Event-by-event charge separation in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with ALICE

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Introduction

Kharzeev *et al.* [1], proposed strong P and CP violation in heavy ion collisions. This is basically due to fact that in the non-central heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC), the electric field induced by a strong magnetic field B $\sim 10^{15}$ T (eB $\sim 10^4$ MeV^2), created by energetic spectator protons, causes charge separation along the system's angular momentum resulting the Chiral Magnetic Effect (CME) [2]. A Large Ion Collider Experiment (ALICE) is specifically designed to study the properties of Quark-Gluon Plasma (QGP), the deconfined state of quarks and gluons. The charge separation effect has been investigated by the STAR at different collision energies $\sqrt{s_{NN}} = 7.7$ - 200 GeV [3] and by the ALICE at $\sqrt{s_{NN}} = 2.76$ TeV [4].

The study of particle correlations is the only way to investigate charge separation due to the CME. For the measurement of parity odd observable, Voloshin [5] proposed the correlator which is defined as,

$$\gamma = \langle \cos(\phi_\alpha + \phi_\beta - 2\psi_{RP}) \rangle \qquad (1)$$

where ϕ_α and ϕ_β are the azimuthal angles of the particles and ψ_{RP} is the reaction plane angle. ALICE has experimentaly observed the charge separation effect using this multi-particle correlator. The centrality dependence of this correlator for the different charge combinations such as same charge pairs (++, - -) and opposite charge pairs (+ -) has been studied by the ALICE Collaboration [4] as shown in FIG. 1 which shows that correlation increases as we move from central to peripheral collisions. The same sign charge pairs signifies strong correlation as compared to the opposite charge pairs. Our main aim is to isolate these events which are showing the charge separation effect, by using the Sliding Dumbbell Method, discussed later in this presentation. Here we present event-by-event charge separation at $\sqrt{s_{NN}} = 2.76$ TeV in Pb-Pb collisions with the ALICE experiment at the LHC.

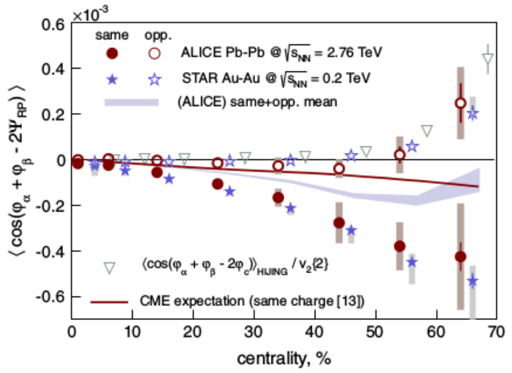

FIG. 1: Centrality dependence of the correlator (γ) for same sign charged pairs and opposite sign charged pairs [4].

Experimental setup

The details of ALICE Experiment and its performance can be found in ref. [6]. For this analysis, data collected by the ALICE Time Projection Chamber (TPC) covering the pseudorapidity region $\eta < |0.9|$ is used. To avoid the contamination from the secondary particles, standard ALICE event selection criteria [7] are applied which includes collision vertex cut of ±10 cm along the beam direction. Standard track selection cuts are also applied [7]. The VZERO detector is used to measure collision centrality. The selected min-

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imum bias trigger events are divided into different centrality classes ranging from $60-70\%$ to $10-20\%$. Charged particles reconstructed by the TPC are accepted for analysis within $|\eta| < 0.8$ and $0.2 < p_T < 5$ GeV/c.

Sliding Dumbbell Method

In the present analysis, an attempt is made to analyse the data event-by-event to look localized charge separation using a method similar to the Sliding Window Method [8] used for neutral-charged fluctuations in Pb-Pb collisions at 158 A GeV [9] at SPS. We plan to use Sliding Dumbbell Method (SDM). Here, one looks for events with positive charge excess on one side of the dumbbell and negative charge excess on other side of the dumbbell. Due to Chiral Magnetic Effect one expects charge separation normal to the collision reaction plane. We define,

$$Db_{+-} = \frac{N_+}{(N_+ + N_-)} + \frac{N_-}{(N_+ + N_-)} \qquad (2)$$

where N_+ and N_- represent number of positive and negative charge particles, respectively, in either side of dumbbell. The first term gives the fraction of positive charged particles on one side of the dumbbell and the second term gives the fraction of negative charged particles on other side of the dumbbell. If the particles are uniformly distributed then the each fraction will be equal to 0.5 and the sum will be $Db_{+-} = 1$ but if the charged particles are not uniformly distributed then the value of each fraction will be different. Hence Db_{+-} will not be equal to 1. The azimuthal plane is scanned by sliding the $\Delta\phi = 90°$ dumbbell in steps of $\delta\phi = 1°$ and calculating fraction (Db_{+-}) for each 90° dumbbell to extract the maximum values of Db_{+-} in each event. We will compare Db_{+-} distribution of maximas' in a sample using the sliding dumbbell with those randomly selected dumbbell in each event.

Results and Discussion

We have analyzed about 1 million minimum bias Pb-Pb events at 2.76 TeV. Db_{+-} distributions for maximas obtained in different centrality bins using the Sliding Dumbbell Method (SDM) are obtained by fixing the dumbbell at random azimuth in each event were also obtained for similar centralities. Db_{+-} values obtained using the random dumbbell method shows a gaussian distribution as expected and it peaks around Db_{+-} = 1 but the distribution for maximas obtained using SDM shifts towards higher values of Db_{+-} which is more for semi-central events as compared to those for central events. Few semi-central events were seen with much higher Db_{+-} values i.e., positive charged particles are on one side of the dumbbell and the negative charged particles are on the other side of dumbbell. The centrality dependence of the correlator for same sign and opposite sign charged pairs is compared for the tail events of Db_{+-} distribution with those shown in FIG. 1. The investigation of these events using different dumbbell sizes i.e., $\Delta\phi = 90°, 60°$ and $40°$ is ongoing.

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