Neutron Scattering Experiment for the CRESST Dark Matter Search

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The CRESST dark matter search experiment [1,2,3,4,5,6,7] presently is using sapphire absorbers with tungsten superconducting phase transition thermometers evaporated onto their surface. For both, the investigation of possible backgrounds and for the elucidation of the nature of a Dark Matter candidate in case of a positive signal, it would be desirable to vary the absorber material. CRESST recently has developed detectors, capable of simultaneously measuring a temperature signal and scintillation light produced in the absorber crystal. Since the light output is different for nuclear recoils and electron recoils, one can distinguish Gamma- and Beta-background from nuclear recoils scattering events. The sensitivity for the search to particle Dark Matter candidates is increased by orders of magnitude. The scintillating crystal used as absorber is $CaWO_4$.

As soon as large CaWO4 detectors are available, the efficiency of light production of nuclear recoils can be measured and calibrated. The TUM group is in the process of setting up a dilution refrigerator, pumped by an absorption pump. Since this refrigerator, which will be fully functioning within a few weeks, needs no gas handling system, it can easily be transported to the close by Munich Accelerator Laboratory, where the measurements will be carried with a pulsed neutron beam. Since the tungsten in CaWO4 will be dominant in the coherent scattering of dark matter candidates, it is very important to calibrate the light output for nuclear recoils on tungsten. During the measurement with neutrons, thus scattering on Ca, O and W have to be distinguished. This will be done by the different energy transfers, if the neutron energy and the scattering angle are fixed. The neutron energy will be fixed by the production reaction and by time of flight measurement.

A suitable low background reaction for monoenergetic neutron production at 11 MeV was found to be $^{1}H(^{11}B,n)^{11}C$. In order to investigate reaction properties, a hydrogen gas cell target was designed and installed in hall II of the accelerator laboratory. The hydrogen gas was contained in a cylindrical stainless steel cell with an entrance window of a 5μm thick Mo foil, and the beam stopper was a 1.5mm thick electrically isolated Au plate. Together with an electrically isolated Au aperture in front of the entrance window, this assembly served as a Faraday cup to easily threading the beam onto the target and reading the beam current during the experiment. The pressure of H_2 gas was 0.3MPa absolute. From the cesium sputtering source, typically -1μA of either BO^- or B^- was extracted. This beam was then chopped by a combination of both a 5MHz low and high energy oscillator and bunched by a rf wave. The repetition rate of the beam was 1.25MHz with a burst duration of about 1ns.

The neutrons were detected by a 5cm thick NE213 szintillator optically coupled to a Philips XP3461B photomultiplier tube set at several angles. Conventional time of flight technique with a pulse-shape n–γ discrimination was used. Data acquisition was established, and source properties were measured for an incident ^{11}B beam of 61MeV hitting the hydrogen target.

Neutrons were produced with high monochromaticity and collimate into a forward cone with a maximal opening angle $\theta_{max} = 39°$ according to the inverse kinematical condition. For the calibration of the cryogenic detectors, the neutron pulse repetition rate has to be much lower, such as 5kHz. Since the rate of events, coincident in the cryogenic detector and the neutron detectors will be very low, the background of randomly scatterd neutrons will pose the main problem. During the next year we plan beam times to optimize all parameters with respect to the background. To increase the rate of 'good' coincidences, we will install and test up to 50 neutron detectors.

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