**Project Title: Advanced Materials for Underground Physics and Applications**

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Recommended by the National Research Council (NRC), the Sanford Underground Research Facility (SURF) in Lead, South Dakota will host the most sensitive dark matter, neutrinoless double-beta decay, and long baseline neutrino experiments to address several of the most intriguing open questions in fundamental physics and cosmology. These highly sensitive experiments require the development of **high** purity materials, **high** sensitivity detectors, and **high** efficiency workforce. The goal of this white paper is to describe the research activities that the Center for Ultralow Background Experiments in the Dakotas (CUBED) is planning to do in the next few years.

CUBED is dedicated to the development of **a multi-disciplinary research center** in the State of South Dakota for neutrino physics and direct dark matter search experiments at SURF. The center will coordinate multi-disciplinary research efforts across the recognized strengths of South Dakota in physics, materials science, engineering and technology, chemistry, computer science, and mathematics, and as a result will allow South Dakota faculty and students to play important roles in groundbreaking scientific endeavors. The science, engineering and technology involved in this plan include: 1) the systematic study of rare underground events; 2) the development of isotope separation techniques; 3) the development of innovative purification techniques for metals, noble gases, and organic liquids; 4) the fabrication of substrates to serve as bases for new materials; and 5) the development and manufacture of sensitive detectors and imaging systems. Advances in these key areas will provide strong technical support to the discovery of new science at both the microscopic and cosmologic frontiers. The strategic foci of CUBED include full participation in: 1) the key underground science experiments centered at SURF, including the large-scale xenon experiments (LUX/LZ) searching for dark matter, the Majorana neutrinoless double-beta experiment (MJD), the Long-Baseline Neutrino Experiment (LBNE), and the low-background counting program; 2) the development of innovative new methods for material purification and enrichment; 3) the identification and elimination of critical problems in the growth of detector-grade crystals; 4) construction of an underground facility at SURF to fabricate germanium crystals and detectors for next generation experiments; 5) development of detectors and devices for next generation underground physics experiments; 6) development of advanced analytical methods such as state-of-the-art characterization tools; and 7) the study of several unresolved theoretical problems of our times through advanced computational techniques.

The projected work scope, cost, and timelines are below:

1) Crystal growth and detector development for underground experiments: ~$4M 2013 – 2016.
2) Underground fabrication of crystals and detectors: ~$8M 2016 – 2025.
3) Material purification and enrichment: ~$15M, 2013-2019.
4) Electroforming copper underground and detector development: ~$5M, 2013 – 2019.
5) Ultralow background counting with liquid scintillation detector: ~$3M, 2013-2016.
6) Monte Carlo and analytic study of rare event physics processes: ~$1.2M 2013 -2019.

In addition to basic research, this integrated multi-disciplinary center will also contribute significantly to the economic development in South Dakota by creating opportunities for businesses utilizing the developed technologies and by training a qualified workforce to support local high-tech economic growth. The goal is to work with businesses on both the east (Vermillion, Brookings & Sioux Falls) and west (Rapid City) sides of the state to transfer and industrialize the newly developed materials, new methods and technologies. The successful performance of these projects will eventually foster a strong and sustainable interdisciplinary research community in South Dakota, which will further stimulate the development and commercialization of advanced new technologies in decades to come.