# KID-Based Phonon-Mediated DM Detectors

2020/08/19

Snowmass Quantum Sensors Info Session

S. Golwala for

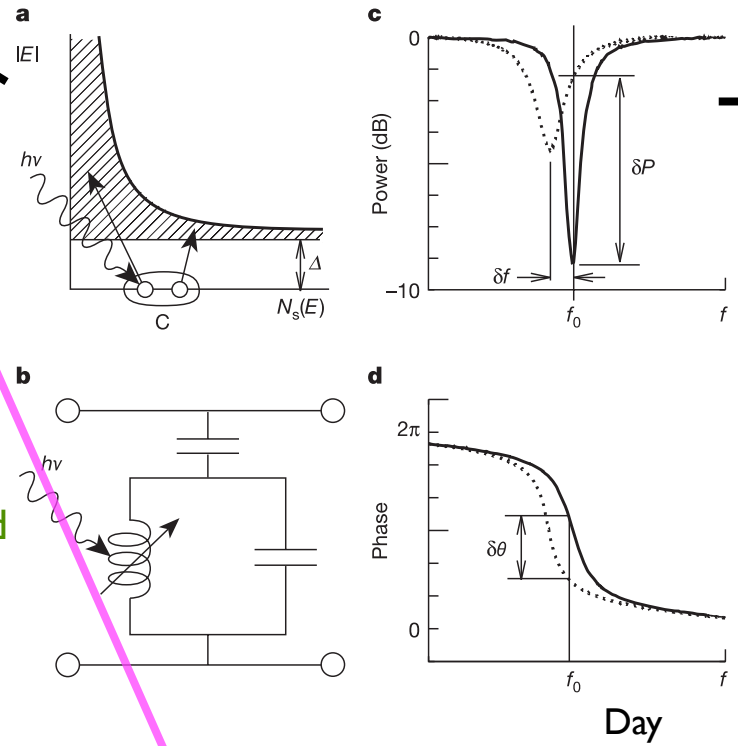
Taylor Aralis, Yen-Yung Chang, Alvaro Loya, Rito Thakur, Osmond Wen (Caltech)

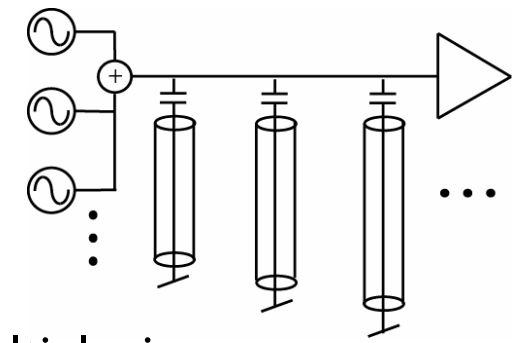
w/NEXUS-FNAL group and LBNL QIS program

# Why sense phonons with kinetic inductance detectors (KIDs)?

Energy resolution:
sub-eV → meV
thresholds w/o HV

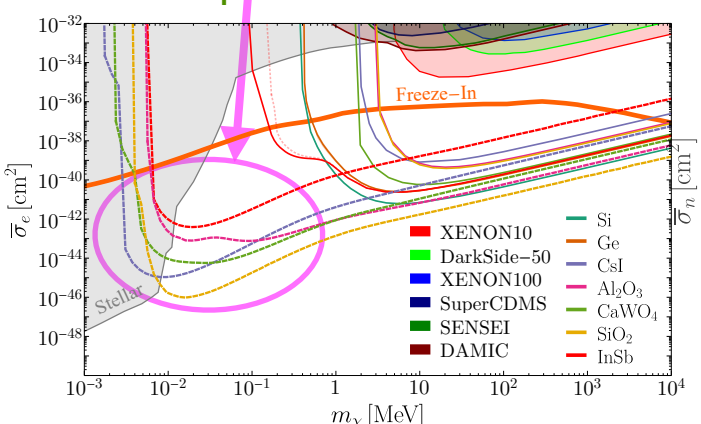
- Direct sensitivity to pair-breaking phonons
  - Large resonators obviate qp trapping
- Gapped density of states
  - Thermal qp population exponentially suppressed
- Fundamentally non-dissipative
- Noise is limited by
  - qp population fluctuations
  - amplifier noise

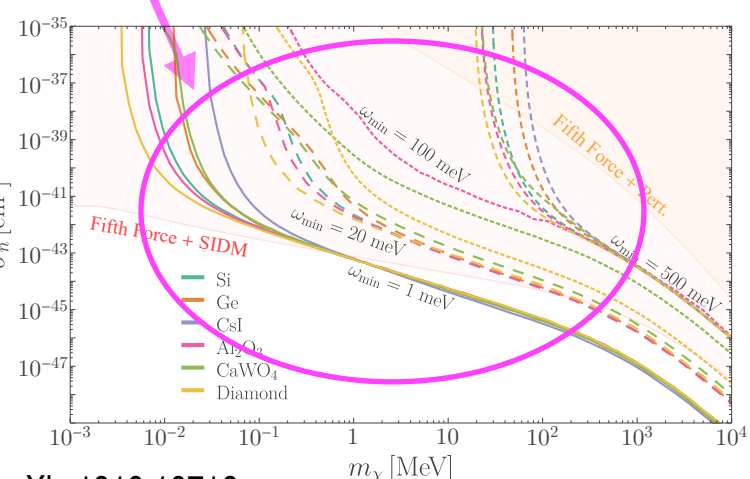


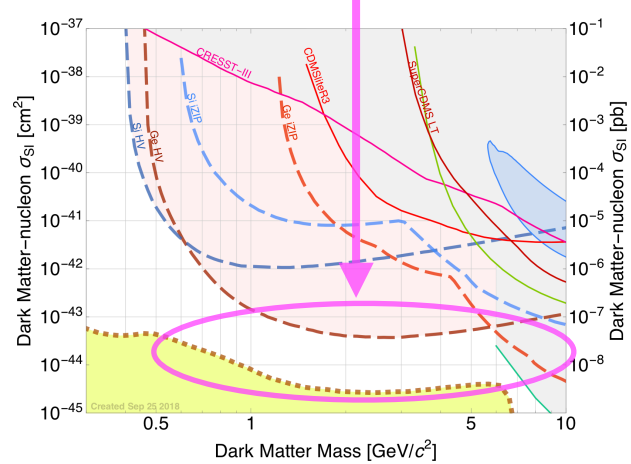



Multiplexing:
Highly position-resolved phonon detection
→ NR/ER discrimination, position fiducialization

KIDs are Q>$10^5$ resonators
→ Readout many with one cryo line/amplifier; most electronics at 300K



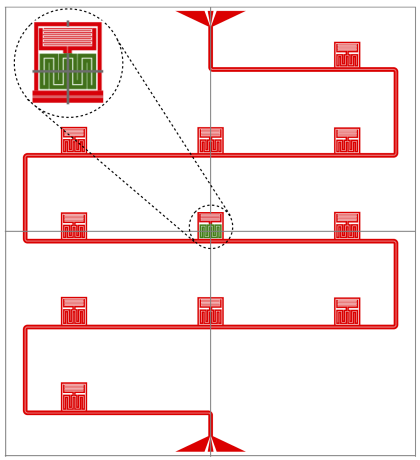

+ dark photons, ALPs, etc.

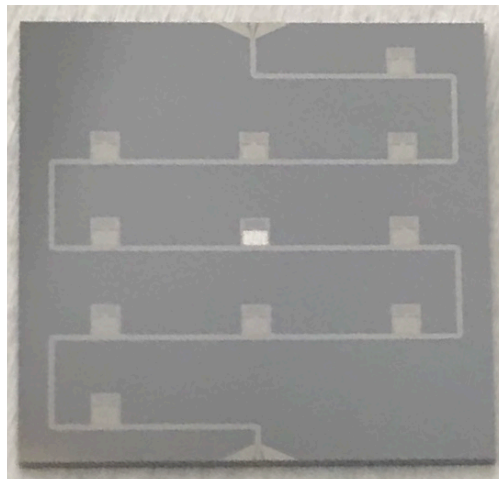
Griffin et al. arXiv:1910.10716

# Two Architectures

Low-threshold:

1 KID on a gm substrate for NEXUS/LBNL





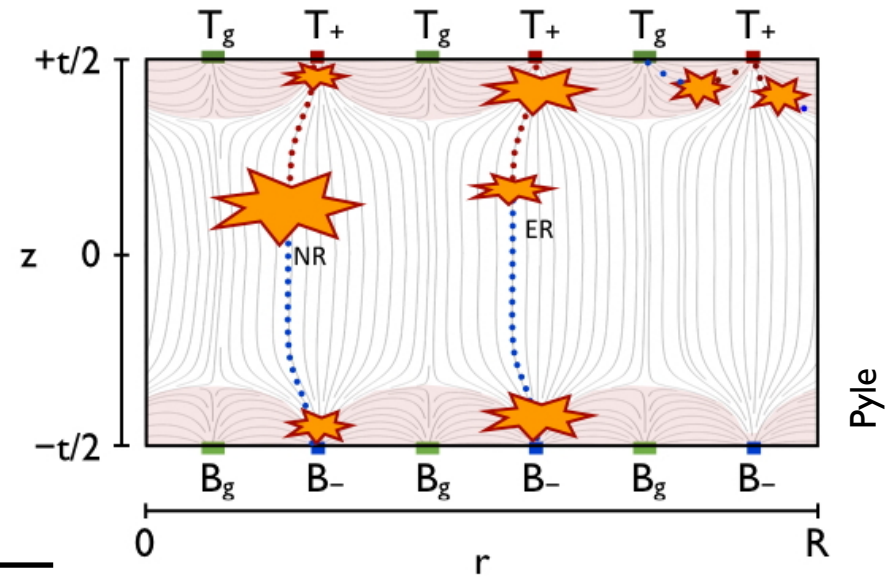
22 mm
x 1 mm

"piZIP": Fine-grained phonon sensor enables:

Phonon-based fiducialization in z and r

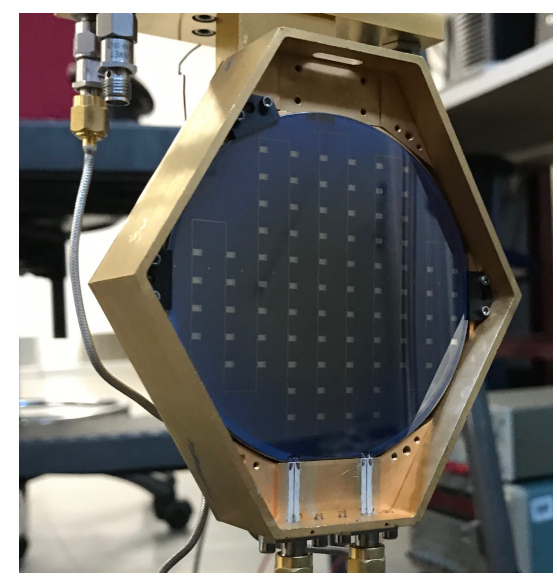
NR/ER discr. via NTL phonon position

TAMU demo!




| stage | $\sigma_{pt}$ low-threshold | piZIP |
|---|---|---|
| current (estimated) | 20 eV | 240 eV |
| single-KID optimized | 1-7 eV | — |
| increase $\tau_{qp}$ to 1 ms | 0.3-2 eV | 80 eV |
| quantum-limited amplifier | 45-360 meV | 25 eV |
| AlMn ($T_c$ in K) | 5-70 meV (0.1K) | 5 eV (0.2K) |
| squeezed vacuum/ amplification | 0.5-7 meV | — |

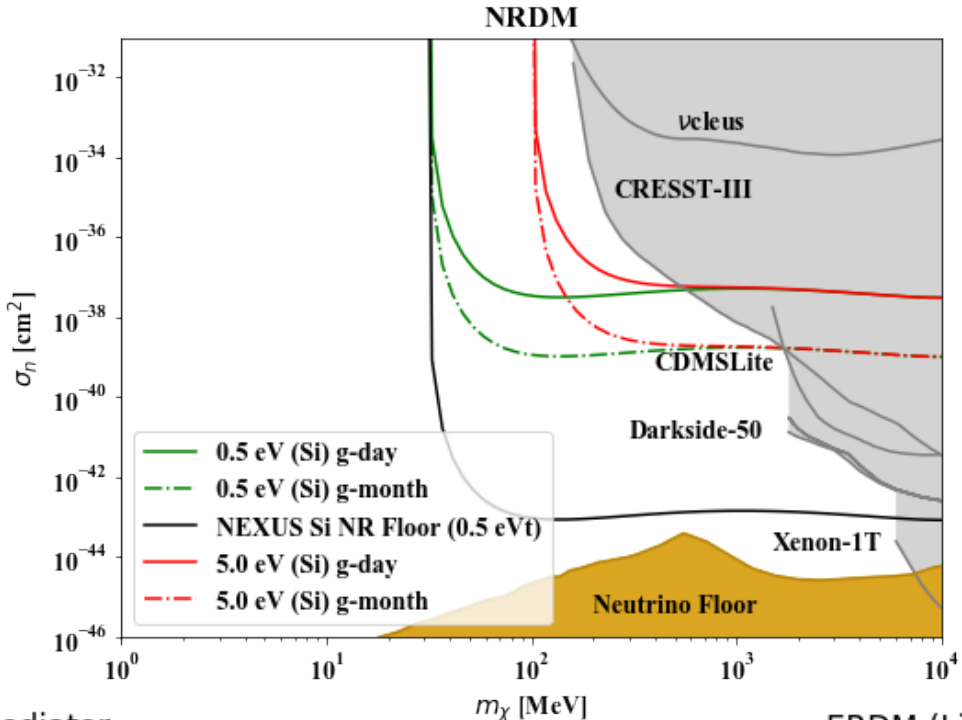
NR/ER discr. down to O(100) MeV!



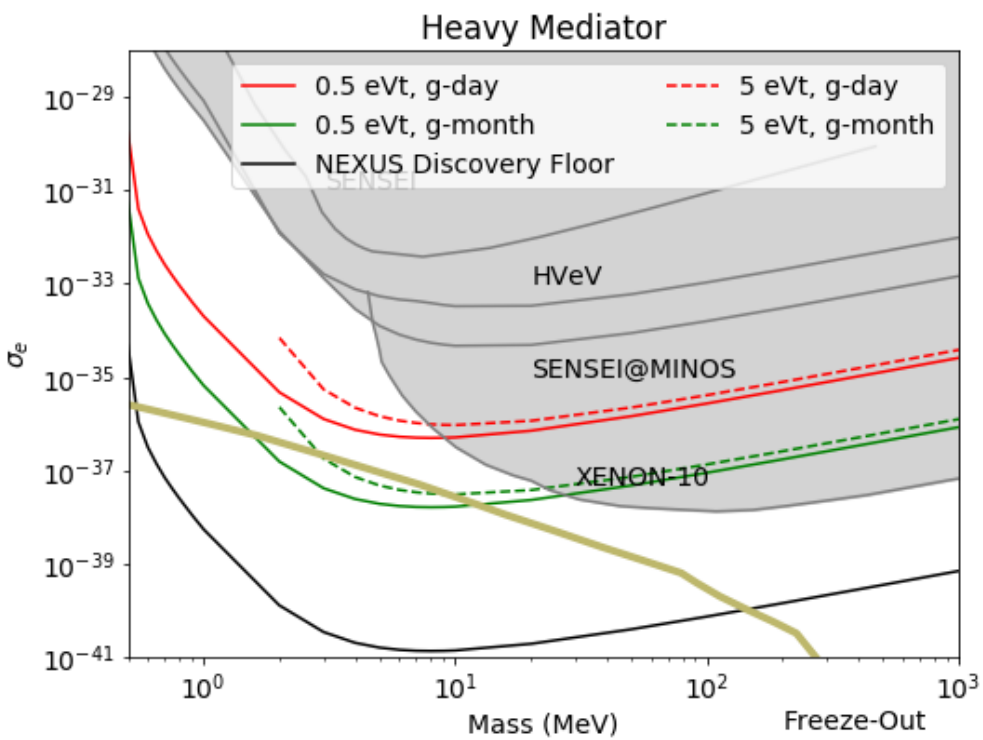
75 mm
x 1 mm

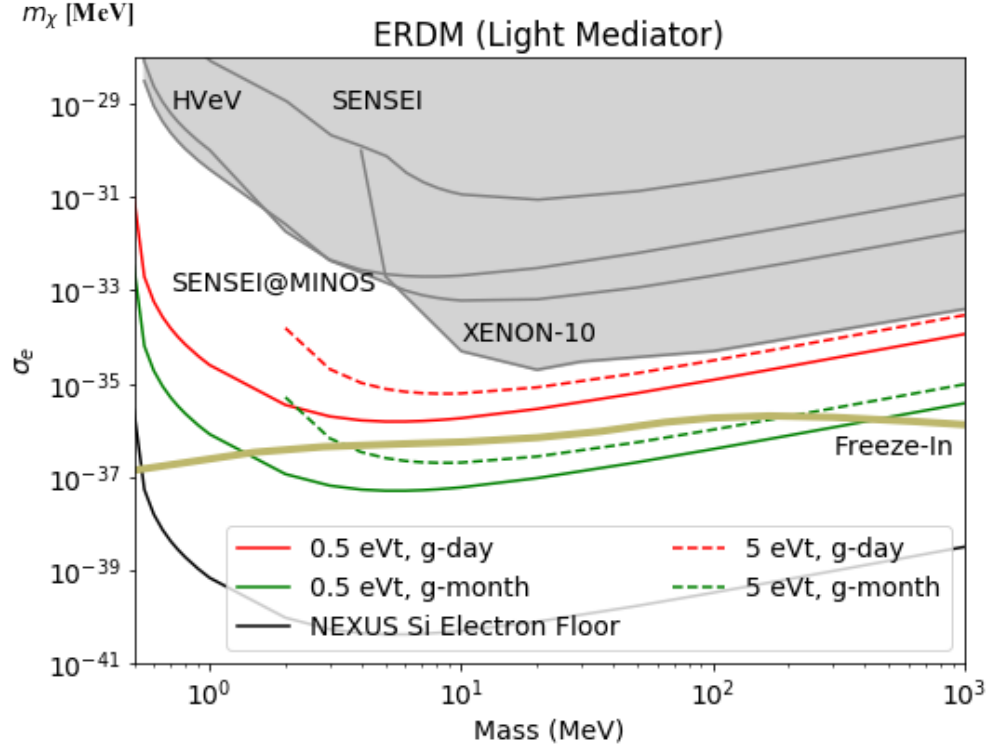
Both architectures funded for development.: LBNL QIS + FNAL LDRD for low-threshold, DOE HEP DetRnD for piZIP, grad+postdoc fellowships

# Demonstration Runs Planned at NEXUS




Thresholds (not $\sigma_{pt}$) are shown




Limit plots from N. Kurinsky