# Charge balance correlations & Contributions to local parity violation observables

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## Motivation

In the evolution of the matter created in RHIC, charged particles can only be produced in balancing pairs. As the subsequent dynamics is in general highly collective, the initital correlation in space-time is transformed to momentum space and can be observed experimentally. These correlations then contain information about the production mechanism as well as the subsequent time evolution. The observable measured by STAR is the charge-balance function [1]

$$B(\Delta\eta) = \frac{N_{+-}(\Delta\eta) - N_{++}(\Delta\eta)}{M} + \frac{N_{-+}(\Delta\eta) - N_{--}(\Delta\eta)}{M}$$

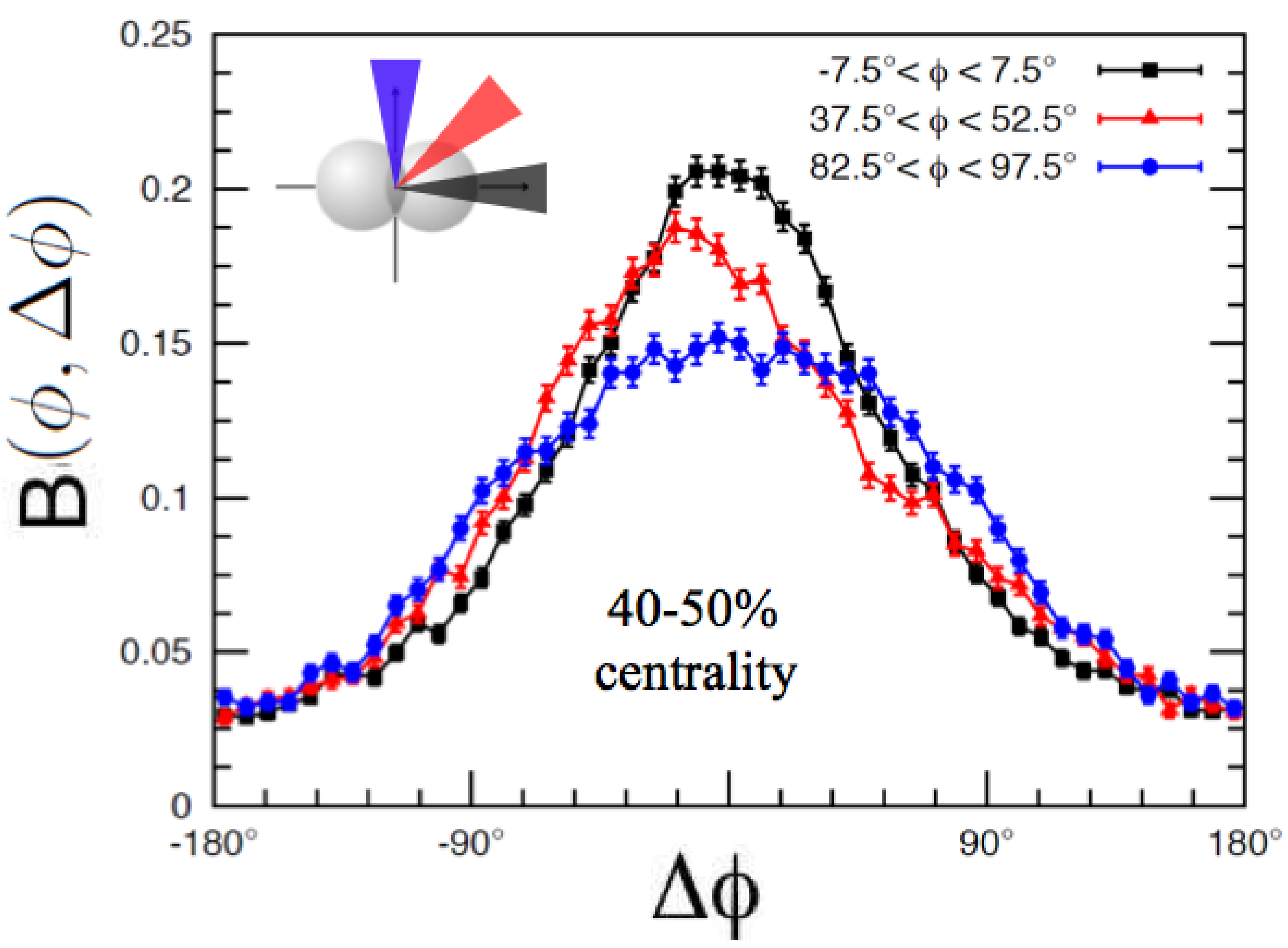
which has the interpretation of a conditional probability to find the balancing partner separated by $\Delta\eta$ . If charge conservation was perfectly local the balance function would be a delta peak. In reality thermal motion and diffusion effects lead to a distribution with finite width. The thermal properties can be extracted independently from single particle spectra, while the remaining separation from diffusive processes is independent of single particle properties. By accounting for both, we obtain a measure for the locality of charge conservation at freeze-out.

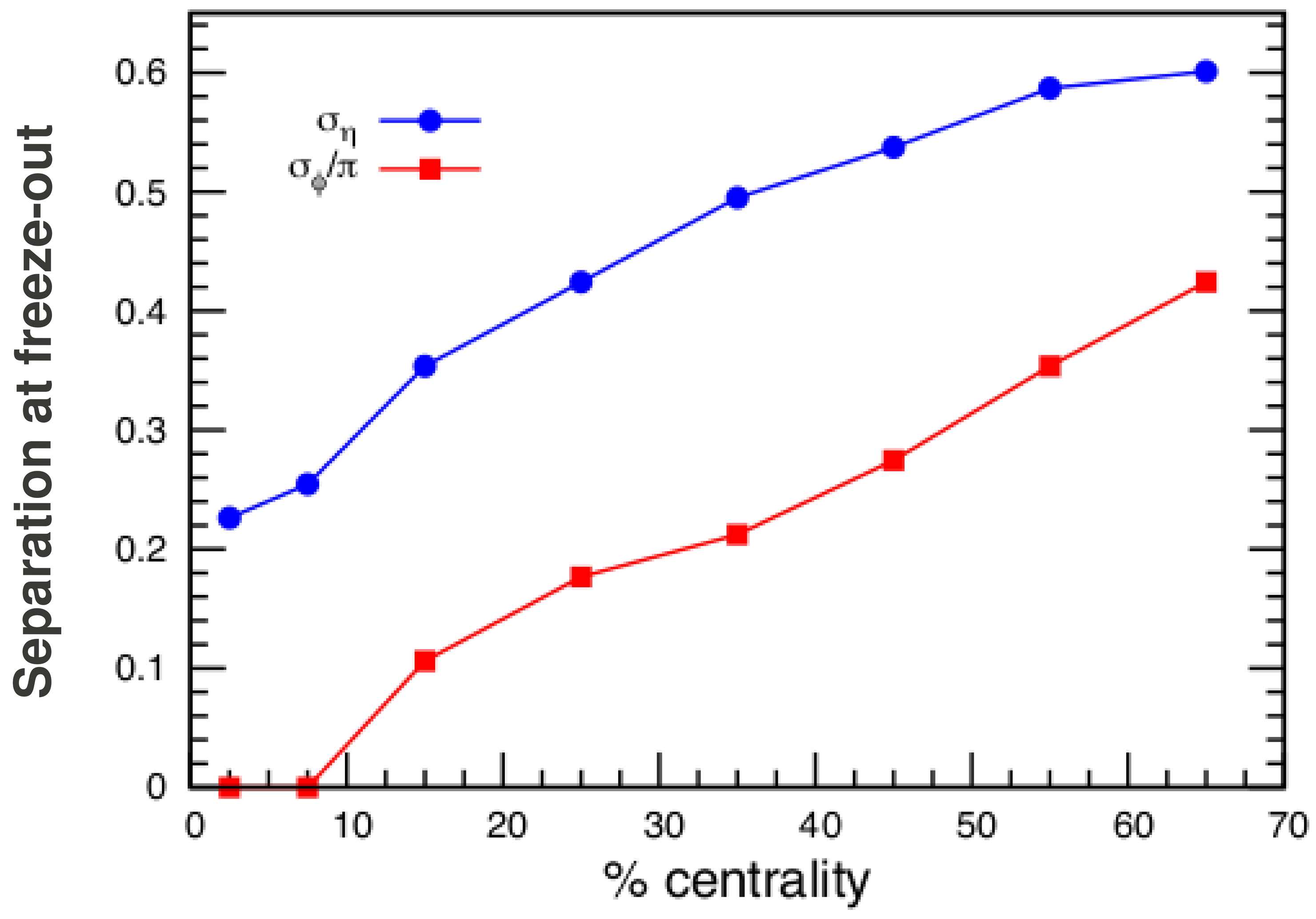
## Implementation

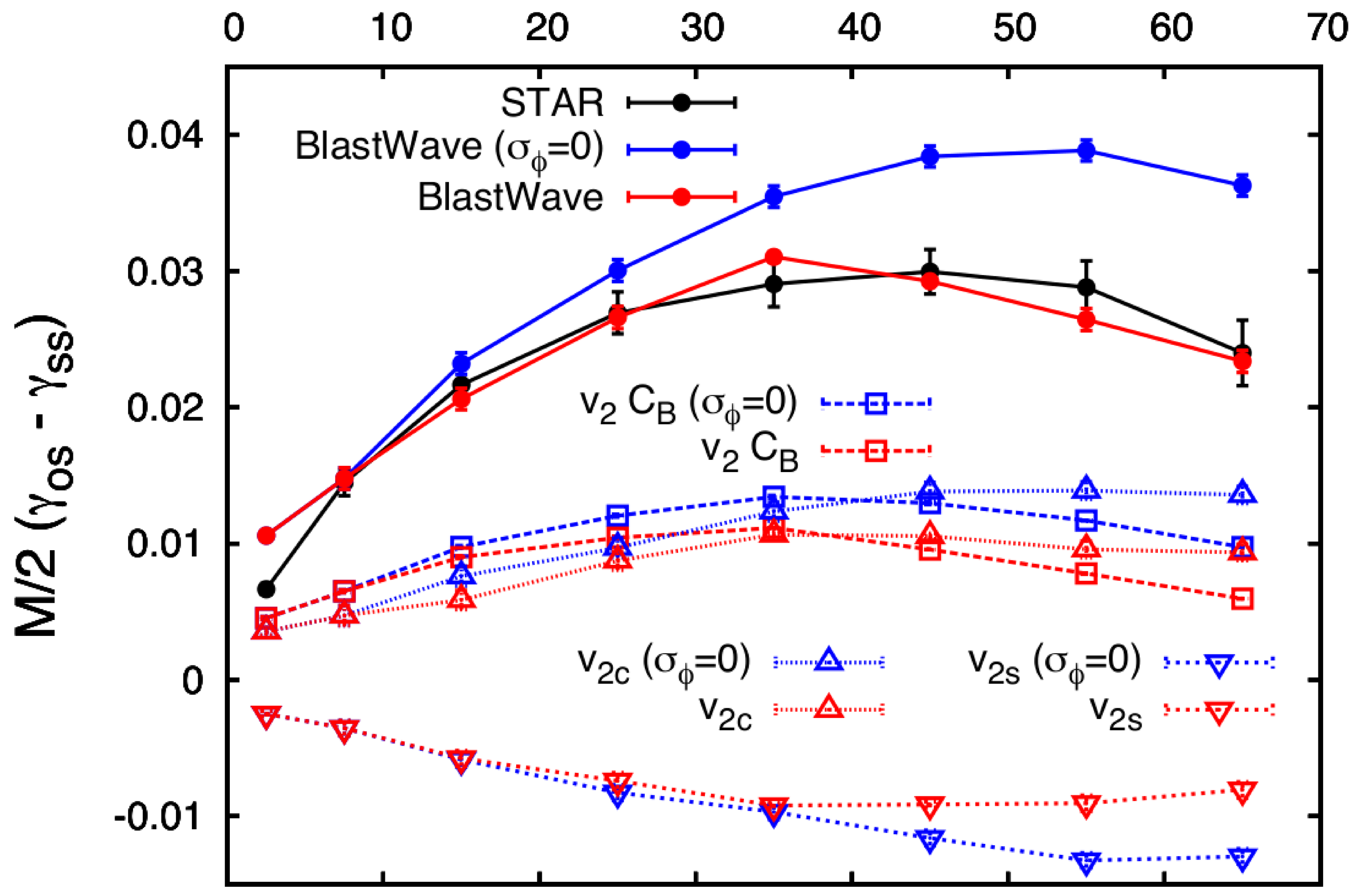
We consider a thermal freeze-out model that has been fit to reproduce single-particle spectra. Instead of requiring single particles to obey the blast-wave description we consider canonical ensembles with locally exactly conserved charges. By varying the degree of locality of charge conservation at freeze-out we can reproduce the experimental results and extract the separation of balancing charges at freeze-out [2].

## Results

The separation of balancing charges at freeze-out is significantly smaller for more central collisions. This points to a change in the production mechanism, with more charged particles being produced later in the collison.




## Contributions to LPV measurement

The local parity violation observable employed by STAR can be expressed in terms of moments of the charge balance function

$$\gamma_{\alpha,\beta} = \frac{\sum_{i\in\alpha,j\in\beta} \cos(\phi_i + \phi_j)}{M_\alpha M_\beta} \qquad \gamma_P \equiv \frac{1}{2}\left[2\gamma_{+-} - \gamma_{++} - \gamma_{--}\right]$$

$$\gamma_P = \frac{2}{M^2}\int d\phi\, d\Delta\phi\, \frac{dM}{d\phi}\, B(\phi,\Delta\phi)\, \left[\cos 2\phi \cos\Delta\phi - \sin 2\phi \sin\Delta\phi\right]$$

with the reaction plane dependent balance function $B(\phi,\Delta\phi)$ , where the first particle is restricted to have the angle $\phi$ w.r.t the reaction plane. There is three contributions from having

$v_2\langle c_b\rangle$ more particles in-plane than out-of-plane

$v_{2c}$ particles more focussed in-plane than out-of-plane

$v_{2s}$ asymmetric balance functions at intermediate angles

$$\gamma_P = \frac{2}{M}\left[v_2\langle c_b\rangle + v_{2c} - v_{2s}\right]$$

By comparing to STAR data [3] one finds that collective flow plus local charge conservation readily explains the observed behavior of $\gamma_P$ .

## References


[1] M.M. Aggarwal et al. [STAR Collaboration] arXiv:1005.2307v01 [nucl-ex]
[2] S. Schlichting and S. Pratt, Phys. Rev. C **83** 014913 (2011)
[3] B.I. Abelev et al. [STAR Collaboration] Phys. Rev. Lett. **103**, 251601 (2009)



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