

## 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 ( $Q\bar{Q}$ ) 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 ( $Q\bar{Q}$ ) pairs in  $pp$  collisions at Next-to-Leading Order (NLO).

### Correlations of $Q\bar{Q}$ 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:

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

where  $y_1$  and  $y_2$  are the rapidities of heavy quark and anti-quark and  $p_{T_1}$  and  $p_{T_2}$  are their transverse momenta. We calculate the initial production of heavy quarks using the NLO pQCD treatment (NLO-MNR) developed by Mangano et al (**mnr?**). 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.

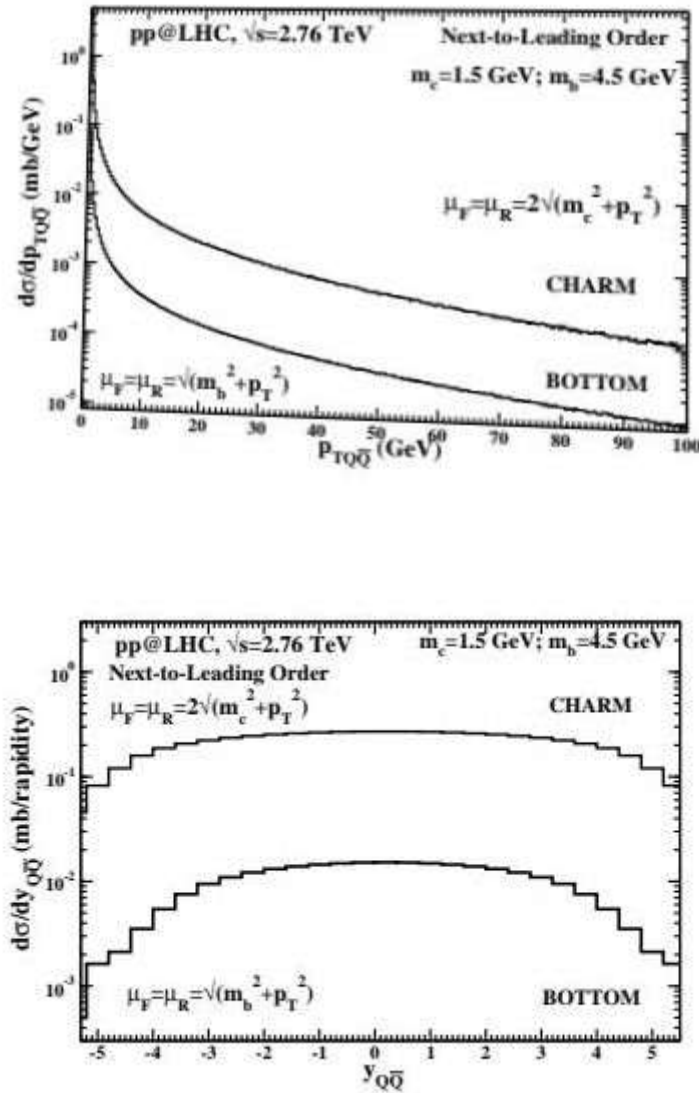


Fig1: Transverse momentum, and rapidity distribution of charm and bottom quark pairs in  $pp$  collision at  $\sqrt{s}_{NN}=2.76$  TeV.

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 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-transverse momentum.

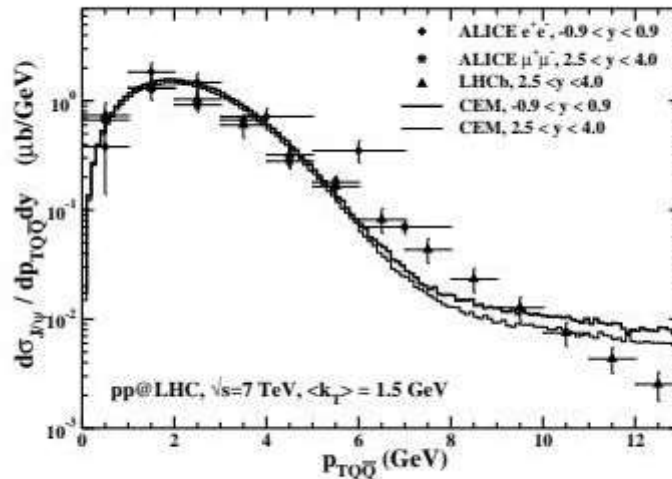
## $J/\psi$ production in pp collisions

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

Using the colour evaporation model, one can write:

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

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. **(braaten?)**) and in our calculation for  $J/\psi$  we impart an intrinsic  $k_T$  of 1.5 GeV/ $c$  to the partons.



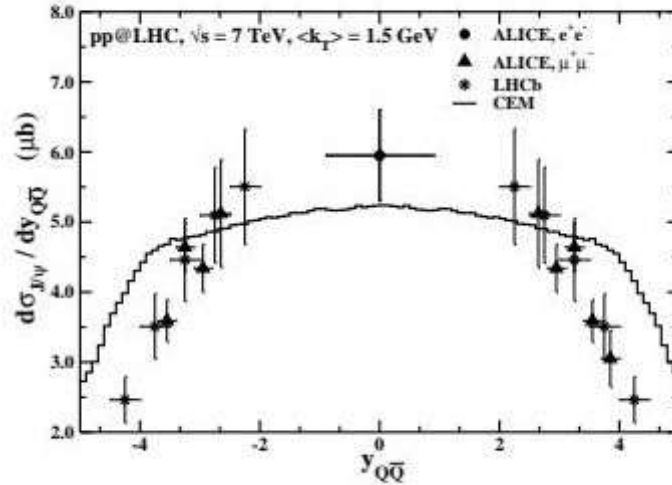


Fig2: Transverse momentum and rapidity distribution of  $J/\psi$  in  $pp$  collision at  $\sqrt{s} = 7$  TeV, using color evaporation model.

In Fig. 2, we show our results for the transverse momentum and the rapidity distribution of  $J/\psi$  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.

## References

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