Bubbles and Neutrinos

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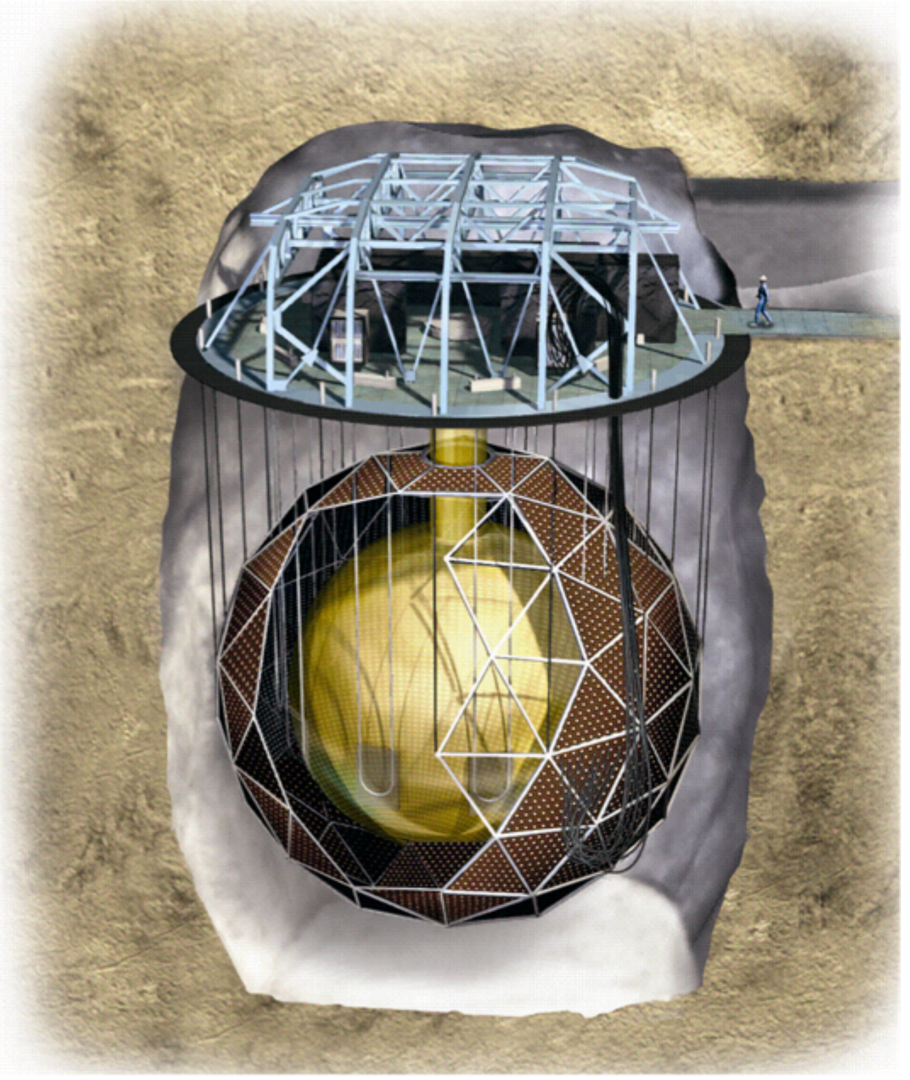
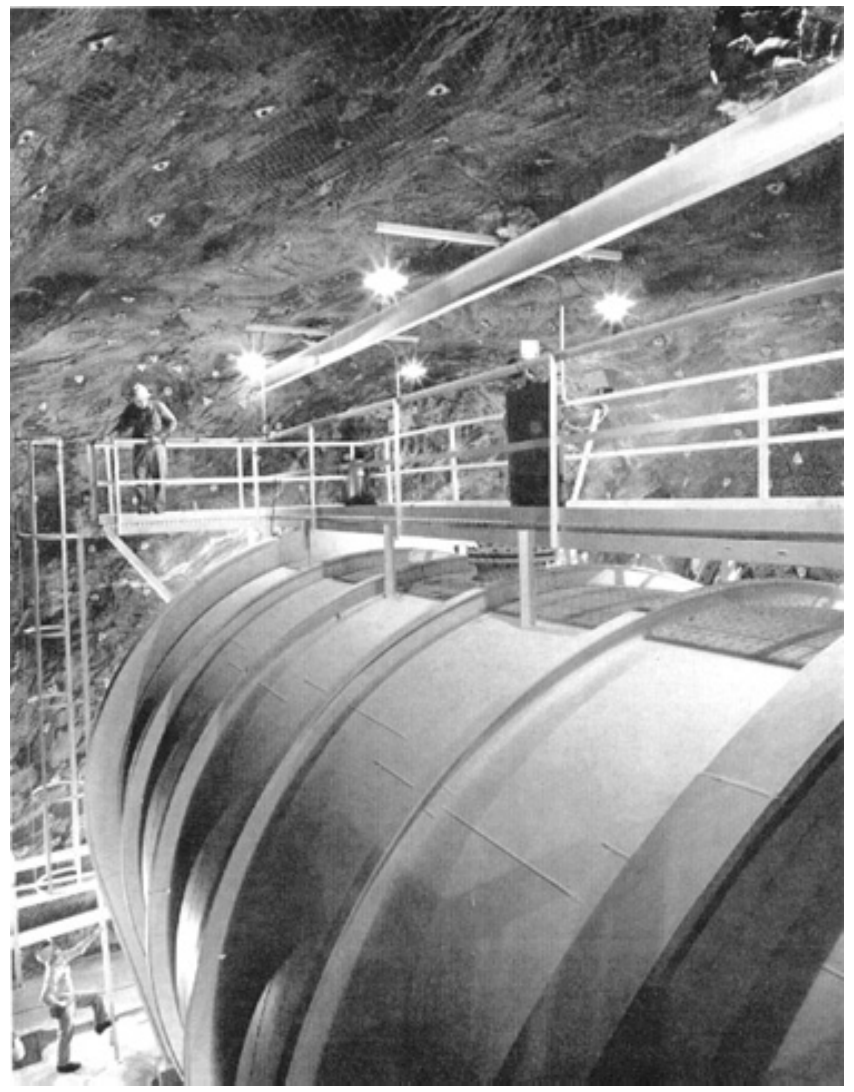
Detecting Neutrinos

- Lots of different kinds of detectors…

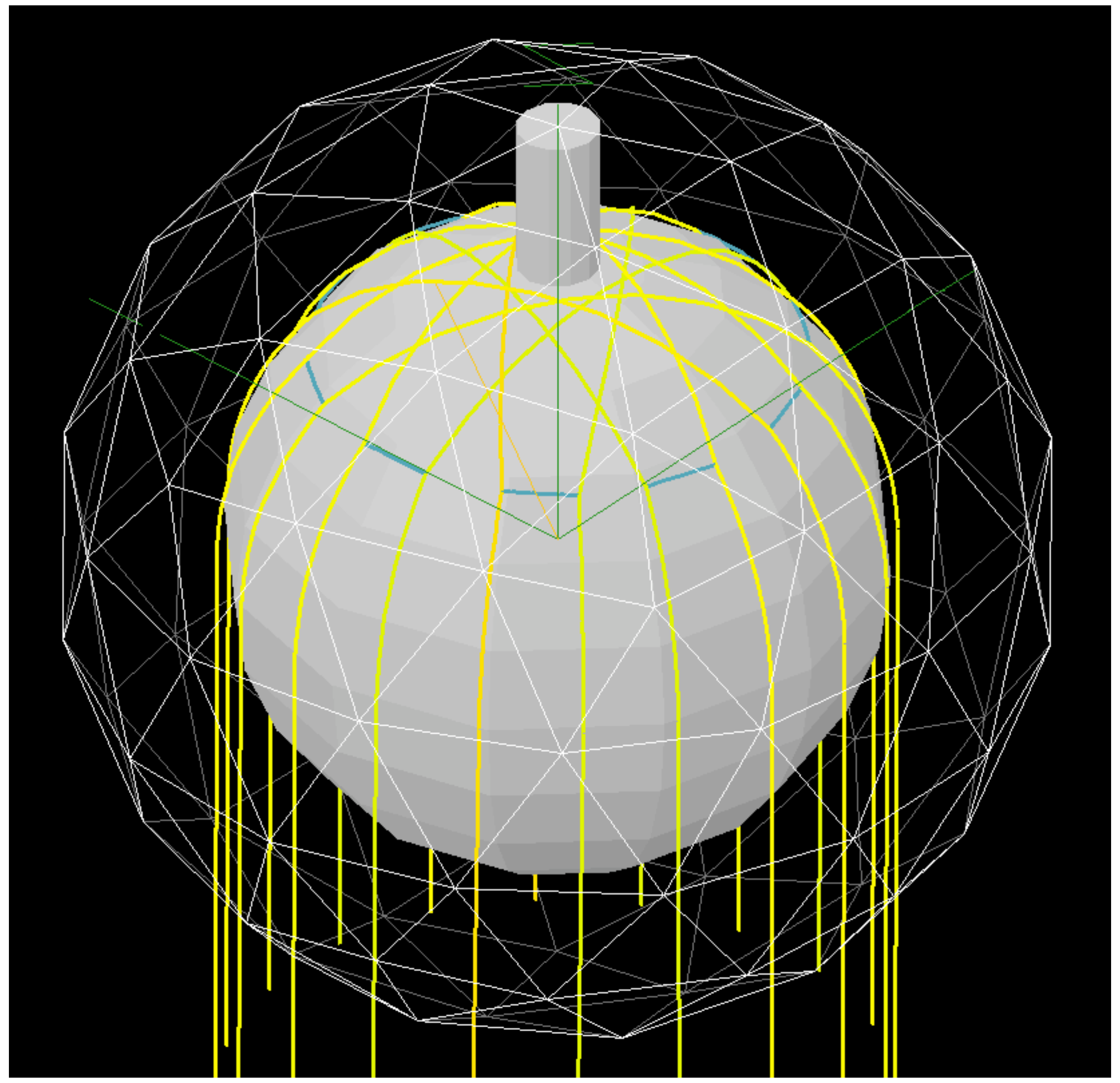


Cerenkov
Threshold $\mathcal{O}$(MeV)

Radiochemical
Threshold $\mathcal{O}$(hundreds keV)



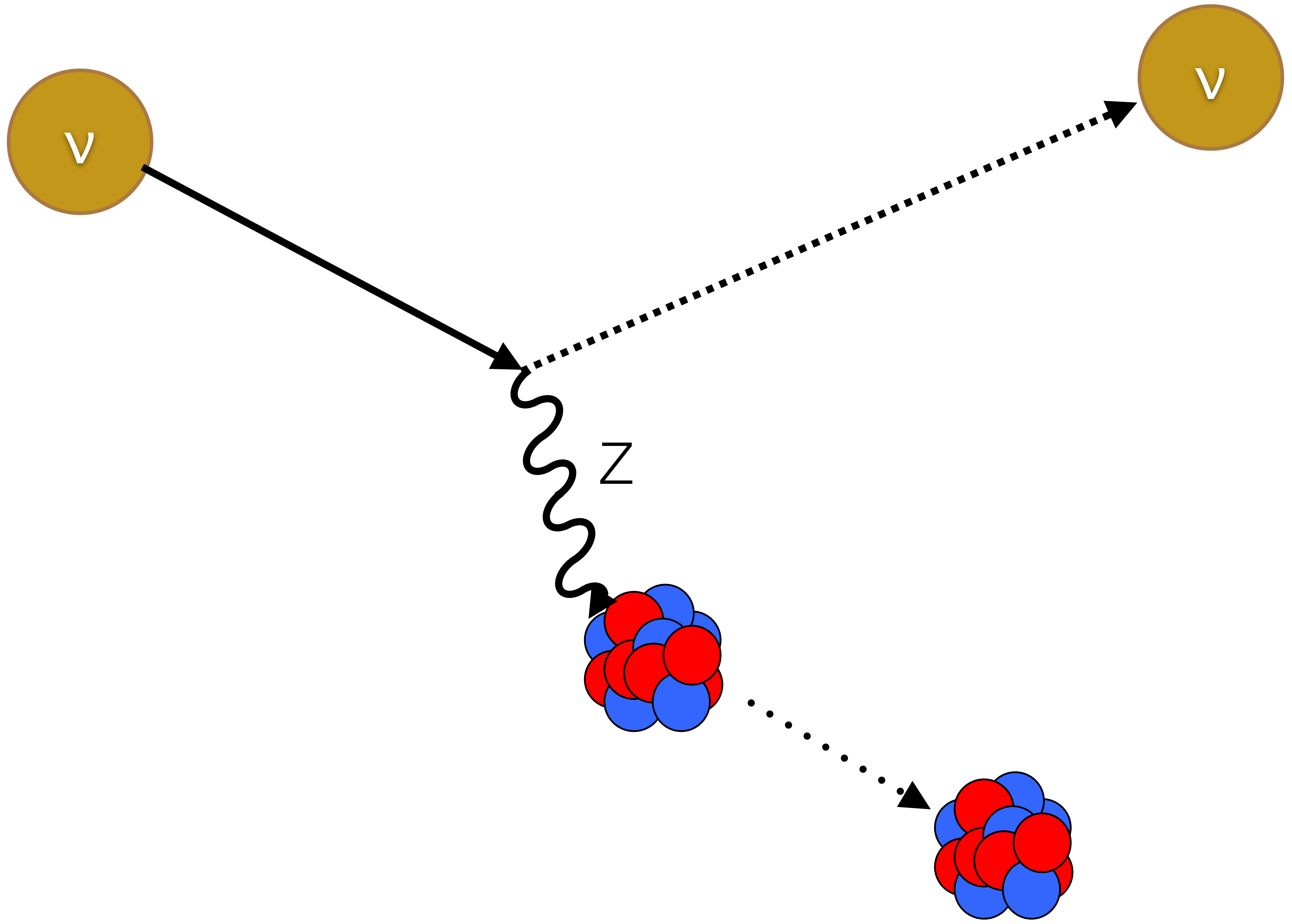
Scintillation
Threshold $\mathcal{O}$(MeV)



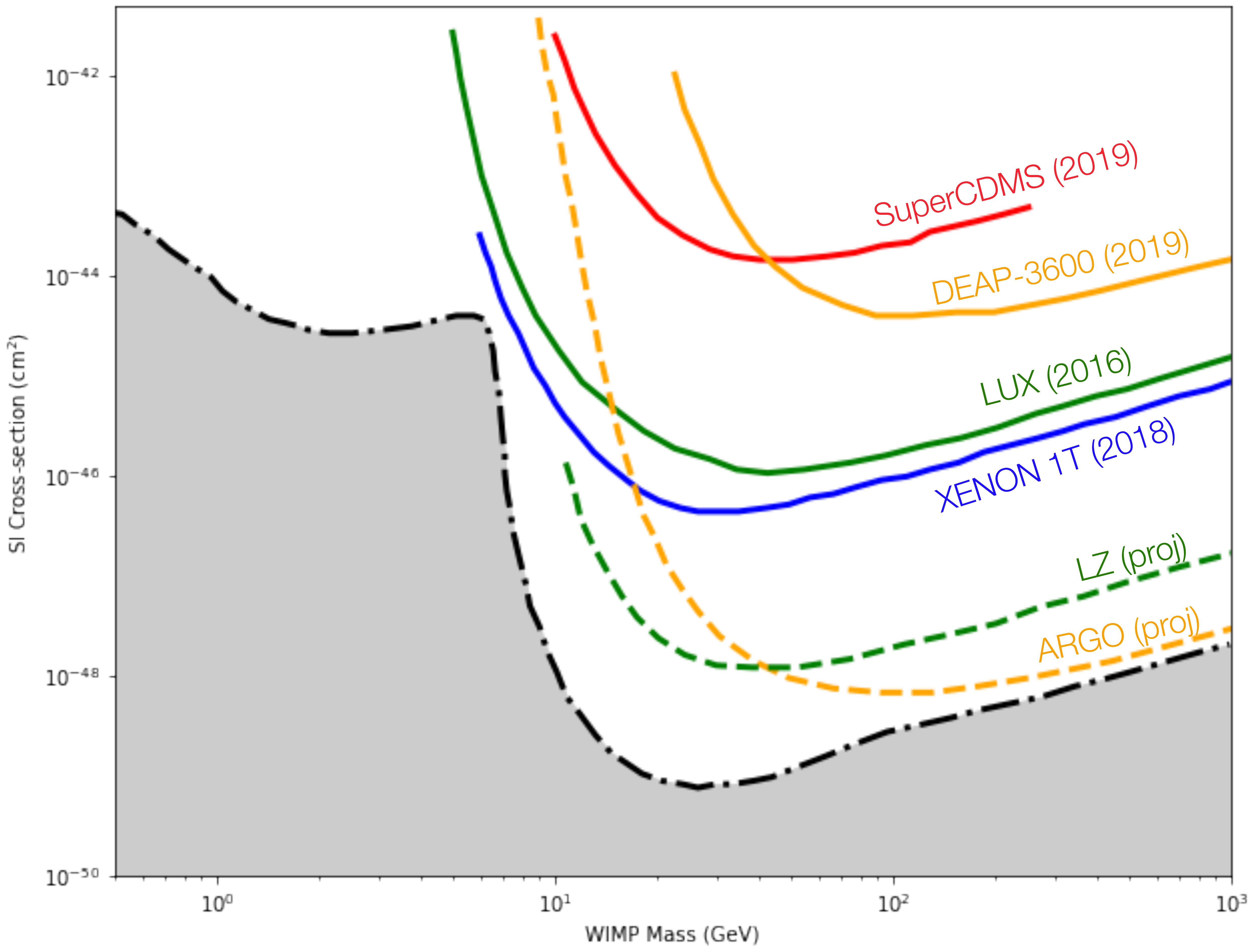
Tracking
Threshold $\mathcal{O}$(Gev)

Different Neutrino Interaction

- Neutrinos can scatter elastically with an entire nucleus
  - Coherent Elastic Neutrino-Nucleus Scattering (CEvNS)
- Search for the nuclear recoil
- UPPER energy threshold of tens of MeV neutrinos for most nuclei



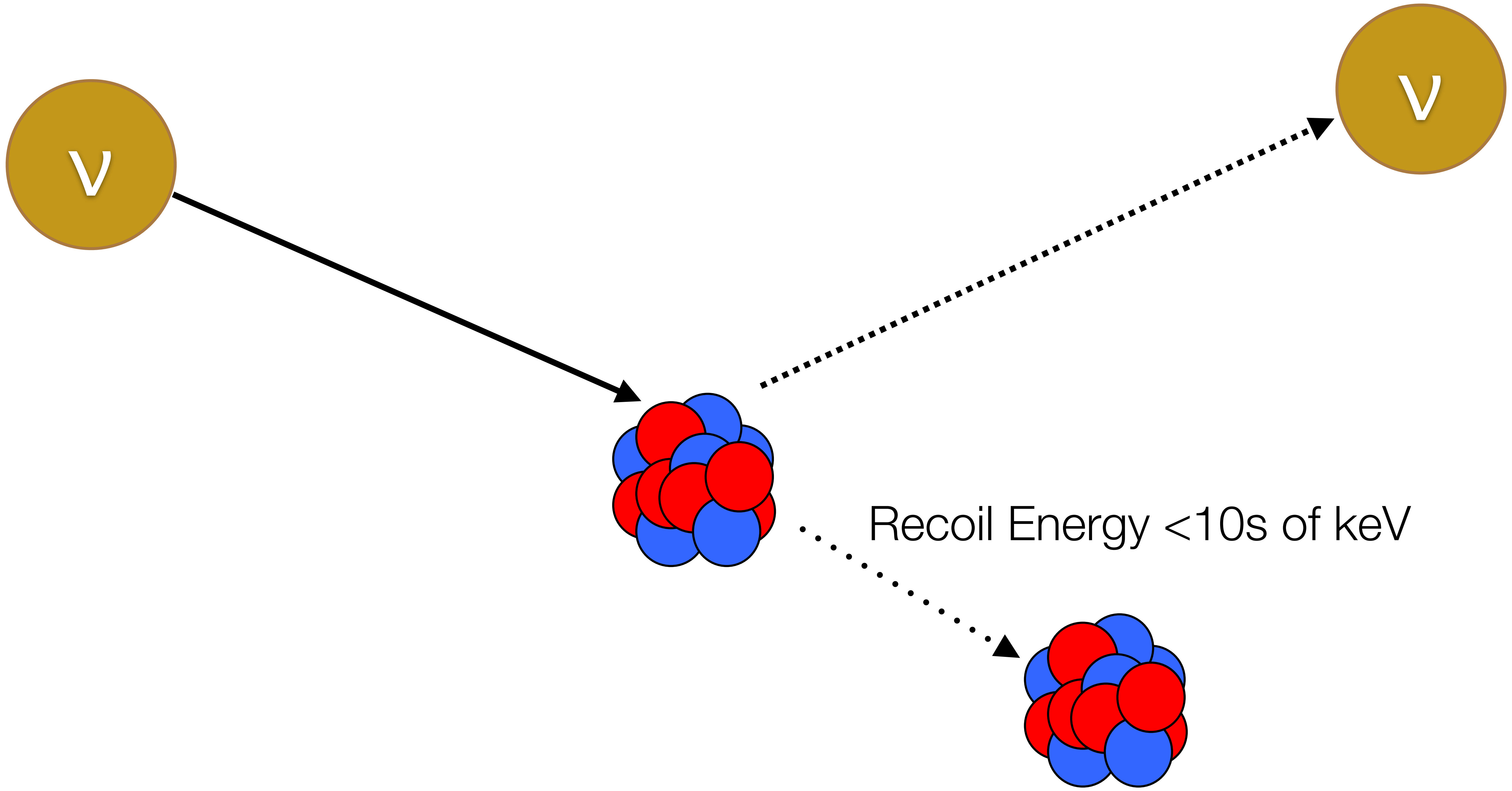
Look to our peers



- This is an issue dark matter detectors have been dealing with for years
- Many MANY ways to see that small energy deposit
- Trickiest part may be the background rejection…

Coherent Neutrino Scattering

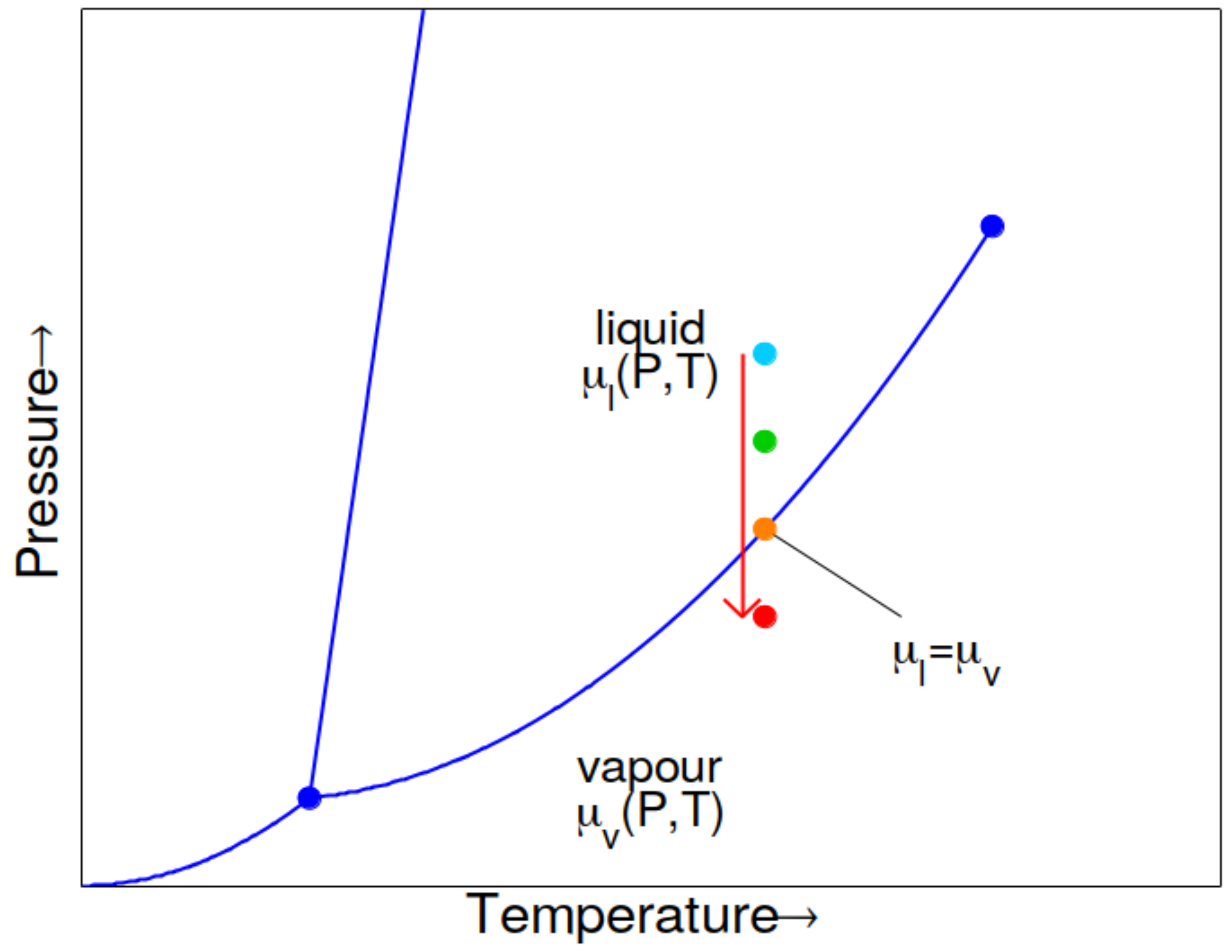
- I said we were looking for this

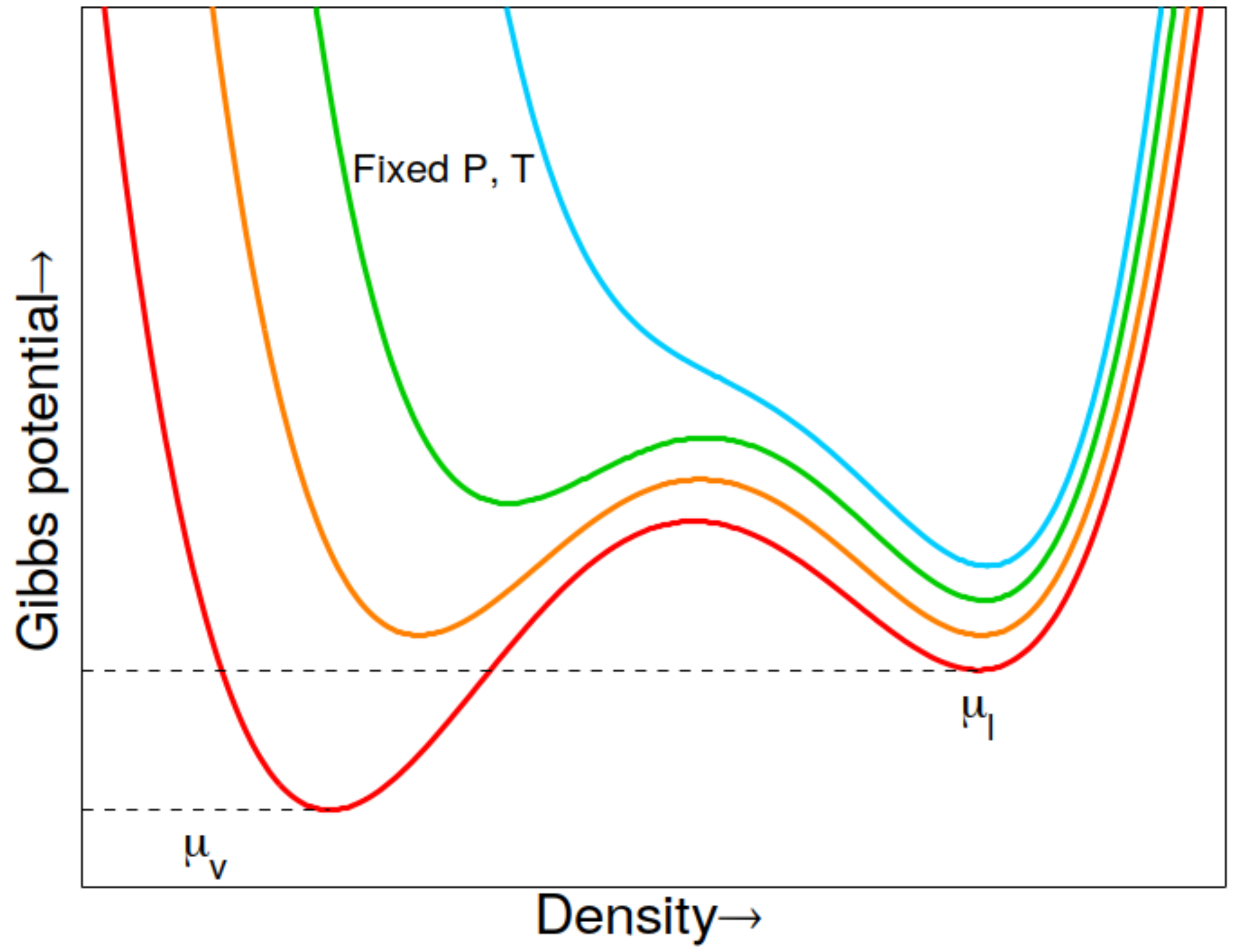


Coherent Neutrino Scattering

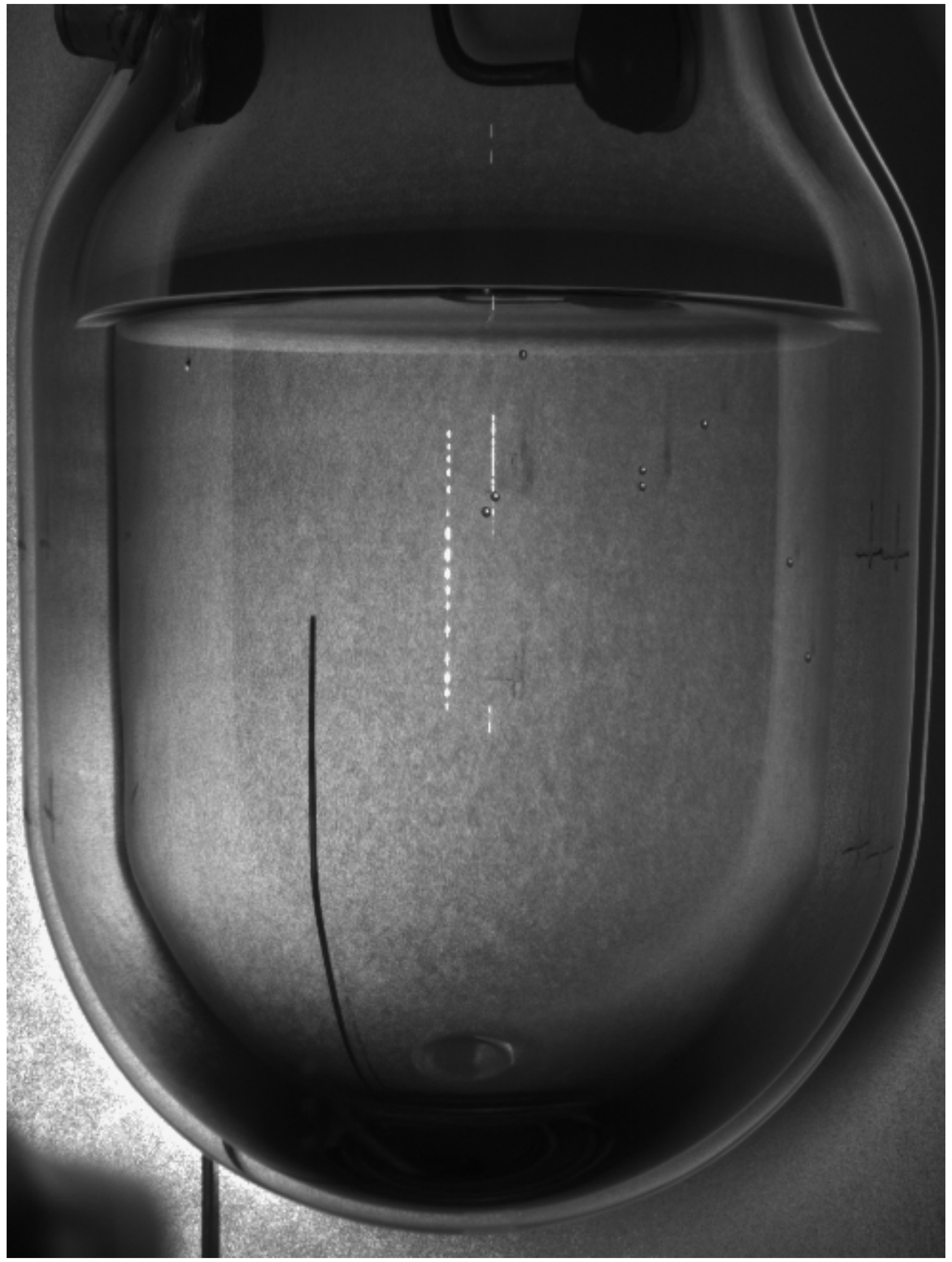
- We're actually looking for this

Example Dark Matter Detector - PICO





- 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



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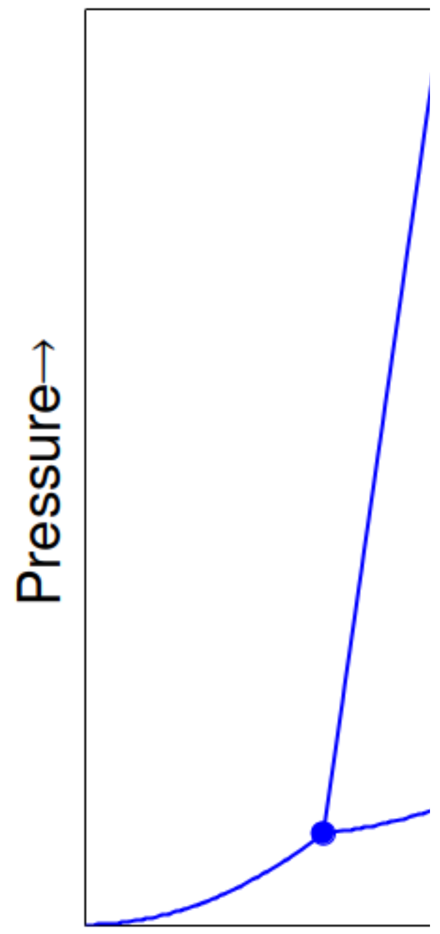
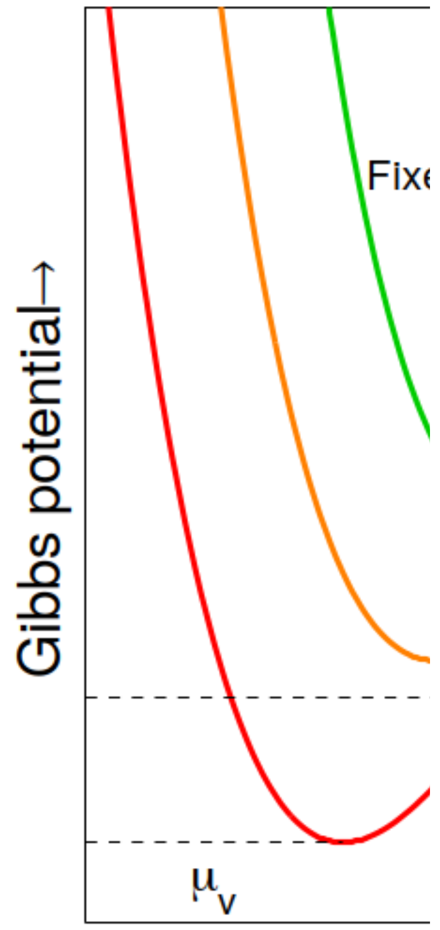
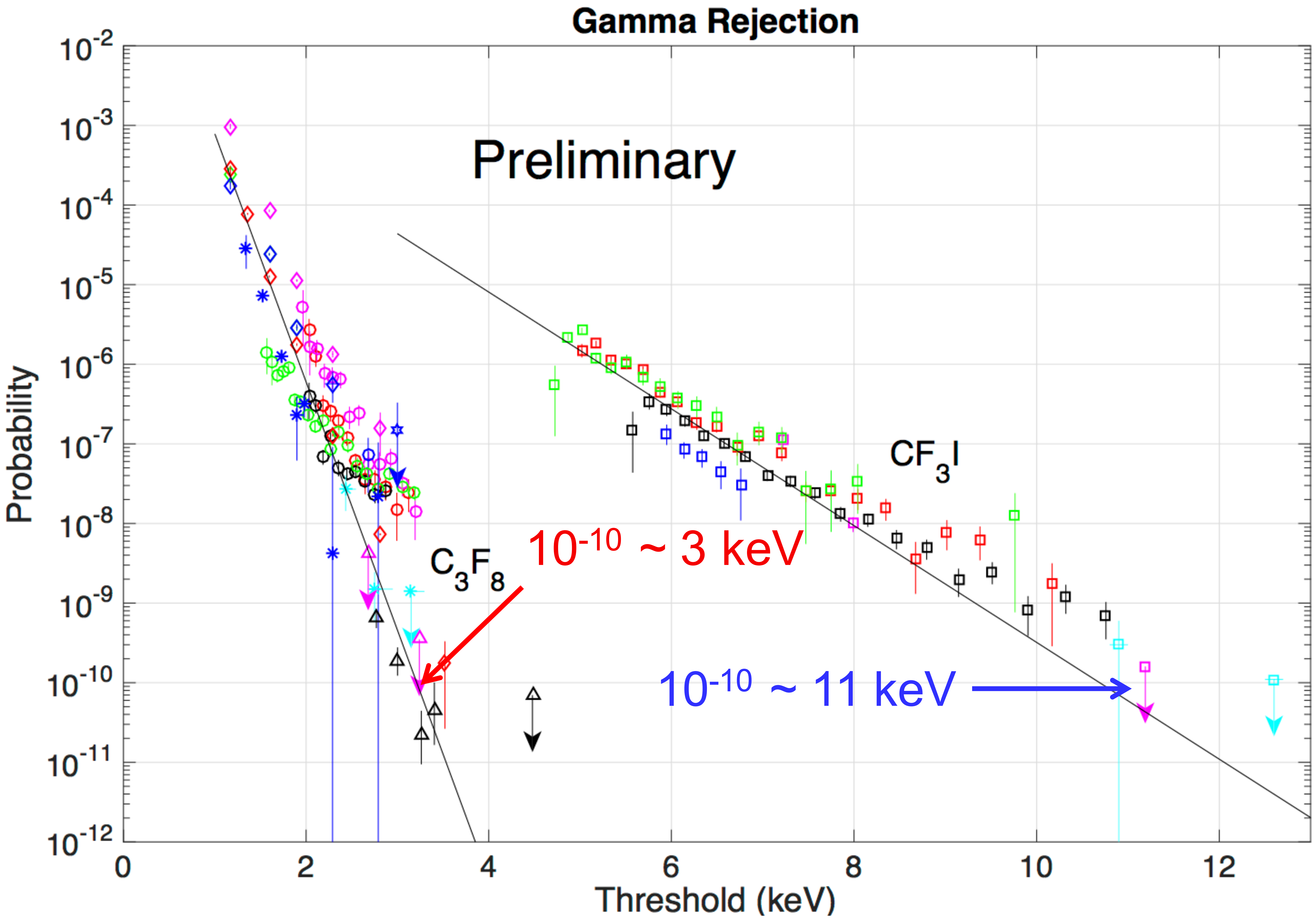
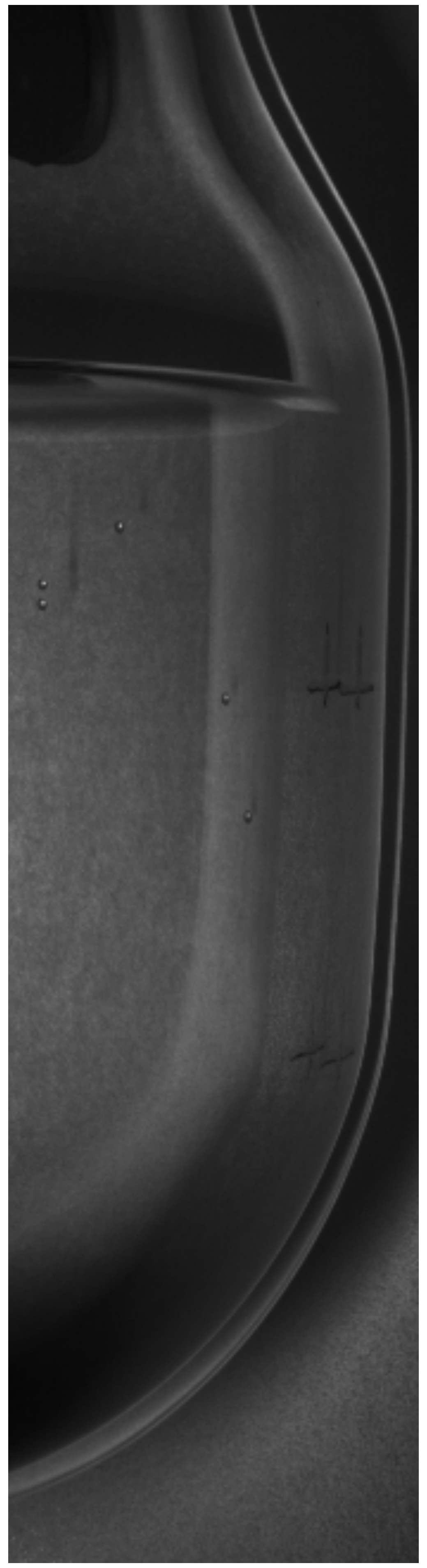
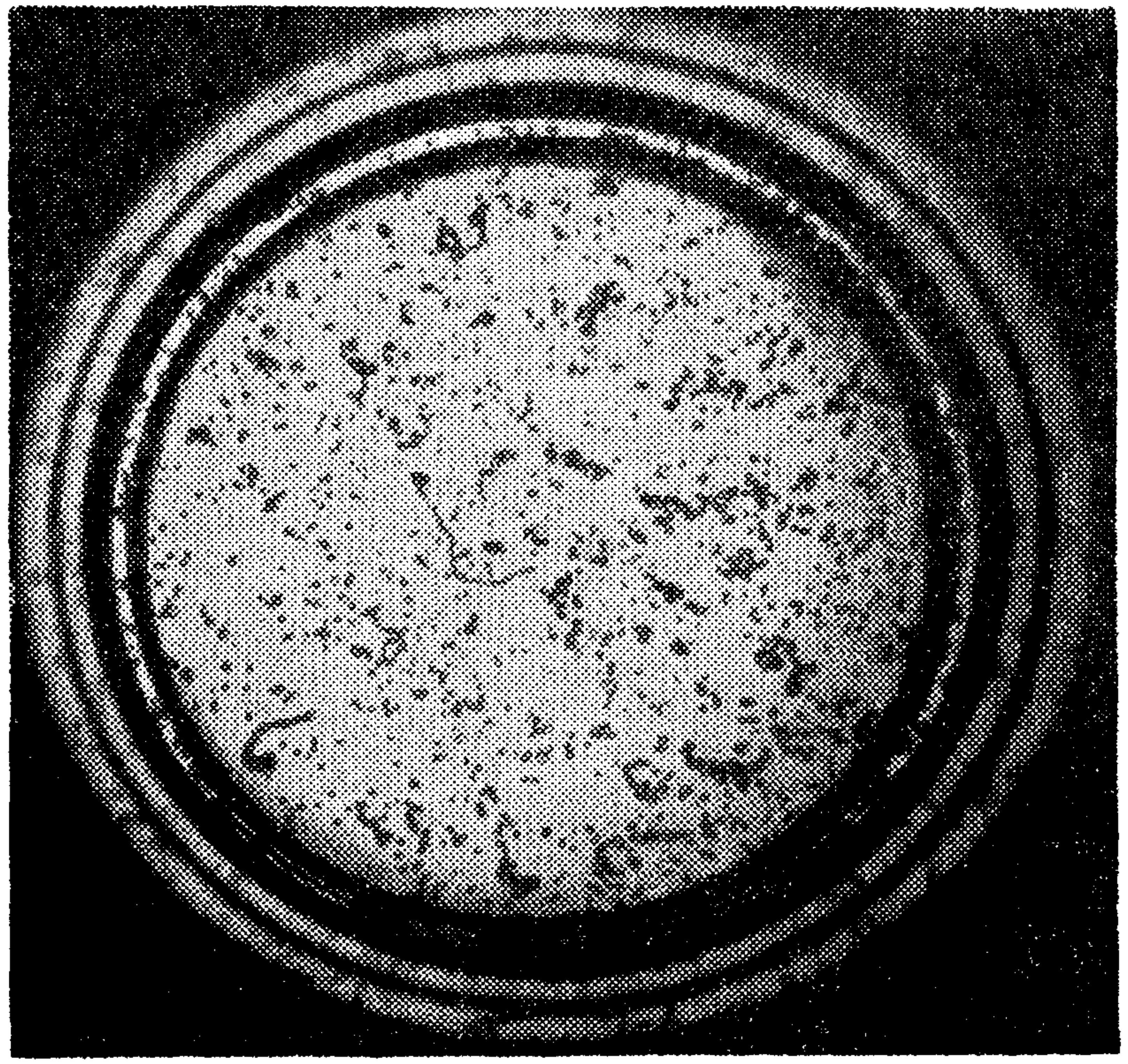








Revisit a bit of history

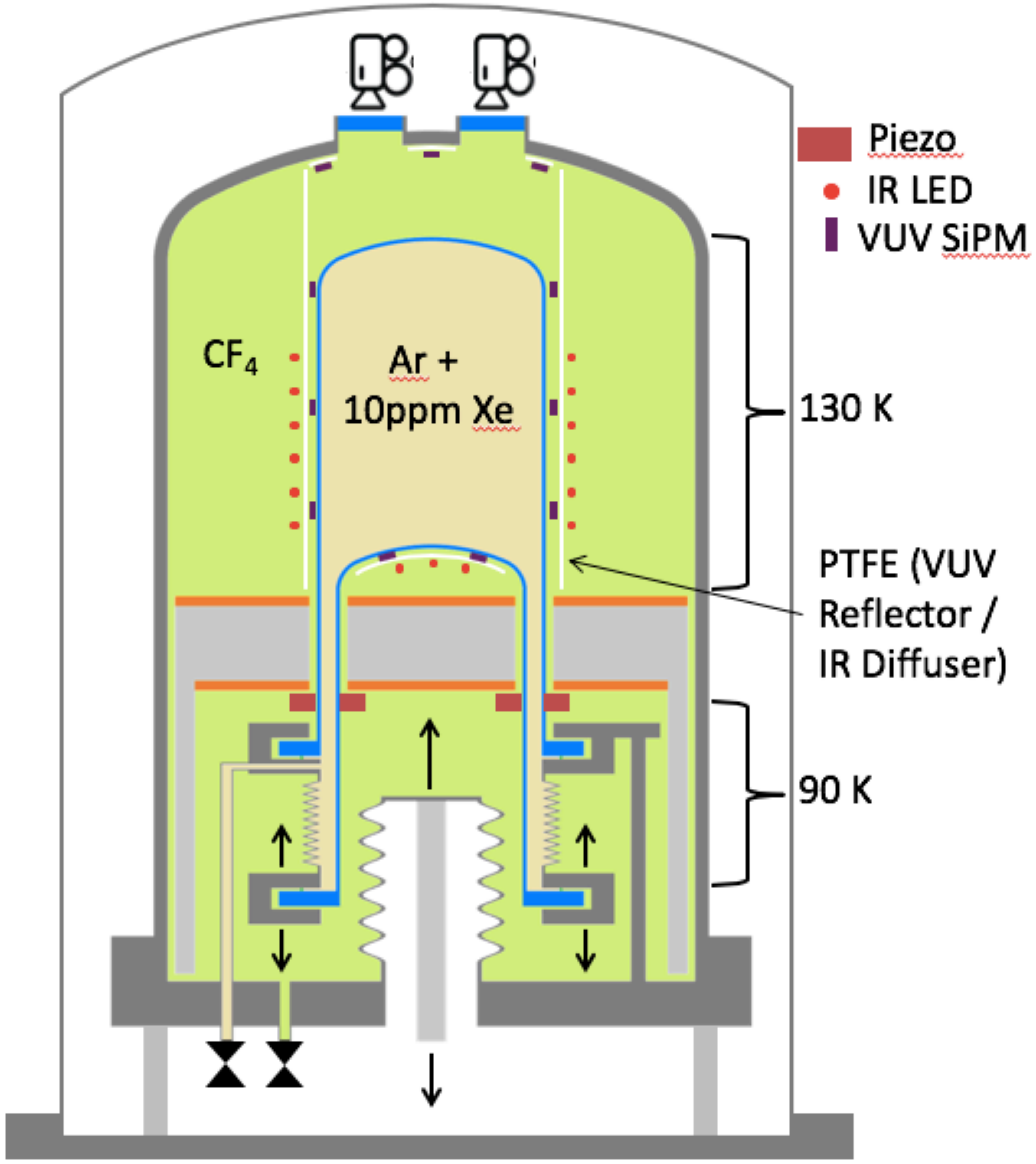


Phys. Rev. 102, 586 (1956)

- 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 (?)

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



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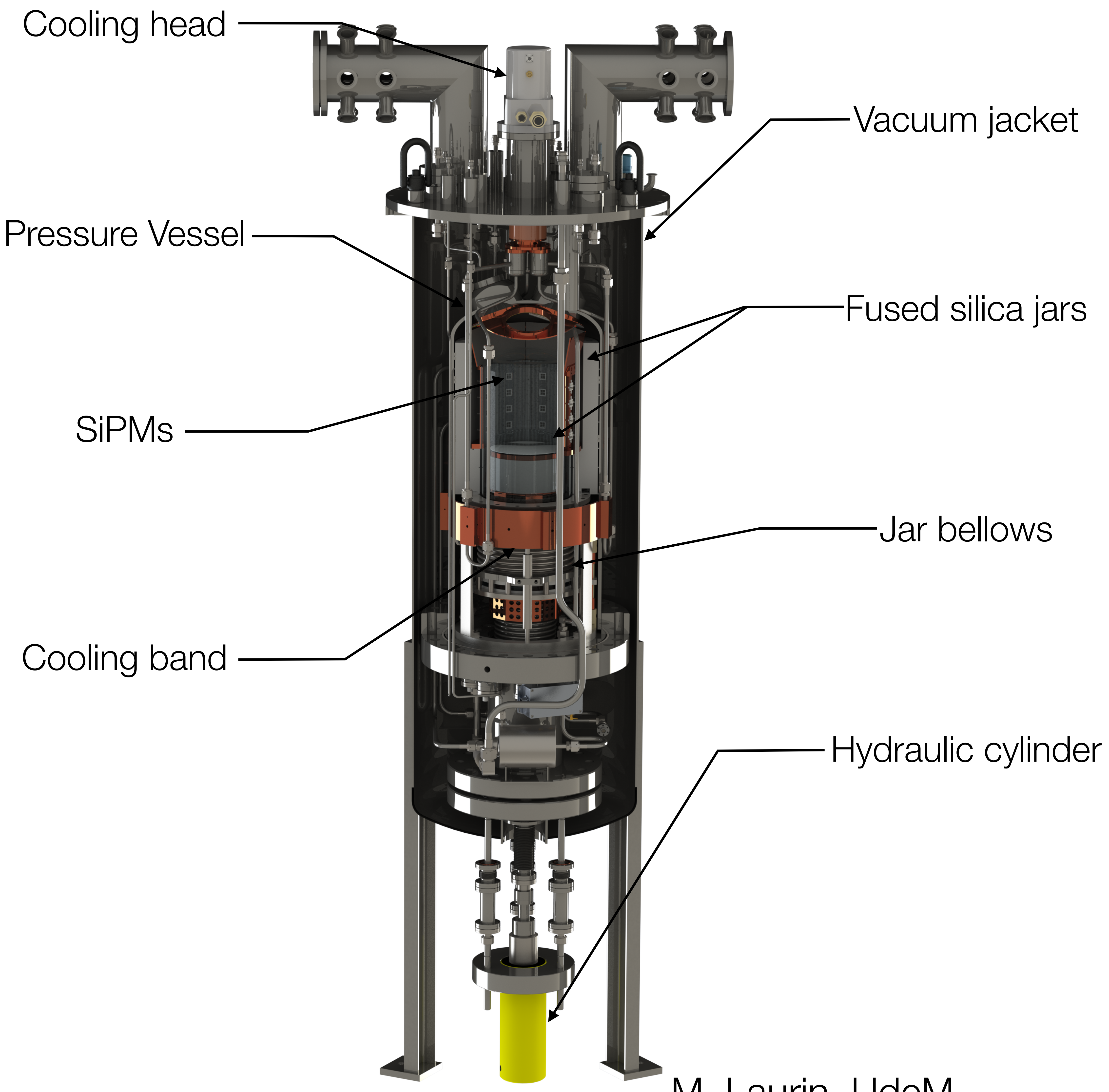


M. Laurin, UdeM

Ongoing work

Vacuum jacket

Pressure vessel

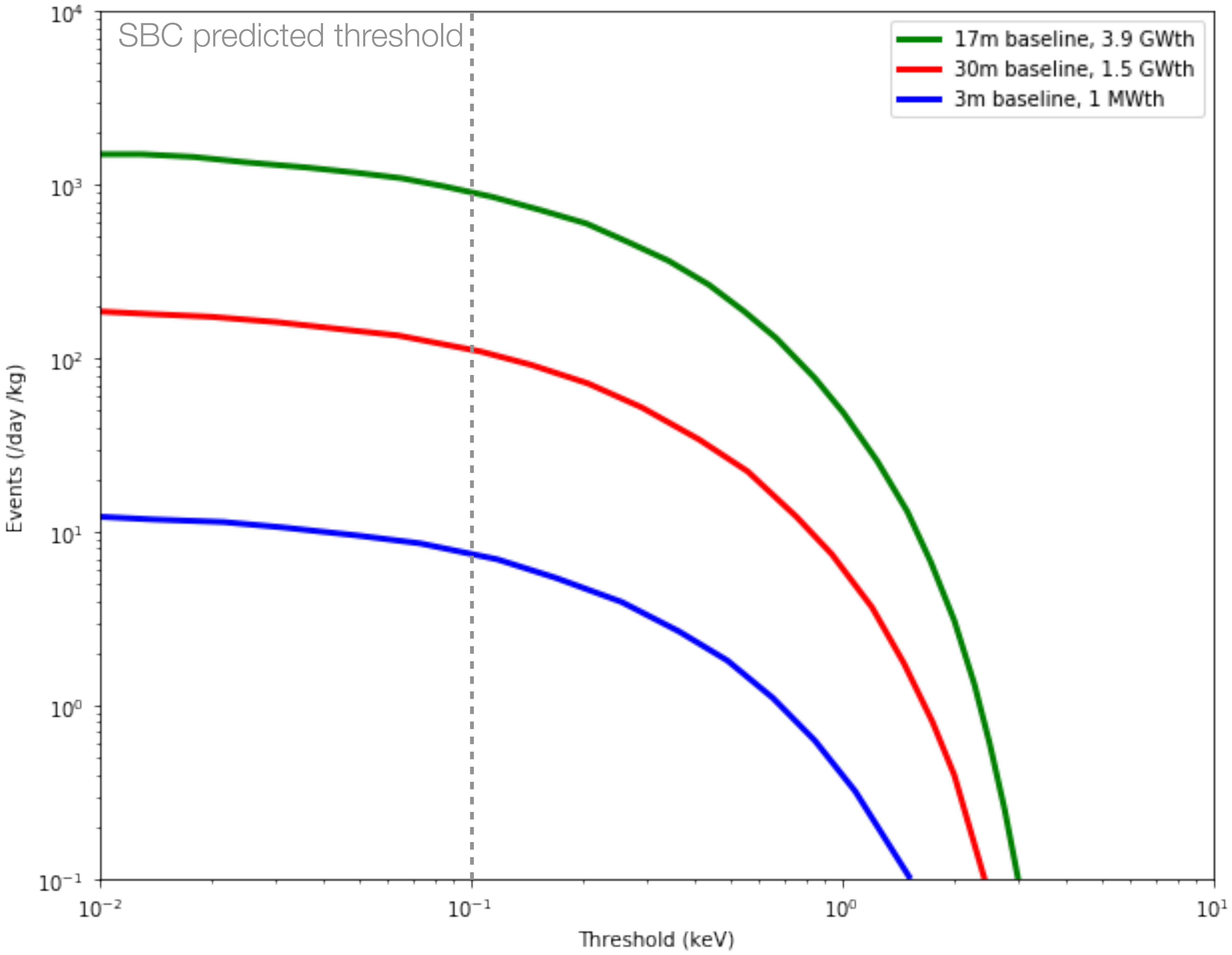
SiPM testing

Pressure bellows

A neutrino source

- Now need to find somewhere to produce these neutrinos
- Candidates:
  - Supernovae - high flux pulse, little control on timing
  - Stopped pion sources - controllable, but low flux
  - Reactors - huge flux but no on/off control

Expected Reactor Rate



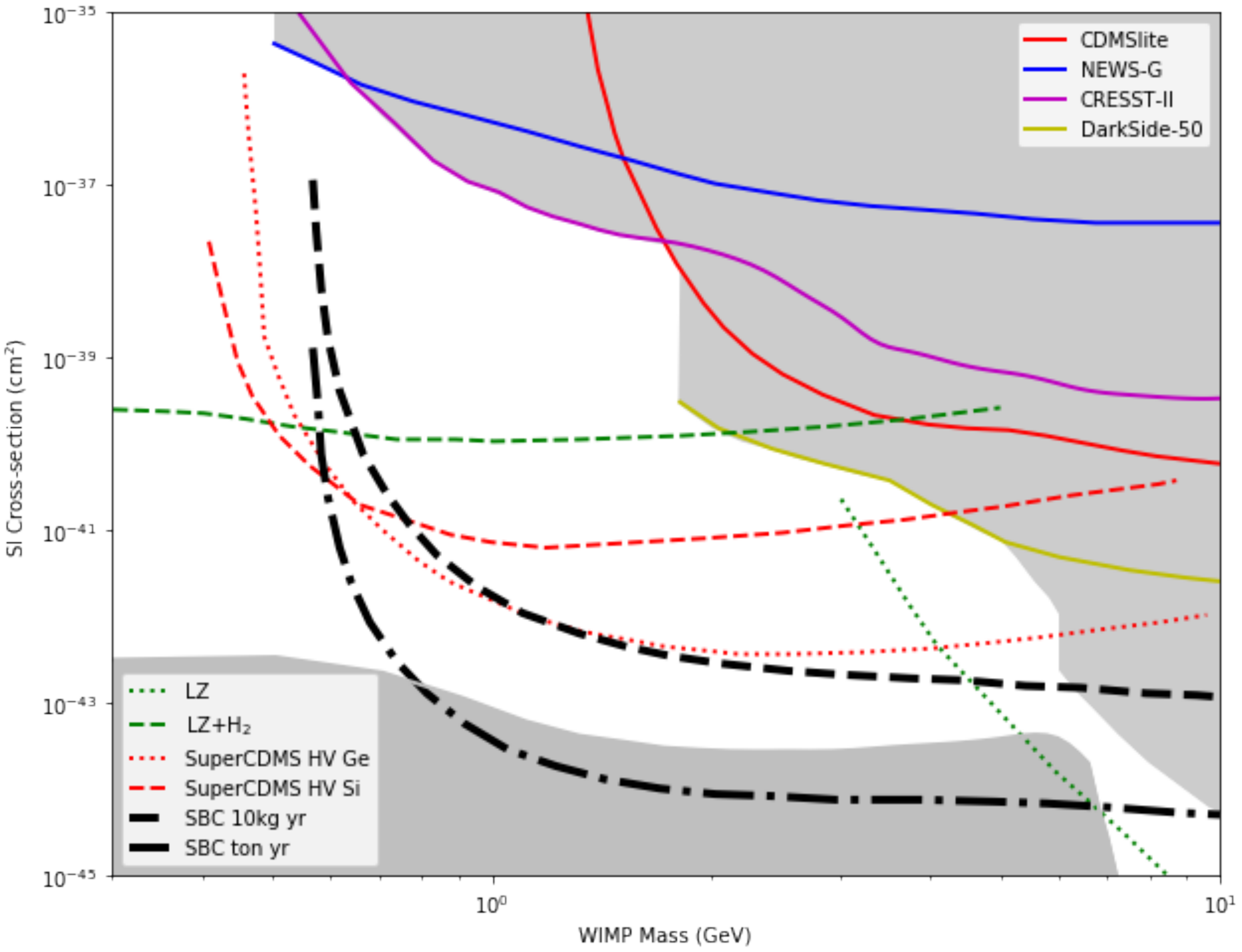
L.J. Flores, E. Peinado, UNAM

- SBC has investigated several reactor options
- With the projected threshold shown, could be a significant number of events
- Preliminary talks with Laguna Verde reactor in Mexico

What can we do?

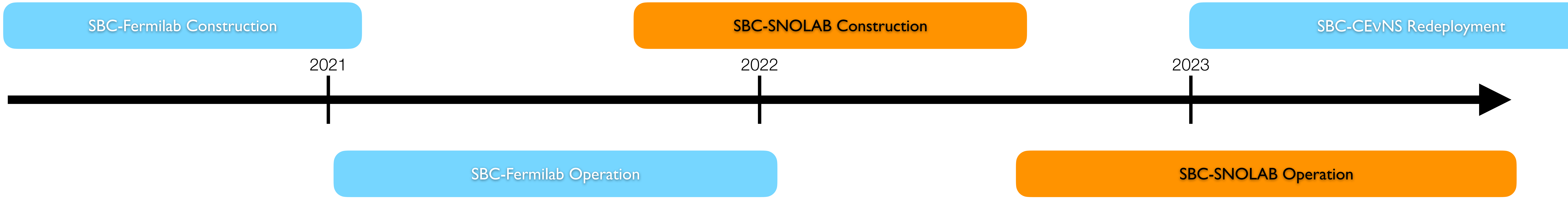
- Improvement on statistics could be very important for future Ar dark matter experiments
- This process is also very dependent on $\sin^2\theta_W$, providing another way to constrain it
- This also means any non-standard interactions of neutrinos could be seen here…

… also we can look for dark matter

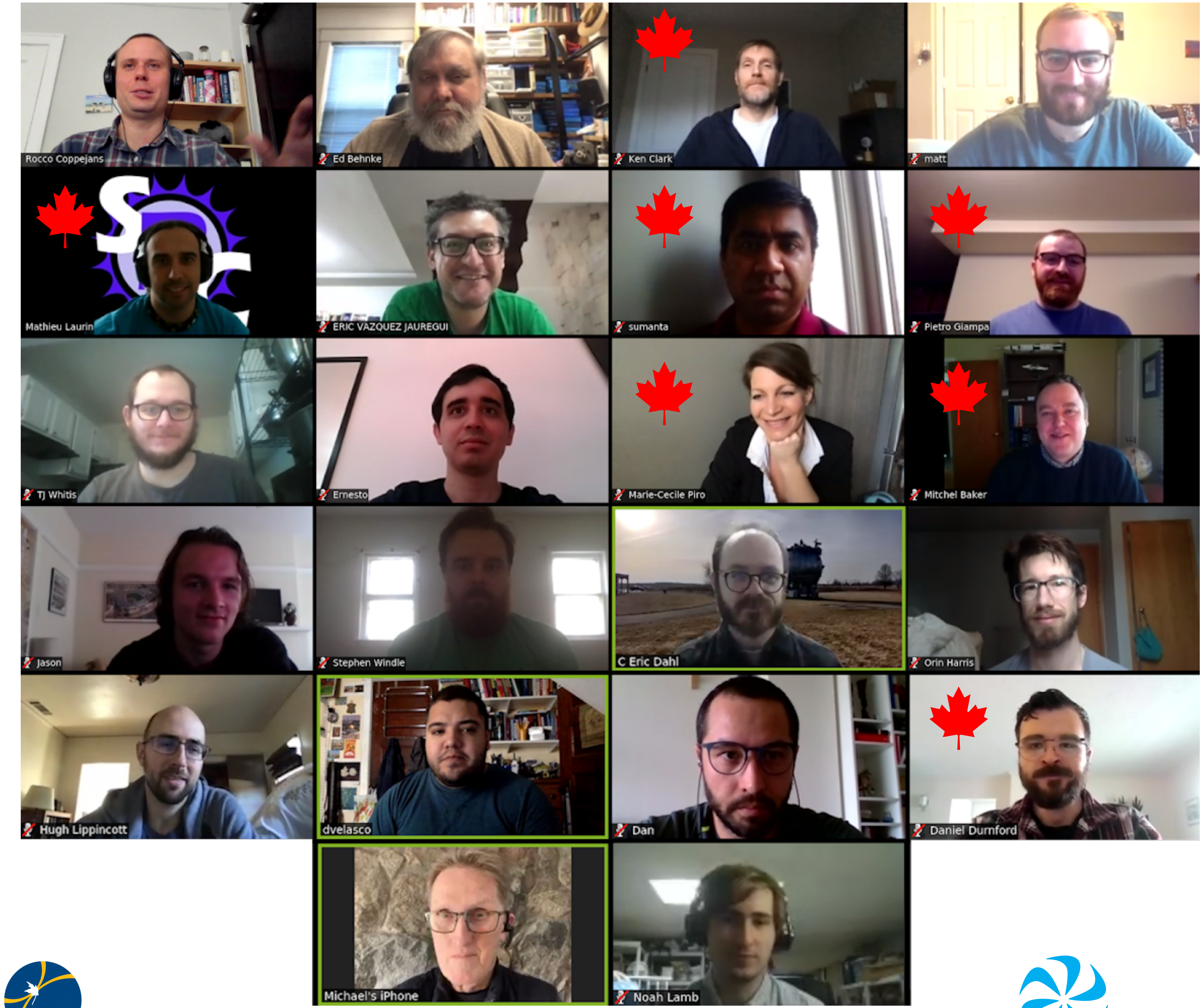


Multiple goals

- 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

Conclusions

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