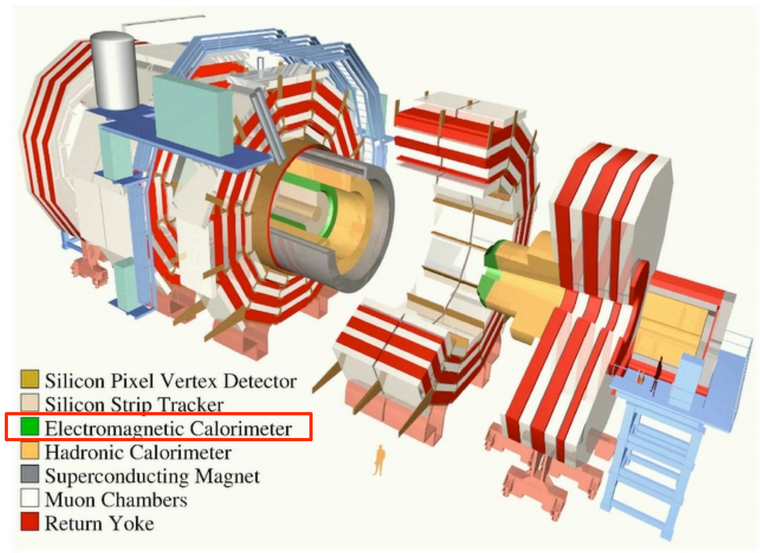
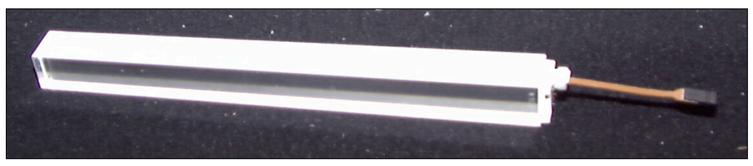
The CMS Electromagnetic Calorimeter detector control and monitoring system

Wieland Hintz on behalf of the CMS ECAL group
ETH Zurich, Switzerland
wieland.hintz@cern.ch

Compact Muon Solenoid Experiment at the Large Hadron Collider

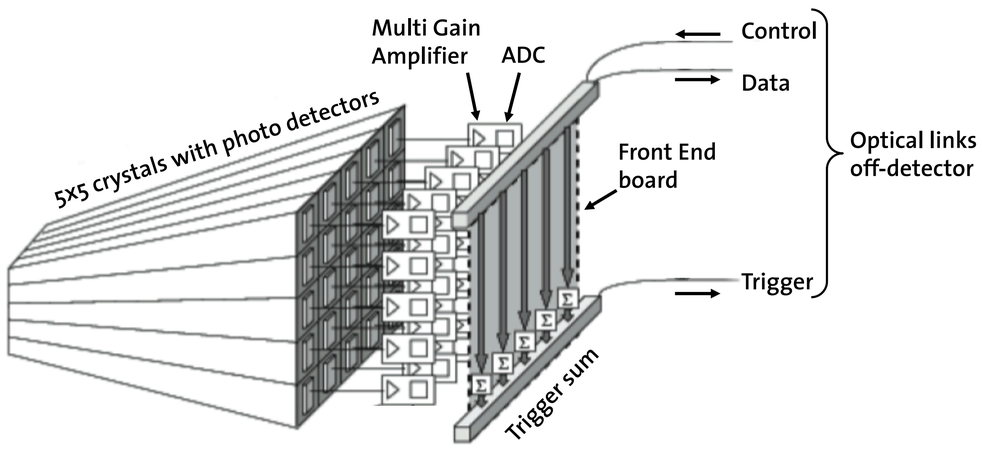


Electromagnetic Crystal Calorimeter (ECAL)



- measures precisely energy of electrons, positrons and photons
- **75848 scintillating $PbWO_4$ crystals** in the ECAL barrel and end-cap
- **pre-shower detector** in the end-cap (lead absorber and silicon strip detectors)
- scintillation light is collected by **photo detectors** glued on the end face of crystals operating under high voltages of several hundred Volts
- crystals' light yield and barrel photo detectors' gain are strongly dependant on their temperature (~2.4% per °C)
- water cooling system used to keep nominal temperature of 18.00°C ± 0.05°C

Trigger Tower – the basic unit of the ECAL readout electronics



- Multi Gain Amplifier **shapes and amplifies signals** with gains 1, 6 and 12
- ADC **digitizes** the three signals in parallel with 12 bit and 40 MHz
  a dedicated logic **chooses the highest non-saturated signal**
- Front End Board **calculates trigger sum** of one tower or strip (for barrel and end-cap, respectively), **buffers data** until reception of trigger and **connects optically to off-detector** trigger, control and data acquisition systems

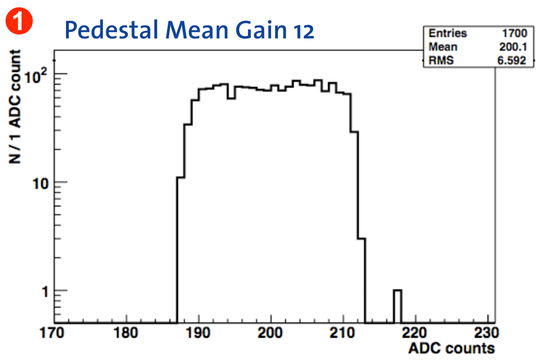
Detector Control System tasks

- Precision monitoring **of crystals' and photo detectors' temperature** (<0.01°C)
- monitoring of **temperature of electronics components**
- **detecting water leaks**
- automatically **protect ECAL** in case of problematic situations (hardwired iinterlocks, predefined control actions, alerting etc.)
- **control software for parameterization and operamtion** of the electronics' low voltage supplies, the photo detectors' high voltage supplies, the ECAL laser calibration and the cooling system

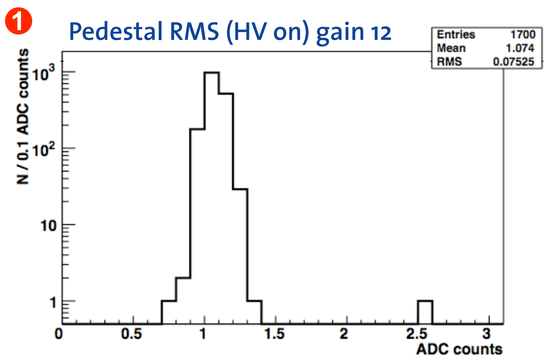
Data Quality Monitoring (DQM) tests of all ECAL channels

1. **Pedestal run (HV on):** measures the mean outputs (pedestal) and its fluctuation (RMS) without signal injection,
   RMS is considered as electronic noise which contributes to the ECAL resolution
2. **Pedestal run (HV off):** finds bad connections between photo detector and readout chain
3. **Test Pulse run**: tests the readout-chain by measuring amplitudes of injected test pulses
4. **Laser run:** dedicated laser system injects 532 nm laser pulses in each crystal,
   tests the whole detector chain including crystals and photo detectors
5. **Detector Control Unit run:**
   monitors crystal and electronics temperatures and leakage currents of photo detectors

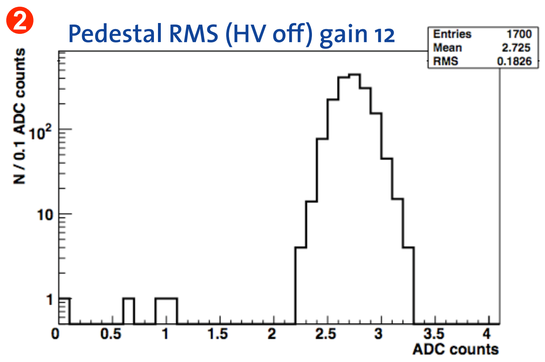
1 Pedestal Mean Gain 12



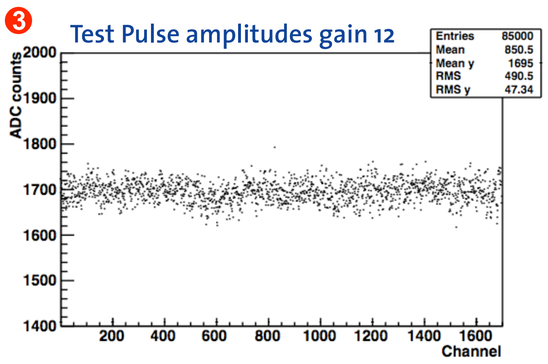
1 Pedestal RMS (HV on) gain 12



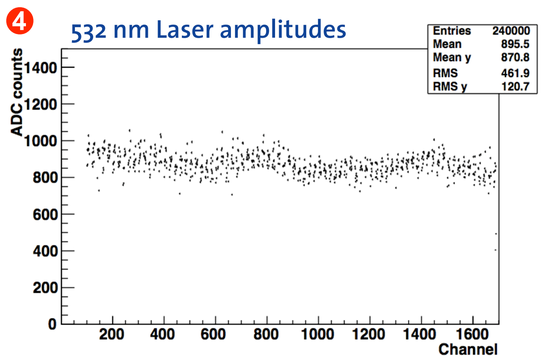
2 Pedestal RMS (HV off) gain 12



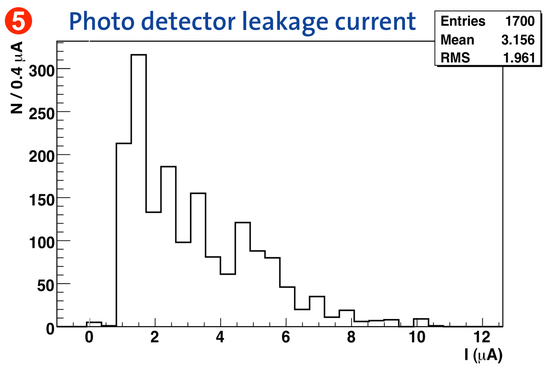
3 Test Pulse amplitudes gain 12



4 532 nm Laser amplitudes



5 Photo detector leakage current



Classification of problematic channels according to DQM tests

	Outcome of test No.:					
Identified hardware problem	**1**	**2**	**3**	**4**	**5**	**Usable channel**
A) Bad connection of Photo Detector and readout-chain	✔	✘	✔	✘	✔	NO
B) Photo Detector broken due to short	✘	✔	✔	✔	✘	NO
C) Read-out channel's input chip broken	✘	✔	✘	✘	✔	NO
D) Noisy Channel	✘	✔	✔	✔	✔	YES
E) Low laser amplitude*	✔	✔	✔	✘	✔	YES

*Channels of the category 'Low Laser amplitude' work perfect with cosmic muons → ignore

ECAL single problematic channels in time (total 75 848)

Identified hardware problem	**A)**	**B)**	**C)**	**D)**	**Total not usable**
Electronics integration in ECAL in spring 2007	21	6	0	14	27
ECAL installation in CMS in summer 2007	23	5	4	15	32
'Good Health Test' in Winter 2009	23	6	20	24	49

Conclusions

- The Electromagnetic Calorimeter of CMS has an excellent noise performance of ~1.1 and 2 ADC counts in the highest amplification gain in barrel and end-cap, respectively.
- The contributing resolution terms are ~40 and ~50 MeV in barrel and end-cap.
- In spring 2009 we find 49 single channels, that are unusable for physics measurements.
- 20 channels are dead due to low voltage problems.
- About 8 Trigger Towers have problems with optical links and/or the data integrity.
- In total, we reached a very low plateau of less than 4‰ unusable channels in the ECAL.

References

[1] CMS Collaboration, "The Compact Muon Solenoid Technical Proposal", CERN/LHCC 94-38
[2] CMS Collaboration, "The Electromagnetic Calorimeter Technical Design Report", CERN/LHCC 97-33
[3] CMS Collaboration, "Implementation and performance of DCS for the ECAL of the CMS experiment ", CMS CR-2007/059