Study of Jet Shapes in Pb-Pb collisions at 2.76 TeV with CMS Experiment

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Introduction

CMS (Compact Muon Solenoid) experiment at LHC (Large Hadron Collider) have rcently shown striking imbalance of dijet transverse momentum with increasing centrality, consistent with "jet quenching" phenomena in $PbPb$ collisions at 2.76 TeV center of mass energy [1]. Jet shapes or the flow of energy in different annular region of jets, depends strongly on the properties of the medium, and modification of jet structures can be used to discriminate between different jet quenching models [2]. In this paper, we will present the jet shape analysis for $PbPb$ and pp collisions at 2.76 TeV for 2010 and 2011 run. The results are compared with the predictions from various QCD inspired Monte Carlo generators to extract the information of the parton medium interactions.

Simulations

Monte Carlo (MC) simulations are used to understand the detector performance in high multiplicity envioronment and as a reference analysis. Dijet events are generated using PYTHIA (tune Z2) event generator [3] modified for the isospin content of the colliding nuclei at a collision energy of 2.76 TeV. To simulate the influence of underlying PbPb event on the jet finding and track reconstruction, the PYHTIA dijet events are embedded in the minimum biased PbPb background simulated with HYDJET event generator [4].

Jet reconstruction

Jet reconstruction in heavy ion collisions in CMS is performed with anti-k_T clutering algorithm. This collinear and infrared safe algorithm use the Particle Flow (PF) candidates as input with resolution parameter $R = 0.3$. The PF algorithm combines the information from all subdetectors including the silicon tracking system, the electromagnetic calorimeter (ECAL), hadronic calorimter (HCAL) and the muon system in order to reconstruct and identify individual particles in an event.

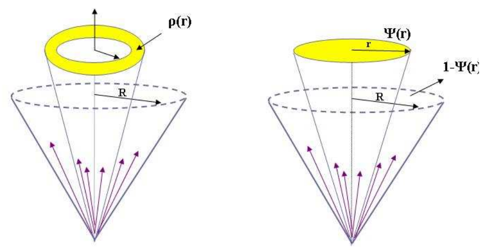

FIG. 1: Definition of the differential and integral jet shape $\rho(r)$ and $\Psi(r)$.

Jet Shape

The jet shape is defined as the average fraction of the jet transverse momentum within a cone of a given size r around the jet axis, $r_i = \sqrt{(\eta_i - \eta_{jet})^2 + (\phi_i - \phi_{jet})^2}$, where i refers to the particle. The differential and integrated jet shapes (see Fig.1) are being used to characterize the jet structure in heavy ion collisions. The differential jet shape $\rho(r)$ is defined as the average fraction of the transverse momenta contained inside the annulas of inner radius of $r_a = r - \delta r/2$ and outer radius $r_b = r + \delta r/2$

$$\rho(r) = \frac{1}{\delta r} \frac{1}{N_{jets}} \sum_{jets} \frac{\sum_{r_a<r_i<r_b} p_T^i}{p_T^{jet}}; \qquad (1)$$

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where $\delta r = 0.05$. The integrated jet shape $\Psi(r)$ is defined as

$$\Psi(r) = \frac{1}{N_{jets}} \sum_{jets} \frac{\sum_{r_i<r} p_T^i}{p_T^{jet}} \tag{2}$$

In the present study, only two leading jets (leading jet $p_T > 100$ GeV and subleading jet $p_T > 40$ GeV) within $|\eta| < 2$ are considered per event. All PF candidates or charged tracks within distance $R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} = 0.3$ in $\eta - \phi$ space from the jet axis are being used. The small cone size helps to reduce the background due to underlying events.

Background subtraction

The background of jet shape analysis arise due to presence of uncorrelated tracks which are not associated with jets and originating from the multiple soft scatterings. The background is being estimated considering the region outside the hard scattering. Three methods are used to to study the background fluctuation, (1) Eta reflected method, (2) Event mixing method and (3) Random cone method. To establish the background subtraction strategy, the background shapes from different methods are being compared.

Results

The analysis is performed in different centrality bin (0−5%, 5−10%, 10−30%, 30−50%, 50 − 70%, 70 − 90%) and in different leading jet p_T bin (100−120 GeV/c, 120−140 GeV/c, 140 − 160 GeV/c, 160 − 200 GeV/c 200 − 300 GeV/c, 300 − 500 GeV/c) to charactise the possible modification of the jet properties in the PbPb collisions compared to pp collisions. Fig.2 (top pannel) shows the distribution of fraction of sum p_T of PF charged hadrons and tracks flowing within the jet cone for p_T of PF charge and tracks > 4 GeV/c in different leading jet p_T bin (from lower to higher p_T bin: top-left to right-bottom) for 10 − 30% centrality. Fig.2 (bottom panel) gives the multiplicity distrbution inside the jet cone. The inputs from MC used as reference for the jet shape analysis of PbPb data.

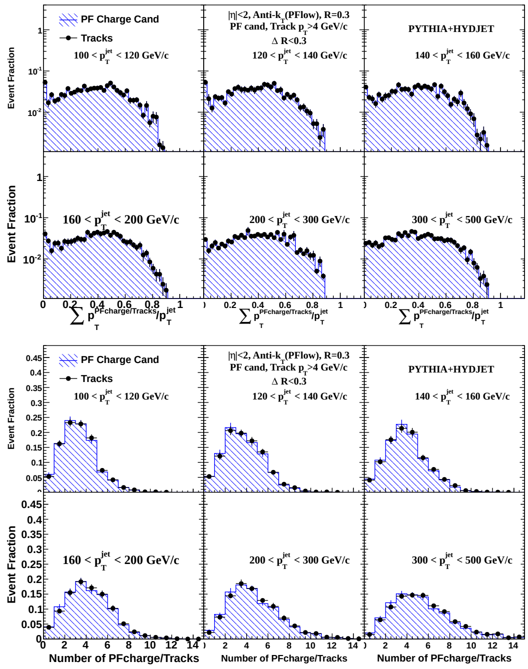

FIG. 2: (top) Distribution of fraction of sum of p_T of PF charged hadron and tracks; (bottom) Multiplicity distribution of PF charged hadron and tracks within the jet cone.

Summary

The jet shape provides crucial information about the energy loss mechanism of partons in the QGP medium. This study presents the results for *PbPb* as well *pp* collisions for 2.76 TeV and compared with MC results.

References

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