Photon pair-production Resolution Studies of the High Granularity Calorimeter of the CMS experiment at the LHC at CERN

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Introduction

The Large Hadron Collider (LHC) is currently in the middle of the second Long Shutdown, which is used as part of a larger program to upgrade the collider to the High Luminosity LHC by the mid 2020s. The main goal of coming upgrades to the LHC is to increase the instantaneous luminosities which the collider can produce, in order to zero in on anomalies in the data. Figure 1 shows the past and expected future luminosities achieved. The big jump in instantaneous luminosity during the Third Long Shutdown (LS3), is the switch to the High Luminosity LHC (HL-LHC).

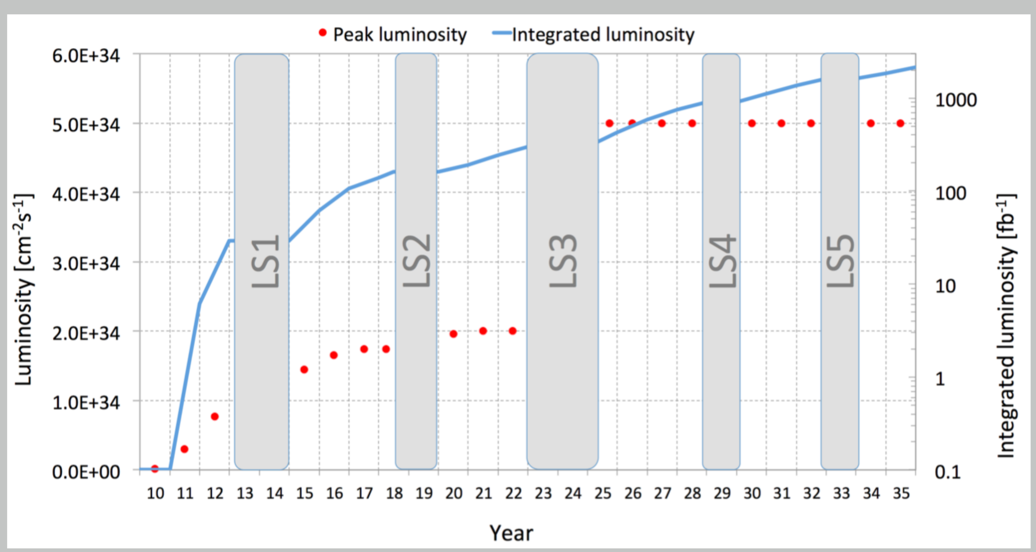

Figure 1: Instantaneous luminosity (red dots) and Integrated luminosity (blue line) of the LHC, during various phases in the upgrade cycle.

As part of the H-LHC upgrade, the dectector systems on the experiments are also being upgraded. This project is specifically concerned with the High Granularity Calorimeter (HGCAL) of the CMS experiment, and studying how the new detector will respond to photons with different detector settings. The detector will produce data at rates exceeding 100TB/s, which far exceeds the capacity of the read out channels. Therefore, a decision whether or not to read out the data (trigger decision) has to be made on detector within a small latency. The studies in presented in this poster aim to inform the development of such a trigger algorithm.

Background: The CMS HGCAL

The CMS HGCAL is radially symmetric every 60° around the beam axis. Longitudinally, it is made up of 52 layers, most of which use hexagonal Silicone Wafers as the detector material. On the Silicon wafers there are hexagonal subdivisions of area either

Background: Pileup

There is pileup. Basically there are always some particles flying around as a background. These also get caught in the detector, but have nothing to do with the event being observed. This is called pileup.
The HGCAL is mainly made out of xx layers of small hexagonal silican wafers, in which particles deposit their energy. This energy is then read out via an HGC read out chip (HGROC) and passed to a motherboard. 3 HGCROCs run into one motherboard. There are also some layers of scinitllator material in the hadronic calorimeter.
The detector geometry is usually destribed in reduced coordinates and in eta and phi. Eta is some complicated shit.

Methods

We are working on data compiled from CMSSW, the advanced software produced by the CMS team to simulate the physics of incoming collisions. These are very computationally heavy, so we work on the output files of these simulations. These files are root ntuples, containing segmented data of all the results. We then simulate a detector environment and different trigger mechanisms, and analyse the resulting output.
There are several clustering mechanisms:

1. Triggering on the generated particle (only in theory).
2. Triggering on all trigger cells above a threshold.
3. Triggering on trigger cells whose energy content is significantly higher than the surroundings.
4. Triggering on groups of trigger cells whose energy content is significantly higher than the surroundings.

Results

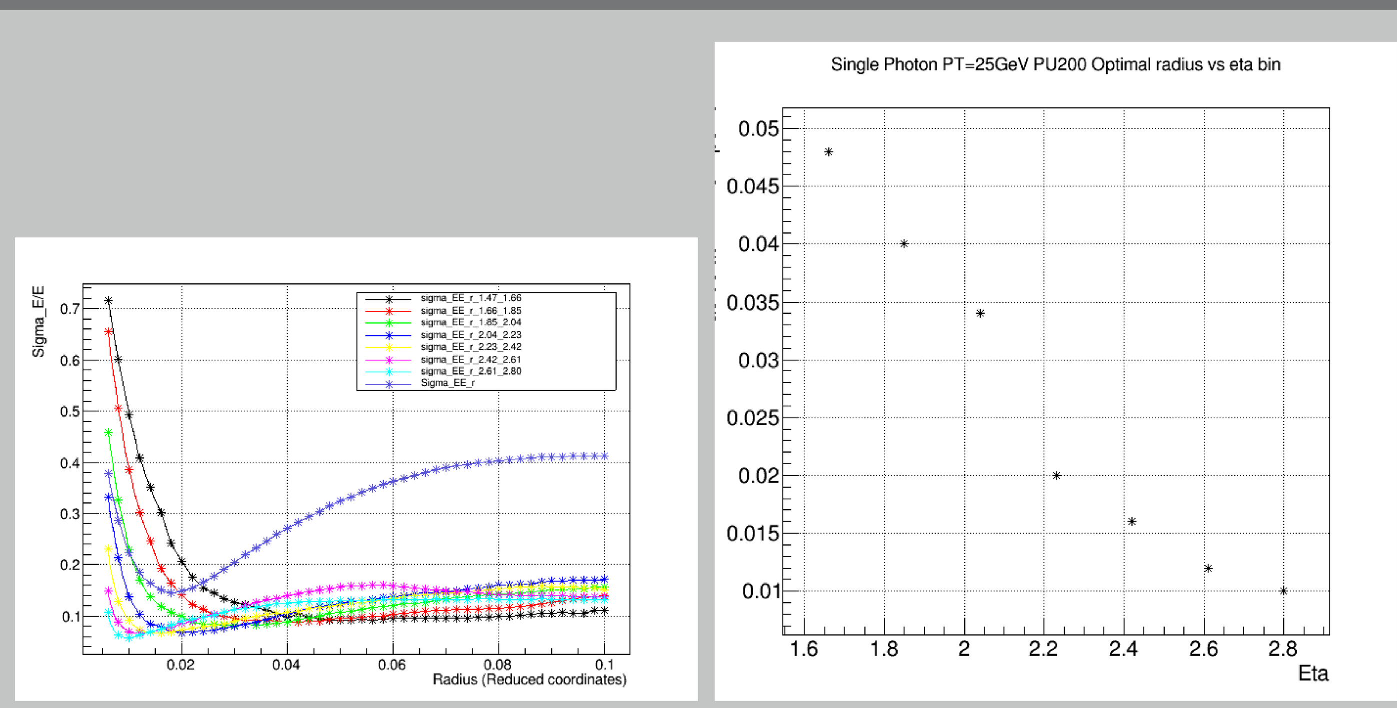

Figure 2: This shows the standardized error on the energy measurement (y-axis) plotted against different radii for the whole detector (dark blue line), and for individual eta segments(other lines). The key result is that the smallest achievable error significantly decreases when different radii are used for different eta segments.

Conclusion

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References

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