

THE SABRE SOUTH EXPERIMENT AT THE STAWELL UNDERGROUND PHYSICS LABORATORY



THE UNIVERSITY OF
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The SABRE (Sodium iodide with Active Background REjection) experiments aim to detect an annual rate modulation from dark matter interactions in ultra-high purity NaI(Tl) crystals in order to provide a model independent test of the signal observed by DAMA/LIBRA. The SABRE South experiment is located at the Stawell Underground Physics Laboratory (SUPL), Australia, and is partnered with SABRE North at the Laboratori Nazionali del Gran Sasso (LNGS). SUPL is the first deep underground laboratory in the Southern Hemisphere and is due to be ready for use by mid-2022.

Michael Mews, Phillip Urquijo
(The University of Melbourne)
On behalf of SABRE South
mmews@student.unimelb.edu.au

SABRE

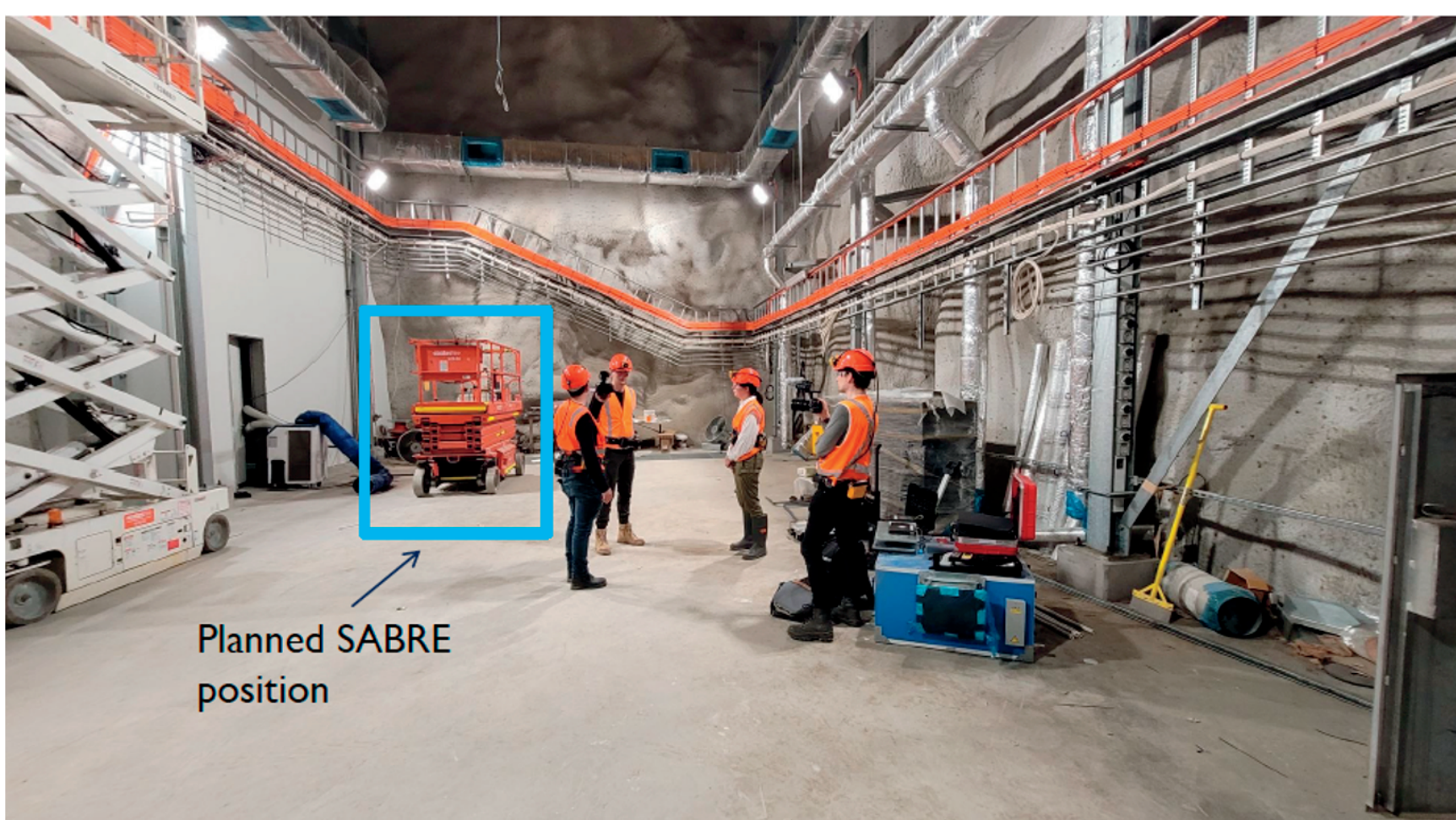
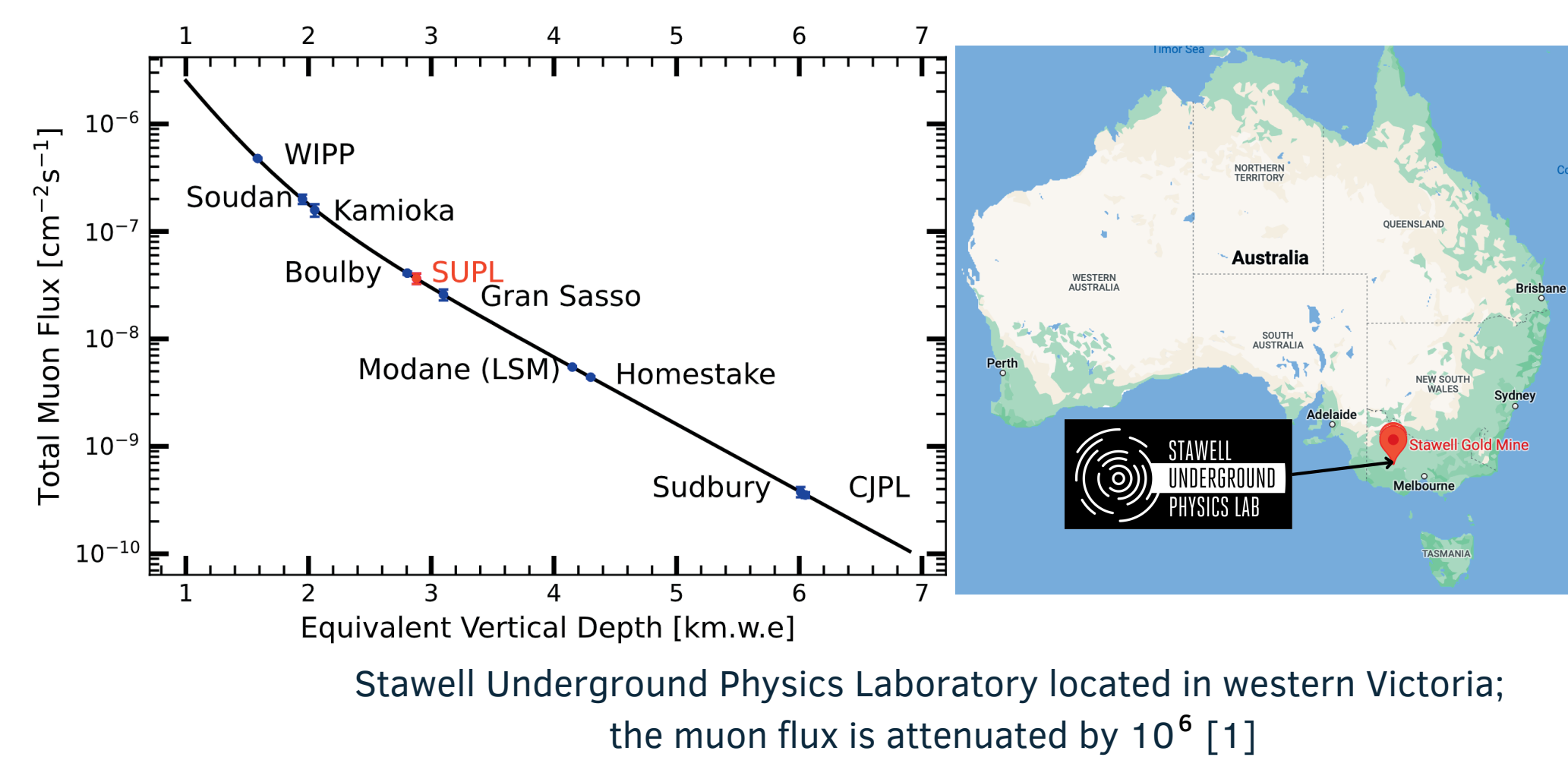
The SABRE South experiment will probe the annual modulation signal reported by DAMA/LIBRA with the improvements:

- Active background rejection
- Ultra high-purity crystals
- Low energy threshold
- First southern hemisphere measurement

SABRE South will operate in tandem with the SABRE North experiment (see Claudia Tomei's talk at this conference) - detectors placed in SUPL (Victoria, Australia) and LNGS (Gran Sasso, Italy). Data collection to commence 2023.

STAWELL UNDERGROUND PHYSICS LABORATORY

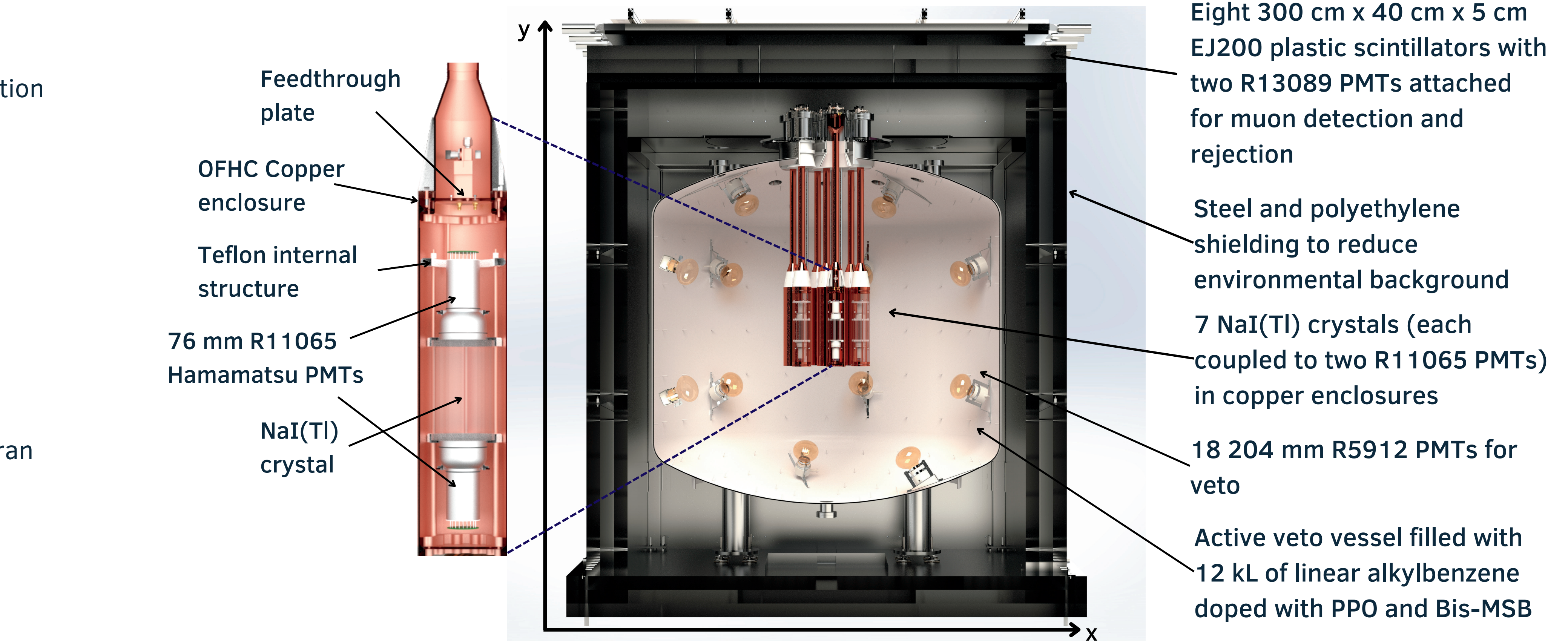
- 240 km north-west of Melbourne
- 1025 m (2870 m w.e.) underground
- Flat overburden of rock (predominantly basalt)
- 10 m x 24.5 m x 12 m experimental hall
- Shotcrete walls and sealed with Tekflex to reduce radon intrusion
- Construction completed June 2022



Stawell underground physics laboratory, 1025 m underground in the final stages of construction. The SABRE South vessel will operate in the blue region



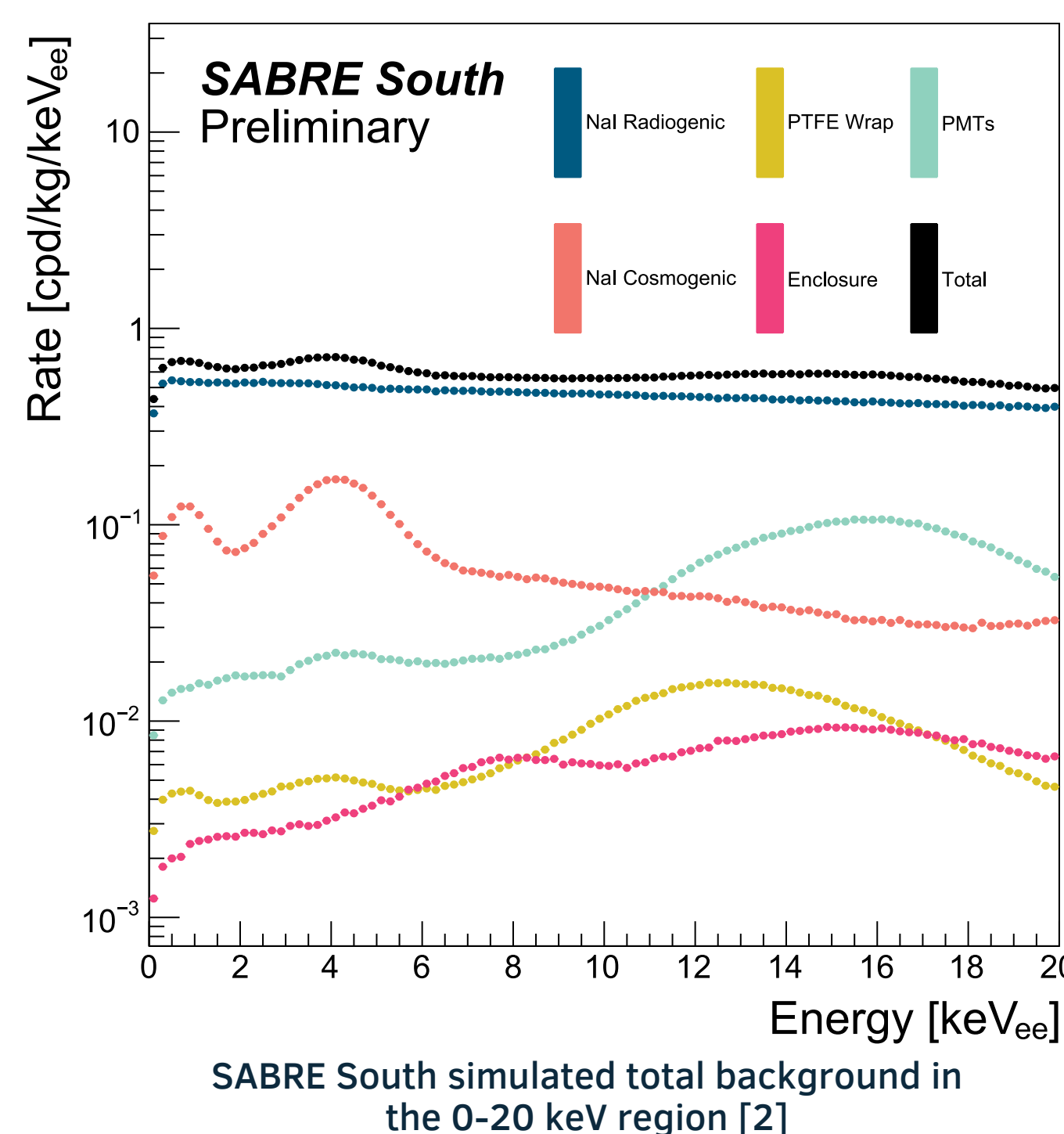
Layout of SUPL: The main hall is depicted in the red region; the SABRE south vessel is located within the orange region.



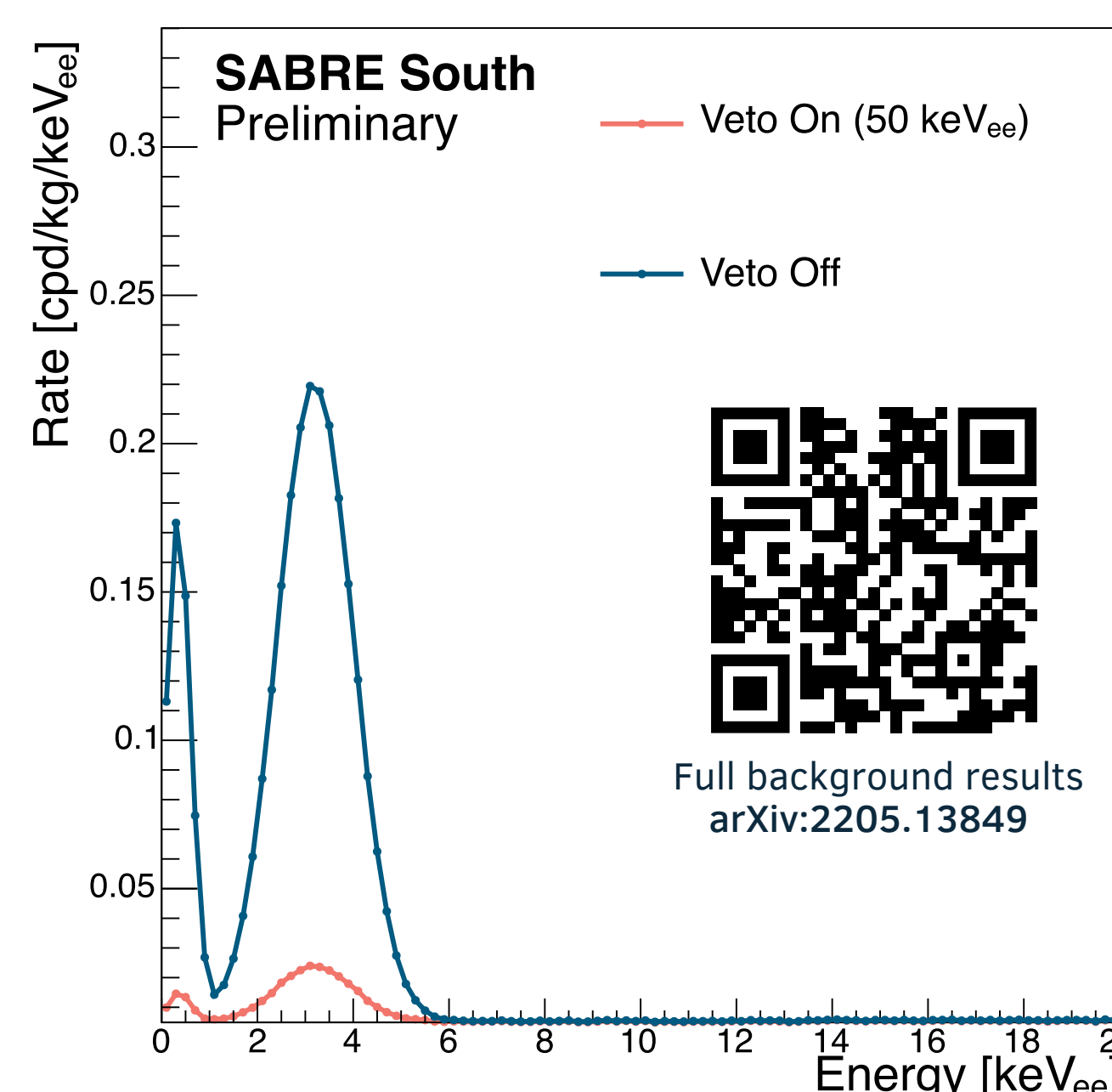
BACKGROUND SIMULATION

Monte Carlo simulation of SABRE South in Geant4 predicts the following major backgrounds for the experiment:

- Contamination of the NaI(Tl) is a significant radioactive contribution to the background
- We estimate a 0.72 cpd/kg/keV_{ee} background in the 1-6 keV_{ee} region
- Majority of the background from ²¹⁰Pb in the crystals (0.28 cpd/kg/keV_{ee})
- Cosmogenic exposure produced ³H, contributing a further 0.032 cpd/kg/keV_{ee}



- Veto tags and rejects events >50 keV_{ee}
- 0.12 PE/keV_{ee} light yield
- Veto reduces ⁴⁰K background from 0.1 to 0.013 cpd/kg/keV_{ee}

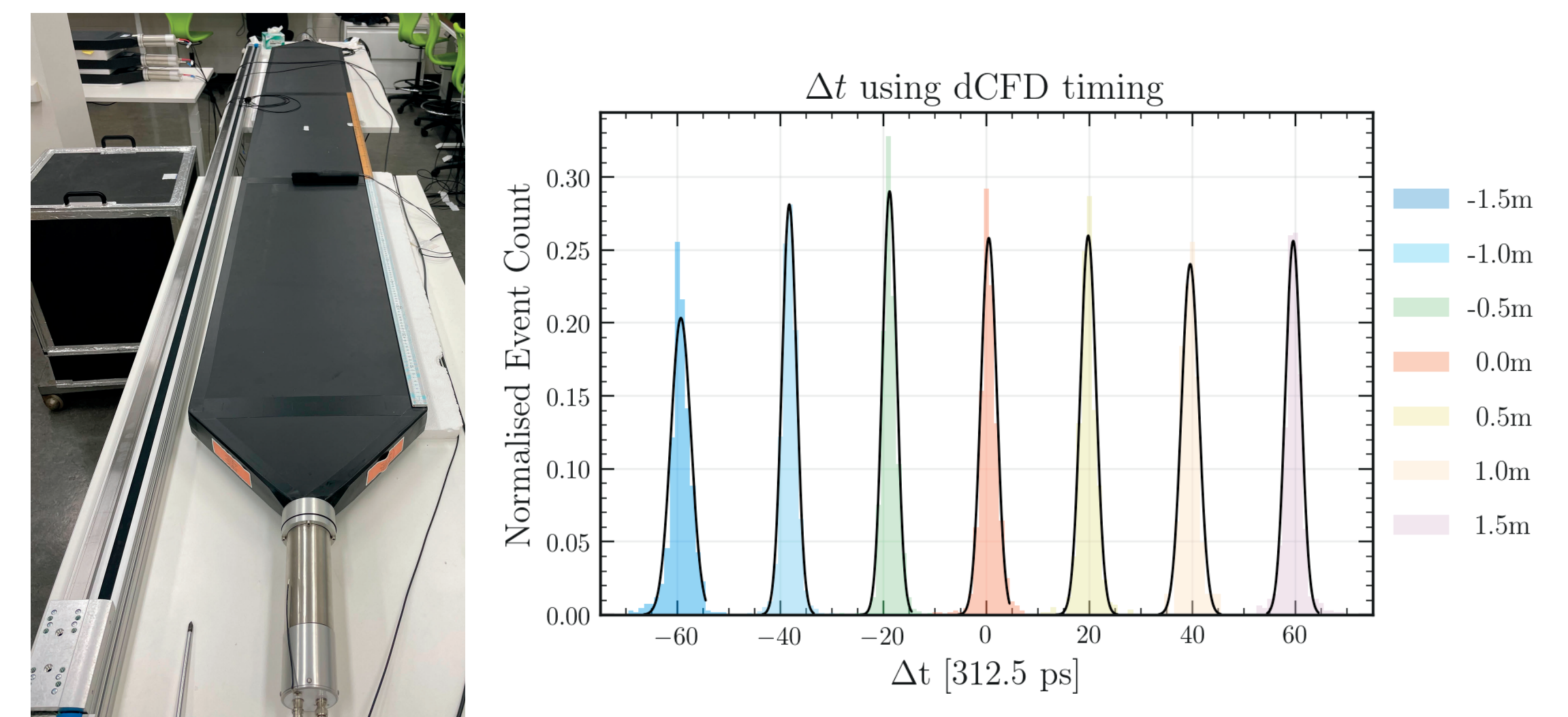


VETO POSITION RECONSTRUCTION

SABRE's background will modulate seasonally → we can track and identify particles in both vetos to further understand background processes

MUON VETO

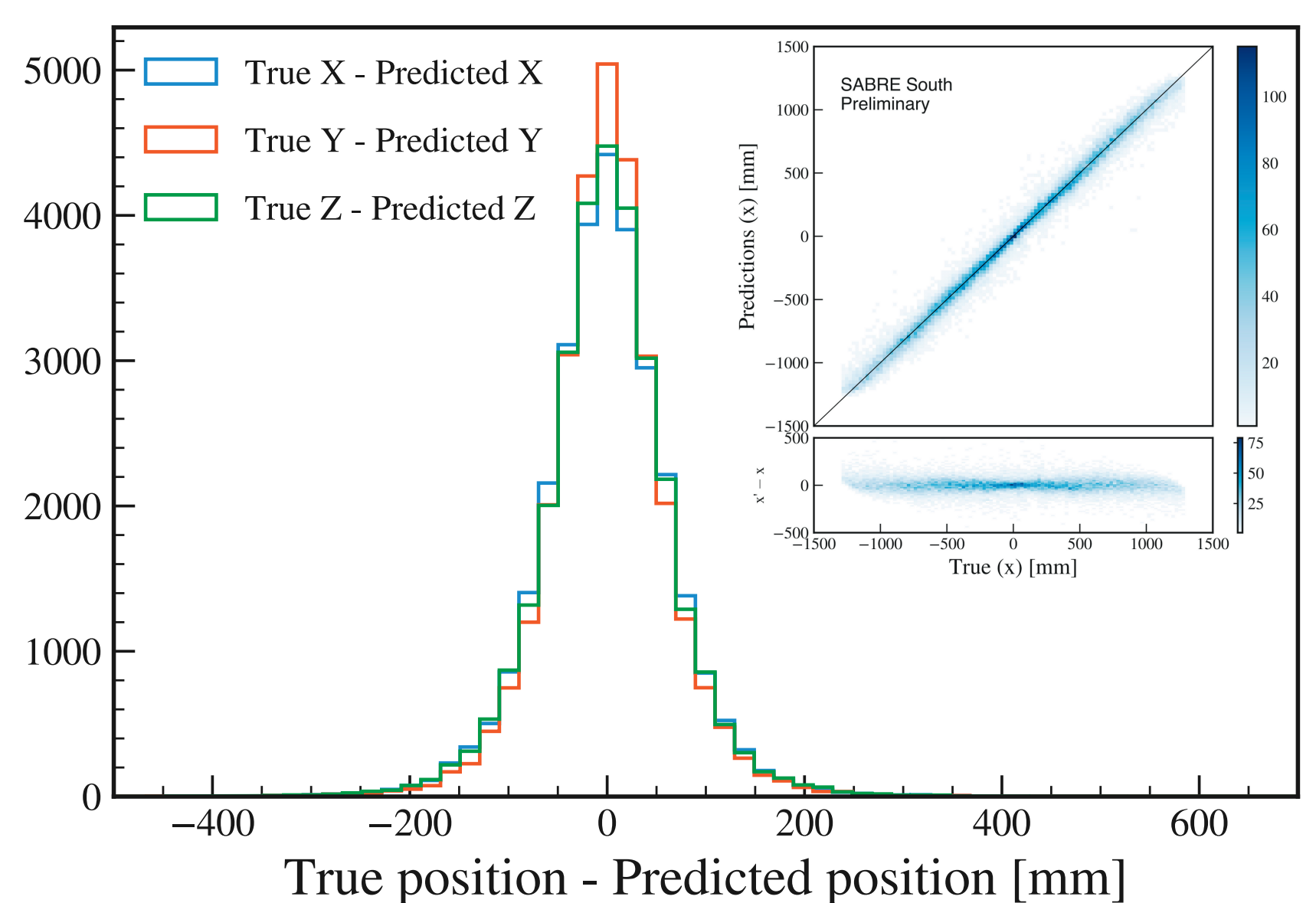
- Coverage above SABRE to veto majority of cosmic rays
- Will measure long-term muon flux at SUPL
- Measured a 400 ps resolution for the time differences between each PMT → 7 cm position resolution



Left: A single muon detector module with calibration stage and external trigger detector. Right: Time differences in a single muon detector at seven independent locations along the longest dimension, isolated with an external trigger detector

VETO POSITION RECONSTRUCTION

- Generated 1 MeV depositions in the LAB using Geant4
- 8 cm position resolution achieved by training a boosted regression model from XGBoost on event times and energy
- We can use time-of-flight between the muon and liquid veto for particle identification



CONCLUSION

SABRE South is currently being commissioned in the newly constructed SUPL laboratory, and is expected to commence operation in 2023. Each sub-detector system is undergoing full characterisation before installation later this year. Based on the background simulation results, SABRE South is expected to reject the DAMA/LIBRA modulation at 3σ or confirm it at 5σ within 2.5 years of live data taking.

ACKNOWLEDGEMENTS

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REFERENCES

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- [2] E. Barberio et al 2022 (SABRE Collaboration) [arXiv:2205.13849](https://arxiv.org/abs/2205.13849)

