INCLUSIVE J/ψ PRODUCTION IN PROTON–PROTON COLLISIONS AT THE ALICE EXPERIMENT*

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The ALICE experiment at the CERN Large Hadron Collider allows the study of J/ψ production for various colliding systems at different energies. In particular, ALICE has studied J/ψ production in proton–proton collisions at 2.76 and 7 TeV centre-of-mass energies, as well as in lead–lead collisions at 2.76 TeV per nucleon pair. In this paper, ALICE results on inclusive J/ψ production in proton–proton collisions, measured in the rapidity region $|y| < 0.9$ for the dielectron channel and $2.5 < y < 4$ for the dimuon one, are given. The integrated and differential inclusive cross sections, together with the charged particle multiplicity dependence are discussed. First preliminary results on non-prompt J/ψ from B mesons decays are also given.

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1. Introduction

In recent years, there has been an increasing interest in studying quarkonia production at hadronic colliders [1, 2, 3, 4, 5]. Theoretical models on charmonium production [6, 7, 8, 9] have been challenged by J/ψ polarisation measurements at the Tevatron [2]. The LHC provides the opportunity to measure charmonium production in a new kinematic regime, promising to shed light on fundamental components of the hadroproduction mechanism. Thanks to the incredibly fast growth of the LHC luminosity, and to excellent detectors, first results on inclusive J/ψ production were made available over the course of a few months in 2010 [10, 11, 12, 13]. Despite what seems

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a successful description of various theoretical approaches on the J/ψ's p_{t} spectra from a p_{t} of 3 GeV/c [14, 15, 16, 17], the lack of LHC measurements on J/ψ polarisation may imply that the discrepancy between models is still present[1]. As discussed in this document, recent progress was made in other related studies. This paper begins by describing the experimental apparatus and the collected data, it will then go on to discuss the way integrated and differential J/ψ cross sections were obtained at two centre-of-mass energies. This paper will also mention how J/ψ production depends on charged particle multiplicity, giving, at the same time, the fraction of inclusive J/ψ that is measured from B meson decays at central rapidity. Finally, a summary will be given.

2. The ALICE detector

The ALICE experiment [19] allows for the reconstruction of J/ψ mesons at $|y| < 0.9$ using central barrel detectors, that perform tracking and particle identification of charged and some neutral particles, and also at $2.5 < y < 4.0$ using a muon spectrometer. The latter 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 stations composed of Resistive Plate Chambers [19]. The central barrel detectors are embedded in a large solenoid magnet ($B = 0.5$ T). In this analysis, both the Inner Tracking System (ITS) and the Time Projection Chamber (TPC) were used. Similar measurements are expected to be achieved with the Transition Radiation Detector (TRD) and an electromagnetic calorimeter (EMCAL) in the future. Two trigger selections are used for this study: minimum-bias (MB) events and MB events with at least one muon candidate (MUON-MB). The ALICE data acquisition system collected MB events with a trigger based on the Silicon Pixel Detector (SPD) and the VZERO counters. The VZERO detector consists of two arrays of 32 scintillator hodoscopes each, which are placed around the beam pipe on either side of the interaction region: VZERO-A and VZERO-C covering the pseudo-rapidity range $2.8 < \eta < 5.1$ and $-3.7 < \eta < -1.7$, respectively. The MB trigger was defined by demanding at least one hit in any one of the VZERO or in the SPD. This means that at least one charged particle in 8 units of pseudo-rapidity was required. In addition, the muon trigger was read out together with the MB triggering detectors. Such collected data will be referred to as MUON-MB events. At least one triggered track with a p_{t} larger than 0.5 GeV/c was demanded at the trigger level. Note that such a cut is not sharp and the plateau value is achieved at a p_{t} of about 1.5 GeV/c [20].

[1] ALICE has recently published its results on polarisation [18].

3. Results

Inclusive J/ψ cross sections at $\sqrt{s} = 7\,\text{TeV}$, *i.e.* $p + p \to J/\psi + X$, were obtained using data collected during the first couple of months of the 2010 proton running, when the instantaneous luminosity was rather low. At present, ALICE uses the van der Meer method [21] to estimate the luminosity; a visible cross section associated to the coincidence of both VZERO counters was obtained [22]. The analysis of J/ψ at $\sqrt{s} = 7\,\text{TeV}$ p+p was carried out on a data sample of 15.6 nb^{-1} [23] for MUON-MB and of 5.6 nb^{-1} for MB. Data at $\sqrt{s} = 2.76\,\text{TeV}$ was taken in spring 2011. Both data samples followed the same analysis steps. A detailed description on the event selection can be found in [10]. Figure 1 shows the J/ψ differential cross section in proton–proton collisions at both $\sqrt{s} = 2.76$ and 7 TeV, as a function of rapidity. For the latter, the measured cross sections are $\sigma_{J/\psi}(2.5 < y < 4) = 6.31 \pm 0.25\,(\text{stat.}) \pm 0.76\,(\text{syst.})$ and $\sigma_{J/\psi}(|y| < 0.9) = 10.7 \pm 1.0\,(\text{stat.}) \pm 1.6\,(\text{syst.})$. Systematic uncertainties associated to the unknown polarisation were quoted separately and can be found in [10]. These results are in good agreement to those published by other LHC experiments [11, 12, 13]. With a somewhat larger sample, the mean number of produced J/ψ per MB event was measured as a function of charged particle multiplicity. This was carried out by studying reconstructed tracklets in the SPD detector at central rapidity. J/ψ results at

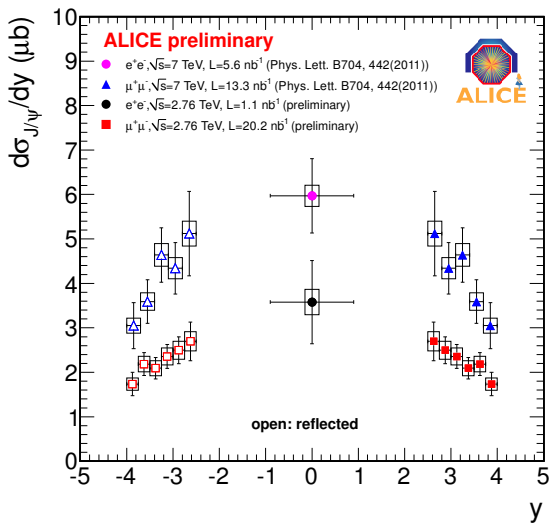

Fig. 1. Differential J/ψ production cross section as a function of rapidity at two centre-of-mass energies. Vertical bars are for statistical errors and boxes for systematic uncertainties. The systematic uncertainties on luminosity determination are not shown [10].

both central and forward rapidities were obtained. An almost linear increase of produced J/ψ with multiplicity was observed in both cases [24], as can be seen in figure 2. This measurement is thought to provide information on multi-parton interactions [25]. More recently, the fraction of J/ψ originating from B meson decays at central rapidity was also measured. Figure 3

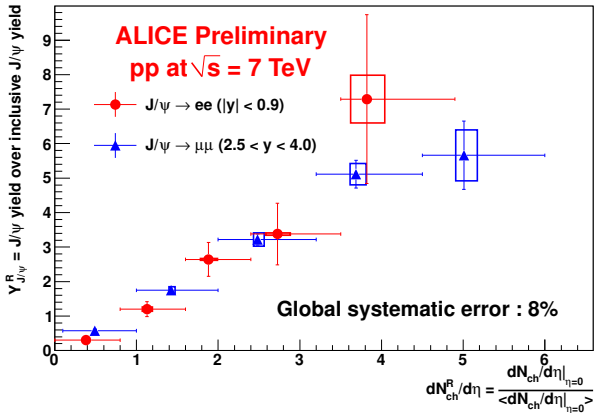

Fig. 2. The J/ψ yield as a function of the charged particle multiplicity densities at mid-rapidity. This is normalised to the corresponding multiplicity in the minimum bias proton–proton event. Results are given for proton–proton collisions at $\sqrt{s} = 7\,\text{TeV}$ at both central and forward rapidity. The error bars represent the statistical uncertainty on the J/ψ yield, while boxes give the associated systematic uncertainties.

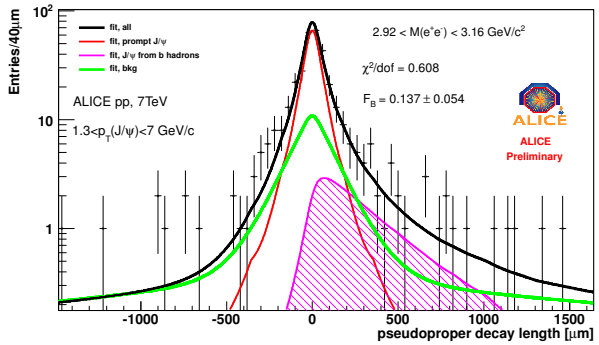

Fig. 3. Pseudo-proper decay length distribution for J/ψ at central rapidity in p+p collisions at $\sqrt{s} = 7\,\text{TeV}$. Also shown is an unbinned-likelihood fit that leaves the signal-to-background ratio as a free parameter. It accounts for the invariant mass range $2.4 < M(e^+e^-) < 4\,\text{GeV}/c^2$, after requiring $1.3 < p_\text{t} < 7\,\text{GeV}/c$. Curves are projected along the pseudo-proper decay length axis and restricted to the invariant mass $2.92 < M(e^+e^-) < 3.16\,\text{GeV}/c^2$.

shows the pseudo-proper decay length distribution for J/ψ in p+p collisions at $\sqrt{s} = 7\,\mathrm{TeV}$. The J/ψ fraction from B meson decays was found to be $0.137 \pm 0.054\,(\mathrm{stat.})^{+0.025}_{-0.018}\,(\mathrm{syst.})^{+0.023}_{-0.027}\,(\mathrm{syst.\ polar.})$ at $|y| < 0.9$. Figure 4 shows this value as a function of p_t, comparing it to that from other experiments [1, 11, 13]. These findings add to the existing data at central rapidity, but provide a unique LHC measurement as is down to $p_\mathrm{t} \sim 1.3\,\mathrm{GeV}/c$.

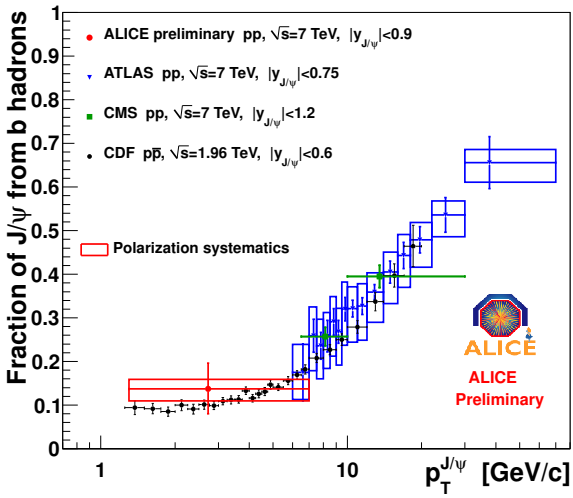

Fig. 4. Fraction of J/ψ from beauty hadrons, as a function of transverse momentum, given by several experiments. Only measurements at central rapidity are shown. Vertical bars give the quadratic sum of both statistical and systematics errors, while boxes are the systematics uncertainties associated to the unknown polarisation.

4. Summary

In summary, the status of ALICE measurements related to J/ψ mesons produced in proton–proton collisions was given. The present plan for quarkonia analyses includes cross section measurements for other quarkonia states, together with measurements on J/ψ polarisation.

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