Constraining Heavy Quark Energy Loss Using B and D Mesons in Heavy Ion Collision

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Introduction

The heavy quarks are produced in initial hard interactions in heavy ion collisions. These heavy quarks loose energy while traversing through the collective partonic mediuum formed after the collisions which is reflected in the nuclear modification factor R_{AA}. The quarks loose energy either due to the collisions with the partons or by the radiating a gluon or both. There are several formulations to calculate collisional as well as radiative energy loss which are employed to calculate the R_{AA}. The R_{AA} also contains other effects such as nuclear shadowing which must be taken into account in addition to energy loss.

In this paper, we calculate the radiative energy loss of heavy quarks (both charm or bottom) using reaction operator formalism [1–3] (DGLV) and using and generalized dead cone approach AJMS [4]. The nuclear modification factor R_{AA} including shadowing and energy loss is evaluated for B and D and are compared with the measurements in Pb-Pb collision at $\sqrt{s_{NN}} = 2.76$ TeV.

Energy Loss mechanisms of heavy quarks

The energy loss of fast partons is dominated by radiation of gluons. The reaction operator formalism is used in Ref. [1] to obtain the energy loss due to gluon radiation for light quark jets. Analytical expression is obatined for energy loss in powers of gluon opacity (L/λ) where λ is the mean free path of the quark and L is the path length traversed in the medium. This formalism was then extended to obtain the energy loss for heavy quarks in Ref. [2] and was simplified for the first order of opacity expansion in Ref. [3].

The radiative energy loss can be written as

$$\frac{dE}{dx} = \frac{< \omega >}{\lambda}. \qquad (1)$$

Here $< \omega >$ is the mean energy of emitted gluons and λ is the mean free path of the traversing quarks. $< \omega >$ is obtained using the spectrum of gluons emitted by heavy quarks for the process $Q\ q \rightarrow Q\ q\ g$ referred as generalized dead cone approach (AJMS) [4]. The λ is obtained using the cross section of the above process.

We rederive the energy loss expression using same assumptions as AJMS but obtain slighly different results from them. We refer to it as present calculations. To model the quark gluon plasma we use same model as given in Ref. [4] with same initial conditions. The effective path length travelled by heavy quark in the plasma is given by

$$< L >_{eff} = min[< L >, \frac{p_T}{m_T}\ \tau_c] \qquad (2)$$

where $< L >$=6.14 fm, τ_c=5.9 fm/c and tempearture T is calculated at $\tau = \frac{<L>_{eff}}{2.0}$.

The initial parton distributions from pp collisions and shadowing are obtained using NLO calculations given in Ref. [5].

Results and Discussion

Figure 1 shows the nuclear modification factor R_{AA} for D meson obtained using radiative energy loss (DGLV, AJMS and Present calculations) and shadowing in Pb-Pb collision at $\sqrt{s_{NN}} = 2.76$ TeV compared with alice measurements [6]. It is noticed that shadowing

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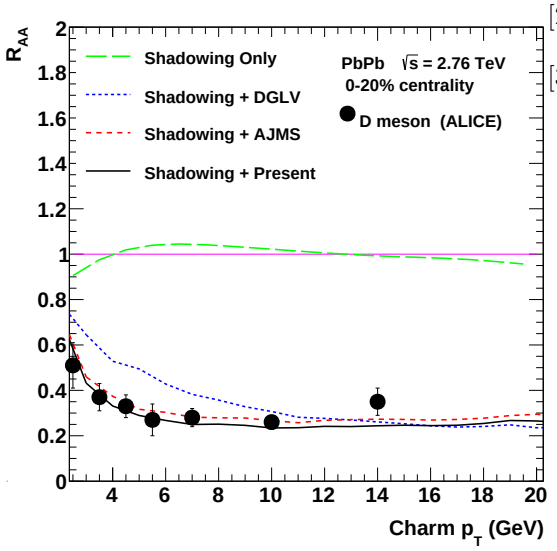

FIG. 1: Nuclear modification factor R_{AA} for D meson obtained using radiative energy loss (DGLV, AJMS and Present calculations) and shadowing in Pb-Pb collision at $\sqrt{s_{NN}} = 2.76$ TeV.

plus radiative energy loss calculated by DGLV is not enough to describe the D meson data at LHC. Both AJMS and present calculations describe the data very well.

Figure 2 shows the nuclear modification factor R_{AA} for B meson obtained using radiative energy loss (DGLV, AJMS and Present calculations) and shadowing in Pb-Pb collision at $\sqrt{s_{NN}} = 2.76$ TeV compared with CMS measurements [7]. It is noticed that shadowing plus radiative energy loss calculated by DGLV is not enough to describe the B meson data at LHC. The present calculations are very close to the data.

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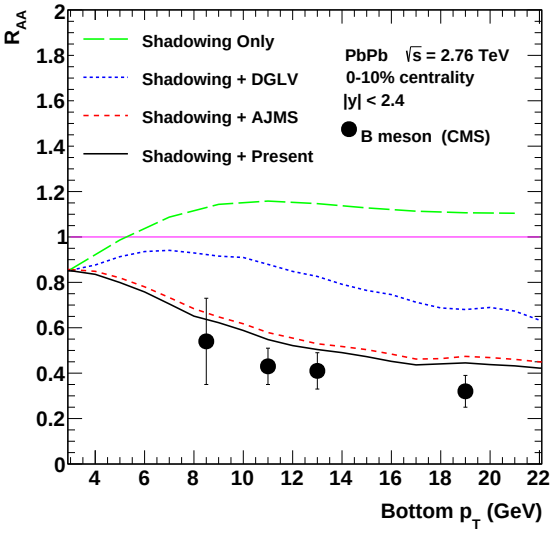

FIG. 2: Nuclear modification factor R_{AA} for B meson obtained using radiative energy loss (DGLV, AJMS and Present calculations) and shadowing in Pb-Pb collision at $\sqrt{s_{NN}} = 2.76$ TeV.

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