Phi Meson Production in Relativistic Heavy Ion Collisions

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One possible signal for the quark-gluon plasma formed in relativistic heavy ion collisions is the enhanced production of strange particles such as the phi meson [1]. Since phi meson is not a stable particle, it can only be detected via its decay product of K^+K^- or $\mu^+\mu^-$. The rescattering of K^+ and K^- in the hadronic matter, however, prevents the reconstruction of all phi mesons produced in heavy ion collisions. This makes the $\mu^+\mu^-$, which does not suffer final-state interactions, a more reliable way to extract the phi meson yield. Recent experiments at the CERN/SPS have, indeed, shown that the number of phi meson reconstructed from the $\mu^+\mu^-$ channel [2] exceeds by a factor between two and four from that reconstructed from the K^+K^- channel [3]. To understand these experimental results, we have extended a multiphase transport (AMPT) model [4], that takes into account both initial partonic and final hadronic interactions, to include phi meson production, scattering, and absorption in the hadronic stage of heavy ion collisions [5].

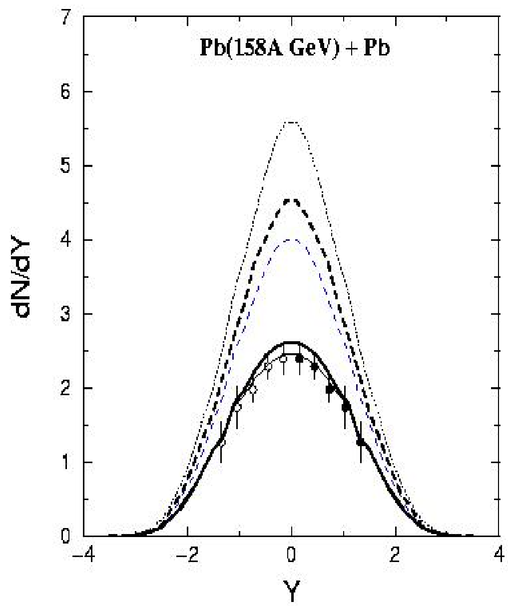

Figure 1: Rapidity distribution of phi meson reconstructed from K^+K^- (solid curves) and $\Phi^+\Phi^-$ channel (dashed curves) for Pb+Pb collisions at 158A GeV at an impact parameter of *b*#3.5 fm in the AMPT model. The results are for without (thin curves) and with (thick curves) in-medium mass modifications. The dotted line corresponds to phi mesons from the dimuon channel with in-medium masses and with the phi meson number from initial string fragmentation increased by a factor of two. The solid circles are the NA49 experimental data [3] from the $K^+ K^-$ channel.

In this improved AMPT model, phi mesons are produced not only from the fragmentation of excited strings in the initial collisions but also from the hadronic matter through various baryon-baryon, meson-baryon, and meson-meson scatterings. In Fig. 1, we show the rapidity distribution of phi mesons in central Pb+Pb collision at 158A GeV. It is seen that the number of phi meson at midrapidity extracted from the K^+K^- channel (thin solid curve) is in good agreement with the NA49 experimental data [3] (solid circles), while that extracted from the dimuon channel (thin dashed curve) is about a factor 1.8 larger and corresponds to the lower bound of the NA50 experimental data [2]. Although the phi meson number extracted from the $\mu^+\mu^-$ channel is further increased when we include the medium effect due to reduced phi meson and kaon masses [6] (thick curves), it is still not as large as the upper bound found in the NA49 data. This may suggest that other mechanisms, such as formation of color rope [7] or quark-gluon plasma [1], are needed for phi meson production. To mimic these effects, we made an ad hoc increase in the phi meson number by a factor of two in the initial string fragmentation. Including also the medium effect, the rapidity distribution of phi mesons extracted from the

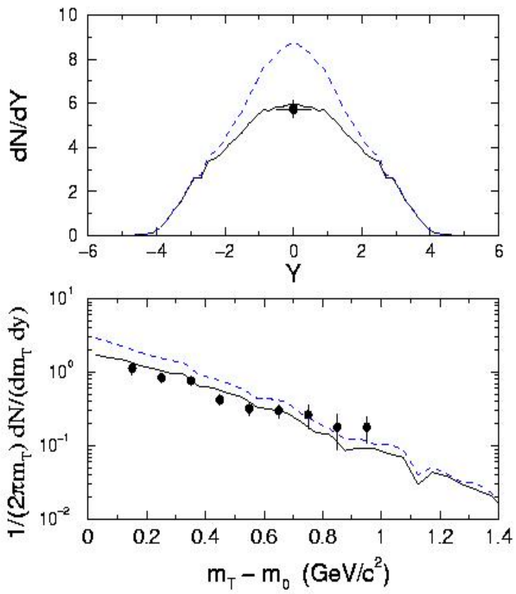

Figure 2: The rapidity distribution (top panel) and the transverse mass spectra (bottom panel) for midrapidity ($|y| < 0.5$) phi mesons reconstructed from K^+K^- pairs (solid lines) and from $\mu^+\mu^-$ channel (dashed lines) for Au+Au collisions at RHIC energy of $\sqrt{s} = 130\,AGeV$ at an impact parameter of $b \leq 5.3$ fm in the AMPT model. The solid circles are the STAR experimental data [8] for 0-11% central collisions for ϕ reconstructed from K^+K^- decay.

K^+K^- channel is increased by another 8%, whereas the yield from $\mu^+\mu^-$ channel is considerably enhanced (dotted curve). We note that the suppression of phi mesons in the K^+K^- channel relative to those in the $\mu^+\mu^-$ channel is mainly in the low transverse mass region.

We have also used the AMPT model to study phi meson production in central Au+Au collisions at the RHIC energy of $\sqrt{s} = 130\,AGeV$. As shown in Fig. 2, both the multiplicities (top panel) and transverse mass spectrum of phi mesons reconstructed from the K^+K^- channel at midrapidity in the AMPT model are consistent with the STAR data [8]. Similar to results for heavy ion collisions at SPS, the phi meson yield from the $\mu^+\mu^-$ channel at RHIC is about 1.5 times larger than that from the K^+K^- channel. This number is expected to increase significantly if we include additional phi meson production due to the formation of the initial partonic stage, which is at present neglected in the AMPT model. These phi mesons should contribute dominantly in the $\mu^+\mu^-$ channel while most of them will escape detection in the kaonic channel. It is thus of great interest to have experimental data on phi mesons from the $\mu^+\mu^-$ measurement at the RHIC energy.

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