# Measurement of $\Psi$(2S)/$\Psi$(1S) ratio in pp collisions at $\sqrt{s}$ = 7 TeV

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## Introduction

ALICE [1] is one of the detector at LHC, dedicated to the study of nucleus-nucleus collisions. It consists of a central barrel ($|\eta| \leq 0.9$) and a forward Muon Spectrometer ($-4 \leq \eta \leq -2.5$). The ALICE Muon Spectrometer (ALICE-MS) is designed to measure and separate the $\Psi$ and $\Upsilon$ states ($\Psi(1S)$,$\Psi(2S)$ and $\Upsilon(1S)$,$\Upsilon(2S)$,$\Upsilon(3S)$). These measurements are crucial for the investigation of the properties of the strongly-interacting system formed in the early stages of heavy ion collisions [2]. In addition to the measurement of individual nuclear modification factors ($R_{AA}$) [3] for $\Psi$ and $\Upsilon$ states, ALICE-MS also aims to measure the $\Psi(2S)/\Psi(1S)$ ratio. This ratio can be determined accurately since the uncertainities in the cross-section measurement due to various systematic errors (e.g. luminosity determination) gets cancelled out. Thus, this ratio is a sensitive probe to the properties of the medium formed in Pb-Pb collision. However, it is essential to determine the baseline values of this ratio in p-p collision. In the present work, we report the measurement of $\Psi(2S)/\Psi(1S)$ ratio in p-p collision at $\sqrt{s}$=7 TeV as a function of transverse momentum ($p_T$) at the forward rapidities ($-4 \leq \eta \leq -2.5$).

The result presented are obtained by analyzing the data collected during the LHC11c and LHC11d periods. The event sample used in this analysis corresponds to minimum-bias (MB) events. The minimum-bias collisions were triggered by requiring atleast one hit in either of the VZERO scintillator hodoscopes or in the SPD, in coincidence with LHC Branch-crossing trigger. In addition, the muon data sample was selected by the condition that at least one muon with $p_T > 1$ GeV was present within the angular acceptance of the Muon Spectrometer. The Invariant mass spectrum was built from those events which have atleast two matched tracks in tracking and trigger detectors. The standard cuts of Muon Spectrometer: $-4 \leq \eta_\mu \leq -2.5$, $-4 \leq \eta_{\mu\mu} \leq -2.5$ and 17.6 cm $\leq R_{abs} \leq$ 89.5 cm have been employed [1].

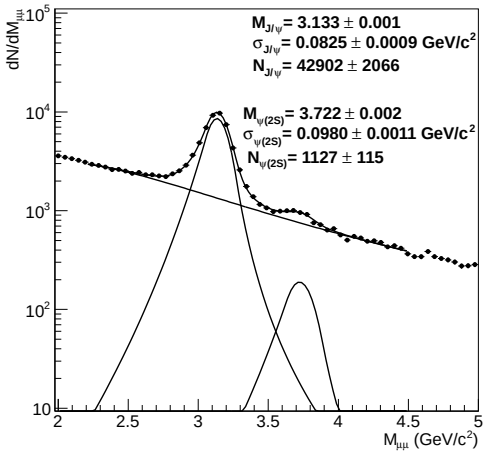


FIG. 1: Invariant mass distribution for opposite-sign muon pairs, in the mass region $2 < m_{\mu\mu} < 5$ GeV/c$^2$ with the result of the fit.

The invariant mass spectrum between 2 GeV/c$^2$ and 5 GeV/c$^2$ for 23.3 million MB events with muon trigger is showed in figure 1. A total of 42902 $\Psi(1S)$ and 1127 $\Psi(2S)$ have been found by fitting the spectrum with double crystal ball function for each peak and a variable width gussian function for the back-

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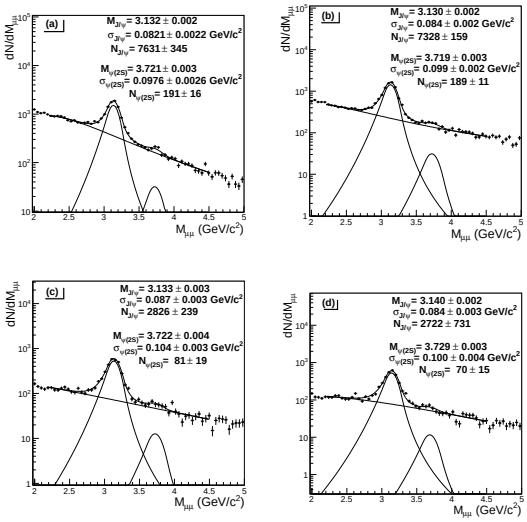


FIG. 2: Invariant mass distribution for unlike-sign muon pairs in four $p_T$ bins, (a) for $p_T$ 0-1 GeV/c (b) for $p_T$ 3-4 GeV/c (c) for $p_T$ 5-6 GeV/c (d) for $p_T$ 6-8 GeV/c, with fit results.

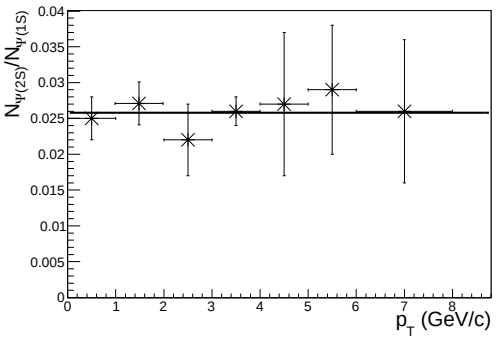


FIG. 3: Ratio of $N_{\Psi(2S)}$ and $N_{\Psi(1S)}$ in different $p_T$ bins.

ground [4]. The width of $\Psi(1S)$ and $\Psi(2S)$ has been found to be 82 MeV/c$^2$ and 98 MeV/c$^2$ respectively. It is to be noted that the mass resolution are expected to improve by ∼10% with the new alignment data.

Figure 2 shows a differential study of obtaining $N_{\Psi(1S)}$ and $N_{\Psi(2S)}$ as a function of the kinematic variable $p_T$. These invariant mass spectrum have been obtained in seven $p_T$ bins of which four $p_T$ bins have been shown in figure 2 corresponding to 0-1 GeV/c (a), 3-4 Gev/c (b), 5-6 GeV/c (c) and 6-8 GeV/c (d). The same fitting technique mentioned above, has been used for every mass spectrum.

Figure 3 shows the $\Psi(2S)/\Psi(1S)$ ratio as a function of $p_T$. The acceptance X efficiency factor has been assumed to be the same for $\Psi(1S)$ and $\Psi(2S)$. It is observed from the figure that the ratio does not depend on the $p_T$ bins. Thus, the average baseline value of $\Psi(2S)/\Psi(1S)$ in p-p collision at $\sqrt{s}$ = 7 TeV is 0.026 ± 0.02 .

## References

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[3] Suppression of Charged Particle Production at Large Transverse Momentum in Central Pb-Pb Collisions at $\sqrt{s}_{NN}$ = 2.76 TeV, Phys. Lett. B 696 (2011) 30-39.

[4] Rapidity and transverse momentum dependence of inclusive J/$\psi$ production in pp collisions at $\sqrt{s}$=7 TeV, Phys.Lett. B704 (2011) 442-455.