Charmonium Production in Pb+Pb Collisions at $\sqrt{s}_{NN}$ = 2.76 TeV

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Introduction

In high-energy heavy-ion collisions, one of the most striking characteristics is the suppression of quarkonium states. The suppression is predicted to occur above a critical temperature of the medium, and sequentially, in the order of the $Q\overline{Q}$ binding energy [1]. The ψ(2S) meson yield in PbPb collisions is of particular interest when compared to the J/ψ meson. The sequential melting should manifest itself in nuclear modification factors (R_{AA}) for the ψ(2S) that are smaller, or at most equal, to those measured for the J/ψ. In the analysis, the main result is presented in the form of a double ratio $(N\psi(2S)/NJ/\psi)_{PbPb}/(N\psi(2S)/NJ/\psi)_{pp}$ [2]. The double ratio can also be written as the ratio of ψ(2S) and J/ψ nuclear modification factors: $(N\psi(2S)/NJ/\psi)_{PbPb}/(N\psi(2S)/NJ/\psi)_{pp}$ = R(PbPb)/R(pp) = $R_{AA}(\psi(2S))/R_{AA}(J/\psi)$.

Data Selection

The analysis is based on a data sample recorded by the CMS detector in pp and PbPb collisions at $\sqrt{s}_{NN}$ = 2.76 TeV with higher luminosity about a factor of 20 compared to 2010 PbPb run. Hadronic PbPb collisions were selected using information from the two Beam Scintillator Counters and Forward Hadronic calorimeters (HF). After filtering, a sample of 1 billion minimum bias (MB) events were collected. Assuming an inelastic PbPb cross section of σ_{PbPb} = 7.65 barn, this sample corresponds to an integrated luminosity of L_{int} = 150 μb^{-1}. The recorded pp luminosity in CMS was 225 nb^{-1}.

Signal extraction and analysis

The analysis is performed in two [p_T,|y|] kinematical ranges: 1) Lower-p_T J/ψ and ψ(2S), down to 3 GeV/c, can only be reached for 1.6 < |y| < 2.4. 2) At mid-rapidity, |y| < 1.6, only J/ψ and ψ(2S) of p_T > 6.5 GeV/c are reconstructed, as imposed by the single-muon acceptance. The centrality classes used in this analysis are 40-100% 20-40% and 0-20%, ordered from the lowest to the highest HF energy deposit.

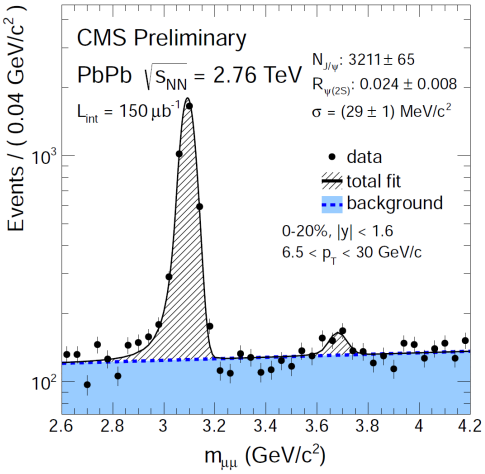

FIG. 1: Invariant mass spectrum of $\mu^+\mu^-$ pairs

The invariant mass (m) spectrum of $\mu^+\mu^-$ pairs with 6.5 < p_T < 30 GeV/c, in the region 2.6 ≤ m < 4.2 GeV/c, is shown in Figure 1. The black curve is an unbinned maximum likelihood fit with sum of a Crystal Ball (CB) and a Guassian function with common mean m_0 and an exponential for the background. The CB function f_{CB}(m) combines a Gaussian core and a power-law tail with an exponent n to account for energy loss due to final-state photon radiation.

The systematic uncertainties on the single

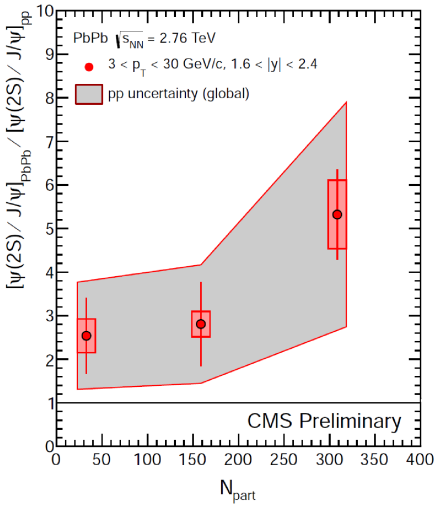

FIG. 2: Measured yield double ratio as a function of centrality. The p_T and rapidity bins are 3.0 < p_T < 30 GeV/c and 1.6 < |y| < 2.4

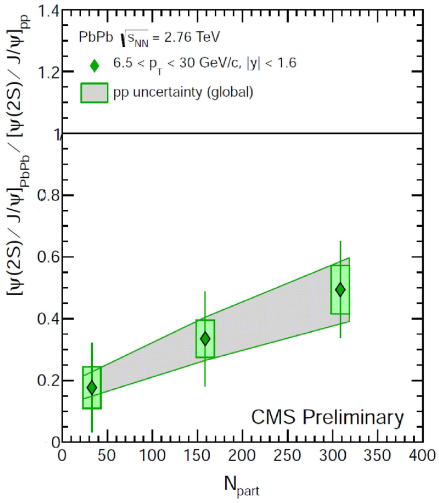

FIG. 3: Measured yield double ratio as a function of centrality. The p_T and rapidity bins are 6.5 < p_T < 30 GeV/c and |y| < 1.6.

ratio due to the fitting method are studied by varying the signal and background shapes. Typical variations are found between 5% and 40%. To evaluate possible imperfect cancellations of acceptance and efficiency effects in the double ratio, efficiencies and acceptances have been calculated from full MC simulations of ψ(2S) and J/ψ in PbPb and pp.The double ratio of efficiencies is found to be compatible with unity in all cases, with a MC statistical uncertainty of 2% in the higher p_T range, going up to 10% in the lower p_T range, that is considered as a systematic uncertainty.

Results

The results of the double ratio measurement are shown in Figure 2 and 3 as a function of centrality, for the lower p_T and higher p_T selections. Since the uncertainties on R(pp) are common to all centralities, they are shown as a grey area, adding the statistical and systematic uncertainties in quadrature. The error bars and boxes stand for the statistical and systematic uncertainties due to R(PbPb). For p_T > 6.5 GeV/c and |y| < 1.6 the double ratio is always less than unity, meaning that high-p_T ψ(2S) are more suppressed than J/ψ. Within uncertainties, no centrality dependence is observed. However, going to lower p_T (3 < p_T < 30 GeV/c) in the forward rapidity range, the data show an increase of the double ratio with centrality, though with large uncertainties. In the most central collisions the double ratio is 5.32±1.03(stat.)±0.79(syst.)±2.58(pp) which means that more ψ(2S) are produced compared to J/ψ than in pp collisions, again with large uncertainties.

In summary, at lower p_T and forward rapidity, the data suggests an enhancement of the ψ(2S)/J/ψ ratio and in higher p_T and midrapidity ψ(2S) is more suppressed than J/ψ.

References

[1] CMS Collaboration, "Suppression of non-prompt J/ψ, prompt J/ψ, and in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV", JHEP **05** (2012) 063.

[2] CMS Collaboration, "Measurement of the ψ(2S) meson in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV", CMS PAS HIN-12-007.