SABRE SOUTH

OVERVIEW, SIMULATION, BACKGROUND MODELLING, PROSPECTS

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On behalf of the SABRE South Collaboration

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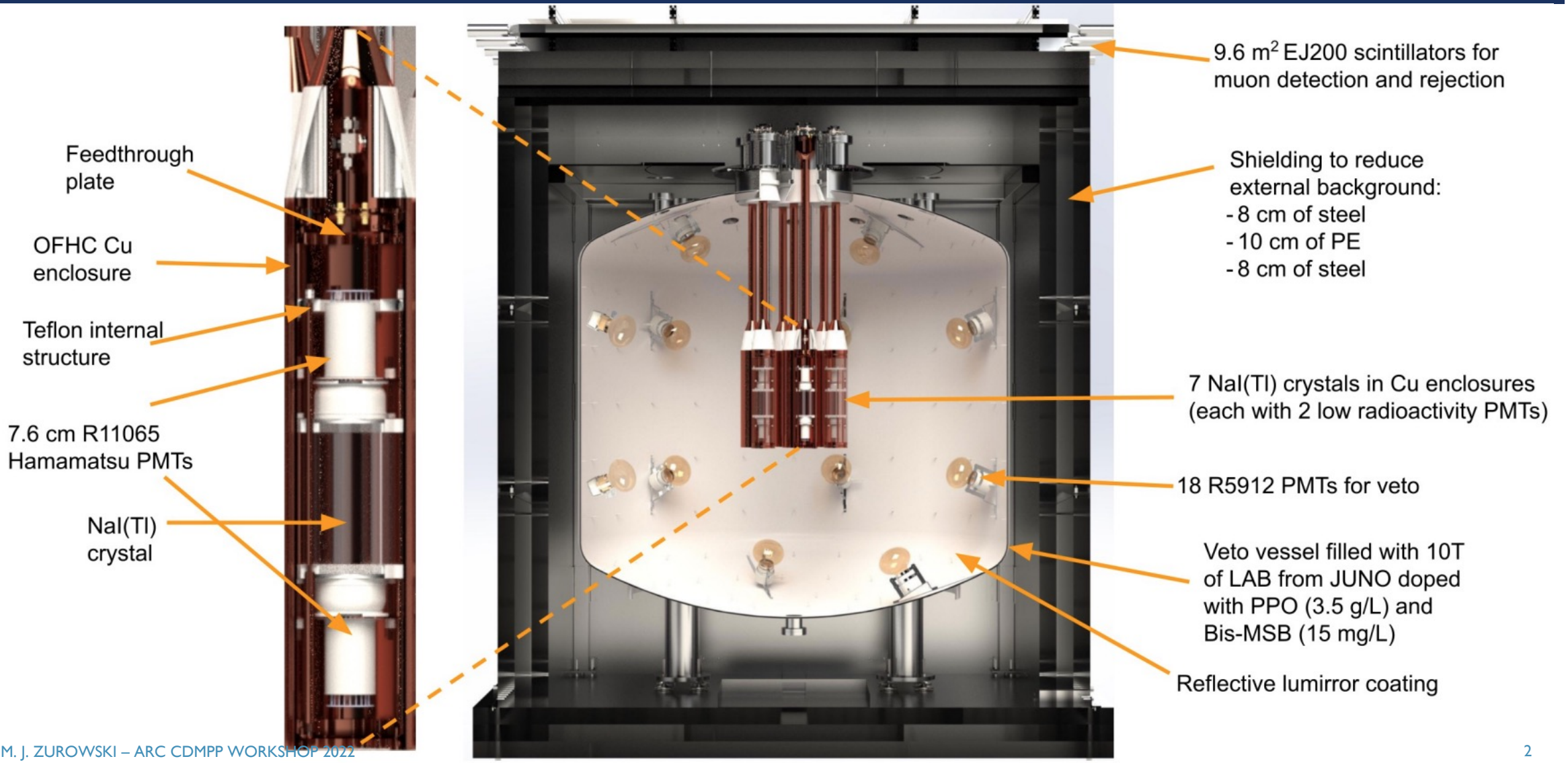
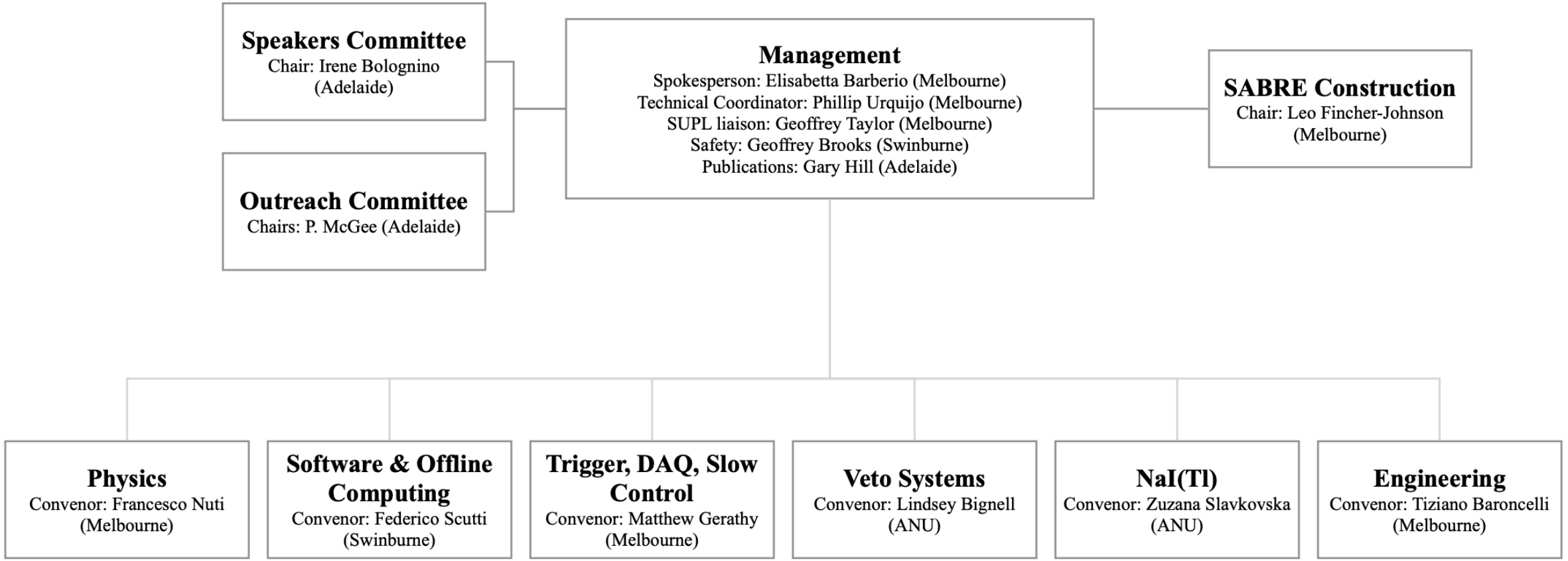
SABRE SOUTH


Feedthrough plate
OFHC Cu enclosure
Teflon internal structure
7.6 cm R11065 Hamamatsu PMTs
NaI(Tl) crystal
9.6 m^2 EJ200 scintillators for muon detection and rejection
Shielding to reduce external background:
- 8 cm of steel
- 10 cm of PE
- 8 cm of steel
7 NaI(Tl) crystals in Cu enclosures (each with 2 low radioactivity PMTs)
18 R5912 PMTs for veto
Veto vessel filled with 10T of LAB from JUNO doped with PPO (3.5 g/L) and Bis-MSB (15 mg/L)
Reflective lumirror coating

COLLABORATION STRUCTURE



2022 MILESTONES/ACHIEVEMENTS

- SUPL construction completed, access agreement being finalised
- Designed for fluid handling, crystal enclosures, and glove box complete
- Shielding design complete and out for tender
- Initial tests for Lumirror and PMT mounting
- Crystal insertion system arrived
- PMTs arrived and testing and characterisation commenced
- Software framework developed and used for prototype studies
- Baseline DAQ and run control established and in use for prototyping
- Plastic scintillator muon detectors characterized with above ground muons and radioactive sources
- Ongoing development of particle ID in liquid scintillator and crystal systems
- Crystal procurement and analysis begun at LNGS
- Publications on detector simulation and particle ID in NaI
- Presentations at 15 global conferences

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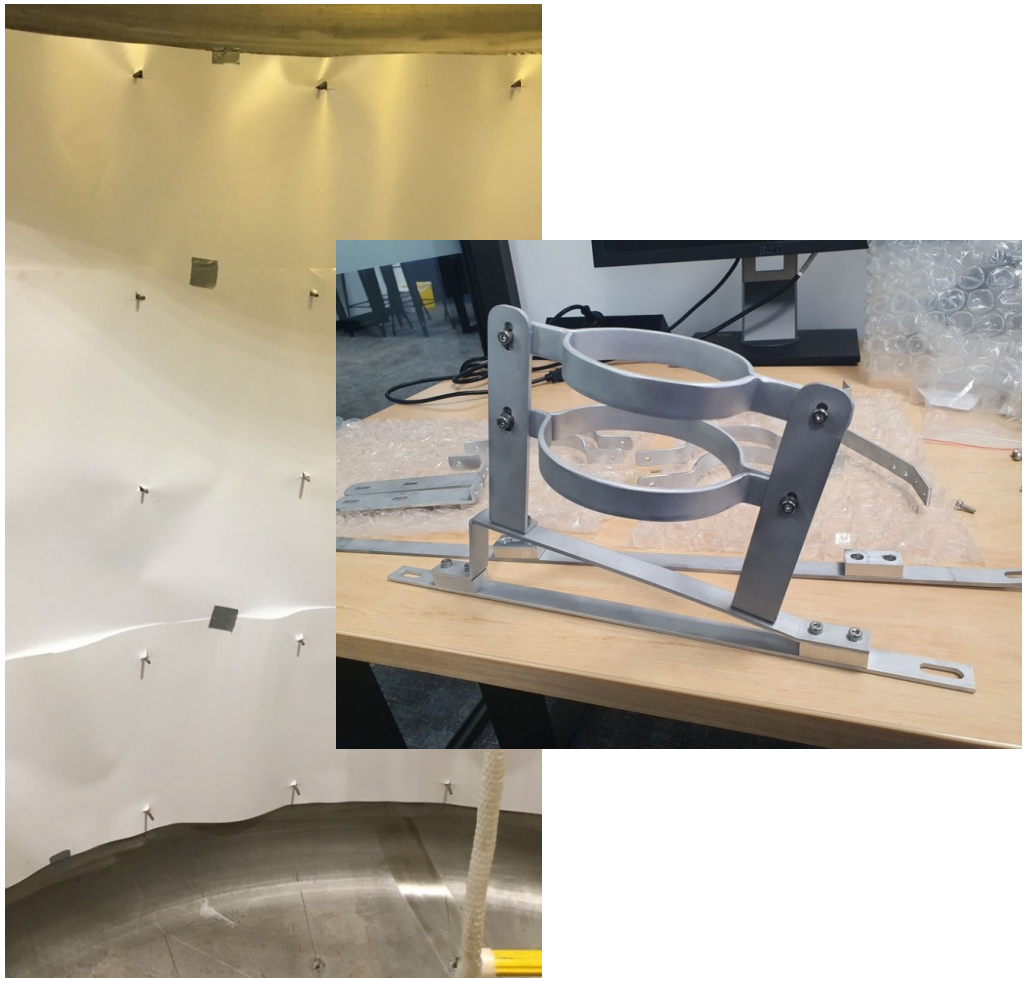

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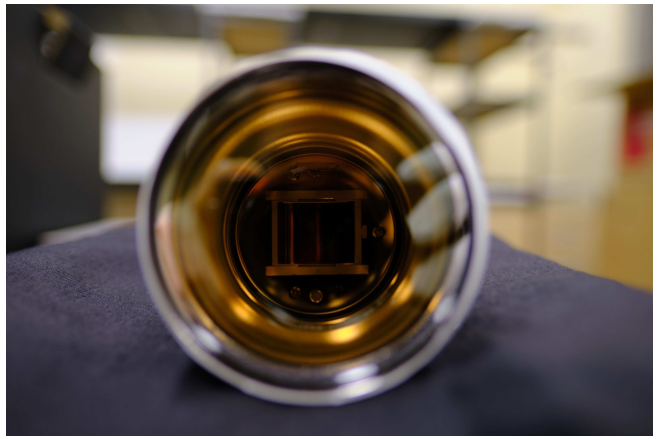

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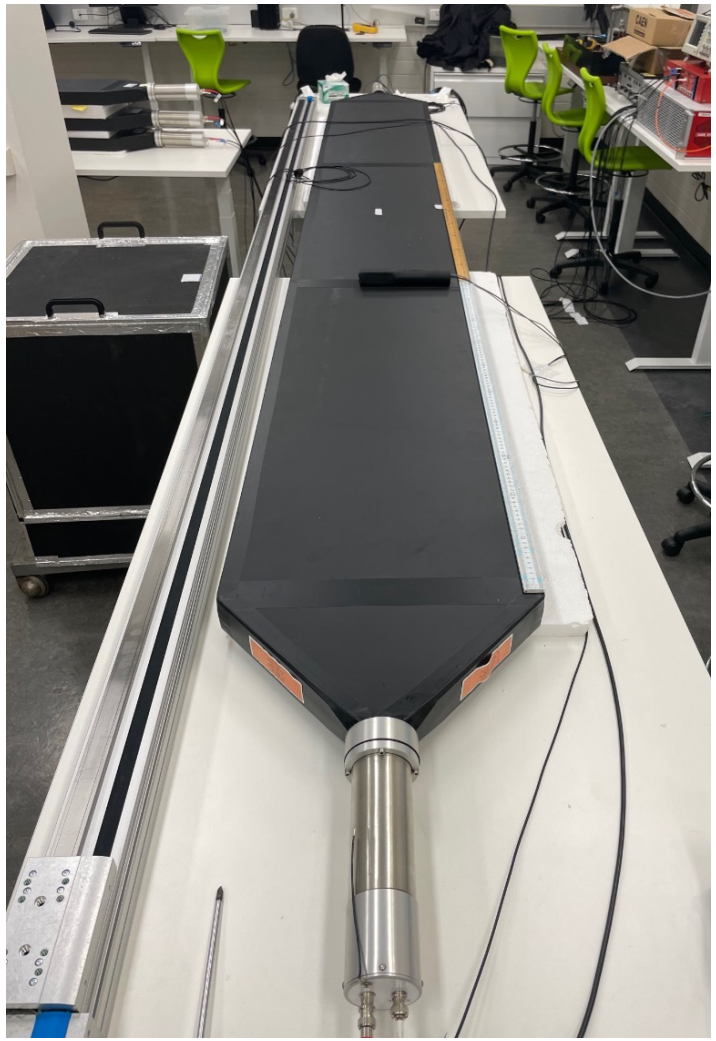

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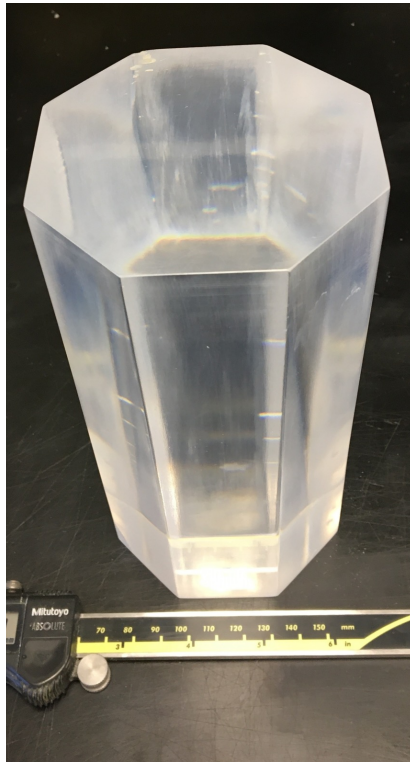

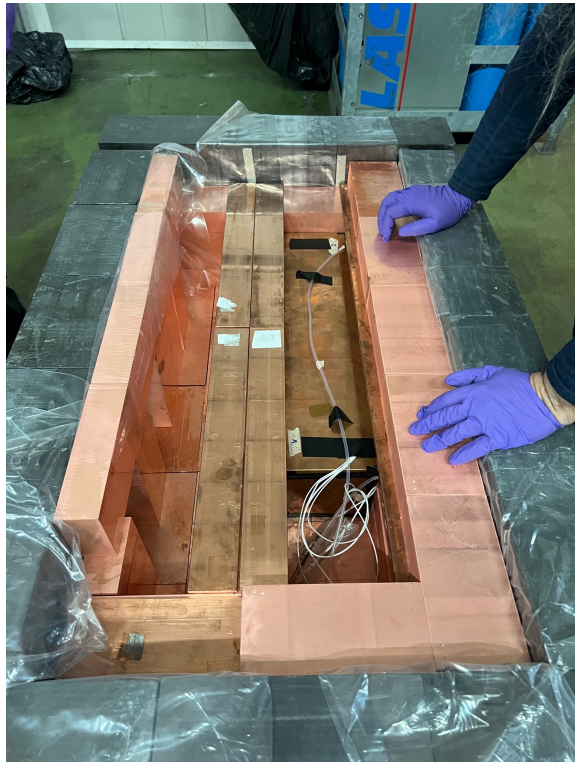

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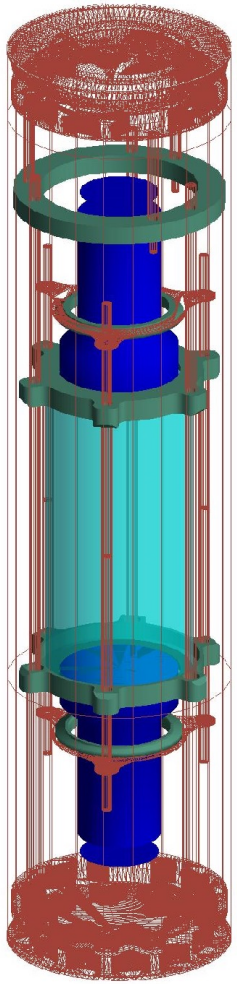
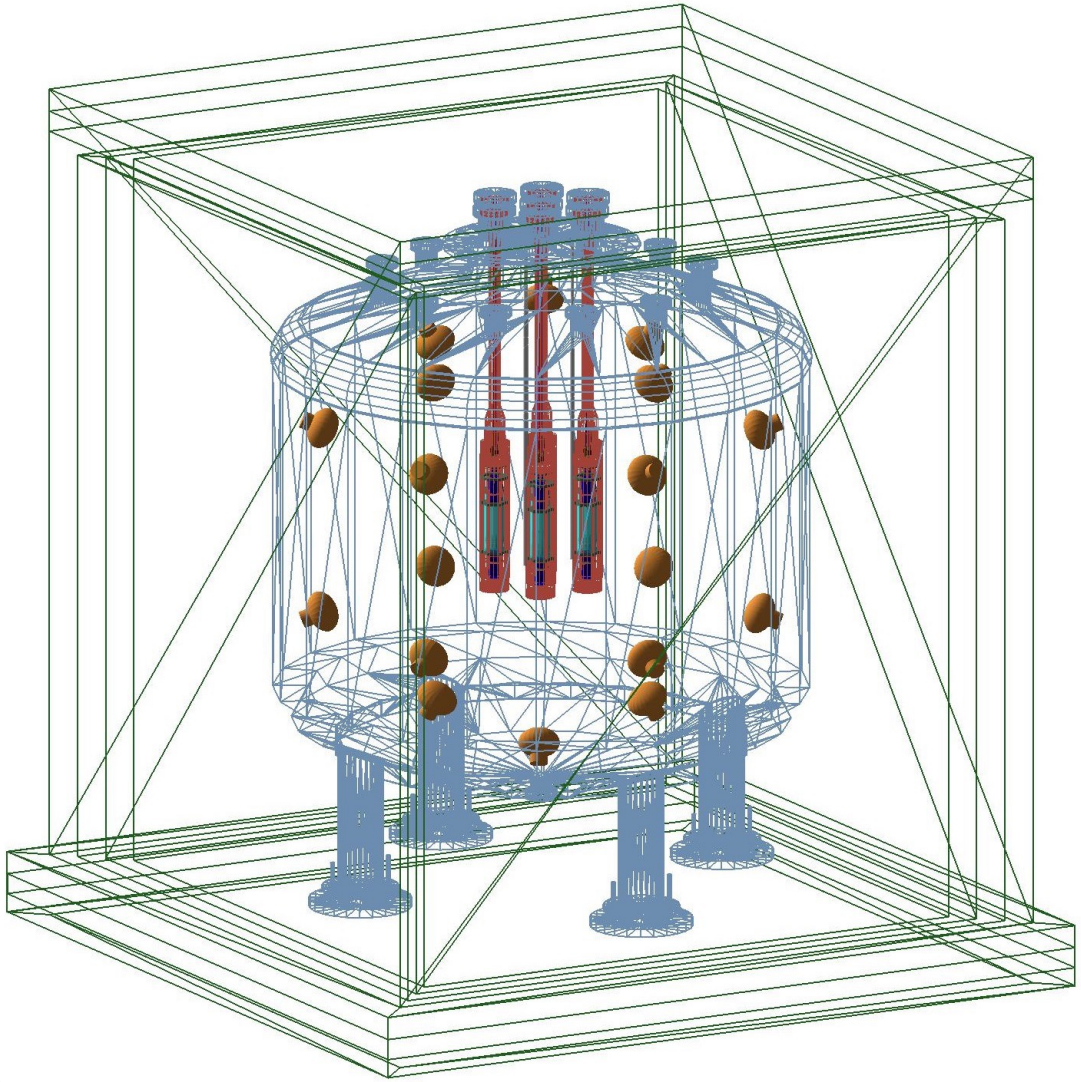
SIMULATION UPDATES



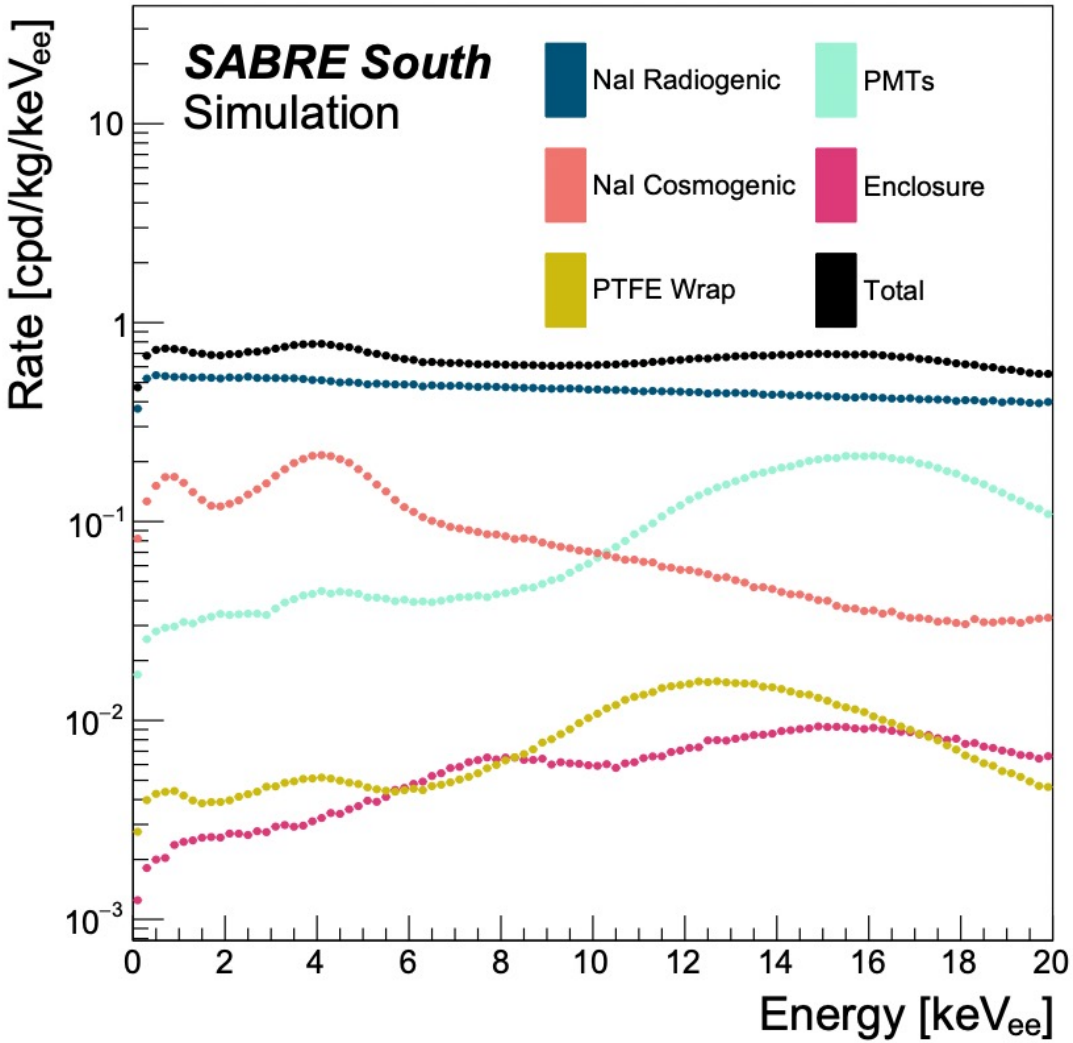


Detector reconstructed with high fidelity in Geant4.

Full MC background simulation conducted with version 10.7, but since have completed update to version 11.

MC PAPER

arxiv:2205.13849



Paper submitted to EPJC: simulation of radioactive background components

	Rate [cpd/kg/keV$_{ee}$]	Veto Efficiency [%]
Crystal radiogenic	$5.2 \cdot 10^{-1}$	13
Crystal cosmogenic	$1.6 \cdot 10^{-1}$	40
Crystal PMTs	$3.8 \cdot 10^{-2}$	60
PTFE wrap	$4.5 \cdot 10^{-3}$	13
Enclosures	$3.2 \cdot 10^{-3}$	85
Conduits	$1.9 \cdot 10^{-5}$	96
Liquid scintillator	$4.9 \cdot 10^{-8}$	> 99
Steel vessel	$1.4 \cdot 10^{-5}$	> 99
Veto PMTs	$1.9 \cdot 10^{-5}$	> 99
Shielding	$3.9 \cdot 10^{-6}$	> 99
External	$O(10^{-4})$	> 99
Total	$7.2 \cdot 10^{-1}$	27

For comparison: DAMA's background is 0.8 dru, with COSINE and ANAIS closer to 3 dru

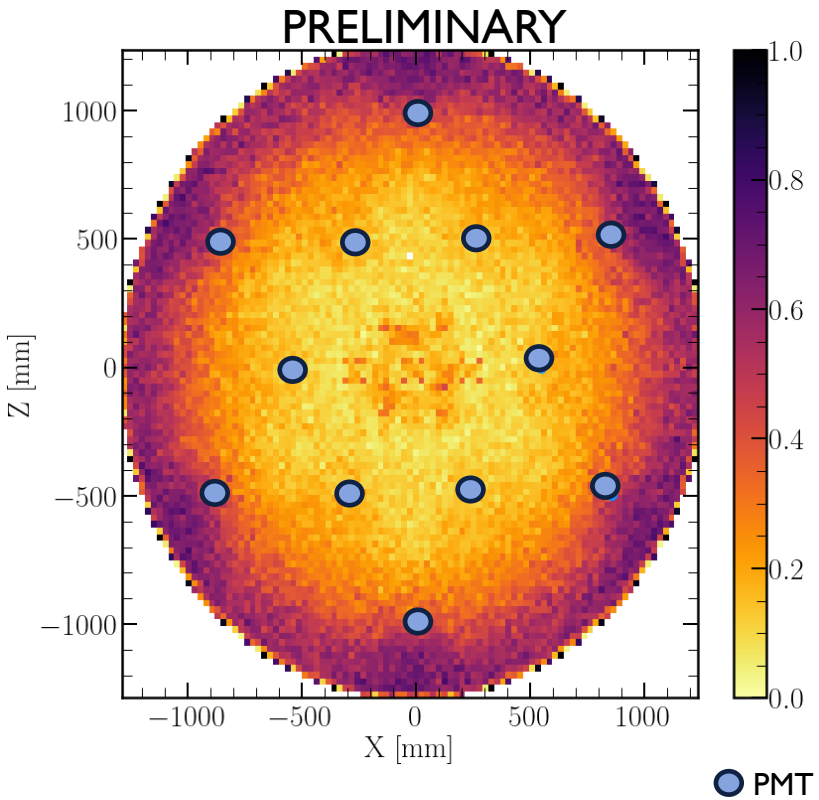
ONGOING SIMULATION PROJECTS

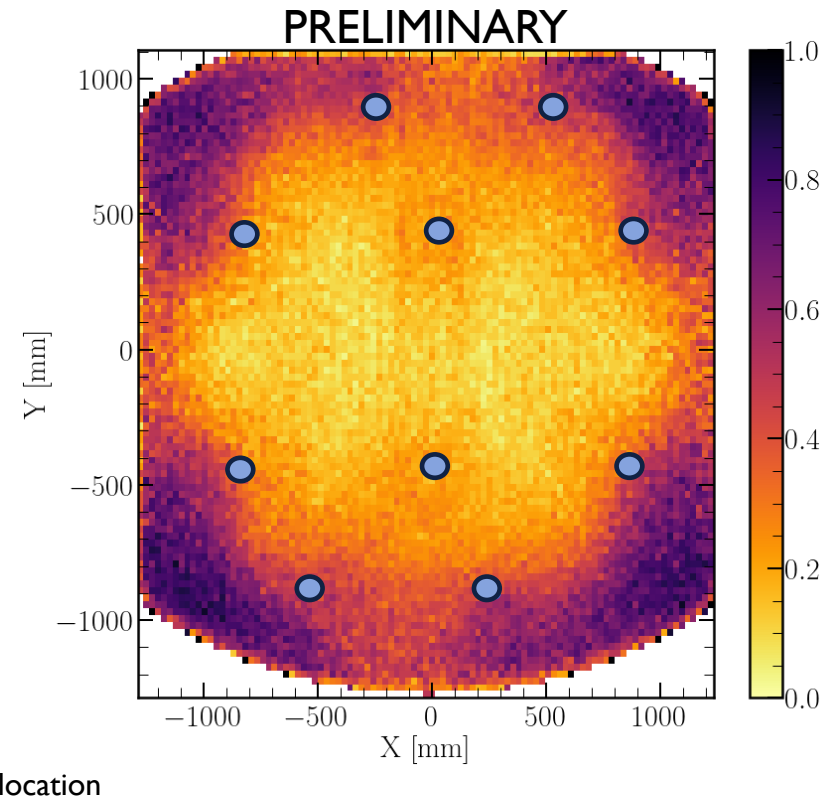
- Veto detector efficiency – M. Verde, M. Zurowski
- Calibration methods – I. Bolognino, K. Leaver, F. Nuti
- Induced modulation signatures – K. Rule
- Sensitivity projections – K. Leaver, M. Zurowski
- Muon rates and associated backgrounds – G. Fu, M. Tan Ha
- Optical studies in crystal – P. McNamara
- Cosmogenic activation – Y. Y. Zhong
- Non linear light yield modelling – Y. Y. Zhong
- Waveform simulation – W. Melbourne, N. Spinks, M. Zurowski

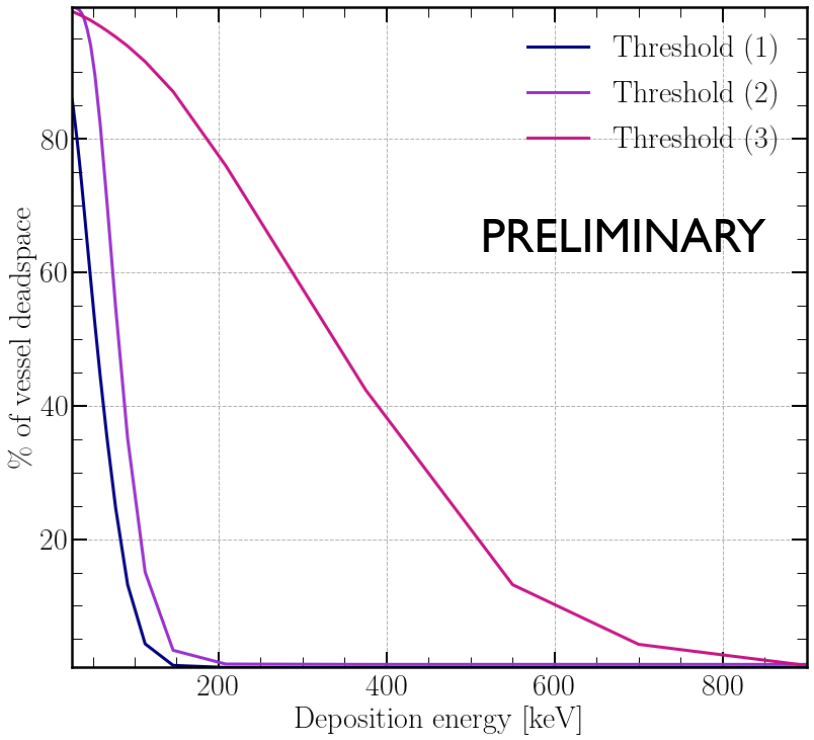
Australian National University
University of Adelaide
University of Melbourne

ONGOING SIMULATION PROJECTS

Veto efficiency: how does the PMT number and position impact dead-space and detector efficiency? How does that roll over into our energy thresholds and signal triggers?

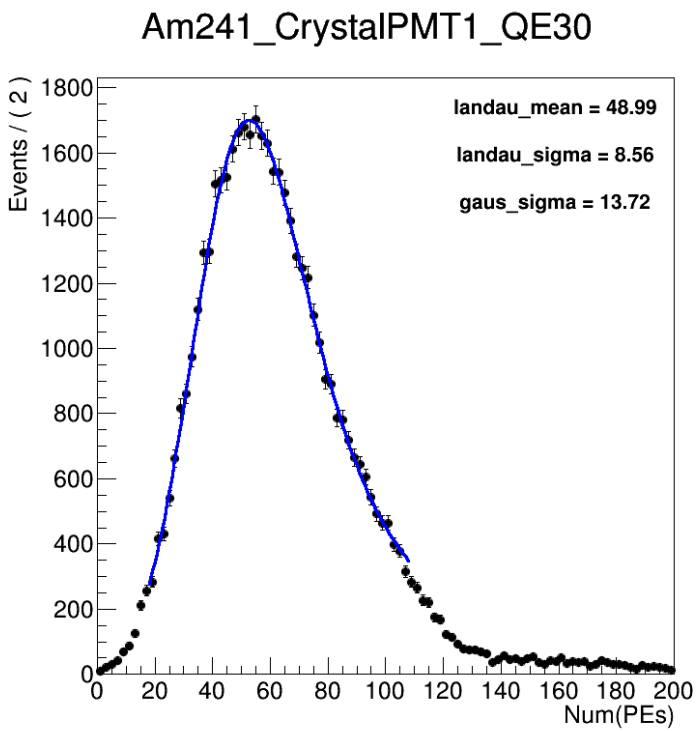




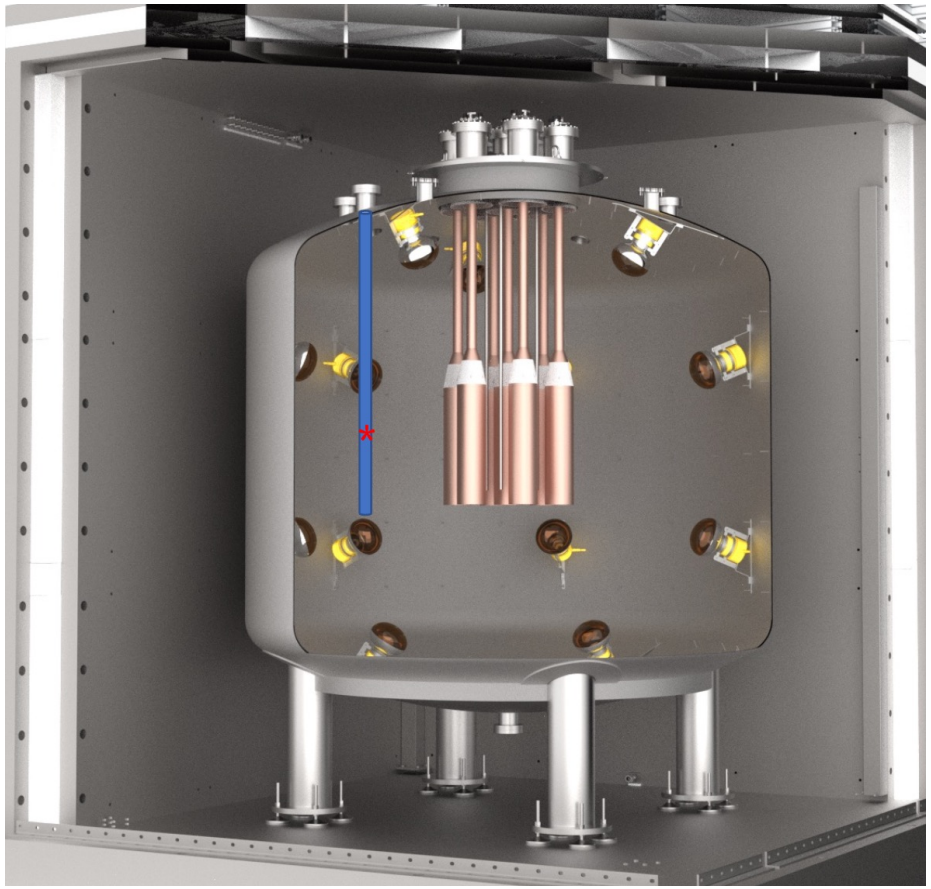


ONGOING SIMULATION PROJECTS

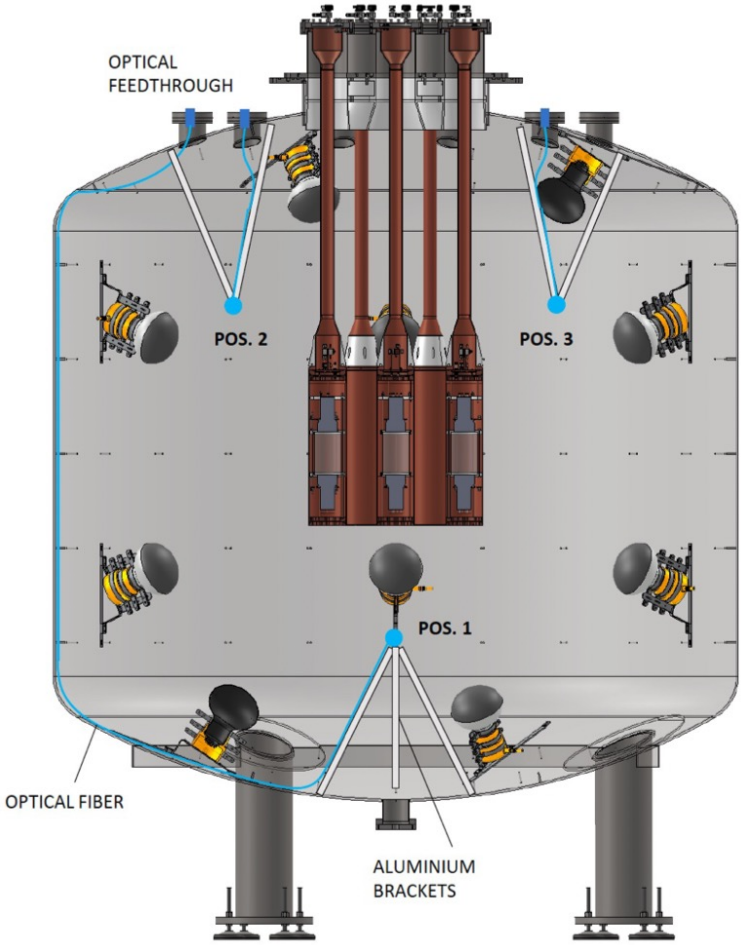
Calibration: what lasers and radioactive sources should we use to calibrate? Where should they be placed?



Shifts in crystal calibration source due to changes to quantum efficiency



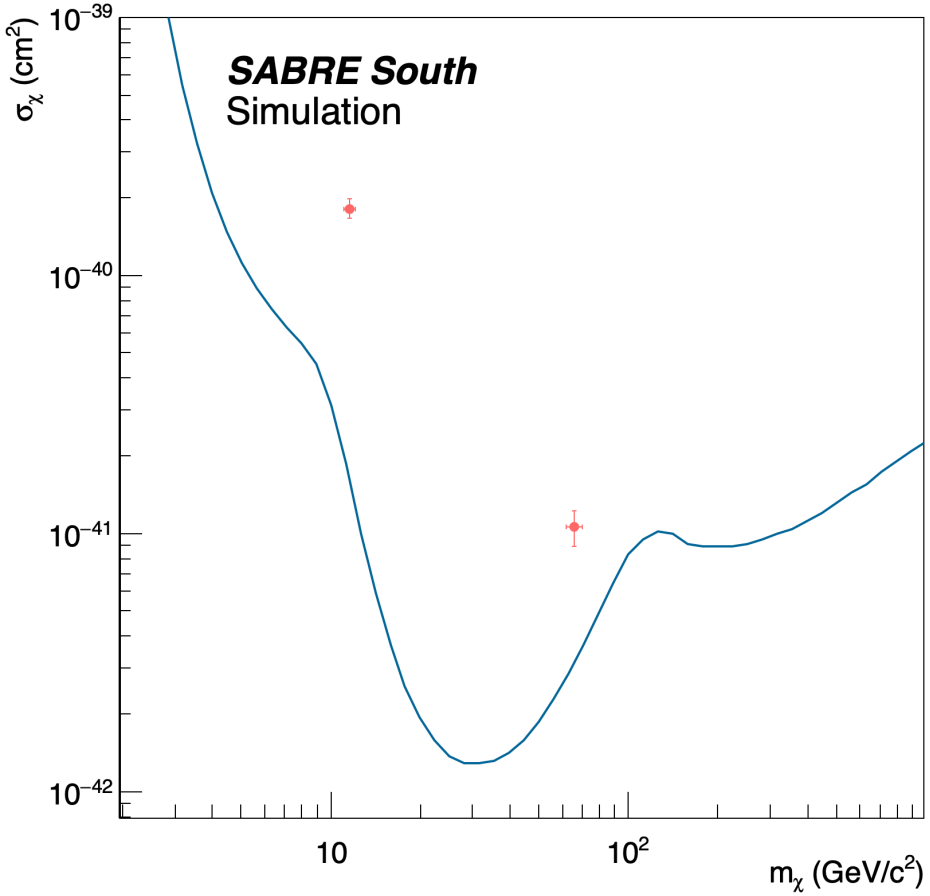
Finalised location of veto system radioactive calibration

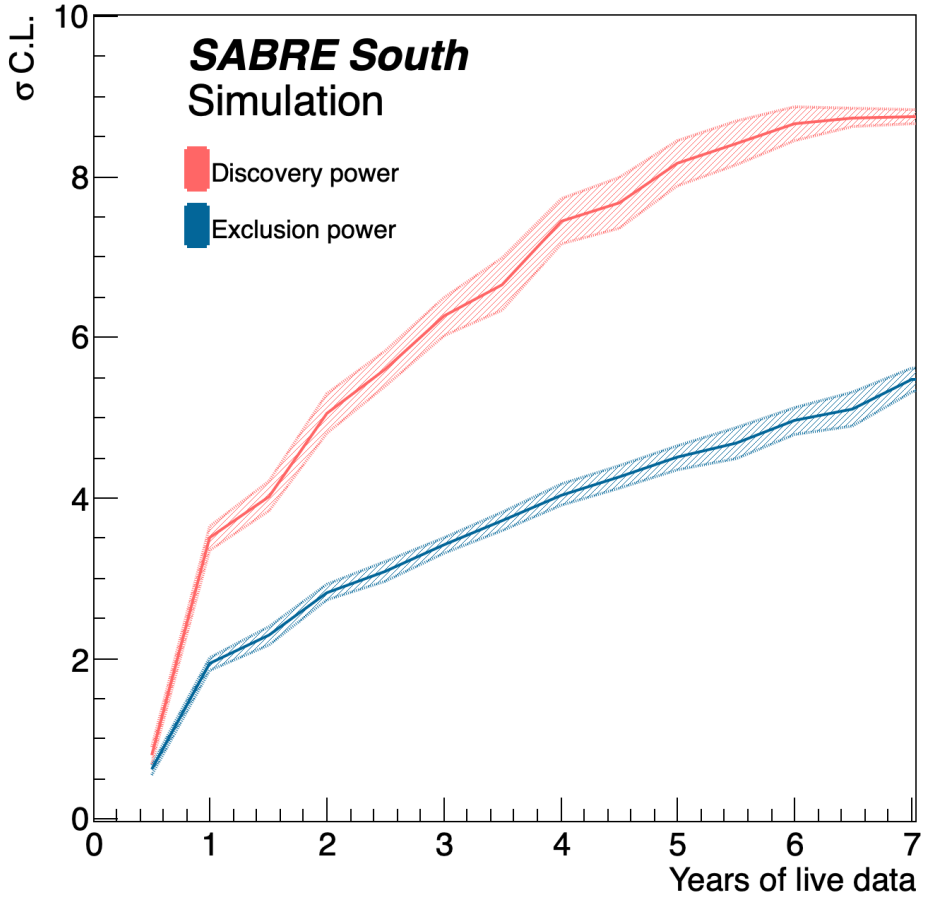


Test position for optical veto calibration

ONGOING SIMULATION PROJECTS

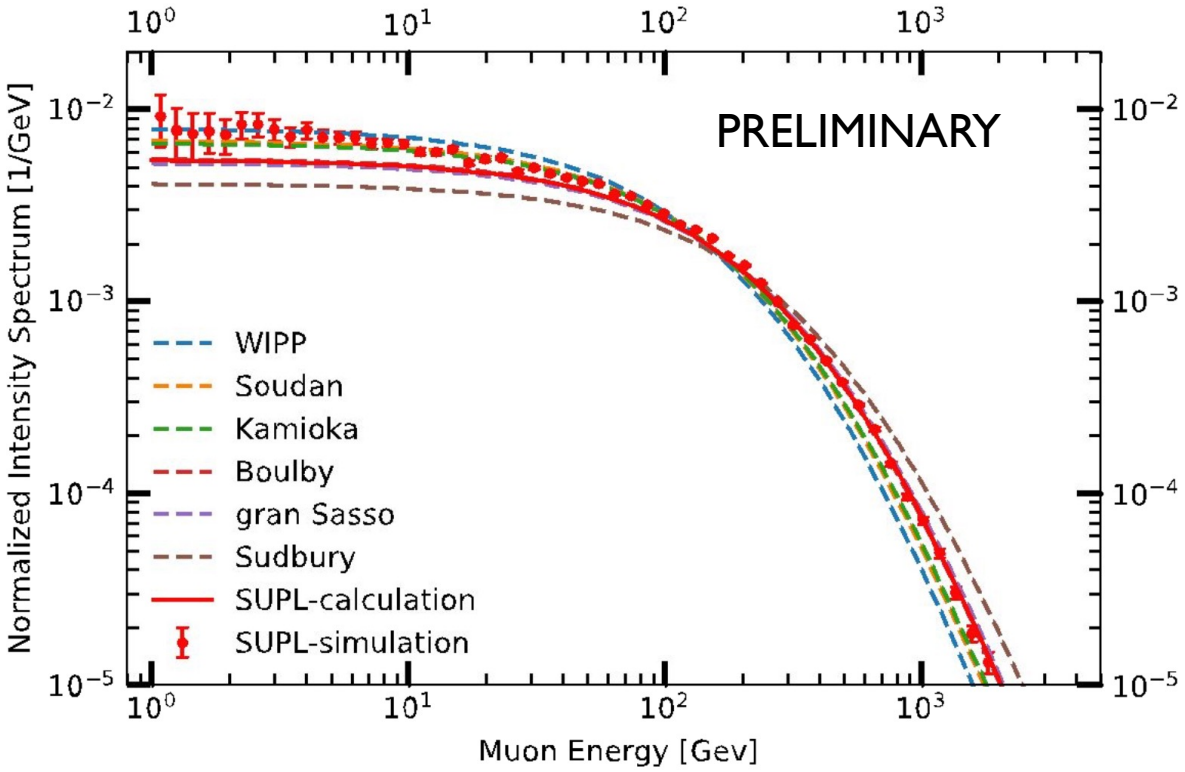
Sensitivity projections: how well will SABRE ultimately perform? What happens when we consider more complex signals or background sources?

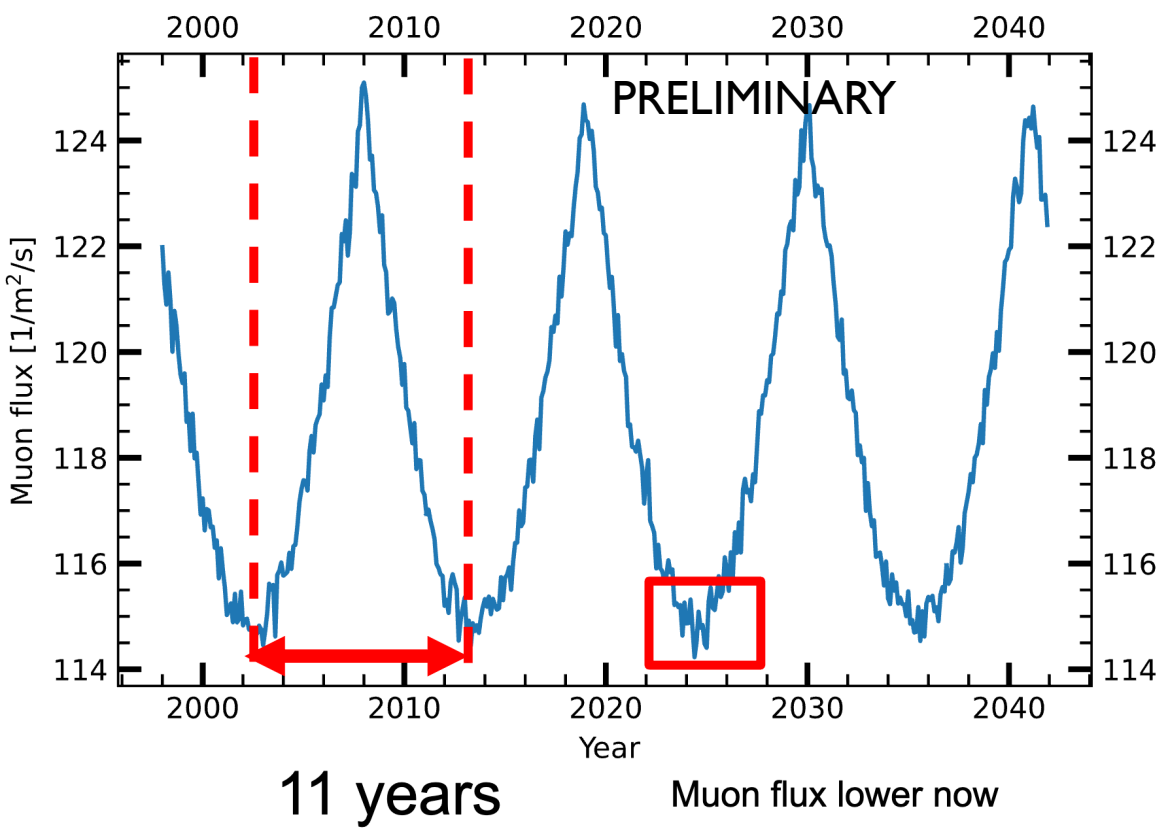




ONGOING SIMULATION PROJECTS

Muon simulations: what energy and position will muons have in SUPL? What kinds of background might these induce at the detector?



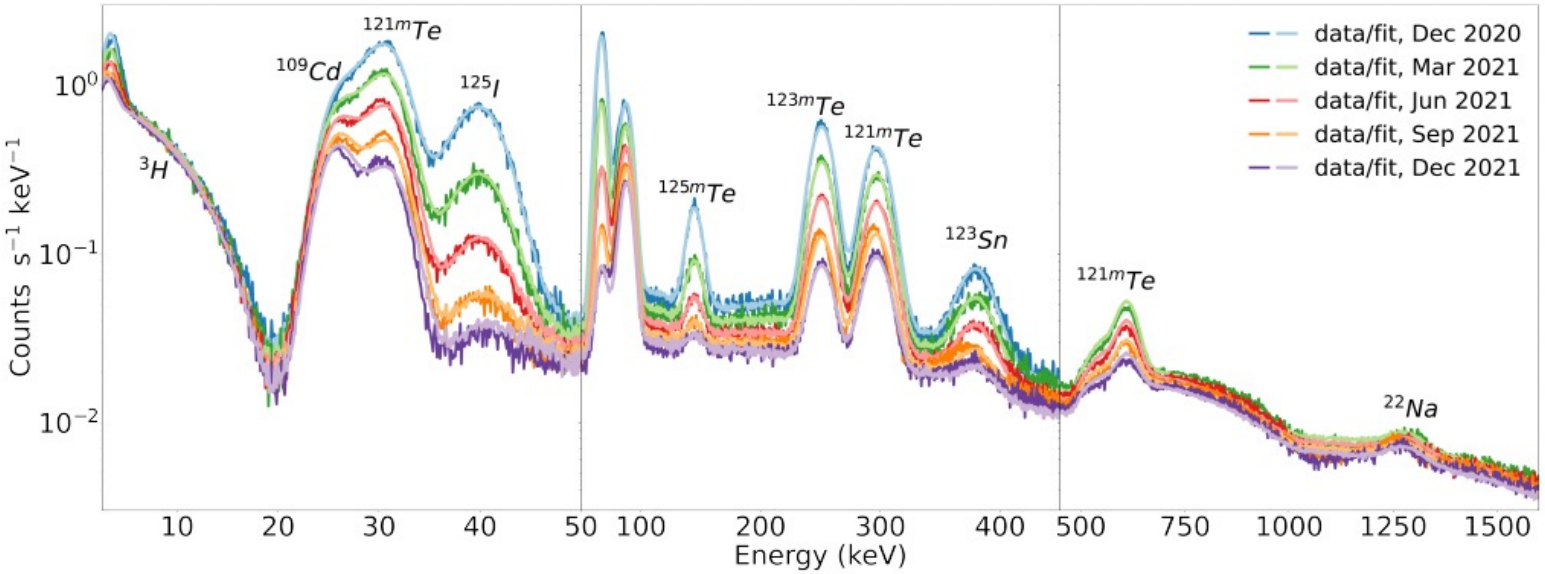


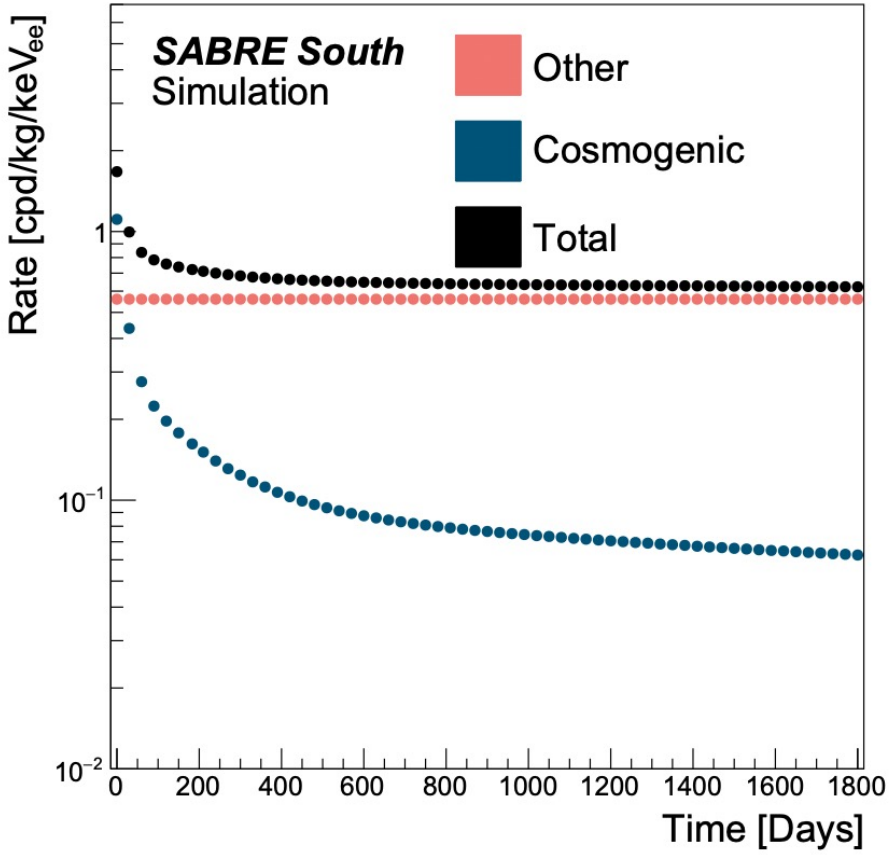
See Guangyong Fu and Min Tan Ha's posters

ONGOING SIMULATION PROJECTS

arxiv:2209.14898
arxiv:2205.13849

Cosmogenic simulations: what kinds of energies will the crystals be exposed to in travel? What backgrounds will this induce in them? How would this time dependence impact our sensitivity?

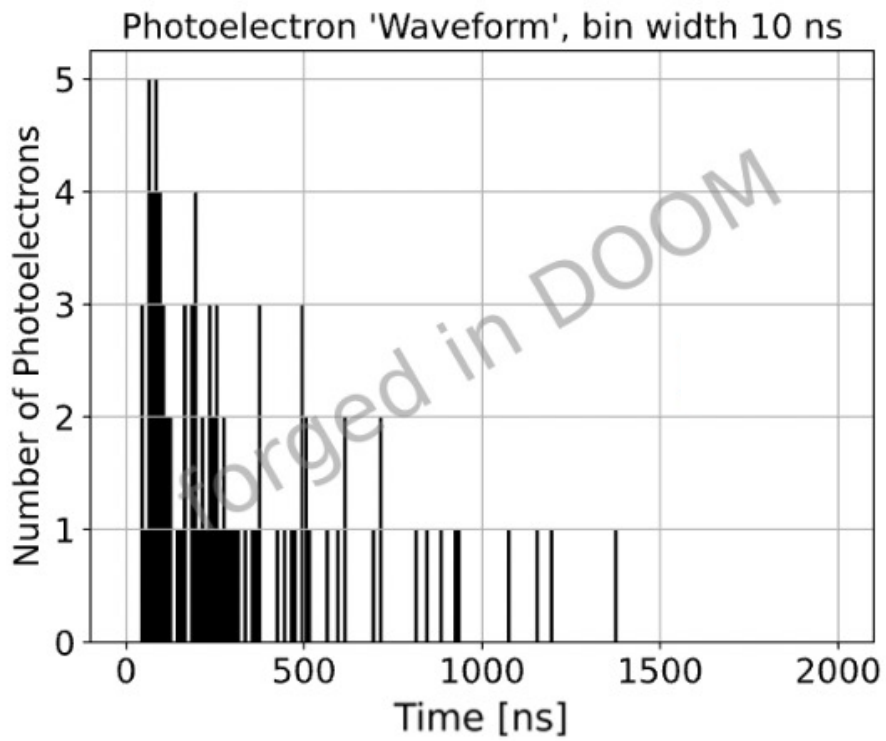


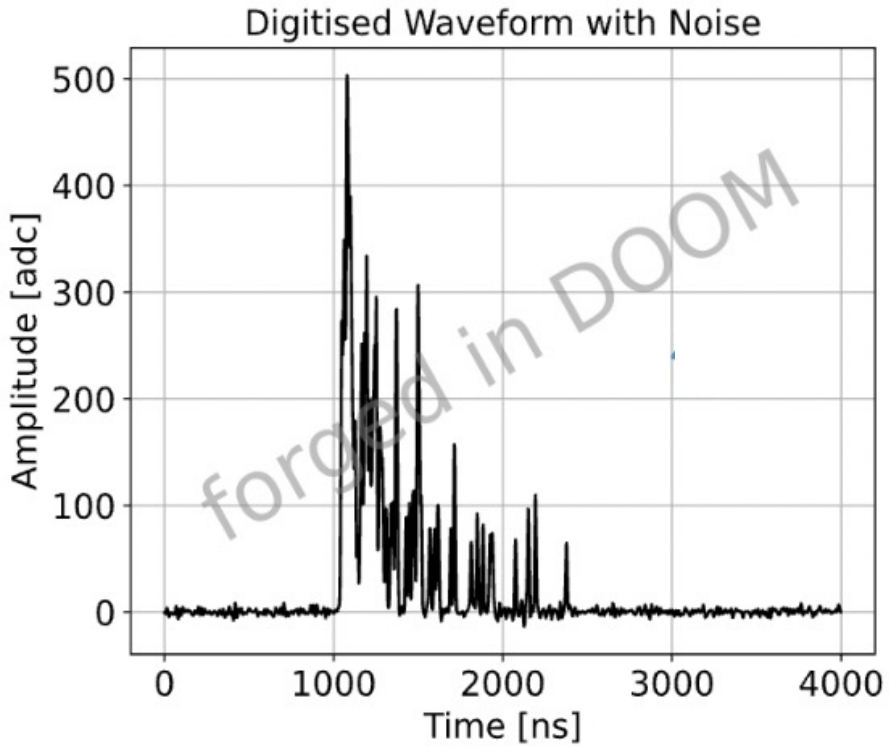


See Yi Yi Zhong's poster

ONGOING SIMULATION PROJECTS

Waveform simulation: how can we improve the statistics used to design and test analysis methods? Outputs from Geant4 are too "perfect", and need to be adjusted to create more realistic waveforms to help inform position reconstruction and particle ID





SUMMARY

- Lots of movement and achievements for SABRE South this year, with the collaboration on track to begin taking underground data next year
- Simulation work has been ramping up in the meantime to make sure we fully understand our detection systems (as much as possible) before this happens
- Simulation projects span detector design, calibration, performance, analysis methods, and prospects, and involve collaboration across a number of nodes
- Most of this work in the process of being finalised for publication next year

ARC CENTRE OF EXCELLENCE FOR DARK MATTER

SABRE South

Australian Government

SABRE

Australian National University

SWINBURNE UNIVERSITY OF TECHNOLOGY

THE UNIVERSITY of ADELAIDE

THE UNIVERSITY OF MELBOURNE