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Engineering challenges in mechanics and electronics in the world's first particle-flow calorimeter at a hadron collider: The CMS High-Granularity Calorimeter

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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 biphase 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 -35oC 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 development of low-power high-dynamic-range front-end electronics for over 6 million detector channels; the integration of all services in a volume of only a couple of mm in 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.

Collaboration

CMS

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