Heavy quark energy loss and heavy meson spectra in heavy ion collisions at LHC energies

Kapil Saraswat[1], Prashant Shukla[2,3], Vineet Kumar[2], and Venktesh Singh[1]
[1] *Department of Physics, Institute of Science, Banaras Hindu University, Varanasi - 221005, INDIA*
[2] *Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA. and*
[3] *Homi Bhabha National Institute, Anushakti Nagar, Mumbai - 400094, INDIA.*

Introduction

The heavy ion collisions at RHIC and LHC energies are performed to study the creation and characterization of the Qurak Gluon Plasma (QGP). Heavy quarks are the best tools to study QGP. Due to their large mass, heavy quarks are mostly produced in early phase of collisions when parton momenta are very high before the formation of QGP and the production of heavy quarks is small making them special as a probe for QGP. While traversing the hot/dense medium formed in the collisions, these quarks loose energy due to the elastic collisions with the plasma constituents or by radiating gluon. There are several formulations to calculate the collision as well as radiative energy loss which are used to calculate the nuclear modification factor R_{AA}.

Methodology

In this paper, we calculate the transverse momentum (p_T) spectra of heavy mesons in pp collision using pQCD approach. CT10 sets are used to calculate the parton distribution functions (PDFs). We calculate the energy loss of heavy quark using reactor operator formalism DGLV [1] and generalised dead cone approach (present) [2]. The collisional energy loss is calculated using Peigne and Peshier (PP) formalism [3]. The initial temperature of the QGP medium and the path length travelled by the heavy quark in the plasma are obtained using the evolution model which is described in Ref.[4, 5]. Peterson fragmentation is used for the fragmentation of heavy quarks into heavy mesons. The spatially dependent EPS09s sets are used to calculate the modifications of the PDFs inside the nucleus.

Results and discussions

Figure 1 shows R_{AA} of D^0 mesons as a function of p_T, obtained by including shadowing energy loss (DGLV, Present, PP+DGLV and PP+Present calculations) in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. The calculations are compared with the CMS data [6]. Figure 2 is the same as Figure 1 but for the case of minimum bias PbPb collisions. The radiative energy loss by present formalism reproduces CMS data without adding collisional energy loss. The radiative energy loss by DGLV added to the collisional energy loss by PP describes the data at high p_T. The sum of the radiative energy loss by present formalism and collisional energy loss by PP formalism overestimates the measured suppression of D^0 meson. Figure 3 shows R_{AA} of D^0 as a function of p_T, obtained by including shadowing and energy loss (DGLV, Present, PP + DGLV, PP + Present calculations) for the minimum bias PbPb collision at $\sqrt{s_{NN}} = 5.02$ TeV. The calculations are compared with the CMS data [7]. The radiative energy loss by present formalism describes the CMS data within the uncertainties of the data. The sum of radiative and collisional energy loss (PP + DGLV) gives good description of the data at high p_T. The radiative energy loss by present formalism added to the collisional energy loss by PP formalism overestimates the measured suppression of D^0 meson. Figure 4 shows R_{AA} of B^+ as a function of p_T, obtained by including shadowing and energy loss (DGLV, Present, PP + DGLV and PP + Present calculations) for the minimum bias PbPb collision at $\sqrt{s_{NN}}$ = 5.02 TeV. The calculations are compared with the CMS data [8]. The sum of the radiative energy loss by present formalism and col-

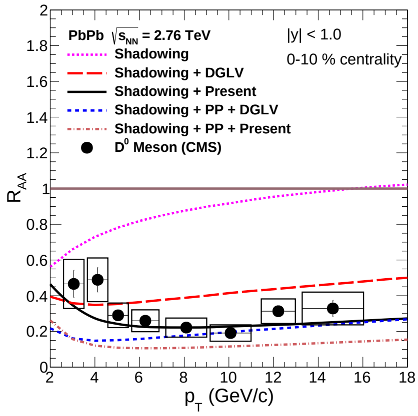

FIG. 1: R_{AA} of D^0 as a function of p_T.

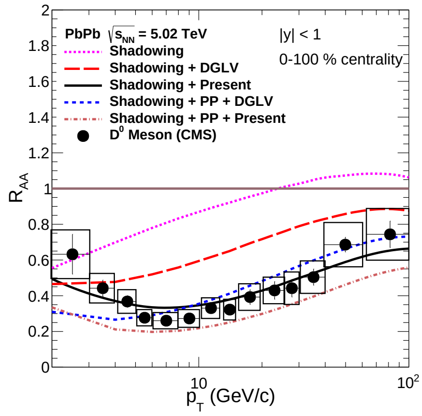

FIG. 3: R_{AA} of D^0 as a function of p_T.

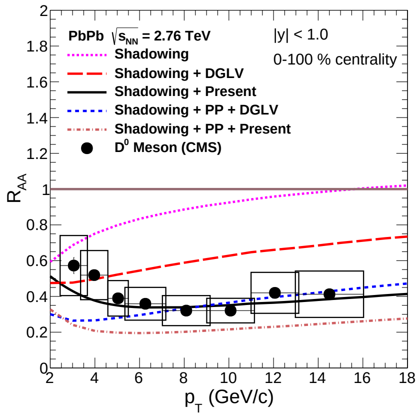

FIG. 2: R_{AA} of D^0 as a function of p_T

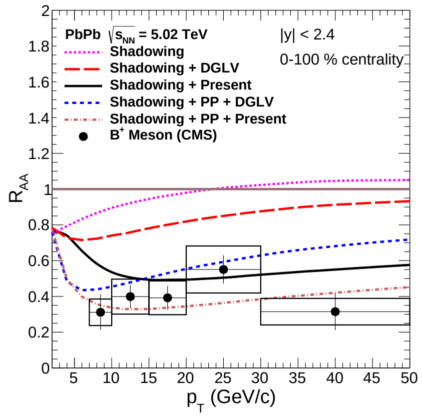

FIG. 4: R_{AA} of B^+ as a function of p_T

lisional energy loss by PP formalism describes the CMS data within the uncertainties of the data. The sum of the radiative energy loss by DGLV formalism and collisional energy loss by PP formalism underestimates the B^+ meson suppression.

Conclusion

We find that the radiative energy loss from present formalism alone is sufficient to produce D^0 meson R_{AA}. For the case of B^+ meson, the radiative energy loss from present formalism plus collisional energy loss gives good description of the data. The radiative energy loss from DGLV formalism plus collisional energy loss gives good description of D^0 meson R_{AA}, but the sum of the radiative energy loss by DGLV formalism and collisional energy loss underestimates the B^+ meson suppression.

References

[1] S. Wicks et al, Nucl. Phys. A **784**, 426 (2007).
[2] K. Saraswat, P. Shukla and V. Singh, Nucl. Phys. A **943**, 83 (2015).
[3] S. Peigne et al, PRD **77**, 114017 (2008).
[4] V. Kumar, P. Shukla and R. Vogt, Phys. Rev. C **92**, 024908 (2015).
[5] K. Saraswat, P. Shukla, V. Kumar and V. Singh, Nucl. Phys. A **961**, 169 (2017).
[6] CMS Collaboration, CMS-PAS-HIN-15-005.
[7] CMS Collaboration, CMS-PAS-HIN-16-001.
[8] CMS Collaboration, CMS-PAS-HIN-16-011.