Operation and performances of the CMS Electromagnetic CALorimeter during the 2010 collision run at $\sqrt{s} = 7$ TeV

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Outline

- CMS Electromagnetic CALorimeter: description and goals
- Status and stability
- Calibration strategy and results
- Reconstruction
  - Low level variables
  - Photons
  - Electrons
- Summary
CMS Electromagnetic CALorimeter

- **ECAL Barrel**
  - 61200 2x2x23 cm$^3$ PbWO$_4$ crystals – 26 $X_0$
  - 36 Super Module (SM)
  - Avalanche Photo Diods (APD)
- **ECAL Endcap**
  - 14648 3x3x22 cm$^3$ PbWO$_4$ crystals – 25 $X_0$
  - 4 Dees
  - Vaccum Photo Triod (VPT)
- **ECAL Preshower**
  - Pb (2$X_0$) + Si + Pb(1$X_0$) + Si planes
  - 4300 1.8x63 mm$^2$ Si sensors
ECAL goals and performance target

Physics goals

- QCD
  - $\gamma + \text{jets}$
  - $J/\psi$ and $\gamma$
  - $WW, WZ + \text{jets}$
- SUSY
  - Electrons + MET + jets
- Higgs
  - $H \rightarrow ZZ \rightarrow 4e$
  - $H \rightarrow WW \rightarrow 2\epsilon 2\nu$
  - $H \rightarrow \gamma\gamma$
- Exotic particles
  - $Z'/G \rightarrow \epsilon\epsilon$
  - $W' \rightarrow \epsilon\nu$
  - $G \rightarrow \epsilon\epsilon$

Detector design

- High granularity
  - Space resolution
  - Particle identification
- Excellent energy resolution
  - High mass resolution (together with excellent space resolution)
  - 0.5% target for high energy unconverted photons

Temperature/HV stability
Accuracy of intercalibration
Non uniformity of longitudinal light collection

Higgs Boson Mass Resolution

No mis-calibration
After final calibration corrections

4% mis-calibration
No corrections
ECAL status and stability

99.1% (98.6%) fully operational scales in EB (EE)

Temperature stability well within specifications (<0.05° EB, 0.1 EE)

Light monitoring below the required 0.2% (RMS variation < 0.03%)
**ECAL calibration strategy**

- **Precalibration**
  - Test Beams, Lab measurements, Cosmics and Beam Dumps

- **Calibration in-situ**
  - **φ-symmetry calibration**: invariance of energy flow around the beam axis in minimum bias events. Intercalibrate crystals at the same pseudorapidity.
  - **π⁰ and η calibration**: mass constraint on photon energy, use unconverted γ’s reconstructed in 3x3 matrices of crystals.
  - **High energy electron from W and Z decays** (E/p with single electrons and invariant mass with double electrons).

- **Absolute energy scale** monitor and correction with Di-electrons resonances and Z→ee and J/ψ→ee
ECAL calibration results

- **Intercalibration**
  - Target precision at 0.5%: almost there with first 6 months of data taking

- **Absolute scale**
  - DataMC Z mass agreement at 0.1% (2%) level in EB (EE)
ECAL objects reconstruction

- **Step 0**: energy deposits → RecHits
- **Step 1**: clustering → BasicClusters
  - Already enough to reconstruct unconverted photon energy (5x5 crystal matrix contains 97% of the energy)
- **Step 2**: super-clustering → SuperClusters
  - Necessary to collect bremsstrahlung and conversion energies: look for nearby clusters in along $\phi$ (bending direction)
- Excellent Data-MC agreement for all the Steps
Photons & Electrons

- Each supercluster which does not match a track and an hadronic deposit is a photon candidate.
- Two main handles can be used to distinguish prompt $\gamma$ (coming from the hard scattering) from hadronic decays:
  - Topology of the E.M. Shower
  - Isolation

- Each supercluster which does match a track and NOT an hadronic deposit is an electron candidate.
- 4-mom is build using information from both ECAL and Tracker.
- Same handles used for $\gamma$s to distinguish real electrons from fakes: E.M. Shower Shape+Isolation.

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**Physics Object**

**Physics Analysis**

- Y(1S) Y(2S) Y(3S) Di-Electron inv. mass
- Data/MC

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Data/Theory

- CMS Preliminary 2010
- $\sqrt{s} = 7\, \text{TeV}$
- $L = 74\, \text{nb}^{-1}$
- $|\eta| < 1.4442$
- $E_{T}^{\gamma} < 5\, \text{GeV}$

- CMS Preliminary 2010
- $\sqrt{s} = 7\, \text{TeV}$
- $L = 2.9\, \text{pb}^{-1}$
- $|\eta| < 1.45$
- $E_{T}^{\gamma} < 5\, \text{GeV}$

- CMS Preliminary 2010
- $\sqrt{s} = 7\, \text{TeV}$
- $L_{int} = 35\, \text{pb}^{-1}$
- $E_{T}/2 < \mu < 2 E_{T}$
- Theory scale dependence
- PDFs uncertainty
- Stat. + syst. uncertainty
- $\pm 11\%$ lumi. unc. not shown

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Photon Isolation

- Data/MC

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Isolated photon $p_{T}$
Crystal and preshower CMS Electromagnetic Calorimeter fully operational

- ECAL stability is within specifications and constantly monitored

Successful data taking in 2010

- In-situ calibration procedures are being carried out
  - Channel-to channel calibration precision at 0.6% level in the central EB region (near 0.5% target for $H \rightarrow \gamma \gamma$)
  - Global energy scale in agreement with expectations within 0.1% (EB) and 2% (EE)

- Electromagnetic objects reconstruction fully validated w.r.t. MC predictions
  - $e/\gamma$ commissioning done → ECAL ready for physics measurements
BACKUP
The CMS detector

- Momentum / charge of tracks and secondary vertices (e.g. from b-quark decays) measured in TRACKER (Silicon layers).
- Energy and positions of electrons and photons measured in ECAL
- Energy and position of hadrons and jets measured mainly in HCAL
- Muons identified and momentum measured in external muon spectrometer
- Neutrinos “detected and measured” through measurement of missing transverse energy in calorimeters (hermeticity + good Missing Et resolution)
Anomalous signals

- ECAL observes anomalous signals in collision events: apparent large energy deposition in a single crystal
- Signals uniformly distributed in barrel → APD readout
- Origin: deposits by heavily ionizing particles in APDs
- Signal quality checked and detector anomalies dealt with
  - energy pattern inconsistent with electromagnetic showers
  - timing distribution