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Overview of sensor radiation tolerance at HL-LHC levels

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Radiation damage effects in silicon sensors were extensively studied during LHC construction. These studies concentrated mostly on silicon sensors of n-type and led not only to reliable prediction of sensors operation by parametrizing damage effects at LHC, but also to ways of improving radiation hardness detectors by defect engineering (oxygenated detectors). Understanding the radiation hardness effects in silicon at HL-LHC cannot be achieved simply by extrapolating the effects and concepts measured at fluences <~1e15 cm-2. Also alternative ways of using characterization techniques are required for determining the detector properties.

Although silicon detectors with segmented n+ electrodes (usually p-type detectors) with proper choice of geometry and technology (thin planar, 3D, HV-CMOS…) offer successful operation even beyond few 1e16 cm-2, not all aspects of detector operation is fully understood. Moreover, the use of segmented silicon detectors with gain in timing applications changes in many ways the radiation damage paradigm.

In the presented work radiation effects determining the operation of detectors at HL-LHC fluences will be reviewed. An emphasis will be given to electric field modelling, effects of impact ionization, trapping and mobility changes with irradiations. Effective acceptor removal, which importantly influences performance of novel detector concepts (HV-CMOS, LGAD) will also be addressed.

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