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J/Ψ and Z production in Pb-Pb collisions at LHC with the ATLAS experiment

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Summary. — Using the ATLAS detector, a centrality-dependent suppression has been observed in the yield of J/ψ mesons produced in Pb-Pb collisions at the LHC at a nucleon-nucleon center-of-mass energy $\sqrt{s_{NN}} = 2.76\,\text{TeV}$. Moreover the first observation of Z bosons in heavy ion collisions has been performed. J/ψ mesons and Z bosons are reconstructed via their decays to $\mu^+\mu^-$ pairs.

PACS `12.38.Mh` – Quark-gluon plasma.
PACS `14.40.Pq` – Heavy quarkonia mesons.
PACS `21.65.Qr` – Quark matter.
PACS `25.75.Nq` – Quark deconfinement, quark-gluon plasma production and phase transitions in relativistic heavy ions collisions.

1. – Introduction

The measurement of a suppression in the J/ψ yield in heavy ions collisions could be an indication of the production of quark-gluon plasma [1]. A suppression of J/ψ events has been observed in the past, by the NA50 experiment [2] at the CERN SPS, and by the PHENIX experiment [3] at RHIC.

Further measurements at the LHC, providing additional data at higher $\sqrt{s_{NN}}$, hence higher temperature, allow to improve our understanding of the quarkonia suppression mechanism. Also, first studies on W and Z bosons become possible and, since no suppression is expected there, represent a very useful and clean control sample for the quarkonia studies.

2. – Data and Monte Carlo samples

ATLAS integrated, in 2010, approximately $8\,\mu\text{b}^{-1}$ of Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76\,\text{TeV}$. For this measurement [4], $6.7\,\mu\text{b}^{-1}$ are analyzed. A 100% efficient minimum bias trigger was used, and tight selections on the tracks quality are applied because of the high track multiplicity in heavy ion events. 613 J/ψ candidates are found, using only muons associated to a track reconstructed both in the ATLAS inner tracker and in the

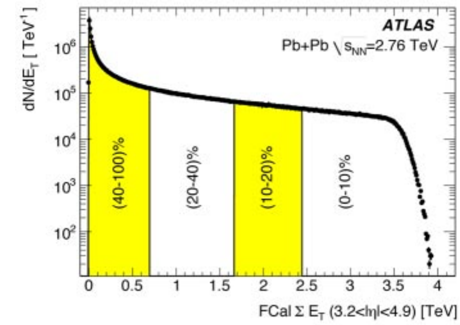

Fig. 1. – Transverse energy distribution in the ATLAS forward calorimeter in Pb-Pb collisions. The centrality bins used in the measurement are defined as fractions of the total cross-section of the interaction.

muon spectrometer, each with a transverse momentum (p_T) larger than 3 GeV. For the efficiency estimate a J/ψ and Z p-p PYTHIA [5] Monte Carlo (MC) overlayed with an HIJING [6] Pb-Pb simulated sample is used.

3. – Di-muon measurements in Pb-Pb collisions

In this section the J/ψ suppression and Z observation measurements are presented.

3˙1. *Centrality definition.* – Since ions are not point-like but composed by nucleons, in each ion collision we have a N_{coll} number of binary collisions. Hence a yield measurement should be normalized on this number, which depends on the Impact Parameter (IP) of the collision: the larger the IP is, the smaller N_{coll} will be.

In order to compute N_{coll} we use the centrality variable, defined using the sum of the transverse energy deposited in the ATLAS forward calorimeter ($3.2 < |\eta| < 4.9$), and shown in fig. 1 [7]. This variable monotonically increases as the IP decreases, so central events correspond to smaller IP, whereas peripheral events to larger ones.

We split the centrality in four bins as shown in fig. 1. The 80–100% slice of the most peripheral one has been removed. From the centrality of the event we then estimate N_{coll} using a Glauber MC [8].

3˙2. *J/ψ suppression.* – The J/ψ yield extraction is performed using two methods: a sideband subtraction, and an unbinned maximum-likelihood fit on the muon pair invariant mass in each of the four centrality bins. In fig. 2 (top left plot) the J/ψ candidates in the 0–10% bin are shown. To exclude any effect independent of the centrality, we normalize the yield in each bin with the one measured in the most peripheral one.

The yields ratios are then corrected for the reconstruction efficiency of the muons. Only the centrality dependence of the efficiency, extracted from MC, matters here: a 3–4% efficiency drop is observed for central events. A systematic effect was associated to the correction comparing data-MC tracking-related quantities.

We subsequently normalize the yield ratio on the ratio between the number of binary collisions in the given centrality bin and the same number in the most peripheral centrality bin: $R_{coll} = \frac{N^{c}_{coll}}{N^{40-80\%}_{coll}}$. We then obtain the distribution shown on the right-hand plot

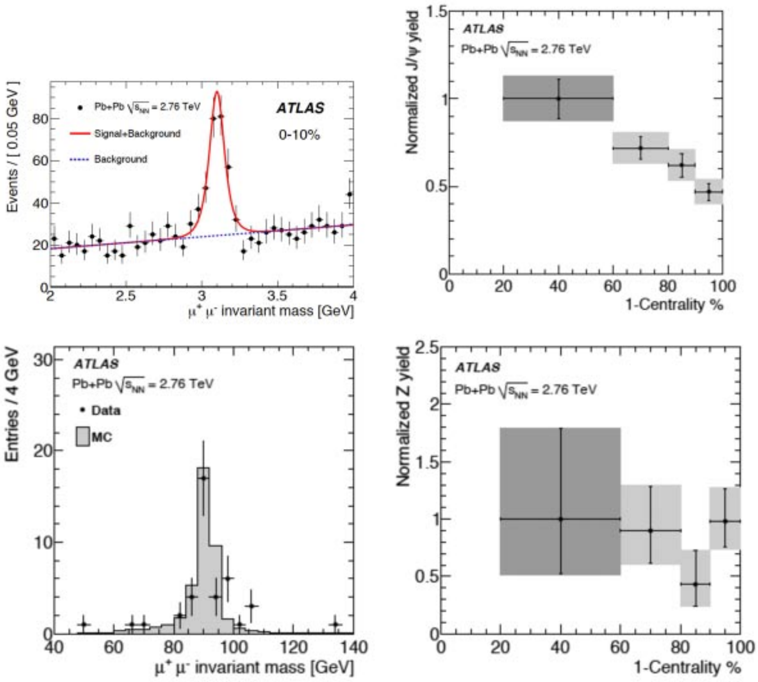

Fig. 2. – Left: J/ψ candidates invariant-mass distributions in the 0–10% centrality bin (top) and Z candidates' invariant mass (bottom). Right: normalized J/ψ (top) and Z (bottom) yield ratio as a function of centrality.

in fig. 2. The black error bars represent the statistical uncertainty on the measurement, whereas the grey bands their sum in quadrature with systematic uncertainties.

Data points are not consistent with their average, a constant fit has a χ^2 p-value of 0.11%. Hence a significant suppression is observed as a function of centrality. Qualitatively this is the same effect as the one observed at NA50 and PHENIX, at different temperatures. The systematics come from the reconstruction efficiency, 2.3–6.8%, the signal extraction, 5.2–6.8% and the R_{coll} estimate, 3.2–5.3%.

3˙3. *Z observation*. – The same analysis was applied on the 38 Z candidates, shown in the bottom left-hand plot of fig. 2. Statistics is very low, therefore the yield ratio distribution in the bottom right-hand plot is not very significant. It is still interesting that no trend is observed in this case.

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