Lack of color charge dependence of energy loss in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

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Ultra-relativistic heavy ion collisions provide a unique environment to study properties of strongly interacting matter in the extreme conditions of high temperature and energy density. When hard partons traverse the medium, they lose energy [1]. This leads to a softening of the hadron spectra at high p_T ($p_T > 6$ GeV/c). The amount of energy loss can be calculated in Quantum Chromodynamics (QCD) and is expected to be different for energetic gluons, light quarks and heavy quarks [2, 3]. Thus identified particles at high p_T provide direct sensitivity to differences between quark and gluon fragmentation. For example, proton and pion production at high p_T is expected to have significant contributions from quark fragmentation while anti-protons are mostly from gluon fragmentation [2, 4]. Therefore, $\bar{p}/p$ and $\bar{p}/\pi$ ratios in different systems are sensitive to the possible color charge dependence of energy loss [2]. We discuss the color charge dependence of the energy loss and the fragmentation functions at high p_T.

Fig. 1 shows the p/π^+ and $\bar{p}/\pi^-$ ratios as a function of p_T in 0-12%, 60-80% Au+Au and d+Au [5] collisions. The ratios in Au+Au collisions are observed to be strongly centrality dependent at intermediate p_T (2 $< p_T < 6$ GeV/c). In central Au+Au collisions, the p/π^+ and $\bar{p}/\pi^-$ ratios peak at $p_T \sim$ 2-3 GeV/c with values close to unity, decrease with increasing p_T, and approach the ratios in d+Au, p+p and peripheral Au+Au collisions at $p_T \gtrsim 5$ GeV/c. The dotted and dashed lines are predictions for central Au+Au collisions from recombination [6] and coalescence with jet quenching and KKP fragmentation functions [7, 8] respectively. These models can qualitatively describe the $p(\bar{p})/\pi$ ratio at intermediate p_T but in general under-predict the results at high p_T. At high p_T, the p/π^+ ratios can be directly compared to results from quark jet fragmentation as measured in $e^+ + e^-$ collisions by DELPHI [9], indicated by the dot-dashed line in Fig. 1 (a). The p/π^+ ratios in d+Au and Au+Au collisions are measured to be higher than in quark jet fragmentation. This is likely due to a significant contribution from gluon jets, which have a $(p+\bar{p})/(\pi^+ + \pi^-)$ ratio up to two times larger than quark jets [10]. A similar comparison cannot be made for $\bar{p}$ production (Fig. 1 (b)), because there is a significant imbalance between quark (q) and anti-quark ($\bar{q}$) production at high p_T in d+Au and Au+Au collisions and the fragmentation function of q to $\bar{p}$ can not be readily derived from $e^+ + e^-$ collisions. It is, however, known from lower beam energies, where quark fragmentation is dominant, that the $\bar{p}/\pi$ and $\bar{p}/p$ ratios from quark jets are very small (< 0.1) [5, 11]. The large $\bar{p}/\pi^-$ ratio of ≈ 0.2 seen in Fig. 1 (b) is likely dominated by gluon fragmentation.

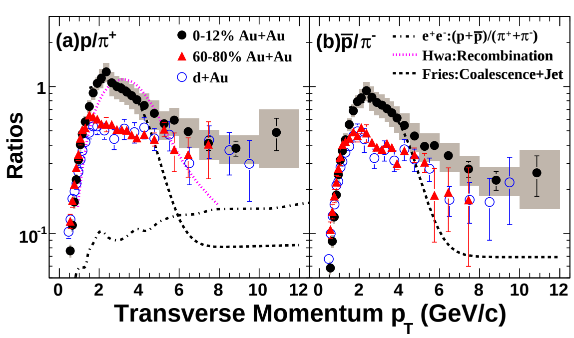

FIG. 1: The p/π^+ and $\bar{p}/\pi^-$ ratios from 200 GeV d+Au and Au+Au collisions. The $(p+\bar{p})/(\pi^+ + \pi^-)$ ratio from light quark jets in $e^+ + e^-$ collisions at $\sqrt{s} = 91.2$ GeV are shown as a dot-dashed line [9]. The dotted and dashed lines are model calculations in central Au+Au collisions [6, 8].

At high p_T, the p/π^+ and $\bar{p}/\pi^-$ ratios in central Au+Au collisions are similar to those in p+p and d+Au collisions [5]. This indicate that at sufficiently high p_T, fragmentation in central Au+Au and p+p events is similar and that there is no evidence of different energy loss for quarks and gluons in the medium. It has been postulated that the addition of collisional energy loss to radiative energy loss may explain the large suppression of leptons from heavy flavor decays in Au+Au collisions. The latest calculations [12, 13] including collisional energy loss and path length fluctuations show that the nuclear modification factor of gluons is still expected to be a factor of three lower than that of light quarks. That the relative particle abundances show no system dependence among p+p, d+Au and Au+Au collisions at high p_T indicates that the partonic sources of $\pi^{\pm}$, p and $\bar{p}$ have similar energy loss when traversing the nuclear medium.

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