Simulation Study of E-by-E Dynamic Charge Fluctuation At FAIR Energies

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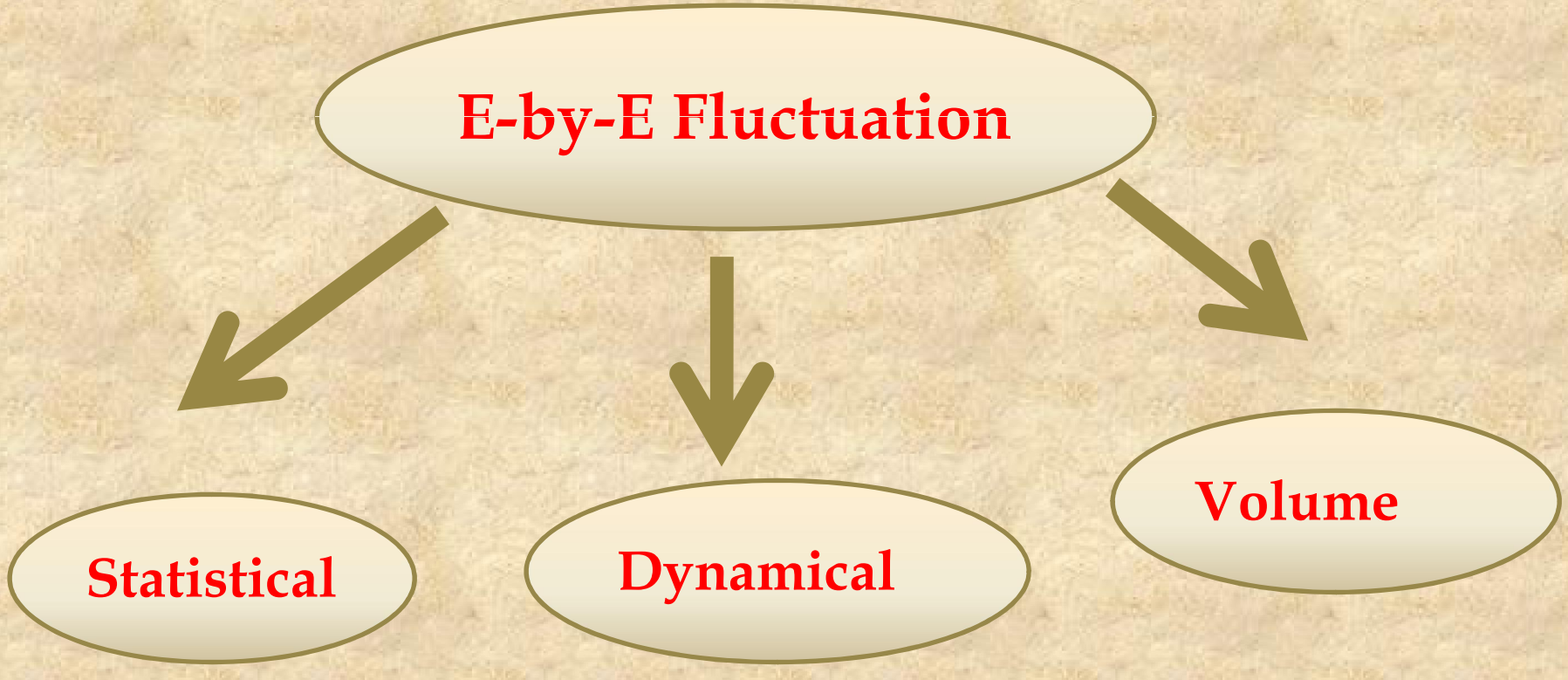
Outline of the Talk

- Introduction
- Dynamical Charge Fluctuation
- Properties of dynamic fluctuation term
- Analysis
- Summary & Future Agenda

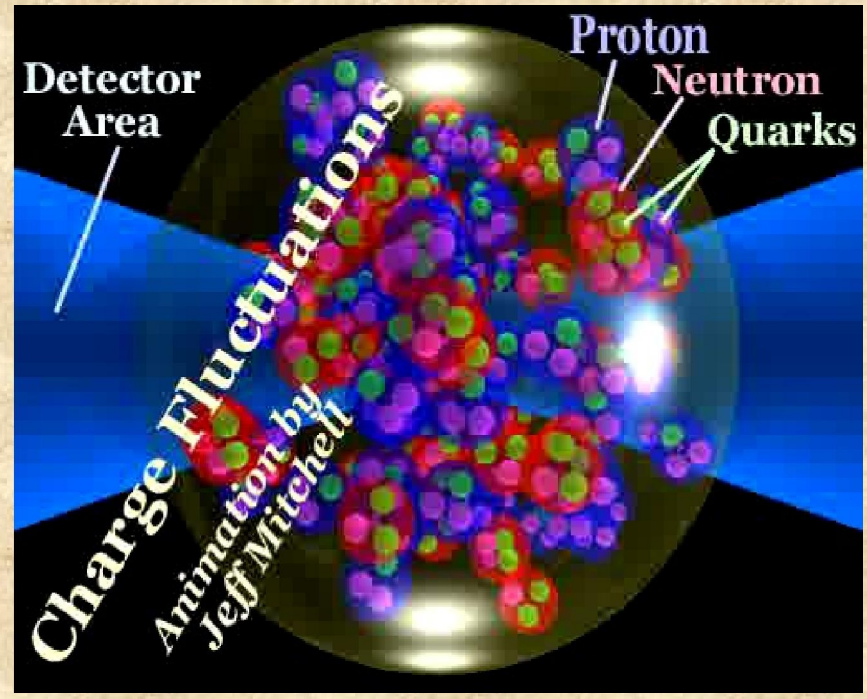
Introduction:

- E-by-E fluctuation of conserved quantities (Baryon No., Strangeness , Net-charge etc.) provide information of early stage of evolution.

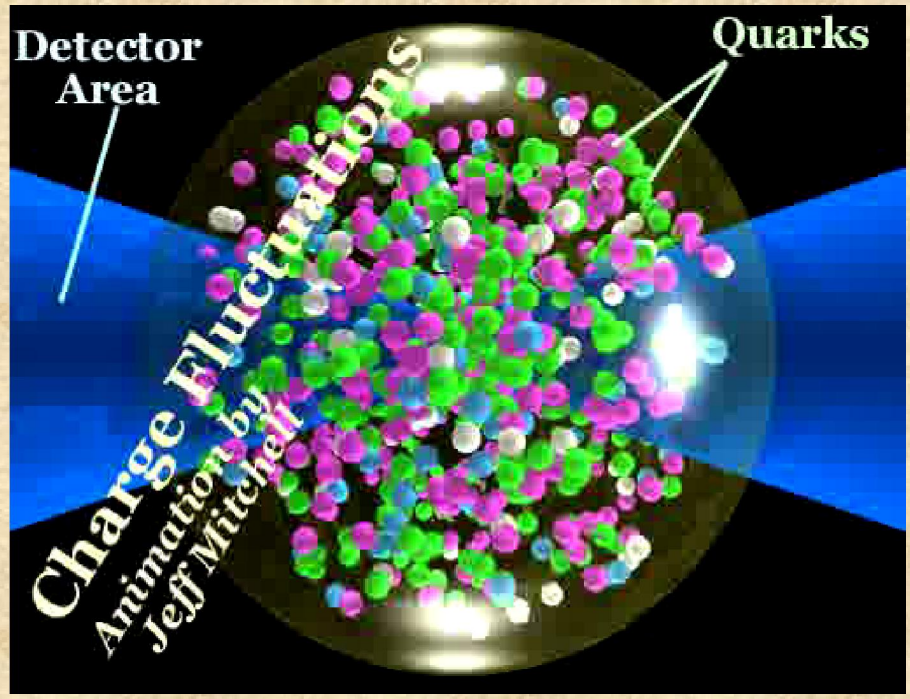


Net-Charge fluctuation a QGP Signal??

Hadron Gas



QGP State



Charge more evenly spread in plasma due to the fractional charges of quarks

- Net charge fluctuations ***dramatically reduced*** in a QGP compared to a hadron or resonance gas

$$Q = (N_+ - N_-)$$

$$R = \frac{N_+}{N_-}$$

$$D \equiv \langle N_{ch} \rangle \langle \delta R^2 \rangle = 4 \frac{\langle \delta Q^2 \rangle}{\langle N_{CH} \rangle} = 4\varpi_Q$$

(Jeon, Koch, PRL 85 (2000) 2076)

Model	D value	$\nu_{+-,dyn}$
Poisson , Hadron Gas	4.0	0
Resonance Gas	2.8	$-1.2/n_{ch}$
QGP	0.75	$-3.25/n_{ch}$

Dynamic Fluctuation :

$$\nu_{+-} = \left\langle \left(\frac{N_+}{\langle N_+ \rangle} - \frac{N_-}{\langle N_- \rangle} \right)^2 \right\rangle$$

Independent Particle (Poisson) Limit

$$\nu_{+-,stat} = \frac{1}{\langle N_+ \rangle} + \frac{1}{\langle N_- \rangle}$$

(C. *Pruneau et al, PRC66 (2002) 044904*)

Definition:

$$\nu_{+-,dyn} = \nu_{+-} - \nu_{+-,stat}$$

Measurement:

$$\nu_{+-,dyn} = \frac{\langle N_+(N_+ - 1)\rangle}{\langle N_+ \rangle^2} + \frac{\langle N_-(N_- - 1)\rangle}{\langle N_- \rangle^2} - 2\frac{\langle N_+ N_- \rangle}{\langle N_+ \rangle \langle N_- \rangle}$$

In terms of correlation term:

$$\nu_{+-,dyn} = R_{++} + R_{--} - 2R_{+-}$$

Properties of dynamic fluctuation:

1. Collision Dynamics
   Independent of collision centrality
2. Pseudorapidity dependence.
3. Relation with D
4. Charge Conservation effect

$$\langle N(b)\rangle \upsilon_{+-,dyn}(b) = \text{constant}$$

$$\left\langle \frac{dN}{dy} \right\rangle_{AA} \upsilon_{AA,dyn} = \left\langle \frac{dN}{dy} \right\rangle_{pp} \upsilon_{pp,dyn}$$

$$\upsilon_{+-,dyn}(\delta\eta)$$

$$D = < N_{ch} > \upsilon_{+-,dyn} + 4.0$$

$$\nu_{+-,dyn} = -\frac{2}{\langle N_{+} \rangle_{4\pi}} \approx -\frac{4}{\langle N \rangle_{4\pi}}$$

4. Independent of volume fluctuation.
5. Detector efficiency independent.

Analysis:

Simulation models used:

1.UrQMD (hadronic string transport model)

2. MC Glauber model

Energy used: E_{Lab} = 10A,20A,30A,40AGeV

Event statistics: 1 M Min. Bias events(approx.)

System : Au + Au

pT Range used: $0.2<p_T<2.0$ GeV/c

Analysis done for all charged hadrons.

Dynamical fluctuation with centrality:

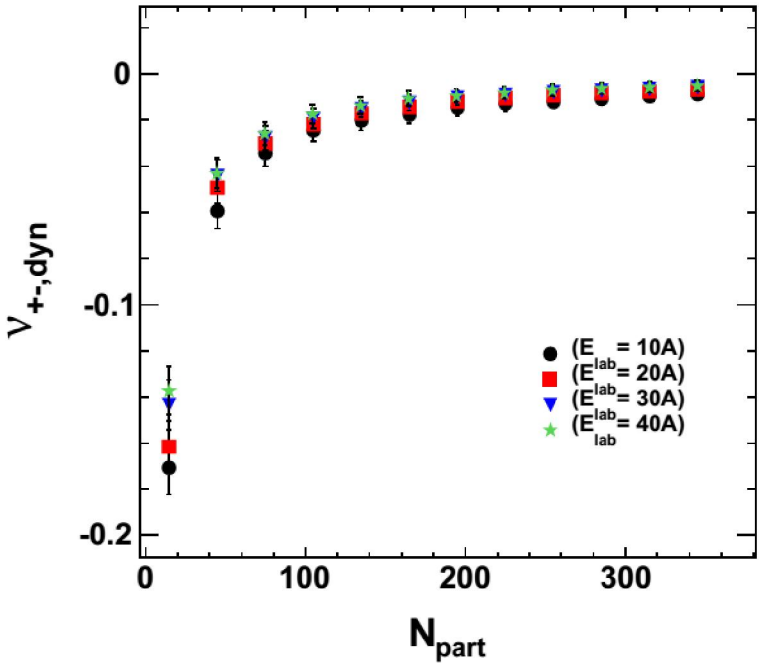


Fig1: ν+-,dyn vs centrality i.e Npart at δη=1.0

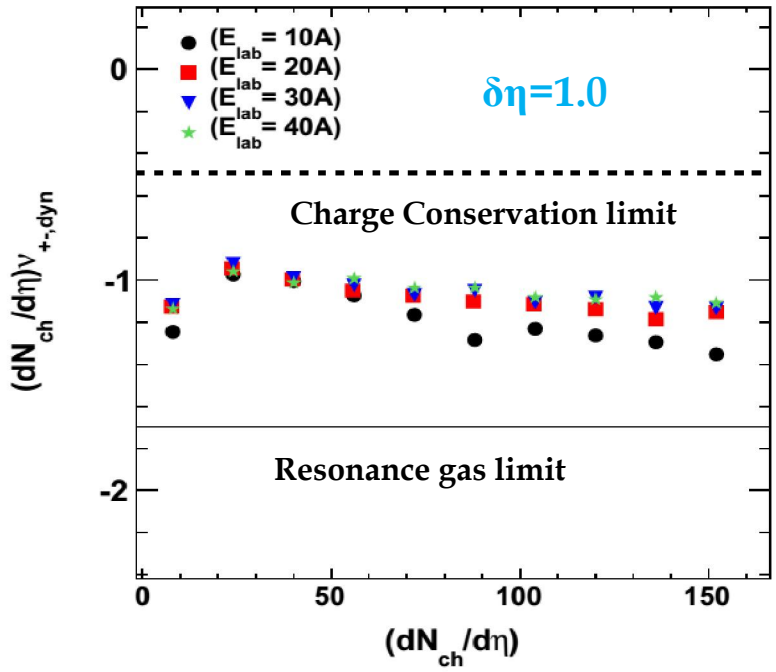


Fig2: ν+-,dyn scaled by (dNch/dη) with (dNch/dη)

➢In case of first picture it is observed that ν+-,dyn is inversely proportional with Npart. Mild energy dependence observed. Similar as previous expt.s.

➢In case of fig.2 it is observed that the scaling behavior is observed but as we move towards higher (dNch/dη) value the plots moves towards resonance gas limit. This is quite similar as previous expts. The distinct energy dependence is observed. Due to low multiplicity 10AGeV data show higher value of fluctuation.

Does scaling of dynamic fluctuation with $1/N_{part}$ & $1/N_{coll}$ independent of collision centrality in CBM energies??

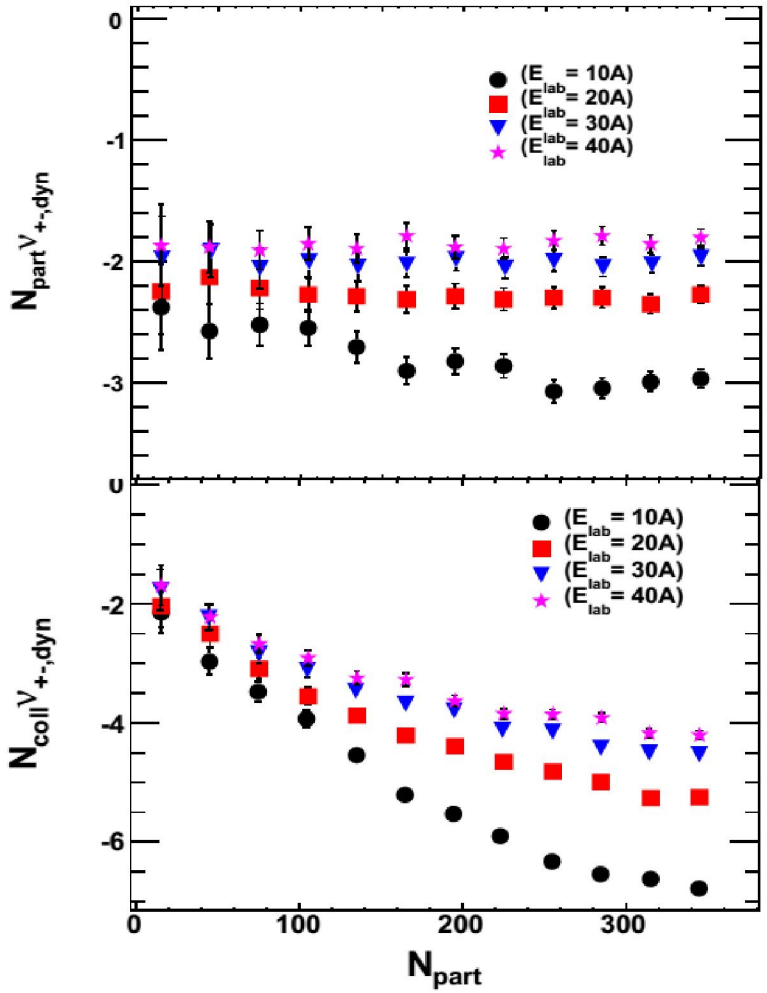


Fig3: $\nu_{+,-,dyn}$'s scaling with N_{part} and N_{coll}

- N_{part} scaling is well observed in in the simulated data. However no such scaling observed for N_{coll}. The multiplication of $\nu_{+,-,dyn}$ with N_{coll} decreases monotonically.
- Energy dependence observed in both cases. The fluctuation decrease as energy increases.

For E_{lab} =10AGeV data fluctuation is much higher ……..

(Possible cause: Low Multiplicity effect).

- Results are similar as Previous expt.s

Ref: B.I Abelev *et al* for STAR collab.

Pseudorapidity dependence of $\nu_{+-,dyn}$

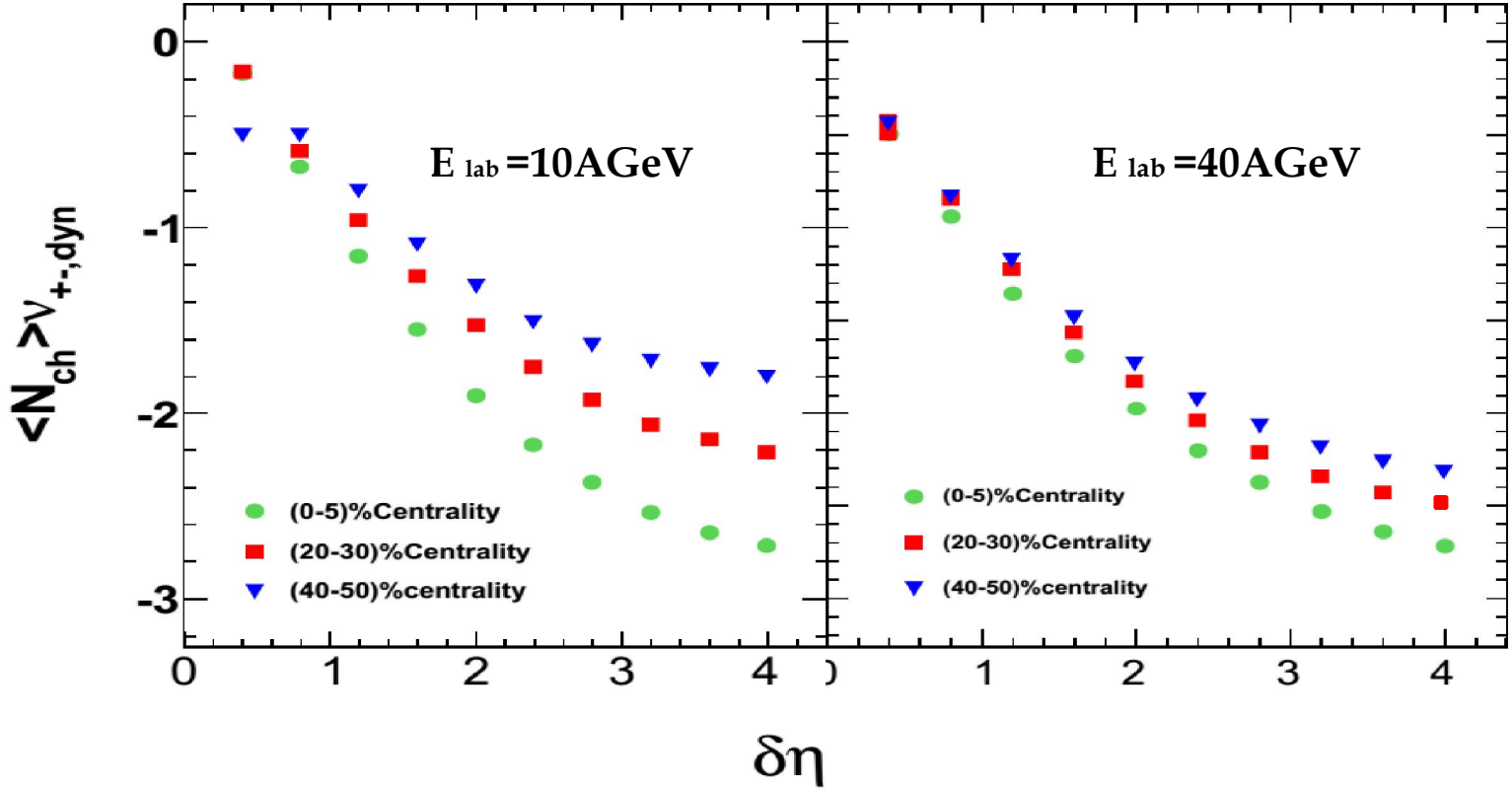
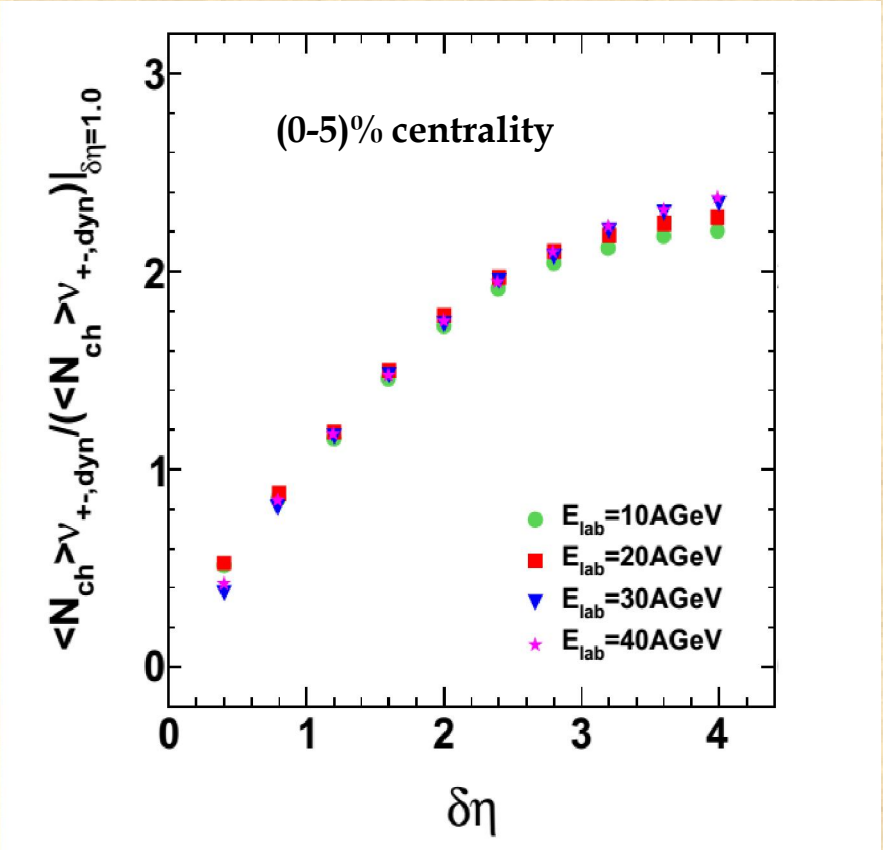
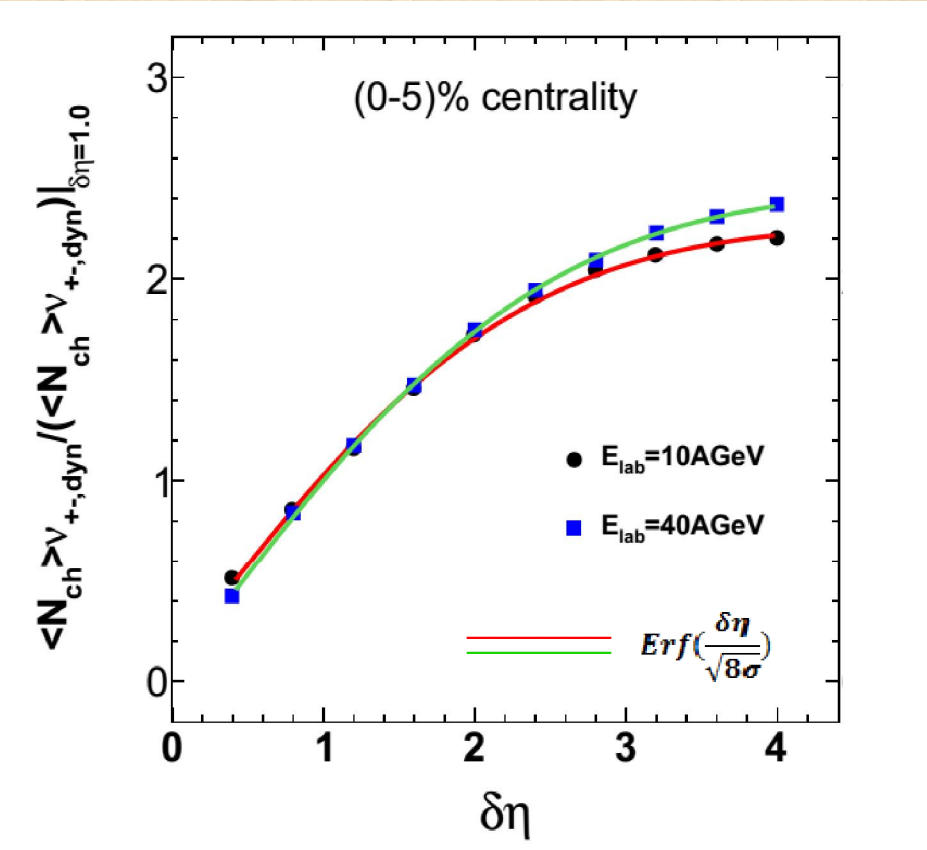


Fig. variation of $\langle Nch \rangle \nu_{+-,dyn}$ with $\delta\eta$ at three different centralities:

$\langle N_{ch}\rangle \nu_{+-,dyn}$ normalized at the value of $\delta\eta$=1.0 with $\delta\eta$:



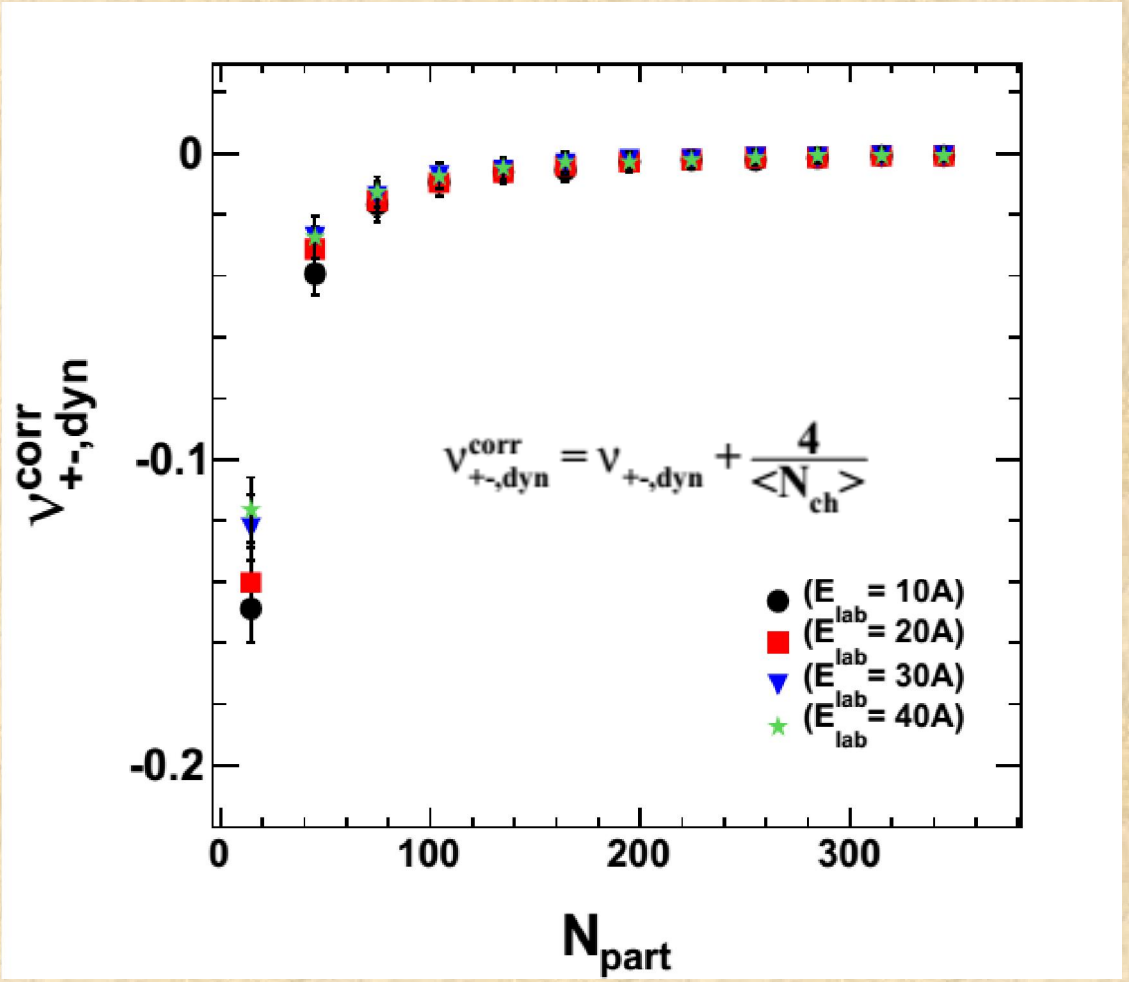


Energy dependence becomes weaker.

$\sigma(E_{lab}$ = 10AGeV) =1.0997, $\sigma(E_{lab}$ =40AGeV)=1.043

"Pseudorapidity dependence of $\nu_{+-,dyn}$ --- a result of diffusion of charged particles"

Effect of Charge conservation on dynamic charge fluctuation



- The magnitude of dynamic fluctuation term becomes smaller after employing charge conservation effect.
- The energy dependence remains similar as previous one.

E_{lab}	$\nu_{+-,dyn}$	$\nu^{corr}_{+-,dyn}$
10AGeV	-0.00862	-0.0008
40AGeV	-0.00525	-0.0003

Fig: $\nu^{corr}_{+-,dyn}$ as a function of centrality

Ref: B. Abelev et al for ALICE collab.

Pseudorapidity dependence of $\langle N_{ch} \rangle \nu^{corr}_{+-,dyn}$

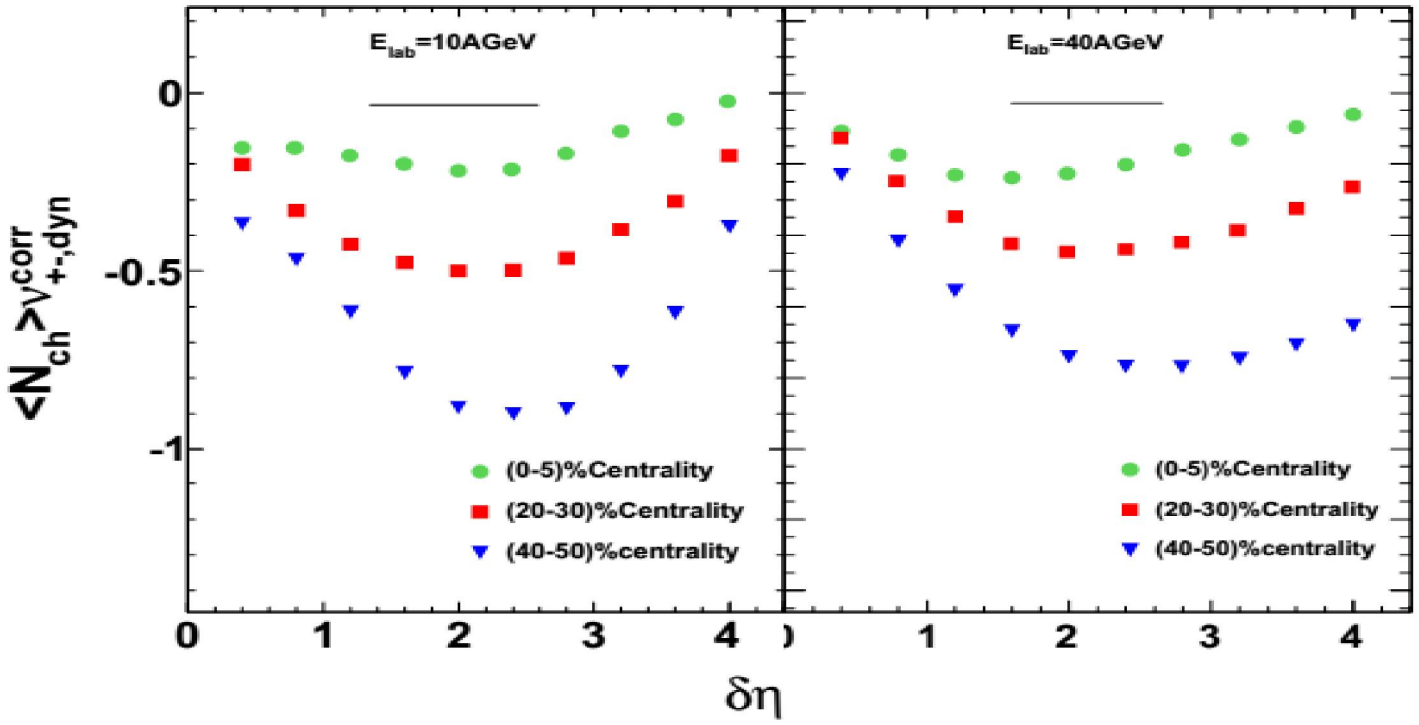
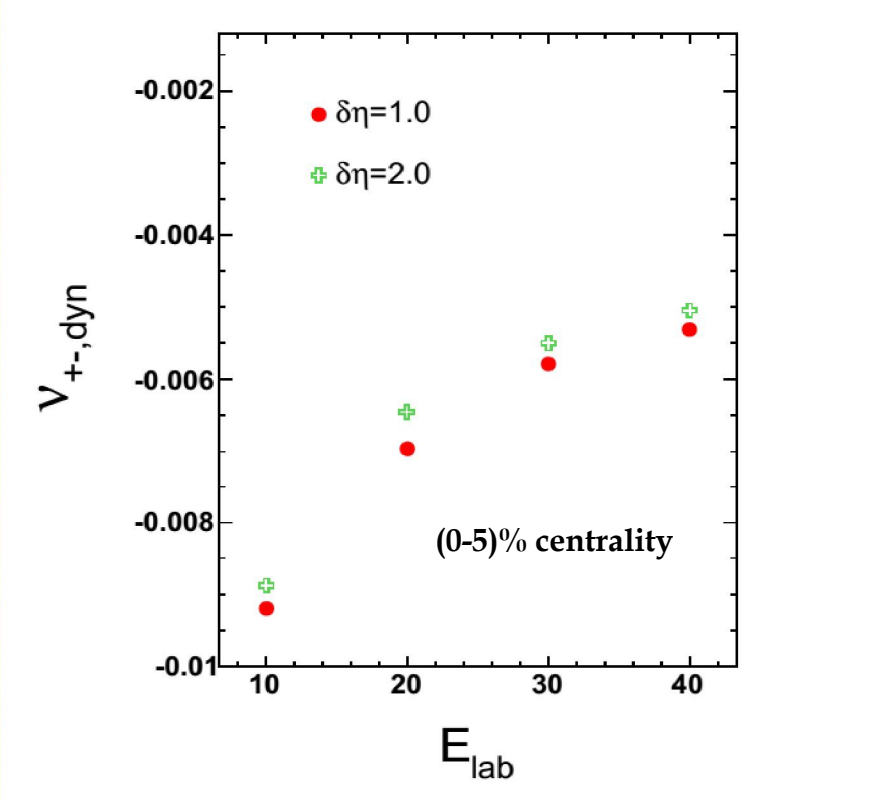


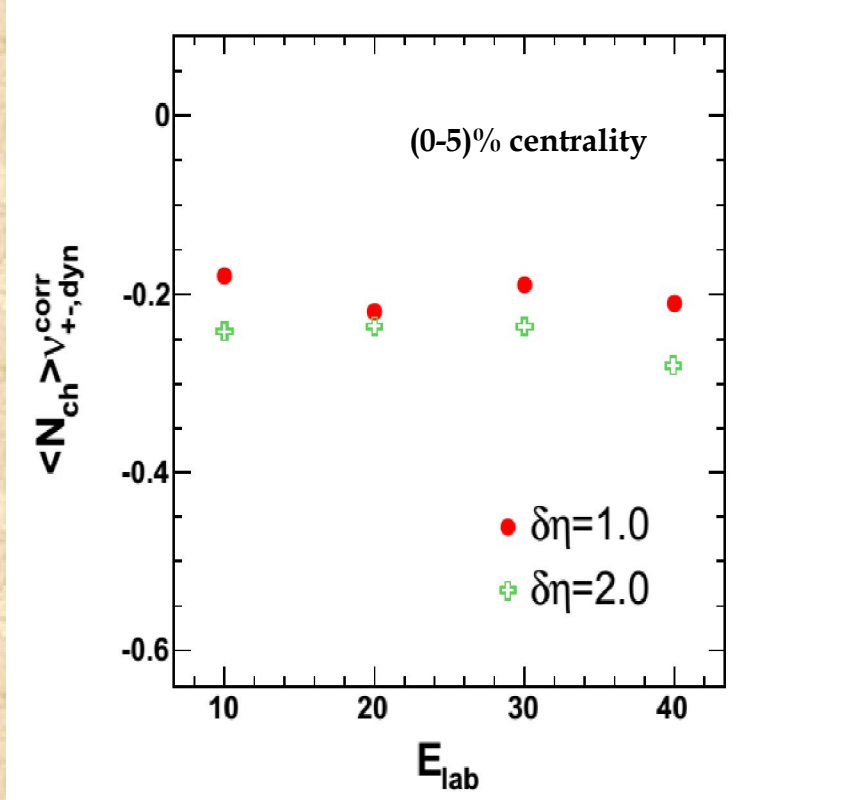
Fig: $\langle N_{ch} \rangle \nu^{corr}_{+-,dyn}$ as a function of centrality

Fluctuation falls to zero at higher δη value for higher energy

Centrality dependence becomes different, New result??

Beam energy dependence of dynamic charge fluctuation term:





Fluctuation increases continuously with increase in energy. $\langle N_{ch} \rangle$ $\nu^{corr}_{+-,dyn}$ however changes little.

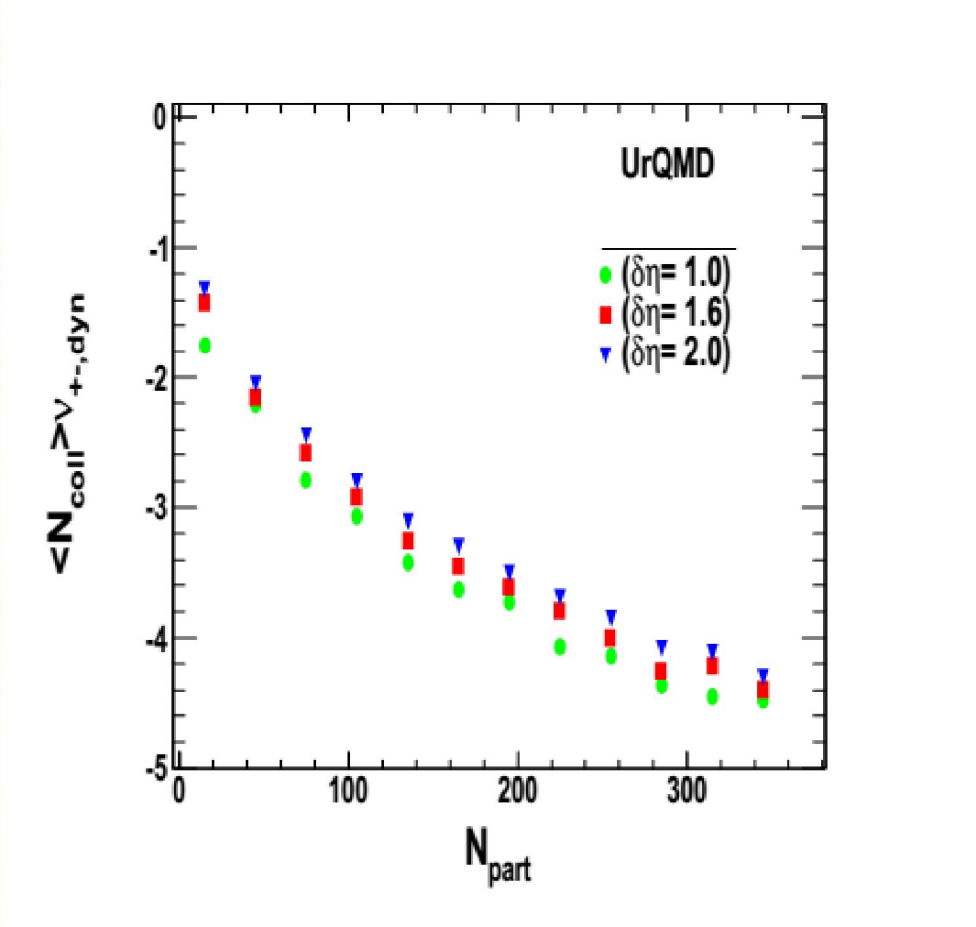
Summary & Future Agenda:

- A distinct centrality dependence achieved for UrQMD simulation.
- Most of the results achieved here are similar as other expt. (RHIC & LHC).
- The effect of global charge conservation does contradict with previous Results.
- In future we will study the azimuthal angle dependence also.
- We will also try to use other models . (PHSD)
- We have to compare the results with NA49 & other experimental datas.
- We are interested in studying e-by-e fluctuation of mean p_T & particle ratio fluctuation also.

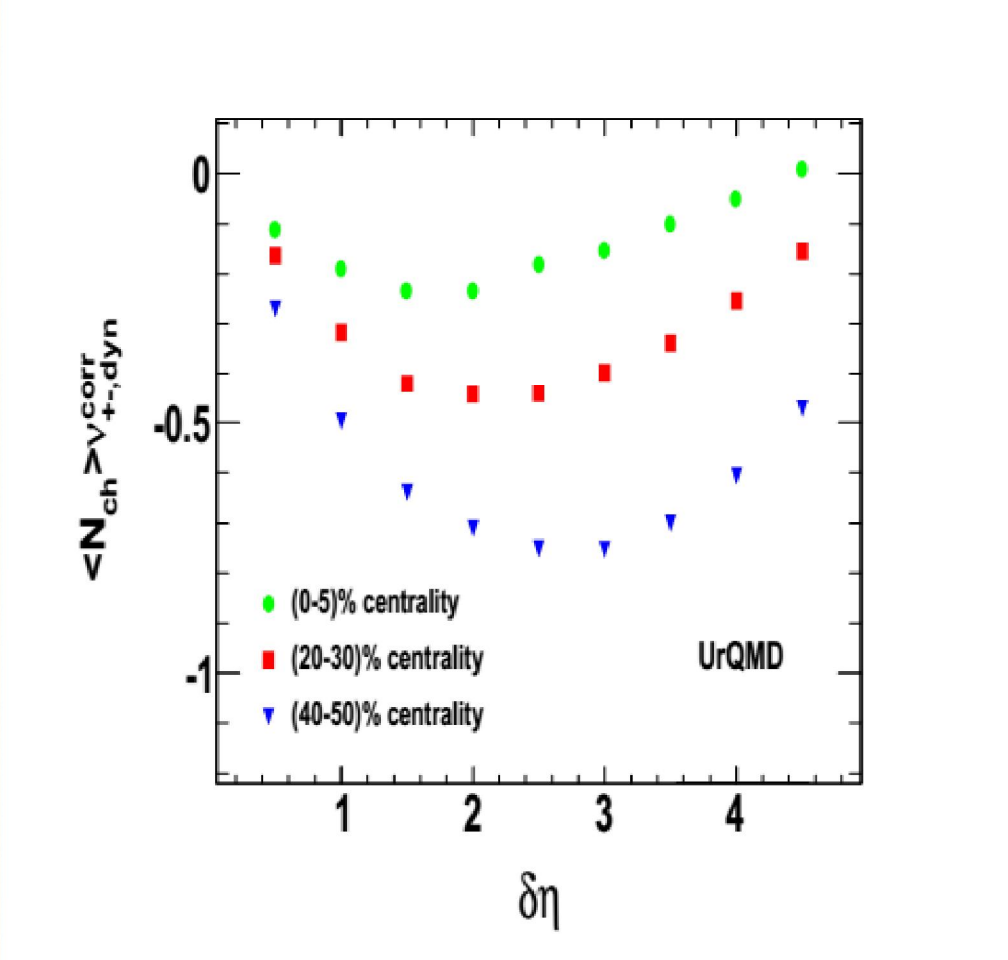
Thank

you

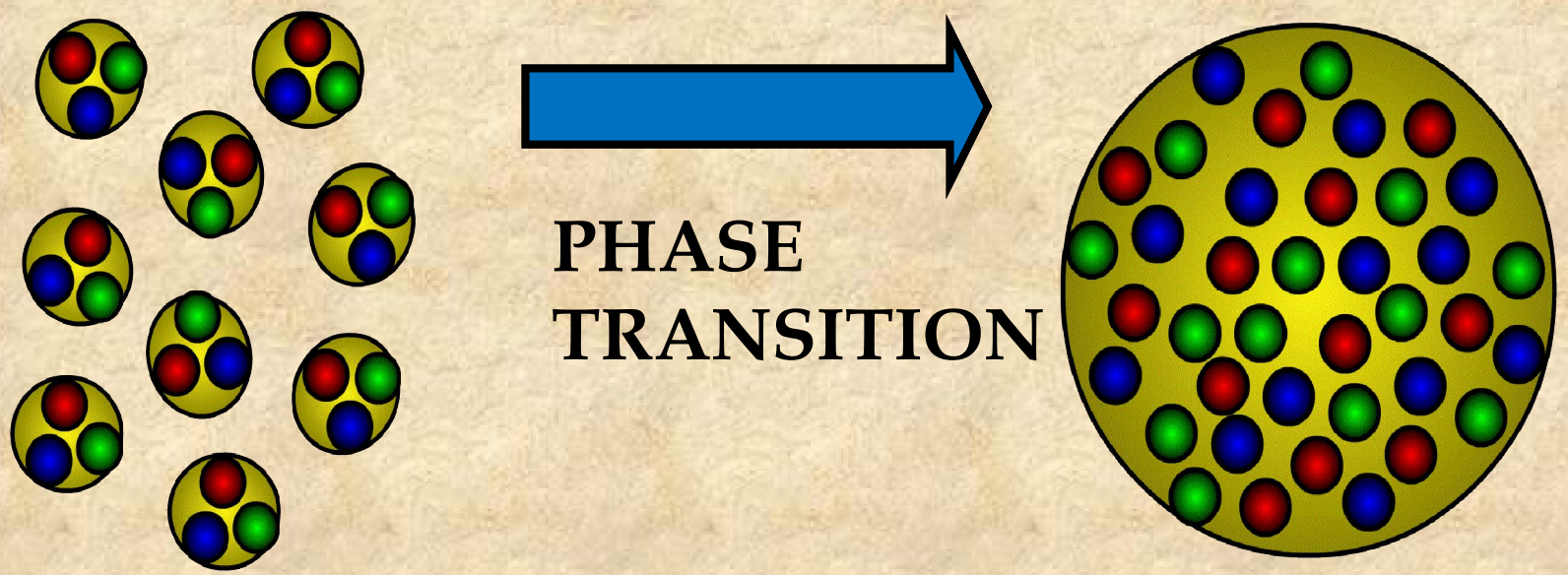
Back ups:


UrQMD
(δη= 1.0)
(δη= 1.6)
(δη= 2.0)
$\langle N_{coll} \rangle \nu_{+-,dyn}$
N_{part}
0
-1
-2
-3
-4
-5
0
100
200
300

Back up 3:


0
-0.5
-1
1
2
3
4
δη
$\langle N_{ch} \rangle \nu^{corr}_{+-,dyn}$
(0-5)% centrality
(20-30)% centrality
(40-50)% centrality
UrQMD

Quark Gluon Plasma



Hadron Gas

QGP

Deconfinement