Suppression of bottomonia states in finite size quark gluon plasma in PbPb collisions at LHC

P. Shukla,* Abdulla Abdulsalam, and Vineet Kumar
Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA

Introduction

We estimate the suppression of bottomonium states in an expanding QGP of finite lifetime and size with the conditions relevant for PbPb collisions at LHC. The recent results on the properties of Υ states have been used as ingredient in the study. The nuclear modification factor and the ratios of yields of Υ states are then obtained as a function of transverse momentum and centrality. We compare our calculations with the bottomonia yields measured in Pb+Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV.

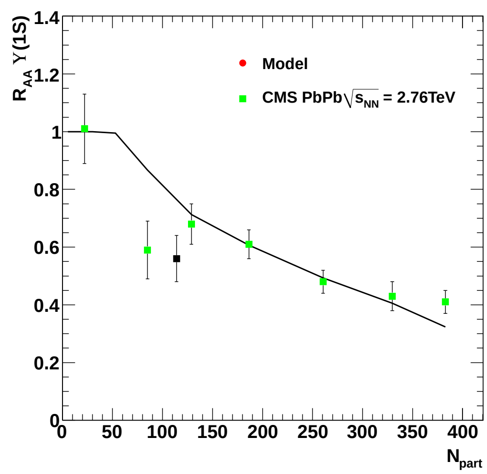

FIG. 1: The nuclear modification factor of $\Upsilon(1S)$ versus centrality of the collisions.

Quarkonia suppression model

The bottomonia suppression is calculated based on the model by Chu and Matsui [1] which takes into account the finite QGP lifetime and spatial extent. The model assumes that quark gluon plasma is formed at some initial entropy density s_0 at time τ_0 which undergoes an isentropic expansion and cools to entropy density s_D corresponding to the dissociation temperature in time τ_D which is given by

$$\tau_D = \tau_0 \left(\frac{s_0}{s_D}\right) = \tau_0 \left(\frac{T_0}{T_D}\right)^3, \qquad (1)$$

In finite system the initial entropy density is assumed to be dependent on radius R as

$$s_0(r) = s_0 \ \left(1 - \left(\frac{r}{R}\right)^2\right)^{1/4}, \qquad (2)$$

Using Eq. (1) and Eq. (2) one can obtain the r dependence of τ_D. If a $Q\overline{Q}$ pair is created at the position $\mathbf{r}$ in the transverse plane with a transverse momentum $\mathbf{p_T}$ then the boundary of suppression region r_D, is obtained as

$$r_D = R\left(1 - \left(\frac{\gamma\tau_F}{\tau_D(0)}\right)^4\right)^{1/2}. \qquad (3)$$

where $\gamma = E_T/M$ is the Lorentz factor associated with the transverse motion of the pair and τ_F is the formation time. There is a range of ϕ, angle between $\mathbf{p_T}$ and $\mathbf{r}$, for which the bottom-quark pair can escape:

$$\cos\phi \geq z \quad \text{where} \quad z = \frac{r_D^2 - r^2 - (\tau_F p_T/M)^2}{2r\ (\tau_F p_T/M)}.$$

With this we can then calculate probability $\phi(r, p_T)$ for the pair created at $\mathbf{r}$ with trans-

*Electronic address: pshuklabarc@gmail.com

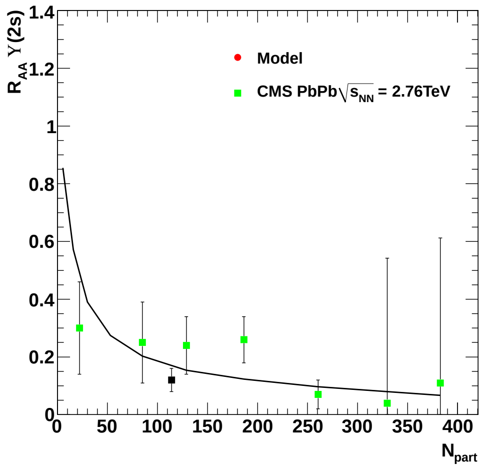

FIG. 2: The nuclear modification factor of $\Upsilon(2S)$ versus centrality of the collisions.

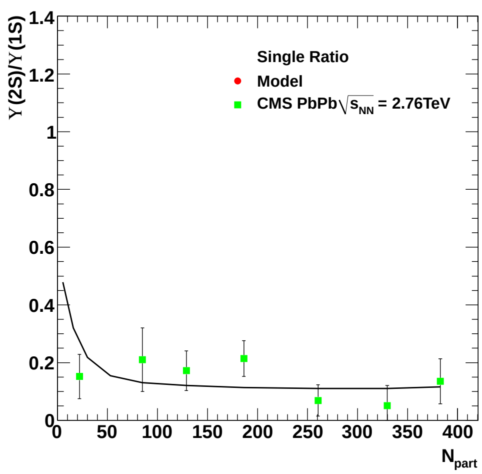

FIG. 3: The double ratio versus centrality of the collisions.

verse momentum $\mathbf{p_T}$ to survive. If the probability of a quark pair to be created at r is given by $\rho(r)$ then the survival probability of quarkonia becomes

$$S(p_T, R) = \frac{\int_0^R dr\ r\ \rho(r)\ \phi(r, p_T)}{\pi \int_0^R dr\ r\ \rho(r)}. \quad (4)$$

The integrated survival probability as a function of centrality can be obtained if we know the p_T distribution of quarkonia. The radius R as a function of centrality is obtained in terms of the radius of the Pb nucleus and the total number of participants. The Υ parameters are taken from Refs. [2, 3]. For τ_0 = 0.1 fm/c, the temperature is T_0 = 0.636 GeV. The critical temperature is taken as T_C = 0.160 GeV.

Results and Discussion

The survival probabilities can be taken as the nuclear modification factors of the Υ states. To compare with the experimental data one should take into account the feed-down corrections. Figure 1 shows the calculated nuclear modification factor of $\Upsilon(1S)$ versus centrality of the collisions along with the CMS data [4]. The black circle is minimum bias point. Figure 2 is same for the $\Upsilon(2S)$. In figure 3 we show the double ratio which is the ratio of the ratio of two states in PbPb and pp collisions. In the double ratio, the feeddown correcetions almost cancel out. The model gives very good description of the data and it can be concluded that Υ production in PbPb collisions at LHC is consistent with the QGP formation scenario.

References

[1] Chu M C and Matsui T 1988 *Phsyical Review* C **37** 1851.

[2] Satz H 2006 *J Phys* G **32** R 25.

[3] Mocsy A and Petreczky P 2007 *Phys. Rev. Lett.* **99** 211602 (arXiv:0706.2183 [hep-ph]).

[4] V. Kumar (CMS collaboration), this proceedings.