Electron and photon measurement with the CMS detector

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Electrons and Photons play a crucial role at LHC in several fields. They provide important signatures for discovery of the Higgs Boson, for discovery of supersymmetry, or for the discovery of new heavy bosons like the Z'. Clean identification and excellent energy and momentum resolution where given high priority in the design of the CMS detector. The instrument, featuring a finely grained, high-resolution electromagnetic calorimeter and excellent tracking performances, is well equipped for the task of measuring these particles with high precision. In this contribution we will describe the CMS electron and photon identification and reconstruction capabilities.

1 Introduction

The CMS detector was designed giving great importance to the identification and measurement of photons and electrons. The goals of the experiment include the search for the Higgs boson, the search for new heavy bosons and the identification of possible supersymmetric particles. Two of the most promising discovery channels for the Higgs boson are $H \rightarrow \gamma\gamma$ and $H \rightarrow l^+l^-e^+e^-$ with $l = \mu, e$. For the first one, an excellent resolution of the photon energy is required in order to discern a possible invariant mass peak from the background. An hypothetical Z' boson could decay to an electron pair, which would be important to measure with high precision. Also, it is important to measure leptons in the final state of possible supersymmetric particles. The CMS detector relies on the Electromagnetic calorimeter (ECAL) to measure photons with high precision, and on the combination of the ECAL and tracking detectors to identify and reconstruct electrons.

2 The Electromagnetic Calorimeter (ECAL)

The ECAL is made of 76000 lead tungstate scintillating crystals, arranged in a *barrel* for the central region and an *endcap* for the forward regions. Crystals are equipped with avalanche photo diodes in the barrel and vacuum photo triodes in the endcaps. For energies above 100GeV the resolution is dominated by a constant term determined predominantly by the intercalibration precision. For lower energies the resolution is dominated by a stochastic term of around $2.8\% /\sqrt{E}$. Several studies have shown that it will be possible to intercalibrate each channel to a precision of 0.5%.

3 Energy reconstruction

97% of the shower produced by unconverted photons is contained in the 5x5 matrix of crystals in the η, ϕ plane. Nearly 50% of the photons will convert in the tracker material. For electrons the measurement is complicated by bremsstrahlung phenomena. Because of the 3.8 T solenoidal magnetic field, bremsstrahlung photons will deposit their energy in the calorimeter in the form of small clusters along the ϕ coordinate. This energy is recovered using appropriate clustering algorithms that identify superclusters, i.e. clusters of clusters including those produced by the original electron and its radiated photons. Starting with a seed crystal containing a local maximum of energy, superclusters are built within a narrow window in eta, following the energy spread by the magnetic field in the phi direction.

4 Photon identification and reconstruction

Excellent reconstruction of unconverted photons can be achieved in CMS. The energy of those photons is measured best using the energy contained in a 5×5 crystal matrix around the seed crystal, corrected for the lateral leakage correction $f(\eta)$ and for module border effects but otherwise uncorrected. Several criteria are used to identify true photons: tracker isolation, ECAL isolation, hadron calorimeter isolation, hadronic to electromagnetic ratio and R_9, which is the ratio of the energy contained in a 3×3 matrix and the supercluster energy. For example a π^0 will have a lower value of R_9 (Figure 1) when compared to an isolated photon.

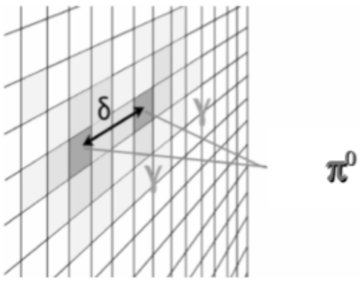

Figure 1: A π^0 produces a shower with a low value of R_9

5 Electron identification and reconstruction

Electron candidates are found when a supercluster can be associated to a track reconstructed in the silicon tracker detector, and in particular its innermost layers. The seeding strategy can be ECAL driven or tracker driven. The ECAL driven electron seeding is very efficient for $p_T^e > 10GeV/c$. The tracker driven seeding uses a boosted decision tree to perform a preselection of the tracker clusters, in order to reduce the fake rate due to light hadrons. This strategy is more efficient for low p_T electrons and electrons within jets (non isolated). The electron track fit must account for the different energy loss mechanism of electrons compared to other charged particles, in particular the non gaussian nature of bremsstrahlung losses. This is accomplished using the Gaussian Sum Filter, that allows a good estimation of the track momentum both at the ECAL surface and at the interaction point. The reconstruction efficiency measured on di-electron events using a tag and probe method is shown in Figure 2 .

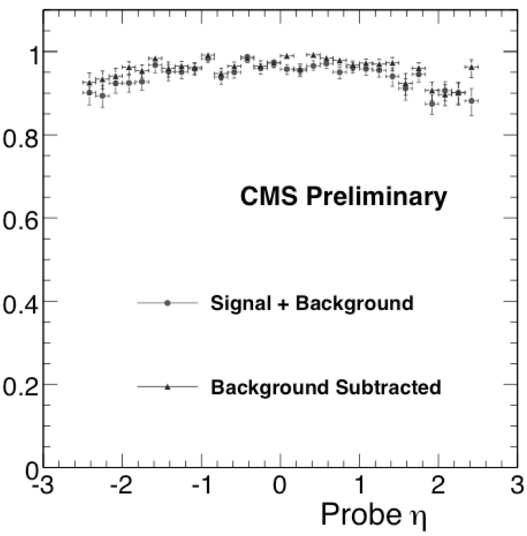

Figure 2: Electron reconstruction efficiency as a function of pseudorapidity studied on di-electron events

6 Conclusions

The CMS electromagnetic calorimeter is ready for data taking. It has been intercalibrated using cosmic rays stands and test beams to a level of 1% or 2% in the barrel and 10% in the endcaps. Cross checks have been performed using dE/dx measurements and beam dump events. Simulations show that the electron and photon reconstruction algorithms perform well. Of course much tuning work will be needed to understand the detector once real data are available.

References

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