# Sub-GeV mass dark matter with SuperCDMS

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Southern Methodist University
on behalf of the SuperCDMS collaboration

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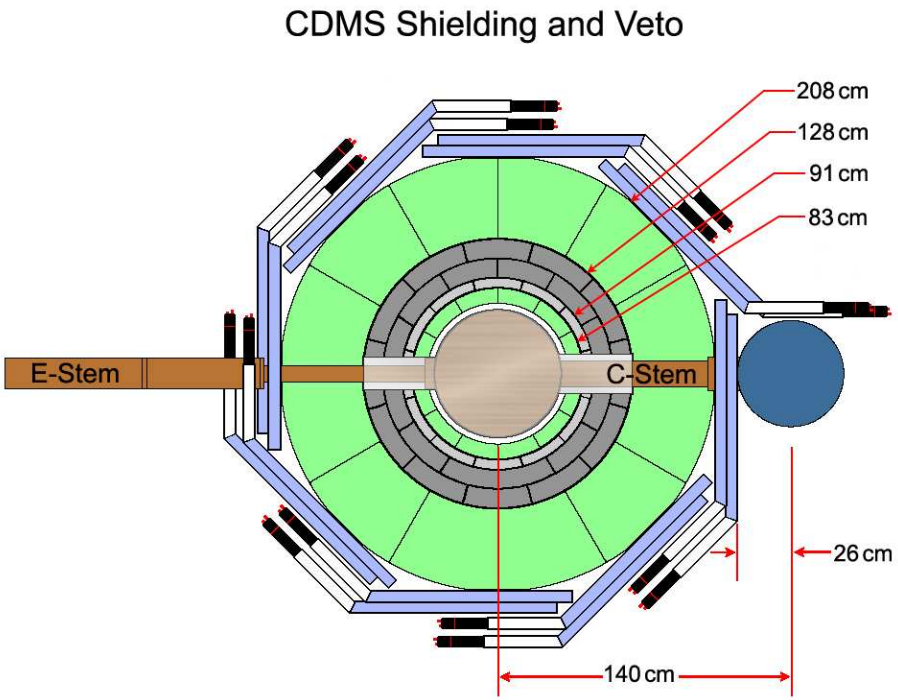
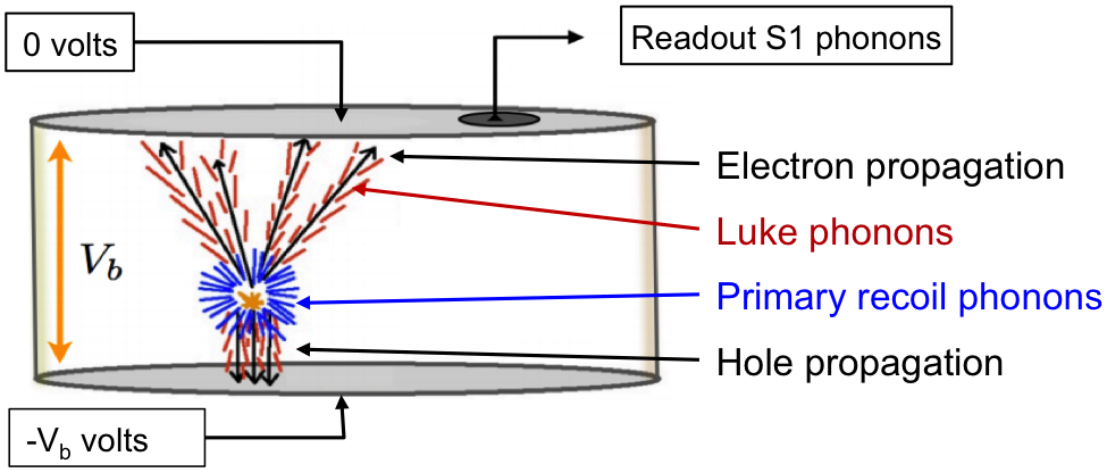
SMU®

# SuperCDMS Soudan



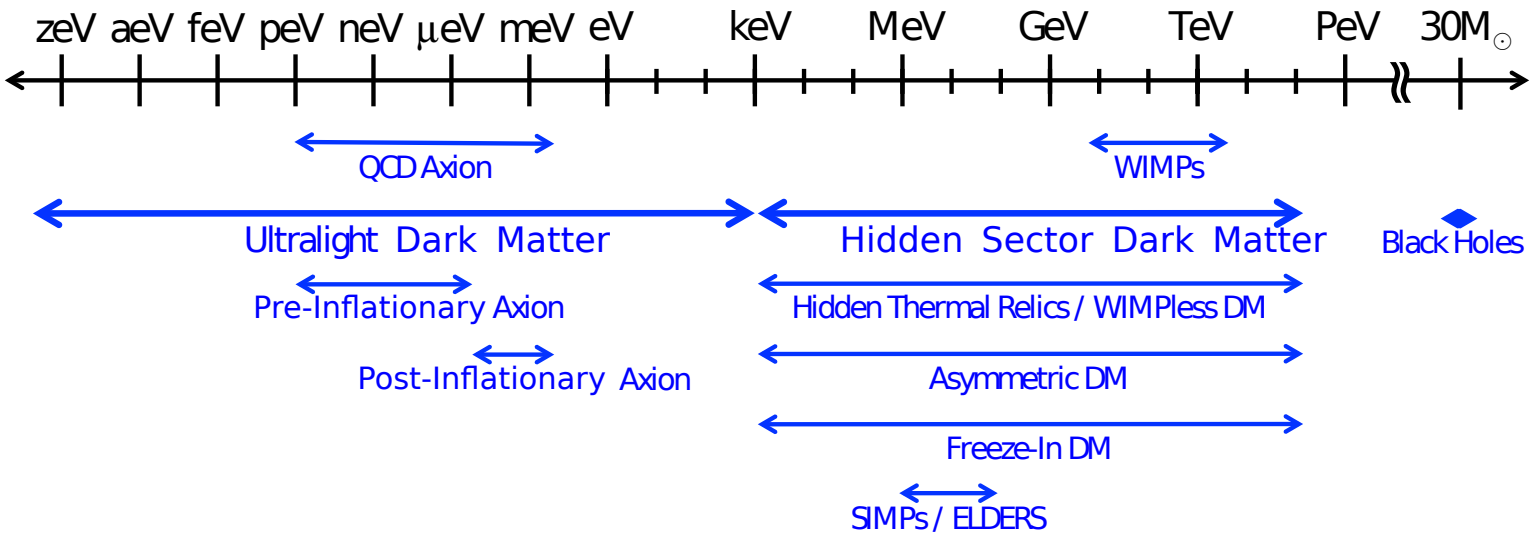

- Located in Soudan Underground Lab, $\approx \frac{1}{2}$ mile underground with 2090 M.W.E. of overburden
- Utilizes the same shielding and cryostat from CDMS-II experiment
- Collected about 2500 kg-days of raw exposure over experiment lifetime
- Data taking ended in 2015, collaboration shifting focus to SNOLAB

# HV Biasing

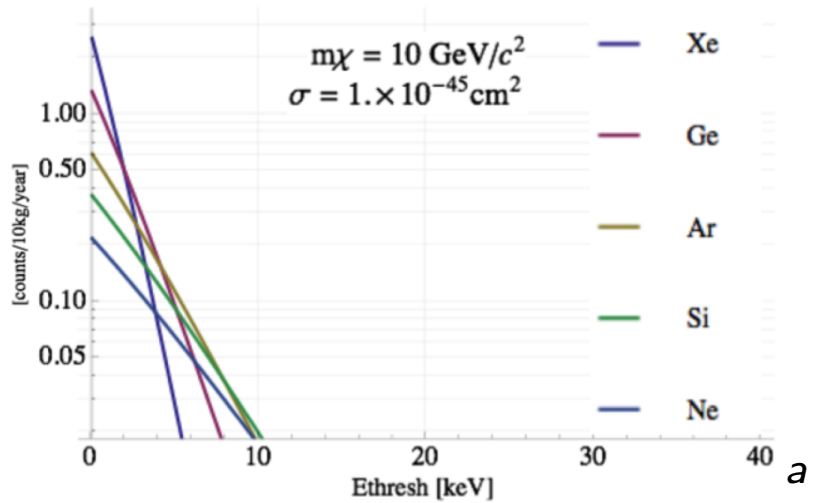



- Phonons are created from charges passing through a crystal through Neganov-Trofimov-Luke effect
- The contribution to total phonon energy goes as $N_{e/h}eV_b$ : proportional to bias voltage $V_b$
- High bias voltage allows us to measure small amount of charges through phonon signal (CDMSlite mode/HV)
- Trade-off: no separate measurement of primary phonon signal, sacrifices ER/NR discrimination

# Low mass dark matter Battaglieri et al. arXiv:1707.04591

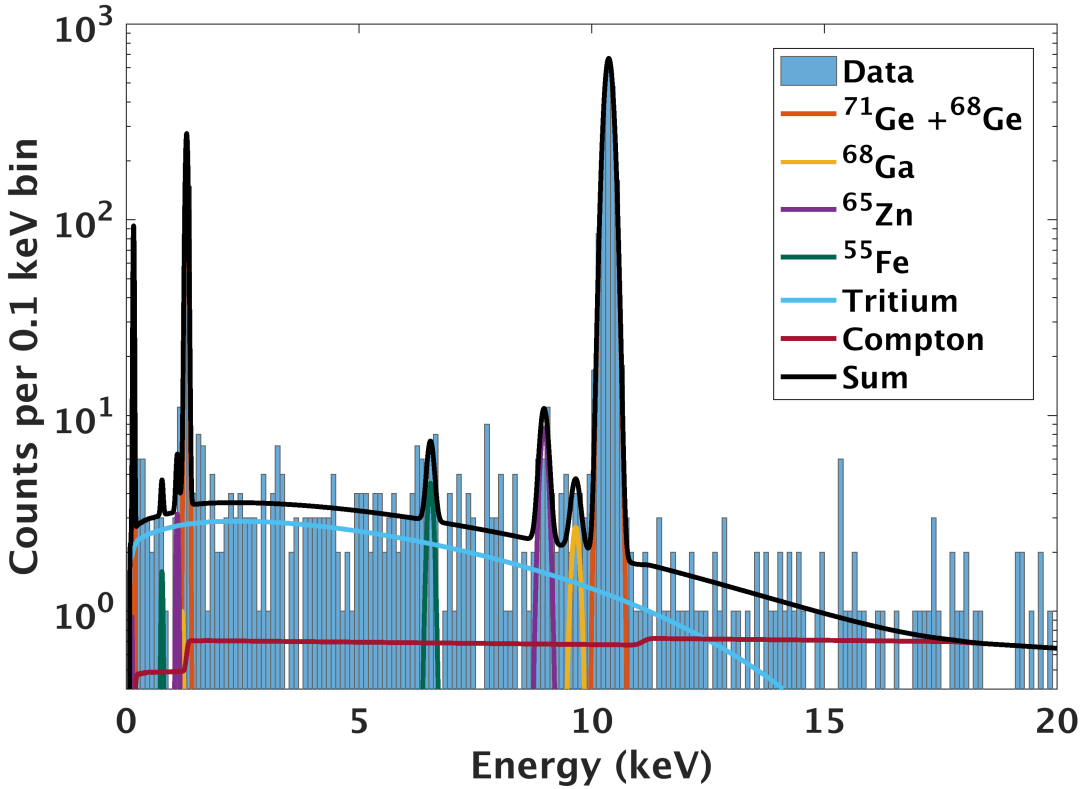



- WIMPs are just one possibility
- Kinematics for light masses disfavorable, sensitivity driven by threshold
- Need new ideas and approaches to probe these low masses



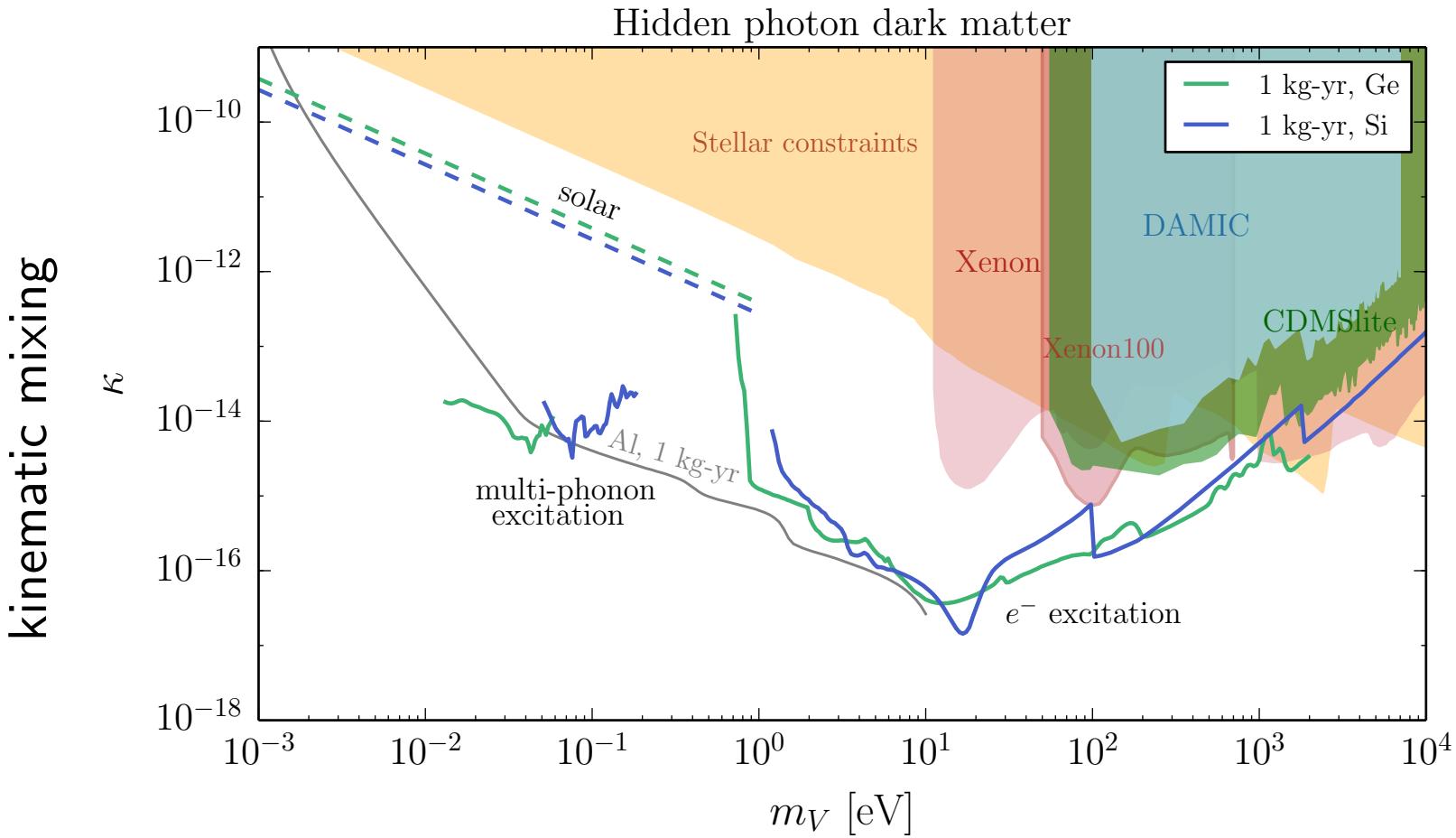

[a] Mirabolfathi - arXiv:1308.0044

# Dark photon absorption with CDMSlite data



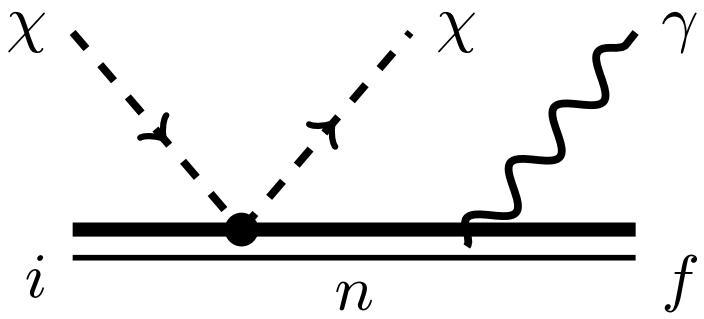

- Mediator between standard model and dark matter with finite mass ($m_{A'}$)
- Absorption rate, $R \simeq \frac{\rho_{DM}}{m_{A'}c^2}\epsilon^2\sigma_{p.e.}(E_{gamma} = m_{A'})c$
- Signal is mono-energetic electron with $E = m_{A'}$
- Search strategy is a bump-hunt in our spectrum!

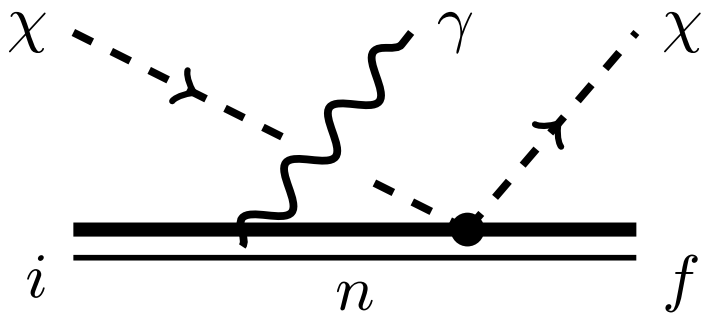
# Dark photons - Hochberg, Lin and Zurek Phys. Rev. D 95, 023013

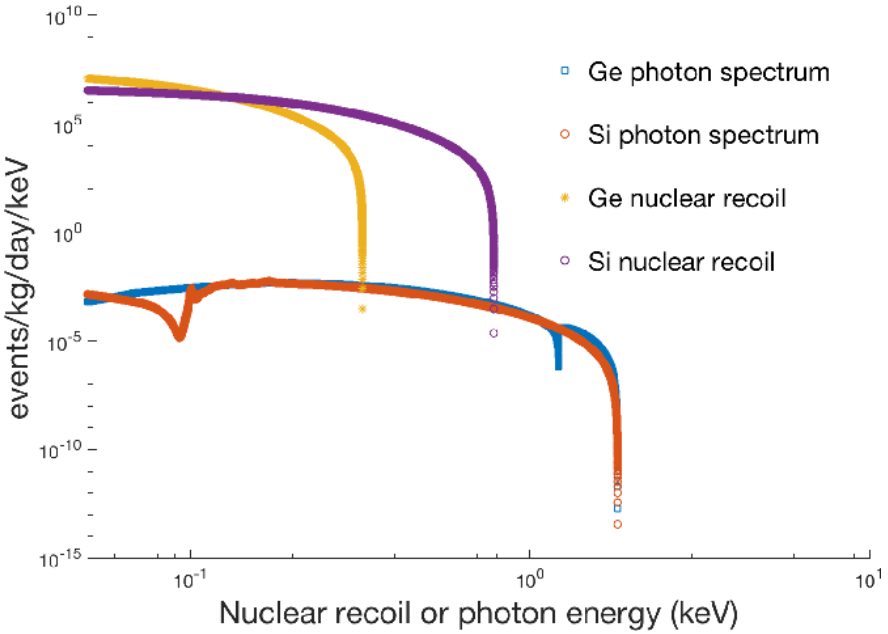



- Sensitivity extends down to band gap (Ge .7 eV, Si 1.1 eV)
- We can expect to cover a large amount of parameter space at SNOLAB

# Bremsstrahlung - Kouvaris and Pradler Phys. Rev. Lett. 118, 031803



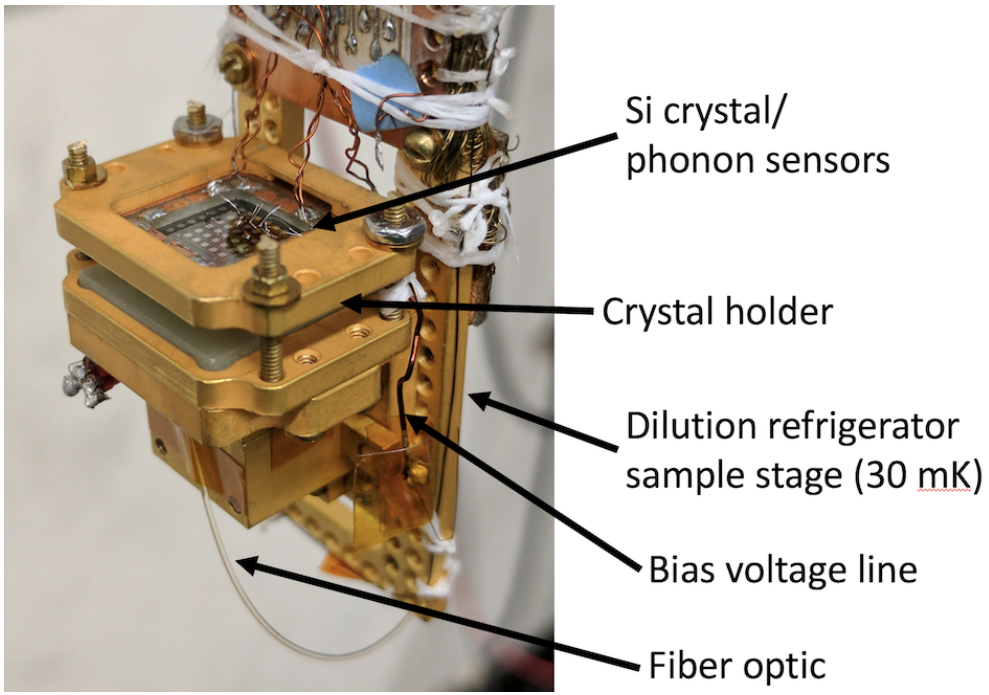



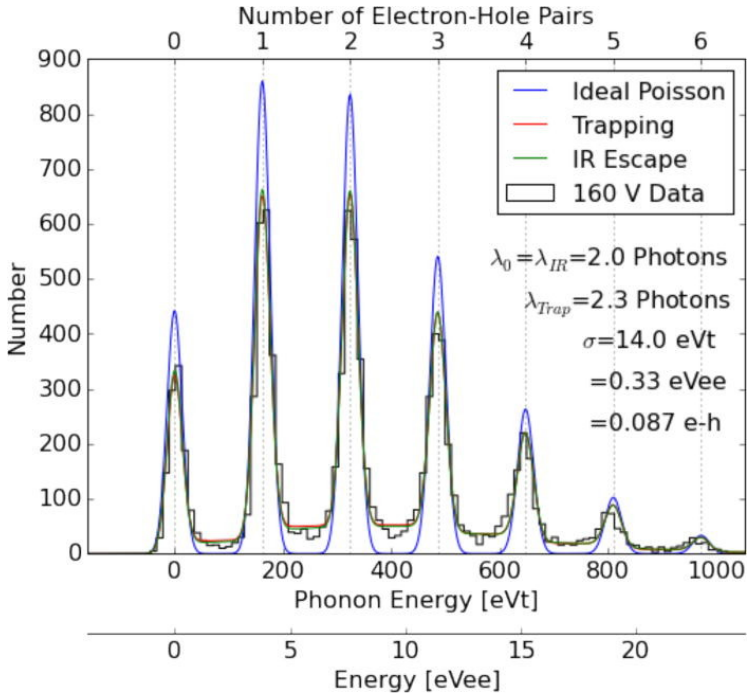




1 GeV WIMP

- Recoiling nucleus can emit a photon as it slows down in material
- Energy of this photon can extend to higher energies than NR
- Photon acts as probe to low mass WIMP scattering below detector threshold

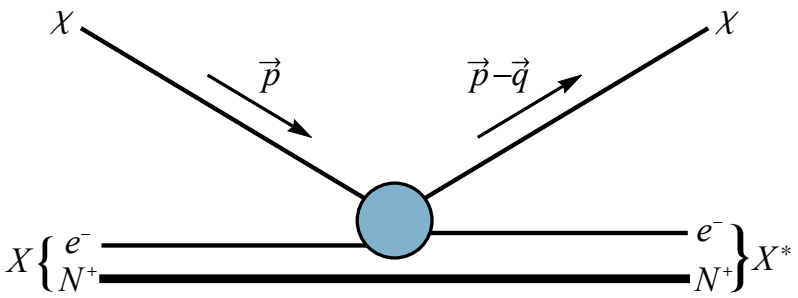
# Single e/h device - Romani et al. Appl. Phys. Lett. 112, 043501

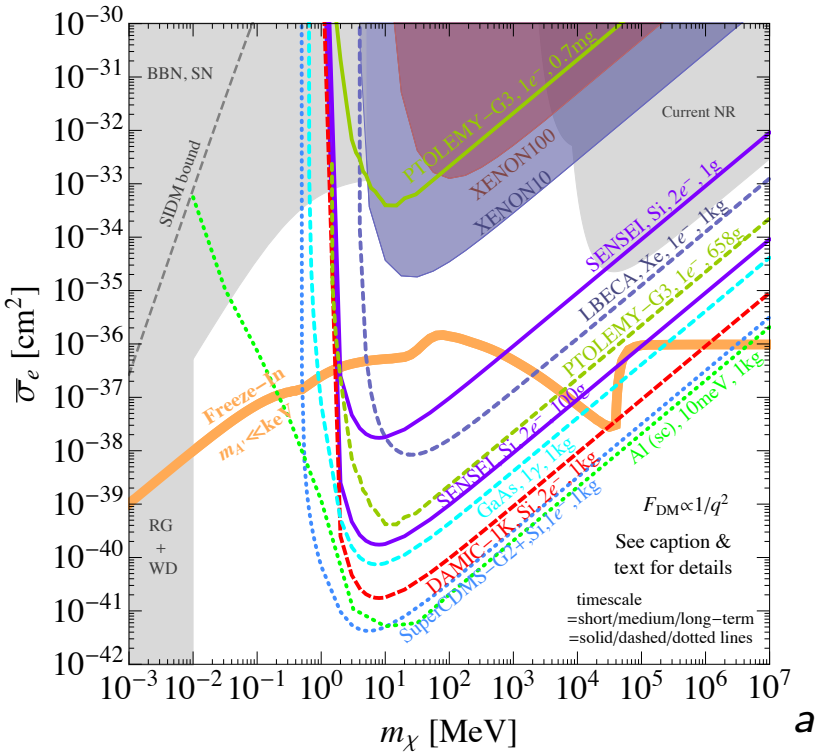


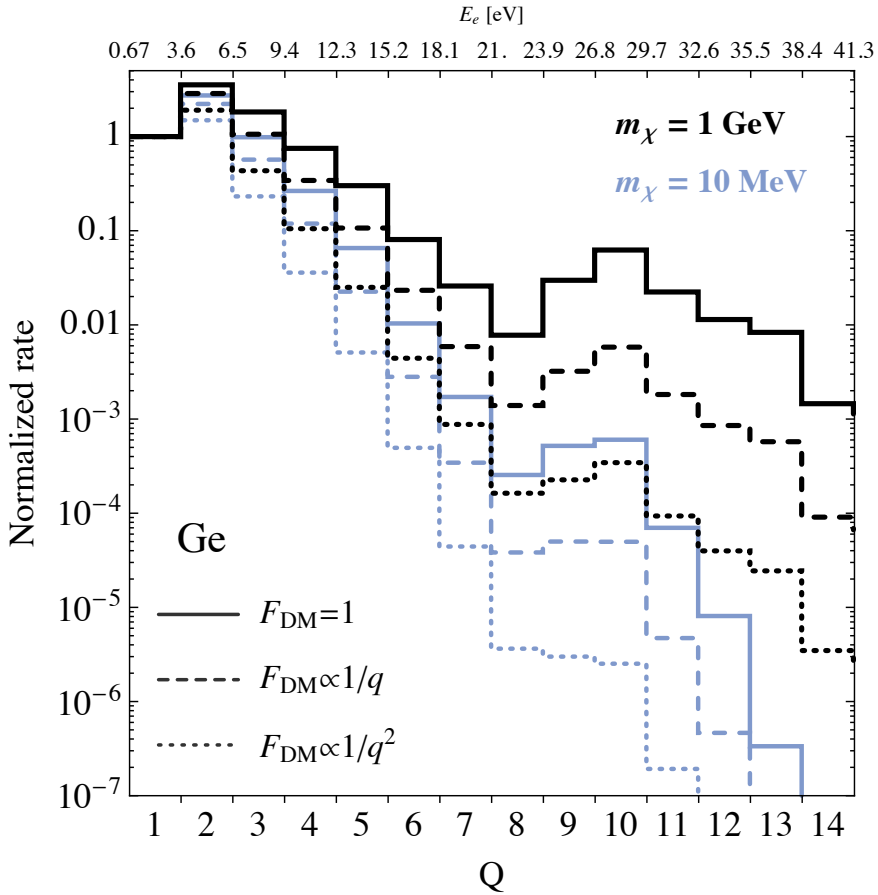




- Single e/h-pair sensitivity has been recently demonstrated in 0.93g Si crystal
- Single e/h-pair resolution goal of SuperCDMS SNOLAB
- Such devices will have sensitivity to a variety of sub-GeV DM models with ∼g*d exposures

# DM-electron scattering - Essig et al. JHEP 1605 (2016) 046



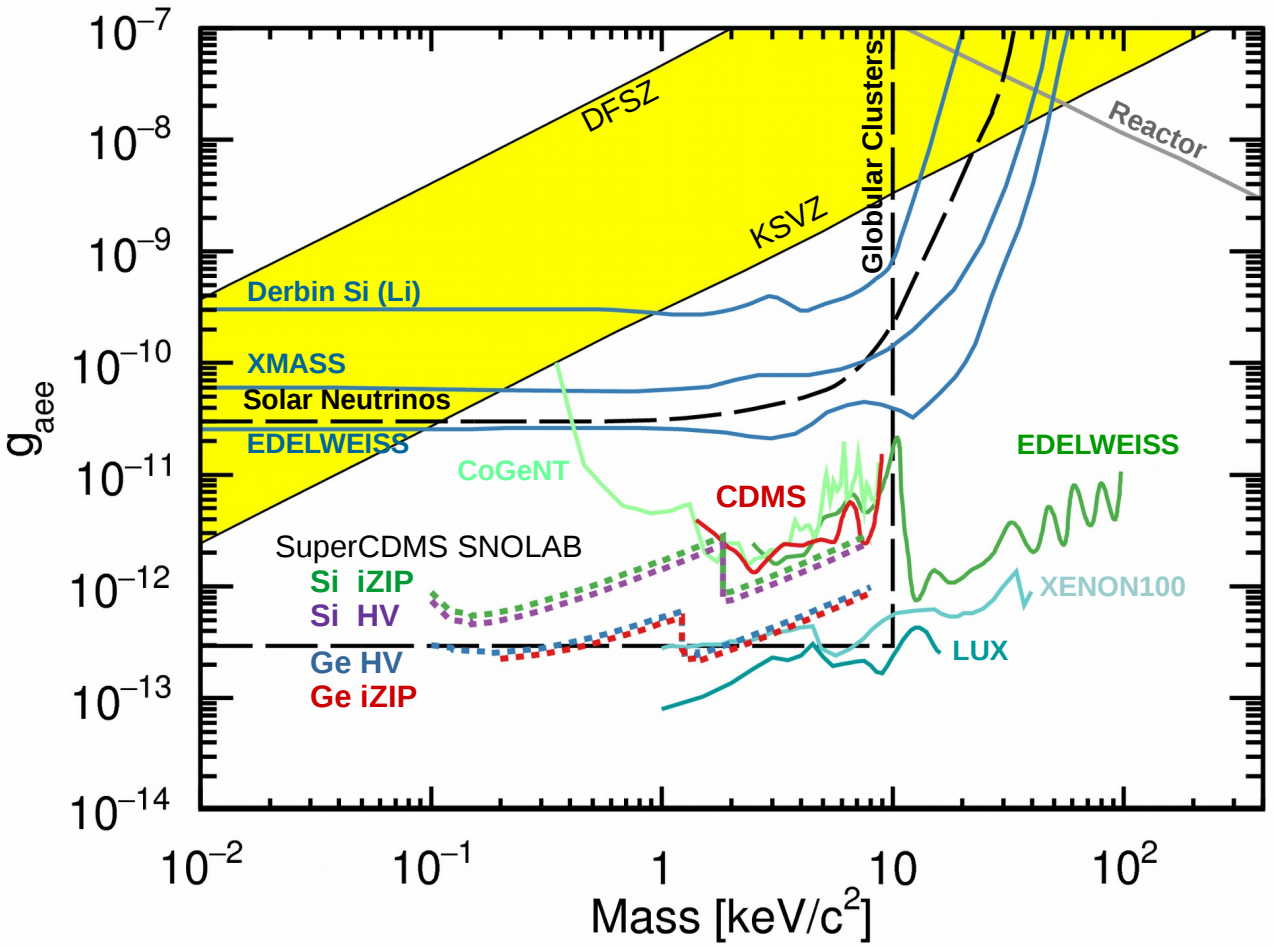




- Sensitivity driven by thresholds
- Search requires good knowledge of electronic structure of target

[a] Battaglieri et al. arXiv:1707.04591

# Galactic axions




- Axions interact through axio-electric effect
- Peak at axion mass
- 5 year exposure and simple counting experiment

- Uncertainty in photo-electric cross section at low energies limits search

# Summary

- SuperCDMS Soudan WIMP searches are nearly complete see B. Loer's talk
- Theorists have provided us with many new channels to explore
- Current CDMSlite data can be used to search for these signals
- Future is looking equally bright with new technological achievements and the planned SuperCDMS SNOLAB experiment ! see B. Loer's talk

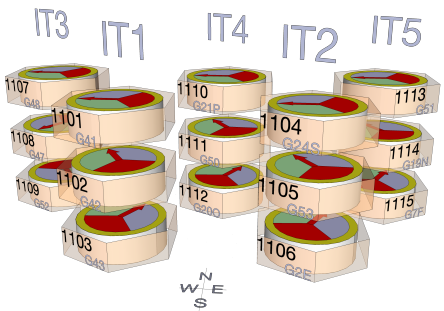
# Backup Slides

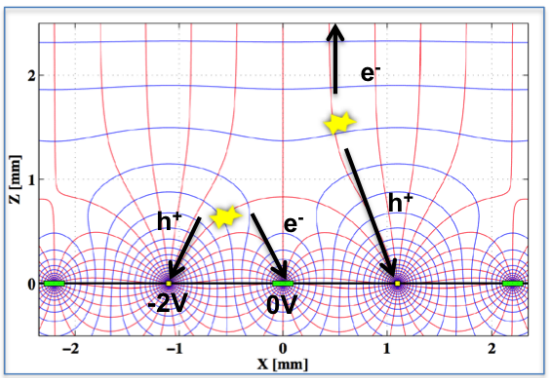
# SuperCDMS collaboration

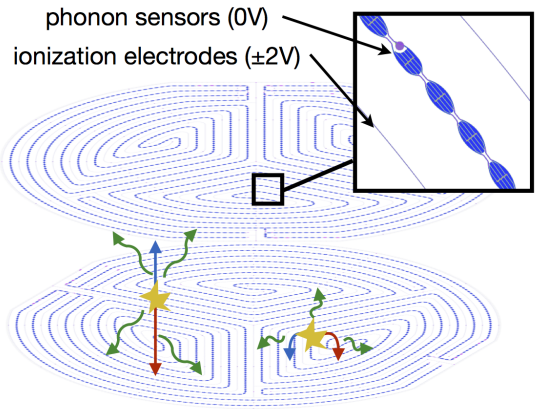
California Inst. of Tech.
CNRS-LPN*
Durham University
FNAL
NISER
NIST*
Northwestern
PNNL
Queen's University
Santa Clara University
SLAC
South Dakota SM&T
SMU
SNOLAB
Stanford University
Texas A&M University
TRIUMF
U. British Columbia
U. California, Berkeley
U. Colorado Denver
U. Evansville
U. Florida
U. Montréal
U. Minnesota
U. South Dakota
U. Toronto

*Associate members

# interleaved Z-sensitive Ionization and Phonon (iZIP) Detectors

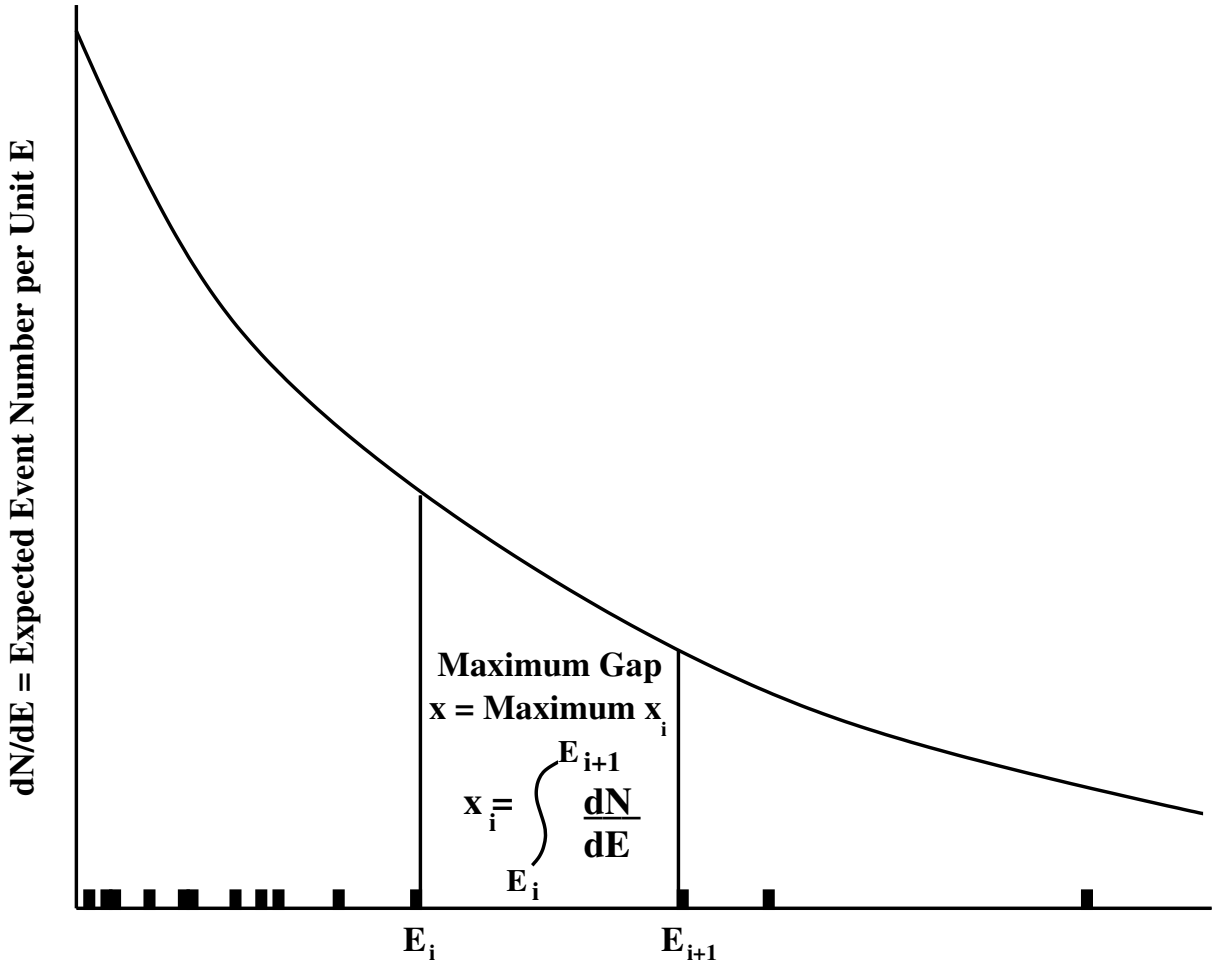



- Detector array: 15 Ge iZIP detectors (0.6 kg each) opperating around 50 mK
- 4 phonon and 2 charge channels on each detector face
- Phonon channels are grounded, charge channels are biased at $\pm$ 2 V
- Field configuration causes events near surface to have charge collection localized to one side

# Yellin Optimal Interval




Conceptually similar to the optimal gap method except that it allows for N events to fall into region.