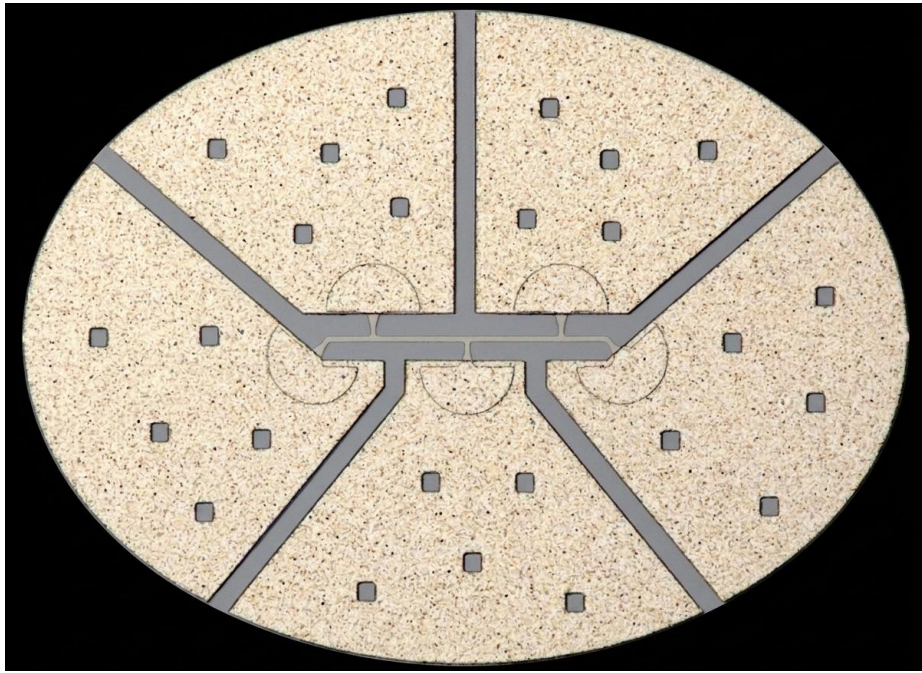
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TESSERACT

Cryogenic Detector R&D for Future Rare Event Searches

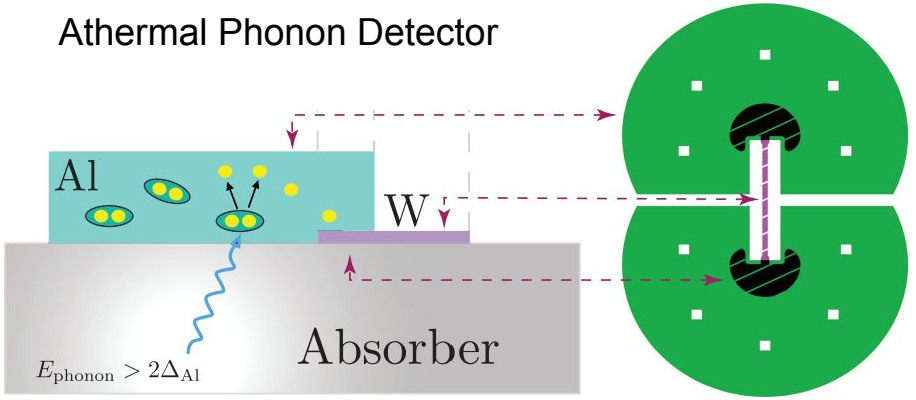


Michael Williams
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CPAD 2026
20th-23rd October, 2026

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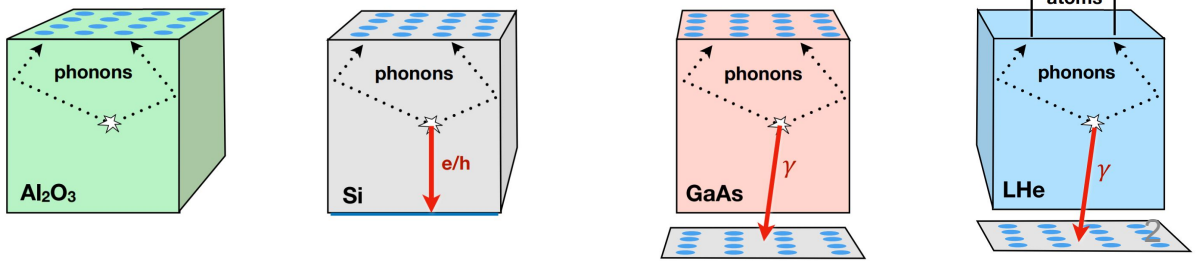
Cryogenic Detector R&D at LBNL

- Fundamental sensor R&D enables future projects
- LBNL focus for 2026
  - Calibration
  - Sensors for Helium
  - Backgrounds
  - Superconducting Films



World leading 260 meV resolution

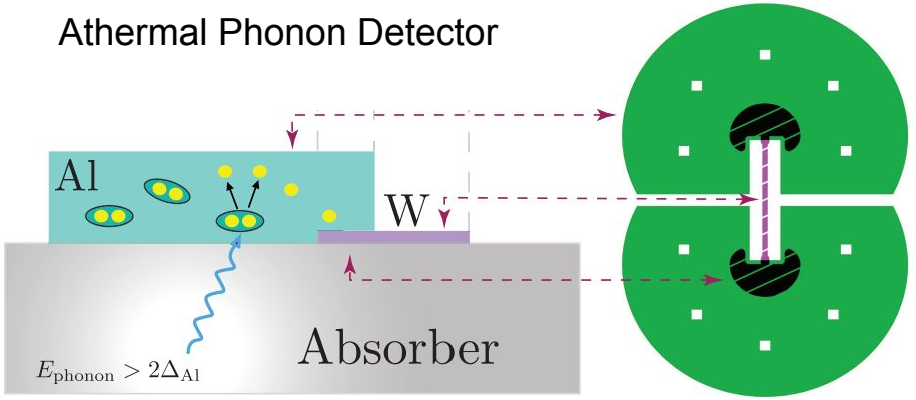
TESSERACT TARGETS



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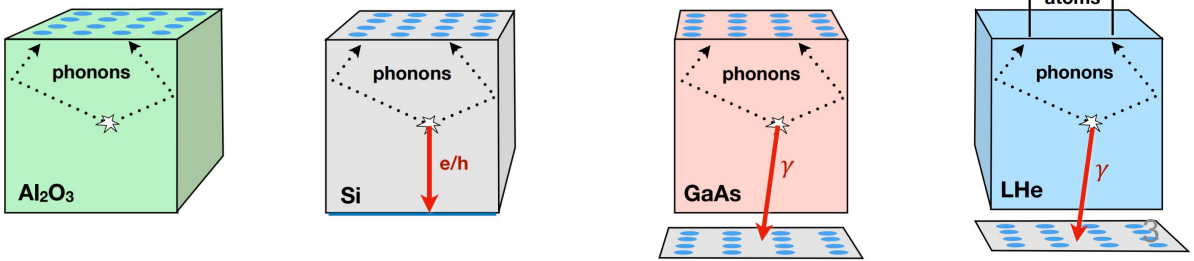
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Studying Calibration Systematics

- Laser calibrations typically use sweep of laser power
- Assume $\sigma_{\mathcal{I}}^2 = I_0 \mu_{\mathcal{I}} + \sigma_i^2$
- Really is $\sigma_{\mathcal{I}}^2 = I_0(1+\delta)\mu_{\mathcal{I}} + \sigma_i^2$
- Assuming delta = 0 leads to miscalibration!
- Position dependence is biggest driver of delta!

PHYSICAL REVIEW D **114,** 032007 (2026)

Editors' Suggestion

2605.24116

Photon calibration techniques for high resolution cryogenic detectors

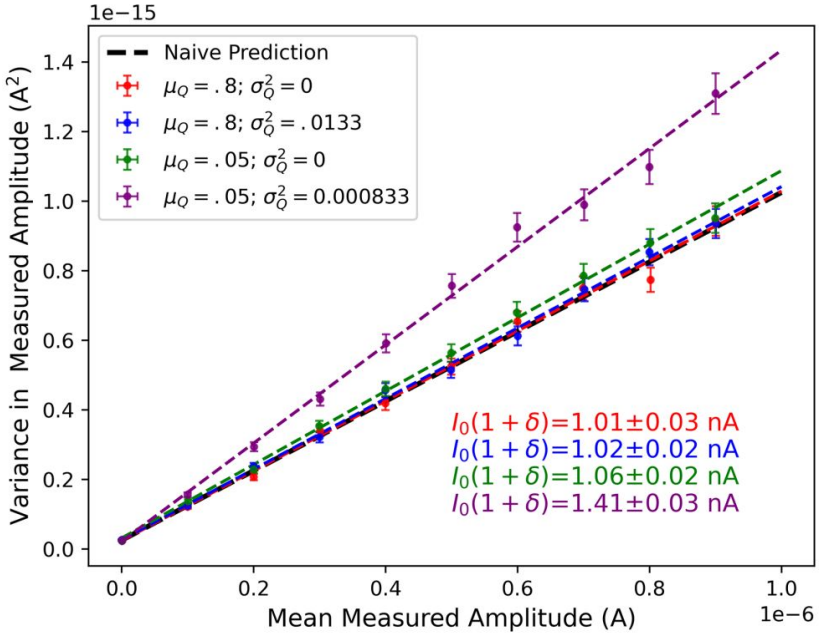
W. Matava*

University of California Berkeley, Department of Physics, Berkeley, California 94720, USA and Lawrence Berkeley National Laboratory (LBNL), Berkeley, California 94720-8099, USA

M. R. Williams†

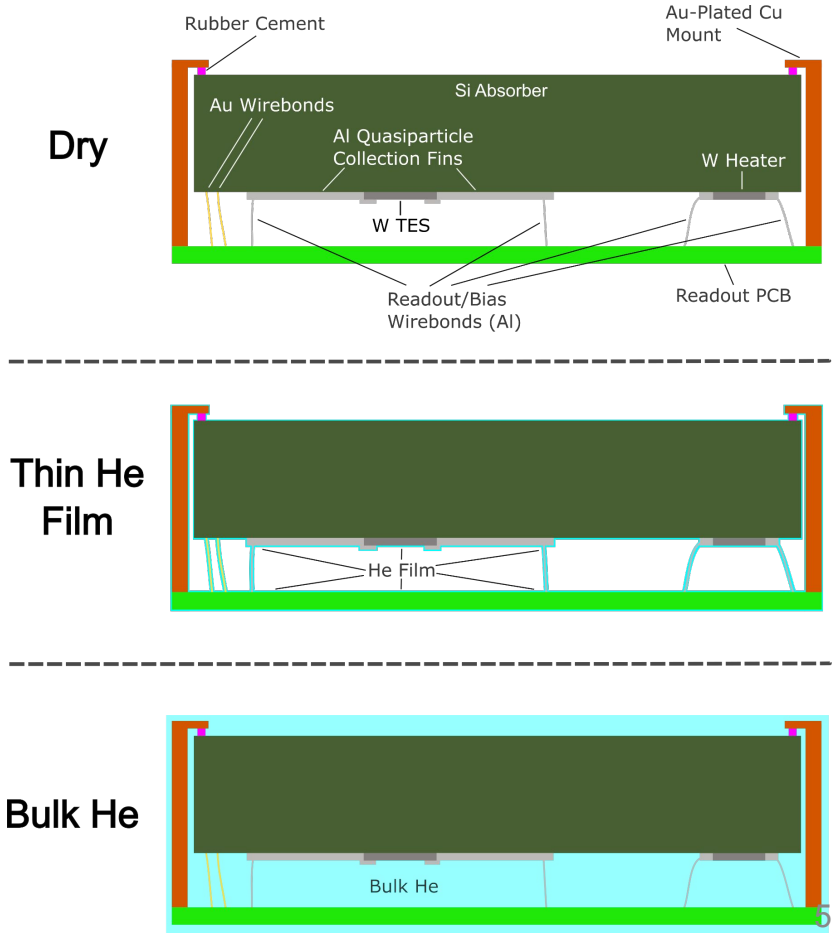
Lawrence Berkeley National Laboratory (LBNL), Berkeley, California 94720-8099, USA

(Received 26 May 2026; accepted 27 July 2026; published 12 August 2026)



How to Test This?

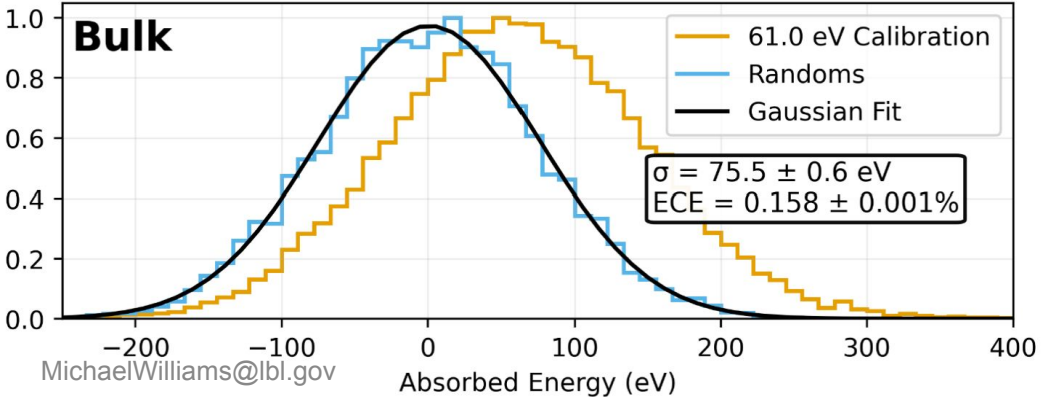
- Detectors immersed in superfluid have phonon loss!
  - See S. Steinfeld talk during E.C. plenary session
- Test if we can measure a delta that would lead to bad calibration



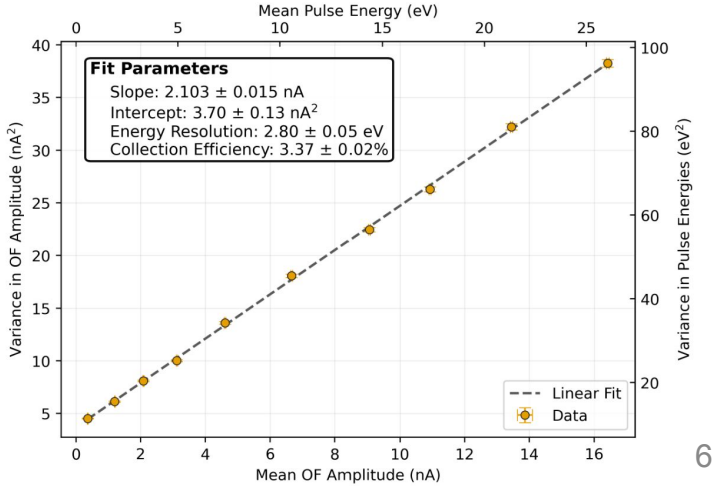
Measurement of Delta

- Compare resolution from sweep to when known number of photons hits the detector
- “Fixed” resolution: 75.5 eV, “Sweep” resolution: 2.8 eV
- Delta is non-negligible -> we would have been wrong! Experiments should study position dependence to avoid!

Fixed laser power



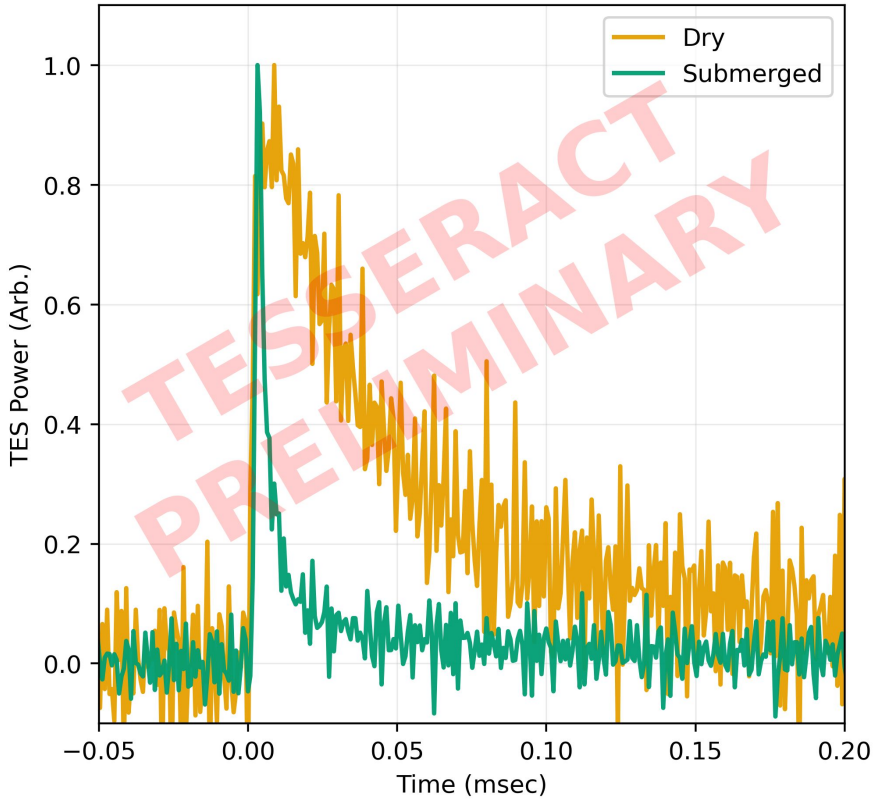
Laser sweep



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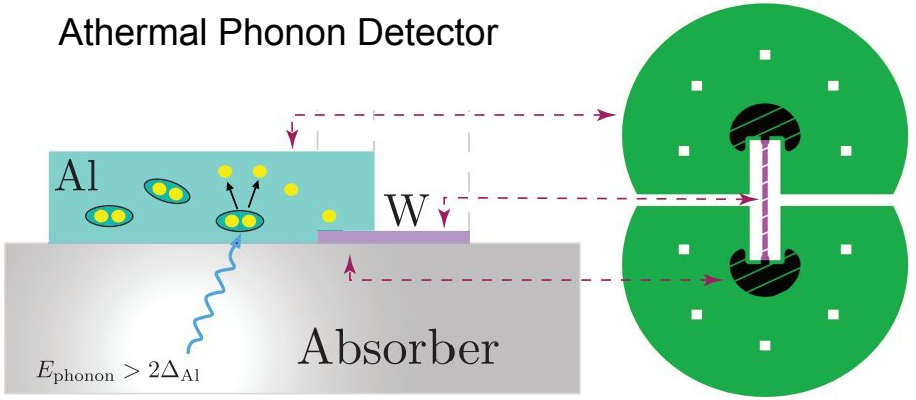
Detectors Immersed in Superfluid

- Superfluid helium takes away 99% of phonon signal
- Idea: use superfluid to remove phonons from the substrates of qubits
- May lower impact of ionizing radiation when used with other common methods!



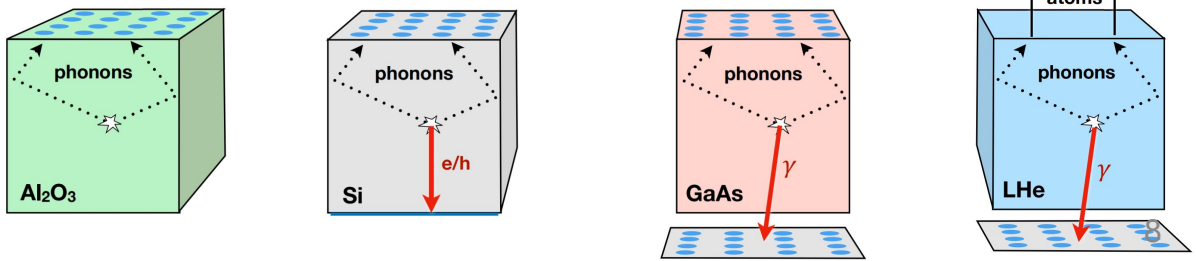
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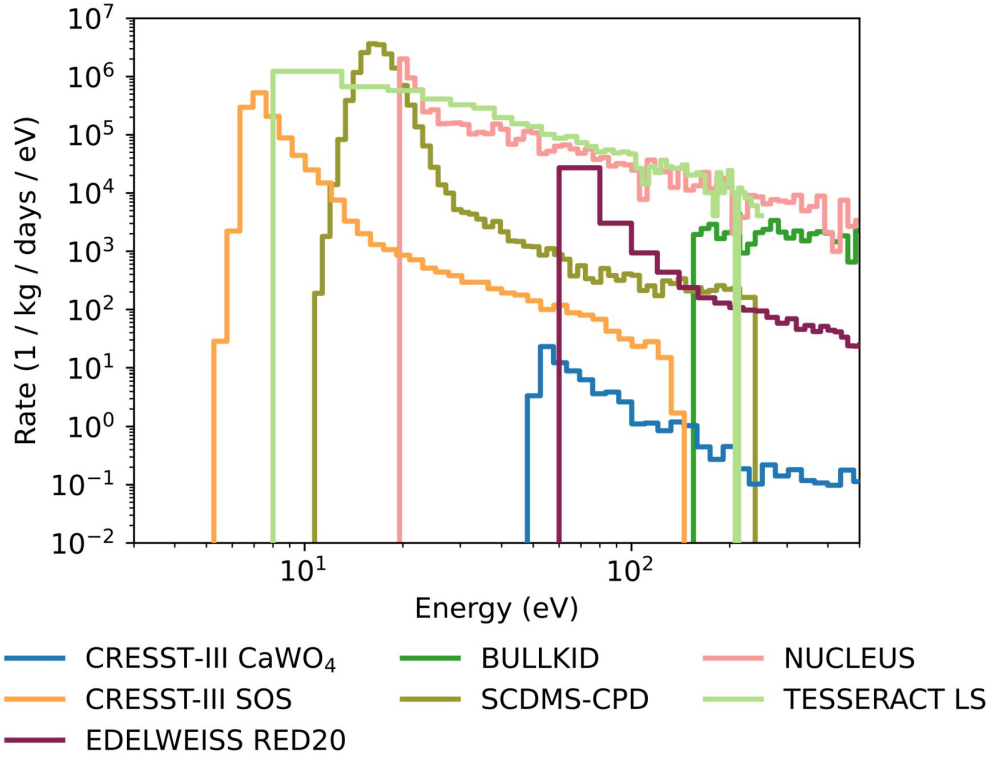
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Low Energy Excess

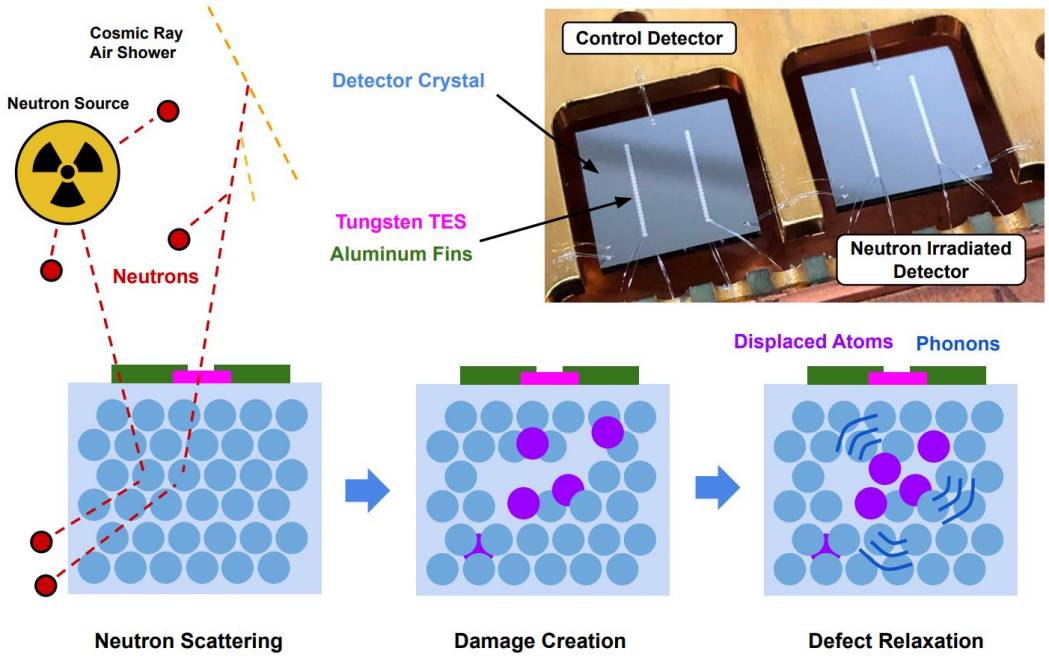
- Phonon mediated LEE tells us something about the substrate
- What could cause such a high rate of phonons at 1 eV?



Neutron Induced Defect LEE

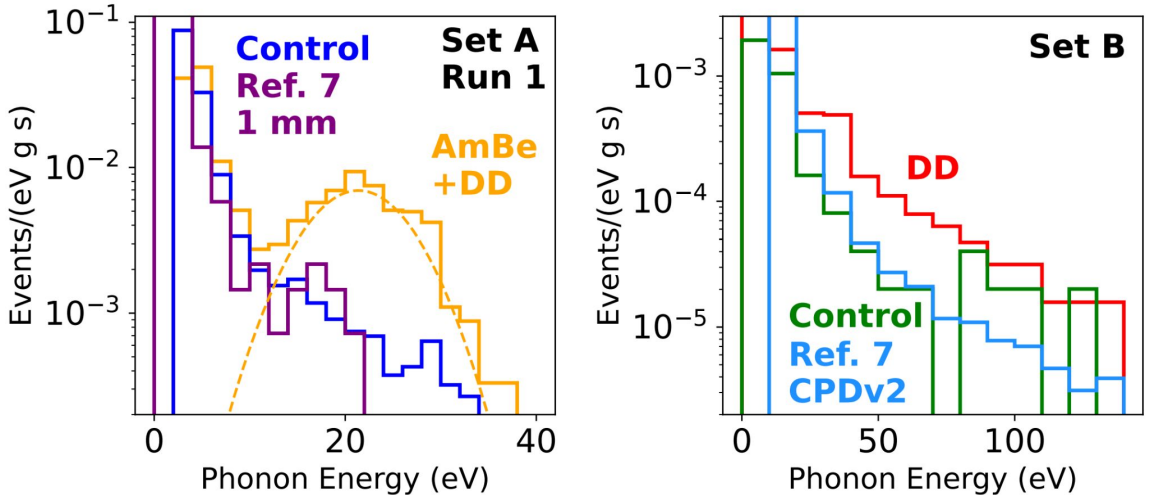
- Energetic neutrons could make defect “complexes”
- As these migrate and relax they make phonons
- To test, smack a detector with neutrons!

2603.17964



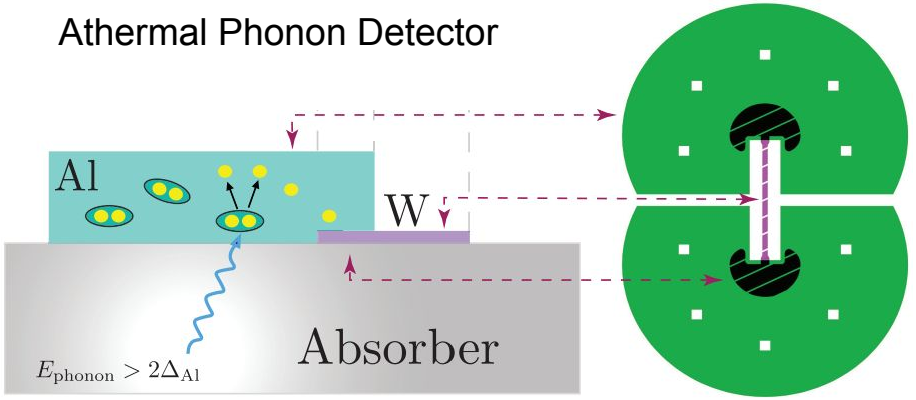
Neutron Induced Defect LEE

- We see an elevated event rate on irradiated chips
- Neutrons damage indeed induces some LEE, but questions remain
  - Why does AmBe spectrum have a peak
  - Results can't exclude CRs as source
- More measurements on hypothesis to be done



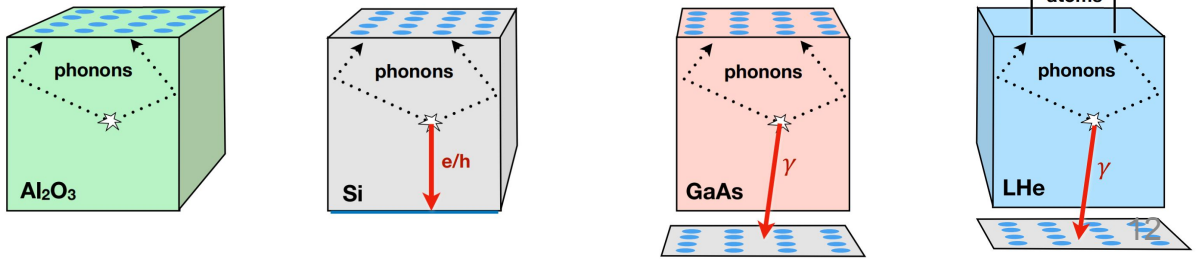
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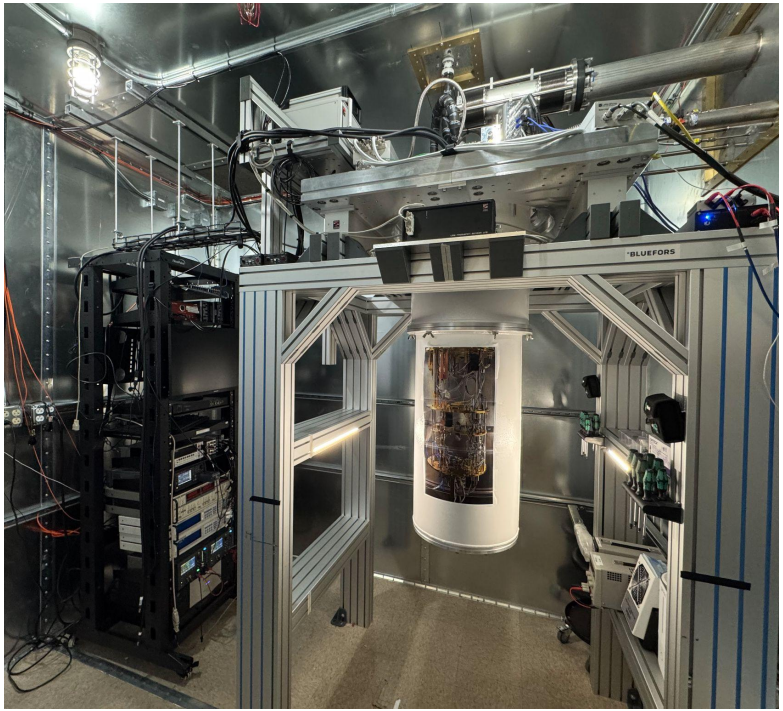


World leading 260 meV resolution

TESSERACT



Sensor R&D at LBNL

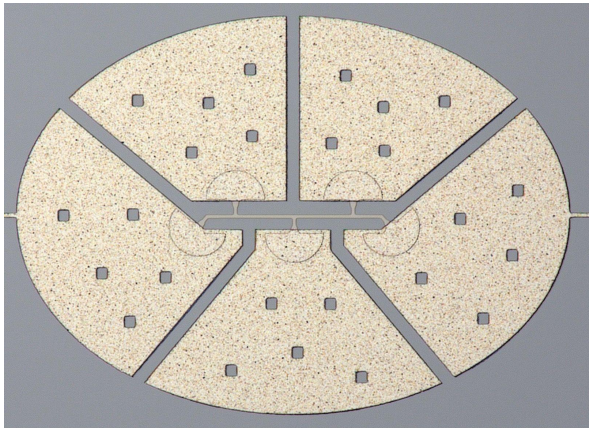


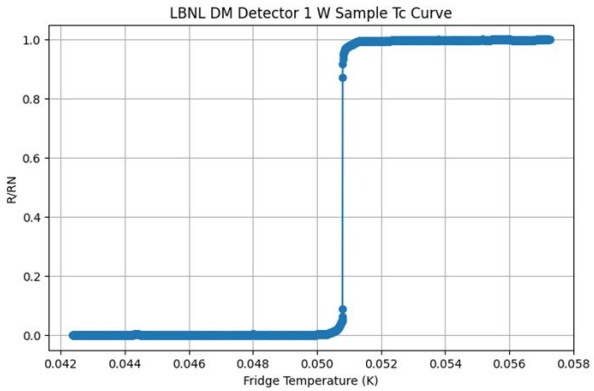


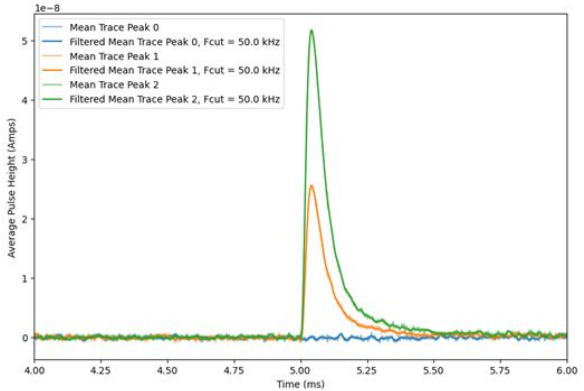
- Bring together experts in detectors, nanofabrication, materials science and QIS
- Find links between materials and fab to detector performance

Detectors from LBNL

- Successfully fabricated TESSERACT-style detectors
- Matched world-leading resolution
  - ~300 meV for phonons
  - Enables low energy studies

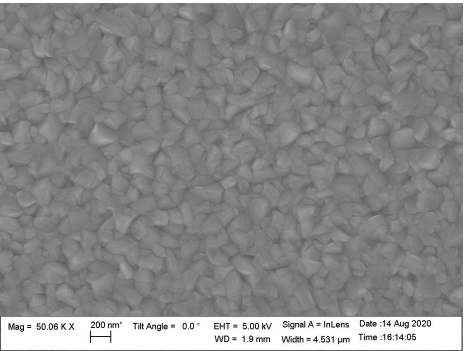


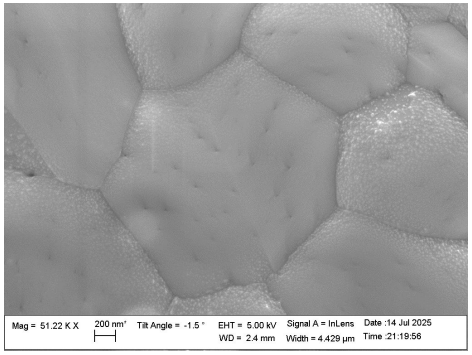


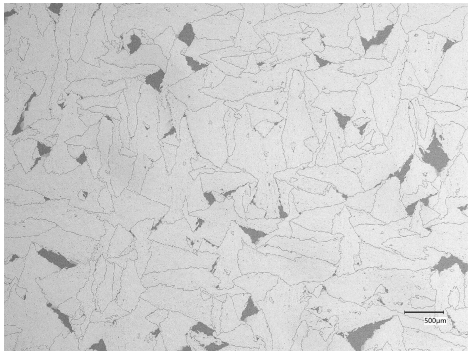


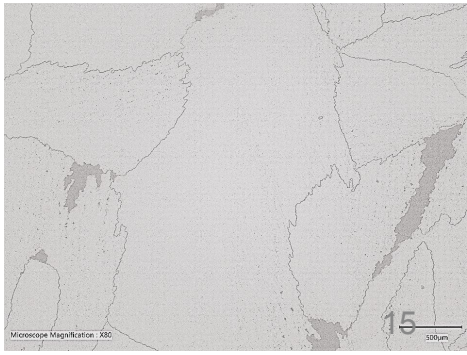
Aluminum Film Development

- First focus is on Al films that make our QETs
  - Dominate energy loss, if we can make better films we can boost total energy collection
- We have achieved mm-scale grains using sputtering for the first time
- Potential large ramifications for film studies beyond HEP
  - Studies of film parameters ongoing

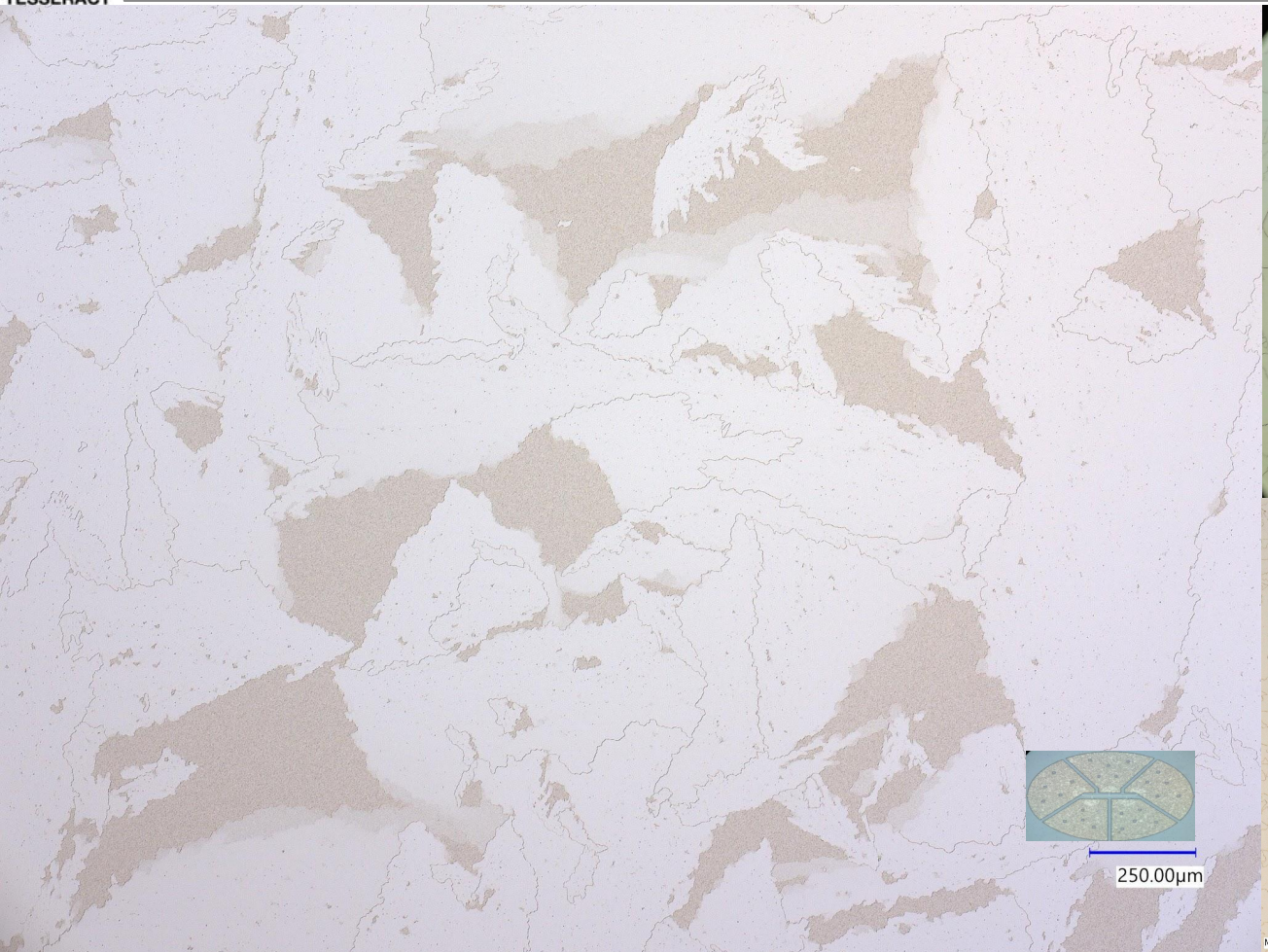


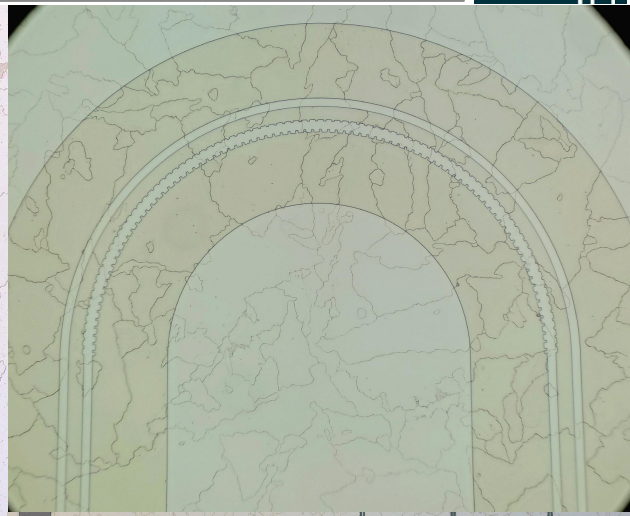


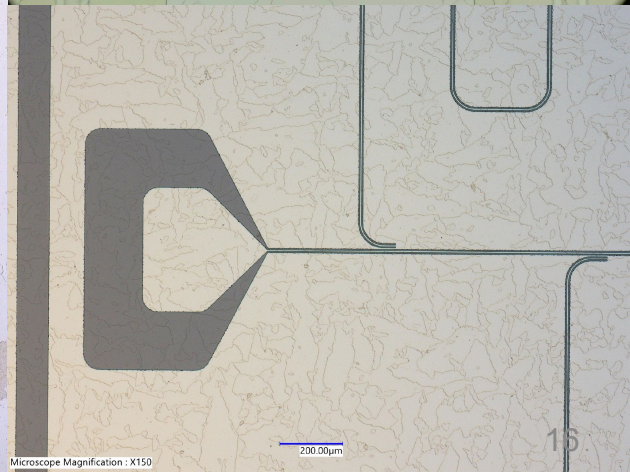




Pretty Pictures

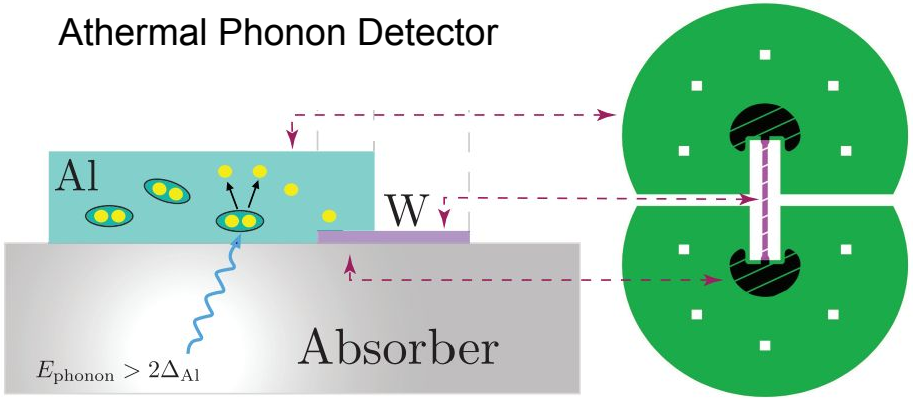






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Future Experiments?

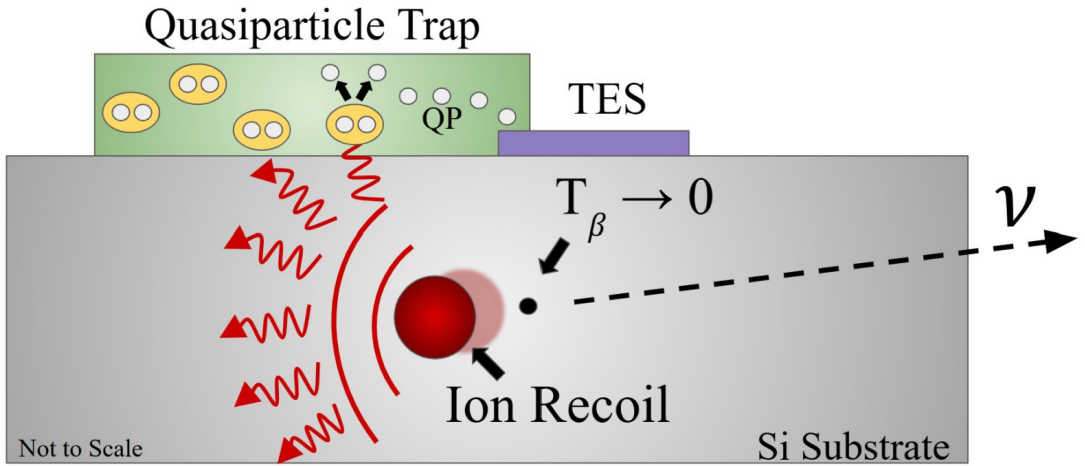
New Experimental Concept

- Use LBNL made detectors to search for sterile neutrinos
- Use embedded P^{32} to measure “start point” of beta decays
- 49 eV NR at start point, useful for calibration too!

Ultralow-Energy Measurements using the Startpoint of β Decays

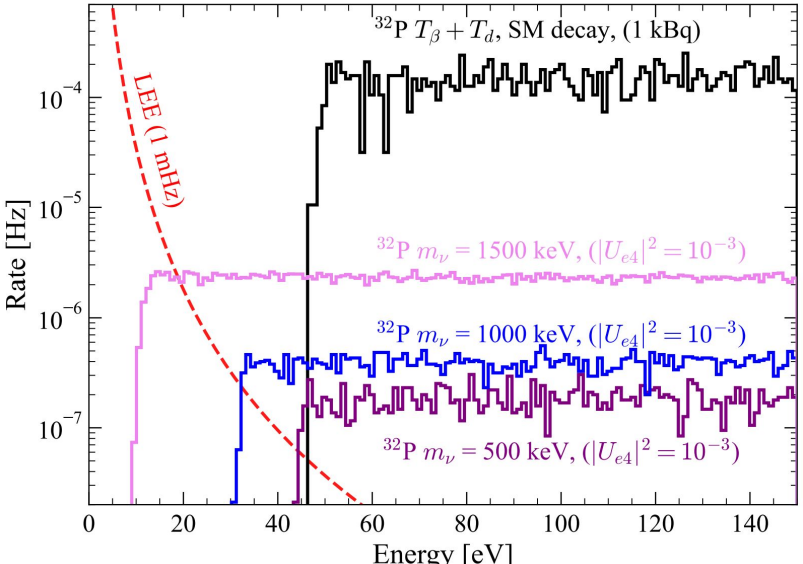
D. Kodroff[1,*] and M.R. Williams[1,†]
[1] *Lawrence Berkeley National Laboratory (LBNL), Berkeley, CA 94720-8099, USA*

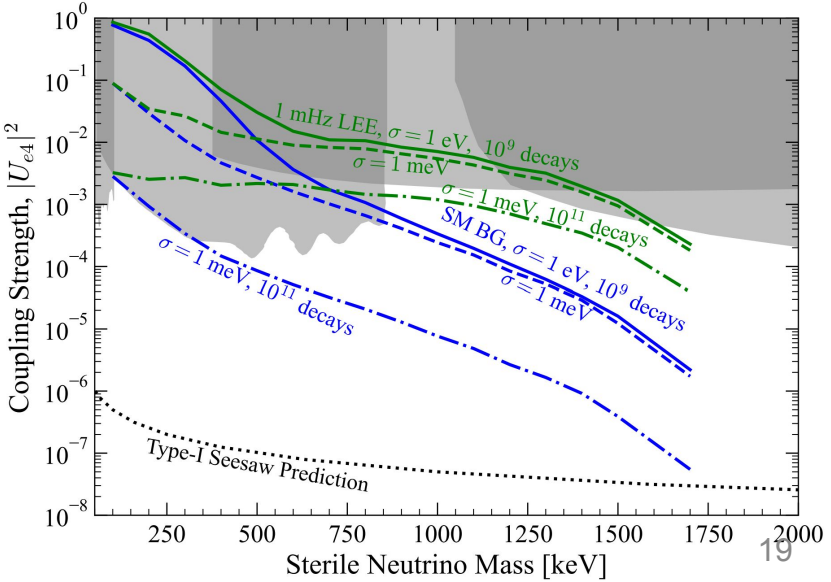
2606.15014



Sterile Neutrino Experiment at LBNL

- Shift in NR spectrum gives clear signal
- Can probe new parameter space with just a few detectors in a fridge!
- First measurements expected soon!





Conclusions

- The understanding of calibration techniques is still evolving!
- Superfluid helium is an interesting medium for understanding phonon physics and the impact of ionizing radiation on qubits
- The LEE puzzle remains unsolved, but I'm optimistic
- New methods in metal film fabrication can open the door to improved technologies
- Detector R&D enables new experiments in fundamental physics

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TESSERACT

Cryogenic Detector R&D for Future Rare Event Searches

Michael Williams

CPAD 2026

20th - 23rd October

Thank you!

