



Highlights from PHENIX

IWHSS 2023

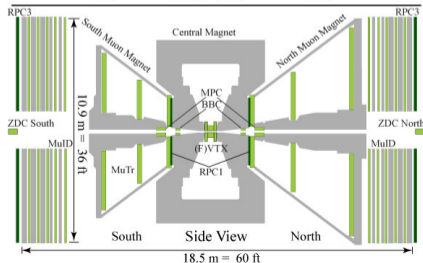
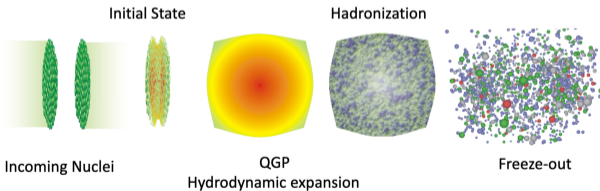
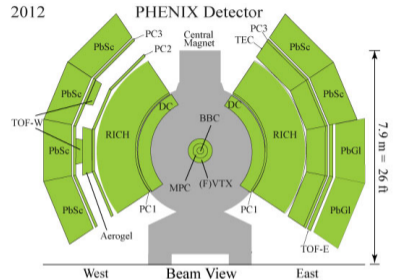
Ujvári Balázs

ujvari.balazs@inf.unideb.hu

UNIVERSITY OF DEBRECEN

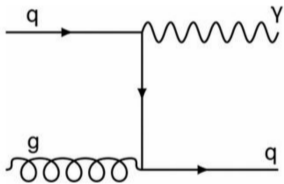


1. PHENIX stopped data taking after 2016
2. Ongoing analyses of large data sets taken in 2014, 2015, and 2016
3. Data and Analysis Preservation

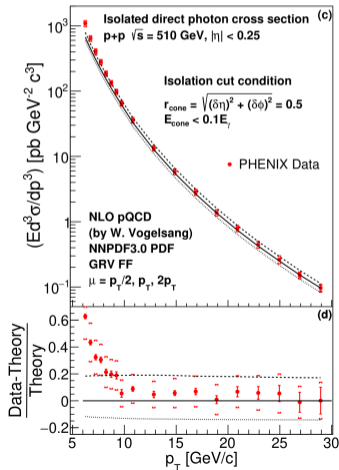


p + p

The quark-gluon Compton process sensitive to polarized gluon distribution



in proton-proton collisions at RHIC is the dominant contributor to the **direct photons** with $p_T > 5$ GeV
arXiv:2202.08159

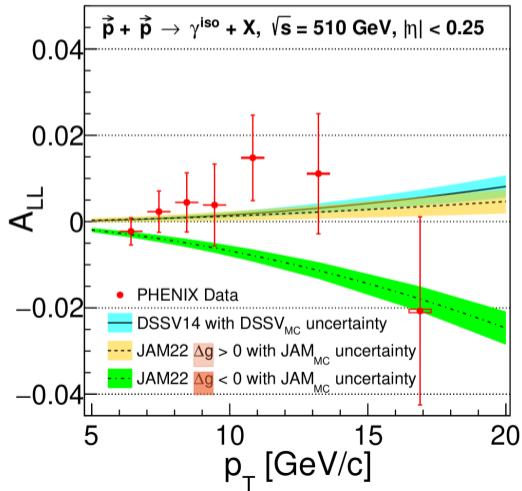
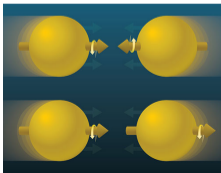


The double-helicity asymmetry is defined as:

$$A_{LL} = \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}}$$

Our data are well consistent with the **positive gluon-spin contributions** and strongly disfavor the negative gluon-spin scenario, that the previously published data were unable to resolve.

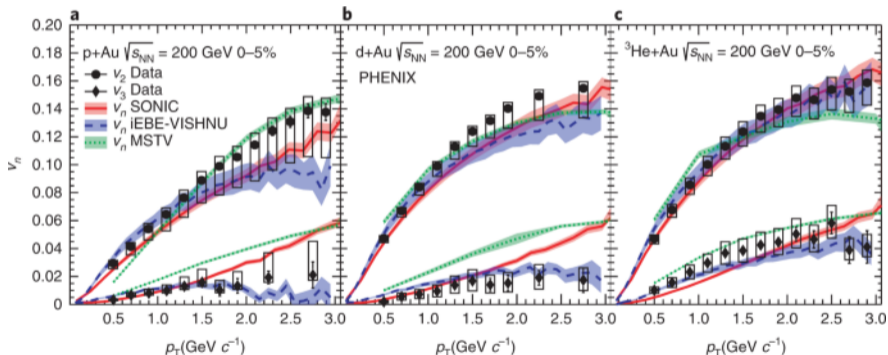
arXiv:2202.08159



Small Systems – flow with event plane (EP) method

v_2 : p+Au < d+Au \sim ^3He +Au

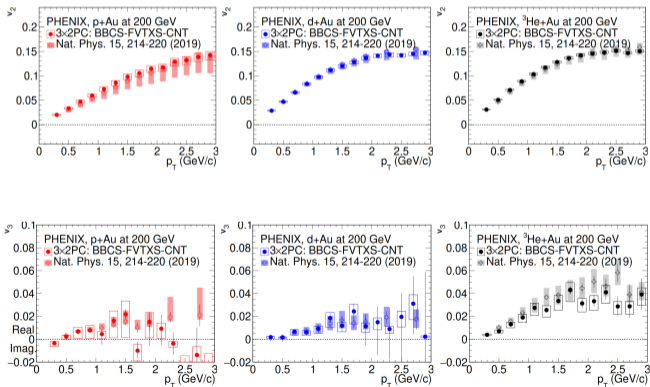
v_3 : p+Au \sim d+Au < ^3He +Au



Anisotropy of charged particle production **consistent with hydrodynamic** expansion.
 Nature Phys. 15 (2019) 214 – QGP droplets even in small systems?

Small Systems – flow cross-checked with 2-particle correlations

Three sets of detector combinations to extract two-particle correlations \rightarrow 3 \times 2PC
 Less sensitive to non-flow effects



PRC 107 (2023) 024907 – consistent with EP results

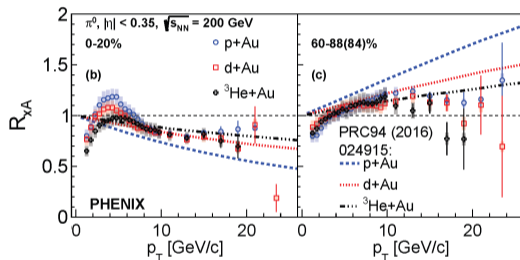
If QGP droplets, do we also see initial/final state effects?

What about nuclear modification factor (R_{xA})?

QGP droplets may or may not cause suppression (parton energy loss needs path-length)

Suppression observed in central, but enhancement seen in peripherals – no obvious explanation

Possible p_T -dependent bias in centrality categorization?



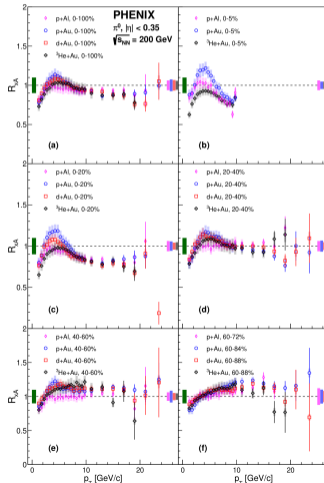
Data PRC 107 (2023) 024907

Theory curves PRC 94 (2016) 024915 –
fluctuating nucleon size: predicted ordering
with system size not observed

R_{xA} evolution with centrality in small systems

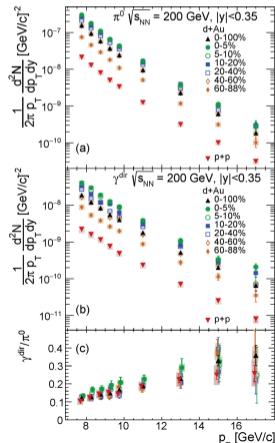
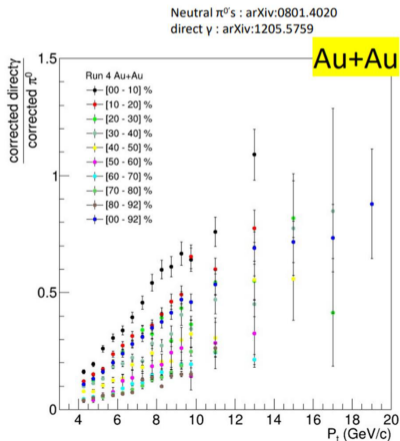
1. $p_T > 8 \text{ GeV}/c$ constant for the same centrality selection from different collision systems
2. **Central** the Cronin peaks height value shows a clear system size dependence
 $p \rightarrow d \rightarrow {}^3\text{He}$
3. **Peripheral** 15 % enhancement - unexplained.
Potential bias in centrality determination?

PRC 105 (2022) 064902



Use direct photons (not sensitive to QGP) to normalize hadron spectra?

γ/π^0 ratios: in case of Au+Au clear separation with centrality, but overlapping for d+Au (except for extremely central collisions)

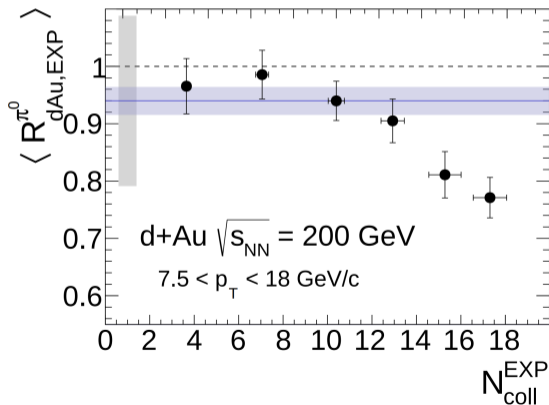


No enhancement in peripherals, but still signs of suppression in most central collisions

High p_T direct photons are used to experimentally estimate the number of binary collisions.

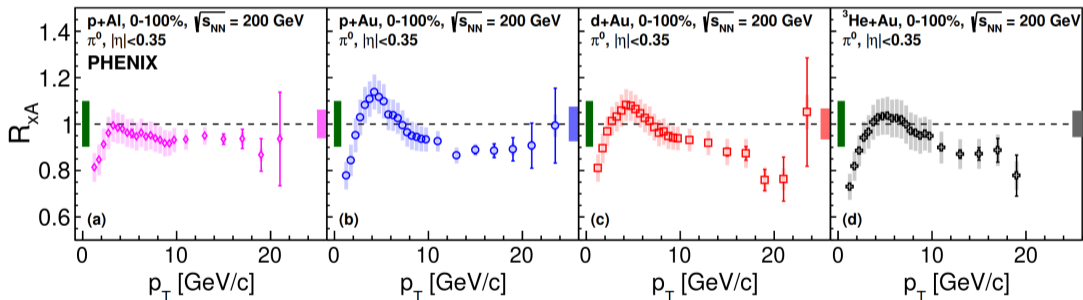
$R_{dAu,EXP}^{\pi^0}$ for 0-100%

Further studies of the system size dependence with p+Au, d+Au, and 3He+Au collisions may shed more light on the existence of droplets of QGP in small systems



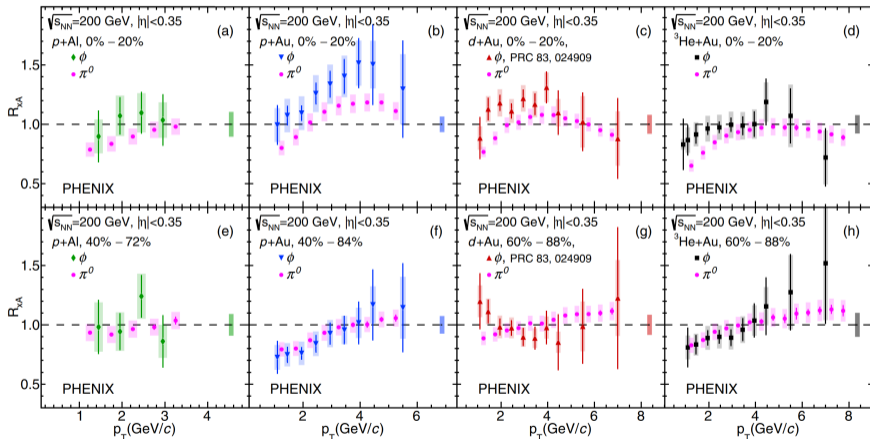
System-size dependence of R_{xA} in 0-100% centrality

Cronin peaks, around 4 GeV/c, increase with the target size and broadening with projectile. At high p_T data consistent with unity.



No or minimal modification of the hard scattering component in small systems for 0-100%.
 PRC 105 (2022) 064902

Strangeness enhancement should be another sign of QGP



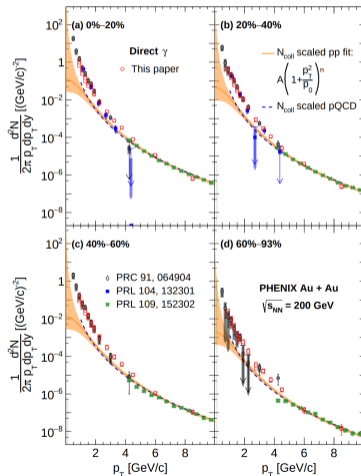
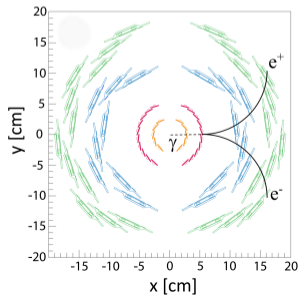
PRC 106, 014908 (2022) **strangeness enhancement cannot be concluded**

Au + Au

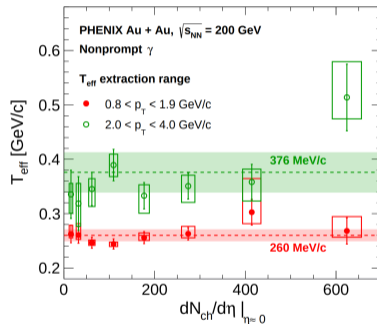
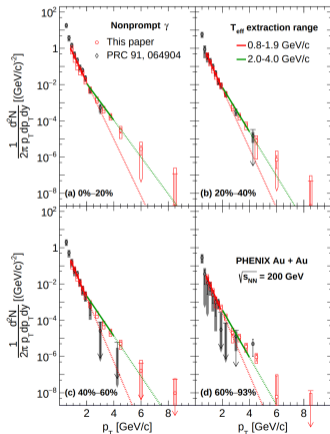
direct photons with conversion method

$p_T > 5 \text{ GeV}/c$ well described by N_{coll} -scaled
p+p results and pDQC calculation

$p_T < 5 \text{ GeV}/c$ direct-photon excess
becoming larger towards lower p_T



Photon effective temperatures vs $dN/d\eta$ in different p_T ranges



late QGP stage until freeze-out

contributions from the pre-equilibrium phase

arXiv 2203.17187

Summary

Small step in 'spin crisis', waiting for EIC

Small systems: more and more questions

Au+Au more results after finishing the Run14 and Run16

Direct photon puzzle: more analyses to solve

N_{coll} , centrality, need new methods

Thank you for your attention!



Thanks to the National Research, Development and Innovation Office (Hungary)
OTKA-131991.