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At the 100 eV Frontier: Calibrating Nuclear Recoils with CRAB

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Searches for light dark matter (DM) imply the detection of sub-keV nuclear recoils. However, an absolute energy calibration in this regime is still missing. The CRAB project proposes a method based on nuclear recoils induced by the emission of MeV-γ-rays following thermal neutron capture. Single MeV-γ transitions are of particular interest as they induce well-defined nuclear recoil peaks in the 100 eV-1 keV range for many different materials. The proposed method offers the only direct calibration of pure nuclear recoils so far. With detailed GEANT4 simulations, we studied the expected energy spectrum in various cryogenic detectors used for DM search. For a cryogenic $CaWO_4$ detector, similar to the ones used in the CRESST experiment, clear nuclear recoil calibration lines at 112 eV and 160 eV are predicted.

Currently, we are preparing a proof-of-concept measurement with a portable neutron source at the Technical University of Munich. For a precision measurement, the low power TRIGA reactor in Vienna will provide a clean beam of thermal neutrons. In the first phase, the CRAB project foresees to perform a precise nuclear recoil calibration of cryogenic $CaWO_4$ detectors read-out with a W-TES. In the second phase, additional tagging of the γ-rays produced in the de-excitation process will allow to extend the calibration method below 100˜eV and to a wider range of detector materials, such as germanium or silicon. Combined with an electronic recoil calibration, CRAB will allow to measure energy quenching in the sub-keV regime. With its novel idea, CRAB provides a direct and accurate calibration of nuclear recoils in the region of interest of light DM experiments, which is essential for finding and studying new physics. Latest simulation results and the experimental strategy will be presented.

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