INPC 2025

PHENIX

Recent Highlights From the PHENIX Experiment

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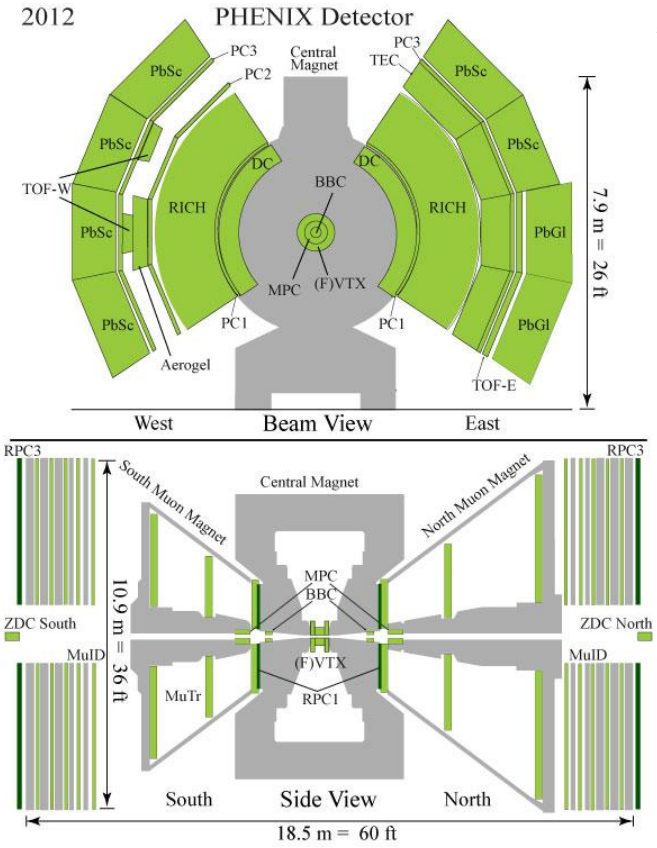
May 29, 2025

The 29th International Nuclear Physics Conference(INPC 2025)@ Daejeon, Korea

THE PHENIX EXPERIMENT

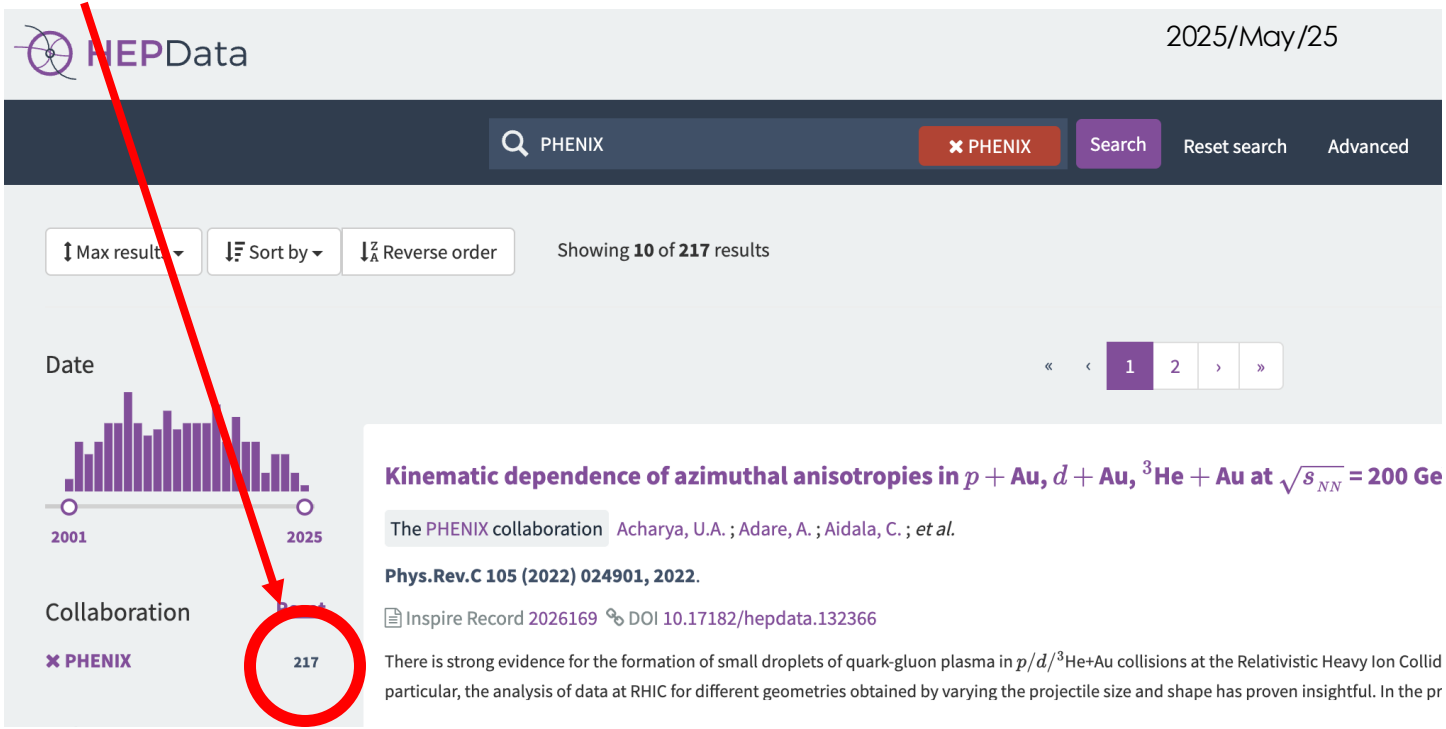
- PHENIX had been in operation for 16 years since 2000 at BNL-RHIC.
- Data with 9 collision species and 9 collision energies have been obtained.
- Data taking is completed in 2016
- Collaboration is actively working for data analysis.

$\sqrt{s_{NN}}$ [GeV]	p	Al	Au	Au	Au	Cu	Cu	Au	Au	U	U
510	✓										
200	✓	✓	✓	✓	✓	✓	✓	✓	✓		
130								✓			
62.4	✓			✓		✓		✓			
39				✓				✓			
27								✓			
20				✓		✓		✓			
14.5								✓			
7.7								✓			



PHENIX results are in HEPData!!

- 217 papers are in the database and ready to use!



PHENIX publications

- **225 physics papers published**
  - Phys. Rev. Lett. 77
  - Phys. Rev. C 95
  - Phys. Rev. D 47
  - Nature Physics 1
  - Phys. Letter B 4
  - Nucl. Phys. A 1
- **Total citation: ~37000**
- Topcite 1000+ 3
  - 500-1000 7
  - 250-500 24
  - 100-250 67
  - 50-100 45

PHENIX White Paper: 3797 cites

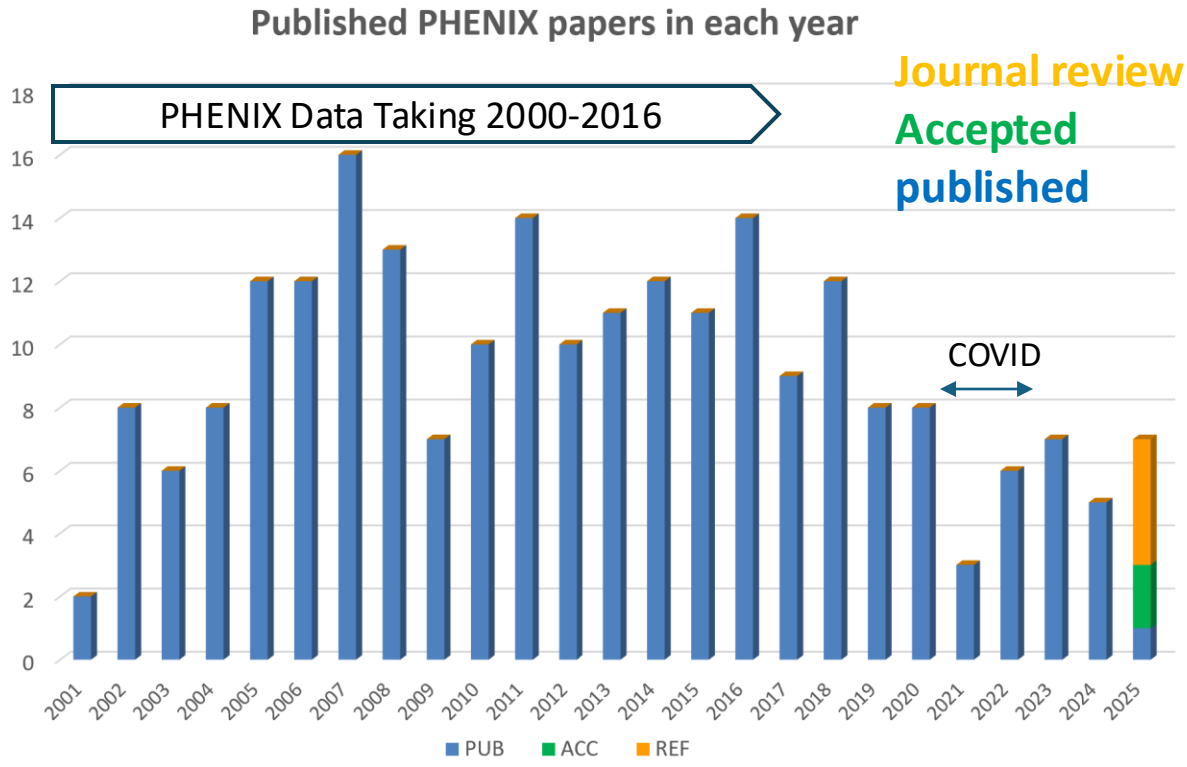
Jet quenching discovery: 1261 cites

PID hadron in AuAu: 1037 cites

Nature P paper: 345 citations

146 physics papers in topcite 50+

(167 if proceedings and detector papers are included)



Recent publications from PHENIX

[PRL 134, 022302 (2025)] Disentangling centrality bias and final-state effects in the production of high-p_T π^0 using direct γ in d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV

[PRC 109, 044912 (2024)] Nonprompt direct-photon production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV

[PRC 109, 054910 (2024)] Identified charged-hadron production in p+Al, 3He+Au, and Cu+Au collisions at $\sqrt{s_{NN}}$ = 200GeV and in U+U collisions at $\sqrt{s_{NN}}$ = 193GeV

[PRC 110, 044901 (2024)] Jet modification via at $\sqrt{s_{NN}}$ = 200 GeV π^0-hadron correlations in Au+Au collisions

[PRC 110, 064909 (2024)] Centrality dependence of Lévy-stable two-pion Bose-Einstein correlations in $\sqrt{s_{NN}}$ = 200 GeV Au+Au collisions

[PRC 109, 044907 (2024)] Charm- and bottom- quark production in AuAu collisions at $\sqrt{s_{NN}}$ = 200GeV

[PRC 107, 014907 (2023)] Measurement of ϕ-meson production in Cu+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV and U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV

PRC accepted ![arXiv:2409.12756] Measurement of J/ψ elliptic flow in $\sqrt{s_{NN}}$ = 200 GeV Au+Au collisions at forward rapidity

PRD accepted ![arXiv:2408.11144] Measurement of inclusive jet cross-section and substructure in $p + p$ collisions at $\sqrt{s_{NN}}$ = 200 GeV

[arXiv:2409.12715] Measurements at forward rapidity of elliptic flow of charged hadrons and open-heavy flavor muons in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV

[arXiv:2409.03728] Multiplicity dependent J/ψ and $\psi(2S)$ production at forward and backward rapidity in $p + p$ in collisions at $\sqrt{s_{NN}}$ = 200 GeV

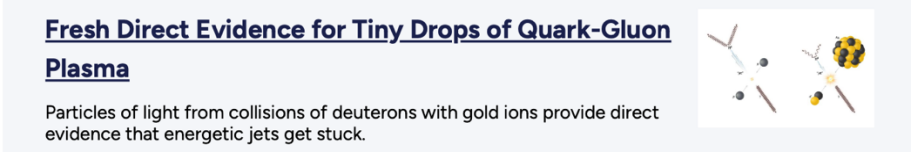
[arXiv:2504.02955] Azimuthal anisotropy of direct-photons in Au+Au collisions at sNN = 200GeV

DOE highlight and Editor's suggestion

DOE highlight!

[PRL 134, 022302 (2025)]

Disentangling centrality bias and final-state effects in the production of high-p_T π^0 using direct γ in d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV



Editor's suggestion!

[PRC 110, 064909 (2024)]

Centrality dependence of Lévy-stable two-pion Bose-Einstein correlations in $\sqrt{s_{NN}}$ = 200 GeV Au+Au collisions

Contents

(1)PID Charged hadron measurement at various collision systems

- π^0 R_{AA} with experimental N_{coll} at small system
- Centrality Dependence of Lévy-stable Two-Pion Correlations (HBT)

(2)Heavy flavor at mid and forward rapidity

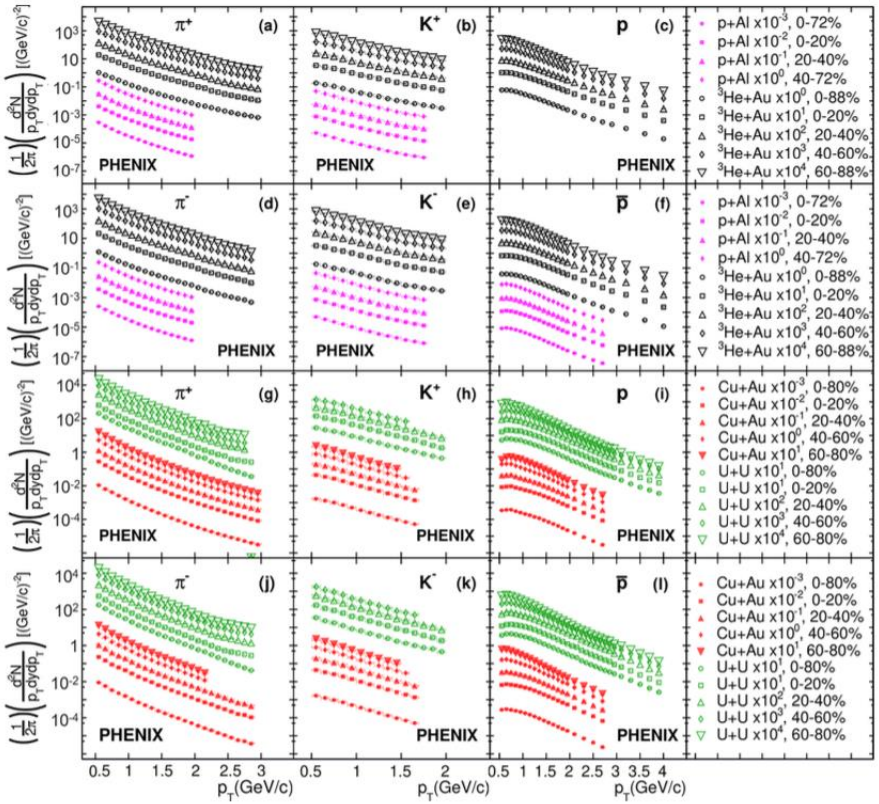
(3)Direct photon with large statistics

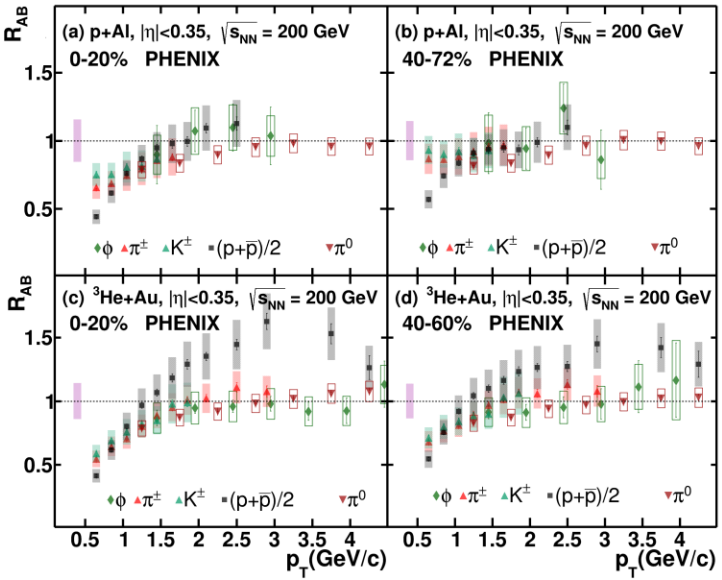
(1)PID Charged hadron measurement at various collision systems

PID Charged hadrons

PHENIX, PRC 107, 014907 (2023)

PHENIX, PRC 109, 054910 (2024)

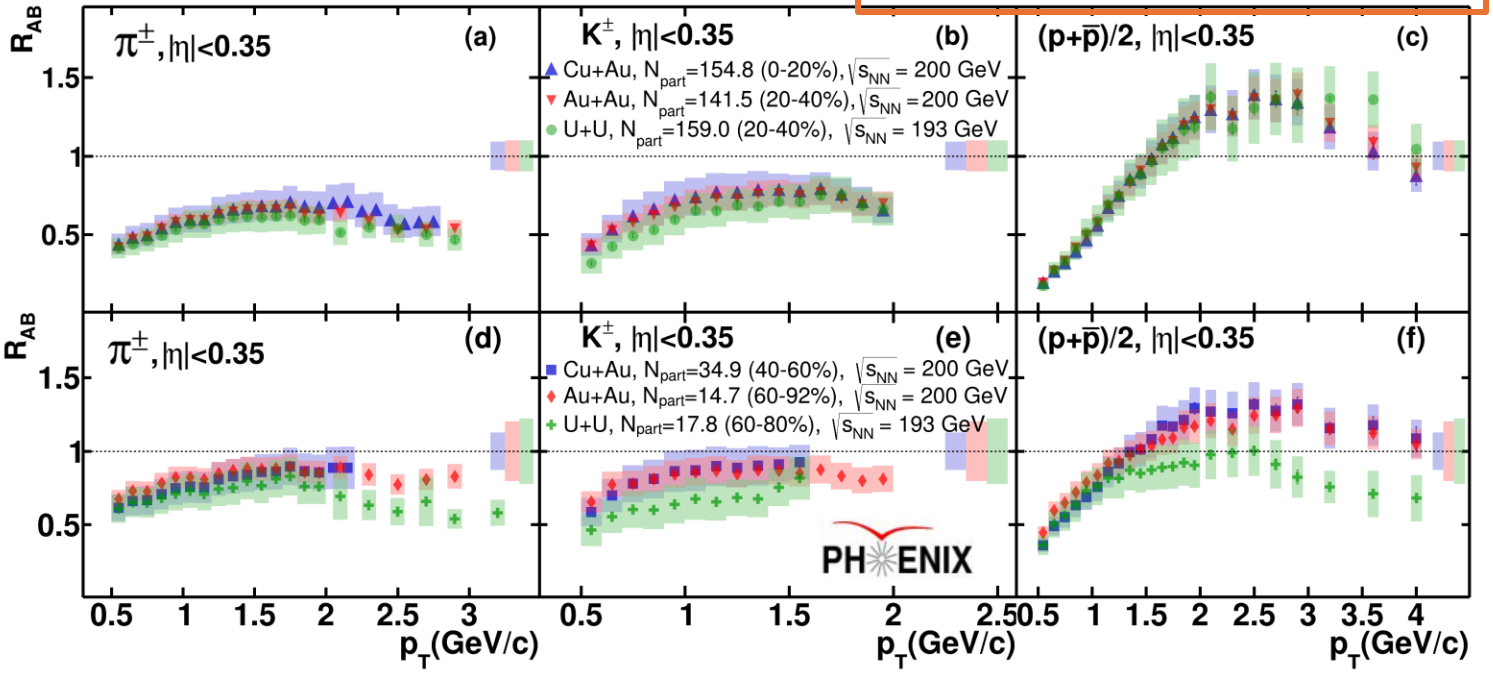




The systematic study of various collision systems are preformed.

R_{AB} in Large systems

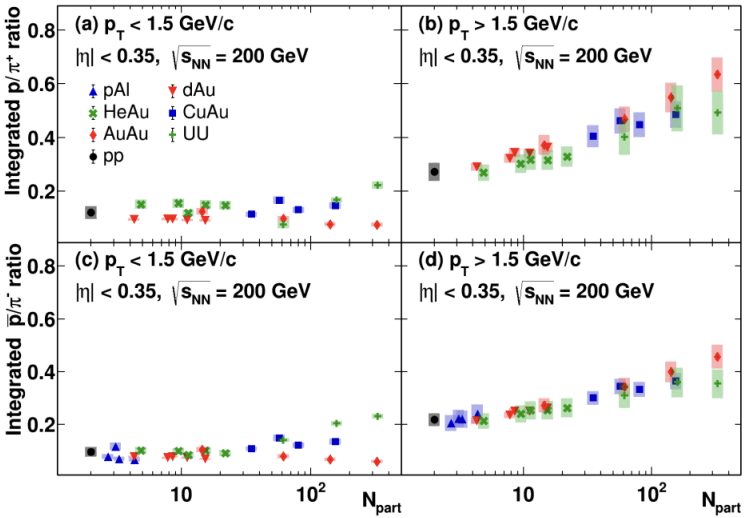
PHENIX, PRC 109, 054910 (2024)



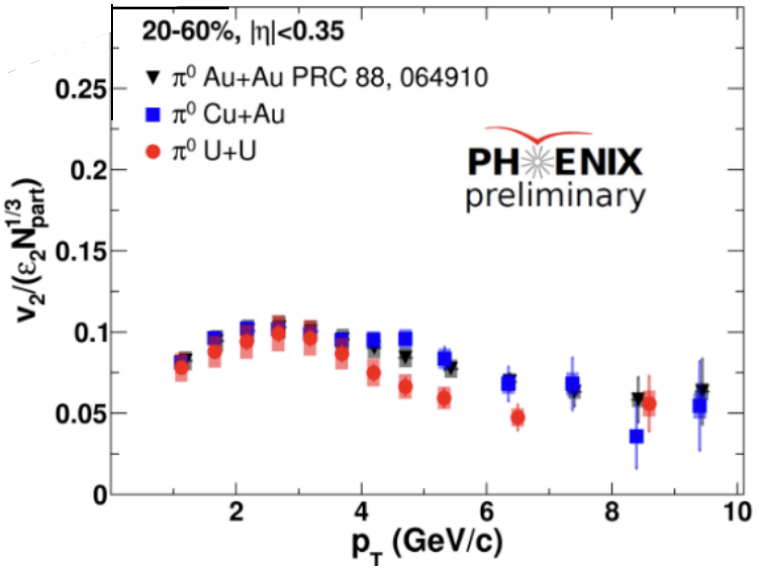
R_{AA} in large system depends on collision overlap size (N_{part}) but not collision systems

Flow measurements

Radial flow effect



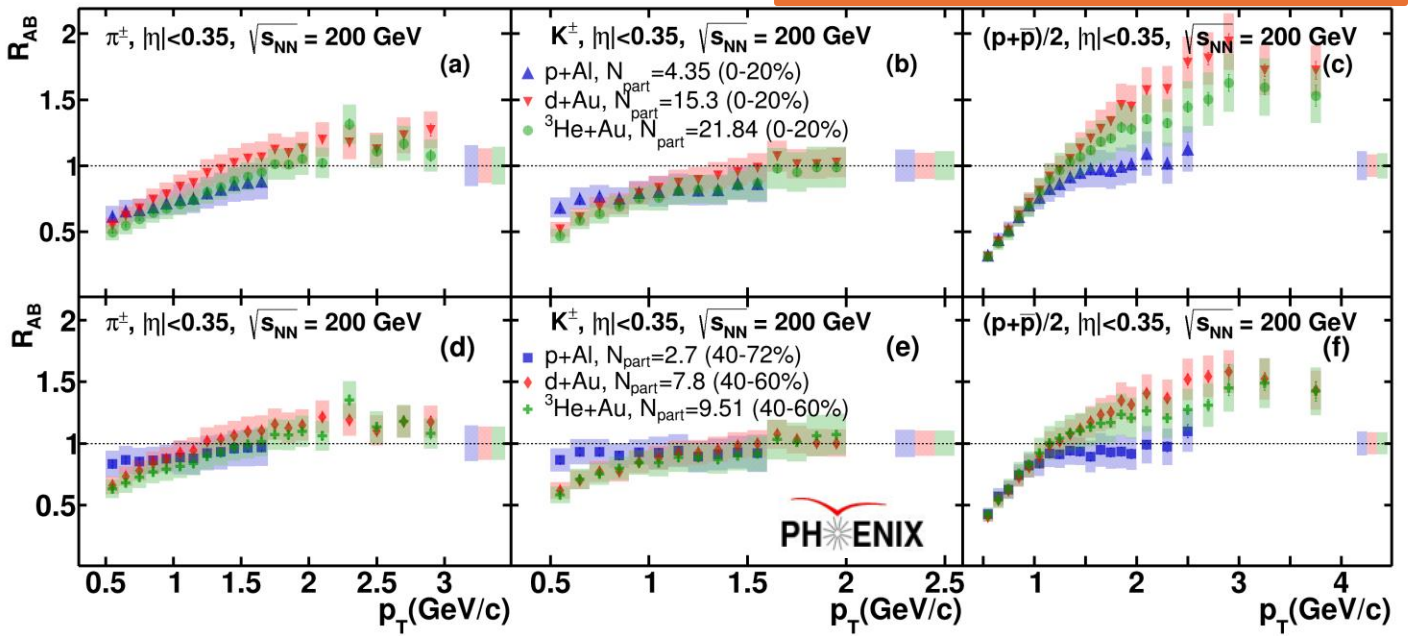
Elliptic flow



- **Baryon enhancement is stronger in larger system.**
- **v_2 is consistent with $N_{part}^{1/3}$ scaling.**

R_{AB} in small systems

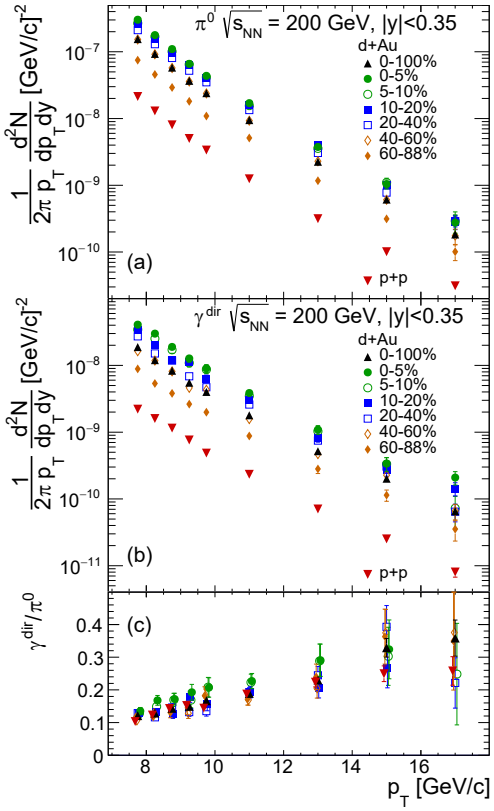
PHENIX, PRC 109, 054910 (2024)



- Small system also has dependence of the collision overlap size (N_{part})
- Proton R_{AB} at high p_T is not ordering of N_{part}
  - d+Au is imbalanced most

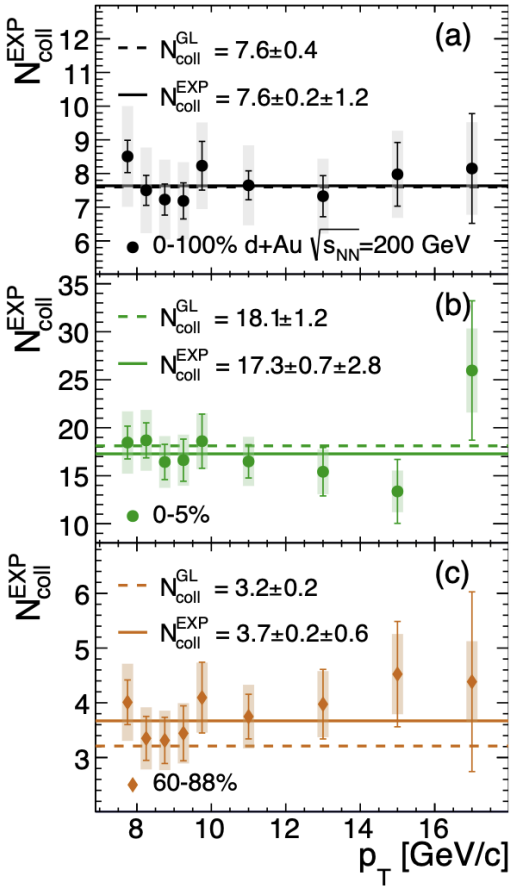
γ^{dir} and π^0 spectra in d+Au

PHENIX PRL 134, 022302 (2025)

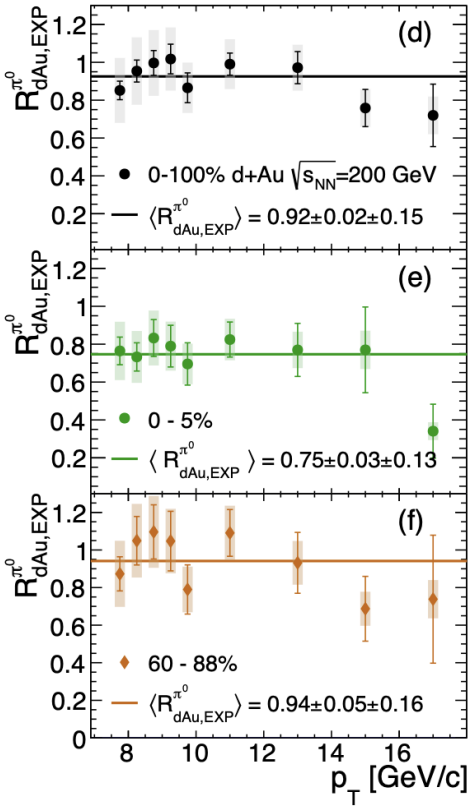


Since γ^{dir} is not suppressed, N_{coll} can be redefined by γ^{dir} ratio of d+Au to pp experimentally

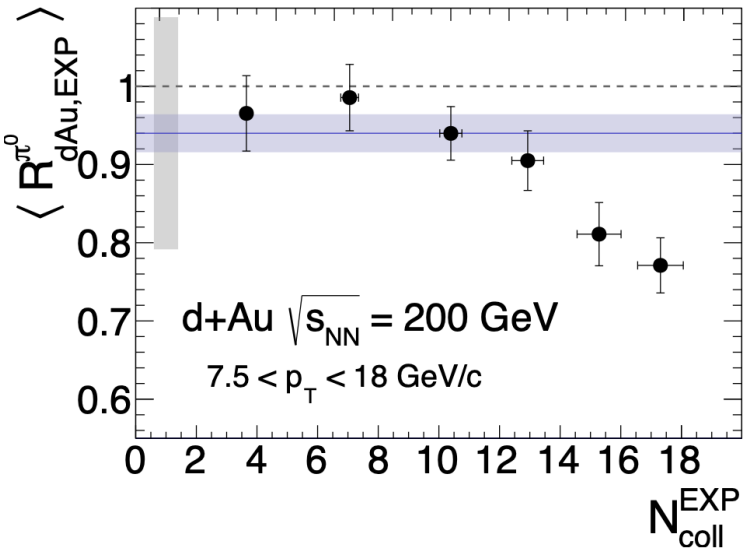
$$N_{\mathrm{coll}}^{\mathrm{EXP}}(p_T) = \frac{Y_{dAu}^{\gamma^{dir}}(p_T)}{Y_{pp}^{\gamma^{dir}}(p_T)}$$



Redefined R_{dAu} with experimental N_{coll}



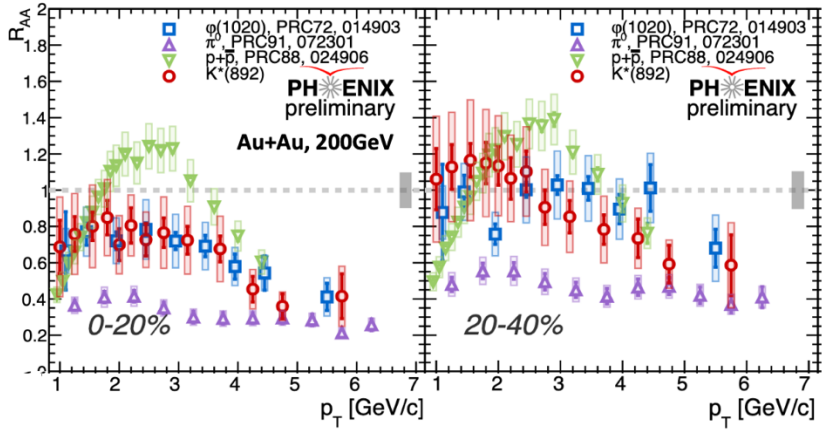
PHENIX PRL 134, 022302 (2025)

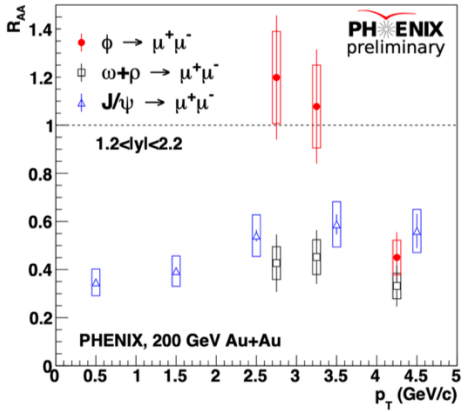


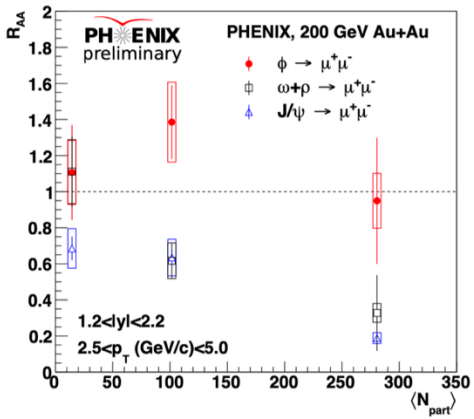
Clear suppression can be seen at central in d+Au while it's consistent to 1 at peripheral

Fresh direct evidence of **the tiny droplet QGP**

Strangeness enhancement







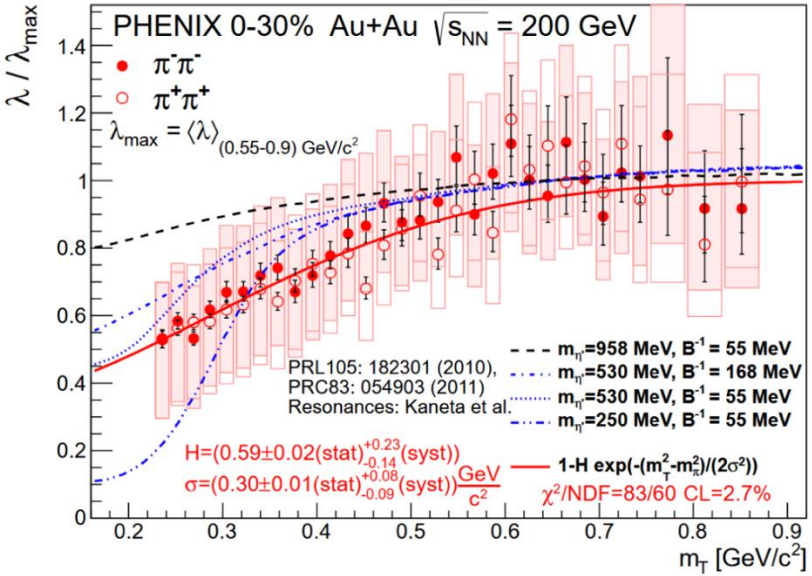
R_{AA} for ϕ is measured.

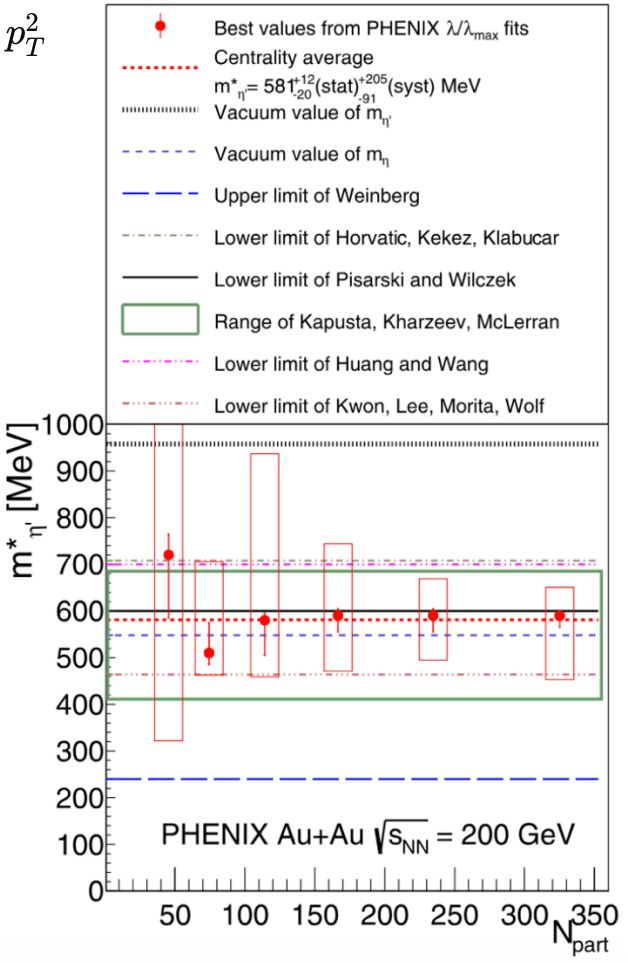
Evidence of strangeness enhancement at mid- and forward rapidity

Hint of U(1) transition

$$m_T = \sqrt{m^2 + p_T^2}$$

Phys. Rev. C 110, 064909 (2024)



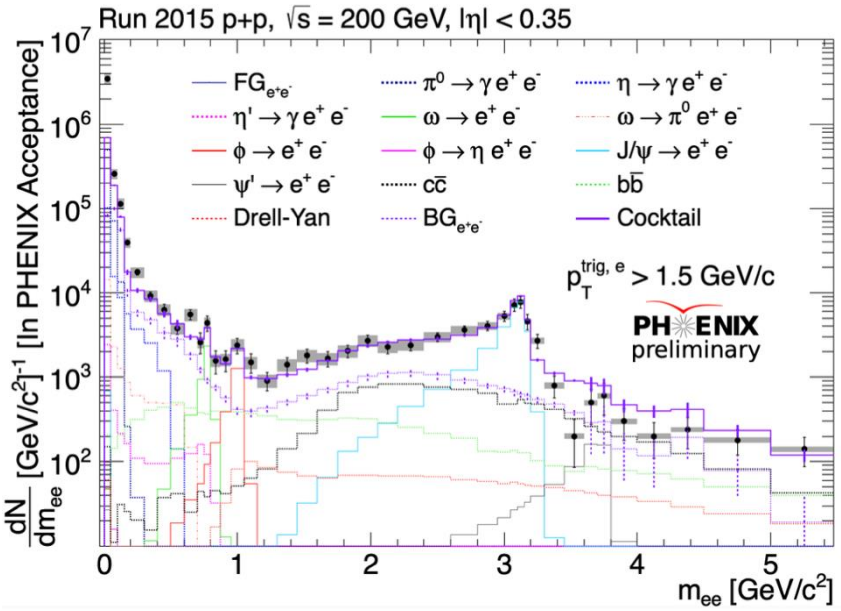


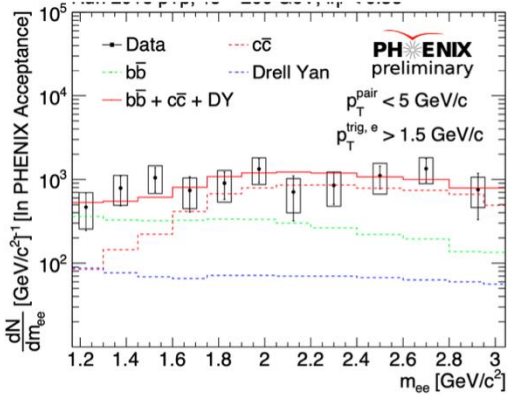
Levy HBT results are not inconsistent with theoretical models including in-medium mass modification of η'

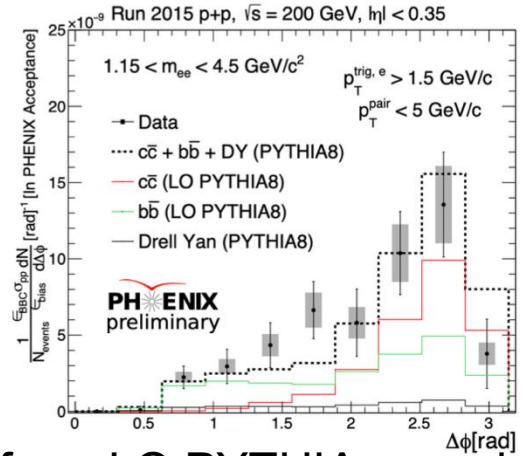
• It calls for direct measurement of η' mass

(2)Heavy flavor at mid and forward rapidity

Disentangling charm and bottom in p+p for dileptons

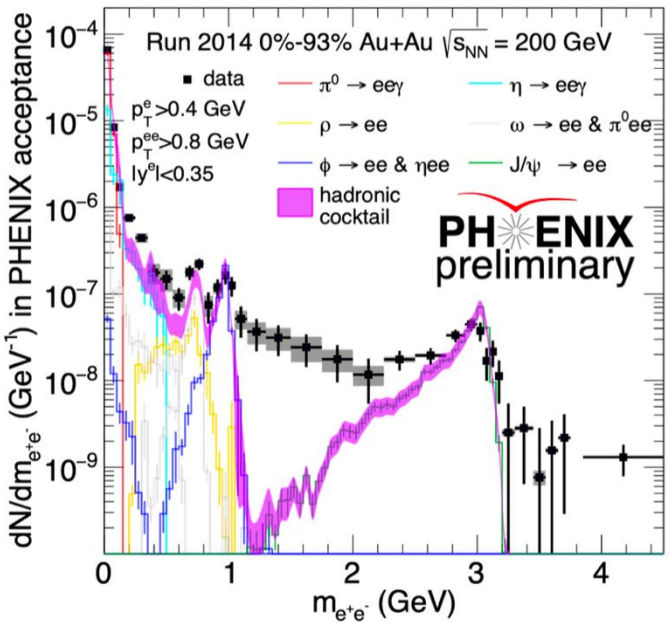


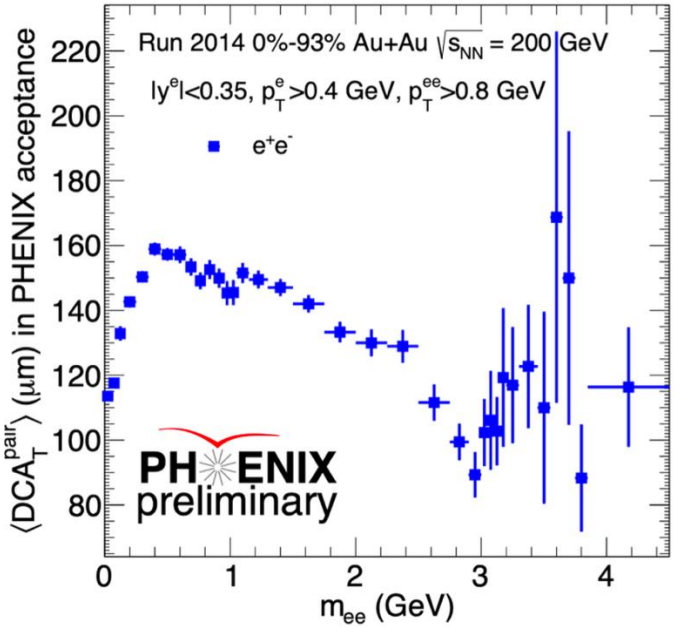




Heavy flavor and Drell-Yan contributions obtained from LO PYTHIA reproduce the data reasonably well

Separating contributions by DCA in dileptons



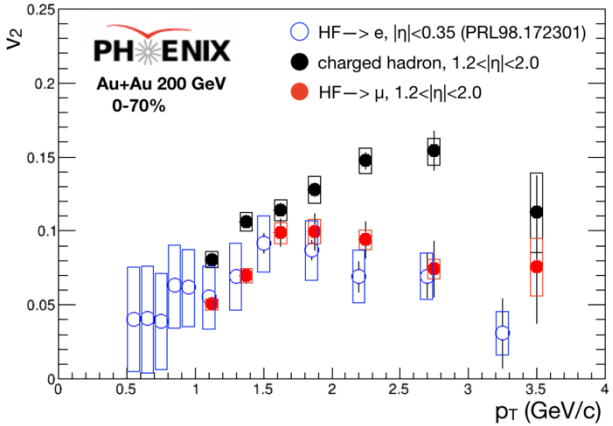


Disentangle the heavy flavor and thermal contribution using the DCA technique in the intermediate mass region

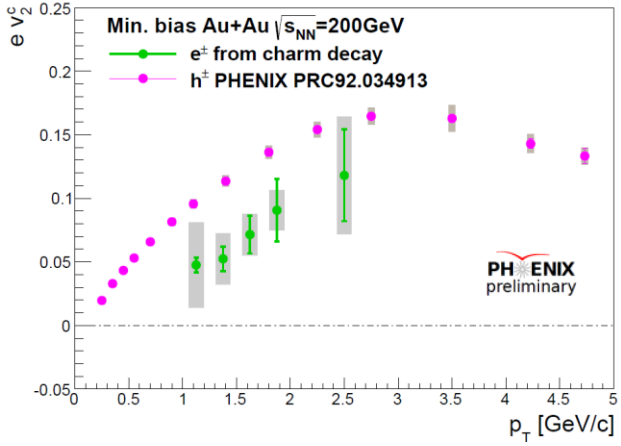
HF v_2 in Au+Au

Forward rapidity

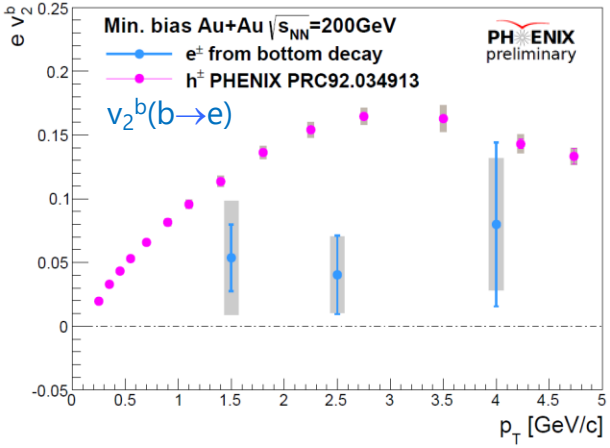
[arXiv:2409.12715]



Mid rapidity



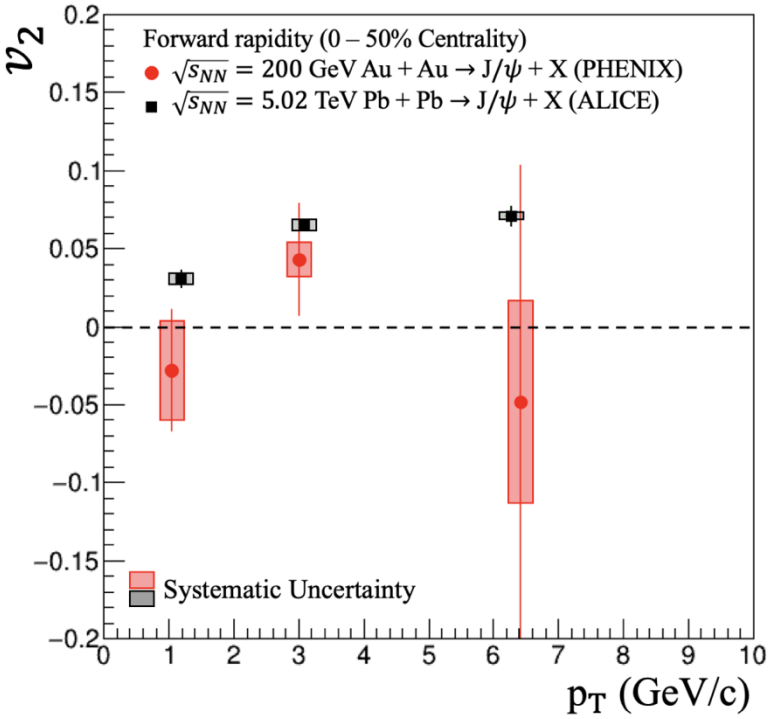
Mid rapidity



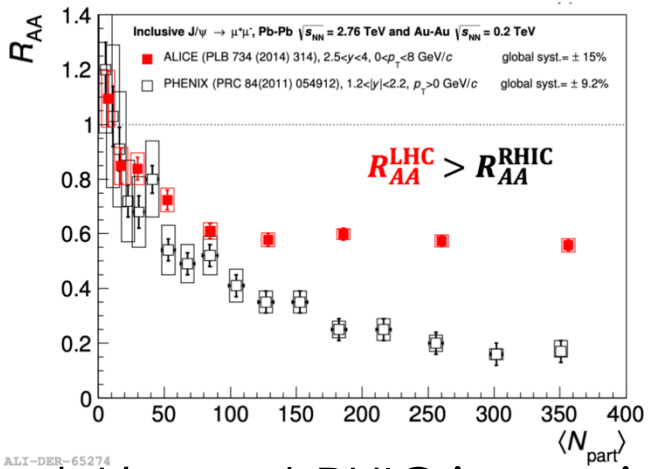
- HF v_2 is positive both at forward and mid rapidity and mostly consistent
- Hadron v_2 > HF v_2 and v_{2c} > v_{2b},
- Heavier quarks has less flow as expected

Forward J/ψ v_2 compared with LHC

[arXiv:2504.02955]



PHENIX, PRC 84, 054912 (2011)



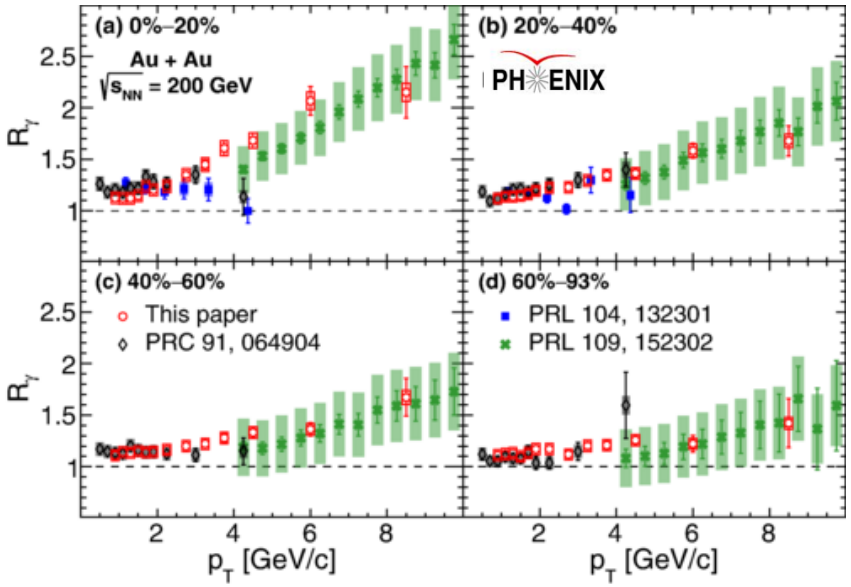
- Forward J/ψ v_2 at RHIC is consistent with zero, while it's non-zero at LHC energy

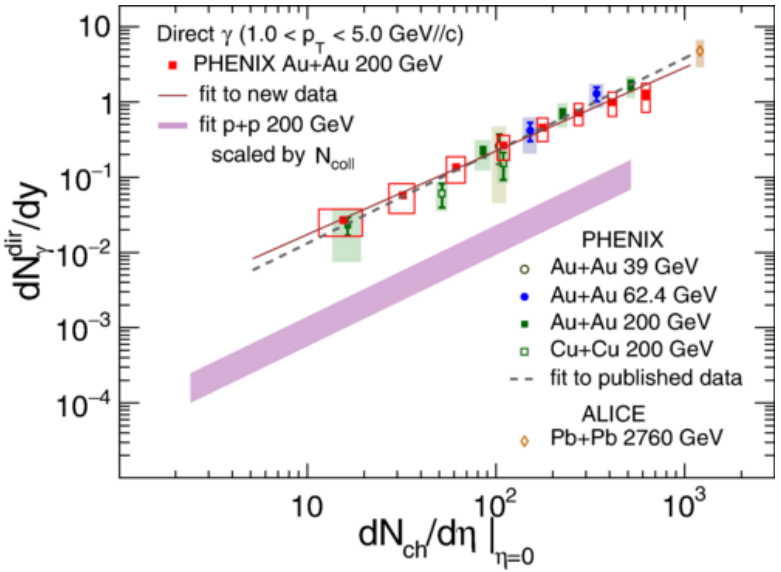
-> Consistent to the regeneration scenario of charm and anti-charm at LHC energy

(3)Direct photons

Direct photon in Au+Au

PHENIX, PRC 109, 044912 (2024)



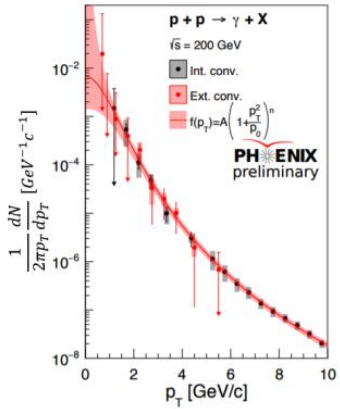


- External conversion method and large statistics give precise measurement for wider p_T ranges for all centrality bins
  - The scaling of yields holds for various large systems

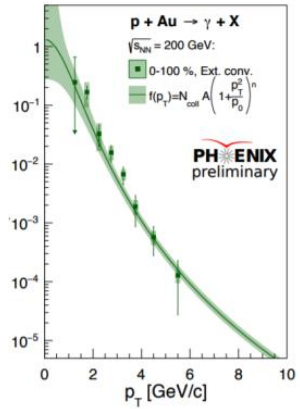
Direct photon enhancement with system size

PHENIX, PRC 109, 044912 (2024)

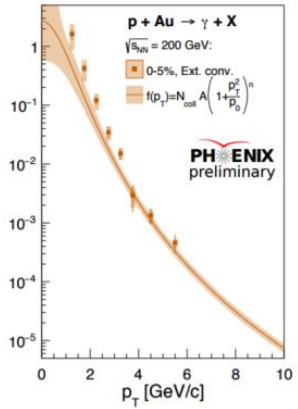
pp



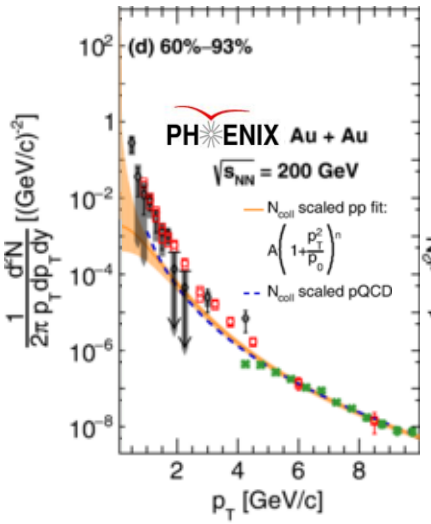
pAu



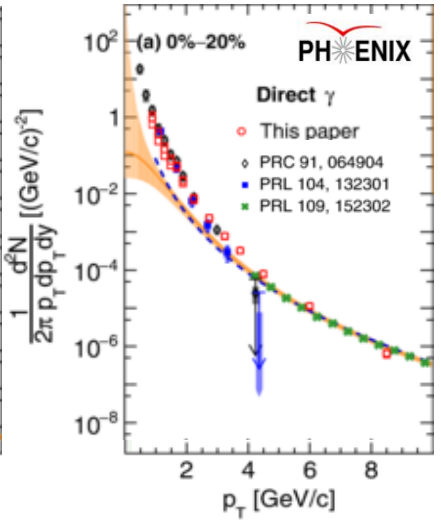
pAu 0-5%



AuAu 60-93%



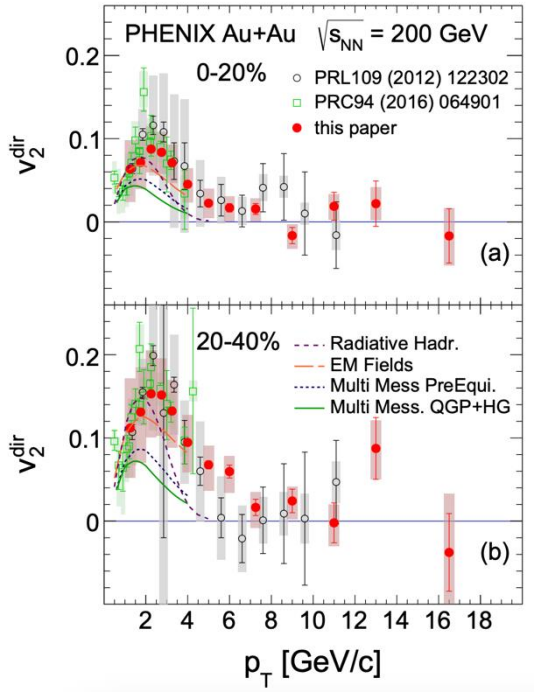
AuAu 0-20%



- Larger system has more enhancement at low p_T compared with N_{coll} scaled pp
  → seems to relate to QGP size ?

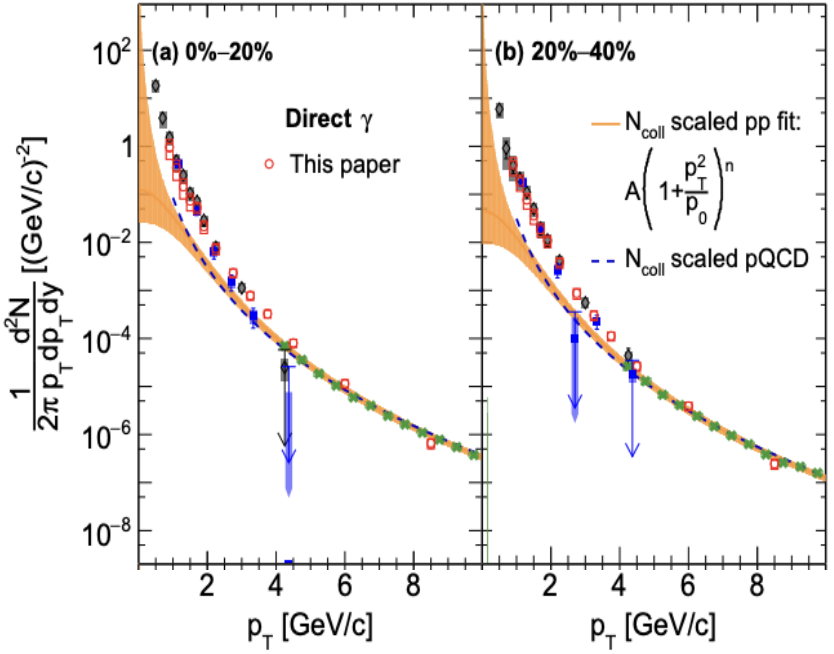
Direct photon v_2

[arXiv:2504.02955]



Low p_T v_2 is large as hadrons.
High p_T is consistent with zero.

PHENIX, PRC 109, 044912 (2024)



Yield enhancement and large v_2 at low p_T
→might be due to hadronization photons ??

Summary

- Charged hadrons
  - PHENIX measured charged hadron production at small to large various collision systems and found mostly R_{AA} only depends on overlap volume(N_{part}).
  - Experimental N_{coll} methods shows the direct evidence of **the tiny droplet QGP.**
  - Strangeness enhancement is observed at mid- and forward rapidity.
  - Levy HBT results are not inconsistent with theoretical models including in-medium mass modification of η'
- Heavy flavor
  - c/b separated HF v_2 are successfully measured.
  - Heavy flavor and Drell-Yan contributions obtained from LO PYTHIA reproduce the data reasonably well
  - Disentangle the heavy flavor and thermal contribution using the DCA technique in the intermediate mass region
  - Excellent agreement with FONLL+CEM predictions over a wide rapidity range.
  - Heavier quarks has less flow as expected
  - Measurement of the forward J/ψ v_2 are performed and it's consistent to zero unlike LHC result.
- Direct photons
  - External conversion method and large statistics give precise measurement for wide p_T ranges and all centrality bins, and the scaling of yields holds for various large systems.
  - Non-prompt direct photon are extracted and show the T_{eff} has the dependences of the p_T
  - Low p_T v_2 is large as hadrons while high p_T v_2 is consistent with zero.

PHENIX is active. New results are coming. Stay tune!