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Heat Extraction through Structural Components of the CMS Phase II Inner Tracker Forward and Endcap Pixel Detector

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The CMS Inner Tracker pixel detector will be rebuilt for the instantaneous luminosity of $7 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ and up to 200 pp collisions at the High Luminosity LHC. The detector will consist of a barrel section, the TBPX, and small and large forward discs, the TFPX and TEPX, respectively. To achieve per mille hit occupancy, the new sub-detectors will feature higher granularities that will result in higher heat dissipation. Cooling the detector will be of paramount importance to avoid thermal runaway and some structural components must serve to extract heat.

This talk focuses on the TEPX and TFPX sub-detectors and first outlines their cooling requirements through finite element analyses. For the TEPX, we showcase the cooling performance of the prototype Dee structure and simulate the effects of the parylene module coating, necessary for the modules' operation at high voltages after large accumulated radiation. We also present results using titanium cooling loops that reduce the effective cooling loop mass to half. We then present detailed thermal conductivity measurements of structural materials proposed for the TFPX using novel, custom-made apparatuses. Through a comprehensive campaign of measurements, we motivate our choices for high thermal conductivity materials that survive high radiation: graphite-doped carbon fiber cured at high pressures, diamond-doped adhesives, and diamond-doped greases. Finally, we present procedures to apply the adhesives and greases using a gantry to construct TFPX Dee structures and mount detector modules on the Dees.

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