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Thermal photons as a quark-gluon plasma thermometer revisited

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Photons are a penetrating probe of the hot medium formed in heavy-ion collisions, but they are emitted from all collision stages. At photon energies below 2-3 GeV, the measured photon spectra are approximately exponential and can be characterized by their inverse logarithmic slope, often called "effective temperature" T_eff. Modeling the evolution of the radiating medium hydrodynamically, we analyze the factors controlling the value of T_eff and how it is related to the evolving true temperature T of the fireball. We find that at RHIC and LHC energies most photons are emitted from fireball regions with T ~ T_c near the quark-hadron phase transition, but that their effective temperature is significantly enhanced by strong radial flow. Although a very hot, high pressure early collision stage is required for generating this radial flow, we demonstrate that the experimentally measured large effective photon temperatures T_eff > T_c, taken alone, do not prove that any electromagnetic radiation was actually emitted from regions with true temperatures well above T_c. We explore tools that can help to provide additional evidence for the relative weight of photon emission from the early quark-gluon and late hadronic phases. We find that the recently measured centrality dependence of the total thermal photon yield requires a larger contribution from late emission than presently encoded in our hydrodynamic model.

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