Results from Cu+Au collisions at 200 GeV in PHENIX experiment

Berdnikov Ya.A., Ivanishchev D.A., Kotov D.O.,
Riabov V.G., Riabov Yu.G., Safonov A.S., Samsonov V.M.
for the PHENIX collaboration

PNPI
SPbSPU

Petersburg Nuclear Physics Institute

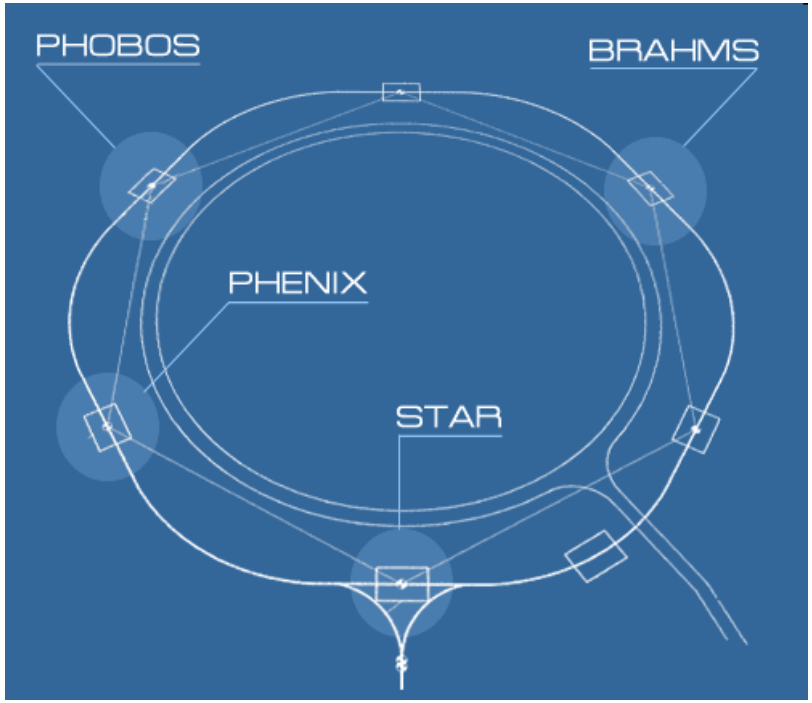
PHENIX

RHIC

• RHIC (Brookhaven National Laboratory, USA) is currently one of the biggest operating beam-to-beam colliders meant for study of heavy nuclei interactions at high energies;

• Lattice QCD predicts hadron-quark phase transition of nuclear matter in conditions of extremely high energy densities ($\varepsilon > 1$ GeV/fm^3) and temperatures ($T \sim 170$ MeV);

• Similar conditions can arise in heavy ion interactions.

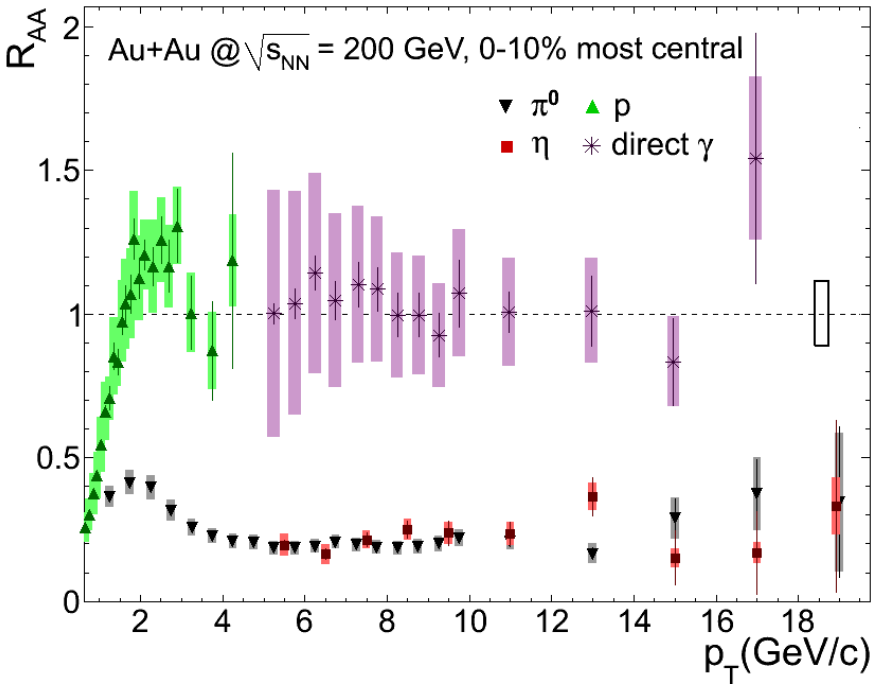


Nuclei system	$\sqrt{s_{NN}}$, GeV
Au+Au	7, 9, 39, 62, 130, 200
d+Au	200
Cu+Cu	22, 62, 200
p↑+p↑	22, 62, 200, 500
Cu+Au	200
U+U	192

Subject of research

In 2005 succession of crucial events allowed all collaborations at RHIC to make a statement about detection of new state of nuclear matter – strongly interacting QGP – ideal liquid with parton degrees of freedom.

Jet quenching

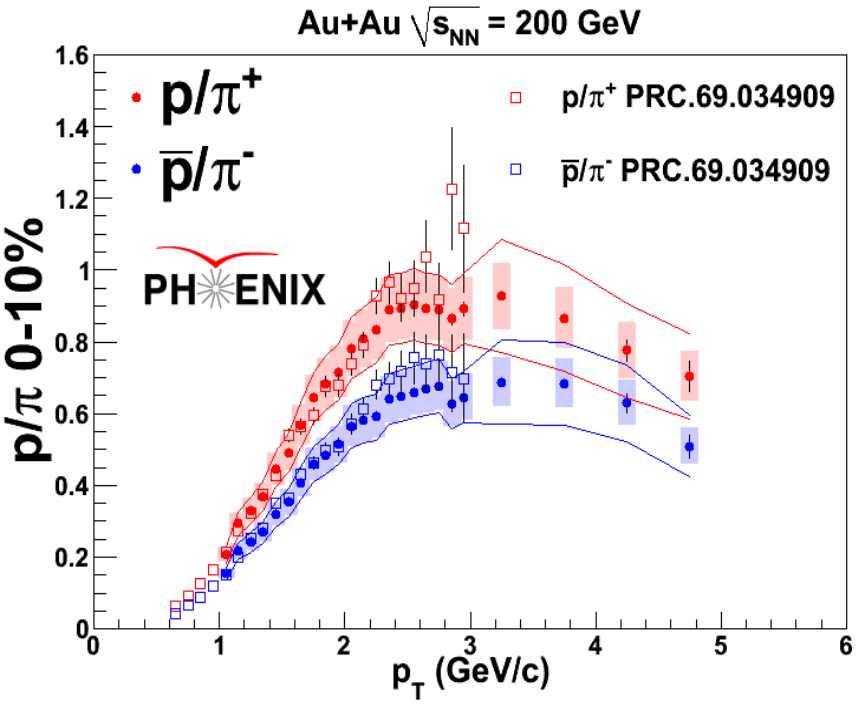


•π^0-mesons yield is suppressed fivefold;

• Direct γ yield not suppressed up to p_T ~ 14 GeV/c:

✓ Energy loss of hard partons in dense nuclear matter in the final state.

Baryon puzzle



• Sudden increase in p/π yields from peripheral to central nuclei interactions;

✓ Recombination of partons in QGP.

PHENIX Experiment

Charged particles

1. Drift chambers (DC):

$\delta p/p = 0.7\% + 1.1\% \cdot p$

2. Pad chambers (PC):

$\sigma_z = 1.7$ mm, $\sigma_\varphi = 2.4$ mm

Energy measurement

1. EMCalorimeter: $\delta E/E \approx 4.5\% + 8.0\%/\sqrt{E}$ (GeV)

Particle identifiifcation

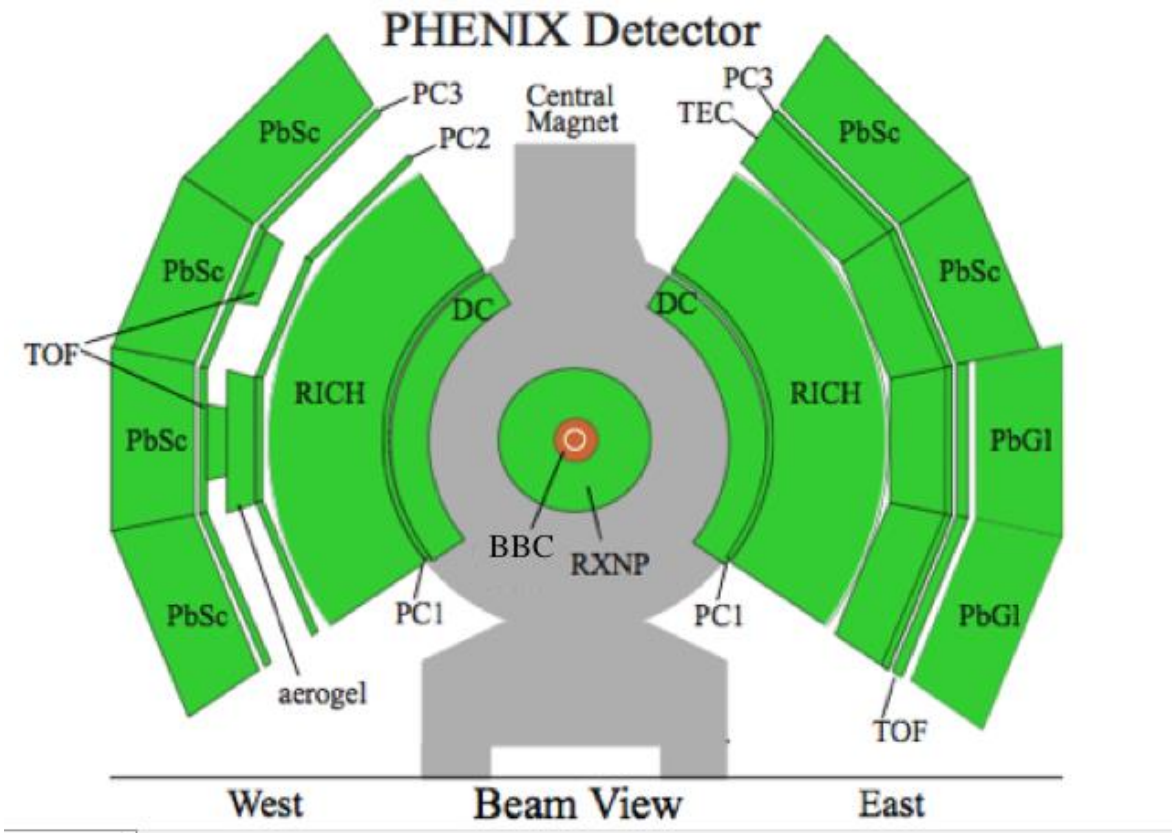
1. Time-of-flight systems:

- TOF.East ($\sigma_T \sim 120$ ps);
- TOF.West ($\sigma_T \sim 84$ ps);

π/K separation:

$0.3 < p_T$ (GeV/c) < 2.2

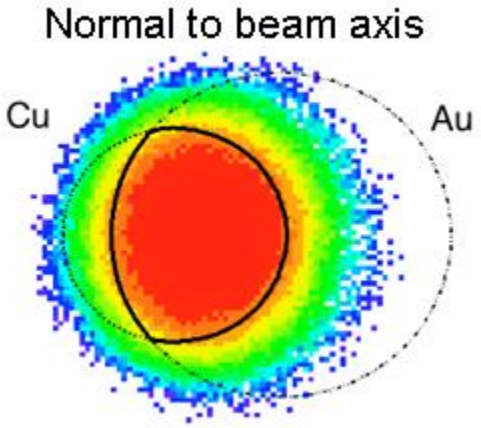
2. EMCal: $\sigma_T \sim 500$ ps.



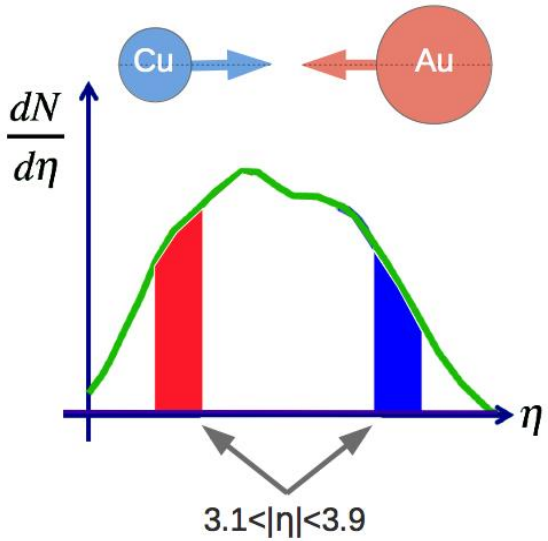
Central spectrometer:

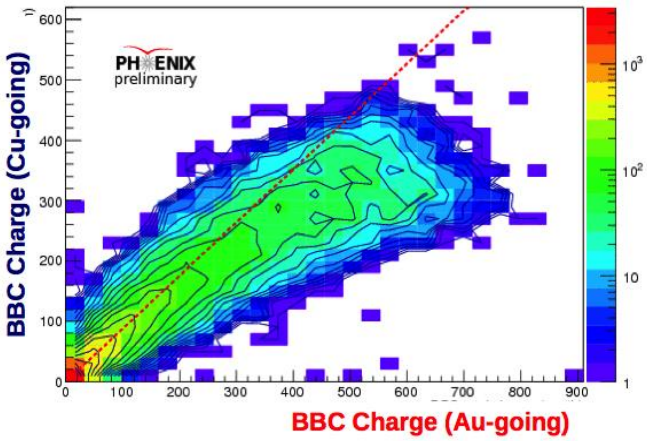
$\Delta\varphi = 2 \bullet \pi/2$, $|y| < 0.35$

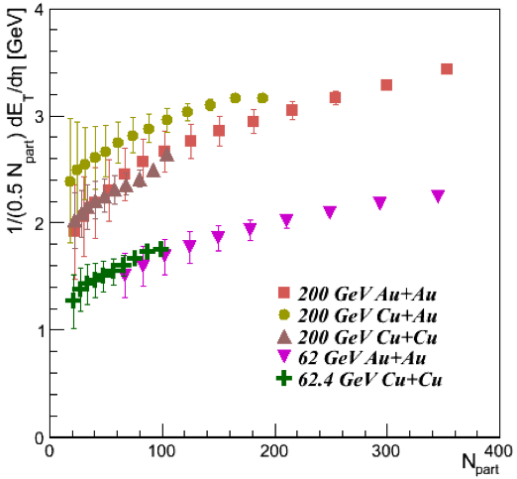
Cu+Au interactions



- In 2012 PHENIX have seen first Cu+Au interactions at 200 GeV:
  - ✓ PHENIX Experiment gathered ≈4.6*10^9 events;
  - ✓ Influence of system asymmetry in the initial state (geometric and density) on particle production mechanisms.





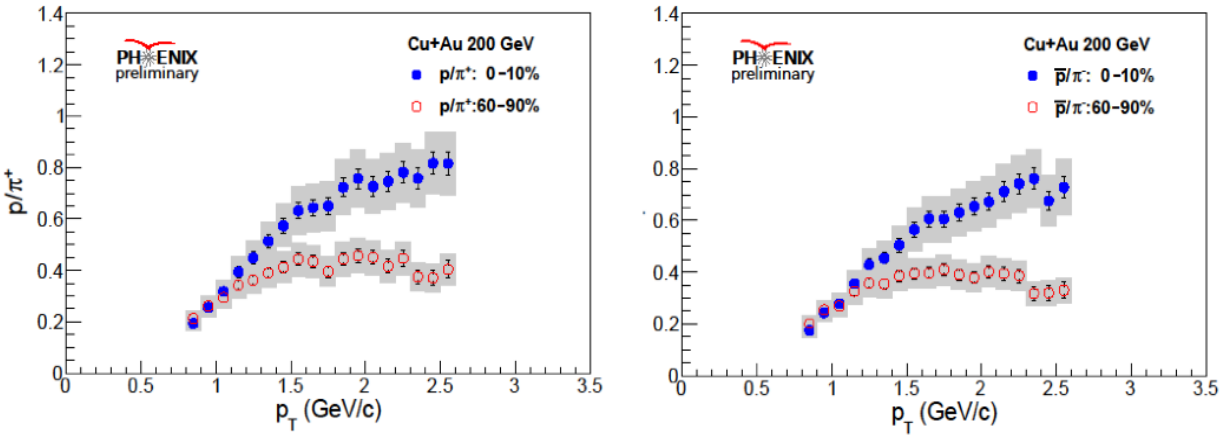


- Following problems are to be discussed in the present report:
  - ✓ Does the “baryon puzzle” analogous to the one in Au+Au occur in Cu+Au interactions?
  - ✓ R_{AA}(Cu+Au) = R_{AA}(Au+Au) or R_{AA}(d+Au)?
  - ✓ Odd harmonics of elliptic flow?

Production of light hadrons in Cu+Au@200 GeV

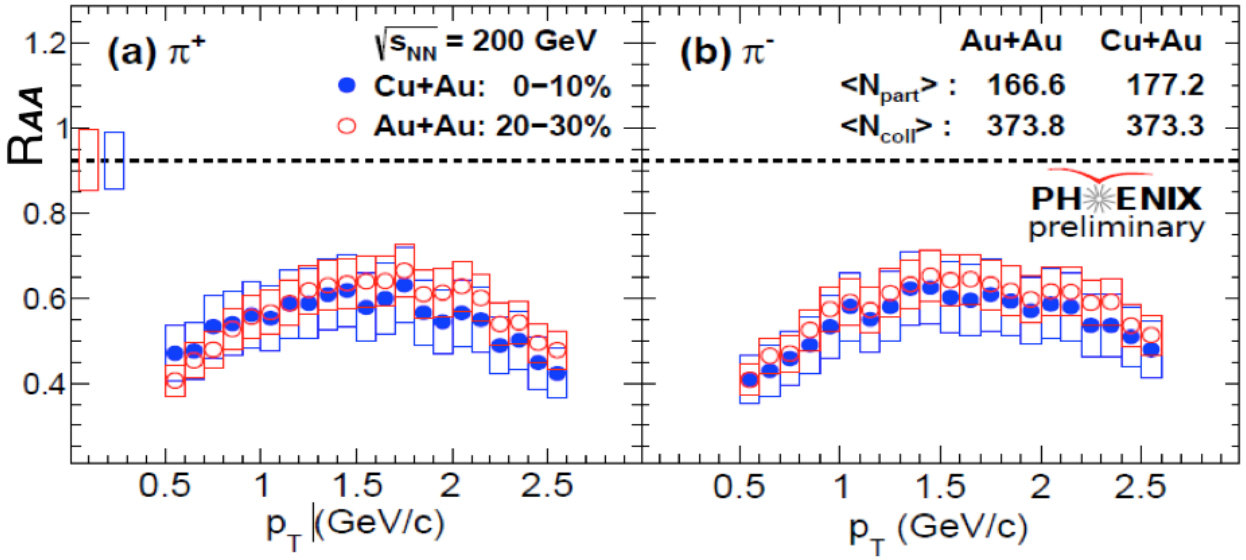
- «Baryon puzzle» occurs in central Cu+Au interactions:
  - ✓ the same for particles of different sign;
  - ✓ magnitude of the effect is comparable to the one in Au+Au.

Proton to pi-meson yield ratios in Cu+Au interactions at 200 GeV

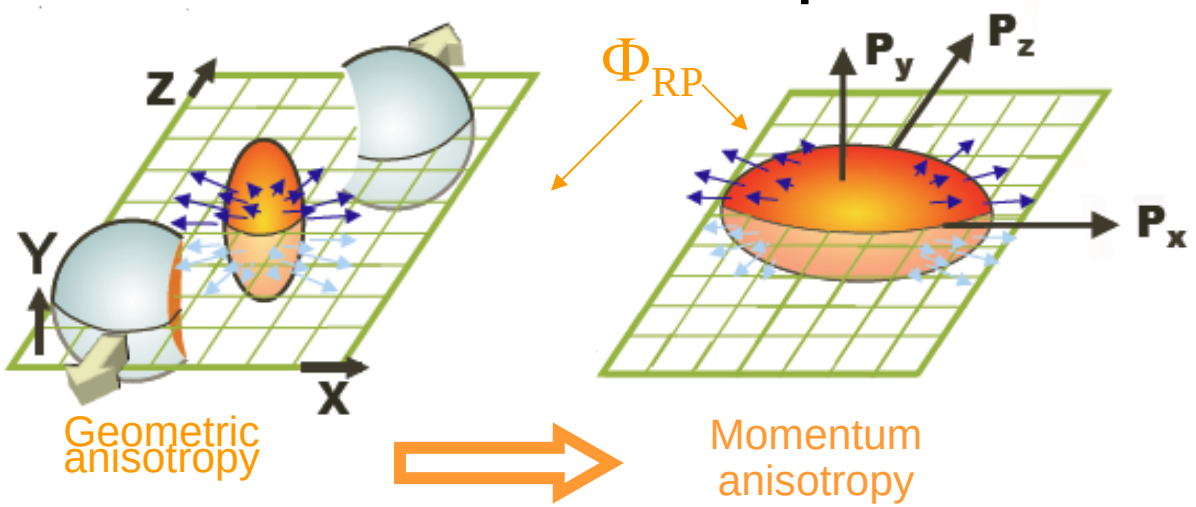


Nuclear modification factors for pi-mesons in Cu+Au and Au+Au interactions at 200 GeV

- Pi-mesons yields are suppressed in central Cu+Au interactions:
  - ✓ At similar N_{part} values R_{AA} in Cu+Au and Au+Au are the same.



Elliptic flows



In noncentral nuclei interactions:

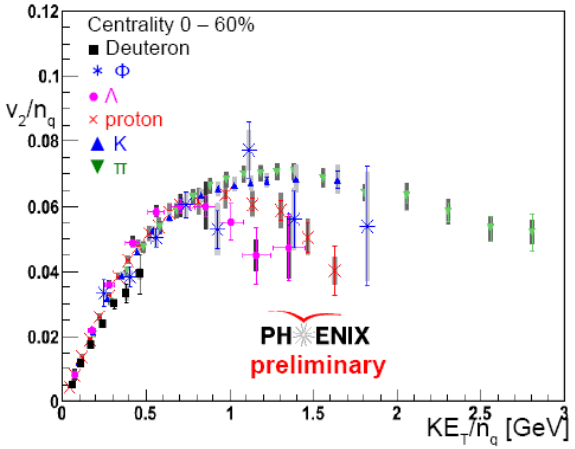
$$\frac{dN}{d\phi} \propto 1 + 2v_2 \cos 2(\phi - \Phi_{RP})$$

Coefficient v_2 is measure of elliptic flow magnitude!

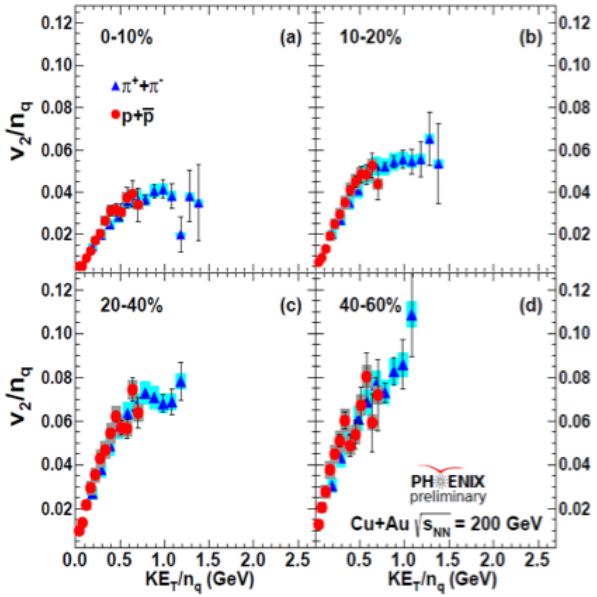
- Universal scaling of v_2:
  - ✓ Ideal liquid with parton degrees of freedom;
  - ✓ Scaling is preserved in Cu+Au.

•Scaling breaking at $KE_T/n_q > 1.0$ GeV bears evidence of activation of different particle production mechanisms.

Au+Au@200 GeV

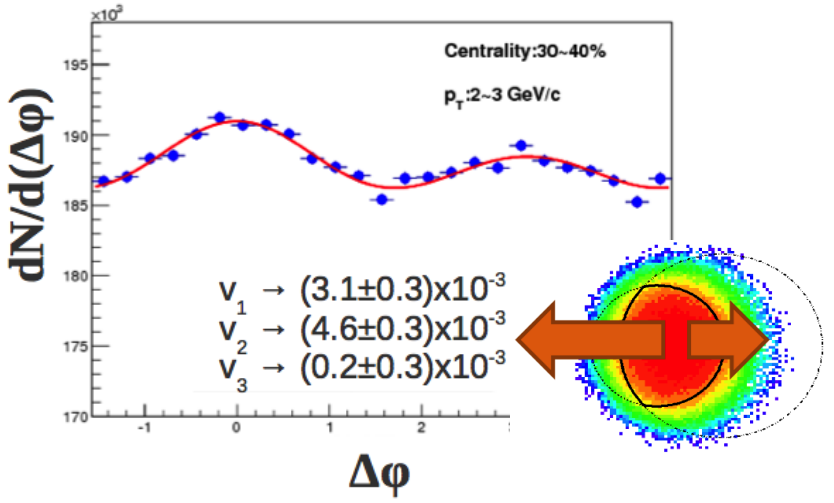


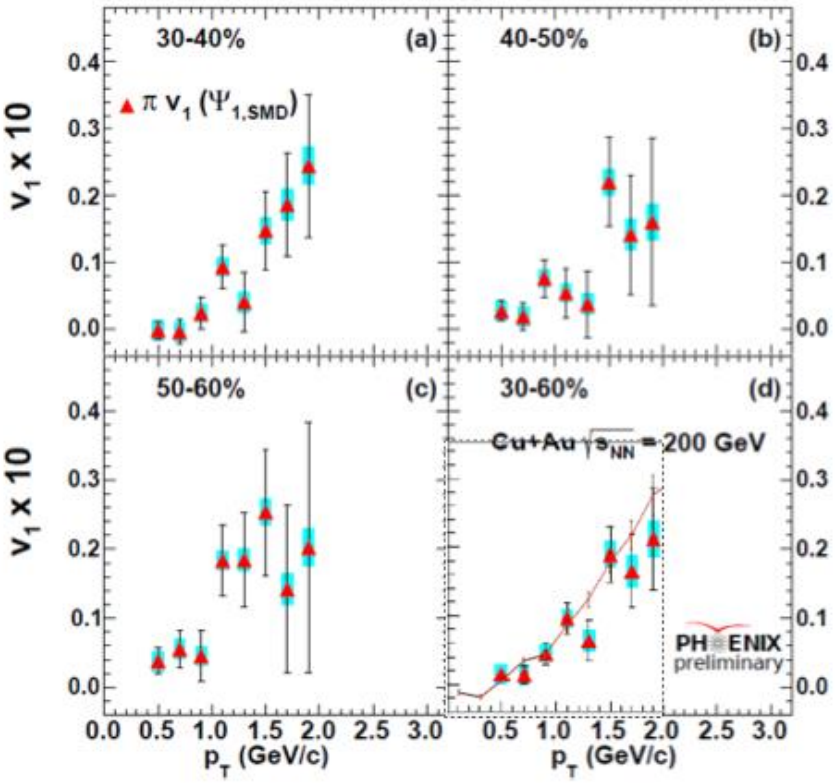
Cu+Au@200 GeV



Odd harmonics of v_n in Cu+Au

- Non-symmetric nuclei overlap region provides generation of distinct pressure gradients:
  - ✓ More particles escape from the side of Au;
  - ✓ Asymmetry of dN/d($\Delta\phi$);
  - ✓ High magnitude of v_1 (in Au+Au v_1=0);
  - ✓ Magnitude and sign of v_1 are described by flow dynamics models, in which nuclei alignment in every Cu+Au interaction is given separately for each event: E-by-E hydro, P.Bozek, Phys.Lett.B717(2012).





Conclusion

1. “Baryon puzzle” occurs in central Cu+Au interactions at 200 GeV – generation of strongly interacting QGP;
2. Light hadrons yields in central Cu+Au interactions are suppressed;
3. R_{AA} for light hadrons acquired in Cu+Au interactions are the same as values of R_{AA} in Au+Au interactions given equal number of nucleons taking part in the interaction;
4. Non-zero value of v_2 bears evidence of elliptic flow occurrence in Cu+Au interactions;
5. “Quark scaling” works for coefficients v_2;
6. Existence of odd harmonics in angular distribution of particles produced in Cu+Au interactions is related to initial spatial and density asymmetry of colliding nuclei;
7. Magnitude and sign of odd flow coefficients are described by theoretical models.