Transverse-momentum spectra of dilepton radiaton at the CERN-SPS

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Dilepton spectra are valuable probes of the strongly interacting matter as created in ultrarelativistic heavy-ion collisions (URHIC's), since the leptons, once produced, penetrate the medium without substantial final-state interactions [1]. Invariant-mass spectra encode rather direct information on medium modifications of the electromagnetic (e.m.) spectral function. Recent dimuon measurements in 158 *A*GeV In-In collisions by the NA60 collaboration at the CERN Super Proton Synchrotron (SPS) [2] have achieved much improved precision over existing dielectron data, providing rather stringent constraints for viable theoretical interpretations. The new data have confirmed a strong broadening of the ρ-meson as predicted several years ago by hadronic many-body theory [3]. However, the increased precision of the data requires further theoretical developments and the inclusion of sources beyond the dominant one from thermal emission via ρ-mesons.

In our previous work [4] it was shown that with a moderate modification of the underlying fireball model, together with contributions from in-medium ω and φ spectral functions, a quantitative description of the low-mass (M≤1GeV) NA60 spectra emerges. In addition, with the source parameters fixed, the ensuing (parameter-free) prediction for thermal emission at intermediate masses (M>1GeV) satisfactorily reproduces the experimental excess in this regime, with the largest yield attributed to 4-pion type annihilation (with medium effects due to "chiral ρ-a1 mixing"), while emission from the Quark-Gluon Plasma is subleading.

In the present work we confront and refine our approach with newly released transverse pair-momentum (q_T) spectra by NA60 [5]. The thermal sources which give a good description of the q_T-integrated mass spectra lead to good agreement with the momentum spectra up to q_T≈1GeV, reconfirming the prevalent role of thermal emission for soft momenta. At higher q_T, however, the data are significantly above the theoretical predictions. In a first step, we have re-evaluated ρ decays at thermal freezeout; it turns out that, due to the lack of regeneration (equilibrium can no longer be sustained), the kinematics for the ρ's decaying at freezeout induce an extra time dilation (Lorentz) factor, γ, which entails a moderate hardening of their q_T spectra [6]. In a second step, we have included the contribution from primordially (hard) produced ρ mesons which do not thermalize with the medium, employing an estimate of the Cronin effect and a schematic surface emission [6] or jet quenching model [7]. Assuming a vacuum spectral line shape, their contribution is concentrated around the free ρ mass, and their q_T slope is substantially harder than any of the thermal or freezeout decays (cf. double-dashed line in the upper panels of Fig.1). Finally, we have evaluated primordial Drell-Yan annihilation using an extrapolation procedure to low mass by matching its q_T spectrum to the (M=0) photon point. Below M=1GeV, the Drell-Yan yield is small up to q_T≈2GeV, while at M>1GeV it becomes significant for q_T≥1.5GeV. In the lower panels of Fig. 1 we compare our calculations to NA60 invariant-mass spectra integrated over two bins in q_T. Again, we see that the additional hard sources are (very) small at low momenta (q_T<0.5GeV, lower left panel) but essential at higher ones (q_T>1GeV, lower right panel).

In summary, our earlier constructed model for thermal dilepton radiation based on an in-medium e.m. spectral function leads to fair agreement with new transverse-momentum spectra measured by NA60 up to q_T≈1GeV. Beyond, the inclusion of non-thermal sources, such as freezeout ρ's, primordial ρ's and

Drell-Yan annihilation are required, even though a quantitative comparison with a local slope analysis of experimental vs. theoretical spectra still reveals some discrepancies. Whether these can be resolved by a refined analysis, e.g. by improved estimates of the Cronin effect using p-A data, or whether additional effects, e.g. due to finite viscosity in the hydro-like fireball expansion, are necessary, remains to be seen.

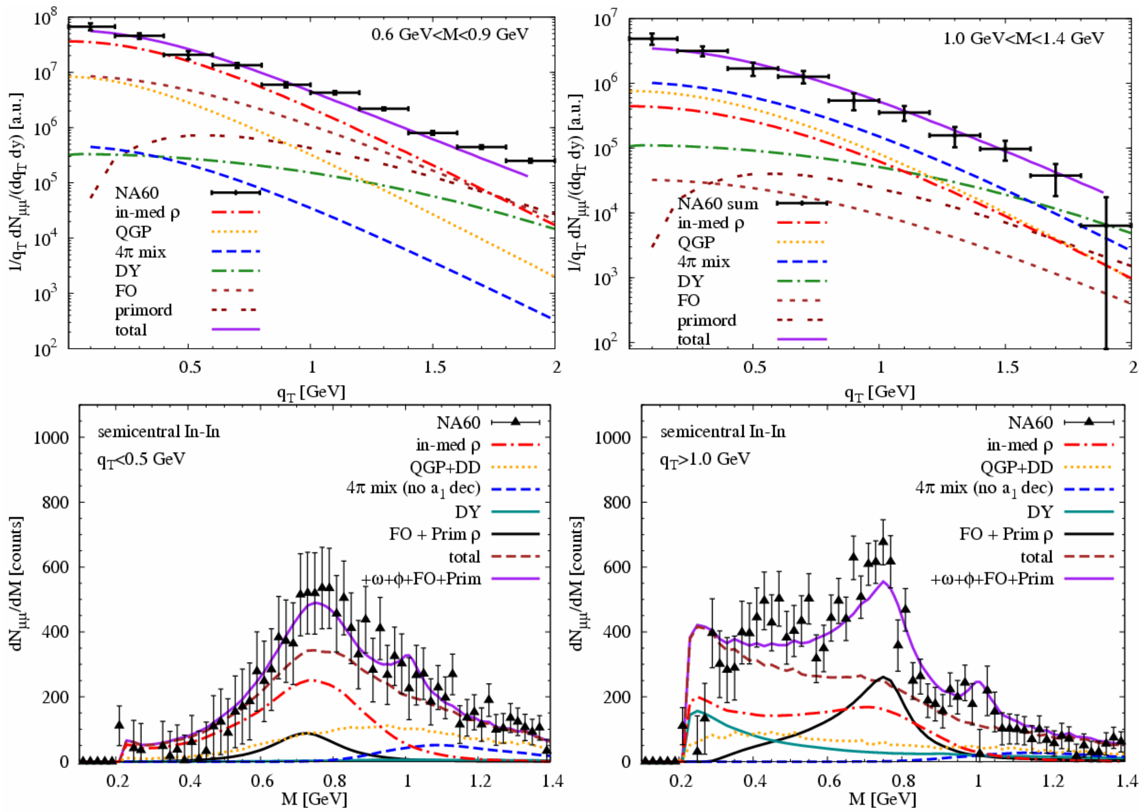

Figure 1. *Upper panels:* NA60 dimuon excess q_T spectra [2] in semicentral In(158AGeV)-In collisions compared to thermal dimuon radiation (based on in-medium ρ, ω and ϕ spectral functions, QGP emission and 4-pion annihilation) supplemented with harder sources due to ρ decays at freezeout, primordial ρ's including Cronin effect and quenching, as well as Drell-Yan annihilation [6,7]. *Lower panels:* NA60 dimuon excess spectra in invariant mass for two bins of transverse momentum (left: q_T<0.5GeV, right: q_T>1GeV) [2,5] compared to the same set of theoretical sources as in the upper panels [6,7].

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