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**Committee on Science, Space and Technology
U.S. House of Representatives**

**A roundtable discussion with key stakeholders to examine the future of the Department of
Energy's (DOE) underground particle physics program.
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Written Comments of Kevin Lesko

Distinguished Committee Members, thank you for the opportunity to provide comments and to participate in this roundtable discussion about the profound, and United States led, science that can be accomplished at a domestic underground physics research facility at the former Homestake Mine in Lead South Dakota.

My comments will focus on the significance of deep underground science to the future of domestic and international physics research and why the proposed facility in South Dakota is the right place to establish domestic capabilities in the field. The three main points that I will make are:

- 1) The proposed science will transform the understanding of the physical universe and represents frontiers to knowledge
- 2) There are significant benefits – including economic savings, operational efficiencies, and scientific synergies – to hosting these research efforts in a single, domestically-based, facility
- 3) The proposed site is a low risk, well-characterized location at which to expeditiously establish world-leading, domestically-based, underground research capabilities that will enable world leading physics research – a site where development can be scaled and phased to meet the scientific opportunities and challenges of the day.

Underground Physics Experiments are of Profound Importance

The proposed physics experiments address questions central to our understanding of the universe – what makes up the majority of the matter in the universe, and understanding the most perplexing particle in the universe, the neutrino, whose unusual properties might hold the key to the most fundamental questions of science.

Identify the Dark Matter

Experiments sited deep underground seek to directly identify the universe's dark matter – the exotic material that makes up nearly a quarter of the universe, whose existence is very well established, and yet whose properties and nature remain a complete mystery. Dark Matter's existence is well established by

astronomical observations, but has never been directly observed, despite the fact that it outnumbers ordinary matter, the stuff we are made of, by five to one.

Understand the Neutrino

Two very different experiments sited underground will greatly advance the understanding of the ghost-like particle – the neutrino. One experiment, the Long Baseline Neutrino Experiment, will utilize the world’s most powerful neutrino source at Fermilab. By directing the neutrinos 1300km across the country, the optimum distance for the research, through the intervening rock, then detecting them in massive detectors deep underground at Homestake, physicists will learn how neutrinos change from one type of neutrino to a completely different type. In another experiment looking at neutrinoless double beta decay, perhaps the rarest form of decay, we will learn about neutrino properties that cannot be observed through any other experiment. Together these complementary experiments will yield findings that are essential for understanding the origins of the universe and its ultimate fate. Neutrinos challenge the best models of particle and nuclear physics and ultimately will provide the best window in to understanding physics at the highest energies – results that are unobtainable with any foreseeable accelerator.

These investigations provide the United States a wonderful opportunity to host, to direct, and to lead truly profound physics experiments. Underground science experiments seeking to detect dark matter and understand neutrinos have been comprehensively reviewed by National Academy of Sciences studies, Interagency Science and Prioritization panels, and by the American Physical Society. These reviews have repeatedly and consistently found the science to be of the highest quality and among the highest priorities for the US physics community. In 2010 the National Research Council of the National Academy of Sciences was charged to assess the experiments proposed for the National Science Foundation’s Deep Underground Laboratory and found that the proposed neutrino and dark matter experiments to be:

“... of paramount and comparable scientific importance”

“Each of the three experiments addresses at least one crucial unanswered question upon whose answer the tenets of our understanding of the universe depend.”

You will hear from the chair of this study during this roundtable in more detail.

There are Tremendous Benefits to Developing a Common, Domestic Facility

United States researchers have played key roles in framing these scientific questions and, up to now, have been critical participants in experiments that were overwhelmingly performed in foreign laboratories. These US scientists are responsible for developing much of the technology essential for conducting underground experiments around the world and are utilizing their skills and expertise on developing a domestic laboratory. The ranks of US scientists and engineers connected to the Homestake experiments number over 600. A domestic facility enables the US to lead and to directly benefit from the technology advances to degrees that cannot be realized in a foreign laboratory. The facility would rapidly become a focus for worldwide underground research and the US would benefit from establishing a technological and intellectual center for world-leading experiments.

The Homestake site does not suffer from competing uses, such as mining or transportation, as is common in the laboratories elsewhere around the world. The facility will be designed and optimized for conducting science and will not be compromised by other uses. The experiments envisioned above, will take decades to conduct. The dedicated Homestake facility will eliminate the risks posed by changes in the mining markets, changes in ownership, or priorities and conditions imposed on the parasitic science experiments by the host facility owners.

The Homestake facility will be developed in phases and steps as required by the science. The existing infrastructure and access to the deep underground provides a significant advantage to expeditiously

develop deep underground facilities. Those facilities and supporting infrastructure will be effectively shared between experiments and will not have to be repeated in multiple locations. In addition to sharing infrastructure the researchers will benefit by sharing technology and research techniques.

This year the Office of Science conducted an assessment of options for underground physics experiments. This Committee concluded:

“That noting the scale of investment and time scales for these experiments that there are major advantages to developing a common underground site for these experiments:

- sharing infrastructure and coordination of design, construction, management and operations*
- training of next and subsequent generations of scientists and engineers”*

You will hear from the chair and co-chair of the Office of Science Assessment during this roundtable in more detail.

The Homestake Site is the Correct Site for an Underground Physics Facility

The State of South Dakota owns the site, and has established a Science and Technology Authority to oversee the rehabilitation and its adaptation for science and education. The Homestake site was selected following a comprehensive selection process led by the National Science Foundation that examined many alternative sites. Assisted by the phenomenal support of a philanthropic donor, T. Denny Sanford, the State of South Dakota has invested over \$120,000,000 in preparing the Homestake site. The DUSEL Project has developed a design for a facility that is optimized for scientific research. Subsequently, we have adapted elements of this design to establish a facility to accomplish the Department of Energy’s mission-driven scope. Utilizing design elements the DUSEL team has advanced pre-conceptual plans for a facility to host these critical research efforts – Long Baseline Neutrinos Experiments and Dark Matter and Neutrinoless Double Beta Decay searches.

The native rock in the facility has been demonstrated to be very appropriate for large scale excavations required by some of the experiments. It is exceptionally low in naturally occurring radioactivity – a crippling background for many underground experiments. There is ready-access to many areas in the underground extending from the surface to over 5000 feet below ground today, and as the State continues to pump the accumulated water out of the site, down to 8000 feet below ground in the near future.

Having rehabilitated the site and much of the infrastructure, the Science and Technology Authority has created a modest laboratory at the 4850 Level, in the cavity once used by the Nobel Prize winning physicist Ray Davis. This laboratory, the Sanford Laboratory, will host important experiments in dark matter and neutrinoless double beta decay while the DOE assesses options for the next generation of experiments and the long baseline neutrino experiment. It is critical for the domestic programs in dark matter and neutrinoless double beta decay that the Sanford Laboratory receives continued support.

This summer the DUSEL Preliminary Design was completed and reviewed by expert panels in project management, operations, civil engineering, multiple science disciplines including by nuclear and high energy physics, as well as cost and schedule estimation. It met the review criteria in all areas and in most areas the design was judged to be more advanced than was required for a project at this stage. In reviewing the DUSEL Preliminary Design the review team found:

“Overall, the committee believes the PDR represents a sound basis for establishing a project baseline that will support construction of the project.”

“The extensive PDR work that had been performed by the DUSEL team allowed them to quickly develop reasonable and sound scope options to provide cost effective reduced scope options to the Marx / Reichenadter panel. The committee believes these options form a good basis for a decision on how to proceed.”

Summary

In summary, the United States is presented with a golden opportunity – an opportunity to lead world-class experiments that will transform the understanding of the universe, and to lead these experiments in a domestic facility. A single facility can host all of the proposed physics experiments in a low-risk, cost effective fashion, and share significant infrastructure in a facility that will likely last several decades. The facility enjoys exceptional state support and an expert project team ready to adapt the facility design to the Department of Energy's requirements. This is the optimum site for hosting neutrino and dark matter experiments. Importantly, the Sanford Laboratory at Homestake will yield important physics results in the coming year if support for its operations and maintenance are maintained.

Thank you for this opportunity to address these points concerning underground physics and thank you for all you do to support the US science efforts.