Results and Initial Stages Implications

Darren McGlinchey
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Initial Stages 2017
Probing the Initial State

Small collision systems
No longer just a “baseline”

Focus on small system flow results from PHENIX
Probing the Initial State

Small collision systems
No longer just a “baseline”

Focus on small system flow results from PHENIX

Geometry Scan
Probing the Initial State

Small collision systems
No longer just a “baseline”

Focus on small system flow results from PHENIX

Geometry Scan

Beam Energy Scan of d+Au

<table>
<thead>
<tr>
<th>√s [GeV]</th>
<th>p+p</th>
<th>p+Al</th>
<th>p+Au</th>
<th>d+Au</th>
<th>³He+Au</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>62.4</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>39</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>20</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

2016 Data
Probing the Initial State

\[ d+Au \cdot \sqrt{s_{NN}} = 200 \text{ GeV} \ 0-5\% \]

\[ C(\Delta \phi) \]

\[ 0.65 < |\Delta \eta| < 3.35 \]

Clear near-side ridge!
Probing the Initial State

**d+Au** $\sqrt{s_{NN}} = 200$ GeV 0-5%

$C(\Delta \phi)$

$\Delta \phi$

2.75 $< |\Delta \eta| < 4.25$

$1 + \sum_{n=1}^{3} 2C_n \cos(n\Delta \phi)$

$1 + 2C_1 \cos(\Delta \phi)$

$1 + 2C_2 \cos(2\Delta \phi)$

$1 + 2C_3 \cos(3\Delta \phi)$

Clear near-side ridge!
Probing the Initial State

\[ d+Au \sqrt{s_{NN}} = 200 \text{ GeV } 0-5\% \]

\[ C(\Delta \phi) \]

2.00 < |Δη| < 6.00

- \(1 + \sum_{n=1}^{3} 2C_n \cos(n\Delta \phi)\)
- \(1 + 2C_1 \cos(\Delta \phi)\)
- \(1 + 2C_2 \cos(2\Delta \phi)\)
- \(1 + 2C_3 \cos(3\Delta \phi)\)

Still a clear near-side ridge!
Probing the Initial State

**d+Au** $\sqrt{s_{NN}} = 200$ GeV, 0-5%

1. $h^\pm$
2. $C(\Delta \phi)$
3. $\Delta \phi$

**BBCS — BBCN**

6.20 < $|\Delta \eta|$ < 7.80

- $1 + \sum_{n=1}^{3} 2C_n \cos(n\Delta \phi)$
- $1 + 2C_1 \cos(\Delta \phi)$
- $1 + 2C_2 \cos(2\Delta \phi)$
- $1 + 2C_3 \cos(3\Delta \phi)$

No clear near-side ridge but, strong $C_2$ component

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Darren McGlinchey - PHENIX Overview - 19 Sep 2017
Probing the Initial State

**Ridge evolution with \( \Delta \eta \)**

![Graphs showing ridge evolution with different variables and initial states](image)

<table>
<thead>
<tr>
<th>Initial State</th>
<th>Range of ( \Delta \eta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBC</td>
<td>(-7.80 &lt;</td>
</tr>
<tr>
<td>FVTX</td>
<td>(-6.00 &lt;</td>
</tr>
<tr>
<td>CNT</td>
<td>(-4.25 &lt;</td>
</tr>
<tr>
<td>FVTX</td>
<td>(-3.35 &lt;</td>
</tr>
<tr>
<td>BBCN</td>
<td>(-7.80 &lt;</td>
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<tr>
<td>FVTXS</td>
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</tr>
<tr>
<td>BBCS</td>
<td>(-7.80 &lt;</td>
</tr>
</tbody>
</table>

![Diagram showing ridge evolution with different variables and initial states](image)

**Equations and Key Points:**

- \( C(\Delta \phi) = 1 + 2C_2 \cos(\Delta \phi) \)
- \( C(\Delta \phi) = 1 + 2C_3 \cos(2\Delta \phi) \)
- \( C(\Delta \phi) = 1 + 2C_3 \cos(3\Delta \phi) \)

**Note:**

- \( d+Au \), \( \sqrt{s_{NN}} = 200 \text{ GeV} \), 0-5% collisions.
Probing the Initial State

**d/p/^{3}\text{He} → Au**

*Phys. Rev. C95 (2017)*

- $p_{T,\text{track}}: 0.5-1.0 \text{ GeV/c}$
- $-0.35 < \eta_{\text{track}} < 0.35$
- $-3.9 < \eta_{\text{BBC}} < -3.1$, Au-going

**d+Au**

*arXiv:1708.06983*

- $d+Au \, \sqrt{s_{\text{NN}}} = 200 \text{ GeV} \, 0-5\%$
- CNT -- BBCS
- $2.75 < |\Delta\eta| < 4.25$
- $1 + 2C, \cos(\Delta\phi)$

**3^{3}\text{He}+Au**

*PRL 115 (2015) 142301*

- $p_{T,\text{track}}: 0.4-1.0 \text{ GeV/c}$
- $-0.35 < \eta_{\text{track}} < 0.35$
- $-3.9 < \eta_{\text{BBC}} < -3.0$, Au-going

**H.M. 3^{3}\text{He}+Au 200 GeV**

**Initial Stages 2017**

Darren McGlinchey - PHENIX Overview - 19 Sep 2017
Is the final state anisotropy related to the initial geometry?
0-5% $\sqrt{s}=200$ GeV $h^\pm$

- $p+Au$ 200 GeV 0-5%,
- $d+Au$ 200 GeV 0-5%,
  - PRL 114 (2015), 192301
- $^3He+Au$ 200 GeV 0-5%,
  - PRL 115 (2015), 142301

$V_2^{pAu} < V_2^{dAu} \sim V_2^{HeAu}$

$0-5% \sqrt{s}=200$ GeV $h^\pm$

- $^3He+Au$ $v_2$, $v_3$ (PRL 115, 142301)
- $d+Au$ $v_2$, $v_3$

PHENIX preliminary

$V_3^{dAu} < V_3^{HeAu}$

$FVTX \quad \text{CNT}$

$d/^{3He} \rightarrow \eta=0 \quad 1 \quad \leftarrow \text{Au}$
What does this tell us?


0-5% p+Au

0-5% d+Au

0-5% $^3$He+Au

$v_2$ & $v_3$ well described by hydrodynamics

See Kurt Hill’s talk
Today @ 15:50
For more details
mass ordering in p/d/He+Au

Effect is smallest in p+Au
Identified Particle $v_2$

mass ordering in $p/d/He+Au$

Effect is smallest in $p+Au$

System dependence described by hydro
Is the final state anisotropy related to the initial geometry?
**Geometry Scan**

- $^3\text{He+Au}$, 2014
- $d+Au$, 2008
- $p+Au$, 2015

$\varepsilon_2^{pAu} < \varepsilon_2^{dAu} \sim \varepsilon_2^{HeAu}$

$\varepsilon_3^{dAu} < \varepsilon_3^{HeAu}$

$V_2^{pAu} < V_2^{dAu} \sim V_2^{HeAu}$

$V_3^{dAu} < V_3^{HeAu}$

**Final State Anisotropy**

$\Leftarrow$

**Initial Geometry**

$+$

**Final State Interactions**
Geometry Scan

$^{3}\text{He}+\text{Au}$ 2014  
$d+\text{Au}$ 2008  
$p+\text{Au}$ 2015

$\varepsilon_2^{p\text{Au}} < \varepsilon_2^{d\text{Au}} \sim \varepsilon_2^{\text{HeAu}}$

$\varepsilon_3^{d\text{Au}} < \varepsilon_3^{\text{HeAu}}$

$V_2^{p\text{Au}} < V_2^{d\text{Au}} \sim V_2^{\text{HeAu}}$

$V_3^{d\text{Au}} < V_3^{\text{HeAu}}$

Final State Anisotropy \(\Leftarrow\)

Initial Geometry +

Final State Interactions

d+Au Energy Scan (2016)

200 GeV  
62.4 GeV  
39 GeV  
19.6 GeV

How does the flow depend on energy?
Significant $v_2$ signal at all 4 energies!
(super)SONIC in good agreement at 200 & 62.4 GeV
(super)SONIC in good agreement at 200 & 62.4 GeV

(super)SONIC under predicts data at 39 & 19.6 GeV
(super)SONIC in good agreement at 200 & 62.4 GeV

(super)SONIC under predicts data at 39 & 19.6 GeV

Nonflow?
Theory Comparison

Working definitions:

Flow: anisotropy correlated with initial geometry

non-Flow: Everything else! (jets, decays, etc)

We do not subtract non-flow, so data contains Flow ⊗ Nonflow

(I’ll come back to this later)
Can we gain any intuition or insight about nonflow?
AMPT

v2.26

Black disk MC Glauber w/ Hulthen w.f.
String Melting
partonic & hadronic scattering

$\sigma_{\text{parton}} = 0.75 \text{ mb}$

Centrality det. $N_{\text{ch}} < 3.9 < \eta < -3.1$

*AMPT details described in arXiv:1708.06983

Data: Flow $\otimes$ Nonflow

AMPT $v_2$\{Parton Plane\}: $\leftarrow$ Flow
Follows expectations:

Difference is small at low-\(p_T\) and grows at high-\(p_T\)

Difference grows with decreasing collision energy

*AMPT details described in arXiv:1708.06983*
**Geometry Scan**

- $^3\text{He}+\text{Au}$ 2014
- $p+\text{Au}$ 2015
- $d+\text{Au}$ 2008

$\varepsilon_2^{p\text{Au}} < \varepsilon_2^{d\text{Au}} \sim \varepsilon_2^{\text{HeAu}}$

$\varepsilon_3^{d\text{Au}} < \varepsilon_3^{\text{HeAu}}$

- $V_2^{p\text{Au}} < V_2^{d\text{Au}} \sim V_2^{\text{HeAu}}$
- $V_3^{d\text{Au}} < V_3^{\text{HeAu}}$

**Final State Anisotropy**

⇔

**Initial Geometry**

+ **Final State Interactions**

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**d+Au Energy Scan (2016)**

- d+Au 2016
- 200 GeV
- 62.4 GeV
- 39 GeV
- 19.6 GeV

**How does the flow depend on energy?**
Geometry Scan

$^3\text{He}+\text{Au}$

$\varepsilon_2^{\text{pAu}} < \varepsilon_2^{\text{dAu}} \sim \varepsilon_2^{\text{HeAu}}$

$\varepsilon_3^{\text{dAu}} < \varepsilon_3^{\text{HeAu}}$

$d+\text{Au}$

$v_2^{\text{pAu}} < v_2^{\text{dAu}} \sim v_2^{\text{HeAu}}$

$v_3^{\text{dAu}} < v_3^{\text{HeAu}}$

Final State Anisotropy  

Initial Geometry  

Final State Interactions  

**d+Au Energy Scan (2016)**

- $d+\text{Au}$
- 200 GeV
- 62.4 GeV
- 39 GeV
- 19.6 GeV

Strong $v_2$ signal even at 19.6 GeV

... 

Interpretation is complicated by nonflow
Strong $v_2$ signal even at 19.6 GeV

... Interpretation is complicated by nonflow

What else can we do to learn more?

Final State Anisotropy $\iff$

Initial Geometry +

Final State Interactions
Pseudorapidity dependence of $v_2$!

Event Plane determined by the Au-going BBC
(-3.9<$\eta$<-3.1)
Interesting behavior at backward rapidity and lower energies

Data: Flow $\otimes$ Nonflow

AMPT $v_2$\{Parton Plane\}: $\leftarrow$ Flow

AMPT $v_2$\{EP\}: $\leftarrow$ Flow $\otimes$ Nonflow

*AMPT details described in arXiv:1708.06983
AMPT $v_2\{\text{EP}\}$ No Scattering: Turn off partonic and hadronic scattering ← Nonflow only

2 conclusions:

1. Measured signal is inconsistent with nonflow only! (according to AMPT)
2. Nonflow is greatest near the region where the event plane is calculated
Why don’t we subtract/estimate nonflow?

Most proposed methods utilize low multiplicity p+p collisions to estimate non flow.

We don’t have measured p+p references at all 4 energies.
Estimating non flow

Why don’t we subtract/estimate nonflow?

Most proposed methods utilize low multiplicity p+p collisions to estimate Non flow

We don’t have measured p+p references at all 4 energies

Also ... most proposed methods assume linear combination of Flow & Nonflow

AMPT results indicate that that may not be the case ...
Estimating non flow

Why don’t we subtract/estimate nonflow?

Most proposed methods utilize low multiplicity p+p collisions to estimate Non flow

We don’t have measured p+p references at all 4 energies

Also ... most proposed methods assume linear combination of Flow & Nonflow

AMPT results indicate that that may not be the case ...

Most proposed methods we’ve tested don’t pass a closure test in AMPT (d+Au @ RHIC)
**v\textsubscript{2} signal persists in peripheral collisions**

\[ \frac{dN_{ch}}{d\eta} (0-5\%) \sim 23 \]
\[ \frac{dN_{ch}}{d\eta} (60-88\%) \sim 5 \]
Centrality Dependence in d+Au

v2 signal persists in peripheral collisions

AMPT v2{EP} describes the data well up to ~ 10-20%

dN_{ch}/d\eta (0-5%) ~ 23

dN_{ch}/d\eta (10-20%) ~ 17
0-5% \( p+Au \) \( \sqrt{s_{NN}}=200 \text{ GeV} \)

\( v_2 \) grows towards peripheral collisions

**AMPT over predicts the p+Au!**

(same settings/method as d+Au)
So far, everything I’ve shown used the Event Plane method.

Cumulants have proven to be effective in both A+A and p+A at the LHC.

What about at RHIC?
Using Cumulants

**New Result!**

Previous results in this talk measured $v_2$ at midrapidity

For cumulants, using tracks in the FVTX

$(1 < |\eta| < 3)$
Using Cumulants

Previous results in this talk measured $v_2$ at midrapidity

For cumulants, using tracks in the FVTX ($1 < |\eta| < 3$)

What about small systems at RHIC?
Cumulants in d+Au

d+Au at 200 GeV follows the same pattern as Au+Au! (And p+Pb)

arXiv:1707.06108
Cumulants in d+Au

Real valued $v_2\{4\}$ down to 19.6 GeV!

Although ... doesn’t follow the same trend

See J. Nagle talk Tue 18:20
Small system flow

Geometry Scan

\[ \varepsilon_2^{pAu} < \varepsilon_2^{dAu} \sim \varepsilon_2^{HeAu} \]
\[ \varepsilon_3^{dAu} < \varepsilon_3^{HeAu} \]

Final State Anisotropy

\[ v_2^{pAu} < v_2^{dAu} \sim v_2^{HeAu} \]
\[ v_3^{dAu} < v_3^{HeAu} \]

Final State Interactions

Initial Geometry

\[ \Rightarrow \]

d+Au Energy Scan (2016)

Strong \(v_2\) signal even at 19.6 GeV

... Interpretation is complicated by nonflow

\[ \begin{array}{c}
\text{d+Au} \\
\text{2016}
\end{array} \]

- 200 GeV
- 62.4 GeV
- 39 GeV
- 19.6 GeV
Small system flow

**Geometry Scan**

\[ \varepsilon_{2}^{pAu} < \varepsilon_{2}^{dAu} \sim \varepsilon_{2}^{HeAu} \]
\[ \varepsilon_{3}^{dAu} < \varepsilon_{3}^{HeAu} \]
\[ v_{2}^{pAu} < v_{2}^{dAu} \sim v_{2}^{HeAu} \]
\[ v_{3}^{dAu} < v_{3}^{HeAu} \]

**d+Au Energy Scan (2016)**

<table>
<thead>
<tr>
<th>Energy (GeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
</tr>
<tr>
<td>62.4</td>
</tr>
<tr>
<td>39</td>
</tr>
<tr>
<td>19.6</td>
</tr>
</tbody>
</table>

Evidence of collectivity even at 19.6 GeV...

Need a better handle on nonflow
Lots of other small system results!
Lots of other small system results!

$\Psi(2S)$ suppression in $p/d/^{3}\text{He}+A$
Suggests co-mover interactions at backward rapidity

$P_{RC} 95\ (2017)\ 034904$
Lots of other small system results!

$\Psi(2S)$ suppression in $p/d/^{3}\text{He}+A$
Suggests co-mover interactions at backward rapidity

Charm & bottom via $e^+e^-$
$d+Au$ is consistent with $N_{\text{coll}}$ scaling
Lots of other small system results!

**ψ(2S) suppression in p/d/³He+A**
Suggests co-mover interactions at backward rapidity

Charm & bottom via $e^+e^-$
d+Au is consistent with N_{coll} scaling

Jets in d+Au
Evidence of proton size fluctuations?
π^0 modification in p/d/\(^3\)He+Au
Help to disentangle soft/hard physics

ψ(2S) suppression in p/d/\(^3\)He+A
Suggests co-mover interactions at backward rapidity

Jets in d+Au
Evidence of proton size fluctuations?

π^0, |η|<0.35, \(\sqrt{s_{NN}} = 200\) GeV
Global uncertainty 9.7%

π^0 modification in p/d/\(^3\)He+Au
Help to disentangle soft/hard physics

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Suggests co-mover interactions at backward rapidity

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Suggests co-mover interactions at backward rapidity

Jets in d+Au
Evidence of proton size fluctuations?
π⁰ modification in p/d/³He+Au
Help to disentangle soft/hard physics

ψ(2S) suppression in p/d/³He+Au
Backward rapidity

h^± R_{cp} in p+Au / p+Al
Strong η and system dependence

π⁰, h||<0.35, \sqrt{s_{NN}} = 200 GeV
Global uncertainty 9.7%
Lots of other small system results!

\( \pi^0 \) modification in p/d/\(^3\)He+Au

Help to disentangle soft/hard physics

\( \Psi(2S) \) suppression in p/d/\(^3\)He+Au

Suggests co-mover interactions at backward rapidity

Charm & bottom via e+e-

d+Au is consistent with N\(_{\text{coll}}\) scaling

Jets in d+Au

Evidence of proton size fluctuations?

\( \pi^0 \) modification in p/d/\(^3\)He+Au

Help to disentangle soft/hard physics

\( h^\pm R_{cp} \) in p+Au / p+Al

Strong \( \eta \) and system dependence

\( \gamma/\pi^0-h \) correlations in p/d+Au

Interesting \( p_T \) & centrality dependence
Lots of other small system results!

π⁰ modification in p/d/³He+Au
Help to disentangle soft/hard physics

Ψ(2S) suppression in p/d/³He+Au
Suggests co-mover interactions at backward rapidity

γ/π⁰-h correlations
Interesting p_T & centrality

h± R_cep in p+Au / p+Al
Strong η and system dependence

And more to come …
Thank you!

PHENIX talks at IS2017

- “Direct Photon Measurements by the PHENIX Experiment at RHIC” - Veronica Canoa Roman
- “PHENIX Results on Geometry Engineering in Small Systems” - Kurt Hill
- “PHENIX Results on Small Systems from the d+Au Beam Energy Scan” - Jamie Nagle
**PHENIX**

**CNT** - Charged particle tracking

**FVTX** - Unidentified particle tracking

Cluster (Event Plane)

**BBC** - Clusters (Event Plane)

Centrality determination

\[ p/d^3He \rightarrow Au \]
Small System Geometry Scan

Evidence points to initial spatial geometry correlations propagated to final state momentum correlations via interactions between medium constituents (hydro -or- parton transport)

Small System Beam Energy Scan

Strong v2 signals measured down to 19.6 GeV, including v2{4}!

We need a better understanding of non-flow contributions in order to learn more

PHENIX data taking might be over, but we’ve got plenty of it left to analyze!
What does this tell us?

IPGlasma+Hydro

SONIC

superSONIC

AMPT
What does this tell us?

0-5% p+Au 200 GeV

- PHENIX $v_2$
- AMPT
- SONIC
- superSONIC
- IPGlasma+Hydro

$\text{IP Glasma (sub-nucleonic structure)}$

$\text{IPGlasma+Hydro}$

0-5% d+Au 200 GeV

- PHENIX
- d+Au
- 2008

0-5% $^3$He+Au 200 GeV

- $^3$He+Au
- 2014

- MC Glauber
- superSONIC
- AMPT

Darren McGlinchey - PHENIX Overview - 19 Sep 2017
What does this tell us?

**0-5% p+Au 200 GeV**
- PHENIX $v_2$
- AMPT
- SONIC
- superSONIC
- IPGlasma+Hydro

**0-5% d+Au 200 GeV**
- $p+Au$
- d+Au
- 2008

**0-5% $^3$He+Au 200 GeV**
- $^3$He+Au
- 2014

**V$_2$ vs $p_T$ (GeV/c)**

**IP Glasma**
(sub-nucleonic structure)

**IPGlasma+Hydro**

**MC Glauber**

**SONIC**

**superSONIC**

**AMPT**

**Hydrodynamics**

**Partonic & Hadronic Scattering**
What does this tell us?


0-5% p+Au

0-5% d+Au

0-5% ^3He+Au

MC Glauber

IP Glasma (sub-nucleonic structure)

iEBE-VISHNU

Hydrodynamics

IPGlasma+Hydro

Partonic & Hadronic Scattering

MC Glauber

superSONIC

AMPT

SONIC

Hydrodynamics

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Using the same AMPT settings as the v2 calculations
Does a good job at mid & forward rapidity @ 200 GeV
Overpredicts backward rapidity & lower energies
New Result!

Good agreement
With previous measurements!

PHENIX

$dN_{ch}/d\eta$ in $d+Au$

$\sqrt{s_{NN}} = 200$ GeV

$0-5\%$

$5-10\%$

$10-20\%$

$20-40\%$

$40-60\%$

$60-88\%$

PHENIX Preliminary

PHENIX Preliminary

PHENIX (arXiv:1708.06983)

PHENIX (Phys.Rev. C93 (2016))

PHENIX (Phys.Rev. C93 (2016))


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V2 scales like $dN/d\eta$ @ 200 GeV

Scaling breaks at Backward rapidity @ 62 & 39 GeV

Interestingly, AMPT & Hydro Show similar scaling at Mid & forward rapidities
v₂ vs centrality

low-p_T (0.6 — 0.8)

AMPT:
v₂ decreases towards peripheral
Nonflow subdominant
(~2% difference v₂[PP] vs v₂[EP])

Data:
v₂ flat or increasing toward peripheral
Increased nonflow?

200 GeV

62.4 GeV

39 GeV
**v₂ vs centrality**

**low-p_T (0.6 — 0.8)**
- AMPT: v₂ decreases towards peripheral
- Nonflow subdominant (~2% difference v₂{PP} vs v₂{EP})

**Data:**
- v₂ flat or increasing toward peripheral
- Increased nonflow?

**high-p_T (2.0 — 2.5)**
- AMPT: v₂{PP} decreases towards peripheral
- v₂{EP} increases towards peripheral
- Nonflow dominant

**Data:**
- v₂ increasing toward peripheral
Cumulants in Au+Au

Au+Au $\sqrt{s_{NN}} = 200$ GeV

$|\eta| < 3$

$|\eta| < 1$

$|\eta| < 1$ (x 0.8)

$|\eta| < 1$ (x 0.8)

Good agreement with previous measurements by STAR

*Note that STAR points are scaled down to account for difference in v2 at mid vs forward rapidities (according to PHOBOS v2 measurement)
Cumulants in Au+Au

Assuming Gaussian fluctuations
Agrees well with both AMPT & MC Glauber
Sub-event methods agree with full $v_2[4]$
Further evidence that flow dominates
$c_2\{4\}$ in different systems

- PHENIX $p$+Au $\sqrt{s_{NN}} = 200$ GeV $1 < |n| < 3$
  - $\langle 4 \rangle$
  - $2\langle 2 \rangle^2$

- PHENIX $d$+Au $\sqrt{s_{NN}} = 200$ GeV $1 < |n| < 3$
  - $\langle 4 \rangle$
  - $2\langle 2 \rangle^2$

- PHENIX Au+Au $\sqrt{s_{NN}} = 200$ GeV $h^{-1} < |n| < 3$
  - $\langle 4 \rangle$
  - $2\langle 2 \rangle^2$

$FVTX$ tracks

$N_{\text{tracks}}$