Pair transverse momentum and rapidity correlations of heavy quarks at LHC

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Introduction

The advent of the ultrarelativistic nucleus nucleus collisions at higher and higher energies highlights heavy quarks as an excellent probe for the Quark-Gluon Plasma (QGP). Heavy quarks are produced in pairs ($Q\overline{Q}$) as the flavour is conserved in strong interaction. Again, as they are massive they would not change direction much during their passage through the QGP, which makes them a valuable probe for the properties of the plasma.

In this work we study the transverse momentum, and rapidity correlations of heavy quark-anti quark ($Q\overline{Q}$) pairs in *pp* collisions at Next-to-Leading Order (NLO).

Correlations of $Q\overline{Q}$ pair in pp collisions

We study the correlations of heavy quarks produced in the initial fusion of gluons and quark-anti quark annihilation in proton-proton collision. The basic formulation which gives the correlation is given by:

$$E_1 E_2 \frac{d\sigma}{d^3p_1 d^3p_2} = \frac{d\sigma}{dy_1 dy_2 d^2p_{T_1} d^2p_{T_2}} = C \ , \tag{1}$$

where y_1 and y_2 are the rapidities of heavy quark and anti-quark and p_{T1} and p_{T2} are their transverse momenta. We calculate the initial production of heavy quarks using the NLO pQCD treatment (NLO-MNR) developed by Mangano et al [1]. The structure function used is CTEQ5M. The mass of the charm quark is taken as m_c = 1.5 GeV, and that for bottom quarks is m_b = 4.5 GeV. The factorization and renormalization scales are taken as $Q = 2\,m_T$ and $Q = m_T$ for charm and bottom quarks respectively, where m_T is the transverse mass.

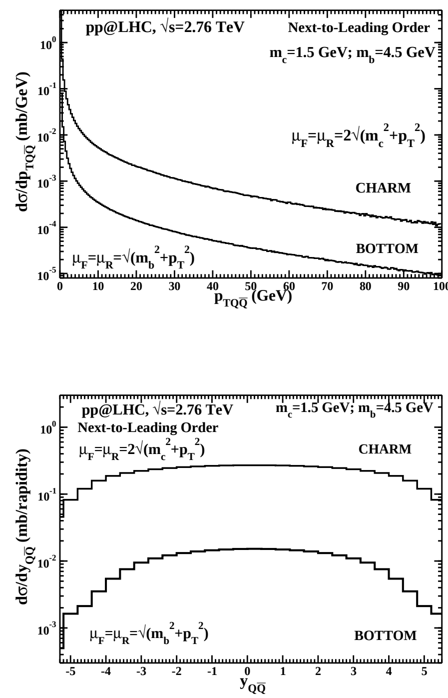

FIG. 1: Transverse momentum, and rapidity distribution of charm and bottom quark pairs in *pp* collision at $\sqrt{s}_{NN}$=2.76 TeV.

In Fig. 1 we show our results for the transverse momentum, and rapidity correlation of charm and bottom quark pairs produced in *pp* collisions at $\sqrt{s}$=2.76 TeV. These results would lead to an interesting situation, where

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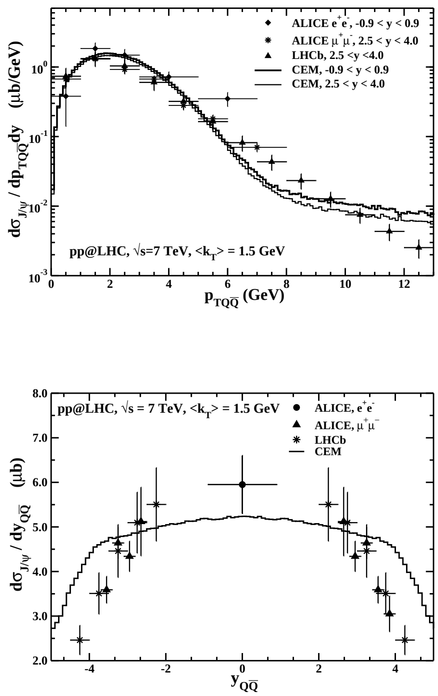

FIG. 2: Transverse momentum and rapidity distribution of J/ψ in pp collision at $\sqrt{s}$= 7 TeV, using color evaporation model.

we can consider a heavy-quark produced in LO pQCD in a nucleus-nucleus collision. As at LO, they will be produced back-to-back and are most likely to cover different lengths of the system before they fragment to a D-meson. Thus they would suffer different amount of energy loss and acquire a net-transverse momentum despite their zero initial net-trnasverse momentum.

J/ψ production in pp collisions

The J/ψ production in pp collisions is also important as the observed suppression of J/ψ in the nucleus nucleus collision carry the information of QGP formation.

Using the colour evaporation model, one can write:

$$\frac{d\sigma_{J/\psi}}{dy} = F \int_{2m_c}^{2m_D} dM \, \frac{d\sigma_{c\bar{c}}}{dM\,dy} \ . \qquad (2)$$

where M is the invariant mass of the pair, y is its rapidity, m_D is the mass of D-mesons, and F is the (constant) colour-evaporation factor. As discussed above, at LO pQCD the heavy quark are produced in pairs with pair-momentum identically equal to zero (though the NLO processes do provide them with a net-transverse momentum). This can be corrected if we consider the partons having an intrinsic k_T (see e.g. [2]) and in our calculation for J/ψ we impart an intrinsic k_T of 1.5 GeV/c to the partons.

In Fig. 2, we show our results for the transverse momentum and the rapidity distribution of J/ψ in pp collision at 7 TeV along with the experimental results. The transverse momentum distribution shows a very good description whereas we see a reasonable description of the rapidity distribution.

Summary

These results will act as a base-line for similar studies in the case of nucleus nucleus collisions at the corresponding centre of mass energies/nucleon, to determine the medium modifications.

A deviation of the observed correlations in nucleus nucleus collisions from the results shown in Fig. 1 and Fig. 2 is expected to give a measure of the medium modification. For a more detailed discussion of correlations please see ref. [3]

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References

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