B-meson measurement via secondary J/ψ production in Pb-Pb collisions at $\sqrt{s}_{NN} = 5.5$ TeV

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Collisions of Pb ions at Large Hadron Collider (LHC) at energies $\sqrt{s}_{NN} = 5.5$ TeV would create strongly interacting matter at very high temperatures where a phase transition to quark gluon plasma (QGP) is expected. The CMS (Compact Muon Solenoid) experiment [1] has extensive heavy ion physics programs besides particle physics interest in pp collisions. A Pb+Pb run at $\sqrt{s}_{NN} = 5.5$ TeV is expected to take place by the end of year 2010. It is convenient to quote all the numbers for one month (10^6 s) of LHC running. The luminosity for Pb+Pb collisions integrated over one month is about 0.5 nb^{-1}.

Quarks lose energy in the medium by gluon brehmstrahlung which is suppressed at angle smaller than the ratio of their mass with energy [2]. Thus, the heavy quarks are predicted to lose less energy as compared to light quarks but at RHIC it was found that c quarks also lose substantial energy as much as light quarks [3]. The production of charm and bottom at LHC would be at least one order of magnitude larger than those at RHIC [4] enabling more precise systematic studies of the energy loss phenomena of heavy flavours for the first time.

One interesting channel at LHC is secondary J/ψ coming from the decays of B-mesons with branching ratio 1.16 %. The secondary J/ψ subsequently decays to dimuon channel with branching ratio 5.93 %. The J/ψ particle produced early in the collision is considered to give crucial information on many body aspects of QCD matter and QGP formation. This J/ψ produced at collision vertex is referred in present study as 'primary'. The secondary J/ψ coming from B decays can be separated from the primary using the secondary vertex information as the B flies to a measurable distance before decaying.

We make a comparative study of these two processes namely J/$\psi \rightarrow \mu^+\mu^-$ and B $\rightarrow$ J/ψ $\rightarrow \mu^+\mu^-$ with the kinematic cuts relevant for CMS detector. We produce both types of events at $\sqrt{s}_{NN} = 5.5$ TeV for p+p collisions using PYTHIA [5] event generator. The $B\bar{B}$ and J/ψ cross sections for pp collisions are taken from CERN yellow report [4] and from Ref. [7] and extrapolated to PbPb collisions. The J/ψ production cross section per nucleon pair is 11.7 μb for PbPb minimum bias collision at 5.5 TeV. This is calculated using parton distribution function (pdf) MRST HO with c quark mass as 1.2 GeV. The BBbar production cross section per nucleon pair is used as 0.17 mb obtained using pdf CTEQ5M1 and b quark mass as 4.75 GeV. EKS98 parameterizations are used to take into account the effect of nuclear shadowing in both the cases.

The Table (I) gives the acceptance of different η and p_T cuts along with the number of produced muon pairs before and after applying those cuts. Both η and p_T cuts are applied on individual muons to get the acceptance. The pseudorapidity η coverage in CMS detector is given by $|\eta| \leq 2.4$. The designed p_T trigger on individual tracks is given by $p_T > 3.0$ GeV. We also give numbers for $p_T > 2.0$ GeV. The η and p_T acceptance for the two processes is different. The Table (II) gives the number of produced muon pairs before and after detector efficiency [8] correction.

A comparative study of primary and secondary J/ψ coming from B decays has been made. Out of total number of J/ψ's detected 25 % are coming from the B decays. A total of 42000 B's coming through J/ψ are expected in one month of Pb+Pb collisions. A secondary Vertex cut has to be applied to separate primary and secondary J/ψ. A large fraction (> 50 %) of B's will be lost if one wants to keep

TABLE I: Comparison of numbers of direct J/ψ and B $\rightarrow$ J/ψ for PbPb collisions at 5.5 TeV for one month of LHC running.

	J/$\psi \rightarrow \mu^+\mu^-$	B$\rightarrow$ J/$\psi \rightarrow \mu^+\mu^-$
cross section	506 mb (J/ψ)	7355 mb (B$\bar{B}$)
No. of $B\bar{B}$	-	3.7×10^9
No. of J/ψ	2.5×10^8	8.6×10^7
No. of $\mu^+\mu^-$ pairs	1.5×10^7	5.15×10^6
Acceptance cuts $\eta < 2.4$	0.360	0.560
Acceptance cuts $\eta < 2.4$ and $p_T > 2.0$	0.038	0.068
Acceptance cuts $\eta < 2.4$ and $p_T > 3.0$	0.0134	0.018
Accepted $\mu^+\mu^-$ for $\eta < 2.4$ and $p_T > 2.0$	5.7×10^5	3.5×10^5
Accepted $\mu^+\mu^-$ for $\eta < 2.4$ and $p_T > 3.0$	2.0×10^5	9.3×10^4

TABLE II: Expected numbers of direct J/ψ and B $\rightarrow$ J/ψ for PbPb collisions at 5.5 TeV for one month of LHC running.

Cut $\eta < 2.4$ and $p_T > 2.0$	J/$\psi \rightarrow \mu^+\mu^-$	B$\rightarrow$ J/$\psi \rightarrow \mu^+\mu^-$
Efficiency	0.64	0.45
Accepted muon pairs	2.0×10^5	9.3×10^4
Muon pairs after efficiency correction	1.30×10^5	4.2×10^4

the contamination minimum from the direct J/ψ's.

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