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Experience in the electron reconstruction with first CMS data

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Abstract

The first CMS data from the center-of-mass energy of 900 GeV proton-proton collisions were analyzed in order to commission electron reconstruction and assess its performance. A comparison between data and simulation of all the key ingredients for the electron physics objects reconstruction and identification was performed. The good agreement shown indicates that the sub-detectors response is well modeled in the simulation and that the algorithms designed and optimized with the simulation are functioning as expected.

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Experience in the Electron reconstruction with first CMS data

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The first CMS data from the center-of-mass energy of 900 GeV proton-proton collisions were analyzed in order to commission electron reconstruction and assess its performance. A comparison between data and simulation of all the key ingredients for the electron physics objects reconstruction and identification was performed. The good agreement shown indicates that the sub-detectors response is well modeled in the simulation and that the algorithms designed and optimized with the simulation are functioning as expected.

1. INTRODUCTION

The Large Hadron Collider at CERN started operation at the end of 2009 providing each experiment proton-proton collisions at the centre-of-mass energies of 0.9 and 2.36 TeV, for a total integrated luminosity of $\sim 10\mu b^{-1}$ and $\sim 4\mu b^{-1}$ respectively. Electron objects have good energy resolution and provide a clean signature, thus being of great importance for physics searches at the LHC and for detector commissioning purposes. Data collected at $\sqrt{s}$=900 GeV were used to check the basic ingredients contributing to the reconstruction of electromagnetic physics objects, through a comparison with the simulation. Since most of the reconstructed electron objects are fakes or conversions, 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 [1].

2. CMS DETECTOR

CMS is one of the two multipurpose experiments collecting data at the LHC.

The central feature of the CMS apparatus is the compact structure given by a superconducting solenoid, of 6 m internal diameter, providing an uniform magnetic field of 3.8 T. Inside the solenoid are the silicon pixel and strip tracker, the crystal electromagnetic calorimeter and the brass-scintillator hadronic calorimeter (HCAL). Muons are measured in gas chambers embedded in the iron return yoke.

The elctromagnetic calorimeter (ECAL) and the tracker are used to measure electrons. ECAL is a homogeneous calorimeter made of 75848 lead tungstate scintillating crystals. It consists of a central barrel covering the pseudorapidity region up to $|\eta| \simeq 1.5$ and two endcaps which extend up to $|\eta|$=3.0 to provide the coverage for precision measurements. The tracker is made of 1440 silicon-pixel and 15148 silicon-strip detector modules and measures charged particles trajectories within the pseudorapidity range $|\eta| < 2.5$. The pixel tracker consists of three barrel layers and two endcap disks on each side of the barrel section. The barrel layers are located at a radius of 4.4 cm, 7.3 cm and 10.2 cm respectively.

A detailed description of the CMS detector can be found in [2].

3. THE ENERGY RECONSTRUCTION

Energy reconstruction relies on the clustering of the energy deposited in the ECAL crystals into superclusters (SC). A dedicated dynamic algorithm was designed flexible in the ϕ direction [3].

Electron and photon showers deposit their energy in several crystals in the ECAL and 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.

Kinematic and shower shape variables were compared in data and Monte Carlo and a good agreement was observed between data and simulation for all the considered variables. As an example, figure 1 shows the distribution in the barrel of R9, the ratio of the energy contained in the 3x3 region around the seed crystal and the total supercluster energy. R9, which is used to discriminate between converted and unconverted photons, can be larger than 1 for the low energy clusters examined here due to fluctuations in the electronic noise.

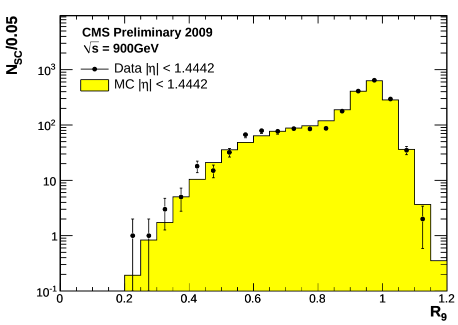

Figure 1. Ratio between the energy contained in the 3x3 region around the seed crystal and the total supercluster energy for barrel superclusters. Data (black dots) are superimposed on Monte Carlo distribution (filled histogram). The MC distribution is normalized to total number of candidates observed in the data.

4. THE ELECTRON TRACKING

Electron objects are characterized in CMS by a charged track pointing to a supercluster in the ECAL. The tracking algorithm starts from a pretrack (seed), which is reconstructed by looking for a couple of measured hits in the tracker layers. Two different algorithms are used in CMS to find electrons. The *ECAL driven* one profits from the supercluster position and energy measurements to estimate the position of the electron track in the innermost part of the tracker. This algorithm is optimized for isolated electrons in the p_T range relevant for Z or W decays down to 4 GeV/c. The *tracker driven* algorithm starts from measured hits in the tracker and uses track extrapolation to associate bremsstrahlung clusters in the ECAL. It is more suitable for low p_T and not-isolated electrons. Figure 2 shows the transverse momentum distribution of ECAL driven (top) and tracker driven (bottom) electrons and the behavior of data is well reproduced by the simulation even at very low energies.

Since the energy loss distribution for electrons tracks is characterized by a long non Gaussian tail due to radiative interactions of electrons in the tracker material, a Gaussian-sum filter (GSF) algorithm for electron track reconstruction in the CMS tracker has been developed and implemented [4]. Such an algorithm, being able to follow the change of curvature of the electron track, allows to obtain an unbiased estimate of the track momentum at both track ends. This allows for a tracker measurement of the fraction of energy lost by bremsstrahlung (*fbrem*), defined as the relative difference between the momentum at the vertex and the momentum at the last point. This variable plays an important role in the electron identification and it is useful to verify its effectiveness, comparing its distribution with the simulation.

5. THE ELECTRON OBJECT

The standard selection of electron candidates at reconstruction level consists of cuts at seeding level and of a preselection. Further electron identification is then achieved using shower shape variables and refined track-cluster matching. As an example, figure 3 shows the *fbrem* distribution for the electron candidates, which is peaked at *fbrem*=0 since most of the candidates are fakes.

Isolation requirements can be imposed to sup-

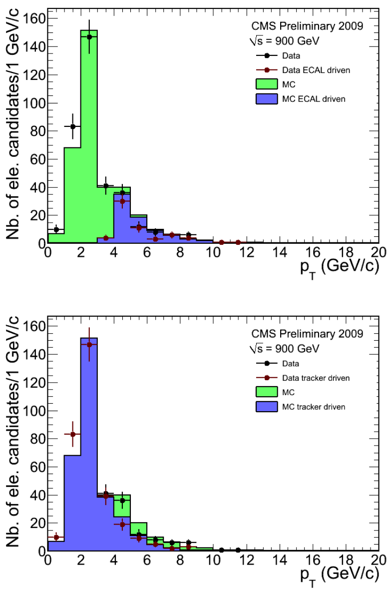

Figure 2. Distribution of the electron candidates transverse momentum in the data (dots) compared to the Monte Carlo (filled histogram): contributions of electron candidates found by the *ECAL driven* algorithm (top) and by the *tracker driven* one (bottom).

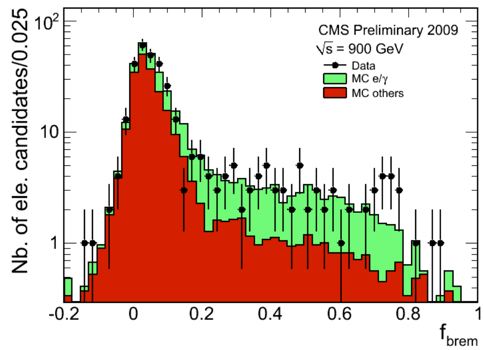

Figure 3. *fbrem* distribution for the reconstructed electron candidates. The Monte Carlo expectation for electron candidates matched to a generated electron or photon is also shown (filled green histogram).

press the QCD background: a simple and powerful isolation criterion comes from the sum of the energy deposited in a ring region around the reconstructed candidate. Isolation variables for superclusters and reconstructed electrons were compared between data and simulation showing an overall good agreement. The modeling of the noise and underlying event simulation was tested by computing the isolation variables for cones centered in random directions.

6. CONCLUSIONS

The first proton-proton collision data collected with the CMS detector at $\sqrt{s}$=900 GeV were used to perform a detailed comparison between data and MC of many quantities entering the reconstruction of electromagnetic objects. The reconstructed electrons in the analyzed samples are mainly from conversions, which are not the electrons for which the reconstruction algorithms have been designed and optimized. All the considered variables 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 behavior is consistent with expectations. The commissioning of the electromagnetic physics objects is continuing with the 2010 LHC data at the center-of-mass energy of $\sqrt{s}$=7 TeV.

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