Detector Development and Characterization for CRESST

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CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) is located in Hall A of the Gran Sasso Underground Laboratory (3600 m.w.e.) in Italy, and is aimed at the direct detection of Dark Matter particles by nuclear recoils on scintillating crystals. Weakly Interacting Massive Particles (WIMPs) are among the best motivated candidates for Dark Matter. CRESST detectors are cryogenic detectors (operating temperature ≈10-20 mK) with $CaWO_4$ crystals as target material. A γ and β background discrimination is possible via a simultaneous measurement of light signal (quenched for nuclear recoils) and phonon signal (independent of the kind of interaction). The Quenching Factor (QF) is defined as the ratio between phonon signal and light signal. In order to be able to have also a neutron background discrimination, investigations are being performed on the QF of the different nuclei (O, Ca and W) present in the crystal.

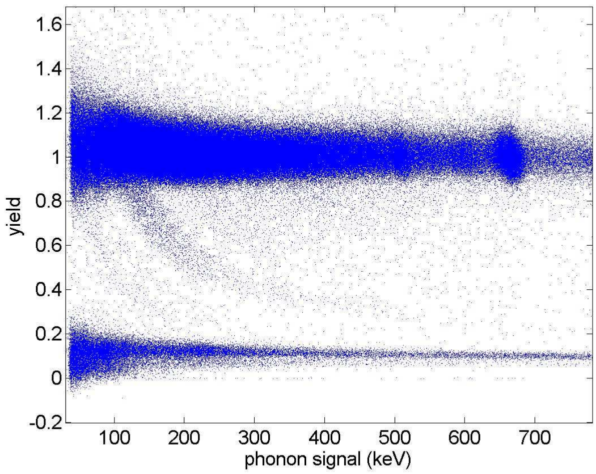

Fig. 1: Data taken during the beamtime in November 2007. Plot of yield (light signal/phonon signal) versus phonon signal. The upper band represents the electron recoil events, the lower band the nuclear recoil events.

At the MLL an experiment is being performed, to measure the QFs with a neutron beam, which is used to produce nuclear recoils on Ca, O and W [1,2]. In 2007 the installation of a new dilution refrigerator (T_{base}≈10 mK) at the MLL was completed. A CRESST-like detector is now being operated in this cryostat. The detector, which was especially produced for this experiment, consists of a phonon detector (a Ø 20mm x 5mm $CaWO_4$ crystal with an IrAu Transition Edge Sensor (TES)) and a light detector (a silicon substrate also with an IrAu TES) [3,4]. With this setup it is possible to investigate the response of a $CaWO_4$ crystal to neutron induced nuclear recoils at mK temperatures. In November 2007 the first measurement with the cryodetector and neutron beam from the accelerator was performed. An 11 MeV neutron beam was produced by the reaction of 65 MeV ^{11}B on H_2. For this first measurement, the response of the detector to the neutron beam was investigated. Fig. 1 shows the data taken during this measurement. Here the yield (ratio between light signal and phonon signal) is plotted versus the phonon signal. The nuclear recoil band (lower band in Fig. 1) is composed of three bands (oxygen, calcium and tungsten recoils). In Fig. 2 it is shown how to separate the different contributions and to obtain values for the QFs of O, Ca and W [5]. In the example shown in Fig. 2, the following values for the QFs are obtained

Element	Quenching Factor
Oxygen	8.6 ± 0.7
Calcium	14.0 ± 0.8
Tungsten	34 +23 -10

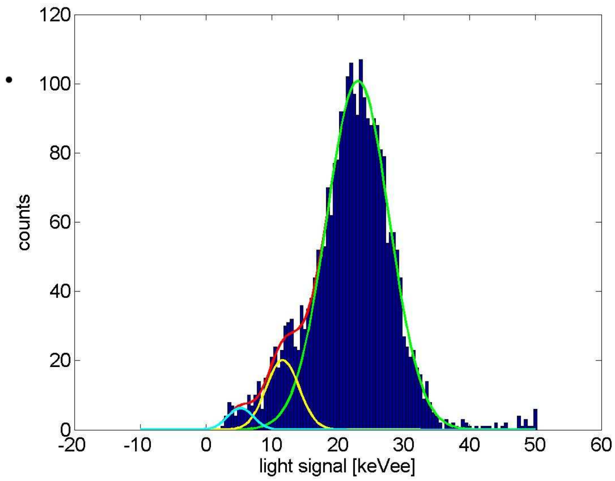

Fig. 2: Histogram of the yield for a section of the nuclear recoil band (160-200 keV) where contributions from O, Ca and W are expected. A three-gaussian fit can be performed, in order to obtain values for the Quenching Factor of the three nuclei.

In the crystal laboratory of the TUM a new furnace has been established, with which in the future $CaWO_4$ crystals Ø 40mm x 40mm will be grown for the CRESST experiment.

References

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