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Boulby Underground Laboratory

Boulby Underground Laboratory and the Boulby Underground Screening Facility

ED BANKS
Facility science technician
(they/them)

Boulby Underground Laboratory

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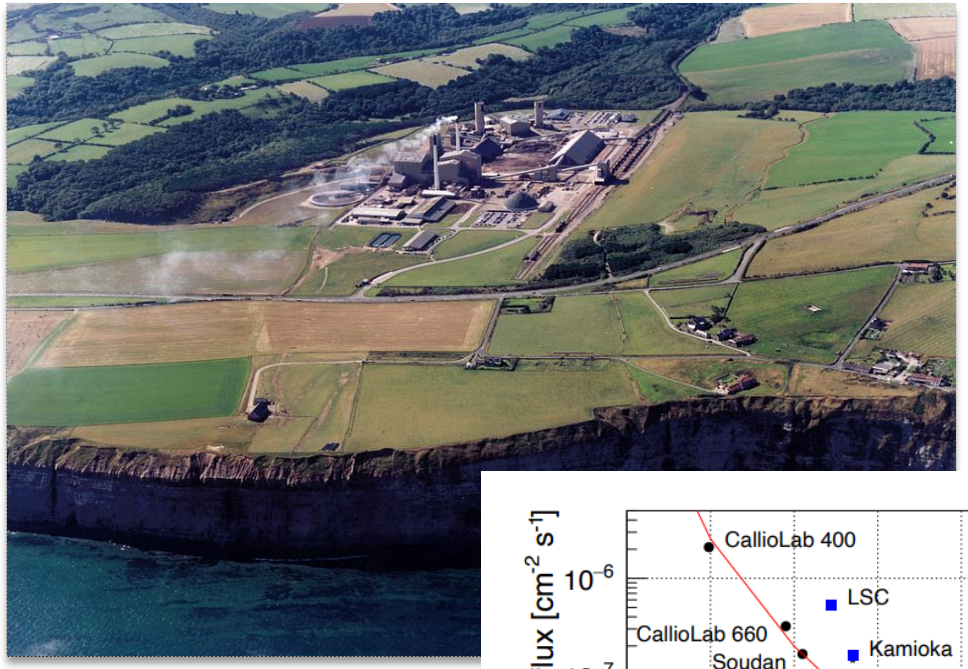
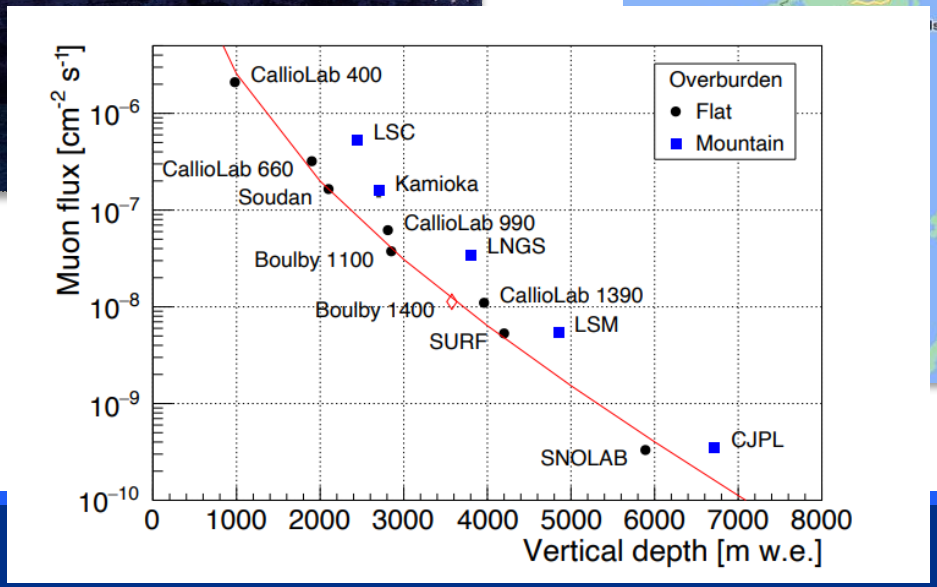
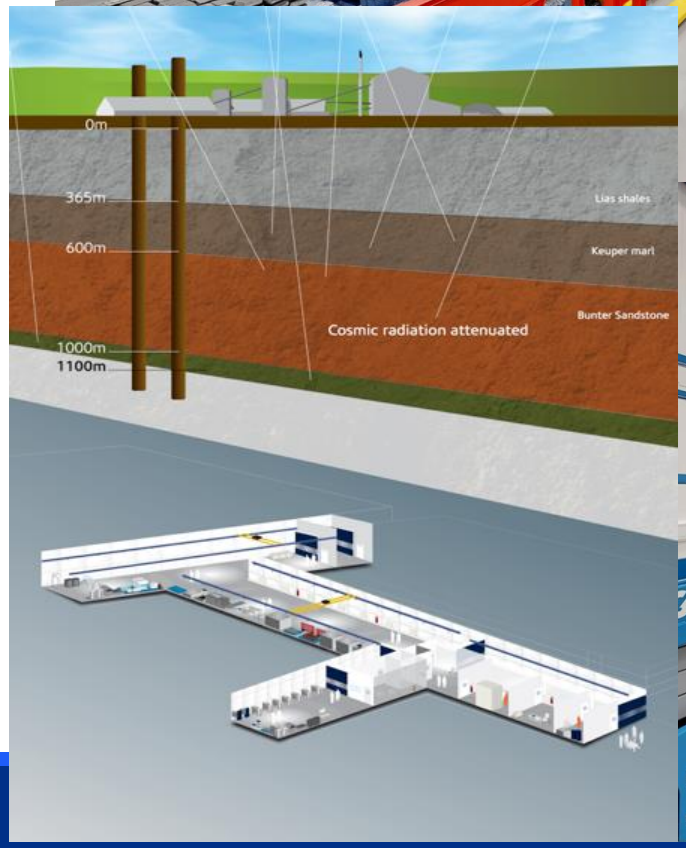




- The UK's deep underground science facility at 1.1km
- One of six STFC sites
- Low natural radon levels (3 Bq/m^3)
- Diverse science programme
- Science and industry partnership

Underground Facility



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- 1.1km deep (2805MWE)
- Provides ~10^6 reduction in cosmic muons
- 4000m^3 lab space, in ISO 7/class 10,000 clean room

The Team

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- Small local team
- Support from wider STFC
- Collaboration with over 40 worldwide institutions, >150 scientists and students.
- Working closely with ICL

Boulby Geology & Mining

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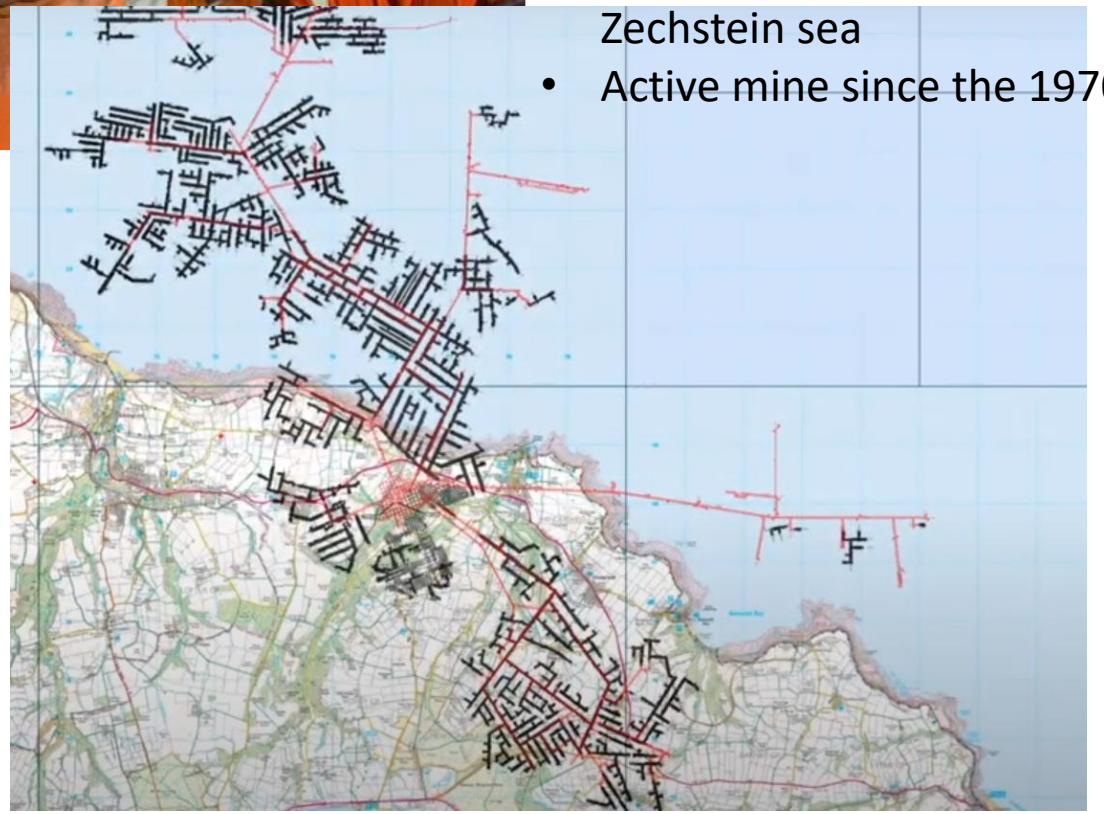
- Israel Chemicals Ltd.
- Mining salts from the Zechstein sea
- Active mine since the 1970s

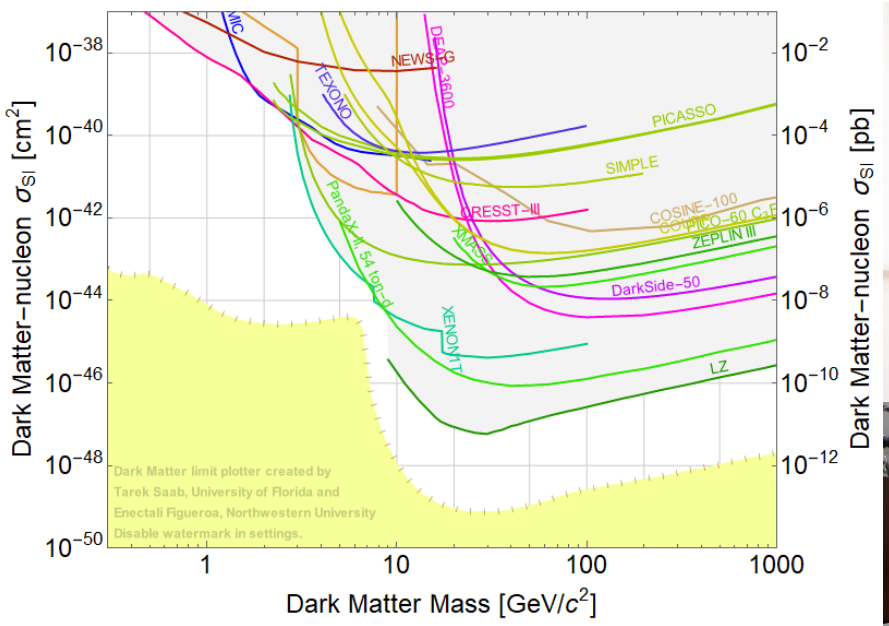
Potash

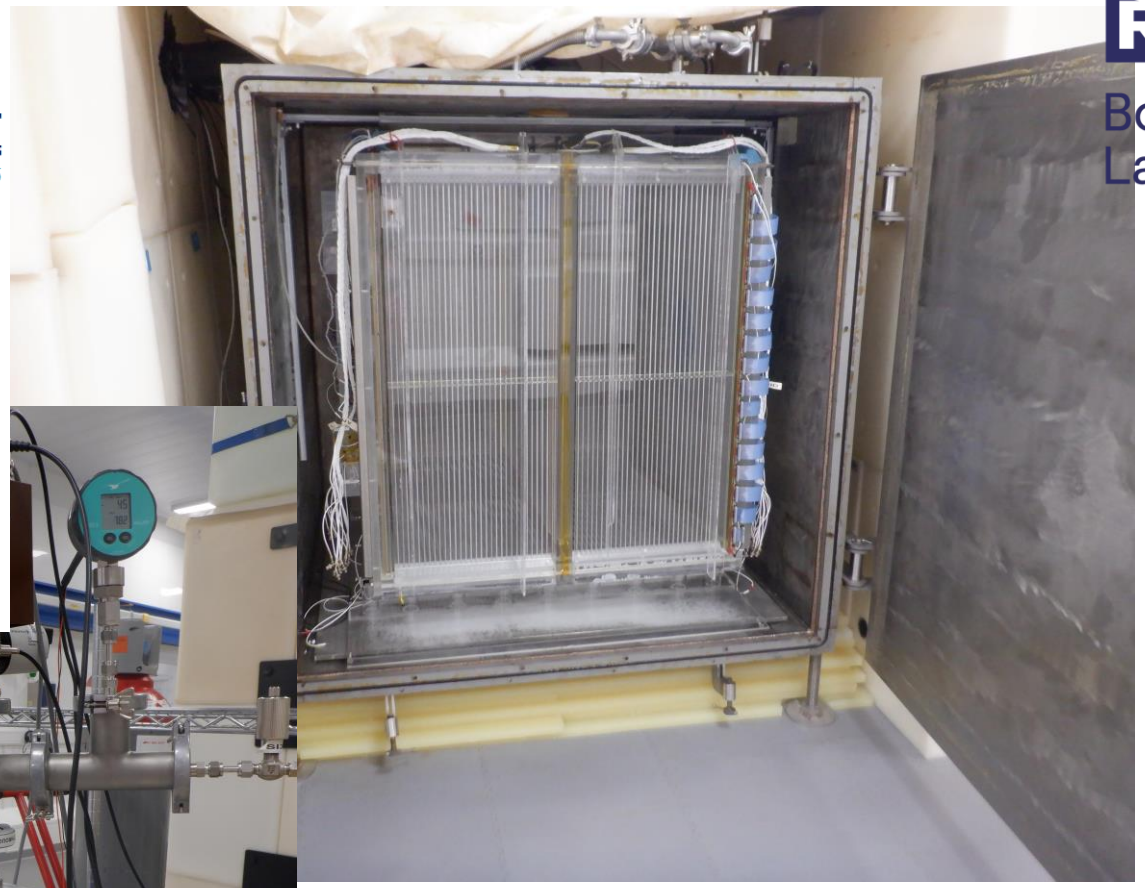
Rock salt

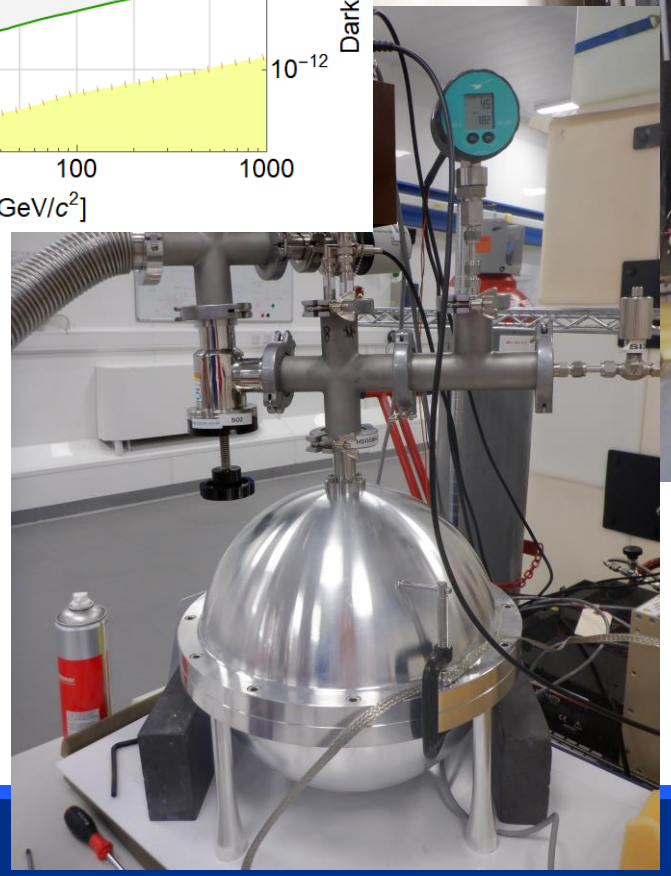
Polyhalite



Dark Matter Searches







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- Active: NEWS-G
- Historical: NAIAD, ZEPLIN, DRIFT
- Future: DarkSPHERE, potential Gen 3

- Helped develop the LZ programme through materials screening

Other Experiments

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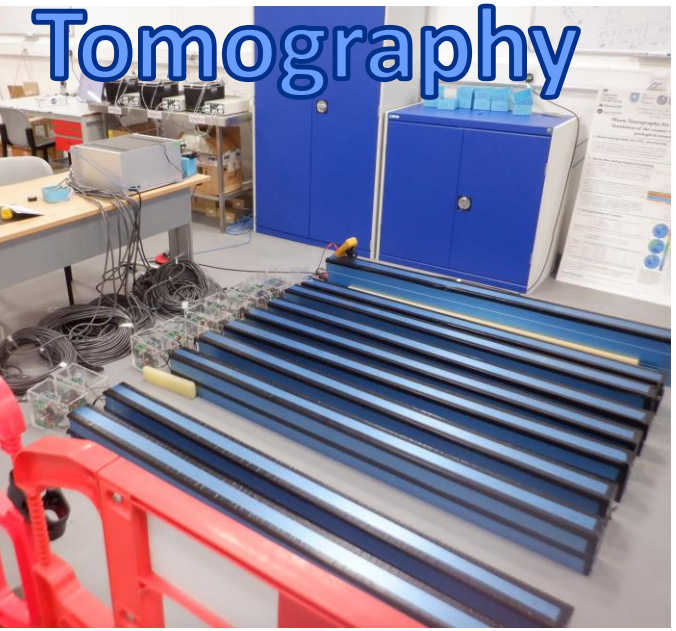
Muon Tomography



Astrobiology

Nuclear Security

Renewable Energy Storage

and more…

BUGS Material Screening

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- Class 1000 (ISO6) cleanroom
- Approx 200m^2

- Current detectors:
- 7 Germanium detectors
- 2 XIA UltraLo-1800
- 2 Radon Emanation detectors

- Have screened for projects including LZ, DAMIC, SuperK and DarkSide

BUGS Nitrogen

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- Recently commissioned upgraded N2 gas system to provide gas for
  - Ge – Purge Gas
  - Ge – LN_2 generator input
  - XIA – dry gas for periods of downtime
  - RnEM – carrier gas/purge gas
- Further improvements planned

Germanium detectors

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- Ortec 1.8 kg (72%) p-type (LB)
- Canberra 2.0 kg (100%) & 3.2 kg (160%) p-types (S-ULB)
- 2x Canberra BEGe detectors (5030 LB, 6530 S-ULB)
- Canberra SAGe Well-type (S-ULB)

- Plans to install a twin system for coincidence

Detector Backgrounds

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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	0.15(7)	0.15(7)	0.8(3)	0.8(2)	0.2(1)
Chaloner	BE5030	5(1)	4(1)	7(1)	8.4(14)	2.1(5)
Belmont	160%	0.7(2)	0.4(1)	0.13(6)	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	104(2) 1.1(7)	60(2) 1.3(3)	166(3) 1.1(7)	7.0(6) 1.7(7)	12(1) 0.7(2)

XIA UltraLo Alpha Particle Counter

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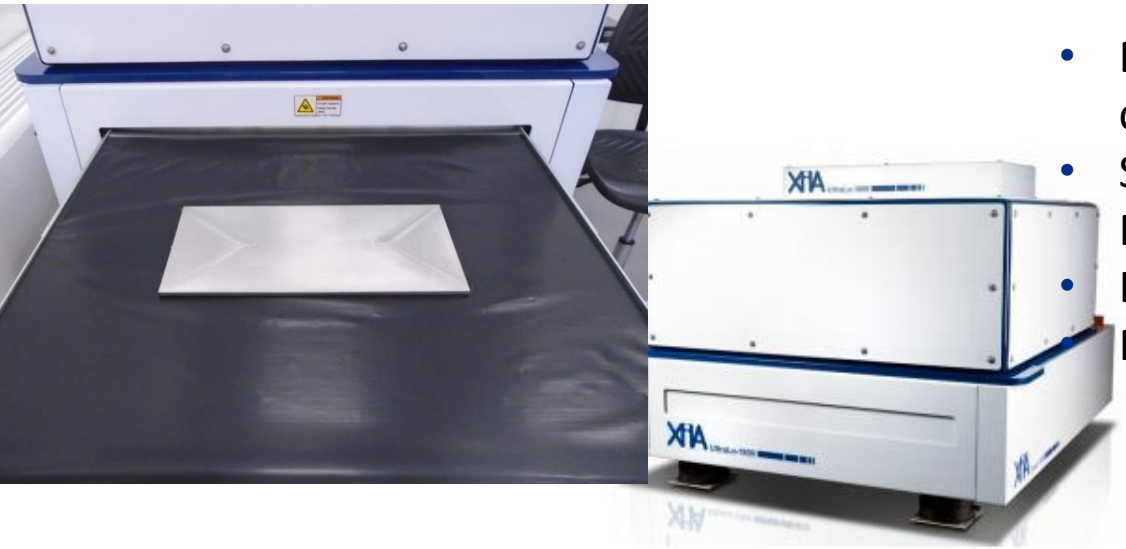

- Two XIA UltraLo-1800 surface alpha counters running at Boulby – Kettleness & Ormesby
- Dedicated argon gas is supplied to the counters via boil off from a 240l dewar. Typical flowrate is 3lpm during measurement and 15lpm during purging. The detector is kept under constant gas flow.

- Developing material cleaning techniques to complement surface assay capabilities.
- Surface measurements of LZ detector components and ultra-pure PNNL copper.
- Installed liner to reduce detector backgrounds.
- Plan to use electroformed copper to further reduce background

UltraLo Results

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The lowest published measurement so far with XIA is XMASS at LRT2015 where they achieved 0.14 ± 0.03 α/khr/cm^2.

Factor three improvement compared to surface lab due to reduced cosmic ray events which can mimic background.

Sample	Duration (hrs)	Alphas	Surface Area (cm^2)	Emissivity (α/khr/cm^2)	Activity (mBq/m^2)
Background (SS Tray)	168	342	1800	1.24 ± 0.07	6.88 ± 0.38
Background (PTFE Liner)	168	103	1800	0.38 ± 0.04	2.12 ± 0.22
PNNL Copper	168	13	707	0.13 ± 0.04	0.72 ± 0.22

Electroforming

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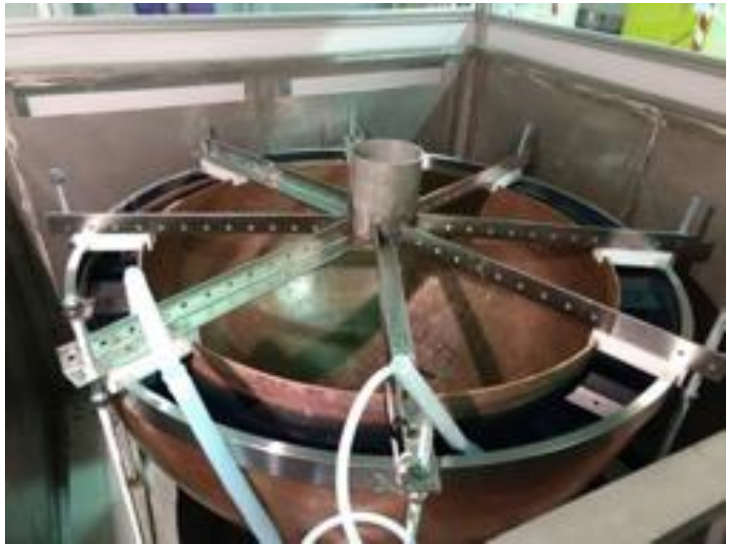
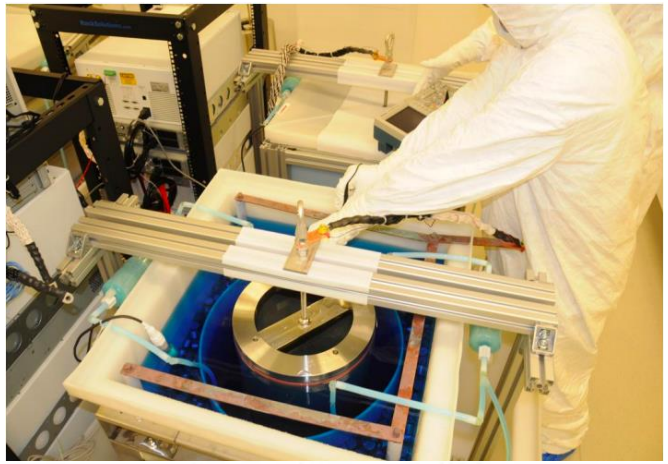
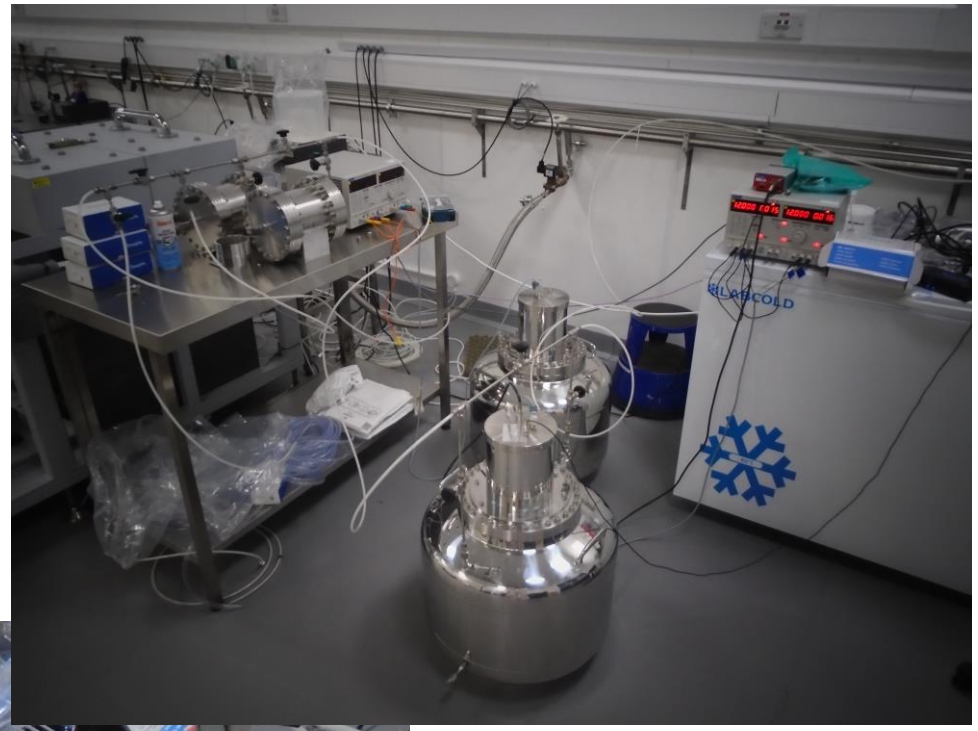
- Electroforming underground suppresses background contribution from cosmogenic activation
- Already demonstrated feasibility by NEWS-G collaboration
- 500 µm layer plated to inner surface of 140 cm detector
- Plating rate ~1 mm/month
- Current ^{238}U and ^{232}Th contaminations below sensitivity of most sensitive assay technique, ICP-MS
- Bounds are just upper limit – value may be much lower
- ^{210}Pb assayed with XIA UltraLo-1800 α-particle counter. Again, below sensitivity of device





Radon Emanation Detectors



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- 2 30L detectors
- 2 3L emanation chambers

- Newly installed, stable and already sensitive to very low levels of Radon emanation

- We are still characterising the system, which will continue for some time, but first results are positive

Radon Emanation Detectors

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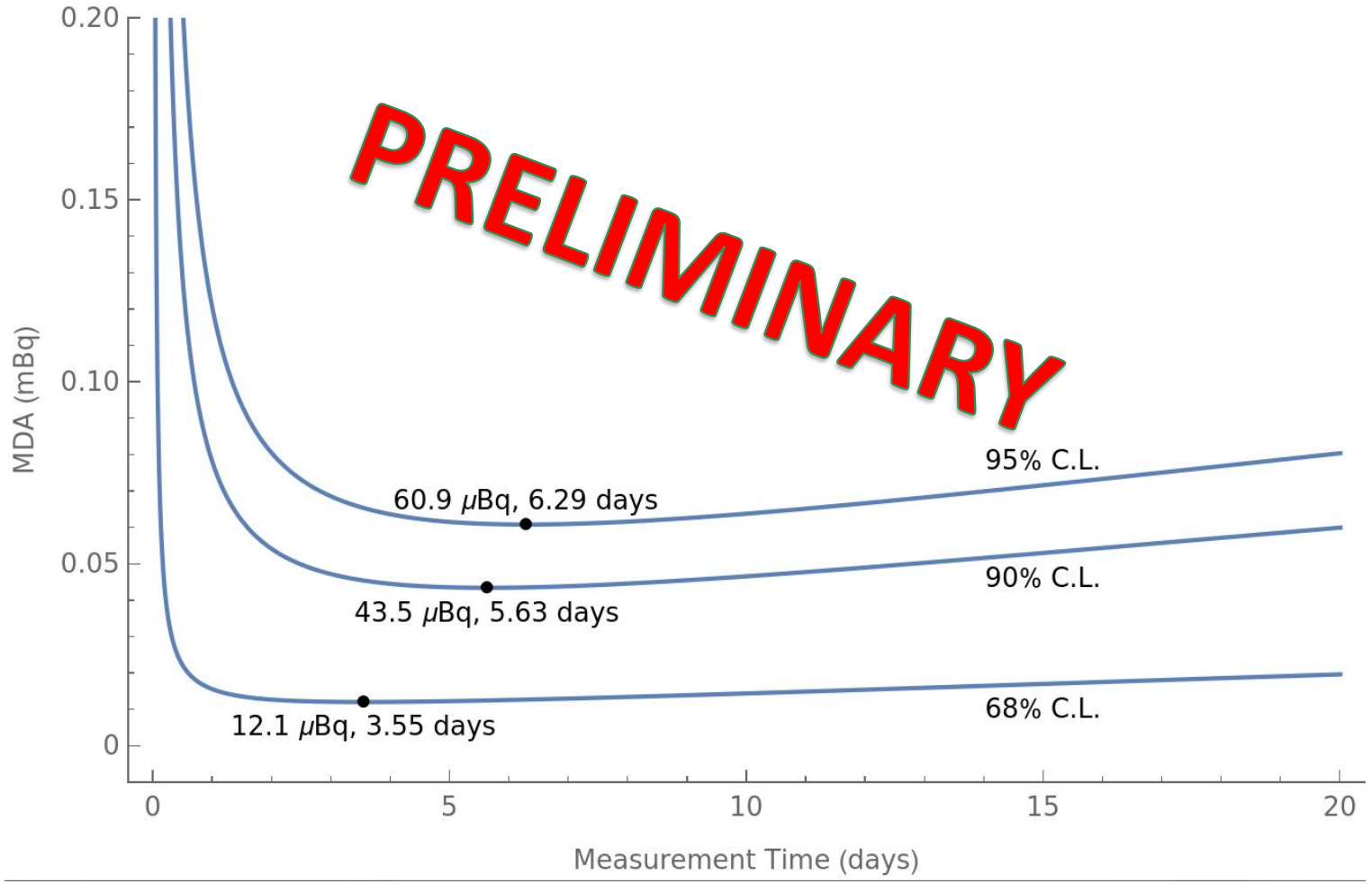

- 16 Po214 counts in 19.7 days of background.
- Less than one count per day

Planned improvements include:

- Improved sensitivity with RnCL and higher N2 flow
- Improved stability and performance with new CAEN DAQ
- Improved usability with expanding sample tracking system and a wider range of emanation chambers

Thanks for listening!

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