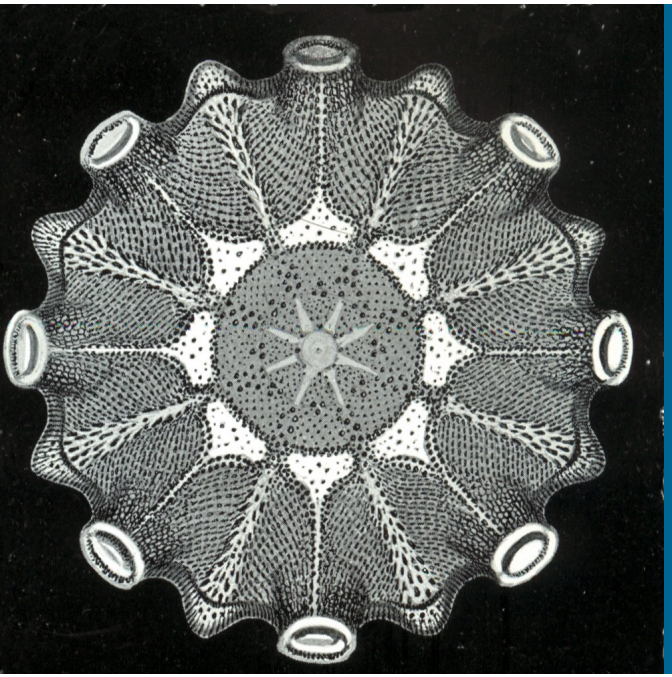


Systematic studies of soft direct photon production in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

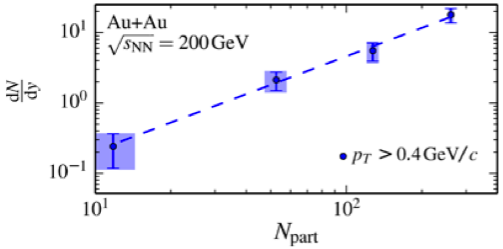
2015 RHIC & AGS Annual Users' Meeting

Benjamin Bannier

Direct photons are

- *produced during all stages* of the interaction, and
- escape with *minimal final state interaction*.

They are a *tool to directly probe the medium properties* in a heavy-ion interaction.



EDITORS' SUGGESTION

Centrality dependence of low-momentum direct-photon production in $\mathbf{Au + Au}$ collisions at $\sqrt{s_{NN}} = 200\ \mathbf{GeV}$

Direct photons produced in relativistic heavy-ion collisions allow access to the state of matter during the collision, because they do not experience the strong interaction and can escape from the fireball without scattering. New data from the PHENIX experiment at RHIC show that as a function of impact parameter the yield of direct photons increases much more rapidly than particle production, which provides new evidence for emission from the system when it was most hot and dense.

A. Adare *et al.* (PHENIX Collaboration)
Phys. Rev. C **91**, 064904 (2015)

based on theses by Richard Petti & B.B., supervised by Axel Drees

Photon sample: external conversions

For each e^+e^- pair we can calculate its apparent invariant mass assuming it came from the vertex, or from the HBD detector shell.

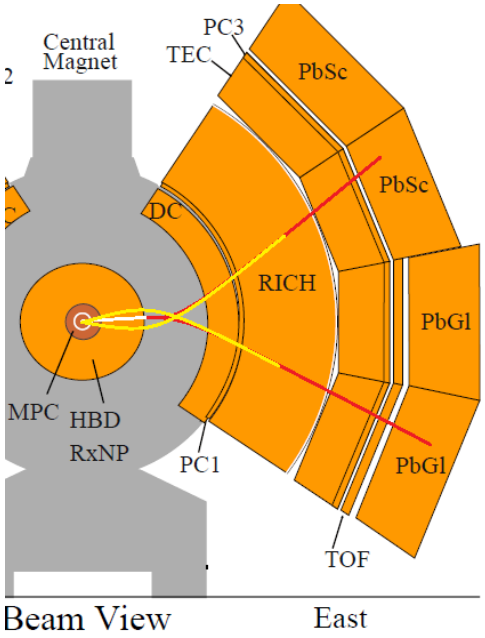


Figure 1: e^+e^- pairs in PHENIX

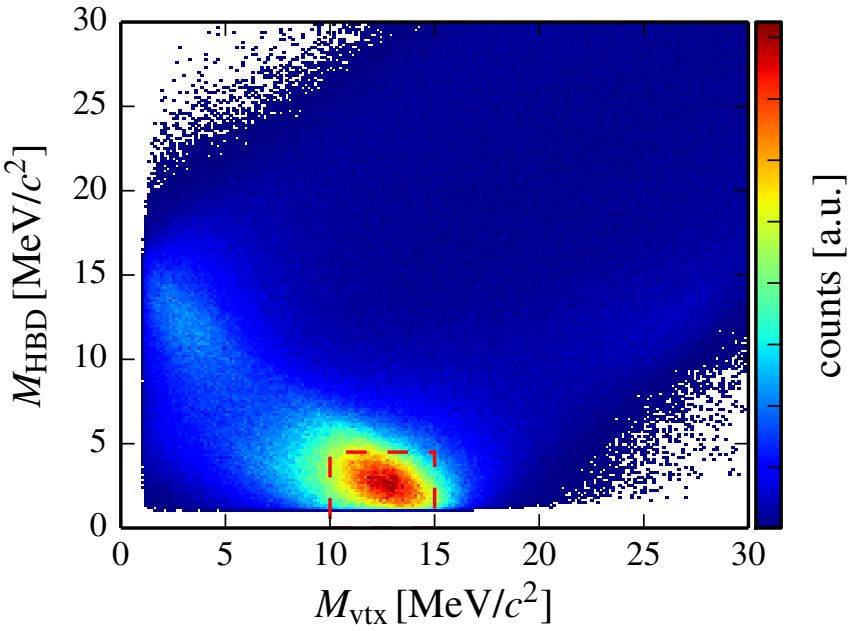


Figure 2: Photon selection

The direct photon yield

Instead of massaging the experimental inclusive γ yield *measure ratio*

$$R_\gamma = \frac{Y_\gamma^{\text{incl}}}{Y_\gamma^{\text{decay}}} = \frac{\frac{Y_\gamma^{\text{incl}}}{Y_\gamma^{\pi^0}}}{\frac{Y_\gamma^{\text{decay}}}{Y_\gamma^{\pi^0}}} = \frac{\left[\frac{a_{ee}\varepsilon_{ee}a_\gamma\varepsilon_\gamma}{a_{ee}\varepsilon_{ee}}\frac{N_\gamma^{\text{incl}}}{N_\gamma^{\pi^0}}\right]}{\frac{Y_\gamma^{\text{decay}}}{Y_\gamma^{\pi^0}}} = \frac{\langle\varepsilon f\rangle\frac{N_\gamma^{\text{incl}}}{N_\gamma^{\pi^0}}}{\frac{Y_\gamma^{\text{decay}}}{Y_\gamma^{\pi^0}}}$$

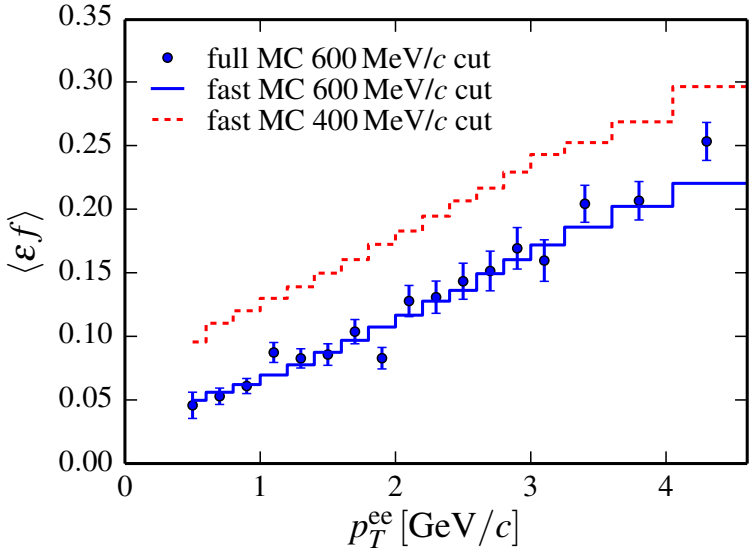


Figure 3: Tagging efficiency corrections from different MCs

Calculation of yield and v_n^{direct} is straight-forward:

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

$$v_n^{\text{direct}} = \frac{R_\gamma v_n^{\text{incl}} - v_n^{\text{hadrons}}}{R_\gamma - 1}$$

Result

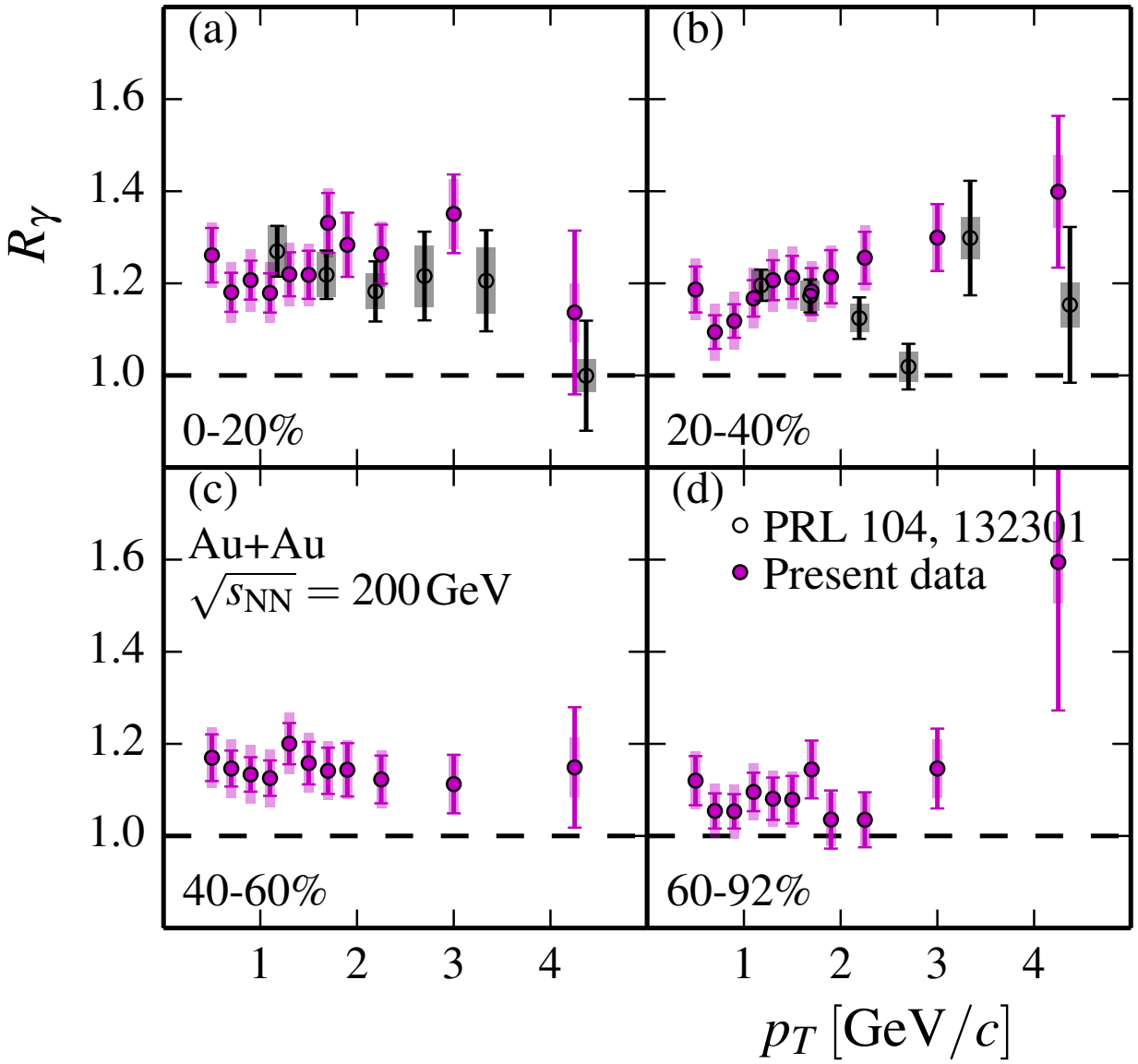


Figure 4: R_γ

Yield

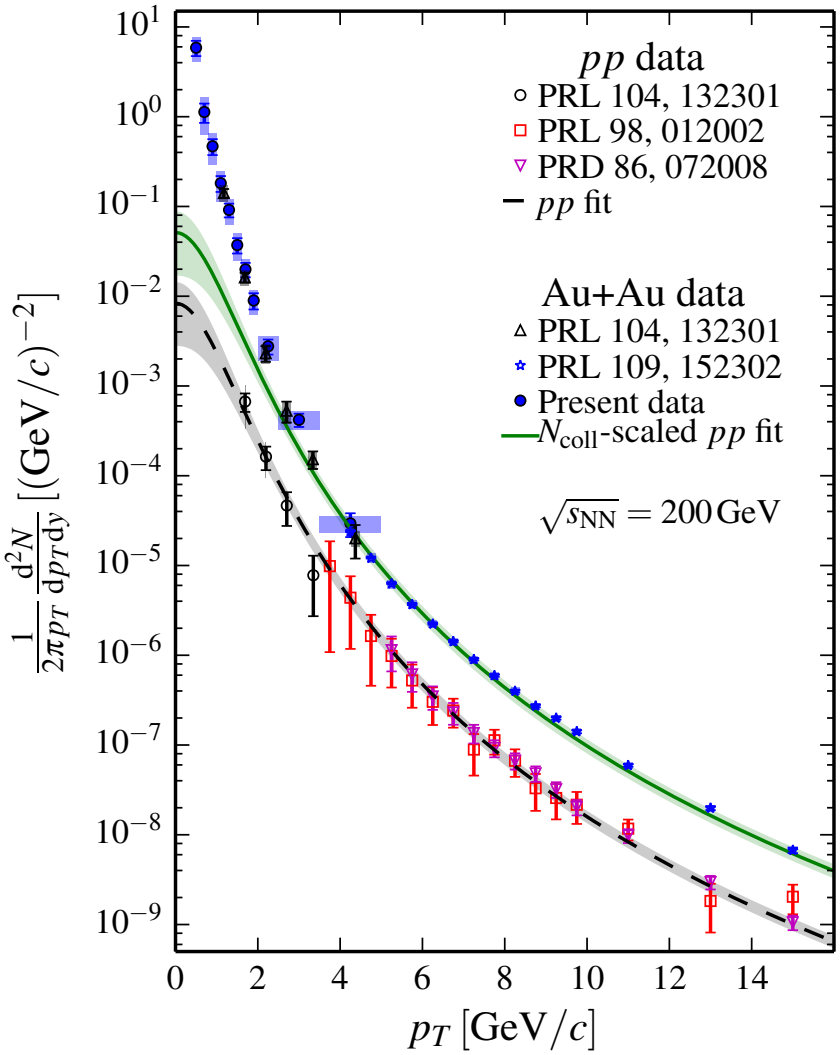


Figure 5: Direct photon yield

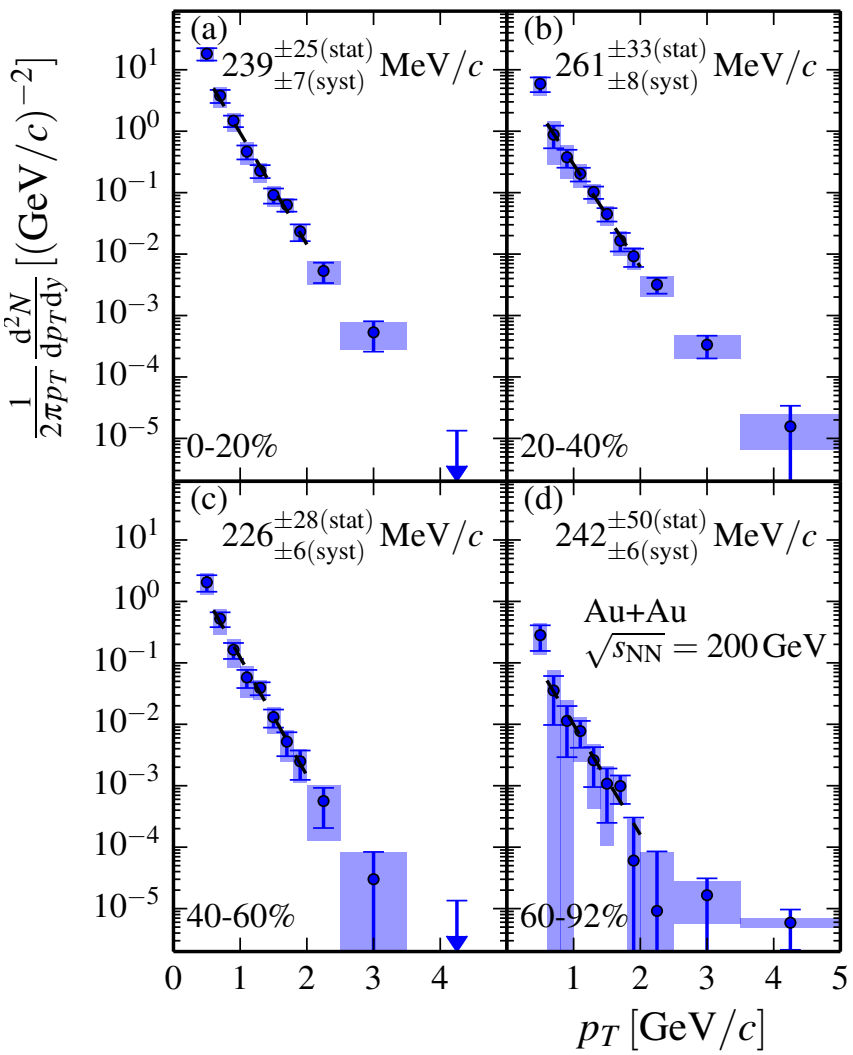


Figure 6: Excess photon yield

Yield – centrality dependence

The excess photon yield has a power-law dependency on N_{part}.

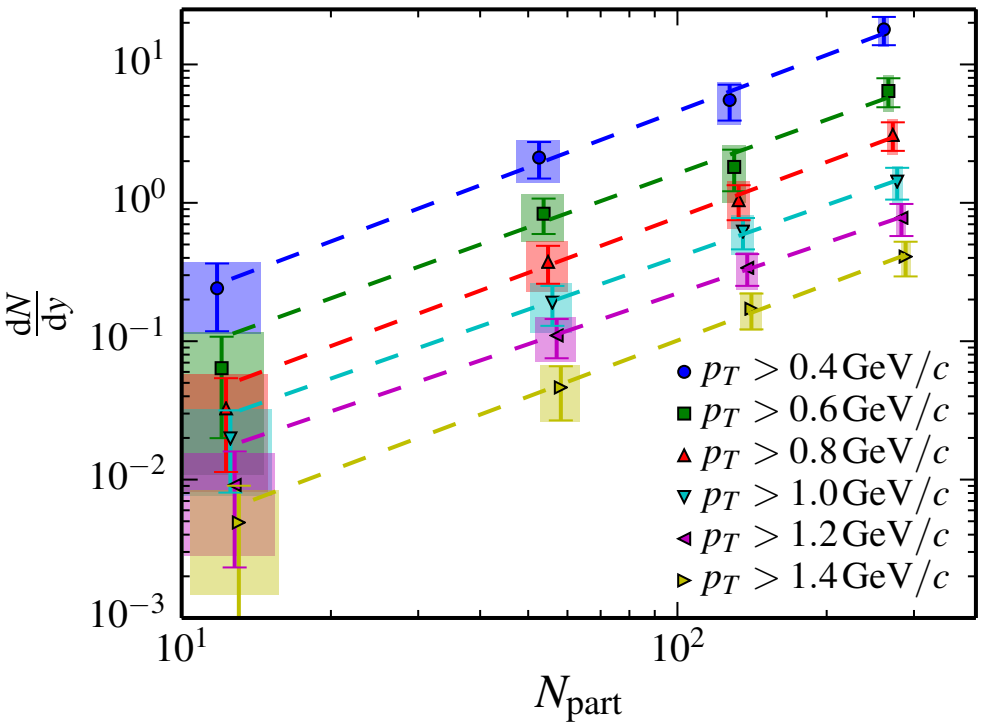


Figure 7: Integrated excess photon yield vs. centrality

Photon anisotropies v_2 & v_3

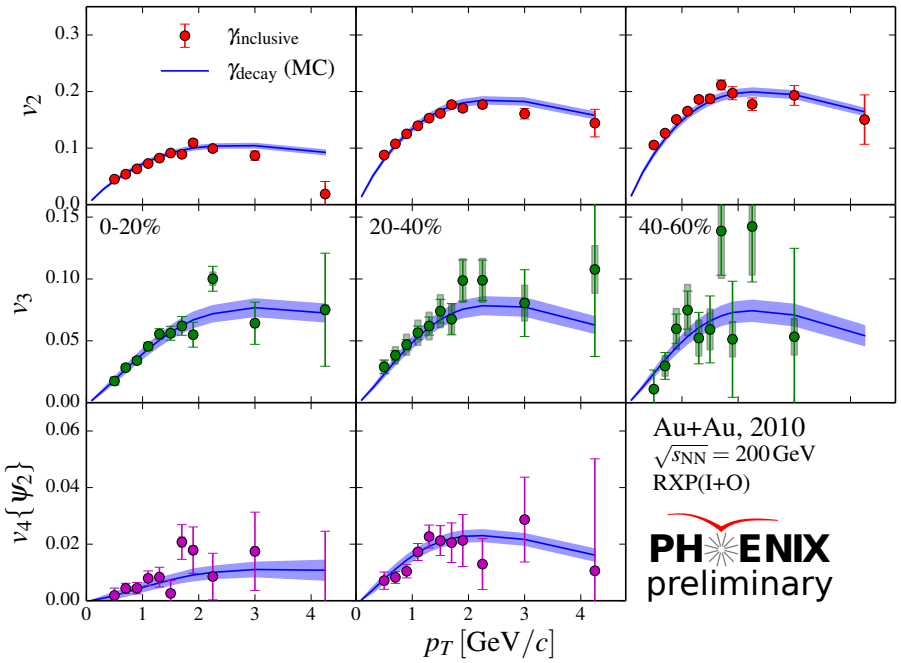


Figure 8: Inclusive and decay photon v_n

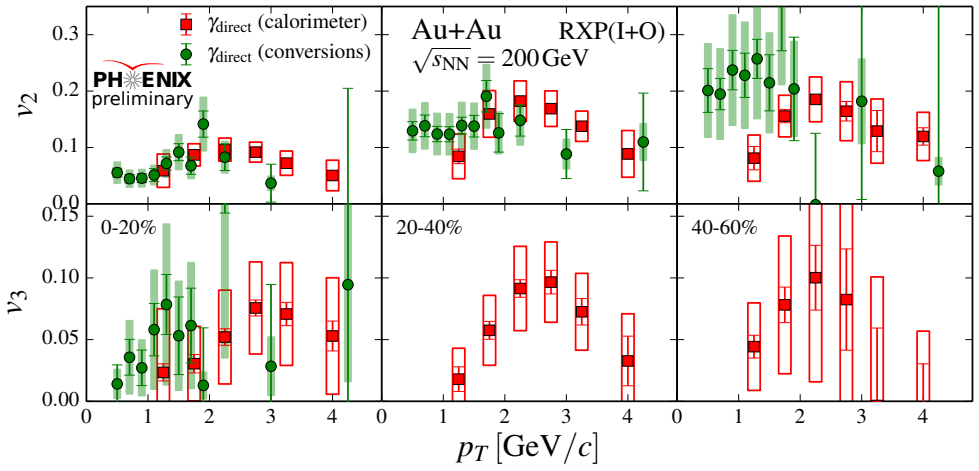
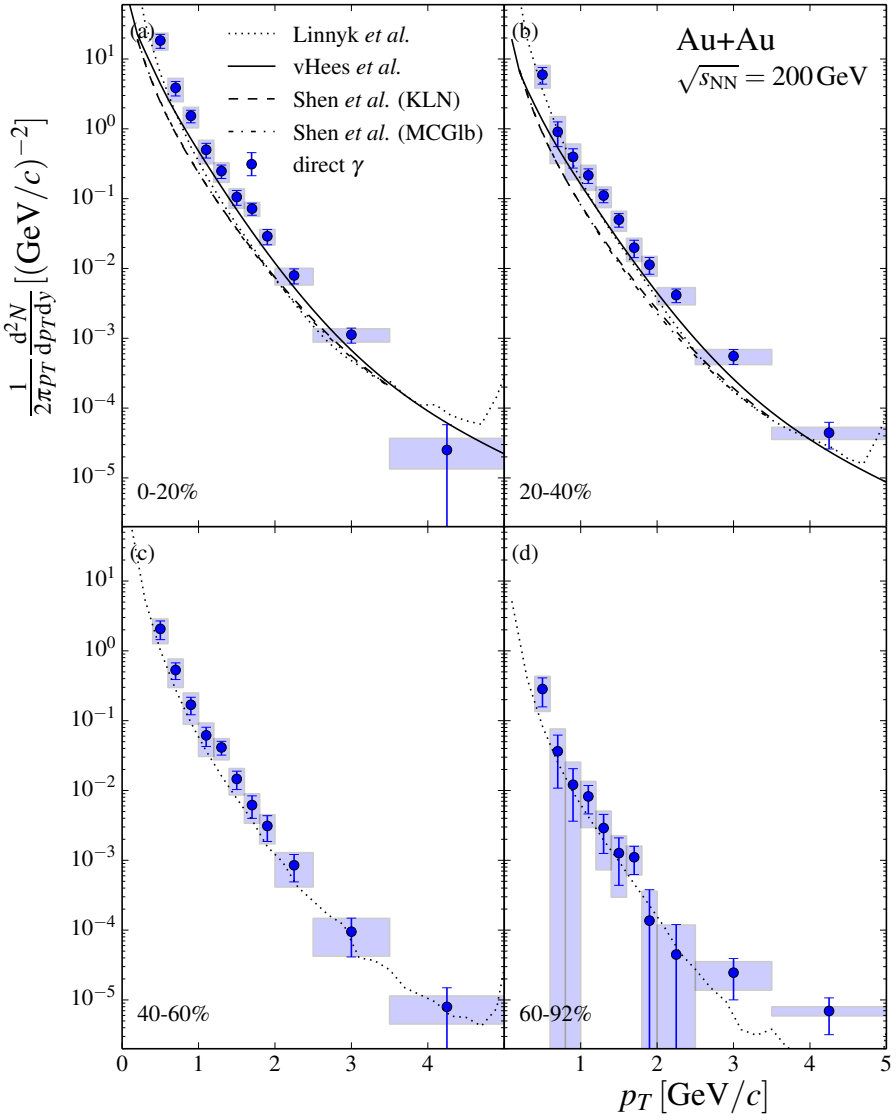


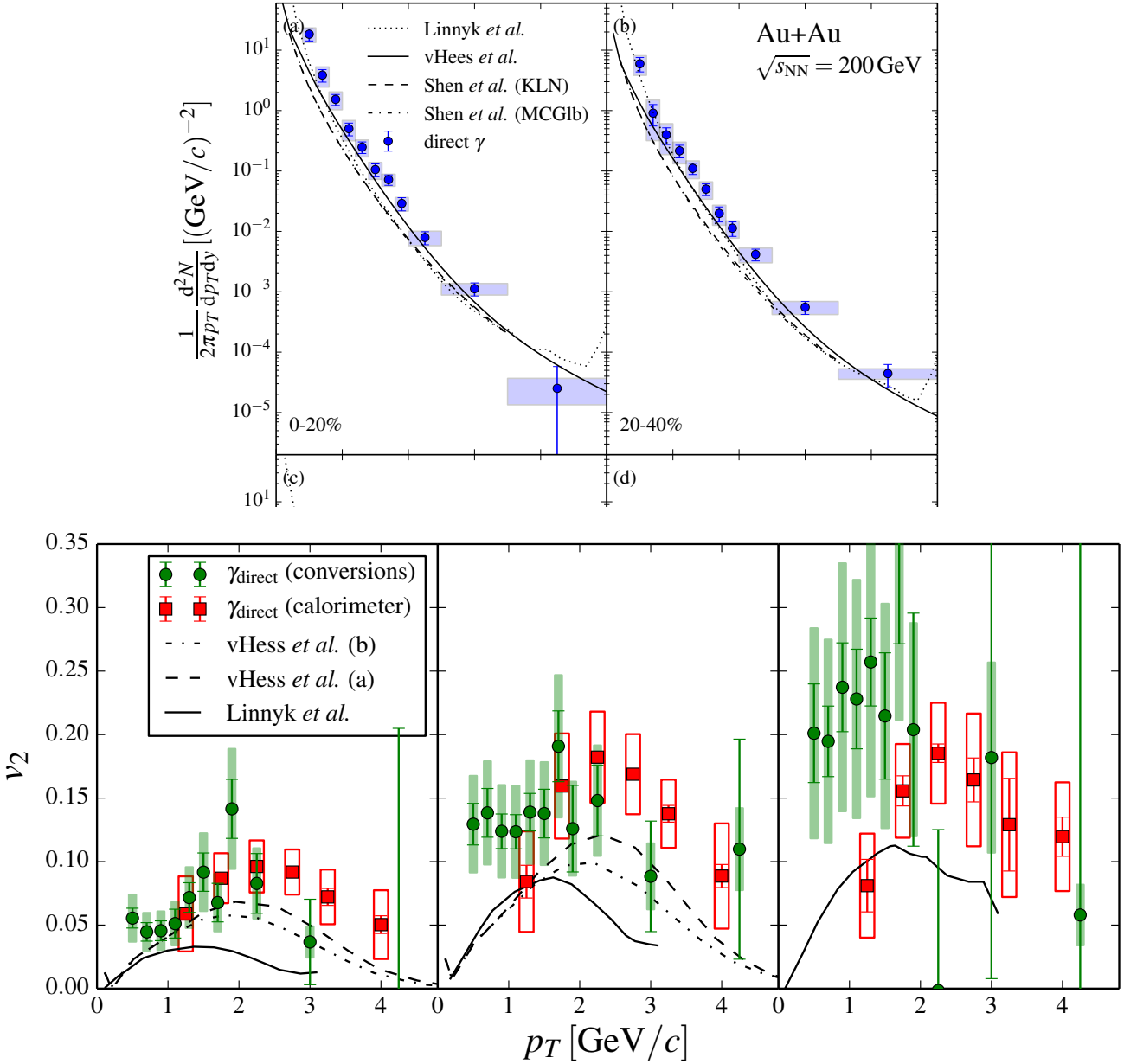
Figure 9: Direct photon v_n

$$v_n^{\text{direct}} = \frac{R_\gamma v_n^{\text{incl}} - v_n^{\text{hadrons}}}{R_\gamma - 1}$$

Models (2014)


Linnyk et al.
vHees et al.
Shen et al. (KLN)
Shen et al. (MCGlb)
direct γ
Au+Au
$\sqrt{s_{NN}} = 200\,\mathrm{GeV}$
(a)
(b)
(c)
(d)
0-20%
20-40%
40-60%
60-92%
$\frac{1}{2\pi p_T}\frac{d^2N}{dp_T dy}\,[(\mathrm{GeV}/c)^{-2}]$
$p_T\,[\mathrm{GeV}/c]$

Models (2014)


Linnyk et al.
vHees et al.
Shen et al. (KLN)
Shen et al. (MCGlb)
direct γ
Au+Au
$\sqrt{s_{NN}} = 200\,\mathrm{GeV}$
(a)
(b)
(c)
(d)
0-20%
20-40%
$\frac{1}{2\pi p_T}\frac{d^2N}{dp_T dy}\,[(\mathrm{GeV}/c)^{-2}]$
γ_{direct} (conversions)
γ_{direct} (calorimeter)
vHess et al. (b)
vHess et al. (a)
Linnyk et al.
v_2
$p_T\,[\mathrm{GeV}/c]$

Summary

Soft direct photons are a great tool to verify our understanding of the evolution of heavy-ion interactions.

Are we missing important photon sources, or just making unjustified simplifications?

Measurements of soft direct photons in other systems can be used to tune the mix of sources.

Backup

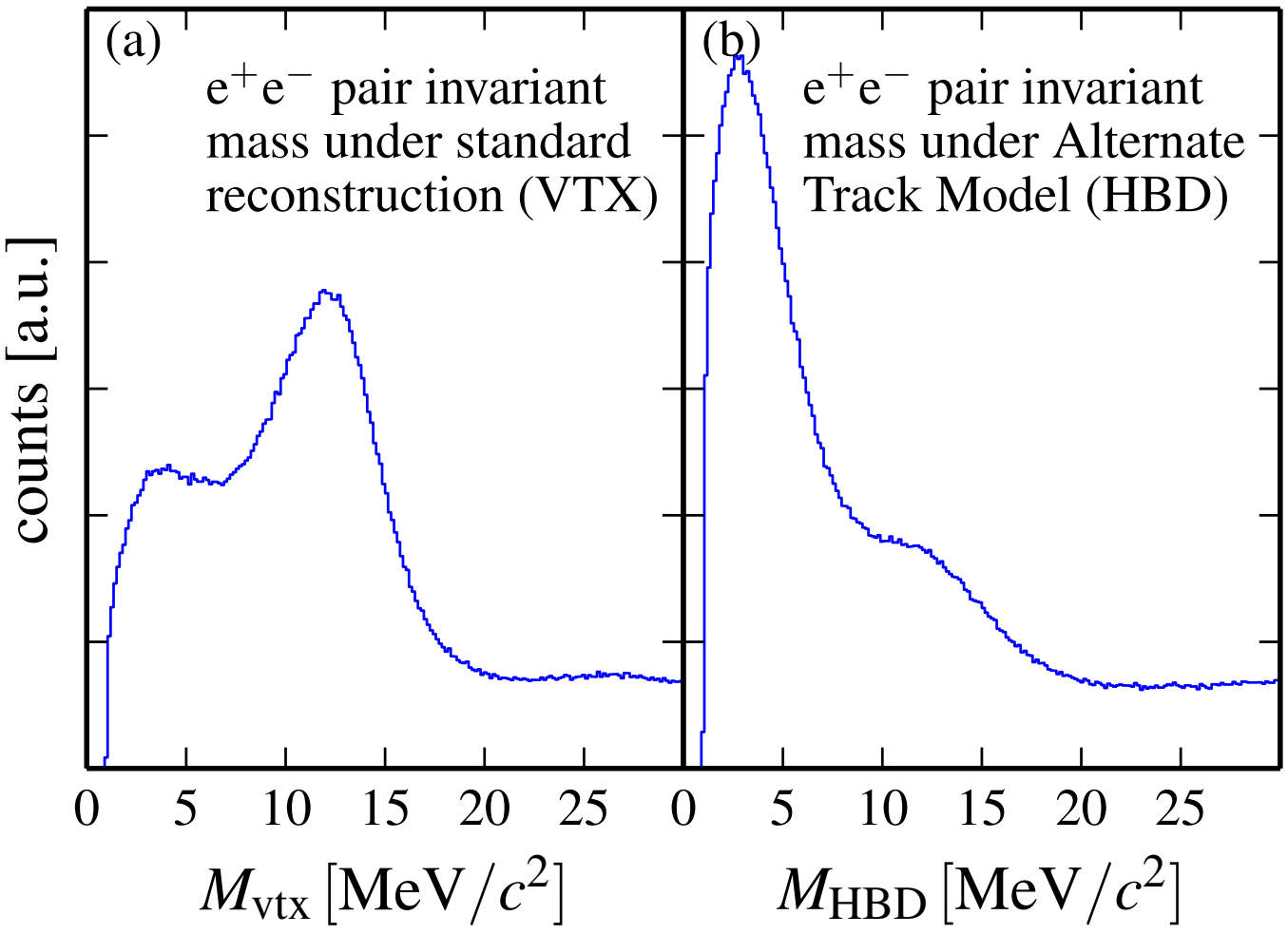


Figure 10: fig

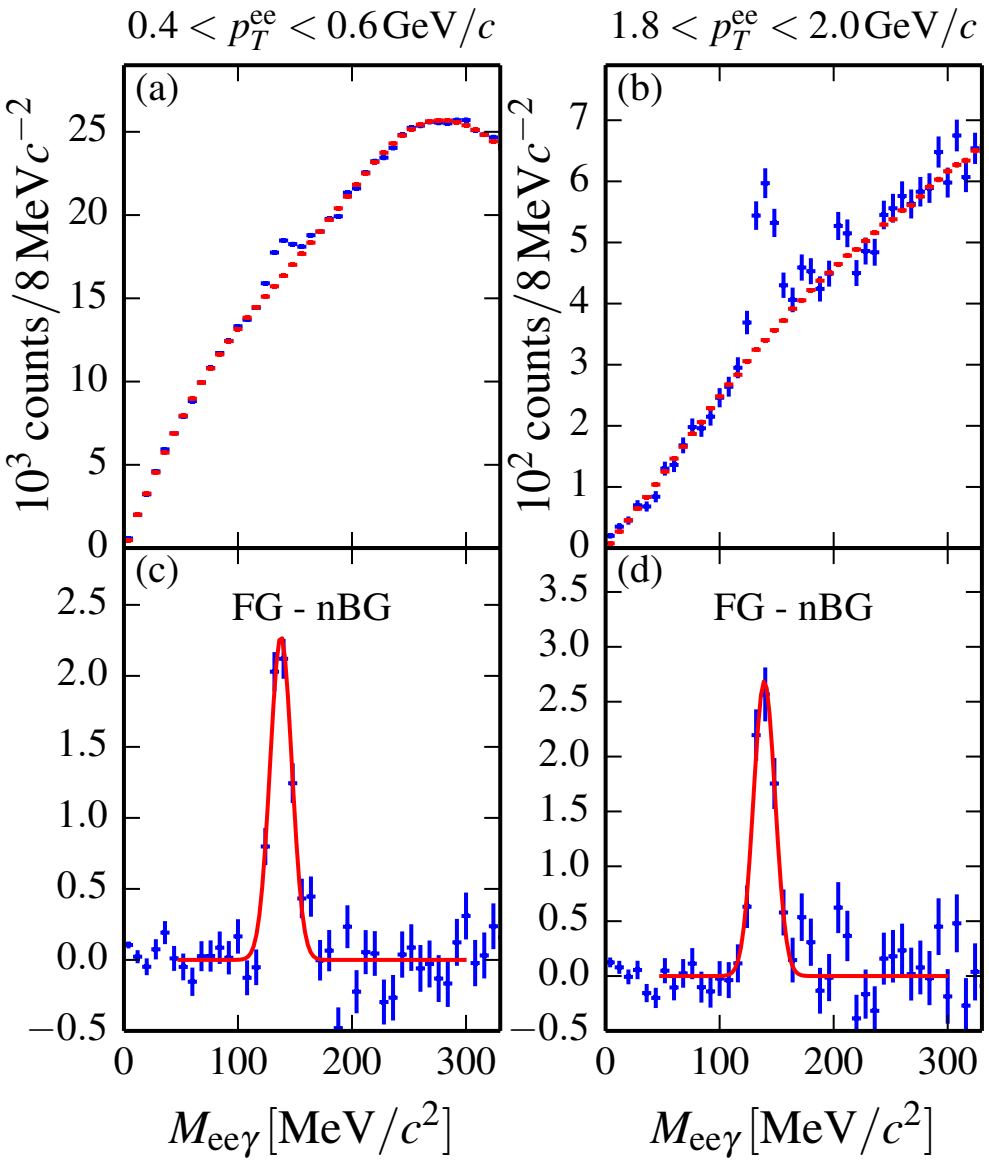


Figure 11: fig

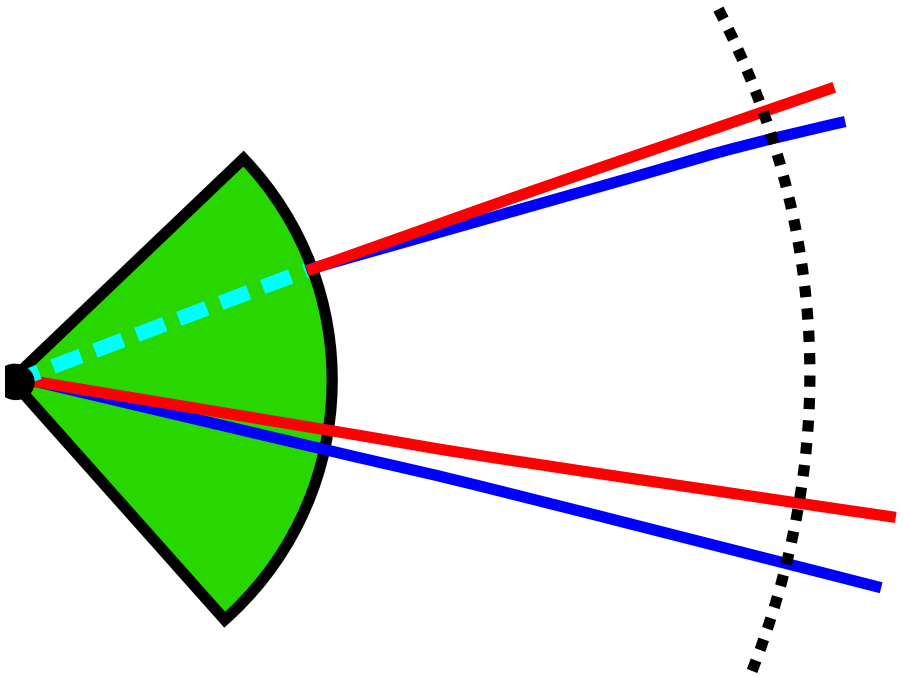


Figure 12: fig

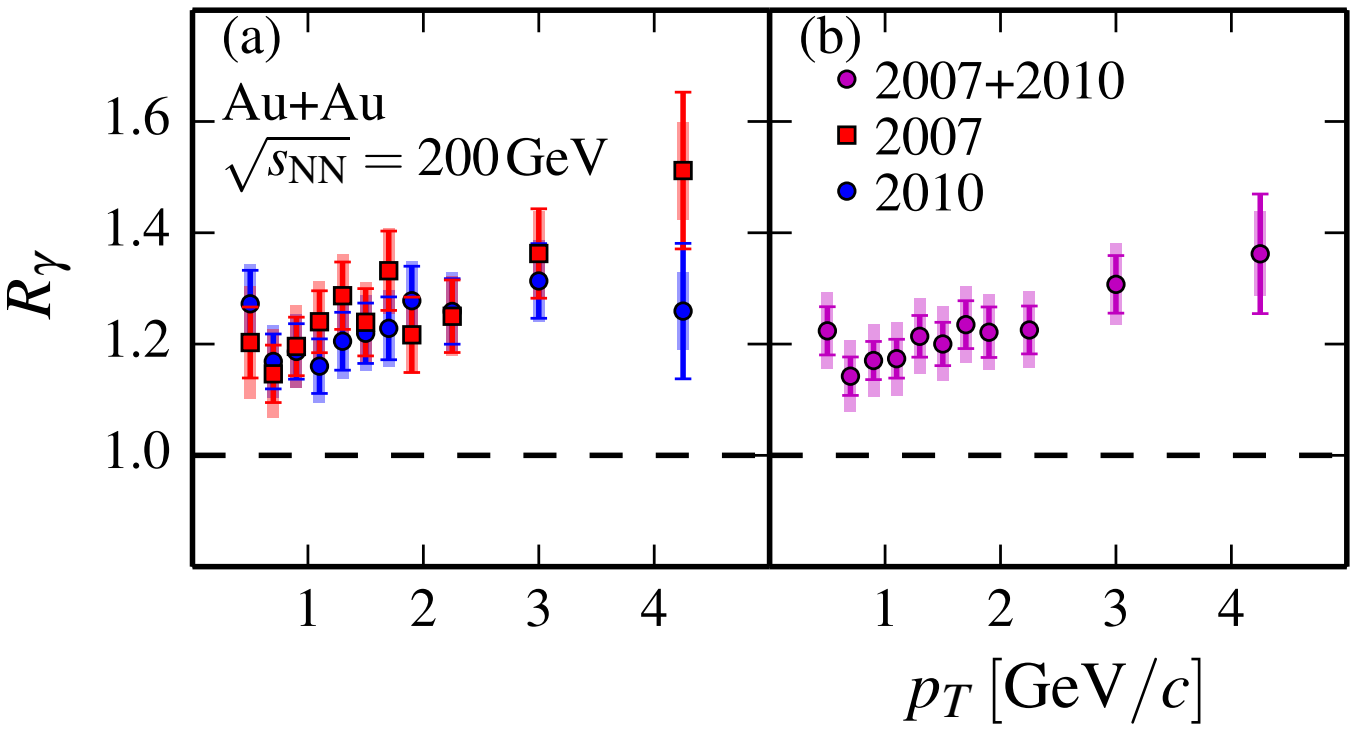


Figure 13: fig

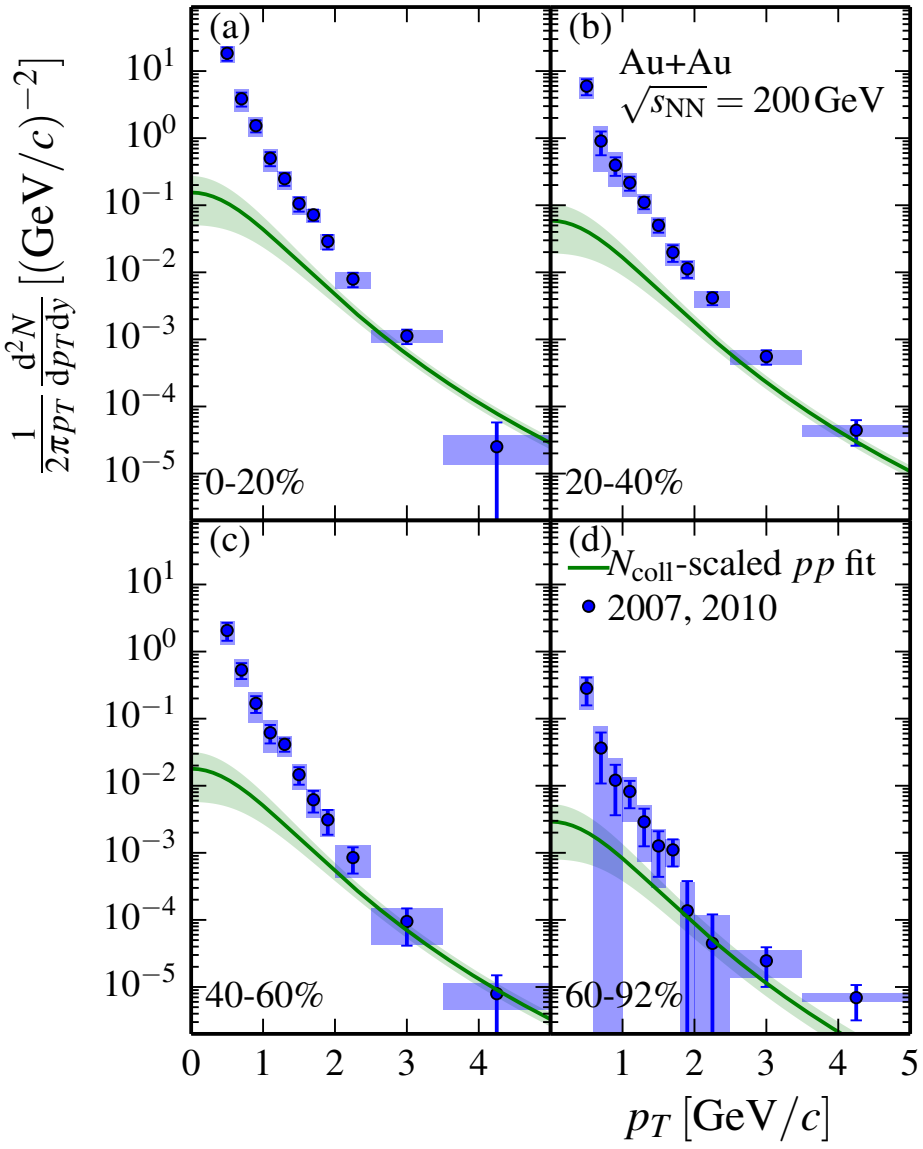


Figure 14: fig

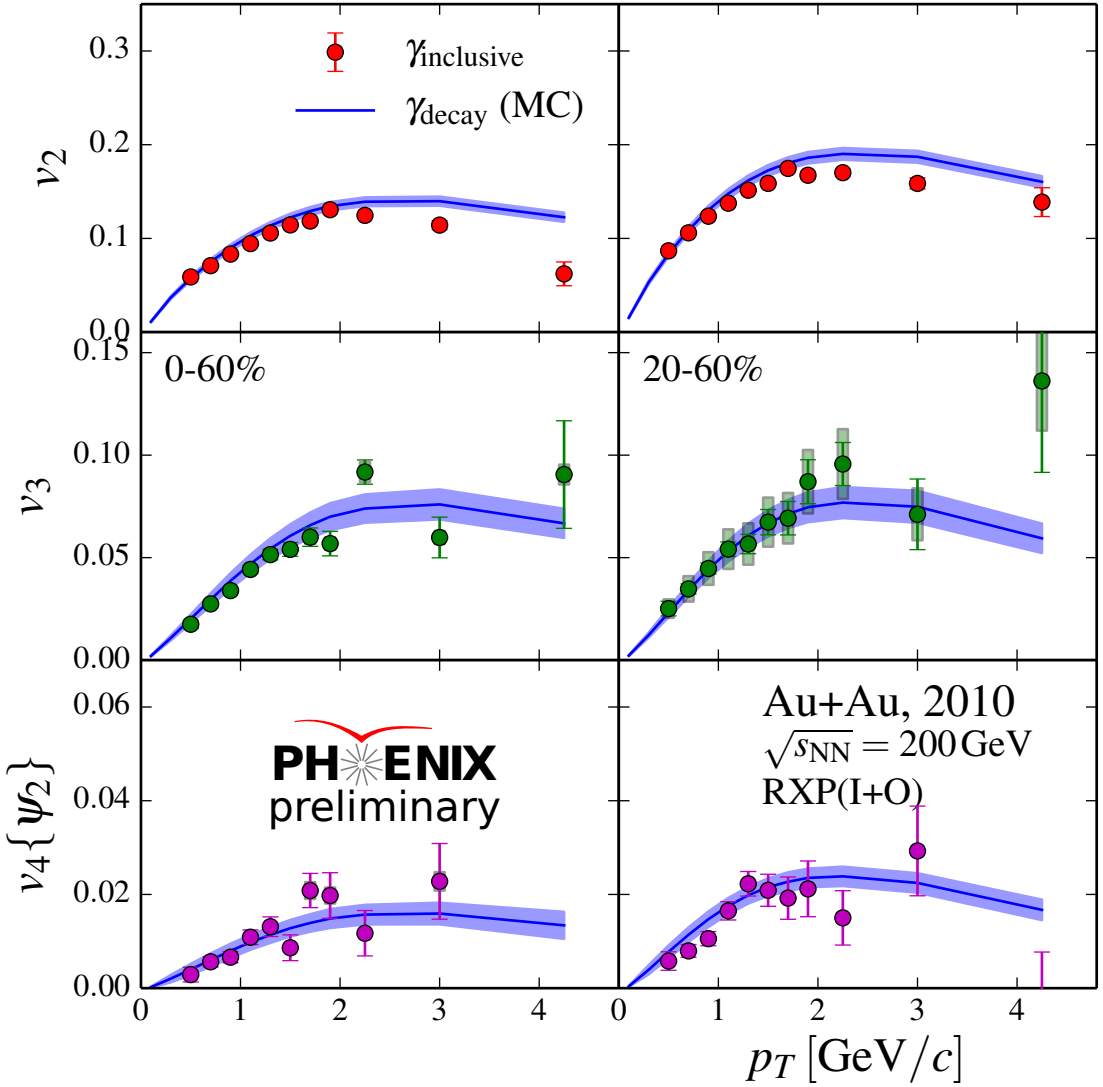


Figure 15: fig