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Strangeness measurements in NA50 experiment with Pb projectiles

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Abstract

Low mass dimuons production has been studied in Pb-Pb collisions at 158 GeV/A . ϕ, ρ and ω contributions are extracted in different transverse mass and transverse energy domains. Preliminary results of the 1996 run display an increase of the $\phi/(\rho+\omega)$ ratio, coming from an increase of the ϕ. Cross sections are presented and temperatures extracted.

In addition to J/ψ suppression, another signature proposed as evidence for the creation of a quark-gluon plasma is an enhancement of strange particle production in nucleus-nucleus collisions as compared to proton-nucleus collisions [1, 2].

In the NA50 experiment, an anomalous J/ψ suppression in Pb-Pb collisions as compared to p-A, and S-U collisions is observed [3, 4].

That led us to study also ϕ, ρ and ω production in p-A, d-U,S-U and Pb-Pb collisions [5, 6], because the ratio $\phi/(\rho+\omega)$ (free from luminosity, efficiencies and acceptance uncertainty) gives us access to the ratio $s\bar{s}/(u\bar{u}+d\bar{d})$. Preliminary results obtained in Pb-Pb collisions at 158 GeV/A at the CERN SPS are reported here. Several other experiments study this strangeness enhancement [7].

In the NA50 experiment, muon pairs are detected in a classic muon filter in the rapidity domain y_{CM}=0.-1., and the transverse energy (E_T) is estimated from an electromagnetic calorimeter measurement. More details on the experiment can be found in references [3, 4].

The NA50 setup optimized for J/ψ measurements does not allow reasonable measurement in the ρ, ω and ϕ mass region for transverse mass lower than $1.5 GeV/c^2$.

The background subtraction is done using like-sign muon pairs to evaluate the combinatorial background . In the resonance region, the signal represents 27% of the opposite sign muon pairs yield. The mass resolution is of the order of $70 MeV/c^2$.

In order to extract the numbers of ϕ, ρ and ω from the dimuon mass spectra, we performed a complete simulation of the detector taking into account acceptance and smearing. Four processes contribute to the mass region considered ($0.25 - 1.8 GeV/c^2$): ϕ, ρ and ω superimposed on a continuum. The continuum is a superposition of different physical processes and is treated in a phenomenological way.

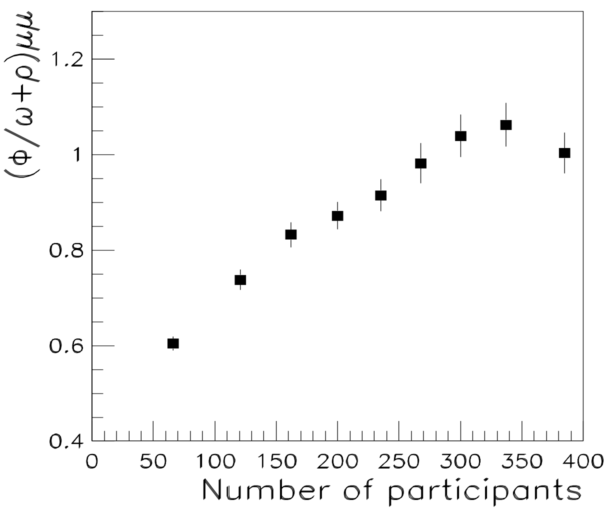

Figure 1: $\phi/(\rho+\omega)$ ratio as a function of the number of participants for $M_T > 1.5 GeV/c^2$.

ϕ and ω mass distributions are generated using Breit-Wigner shapes. For ρ, we use a Breit-Wigner multiplied by a function $\sigma(M)$ related to the non resonant phase space under ρ ($\rho \to \pi\pi$). The transverse mass (M$_T$) for the 3 resonances is generated according to the Hagedorn distribution: $dN/dM_T \propto M_T^2 K_1(M_T/T)$ where K_1 is the Bessel function and T a parameter. The rapidity is generated according to a gaussian distribution. For the continuum, the mass distribution is taken as: $(dN/dM)_{gen} = 1/M^{\alpha} e^{-M/\beta}$, while the transverse mass and rapidity distributions are the same as for the resonances.

The goal of the simulation is to adjust source distributions on experiment for each process and variable, in the corresponding mass region. For this purpose, we define a correction function which is the ratio of the experimental distribution to the corresponding reconstructed one. This correction function is then applied to the generation function; a fit is performed; a new parameter (T for instance in the case of M$_T$ adjustment) is deduced and therefore a new generation function is obtained. The method is iterated until the correction function is as flat as possible, and the parameter stable.

From a fit of the dimuon mass spectra, and assuming the same cross-section for ρ and ω production, we finally extract the numbers of ϕ, ρ and ω in 9 E_T bins and 5 M_T bins.

The ratio $\phi/(\rho+\omega)$ versus M_T is flat for each E_T bin; this indicates a similar behavior in M_T variable for ϕ and $\rho+\omega$.

The ratio $\phi/(\rho+\omega)$ versus the number of participants is plotted on figure 1 (for all M_T values). The number of participants(N_{part}) is deduced for each E_T bin from the mean E_T value. We checked the stability of our method by varying the generation parameters; a 10% systematic uncertainty has therefore to be added to the statistical uncertainties plotted on figure 1. The $\phi/(\rho+\omega)$ ratio displays a smooth increase as a function of centrality. The same behavior is observed for every M_T bin.

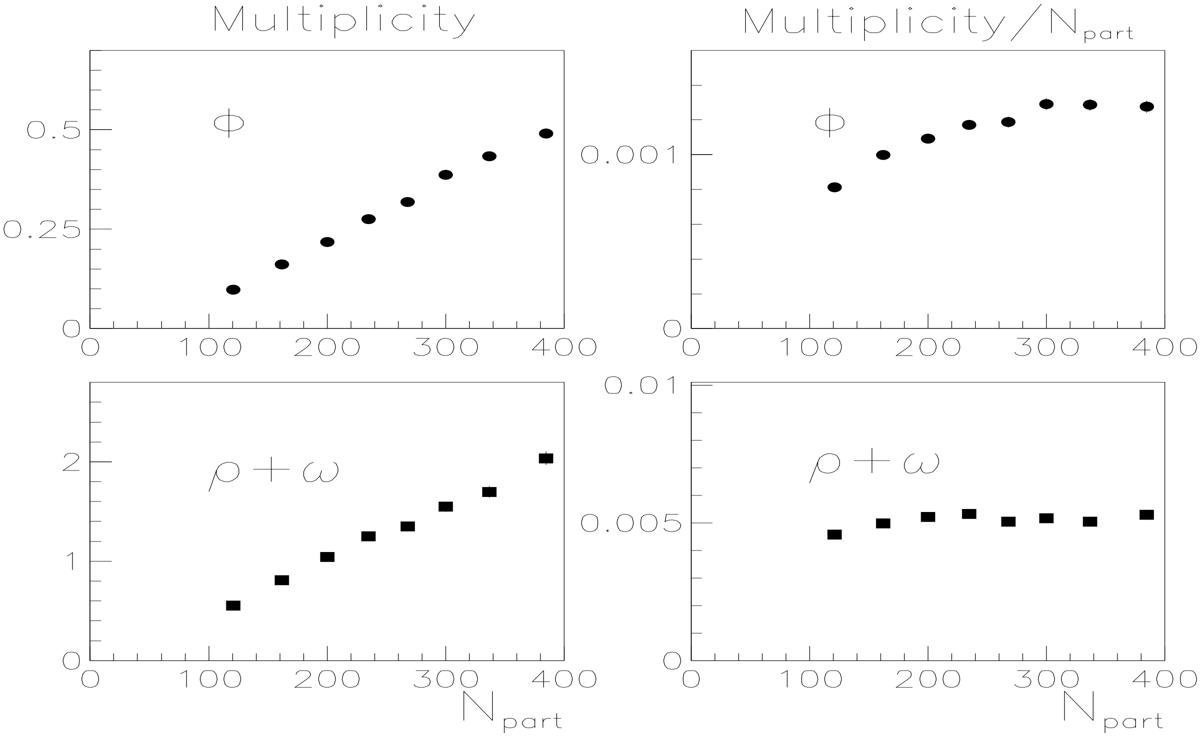

Figure 2: Left: ϕ and $\rho+\omega$ multiplicities versus the number of participants. Right: ϕ and $\rho+\omega$ multiplicities divided by the number of participants versus the number of participants for $M_T > 1.5 GeV/c^2$

In order to be sure that this increase comes from a ϕ increase, multiplicities were then studied. The ϕ multiplicity, for instance, is the number of ϕ divided by the reaction cross section in the same centrality bin. The minimum bias events are prescaled and recorded simultaneously with dimuon triggers. Figure 2 displays on the left side ϕ and $\rho+\omega$ multiplicities versus the number of participants. They both increase with N_{part}. To further quantify this increase, the multiplicities were divided by the number of participants and still plotted versus N_{part} as shown on the right side. One can observe a flat behavior of the $\rho+\omega$ multiplicity divided by N_{part}, while there remains an additional increase of $\sim$ 1.6 of the ϕ multiplicity, which seems to flatten over $N_{part} \simeq 250$. This additional increase of the ϕ multiplicity is observed in each of the 5 M_T bins.

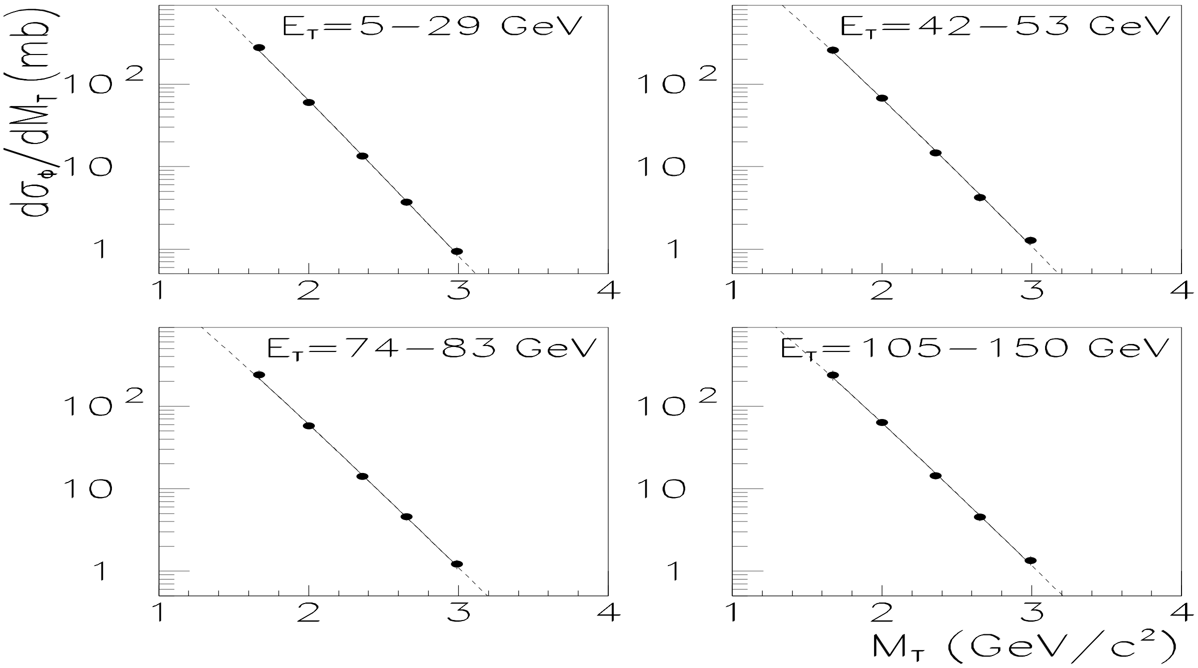

Figure 3: ϕ cross sections versus transverse mass for 4 different transverse energy bins

Cross-sections have been extracted for ϕ and $\rho + \omega$ and plotted versus M_T for each E_T bin. Figure 3 displays the corresponding ϕ values for 4 different E_T bins, with an exponential fit to the data. We find a constant inverse slope for all E_T bins, T=222 +/- 10 MeV, with a good χ^2 of 0.8. For $\rho+\omega$, the same work leads to a constant inverse slope T=219 +/- 10 MeV with a higher χ^2 of 2.7.

To summarize, we observe an increase of the $\phi/(\rho + \omega)$ ratio with centrality in the Pb-Pb system. From the multiplicity studies, it appears that $\rho + \omega$ production displays a linear behavior versus the number of participants, while there is an additional increase for ϕ production. From the temperature studies, we extract the following temperatures: $T_\phi \simeq 220MeV$ and $T_{\rho+\omega} \simeq 215MeV$.

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