Intercomparison of the flow measurements at RHIC experiments

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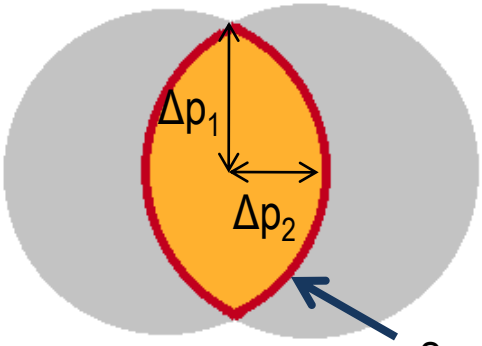
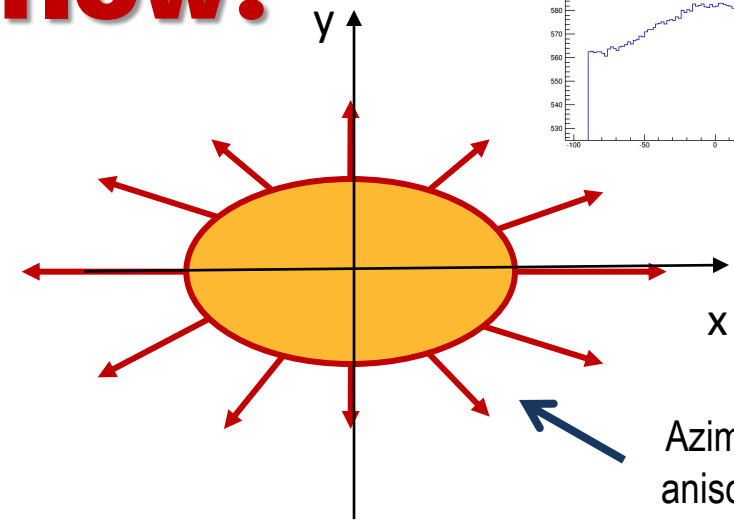
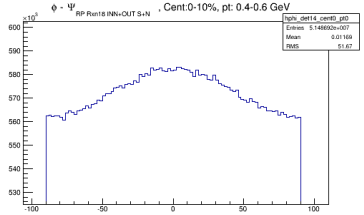
What is the flow?



Space anisotropy

$\Delta p_2 > \Delta p_1$

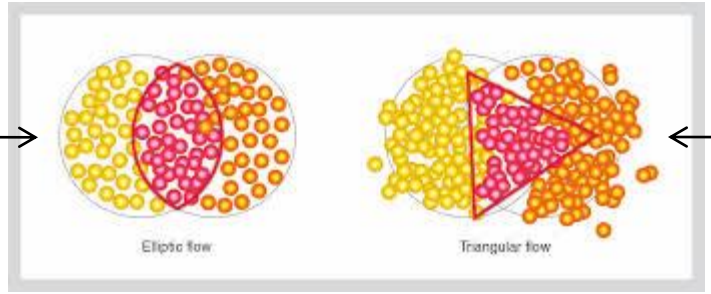




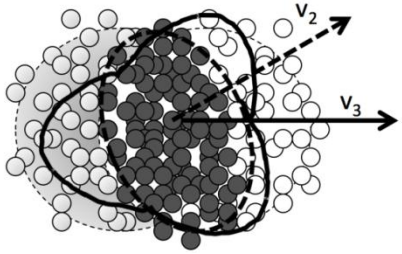
Azimuthal anisotropy

Fourier expansion: $$\frac{dN}{d\phi} \propto 1 + 2\sum_{n=1}^{\infty} v_n \cos(n(\phi - \Psi_n))$$

v_2 →



← v_3



Why do we need flow?

1) The initial state geometry examination

A measure of the deformation with respect to azimuthally symmetric conditions in the transverse plane is given by the ***eccentricity*** ϵ.

Eccentricity ϵ

- From the asymmetry of the nuclear overlap
- From fluctuations

$$\epsilon_n \uparrow \Rightarrow \uparrow v_n$$

2) The transport properties of QGP

The ***viscosity*** of a fluid is a measure of its resistance to deformation by shear stress or tensile stress.

Viscosity

- Bulk viscosity reduces the radial acceleration
- Shear viscosity reduces flow anisotropies

$$\eta/s \uparrow \Rightarrow v_n \downarrow$$

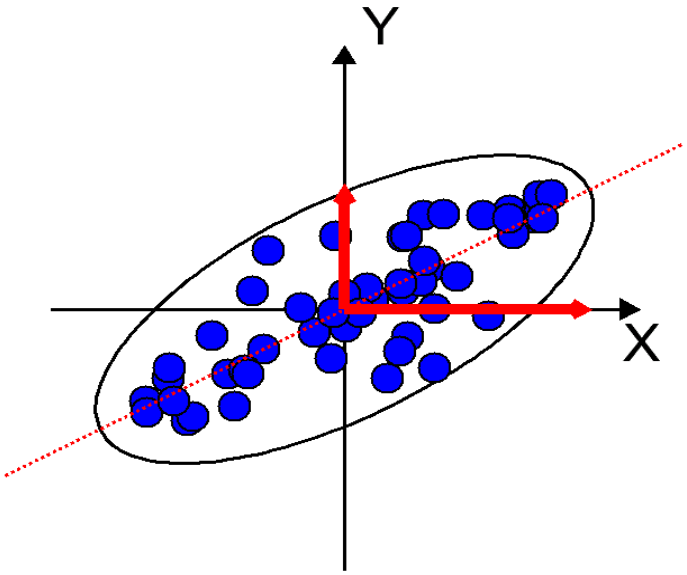
Why comparison is important?

- ✓ Can help with reducing the systematic uncertainty of obtained measurements
- ✓ Qualitative agreement tells about reliability of the data
- ✓ The search of the nature of the differences could cause improvement and more deep understanding of the results

Flow analysis methods

1) Event Plane method

$$v_n\{EP_k\} = \frac{\langle \cos\left(n(\phi - \Psi_k)\right)\rangle}{\sigma_k^n}$$



Brackets denote average over all events and all particles, σ_k^n is "event plane resolution"

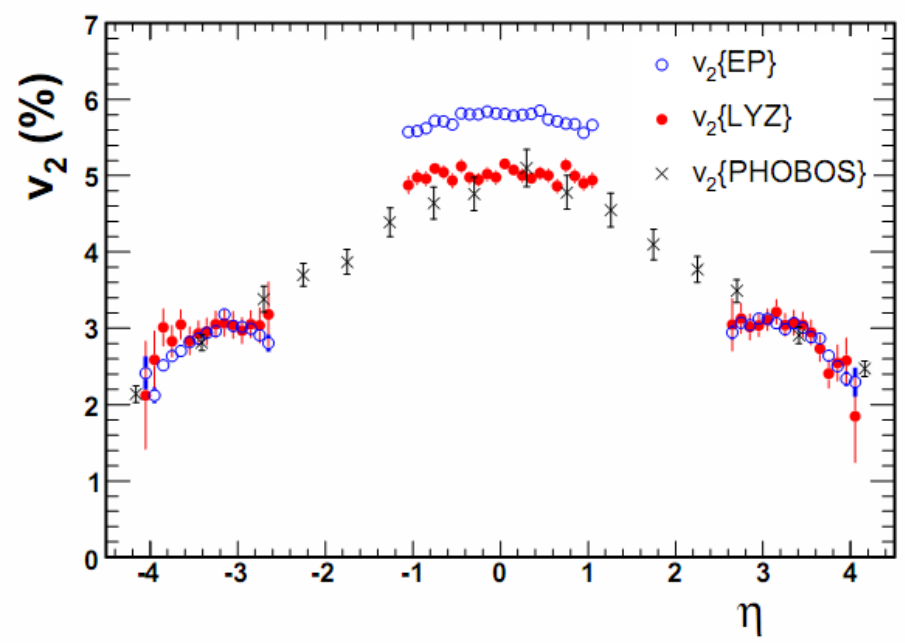
2) Multi-particle methods

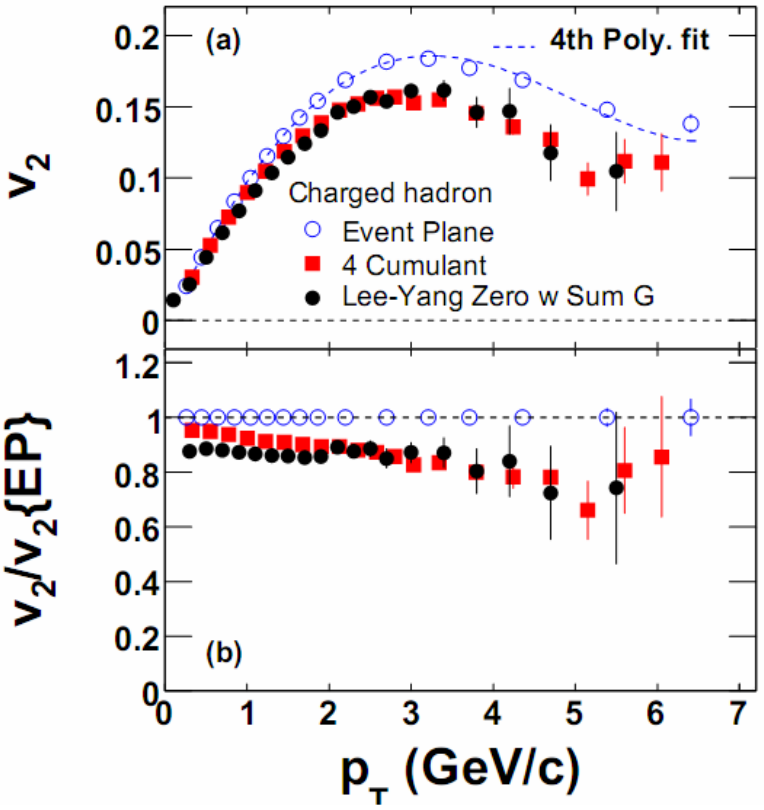
- 4-particle cumulant
- Lee-Yang Zero

Non-Flow:

- resonance decay
- HBT correlations
- jets
- final state interactions

Flow analysis methods

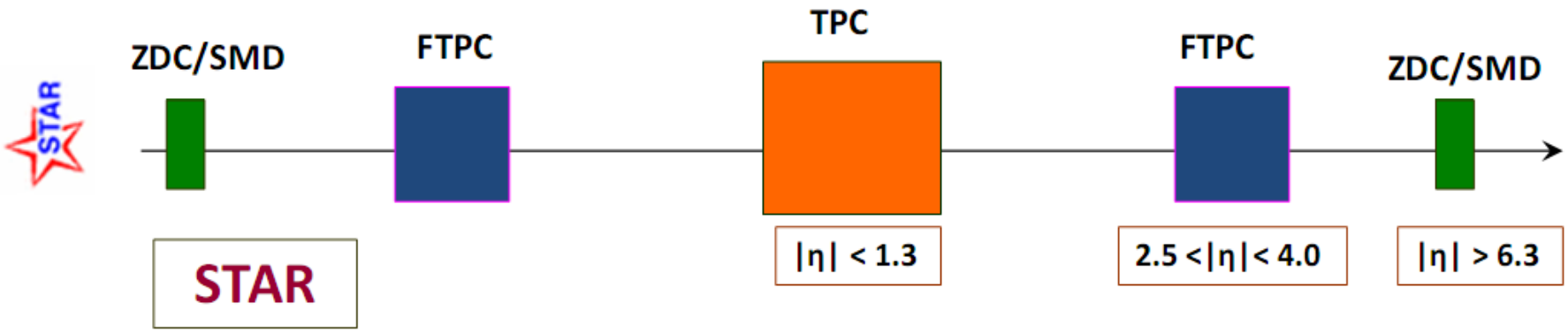


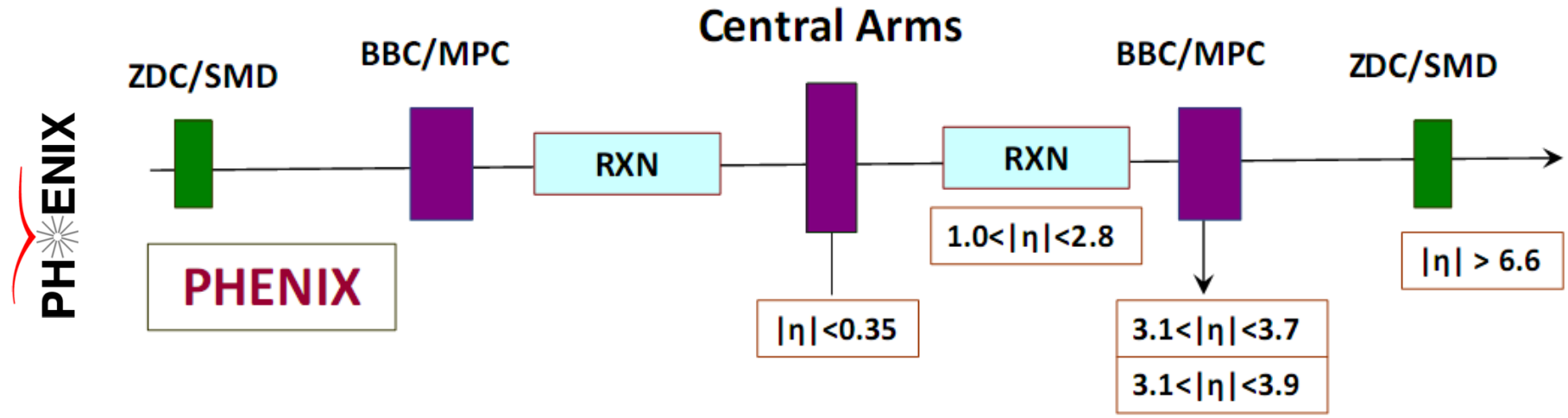


Non-flow effects leads to v_n value increase at high-p_T region in EP method compare to multi-particle methods.

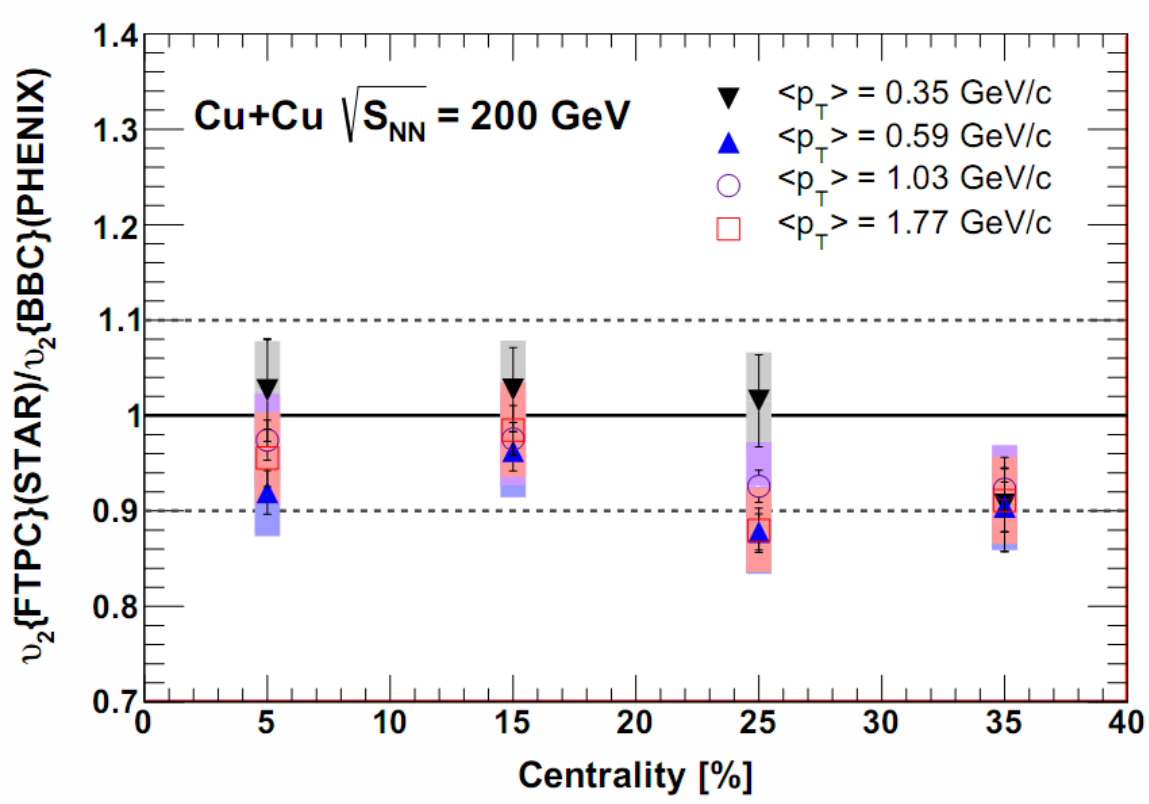
Abelev B I et al. 2008 Phys. Rev. C 77 054901.

PHENIX and STAR detectors





Results. Cu+Cu at 200 GeV



FTPC(STAR) and BBC(PHENIX) the only measurements with similar η-gap!

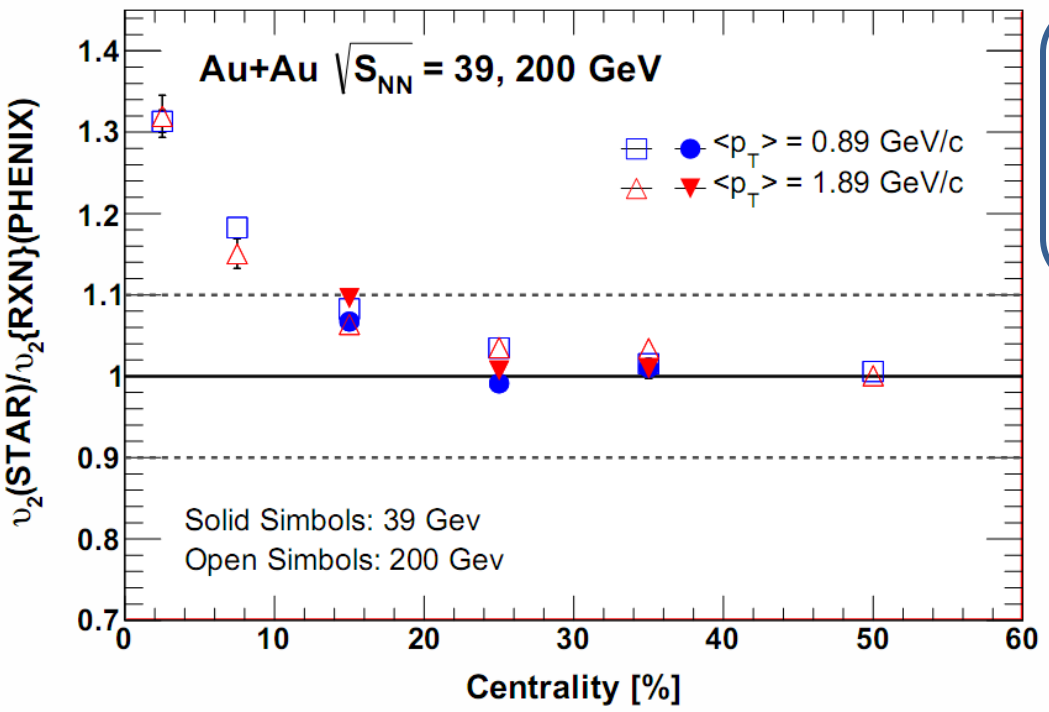
Cu+Cu is a light system → big fluctuations!

The difference between two data sets are less than 5-10%

STAR: Charged and strange hadron elliptic flow in Cu+Cu collisions at 62.4 and 200 GeV, Phys. Rev. C 81 (2010) 44902

PHENIX: Scaling properties of azimuthal anisotropy in Au+Au and Cu+Cu collisions at s(NN) = 200-GeV, Phys.Rev.Lett. 98 (2007) 162301

Results. Au+Au at 200 GeV



Au+Au at 200 GeV is the reference energy/system for beam energy scan and comparison with LHC results!

Two data sets overlap excellently for centralities >20%.

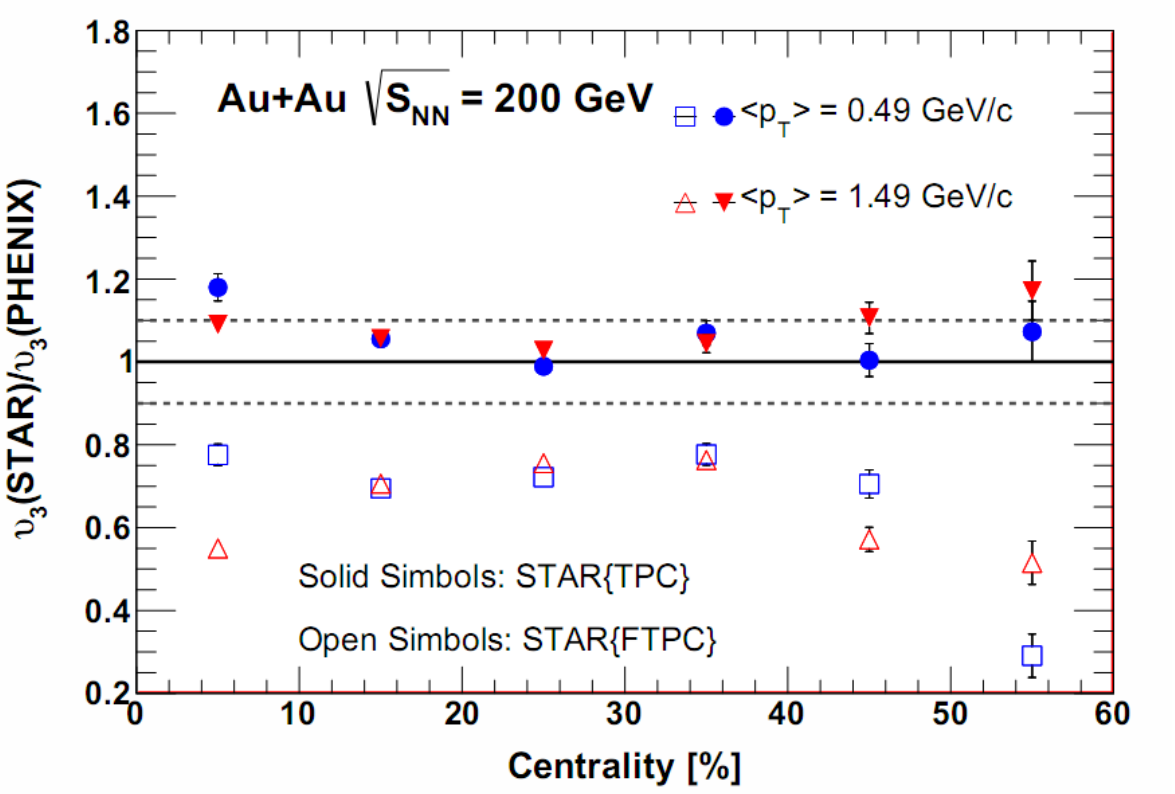
Increasingly diverge at small centralities, with a 30% difference between STAR an PHENIX in the 0-5% centrality bin.

Same behavior pattern for both 39 and 200 GeV energies → difference can't come from non-flow only. Could be explained by a small shift in the centrality definition between the experiments.

PHENIX: QM2011 Preliminary

STAR: Inclusive charged hadron elliptic flow in Au + Au collisions at 7.7 - 39 GeV, Phys. Rev. C 86 (2012) 54908

Results. Triangular flow v_3



A huge difference (40-50%) between STAR TPC and FTPC data.

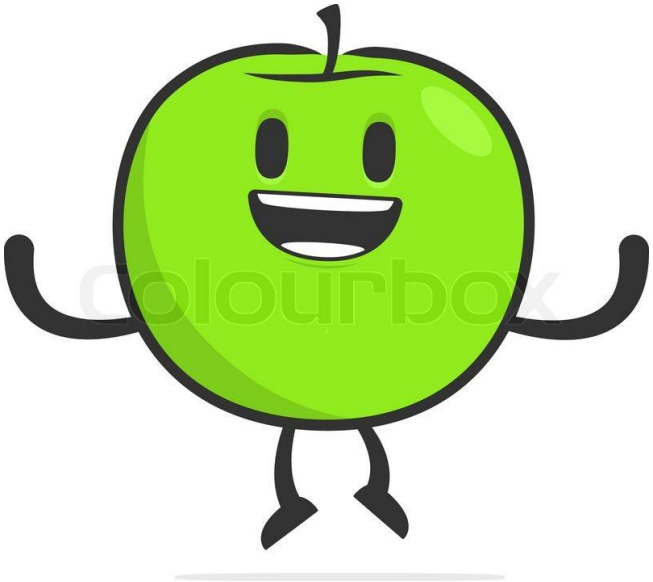
Less than 10% difference between STAR(TPC) to PHENIX(RXN) results on the other hand.

To understand this enormous difference between STAR results more comparisons should be made, e.g. for the elliptic flow between FTPC and TPC EP.

STAR: Third Harmonic Flow of Charged Particles in Au+Au Collisions at 200 GeV, Phys. Rev. C 88 (2013) 14904

Conclusion

- ✓ For every kind of comparison there were the differences between STAR and PHENIX data
- ✓ The nature of the disagreements is not well understood
- ✓ Much more investigations are needed.



Thank you!