Investigation of the initial geometry description using collectivity in the AMPT model

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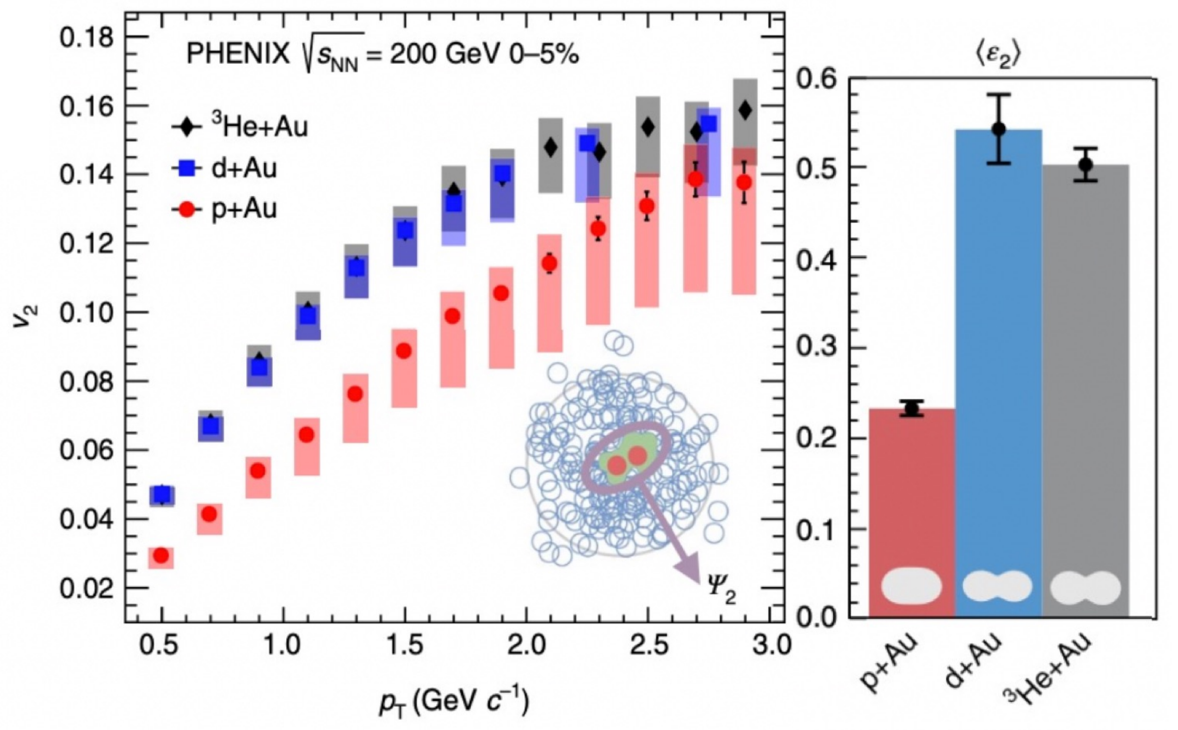
1. MOTIVATION

Collectivity in small collision systems: [1, 2]



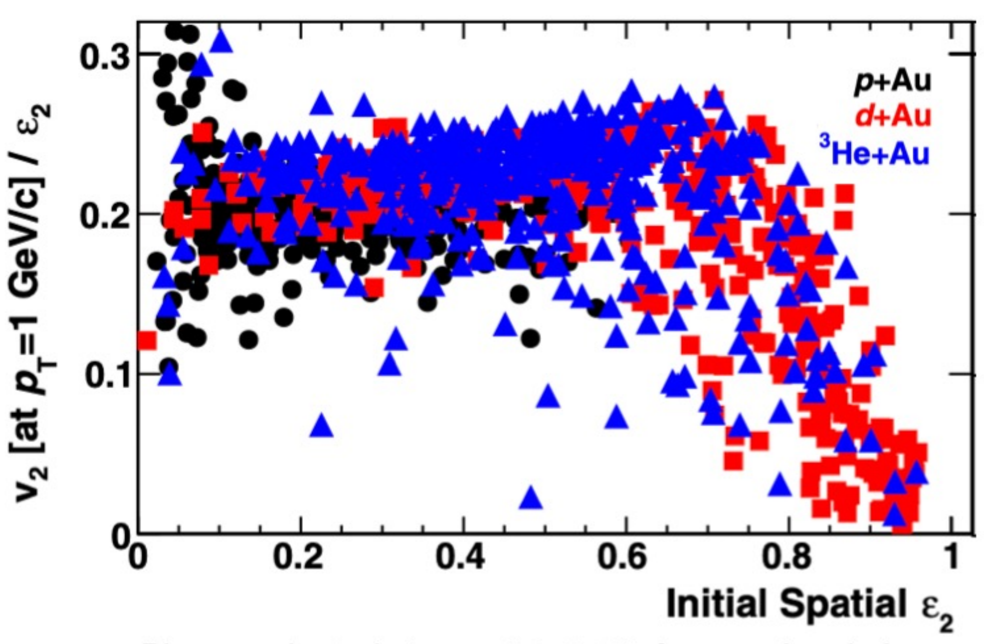
Measurements of $v_2(p_T)$ in the p+Au, d+Au and ^{3}He+Au collisions and average system eccentricities from the MC Glauber model

In recent years, **momentum anisotropies** have been measured **in small systems**. Larger v_2 *in d+Au and ^{3}He+Au* is similar to the ε_2 tendency of the MC Glauber.

$\langle\varepsilon_{2,3}\rangle$	Collision system	Nucl. w/ NBD Fluc.	Quarks w/ NBD Fluc.	IP-G w/ Nucl.	IP-G w/ Quarks
$\langle\varepsilon_2\rangle$	p+Au	0.32	0.38	0.10	0.50
	d+Au	0.48	0.51	0.58	0.73
	^{3}He+Au	0.50	0.52	0.55	0.64

However, the **eccentricities vary depending the initial condition** of models & options.

Correlation of v_2 & ε_2: [3]



Pions evaluated at $p_T = 1.0\ GeV/c$ from p+Au, d+Au and ^{3}He+Au central ($b < 2\ fm$) events in hydrodynamics

Basic assumption is that flow and eccentricity have a linear relation.

$$v_n/\varepsilon_n = k$$

In hydrodynamics, in central *p+Au, d+Au,* and *^{3}He+Au* are comparable.

AMPT(A-Multiphase-Transport) describes the flow at small systems well.

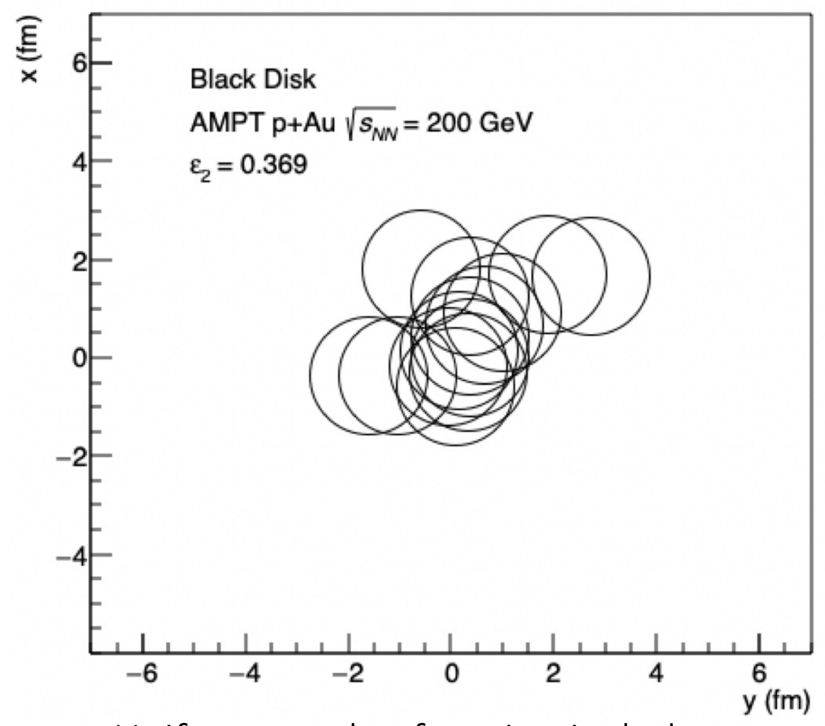
▾

AMPT with the various initial geometry conditions, wide multiplicity range

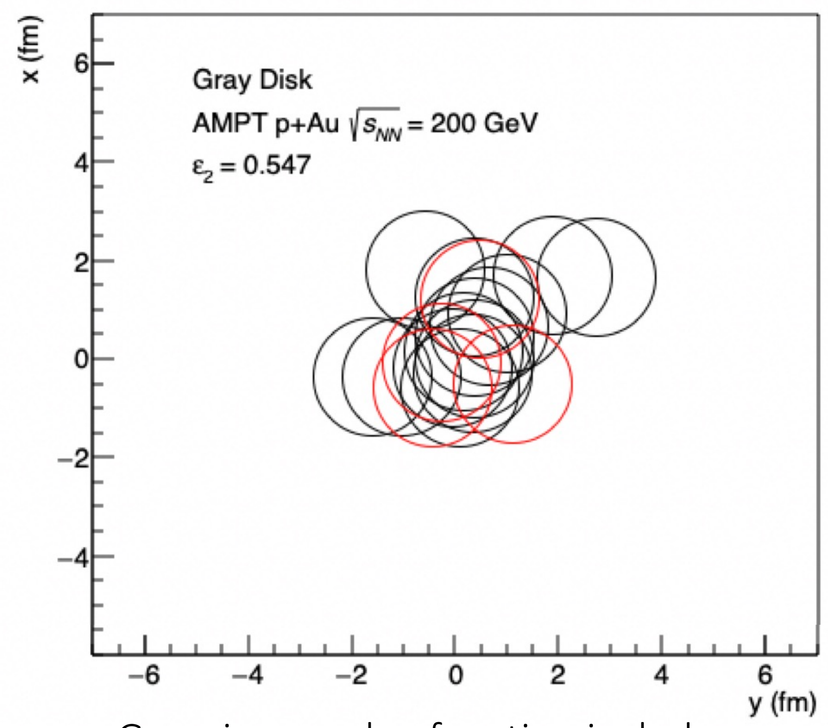
2. ANALYSIS METHOD

Initial geometry of AMPT:

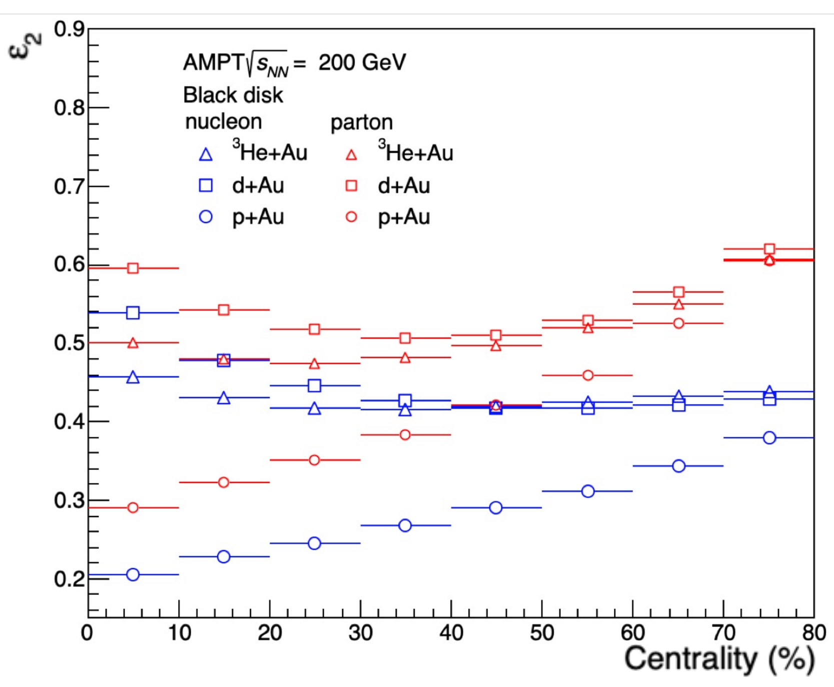
A total of four initial geometry descriptions for each disk & object



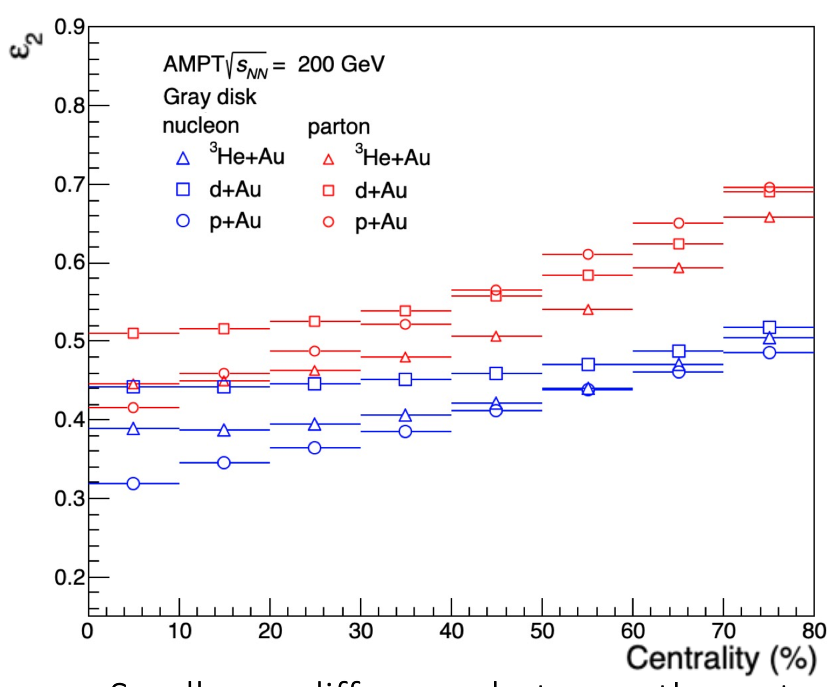
- Uniform overlap function includes inelastic collisions only



- Gaussian overlap function includes inelastic & elastic collisions



- Larger ε_2 difference between the systems



- Smaller ε_2 difference between the systems

- In both Black disk and Gray disk, ε_2 calculated in partons is larger than nucleons

Analysis process:

Collision system: *p+Au* | *d+Au* | *^{3}He+Au*

Black disk (Use only inelastic collisions) X Gray disk (Use elastic and inelastic collisions)

Nucleon (Calculate EP & ε_2 with nucleon) X Parton (Calculate EP & ε_2 with parton)

Centrality 0-70%, 7 bins

v_2/ε_2 vs centrality → Y axis

multiplicity density vs centrality → X axis

v_2/ε_2 vs multiplicity density with centrality bin

- *p+Au, d+Au,* and *^{3}He+Au* simulated at $\sqrt{s_{NN}} = 200\ GeV$
- Calculate with nucleon option: 0.4 fm 2D gaussian smearing
- Centrality is defined as all charged π, K, p, $|\eta| < 1.0$

$k(= v_2/\varepsilon_2)$ is a coefficient that represents the relation between initial geometry and flow

Therefore, it is assumed that k is related to medium property, especially the density

- Multiplicity density:

$$\langle dN_{ch}/d\eta\rangle/\langle s_T\rangle\ (fm^{-2})$$

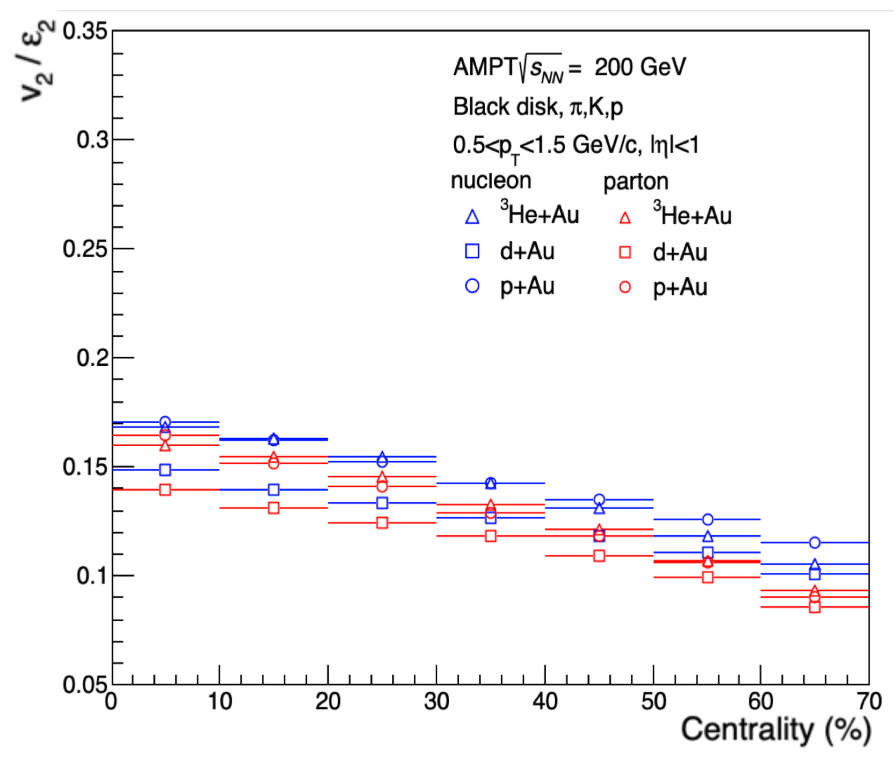
$$\langle s_T\rangle = \sqrt{(\langle x^2\rangle\langle y^2\rangle - \langle xy\rangle^2}$$

▾

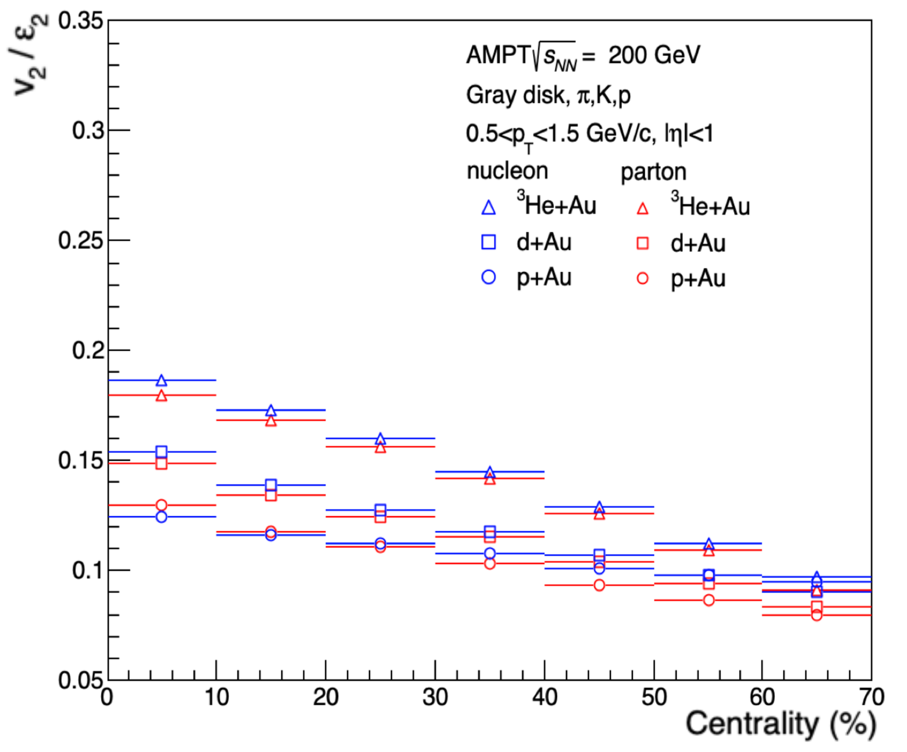
Investigate the k change according to the density with different initial geometry description

3. RESULT

v_2/ε_2 vs centrality:

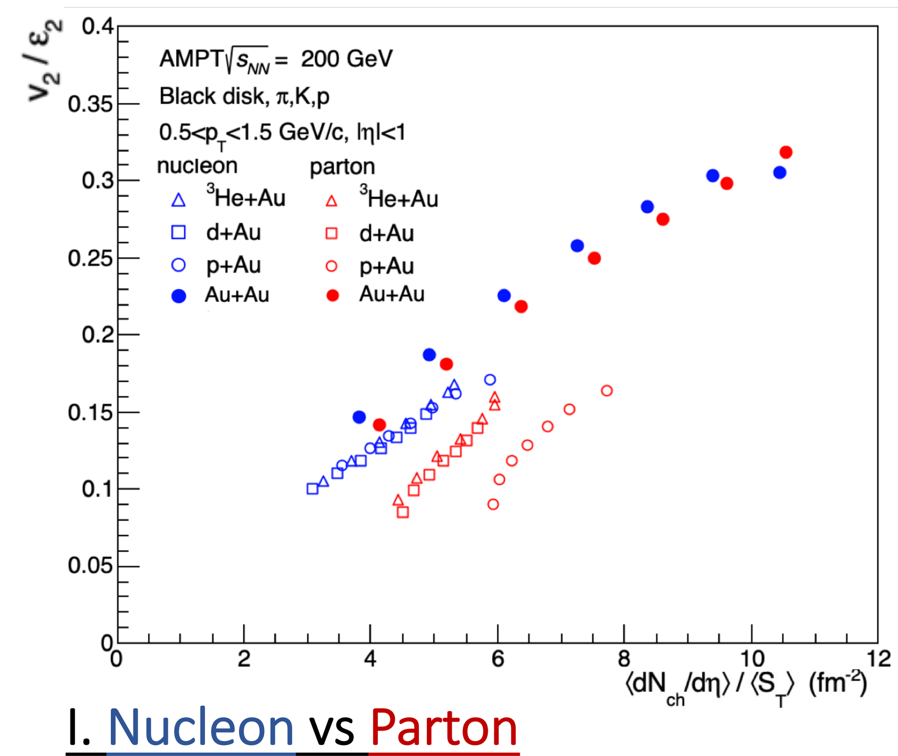


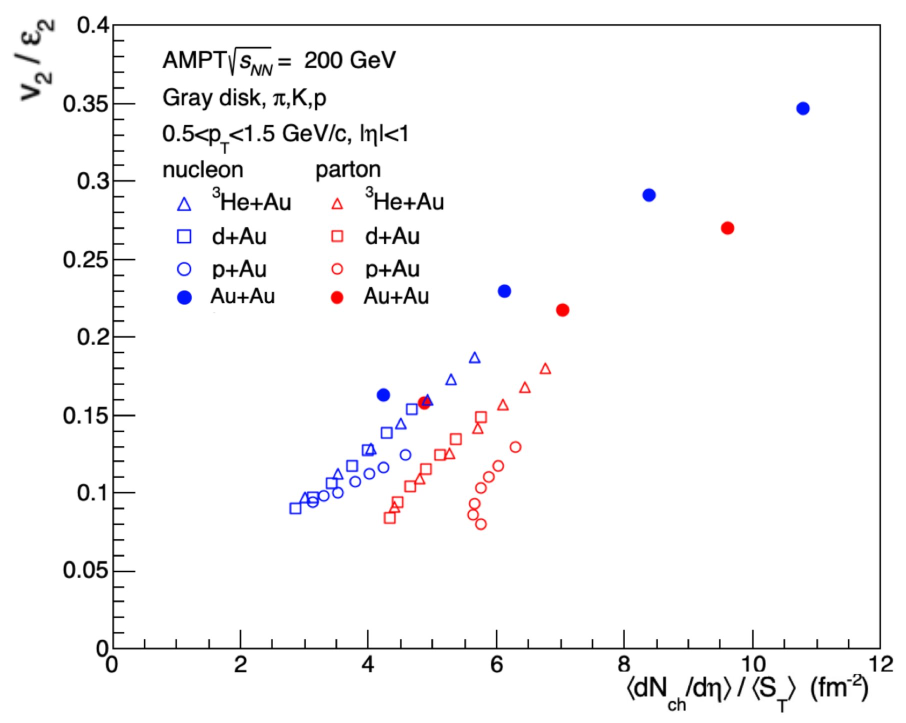
- Systems and options have similar k



- k values are separated according to the system

v_2/ε_2 vs multiplicity density:





I. Nucleon vs Parton

- The values calculated by partons are discontinuous for each system
- Calculated with nucleons in a small system have similar values

→ Compared to parton, nucleon is more similar in trend to heavy ion

II. Black disk vs Gray disk with nucleon

- In gray disk, *p+Au* completely deviates from the trend of other small systems than black disk
- ε_2 and S_T of *p+Au* varies largely from other small systems depending on the disk option
- Since *p+Au* is smaller than other systems, it is sensitive to details to describe initial geometry

→ Need a study on the effect of Gaussian width of gray disk or shape fluctuation

4. OUTLOOK & PLAN

- Calculate $k(= v_2/\varepsilon_2)$ as a function of centrality and multiplicity density, and study the relation between particle flow and initial geometry at *p+Au, d+Au,* and *^{3}He+Au* in the AMPT
- Investigate which description is explain small collision system well:
  - Black disk & Gray disk / (smeared) nucleon & parton
- Compared to partons, nucleons have continuous distribution at k vs multiplicity density
- Depending on the disk option, *p+Au* shows a particularly large difference, since size of system is small and sensitive to the detail of the geometry description
- We don't know how much gray disk affects to the particle flow, so further study is needed

REFERENCES :
[1] PHENIX Collaboration. *Nat. Phys.* 15, 214–220 (2019)
[2] PHENIX Collaboration. Phys. Rev. C 105, 024901 (2022)
[3] J. L. Nagle et al. Phys. Rev. Lett. 113, 112301 (2014)