Database usage in the CMS ECAL Laser Monitoring System

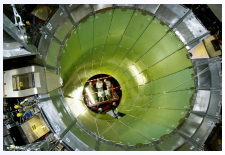
Overview

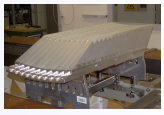
Compact Muon Solenoid (CMS)

One of the two general purpose experiments at LHC

Electromagnetic Calorimeter (ECAL)

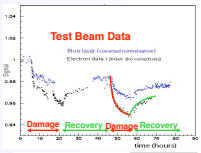
High-resolution,high-granularity scintillating crystal calorimeter consisting of 75,848 lead-tungstate (PbWO4) crystals with short radiation length, small Molière radius, and fast speed as a scintillator.



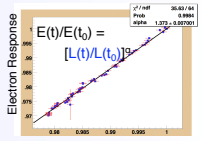


The design energy resolution of the ECAL has a constant term of 0.5%, and to maintain this, calibration and monitoring of the crystals must be performed *in situ* at the LHC.

At the LHC design luminosity, the CMS detector will be exposed to a harsh radiation environment (dose-rates of 15 rad/hour at 10^{34} $cm^{-2}s^{-1}$). The $PbWO_4$ crystals are radiation hard, but suffer from dose-rate dependent radiation damage.

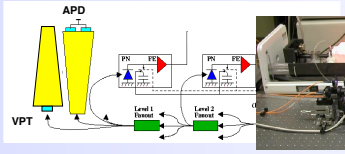


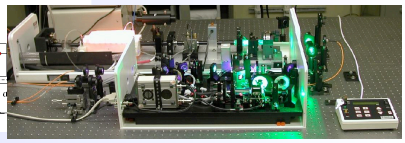
Radiation causes a degradation in crystal transparency due to radiation induced absorption. Therefore, changes in crystal transparency must be corrected for to maintain the energy resolution of the detector.



The CMS ECAL utilizes a laser monitoring system to monitor the light output of the crystals. With this system, we can measure the change in transparency of each crystal continuously during LHC running, with very high precision.

The Laser Monitoring System



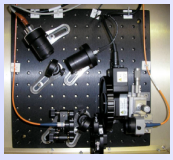


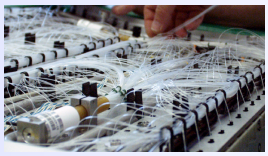
The monitoring light source consists of three lasers. Two wavelengths are available from each laser, making 440, 495, 709, and 796 nm wavelengths available for monitoring.

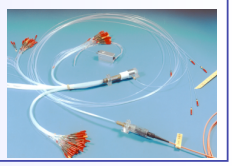
Laser light distribution is controlled by a PC Supervisor. Through a system of optical fibers the light is being delivered to each ECAL crystal.

Laser Specifications:

2 wavelengths per laser;	
Pulse rate (~100 Hz);	Pulse width, FWHM (< 40ns);
Pulse jitter (< 3ns);	Pulse intensity instability (~few%);
Pulse energy 1 mJ/pulse at monitoring wavelength (equivalent to 1.3 TeV in dynamic range)	







Laser Monitoring Dataflow

Laser monitoring data will be taken during the LHC running every 90μs. Event data will arrive at the Filter Farm, containing, among other data, the ECAL laser event data, which will be sorted and then analyzed in a PC farm to extract APD/PN values.

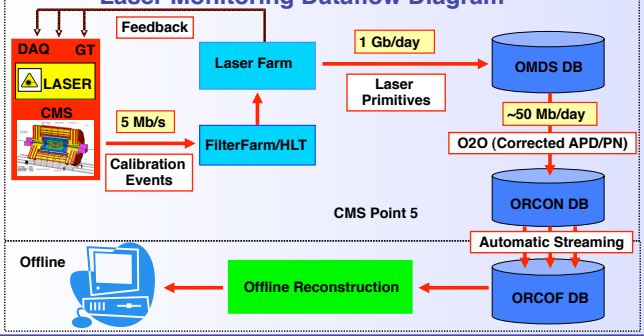
All the necessary Laser Data is then inserted into the On-line Master Data Storage (OMDS) database located in the underground cavern, which is the main Laser Data storage for service, commissioning and monitoring needs.

After that a reduced subset of Laser Data, which will only be required for the offline reconstruction, is transferred to the Off-line Reconstruction Conditions DB On-line subset (ORCON) database in a procedure known as Online to Offline (O2O) transfer. During this (O2O) procedure, corrections and consistency checks will be applied.

The data stored in ORCON, located in underground cavern, will be automatically transferred to the Off-line Reconstruction Conditions DB Off-line subset (ORCOF) with the rest of CMS Conditions Data.

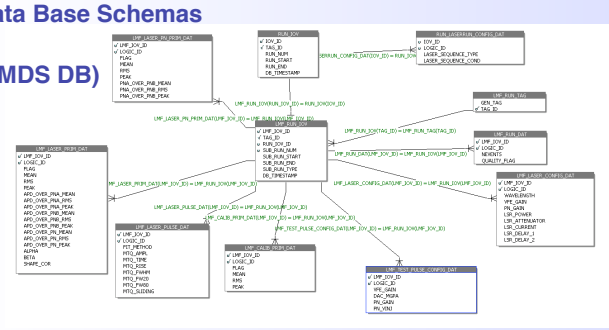
The laser APD/PN ratios, reference values, and scale factors necessary to implement the transparency correction will be kept in ORCOF, and correction will be applied in the offline reconstruction step.

Laser Monitoring Dataflow Diagram



Data Base Schemas

(OMDS DB)



EcalLaserAPDPNRatiosRef	
Channel ID	
APD/PN	

EcalLaserAlphas	
Channel ID	
Alpha	

EcalLaserAPDPNRatios	
Channel ID	Group ID
APD/PN pair	Time pair

(ORCON/ORCOF)

ORCON/ORCOF – are object-relational databases. They are built up of C++ objects. Each entity of the object has an IOV(Interval Of Validity) assigned to it. The shown 3 objects will be stored in ORCON/ORCOF.

Data Base Access Optimization

Laser Primitive data represents a big amount of data stored for each individual ECAL crystal. That leads to a considerable time consumption for data transfer. Access tests showed that using the standard upload procedure is not satisfactory for the required working conditions and an DB Access Optimization should be performed.

To improve performance standard OCCI optimization techniques for bulk writing "setDataBuffer", "executeArrayUpdate" and bulk reading "setPrefetchRowCount" methods were used:

```
writestmt=conn->createStatement(…);
writestmt->setSQL("insert….values (:1, :2, …)")
writestmt->setDataBuffer(1,(dvoid*)values_array, OCCITYPE,sizeof(value[0]), val_len);
writestmt->executeArrayUpdate(nrows);

readstmt=conn->createStatement(…);
readstmt->setSQL("select…. …");
readstmt->setPrefetchRowCount(1000);
ResultSet* rset=readstmt->executeQuery();
While(rset->next(){
rset->get… }
```

In one Update all 61200 values contained in array are written to DB and in one transaction 1000 lines are retrieved, which allows to significantly reduces multiple network roundtrips to the server.

	Time, before	Time, after
Writing	75 sec	2 sec
Reading	22 sec	3 sec

For the test purpose we retrieve from/fill into the Online DB data of a full transparency measurement cycle, i.e. 1700 * 36 (61200) channels.

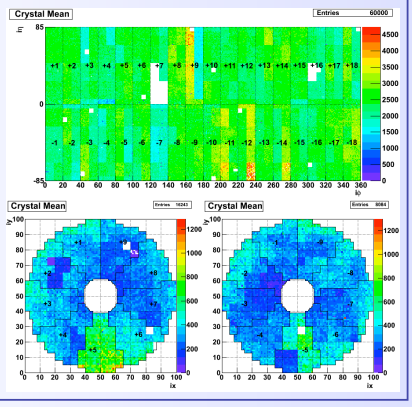
For each channel we read/write apd, pn, apd/pn from/in appropriate tables.

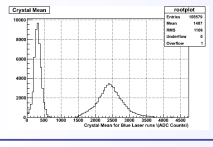
Visualization

Information stored in OMDS DB can be conveniently visualized using Web Based Monitoring (WBM) System.

On the right, mean crystal readout folded out in ECAL geometry.

Bottom, histogram of mean crystal readout, all ECAL.





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