# Energy loss of charm quarks at RHIC and LHC

Umme Jamil* and Dinesh K. Srivastava†
*Physics Group, Variable Energy Cyclotron Centre,*
*1/AF, Bidhan Nagar, Kolkata - 700 064, India*

Heavy quarks are expected to be produced at the earliest stage of heavy ion collisions and then while passing through hot and dense quark gluon plasma(QGP) they loose energy by colliding with the quarks and gluons and radiating gluons. Thus, the energy loss of the heavy quarks within the medium has been regarded as a promising probe for the properties of QGP. The observed nuclear modification factor $R_{AA}$ at the Relativistic Heavy Ion Collider (RHIC) shows a significant energy loss by heavy quarks in a strongly interacting matter [1]. The large difference in the centre of mass energy of collisions at RHIC and Large Hadron Collider(LHC), gives an interesting domain of discussion of the heavy quark energy loss at both the energies. In order to perform a systematic test of various models for energy loss, we have estimated the radiative energy loss of a charm quark considering DGLV formulation [2], XDZR formulation [3] and ASW formulation [4]. We have also estimated the collisional energy loss of a charm quark considering Peigne and Peshier (PP) formulation [5], Braaten and Thoma (BT) formulation [6] and Bjorken formulation [6, 7]. We study the effect of heavy quark energy loss at 200A GeV Au+Au collision at RHIC and 5.5A TeV Pb+Pb collision at LHC at midrapidity(see FIG.1).

All the results are obtained with number of flavours $N_f = 3$, $C_f = 4/3$, mass of charm quark $m_c = 1.6$ GeV, $\alpha_s = 0.3$ and average path length L = 4 fm. We consider the central particle rapidity density at LHC as 2550 and at RHIC as 1000.

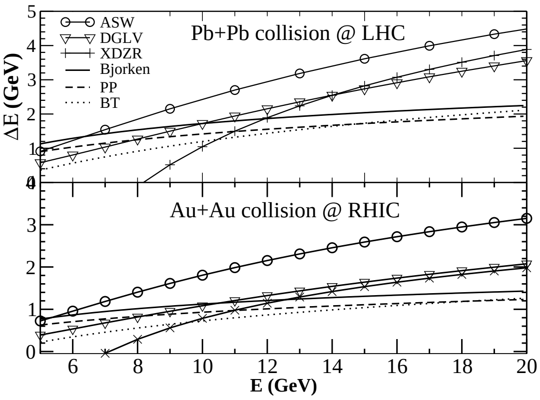


FIG. 1: Collisional(lines without symbol) and radiative(lines with symbol) energy loss of charm quark at mid-rapidity.

## $\mathbf{R_{AA}}$ at midrapidity

We consider a charm quark having zero rapidity, passing through the QGP fluid at rest(central rapidity).

The nuclear modification factor is given by

$$R_{AA}(b) = \frac{dN^{AA}/d\mathbf{p_T}dy}{T_{AA}(b)d\ \sigma^{NN}/\mathbf{dp_T}dy} \quad (1)$$

The nuclear thickness function $T_{AA}(b)$ for 200A GeV Au+Au collision at RHIC is $\approx 240$ fm$^{-2}$ and for 5.5A TeV Pb+Pb collision at LHC is $\approx 260$ fm$^{-2}$ for 0 - 5 % centrality considering Glauber model formalism. The heavy quark cross section for pp collisions are calculated using NLO QCD treatment [8]. The factorization and renormalization scales $\mu_F$=$\mu_R$=1.5 GeV are used and the mean intrinsic transverse momentum $< k_T >$ is calculated from the Gaussian broadening of intrin-

*Electronic address: jamil@veccal.ernet.in
†Electronic address: dinesh@veccal.ernet.in

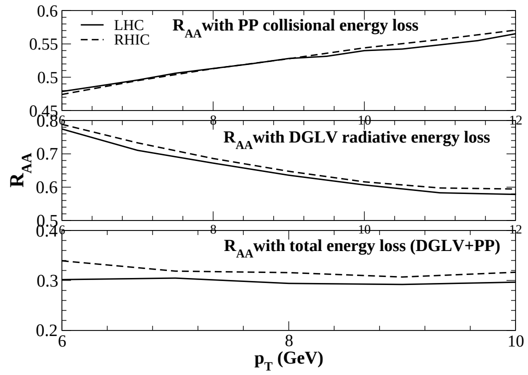


FIG. 2: $R_{AA}$ at midrapidity

sic transverse momentum at both LHC and RHIC energy as 1 GeV [9]. The NLO results have been accurately parametrised by us and $dN_c/d^2p_Tdy$ at RHIC and LHC energies at y=0:

$$\frac{dN_c}{d^2p_Tdy} = \frac{a}{(b+p_T)^c} \tag{2}$$

TABLE I: Parameters for the charm quark distribution $\frac{dN_c}{d^2p_Tdy}$ at rapidity y=0 for Pb+Pb at 5.5A TeV and for Au+Au at 200A GeV (as given in Eq. 2. We have used CTEQ4M PDF data set for nucleon. The range of validity of the parameters is $p_T = 5-20$ GeV

| | $a$ | $b$ | $c$ |
|---|---|---|---|
| RHIC | $2.9\times10^3$ | 2.6 | 8.4 |
| LHC | $5.58\times10^2$ | 1.786 | 5.56 |

In FIG.2 $R_{AA}$ at midrapidity are shown considering the PP collisional energy loss, DGLV radiative energy loss and total energy loss for both 200A GeV Au+Au collision at RHIC and 5.5A TeV Pb+Pb collision at LHC. FIG.1 shows that the energy loss $\Delta E$ has a significant difference for RHIC and LHC only after $p_T$ value 10 GeV. We also see that upto $p_T$ about 12 GeV, the nuclear modification factor $R_{AA}$ changes only marginally if only collisional energy loss is considered, in going from RHIC to LHC. The suppression at LHC increases, when the radiative energy loss is included. However it is also clear the differences will increase substantially at larger $p_T$. This will help us to test the models accurately. Calculations for other energy loss formulations are in progress.

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## References

[1] B. I. Abelev et al, Phys. Rev. Lett. **98**, 192301(2007).

[2] S. Wicks et al, Nucl. Phys. A **784**, 426 (2007).

[3] W. C. Xiang et al, EPJA **373**, 295(2005).

[4] N. Armesto et al, Phys. Rev. D **69**, 114003(2004).

[5] S. Peigne and A. Peshier, Phys. Rev. D **77**, 114017(2008).

[6] E.Braaten and M.H.Thoma, Phys. Rev. D **44**, 2625(1991).

[7] J.D.Bjorken, FERMILAB-PUB-82/059-THY(1982).

[8] M. L. Mangano et al, Nucl. Phys. B **373**, 295(1992).

[9] X. N. Wang, Phys. Rev. Lett. **81**, 2655(1998).