Data Quality Monitoring for the CMS Electromagnetic Calorimeter

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10th Topical Seminar on Innovative Particle and Radiation Detectors
1-5 October 2006, Siena (Italy)
Overview

• the CMS ECAL detector

• the CMS Data Quality Monitor framework

• the ECAL Data Quality Monitor tasks

• future developments and conclusions
The Compact Muon Solenoid

Total weight: 12,500 t
Overall diameter: 15 m
Overall length: 21.6 m
Magnetic field: 4 T
The ECAL Barrel Detector of CMS

The CMS electromagnetic calorimeter (ECAL) is a compact detector designed to operate in a challenging environment:

- 4T magnetic field
- high radiation environment of 1-2 kGy/year
- at the LHC bunch crossing rate of 40 MHz.

The Barrel part of ECAL consists of 61,200 lead-tungstate (PbWO_4) crystals optically coupled to twice as many Avalanche Photo-Diodes (APD):

- short radiation length of 8.9 mm and small Moliere radius of 22 mm
- fast scintillator
- radiation-hard (do need monitoring of transparency)

Resolution design goal:

\[ \frac{2.5\%}{\sqrt{E}} \oplus 0.55\% \oplus 0.2/E \]

Calibrating and maintaining the calibration at this level will be very challenging → MONITORING
The CMS DQM

DQM principle: use same code to serve different customers (DQM, analysis)

Monitoring producers

DQM infrastructure:
Collectors/Servers

Inputs

Physics objects

Triggers

etc...

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The CMS DQM Architecture - 1

(1) Monitoring producer
    Monitoring consumer

    single program/node:
    • defines and fills monitoring elements (MEs)
    • subscribes and receives MEs and periodic updates

(2) “Sources”
    FU FU FU FU
    Collector

    “Collector” or “Server”

    manages request and dispatch of MEs

    Client
    Client
    Client
    Monitoring producers

    “Clients”
    Monitoring consumers

clear separation of production and processing of monitoring information
The CMS DQM Architecture - 2

- "Sources"
- "Collector" or "Server"
- CERN network
- non-CERN network
- "Super Clients"
- "Clients"
- complete setup

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CMS ECAL DQM use cases

ECAL Data Quality Monitoring is under development and continuous update/upgrade/improvements since mid 2005, and is currently in use in several test-beams and integration sites:

1. **at the ECAL cosmic test-beam site**

2. **at the ECAL test-beam site**

3. **at the ECAL-HCAL combined test-beam site**

4. **at the CMS DAQ integration test site**
Low/High level ECAL DQM tasks

- most of the monitoring tasks give access to low level information:
  1. data integrity
  2. pedestal mean/noise
  3. laser/testpulse amplitude & timing response
  4. trigger primitives activity

  *basic diagnosis for noisy/dead channels comes first*

- other monitoring tasks look at high level information ("physics"):
  - cosmic rays per crystal and energy spectrum distributions
  - electrons beam energy deposit (max E crystal, 3x3 crystal E matrix)
  - laser signal pulse shape
  - electrons beam profiles as measured by beam-line hodoscope
  - electrons energy deposit vs. beam position
In order to deal with this flow of information, a detailed and careful bookkeeping is mandatory:

use the web to access the DB,

use the DB to track the locations of the web pages with the DQM results,

and to store the results of the monitoring.
CMS ECAL DQM

gallery of selected screenshots
PEDESTALS

gain 01

mean

rms

gain 16

mean

rms

ECAL DQM - web static pages
**ECAL DQM - web static pages**

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**TEST_PULSE**

- **gain 01**
- **gain 16**

**mean ampl.**

**pulse shape**

**mean ampl.**

**pulse shape**
ECAL DQM - web static pages

COSMICS

effect of cosmic rays
\( \theta \) dependence

cosmic rays per crystal

deposited energy spectrum
ECAL DQM - web static pages

TESTBEAM

- events per crystal

- max E crystal, 3x3 crystal E matrix
Run: 11697
Monitoring task: BeamHodo

- Hodoscope raw
- Hodoscope reco
- Hodo-Calo
- Energy vs position

Hodoscope raw plots:

Hodoscope reco plots:

beam hodoscope
x-y profiles, timing, quality

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Conclusions

• the CMS ECAL DQM is in good shape for detector specific monitoring, under real-life stress-test conditions

• simple access to all high-level products used in analysis, thanks to the re-use of standard CMS framework/code

• ready to include more “physics” stuff

  – jet multiplicity, occupancy, size, energy flow
CMS-ECAL DQM Team

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The Compact Muon Solenoid

Detector characteristics
- Width: 22 m
- Diameter: 15 m
- Weight: 14'500 t
High Level Trigger: Event Filter Farm

Event data partitioned into about 500 separated memory units

Two architectures

≈ 50..100 kHz

≈ 200 Hz per BU

Massive parallel system
ONE event, ALL processors
- Low latency
- Complex I/O
- Parallel programming

Farm of processors
ONE event, ONE processor
- High latency (larger buffers)
- Simpler I/O
- Sequential programming
CMS event display

CMS DAQ integration test
Run 2605
Event 3981
B 3.8 T
27.08.06
ECAL DQM-DB - web pages

TESTBEAM

Crystal Occupancy Plots on cmswebdqm1.cern.ch - Mozilla Firefox

This page is updated daily online. Last updated on 26 August 2006 at 05:08:27

SM16

Occupancy Crystal in Beam SM16

Events per crystal distributions, extracted from ECAL CondDB

Occupancy Crystal with Max Energy SM16

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