Estimation of fractional energy loss of light and heavy flavor mesons in heavy ion collision.

Priyanka Sett[1] and Prashant Shukla[1]
[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*

Introduction

In high energy heavy ion collisions, "jet quenching" is one of the most prominent signals studied. The "jet"s loose energy while traversing through the dense medium leading to the softening of the transverse momentum (p_T) spectra. Usually, the modification in spectra is quantified by the nuclear modification factor (R_{AA}), which is the ratio of the yield in heavy ion collisions to the yield in $p + p$ collisions, scaled by the number of binary collisions. This quantity gives a hint of the presence of hot and dense medium but does not measure the value of the energy loss of particles or partons. It should be noted that, similar value of R_{AA} for different particles does not gurantee similar amount of energy loss.

In this work, we estimate the energy loss of π^0 mesons and single electrons from heavy flavor decay in central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. We give an emperical method to obtain the fractional energy loss of a particle.

Emperical energy loss formulation

The relative decrease of yield in heavy ion collisions can also be thought of the horizontal shift of p_T due to momentum loss. This simple observation leads to the emperical formulation for energy loss. The horizontal shift of momentum can be understood as : let, the particle produced at a certain p_T in heavy ion collisions may have been produced at $p_T + \Delta p_T$ in $p + p$ collisions, where Δp_T is the loss in momentum due to the medium. Then the fractional energy loss takes the form,

$$\frac{\Delta p_T}{p_T} = \frac{p_T + p_0}{p_T} \left(R_{AA}(p_T)^{-1/n} - 1 \right) \quad (1)$$

where the n and p_0 are obtained by fitting the particle spectrum in $p + p$ collisions, by [1],

$$f(p_T) = A \left(1 + \frac{p_T}{p_0} \right)^{-n} \quad (2)$$

where, p_0 is a constant and n determines the shape of spectrum at high p_T.

Results and Discussions

The estimation of the energy loss is obtained for the measured PHENIX data for π^0 [2, 3] mesons and the single electrons (e^-) [4] from heavy flavor decay. In order to find the parameter n, used in Eq. 1, the p_T spectra in $p + p$ collisions are fitted to the function given in Eq. 2. Figure. 1 shows the invariant yield p_T spectrum for π^0 [2] and single e^- [4] fitted to the function.

Figure 2 shows the R_{AA} of π^0 [3] and single e^- [4] in 0-10% centrality bin in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The fractional energy loss obtained from the emperical formula is shown in Fig. 3 for both π^0 and electrons in 0-10% centrality bin in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. It is seen that, for $p_T < 5$ GeV/c, the fractional energy loss for electrons is less than π^0. For $p_T > 5$ GeV/c, the uncertainties in single electron are very large to conclude something definite.

In this energy loss formalism, it should be noted that, for high p_T, $\Delta p_T/p_T$ will depend mainly on the term $R_{AA}(p_T)^{-1/n}$. For higher collisional energies, the value of n decreases [5] which can change the value of $\Delta p_T/p_T$ significantly. For the same R_{AA} values used in this paper for π^0, with the value of n taken for 2.76 TeV [5], the fractional energy loss increases by 66 - 72% with respect to RHIC energy.

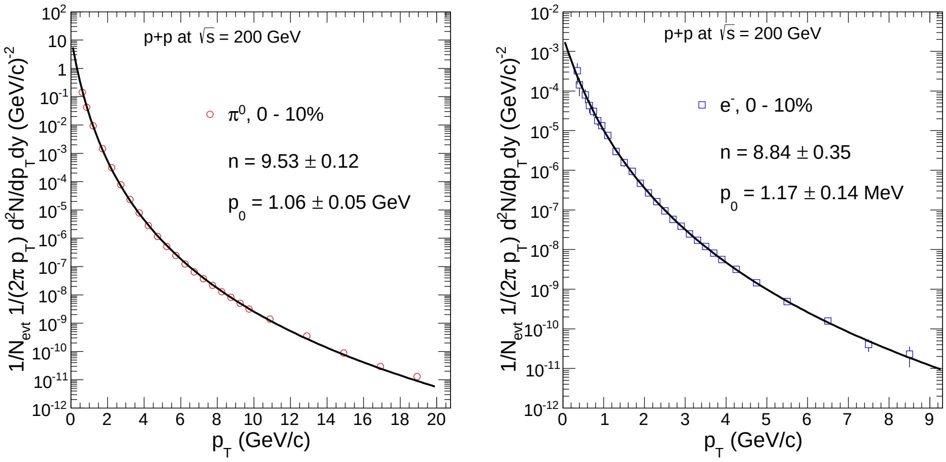

FIG. 1: The invariant yield p_T spectrum for π^0 [2] and single e^- [4] in $p+p$ collisions at $\sqrt{s} = 200$ GeV.

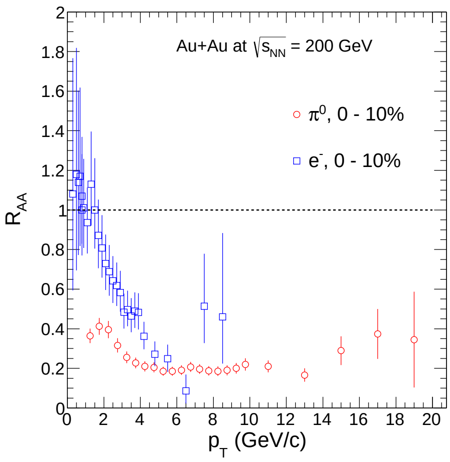

FIG. 2: The nuclear modification factor for the π^0 [3] and single e^- [4] for the 0-10% centrality bin in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV.

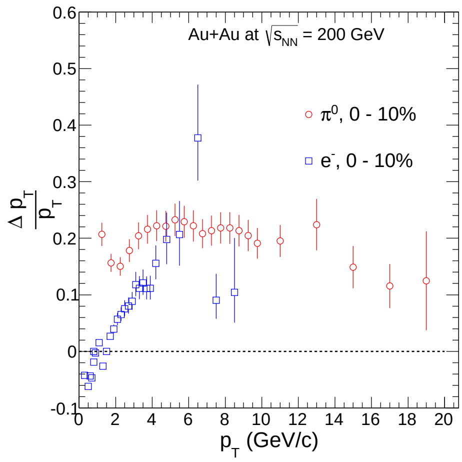

FIG. 3: The fractional energy loss for π^0 [3] and single e^- [4] for the 0-10% centrality bin in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV.

References

[1] P. K. Khandai, P. Sett, P. Shukla and V. Singh, Int. J. Mod. Phys. A**28**, 1350066 (2013).

[2] A. Adare *et.al.* (PHENIX Collaboration), Phys. Rev. D**76**, 051106 (2007).

[3] A. Adare *et.al.* (PHENIX Collaboration), Phys. Rev. Lett. **101**, 232301 (2008).

[4] A. Adare *et.al.* (PHENIX Collaboration), Phys. Rev. C**84**, 044905 (2011).

[5] P. Sett and P. Shukla, Advances in High Energy Physics, **2014**, 896037 (2014).