The CMS electromagnetic calorimeter (ECAL) is composed of 76000 PbWO₄ 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 separate 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.

**Technology & Performance**

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.

![XDAQ online](image)

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.

Technical stack

- **Node.js**: Database engine has been chosen to store the error history.
- **Vue.js**: Vue component cell is created for each electronic unit generating them in a user friendly layout.
- **Webpack**: As module bundler.
- **Express**: Application with low CPU duty and waiting periods.
- **Sass**: simple starting setup and light server when running.
- **Nginx**: 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 poller 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 Monitoring system - Backend**

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:

- **Navbar, monitors list.**
- **History of the channels errors.**
- **Details of the current status of the electronics.**
- **Detailed status monitor of single board.**
- **Status table.**

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

**ECAL DAQ Monitor system - Frontend**

Software references:

- XDAQ: https://it.wikipedia.org/wiki/XDAQ
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- https://vuejs.org

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Author: Giacomo Cucciati, on behalf of the CMS ECAL collaboration

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