Jet energy resolution in p+p and Pb+Pb collisions using CMS detector

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Introduction

Heavy ion collisions (Pb+Pb) at LHC energies, one expects to form a hot and dense deconfined matter of quarks and gluons. One of the most important signature of the formation of such matter is the study the response of high energy jets produced from the collision. The energy loss of the parton inside the dense medium could modify the jet production cross-section in near zero impact parameter Pb+Pb collisions as compared to the elementary p+p collisions at the same center-of-mass colliding energy also called as jet-quenching. This phenomenon has been observed at RHIC energies from the suppression of inclusive high transverse momentum (p_T) particles for central Au+Au collisions almost a factor of 5 when compared to the p+p collisions [2]. Recent CMS data from Pb+Pb collisions showed that dijets become increasingly imbalanced the more central the collision [3]. One of the most difficult measurements in heavy-ion collisions is to fully reconstruct the jets in high multiplicity environment. Also due to other effects like background fluctuation on a event-by-event basis and flow makes these measurements even difficult. To understand all the other effects one has to carefully study the effect of jet-reconstruction in Monte Carlo (MC) simulation. In this work we present the jet-energy resolution for Pb+Pb and p+p collisions for $\sqrt{s_{NN}} = 2.76$ TeV. This would help us in understanding the systematic uncertainties arising from jet-energy resolution in both the colliding systems when studying a quantity called nuclear modification factor (R_{AA}) for fully reconstructed jets.

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Simulation

Monte Carlo simulations are used both to understand the detector performance in a high multiplicity Pb+Pb collision, and as a reference analysis. Dijet events are generated with the PYTHIA [4] event generator. To simulate the influence of the underlying Pb+Pb event on the jet finding and track reconstruction, the Monte Carlo generator dijet events were embedded into minimum bias selection of simulated Pb+Pb data based on the HYDJET [5]. event generator. The embedded MC dijet events were propagated through the full detector simulation and reconstructed with the standard analysis chain. Simulated samples were generated using several different thresholds of the outgoing parton $\hat{p_T}$, for the embedded dijet event: 20, 50 and 80 GeV/c. The statistics for each sample range from 50,000 - 200,000 events. Jets were reconstructed using the CMS particle flow algorithm. This algorithm identify all the stable particles in an event (electron, muons, photons and charged and neutral hadrons) by combining information from all the sub-detector systems [6]. In the heavy-ion configuration electron reconstruction is excluded and the pre-shower detector is not utilized. The anti-k_T sequential recombination algorithm (anti-k_T), as encoded in the *FastJet* framework, is used to combine the particle-flow candidates into jets using a resolution parameter $R = 0.3$ [7]. Jet reconstruction from particle-flow objects has the advantage of reduced sensitivity to the fragmentation pattern of jet, as compared to purely calorimetric jets (CaloJets).

Results

Figure 1 shows the jet resolution of the reconstructed jets to the generator level jets for calojets for $R = 0.5$ and anti-k_T, $R = 0.3$,

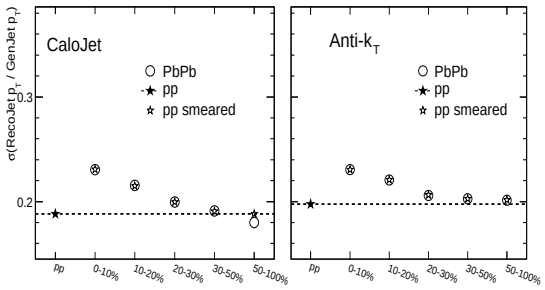

FIG. 1: Jet resolution for calojets for $R = 0.5$ and anti-k_T, $R = 0.3$, particle flow, iterative pileup jets for different collision centralities for Pb+Pb collisions at $\sqrt{S_{NN}} = 2.76$ TeV. The resolution is showed as dotted line. The open star symbols are the smeared p+p resolution to get the resolution measure in Pb+Pb collisions.

particle flow, iterative pileup jets for different collision centralities for Pb+Pb collisions at $\sqrt{S_{NN}} = 2.76$ TeV. The response is shown for 0-10%, 10-20%, 20-30%, 30-50% and 50-100% collisions centrality classes. The p_T resolution of the jets in fig. 1 is calculated from the σ of the Gaussian fits that were used to find the response. As expected, the jet resolution worsens with the larger soft heavy ion background of the most central 0-10% events. The resolution for 50-100% collisions centrality is comparable to the p+p resolution which is shown as dotted line. Also shown are the smeared p+p resolution (open star symbol) to match the Pb+Pb resolution. This smearing of p+p resolution to match the Pb+Pb resolution would help us in improving our jet finding algorithms in Pb+Pb and as well as would also even reduce the effect of resolution in the study of nuclear modification factor. the smearing factor obtained for most central 0-10% Pb+Pb collisions are less than 10% for both calojet and anti-k_T algorithms.

Summary

In summary, we have presented the jet energy resolution for Pb+Pb and p+p collisions at $\sqrt{S_{NN}} = 2.76$ TeV from the Monte Carlo studies using the CMS detector configurations. The resolution is studied for two different jet finding algorithms, calorimetric jets and anti-k_T, with a resolution parameter of R=0.5 and 0.3 respectively. We found that the jet resolution worsens for central 0-10% Pb+Pb collisions for both algorithms and is comparable with p+p collisions for 50-100% Pb+Pb collisions. The smearing of p+p data with the resolution obtained from Pb+Pb would result in systematic uncertainties of less than 10% due to the jet energy resolution. These studies would further improve the understanding of the jet reconstruction algorithms in high multiplicity heavy-ion collisions at LHC.

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