BERKELEY LAB

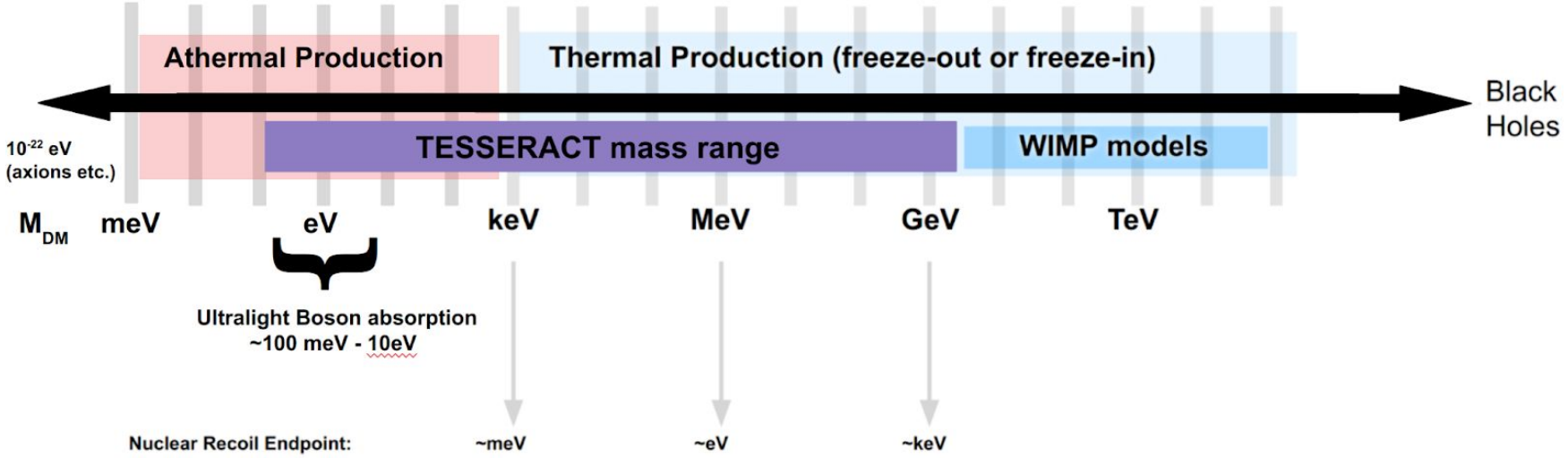
TESSERACT

Status of the TESSERACT Dark Matter Experiment

Michael Williams
On Behalf of the TESSERACT Collaboration

TeVPA 2024
26th-30th August, 2024

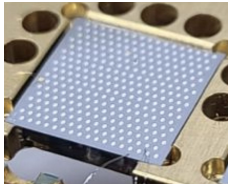
Low Mass Dark Matter



- Sub-GeV dark matter consistent with thermal production and freeze out after inflation (similar to WIMPs)
- Ultralight Bosonic DM is another viable candidate for DM
- Like WIMPs, these particles can recoil off electrons or nucleons or be absorbed and make signals that detectors can measure
- An experiment that has low threshold and multiple targets is ideal - TESSERACT!

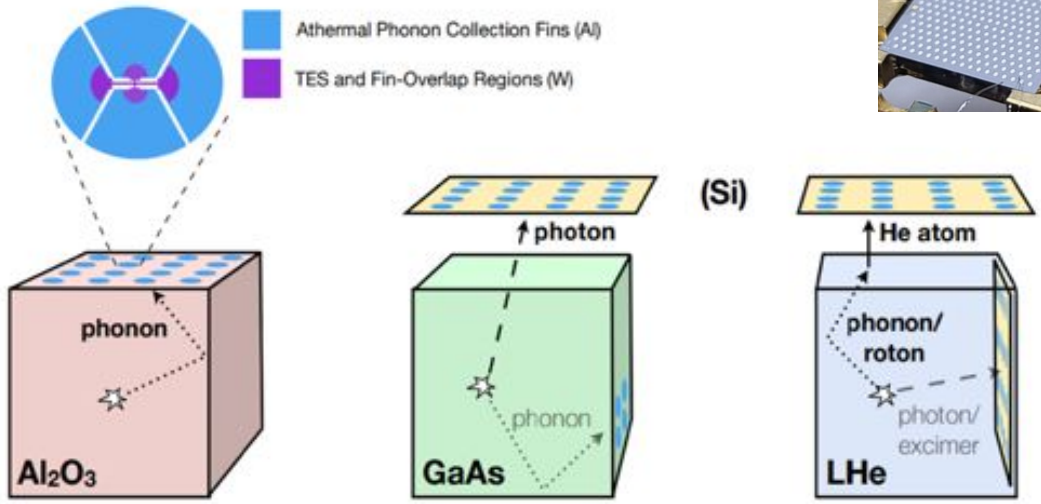
The TESSERACT Project

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

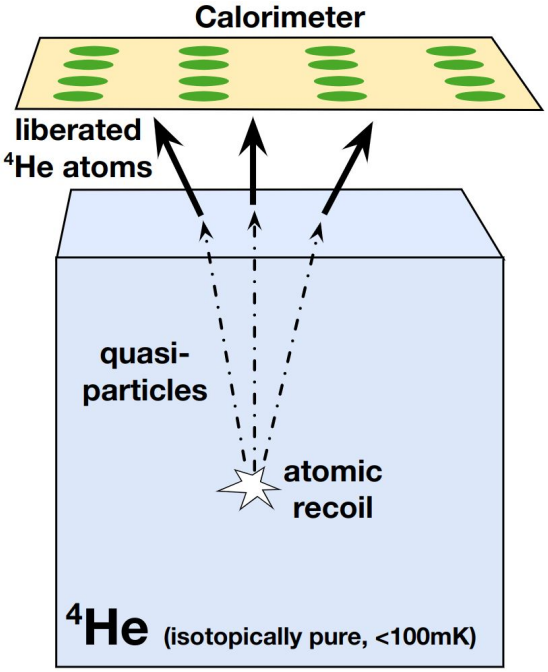


~40 people from 8 institutions + 3 (new!) French institutions (Lyon, Grenoble, Orsay)

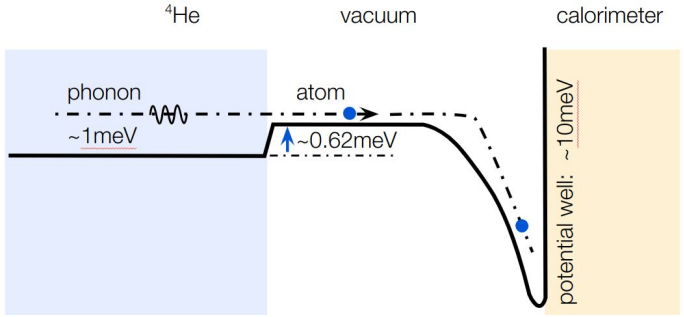
Project funding from DOE-HEP and IN2P3



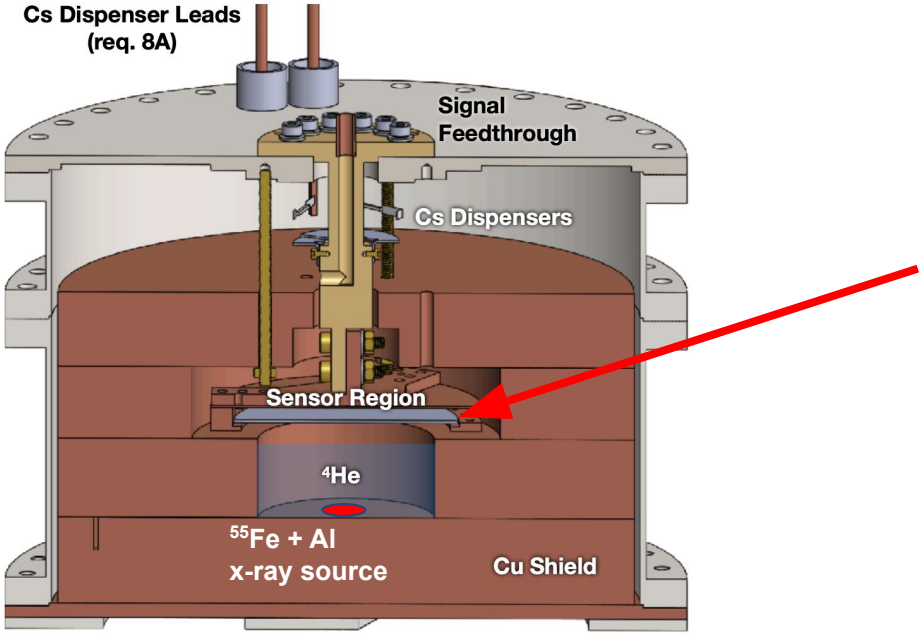
HeRALD - Superfluid He4

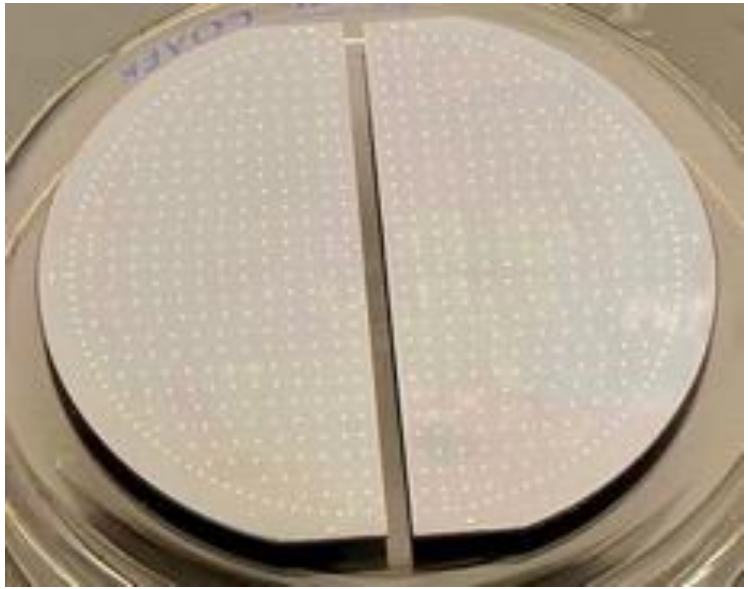


- Primary Signal Channel: Prompt Photon
- Secondary Signal Channel: Quantum Evaporation
  - A single quasiparticle may liberate a single atom from liquid surface
  - Phonon energy in He-4: ~ 1 meV
  - Atomic binding energy: 0.62 meV
- Signal from the binding of He atoms onto the surface of the calorimeter
  - Typical binding energy: 10 meV



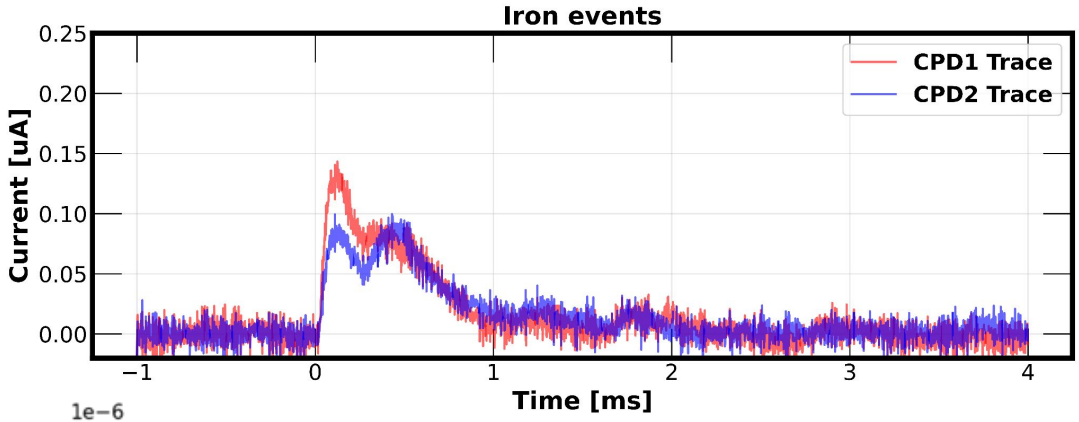
HeRALD v0.1

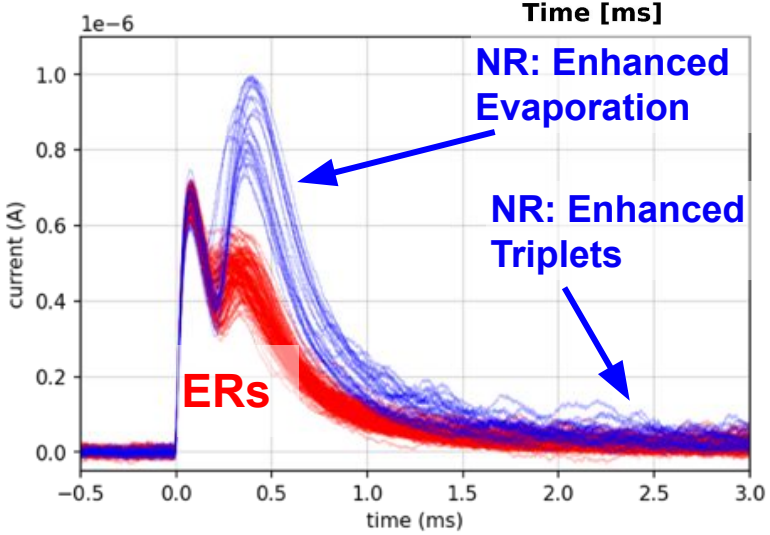




UMass HeRALD v0.1
- two channels to study coincident signals!

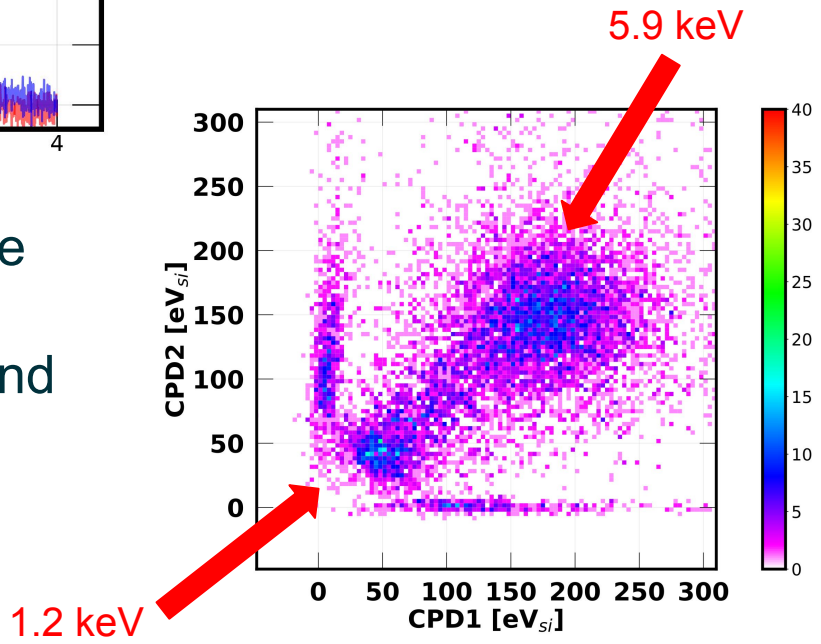
HeRALD v0.1





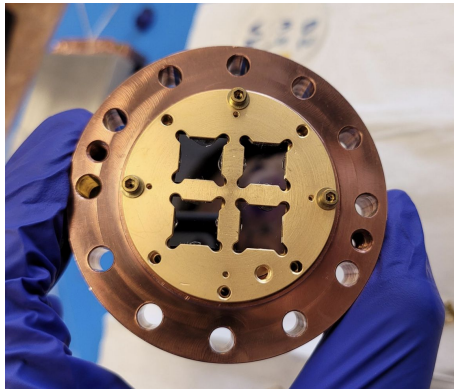
Particle ID for NRs and ERs!

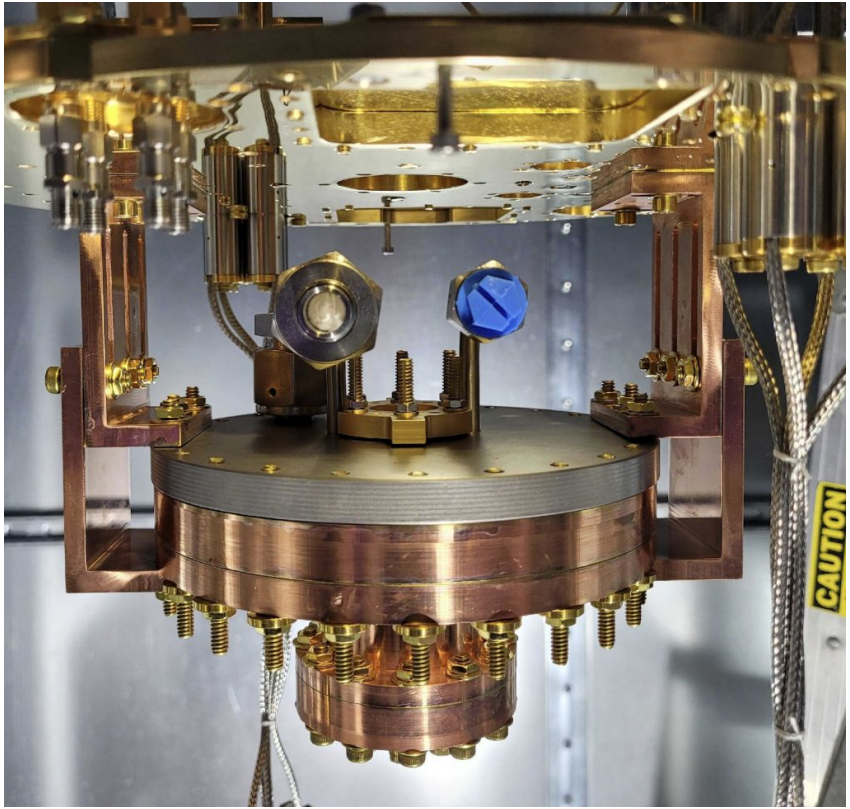
Can observe photon and phonon coincidence in two channels!



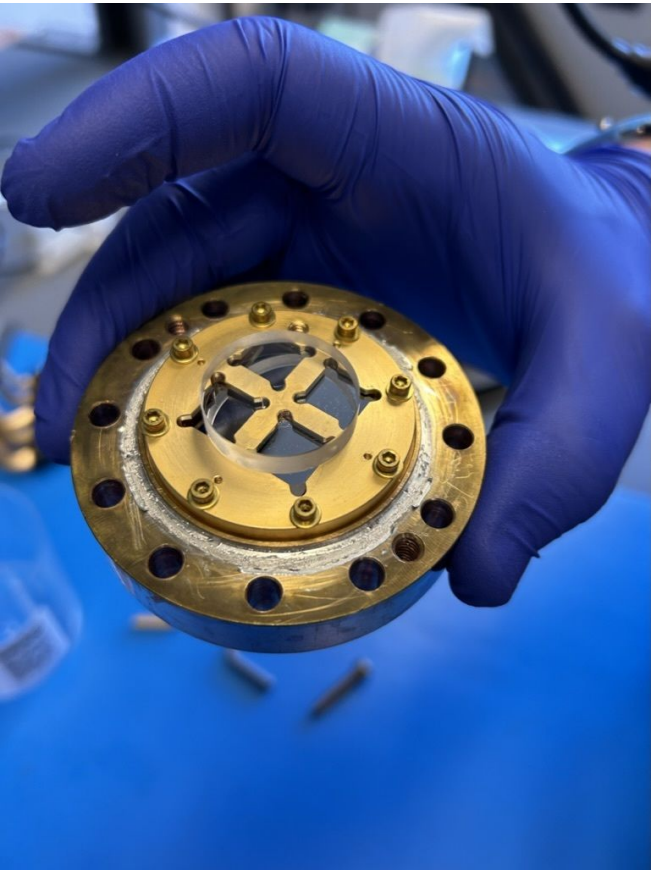
HeRALD v0.2

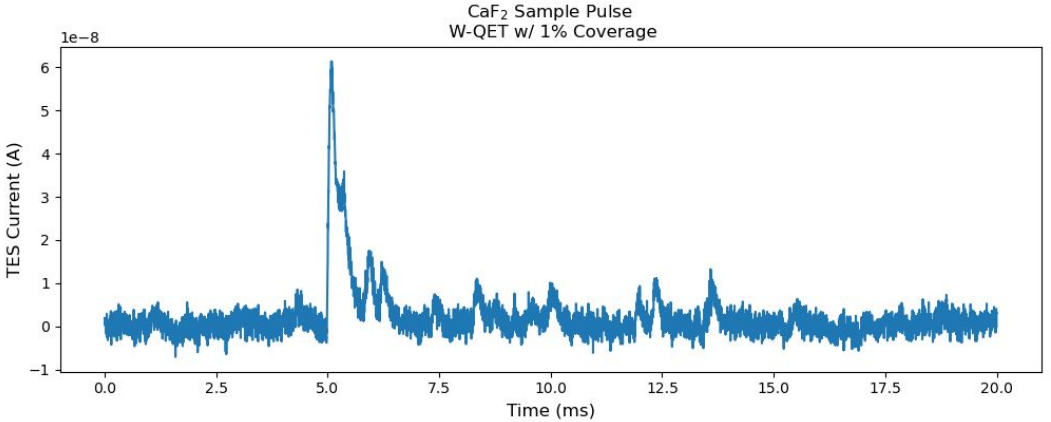
- LBNL HeRALD using cm^2 devices to further study coincidence
- Working on low energy NR/ER calibration techniques

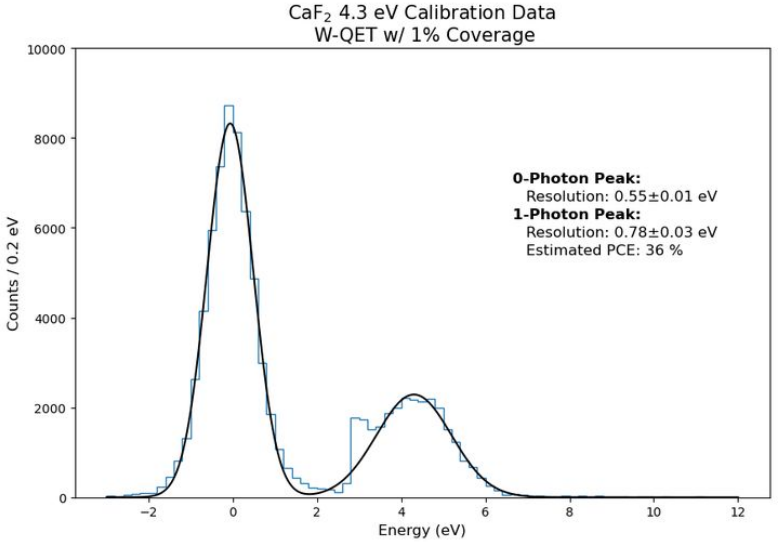




HeRALD v0.2





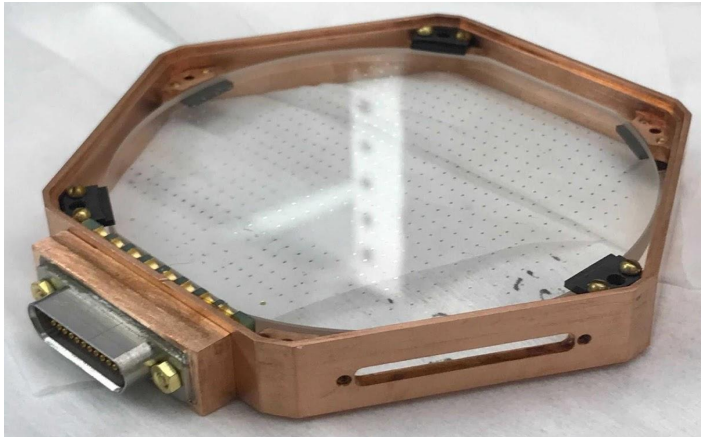


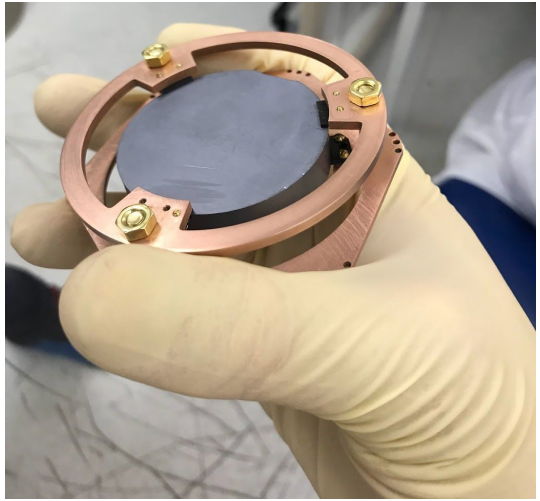
CaF2 sensor calibration shows excellent resolution!

Helium coming this week!

SPICE - Polar Crystals

- **Sapphire** (Al_2O_3):
  - **Sapphire** supports optical phonon modes.
  - DM recoiling off the lattice, ‘exciting a **phonon’**
  - Coupling to E&M-like inputs due to electric dipole → **dark photon sensitivity**

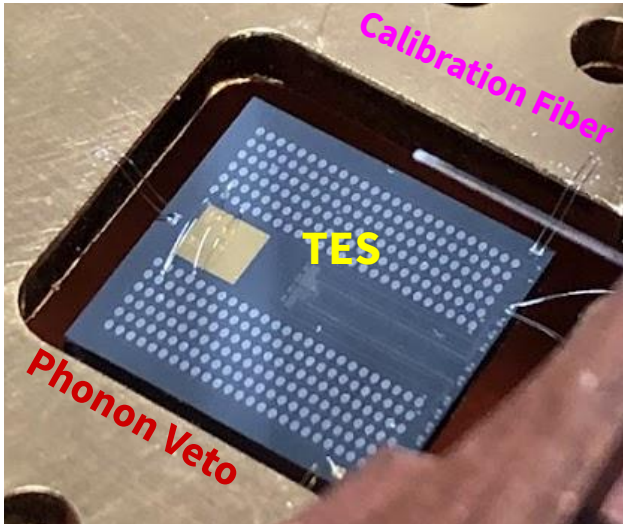


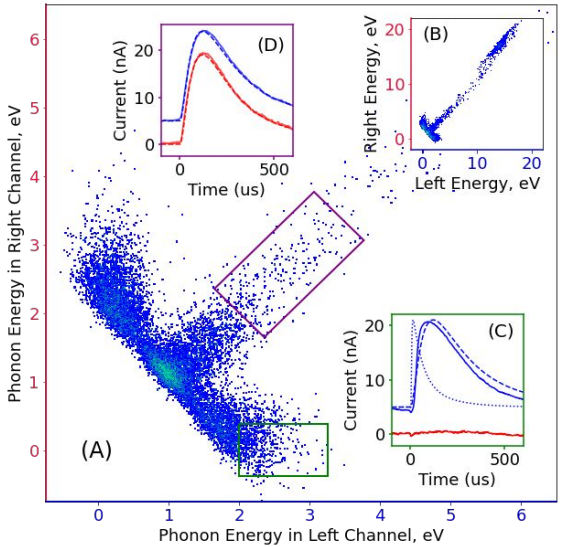


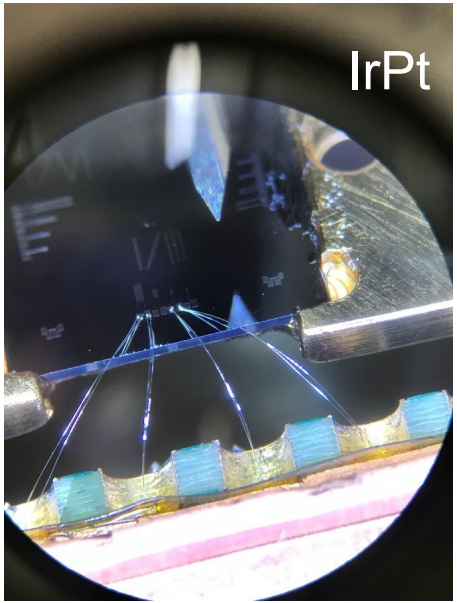
- **GaAs**:
  - **Polar crystal** & **bandgap** well matched to kinematic region of low mass DM
  - **Background discrimination** using phonon/photon ratio
  - Photon-photon and phonon-phonon coincidence can reduce instrumental bkgds
  - High light yield (125 ph/keV, 1904.09362)

Tackling the Low Energy Excess

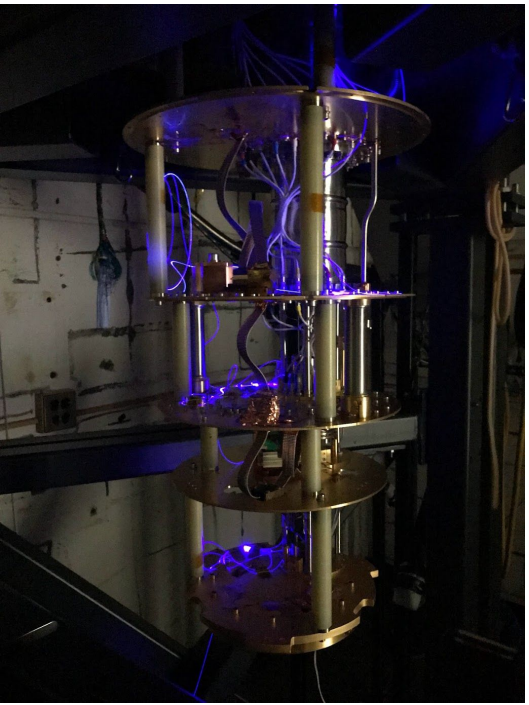
- "LEE" known problem in the field
- Use two channels on one substrate to understand the source
  - Film stress? Photons?
- Test new TES materials to see if film choice matters
  - IrPt TESs interesting candidate







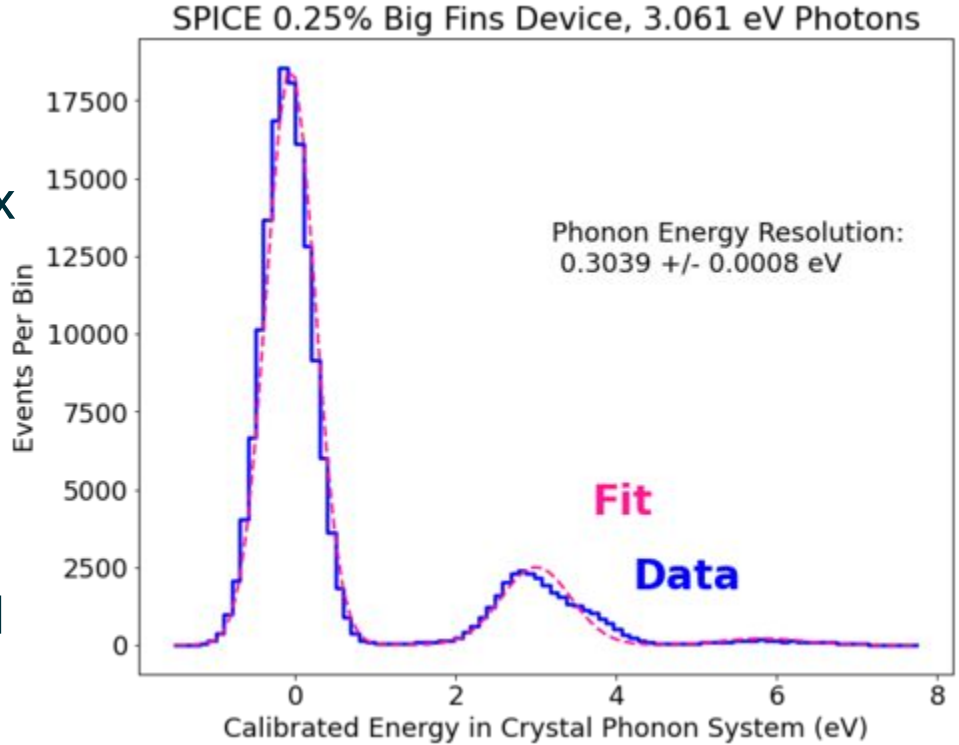
World Leading Energy Resolutions



Calibrate with 3eV photons

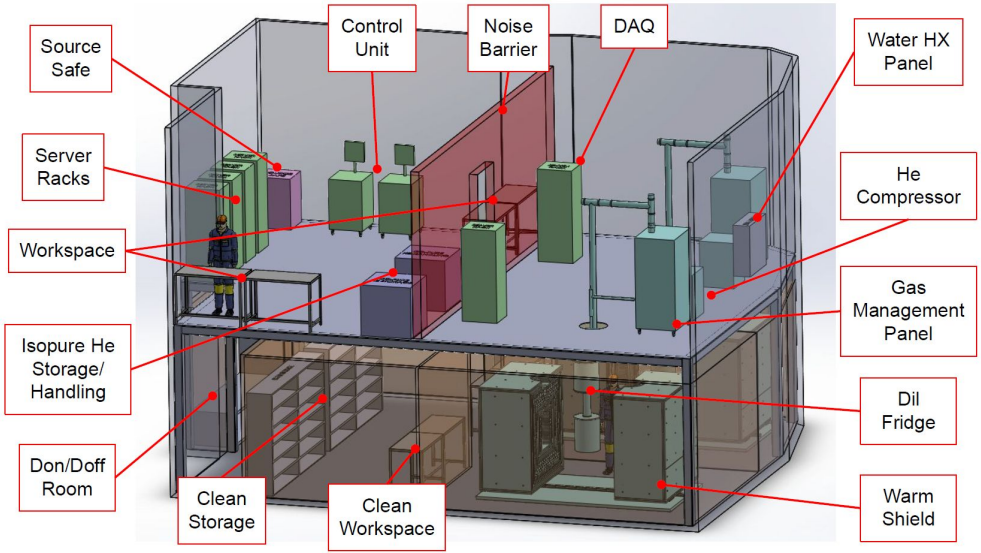
Get resolutions 5x better than nearest competitors!

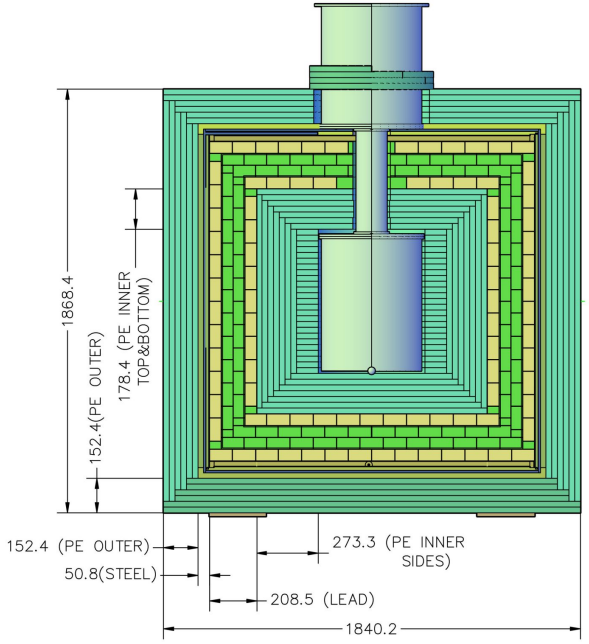
Better resolution means better DM reach!



TESSERACT@Modane(LSM)

- Selected for DOE funding starting FY25
- Plan for two identical setups - each able to house a target
- Installation begins 2025!





TESSERACT - Coming Soon!

- Strong R&D track record turning novel detectors into reality
- HeRALD calibrated and running
- SPICE has developed ways to identify, study, and reject the LEE
- Sensors have shown world leading energy resolutions
- Installation of the underground shielding beginning next year
- Expect to reach world leading sensitivity to multiple signal models
- Exciting results coming soon 😉