Photon and Dilepton Emission from the Hadronization Process in Heavy Ion Collisions

Guangyao Chen and Rainer J. Fries
Cyclotron Institute and Department of Physics & Astronomy, Texas A&M University

Introduction

➢The Relativistic Heavy Ion Collider(RHIC) has established the existence of a deconfined phase of nuclear matter--the Quark Gluon Plasma (QGP).

➢Electromagnetic radiation is an unique probe of QGP due to the large mean free path. Consequently photons and dileptons can provide undisturbed information of QGP. The invariant mass and momentum spectra of dileptons can help to specify the sources.

a. QGP
b. Hadronic Gas
c. Hard processes and fragmentation
d. Pre-equilibrium phase
e. New: Hadronization processes

➢Experiment results from PHENIX [1] and STAR [2] show an excess of dileptons with invariant mass between 0.3-0.7 GeV.

➢Lattice QCD calculations show there is a crossover phase transition from QGP to Hadronic Matter at temperatures around 170 MeV.

➢Hadronization dynamics, for example, quark recombination involves charged quarks and hadrons, thus we must expect electromagnetic radiation from hadronization processes.

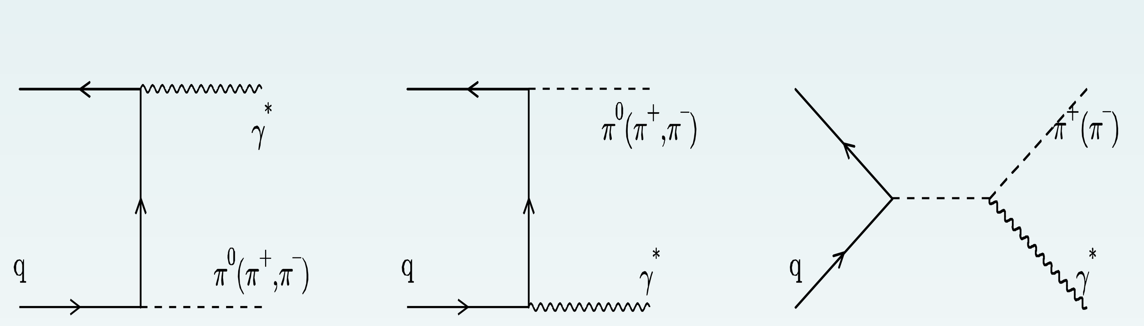
Production Rates at Hadronization

➢Recombination: quarks coupling to pseudoscalar and vector mesons.

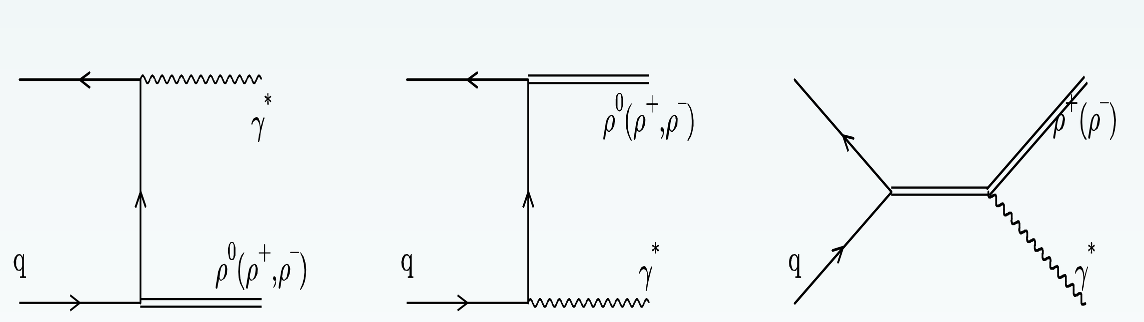
➢ Interaction Lagrangian [3,4]:

$$\mathcal{L}_{int} = i g_{qq\pi} \bar{\psi}\gamma^{5}\vec{\tau}\,\vec{\phi}\psi$$
$$\mathcal{L}_{int} = i g_{qq\rho} \bar{\psi}\gamma^{\mu}\vec{\tau}\,\vec{\phi}_{\mu}\psi$$

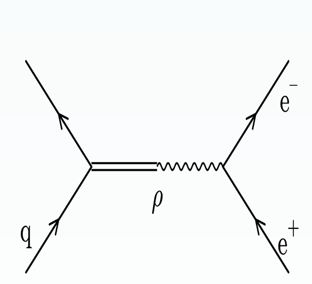
➢Radiation associated with pions



➢Radiation associated with rho-mesons



➢Radiation associated with direct rho decay to dilepton [5]



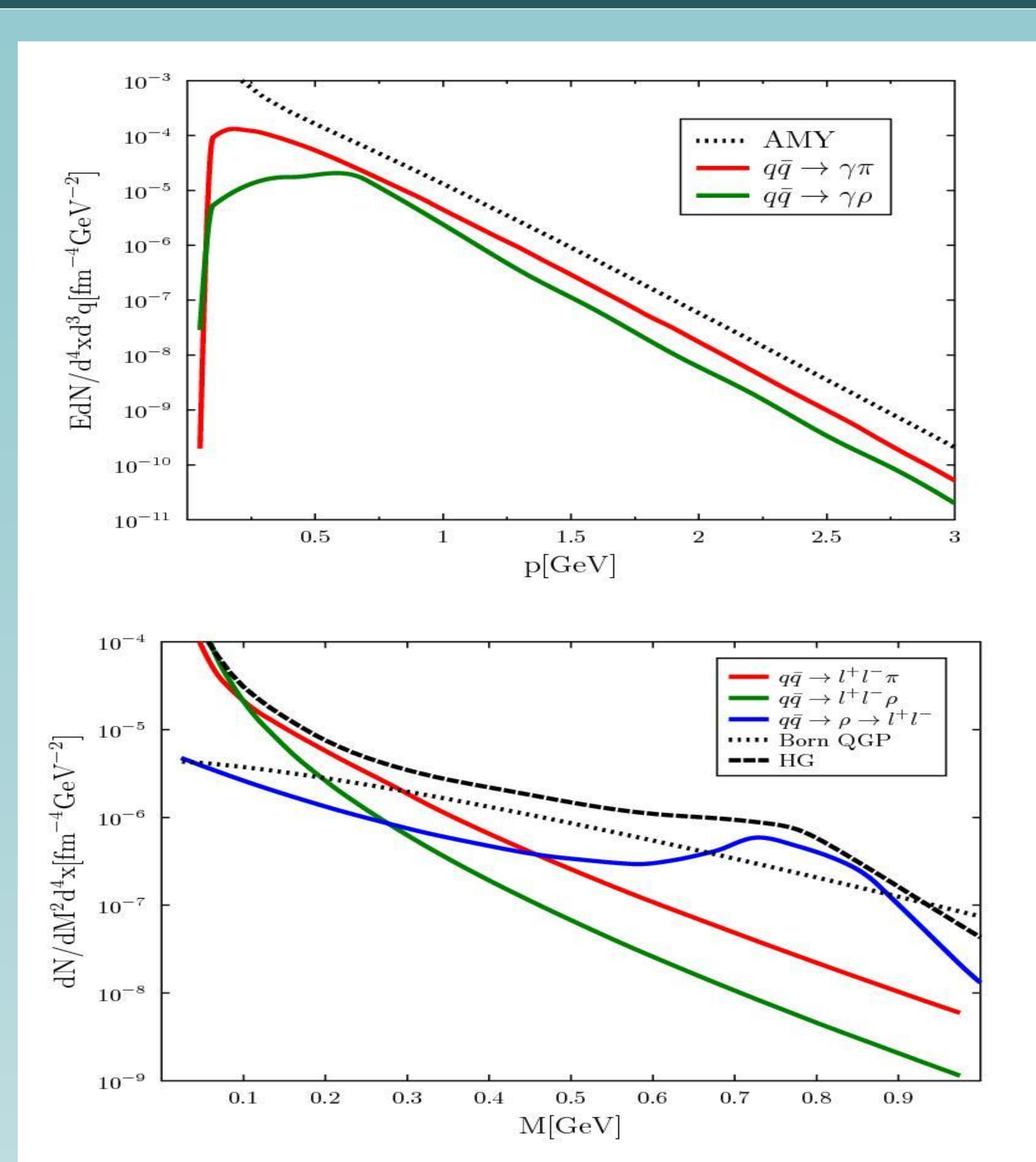


Fig 1. Photon production rate from AMY [6] and hadronization (Top). Dilepton production rate from QGP [7], hadronic gas [8] and hadronization(Botom).

Photon and Dilepton Yields

We use a modified version of boost invariant hydrodynamic code AZHYDRO [9] to describe the evolution of the system after collision. The EOS has a crossover (deconfinement) phase transition from QGP to HG around the critical temperature 170 MeV.

QGP	Hadronization	HG
T>170 MeV	190 MeV>T>170 MeV	T<170 MeV

Table 1. Cells to be integrated for different sources.

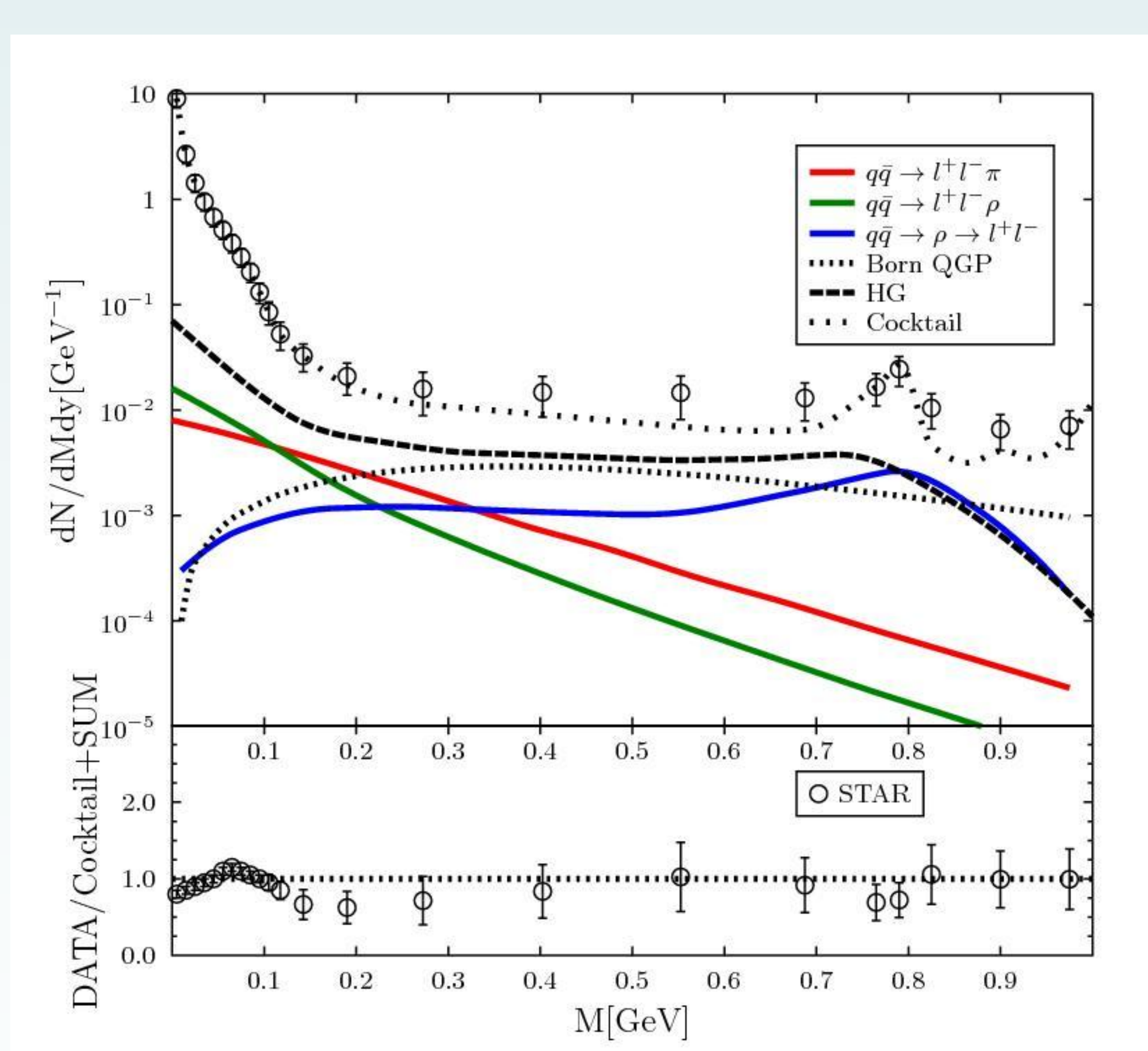


Fig 2. Dilepton yields from different sources for 0-10% centrality Au+Au collision at 200 GeV within STAR acceptance (Top). Ratio of STAR data over the sum of cocktail and complete thermal dilepton yield (Bottom).

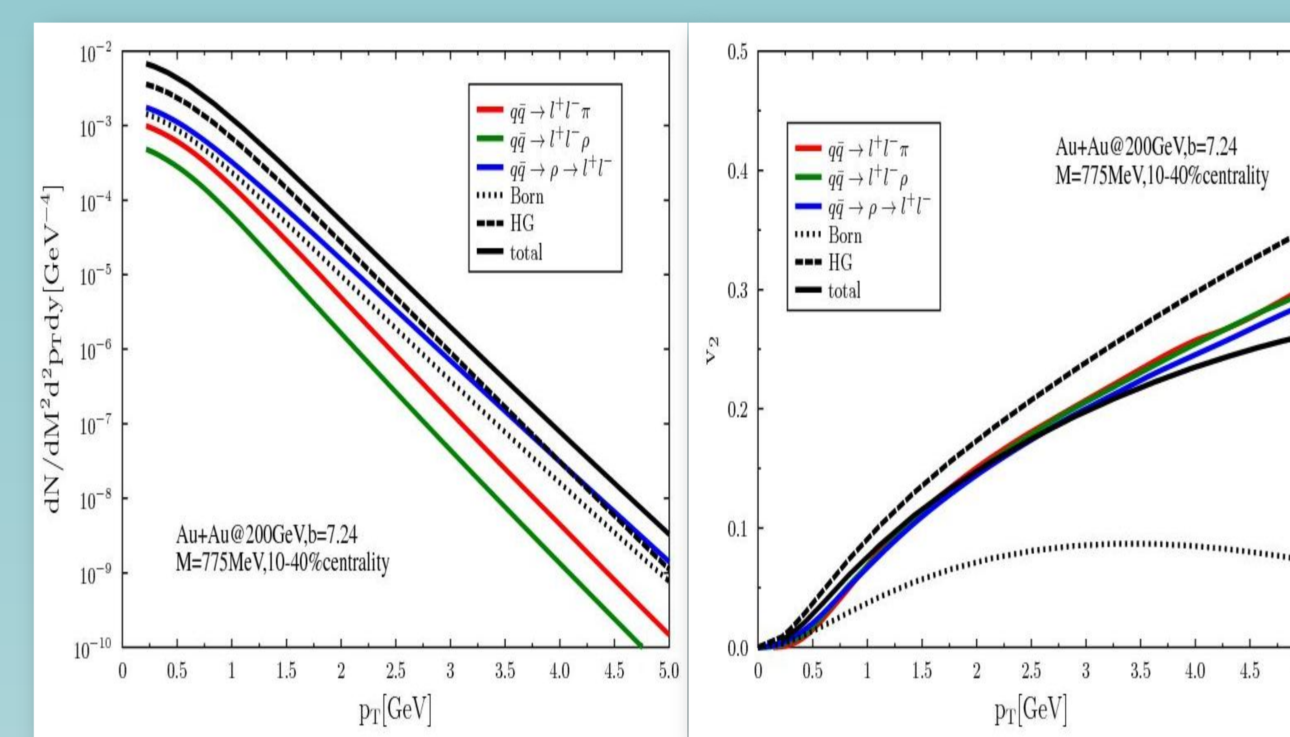


Fig 3. Dilepton transverse momentum spectra (Left) and elliptic flow (Right) for 10-40% centrality Au+Au collision at 200 GeV, M=0.775 GeV.

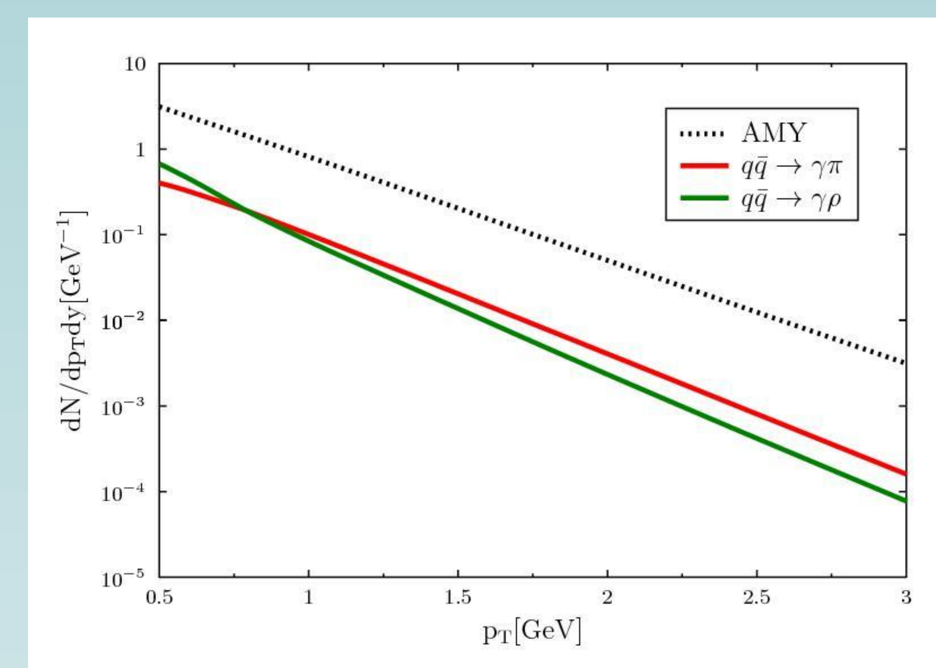


Fig 4. Photon yield from 0-10% centrality Au+Au collision at 200 GeV.

Conclusion

➢Photons and dileptons associated with hadronization have rates competitive with other thermal sources.

➢Photon yields are not found to be important due to small lifetime of hadronization processes.

➢Dilepton yields from hadronization are sizeable at low mass. This can help explain the excess seen by STAR, but it can not explain the excess observed by PHENIX.

➢ Further constraints will be coming from transverse momentum spectra and elliptic flow of dileptons.

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