Charge Fluctuations measured by the ALICE experiment at LHC.

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Charge fluctuations provide a possible signature for the existence of the de-confined Quark Gluon Plasma phase (QGP). Being sensitive to the square of the charges, the fluctuations in QGP, with fractionally charged partons, are significantly different from those of a hadron gas with unit charged particles. Studies of charge fluctuations have been carried out by using the variable, $\nu_{(+-,dyn)}$ which, by its construction, is free from the collisional bias (impact parameter fluctuations and fluctuations from the finite number of charged particles within the detector acceptance). The dependence of charge fluctuations on the rapidity windows for various centrality bins is analyzed for Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV in the ALICE experiment at CERN-LHC. A scaling behavior is observed as a function of increasing pseudo-rapidity window for the charge fluctuations, expressed in terms of $\nu_{(+-,dyn.)} \times N_{ch}$, where N_{ch} is the number of charged particles. The results will be compared to exprimental measurements at lower energies and to model predictions.

Introduction

The presence of the phase transition can manifest itself by the characteristic behavior of several observables which may vary dramatically from one event to the other. Thus the study of various conserved quantities on an event-by-event basis offers the possibility for studying the QGP phase transition and the nature of the high density quark matter. The collisions of ultrarelativistic particles can produce such new state of matter, which is characterized by high temperature and energy density, where the degrees of freedom are given no more by the hadrons but by their constituents, the quarks and the gluons (quark gluon plasma - QGP).

ALICE experiment [1], located at the CERN LHC, is a multi-purpose experiment with highly sensitive detectors around the interaction point. The central detectors that cover the region $|\eta| < 0.9$, provide good reconstruction and particle identification capabilities as well as momentum measurements for each particle species in every event. The forward detectors extend the coverage of charged particles and photons. A combination of the information given by these detectors provides excellent opportunity to study the fluctuations and correlations of physics observables on an event-by-event basis at the LHC.

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Net charge fluctuation

The fluctuations of net–charge depend on the squares of the charge states present in the system. The QGP phase, having the quarks as the charge carriers, should result into a significantly different fluctuations magnitude compared to a hadron gas (HG). Net–charge fluctuations may be expressed by the quantity D, defined as [3]:

$$D = 4\frac{\langle \delta Q^2 \rangle}{N_{\rm ch}}, \tag{1}$$

where $\langle \delta Q^2 \rangle$ is the variance of the net–charge Q with $Q = N_+ - N_-$ and $N_{\rm ch} = N_+ + N_-$. Here N_+ and N_- are the numbers of positive and negative particles. The event–by–event net–charge fluctuations are best studied in the experiments by calculating the quantity $\nu_{(+-,dyn.)}$, defined as

$$\nu_{(+-,dyn)} = \frac{\langle N_+(N_+-1)\rangle}{\langle N_+\rangle^2} + \frac{\langle N_-(N_--1)\rangle}{\langle N_-\rangle^2} -2\frac{\langle N_-N_+\rangle}{\langle N_-\rangle\langle N_+\rangle}, \tag{2}$$

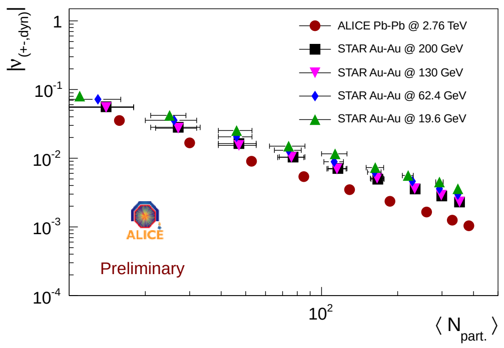

FIG. 1: The absolute value of $\nu_{+-,dyn}$, as a function of the collision centrality compared with same at low energies.

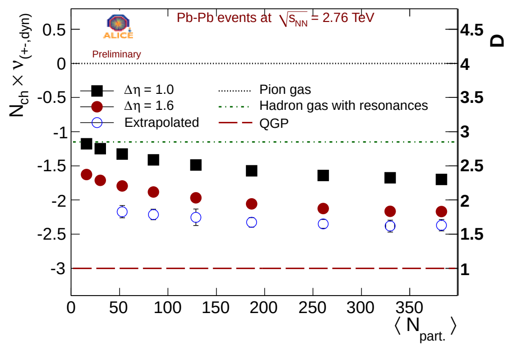

FIG. 2: The net–charge fluctuations, measured in terms of N$_{ch}$ $\times$ $\nu_{+-,dyn}$, as a function of the collision centrality

where the notation $\langle ... \rangle$ denotes an average of the quantity over an ensemble of events. The $\nu_{(+-,dyn.)}$ has been found to be independent of detector acceptance and efficiencies, and is related to D by

$$\nu_{(+-,dyn)} \times \langle N_{\rm ch} \rangle \approx D - 4. \qquad (3)$$

Analysis and results

For this analysis we used the Time Projection Chamber which provides a uniform acceptance with a tracking efficiency which is uniform. The interaction vertex was obtained from the Silicon Pixel Detector, the innermost detector of the Inner Tracking System of ALICE [1]. We considered in the analysis only events with a vertex found in $|z| < 10$ cm The trigger consisted of a hit on both sides of the VZERO scintillator hodoscopes in coincidence with a signal from the silicon pixel detector. We removed the background events offline using the VZERO timing information and the requirement of at least two tracks in the central detectors.

Figure 1 represents the absolute value of the dynamical net charge fluctuations, $\nu_{(+-,dyn.)}$, as a function of number of participants in Pb–Pb collision ar $\sqrt{s_{NN}}$ = 2.76 TeV and Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6, 62.4, 130, and 200 GeV. In this figure, we see that the dynamical net charge fluctuations, in general, exhibit a monotonic dependence on the number of participating nucleons.

Figure 2 presents the net–charge fluctuations, expressed in terms of $\nu_{(+-,dyn.)} \times N_{ch}$ and D (left– and right–axis, respectively) as a function of the number of participating nucleons, for three different $\Delta\eta$ windows, $\Delta\eta = 1$, $\Delta\eta = 1.6$ and the extrapolation at the asymptotic values. By compairing the measured value with the theoretically predicted fluctuations [3, 4], we note that our results are within the limits of the QGP and the HG scenarios. Since the fluctuations should normally grow in the process of the evolution of the system till freeze–out, the value obtained by the experiment might have its origin from a QGP phase.

In summary, the first measurement of the dynamic netcharge fluctuations at the LHC for Pb–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV using the variable $\nu_{(+-,dyn.)}$will be presented. Along with this, the energy dependence of the dynamical fluctuations will be discussed in detail.

References

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