

Snowmass2021 Letter of Interest:

Development of the Boulby Underground Laboratory in the UK into a facility to host major international rare event searches.

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The UK's Science and Technology Facilities Council (STFC) is funding a feasibility study (Boulby-FS) into the potential development of the Boulby Underground Laboratory. The focus is on how the 'facility' aspects of Boulby would need to be enhanced to host a future global 'rare event observatory', such as for Dark Matter and/or Neutrino-less double beta decay studies. This letter is to alert the SNOMASS process to this work and to the potential future expansion and exploitation of the Boulby facility.

The STFC Boulby Underground Laboratory is the UK's deep underground science facility, hosted in a working polyhalite and salt mine in the north East of England. The laboratory has been in operation at Boulby since the 1990s and has been the host of several prominent dark matter experiments including pioneering experiments with liquid and two-phase xenon detectors (ZEPLIN programme), one of the first NaI-based experiment (NAIAD) and the first directional dark matter experiment (DRIFT). In recent years the science at Boulby has expanded and diversified. The facility continues to host astro-particle physics and ultralow background experiments and now also hosts a range of studies of Earth and environmental sciences, astrobiology and planetary exploration technology development. The current facilities at Boulby include a 4000m³ underground cleanroom (class 10k and 1K) laboratory space, a 3000m³ underground outside experimentation areas (OEA) and 2000m³ surface staging and administration facility. Amongst its existing facilities is a world class low-background materials radio assay suite.

In the Boulby-FS feasibility study we are building requirement specifications on several major rare-event detector case studies to assess what sort of 'facility' would be appropriate and required to host such experiments at Boulby in the future. In doing this we are being careful to separate facility from experiment (project) provision. In the first instance we are setting requirements for both liquid xenon and liquid argon direct dark matter search experiments, and a neutrinoless double beta decay experiment. Midway through the study we will invite further input from the wider UK 'rare-event' community, which may extend the range of potential users/experiments.

We are making projections from current experiments and from existing studies, where available.

A key part of the study will be to define any necessary underground facilities, such as clean manufacture and assembly areas to allow some level of actual underground construction of larger experiments which would otherwise be limited by the vertical lift access. There will also be consideration of other requirements related to the use of large volumes of cryogenics and other liquids underground. Furthermore, such facilities would need to be state-of-the-art in terms of radio-cleanliness control. Another critical issue to be addressed is the requirement on the muon-induced background and, hence, on the depth of the laboratory. We are addressing

this with full Monte-Carlo of background evaluation for the existing site and, possibly, a slightly deeper location of the future facility.

The Boulby-FS study is due to report in 2021. In the case of positive outputs and conclusions of these studies, we plan to move forward with a more detailed design of the laboratory.

The Boulby-FS study is separate to, but being usefully informed by, another ongoing Boulby development study: 'AIT' (Advanced Instrumentation Testbed). AIT is a US-UK proposed facility which will host a new major neutrino detector for nuclear non-proliferation monitoring, fundamental science and technology R&D. AIT is currently in conceptual design phase with construction planned for 2022-26. The AIT activities at Boulby will provide useful input/insight into some of the technical issues for Boulby-FS as the main cavern is a similar size to that needed for future rare-event detectors considered by the study.