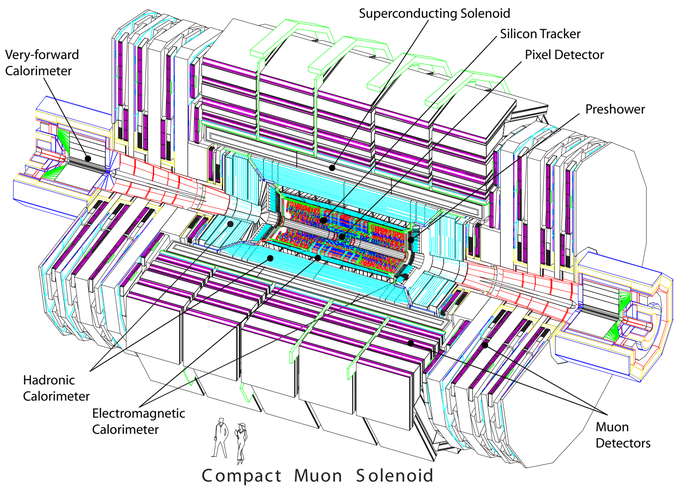
B-meson measurement via secondary J/ψ production in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV in the CMS

Prashant Shukla, Nuclear Physics Division, BARC, Mumbai, INDIA
pshukla@barc.gov.in

Ji Hyun Kim, Department of Physics, Korea University, Seoul, Korea
ji.hyun.kim@cern.ch
on behalf of the CMS collaboration

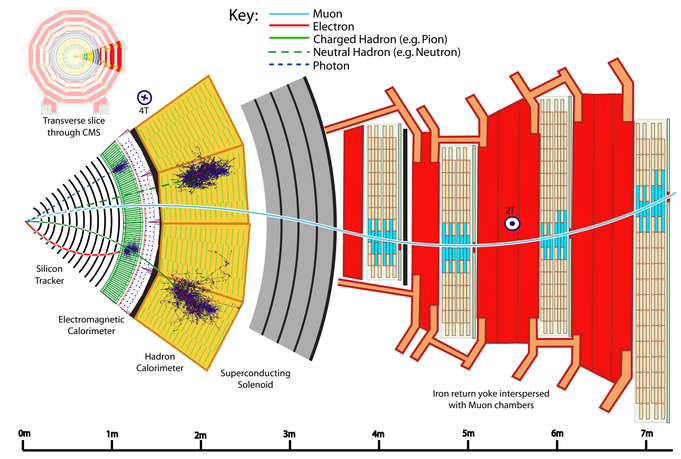
Introduction

- At the LHC, energy density in central PbPb collisions should be well above the threshold where the phase transition to QGP(Quark Gluon Plasma) is expected to occur(> ~0.7GeV/fm^3). Quarks lose energy in the medium by gluon bremsstrahlung which is suppressed at angles smaller than the ratio of their mass over energy. Thus, 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. Due to large production of heavy quarks, the LHC will facilitate accurate and systematic measurements of heavy quark energy loss effects.



- **η and φ coverage of the CMS muon chambers**
  - **$|\eta| < 2.4$**
  - **$0 < \phi < 2\pi$**
- **2 conditions are mandatory for the heavy quark physics.**
  - **The High statistics thanks to the large muon acceptance**
  - **The Good signal/background ratio thanks to the very good dimuon mass resolution resulting from the high granularity of the tracker**

Fig. 1: The CMS Detector



- **J/ψ from B meson subsequently decays to dimuons.**
- **Muons are measured by the CMS muon system :**
  - **DT (Drift Tube Chamber)**
  - **CSC (Cathod Strip Chamber)**
  - **RPC (Resistive Plate Chamber)**

Fig. 2: A transverse slice through one segment of the CMS detector indicating the responses of the various detecting systems to diffrent types of particles[4].

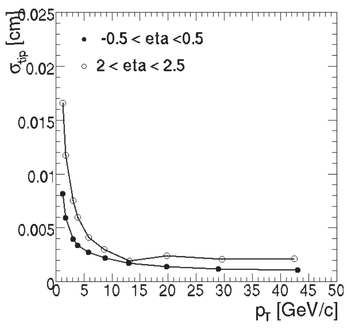


Fig. 3: Impact parameter resolution for the CMS detector.

Goal : Secondary J/ψ as a probe of the medium

- Thanks to the large BBar cross section at the LHC one can measure secondary J/ψ coming from B decay with Branching Ratio 1.16 %.
- The J/ψ particle produced early in the collision is considered to give crucial information on QGP formation. : Primary J/ψ.
- One has to separate primary and secondary J/ψ to understand the medium effects. : Secondary vertex technique is used.

Results

PbPb at 5.5 TeV, PYTHIA 6.409

- **1 month of the LHC running (Integrated luminosity 0.5nb^{-1})**

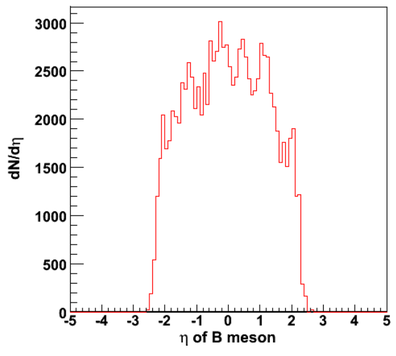


Fig. 4: η distribution of B mesons, with $p^{\mu}_T > 5$ GeV/c and $|\eta^{\mu}| < 2.4$, in minimum bias PbPb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV.

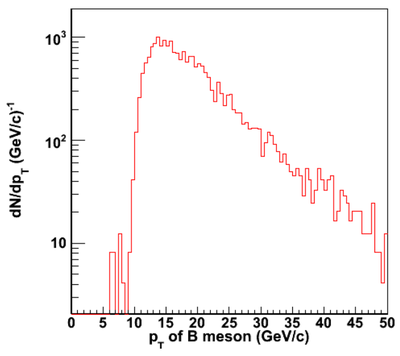


Fig. 5: p_T distribution of B mesons, with $p^{\mu}_T > 5$ GeV/c and $|\eta^{\mu}| < 2.4$, in minimum bias PbPb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV.

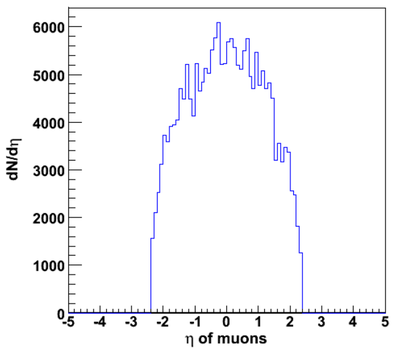


Fig. 6: η distribution of muons from secondary J/ψ, with $p^{\mu}_T > 5$ GeV/c and $|\eta^{\mu}| < 2.4$, in minimum bias PbPb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV.

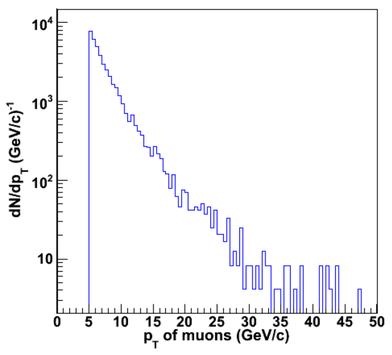


Fig. 7: p_T distribution of muons from secondary J/ψ, with $p^{\mu}_T > 5$ GeV/c and $|\eta^{\mu}| < 2.4$, in minimum bias PbPb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV.

NN cross section for J/ψ and BBar production

- Cross section calculated with QCD (NLO)
- Mass of c quark = 1.2 GeV
- Mass of b quark = 4.75 GeV
- Shadowing: EKS98 parameterization
- Cross section per nucleon pair for minimum bias PbPb events at 5.5 TeV
  - $\sigma_{J/\psi}$ = 11.7 μb
  - σ_{BBbar} = 0.17 mb
- BR $_{J/\psi \to \mu^+\mu^-}$ = 5.93 %
- BR $_{BBbar \to J/\psi + X}$ = 1.16 %
- Source : hep-ph/0311048[3]

Muon pairs from Direct J/ψ and B→J/ψ

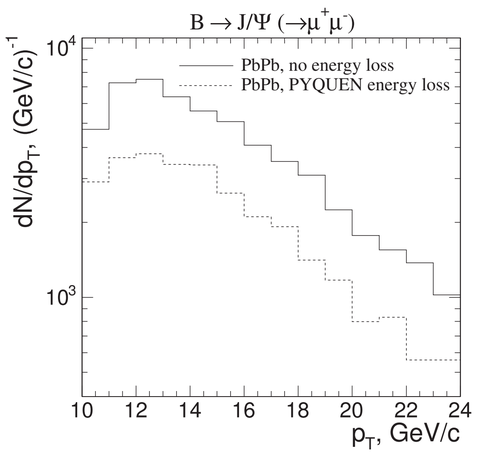


Fig. 8: p_T distribution of muons from secondary J/ψ, with $p^{\mu}_T > 5$ GeV/c and $|\eta^{\mu}| < 2.4$, in minimum bias PbPb collisions[4, 5].

PbPb yield of direct J/ψ and B to J/ψ

	J/ψ→μ+μ-	B→J/ψ→μ+μ-
cross section	506 mb (J/ψ)	7355 mb (BB)
No. of BBar	–	3.7 x 10^9
No. of J/ψ	2.5 x 10^8	8.6 x 10^7
No. of μ+μ- pairs	1.5 x 10^7	5.15 x 10^6
Acceptance cuts $\|\eta\| < 2.4$	0.5386	0.6169
Acceptance cuts $\|\eta\| < 2.4$ and $p_T > 5.0$	0.016	0.0022
Acceptance cuts $\|\eta\| < 2.4$ and $p_T > 3.5$	0.030	0.011
Accepted μ+μ- for $\|\eta\| < 2.4$ and $p_T > 5.0$	2.3 x 10^5	11300
Accepted μ+μ- for $\|\eta\| < 2.4$ and $p_T > 3.5$	4.4 x 10^5	57000

- PbPb at 5.5 TeV, for one month of the LHC running
- Does not include tracking and PID efficiency

Distribution of transverse distance of muon pairs

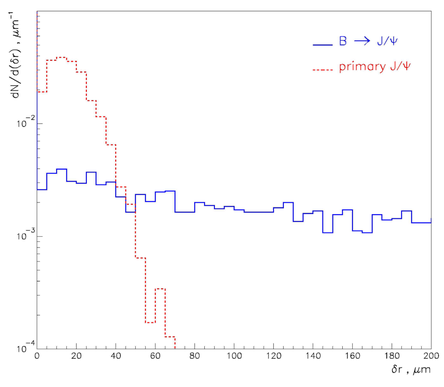


Fig. 9: Transverse distance, δr, distribution of μ+μ- pairs from secodary and primary J/ψ[4, 5].

Summary

1. A comparative study of primary and secondary J/ψ coming from B decays has been made.
2. The ratio R of secondary to primary J/ψ
   - R in all phase space = 0.29
   - R in the CMS acceptance $p_T > 3.5$ GeV = 0.106
3. Studies show that secondary J/ψ carries energy loss effect of the b quarks.
4. The secondary Vertex can be used to separate primary and secondary J/ψ.

Quark Matter 2008, Feb. 4~10, 2008, Jaipur, India

References

[1] The CMS Collaboration: CERN/LHCC-94-38 (1994)
[2] T. Sjostrand, S. Mrenna and P. Skands, JHEP05 (2006) 026
PYTHIA Web Site: http://www.thep.lu.se/~torbjorn/Pythia.html
[3] CERN Yellow Report. "Hard probes in heavy ion collisions at the LHC: Heavy flavor physics", CERN-2004-009-C
[4] D. d'Enterria, (ed.) et al. (The CMS Collaboration), "CMS physics technical design report: Addendum on high density QCD with heavy ions", J. Phys. G 34 (2007) 2307
[5] I.P. Lokhtin and A.M. Snigirev, Eur. Phys. J C 21 (2001) 162; J. Phys. G 27 (2001) 2365.