Measurements of v_2, v_3 in p+Au, d+Au and ^{3}He+Au collisions at 200 GeV from STAR

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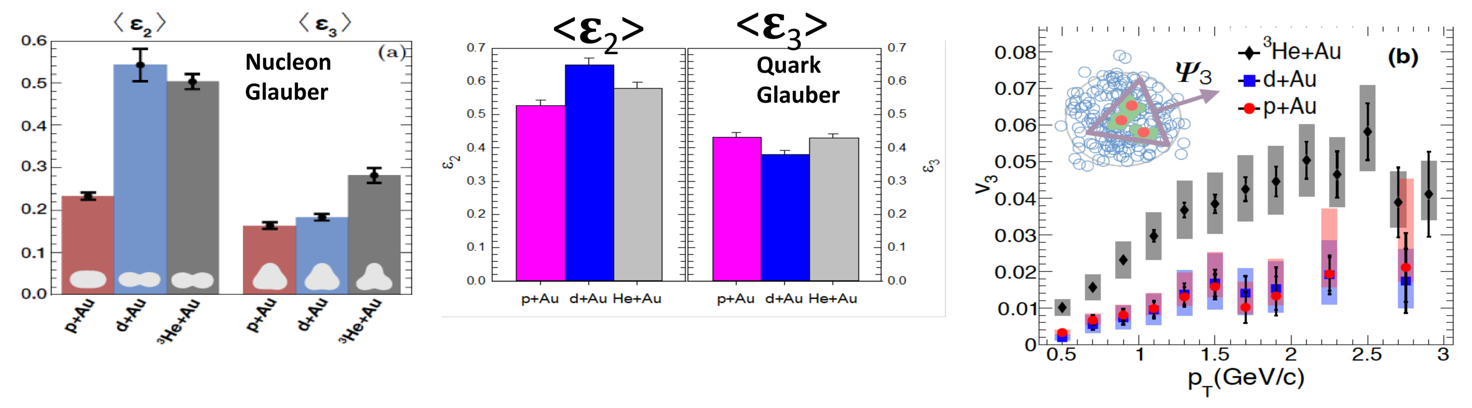
Initial Geometry in Small System



PHENIX EP	^{3}He+Au	d+Au	p+Au
Res(ψ_2^{BBCS})	0.110± 0.0050	0.1073 ± 0.0003	0.062±0.003
Res(ψ_3^{BBCS})	0.034± 0.0051	0.0565 ± 0.0097	0.067±0.009

Nucleon vs. Quark Glauber

ε_3 shows large uncertainties

PHENIX v_3 signal and EP resolution contradict with each other

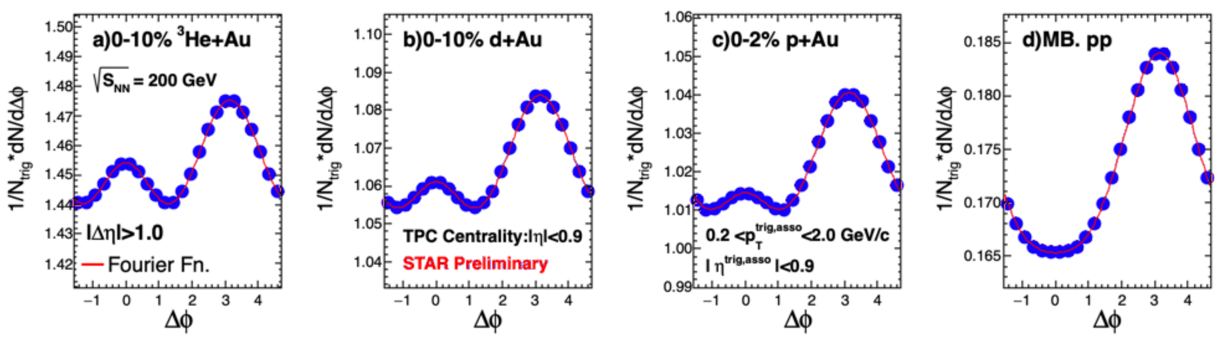
In p+Au, PHENIX v_2 and v_3 EP resolution are same!?

PRC95,034910;nature physics 15, 214–220 (2019); PRL115(2015)142301;PRC96.064905

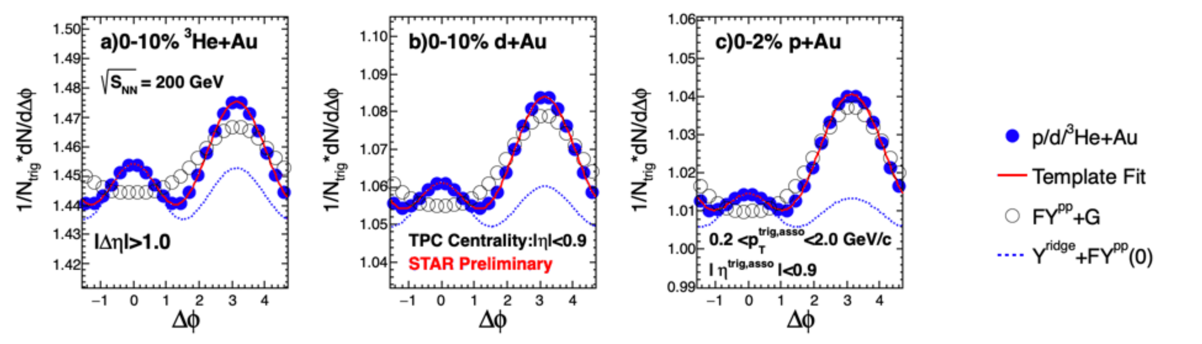
EP resolution ∝ $v_n \times \sqrt{N}$!

Long-range Correlations and Three Subtraction Methods

Fourier Fit: $1/N_{trig}\, dN/d\Delta\phi = c_0(1 + 2\sum_{n=1}^{4} c_n \cos(n\phi))$



Template Fit   *ATLAS:PRL(116)172301*



$0.2<p_T^{trig,asso}<2.0$GeV/c; Centrality: # of tracks in TPC $|\eta|<0.9$

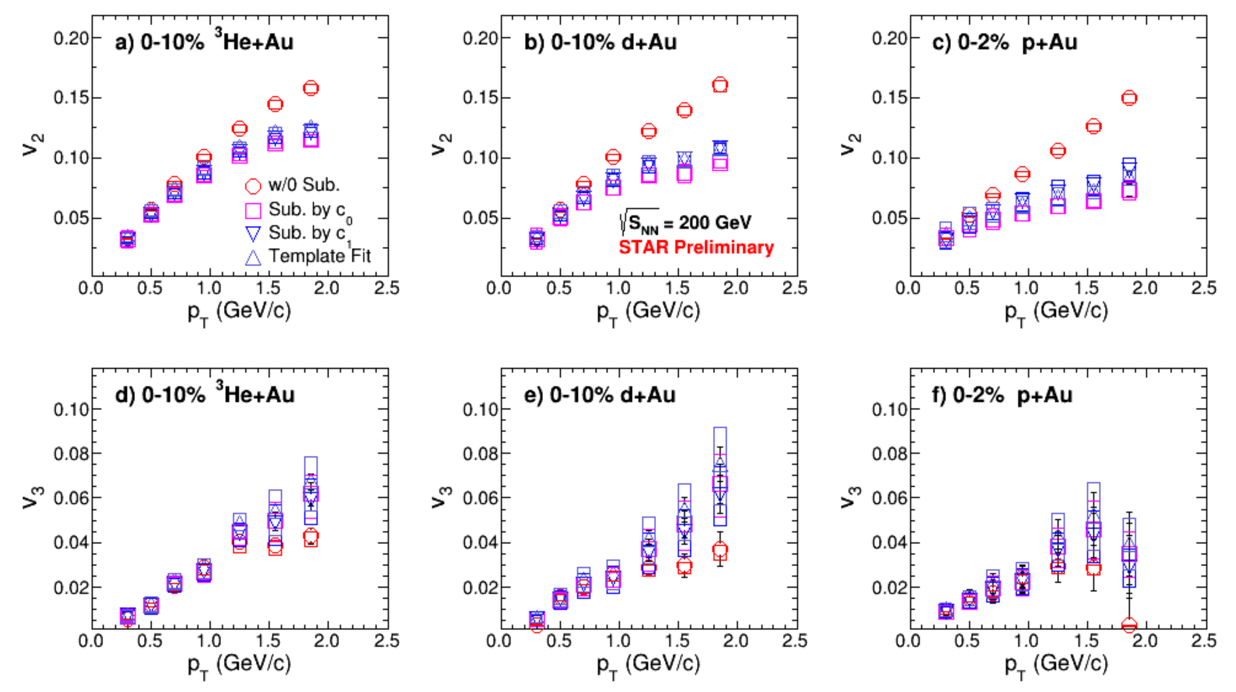
Three Non-flow Subtraction Methods:

1. Sub. by c_0 (yield per trigger): $c_{n,sub}^{sys.} = c_n^{sys.} - (c_0^{pp}/c_0^{sys.}) \times c_n^{pp}$
2. Sub. by c_1: $c_{n,sub}^{sys.} = c_n^{sys.} - (c_1^{sys.}/c_1^{pp}) \times c_n^{pp}$
3. Template Fit: $Y_{templ.}(\Delta\phi) = F\, Y_{pp}(\Delta\phi) + Y_{ridge}(\Delta\phi)$

Where $Y_{ridge}(\Delta\phi) = G(1 + 2\sum_{n=2}^{4} c_{n,sub}^{sys.} \cos(n\Delta\phi))$

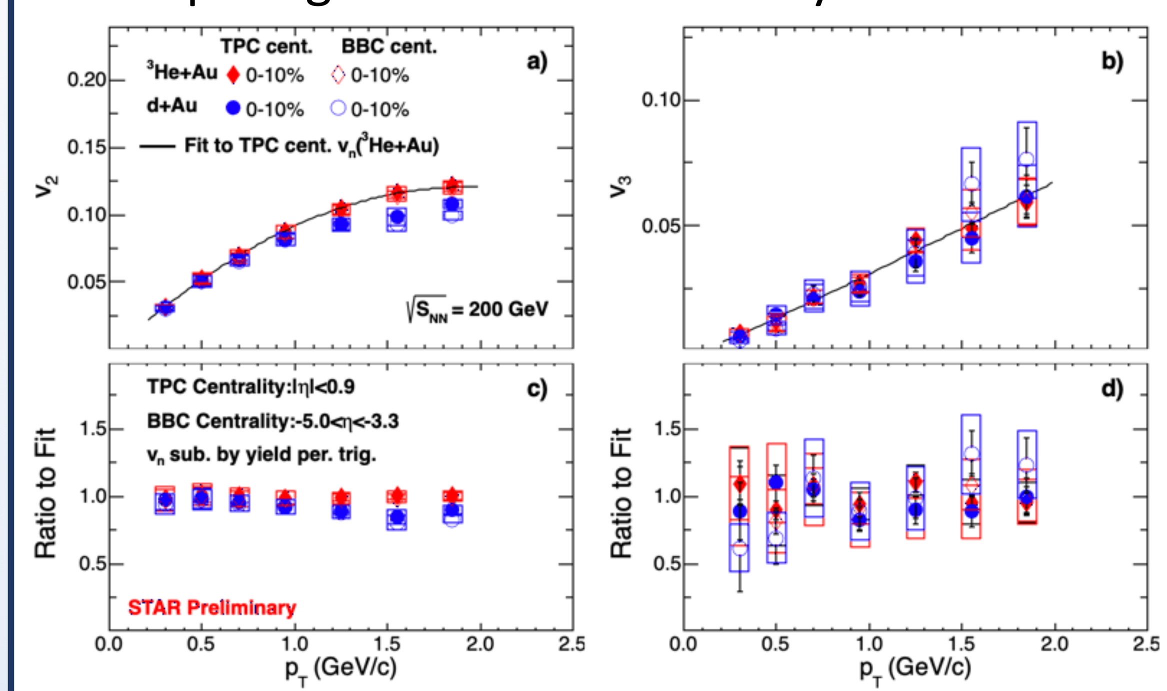
$v_{n,sub}^{sys.} = \sqrt{c_{n,sub}^{sys.}}$; n=2,3

v_n Three subtraction methods



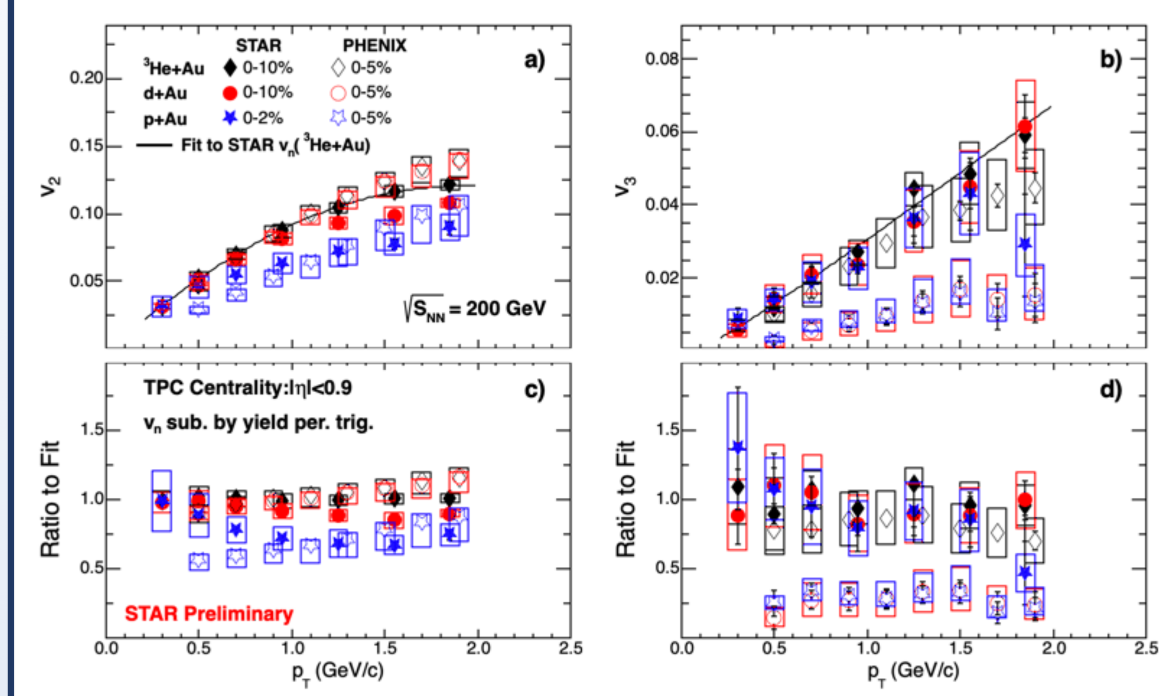
Subtracted v_2 and v_3 in central p/d/^{3}He+Au collisions.
Three different subtraction methods show similar results.
v_3(w/o sub.) will give a low limit! Subtractions only increase signal.

Comparing of different centrality definitions



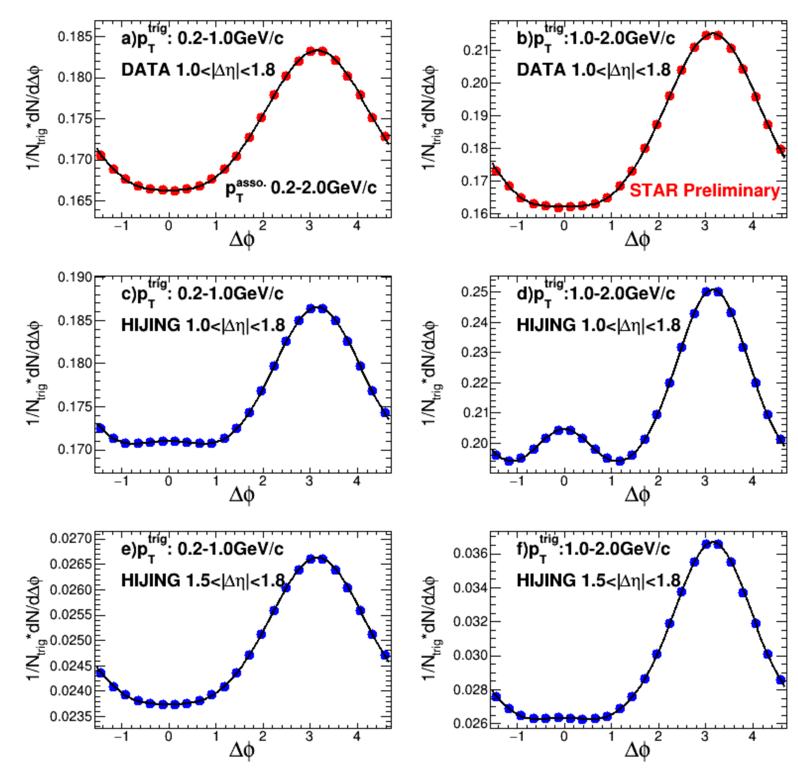
v_n measured with centrality defined by BBC charge in Au-going direction ($-5.0<\eta<-3.3$) is similar to that measured with centrality defined by number of TPC tracks ($|\eta|<0.9$)

Comparing with PHENIX



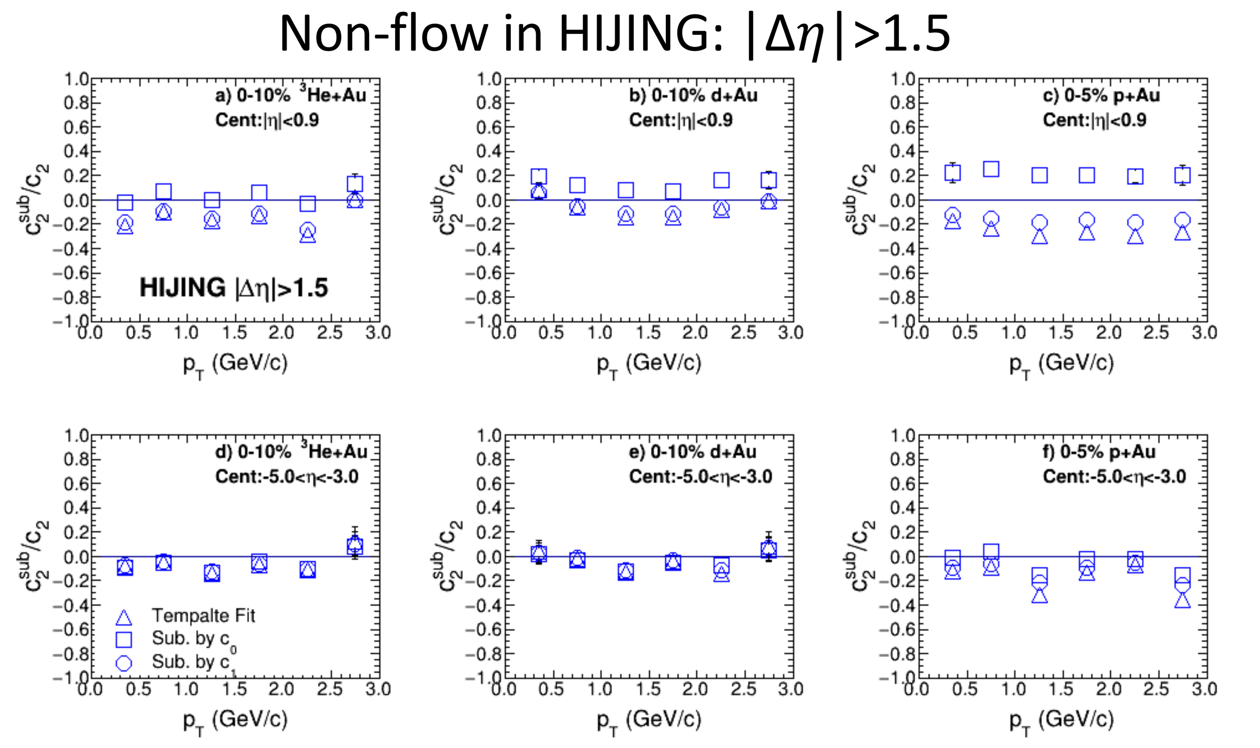
STAR observes a similar v_3 in central p/d/^{3}He+Au collisions at 200 GeV.
PHENIX and STAR have a similar v_3 for ^{3}He+Au while a factor of 3-4 difference for p/d+Au

Closure test with HIJING



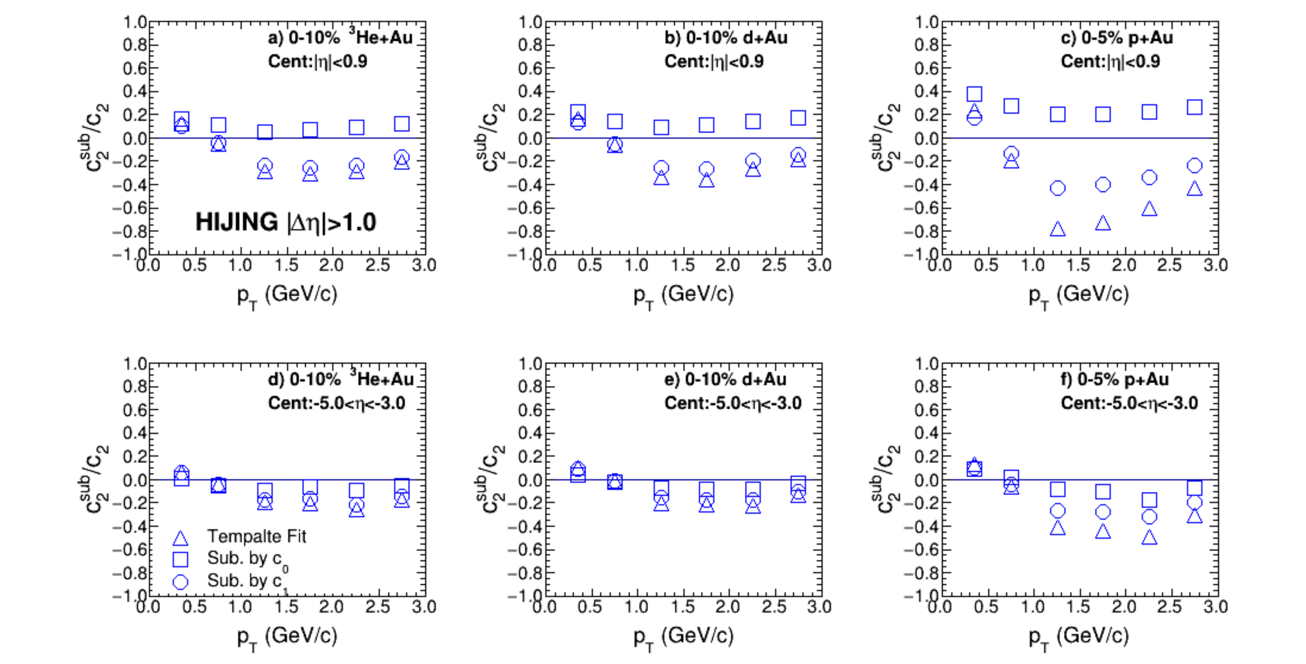
HIJING shows a near-side peak for $|\Delta\eta|>1.0$ while data doesn't in p+p at 200GeV. ***Wider near-side jet in HIJING!***
Results with $|\Delta\eta|>1.5$ in HIJING is more closer to data and will give a more reasonable closure test

Non-flow in HIJING: $|\Delta\eta|>1.5$



From study using $|\Delta\eta|>1.5$ with centrality defined in $|\eta|<0.9$, three methods well estimate the nonflow contribution in d/^{3}He+Au collision. For p+Au collision, the deviation is less than 20%. Since faction of non-flow is less 60% of c_2 in p+Au, it will give less than 12% uncertainties for non-flow subtraction
For centrality defined in $-5.0<\eta<3.0$, three methods well estimate the non-flow contribution in p/d/^{3}He+Au collisions.

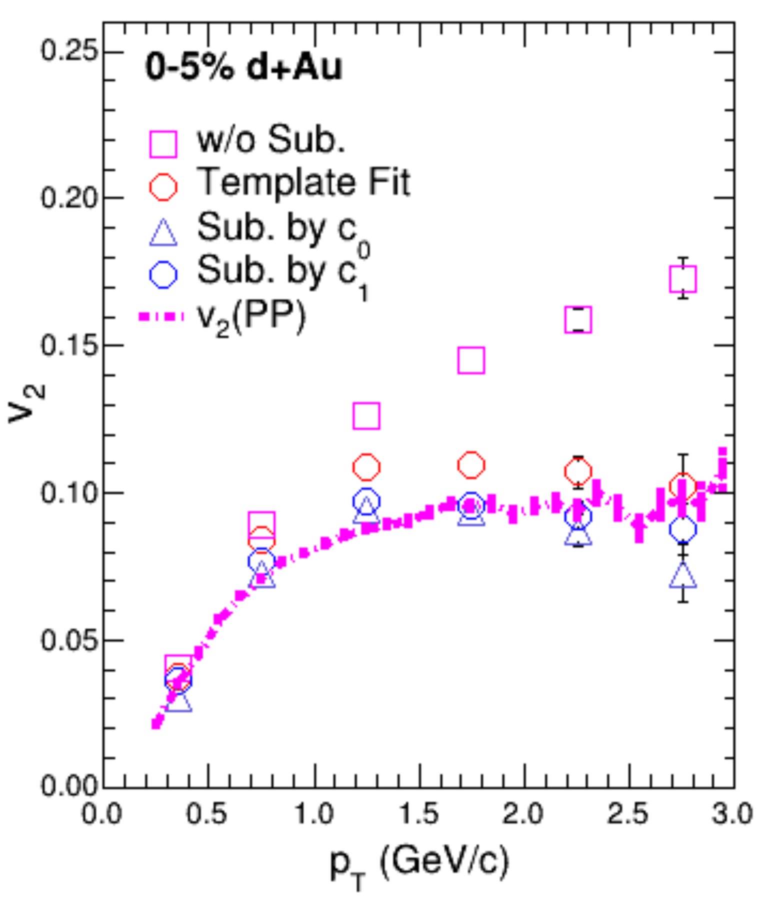
Non-flow in HIJING: : $|\Delta\eta|>1.0$

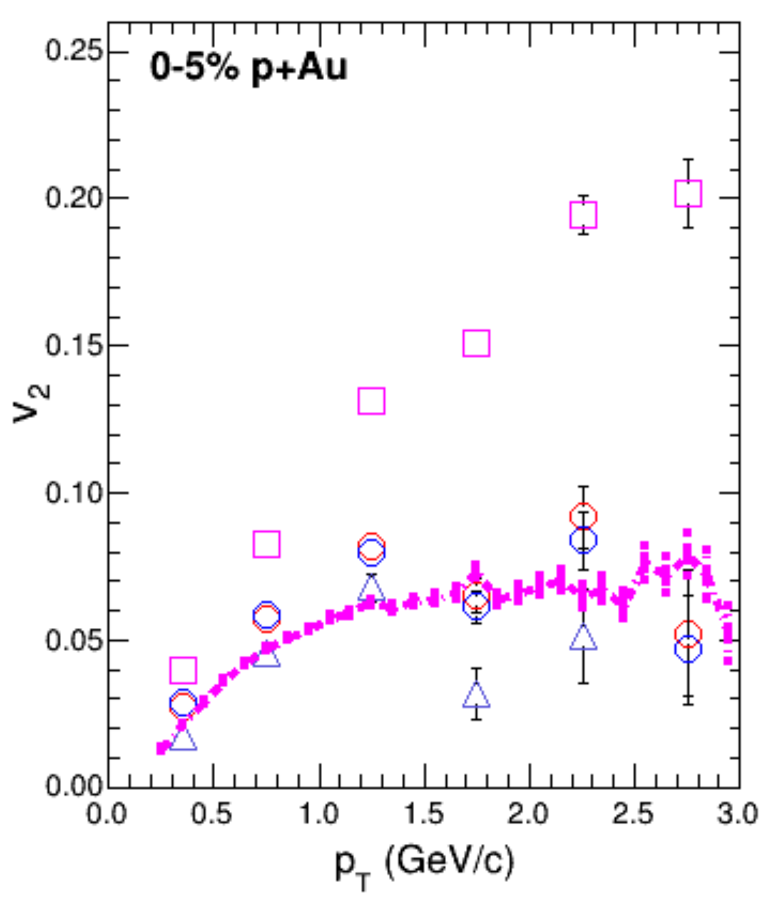


Due to the near-side peak in HIJING, the c_1 and template methods both significantly over subtract the non-flow in p+Au collision for centrality defined in $|\eta|<0.9$. While c_0 method only 20% less subtract the non-flow.

In the real data, results from three methods are similar. It indicates that the closure testing in HIJING with $|\Delta\eta|>1.0$ is not reliable for data!

Closure test with AMPT





$v_2(pp) = \langle\cos 2(\phi - \psi_{PP})\rangle / F$

$$F = \sqrt{\frac{\langle\cos 2(\psi_{PP} - \psi_{EP,A})\rangle \langle\cos 2(\psi_{pp} - \psi_{EP,B})\rangle}{\langle\cos 2(\psi_{EP,A} - \psi_{EP,B})\rangle}}$$

ψ_{PP}: participant plane
$\psi_{EP,A}$:event plant from particles $-4.5<\eta<-2.5$
$\psi_{EP,B}$:event plant from particles $0<\eta<2.5$

From study using $|\Delta\eta|>1.0$ with centrality defined in $|\eta|<0.9$, three methods well reproduce the flow measured by participant plane(v2(pp)) in 0–5% p/d+Au collision at 200 GeV.

Summary

By three different subtraction methods, v_2 and v_3 have been measured in central p+Au, d+Au and ^{3}He+Au collisions as a functions of p_T at 200 GeV

A closure test for non-flow subtraction has been studied with HIJING and AMPT models. Both indicate that the nonflow is well covered with these subtraction methods

A similar v_3 is observed for p/d/^{3}He+Au collisions! It indicates that subnucleon fluctuations play an important role on the initial geometry of small system.