ISMD 2022 – August 02, 2022

Intermittency analysis of charged hadrons generated in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV and 5.02 TeV using Pythia8/Angantyr

Salman K Malik & Ramni Gupta

University of Jammu, Jammu, India

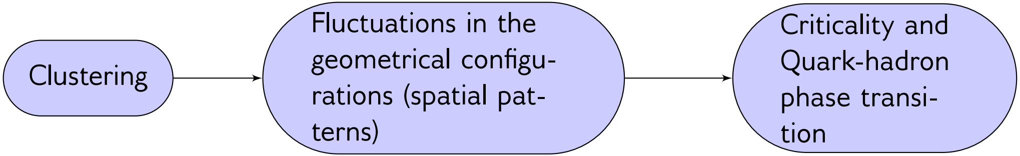
ISMD2022

Outline

1. Motivation
2. Formalism
3. Pythia8/Angantyr
4. Observations
5. Summary

Motivation

- As the system approaches critical temperature, tension between the collective interactions and thermal randomization increases leading to formation of clusters.
- In order to study the resultant scale-invariance in the system, a number of statistical tools are used in heavy-ion collisions.
- Study of fluctuations in the measurable quantities is an important tool to understand the dynamics of the particle production and phase changes.
- Large density fluctuations in the initial stage of collision transfer into final stage collective behaviout as the strongly coupled quark gluon pasma expands.

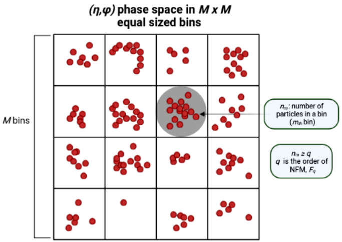


Scaling and Scaling exponent @ LHC energies?

Formalism

Fluctuations are characterized by moments of the particle density distribution within some phase space bins and one of such moments used over a range of bin sizes $\rightarrow$ **Normalized Factorial Moments.**

- For M number of bins, the q^{th} order NFM is defied as:



$$F_q(M) = \frac{\frac{1}{N}\sum_{e=1}^{N}\frac{1}{M}\sum_{i=1}^{M} f_q(n_{ie})}{\left(\frac{1}{N}\sum_{e=1}^{N}\frac{1}{M}\sum_{i=1}^{M} f_1(n_{ie})\right)}$$

where, N is the number of events and

$$f_q(n_{ie}) = \langle n_{ie}(n_{ie}-1)\ldots(n_{ie}-q+1)\rangle_h$$

F_q filters out statistical fluctuations. For purely statistical fluctuations, $F_q = 1$.

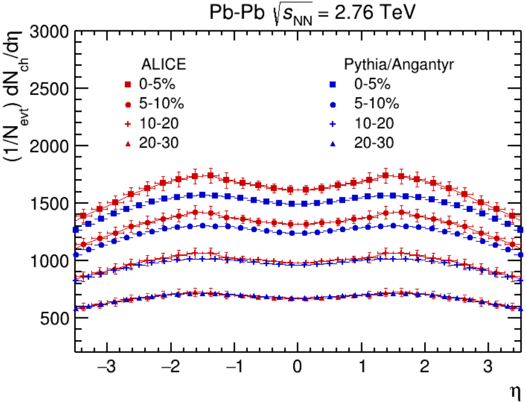
Formalism

Intermittency

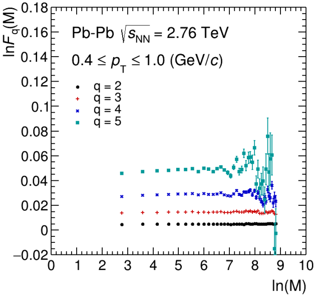
- In case of any scale-invariant pattern, NFMs are expected to scale as: $F_q \propto M^{\phi_q}$.
- Another dependence: $F_q \propto F_2(M)^{\beta_q}$.
- Both the dependencies are different because ϕ_q and β_q depend on different critical parameters.
- β_q is independent of the critical paramters of the system below critical temperature.
- Scaling exponent, ν: $\beta_q \propto (q-1)^{\nu}$.
- Predictions for ν:
  - 1.32 $_{Hwa:1992}$ $\rightarrow$ in case of Ginzburg-Landau formalism for the second-order PT.
  - 1.41 $_{Hwa:2011}$ $\rightarrow$ Critical fluctuations, SCR Model.

Pythia8/Angantyr

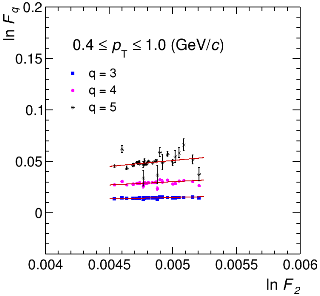
- Extrapolates pp dynamics, to heavy ion collisions.
- Dœsn't assume a hot thermalized medium.
- Motivation is to see differences between the model and experimental results which may show effects of collective behaviour.
- Intermittency observables are already calculated with AMPT $_{link}$, EPOS3$_{link}$ and ALICE PbPb 2.76 TeV$_{QM22poster}$.



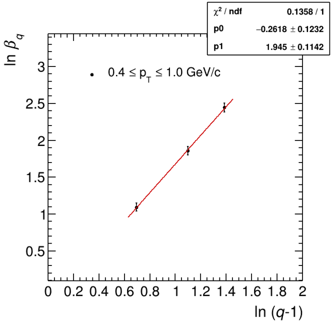
Observations



M-scaling



F-scaling

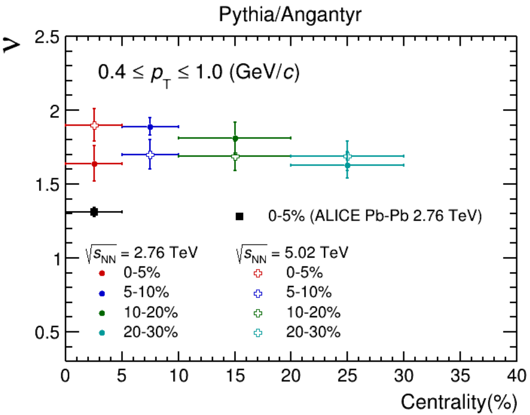


Scaling exponent

- Similar results are seen for 2.76 TeV and 5.02 TeV for all the centralities..
- For narrow width p_T bins ($0.4 \leq p_T \leq 0.6$, $0.6 \leq p_T \leq 0.8$, $0.8 \leq p_T \leq 1.0$), no signal of M-scaling or F-scaling, hence ν is not calculated.

Summary

- Neither M-scaling nor F-scaling observed in the particle generation particularly narrow p_T bins.
- Intermittency, hence scale-invariant fluctuations not present.
- The value of ν is $\sim 1.7 - 1.9, > 1.304$ for wide p_T bins and independent of centrality.
- Angantyr overestimates the predicted value of scaling exponent, ν.



THANK YOU