



Emma Meehan
STFC Boulby Underground Science Facility

Deep Science at Boulby Underground Laboratory:

Current studies & details of new underground facilities to support UK & international underground science.

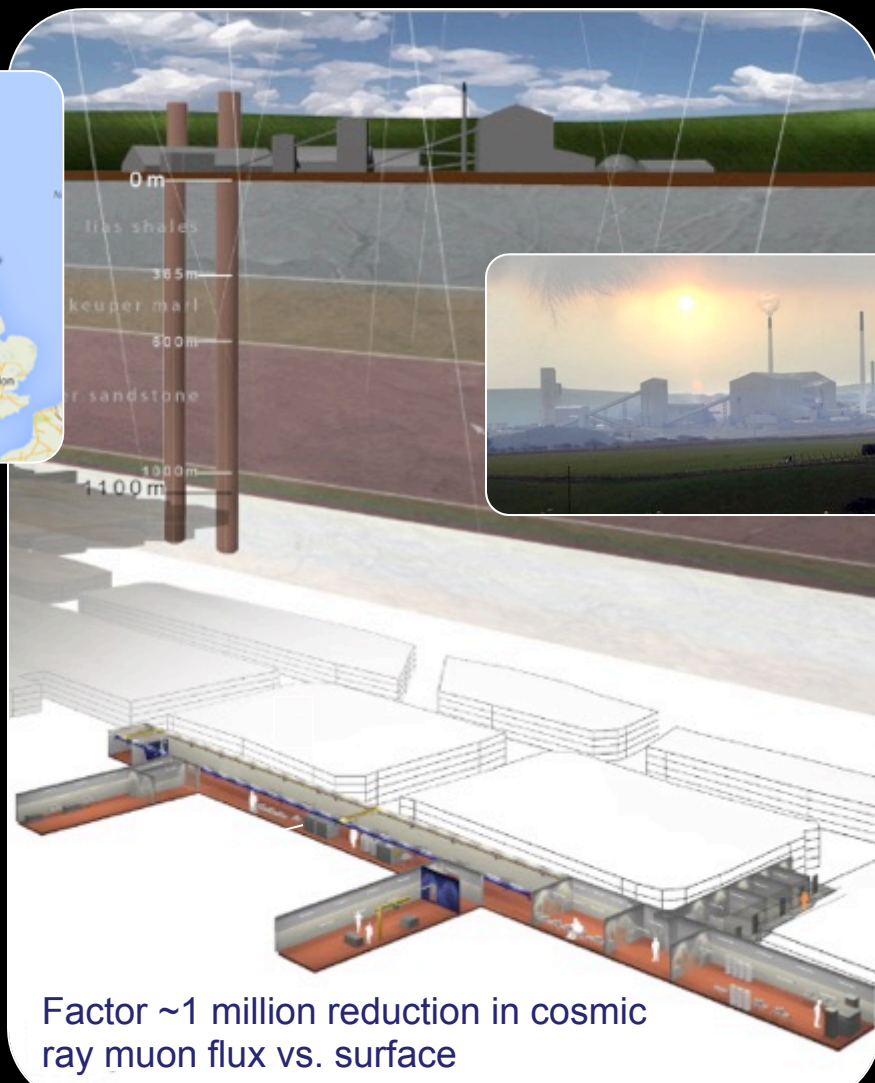


Boulby Underground Laboratory

The UK's deep underground science facility operating in a working potash and salt mine.

1.1km depth (2805 mwe). With low background surrounding rock-salt

Operated by the UK's Science & Technology Facilities Council (STFC) in partnership with the mine operators ICL



Factor ~1 million reduction in cosmic ray muon flux vs. surface



Boulby Palmer lab. >800m² floor space.
Operating since 2001

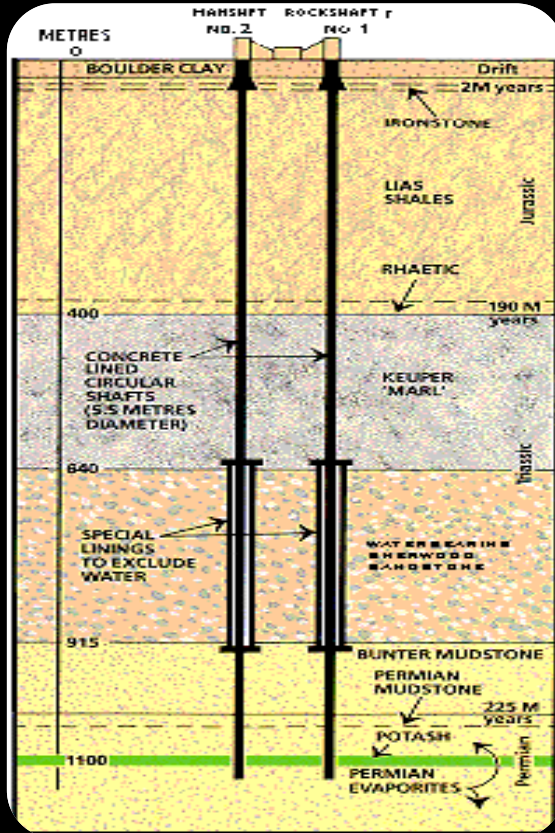




Boulby Geology & Mining

Excavations are in Salt (NaCl) & Potash (KCl) Permian evaporite layers left over from the Zechstein Sea.

Over 40 kms of tunnel mined each year (now >1,000kms in total), the long-lived roadways being cut in the lower NaCl layer.



Boulby Geology

U: 67 ± 6 ppb
Th: 125 ± 10 ppb
Low γ & n backgrounds
Low Rn (<3 Bqm⁻³)

Rock-Salt



Potash



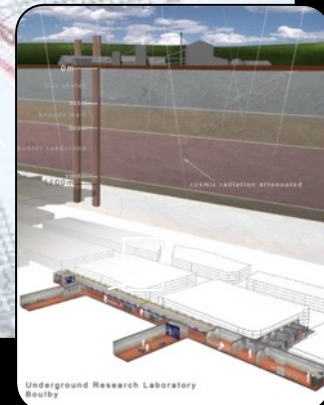
Typical Boulby Salt Roadway



Boulby Mine



Mine Shafts



Underground Research Laboratory Boulby



Palmer Lab

Mining at Boulby...



Underground Science @ Boulby Mine

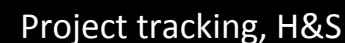
- DRIFT: Directional Dark Matter Search
- BUGs: Ultra-low background material screening
- Deep Carbon: Muon Tomography for CCS (etc)
- ERSaB: Environmental gamma spectroscopy
- BISAL: Geomicrobiology / Astrobiology studies
- MINAR: Space Exploration Tech. Development
- Misc. Geology / Geoscience
- Misc. Low-background support projects
- Etc... (More to come).



A growing multi-disciplinary science programme:
from astrophysics (Dark Matter) to studies of geology,
climate, the environment, life on Earth and beyond.



- ‘A hole in the ground does not make a facility’**



A NEW LABORATORY now being built at Boulby

To replace current facility and host **planned & new projects** for the next decade and more...



Project completion date: End 2016

Mars Analogue Area & outside testing area

Materials Entrance 2

Main hall:
Internal Lab
height/width of
4m/7m

Materials Entrance 1

Offices &
People
Entrance

Material Store

Large Expt. Cave Area:
Internal lab height/
width of 6.5m/7m

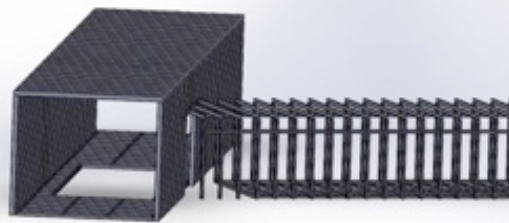
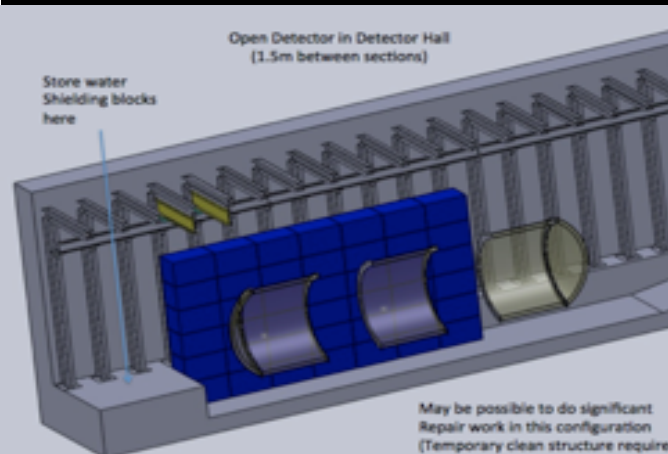
BUGS ULB
Counting facility



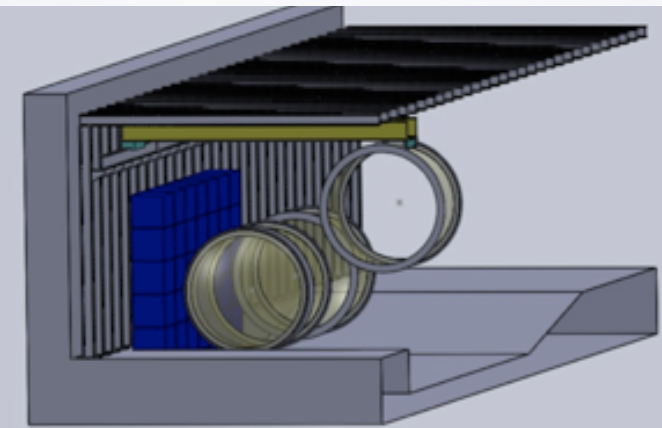
Fully-equipped 4000m³ lab. Class 10K & 1K clean room throughout. 5-10T lifting capacity.

50m

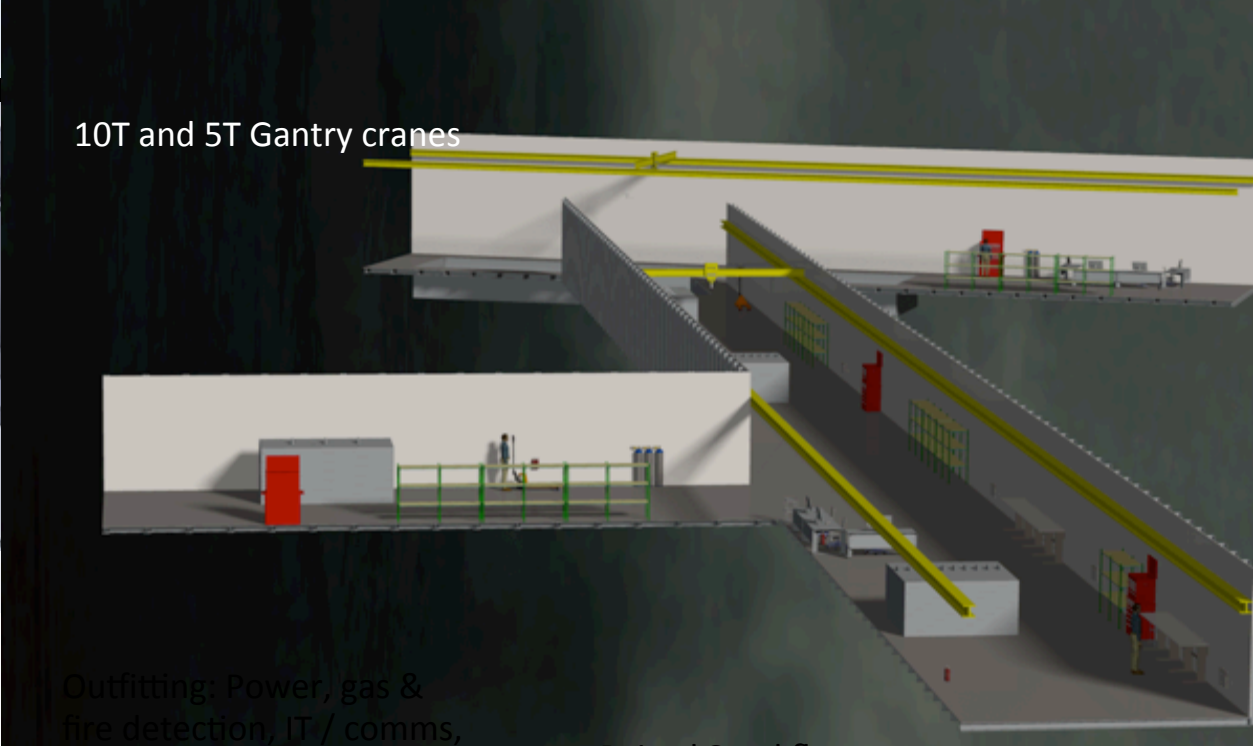
New Laboratory Details



Large Experimental Cavern (6mx7m Internal HxW)

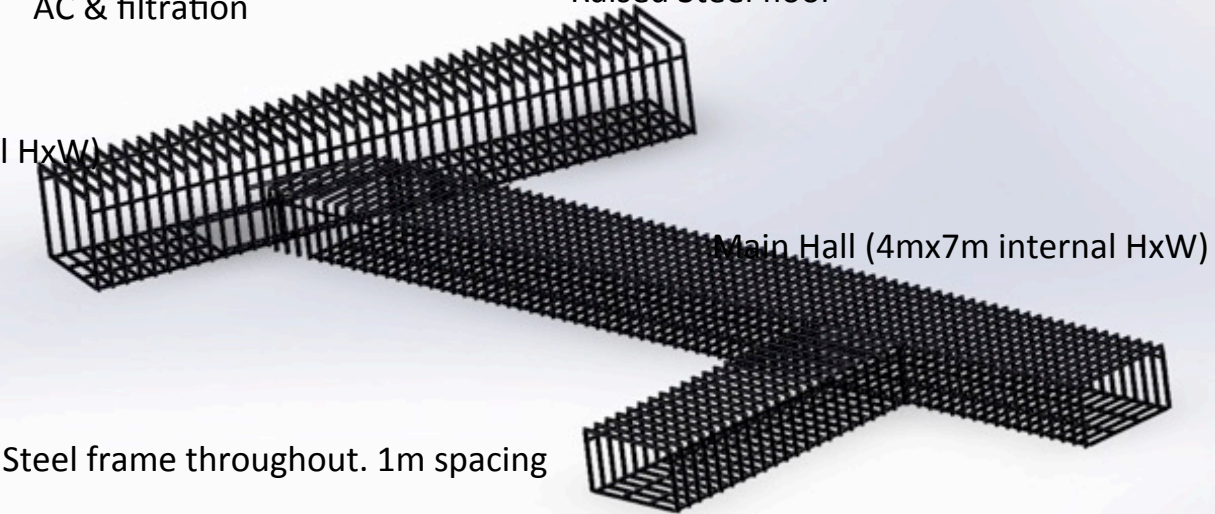


10T and 5T Gantry cranes



Outfitting: Power, gas & fire detection, IT / comms, AC & filtration

Raised Steel floor



Main Hall (4mx7m internal HxW)

Steel frame throughout. 1m spacing

Expected completion
July 2016



Main Experimental Hall (7x4x60m)



BUGS-ULB Germanium Facility



Boulby New Lab
Construction
March 2016



Large Experimental Cavern (LEC)
(7x7x35m)

> 4000m³ of well supported **class 1,000** and **class 10,000** clean room experimental space



Air conditioning, HEPA filtration, internet / comms, 5 & 10 Tonne lifting capacity.

Now moving experiments in from old lab.

Boulby New Lab Large Experimental Cavern (LEC)

July 2016



Boulby Dark Matter Studies

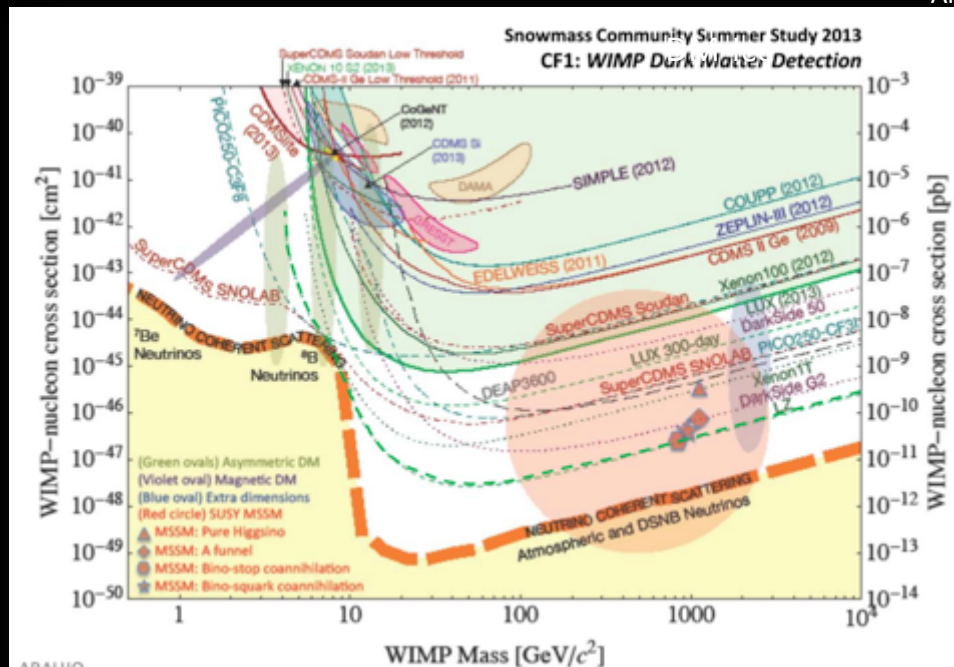
Boulby has hosted Dark Matter search studies for two decades. Including the **NAIAD, DRIFT & ZEPLIN** experiment programmes.

Boulby now hosts DRIFT Directional DM programme, doing R&D for DM-Ice & providing ULB material screening for other studies, inc **LUX-ZEPLIN**



ZEPLIN-III @ Boulby

Alpha



ZEPLIN: The world's first 2-phase Xenon dark matter detector (Finished 2011)



Current limits & future projections

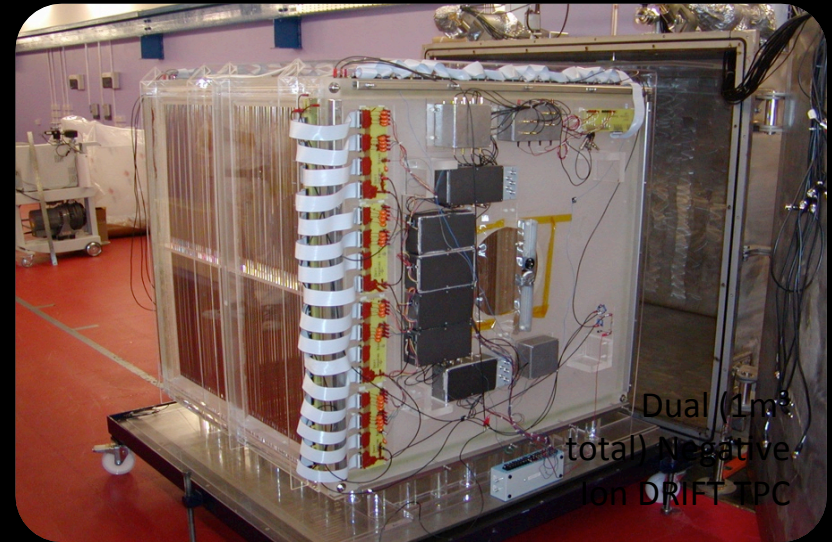


DRIFT-II @ Boulby...

A **DIRECTIONAL** Dark Matter Detector.

Occidental College, New Mexico, Colorado State, Hawaii, Wellesley, Sheffield, Edinburgh, Boulby

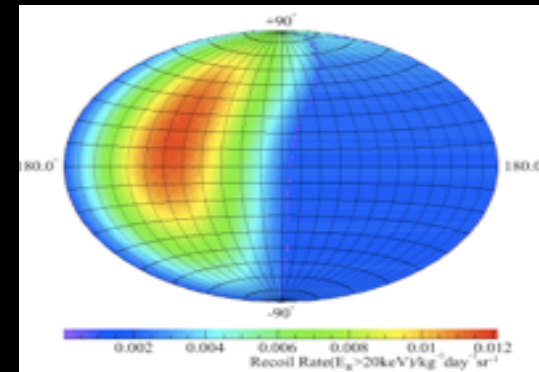
STATUS: Programme operating at Boulby since 2001. Currently limit-setting and conducting system performance & scale-up R&D.



DRIFT-II@d Boulby

Dual (1m³ total) Negative Ion DRIFT TPC

Directional detection



Directional DM detection – providing the most powerful direct detection signature

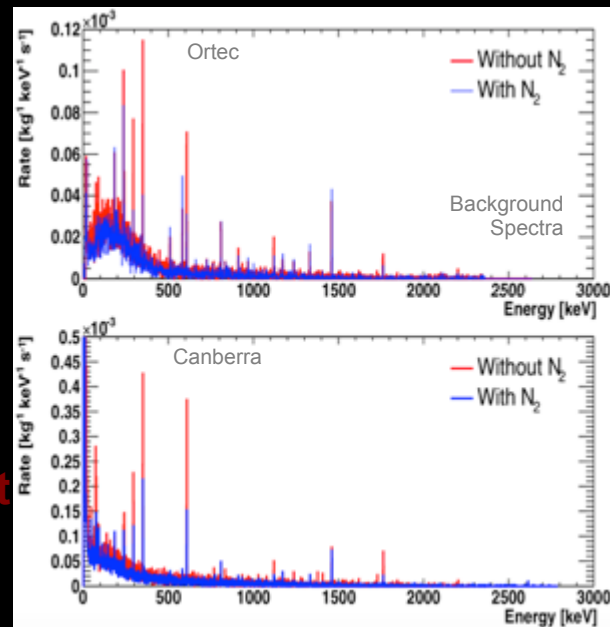
ULB Material Screening

Growing suite ('BUGS') of Ultra-Low-Background germanium detector systems to support Dark Matter & misc 'rare-event' studies.



- Ortec 2kg Coax (90% eff).
- 2 Canberra BEGe detectors
- Canberra SAGe Well-type

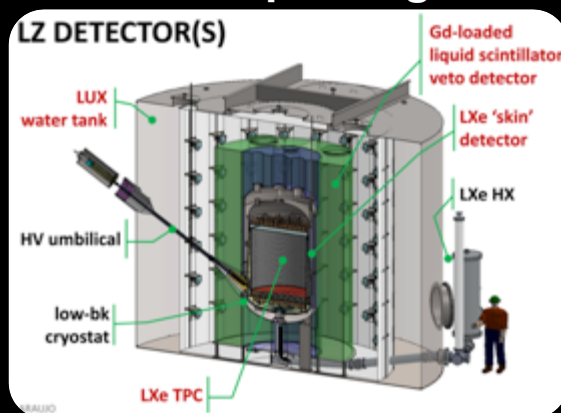
Sensitivity down to <50ppt
U/Th per sample, &
improving



Ultra Low background counting studies supporting UK DM (**LZ**) & 0nuBB communities.

Now **EXPANDING** low BG counting capabilities to meet international demand.

Working in collaboration with UCL, Oxford, DMUK, STFC-RAL



Boulby undertaking major role (50%) in material selection for **LUX-ZEPLIN**



BUGS move to new lab complete... All detectors successfully installed and operating.



Funding for new detectors secured. To support current and future LB experiments (towards PPT sensitivity)



Boulby Multi-Disciplinary Studies



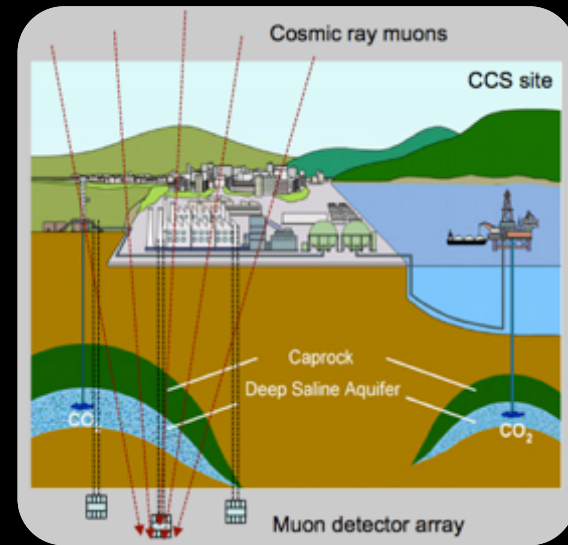
ERSaB: Gamma spectroscopy & low background counting environmental radioactivity studies

Boulby, Scottish Universities Env. Research Ctr (SUERC)

DEEP-Carbon: Muon Tomography for deep geological mapping applications including CCS



Boulby, Durham, Sheffield, Bath, Premier Oil, CPL.



From astrophysics to climate, geology, the environment, life on Earth & beyond...

MINAR: Space Technology Development

Boulby, Edinburgh, NASA, DLR, CPL etc.

Plus Misc. Geology & Geoscience (& more to come)...

Life in Boulby Salt...



BISAL: Astrobiology / Geo-microbiology. Studies of life in salt, life on Earth & beyond

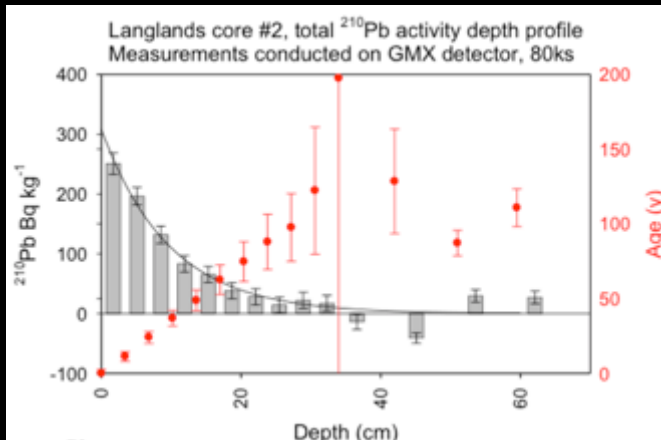




The ultra-low background environment and Ge detectors at Boulby allow existing industrial, environmental and climate-related gamma spectroscopy studies to be extended and improved.



- Radioactive tracers for atmospheric & ecosystem processes
- Radio-dating: C-14, Pb-210, Si-32
- Dosimetry in the environment
- Marine radioactivity
- Landscape evolution
- Sedimentology...



Pb-210 Sediment dating

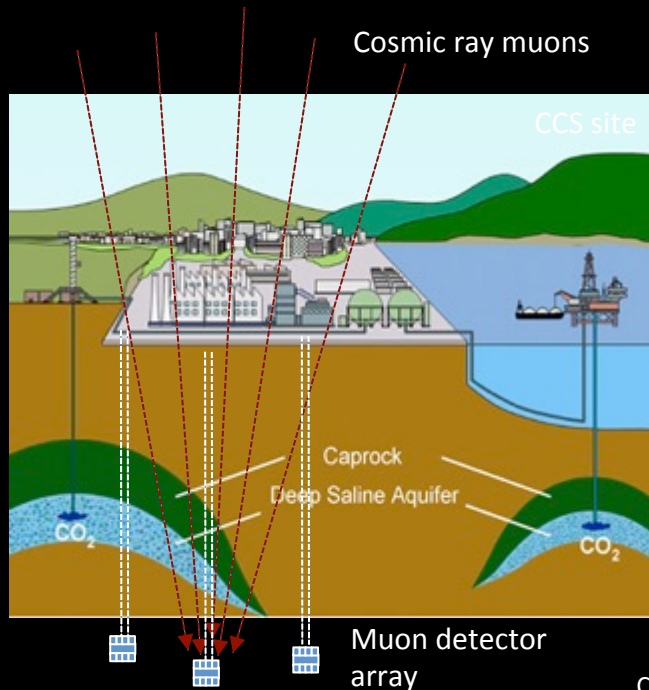


Pb-210 Radio-dating of the 50-250 year timescale is important for understanding RECENT affects of climate change.

Muon Tomography / Geo-survey

Development of a **Muon Tomography** techniques for deep 3D geological surveying - inc Carbon Capture @ Storage (CCS)

STFC-Boulby,
Durham, Sheffield,
Bath, NASA



Potential for cheap, reliable, practical, real-time long-term monitoring of deep structures.

- Deep geological repository monitoring.
- **Monitoring in Carbon Capture & Storage (CCS)**

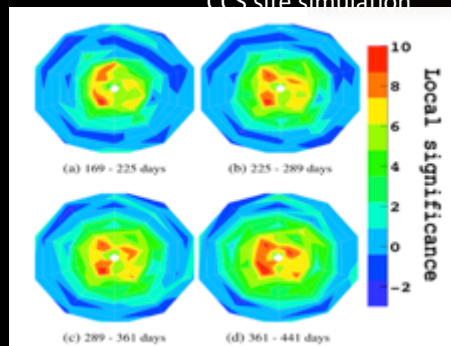


Muon-tides detector development



Bore hole detector installation

Boulby site and skills uniquely well-suited for development and testing: appropriate depth and geology, ease of access, infrastructure & expertise



Deep-Carbon Project: £1.4M funding from UK Dept of Energy & Climate change (DECC) & Premier Oil:

- Bore-hole detector development & testing @ Boulby
- Muon-Tides technology demonstrator
- Simulations of technique performance in CCS



Astrobiology & Mars Analogue



Sampling life in Boulby Brine



Subsurface Astrobiology Laboratory



A base for studies of life in Boulby rock – studies of limits of life on earth and on other planets



ALSO: An important 'Mars Analogue site' – with geology & conditions to allow explorations & astrobiology technique & instrumentation development

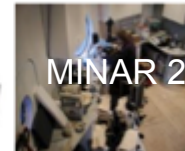
Led by Edinburgh, UKCA



Mining & extraplanetary exploration instrumentation development



Boulby and Instrumentation for Earth and Space Exploration





Boulby New Lab: Outside Experimentation Area

Under construction...



Open salt (etc) roadways support & equipped for easy experiment access





Misc Geology / Geoscience

Misc. geology & geoscience studies @ Boulby.

Improved mining technologies

E.g. enhanced extraction but reduced subsidence?

Rock deformation studies

E.g. salt deformation and oil reservoirs?

Seismology

E.g. how does stress change induce earthquakes?

Carbon Capture & Storage

E.g. The effect of fractures on the sealant properties of anhydrite for CCS

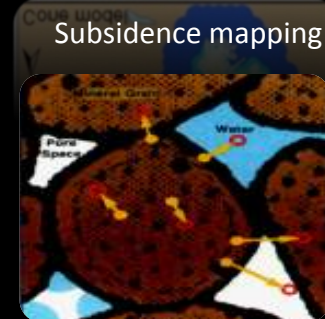
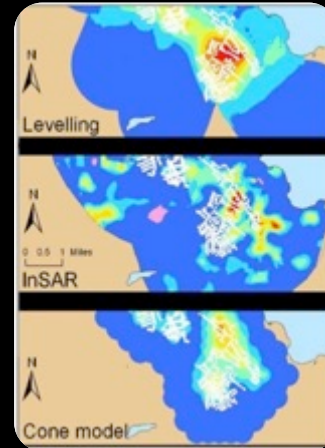
Geochemistry

E.g. how does fluid (oil) move through rock masses?

Geomicrobiology

E.g. What effect do microbes of rock structural integrity (cliff, geological repositories)

**Funding past and present: One NE, CPL / ICL
NERC, Crown Estate**



Geochemistry

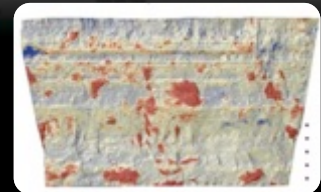
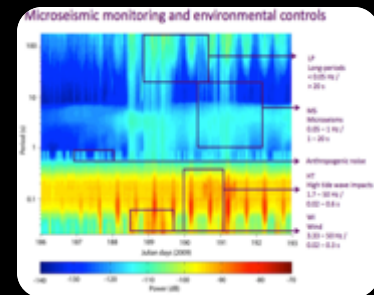
Cliff erosion mapping



Anhydrite mechanical properties

*Durham, Imperial
College, Boulby,
Edinburgh
British Geological
Survey (BGS)*

Micro-seismic monitoring



<http://www.mining-technology.com/projects/boulby/>



Finally...

We need you to tell us how to maximise the potential for our lab to support your type of work

Come and visit!



Boulby Underground Laboratory Review of expressions of interest Coming Soon (early 2017)

Thank You....



Come and visit / work-with us...

Email: Boulby@stfc.ac.uk

Web: www.stfc.ac.uk/boulby

Facebook: Boulby Underground Laboratory

Emma Meehan
STFC Boulby Underground Science Facility