ϕ-meson Production in Au+Au Collisions at RHIC

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The aim of relativistic heavy-ion collisions at RHIC is to create and study a phase of hot and dense nuclear matter called the Quark-Gluon Plasma (QGP). The ϕ-meson, which is the lightest state of hidden strangeness ($s\bar{s}$), is expected to be a clean probe of the medium produced in nucleus-nucleus collisions. The ϕ-meson is relatively long-lived ($\sim$41 fm/c) and presumably has a small cross-section for interactions with non-strange hadrons [1], with the result that its observables should remain largely undisturbed by the hadronic phase and retain information from the early stages of the collision. Previous analysis of ϕ-meson transverse momentum (p_T) distributions have indicated that the ϕ freezes out earlier than other particles such as π, K and protons and therefore likely does not participate in hadronic reinteractions.

Study of particle p_T distributions and comparisons to expectations from particle production models can provide information on the system created in heavy-ion collisions. For example, models of recombination or coalescence of quarks in the partonic stage have been found to describe relatively well the observed baryon/meson ratios at intermediate p_T ($2 \lesssim p_T \lesssim 5$ GeV/c) at RHIC (see for example [2]). Recent results from a recombination model [3] predict that the multistrange particles Ω and ϕ in the p_T region $\sim$2-8 GeV/c, are dominantly produced via the recombination of thermal s-quarks in the medium while the contribution from fragmentation processes is suppressed by a few orders of magnitude in comparison. This results in a prediction for the ratio of Ω/ϕ to rise monotonically as a function of p_T before turning over at $\sim$7-8 GeV/c.

The central ϕ-meson spectrum was extracted using central-triggered data measured with the STAR detector at RHIC for $\sqrt{s_{NN}}$ = 200 GeV Au+Au collisions. The ϕ-meson was reconstructed on a statistical basis through its decay to two charged kaons. The kaon daughter particles were identified in the STAR Time Projection Chamber (TPC) through their ionization energy loss (dE/dx) in the TPC gas. To reconstruct the ϕ signal for each bin in p_T, all positive kaon candidates were combined with all negative kaon candidates from the same event, and the invariant mass of each pair was calculated. Event-mixing, whereby all positive kaons from one event were combined with all negative kaons from a different event, was used to estimate the large combinatorial background from uncorrelated kaon pairs. The mixed-event distribution was then scaled and subtracted from the same-event distribution. For each bin in p_T, the resulting distribution was fitted using a Breit-Wigner function (to describe the shape of the ϕ-meson mass peak) plus a straight line (to parameterize the remaining residual background).

An efficiency$\times$acceptance correction, calculated using Monte Carlo simulated ϕ-mesons embedded in real data files, was applied to the raw yields to correct for losses due to acceptance effects and detector inefficiencies. The final spectrum was also corrected for the branching ratio of 49.1% for the ϕ to decay into two charged kaons.

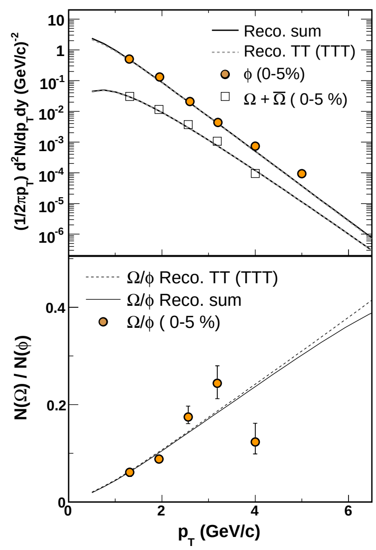

FIG. 1: **Top panel:** ϕ-meson and Ω [4] central p_T-spectra compared to recombination model expectations from [3]. **Bottom panel:** Ω/ϕ ratio as a function of p_T compared to recombination model expectations [3].

The top panel of Fig. 1 shows the central (0-5%) p_T-spectra for Ω [4] and ϕ compared to recombination model expectations from [3]. For both the Ω and ϕ, the dashed lines indicate the contribution to particle production from recombination of thermal s-quarks, while the solid line is the sum of all contributions. Over the measured p_T range, the model describes the data well. The bottom panel of Fig. 1 presents the ratio of Ω/ϕ compared to the model expectations for recombination of thermal s-quarks alone (dashed line) and for the total of all contributions (solid line). The model appears to describe the data for $p_T < 4$ GeV/c, which may imply that the majority of multistrange hadrons are predominantly formed via the recombination of thermal s-quarks in the medium created in Au+Au collisions at RHIC.

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