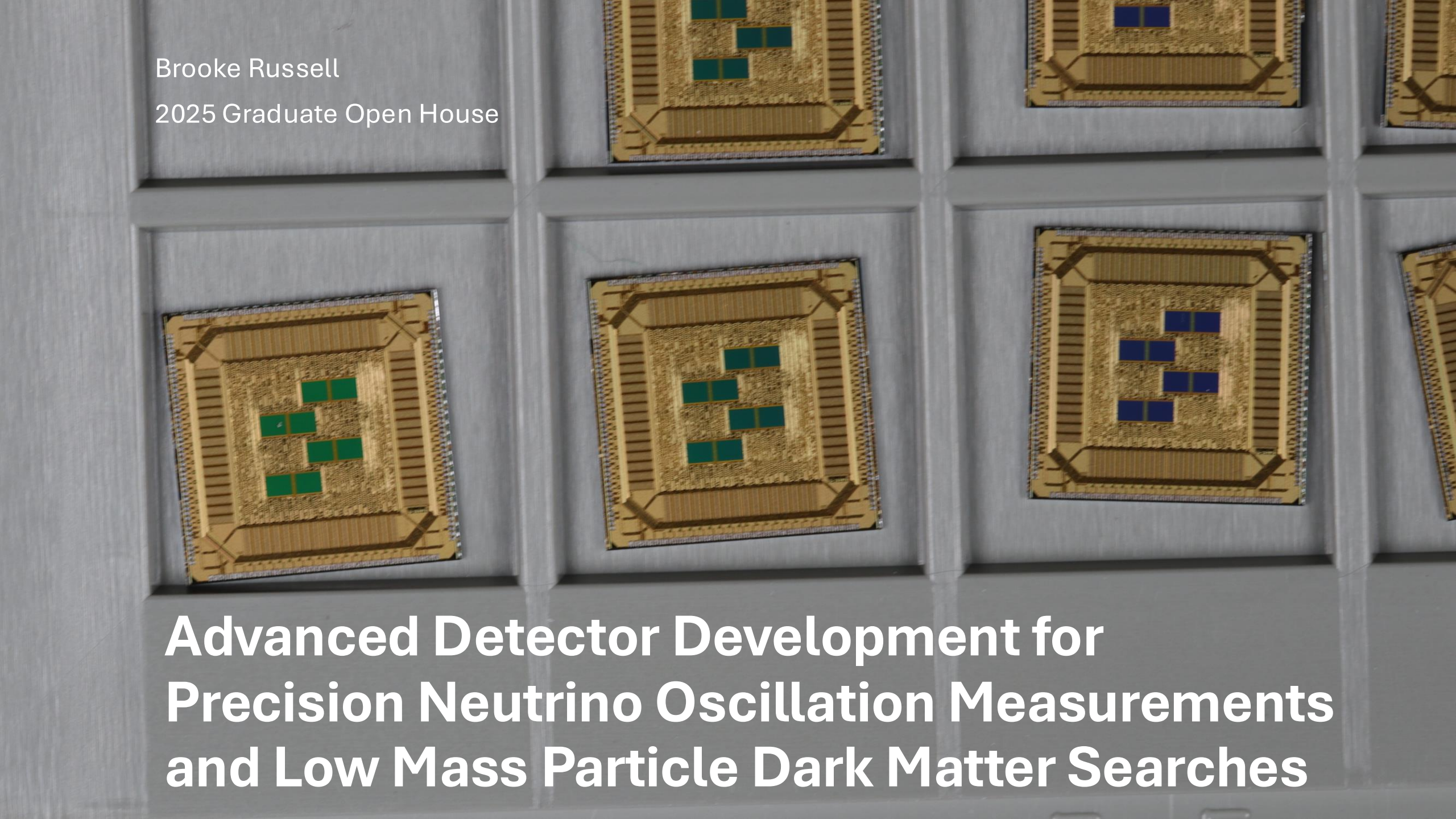
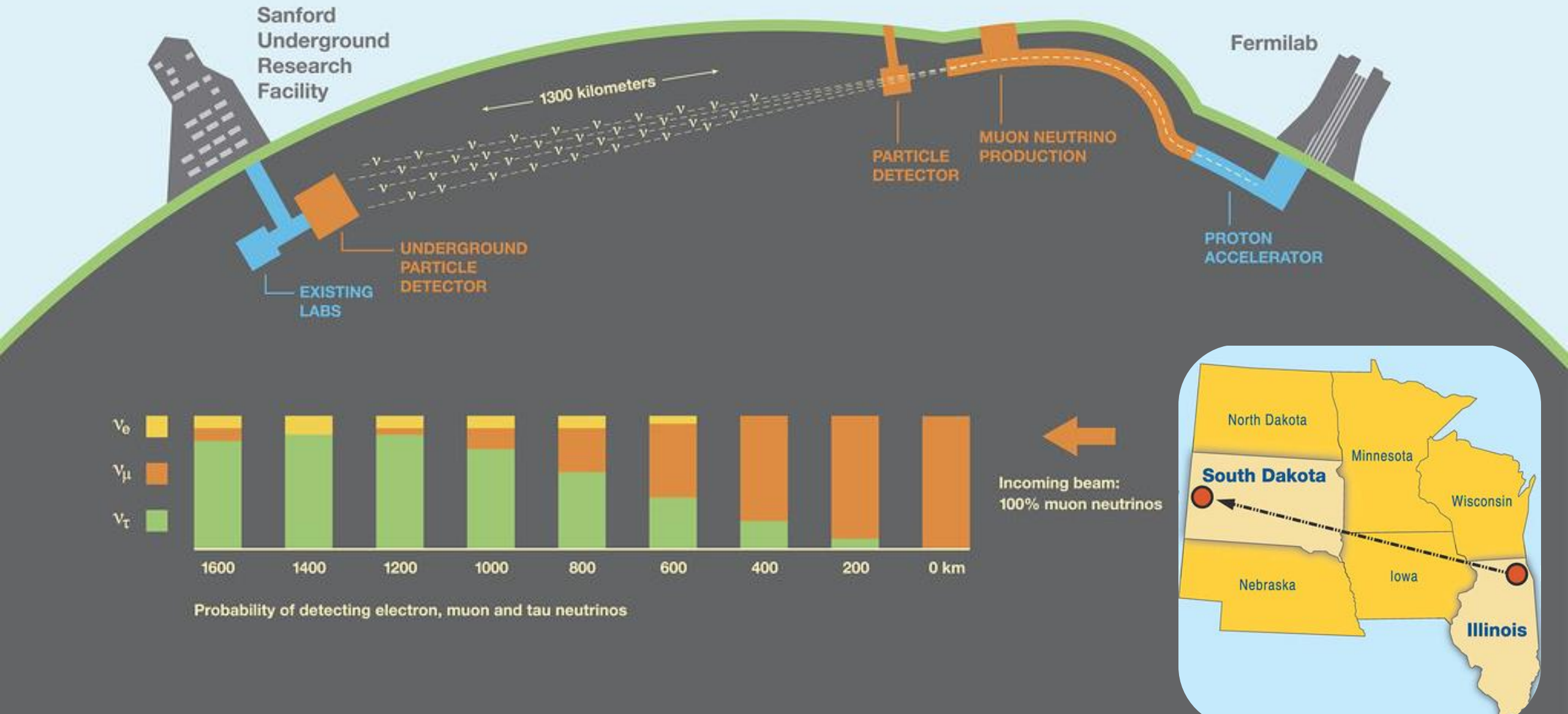


Brooke Russell

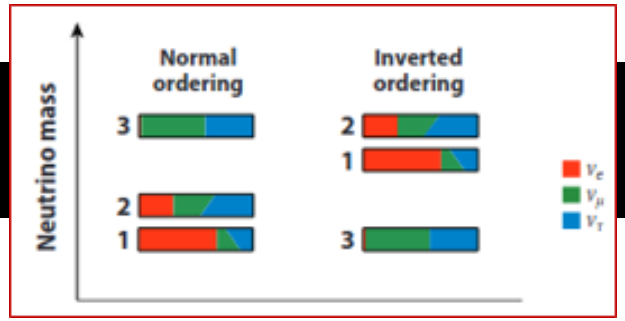
2025 Graduate Open House

Advanced Detector Development for Precision Neutrino Oscillation Measurements and Low Mass Particle Dark Matter Searches

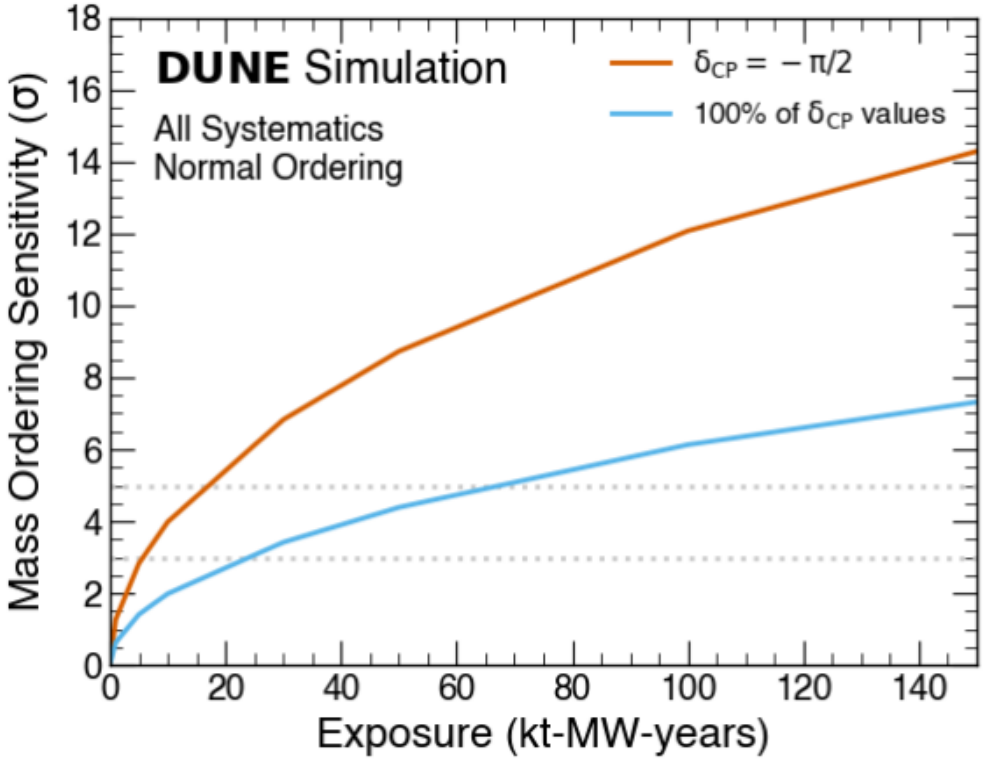
Deep Underground Neutrino Experiment

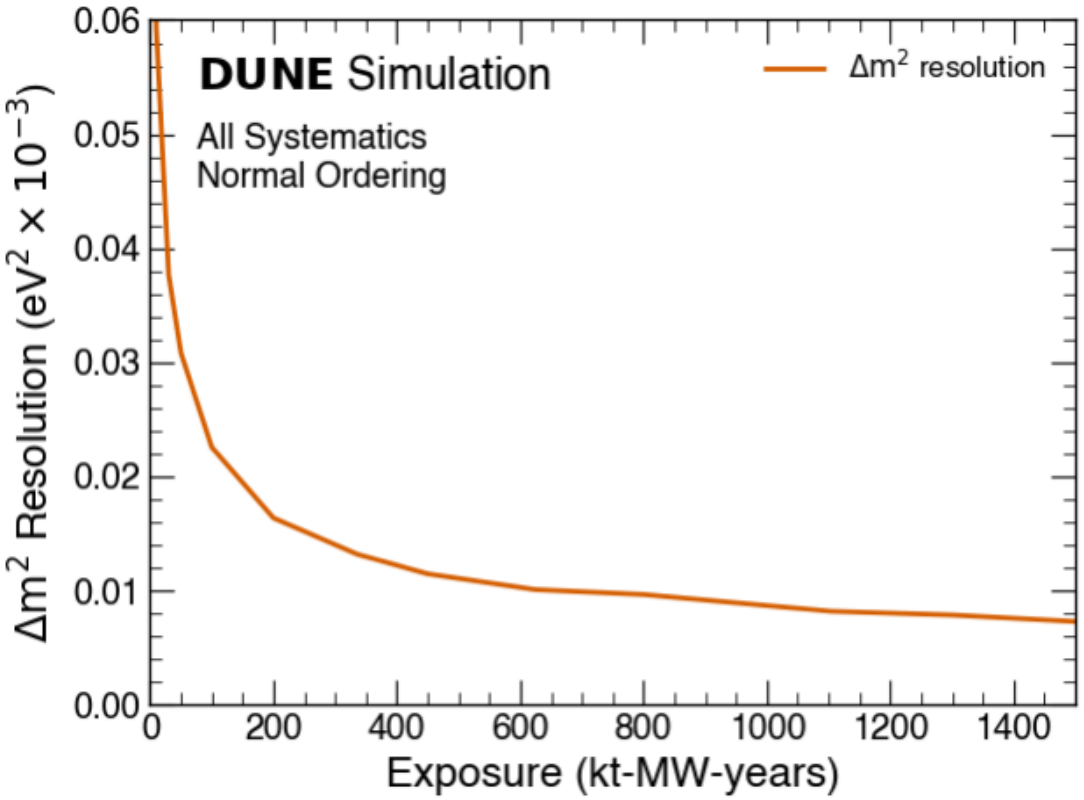


Neutrino Mass Ordering



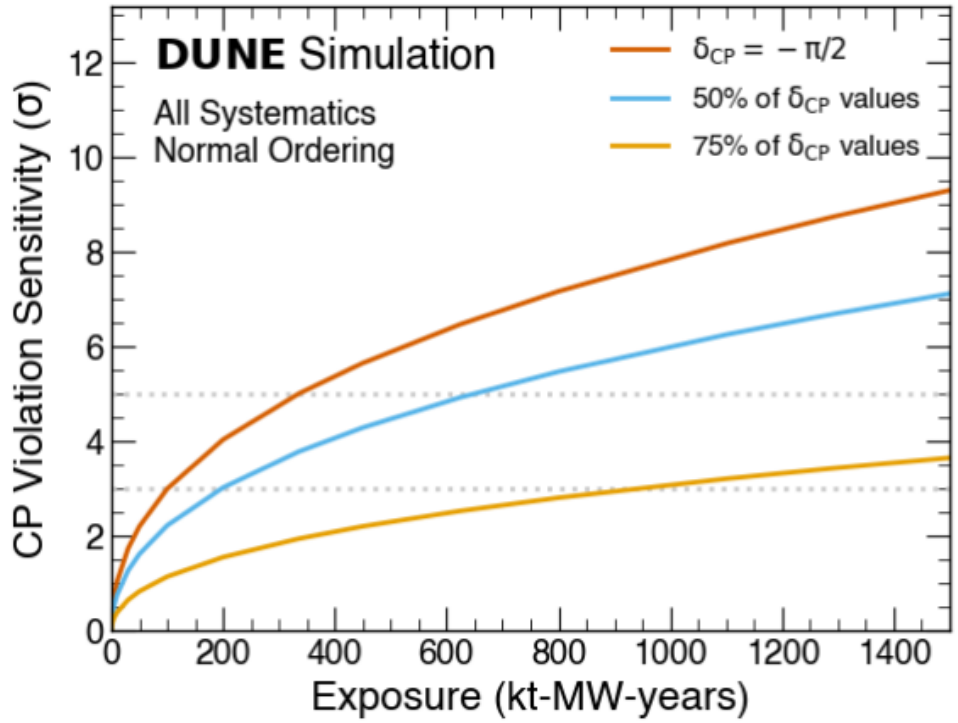
Unambiguous mass ordering determination

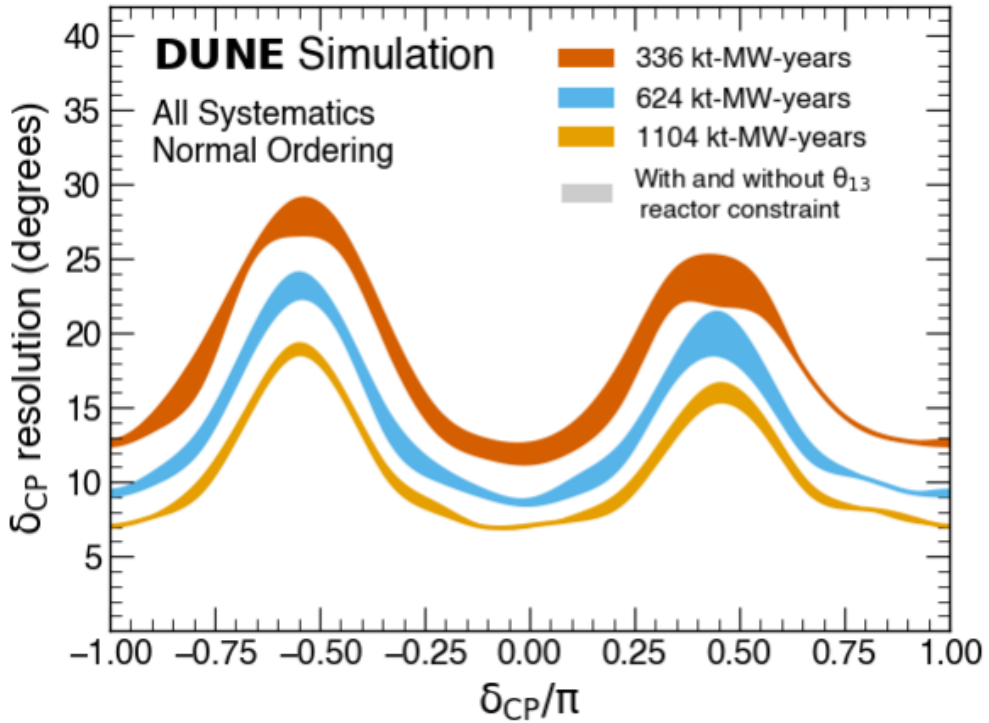




Leptonic Charge Parity Violation

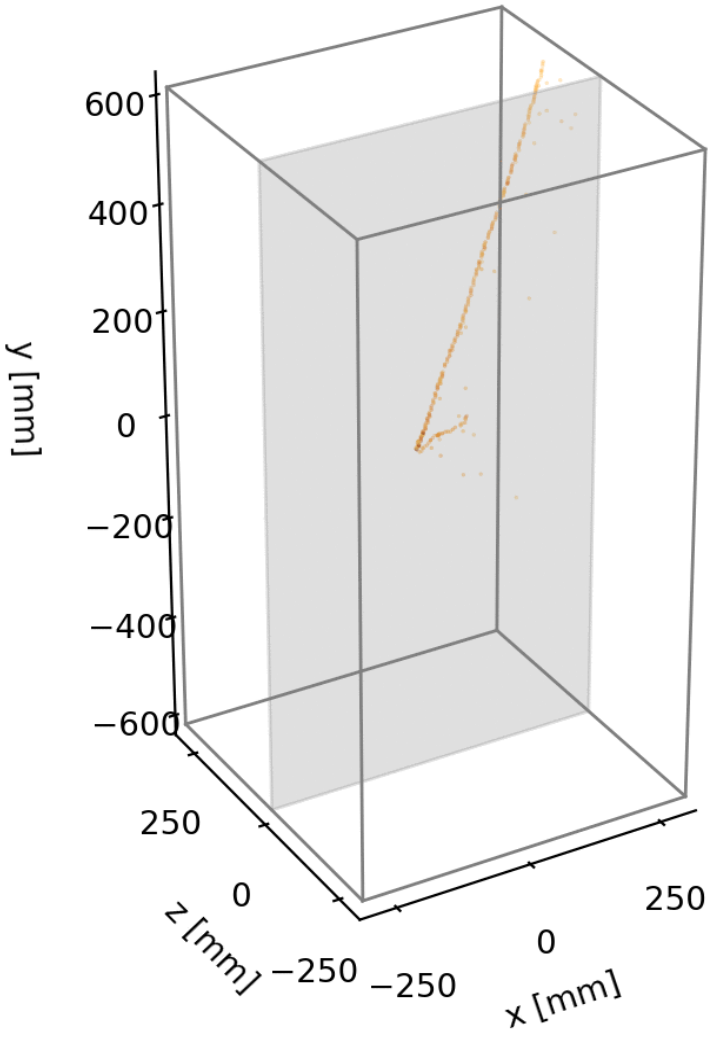
6-16° precision

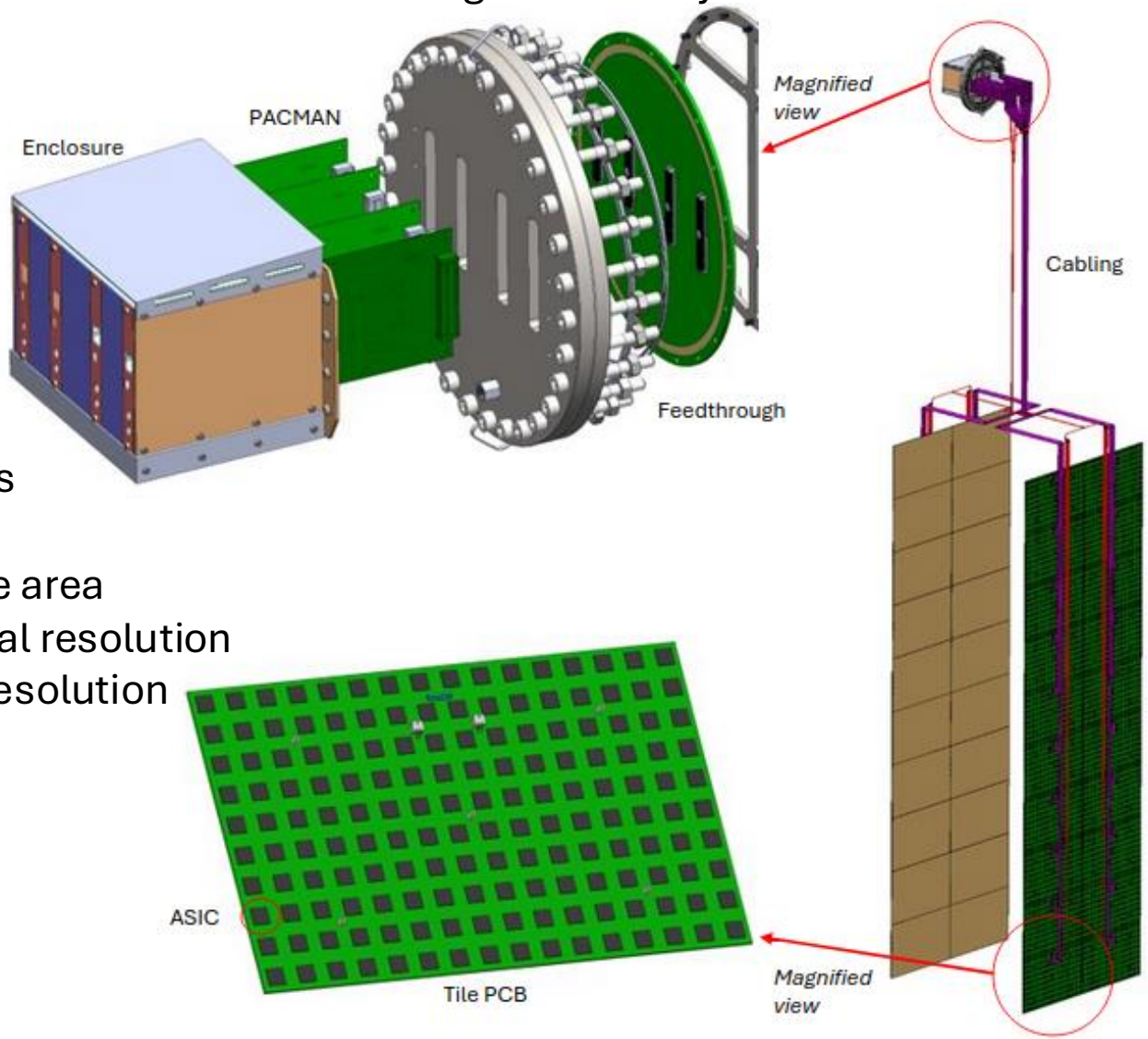




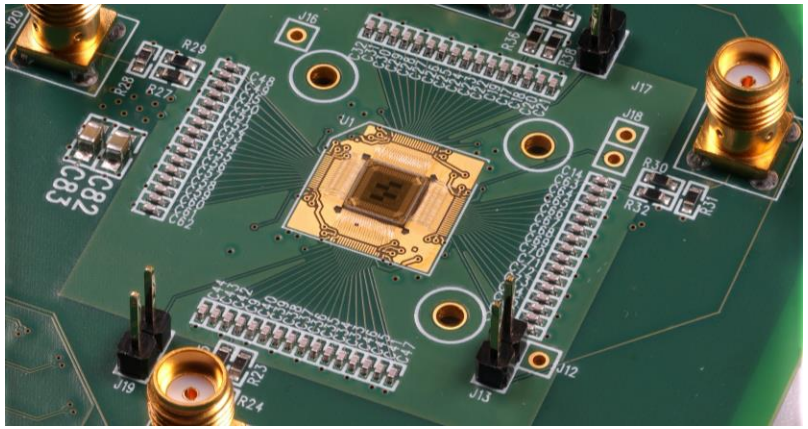
DUNE Near Detector Pixelated Readout System

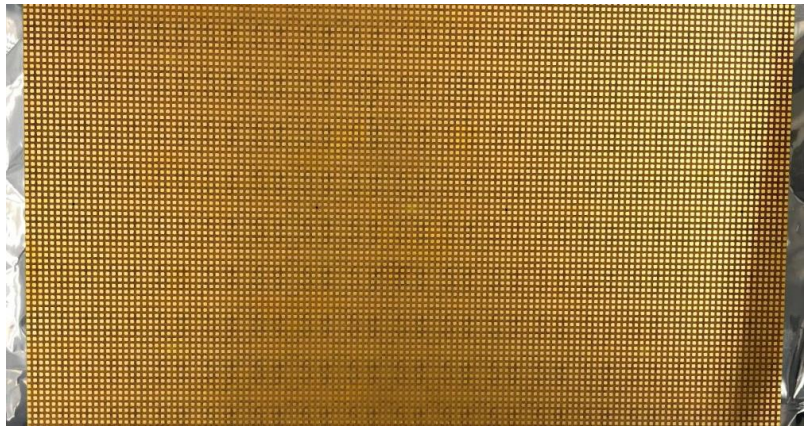
MIT drives the design, implementation, and assessment of an end-to-end charge readout system

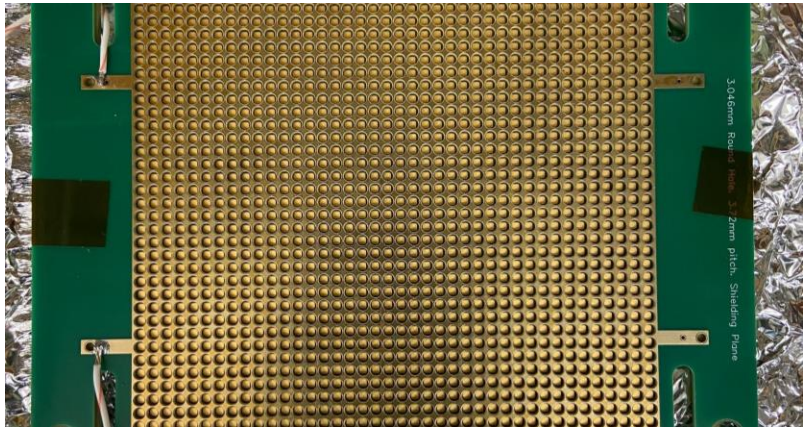


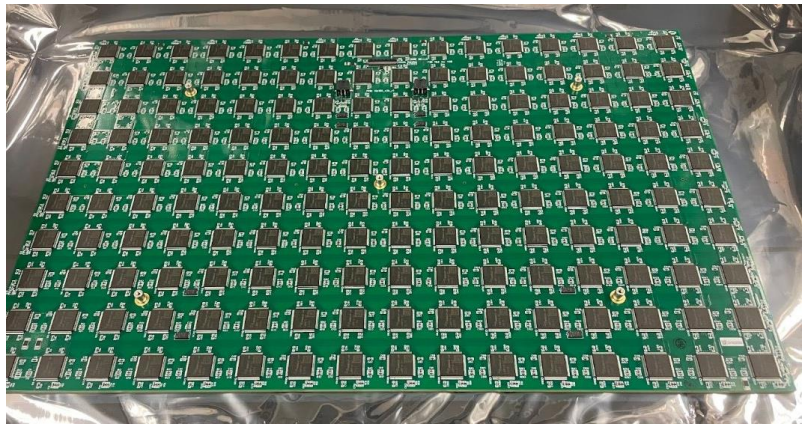


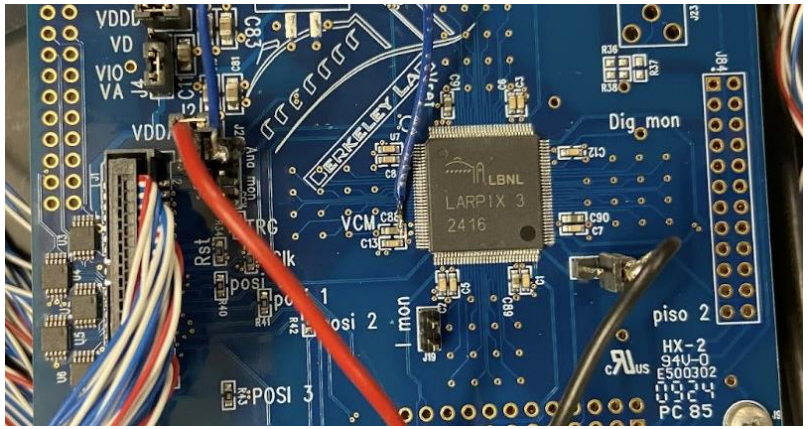
>14M channels
224k ASICs
>200 m^2 anode area
<1.1 mm spatial resolution
0.8 μs timing resolution











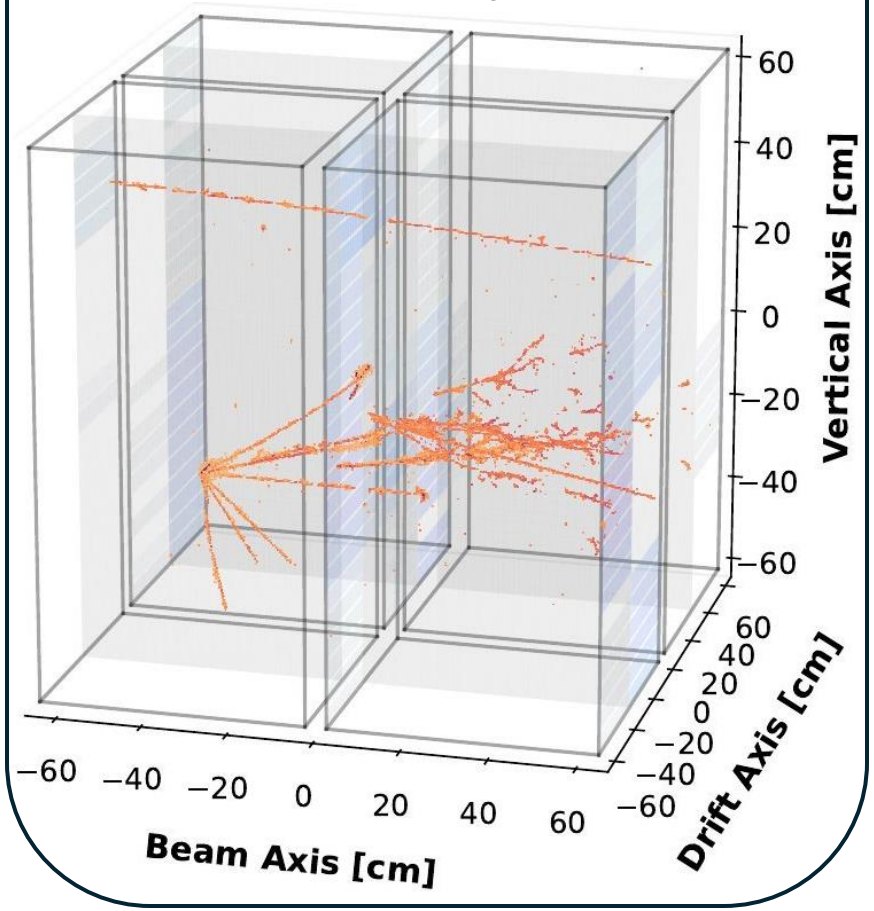
Component Prototyping

Integrated System Prototyping

O(10^5) channel-scale DUNE near detector prototypes

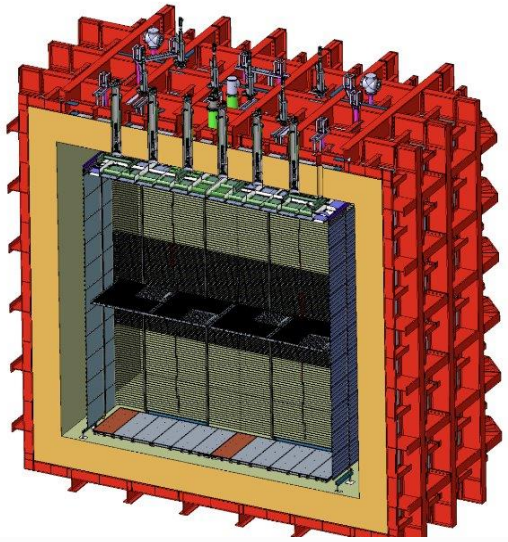
2x2 Demonstrator in NuMI @ FNAL

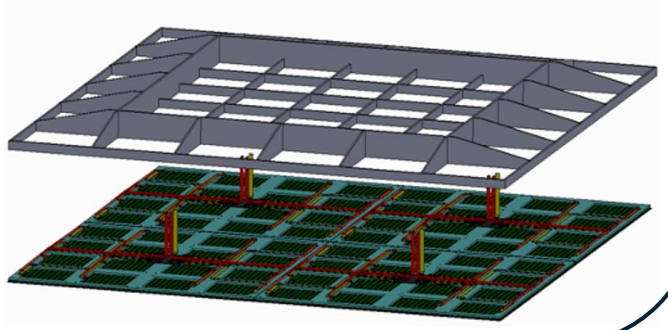
- 1.3E19 POT in 2024
- >1.5E20 POT anticipated in 2026



O(10^6) channel-scale DUNE far detector prototypes

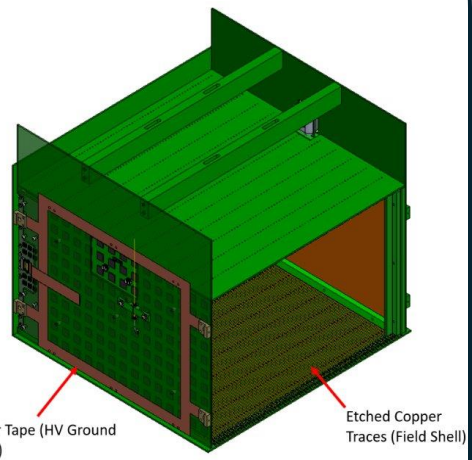
Prospective far detector #3 charge readout technology with CERN ProtoDUNE operations ~2027

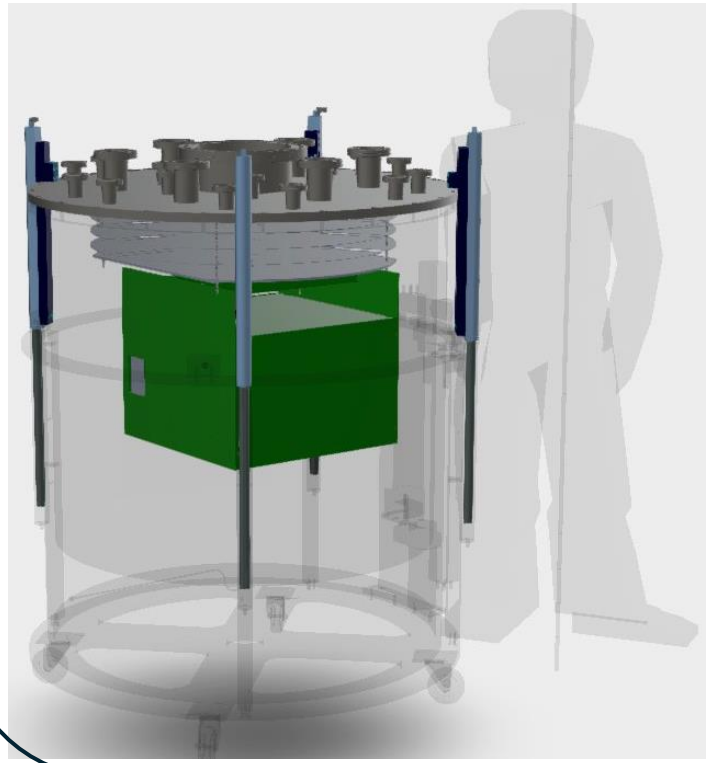




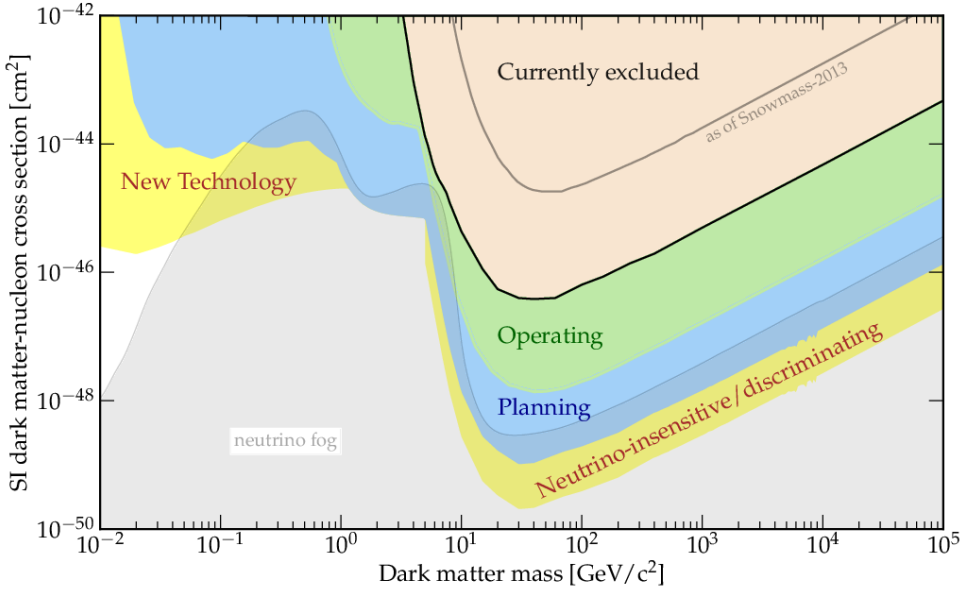
MIT local pixel R&D

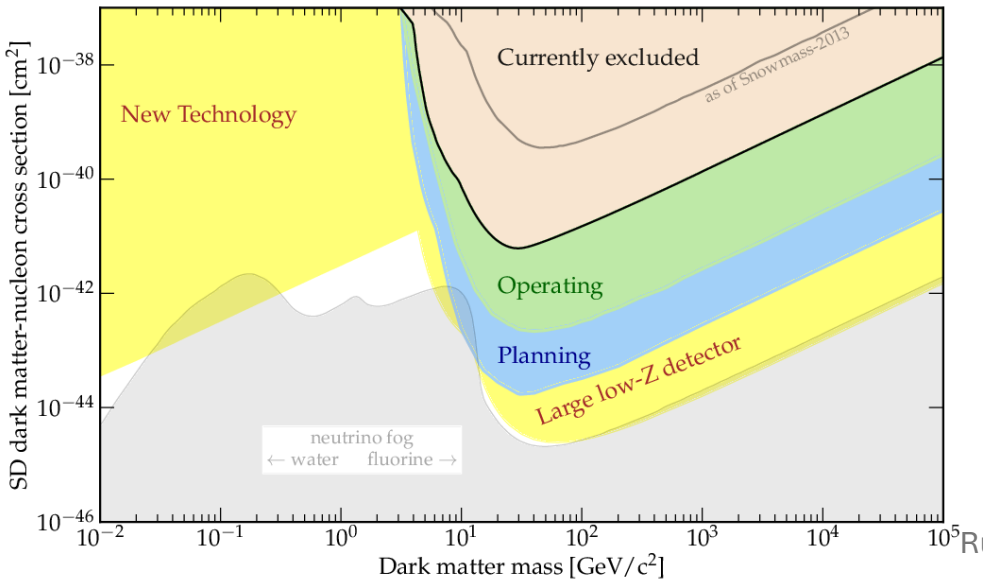
- LArPix architecture optimization for MeV-scale physics
- LightPix: scalable SiPM readout





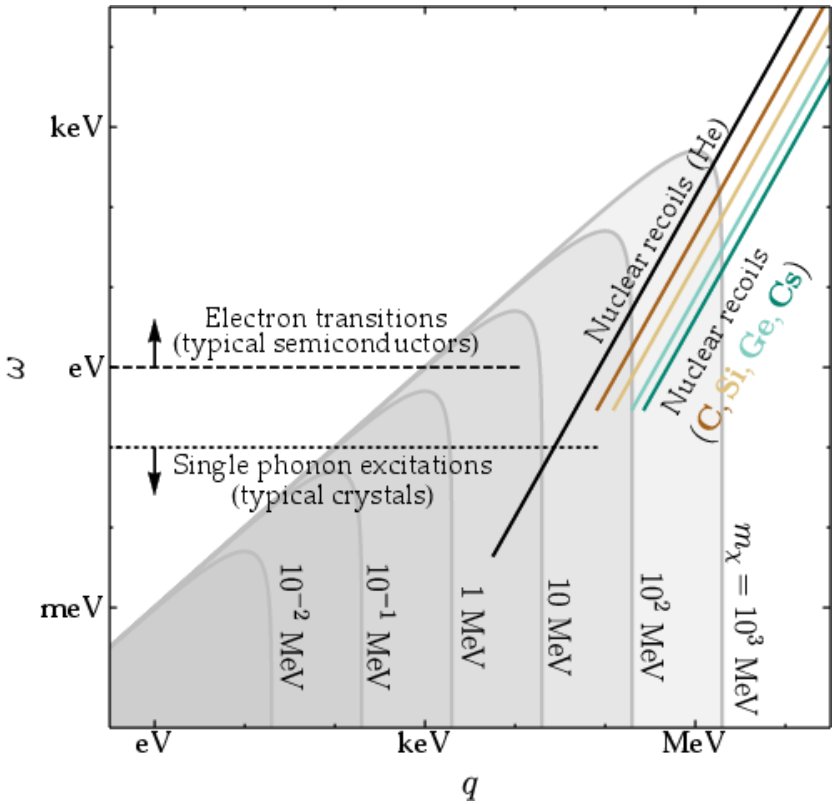
Low-mass Dark Matter Direct Detection





2209.07426

K. Zurek, *Ann. Rev. Nucl. Part. Sci.* **74** (2024) 287



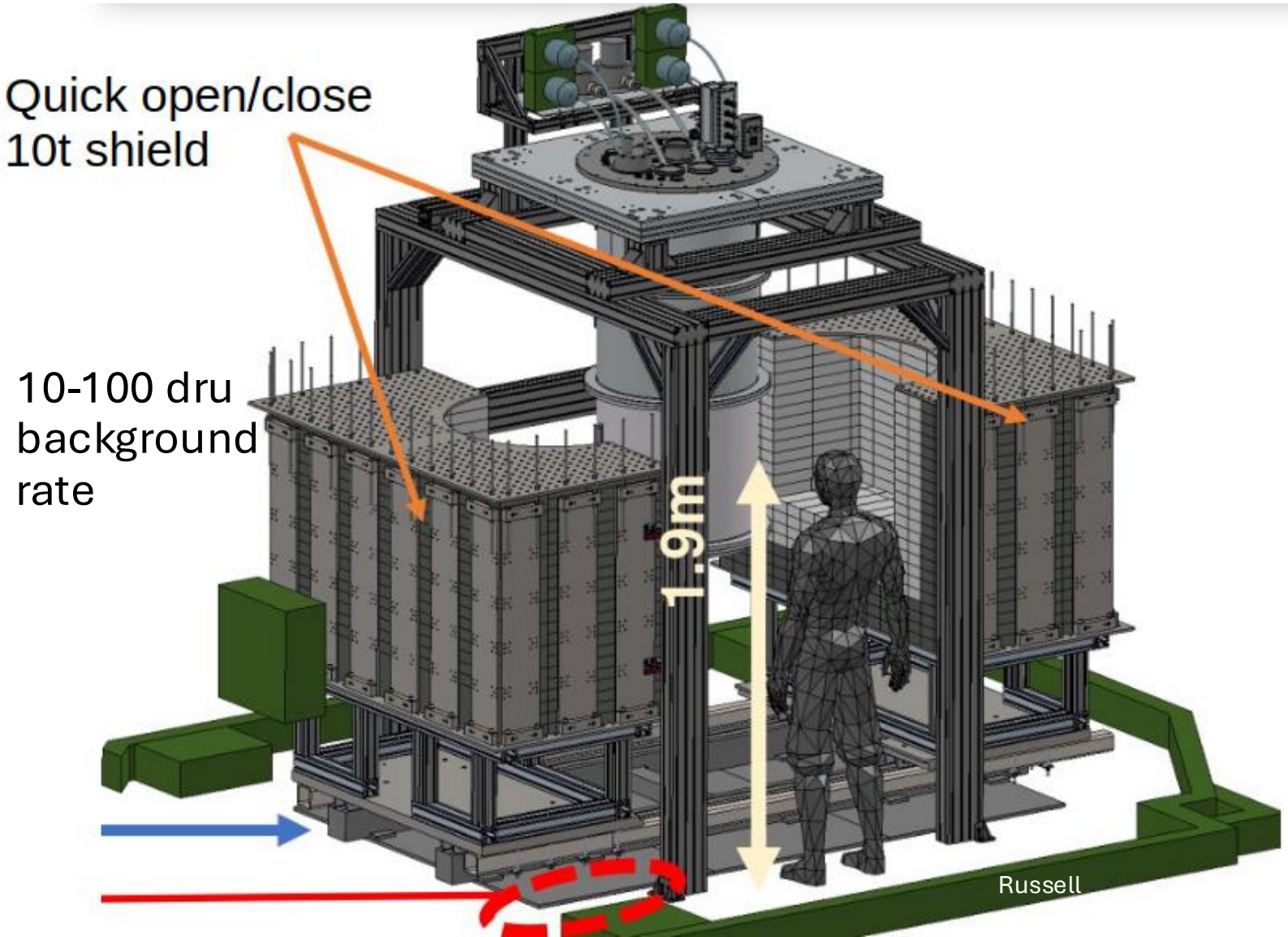
Phonons are not limited to nuclear recoil kinematics

Kamioka Cryolab

Facility dedicated to low mass dark matter searches with quasiparticle detectors

MIT
LBNL
UC Berkeley

Tohoku RCNS
KEK QUP

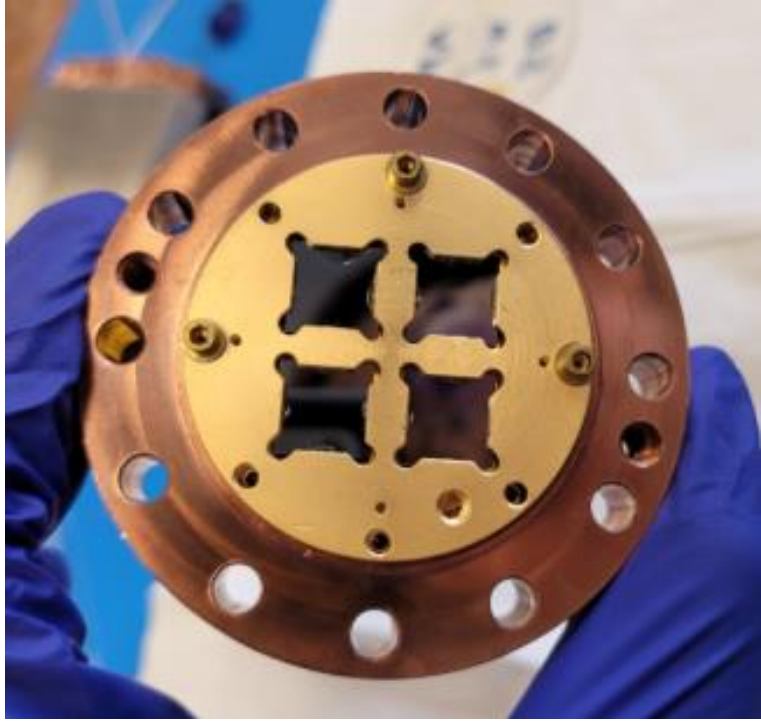


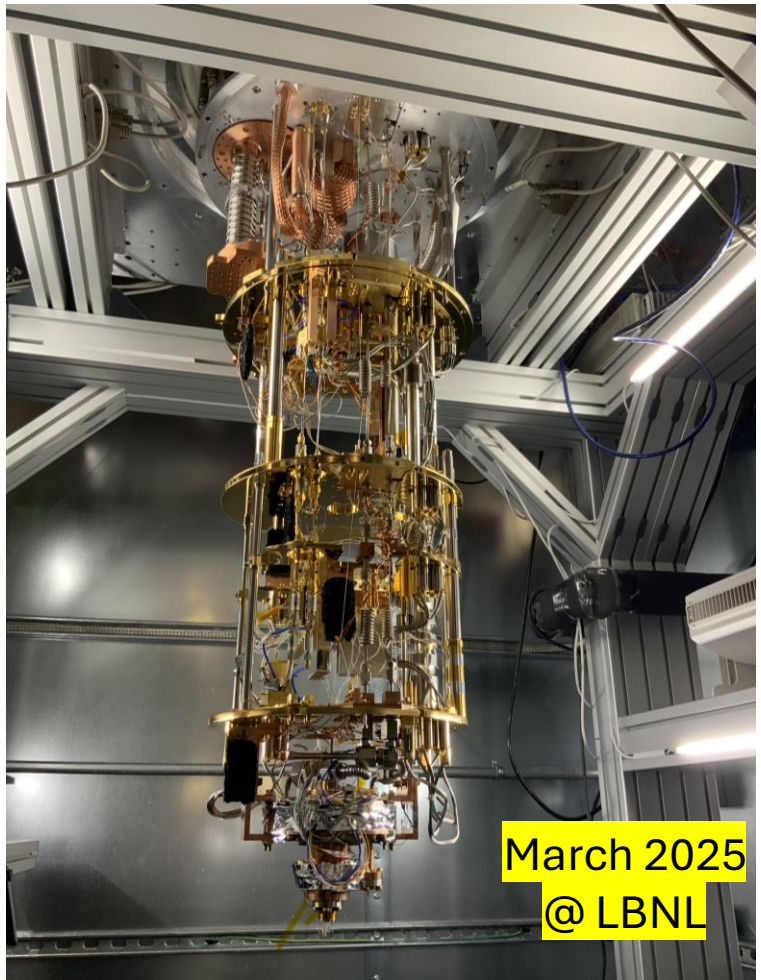
Near-term DM Searches

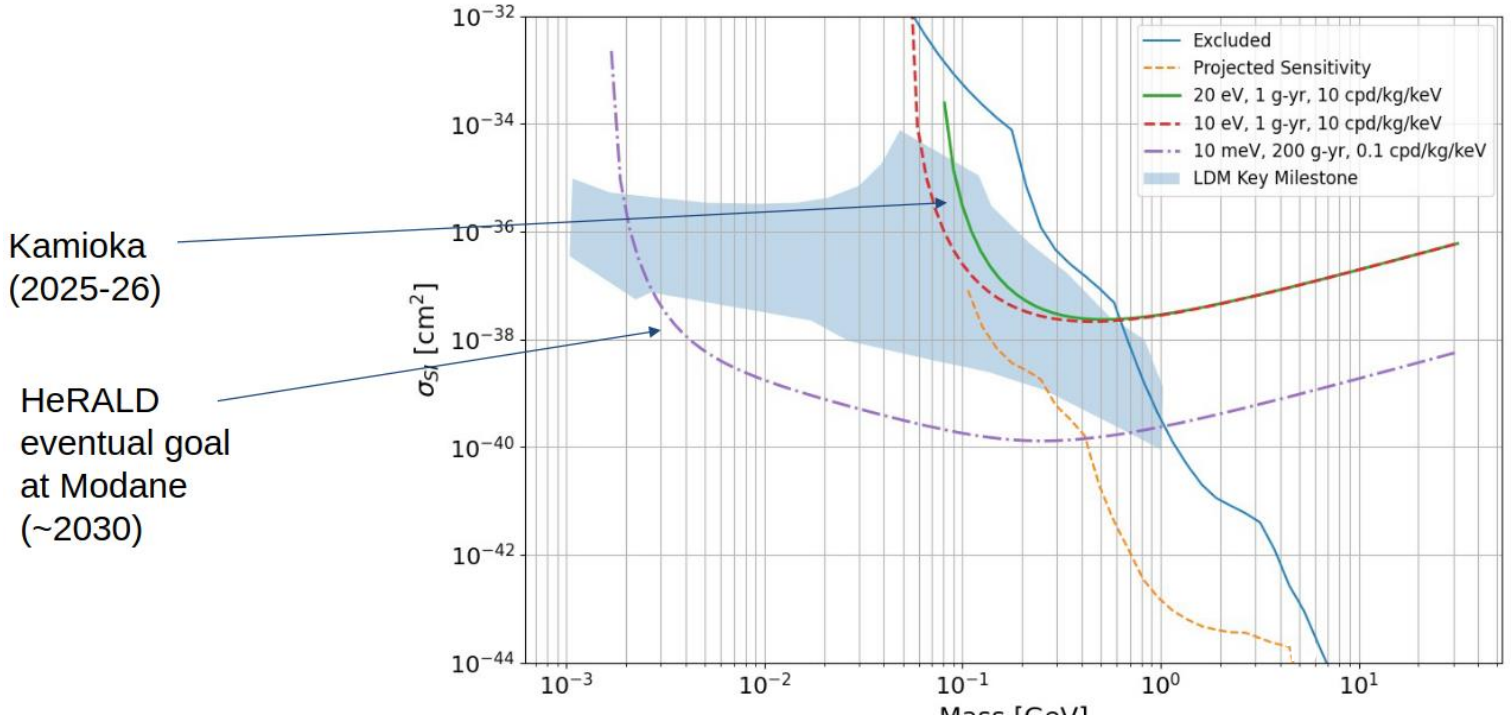
Deploy ~10 g scale HeRALD v0.2 detector in CY 2026 in collaboration with TESSERACT

Site preparation in progress

- SQUID readout commissioning
- He-4 handling commissioning
- Shield installation
- Background measurements





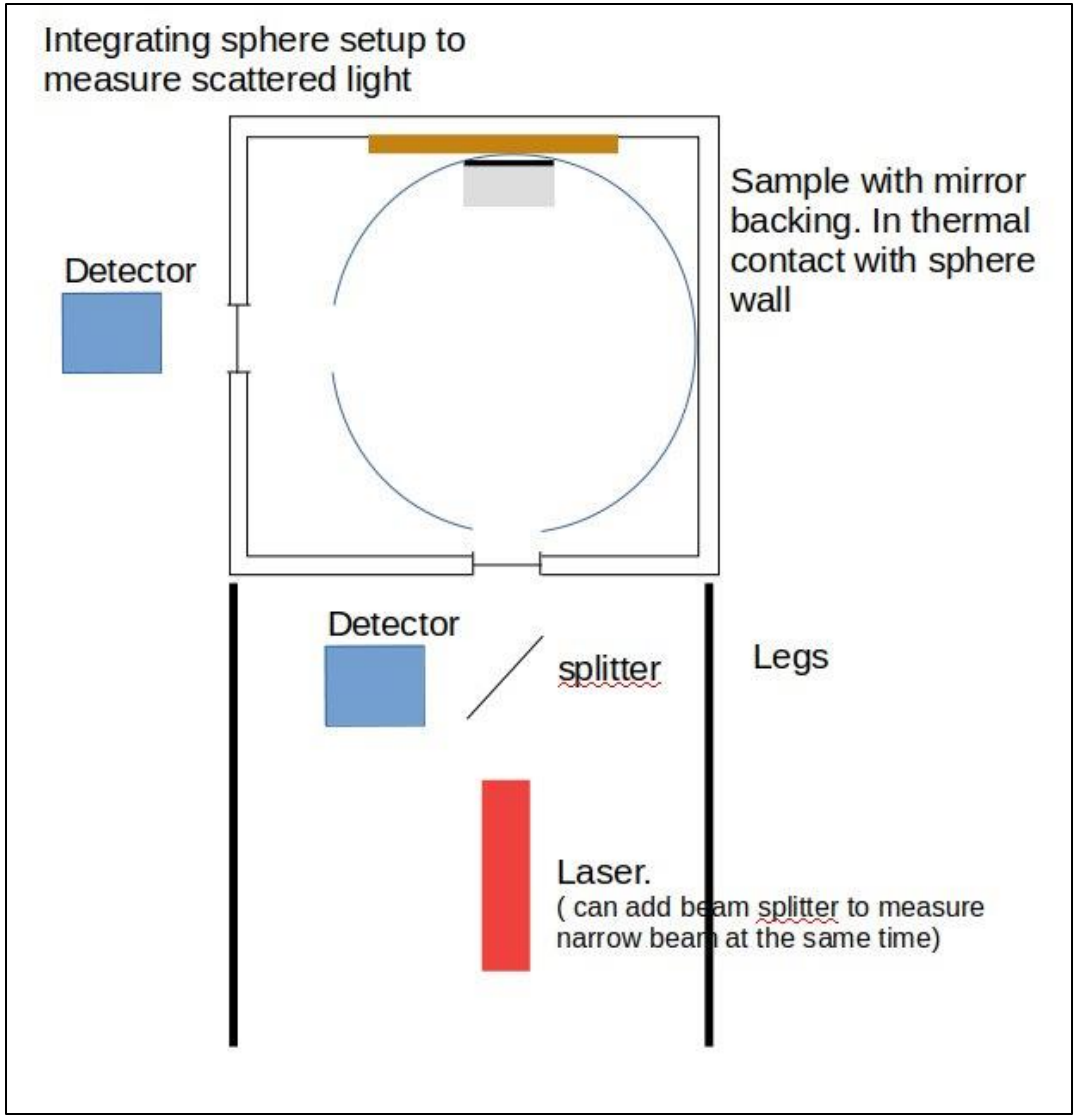


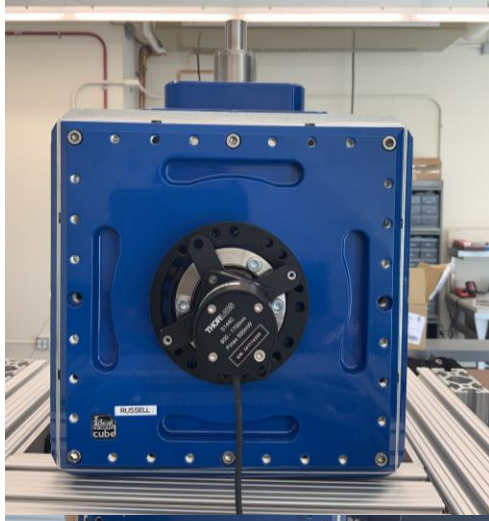
GaAs Cryogenic Scintillation

GaAs is an attractive target material for leptophilic low-mass dark matter direct detection

- 1.52 eV direct band gap
- O(eV) recoil --> O(MeV) dark matter mass
- Bright scintillator in the IR

Goal: understand light scattering inside n-type GaAs





Join the team!

Looking to hire one graduate student

Contact russell3@mit.edu if interested in learning more

Brooke Russell (PI)

Cecilia Ferrari (postdoc starting June)

Based in Cambridge, MA

Frequent travel:
- Domestic: FNAL, LBNL
- Switzerland: CERN, Bern
- Japan: KEK, Kamioka

Near-term physics analyses:
- Low mass particle dark matter searches @ Kamioka
- Exclusive cross sections @ 2x2
- BSM searches @ 2x2

Hardware development:
- LArTPC pixelated charge readout
- Scalable SiPM readout
- GaAs photon/phonon detection
- DR EMI, IR, vibration mitigation for TES readout