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Heavy Flavor Production, Energy Loss and Flow — Experimental Overview

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Abstract

In this proceedings, I highlight selected experimental results on heavy flavor quark production presented at the Quark Matter 2017 conference. I show experimental evidences that charm quarks interact strongly and flow with the QGP medium and that bottom quarks lose less energy compared to charm quarks. These high quality data will offer stringent constraints on theoretical model calculations and help precision determination of QGP medium transport parameters. In the end, I look forward to a more prospective future of the heavy flavor program with further improved detector equipments at both RHIC and LHC.

Keywords: heavy quarks, energy loss, diffusion coefficient, nuclear modification factor, elliptic flow

1. Introduction

Heavy flavor quarks (c, b), due to their large masses, are expected to have unique roles for studying QCD in both vacuum and medium. There have been extensive measurements of heavy quark production in elementary collisions that demonstrate their production is calculable in perturbative QCD. Heavy quark interaction with the hot Quark-Gluon Plasma (QGP) should shed light on the roles of radiative energy loss vs. elastic collisional energy loss in such a medium. In particular, one should expect the mass hierarchy for the parton energy loss in QCD medium: $\Delta E_b < \Delta E_c < \Delta E_q < \Delta E_g$. However, the hierarchy may not be directly revealed in the nuclear modification factor (R_{AA}) observable due to differences in initial parton spectra, fragmentation *etc.*. Model calculations show that although charm hadron R_{AA} is similar to that of light hadrons, the R_{AA} of bottom hadron production in heavy-ion collisions will be less suppressed compared to charm and other light hadrons, revealing the mass hierarchy of parton energy loss unambiguously, as seen in Fig. 1 (left) [1]. And such a difference in R_{AA} will disappear at very high p_{T} as the mass effect becomes less important or negligible. The heavy quark propagation inside the QGP medium can be treated as "Brownian" motion when the heavy quark mass is much larger than the medium temperature as well as the interaction strength. The heavy quark equation of motion can be described by a reliable stochastic Langevin simulation and characterized by one intrinsic medium transport parameter - the heavy quark diffusion coefficient. Here low p_{T} measurements will be more relevant for the determination of this transport parameter. Figure 1 (right) summarizes the latest theory calculations for the charm quark spacial diffusion coefficient [2]. The goal of

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studying heavy quark production in heavy-ion collisions is to reveal the parton energy loss mechanisms and in return to measure the QGP transport parameter, particularly its temperature dependence.

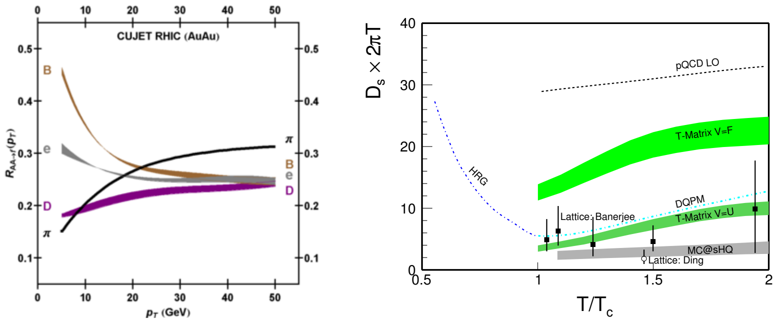

Fig. 1. (Left) CUJET pQCD predictions for different flavor hadrons in central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. (Right) Model predictions on charm quark spacial diffusion coefficient as a function of temperature.

Heavy flavor hadrons decay shortly after they are produced ($c\tau \sim 60-500\mu m$). Precision measurements of heavy quark production in high multiplicity heavy-ion collisions will require separation of their decay vertices from primary collisions in order to reduce combinatorial background. Therefore, precision silicon pixel detectors are critical to achieve necessary pointing resolution in a wide kinematic region. All RHIC and LHC experiments are equipped by such detectors. Particularly, a high resolution pixel detector based on the MAPS technology was firstly applied to the STAR experiment. Its unique features - ultimate pitch size, thin material thickness are perfect fit for precision heavy flavor measurements over a broad momentum range in heavy-ion collisions. The track pointing resolution in Au+Au collisions has reached $< 40\mu m$ at a transverse momentum of 1 GeV/c [3].

Heavy flavor hadrons are measured via either full reconstruction of their decays or inclusive/semi-inclusive decay daughters. In the following part of this proceeding, I will show selected heavy flavor measurements at RHIC and LHC focusing on recent key achievements towards understanding the QGP properties at mid-rapidity.

2. Heavy Flavor Production in $p + p$ and p/d+A Collisions

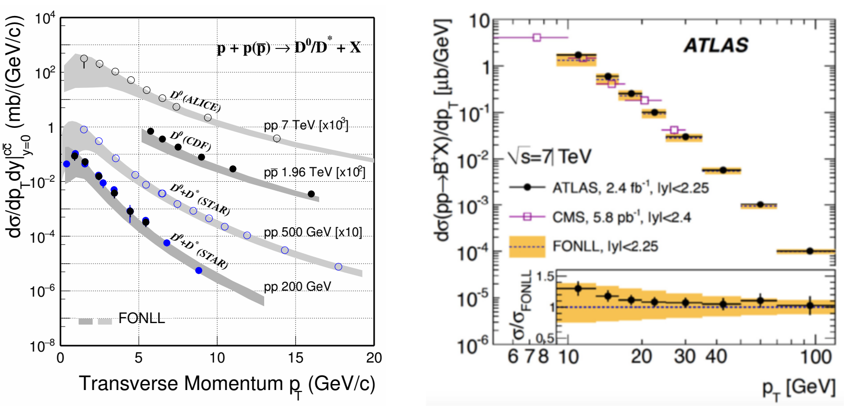

Fig. 2. (Left) D^0-meson production cross section measured in p+$p(\bar{p})$ collisions from $\sqrt{s_{NN}}$ = 0.2-7 TeV compared to pQCD FONLL calculations (grey bands); (Right) B^+-meson production cross section measured in p+p collisions at $\sqrt{s_{NN}}$ = 7 TeV)