PHENIX

Collective behavior in small systems from geometry-controlled measurements at 200

Shengli Huang
for PHENIX collaboration
VANDERBILT UNIVERSITY

Outline

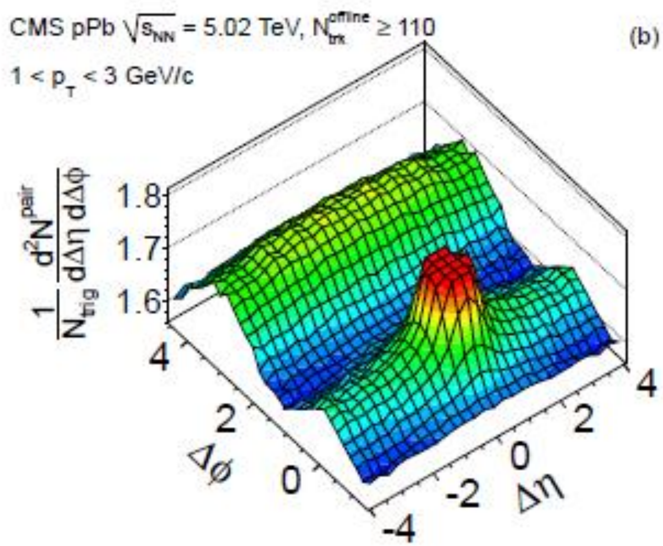
1)Physics Motivation

2)Results and Discussions

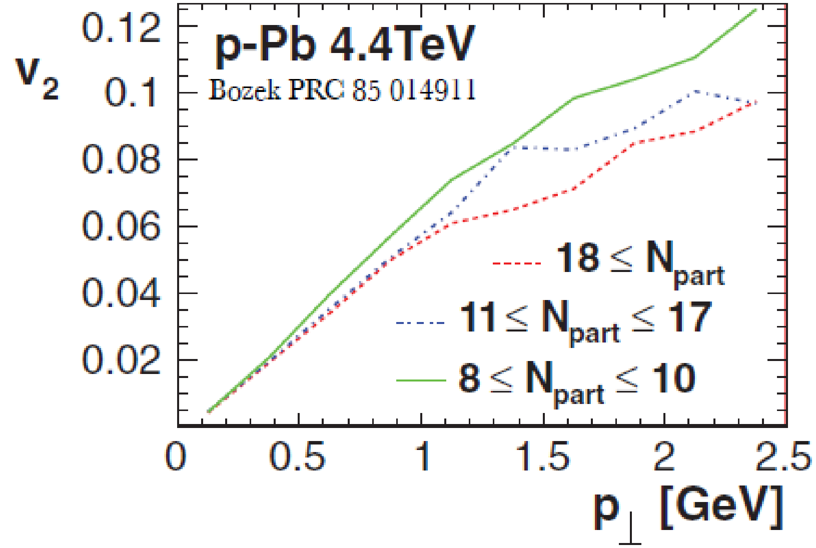
- ✓ Long-range angular correlation in small collisions at 200 GeV
- ✓ Charged hadron v_2 in p+Au, d+Au, ^{3}He+Au and p+Al at 200 GeV
- ✓ Identified particle v_2 in ^{3}He+Au
- ✓ Charged hadron v_3 in ^{3}He+Au at 200 GeV

3)Summary

What is the origin of the ridge in p+A?

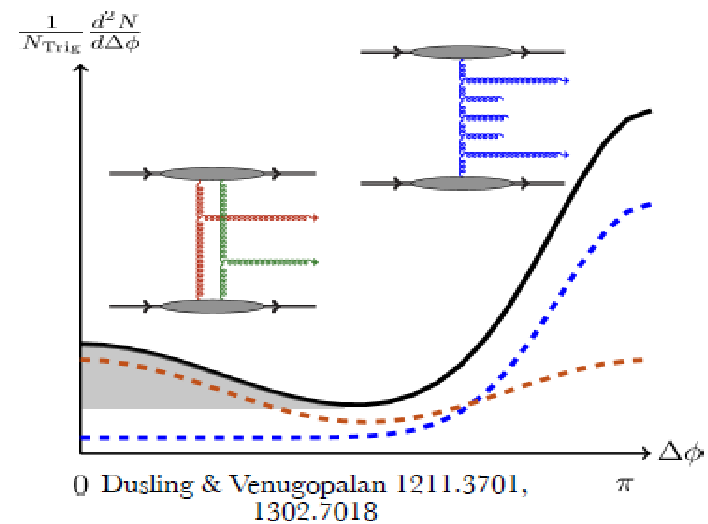


CMS: Phys. Lett. B 7198(2013)

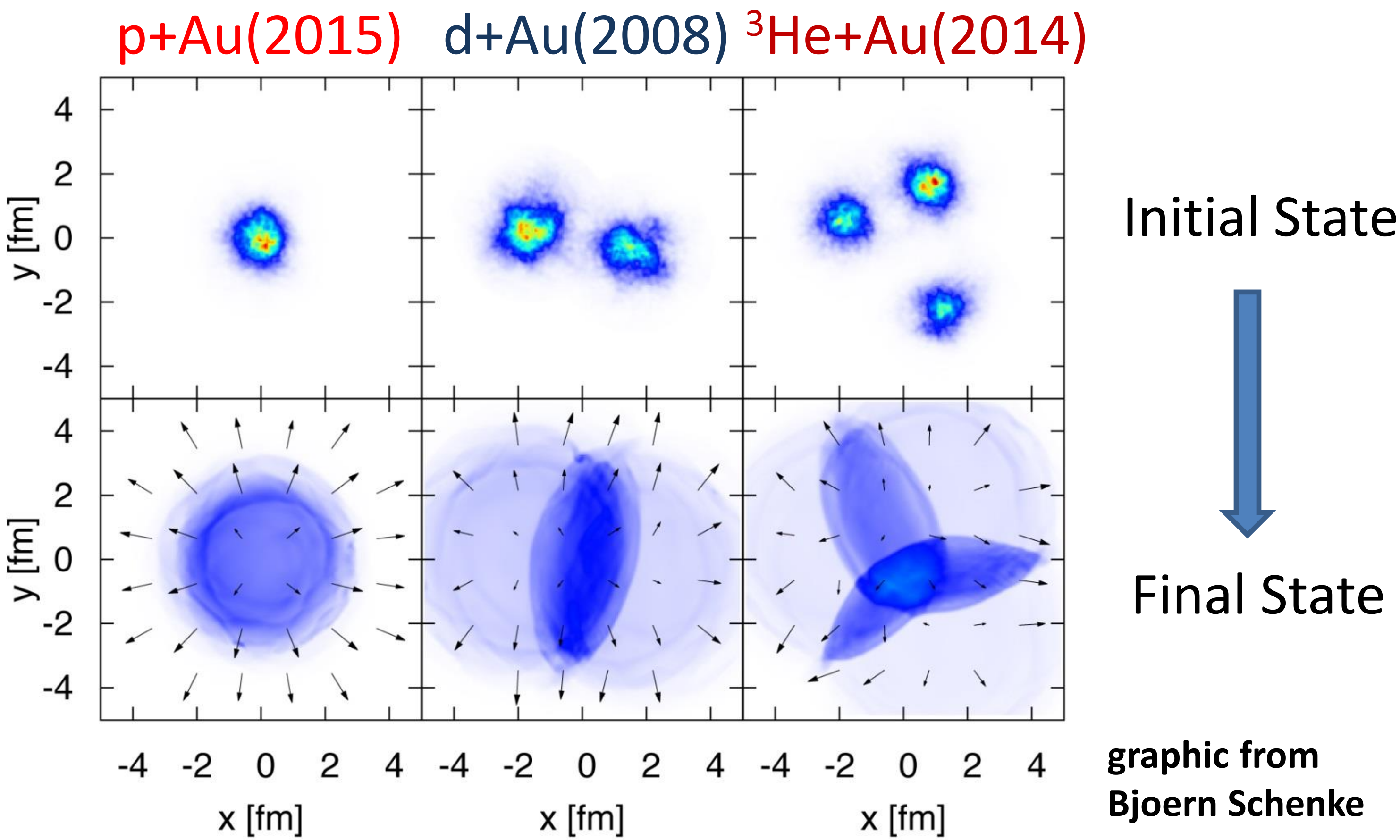


Key Question: What generates the ridge in small collision systems?

- ✓ Final state interaction: Hydrodynamics?
- ✓ Initial momentum correlation: CGC?



Geometry engineering

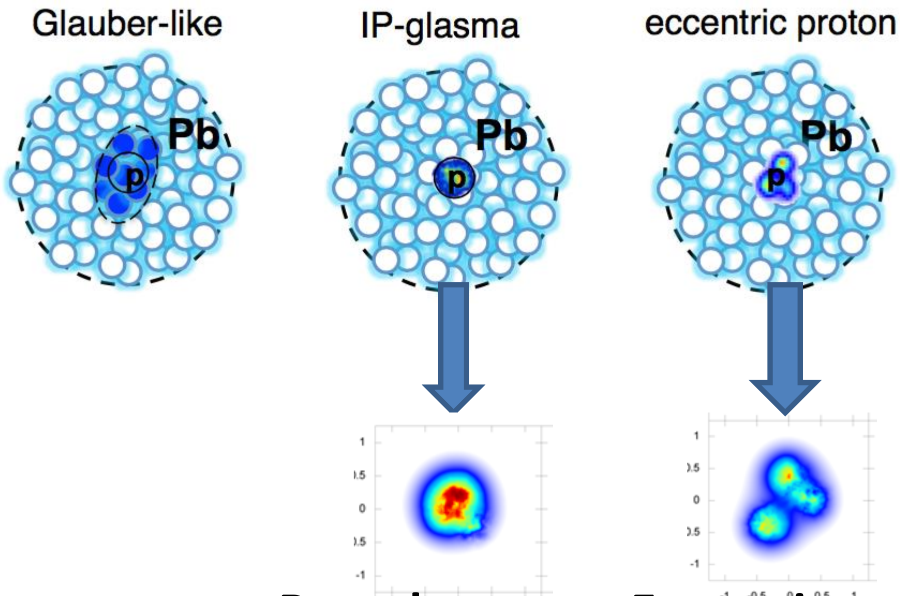


graphic from Bjoern Schenke

- Different initial geometry → different final state particle emission for p+Au, d+Au and ^{3}He+Au collisions
- The dedicated heavy ion machine RHIC can provide this kind of test with its unmatched versatility

The internal structure of proton

arXiv:1509.07939,arXiv:1603.04349

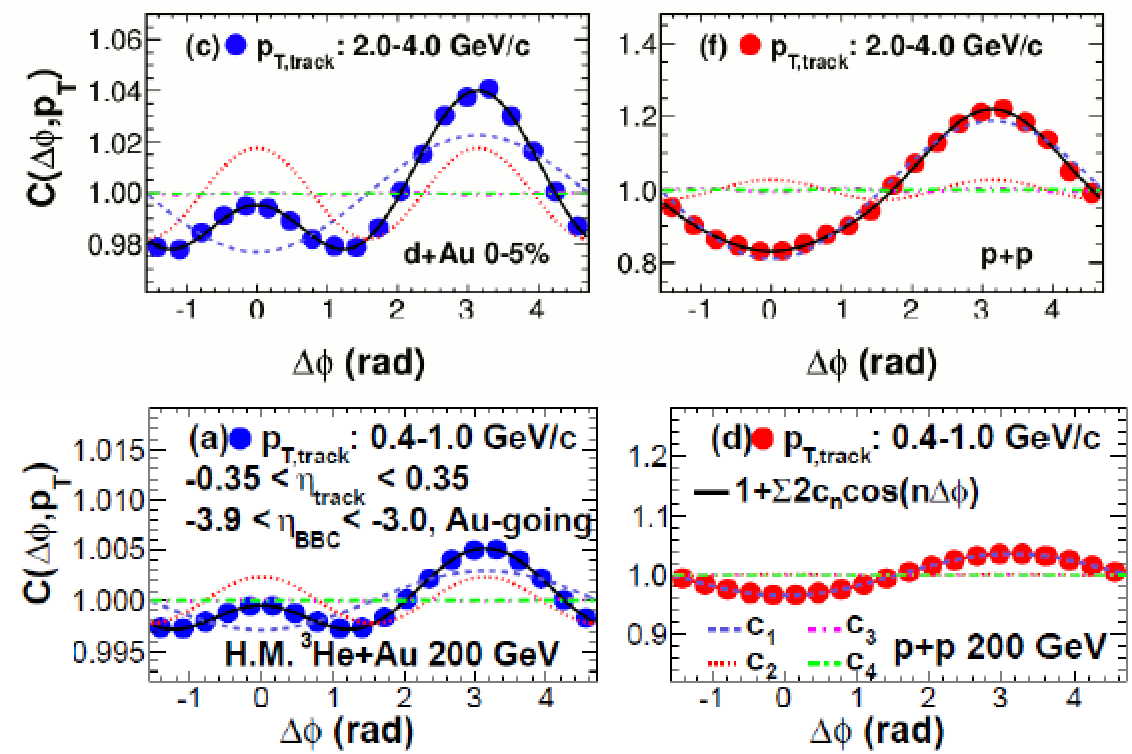


Round proton **Eccentric proton**

The eccentricity is significantly different for round and eccentric proton

The shape of proton does matter!

Ridge in 0-5% d/^{3}He+Au 200 GeV



Central d+Au

Phys. Rev. Lett. 114, 192301

Both PRL highlights!

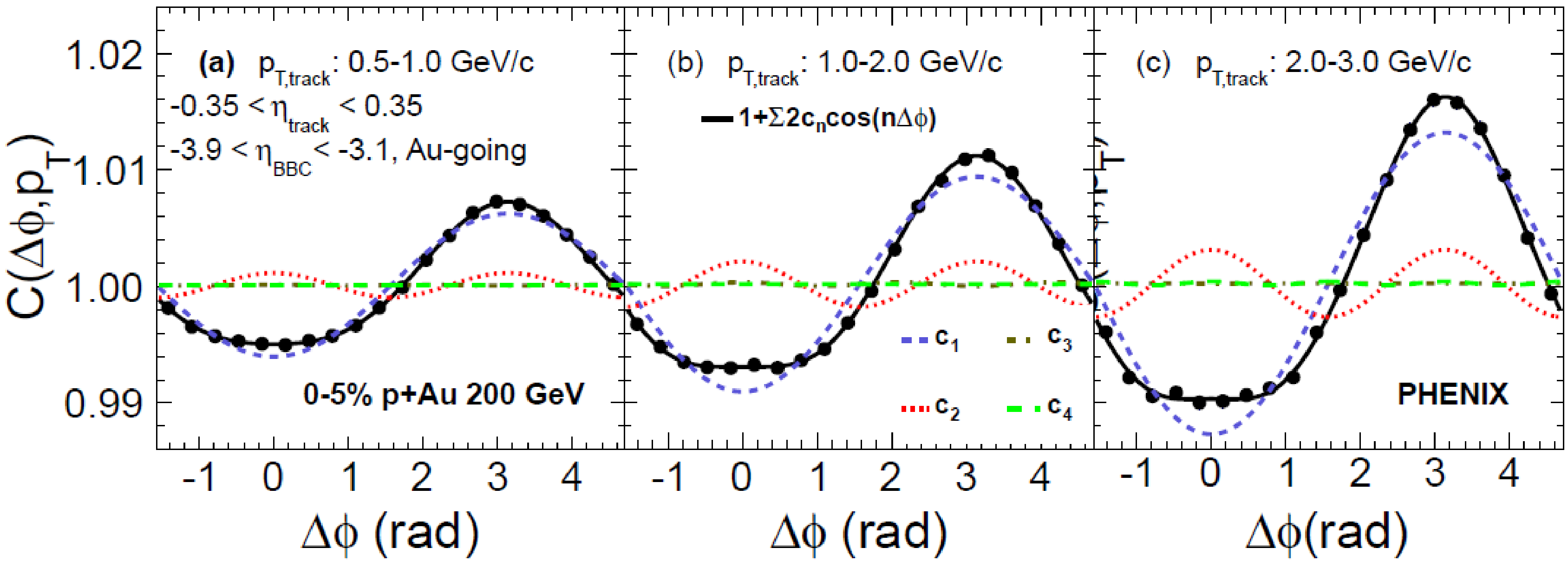
Phys. Rev. Lett. 115, 142301

Central ^{3}He+Au

- ✓ A ridge is observed in high multiplicity(0-5%) d+Au and ^{3}He+Au collisions
- ✓ In the reference pp collision, the correlation is dominated by momentum conservation (including di-jets)
- ✓ A Fourier expansion function is fitted to extract the c_n

Correlation in pAu@200Gev

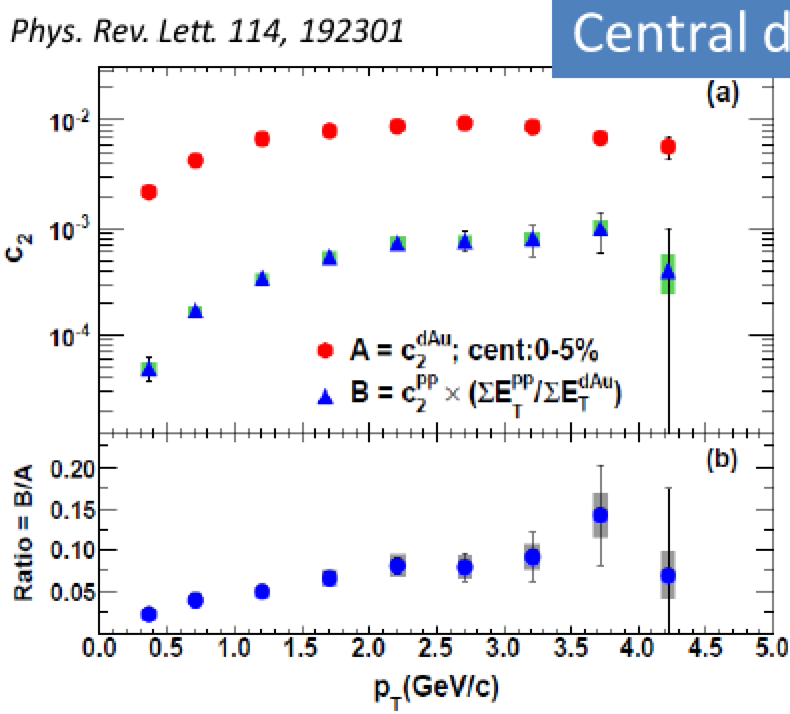
arXiv:1609.02894

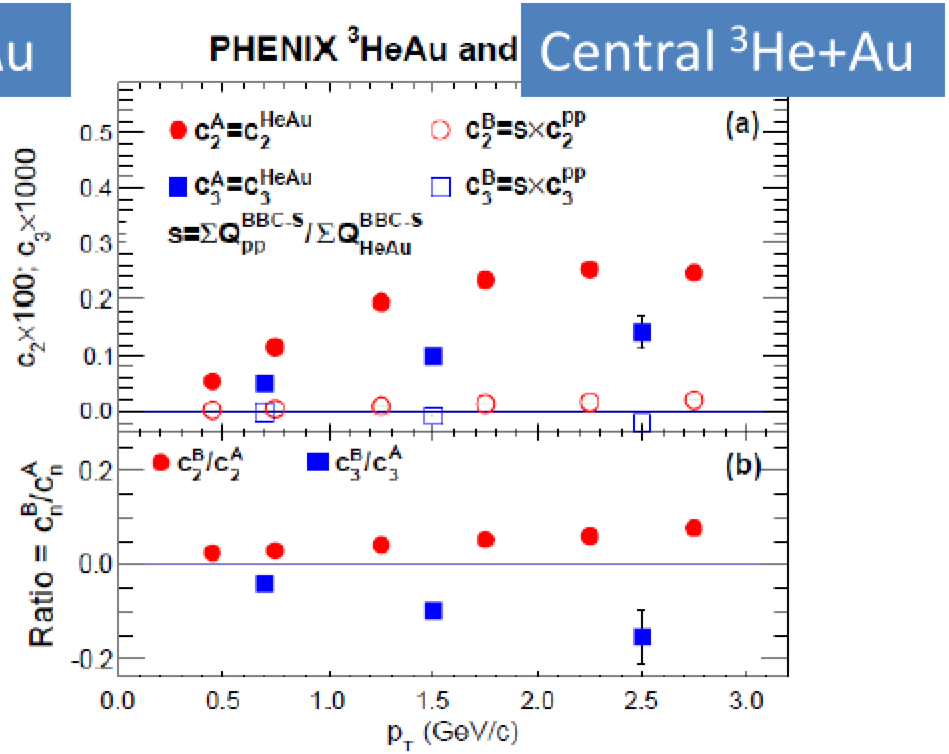


No clear peak is observed for long range angular correlation in p+Au collisions

Still quite different to that of pp, in which a “dip” is seen for the near side two particle correlation

Estimation of non-flow contribution





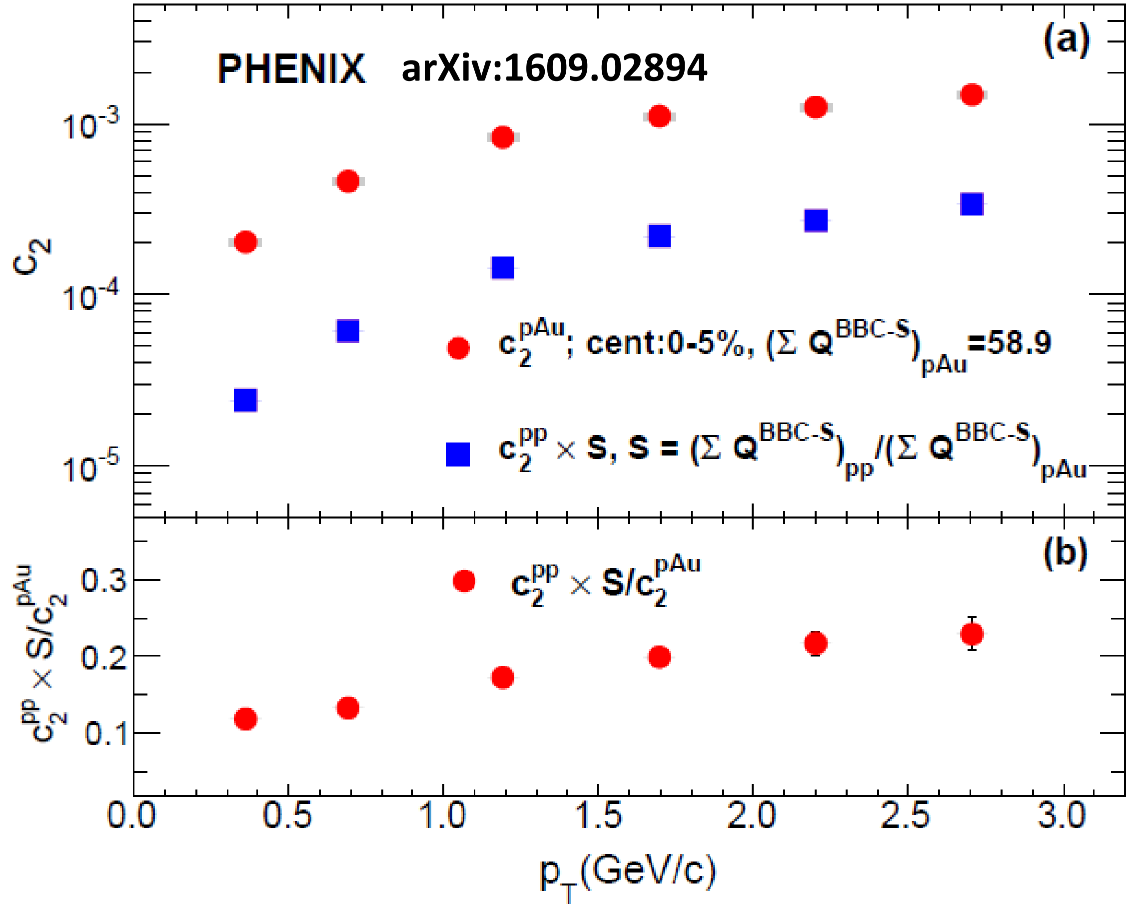
Phys. Rev. Lett. 115, 142301

$$c_2^{dAu}(p_T) = c_2^{\mathrm{Non-elem.}}(p_T) + c_2^{\mathrm{Elem.}}(p_T)$$
$$\approx c_2^{\mathrm{Non-elem.}}(p_T) + c_2^{pp}(p_T)\frac{\Sigma E_T^{pp}}{\Sigma E_T^{dAu}}$$

For c_2, the non-flow contribution estimated using p+p correlation is <10% in 0-5% d/^{3}He+Au collisions

In 0-5% ^{3}He+Au collisions, the non-flow contribution is <15% for c_3

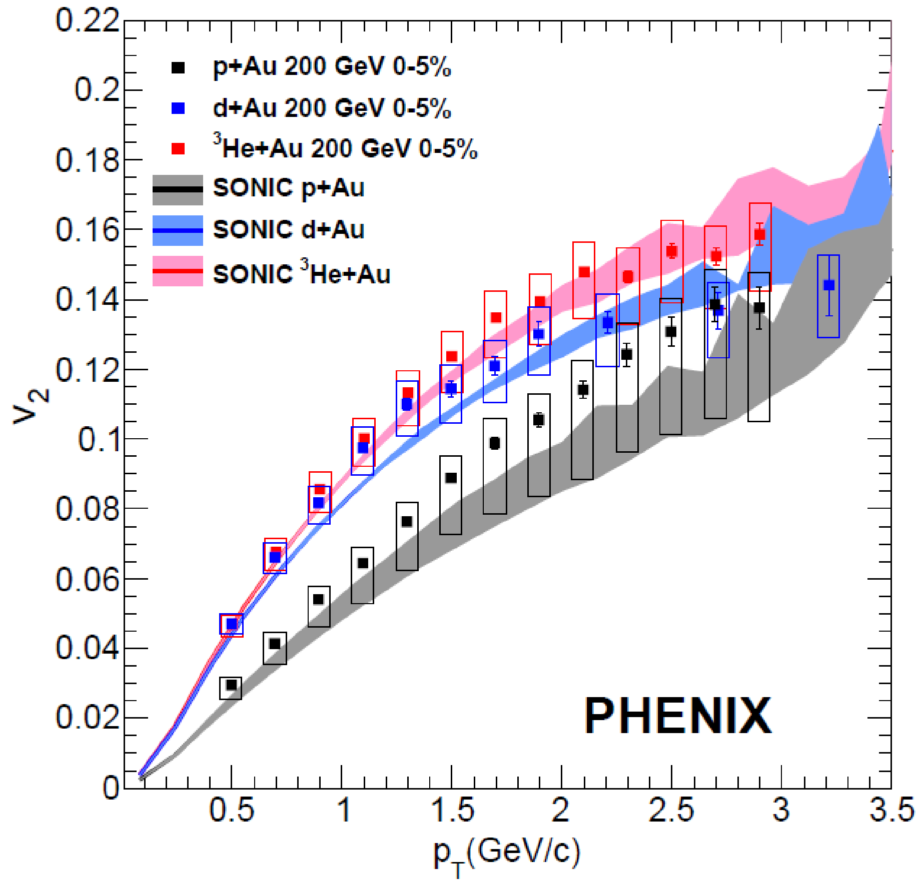
Non-flow Estimation in p+pAu



The jet contribution estimated using p+p correlation rises with p_T and reaches about 25% in 0-5% p+Au collisions

A systematic uncertainty is cited instead of subtraction

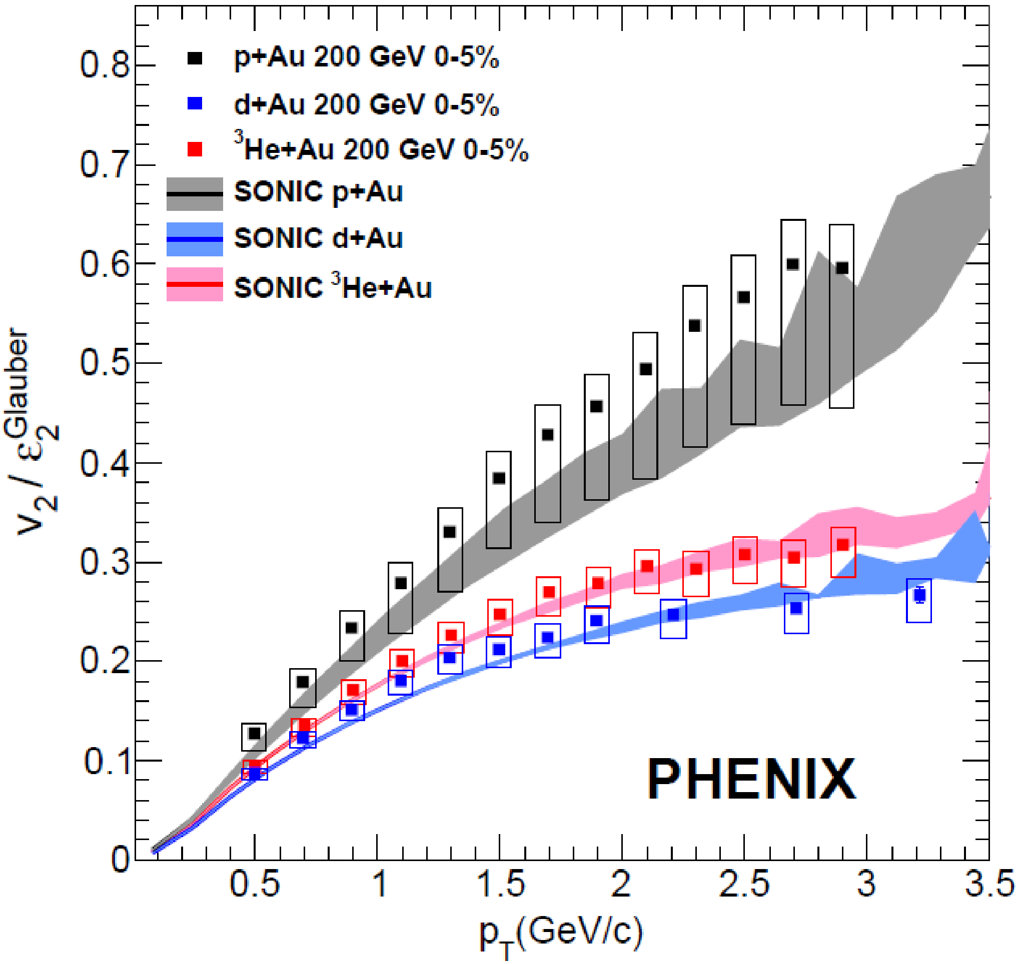
Comparison with p+Au 200 GeV



The v_2 from central p+Au collisions is lower than that of central d+Au and ^{3}He+Au collisions

Smaller initial geometry eccentricity → smaller v_2

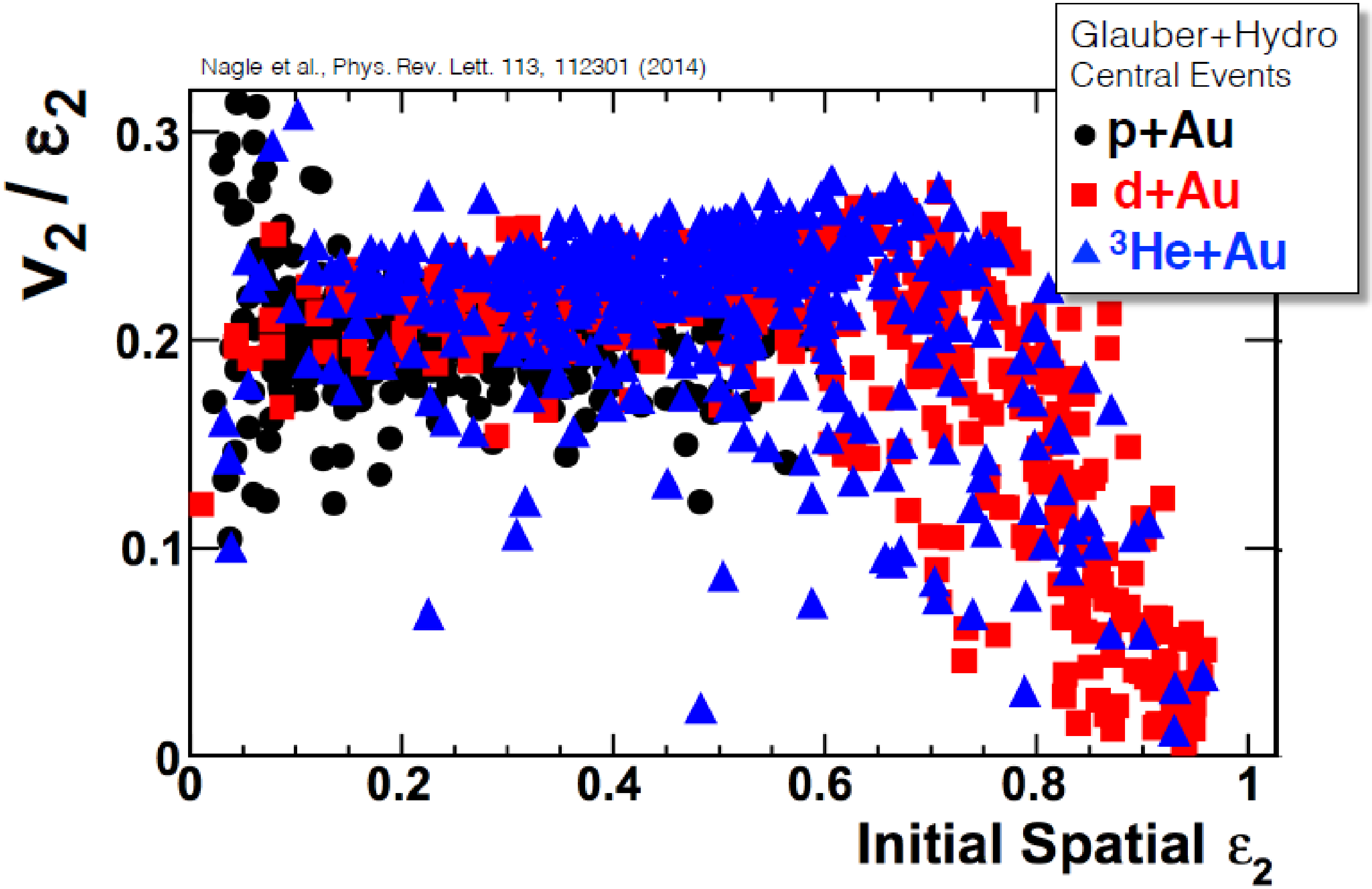
v_2/ε_2 in small collision systems



The v_2/ε_2 in p+Au is higher than that of d+Au and ^{3}He+Au collisions

This behavior is within the expectation of SONIC model, which includes Glauber initial geometry and viscous hydro evolution.

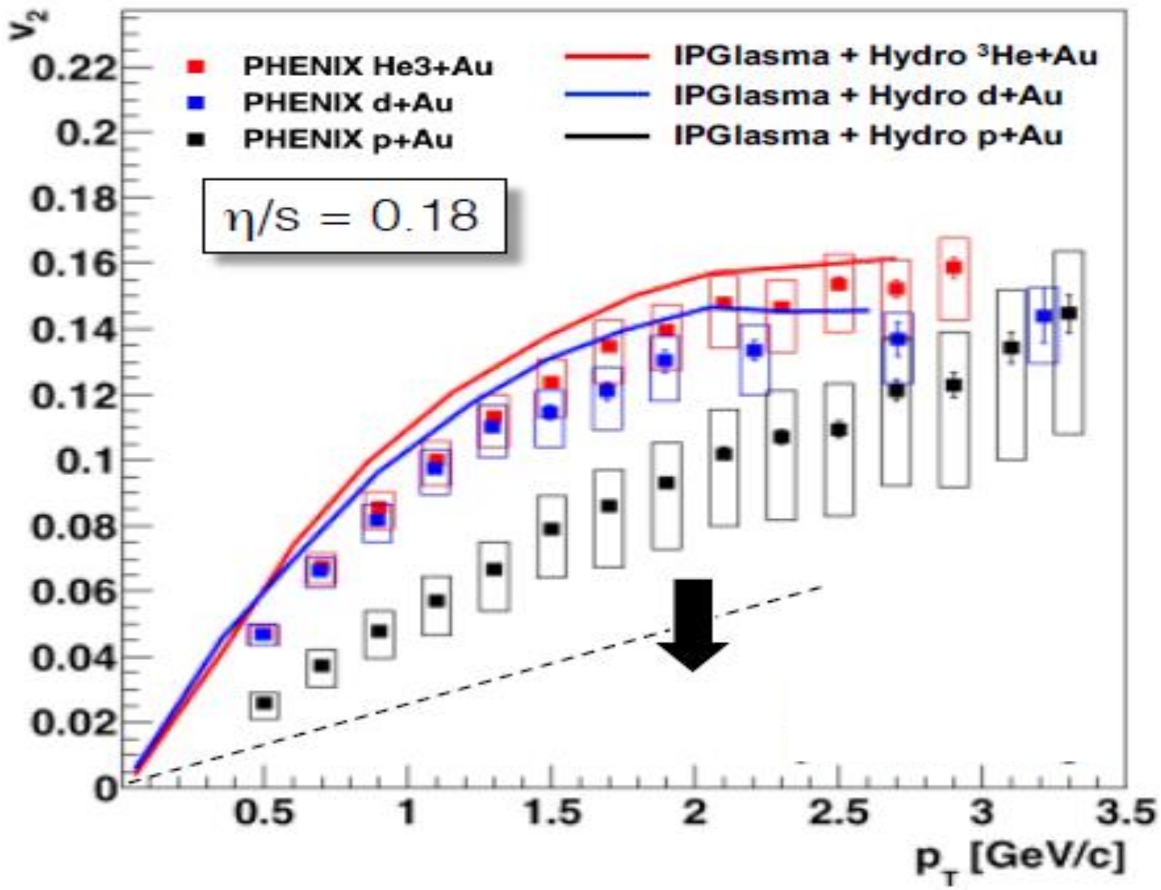
Initial eccentricity=> final momentum flow



For d/^{3}He+Au, the eccentricities are largest at beginning while the systems do not fully flow together

In d/^{3}He+Au, systems are harder to pick up the initial geometry information comparing with that of p+Au

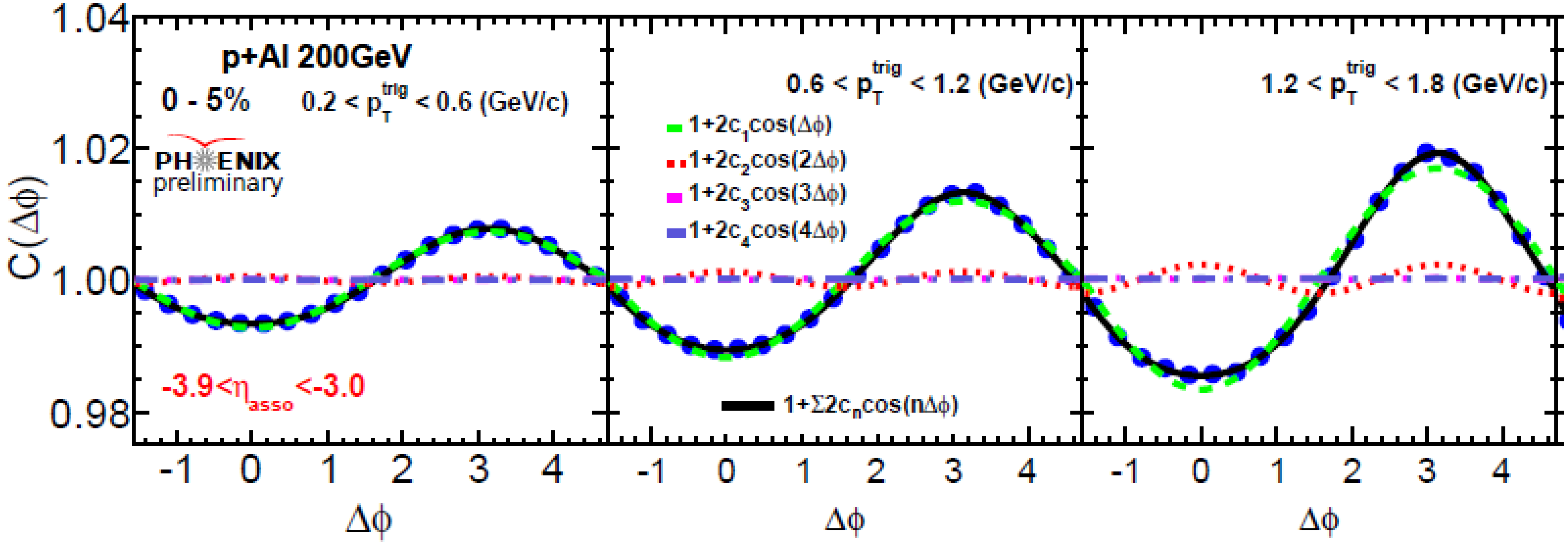
Compare with Hydro + IPGlasma

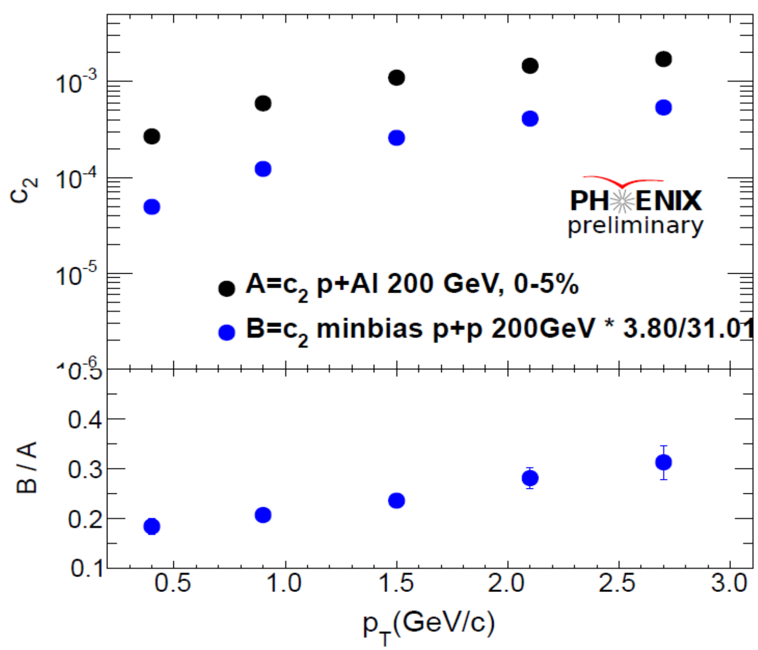


Hydro+IPGlamas with round proton under-estimates the v_2 in p+Au

Shape of proton plays a significant role in the calculation of hydro+IPGlasma

Correlation and nonflow in p+Al@200GeV

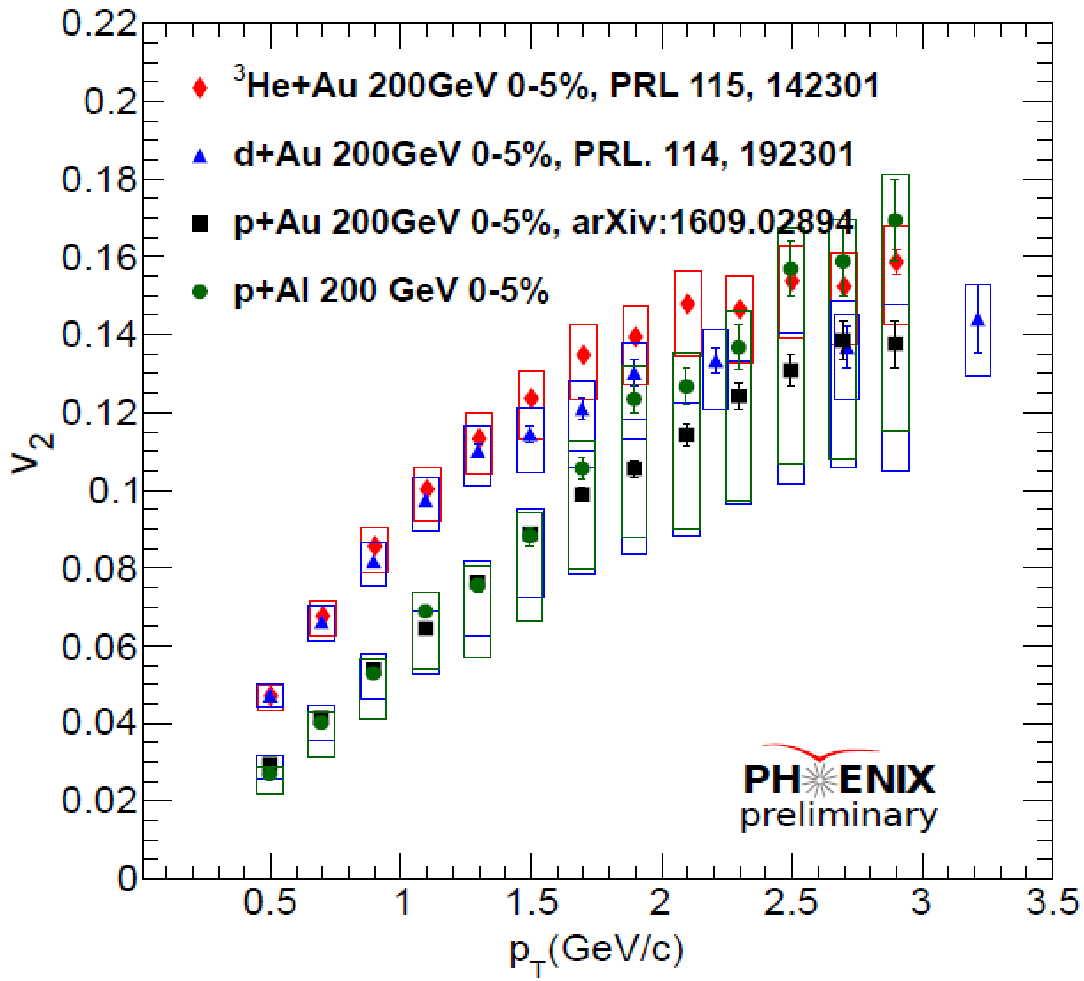




The mean multiplicity in 0-5% p+Al collisions is about a factor two lower than that of p+Au

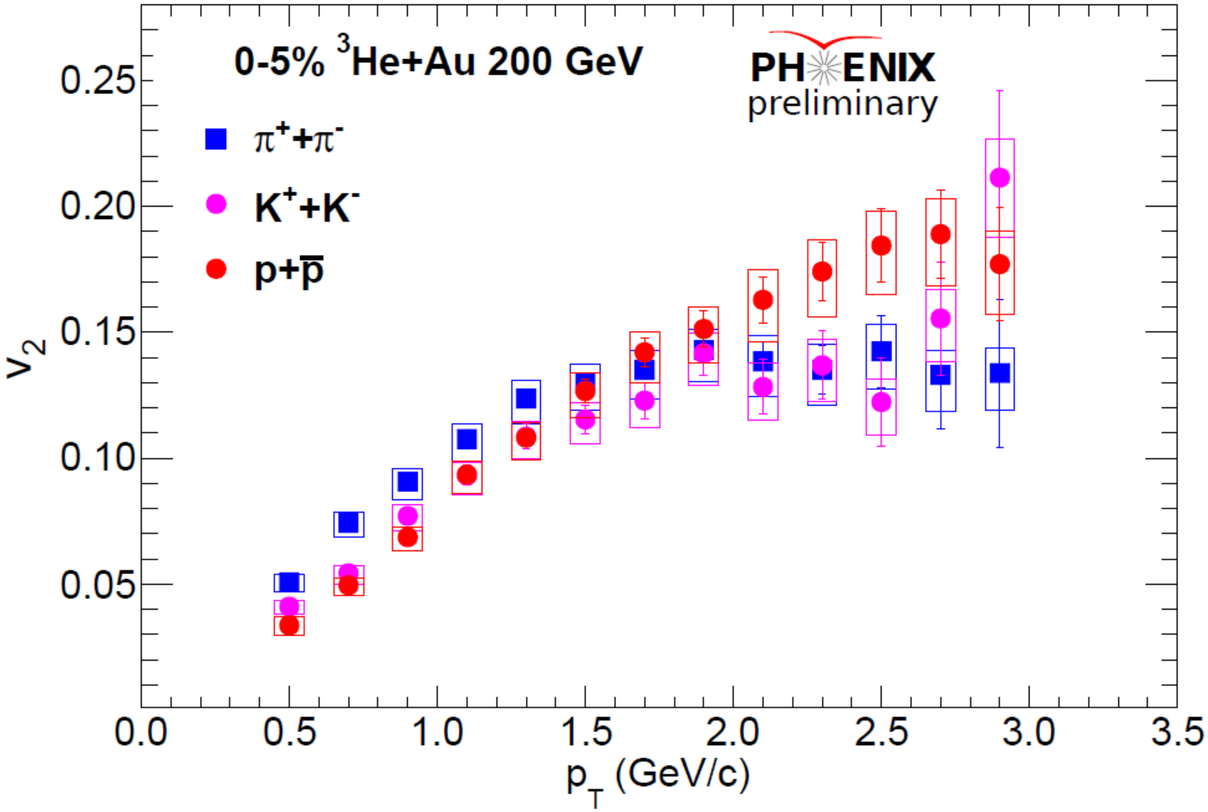
The jet contribution in p+Al is about 33%

The v_2 in p+Al collisions at 200GeV



The v_2 in p+Al is quite similar to that in p+Au collisions

Identified particle v_2 in ^{3}He+Au

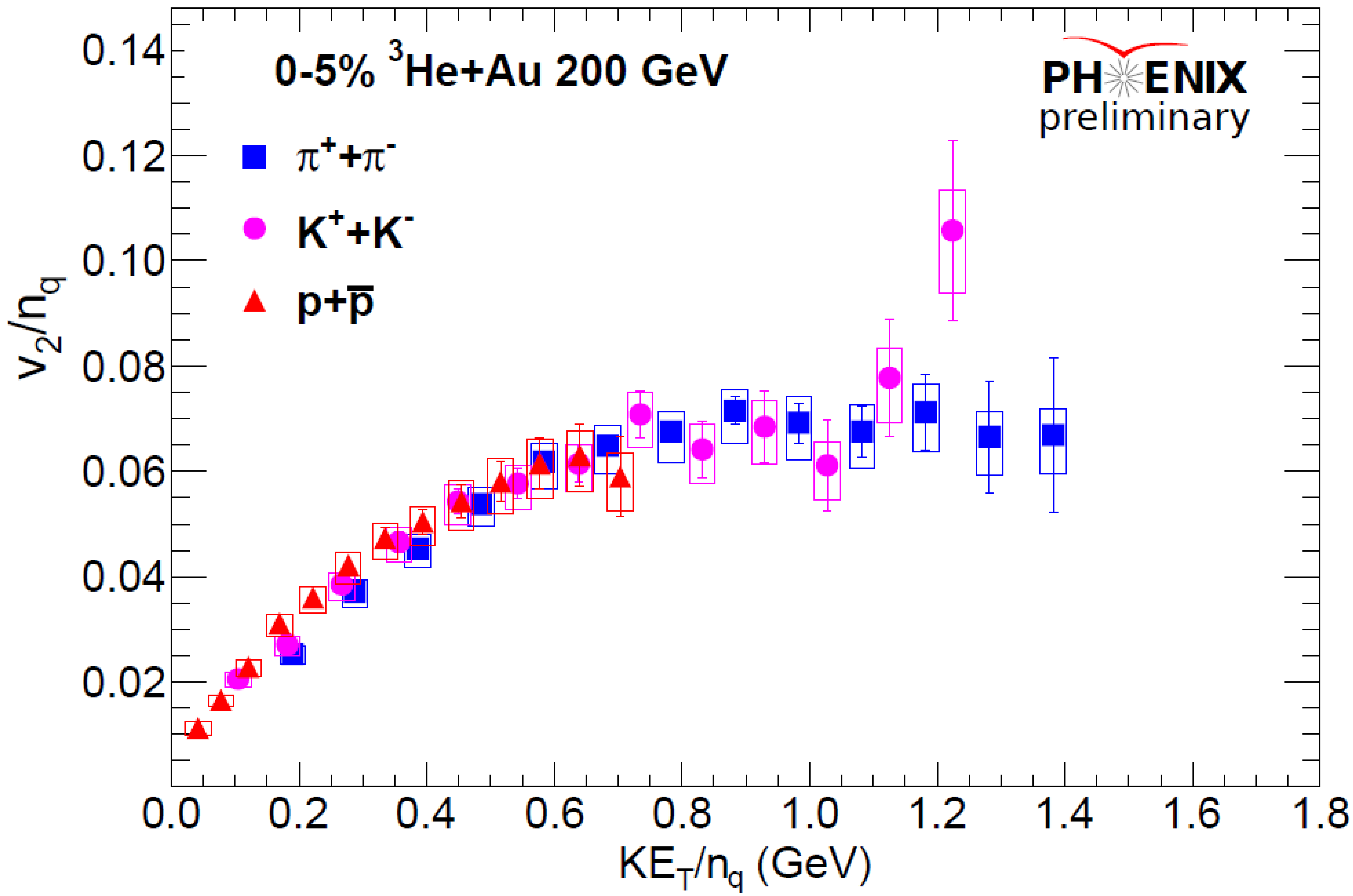


At $p_T < 1.5$ GeV/c: mass order -- v2(proton)< v2(kaon)< v2(pion)

At $p_T > 2.0$ GeV/c: difference for meson and baryon

These behaviors are very similar to that in Au+Au collisions and calculations of viscous hydro.

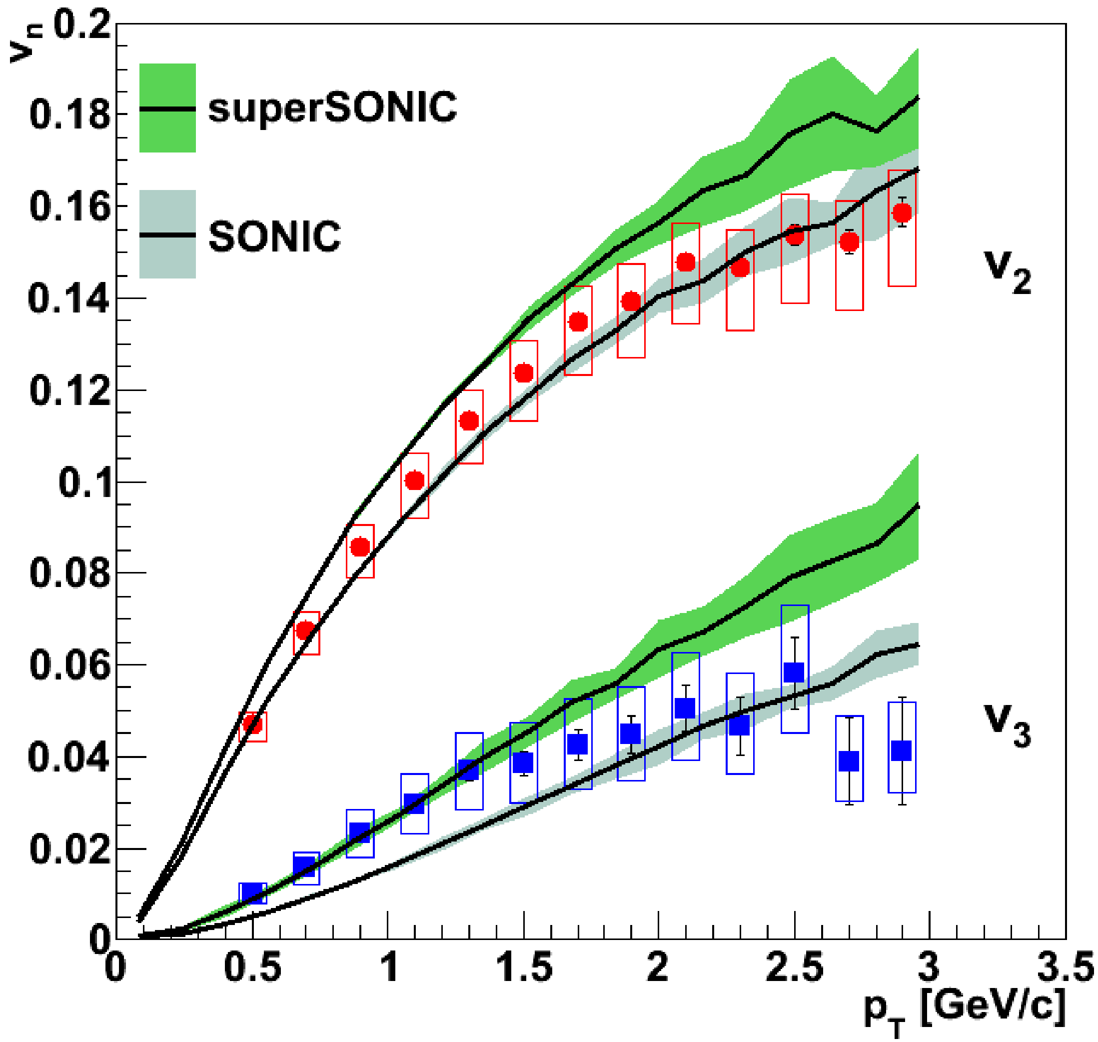
Number of Quark Scaling in ^{3}He+Au



The familiar behavior of number of quark scaling observed in Au+Au collisions is also seen in the small ^{3}He+Au system

The v_3 in ^{3}He+Au collisions at 200 GeV

0-5% 3He+Au collisions PRL 115,142301



(Super)SONIC: arXiv:1502.04745

At low p_T, v_3 in ^{3}He+Au collisions prefer to the calculation from super SONIC which has the pre-equilibrium flow

Require more accurate measurement!

Comparing with v_3 in d+Au would further help us to test the initial geometry effect. New d+Au 200 GeV run in 2016!

Summary

- The ridge is seen in p+Al, p+Au, d+Au and ^{3}He+Au collisions.
- A similar v_2 is seen in p+Al and p+Au collisions and smaller than that of d+Au and ^{3}He+Au collisions
- The number of quark scaling is also observed for identified particle v_2 in ^{3}He+Au collisions
- The sizeable v_3 is observed in ^{3}He+Au collisions and the v_3 of d+Au will come out soon