# STATUS OF THE CRESST DARK MATTER SEARCH

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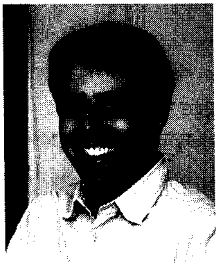

for the CRESST collaboration

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**Abstract**

We are preparing the CRESST experiment in LNGS to search for dark matter WIMPs using cryogenic detectors with superconducting phase transition thermometers. In the first stage of the experiment we plan to use four 250 g sapphire detectors with thresholds of 0.5 keV and resolutions of 0.2 keV at 1 keV. This will provide sensitivity to WIMP masses below 10 GeV, making our experiment complementary to other dark matter searches. In 1995 the construction of the main cryogenic components was completed and successfully tested. The installation of our equipment in LNGS has begun.

The CRESST (**C**ryogenic **R**are **E**vent **S**earch with **S**uperconducting **T**hermometers) experiment is designed to look for low-mass WIMPs as the dark matter of our Galaxy, using the cryogenic calorimeters developed in Munich. WIMPs could be detected via their elastic scattering on nuclei, giving nuclear recoil energies of about a keV for WIMP masses of a few GeV. Since low energy nuclei are very inefficient at producing ionization or scintillation, a low-threshold detector needs to act as a calorimeter, detecting the full nuclear energy. At the Max Planck Institute of Physics and the Technical University of Munich we have developed cryogenic calorimeters using superconducting phase transition thermometers. The thermometer is a small thin film of a superconducting material (tungsten) evaporated onto the surface of a sapphire crystal. The detector is run at a temperature ($\sim$ 15 mK) where the thermometer is in the middle of its transition between the normal and superconducting phases. Here its resistance is very sensitive to the small rise in temperature caused by a recoiling nucleus.

We have been able to detect 1.5 keV X-rays in a 32 g sapphire crystal with a resolution of 100 eV FWHM [1] in an above-ground laboratory. The local radioactivity already makes the background rate quite high in a detector of this size, so that the development of more massive detectors with this sensitivity requires a shielded underground site. However the model [2] which we have developed to describe the behaviour of our detectors leads us to expect that we can increase the detector mass by about an order of magnitude without losing much resolution. For the first phase of our dark matter experiment in Gran Sasso we are making 4 detectors of 250 g each, and hope to achieve a resolution of 200 eV at 1 keV and a threshold of 500 eV.

For a dark matter search experiment we need to combine the requirements of our detector (an operating temperature of $\sim$ 15 mK, provided by a dilution refrigerator) with the requirements of a low-background experiment (elimination of radioactivity). To eliminate cosmic ray background we perform the experiment in Gran Sasso Underground Laboratory (LNGS). Since a standard dilution refrigerator is made with various materials (stainless steel, indium vacuum seals) which are much too radioactive, we decided to separate the dilution refrigerator from the detector. The dilution refrigerator is based on a standard design from Oxford Instruments, with some modification to increase its mechanical strength. The detector will be placed in the "cold box", which hangs from the dilution refrigerator. This cold box is large enough to accommodate 100 kg of sapphire detectors.

The cold box is made of high-purity copper, with high-purity lead used for the vacuum seals. These materials are known to be among the best available for low radioactivity. As shown in the figure, the cold box will be surrounded by room-temperature shielding comprised of a 14 cm layer of high-purity copper and a 20 cm layer of lead. An internal shield serves to block any line of sight for radiation coming from the dilution refrigerator into the experimental volume.

A prototype cold box was designed and constructed in Munich, as was the gas handling system for the dilution refrigerator. The system was set up and its cryogenic properties tested at MPI in the fall of 1995. The temperature as measured in the cold box with $^{60}$Co nuclear orientation thermometry reached 6.8 mK, safely below that needed for the operation of our detectors. With this, a major milestone of the experiment has been reached.

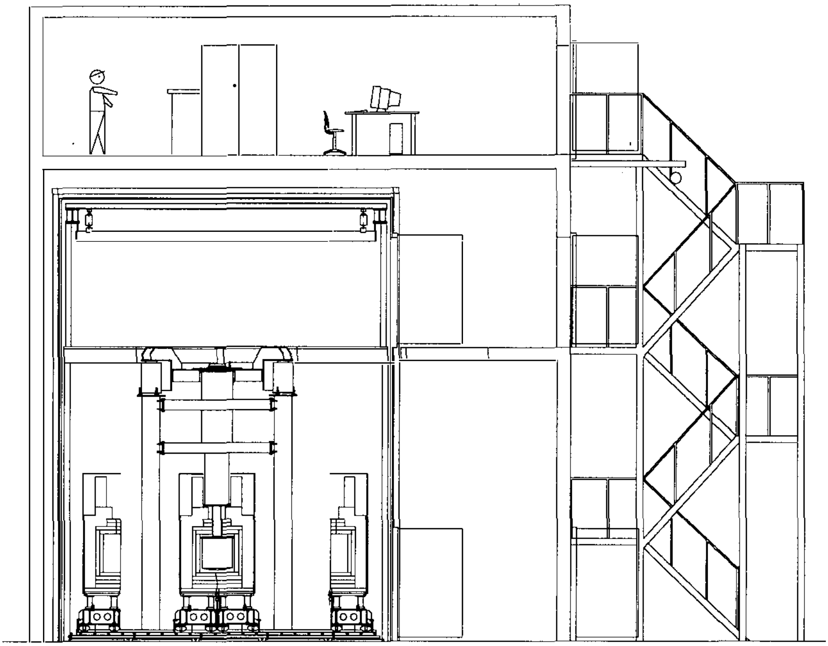

Figure 1: Cross section of CRESST building and experimental equipment in Hall B at Gran Sasso Laboratories. The dilution refrigerator (not drawn in this picture) is placed about 1 m above the "cold box" which is surrounded by low radioactivity shields

The copper for the shielding has undergone special handling [3] to assure its purity and to protect it from exposure to cosmic rays (which can transform copper into radioactive elements such as $^{60}$Co). The copper was produced electrolytically by the Norddeutsche Affinerie in Dec. 1994 and rolled to the desired thickness a few weeks later. It was then placed in the cellar of a beer brewery near Munich, where it was shielded from cosmic rays by more than 10 m water equivalent. The final machining of the copper was performed by a company near Munich using special procedures for cleanliness. Each piece was only brought out of the brewery cellar for the few days needed for its machining, and then sealed in plastic, placed in a shipping crate, and returned to the cellar. The copper has now been transported to Gran Sasso and is stored in the underground laboratory. The total exposure to cosmic rays was 10 weeks.

It is not sufficient to use high-purity materials. Their surfaces must also be kept clean during use, and we have taken care to design our facilities in Gran Sasso to make this possible.

The Faraday cage which surrounds the experiment was chosen large enough so that all work on the low-background components of the experiment can be performed inside the cage. It is divided into two levels, with the upper level allowing access to the top of the cryostat and to the electronics. The lower level of the cage will be equipped as a clean room to protect the low-background components. The external lead and copper shields are in two closely fitting halves, each supported on a "wagon" so that the shielding can be opened without handling the individual pieces. In its retracted position (shown in the figure) the shielding is outside the dilution refrigerator support structure but still inside the clean room. Sufficient room is then available to disassemble the cold box which, since it consists of 5 shells, requires considerably more space as individual pieces. Entrance to the clean room will be through a changing room external to the Faraday cage.

We hope by the end of 1996 to get our first experience with a 250 g detector in our shielded environment in LNGS. Some adjustment of the detector parameters may then be needed to achieve optimum performance. These first measurements, which will be done using our prototype cold box, will also provide a first look at the radioactive backgrounds. The prototype was intended mainly as a test of the cryogenic techniques, and no attempt was made to limit the cosmic ray exposure or surface contamination. A new cold box will be fabricated using clean procedures similar to those used for the shielding. With this cold box, we hope in 1997 to achieve a good background rate and get our first significant data on dark matter.

# References


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