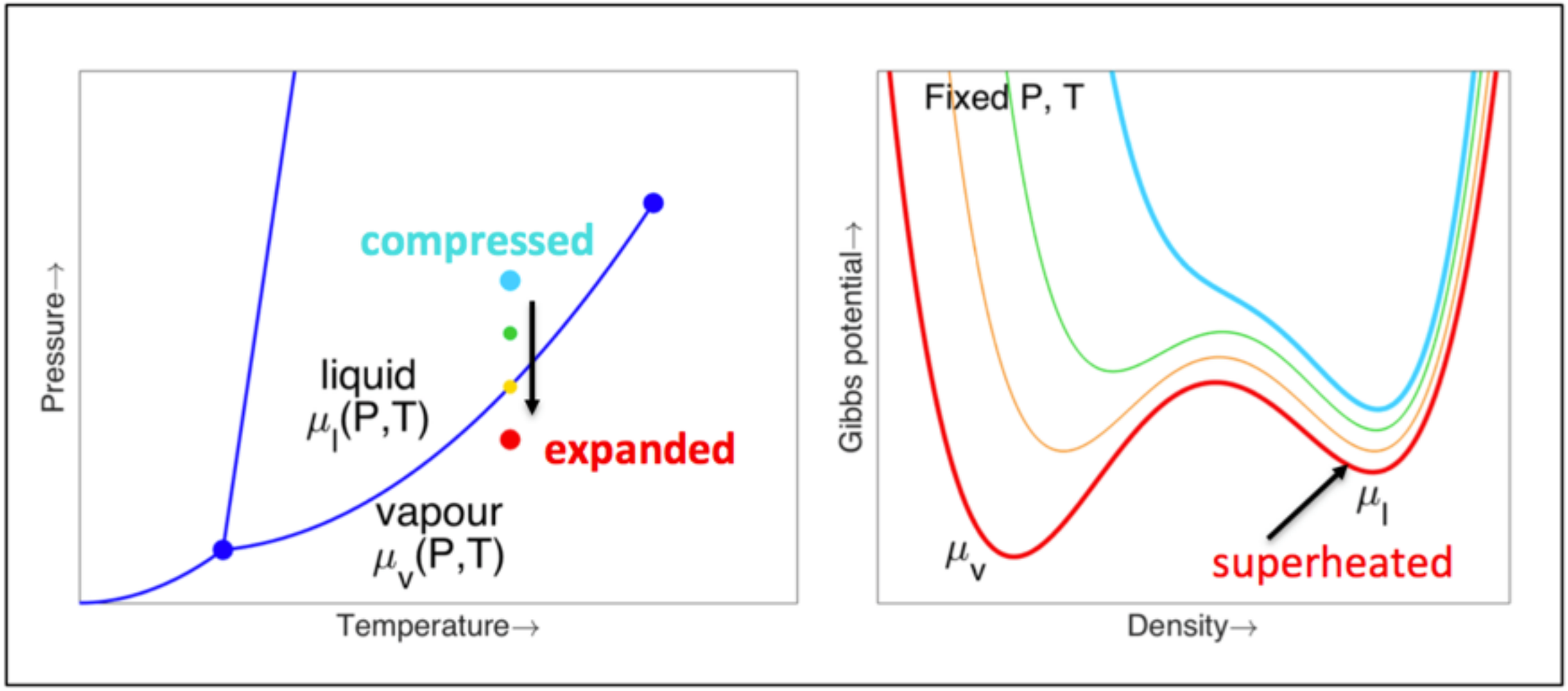
The PICO Dark Matter Search Program

Ken Clark
Queen's University

Bubble Chamber Principles

- Lower pressure to reach a metastable state
- Energy deposition nucleates a bubble



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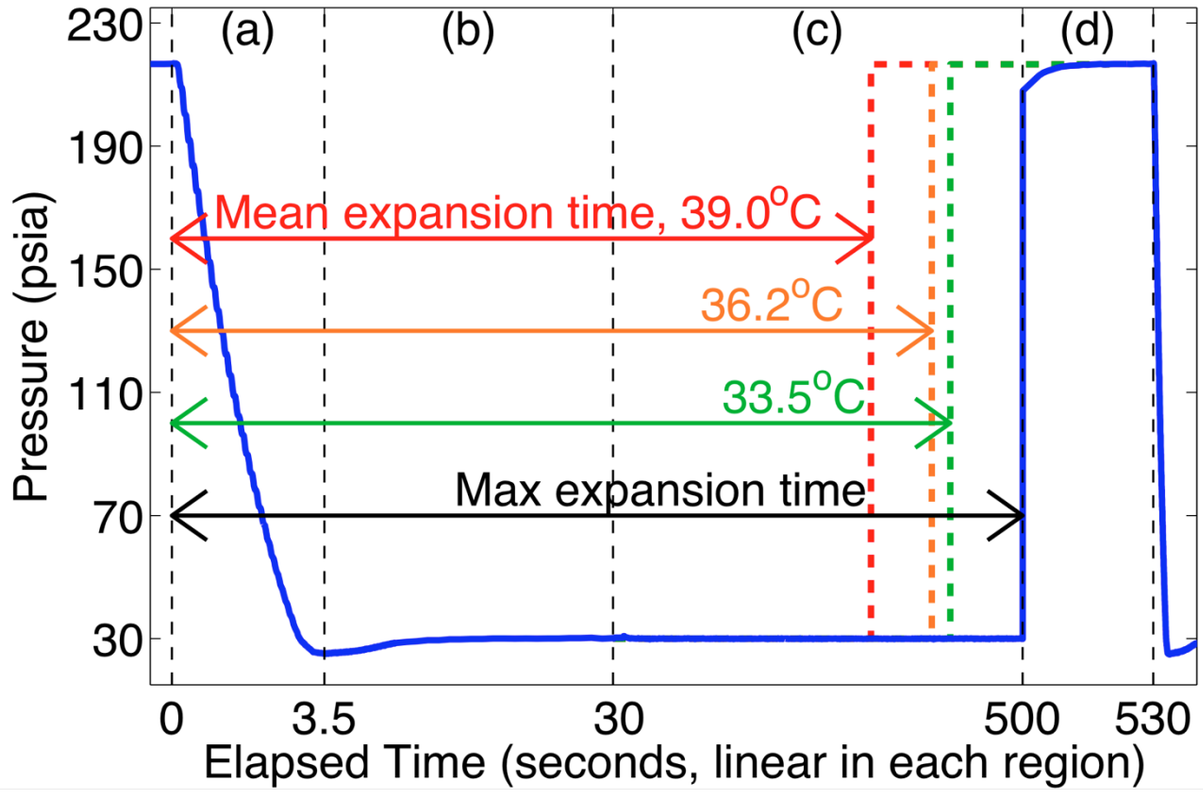
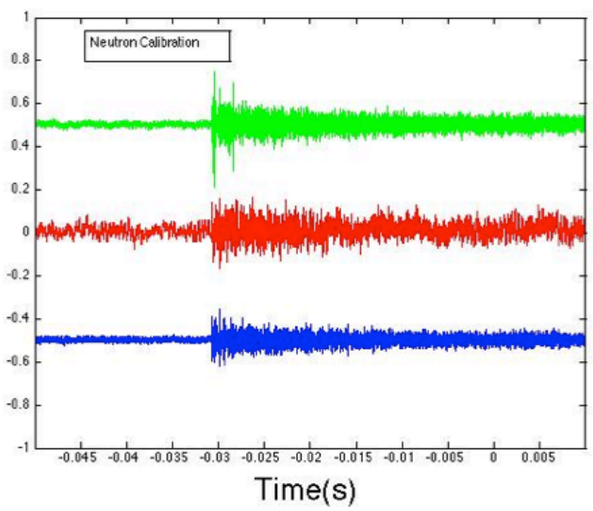
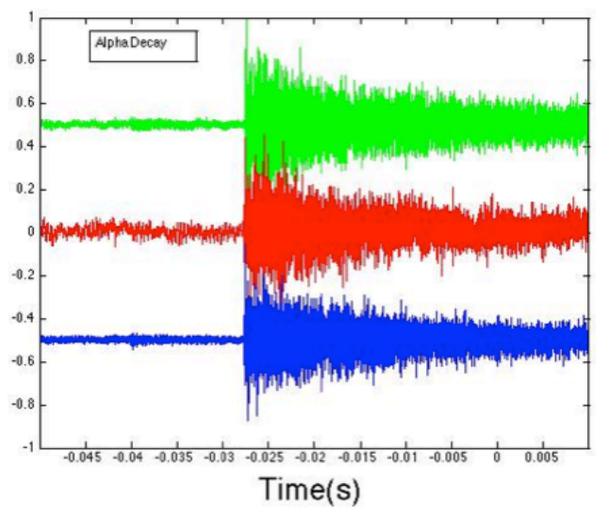
Chamber Operation

- A trigger causes pressurization to force back into liquid state
- Trigger is visual but acoustic information is kept for discrimination

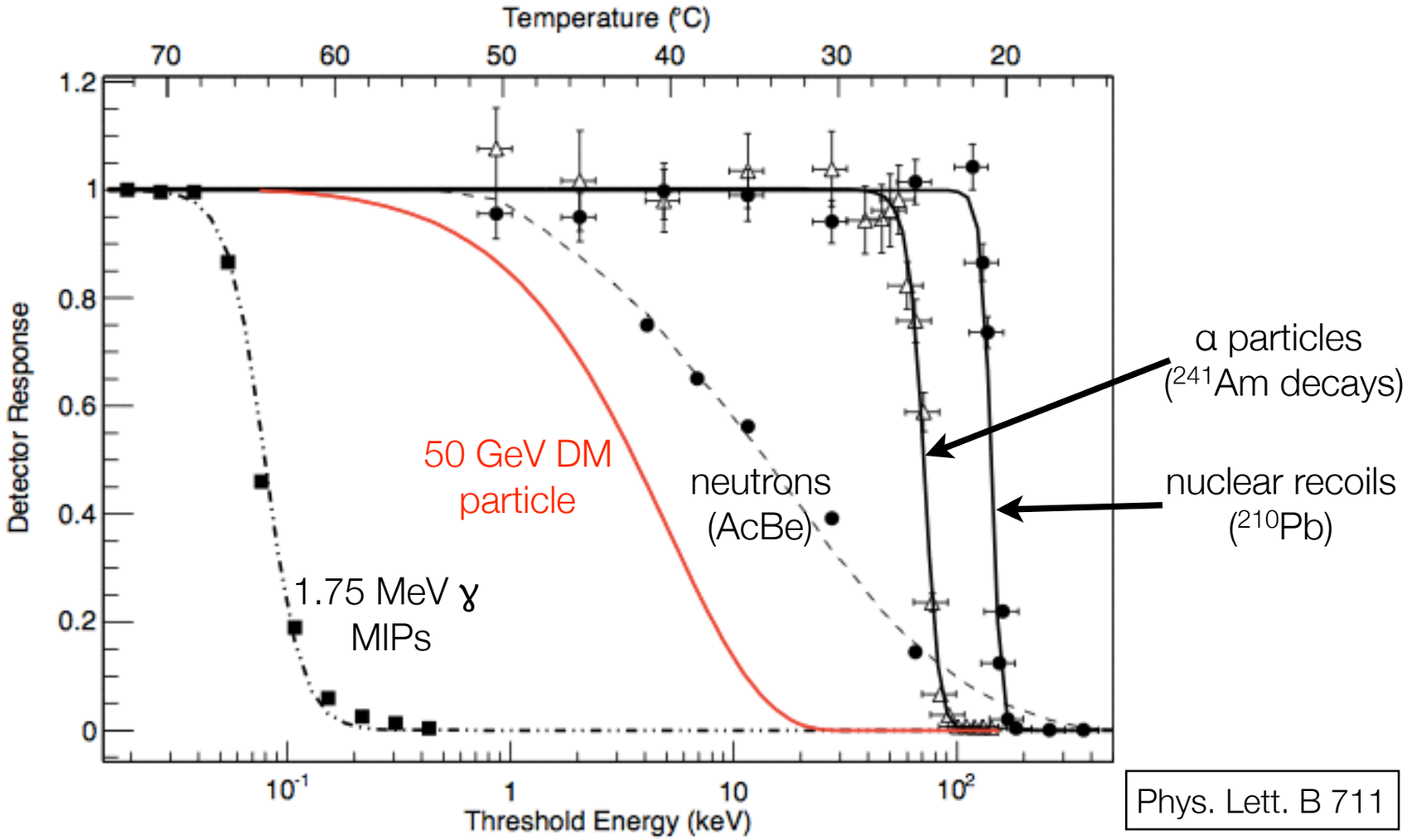






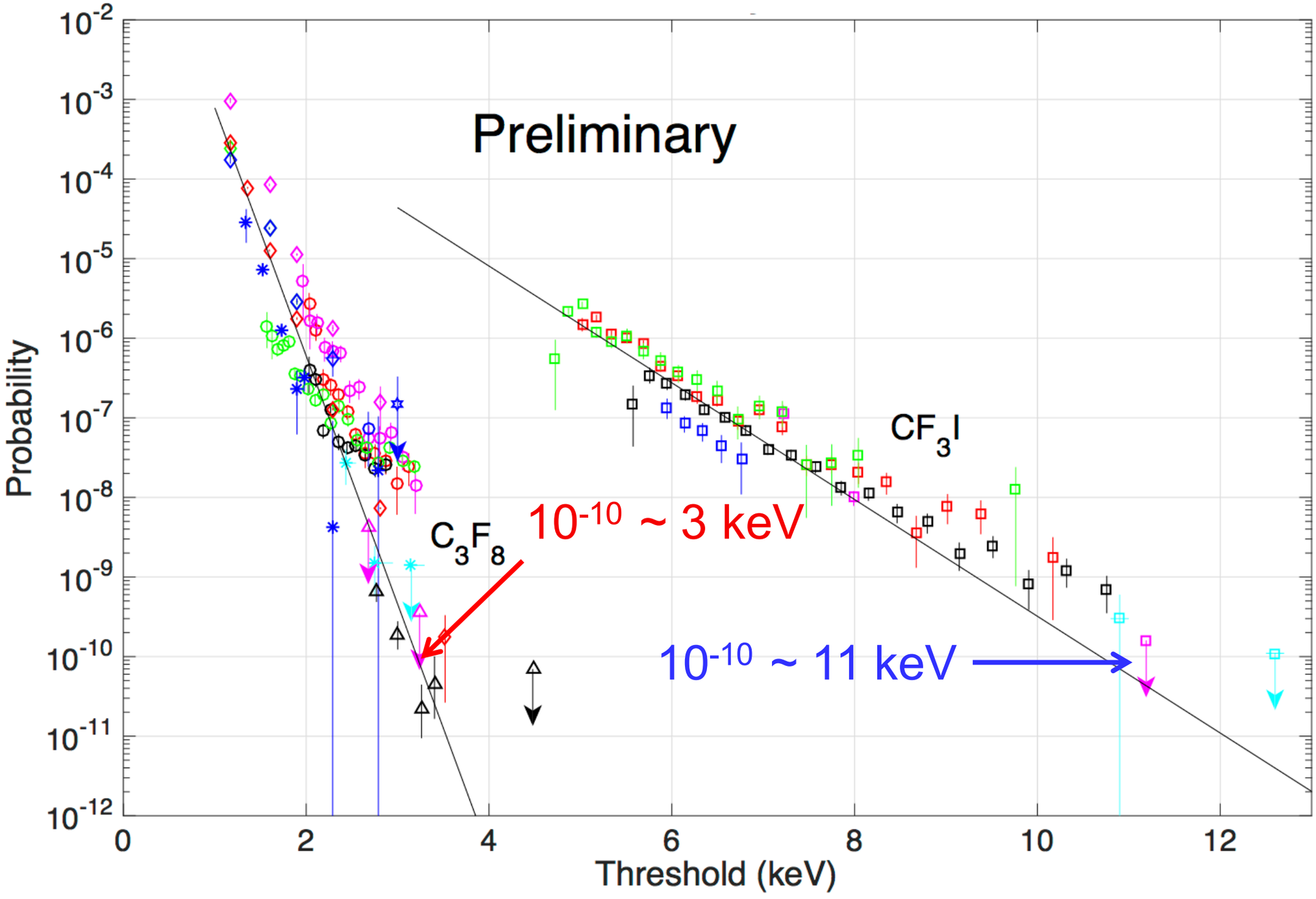
Background Discrimination

- Gammas and betas are effectively not detected by the detector as they do not meet the $E_{threshold}$ in r_c requirement.



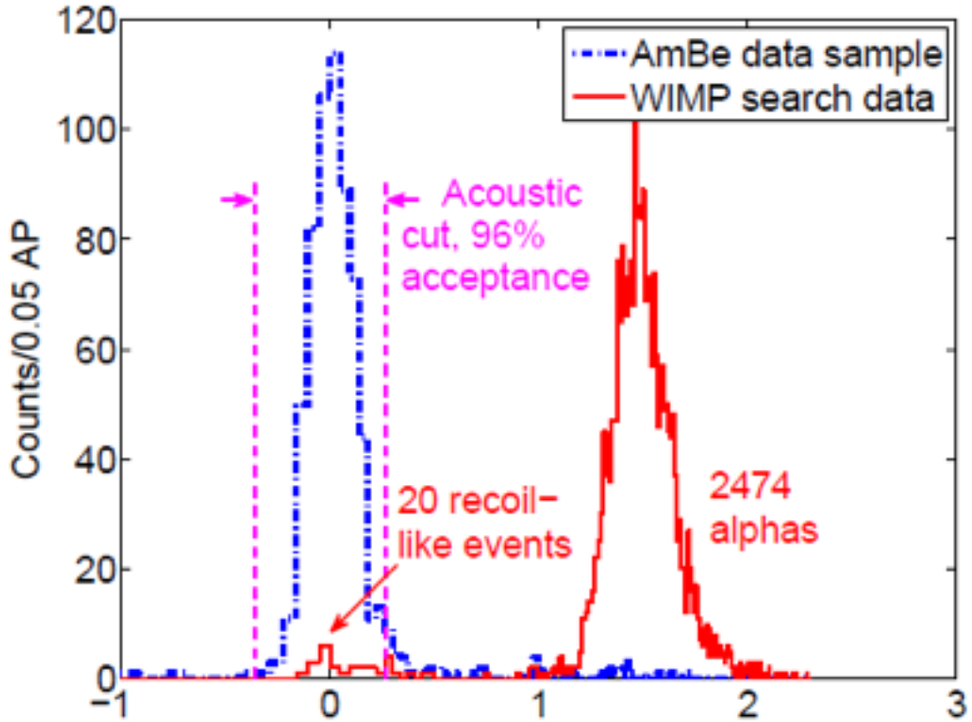
Phys. Lett. B 711

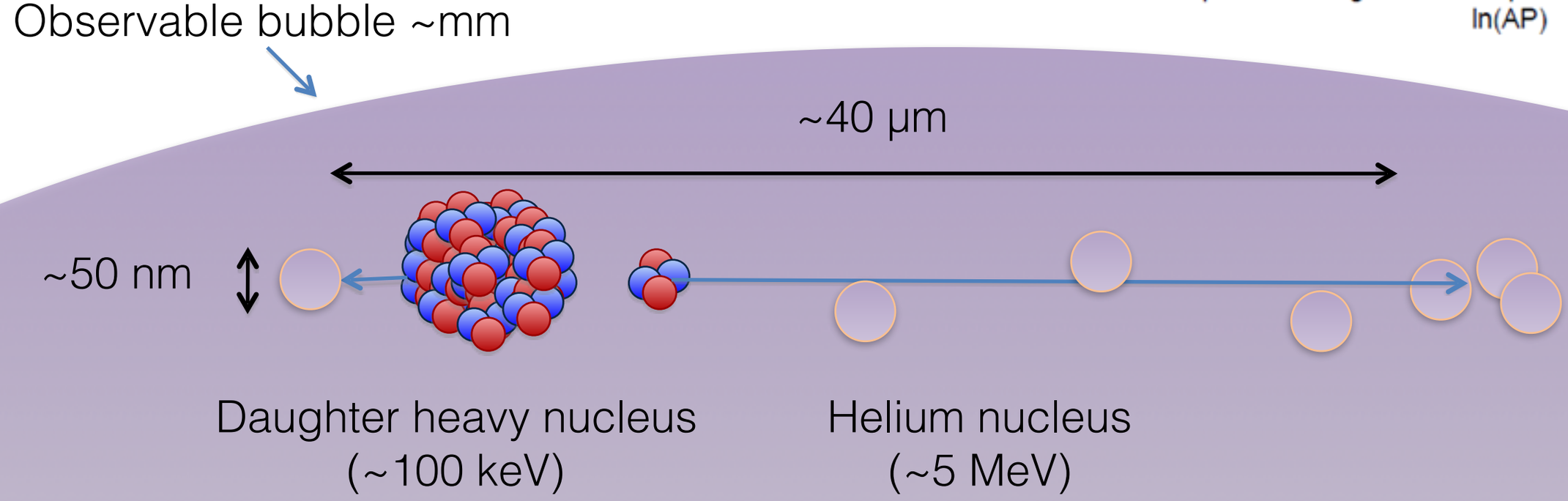
Gamma Rejection



Acoustic Discrimination

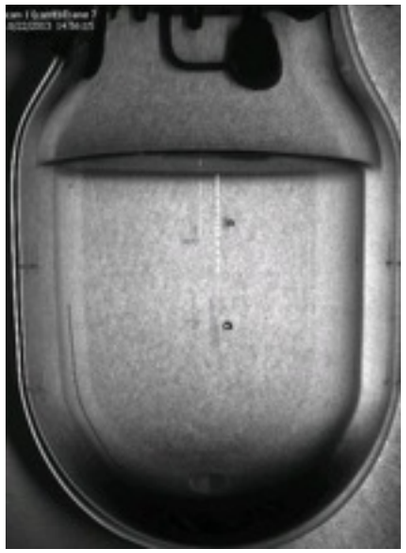
- Alphas deposit their energy over tens of microns
- Nuclear recoils deposit theirs over tens of nanometers



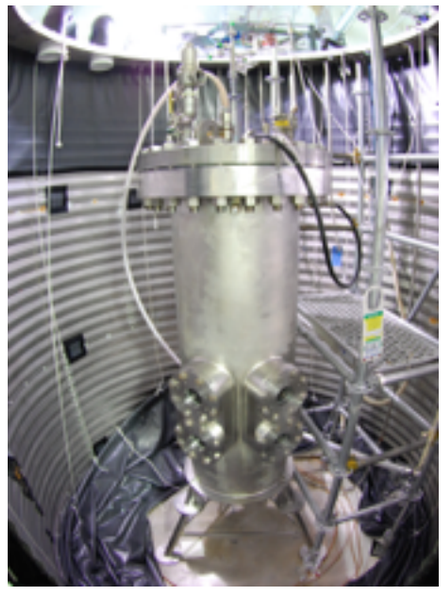


The PICO Program

PICO is the result of a merger between the PICASSO and COUPP collaborations



- PICO-2L C_3F_8 (2014-2017)
  C.Amole *et al.*, Phys. Rev. Lett. **114**, 231302 (2015)
  C.Amole *et al.*, Phys. Rev. D **93**, 061101 (2016)



- PICO-60 CF_3I (2013)
  C.Amole *et al.*, Phys. Rev. D **93**, 052014 (2016)
- PICO-60 C_3F_8 (2016-2017)
  C.Amole *et al.*, Phys. Rev. Lett. **118,** 251301 (2017)
- PICO-40L C_3F_8 (2018-2019)
- PICO-500 (future)

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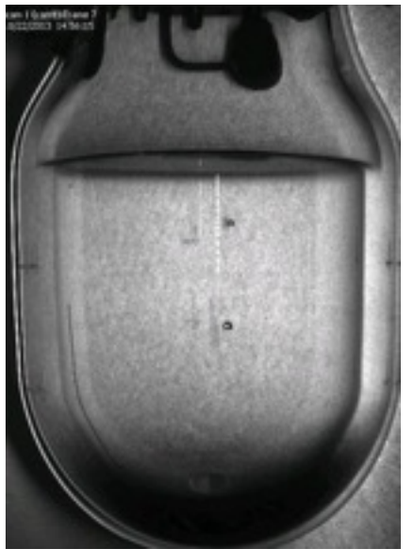

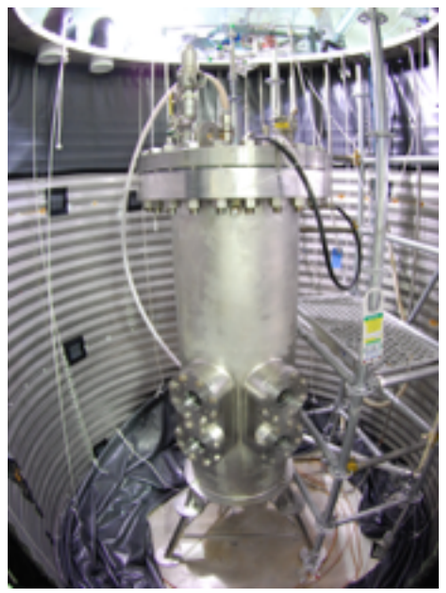

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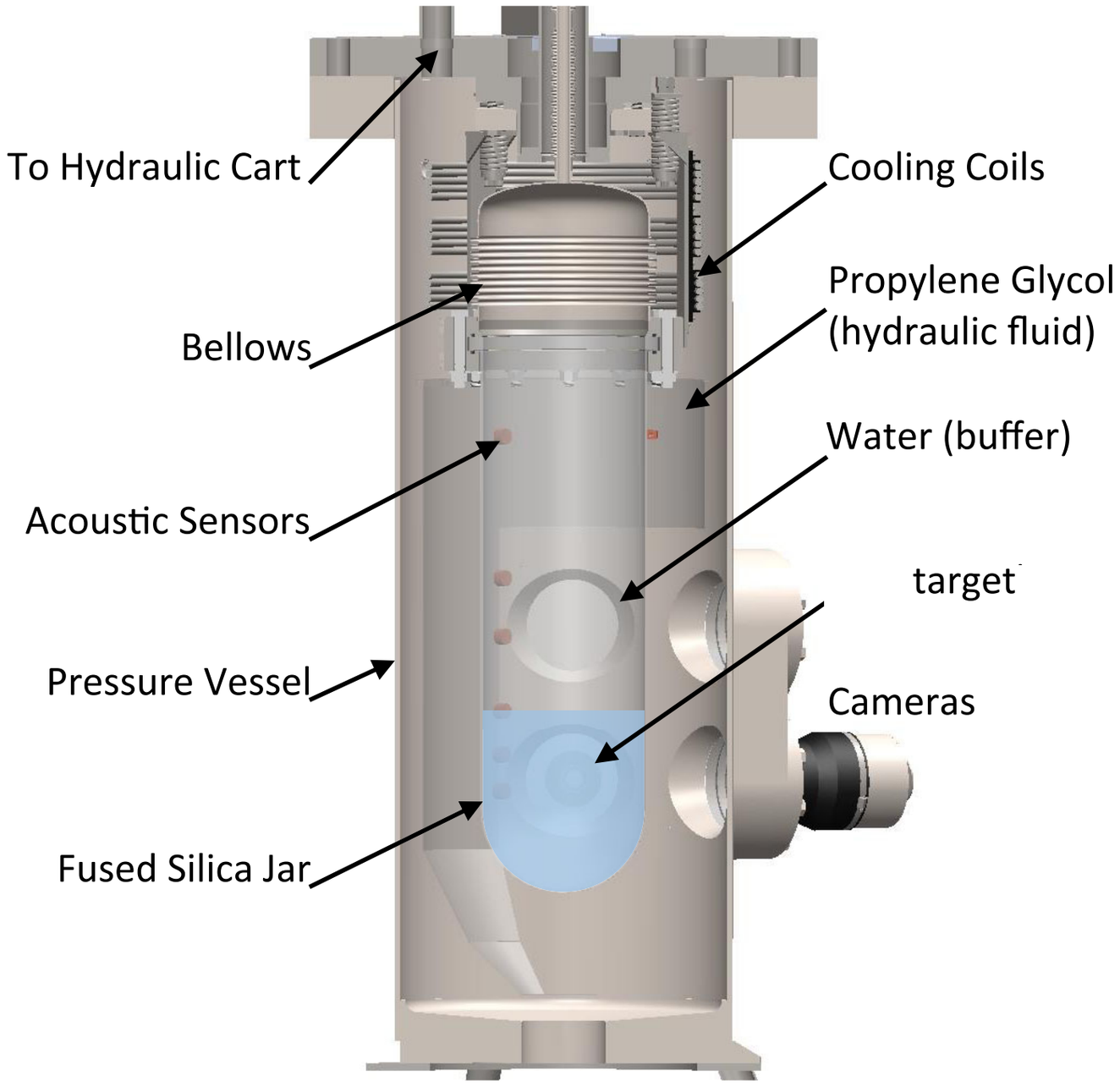
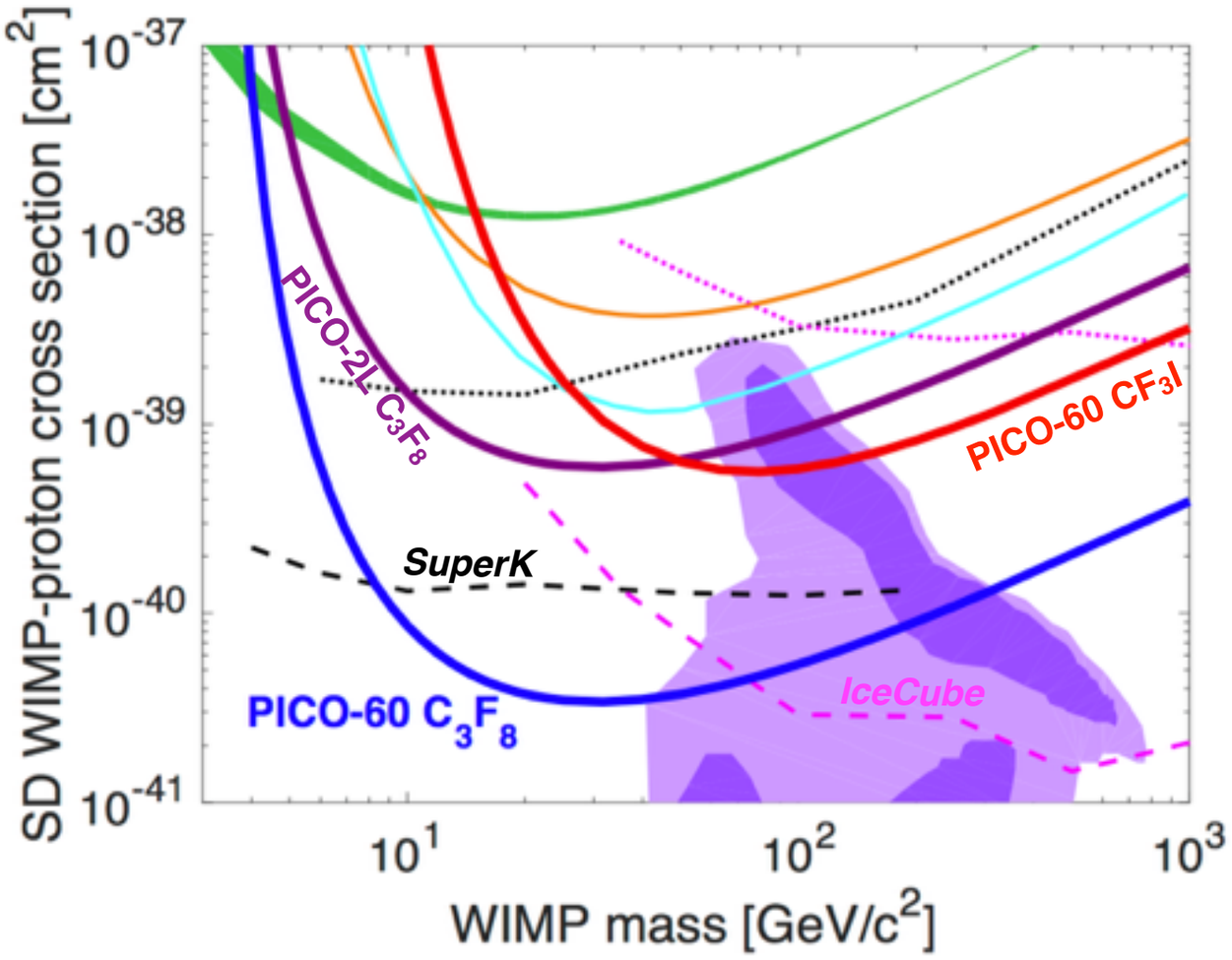
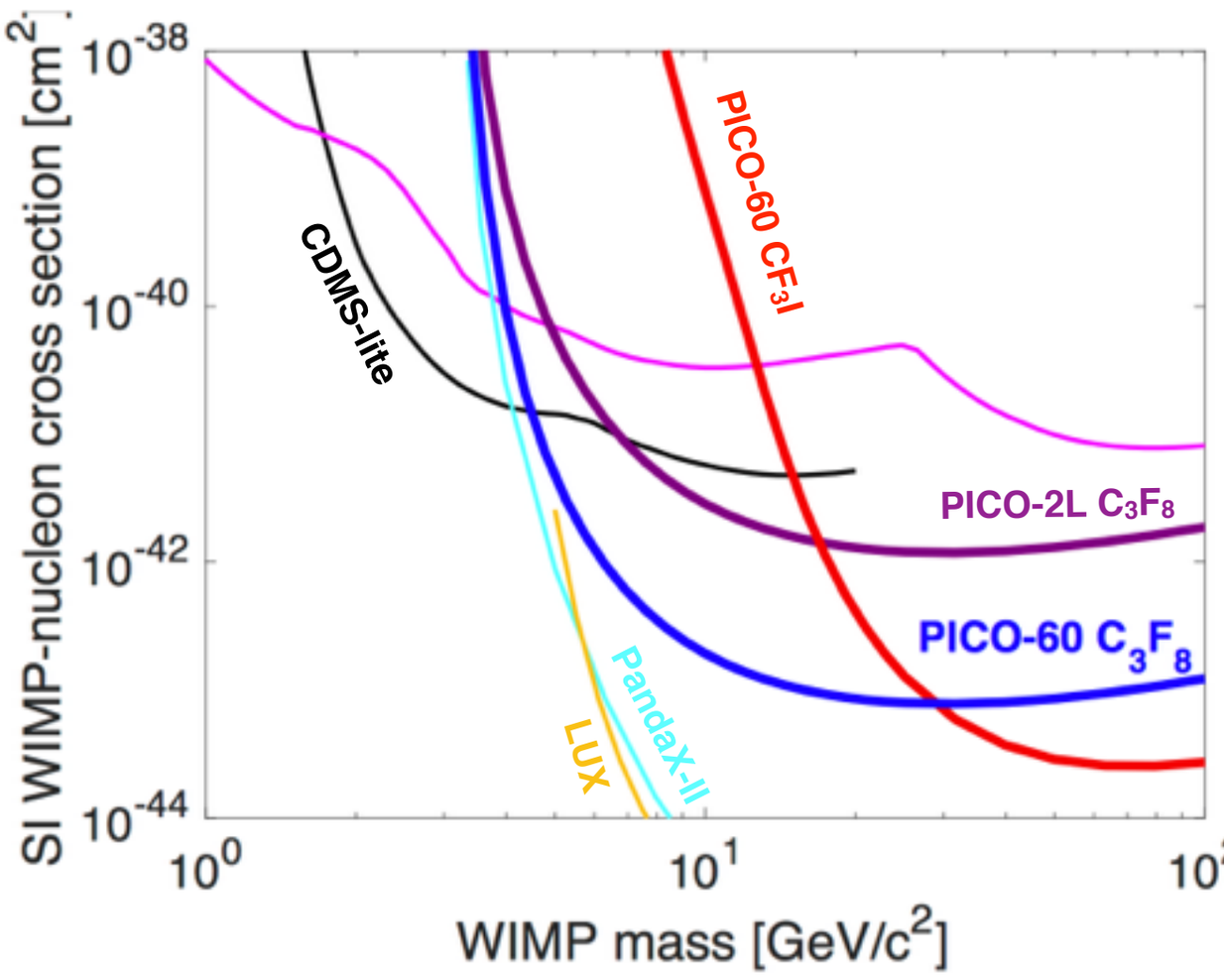
PICO-60

- Active material: 52kg of C_3F_8
- Water used as a buffer fluid to apply pressure for recompression



PICO-60 Results

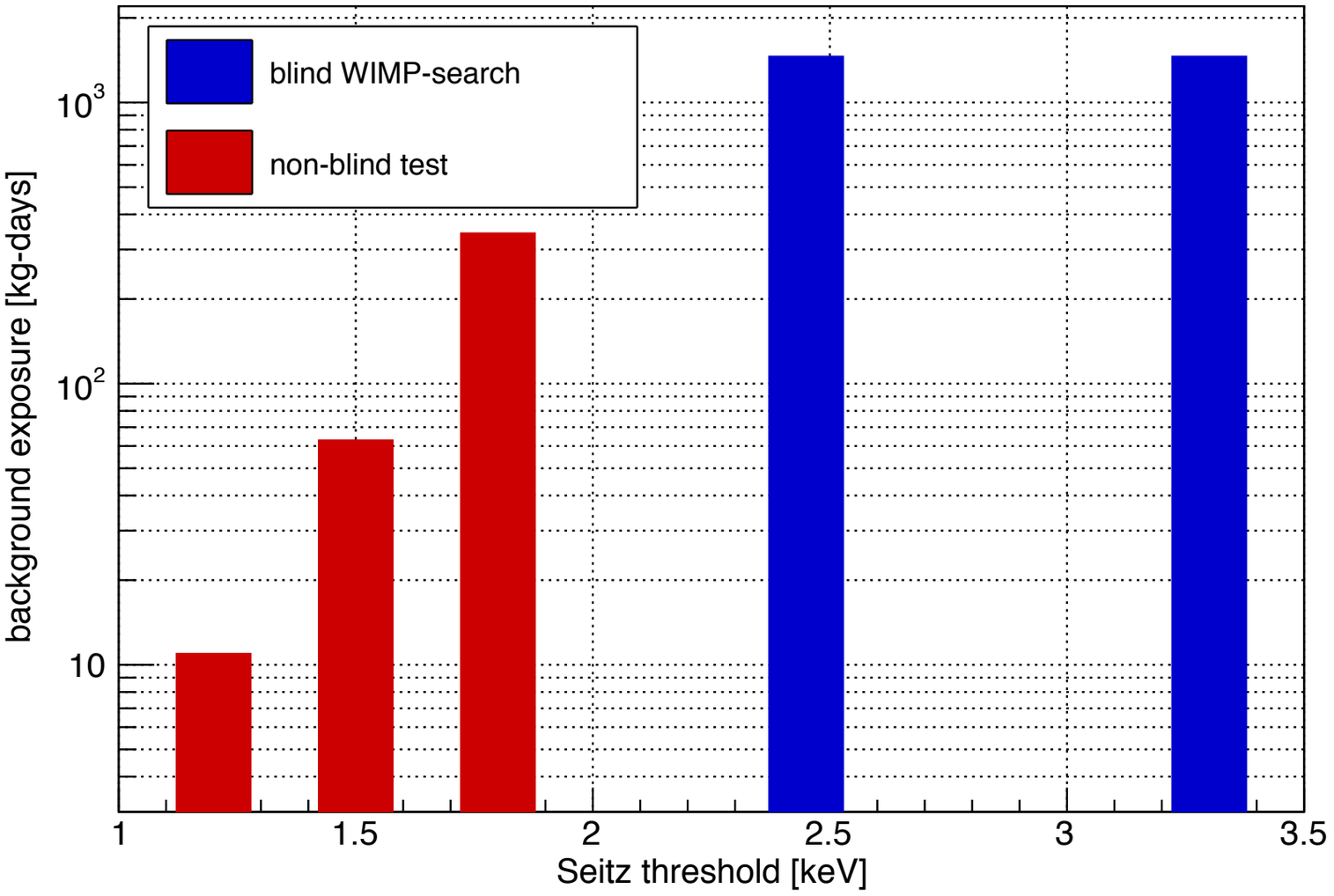




Phys. Rev. Lett. **118**, 251301 (2017)

- 30 live-days at 3.3 keV
- Additional data acquired, but background limited

PICO-60 Lowered Threshold

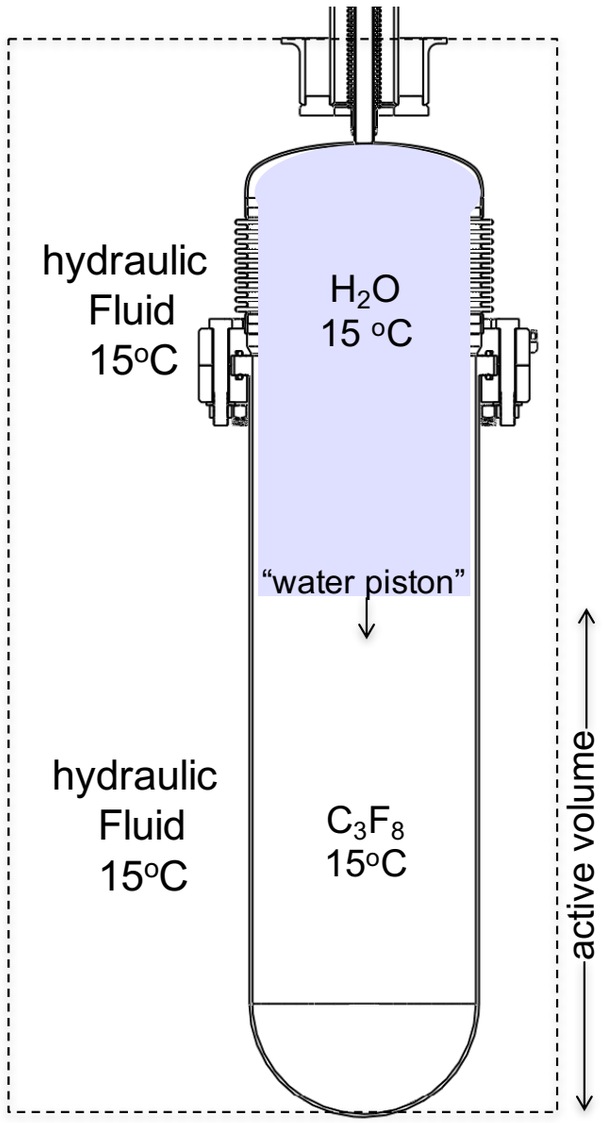


- Stable operation was achieved at lower thresholds
- Analysis proceeding, publication will follow soon

The Future

- Many problems seem connected to water/active fluid interface

PICO-60



The Future

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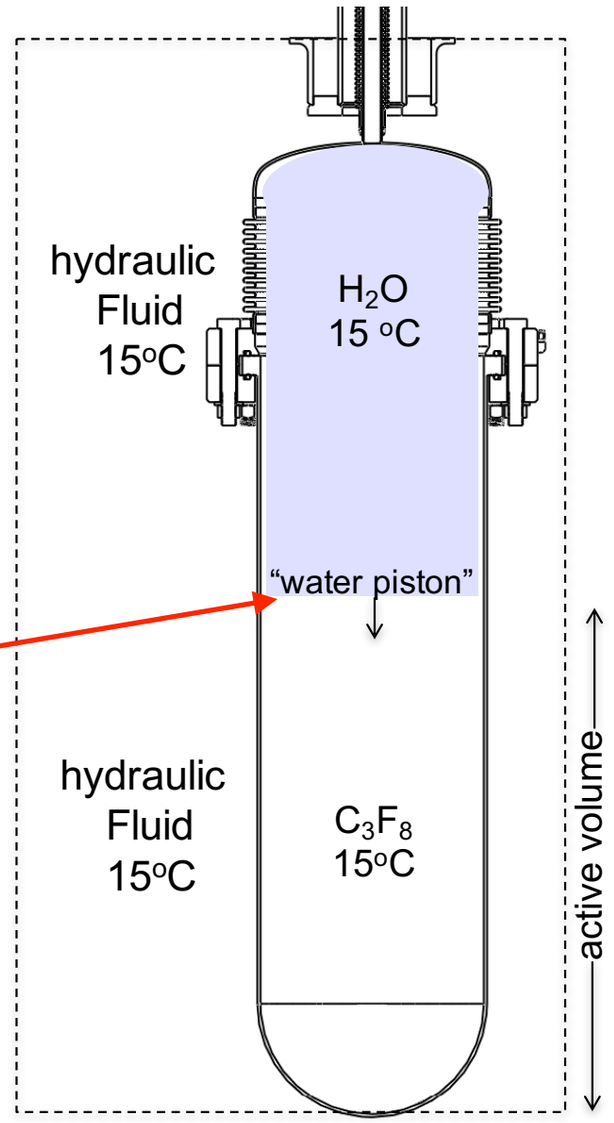
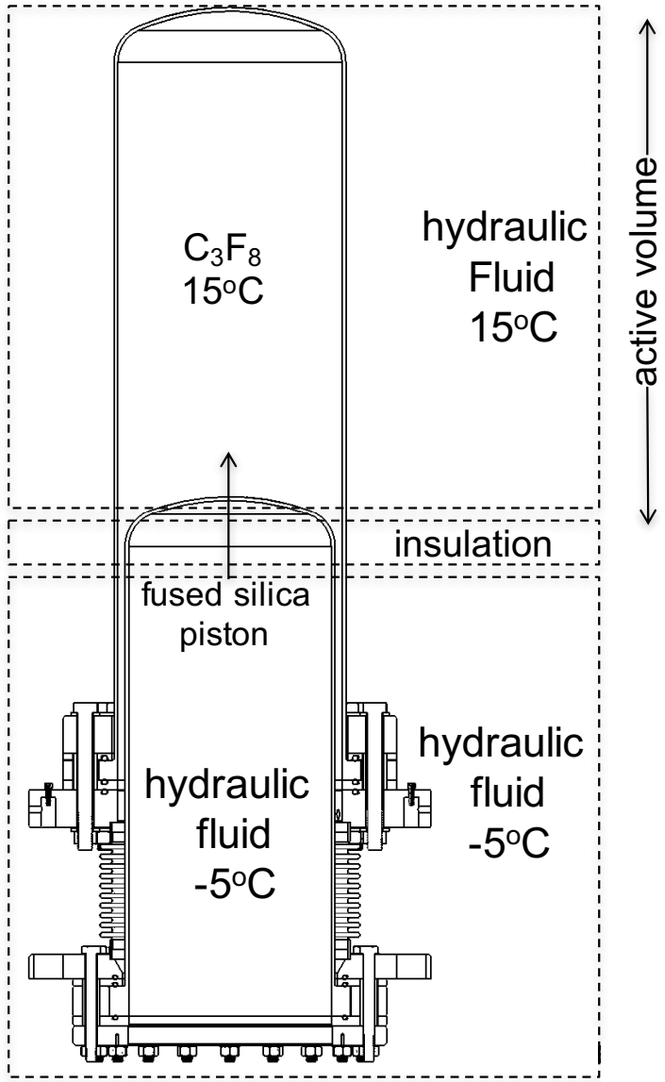
PICO-60

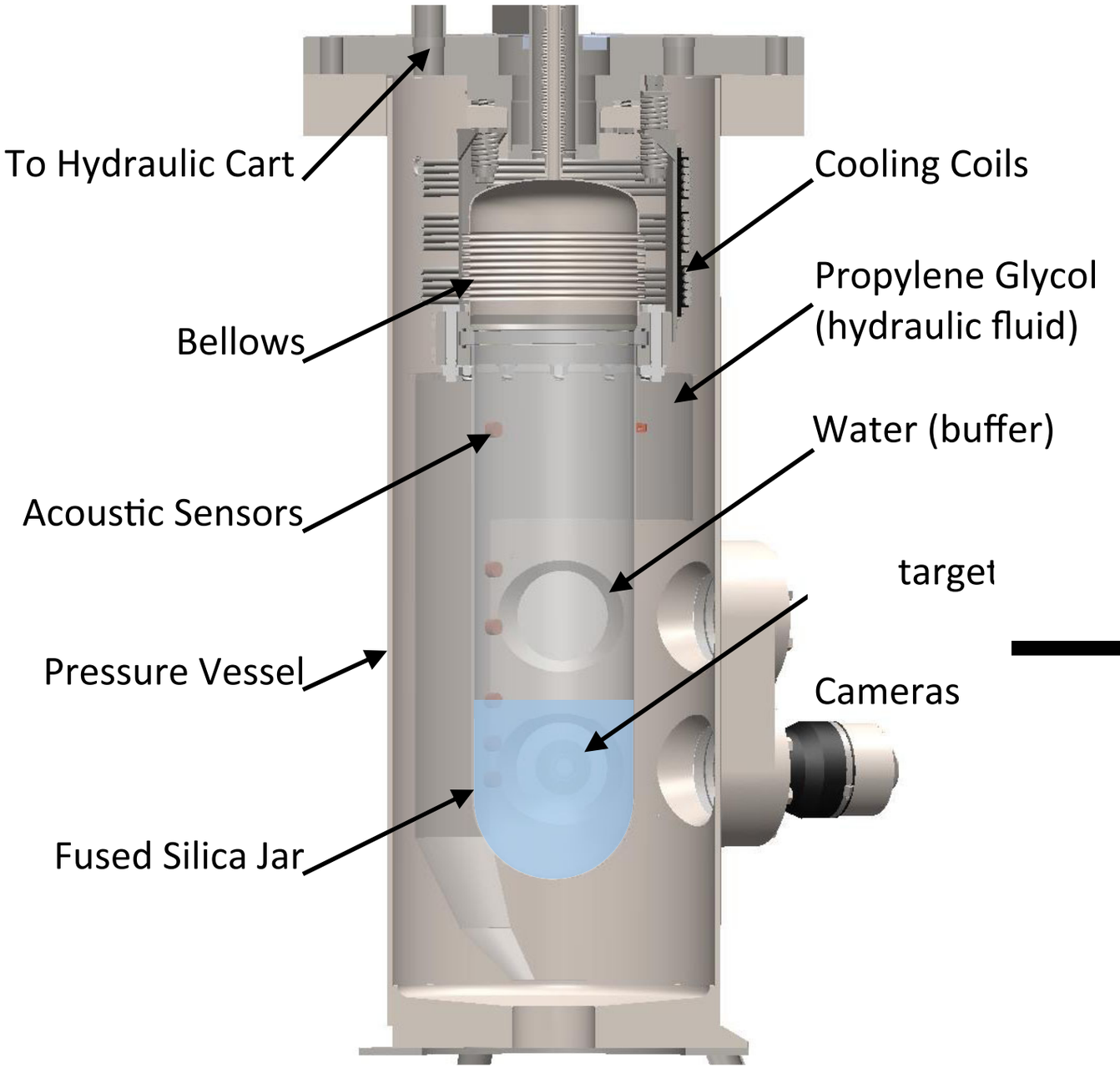


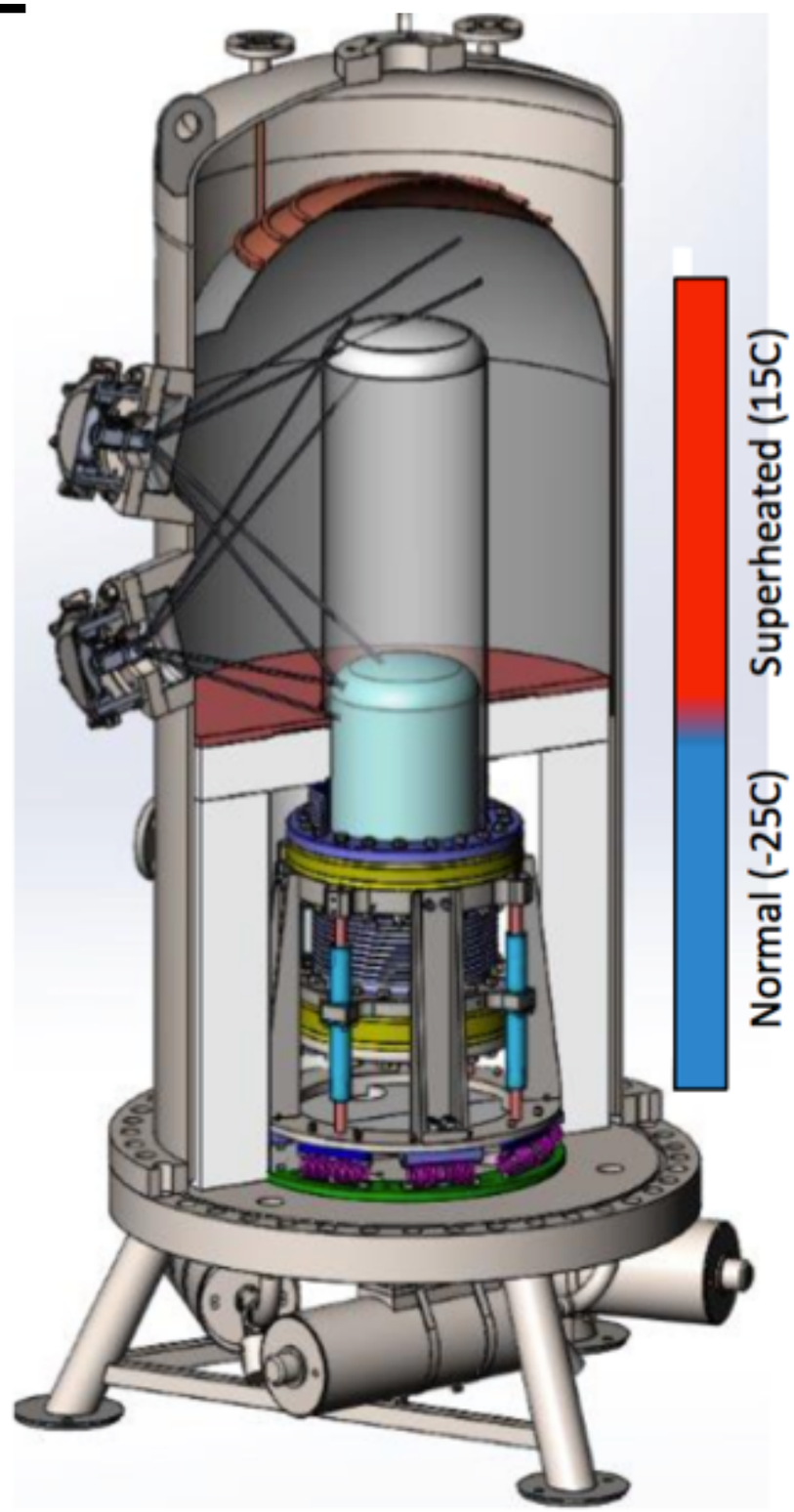
Remove this interface, contact between active fluid H_2O



PICO-40L

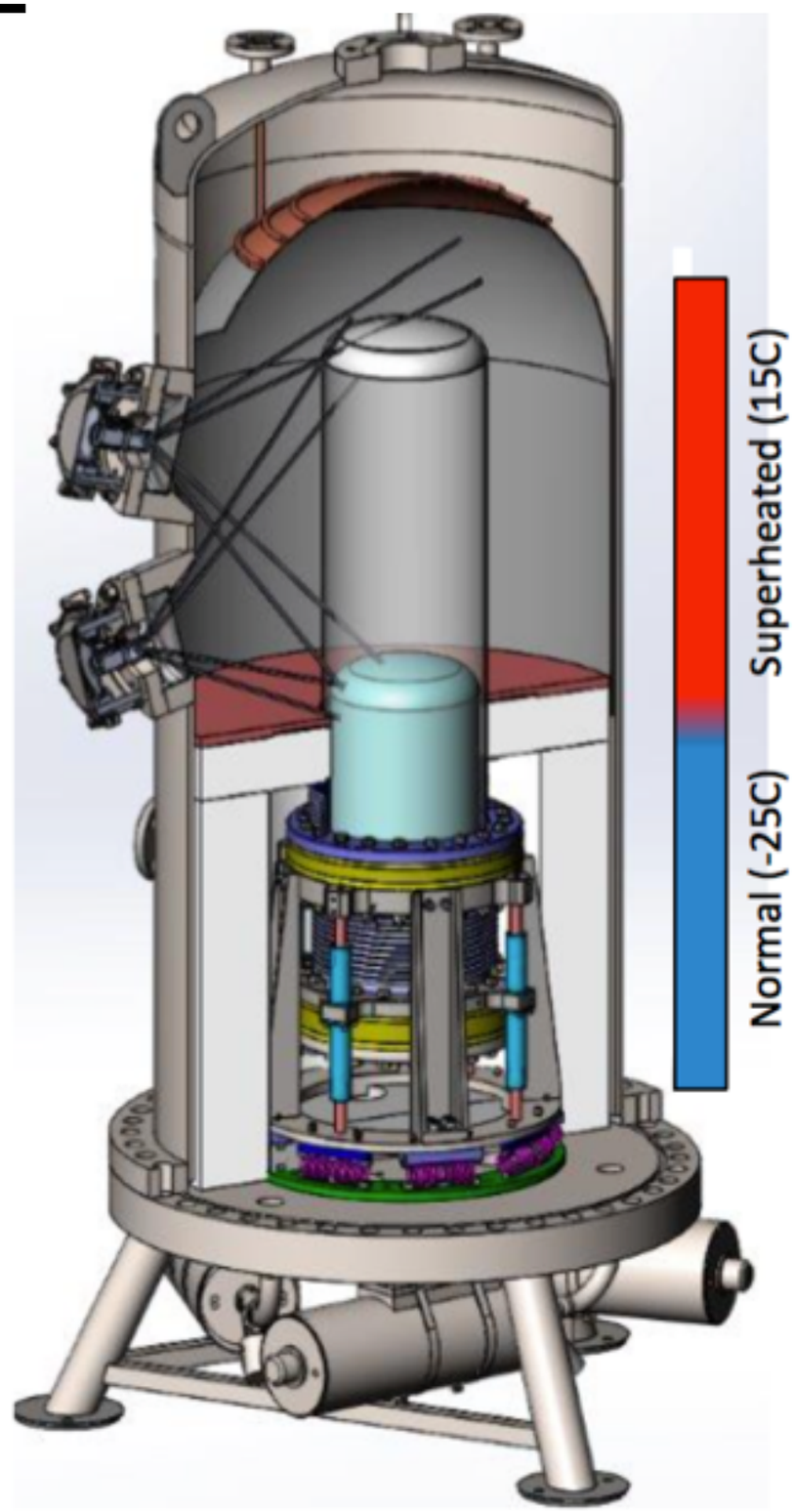
PICO-40L


To Hydraulic Cart
Cooling Coils
Bellows
Propylene Glycol
(hydraulic fluid)
Water (buffer)
Acoustic Sensors
target
Pressure Vessel
Cameras
Fused Silica Jar


Superheated (15C)
Normal (-25C)

PICO-40L

- Deployed at same location as PICO-60
- Target ~40L C_3F_8
- Synthetic fused silica piston removes water interface
- Larger stainless steel pressure vessel minimizes backgrounds



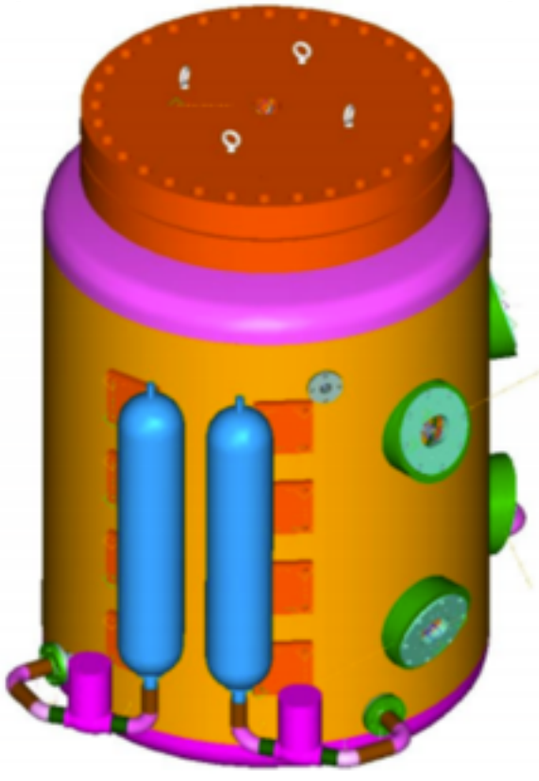
PICO-40L

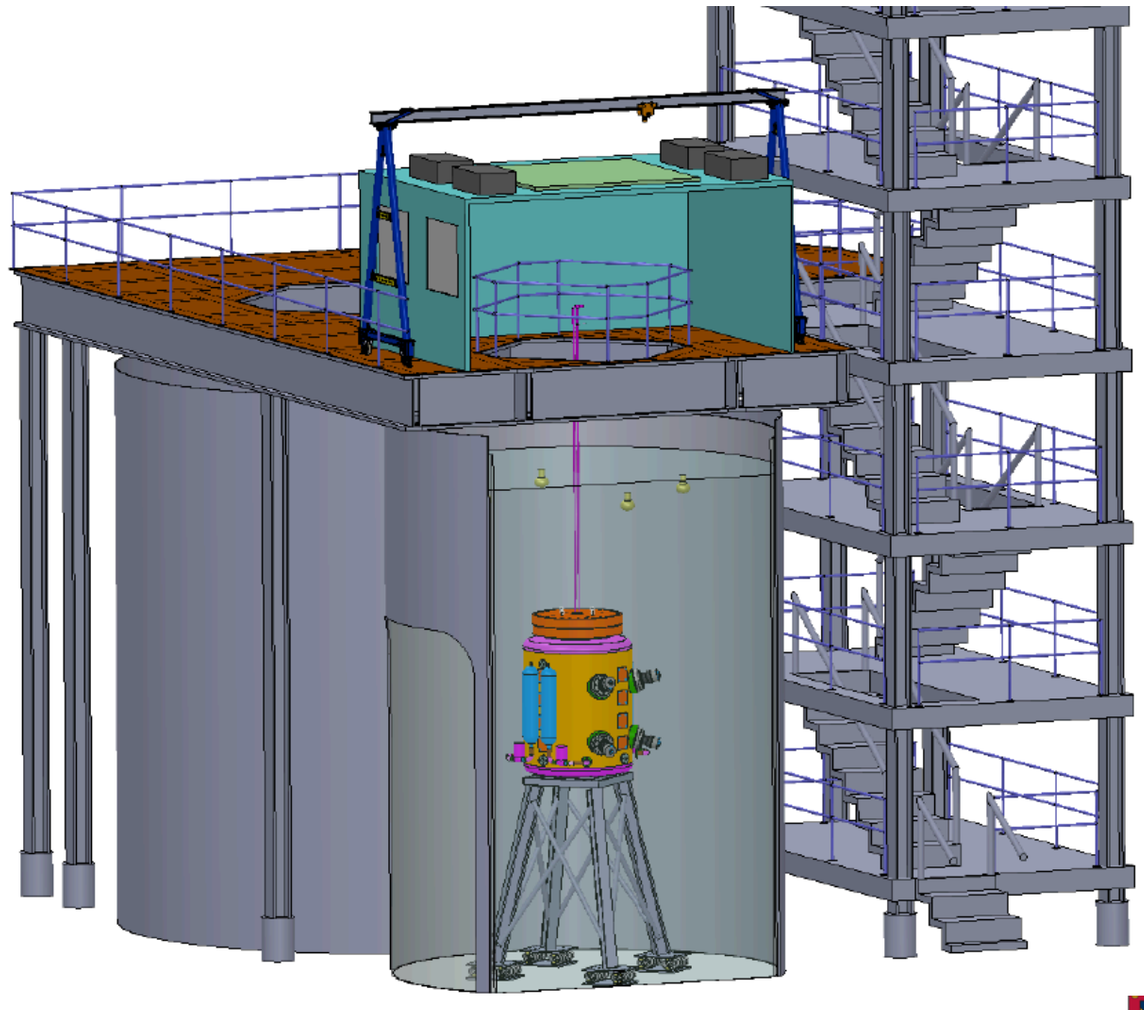
- Currently all major components being tested above ground at SNOLAB
- Shipping underground in March 2018
- Final assembly and commissioning to June 2018
- Data taking for ~a year

The Further Future - PICO 500

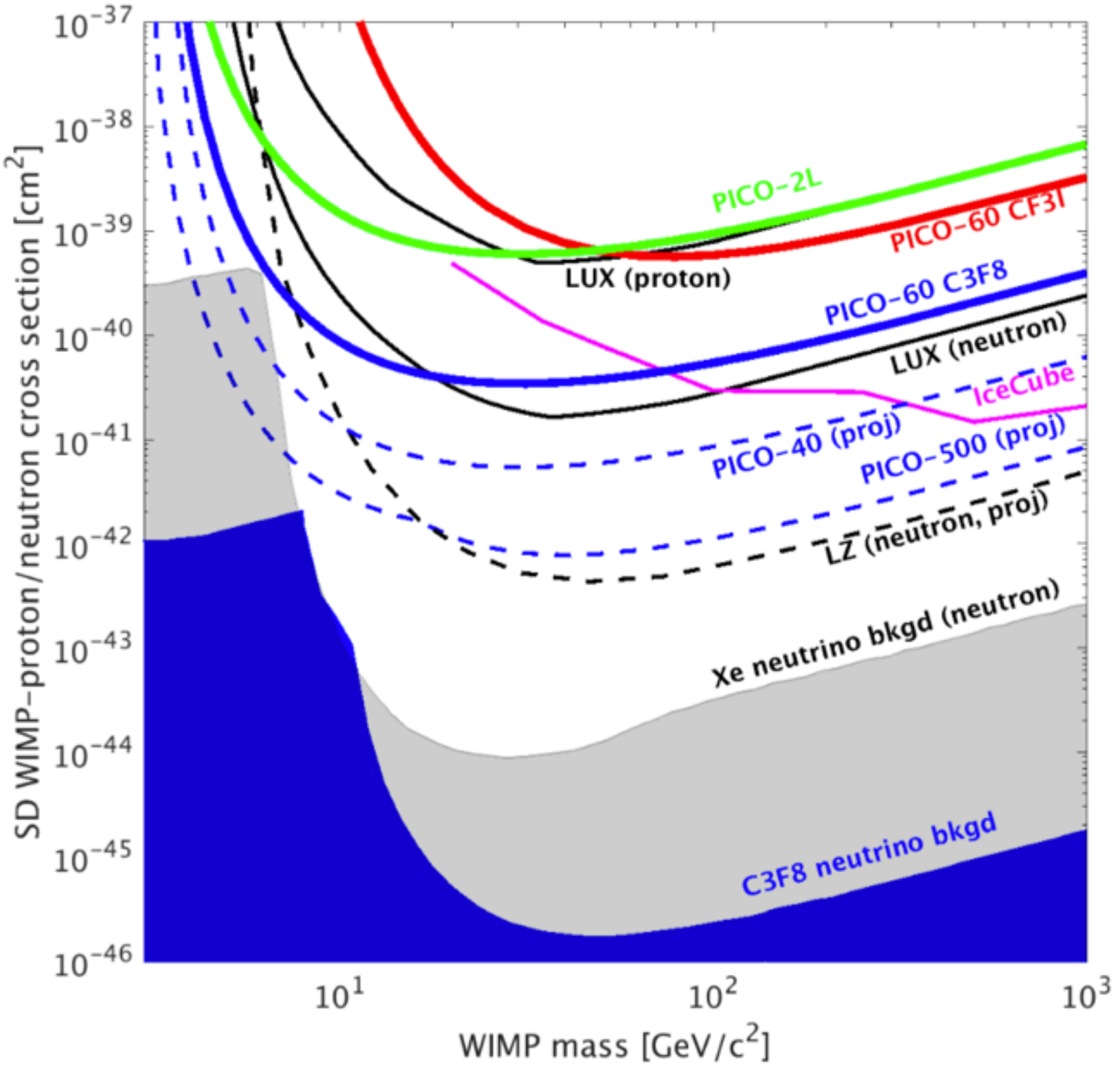
- Designed to increase sensitivity by an order of magnitude
- Could run C_3F_8 and/or CF_3I or other targets

SNOLAB cage width





The Further Future - PICO 500



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Conclusion

- PICO has investigated many backgrounds and developed a detector sensitive to small energy deposits
- PICO-60 (completed) and PICO-40L (construction summer 2018) will explore a large area of SD parameter space
- PICO-500 scheduled to begin construction in 2019

PICO

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Pacific Northwest National Laboratory
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Northwestern University
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