Event-by-event local multiplicity fluctuations in charged particle production at the LHC energies with ALICE

Salman Khurshid Malik,* Sheetal Sharma, and Ramni Gupta
(for ALICE Collaboration)
Department of Physics, University of Jammu, Jammu-180006, India.

Introduction

The plasma of strongly interacting quarks and gluons (QGP) is formed in ultra-relativistic heavy-ion collisions. Charged particle multiplicity fluctuations are one of the key observables for studying the properties of the QGP formed in such collisions, in particular the phase transition from QGP to hadron gas. Local phase space fluctuations are sensitive to this phase transition. They are studied using the Normalized Factorial Moments (NFM), denoted as $F_q(M)$ which are extracted from the spatial configurations of charged particles in pseudorapidity, η and azimuthal angle, φ phase space as shown in Fig. 1.

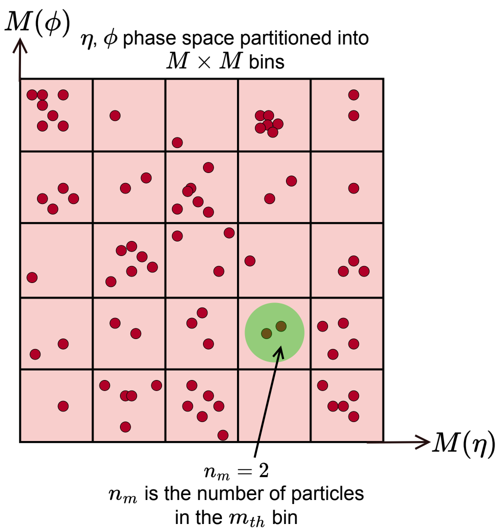

FIG. 1: Illustration of charged particle distributions in bins of the (η, φ) phase space.

The NFMs are defined as

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

where $f_q(n_{me}) = \prod_{j=0}^{q-1}(n_{me} - j)$, e stands for the event, q is the order of the moments and is always ≥ 2. They are sensitive to the distribution of charged particles within the phase space bin and to the correlation between bins. For a system with dynamical fluctuations due to the characteristic critical behavior near the phase transition, $F_q(M)$ exhibits a power-law growth with increasing bin number, i.e., with decreasing bin size [1, 2], indicating self-similar fluctuations. This behavior is referred to as M-scaling

$$F_q(M) \propto (M^2)^{\phi_q},$$

where ϕ_q is the intermittency index. Besides, in the framework of the Ginzburg-Landau theory [3, 4], the qth order NFM is related to the second-order NFM ($F_2(M)$) by the so-called F-scaling

$$F_q(M) \propto F_2(M)^{\beta_q}.$$

The intermittency index, ϕ_q depends on critical parameters that differ from those affecting β_q . Therefore, even if M-scaling is absent in a system, it is still feasible to look for an F-scaling. The β_q is described by the scaling exponent, ν [5] as

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

The value of ν is 1.304 based on Ginzburg-Landau theory and 1.0 for the 2D Ising model [5–7].

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*Email: `salman.khurshid.malik@cern.ch`

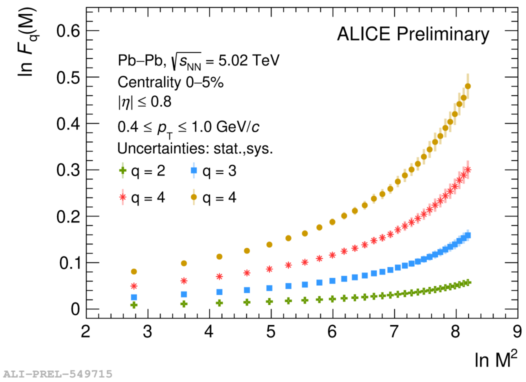

FIG. 2: Mscaling for the transverse momentum interval of $0.4 \leq p_T \leq 1$ GeV/c.

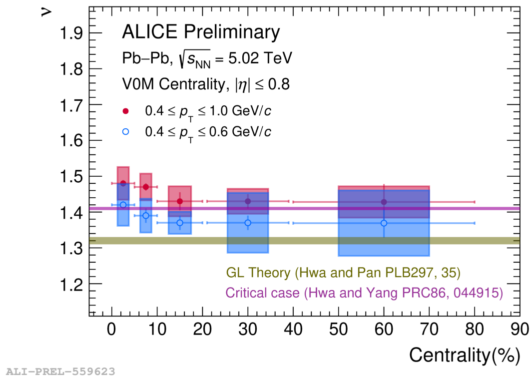

FIG. 3: Dependence of scaling exponent, ν for two p_T intervals: $0.4 \leq p_T \leq 1$ GeV/c and $0.4 \leq p_T \leq 0.6$ GeV/c.

In this report, the factorial moments of charged particle multiplicity distributions are studied in central Pb–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, in ALICE at the LHC.

Analysis

Analysis is performed for events selected using a minimum-bias trigger that requires signals in both V0A ($2.8 < \eta < 5.1$) and V0C ($-3.7 < \eta < -1.7$) detectors. The position of the primary vertex was required to be within $\pm$ 10 cm from the nominal interaction point. Charged particle tracks are reconstructed within the central barrel of ALICE with full azimuthal coverage in $0.4 \leq p_T \leq 1$ GeV/c and $|\eta| < 0.8$.

Results

Figure 2 shows the dependence of the NFMs up to 5th order as a function of phase-space bin resolution. The observed power-law increase indicates a scale-invariant pattern. Dependence of scaling exponent, ν on the collision centrality is shown in Fig. 3 for two different p_T intervals. There is a slight decrease in values with the increasing centrality for both p_T intervals. The values agree with GL formalism [7] and SCR model [1] within the experimental uncertainties.

References

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