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The weighting field of irradiated silicon detectors

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The understanding of the weighting field of irradiated silicon sensors is essential for calculating the response of silicon detectors in the radiation environment at accelerators like at the CERN LHC. Using 1-D calculations of non-irradiated pad sensors and 1-D TCAD simulations of pad sensors before and after irradiation, it is shown that the time-dependence of the weighting field is related to the resistivity of low field regions with ohmic behaviour in the sensor. A simple formula is derived, which relates the time constant of the time-dependent weighting field, τ, with the resistivity and the extension of the low-field region for pad detectors. As the resistivity of irradiated silicon increases with fluence and finally reaches the intrinsic resistivity, τ becomes much larger than the charge-collection time and the weighting field becomes essentially independent of time. The TCAD simulations show that the transition from a time-dependent to a time-independent weighting field occurs at a neutron-equivalent fluence of ≈ 5 × 10¹² cm^{−2} for a 200 µm thick pad diode operated at 40 V and −20°C. It is therefore concluded that the use of a time- independent weighting field calculated with the same method as for a fully-depleted non-irradiated sensor is also appropriate for the simulation of highly irradiated silicon sensors.

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