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Role of the CMS electromagnetic calorimeter in the hunt for the Higgs boson through the two-gamma decay mode

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Summary. — The Electromagnetic Calorimeter (ECAL) of the Compact Muon Solenoid (CMS) experiment at the LHC is a hermetic, fine grained, homogeneous calorimeter, comprising 75848 lead tungstate scintillating crystals, located inside the CMS superconducting solenoidal magnet. The scintillation light is detected by avalanche photodiodes in the barrel section and by vacuum phototriodes in the two endcap sections. A silicon/lead pre-shower detector is installed in front of the endcaps in order to improve γ/π^0 discrimination. Precise calibration of the ECAL detector is required. This includes inter-calibration, to account for the differing response of channels, and calibration of the energy scale. The performance obtained during the LHC physics runs in 2011 and 2012 is presented and the role of the ECAL in the hunt for the Higgs boson, through the two-gamma decay mode, is discussed.

PACS `29.40.Vj` – Calorimeters.
PACS `29.40.-n` – Radiation detectors.

1. – Introduction

The CMS Electromagnetic Calorimeter (ECAL) [1] plays an essential role in the study of the Higgs boson through its two-gamma decay mode. The distinctive signature of this decay channel is a narrow resonance smeared by the photon energy resolution, so the sensitivity to this decay mode is directly related to the performance of the electromagnetic calorimeter. Electromagnetic particles impacting the calorimeter deposit the energy over several crysyals so the total energy is reconstructed summing over the corresponding channels taking into account specific corrections (eq. (1)). The signal amplitude (A_i) from each channel belonging to the cluster has to be corrected to consider the variation in time of crystal transparency and photo-detector response ($L_i(t)$), the intrinsic differences in response of crystals and photodetectors (c_i), the calibration of the ADC to energy conversion (G) and the presence of geometry effects ($F_{e,\gamma}$). For the endcap cluster the preshower energy E_{ES} has also to be added

$$E_{e,\gamma} = F_{e,\gamma} \cdot [G \cdot \Sigma_{i \in \text{cluster}} L_i(t) \cdot c_i \cdot A_i + E_{ES}] \,. \tag{1}$$

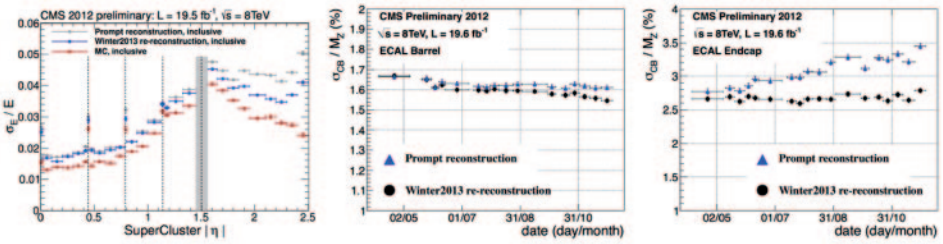

Fig. 1. – Left plot: electron energy resolution measured in different eta regions. The calibration improves the resolution, expecially in the endcap region. Center and right plots: Z mass resolution as a function of time for the barrel and the endcap calorimeters.

2. – ECAL inter-calibration and monitoring

After installation at the LHC several techniques for the *in situ* calibration using collision data have been developed to determine the inter-calibration coefficients c_i to equalize the different channels [1]. Three strategies are applied to inter-calibrate the channels. One is based on the reconstruction of the invariant mass peak of unconverted photons from the decay of π^0 and η mesons, another on the comparison between the energy E measured in ECAL and the momentum p measured in the tracker for isolated electrons from the decay of the W and Z bosons. The third method, instead, is based on the assumption that for a large number of minimum bias events the total transverse energy deposited should be the same for all crystals in a ring at fixed pseudorapidity.

One of the most critical aspects is the monitoring of ECAL response stability. The stability is affected by the radiation that causes the formation of colour centers responsible for a reduction of the crystal transparency, and changes in photo-detector response. To monitor and correct these variations a system [2] based on the injection of laser light at 447 nm into each crystal is used. This system provides one response measurement for each crystal every 40 minutes and corrections are then delivered after 48 h in time for use in the prompt reconstruction of data. During 2012 the response change observed is of the order of few percent in the barrel, it reaches up to 25% in the most forward endcap regions, while it is up to 70% in channels closest to the beam pipe.

3. – Energy and mass resolution

The energy and mass resolutions are studied using events $Z \longrightarrow e^+e^-$. The instrumental contribution to the Z width is extracted fitting the invariant mass distribution with a function obtained from the convolution of a Breit Wigner and a Crystal-Ball function. The Gaussian width parameter of the Crystal Ball function is taken as a measure of the mass resolution. In fig. 1, the electron energy resolution and the Z mass resolutions in the barrel and endcap regions are shown for the 2012 dataset. Electron energy resolutions of better than 2% are obtained for $|\eta| < 0.8$. A Z mass resolution of 1.7% is achieved in the barrel by the end of 2012 and is better than 2.8% in the endcap regions.

REFERENCES

[1] The CMS Collaboration, *JINST*, **3** (2008) S08004.
[2] Anfreville M. *et al.*, *Nucl. Instrum. Methods A*, **594** (2008) 292.