Dilepton radiation in heavy-ion collisions at small transverse momentum

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Recent measurements of dilepton production in heavy-ion collisions (HICs) at RHIC and the LHC have become feasible down to ``very low" transverse pair momenta, $P_T < 0.2$ GeV. In this regime one expects an interesting interplay of two main sources: (i) $\gamma\gamma$ fusion triggered by the coherent electromagnetic fields of the incoming nuclei and (ii) thermal radiation from the quark-gluon plasma (QGP) and hadronic phases of the fireball. The former has been established in ultra-peripheral heavy-ion collisions, where no strong-interaction overlap occurs; its spectrum is very soft and concentrated at low P_T. The latter is well established in semi-/central HICs over a wide range of collision energies, with a spectral slope governed by the temperature and the collective flow of the expanding fireball (inducing a blue-shift in the P_T but not in the mass spectra). For $\gamma\gamma$ fusion we utilize initial fluxes from the Fourier transform of charge distributions of the colliding nuclei in the equivalent-photon approximation [1] while for the thermal radiation we employ the emission from the QGP and hadronic phases with in-medium vector spectral functions which describes the mass and P_T spectra (above 0.2 GeV) of the excess radiation observed in HICs over a wide range of collision energies [2].

We have first verified that the combination of photon fusion, thermal radiation and final-state hadron decays gives a fair description of the low-P_T dilepton mass spectra as recently measured by the STAR collaboration in $\sqrt{s_{NN}}$= 200 GeV Au+Au collisions, cf. Fig. 1. The coherent contribution dominates in peripheral collisions, while thermal radiation shows a markedly stronger increase with centrality. As expected, the significance of the coherent contribution in the P_T spectrum is restricted to $P_T < 0.2$ GeV.

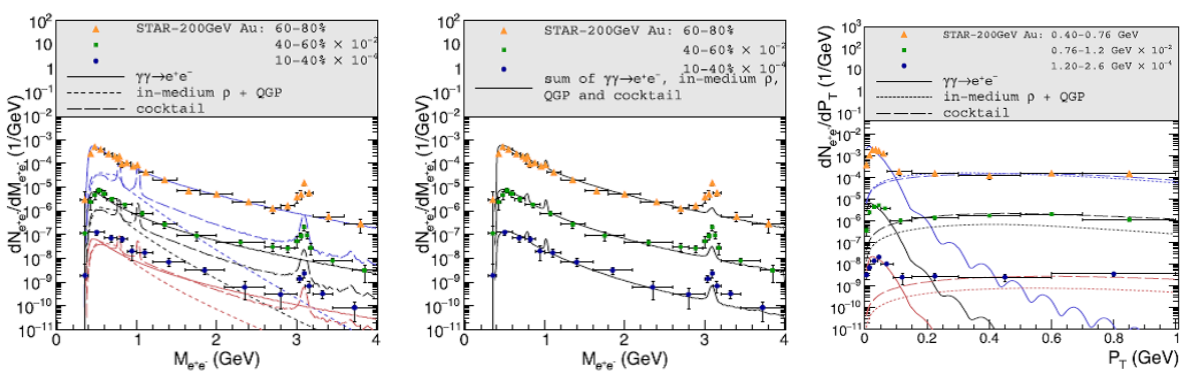

FIG. 1. Dilepton invariant-mass spectra for pair-$P_T < 0.15$ GeV in Au-Au (200GeV) collisions, including experimental acceptance cuts (left panel: individual contributions; middle panel: total) and pertinent P_T spectra in different mass regions (right panel), compared to STAR data [3].

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We have also performed calculations for HICs over a wide range of collision energies, spanning three orders of magnitude from SPS via RHIC to the LHC regime, see Fig. 2. The resulting excitation function of low-P_T radiation shows that coherent production increases rather sharply at SPS energies and then levels off in the RHIC regime near $\sqrt{s_{NN}}$ =100 GeV, whereas thermal radiation increases more

gradually with collision energy. This leads to a non-trivial excitation function where thermal radiation is dominant at the SPS, γγ fusion dominates in peripheral collisions at RHIC, and thermal radiation becomes more important again at the LHC. These predictions will soon be tested at the LHC.

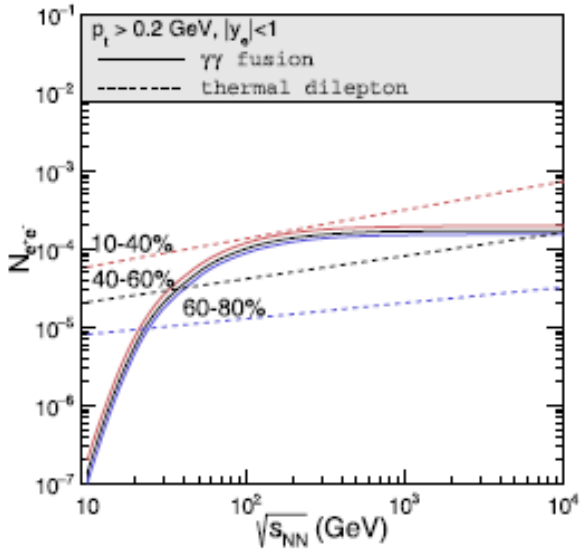

FIG. 2. Excitation function of mass-integrated low-P_T (< 0.15 GeV) dilepton spectra, including acceptance cuts on single-electrons, from the γγ fusion mechanism (solid lines) and thermal radiation (dashed lines) in collisions of two heavy nuclei with A~200 at different centralities (color coded).

[1] A. van Hameren, M. Kłusek-Gawenda, and A. Szczurek Phys. Lett. B **776**, 84 (2018).

[2] R. Rapp and H. van Hees, Phys. Lett. B **753**, 586 (2016).

[3] J. Adam *et al.* (STAR collaboration), Phys. Rev. Lett. **212**, 132301 (2018).