Intermittency analysis of charged hadrons generated in Pb-Pb collision at √s = 2.76 TeV and 5.02 TeV using PYTHIA8/Angantyr

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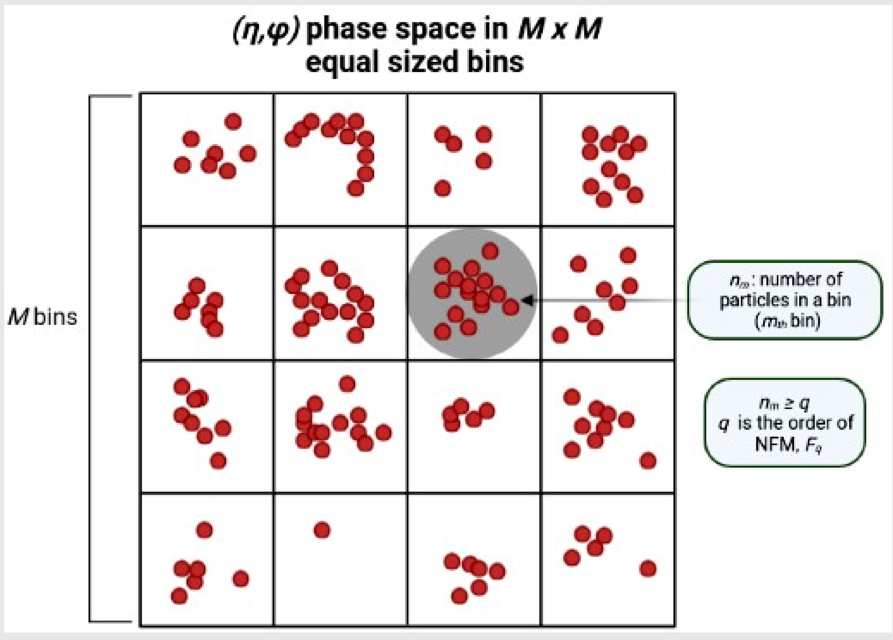
1. Motivation and Formalism

- Event-by-event fluctuations: Experimental approach to study QCD phase diagram at non-zero baryonic chemical potential ($\mu_B > 0$).
- Fluctuations: Non-monotonous increase in fluctuations of order-parameter as system approaches phase transition, critical point.
- Correlation lengths increase rapidly and the system becomes scale - invariant.

Normalized Factorial Moments $F_q(M)$ [1,2]

- Scale-invariance is given by the behaviour of factorial moments.

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



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

- M: number of equal-sized phase space bins
- q is the order of the moment and is constrained to be ≥ 2
- F_q filters out statistical fluctuations.

M-scaling In case of any scale-invariant pattern in the distribution of particles, it is expected that $F_q(M) \propto (M^D)^{\phi_q}$

Scaling of different orders of NFMs, F_q with diminishing bins M is termed as **Intermittency**

F-scaling Intermittency in the framework of Ginzburg-Landau formalism is given by: $F_q(M) \propto F_2(M)^{\beta_q}$

where $\beta_q \propto (q-1)^{\nu}$

β_q and Φ_q depend on different critical parameters : M-scaling and F-scaling can be both independently analyzed

Predictions for ν :
1.304 (GL theory) for second-order PT [3]
1.0 (2D Ising model) [4]

Scaling exponent, ν : independent of the critical parameters of the system

Motivation is to look for scaling behaviour and the value of scaling exponent at LHC energies

2. 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 pPb and PbPb, XeXe collisions [5].
- Intermittency analysis and more specifically, the value of scaling exponent) is already calculated with AMPT[6], EPOS3 and in a recent QM 2022 poster for ALICE data.

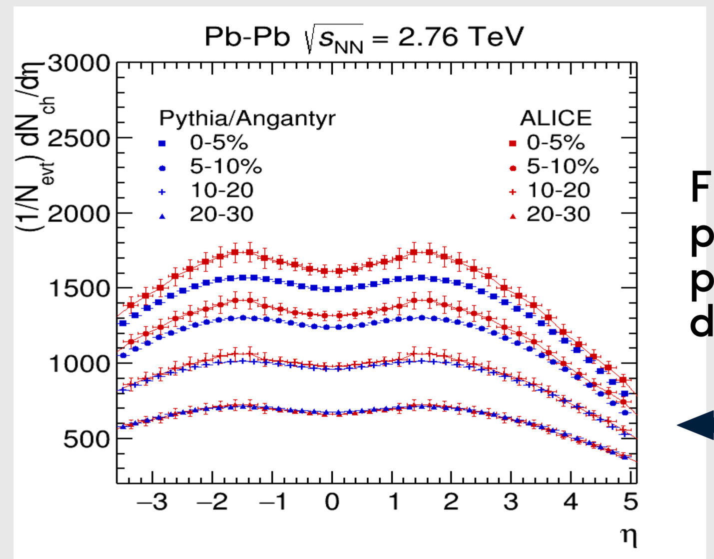
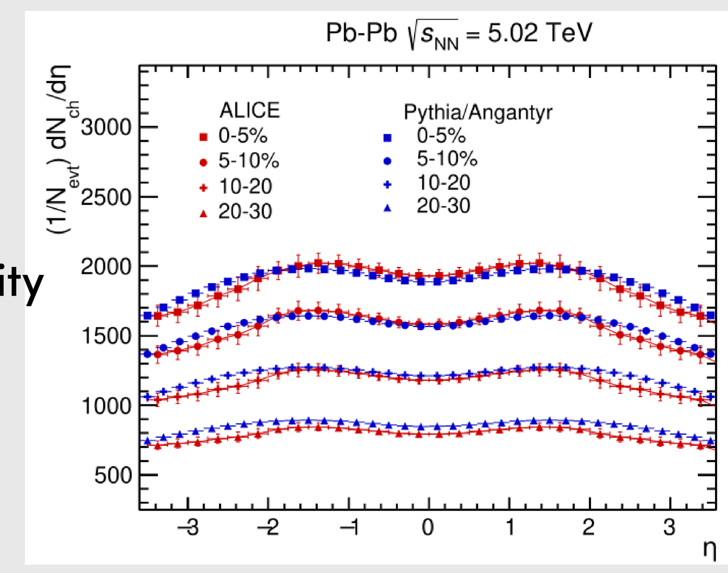


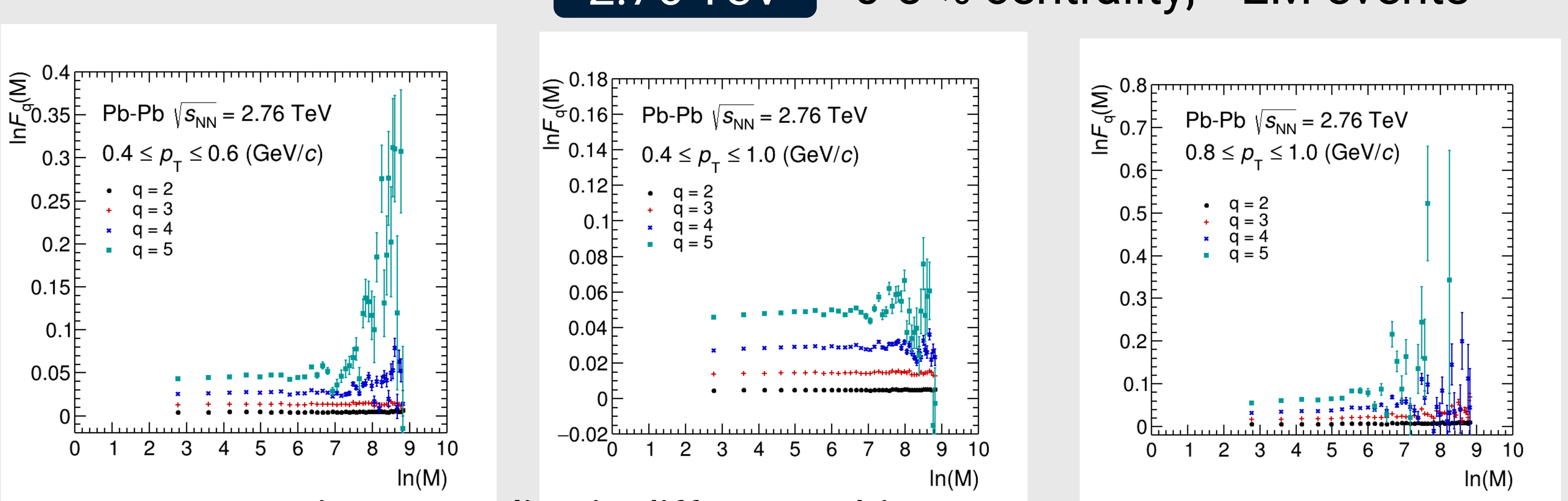
Fig: Charged particle pseudorapidity distribution
2.76 TeV
5.02 TeV



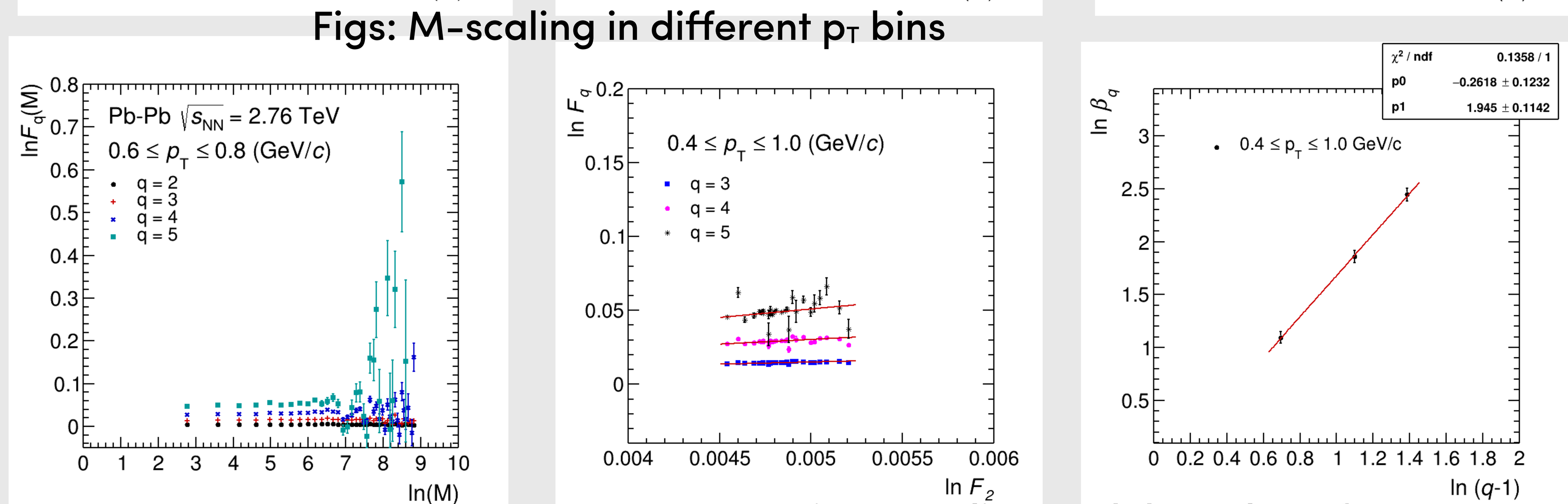
3. Results

Analysis has been performed for various p_T bins: 0.4 ≤ p_T ≤ 1.0, 0.4 ≤ p_T ≤ 0.6, 0.6 ≤ p_T ≤ 0.8 and 0.8 ≤ p_T ≤ 1.0 at √s = 2.76 TeV, 5.02 TeV for different centralities.

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

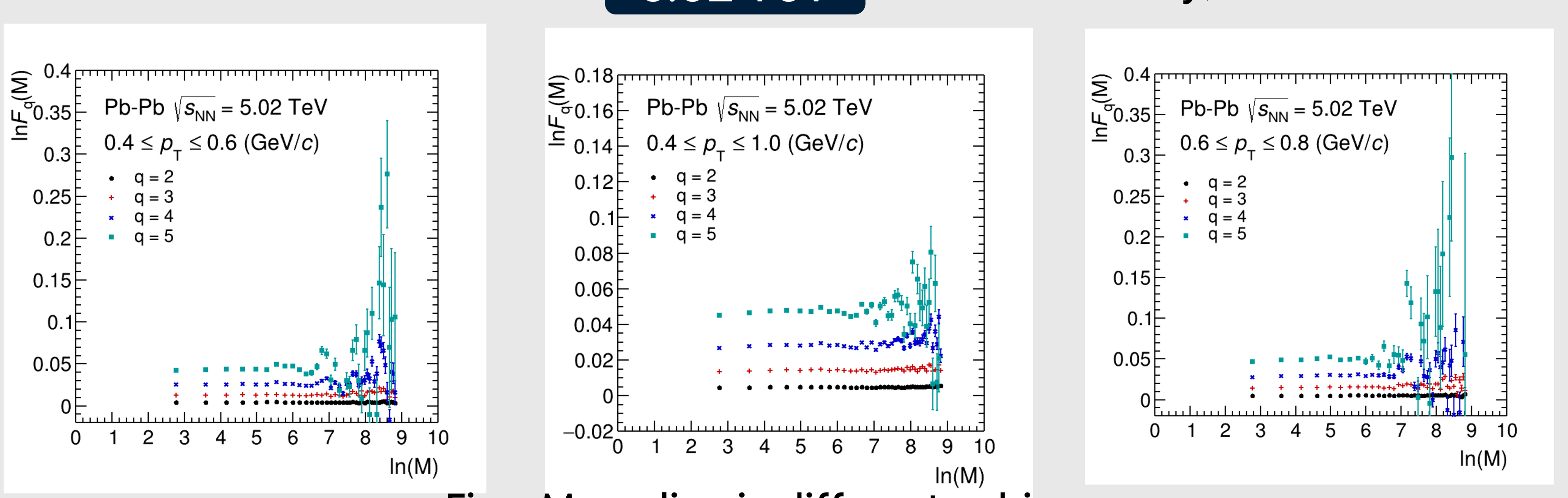


Figs: M-scaling in different p_T bins



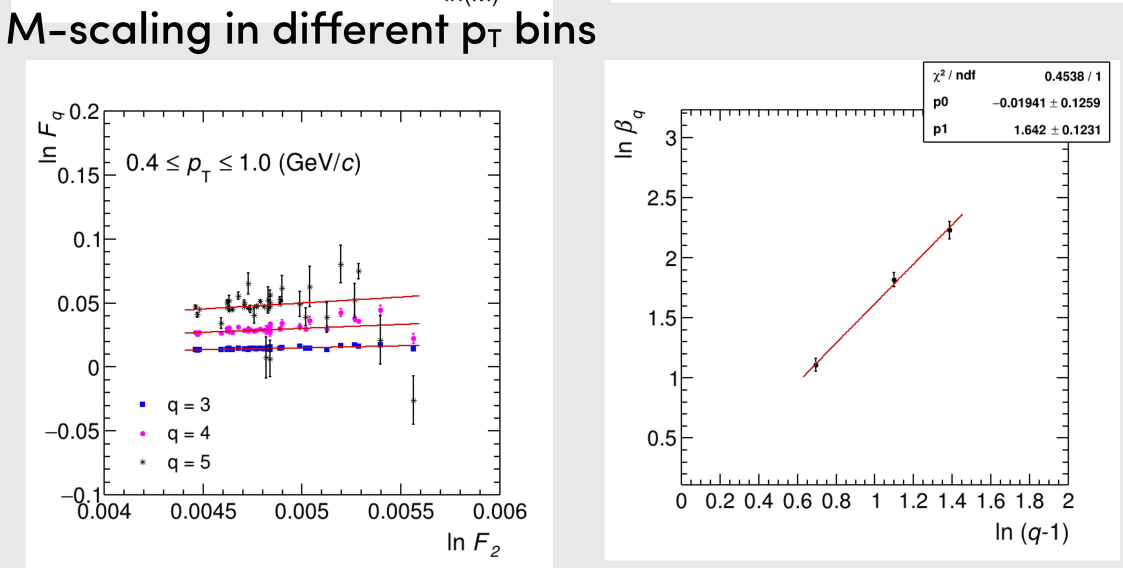
Figs: F-saling and the value of ν

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

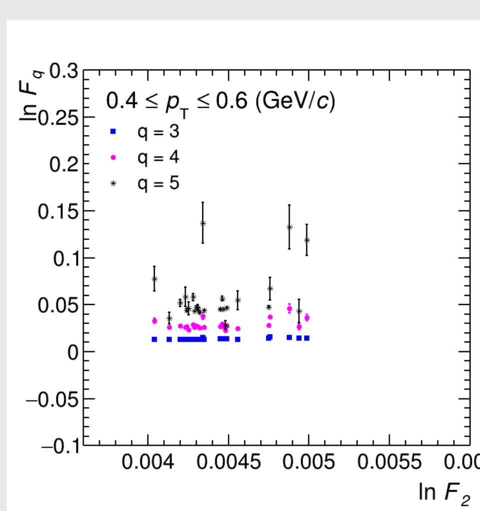


Figs: M-scaling in different p_T bins

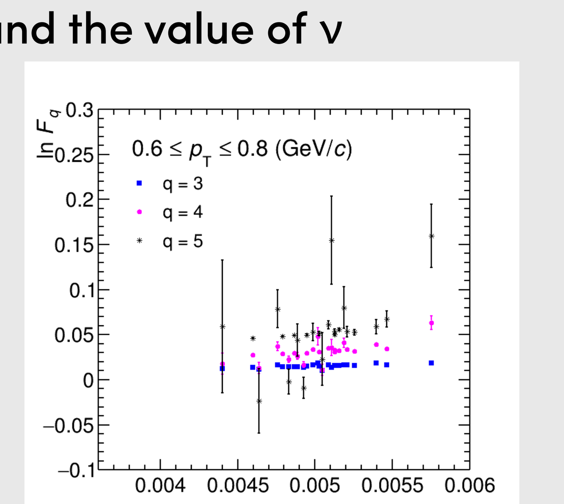
Similar results can be seen for both the energies, even when 2.76 TeV has a much larger statitistics



Figs: F-saling and the value of ν



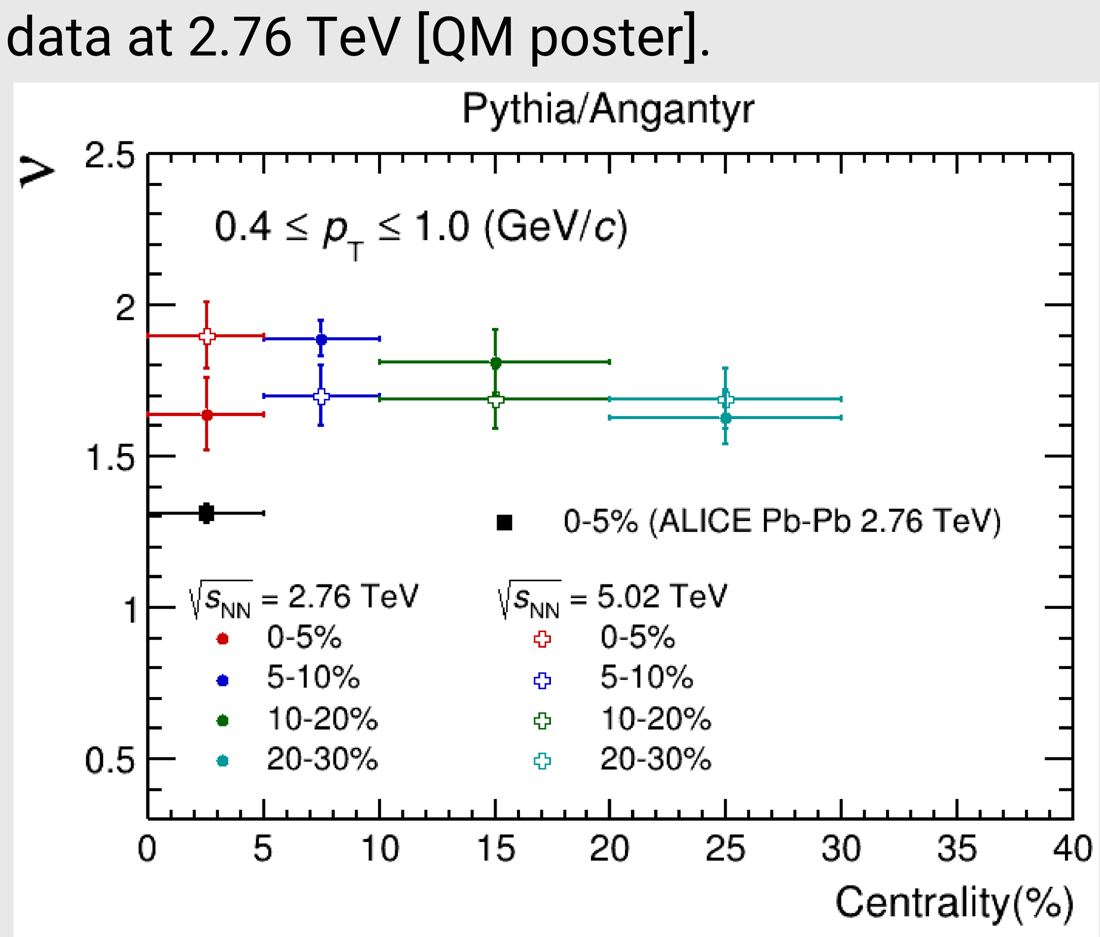
Figs: For smaller width p_T bins, no F-scaling is observed and thus ν cannot be calculated



Conclusions:

- Neither M-scaling nor F-scaling in the particle generation particularly narrow p_T bins.
- Intermittency, hence scale-invariant fluctuations not present.
- In case of wide bins, F-scaling observed and the value of ν is calculated **~ 1.7–1.9** and **> 1.304**, the value given by GL theory for second-order PT.
- Scaling exponent is independent of centrality ranges for wide p_T bin.
- Angantyr overestimates the value of scaling exponent, ν compared with ALICE data at 2.76 TeV [QM poster].

Dependence of ν on centrality



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