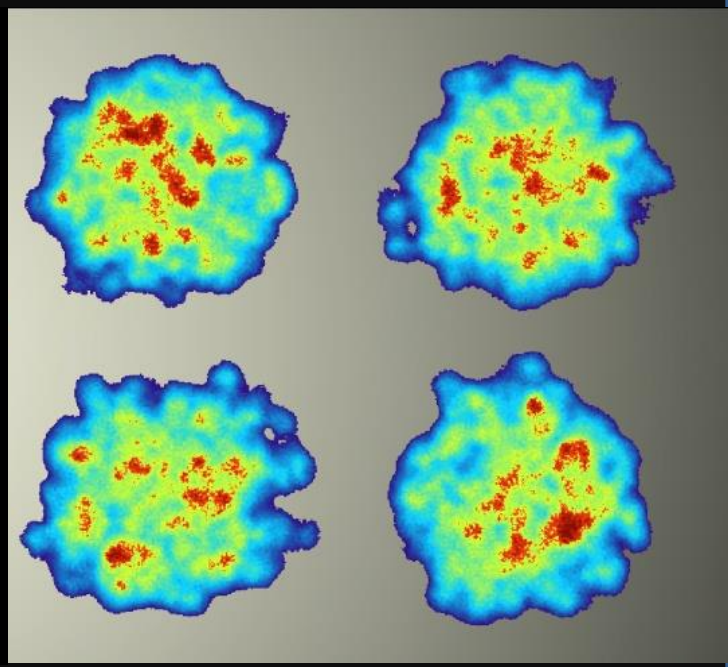
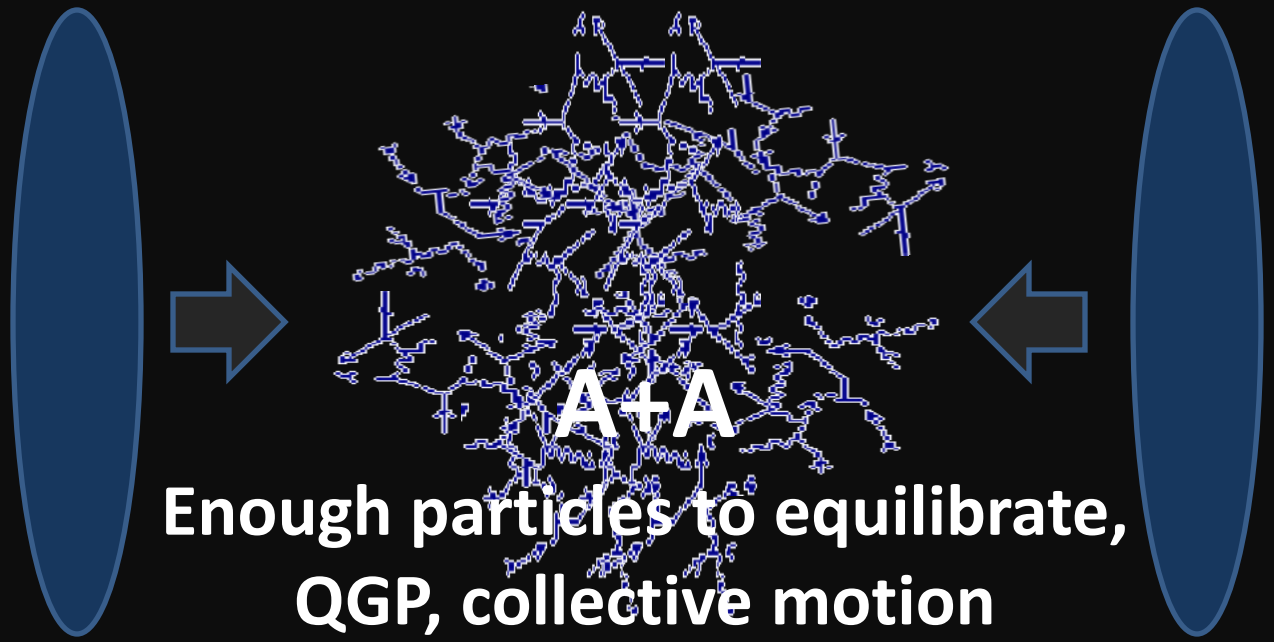
Initial Stages: Overview of My Thoughts Right Now Not of the Conference



Jamie Nagle
University of Colorado, Boulder, USA

Initial Stages Conference, Napa, California December 3-7, 2014

Prejudice

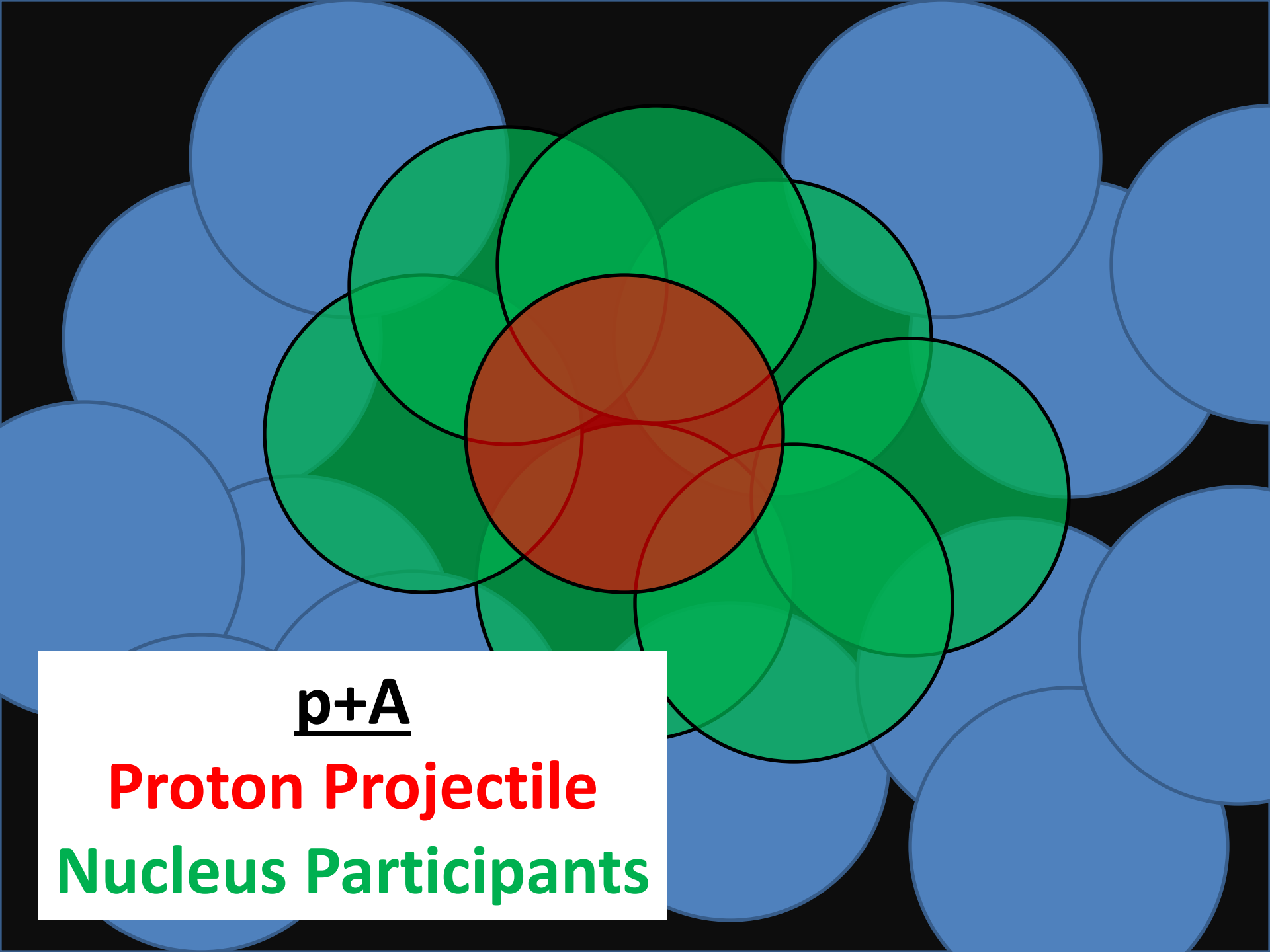


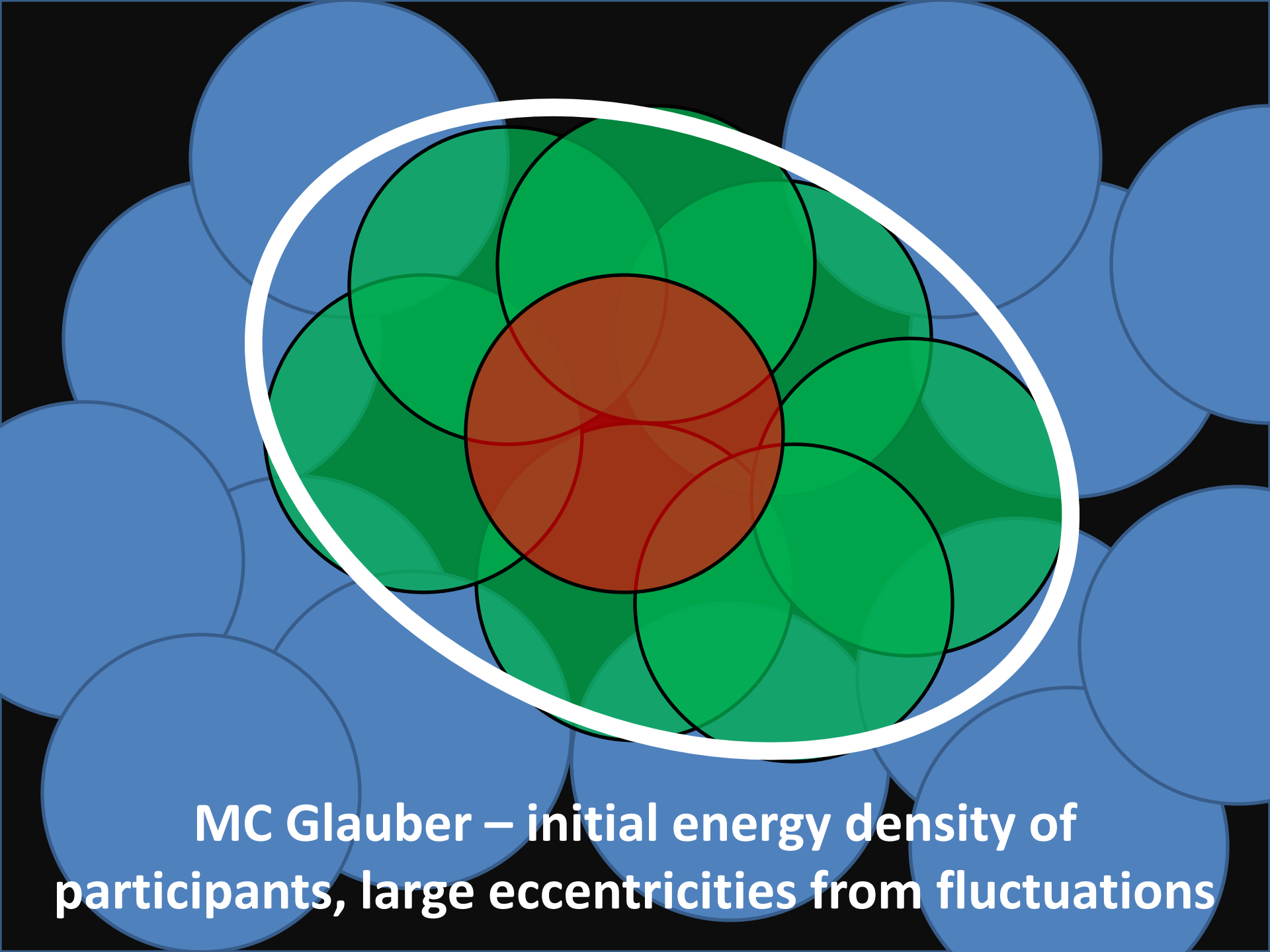
A+A

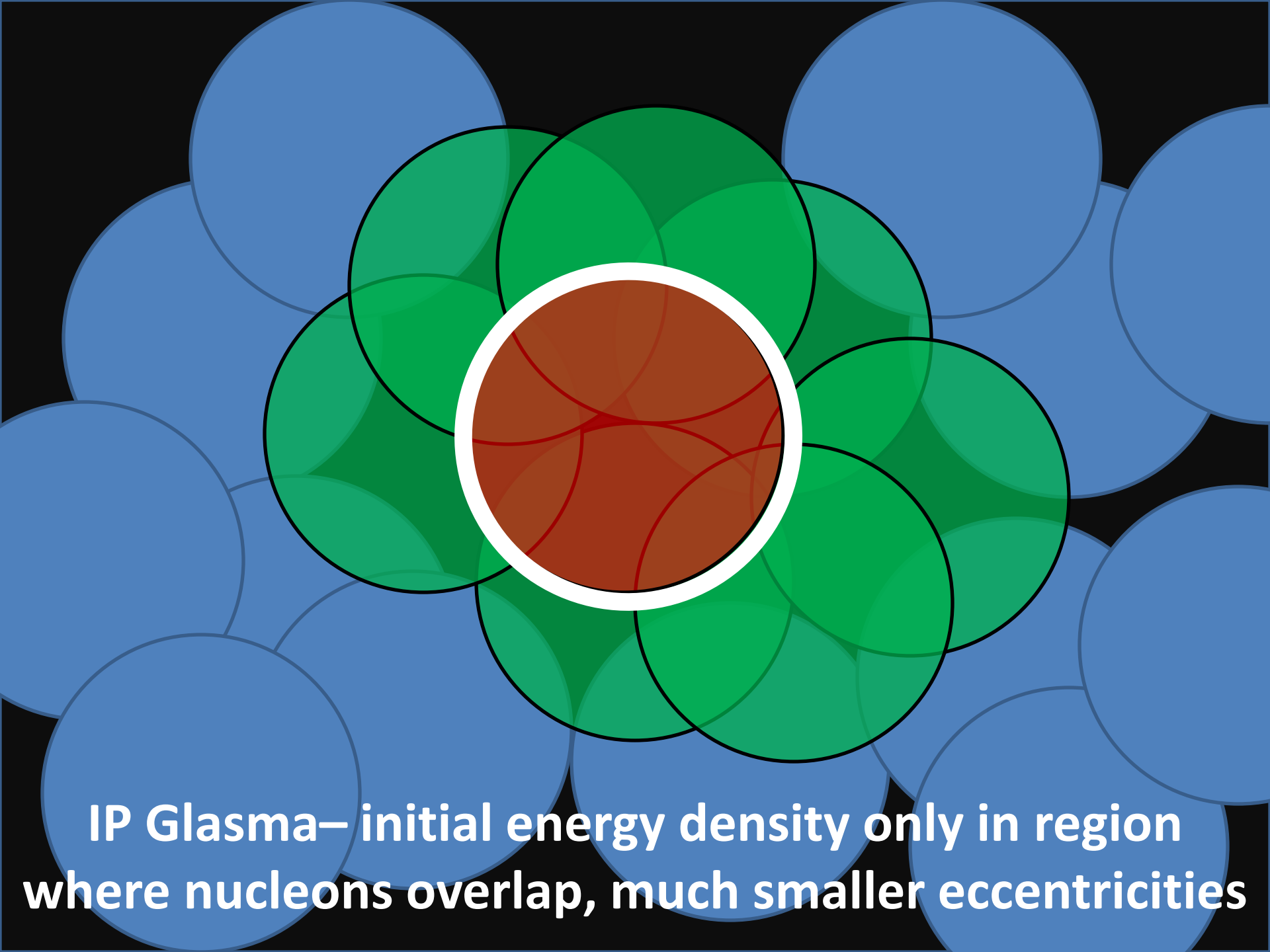
Enough particles to equilibrate, QGP, collective motion

p+A

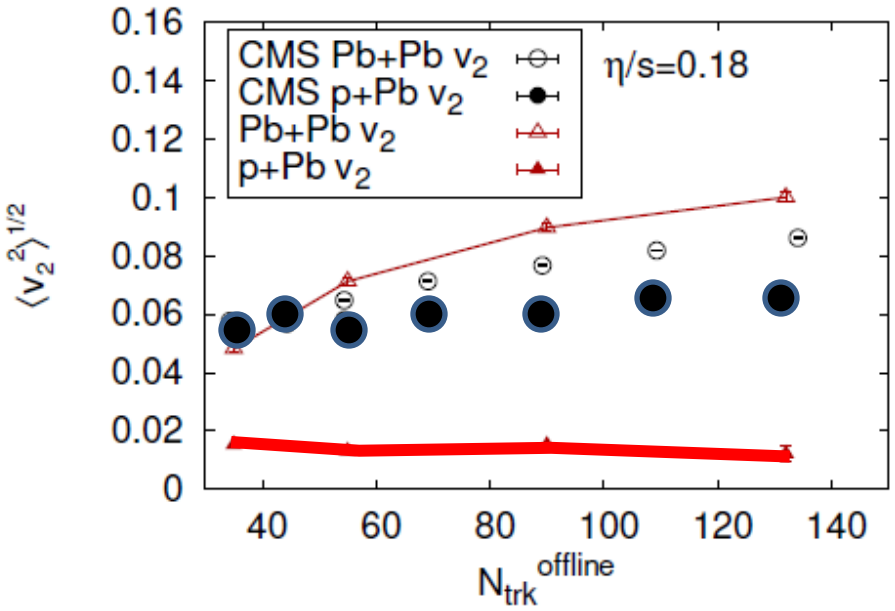
Not enough particles to equilibrate, control experiment

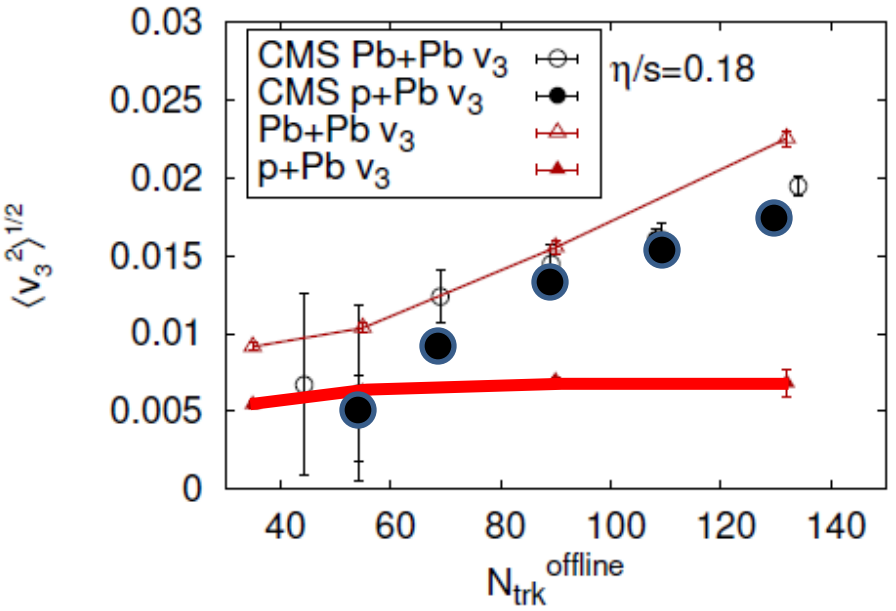

p+A
Proton Projectile
Nucleus Participants


MC Glauber – initial energy density of
participants, large eccentricities from fluctuations


IP Glasma– initial energy density only in region where nucleons overlap, much smaller eccentricities

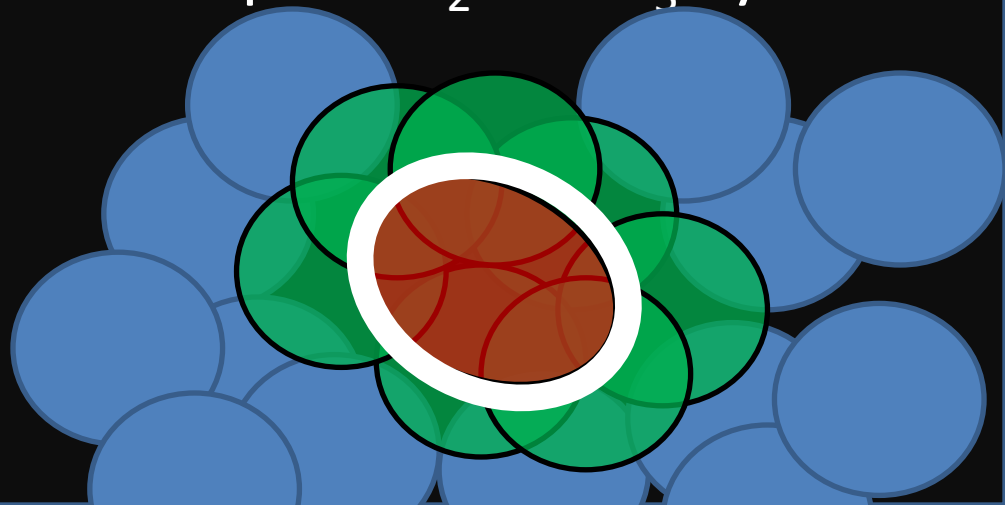
Initial Geometry + Hydrodynamics

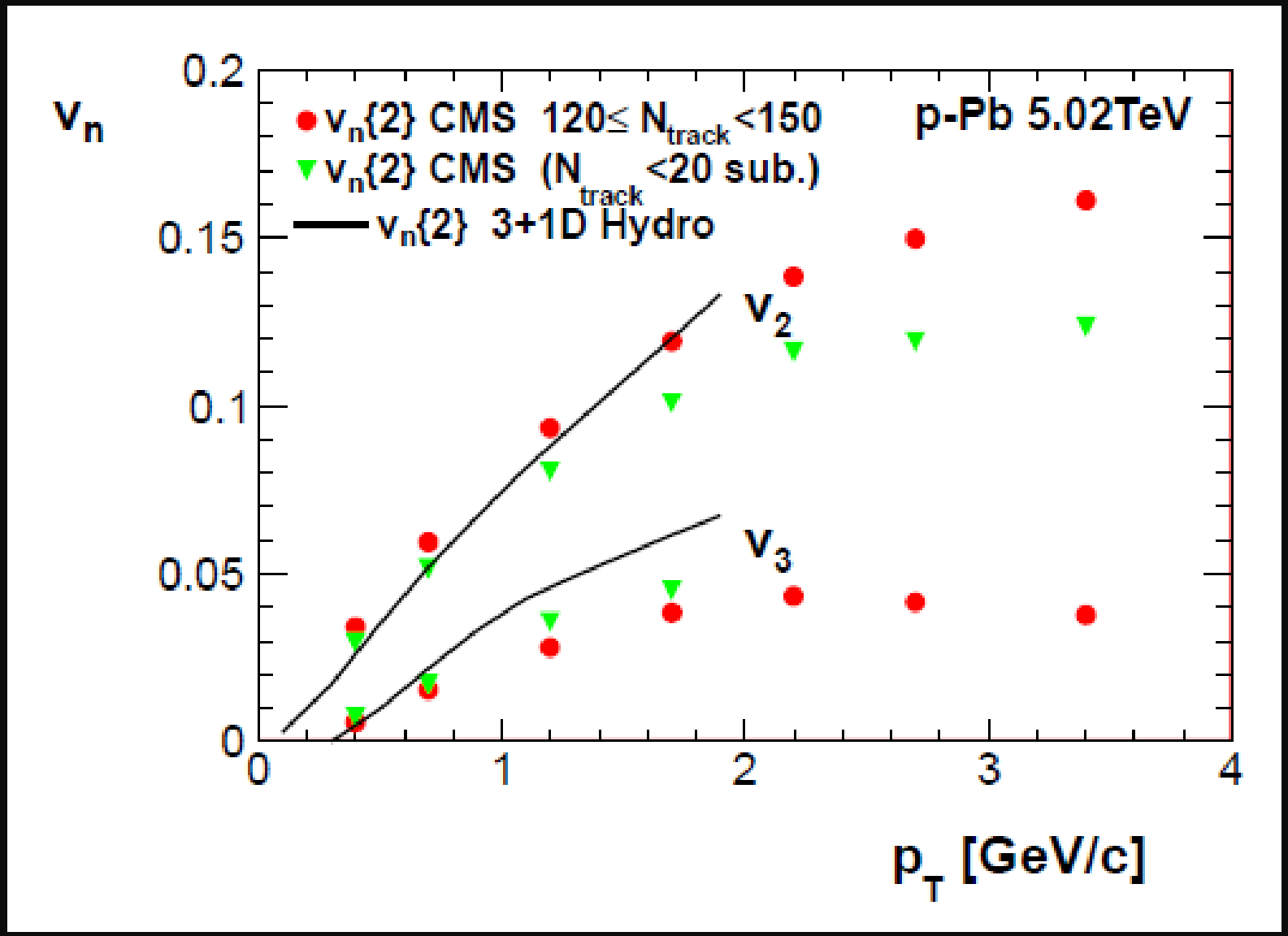




IP Glasma + Hydro – under-predicts p+Pb v_2 and v_3 by x3

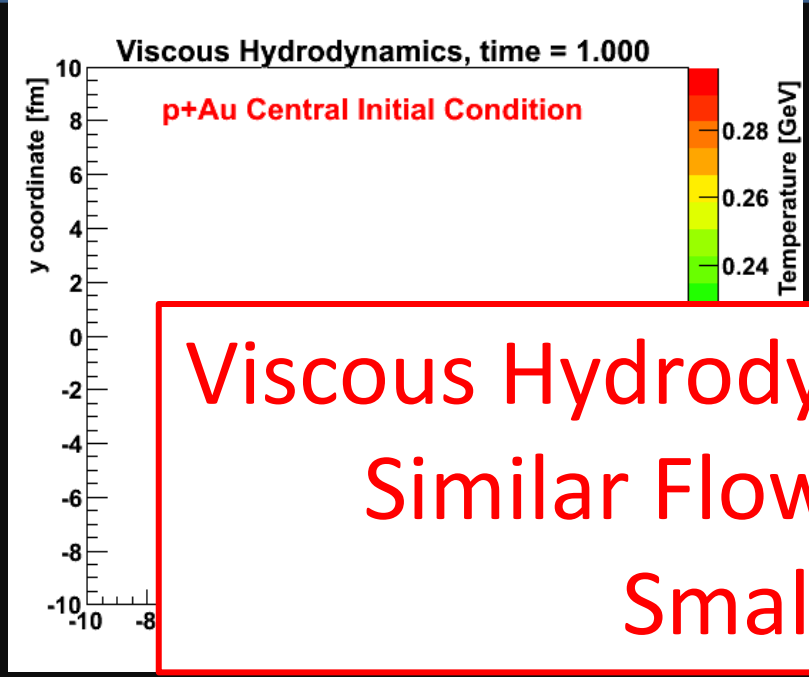
One could enhance the effect by including fluctuating proton shape, still smaller initial size

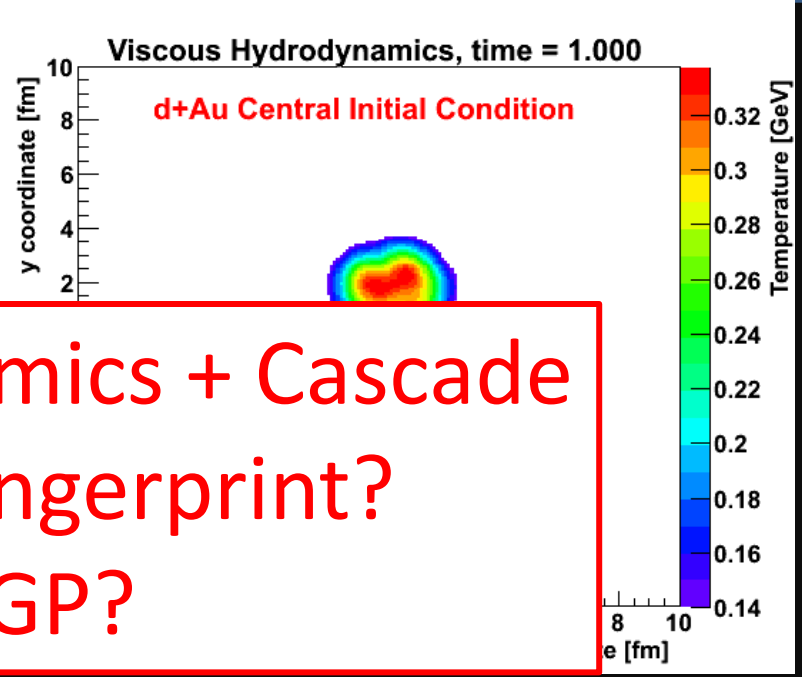




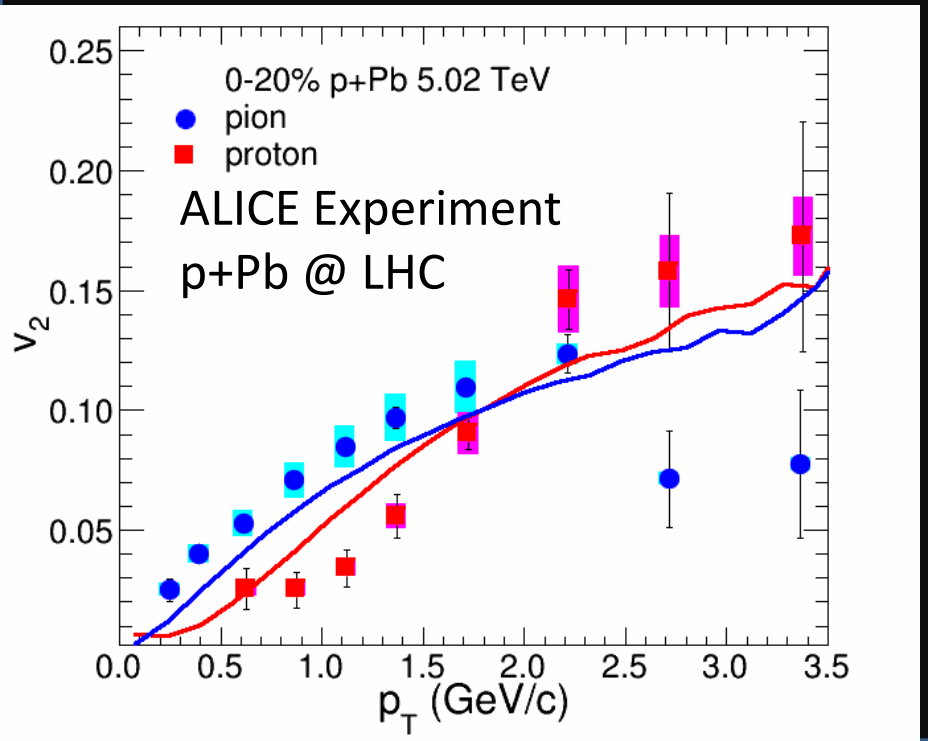
Glauber + Hydro (Bozek) – qualitative description of v_2 and v_3

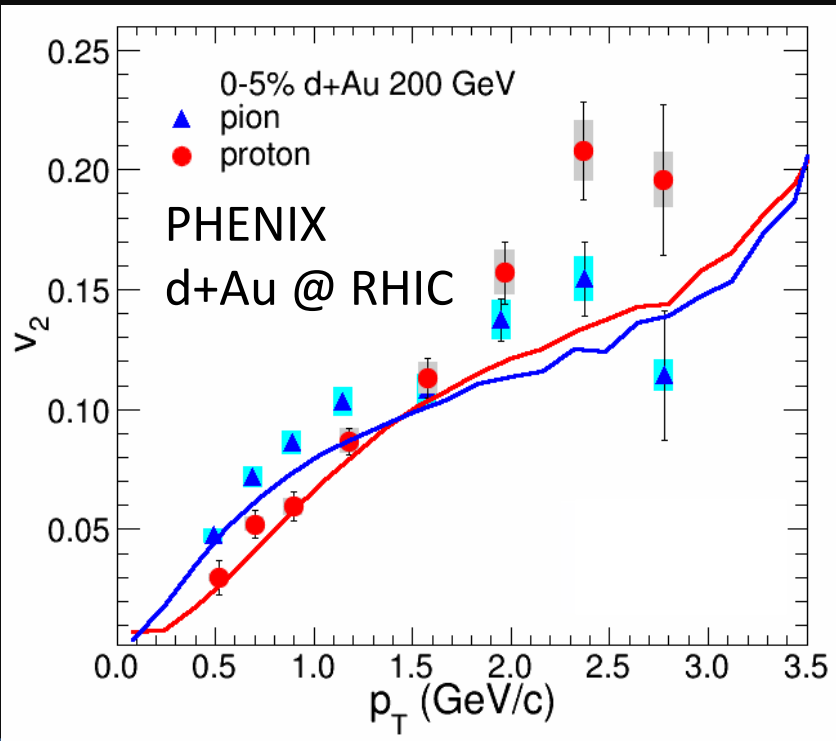
Coincidence (?) – no pre-equilibrium, no hadronic cascade



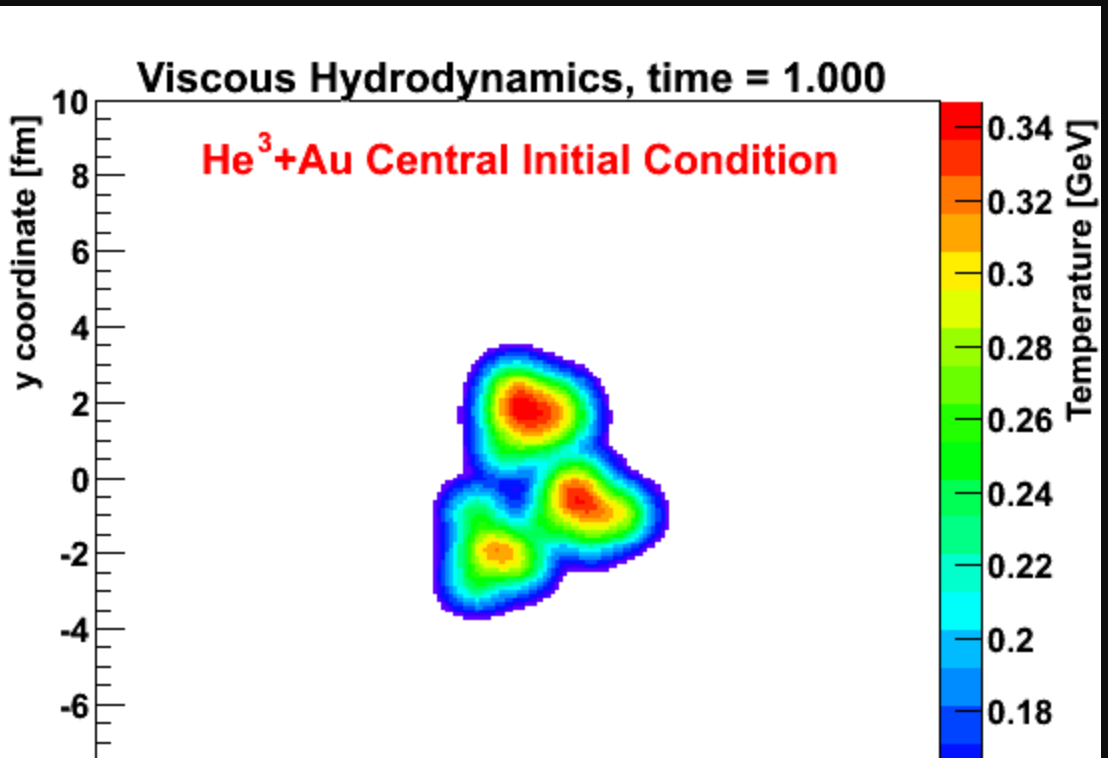


Viscous Hydrodynamics + Cascade
Similar Flow Fingerprint?
Small QGP?



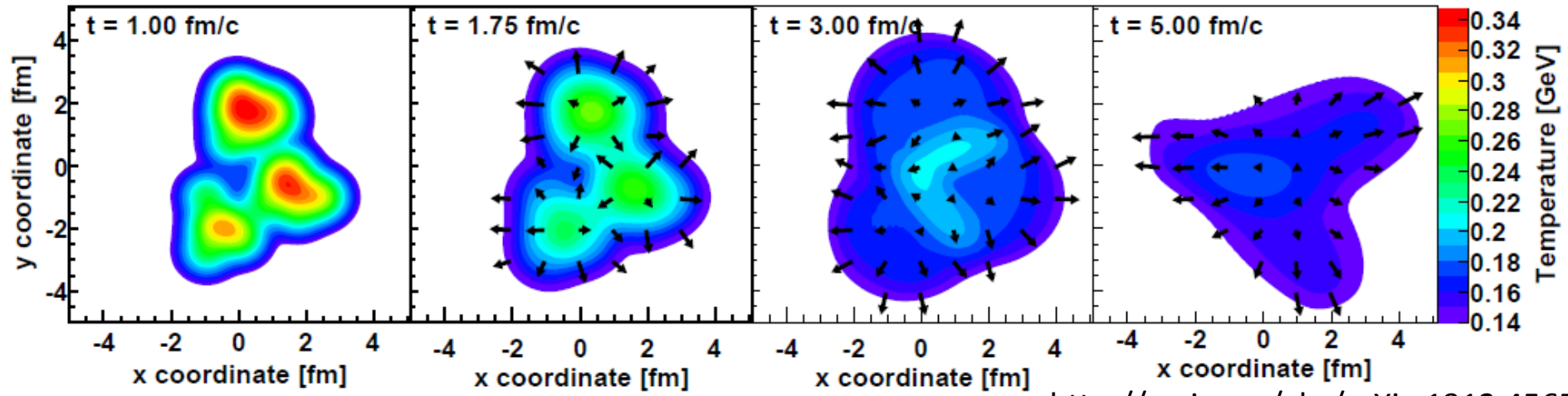


Geometry Engineering



Proposal to run "triangular" system at RHIC

Small systems challenge our picture of required time and size scales



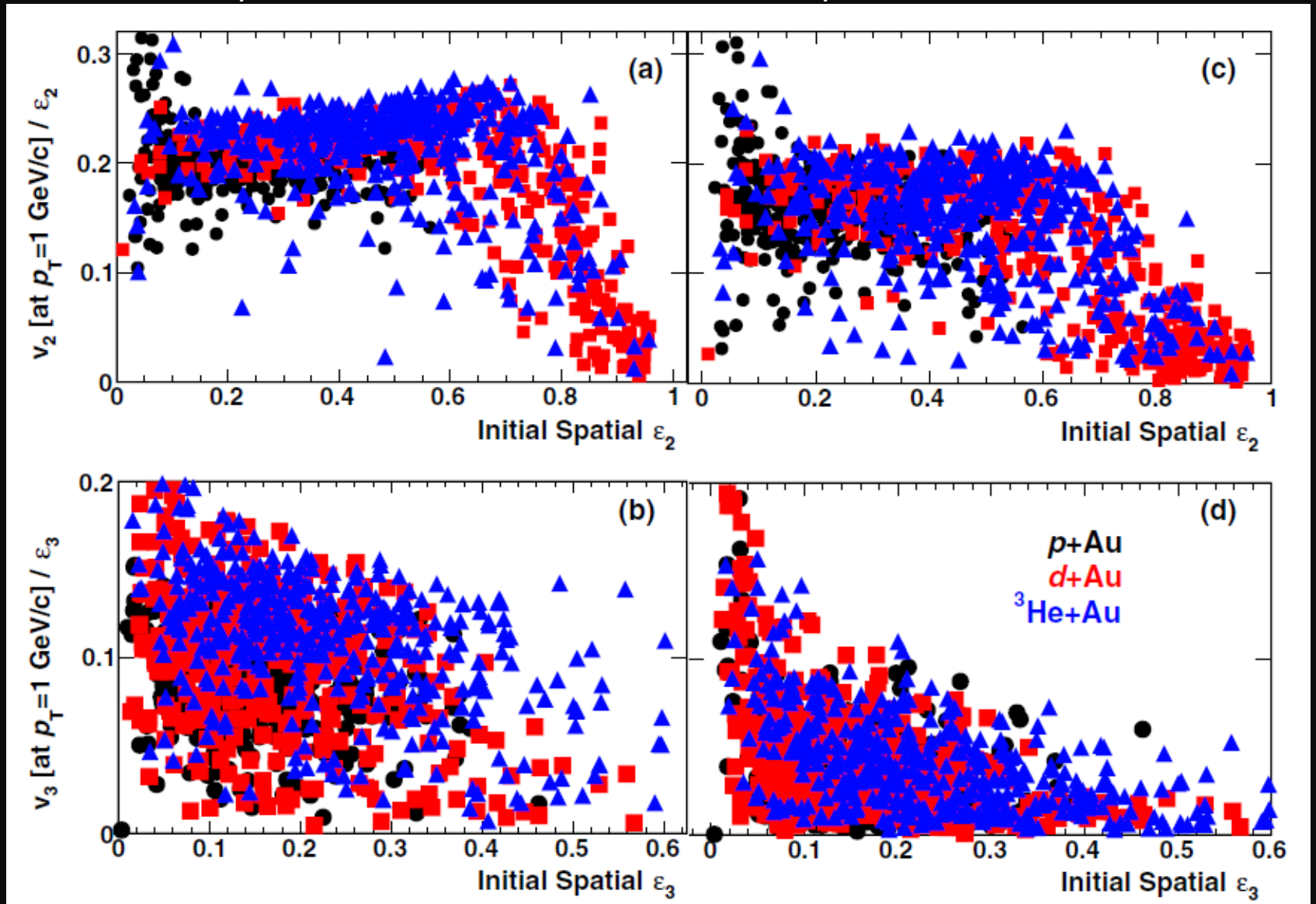
http://arxiv.org/abs/arXiv:1312.4565

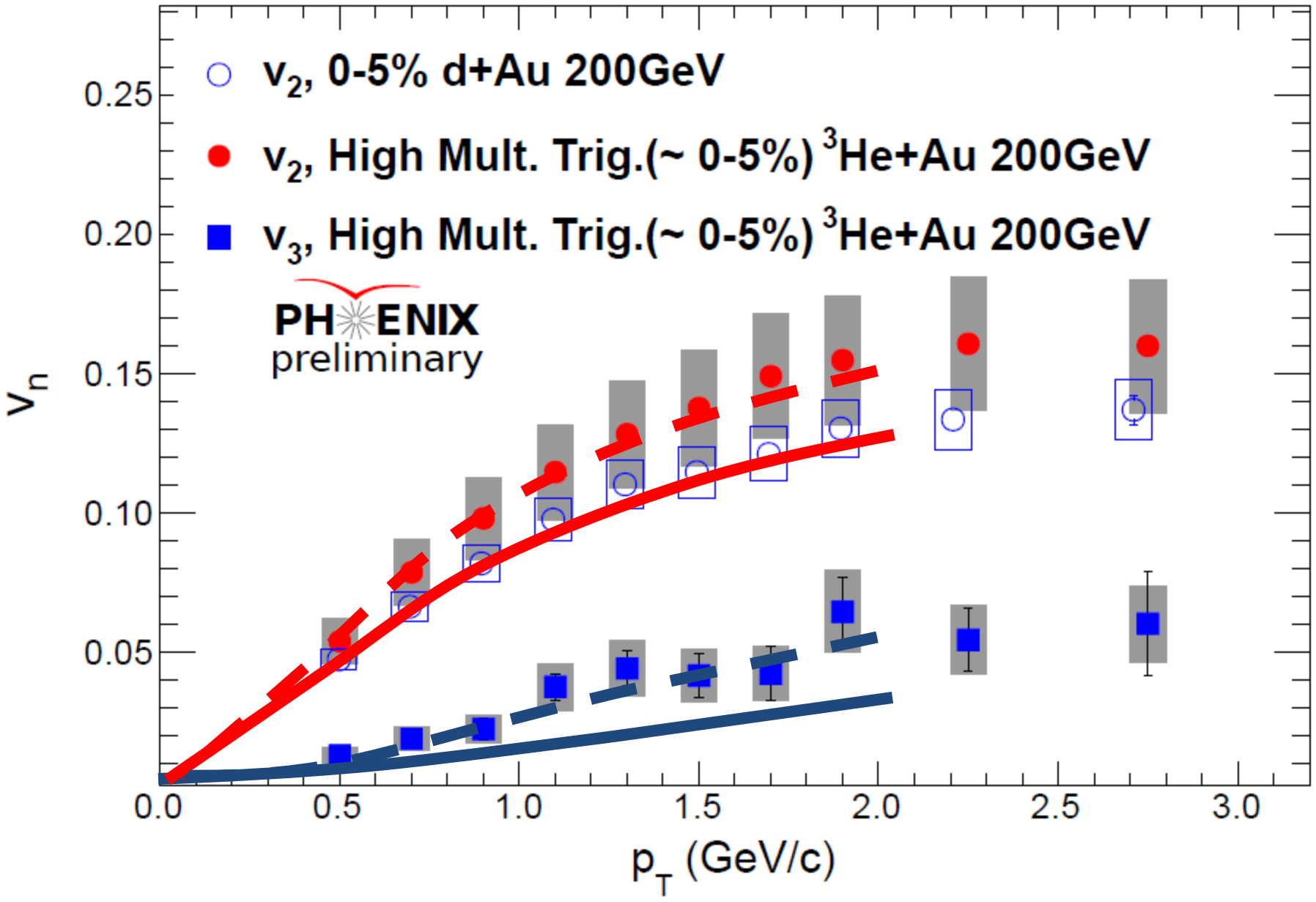
Not Enough Time?

T_f = 150 MeV T_f = 170 MeV

$\frac{v_2}{\varepsilon_2}$

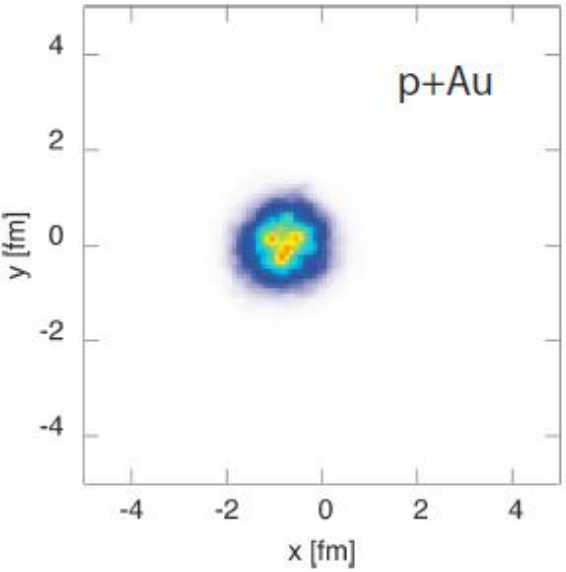
$\frac{v_3}{\varepsilon_3}$

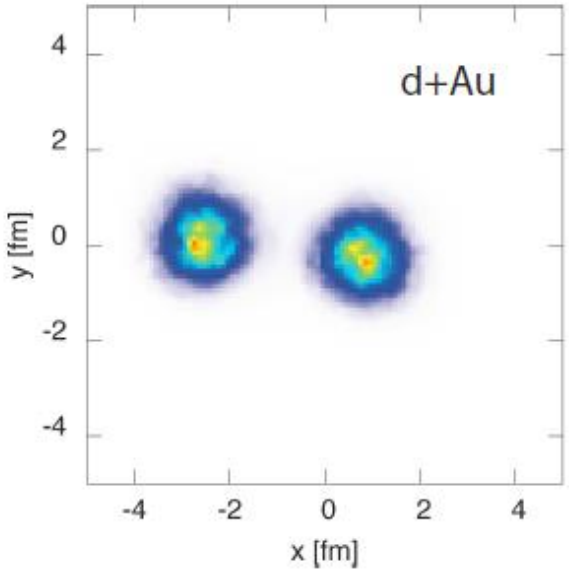


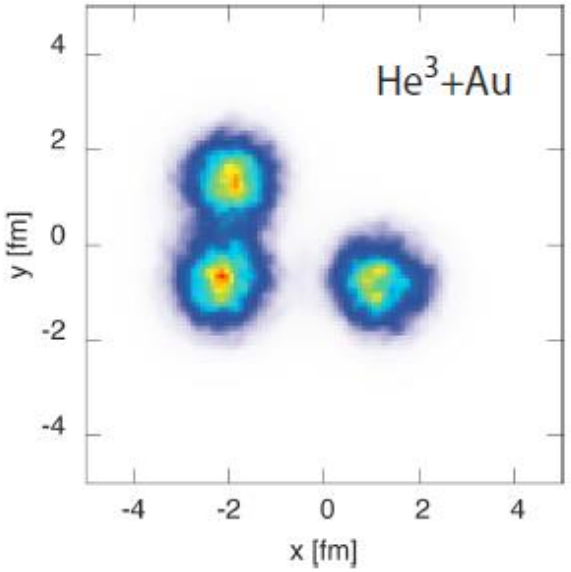


Glauber IC + Hydro ($\eta/s=1/4\pi$) + Hadronic Cascade (PRL 2014)

Dashed Lines – adding pre-flow (see Romatschke's talk)



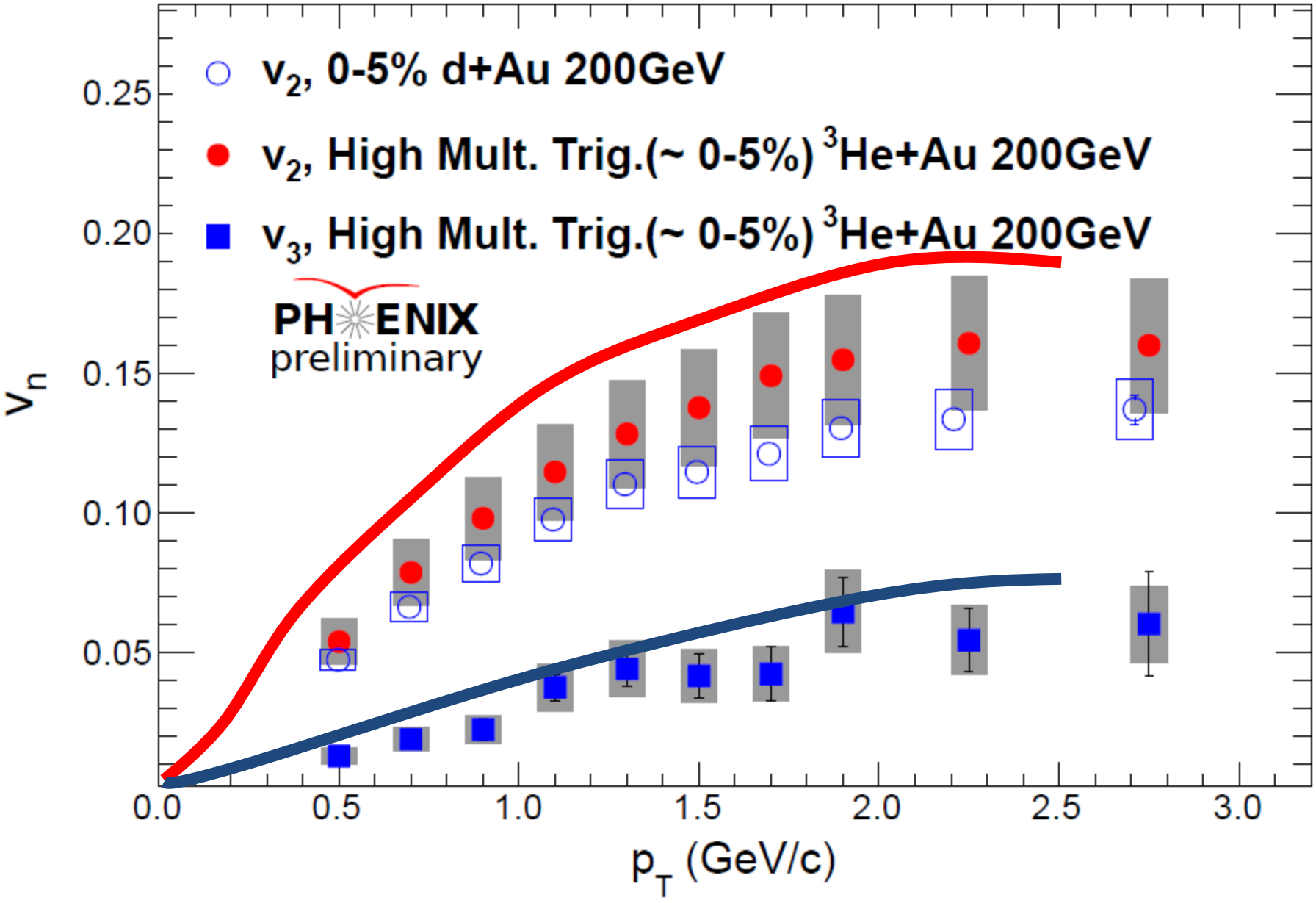




IP Glasma gives very different eccentricity from Glauber in pA

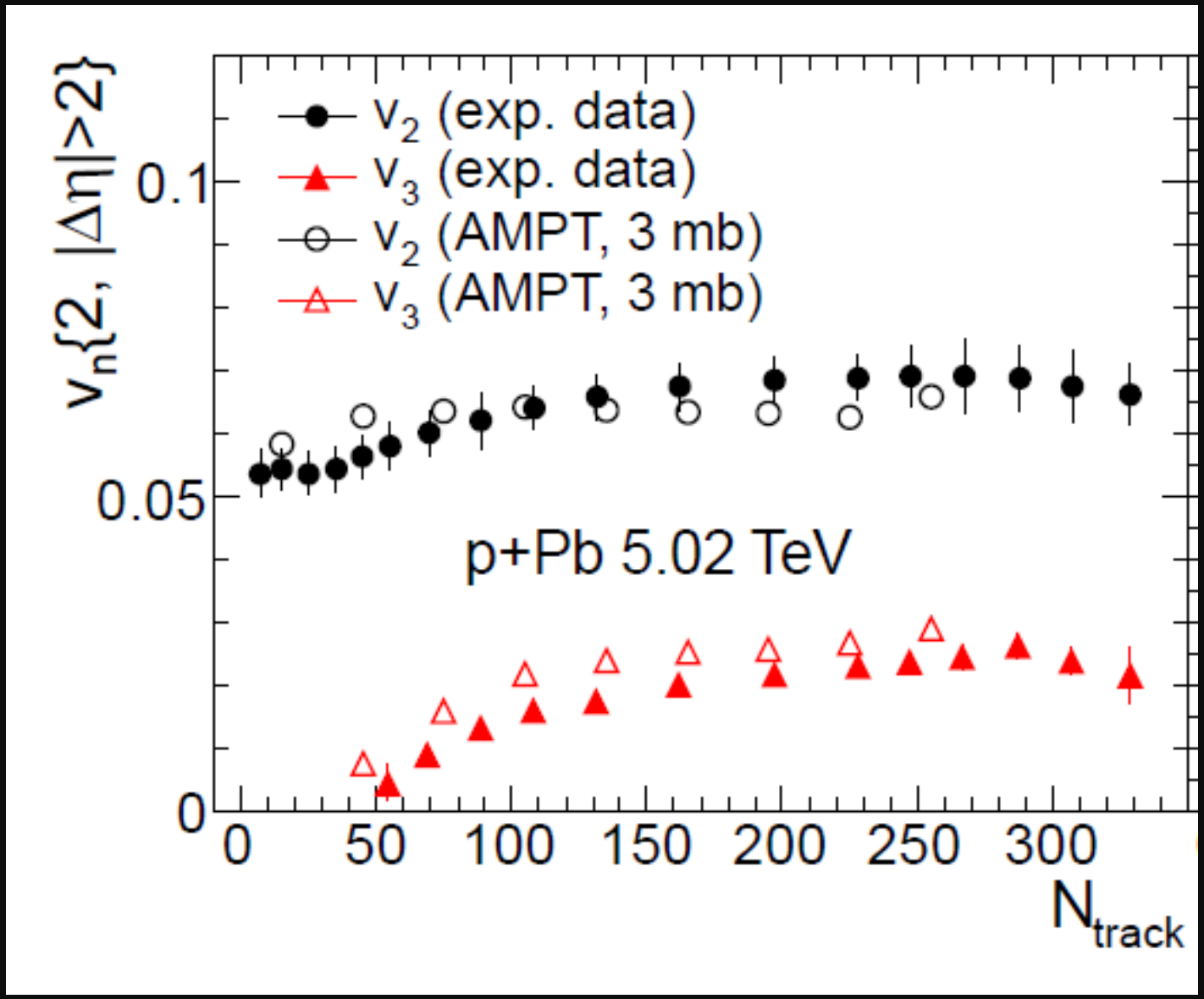
However, in d+Au and ^{3}He+Au,
the eccentricity is driven by the 2 and 3 hot stops,
not their individual geometry

Note though that the IPGlasma has a smaller hot spots
with higher energy density that result in
more rapid radial expansion

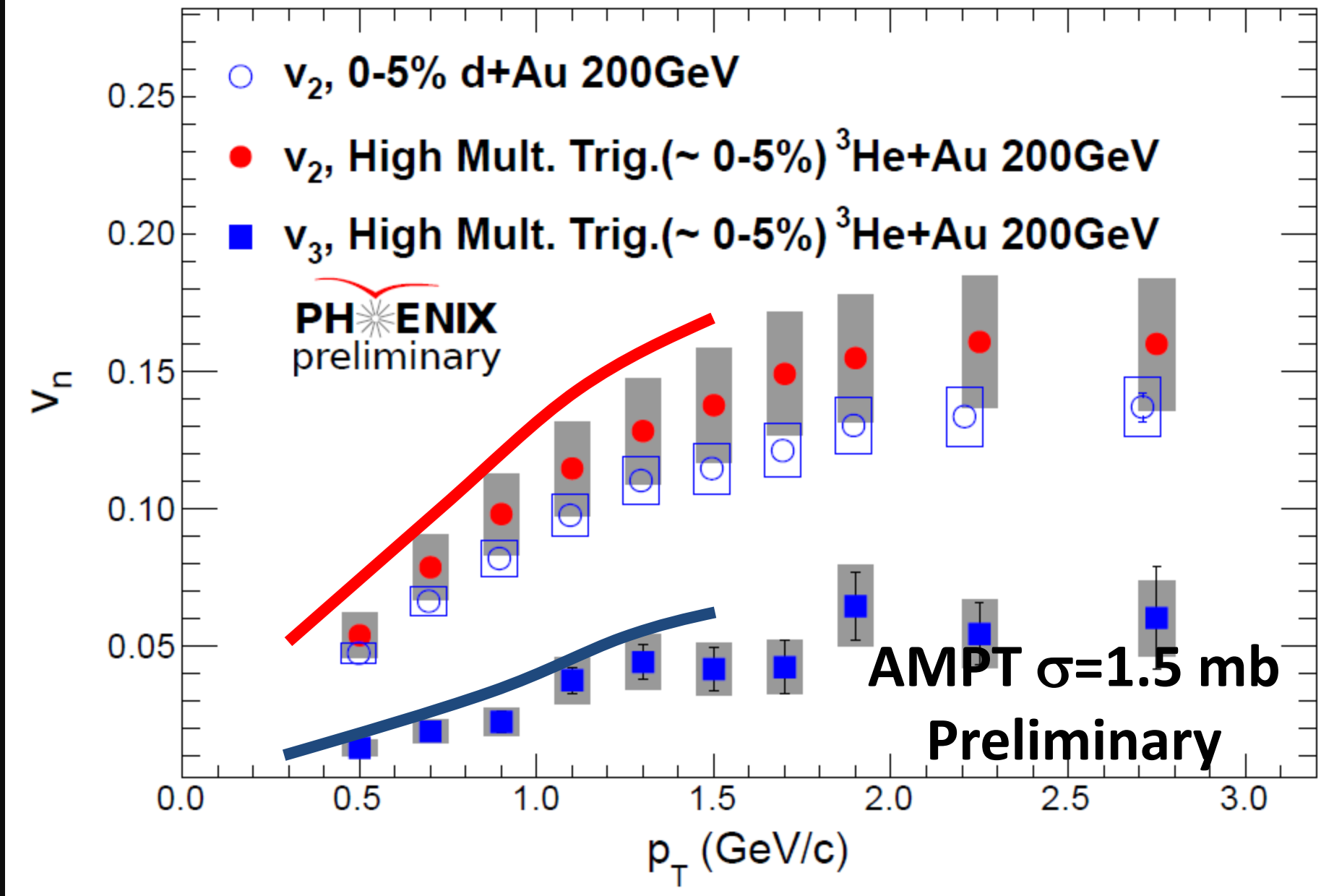


IP Glasma + MUSIC ($\eta/s = 1.5 \times 1/4\pi$)

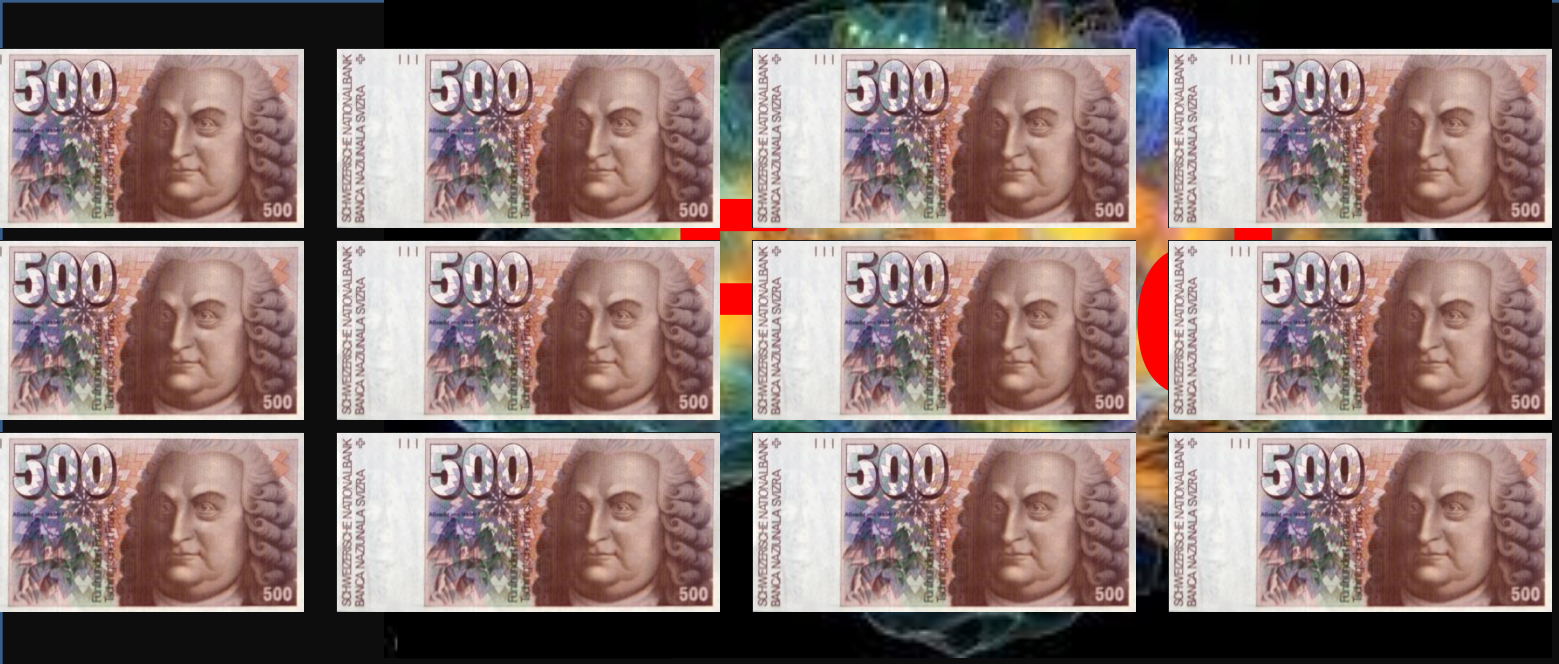
Much larger initial radial expansion, but also no late cascade



Bzdak, Ma (http://arxiv.org/abs/1406.2804) AMPT and p+Pb



AMPT run by Javier Orjuela-Koop (still checking v_n extractions)

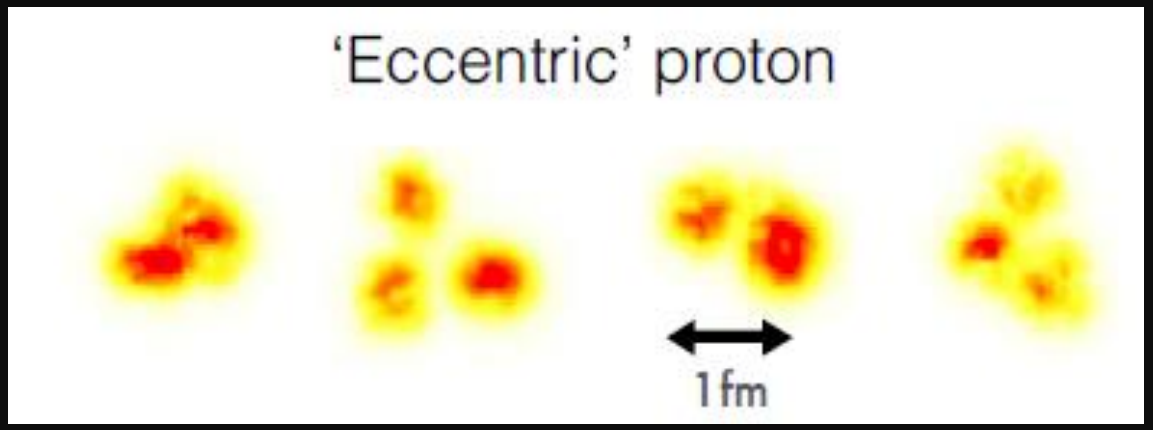


Some thoughts…

1. Want publicly available IP Glasma
2. Want all small system hydro models to include cascade
3. Want to see quantification of gradient expansion limits
4. Want to see strict limits on equilibration time
   → what if one coupled pre-equilibrium to cascade?
5. What would it really cost to run d/^{3}He+Pb at LHC?

Millions of CHF might be well justified. d/^{3}He+Pb workshop?

Best Road(s) Forward



My favorite talk – from S. Schlichting

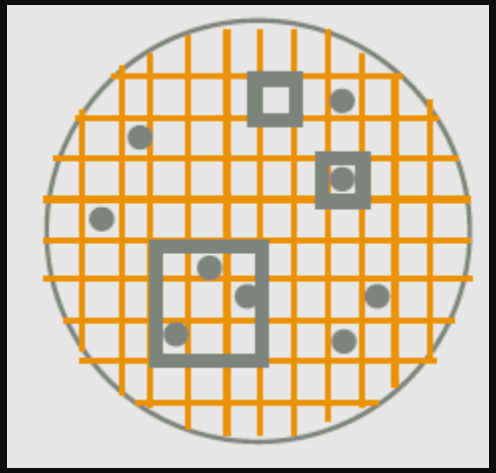
Looks very promising

Need calculations ASAP for p+Au, d+Au, 3He+Au

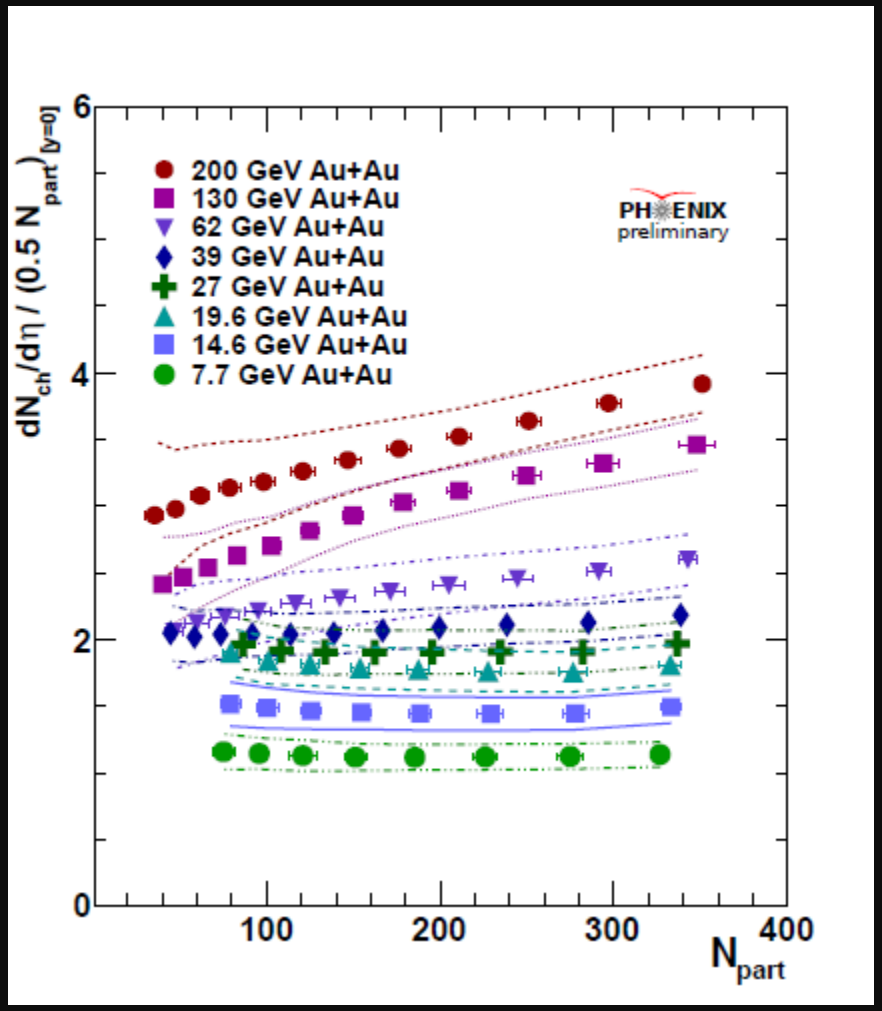
→Naïve expectation is any local effect is diluted by 2 or 3 hot spots with independent orientations (unless they connect!)

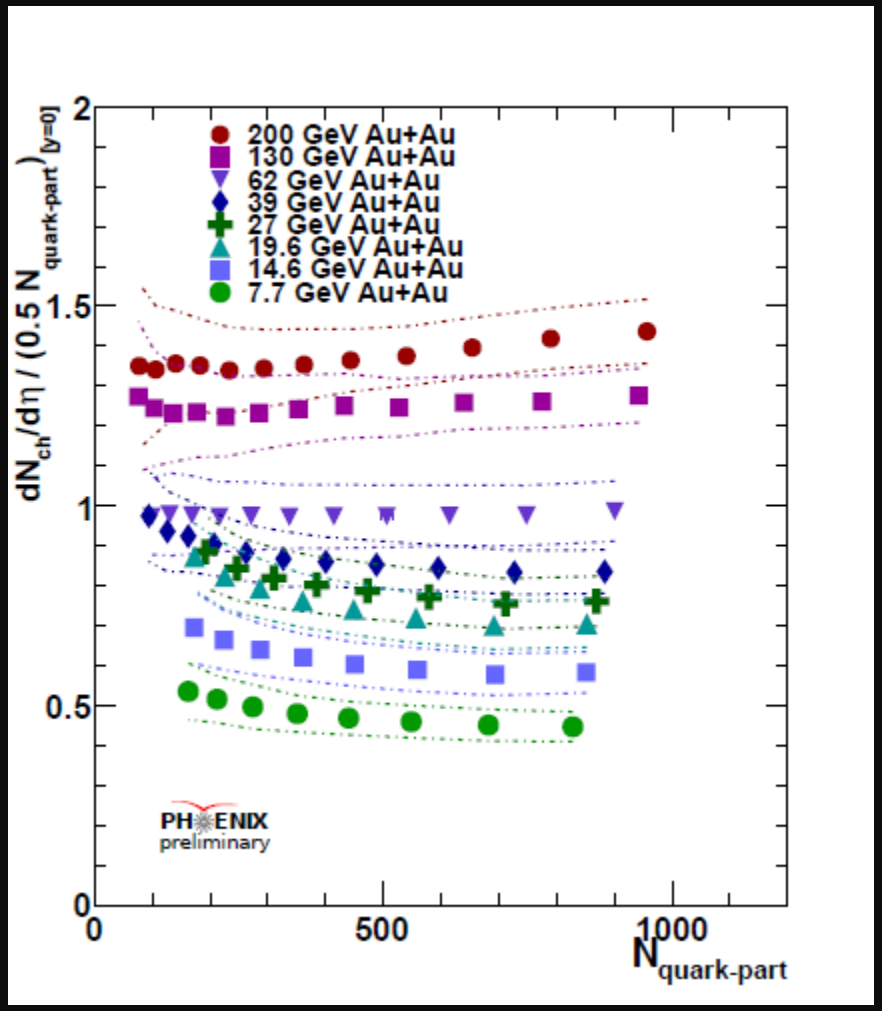
Really like idea of specific model independent approach with scale of granularity.

What scale of sub-nucleonic structure is really needed to describe data



Need for 3 part sub-structure (constituent quarks?)
Interest in how substructure changes with Energy, kinematics





- Below 39 GeV, the dN/dη scales well with participant nucleons
- Above 39 GeV, participant quark scaling describes the data well.

If it really hydrodynamic/QGP, what about the other signatures like jet quenching?

Fluid Probe:

Put a pebble in the stream and watch something out of equilibrium then equilibrate.

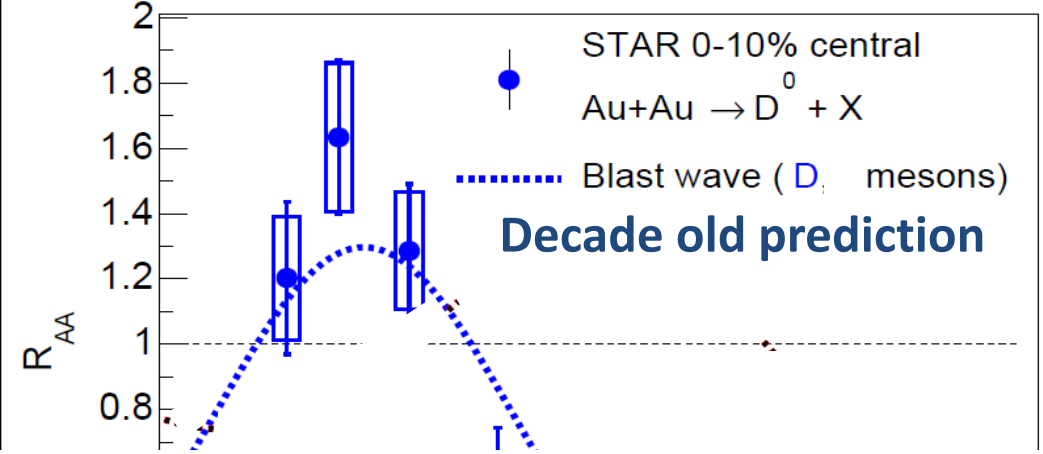
Charm Quark

Beauty Quark

"Does the Charm Flow at RHIC?"

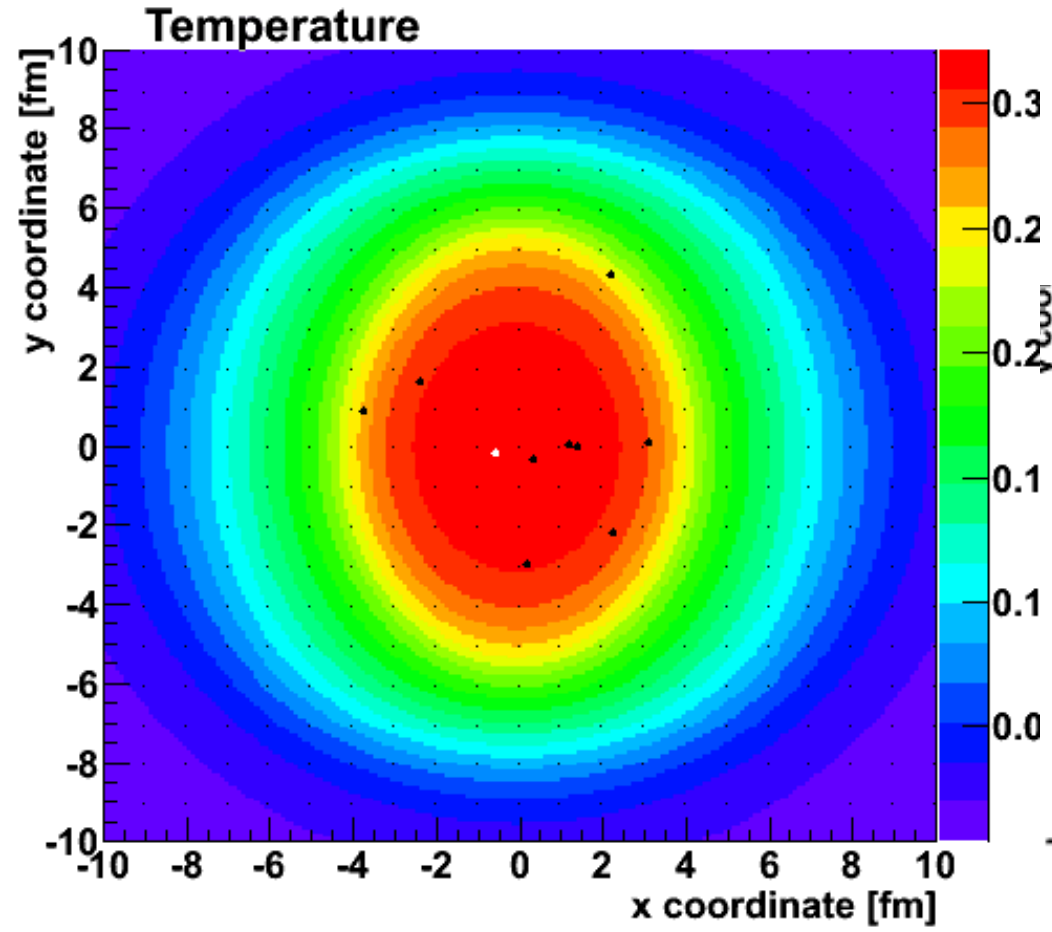
S. Batsouli, S. Kelly, M. Gyulassy (Columbia U.) , J.L. Nagle (Colorado U.) . Dec 2002. 11pp.
Published in **Phys.Lett.B557:26-32,2003**.
e-Print: **nucl-th/0212068**

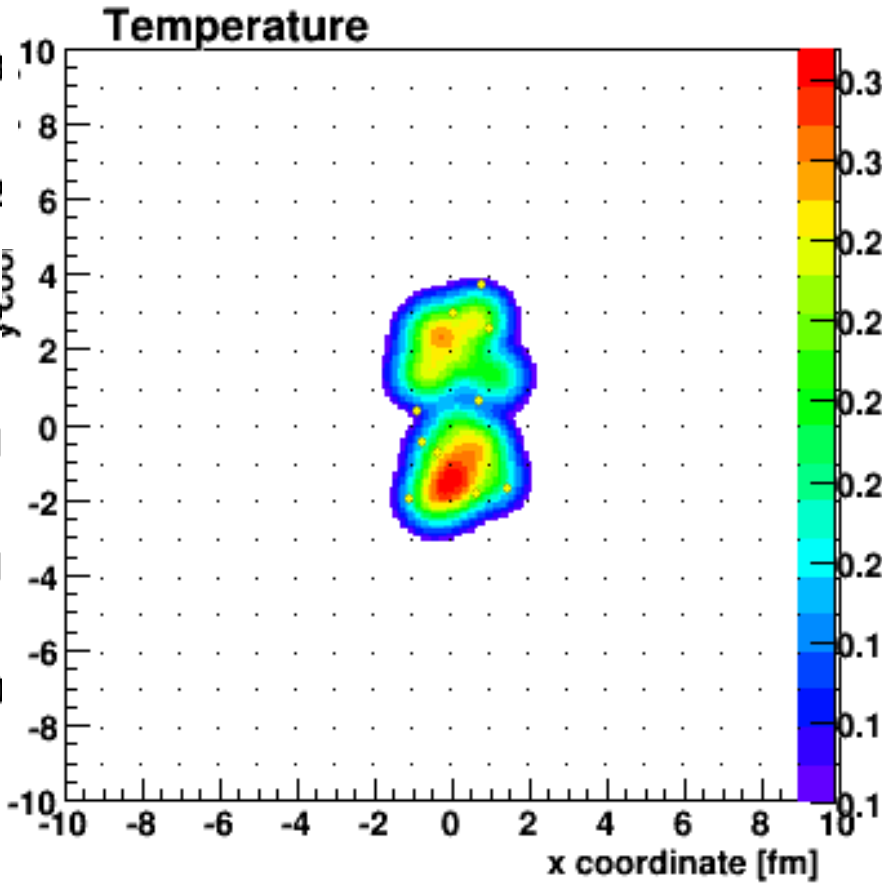
At the time, many said this idea was "ridiculous".

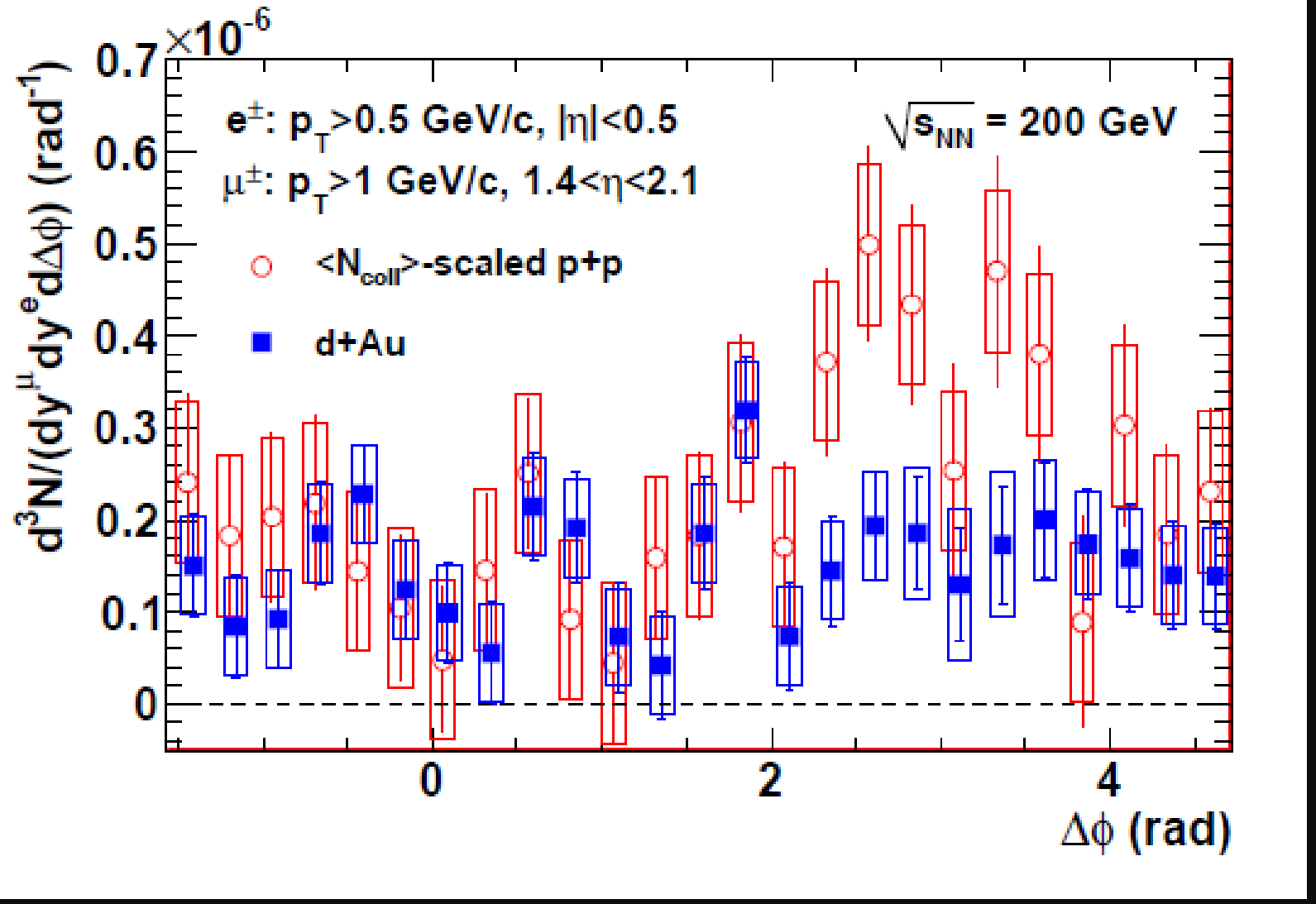


Ratio Au+Au / p+p

Charm quarks pushed out by blast wave of fluid





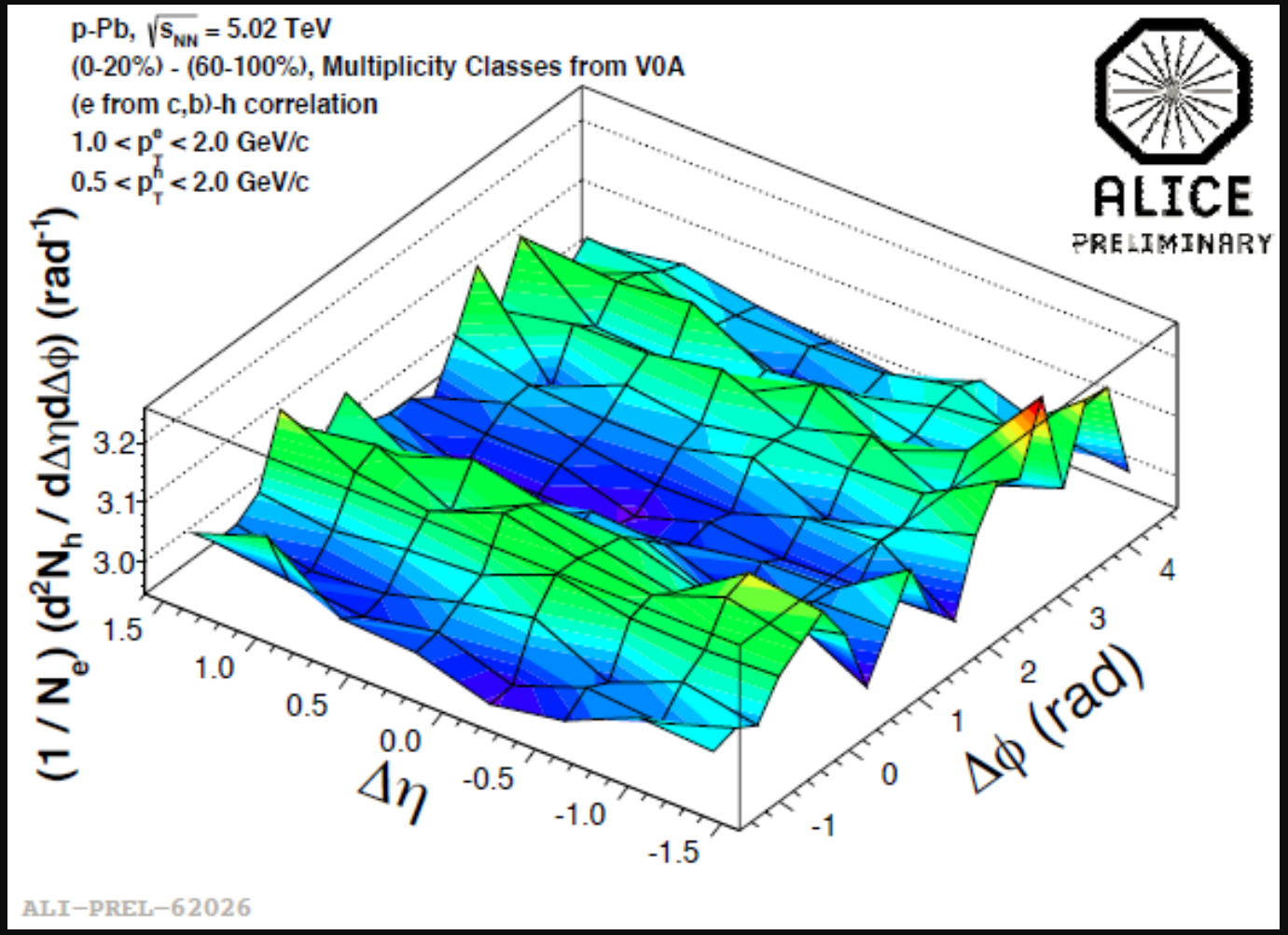


Example – e-μ correlations (away side peak is gone)

Could that be from flow effects, shadowing effects?

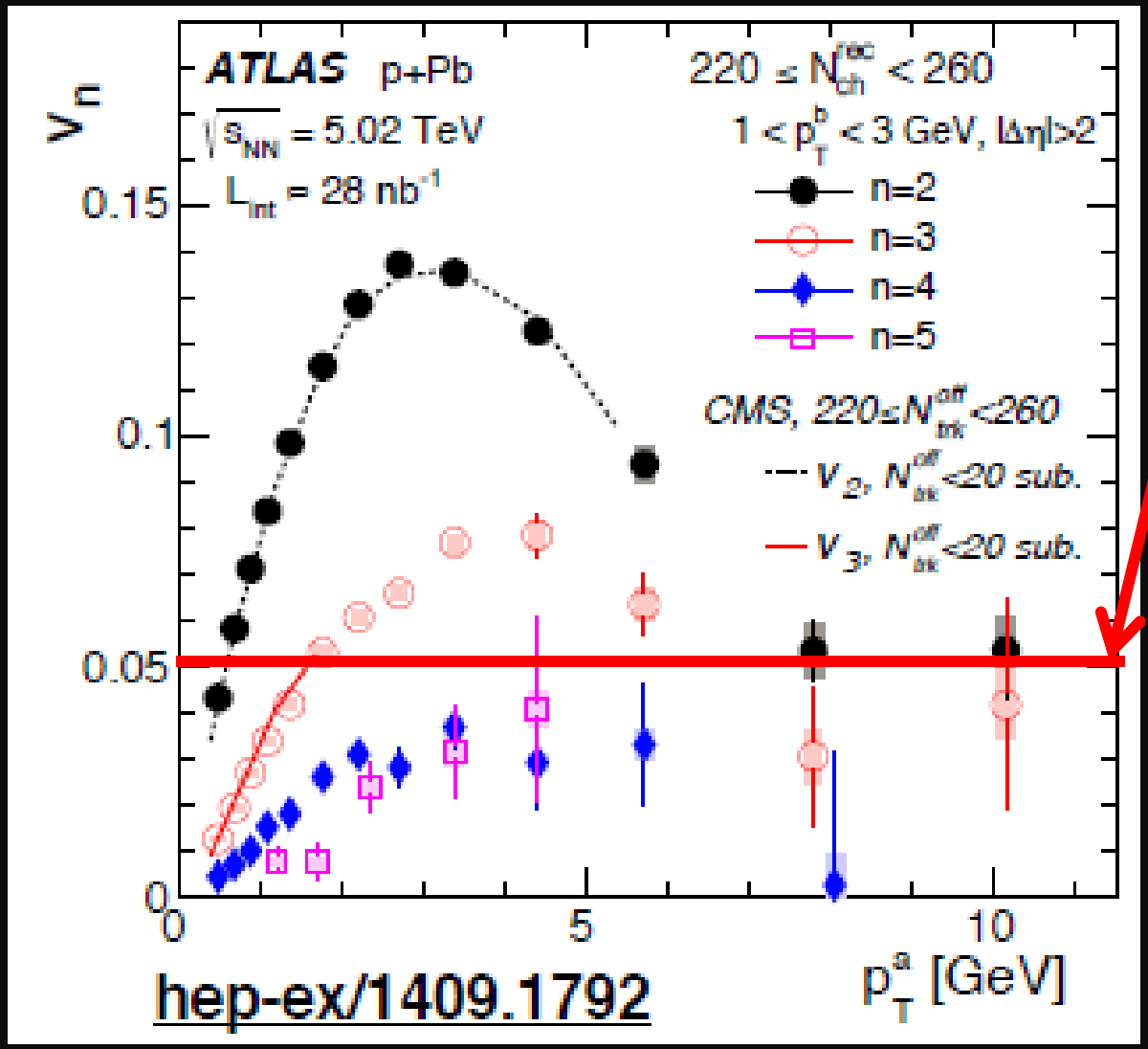
Also, radial flow for charm? (see A. Sickles – arXiv: 1309.6924)

Charm Ridge



STAR – check D-h correlation with HFT in ^{3}He+Au?

Makes sense to run all the usual signal codes and ask the same questions!



Autocorrelation?
Quenching?

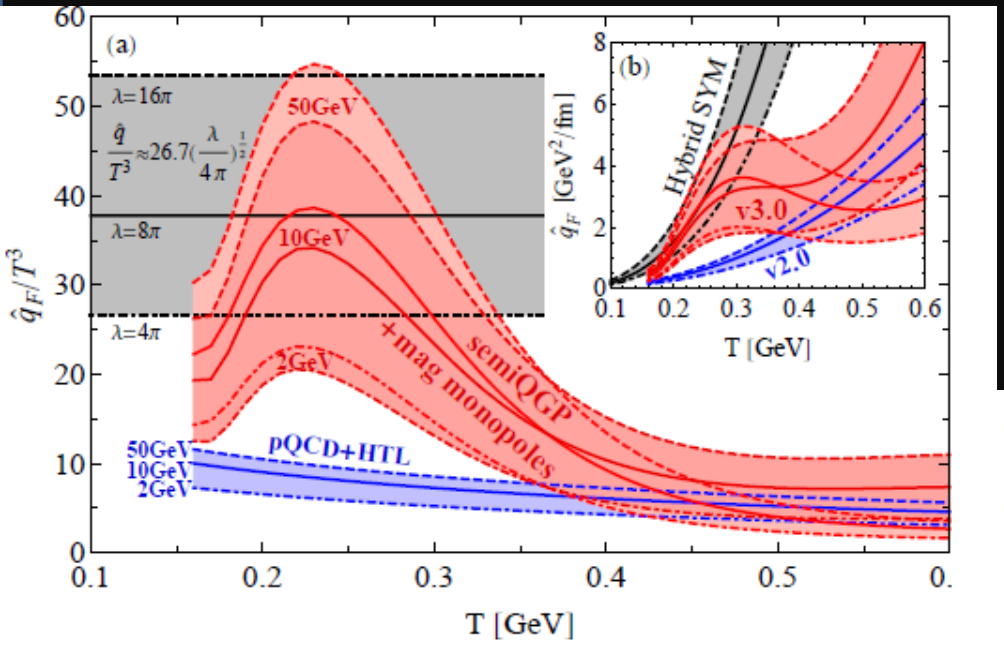
Theory groups use pre-equilibrium + hydro space-time and calculate jet quenching observables.

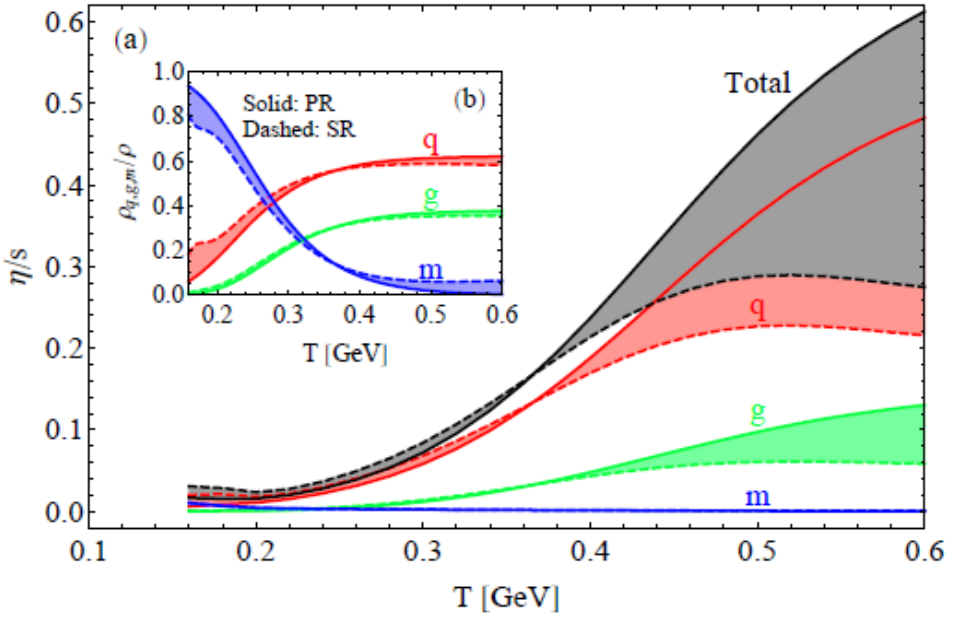
What observables are most sensitive

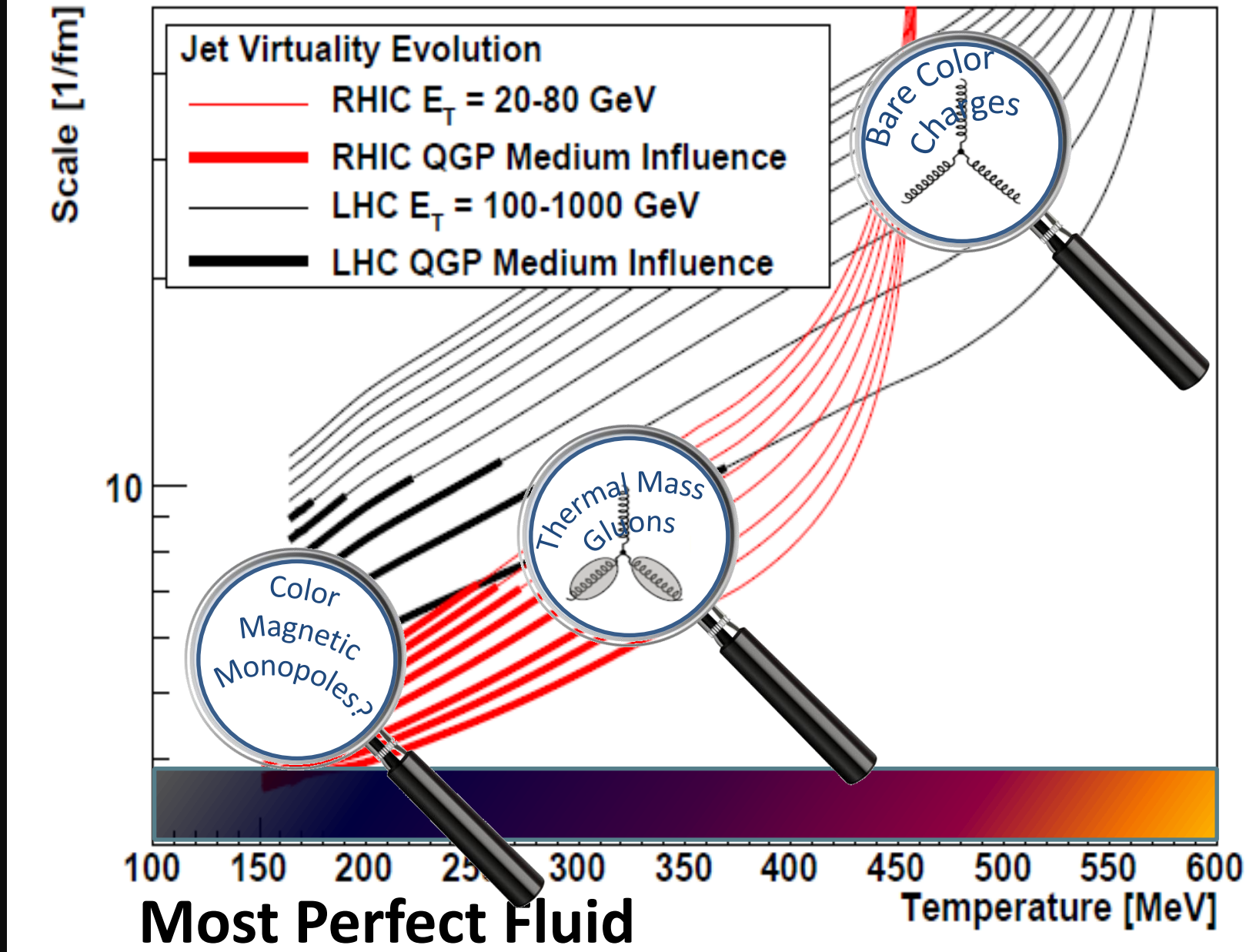
Deeper Connections – Why and How?

Anisotropic Jet Quenching in semi-Quark-Gluon Plasmas with Magnetic Monopoles in Ultrarelativistic Heavy Ion Collisions

Jiechen Xu,[1] Jinfeng Liao,[2,3] and Miklos Gyulassy[1]







Key part of RHIC and LHC future program

Lots of things to think about…

Do we need other geometries?

What about high multiplicity p+p at RHIC?

Carbon + A?

Full connection to U+U central data, Cu+Au data

Geometries at the LHC?

Key next tests – for example Linear / Non-linear pieces
Beam Energy Scan with same observables

Connection to p+p ridge cannot be forgotten

Alternatives – all need same scrutiny and confrontation with full data sets…

Surprising feature may just be our blindness to the obvious

Thank to the Organizers for a Memorable Workshop!

Q1. Do we produce a strongly coupled liquid in "dilute+dense" collisions?

Experiment: What about pp? HeAu at LHC?
Theory: Put on thinking caps

Q2. What provides the connection between soft and hard production?

How many different effects?
Profound or trivial?

Q3. Can we have jet modification without jet quenching?