Quantum Sensing: Role of National Labs

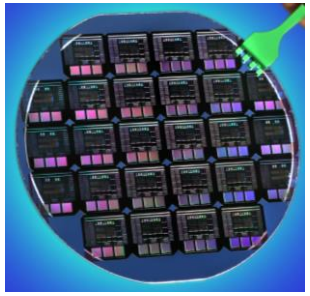
Lab roles in HEP and in general:

- Offer shared ***facilities with unique capabilities*** to enable R&D and experiments.
- Bring an R&D or a small experiment to ***larger scales***.
- Provide ***technical expertise (people)***, both scientists and engineering, in relevant areas for technical development and blue-sky R&D.

Below, showing some relevant examples from the past.

1st fully depleted CCD demonstration / Fabrication at the LBNL MicroSystems Laboratory

LBNL CCD Roadmap



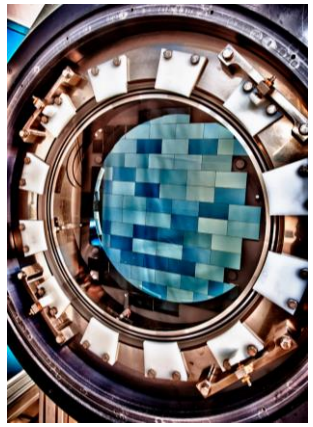
"Blue Sky" phase

200 x 200 Fully depleted CCDs
Spinoff from HEP p-i-n detectors

Key point: Fabrication and device design expertise at LBNL facilitates technology transfer to commercial foundry

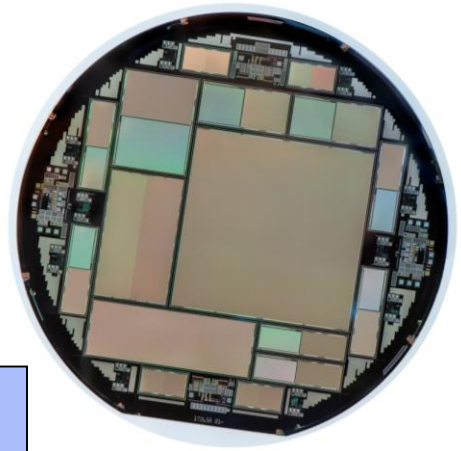
Develop relationship with commercial CCD foundry / Hybrid fabrication model

Foundry for volume fabrication

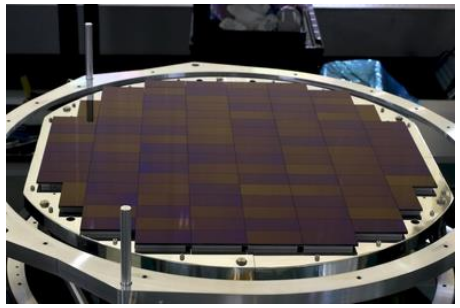


DOE Science
(BOSS, DES, DESI)

R&D investments
Leading to e.g. improved CCDs for DESI, Skipper CCDs

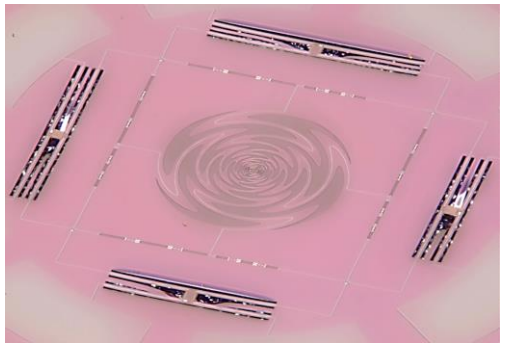


New applications
- ❑ Direct x-ray detection at light sources
- ❑ Direct Dark Matter detection with single electron sensitivity
- ❑ New: Ge CCDs for future Dark Energy studies



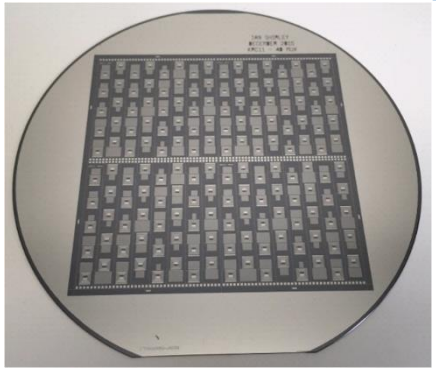
Commercialize
Hamamatsu Corp.
Subaru HyperSuprime CAM
e2V/ITL and LSST

Superconducting devices for CMB measurement



Multi-chroic CMB detectors with transition-edge sensors (TES) Developed @UCB with Marvell Nanolab capability

fMUX invented at LBNL



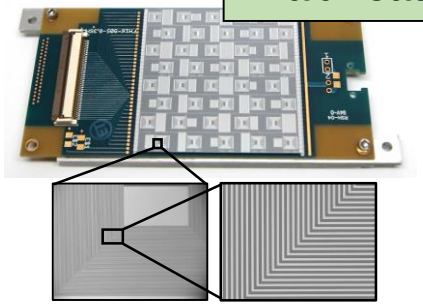
Fully lithographed superconducting micro resonators (multiplexed readout) Developed @LBNL with MSL capability

Develop relationship with commercial microfabrication foundries / hybrid fabrication

Hybrid fabrication with high-throughput packaging

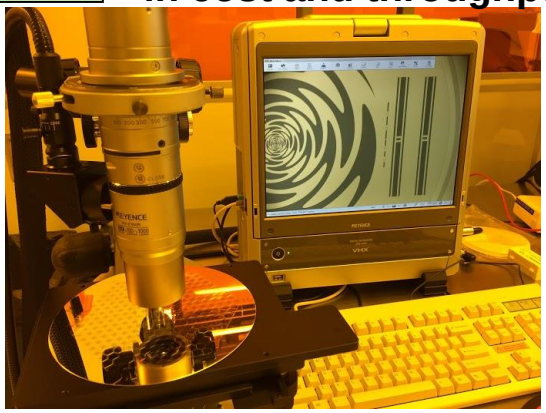
Foundry for volume fabrication

Commercial fabrication adopting hybrid model
Significant improvement in cost and throughput



Providing capabilities to University groups

(POLARBEAR, SPT)

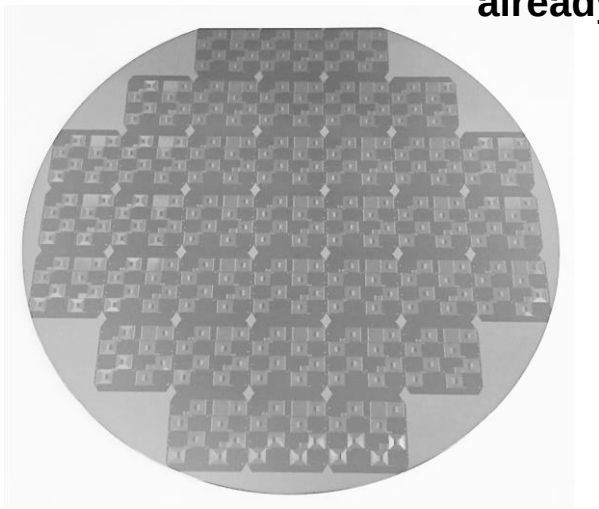


<u>DOE Science</u>

(CMB-S4)

<u>R&D investments</u>
Leading to e.g. improved readout systems

Compact LC resonators possible to integrate with TES detectors.
(SBIR and LDRD support)
Test chips with both TES and resonators on are already fabricated



Facilities

BERKELEY LAB

MOLECULAR FOUNDRY

Nano-imaging and nano-fabrication machines.
Discussion for “shared platform” for quantum devices.

BERKELEY LAB **MicroSystems Lab (Physics Division)**

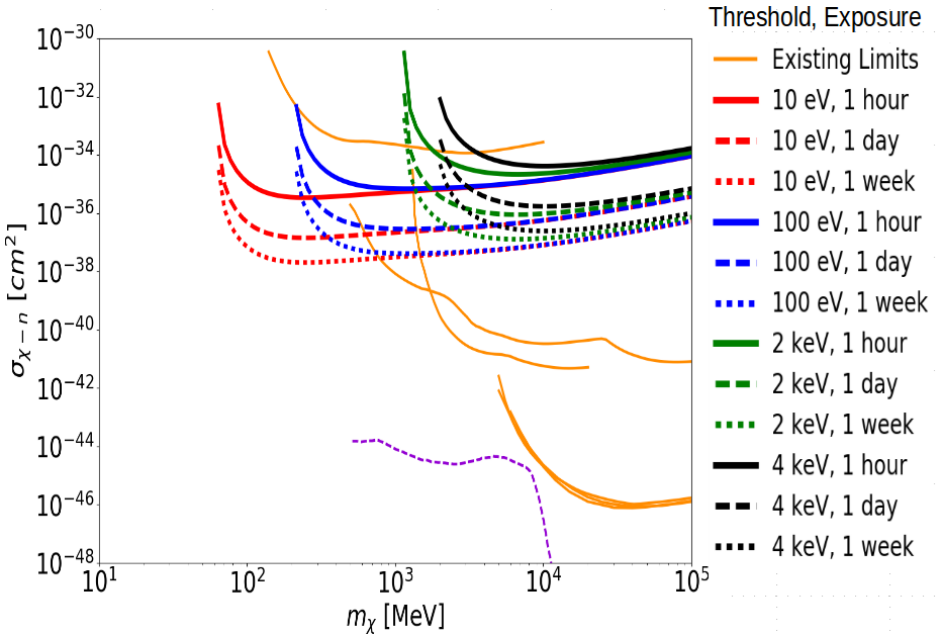
Class 10 clean room.
Mass-fabrication of CCDs for DECam and DESI.
(co-fab with industry)

Marvell Nanofabrication Laboratory

Strong synergy with capability available at UCB campus

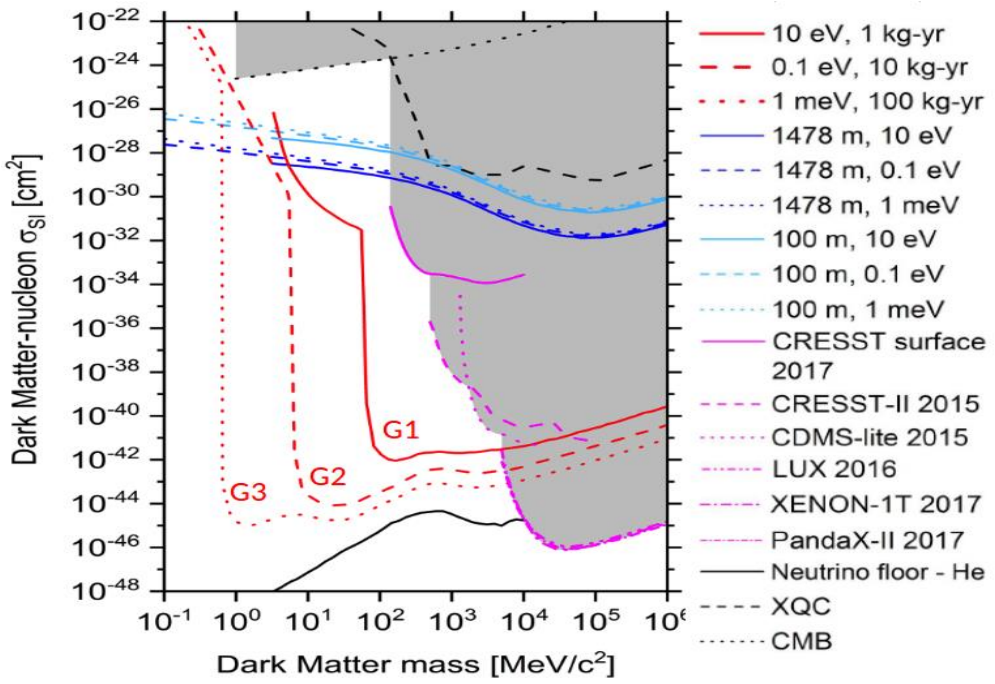
New technology for low mass Dark Matter

2g LHe on surface. Zero background



From demo to Experiment

1-10 kg LHe underground.



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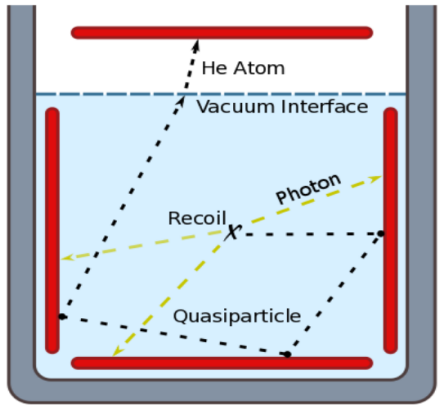
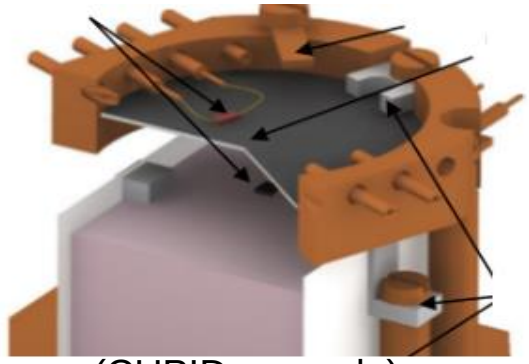


Quantum evaporation gain



(CUPID example)

Zero dark count single quantum detectors