XXIV QUARK MATTER
DARMSTADT 2014

PHENIX Overview

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For the PHENIX Collaboration

PHENIX

Outline

We hope you have gone to all PHENIX parallel talks and visited our great posters.

This talk is to highlight for you our new results and encourage you to go and find our analyzers to ask all the detailed questions.

Here we focus on just a few themes:

- Electromagnetic Probes

- Small Systems ⇒ Small QGP?

- Heavy Quarks and Quarkonia

- Event Engineering and Correlations

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- Electromagnetic Probes

- Small Systems ⇒ Small QGP?

"Challenges, Opportunities"
– Frank Wilczek, Monday

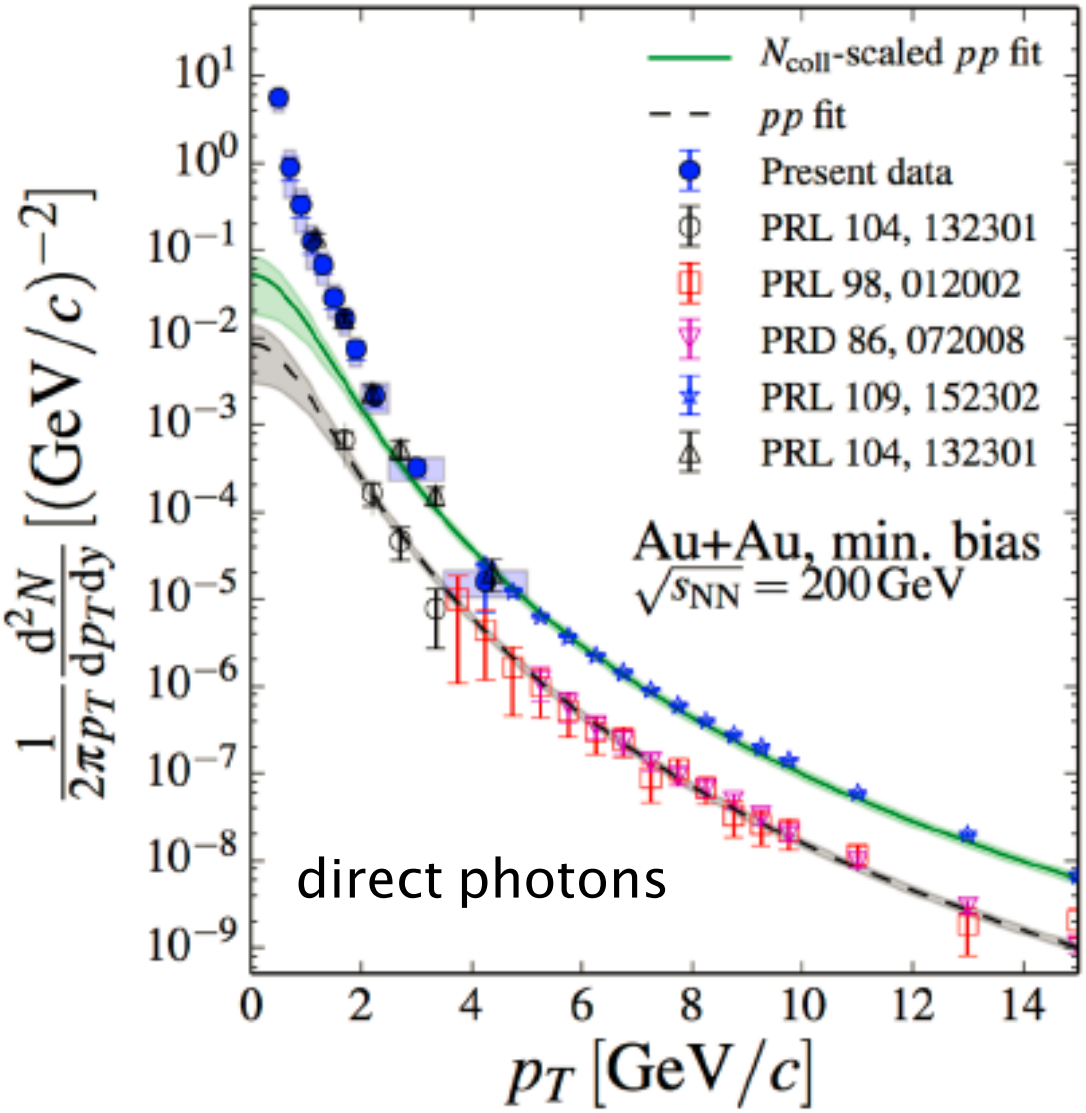
- Heavy Quarks and Quarkonia

- Event Engineering and Correlations

Electromagnetic Probes

Au+Au @ 200 GeV: Real and Virtual Photons

arXiv:1405.3940



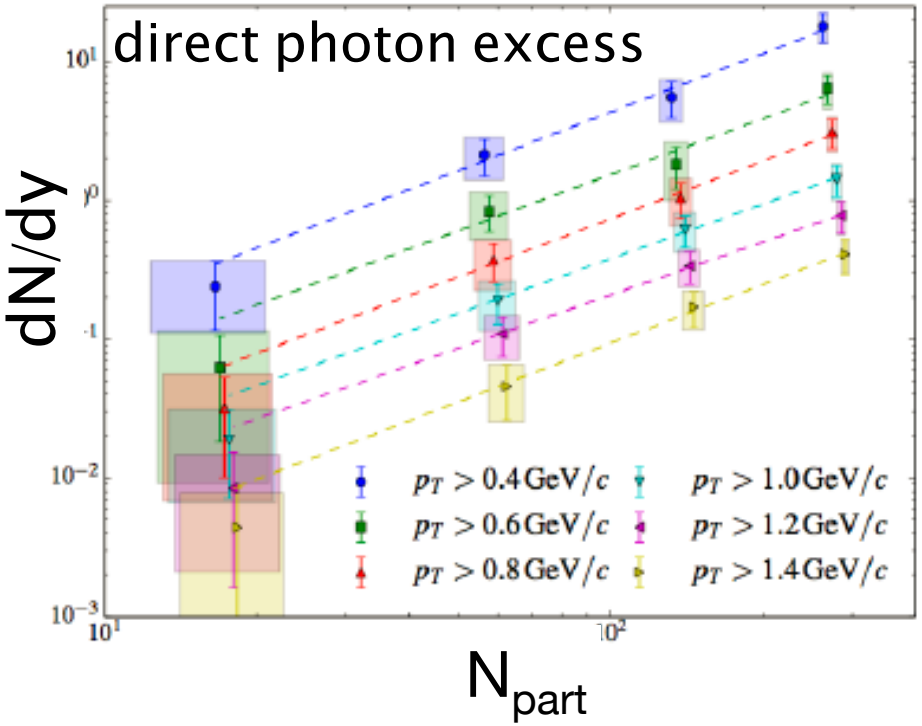
New analysis using external conversion of real photons

Agreement with virtual photon method publication (earlier discovery of thermal photon radiation)

Extended p_T range, centrality, precision

Au+Au @ 200 GeV: Real Photons

arXiv:1405.3940



Strong new constraint on hydrodynamic time evolution and modeling of radiation emission

Integrated excess photon yields scale as

$$\textbf{Yield} = A\, N_{part}^{\alpha}$$

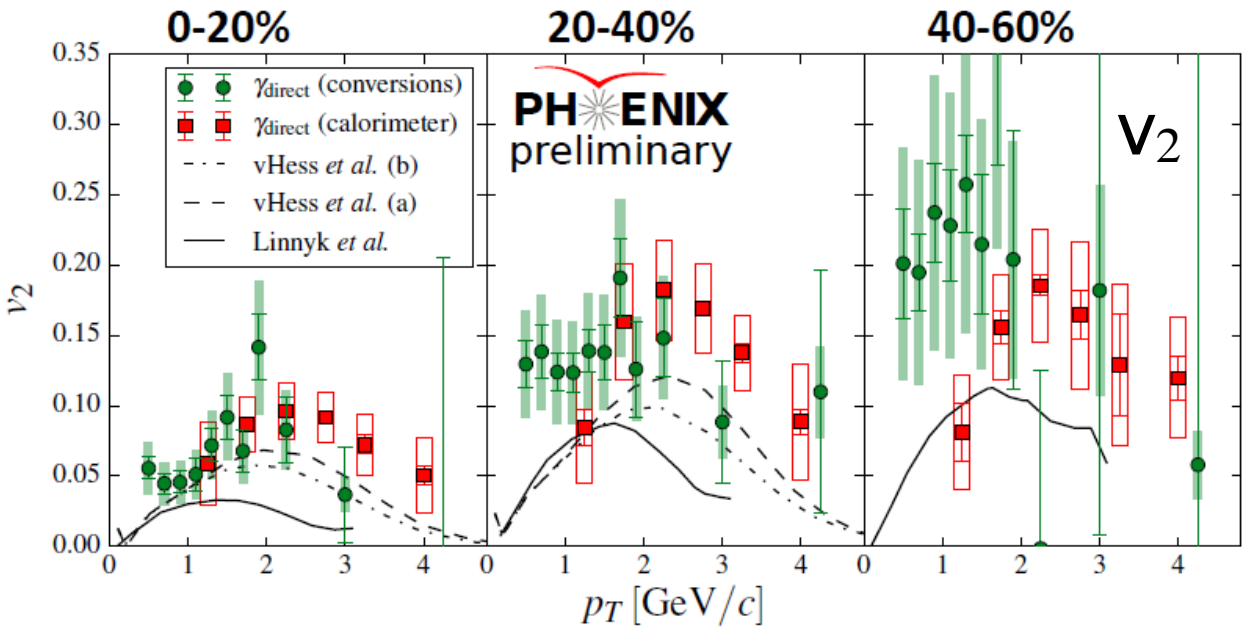
$\alpha = 1.48 \pm 0.08\ (stat) \pm 0.04\ (sys)$

Exponential slopes of photon excess are centrality independent within uncertainties

$$\textbf{Yield} = B \exp(-p_T/T)$$

T (0-20%) = 239 ± 25 ± 7 MeV
T (20-40%) = 260 ± 33 ± 8 MeV
T (40-60%) = 225 ± 28 ± 6 MeV
T (60-92%) = 238 ± 50 ± 6 MeV

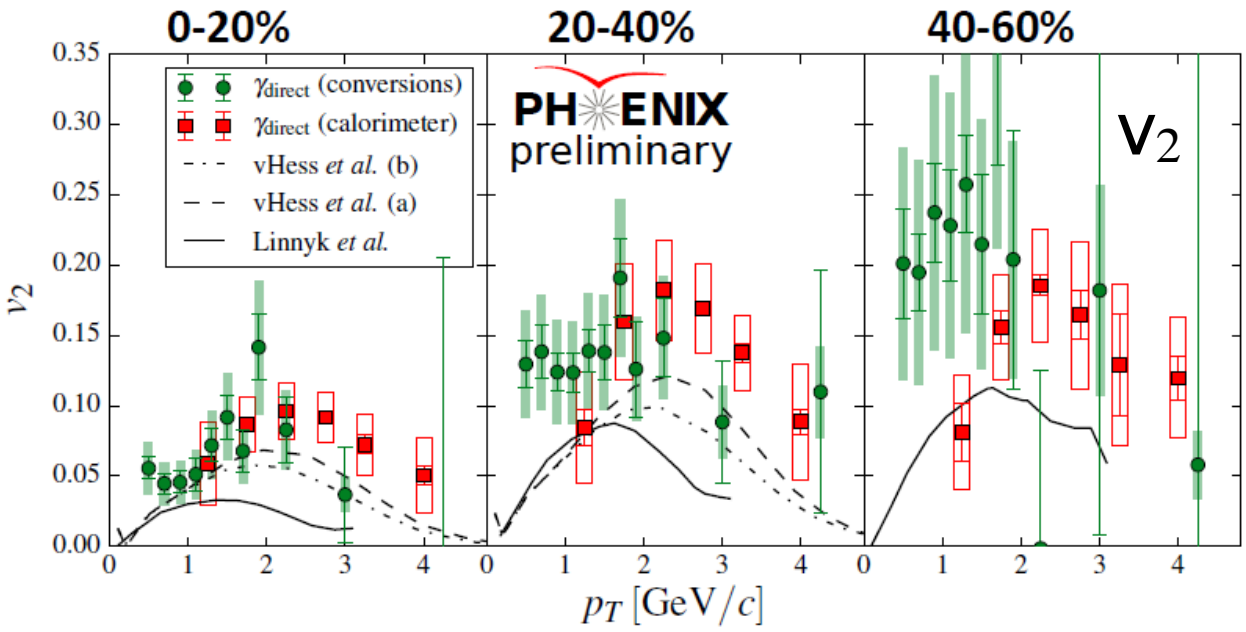
Au+Au @ 200 GeV: Real Photon Anisotropy

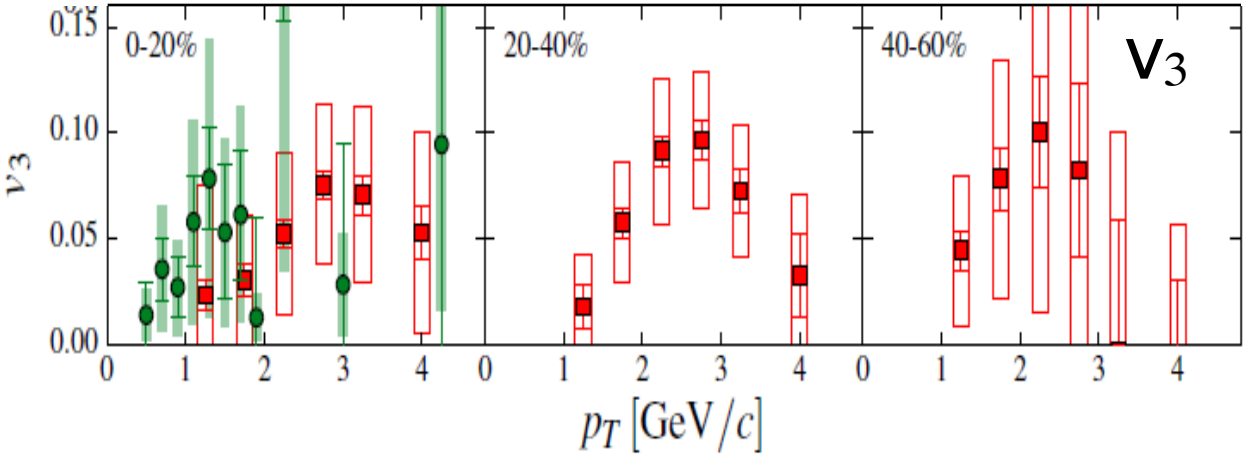


Two new methods to measure direct photon $\mathbf{v_2}$

Challenge for dynamical models

Au+Au @ 200 GeV: Real Photon Anisotropy





Two new methods to measure direct photon **v_2**

Challenge for dynamical models

Now also direct photon **v_3** !

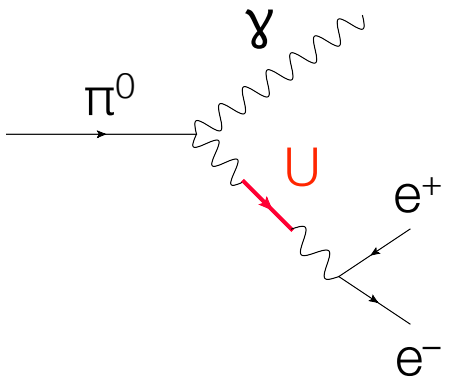
Super challenge for dynamical models

Virtual, Real, and now Dark Photons

Muon g-2 experiment has 3.6σ result beyond the Standard Model calculation.

One option is dark photon – low mass, very weak coupling.

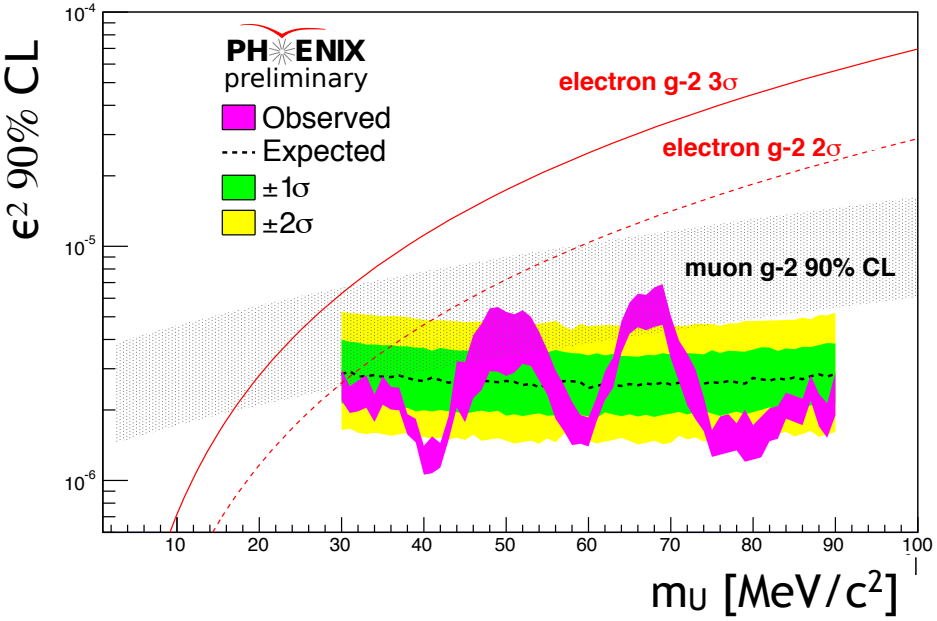
Many searches via fluctuation of virtual to dark photon



PHENIX has excellent capabilities to look for dark photons

No dark photon signal is seen.

Our upper limit, plus others (including recent HADES result) nearly rules out dark photons

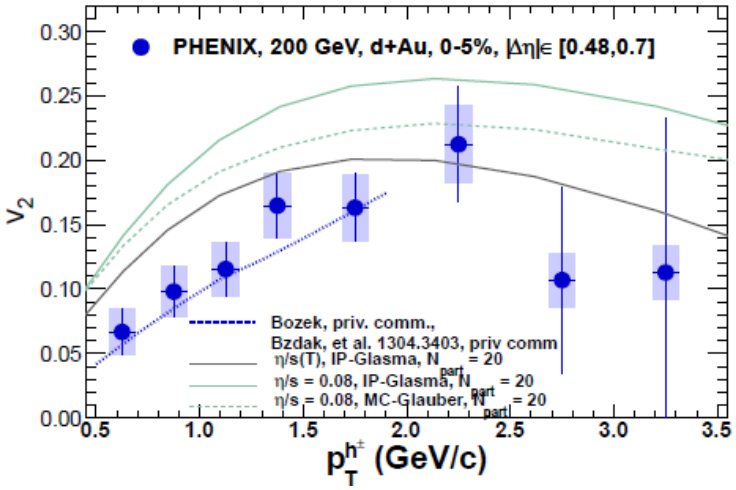


Small Systems ⇒ Small QGP?

d+Au @ 200 GeV: Long Range Correlations

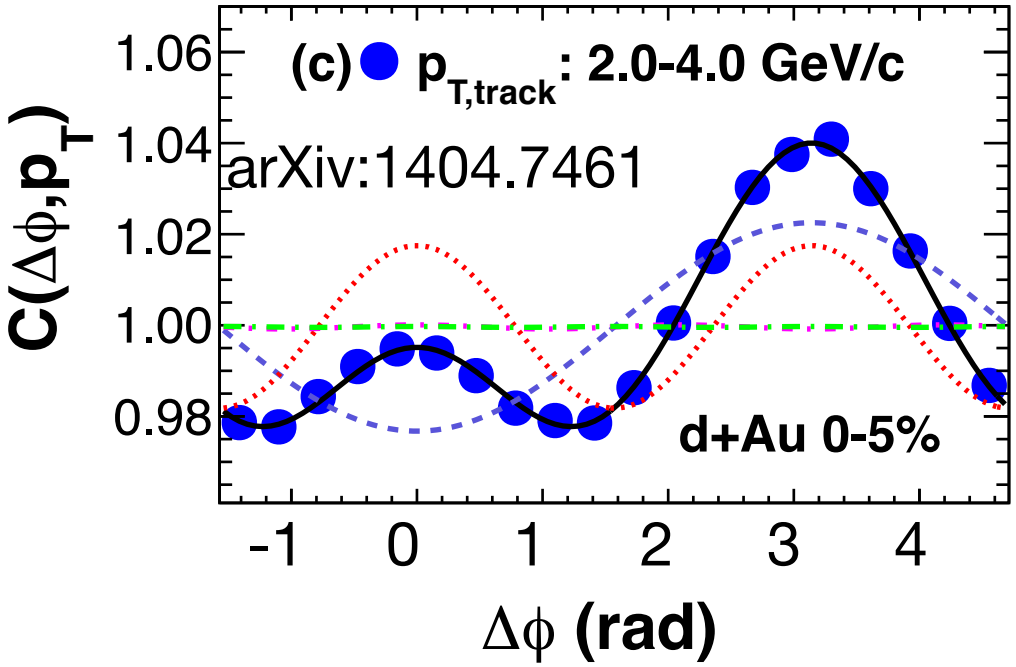
PRL111, 212301 (2013)

First PHENIX d+Au result was analyzed with small $\Delta\eta$ gap = 0.47 – 0.7



$-0.35 < \eta_{track} < 0.35$

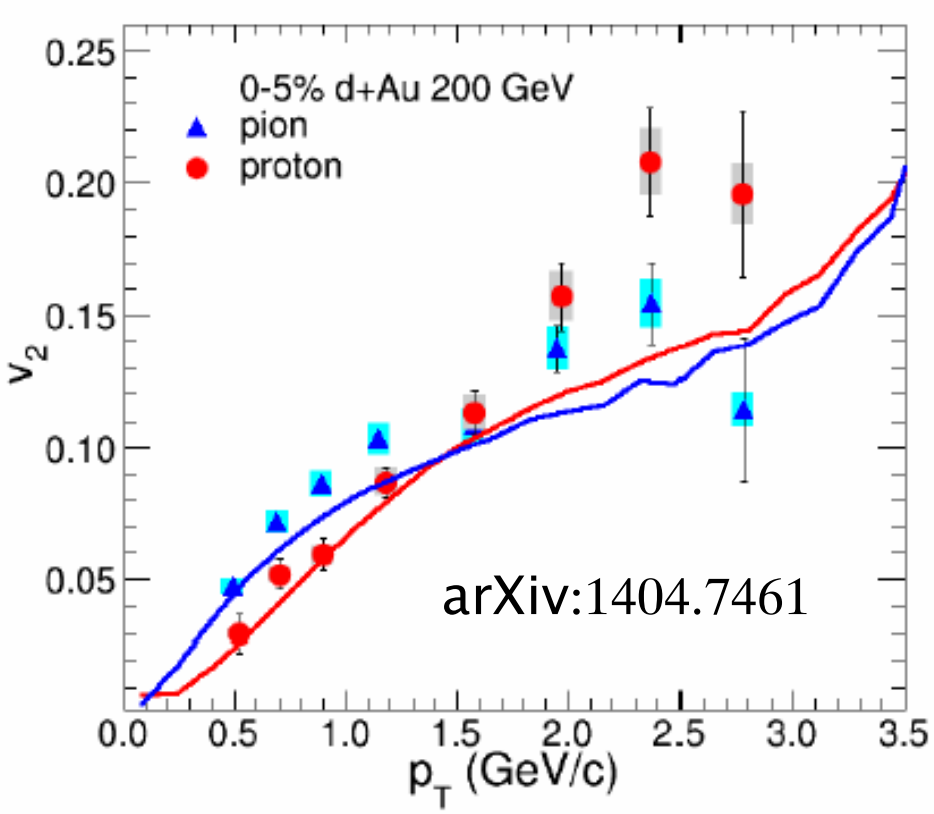
$-3.7 < \eta_{track} < -3.1$, Au-going



This is confirmed with our new result with $|\Delta\eta| > 2.75$

Clear long-range ridge is seen in central d+Au collisions

d+Au @ 200 GeV: Flow in Small Systems?

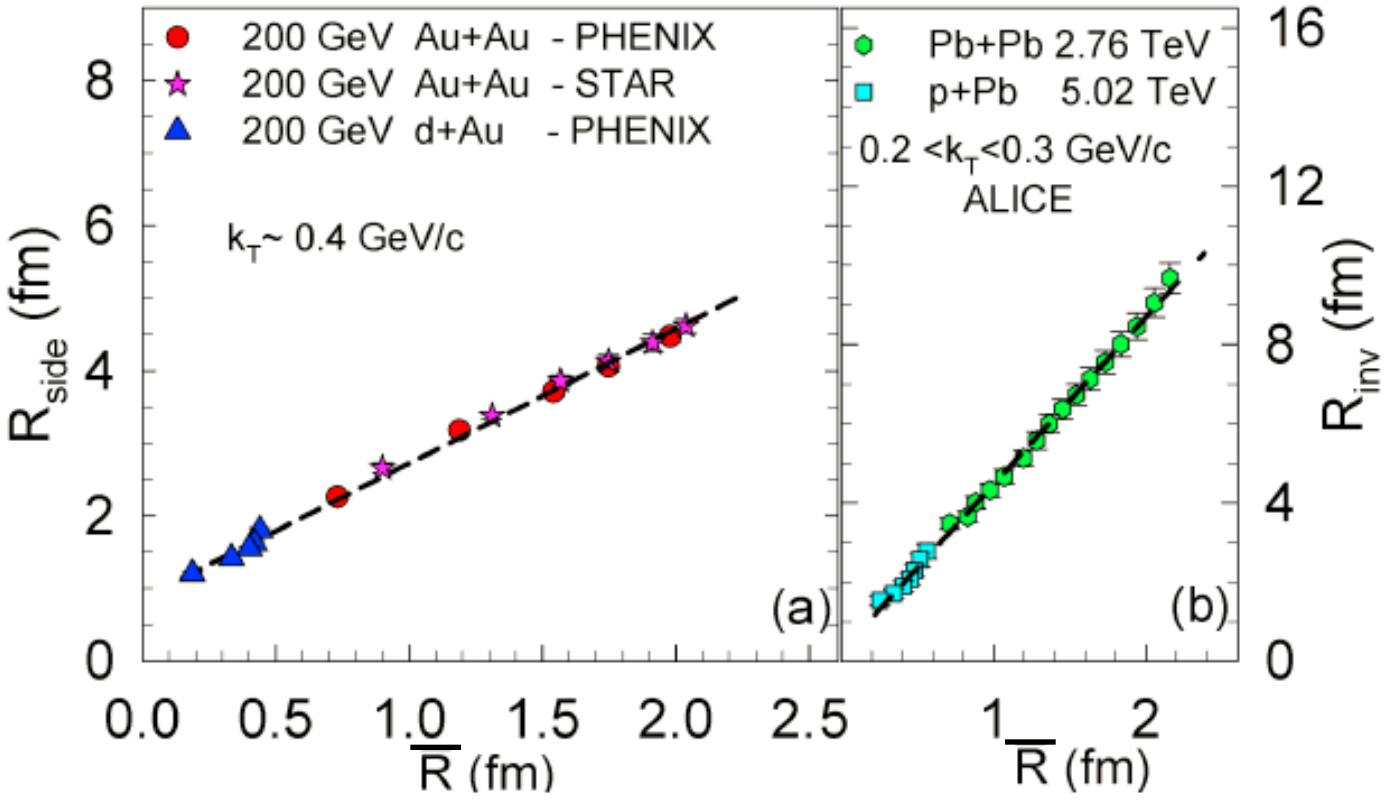


v_2 measured with 2.75 unit rapidity gap between EP and particle

Characteristic mass ordering is observed

Viscous Hydrodynamics (η/s = 1/4π) + Hadronic Cascade qualitatively describes features.

d+Au @ 200 GeV: HBT Radii



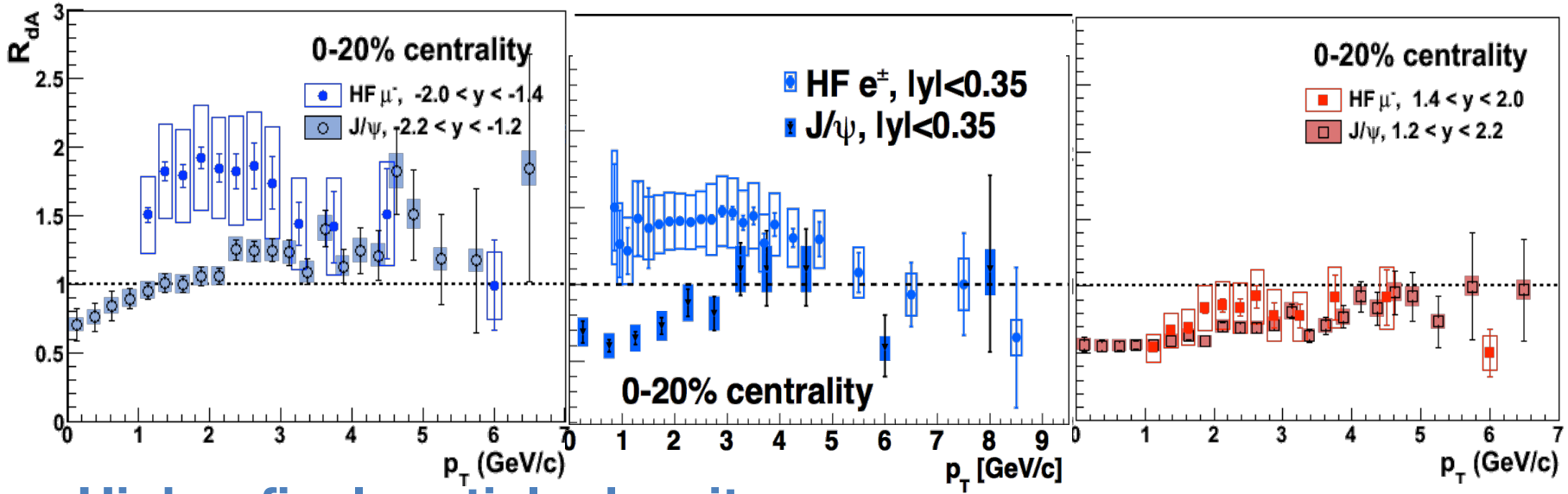
Three-dimensional HBT analysis in d+Au

Radii scale for small systems along with large systems (A+A) as a function of the characteristic initial length scale (calculated from Glauber Monte Carlo)

Another strong constraint for dynamical models

d+Au @ 200 GeV: Heavy Flavor

arXiv:1310.1005, Phys.Rev.Lett. 109 (2012) 24, 242301, Phys.Rev. C87 (2013) 3, 034904



Higher final particle density

Probing lower-x gluons in Au

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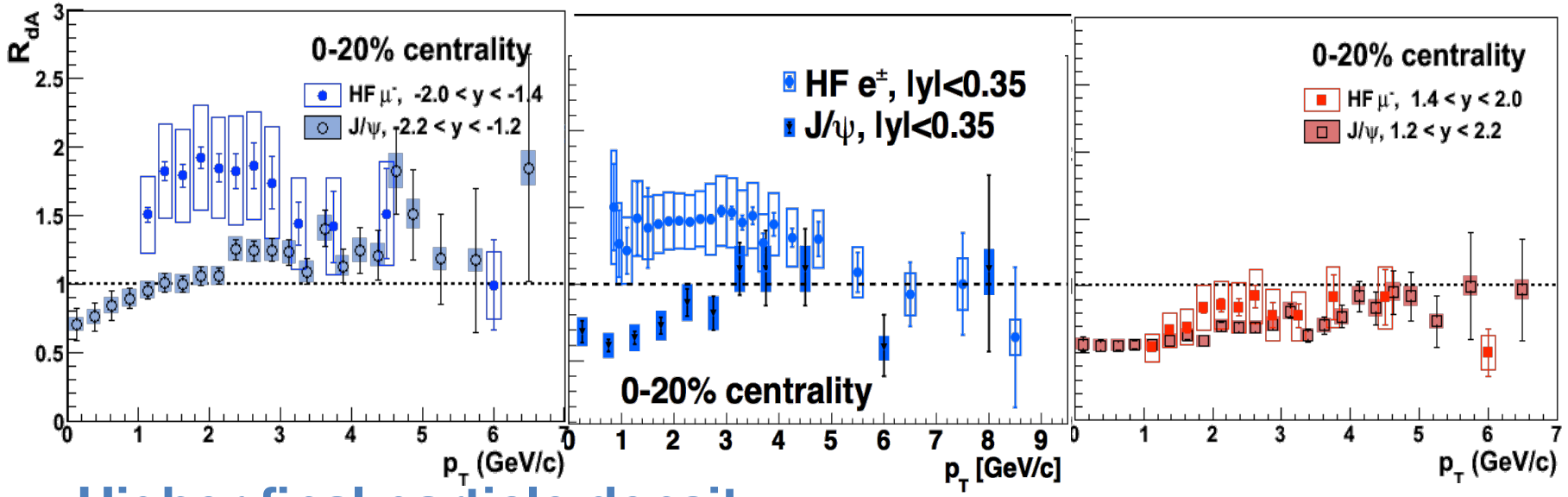


Higher final particle density

Probing lower-x gluons in Au

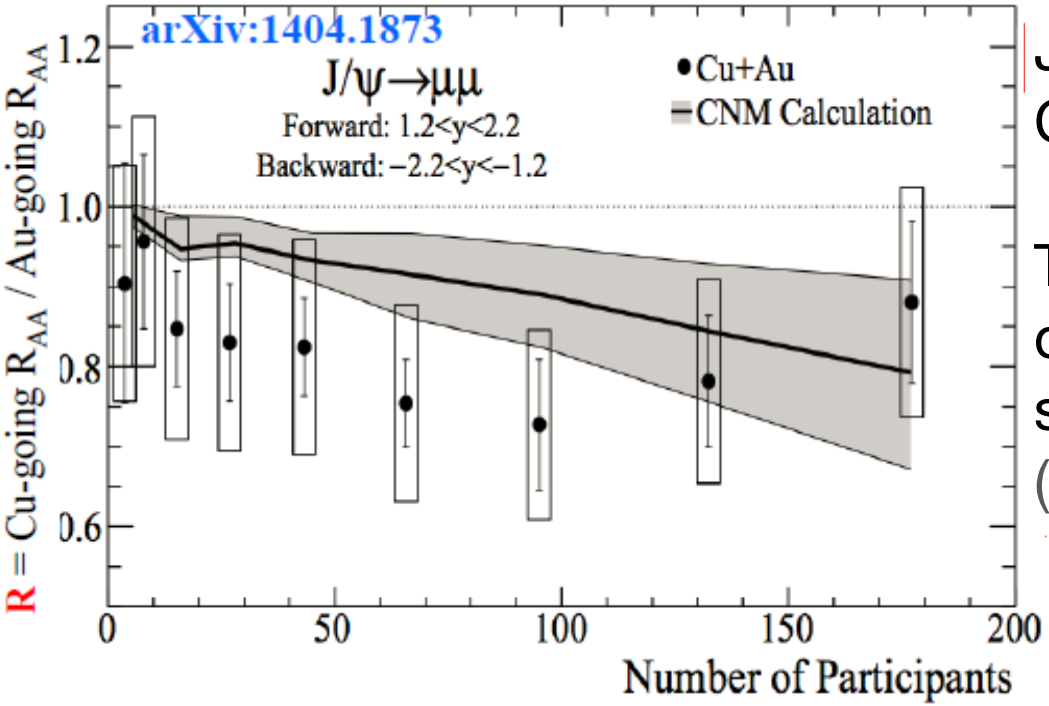
- Open charm enhancement at mid and backward rapidity
- Open charm and J/ψ suppression at forward rapidity
- Enhancement much larger than anti-shadowing expectations
- **Radial push of charm quarks even in d+Au?**

Heavy Quarks and Quarkonia

Cu+Au @ 200 GeV: J/ψ

J/ψ Cu-going / J/ψ Au-going R_{AA}

arXiv:1404.1873



J/ψ is more suppressed in Cu-going direction!

Trend is consistent in the direction of more low-x shadowing in Au than Cu (ratio is calculated with EPS09)

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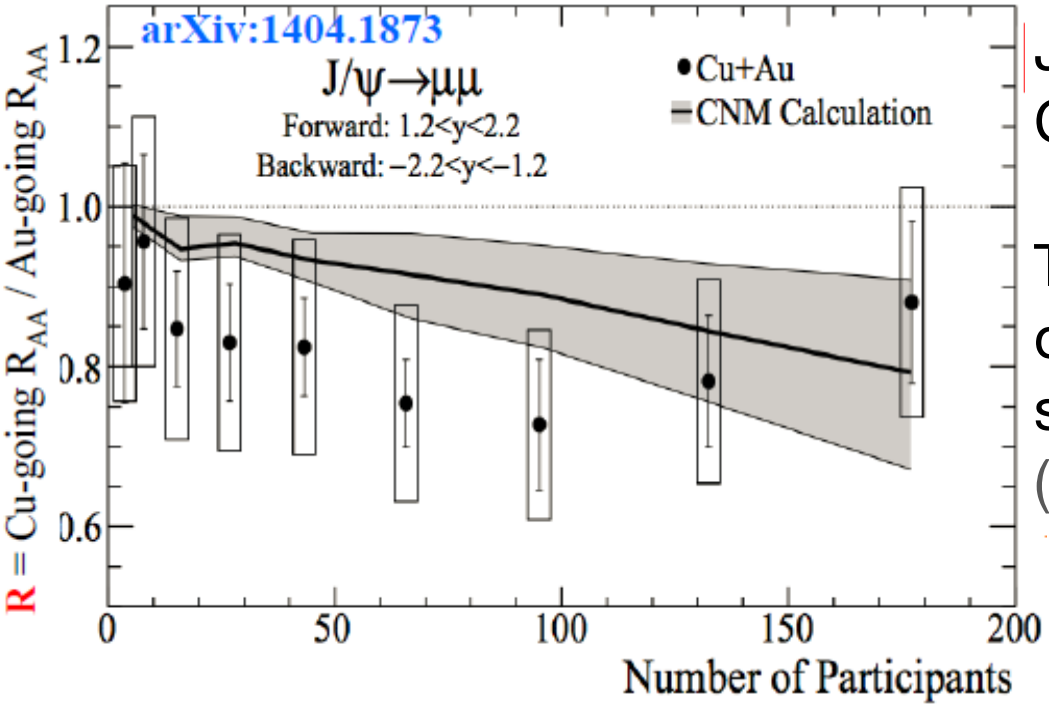

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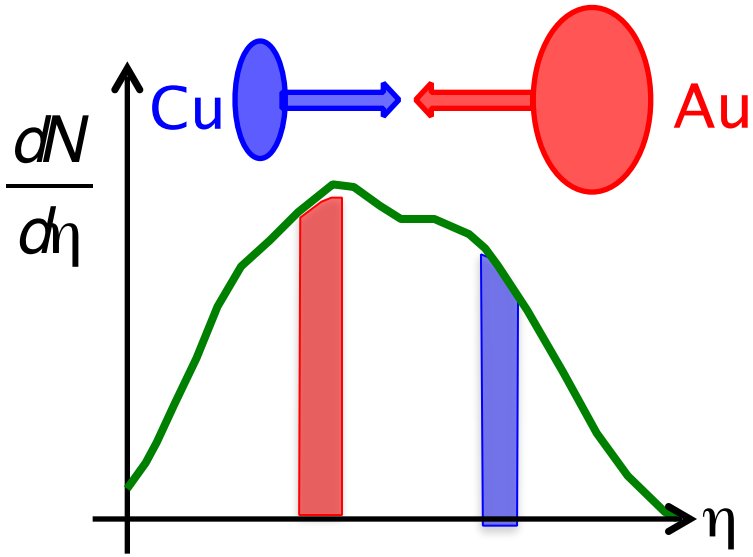
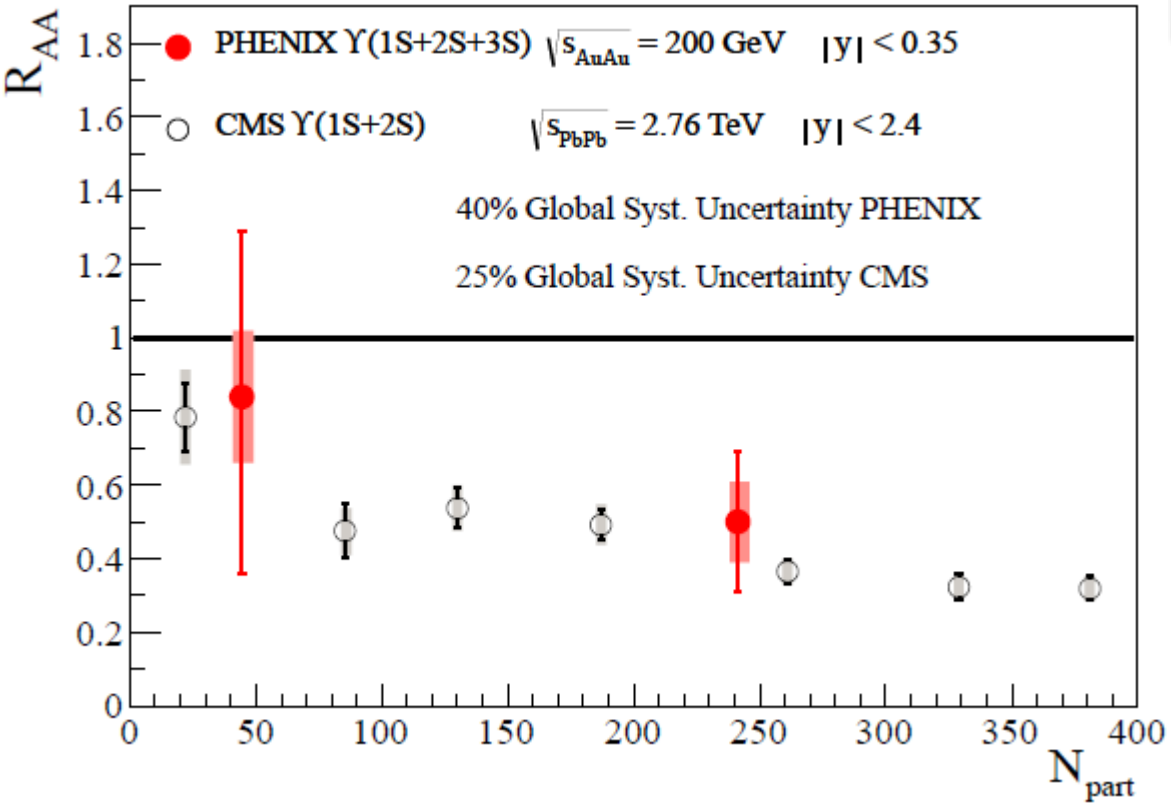
Less suppression in region of **lower particle density** would produce a rising trend in the ratio above.

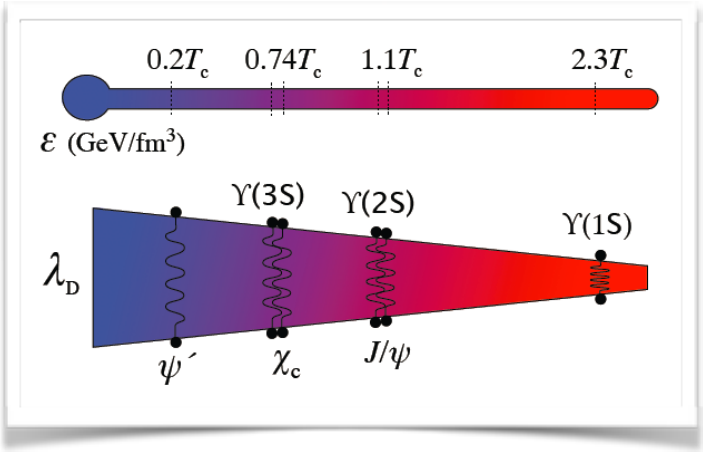


Au+Au @ 200 GeV: Upsilons

Extending quarkonia measurements to more states

arXiv:1404.2246



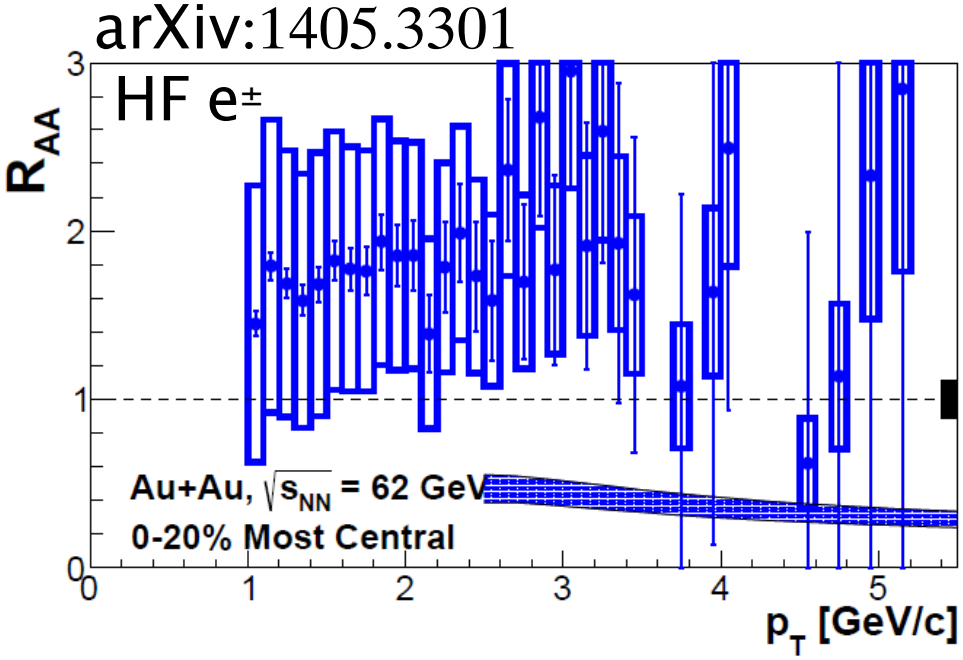


Suppression of Upsilons at RHIC observed

Consistent with disappearance of **2s** and **3s** contributions

Within uncertainties similar suppression in Pb+Pb at LHC energies

Au+Au @ 62 GeV: Heavy Flavor



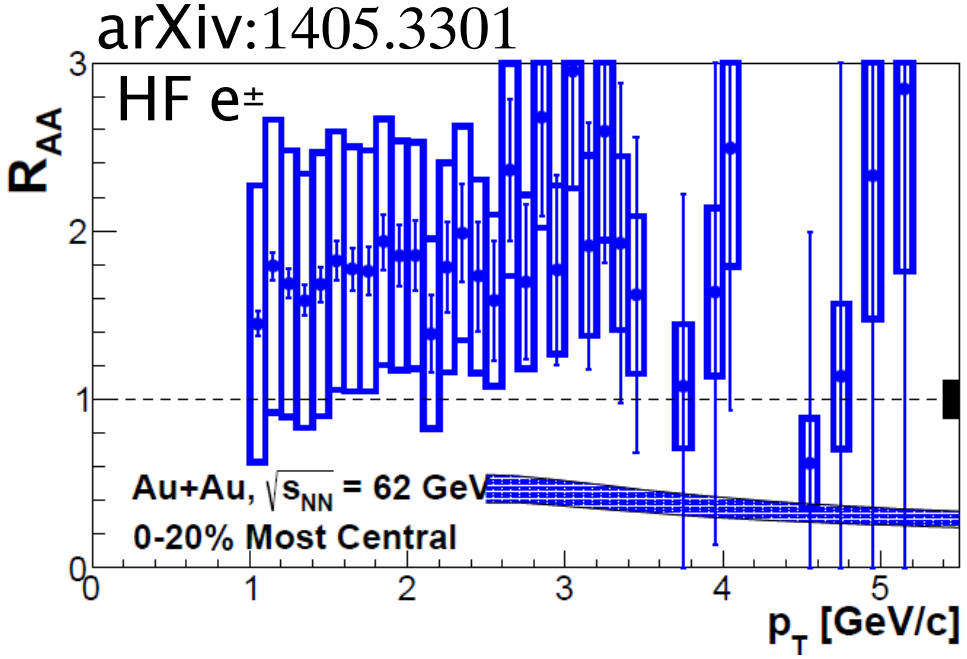
HF electrons enhanced

Opposite to Au+Au @ 200 GeV

Opposite to energy loss models

Different dynamics dominate?

Au+Au @ 62 GeV: Heavy Flavor



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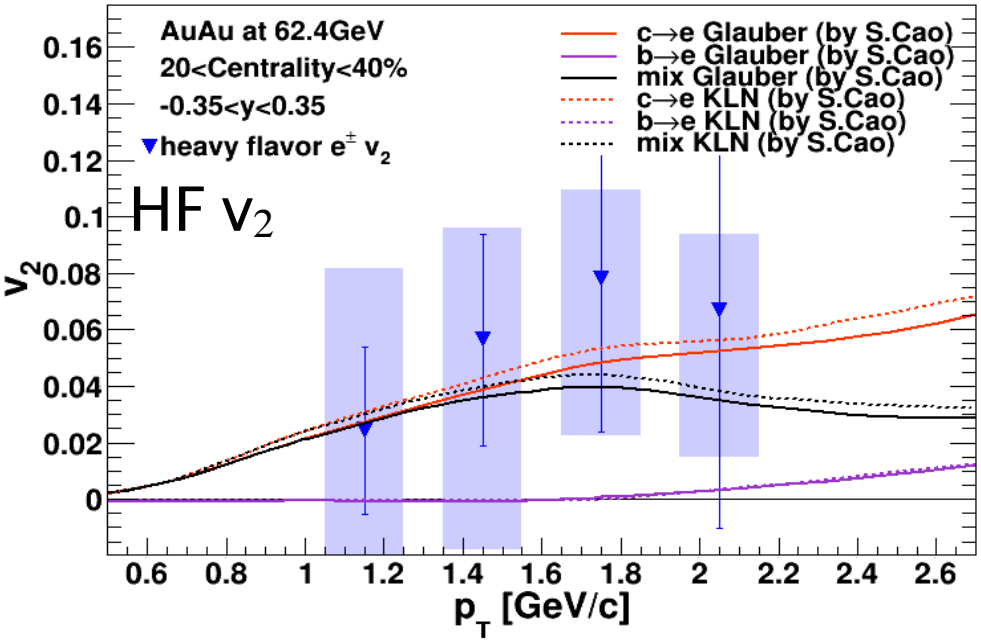


Heavy flavor v_2 measurement

Flow of heavy quarks also impacting spectra and thus R_{AA}?

PHENIX is proposing high statistics future running of p+p and Au+Au at 62 GeV

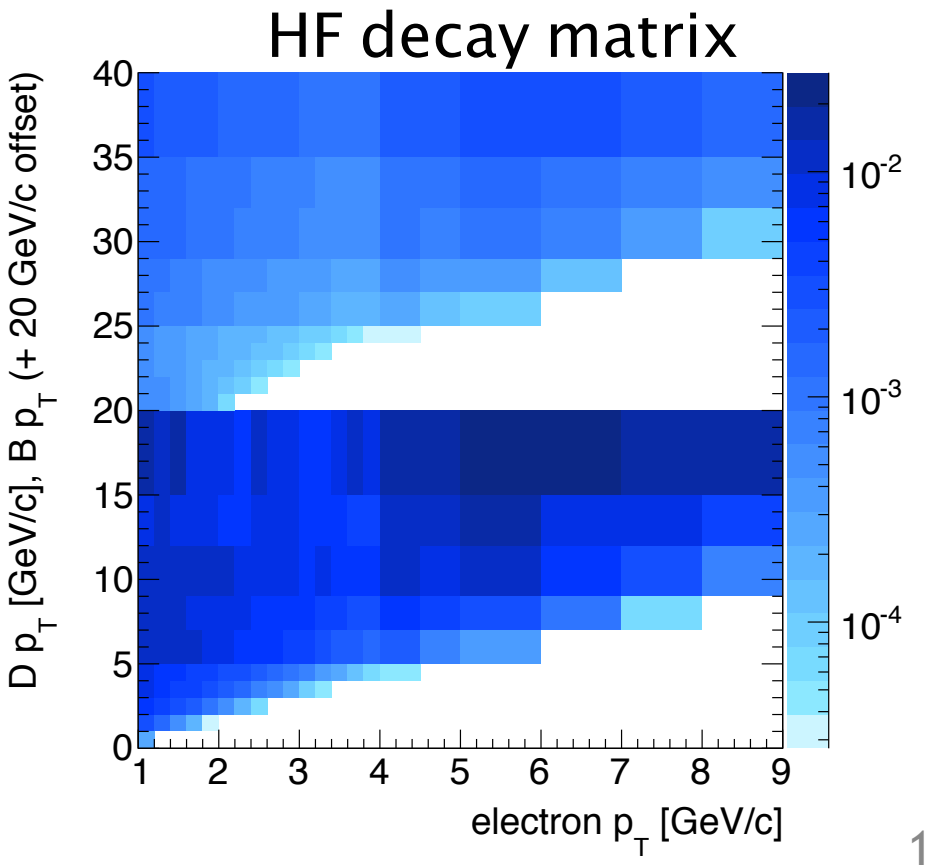
Heavy Flavor with Displaced Vertex

Previous results are without silicon vertex detectors.

Analysis with silicon vertex detector requires unfolding to parent hadron distributions for charm and beauty separation.

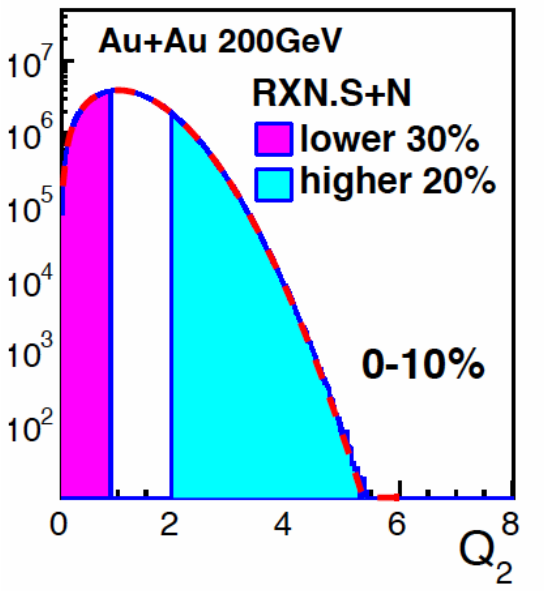
More challenging in the lower statistics 2011–2012 data.

We do not show a snapshot of the analysis here and are moving straight to publication later this year.



Event Engineering and Correlations

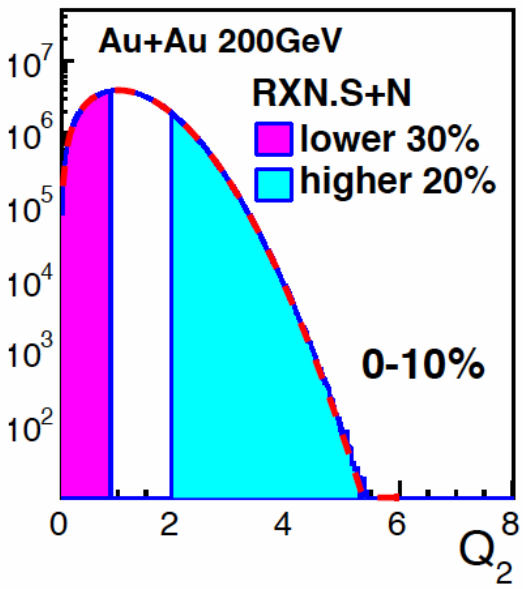
Event Shape Engineering



Select event with larger or smaller anisotropy, as measured away from midrapidity

Does this actually enable the engineering of events with larger anisotropy and spatial eccentricity at midrapidity?

Event Shape Engineering



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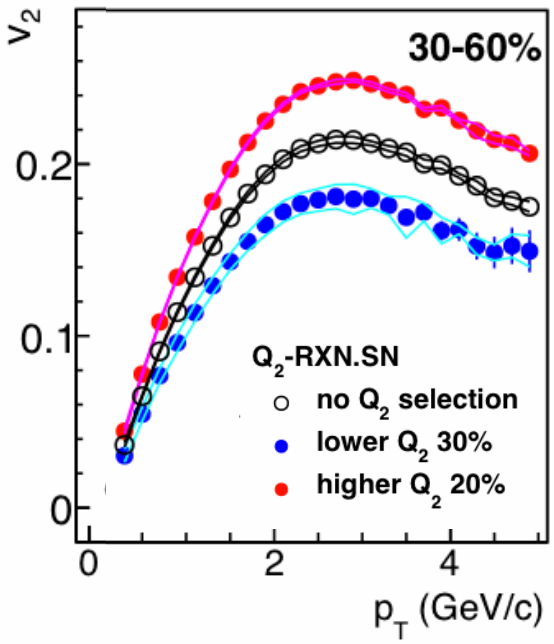
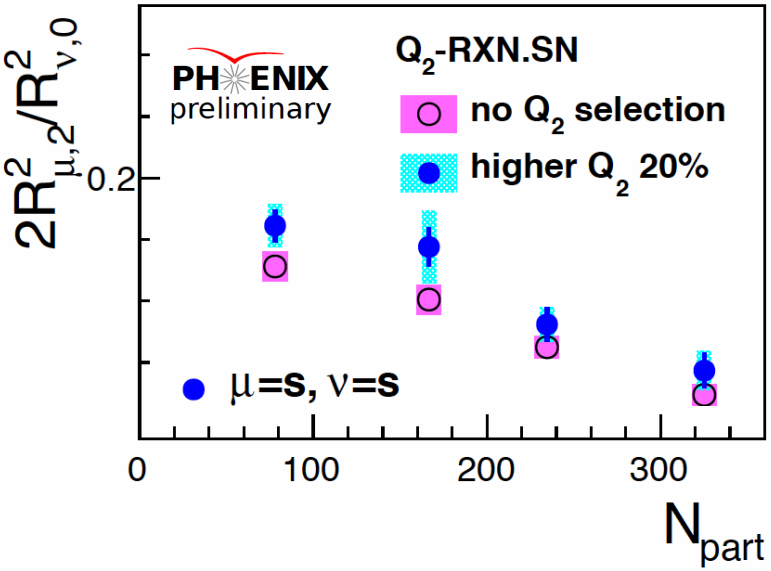
Yes



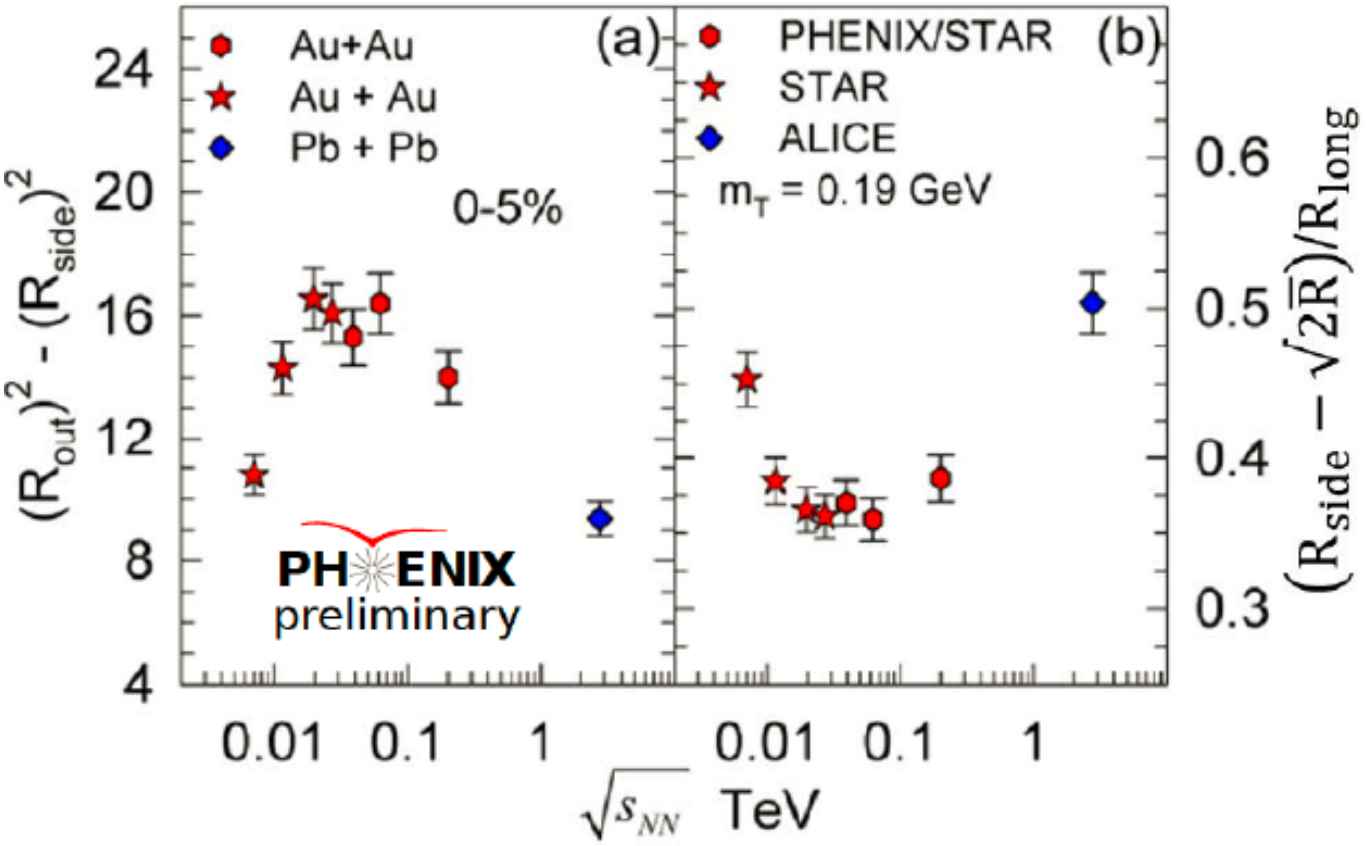
Yes



Au+Au 39, 62, 200 GeV: HBT Radii

RHIC Beam Energy Scan allows tests of changing Equation of State and possible effects of Critical End Point

Three-dimensional HBT result, combined with STAR and ALICE results, show interesting energy dependence of R_{out}, R_{side}, R_{long}



The present and the future

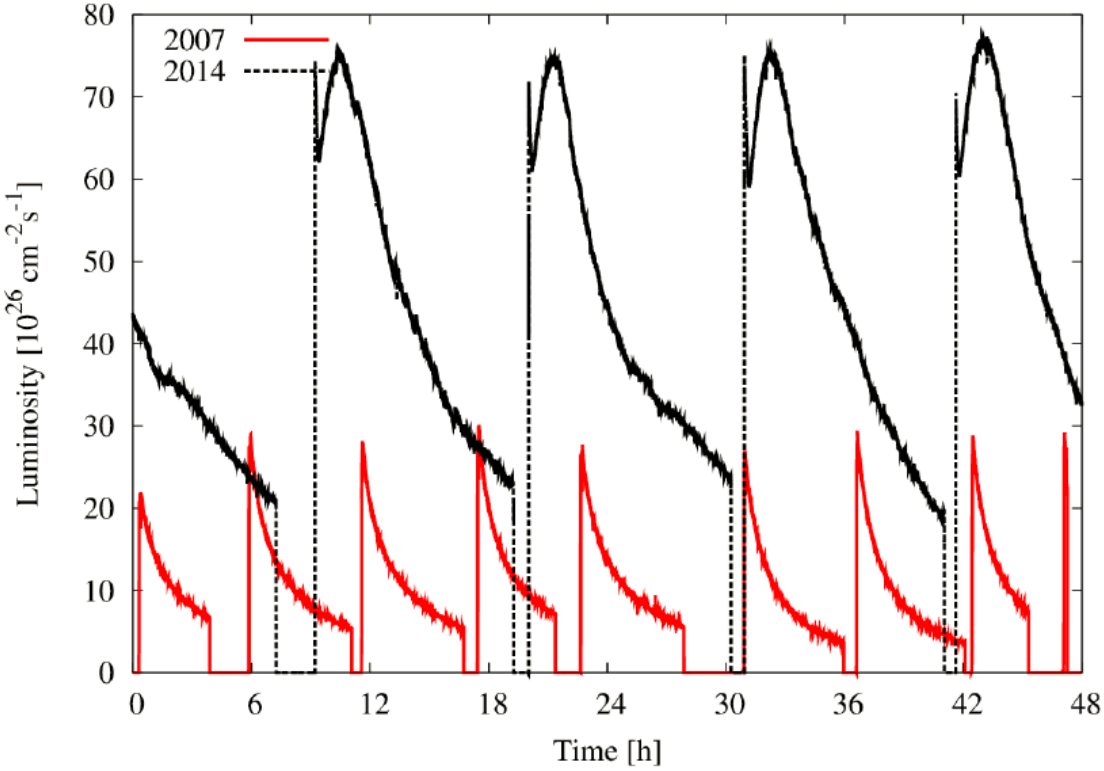
Run-14 – Golden Au+Au @ 200 GeV Data Set

Unbelievably successful 2014 run ongoing

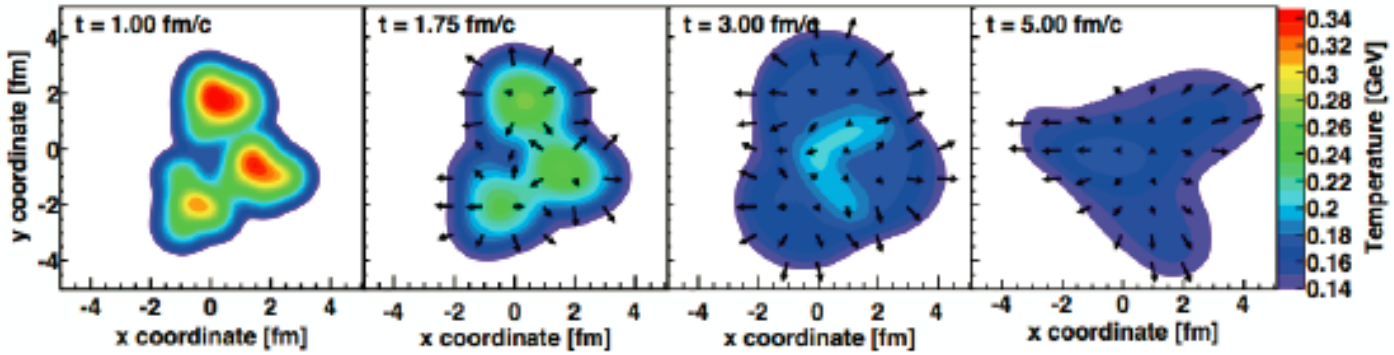
15B Au+Au events recorded!

Silicon detectors operating very well

RHIC accelerator delivering well above max projection with stochastic cooling



Planning for ^{3}He+Au run in the last two weeks for unique geometry test



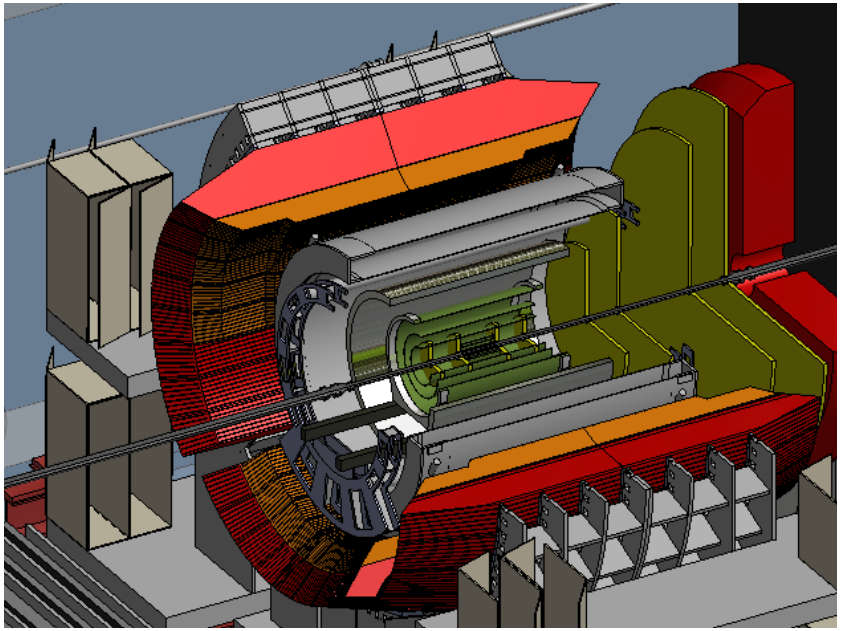
Bright Physics Future

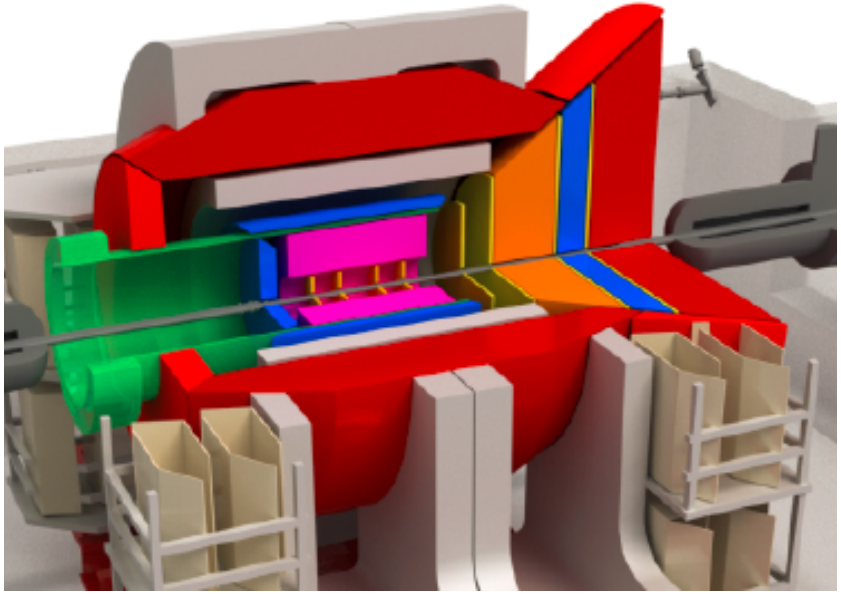
sPHENIX moving forward

Acquired 1.5 T BaBar magnet

Excellent jet, dijet, γ-jet, h-jet, quarkonia capabilities

DOE Science Review in July 2014





Excitement about Electron-Ion Collider

BaBar magnet and sPHENIX calorimetry are excellent foundation for an EIC Detector

arXiv:1402.1209

PHENIX Summary

Broad array of new publications on many topics

Raising the question of how small the QGP can be and how quickly such a small system might equilibrate

New challenges for full dynamical models with direct photon and heavy flavor observables, with more to come!

Excellent current 2014 Au+Au running

Looking forward to polarized p+A running in 2015

Bright future opportunities with sPHENIX and then Electron-Ion Collider