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)

$$\kappa_2(N) = \langle N_W \rangle \, \kappa_2(n) + \boxed{\langle n \rangle^2 \kappa_2(N_W)}$$

  - Strongly intensive quantities [3]:

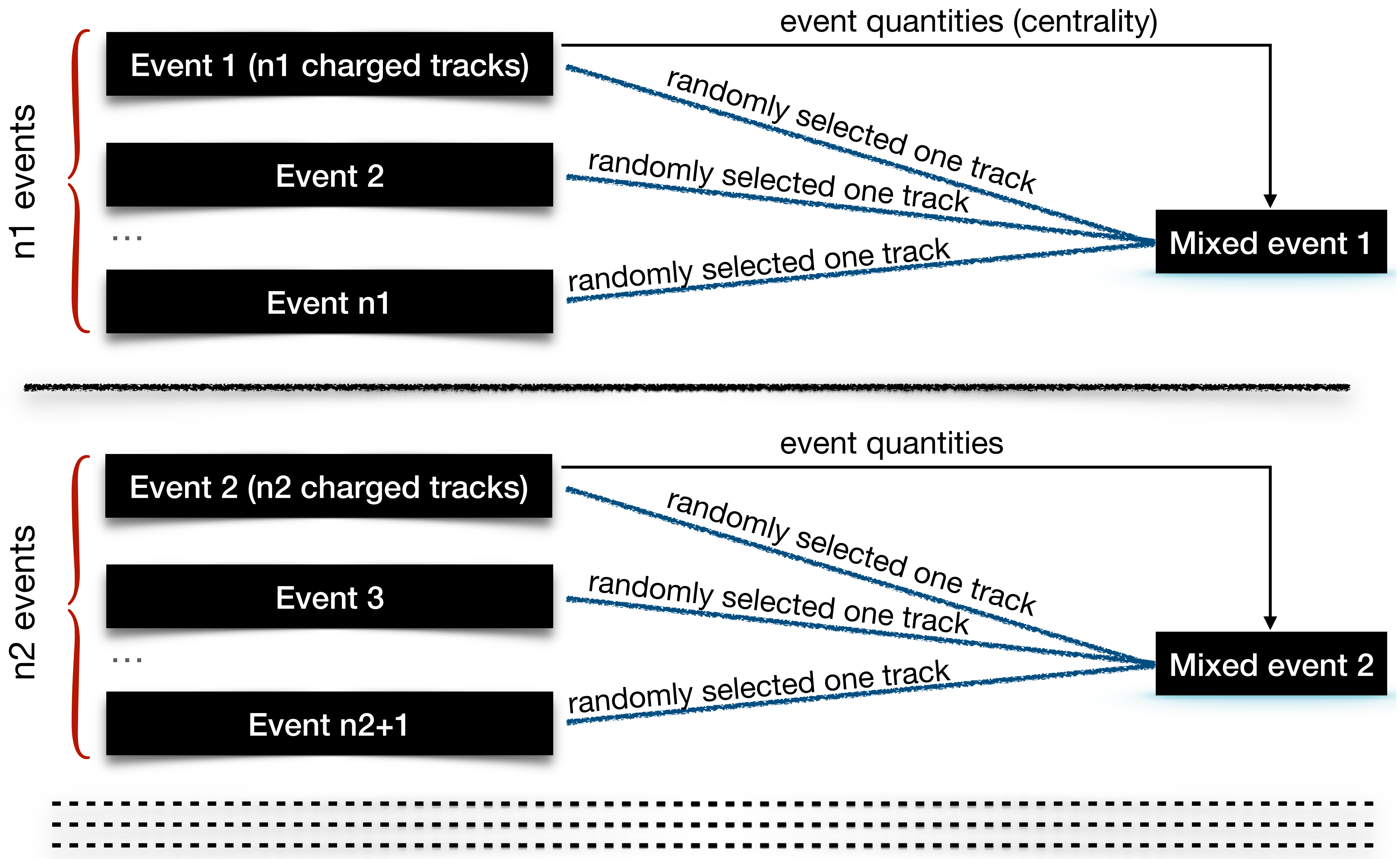
$$\Sigma[A,B] = \frac{\langle A \rangle \, \omega(B) + \langle B \rangle \, \omega(A) - 2cov(A,B)}{\langle A + B \rangle}$$

unity for uncorrelated pairs

- Unfolding approach [4]:

[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

proposed event mixing scheme



extracting volume fluctuations (mixed events)

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

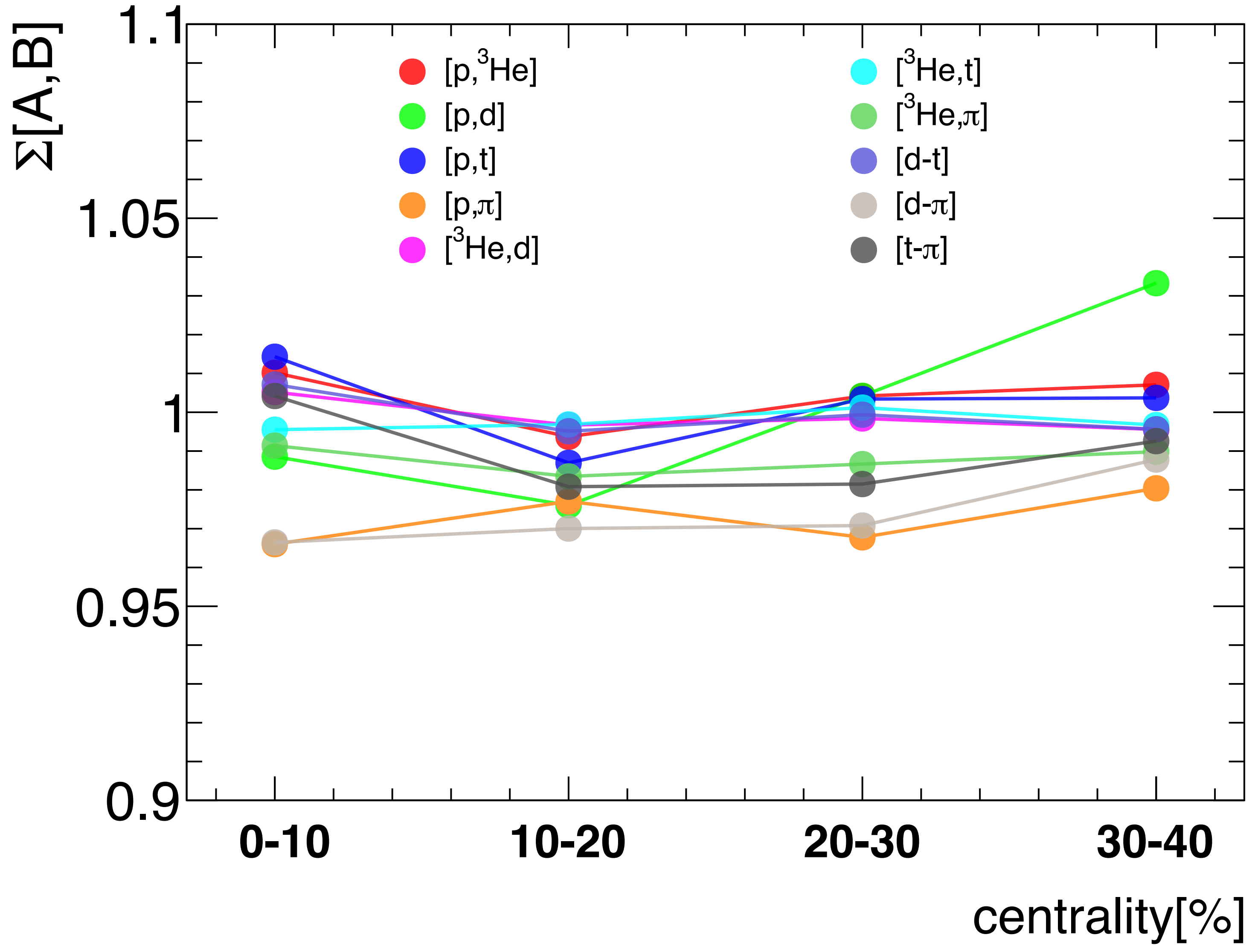
$$\boxed{\frac{\kappa_2(N_W)}{\langle N_W \rangle^2}} = \frac{cov(N_1, N_2)}{\langle N_1 \rangle \langle N_2 \rangle}$$

Results from Au-Au simulations based on IQMD

$\Sigma[A, B]$ signal

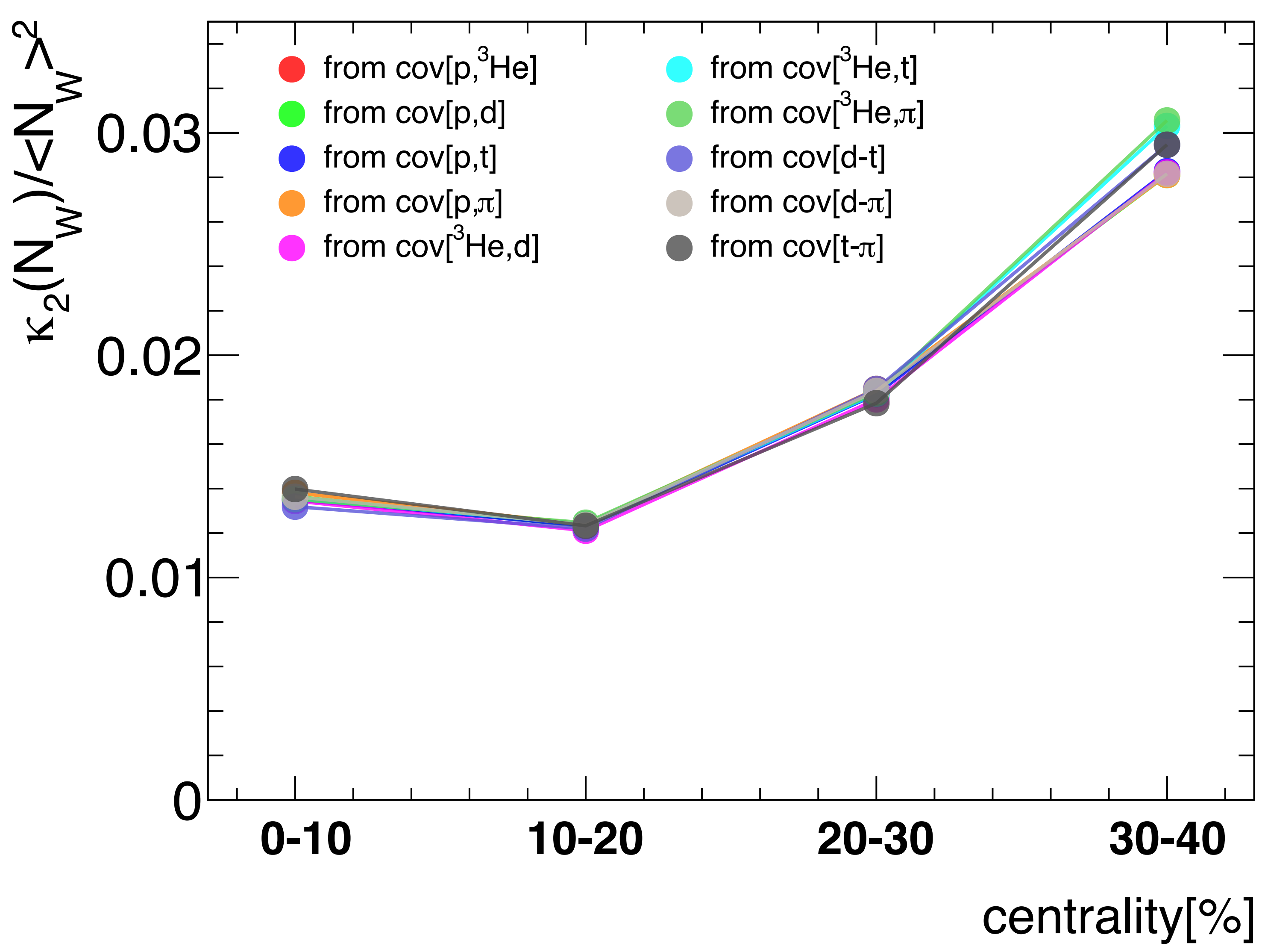
Extracted volume fluctuations

Original IQMD events

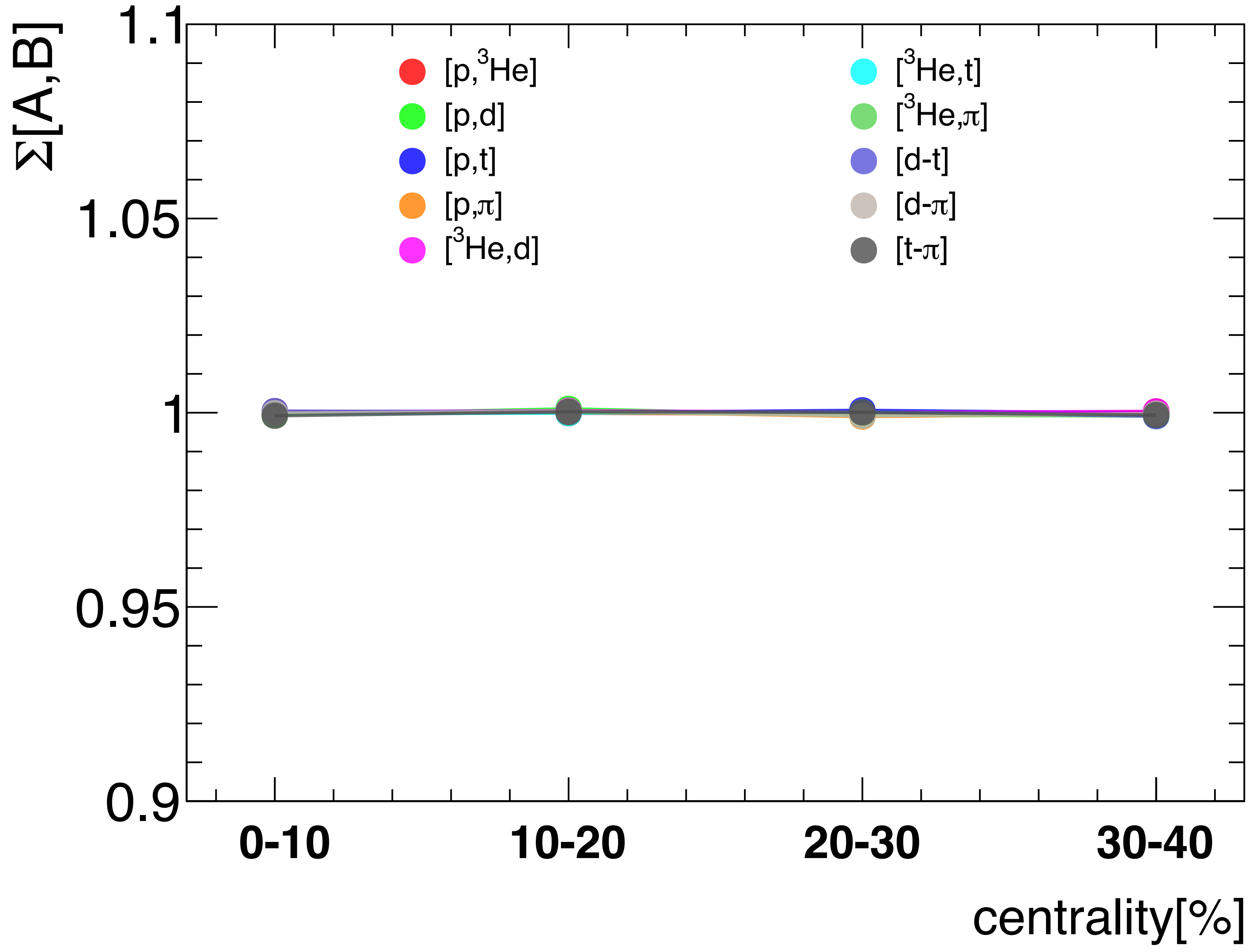


$$\frac{\kappa_2(N_W)}{\langle N_W \rangle^2} = \frac{cov(N_1, N_2)}{\langle N_1 \rangle \langle N_2 \rangle}$$

Mixed IQMD events

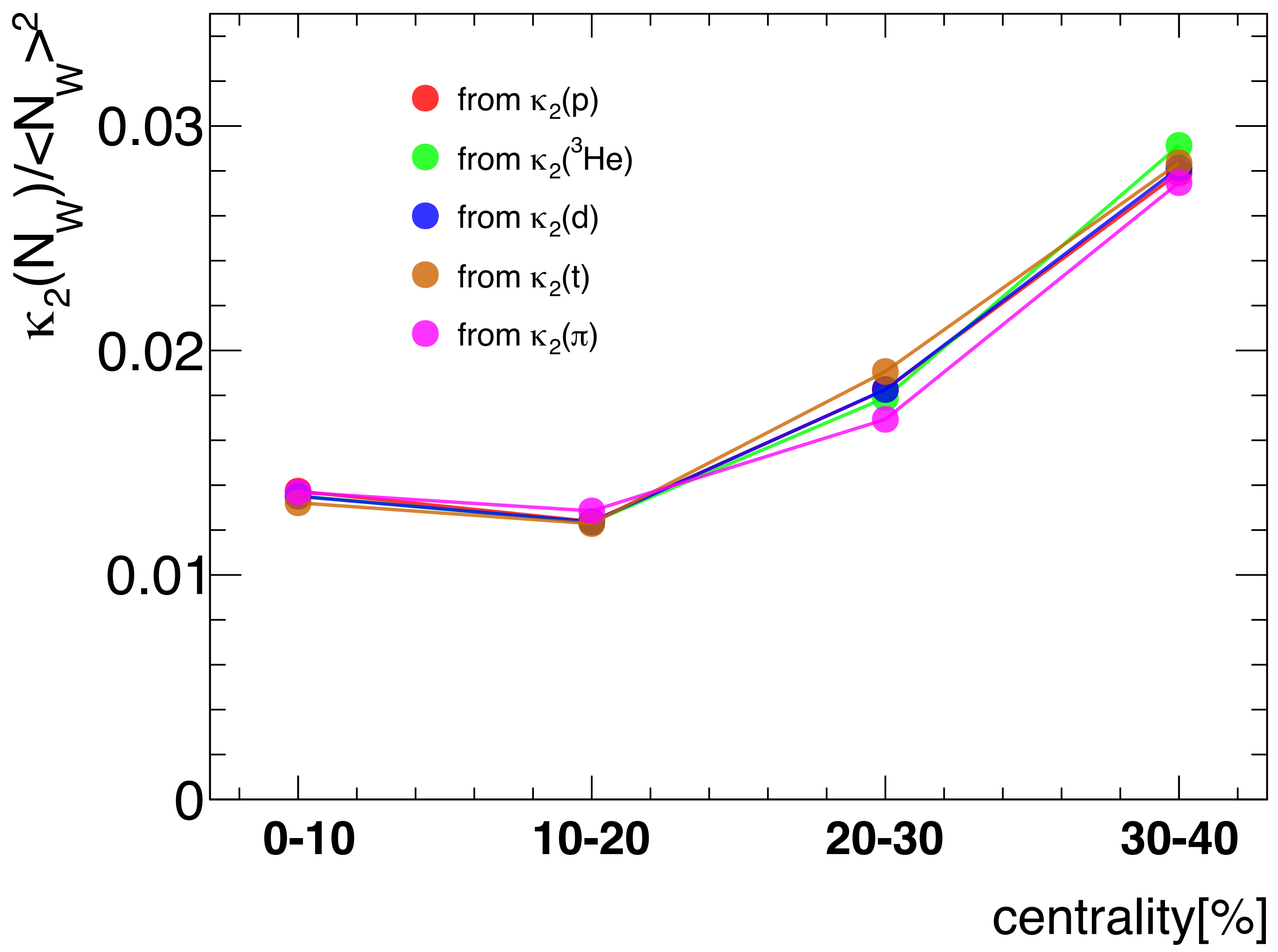


Mixed IQMD events

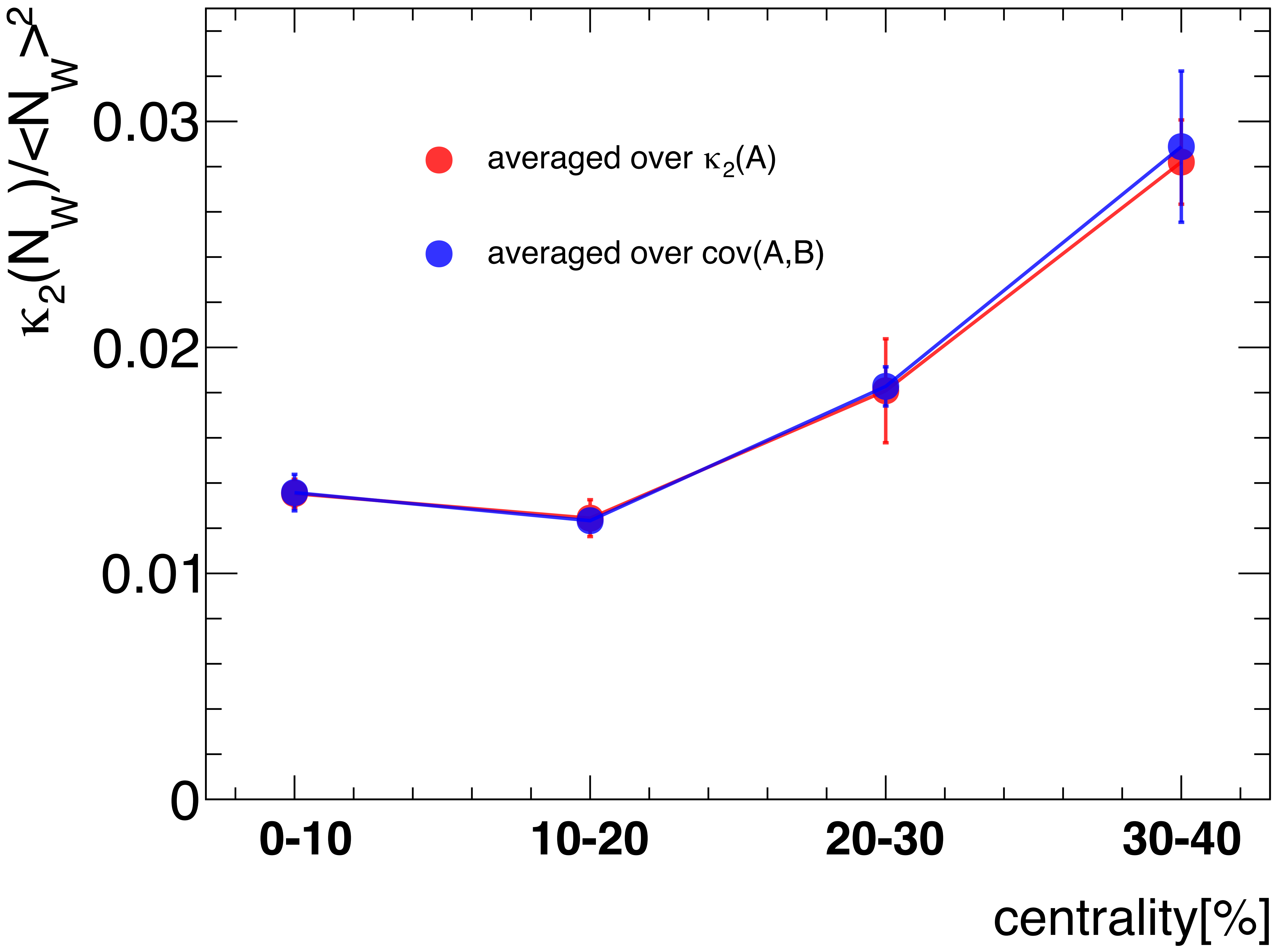


$$\frac{\kappa_2(N_W)}{\langle N_W \rangle^2} = \frac{\kappa_2(N)}{\langle N \rangle^2} - \frac{1}{\langle N \rangle}$$

Mixed IQMD events



Averaged values for volume fluctuations



Averaged values for Volume fluctuations

- Averaged over $\kappa_2(N)\ \ N \in \{p, {}^3He, d, t, \pi\}$
- Averaged over $cov(N_1, N_2)$ for 10 different particle pairs

The method proposed gives consistent results

- Extracted from $\kappa_2(N)$ and $cov(N_1, N_2)$
- 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