

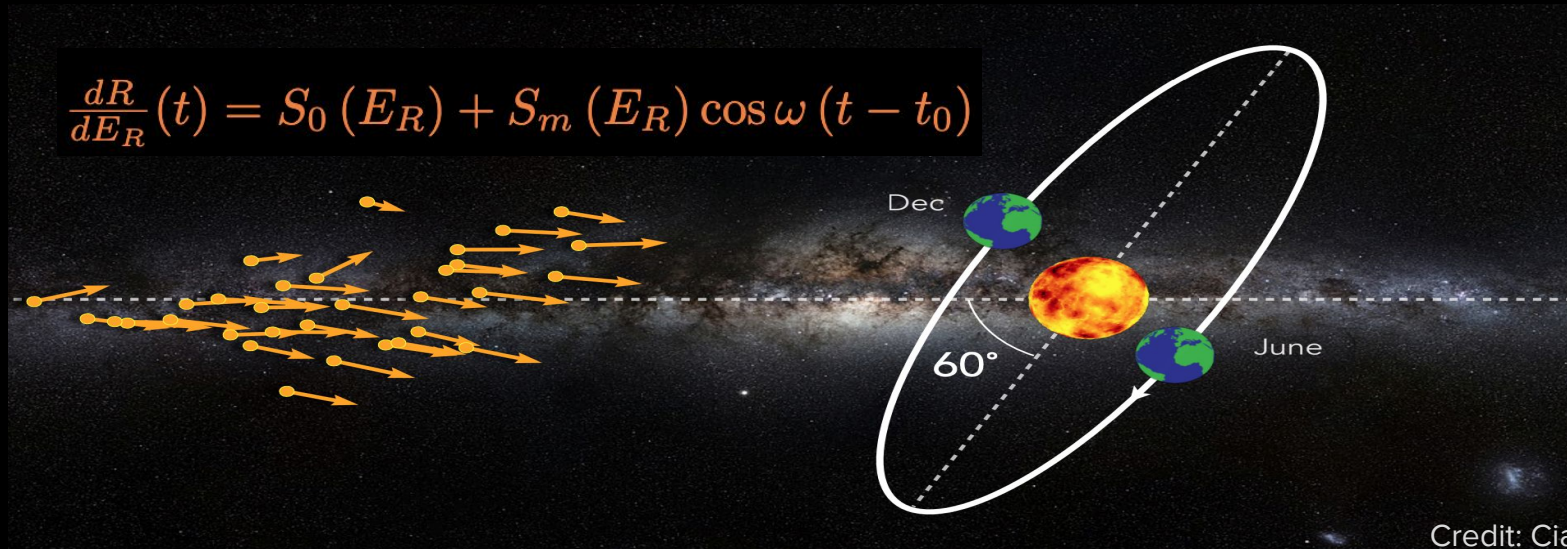
The SABRE South Experiment at the Stawell Underground Physics Laboratory

Sharry Kapoor (On behalf of the SABRE South)
The University of Sydney



Annual Modulation

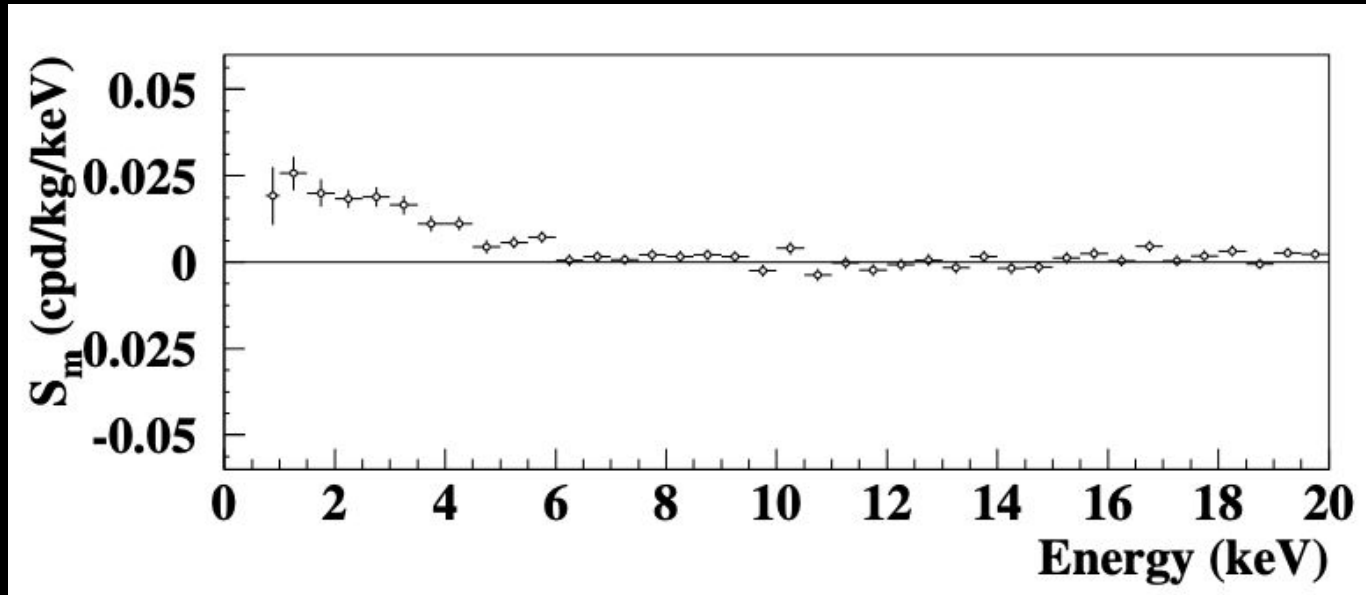
The Earth's orbit around the Sun causes variations in the relative velocity between the Earth and the dark matter halo, leading to seasonal changes in the interaction rate.



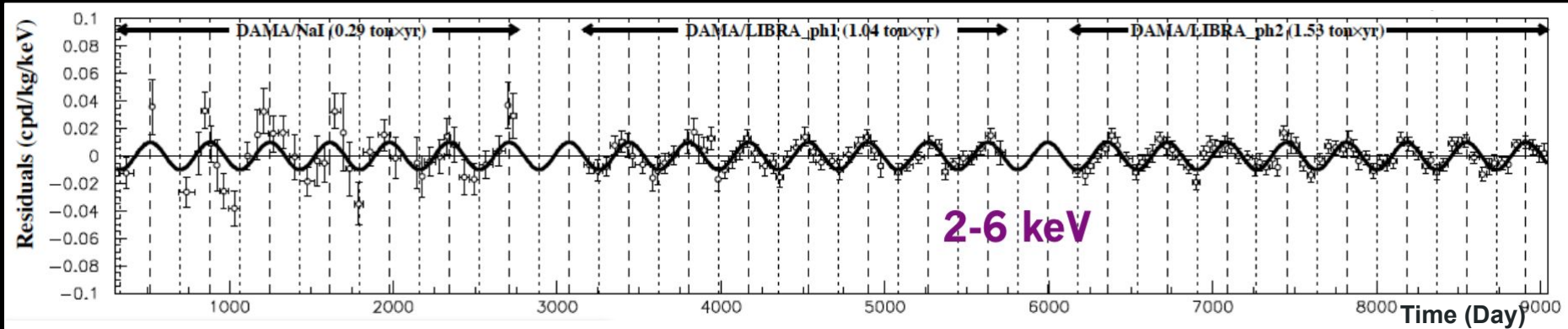
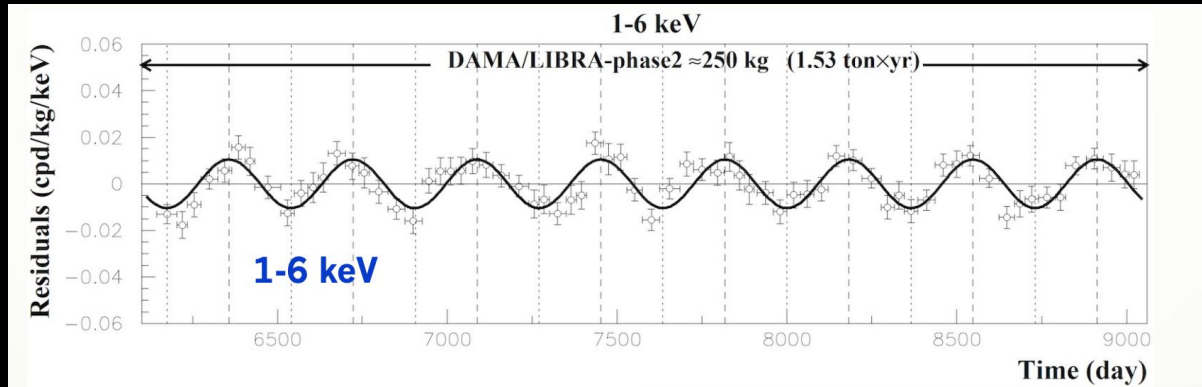
Credit: Ciaran O'Hare

DAMA/LIBRA results

- 250 kg NaI(Tl) detector based in LNGS consistently observed modulation rate compatible with DM expectations for ~ 20 years w/ 13.7σ C.L.
- $\Delta E = 2\text{--}6$ keV, Rate = 0.01014 ± 0.00074 cpd/kg/keV, Time = 142.4 ± 4.2 days

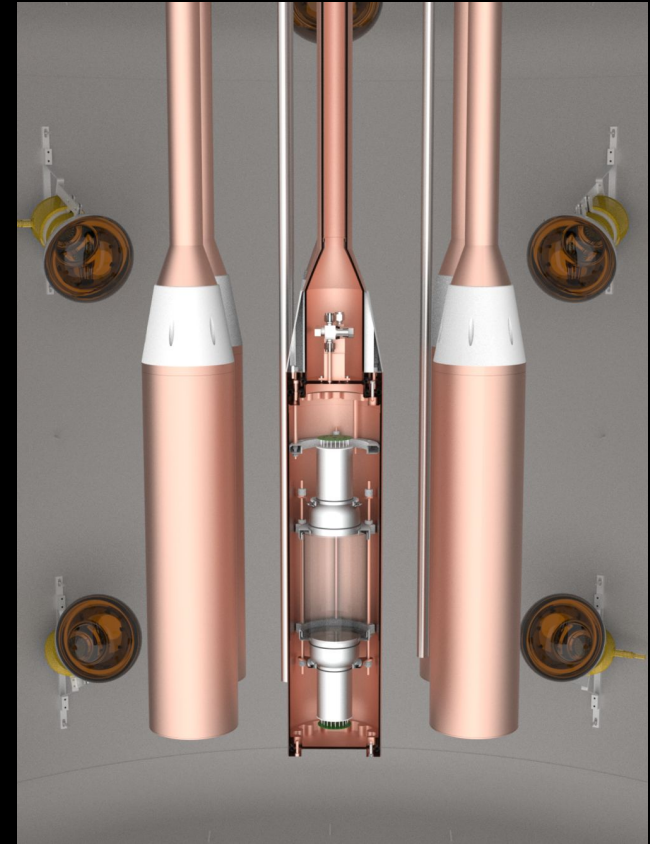


DAMA/LIBRA results



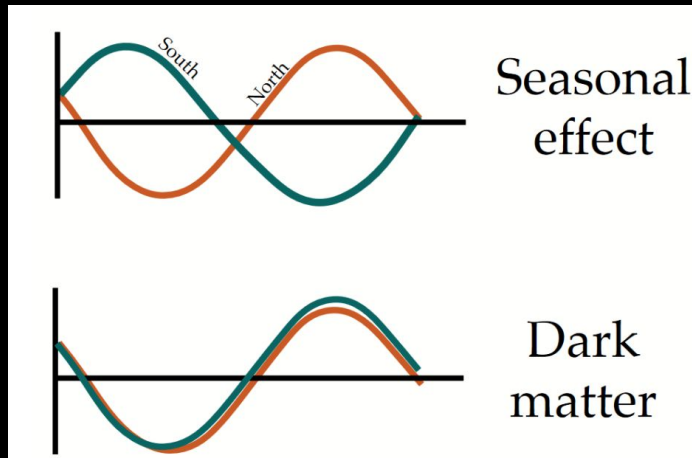
What is SABRE?

- Aim – detect an annual rate modulation from dark matter interactions in ultra-high purity NaI(Tl) crystals



What is SABRE?

- Aim – detect an annual rate modulation from dark matter interactions in ultra-high purity NaI(Tl) crystals
- Dual-site design – SABRE South (SUPL, Australia) and SABRE North (LNGS, Italy) – avoids seasonal effects



Credit: Ciaran O'Hare

[j.nima.2022.167585](https://arxiv.org/abs/2205.16758)

SABRE South

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Daniel Tempra (Technician)
Victoria Bashu (PhD)
Ferdos Dastgiri (PhD)
Lachlan McKie (PhD)



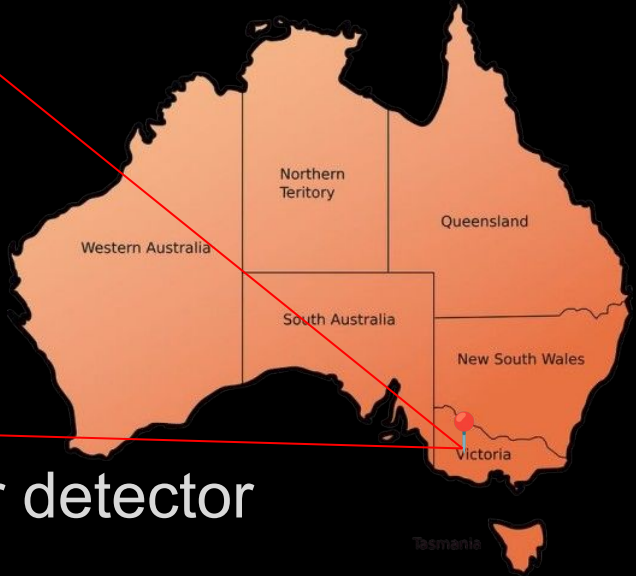
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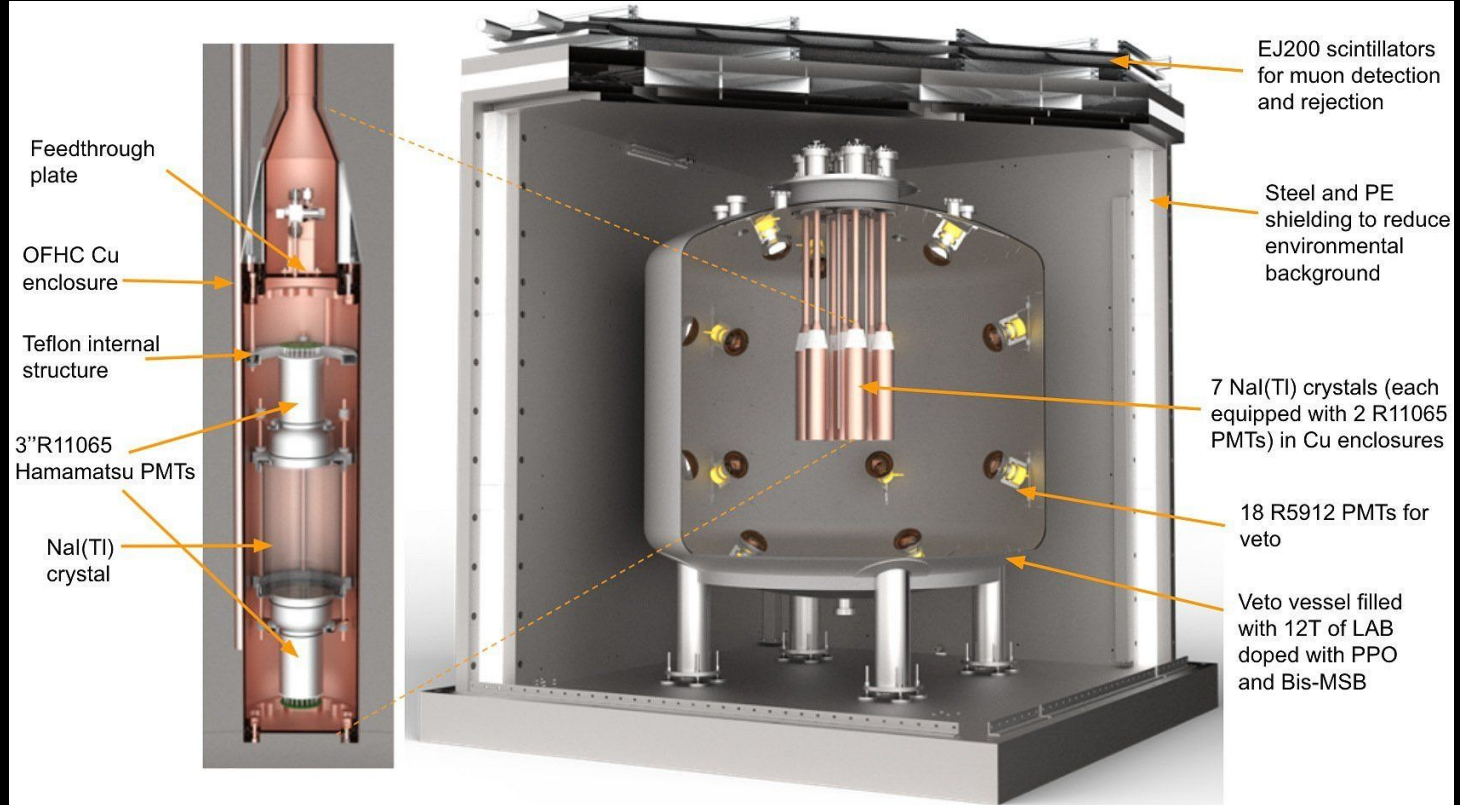
First deep underground lab
in the southern
hemisphere!



Completed in 2023. First access & major detector
installation in Jan/Feb 2024

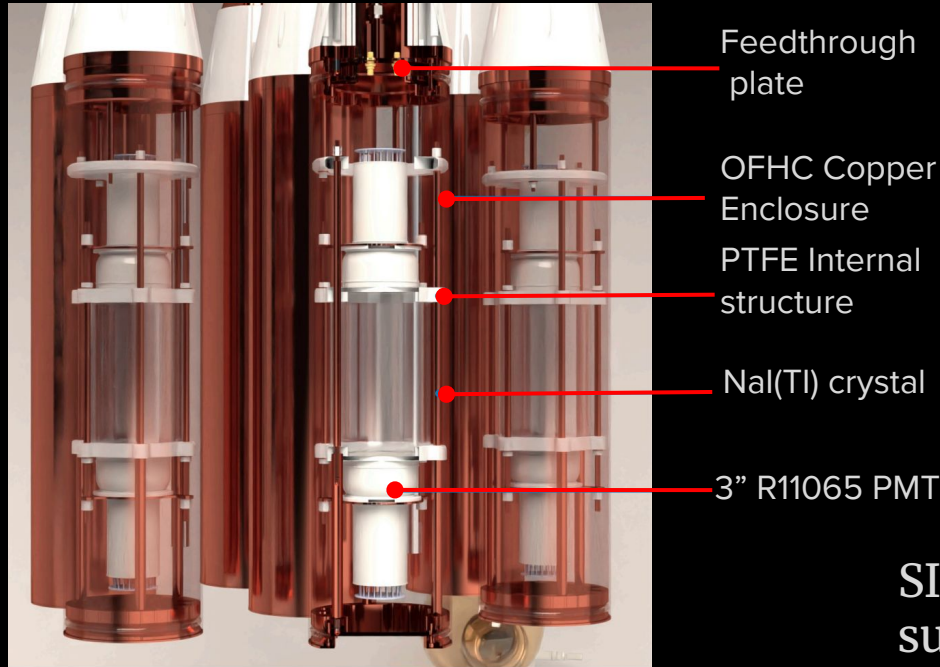
[j.nima.2022.167585](https://arxiv.org/abs/2202.16758)

Detector Design



NaI(Tl) crystals

Array of 7 NaI(Tl) crystals (50 kg) doped with thallium and flushed with Nitrogen.



Parameter	Value
Light yield	11.1 ± 0.2 PE/keV [10]
Energy resolution	13.2% (FWHM/E) at 59.5 keV [10]
Efficiency	
Crystal energy threshold	1 keV
Veto energy threshold	50 keV
Total active mass	35 - 50 kg
Background rate (PoP)	0.36 cpd/kg/keV [11]
Background rate (South)	0.72 cpd/kg/keV [12]

SICCAS and/or RMD likely to provide suitable crystals that meet requirements.

Active Veto System

~ 12 kL of linear alkyl benzene (LAB) procured from JUNO production line, doped with PPO and bisMSB.



Active Veto System

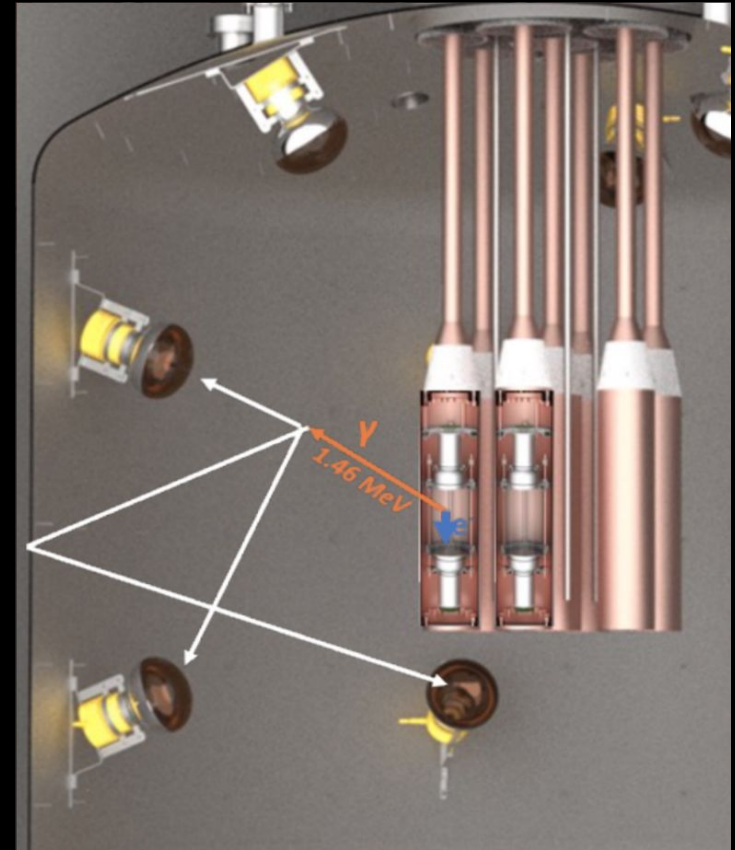
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~ Provides 4π coverage.



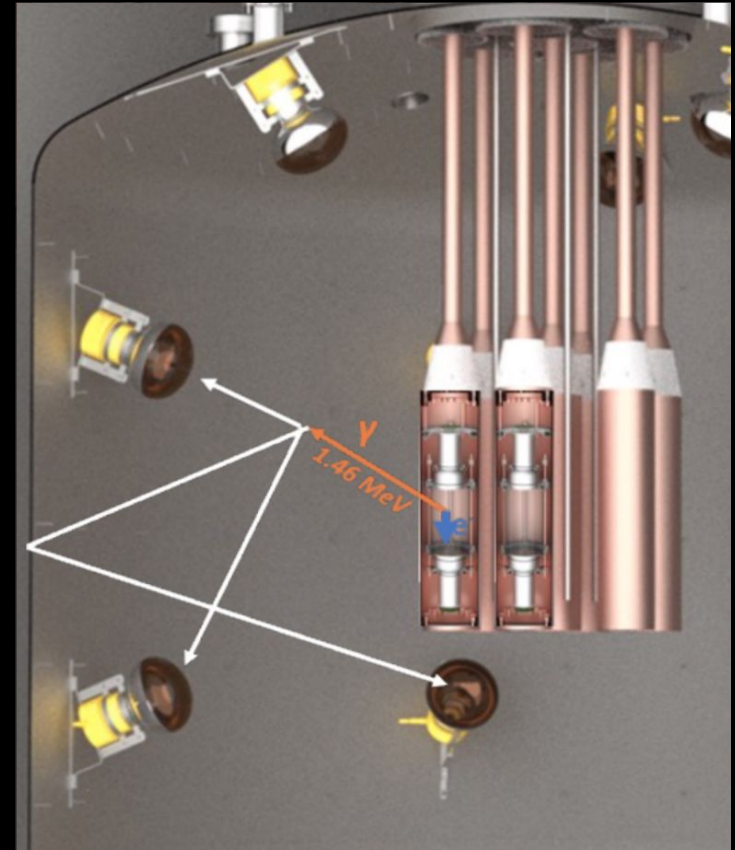
Active Veto System

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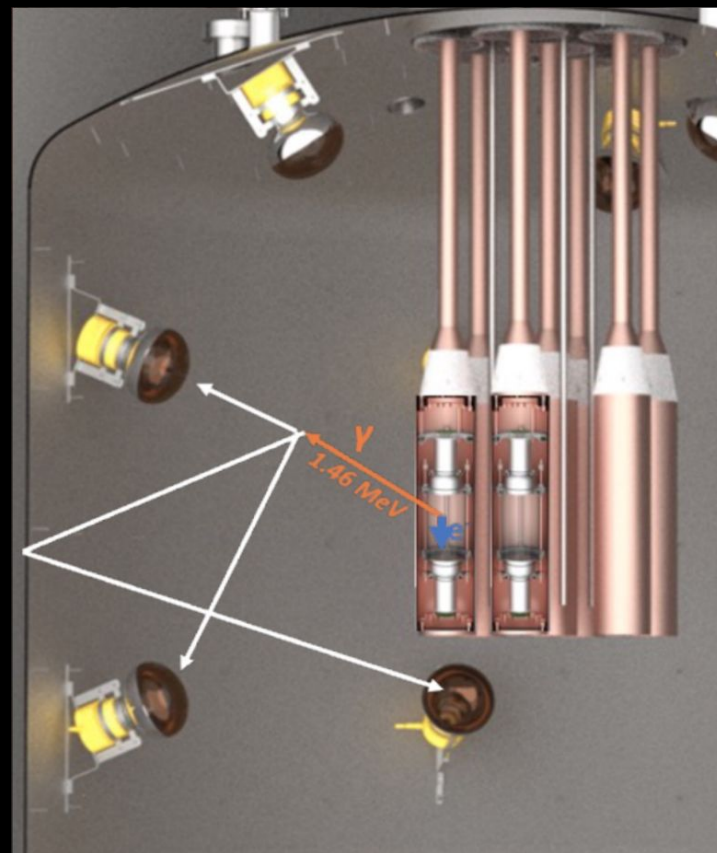
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- ~ Reduces the background from K-decays by a factor of 10.



Active Veto System

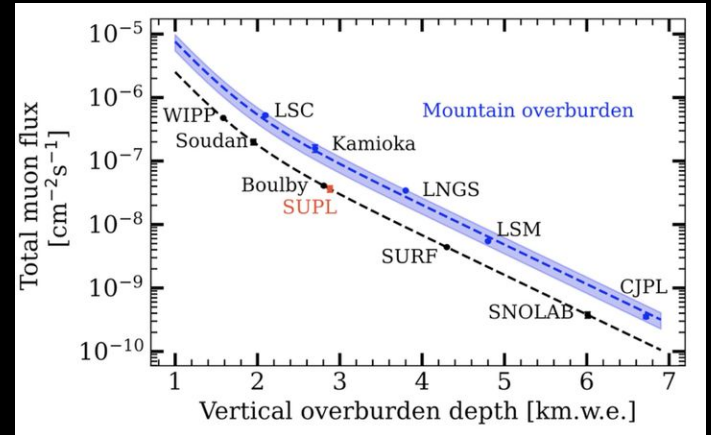
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- ~ Provides 4π coverage.
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- ~ Reduces the background from K-decays by a factor of 10.
- ~ 18 R5912 PMTs oil proof, sampled at 500 MS/s +14 from Daya Bay decommissioning



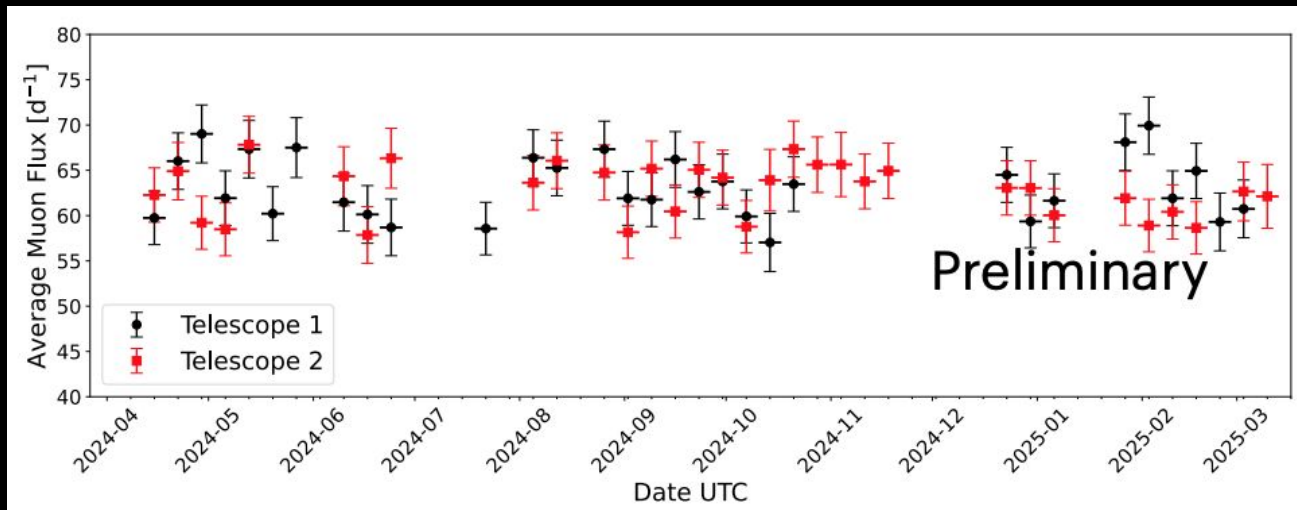
[E. Barberio et al 2025 JINST 20 T04001](#)

Muon Veto System

- Provides tagging of Cosmic Muons
- 8 x EJ200 organic scintillator panels (3x 0.4x 0.05 m) with PMTs at opposite ends.
- Total coverage 9.6 m² above main vessel.



Muon Flux measurement



Acceptance ~ 0.63
modeled with Pyrate
(Scutti, JPhysConfSer
2438(2023) 1, 012061)
and pyvista with
PUMAS input.

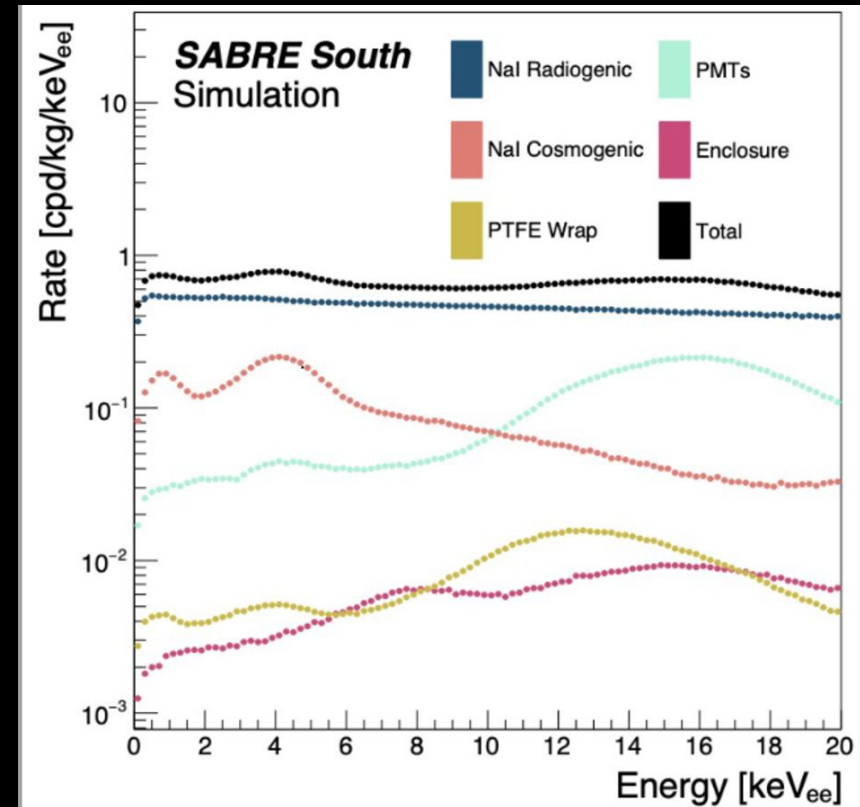
	Telescope 1 (N/S)	Telescope 2 (E/W)
Flux / [s x cm ²] x 10 ⁻⁸	3.06 ± 0.02 (stat)	3.04 ± 0.03 (stat)

Expected	4.78 x 10 ⁻⁸ / [s x cm ²]
Measured, acceptance corrected	(4.82 ± 0.03 (stat)) x 10 ⁻⁸ / [s x cm ²]

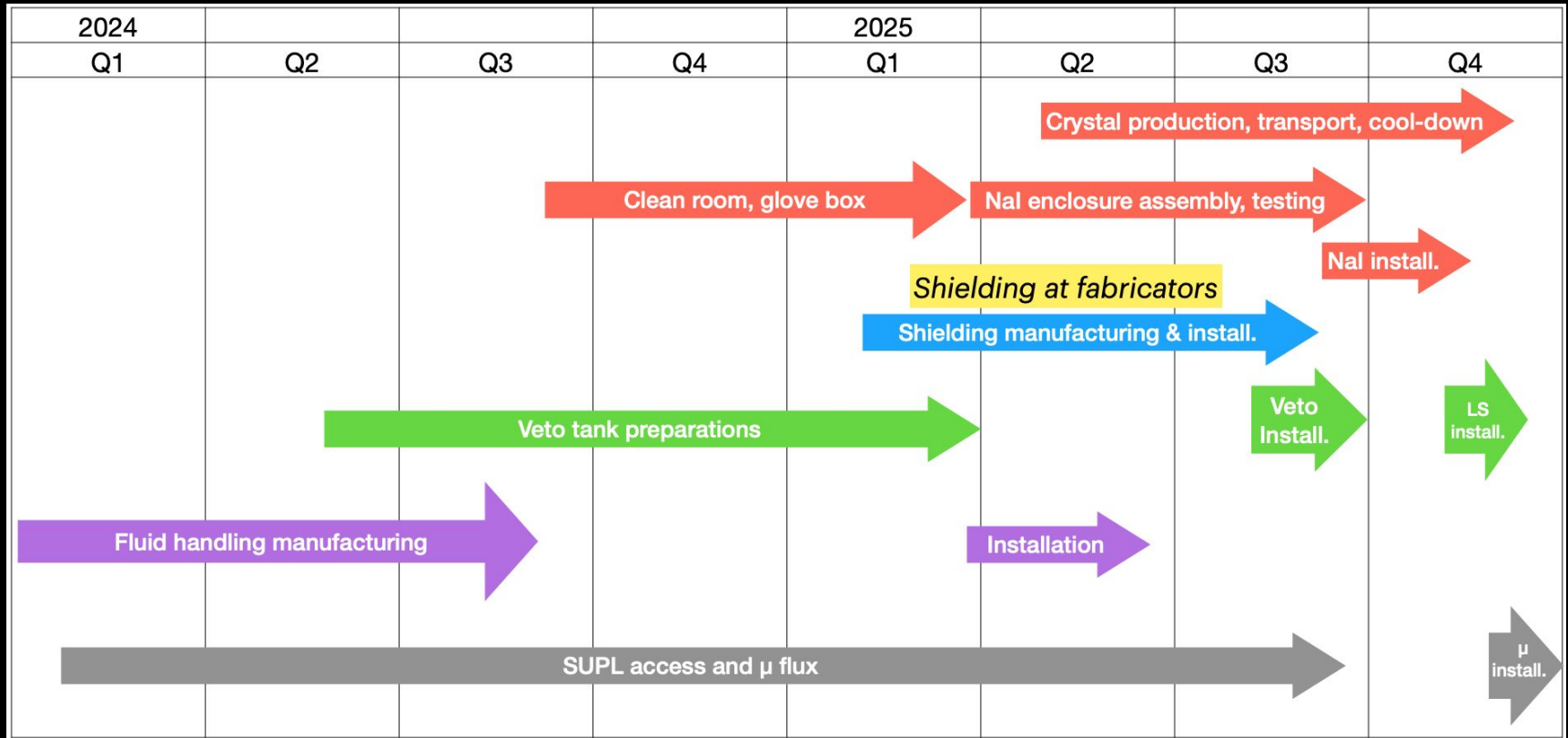
Total Background Model

- Less than 10% of experimental background comes from non-crystal sources (detector materials and environmental sources)
- Average background in 1-6 keV RoI is 0.72 cpd/kg/keV for Na-33

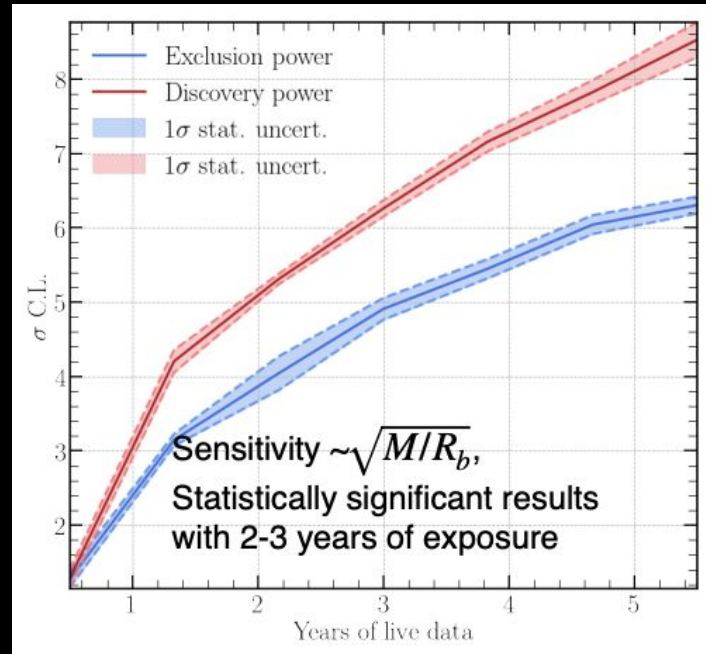
Component	Rate (cpd/kg/keV)	Veto efficiency (%)
Crystal intrinsic	$<5.2 \times 10^{-1}$	13
Crystal cosmogenic	1.6×10^{-1}	45
Crystal PMTs	3.8×10^{-2}	57
Crystal wrap	4.5×10^{-3}	11
Enclosures	3.2×10^{-3}	85
Conduits	1.9×10^{-5}	96
Steel vessel	1.4×10^{-5}	>99
Veto PMTs	1.9×10^{-5}	>99
Shielding	3.9×10^{-6}	>99
Liquid scintillator	4.9×10^{-8}	>99
External	5.0×10^{-4}	>93
Total	0.72	27



Experiment Timeline



Sensitivity of SABRE South



Summary

- Expecting to receive the highest purity crystal that meets our requirement



Summary

- Expecting to receive the highest purity crystal that meets our requirement
- 4π coverage active background veto system



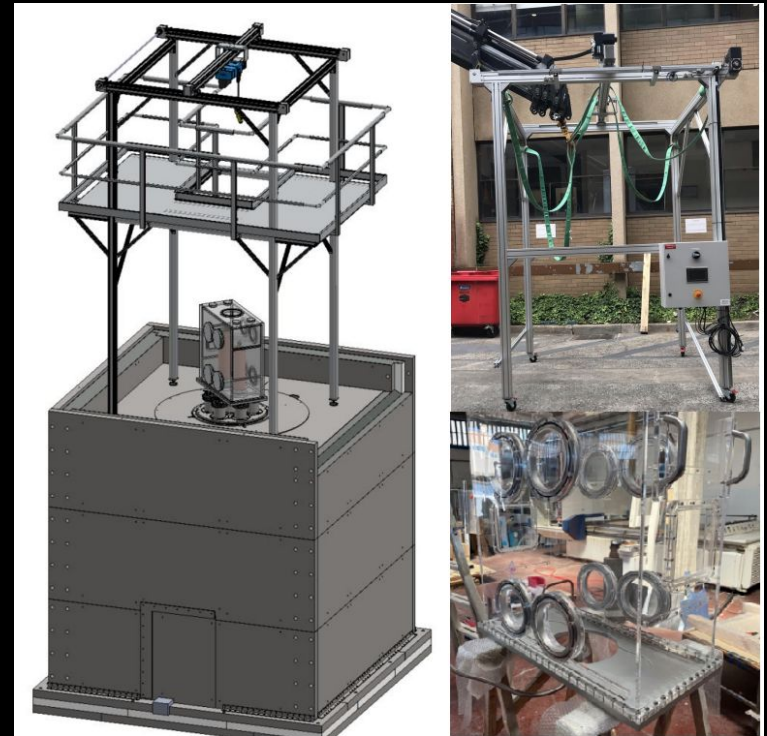
Summary

- Expecting to receive the highest purity crystal that meets our requirement
- 4π coverage active background Rejection system



Summary

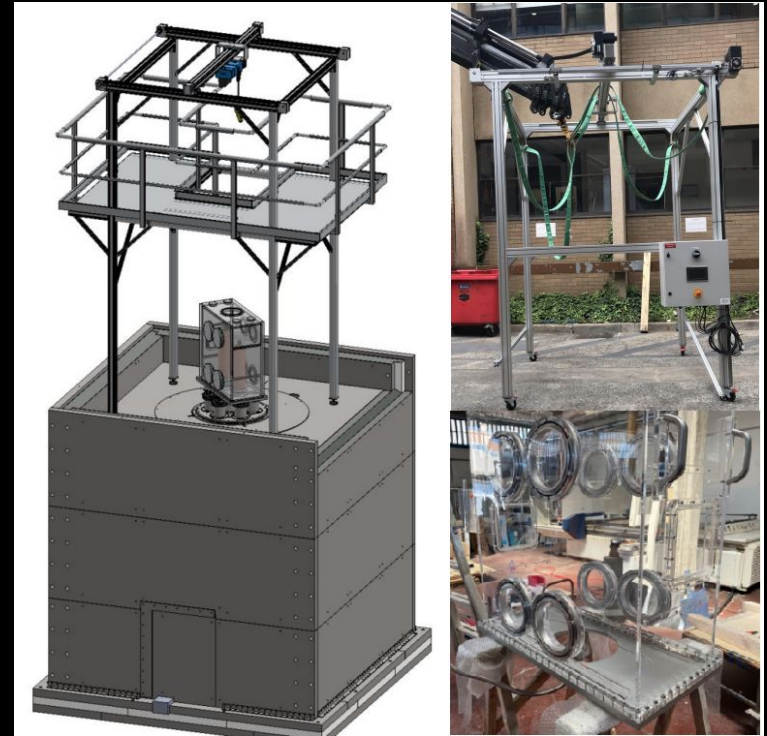
- Expecting to receive the highest purity crystal that meets our requirement
- 4π coverage active background Rejection system
- Targeted to finish installation by the end of 2025



Crystal Insertion System

Summary

- Expecting to receive the highest purity crystal that meets our requirement
- 4π coverage active background Rejection system
- Targeted to finish installation by the end of 2025
- Projected sensitivity of 5σ C.L. in 2 years



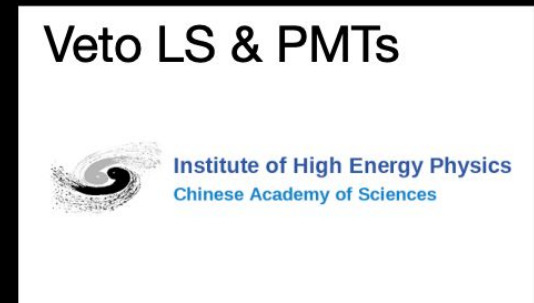
Crystal Insertion System

Conclusion:

SABRE South is uniquely positioned to resolve a 20-year controversy in direct dark matter detection. While final results are pending, the experiment's design, location, and methodology provide a strong foundation for a definitive test of DAMA's claimed annual modulation



Thank you!



Back up

SABRE South and North

Common Features:

- Same crystal production and R&D.
- Same detector module concept (Ultra-pure crystals and HPK R11065 PMTs)
- Common simulation, DAQ and data processing frameworks

Different Shielding designs:

- SABRE North has opted for a fully passive shielding due to the phase out of organic scintillators at LNGS.
- For SABRE South, the liquid scintillator will be used for in-situ evaluation and validation of the background in addition to background rejection and particle identification.

Status of SABRE North



SABRE North facilities are now installed in the final site at LNGS

