Deep Science at Boulby Underground Laboratory:
Current studies & details of new underground facilities to support UK & international astro-particle physics studies & beyond.
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

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

S.M.Paling - Boulby@stfc.ac.uk
World Underground Science Sites

Also...
Homestake/SURF (USA)
SNOLab (Canada)
Kamioka (Japan)
And more...

European deep underground facilities

Canfranc (Spain)

Frejus (France)

Gran Sasso (Italy)

IGEX, ROSEBUD, ANAIS

DRIFT, DM-Ice, Deep Carbon... etc

Borexino, LVD, Gerda, DAMA, CRESST, LUNA etc

EDELWEISS, NEMO3

Links supported by ‘ILIAS’ in FP6

Links
How does Boulby compare?

What Makes Boulby Special?

Requirements for an underground laboratory...

1.1 km deep (2,850 +/- 20 mwe)
CR muons attenuated by ~10^6
(3.79 +/- 0.15) x 10^-6 cm^-2 s^-1

Salt = low in U/Th (67 +/- 125 range (10 ppb))
→ Low gamma & neutron backgrounds
→ Low Radon (<3 Bq/m^3)

Low Backgrounds
• Deep (to shield from cosmic rays)
• Low background rock/lab (and/or adequate shielding)

Plenty of Laboratory space
>1000 m^2 existing lab space & excellent potential for expansion.

Easy access for equipment
Via mine shaft (5m diam. – 2x2x2m cage) + Transport underground
20 min → Whitby, Saltburn
1 hour → York, Leeds, Middleborough
< 5 hrs → London, Manchester etc.

Proximity of services / civilisation
• JIF Underground & surface facilities
• Wide-ranging support from mine operators (Cleveland Potash Ltd)

Good infrastructure + support

A unique science / industry partnership

- VERY low ambient Radon background: <3 Bq/m^3
- Low ambient gamma backgrounds
- Interesting geology: Permian evaporite NaCl
- Operations well-supported by mine owners ICL

S.M. Paling - Boulby@stfc.ac.uk
Underground Science @ Boulby Mine

• DRIFT: Directional Dark Matter Search
• DM Ice: NaI(Tl) Dark Matter detector
• 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 astro-particle physics to studies of geology, climate, the environment, life on Earth & beyond.

S.M.Paling - Boulby@stfc.ac.uk
Boulby Dark Matter Studies

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

Boulby now hosts two on-site dark matter studies (DRIFT & DM-Ice) & provides ULB material screening for other studies, inc LUX-ZEPLIN.

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

Current limits & future projections
Boulby Dark Matter Studies

**DRIFT-II: A DIRECTIONAL Dark Matter Detector...**

*Participants: Occidental College, New Mexico, Colorado State, Hawaii, Wesley Coll. Sheffield, Edinburgh, Boulby*

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

**DM-Ice: NaI(Tl) array for studying WIMP wind annual modulation**

*Participants: Wisconsin, Yale, Fermi Nat. Accel, Lab, Illinois, Alberta, Sheffield, Boulby*

**STATUS:** ULB NaI (Tl) detector array assembly, characterisation & operation prior to installation at the South Pole.
Growing suite (‘BUGS’) of Ultra-Low-Background germanium detector systems to support Dark Matter & misc ‘rare-event’ studies...

- Ortec 2kg Coax (90% eff).
- Canberra BEGe detector
- 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, STFC-RAL

Boulby undertaking major role in material selection for LUX-ZEPLIN

S.M.Paling - Boulby@stfc.ac.uk
Expanding Multi-Disciplinary Studies

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

**ERSaB:** Gamma spectroscopy & low background counting environmental radioactivity studies

**MINAR:** Space Technology Development

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

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

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

Boulby, Scottish Universities Env. Research Ctr (SUERC)

Boulby, Edinburgh, NASA, DLR, CPL etc.

S.M. Paling - Boulby@stfc.ac.uk
Building a New UG Laboratory

Problems with the current lab...

Eastern end: Degradation of lab – due to local fault line
£1.77M - funding now granted by government (STFC) to build a new lab to host next 10 (+) years of science

New lab design: Mar 2015
£1.77M - funding now granted by government (STFC) to build a new lab to host next 10 (+) years of science
£1.77M - funding now granted by government (STFC) to build a new lab to host next 10 (+) years of science

New lab

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

Materials Entrance 1

Offices & People Entrance

Materials Entrance 2

Mars Analogue Area and Outside Experimentation Area

Large Expt. Cave Area: Internal lab height/width of 6m/7m

Stub 2: Low Background laboratory

Materials Store

New lab design: Mar 2015

S.M.Paling - Boulby@stfc.ac.uk
New lab design: Mar 2015

£1.77M - funding now granted by government (STFC) to build a new lab to host next 10 (+) years of science

New lab

Materials Entrance 2

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

Materials Entrance 1

Offices & People Entrance

Mars Analogue Area and Outside Experimentation Area

Large Expt. Cave Area: Internal lab height/width of 6m/7m

Stub 2: Low Background laboratory

Materials Store

Main hall:

Internal Lab height/width of 4m/7m

Materials Entrance 1

Offices & People Entrance

Mars Analogue Area and Outside Experimentation Area

Large Expt. Cave Area: Internal lab height/width of 6m/7m

Stub 2: Low Background laboratory

Materials Store

S.M.Paling - Boulby@stfc.ac.uk
New Laboratory Details

Steel frame throughout. 1m spacing

10T and 5T Gantry cranes

Large Experimental Cavern (6mx7m Internal HxW)

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 2015

S.M.Paling - Boulby@stfc.ac.uk
A new lab for UK low-background and underground science for next decade and more

Latest pictures... March 2015

Lab outfitting well underway

Steelwork in...

Expected completion
July 2015

S.M.Paling - Boulby@stfc.ac.uk
THANK YOU...

Come and visit / work-with us...

Email: Boulby@stfc.ac.uk
Web: www.stfc.ac.uk/boulby
Facebook: Boulby Underground Laboratory