

Status of the PICO-40L Bubble Chamber

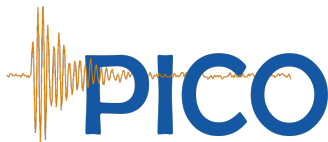
Colin Moore

Queen's University

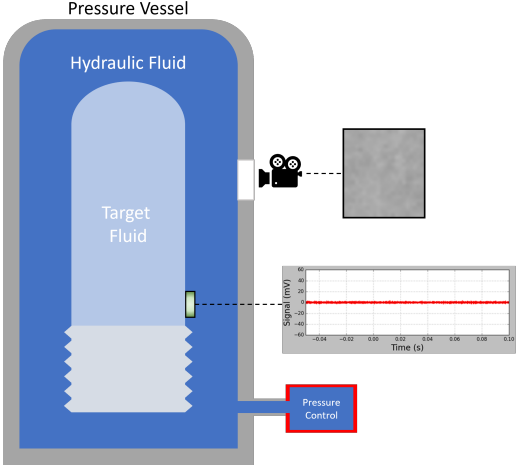
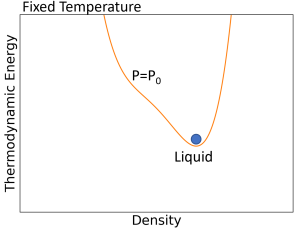
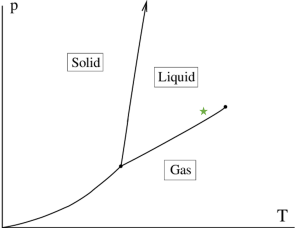
May 26, 2022



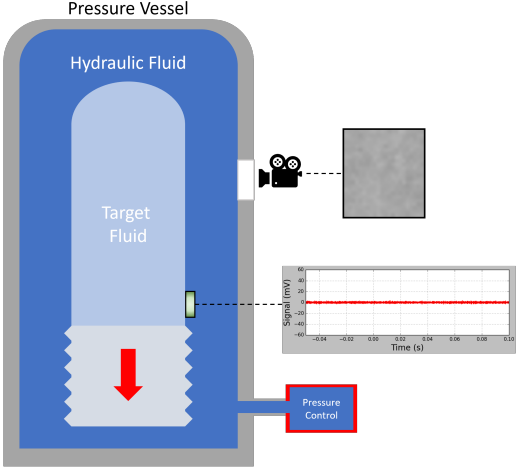
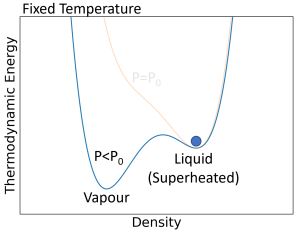
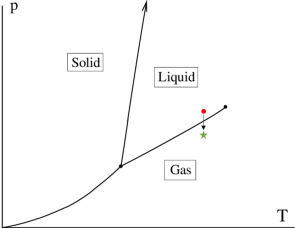
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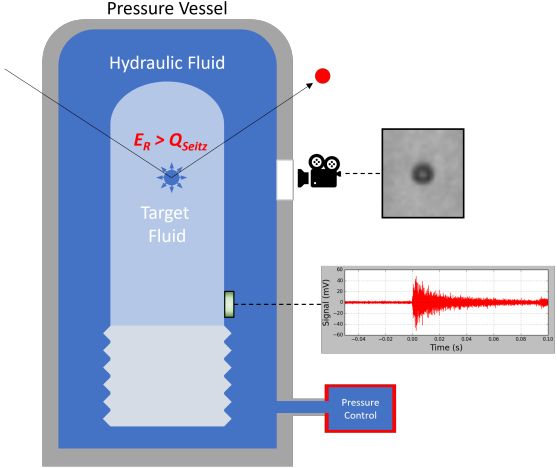
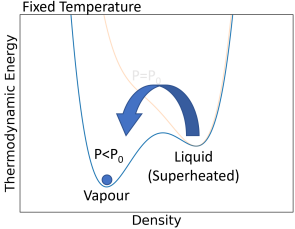
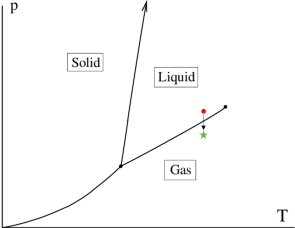
Bubble Chambers as Particle Detectors



Bubble Chambers as Particle Detectors



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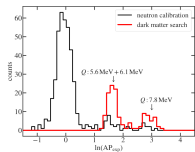


Background Events in Bubble Chambers

Alphas

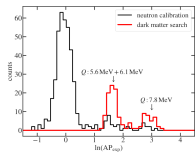
Nuclear Recoils

Electron Recoils



Background Events in Bubble Chambers

Alphas

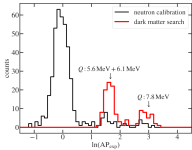


Nuclear Recoils

Electron Recoils

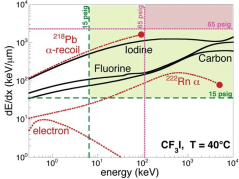
Background Events in Bubble Chambers

Alphas



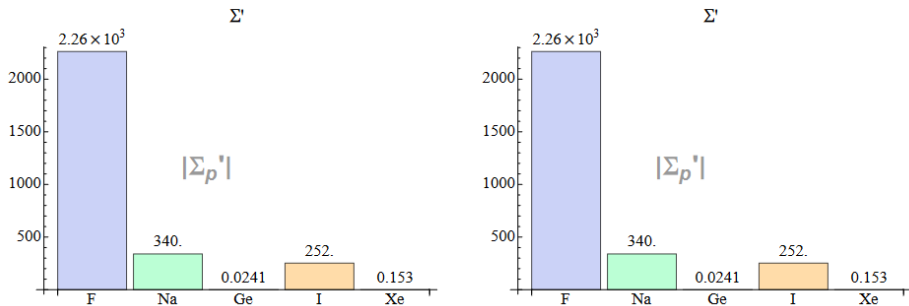
Nuclear Recoils

Electron Recoils



Why Bubble Chambers?

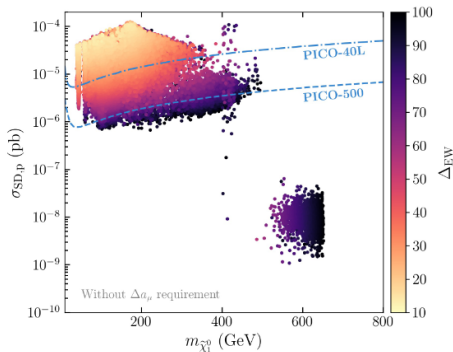
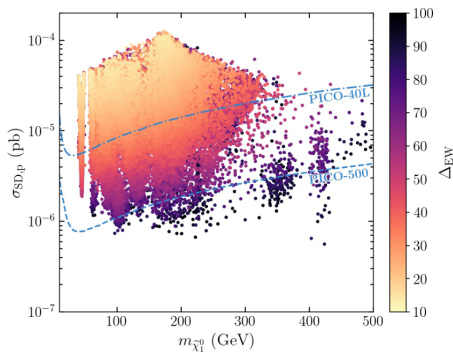
- Very low sensitivity to electron recoil events
- Ability to rapidly change target fluids to exploit sensitivities
- Large unexplored parameter space with promising physics results



Fitzpatrick (2012)

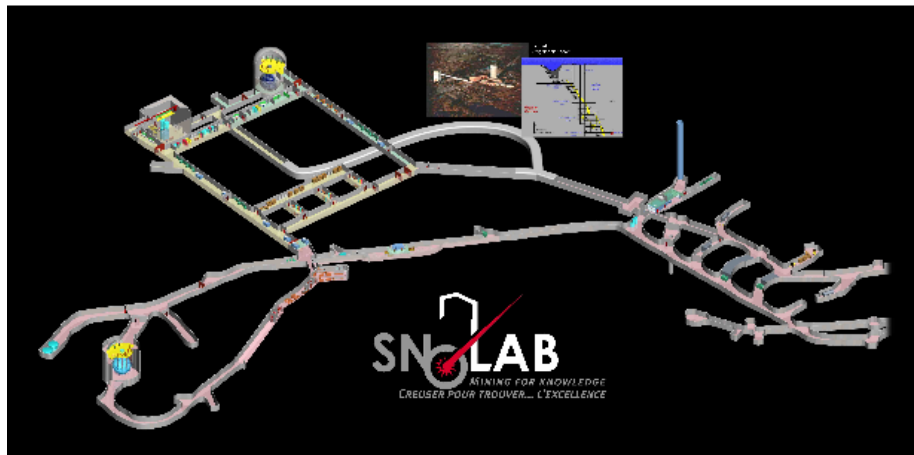
Why Bubble Chambers?

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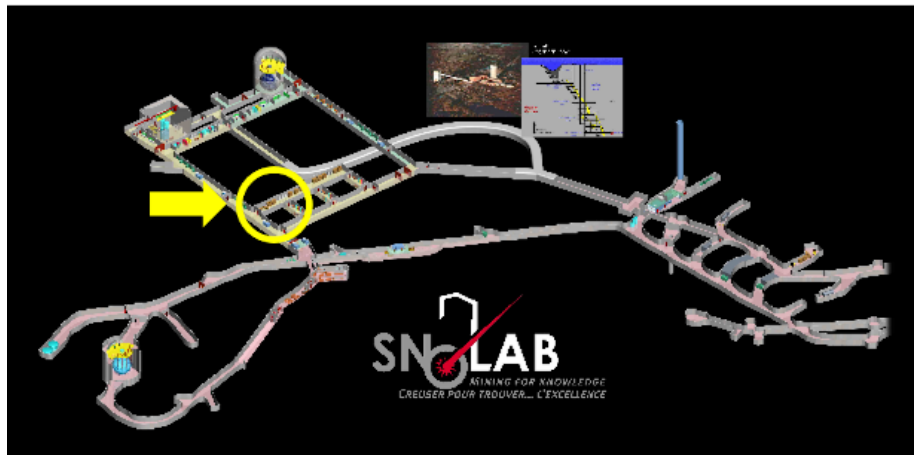
Beekveld et al. *Dark matter, fine-tuning and $(g - 2)\mu$ in the pMSSM*, (2021). 10.21468/SciPostPhys.11.3.049

PICO at SNOLAB



Jillings, Chris. (2016). The SNOLAB Science Program. *Journal of Physics: Conference Series*. 718. 062028.
10.1088/1742-6596/718/6/062028

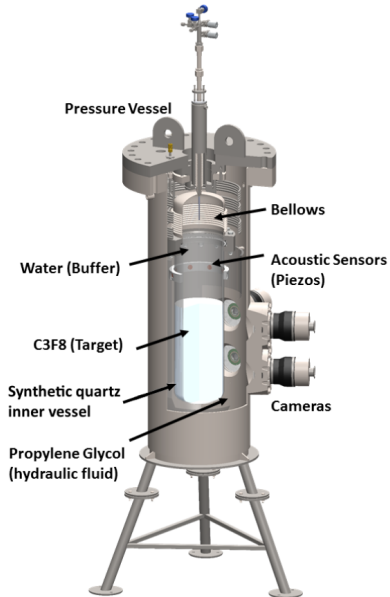
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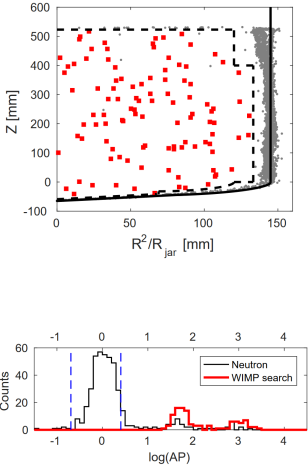
PICO-60

- 60 kg fiducial volume
- “Upside-down” design
- Full detector at constant temperature
- Superheated freon separated from bellows by layer of water
- World-leading WIMP-proton limit set in 2016 and 2017

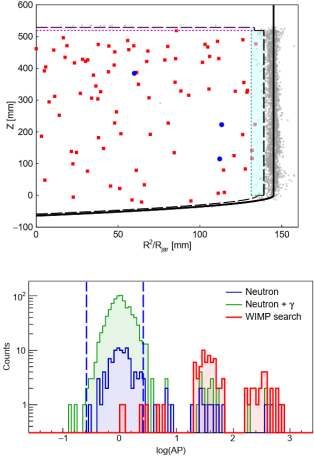


PICO-60 Results

Run 1 ($Q_{Seitz} = 3.29 \text{ keV}$)

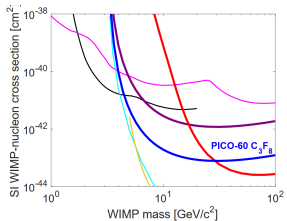
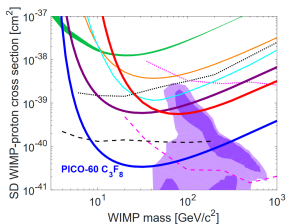


Run 2 ($Q_{Seitz} = 2.45 \text{ keV}$)

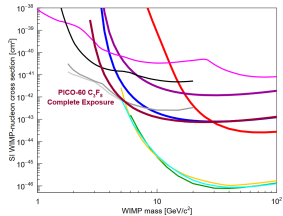
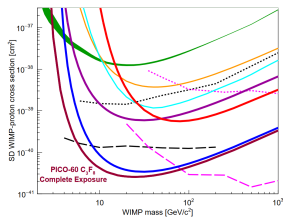


PICO-60 Results

Run 1 ($Q_{Seitz} = 3.29$ keV)

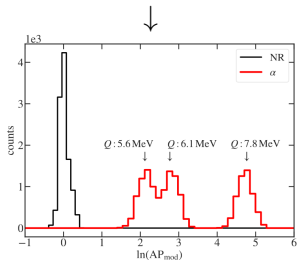
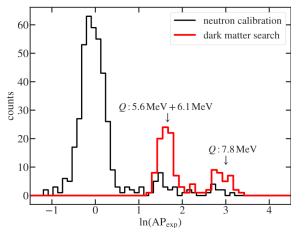


Combined (Run 1 + 2)



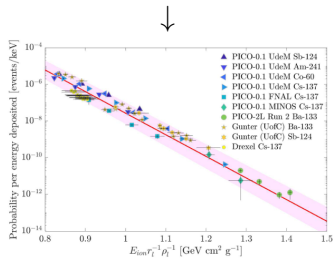
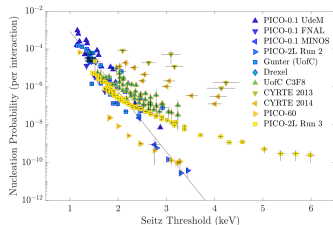
Other Physics

Molecular dynamics to model AP



arXiv:1906.04712

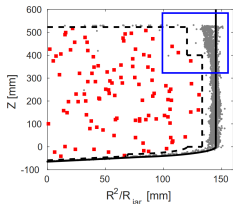
Improved ER model



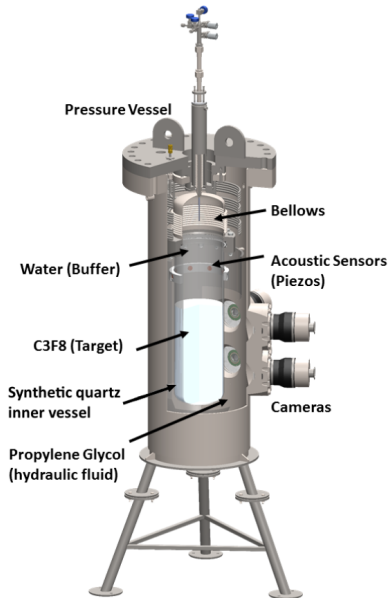
arXiv:1905.12522

PICO-60 Issues

- Water and freon mixed at interface
 - ▶ Water droplets stick to jar wall
 - ▶ Far higher rates observed near wall/freon/water interface

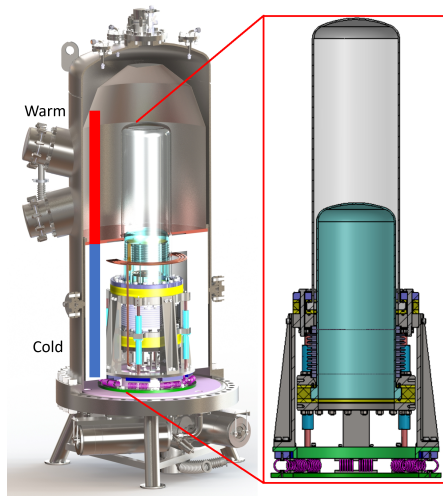


- Orientation of jar may lead to debris accumulating at bottom of jar

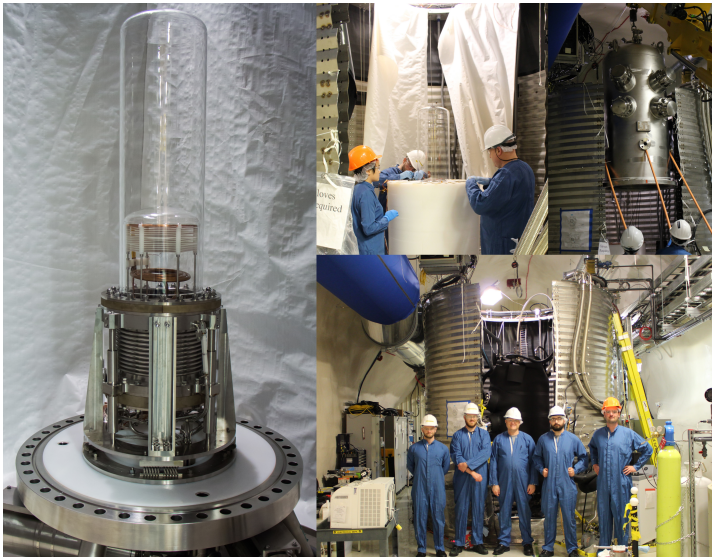


PICO-40L

- First large-scale implementation of “right-side up” design:
 - 1 Eliminate water buffer, replace with second jar
 - 2 Flip inner vessel, bellows at the bottom
 - 3 Keep bellows region cold to prevent nucleation on bellows



PICO-40L

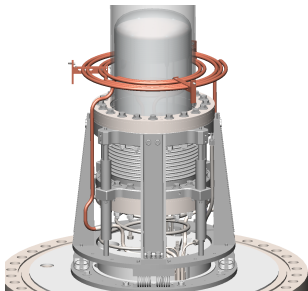


PICO-40L Timeline

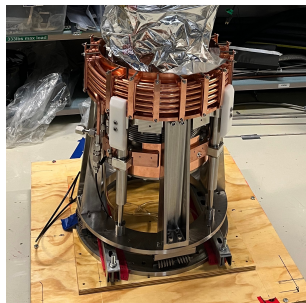
- 2019: Assembly and system tests
- May 2020: Commissioning begins with all systems active
- September 2020: Commissioning halted due to chiller failure
- May 2021: Leak appears internal to detector; disassembly begins

- 2021-2022: Fix leak, upgrades to address shortcomings of thermal system
- 2022: Reassembly
- August 2022: Recommissioning

Post-disassembly Work



Old cooling coil. Relied on convection of hydraulic fluid.



New cooling coil. Relies on conduction to cool critical components.

Current Status

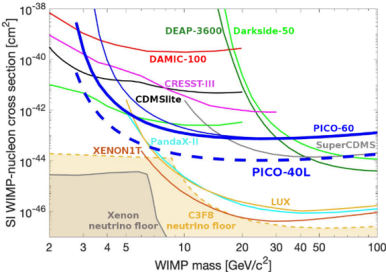
- Jars reassembled
- New cooling coils reinstalled
- Internals being reassembled



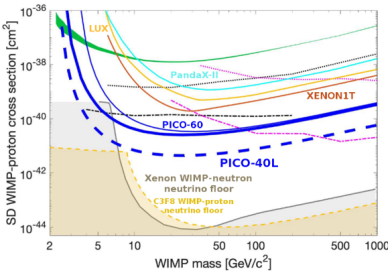
PICO-40L Limits

Approximately 1 live year of data at 2.8 keV, with 2 background events.

Spin Independent Limit

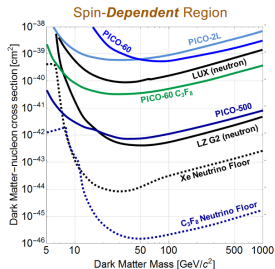
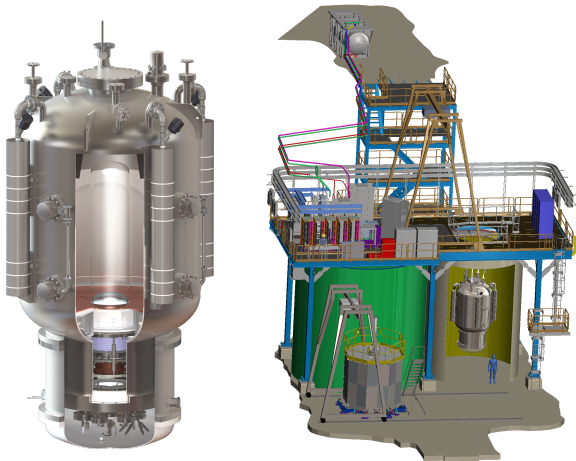


Spin Dependent Limit



PICO-500: The Next Generation Chamber

- 250 L of C_3F_8
- Situated in cube hall at SNOLAB
- Currently in procurement phase



Thanks



PICO

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C. Coutu, N.A. Cruz-Venegas, S. Fallows, T. Kozymets, C. Krauss, S. Pal, M.-C. Piro, W. Woodley

INDIANA UNIVERSITY SOUTH BEND
K. Allen, E. Behnke, I. Levine, N. Walkowski, A. Weesner

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S. Chen, M. Laurin, J.-P. Martin, A.E. Robinson, N. Starinski, D. Tiwari, V. Zacek, C. Wen Chao

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KICP
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Extra Slides



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