Systematic studies of the centrality-dependence of soft photon production in Au+Au collisions with PHENIX

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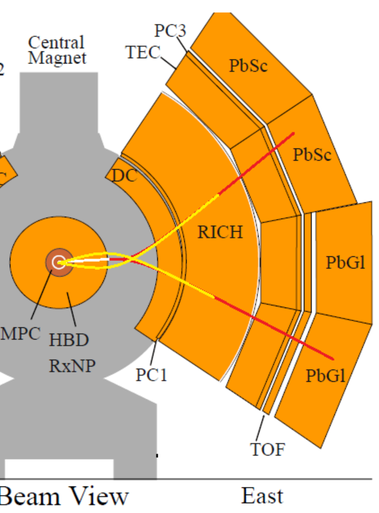
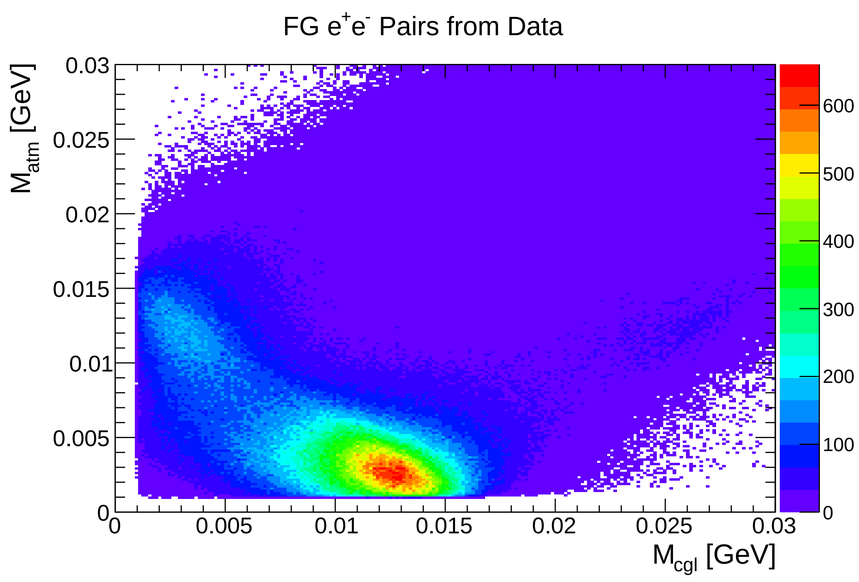
Motivation

Photons are *produced at all times* of a nuclear collision and *escape* with minimal interactions.
The photon yield gives experimental access to the *photon rates* of the different production processes, the elliptical and triangular flow v_2 and v_3 are *very sensitive to the dynamics* of the medium.

Low-momentum photon sample

Measurements of low-momentum photons are notoriously difficult in electromagnetic calorimeters due to large contamination from misidentified hadrons and a deteriorating energy resolution.
Instead we here reconstruct *photons from external conversion pairs* to electrons and positrons. Conversion pairs are identified by a characteristic apparent pair mass (opening angle) at the vertex and at the HBD detector shell. Momenta of electrons and positrons can be recalculated assuming they came from the HBD shell, and their mass (opening angle) at the vertex and the HBD shell can be compared. This allows a *clean separation* of electron-positron pairs from Dalitz-decays and external photon conversions with the level of background $< 1\%$ with *very good photon momentum resolution*.





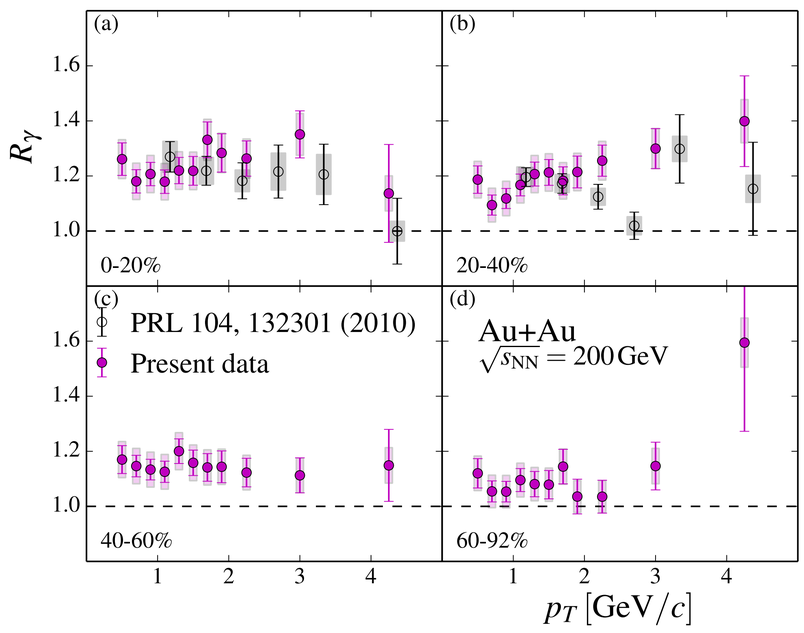
The direct photon yield

We measure the yield ratio $R_\gamma = Y_\gamma^{\text{incl}}/Y_\gamma^{\text{decay}}$ for this photon sample by also measuring the yield of photons from π^0 decays so that most detector-dependent factors cancel.

$$R_\gamma = \frac{Y_\gamma^{\text{incl}}}{Y_\gamma^{\text{decay}}} = \frac{\langle \varepsilon f \rangle \frac{N_\gamma^{\text{incl}}}{N_\gamma^{\pi^0}}}{\frac{Y_\gamma^{\text{decay}}}{Y_\gamma^{\pi^0}}}$$

- $\langle \varepsilon f \rangle$ tagging efficiency for γ from π^0
- $N_\gamma^{\text{incl},\pi^0}$ experimental yields
- $Y_\gamma^{\pi^0,\text{decay}}$ from π^0/hadron decays (simulated)

All quantities are *evaluated at the converted photon* p_T.



Direct photon yield

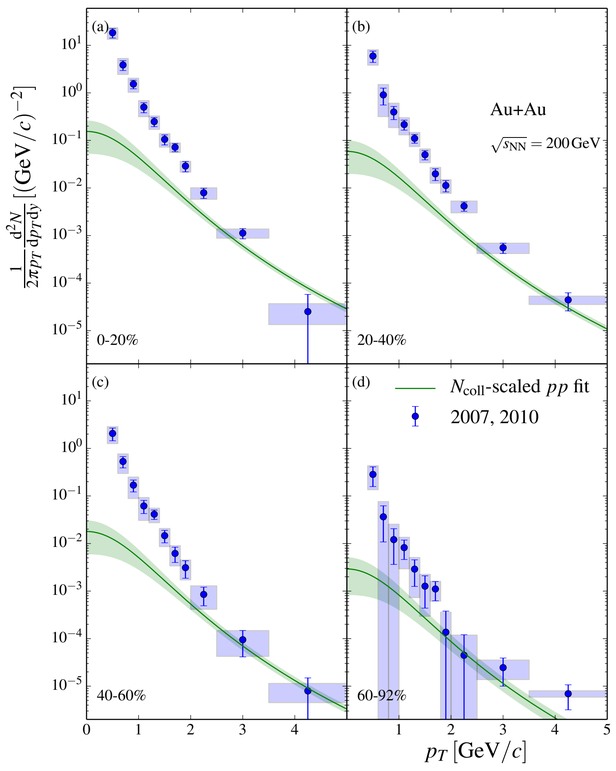
From R_γ we can calculate the direct photon yield,

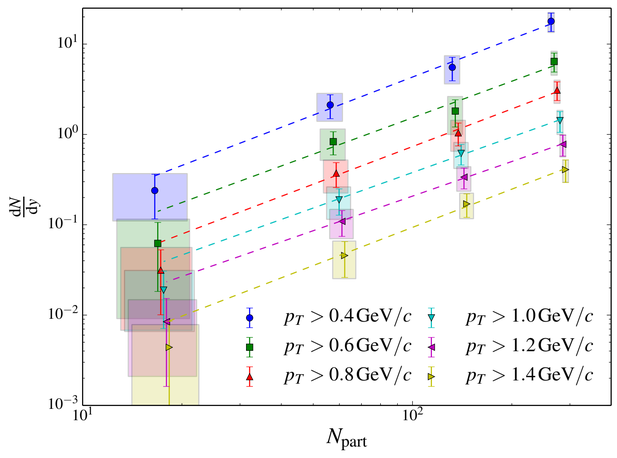
$$Y_\gamma^{\text{direct}} = (R_\gamma - 1) Y_\gamma^{\text{decay}}$$

and analyze its centrality-dependence. We find that the excess over N_{coll}-scaled pp yields has inverse slopes roughly independent of centrality.

centrality	inverse slope
0-20%	$(239 \pm 25 \pm 7)$ MeV
20-40%	$(260 \pm 33 \pm 8)$ MeV
40-60%	$(225 \pm 28 \pm 6)$ MeV
60-92%	$(238 \pm 50 \pm 6)$ MeV

Centrality-dependence of the excess yield:
$N_\gamma \propto N_{\text{part}}^{1.48}$.

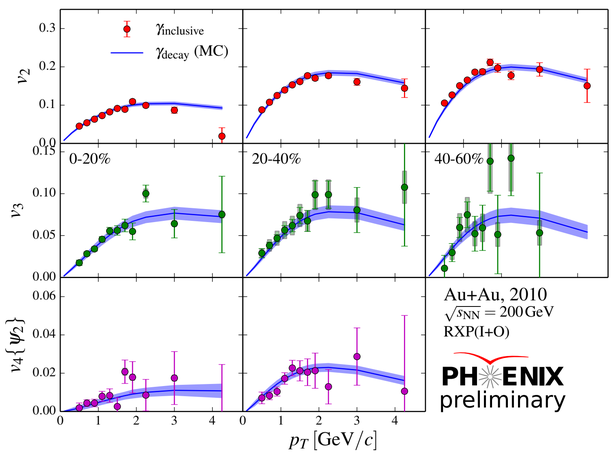


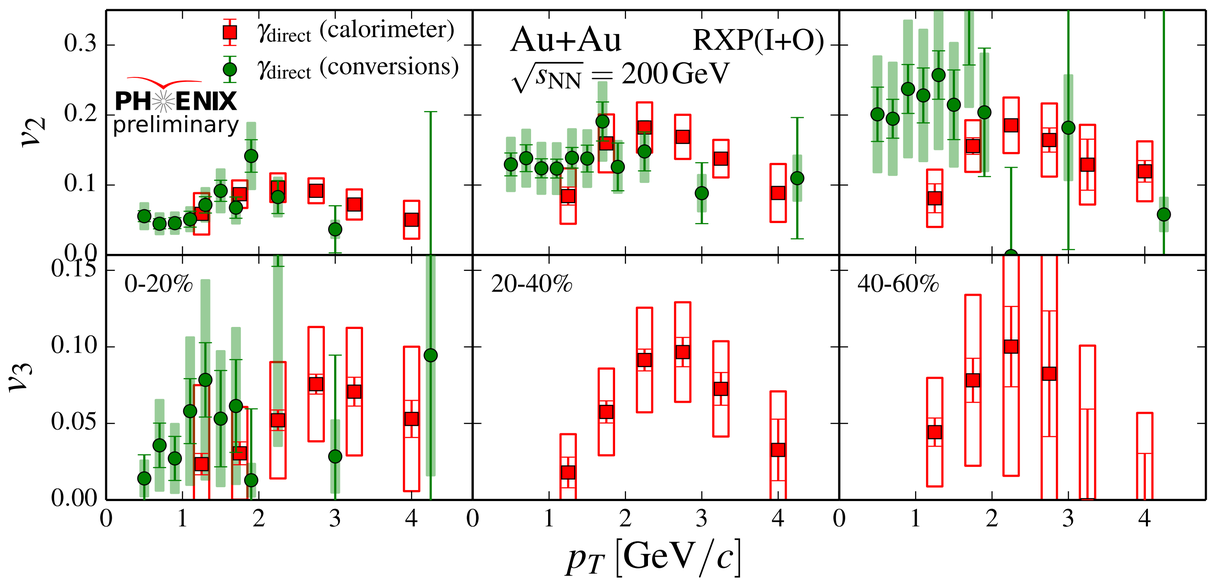


Direct photon v_2 and v_3

The direct photon v_n can be calculated with R_γ, the inclusive measurement and the known distribution from decay photons,

$$v_n^{\text{direct}} = \frac{R_\gamma v_n^{\text{inclusive}} - v_n^{\text{decay}}}{R_\gamma - 1}$$





- **Direct photon v_2 remains large down to very low p_T, also across centralities.**
- **Direct photon v_3 appears to be non-zero and positive.**

also see poster by S. Mizuno

References

A. Adare *et al.* [PHENIX Collaboration], arXiv:1405.3940 [nucl-ex].

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