J/Ψ -muon correlation as a probe for b-bbar production and interaction mechanism at LHC

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Introduction

The collision of heavy ions at $\sqrt{s_{NN}}$ = 2.76 TeV at LHC would create matter at extreme high temperatures where a new phase called Quark Gluon Plasma (QGP) is expected. It is envisaged that at LHC the b-bbar production is substantial, providing us a handy probe for QGP. The b quark loses energy in the medium and can measure the properties of the hot/dense medium. The b-bbar production has to be accurately known before it can be used to tag the final state interactions. Three mechanisms contribute to the beauty production at hadron colliders:

(i)*Flavor Creation*: This process includes b-bbar production through q-qbar annihilations and gluon fusion, plus higher order corrections to these processes. Because, this production is dominated by two-body final states, it tends to yield b-bbar pairs that are back to back in $\Delta\varphi$ and balanced in p_T.

(ii)*Flavor Excitation*: This corresponds to diagrams where a b-bbar pair from the quark sea of the proton is excited into final state due to one of the b quarks undergoes a hard QCD interaction with a parton from the other proton.

(iii)*Gluon Splitting*: It refers to the process in which the b-bbar pair arises from a g $\rightarrow$b-bbar spilitting in the initial or final state.

The observed shapes of the distributions and correlations are reasonably well explained by perturbative QCD.

Study of b-bbar correlations with Pythia event generator

Correlations measurements are foreseen at LHC in order to study details of the production mechanisms discussed above. The angular distance $\Delta\varphi$ between the b quark directions in the transverse plane is the main discriminating variable to disentangle contributions from the gluon-gluon fusion, gluon splitting and flavor excitation. The $\Delta\varphi$ distributions for gluon splitting is slightly peaked at small $\Delta\varphi$ values. The angle between the two b quarks produced by the gluon fusion mechanism has a peak at 180 degrees, as expected, since in the process g $\rightarrow$b-bbar the b quarks are produced back to back in the transverse plane. For the flavor excitation mechanism the back to back topology is preferred too [1].

Bottom quark decays by semi-leptonic decays (Branching Ratio = 10.69/-0.22%).Also there is a branching in J/ψ (Branching Ratio = 1.14% +/-0.06%) which finally decays to two muons. In the experiment such as Compact Muon Solenoid (CMS) the b-bbar correlation can be measured through $\mu^+\mu^-$ correlation. Another interesting possibility is J/ψ–μ correlation. In this work we study both of these methods.

With PYTHIA, b-bbar are produced with gg$\rightarrow$b-bbar and q-qbar$\rightarrow$b-bbar. In one case we force both of these to decays to muons to study μ - μ correlations. In the other case one of the b is forced to decay to J/ψ and other to muon.

Results

First the angular correlation between b-bbar is obtained which shown is in Fig.1. One can see that the distribution peaks at π as a result of back to back pair emission. In Fig. 2 the angular correlation between the decay $\mu^+\mu^-$ pair is shown while the J/ψ – μ correlation is shown in Fig. 3. One can observe from these figures that the correlations in bbar survive in the correlation of their decays products. If one compares distribution in Fig. 2 to that in Fig. 3 one can notice that J/ψ-μ channel is better than the μ - μ channel. The other advantage with J/ψ-μ channel is it will have much smaller background as compared to the μ - μ channels and will be a cleaner probe.

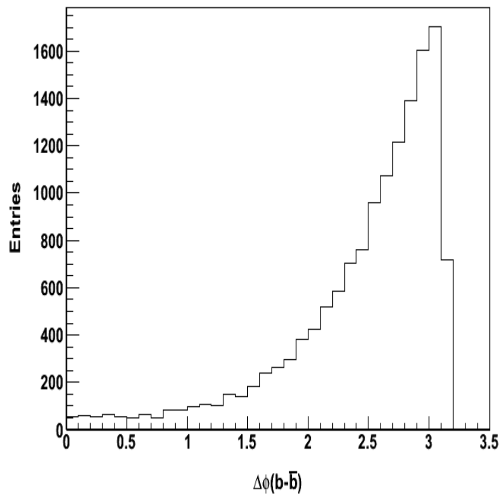

Fig.1 Correlation between b-bbar

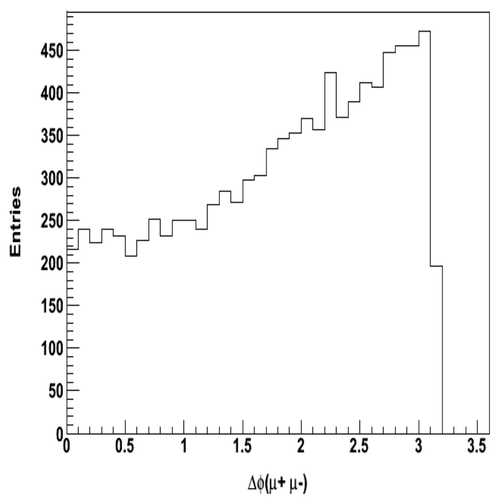

Fig.2 Correlation between muons coming from b decays

Fig.4 shows the transverse momentum distributions of the muons. The muons coming from the b decays are more likely to have higher p_T hence, by using a cut on p_T, we can reduce the background of muons coming from other sources. Muons from background sources have softer p_T distributions.

The above study shows that we can measure b-bbar correlations with the help of J/ψ-μ correlation. It will be interesting to see how the correlation pattern changes with energy loss of b quarks in medium. The correlation pattern for different p_T range is under investigation.

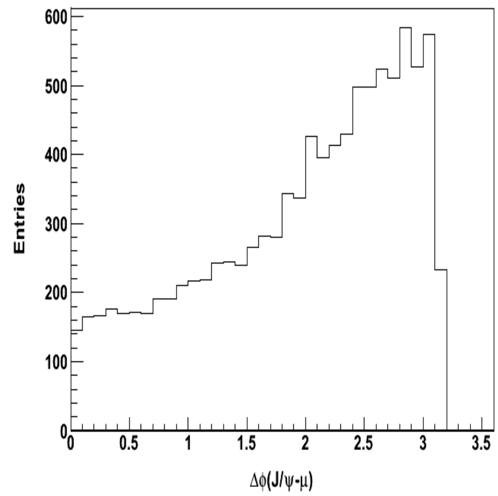

Fig.3 Correlation between J/psi and muons coming from b decays

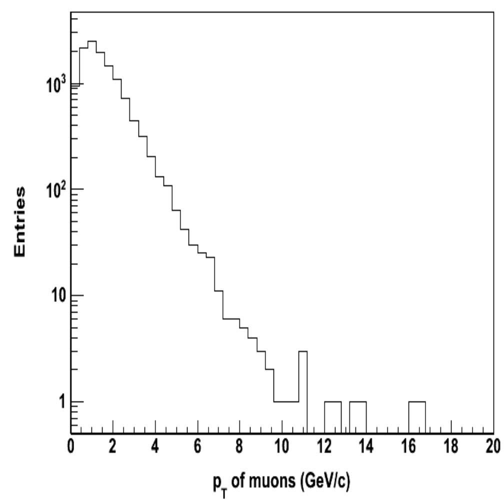

Fig.4 Transverse momentum of muons coming from b decays

References

[1] V.P.Andrrev, arXiv:0706.1789[hep-ex].

[2] Pythia, http:*//projects.hepforge.org/**pythia6/***