Beam Energy Dependent Charge Balance Functions in Heavy Ion Collisions at STAR

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Abstract
The study of correlations between opposite sign charge pairs can provide a powerful tool to probe the properties of the quark-gluon plasma (QGP). The balance function, which measures the correlations between opposite sign charge pairs, is sensitive to the mechanisms of charge formation and the subsequent relative diffusion of the balancing charges. The study of the balance function can provide information about the charge formation time as well as the subsequent collective behavior of particles.

We will present charge balance function results for relative pseudorapidity and azimuthal angle from Au+Au collisions at \( \sqrt{s_{NN}} = 7.7 \) to 200 GeV from the recent RHIC beam energy scan. Results from new measurements of balance functions at \( \sqrt{s_{NN}} = 19.6 \) and 27 GeV are added to the suite of observations. We will also present balance function results in terms of relative rapidity and Lorentz invariant momentum difference between the two particles for identified pions, kaons, and protons using STAR Time Of Flight (TOF) detector. The normalized balance function width (W parameter) is applied to compare different experimental measurements of the width of the balance function in terms of relative pseudorapidity. UrQMD transport model calculations are also compared with data.

Motivation
• In heavy ion collisions, most of the detected charge is created during the evolution of the system.
• Balance functions are sensitive to charge formation mechanisms and relative diffusion

\[
B(\Delta\eta) = \frac{1}{N} \left( N_+(\Delta\eta) - N_-(\Delta\eta) \right) \]

• The width of balance function is calculated via weighted average

\[
\langle \Delta\eta \rangle = \frac{\sum B(\Delta\eta) \Delta\eta}{\sum B(\Delta\eta)} \quad \text{W} = \frac{100(\langle \Delta\eta \rangle_{\text{shuffled}} - \langle \Delta\eta \rangle_{\text{data}})}{\langle \Delta\eta \rangle_{\text{shuffled}}} \]

Data Set

<table>
<thead>
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<th>Energy (GeV)</th>
<th>Species</th>
<th>Year</th>
<th>Data Set</th>
</tr>
</thead>
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<td>Au + Au</td>
<td>2010</td>
<td>All Charged Particles</td>
</tr>
<tr>
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<td>Au + Au</td>
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</tr>
<tr>
<td>27</td>
<td>Au + Au</td>
<td>2011</td>
<td>Electrons</td>
</tr>
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<td>7.7</td>
<td>Au + Au</td>
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</tr>
</tbody>
</table>

• Identified Particles
TPC+TOF PID
Use TOF to identify tracks if they have TOF match, otherwise use TPC dE/dx for particle identification

Summary
• Balance functions for \( \Delta\eta \) narrow at higher collision energies, which may be related to delayed hadronization
• Preliminary results of the balance functions for identified protons are wider in central events, which might due to two-wave production of charges [2]

References