Elliptic flow for π^0 mesons in asymmetric Cu+Au collision system at $\sqrt{s_{NN}} = 200\ GeV$

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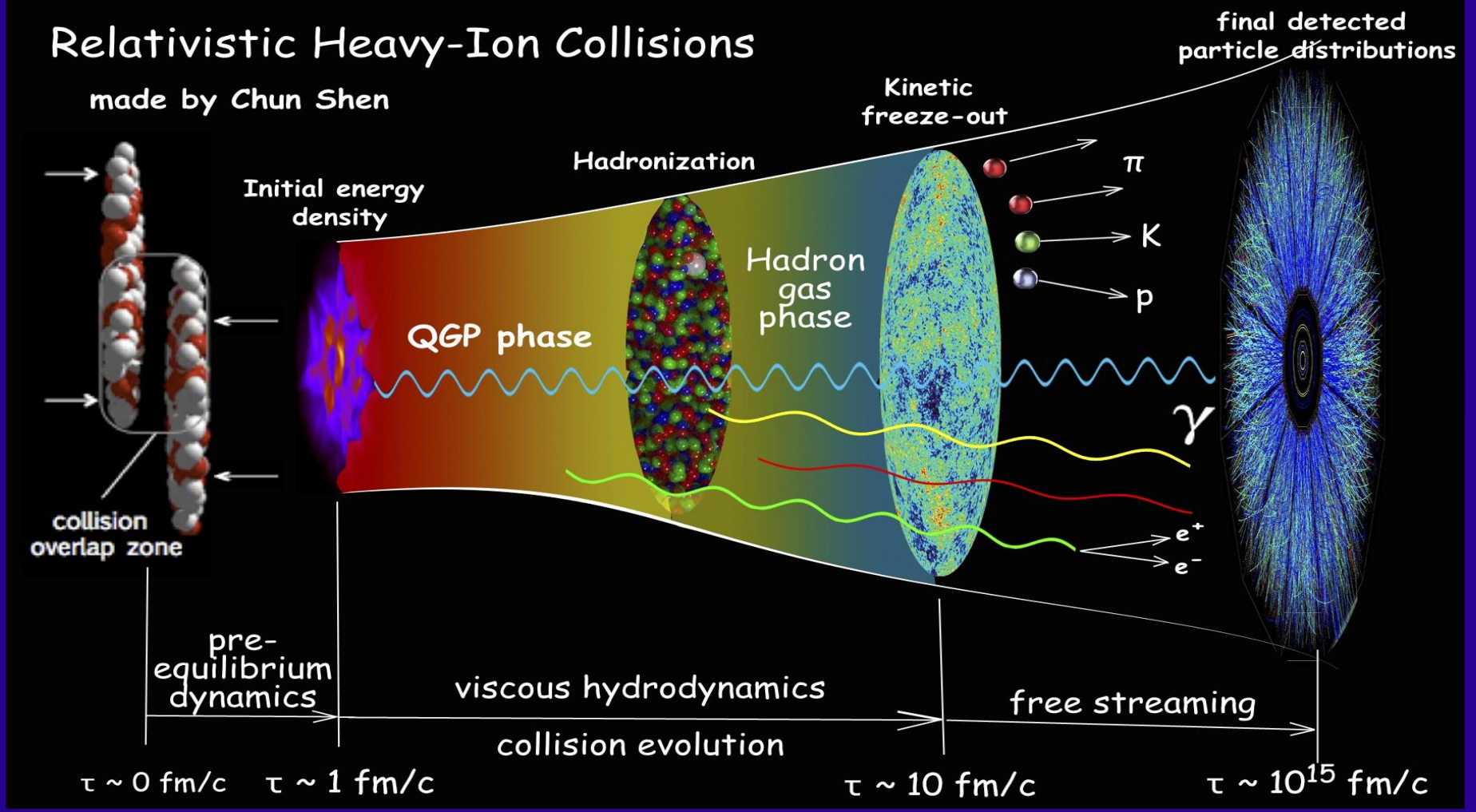
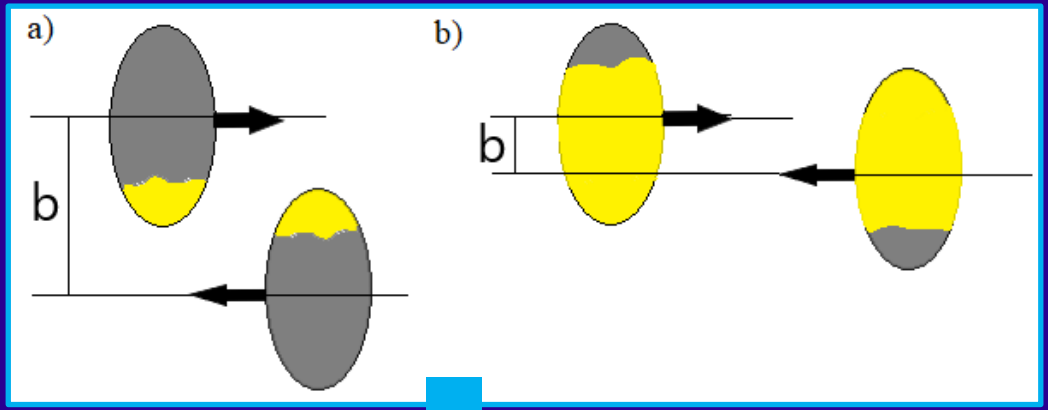
01 Quark-gluon plasma


Relativistic Heavy-Ion Collisions
made by Chun Shen
final detected particle distributions
Kinetic freeze-out
Hadronization
Initial energy density
Hadron gas phase
QGP phase
π
K
p
γ
e+
e-
collision overlap zone
pre-equilibrium dynamics
viscous hydrodynamics
free streaming
collision evolution
τ ~ 0 fm/c
τ ~ 1 fm/c
τ ~ 10 fm/c
τ ~ 10^15 fm/c

02 Centrality. Reaction plane

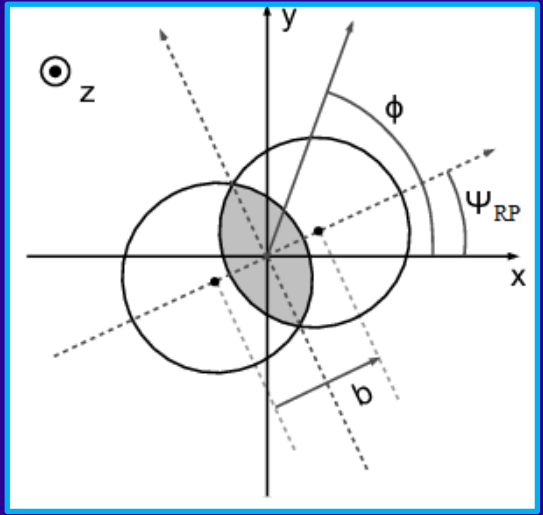


CENTRALITY.

a) Central collisions;
b) Peripheral collisions.

b – impact parameter.

- **participants**
- **spectators**

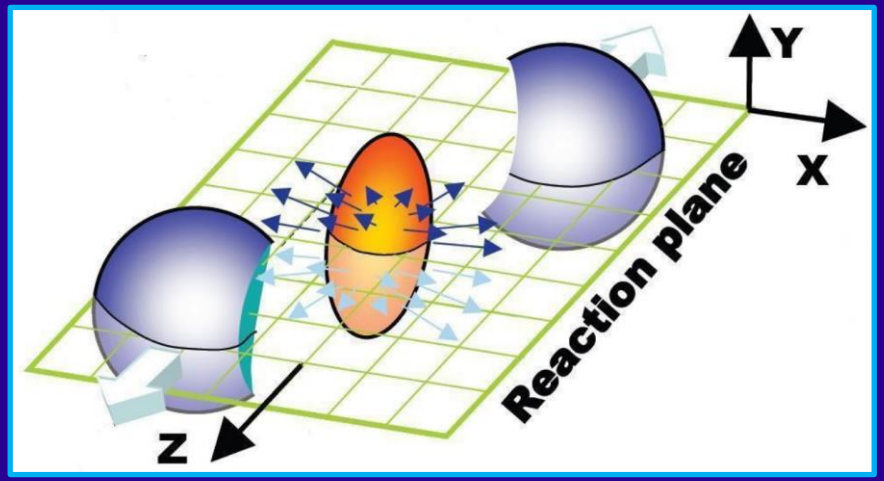


REACTION PLANE (RP).

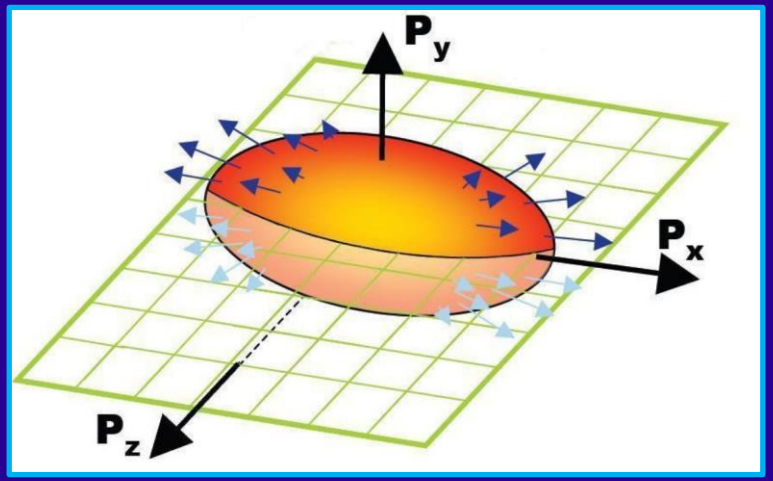
φ – particle angle,
z – beam direction,
b – impact parameter,
Ψ_{RP} - reaction plane angle.

Impact parameter + beam direction ➡ **RP**

03 Azimuthal anisotropy



Pressure gradient



$$v_2 = \left\langle \frac{p_x^2 - p_y^2}{p_x^2 + p_y^2} \right\rangle$$

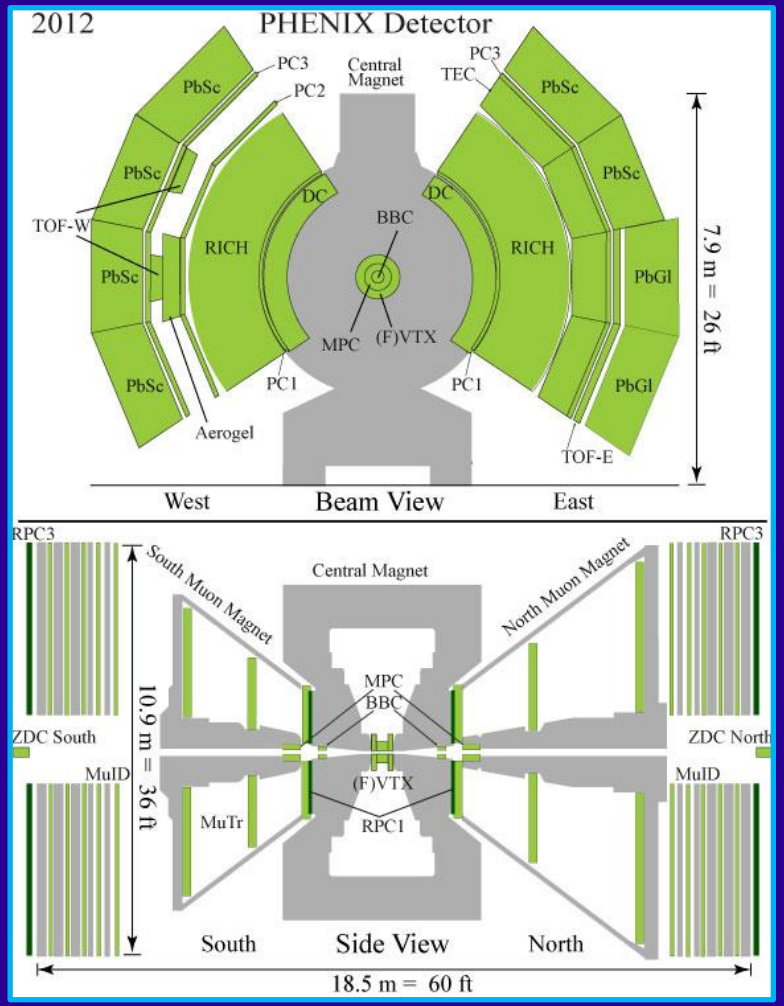
The azimuthal angle distribution of particle transverse momentum relative to the reaction plane:

$$f(\varphi, p_T) \propto 1 + 2\sum_{n=1}^{\infty} v_n(p_T)\cos(n\varphi)$$

The elliptic flow (v_2) is quantified by the second coefficient:

$$v_2 = \langle(\cos(2(\varphi - \Psi_{RP})))\rangle$$

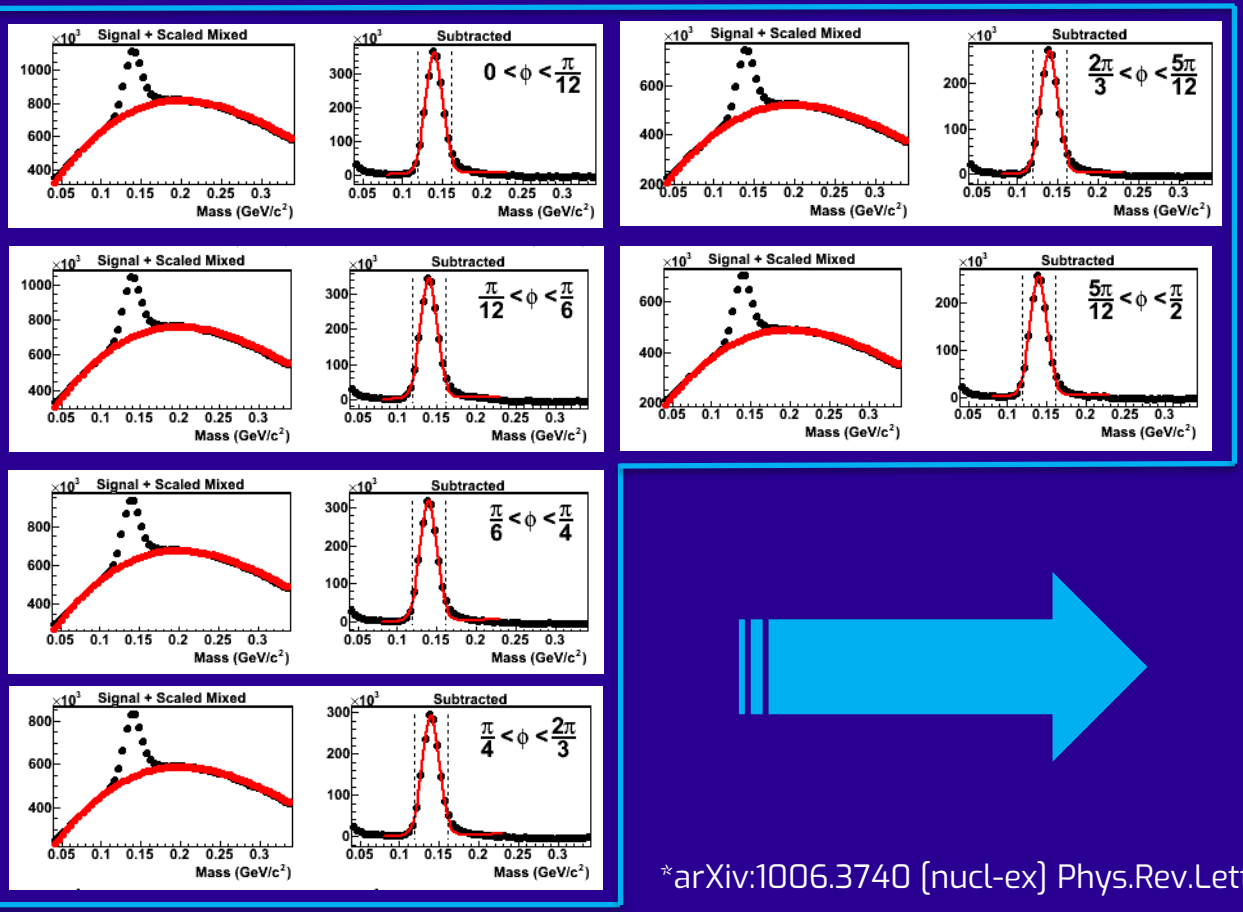
04 PHENIX detector

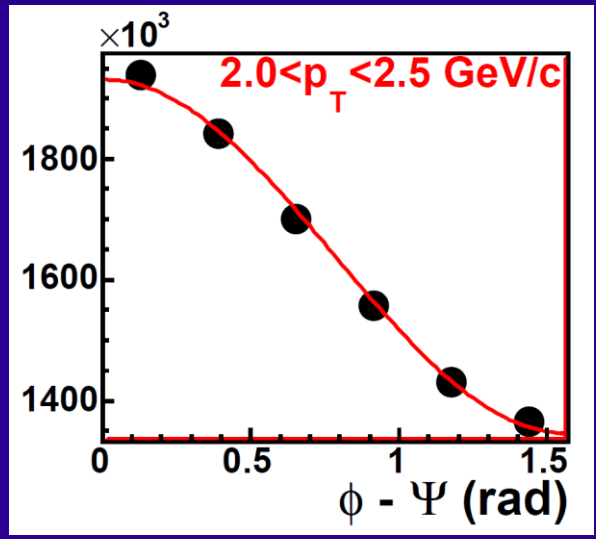


- Located at Brookhaven National Laboratory (BNL) at the RICH
- There are 2 central arms (East and West) and 2 muon arms (North and South)
- Pseudorapidity range of $|\eta| < 0.35$

v_2 05 measurement methods

1. Subtraction method

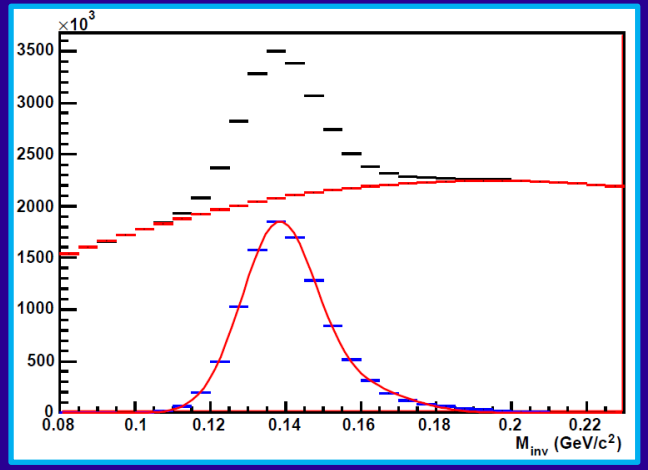




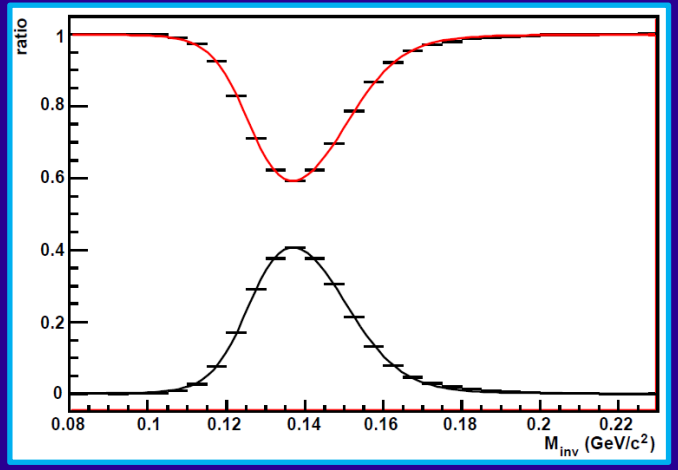
*arXiv:1006.3740 [nucl-ex] Phys.Rev.Lett.105:142301,2010

2. Invariant mass fit method

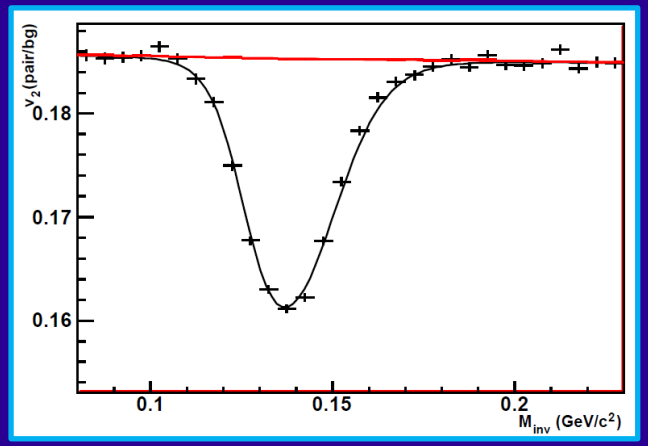
a)



b)



c)

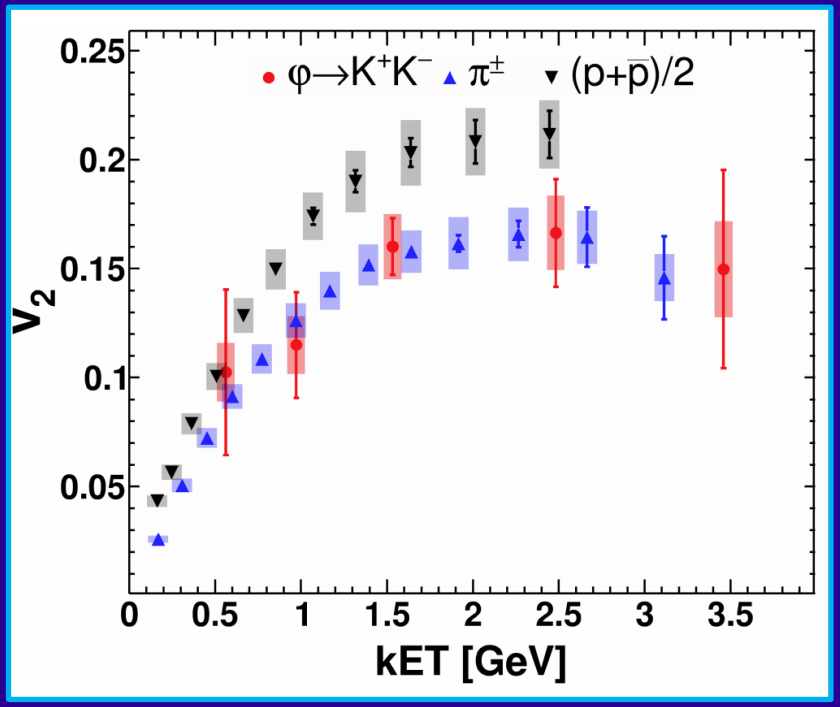


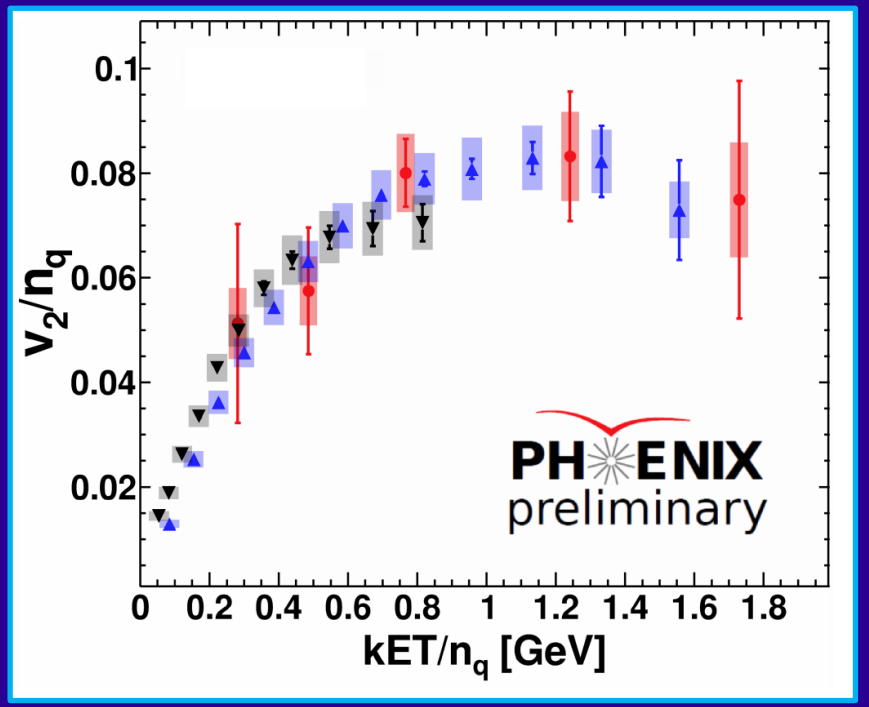
a – invariant mass distribution for total pairs (black line), background (BG – red line) and signal (blue points fitted with Gaussian);
b – ratios N_{BG}/N_{pair} (red line), N_{signal}/N_{pair} (black line);
c – the fit to v_2^{pair} (black line) and to v_2^{BG} (red line).

*arXiv:1309.4437 [nucl-ex] Phys.Rev.C 88, 064910 (2013)

06 Results

1. v_2 for φ, $\pi^{\pm}$ and for $p/\bar{p}$ as a function of kinetic energy (kE_T) and those scaled with number of quarks (n_q) in Cu+Au collisions at 200 GeV

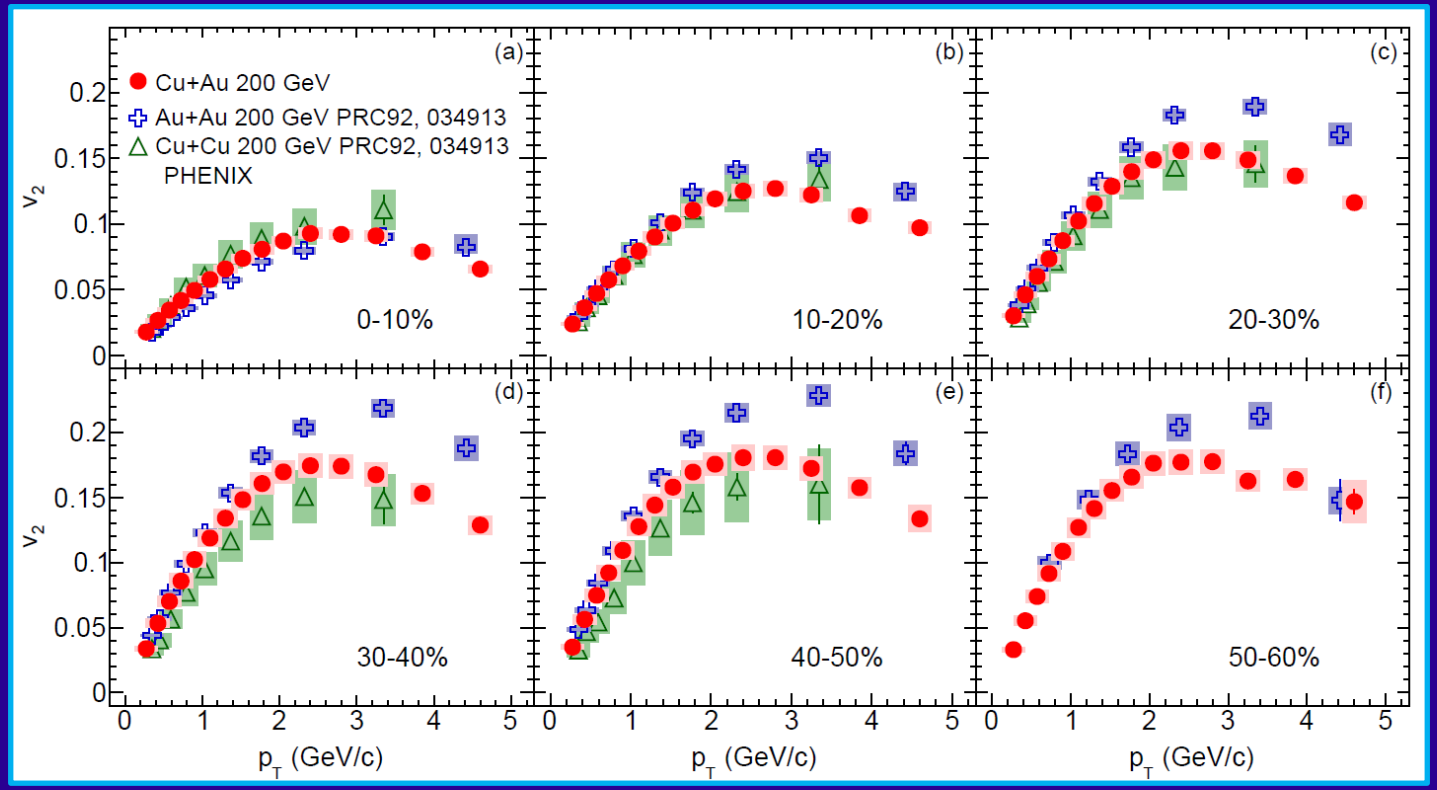




n_q **scaling is observed** → v_2/n_q values do not depend on the number of quarks

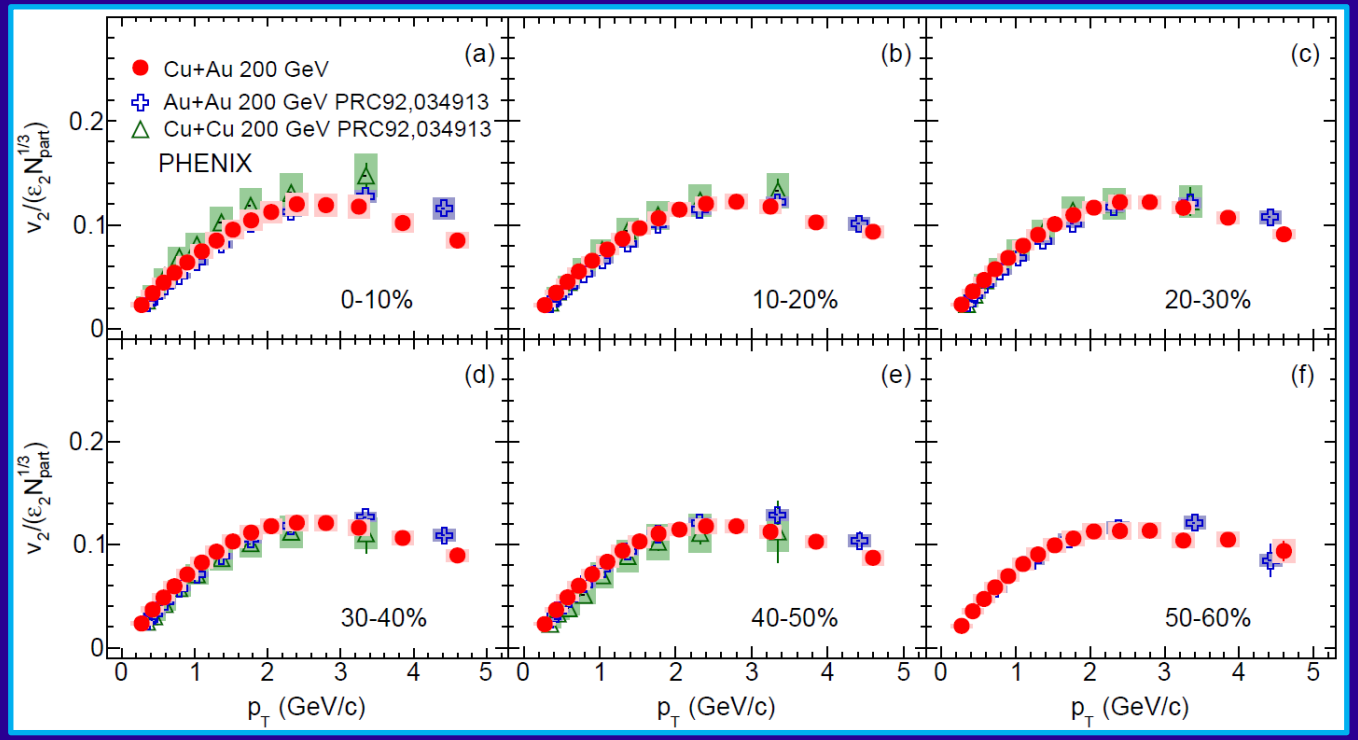
* Iu M Mitrankov *et al* 2021 *J. Phys.: Conf. Ser.* **2103** 012133

2. Charged hadrons as a function of transverse momentum (p_T) in Cu+Cu, Cu+Au and Au+Au collisions at 200 GeV



* arXiv:1509.07784v2 [nucl-ex] Phys. Rev. C 94, 054910 (2016)

3. Previously measured dependency scaled with eccentricity and the third root of the number of participants nucleons ($\varepsilon_2 N_{part}^{1/3}$)

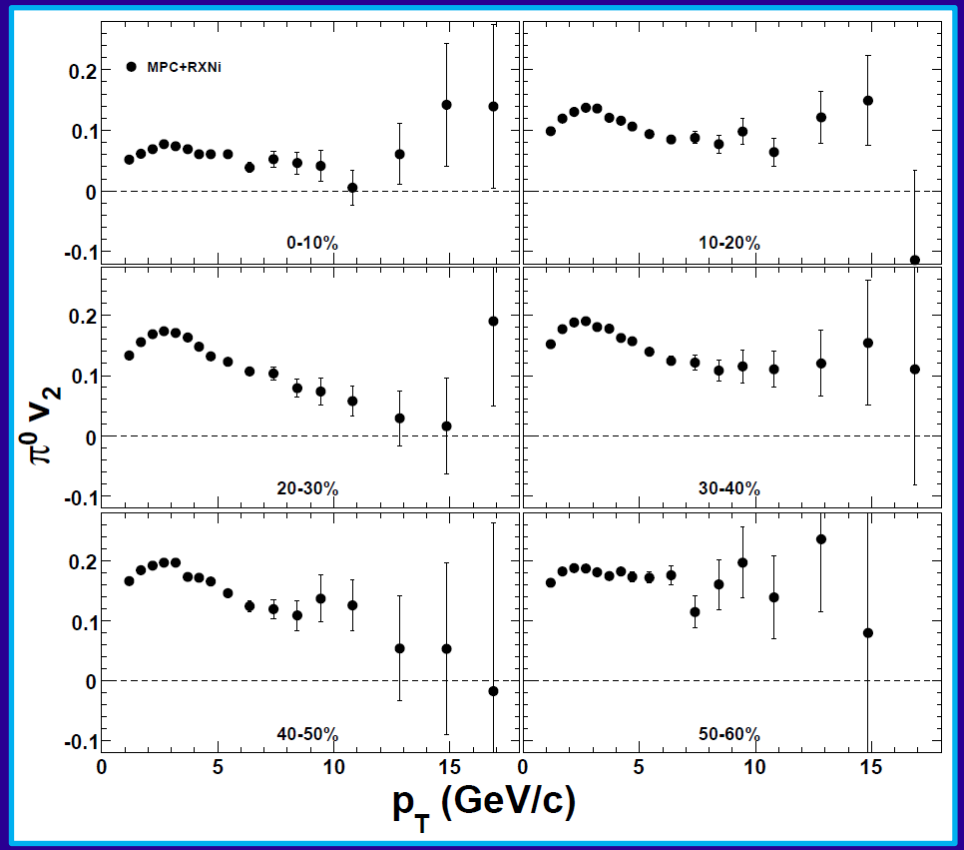


* arXiv:1509.07784v2 [nucl-ex] Phys. Rev. C 94, 054910 (2016)

$\varepsilon_2 N_{part}^{1/3}$ scaling in these systems

$v_2/(\varepsilon_2 N_{part}^{1/3})$ values for charged hadrons do not depend on initial size of the system

4. v_2 for π^0 as a function of transverse momentum (p_T) in Au+Au collisions at 200 GeV



- There are nonzero v_2 values at high $p_T > 5\ GeV/c$.

*arXiv:1006.3740 [nucl-ex]
Phys.Rev.Lett.105:142301,2010

07 Summary

- The scaling of v_2 for $\pi^{\pm}, \varphi$ and $p/\bar{p}$ with n_q was observed in Cu+Au collisions at 200 GeV;
- The elliptic flow values for charged hadrons in Cu+Cu, Cu+Au, Au+Au collisions systems scaling with $\varepsilon_2 N_{part}^{1/3}$ do not depend on initial size of the system;
- v_2 for π^0 is well-measurable up to high $p_T > 5\ GeV/c$.

For these reasons, the investigation of v_2 for π^0 in asymmetric Cu+Au collision system is the effective tool to study QGP properties.

→ This analysis is currently underway. Stay tuned!