Study of kinematic dependence of azimuthal anisotropies in small collision systems at PHENIX

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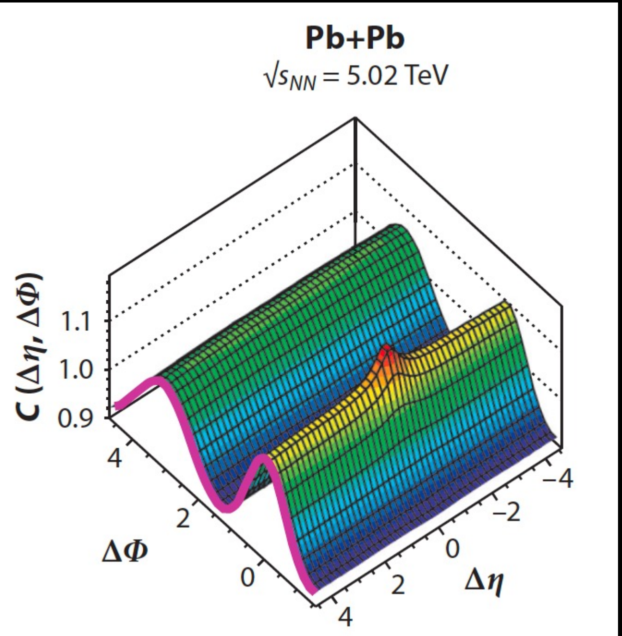
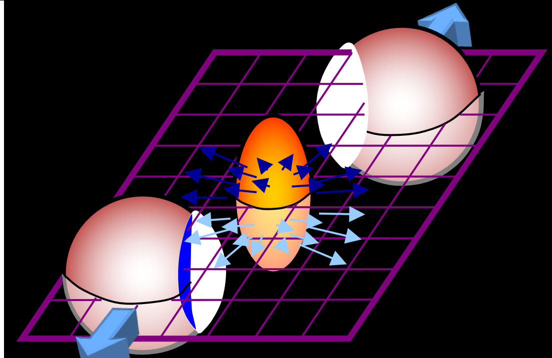
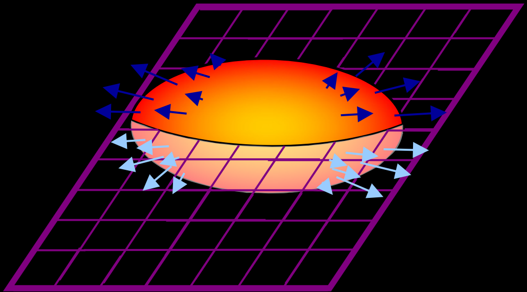
Collectivity in heavy-ion collisions



Azimuthal correlation
in long-range

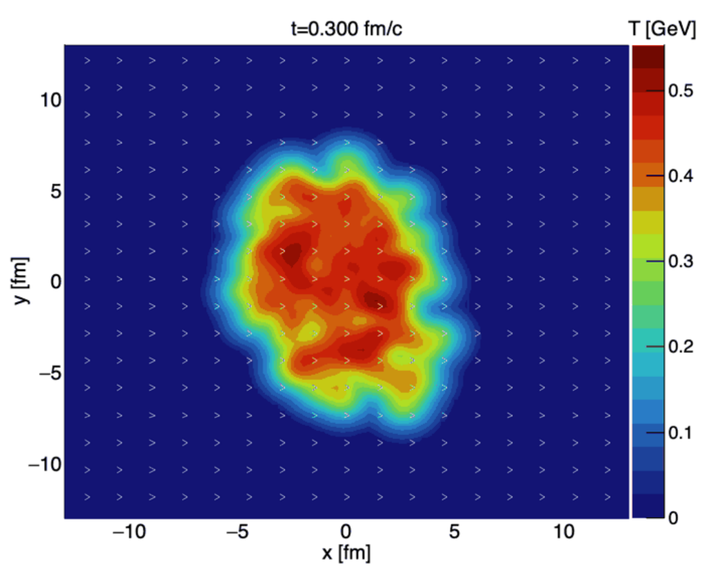


Initial geometry

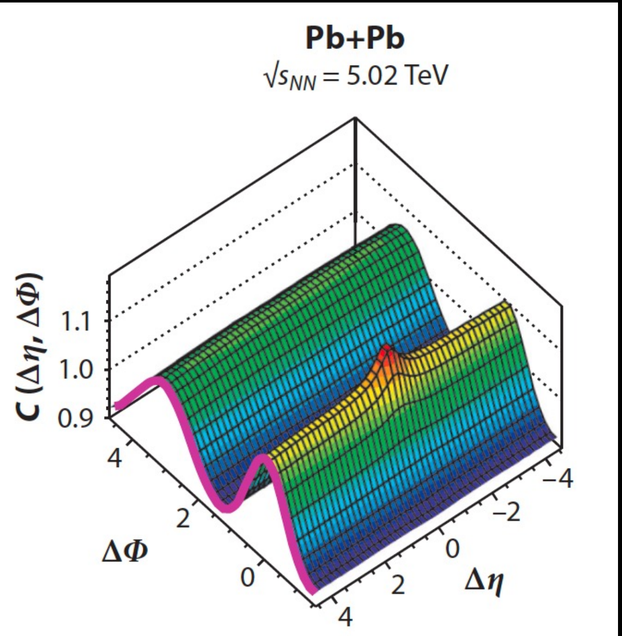


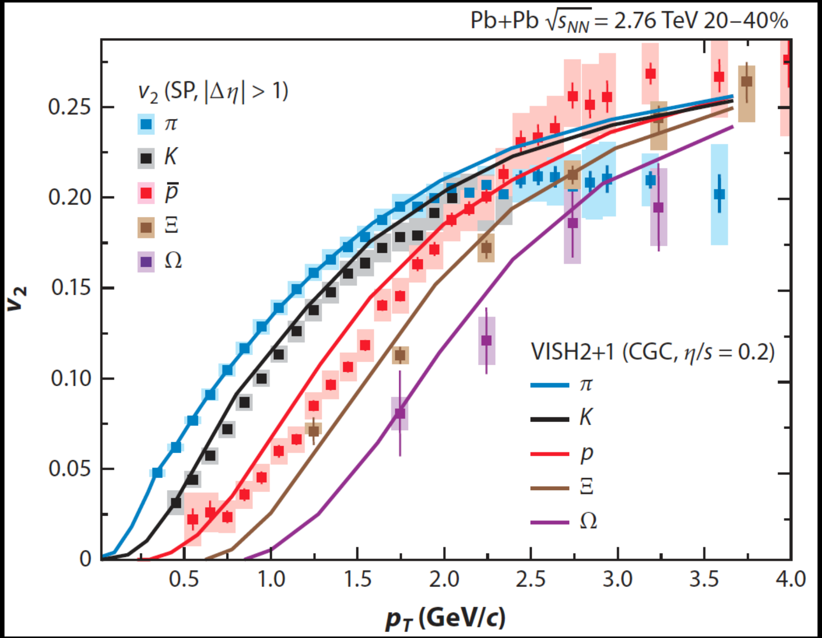
Momentum anisotropy

$$\frac{dN}{d\phi} = 1 + 2v_2\cos[2(\phi-\Psi_2)] + 2v_3\cos[3(\phi-\Psi_3)] + 2v_4\cos[4(\phi-\Psi_4)] + 2v_5\cos[5(\phi-\Psi_5)] + \dots$$



MC Glauber+SONIC

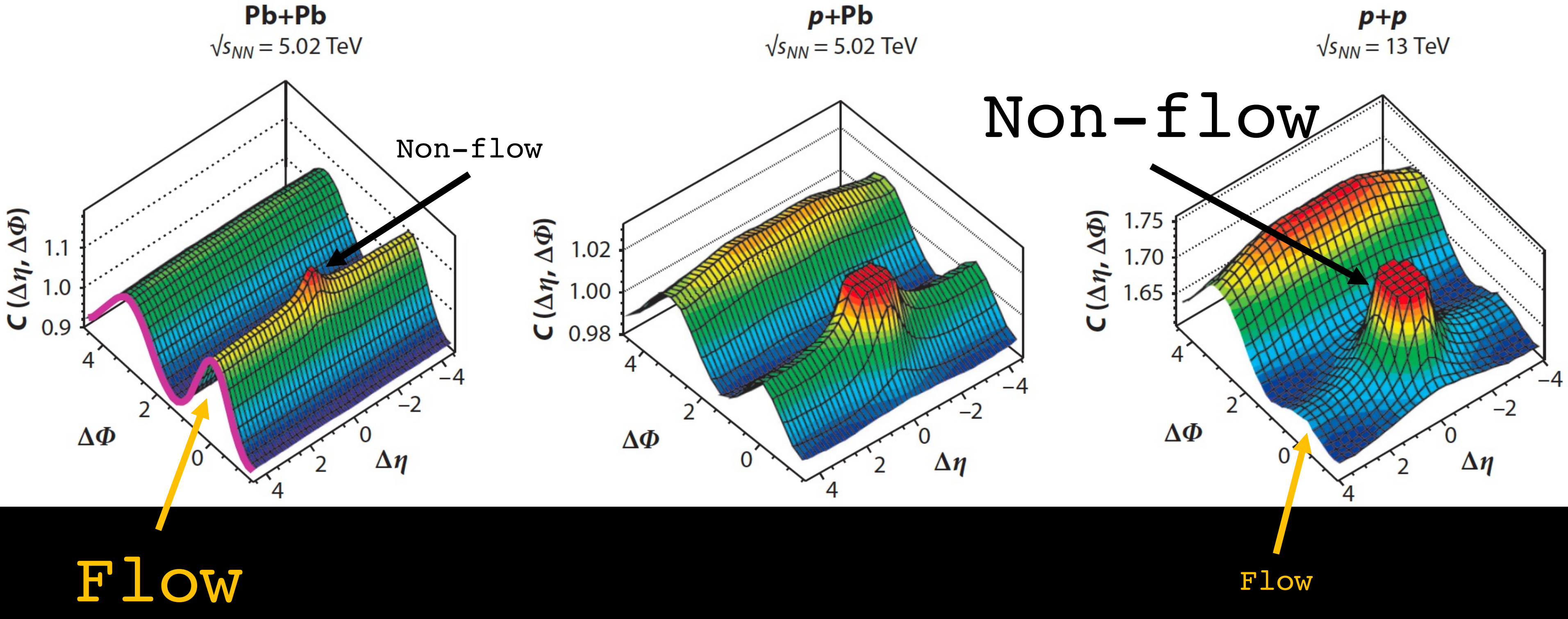




Azimuthal correlation in long-range

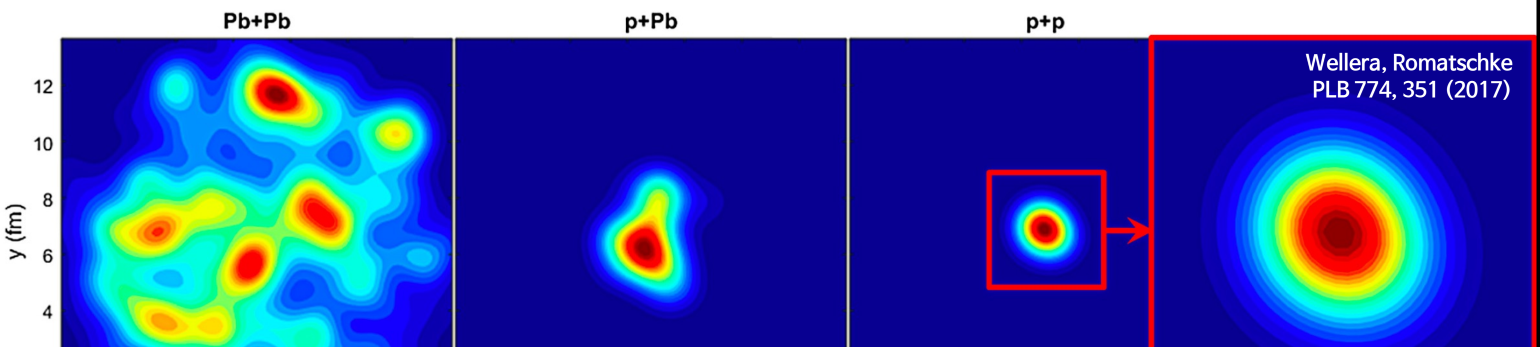
Event-by-event initial geometry & viscous hydrodynamics successfully describe flow results!

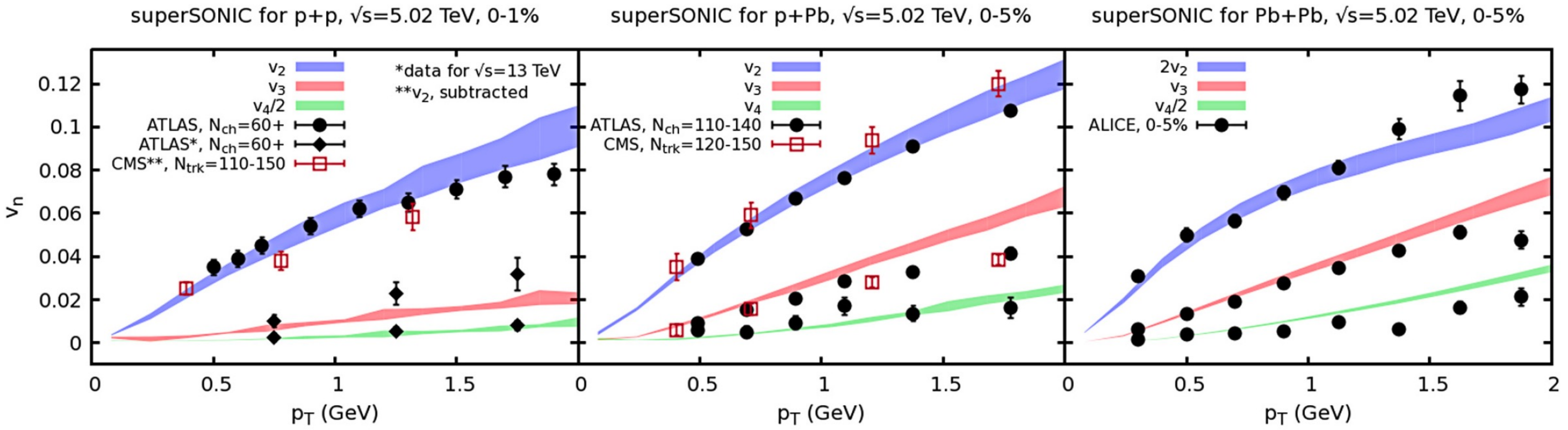
Collectivity in small collision systems



Long-range correlation is observed even in small systems
But, the non-flow contribution should be considered (subtracted) properly

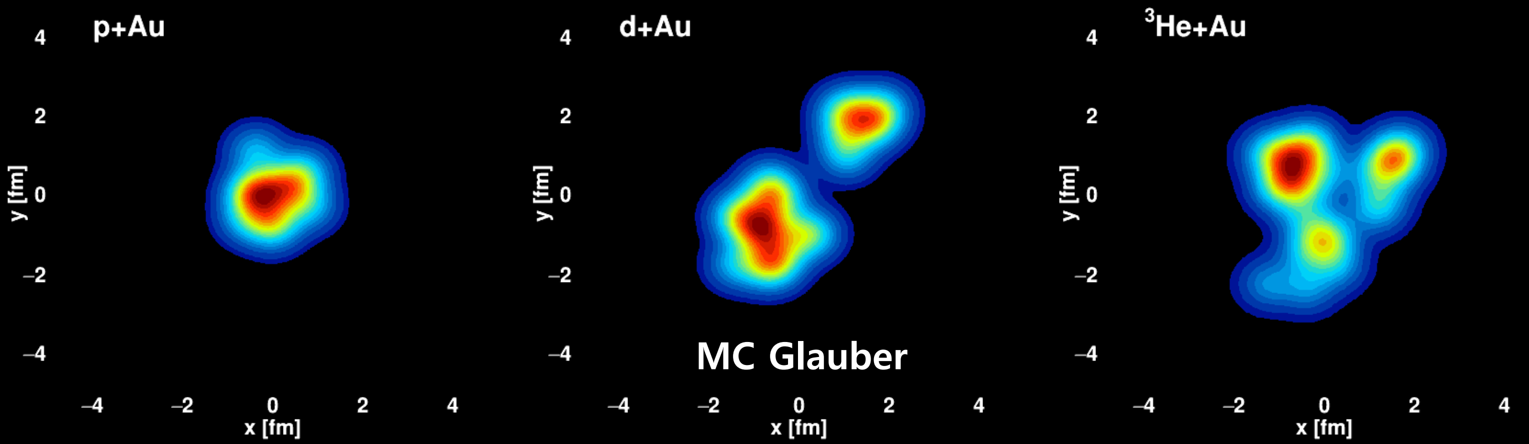
One fluid to rule them all?

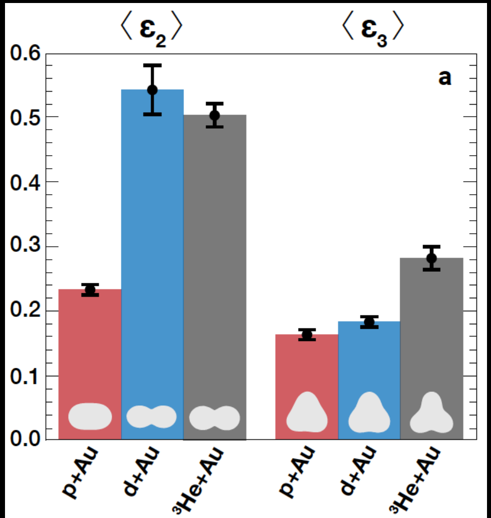




Well described by hydrodynamics with nucleon substructure

Geometry engineering





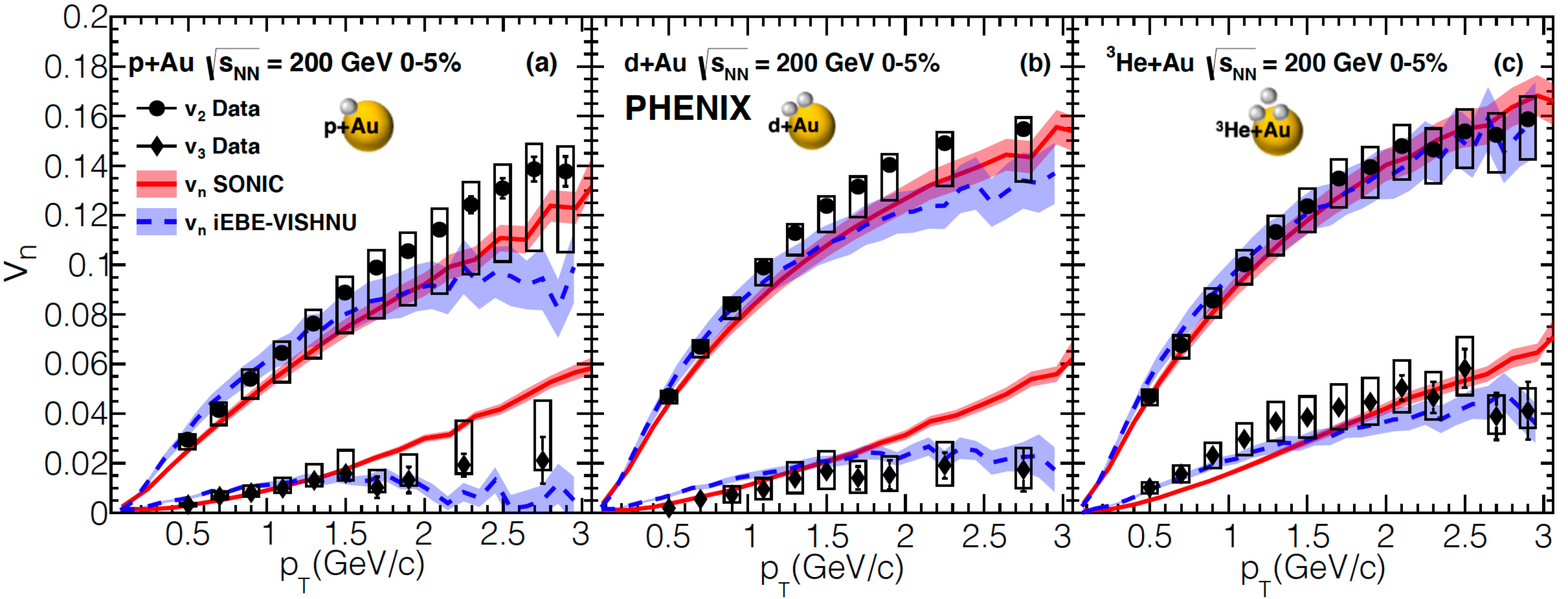
Nature Physics 15, 214 (2019)

Smaller $\langle \varepsilon_2 \rangle$ in p+Au
Larger $\langle \varepsilon_3 \rangle$ in ^{3}He+Au

Various initial conditions

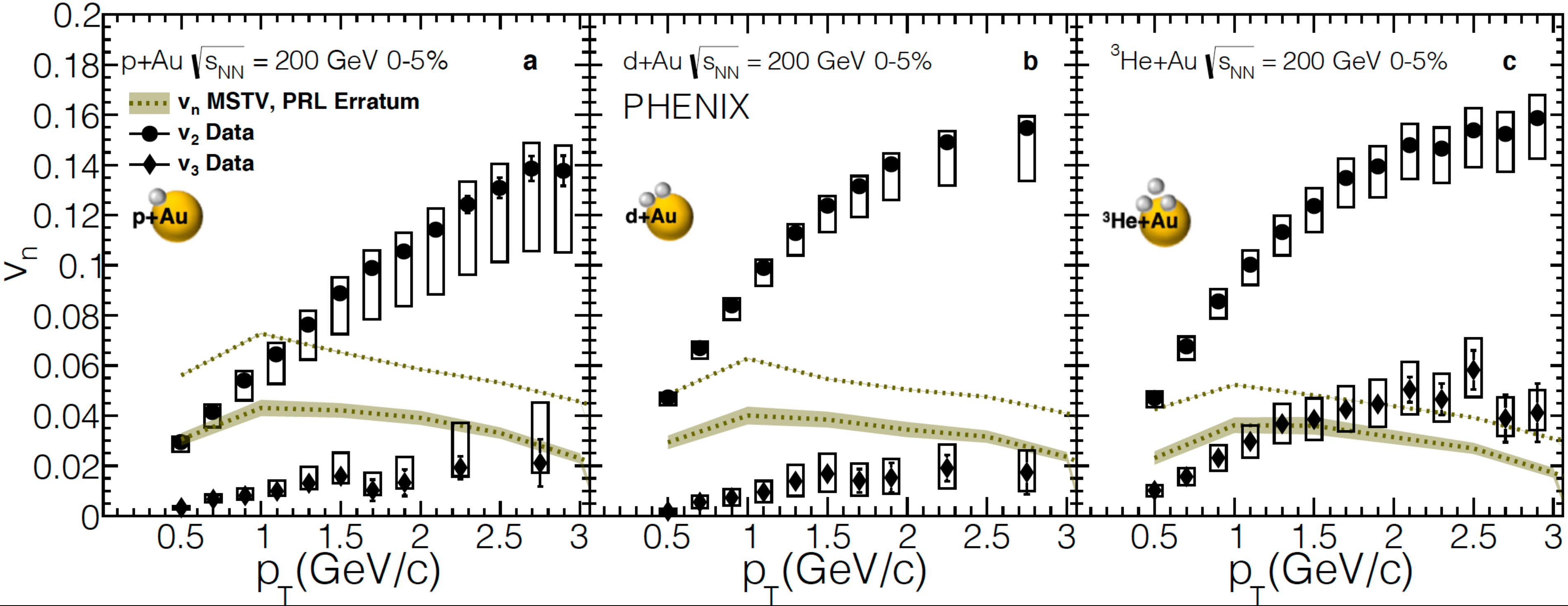
Collision system	Nucl. without NBD fluc.	Nucl. with NBD fluc.	Quarks with NBD fluc.	IP-G with nucl.	IP-G with quarks
			$\langle \varepsilon_2 \rangle$		
p+Au	0.23	0.32	0.38	0.10	0.50
d+Au	0.54	0.48	0.51	0.58	0.73
^{3}He +Au	0.50	0.50	0.52	0.55	0.64
			$\langle \varepsilon_3 \rangle$		
p+Au	0.16	0.24	0.30	0.09	0.32
d+Au	0.18	0.28	0.31	0.28	0.40
^{3}He +Au	0.28	0.32	0.35	0.34	0.46

PRC 105, 024906 (2022)



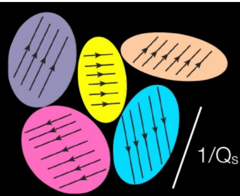
Nature Physics 15, 214 (2019)
PRL 113, 112301 (2014)
PRC 95, 014906 (2017)

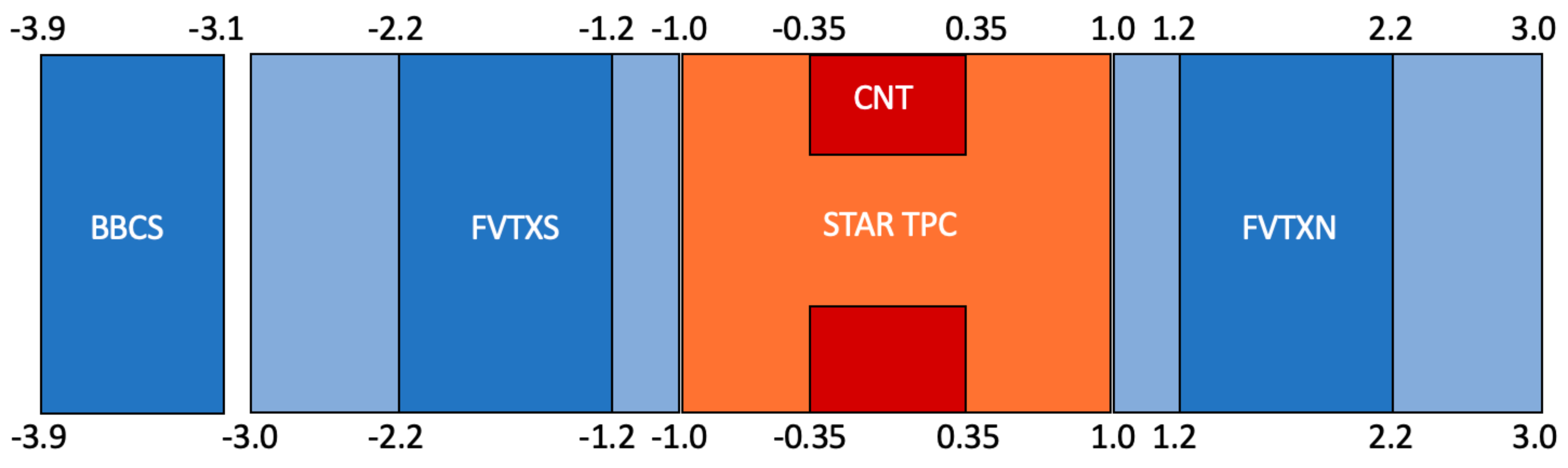
Smaller v_2 in p+Au and larger v_3 in ^{3}He+Au
➔ Consistent with hydrodynamic models



Nature Physics 15, 214 (2019)
PRL 123, 039901 (Erratum) (2019)

Initial-state correlation model fails to describe the data





Two-particle correlation
w/ non-flow subtraction

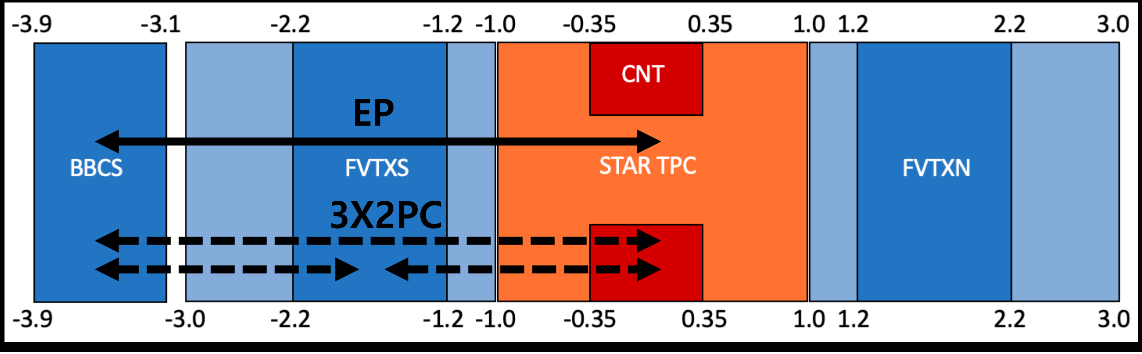
Event plane

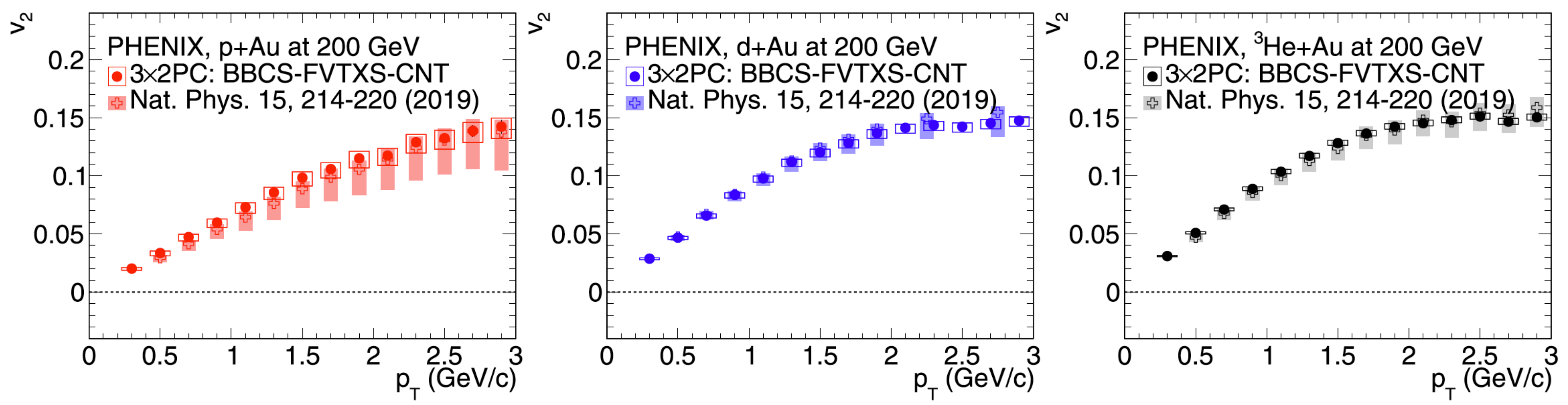
Three combinations of two-particle correlation

$$c_n^{AB} = \langle \cos(n(\phi_A - \phi_B)) \rangle = \langle v_n^A v_n^B \rangle$$
$$c_n^{AC} = \langle \cos(n(\phi_A - \phi_C)) \rangle = \langle v_n^A v_n^C \rangle$$
$$c_n^{BC} = \langle \cos(n(\phi_B - \phi_C)) \rangle = \langle v_n^B v_n^C \rangle$$

$$v_n^C(p_T) = \sqrt{\frac{c_n^{AC}(p_T)\, c_n^{BC}(p_T)}{c_n^{AB}}}$$

Detector acceptance

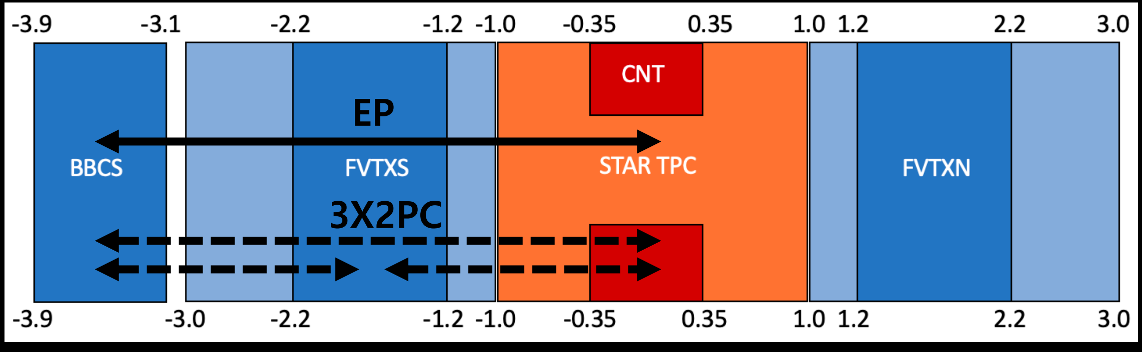


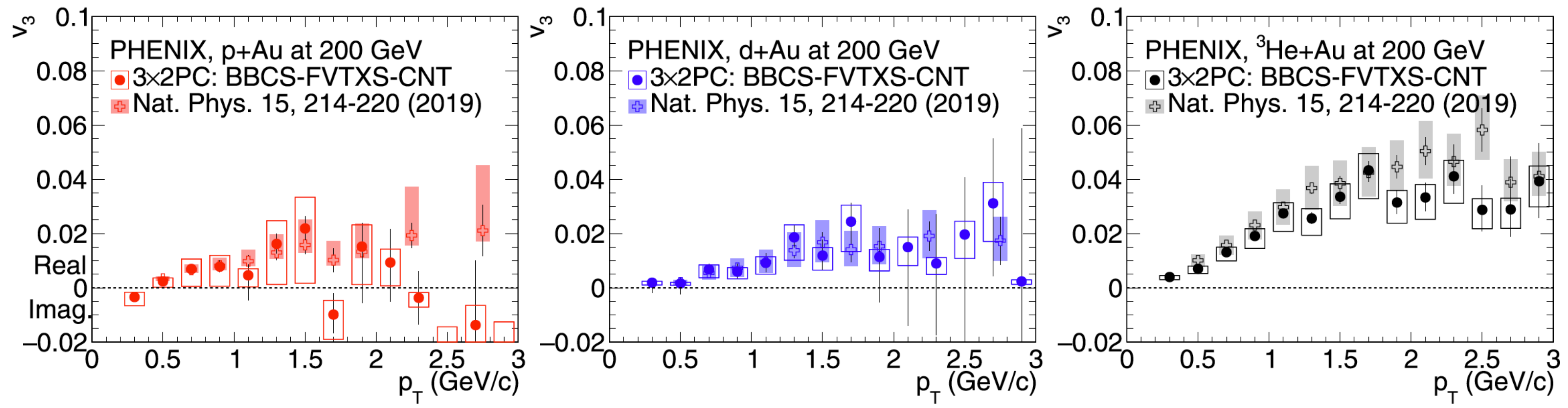


PRC 105, 024901 (2022)

Consistent v_2 with two methods

Detector acceptance

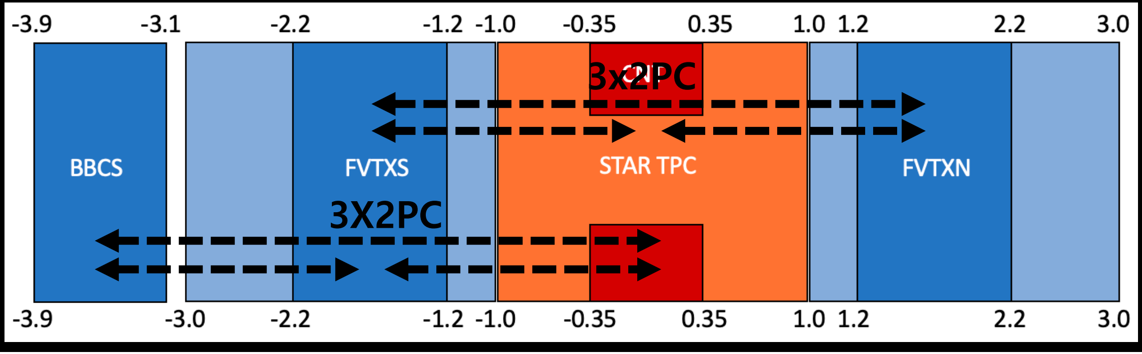


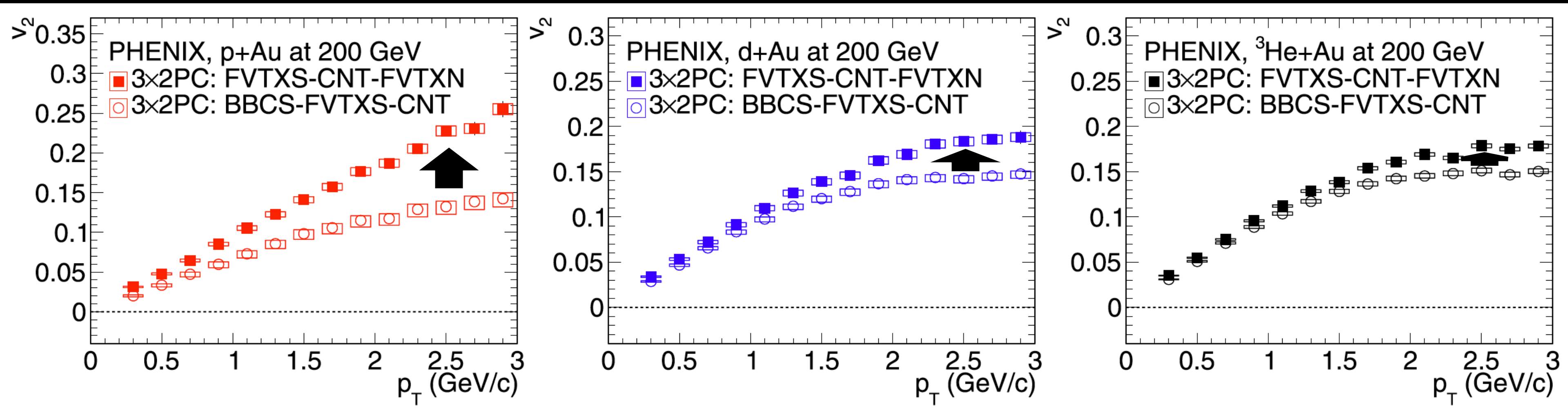


PRC 105, 024901 (2022)

Consistent v_2 and v_3 with two methods

Detector acceptance

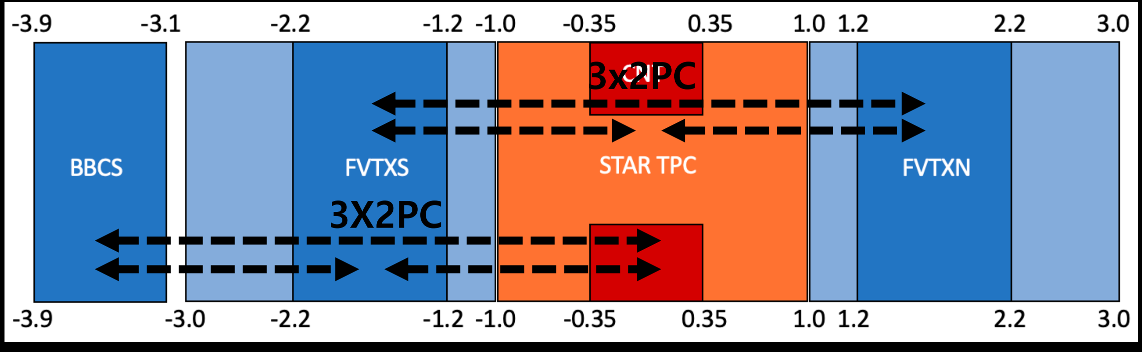


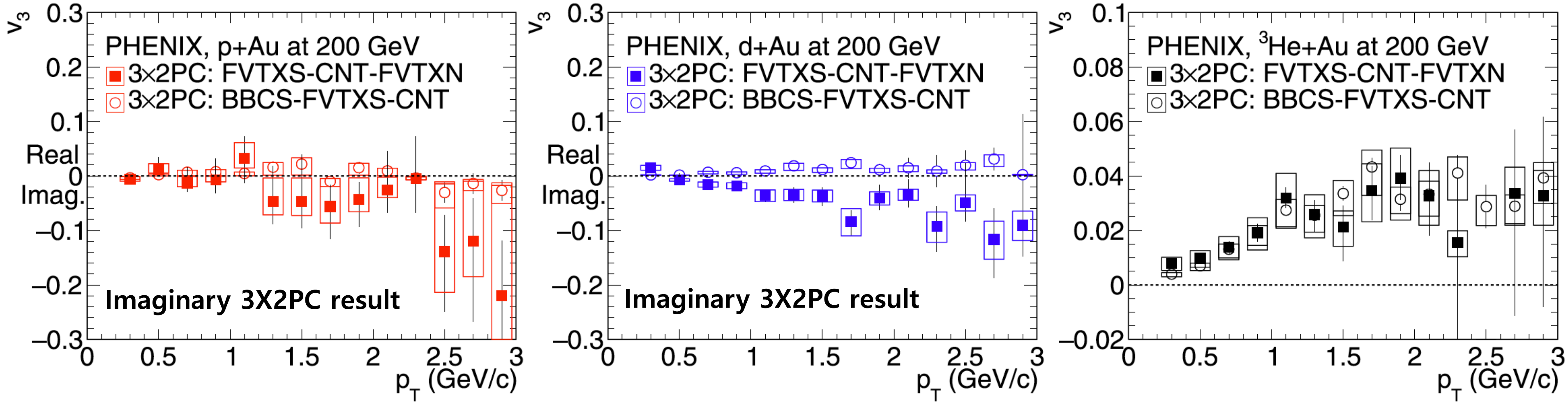


PRC 105, 024901 (2022)

Consistent v_2 when using similar η coverage
Stronger non-flow in smaller η gap

Detector acceptance

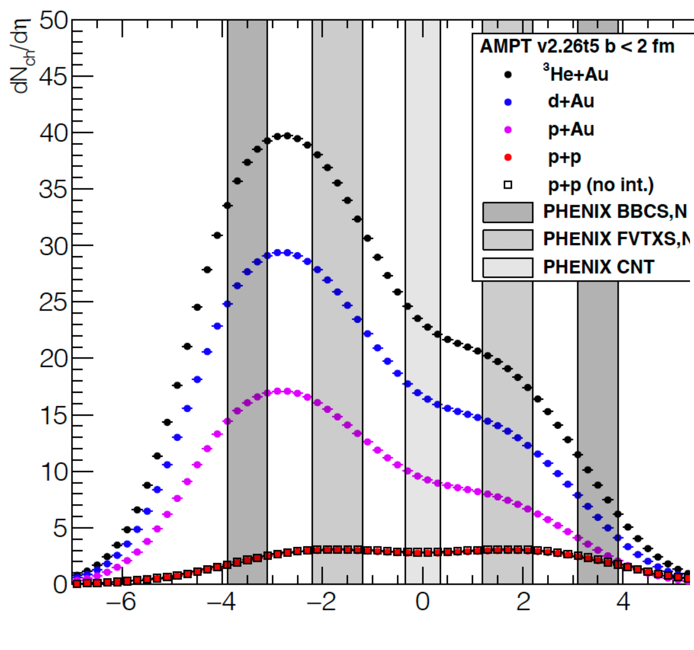


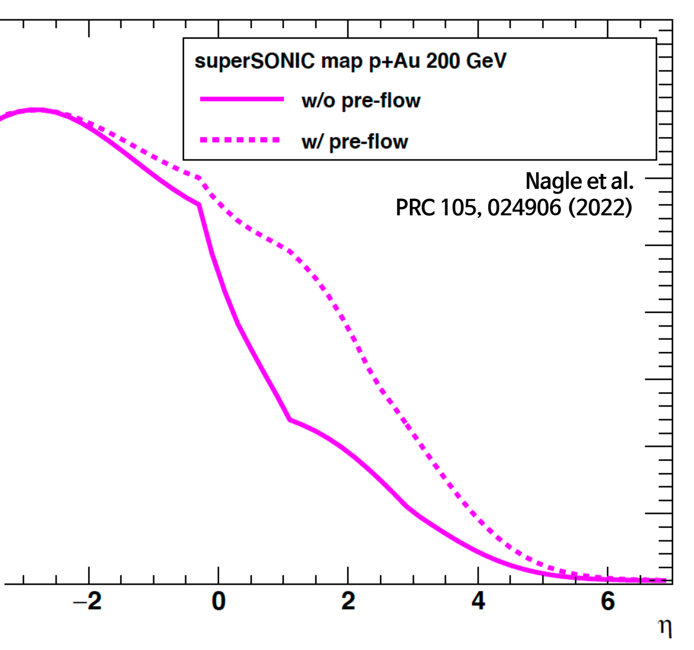


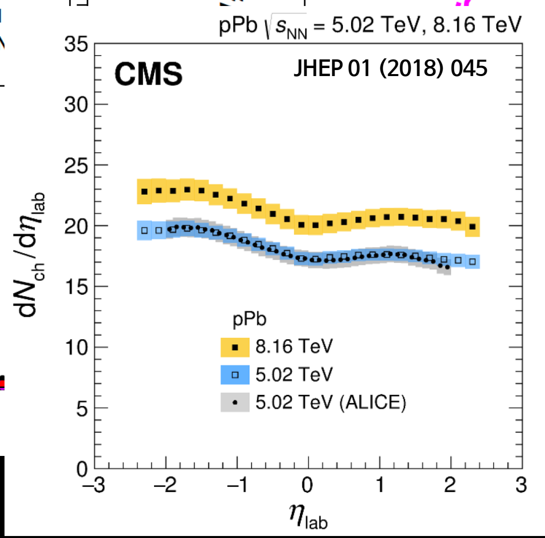
PRC 105, 024901 (2022)

Can not calculate v_3 in p+Au and d+Au due to negative coefficient c_3 between CNT-FVTXN

Longitudinal decorrelation? Pre-flow?

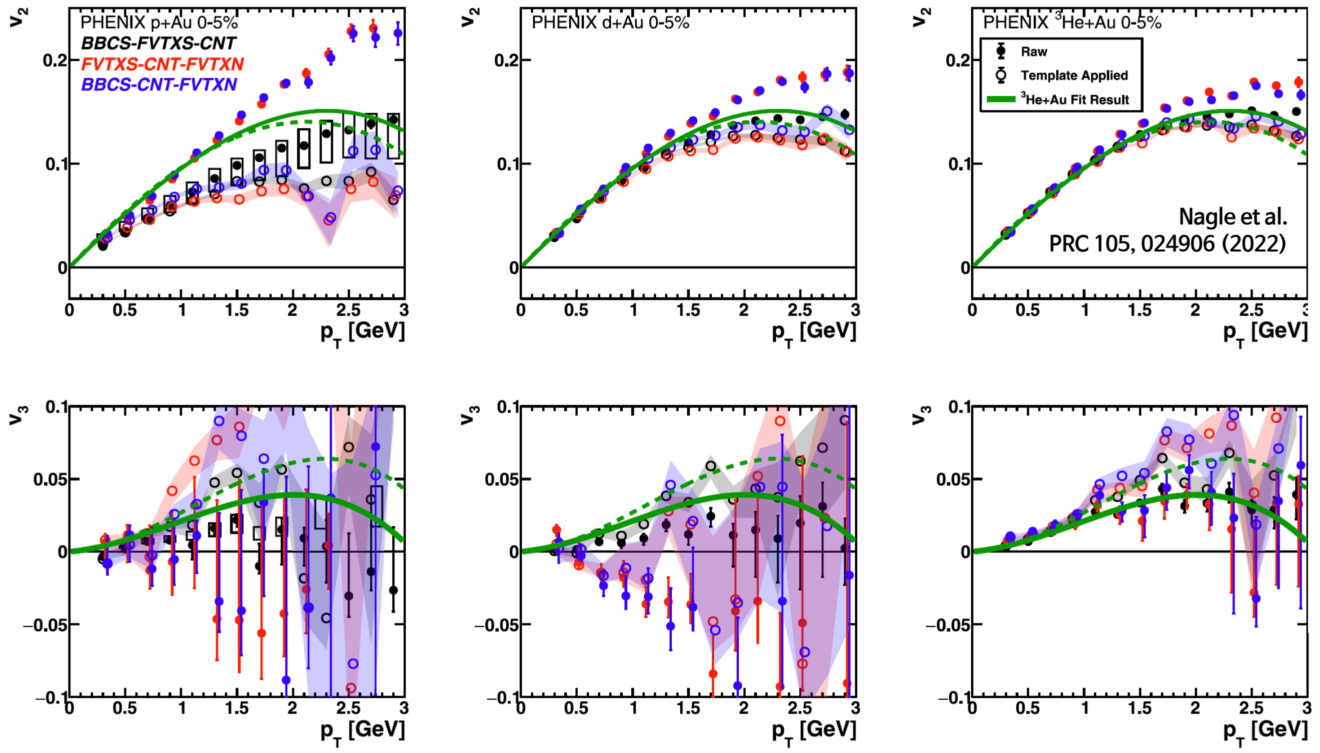


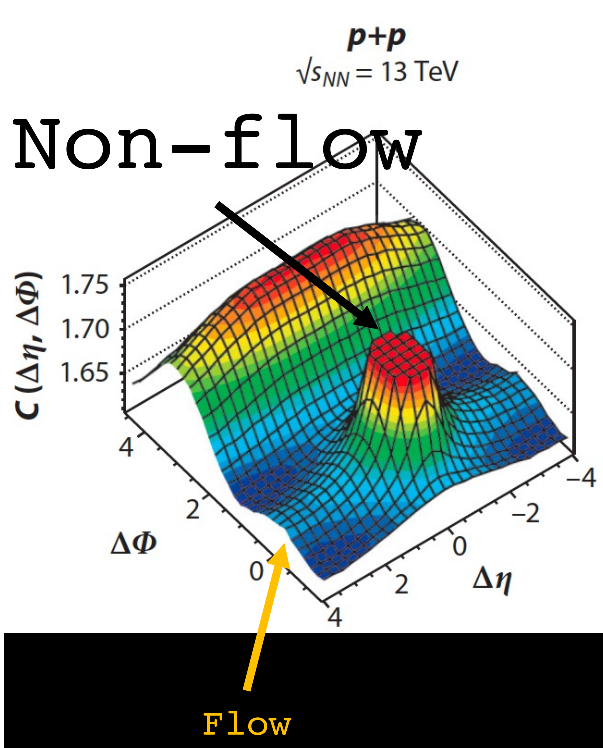




Significantly weaker translation of v_3 than v_2 in the lower multiplicity case

Non-flow subtraction

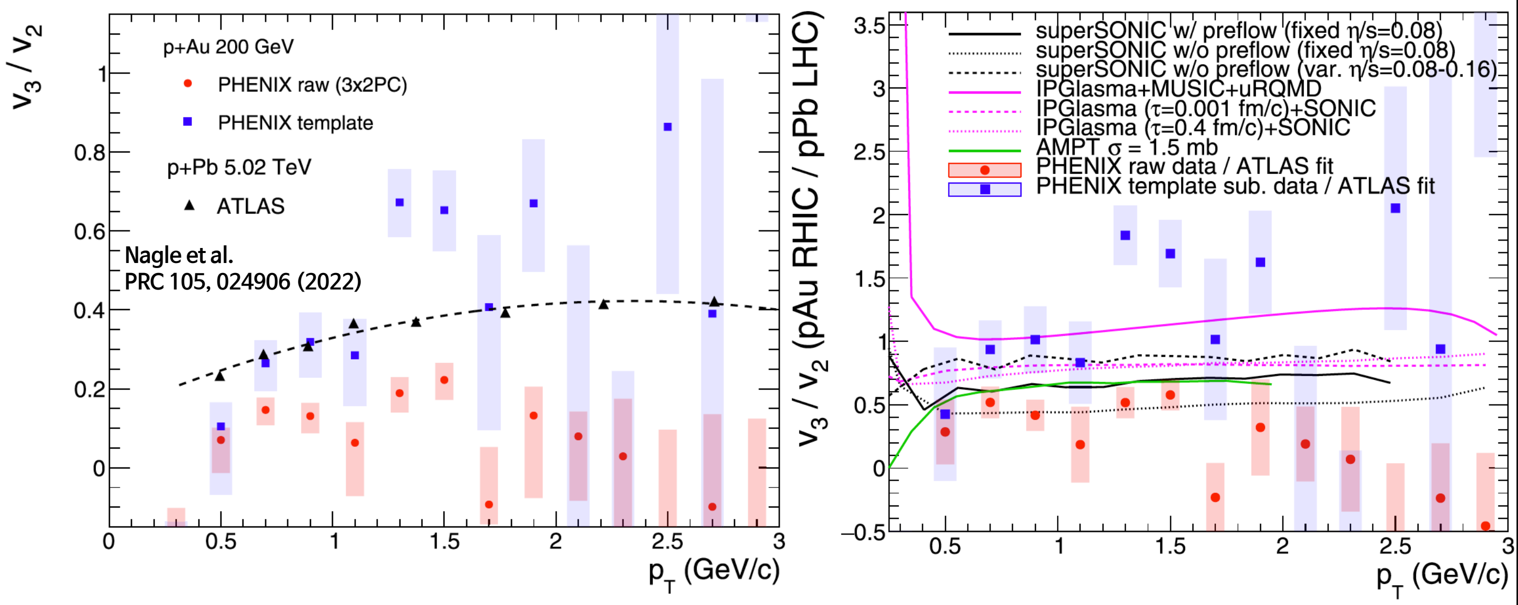




Unstable non-flow correction depending on systems and kinematic regions

Non-flow correction should be done carefully

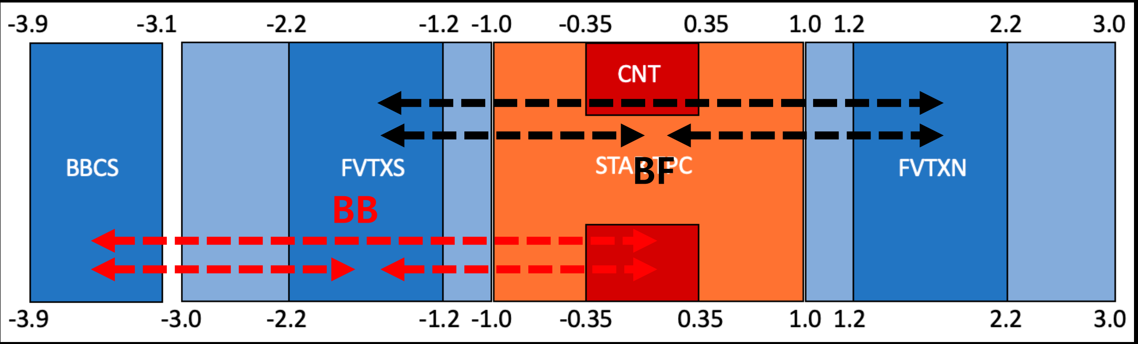
Comparison RHIC and LHC

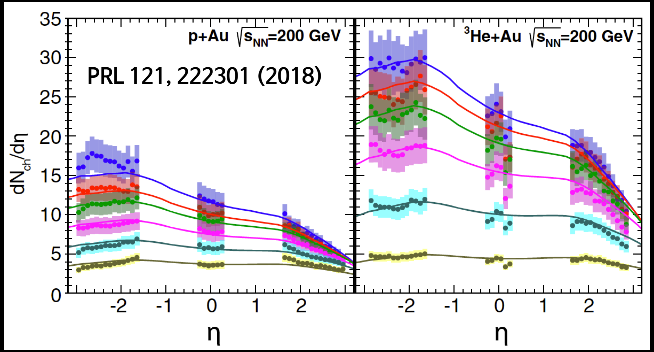


Most of theory calculations show higher v_3/v_2 at the LHC

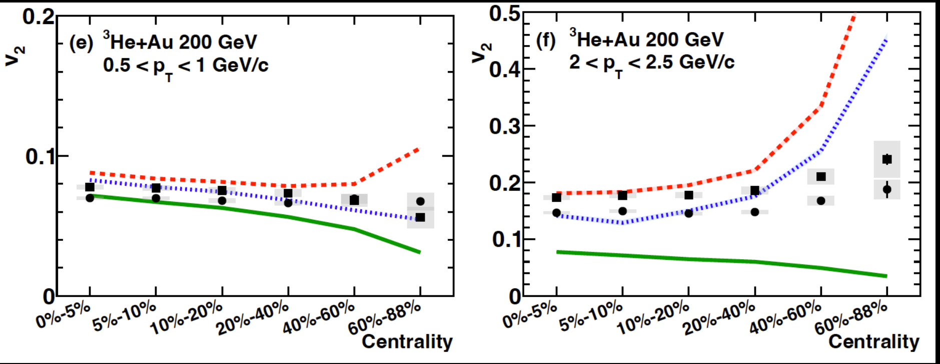
Non-flow subtracted results show higher v_3/v_2 at RHIC

Multiplicity dependence

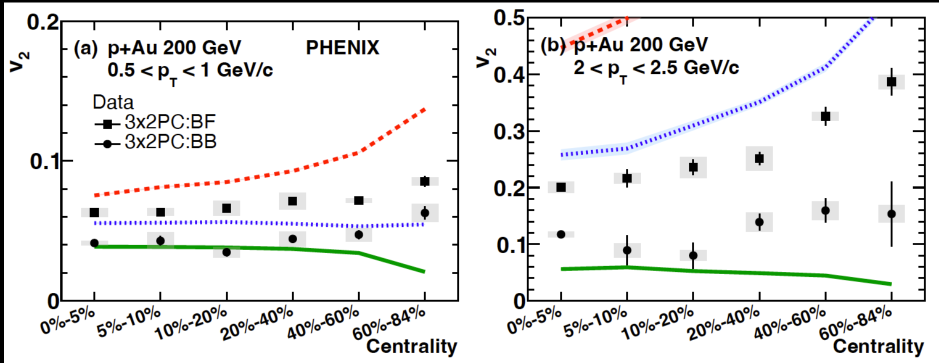




^{3}He+Au



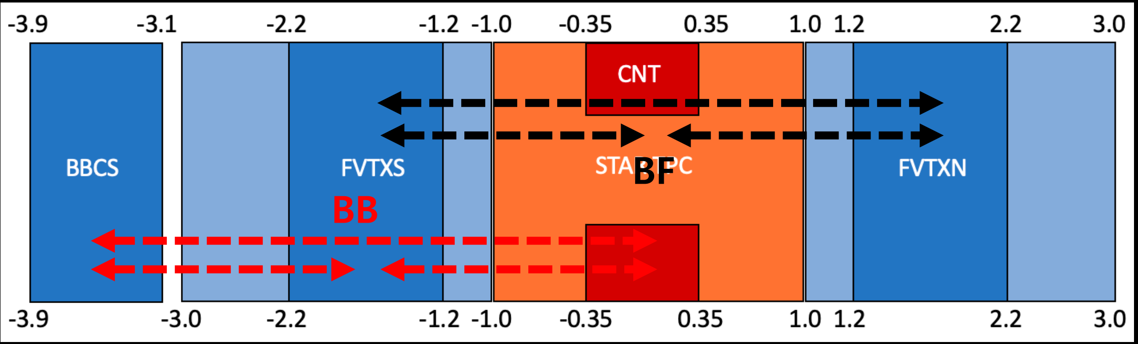
p+Au

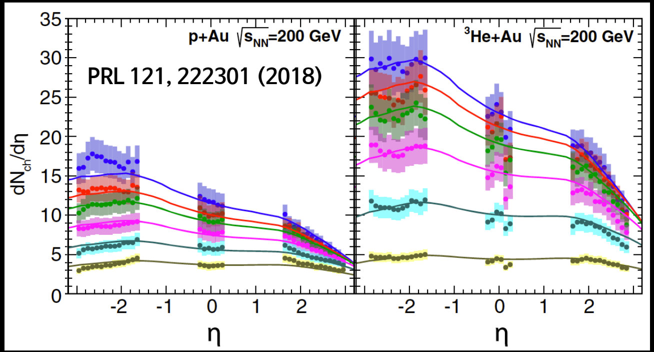


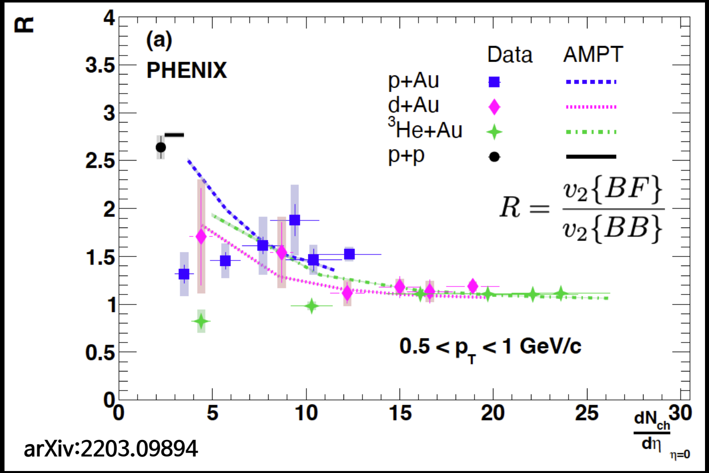
arXiv:2203.09894

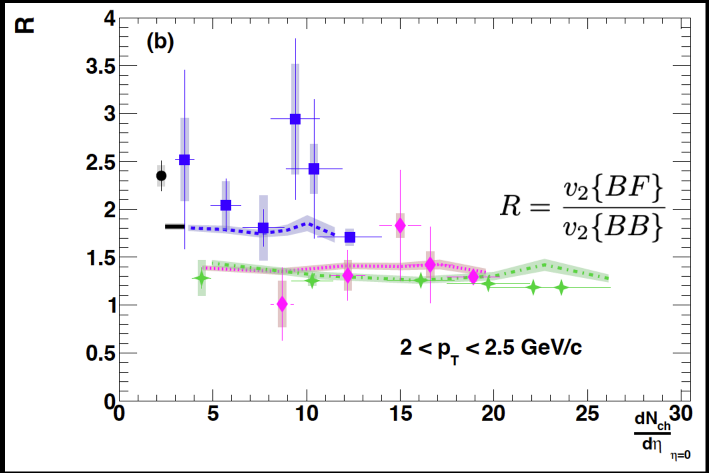
Stronger kinematic dependence in lower multiplicity and higher p_T

Multiplicity dependence







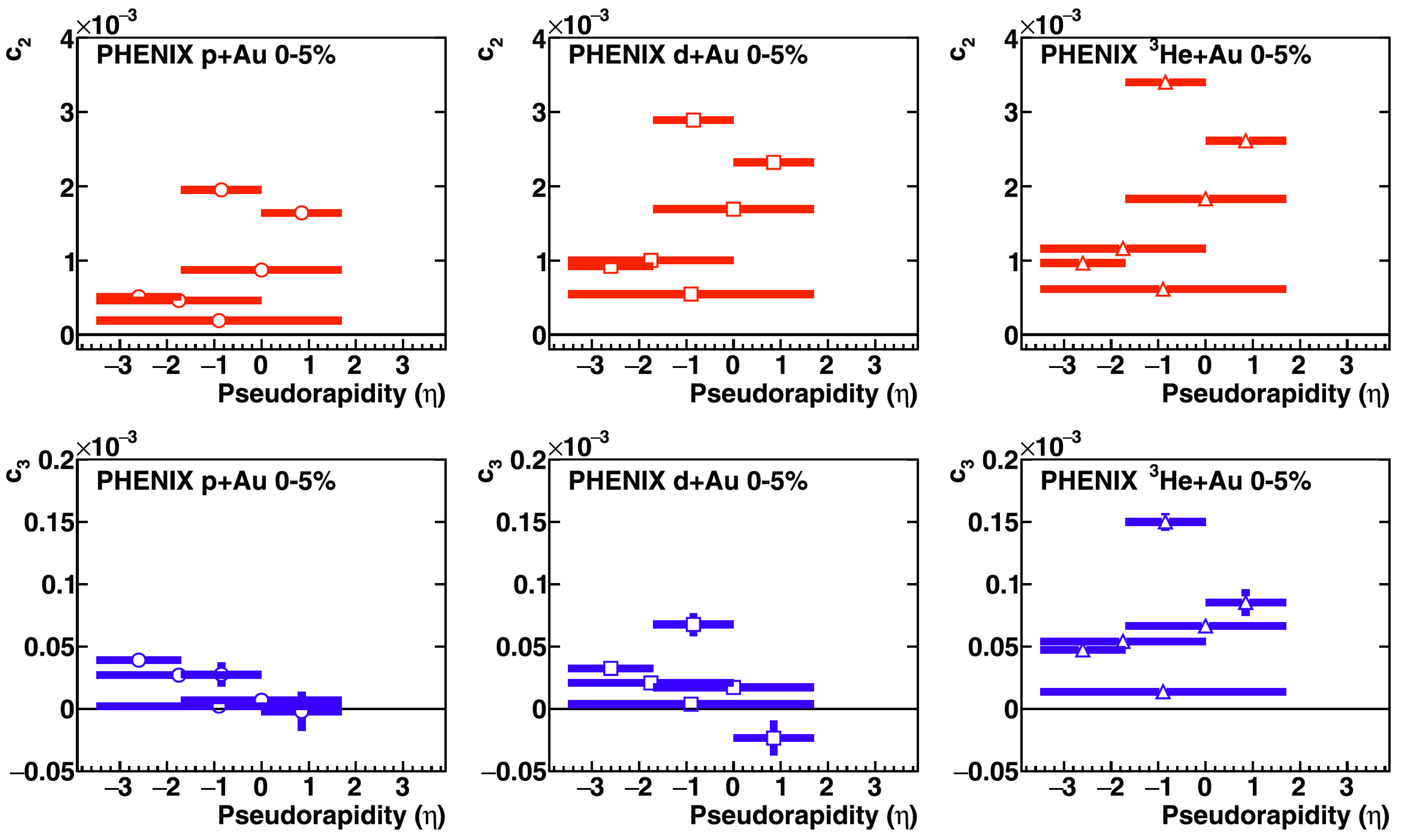


AMPT qualitatively describes the kinematic dependence

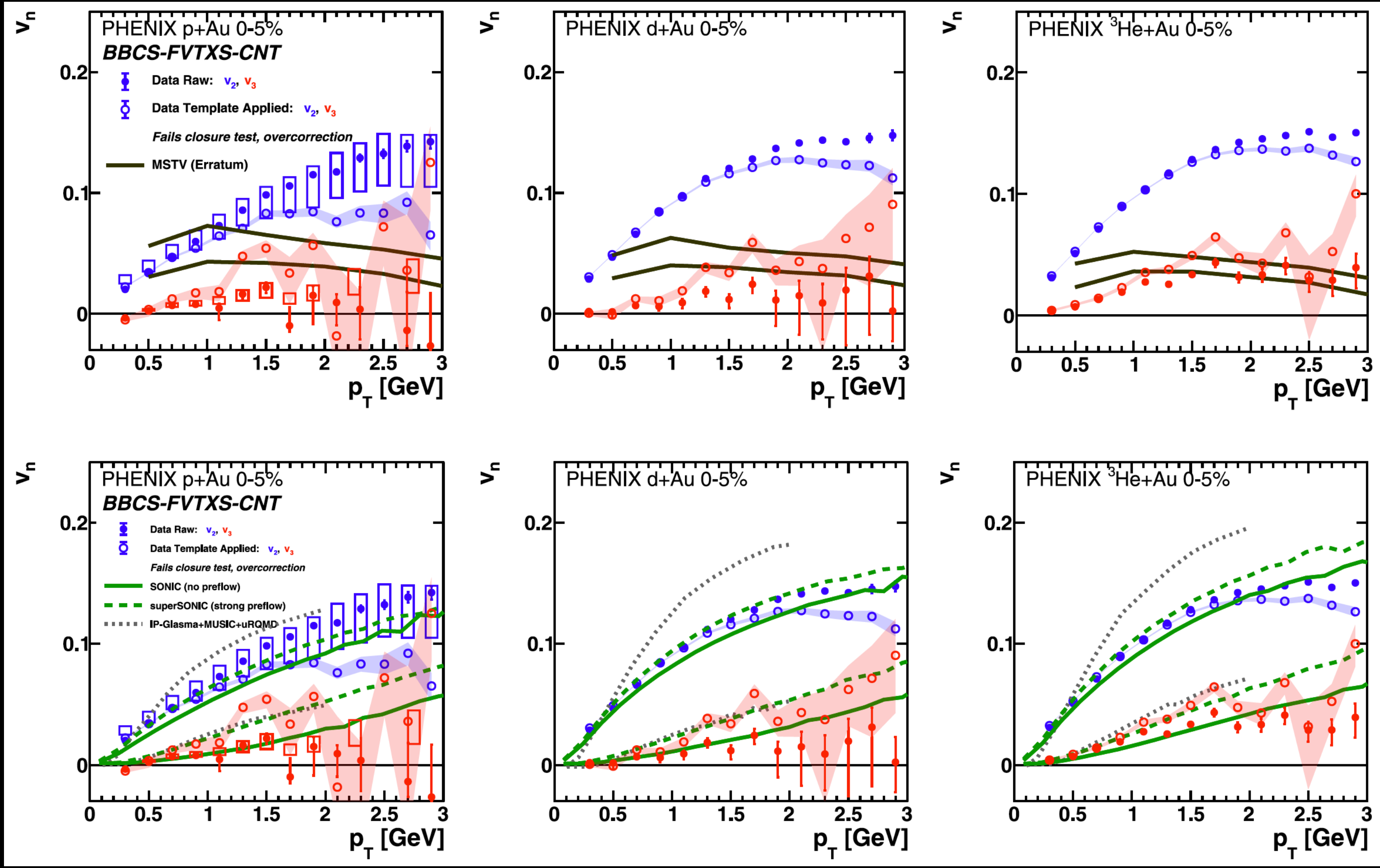
- PHENIX has performed new analyses with the two-particle correlation method
  - In the same kinematic region of the EP method:
    Obtained consistent v_2 and v_3 with the EP method
  - In the other kinematic region with a smaller $\Delta\eta$ gap:
    Could not extract v_3 due to negative Fourier coefficients
    Stronger kinematic dependence in lower multiplicity and higher p_T
- In smaller multiplicity, the flow coefficients are very sensitive to:
  non-flow effect, fluctuation, decorrelation

BACKUP

Fourier coefficients



Model comparison



Non-flow correction in models