A model-free procedure to correct for volume fluctuations in E-by-E analyses of particle multiplicities

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based on: https://arxiv.org/pdf/2211.14849.pdf

CPOD2022- discussion session on “fluctuations and search for a critical point”
Contributions from volume fluctuations

**previous approaches**

- WNM-like particle production mechanism (production from independent sources)
- Factorizing volume fluctuations [1][2] (example for second cumulants)
  \[
  \kappa_2(N) = \langle N_W \rangle \kappa_2(n) + \langle n \rangle^2 \kappa_2(N_W)
  \]
- Strongly intensive quantities [3]:
  \[
  \Sigma[A, B] = \frac{\langle A \rangle \omega(B) + \langle B \rangle \omega(A) - 2cov(A, B)}{\langle A + B \rangle}
  \]
  unity for uncorrelated pairs
- Unfolding approach [4]:

**proposed event mixing scheme**

Event quantities (centrality)

\[
\kappa_2(N_W) = \frac{\kappa_2(N) \langle N_1 \rangle \langle N_2 \rangle}{\langle N \rangle^2 - \langle N \rangle}
\]

\[
\kappa_2(N_W) = \frac{\text{cov}(N_1, N_2)}{\langle N_1 \rangle \langle N_2 \rangle}
\]

extracting volume fluctuations (mixed events)

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[1] V. Skokov, B. Friman, K. Redlich, *PRC* 88 (2013) 034911
[2] P. Braun-Munzinger, AR, J. Stachel, *NPA* 960 (2017) 114-130
[3] M. I. Gorenstein, M. Gazdzicki, *Phys.Rev.C* 84 (2011) 014904
[4] S. Esumi, K. Nakagawa, T. Nonaka, NIMA 987 (2021) 164802
Results from Au-Au simulations based on IQMD

\[ \Sigma[A, B] \text{ signal} \]

\[ \frac{\kappa_2(N_W)}{\langle N_W \rangle^2} = \frac{\text{cov}(N_1, N_2)}{\langle N_1 \rangle \langle N_2 \rangle} \]

\[ \frac{\kappa_2(N_W)}{\langle N_W \rangle^2} = \frac{\kappa_2(N)}{\langle N \rangle^2} - \frac{1}{\langle N \rangle} \]

\[ \text{Extracted volume fluctuations} \]

\[ \kappa_2(N_W) = \text{cov}(N_1, N_2) \]

\[ \langle N_1 \rangle \langle N_2 \rangle \]

\[ \text{centrality[%]} \]

\[ \Sigma[A, B] \text{ events} \]

\[ \text{Mixed IQMD events} \]

A. Rustamov, J. Stroth, R. Holzmann, CPOD2022, Discussion Session, 1.12.2022
Averaged values for volume fluctuations

\[ \kappa_2(N) \] averaged over \( \{p, ^3He, d, t, \pi\} \)

\[ \text{cov}(N_1, N_2) \] for 10 different particle pairs

The method proposed gives consistent results

Extracted from \( \kappa_2(N) \) and \( \text{cov}(N_1, N_2) \)

Extracted for different particle species

The method is general enough to allow reconstructing any higher-order cumulant of the participant distribution

more possibilities will be demonstrated in our followup paper