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An investigation of forward-backward correlations in hybrid UrQMD-hydro generated data

Somen Gope

Supriya Das, Saikat Biswas

Bose Institute, Kolkata-700091, India

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Outline

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- Analysis detail
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- Results
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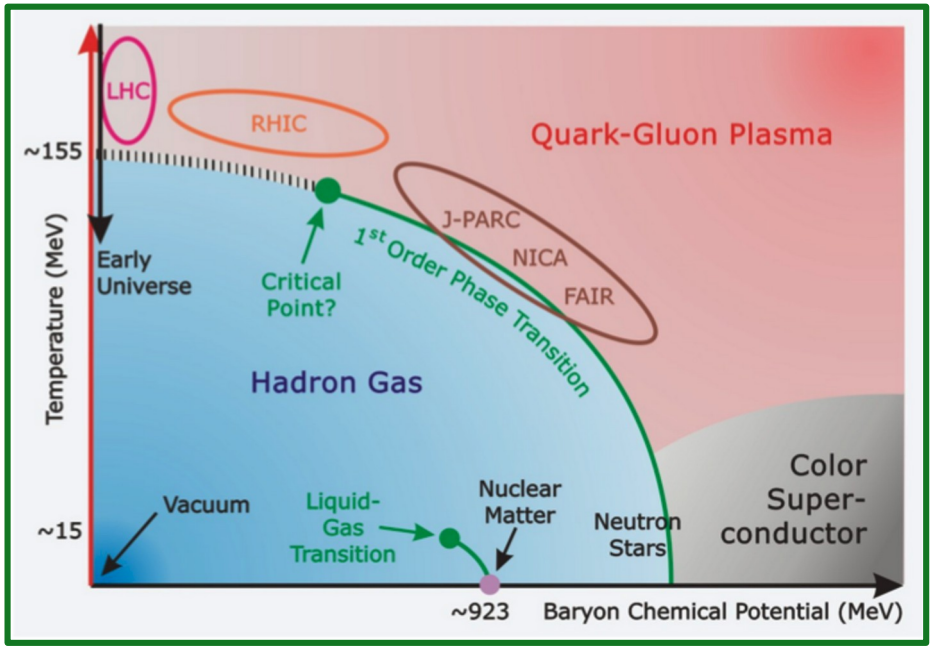
Introduction

- *There are various observables to study QGP or medium produced in HIC.*
  I. Studies of correlations & fluctuations.
  II. Strangeness enhancement.
  III. Flow etc.

- *Forward-backward correlations:*
  Understand the initial conditions and dynamics of the collision.
  F-B correlation can provide insights into:
- *The longitudinal and transvrese dynamics of the collision.*
- *The strenght and range of correlations between particles produced in different regions of the collision.*
- *The potential presence of collective effects such as flow, in the collision.*



https://www.gsi.de/work/forschung/theorie/theory-new/hot-and-dense-qcd

Motivation

Why FB correlation?

- *The primary goal of these analyses is to get insight into the space-time dynamics of the earlies stages of the reaction, probed via the long-range correlations.*
- *Sensitive to medium modifications in dense nuclear matter.*
- *Check the viability of model calculation.*
- *Large acceptance CBM detctor at 10 AGeV energy will be very much effective to study such observables.*

UrQMD-hydro model

Initialisation:

-> Initialization of two nuclei.

-> Non-equilibrium hadron-string dynamics.

-> Initial state fluctuations are included naturally.

-> E-by-E fluctuation are taken into account.

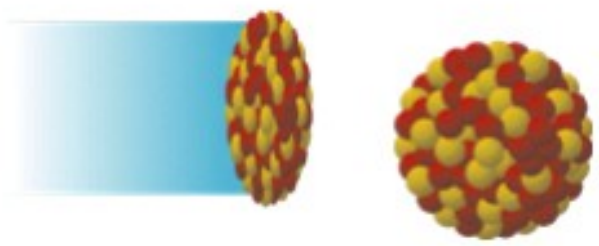
Intermediate state:

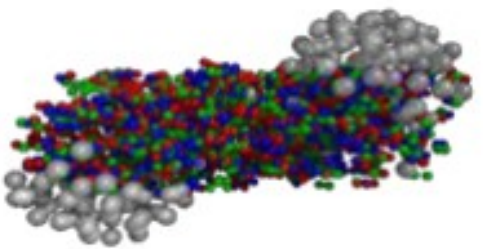
-> SHASTA ideal relativistic fluid dynamics.

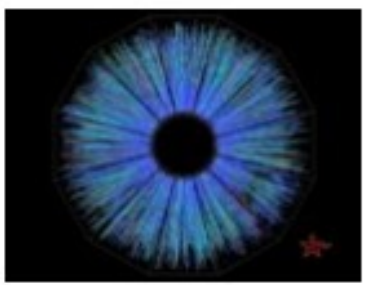
-> Net baryon density is explicitly propagated.

-> Equation of state at finit μ_B

$$p^\mu \cdot \partial_\mu f_i(x^\nu, p^\nu) = C_i \qquad d_{\min} \leq d_0 = \sqrt{\frac{\sigma_{tot}}{\pi}}$$







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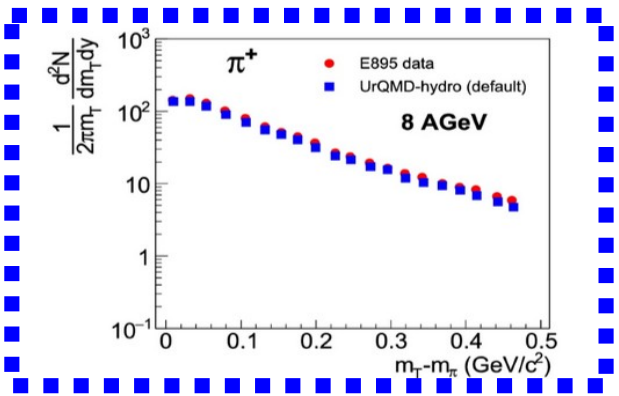
P. Huovinen, H. P. EPJ A48 (2012) 171

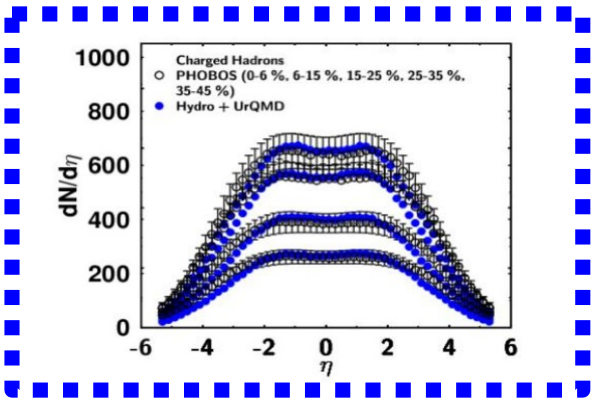
UrQMD-hydro model

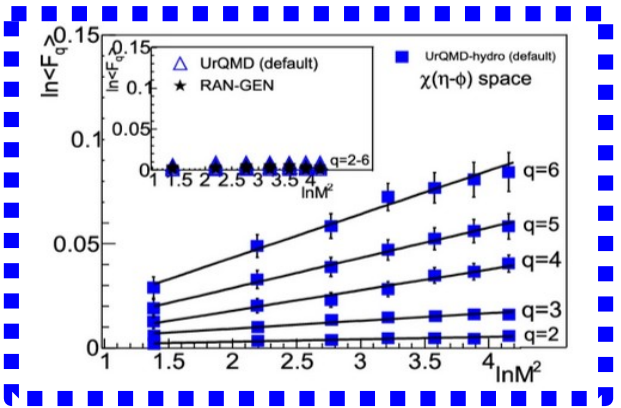
- *Initial state: All particles with their final positions and momenta.*
- *Transition from hydro to transport when ϵ<730 MeV/fm^3*
- *Particle distribution are generated according to Cooper-Frye (CF) formula. Rescattering & hadronic decays via hadronic cascade.*
- *Very successful in describing different observables in a broad energy range.*

Previously published results using UrQMD-hydro model

- *Succesfull in describing different observables in a broad range of energy.*







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Chiho Nonaka et al., J. Phys. G: Nucl. Part. Phys. 35 (2008) 104099 (4pp)

Mathematical formalism

$$b_{corr} = \frac{\langle N_F N_B \rangle - \langle N_F \rangle \langle N_B \rangle}{\langle N_F^2 \rangle - \langle N_F \rangle^2}$$

$$b_{corr} \propto \exp\left(-\frac{y_{gap}^2}{\delta^2}\right)$$

$$D_{BF}^2 = \langle N_B N_F \rangle - \langle N_B \rangle \langle N_F \rangle.$$

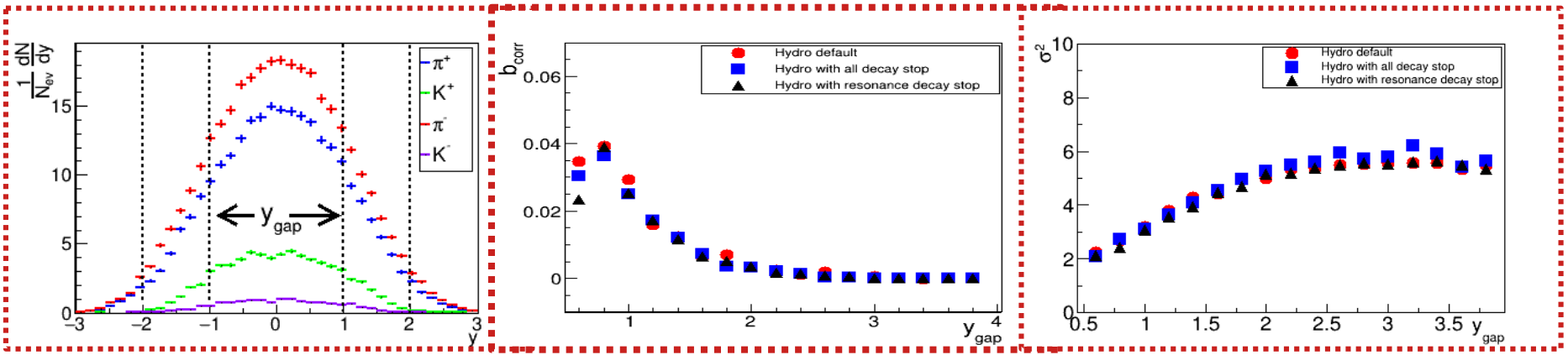
$$\sigma_c^2 = \frac{D_{FF}^2 + D_{BB}^2 - 2D_{FB}^2}{\langle N_F + N_B \rangle}$$

- b_{corr}: *This is a quantitative measure of the strength of the forward-backward correlation. It indicates how strongly fluctuations in particle production in the forward region are connected to those in the backward region.*
- *A high* b_{corr} *value suggests strong correlations, potentially due to mechanisms like string fragmentation, energy-momentum conservation, or collective flow effects.*
- *Sigma provides the type of correlation: long range or short range.*

Analysis Detail

- System: Au+Au
- Energy: 10 AGeV
- Centrality: b = 0-3 fm/c
- Event Generator: UrQMD-hydro
- Statistics: ~ 40 K

Results



- *When the forward and backward regions are close together in rapidity space, particles produced in these regions are strongly correlated because they originate from the same localized processes (e.g., string breaking, jet fragmentation).*

Results

- The Cooper-Frye equation incorporates the thermalization
- of the system at freeze-out.
- It would fail to reflect the thermal properties of the system
- at freeze-out, which is crucial for describing the transition
- from quark-gluon plasma to hadronized phase.

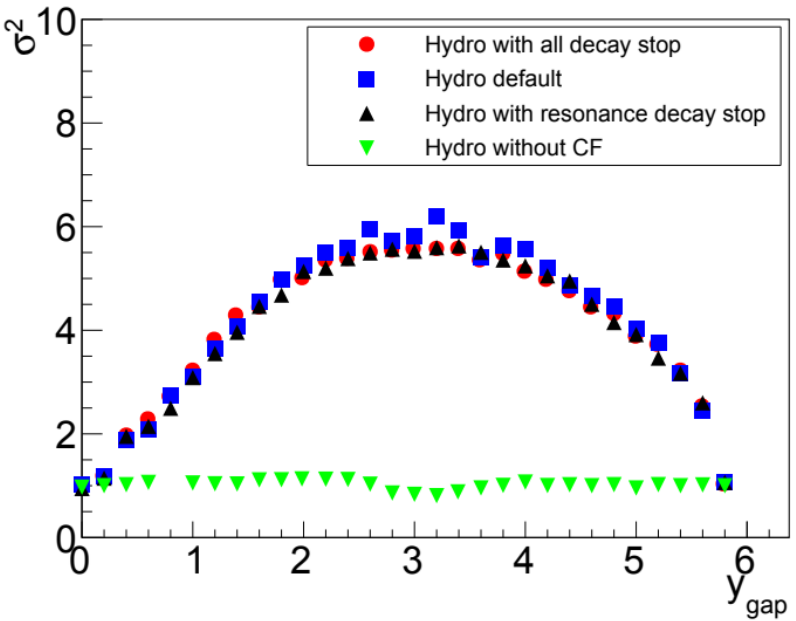
σ^2=1 (poisson limit) : indicates no clear, strong clustering of correlations occurs.

σ^2=1.5 (resonance limit) : dominance of long range correlation leads to increase in σ^2.

Cooper-Frye formula:

$$E\frac{dN}{d^3p} = \int_\sigma f(x,p)p^\mu d\sigma_\mu$$

f(x,p)- thermal distribution function.



Summary

- The FB multiplicity correlations are studied in rapidity sectors for Au-Au collisions at 10 AgeV.
- Our study confirms the results , namely, that for the UrQMD-hydro generated data at 10 AGeV shows stronger correlations.
- When disable Cooper-Frye approach, suddenly the there is flat plot of rapidity dependent variance. It indicates there is no correlation if we not consider thermalization.

Outlook:

- Have to check for various centrality classes and for minimum bias data.
- If possible: Tracking using CBM-ToF setup.

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Thanks for your attention!!