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The powering systems of the CMS tracker for HL-LHC

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The upgraded CMS tracker for HL-LHC is going to require more than 200 kW power. Two different powering strategies are being adopted for the Inner Tracker and the Outer Tracker. The talk describes the two powering schemes and discusses the intrinsic constrains. Specifications for the powering units and for the cables of the two systems are outlined in combination to preliminary results with prototypes

Summary (500 words)

The power consumption is one big challenge faced by detectors for high-luminosity LHC (HL-LHC). The huge number of electronic channels, the high acquisition bandwidth and the long Level-1 trigger latency make the phase-2 CMS tracker power hungry. Voltages must be provided within narrow (˜10 mV) tolerances. The power distribution is hence one of the key elements driving the detector design.

The CMS Outer Tracker is composed by more than 13 thousands silicon detector modules. Each module hosts dc/dc converters which ensure proper local regulation at required voltages and is individually connected to the backend power system, which provides Low Voltage (LV, 8÷12V) to dc/dc converters and High Voltage (HV, 0 ÷ -800V) to bias the silicon sensors. Since no line drop recovery can be implemented, the power delivered is constrained by the maximum voltage applied and by the resistivity along the electrical lines. This critical interplay is discussed in the talk. Special power cables, which deploy enamelled copper conductors, are developed to achieve sufficiently low resistivity; the electrical interconnection to each module is one of the challenges to be addressed. The system is designed to provide a power which can exceed by 25% the consumption expected in nominal conditions. The full backend power system is to be hosted in 24 racks inside the CMS experimental cavern and is going to be composed by 1220 power supply units and cables, each providing LV and HV to up to 12 detector modules, individually monitored and operated. The units operate in hostile environment with up to 100 mT stray magnetic field and high-energy hadron (E>20MeV) fluences of 2E11 h/cm2 over ten years of HL-LHC operation, with TID up to 20 Gy. Preliminary results from irradiation tests on components and from the first power supply prototype unit are shown.

The Inner Tracker detector is composed by ˜3900 silicon hybrid pixel detector modules equipped with either two or four readout chips (ROC). A serial powering scheme is adopted to power the ROCs: modules are organised to form a total of 500 serial chains of various lengths (5 to 11 modules). The serial scheme allows to reduce number and mass of wires used to power the detector, thus reducing the material budget inside the tracking volume, which is key to the tracker performance, and needs careful considerations to properly assess the total power required during operations. In addition to ROC powering, the detector demands bias distribution to the sensors (0 ÷ -800 V), LV power (8 ÷ 12V) for the optomodules which implement ROC communications with DAQ, control and trigger backend systems, and pre-heaters needed by the CO2 cooling system. These powering sources must work together respecting interdependencies which are outlined in the talk. The proposed powering system is based on a modular complex of power supply units, each providing the power sources (serial, LV, HV) needed by one serial chain of modules. Specifications and plans for this system are outlined.

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