The CMS ECAL DAQ Monitoring System

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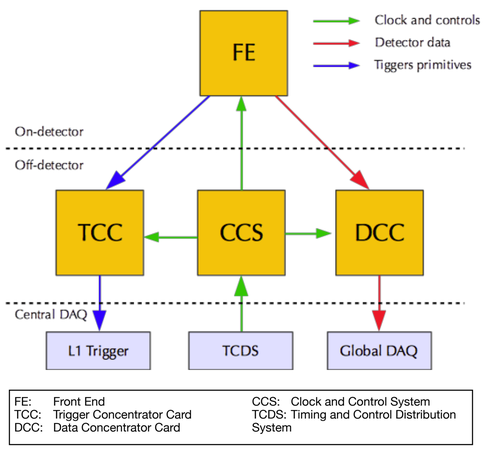
The CMS electromagnetic calorimeter (ECAL) is composed of 76000 $PbWO_4$ scintillator crystals and 4288 silicon sensors. The data collection for the CMS ECAL is controlled by a data acquisition (DAQ) system made of more than 200 off-detector electronic boards. The electronics has to be monitored to guarantee smooth and uniform data taking. With this purpose, in 2017 a new online ECAL monitoring system was developed and deployed.

ECAL DAQ Electronics

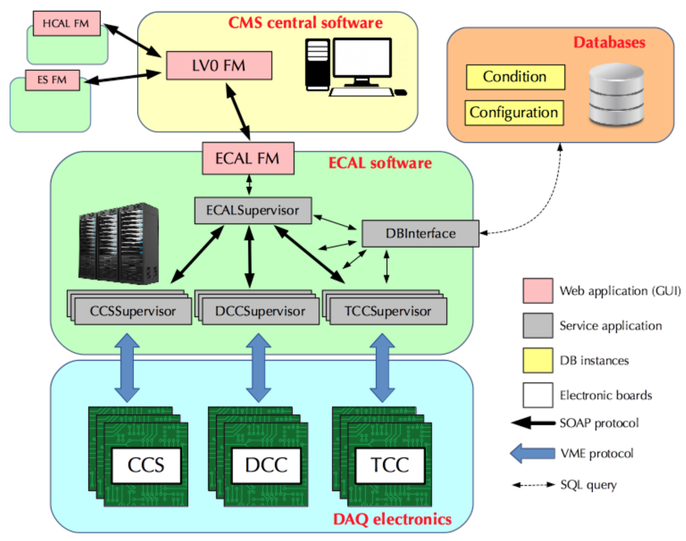


ECAL electronics is partially mounted on the detector (VFE, FE cards and TRL Boards) and partially installed in a separated facility. In particular, off-detector electronics is hosted by eighteen 9U and one 6U VME crates.

Each crate contains also a V2718 VME controller which is connected to computers mounting CAEN A3818 PCI Express cards.

Off-detector CCS card controls the FE electronics via optical fibres; in this way the entire ECAL DAQ system can be managed by users and applications remotely.

ECAL DAQ Software



ECAL software is essential for the control and the setting of the data acquisition. It is composed of hundreds of distributed applications mainly running on the machines mounting the A3818 cards.

The applications linked to the electronics are called Resource Supervisors whose main activities are:

- Changing the internal state of the board (*Ready*, *Stop*, *Idle*…).
- Configuring the board with parameters tuned on the detector and run conditions.
- Monitoring the status of the electronics and informing about possible problems.
- Blocking the data acquisition in case of major errors.

XDAQ Framework

ECAL Software is based on XDAQ libraries, a software platform designed specifically for the development of distributed data acquisition systems.
The framework builds upon industrial standards, open protocols and libraries.

An application called Slash (Smart Life Access Server Hub) hosts the information on the electronics status sent cyclically by the ECAL Resource Supervisors in dedicated tables.

Tables can be retrieved in JSON format, as done by the ECAL monitoring system.

Technology & Performance

Backend: the server application has been built using Nodejs framework extended with Express libraries. The reasons for this choice:

1) simple starting setup and light server when running;
2) asynchronous JavaScript engine (not multiprocessing) that fits an application with low CPU duty and waiting periods;
3) same language, JavaScript, as in the frontend.

SQLite Database engine has been chosen to store the error history.

Frontend: built with Vue.js framework and Webpack as module bundler:

1) modular implementation of web pages;
2) reuse of templates and same constructors;
3) simple linkage between data displayed and backend informations.

Memory and CPU:
The application is constantly running on a machine with 8 GB and 8 2.3 GHz CPUs. The process uses on average 11.5% of CPU time and 175 MB (2.2%) of the system memory.

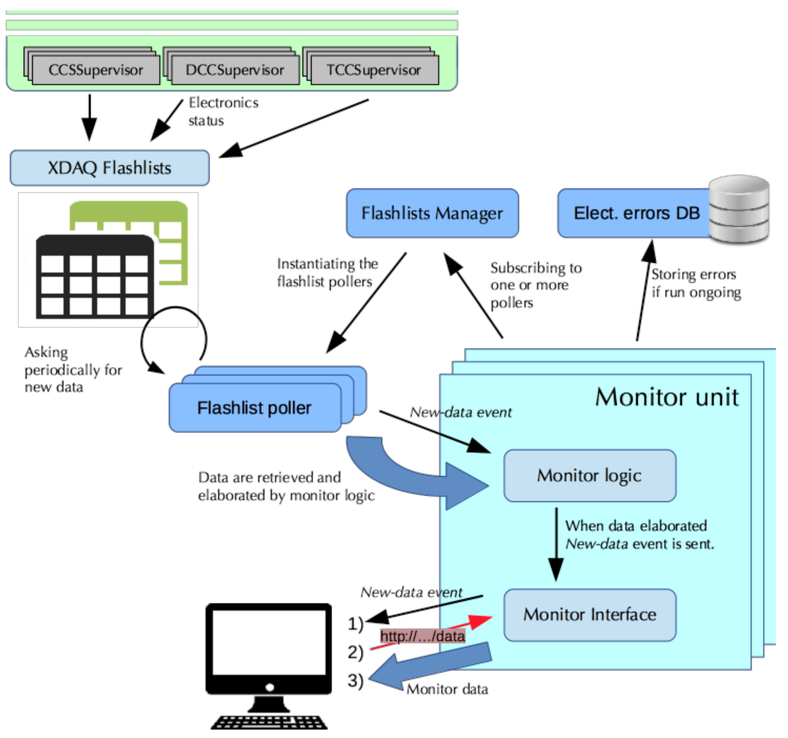
Client side:
The payload of the client requests depends on the monitor displayed by the browser. Most of the monitors have a rate of 15 kB/s, with one exception requiring up to 100 kB/s.

ECAL DAQ Monitoring system - Backend

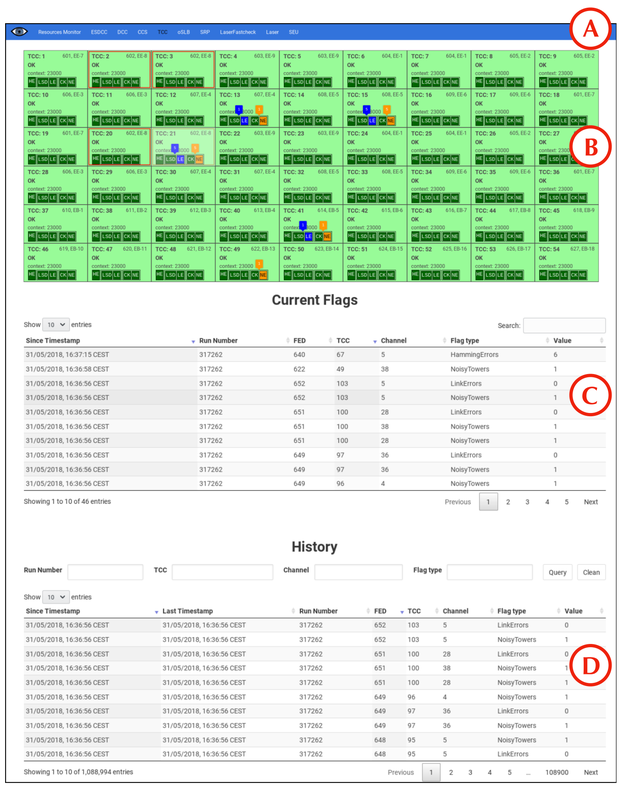
The backend is composed by multiple asynchronous modules, called monitors:

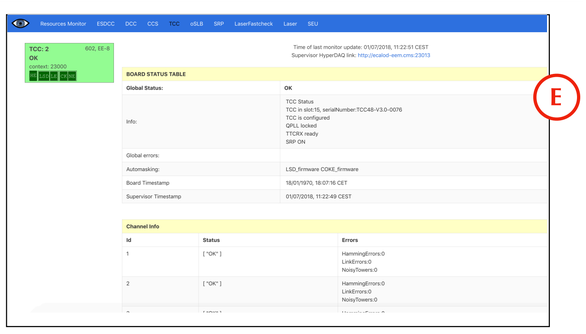
- Each monitor unit is in charge of elaborating the electronics status data of a specific board type (DCC, CCS, TCC boards …).
- A monitor obtains updated data from the flashlist pollers service it is subscribed to.
- In turn, the flashlist pollers collect periodically the raw data published by the Resources Supervisors.
- Each monitor has a DB where electronics errors are stored to create an history of the main problems.
- SMS or email warnings can be sent to DAQ experts in case of major problems.

The data flow for each monitor unit depends on the flashlist poller reading rate. When data are collected, events driven calls move them from the poller to the client. It is monitor dependent but on average a data refresh happens every 10 seconds.



ECAL DAQ Monitor system - Frontend



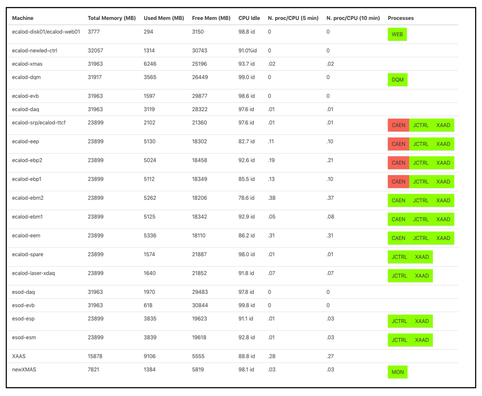


Each monitor unit has a correspondent webpage in the frontend application which retrieves the data via GET requests and displays them in a user friendly layout.
Data are retrieved only when the client receives a *new-data* available event, avoiding requests over old information.
A Vue component cell is created for each electronic unit generating the status table.

Typical monitor interface structure:

A. Navbar, monitors list.
B. Electronic status main table.
C. List of ongoing channels errors.
D. History of the channels errors.
E. Detailed status monitor of single board.

In addition to the main monitors, some other tools have been introduced to improve the overview of the ECAL DAQ system, like a resources monitor and a SEU statistics monitor.



Software references:
- XDAQ: https://svnweb.cern.ch/trac/cmsos
- https://it.wikipedia.org/wiki/Node.js
- https://vuejs.org

Acknowledgments
Special thanks to all of the members of the CMS ECAL group