Overview and Status of the SPLENDOR Experiment

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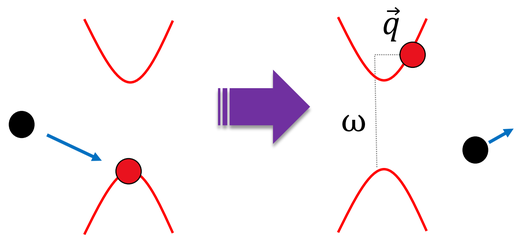
CPAD Workshop

The SPLENDOR (**S**earch for **P**articles of **L**ight Dark Matt**e**r with **N**arrow-gap Semicon**d**uct**o**r**s**) experiment is a search for light dark matter via the electron-recoil interaction channel, taking advantage of novel single-crystal narrow-bandgap (order 10-100 meV) semiconductors synthesized within the collaboration. Operation as ionization detectors at cryogenic temperatures using HEMT based amplification should allow for probing sub-MeV dark matter masses.

Dark Matter - Electron Scattering

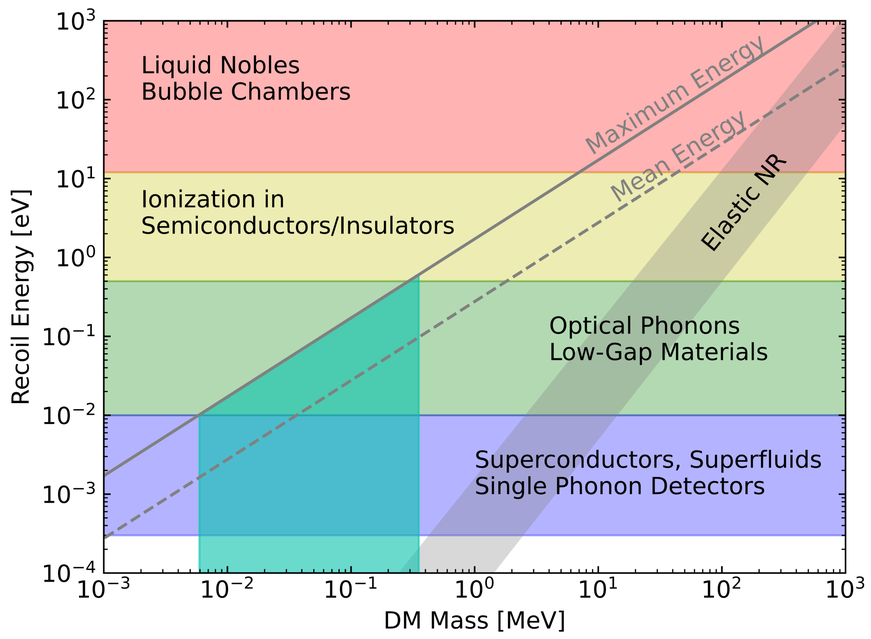


Inelastic scattering process formulated in terms of the experimentally measurable and theoretically calculable **Loss Function**

$$\Gamma(\mathbf{v}_\chi) = \int \frac{\mathrm{d}^3\mathbf{q}}{(2\pi)^3} |V(\mathbf{q})|^2 \left[2\frac{q^2}{e^2}\,\mathrm{Im}\left(-\frac{1}{\varepsilon(\mathbf{q},\omega_\mathbf{q})}\right)\right] \quad \mathcal{W}(\mathbf{q},\omega) \equiv \mathrm{Im}\left(-\frac{1}{\varepsilon(\mathbf{q},\omega)}\right)$$

Y Hochberg *et al*, *Phys. Rev. Lett.* ***127***, 151802 (2021).

WHY NARROW BANDGAPS?

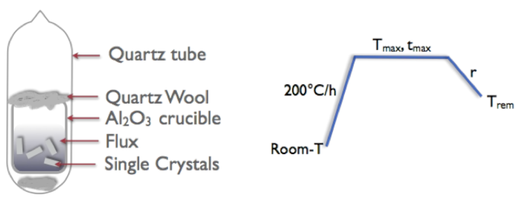


Recoil energy scales and detection technology. Adapted from arXiv:2203.08297

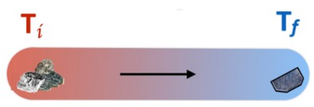
- Light dark matter searches via DM-electron scattering are fundamentally limited by bandgap
- With novel materials with small (order 10-100 meV) bandgaps, we can search for sub-MeV fermionic dark matter and sub-eV bosonic dark matter

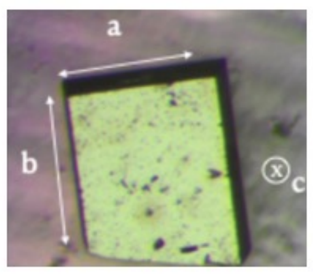
In-House Materials Discovery

Flux Growth

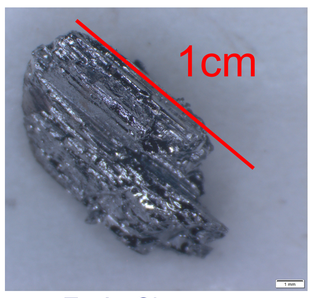


Chemical Vapor Transport

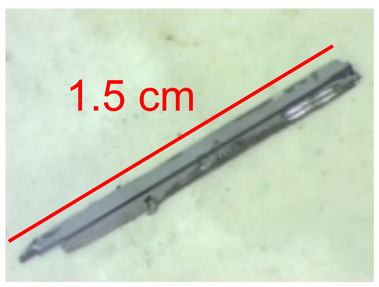




$La_3Cd_2As_6$

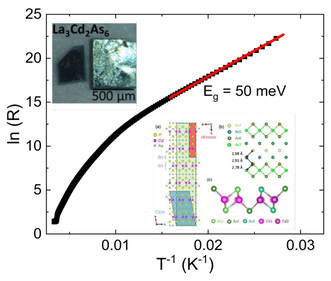


$Eu_5In_2Sb_6$

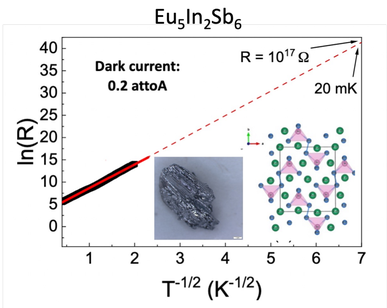


$Ba_3Cd_2As_4$

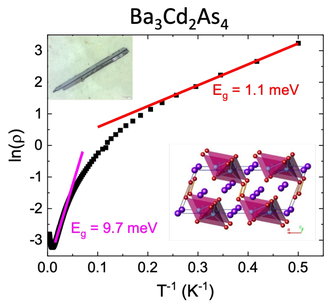
$La_3Cd_2As_6$



$Eu_5In_2Sb_6$



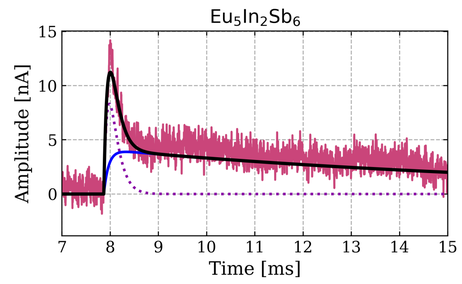
$Ba_3Cd_2As_4$

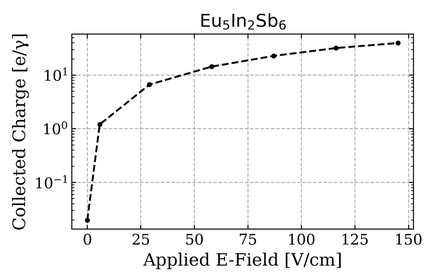


$$\rho(T) = A\exp[(T_0/T)^\beta]$$

- Resistivity measurements show activated behavior with bandgaps of O(1-100meV)
- Indicates a dark rate of sub atto-amps at mK temperatures

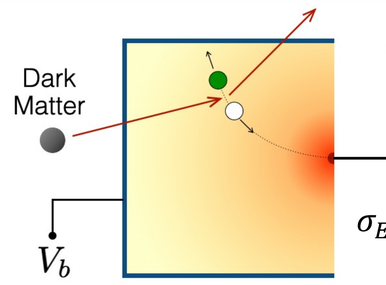
Materials Photoresponse





- Materials have photoresponse to IR light
- Beginning to show signs of full charge collection – ongoing studies at lower temperatures

Detection Scheme

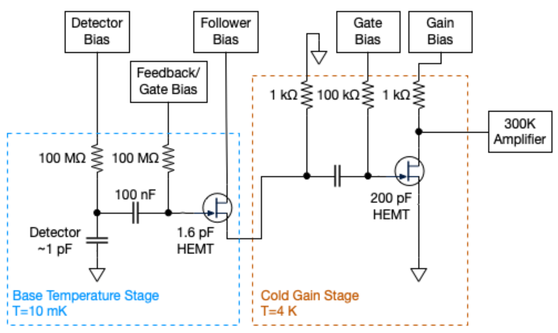


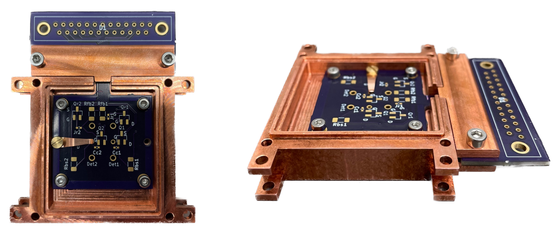
- Use well-known point-contact style detector design

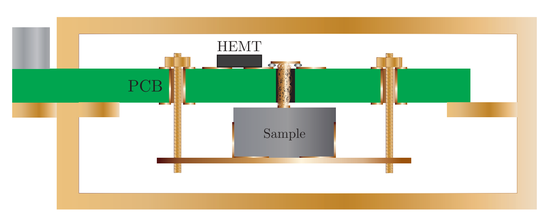
$$\sigma_E \sim E_{gap} \times \sigma_V \times (C_{detector} + C_{input} + C_{parasitic})$$

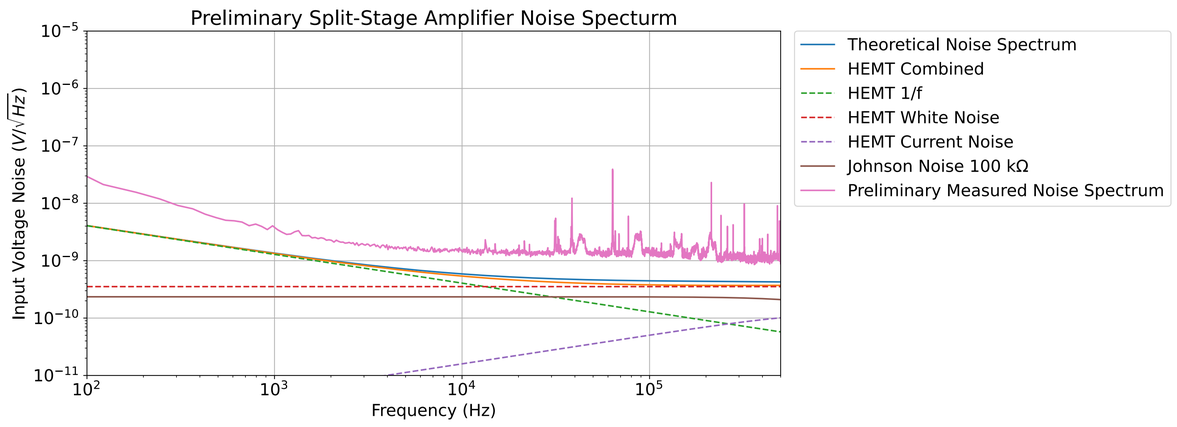
charge resolution
(goal: $\sigma_{e^-} \sim O(1)\, e^-$)

- Minimize parasitic capacitance using front end HEMT buffer directly connected to detector at base temperature stage





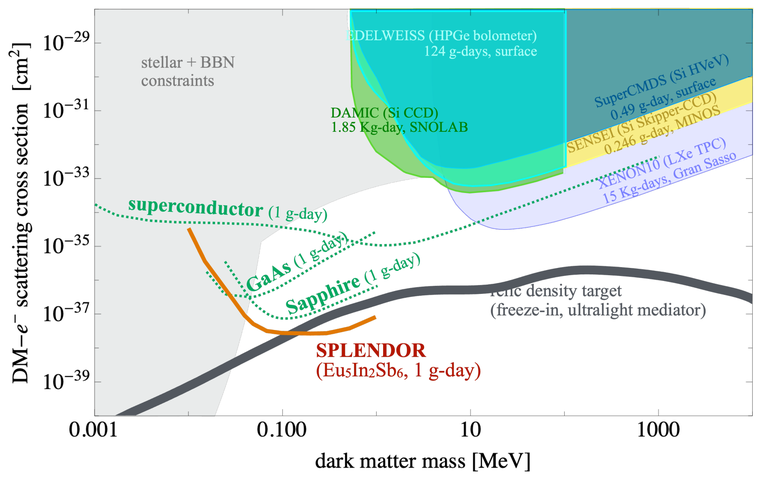




- Initial measurements show an estimated $12e^-$ charge resolution!

Estimated Sensitivity

Assuming a light mediator, with a preliminary dielectric function, SPLENDOR's 90% C.L. sensitivity with no background



DM data with prototype detector operated at a surface facility expected late 2023/early 2024 – Stay tuned!

Los Alamos NATIONAL LABORATORY

NNSA National Nuclear Security Administration

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