Electromagnetic cluster commissioning with first CMS data

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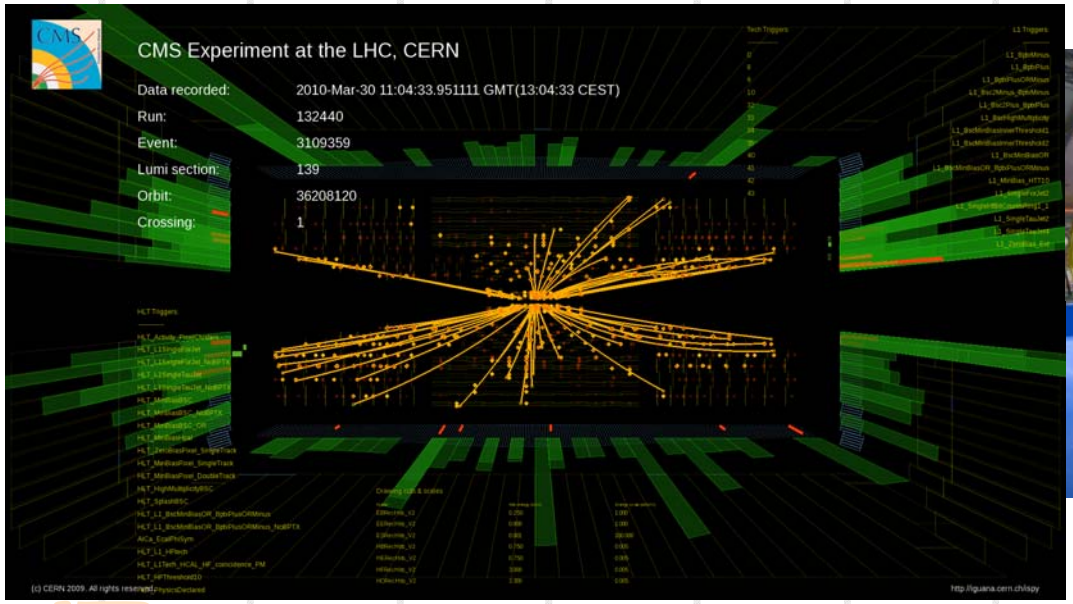
The exciting news

- Geneva, March 30th 2010 :
- LHC at CERN has collided two beams of 3.5 TeV protons – a new world record of energy. The CMS experiment has detected these collisions successfully, signifying the beginning of the “First Physics” at the LHC.
- LHC collided at 900GeV and 2.4TeV at the end of last year.



Collaboration of subgroups in egamma group(published paper)

Available on the CERN CDS information server

CMS PAS EGM-10-001

CMS Physics Analysis Summary

Contact: cms-pog-conveners-egamma@cern.ch

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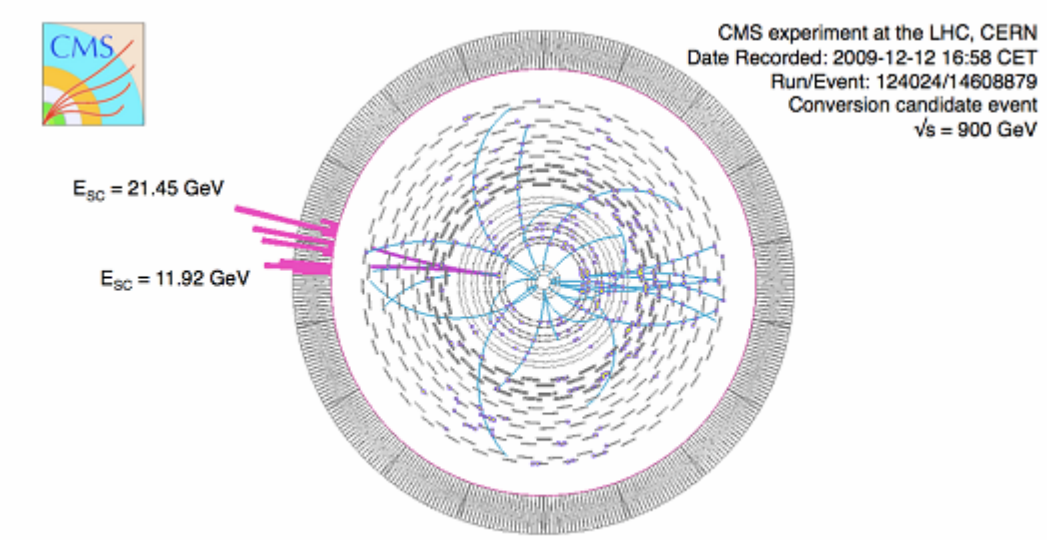
Electromagnetic physics objects commissioning with first LHC data

The CMS Collaboration

Event display of 900GeV

- Approximately 200k minimum bias events recorded by the CMS detector at a center of mass energy of 900 GeV were used to commission the reconstruction of cluster physics objects which is the first comparisons between the data and the simulation



Electron tracks are shown in purple, and their superclusters in pink in the ECAL.
General tracks are in blue and tracker clusters (silicon strips) are shown by small squares.

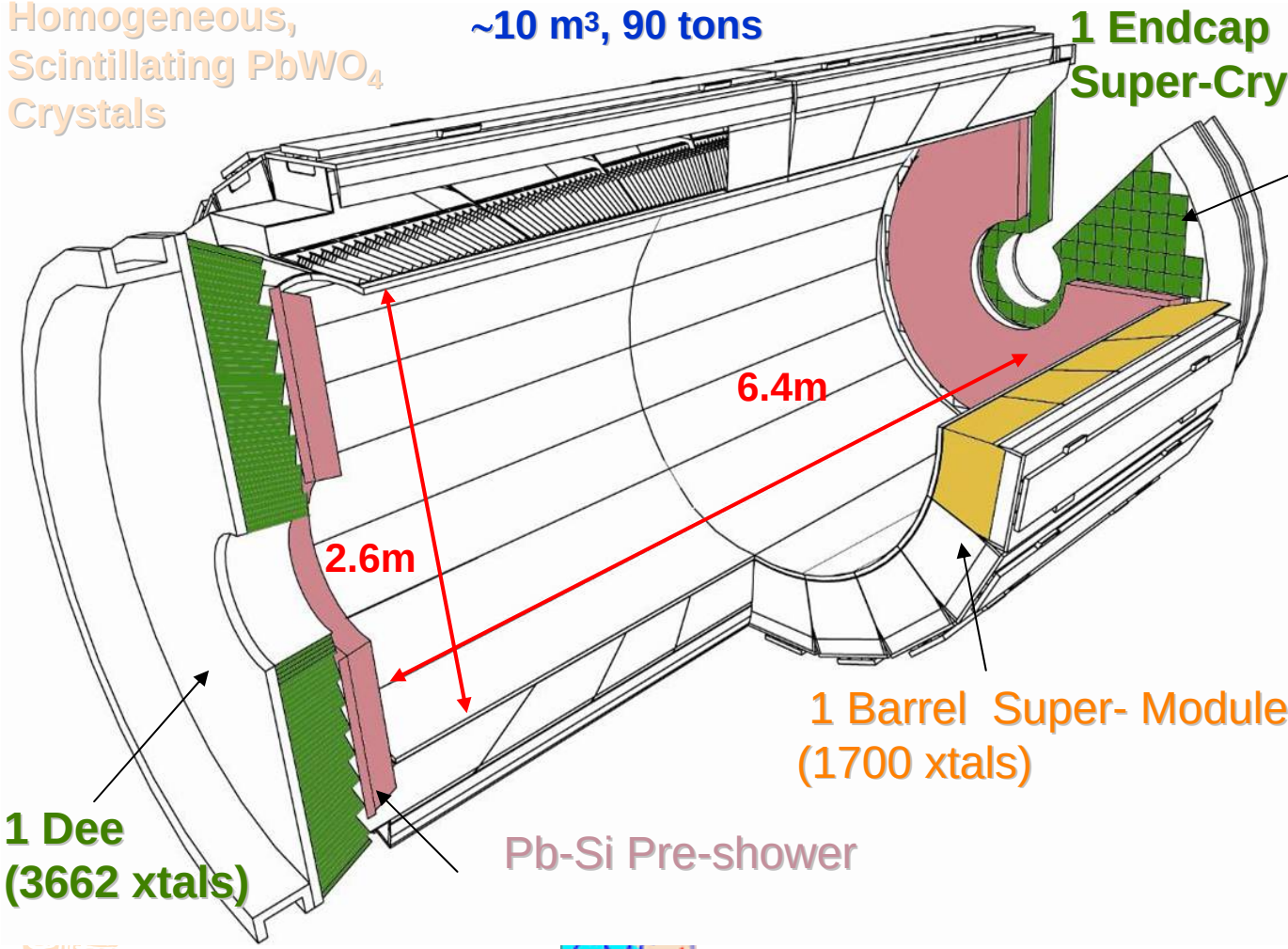
Introduction

- It should be noted that, given the low integrated luminosity and the absence of identification requirements, most of the reconstructed cluster physics objects are due to fakes, so the comparison is mainly carried out for background.
- Nevertheless this is still sufficient to assess the general quality and the proper functioning of the algorithms and the modeling of the detector response in the simulation.
- There is a good agreement, suggesting a good modeling of the response of the calorimeters.

ECAL

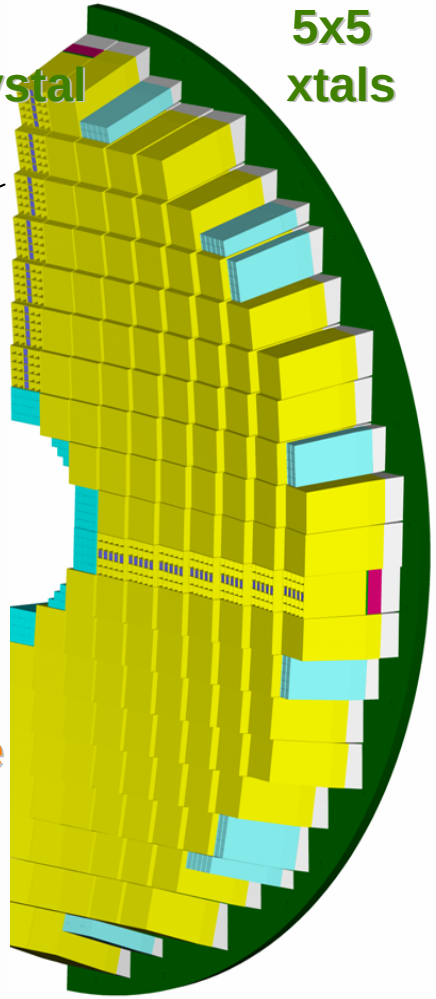
Homogeneous, Scintillating $PbWO_4$ Crystals

~10 m³, 90 tons



1 Endcap Super-Crystal

5x5 xtals



Datasets and event selection (real data)

- Minimum bias events are triggered using scintillator planes that are located in front of the Hadron Calorimeter Forward detectors (Beam Scintillator Counters or BSC). The Level 1 trigger requires at least one hit in one of the BSC.

- Offline selection is then applied. The requirements are the following: (5 criterias)

* the event has to be in time with a valid beam crossing measured by the coincidence of the two beam pickup monitors;
* the BSC beam halo trigger should not be present;
* there should be at least one primary vertex reconstructed with more than four tracks consistent with the beam spot;
* the fraction of high purity tracksshould be at least 25% for events with at least 10 tracks;
* there should be at least one hit with energy greater than 2 GeV in each of the Forward Hadron calorimeter detectors (HF).

- We selected runs where all relevant subdetectors were properly functioning. The selected sample consists of 185330 minimum bias events.

Datasets and event selection (MC sample)

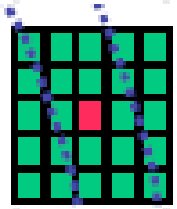
- Full MC simulation based on Geant4 of 10M PYTHIA 6.4 minimum bias events are used. The simulation is carried out using mis-alignments, mis-calibrations and dead channel lists corresponding to the startup conditions of the CMS detector.

Cluster studies

- In this study we concentrate on the raw energy measurement of the superclusters, namely the sum of the energies deposited in the ECAL crystals without any correction.

Clustering

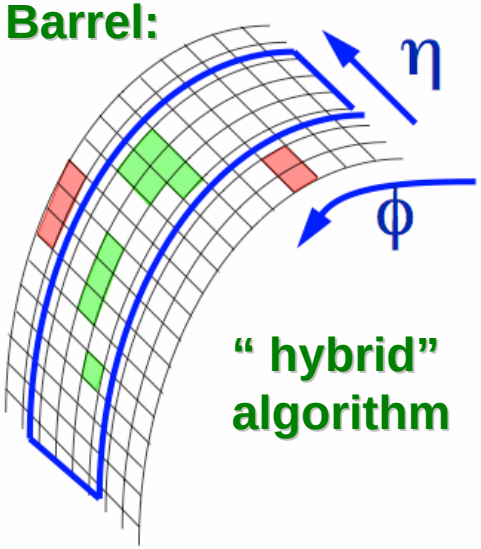
5x5 matrix



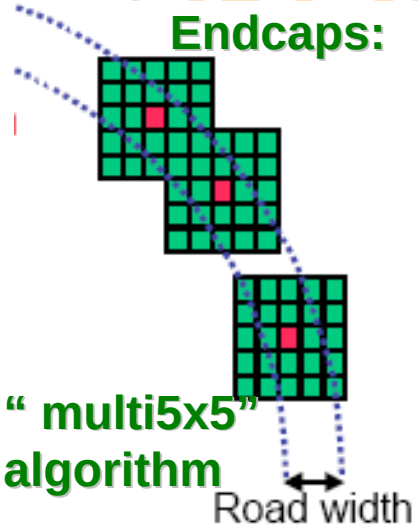
Contains 96.5% (97.5%) of unconverted photon energy in Barrel (Endcaps)

Gives best energy estimate

Barrel:



Endcaps:



Form Super-clusters of clusters along ϕ (bending direction) to recover energy from conversions in the tracker

In the endcaps, add also the energy deposited in the preshower detector

Supercluster selection and plot normalization

- SCs are selected with the following requirements:
- * the SC η must satisfy |η| < 1.4442 and 1.566 < |η| < 2.5, avoiding the transition region between barrel and endcaps.
- * the raw SC Et must be greater than 2 GeV.
- In total 3226 SCs satisfy these requirements in the data. Of these, 2120 are reconstructed in the barrel while 1106 in the endcap.
- In the following plots the Monte Carlo is normalized to the total number of SCs observed in the data, in case of barrel/endcaps plots two different normalizations have been used.

Supercluster multiplicity and E_T

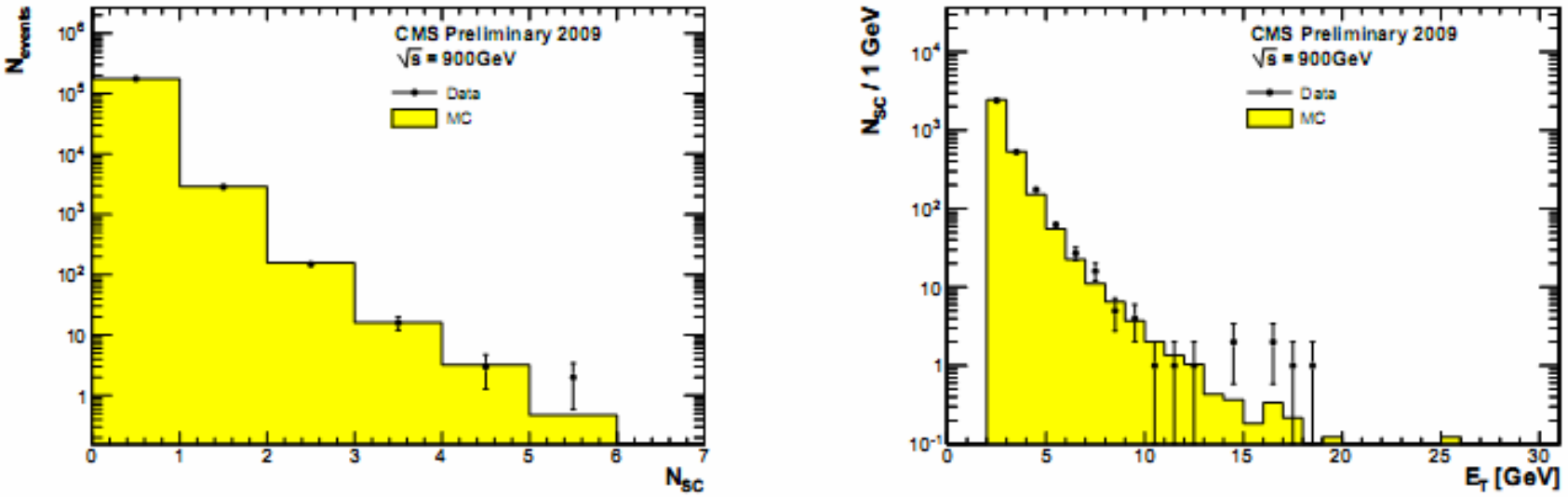


Figure 1: Number of selected superclusters per event (left) and raw Supercluster transverse energy distribution (right). The black points correspond to data and the histogram to simulated minimum bias events.

Supercluster η

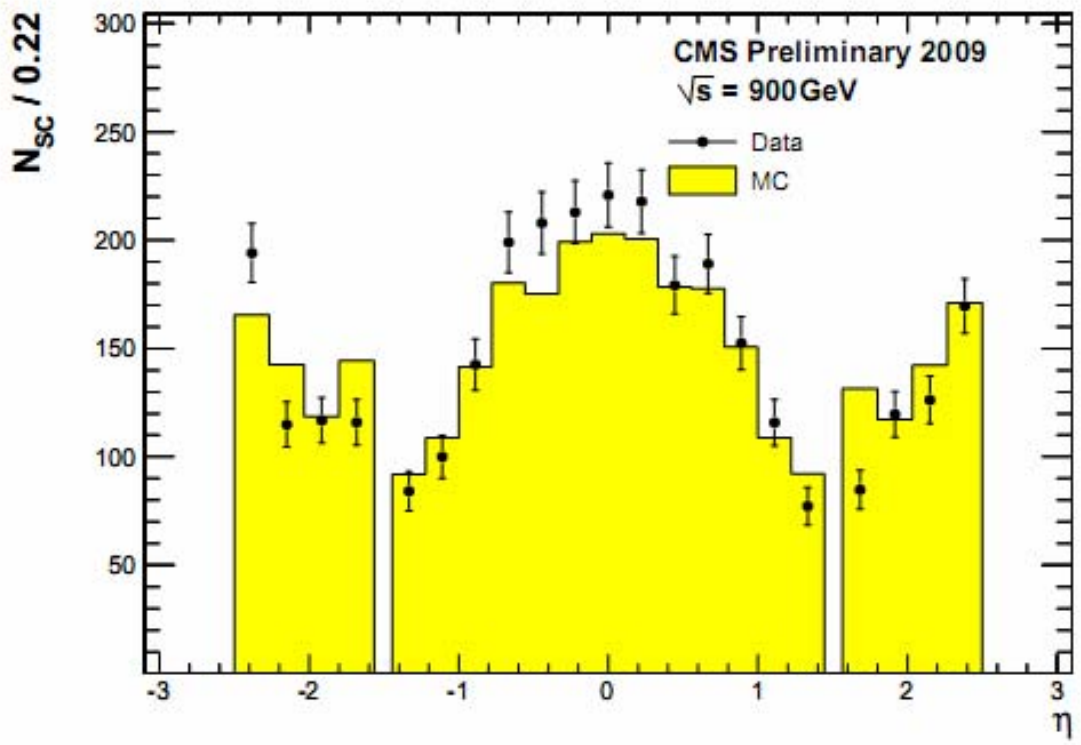
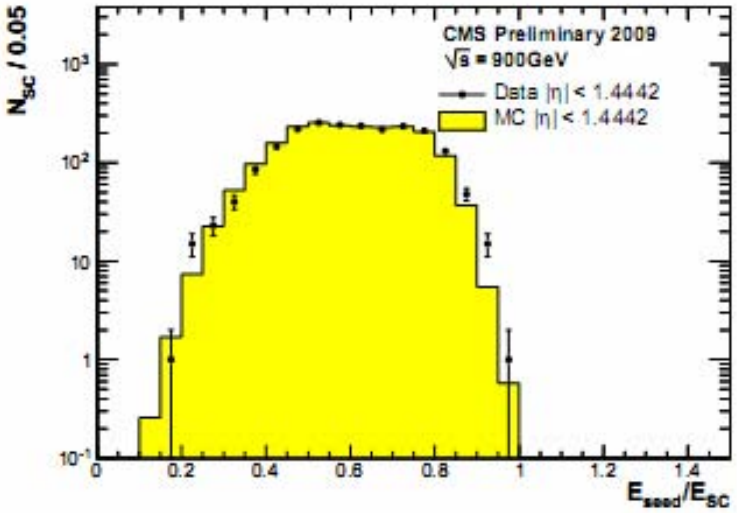


Figure 2: Pseudorapidity distribution of the superclusters. The black points correspond to data and the histogram to simulated minimum bias events.

E_1/E_{SC}



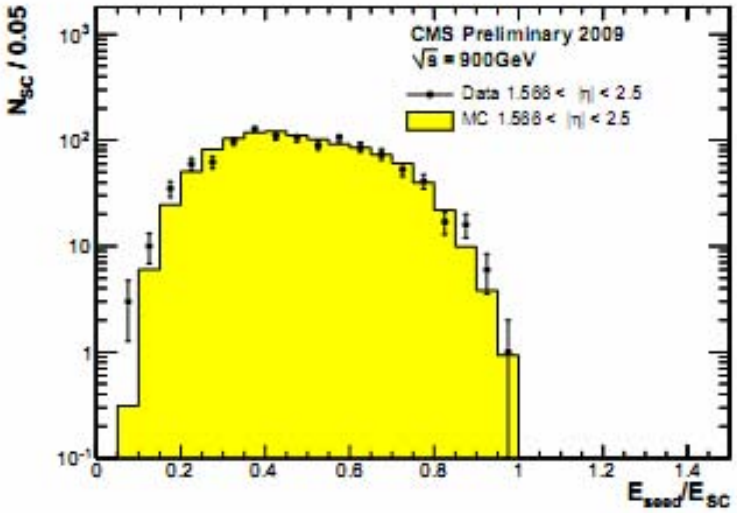


Figure 3: Ratio between the most energetic crystal energy and total supercluster energy for the barrel (left) and endcaps (right) SCs. The black points correspond to data and the histogram to simulated minimum bias events.

E_{2x5}/E_{5x5}

This ratio may be larger than one due to fluctuation of the electronic noise to the lower side of the pedestal for crystals in regions that are fully read out.

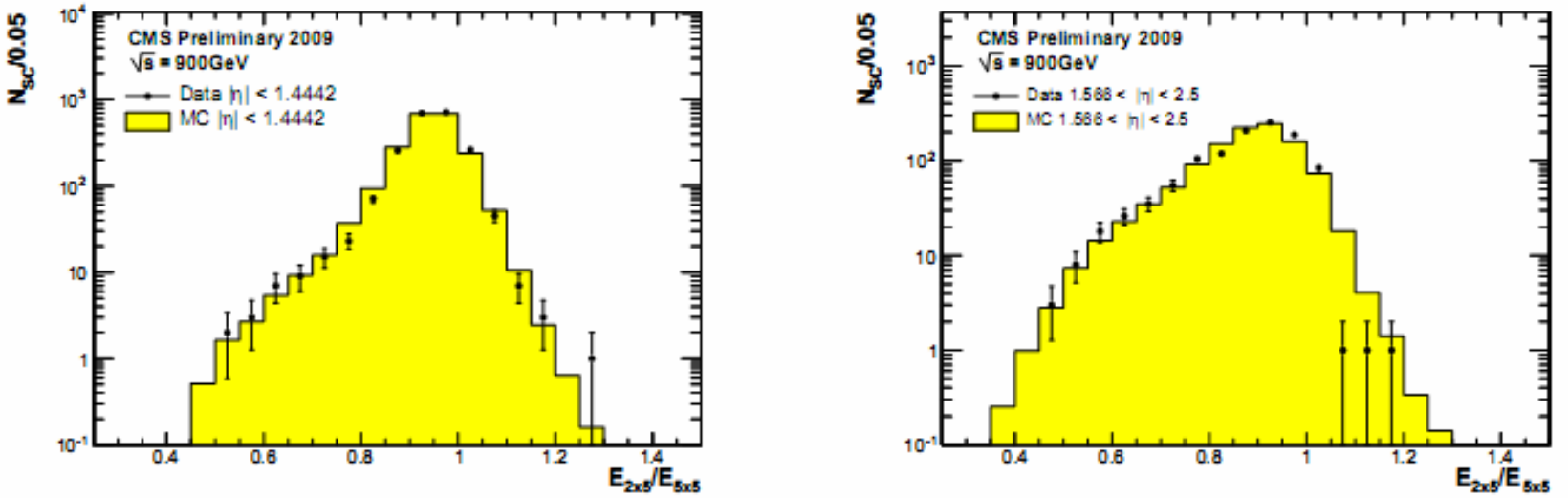


Figure 4: Ratio between the energy contained in the 2x5 crystal eta-strip and the energy in the 5x5 crystal array for the barrel (left) and endcaps (right) SCs. The black points correspond to data and the histogram to simulated minimum bias events.

$R9=E_{3x3}/E_{sc}$

R9 is used to discriminate between converted and unconverted photons(the same reason for the values larger than one)

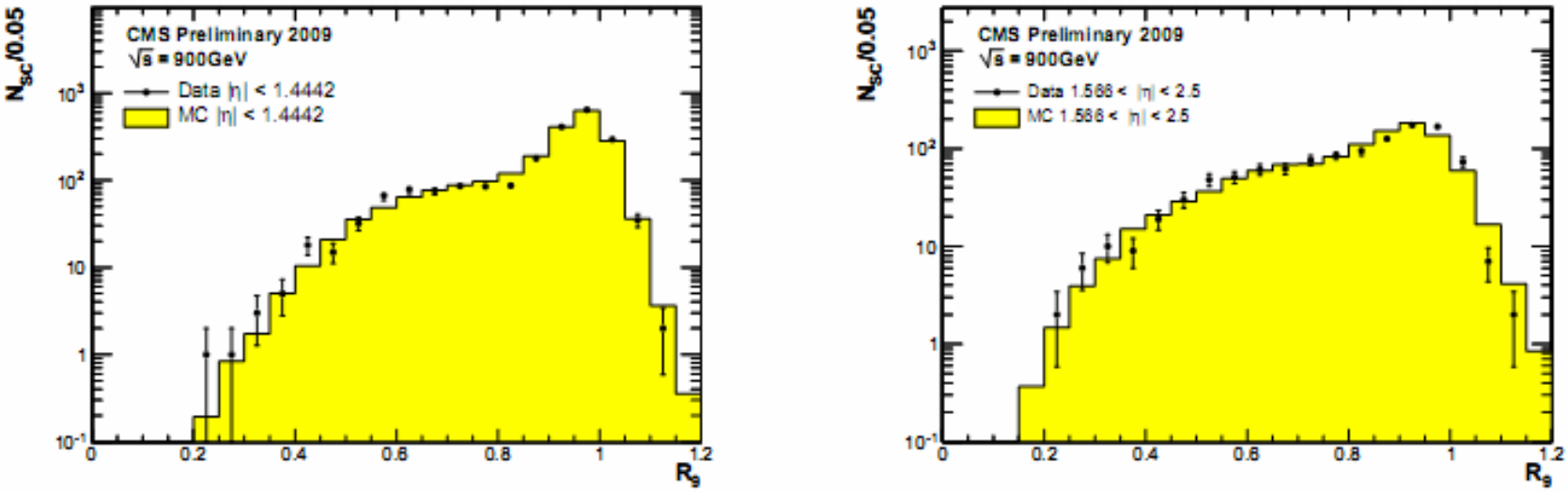


Figure 5: R9: ratio between the energy contained in the 3x3 region around the seed crystal and the total supercluster energy for the barrel (left) and endcaps (right) SCs. The black points correspond to data and the histogram to simulated minimum bias events.

H/E

The ratio of the energy in the HCAL behind the SC and the energy of the SC itself. For HCAL, only towers with energy greater than 0.7 and 0.8 GeV are considered in the sum respectively for barrel and endcaps.

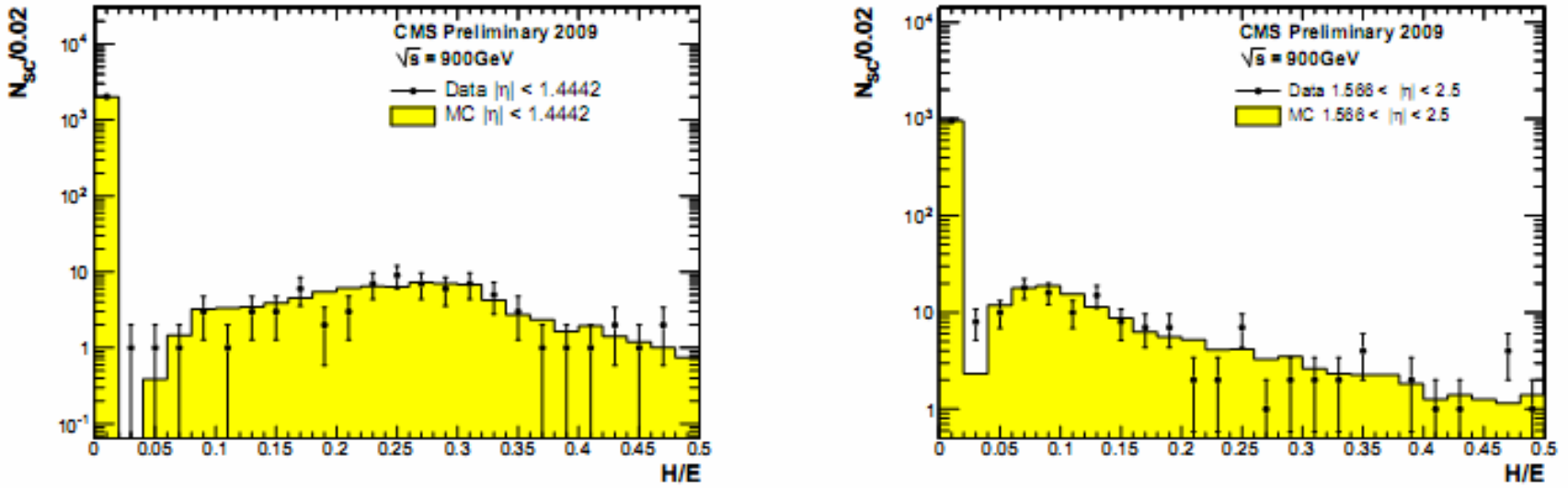


Figure 6: H over E distribution for SCs in the barrel (left) and endcaps (right). The black points correspond to data and the histogram to simulated minimum bias events.

Conclusion for supercluster part

- good agreement is observed for all the variables considered.

Preshower data-MC comparisons

- The preshower clusters are associated to ECAL superclusters with raw transverse energy larger than 2 GeV and $|\eta| < 2.5$.

Preshower data-MC comparisons

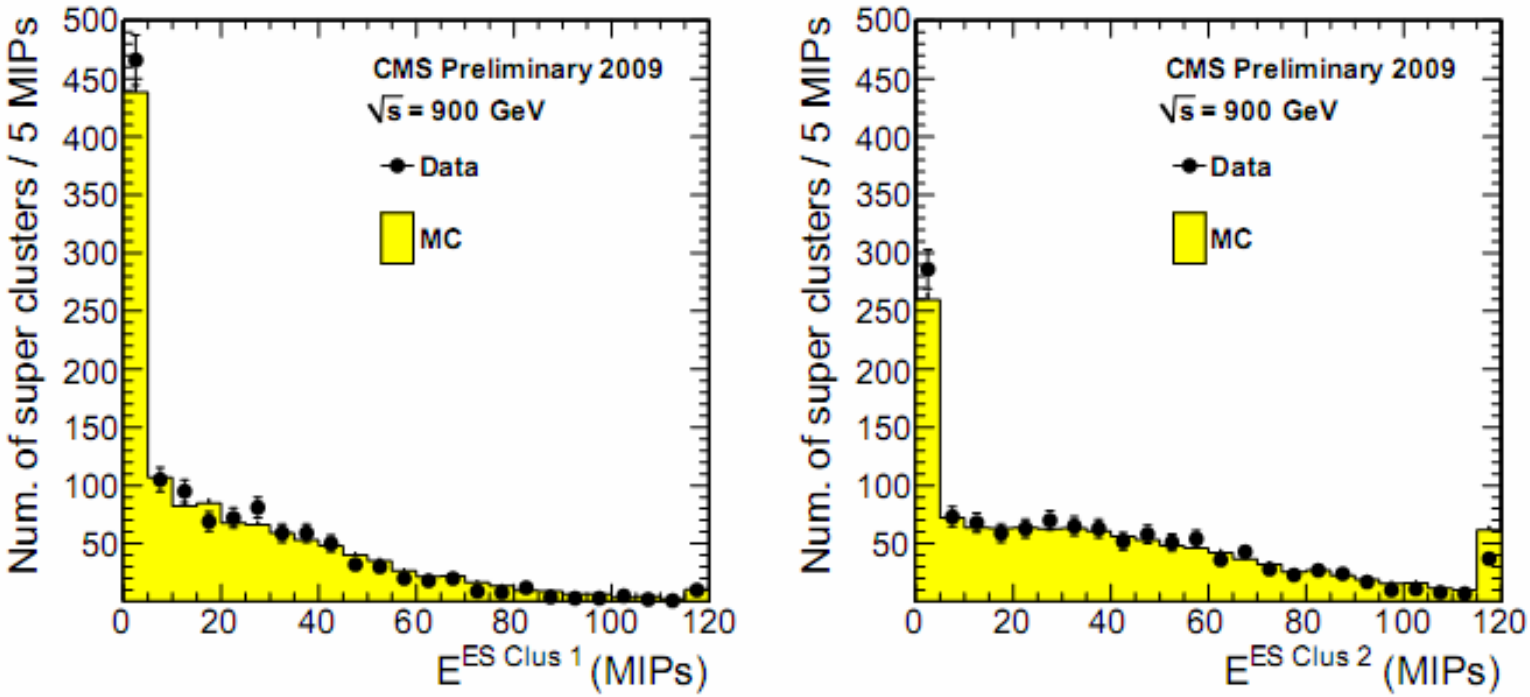
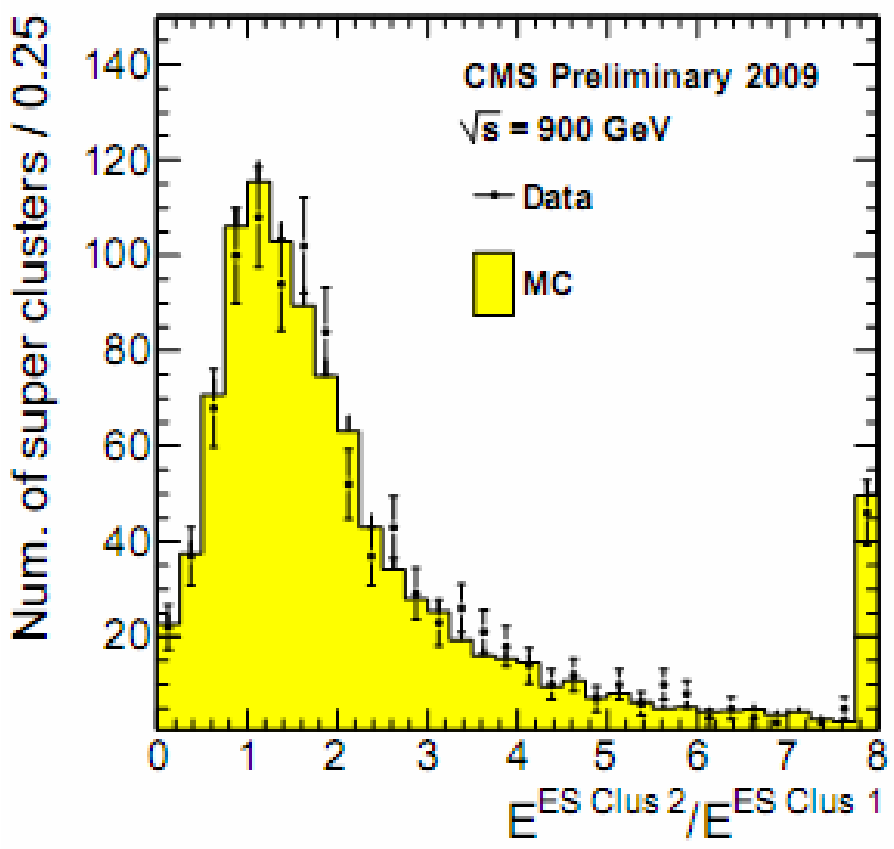


Figure 8: Energy deposited in each of the two ES planes for supercluster raw transverse energy larger than 2 GeV. Overflows are added to the last bin.

The preshower detector (ES) in front of the ECAL endcaps covers the 1.65< | η | < 2.6 region.

- The ratio of the energy deposit associated with a supercluster on the second ES plane to the first one for supercluster raw transverse energy larger than 2 GeV. Overflows are added to the last bin.

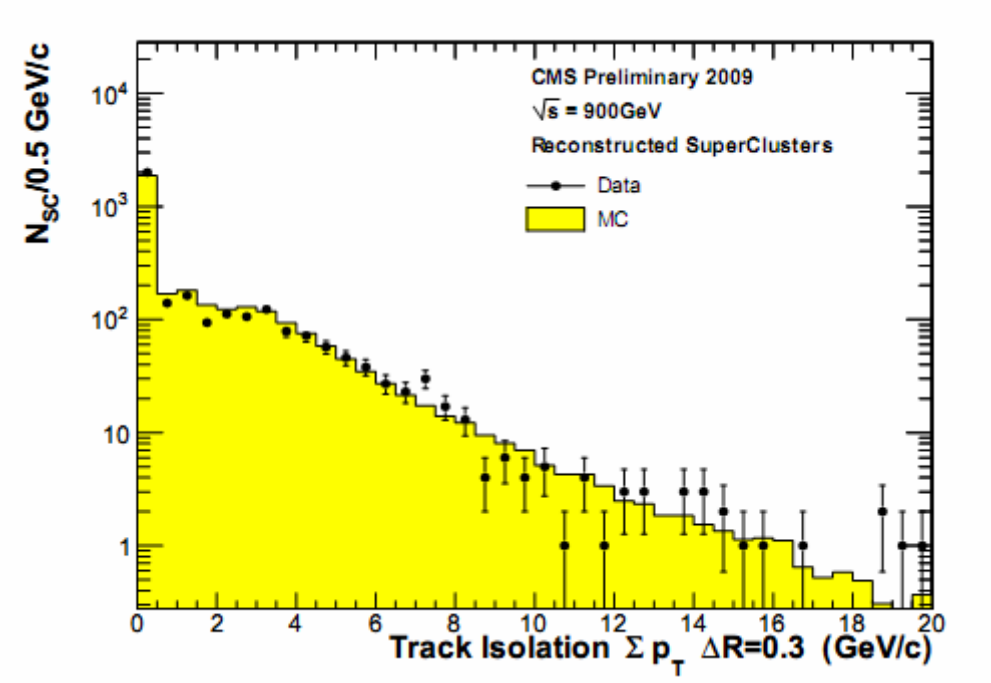


Conclusion for preshower part

- Also a good agreement.
- We also checked that the individual distributions observed in the two endcap halves are consistent with each other.

Supercluster isolation studies

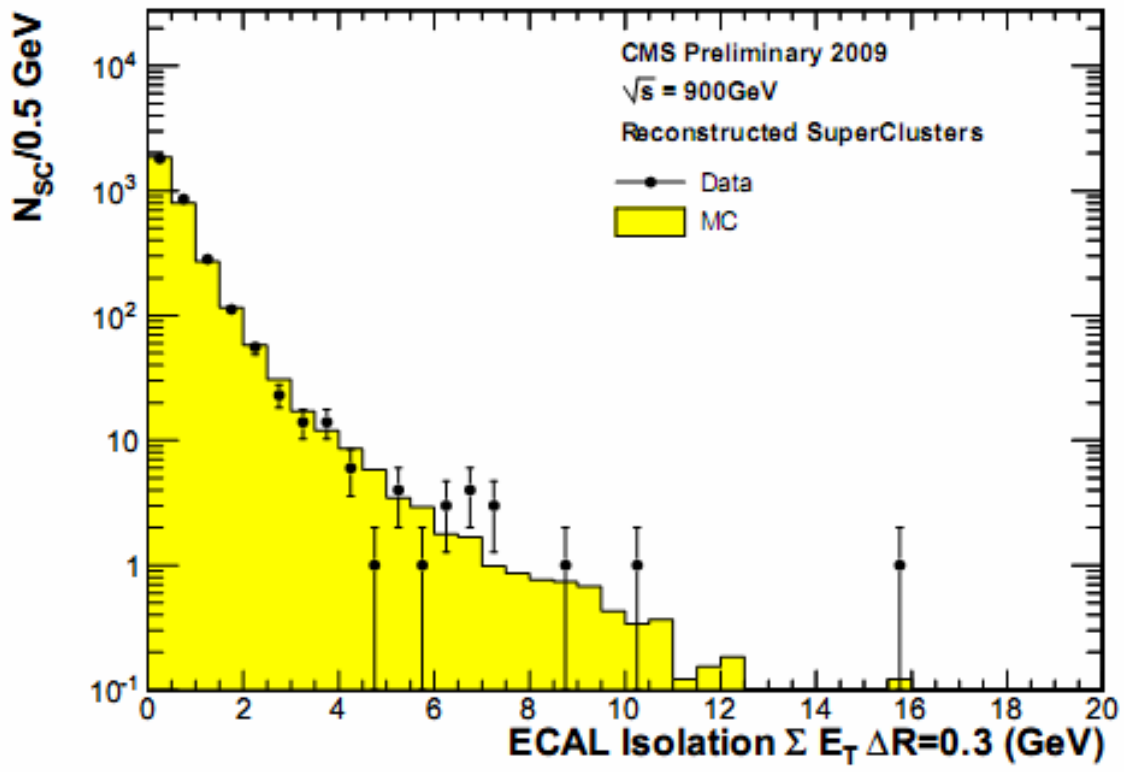
- Track isolation: the sum of the transverse momenta of Kalman Filter tracks that are reconstructed in a hollow cone around the reconstructed object. The dimensions of the cone are $0.04 < \Delta R < 0.3$. Only tracks with transverse momentum greater than 0.7 GeV are considered in the sum.



Ecal isolation

- the sum of the transverse energy reconstructed in individual channels of the ECAL in a cone around the reconstructed object with outer cone sizes $\Delta R = 0.3$ and inner cone radius corresponding to the size of 3 ECAL crystals ($\Delta R \sim 0.05$ in barrel region). The transverse energy in channels that are found in a strip along Φ centered at the ECAL position of the reconstructed object with an η-width of 3 crystals are also not considered in the sum.
- Only those reconstructed hits with the absolute value of the energy greater than 0.08 GeV in the ECAL barrel (EB) and 0.1 GeV in the ECAL endcaps (EE) are considered. The cut on the absolute value of the energy is aimed at averaging out the effect of noise and it may give rise to negative values of the ECAL isolation variable.

Ecal isolation

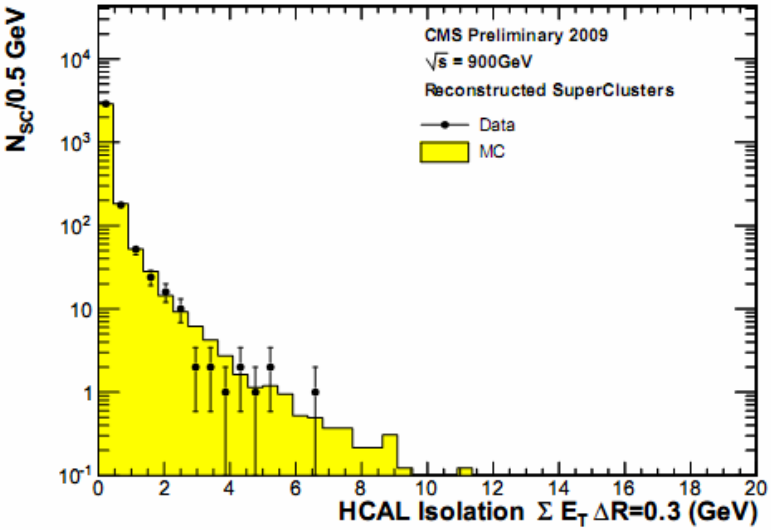


Hcal isolation

the sum of the transverse energy of HCAL towers in the region behind the ECAL cluster of the reconstructed object in a cone with dimensions $0.15 < \Delta R < 0.3$. The energy is summed of towers which have an energy greater than

0.7 GeV in the barrel and

0.8 GeV in the endcap.



Conclusion for supercluster isolation part

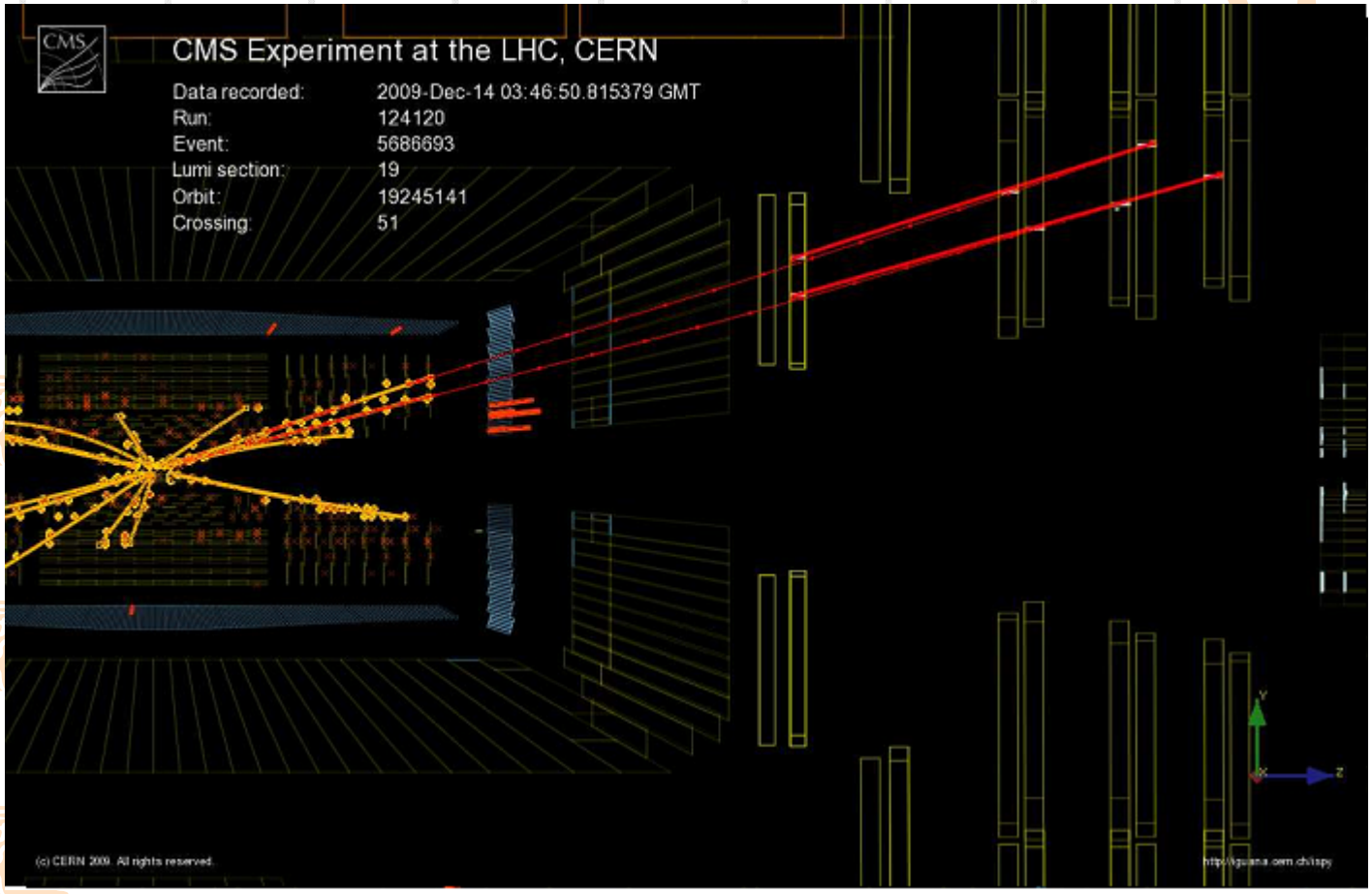
- Also a good agreement.

Summary

- All kinematic and identification variables which have been considered show a good agreement between data and Monte Carlo, leading to the conclusion that the response of the subdetectors is well modeled in the simulation and that the algorithms designed and optimized in the simulation show a behavior consistent with what is expected.
- The commissioning of the electromagnetic physics objects will continue with the upcoming LHC data at higher center of mass energies.

Backup

To show barrel and endcap



Something about the supercluster reconstruction

- A characteristic of the ECAL is the so called 'Selective Readout' SR. It consists of the full readout of groups of 5x5 crystals corresponding to the trigger towers. When one of the ECAL trigger towers measures a transverse energy larger than 1 (or 2) GeV, all channels in that tower (or in that tower and in the eight towers around it) are read out. In all the rest of the ECAL a zero suppression is applied.
- During the 2009 data taking, some of the ECAL trigger towers,particularly in the endcaps, were not perfectly timed in and this caused the SR to sometimes not trigger the full read-out even when a region was above threshold. We did not correct the MC to account for this effect and this caused some small discrepancies for variables that are sensitive to very little amount of noise or to negative fluctuations below the pedestal.

About the phi plot

- The presence of material in front of the calorimeter results in bremsstrahlung and photon conversions.
- Because of the strong magnetic field the energy reaching the calorimeter is spread in ϕ.