Voltage-assisted calorimetric detection of gamma interactions in cryogenic coplanar grid germanium detectors for dark matter search

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As a part of an R&D project to improve the sensitivity of its detectors to low-mass (<10 GeV) weakly interacting massive particles (WIMPs), the Edelweiss dark matter search collaboration has developed cryogenic ionization-and-heat coplanar grid Ge detectors, operated in a high-bias mode where advantage is taken of the voltage-assisted (Neganov-Luke) amplification of the ionization signals for enhanced sensitivity to low-energy (< a few keV) interactions. A prototype 200 gram detector has been produced, capable of sustaining up to 60 volts between intertwined sets of collection electrodes. Depending on the electrode biases, a heat gain of up to 40 is achieved for fiducial electron recoil events. The device retains at the same time its basic capabilities for surface event discrimination, based on selection cuts in the ionization signal amplitudes (this, as far as can be done given the baseline noise in the charge measurement channels). Calibration experiments have been made with gamma sources (241Am and 55Fe) enabling to characterize the heat response of the detector to surface interactions, a main component of the radiation background in these experiments. Based on a computer modeling of the detector signals, simulated distributions are obtained for the heat signal amplitudes, which we compare with our experimental data. Quantitative estimates are derived for the respective contributions to the heat histograms, arising from surface interactions of incomplete charge collection and from events with charge sharing between the different sets of electrodes. On-going experiments are aimed at defining optimal biasing conditions for the detector, and a reset procedure appropriate for space and surface-charge cancellation.