PROCEEDINGS OF SCIENCE

# The CRESST Dark Matter Search

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The CRESST cryogenic direct Dark Matter search is located in the Gran Sasso underground laboratories. $CaWO_4$ crystals have been used as scintillating targets for WIMP interactions. Each crystal is operated as a cryogenic calorimeter in combination with a second cryogenic detector used to measure the scintillation light produced in the target crystal. For each particle interaction, the combination of phonon and light signals enables an event by event discrimination allowing an effective separation of nuclear recoils from electron-photon backgrounds. Furthermore, information from studies on the light yield of different nuclear recoils allows the definition of a region of the energy-light yield plane which corresponds to tungsten recoils. After a major upgrade of the setup which includes a new detector support structure capable of accommodating 33 detector modules, the associated multichannel readout with 66 SQUID channels, a neutron shield, a calibration source lift and the installation of a muon veto, the experiment has been successfully commissioned and data from the commissioning phase carried out in 2007 collected with two detector modules (total exposure of $\sim 48$ kg-days) are presented here. With standard assumptions on the dark matter flux, the three events found in the "tungsten recoils" acceptance region yield a limit of $4.8 \times 10^{-7}$ pb at $M_{WIMP} \sim 50$ GeV for coherent or spin-independent WIMP-nucleon scattering cross section.

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## 1. Introduction

The CRESST dark matter search is aiming to directly detect WIMPs via their elastic scattering off nuclei in a target material by the use of cryogenic detectors. Since only small recoil energies ($\sim$ keV) are anticipated in WIMP-nucleus scattering, cryogenic detectors, with their high sensitivity, are well suited to the problem. CRESST-II is an upgrade of the original CRESST [1] apparatus where the detectors are arranged in modules, each consisting of two cryogenic detectors: a large detector consisting of a scintillating $CaWO_4$ crystal, comprising the target mass, measuring the energy of an event and a similar, but with a much smaller mass, light detector measuring simultaneously the emitted scintillation light. $CaWO_4$ has been selected for its high light output and the presence of the heavy nucleus tungsten, which gives a large factor $\sim A^2$ in the presumed coherent or spin-independent scattering of the WIMP. The crystals are cylinders of 4 cm height and 4 cm diameter, and about 300 g in weight. The separate cryogenic light detectors are made from sapphire wafers of 40 mm diameter and 0.4 mm thickness, with an epitaxially grown silicon layer on one side for photon absorption. A comparison of the signals from the two detectors, constituting a module, allows an effective background discrimination. This is a consequence of the property of electron-photon events, representing the dominant background, to give a much higher light output than nuclear recoils. The paired detectors are enclosed together in a reflective and scintillating housing, as described in Ref. [2].

## 2. Setup Upgrade

Details on the various changes implemented during the upgrade of the installation are extensively discussed in Ref. [3]. In the cryostat volume itself, a new detector support structure capable of accommodating 33 detector modules (for a total target mass of $\sim$ 10 kg) has been mounted and a new 66-channel SQUID readout with associated wiring and data acquisition electronics has been installed. A significant upgrade of the setup is the implementation of a neutron shield, consisting of a 45 cm thickness of polyethylene plates. The shield is mounted on rails to allow access to the inner parts of the experiment. With the aim of identifying the effects of muons entering the apparatus and reducing the associated background a muon veto has been installed. It consists of plastic scintillator panels surrounding the inner shielding. A total solid angle coverage of 98.7 % is achieved [3]. The inner passive shielding of the detector volume is as used in previous phases of the experiment and is described in Ref. [1].

## 3. Commissioning Run

Ten detector modules were installed for the commissioning run. For the dark matter analysis we use data taken between March 27th and July 23rd 2007 with the two detector modules (Zora/SOS23) and (Verena/SOS21).
Events from a given module are plotted as points in the energy-light yield plane. An energy is assigned to an event as described in [3]. The light yield is given by the ratio of the energy in the light detector to that in the target detector, normalized such that it is 1 for a 122 keV calibration photon absorbed in the large detector. Since the factor of reduction for the light yield of a nuclear

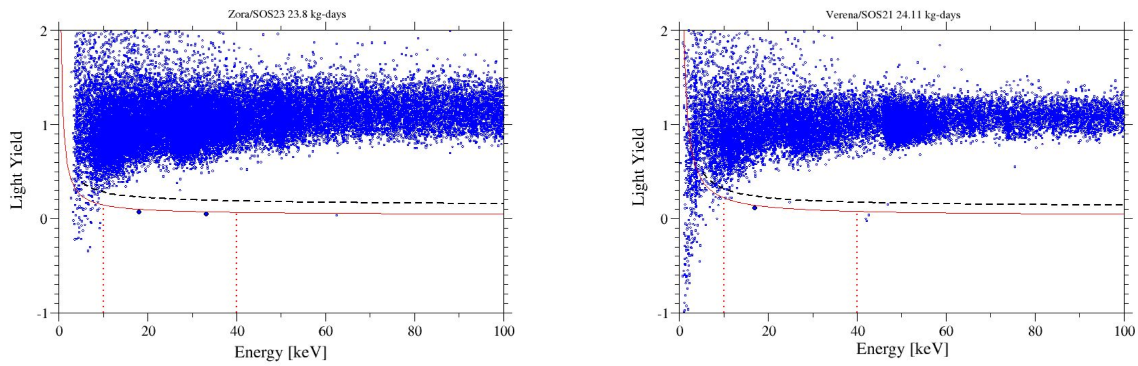


**Figure 1:** Low-energy event distribution measured with two 300 g $CaWO_4$ detector modules during the commissioning run. The vertical axis represents the light yield (see text), and the horizontal axis the total energy, as measured by the phonon channel. The heavy dots show the events in the "tungsten recoils" acceptance region (10 to 40 keV).

recoil relative to that of the electron-photon event of the same energy varies widely, up to $\sim 40$ for heavy elements, the level of light output can be used not only to distinguish nuclear recoils from electron-photon events, but also to distinguish tungsten recoils from those of the lighter nuclei. The data are shown in Fig. 1. The cumulative exposure was 47.9 kg-days. For the tungsten this corresponds to an exposure of 30.6 kg-days. A neutron test was performed during the commissioning run which confirms the principle of identifying the recoiling nucleus via the light yield. Details are given in [3].

## 4. Results

We perform a dark matter analysis on the assumption of coherent (spin-independent) scattering for the WIMP. This process should strongly favor tungsten recoils due to the $\sim A^2$ factor in the WIMP-nucleus cross section. We define an acceptance region on the plots based on the reduction factor for the light yield and on the maximum energy expected for tungsten recoil.
The light yield boundaries are shown on the plots of Fig. 1 by the curves. Below the dashed black curve 90 % of all nuclear recoils, and below the solid red curve 90 % of the tungsten recoils are expected. The energy boundaries are shown by the vertical lines. The upper limit at 40 keV is set by form-factor effects [4], which effectively limit the energy transfer to the tungsten nucleus. The lower limit is set at 10 keV, where "leakage" from the electron/photon events, due to detector sensitivity constraints, becomes evident and so recoil discrimination becomes inefficient. Three candidate events (heavy dots) are observed in Fig. 1 for the "tungsten recoils" acceptance region. The corresponding rate is 0.063 per kg-day. The possible nature of the few observed events is widely discussed in [3]. From the measured rate we can derive a limit on the spin-independent WIMP-nucleon scattering cross section. Using standard assumptions on the dark matter halo [5], an upper limit for the coherent or spin-independent WIMP-nucleon scattering cross-section is obtained using the maximum energy gap method [6]. This limit is plotted as the red curve in Fig. 2. The minimum of the curve, for a WIMP mass of $\sim$50 GeV, is at $4.8 \times 10^{-7}$ pb.

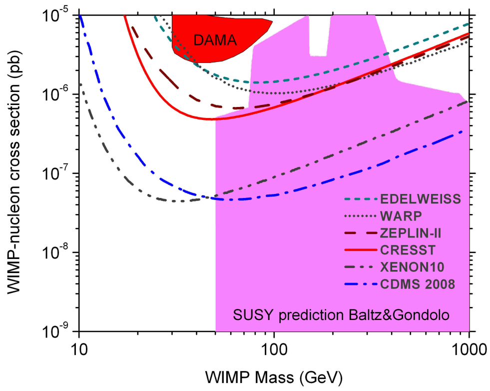


**Figure 2:** Coherent or spin-independent scattering cross section exclusion limit derived from the data of Fig. 1 using the maximum energy gap method. For comparison the limits from other experiments [7], [8], [9], [10], [11] and the range predicted by some supersymmetry models [12] are also shown.

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