

Momentum resolution of the CMS detector in high pileup pp collisions

Karla J. Pena Rodriguez
Summer Student Programme

August 9, 2013

1 Introduction

The momentum resolution of the CMS detector for electrons in high luminosity events is estimated from Monte Carlo (MC) simulation, as part of the Phase-II upgrade studies for the High Luminosity Large Hadron Collider (HL-LHC). The events considered in the analysis have a large number of interactions per bunch crossing which do not come from the primary vertex (PV) and its underlying event, known as pileup (PU) interactions. The electron momentum resolution is estimated from Monte Carlo (MC) simulation of events with a 140 pileup events.

2 Momentum resolution for electrons from simulated $gg \rightarrow H \rightarrow ZZ \rightarrow 4l$ events

The momentum resolution for electrons in $gg \rightarrow H \rightarrow ZZ \rightarrow 4l$ events is estimated from Monte Carlo (MC) simulation. The momentum resolution is computed as

$$\sigma = \frac{p_{\text{reco}} - p_{\text{true}}}{p_{\text{true}}} \quad (1)$$

where p_{true} is the true momentum of the generated electron and p_{reco} is the electron momentum reconstructed by the clustering algorithm.

The momentum resolution distribution is extracted in several bins of pseudorapidity (η) and transverse momentum (p_T), and is fitted with a Crystal Ball (CB) function:

$$\text{CB}(x) = \begin{cases} N e^{-\frac{1}{2} \left(\frac{x - \mu_{\text{CB}}}{\sigma_{\text{CB}}} \right)^2} & \frac{x - \mu_{\text{CB}}}{\sigma_{\text{CB}}} < \alpha \\ N \left(\frac{n}{\alpha} \right)^n e^{-\frac{\alpha^2}{2}} \left(\frac{n}{\alpha} - \alpha + \frac{x - \mu_{\text{CB}}}{\sigma_{\text{CB}}} \right)^{-n} & \frac{x - \mu_{\text{CB}}}{\sigma_{\text{CB}}} \geq \alpha \end{cases} \quad (2)$$

where the parameter μ_{CB} represents the relative mean deviation of the reconstructed electron momentum with respect to the true electron momentum, σ_{CB} is the width of the Gaussian component of the CB function, and the parameters α and n of the CB function account for electrons whose energy is not correctly reconstructed by the clustering algorithms [1]. The electron momentum resolution is estimated by the σ_{CB} parameter.

A chi-square fit to the momentum resolution is performed. Figures [reffig](#): show the momentum resolution distributions for electrons detected the electromagnetic calorimeter (ECAL) barrel and endcap. In each plot, fitted values of μ_{CB} and σ_{CB} are listed, as well as the histogram mean and RMS. The errors computed for each bin is the square root of the sum of the square of weights for that bin. The result has a systematic uncertainty due to the dependence of the result on the fitting method, which must be determined from further analyses.

2.1 Momentum resolution as a function of pseudorapidity

Figure 1 shows the value of the σ_{CB} parameter in several bins of pseudorapidity, from the central region of the ECAL barrel ($|\eta| < 0.8$), where momentum is expected to be better reconstructed, to the limit between barrel and endcap ($|\eta| = 1.5$), and the end of the region covered by the silicon tracker ($|\eta| < 2.5$). For greater values of pseudorapidity, electron and photon separation is not possible.

Figure 5 shows the value of the distribution RMS and of the σ_{CB} parameter, which is width of the Gaussian component of the fit, as a function of pseudorapidity. This plots includes information for $2.5 \leq |\eta| < 3.0$, which is the region of the endcap where photon and electron separation is not possible. As expected, the error is larger than for regions of lower pseudorapidity.

2.2 As a function of transverse momentum

Figures 3 and 4 show the value of the σ_{CB} parameter, which is width of the Gaussian component of the fit, as a function of transverse momentum, p_T .

Figure ?? shows the value of the σ_{CB} parameter as a function of transverse momentum, for electrons detected in the ECAL barrel and endcap.

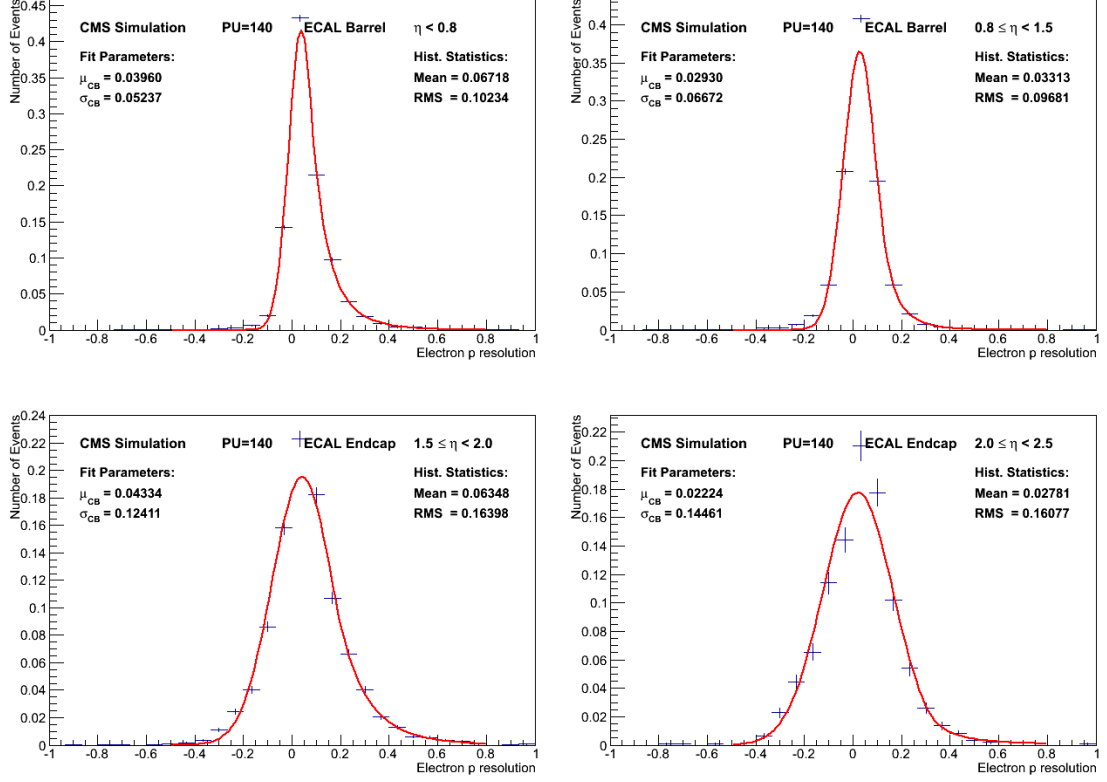


Figure 1: Electron momentum resolution in bins of pseudorapidity

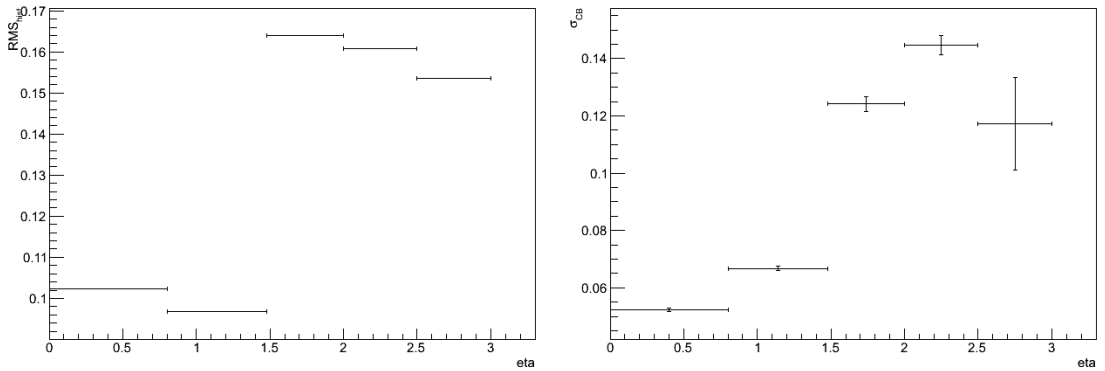


Figure 2: Electron momentum resolution as a function of pseudorapidity

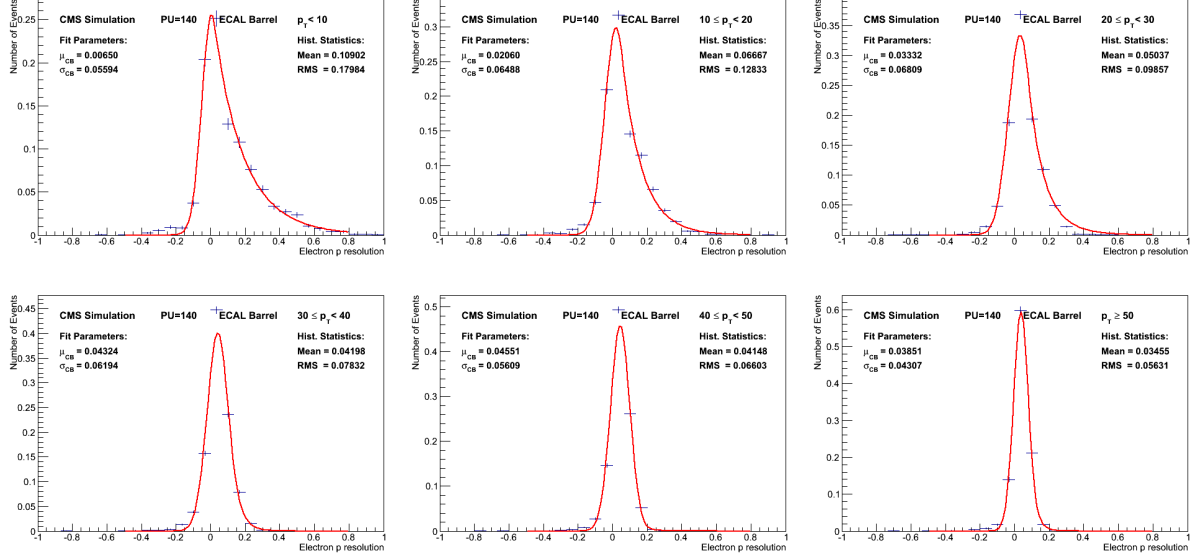


Figure 3: Electron momentum resolution for electrons detected in the ECAL barrel (EB) in bins of transverse momentum

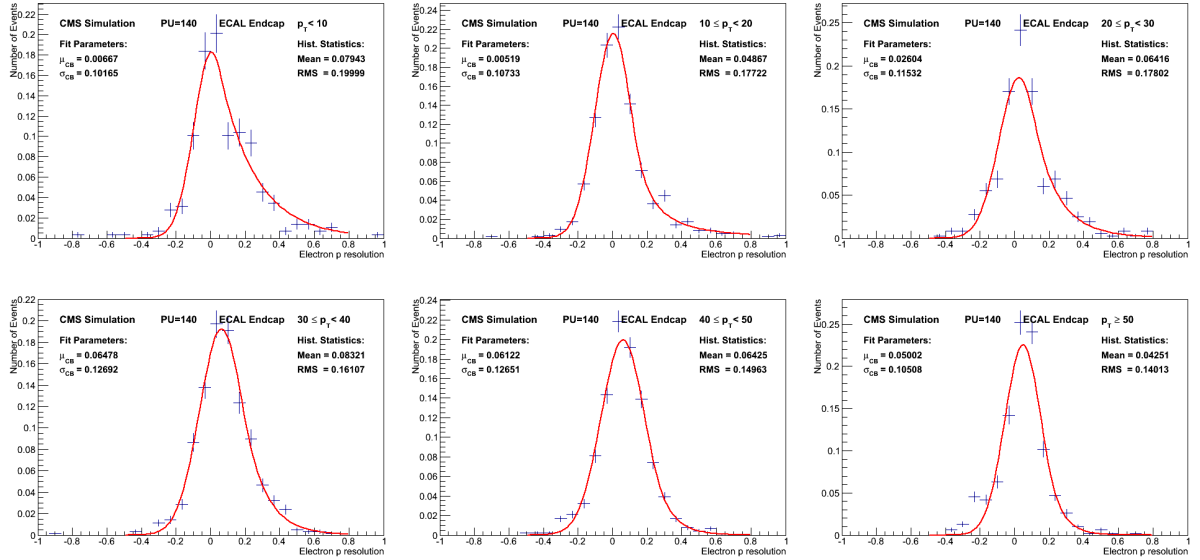


Figure 4: Electron momentum resolution for electrons detected in the ECAL endcap (EE) in bins of transverse momentum

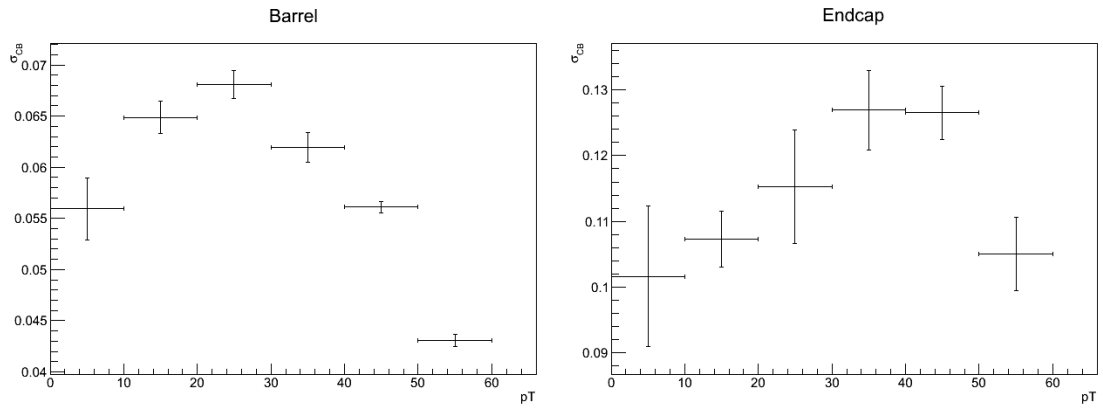


Figure 5: Electron momentum resolution as a function of pseudorapidity

References

- [1] CMS Collaboration, “Energy calibration and resolution of the CMS electromagnetic calorimeter in pp collisions at $\sqrt{s} = 7$ TeV”, CMS-EGM-11-001, (2013).