

For the CMS HGCAL Collaboration

Introduction to the CMS HGCAL

• The CMS end-cap calorimeter will be replaced in view of the phase II LHC upgrade to cope with the increased pileup and radiation damage due to the high luminosity. The new detector will be a **5D (imaging) calorimeter using particle flow** operating at -30°C

• Absorbers: • Cu, CuW and Pb absorbers in the electromagnetic calorimeter (ECAL) covering 27.7 X_0 or 1.5 λ • Steel absorbers in the hadronic calorimeter (HCAL) covering about 8.5λ

• The active volume will be instrumented with two technologies depending on the radiation level:



- Silicon detector section
 - Consisting of hexagonal silicon sensors
 - Where expected fluence at end of life is above 5x10¹³ n/cm²
 - Covers the ECAL and innermost part of the **HCAL**

Scintillator section

- Consisting of trapezoidal plastic scintillators read out using silicon photomultipliers (SiPM-on-tiles)
- In region where expected fluence at end of life is below 5x10¹³ n/cm² (Outer HCAL region)

• Ensures S/N > 3 for minimum ionizing particles (MIPs)





- The cells vary in size depending on its location in the calorimeter
- More than 6 000 000 silicon sensors covering 620 m² area
- throughout the detector lifetime
- The cells increase in size radially from the beamline
- More than 240,000 SiPM-on-tiles covering 370 m² area

The HGCAL Scintillator Section

Sensors : The SiPM-on-Tile Technology

• SiPM-on-tiles consist of individually wrapped plastic scintillator tiles read out by silicon photomultipliers (SiPM) Low-intensity LED





SiPMs consists of thousands of single photon avalanche diodes (SPAD) working in Geiger-Mode

Detection Principle



SPAD Cell HGCROC (HGCAL Read Out Chip) Mixed-Signal ASIC Signal Amplification And Digitization

SiPM-on-Tile Section Layout • Eight Tilemodule Types including 35 variants

- 21 scintillator tile sizes
- 23 mm to 55 mm side length
- Two SiPM sizes
- 4mm² SiPMs

• 9mm² SiPMs

Front-End Electronics

- HGCROC:
- Reads out the SiPM-on-tiles on the Tilemodule

• ECON-D:

Receives data from HGCROC





HGCAL Tilemodules



• The basic detector module in the SiPM-on-tile section

• Consists of a PCB, HGCROC, SiPMs, scintilators and other onboard electronic systems

• Most tileboards will hold one HGCROC

• HGCROC can reads out up to 72 channels simultaneously

 Each individual SiPM-on-tile is equipped with a low intensity LED used for calibration

Concentrates data and sends to LpGBT

• ECON-T:

- Receives trigger data from HGCROC
- Concentrates data and sends to LpGBT

• LpGBT:

- Transmits data to back-end via VTRx+
- Distributes clock, fast commands and configurations to the front-end electronics

• VTRx+:

 Optically sends and recieves signals from the back-end

• **GBT-SCA:** Responsible for all slow control tasks on the Tilemodule

• **ALDOV2** : Voltage regulator chip for SiPMs on the Tilemodule

Tilemodule Production and Assembly



Quality Control







