Kinematic dependence of the v_2 measured in small collision systems at PHENIX

Takahito Todoroki
(for the PHENIX Collaboration)
University of Tsukuba, Ibaraki, Japan
todoroki@bnl.gov

PHENIX

筑波大学
University of Tsukuba

Motivation

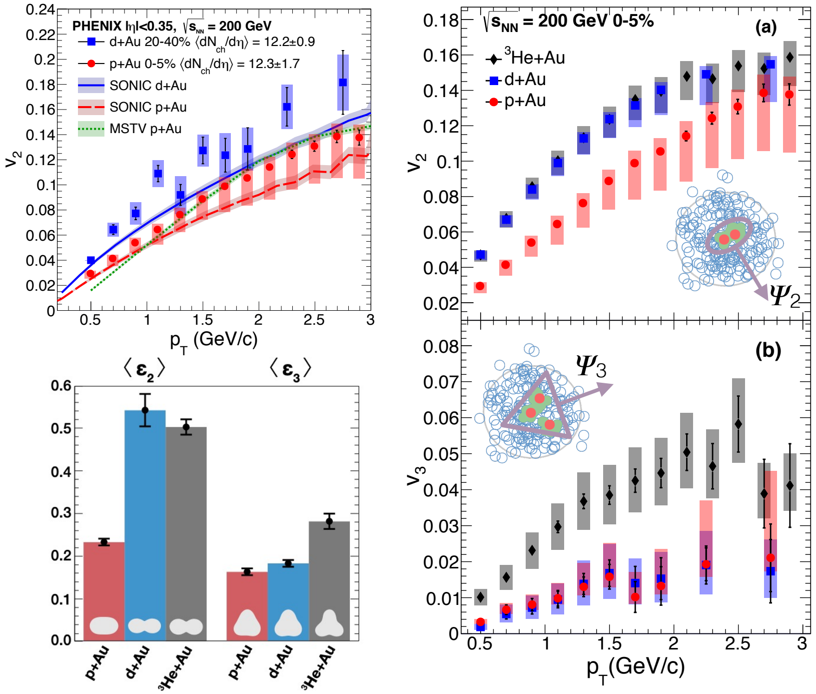
- Mid-rapidity v_2 and v_3 measured in small collisions
  - can be described by hydrodynamic calculations
  - show a scaling with respect to the initial geometry

$$\varepsilon_2^{^3\mathrm{He+Au}} \sim \varepsilon_2^{\mathrm{d+Au}} > \varepsilon_2^{p+Au} \quad \Rightarrow \quad v_2^{^3\mathrm{He+Au}} \sim v_2^{\mathrm{d+Au}} > v_2^{p+Au}$$

$$\varepsilon_3^{^3\mathrm{He+Au}} > \varepsilon_2^{\mathrm{d+Au}} \sim \varepsilon_2^{p+Au} \quad \Rightarrow \quad v_3^{^3\mathrm{He+Au}} > v_2^{\mathrm{d+Au}} \sim v_2^{p+Au}$$

→ Compelling evidence of the QGP formation in small collision systems at RHIC top energy

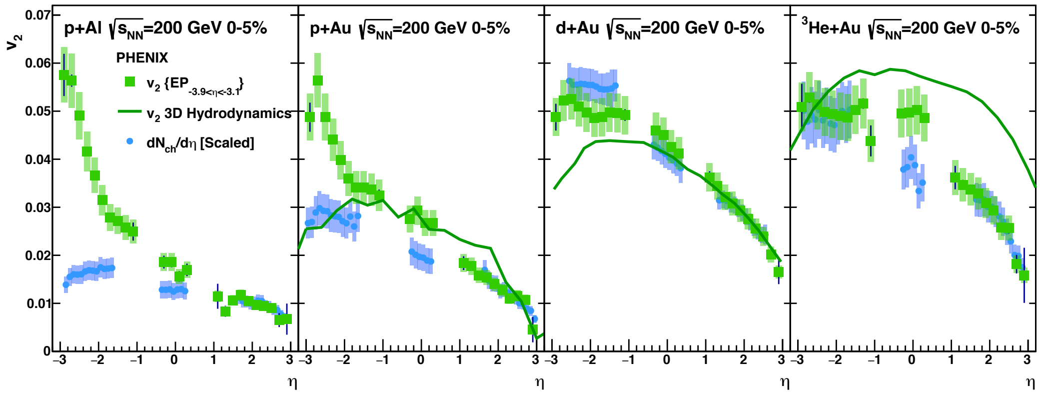
Nature Phys. 15 (2019) 3, 214-220, PHENIX Collaboration



- Further measurements find strong depedence of v_2 and multiplicity on pseudo-rapidity

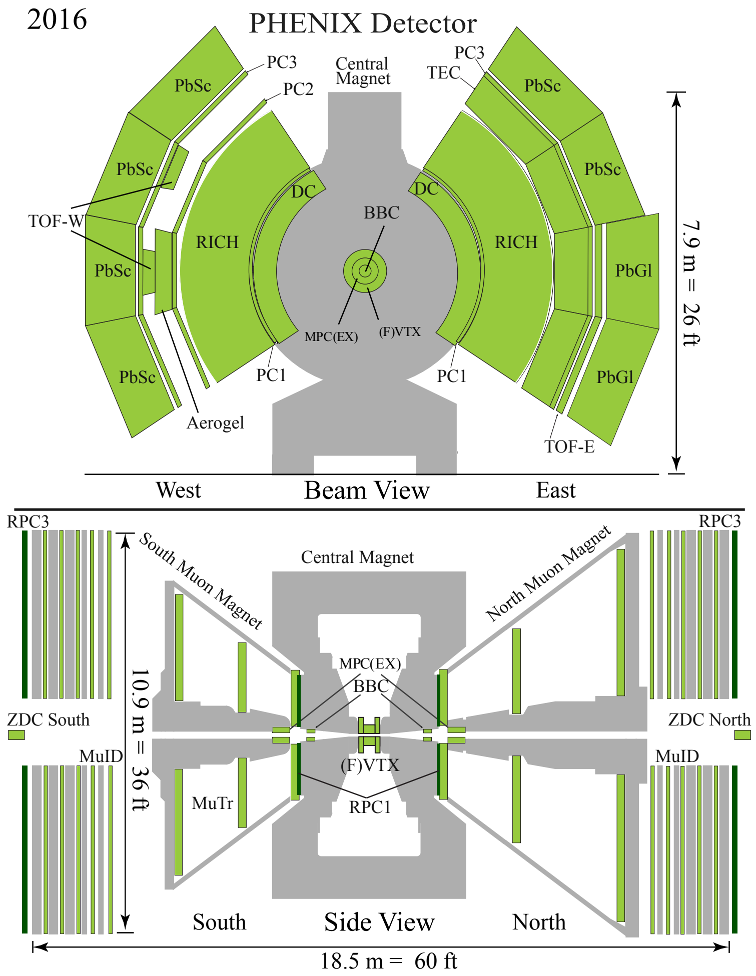
→ Important to understnd possible dependence of mid-rapidity v_2 on kinematic range selections used in the measurements in p+Au, d+Au, and ^{3}He+Au collisions

Phys. Rev. Lett. 121, 222301 (2018), PHENIX Collaboration



PHENIX Detector

- BBC ($3.1 < |\eta| < 3.9$)
  - triggers on events
  - provides z-vertex information
  - categorizes event multiplicity using a sum of ADC in PMTs
- Central Arm ($|\eta| < 0.35$, $\phi = \pi/2 \times 2$)
  - provides tracking with momentum information
- FVTX ($1 < |\eta| < 3$)
  - determines precise vertex position
  - provides tracking without momentum information

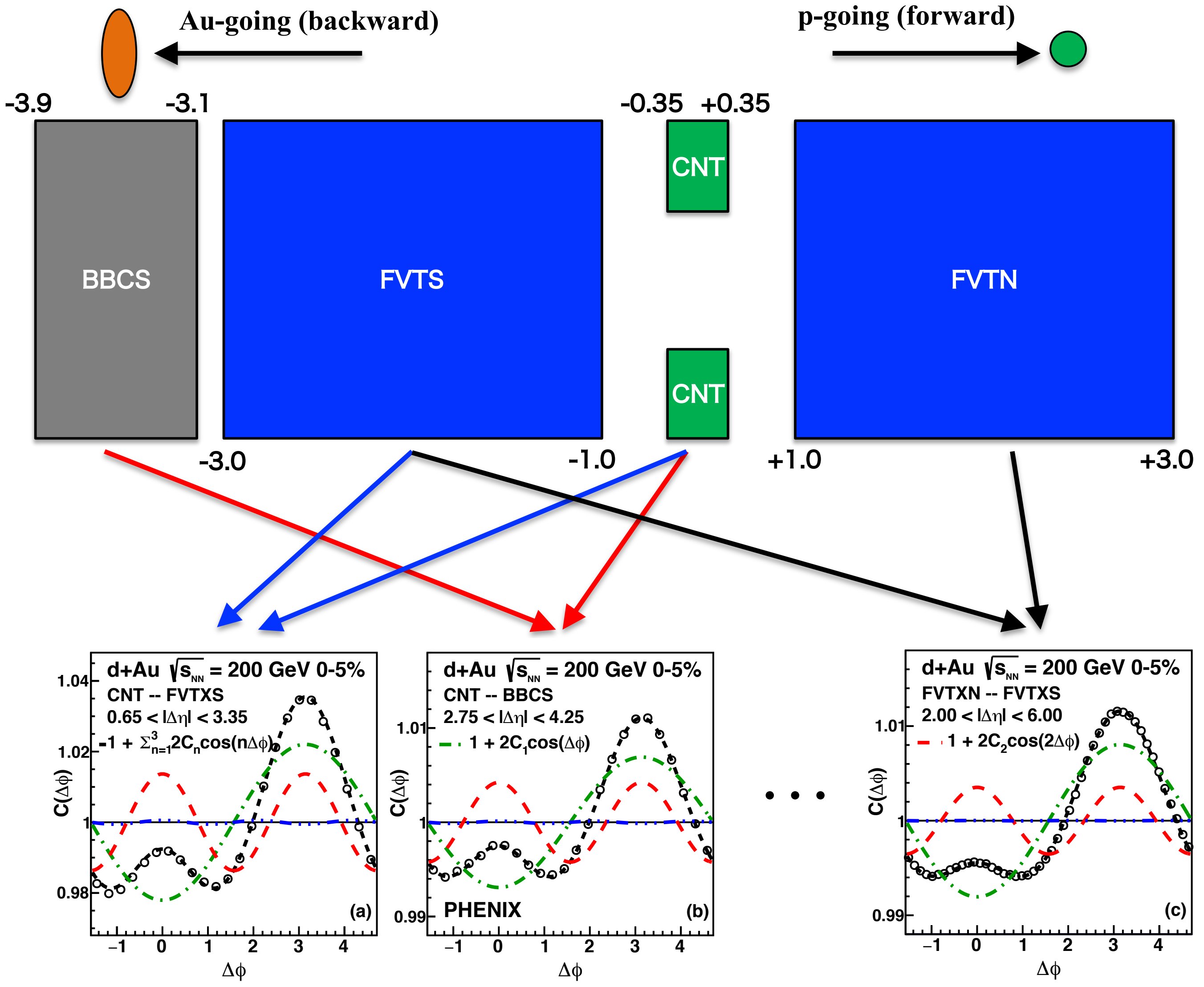


Analysis Method

- Construct three different two-particle correlations (3 × 2PC) with a set of three kinematic ranges using event mixing
- Obtain second-order oscillations C_2 in the 3 × 2PC using Fourier fits
- Calculate v_2 using the C_2 as

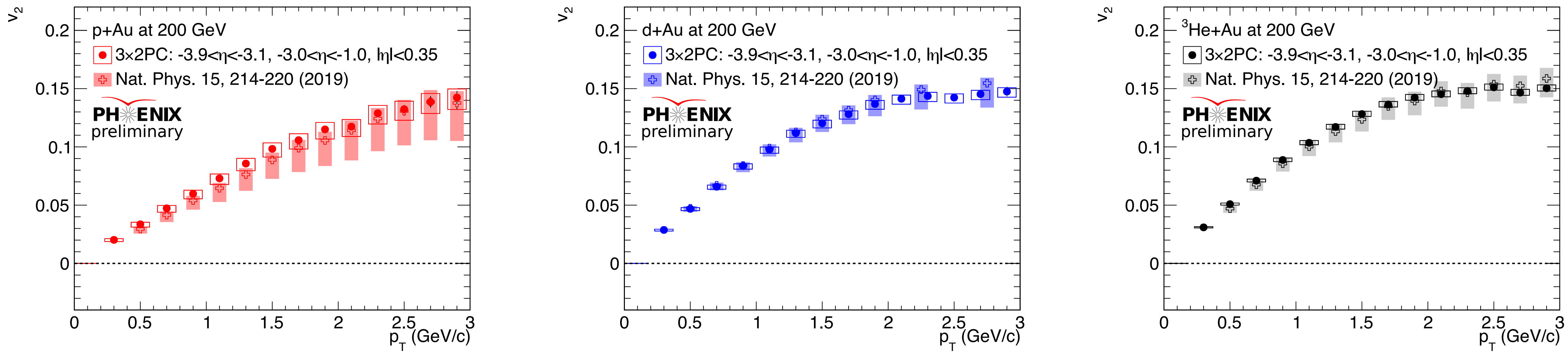
$$v_2^{\mathrm{A}} = \sqrt{\frac{C_2^{\mathrm{AB}} \times C_2^{\mathrm{AC}}}{C_2^{\mathrm{BC}}}} \qquad C_2^{\mathrm{AB}} = v_2^{\mathrm{A}} \times v_2^{\mathrm{B}}$$

A, B, C : kinematic ranges



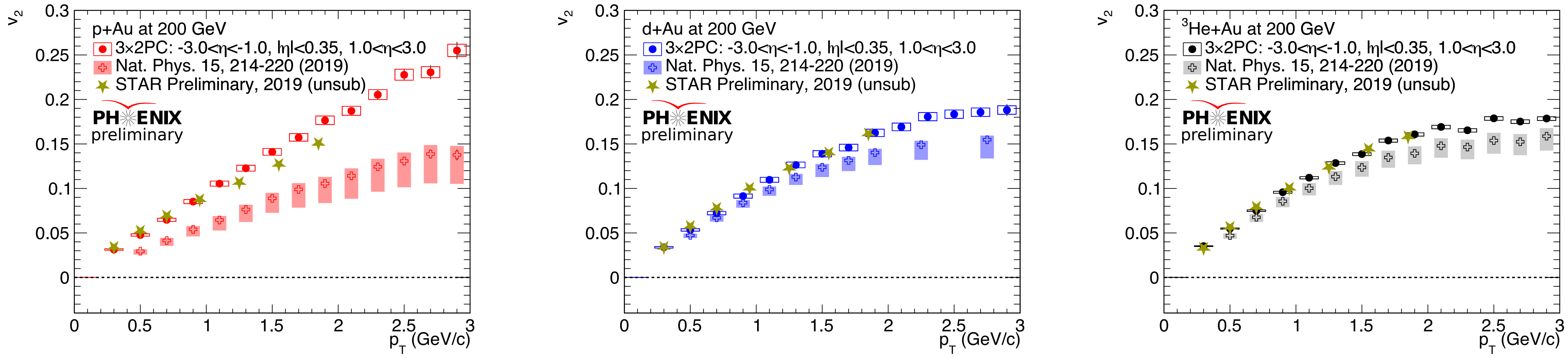
- Measure v_2 with **backward-backward-mid** and **backward-forward-mid** rapidity combinations using these detectors :
  - **FVTXS – BBCS – CNT**
  - **FVTXS – FVTXN – CNT**

v_2 using FVTXS – BBCS – CNT



- New v_2 results via 3×2PC using FVTXS – BBCS – CNT are in excellent agreement with the previsouly reported PHENIX Nature results that use the same detectors in p+Au, d+Au, and ^{3}He+Au collisions
- Confirm the robustness of the Nature and 3×2PC results

v_2 using FVTXS – FVTXN – CNT



- New v_2 results via 3×2PC, including FVTXN instead of BBCS, are higher than the Nature results
- These observations are consistent with the expectations :
  - Smaller multiplicity in FVTXN results in more non-flow in the numerator → larger v_2
  - Wider rapidity gap btwn FTXS-N results in more de-correlation effects in the denominator → larger v_2

$$v_2^{\mathrm{CNT}} = \sqrt{\frac{C_2^{\mathrm{CNT-FVTXS}} \times C_2^{\mathrm{CNT-FVTXN}}}{C_2^{\mathrm{FVTXS-FVTXN}}}}$$

- Interestingly, this detector combination can qualitatively or quantitatively reproduce STAR preliminary results in p+Au, d+Au, and ^{3}He+Au collisions

Summary

- New v_2 results via 3×2PC using FVTXS – BBCS – CNT are in excellent agreement with the previously reported PHENIX Nature results in p+Au, d+Au, and ^{3}He+Au collisions cofirming the robustness of these results

- New v_2 results via 3×2PC using FVTXS – FVTXN – CNT are higher than the PHENIX Nature results in p+Au, d+Au, and ^{3}He+Au collisions, which is consistent with the expectations that more non-flow and de-correlation effects exsit in this kinematic range combination
- These v_2 are qualitatively or qunatitatively consistent with STAR preliminary results in p+Au, d+Au, and ^{3}He+Au collisions

- These new measurements find that kinematic range selection is very important in v_2 measurements in small collision systems and one needs to keep in mind this when comparing different measurements