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Charge collection efficiency study of neutron irradiated silicon pad detectors for the CMS High Granularity Calorimeter

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The replacement to the existing endcap electromagnetic and hadronic calorimeters in CMS for the high-luminosity running at the LHC (HL-LHC), will be a High Granularity Calorimeter (HGCAL) that will provide unprecedented information on electromagnetic and hadronic showers in the intense pileup of the HL-LHC. The electromagnetic section and the high-radiation region of the hadronic section will use hexagonal silicon sensors of thicknesses from 100 to 300 μm as active material. The radiation hardness of these sensors is the focus of this study.

Charge collection efficiency (CCE) is the single most revealing parameter to determine the level of radiation hardness of a silicon detector. To reduce increasing bulk leakage current with fluence the silicon sensors at HGCAL will be operated at -30° C. Thus, the CCE investigation of 30 irradiated samples was carried out at the target temperature of HGCAL.

We present CCE results of silicon sensors irradiated with neutrons at Rhode Island Nuclear Science Center (RINSC) and UC Davis McClellan Nuclear Research Center (MNRC) reactors up to 1e16 neq/cm2 fluences, as expected for HGCAL. Charge injections were generated by an infrared laser that models a minimum ionizing particle by penetrating the whole thickness of the investigated sensors, that include both polarities for the three thicknesses planned for HGCAL. The study involved samples from 8-inch wafers, which will be the HGCAL sensor size, as well as reference samples from 6-inch wafers. Conclusions between polarities and thicknesses to be applied for different fluence regions will be made, as well as comparisons with CCE reproduced by a simulation.

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