

Dark Matter Detection with CRESST

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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 experiment (Cryogenic Rare Event Search with Superconducting Thermometers) is located in Hall A of the Gran Sasso Underground Laboratory (3600m.w.e.) in Italy and is aimed at the direct detection of Dark Matter WIMPs with ordinary matter by means of scintillating cryogenic detectors. These low-temperature devices, typically consisting of a $\sim 330\text{g}$ CaWO_4 single crystal and an additional light detector, are capable of discriminating most of the radioactive background by the different ratio of the thermal and the scintillation signal for electron recoils (background) and nuclear recoils (as induced by WIMPs or neutrons). This background suppression technique was successfully demonstrated in the past and has ever since been optimized [1].

Several upgrades have been performed, comprising: a 50 cm thick polyethylene neutron moderator installed around the existing setup to drastically reduce the neutron flux from environmental radioactivity, the setup of a muon-veto consisting of 20 plastic scintillator panels to reduce the background originating from muon-produced neutrons in the lead shielding, the mounting of a new detector holder and a SQUID read out system for 66 channels and the introduction of a movable ^{57}Co calibration system for the 33 detector modules (i.e. ~ 10 kg target mass), commissioning runs have started in early October 2006 using ~ 1 kg of target material.

In order to guarantee a thorough 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 have to be performed. In these so called quenching factor

measurements (light reduction for nuclear recoils as compared to electron recoils) the different light outputs for nuclear recoils on Ca, W, and O could be utilized to discriminate between WIMP and neutron signatures, the latter of which can mimic Dark Matter events [2]. For kinematic reasons, WIMPs are expected to scatter mainly on the heavy W nucleus rather than on O or Ca. Up to now measurements of that kind have only been performed at room temperature. However, it is of crucial importance to investigate the scintillation efficiencies at the operational temperature of the detectors namely in the 10mK range, too. Such an experiment is currently being set up in Hall2 at the neutron scattering facility of the MLL. In fall 2006 a new $^3\text{He}/^4\text{He}$ dilution refrigerator (base temperature $\sim 10\text{mK}$) was installed, successfully cooled down and is now being equipped with 2 SQUID read-out channels and the necessary electronics to operate cryogenic detectors.

Another important source of background lies in the CaWO_4 surface events originating from ^{210}Po , a daughter of ^{210}Pb , which again is a daughter of the omnipresent ^{222}Rn . For the characterization of these events, which - like neutrons - can mimic WIMP events, dedicated experiments with artificially introduced ^{210}Po activities have been performed, thus significantly contributing to the understanding of this sort of events [3].

Furthermore the development of light-detectors in collaboration with KETEK GmbH using the Neganov-Luke amplification [4] to increase their sensitivity possibly to the level of single photon detection, has been ongoing and is showing promising results.

In addition to that the development of an optimal cryodetector for the neutron scattering experiment has been started. This detector should be able to cope with high counting rates and should be such that no double neutron scattering occurs in the CaWO_4 crystal. To have better control over the CaWO_4 quality in terms of crystal structure and radiopurity, our group has started to grow CaWO_4 crystals in the crystal laboratory of the TUM.

Eventually these developments will also be beneficial for the next generation cryodetector experiment EURECA which will be in the ton-scale. The collaboration for this experiment was officially formed in 2006 and is currently preparing the proposal for a design study.

References

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