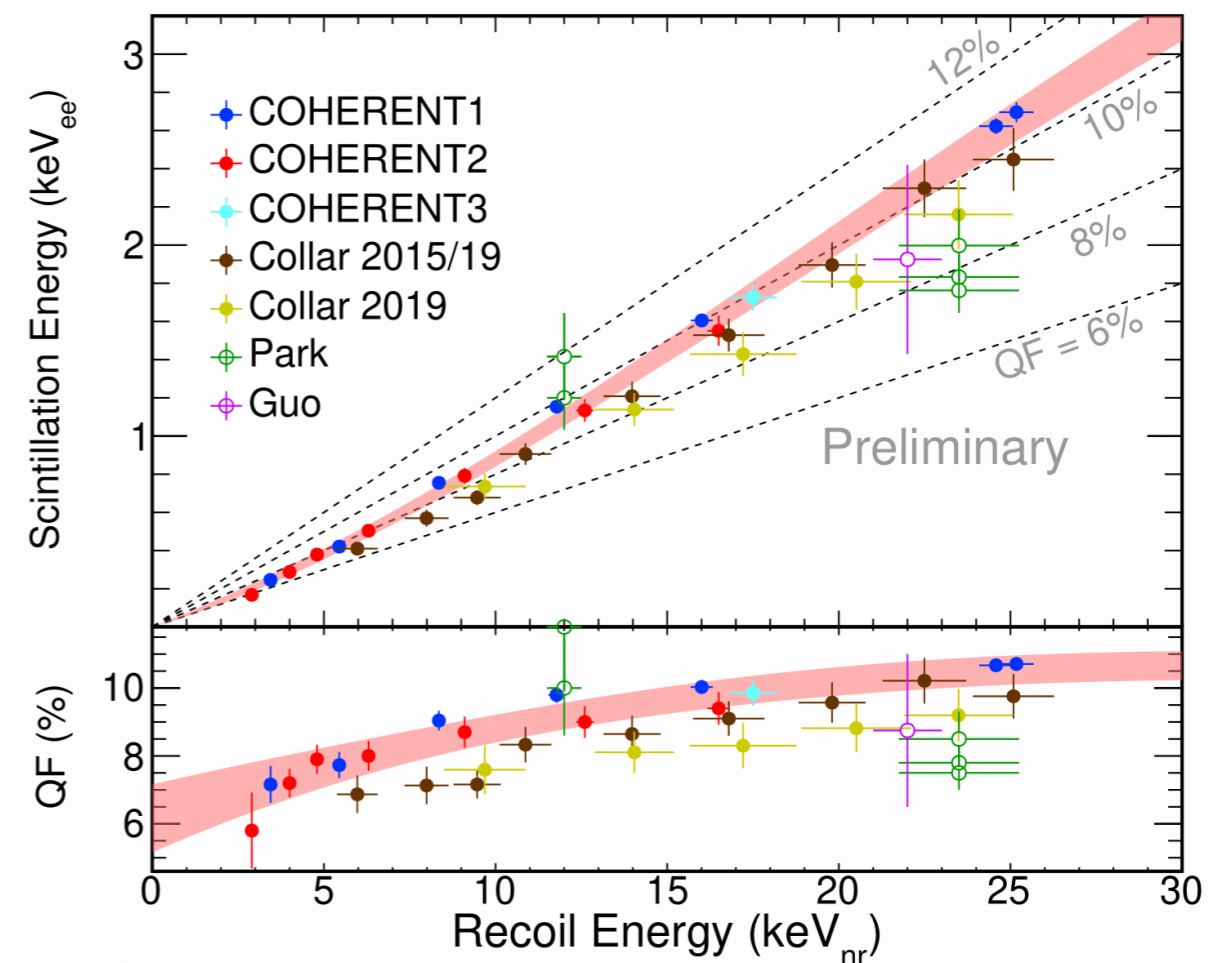
# Improving the Precision: Quenching Factor



CsI[Na]

Facility also used for:

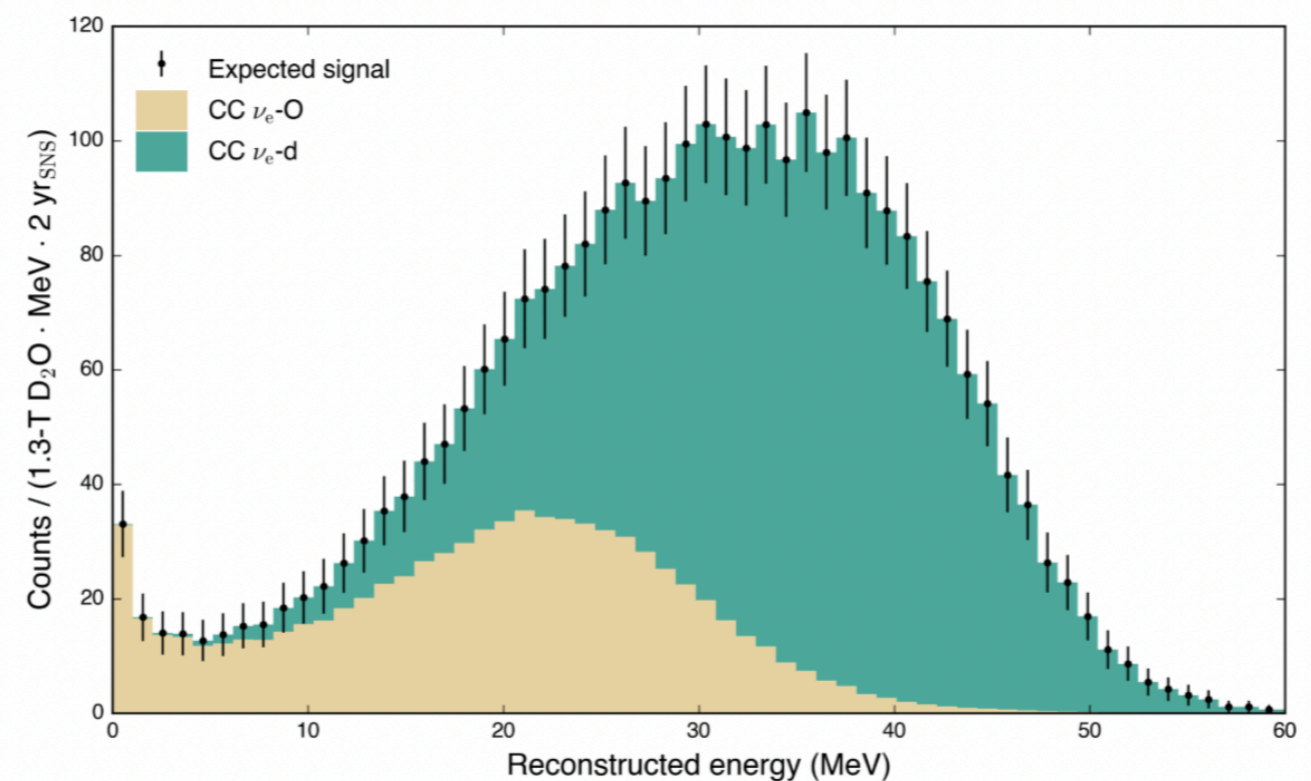
- Ge, Si, LXe, GNe, GHe, NaI(Tl), EJ-301, Stilbene (Channeling), MicroCHANDLER



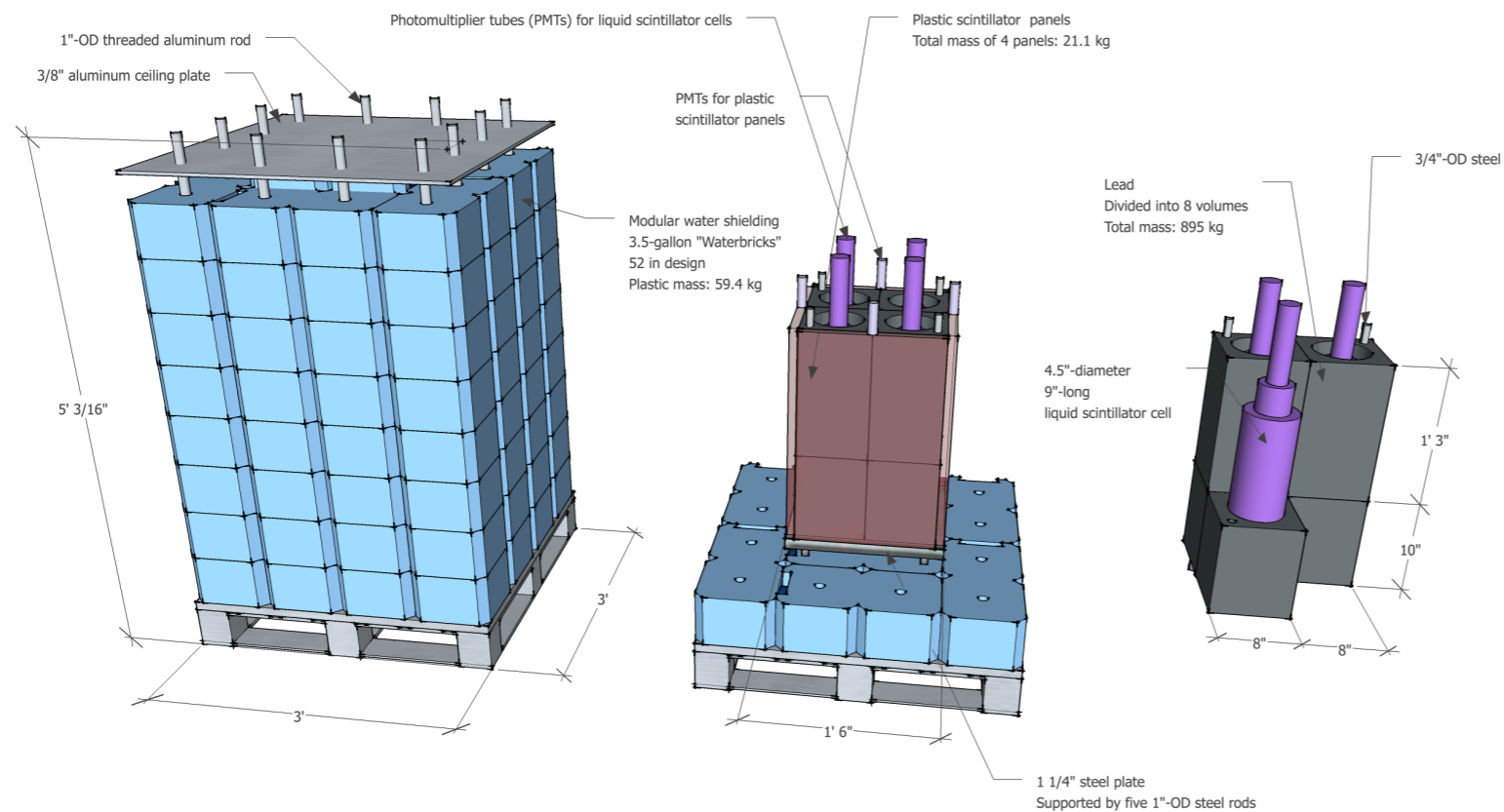
# Improving the Precision: Neutrino Flux Measurement (R2D2O)



- Charged-current cross section on D well understood (2-3%)  
—measure neutrino flux
- Already have Heavy Water on hand
- Fiducial volume inside acrylic vessel
- Background: beam neutrons
- First measurement on  $^{16}\text{O}$  will be possible



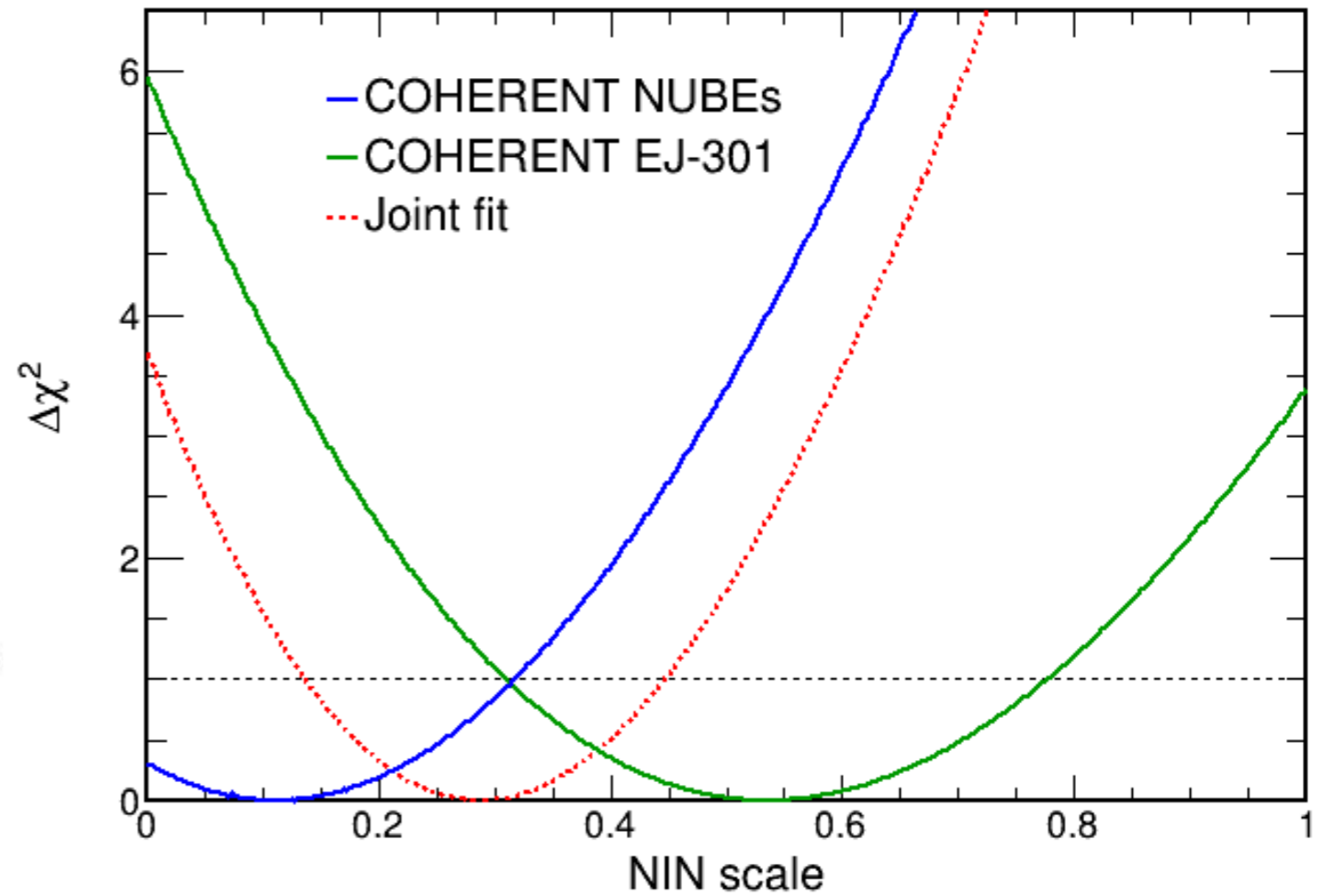
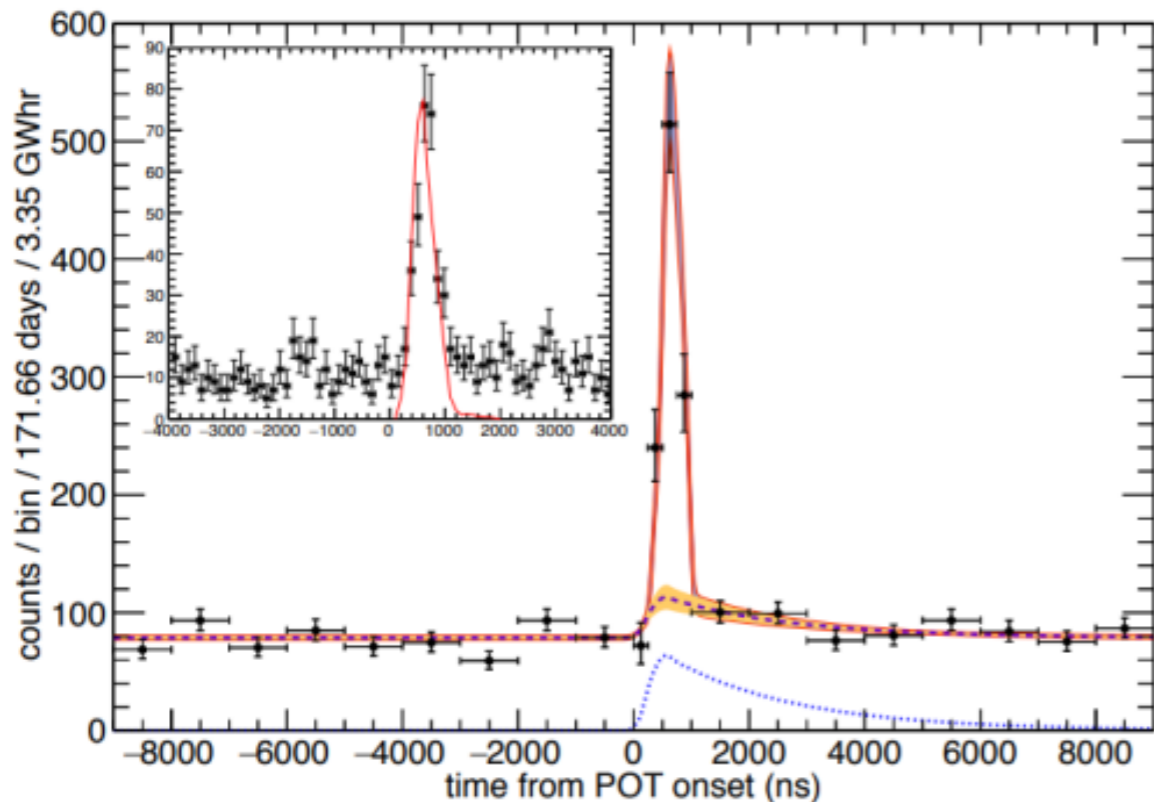
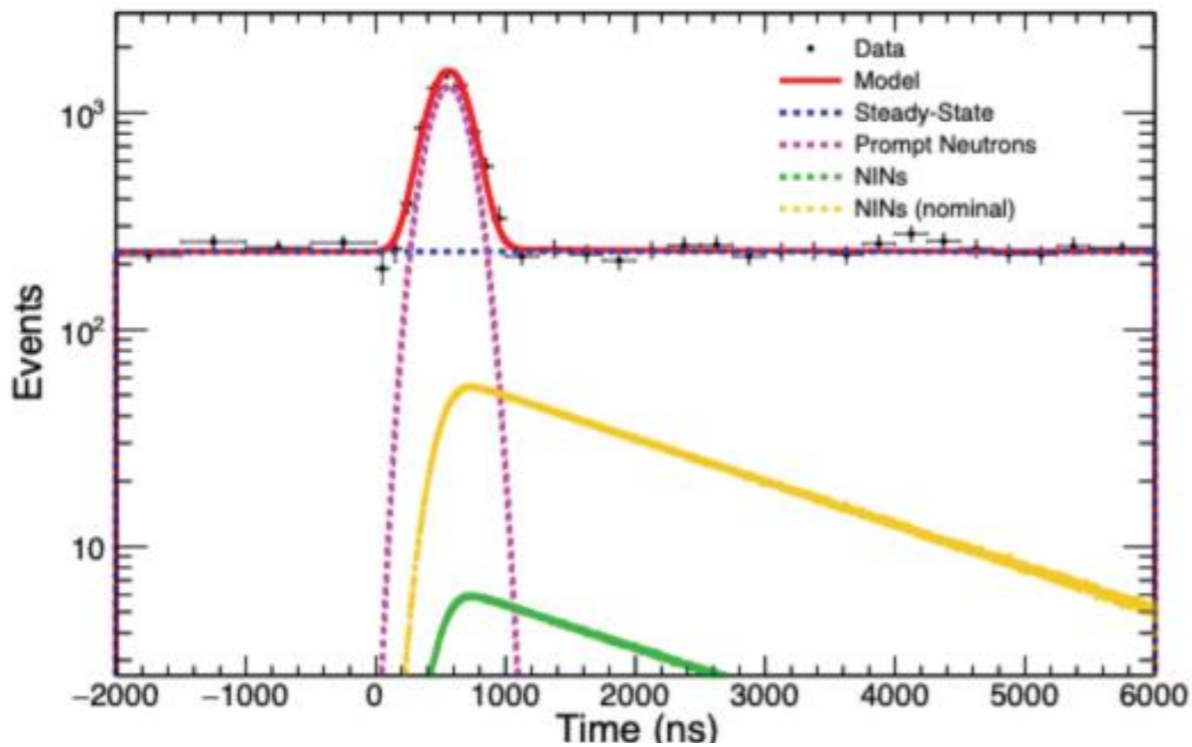
# Improving Precision: Backgrounds (Nubes)



- Measure neutrino-induced-neutrons on Pb (r-process nucleosynthesis & nuclear structure)
- and Fe (nuclear structure & SN shock revival)
- Data Open...

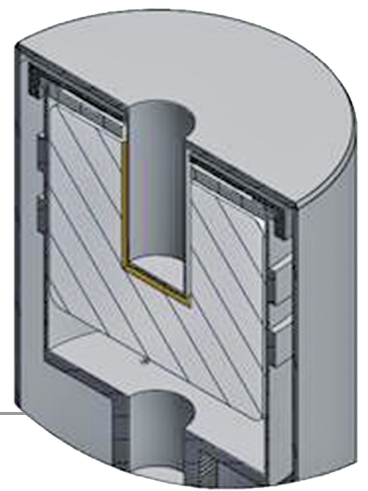


# Improving Precision: Backgrounds (Nubes)



- Improved systematic estimates with a better understanding of the Beam Related Neutron propagation
- Significant suppression seen from theory predictions
- Could this be due to  $g_a$  quenching?

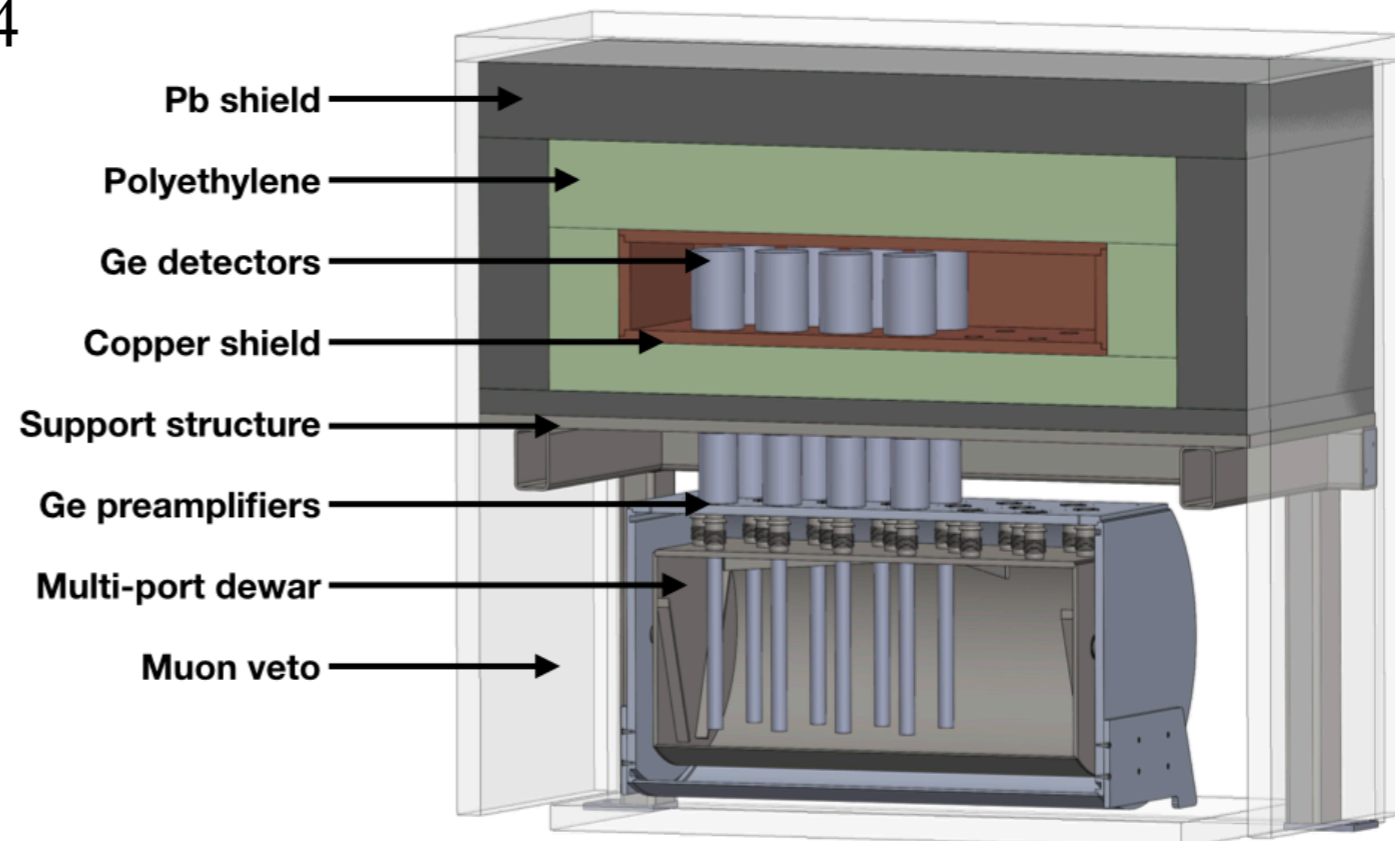
# More COHERENT Detectors: Ge-mini



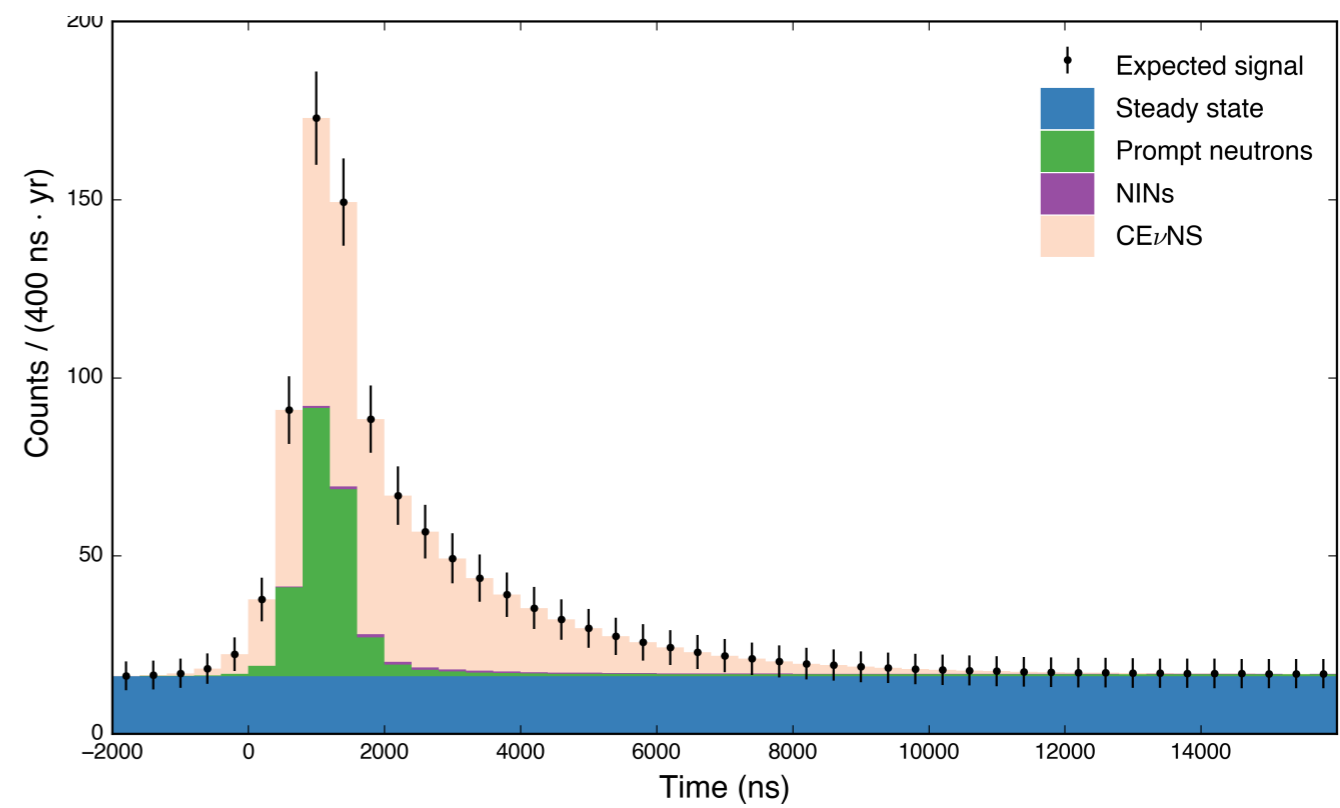
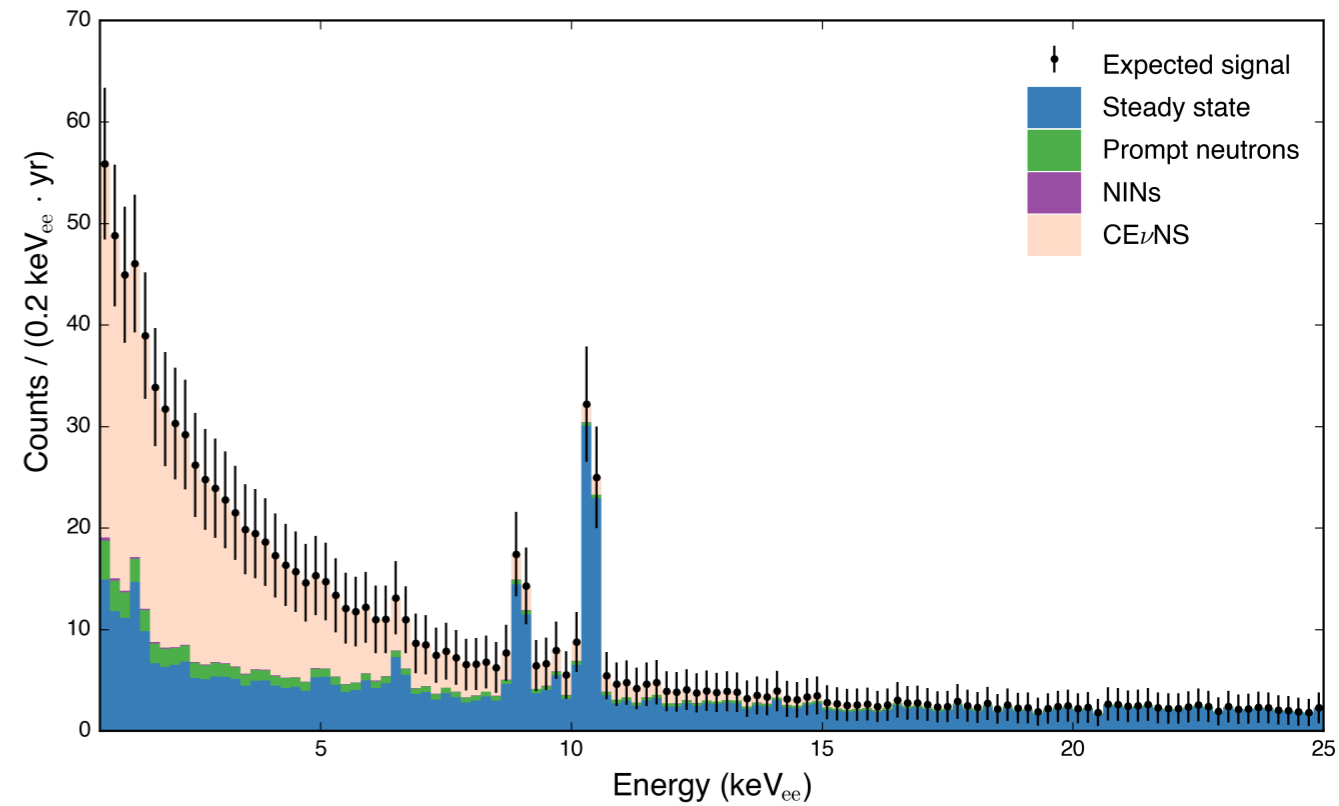
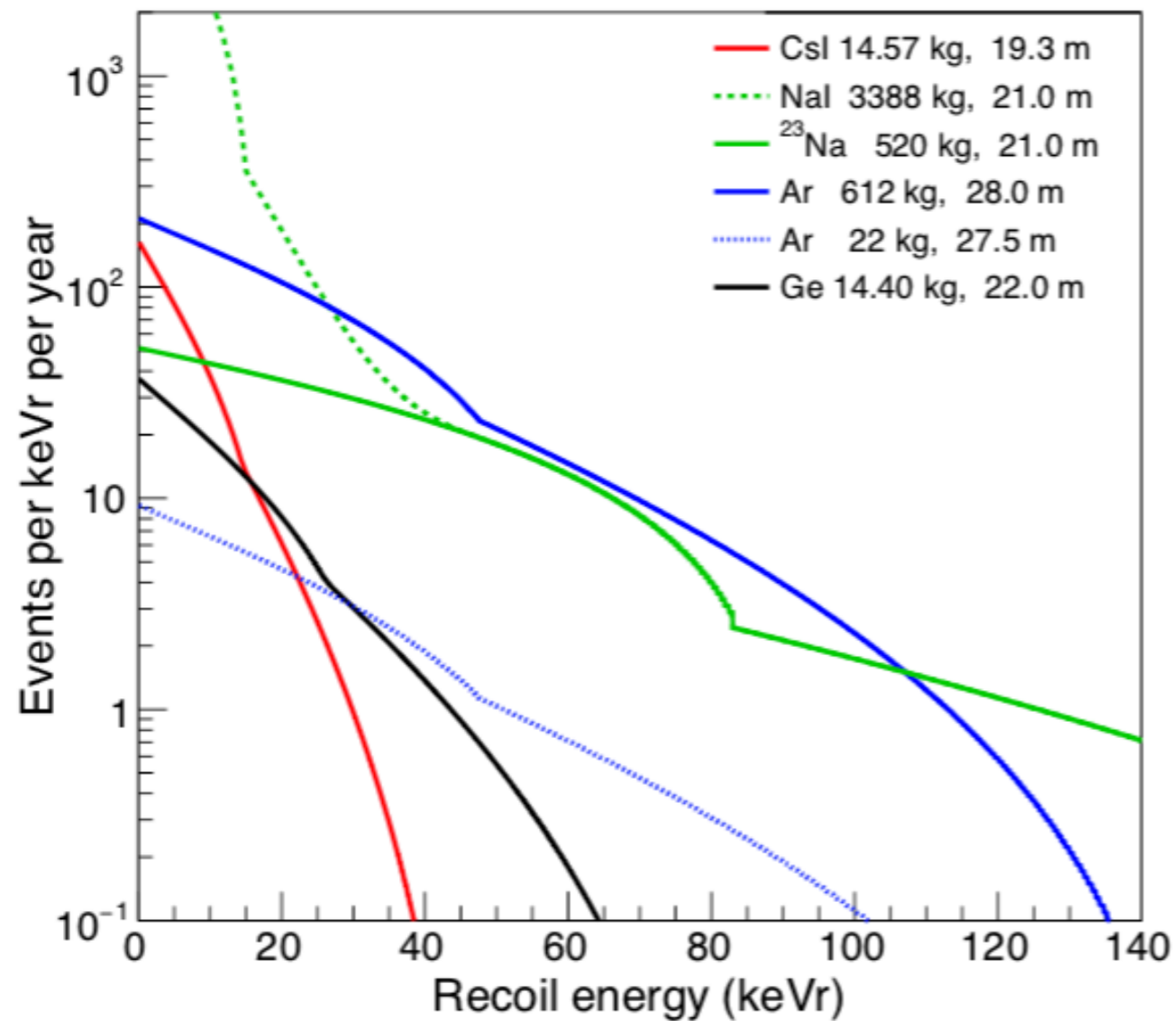
- Estimate 500 - 600 CEvNS events/year in a 16 kg array.
- Electronic noise from detector + preamp limited to  $< 150$  eV FWHM.
  - Results in an energy threshold of  $\sim 0.4$  keVee, roughly 2-2.5 keVnr.
- Cryostat already available.
- Quenching factor well understood (an in house measurement will be published soon).

**\$1.1M NSF funded MRI will cover 16 kg deployment to NSF starting this year**

**5 detectors already delivered and looking great**

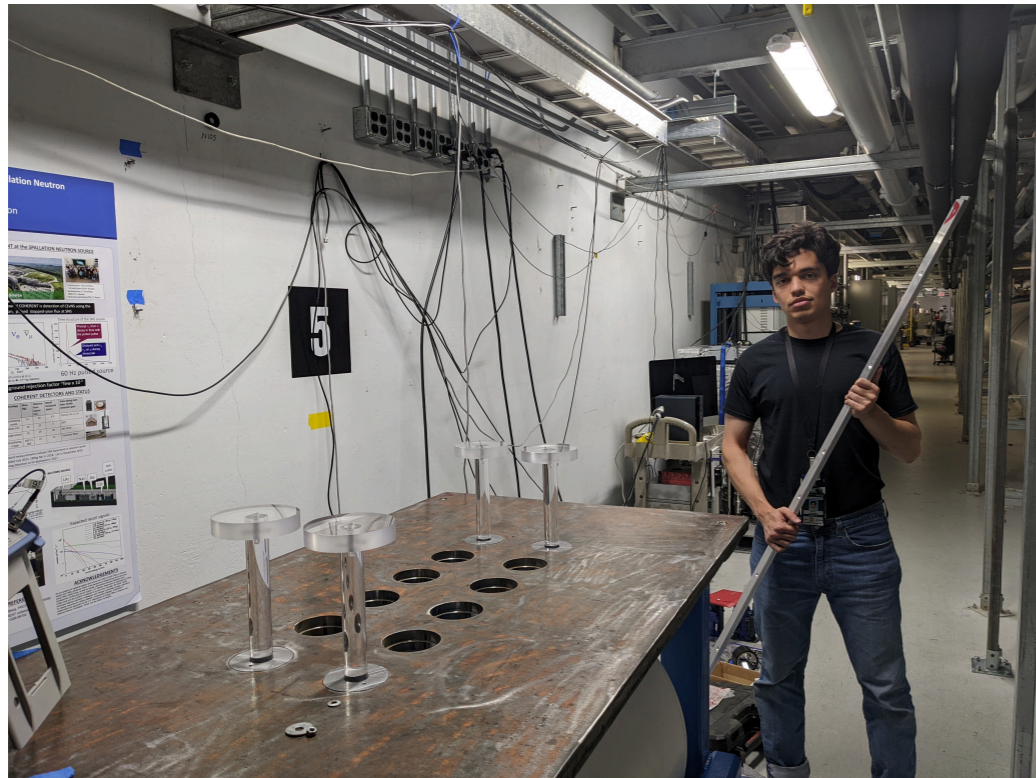


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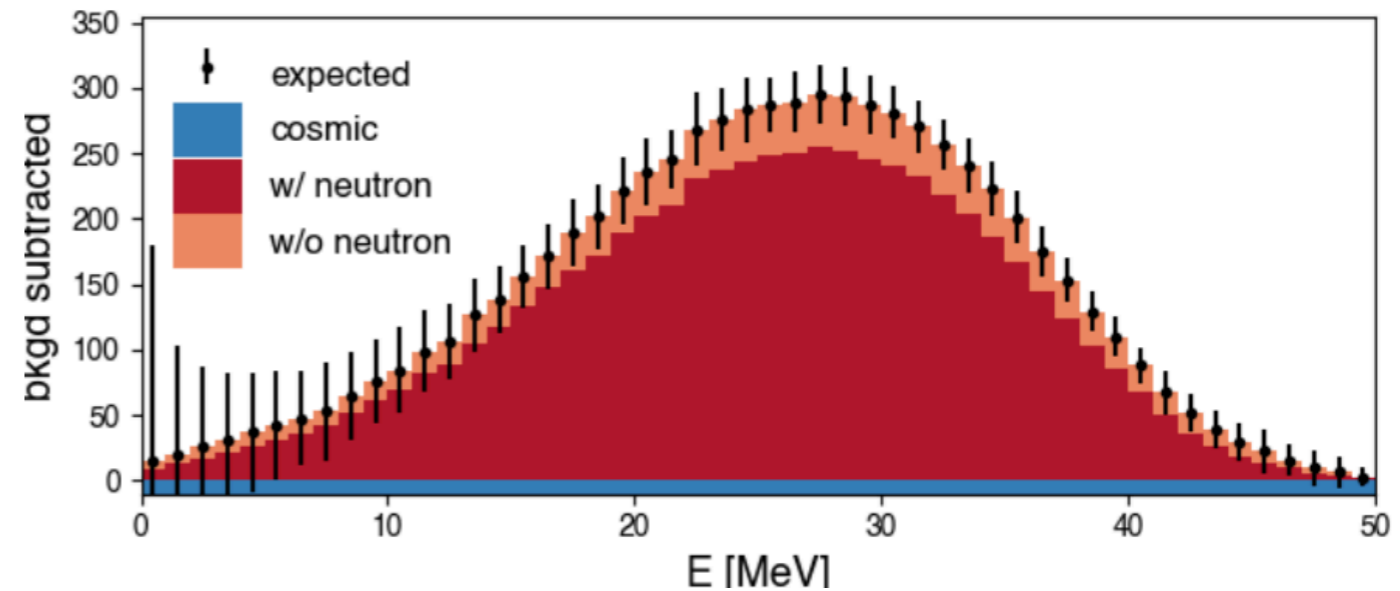
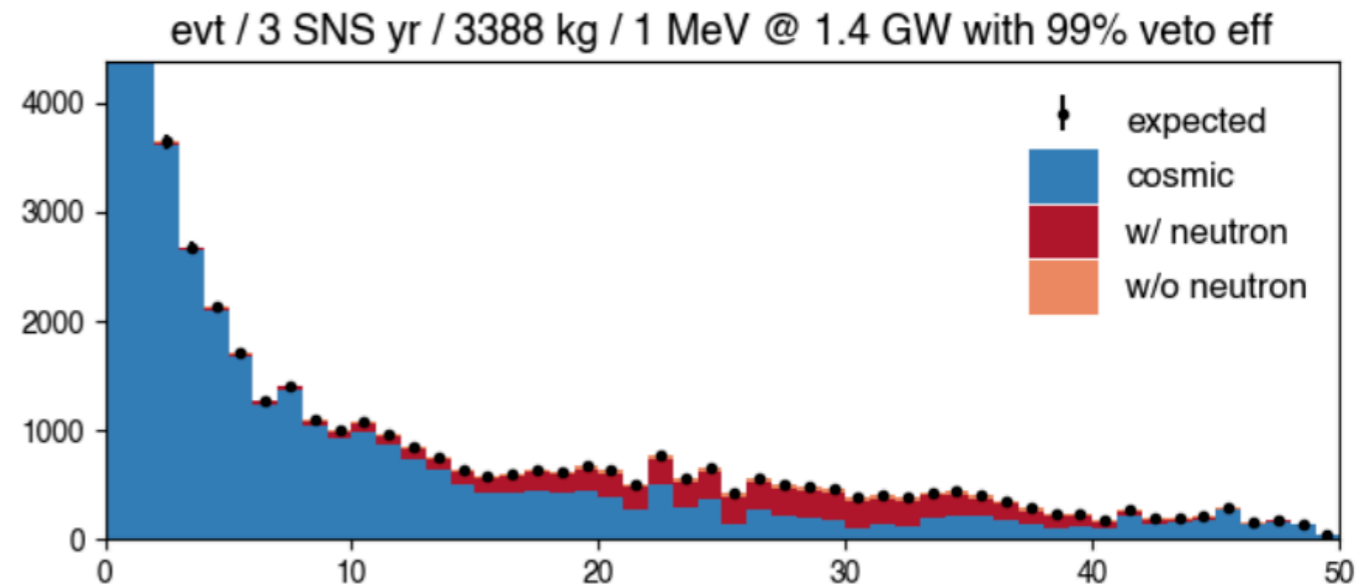
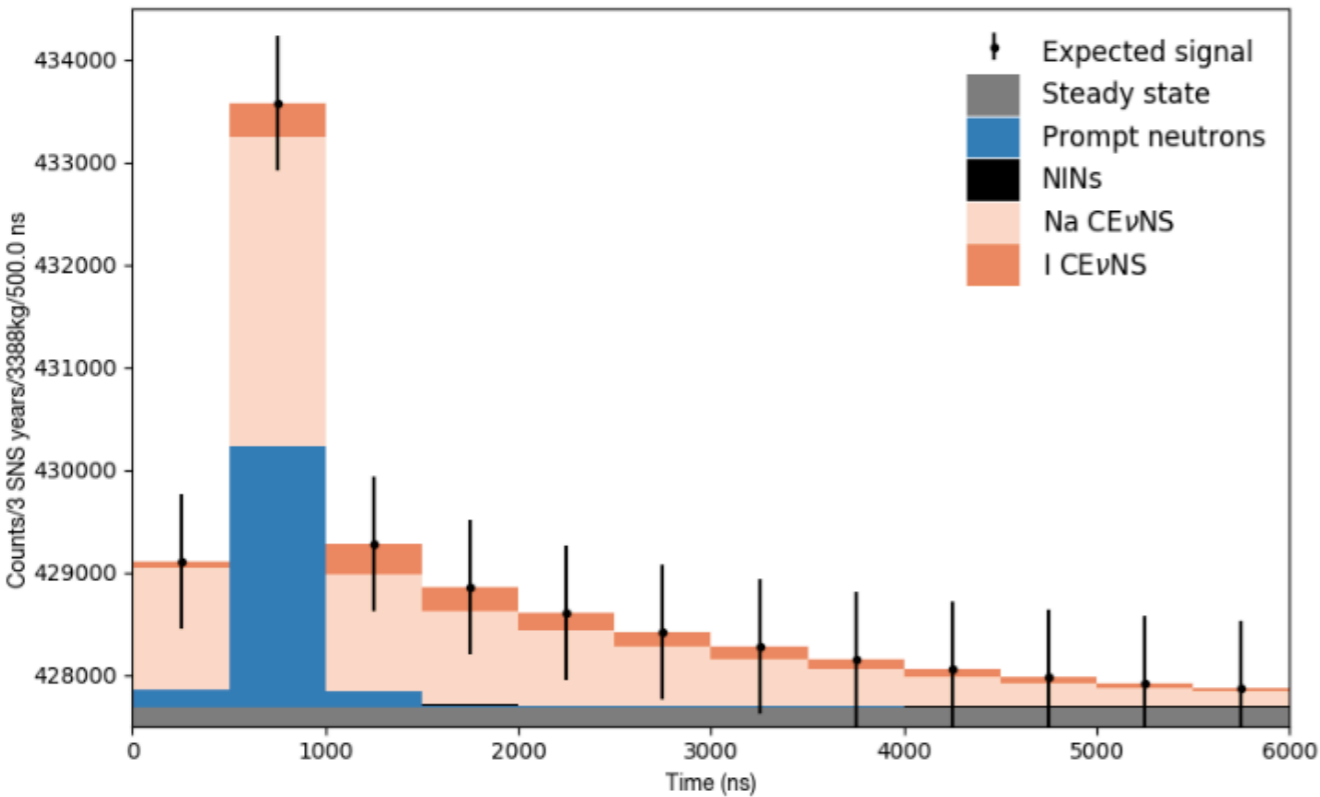
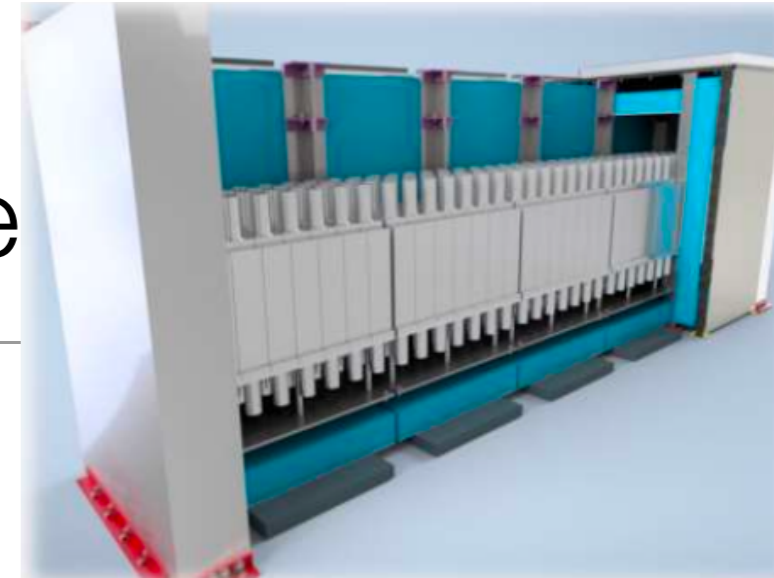




# More COHERENT Detectors: Ge-mini

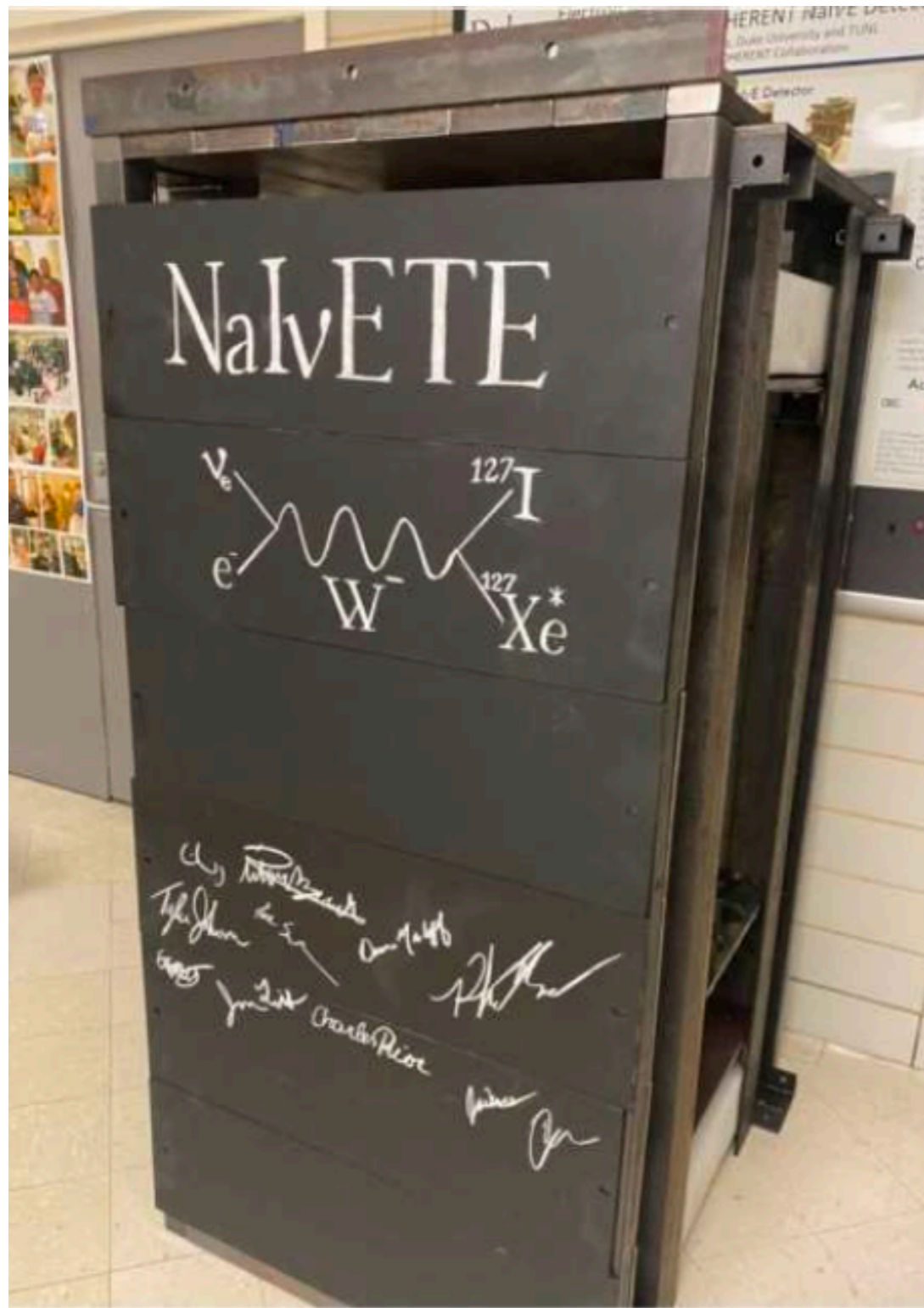


# More COHERENT Detectors: NaIvETe



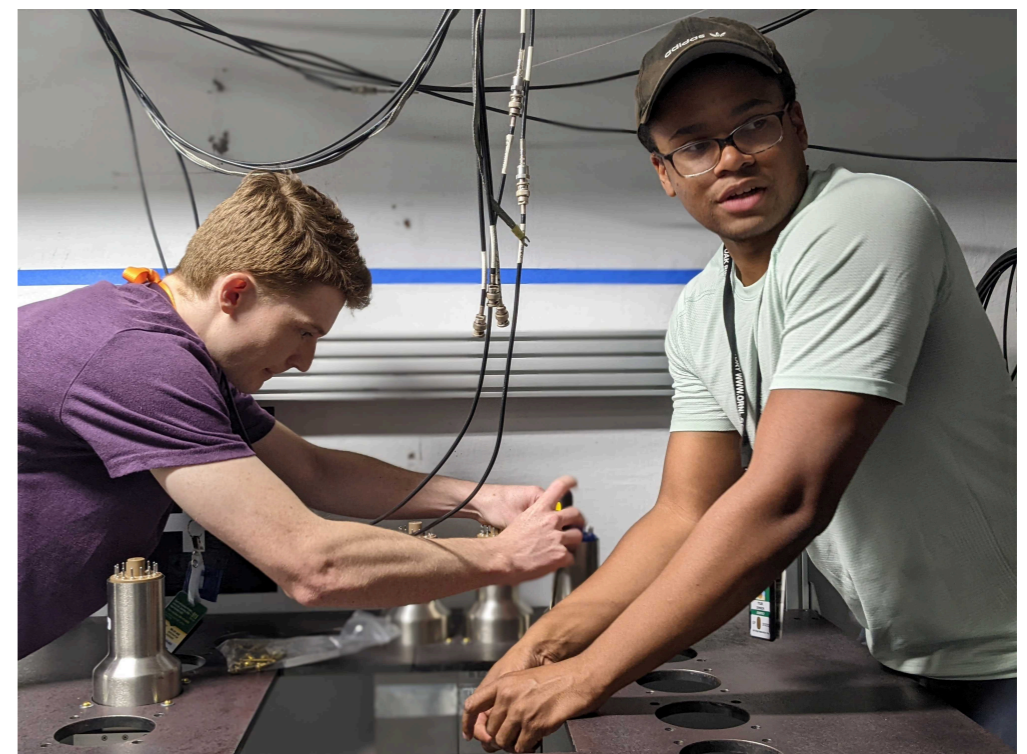
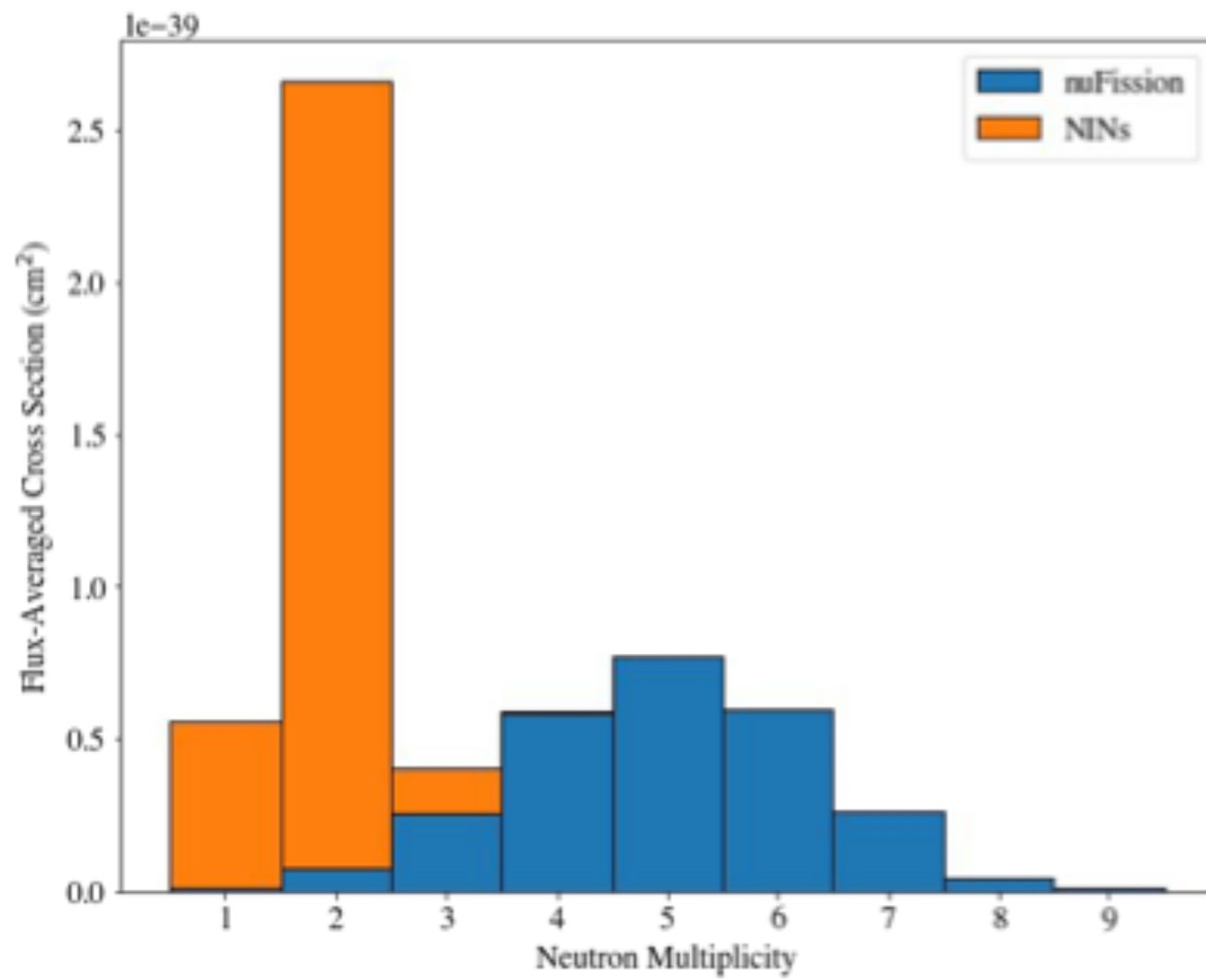
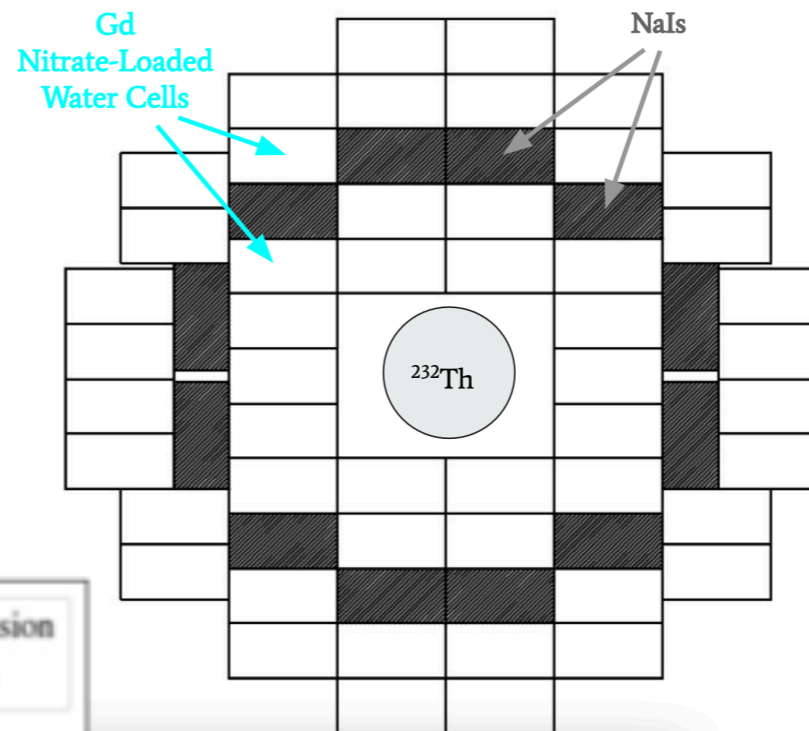
- A multi-ton array is being designed to measure CEvNS on Na
- Detector evaluation & calibration ongoing

# More COHERENT Detectors: NalvETe



# More COHERENT Detectors: NuThor

- Opportunistic search for Neutrino-Induced Fission on  $^{232}\text{Th}$
- Could tell us if  $g_a$  suppressed for heavy elements
- Pb-run will also cross-check Nubes results



# Summary

- Detailed program that addresses all systematics
  - LAr
  - NalvETe
  - Ge-mini
  - R2D2O
  - NuThor
  - Improved QFs
- What I didn't get to cover:
  - NalvE-185 CC measurements (I, Na)
  - MARs background Measurements
  - R&D with LAr (CENNS-10)
  - Ton-Scale LAr (CENNS-750)
  - Cryogenic CsI
- At the same time, we are looking forward to doing new physics at the Second Target Station

