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Monte Carlo Simulations of Dark Matter Detectors for SuperCDMS

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The SuperCDMS experiment is a direct detection dark matter (DM) experiment currently located at the SNOLAB underground facility in Sudbury, Ontario. Employing cryogenically cooled silicon and germanium crystals held just above absolute zero, the experiment detects DM particles via nuclear and electron recoils. The High Voltage (HV) detectors boast a low energy threshold granting high sensitivity to low mass particles while the interleaved Z-dependent Ionization and Phonon (iZIP) detectors effectively discriminate signals from normal matter interactions. Through the strategic arrangement of these detectors in towers, the SuperCDMS experiment increases the probability of detecting a DM particle and establishes world-leading limitations on DM interactions with normal matter. Maximizing the sensitivity of the experiment, and performing R&D to extend the sensitivity in the future necessitates a thorough understanding of individual detectors

Monte-Carlo simulations play a pivotal role in the process of understanding the detector physics. The SuperCDMS Detector Monte-Carlo (DMC) relies on the Geant4-based Condensed Matter Physics (G4CMP) package. By simulating many physical processes in the cryogenic semiconductor crystals –including electron and hole propagation, and phonon and charge carrier transport –and detector response, the simulation is able to match the data acquired from test facility runs of HVeV detectors (gram-scale prototypes with single electron-hole pair sensitivity) extremely well.

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