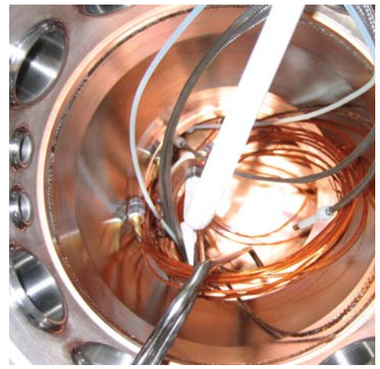
Boulby Underground Laboratory

Welcome to Boulby

The Boulby Underground Laboratory is an amazing place: a self-contained, high-tech laboratory located 1.1km below ground, in the hot, desert-like conditions of the largest and deepest salt and potash mine in Europe. In this underground laboratory scientists and students from around the world work to try to answer some of the most fundamental questions in nature. Why is this cutting edge laboratory built deep underground, and just what is so important about the science we think we can do there? Read on and discover the strange world of underground science.



Why do science deep underground?

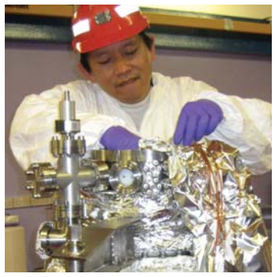
The Universe is full of strange and illusive fundamental particles. There are some, like neutrinos, which we know exist but don't really understand. Others are strongly suspected to exist but have not so far even been found. An example of these are Weakly Interactive Massive Particles (WIMPS).

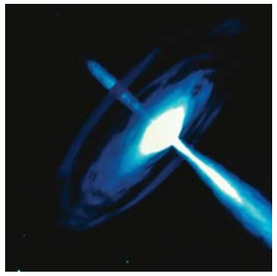
We now know that only about 0.5% of the Universe is made of stars. The rest is probably accounted for by so-called dark matter, most likely made up of of WIMPS, and dark energy. Dark matter not only dictates how matter behaves at the very small, sub-atomic, scale but also how the very fabric of the cosmos is built. A new field of science, Particle Astrophysics, has been created to unlock these mysteries and will probably change our understanding of the Universe for ever.

To understand these new particles we need instruments to detect them and measure their properties. However, the Earth, like everything in the cosmos, is bombarded by high energy particles in the form of cosmic rays, which stream at us from stars, supernovae and distant galaxies. We are also surrounded by other natural radiation, such as gamma-rays, x-rays, alpha particles, neutrons and the photons that make light. We need to stop all these other known particles from getting at the instruments because that might give us misleading signals or swamp out the signals we are looking for.

A site deep underground is the first step in this battle, a place with so much rock above it that there is little or no chance that the penetrating cosmic rays can reach the experiments. Boulby mine provides such a place. At around 1.1 km deep the number of muon particles, produced by cosmic rays, that reach that depth is reduced by a factor of over one hundred thousand times.

Some experiments not only need protection from cosmic rays, but also need protection from other natural radioactivity in the surroundings. Layers of highly pure and dense materials such as lead and copper can be used to achieve this but at Boulby the halite rock is particularly low in natural radioactivity. This is one of the features that helps make the Boulby laboratory a rather unique place to do science.





What facilities are there at Boulby?

Boulby mine is a working potash and salt mine operated by Cleveland Potash Ltd. with over 900 km of tunnels stretching in all directions at depths of around 1.1 km below sea level. The main underground science laboratory is located about 800 m from the shaft bottom in a purpose built excavation close to one of the principal roadways. The laboratory was built using £3.1m awarded to the University of Sheffield in partnership with the CCLRC Rutherford Appleton Laboratory in 1999.

Access to the laboratory from the surface takes about 25 minutes, including the ride down the shaft in the man carrying cage and the short walk to the site. Entrance to the main facility is via a changing area where everyone must change into clean room suits. Before this there are a series of service rooms including a mess room and kitchen, internet and office area, a small electrical laboratory and machine room. Air filters and strict cleanliness protocols ensure the facility is as clean as possible, so as not to contaminate any of the experiments. Once you are inside the facility you would not know that you are 1.1 km below ground, apart from a certain lack of windows!

On the surface, close to the mine shaft entrance, a purpose designed laboratory and office block facility has been built to help service the underground science and give space for the scientists and engineers to work when not needed underground. The building includes electronics and machine laboratories, a conference room, kitchen and showers as well as office space. The surface building, the John Barton building, also provides a base for the Boulby facility manager and staff permanently employed at the site.

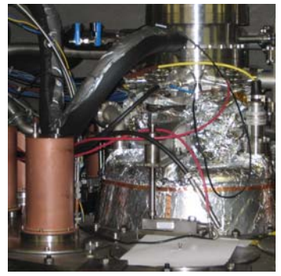
What science can be done at Boulby?

Boulby is ideal for almost any science that needs protection from the effects of cosmic rays. The search for dark matter in the form of new sub-atomic particles such as the Weakly Interacting Massive Particles (WIMPs) mentioned on page 3 is an important example. Several experiments to search for dark matter have been successfully deployed at Boulby. One of the first was the NaI Advanced Detector (NAIAD) experiment that used very pure sodium iodide crystals to search for WIMPs. This produced an early major advance in the search, reaching a sensitivity around 100 times better than previous attempts.

The ZEPLIN experiments at Boulby use a new technology for WIMP searches based on use of liquid xenon. Like sodium iodide, this material is a scintillator: it produces a burst of light when a particle interacts. This can be detected and converted into an electrical signal for analysis. The first ZEPLIN experiment produced improved sensitivity to WIMPS and is now the basis of an on-going programme to develop larger and more sensitive experiments using xenon at Boulby.

One of the ultimate challenges for dark matter searches is to measure the direction of the WIMP particles as they travel through the Earth. The DRIFT (Directional Recoil Identification From Tracks) experiment is designed to do this using a completely different technique. The idea is that a WIMP particle can cause an atom in a gas to move by a few millimetres. The direction of this movement can be measured and related to the direction of the WIMP. The DRIFT programme at Boulby provides the world's first direction sensitive gas dark matter detector.

In the future there are prospects at Boulby for many new Particle Astrophysics projects. Experiments to search for the pairs of neutrinos thought to be emitted by very rare decays of certain specific isotopes is one possibility. These could tell us about the mass of the neutrino. Another example is experiments to search for neutrinos from exploding stars. These could help explain why there are supernovae and Black Holes. Boulby can also host projects in other fields of science such as microbiology and environmental science.



How do I visit Boulby?

Not just scientists can visit Boulby. We regularly have groups and individuals from the general public tour the site and we greatly encourage this. A typical day visit begins with a short safety session to provide information on safety precautions including use of the self-rescuer. This is a breathing device that converts carbon monoxide into carbon dioxide and must be carried at all times underground in case of fire. Visitors then proceed to dress in overalls, hard hat, boots, lamp and battery, prior to transfer to the mine cage for the fast descent to the shaft bottom. Most tours involve a visit to the science laboratories but sometimes the mine company can provide a visit to the working mine face as well. This involves an exciting underground drive of up to 16 km, there and back.

A great variety of people have already visited the site including TV astronomer Patrick Moore, politicians, many astronomy clubs, teachers, school groups and even artists and poets. For school parties it is possible to arrange interactive sessions and talks with the scientists. There is an age restriction of 16+ for underground visits but younger groups can still participate in activities using our surface facilities.

Scientists intending to work at Boulby on a regular basis go through a more rigorous instruction, including a two day first aid and safety training course repeated every year.

Who owns the laboratory and how is it run?

The science facilities are based within the property of Cleveland Potash Limited but the facilities themselves are owned by the University of Sheffield through the Department of Physics and Astronomy, within the framework of the Institute of Underground Science (IUS) at Sheffield. Funding for the majority of the facilities was provide by a government Joint Infrastructure Fund (JIF) grant to the University in partnership with CCLRC Rutherford Appleton Laboratory in 1999.

Management and financial control is provided by the Boulby Management Board, which is advised by the Boulby Science Committee and the Boulby Operations Committee.

How do I do science at Boulby?

Anyone with an idea for an experiment that needs a deep underground site is welcome to submit a proposal. We aim at Boulby to facilitate world class science, accommodating experiments that best suit the benefits, and limitations, offered by the laboratory. To this end all new proposals need to go through a process of evaluation. The first step is submission of a Statement of Interest (SOI) to the Boulby Science Committee. Scientific review of the proposal and assessment of suitability of the site for the experiment will then determine whether to proceed to a detailed proposal, including assessment of safety implications. If the detailed proposal is acceptable then the Science Committee will make recommendations to the Management Board to proceed. The board will pay particular attention to financial, legal and strategic issues. The final stage is agreement with the mine owners CPL.

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