Jet energy loss obtained from Di-jet and photon-jet asymmetry in PbPb collisions at LHC

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Introduction

The PbPb collisions at LHC create matter at high temperatures where the properties of deconfined phase, quark-gluon plasma (QGP) are studied. Jets which are generated by hard (high Q^2) interactions of partons contained in the colliding hadrons suffer energy loss in the QGP medium, a phenomenon known as "jet quenching". The jet quenching is quantified using jet nuclear modification factors in various kinematic regions [1]. With the advent of LHC detectors more robust probes such as energy imbalance in Di-Jets events (two back to back jets) which might be a result of one of the jets traversing longer path and suffering larger energy loss. Photon tagged jets may provide even better estimates of jet energy loss since the tagging photon energy remains intact. In this work, we model the jet energy loss in the medium in the PbPb collisions at LHC and use Monte Carlo method to obtain Di-Jet and γ-Jet asymmetry. We compare the model with the Di-Jet and γ-Jet asymmetry measured by CMS and ATLAS experiments. Some of the representative figures are shown in the paper.

Jet energy loss model

The jet $p_{\rm T}$ distribution in pp collisions measured by CMS and ATLAS experiments at LHC can be described with the Hegedorn function [1]. The jet $p_{\rm T}$ in our model is generated from the fitted Hegedorn function. The QGP medium is considered as cylindrical with radius R which is related to the centrality of the collision as [3]

$$R = R_A \sqrt{\frac{\rm N_{part}}{2A}}.$$

Here R_A and A are the radius and atomic mass of the Pb nucleus and $N_{\rm part}$ is the number of participant in that particular centrality class. The specific

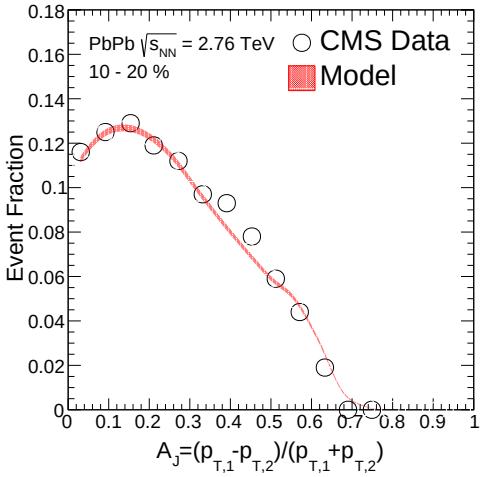

FIG. 1: Di-Jet asymmetry in 10-20% centrality bin measured in PbPb collision by CMS [2] compared with our model.

energy loss, dE/dx is modeled as a power law in $p_{\rm T}$ of jet [1]

$$\frac{dE}{dx} = M \left(\frac{p_{\rm T}}{p_{\rm T0}}\right)^{\alpha}$$

The parameters M and α are dependent on medium properties such as the temperature of QGP and $p_{\rm T}$ of jet. Here $p_{\rm T0}$ is a scale set as 1 GeV/c. The position r and direction ϕ of the jets in Di-Jet or γ-Jet pairs are generated randomly within the transverse cross section of the medium.

The path lengths d_1 and d_2 of two back to back jets are then obtained as

$$d_1 = \sqrt{R^2 - r^2\ sin(\phi)} - r\ cos(\phi)$$
$$d_2 = \sqrt{R^2 - r^2\ sin(\pi+\phi)} - r\ cos(\pi+\phi)$$

The energy loss of a jet then can be calculated as

$$\Delta E = \frac{dE}{dx} \times d$$

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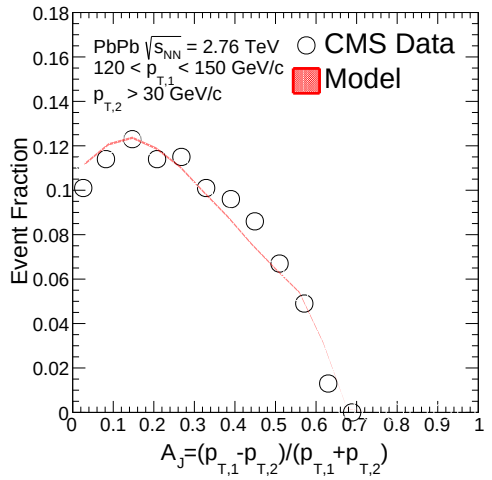

FIG. 2: Di-Jet asymmetry in a jet $p_{\rm T}$ window in PbPb collisions measured by CMS [2] compared with our model.

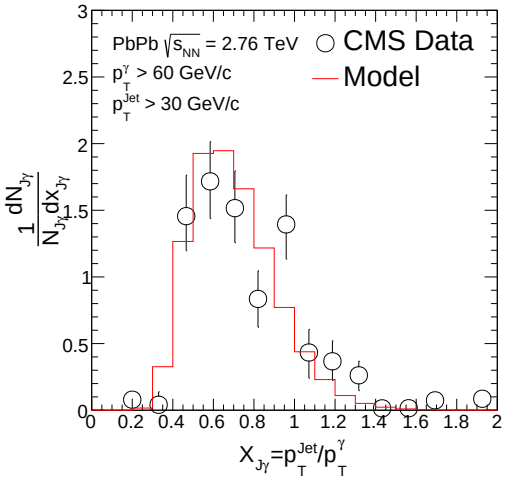

FIG. 3: Photon-Jet asymmetry in PbPb collision measured by CMS [4] compared with the model.

where $d(= d_1, d_2)$ is the path length of the jet inside the medium. These are then used to calculate the asymmetry parameter of the Di-Jet or γ-Jet Pair.

Results and discussions

Figure 1 shows the distribution of Di-Jet asymmetry in one of the centrality bins in PbPb collision at $\sqrt{s_{NN}}$ = 2.76 measured by the CMS experiment [2]. The distribution of asymmetry is well generated with the model. Figure 2 shows the Di-Jet asymmetry in a $p_{\rm T}$ window in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV measured by the CMS experiment [4]. The measurements are compared with our model using the same parameters as for the centrality bin shown in Fig 1. The model gives very good description of data in both $p_{\rm T}$ and centrality regions. Figure 3 shows the γ-Jet asymmetry as measured by CMS experiment [4] in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV along with the calculations of our model.

Summary

In this work, we provide a model using Monte Carlo method to obtain the distributions of Di-Jet and γ-Jet asymmetries. The model with energy loss parameters $M = 0.6$ GeV/fm and $\alpha = 0.45$ gives excellent description of Di-Jet asymmetry in both the centrality and $p_{\rm T}$ windows and γ-Jet asymmetry measured in PbPb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV. We give few illustrative figures in this write up. The extended results of Di-Jet and γ-Jet asymmetry in all centrality and $p_{\rm T}$ intervals in PbPb collisions at both $\sqrt{s_{\rm NN}}$ = 2.76 TeV and 5.02 TeV energies will be presented. The nuclear modification factor of jets obtained using same formalism will also be given.

References

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