CUORE

- The Cryogenic Underground Observatory for Rare Events (CUORE) will search for $0\nu\beta\beta$ in $^{136}\text{Te}$.
- $^{98}$Te, $^{136}$Te, crystals as both the $0\nu\beta\beta$ sources and as bolometric detectors, with 206 kg of $^{136}\text{Te}$ mass.
- CUORE is also suitable for the direct dark matter search due to its low background and significant target mass.
- CUORE-0, the first tower from the CUORE assembly line, is operating as a standalone experiment and has been taking data since March 2013.
- The CUORE experiment is currently in the advanced stages of detector construction and scheduled to take data in 2015, with ~5 years of expected data taking.

Both CUORE and CUORE-0 are located underground at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. The average rock coverage of 1.4 km (3600 m weft) provides a factor of $10^7$ reduction of the surface muon flux.

TeO$_2$ Bolometers for $0\nu\beta\beta$ Search

- $^{136}$Te has relatively high Q-value of 2528 keV.
- $^{136}$Te also has high natural isotopic abundance at 34.2% and enrichment of TeO$_2$ is not required.
- TeO$_2$ bolometers, which measure energy through a rise in the temperature of the detector, provide excellent energy resolution (0.2% at Q-value).
- Excellent energy resolution of the detector helps identify the signal and suppresses intrinsic background from $2\nu\beta\beta$.

CUORE Detector

Bolometric Detectors

- CUORE consists of 19 towers, each tower is composed of 13 planes of four $5 \times 5 \times 5$ cm$^3$ TeO$_2$ crystals, mounted in a frame made of copper.
- Radiopure TeO$_2$ crystals are produced in collaboration with Shanghai Institute of Ceramics, Chinese Academy of Science, and transported to LNGS by ground and sea transportation to minimize cosmogenic activation.
- Each crystal is instrumented with one neutron transmission doped (NTD) Ge thermistor and one silicon Joule heater.
- Bolometer operating temperature is 10 mK.
- The detector assembly procedure is performed in a classroom environment.
- Flexible printed circuit board copper traces were bonded to the thermistors and heaters using 25 μm diameter gold wires.

Electronics, Data Acquisition, and Analysis Software

- The bolometer signals are amplified and then filtered with six-pole Bessel low-pass filters.
- The signals are digitized by National Instruments 18-bit digitizers with a 125 Ms/s sampling rate.
- DAQ software package designed to read signals from ~1000 bolometers will digitize the analog waveforms, run trigger algorithms, and store data for offline analysis.
- Continuous data collection and off-line triggering allow for multiple physics analyses by applying different energy thresholds in software.
- Raw data will be processed with C++ based software framework for the analysis.

Sensitivity and Physics Reach of CUORE

Prospects of CUORE

Background Budget

CUORE Preliminary

<table>
<thead>
<tr>
<th>Near Surfaces</th>
<th>CuO$_2$</th>
<th>CuO$_2$</th>
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</thead>
<tbody>
<tr>
<td>Near Bulks</td>
<td>Te$^{51}$</td>
<td>Te$^{51}$</td>
</tr>
<tr>
<td>Cosm. Actives</td>
<td>Te$^{51}$</td>
<td>Te$^{51}$</td>
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Counts/ROI/ton/yr

<table>
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<tr>
<th>Energy (eV)</th>
<th>Counts/ROI/ton/yr</th>
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<td>10$^5$</td>
<td>10$^0$</td>
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<tr>
<td>10$^0$</td>
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<td>10$^2$</td>
</tr>
<tr>
<td>10$^2$</td>
<td>10$^3$</td>
</tr>
</tbody>
</table>

Projected 90% C.L. sensitivity in $\text{kg} \times \text{yr}$

CUORE-0 is expected to surpass Cuoricino upper limit of $2.8 \times 10^{25} \text{yr}$ in 1 year of live time.

With a background rate of 0.01 events/(kg × keV × yr), 5 keV FWHH region of interest resolution, and 5 years of live time, we expect a 90% C.L. sensitivity of:

$$\frac{m_{\beta\beta}}{m_{\text{min}}}/(\text{keV}) = 0.05-0.13 \times 10^{-1}$$

Dark Matter Perspective

- With 3 keV energy threshold for all detectors, the same background rate measured from the CUORE Crystal Validation Run II in the region of interest, and 5 years of live time, CUORE is sensitive to the regions allowed by DAMA, CoGeNT, and CRESST.

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