

The CRESST Experiment

Cryogenic Rare Event Search with Superconducting Thermometers

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Abstract

CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) is an experiment located at the Gran Sasso Underground Laboratory (Italy) that aims at direct detection of dark matter particles via elastic scattering off nuclei in different target crystals. The detector is optimised in order to be sensitive to low mass dark matter particles. Therefore it is operated at cryogenic temperatures. It consists of various modules, each made of an absorber crystal and a Transition Edge Sensor (TES) which measures the temperature variations caused by the energy transfer of the incoming particle. Each module is also equipped with a light detector which allows for background discrimination.

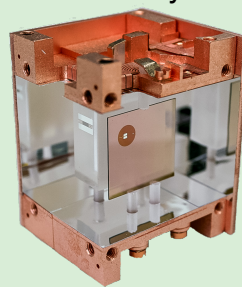
Direct dark matter search

- Located at Laboratori Nazionali del Gran Sasso (LNGS)
- 1400 m of rock (3500 m.w.e.) for background shielding
- Detect WIMPs in the light mass range via their scattering off target nuclei
- Operated at ~ 15 mK

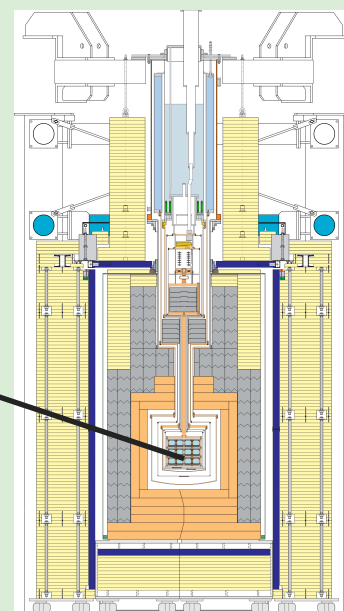


Experimental setup

- Multiple passive shielding layer
- Active muon veto
- Different crystals in the carousel



- **Phonon** channel to detect signal
- **Light** channel for background discrimination



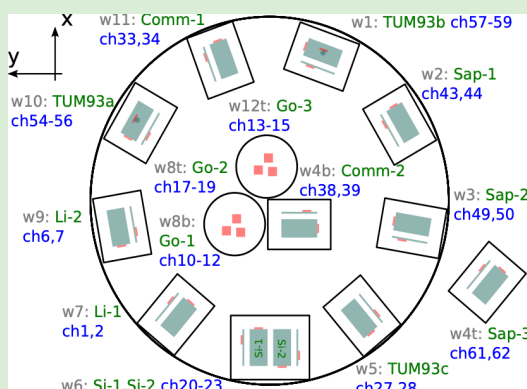
Currently used target materials

Different scintillating crystals:

- Sapphire (Al_2O_3)
- Lithium Aluminate ($LiAlO_2$)
- Calcium tungstate ($CaWO_4$)

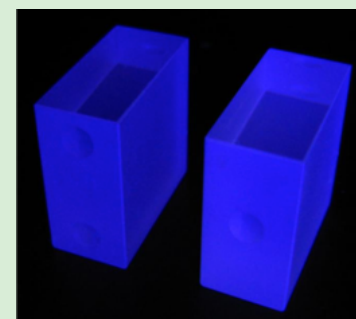
Non scintillating material:

- Silicon (Si)



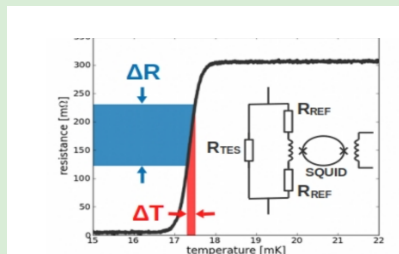
Crystal Production

- Some of the $CaWO_4$ crystals are produced within the collaboration, starting from the cleanest available raw materials
- Those show much better radio purity than the commercial ones



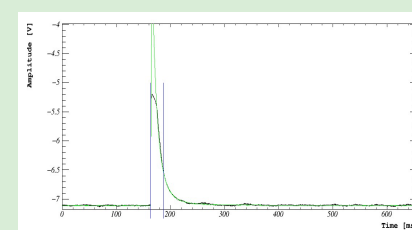
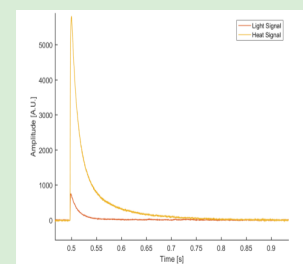
Transition Edge Sensors

- TES = thermometer made of a superconducting tungsten film, operated at its transition temperature
- Incident particles deposit energy $\sim keV$, causing an increase in the crystal temperature $\sim \mu K$
- Even small changes, near transition, are measurable as a variation in the sensor resistance $\sim m\Omega$



Signal

- An event corresponds to a pulse in the stream of data
- Phonon pulses higher than light pulses
- Pulses reaching the normal conducting phase saturate
- Template fits for recognition of small pulses and correct reconstruction of saturated pulses



Event discrimination

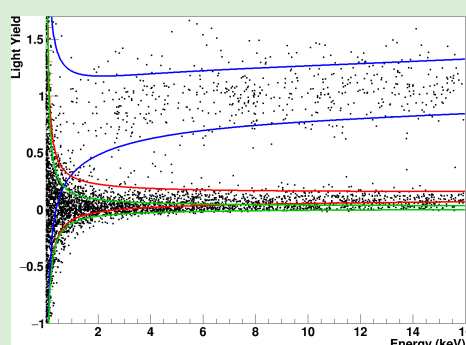
- Discrimination variable to distinguish between e^-/γ and nuclear-recoil events:

$$\text{Light Yield} = \frac{\text{Light Signal}}{\text{Phonon Signal}}$$

Blue= e^-/γ events

Red=Nuclear-recoil on oxygen

Green=Nuclear-recoil on tungsten



Exclusion Limits

Yellin method: assume every event is a dark matter event signal

