ϕ, ρ and ω production in collisions induced by deuteron and heavy ions around 200 GeV per nucleon

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The production of low mass dimuons has been measured in d-C, d-U and S-U collisions at 200 GeV per nucleon, and in Pb-Pb collisions at 158 GeV per nucleon. $\phi/(\omega+\rho)$ ratio and ϕ and $\omega+\rho$ cross sections are studied showing ϕ increase relatively to the $\omega+\rho$, with increasing size of the system or centrality, and cross sections increase rates which are different in ion and deuteron induced reactions.

The NA38 experiment measures muon pair production in coincidence with the transverse energy produced in ultrarelativistic heavy ion collisions. For the most central collisions, the energy density is sufficient to reach the critical temperature T_c [1] of the phase transition toward a plasma of quarks and gluons. A possible signature of this phase transition could be the J/ψ suppression [2] due to the screening effect of the plasma on the

$c\bar{c}$ pair. In the Pb-Pb system, anomalous suppression has been observed [6], bringing additional interest in looking to the remaining information of the dimuon spectrum.

In this work, we will focus on the low mass part, observing another possible signature of the QGP[4,5], linked to the general strangeness enhancement which has been also observed in several experiments [7].

More details on the experiment and on the analysis can be found in this conference [6], in preliminary versions of these results [8,9] (S-U is a new set of data with increased statistic), in previous publications [10,11], and thesis[12]. In particular, background subtraction is detailed elsewhere [13,14]

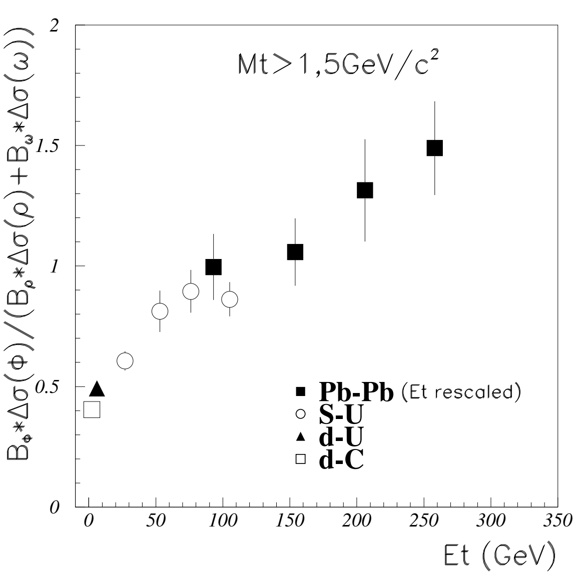

Figure 1. Evolution of $\phi/(\omega+\rho)$ as a function of the transverse energy, for $M_T > 1.5Gev/c^2$

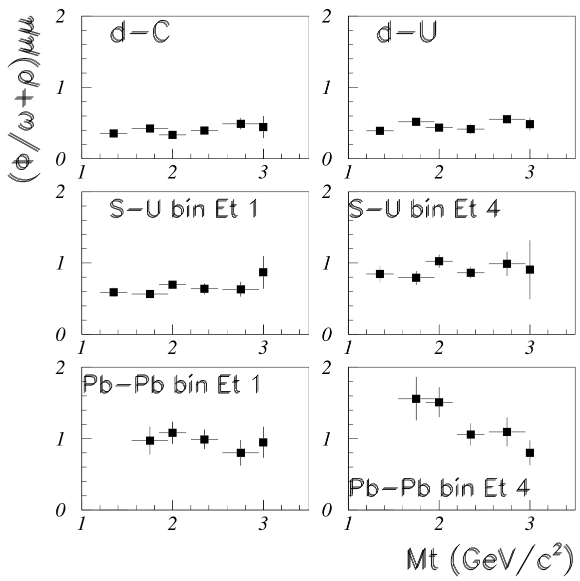

Figure 2. $\phi/(\omega+\rho)$ as a function of the transverse mass for different systems and centrality.

In order to improve the mass resolution as compared to first results [10], some changes were done in the materials immediately following the target [11]. For S-U measurements the inner part of the calorimeter was replaced by Al_2O_3, and for Pb-Pb by BeO. For deuteron induced collisions, there was no calorimeter and the target was a simple cylinder of matter. On the contrary, the Pb-Pb setup was optimized for J/ψ measurements, with an increased magnetic field which was also suppressing the low transverse momenta of low masses dimuons. Iron in the absorber was also added to reduce background hits in the chambers.

In order to extract the number of ϕ, ρ, ω from the dimuon mass spectra we perform a complete simulation of the detection, which takes into account smearing and acceptance effects and so allows to correct the results. Initial transverse mass Mt and rapidity Y distributions are adjusted to data. The mass continuum is considered as a whole, with an exponential-like distribution, and for the resonances, Breit-Wigner mass distributions are assumed for ϕ and ω, multiplied by $1/M^4_{\mu\mu}$ to account for the phase space effect[15] on the broader ρ. The ratio ω/ρ is fixed, assuming same production cross sections for ρ and ω. Fits of the mass spectra are performed in various Mt domains and then give the amount of *produced*, i.e. without apparatus effects, dimuons in the kinematical available domain (M_T bin, $0. < Y_{cdm} < 1.$, $-0.5 < \cos\theta < 0.5$) for each component. Systematic effects as changes in Mt slopes, determination of ρ and continuum shapes, multiple scattering and background subtraction are taken into account in the error bars.

The ratio $\phi/\rho+\omega$ is of particular interest with regard to strangeness production, as a possible direct measurement of $s\bar{s}/u\bar{u}+d\bar{d}$ production in similar kinematical conditions. In addition it is not dependent on the luminosity nor sensitive to the acceptance uncertainty.

In picture 1 this ratio is presented for the various systems, as a function of the transverse energy. This variable is mainly used for convenience, and is only indicative for Pb-Pb since an extrapolation has to be used, but could be linked to volume effects which may be important for these rather low masses productions.

For production with transverse mass above 1.5 GeV/c^2, i.e. in the kinematical domain available in Pb-Pb, the ratio *increases as a function of the system mass, or with centrality* in S-U. In Pb-Pb the same behavior is also visible, both on the average and versus Et. Nevertheless contrarily to S-U this increase with centrality is only existing for the lowest Mt domains. This is indirectly visible in picture 2, where the ratio $\phi/\rho+\omega$ looks flat with respect to the transverse mass, except for the most central Pb-Pb collisions which display a very different and then *very atypical behavior*.

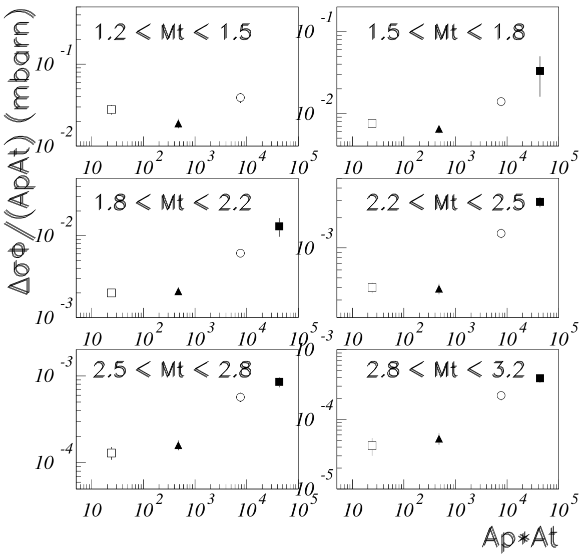

Figure 3. ϕ cross section in various Mt bins (full square: Pb-Pb, open circle S-U, full triangle: d-U, open square d-C)

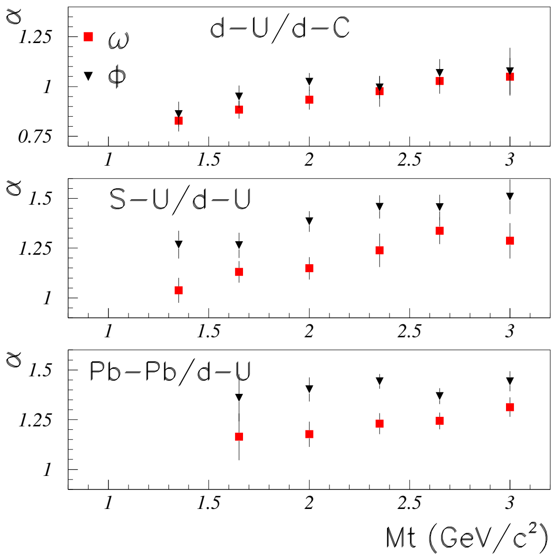

Figure 4. α parameter (see text) measuring the increase rate of the cross section between different systems. Note the change of vertical scale.

Thanks to cross sections it is possible to get another piece of information. The ϕ cross section in the experimental window displays a different rate for ion and for deuteron induced reactions (picture 3). Corresponding rates of increases between the various systems A-B, parameterized as $(AB)^{\alpha}$ in order to get a common scale, are presented in picture 4. In any case there is an increase of the rate with Mt (Cronin effect). With deuteron projectile ϕ and $\rho+\omega$ are very similar whereas in ion induced reactions we observe again the additional increase of the ϕ, already noticed thanks to the ratio. Rates obtained for Pb-Pb are consistent with the ones obtained for S-U. This suggests that the smaller increase observed on the average between S-U and Pb-Pb than between d-U and S-U, say 1.5 with respect to 2., could be due to the smaller lever arm. Between deuteron and ion induced reactions there is also an increase of the $\rho+\omega$ α parameter. This increase may be linked to the change of direction of the shift of the rapidity distribution when going from an increase of the target to an increase of the projectile.

Beside, the same treatment applied to the continuum at lower and higher masses than the resonances (not shown here) suggests that it could behave similarly to the $\omega+\rho$, in d-C, d-U and S-U. This could be the sign of some special meaning of the transverse mass in the low mass dimuons production process.

As a summary, in our experimental window ρ+ω and ϕ production both follow different increase rates in deuteron and ion induced reactions, the ϕ showing an higher increase than the ρ+ω and, in S-U, than the rest of the low mass spectrum. ρ+ω and ϕ production appear consistent between Pb-Pb and S-U.

In addition to these global trends, ϕ production increases with respect to $\rho+\omega$ as a function of centrality in S-U and in Pb-Pb. In Pb-Pb this is associated with a saturation of the $\phi/\rho+\omega$ ratio for the highest Mt values, which does not exist in S-U. We then observe an atypical behavior in the most central Pb-Pb collisions.

These observations suggest at least that the conditions created in the S-U collisions are modified in the Pb-Pb collisions. This may be related to the causes of the anomalous suppression of J/ψ production observed in the same experiment [6]. The atypical behavior of the ratio $\phi/(\rho+\omega)$ versus Mt may be another effect of the peculiar conditions created in the most central Pb-Pb collisions.

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