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HO Weight Factor in Particle-Flow Algorithm in CMS Experiment

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Abstract

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HO Weight Factor in Particle Flow Algorithm in CMS Experiment

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Abstract. The weight factors of Outer Hadron Calorimeters in Particle Flow algorithm used in CMS has been optimized using dijet and γ+jet samples from the data collected in 2015 and 2016. The response of the hadron calorimeter depends on the shower depth as well as the total energy of the jet, hence energy dependent weight factors are also considered in this study along with its dependence on pseudorapidity.

Keywords: Experimental High Energy Physics, Calorimeter, Detector Calibration, Data Analysis

1 Introduction

The Compact Muon Solenoid (CMS)[1], one of the two general purpose detectors at LHC, contains, as we go radially outward from the beam line, a tracker, an electromagnetic calorimeter, a hadron calorimeter inside 3.8 T solenoidal magnetic field and a muon spectrometer outside the magnetic field. CMS also has a Outer Hadron calorimeter (HO) outside the magnetic field, before the muon chamber, to sample the tail of the highly energetic hadron showers as hadron calorimeter inside the magnet is not sufficiently thick to capture completely the shower initiated by the highly energetic jets. HO consists of five rings in total. The one at central region with two layers, about $\eta = 0$, at different depths is known as Ring 0. The other four rings are Ring $1(-1)$, Ring $2(-2)$ as one goes along positive (negative) z direction. Each ring covers the full angular space (2π) in ϕ direction and they are subdivided to form towers of $\Delta\eta \times \Delta\phi \simeq 0.87 \times 0.87$ mapping the hadron calorimeter layers inside the magnet.

In Particle Flow algorithm, total energy measured in calorimeter is taken as

$$E_{total} = E_{ECAL} + 1.3 \times (E_{HB} + w \times E_{HO})$$

where w is the weight factor HO w.r.t. HB (portion of hadron calorimeter inside the magnet up to $\eta = 1.4$). Aim of this project is to measure w and its energy and direction dependence at a function of the energy deposit the jets in HO.

2 Event Selection

The events with at least one jet with $P_T > 200$ GeV in barrel (HB) calorimeter inside the magnet and energy deposit in HO more than 5 GeV are selected. Roughly 7% of the total hadronic events satisfy these selection criteria.

3 Method of Approach and Experimental Results

HO weight can be optimized to counterbalance the energy leakage which gives rise to Missing Transverse Energy (MET). HO weight is also calculated from the best resolution of P_T difference of two jets in the dijet events. Figure 1 depicts the performance of HO weight to reduce MET (left) and to make the resolution of dijet balance better (right).

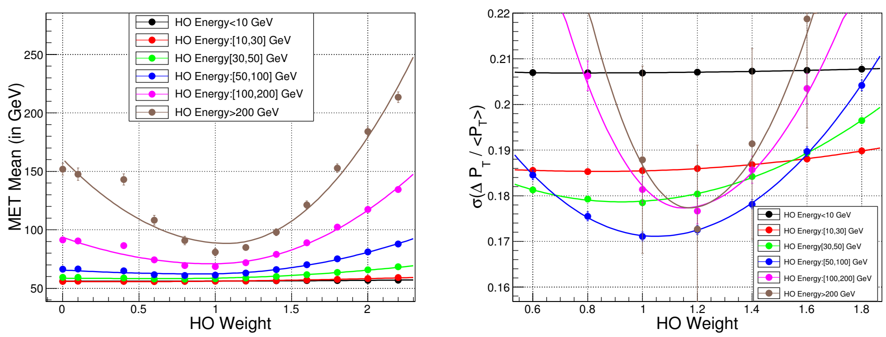

Fig. 1. Variation of the mean of MET distribution and variation of Gaussian width of relative P_T difference of two jets with HO weight factor for different ranges of HO cluster energy [2]

From Figure 1, it can be concluded that HO weight factor increases with the energy recorded in HO cluster; to describe this pattern a functional form was tried for HO weight factor where HO weight has a linear dependence on HO cluster energy, $w = 0.5 \times (1 + \beta \times E_{HO})$ and checked how MET and dijet resolution varies with β. We find that almost same value of β (∼0.012) corresponds to minimum MET / best resolution for dijet balance for all the ranges of HO cluster energy. Photon+jet balance, also used in this study, exhibit similar results.

4 Conclusion

We observe that HO weight, with a clear energy dependence, has an appreciable impact on physical observables and can be optimized for different ranges of the energy measured in HO. We have also shown that it is possible to optimize the measurement of different observables by approximating HO weight as a linear function of the energy recorded in HO cluster.

References

1. CMS Collaboration, JINST 3 S08004 (2008)
2. Details of this study are documented in CMS note DN-2016/023.