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

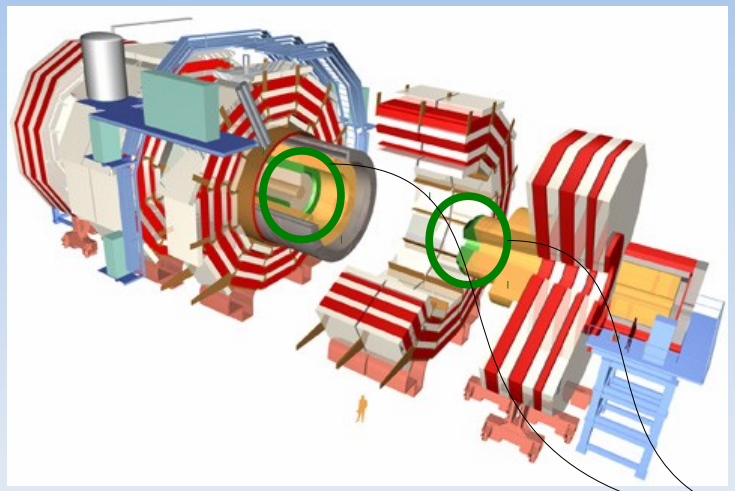
Incontri di Fisica delle Alte Energie
Perugia, 27-29 Aprile 2011

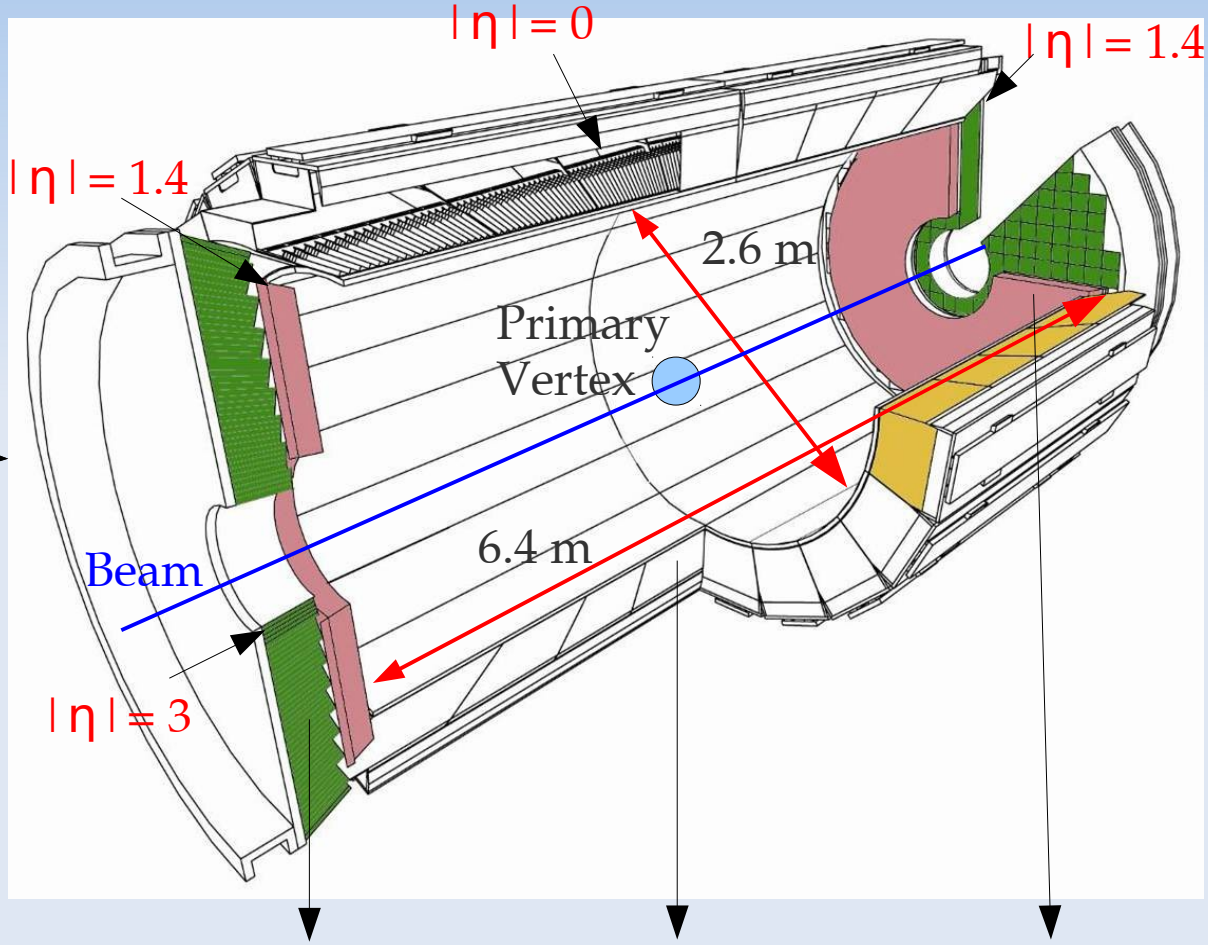
Leonardo Di Matteo
University of Milano-Bicocca

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 ($2X_0$) + Si + Pb($1X_0$) + Si planes
  - 4300 1.8x63 mm^2 Si sensors

ENDCAP (EE) $1.48 < |\eta| < 3$

BARREL (EB) $|\eta| < 1.48$

PRESHOWER (ES) $1.6 < |\eta| < 2.6$

ECAL goals and performance target

Physics goals

- **QCD**
  - γ + jets
  - J/ψ and Υ
  - WW, WZ + jets
- **SUSY**
  - Electrons + MET + jets
- **Higgs**
  - H → ZZ → 4e
  - H → WW → 2e2ν
  - **H → γγ**
- **Exotic particles**
  - Z'/G → ee
  - W' → enu
  - G → ee

Detector design

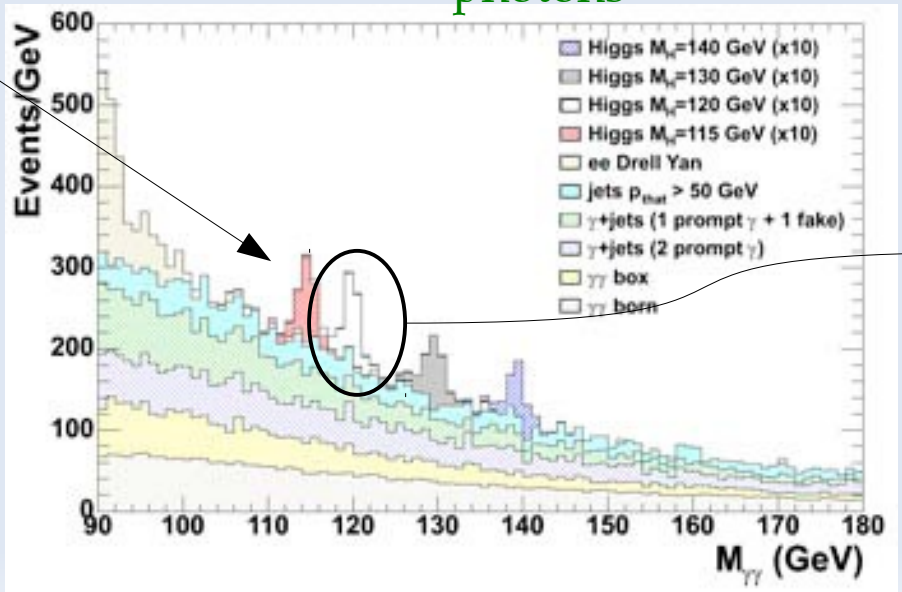
- **High granularity**
  - Space resolution
  - Particle identification
- **Excellent energy resolution**
  - High mass resolution (together with excellent space resolution)
  - 0.5 % target for high energy unconverted photons

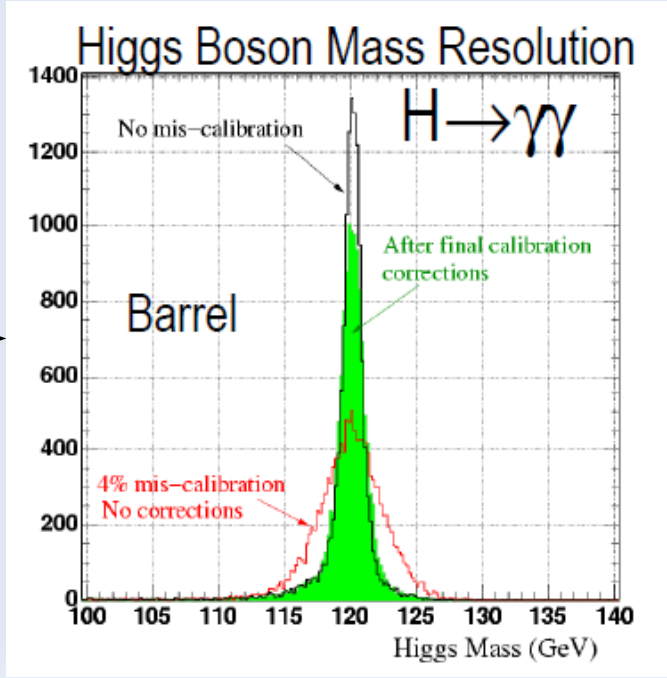
$$\frac{\sigma_E}{E} = \frac{a}{\sqrt{E}} \oplus \frac{b}{E} \oplus c$$

Temperature/HV stability

Accuracy of intercalibration

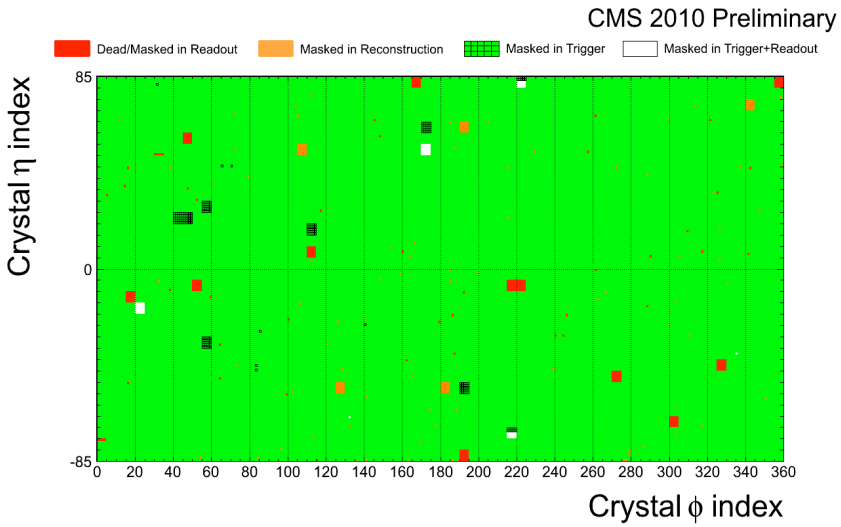
Non uniformity of longitudinal light collection

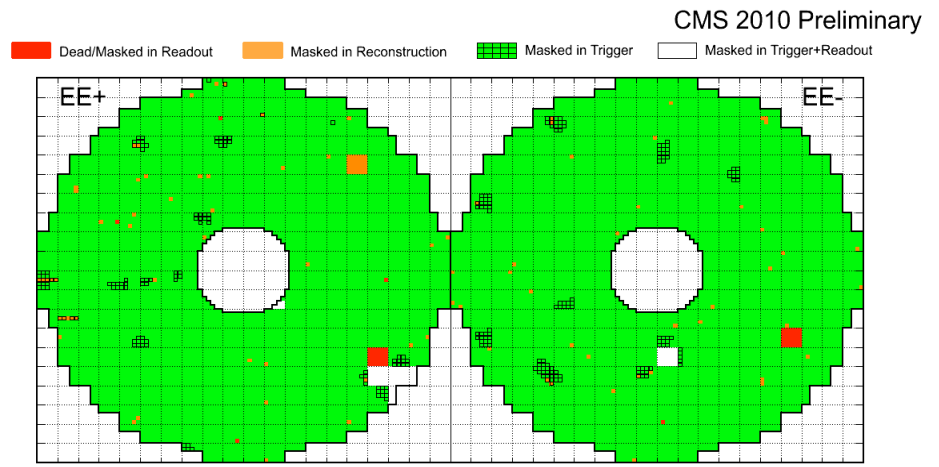


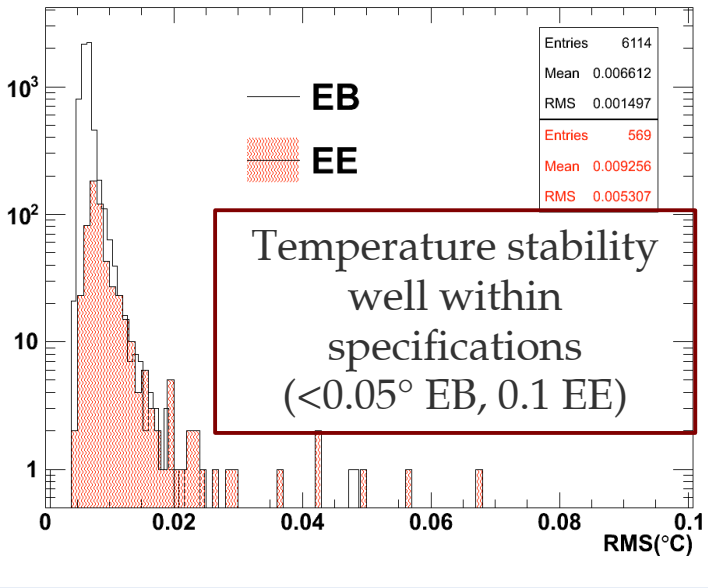


ECAL status and stability

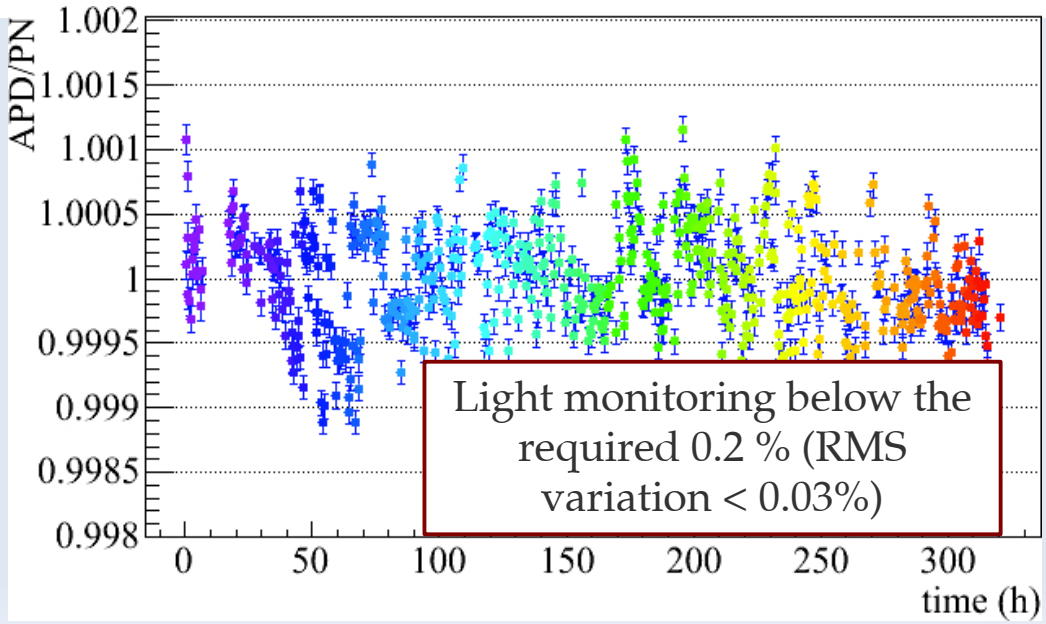
99.1 % (98.6 %) fully operationals channels in EB (EE)







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

IC road map

$L^{int}(fb^{-1})$ - σ^{IC}

0 - 2/10%

- Precalibration

  Test Beams, Lab measurements, Cosmics and Beam Dumps

10^{-6} - 1.5/3%

SUMMER10

- Calibration in-situ

  φ-symmetry calibration: invariance of energy flow around the beam axis in minimum bias events. Intercalibrate crystals at the same pseudorapidity.

10^{-3} - 0.5/3%

IFAE11

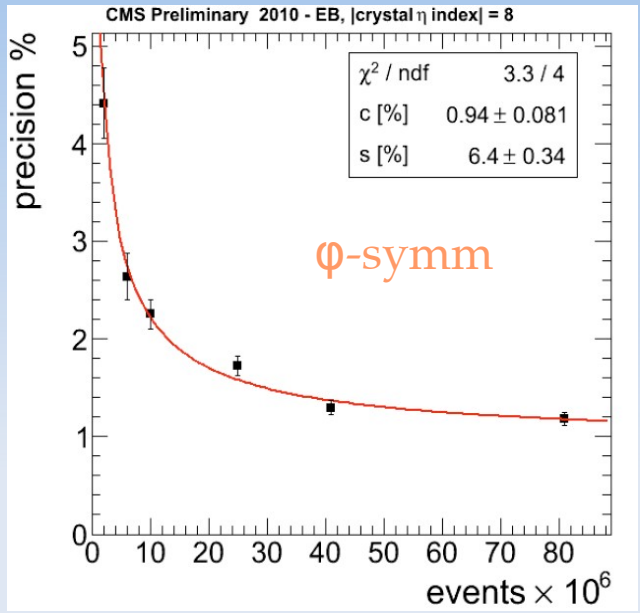
  π^0 and η calibration: mass constraint on photon energy, use unconverted γ's reconstructed in 3x3 matrices of crystals.

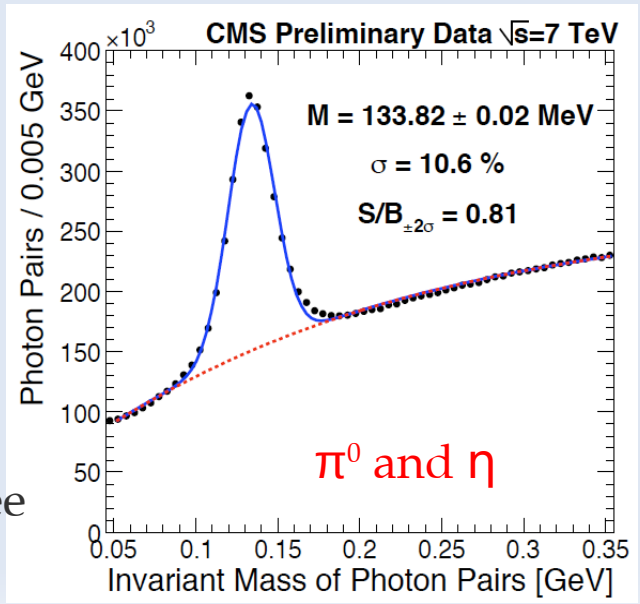
  High energy electron from W and Z decays (E/p with single electrons and invariant mass with double electrons).

5 - < 0.5%

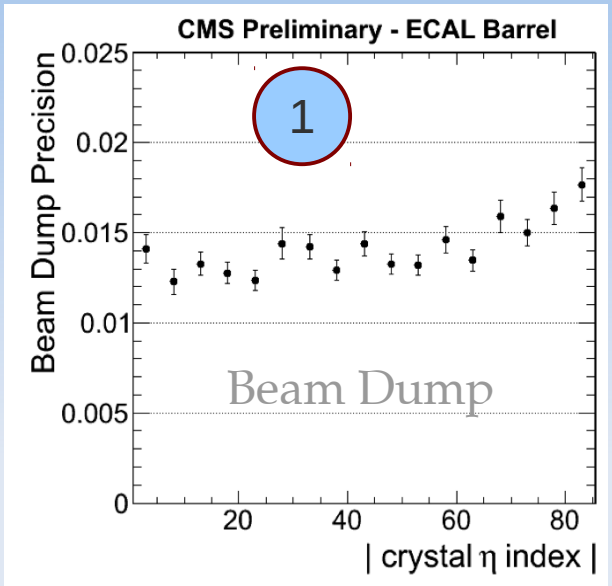
WINTER11

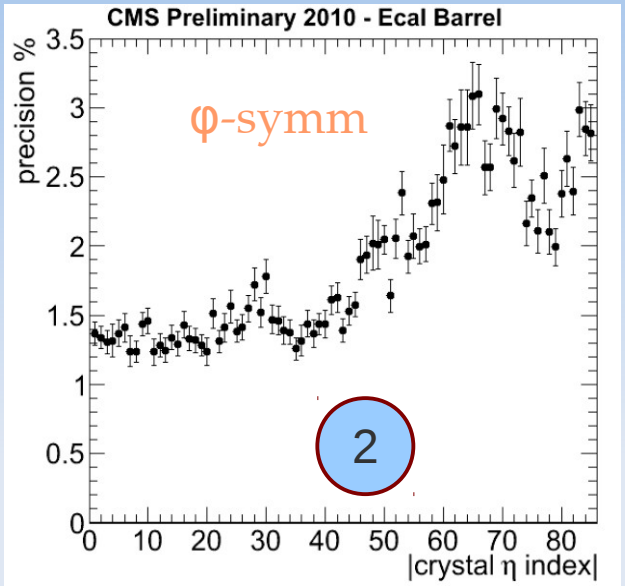
- Absolute energy scale monitor and correction with Di-electrons resonances and Z→ee and J/ψ→ee

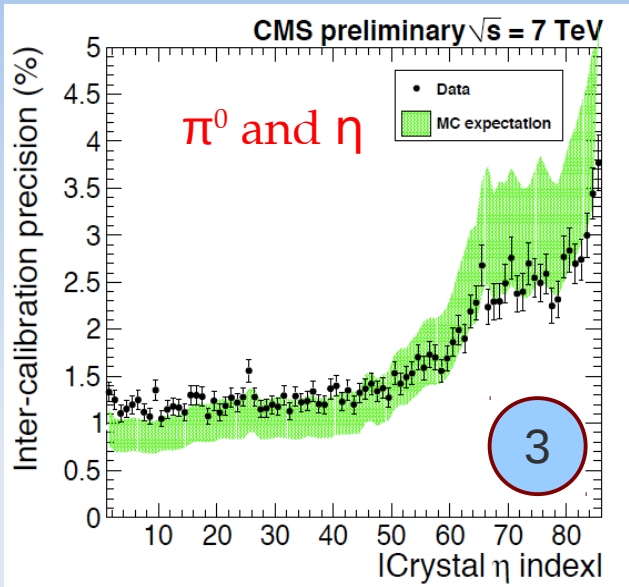


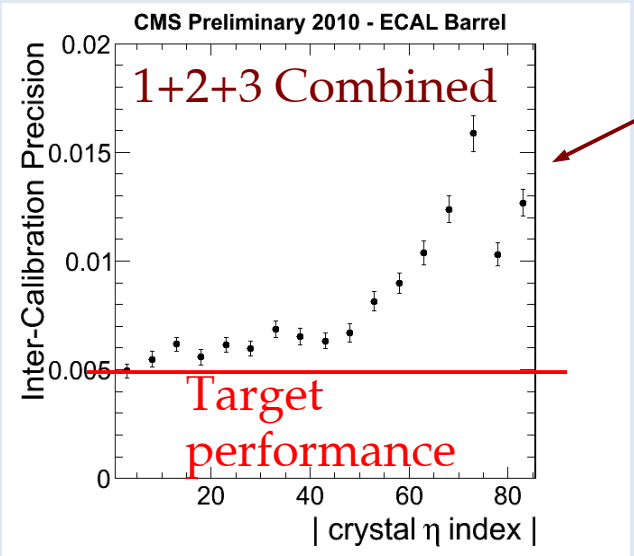


ECAL calibration results

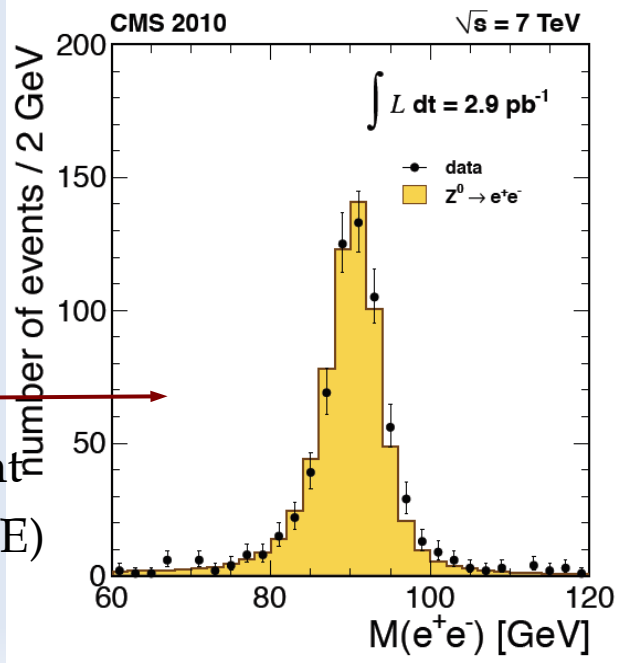








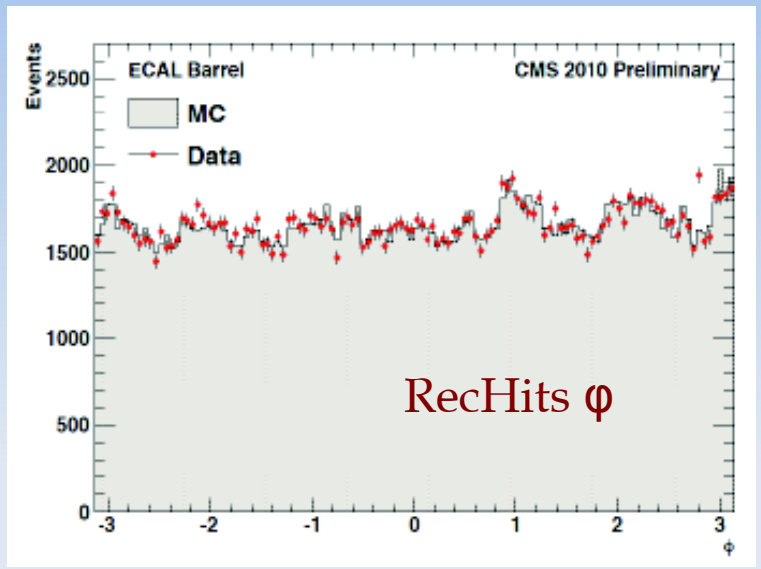
- **Intercalibration**
  - Target precision at 0.5%: almost there with first 6 months of data taking
- **Absolute scale**
  - DataMC Z mass agreement at 0.1% (2%) level in EB (EE)

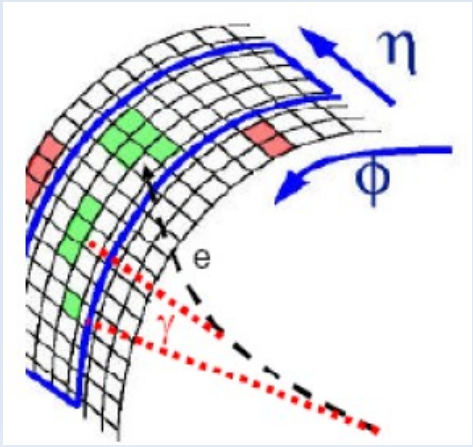


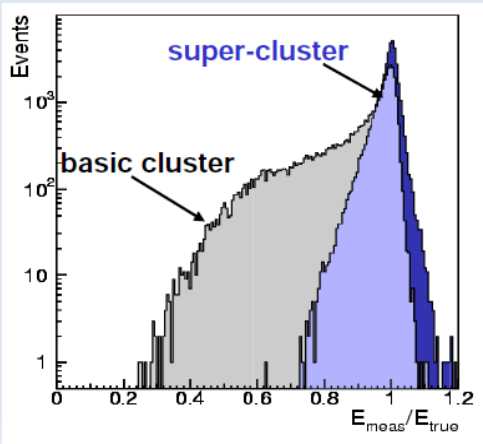
ECAL objects reconstruction

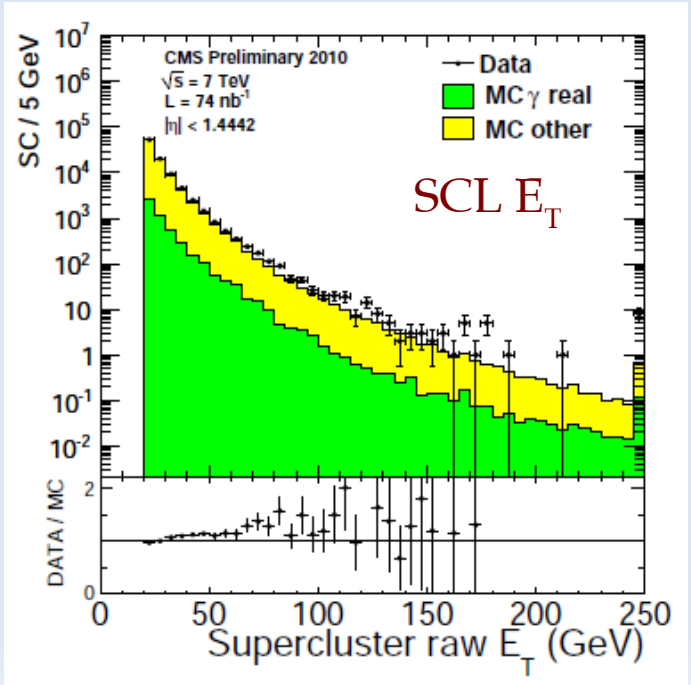
Complexity

- 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 φ (bending direction)
- Excellent Data-MC agreement for all the Steps









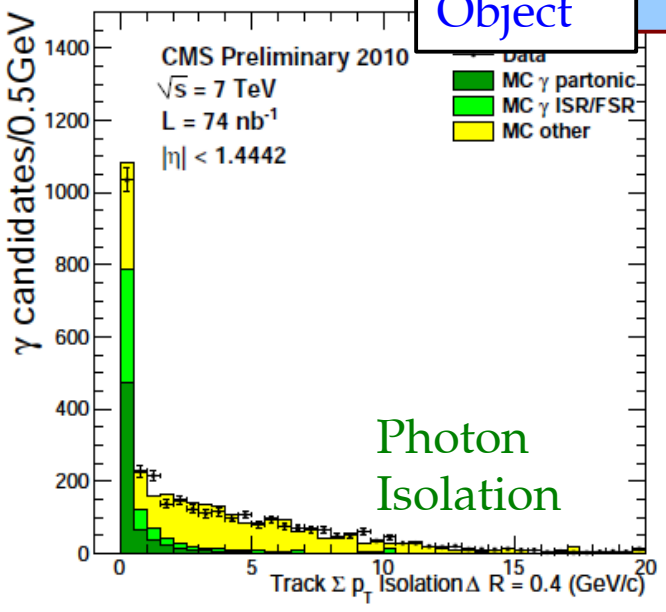
Photons & Electrons

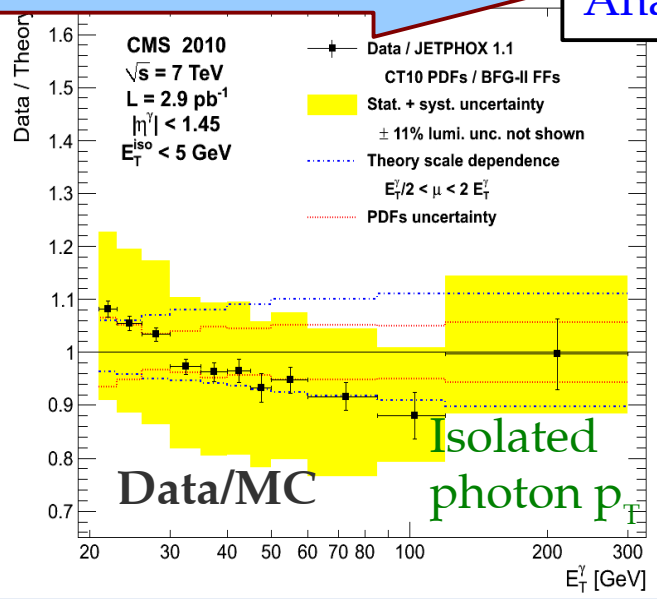
- Each supercluster which does not match a track and an hadronic deposit is a photon candidate
- Two main handles can be used to distinguish prompt γ (coming from the hard scattering) from hadronic decays
  - Topology of the E.M. Shower
  - Isolation

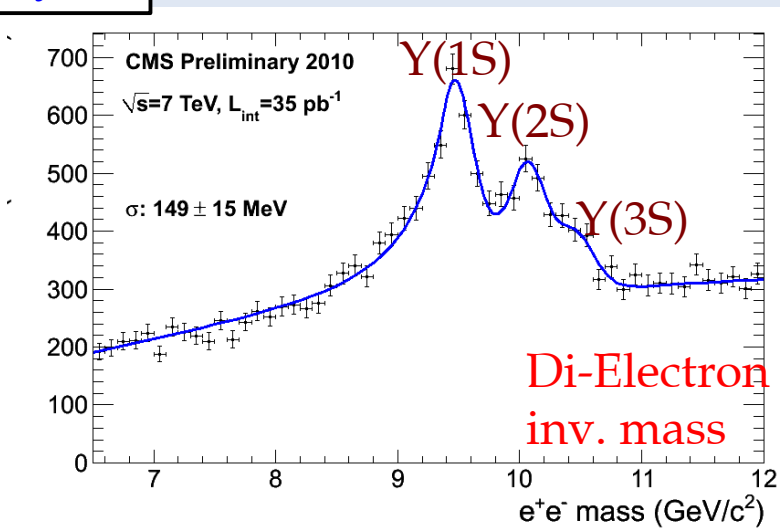
- Each supercluster which does match a track and NOT an hadronic deposit is an electron candidate
- 4-mom is build using information from both ECAL and Tracker
- Same handles used for γs to distinguish real electrons from fakes : E.M. Shower Shape+Isolation

Physics Object

Physics Analysis





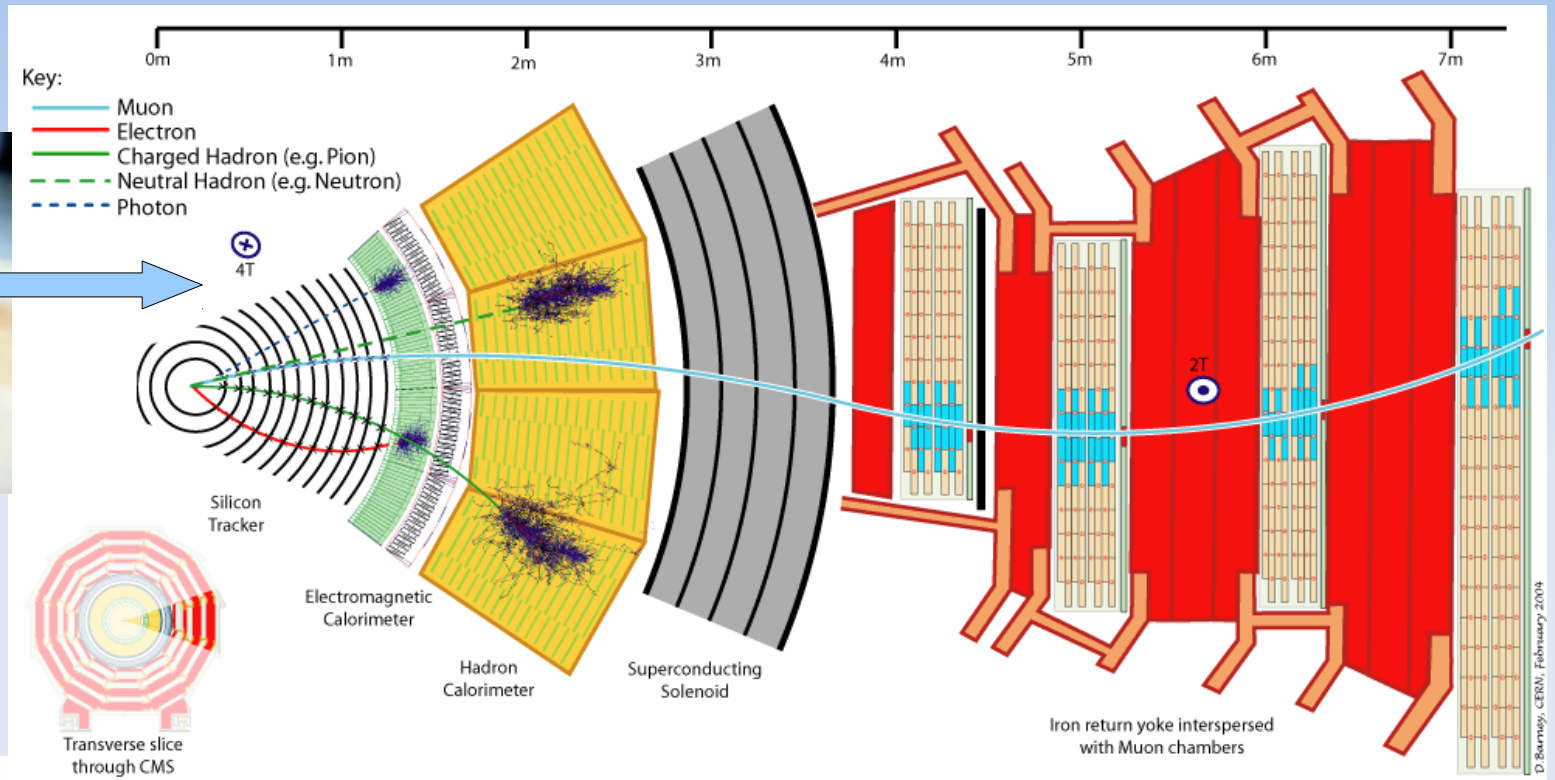


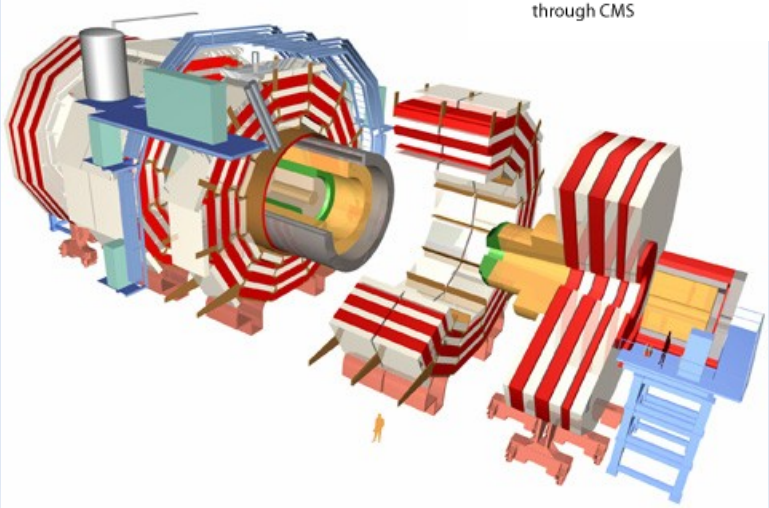
Summary

- 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/γ commissioning done → ECAL ready for physics measurements

BACKUP

The CMS detector





- Momentum / charge of <u>tracks and secondary vertices</u> (e.g. from b-quark decays) measured in **TRACKER** (Silicon layers).
- Energy and positions of <u>electrons and photons</u> measured in **ECAL**
- Energy and position of hadrons and jets measured mainly in **HCAL**
- <u>Muons</u> identified and momentum measured in **external muon spectrometer**
- <u>Neutrinos</u> "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