Phase-II Upgrade of the CMS Electromagnetic Calorimeter Detector Control and Safety Systems for the High Luminosity Large Hadron Collider

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Introduction

The LHC will undergo a major upgrade during the 2026-2029 period to build the High-Luminosity LHC (HL-LHC). At the same time, the CMS ECAL endcaps (EE) will be decommissioned and the remaining ECAL barrel (EB) will be equipped with new electronics. This poster summarises the forthcoming hardware and software modifications to prepare the control systems for the Phase-2 period.

Component-based software architecture of the CMS ECAL DCS Supervisory layer

The large modification of the underlying hardware and software components will have a considerable impact on the architecture of the detector control system (DCS).

Software components to reuse

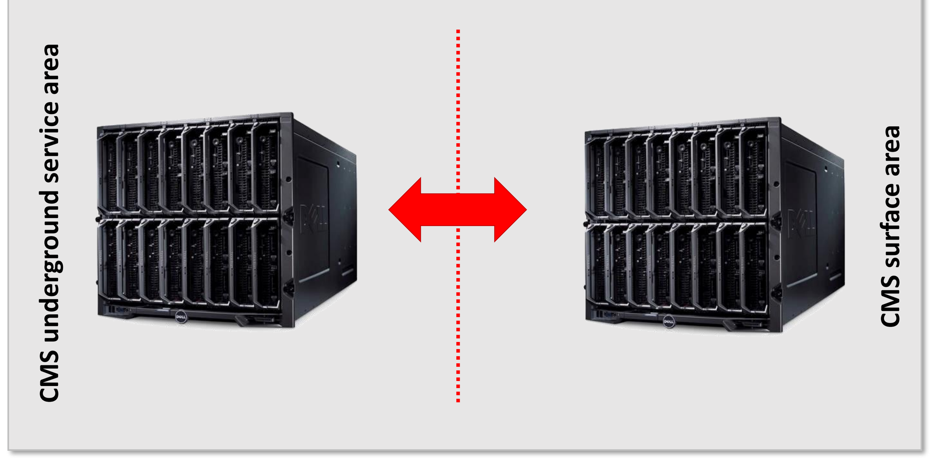
- **ECAL framework utilities** Common utilities to help programming ECAL DCS applications.
- **PC Configuration framework** ECAL Framework application to ease the installation and configuration of the control systems.
- **Health Checks** Application to monitor the communication status with various hardware devices.
- **Infrastructure monitoring** Application to monitor the CMS rack infrastructure.
- **ECAL Filtering** Application to provide data processing and data smoothing.
- **Majority application** Application to calculate percentages using the ECAL finite state machine.

Software components to deprecate

- **OPFC Automatic control** LV power distribution control
- **Humidity monitoring** Humidity of EE/EB
- **Preshower environment** Env. parameters of the ES
- **Preshower Front-End** LV and HV power distribution
- **Preshower HV Monitoring** HV distribution of the ES
- **Preshower Cooling** Cooling monitoring
- **Preshower Cooling Pumps** Temperatures at the pumps
- **Preshower Safety Systems** Interact with the safety sys.
- **Preshower Heating** Monitor the heating system
- **CAEN Reboot** Reboot CAEN mainframes
- **Laser monitoring** Status of the ECAL laser
- **Power factor correction** Monitor power conversion

Computing infrastructure

Redundant, distributed set of computers.



Software components to modify or re-design

- **ECAL Safety System Monitoring** Application to monitor and interface the ECAL Safety System.
- **Precision Temperature Monitoring** High precision application to monitor the temperatures in the ECAL barrel and endcaps.
- **ECAL LV Control** Application to monitor and control the LV power supplies for the ECAL endcaps and barrel partitions.
- **ECAL HV Control** Application to monitor and control the HV power supplies for the ECAL endcaps and barrel partitions.
- **ECAL Supervisor** Top level application enclosing all control applications.
- **ECAL Cooling** Application to monitor the cooling stations of the ECAL detector.

Construction of the EB Safety System

Fig. 1.: Development setup of the EB Safety System.

Main features

- Single Siemens S7-1500 series CPU design.
- Redundant capabilities at the level of the sensors, cable pathways and connectors.
- 288 platinum based (PT1000) sensors for temperature monitoring.
- Four wires read out from the experimental cavern to the service cavern.
- Up to 256 digital I/O signals.

The ECAL Precision Temperature Monitoring

Fig. 2.: Picture of the Keithley DAQ 6510 system and two connector cards.

Main features

- 360 negative temperature coefficient (NTC) thermistors.
- Setup installed in the service cavern.
- Interface cables will be extended about 80 meters, using four wires method.
- Based on Keithley DAQ6510 system [1].
- Higher precision (~0.0015% vs ~0.0045%) with respect to the existing system.

Software for the HV power supplies

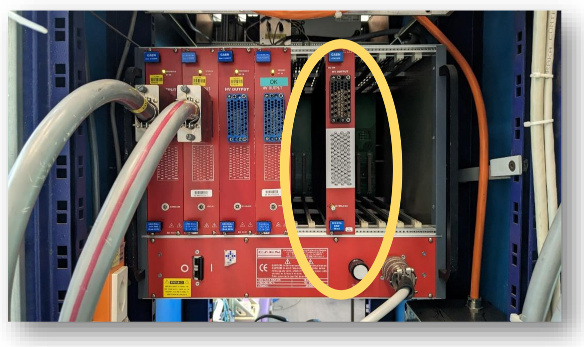


Fig. 3.: Back side of a CAEN SY4527 mainframe, with one A7420 HV board.

Main features

- 144 modular power supply boards, inserted across 18 different crates.
- New A7420 boards with similar specifications with 9 channels.
- Each mainframe with up to 8 of boards for two submodules.
- Board compatible with the existing SY4527 mainframes.

Controls for the LV power supplies

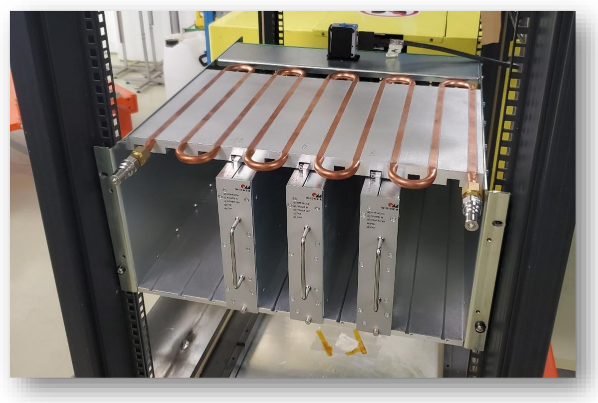


Fig. 4.: Drawing of the new chassis with 3 Wiener power supplies.

Main features

- Units installed in the experimental cavern.
- Controller Area Network (CAN) buses from the experimental area to the service area.
- Data transmission using a fault-tolerant version of the CAN protocol.
- 12 buses over approximately 100m cables, each of them containing between 18 and 20 nodes.

The CMS ECAL DCS Supervisor

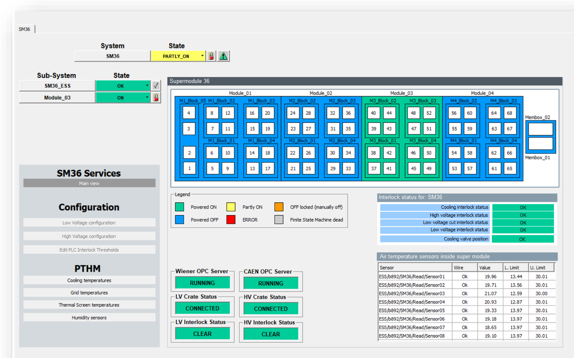


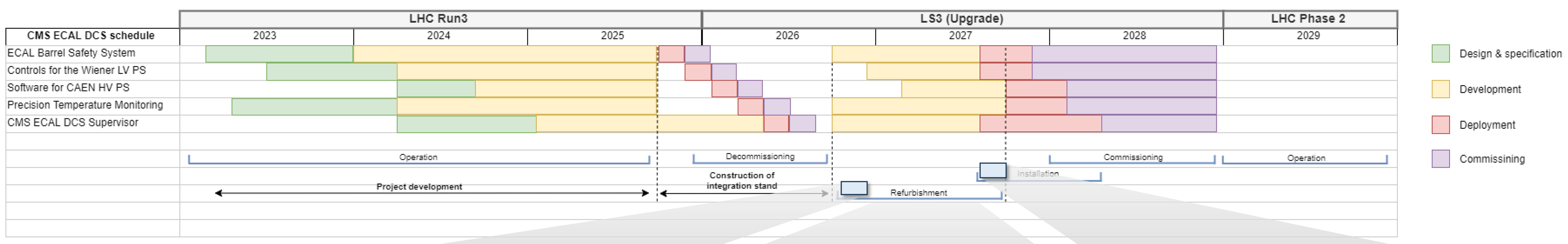
Fig. 5.: Prototype interface of the CMS ECAL DCS supervisor implementing finer granularity automatic actions.

Main features

- Monitors and controls a wide range of hardware.
- New Finite State Machine will provide a higher granularity of Automatic Actions, through the concept of "Power groups".
- Focus on the alarm system, web-based instructions for the future operations.

CMS ECAL DCS Upgrade activities

Our projects are subject to certain activities listed in the CMS master schedule and influenced by many external factors. To help managing this complexity, we have made a retro planning of activities anchoring our projects to one of the most important upgrade milestones, the construction of the ECAL integration stand.



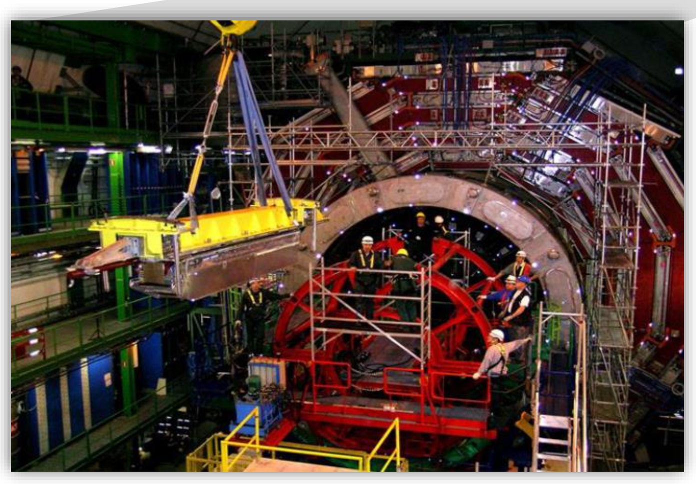


Fig. 6.: Picture of the insertion of an ECAL supermodule, showcasing the extraction procedure.

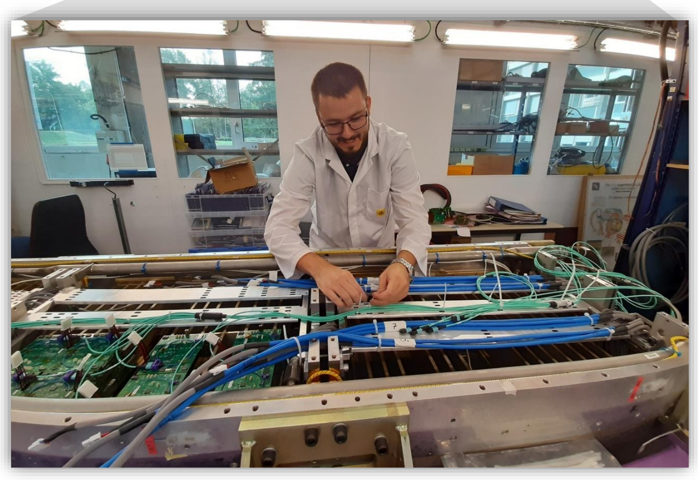


Fig. 7.: Picture of the fibre's installation during the electronics refurbishment of one spare supermodule.

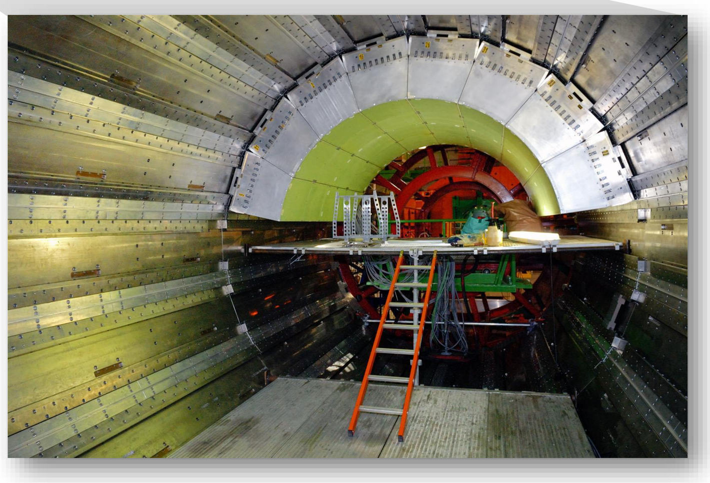


Fig. 8.: Picture of the construction of ECAL, the insertion of the ECAL supermodules.

The ECAL Integration stand

- 5 crates with 36 HV CAEN A7420 boards.
- 6 crates with 54 LV Wiener power supplies.
- A version of the EB Safety System.
- 3 Keithley DAQ 6510 systems.
- A future version of the CMS ECAL DCS Supervisor, running on a computer server.

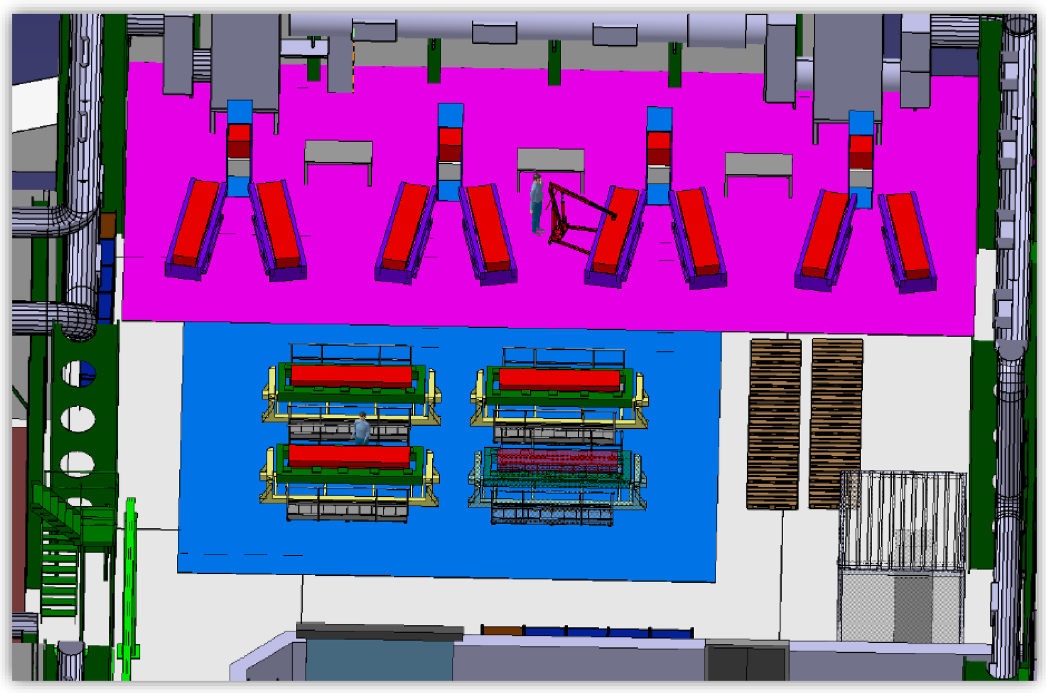


Fig. 9.: Drawing of the future Integration stand during the EB refurbishment, with the layout of 4 racks and 8 supermodules.

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