ANOTHER LOOK AT ANOMALOUS J/Ψ SUPPRESSION IN Pb + Pb COLLISIONS AT $P/A = 158$ GeV/c

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A new data presentation is proposed to look at anomalous J/Ψ suppression in Pb + Pb collisions at $P/A = 158$ GeV/c. If inclusive distributions of centrality variable are available, one can plot the yield of J/Ψ events per Pb-Pb collision as a function of an estimated squared impact parameter (b^2). Both quantities are raw experimental data and have a clear physical meaning. As compared to the usual J/Ψ over Drell-Yan ratio, there is no loss of statistics for J/Ψ.

Introduction. Very interesting data have been obtained recently by the NA50 experiment at CERN concerning J/Ψ production in Pb + Pb collisions at $P/A = 158$ GeV/c. [1] In most central collisions, the J/Ψ events are significantly suppressed with respect to what is expected from normal nuclear absorption as measured in lighter systems. [2-4] This anomalous J/Ψ suppression could sign the formation of quark-gluon plasma. [5]

Usual data presentation. In the usual data presentation the ratio between J/Ψ and Drell-Yan events is plotted as a function of the transverse energy E_{T}, measured in an electromagnetic calorimeter and taken as centrality variable to sort out all events according to the impact parameter of the collision. The relative statistical uncertainty on this ratio comes from the denominator. With respect to the relative statistical uncertainty on the number of events in the J/Ψ peak, it is increased by a factor 5 (10) for central (peripheral) collisions. This is a first deficiency of the usual presentation. One would like to use another quantity for normalizing J/Ψ without loosing so much in statistical accuracy.

The ratio between J/Ψ and Drell-Yan events is obtained from the differential E_{T} distributions of cross section for both classes of events. These raw experimental data, $\mathrm{d}\sigma_{\mathrm{p}}/\mathrm{d}E_{\mathrm{T}}$ and E_{T} where "p" stands for either J/Ψ or Drell-Yan process, are not so easy to digest. They are not physical quantities which can be compared directly with simple models. For their understanding one needs to know the response of the E_{T} detector. There is no direct physical meaning for the increase or the decrease of $\mathrm{d}\sigma_{\mathrm{p}}/\mathrm{d}E_{\mathrm{T}}$ as a function of E_{T}. This is the second deficiency of the usual presentation. One would like to find other quantities, not too far from $\mathrm{d}\sigma_{\mathrm{p}}/\mathrm{d}E_{\mathrm{T}}$ and E_{T}, which would have a more direct physical meaning and could be compared directly with simple models.

New data presentation. One key quantity that could be used to remove the above-mentioned deficiences is the inclusive distribution of cross section for the centrality variable, denoted as C hereafter for more generality.

The differential inclusive distribution $\mathrm{d}\sigma_{\mathrm{inc}}/\mathrm{d}C$ can be used for normalizing $\mathrm{d}\sigma_{\mathrm{p}}/\mathrm{d}C$. After this first step one gets, as a function of the centrality variable C, the yield Y_{p} of "p" events per nucleus-nucleus collision, equal to $(\mathrm{d}\sigma_{\mathrm{p}}/\mathrm{d}C)/(\mathrm{d}\sigma_{\mathrm{inc}}/\mathrm{d}C)$. This quantity has a direct physical meaning. For copiously produced particles it is simply their multiplicity. One expects that, for both J/Ψ or Drell-Yan processes, it increases steadily towards more central collisions, unless the J/Ψ is very strongly suppressed.

The integral inclusive cross section $\sigma_{\mathrm{inc}}(C)$, from most central collisions to any given value of C, can be used instead of C itself. All centrality variables are expected to vary monotonously as a function of the impact parameter b. When divided by π, $\sigma_{\mathrm{inc}}(C)$ becomes an estimate of (b^2), with an obvious physical meaning. Such a quantity has been used by many experiments in the field of nucleus-nucleus collisions at various incident energies. [6]

After this second step one gets the new data presentation, i.e. the yield Y_{p} of "p" events per nucleus-nucleus collision as a function of the estimated (b^2). Both quantities are raw experimental data and have a clear physical meaning. There is no loss of statistics for J/Ψ as long as $\mathrm{d}\sigma_{\mathrm{inc}}/\mathrm{d}C$ can be measured with better statistical accuracy than $\mathrm{d}\sigma_{J/\Psi}/\mathrm{d}C$.

With this new data presentation one can look at any process independently of all others. There is no loss of information in going from C to estimated (b^2). The integral of Y_{p} as a function of estimated (b^2) is equal to the total cross section for "p" process divided by π. Results obtained with various centrality variables can be directly compared. For comparison between data and models, it should be better to use the same procedure of (b^2) estimation for both experiment and theory, rather to compare experiment at estimated (b^2) with theory at real (b^2).

Application. In a thesis by F. Bellaiche [7] from the NA50 collaboration, all necessary pieces of information are available from the 1995 data taking for applying this method. Very accurate results are obtained for J/Ψ production, showing a clear change of behaviour between peripheral and central collisions, at $b \sim 9$ fm. The model by Blaizot and Ollitrault [8] is able to fit them quite satisfactorily with a cross section of 7.3 mb for J/Ψ nuclear absorption and a critical density of 3.0 fm^{-2} above which all J/Ψ are suppressed (Fig. 1).

Discussion and perspectives. This new data presentation and its first application have been proposed to the NA50 collaboration in March 1998. One idea, the normalization of J/Ψ events to the inclusive E_{T} distribution,

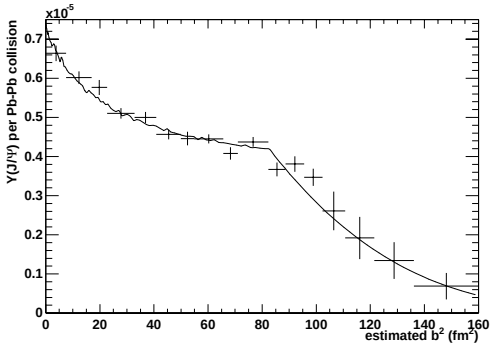

Figure 1. J/Ψ yield per Pb-Pb collision versus estimated (b^2) : NA50 data [7] (crosses) and model [8] (solid line, see text for more details).

has been used subsequently by NA50, [9] making the most of the whole statistics available for J/Ψ production in their 1996 data taking. The anomalous J/Ψ suppression in most central collisions can be studied with much more detail than with the J/Ψ over Drell-Yan ratio. It would be very interesting that the new presentation be applied as a whole to these most recent, and also to future, NA50 data. It would be particularly helpful to compare the results obtained with the three centrality variables measured in this experiment.

For future experiments that will take place at RHIC and LHC, the present work shows that it is possible to study any process independently of all others. The only requirement is the measurement of the inclusive distribution for, if possible, several centrality variables.

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