Design of the energy calibration system for the CUORE experiment

INTRODUCTION

The thermal signal is read by a temperature rise (heat) particle impinging into the source (e.g. from a fit of a calibration measurement with a radioactive source). The calibration measurement for Rare Events is an underground observatory. The design of the energy calibration system for the CUORE experiment is performed regularly (~ monthly).

Calibration of bolometers

The energy E released by a particle impinging into the absorber of the detector is degraded into phonons (heat), thus producing a temperature rise $\Delta T = \frac{E}{C}$. The thermal signal is read by a Ge Thermistor for which $R(T) = R_0 \exp(T/T_0)$ and converted into a voltage pulse.

The voltage vs energy relationship is obtained from a fit of a calibration measurement with a $\gamma$ source (e.g. $^{137}$Cs). The calibration measurement is performed regularly (~ monthly).

DCS goals and requirements

**GOAL:** use a $\gamma$ source to calibrate all detectors in the energy region 500-3000 keV. It's important to have a peak at ~ 2.5 MeV to have smaller uncertainty in the $\beta\beta_0$ decay region.

**REQUIREMENTS:**
- do not affect the working point of the detectors
- negligible contribution to background during normal data taking
- avoid excessive pile-up on bolometers
- avoid radioactive contamination of the detectors
- minimize thermal load on the cryostat
- minimize calibration time
- reliable operation for > 5 years
- meet cryostat integration constraints

Source storage and deployment

Vacuum boxes sit on top of the cryostat and house drive spools which wind and store the source carriers (6 per cryostat). Each spool is individually controlled by a computer system.

Source carrier

- Source is hosted inside copper sleeves that are crimped on the Kevalar string at both edges.
- A Teflon heat shrink sleeve is placed around the copper crimp to reduce friction.
- Falls by gravity through the guide tubes.

A frame of 4 bolometers of $^{130}$Te. Each crystal is 5x5x5 cm$^3$.• 988 5x5x5 cm$^3$ TeO$_2$ bolometers• total detector mass: ~ 750 kg• operated at Underground Gran Sasso laboratory (Italy)• large size cryogen-free dilution refrigerator• lead shielding inside and outside the cryostat

GOAL

The basic concept is to move 12 strings, with radioactive $\gamma$ sources on them, through guide tubes that go from deployment boxes on the top of the cryostat down in the inner regions of the cryostat where the bolometers are placed.

Schematic drawing of the cryostat with reference routings for the sources

Source guides

A system of tubes guides the sources from the motion boxes into their final position and also provide a thermal and mechanical connection to various stages of the cryostat.

- low radioactive materials
- low conductivity
- vibration decoupling

Complication: some calibration sources need to go BETWEEN the detector towers for even illumination.

DCS concept

For more information visit http://neutrino.physics.wisc.edu/cuore/ or heeger@wisc.edu