Results from the Commissioning Run of CRESST-II

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There is compelling evidence for the existence of large amounts of non-luminous matter in the universe. About 85 % of this Dark Matter is non-baryonic and not composed of any type of particles known in the standard model of particle physics. Weakly Interacting Massive Particles (WIMPs) are among the best motivated candidates for Dark Matter. This hypothesis is also supported by the prediction of supersymmetric extensions of the standard model of particle physics, where the lightest of the supersymmetric particles is neutral and stable and as such has the right properties to explain the cosmological and astrophysical observations of Dark Matter.

The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) direct Dark Matter experiment located at the Gran Sasso underground laboratory (3600 m.w.e.), searching for WIMPs via nuclear recoil, has been upgraded to CRESST-II by several changes and improvements. The upgrade includes a new detector support structure capable of accommodating 33 modules (i.e. ∼10 kg of target mass), the associated multichannel readout with 66 SQUID channels, a neutron shield, a calibration source lift, and the installation of a muon veto.

The basic element of CRESST-II are detector modules consisting of a large (∼300g) $CaWO_4$ crystal and a very sensitive smaller (∼ 2g) light detector to detect the scintillation light from the $CaWO_4$. The large crystal gives an accurate total energy measurement, while the light detector gives the possibility to determine the light yield for an event, allowing an effective separation of nuclear recoils from electron-photon backgrounds.

Results from data obtained with only two detector modules for a total exposure of 48 kg-days are reflected in the WIMP-nucleon cross section exclusion plot depicted in Fig.1 and described in detail in [1]. Judging by the rate of events in the "all nuclear recoils" (i.e. recoils on Ca, O and W, respectively) acceptance region the apparatus showed a factor ∼ten improvement with respect to previous results, which can be mainly attributed to the presence of the neutron shield. In the "tungsten recoils" acceptance region three events are found, corresponding to a rate of 0.063 per kg-day. Standard assumptions on the Dark Matter flux, coherent or spin independent interactions, then yield a limit of CRESST-II for WIMP-nucleon scattering of 4.8×10^{-7} pb, at $M_{WIMP} \sim 60$ GeV.

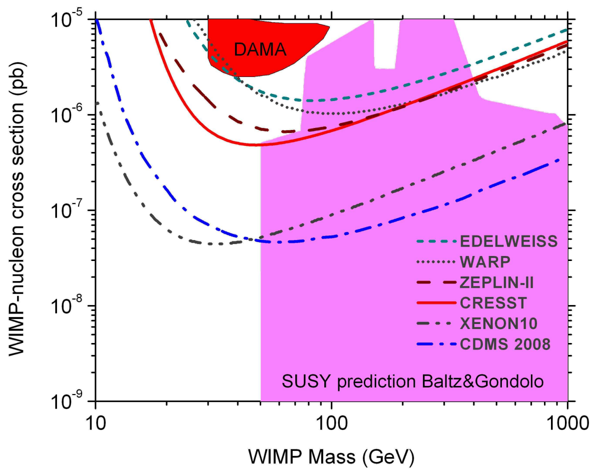

Fig. 1: Coherent or spin-independent WIMP-nucleon scattering cross section exclusion limit (solid red line) derived from the data obtained with only 2 detector modules during the commissioning phase of CRESST-II. For comparison the limits from other direct Dark matter experiments are also shown [1].

To strengthen our understanding of the detector response and a reliable interpretation of the experimental data gained with cryodetectors using $CaWO_4$ as target material, dedicated neutron scattering experiments are being performed to measure with high accuracy the so called quenching factors (light reduction factor for nuclear recoils as compared to electron recoils) for nuclear recoils on Ca, O, and W. These measurements are mandatory to discriminate between WIMP and neutron signatures since for kinematic reasons, WIMPS are expected to scatter mainly on the heavy W nucleus rather than on O or Ca. Such a neutron scattering experiment at mK-temperatures (∼10 mK), as well as a dedicated detector module, have been set up and are being optimized in Hall2 of the MLL. First results have been obtained using a continuous neutron-beam [2] and looked promising, but also indicated that new and faster electronics are needed. This upgrade of the experiment is presently being performed.

Furthermore, rapid progress is being made regarding the design and coordination towards the future European tonne-scale and multi-target Dark Matter experiment EURECA (European Underground Rare Event Calorimeter Array) [3].

References

[1] G. Angloher *et al.*, Astroparticle Physics **31** (2008) 270
[2] J.-C. Lanfranchi *et al.*, **arXiv** : **0810.0132v1** [astro-ph]
[3] H. Kraus *et al.*, Nucl. Phys. B - Proc. Suppl. **173** (2007) 168