The performance of the CMS ECAL Preshower detector at LHC

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1. Preshower in CMS

Overview of Preshower detector

The CMS Preshower detector (ES) is part of the CMS endcap electromagnetic calorimeter (EE), located in front of the lead tungstate crystals (**Fig. 1**). The coverage of the ES is $1.653 < |\eta| < 2.6$. The primary function of the ES is to identify two closely spaced photons from π^0 decays, which allow an additional rejection of background for Higgs to two photon decay channel (**Fig. 2**).

The ES comprises 4 planes of silicon strip sensors and associated mechanics, cooling and front end electronics. The Internal structure is shown in **Fig. 3**. The sensors have an active area of $61 \times 61 mm^2$, divided into 32 strips. The planes are known as ES+F, ES+R, ES-F and ES-R, reflecting the nomenclature of the endcaps (+ or -) and whether the plane is **F**ront (closest to the interaction point) or **R**ear. The ES can operate in **H**igh **G**ain (HG, for calibration purposes and low-energy collision running) and **L**ow **G**ain (LG, for higher energy collision runs) mode, and was operated in HG mode throughout the 7 TeV collision running.

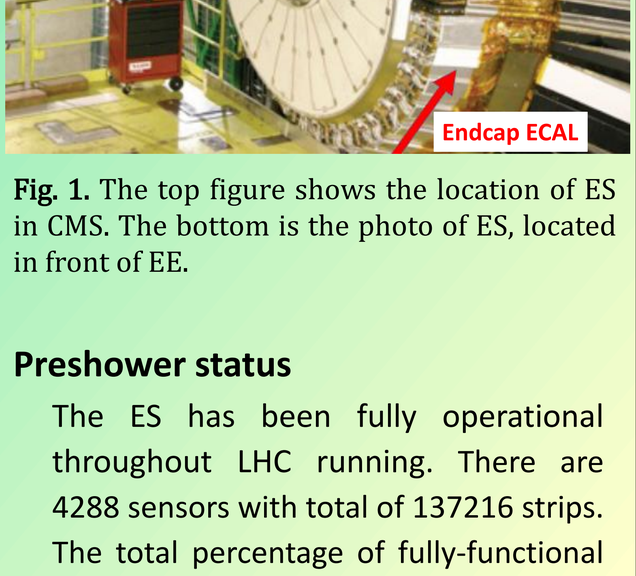


Fig. 1. The top figure shows the location of ES in CMS. The bottom is the photo of ES, located in front of EE.

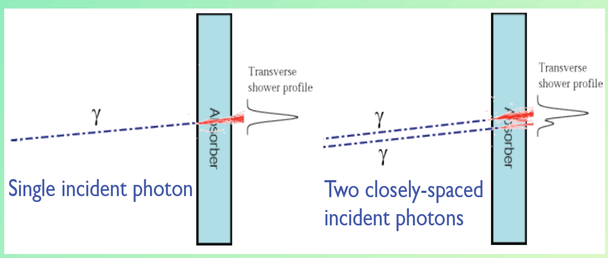


Fig. 2. The purpose of ES is to reject π^0 background by measuring the shower shape in front of endcap crystal calorimeter.

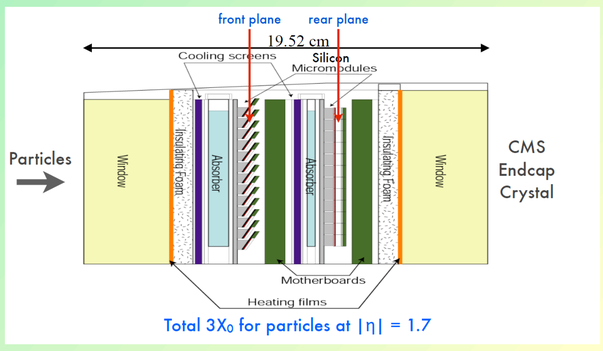
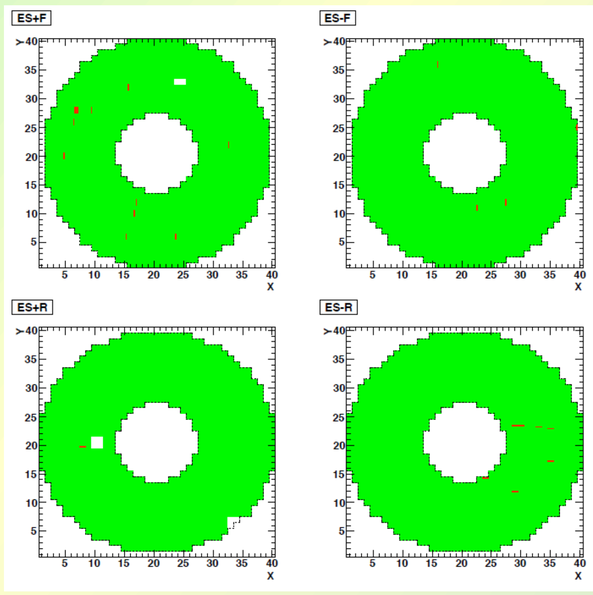


Fig. 3. The internal structure of the ES.

Preshower status

The ES has been fully operational throughout LHC running. There are 4288 sensors with total of 137216 strips. The total percentage of fully-functional strips is 99.8% (**Fig. 4**).

Fig. 4. Graphical representation of the four ES planes, showing the dead sensors (white squares) and noisy strips (red strips).



2. Preshower Occupancy in 7 TeV collisions

The ES occupancy is calculated as the percentage of strips with a reconstructed energy greater than 4σ of the noise. **Figure 5** shows the variation of occupancy with η and Φ, both compared to simulation, where absolute values of the MC occupancies have been normalized to the data. The Φ variations are due to the X-Y geometry of the ES, and are well-modeled by simulation. The occupancy increases as a function of η as expected.

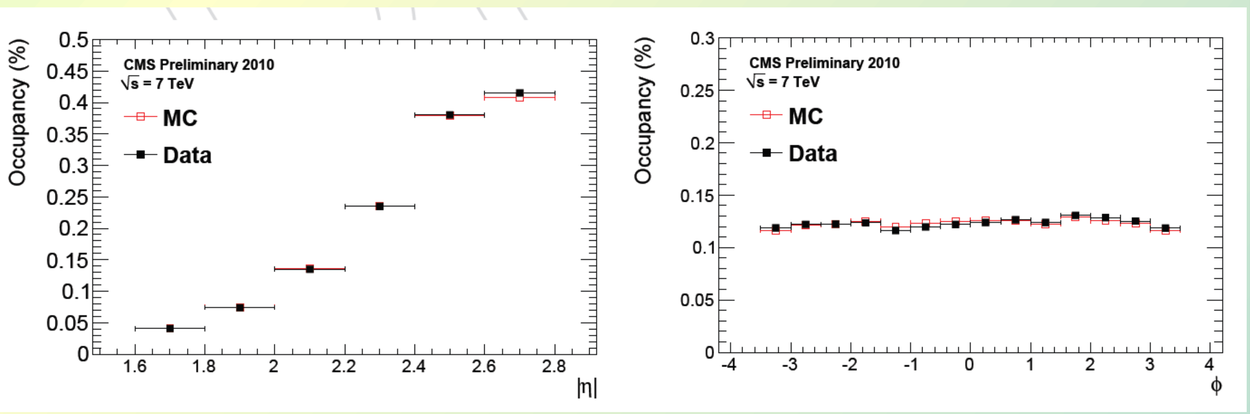


Fig. 5 ES occupancy as functions of η(left, averaged over all Φ)) and Φ (right, averaged over all η).

3. Preshower calibration and clustering

ES calibration with charged particles

The ES is a sampling calorimeter and essentially counts the number of charged particles passing through the silicon. The particles used to calibrate the ES are currently pions, with p > 1 GeV/c and an average momentum of 6.1 GeV/c. This means that they are nearly minimum ionizing, so for simplicity we refer to them as "MIPs".

Following a laboratory pre-calibration with cosmic rays (with ~2.5% precision) we use charged pions from 7 TeV collisions, with p > 1 GeV/c pointing to the ES, to carry out the first in-situ ES MIP calibration. The MIP value is defined as the fitted peak position from the energy distribution. The observed S/N ratio for single ionizing particles, as shown in **Fig. 6 (left)** is between 9 and 11. **Figure 6 (right)** shows the correlation between sensor MIP values obtained from in-situ calibration and pre-calibration. The precision of in-situ calibration is estimated to be about 2.2%.

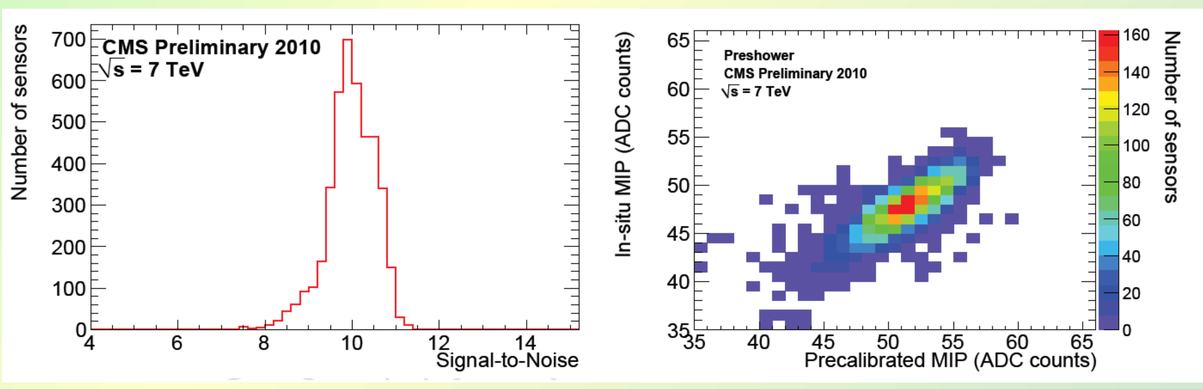


Fig. 6. The ES signal to noise ratio for single particles (left) and the correlation between sensor MIP values obtained from in-situ calibration and pre-calibration (right).

Preshower Clustering

In EE, cluster of groups of crystals are formed around seed crystals having E_T>1GeV. Then, EE cluster positions are extrapolated to the ES and ES clusters built. **Figure 7** shows the total cluster energies measured by each plane of the ES for both data and simulation. In HG mode there is some saturation at high energies, seen by the bins at high MIP/ratio values.

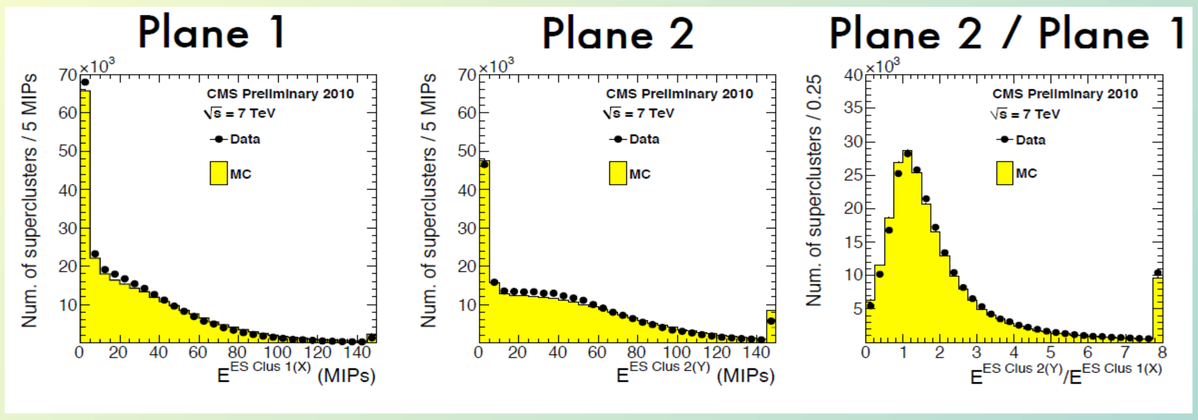


Fig. 7. Comparison between data and simulation for the total cluster energies measured by each plane of the ES, expressed in units of MIP, as well as the ratio between the energies.

Correspondence between EE and ES

Figure 8 shows the correspondence between EE cluster energies and associated ES clusters, for both data and MC, for electron candidates without any identification requirement and with energy measured by the combination of the silicon tracker and ECAL between 70 GeV and 75 GeV. This correspondence is used to re-calibrate the energy measured in the EE with that in the ES. The total endcap cluster energy is a weighted linear combination of cluster energies in the EE and ES.

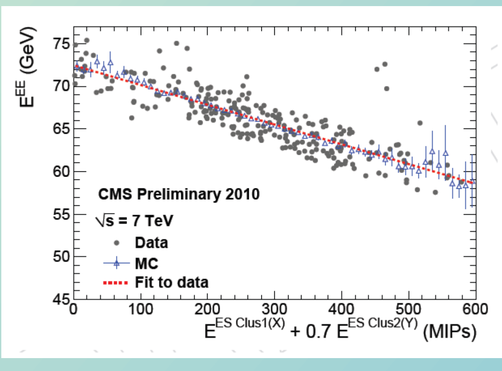


Fig. 8. Correspondence between the energy measured in EE and the weighted ES.

4. Summary

The ES has been operating stably throughout the 2009 and 2010 LHC running, with more than 99.8% of its strips fully functional. The first results compare well with simulation and are as expected.

5. Reference

[1]. CMS Collaboration, "The CMS experiment at the CERN LHC", JINST 0803 (2008) S08004.
[2]. CMS Collaboration, "Electromagnetic calorimeter commissioning and first results with 7 TeV data", CMS NOTE -2010/012 (2010)
[3]. CMS Collaboration, "CMS Physics TDR: Volume I (PTDR1), Detector Performance and Software", CERN/LHCC-2006-001 (2006).