Reviews on QM2018

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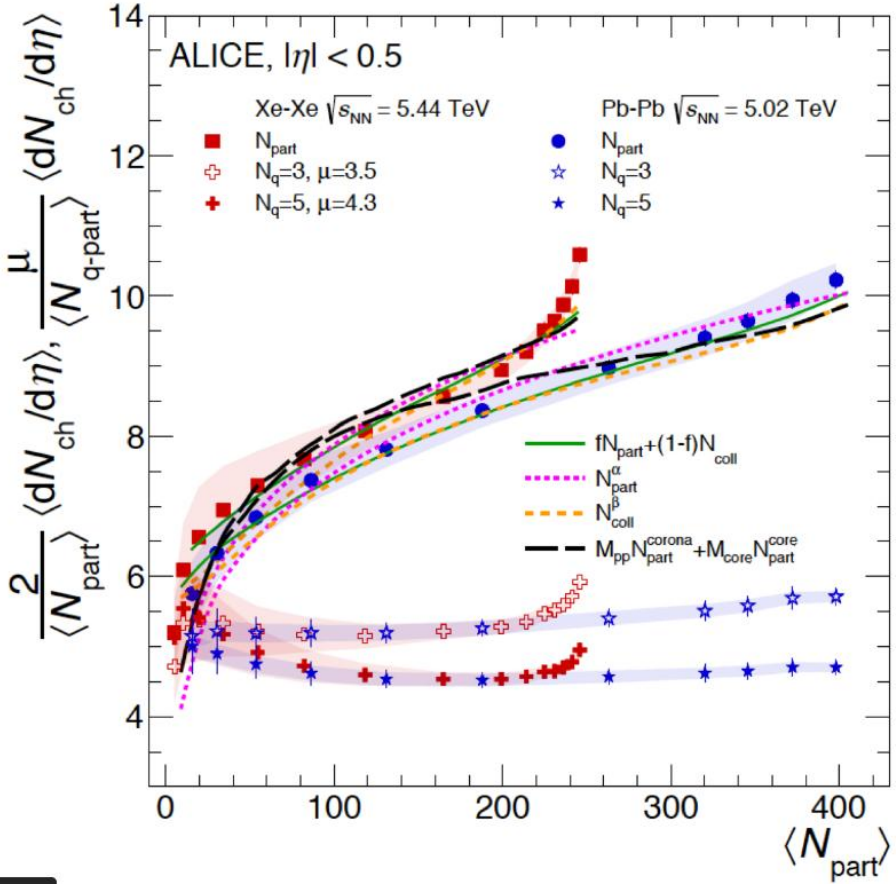
Outline

- Collective flows
- Flow fluctuations and correlations
- Initial dynamical model for BES

Collective flows

- Talk: Highlights from Alice, May 14th
- Talk: Jacopo Margutti, May 15th
- Talk: YouZhou, May 17th

$\langle dN/d\eta \rangle$ in Xe+Xe



Two scaling violations

(1) N_{part} scaling violated, but well described by participate quark scaing and many theoretical models

(2) Central collisions of medium-size nuclei produce more particles per N_{part} than mid-central collisions of large nuclei at the same N_{part}

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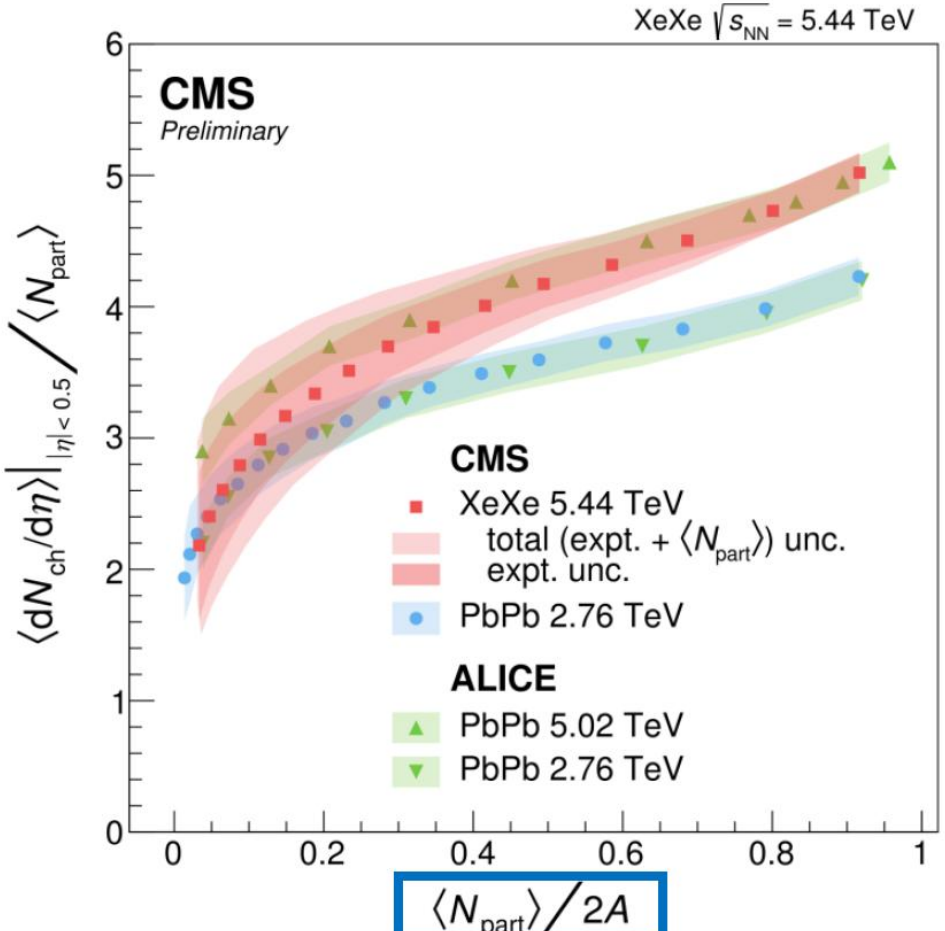

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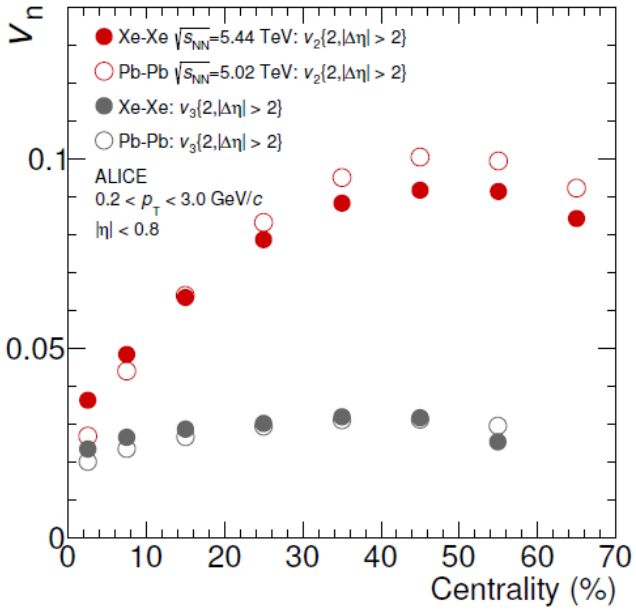
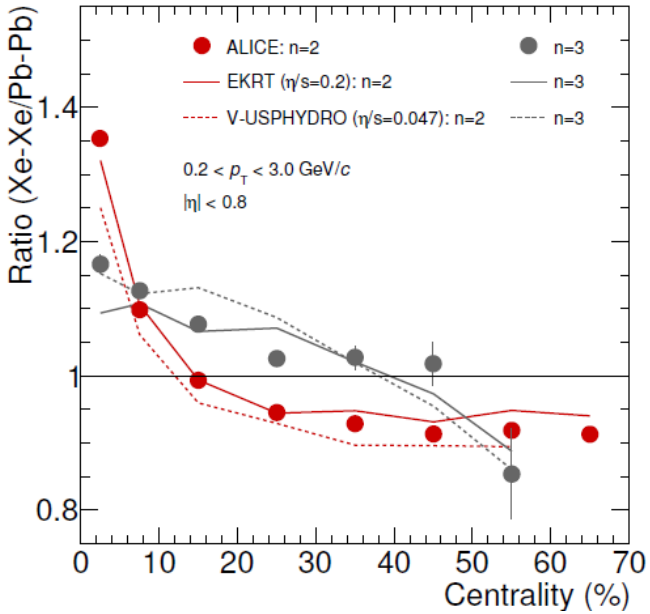
CMS:
Charged-particle production depends on collision geometry, not system size.

Flow in Xe+Xe and Pb+Pb





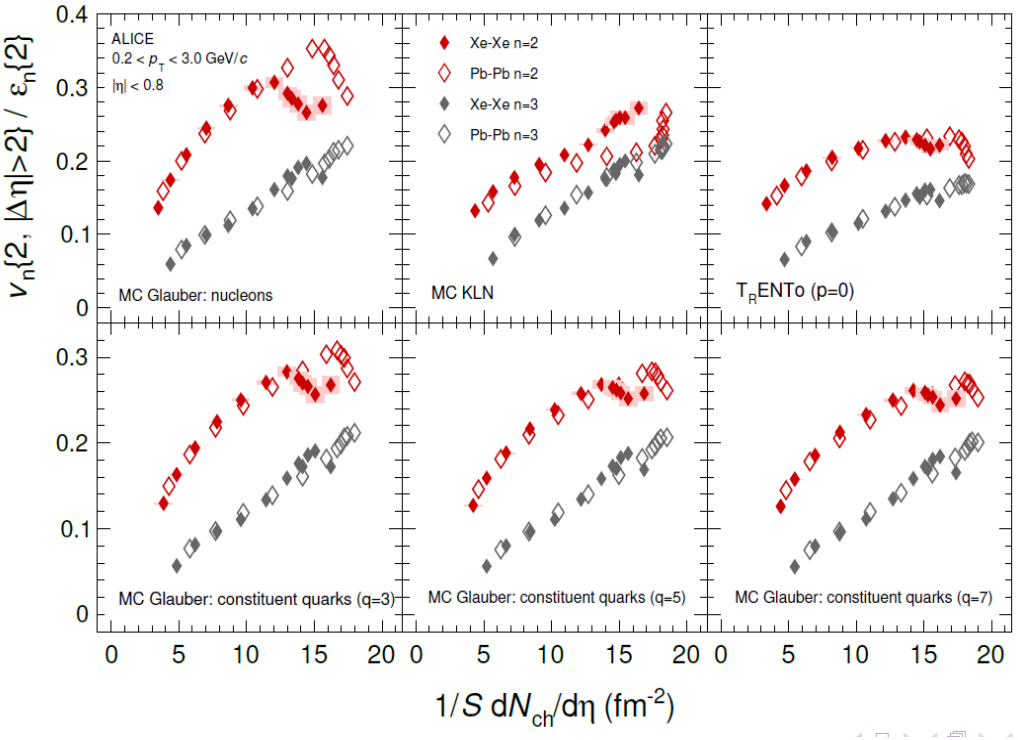
v_2 in Xe+Xe vs Pb+Pb

- in central collisions, Xe+Xe v2 is higher up to 35% → Initial geometry fluctuations with consideration of Xeon deformation
- for non-central collisions, it is smaller in Xe+Xe by 10% → smaller radial flow and/or large viscous effects

v3 in Xe+Xe

- larger in almost all centralities, decreasing from central to peripheral → larger initial geometry fluctuations in Xe+Xe

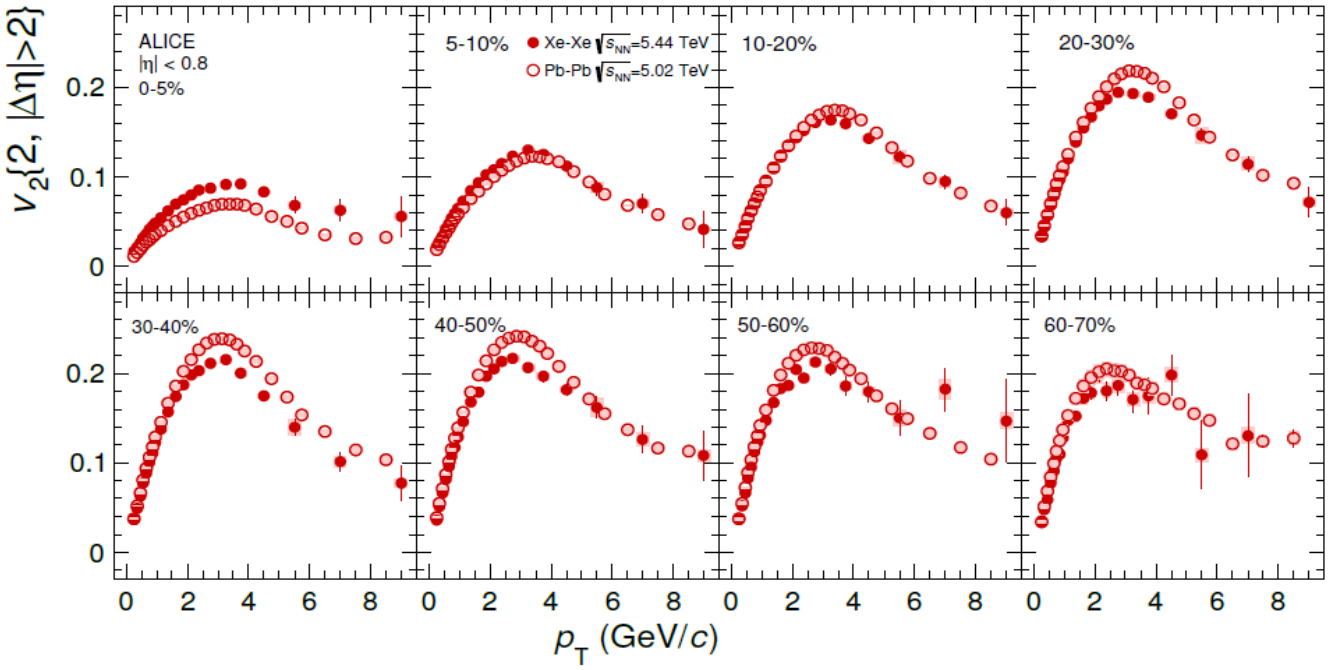
v_n/ε_n vs transverse energy density



- v_n/ε_n the theoretical curves become insensitive to the experimental method
- Hydro predicts v_n/ε_n to increase with $1/S\, dN_{ch}/d\eta$, same for Xe+Xe and Pb+Pb
- Not observed for most models in central collisions: deciencies in estimating ε_2?

Note: v_n/ε_n : monotonic dependence on η/s and independence on experimental methods.

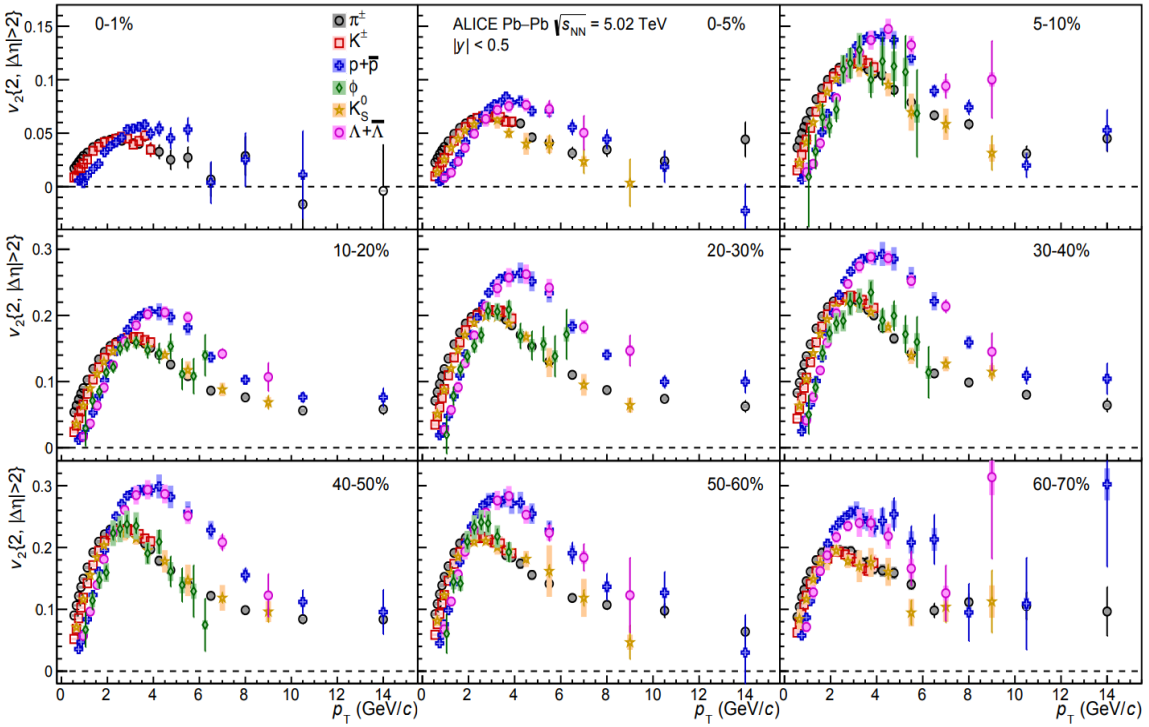
p_T dependence



$v_2(p_T)$ in Xe+Xe vs Pb+Pb

- Same trend: larger in central, smaller otherwise
- Larger differences at intermediate p_T

Harmonic flow of identified particles



- Low p_T: mass ordering
- Intermediated p_T, baryon-meson v_n grouping, partonic collectivity and coalescence?
- High p_T: non-zero vn(p_T) for all particle species, better understanding on parton energy loss.

Flow fluctuations and correlations

- Talk: N. Mohanmodi, May 15th
- Talk: M. Nie, May 15th
- Talk: T. Bold, May 15th
- Talk: K. Gajdosova, May 15th
- Talk: YouZhou, May 17th

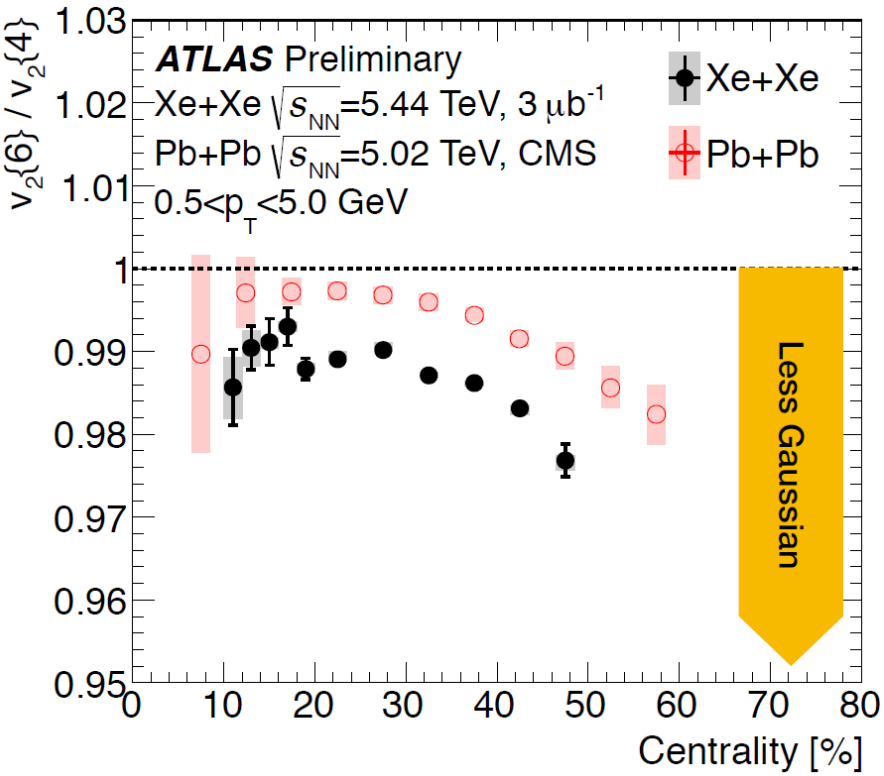
Flow fluctuations in Xe+Xe and Pb+Pb

- If gaussian flow fluctuations:

$$v_n\{2\} = \sqrt{\overline{v}_n^2 + \delta_n^2},\ v_n\{4\} = v_n\{6\} = \overline{v}_n$$

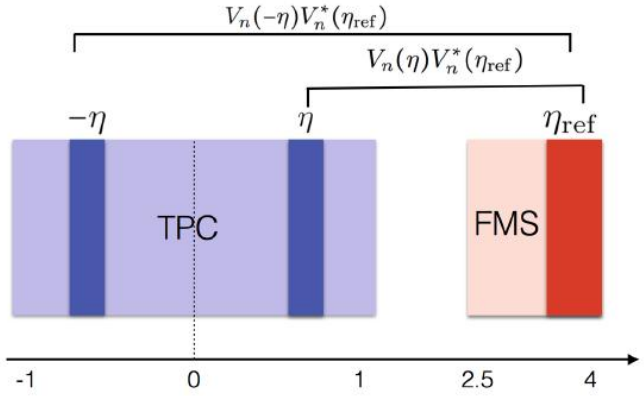
- Comparison of $v_2\{6\}/v2\{4\}$ allows to check if fluctuations or not

- $v2\{6\} / v2\{4\} \lesssim 1$ in Xe+Xe smaller than in Pb+Pb: smaller number of sources.

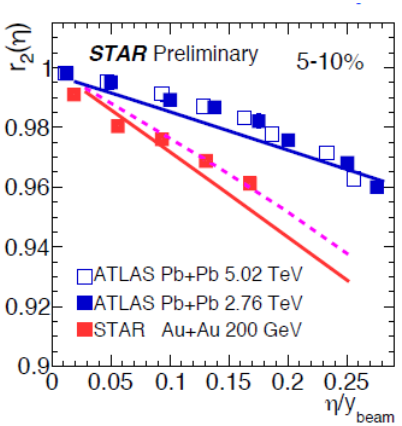


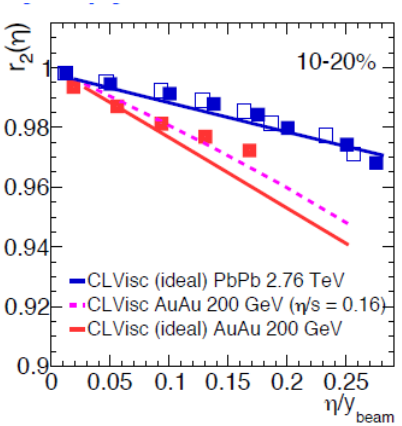
Longitudinal decorrelation with r_n

$$r_2(\eta) = \frac{\langle V_2(-\eta) V_2^*(\eta_{\rm ref}) \rangle}{\langle V_2(\ \eta) V_2^*(\eta_{\rm ref}) \rangle}$$

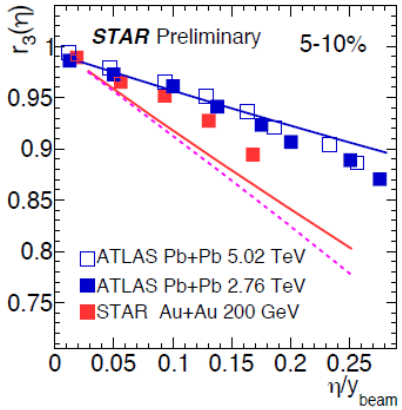


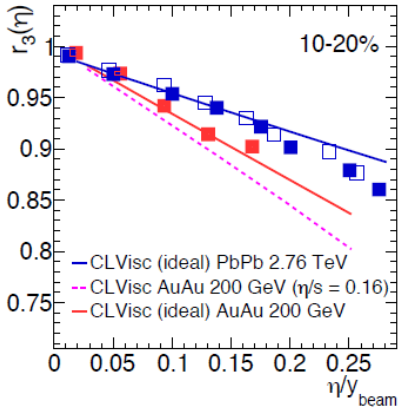
r_2





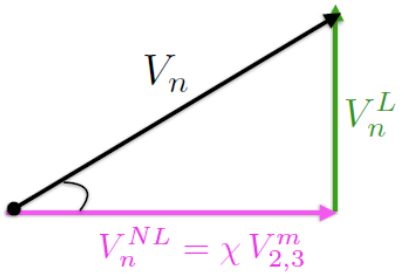
r_3





- Breakdown of factorization is stronger in RHIC comparing with LHC
- Ideal hydro tuned to the LHC data overestimates the decorrelation at RHIC
- The viscosity correction leads to a weaker decorrelation for v2 and stronger decorrelation for v3

Non-linear flow mode



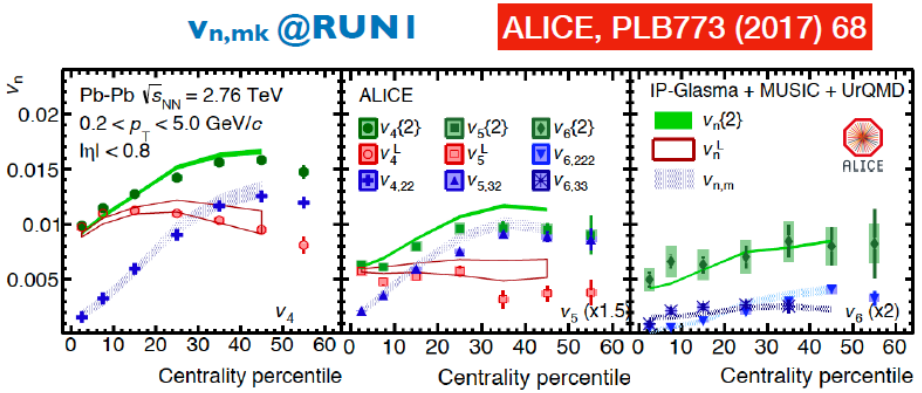
$$V_n = V_n^{NL} + V_n^L$$

non-linear response

linear response

- Non-linear mode V_n^{NL}
  - ☆ corresponds to lower order initial anisotropy coefficient $\varepsilon_{2,3}$
  - ☆ V_n projection on V_2 or V_3
  - ☆ $v_{n,m}$: magnitude of non-linear response in V_n
- Linear mode V_n^L
  - ☆ naively expected to correspond to ε_n
  - ☆ v_n^L: magnitude of linear response in V_n

❖Higher harmonic flow is modeled as the sum of linear and nonlinear response terms to the initial anisotropy coefficients ε_n



☆ Similar results were presented by CMS @ QM17, and by ATLAS using Event-Shape Engineering

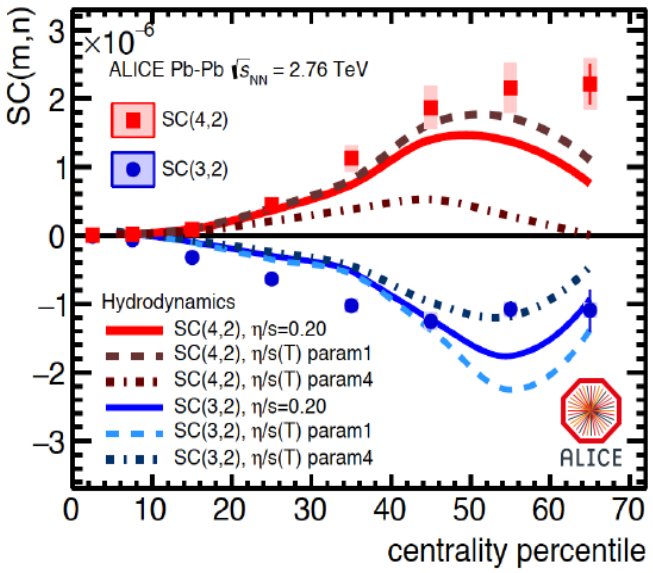
Cumulants in Xe+Xe and Pb+Pb

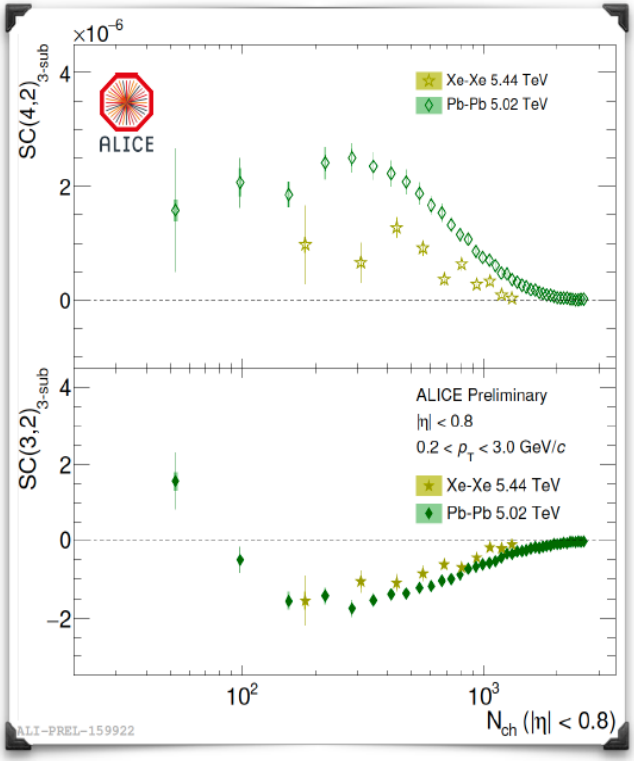
Correlations between v_m and v_n via
Symmetric cumulants:

$$SC(m,n) = \langle v_m^2\, v_n^2 \rangle - \langle v_m^2 \rangle \langle v_n^2 \rangle$$

A. Bilandzic et al., PRC 89, 064904 (2014)

ALICE, PRL117, 182301 (2016)



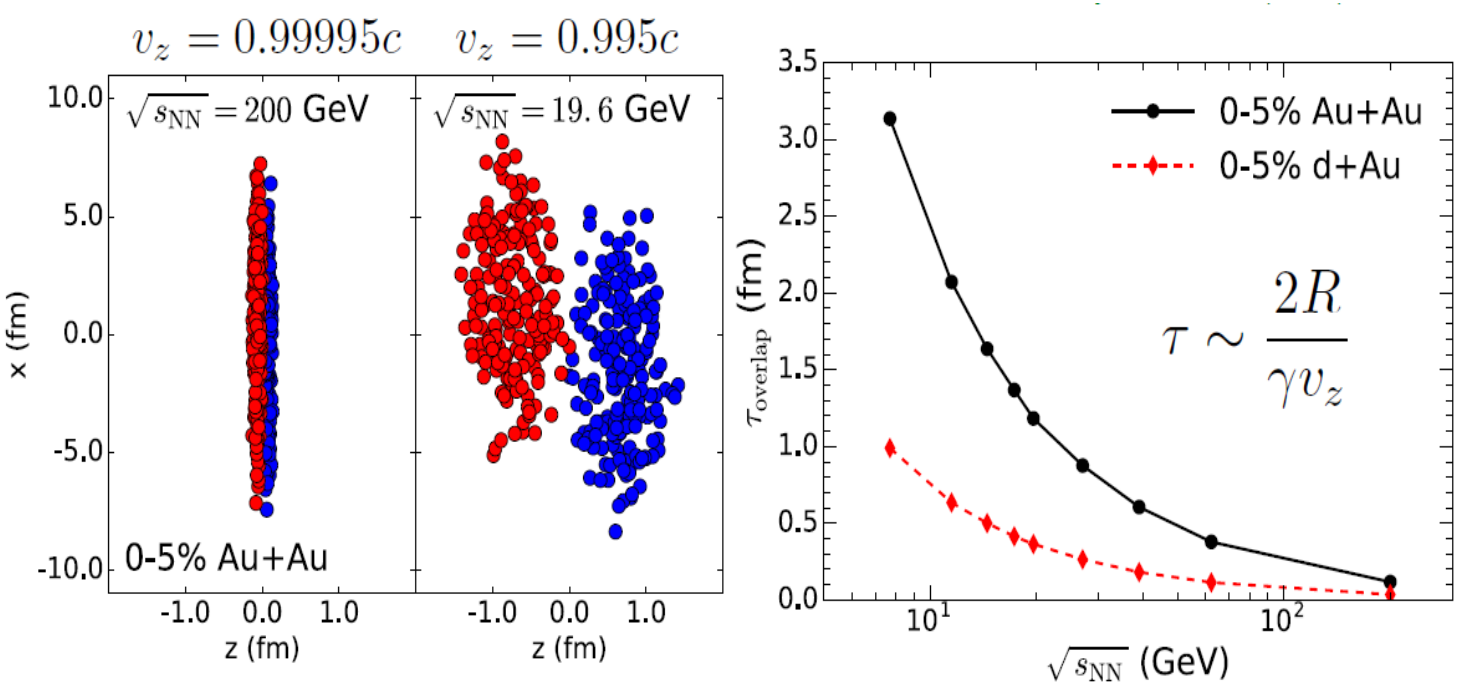


- Weaker (anti-)correlations in Xe-Xe than Pb-Pb at same N_{ch}
- Unique sensitivity to initial conditions (ε_m and ε_n correlations) and $\eta/s(T)$, constraining future theoretical calculations.

Initial dynamical model for BES

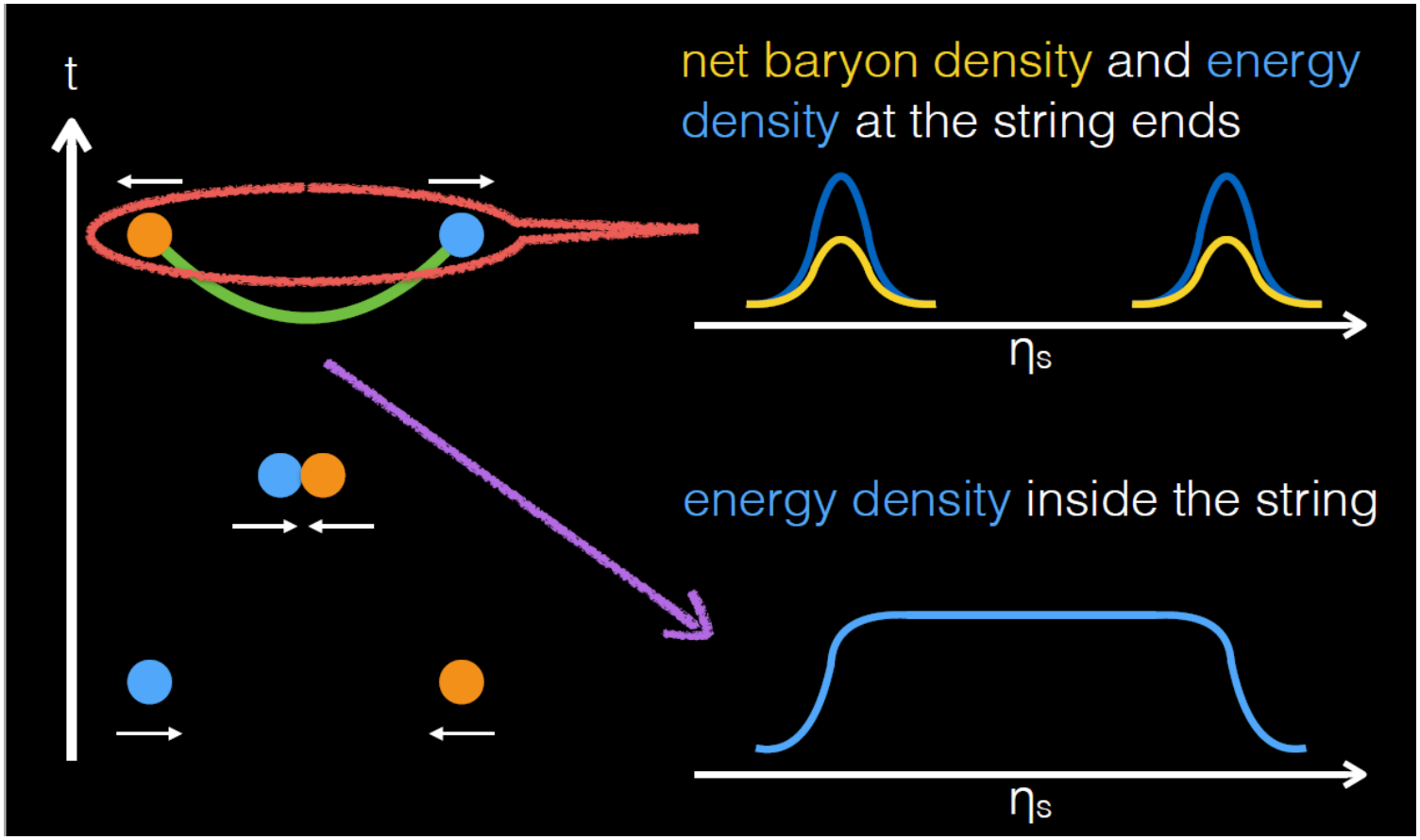
- Talk: S. Chun, May 14th
- Talk: L. Du, May 14th

When to start hydrodynamics?

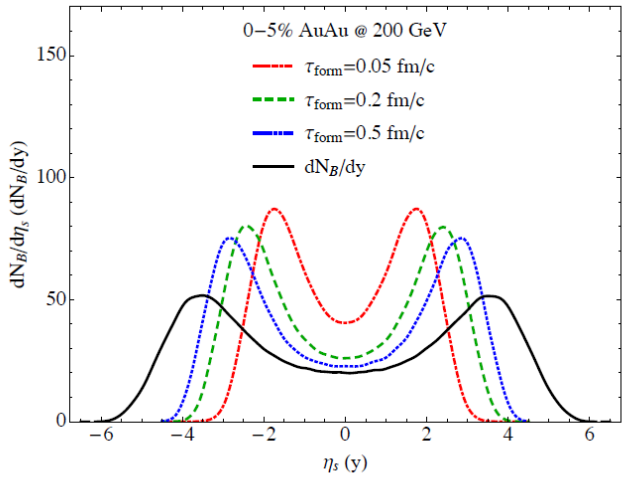


- Nuclei overlapping time is large at low collision energy
- Pre-equilibrium dynamics can play an important role

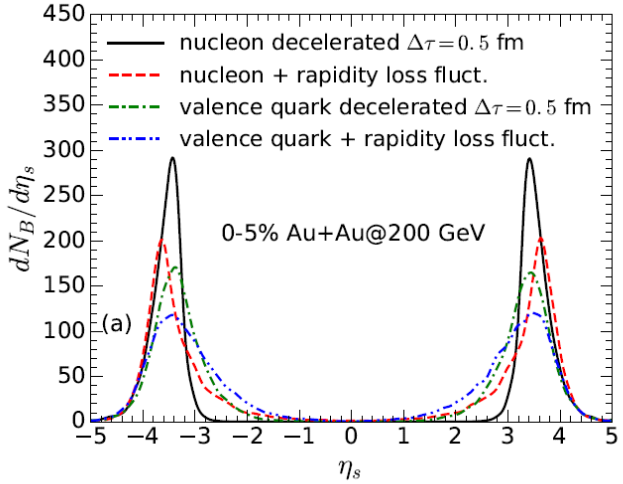
Details about the dynamical initialization



Baryon distribution in space-time rapidity



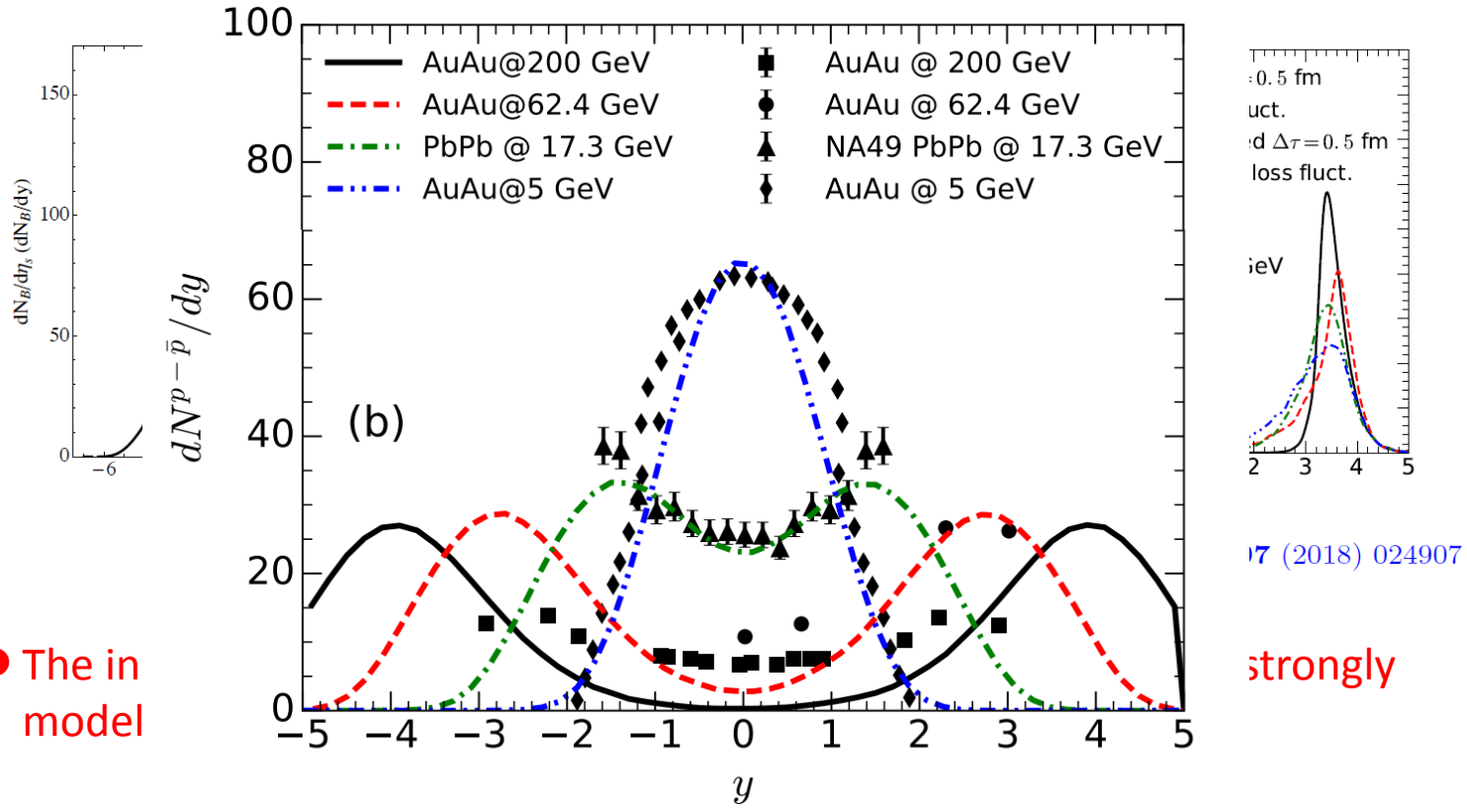
This model



C. Shen and B. Schenke, Phys.Rev. **C97** (2018) 024907

- The initial spacetime distribution of net baryon number can be strongly model dependent.

Baryon distribution in space-time rapidity

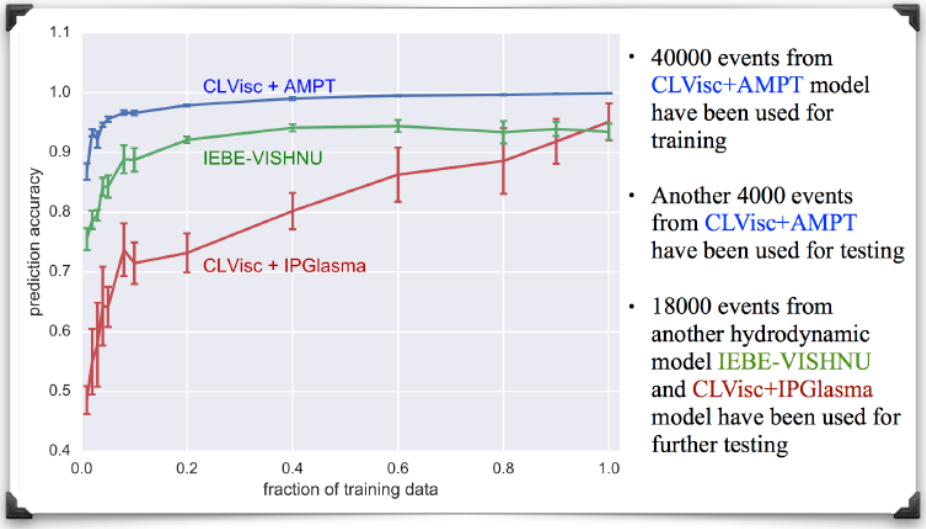


7 (2018) 024907

- The in
  model

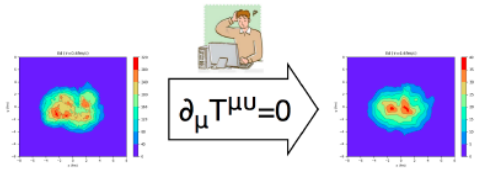
strongly

Deep learning

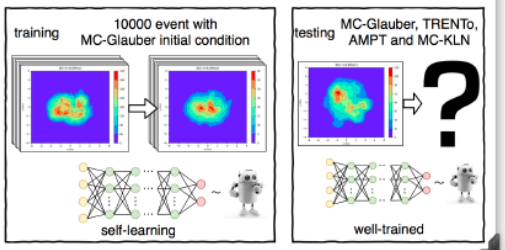


- 40000 events from CLVisc+AMPT model have been used for training
- Another 4000 events from CLVisc+AMPT have been used for testing
- 18000 events from another hydrodynamic model IEBE-VISHNU and CLVisc+IPGlasma model have been used for further testing

- traditional hydrodynamics



- deep learning



Conclusion

1. New experimental results of Xe+Xe collisions can help us to constrain the initial conditions and transport coefficient of QGP.

2. Pre-equilibrium dynamics is very important in the evolution of QGP in BES energy.

3. New technology deep learing maybe become another method to study heavy-ion physics.