The CUORE bolometric detectors: pulse shape analysis of the thermal signals

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The CUORE experiment
CUORE (Cryogenic Underground Observatory for Rare Events) located deep underground (3500 m.s.l.) at the Laboratori Nazionali del Gran Sasso (Assergi, Italy)

Primary goal: Search for 0νββ of 130Te
- Qββ (130Te) 2527.5 keV
- Highest natural isotopic abundance (34.2%)
- Nominal background index in the ROI: 0.01 counts/keV/kg/yr
- Nominal energy resolution at Qββ: 5 keV

Detectors: 1988 TeO2 crystals,
- Divided in 19 towers, total mass 742 kg (206 kg of 130Te)
- TeO2 crystals are the 0νββ source material and are operated as bolometric detectors at ~10 mK

The CUORE detectors
Bolometric technique
- Thermal coupling
- Absorber Crystal
- Ge-NTD

CUORE instrumented bolometers
- Au-wire bonding to CuPEN head-out strips
- Si-heater
- PTFE holders

Load Curves analysis and NTDs Working Points selection
Dedicated procedures and algorithms in CUORE to automate the NTDs load curve measurement and the working point identification at each Tbase
- Optimize the sensor response to particles energy deposition
- Linear and uniform behavior for small temperature variations avoiding pulse deformation

Pulse shape and working point selection
Novel approach for checking the pulse shape at each NTD bias voltage: utilize the parameters coming from the fit of the heater pulses with a thermal model reproducing the main features of the thermal pulse

Thermal model R function:
- Transfer function for the bolometer and NTD system composed by two real poles, two complex conjugate poles and one zero

Working Point Bias (WP) chosen in region dominated by real poles
- pulse shape with 3 time constants
- uniform response: pulse shape is not amplitude dependent

Outlook
- Developed a (phenomenological) pulse template to describe the CUORE pulses:
  - Utilized to set WPs
  - Correlate pulse analytical template parameters with physical quantities related to the thermal circuit
  - Utilize (energy dependent) analytical pulse templates for the Optimum Fitter (OF) sequence for the CUORE standard data processing

Conclusions
The CUORE experiment started taking data in 2017.
- First time such a large number of bolometric detectors simultaneously operated in a completely new and unique cryogenic system
- Detector optimization campaigns performed during 2017 in order to characterize and improve the detectors and overall system performance, different compared to previous smaller scale bolometer experiment
- Optimization procedures performed manually in small-size bolometric experiments with a limited number of channels (like CUORE-0)
- CUORE: ~1000 channels to be optimized, high values and wide spread of NTDs resistances.
- New procedures and algorithms to automate the characterization measurements and the setting of the optimal operating conditions

References
- Alduino C. and al. (CUORE collaboration), J. Inst. 11 (2016) P07009