



# PICO Update SEF

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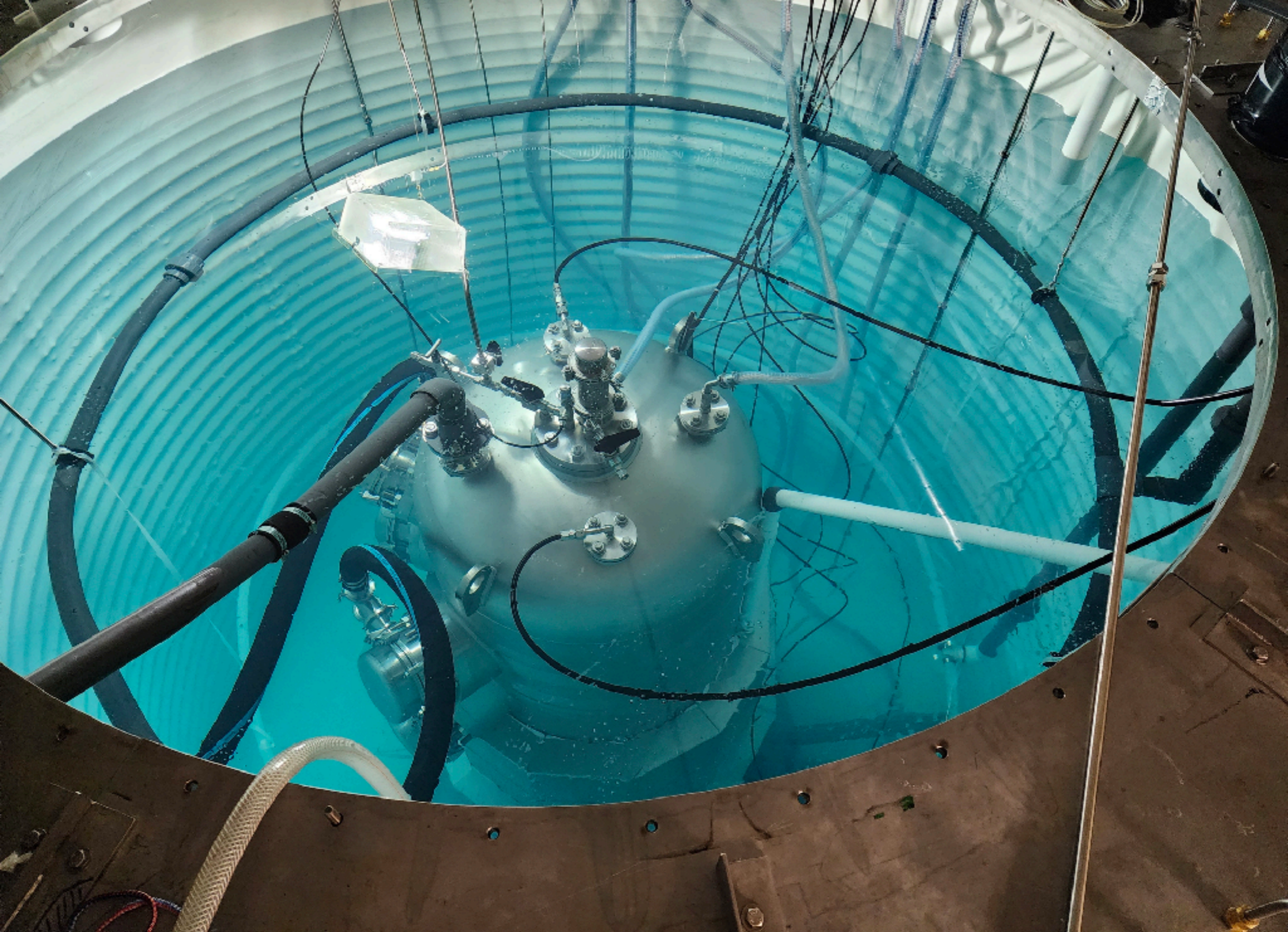
**UNIVERSITY  
OF ALBERTA**

# Experiment Overview



- PICO operates bubble chambers that are filled with a fluorine rich target fluid that gives PICO a world leading sensitivity to interactions between dark matter particles with spin and the detector
- Bubble chambers can be operated so that electron recoil events from natural radioactivity are not causing any bubble, but dark matter can
- PICO chambers offer the ability to distinguish between the remaining background events and dark matter interactions
- PICO-40L was designed as a large bubble chamber with a new chamber design that optimizes the sensitivity to ultimately allow a 10 times increased sensitivity compared to previous PICO chambers.



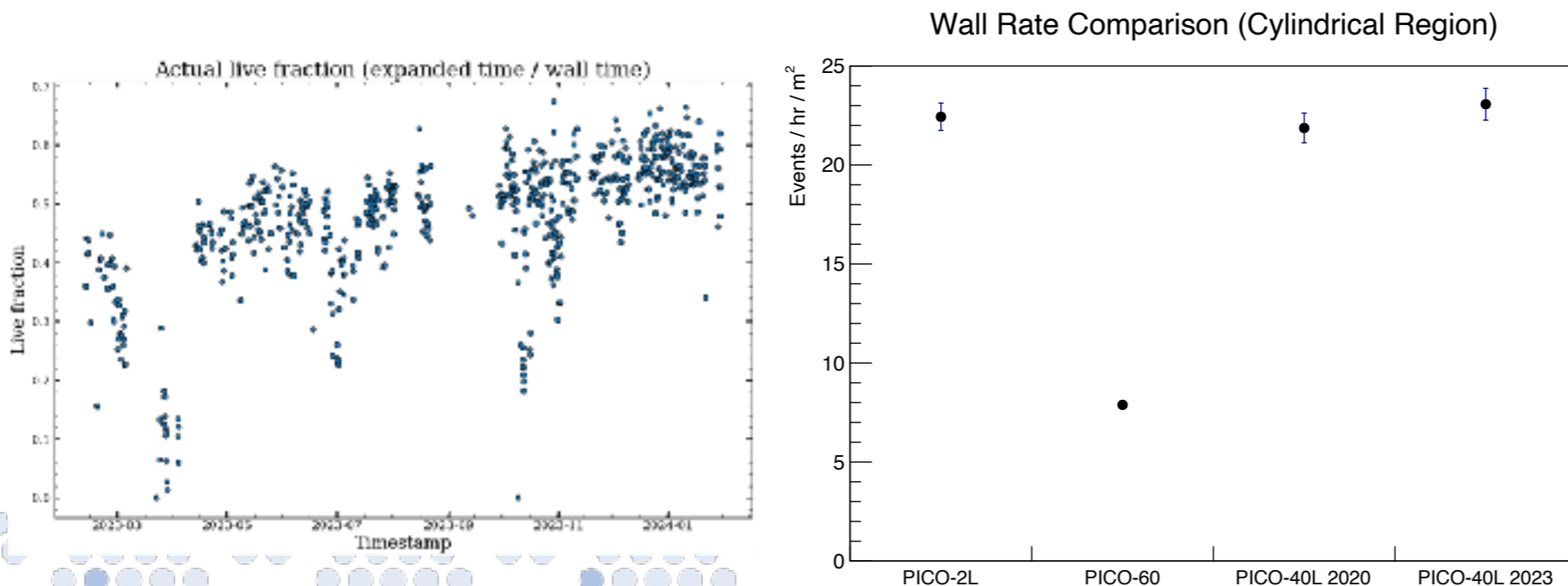




# New developments: PICO-40L



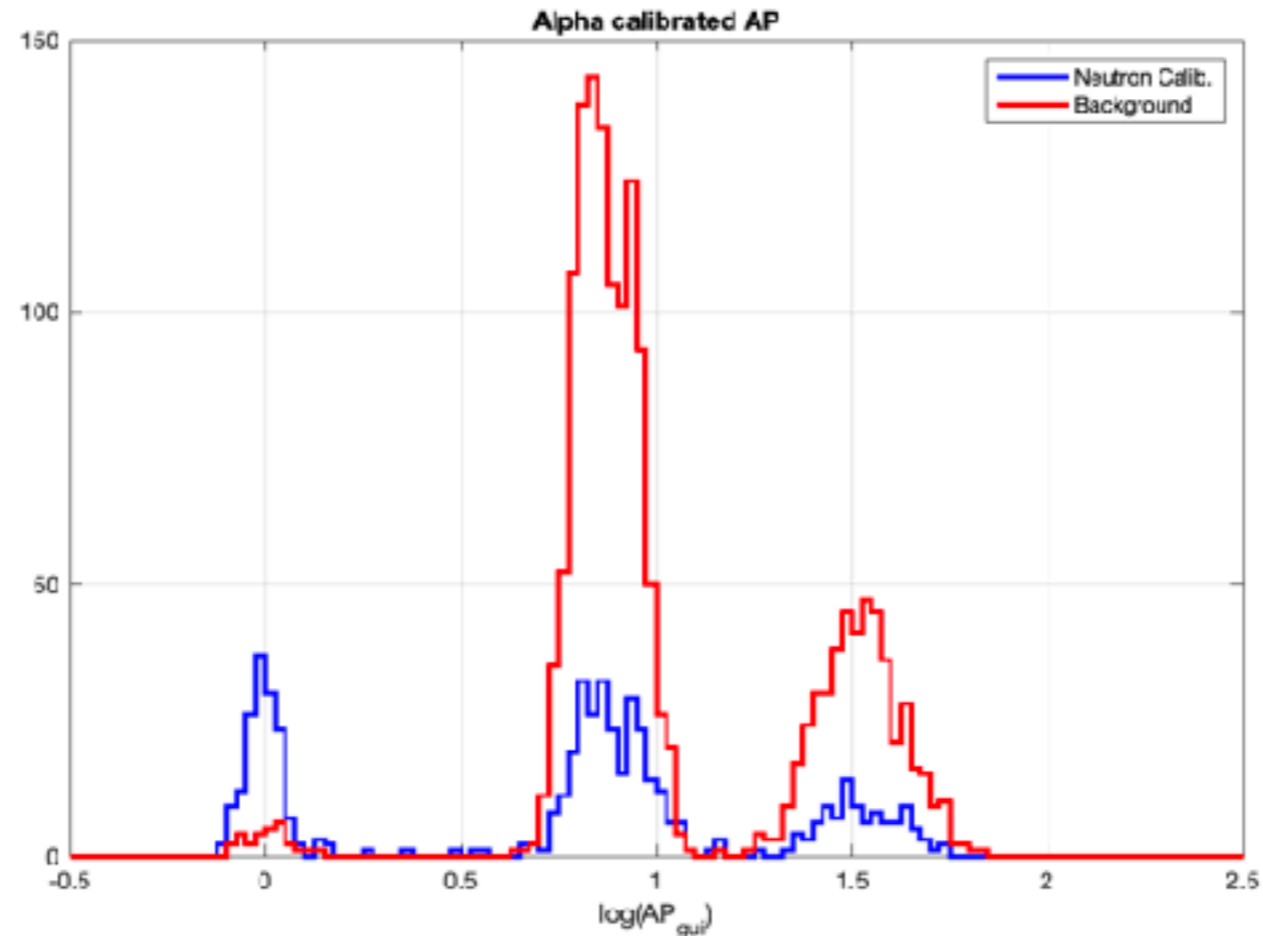
- The upgrade, assembly and testing of PICO-40L was completed and the detector has been running stably since October 2023 with full neutron shield!
- Data analysis of the commissioning data is well advanced, we are able to identify acoustic alpha peaks like in previous detectors (now also established for PICO-40L), we are able to distinguish single and multi bubbles with the fast pressure transducer and the optical reconstruction of bubble events is working well!
- We have a wall rate that is consistent with the wall rate of PICO-2L and PICO-40L run 1 (2020), but higher than in PICO-60



# Acoustic Spectrum PICO-40L



- Resolution is as good as our best past chambers (aided by the elevated population of alpha events)
- We are seeing the  $^{218}\text{Po}$  and  $^{214}\text{Po}$  peaks clearly separated. An analysis of the timing structure is underway, many alpha events come in pairs
- The background events are evenly distributed in space and time



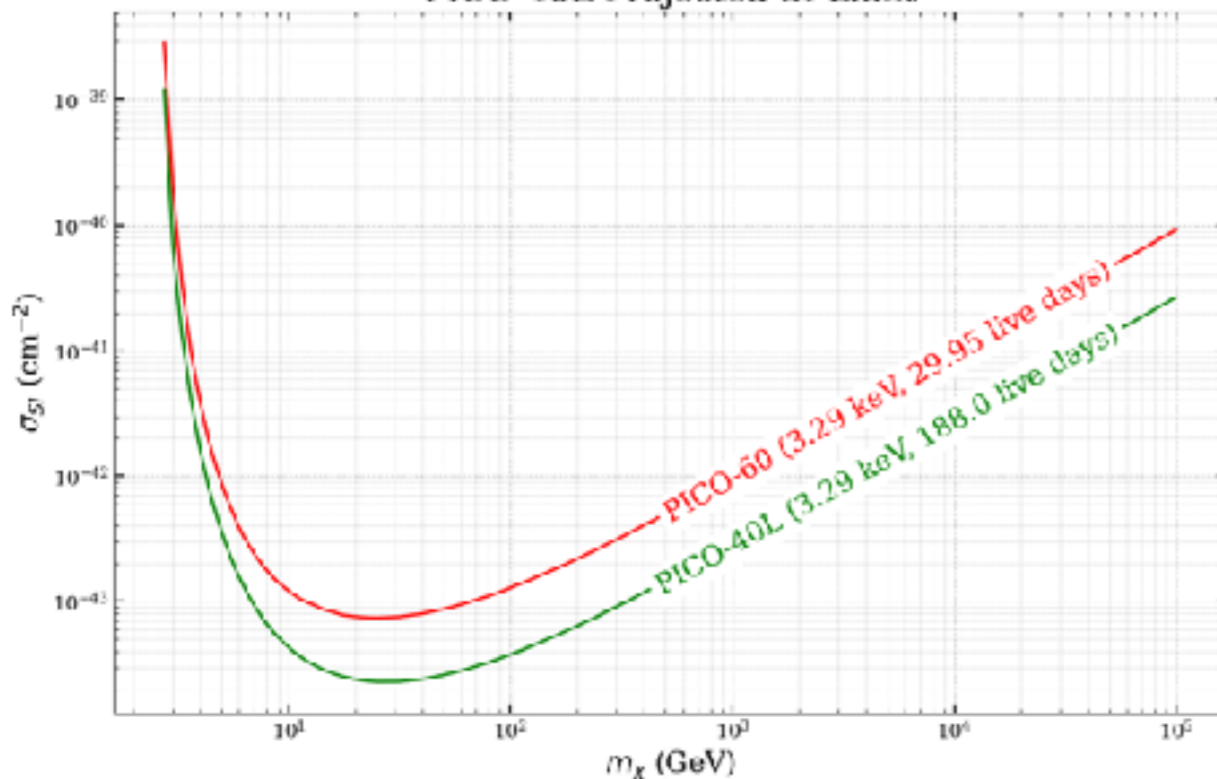
# PICO-40L projection

At 25 GeV:

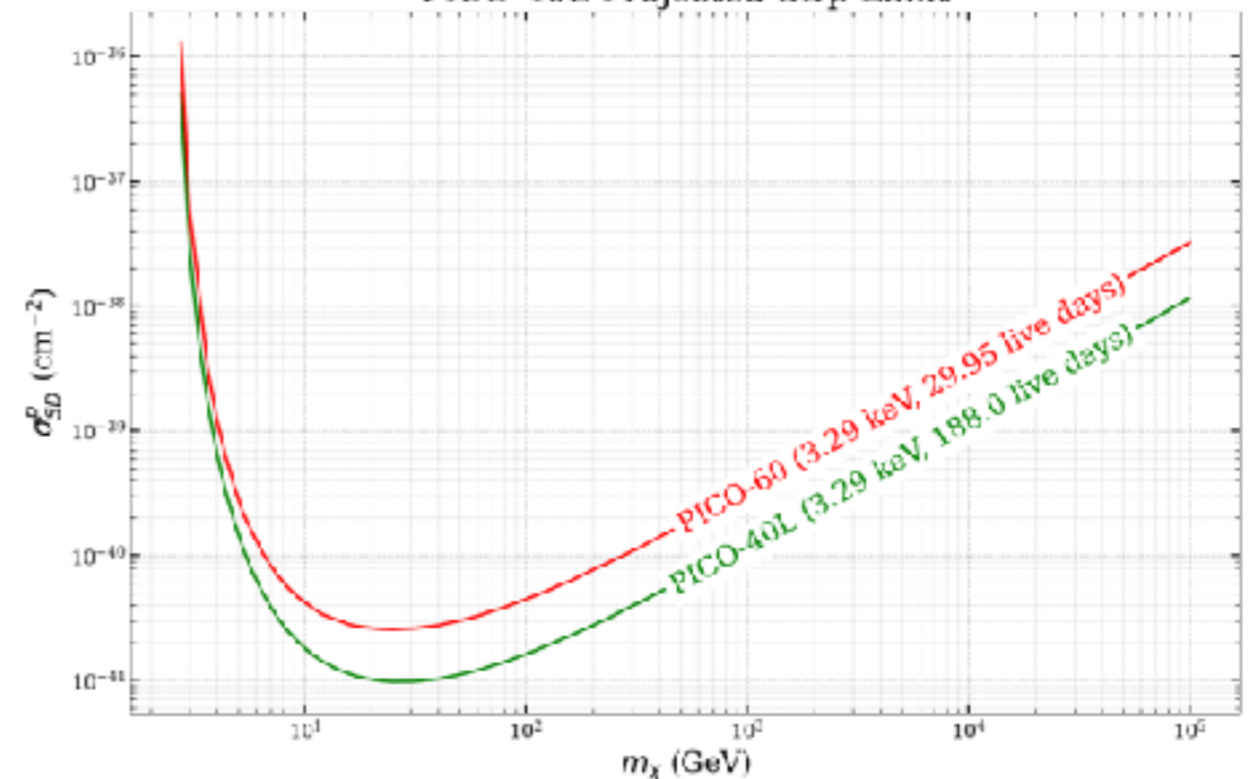
- 3.3x improvement in SI
- 2.6x improvement in SD

- Alpha rate: 62.4 cts/live day (20.6  $\mu\text{Bq/L}$ )
- Wall rate: 459.6 cts/live day (25.6 events/h/m<sup>2</sup>)
- Bellows rate: 306.4 cts/live day
- Dead time: 97 seconds (current average dead time)
- 3.29 keV threshold, 45.3 kg fiducial mass
- Running time: 1 year @ 51.5% live fraction (188 live days)
- **2 low-AP events**

PICO-40L Projected SI Limit

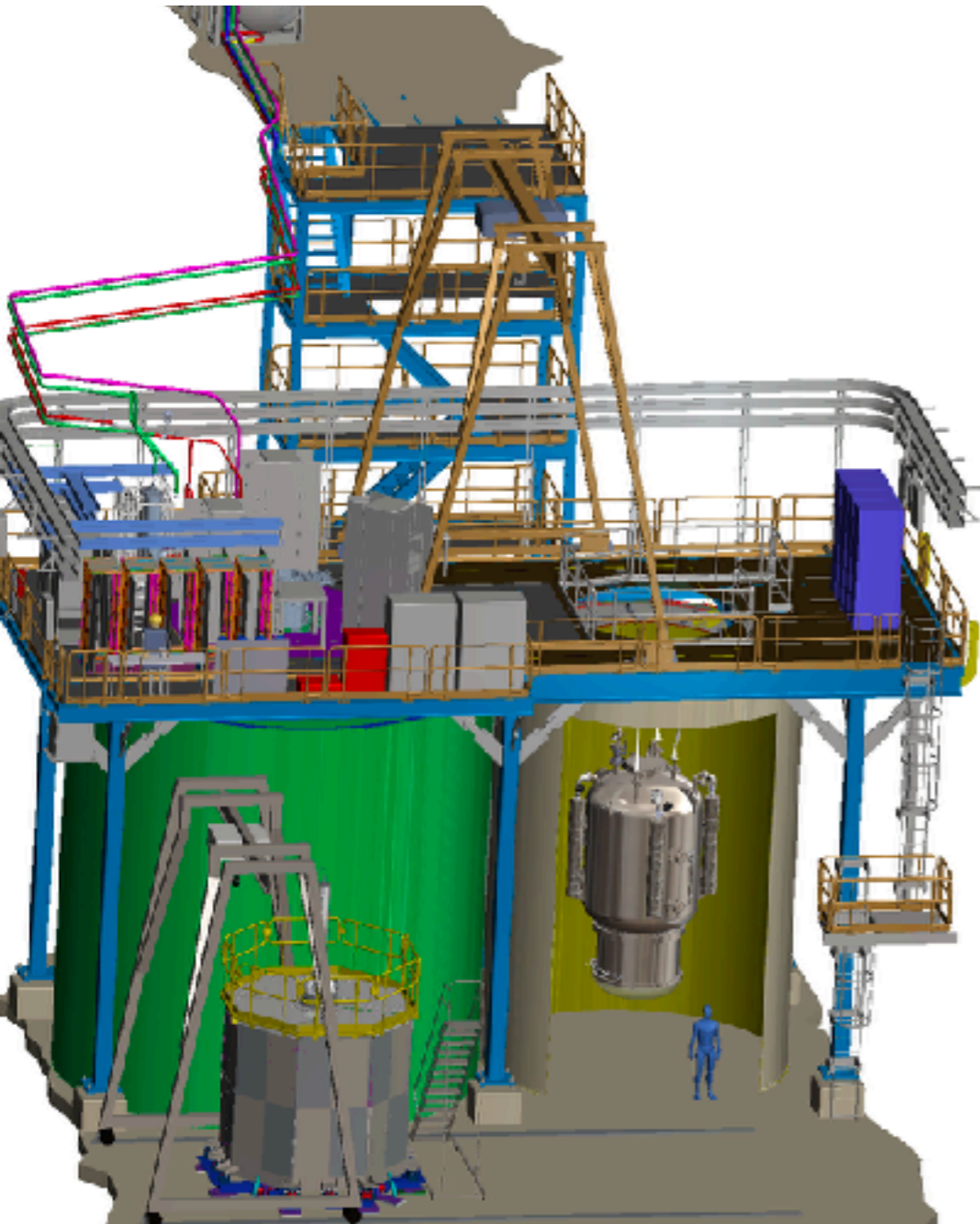


PICO-40L Projected SDp Limit





# PICO-500



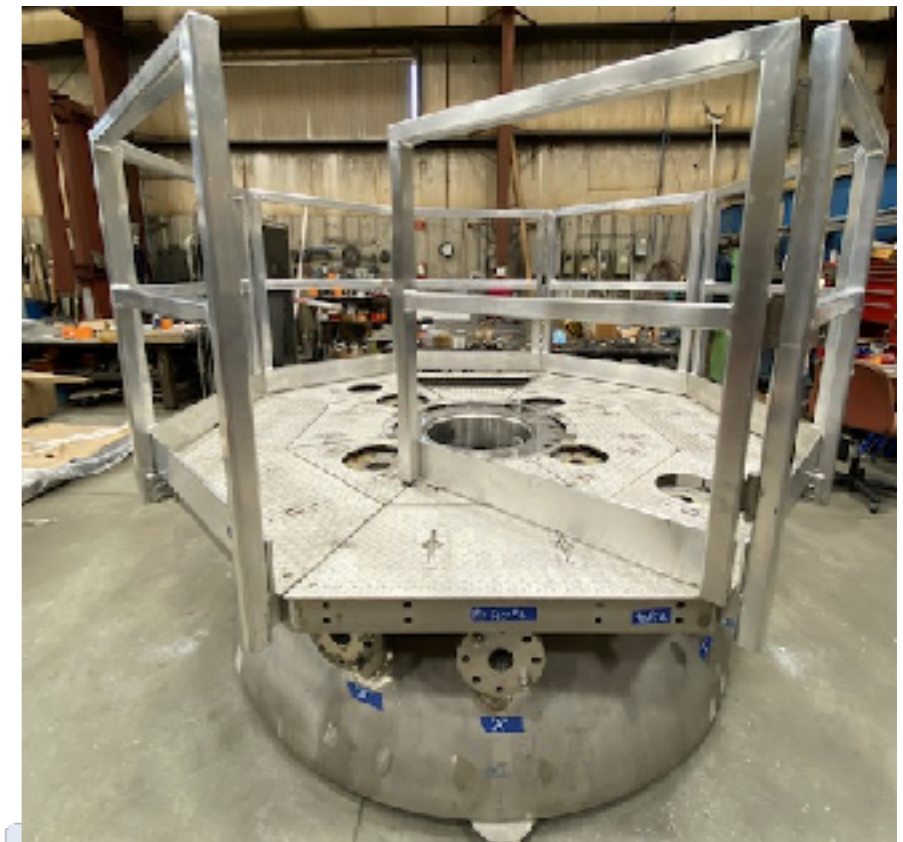
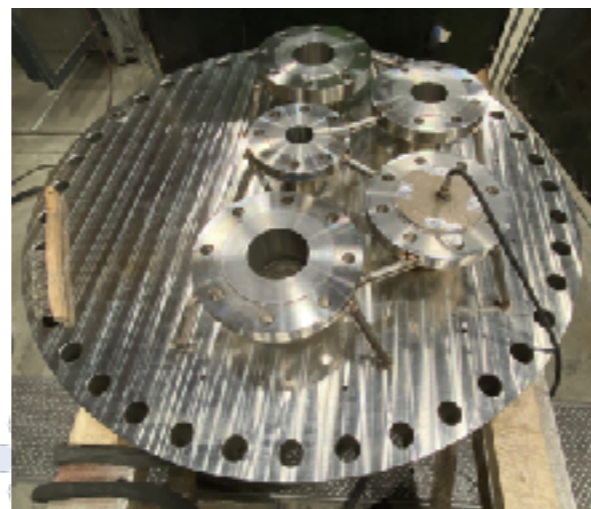
- PICO-500 is a larger bubble chamber using the same principle as PICO-40L that is being build in 2024 and 2025 at SNOLAB
- This chamber pushes the limit of our current ability to build and operate low background bubble chambers
- We expect a factor of 10 in increased sensitivity to spin carrying dark matter



# New developments: PICO-500



- The pressure vessel is under construction at SAS in Lively
- Suspension and seismic design have stopped underground progress
- The inner vessel components are finished, have been test assembled and hold vacuum well. All IV parts are being packed for shipping to SNOLAB
- The planning of the underground assembly and cleaning is complete
- We are now focusing on the suspension system and upcoming reviews and the building and testing of the pressure system, calibration systems and the freon fill system





# Schedule impacts & milestones



- PICO-40L is expected to run for the coming 12 months at least. The goal is to find out what the background is and reduce or eliminate it (or verify that it's a signal)
- We will bring large PICO-500 parts underground in the coming weeks and months
- The PICO-500 TDR is scheduled for April 3rd. The inner vessel assembly will start around the same time
- The suspension system design review will be completed around the same time and then independently reviewed.
- The PICO-500 detector construction could be finished in 2025, operation could start as early as Oct 2025 if the Vale PMP doesn't disrupt installation and the suspension design can be finished as planned.

# Challenges



- PICO-500 was held up by the final review of the seismic suspension system. Since the initial design the detector became lighter and the design earthquake got less severe. Initial studies by SNOLAB's new structural engineer show that the most severe load case is still viable. The smaller load seismic cases are a bit harder to analyze and need to be completed and signed off before the PICO-500 PV welding will commence.
- PICO-40L has more backgrounds than designed for (alpha, due to a mixup during the design phase, wall for unknown reasons, bellows background due to lack of ability to reach low enough temperatures). These backgrounds reduce live time.
- The physics background does not seem particle induced. We are systematically changing running conditions to understand the origin of these events.



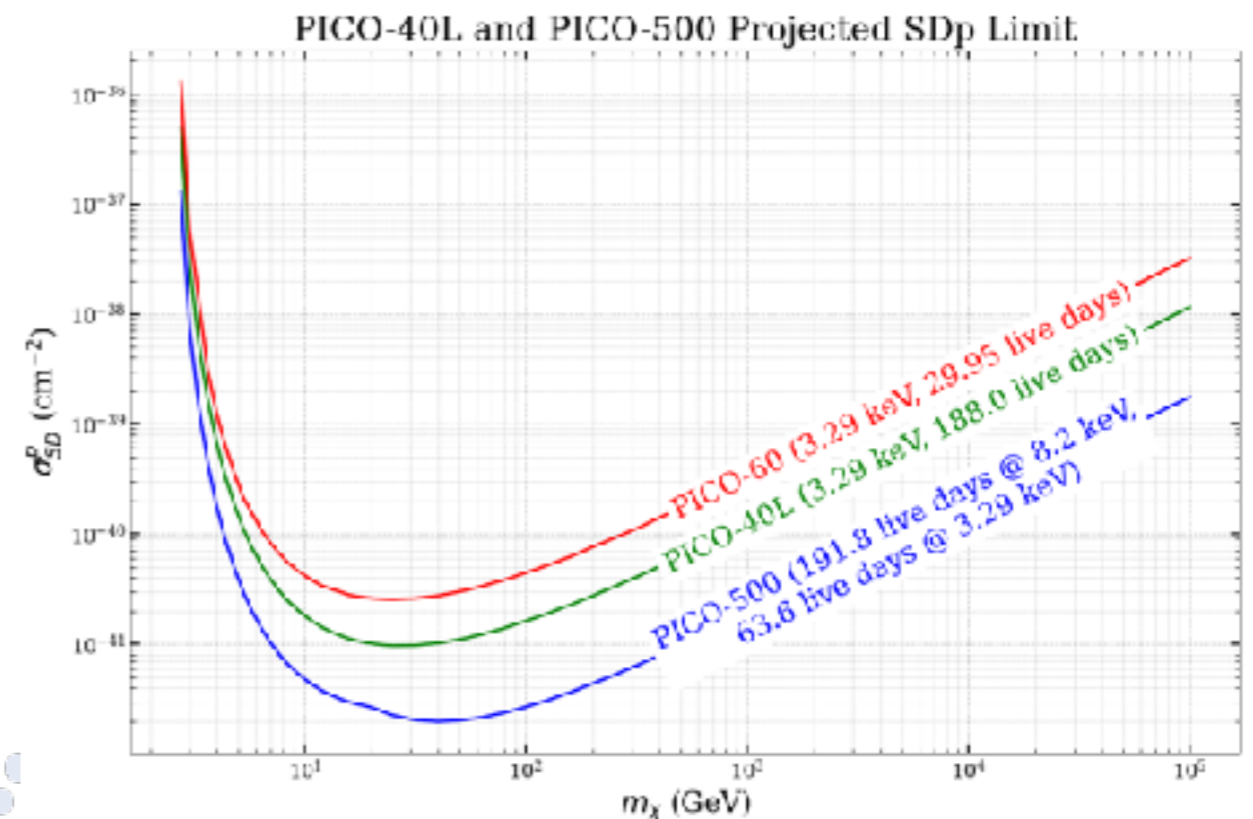
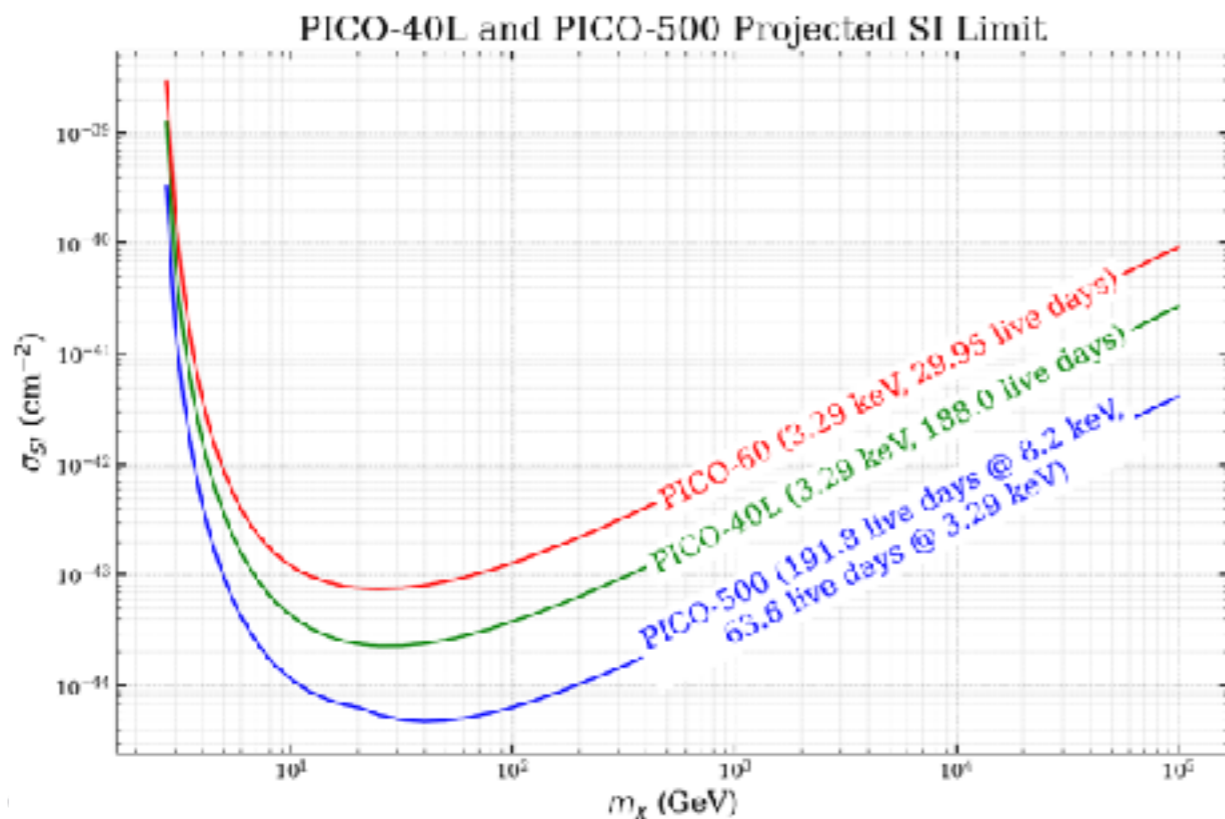
# PICO-500 projection



At 40 GeV:

- 16.9x improvement in SI
- 14.0x improvement in SD

- Alpha rate: 462.2 cts/live day (20.6 uBq/L)
- Wall rate: 1472.3 cts/live day (25.6 events/h/m<sup>2</sup>)
- Bellows rate: 414.1 cts/live day
- Dead time: 168 seconds
- Live fraction: 17.5%
- Fiducial mass: 366.9 kg
- 1 running year at 3.29 keV (63.6 live days), **1 background event**
- 3 running years at 8.2 keV (191.8 live days), 2 background events



# Conclusion



- The operational goals of PICO-40L have been achieved. Large “Right-side up” bubble chambers can stably operate.
- We are exploring the background events observed
- Data analysis of PICO-40L data is still wonderfully easy and progresses at a very fast pace. The acoustic alpha energy resolution is excellent
- PICO-500 is waiting for the seismic re-analysis of the system to be completed. The first shipments of major PICO-500 components are scheduled for the coming weeks.



