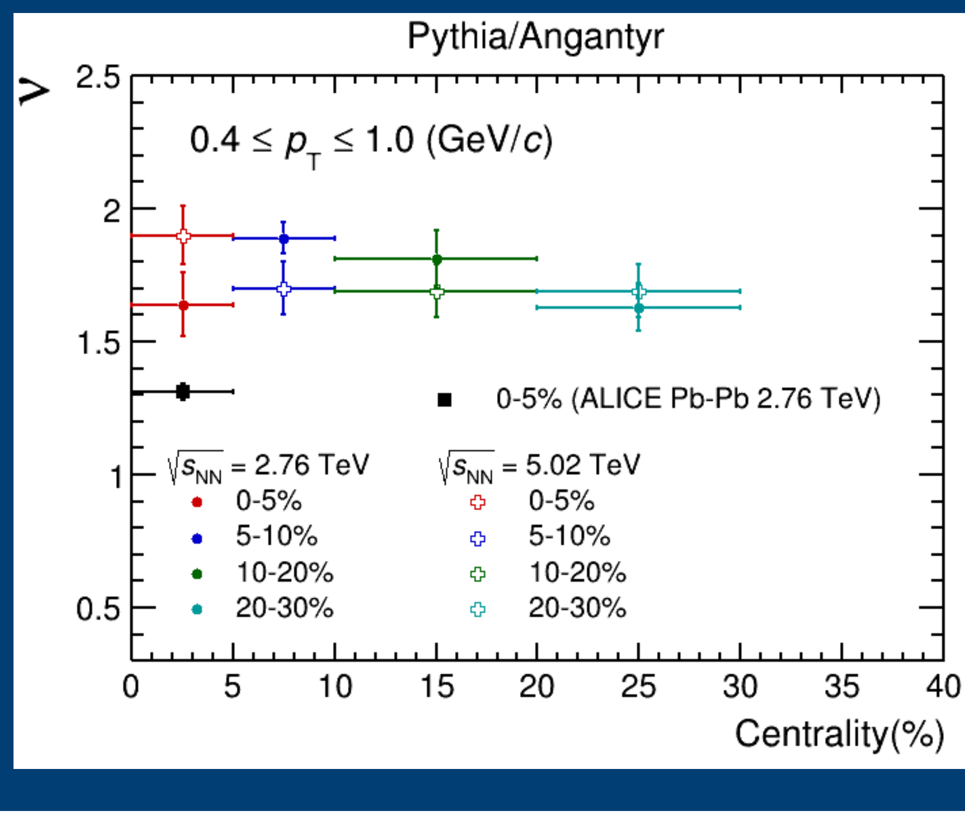
Conclusion

- Neither M-scaling nor F-scaling in the particle generation particularly narrow p_T bins.
- Intermittency and hence scale invariant fluctautions not present.
- For wide p_T bins, F-scaling observed with $\nu \sim 1.7 - 1.9 > 1.304$, the theoretical value predicted by GL theory for second-order phase transition.
- Scaling exponent is independent of centrality cut for wide p_T bins.
- Angantyr overestimates the value of scaling exponent compared with ALICE data for Pb-Pb collisions at $\sqrt{s_{NN}}$ =2.76 TeV.



Intermittency analysis of charged hadrons generated in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV and 5.02 TeV using PYTHIA8/Angantyr

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Introduction

- At $\mu_B > 0$ (baryonic chemical-potential), experimental approach to study phase-diagram is via event-by-event fluctuations.
- Non-monotonous increase in fluctuations near phase transition and critical point.
- At critical point, correlation increases rapidly, and the system becomes scale-invariant.
- It is given by the scaling behaviour of moments → Normalized Factorial Moments (NFMs) in our case.

Intermittency

NFMs are given by: *Bialas*:1988,*Bialas*:1985:

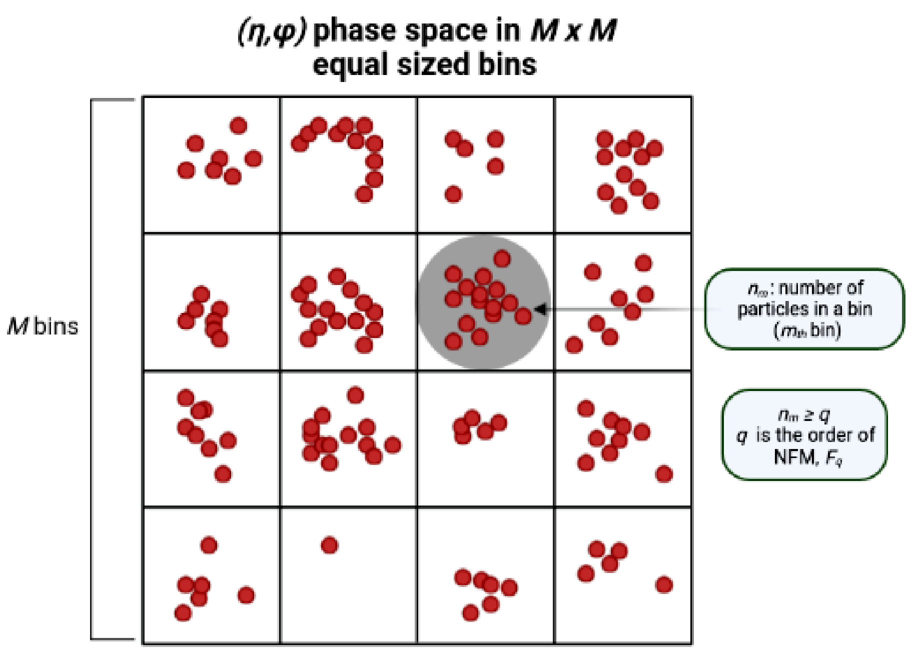
$$F_q(M) = \frac{\frac{1}{N}\sum_{e=1}^{N}\frac{1}{M}\sum_{m=1}^{M} f_q(n_{me})}{\left(\frac{1}{N}\sum_{e=1}^{N}\frac{1}{M}\sum_{m=1}^{M} f_1(n_{me})\right)^q}$$

where, $f_q(n_{me}) = \prod_{j=0}^{q-1}(n_{me} - j)$

q (order of the moment) ≥ 2

Scaling of F_q with the number of bins M:

- $F_q(M) \propto (M^D)^{\phi_q}$ → M-scaling
- Scaling of NFMs with M, number of bins is called *intermittency*.



M-scaling depends on different critical parameters of the system than F-scaling. F-scaling is defined as:

- $F_q(M) \propto F_2(M)^{\beta_q}$, where
- $\beta_q \propto (q-1)^{\nu}$

ν, the scaling exponent is independent of the critical paramters of the system. Predictions:

→ 1.304 in GL theory for second-order phase transition *Hwa*:1992

→ 1.0 in 2D Ising model *Hwa*:1992.

PYTHIA8/Angantyr

- Extrapolates pp dynamics, to heavy ion collisions, retaining as much as possible from pp.
- It does not assume a hot thermalised medium and is developed with the motivation that differences between the model and experimental results may show some effects of collective behaviour.
- Angantyr gives a good description of general final state properties, in p-Pb and Pb-Pb, Xe-Xe collisions. *Bierlich*:2018*xfw*.
- Intermittency analysis and more specifically, the value of ν (Scaling exponent) is already calculated with AMPT, EPOS3 and in a recent QM 2022 poster for ALICE data.

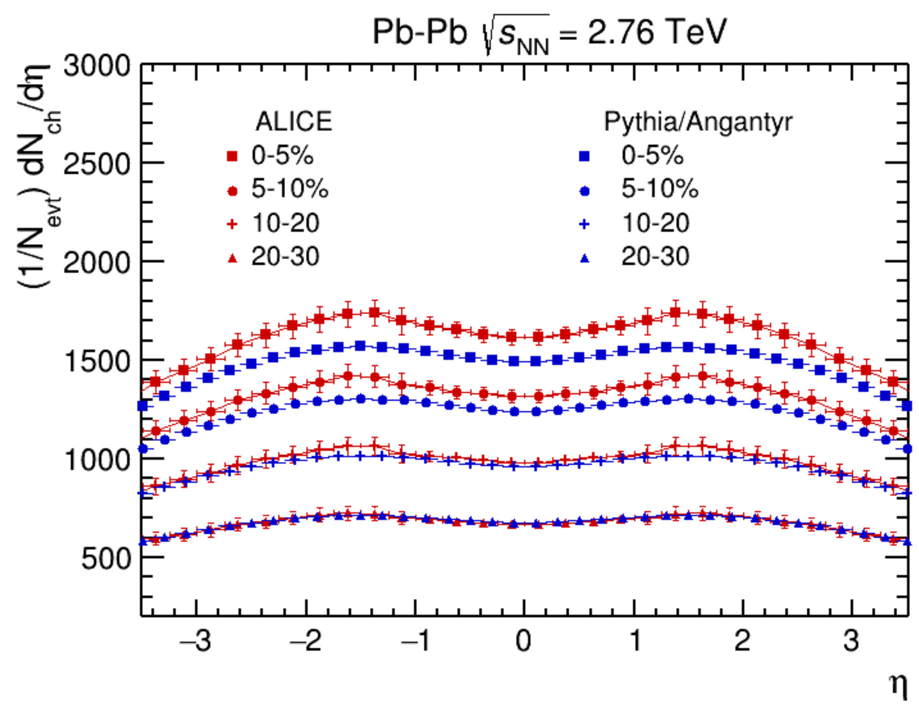
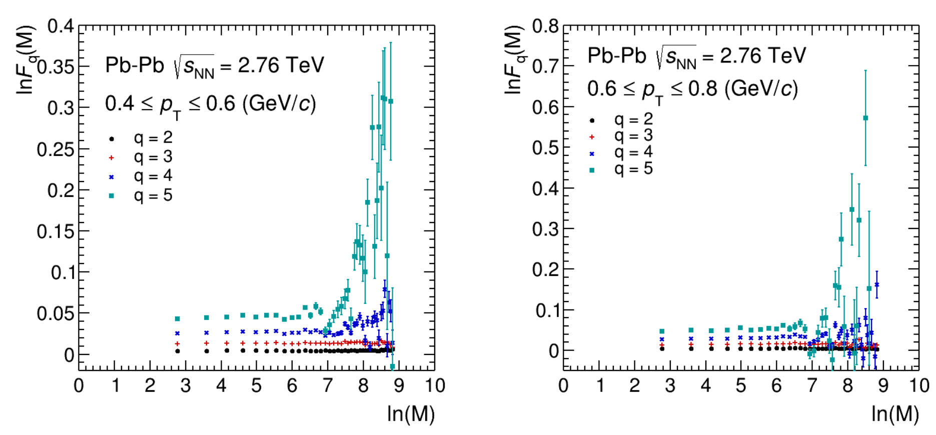


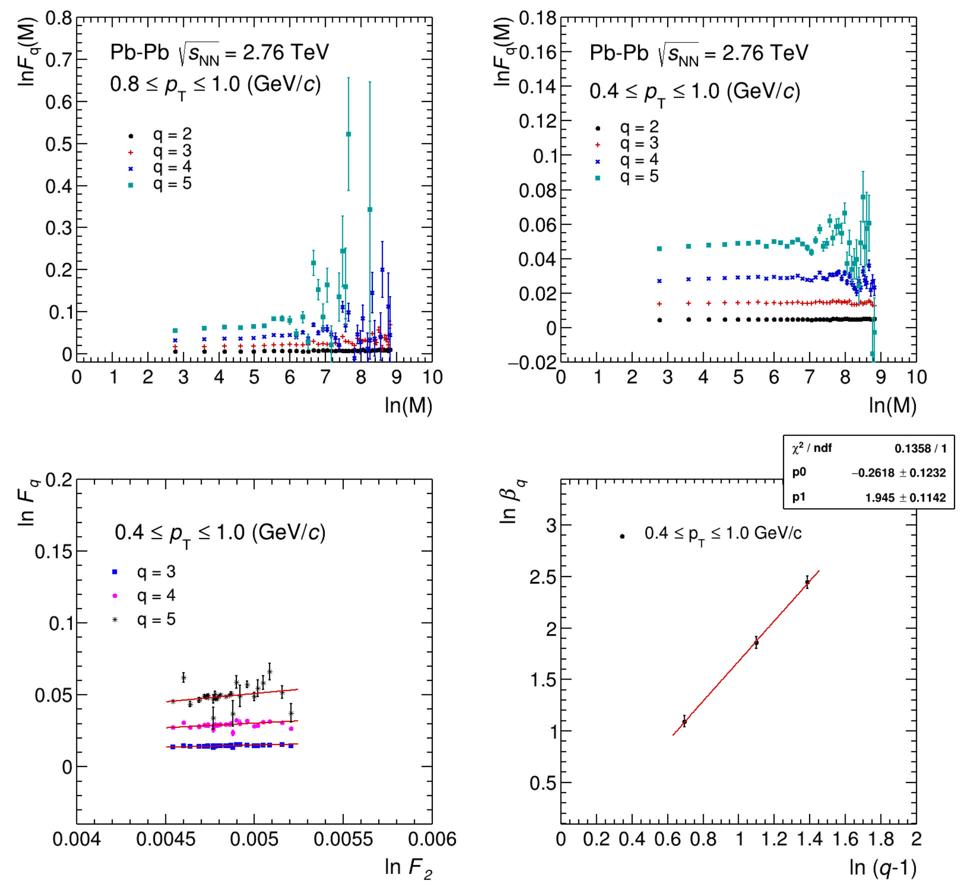
Fig: Charged particle pseudorapidity density distribution compared with ALICE data.

Observations

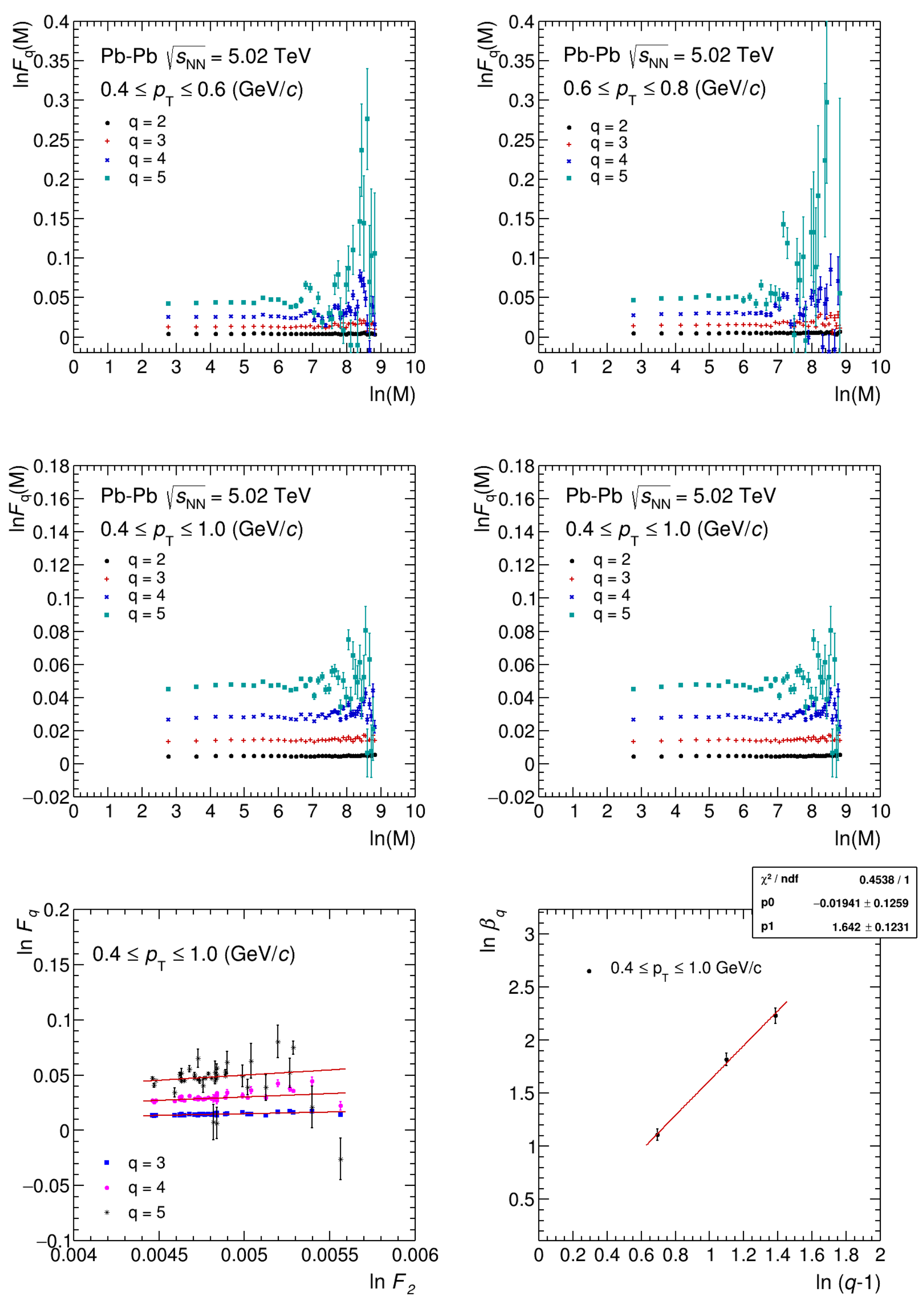
Intermittency analysis has been performed for various p_T bins ($0.4 \leq p_T \leq 1.0$, $0.4 \leq p_T \leq 0.6$, $0.6 \leq p_T \leq 0.8$, $0.8 \leq p_T \leq 1.0$ GeV/c) at $\sqrt{s_{NN}} = 2.76$ & 5.02 TeV for different centralities.

2.76 TeV: ~2M events, 0-5 % centrality

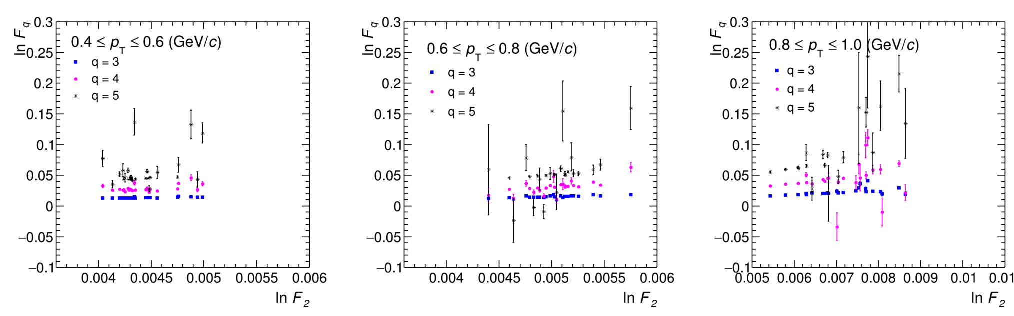




5.02 TeV: ~1M events, 0-5 % centrality



Figures show M-scaling for four p_T bins, at two different energies and F-scaling, ν for $0.4 \leq p_T \leq 1.0 GeV/c$. For smaller width p_T bins, no F-scaling is observed, and hence ν is not calculated.



The Tenth Annual Large Hadron Collider Physics (LHCP2022),Taiwan (Online)