The Scintillating Bubble Chamber

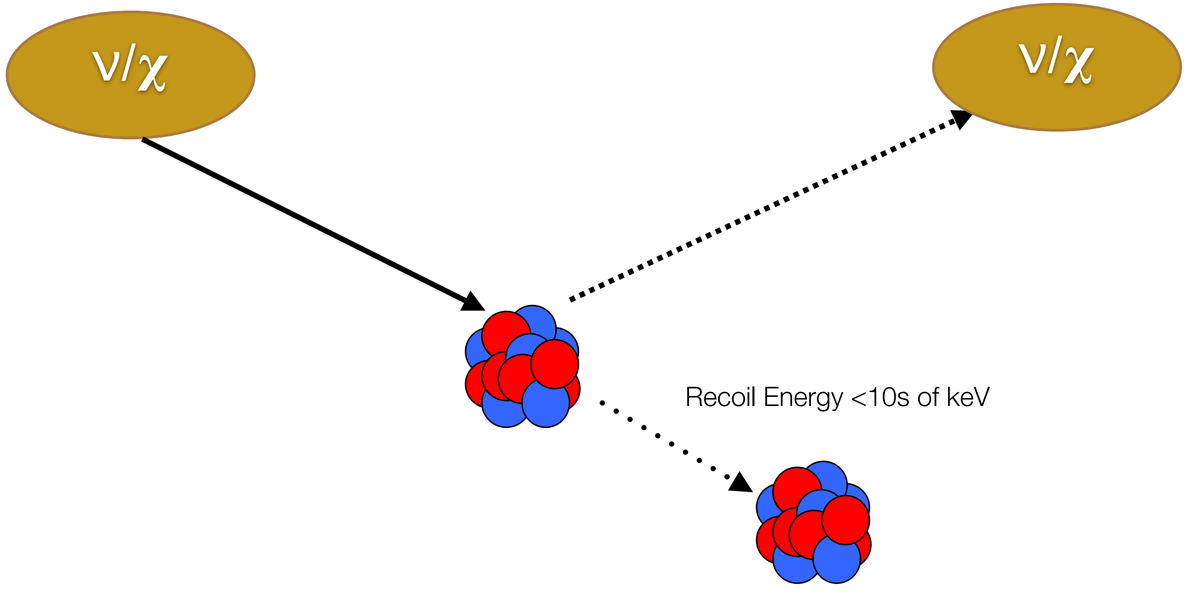
Ken Clark
for the SBC collaboration

Arthur B. McDonald
Canadian Astroparticle Physics Research Institute

TRIUMF

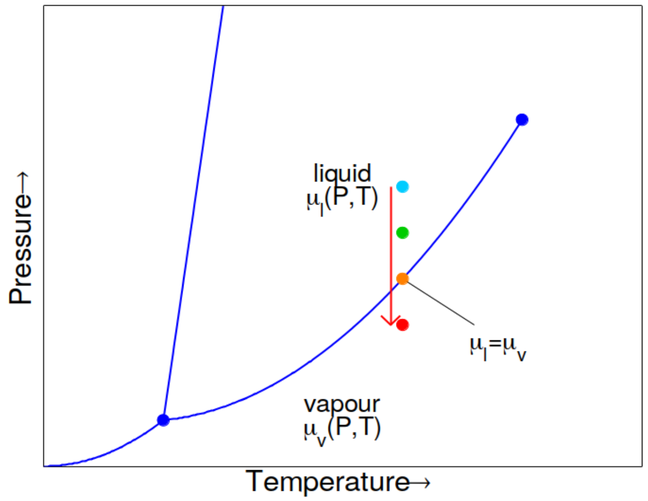
Queen's UNIVERSITY

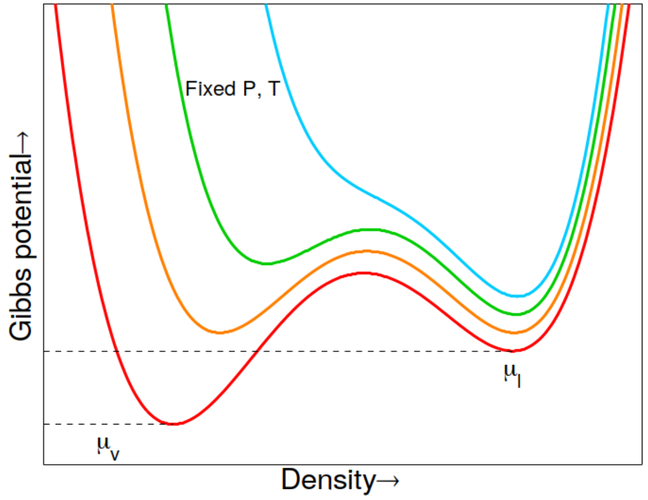
Detector Essentials



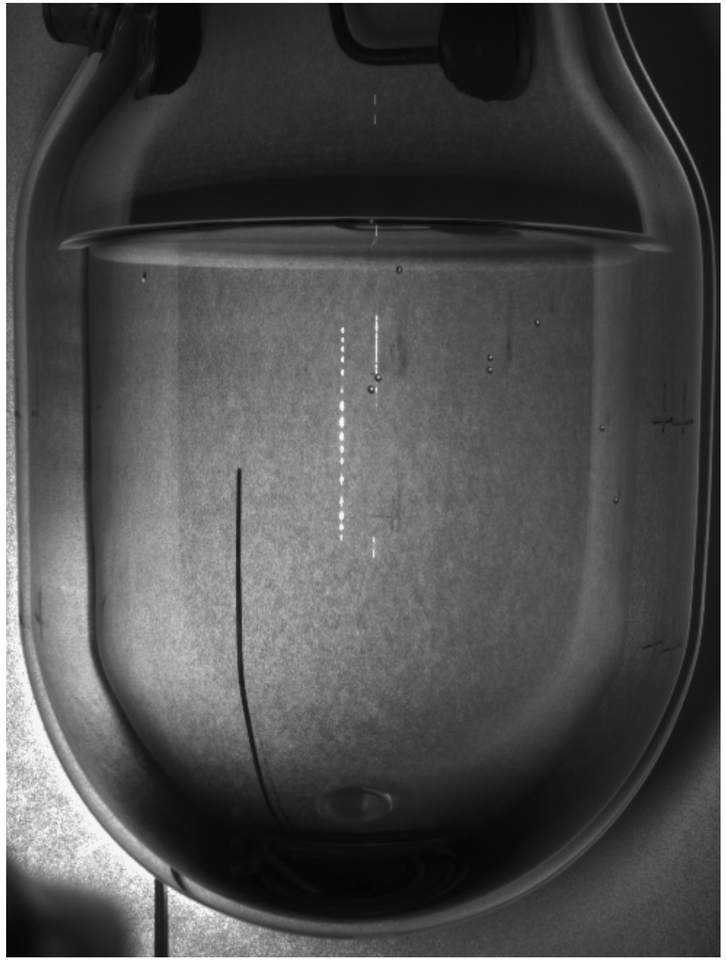
- Direct dark matter detectors look for energy deposited when nucleus recoils after collision
- Signal from coherent elastic neutrino-nucleus scattering (CEvNS) is identical
- Same detector can be used for both!

Superheated Fluid Detectors



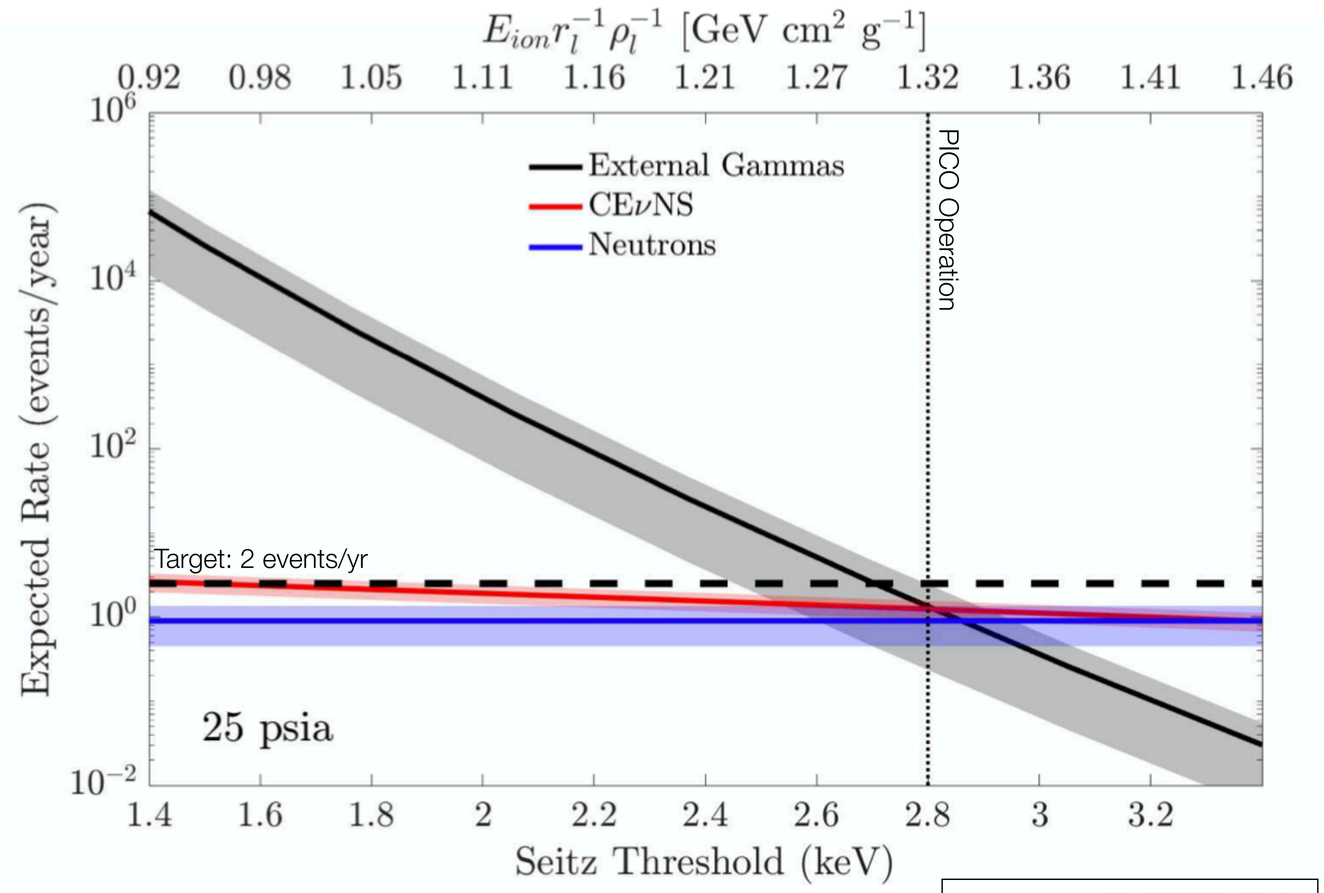


- Small deposit of energy overcomes threshold in Gibbs potential
- This then results in vaporization - production of bubble
- Note that threshold is controllable
  - At most thresholds, gammas not an issue



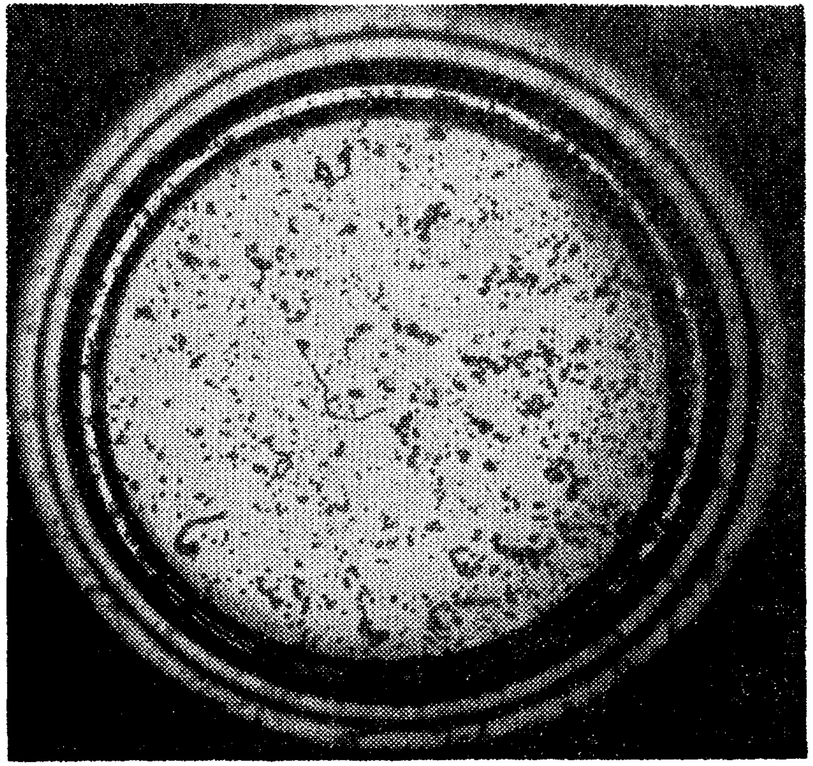
The Bubble Chamber

- Used for many discoveries
- World-leading dark matter results from PICO
- Main strength is insensitivity to electron recoils in most operational cases
- At low thresholds, gamma backgrounds can become overwhelming



Phys. Rev. D 100, 082006 (2019)

Revisit a bit of history

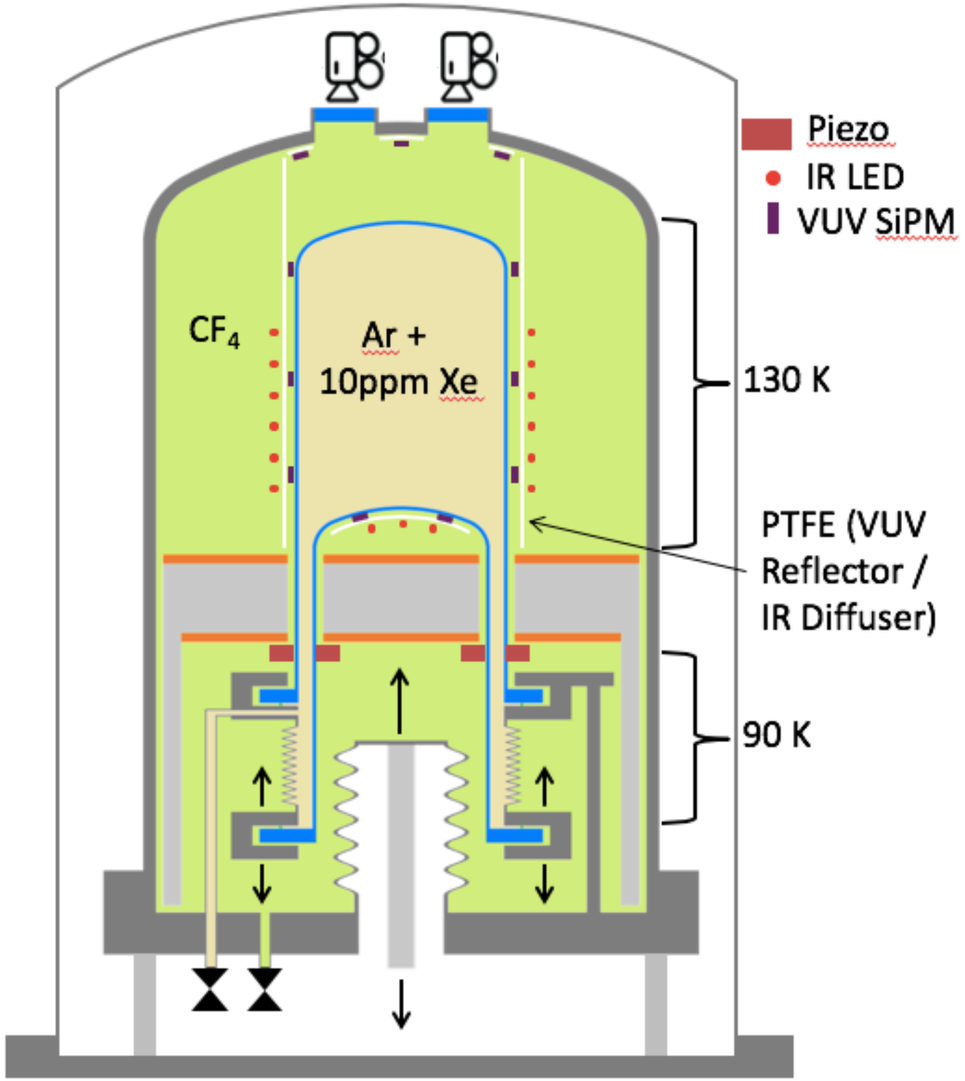


Phys. Rev. 102, 586 (1956)

- In 1956, Glaser made a xenon bubble chamber
  - No bubbles in pure xenon even at 1keV threshold with gamma source
  - Normal production in 98% xenon + 2% ethylene (scintillation completely quenched)
- Scintillation suppresses bubble nucleation
- Prototype xenon detector operated by SBC collaborators at Northwestern backs this up [Phys. Rev. Let. 118, 231301 (2017)]

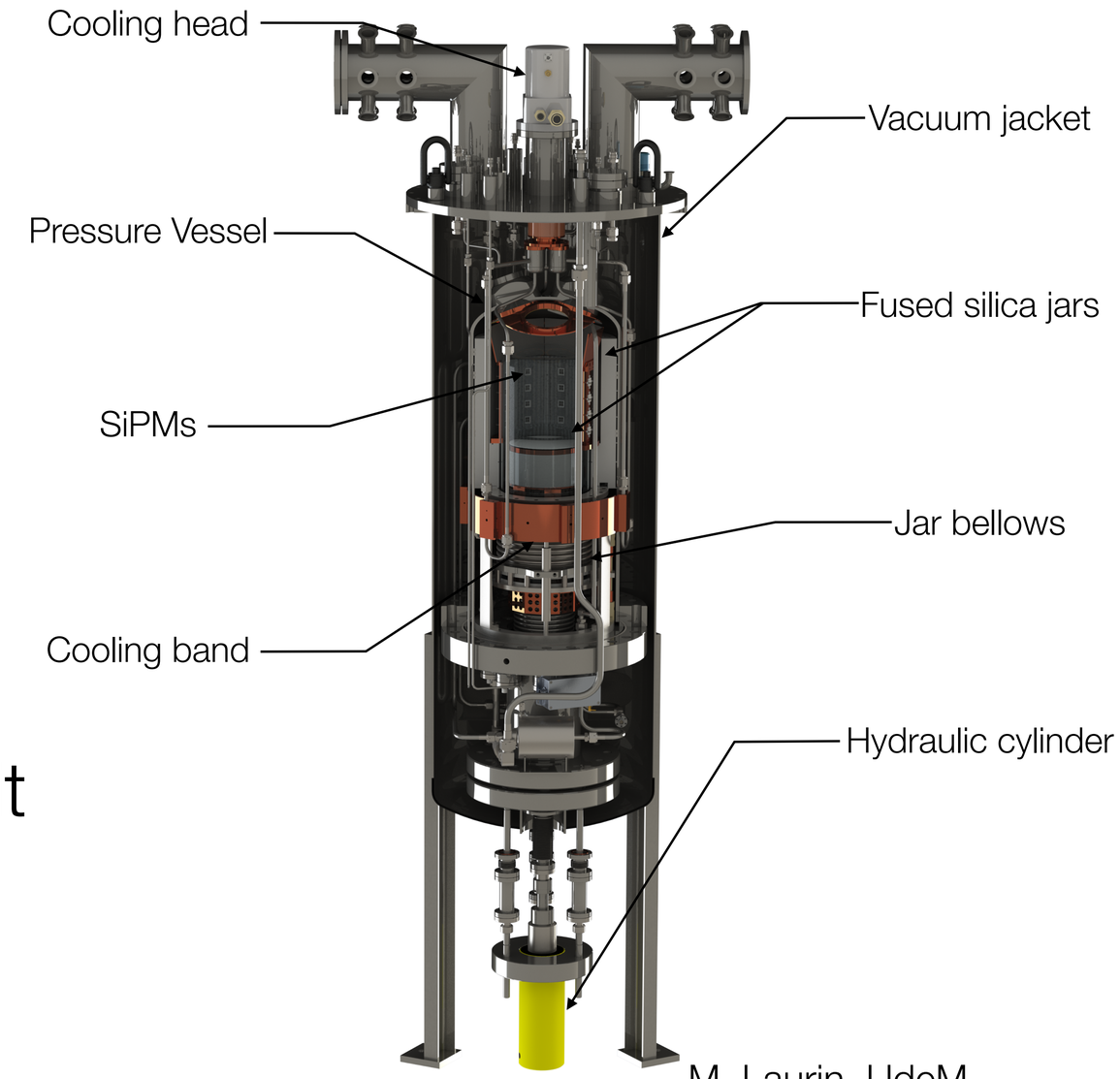
The SBC Detector

- Roughly 10kg of Argon
- SiPMs used for scintillation detection
- Much of the internal detail modelled on PICO 500
- Only added challenge is to keep it cold



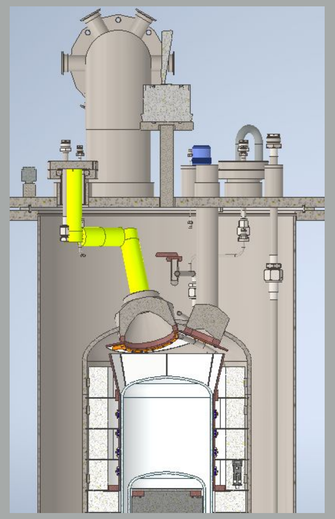
The SBC Detector

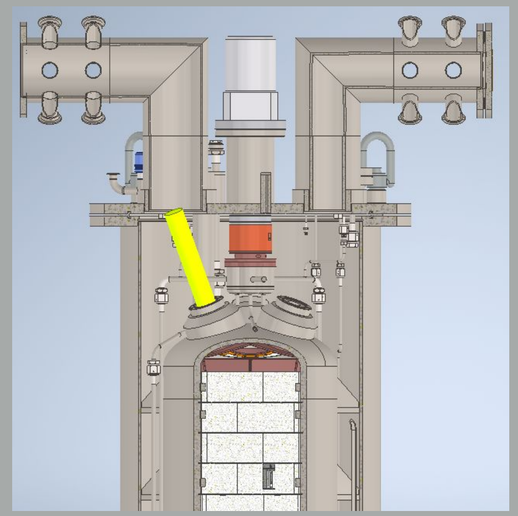
- Roughly 10kg of Argon
- SiPMs used for scintillation detection
- Much of the internal detail modelled on PICO 500
- Only added challenge is to keep it cold



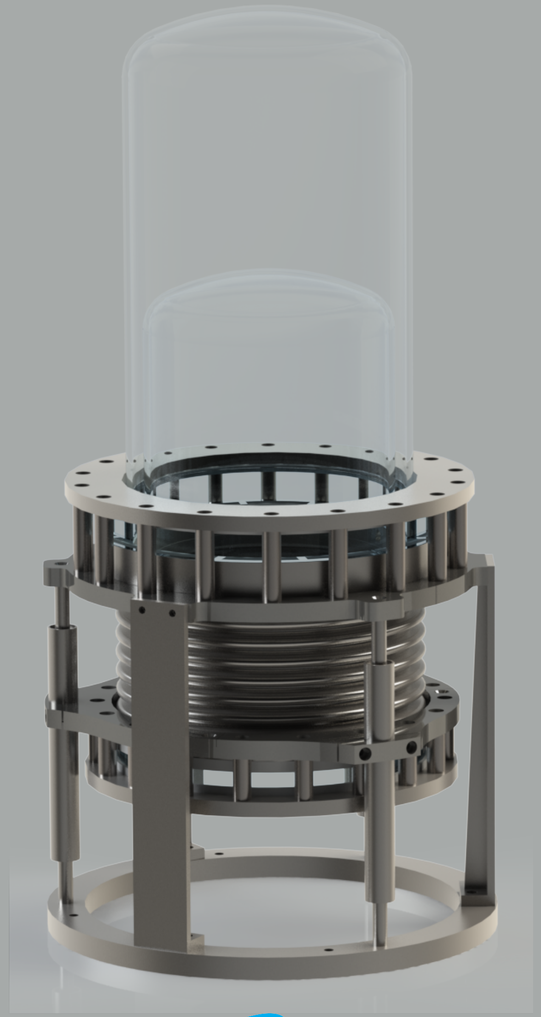
M. Laurin, UdeM

Canadian Responsibilities

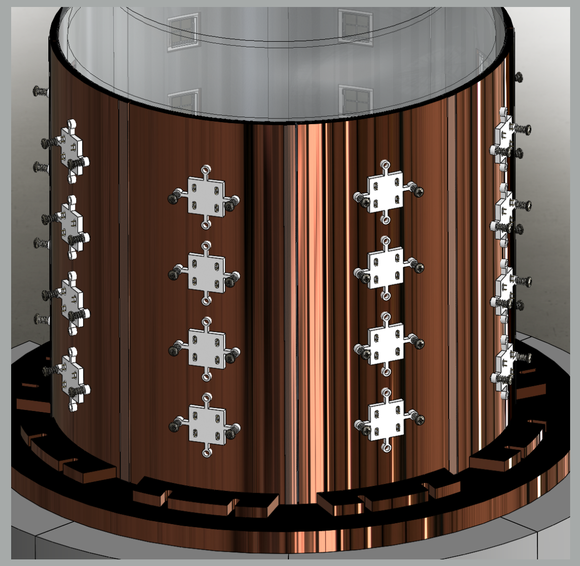




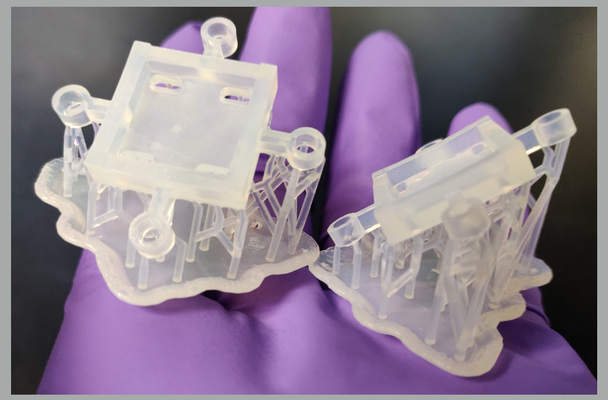
Internal imaging system



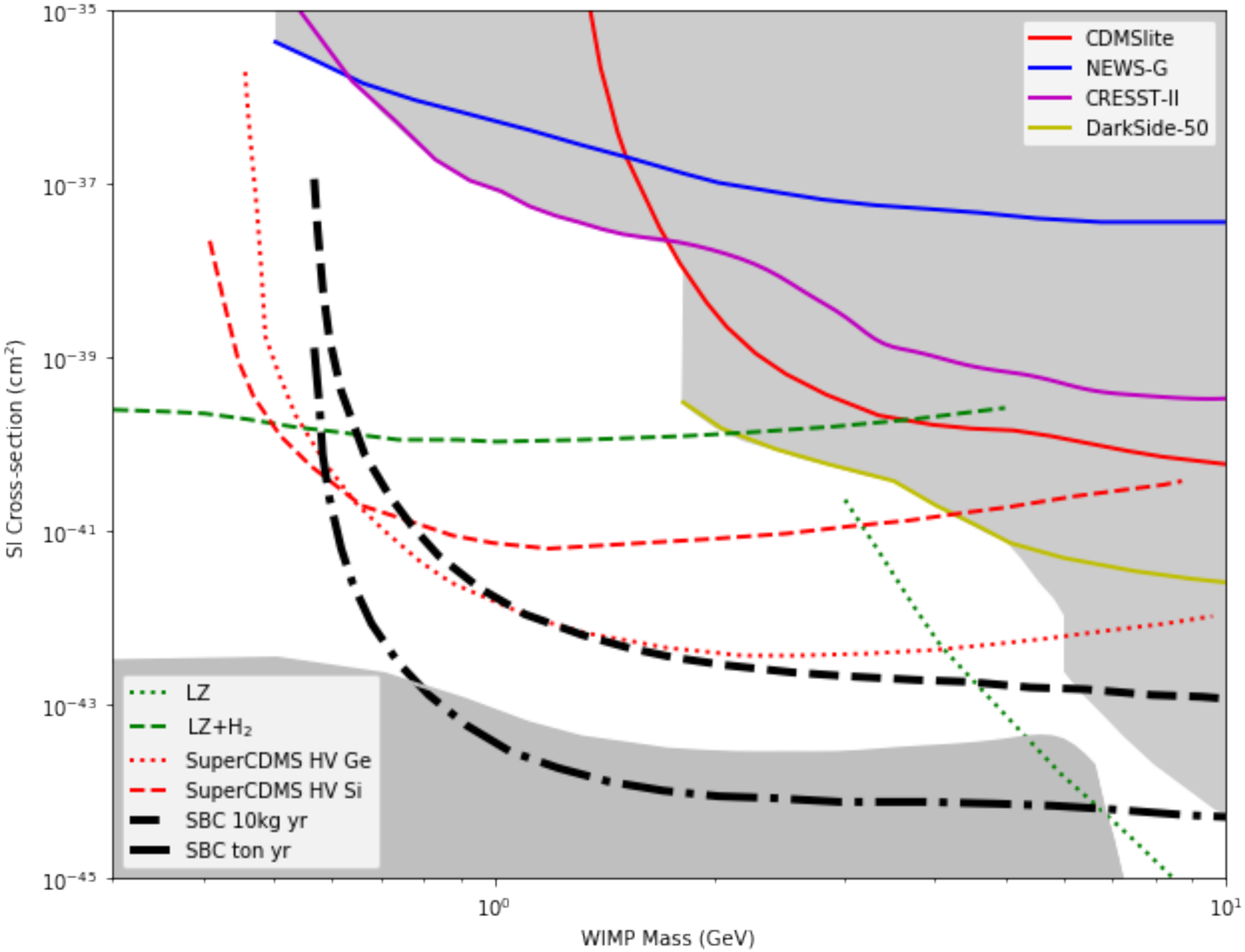
Entire inner assembly



SiPM testing and mounting



SBC Performance - Dark Matter



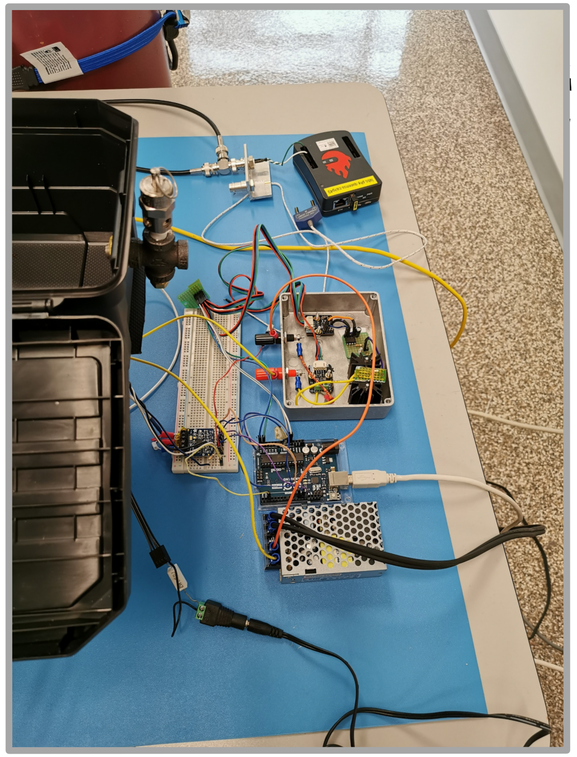
SBC curves assume NR threshold of 100 eV

Progress

Vacuum jacket

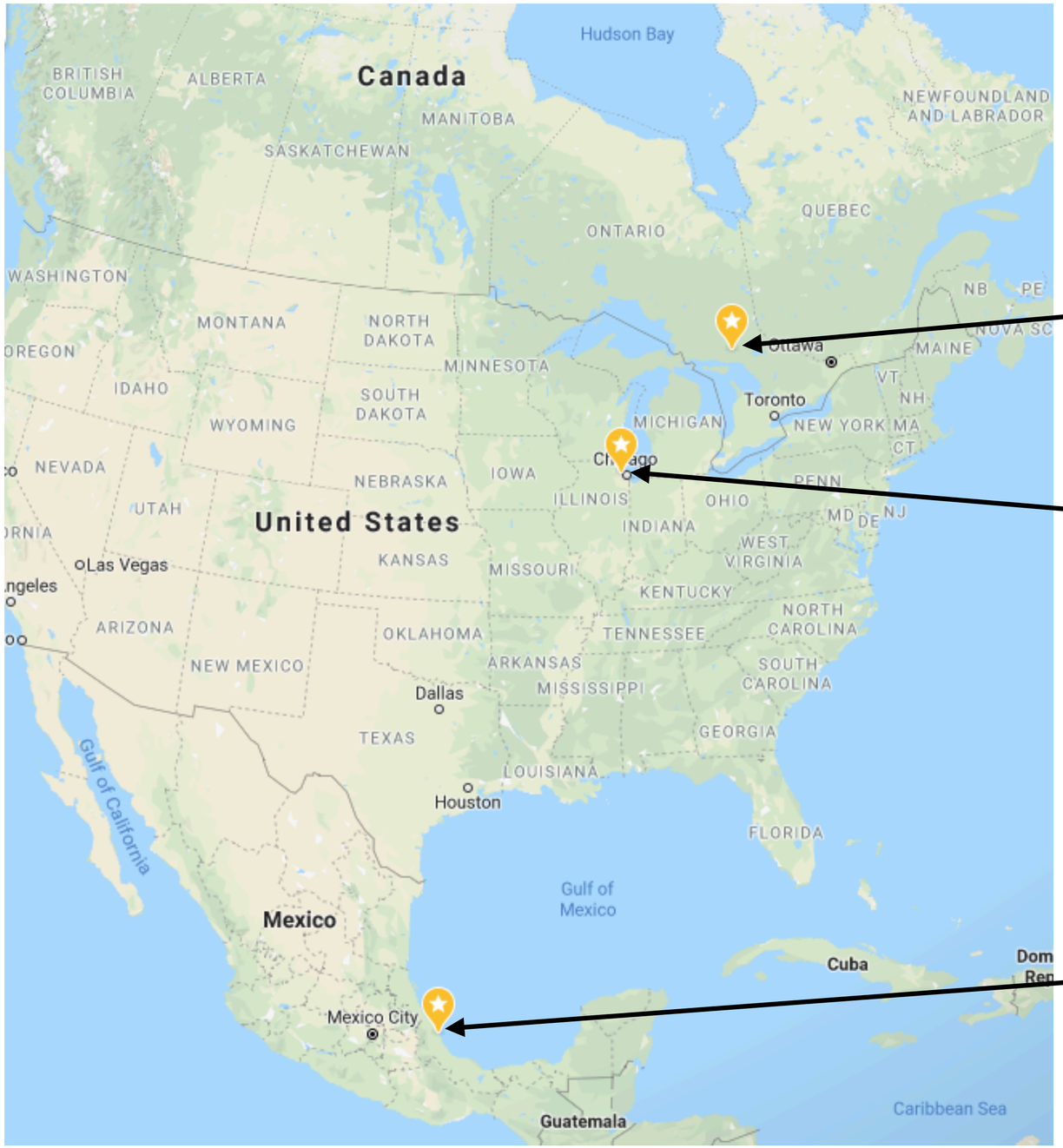
Pressure vessel

Pressure bellows



SiPM testing

Collaboration Plan



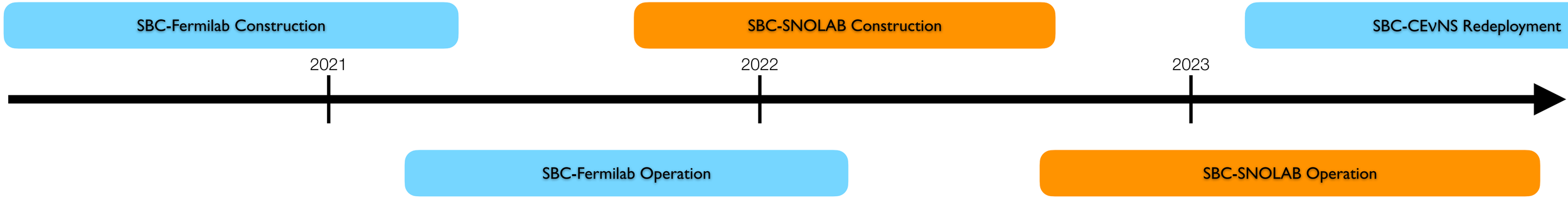
2) Build and install detector at SNOLAB for DM search

1) Build and commission detector at Fermilab

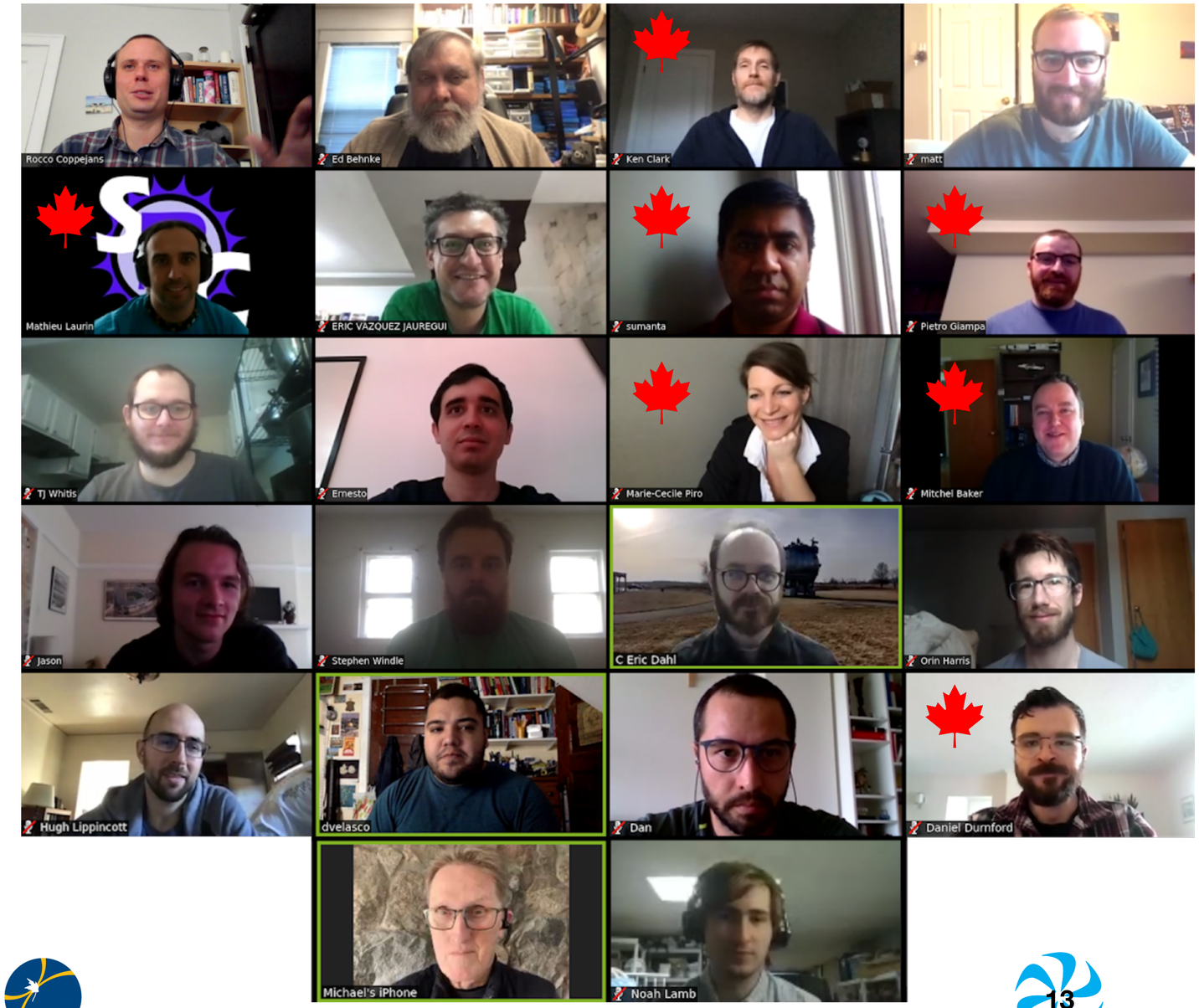
3) Upgrade and install detector from 1) at a reactor for CEvNS studies

Multiple goals

- Having several goals means building several detectors
- First undergoing construction and commissioning at Fermilab, then to be used for CEvNS
- Second to be built at SNOLAB starting in 2021



The collaboration



- Canadian groups at Queen's, University of Alberta, TRIUMF, Université de Montréal
- US groups at Northwestern, Fermilab, IUSB, UCSB, Drexel, NEIU, PNNL
- Mexican group at UNAM
- Collaboration was formed with a code of conduct and ombudspeople defined from the start

Conclusions

- The SBC collaboration will be investigating both CEvNS and dark matter
- Vibrant group, always looking for collaborators
- Look for us in the future!