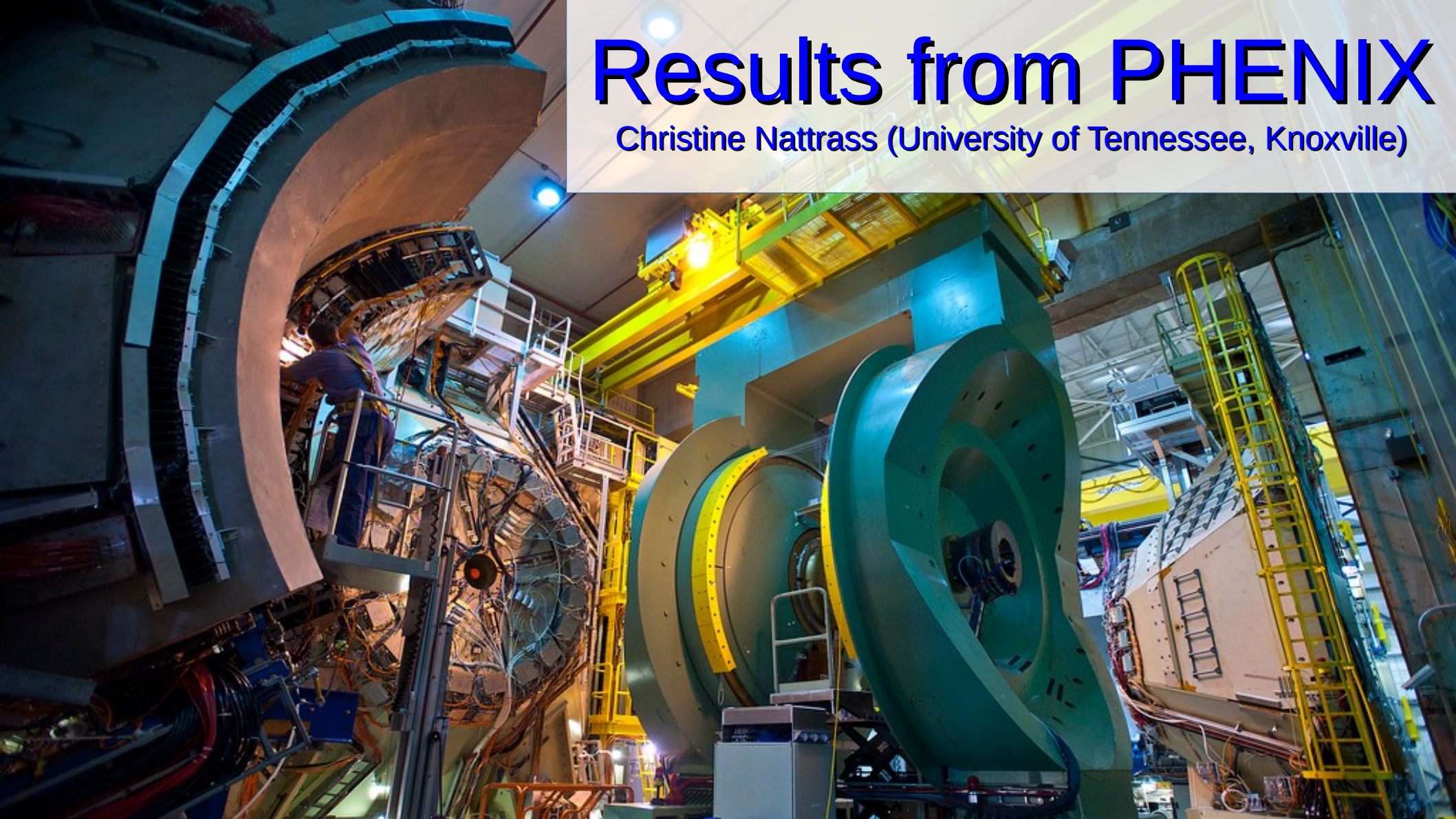


Results from PHENIX

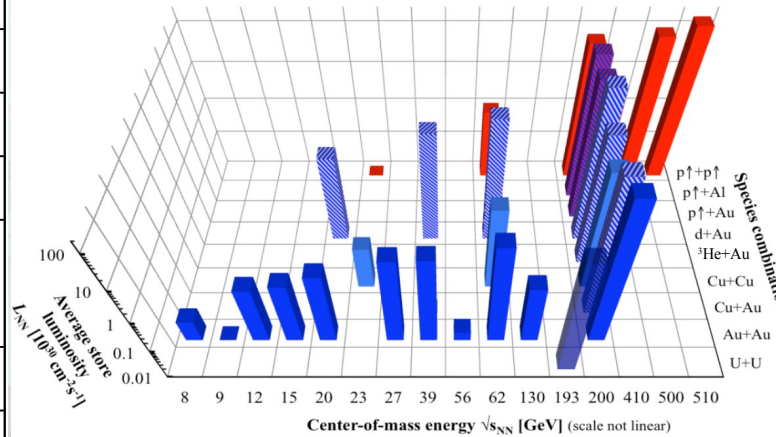
Christine Nattrass (University of Tennessee, Knoxville)



Data collected

Run	Species	Energy $\sqrt{s_{NN}}$ (GeV)	Integrated Luminosity (mb^{-1})
1 (2000)	Au+Au	56	1.0E-6
2 (2001/2002)	Au+Au	200	2.4E-5
	p+p	200	1.5E+5
3 (2003)	d+Au	200	2.7E+3
	p+p	200	3.5E+5
4 (2004)	Au+Au	200	2.4E+2
	Au+Au	62.4	9.0E+0
5 (2005)	Cu+Cu	200	3.0E+3
	Cu+Cu	62.4	1.9E+2
	Cu+Cu	22.4	2.7E+3
	p+p	200	3.4E+6
6 (2006)	p+p	200	7.5E+6
	p+p	62.4	8.0E+4
7 (2007)	Au+Au	200	8.1E+2
8 (2008)	d+Au	200	8.0E+4
	p+p	200	5.2E+6
9 (2009)	p+p	500	1.4E+7
	p+p	200	1.6E+7
10 (2010)	Au+Au	200	1.5E+3
	Au+Au	62.4	1.1E+2
	Au+Au	39	4.0E+4
	Au+Au	7.7	3.0E+2

RHIC energies, species combinations and luminosities (Run-1 to 16)



Completed taking data in 2016
Many high impact analyses ongoing

Run	Species	Energy $\sqrt{s_{NN}}$ (GeV)	Integrated Luminosity (mb^{-1})
11 (2011)	p+p	500	1.8E+7
	Au+Au	19.6	2.0E+0
	Au+Au	200	1.7E+3
	Au+Au	27	7.0E+0
12 (2012)	p+p	200	1.0E+7
	p+p	510	3.2E+7
	U+U	193	2.0E+2
	Cu+Au	200	5.0E+3
13 (2013)	p+p	510	1.6E+8
14 (2014)	Au+Au	14.6	4.0E+0
	Au+Au	200	7.5E+3
	³ He+Au	200	2.4E+4
15 (2015)	p+p	200	6.0E+7
	p+Au	200	2.0E+5
	p+Al	200	5.0E+5
16 (2016)	Au+Au	200	7.0E+3
	d+Au	200	5.0E+4
	d+Au	62.4	5.0E+3
	d+Au	19.6	8.0E+1
	d+Au	39	2.0E+3

Papers since Quark Matter 2022

- PRL130, 251901 (2023) Direct γ cross section in p+p $\sqrt{s}=510$ GeV ← Press coverage
- PRD107, 112004 (2023) Transverse spin asymmetry of π^0 , η in p+Al and p+Au $\sqrt{s_{NN}}=200$ GeV
- PRD107, 052012 (2023) Transverse spin asymmetry of heavy flavor decay electrons
- PRC107, 024907 (2023) Flow in p+p, p+Al, d+Au, $^3\text{He}+\text{Au}$ $\sqrt{s_{NN}}=200$ GeV
- PRC107,024914 (2023) Low p_T γ in Au+Au at $\sqrt{s_{NN}}=39$ and 62.4GeV ← PRC Editor's suggestion
- PRC107, 014907 (2023) ϕ in Cu+Au and U+U $\sqrt{s_{NN}}=200$ GeV
- PRC106, 014908 (2022) ϕ in p+p, p+Al, d+Au, $^3\text{He}+\text{Au}$ $\sqrt{s_{NN}}=200$ GeV
- PRC105, 064912 (2022) $\psi(2S)$ in p+p, p+Al, and p+Au $\sqrt{s_{NN}}=200$ GeV ← PRC Editor's suggestion
- arXiv:2303.12899 Suppression of high p_T π^0 relative to direct γ in central d+Au $\sqrt{s_{NN}}=200$ GeV
- arXiv:2303.07191 Transverse spin asymmetry of h^\pm in p+p, p+Al, and d+Au $\sqrt{s_{NN}}=200$ GeV
- arXiv:2203.17187 Non-prompt γ in Au+Au $\sqrt{s_{NN}}=200$ GeV
- arXiv:2203.17058 Charm and bottom production in Au+Au $\sqrt{s_{NN}}=200$ GeV

8 published + 4 in journal review

New preliminary results for QM23

Dilepton continuum in p+p $\sqrt{s}=200$ GeV

Talk Tues. 15:30 **Vassu Doomra** Poster **Roli Esha**

Elliptic flow of direct γ in Au+Au at 200 GeV

Talk Tues. 15:30 **Vassu Doomra**

Elliptic flow of μ^\pm from heavy flavor decays in Au+Au at $\sqrt{s_{NN}}=200$ GeV

Talk Tues. 11:00 **Krista Smith** Poster **Brandon Blankenship**

Elliptic flow of π^0 in Cu+Au at 200 GeV

$\Psi(2s)$, J/Ψ vs N_{ch} in p+p $\sqrt{s}=200$ GeV

Talk Tues. 11:00 **Krista Smith** Poster **JongHo Oh**

Forward η cross-section in p+p $\sqrt{s}=200$ GeV

N_{part} dependence of v_2 to investigate multiparton interactions in Au+Au at $\sqrt{s_{NN}}=200$ GeV

Poster **Maya Shimomura**

PHENIX at QM23

Talk Heavy Flavor and Quarkonia results from the PHENIX experiment Tues. 11:00 **Krista Smith (LANL)**

Talk Isolating final state effects in high p_T π^0 production using direct photons in small system collisions with PHENIX Tues. 13:00 **Daniel Firak (Stony Brook)**

Talk Measurement of low p_T direct photons with PHENIX Tues. 15:30 **Vassu Doomra (Stony Brook)**

Talk Measurement of in-medium modification of energy-space structure of jets via and triggered hadrons in Au+Au collisions at RHIC Wed. 10:10 **Megan Connors (Georgia State)**

Poster Elliptic flow measurement of J/ψ in PHENIX Run14 Au+Au at $\sqrt{s_{NN}}=200$ GeV Tues. 17:30 **Luis Bichon III (Vanderbilt)**

Poster Forward Physics with light vector mesons and π^0 from the PHENIX Experiment Tues. 17:30 **Uttam Acharya (Georgia State)**

Poster Particle multiplicity dependent Charmonia production in p+p collisions by the PHENIX experiment Tues. 17:30 **JongHo Oh (Pusan National University)**

Poster PHENIX measurements of identified charged hadron production in p+Al, p+Au, and Cu+Au collisions at $\sqrt{s_{NN}} = 200$ GeV Tues. 17:30 **Sanghoon Lim (Pusan National University)**

Poster Systematic study of energy loss in the QGP for various collision systems at PHENIX Tues. 17:30 **Takashi Hachiya (Nara Women's University)**

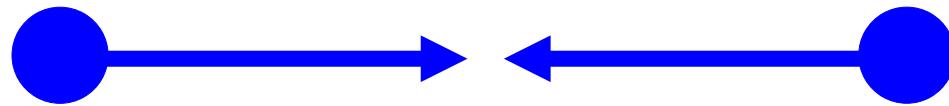
Poster Di-electron continuum in p+p collisions at 200 GeV Tues. 17:30 **Roli Esha (Stony Brook)**

Poster Neutral pion and eta meson production in Au+Au collisions at 200 GeV Tues. 17:30 **Dading Chen (Stony Brook)**

Poster Measurement of neutral pions and direct photons in $^3\text{He}+\text{Au}$ collisions Tues. 17:30 **Daniel Firak (Stony Brook)**

Poster PHENIX Measurements of Azimuthal Anisotropy of Light and Heavy Flavor Hadrons in Au+Au Collisions at Forward Rapidity Tues. 17:30 **Brandon Blankenship (Vanderbilt)**

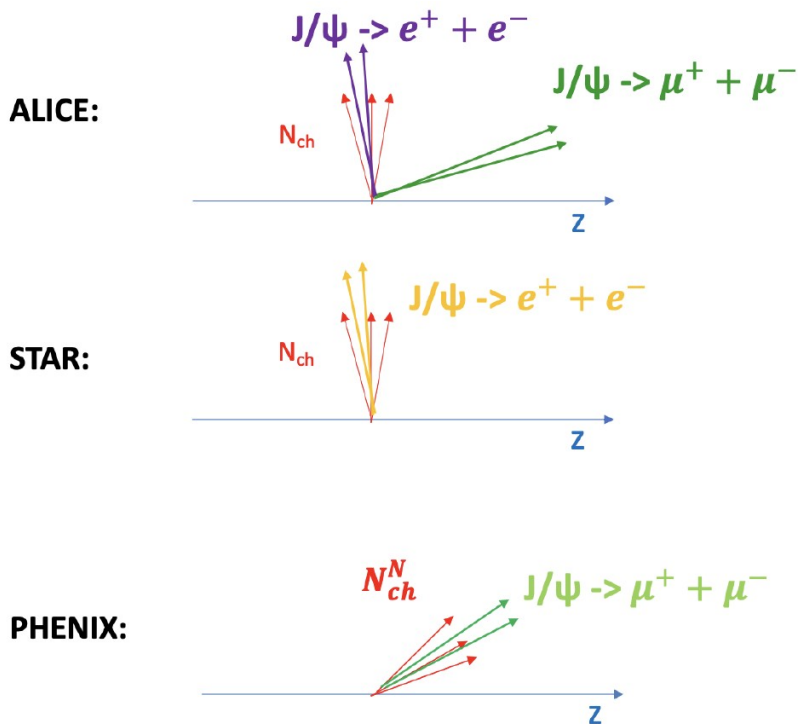
Poster The study of with a new double-differential event categorization using multiplicity and spectator neutrons in PHENIX Tues. 17:30 **Maya Shimomura (Nara Women's University)**



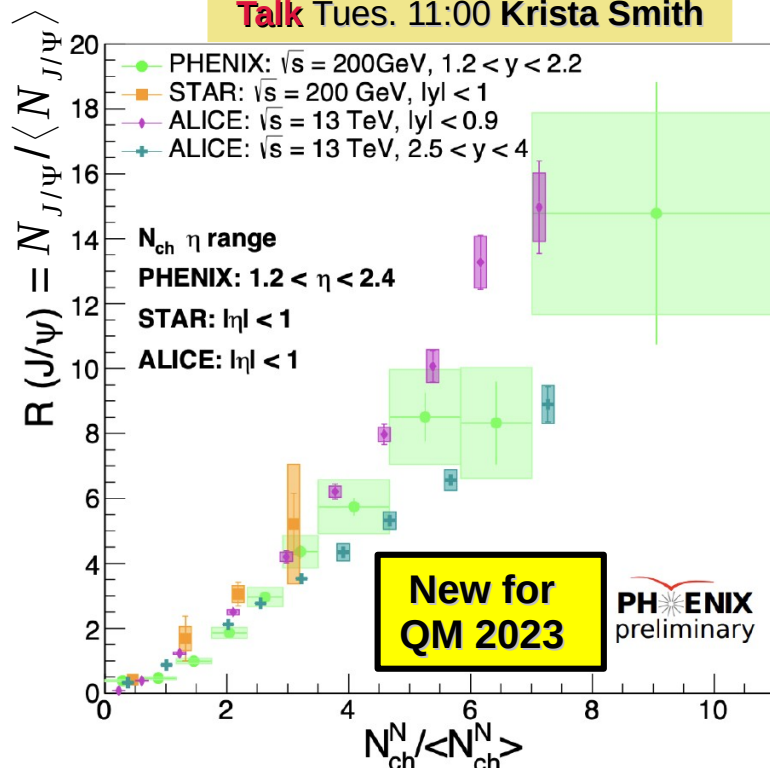
$p+p$



J/ψ yield in p+p



Talk Tues. 11:00 Krista Smith



Poster
JongHo Oh

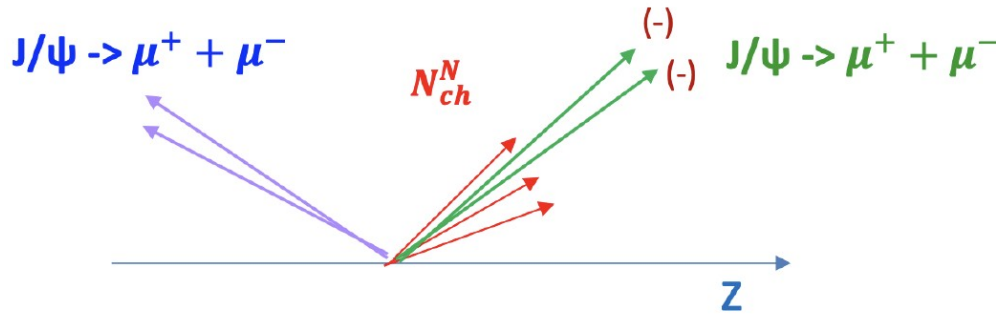
- J/ψ yield exhibits large dependence on local track multiplicity

Often attributed to multi-parton interactions



J/ψ yield in p+p

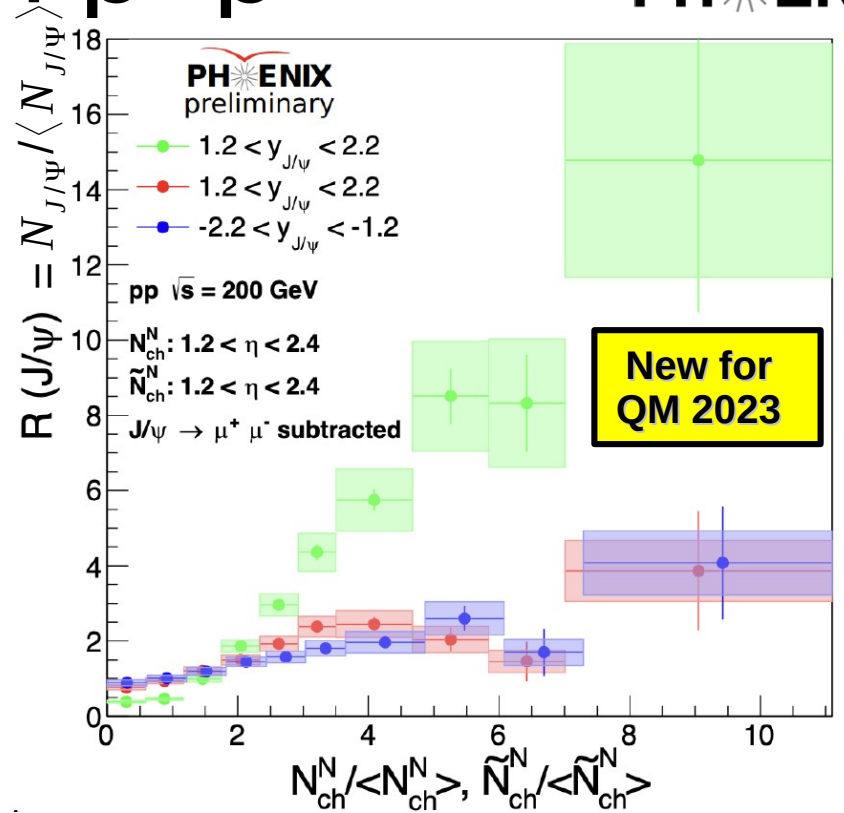
Red = Tracklets N_{ch}^N ($1.2 < \eta < 2.4$)
Green = J/ψ ($1.2 < y < 2.2$)
Green = J/ψ ($-2.2 < y < -1.2$)



- J/ψ yield vs multiplicity significantly reduced when Looking at J/ψ and multiplicity in separate rapidity windows

- Looking at J/ψ and multiplicity in the same rapidity window but removing the $\mu^+ \mu^-$ from the multiplicity

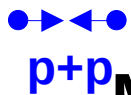
Implications for MPI picture



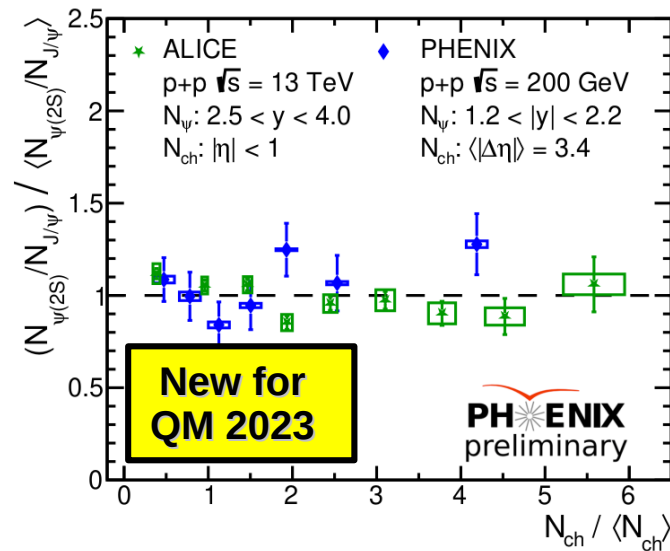
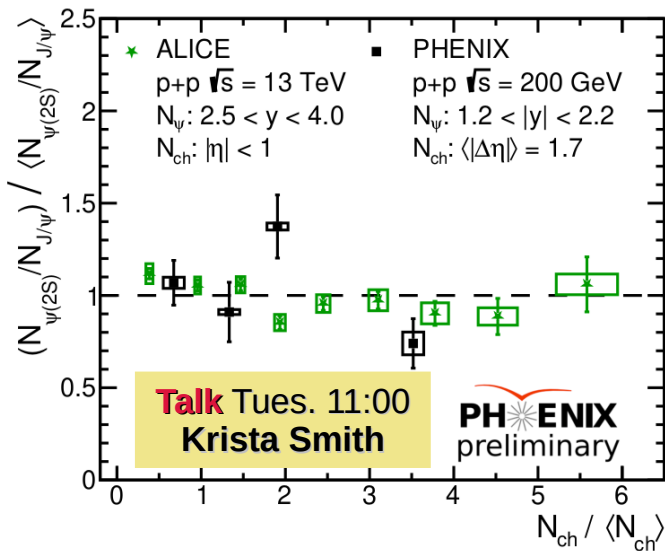
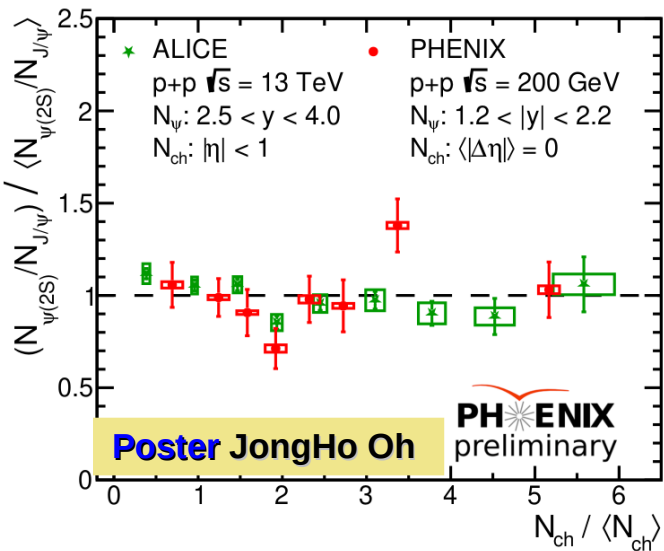
Poster JongHo Oh

Talk Tues. 11:00 Krista Smith





Multiplicity dependent $\psi(2s)$ to J/ψ ratio

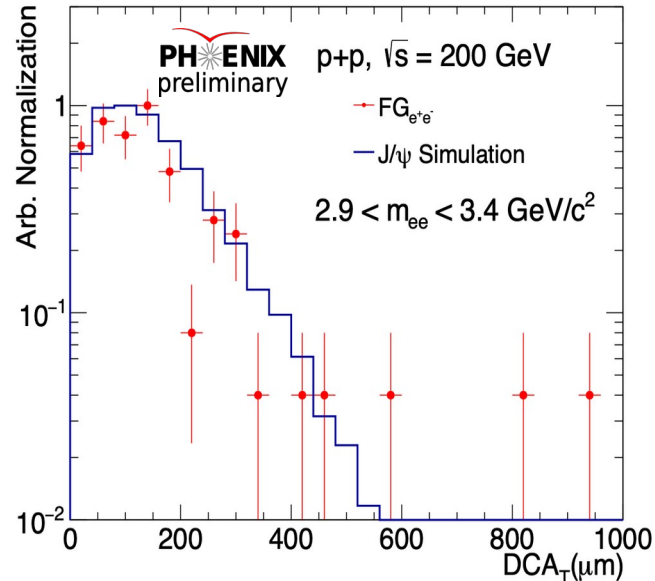
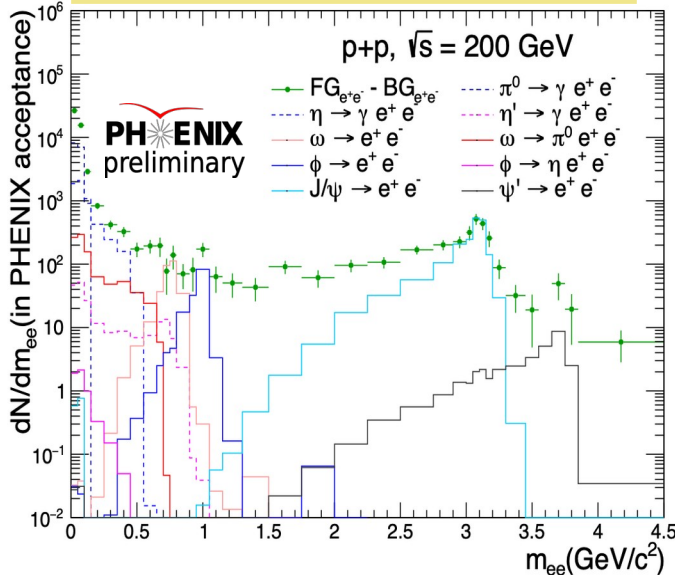
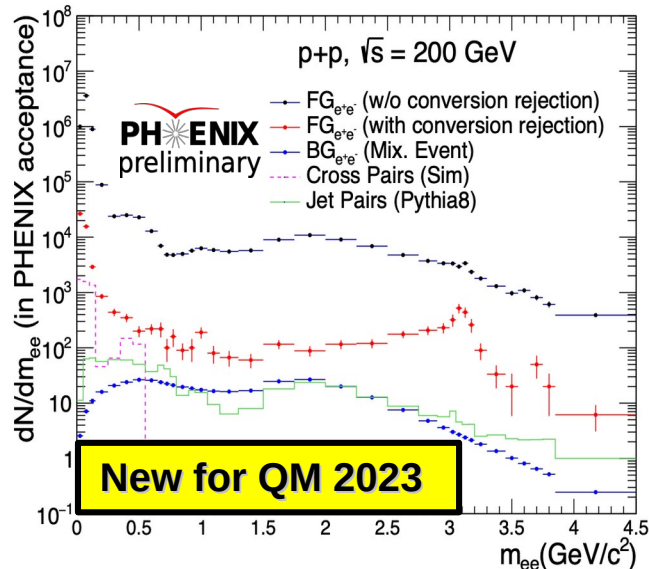


- Multiplicity-dependent studies test for onset of QGP-like effects
- PHENIX and ALICE results consistent, weak multiplicity dependence consistent w/unity



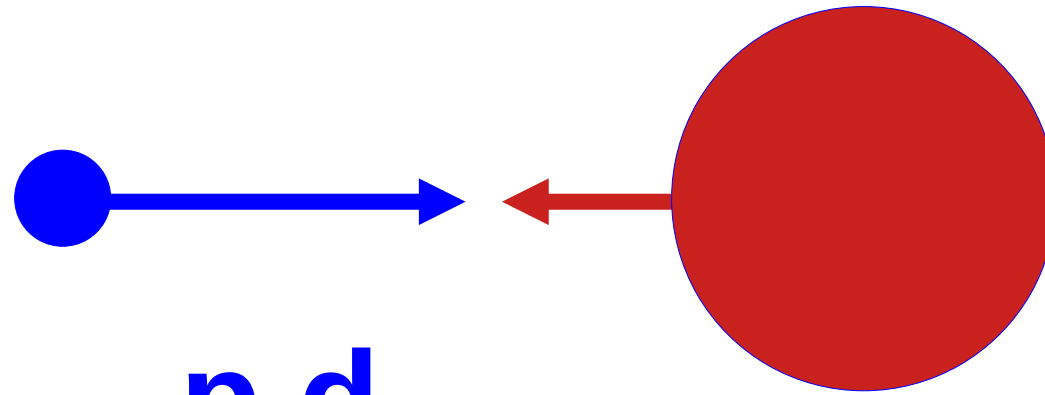
Dilepton invariant mass

Talk Tues. 15:30 Vassu Doomra



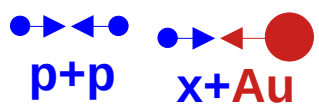
Measurements of intermediate mass dilepton pairs
Separation from semi-leptonic decay and prompt pairs



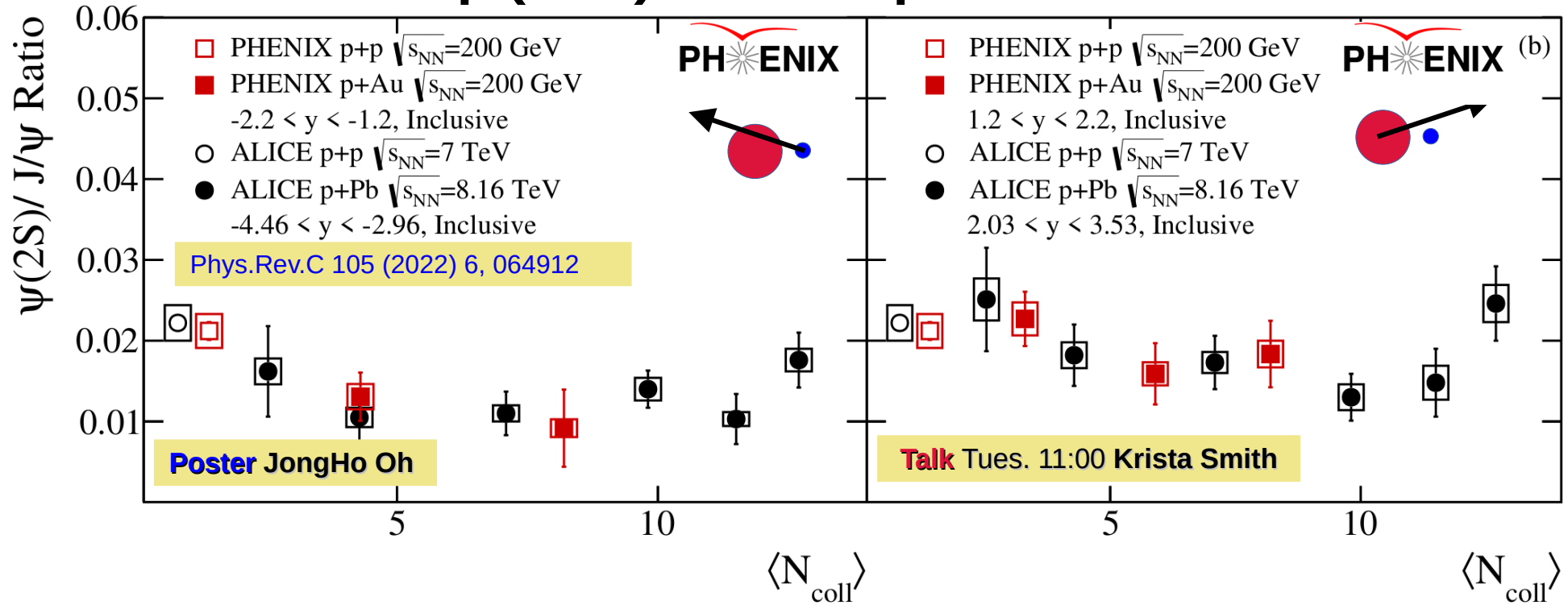


$p, d,$
 ${}^3\text{He}, \text{Al} + \text{Au}$





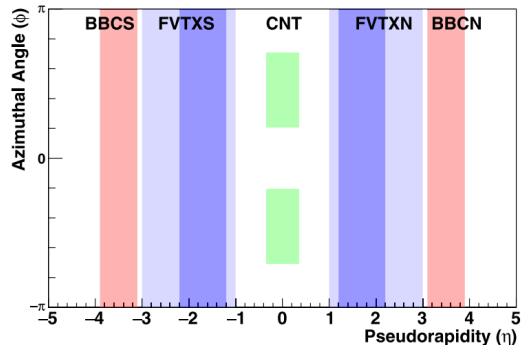
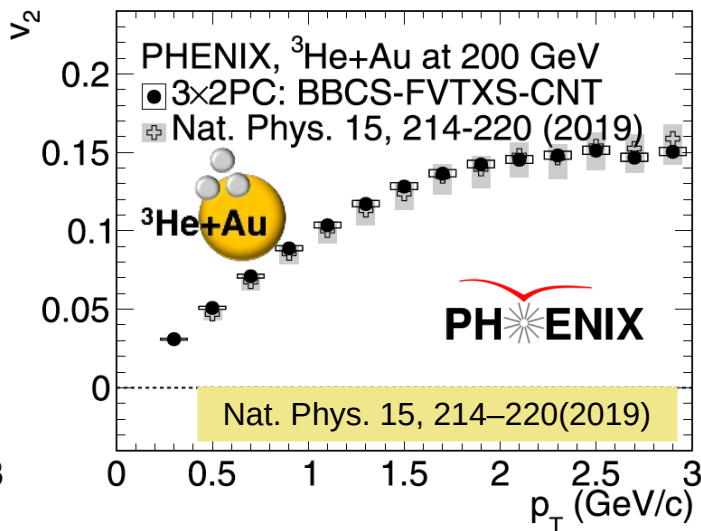
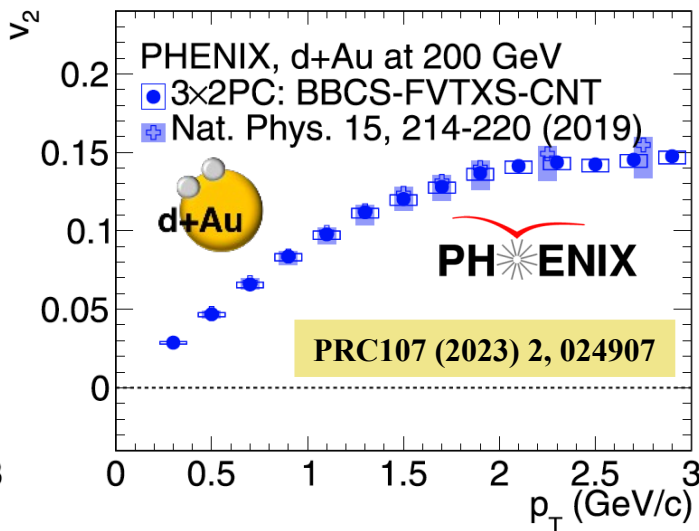
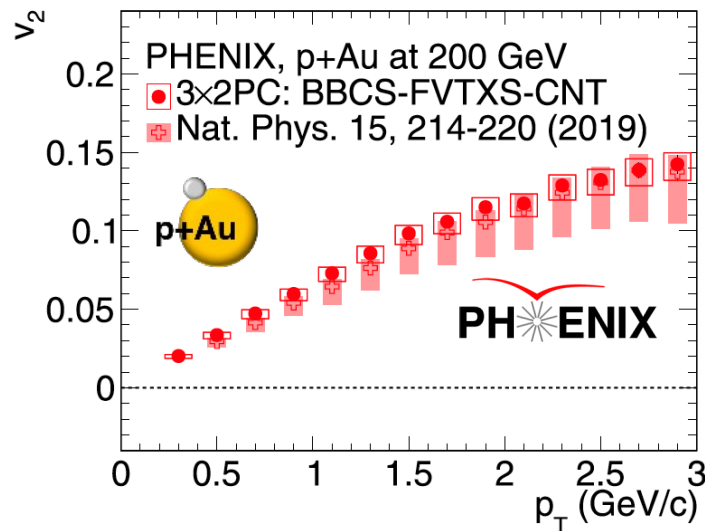
$\psi(2s)$ to J/ψ ratio



- $\psi(2s)$ to J/ψ ratios p+p at RHIC, LHC show no clear energy dependence
- Suggests final state effects at backward rapidity



v_2 in small systems

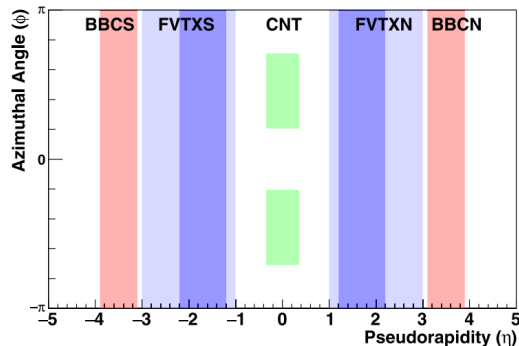
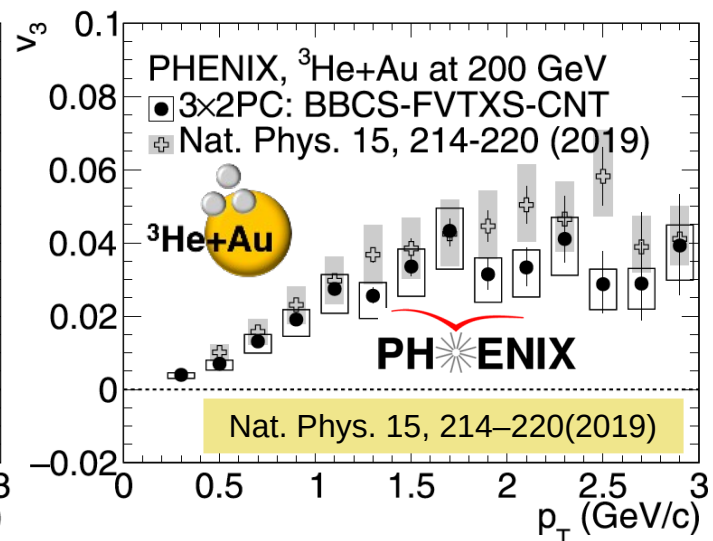
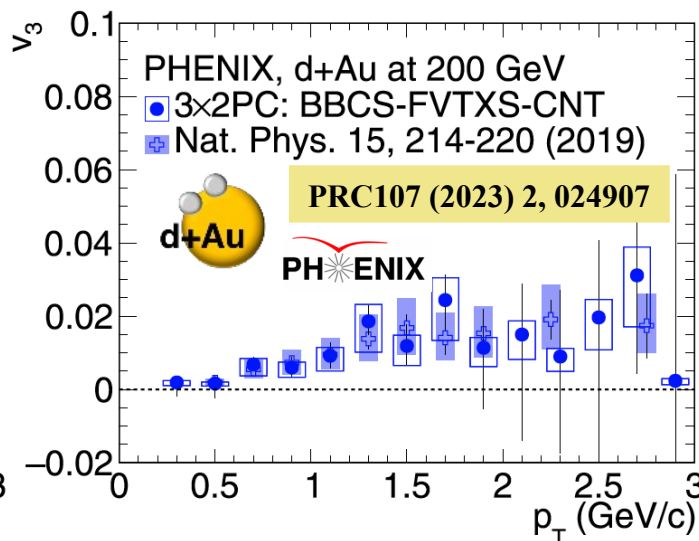
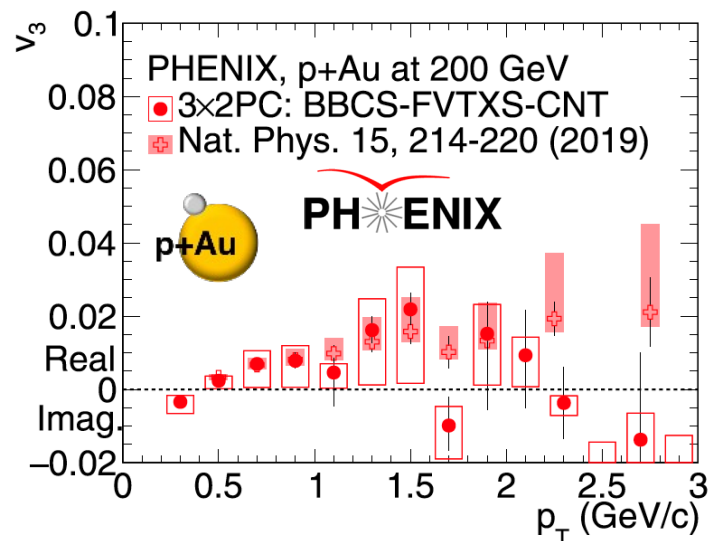


Using two particle correlations over large rapidity range

- **Nature Physics results confirmed**
- **Consistent with small droplet of QGP**
- Different systematics, different sensitivity to non flow effects
- **Consistent v_2**



V_3 in small systems

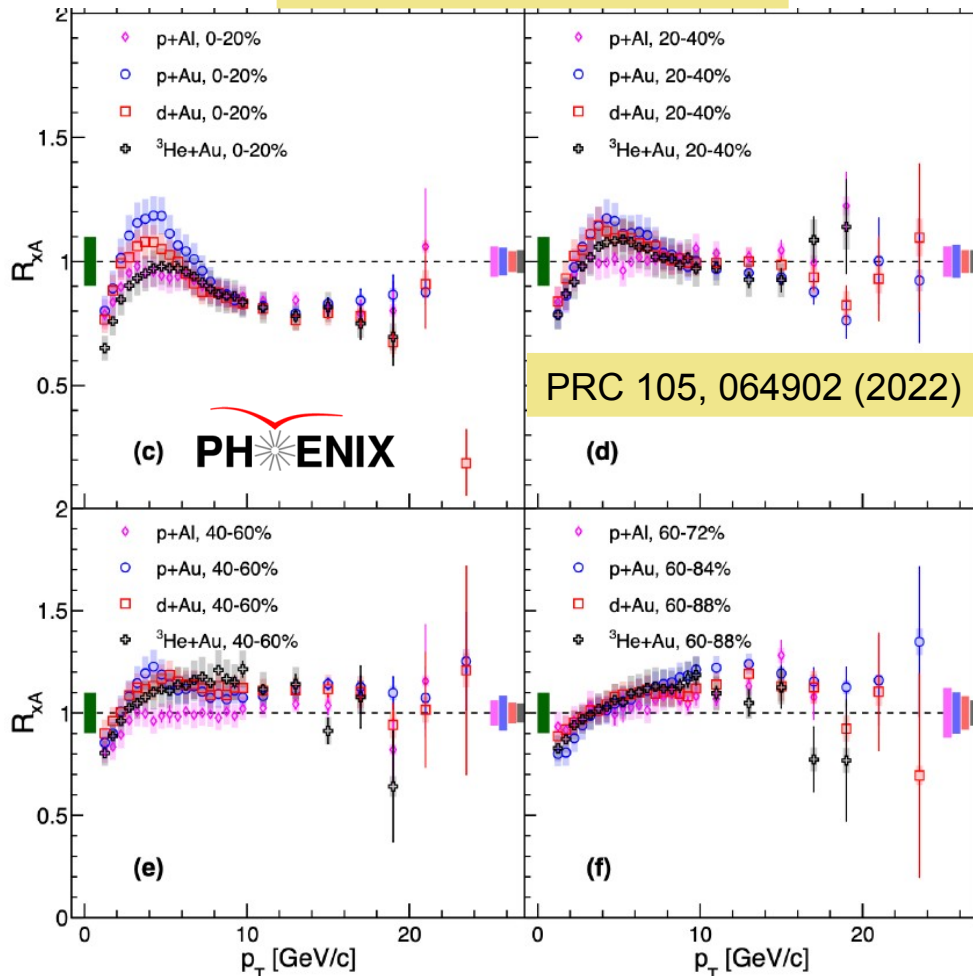


Using two particle correlations over large rapidity range

- **Nature Physics results confirmed**
- **Consistent with small droplet of QGP**
- Different systematics, different sensitivity to non flow effects
- Consistent V_3



Talk Tues. 13:00 Daniel Firak



Same suppression at high p_T in centrals

Some enhancement in peripherals

Ordering with system size NOT seen at high p_T

Potential bias in centrality determination?

Final state effect?

High and low p_T : quite different physics!

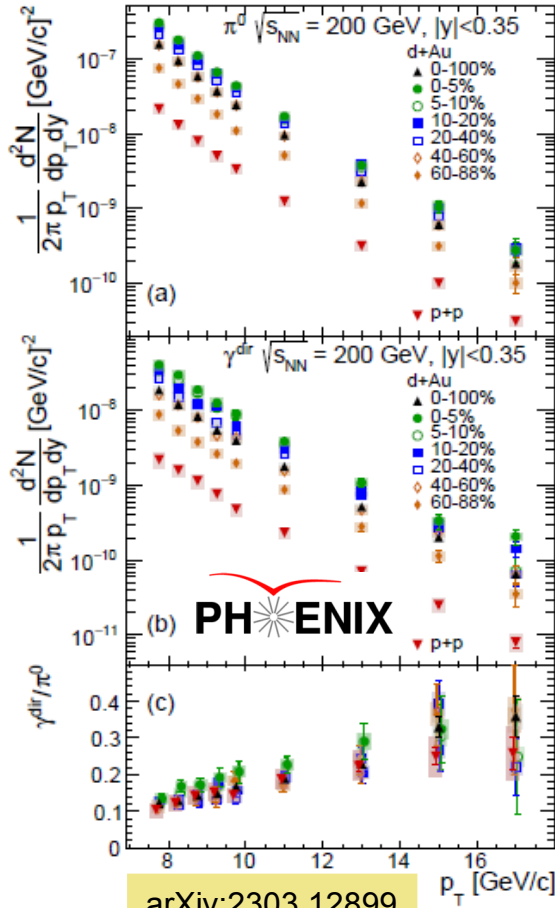
Bias in N_{coll} at high p_T ?



Talk Tues. 13:00 Daniel Firak

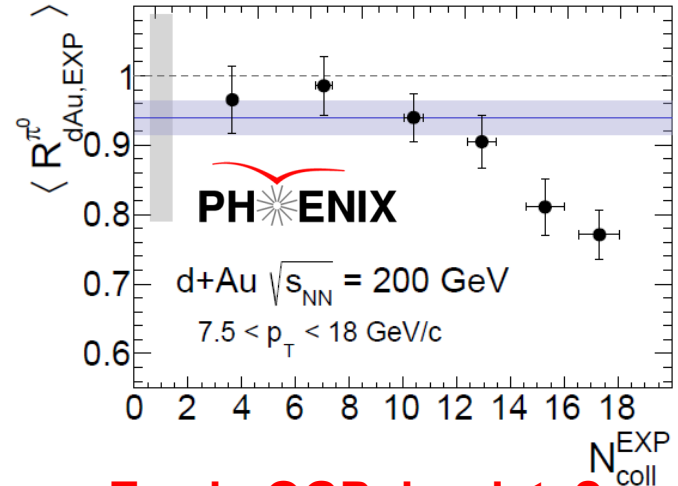
Use electroweak probes
(in our case photons)
to directly measure N_{coll}

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



arXiv:2303.12899

No enhancement in
peripheral
Suppression in most
central collisions

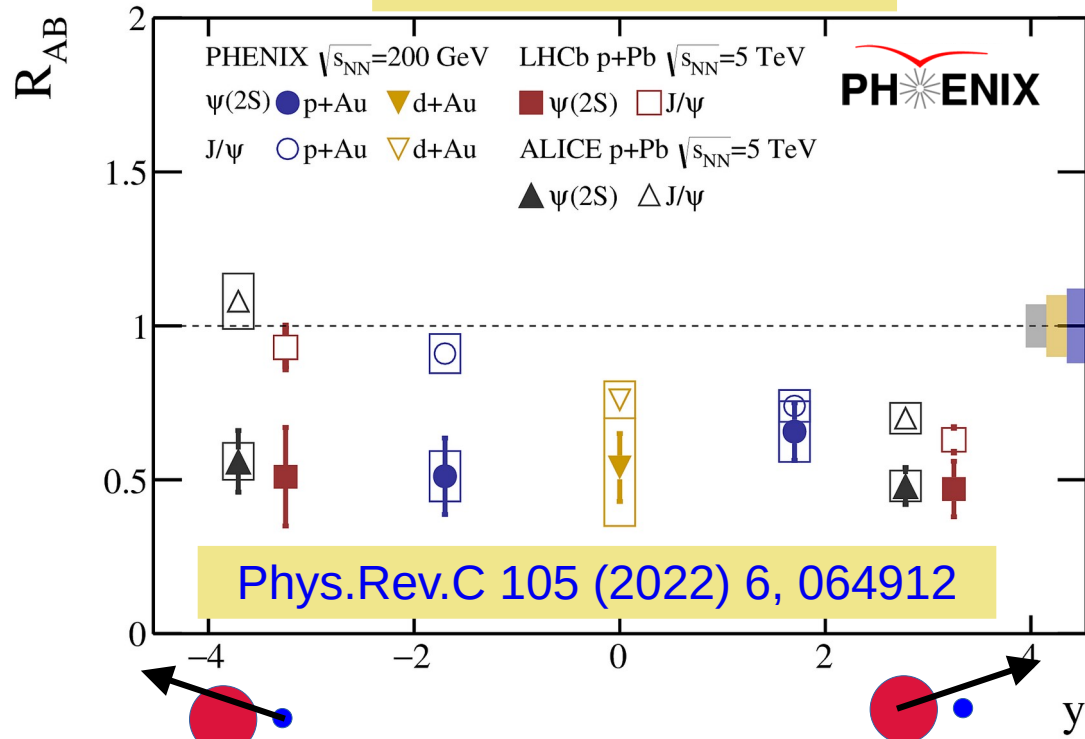


arXiv:2303.12899

E_{loss} in QGP droplets?
Something else?



Talk Tues. 11:00 Krista Smith



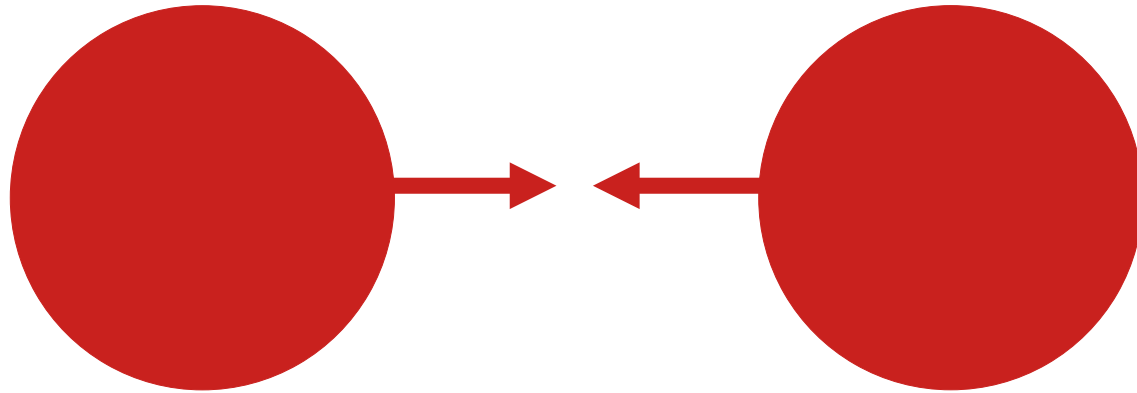
PRC Editor's suggestion

Phys.Rev.C 105 (2022) 6, 064912

Similar patterns for J/ψ and ψ(2S) found at RHIC and LHC

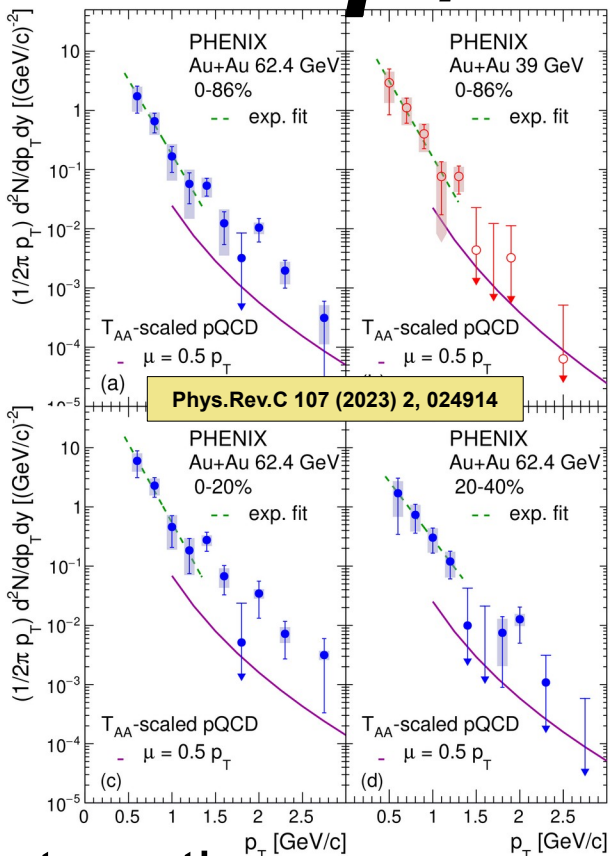
Result consistent with final state effects at backward rapidity





Au+Au



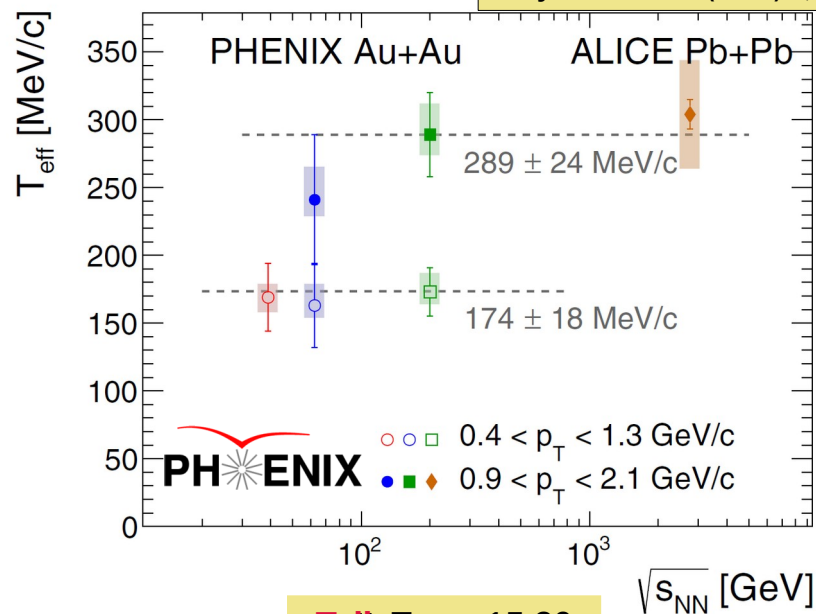


Phys.Rev.C 107 (2023) 2, 024914

Editors' Suggestion

Phys.Rev.C 107 (2023) 2, 024914

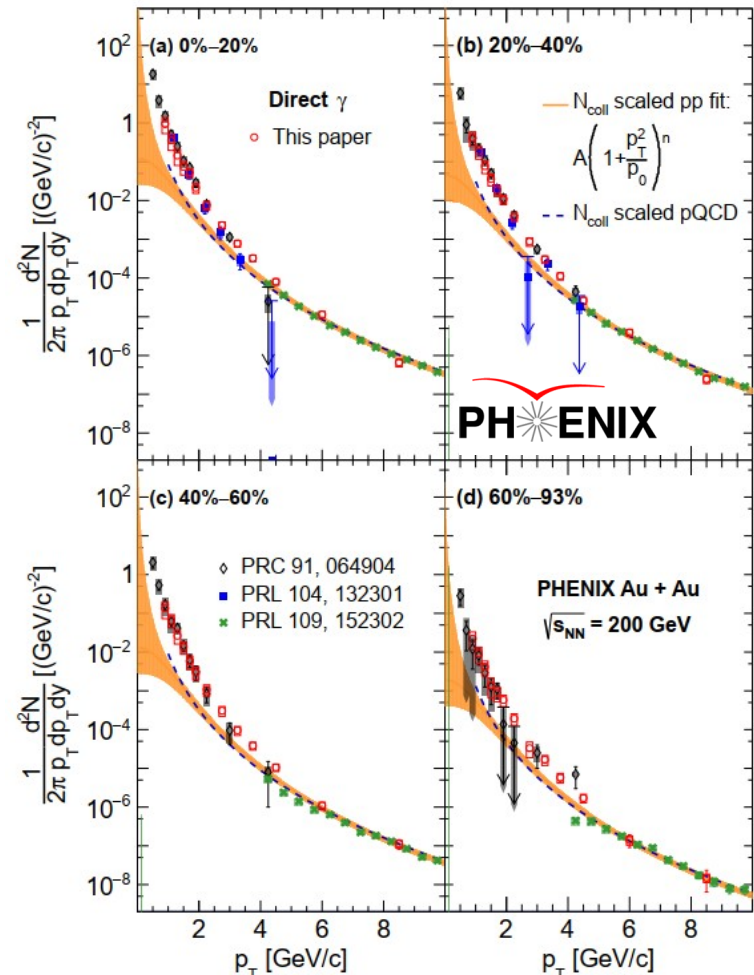
PHYSICAL REVIEW C 107, 024914 (2023)



Talk Tues. 15:30
Vassu Doomra

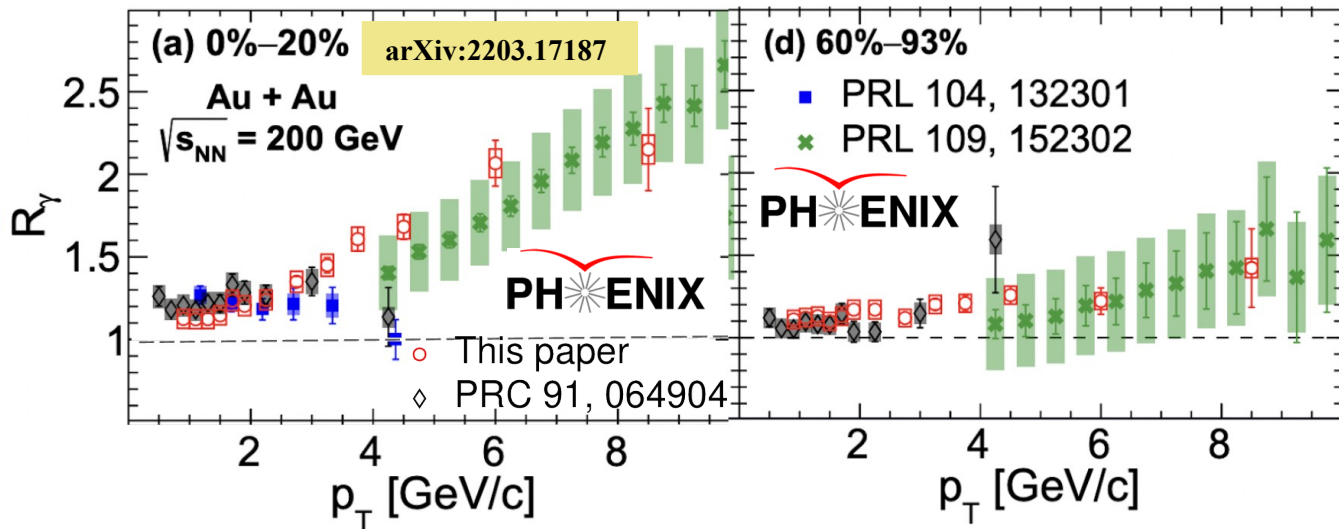
- Systematic measurement of direct γ in various systems and beam energy in wide p_T range





$$R_\gamma = \frac{\mathcal{Y}_{inclusive}}{\mathcal{Y}_{decay}}$$

Talk Tues. 15:30
Vassu Doomra



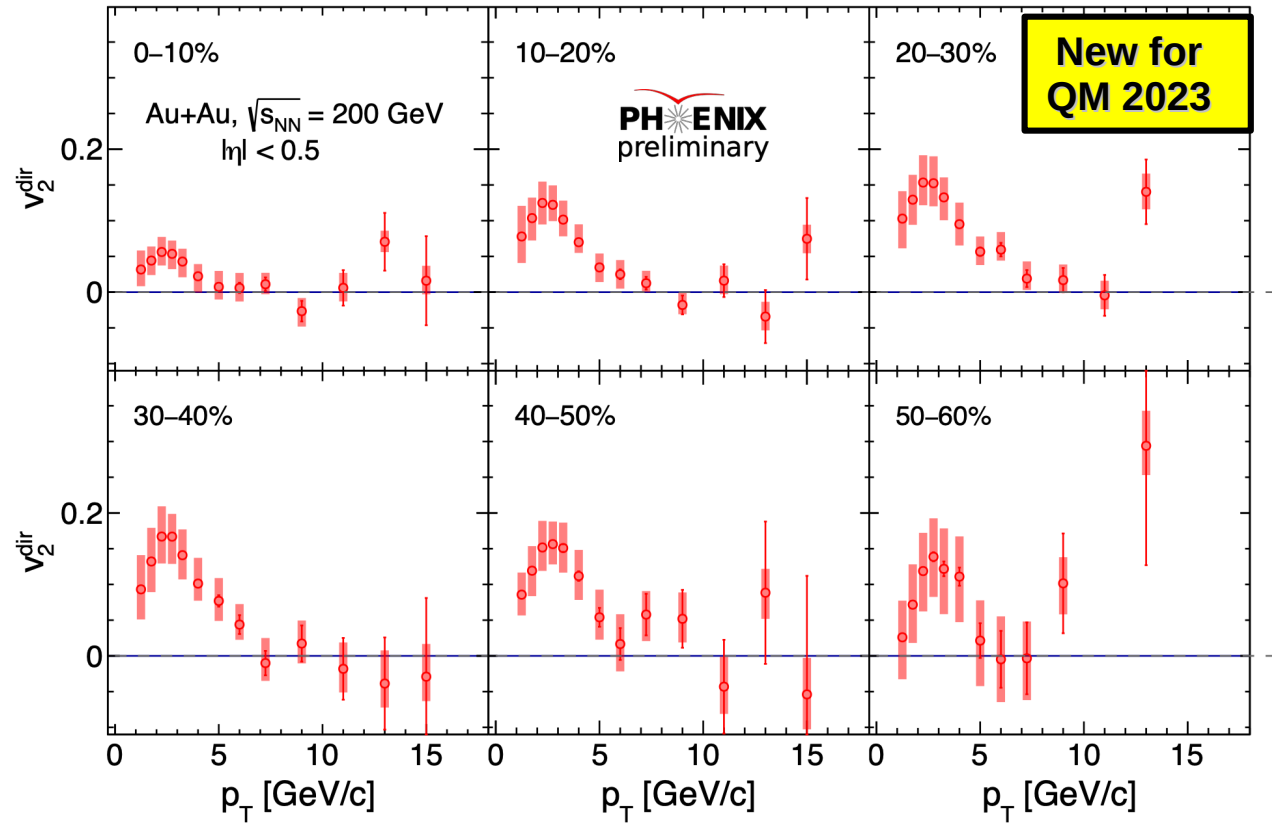
~10× higher statistics

Agreement with previous results

$R_\gamma > 1 \rightarrow$ excess direct photon yield



Direct photon v_2

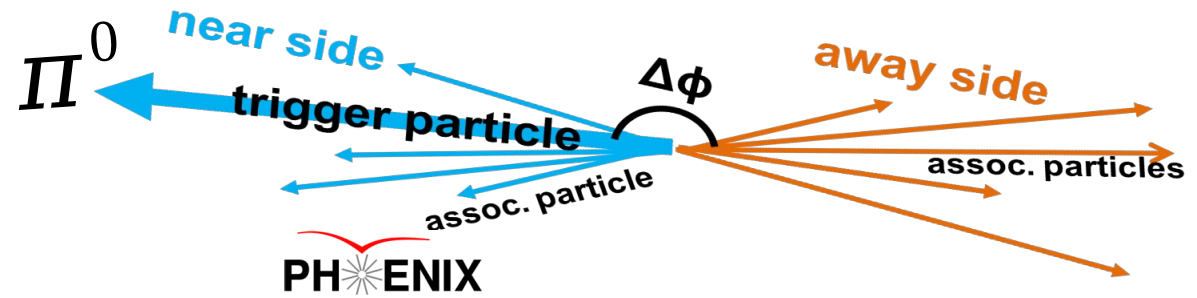
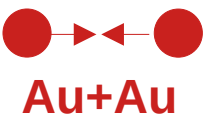


Talk Tues. 15:30
Vassu Doomra

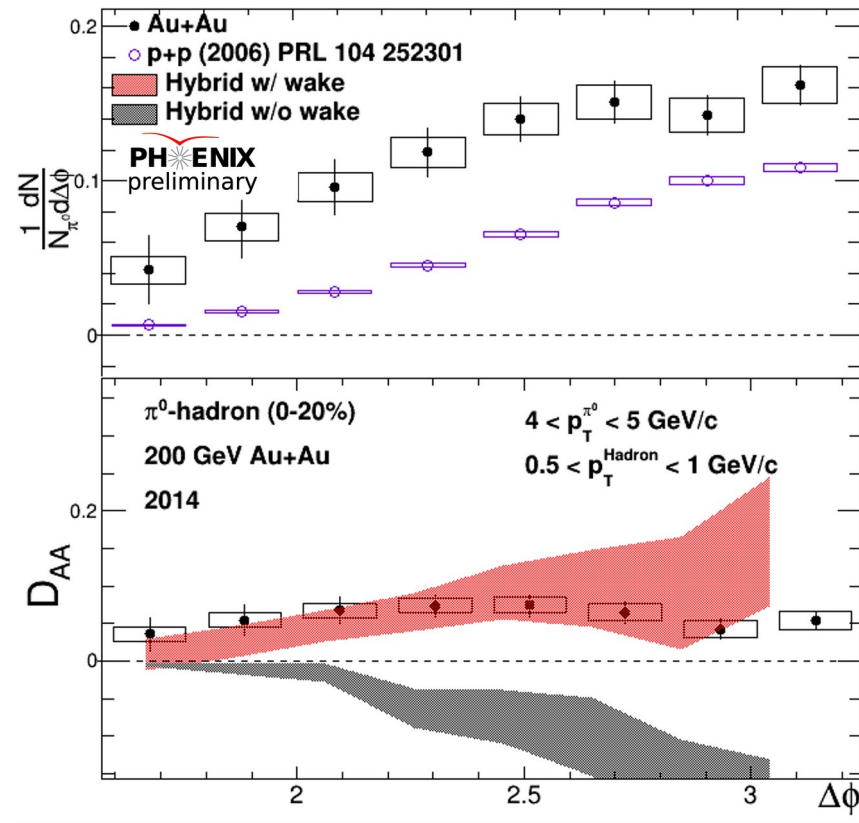
- Significant reduction in stat. & sys. uncertainties
- Direct photon v_2 at high p_T consistent with 0



Medium response to jets



- Enhancement of low p_T hadrons quantified with $D_{AA} = Y_{AA} - Y_{pp}$
- Hybrid model with wake consistent with PHENIX π^0 -h correlations
- Progressing toward direct γ -hadron in high statistics Au+Au data sets



Talk Wed. 10:10 Megan Connors





v_2 at different ZDCe event categorization PHENIX

With fixed ZDC bins, measure v_2 as a function of multiplicity.

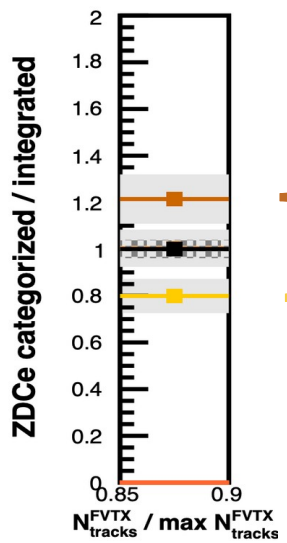
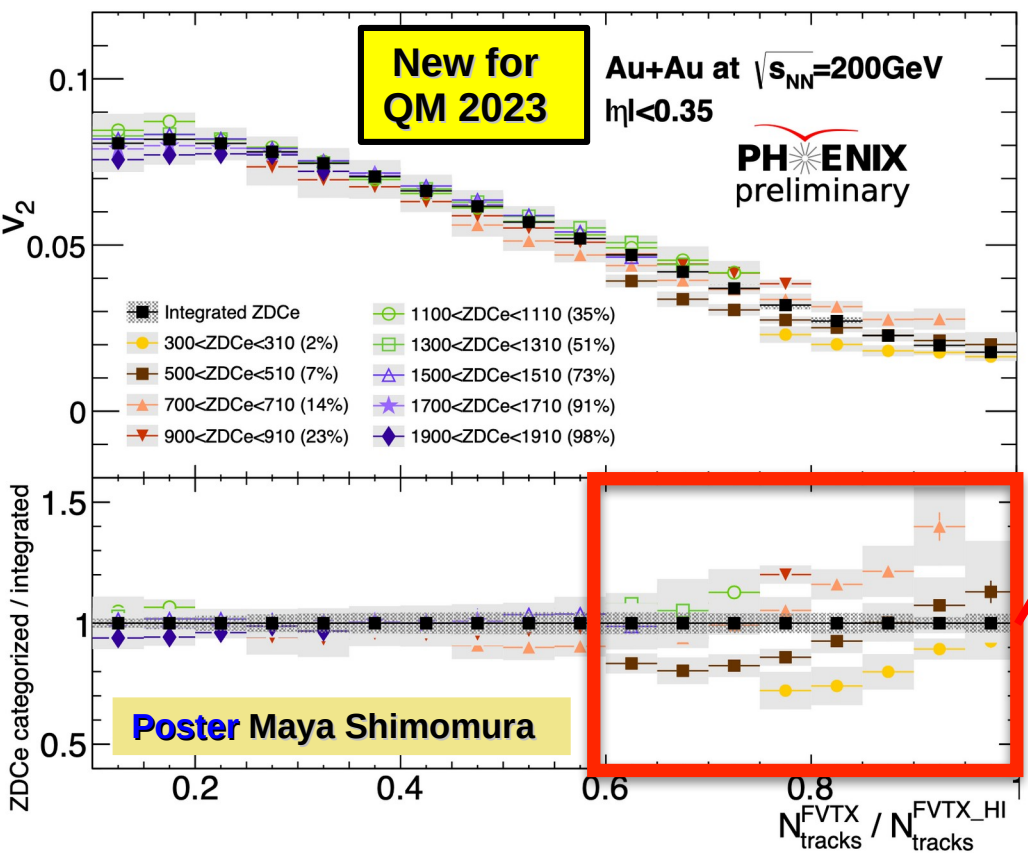
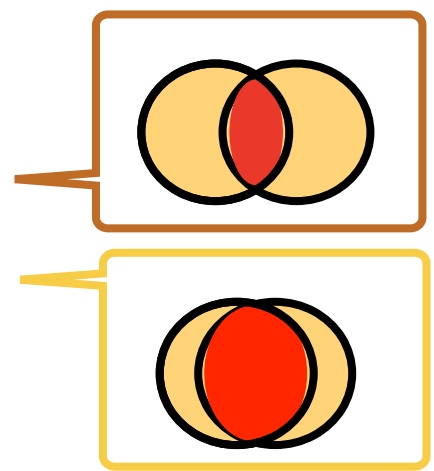


Image of the initial geometry



- These v_2 seem to reflect different initial geometry with same multiplicity.
- N_{part} is different but multiplicity is the same.

Poster Maya Shimomura



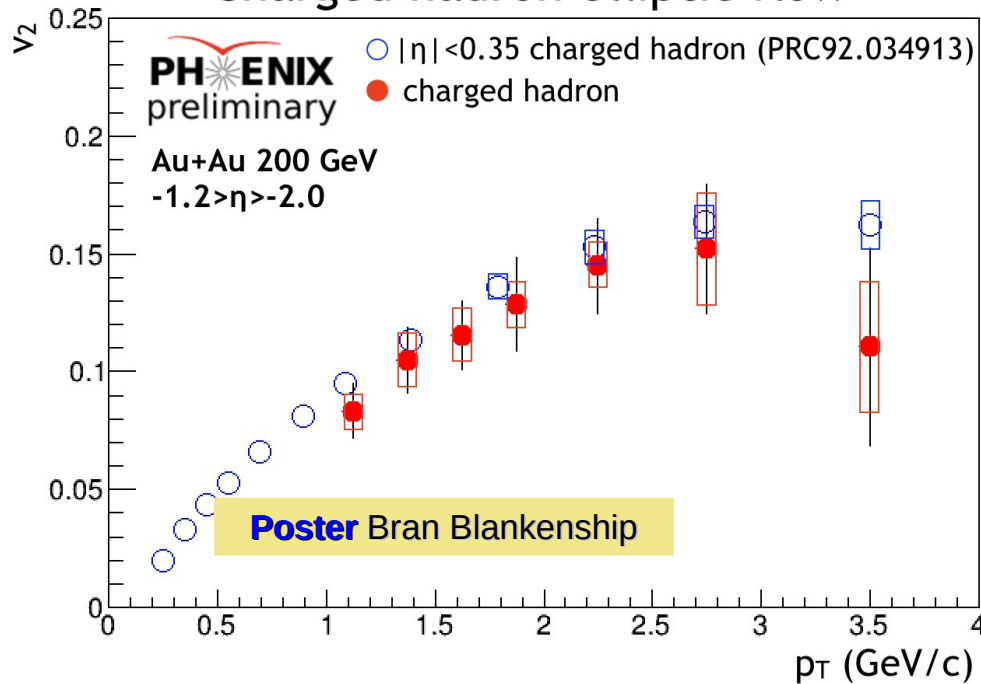


Au+Au

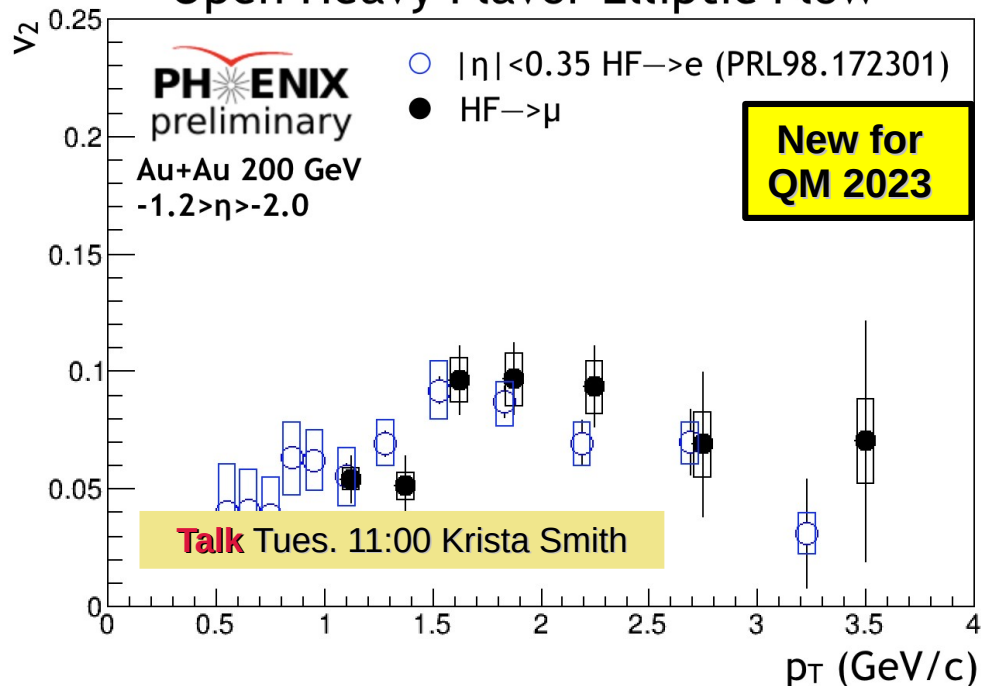
Open Heavy Flavor v_2 at RHIC



Charged hadron elliptic flow



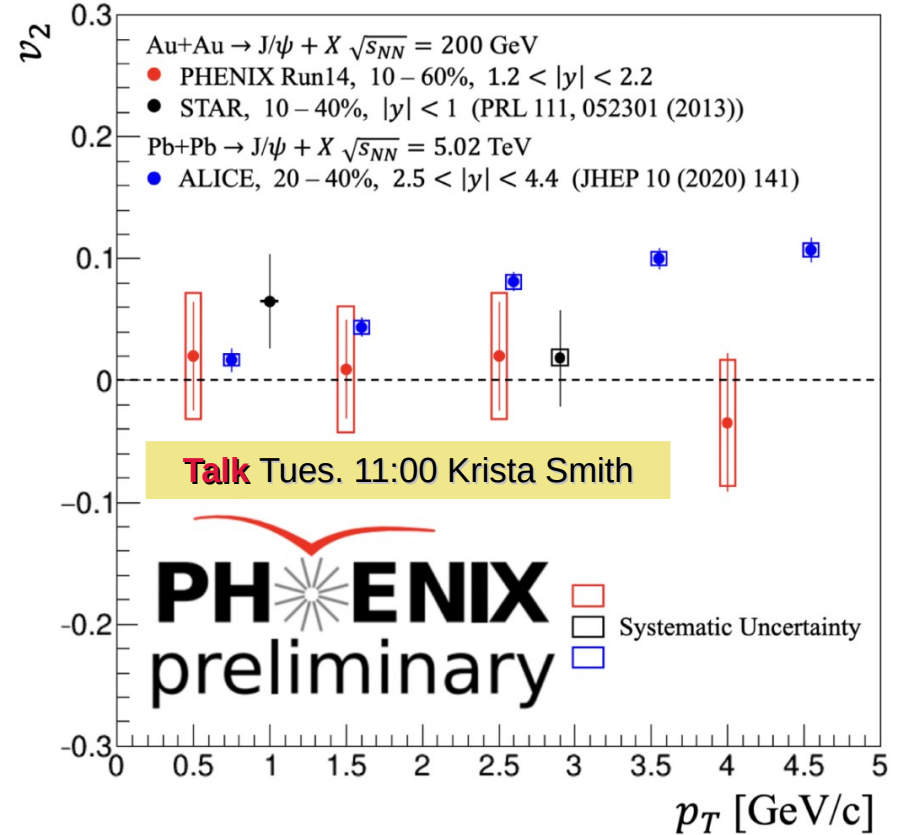
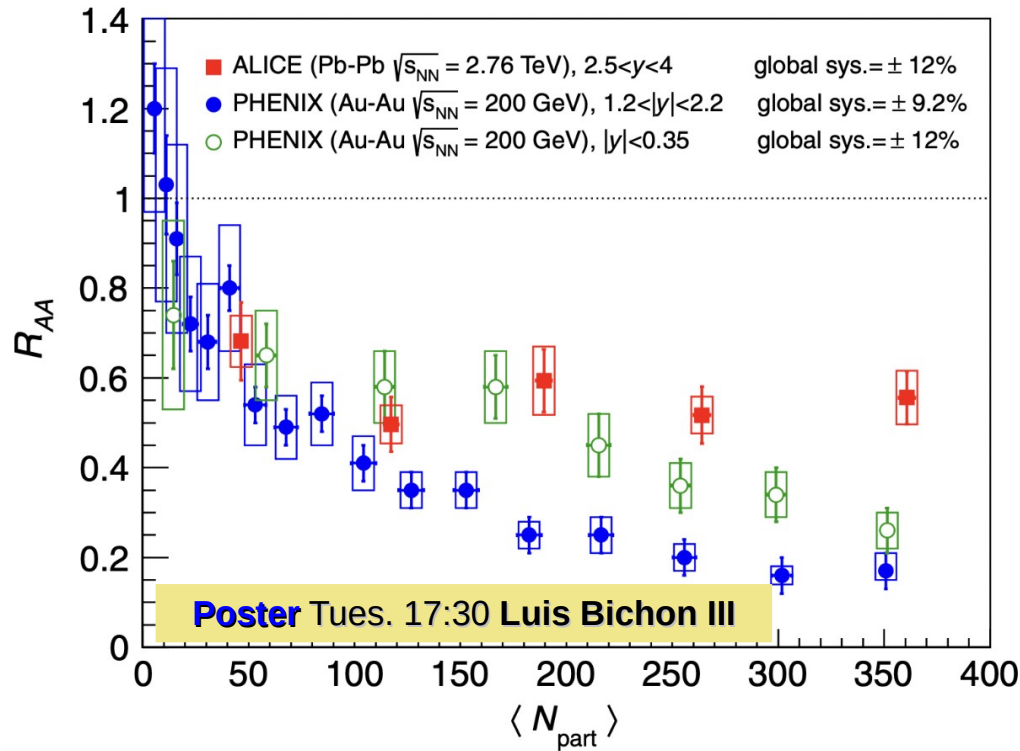
Open Heavy Flavor Elliptic Flow



First-ever RHIC measurement of open heavy flavor elliptic flow at forward rapidity

Mass ordering apparent





- PHENIX J/ψ shows stronger suppression at both forward and mid-rapidity

At RHIC energies, regeneration not as significant, J/ψ flow consistent with zero



Data and analysis preservation

- 192/218 PHENIX papers on HEPData
- REANA is a framework of analysis preservation
- Analysis environment (libraries, etc) are in container (Docker)
- Workflow in YAML
- π^0 and direct γ d+Au analyses implemented

The screenshot shows the HEPData website interface. At the top, there is a search bar with the text "Search HEPData" and a search button. To the right of the search bar are links for "About", "Submission Help", "File Formats", and "Sign in". Below the search bar, there are filters for "PHENIX" and "Advanced", and a "JSON" button. The main content area displays search results for "PHENIX" with 162 results. A sidebar on the left shows filters for "Date", "Collaboration", "Subject areas", "Phrases", "Reactions", and "CM Energies (GeV)". The main content area shows two search results. The first result is titled "Transverse single-spin asymmetry of midrapidity π^0 and η mesons in p^+Au and p^+Al collisions at $\sqrt{s_{NN}} = 200$ GeV" and includes a bar chart showing the date of publication from 2001 to 2023. The second result is titled "Measurement of ϕ -meson production in Cu+Au at $\sqrt{s_{NN}} = 200$ GeV and U+U at $\sqrt{s_{NN}} = 193$ GeV" and includes a line graph showing invariant transverse momentum spectra.

Conclusions

- PHENIX continues many high impact analyses
- Signatures consistent with hot nuclear matter in small systems
 - Direct photon excess
 - Azimuthal anisotropies
 - Suppression in central d+Au
- New precision measurements of QGP in Au+Au
 - Direct photon v_2 , spectra
 - Heavy flavor v_2 , spectra

PHENIX at QM23

Talk Heavy Flavor and Quarkonia results from the PHENIX experiment Tues. 11:00 **Krista Smith (LANL)**

Talk Isolating final state effects in high p_T π^0 production using direct photons in small system collisions with PHENIX Tues. 13:00 **Daniel Firak (Stony Brook)**

Talk Measurement of low p_T direct photons with PHENIX Tues. 15:30 **Vassu Doomra (Stony Brook)**

Talk Measurement of in-medium modification of energy-space structure of jets via and triggered hadrons in Au+Au collisions at RHIC Wed. 10:10 **Megan Connors (Georgia State)**

Poster Elliptic flow measurement of J/ψ in PHENIX Run14 Au+Au at $\sqrt{s_{NN}}=200$ GeV Tues. 17:30 **Luis Bichon III (Vanderbilt)**

Poster Forward Physics with light vector mesons and π^0 from the PHENIX Experiment Tues. 17:30 **Uttam Acharya (Georgia State)**

Poster Particle multiplicity dependent Charmonia production in p+p collisions by the PHENIX experiment Tues. 17:30 **JongHo Oh (Pusan National University)**

Poster PHENIX measurements of identified charged hadron production in p+Al, p+Au, and Cu+Au collisions at $\sqrt{s_{NN}} = 200$ GeV Tues. 17:30 **Sanghoon Lim (Pusan National University)**

Poster Systematic study of energy loss in the QGP for various collision systems at PHENIX Tues. 17:30 **Takashi Hachiya (Nara Women's University)**

Poster Di-electron continuum in p+p collisions at 200 GeV Tues. 17:30 **Roli Esha (Stony Brook)**

Poster Neutral pion and eta meson production in Au+Au collisions at 200 GeV Tues. 17:30 **Dading Chen (Stony Brook)**

Poster Measurement of neutral pions and direct photons in $^3\text{He}+\text{Au}$ collisions Tues. 17:30 **Daniel Firak (Stony Brook)**

Poster PHENIX Measurements of Azimuthal Anisotropy of Light and Heavy Flavor Hadrons in Au+Au Collisions at Forward Rapidity Tues. 17:30 **Brandon Blankenship (Vanderbilt)**

Poster The study of with a new double-differential event categorization using multiplicity and spectator neutrons in PHENIX Tues. 17:30 **Maya Shimomura**