Simultaneous description of Di-jet asymmetry and jet R_{AA} at LHC energies using MC methods

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Introduction

The heavy ion collisions at LHC (Large Hadron Collider) are performed to create and study the properties of deconfined state of matter known as Quark Gluon Plasma (QGP). Particles jets are generated in hard (high momentum transfer) partonic interactions which are measured as back-to-back jets called di-jets. The jets interact and suffer energy loss in the QGP medium, a phenomenon known as "jet quenching" In heavy ion collisions, the jets loose energy in the medium and the energy lost by jets gives the opacity of the medium. The jet quenching is quantified using jet nuclear modification factors (R_{AA}) in various kinematic regions [1]. With the advent of LHC detectors more robust probes such as energy imbalance in di-Jet events (two back to back jets) which might be a result of one of the jet traversing longer path and suffering larger energy loss.

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 asymmetry and nuclear modification factor. We compare the model calculations with the di-Jet asymmetry and jet R_{AA} measured by CMS and ATLAS experiments at LHC.

Jet energy loss model

The jet p_T distribution in pp collisions measured by CMS and ATLAS experiments at LHC can be described with the Hegedorn function [1]. The jet p_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 [5]. The specific energy loss, dE/dx is modeled as a power law in p_T of jet [1]

$$\frac{dE}{dx} = M\left(\frac{p_T}{p_{\mathrm{T0}}} - C\right)^{\alpha}$$

The parameters M and α are dependent on medium properties such as the temperature of QGP and p_T of jet. Here p_{T0} is a scale set as 1 GeV/c and value of $C = 0$. The position r and direction ϕ of the jets in di-Jet pairs are generated randomly within the transverse cross section of the medium. The path lengths d = (d_1,d_2) of two back to back jets are then obtained by geometry. The energy loss of a jet then can be calculated as

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

These are then used to calculate the asymmetry parameter of the di-Jet and Jet R_{AA}. Other then the energy loss, the Jet p_T will also be modified due to the experimental resolution of Jet reconstruction. We used the p_T dependent resolution factor used by the CMS collaboration [2].

Results and discussions

Figure 1 shows di-Jet asymmetry in three most central centrality bins in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV measured by the CMS experiment [2] compared with our calculations. The values of the parameters used are $\alpha = 0.40$ and $M = 0.5$ GeV/fm. The MC calculations are compared with the pQCD based DGLV (Djordjevic, Gyulassy, Levai and Vitev) formalism [3]. The parameters extracted from the asymmetry measurement also give good description of the R_{AA} measurements.

Figure 2 shows the jet R_{AA} as a function of jet p_T in three most central centrality bin in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV measured by the ATLAS experiment [4] along with our calculations.

Summary

In this work, we provide a Monte Carlo method to estimate the jet energy loss using the the distributions of Di-Jet asymmetry and Jet R_{AA}. The

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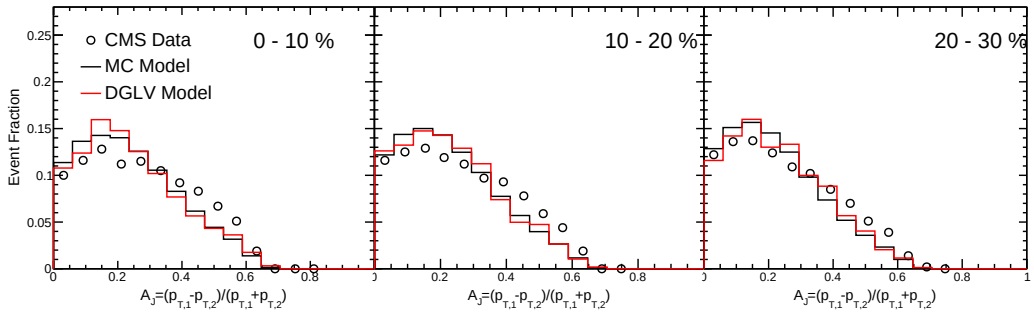

FIG. 1: di-Jet asymmetry in different centrality windows in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV measured by the CMS experiment [2] compared with our calculations. The values of the parameters used are $\alpha = 0.4$ and $M = 0.5$ GeV/fm. The DGLV [3] calculations are also shown in the figure.

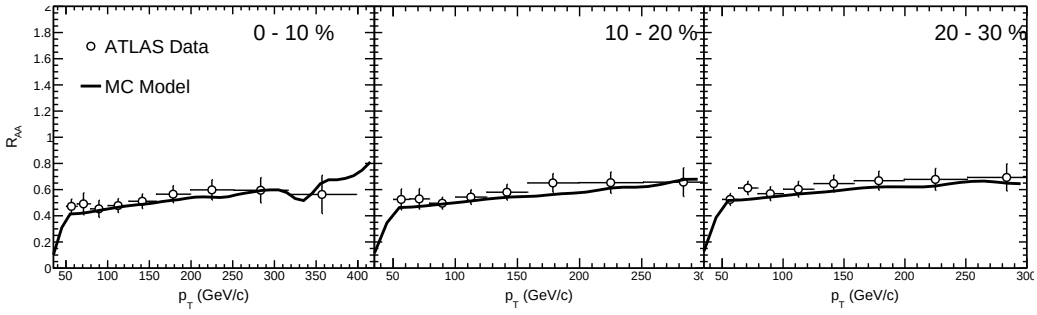

FIG. 2: Jet R$_{AA}$ as a function of jet p_T in several collision centrality bins in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV measured by the ATLAS experiment [4]. The measurements are compared with our model calculations.

model gives excellent description of Di-Jet asymmetry in both the centrality and p_T windows in PbPb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV. The nuclear modification factor as a function of jet p_T in several collision centrality bins in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV and 5.02 TeV have also been obtained. The MC calculations are compared with the pQCD based DGLV formalism [3] and are in good agreement with these.

References

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