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Development of Planar Pixel Sensors for the CMS Inner Tracker at the High-Luminosity LHC

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The LHC is planning an upgrade program which will bring the luminosity up to about 7.5E34 $cm^{-2}s$ in 2027, with the goal of an integrated luminosity of 3000 fb^{-1} by the end of 2037. This High Luminosity scenario, HL-LHC, will present new challenges of higher data rates and unprecedented radiation levels for the pixel detector (2E16 $n_{eq}cm^{-2}$, or equivalently 1 Grad, is expected for the inner layer of the CMS Inner Tracker (IT) for 3000 fb^{-1} integrated luminosity).
To maintain or even improve the performance of the present system, new technologies have to be exploited for the so-called Phase-2 upgrade. Among them is the future version of front-end chips in 65-nm CMOS by the CERN RD53 Collaboration which supports small pixel sizes of 50x50 or 25x100 μm^2 and low pixel charge thresholds (˜1000 e-).
Thin planar n-in-p type silicon sensors with a thickness of the active layer of 150 µm, segmented into pixel sizes of 25x100 μm^2 or 50x50 μm^2 will be used throughout most of the IT. They have been shown to allow for a good detector resolution that is much more stable with respect to radiation damage compared to the Phase-1 detector. CMS has launched several R&D submissions for the development of suitable planar silicon sensors at HPK photonics, FBK Trento and LFoundry. We will present results for measurements on such prototype sensors bump bonded to the RD53A prototype chip developed by the RD53 collaboration at CERN. The presentation will concentrate on planar sensors manufactured by Hamamatsu and FBK. Different pixel cell designs are compared and evaluated in testbeams at CERN, DESY and FNAL for spatial resolution and hit efficiency at various track angles before and after irradiation. As an example, hit efficiencies of 99% at vertical incidence were reached after irradiation to 5E15 $n_{eq}cm^{-2}$ which corresponds to the layer 2 lifetime fluence of the CMS IT.

Submission declaration

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