CUORE and CUORICINO: A Search for Neutrinoless Double Beta Decay

R.H. Maruyama[1,2], J.W. Beeman[3], M.J. Dolinski[2,4], S.J. Freedman[1,2], T.D. Gutierrez[2], E.E. Haller[3,5], K.M. Heeger[6], Yu.G. Kolomensky[2,6], E.B. Norman[4] A.R. Smith[7], N. Xu[1]

[1] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720*
[2] *Department of Physics, University of California, Berkeley, California 94720*
[3] *Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720*
[4] *N-Division, Lawrence Livermore National Laboratory, Livermore, California, 94550*
[5] *Department of Material Science and Engineering, University of California, Berkeley, California, 94720*
[6] *Physics Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720*
[7] *Environmental Health and Safety Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720*

The CUORE experiment is designed to search for neutrinoless double beta decay with about an order of magnitude improvement in sensitivity than current experimental limit and probe effective neutrino masses well into the inverted mass hierarchy. Observation of neutrinoless double beta decay ($0\nu\beta\beta$) would be an unambiguous signal for the Majorana nature of neutrinos. The lifetime measurement for the $0\nu\beta\beta$ process allows one to infer an effective mass and mass scale of neutrinos.

CUORE (Cryogenic Underground Observatory for Rare Events) [1] is a proposed cryogenic bolometer detector, consisting of 988, 750 g TeO_2 crystals for a total mass of over 200 kg of ^{130}Te, operated at a temperature of 10 mK inside a dilution refrigerator. ^{130}Te is an even-even nucleus decaying exclusively through a double beta decay process, and it is found with 34% abundance in natural tellurium. The large natural abundance of ^{130}Te makes it an attractive isotope for a sensitive $0\nu\beta\beta$ experiment since it does not require expensive enrichment.

CUORE aims to reach the sensitivity of $T^{0\nu}_{1/2} = 2.1 \times 10^{26}$ years in 5 years of operation, which would correspond to a limit on the effective Majorana neutrino mass of $\langle m_\nu \rangle$ = 19-100 meV, depending on the nuclear matrix element used to relate the halflife to the effective neutrino mass. Further reduction in the background rates by another order of magnitude would allow us to reach the sensitivity of $T^{0\nu}_{1/2} = 6.5 \times 10^{26}$ years. In addition to the search for the neutrinoless double beta decay, the CUORE detector would be able to make other interesting measurements, such as searches for cosmological dark matter particles, solar axions, and other rare nuclear decays.

CUORICINO has been operating since 2003 with a TeO_2 detector mass of 40.7 kg, and is currently the most sensitive $0\nu\beta\beta$ experiment in operation. The only DBD experiment larger than CUORICINO is the Heidelberg-Moscow ^{76}Ge experiment, no longer running. CUORICINO has obtained a $0\nu\beta\beta$ half-life limit of $T^{0\nu}_{1/2} = 1.8 \times 10^{24}$ years at 90% c.l. in ^{130}Te, corresponding to a limit on the effective neutrino mass ranging from 0.2 to 1.1 eV depending on the value of the nuclear matrix element [2]. In the next 3 years with the present background level, CUORICINO will yield a half-life sensitivity for neutrinoless double beta decay of $T^{0\nu}_{1/2} = 6.1 \times 10^{24}$ years, corresponding to an effective neutrino mass of the order of 300 meV.

The activities at LBL includes the Nuclear Science, Physics, Materials Sciences, and EH&S Divisions. The main efforts are in the development and production of the Neutron Transmutation Doped (NTD) thermistors, development of the analysis framework, and characterization of the sources of background observed in CUORICINO and identification of ways to reduce possible sources for CUORE.

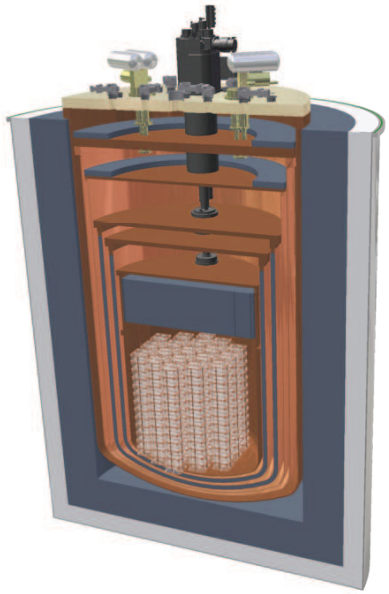

FIG. 1: Cryostat design of CUORE.

[1] R. Ardito and *et al.*, arXiv:hep-ex/0501010 (2005).
[2] C. Arnaboldi and *et al.*, Phys. Rev. Lett. **95**, 142501 (2003).