# Study of $\phi$ Meson Production in Ultrarelativistic Au+Au Collisions

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## 1. The BNL-E917 experiment

The study of $\phi$ meson production in ultrarelativistic Au+Au collisions is one of the main objectives of experiment E917 at the AGS in Brookhaven. Other aspects being studied are the excitation function of collective flow and of $K^{\pm}$ and $\bar{p}$ production, as well as the production of multi-strange baryons and strange antibaryons, and correlations of identical and non-identical particles [1]. Experiment E917, a successor experiment to E859 and E866, had a 3 months run in winter 1996/97, divided into a 1 month 'low energy' part at incident energies of 6 and 8 GeV/nucleon and a 2 months full energy run at 10.8 GeV/nucleon. The experimental setup is shown in fig. 1.

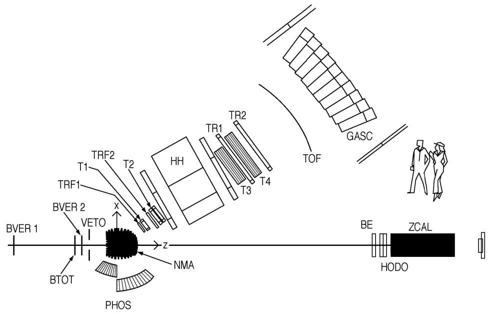


Fig. 1: Experimental setup of E917 as explained in the text

It consists of the $0^{\circ}$ line with detectors for the projectiles and projectile fragments, and the Henry-Higgins (HH) spectrometer arm with an aperture $\Delta\Omega \approx 25\,\mathrm{msr}$ which can be rotated to cover polar angles from $\theta = 14^{\circ}$ to $\theta = 58^{\circ}$. As one of the improvements compared to previous experiments a beam vertex detector consisting of two pairs of scintillating fiber detectors was developed. It allowed to determine the interaction point on the target to a precision of $\sigma \simeq 150\,\mu\mathrm{m}$ as well as the incident angle on an event by event basis [2]. The centrality of the collision is characterized by the charged particle multiplicity in the NMA, an array of lucite Cerenkov detectors and, complementary, by the total energy of projectile spectators measured in the $0^{\circ}$ calorimeter ZCAL.

At most forward angle $\theta \approx 14^{\circ}$ the spectrometer accepts particles near mid rapidity ($y_{\mathrm{mid}} \approx 1.6$ at $\mathrm{T}_{beam} = 10.8\,\mathrm{AGeV}$). Charged particles, being deflected in the HH magnet, are momentum analysed by the tracking chambers T1-T4 and identified using the time of flight information from the TOF wall.

The spectrometer also has high acceptance for shortlived particles at mid rapidity decaying into charged particles with low cm momenta such as $\phi \to K^+K^-$, $\Lambda \to p\pi^-$, $\bar{\Lambda} \to \bar{p}\pi^+$, $\Xi^- \to \Lambda\pi^-$, $\bar{\Xi}^+ \to \bar{\Lambda}\pi^+$. The invariant mass of the decaying particle can be reconstructed with a mass resolution $\delta M_{\mathrm{fwhm}} \simeq 4\,\mathrm{MeV/c^2}$. In recent studies of Si+Au collisions an indication for a $\phi$ mass shift due to medium effects was discussed [3]. Experiment E917 allows to study this question in Au+Au collisions with much higher statistics.

## 2. Simulation of $\phi$ decay

The search for a medium modification of the $\phi$ in $\phi \to K^+K^-$ is problematic because of the final state interaction of the kaons. The yield of observable $K^+K^-$ pairs carrying the information on the $\phi$ will be reduced by new 'decay' channels of the $\phi$ in the medium such as $\phi N \to K\Lambda, K\Sigma, \pi N$ etc., and by elastic and inelastic $K^{\pm}N$ channels. On the other hand the partial width $\Gamma_{\phi\to K\bar{K}}$ may be increased by a lower $K\bar{K}$ threshold in medium. In order to get some insight into the sensitivity of the observable $K^+K^-$ yield to medium effects to the $\phi$, $\phi$ decay in a hot fireball was simulated in a simple model. An ensemble of $\phi$ mesons was created with a thermal momentum distribution in a hot fireball of $\sim 400$ nucleons at $\mathrm{T} = 130\,\mathrm{MeV}$ which expands from an initial density $\rho_{\mathrm{t}=0}$ with a radial velocity $\langle\beta_r\rangle = 0.35$. All $\phi$, $K^+$, and $K^-$ are propagated through the medium in small time steps. For the $\phi$ mesons the survival probability and $K^+K^-$ decay probability within each step was determined according to the density dependent widths $\Gamma_{\phi N\to K\Lambda, K\Sigma, \pi N}$, $\Gamma_{\phi\to K^+K^-}$, and $\Gamma_{\phi\to K^0\bar{K}^0}$, while for the $K^{\pm}$ the probability of not being scattered was estimated using the known energy dependent $K^{\pm}N$ total cross sections. Medium modifications of widths are assumed to be proportional to the density. Similar to the values obtained in [4], for $\rho = \rho_0$ the 'absorptive' width of the $\phi$ was assumed to be $\Gamma_{\phi N} = 20\,\mathrm{MeV}$ and the $K^+K^-$ decay width $\Gamma_{\phi\to K^+K^-} = 5\,\mathrm{MeV}$ (about twice the vacuum value). As a result the decay yield of $\phi$ mesons as a function of the density of the medium at the time of the decay is shown in fig. 2 for initial density $\rho_0$ and $3\rho_0$, respectively. As the lowest curve indicates the probability for the $\phi$ to decay at densities $\rho > 0.5\rho_0$ into a $K^+K^-$ pair surviving the path through the medium is expected to be only of the order of 1%.

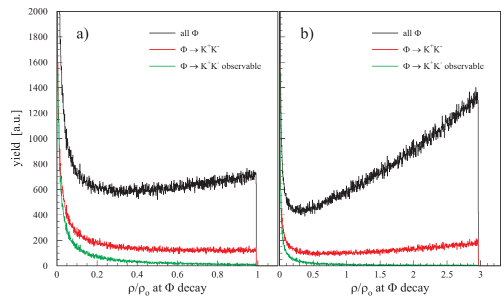


Fig. 2: Simulated yield of $\phi$ decay as a function of the density at the time of decay with $\rho_{\mathrm{t}=0} = \rho_0$ (left) and $\rho_{\mathrm{t}=0} = 3\rho_0$ (right).

### References

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[4] F. Klingl *et al.*, Nucl. Phys. **A624** (1997) 527, hep-ph/9709210

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