EVIDENCE FOR DECONFINEMENT FROM THE J/ψ SUPPRESSION PATTERN IN Pb-Pb COLLISIONS BY THE NA50 EXPERIMENT

M.C. Abreu[6,a], B. Alessandro[10], C. Alexa[3], R. Arnaldi[10], M. Atayan[12], C. Baglin[1], A. Baldit[2], M. Bedjidian[11], S. Beolè[10], V. Boldea[3], P. Bordalo[6,b], A. Bussière[1], L. Capelli[11], L. Casagrande[6,c], J. Castor[2], T. Chambon[2], B. Chaurand[9], I. Chevrot[2], B. Cheynis[11], E. Chiavassa[10], C. Cicalò[4], T. Claudino[6], M.P. Comets[8], N. Constans[9], S. Constantinescu[3], N. De Marco[10], A. De Falco[4], G. Dellacasa[10,d], A. Devaux[2], S. Dita[3], O. Drapier[11], L. Ducroux[11], B. Espagnon[2], J. Fargeix[2], P. Force[2], M. Gallio[10], Y.K. Gavrilov[7], C. Gerschel[8], P. Giubellino[10], M.B. Golubeva[7], M. Gonin[9], A.A. Grigorian[12], J.Y. Grossiord[11], F.F. Guber[7], A. Guichard[11], H. Gulkanyan[12], R. Hakobyan[12], R. Haroutunian[11], M. Idzik[10,e], D. Jouan[8], T.L. Karavitcheva[7], L. Kluberg[9], A.B. Kurepin[7], Y. Le Bornec[8], C. Lourenço[5], P. Macciotta[4], M. Mac Cormick[8], A. Marzari-Chiesa[10], M. Masera[10], A. Masoni[4], S. Mehrabyan[12], M. Monteno[10], A. Musso[10], P. Petiau[9], A. Piccotti[10], J.R. Pizzi[11], F. Prino[10], G. Puddu[4], C. Quintans[6], S. Ramos[6,b], L. Ramello[10,d], P. Rato Mendes[6], L. Riccati[10], A. Romana[9], I. Ropotar[5], P. Saturnini[2], E. Scomparin[10] S. Serci[4], R. Shahoyan[6,f], S. Silva[6], M. Sitta[10,d], C. Soave[10], P. Sonderegger[5,b], X. Tarrago[8], N.S. Topilskaya[7], G.L. Usai[4], E. Vercellin[10], L. Villatte[8], N. Willis[8].

[1] LAPP, CNRS-IN2P3, Annecy-le-Vieux, France; [2] LPC, Univ. Blaise Pascal and CNRS-IN2P3, Aubière, France; [3] IFA, Bucharest, Romania; [4] Università di Cagliari/INFN, Cagliari, Italy; [5] CERN, Geneva, Switzerland; [6] LIP, Lisbon, Portugal; [7] INR, Moscow, Russia; [8] IPN, Univ. de Paris-Sud and CNRS-IN2P3, Orsay, France; [9] LPNHE, Ecole Polytechnique and CNRS-IN2P3, Palaiseau, France; [10] Università di Torino/INFN, Torino, Italy; [11] IPN, Univ. Claude Bernard Lyon-I and CNRS-IN2P3, Villeurbanne, France; [12] YerPhI, Yerevan, Armenia.

a) also at UCEH, Universidade de Algarve, Faro, Portugal; b) also at IST, Universidade Técnica de Lisboa, Lisbon, Portugal; c) now at CERN; d) Universitá del Piemonte Orientale, Alessandria and INFN-Torino, Italy; e) now at Faculty of Physics and Nuclear Techniques, University of Mining and Metallurgy, Cracow, Poland; f) on leave of absence of YerPhI, Yerevan, Armenia.

The NA50 experiment at CERN has found evidence for deconfinement in central Pb-Pb collisions at 158 A GeV/c at the CERN SPS. The anomalous (with respect to ordinary nuclear absorption) suppression of J/ψ has been observed in 1995 and 1996 data and has been confirmed with the 1998 data analysis, where a detailed study of the suppression pattern vs. centrality has been performed. NA50 results exclude present conventional hadronic models, while they find a natural explanation in the formation of a deconfined state of quarks and gluons.

1 Charmonium production in p-A and light ion interactions

Charmonium suppression was proposed by Matsui and Satz [1] as a possible signal of colour deconfinement, the mechanism being Debye screening of the $c\bar{c}$ potential. Experiments NA38 and NA51 at CERN have studied charmonia in proton-nucleus and light ion induced reactions, and experiment NA50 has extended the study to Pb ion induced reactions.

Experiments NA38, NA50 and NA51 all share the same muon spectrometer. In the standard analysis the signal is extracted from the $\mu^+\mu^-$ invariant mass spectrum after subtracting the combinatorial background; a fit to the spectrum provides the yields of J/ψ, ψ', Drell-Yan and open charm. For ion-induced reactions, in experiments NA38 and NA50, the centrality of the reaction is estimated from transverse energy E_T and (only for NA50) from zero-degree energy E_{ZDC} or charged multiplicity N_{ch}.

The systematics of J/ψ production from p-p to S-U reactions can be summarized [2] by the simple law $\sigma_{AB} = \sigma_0(AB)^\alpha$ (A and B are the projectile and target mass number, resp.) with the exponent $\alpha = 0.918 \pm 0.015$ representing the amount of ordinary suppression.

In order to perform the same study as a function of centrality, the Drell-Yan process is used as a reference (it scales linearly with AB) and the path of nuclear matter L traversed by the resonance is used instead of the product AB. In figure 1 the results for the ratio $B_{\mu\mu}\sigma(J/\psi)/\sigma(DY)$ in p-p, p-d, p-W, p-U and S-U collisions are reported, together with a simple fit to the expression $\exp(-\sigma_{abs}\rho_0 L)$, with $\sigma_{abs} = 6.5 \pm 1.0$ mb (the Pb-Pb points will be discussed in the next section). Regarding the ψ' a quite different behaviour is seen [2] in the S-U data, which give a much higher absorption cross-section $\sigma'_{abs} = 25 \pm 5$ mb.

The current interpretation of this so-called *ordinary* suppression of charmonia relies first of all on a two step formation mechanism: (i) gluon fusion producing $c\bar{c}$ in both colour singlet and colour octet states (as required by CDF data) and (ii) colour neutralization of the $c\bar{c}g$ state which, for positive x_F in p-A collisions, happens outside the nucleus. The same nuclear absorption is then expected in p-A for both J/ψ and ψ', since they traverse the nucleus as a not yet fully formed resonance. On the other hand, the larger volume in S-U collisions means that the ψ' is more easily suppressed by nucleons and comoving hadrons.

2 NA50 results: anomalous J/ψ suppression

Results on J/ψ suppression from the 1996 run of NA50 are reported on fig. 1. The *anomalous* suppression is clearly visible with an onset at $L \simeq 8$ fm. The results reported are coming from the standard analysis which uses the measured

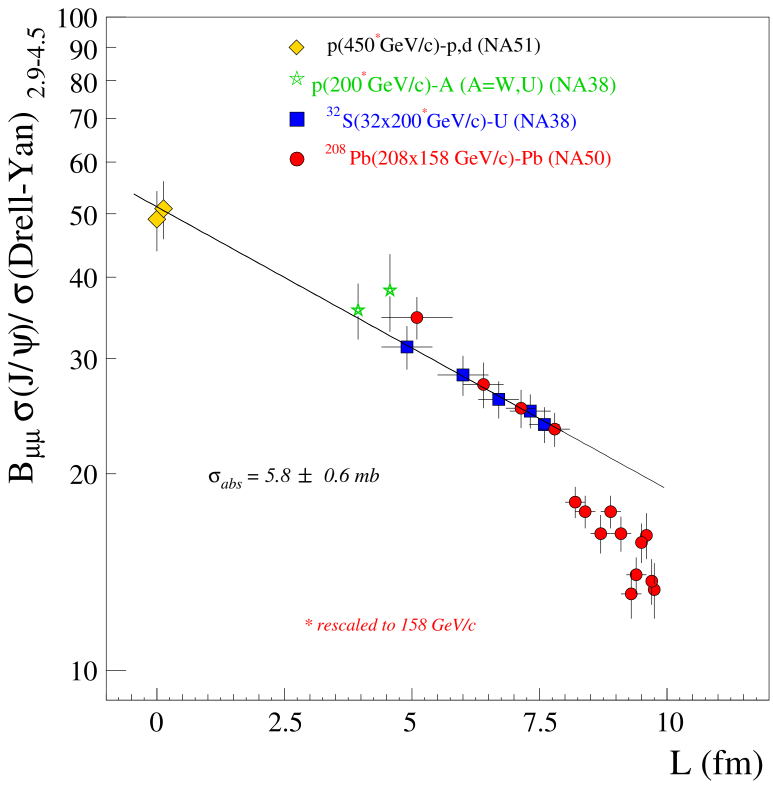

Figure 1: The $(J/\psi)/Drell-Yan$ ratio vs. L from pp to Pb-Pb.

Drell-Yan events as a reference. To overcome the statistical limitation coming from the Drell-Yan sample, a new method based on the Minimum Bias trigger has been developed [3].

In fig. 2 results of the new analysis on 1996 and 1998 Pb-Pb data are shown as a function of transverse energy. These results (open symbols) agree with the previous analysis (full circles) and confirm the drop of the J/ψ yield in the region $30 \leq E_T \leq 55$ GeV, which is consistent with a sharp threshold due to our resolution of about 10%. Note that 1996 data above $E_T = 90$ GeV have been excluded for reinteraction problems in the 12 mm Pb target. The J/ψ yield exhibits a further decrease at the high E_T end, showing no sign of saturation.

Hadronic absorption models, based on final state interactions with co-

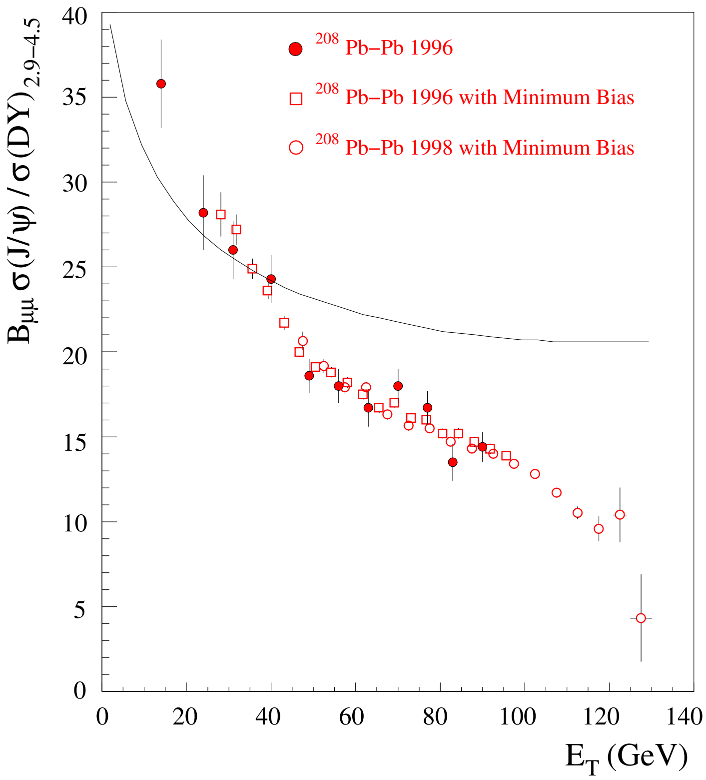

Figure 2: The $(J/\psi)/Drell-Yan$ ratio vs. E_T in Pb-Pb collisions.

movers in addition to ordinary absorption by nucleons, are in general unable to reproduce the observed J/ψ suppression pattern [4]. NA50 results exclude such conventional hadronic models, while they find a natural explanation in the formation of a deconfined state of quarks and gluons in central Pb-Pb collisions at the CERN SPS.

References

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