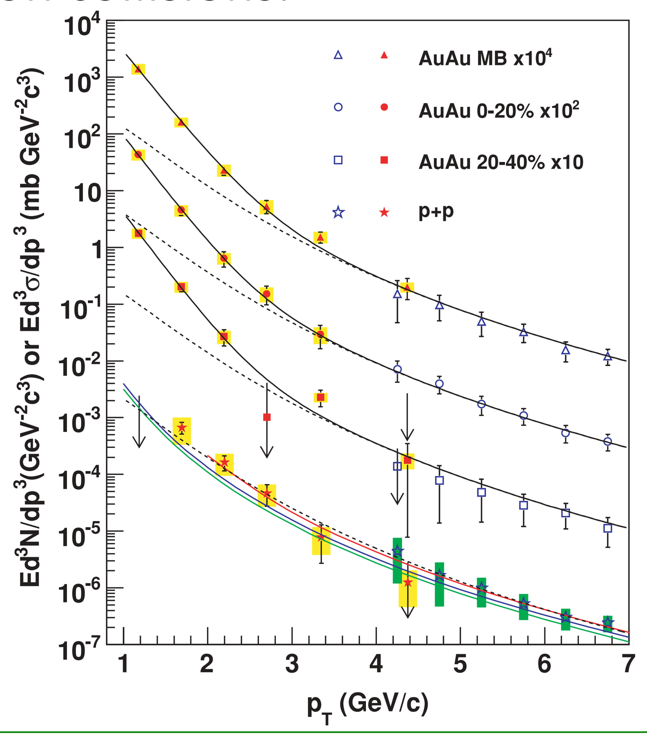
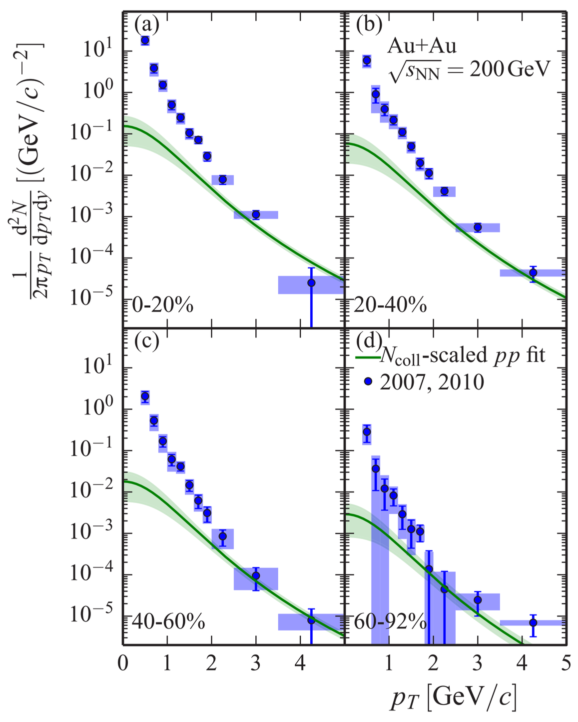
Analysis status on low-momentum direct-photons in Cu+Cu collisions at $\sqrt{s_{NN}}$ = 200 GeV at PHENIX

Tomoya Hoshino for the PHENIX collaboration
Quark Physics Laboratory (Hiroshima University)

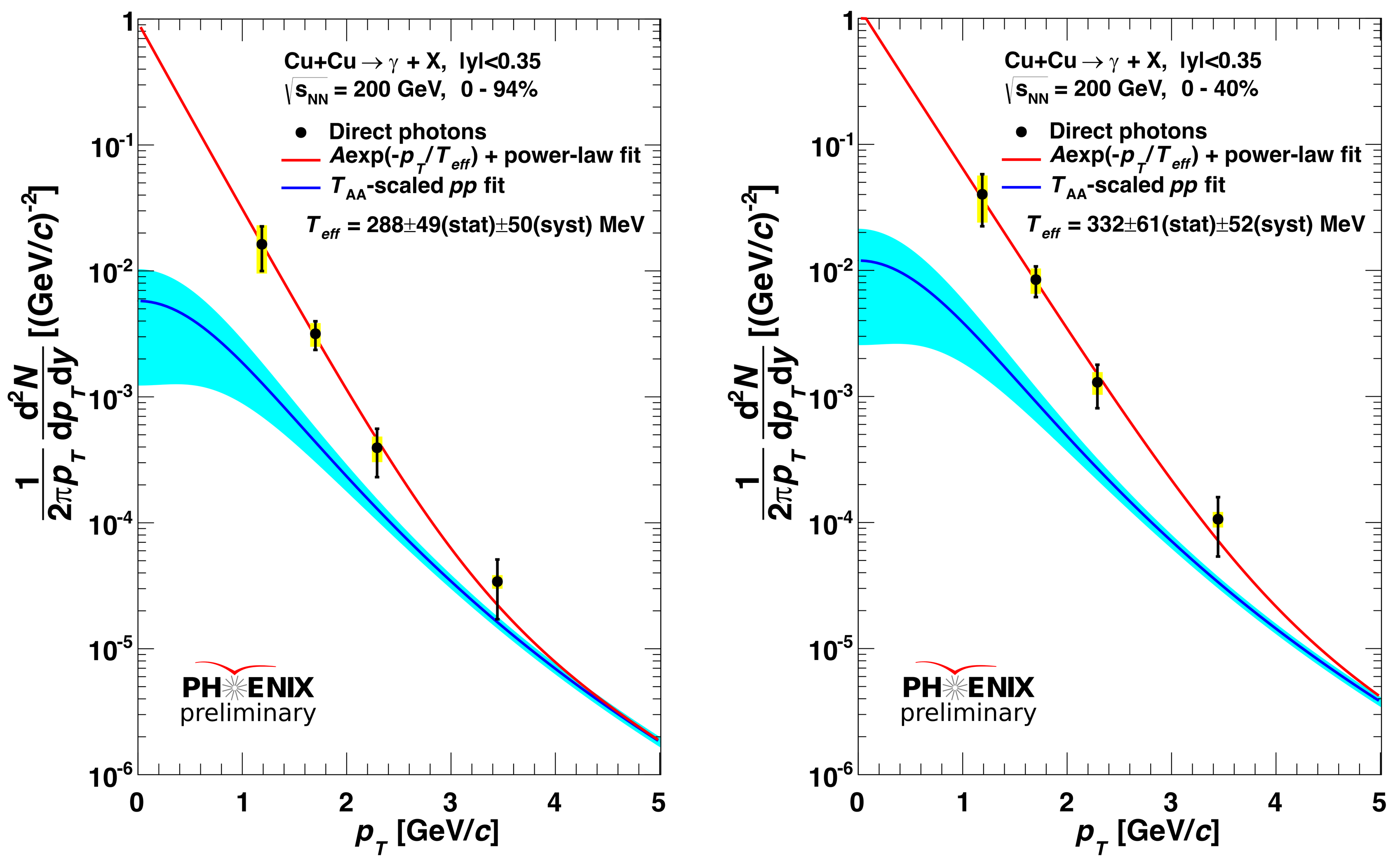
Motivation

- Photons and dileptons are good probes to understand space-time evolution of matter produced in heavy ion collisions.
- The PHENIX experiment has measured and published spectra of low-momentum direct-photons:
  - Through virtual photon emission in *p*+*p*, *d*+Au, and Au+Au at 200 GeV [1, 2]
  - Through external conversions in Au+Au at 200 GeV [3]
- Direct photon measurement in Cu+Cu at 200 GeV can help to understand the system size dependence of direct photon production in heavy ion collisions.



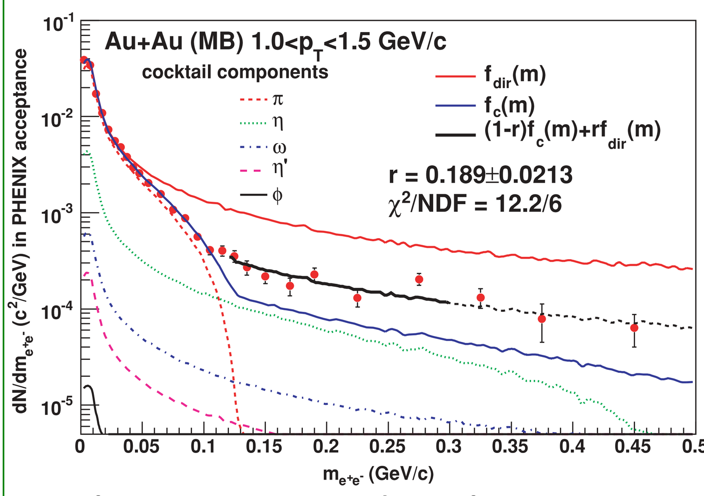


Direct photon spectrum



Direct photon spectra from Cu+Cu at 200 GeV. The black makers represent the measured direct photons, the red lines are fits (exponential + *p*+*p*) to the data, and the blue lines are fits to *p*+*p* data scaled by the nuclear overlap function T_{AA} representing the expected yield from pQCD process. A $\pm 1\sigma$ error band is shown. An enhancement above the expected yield is observed in both of Min.Bias and central collisions.

Virtual direct photon



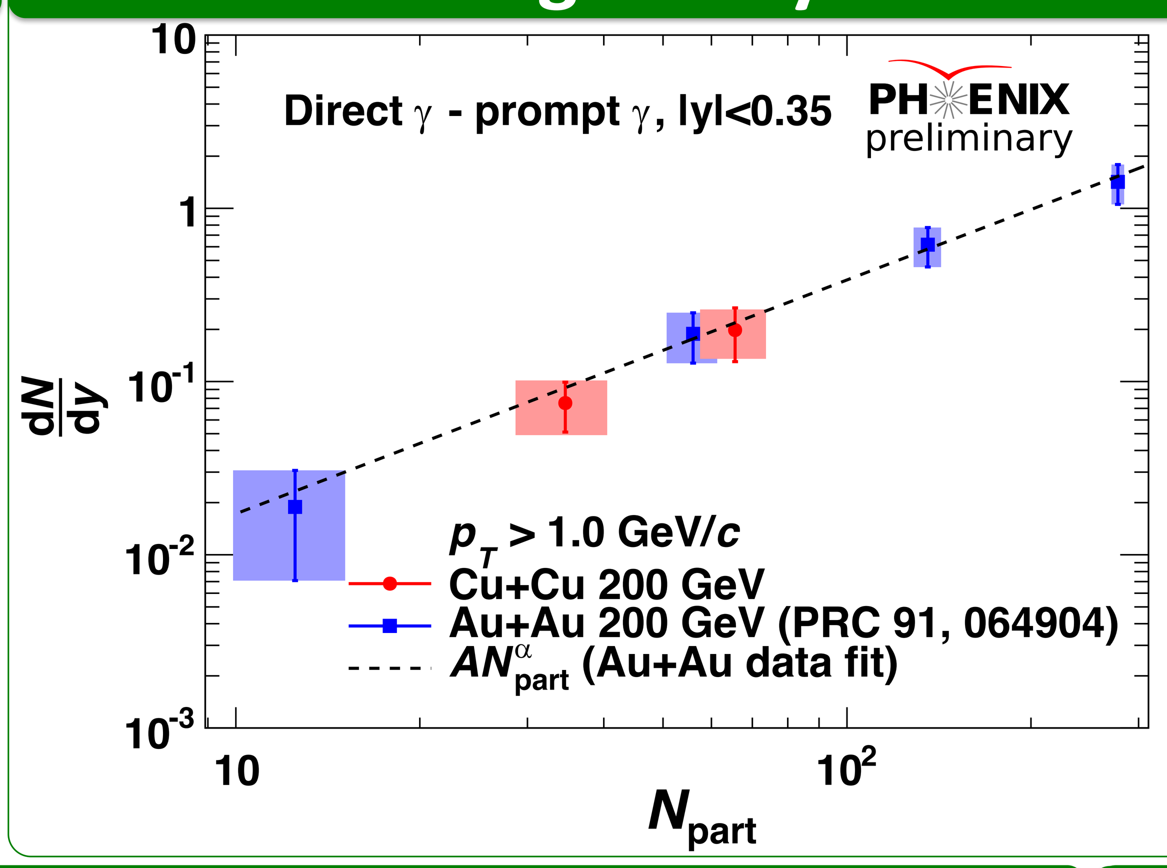
Dielectron mass distribution with cocktail comparison for Au+Au (MB) events for $1.0<p_T<1.5$ GeV/c [1].

Virtual direct photons (e^+e^- pairs) are measured as an excess compared to hadronic cocktail after subtracting uncorrelated and correlated backgrounds. Above the π^0 mass the excess is clearly visible. The excess is quantified with a two-component fit.

$$f(m_{ee}; r) = (1-r) f_c(m_{ee}) + r f_{dir}(m_{ee})$$

Here f_c is the shape of the cocktail, and f_{dir} is the expected shape from the virtual direct photons.

Integrated yield of thermal photons



Integrated yield of "excess photons" are calculated as a function of N_{part}.
Direct photons from prompt process are subtracted to obtain the excess photons.
The results is shown with published Au+Au results.
The Au+Au yield increases with AN_{part}^{α} where A is 7.70×10^{-4} and α is 1.35. The Cu+Cu results are consistent with Au+Au results.

Background estimation

The combinatorial background is evaluated by the mixed-event method. So called "cross pairs" that originate decays of π^0 and η simulated with EXODUS. "Jet pairs" that are produced by two electrons in a jet or back-to-back jets are simulated with PYTHIA8. The normalization of all backgrounds are determined with a 4-component fit to the like-sign mass e^+e^- distribution.

Hadronic cocktail

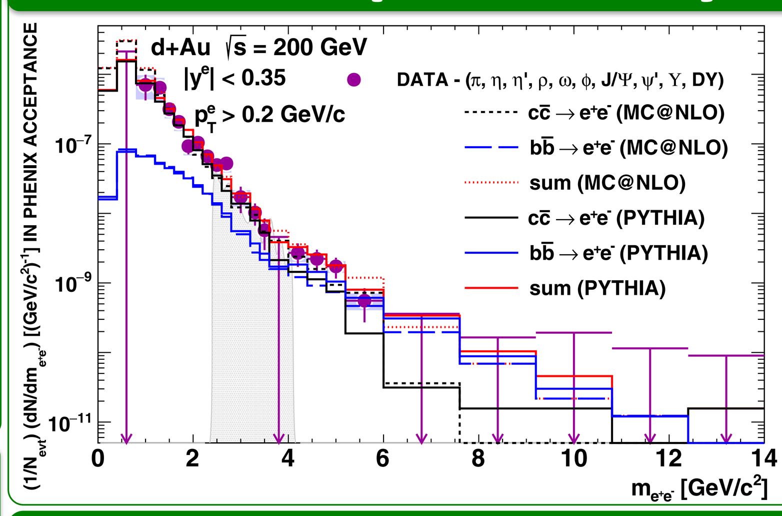
Electron pairs from hadronic decays are simulated using EXODUS. The input p_T spectrum for π^0 meson is parameterized by a modified Hagedorn function fitted to PHENIX data from Cu+Cu collisions. All other mesons spectra are determined via m_T scaling using measured meson to π^0 ratios.

	η	ω	η′	ϕ
meson/π^0	0.48	0.90	0.25	0.40

meson/π^0 at high p_T (>5 GeV/c)

$$E\frac{d^3\sigma}{dp^3} = A\left(e^{-(ap_T + bp_T^2)} + \frac{p_T}{p_0}\right)^{-n}$$

Open heavy flavor



ccbar contribution: e^+e^- pair from PYTHIA8 simulation normalized to the measured ccbar cross section and scaled with N_{coll} [4].

Decay photon spectrum

The direct photon spectrum is calculated from the decay photon spectrum and the direct photon fraction r_γ.

$$\gamma^{dir} = r_\gamma/(1 - r_\gamma)\ \gamma^{decay}$$

The decay photon spectrum is obtained from the same EXODUS simulation used to determine the e^+e^- pair spectrum from hadron decays.

Data set and selections

Data set

Cu+Cu collisions at $\sqrt{s_{NN}}$ = 200 GeV collected during the run in 2005.

Event selection

Minimum Bias trigger based on the Beam-Beam Counters (BBCs).
An offline cut on the vertex position is applied $|z| < 25$ cm.
The centrality classes are determined by BBC charge.

Track selection and eID

Charged particles are reconstructed with the PHENIX Drift Chambers and Pad Chambers. Electrons are identified using EMCal and the RICH.

The PHENIX experiment

Electron identification

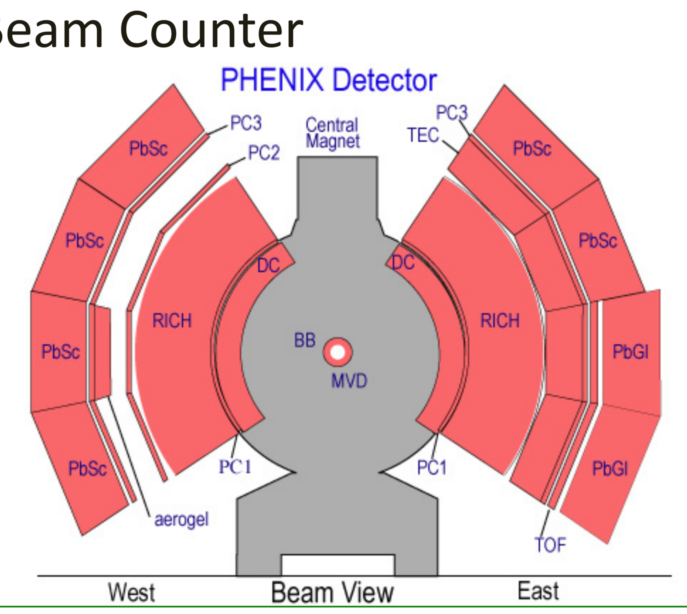
Ring-imaging Cherenkov detector (RICH) and Electro-magnetic calorimeter (EMCal)

Momentum Measurement

Drift chamber (DC)

Centrality, z-vertex, and reaction plane

Beam-Beam Counter



$\Delta\phi = \pi$
$|\eta| < 0.35$

Simulations

EXODUS

EXODUS is a phenomenological event generator, which simulates the phase-space distribution of e^+e^- pairs from hadron decays.

PYTHIA8

PYTHIA8 is used to calculate correlated e^+e^- pairs from jets and to estimate the e^+e^- pair contribution from ccbar production. PYTHIA8 is used with the CTEQ 5L parton distribution function.

Particles generated EXODUS/PYTHIA8 are passed through the PHENIX GEANT simulator.

Summary and Outlook

- Direct photons are a good probe to determine the space-time evolution of the matter produced in heavy-ion collisions.
- Direct photon spectra from Cu+Cu are obtained for Min.Bias (0 – 94%) and 0 – 40% centrality.
- Inverse slopes and integrated yields measured in Cu+Cu collisions are consistent with those found in Au+Au collisions at similar N_{part}.

References

[1] Physical Review C 87, 054907 (2013), PHENIX
[2] Physical Review C 81, 034911 (2010), PHENIX
[3] Physical Review C 91, 064904 (2015), PHENIX
[4] Physical Review C 91, 014907 (2015), PHENIX