

MAJORANA Neutrinoless Double-Beta Decay DUSEL R&D 2007 - Final Report

September 4, 2009

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Grant Summary and Abstract

Grant Title: MAJORANA Neutrinoless Double-Beta Decay DUSEL R&D at the University of Washington

Principle Investigator: John F. Wilkerson, Univ. of Washington

Collaboration: MAJORANA Collaboration

Collaborating Institutions/PIs (on original joint submission):

Lawrence Berkeley National Laboratory / Kevin Lesko

Los Alamos National Laboratory / Steve Elliott

Oak Ridge National Laboratory / David Radford

Pacific Northwest National Laboratory / Jim Fast

University of Washington / John Wilkerson

Coordinator for combined research activity: John Wilkerson

Abstract

The MAJORANA research and development is addressing key issues and risks related to the collaboration's goal of undertaking a search for neutrinoless double-beta decay ($0\nu\beta\beta$) in ^{76}Ge using an array of hyper-pure Ge-diodes (HPGe). The observation of this decay would provide critical insight into our understanding of neutrinos, yielding definitive evidence that neutrinos are Majorana particles and providing information on the absolute mass of neutrinos. Achieving sensitivities to $0\nu\beta\beta$ decay half-lives on the order of 10^{26} years requires ultra-low backgrounds in the 2039 keV region where a $0\nu\beta\beta$ decay peak would be observed. The goal of our R&D program has been to demonstrate the feasibility of all components of MAJORANA and to provide an integrated evaluation framework, allowing for optimization of these components in terms of background, background suppression, and signal detection efficiency and acceptance.

This report covers work carried out by MAJORANA collaboration members at the University of Washington as part of the overall MAJORANA collaboration activities. Specifically the MAJORANA group at the University of Washington was involved in moving forward on demonstrating technology for clean large-scale cryostats and mounting the HPGe crystals in low-mass holders. The UW activities included assistance in the procurement and assembly of an electroforming system for large size cryostats, and design and fabrication of prototype crystal mounting hardware.

Grant Narrative

Grant Title: MAJORANA Neutrinoless Double-Beta Decay DUSEL R&D

Applicant/Institution: University of Washington, Office of Sponsored Programs

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University of Washington / John Wilkerson

Coordinator for combined research activity: John Wilkerson

1 MAJORANA Research & Development Activities

The MAJORANA research and development is addressing key issues and risks related to the collaboration's goals of undertaking a measurement of ^{76}Ge neutrinoless double-beta decay with ultra-low backgrounds in the 2039 keV region where a $0\nu\beta\beta$ peak would be located. To a large extent, the basic technology of Ge-diodes is proven. The R&D that remains is focused on areas in which we are extrapolating from proven technology. The goal is to demonstrate the feasibility of all components of the MAJORANA detector and to provide an integrated evaluation framework, allowing for optimization of all components in terms of background, background suppression, and signal detection efficiency and acceptance.

As part of the FY2007 DUSEL R&D funds, the collaboration carried out research activities that it identified as having the highest overall priorities. These activities are listed in Table 1.1.

Table 1.1: Summary of MAJORANA Collaboration activities supported by FY2007 DOE DUSEL R&D Grants.

Radioactivity in cables and small parts

Technology for clean large-scale cryostats, HPGe mounting, and readout

Determine and reduce activity levels in Ge crystal dead layers and contacts

The following is a brief summary of the MAJORANA R&D tasks supported at UW by this grant.

1.1 Demonstrate technology for clean large-scale cryostats, HPGe mounting, and readout

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MAJORANA aims at mounting an unprecedented number of Ge detectors in one cryostat. This large-scale cryostat needs to provide sufficient cooling, thermal shielding and mechanical support for the detectors and additional components while minimizing the background contribution by minimizing the weight. The requirement for ultra high purity will likely require that it be constructed from electroformed copper. All together, these requirements dictate a careful design and demonstration of the cryostat before it can be deployed for MAJORANA.

The design for the mounting of HPGe detectors in the cryostat, and of the signal and HV cabling, should be properly demonstrated before the conceptual design of MAJORANA is finalized. In addition to structural and mechanical issues, signal quality, bandwidth and cross-talk from the preamplifier front-ends should be properly evaluated. To this end, we plan to construct one or more of the MAJORANA “string” crystal mounts, together with the required cables and contacts and preamplifiers. These mounts will be loaded with HPGe crystals, and deployed in a prototype test cryostat R&D system. Noise, bandwidth, and crosstalk performance of the electronics front-end will be studied and the signal-handling system modified until satisfactory performance is achieved.

As part of this grant the collaboration worked with a commercial firm to develop a prototype rampable power supply capable of electroforming Cu onto the large mandrels required for producing cryostats with the capacity to hold 20 kg of Ge crystals. This power supply was delivered and has been tested by our colleagues at PNNL and shown to perform as expected. Smaller test parts have been produced, and larger parts will be made once fabrication of a large mandrel is complete.

Additional work has been carried out to assembly and test of one or more detector strings and a small cryostat to house them. A test has been successfully carried out in collaboration with colleagues at LANL, and we have now demonstrated that we can operate a Ge crystal suspended from a low-mass “string”. A revised string design has been generated that is now in the fabrication stage.