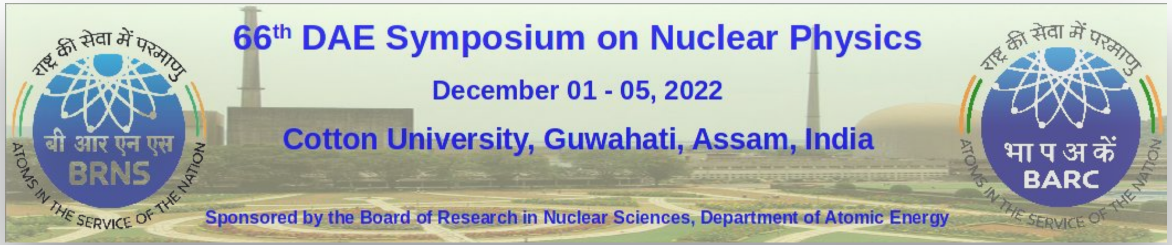
Elliptic flow of light nuclei in Au+Au collisions at STAR

Rishabh Sharma (for the STAR Collaboration)
Indian Institute of Science Education and Research (IISER) Tirupati, India



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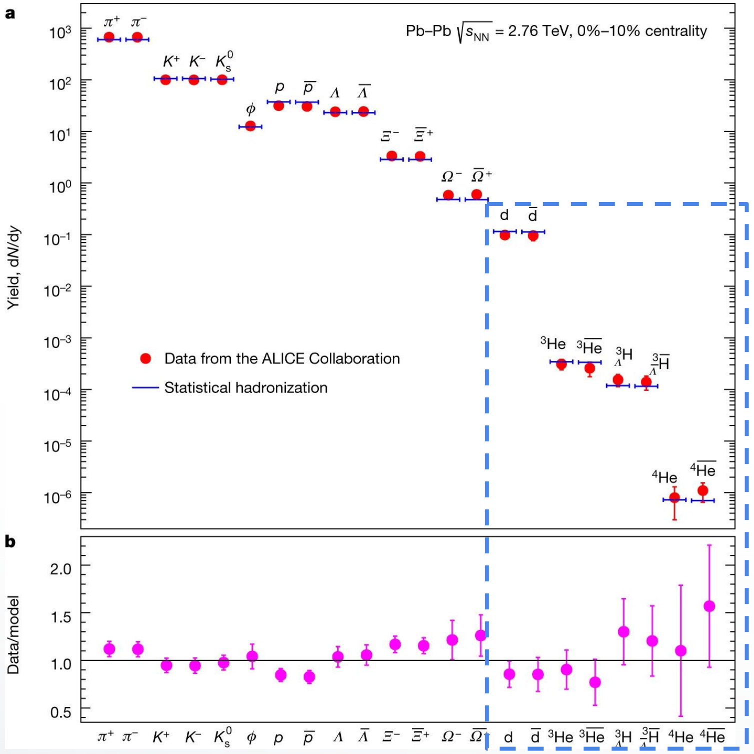
The STAR Collaboration:
https://drupal.star.bnl.gov/STAR/presentations

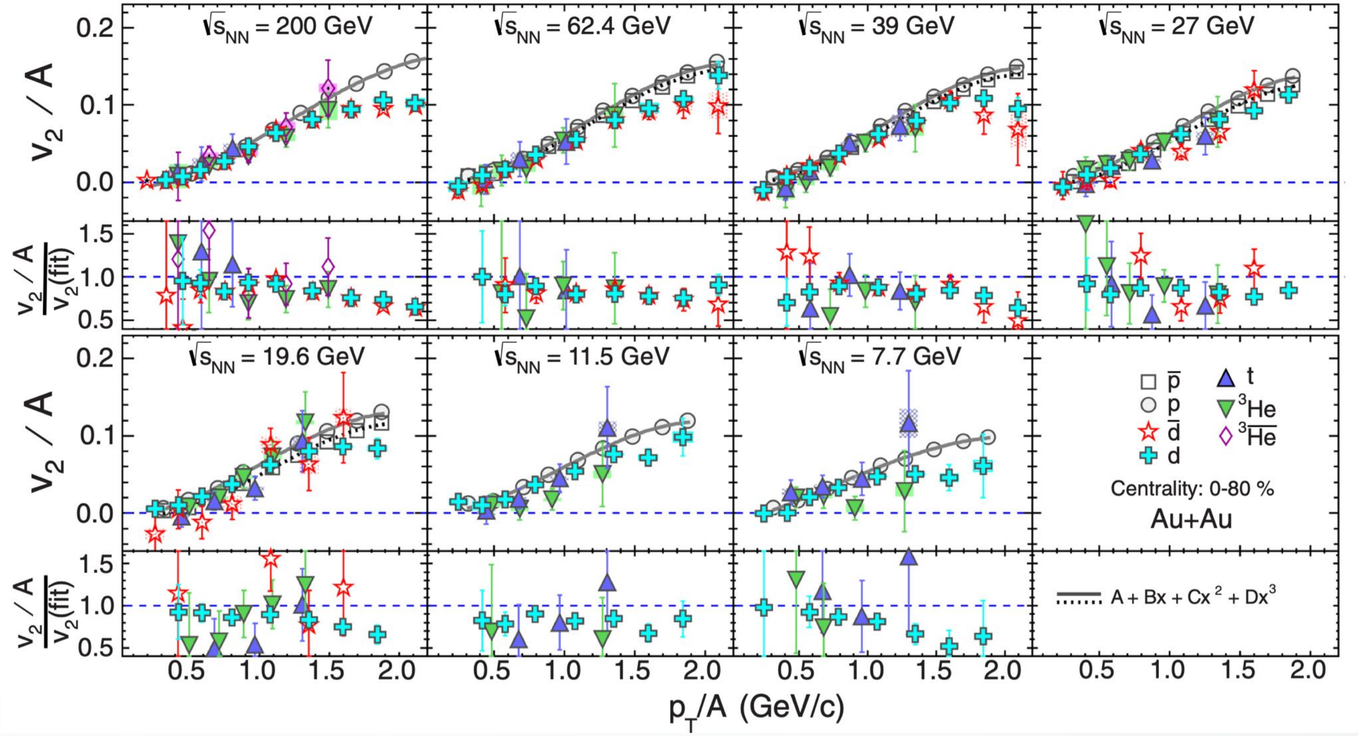
Overview

- ★ Motivation
- ★ The STAR experiment
  - ○ Analysis details
- ★ Results
  - ○ p_T and centrality dependence of elliptic flow of d, t, and ^{3}He
  - ○ Mass number scaling of elliptic flow
- ★ Summary

Motivation



A. Andronic *et al.*, Nature 561 321–330 (2018)



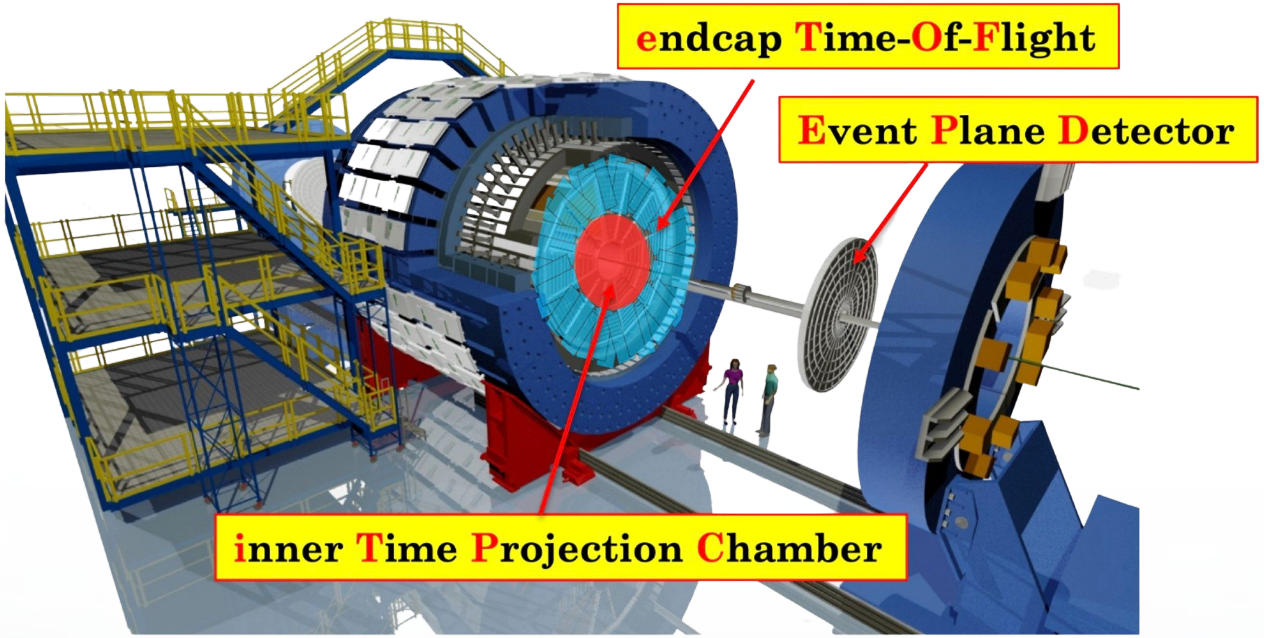
STAR, PRC 94, 034908 (2016)

★ Light nuclei production in heavy-ion collisions can be explained either by the **thermal model** or the **final-state coalescence** of nucleons

★ Approximate mass number scaling of light nuclei v_2 was observed upto $p_T/A < 1.5$ GeV/c in BES-I data

★ Higher statistics dataset in BES-II program will allow us to revisit and better understand the production mechanism of light nuclei

The STAR Experiment

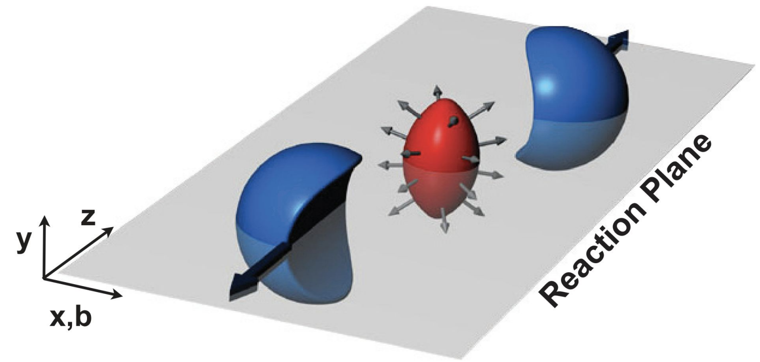


C. Yang *et al*., JINST 15 C07040 (2020)

- ★ **Solenoidal Tracker at RHIC (STAR)** is one of the detector systems at RHIC consisting of several sub-detectors
- ★ dE/dx information from **Time Projection Chamber (TPC)** and m^2 information from **Time of Flight (TOF)** are used for particle identification
- ★ Upgrade to **iTPC**
  - ○ Large acceptance ($|\eta| < 1.5$)
  - ○ Better track resolution
- ★ Datasets:
  - ○ BES II: Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6, 19.6, 27, and 54.4 GeV

- The particle azimuthal distribution can be written as:

$$E\frac{d^3N}{d^3p} = \frac{1}{2\pi}\frac{d^2N}{p_T dp_T dy}\{1 + \sum_{n=1}^{\infty} 2v_n \cos(n(\phi - \Psi_R))\} \qquad v_n = \langle \cos(n(\phi - \Psi_R)) \rangle$$



R. Snellings, New J.Phys.13:055008 (2011)

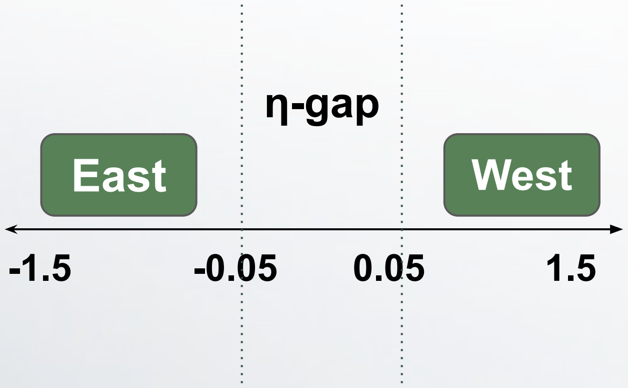
- n^{th} harmonic plane is calculated using the Q-vector:

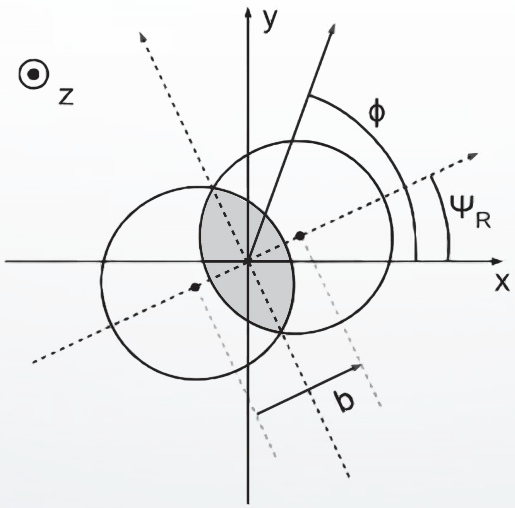
$$Q_x = Q_n \cos(n\Psi_n) = \sum_i w_i \cos(n\phi_i)$$

$$\Psi_n = \frac{1}{n}\tan^{-1}\frac{Q_y}{Q_x}$$

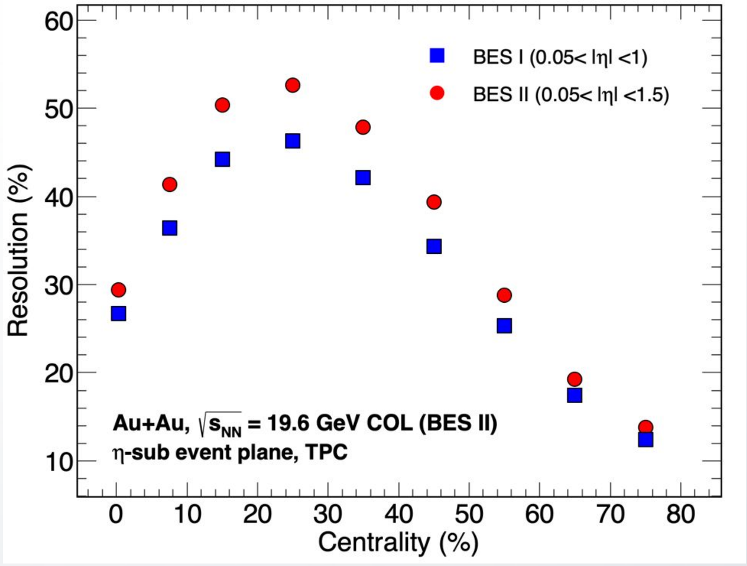
$$Q_y = Q_n \sin(n\Psi_n) = \sum_i w_i \sin(n\phi_i)$$

- η-sub event plane method is used





CMS, PRC 87 014902 2013)



Improvement of resolution by ~10% from BES I owing to higher TPC acceptance and track resolution

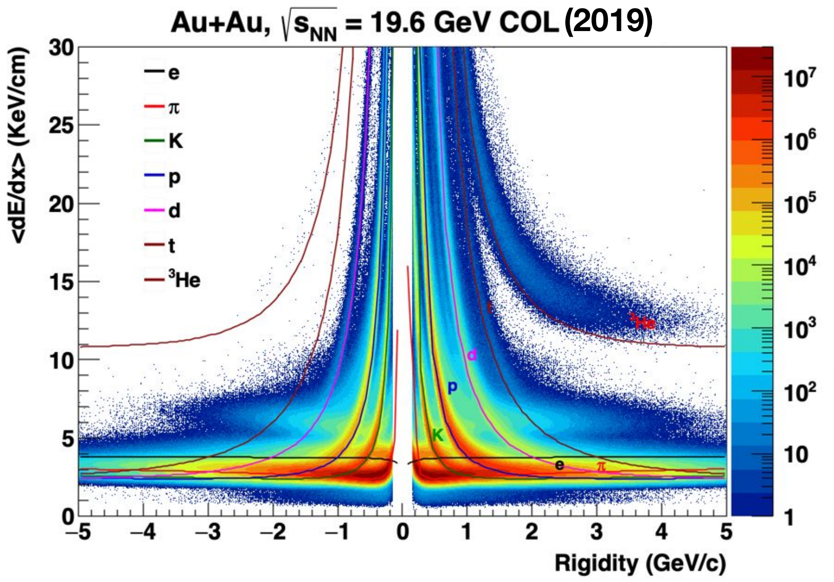
Particle Identification

★ Particles are identified using dE/dx information from TPC in the range $|\eta| \leq 1.0$

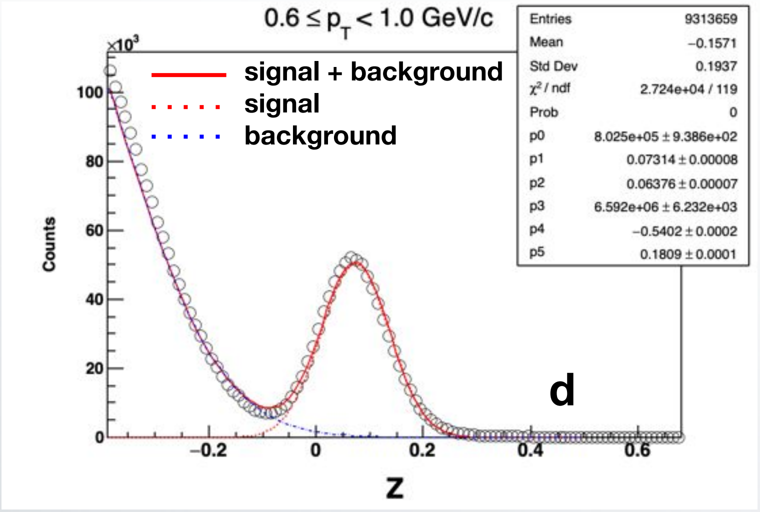
$$z = \ln\left(\frac{\langle dE/dx \rangle_{\text{measured}}}{\langle dE/dx \rangle_{\text{theory}}}\right)$$

★ $\langle dE/dx \rangle_{\text{theory}}$ is calculated using Bichsel function

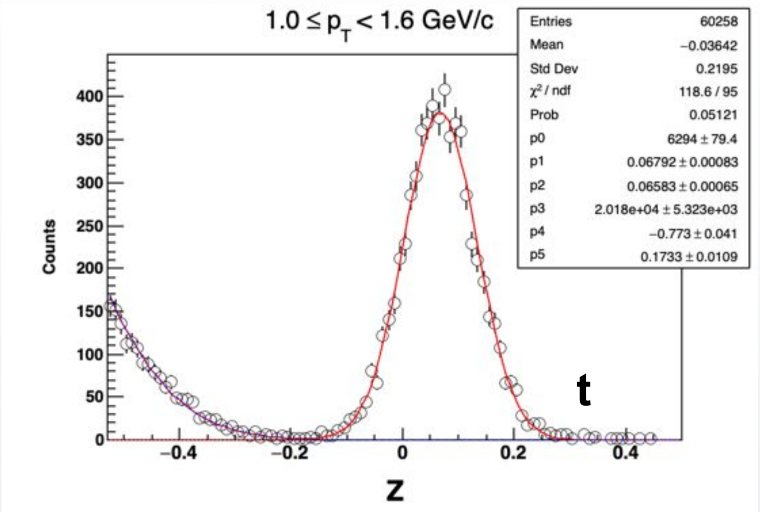
★ Double Gaussian fit is done to calculate yield in each p_T and $\phi - \Psi_2$ bin



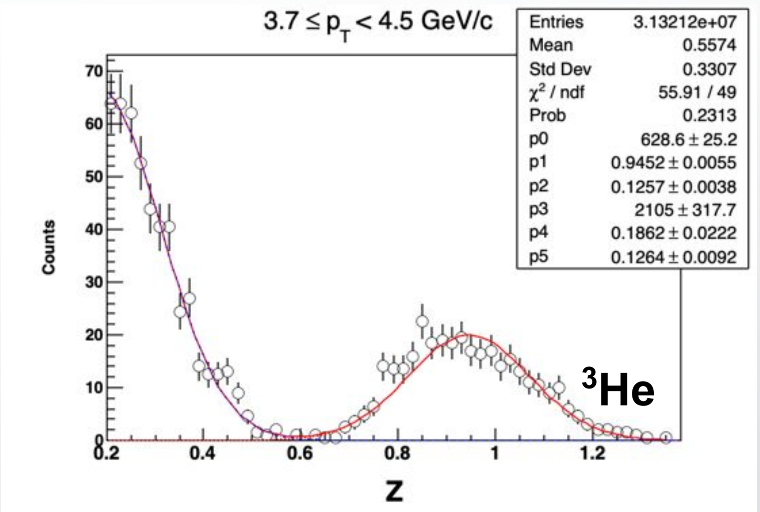
Au+Au $\sqrt{s_{NN}}$ = 19.6 GeV COL (2019), d



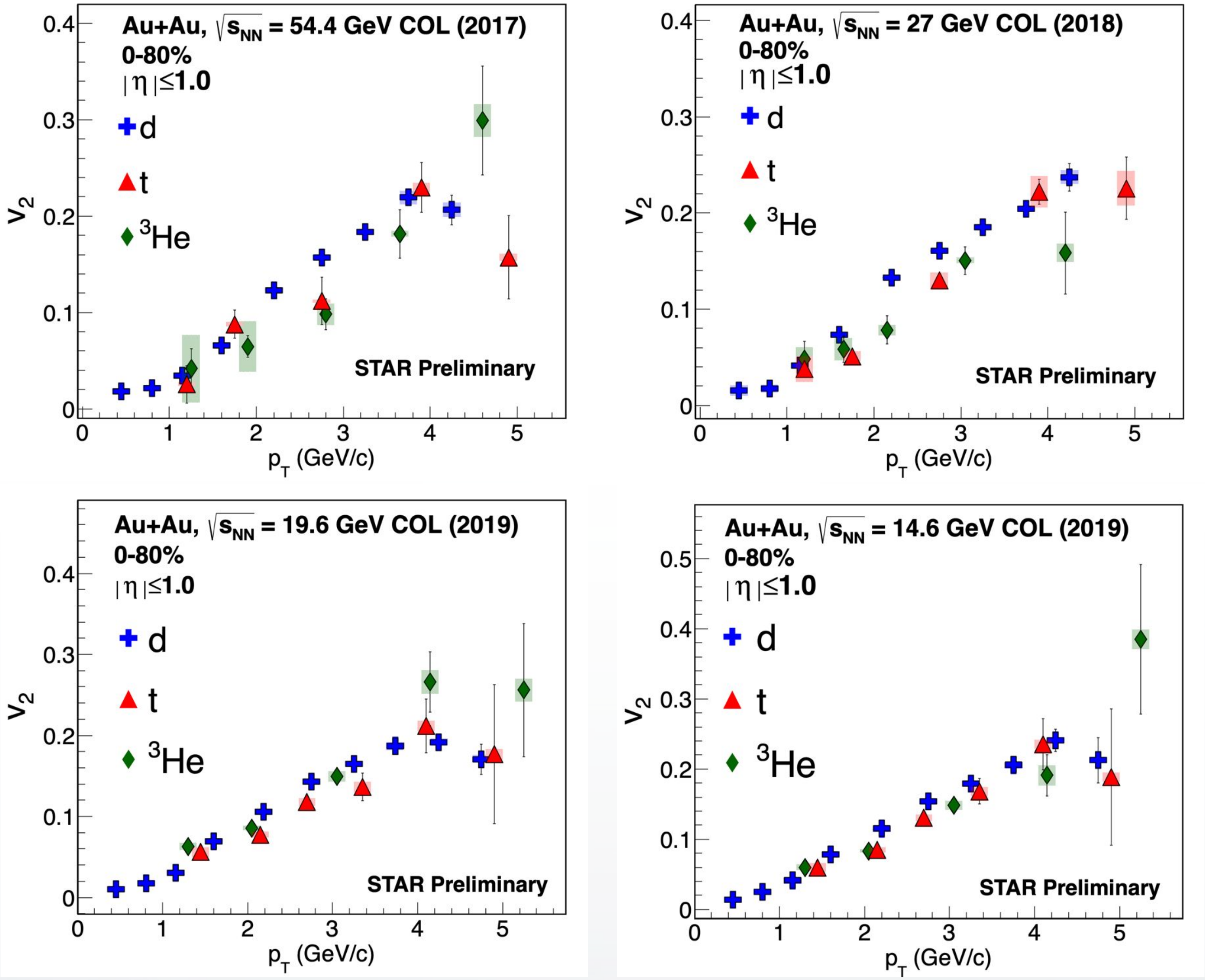
Au+Au $\sqrt{s_{NN}}$ = 19.6 GeV COL (2019), t



Au+Au $\sqrt{s_{NN}}$ = 19.6 GeV COL (2019), ^{3}He

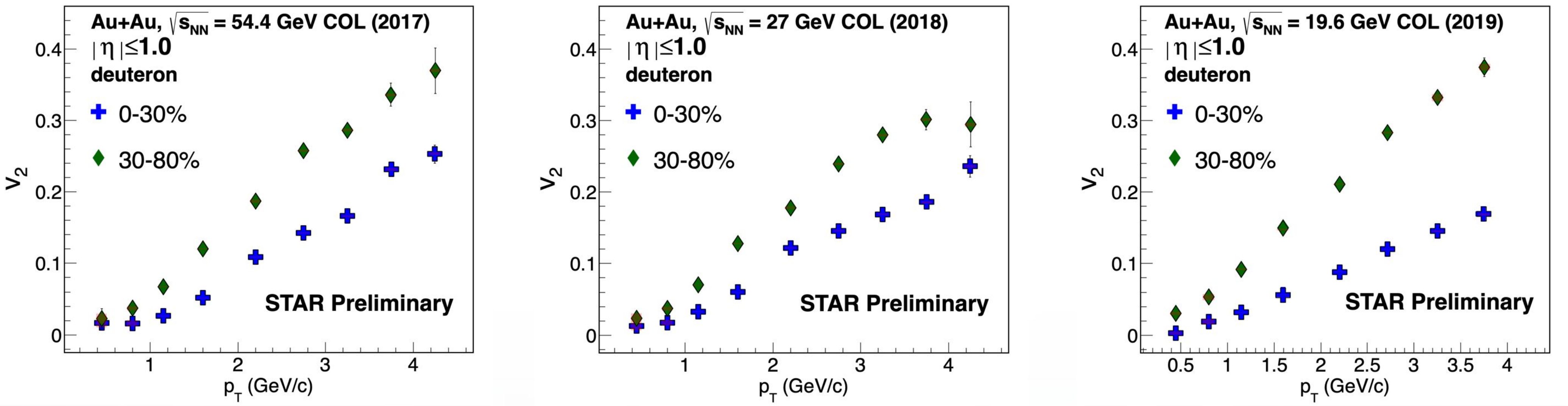


Elliptic flow of light nuclei



★ The $v_2(p_T)$ for all nuclei species increases with increasing p_T for all collision energies

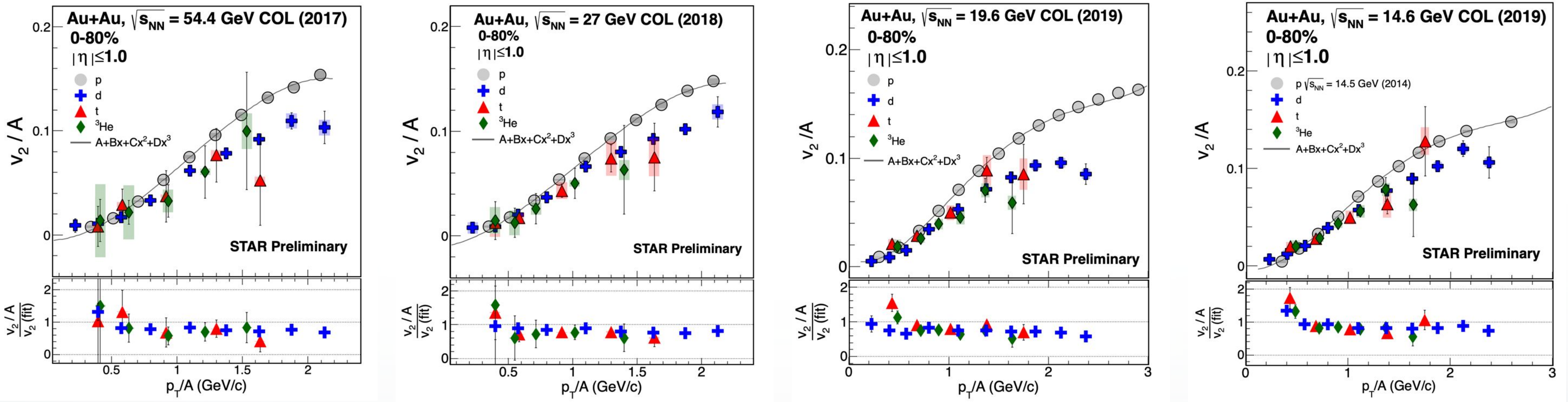
Centrality dependence



★ v_2 of deuterons shows a strong centrality dependence

- Peripheral collisions have relatively larger v_2 due to their larger initial spatial anisotropy

Mass number scaling



*lines correspond to 3rd order fit to the proton v_2 data

★ v_2 of light nuclei obeys the mass number scaling within 20-30%

Summary

★ v_2 of d, t, and ^{3}He is measured in Au+Au collisions at $\sqrt{s_{NN}}$= 14.6, 19.6, 27, and 54.4 GeV (Collider)

- Clear centrality dependence is observed for deuterons for all collision energies
- Light nuclei v_2 seems to be obeying mass number scaling within 20-30%

Outlook

★ Stay tuned for more exciting results on light nuclei flow from BES II energies

Thank you