Transverse momentum and transverse mass distributions of J/ψ mesons produced in p-A and Pb-Pb interactions at the CERN SPS

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We present a study of the transverse momentum and transverse mass of J/ψ mesons produced in nucleus-nucleus and p-nucleus reactions. They include the most recent data collected by the NA50 experiment in Pb-Pb and p-A reactions at 158 GeV/c and 400 GeV/c incident momentum respectively. Together with S-U results previously published by experiment NA38, the mean squared transverse momentum of J/ψ mesons exhibit a scaling behaviour which could result from initial state parton interaction. However, for the most central Pb-Pb collisions a saturation effect is observed as a function of centrality.

1. Introduction

The measurement of the transverse momentum and transverse mass distributions of J/ψ mesons produced in lead-lead collisions could provide a deeper insight on the nature of the

anomalous J/ψ suppression as observed by the NA50 experiment [1]. Within the frame of experiment NA50, we have therefore made a systematic study of these distributions which is reported hereafter. The details of the experiment, the method of analysis and first results can be found in [2]. The analysis of the most recent data collected during year 2000 with improved experimental conditions was presented recently [3].

The study is based on a total of 350 000 J/ψ events from Pb-Pb and 220 000 from p-A interactions, the latter collected at 400 GeV/c on five different targets (Be, Al, Cu, W, Pb). Results previously published by the NA38 experiment [4] on S-U collisions are also used for comparison and systematic investigation.

In the dimuon invariant mass distribution, the J/ψ peak clearly emerges from the mass continuum which is due to the combinatorial background from uncorrelated decays of pions and kaons and to the physical muon pair production. Below the J/ψ peak, the physical mass continuum amounts to 3% in the range $2.9 < M < 3.3$ and is mostly due to Drell-Yan. It is taken into account through a fit procedure which desentangles the different contributions to the invariant mass spectrum, i.e. the J/ψ , the ψ' , the Drell-Yan, the pairs of muons originating from the simultaneous semileptonic decay of $D\bar{D}$ pairs and the combinatorial background. The total background contribution is 8% in the same mass range.

2. Transverse momentum distributions

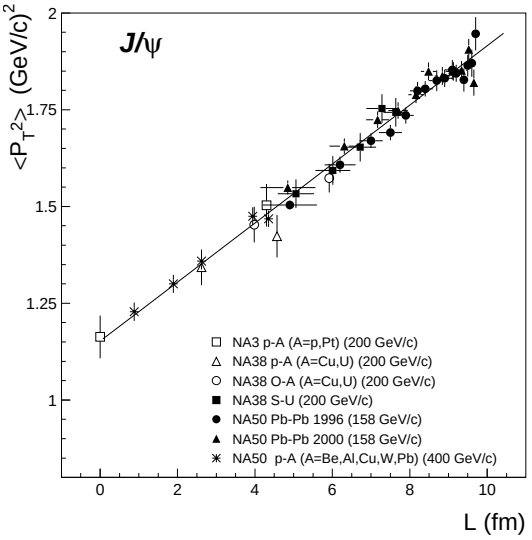

Figure 1. Scaling behaviour of $\langle p_{\mathrm{T}}^2 \rangle$ values for the J/ψ produced in different colliding systems.

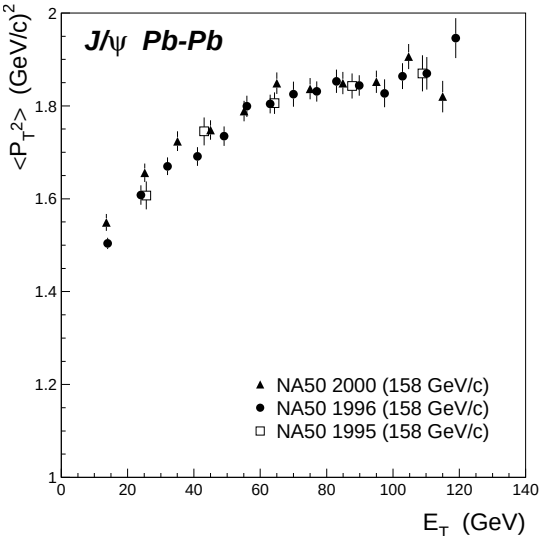

Figure 2. $\langle p_{\mathrm{T}}^2 \rangle$ dependence on the transverse energy for several Pb-Pb data taking runs.

Distributions of transverse momentum up to 4 GeV/c were obtained for different bins in the neutral transverse energy released in the collision, as measured, in a limited rapidity region, by an electromagnetic calorimeter. These different bins correspond to different centrality bins of the Pb-Pb collision. In order to have a meaningful comparison of results

obtained from Pb-Pb, from p-A and from light ions, the corresponding experimental points are plotted as a function of L, the average length of nuclear matter traversed by the produced $c\bar{c}$ pair before leaving the target [5]. As a function of L, the values of the mean squared transverse momentum $\langle p_{\rm T}^2 \rangle$ exhibit a linear dependence with a common slope for all p-A and nucleus-nucleus data and a value, for L=0, proportional to $\sqrt{s}$, the total energy in the nucleon-nucleon center of mass. Therefore, data at different interaction energies can be rescaled to 158 GeV for example, and behave as shown on Fig. 1. This scaling behaviour can be interpreted as if transverse momentum of the produced J/ψ would be the result from initial state parton multiple scattering [6–8].

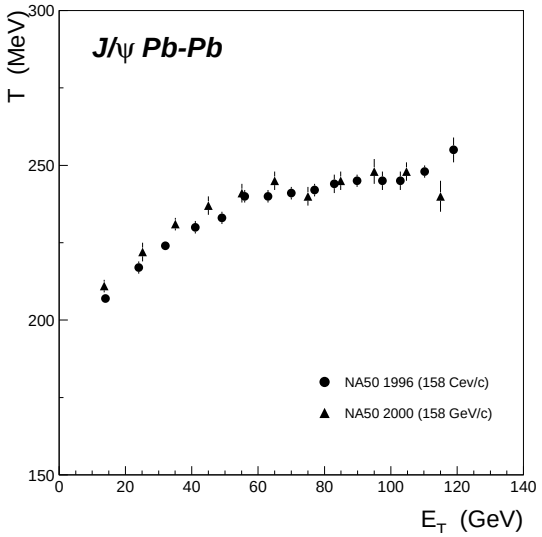

Figure 3. Inverse slope parameter T dependence on the transverse energy for two Pb-Pb data taking samples.

In order to explore in detail the behavior of $\langle p_{\rm T}^2 \rangle$ for the most central Pb-Pb collisions where L saturates, it is more appropriate to plot the results directly as a function of the transverse energy $E_{\rm T}$, as shown in Fig. 2 for three sets of data collected at 158 GeV/c incident momentum. The overall behaviour is observed - first increase and then tend to flatten when the centrality of the collision increases.

3. Transverse mass distributions

The study of the J/ψ transverse mass distributions fitted with a modified Bessel function of M_T/T leads to the so called inverse slope parameter T which, in thermal models, can be related to the effective temperature of the system. The dependence of T on centrality (or $E_{\rm T}$) should exhibit similar features as those of $\langle p_{\rm T}^2 \rangle$. Indeed, as shown on Fig. 3, T increases for the most peripheral Pb-Pb collisions and then tends to a much flatter behaviour.

4. Conclusions

In conclusion, the present analysis supports the general mechanism of the initial state parton scattering seen in p-A, light ions collisions and peripheral lead-lead collisions. However, for the most central Pb-Pb collisions, a saturation effect is observed with a flatter behaviour of $\langle p_{\mathrm{T}}^2 \rangle$ or, equivalently, of the inverse slope T of the transverse mass distribution as a function of centrality.

REFERENCES

1. M.C. Abreu et al. (NA50 Coll.), Phys. Lett. B477 (2000) 28.
2. M.C. Abreu et al. (NA50 Coll.), Phys. Lett. B499 (2001) 85.
3. N.S.Topilskaya for NA50 Collaboration, Quark Matter 2002, to be published.
4. M.C. Abreu et al. (NA38 Coll.), Phys. Lett. B423 (1998) 207.
5. M.C. Abreu et al. (NA50 Coll.), Phys. Lett. B410 (1997) 337.
6. J. Hüfner, Y. Kurihara and H.J. Pirner, Phys. Lett. B215 (1988) 218.
7. S.Gavin and M.Gyulassy, Phys. Lett. B214 (1988) 241.
8. J.P.Blaizot and J.Y.Ollitrault, Phys. Lett. B217 (1989) 392.