Contribution ID: **15** Type: **not specified**

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

Monday, 17 June 2019 16:15 (30 minutes)

The High Luminosity LHC will reach an instantaneous luminosity of $5 \times 10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$ with 140 to 200 pp collisions per bunch crossing and collect a total of 3 ab^{-1} of 14 TeV data. To cope with these challenging data conditions, the CMS Inner Tracker will be rebuilt for Phase II Upgrades. To limit particle occupancy to the per mille level and improve track resolution, we will increase the granularity of the sensors. This will result in power dissipation of approximately 60 kW. For sensors to survive the radiation close to the beam pipe, we will need to maintain them around -20°C. Thus, cooling the detector will be of paramount importance and structural components will also serve to extract heat. We present thermal transport property measurements of these structural materials using novel, custom-made apparatuses. These measurements inform finite element analysis simulations that point to potential heat transfer bottlenecks that can lead to thermal run-away in the sensors and their readout chips. To improve one of the bottlenecks, we investigate the variation of thermal conductivity of an adhesive by loading it with various compounds at varying concentrations. We also present measurements of thermal conductivity of these structural materials after irradiation.

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