Consequences of a L_c/D enhancement effect on the non-photonic electron nuclear modification factor in central heavy ion collision at RHIC energy

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La suppression des électrons non-photoniques observée par les expériences de RHIC dans les collisions centrales Au+Au à 200 GeV pourrait être, en partie, expliquée par une augmentation du rapport baryon/méson dans le secteur du charme (Λ_c / D). En supposant un rapport Λ_c / D de l'ordre de l'unité pour des impulsions transverses de 5 GeV/c, une suppression de 40% des électrons de la décroissance semileptonique du charme est prédite.

One of the most robust experimental evidence for the creation of a new state of matter in heavy ion collisions at the Relativistic Heavy Ion Collider (RHIC) is the large suppression of light hadrons at high transverse momentum (pt). This phenomenon is well reproduced by models which take into account the radiative energy loss of high pt light quarks and gluons propagating through a dense medium of colored quarks and gluons. Further insights into the underlying mechanism can be obtained from the study of heavy hadrons. In contrast to intermediate-pt light hadrons which are predominantly produced by gluon fragmentation, charm and bottom hadrons originate from the fragmentation of heavy quarks. Quarks are supposed to lose less energy than gluons in the medium due to a smaller color charge coupling. In addition, radiative energy loss was predicted to be smaller for heavy quarks as compared to light quarks because of the so-called "dead-cone" effect which limits the medium induced radiative energy loss at forward angles. Surprisingly, recent data from the PHENIX and the STAR collaborations in Au+Au collisions at 200 GeV show that the quenching of heavy quarks, as studied indirectly via the so-called non-photonic electrons, is stronger than theoretical expectations and is as large as that of light mesons. Reconciling these data with model predictions is a real challenge which triggers a lot of theoretical activities nowadays.

In this work we investigate the possibility that part of the strong suppression of non-photonic electrons might be due to another source of electrons, namely charmed baryons. Indeed, whereas light mesons are largely suppressed in heavy ion collisions at RHIC, the suppression of non-strange and strange baryons is observed to be much less in the intermediate pt range (2 < pt < 4 GeV/c). This anomalous baryon/meson enhancement is relatively well understood in the framework of the recombination model, which assumes that, at low and intermediate pt, hadronization occurs via the coalescence of "free" quarks. An anomalous baryon/meson enhancement for charm hadrons leads naturally to a non-photonic electron R_{AA} smaller than one. This is mostly due to a smaller semileptonic decay branching ratio of charm baryons (Λ_c) as compared to charm mesons. The main assumption we put forward is that, in a deconfined medium, charm baryon production is enhanced relative to charm meson production, as compared to the vacuum.

This assumption is qualitatively justified in the framework of the recombination model. We will assume a baryon/meson (Λ_c/D) enhancement as a Gaussian shape. For pp collisions, we use the predictions from PYTHIA. Our simulation framework is based on the PYTHIA-6.152 event generator. The PYTHIA input parameters were first tuned according to [1] and the PHENIX acceptance cut ($|\eta| < 0.35$) was applied in order to correctly reproduce the pt distribution of non-photonic electrons measured in pp collisions at 200 GeV. As it can be seen in Fig. 1, the agreement between the simulation and the data is rather good except in the high pt region where the simulation under-predicts the data.

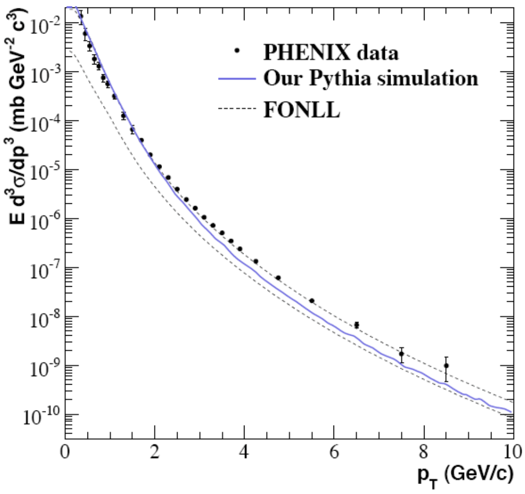

Fig. 1: Invariant differential cross-section of non-photonic electrons (dots) measured in pp collisions at 200 GeV . The solid curve shows the result of the PYTHIA simulation as described in the text.

The following Gaussian parameters of Λ_c/D ratio have been chosen: Mean: 5 GeV/c, constant: 0.9 and sigma: 2.9 GeV/c. The constant of 0.9 is justified since the resulting Λ_c/D ratio of 0.9 is of the same order of magnitude as the non-strange and strange baryon/meson ratios measured by the STAR collaboration. The enhancement is applied such that the pt-differential charm cross-section is conserved. The latter is an arbitrary choice that could be justified since most of the charm hadron transverse momentum is given by the charm quark whatever, baryon or meson, this hadron is. We finally compute the R_{AA} ratio from the non-photonic electron pt spectra assuming that the only medium induced effect is the Λ_c/D enhancement. The results are shown in Fig. 2 together with the PHENIX data. One can see that the Λ_c/D ratio close to unity in central collisions at pt = 5 GeV/c can already explain40% of the suppression of non-photonic electrons in the 2 − 4 GeV/c pt range. Even in the high pt region (8−9 GeV/c) the Λ_c/D enhancement results in a significant suppressionof electrons from charm semileptonic decay.

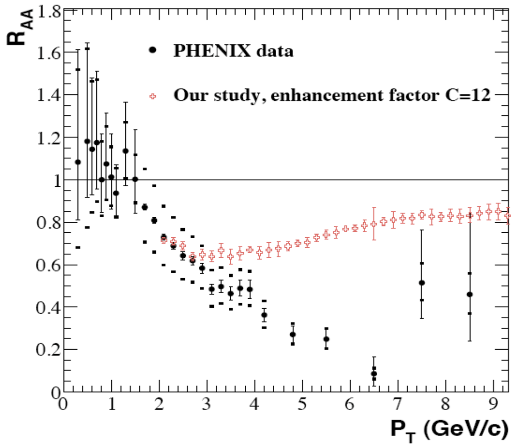

Fig. 2: Nuclear modification factor of non-photonic electrons (dots) measured in central (0 − 10%) Au+Au collisions at 200 GeV. The crosses correspond to the results of the simulation described in the text for a Λ_c/D enhancement factor of 12 (Λ_c/D equal to unity at 5 GeV/c).

La distribution en impulsion transverse des électrons non-photoniques est évaluée avec le générateur PYTHIA. Ces calculs sont en accord avec les mesures réalisées par la collaboration PHENIX (voir Fig.1). Le facteur de modification nucléaire des électrons de la décroissance semi-leptonique du charme a été calculé en supposant qu'une surproduction de baryons a lieu dans le secteur du charme dans les collisions centrales Au+Au à 200 GeV. Nous observons qu'une suppression de jusqu'à 40% du facteur des modification nucléaire des électrons procédant de la décroissance semileptonique du charme, peut être compris par un mécanisme de surproduction de baryons charmés comme il a été observé pour les baryons contenant quarks légers. Ce travail a été publié dans la revue internationale *Physics Lettes* B, volume 663 page 55.

References

[1] *PHENIX Collaboration, Phys. Rev. Lett. 88, (2002) 192303* [arXiv:nucl-ex/0202002].

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