# Analyzing CUORE Data and Geant4 Simulation

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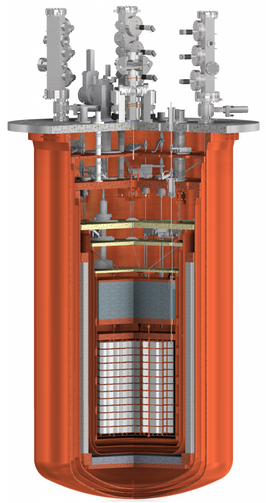
## Objective and Purpose

We compare recent CUORE calibration data to Monte Carlo simulations of the data in order to gain insight into both the simulation and data collection.

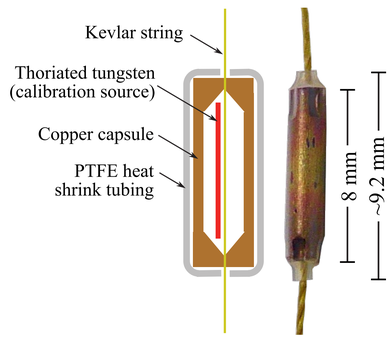
## Cryogenic Underground Observatory for Rare Events (CUORE)

- Searching for neutrinoless double-beta (0νββ) decay of $^{130}$Te
- 988 $TeO_2$ crystals in 19 towers operated as bolometers serving as both sources and detectors of 0νββ
- Operated at ~15 mK and surrounded by lead and copper shielding



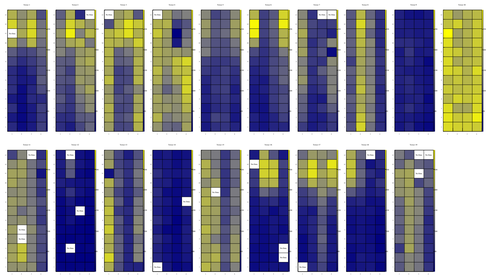
## Calibration of CUORE

- $^{232}$Th sources placed in capsules and deployed on strings before and after each data collection run
- 12 strings located among and around the detectors
- $^{232}$Th used as source of gamma rays for calibration




## String Placement

Calibration data from June 2017 is used to study signals at both high and low rates on different towers. This image shows which crystals detected strong calibration signals with higher rates in yellow and lower rates in blue.

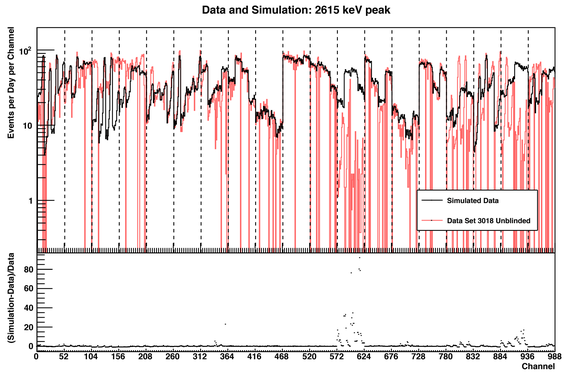


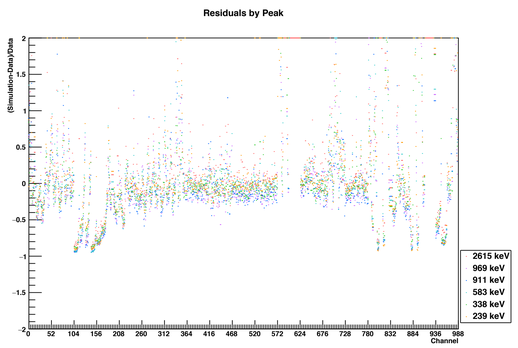
- Some calibration sources fully deployed, others partially deployed, or not at all

## Comparison to Simulations

- Calibration uses multiple peaks from the $^{232}$Th Decay chain: 2615, 969, 911, 583, 338, and 239 keV
- Differences between calibration and simulated data were analyzed on a tower-by-tower, crystal-by-crystal, basis at each of the energies

In general, differences were small and seemed to be isolated to certain towers.



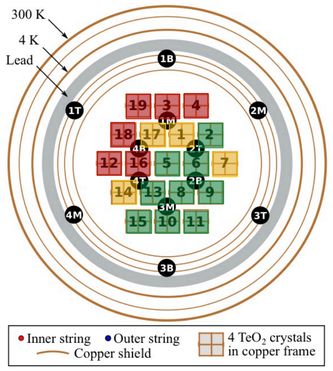




We also examined if these areas of discrepancy were consistent across each energy peak.

- Demonstrates areas of simulation over- and underestimation
- Consistent places of interest across all energies
- When examining residuals on a specific tower, there is a periodic pattern with each column of 13 crystals

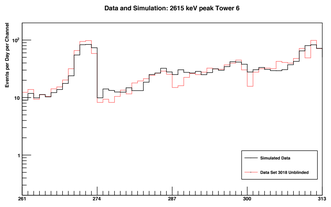
## Discussion of Results

Most channels and towers have good agreement between data and simulations, but not all. The towers with less agreement are in the same general locations. The periodic variation shown in individual towers suggests a discrepancy between the actual string positions and the simulation.

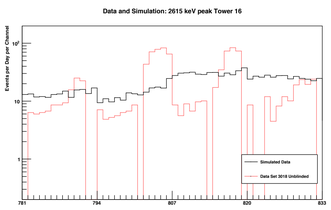



*Above:* Map of the CUORE tower and string location denoting green for good fit, yellow for fits with minor discrepancies, and red for poor fits.

**GOOD FIT: Tower 6**




**POOR FIT: Tower 16**




## Summary

The cross-check of data and simulation is still ongoing. One key finding is that the simulations are not consistently over or under estimating the data which would signify a larger underlying issue. Specific areas of interest with significant differences between data and simulation have been identified that can be examined in more detail.

## Next Steps

We will try changing simulation parameters to see if it is possible to create a better agreement with data. In addition, we will investigate calibration runs from other months with more consistent tower illumination.

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