Inclusive J/ψ production in proton-proton interactions at $\sqrt{s}$ = 7 TeV with ALICE at LHC

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Abstract. The ALICE experiment at the CERN's Large Hadron Collider allows the study of charmonium production in both e^+e^- and $\mu^+\mu^-$ decay channels. In this paper, the first results obtained from reconstructing J/ψ mesons in proton-proton interactions at $\sqrt{s}$ = 7 TeV are discussed. The present plans for quarkonia analyses are also mentioned.

Keywords: Quarkonia production, J/ψ, LHC
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INTRODUCTION

By colliding proton beams at a centre-of-mass-energy of 7 TeV, the Large Hadron Collider (LHC) set a record for high-energy collisions in March 2010. Although the ALICE experiment [1] was optimised for the study of heavy-ions, a complementary p+p physics programme to that of the other LHC experiments was also envisaged [2, 3]. One natural example is the study of charmed hadrons. Recent results by Tevatron [4, 5] and RHIC [6] experiments have been compared to theoretical models of charmonia production [7, 8]. At present, none of the existing theoretical frameworks are able to describe consistently the experimental measurements. In particular, the polarisation of J/ψ mesons is still puzzling. Measurements of charmonia and bottomonia states at the LHC promise to shed light on their hadro-production mechanism. During the *5th Workshop on High p_T physics at the LHC* the first results on inclusive J/ψ production in proton-proton interactions at $\sqrt{s}$ = 7 TeV were presented, and are now discussed in this document. The inclusive reaction is given as feed-down contributions from other charmonium states and from B meson decays were not corrected for.

THE ALICE DETECTOR

The ALICE experiment can reconstruct J/ψ mesons at $|\,y\,|$<0.9 using the central barrel detectors and at -2.5 < y < -4.0 thanks to the muon spectrometer. The central barrel detectors are embedded in a large solenoid magnet (B=0.5T). In this analysis, both the Inner Tracking System (ITS) and the Time Projection Chamber (TPC) were used [9, 10]. J/ψ mesons can be reconstructed down to zero p_T. For this analysis, as is discussed in the next section, only the TPC was used for PID purposes. Future measurements will make use of a Transition Radiation Detector (TRD) for both PID and triggering. The muon spectrometer was designed to identify muons with a momentum larger than 4 GeV/c. It consists of a front absorber followed by a 3 T·m dipole magnet, five tracking stations based on Cathode Pad Chambers, a passive muon-filter wall, and two trigger chambers composed of Resistive Plate Chambers [1].

As for the other LHC experiments, ALICE collected data in p+p collisions at $\sqrt{s}$ = 7 TeV from March to November this year. The results presented here were obtained during the first couple of months when the instantaneous luminosity was low. Two trigger selections are relevant for this study: minimum-bias (MB) events and events with at least one muon candidate. MB events are defined by requiring a hit in the Silicon Pixel Detector (SPD) of the ITS or in either of the scintillator hodoscopes, known as VZERO [1], located at each side of the interaction point. The coincidence from two beam pick-up counters, at either side of the interaction point, was also demanded. This MB trigger requires at least one charged particle in 8 rapidity units. A programmable cut of at least one single muon track with a p_T larger than 0.5 GeV/c was applied at the trigger level. Such a p_T threshold is not sharp and 100% efficiency is achieved at a p_T of about 1.5 GeV/c. The coincidence of MB and muon triggers exhibits an efficiency close to 100% for detecting J/ψ mesons. The results presented here were obtained from a sample of 1.1×10^8 MB and 4.7×10^6 muon triggered events.

EVENT AND TRACK SELECTION

Electron channel

An event with a reconstructed vertex position z_v is accepted if $\mid z_v \mid$ < 10 cm, corresponding to about 2.5 standard deviations of the reconstructed event vertex distribution [11]. At least 120 clusters in the TPC are required for each track, as well as a hit in the innermost layer of the SPD in order to reject almost all electrons from γ conversions. The particle identification information that is provided by the TPC was used to identify the electrons. A $\pm$ 2 σ inclusion cut for electrons and a $\pm$ 2 σ exclusion cut for pions and protons was applied in the dE/dx distribution. Tracks are also required to have a minimum p_T of 1.0 GeV/c. Figure 1 shows the e^+e^- invariant mass distribution around the J/ψ mass range. This spectrum was fitted to a Crystal Ball (CB) function together with an exponential to describe both the signal and background contributions. Work is in progress to proceed with detailed studies in this channel.

Muon channel

At least one of the reconstructed muon candidates is required to match the trigger chambers. The reconstructed vertex selection is less restrictive than in the electron analysis as at least a SPD vertex is demanded. In order to reject muons emitted at small angles that have passed through the beam shield, the reconstructed track position at the end of the front absorber was required to be larger than 17.5 cm. For the analysis presented here it was decided to restrict the rapidity acceptance of the muon pair to -2.7 $<$ y $<$ -3.8. Figure 2 shows the $\mu^+\mu^-$ invariant mass distribution after the event and track selections. The fitting strategy was the same as for the electron decay channel.

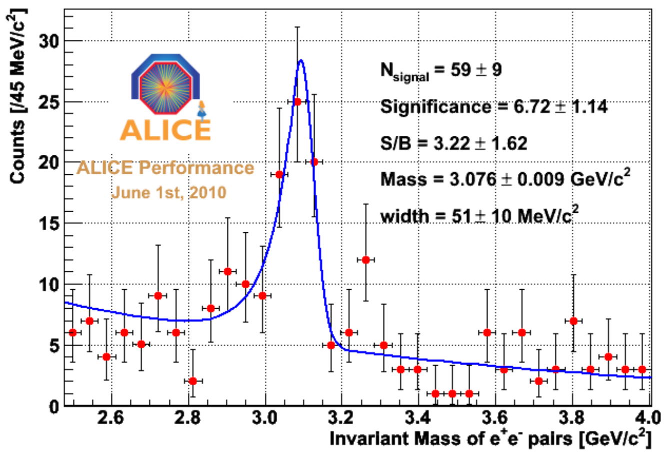

FIGURE 1. The e^+e^- invariant mass distribution showing the J/ψ signal (see text for more details).

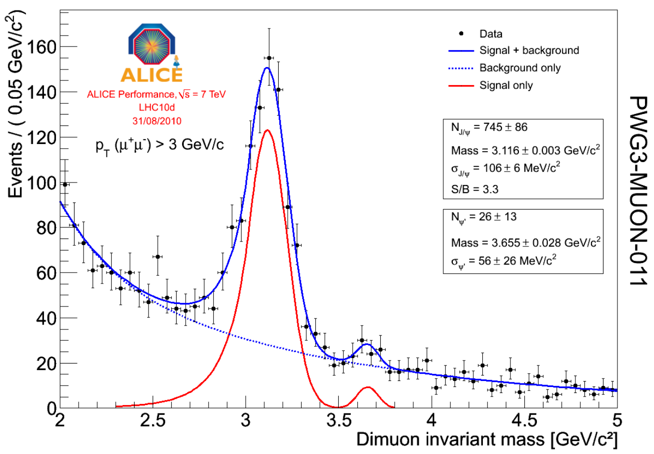

FIGURE 2. The $\mu^+\mu^-$ invariant mass distribution, together with the fitting function results.

To obtain these results the number of J/ψ candidates was estimated using a Gaussian shape instead of a CB, either in bins of transverse momentum or rapidity. It was then corrected for acceptance and efficiency (Acc $\times$ ε) for each bin. Non-polarised J/ψ signals were generated from a Monte Carlo that was tuned to the p_T spectrum measured at CDF and a rapidity distribution estimated from Color Evaporation Model Calculations (CEM) [7]. These simulations were performed over kinematical ranges wider than those covered by the muon system acceptance. A data-driven approach was used to estimate both the tracking and trigger efficiencies, turning out to be about 95% for both cases in single muon tracks. The variation of these efficiencies with time was also considered.

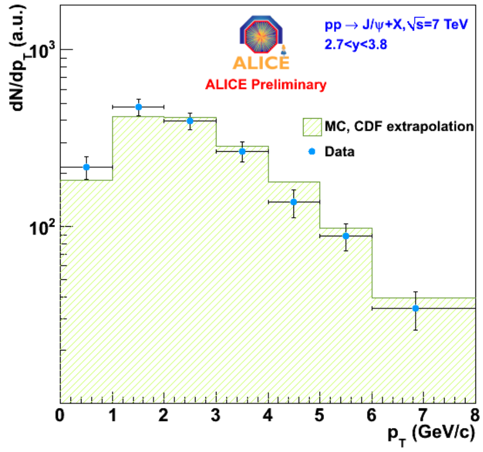

FIGURE 3. The transverse momentum distribution for inclusive J/ψ production (arbitrary units).

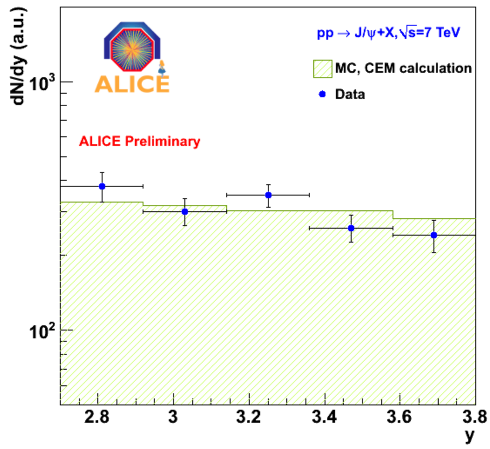

FIGURE 4. The rapidity distribution of inclusive J/ψ production (arbitrary units).

PRELIMINARY RESULTS

Figure 3 and 4 show, respectively, the acceptance corrected p$_T$ and y distributions of reconstructed J/ψ candidates compared to that of the MC. The J/ψ's $< p_T^2 >$ [12] was estimated to be $9.4^{+1.4}_{-1.3}$ (GeV/c)^2, adding quadratically both the statistical and systematic errors associated to the fitting procedure. This value was also compared to those obtained at other experiments [6, 13, 14, 15, 16, 17] using the expression depicted in Figure 5. As shown in Figure 6, the ALICE point follows the rising trend that has been seen at lower energies [18].

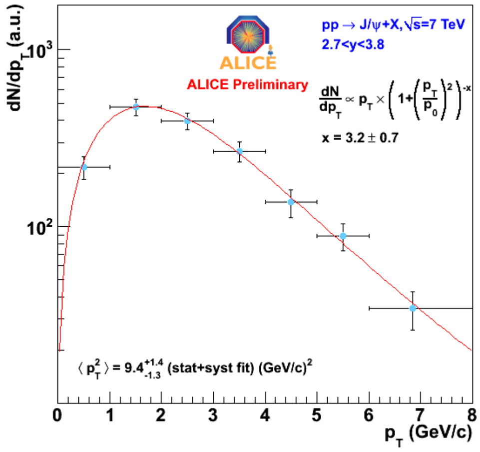

FIGURE 5. J/ψ transverse momentum distribution fitted to the formula inserted in this figure.

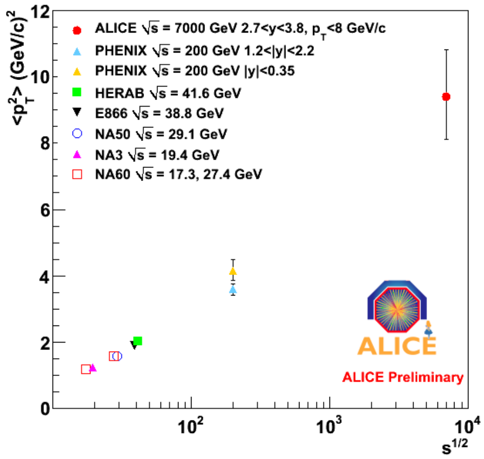

FIGURE 6. The J/ψ's $< p_T^2 >$ as a function of $\sqrt{s}$ (see text for more details).

SUMMARY AND OUTLOOK

In summary, preliminary results on the transverse momentum and rapidity distributions of inclusive J/ψ production in p+p collisions at $\sqrt{s}$ = 7 TeV were given. The present plans for quarkonia analyses include the measurement of differential cross sections for the J/ψ in both central and forward pseudo-rapidity regions, together with the polarisation. Other quarkonia analyses such as ψ(2S) and the Υ family will be carried out. With the heavy-ion data available this year some detailed studies on J/ψ production as a function of centrality are also expected.

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