

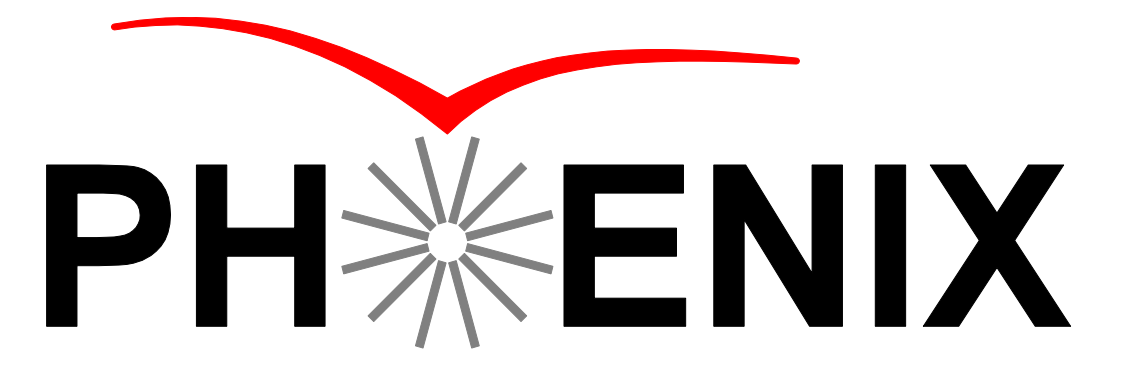


Measurement of multi-particle cumulants in p+Au, d+Au, and ³He+Au collisions with PHENIX



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Motivation

The PHENIX experiment has collected data of p+Au, d+Au, and ³He+Au collisions at 200 GeV, giving a unique set of initial geometries. Shown in Fig. 1 are measurements of elliptic and triangular flow in the three systems [1] that are compared with hydrodynamics calculations [2,3]. These calculations provide a simultaneous quantitative description of the data in all three systems, indicating that the observed collectivity is geometric in origin.

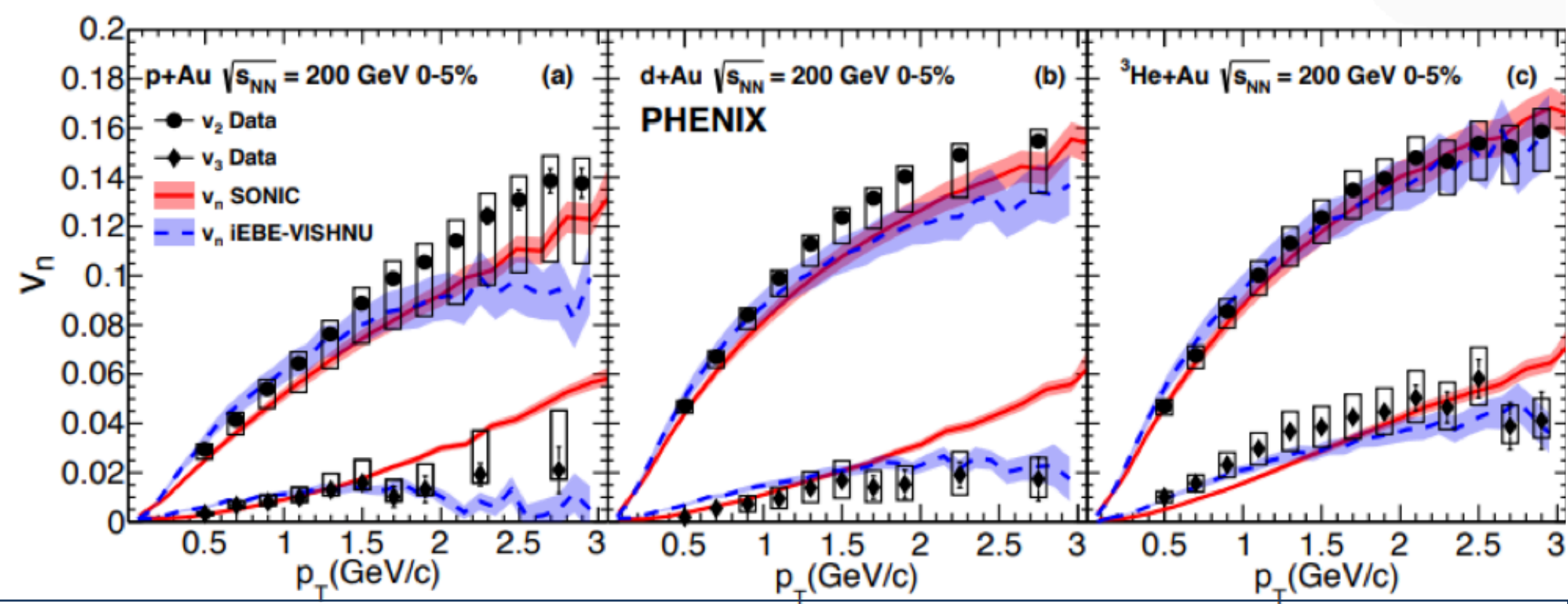


Figure 1 PHENIX measurements of elliptic and triangular flow in p/d/³He+Au collisions [1] compared to hydrodynamic calculations.

Multi-particle correlations, including sub-event cumulants, are studied to investigate the role of possible non-flow correlations and the event-by-event flow fluctuations.

Experimental Details

Data sets: 2,261M p+Au events, and 628M d+Au events
Tracks are reconstructed in the Forward Silicon Vertex Tracker

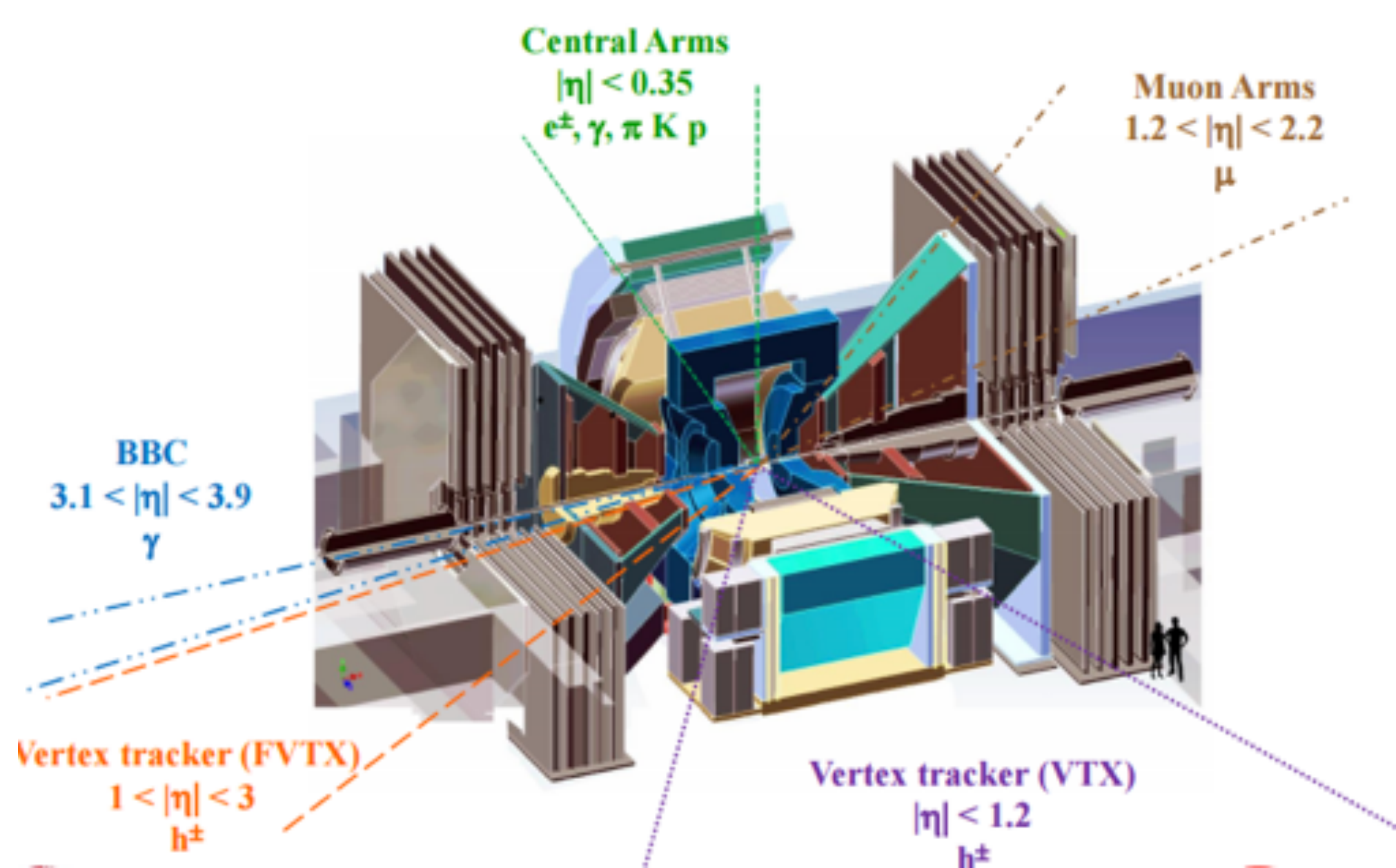
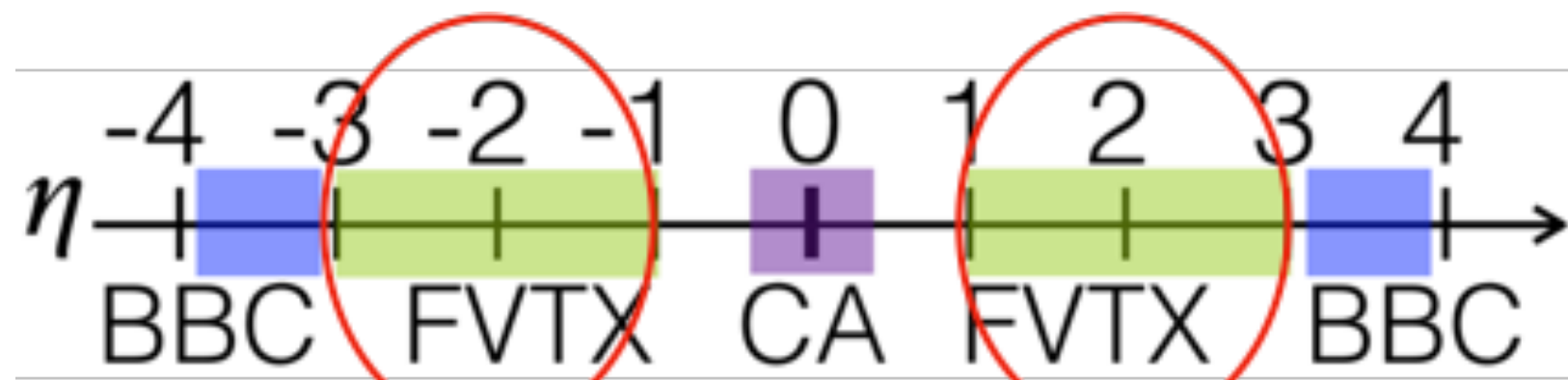


Figure 2 PHENIX Detector configuration for Run15/16

Methods

Multi-particle correlation method



$$\langle\langle 2 \rangle\rangle = \langle\langle e^{in(\phi_1 - \phi_2)} \rangle\rangle$$

$$\langle\langle 4 \rangle\rangle = \langle\langle e^{in(\phi_1 + \phi_2 - \phi_3 - \phi_4)} \rangle\rangle$$

$$c_2\{4\} = \langle\langle 4 \rangle\rangle - 2 * \langle\langle 2 \rangle\rangle^2$$

$$v_2\{4\} = (-c_2\{4\})^{-1/4}$$

1. Multi-particle correlations suppress non-flow effectively
2. Multi-particle correlations also provide information about how flow fluctuates event-by-event

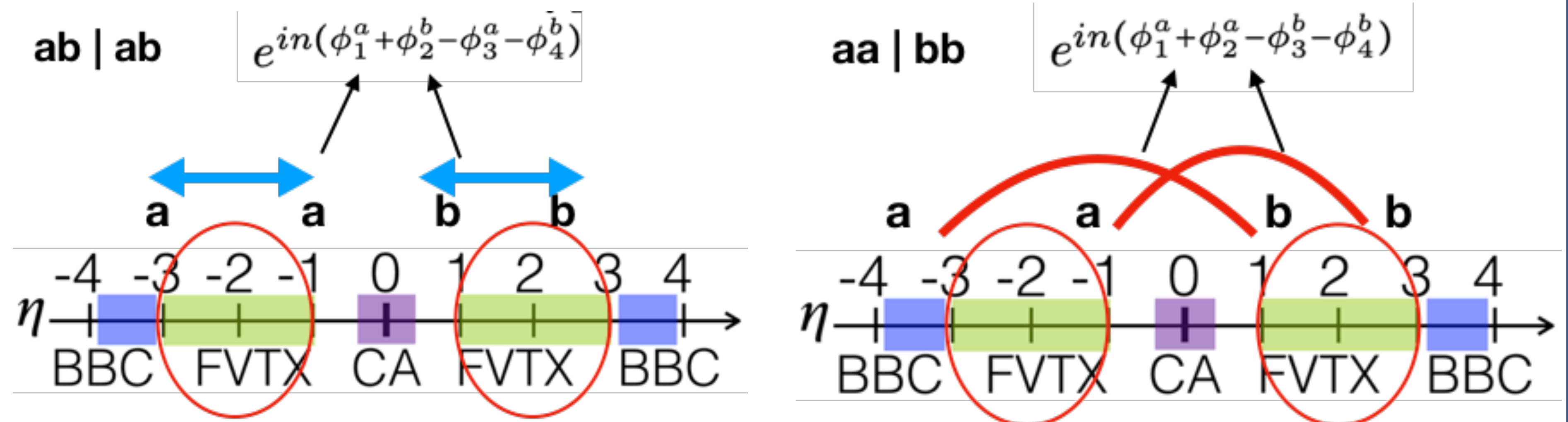
$$v_2\{4\}^2 \approx v_2\{6\}^2 \approx \langle v_2^2 \rangle - \sigma_{v_2}^2$$

$$v_2\{2\}^2 \approx \langle v_2^2 \rangle + \sigma_{v_2}^2 + \delta v_2$$

Methods

Sub-event cumulants method

1. Further suppress non-flow and investigate the role of fluctuations
2. Expected non-flow contributions: $aa|bb < ab|ab < \text{standard method}$



Results

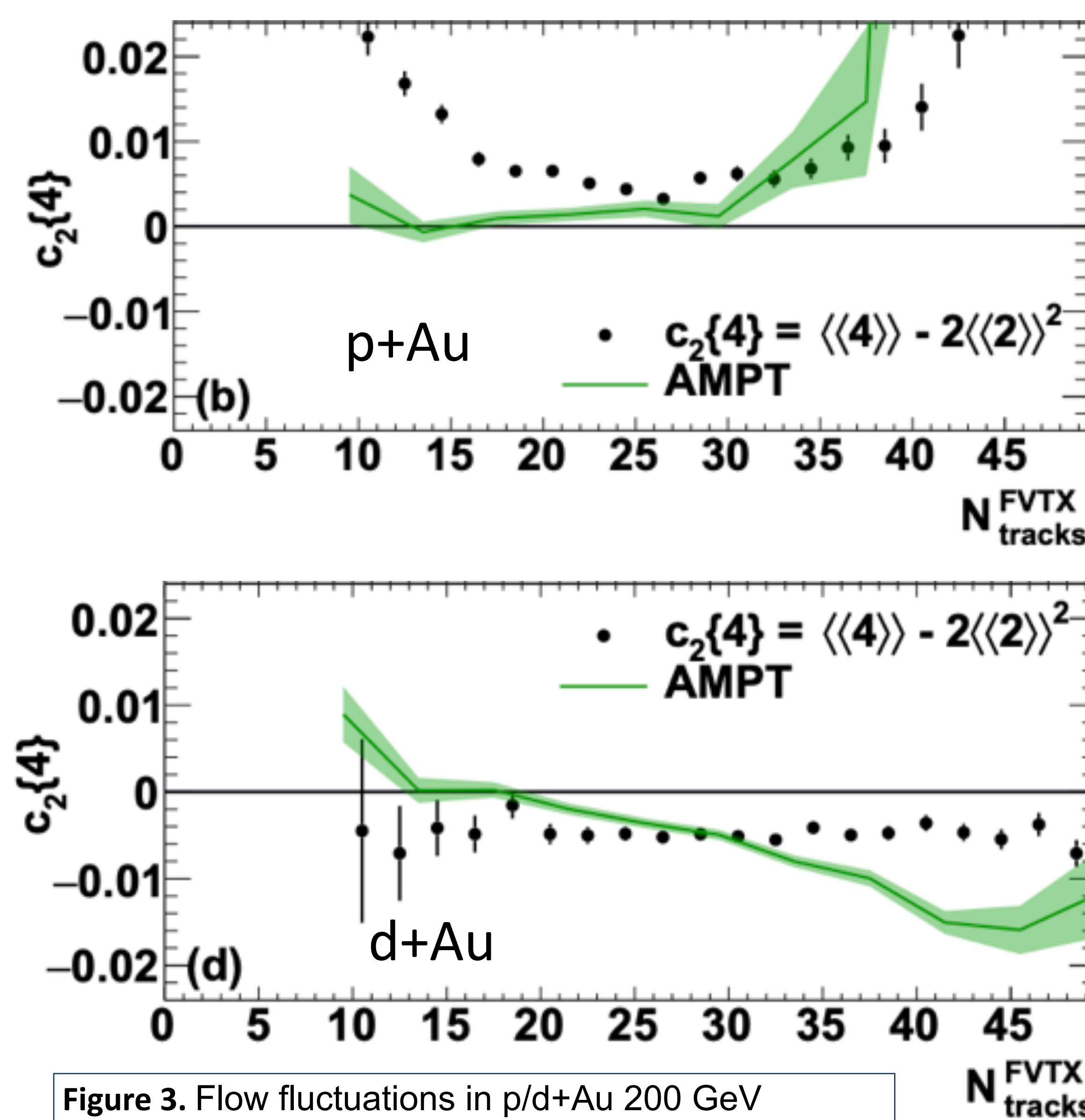


Figure 3. Flow fluctuations in p/d+Au 200 GeV

- Implies $c_2\{4\}$ in p+Au is dominated by fluctuations
- AMPT (A Multi-phase transport model) describes the sign

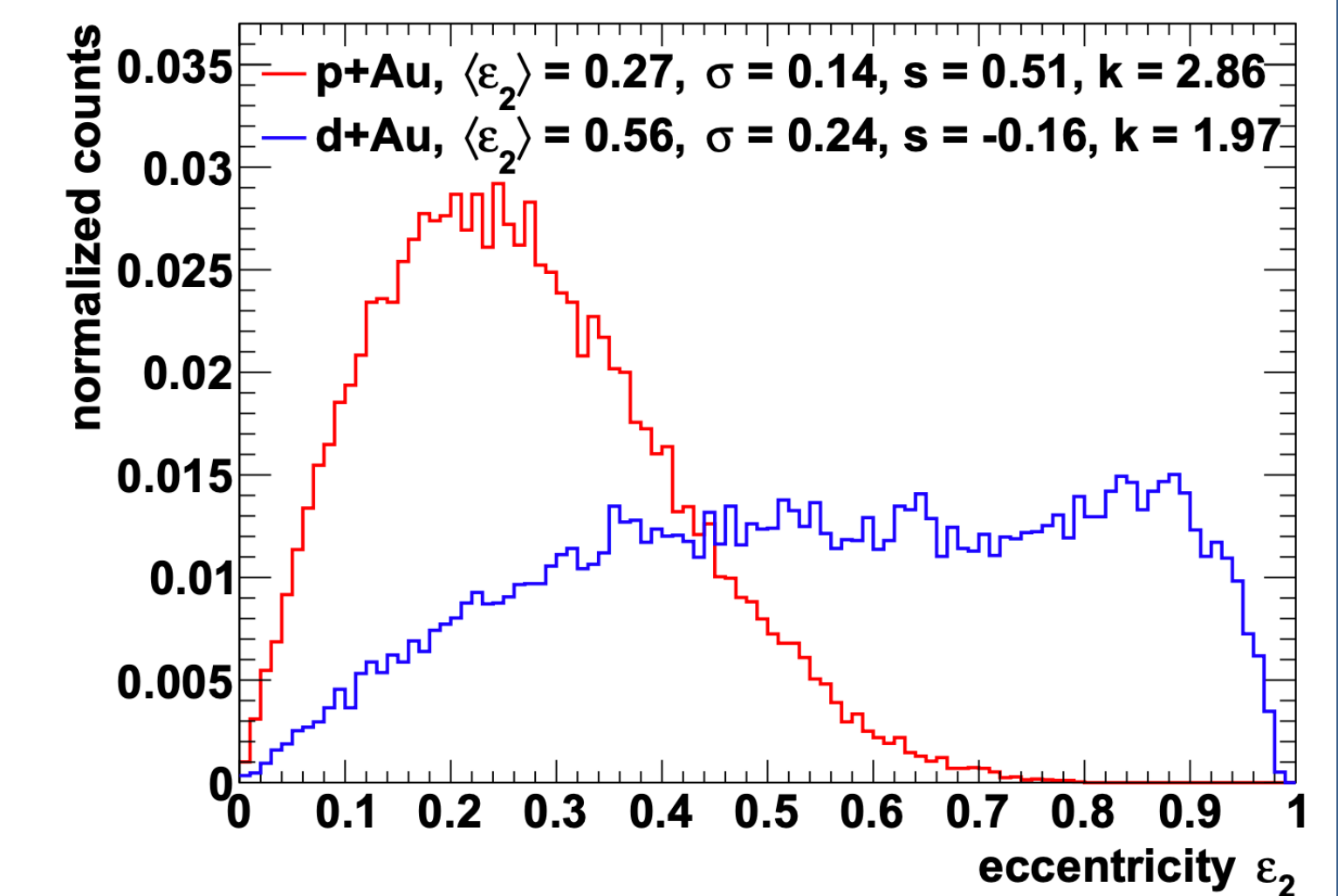


Figure 4. MC Glauber initial eccentricity distribution in p/d+Au collisions

- Initial eccentricity distribution is highly non-Gaussian
- Fluctuations are highly non-trivial in small systems

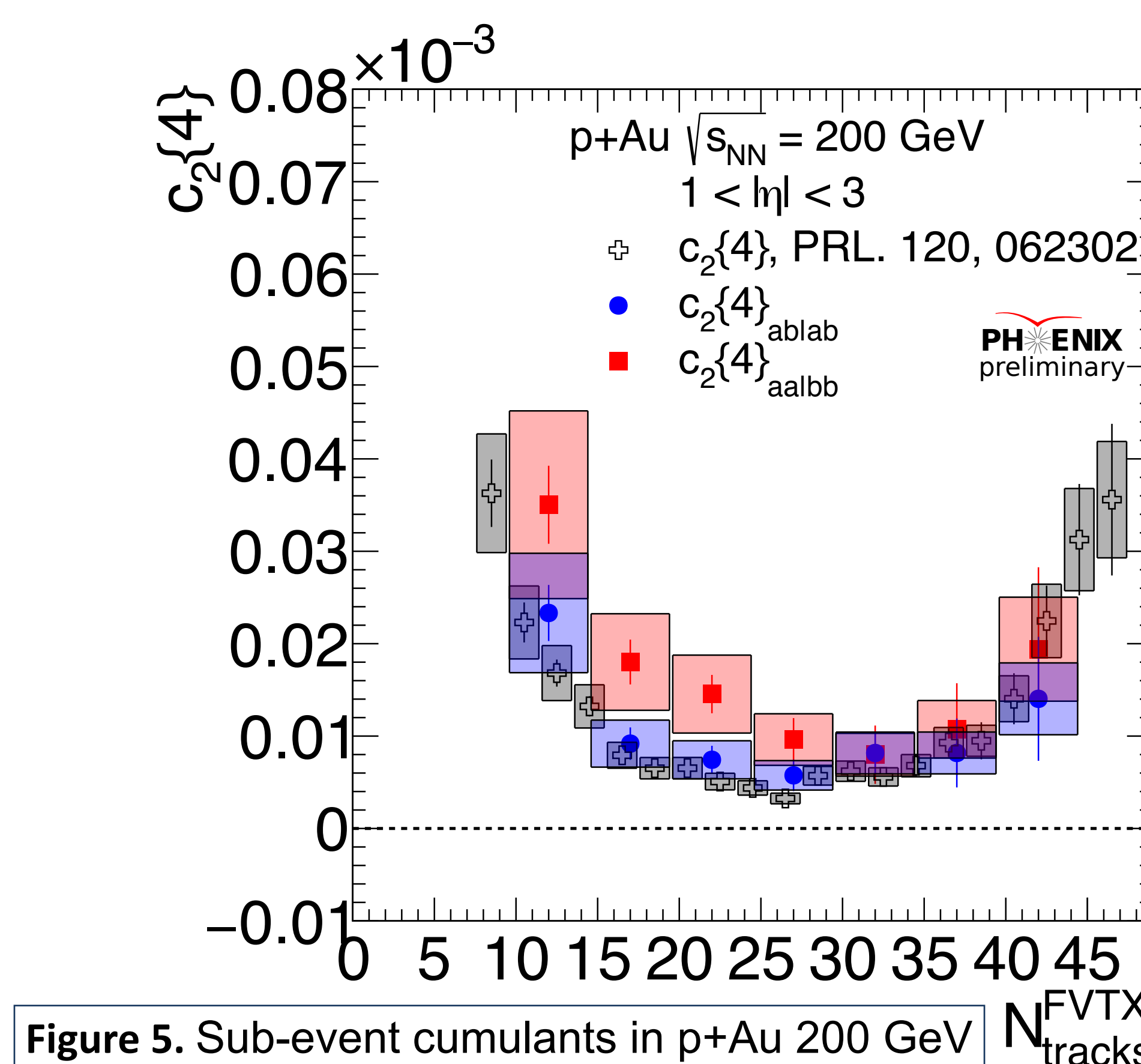


Figure 5. Sub-event cumulants in p+Au 200 GeV

- Two sub-event $c_2\{4\}$ in p+Au is still positive
- Confirms observed positive $c_2\{4\}$ is due to fluctuations rather than nonflow in p+Au

Conclusions

- Initial geometry is the driving force of the final-state correlations
- Small variance limit breaks in p+Au and in d+Au collisions
- Flow fluctuations are significant in $c_2\{4\}$ in p+Au collisions confirmed by sub-event cumulant analysis