ELLIPTIC & TRIANGULAR FLOW IN THE RHIC GEOMETRY SCAN

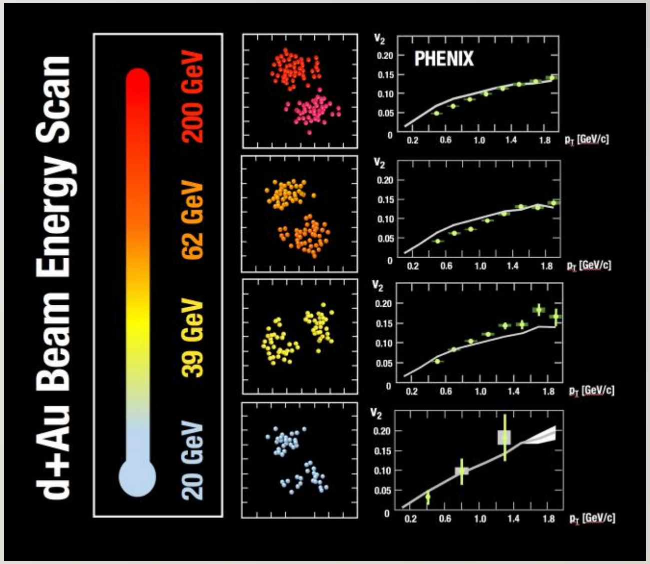
PRL 121 (2018) 222301, NATURE PHYSICS AIP
BASED ON THE DNP TALK OF SYLVIA MORROW

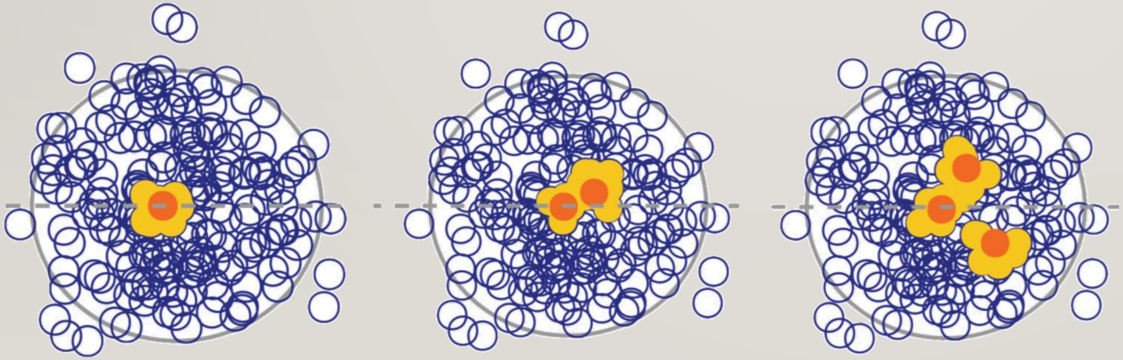
MÁTÉ CSANÁD (EÖTVÖS U) FOR PHENIX

18TH ZIMÁNYI SCHOOL WINTER WORKSHOP

ORIGIN OF FINAL STATE COLLECTIVITY?

- Is it due to the appearance of the sQGP (i.e. a strongly coupled fluid)?
  - If yes, how much time is needed to spend in QGP phase?
  - Test: d+Au collisions from 20 to 200 GeV
- Is it due to initial geometry and hydro?
  - Hydrodynamics: initial spatial correlations
  - Alternative: initial momentum correlations
  - Test: p+Au, d+Au, ^{3}He+Au
  - How do v_2 and v_3 evolve with initial state geom.?



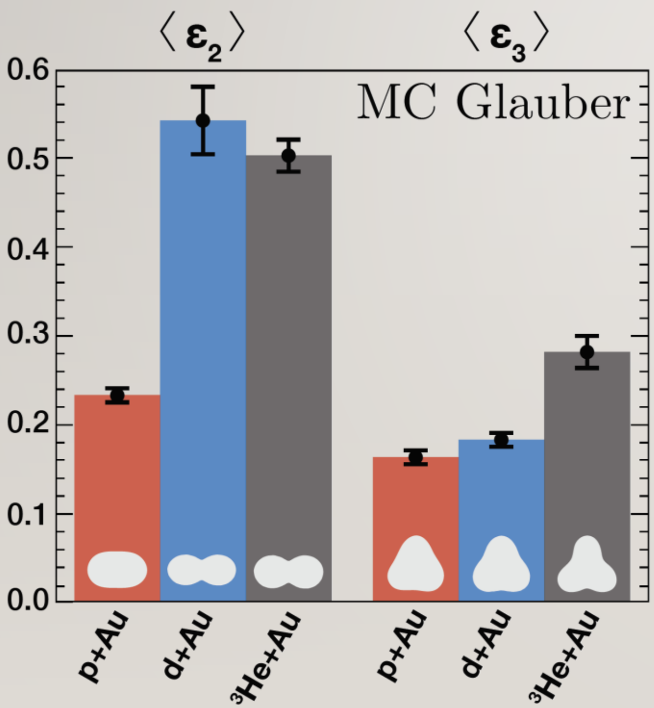


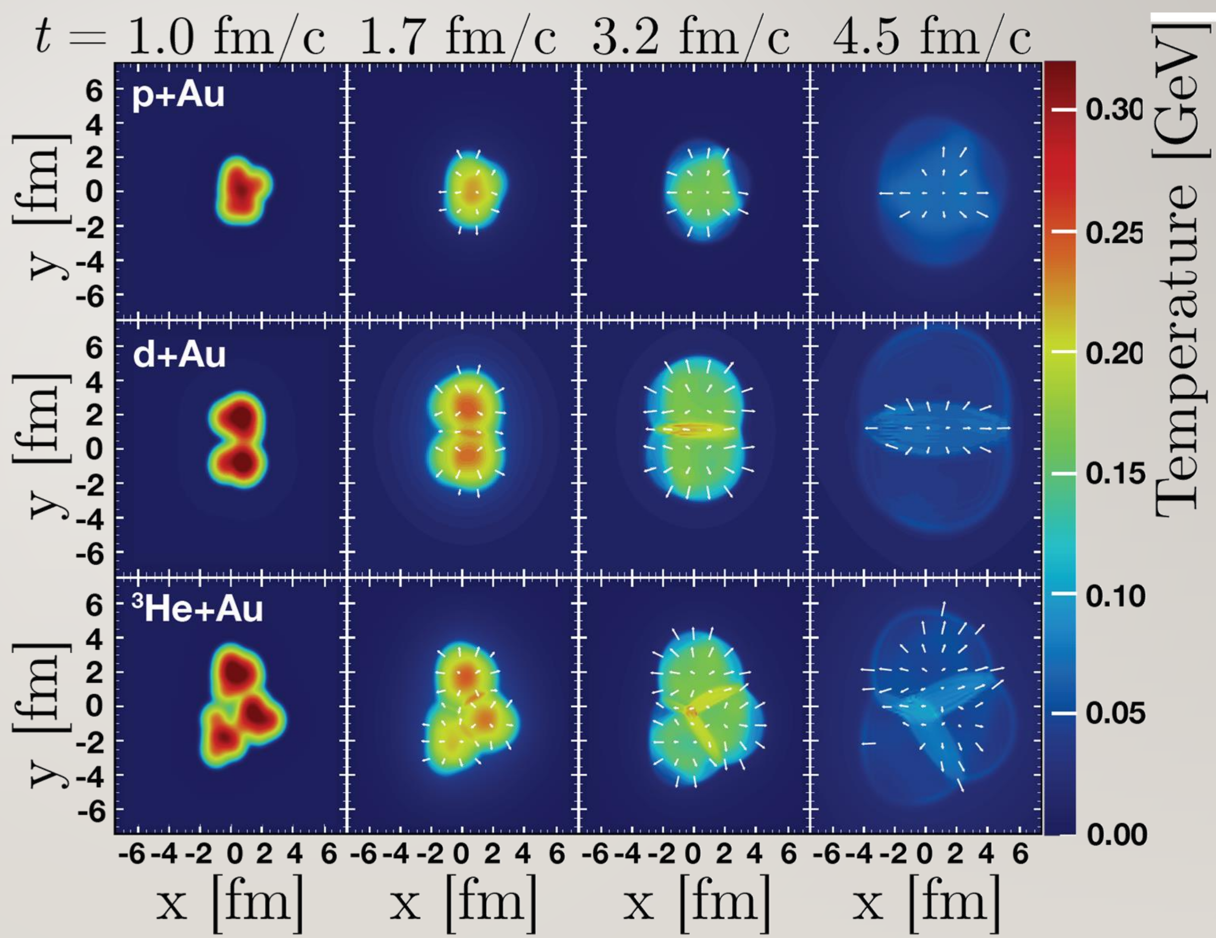
3/12 INITIAL STATE AND HYDRO EVOLUTION

- Evolution from SONIC
- Initial stage:

$$\epsilon_2^{p+\mathrm{Au}} < \epsilon_2^{d+\mathrm{Au}} \approx \epsilon_2^{^3\mathrm{He+Au}}$$

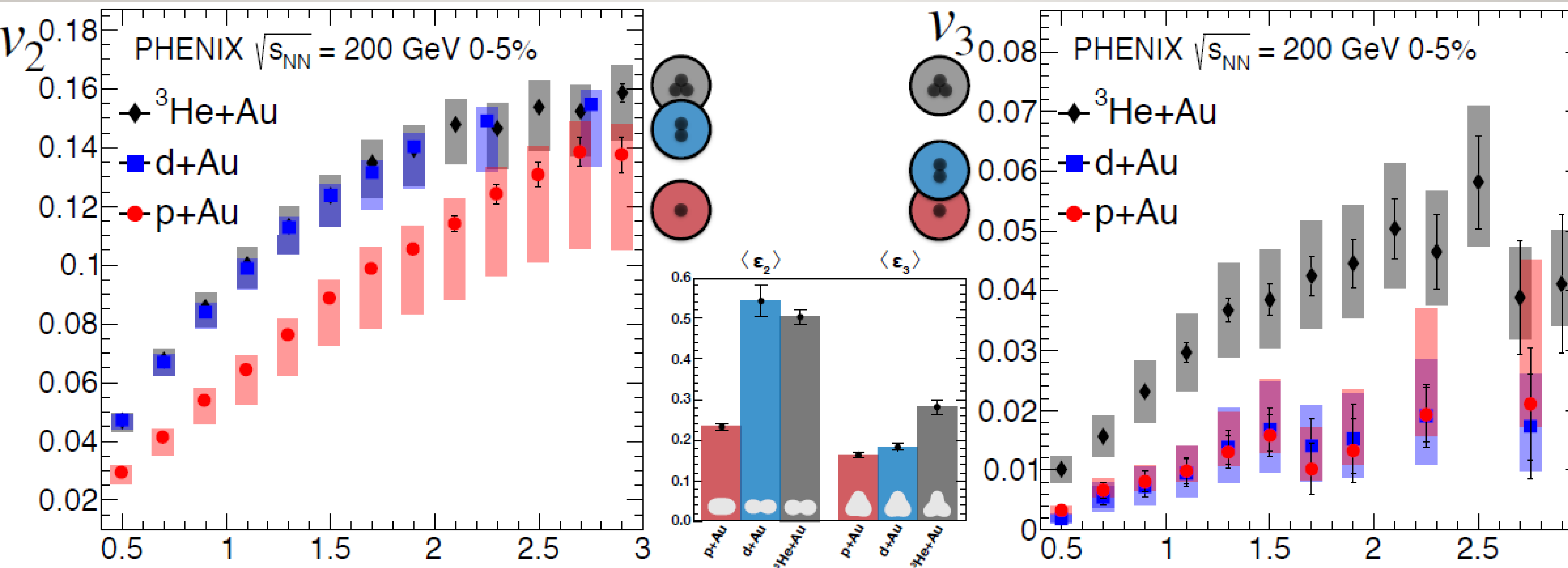
$$\epsilon_3^{p+\mathrm{Au}} \approx \epsilon_3^{d+\mathrm{Au}} < \epsilon_3^{^3\mathrm{He+Au}}$$





FLOW IN SMALL SYSTEMS: GEOMETRIC ORDERING

- Flow ordered similarly as initial state:



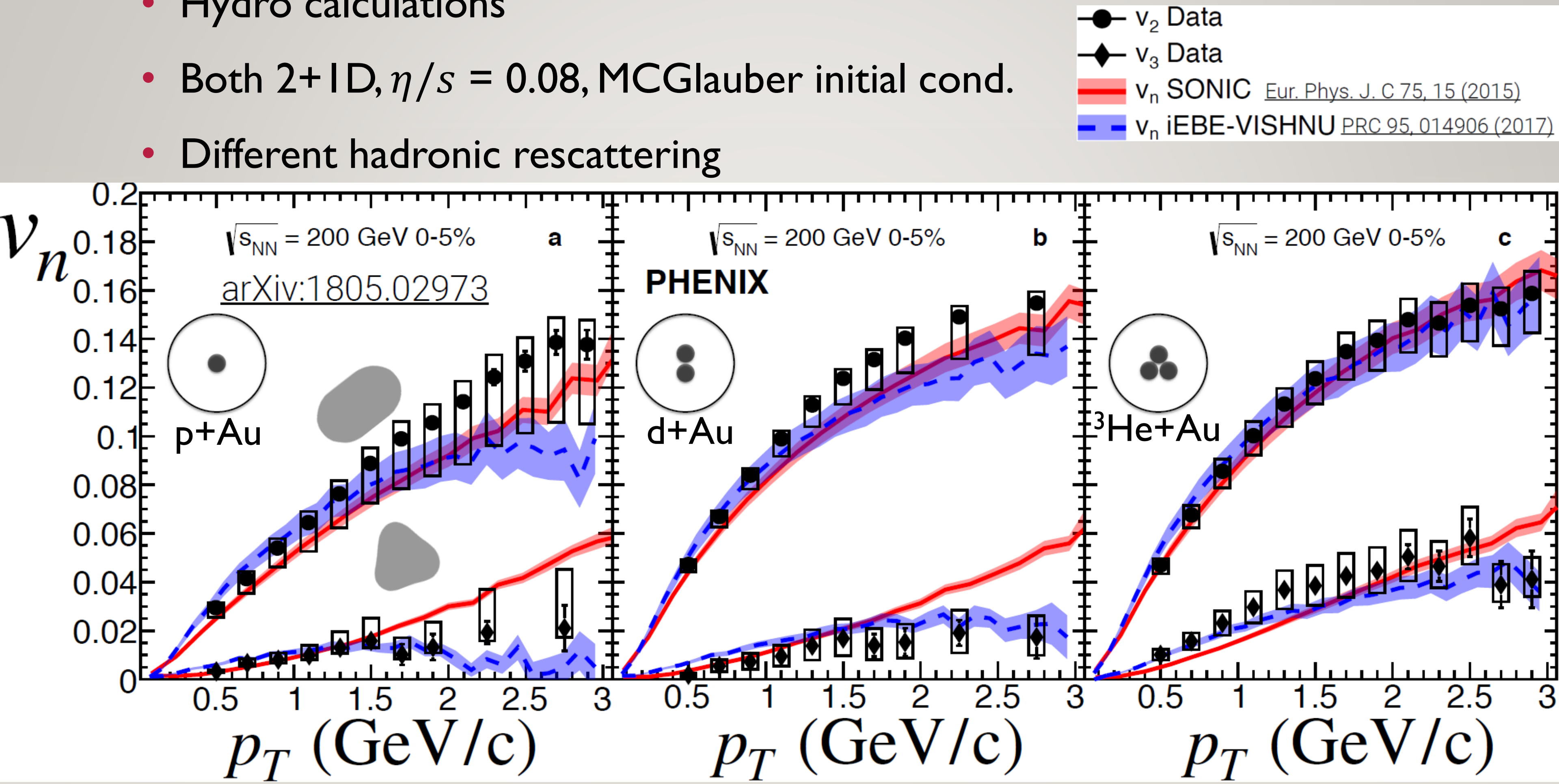
arXiv:1805.02973

$v_2^{p+\mathrm{Au}} < v_2^{d+\mathrm{Au}} \approx v_2^{^3\mathrm{He+Au}}$

$v_3^{p+\mathrm{Au}} \approx v_3^{d+\mathrm{Au}} < v_3^{^3\mathrm{He+Au}}$

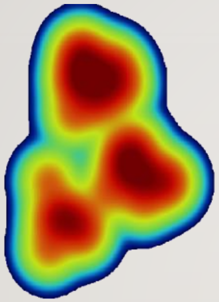
COMPARISON TO HYDRO CALCULATIONS

- Hydro calculations
- Both 2+1D, η/s = 0.08, MCGlauber initial cond.
- Different hadronic rescattering

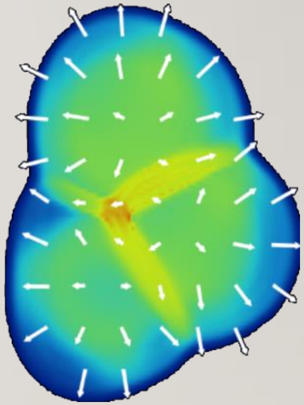


6/12 IS THERE AN ALTERNATIVE EXPLANATION?

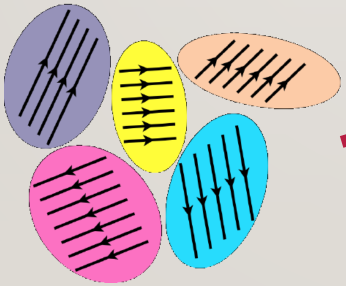
- Hydro: initial state spatial correlations a.k.a. geometry



Final state momentum correlations

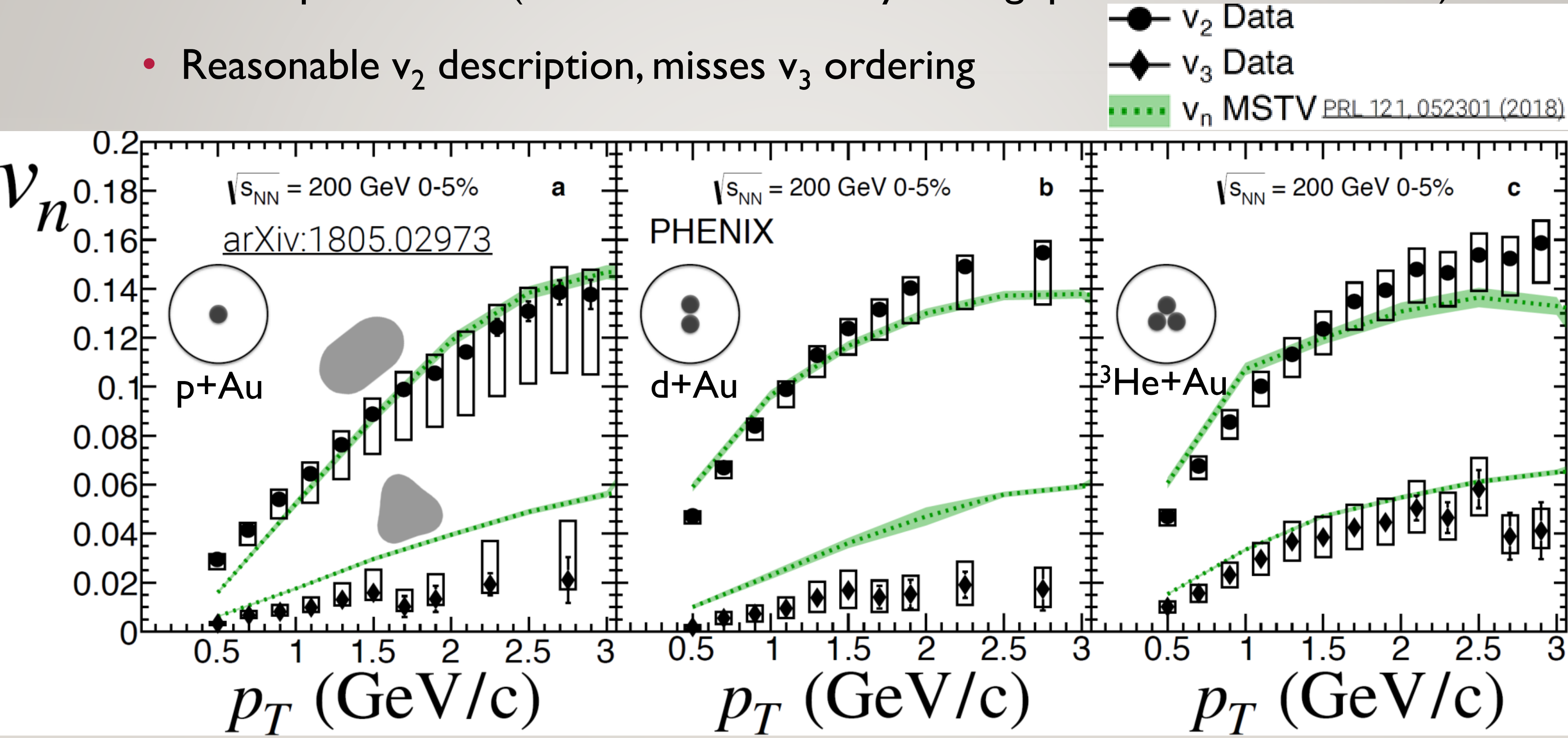


- Alternative: initial state momentum correlations
  Mace et al. Phys. Rev. Lett. 121, 052301 (2018)



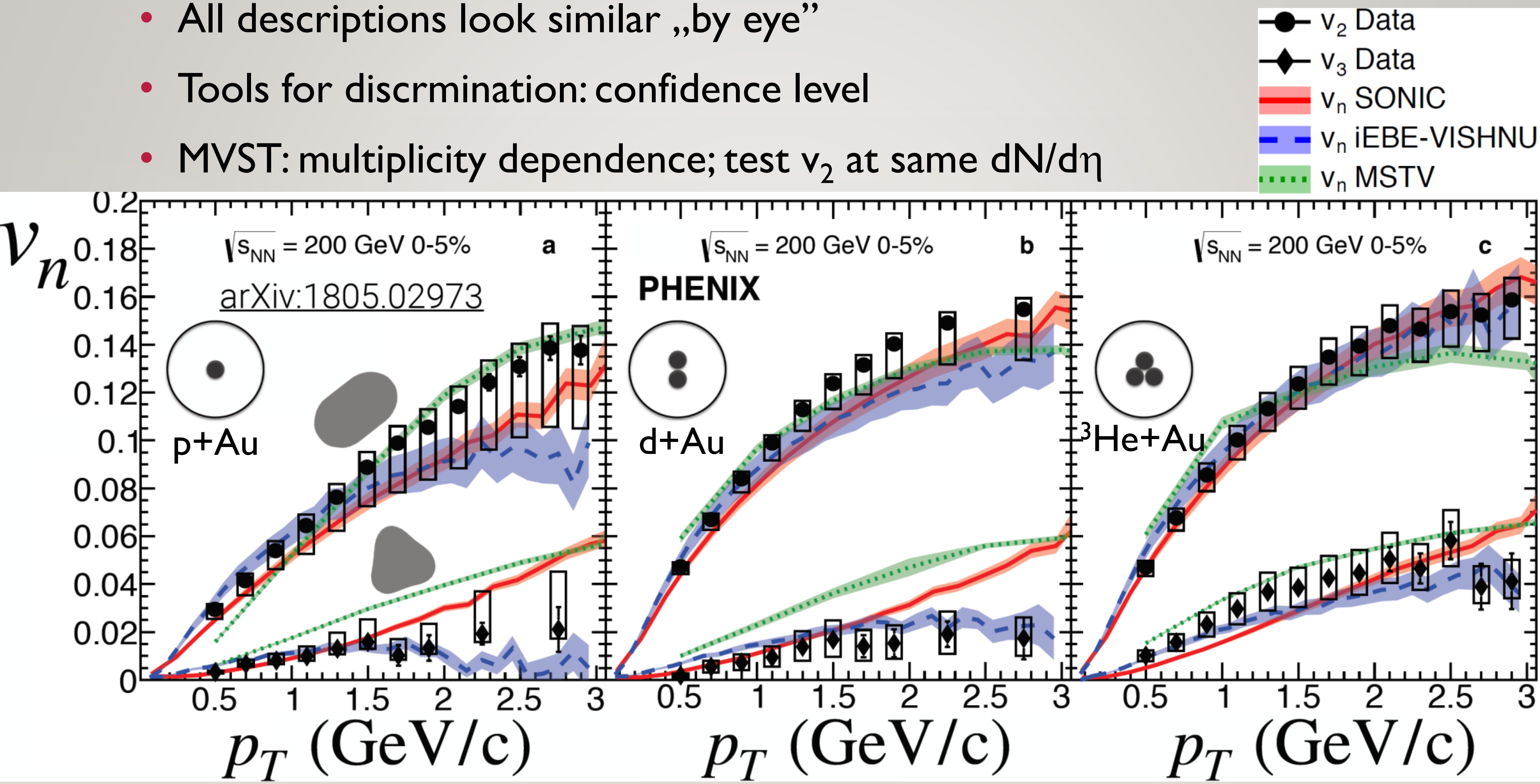
7/12 ALTERNATIVE MODEL VS DATA

- MVST postdiction (Mace, Skokov, Tribedy, Venugopalan, PRL121, 052301)
- Reasonable v_2 description, misses v_3 ordering



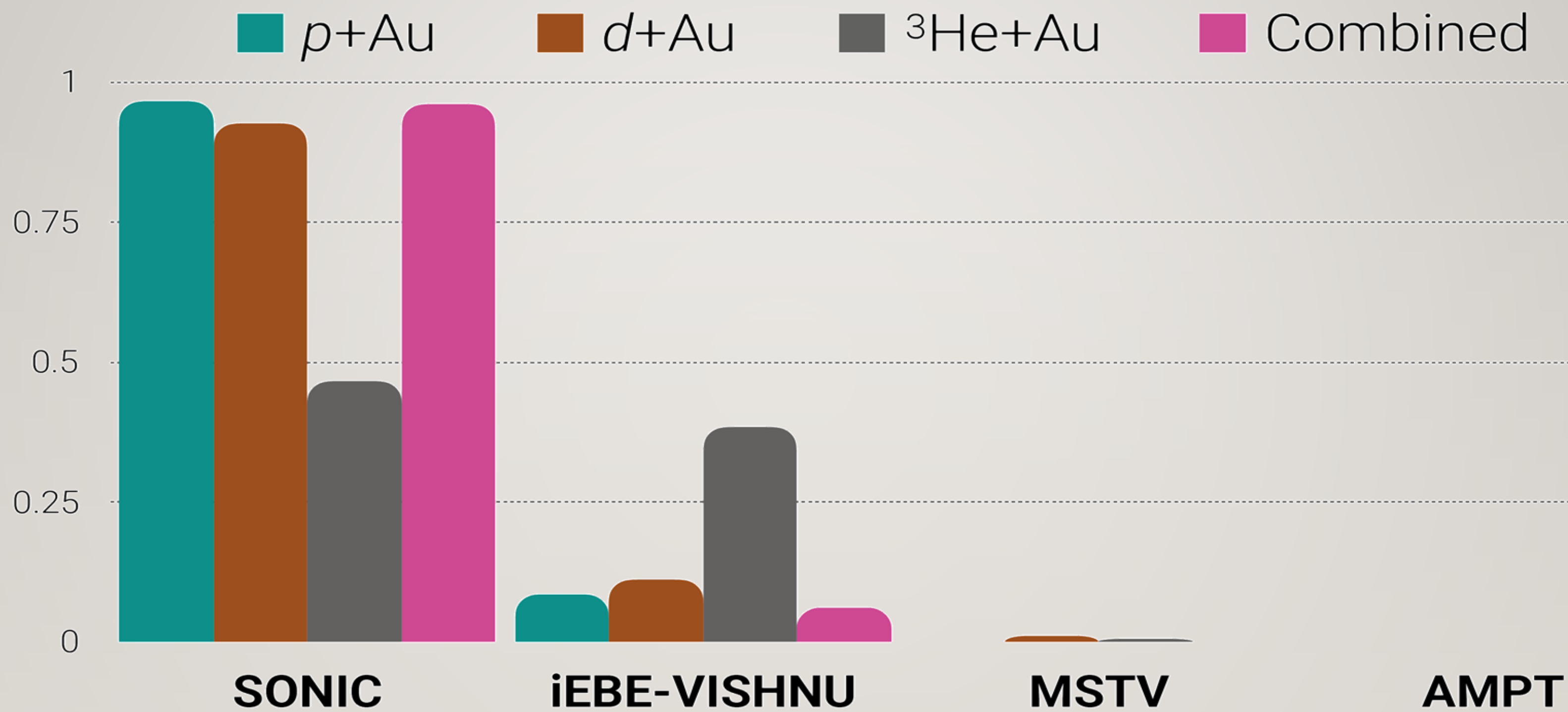
8/12 ALL MODELS VS DATA

- All descriptions look similar „by eye"
- Tools for discrmination: confidence level
- MVST: multiplicity dependence; test v_2 at same dN/dη



STATISTICAL TEST OF ALL MODELS

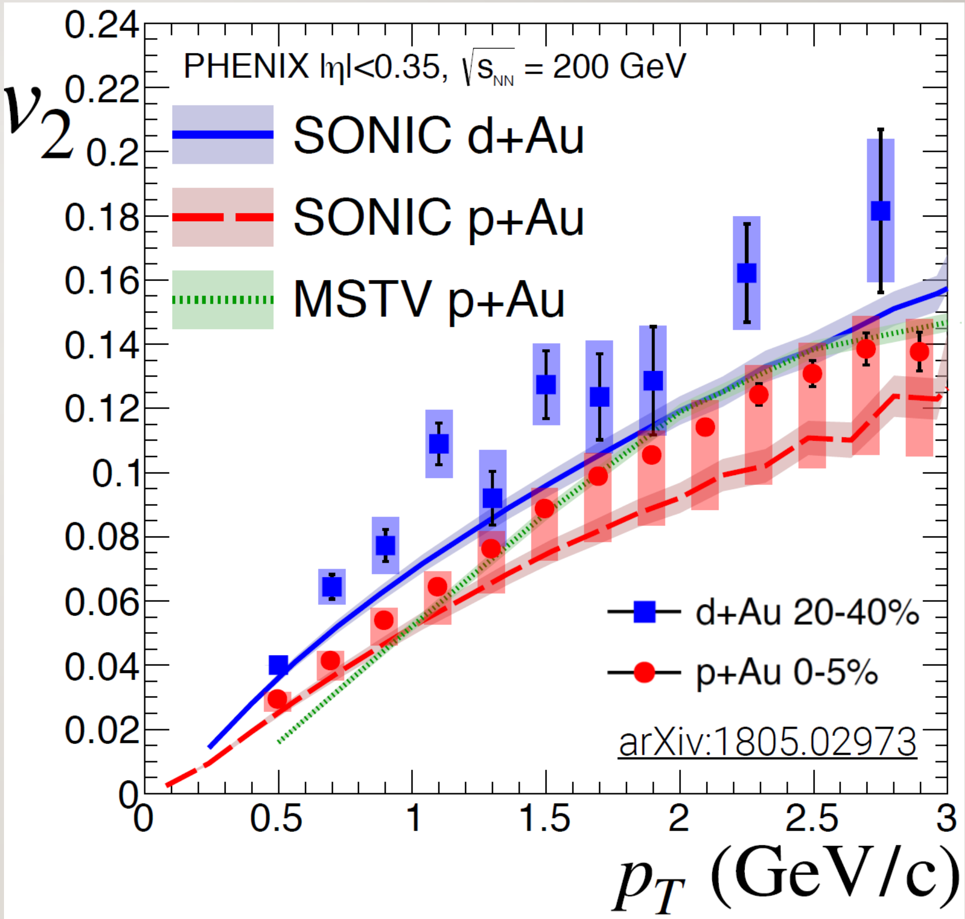
- QGP droplet and hydro describes data the best; MSVT close to marginal



	SONIC	iEBE-VISHNU	MSTV	AMPT
p+Au	0.966	0.086	7.07×10^{-17}	2.09×10^{-7}
d+Au	0.689	0.313	0.011	1.58×10^{-18}
3He+Au	0.465	0.432	0.007	2.17×10^{-22}
Combined	0.896	0.139	9.8×10^{-17}	2.67×10^{-43}

MVST PREDICTION FOR FIXED MULTIPLICITY

- Compare similar collision systems
  - d+Au 20-40% ($dN/d\eta = 12.2 \pm 0.9$) PRC 96, 064905 (2017)
  - p+Au 0-5% ($dN/d\eta = 12.3 \pm 1.7$) PRC 95, 034910 (2017)
- Fixed multiplicity: same MVST prediction for v_2
- Hydro description: better qualitative agreement (same multiplicity scales with eccentricity)
- Note: no nonflow systematics estimate in d+Au (≤ than in p+Au)



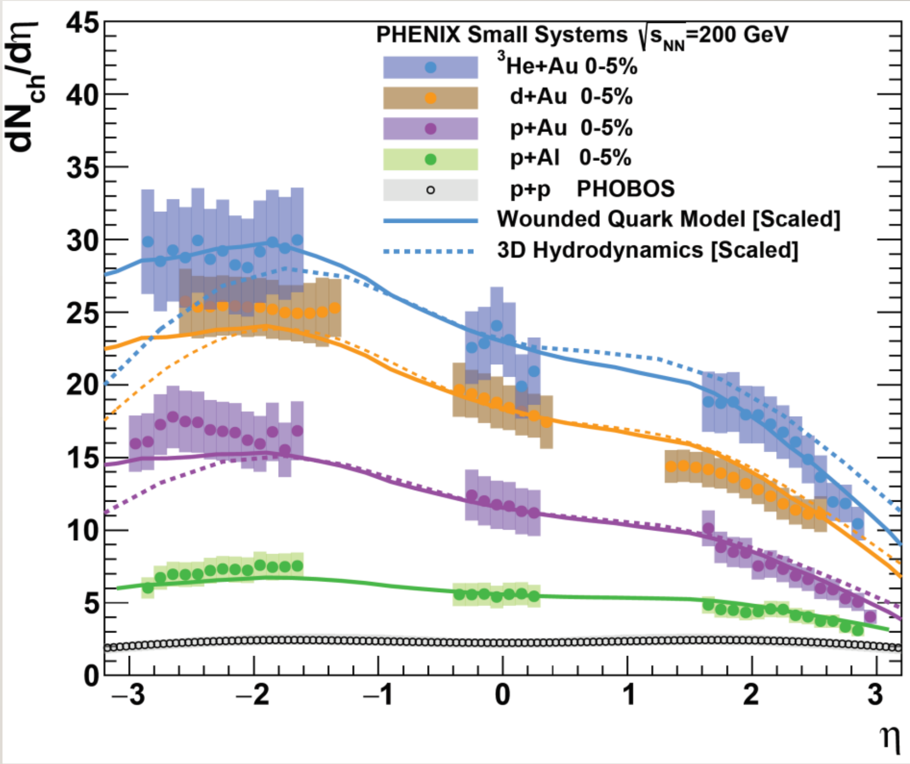
FORWARD PARTICLE PRODUCTION?

- Wounded quark model:
  - Each quark participant produces hadrons, common emission function $F(\eta)$
  - Constrained by $dN/d\eta$ in d+Au

  Barej, Bzdak, Gutowski, PRC97, 034901 (2018)

- Hydrodynamic simulation
  - MC Glauber initial condition
  - Longitudinal entropy distribution
  - 3+1D viscous evolution
  - $\eta/s = 1/4\pi$, T-dependent bulk viscosity
  - Statistical hadronization

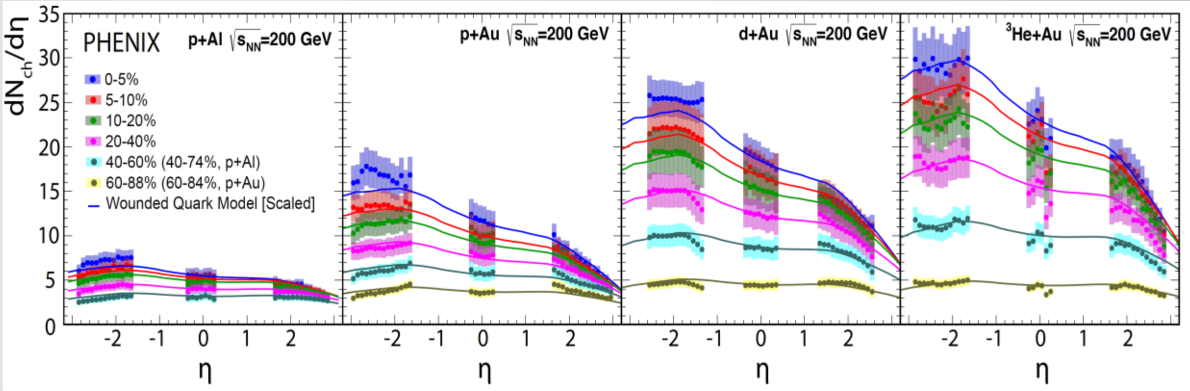
  Bozek, Broniowski, PLB739, 308 (2014)

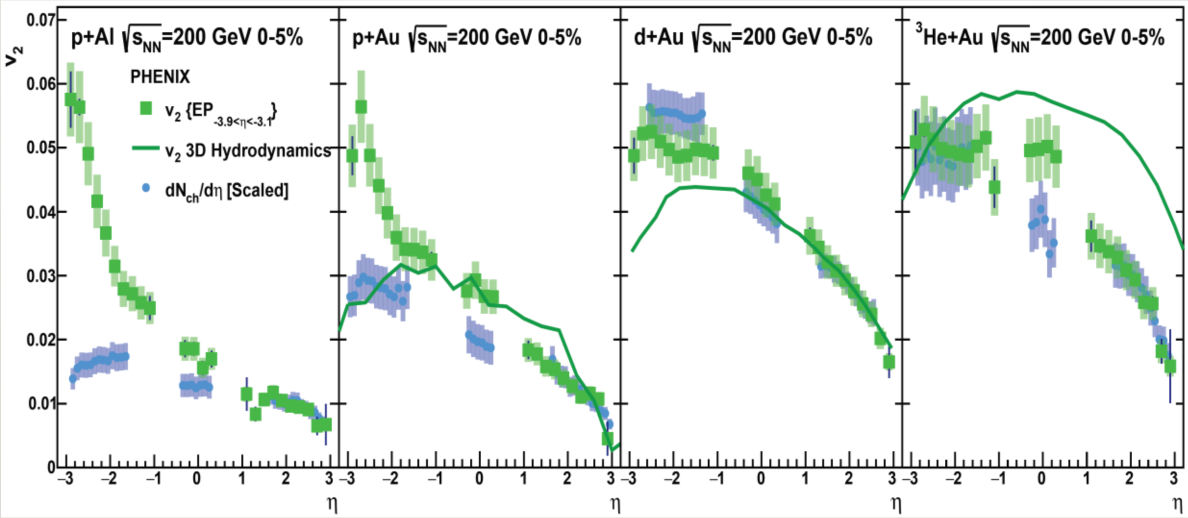


Phys.Rev.Lett. 121 (2018) 222301

FURTHER DETAILS INVESTIGATED

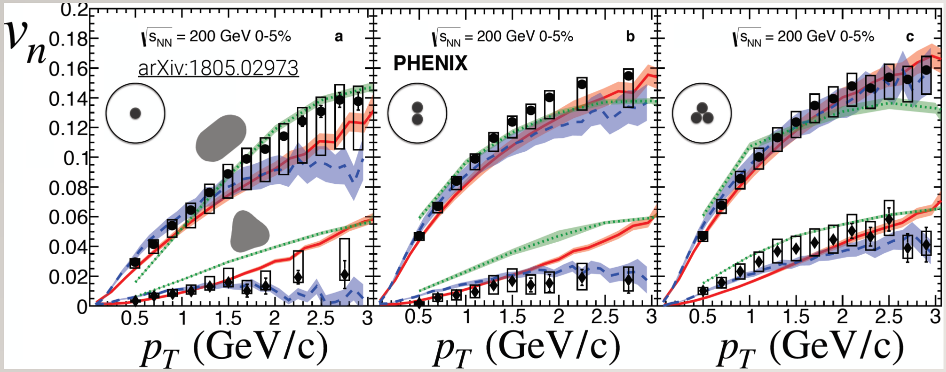
- Wounded quark model works for $dN/d\eta$ at all centralities, from p+Al to ^{3}He+Au
- Flow: increase with system size at forward rapidities (consistently with initial geometry)
- Enhancement at backward rapidity: nonflow?
- Compare $dN/d\eta$: approximate scaling

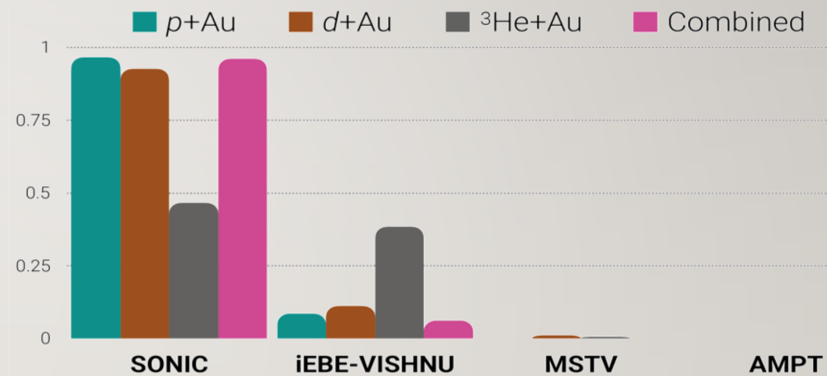




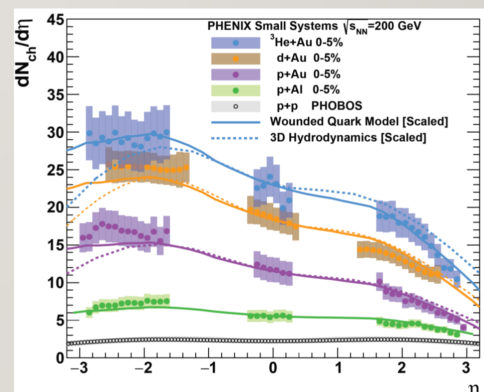
SUMMARY

- Strong evidence for QGP droplets in small systems
  - Acceptable confidence levels for hydro in p/d/^{3}He+Au





- Longitudinal dynamics explored in detail
  - Wounded quark model works well
  - Hydro describes qualitative features



- Thanks to Sylvia Morrow for the talk material
- arXiv:1807.11928 PRL 121 (2018) 222301
- arXiv:1805.02973, Nature Physics AiP