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Performance studies for the new CMS outer tracker module concept at HL-LHC based on measurements of charge collection properties in irradiated silicon sensors

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In order to increase the discovery potential of the experiments at the Large Hadron Collider, the high-luminosity phase of the LHC (HL-LHC) is expected to deliver a total of 3000 fbˆ{-1}. The instantaneous luminosity will be increased by a factor of 5 compared to the LHC design luminosity. This results in an intensified radiation level and track density especially in the tracking systems, requiring new radiation hard sensors for the CMS outer tracker. The CMS tracker collaboration initiated a large campaign to evaluate several different silicon base materials and sensor layouts in order to cope with the increasing demands to radiation hardness and track density. The measurements performed on the sensors include electrical characterization and measurements of the charge collection process in the sensor using a beta source, laser and in testbeams. Additionally, the influence of the strong magnetic field present in the CMS tracker volume has been studied. To cope with the increased track density and trigger rates, a new module concept based on the coincidence of hits in two closely stacked sensors is pursued for the new tracker, allowing the use of tracking and transverse momentum information already at the first trigger level. This is needed to keep the overall readout bandwidth at a manageable level. For further data reduction, the next readout chip will implement a binary readout, comparing the signal height to a threshold value directly in the detector. The performance of the new trigger module concept has been studied using a parametrization of the charge drift in the electric and magnetic field in the sensor. From that, the phase-space of efficient operation of the module concept and the binary readout in terms of collected charge and noise has been explored.

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