Charge fluctuations in Pb–Pb collisions at $\sqrt{s_{NN}}$ =2.76 TeV measured by ALICE experiment at LHC

(Satyajit Jena for ALICE Collaboration)*
IIT Bombay, Powai, Mumbai - 400085, INDIA

Charge fluctuations are considered to provide a possible signature for the existence of the de-confined Quark Gluon Plasma phase (QGP). Charge fluctuations are sensitive to the number of charges in the system, thus the fluctuations in the QGP, with fractionally charged partons, are significantly different from those of hadron gas with unit charged particles. The study of charge fluctuations have been carried out by using the variable, $\nu_{(+-,dyn)}$ and the dependence of charge fluctuations on the rapidity windows for various centrality bins are analyzed for Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV in the ALICE experiment at CERN-LHC. The results are compared to experimental measurements at lower energies and to model predictions.

The presence of the phase transition can manifest itself by the characteristic behavior of several observable which may vary dramatically from one event to the other. Heavy-ion collisions at ultra-relativistic energies can produce a new state of matter, which is characterized by high temperature and energy density, where the degrees of freedom are given no more by hadrons but by their constituents, the quarks and gluons. The ALICE experiment [1], located at the CERN LHC, is a multi-purpose experiment with highly sensitive detectors around the interaction point. The central detectors cover the pseudo-rapidity region $|\eta| < 0.9$, with good momentum measurement as well as good impact parameter resolution. This gives us an excellent opportunity to study the fluctuations and correlations of physical observable on an event–by–event basis. Details of the ALICE experiment and its detectors may be found in ref.[1].

The fluctuations of net–charge depend on the squares of the charge states present in the system. As discussed in [2], The net–charge fluctuation is measured in terms of D defined as

$$D = 4\frac{\langle \delta Q^2 \rangle}{\langle N_{\rm ch} \rangle} \approx \nu_{(+-,dyn)} \times \langle N_{\rm ch} \rangle + 4 \quad (1)$$

where $Q = N_+ - N_-$ is the net–charge and $N_{\rm ch} = N_+ + N_-$, here N_+ and N_- are the numbers of positive and negative particles. $\nu_{(+-,dyn.)}$ is a robust variable estimated on an event–by–event basis in the the experiments by calculating the quantity, "non-statistical" or "dynamical" fluctuations. The $\nu_{(+-,dyn.)}$ is a measure of the relative correlation strengthof ++, −−, and +− particles pairs. Note that by construction, these correlations are identically zero for Poissonian, or independent particle production.

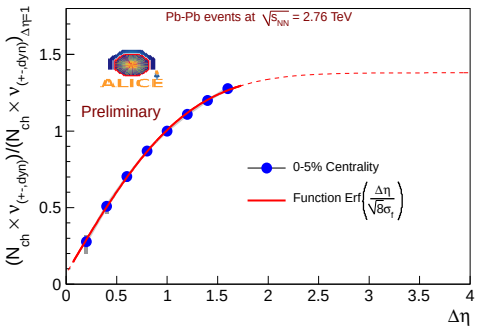

FIG. 1: $N_{ch} \times \nu_{(+-,dyn)}$, normalized to the values for $\Delta\eta$= 1, are plotted as a function of $\Delta\eta$. The data points are fitted with the functional form erf($\Delta\eta/\sqrt{8}\sigma_f$) normally used for diffusion equations. The dashed line is an extrapolation of the fitted line.

In this article we report the first measurement of the net–charge fluctuations in Pb–

*Electronic address: sjena@cern.ch

Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV measured with the ALICE detector.The recorded data were analyzed using ALICE standard minimum bias events cuts. The analysis details are reported in ref. [3, 4] The dynamic fluctuations, $\nu_{(+-,dyn.)}$, were calculated on an event–by–event basis from the experimental measurements of positive and negatively charged particles produced within $\Delta\eta$ windows defined around mid-rapidity[3, 4]. The variation of $\nu_{(+-,dyn.)} \times N_{ch}$ in rapidity space is examined by plotting its ratio with respect to the value at $\Delta\eta$= 1, as shown in figure 1. This behavior has been predicted in [5, 6] and was attributed to the spread of the signal arising from the diffusion during the evolution from the early QGP stage to the hadron resonances gas (HG). Charge conservation and longitudinal expansion affect the growth, which may limit the increase to an asymptotic value. We fit the data points of Fig. 1 with a function of the form erf($\Delta\eta/\sqrt{8}\sigma_f$) [5, 6], representing the diffusion in rapidity space, where σ_f is the diffusion parameter. It has been conjectured that, taking only dissipation into account, the extrapolated asymptotic value of fluctuations may give back the original value of fluctuations at the early QGP stage.

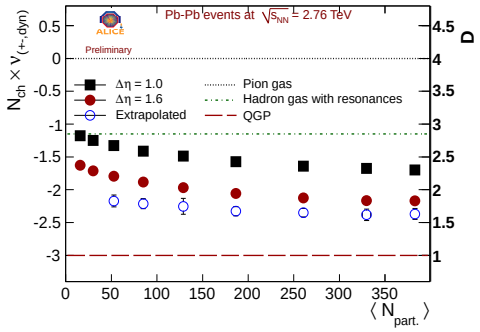

FIG. 2: $\nu_{(+-,dyn.)} \times N_{ch}$ (left-axis) and D (right-axis) are plotted for $\Delta\eta$= 1 and 1.6 as a function of the number of participants. The values after extrapolating to higher $\Delta\eta$ are shown by open circles.

In Fig. 2, 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 N_{part} are shown for three different $\Delta\eta$windows, i.e. $\Delta\eta$ = 1, $\Delta\eta$ = 1.6 and the extrapolated asymptotic values at $\Delta\eta$ = 3, along with the lines indicating the predicted values of fluctuations for three cases: pion gas, HG and QGP. By confronting the measured value with the theoretically predicted fluctuations [2, 5], it is observed that the 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, we have presented the first measurements of dynamic net–charge fluctuations at the LHC in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV using the observable $\nu_{(+-,dyn)}$. The net–charge fluctuations are observed to be dominated by the correlations of oppositely charged particles. The energy dependence of the dynamical fluctuations shows a decrease in fluctuation going from RHIC to LHC energies. A fit to the fluctuation in rapidity space is using the diffusion equation, which yields the asymptotic value of fluctuation, which is closer to the theoretically predicted value of Quark Gluon Plasma.

References

[1] K. Aamodt *et al.* [ALICE Collaboration], JINST **3**, (2008) S08002.
[2] S. Jeon, V. Koch, Phys. Rev. Lett. **85**, (2000) 2076.
[3] Satyajit Jena for ALICE collaboration, arXiv:1203.0542v1.
[4] Satyajit Jena for ALICE collaboration, arXiv:1201.0130v1
[5] E. V. Shuryak, M. A. Stephanov, Phys. Rev. C **63**, (2001) 064903.
[6] M. A. Aziz, S. Gavin, Phys. Rev. C **70**, (2004) 034905.