



Contribution ID: 123

Type: **not specified**

Engineering challenges in constructing the CMS High-Granularity Calorimeter (HGCAL)

The CMS Collaboration is preparing to build replacement endcap calorimeters for the HL-LHC era. The new high-granularity calorimeter (HGCAL) is, as the name implies, a highly-granular sampling calorimeter with 47 layers of absorbers (mainly lead and steel) interspersed with active elements: silicon sensors in the highest-radiation regions, and scintillator tiles equipped with on-tile SiPMs in regions of lower radiation. The active layers include copper cooling plates embedded with thin pipes carrying biphasic CO₂ as coolant, front-end electronics and electrical/optical services. The scale and density of the calorimeter poses many engineering challenges that we discuss here. These include: the design & production of 600 tonnes of stainless-steel absorber plates to very-high physical tolerances; the development of the CO₂ cooling system to maintain each 220-tonne endcap at -35°C whilst the electronics dissipate up to 140kW; the need to cantilever the calorimeters from the existing CMS endcap disks, using titanium wedges; the production of a thin but strong inner cylinder to take the full weight but have little impact on physics performance; the integration of all on-detector services in a restricted volume with only a couple of mm height. We give an overview of the design of HGCAL, focusing on the materials and techniques being used to overcome the many challenges for this world's first calorimeter of its type at a hadron collider.

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