Contribution ID: **172**

Type: **Oral**

The development of a laser system for use in the timing performance measurements of CMS HGCAL silicon modules

Friday 6 October 2023 10:10 (20 minutes)

For optimal operations in the high radiation and pileup environment of the **HL-LHC**, the **CMS-HGCAL** requires precise timing information at the level of 30ps (RMS) for a particle shower. The time measurement in Silicon detector modules is performed using a per-channel time-of-arrival discriminator coupled with charge measurement to correct for the time-walk. The module design includes access holes in the PCB and in the sensor passivation to enable infrared laser light to be injected directly into the sensor cells. We present the calibration and timing-in of the system used to perform measurements as well as the module time performance results.

Summary (500 words)

The Large Hadron collider will enter the High Luminosity phase of operations in the last quarter of this decade. High radiation levels and large pile-up (on average of 200 collisions simultaneously) will be major challenges for the HL-LHC operations. Studies show that there will be a spread of interaction vertices in position of approximately ±50 mm along the beam axis, and in time of approximately ±150 ps. Detector simulation studies indicate that the physics potential can be improved by mitigating events pileup through time-tagging events with a precision of ˜30 ps (RMS). To cope with all these challenges, the present CMS endcap calorimeters ECAL and HCAL will be replaced by the new High Granularity Calorimeter (HGCAL). The HGCAL is a 47-layer sampling calorimeter based on lead and stainless-steel absorbers, with 620 m2 of silicon active layers in the high occupancy regions and ˜ 370 m2 of scintillating plastic tiles read-out by SiPM in the low occupancy regions. Both endcaps of the HGCAL will be instrumented with ˜ 28K silicon detector modules (usually known as Hex-module) which is the glued assembly of Hexaboard PCB with silicon-sensor, Kapton foil and base plate, where the bonding pads from Hexaboard are bonded to silicon sensor via stepped hole structures. The Hexaboard is the front-end read-out board for the silicon Hex-module incorporating radiation hard ASIC HGCROC. The HGCAL front-end electronics have very stringent specifications of low noise (<2500 e- for 65 pF silicon sensor), large dynamics range (0.2fC to 10pC) and the capability to measure time of arrival (TOA) for hits having charge > 12 fC with precision better than 100 ps. To validate the Hex-module timing performance, the Hexaboard design includes 1 mm diameter holes in the center of silicon cell, which are coincident with openings in the sensor passivation to allow the injection of short (100ps FWHM), infrared (1060 nm) high time resolution laser pulses directly into the silicon sensor sensitive layers. The synchronization of the laser subsystem with the Hex-module clock distribution and DAQ system is of critical importance and great care has been taken to attain this to better than 20 ps (RMS), whilst still allowing the timing of the light injection to be stepped relative to the Hex-module clock and trigger signal in steps of less than 10 ps. The laser light is delivered though a micro-focal lens, giving a FWHM spot size of less than 10 um. The laser system equipped with X, Y, Z stages permitting the automated movement of the Hex-module relative to the micro-focal lens, allows automated channel selection, and optimizing spot size. The light intensity, translating to the charge injected into the sensor, can be selectively attenuated from 2.58 dB to 50 dB using an attenuator inserted into the fibre network. This combination permits a detailed investigation of the Hex-module performance of over these parameters. A detailed description of the laser system and the timing-in procedure, as well as the performances of both the laser system and the Hex-module will be presented.

Primary author: KHAN, Fakhri Alam (Universite Libre de Bruxelles (BE))

Co-author: NOY, Matt (CERN)

Presenter: KHAN, Fakhri Alam (Universite Libre de Bruxelles (BE))

Session Classification: Module, PCB and Component Design

Track Classification: Module, PCB and Component Design