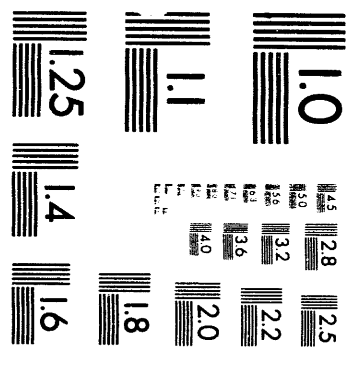
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Production of ϕ mesons in central Si+Au collisions at 14.6 A·GeV/c

Yufeng Wang, for the E859 Experiment (E-802 Collaboration)
Nevis Laboratories, Columbia University, New York, NY 10027

The production of ϕ mesons from central Si+Au collisions has been measured by E859 at the BNL-AGS by selecting events with identified K^+K^-pairs. The values for the mass and width of the ϕ obtained from the invariant mass of the kaon pairs are consistent with those of the Particle Data Book. Preliminary results for the invariant $\frac{1}{2\pi m_T}\frac{d^2n}{dm_T dy}$ distribution and dN/dy are presented.

1. Introduction

The ϕ meson, as the lowest mass bound state of $s\bar{s}$ quarks, is the lightest meson with flavor-symmetric hidden strangeness. This property, coupled with the general interest in strangeness production in heavy ion reactions[1], implies that measurement of ϕ production is an important goal in the programmatic study of heavy ion reaction dynamics. Enhanced production of ϕ's in ultrarelativistic heavy-ion collisions could be one of the signatures of the formation of the quark-gluon plasma (QGP)[2]. The production of ϕ's is suppressed in ordinary *pp* collisions in accordance with the OZI rule. However, if a quark-gluon plasma were formed, ϕ's could be produced copiously via the coalescence of s and $\bar{s}$ quarks during the hadronization phase, and so could result in the ratio of ϕ to non-strange mesons several times larger than that found in ordinary *pp* collisions.

Since the mass of the ϕ is very close to two-kaon mass and the width of the ϕ is narrow, ϕ meson yields should be very sensitive to any modifications of kaon and/or ϕ parameters. This could be an indicator of chiral symmetry restoration[3].

The existing data allow for a variety of theoretical explanations[4],[5],[6]. Accurate measurement of absolute yields and p_T spectra of the ϕ will presumably help differentiate between these alternative approaches. In addition to the various exotic prospects, ϕ meson production in heavy ion collisions is interesting simply because it is the heaviest meson yet to be measured in BNL-AGS heavy ion experiments to date.

2. Experimental Apparatus

The data were taken using the E859 experiment apparatus, which is based on the E802 magnetic spectrometer[7], and augmented by a sophisticated second-level trigger[8]. Potential events must first satisfy a hardware trigger that selected those interactions corresponding to the uppermost 15% of the charged multiplicity distribution as measured by the Target Multiplicity Array (TMA). The second-level trigger then was applied, substantially enriching the sample of interesting events by identifying particles online and retaining only those events containing (in this case) pairs of kaons.

Two experimental settings were used, namely 5° (5°-19°) and 14° (14°-28°) to extend the rapidity coverage and to provide a consistency check of the data analysis procedures. After acceptance corrections, the two data sets were combined together to obtain the rapidity distribution of ϕ.

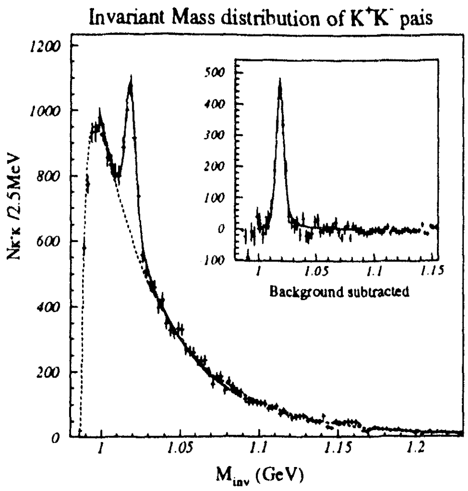

Fig. 1

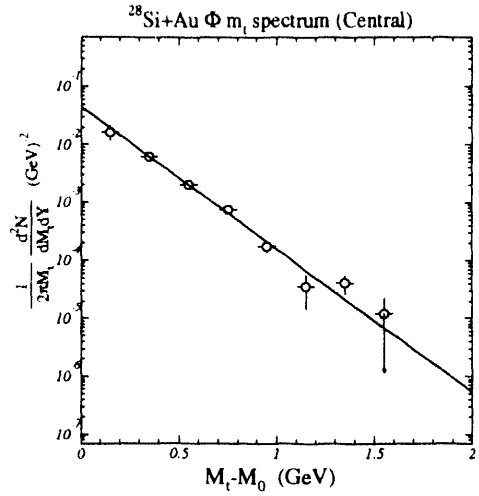

Fig. 2

Fig. 1: The invariant mass distribution of K^+K^- pairs. The solid line is the fit to a function combining a relativistic Breit-Wigner and the background. The dashed line is the background distribution from mixing events. The insert shows the the background-subtracted M_{inv} distribution.

Fig. 2: The invariant yield of ϕ versus m_T-m_0. Invariant cross-section may be obtained by multiplying by the trigger cross-section σ_{TRIG} = 0.578 barns to convert into invariant cross section. The rapidity range of the data is 1.2 to 1.7. The line is a fit to an exponential m_T distribution.

3. Data Analysis and Discussion

In the off-line analysis, both time-of-flight and information from a segmented Čerenkov counter were used, in conjunction with the momentum determined in the tracking system, to unambiguously identify kaons. Following particle identification, the invariant mass of K^+K^- pairs was constructed, as shown in Fig. 1. The solid line in the figure is a fit to a function combining a relativistic Breit-Wigner[9] and the background: $N_{K^+K^-}(m) = a{\cdot}BW(m) + b{\cdot}BG(m)$. Space requirements do not permit a detailed discussion; for further details on the formalism and the fitting procedure please see Ref. [10]. The mass and the width of the ϕ obtained by fitting to the data with the experimental mass resolution σ fixed to (the GEANT-predicted) σ = 2.2 MeV are m_0 = 1019.1 $\pm$ 0.4 MeV and Γ_0 = 4.3 $\pm$ 0.4 MeV, respectively. The quoted errors are statistical only. The values for the mass and the width are consistent with the values in the Particle Data Book.

To find the transverse mass spectrum for ϕ's, the invariant mass distribution is calculated as a function of the m_T of the ϕ. The number of ϕ's in a given m_T bin is found by a background subtraction, then converted to a normalized spectrum by making an m_T-dependent acceptance correction. To obtain a good m_T spectrum, only the 14° data set was used and restricted in a relatively narrow rapidity range ($1.2 < y < 1.7$). The results of this procedure are shown in Fig. 2 as the absolute invariant yield.

The solid line in Fig. 2 shows the results from fitting the m_T spectrum to $\frac{1}{2\pi m_T}\frac{dN}{dy dm_T} = Ae^{-m_T/T}$, from which it was determined that T = 176$\pm$7 MeV (statistical error only). As a comparison, the inverse slope parameters for pion's, kaon's[11] and our result for the ϕ are tabulated in Table 1. The inverse slope parameter of ϕ is comparable to those of

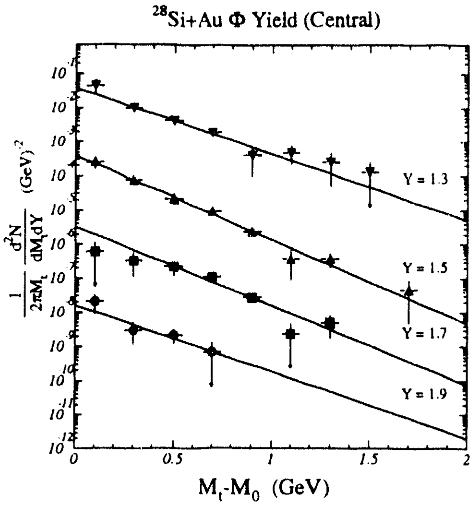

Fig. 3

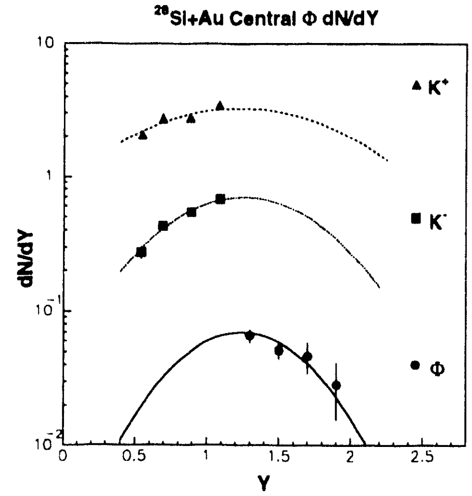

Fig. 4

Fig. 3: The invariant yield of ϕ's for different rapidity bins. The lines are fits to exponential m_T distribution for the various rapidity bins. In successive rapidity bins factor of $10^{-}2$ are included for clarity.

Fig. 4: The dN/dy distributions of K^+, $K^-$and ϕ. The dashed line and dotted line are Gaussian functions fit to the dN/dy distributions of $K^+$and K^-, respectively. The solid line is the product of these two Gaussian functions (dashed and dotted) multiplied by 0.03.

K^+ and K^-, but higher than pion's.

In order to obtain the rapidity distribution, the same procedure was applied to narrower rapidity bins (0.2 unit of rapidity). Both 5° and 14° data sets were used. The m_T spectra, shown in Fig. 3, are then integrated (assuming exponential m_T distributions) to produce the rapidity distribution for the ϕ, as shown in Fig. 4, as well as the dN/dy distribution of K^+ and K^- [12],[13]. One interesting aspect of the dN/dy distribution of the ϕ can be seen from these data. If one fits the $K^+$and K^-dN/dy distributions to Gaussian, it is found that the dN/dy distribution of the ϕ is consistent with the (scaled) product of the $K^+$and K^-rapidity distributions, at least in the region where the data were measured. Namely, $(\frac{dN}{dy})_\phi \approx 0.03 \cdot (\frac{dN}{dy})_{K^+} \cdot (\frac{dN}{dy})_{K^-}$. This aspect may give us a clue of the ϕ production in heavy-ion collisions.

In heavy-ion collisions, for ϕ production, two processes may co-exist and compete. One is direct production, the same as in pp collisions, which may happen at the initial stage of the collision. Another is indirect, via secondary rescattering between meson-meson and meson-baryon or coalescence between K and $\bar{K}$. Based on the measured dN/dy distribution, one can estimate the total yield of ϕ as 0.04 $\pm$ 0.02 per central Si+Au collisions, where the error includes the estimated uncertainty in the extrapolation procedure. The ϕ yield has been compared with the yields of pions, $K^+$and K^-. For pions, we have taken the average yield of π^+'s and π^-'s, as measured in the E859 apparatus. Identical centrality and rapidity cuts were imposed on the pions and the kaons as for the ϕ's. These ratios are shown in Table 2. Their implications for rescattering versus direct production are difficult to assess, due to the lack of data from pp collisions

Inverse Slope	ϕ	π^+	π^-	K^+	K^-
T (MeV)	176 ± 7	163 ± 2	154 ± 3	191 ± 7	174 ± 11

Table 1: Inverse slope parameters for ϕ's, pions and kaons at y = 1.45 in Si+Au central collisions.

System	ϕ/π	ϕ/K^+	ϕ/K^-
Si + Au $\rightarrow \phi + X$	$(0.45 \pm 0.12)\%$	$(1.6 \pm 0.4)\%$	$(8.1 \pm 2.4)\%$

Table 2: The ratios of the ϕ to other particles in central(15% TMA) Si+Au collisions; ratios were obtained from dN/dy at y=1.5.

at the same energy. Ideally, one would also like to investigate the ϕ yield as a function of centrality, and to compare these results to those obtained from $p - A$ and $p - p$ collisions at the same $\sqrt{s}$. Unfortunately, the difficulties in obtaining a large sample of ϕ's do not allow this, either within our data set or via comparison to world data.

4. Conclusions

The ϕ meson has been measured in experiment 859 at the BNL-AGS in Si+Au central collisions at 14.6 A·GeV/c. The measured mass and width of the ϕ are consistent with world averages. The inverse slope of m_T spectrum of ϕ is comparable to that of kaons. The dN/dy distribution of ϕ is consistent with the product of dN/dy of $K^+$and K^-in the region where the data were measured.

Acknowledgements

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