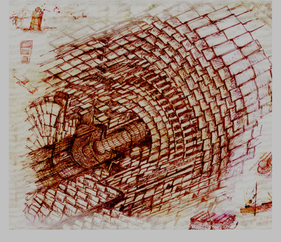


CMS Tracker Safety System (TSS)

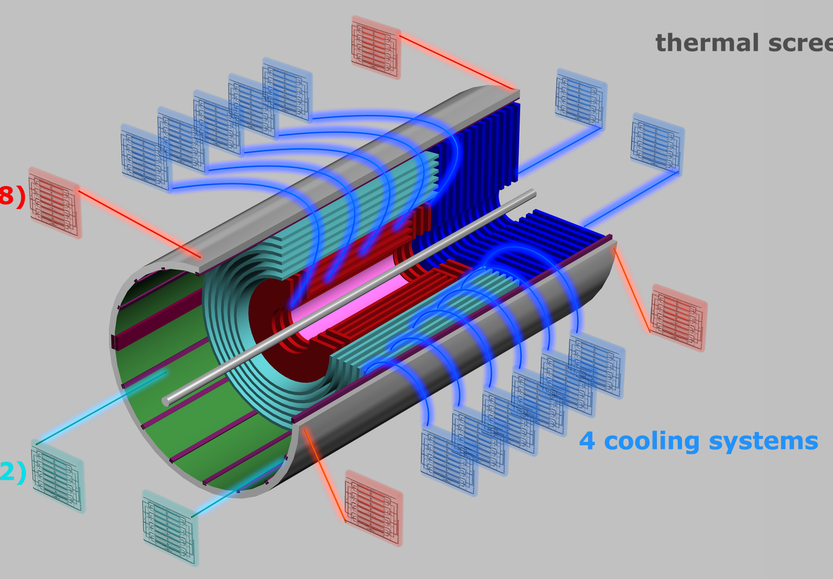
• Tsirou, P.G. Verdini

The CMS Tracker, a 200 m² semiconductor track recording device, is the world's largest Si- detector. Like any device of comparable complexity, it is equipped with a Safety and Control system that must run continuously through the full Tracker lifespan in order to fulfill its role - safeguarding the irreplaceable investment of the scientific community that built it and enhancing the Tracker's functionality by turning it into a tool for doing Physics and expensive, hard-to-maintain, fragile equipment. To do so, the Safety system controls in an active manner the temperature of the Tracker boundaries and services and the dry atmosphere inside the CMS subdetector, acts as an interlock system for the Tracker power distribution and provides permanent monitoring of the Tracker environmental parameters (temperature, humidity). It also acts as the interface to the CMS Central Safety system (DCS), to the Cooling plants that will keep the Tracker volume permanently at subzero temperature, to the Dry Gas plants and to other critical external systems. These functionalities have been obtained by using a distributed discrete event control system consisting of 10 medium-range PLC systems that monitor the analog inputs from more than 1000 radiation-tolerant sensors, and provide outputs to more than 100 actuators used in temperature regulation and 600 interlock lines controlling the power distribution.

Controlled by CMS DSS

Partially controlled by CMS DCS/ Tracker DCS

Controlling cooling an dry gas (external) systems



CMS Tracker

Four Cooling systems, two for the subdetector and two for the Thermal screen ensuring operation at -20⁰C, three dry gas systems, more than 80kW power, 10,000,000 readout channels, 8,000 low/highvoltage channels, more than 10,000 monitoring channels

Tracker Thermal Screen

Analog regulation of the Tracker-ECAL interface surface (-20°C inside, +18°C outside) minimizing the thermal induced stress on the Tracker Support Structure.
Control Process: 58 PID regulators, following the status of the detector cooling and powering.
PID Inputs : 58 redundant pairs of embedded Pt1000 RTD;
PID outputs : 8 0-10 V DAC outputs controlling 58 linear power supplies, feeding the heating foils covering the outer skin of the Thermal Screen Barrel and Endcaps, for a maximum power of 6 kW.

Tracker Service Channel

On-Off regulation of the temperature in the Tracker Service Channels, where the heating cables powering the Tracker run along the pipes carrying coolant. The aim is to prevent condensation of water or deposition of ice.
Control Process: 32 On/Off PID regulators, indirectly following the powering and cooling status of the Tracker
PID Inputs: 32 Platinum RTD;
PID Outputs: 32 Digital Outputs controlling 32 low-noise zero-crossing switches that feed 230 VAC to Heating Wires, for a maximum total power of 15 kW.

Tracker Power Interlocking

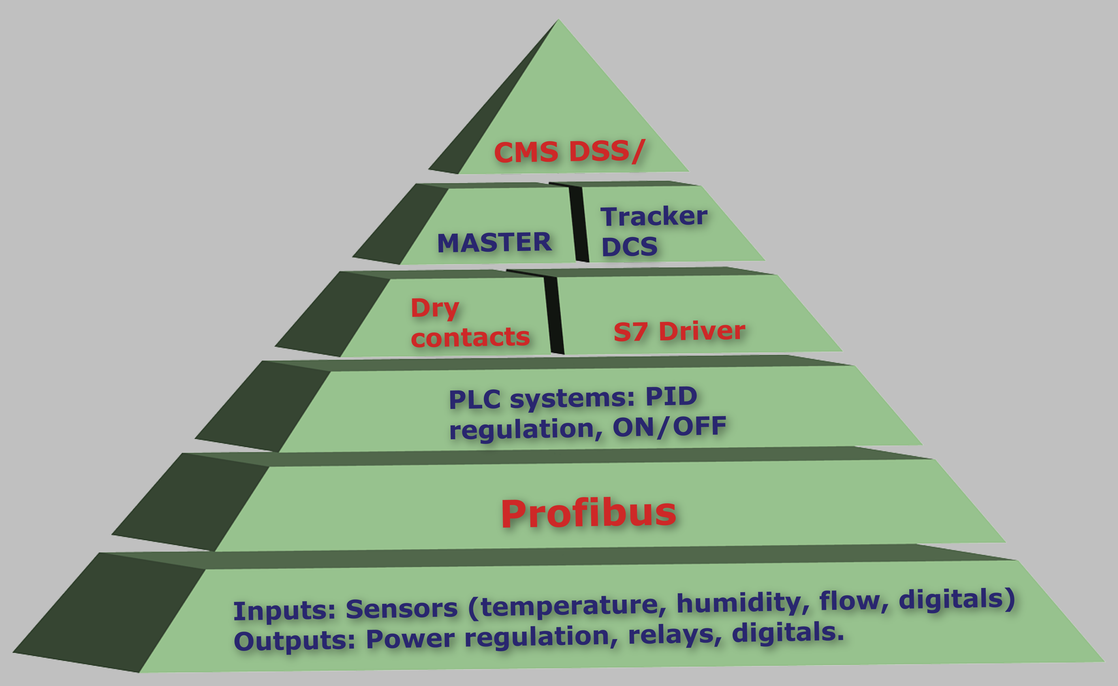
for extended operation, the CMS Tracker will be operated well below 0°C with a total power dissipation in the Tracker volume close to 100 kW.
To prevent damage, not only is a prompt response needed in case of overheating, but the dewpoint must be monitored. Due to the length of the power lines, damage to the front-end electronics could also arise from sudden, disorderly power cuts, either due to external causes or triggered by an Emergency signal. Failures in the Cooling Plants or in the Dry Gas System could also prove dangerous. To protect the Tracker, the Interlock Systems must trigger the correct fast power-down sequence in any of these cases, either locally or globally
Control Process: distributed Action Matrix processing on 6 + 2 PLC systems; Inputs : 800 temperature sensors (Platinum RTDs and NTC thermistors), 300 radiation tolerant humidity sensors for "local" Interlocks.In addition, digital status signals from Central Safety, Cooling Plants, Dry Gas System, Early AC Fail Warning for "global" ones.
Outputs: 700 Interlock lines controlling the power distribution from 200 power supply crates, each of which houses about 40 channels, disabling the Cooling Plants and the Dry Gas System and providing feedback to the Central Safety System.

Tracker Permanent Monitoring

in order to ensure safe operation, some quantities, such as relative humidity, temperature, dry gas flow among others, must be monitored on a permanent basis, and actions may need to be taken if the values do not fall in the appropriate range. The Monitor PLC also receives a set of status flags from the Master, for propagation to the Tracker DCS and finally to the operator on shift and for recording.
Inputs: 112 analog signals (temperature, humidity, flow, pressure), 80 digital inputs, some of which mirror the Master digital inputs and outputs.
Outputs: 16 sets of dry contacts to the MASTER, to signal out-of-range values or otherwise request an intervention.

Tracker MASTER

this is the central, supervisory unit of the PLC-based Tracker Safety System. It receives all "global" status information from the CMS DSS and RSS, the Tracker Services and the other Tracker PLC subsystems and handles all situations requiring the interlocking of large parts of the Tracker or the Tracker services. For additional safety, the Master PLC has no external access, and no downloading of thresholds or conditions is possible.
Control Process: a "hard-wired" Action Matrix establishes under which conditions the various subsystems and Services are enabled. If the required conditions are missing, one or more Interlock signals are generated.
Inputs: 64 digital inputs coming from DSS, Tracker Services and Tracker subsystems. This includes the output of individual Watchdog Timers for all Tracker PLC systems and the status of the individual PLC power supplies and backup batteries.
Outputs: 64 digital outputs to DSS, Services and subsystems. Hardware-generated "copies" of some are also sent to the Monitor to be made available to the Tracker DCS.



tracker model and rendering
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