

Quark Gluon Plasma at the Smallest Scale?

Proposal for small system size scan (arXiv.1904.10415)

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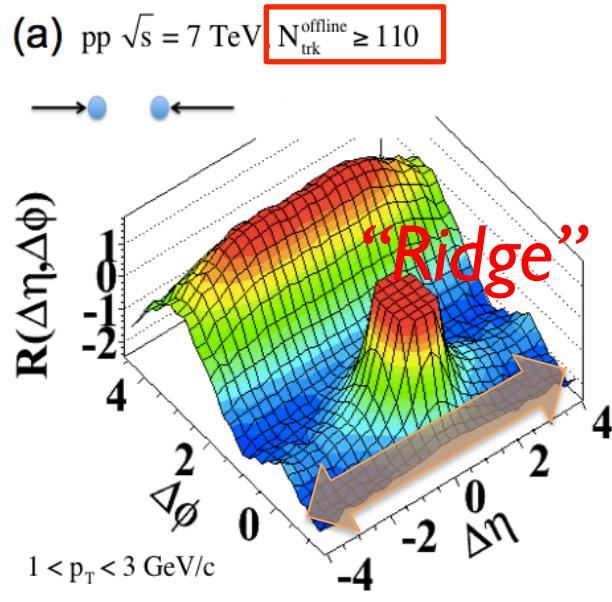
Shandong University

第十七届全国核物理大会

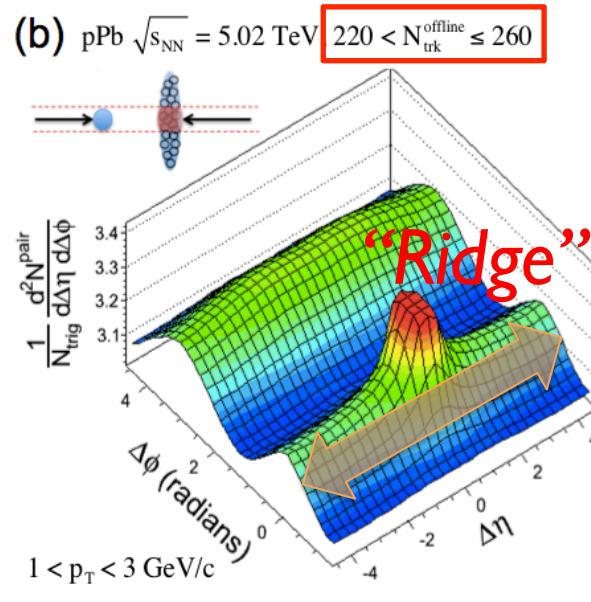
武汉 2019



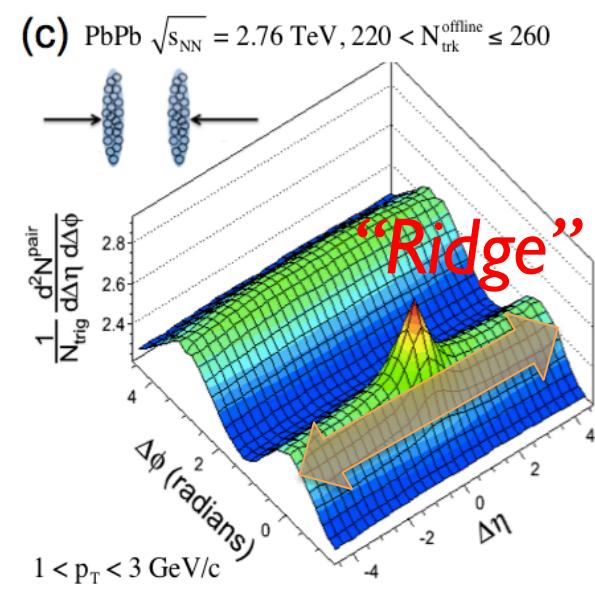
“Ridge” in small systems



JHEP 09 (2010) 091



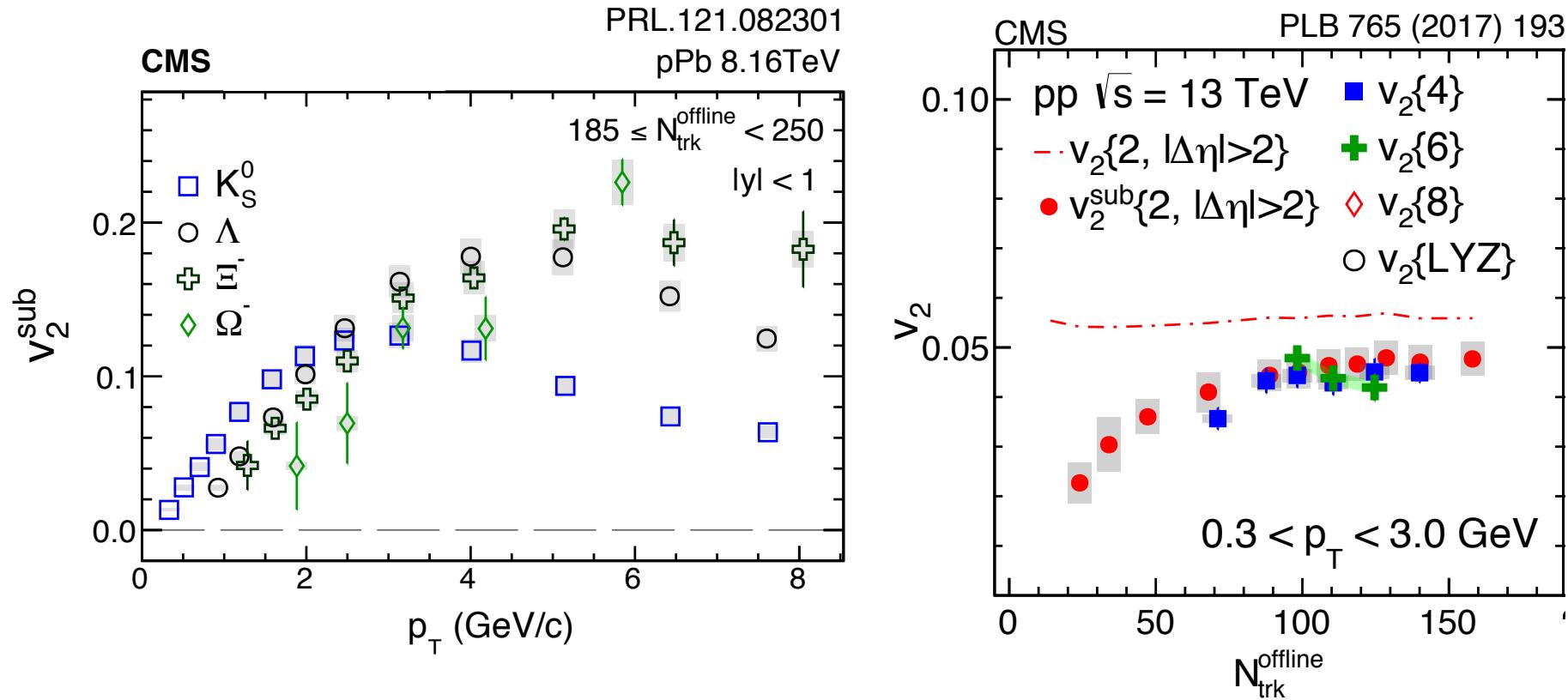
PLB 724 (2013) 213



PLB 724 (2013) 213

Beginning of the story:
“Ridge” in all hadronic high-multiplicity collisions

Collective natures in small system



Dozens of results from LHC and RHIC
Similar collective natures as in AA!!

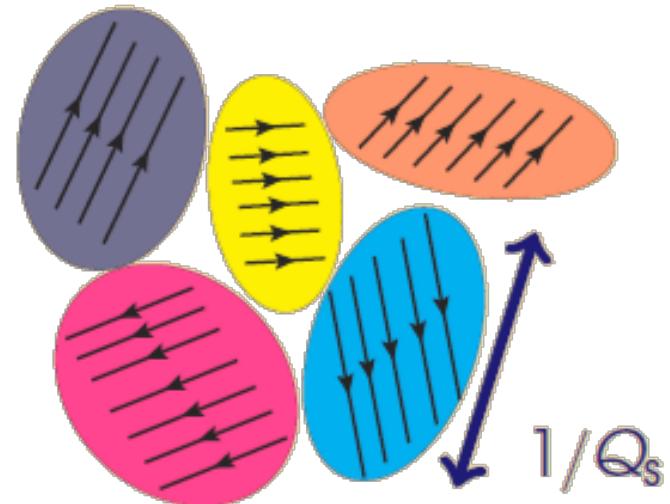
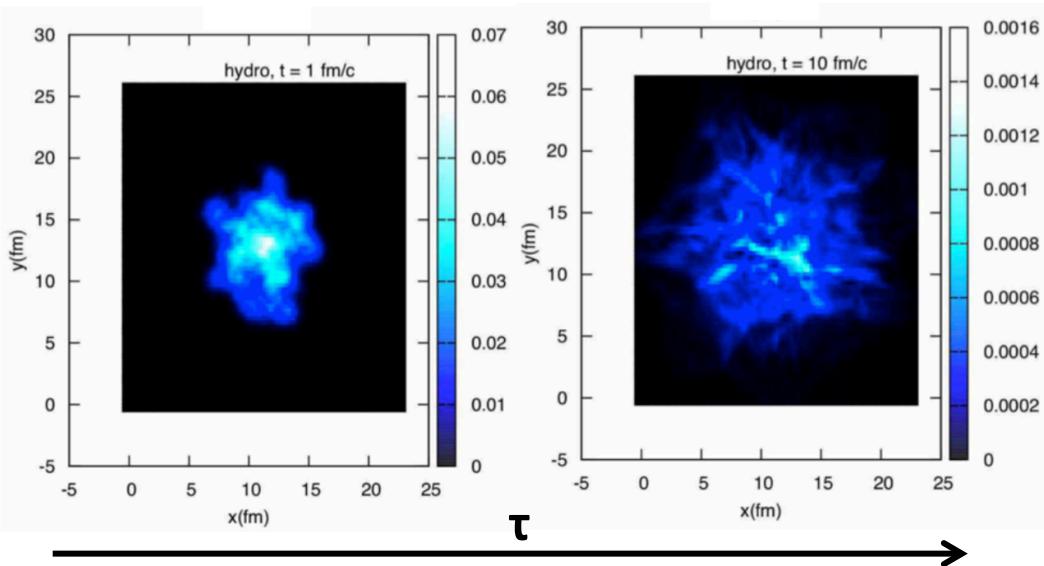
A small droplet of QGP? Other novel QCD effects?

Origin of collectivity?

Final-state interactions
("Hydro" or transport)

vs

Initial-state dynamics
(Color-Glass-Condensate)



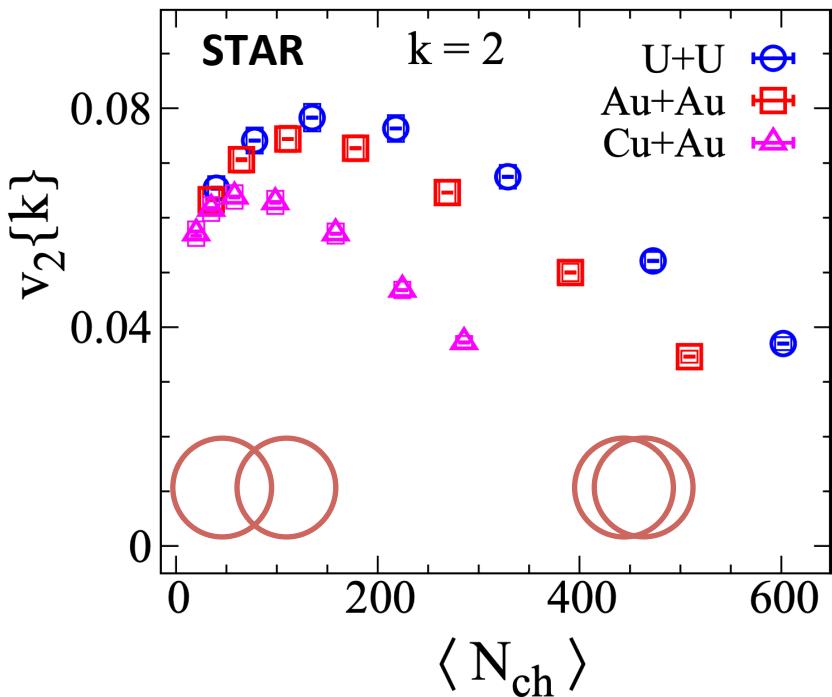
Both scenarios describe collective natures

What key measurements can distinguish them?

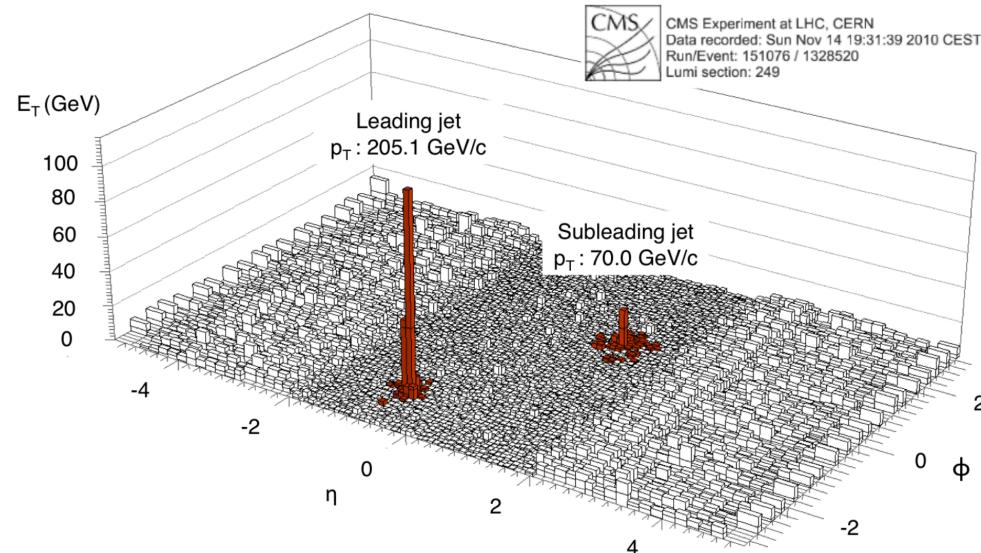
Overviews: K.Dusling, W.Li, B.Schenke arXiv:1509.07939; J.L.Nagle, W.A.Zajc arXiv:1801.03477

Hydro paradigm in large systems

Initial geometry driven



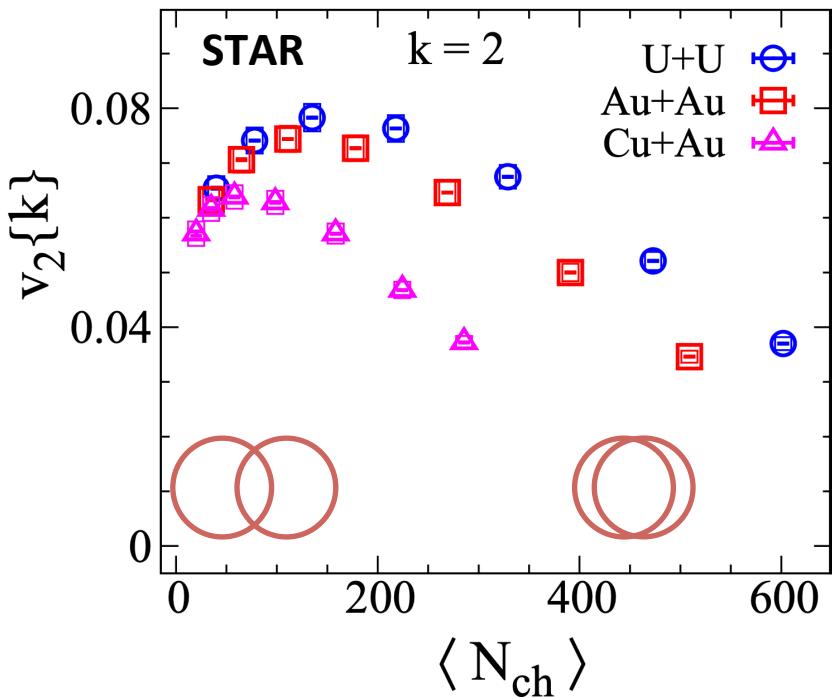
Later-time interactions



- ✧ **Centrality dependence**
- ✧ **Flow fluctuation**
- ✧ **Longitudinal de-correlation**
- ✧ ...
- ✧ **Jet quenching**
- ✧ **Heavy Flavor suppression**
- ✧ ...

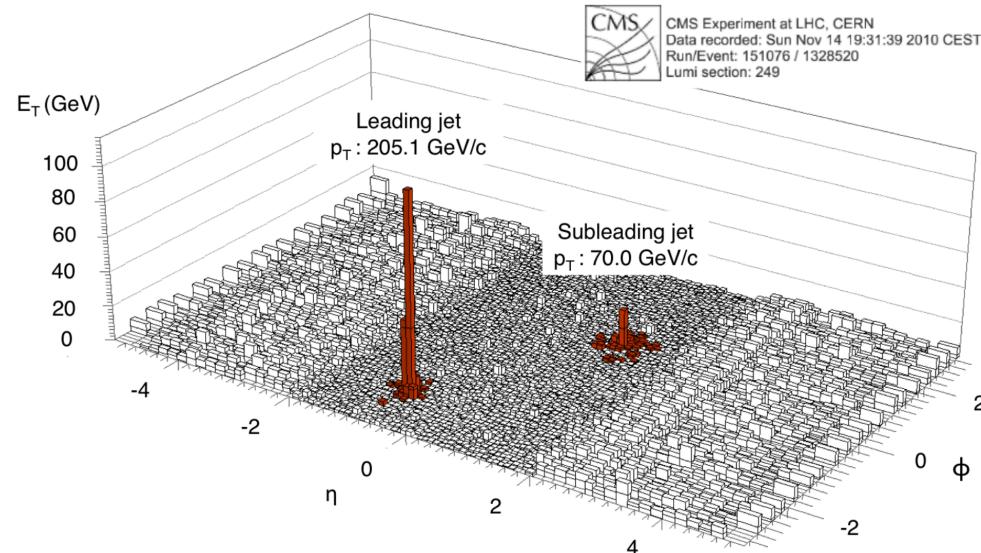
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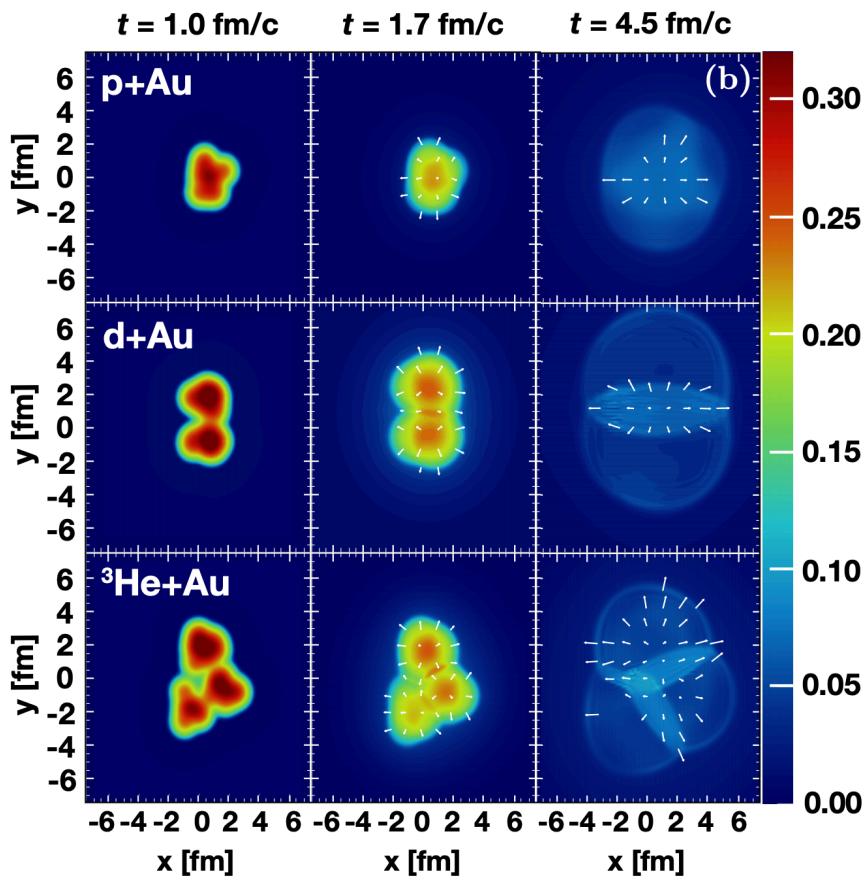
Later-time interactions



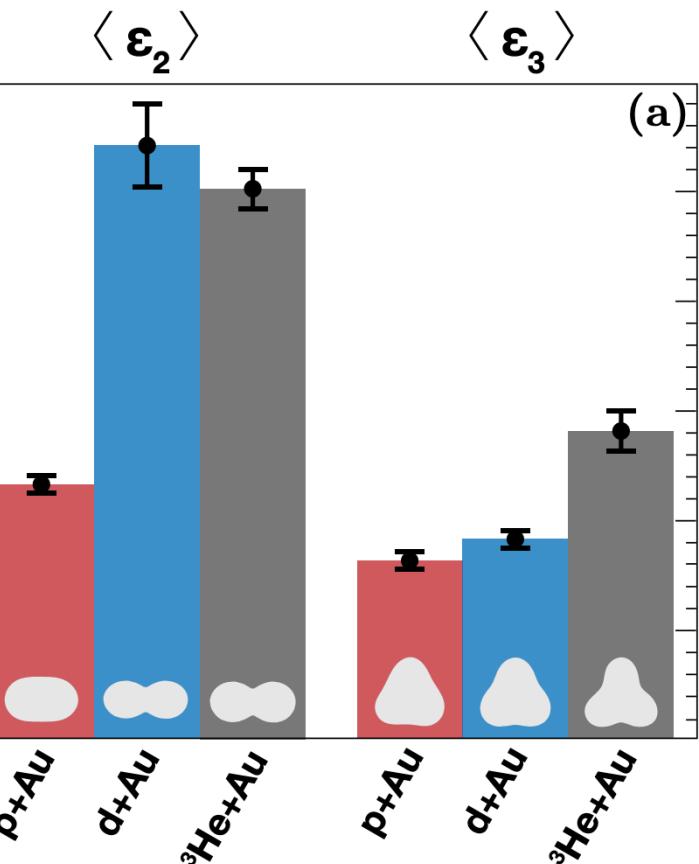
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- ✧ ...

What about small systems?

Geometry response in small systems



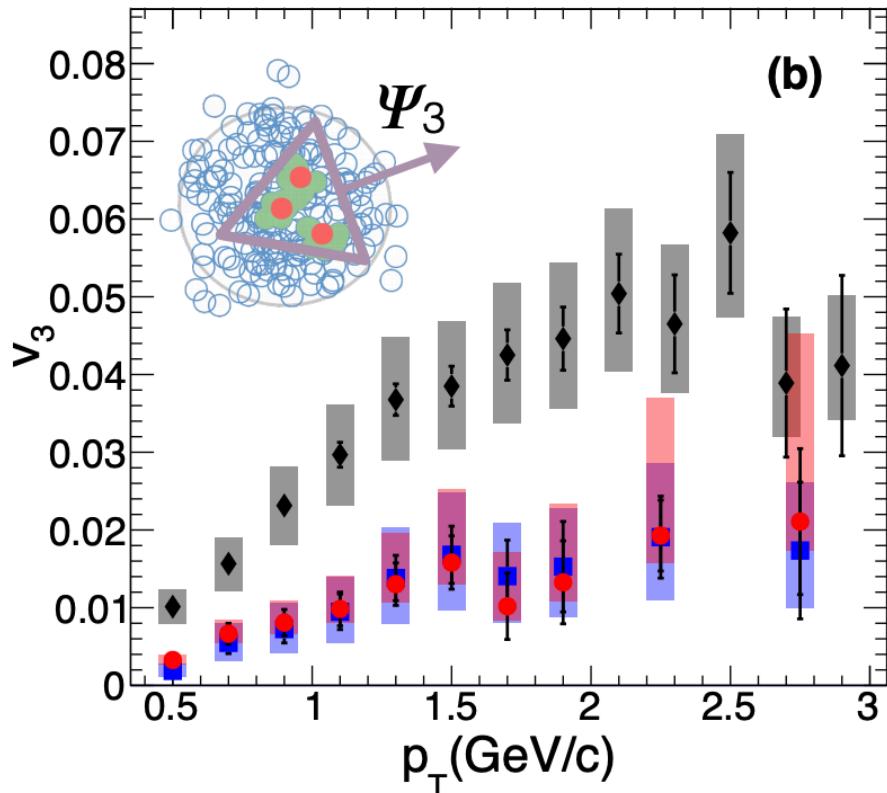
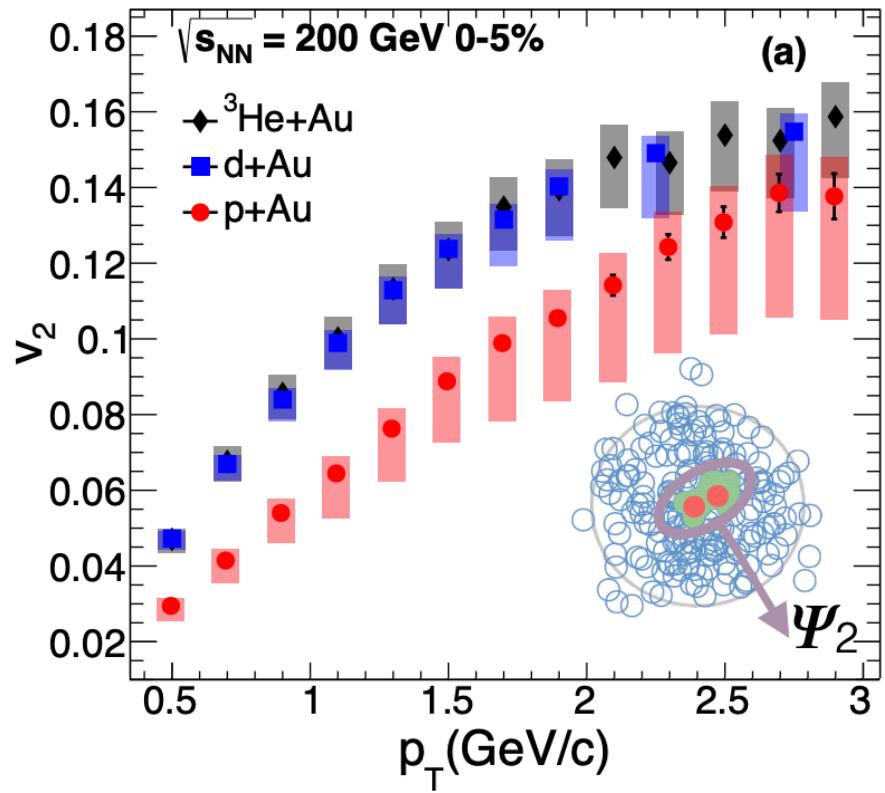
Nature Phys. 15 (2019) no.3, 214-220



v_n expected to reflect eccentricity ordering

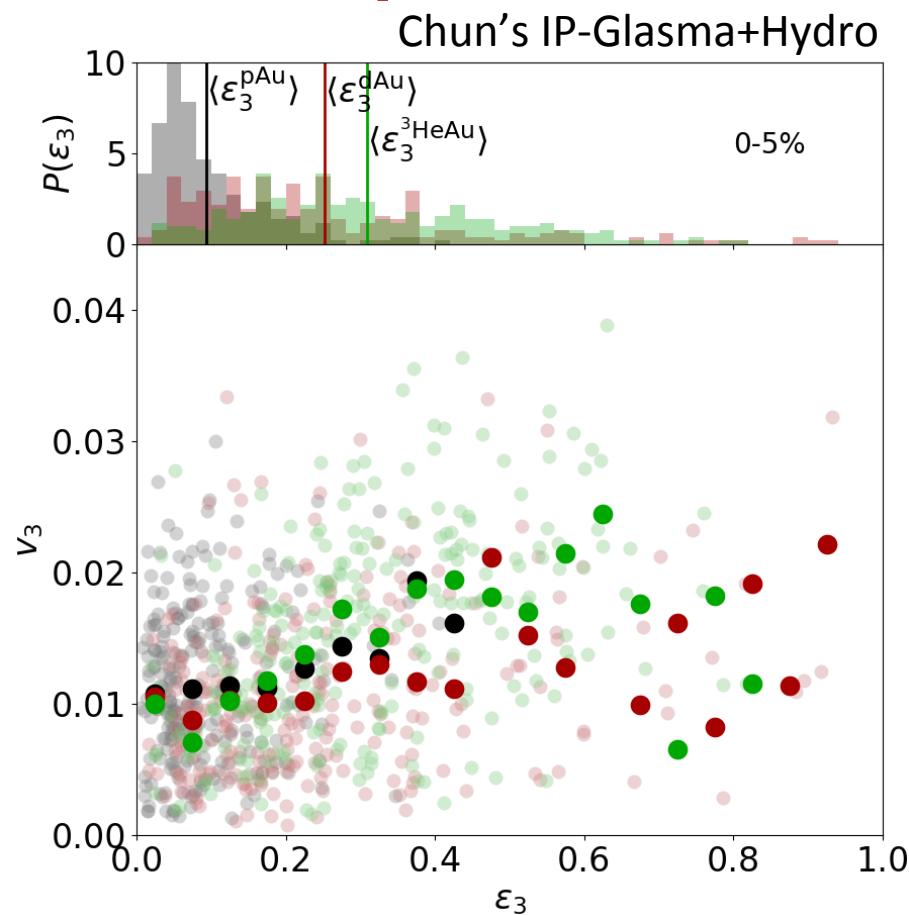
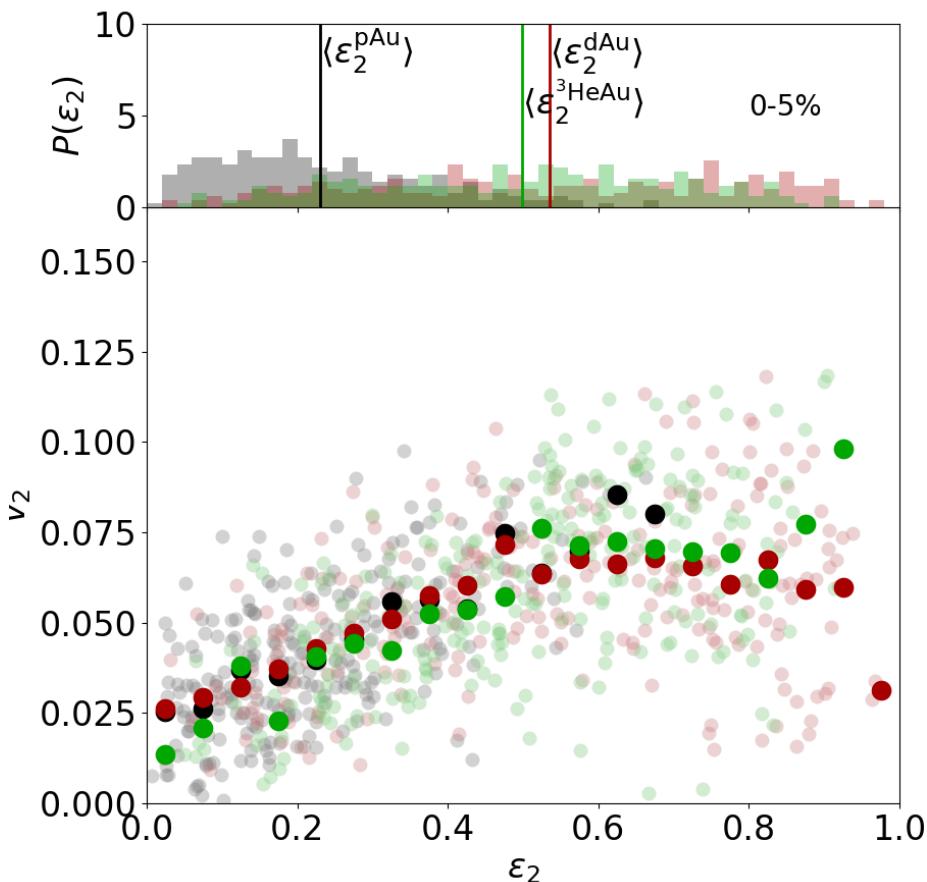
Geometry response in small systems

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v_n reflect eccentricity ordering!

Geometry response in small systems



v_n reflect eccentricity ordering?

Model dependent? Further checks needed!

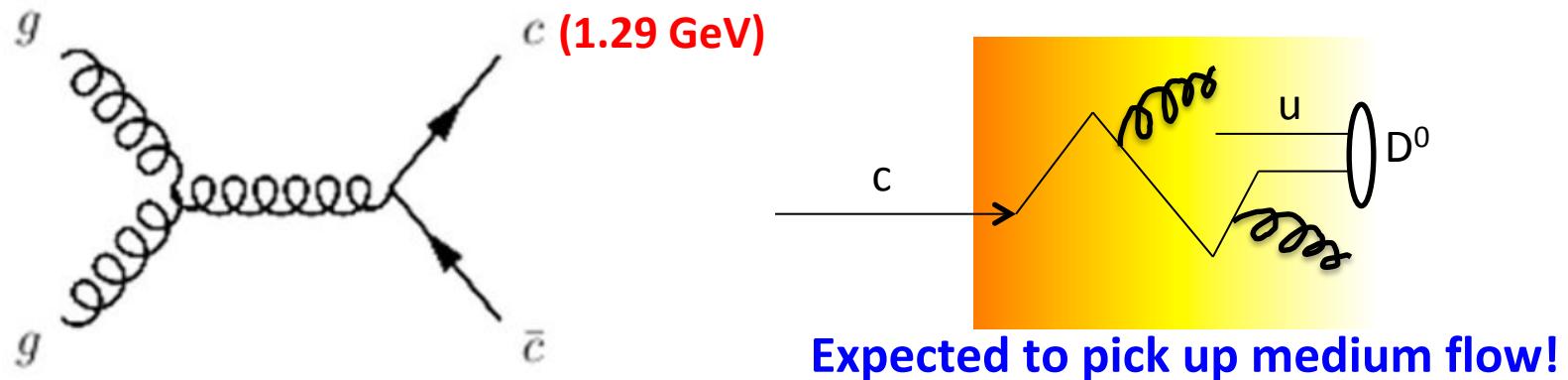
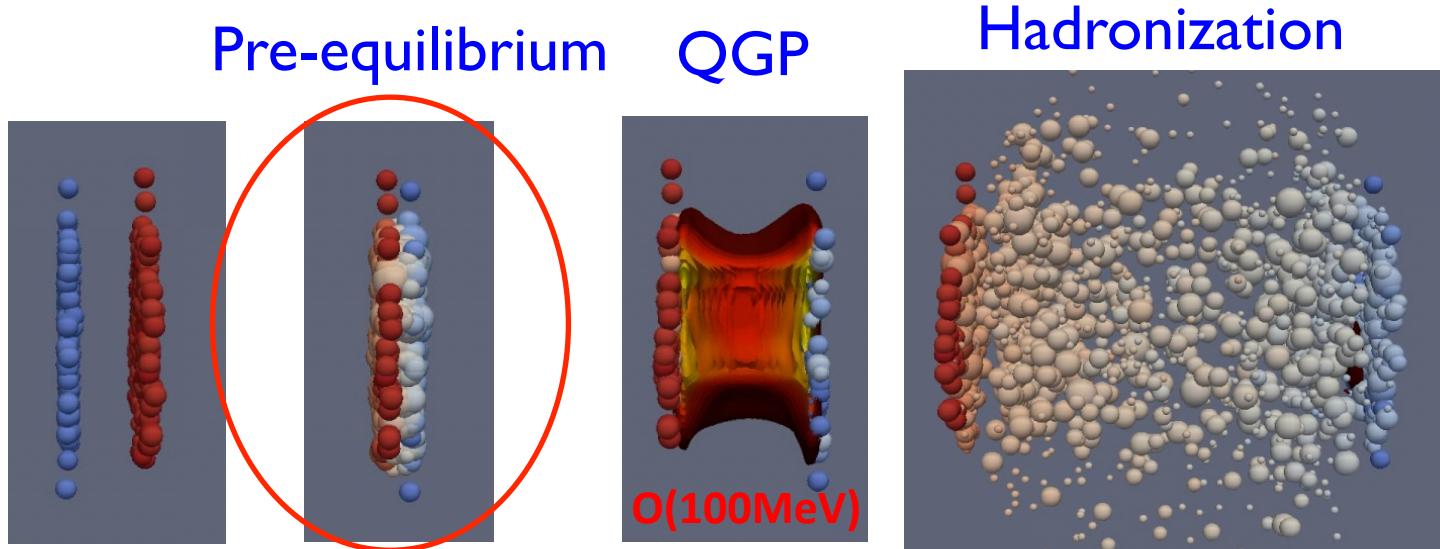
Later-time interaction

No jet-quenching in small system?!

Later-time interaction

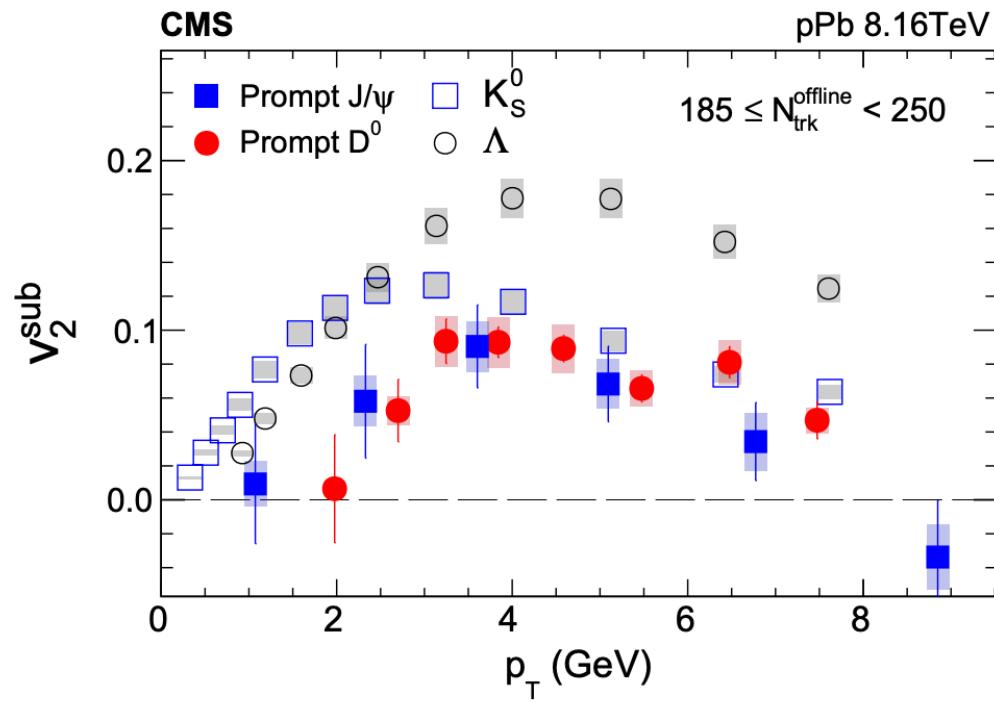
No jet-quenching in small system?!

Heavy flavor quark as external probe



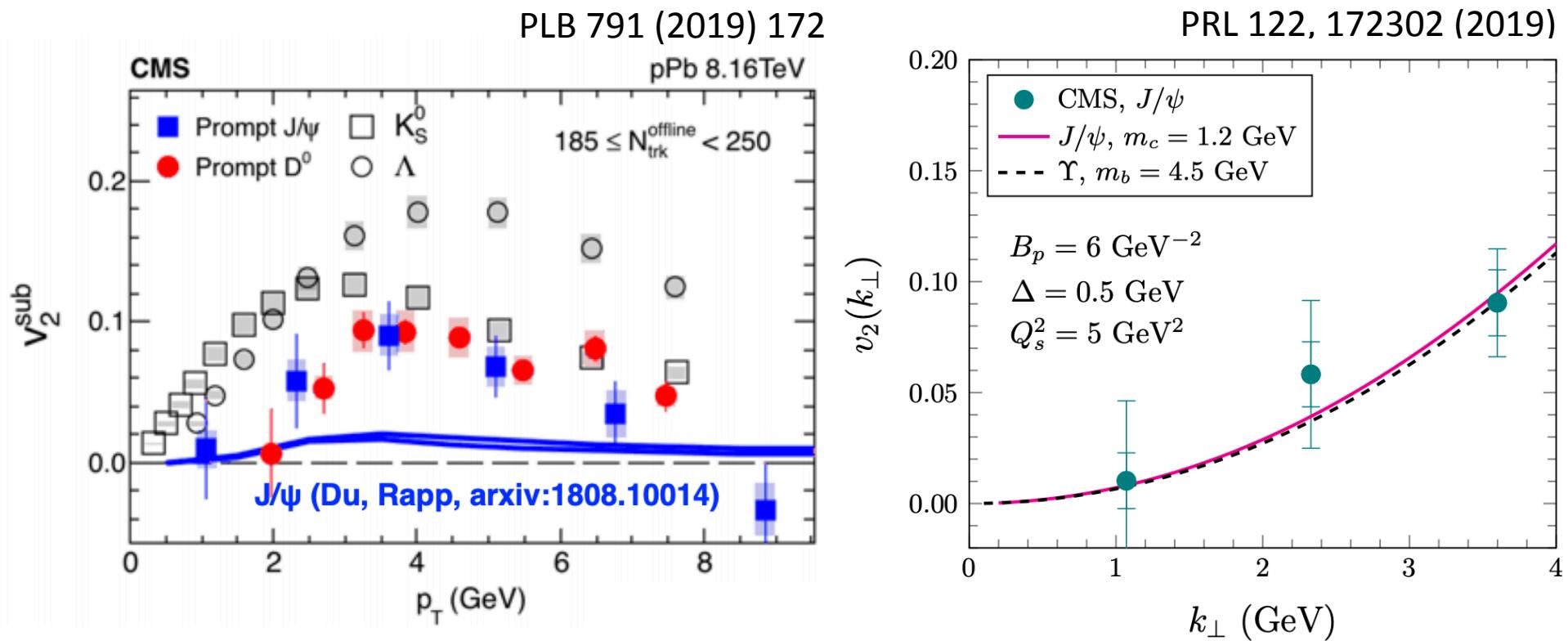
Heavy quark flow in small systems

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Significant v_2 for D^0 and J/Ψ

Heavy quark flow in small systems

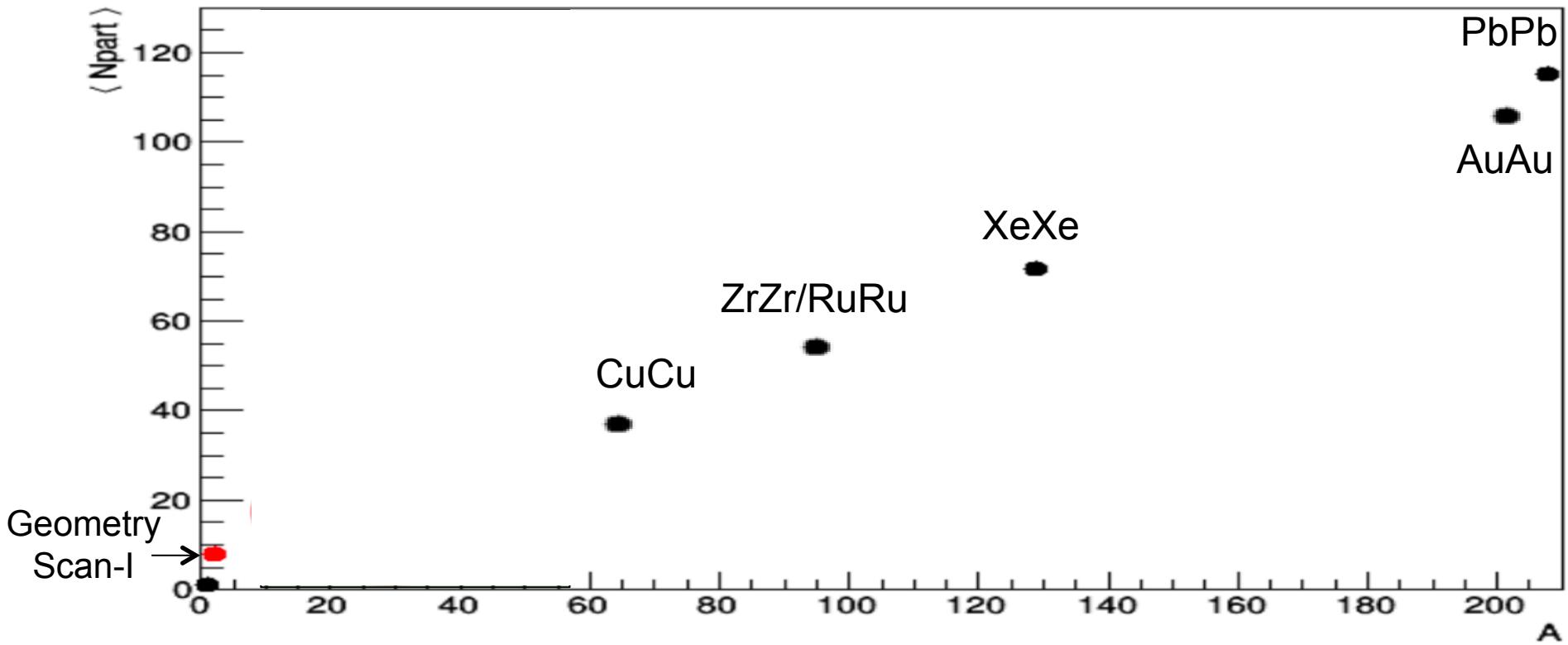


Significant v_2 for D^0 and J/Ψ

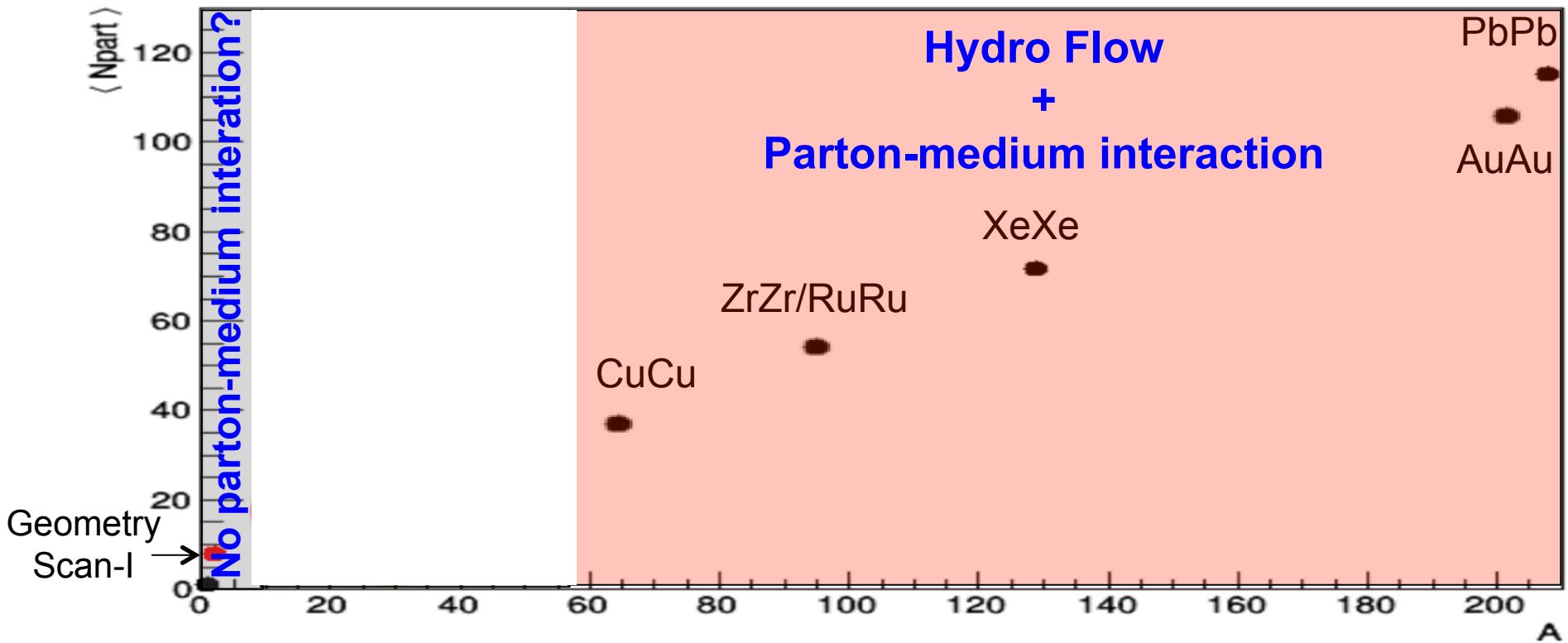
Hydro picture failed! CGC describes data!

Evolution from large (Hydro) to small (CGC) systems?

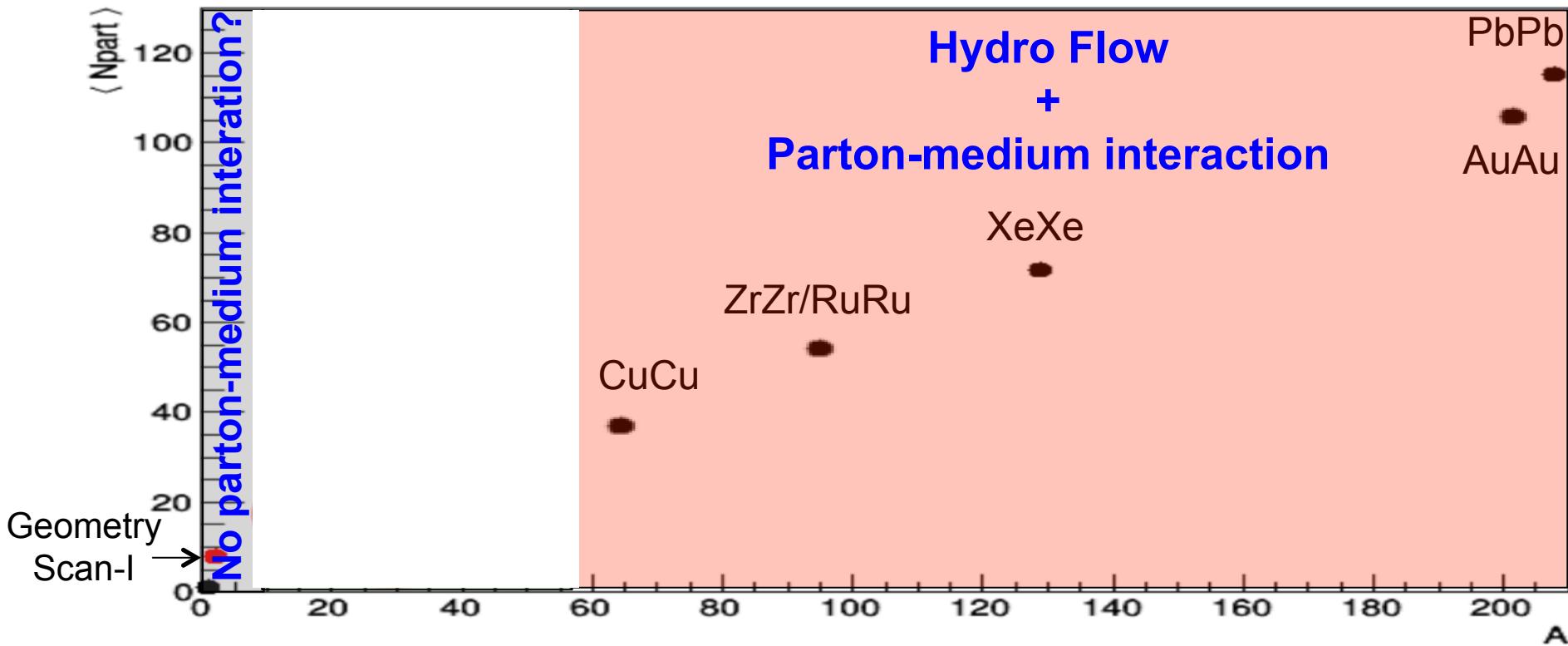
System size scan at RHIC



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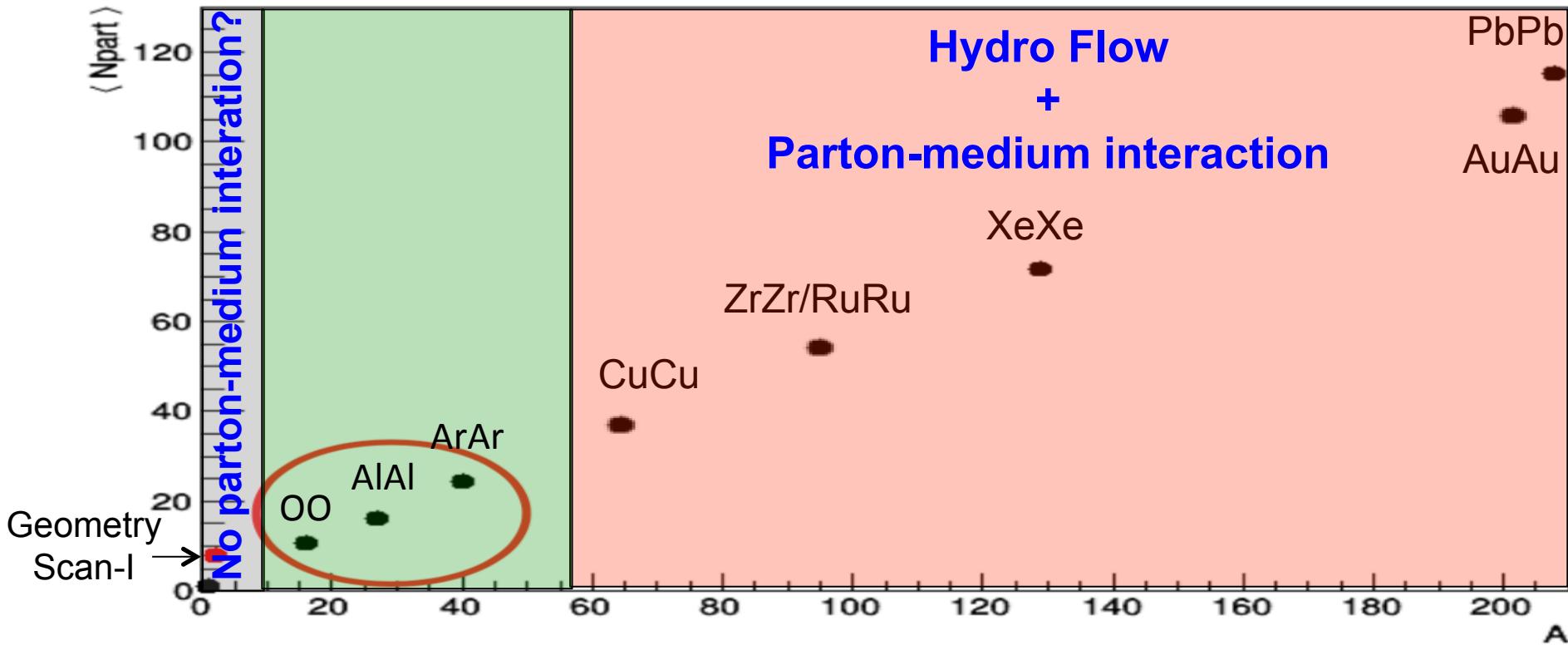


System size scan at RHIC



Does flow reflect the changing initial geometry?
Where initial-state effects become sub-dominant?
Turn-on of jet quenching and heavy-flavor “thermalization”?

System size scan at RHIC

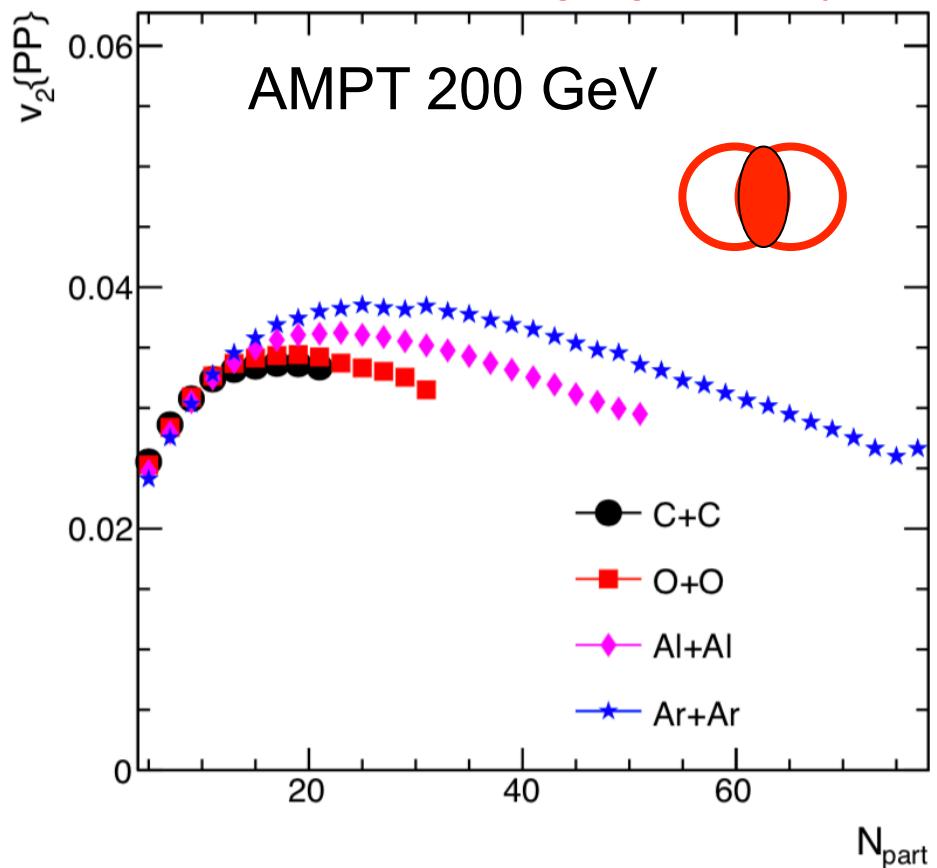


Does flow reflect the changing initial geometry?
Where initial-state interaction become sub-dominant?
Turn-on of jet quenching and heavy-flavor “thermalization”?
RHIC & LHC system size scan can provide the answer!

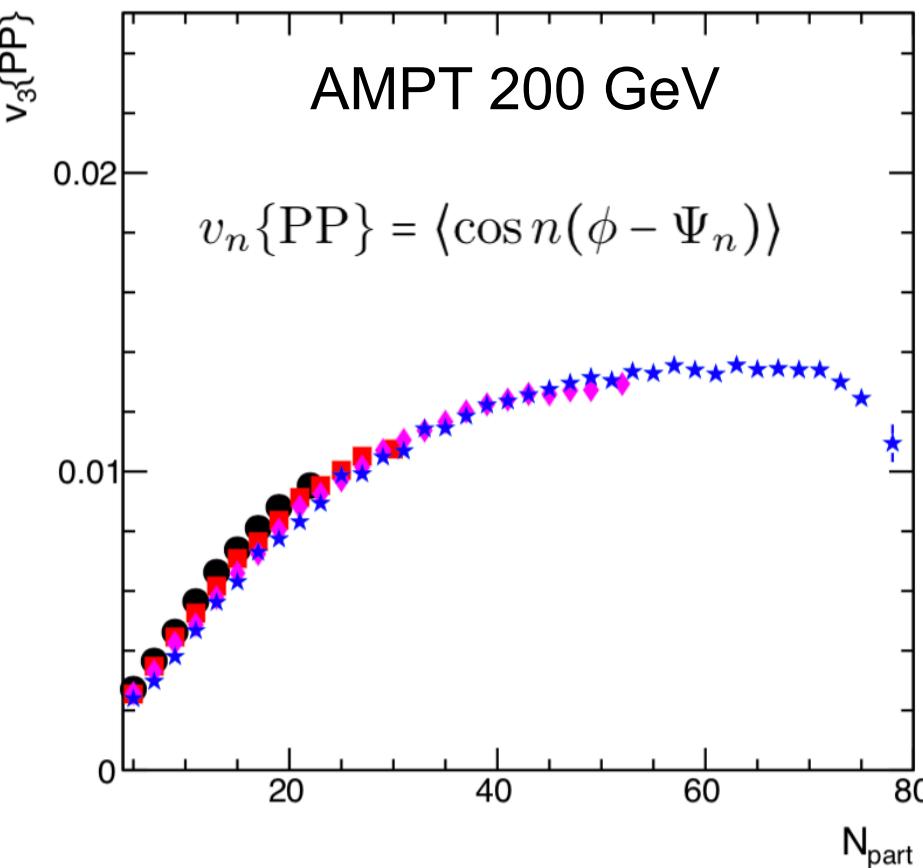
Geometry response of flow

Arxiv.1904.10415

Split due to average geometry



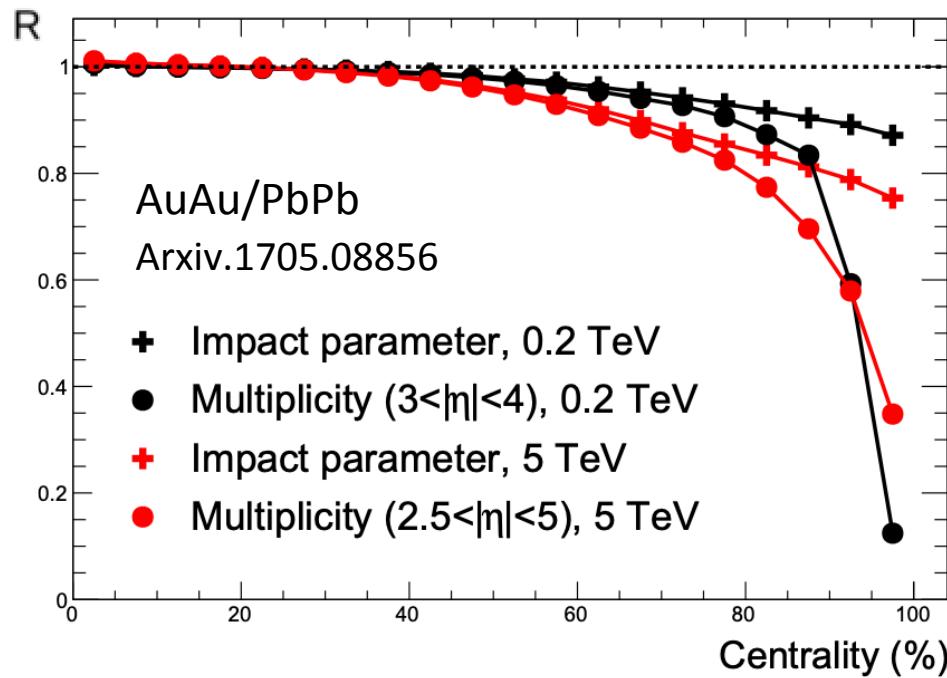
Fluctuation dominant



Geometry response of v_2 not expected in initial-state picture
Potential to constrain transport vs. hydro

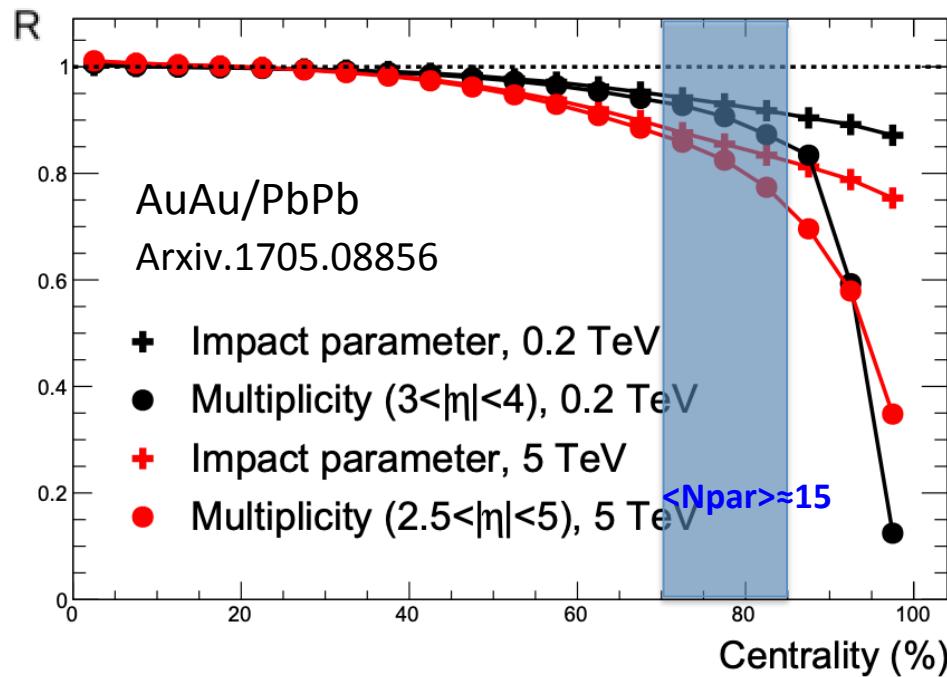
Parton medium interaction

Expected centrality bias on R_{AA}



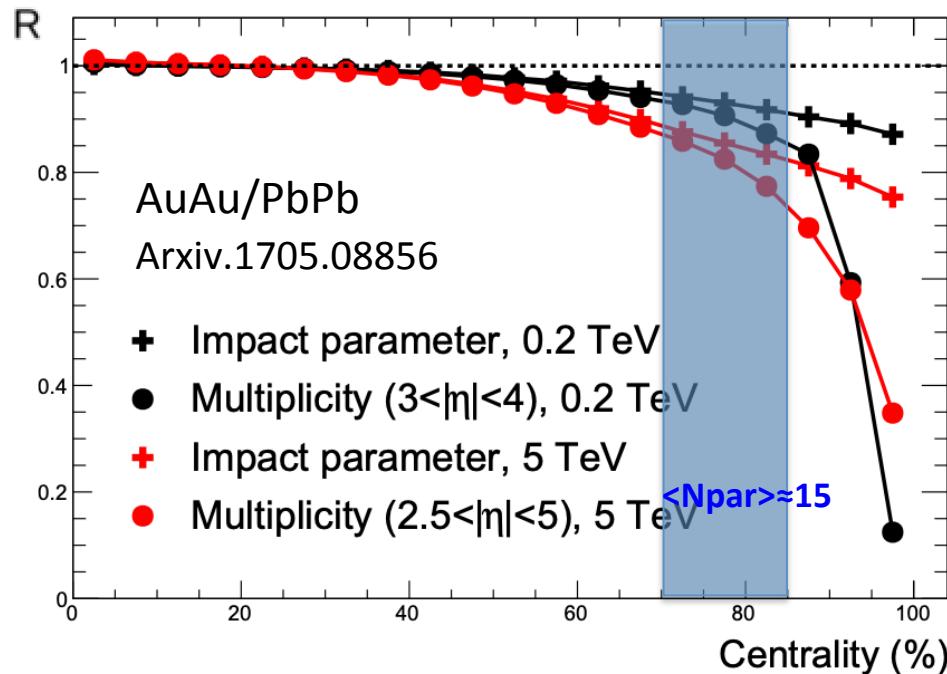
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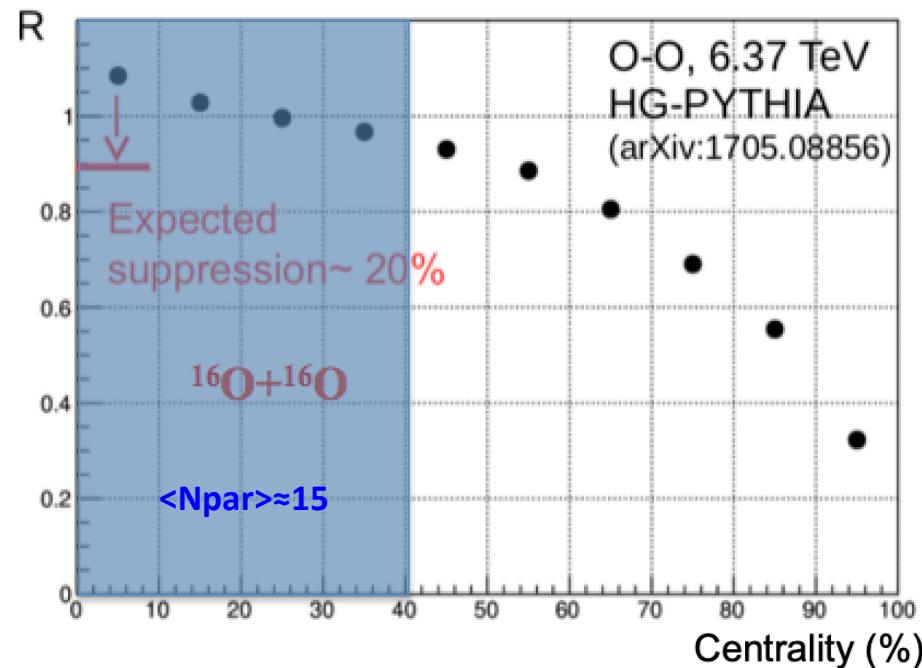


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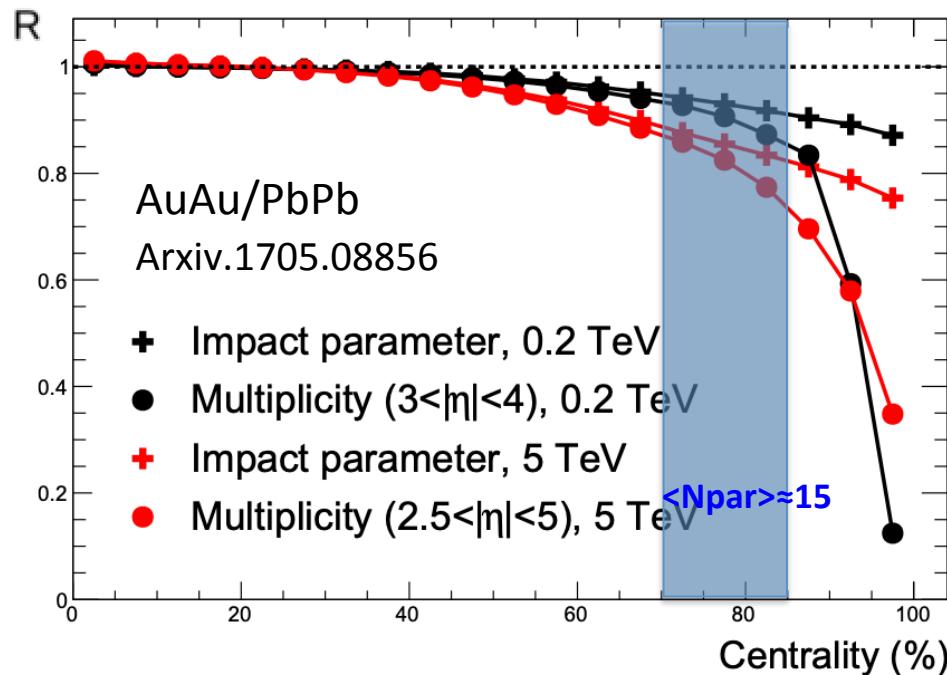
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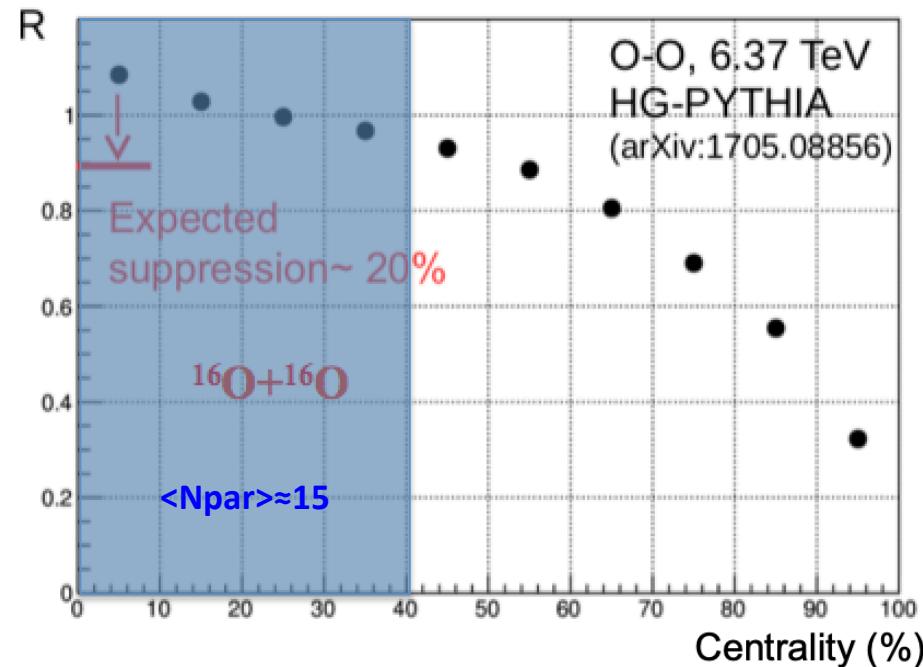
Better control of centrality bias at same $\langle N_{\text{part}} \rangle$

Parton medium interaction

Expected centrality bias on R_{AA}



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Better control of centrality bias at same $\langle N_{\text{part}} \rangle$

Size scan -> Same parton spectra with changing system size

Full proposal for scan (developing)

Short run of O+O before LHC (2020/2021)

- Synergy with LHC
- Motivate & strengthen future small system scan

Potential trigger commissioning in cold QCD (2022-23)

- Low and high multiplicity triggers at low pile-up
- First “ridge” in 500 GeV pp?

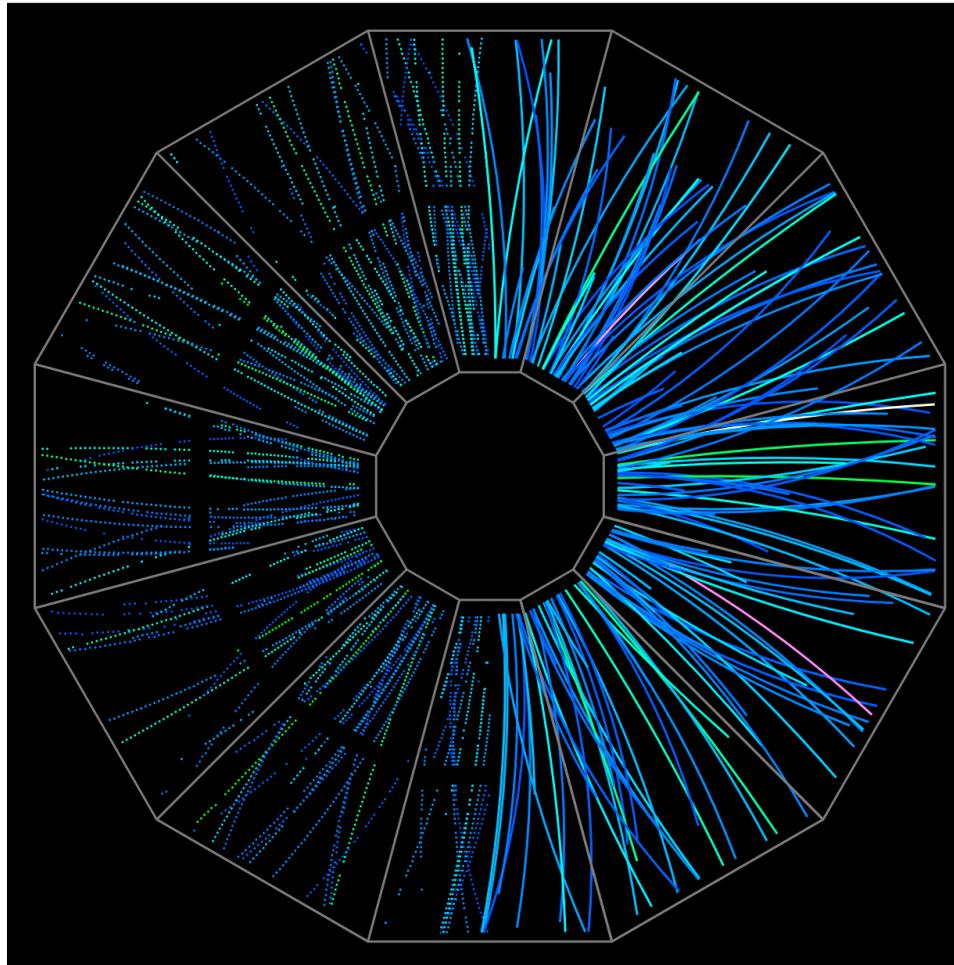
Scan of small asymmetric & symmetric systems (2023+)

- Full benefits from STAR forward upgrade and sPHENIX
- Find the **TRUTH** of collectivity in small systems

STAR proposal for O+O in 2020/2021

The STAR Beam Use Request for Run-20 and Run-21

The STAR Collaboration



May 15, 2019

全国核物理大会

STAR proposal for O+O in 2020/2021

2020

Single-Beam Energy (GeV/n)	$\sqrt{s_{NN}}$ (GeV)	Run Time	Species	Events (MinBias)	Priority	Sequence
5.75	11.5	9.5 weeks	Au+Au	230M	1	1
4.55	9.1	9.5 weeks	Au+Au	160M	1	3
19.5	6.2 (FXT)	2 days	Au+Au	100M	2	5
13.5	5.2 (FXT)	2 days	Au+Au	100M	2	6
5.75	3.5 (FXT)	2 days	Au+Au	100M	2	2
4.55	3.2 (FXT)	2 days	Au+Au	100M	2	4
3.85	3.0 (FXT)	2 days	Au+Au	100M	2	7
100	200	1 week ²	O+O	400M 200M (central) (0-5%)	3	8

2021

Single-Beam Energy (GeV/n)	$\sqrt{s_{NN}}$ (GeV)	Run Time	Species	Events (MinBias)	Priority	Sequence
3.85	7.7	12 weeks	Au+Au	100M	1	1
8.35	16.7	5 weeks	Au+Au	250M	2	2
100	200	1 week ⁴	O+O	400M 200M (central) (0-5%)	2	3

Summary

Further understanding of the collectivity in small systems requires the answers to following questions

- Geometry response of flow from small to large systems
- Turn-on of jet quenching vs. system size
- Turn-off of initial state effects vs. system size

A scan of small (A)symmetric systems at RHIC will provide unique inputs

- Shape, size, density dependence of collectivity
- Medium property via turn-on of parton-medium interaction

STAR is proposing a short O+O run in 2020/2021 to motivate & strengthen future small system scan

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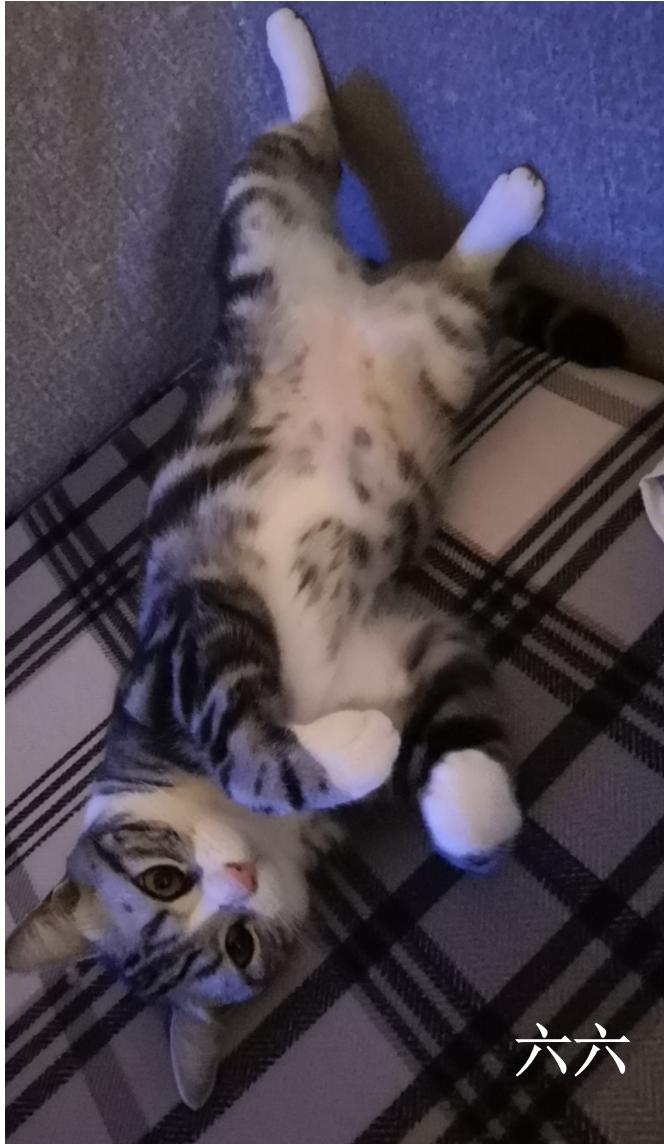
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You are welcome to join the effort!!



Thank you!!



19/8/18



Why showing my cats in physics conference?!
Simply because they are too cute!!

全国核物理大会

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