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Prospects for CUORE and Latest Results from CUORICINO

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Abstract. The present status of the Cryogenic Underground Observatory for Rare Events (CUORE) is presented along with the latest results from its operating prototype, CUORICINO.

Keywords: double beta decay, neutrino mass, cryogenic detectors

PACS: 14.40.Pq, 23.40.-s, 23.40.Bw, 27.60.+j

CUORE (Cryogenic Underground Observatory for Rare Events) is a proposed next generation experiment designed to search for the neutrinoless DBD of ^{130}Te using a bolometric technique. The source/detector will be composed of 988 5x5x5-cm single crystals of TeO_2 all housed in a common dilution refrigerator and operated at a temperature of 8-10 mK. The total mass of ^{130}Te contained in CUORE will be approximately 203 kg. Attached to each crystal will be one or more neutron-transmutation doped (NTD) germanium thermistors that will measure the small temperature rise produced in a crystal when radiation is absorbed. A schematic illustration of the CUORE detector is shown in Figure 1. Details about the TeO_2 cryogenic detector are contained in a NIM A paper¹ and the physics potential of CUORE is described in a recent article in *Astroparticle Physics*.² A complete description of the CUORE project is also available online.³ The estimated sensitivity of CUORE illustrated in Figure 2 is sufficient to cover essentially all of the so-called inverted mass hierarchy region deduced from ν oscillation experiments. There are several compelling reasons to study ^{130}Te DBD. The $\beta\beta$ decay of ^{130}Te has been observed in geo-chemical experiments. Thus, a direct laboratory measurement of the $2\nu\beta\beta$ decay rate will provide an excellent calibration for $0\nu\text{-DBD}$. Second, because of its large decay energy and large expected nuclear matrix element, the half-life of ^{130}Te is predicted to be shorter than that of a number of other candidate isotopes. Third, based on the sensitivity needed to reach the mass scales inferred from the above-mentioned oscillation experiments, the ^{130}Te experiment can be done utilizing the natural abundance of ^{130}Te (34%), without the time and expense of obtaining separated isotopes. Of all the proposed next generation DBD experiments, only CUORE can reach the needed sensitivity without isotopic enrichment.

One of the great strengths of CUORE is its modular nature and the fact that many isotopes can be incorporated in a bolometer. Once CUORE is constructed, one could remove a number of crystals from the center of the array and replace them with crystals containing other materials of interest. The rest of CUORE could then be used as an anti-coincidence shield, which would provide the lowest background environment in the world in which to search for rare events. Exquisitely sensitive searches could be made for rare nuclear decays or for exotic processes such as the decay of the electron. CUORE has been approved by the Scientific Committee of the Gran Sasso National Laboratory (LNGS) in Italy and has been assigned space in this facility.

Array of 988 crystals:
 19 towers of 52 crystals/tower.
 M = 0.78 ton of TeO₂

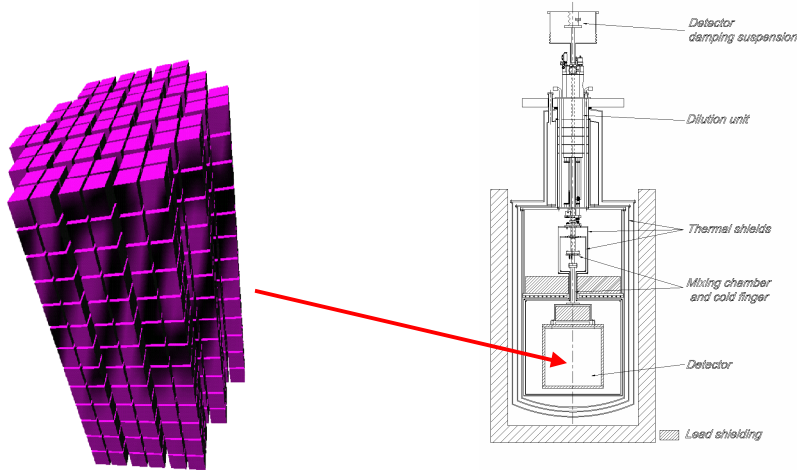


FIGURE 1. Schematic drawing of the CUORE detector

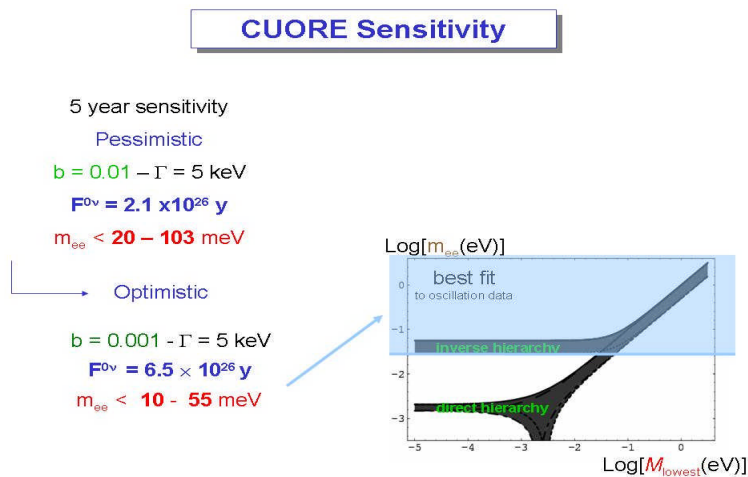


FIGURE 2. Estimated sensitivity of CUORE from 5 years of running.

A prototype experiment, CUORICINO, which consists of 62 TeO₂ crystals, is now running at the LNGS. CUORICINO is presently the largest operating double beta decay experiment in the world and has recently published its first physics results^{4,5} – a limit on neutrino mass only slightly less stringent than those obtained from previous ⁷⁶Ge experiments.

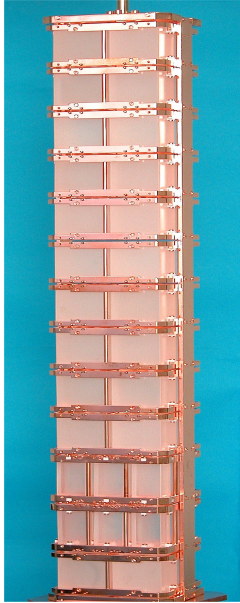


FIGURE 3. CUORICINO array currently operating at the LNGS.

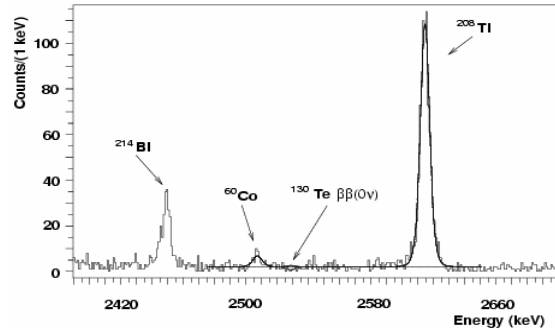


FIGURE 4. Background spectrum obtained from CUORICINO in an exposure of 10.85 kg-y. The energy resolution measured at 2615 keV = 9.2 ± 0.5 keV (FWHM). The background in the $0\nu\beta\beta$ region = 0.18 ± 0.01 counts/(keV/kg/y). No peak is observed at the expected position of $0\nu\beta\beta$ and a limit of $t_{0\nu\beta\beta/2} > 1.8 \times 10^{24}$ y at 90% C.L. has been obtained. The inferred limit on neutrino mass derived from this results is: $m_\nu < 0.2 - 1.1$ eV, depending on the assumed nuclear matrix elements

Since 1990, members of the CUORE collaboration have developed and operated cryogenic TeO₂ bolometers ranging in mass from 73 grams up to the present CUORICINO mass of 62 kg. Thus, CUORE is a very natural and reachable extension based upon what we have already demonstrated.

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