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Production of ϕ Mesons in Au-Au Collisions at the AGS

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The first measurements of ϕ meson production in Au-Au collisions at AGS energies are presented via the decay to K^+K^-. A measurement of the centrality dependence of the yield shows an increase similar to that seen for the K^- with a spectral shape consistent with a relativistic Breit-Wigner distribution within the statistical errors of the present data set. Future analysis using the full data set with 4 times the statistics will allow a more accurate determination of the yields, slopes and spectral shapes.

1. INTRODUCTION

The measurement of ϕ mesons in heavy ion collisions is of considerable interest for several reasons. First, because the ϕ meson consists of $s\bar{s}$, its yield and slope provides

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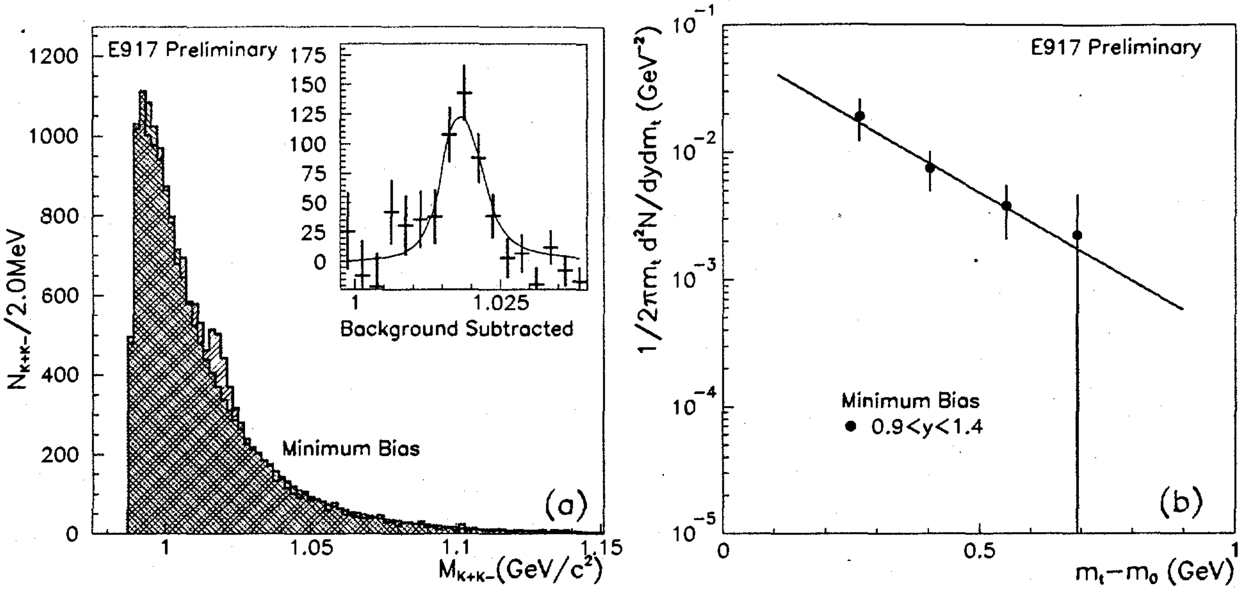

Figure 1. (a) K^+K^- invariant mass distribution for minimum bias events with the background from mixed events superposed. The inset shows the background subtracted distribution fit as discussed in the text. (b) The measured ϕ $m_\perp$ spectrum.

information on strangeness production in heavy ion collisions [1]. A breaking of the OZI rule because of the formation of a QGP would give an enhanced ϕ/K^- ratio as a function of the number of participants[2]. Finally, a deviation of the the invariant mass distribution of K^+K^- pairs from the standard relativistic Breit-Wigner would be an indication of chiral symmetry restoration[3] or at the least collision broadening due to the high baryon density[4].

The E917 experiment[5] took data using a gold beam with p = 11.7 GeV/c on a gold target, for which mid-rapidity is at $y = 1.6$. A rotating spectrometer with a 25 msr acceptance was used to measure momenta and identify particles. A zero degree calorimeter (ZCAL) provided the centrality measurement and an online second level trigger was used to select candidate events with either an identified $\bar{p}$ or a pair of kaons of either sign. The data set used for this analysis was taken with the spectrometer at 19°, giving coverage for K^+K^- pairs over the interval $0.9 < y < 1.4$.

2. RESULTS

The measured time-of-flight is used to unambiguously identify kaons up to a momentum of 1.75 GeV/c with a tracking momentum resolution of $\Delta p/p < 2\%$. All events used in the analysis passed standard beam-quality cuts and the absolute momentum scale is checked by reconstructing Λ's from $p\pi^-$ pairs in the same data set.

The invariant mass distribution of the K^+K^- was then constructed for minimum-bias events, as shown in Figure 1. The opening angle of the kaon pair is required to be greater than 15 mr keeping the two track efficiency above 0.95. A distinct peak is seen above the background which is formed by using pairs of kaons from different events and then normalized to a region excluding the peak from 1.006 to 1.030 MeV/c^2. The background subtracted distribution is fit to a relativistic Breit-Wigner convoluted with a Gaussian. The mass resolution of the spectrometer is fixed to 2.4 MeV/c^2 from the Λ mass resolution

Table 1
Inverse slopes and yields of the ϕ as a function of $\langle N_p \rangle$ and $0.9 < y < 1.4$. Data from E917 are *preliminary* results. The SiAu point is from [7].

Centrality	E_{ZCAL} range (GeV)	$\langle N_p \rangle$	T(MeV)	dN/dy
0−23%	0-1000	301	174 ± 56	0.252±0.107
12−39%	600-1500	200	229 ± 55	0.129±0.027
23−76%	>1000	104	199 ± 44	0.058±0.015
7% SiAu	na	84	215 ± 24	0.072±0.021

and multiple scattering in the target taken from a Monte-Carlo calculation. We also fix the width to the standard value of $\Gamma = 4.43$ MeV/c^2. The fitted value of the mass is 1018.5 ± 0.5(stat) MeV/c^2 with a χ^2/DOF for the fit of 0.65. We believe we understand the deviation from the standard value of 1019.4 as a systematic error due to the decreasing acceptance for K^+K^- pairs with increasing opening angle.

To obtain a yield, corrections are made for tracking and particle identification efficiency, multiple scattering, hadronic interactions, hardware inefficiencies and kaon decays. Overall corrections are also made for the opening angle cut and geometric acceptance. This is done in bins of $m_\perp$ to yield the transverse mass spectra shown in Figure 1b. The inverse slope and yield are obtained by fitting the $m_\perp$ spectra to an exponential.

The data was divided into two centrality bins, 0-23% and 23-77%; and an additional overlapping, "mid-centrality" bin from 12-39%. The yields and slopes obtained are shown in table 1. The number of participants, $\langle N_p \rangle$, is calculated from
$\langle N_p \rangle = 2A_{Au}(1 - E_{ZCAL}/E_{Beam})$, where A_{Au} is the atomic number of gold, E_{ZCAL} is the amount of energy deposited in ZCAL, and E_{Beam} is the energy of the gold beam.

Figure 2a shows the yield of the ϕ for $0.9 < y < 1.4$ as a function of $\langle N_p \rangle$, where the dotted line shows an extrapolation to central events of a linear dependence of the ϕ yield on $\langle N_p \rangle$. The data point for central Si+Au collisions [7] at 14.6 GeV/c is also shown for comparison. At present, the data is consistent with a linear scaling with $\langle N_p \rangle$. The yield of the ϕ relative to the K^- is shown as a function of $\langle N_p \rangle$ in Figure 2b. Within the statistics, this ratio is independent of centrality. This behavior is similar to the K^+/K^- ratio[6] which is also independent of centrality.

In order to look for possible evidence of changes in the ϕ mass due to interactions in the collision environment, the minimum bias data was divided at 1.4 GeV/c into two bins of $m_\perp$; this value was chosen to give reasonable statistics in each bin. Since the ϕ mesons at lower $m_\perp$ would spend a greater amount of time in the collision zone relative to those at high $m_\perp$, they would exhibit any such effects more strongly. In reality this should be done for central events where the fireball is thought to be the largest; however, the statistics at the moment do not allow for this. Fits were made using the fixed value of the widths explained previously and the value of the mass obtained in the minimum bias fit. The high $m_\perp$ data set yielded a χ^2/DOF of 1.3 and the low $m_\perp$ data set yielded a χ^2/DOF of 1.1; hence, within the limited statistics we see no evidence for changes in either the mass or width of the ϕ in the invariant mass spectra for the two bins of $m_\perp$.

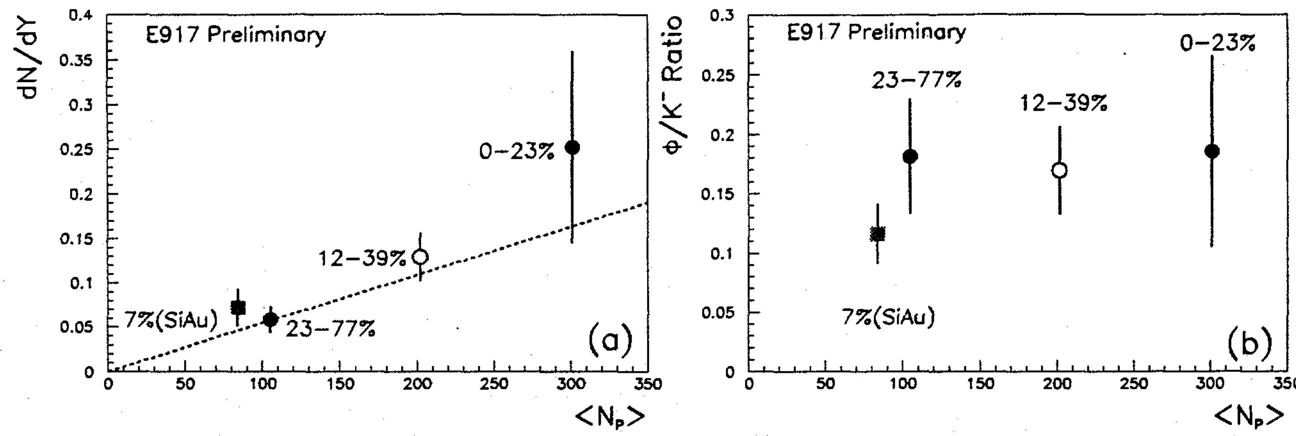

Figure 2. (a) ϕ yield as a function of $\langle N_p \rangle$ and $0.9 < y < 1.4$, from Table 1. (b) ϕ/K^- ratio as a function of $\langle N_p \rangle$. The ratio for SiAu is taken from [7] and is for total yields.

3. SUMMARY AND OUTLOOK

We have presented initial results on ϕ production in Au+Au collisions at AGS energies. The data are consistent with a linear dependence of the ϕ yield on $\langle N_p \rangle$, but are also consistent with a greater than linear dependence. The ϕ/K^- ratio exhibits the same independence as the K^+/K^- ratio does with respect to centrality. No significant changes are observed in the mass spectra for ϕ's in bins of low and high $m_\perp$.

We hope to increase the data sample by at least a factor of 4 in the coming months. More statistics will allow us to see whether there is an enhanced production of ϕ mesons in central events and to perform a more detailed analysis of the invariant mass spectra.

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