PROCEEDINGS OF SCIENCE

Measurements of charge-dependent correlations with CMS

Subash Chandra Behera for the CMS Collaboration*

Indian Institute of Technology,
Madras, Chennai, India

E-mail: subash.chandra.behera@cern.ch

In this proceeding we discuss the measurement of charge balance function in PbPb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV and pPb collisions at $\sqrt{s_{\mathrm{NN}}} = 8.16$ TeV. Two-particles electric charge balance function is used as a probe to study the charge creation mechanism in high energy heavy ion collisions. The balance function is constructed using like- and unlike charged-particle pairs. The width of the balance function, both in relative pseudorapidity ($\Delta\eta$) and relative-azimuthal angle ($\Delta\varphi$), increases from more central collisions to peripheral ones. Narrowing and widening of these widths indicate late and early hadronization, respectively.

**** 41st International Conference on High Energy physics - ICHEP2022 ****
**** 6 - 13 July, 2022 ****
**** Online ****

*Speaker

PoS(ICHEP2022)938

1. Introduction

The study of two-particles correlation [1, 2] is one of the major tool to investigate the hot and dense medium, known as Quark–Gluon Plasma, created in ultra-relativistic nucleus-nucleus (AA) collisions [3, 4]. The production mechanism of particles emitted in the collisions is mainly governed by local charge conservation, which ensures that for each positive charge, there is always an opposite balancing partners. When the like-sign correlation is substracted from the unlike-sign one, the charge-independent correlation, which is present in both correlations, is removed. The balance function is defined as the combinations of unlike- and like-sign correlations and can be written as

$$B(\Delta\eta, \Delta\varphi) = \frac{1}{2}[C_2(+,-) + C_2(-,+) - C_2(-,-) - C_2(+,+)], \tag{1}$$

where, $\Delta\eta$ is the relative pseudorapidity and $\Delta\varphi$ is the relative azimuthal angle of the pairs of the paticles. $C_2(+,-), C_2(-,+)$ are the unlike-sign correlations and $C_2(+,+), C_2(-,-)$ are the like-sign correlations, respectively. The correlation between space and time is reflected in momentum space due to the radial expansion and hadronization [1]. Particularly, the width of the balance is expected to be narrower if the particles are produced at the later stage affected by the radial flow. Conversely, a wider distribution may correspond to charge creation early in the evolution. Results are presented in this talk as a function of multiplicity in PbPb and pPb collisions.

This article is organized as follows. In Section 2 we discuss the balance function calculations and average width in $\Delta\eta$ and $\Delta\varphi$ in pPb and PbPb collisions. Finally, in Section 3 we present the summary of these measurement.

2. Results

This article presents the results on the balance function for non-identified charged particles using the large rapidity coverage of the CMS detector [5].

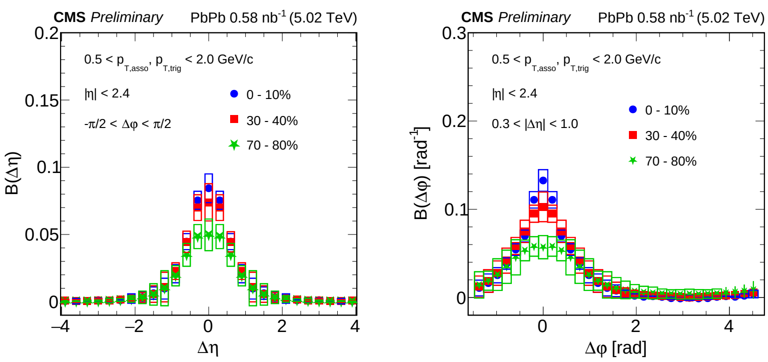

Figure 1: The projection of the balance function in $\Delta\eta$ (left) and $\Delta\varphi$ (right) in PbPb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV.

Figure 1 shows the centrality dependence of the charge balance function in PbPb collisions [6]. The one dimensional projections, is derived in $\Delta\eta$ ($-\pi/2 < \Delta\varphi < \pi/2$) and in $\Delta\varphi$ ($0.3 < |\Delta\eta|$

< 1). The magnitude of the balance function also changes with multiplicity, with higher values corresponding to collisions with higher multiplicity. A narrower balance function distribution is observed as the final state particles are produced at the later stages of the collisions and are separated longitudinally smaller in $\Delta\eta$.

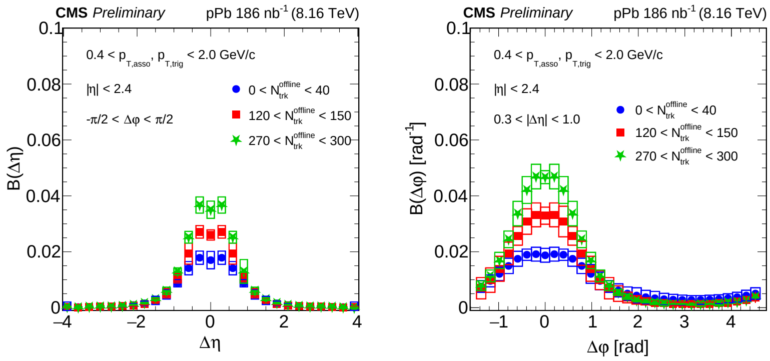

Figure 2: The projection of the balance function in $\Delta\eta$ and $\Delta\varphi$ in pPb collisions at $\sqrt{s_{NN}}$ = 8.16 TeV.

Figure 2 represents the multiplicity dependence of the balance function in pPb collisions [6]. We observed a similar trend for the balance function in $\Delta\eta$ and $\Delta\varphi$ as PbPb collisions with increasing multiplicity. The narrowing of the balance function width for $p_T < 2$ GeV/c regions can be understood in a delayed hadronization picture, where the particles are produced at later stage during the medium's evolution. Also, the multiplicity dependence in PbPb for this p_T is attributed to the centrality dependence of radial flow, which retains part of the initial correlations of the balancing partners. Similarly, the multiplicity dependence for the small system could be explained by collectivity. Collectivity in small systems is already suggested by the observation of long-range ridge correlations in pPb collisions [7].

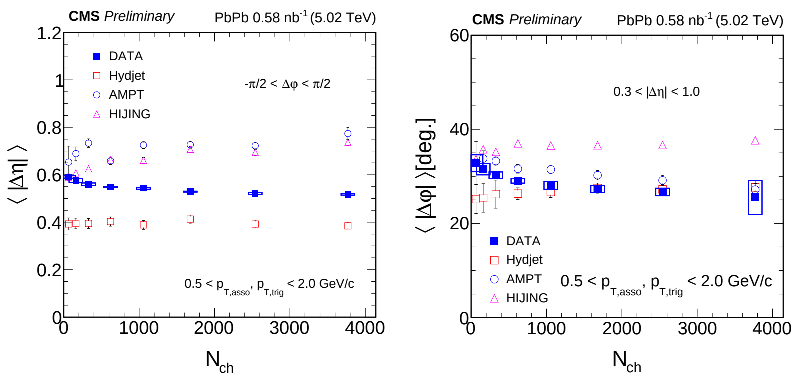

Figure 3: The width of the balance function with N_{ch} in $\Delta\eta$ (left) and in $\Delta\varphi$ (right) for PbPb collisions.

Figure 3 presents the experimental data results, represented by blue squares, which exhibit a strong multiplicity dependence in $\Delta\eta$ and $\Delta\varphi$. The data results are compared to different model predictions, such as HYDJET [8], AMPT [9], and HIJING [10]. The results in HYDJET do not show any significant dependence on either $\Delta\eta$ and $\Delta\varphi$. In this model, local charge conservation for more peripheral events (lesser multiplicities) has more influence on the charge balance function than for large multiplicities. Comparing HIJING to the PbPb data, we do not see any significant multiplicity dependence. In addition, the magnitude in the width of the balance functions is larger than the data results because the model lacks collective flow. A significant multiplicity dependence is shown in $\langle|\Delta\varphi|\rangle$ because of the radial flow effect in AMPT, which acts over the balancing partners by preserving their initial state correlations in $\Delta\varphi$.

3. Summary

In this proceeding we have discussed results of the charge balance function for non-identified particles in PbPb and pPb collisions using the broad pseudorapidity coverage with the CMS detector. For both systems, the dependence of the balance function in relative pseudorapidity and relative azimuthal angle was studied for different multiplicity classes. We observed that the width in $\Delta\eta$ and $\Delta\varphi$ decreases as multiplicity increases in PbPb and pPb systems. These results are consistent with the scenario of the system possessing a large radial flow, and charged particle creation at a later stage of the collision. Model comparisons such as HYDJET, AMPT and HIJING cannot reproduce the multiplicity dependence of the width in $\Delta\eta$. On the other hand, AMPT, which incorporates collective effects, can reproduce the narrowing of the width similar to the data results in $\Delta\varphi$.

References

[1] CMS Collaboration, *Journal of High Energy Physics* **09**, 091 (2010).

[2] BRAHMS experiment, *Nuclear Physics A* **757**, 1 (2010).

[3] Wit Busza et al., *Annual Review of Nuclear and Particle Science* **68**, 339-376 (2018).

[4] STAR Collaboration, *Nuclear Physics A* **757**, 102 (2005).

[5] CMS Collaboration, *JINST* **03**, S08004 (2008).

[6] CMS Collaboration, CMS Physics Analysis Summary, CMS-PAS-HIN-21-017 (2022), https://cds.cern.ch/record/2825805.

[7] CMS Collaboration, *Physics Letters B* **718**, 795 (2013).

[8] Lokhtin and et al., *Computer Physics Communications* **180**, 779 (2009).

[9] Zi-Wei Lin and et al., *Phys. Rev. C* **72**, 064901 (2005).

[10] Moravcova and et al., *Phys. Rev. C* **103**, 024913 (2021).