Journal of Physics: Conference Series **136** (2008) 042085 doi:10.1088/1742-6596/136/4/042085

Thermal detector model for cryogenic composite detectors for the dark matter experiments CRESST and EURECA

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Abstract. The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) and the EURECA (European Underground Rare Event Calorimeter Array) experiments are direct dark matter search experiments where cryogenic detectors are used to detect spin-independent, coherent WIMP (Weakly Interacting Massive Particle)-nucleon scattering events by means of the recoil energy. The cryogenic detectors use a massive single crystal as absorber which is equipped with a TES (transition edge sensor) for signal read-out. They are operated at mK-temperatures. In order to enable a mass production of these detectors, as needed for the EURECA experiment, a so-called composite detector design (CDD) that allows decoupling of the TES fabrication from the optimization procedure of the absorber single-crystal was developed and studied. To further investigate, understand and optimize the performance of composite detectors a detailed thermal detector model which takes into account the CDD has been developed.

1. Results

For each of the phonon populations and propagations studied, the expected signal contribution (pulse rise and decay times) was calculated and then compared to the pulse shapes obtained experimentally for three different realized composite detectors (*for details, see [1] and [2]*). The dominant signal contributions in a composite detector and the underlying mechanisms could be identified successfully. The main conclusions have been, that the glue is basically transparent for nonthermal (nt) phonons, and that it has to be included into the model only as a thermal conductance. Since no dominant contribution from nt phonons decaying in the glue could be detected, the glue cannot be contributing a noticeable thermal component to the system. Furthermore, only two different phonon populations were found to dominantly contribute to the signal in the TES: *a)* nt phonons from the absorber can propagate through the glue into the TES-substrate, where they can either be directly absorbed in the TES or decay into thermal (t) phonons, and then be absorbed in the TES; and *b)* t phonons from the absorber that already decayed there can contribute to the signal via the thermal conductance delivered by the glue. However, depending on the exact detector design, i.e., the *TES-to-glue-area* ratio, not in every composite detector *both* of these two contributions are significant for the signal in the TES. (*For further details, see [2].*) A discussion concerning the implications on the composite detector design for dark matter experiments like CRESST and EURECA can be found in [1].

References

[1] Roth S *et al.* 2008 *Opt. Mat. - Conf. Proceed. CryoScint08* to be published, arXiv:0810.0423 astro-ph, 0809.5183 hep-ph

[2] Roth S 2007 Diploma Thesis *Technische Universität München*, link: `http://www.e15.physik.tu-muenchen.de/fileadmin/downloads/thesis/dipl/2007_Sabine_Roth.pdf`