# Event-by-event charge separation in Au-Au collisions at $\sqrt{s_{NN}} = 200$ GeV

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## Introduction

The relativistic heavy-ion collisions provide a distinctive environment to study the particle interactions at a very high temperature and extreme energy density. One of the various significant characteristics of non-central heavy ion collisions is the strong magnetic field produced by fast moving ions and large orbital angular momentum. The interplay between the magnetic field and deconfined state created in these collisions might result in the phenomena of Chiral Magnetic Effect (CME) [1, 2]. The CME leads to the separation of positively and negatively charged particles along the axis of magnetic field. The charge separation according to this effect is predicted to be perpendicular to the reaction plane.

It has been suggested that the multi-particle correlator can be the only experimental observable to detect the charge separation [3, 4]. The correlator $\langle\cos(\phi_\alpha+\phi_\beta-2\psi_{RP})\rangle$ has been proposed by Voloshin [5] for the measurement of this effect, where $\phi_\alpha$, $\phi_\beta$ denote the azimuthal angles of the particles $\alpha$, $\beta$ and $\psi_{RP}$ is the reaction plane angle. Since the reaction plane angle is not known, experimentally, so one can use the three particle correlator $\langle\cos(\phi_a + \phi_b - 2\phi_c)\rangle$, here $\phi_a$, $\phi_b$ and $\phi_c$ are the azimuthal directions of particles a, b and c, respectively [5].

## Sliding Dumbbell Method

The STAR experiment at RHIC and ALICE at LHC investigated the charge separation using the above observables [4]. Since, the observation of the effect till date has been made by measuring the three particle correlator averaged over a collection of events and hence, there is a possibility that the effect gets diluted. The event-by-event charge separation is studied using Sliding Dumbbell Method (SDM) similar to the Sliding Window Method [6] used for the study of neutral-charged fluctuations in Pb-Pb collisions at 158 A GeV [7] at SPS. In this method we calculate the fraction $Db_{+-}$, which is written as :

$$Db_{+-} = \frac{N^l_+}{(N^l_+ + N^l_-)} + \frac{N^r_-}{(N^r_+ + N^r_-)} \quad (1)$$

where, $N^l_+$ and $N^l_-$ respectively are the number of positively and negatively charged particles on the left side of the dumbbell, whereas, $N^r_+$ and $N^r_-$ respectively are the number of positively and negatively charged particles on the right side of the dumbbell. The whole azimuthal plane is scanned by sliding the $\Delta\phi = 90°$ dumbbell in steps of $\delta\phi = 1°$ and calculating fraction ($Db_{+-}$) for each $\Delta\phi$ region to extract the maximum value of $Db_{+-}$ in each event. $Db_{+-}$ is the sum of the ratios of positive and negative charged particles in left and right side of dumbbell. The maximum possible value of fraction $Db_{+-}$ is 2. The higher values of the fraction $Db_{+-}$ indicates the separation of positive and negative charged particles in an event. The quantity, $Db_{+-}$ has also been obtained for random dumbbell in the azimuthal plane for each event.

## Analysis Details

We report on the measurement of event-by-event charge separation in Au+Au collisions at $\sqrt{s_{NN}}$=200 GeV using SDM. The data used in this analysis were recorded in the 2004 RHIC run. The data set contains about one million minimum-bias-trigger events. The TPC tracks in the pseudorapidity region $|\eta| < 1.0$ and transverse momentum

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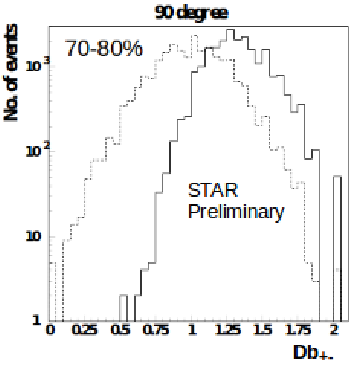


FIG. 1: $Db_{+-}$ distributions obtained for random dumbbell (dotted hist) and sliding dumbbell (solid hist) in 70-80 % centrality interval.

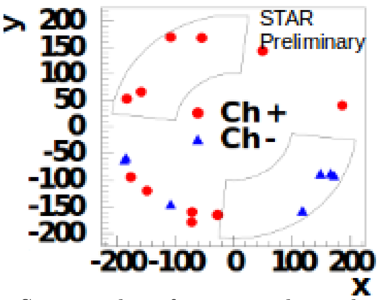


FIG. 2: Scatter plot of positive charged particles (solid red circles) and negative charged particles (solid blue triangles) in the azimuthal plane for an event in the $70-80\%$ collision centrality.

range $0.15 < p_T < 2.0$ GeV/c are used. Standard STAR track quality cuts, $N_{Hits} > 14$ and $N_{HitsFit}/N_{HitsPoss} > 0.52$ have been applied.

## Results and Discussions

The fraction $Db_{+-}$ using the Sliding Dumbbell Method and random dumbbell method are evaluated for azimuthal dumbbells of different sizes. Fig. 1 shows the $Db_{+-}$ distribution for 70-80% central events using SDM and random method for the $90^0$ dumbbell. The dotted curve is for random method and solid curve is for SDM. It is clearly seen that the distribution peaks at 1 for random method whereas for SDM it is shifted towards 2. This shift indicates that there are some events showing charge separation.

Analyzing the tail events of $Db_{+-}$ distribution, some interesting events showing back to back charge separation are found. Figs. 2 and 3 show the scatter plot ($x = 200 * \sin\theta\cos\phi$, $y = 200 * \sin\theta\sin\phi$) of hit distribution of positive and negative charged particles in the azimuthal plane for two such events. Here, hits of positive particles are indicated by red circles and those of negative particles are indicated by blue triangles. The arcs opposite to each other are drawn here to enhance the visualization of the charge separation. It is seen in Figs. 2 and 3 that red circles (positive particles) are more in number as compared to the blue triangles (negative particles) in one arc and vice-versa. The analysis of event-by-event charge separation is presented in this report and the work on efficiency correction and acceptance correction is ongoing.

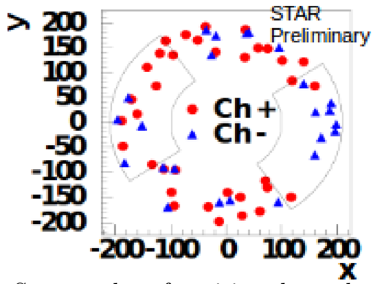


FIG. 3: Scatter plot of positive charged particles (solid red circles) and negative charged particles (solid blue triangles) in the azimuthal plane for an event in the $60-70\%$ collision centrality.

## References

[1] D.E. Kharzeev, *et al.*, Prog. Part. Nucl. Phys. **88**, 1-28 (2016).
[2] Ilya Selyuzhenkov, arXiv: 0910.0464, (2003).
[3] A. Bzdak, V. Koch and J. Liao, Phys. Rev. **(C81)**, 014905(2011).
[4] B. I. Abelev *et al.*, (STAR Collaboration), Phys. Rev. C **81** 054908 (2010), B. Abelev *et al.*, (ALICE Collaboration), Phys. Rev. Lett. **110** 012301 (2013).
[5] Segei A. Voloshin, Phys. Rev. C **(70)**, 057901 (2004).
[6] M.M. Aggarwal, G. Sood, Y.P. Viyogi, Phys. Lett. B **638**, 39 (2006).
[7] M.M. Aggarwal, *et al.*, (WA98 Collaboration), Phys. Lett. B **701**, 300 (2011).