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Abstract. The CRESST-III experiment, located in the Gran Sasso underground laboratory (LNGS, Italy), aims at the direct detection of dark matter (DM) particles. Scintillating $CaWO_4$ crystals operated as cryogenic detectors are used as target material for DM-nucleus scattering. The simultaneous measurement of the phonon signal from the $CaWO_4$ crystal and of the emitted scintillation light in a separate cryogenic light detector is used to discriminate backgrounds from a possible dark matter signal. The experiment aims to significantly improve the sensitivity for low-mass ($\lesssim$ 5-10 GeV/c^2) DM particles by using optimized detector modules with a nuclear recoil-energy threshold $\lesssim$ 100 eV. The current status of the experiment as well as projections of the sensitivity for spin-independent DM-nucleon scattering will be presented.

1. Introduction

Numerous astronomical observations provide undisputed evidence for the existence of cold dark matter [1, 2, 3], yet the underlying nature of dark matter is still not understood. Unravelling the origin and nature of dark matter is therefore currently one of the key scientific endeavours in astroparticle physics and cosmology. The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) direct dark matter search experiment [4] aims to detect DM particles scattering off nuclei in scintillating $CaWO_4$ (calcium tungstate) single crystals. In order to allow for a precise reconstruction of the deposited energy, the $CaWO_4$ target crystals

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are operated as cryogenic detectors at mK temperatures [5]. The heat signal from these cryogenic particle detectors is read out using tungsten (W) transition edge sensors (TES). By simultaneously measuring the phonon signal in the main target crystal and the emitted scintillation light in a separate cryogenic light detector, CRESST detectors can discriminate between electron and nuclear recoils based on their different light yields [6]. This enables an efficient suppression of background events (primarily electrons and γ radiation [7]) in the search for the interaction of DM particles (nuclear recoils). Recent results from the CRESST-II experiment [4, 8] show that these cryogenic particle detectors have a high sensitivity for low-mass dark matter particles with masses below ~ 5 - $10\,\mathrm{GeV/c^2}$. This high sensitivity is achieved by an excellent intrinsic radiopurity of the $CaWO_4$ target crystals [8] and, more importantly, by sub-keV nuclear recoil energy thresholds [4, 8].

2. The CRESST-III experiment

The CRESST-III experiment [9] aims at a significant improvement of the sensitivity for low-mass dark matter particles by using optimized detector modules with a nuclear recoil energy threshold of the main $CaWO_4$ crystal of $\lesssim 100$ eV. This is achieved by reducing the size of the main target crystal by a factor of $\times 10$ [10]. Such a CRESST-III detector module is depicted in figure 1. An excellent radiopurity of the $CaWO_4$ target crystals is ensured by primarily employing crystals grown in-house at the Technische Universität München [11]. To reject potential background events from surface α-decays, the inner detector housing is fully scintillating [12] and is covered by a highly reflective and scintillating foil (3M Vikuiti) and both the main target crystal as well as the light detector are held using $CaWO_4$ sticks. A new source of background events due to energy transmitted from the $CaWO_4$ holding sticks to the main target crystal has been identified. In order to provide an efficient veto against this class of events, the holding sticks of the main target crystal are each instrumented with an individual W TES [10].

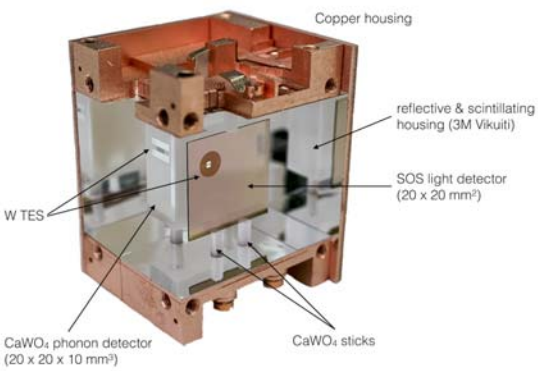

Figure 1. A CRESST-III detector module consisting of a $20 \times 20 \times 10\,\mathrm{mm^3}$ $CaWO_4$ target crystal (mass: 24 g) and a $20 \times 20 \times 0.4\,\mathrm{mm^3}$ silicon-on-sapphire (SOS) light detector, both read out by tungsten (W) transition edge sensors. Both detectors are mounted inside a copper housing and in order to achieve a full veto against surface backgrounds, the inner detector housing consists of a reflective and scintillating foil (3M Vikuiti) and both detectors are held by $CaWO_4$ sticks.

3. Outlook and perspectives

As demonstrated by the CRESST-II experiment, cryogenic particle detectors have a high sensitivity to probe parameter space of DM-nucleon scattering cross section for low-mass ($\lesssim 5 - 10\,\mathrm{GeV/c^2}$) DM particles [4, 8]. The CRESST-III experiment, using optimized detector modules, employs a phased approach to further improve the sensitivity on the scattering cross section of these low-mass DM particles [9]. A first phase (CRESST-III Phase 1) where 10 detector modules with a total target mass of 250 g and a radiopurity on the level reported in [7, 8], started data taking in summer of 2016 and will be operated for 1 year. A second phase (CRESST-III Phase 2) where the number of detector modules will be increased and the radiopurity of the $CaWO_4$ target crystals will be further improved is planned to start by the end of 2017. Figure 2 shows recent results on the spin-independent DM-nucleon scattering cross section from various direct DM searches. The results of CRESST-II are shown as dashed and solid red lines [4, 8]. The 1σ projections for the sensitivity of the CRESST-III experiment are shown as green (Phase 1) and pink (Phase 2) bands (for further details refer to [10]). These projections show that the CRESST-III experiment has the potential to probe the spin-independent DM-nucleon scattering cross section parameter space down to the neutrino floor [13] within the next years.

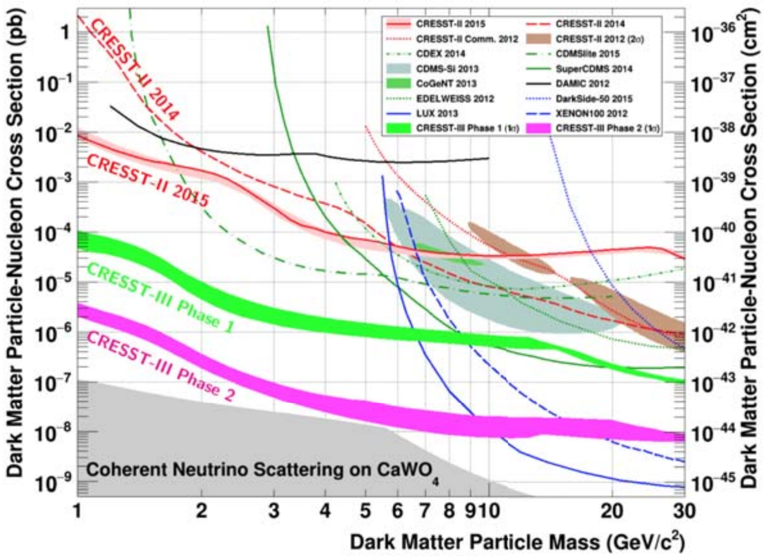

Figure 2. Recent results from direct DM searches for the spin-independent DM-nucleon scattering cross section (for further references see [10]). The results of CRESST-II Phase 2 [4, 8] (dashed and solid red lines) as well as the 1σ projections for the sensitivity of the CRESST-III experiment [9] (green and pink bands) are indicated. Figure taken from [10].

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