The Majorana Experiment

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The Majorana experiment[1] is a proposed enriched, segmented, HPGe detector array that will primarily search for neutrinoless double-beta ($0\nu\beta\beta$)decay and dark matter. It will be constructed in phased approach, with the first phase been 180-kg, scalable to 500-kg. It will rely on pulse-shape discrimination and segmentation to suppress remnant backgrounds following careful materials selection. The projected sensitivity of Majorana to $0\nu\beta\beta$ decay is 4×10^{27} years.

Double beta decay ($2\nu\beta\beta$) occurs when two neutrons in a nucleus spontaneously convert into two protons with the associated emission of two electrons and two neutrinos. It is a rare, second-order weak process that has been observed in several nuclei with half-lives on the order of 10^{19} years or longer. Neutrinoless double beta decay ($0\nu\beta\beta$) is a hypothetical process where the neutrinos are not emitted. The conclusive observation of neutrinoless double-beta decay will have significant implications, since it requires very specific properties of the neutrino:

1. It will show that the nature of the neutrino is Majorana, since $0\nu\beta\beta$ decay can only occur if the neutrino is its own antiparticle.
2. It will show the violation of lepton number and indicate physics beyond the standard model.
3. A measurement of the half-life will provide the value of the Majorana electron neutrino mass.

Beta decay for most even-even nuclei is energetically forbidden, but double beta decay for some of these nuclei is energetically allowed. These nuclei are good candidates to search for $0\nu\beta\beta$, since there is no dominant background from normal beta decay. ^{76}Ge is such a nuclei and germanium also has the attractive property of being a semiconductor that can be formed into large diode radiation detectors with excellent energy resolution, hence allowing the source and detector to be the same material.

The LBNL group, led by Kevin Lesko, continues its involvement in Majorana. LBNL is contributing to several key aspects of the Majorana experiment:

1. LBNL is coordinating the Monte Carlo efforts and hosting of simulation software and results at NERSC. It is foreseen that NERSC will host the data and analysis software of the experiment as well.
2. The LBNL Majorana group will work closely with the GRETA/Gretina group in segmentation and pulse-shape discrimination studies that are essential for background reduction in Majorana. These experiments would benefit from collaboration, since there is overlap in the research being done.
3. The Majorana experiment can utilize the developed and tested DAQ electronics from the Gretina experiment. The feasibility of this is being studied.
4. LBNL and collaborators at LLNL have installed a 5-by-8 segmented HPGe detector at the Oroville low-background counting facility to study background rejection in a highly segmented crystals.

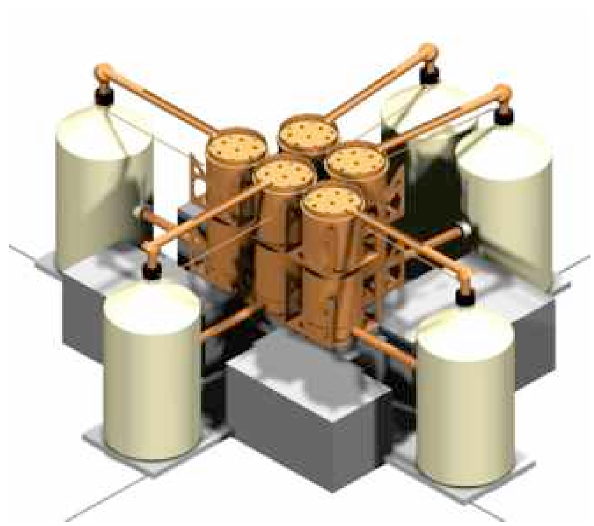

FIG. 1:Nominal design of the Majorana experiment in the final 500-kg configuration. The brown cylinders are the copper cryostats, each containing 57 1 Kg HPGe crystals. Also shown are the partially removed lead shielding in grey and the LN2 dewars in white.

REFERENCES

[1] The Majorana Zero-Neutrino Double-Beta Decay Experiment White Paper. nucl-ex/0311013.