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TESSERACT

Status of the TESSERACT Dark Matter Experiment

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TeVPA 2026
31st August, 2026

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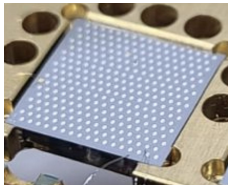
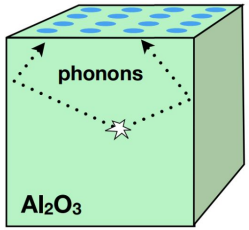
The TESSERACT Project

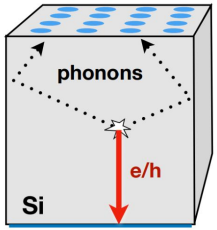
Transition **E**dge **S**ensors with **S**ub-**E**v **R**esolution **A**nd **C**ryogenic **T**argets

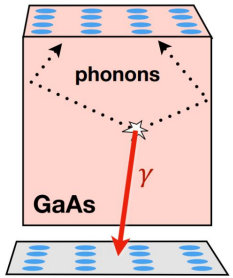


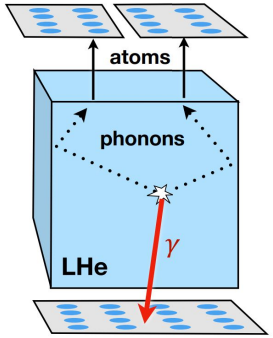
~60 people from 11 institutions

Project funding from DOE-HEP and IN2P3









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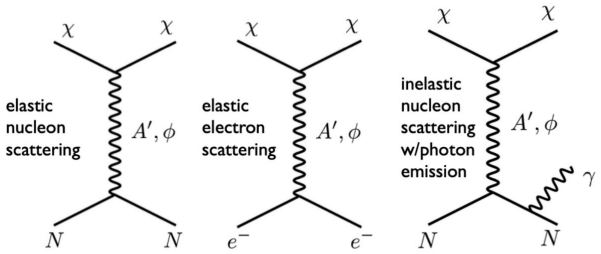
Phonon Detectors

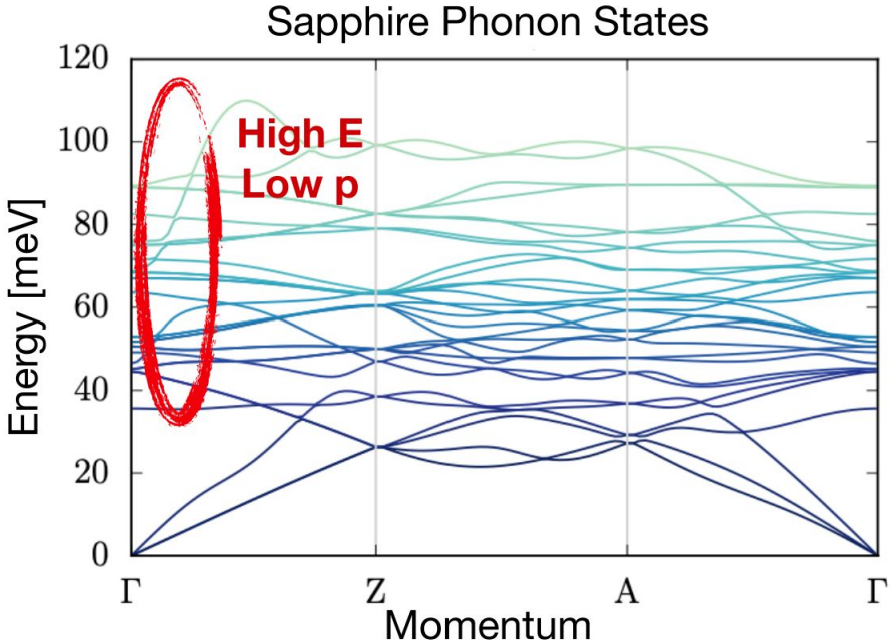
- All DM couplings testable via phonons
- Some *only* testable via phonons



From S. Golwala

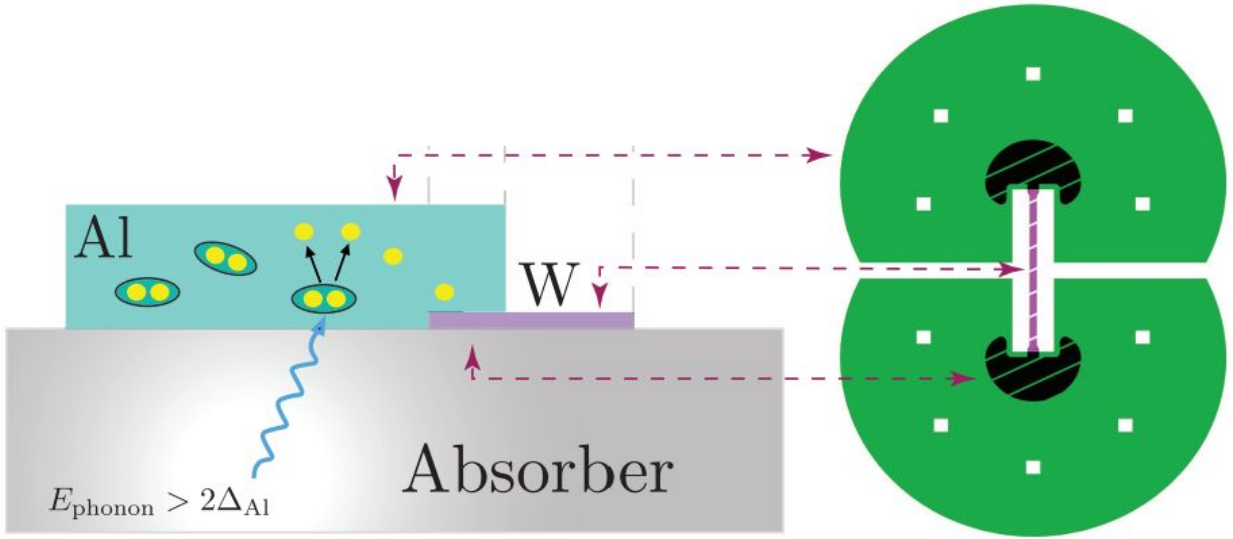
Direct phonon production only accessible to cryogenic solid-state detectors

- Phonons are not limited to NR kinematics
- Couple to phonon modes in solids



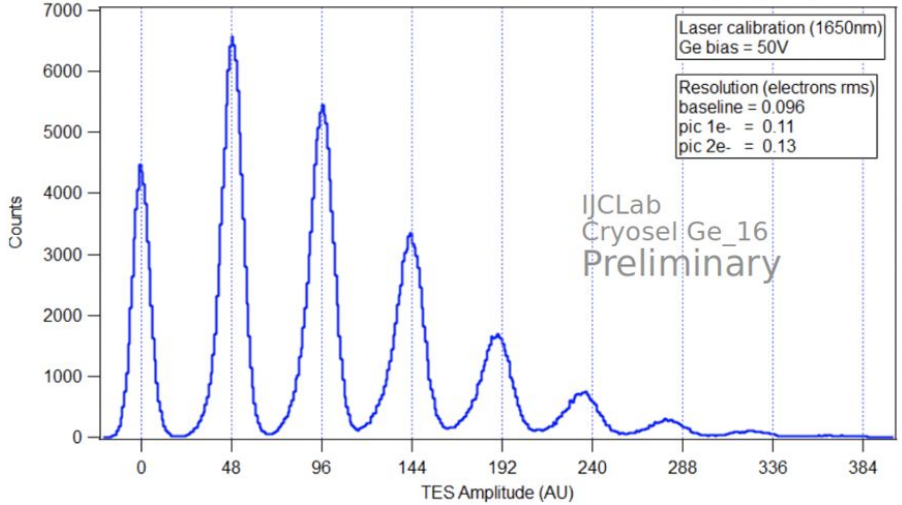
TESSERACT Phonon Sensors

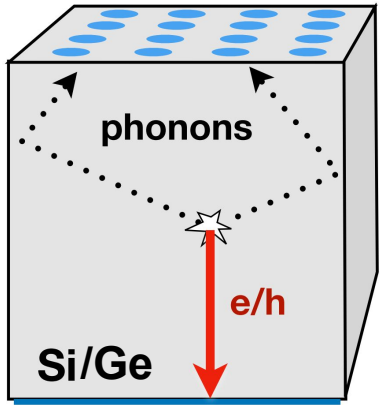
- Tungsten TES coupled to aluminum fins
- “Catch” athermal phonons and shuttle them to sensitive TES

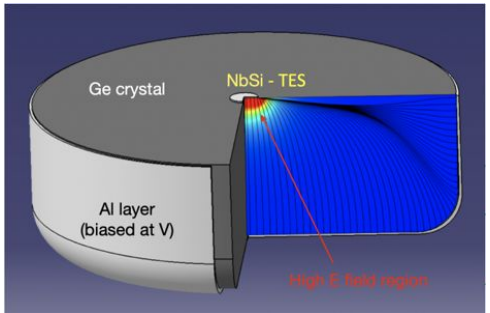


High Voltage Detectors

- Measure NTL phonons via TES on top surface
  - Measure thermal energy with NTD
- Sub e-h resolution in Ge
  - Publication imminent

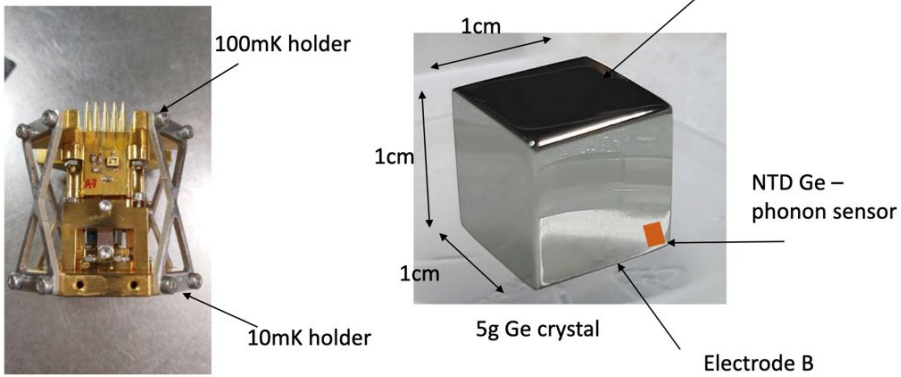


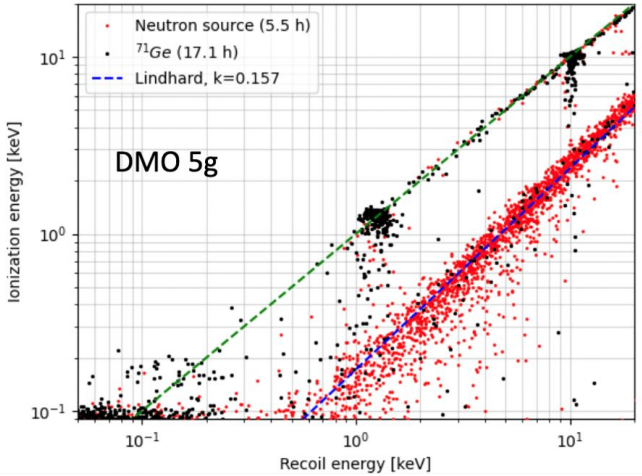




Low Voltage Detector

- Dual channel readout of charge and heat
  - Allows for discrimination between signal and backgrounds
  - ~20 eV resolution in phonon and charge channels
- Moving to TES based sensors soon





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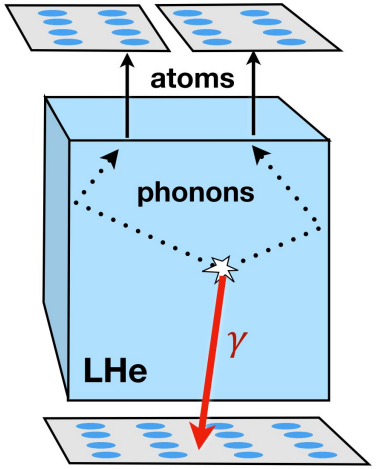
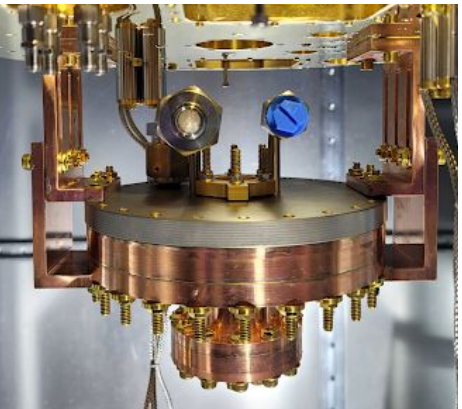
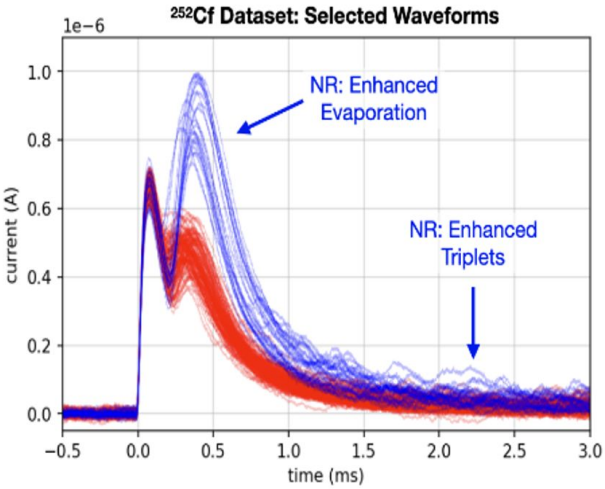
Superfluid He Detector



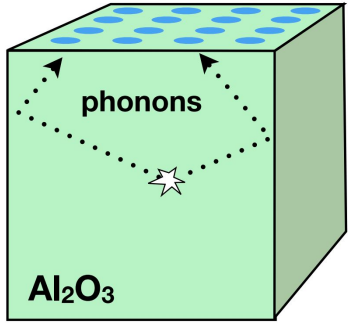


- Detect prompt scintillation photons (S1) and delayed quantum evaporation (S2) signals
- Many QET instrumented sensors above He
  - Coincidence to reject backgrounds
- Proven ER/NR discrimination
- New results coming soon!

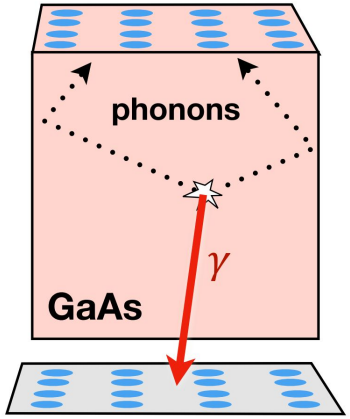


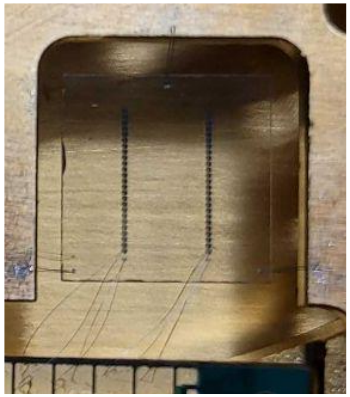
Phys. Rev. D **110**, 072006

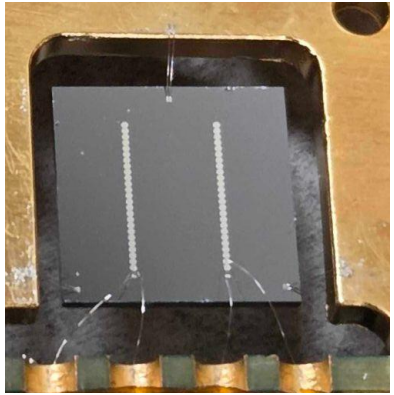
Polar Crystal Detectors



- Gapped phonons are well matched to low mass DM
- Oscillating dipole yields sensitivity to dark photons
- GaAs is known scintillator
  - Measure heat and light signals!
- Both technologies being studied now! Results to come!







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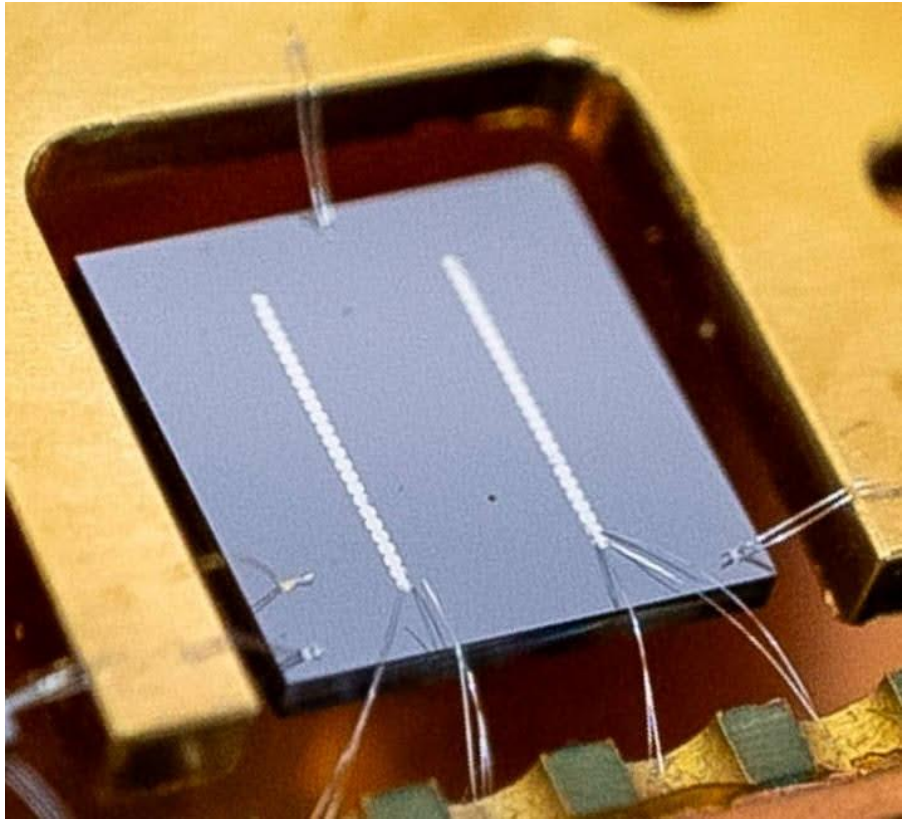
TESSERACT cm^2 Device

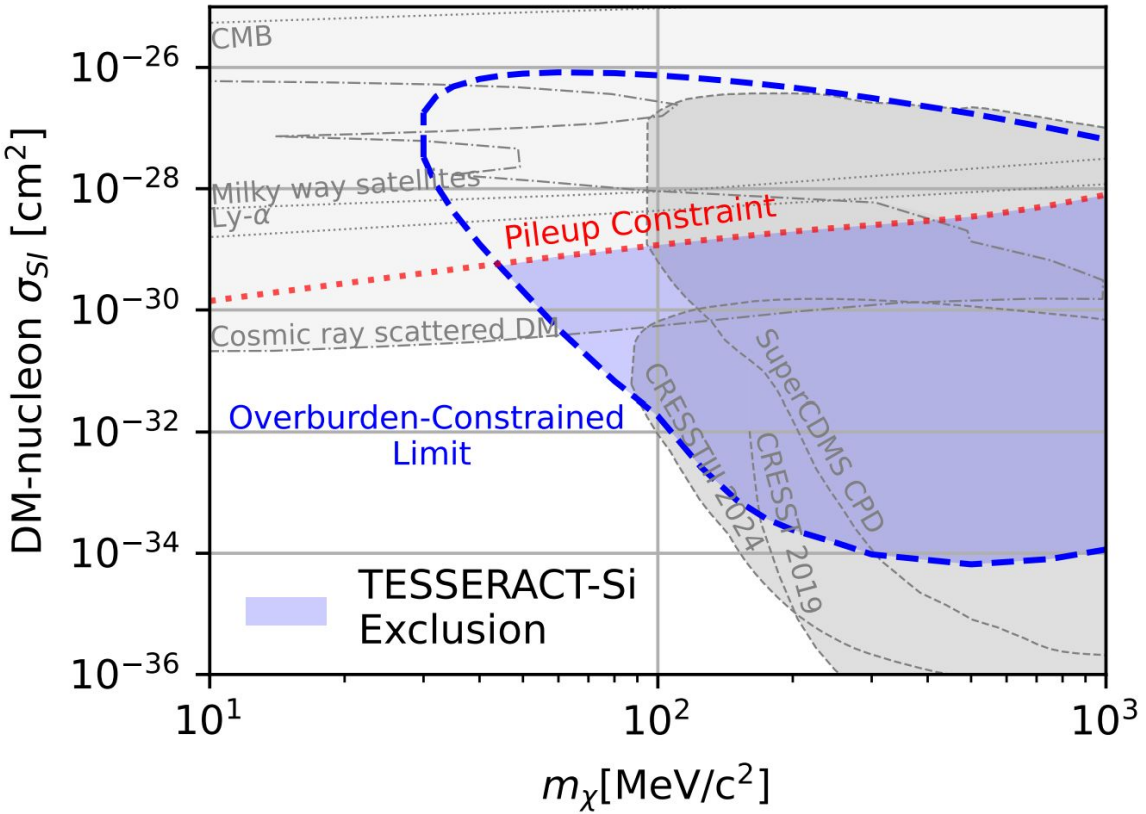
- 1cm^2 X 1mm “pixel” calorimeter made of silicon
  - 0.233 g mass of Si
  - Allows us to test TESs on convenient substrate
- Tungsten-Aluminum sensors fabricated directly on Si
- Designed for optimal resolution
  - **World-leading resolution of 260 meV**



First TESSERACT-Si Dark Matter Search

- Blue: Yellin Optimal Interval with overburden constraints
  - Atmosphere and building shielding
- Red: No DM-DM pileup requirement
  - 5.5 kHz detector bandwidth
- Lowest SI-NR DM search ever done! **44 MeV/c^2**

Phys. Rev. Lett. 135, 161001 (2025)



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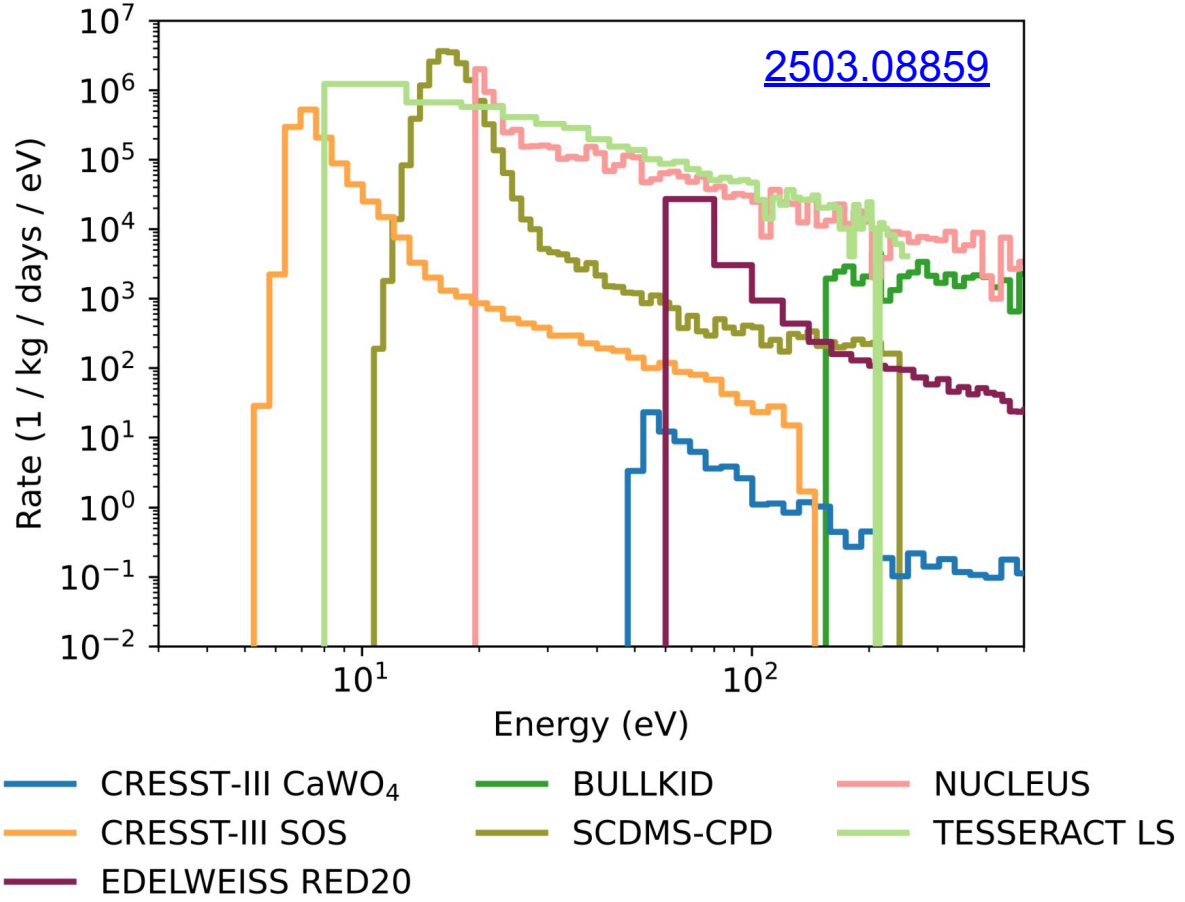
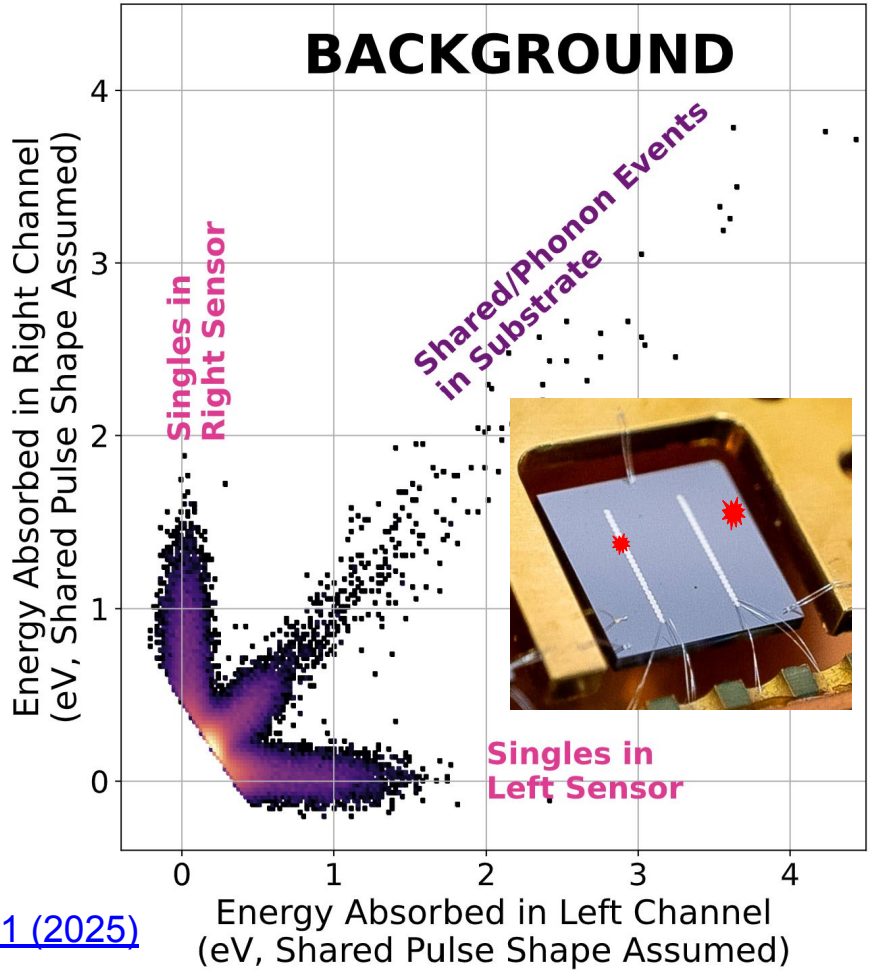
Low Energy Excess

- Cryogenic detectors see rise in event rate near threshold
- Presently the largest limitation for all cryogenic detectors



What is LEE?

- We observe two different types of LEE:
  - Some occur in the bulk substrate
  - Some occur only in a single sensor
- Tells us some comes from bulk phonons and some that are local to the metal films themselves!



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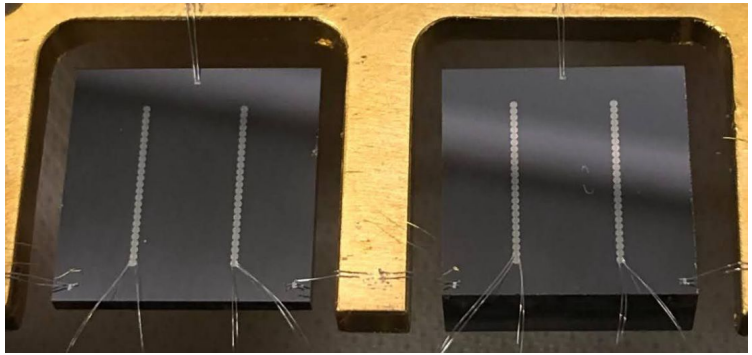
Appl. Phys. Lett. 126, 102601 (2025)

What is LEE?

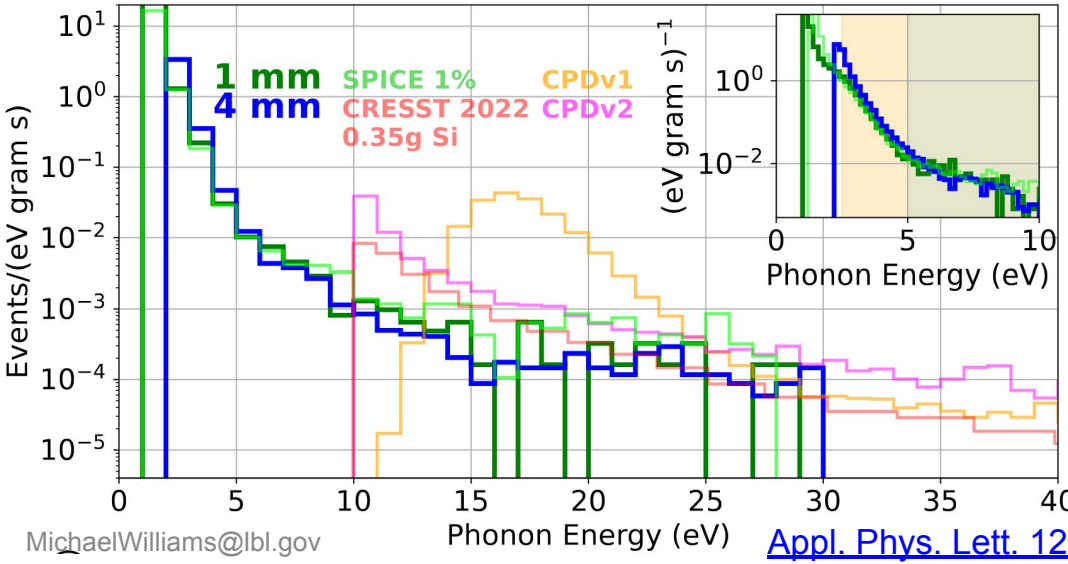
1mm

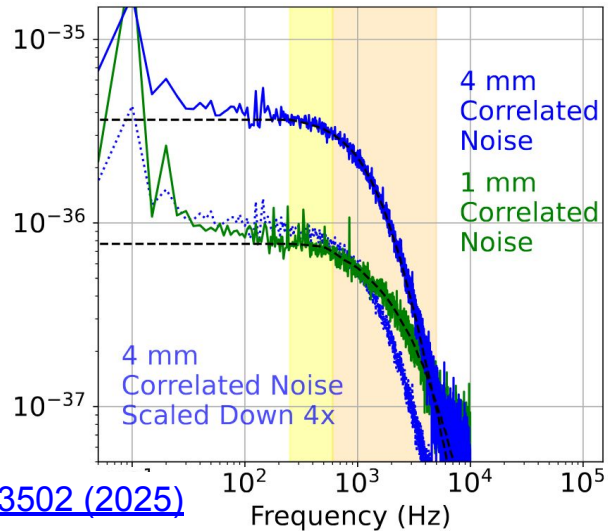


4mm

We see that the rate of bulk phonon LEE scales with volume!

- This is confirmation this is happening in the bulk

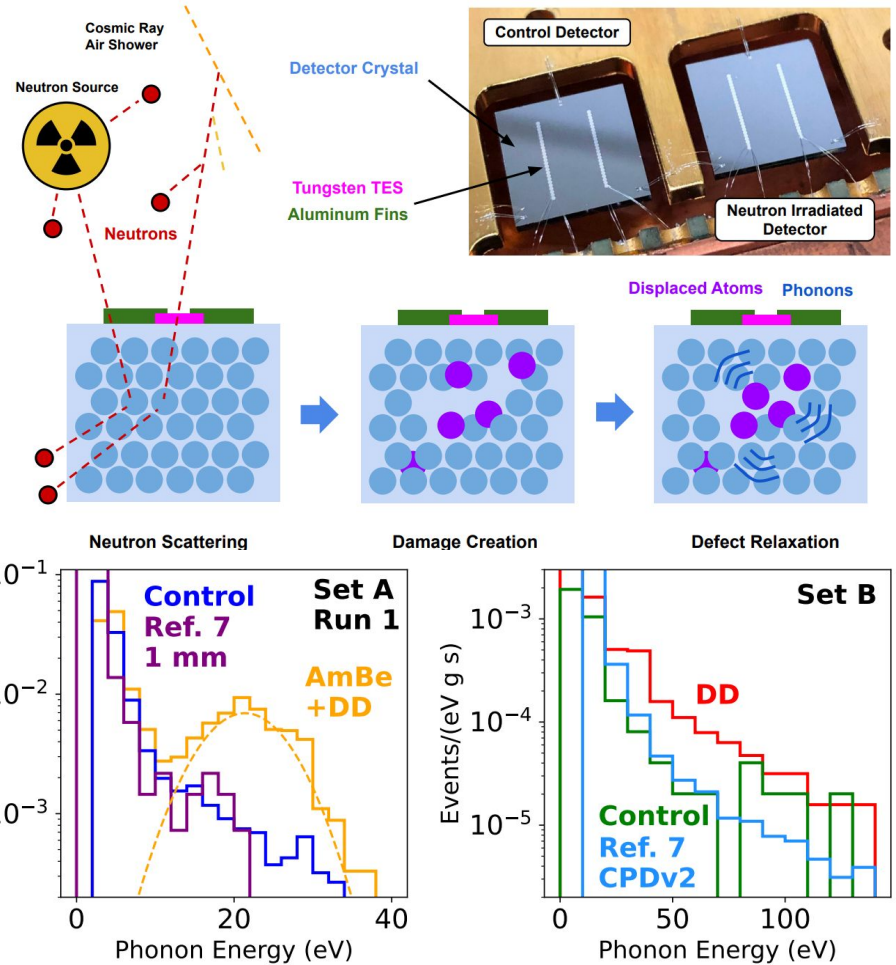




Appl. Phys. Lett. 127, 263502 (2025)

What is LEE?

- A potential cause of LEE could be defects
  - These could be caused by high energy radiation
- After purposefully irradiating detectors with neutrons, we can see an elevated rate of LEE
  - This doesn't mean that all or a majority of LEE is caused by radiation



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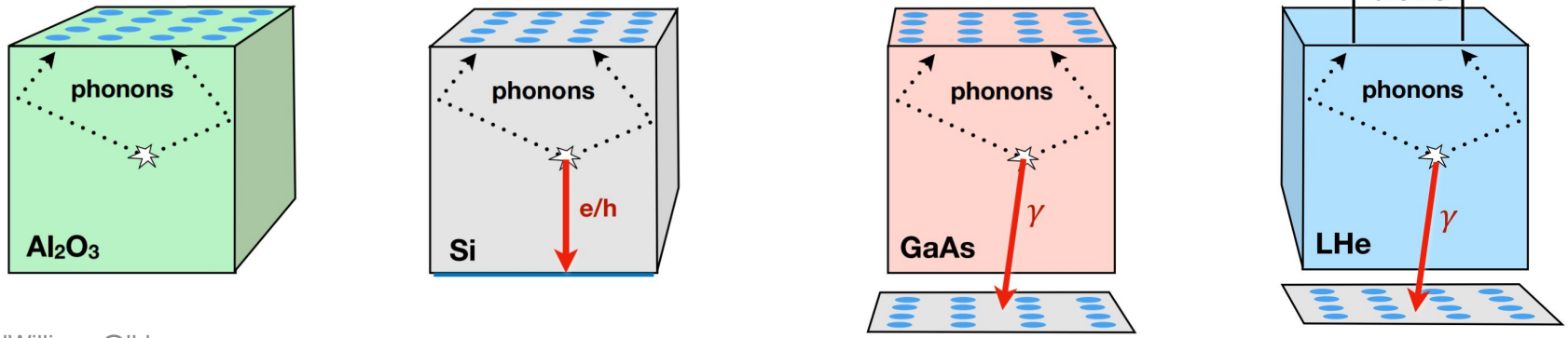
2603.17964

Mitigating LEE

- The TESSERACT detectors will require coincidence between different channels to mitigate LEE
  - Charge vs Heat
  - Light vs Heat
- Helium detector may have very low LEE due to many channel coincidence requirement



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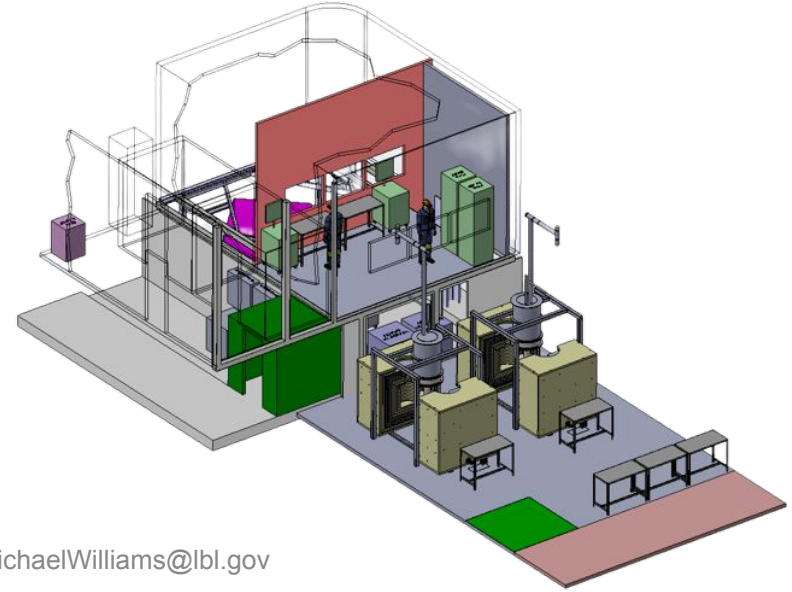
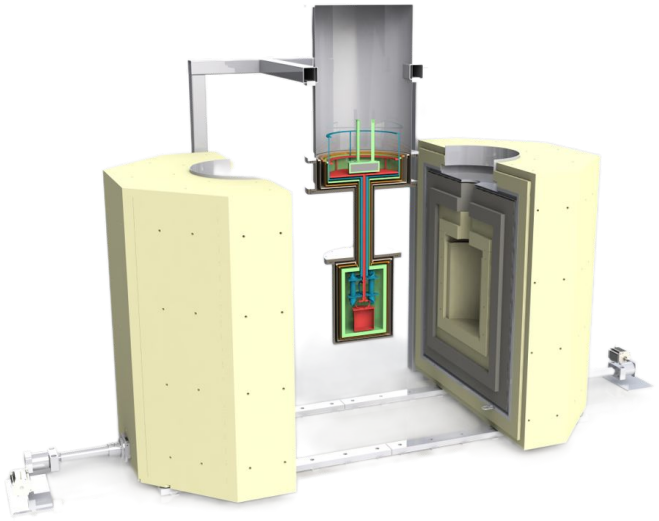
TESSERACT at Modane

- Field two identical shielded cryostats at LSM
  - Detectors and fridges designed for easy swapability
- Commissioning at Grenoble and Berkeley begins 2027
- Underground commissioning 2028, science begins 2029





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Summary

- Cryogenic detectors are sensitivity to all DM models
  - *Only* cryogenic detectors can target all models
- TESSERACT will field a variety of detectors, each with certain advantages
  - Charge detectors
  - Superfluid He
  - Polar Crystals
- Above ground commissioning starting 2027, underground commissioning at LSM starting in 2028
- Multiple publications imminent, stay tuned!

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TeVPA 2026

31st Aug. - 3rd Sep. 2026

Thank you!