DESIGN OF THE ENERGY CALIBRATION SYSTEM FOR THE CUORE DOUBLE BETA DECAY BOLOMETRIC EXPERIMENT

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INTRODUCTION

The CUORE experiment (1) will search for neutrinoless double beta decay ($\beta\beta0\nu$) of ^{130}Te in the Gran Sasso Underground Laboratory (Italy) using an array of 988 TeO_2 bolometers. These detectors operate as thermal calorimeters at a temperature of ~ 10mK. The energy released by a particle is converted into phonons and the subsequent temperature rise is read out by a NTD thermistor and converted into a voltage pulse.

The signature for $\beta\beta0\nu$ is a peak at 2.5 MeV in the summed energy spectrum of all detectors. A good and reliable energy calibration is therefore needed. In order to take advantage of the experience gained from the previous Cuoricino experiment (2), the energy calibration and control in CUORE will, as in its predecessor, be based on measurements of γ sources at regular intervals and continuous monitoring by means of heaters attached to each detector. More details are given in (2).

The goal of the CUORE DCS is to provide an energy calibration of all the 988 detectors by means of known γ sources in the range from 500 keV to above 3 MeV. The DCS needs to meet several requirements: do not exceed a maximum hit rate on each detector (due to the intrinsic slow response of bolometers); meet the maximum allowed heat power on the cryostat; use only certified low background materials and avoid any risk of radioactive contamination; integrate with the cryostat and its subsystems.

DESIGN OVERVIEW

The basic concept of the DCS is to move 12 source carriers through guide tubes that go from deployment boxes on the 300K flange down to the inner regions of the cryostat where the detectors are placed.

The source carriers will be collections of small, individual sources, 'chained' together to form a single, flexible unit. More precisely, radioactive wires will be encapsulated in small copper tubes (dia: 1.6mm length: 8mm) that are crimped onto a Kevlar® string of 0.35 mm dia. A PTFE heat shrink sleeve surrounds each copper capsule. A prototype of these sources is shown in Figure 1, bottom right. Each source carrier will be able to move, under its own weight, through a set of guide tubes which will route it, through the levels of the cryostat, into position in the detector region (see Figure 1, left). Simulations were performed to determine these positions and a configuration with 6 internal and 6 external sources (Figure 1, top right)) was found to provide uniform illumination of the detectors. The relative activity of internal and external sources was optimized in the same way. The guide tubes will provide the necessary thermal connections to the cryostat to thermalize the source carriers and minimize the thermal load on the cryostat. A preliminary thermal model of the DCS has been developed which takes into account all the static loads (radiation and conductances of the guide tubes and source carriers) as well as the heat produced by friction during the source motion. Storage and a deployment mechanism for the source carriers will be provided by four motion boxes on the top of the cryostat, each of which will host three independently controlled drive spool assemblies. A remote control system, linked to both the cryostat slow control system and the database for the experiment, will drive the insertion and extraction of the calibration sources.

Two possible candidate γ sources are being studied: ^{232}Th and ^{56}Co. Thoriated Tungsten wires are commercially available sources of ^{232}Th while proton activation of Fe wires allows the production of a ^{56}Co source. Simulations show that both these nuclides have five to seven γ lines in the energy region of interest that have enough intensity to provide good calibration. The different half-lives of the two isotopes have been taken into account in the study of possible detector contaminations and procedures for the exchange of the source carriers in clean conditions.

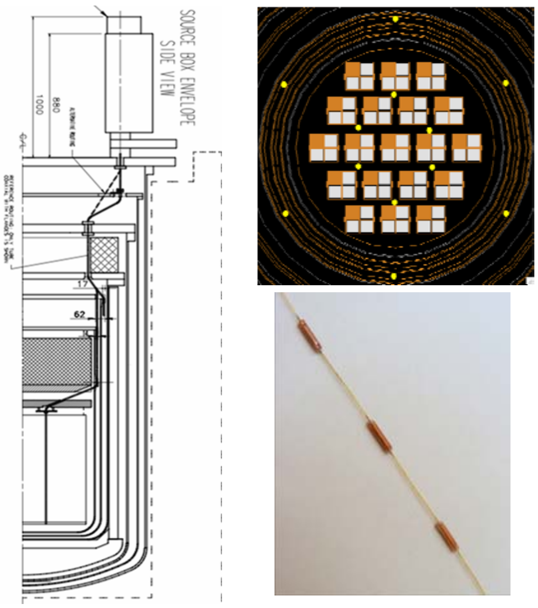

Figure 1: (left) Radial view of cryostat, showing motion box and guide tube routing. (top right) Top view of calibration source layout with respect to the detector array (sources enlarged for visibility) (bottom right) Photo of prototype sources.

CONCLUSIONS

The design and prototyping of the system will be completed by the end of 2008. The cryostat for CUORE will be installed in 2009, along with two full sets of calibration routings for testing purposes. Final commissioning and testing of the DCS will take place in 2010.

REFERENCES

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2. C. Arnaboldi et al., PRC, accepted for publication, July 2008

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