The Scintillating Bubble Chamber

SBC

Ken Clark
Queen's University

Arthur B. McDonald
Canadian Astroparticle Physics Research Institute

Queen's University

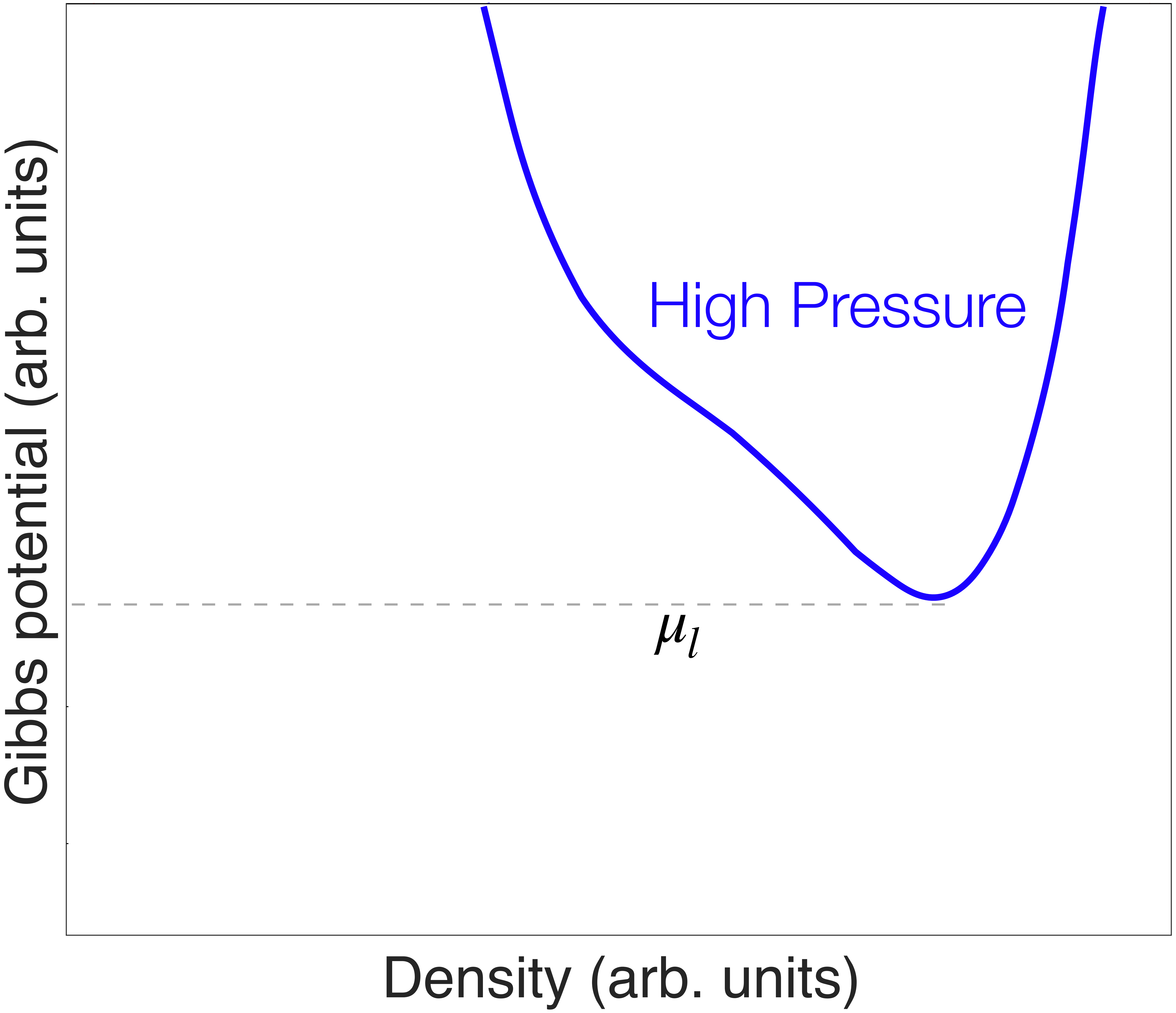
Bubble Chambers - Why?

Lots of other good ways to detect dark matter, what advantages do bubble chambers offer?

1. Background control inherent in the detection method
2. Focus can be adjusted with minimal effort
3. Threshold is controllable
4. Inexpensive(-ish)

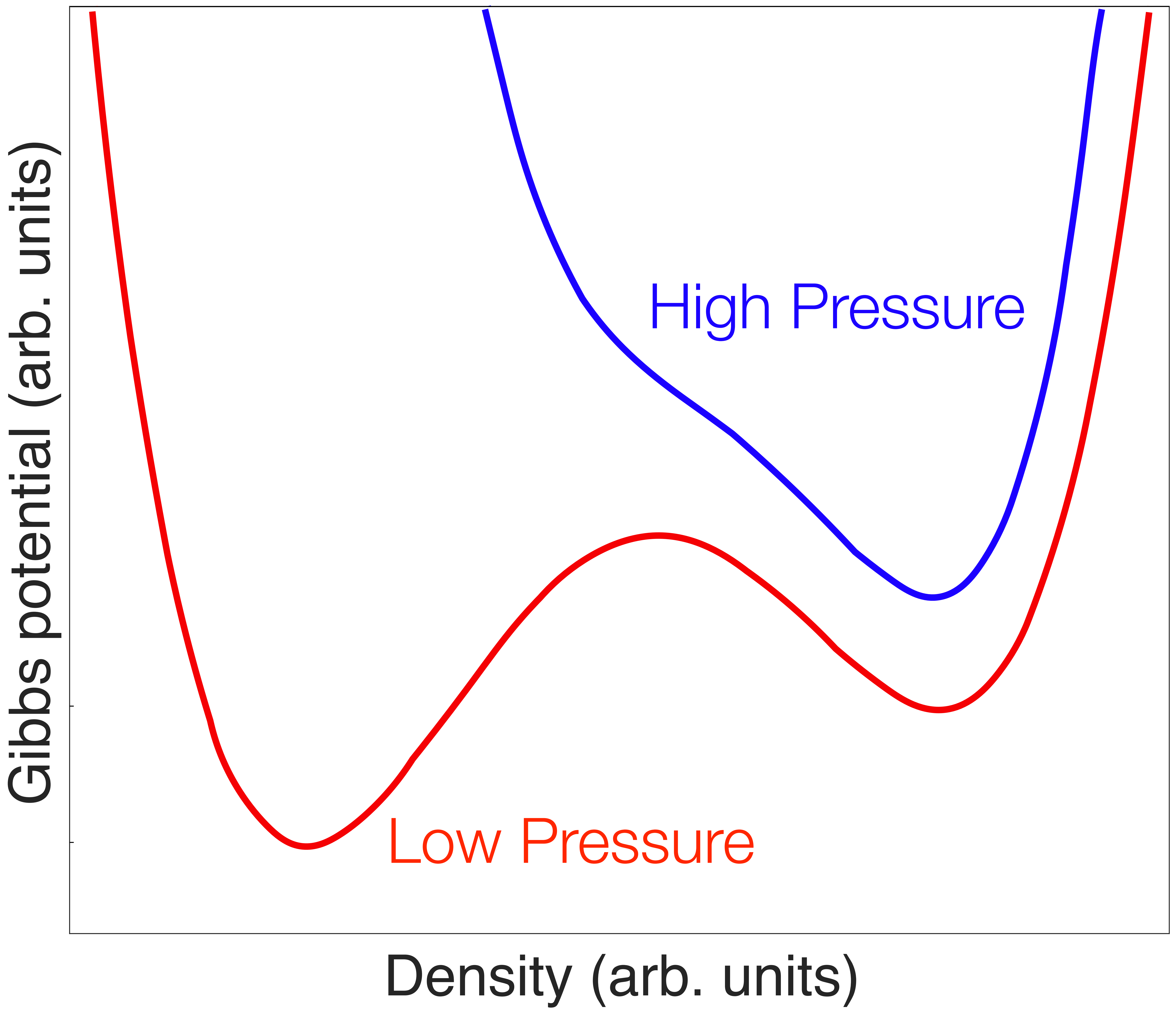
Bubble Chamber Theory

- At high pressure the medium is stable in the liquid state



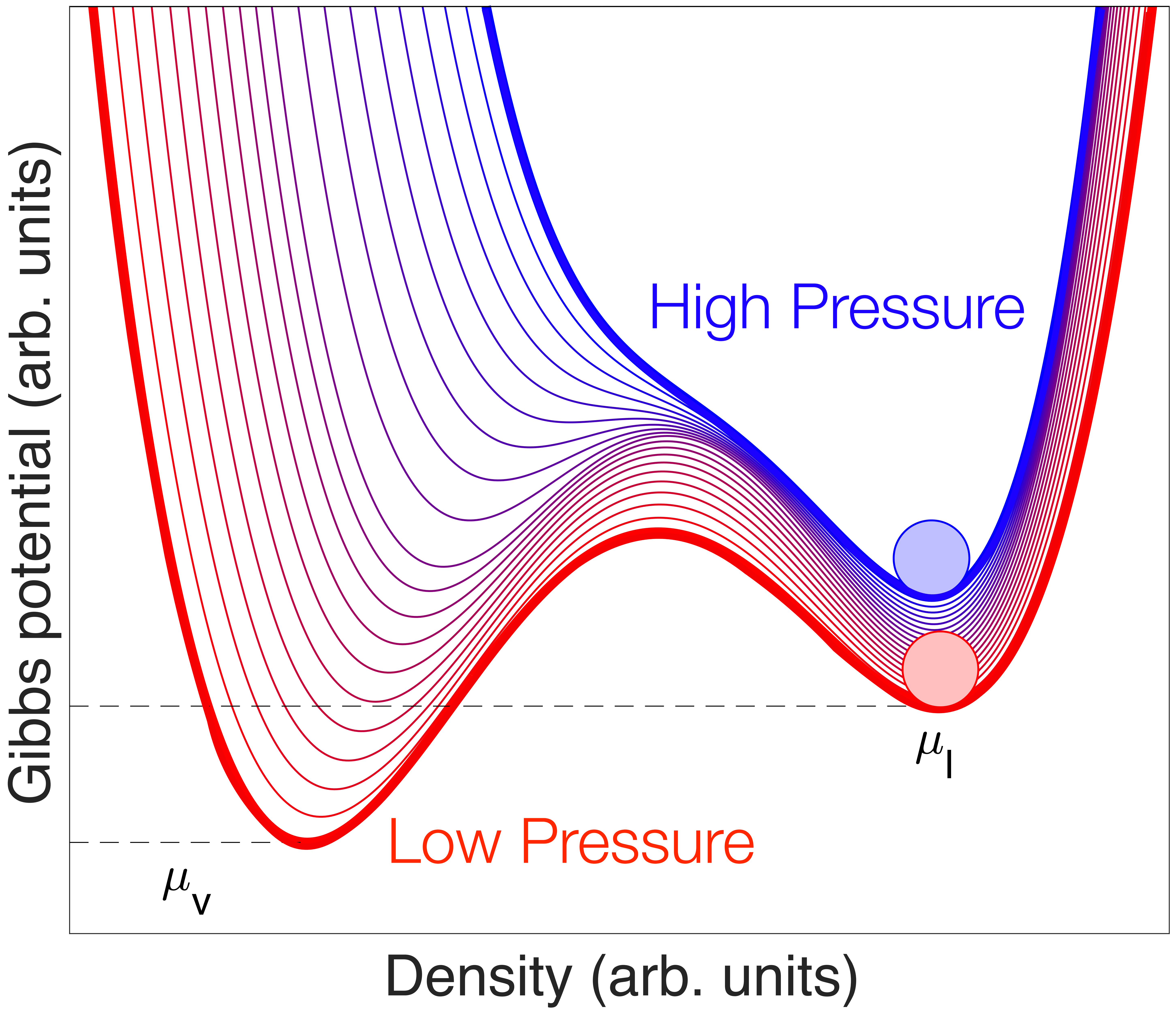
Bubble Chamber Theory

- As the pressure is lowered, this becomes metastable, with a potential threshold to overcome before changing state



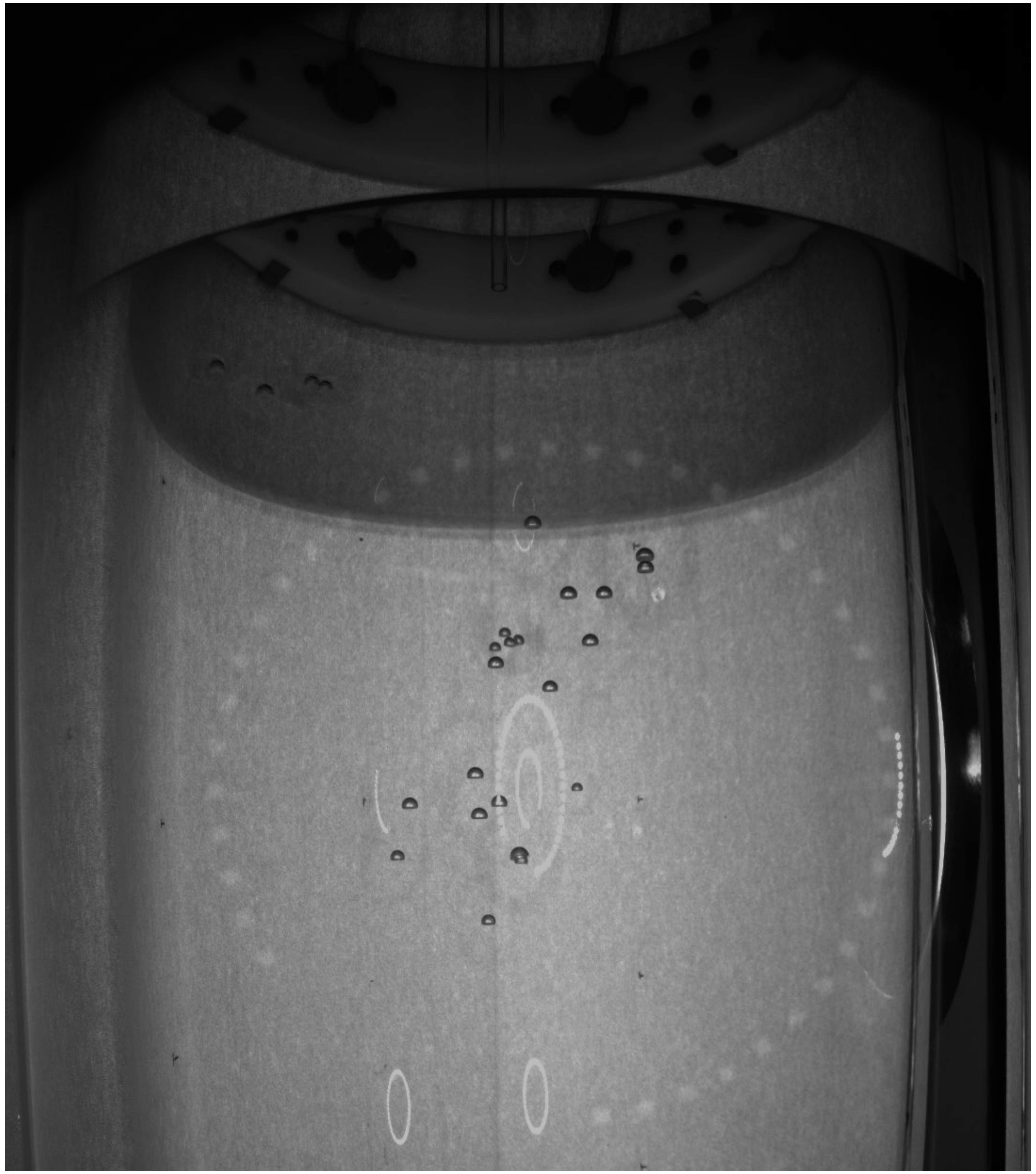
Bubble Chamber Theory

- The potential step is controllable with pressure (or temperature) providing a variable threshold



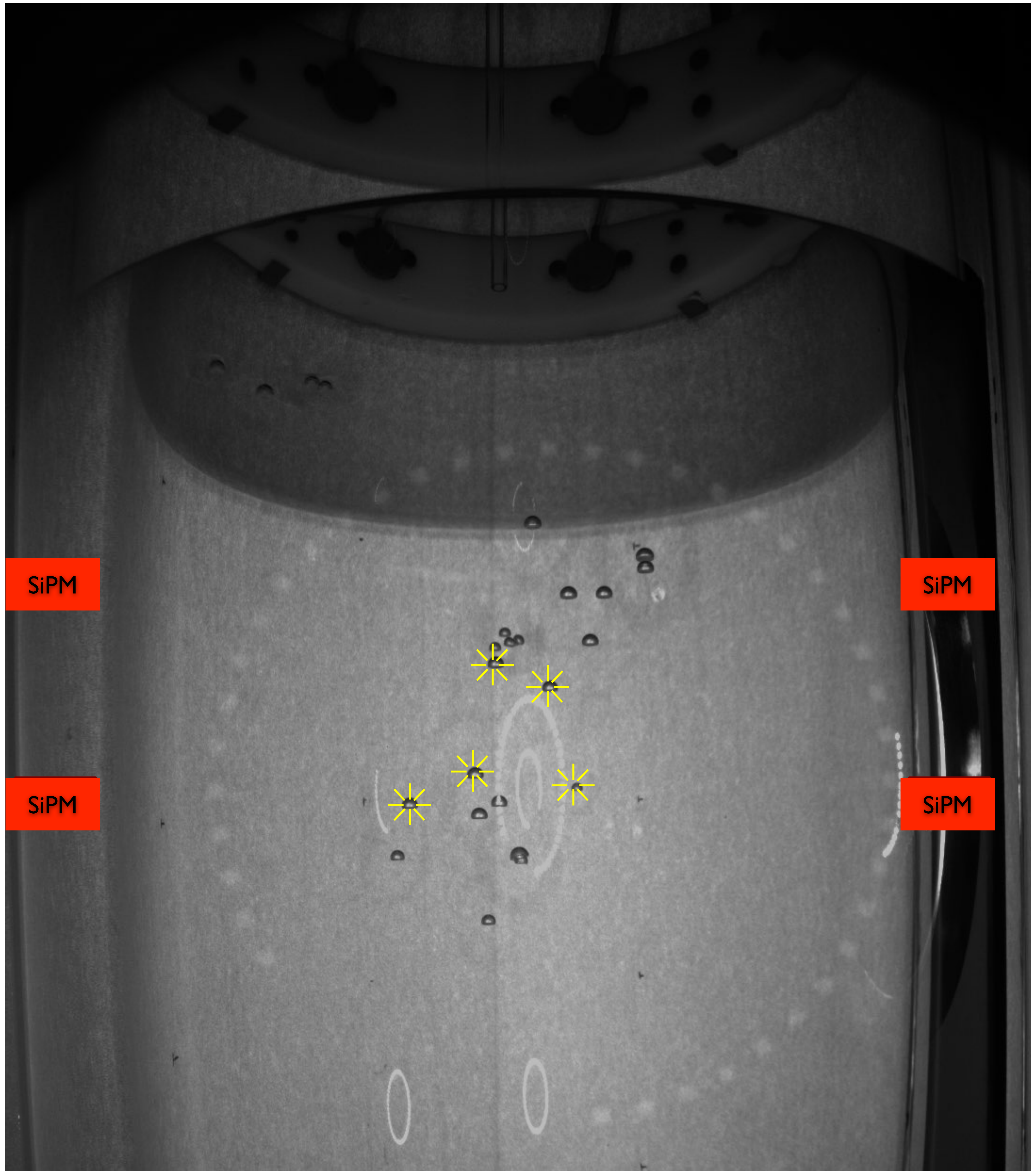
The "traditional" bubble chamber

- Superheated target (C_3F_8, CF_3I…)
- Particle interactions nucleate bubbles
- Cameras and acoustic sensors capture signals
- Chamber recompresses after each event



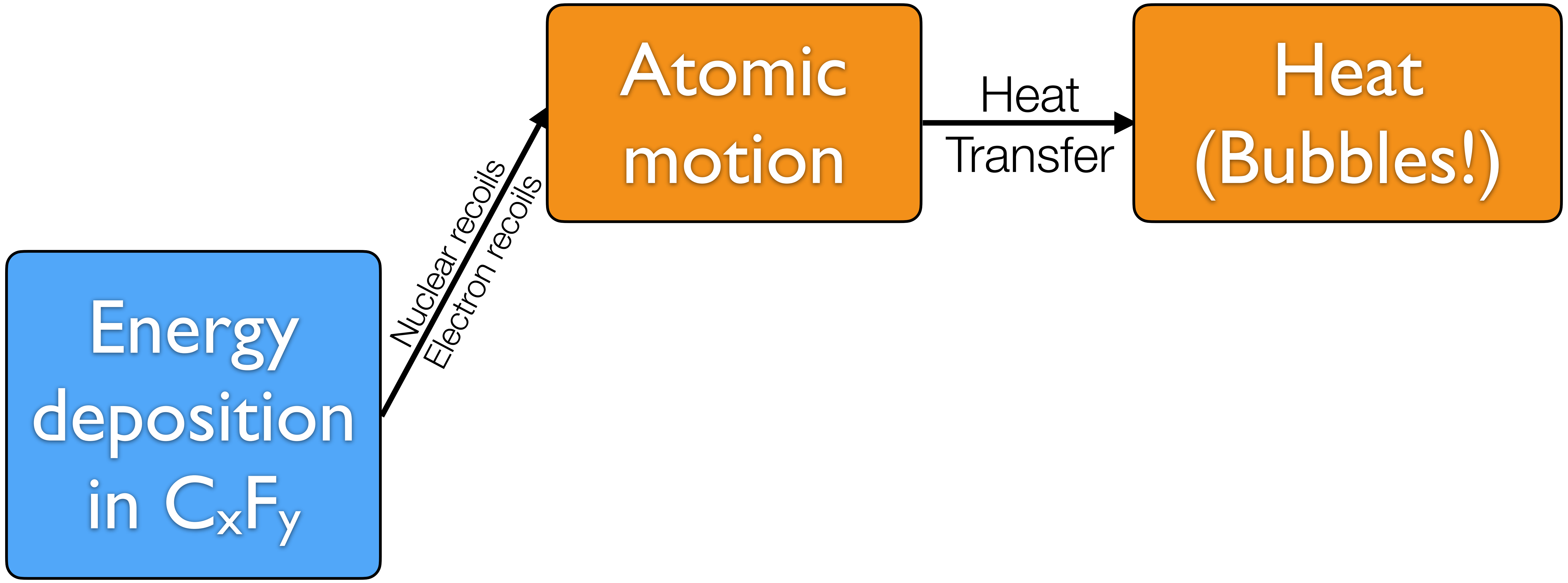
The *scintillating* bubble chamber

- Superheated scintillator (Xe, Ar…)
- Particle interactions nucleate bubbles and cause scintillation
- Cameras and acoustic sensors capture signals, photodetectors collect scintillation light
- Chamber recompresses after each event



Why would we want to do this?

- This is a difficult thing to do
- Lower thresholds are not possible with a traditional chamber
- The superheated scintillator allows this to happen



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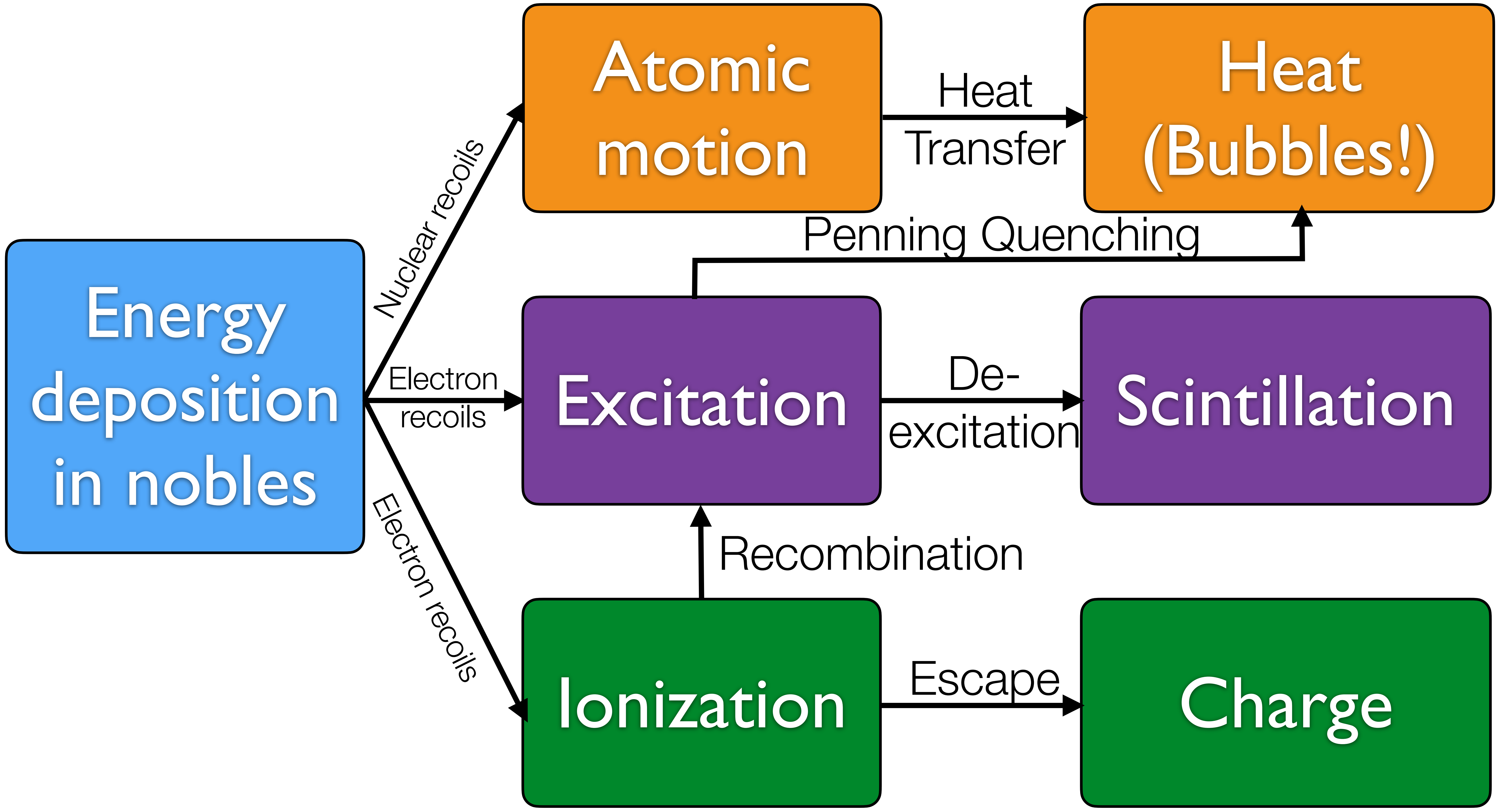

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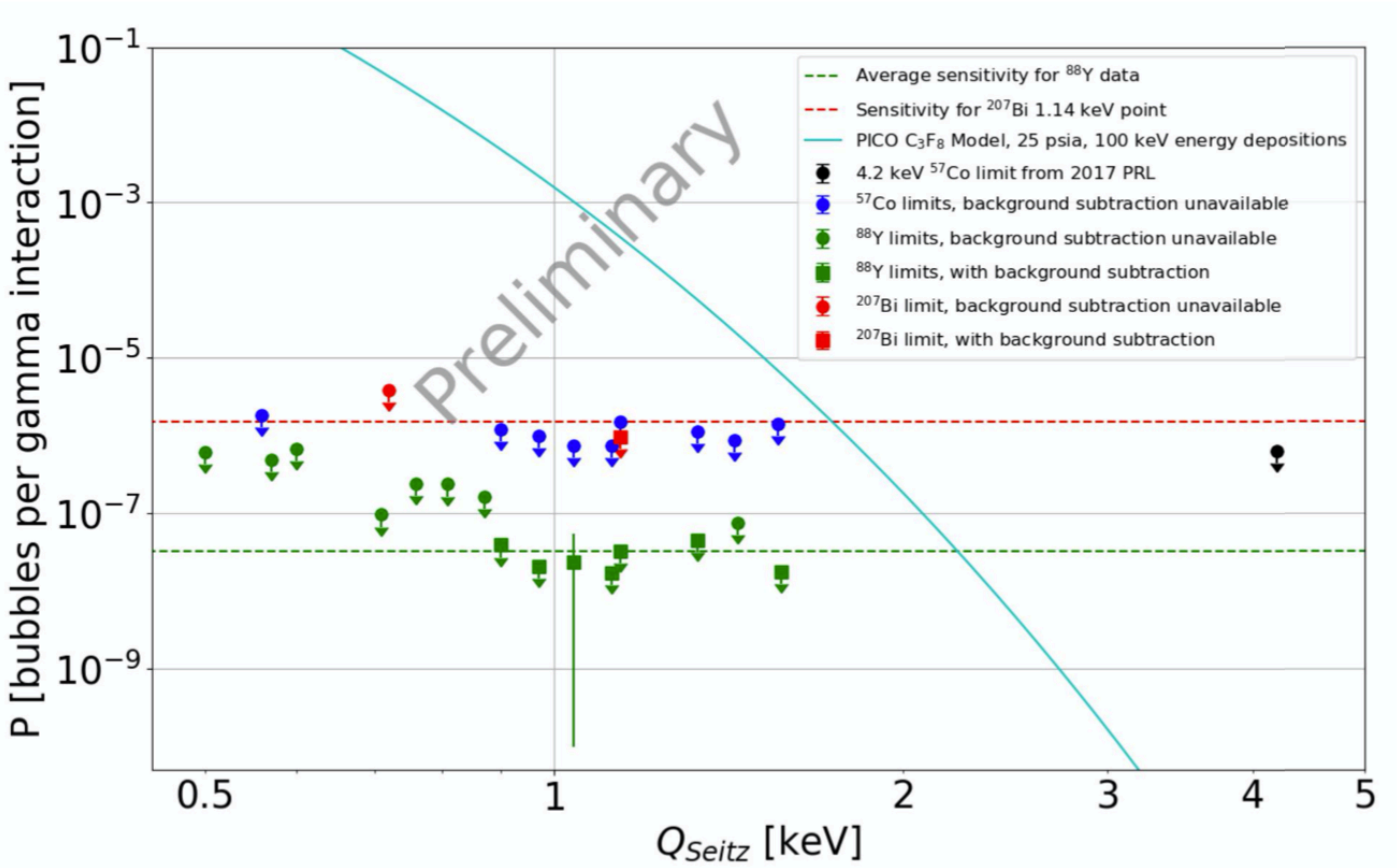
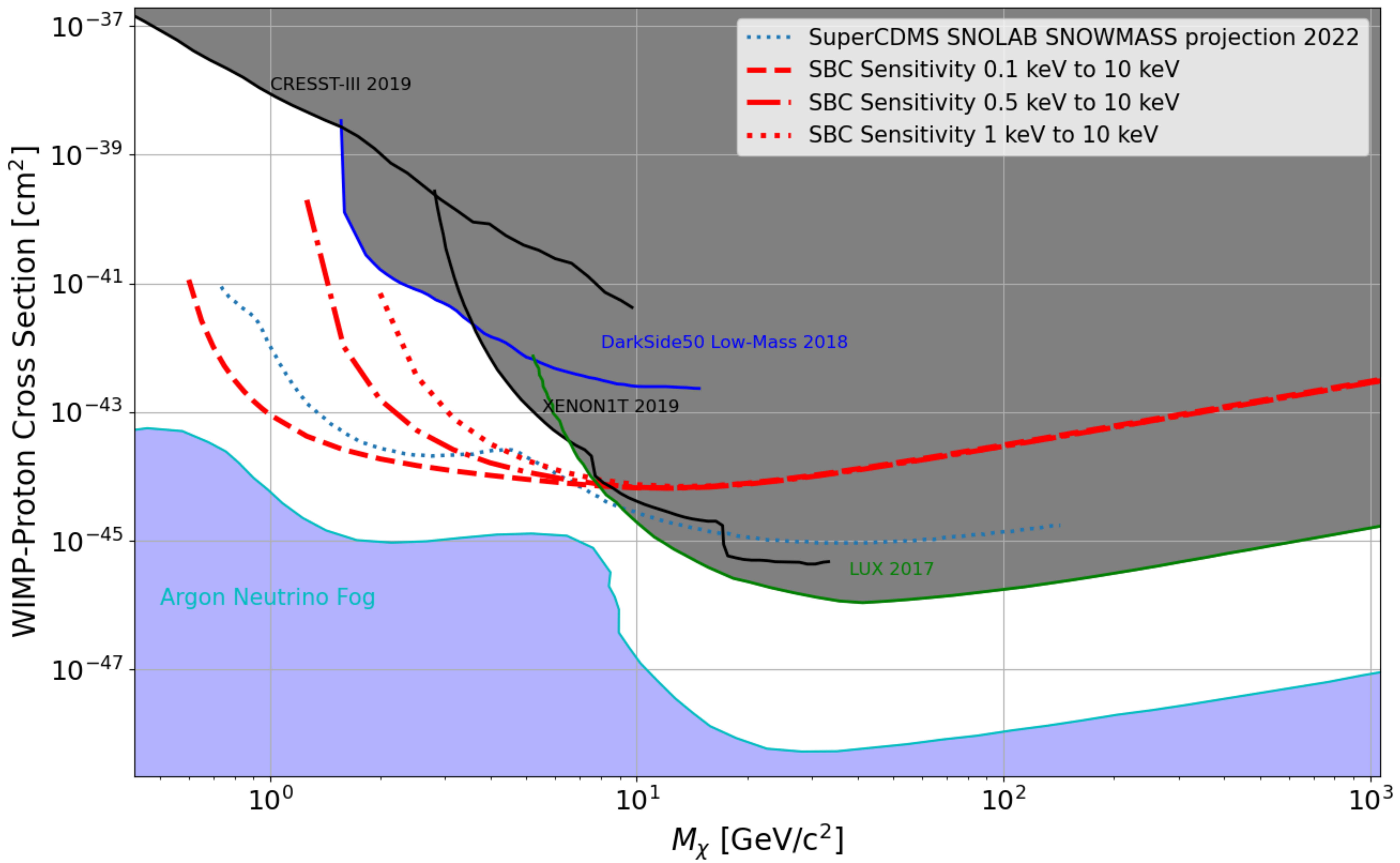
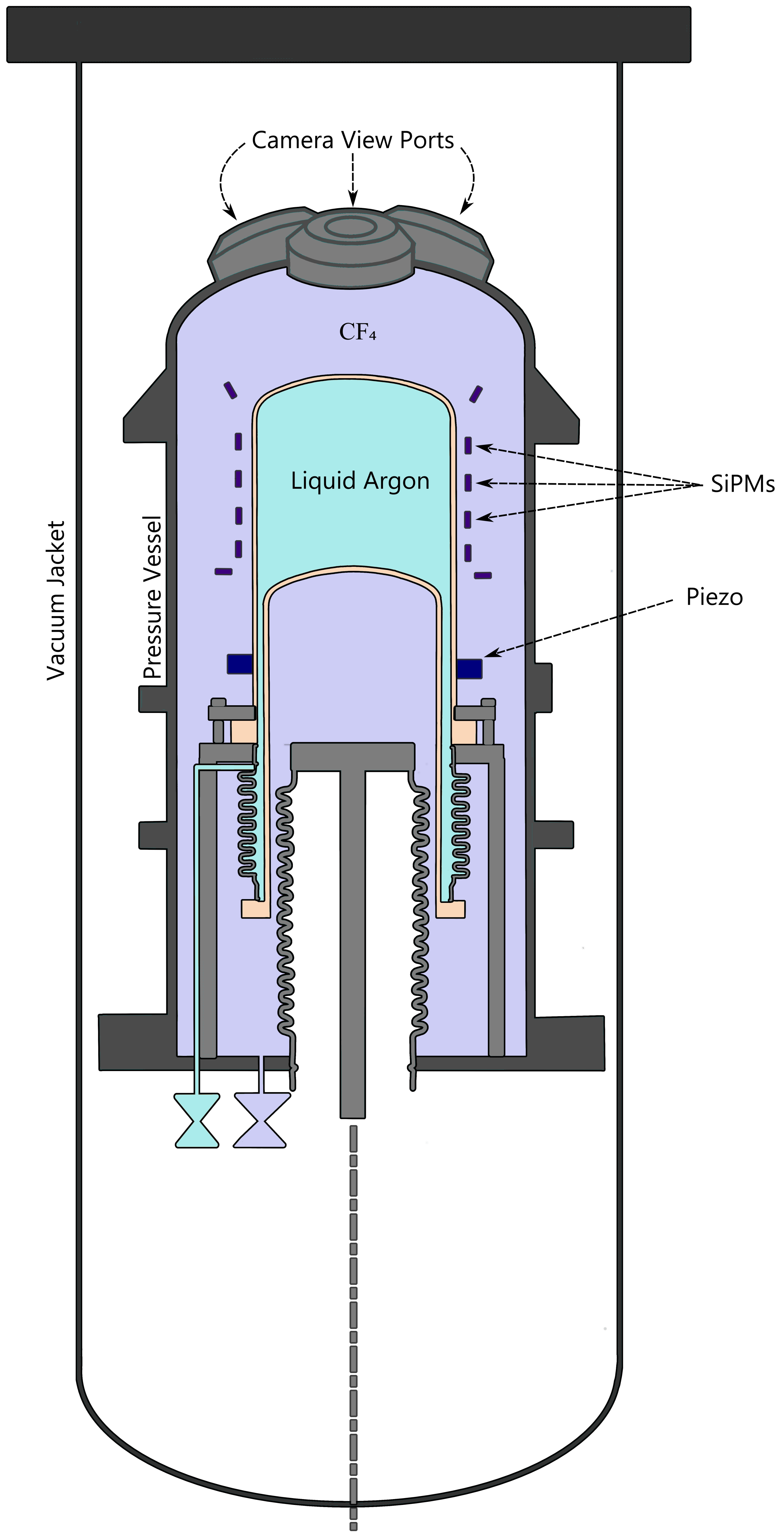


What does this gain us?



- Lowering the threshold opens up significant area in the low mass search
- Note this assumes only CEvNS backgrounds and 10kg-year live time

How are we doing this?



- 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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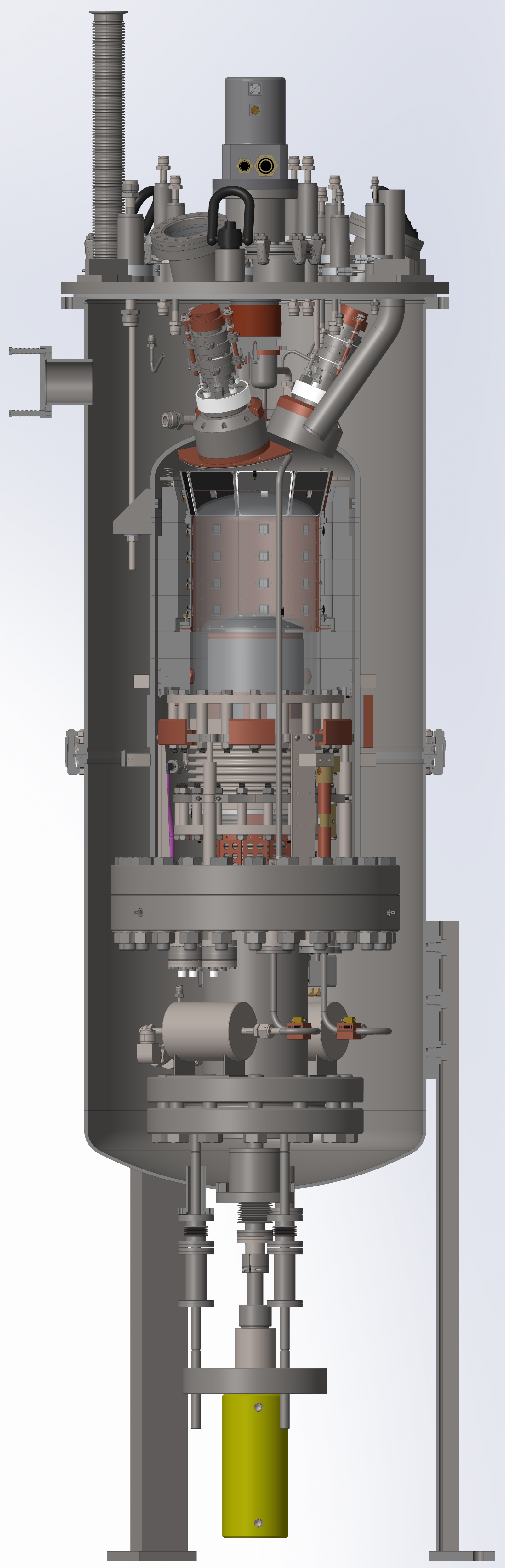

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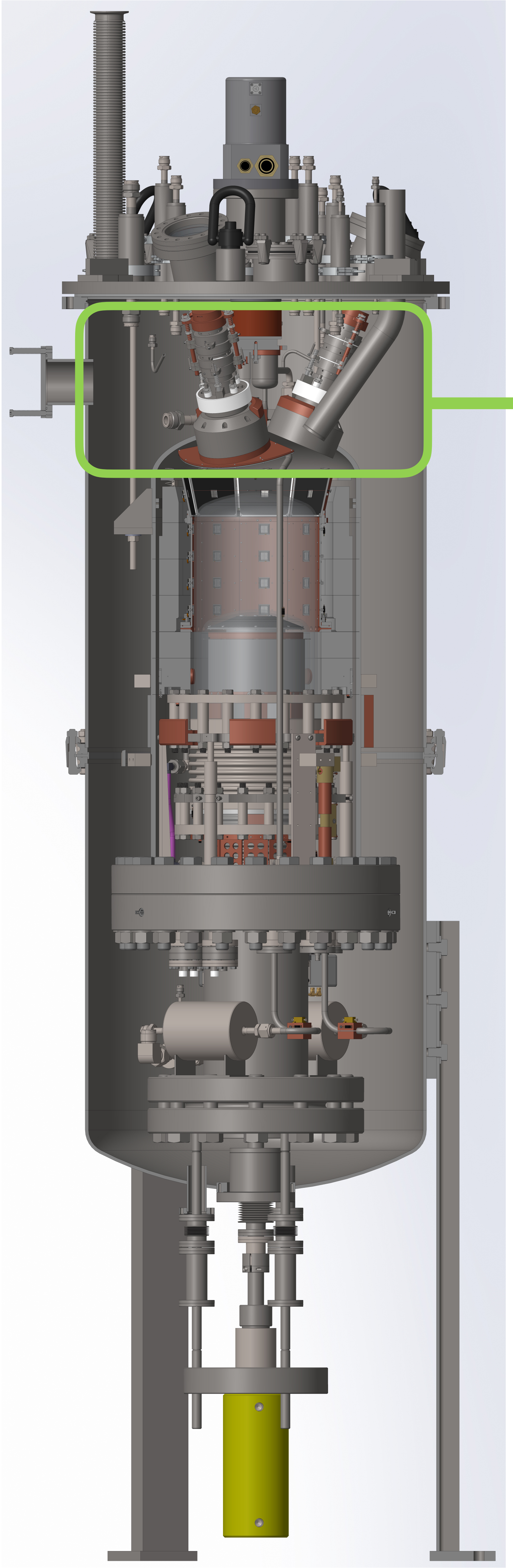
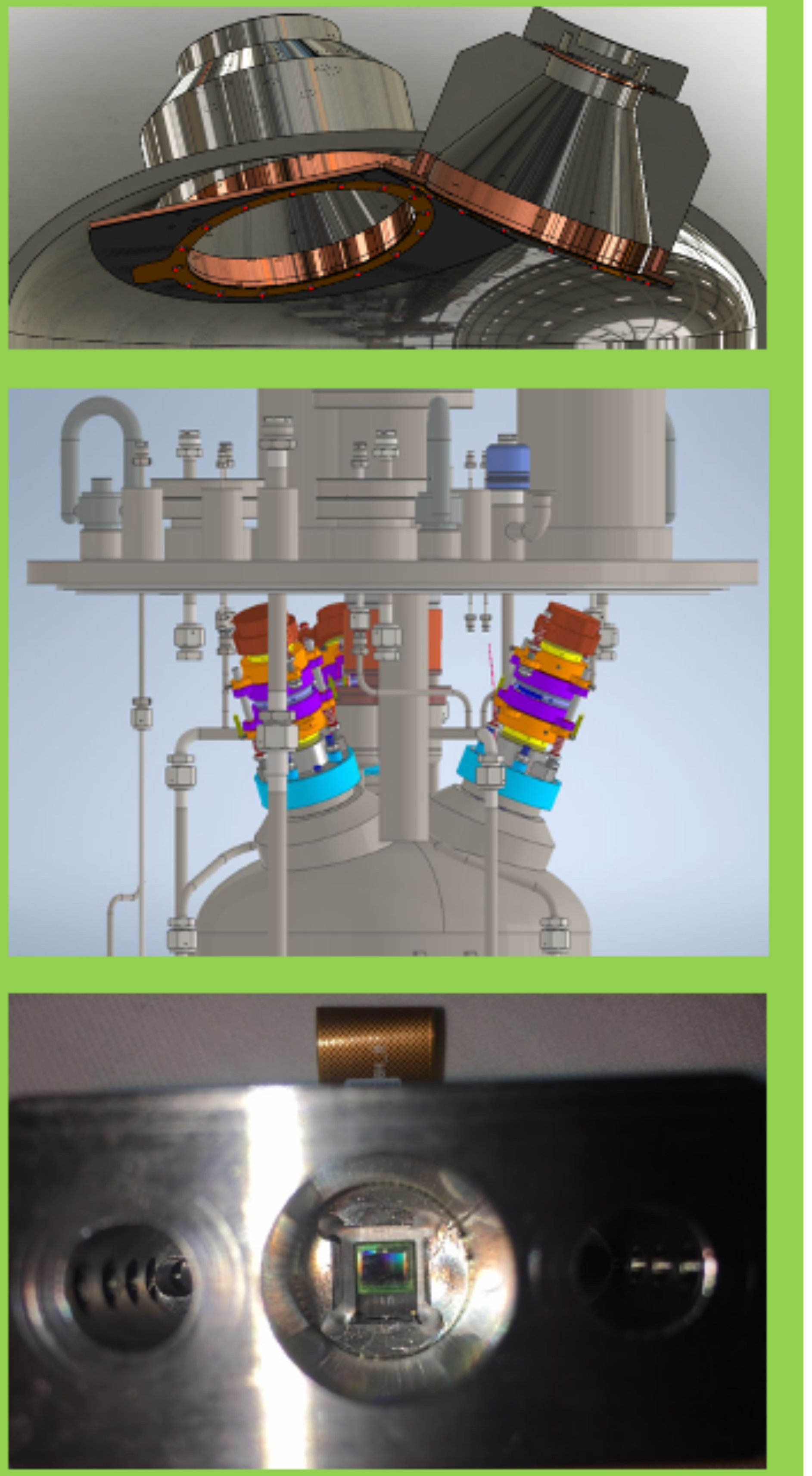
Data Collection



Bubble Imaging

3 Raspberry-Pi Cameras + LEDs



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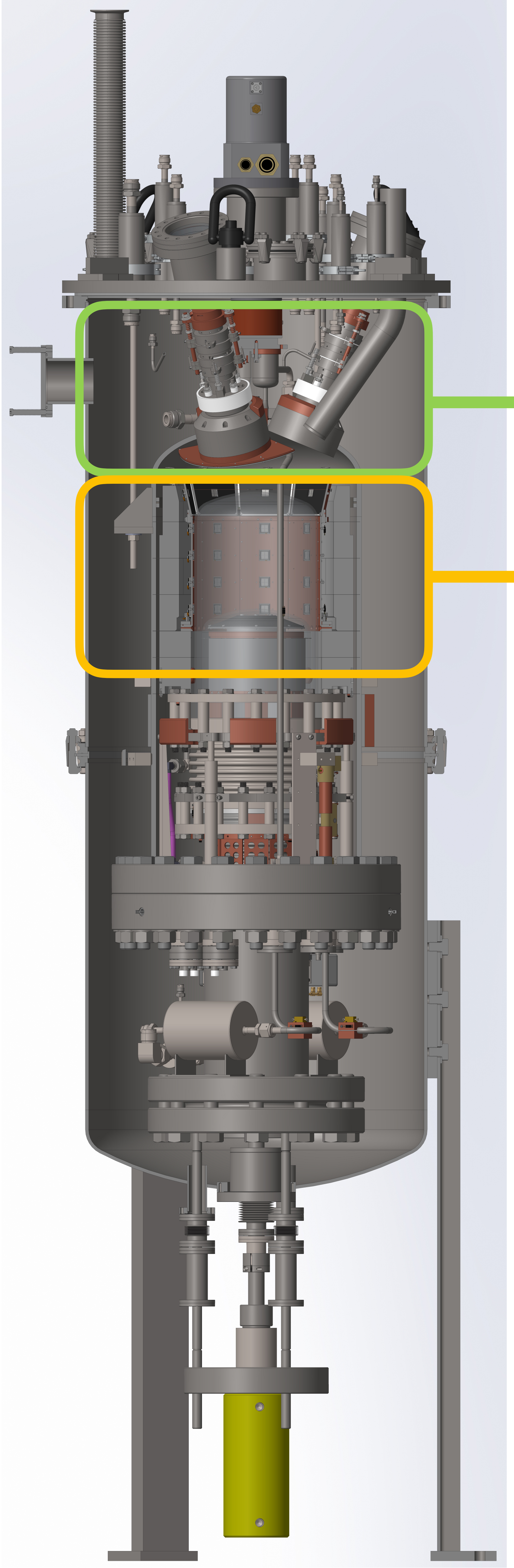

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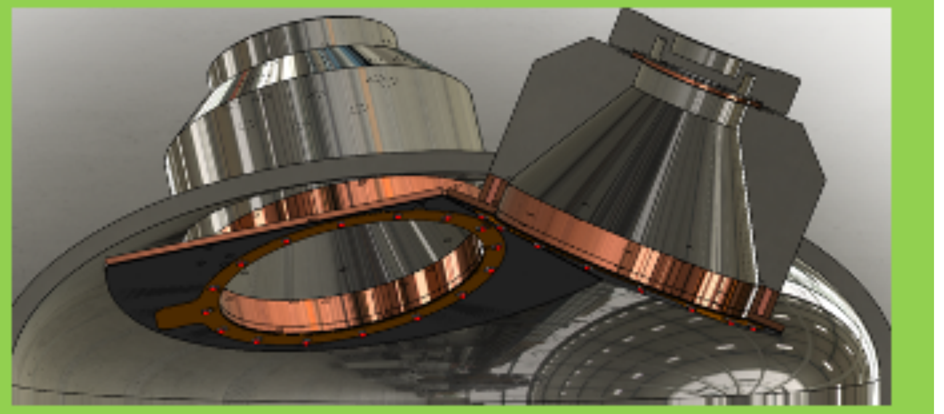
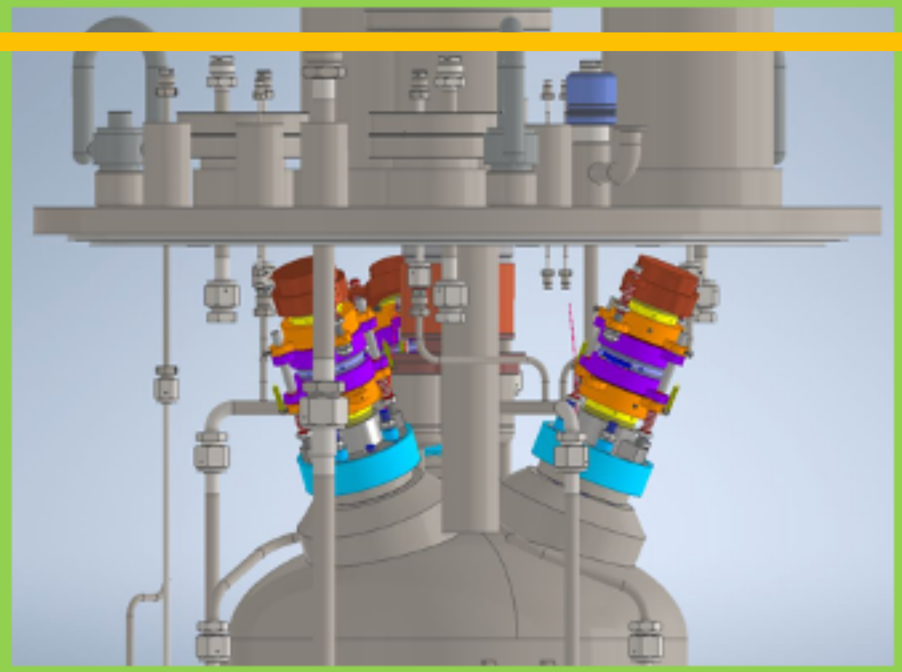
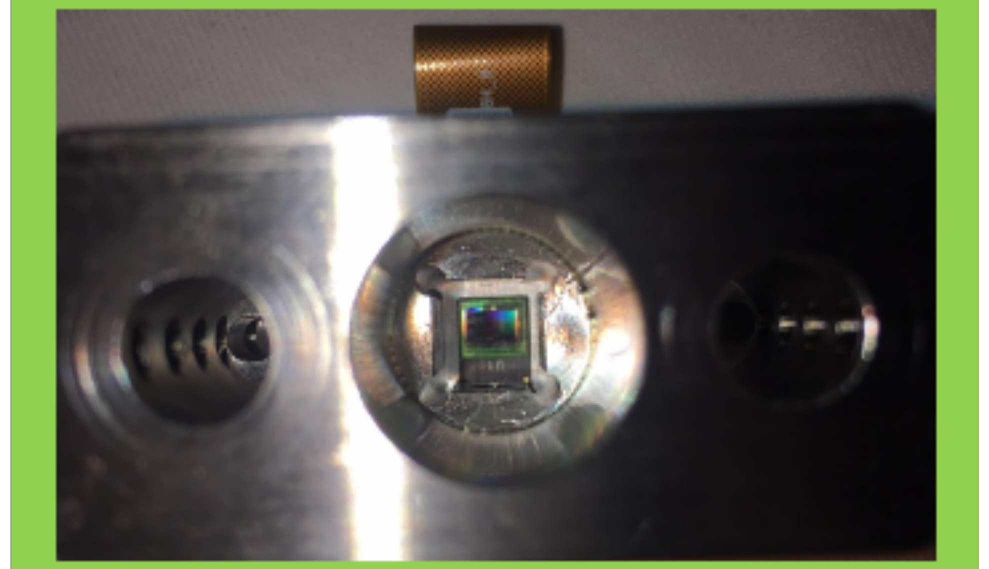
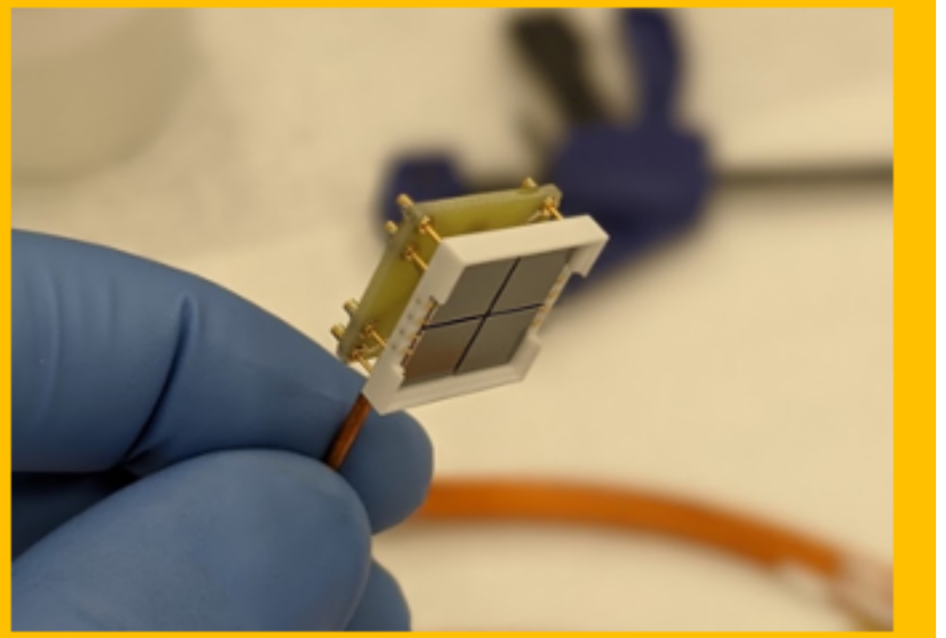






Scintillation System

32 FBK SiPMs



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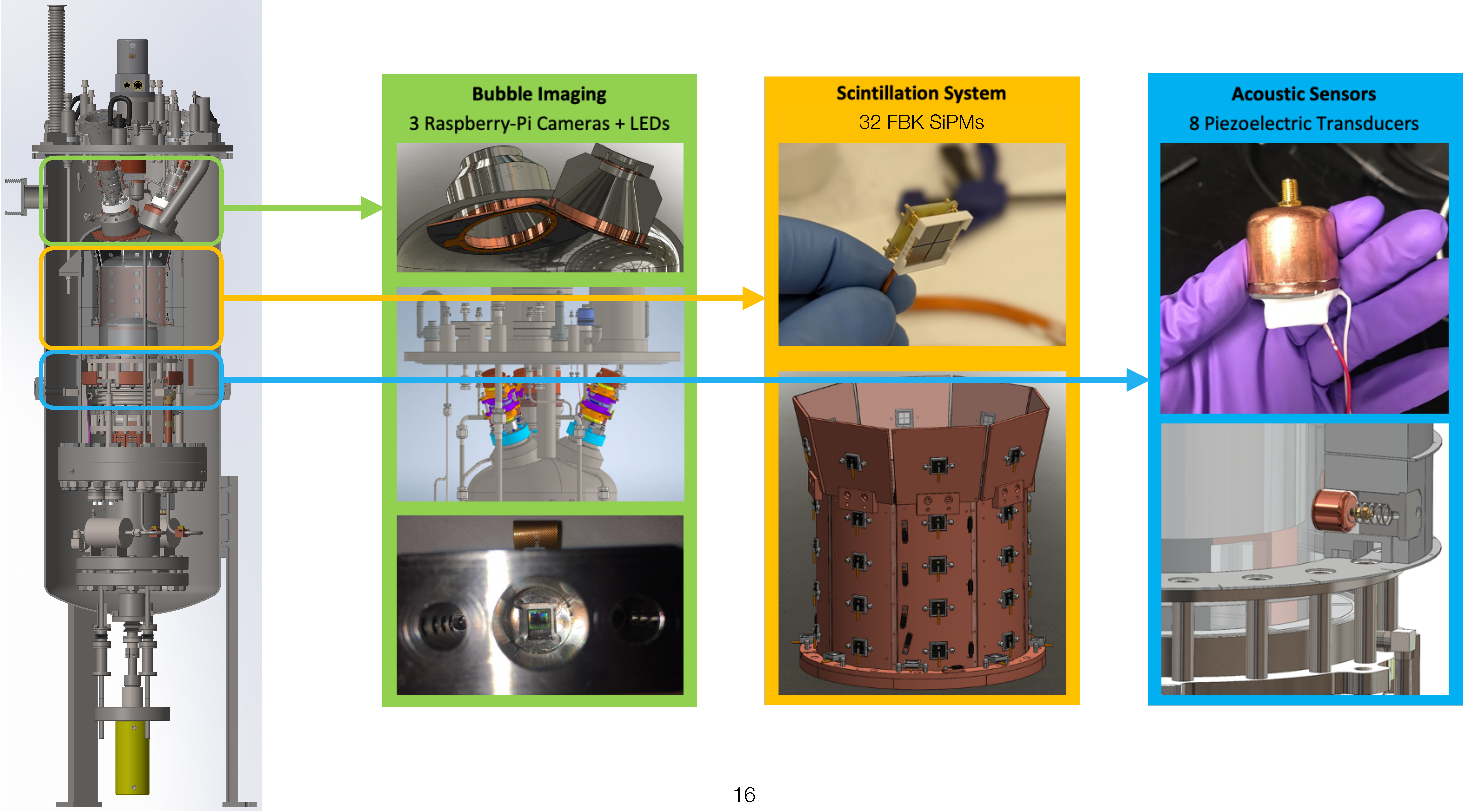
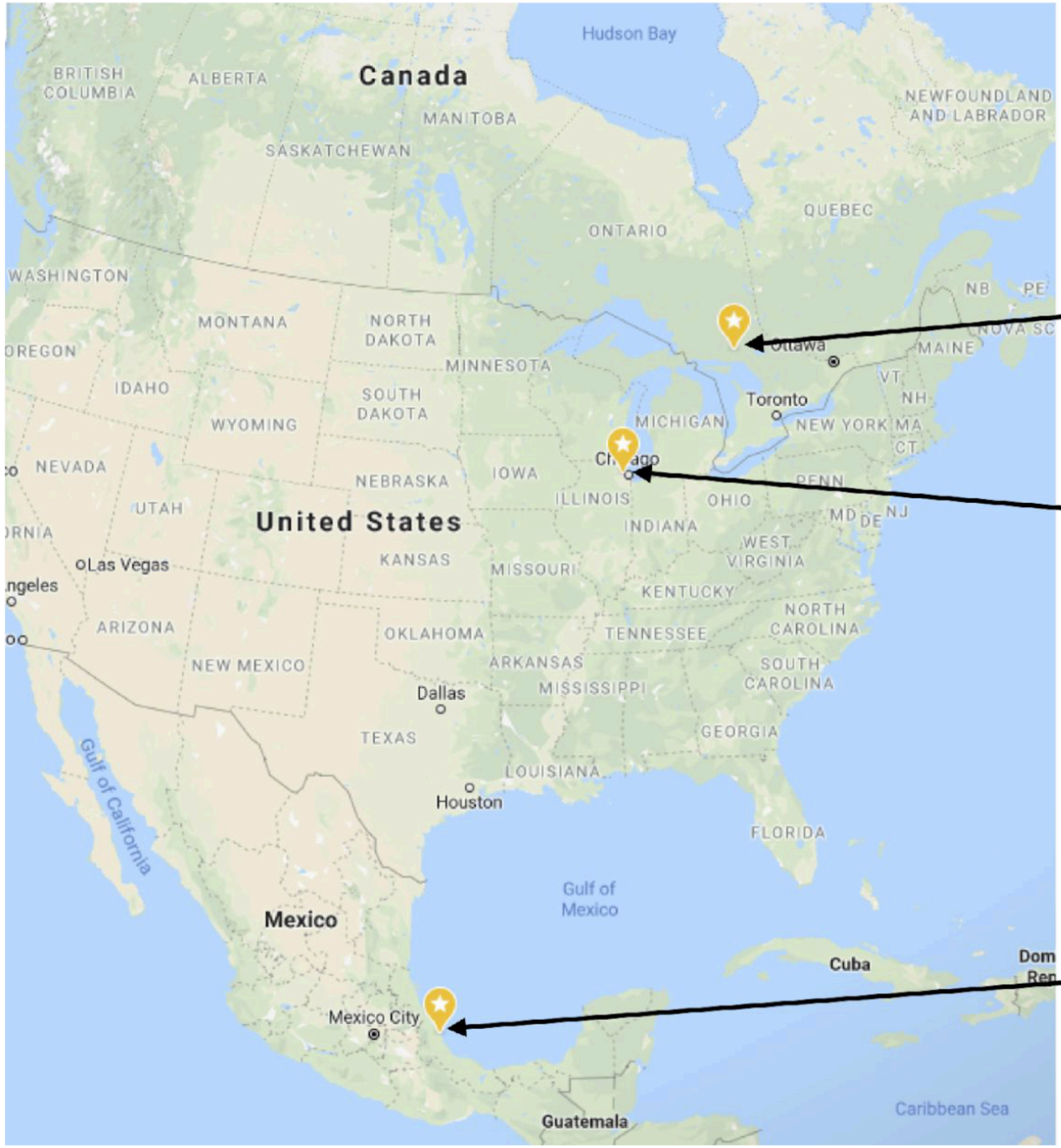


Collaboration Plan

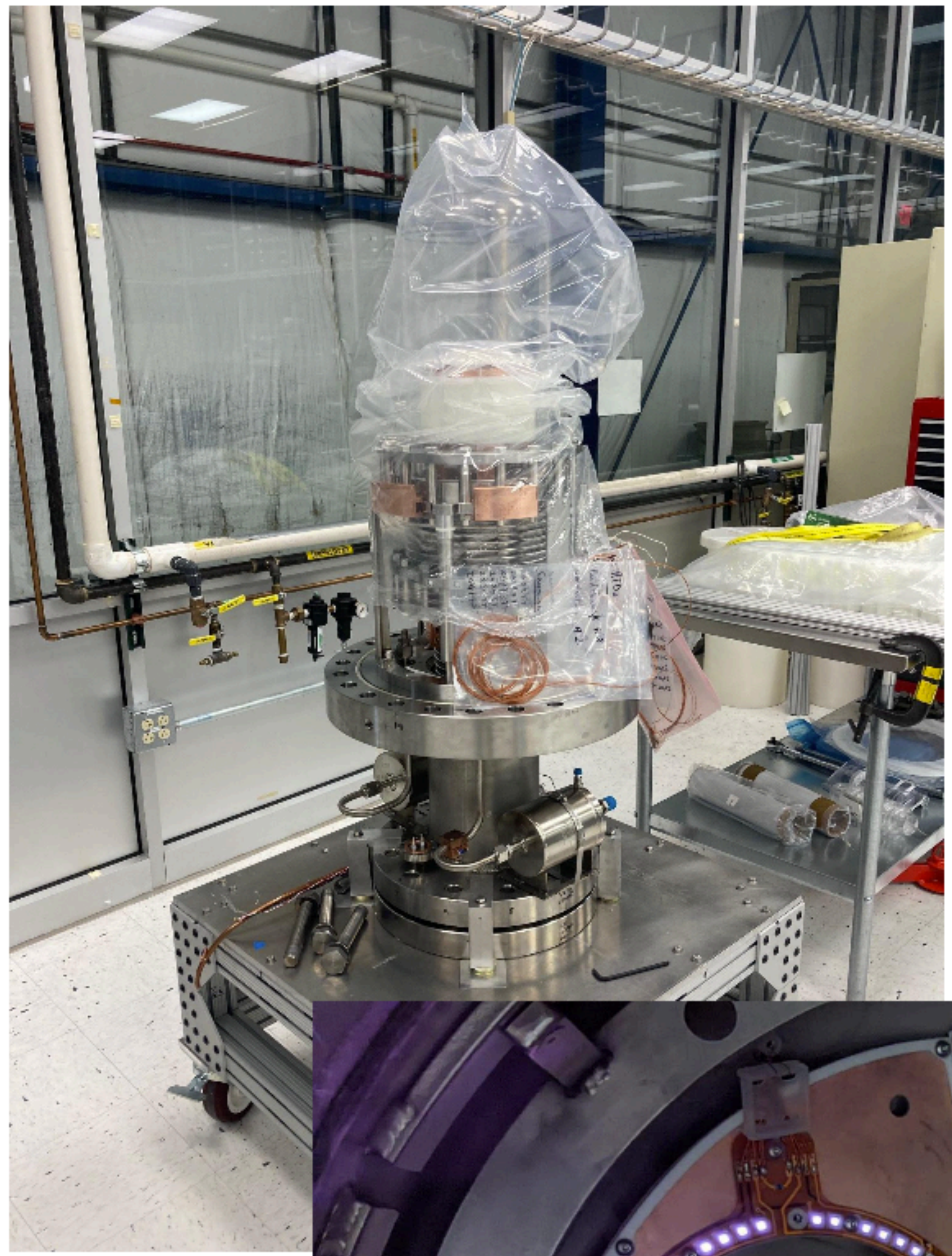


1) Build and commission detector at Fermilab

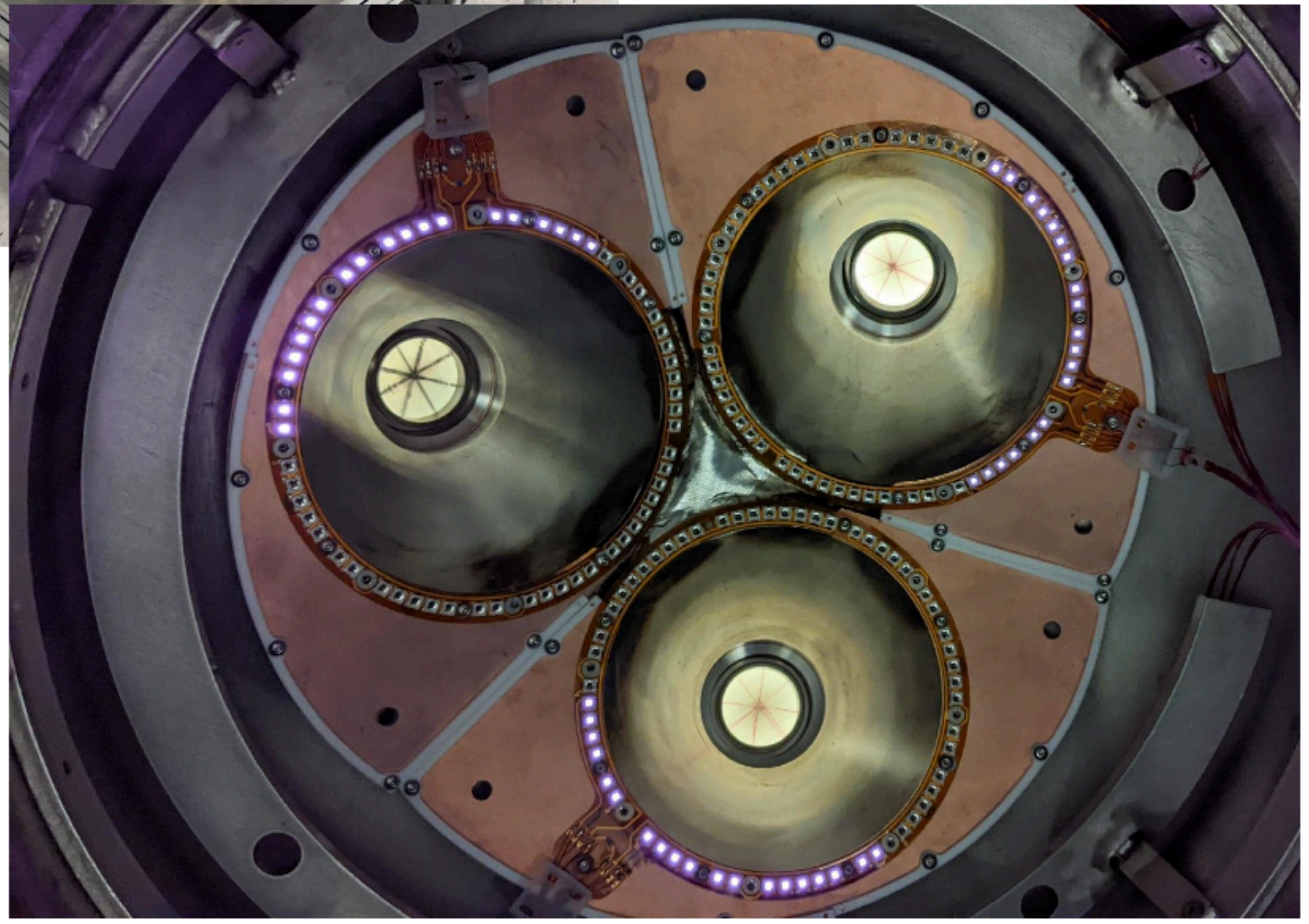
2) Build and install 2nd detector at SNOLAB for DM search

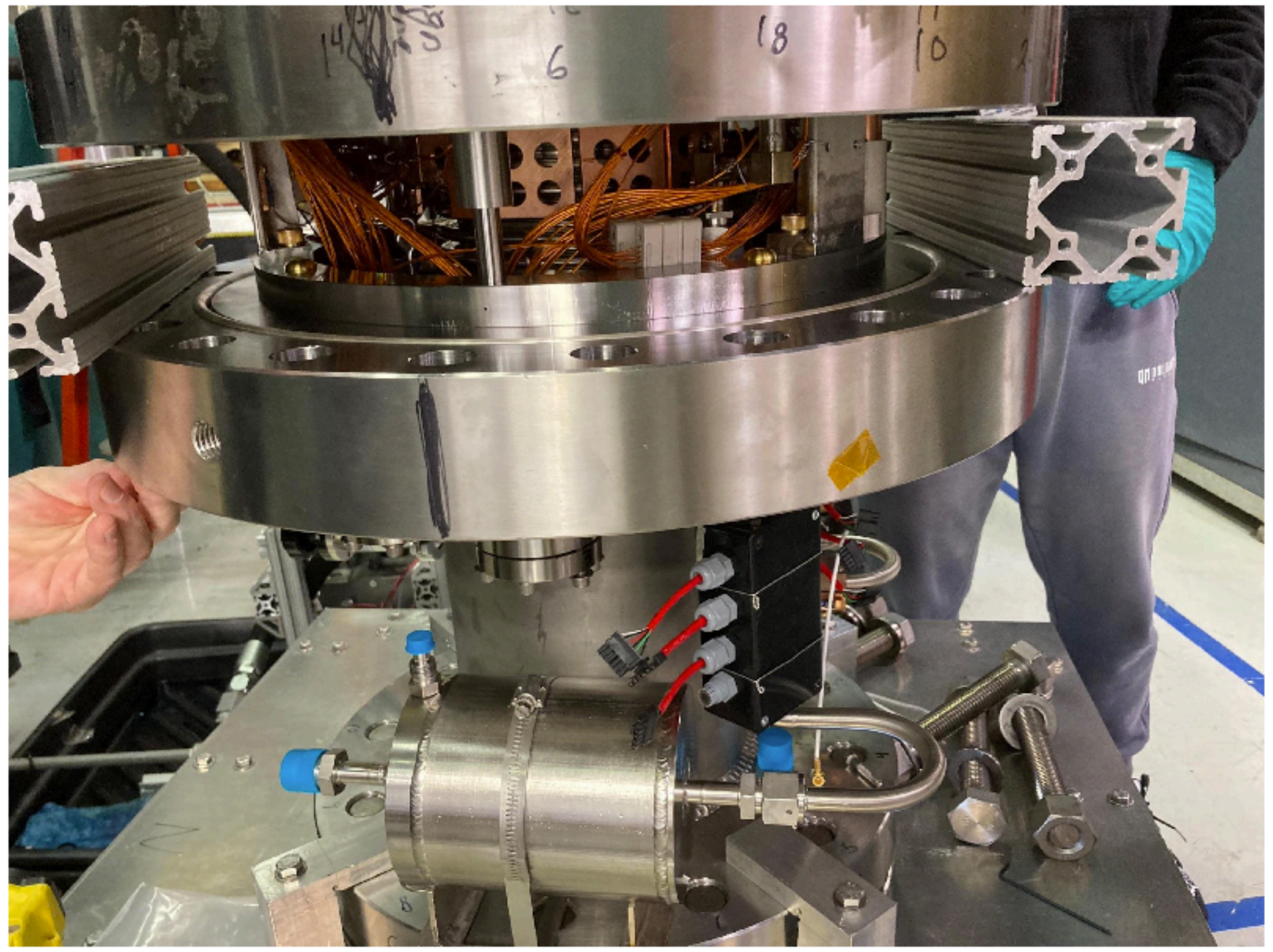
3) Upgrade and install detector from 1) at a reactor for CEvNS studies

Fermilab Progress



- Instrumentation wiring is complete
- PV installed in vacuum jacket
- Cold test on surface





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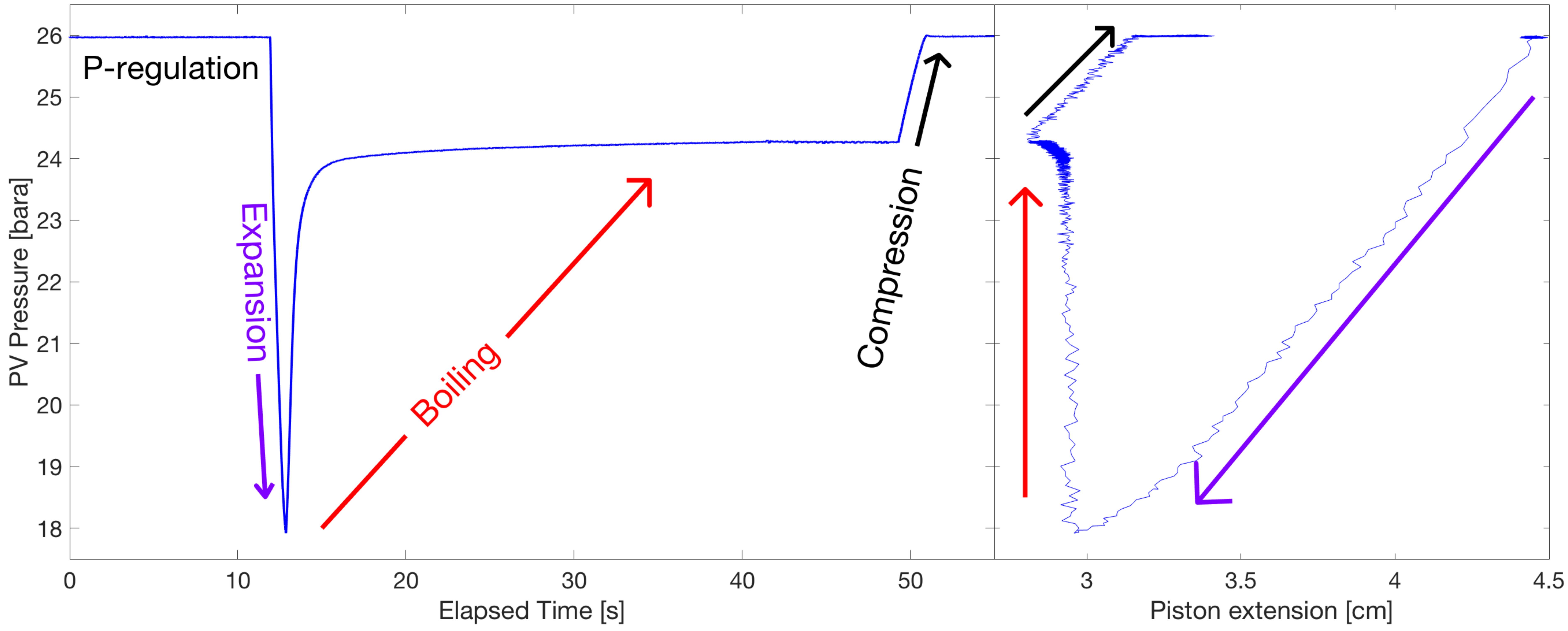


- During the extensive cryogenic testing required at Fermilab, we did sneak in some superheating
- Everything looks good, and what we expected

Fermilab Progress

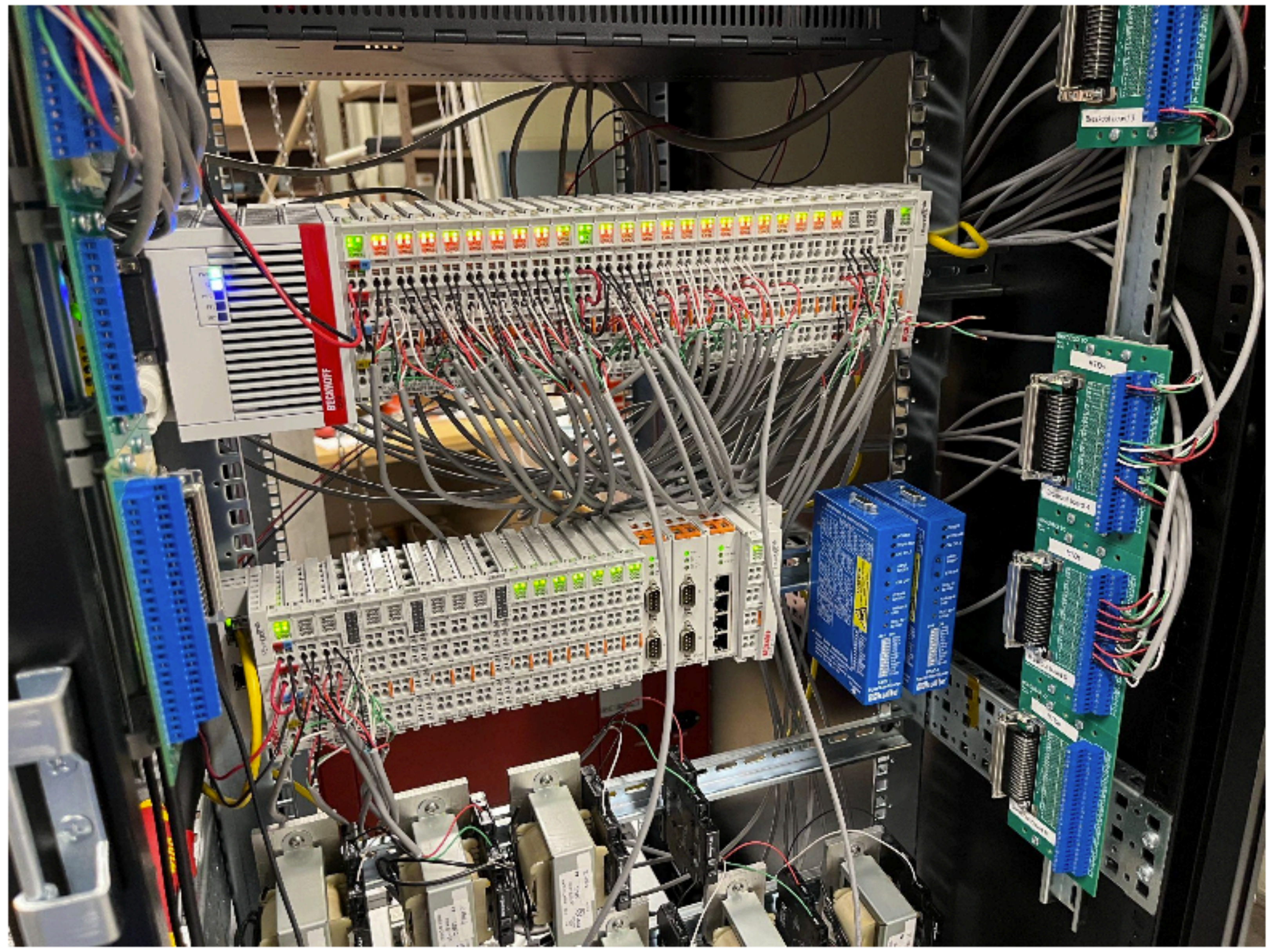
Relocated to MINOS tunnel underground space.

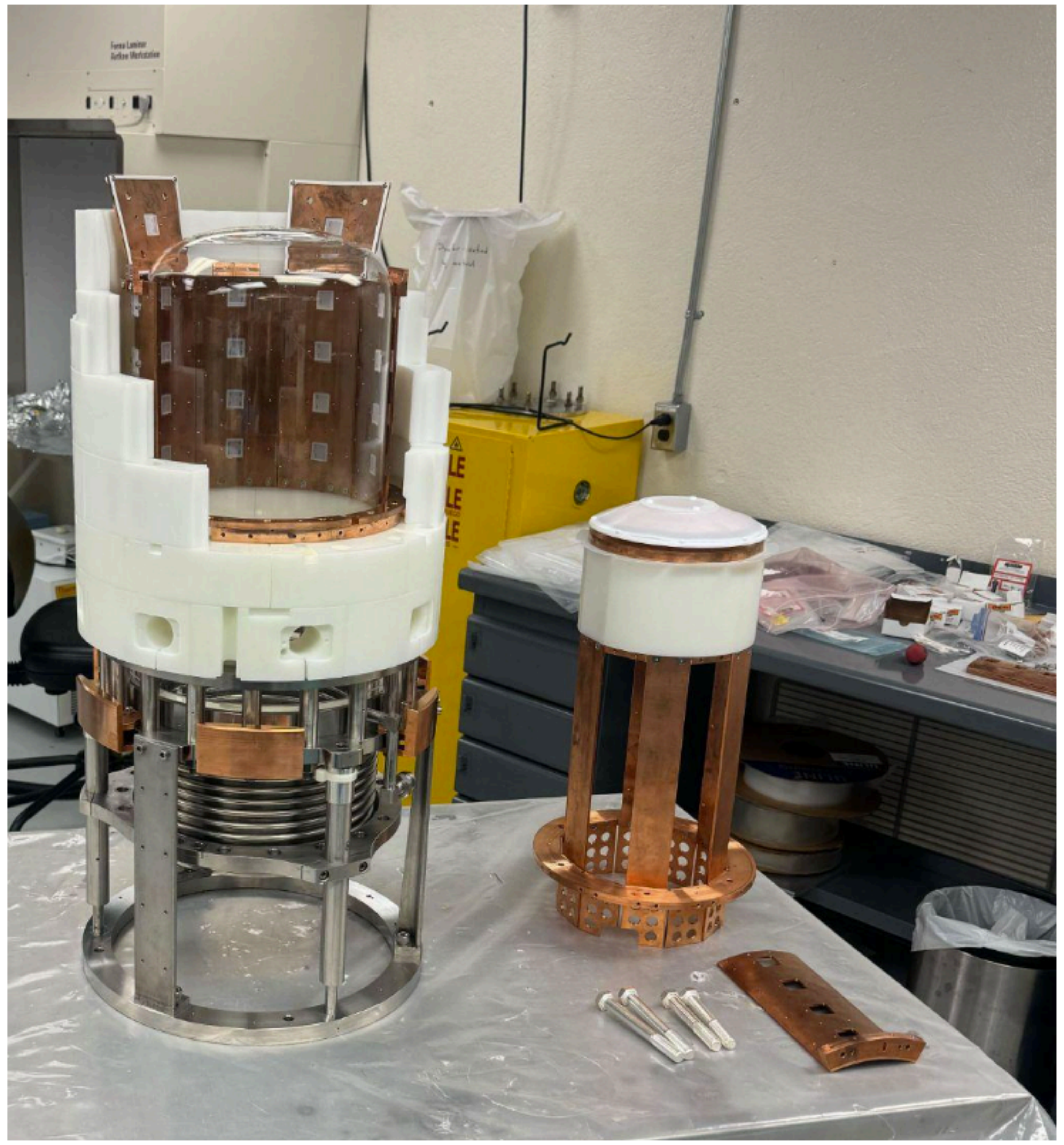
Fermilab Progress

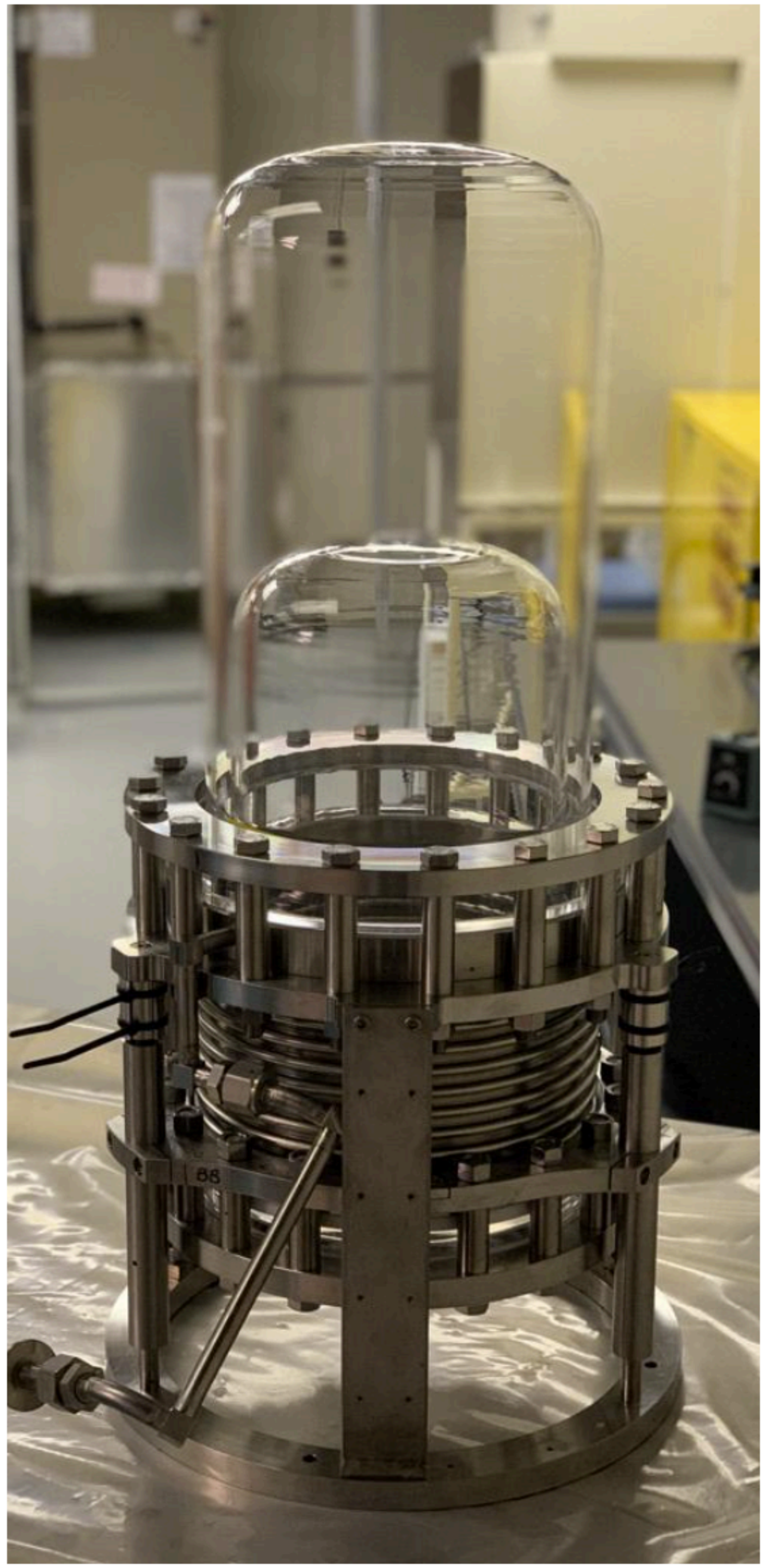
- Now located in the MINOS tunnel, engineering/calibration studies to begin in ~month

SNOLAB Progress

- The inner assembly components built
- A fabricator for the pressure vessel and vacuum jacket has been identified, the contract is signed, iterating final design
- Wiring & PLC work has begun



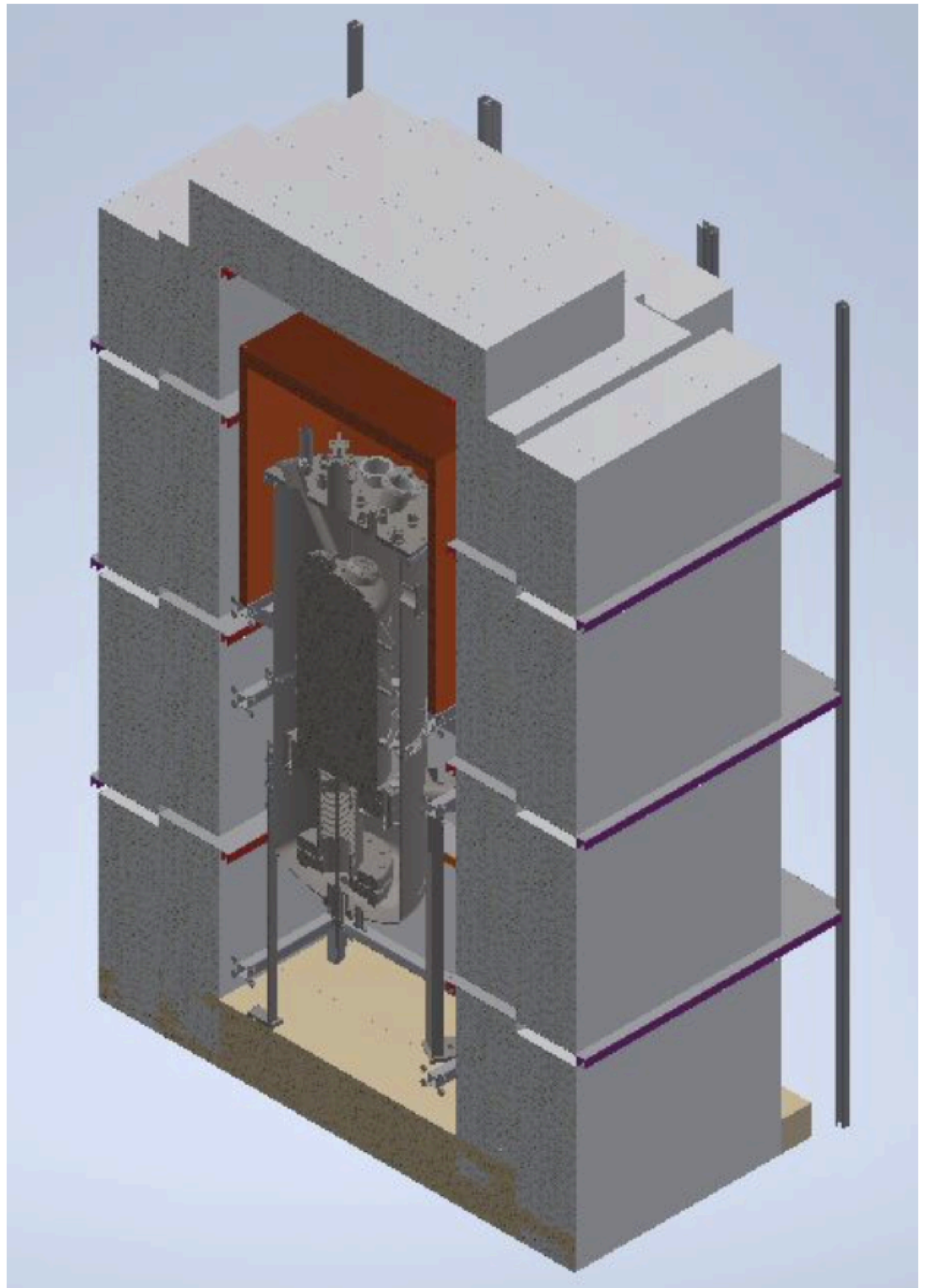




Experiment Status - Shielding

- Extensive effort put into determining shielding necessary to run u/g
- Both neutron and gamma budget being finalized, have guided the path forward for our operations plan
- Shield design through SNOLAB engineering support

Water box + Cu shield



	Neutrons		Gammas
	Single Scatters / y	Single Scatters in ROI / y	Single Scatters in ROI / y
Unshield	4009 +/- 771 (Sys.) +/- 41 (Stat.)	3310 +/- 652 (Sys.) +/- 38 (Stat.)	2100
w/ shield	5 +/- 1 (Sys). +/- 2 (Stat.)	5 +/- 1 (Sys). +/- 2 (Stat.)	10 +/- in progress

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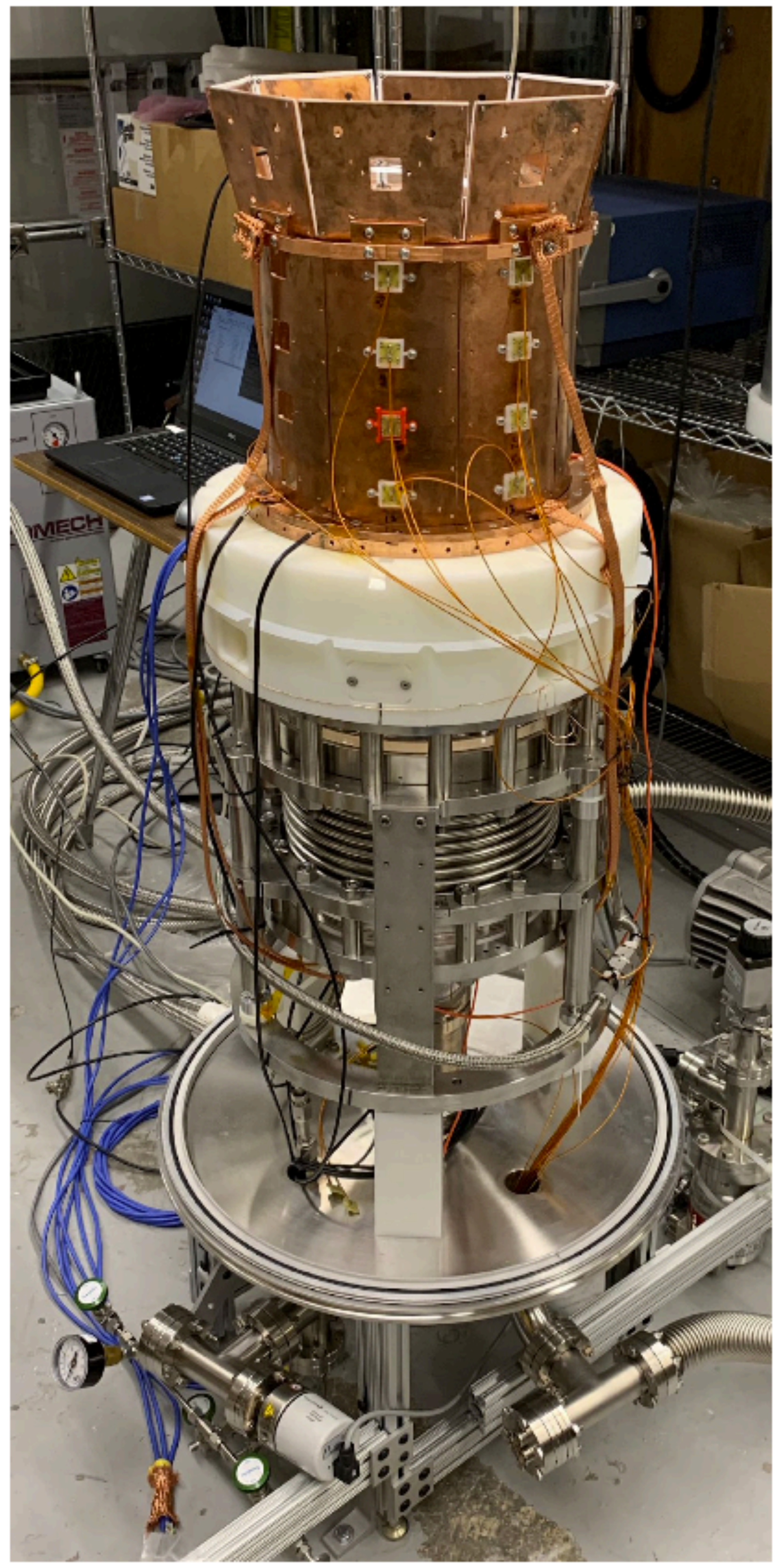
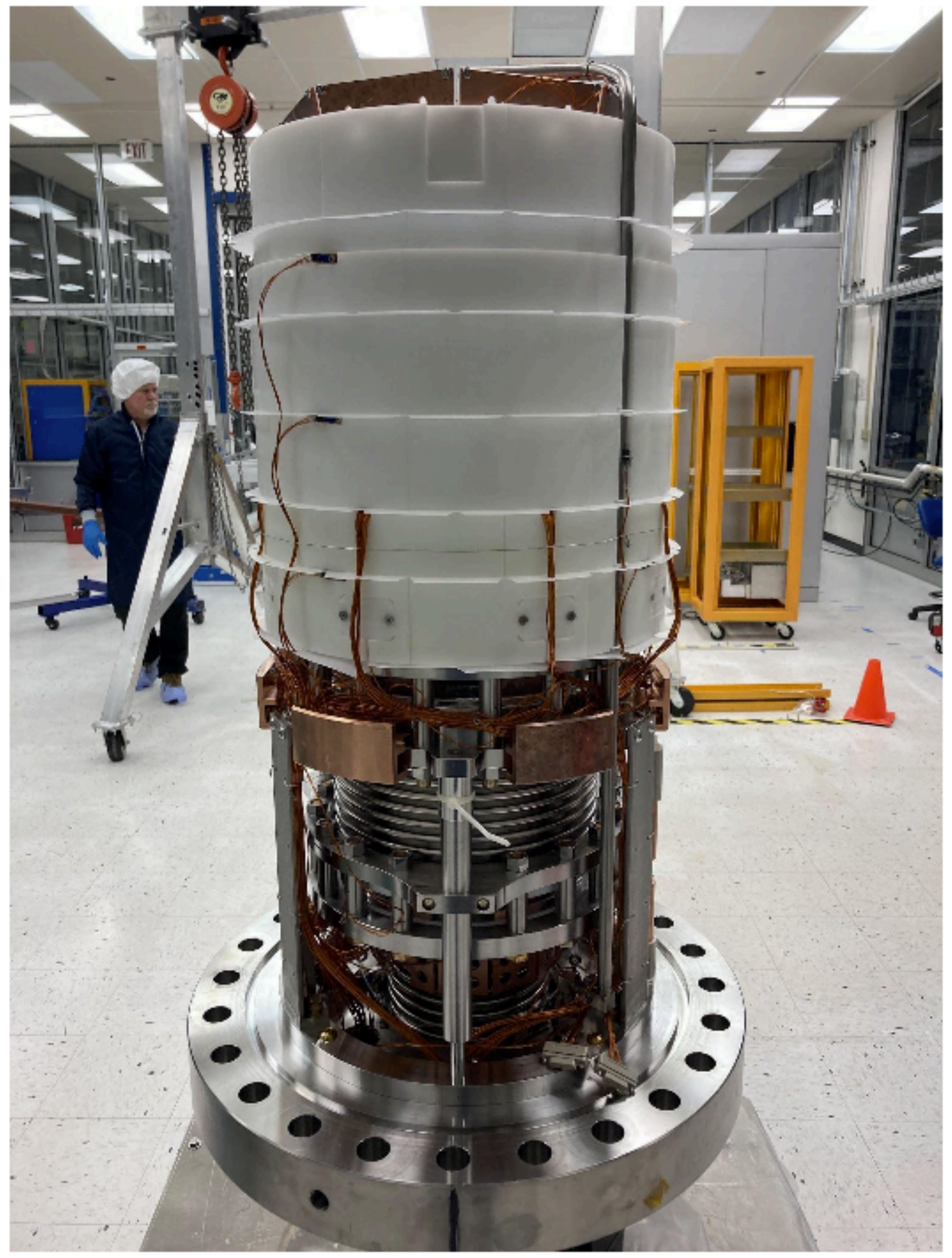
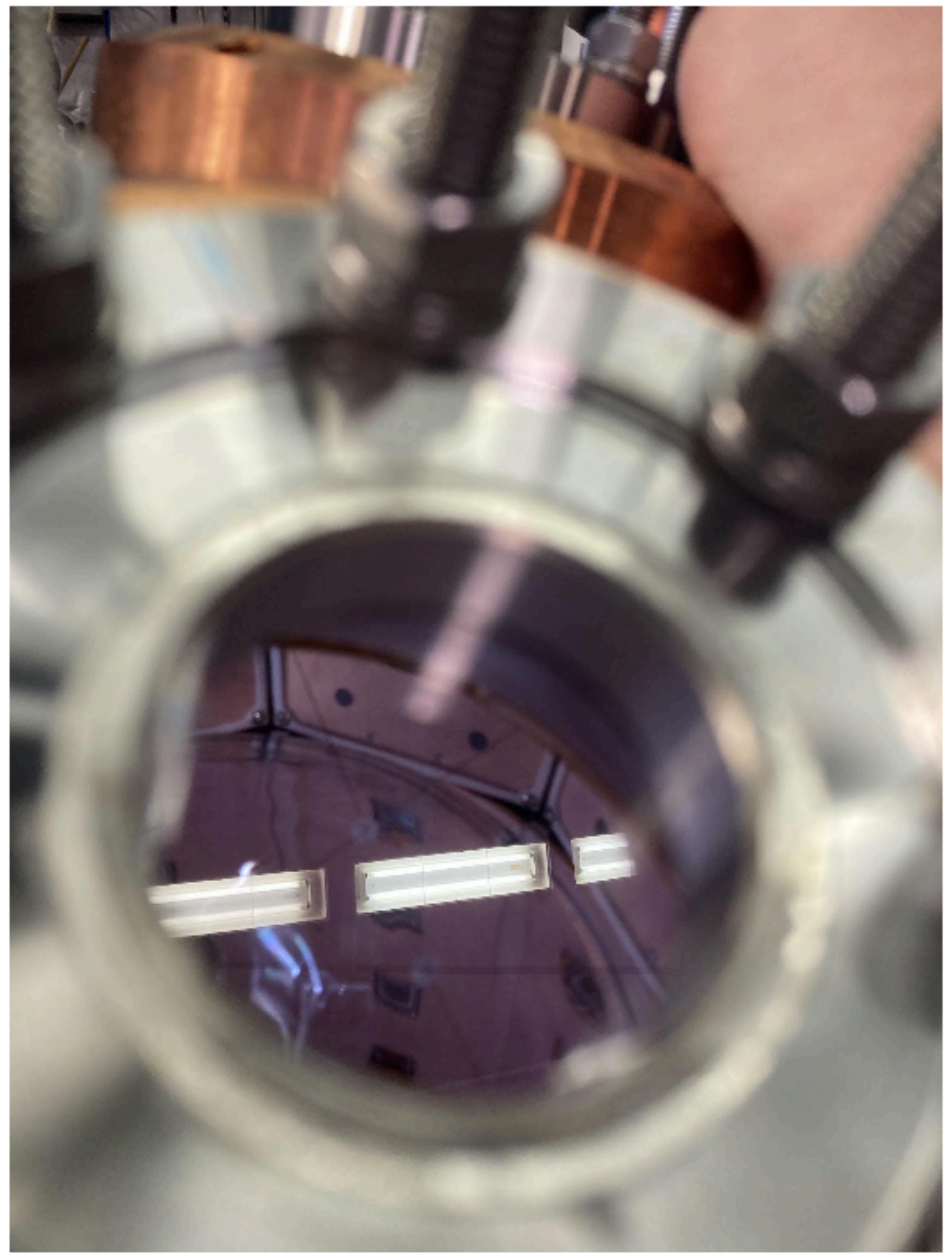
Conclusion

- SBC continues to make progress, faster than in the past and accelerating all the time
- Operation of the Fermilab chamber will provide proof of threshold, the SNOLAB chamber will proceed quickly
- The next update should continue this positive trend







Collaboration

Queen's University

K. Clark, A. Wright, B. Broerman
A de St Croix, C. Garrah, H. Hawley
Herrera, G. Sweeney, E. Wyman,
J. Walker, K. Dering,
J. Corbett, N. Moss

University of Alberta

M.-C. Piro, M. Baker, Y. Ko

SNOLAB

R. Castilloux, J. Hall

Université de Montréal

M. Laurin

TRIUMF

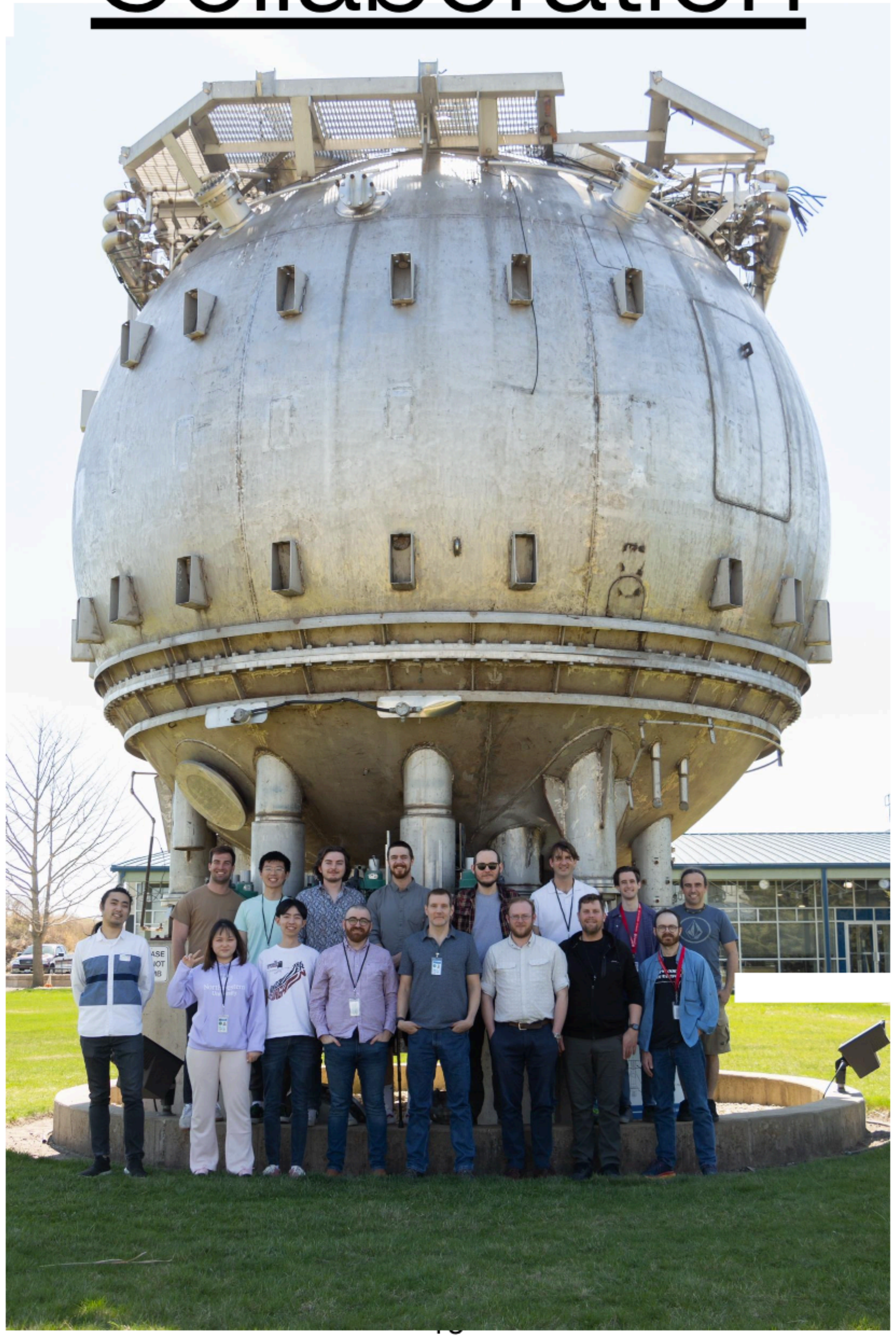
P. Giampa

Universidad Nacional Autónoma de México

E. Vazquez-Jauregui,
E. Alfonso Pita,
O. Ivan Valdez Martinez

Northeastern Illinois University

O. Harris



Drexel University

R. Neilson, N. Lamb,
D. Pyda, J. Fritz-Littman

Indiana University South Bend

I. Levine, E. Behnke,
C. Cripe

PennState

S. Priya

Pacific Northwest National Laboratory

C. Jackson

Northwestern University

C.E. Dahl, B. Mitra, J.
Long, Z. Sheng,
E. Rengifo, P. Rodriguez,
D. Campos

University of California Santa Barbara

H. Lippincott, T. Whitis,
R. Zhang, L. Joseph

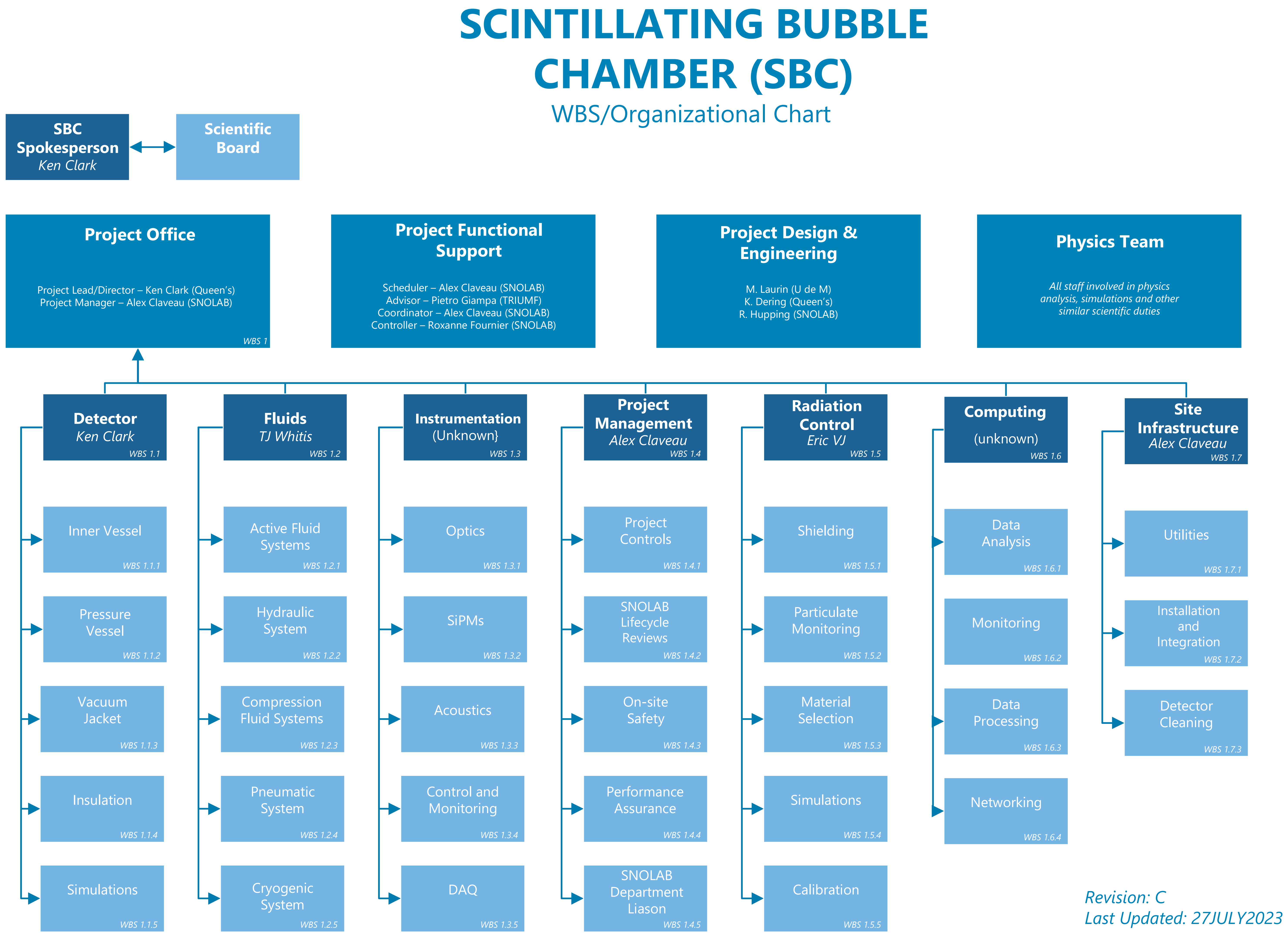
Fermilab

D. Baxter, G. Putnam

UC Riverside

S. Westerdale

Canadian & HQP Leadership



- Canadians hold many leadership positions
- Of particular note, Canadian HQP (non-faculty) lead several of the major components