Physics Letters B 734 (2014) 314–327

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Centrality, rapidity and transverse momentum dependence of J/ψ suppression in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV

ALICE Collaboration *

A R T I C L E I N F O

Article history:
Received 3 November 2013
Received in revised form 15 May 2014
Accepted 20 May 2014
Available online 27 May 2014
Editor: L. Rolandi

Keywords:
Relativistic heavy ion collisions
Quark gluon plasma
Quarkonium
J/ψ suppression
Experimental results

A B S T R A C T

The inclusive J/ψ nuclear modification factor ($R_{\rm AA}$) in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV has been measured by ALICE as a function of centrality in the e^+e^- decay channel at mid-rapidity ($|y| < 0.8$) and as a function of centrality, transverse momentum and rapidity in the $\mu^+\mu^-$ decay channel at forward-rapidity ($2.5 < y < 4$). The J/ψ yields measured in Pb–Pb are suppressed compared to those in pp collisions scaled by the number of binary collisions. The $R_{\rm AA}$ integrated over a centrality range corresponding to 90% of the inelastic Pb–Pb cross section is $0.72 \pm 0.06(\text{stat.}) \pm 0.10(\text{syst.})$ at mid-rapidity and $0.58 \pm 0.01(\text{stat.}) \pm 0.09(\text{syst.})$ at forward-rapidity. At low transverse momentum, significantly larger values of $R_{\rm AA}$ are measured at forward-rapidity compared to measurements at lower energy. These features suggest that a contribution to the J/ψ yield originates from charm quark (re)combination in the deconfined partonic medium.

1. Introduction

The theory of Quantum Chromodynamics (QCD) predicts that the hot and dense nuclear matter produced during the collision of ultra-relativistic heavy nuclei behaves as a deconfined Plasma of Quarks and Gluons (QGP). This phase of matter exists for only a short time before the fireball cools down and the process of hadronization takes place. Heavy quarks are an important probe of the QGP since they are expected to be produced only during the initial stage of the collision in hard partonic interactions, thus experiencing the entire evolution of the system. It was predicted that in a hot and dense deconfined medium like the QGP, bound states of charm (c) and anti-charm ($\bar{c}$) quarks, i.e. charmonia, are suppressed due to the screening effects induced by the high density of color charges [1]. The relative production probabilities of charmonium states with different binding energies may provide important information on the properties of this medium and, in particular, on its temperature [2,3]. Among the charmonium states, the strongly bound J/ψ is of particular interest. The J/ψ production is a combination from prompt and non-prompt sources. The prompt J/ψ yield consists of the sum of direct J/ψ ($\approx 65\%$) and excited $c\bar{c}$ states such as χ_c and $\psi(2S)$ decaying into J/ψ + X ($\approx 35\%$) [4]. These excited states have a smaller binding energy than the J/ψ. Non-prompt J/ψ production is directly related to beauty hadron production whose relative contribution increases with the energy of the collision. Experimentally, J/ψ production was studied in heavy-ion collisions at the Super Proton Synchrotron (SPS) and at the Relativistic Heavy Ion Collider (RHIC), covering a large energy range from about 20 to 200 GeV center-of-mass energy per nucleon pair ($\sqrt{s_{\rm NN}}$). A suppression of the inclusive J/ψ yield in nucleus–nucleus (A–A) collisions with respect to the one measured in proton–proton (pp) scaled by the number of binary nucleon–nucleon collisions was observed. In the most central events, the suppression is beyond the one induced by cold nuclear matter effects (CNM), such as shadowing and nuclear absorption, at both SPS [5,6] and RHIC [7]. At the SPS the J/ψ suppression is compatible with the melting of the excited states whereas the RHIC data suggest a small amount of suppression for the direct J/ψ [8,9]. Similar predictions on sequential suppression [3] were made for the bottomonium family, which has become accessible at the Large Hadron Collider (LHC) energies. The sequential suppression of the $\Upsilon(1S)$, $\Upsilon(2S)$ and $\Upsilon(3S)$ states was first observed by the CMS experiment in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV [10].

The first ALICE measurement of the inclusive J/ψ production in central Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV at forward-rapidity has shown less suppression compared to PHENIX results in central Au–Au collisions at $\sqrt{s_{\rm NN}} = 0.2$ TeV [11]. At $\sqrt{s_{\rm NN}} = 2.76$ TeV, the charm quark density produced in the collisions increases with respect to SPS and RHIC energies [12]. This may result in the enhancement of the probability to create J/ψ mesons from (re)combination of charm quarks [13,14]. If the J/ψ mesons are fully suppressed in the QGP, their creation will take place at chemical freeze-out (near the phase boundary) as detailed in [13,15,16]. If J/ψ mesons survive in the QGP, production may take place continuously during the QGP lifetime [14,17,18]. Because of the

* For correspondence, please use e-mail address: alice-publications@cern.ch.

http://dx.doi.org/10.1016/j.physletb.2014.05.064