Effect of Non-Binomial Efficiency on Cumulants of Net-Proton Multiplicity Distributions at the STAR Experiment

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Venezia 2018 Quark Matter

Abstract

Fluctuations of conserved quantities are sensitive observable to search for QCD critical point in heavy-ion collisions. To obtain precise measurements for the cumulants of conserved charge distributions, the finite detection efficiency needs to be carefully corrected, especially for the possible non-binomial detector effects. In this poster, we apply the new unfolding method to the net-proton distributions in central Au+Au collisions at 19.6 GeV. We performed the embedding simulation using the real experimental data to determine the detector response matrices. An example of the response matrix is shown, and discuss how it can be non-binomial distributions. Finally, we apply the response matrix to the experimental data by using the unfolding method, and compared to the results from conventional efficiency correction method based on the binomial model.

Effects of non-binomial efficiency

- The efficiency correction on cumulants have been established based on the binomial model [1], and applied to the experimental data to correct for the detector efficiency [2,3].
- However, the efficiency can be non-binomial by many reasons, e.g., track splitting/merging effects and the multiplicity dependent efficiency, where the conventional correction method is no longer applicable, the unfolding approach would be thus necessary [4].

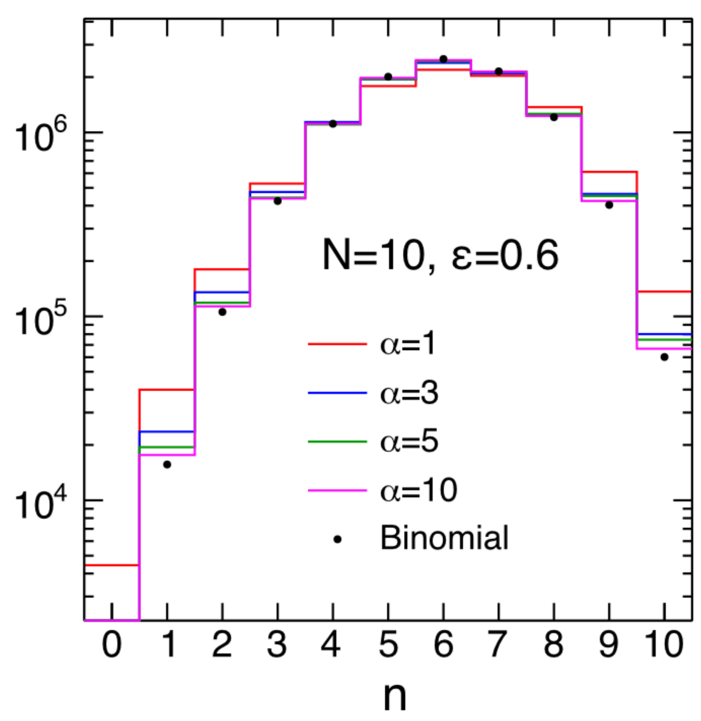
Non-binomial distribution

- The beta-binomial distribution, which are wider than the binomial distribution, can be defined by the urn model [4].
- In the urn model, the **parameter α** determines the # of white balls, where $\mathbf{N_w = \alpha \times N}$, with N being the injected particles.

$$N_w = \alpha N_p \quad \varepsilon = N_w/(N_w + N_b)$$

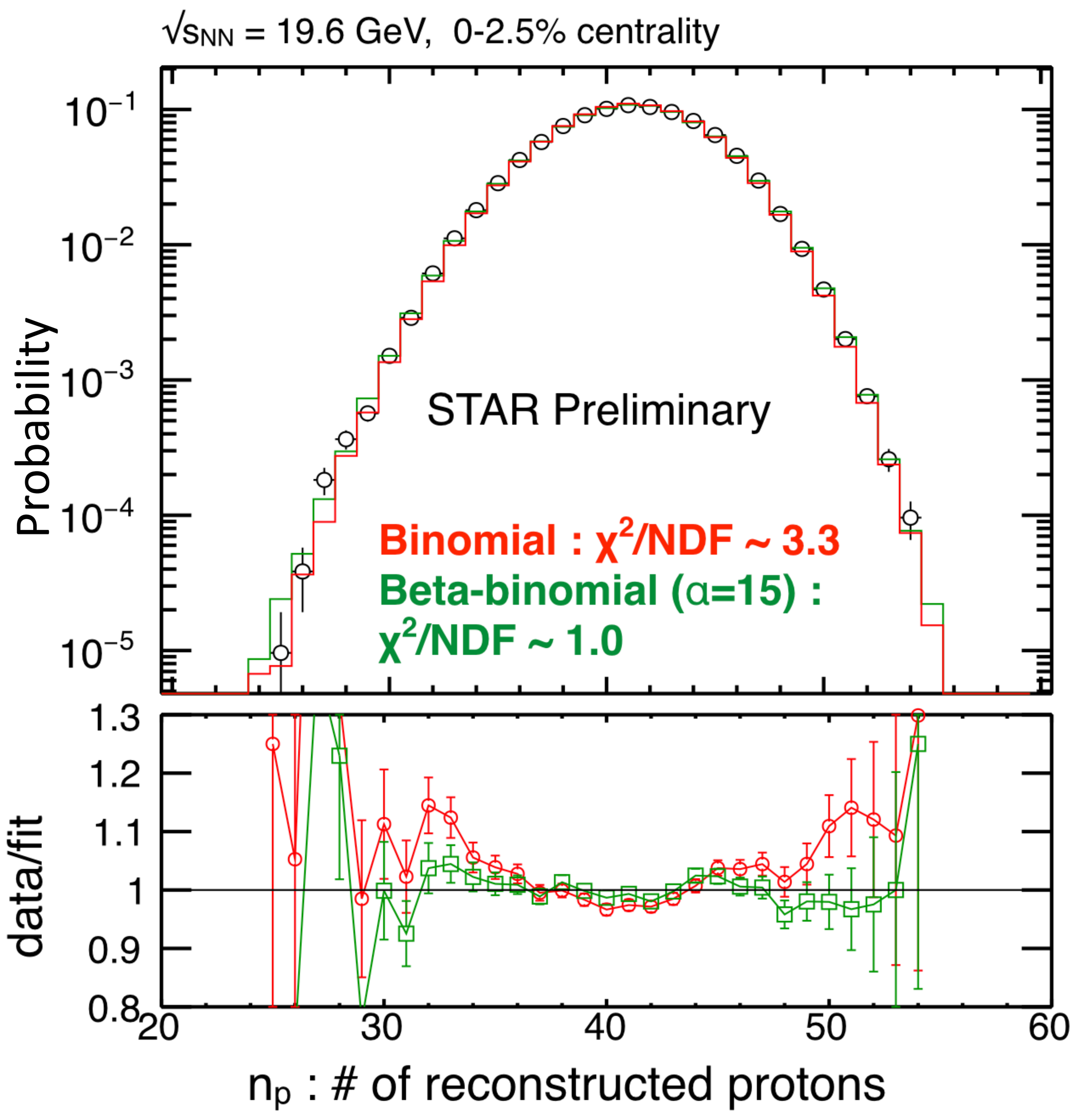
- Smaller α, more wider (narrower) for beta-binomial (hypergeometric) distribution. Larger α, closer to the binomial.

Beta-binomial distribution
Draw a ball from urn, if it is white, count particle. And return two white balls to urn (similar for black balls).



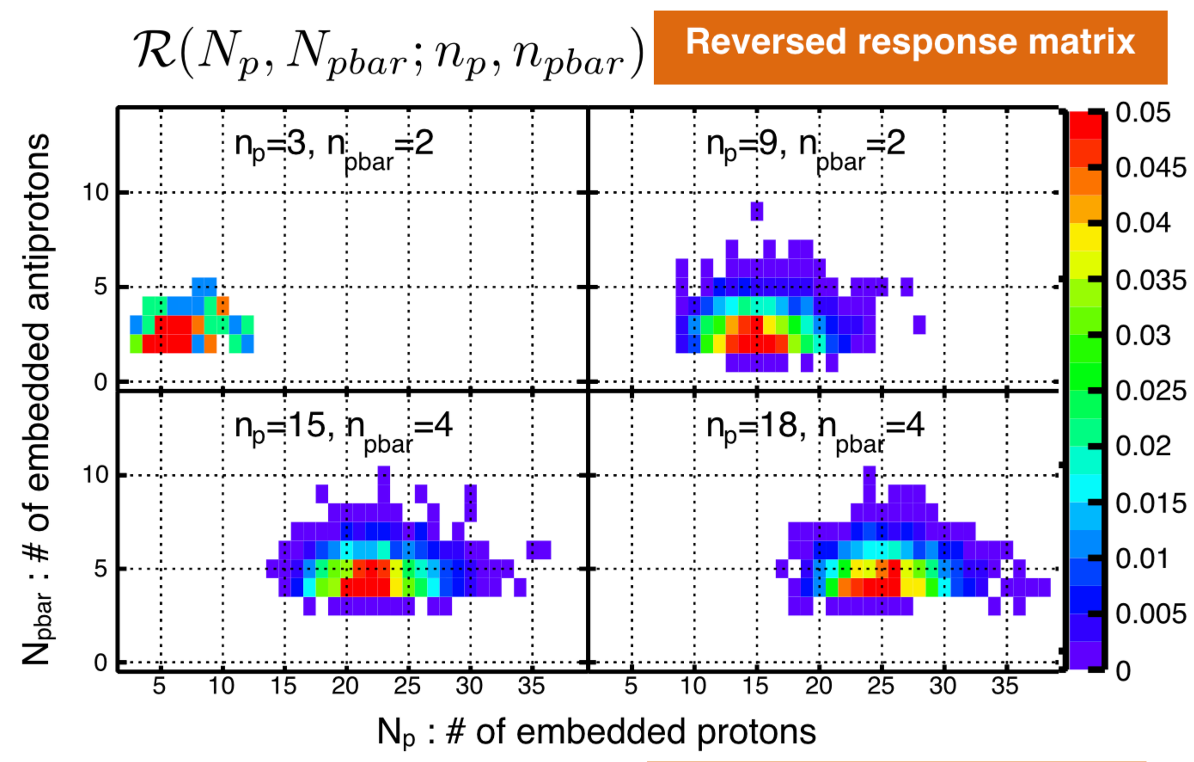
Non-binomial test with embedding simulation

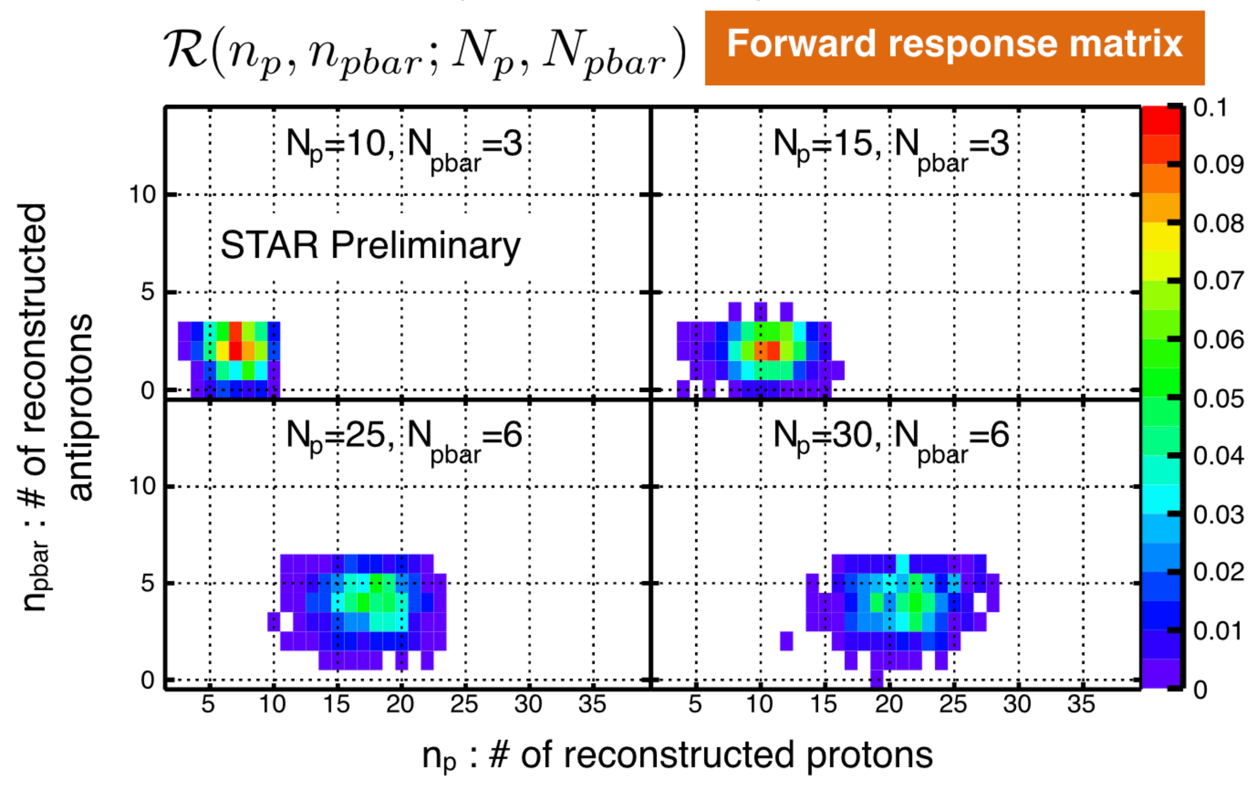
- 60 protons and 15 antiprotons are embedded into the real data to construct the response matrix.
- Numerical fitting has been done to the 1-D response matrix by using beta-binomial distributions with different α parameter, as well as the binomial.
- It can be found that the data can be described very well by the beta-binomial distribution in the case of 60 protons and 15 antiprotons embedded.



4-D Response matrices

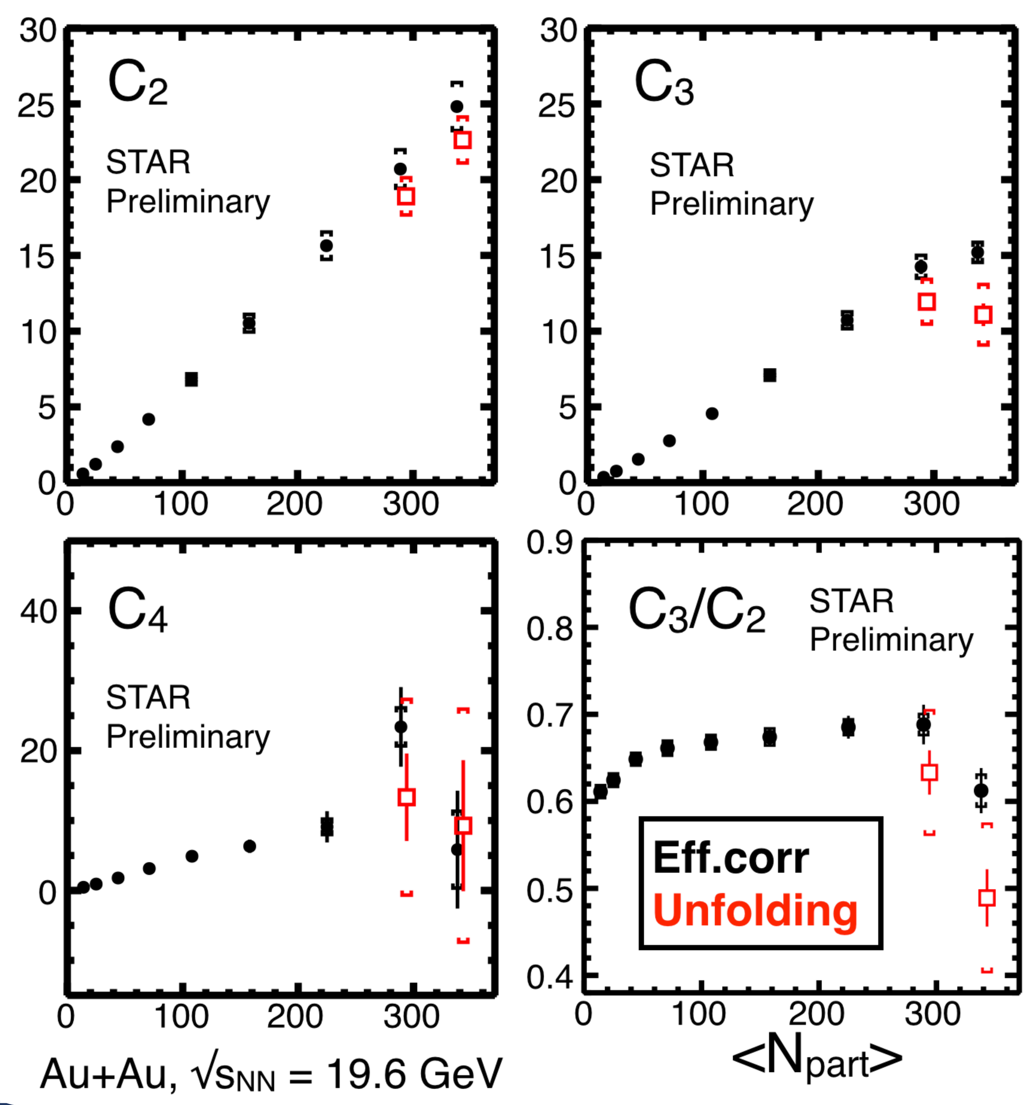
- The deviation from binomial would depend on the mulitplicity (N_p and N_{pbar}), so 4-D response matrices are determined by embedding different number of p and pbar, which can be directly used for unfolding in order to reconstruct the distribution itself.



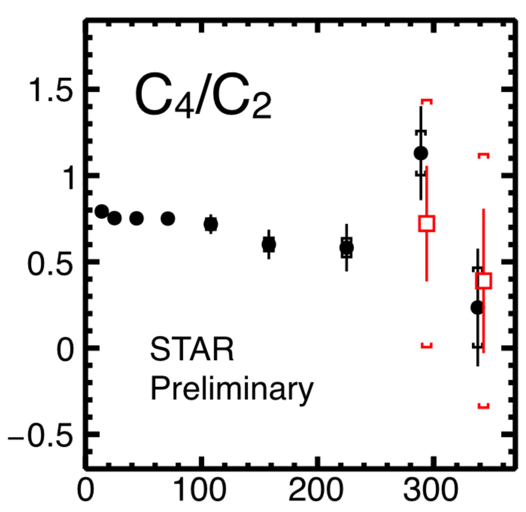


Results

- Unfolding results are consistent with those of conventional efficiency correction within large statistical/systematic uncertainties.



- For unfolding, Centrality Bin Width Correction (CBWC) is applied with Δ2.5% centrality bin width.



References

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