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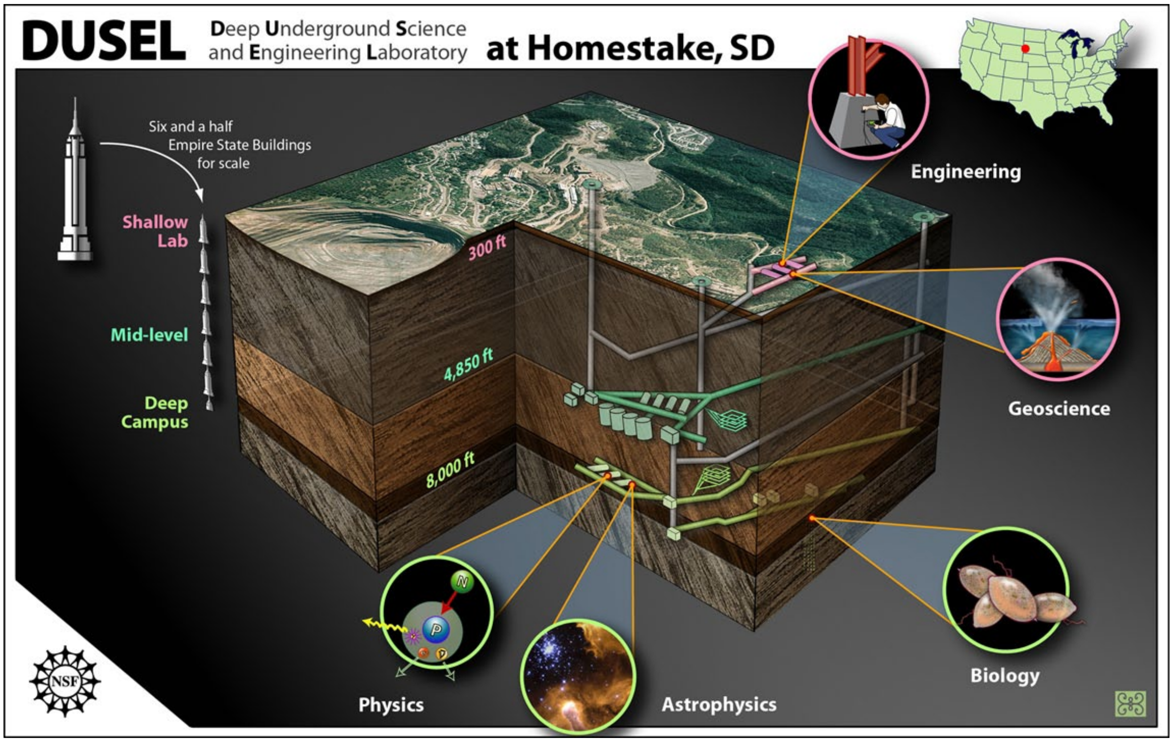
REPORT IN BRIEF

An Assessment of the Deep Underground Science and Engineering Laboratory (DUSEL)

Board on Physics and Astronomy
July 2011

Laboratories located deep under the surface of the Earth provide a unique environment where scientists can study the behavior of the smallest subatomic components of matter, shielded from the cosmic rays and other environmental "noise" that permeate the environment on the surface. Such labs were virtually nonexistent 50 years ago; since then, cutting-edge facilities for underground research have sprung up around the world. The research pursued in these laboratories has the potential to make profound contributions to our understanding of nuclear and particle physics. Scientists working in these areas, many of whom are affiliated with underground laboratories in Canada, Europe, and Japan, have long clamored for a world-class facility in the United States. Their appeals, with the support of the U.S. Department of Energy (DOE) and the National Science Foundation (NSF), resulted in the development of a planned set of experiments to be built in a laboratory in the abandoned Homestake mine in Lead, South Dakota, called the Deep Underground Science and Engineering Laboratory, or DUSEL.



A diagram of the planned facilities in the Underground Science and Engineering Lab, to be located in the Homestake Mine in South Dakota. Credit: Zina Deretsky, National Science Foundation

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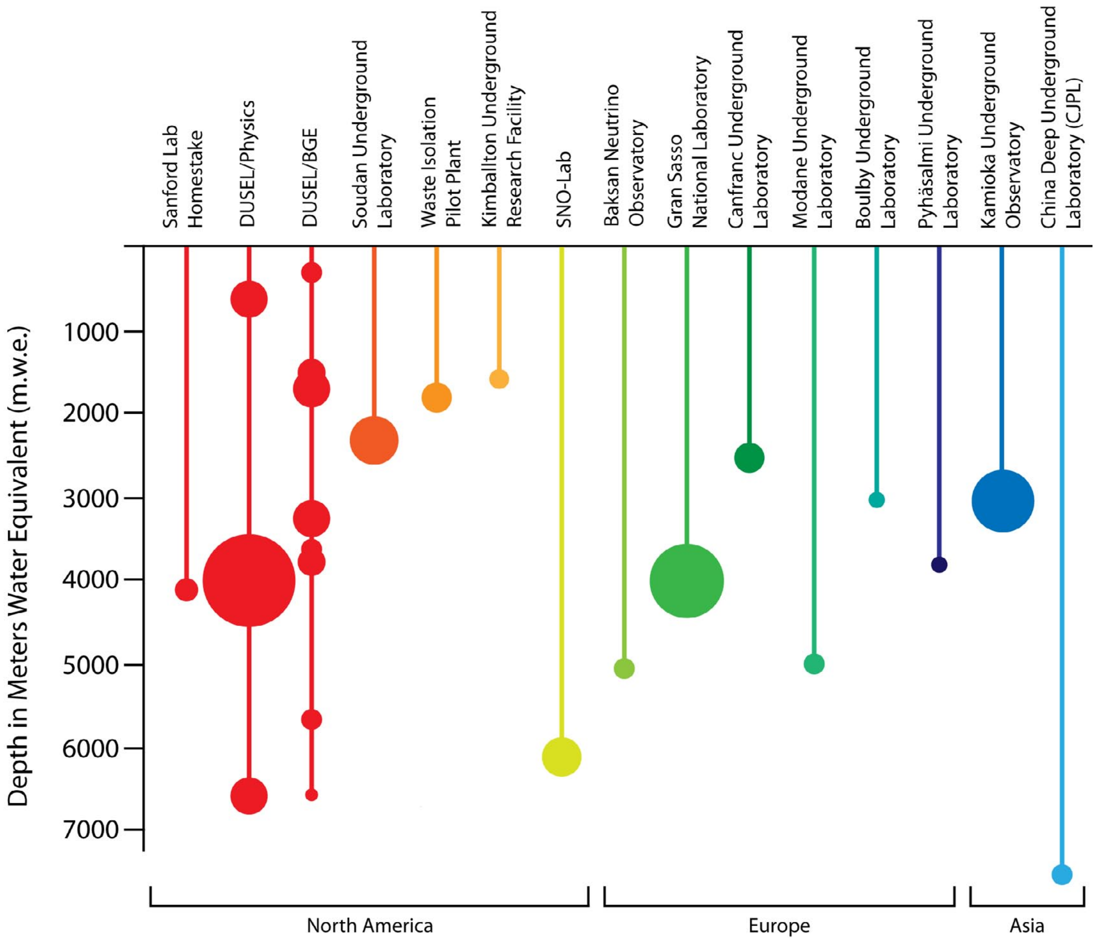

The depth and relative volumes (represented by circles) of the principal underground laboratories in the world. The DUSEL facility, represented by the three leftmost red bars, would be the largest underground laboratory in the world and among the most protected from cosmic rays. The facilities' depth is measured in meters water equivalent, which compares the level of protection from cosmic radiation provided by the earth to its equivalent underwater. Using this metric helps account for variations rock density and formation.

Study Background

This study, commissioned as part of the planning process for the DUSEL facility, identifies the most important questions and experiments that could be addressed by the proposed program of research. It also examines the need for such a laboratory in the United States, given the presence of similar labs in other countries, taking into account the impact that such a laboratory would have on the stewardship of the U.S. scientific community and on its possible benefit to broader communities and the public at large.

From the list of proposed experiments, the study identified three as the top priorities for DUSEL. They are:

- The **direct detection dark matter experiment** would determine the nature of the mysterious dark matter that constitutes approximately eighty percent of the matter of the universe (the remaining roughly twenty percent being the ordinary matter that our world is made of). Determining the properties of dark matter is of fundamental importance to the fields of astrophysics and particle physics.

- The **long baseline neutrino oscillation experiment** could provide a significant advance in the study of the properties of neutrinos, especially if used, as planned, in conjunction with a neutrino beam produced using a new high-intensity proton source at the Fermi National Accelerator Laboratory. This experiment might also provide the increased sensitivity needed for the detection of proton decay and of neutrinos from supernovae, two phenomena whose observation would be of momentous scientific significance.
- The **neutrinoless double beta decay experiment** could determine whether neutrinos are their own antiparticles, a question whose answer will contribute to our understanding of how the universe has evolved.

Because these three experiments address fundamental questions at the forefront of physics research, all could produce a breakthrough discovery upon which the future of particle, nuclear, and astrophysics will be built. For this reason, and to foster future U.S. leadership in the expanding field of underground science, the committee concluded that United States should proceed with plans to conduct the above three experiments, even if they must take place in a facility other than DUSEL.

Co-location and Collaboration

Locating the three major underground physics experiments at a single site, such as the one proposed for DUSEL, would provide significant value by allowing infrastructure, personnel and expertise to be shared and by facilitating the exchange of ideas among user communities. The initial infrastructure could also be used for research initiatives beyond those for which it was originally designed, fostering long-term scientific growth. The addition of a small underground accelerator facility that would study astrophysical processes, if co-located with one or more of the major underground physics experiments in the United States, would further extend the usefulness of shared infrastructure, personnel and expertise.

Interdisciplinary Opportunities

Outside of the field of physics, the proposed DUSEL facility would allow the geoscience and geoengineering communities to explore the physical and mechanical properties of rock at depths and on scales of length and time not currently available to them. Among the proposed experiments are controlled studies of the influence of fracture systems on rock response to applied loads, the interdependence of the thermo-hydro-mechanical-chemical-biologic aspects of subsurface systems, and efforts to make rock more "transparent" by developing imaging techniques that would allow the exploration of subsurface material at a distance. The subsurface environment also provides biological researchers with an opportunity to explore life in extreme environments. In light of the many valuable experiments that could be enabled by a deep underground research facility, developing a mechanism to allow scientists in fields other than physics to perform research using the facility would be of great benefit to those fields.

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