Azimuthal Correlations of Charm

Mohammed Younus[1*] and Dinesh K. Srivastava[1]
[1] *Theoretical Physics Division, Variable Energy Cyclotron Centre, 1/AF, Bidhan Nagar Kolkata-700064, INDIA*

Azimuthal correlation of heavy quarks produced at LHC, can be one of the most powerful and discerning probes for quark gluon plasma. Heavy quarks suffer energy loss which manifests through changes in nuclear modification factor, $R_{\mathbf{AA}}$. On the other hand, azimuthal correlation of heavy quark will be sensitive to diffusion through quark gluon plasma, as the heavy quarks undergo collisions and radiate gluons. In the present work we present the azimuthal correlation of heavy quarks for proton-proton collisions as well as for lead-lead collisions for prompt interaction and other secondary multiple scatterings. We also study the effect of collective flow on the correlation of the heavy quarks.

The correlation of heavy quark pair produced in pp collisions can be defined in general, as:

$$\frac{d\sigma}{dy_1 dy_2 d^2p_{T1} d^2p_{T2}} = E_1 E_2 \frac{d\sigma}{d^3p_1 d^3p_2} = C \qquad (1)$$

where y_i are the rapidities, ϕ_i are the azimuthal angles, and (E_i, p_i) are the four momenta of the heavy quark and anti-quark produced.

For lead on lead collision, the primary mech-

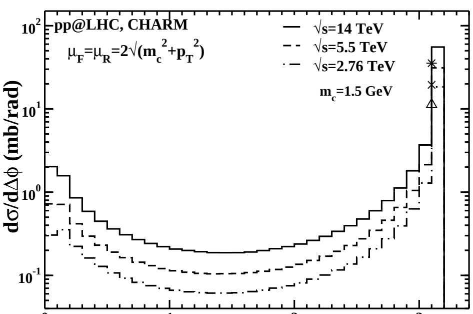

FIG. 1: Energy dependence of azimuthal correlation of charm quarks.

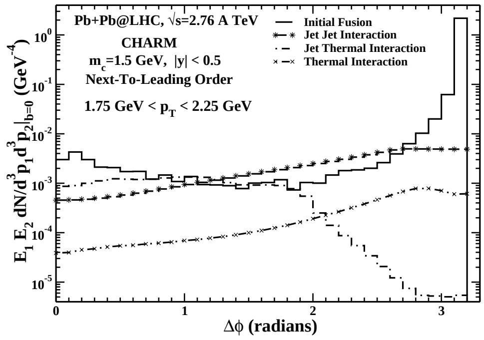

FIG. 2: Azimuthal correlation of charm quarks from various mechanisms.

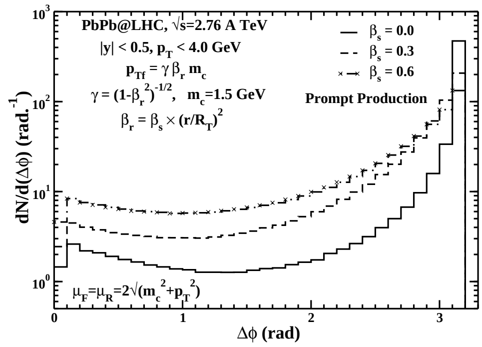

FIG. 3: Effect of flow on correlation of charm having low p_T.

*Electronic address: mdyounus@vecc.gov.in

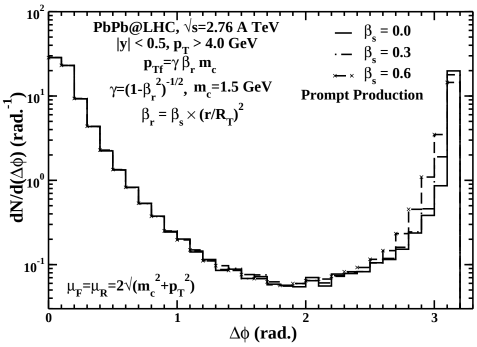

FIG. 4: Effect of flow on correlation of charm having high p_T.

anism for heavy quarks production is prompt interaction. The azimuthal correlation for prompt production is given by

$$E_1 E_2 \frac{dN}{d^3p_1 d^3p_2} = C(\Delta\phi) = T_{AA} \cdot \frac{d\sigma}{d^3p_1 d^3p_2} \quad (2)$$

The other mechanisms leading to production of heavy quarks are jet-jet, thermal and jet-thermal interactions. If we ignore the energy loss of the heavy quarks, the azimuthal distribution of heavy quarks at b=0 resulting from multiple secondary interaction is given by

$$\begin{aligned} & E_1 \ E_2 \frac{dN}{d^3p_1 d^3p_2} = \\ & \frac{1}{16(2\pi)^8} \int d^4x \int \frac{d^3p_a d^3p_b}{\omega_a \omega_b} \delta^4(\Sigma p^\mu) \\ \times & \left[\frac{1}{2} g_g^2 f_{jet/th}(p_{Ta}) f_{jet/th}(p_{Tb}) \left| M_{gg\to Q\overline{Q}} \right|^2 \right. \\ + & \left. g_q^2 N_f f_{jet/th}(p_{Ta}) f_{jet/th}(p_{Tb}) \left| M_{q\bar{q}\to Q\overline{Q}} \right|^2 \right] \end{aligned} \quad (3)$$

where $f(p_T)$ is the distributions functions of partons taking part in multiple scatterings producing heavy quarks. These are given by

$$\begin{aligned} f_{\text{jet}}(p_T) = & \frac{(2\pi)^3}{g_i \tau \pi R_T^2 p_T} \frac{dN}{dy d^2p_T} \delta(y-\eta) \\ & \Theta(\tau_f - \tau)\Theta(\tau - \tau_i) \ , \end{aligned} \quad (4)$$

where thermal distribution of partons is given by

$$f_{th}(p_T, y, \eta) = \exp\left[-\frac{p_T}{T}\cosh(y-\eta)\right] \quad (5)$$

(see for eg. Ref. [1])

We estimate the likely effect of the collective flow by a vectorially addition of the flow momentum $\mathbf{p_{Tf}}$ and the charm momentum $\mathbf{p_T}$:

$$\begin{aligned} p_{Tf} &= \gamma \beta_r m_Q \ , \\ \beta_r &= \beta_s \times \left(\frac{r}{R_T}\right)^2 \ . \\ r &= \sqrt{x^2 + y^2}. \end{aligned} \quad (6)$$

From our results we find in Fig. 1, that at leading order all the heavy quark pairs are correlated back to back, while for NLO processes we have azimuthal distribution with a smaller forward peak. In Fig. 2 we show the azimtuthal correlation for lead-lead collisions for prompt production as well all for other secondary interactions. We see that while the primary productions dominate, the productions due to multiple scatterings are still substantial. In Fig. 3 and Fig. 4 we give the effect of collective flow on the azimuthal correlation of charm produced from prompt interaction. We note that the charm quarks having large p_T are only marginally affected by the flow.

Acknowledgements

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References

[1] Md. Younus, U. Jamil, D. K. Srivastava, arXiv:1108.0855 [hep-ph]