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Non-Ionizing Energy Loss: Geant4 simulations and OPTICS clustering towards more advanced NIEL concept for radiation damage modelling and prediction

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The Non Ionizing Energy Loss (NIEL) concept compares and scales the damage impacted on semiconductor devices in different radiation fields. A particular weakness of the present NIEL concept consists in the inability to predict the different formation rates of cluster and point defects in the silicon (Si) crystal for different particles and particle energies. Specifically, differences between radiation damage produced by neutrons and protons of the same displacement energies (i.e. damage parameters
normalized to the NIEL) has been observed experimentally. In previous RD50 contribution the interactions of neutrons and protons of different energies in a 100 um thick Si target were studied and the kinematics of the Primary Knock-on Atoms (PKA) has been characterized. In this work, we present subsequent silicon cascade studies.
A full Si cascade is simulated in Geant4 and results are further proceeded by an OPTICS (Ordering points to identify the clustering structure) algorithm. The dependency of the isolated vs clustered defects ratio along with the cluster sizes and quantities is explored as a function of Si-recoil energy.

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