The statistical model in Pb-Pb collisions at the LHC*

A. Andronic[1], *P. Braun-Munzinger*[1,2,3], *K. Redlich*[1,4], *and J. Stachel*[5]

[1]EMMI & GSI Darmstadt, Germany; [2]Technical University Darmstadt, Germany; [3]Frankfurt Institute for Advanced Studies, J.W Goethe University, Germany; [4]University of Wroclaw, Poland; [5]Physikalisches Institut der Universität Heidelberg, Germany

We investigate the production of hadrons in nuclear collisions within the framework of the thermal (or statistical hadronization) model. We discuss both the ligh-quark hadrons as well as charmonium and discuss the predictions for the LHC energy [1] in light of the recently released data from ALICE.

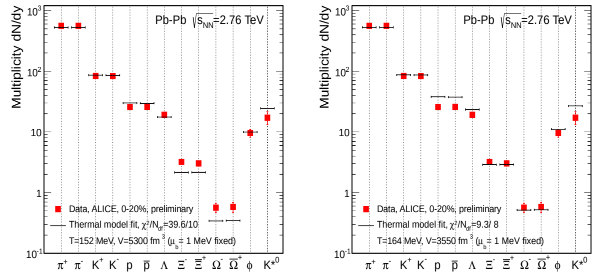

Figure 1: Thermal model fits to ALICE data on hadron production in central Pb–Pb collisions. The left panel shows the result of the fit to all available data, while protons and anti-protons are excluded from the fit in the right panel.

In Fig. 1 we show the results of thermal model fits to recently released ALICE data [2]. The left panel shows a fit to all currently available data. The unexpectedly low yields for protons and anti-protons drive the temperature of the fit to a rather low value ($T = 152$ MeV) while the yield of multi-strange baryons is significantly underpredicted. This is somewhat similar to the situation observed at RHIC. With the more than a factor of 2 smaller error bars of the ALICE data compared to results from the RHIC experiments the reduced χ^2 value approaches 4, and the temperature parameter is significantly lower than expected from the extrapolation from the data at lower energies. The right hand panel in Fig. 1 shows the result of excluding protons and anti-protons from the fit. This leads to a very good description of all remaining data, with excellent χ^2 parameter and a temperature value (164 MeV) completely in line with expectations. Naturally, the nucleon yields are now about a factor of 1.4 below the calculated values. This apparent proton anomaly could be due to annihilation in the hadronic phase near the phase boundary. Indeed, schematic model calculations indicate such an effect [3].

The centrality dependence of the nuclear modification factor $R_{AA}^{J/\psi}$ as measured recently by ALICE [4] is shown in Fig. 2, for central and forward rapidity, and compared to RHIC data from the PHENIX collaboration [5] as well

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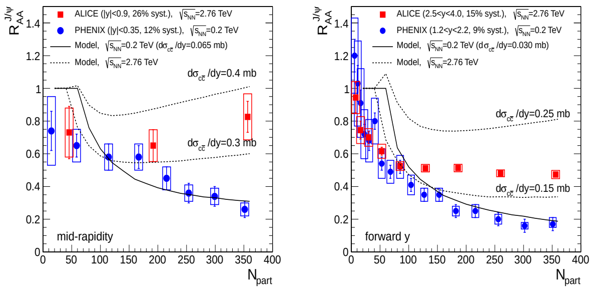

Figure 2: Centrality dependence of $R_{AA}^{J/\psi}$ for RHIC and LHC energies at mid-rapidity (left panel) and forward rapidity (right panel). The two curves shown for the LHC energy correspond to a range of expected shadowing.

as to predictions from the statistical hadronization model. We first note that, at LHC energy, much less suppression is observed compared to the RHIC results, both at forward- and at mid-rapidity. The model calculations reproduce this trend very well. In our model the larger $R_{AA}^{J/\psi}$ values at midrapidity are due to the enhanced generation of charmonium around mid-rapidity, determined by the rapidity dependence of the charm production cross section. Also the observed centrality dependence is correctly reproduced.

The successful description of the new ALICE data lends strong support to the interpretation that, at LHC energy, J/ψ mesons do not form or survive inside the QGP, implying strong color screening. Rather, the observations are consistent with the formation of charmonium bound states at hadronization of the QGP. Conceptually, this is very different from the mechanism of continuous formation and destruction of charmonia in the QGP, as employed in transport models. In our model, charmonium production is a direct signal for deconfinement of charm quarks: the charmonia are dominantly formed from initially uncorrelated c and $\bar{c}$ quarks.

References

[1] A. Andronic, P. Braun-Munzinger, K. Redlich, J. Stachel, J. Phys. G **38** (2011) 124081; arXiv:1210.7724.

[2] B. Abelev et al. [ALICE collab.], Phys. Rev. Lett. **109** (2012) 252301; D. Chinellato, arXiv:1211.7297

[3] J. Steinheimer, J. Aichelin and M. Bleicher, Phys. Rev. Lett. **110** (2013) 042501.

[4] I.C. Arsene, arXiv:1210.5818; R. Arnaldi, arXiv:1211.2578

[5] A. Adare et al. (PHENIX coll.), Phys. Rev. Lett. **98** (2007) 232301; arXiv:1103.6269.