



Science and
Technology
Facilities Council

Boulby Underground
Laboratory

Materials Screening at Boulby Underground Laboratory

Alice Hamer

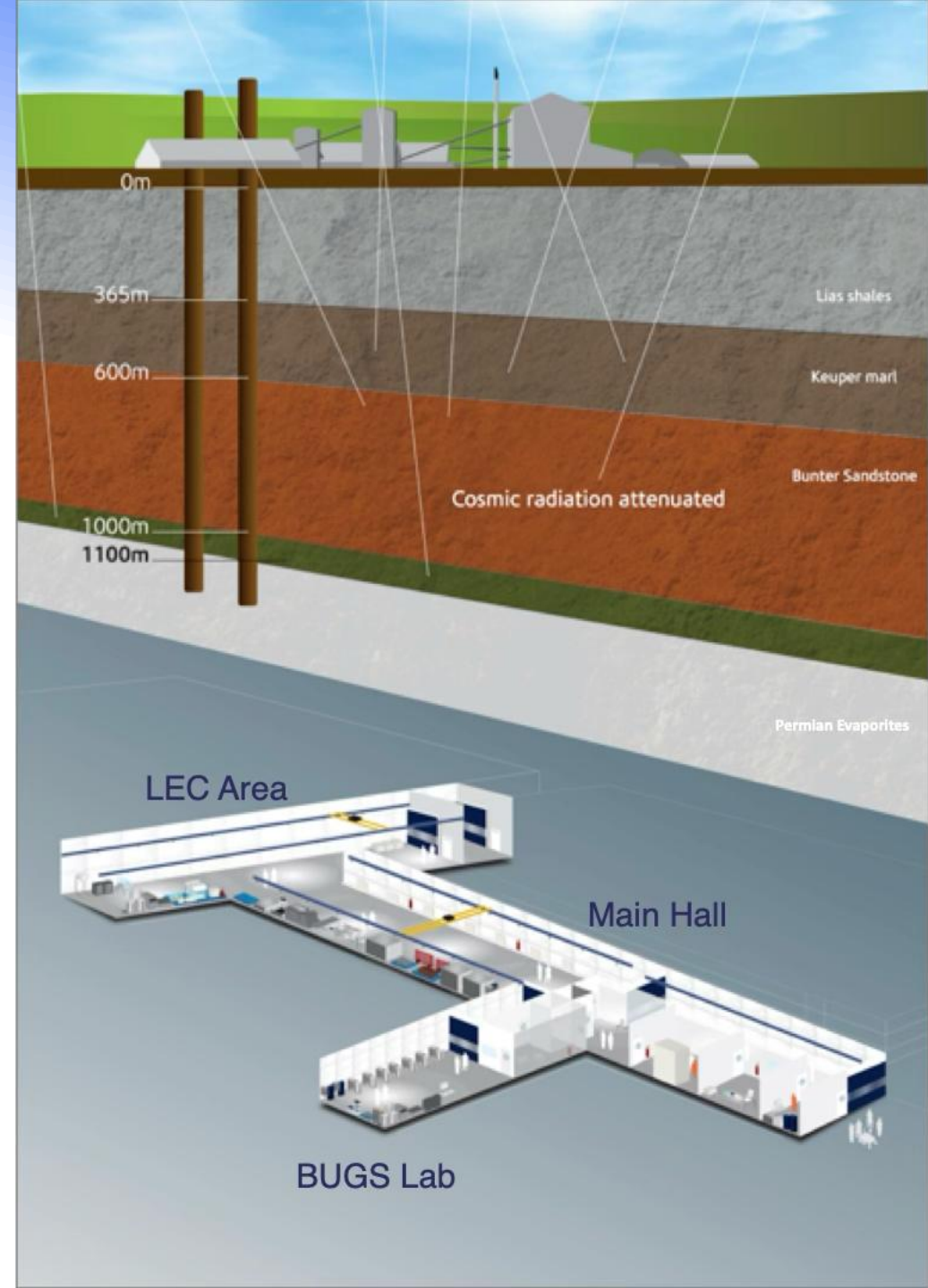
IOP APP/HEPP Conference

07/04/2025



Boulby Underground Laboratory

- The UK's deep underground science facility – 1.1km underground
- Main lab is class 10k cleanroom
- BUGS lab is class 1k cleanroom
- See Sean's talk on Wednesday for more details



Germanium gamma spectroscopy



Surface alpha counting



BUGS: Boulby UnderGround Screening



Radon emanation measurements



Inductively Coupled Plasma Mass Spectrometry (see Sid's talk tomorrow)

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Photo:
Beth
Green

Germanium detectors

- Gamma spectroscopy using high purity germanium crystals.
- Gammas deposit energy in the germanium crystal, producing charge carriers.
- The resulting energy spectrum has distinct peaks corresponding to different gamma emitters.

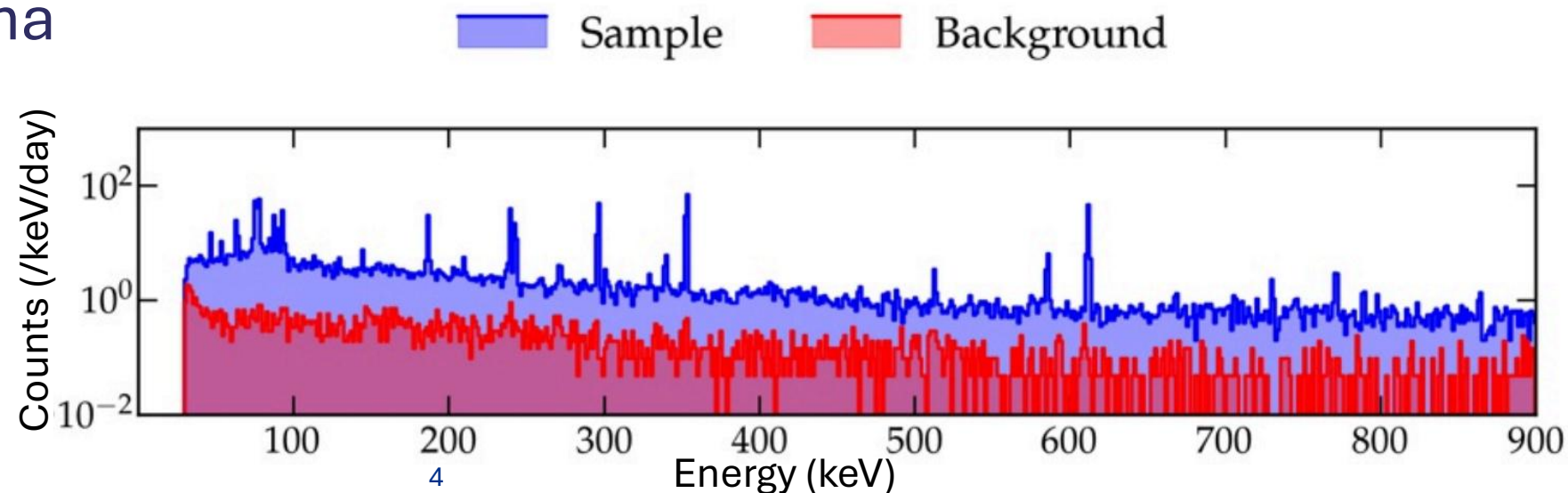
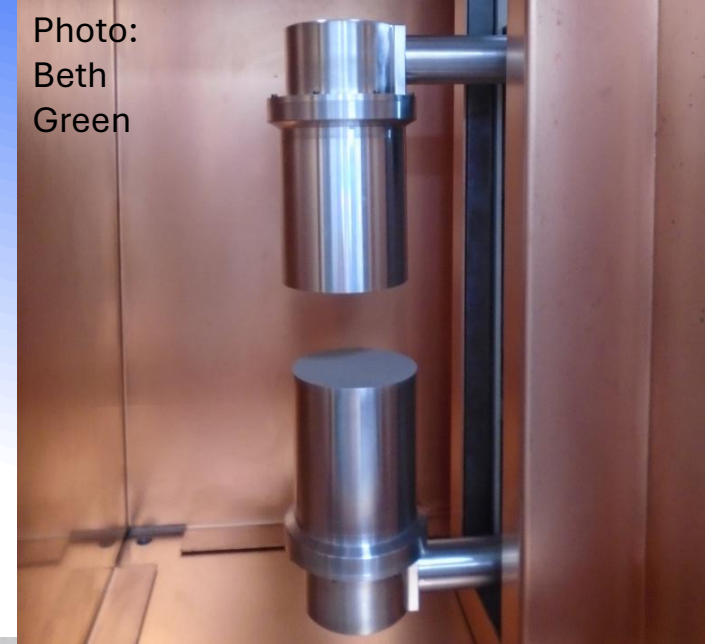


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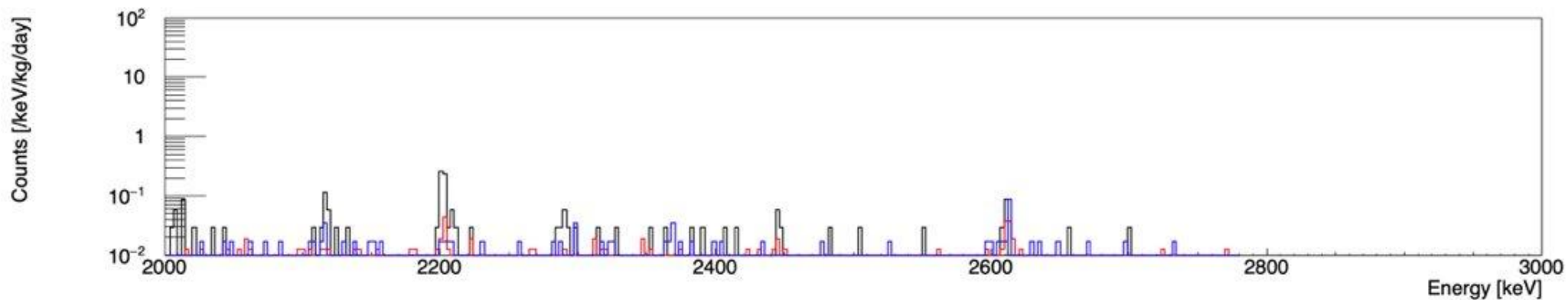
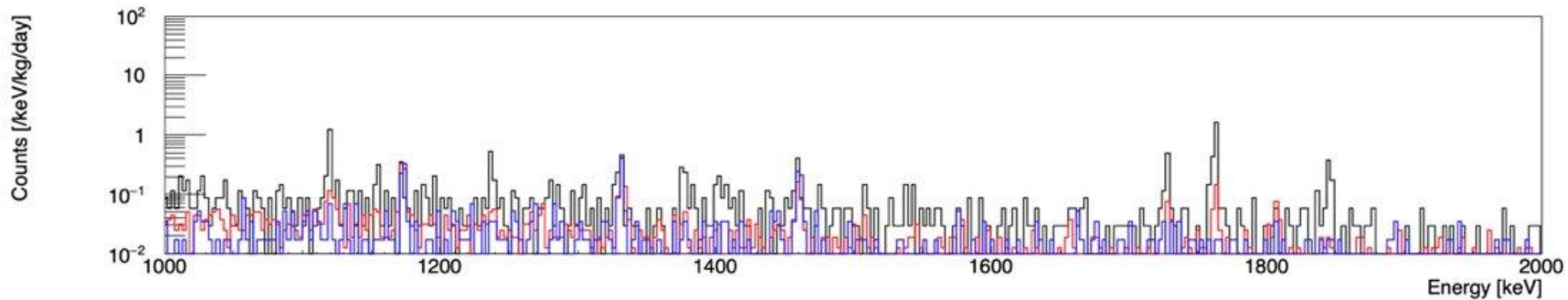
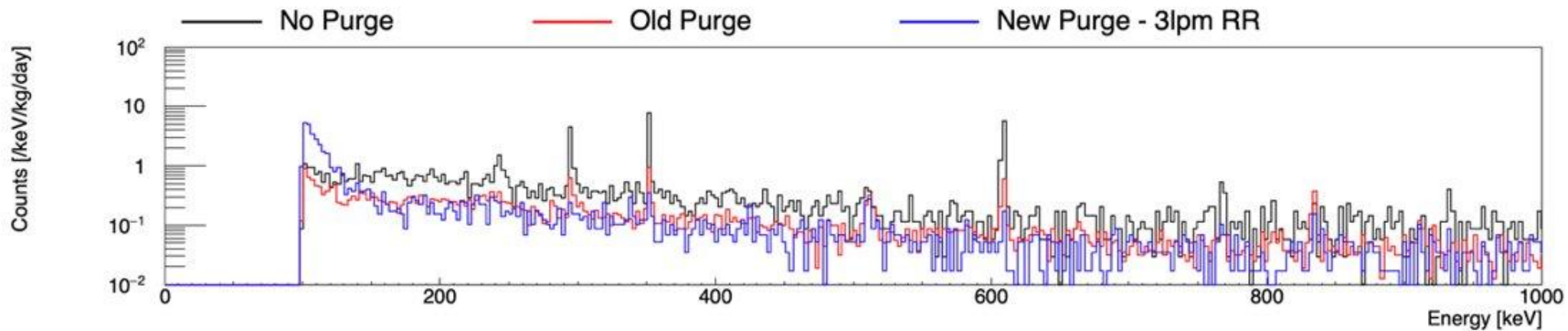
Germanium detectors

- 6 individual detectors, each in their own copper-lined lead castle.
- Plus a new twin system
- All castles are purged at 3L/min with radon-reduced nitrogen gas which is produced in our lab.



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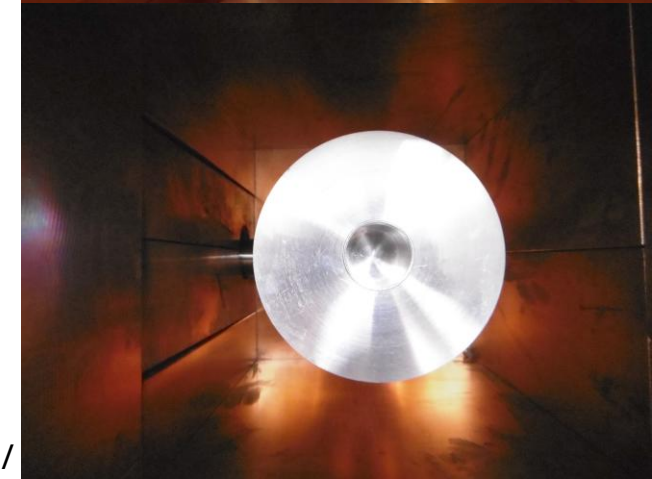
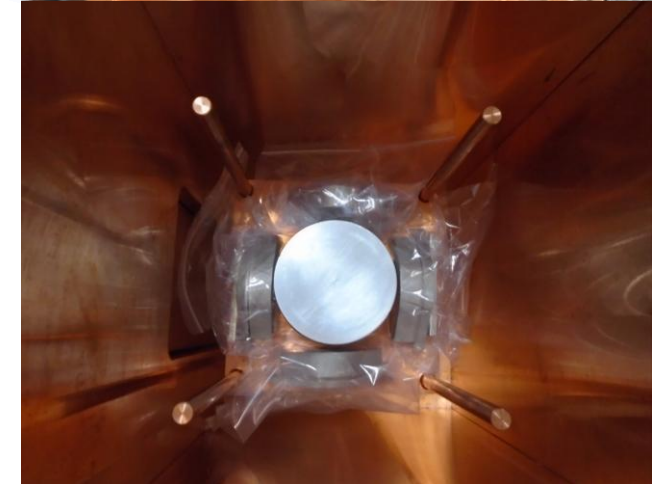
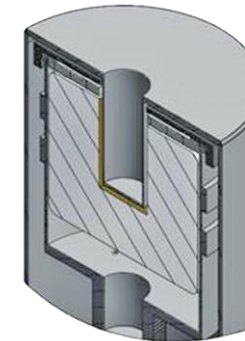
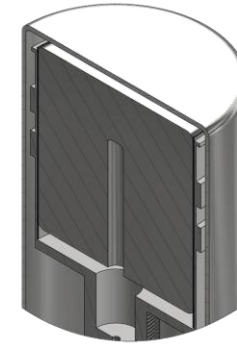
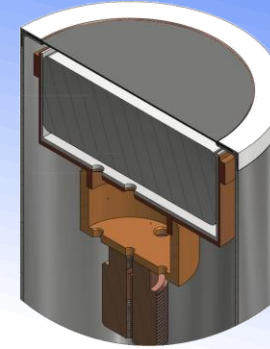
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Germanium detectors

Variety of detectors with different uses:

- 2 BEGe detectors (Roseberry, Chaloner)
- 3 Coaxial detectors (Belmont, Lunehead, Merrybent)
- Well detector (Lumpsey)
- Twin detectors (Upleatham and Kirkleatham)



Germanium detectors

- Roseberry is world leading at low energies
- Working with XLZD to reduce backgrounds to achieve even better sensitivities

Detector	Relative Efficiency or type	Count rate (/kg/day)				
		351 keV (^{214}Pb)	609 keV (^{214}Bi)	238 keV (^{212}Pb)	1461 keV (^{40}K)	2615 keV (^{208}Tl)
Roseberry	BE6530	0.2(1)	0.15(7)	0.8(3)	0.8(2)	0.3(1)
Chaloner	BE5030	5(1)	4(1)	7(1)	8.4(14)	2.1(5)
Belmont	160%	0.2(1)	0.4(2)	0.13(8)	1.0(2)	0.3(1)
Merrybent	100%	2.5(3)	1.8(3)	0.3(1)	1.9(3)	0.8(2)
Lunehead	100%	5.6(5)	4.7(4)	8.3(5)	9.1(6)	2.0(3)
Lumpsey	SAGe-Well	1.1(7)	1.3(3)	1.1(7)	1.7(7)	0.2(2)

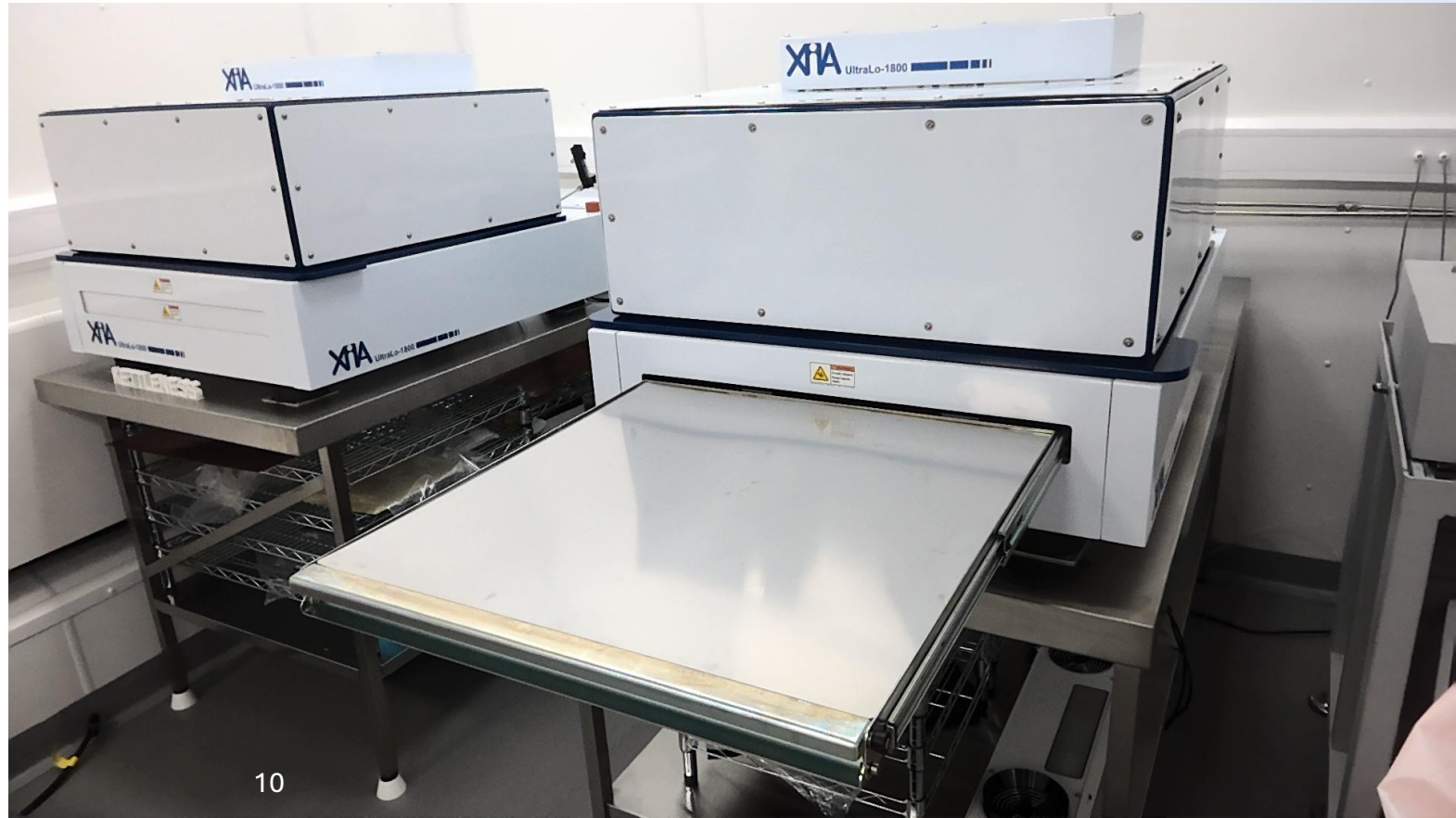
XIA

- Surface alpha counting using XIA UltraLo-1800 detectors
- Uses gaseous argon as an ionisation medium between two electrodes to detect alpha particles emitted from the sample surface.



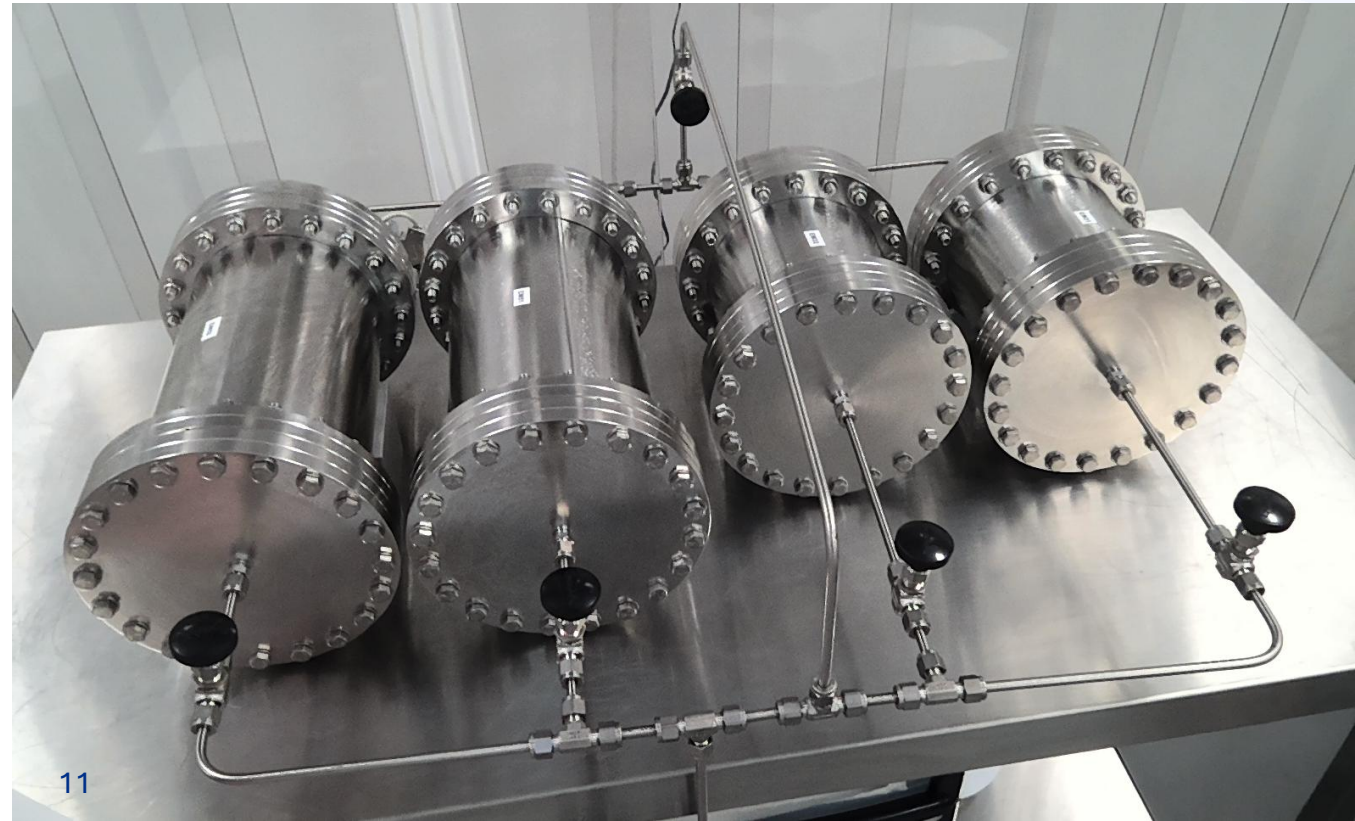
XIA

- The detector trays can accommodate samples up to 42x42 cm and 1.58 mm thick. Works best with thin, flat samples.
- Argon used is boil off from LAr.
- When not in use, the detectors are kept dry with a nitrogen gas purge.



Radon Emanation

- Measurement of the amount of radon emanated from the sample.
- Samples are placed in sealed chambers and left to emanate for 30 days, allowing radon to reach secular equilibrium.
- The gas from the chamber is then flushed through to the detector using radon-reduced nitrogen gas.



Radon Emanation

- In the detector, positively charged radon daughters are attracted to the anode where a PIN diode detects their decays.
- Two detectors with a concentration line setup.
- See Sophie's poster for more details.



Summary

- Boulby has a wide array of assay facilities.
- 4 different technologies in close proximity, to reduce likelihood of contamination.
- Continuing to improve to reach even better sensitivities.