Contribution ID: **175** Type: **poster**

Design and integration of CMOS tracker layers in digital tracking calorimeter for pCT application

Friday 17 September 2021 08:06 (1 minute)

Proton Computed Tomography (pCT) is an emerging imaging modality in particle therapy as it enables direct reconstruction of 3D map of relative stopping power (RSP) values of the target. A typical pCT detector records the direction and position of every single particle before and after crossing the target and residual energy after crossing the target. A typical pCT detector is thus made of extra-thin tracking detectors and an energy/range detector.
Bergen pCT collaboration is building a prototype Digital Tracking Calorimeter (DTC) consisting of 43 layers of pixelated silicon radiation detectors. The first two layers, called as tracker layers, are used for tracking the position of the protons. The next 41 layers, separated by absorber Al plates are used as calorimeter. Each layer is made up of 108 CMOS Monolithic Active Pixel Sensors (MAPS), covering an area of 27 cm × 16.6 cm. Each sensor has almost half-million pixels of the size of 29.24 x 26.88 μm^2.
The tracker layers of DTC and their integration steps will be discussed in this paper. The task is extremely challenging due to the contradictive demands of minimization of multiple scattering vs. thermo mechanical stability. These large area tracking layers must have the least low-Z material budget possible, should be mechanically stable and maintained at reasonable working temperature conditions for MAPS. The following steps are included in the paper: 1. Fabrication of carbon fiber sheets with thermal conductivity comparable to aluminum, as a support and heat-transfer material on which MAPS will be mounted, 2. Single-point TAB ultrasonic bonding method used to mount the MAPS on aluminium-polyimide flexible microcables, 3. Details of the design of the mechanical support structure the layers and 4. First results of combined water and air cooling of the prototype tracking layers.

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Session Classification: Poster Sesion 6 (Advances in Pixel Detectors and Integration Technologies)

Track Classification: Advances in Pixel Detectors and Integration Technologies