Update: Event by event strangeness fluctuation in MPD-NICA experiment

Rodrigo García Formentí Mendieta

Instituto de Ciencias Nucleares
UNAM

Content

Cumulants and Moments

Let $\Delta N = N - \bar{N}$ be the net multiplicity of a particle, then the standard deviation is $\delta N = \Delta N - \langle \Delta N \rangle$, and the first order cumulants are defined as:

$$C_1 = \langle \Delta N \rangle, \quad C_2 = \langle (\delta N)^2 \rangle, \quad C_3 = \langle (\delta N)^3 \rangle, \tag{1}$$
$$C_4 = \langle (\delta N)^4 \rangle - 3\langle (\delta N)^2 \rangle^2.$$

The cumulants are related with the statistical moments as:

$$M = C_1, \quad \sigma^2 = C_2, \quad S = \frac{C_3}{(C_2)^{3/2}}, \quad \kappa = \frac{C_4}{(C_2)^2} \tag{2}$$

Data Analysis

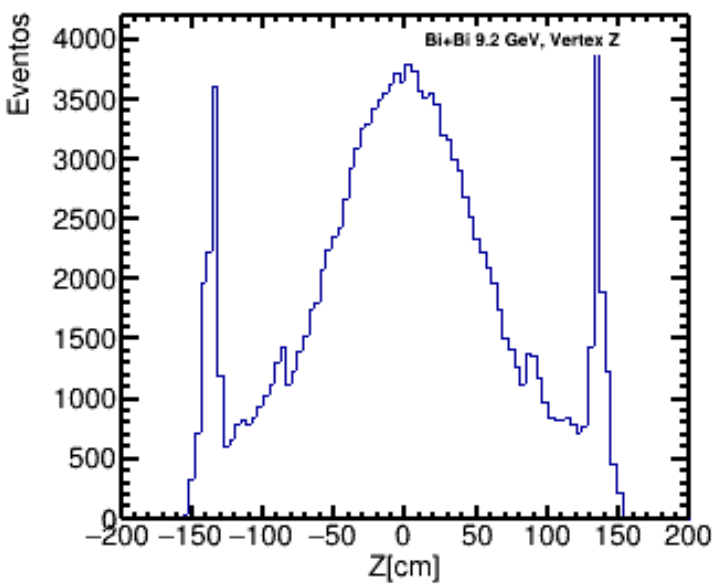
Data sample

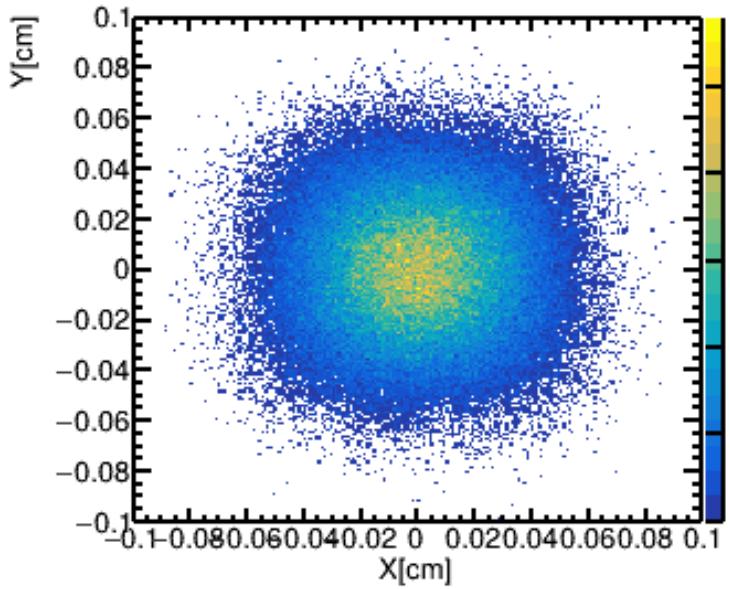
The following events were generated using UrQMD.

Collision Type	$\sqrt{S_{NN}}$	Events	Analysis
Bi+Bi (Request 25)	9.2 GeV	480,000	Reconstructed

Event Selection

Vertex cut $|z| \leq 80$ cm. Events with at least 1 charged kaon.

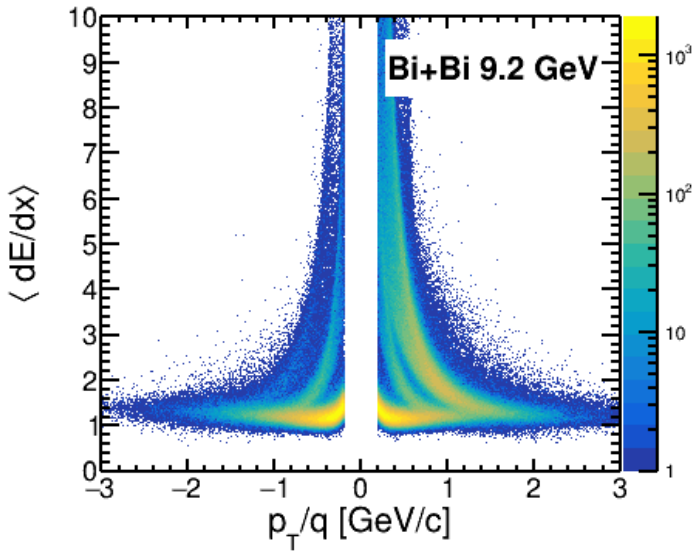


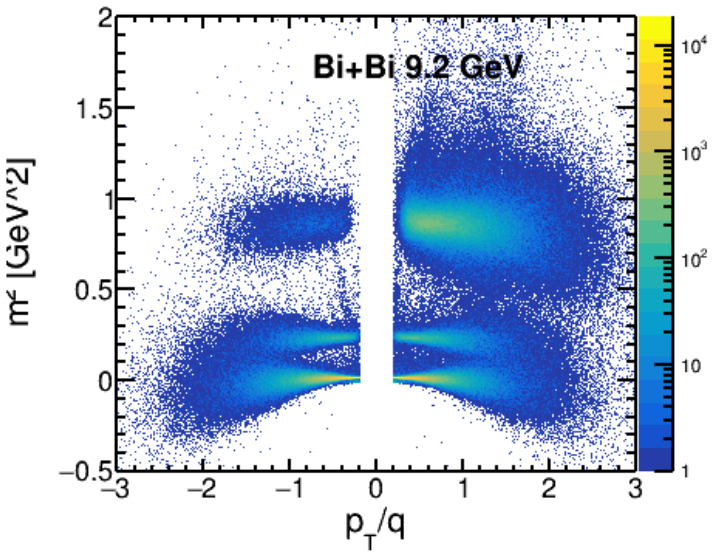


Collision	$\sqrt{S_{NN}}$	Events	Events after cuts
Bi+Bi	9.2 GeV	480,000	238,8000

Particle Identification

TPC and TOF information to identify K using the PID wagon. Only primary tracks were selected, and the following cuts were applied: $0{,}4 \leq p_T \leq 1{,}6$ GeV/c, $|y| \leq 0{,}5$, nHits> 20.





$p_T \leq 0{,}6$

- $\sigma_{TPC}, \sigma_{TOF} \leq 2$
- Or $\sigma_{TPC} \leq 2$ (Mismatch)

$p_T > 0{,}6$ $(\sigma_\phi, \sigma_z \leq 2)$

- $\sigma_{TPC} \leq 2$
- $\sigma_{TOF} \leq 2$

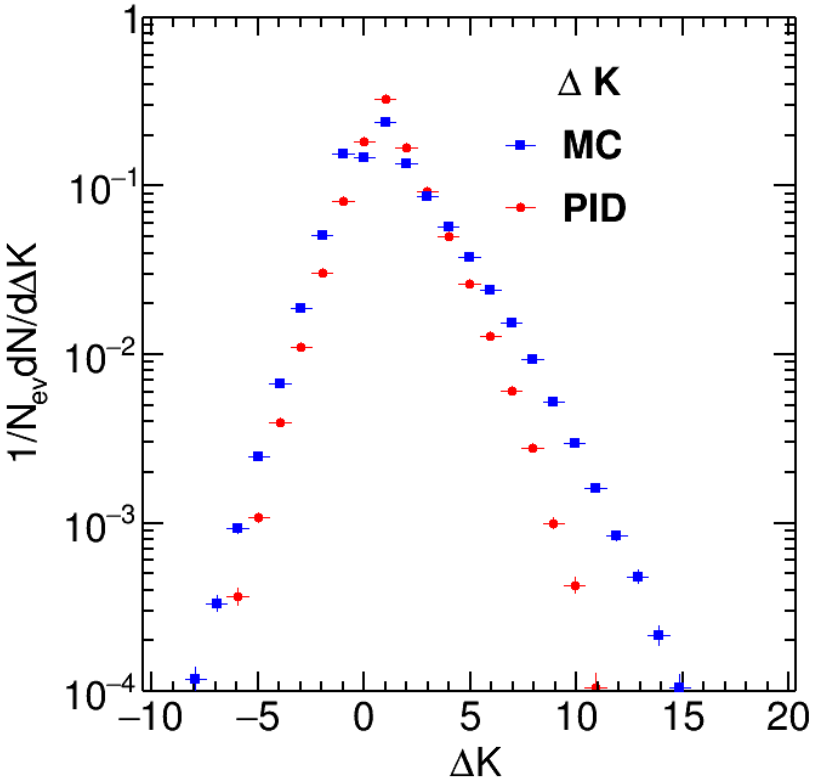
Update: Centrality Bin Width Correction (CBWC)

The initial collision geometry is not directly measurable, which can cause a centrality bin width effect due to volume variations. To correct this, we apply the Centrality Bin Width Correction:

$$C_i = \frac{\sum_r n_r C_{i,r}}{\sum_r n_r}$$

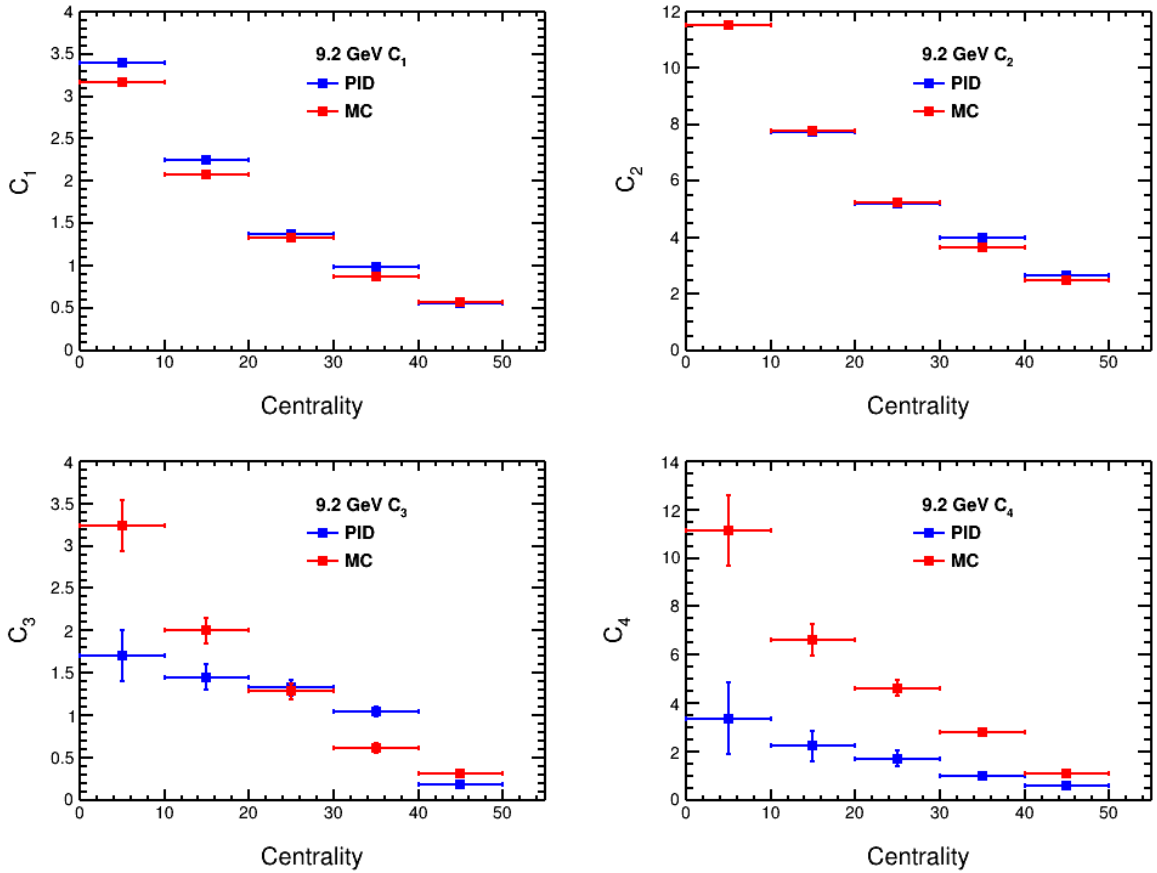
where n_r is the number of events in the $r-$th multiplicity.

Net Kaon Distribution



Net kaon distribution from Bi+Bi collisions at 9.2 GeV. Monte Carlo and PID uncorrected distribution.

Calculation of cumulants (Corrected by CBWC)



Statistical cumulants (corrected by CBWC) compared with Monte Carlo. It is not possible to perform the physical analysis without correction.

Cumulants Corrections

To perform the correction, we assume that the difference between the real distribution P and the measured distribution p can be modeled as a binomial distribution, so defining the factorial moments of p and P as

$$f_{ik} = \left\langle \frac{n_1!}{(n_1-i)!}\frac{n_2!}{(n_2-k)!} \right\rangle, \quad F_{ik} = \left\langle \frac{N_1!}{(N_1-i)!}\frac{N_2!}{(N_2-k)!} \right\rangle \tag{3}$$

we can get the relation

$$F_{ik} = \frac{1}{p_+^i p_-^k} f_{ik}. \tag{4}$$

p_+ and p_- the acceptance of the identification. With this relation, is possible to obtain the real value of the cumulants.

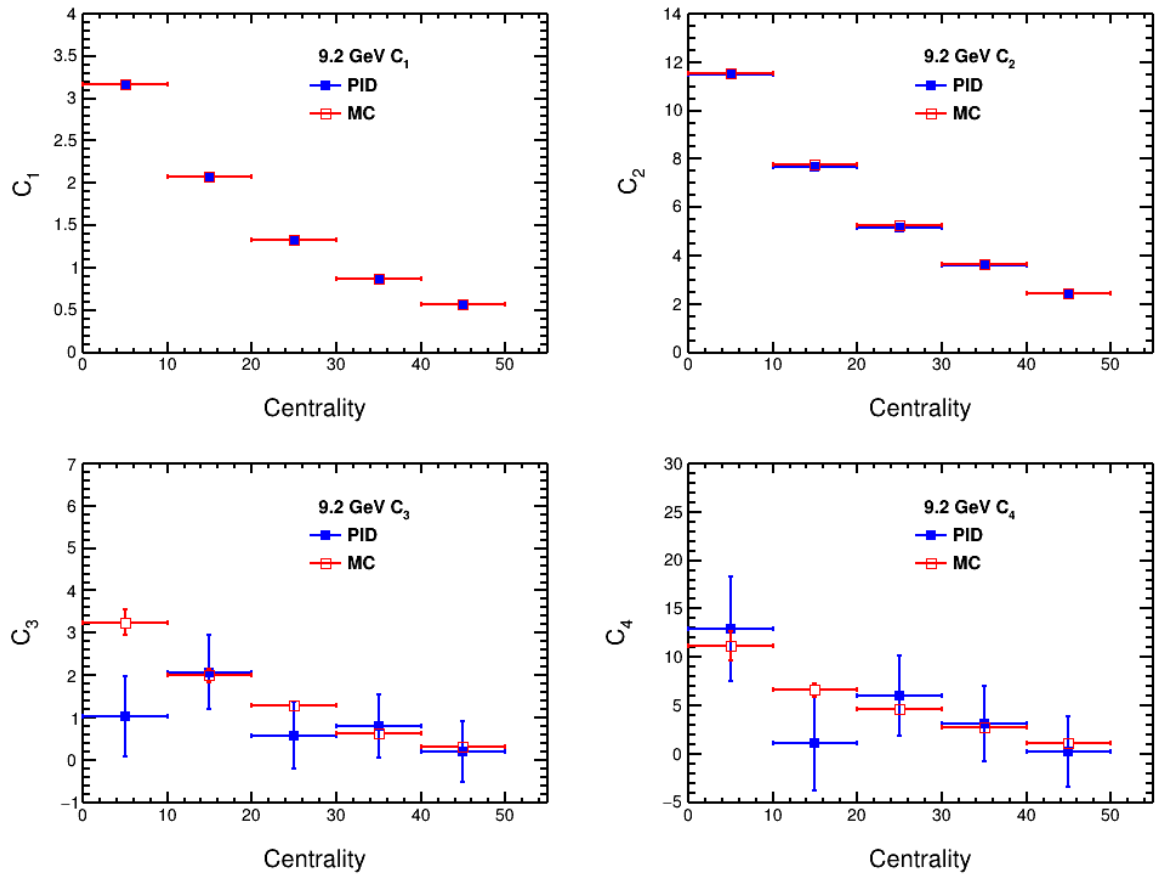
Cumulants Corrections

Using the previous relations and by the definition of statistical cumulants, the following equalities are obtained:

$$
\begin{aligned}
C_1 &= F_{10} - F_{01}, \\
C_2 &= N - C_1^2 + F_{02} - 2F_{11} + F_{20}, \\
C_3 &= C_1 + 2C_1^3 - F_{03} - 3F_{02} + 3F_{12} + 3F_{20} - 3F_{21} + F_{30} \\
&- 3C_1(N + F_{02} - 2F_{11} + F_{20}), \\
C_4 &= N - 6C_1^4 + F_{04} + 6F_{03} + 7F_{02} - 2F_{11} - 6F_{12} - 4F_{13} \\
&+ 7F_{20} - 6F_{21} + 6F_{22} + 6F_{30} - 4F_{31} + F_{40} \\
&+ 12C_1^2(N + F_{02} - 2F_{11} + F_{20}) - 3(N + F_{02} - 2F_{11} + F_{20})^2 \\
&- 4C_1(C_1 - F_{03} - 3F_{02} + 3F_{12} + 3F_{20} - 3F_{21} + F_{30}).
\end{aligned}
$$

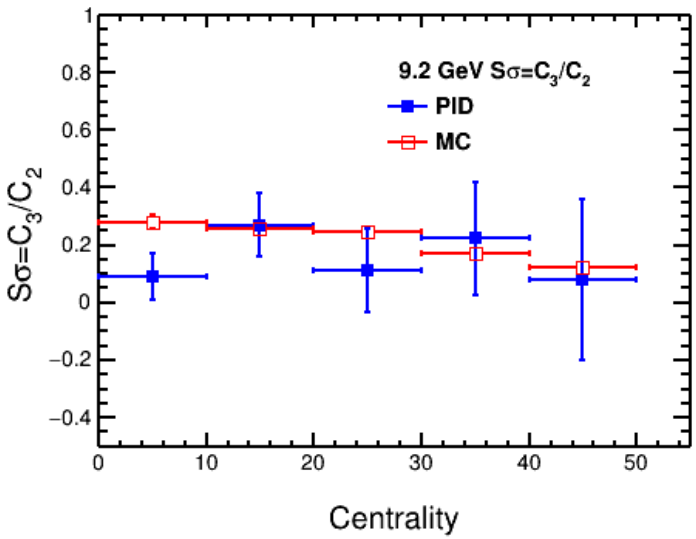
C_n are the cumulants of the real distribution.

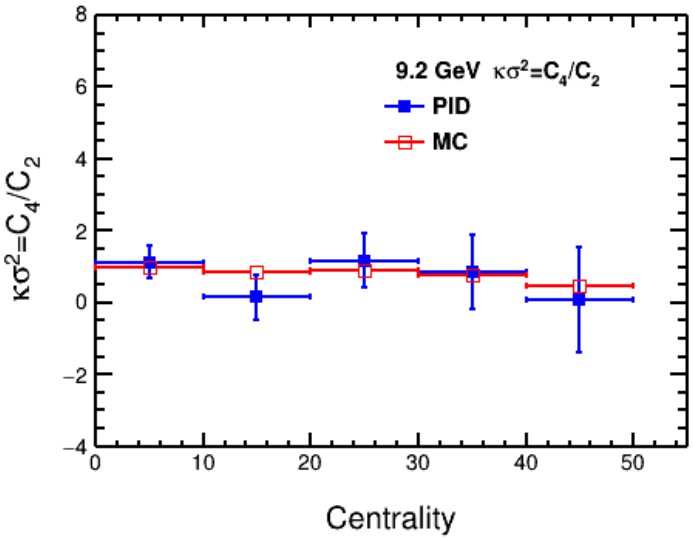
Calculation of cumulants (corrected)



Statistical cumulants with correction. Higher order cumulants have more discrepancy in central collisions.

Cumulants Ratios





Cumulants ratios with correction. Discrepancy in central collisions.

Summary and perspectives

The study of strangeness number fluctuations and the calculation of the first 4 cumulants were presented at the reconstruction level in the MPD experiment.

- UrQMD (Request 25) produce a reasonable description of the strangeness.
- The cumulants (C_1, C_2, C_3, and C_4) for strangeness were calculated and corrected using factorial moments. Results from cumulants at the most central collision indicate that we need a lot of data.
- Data have been corrected by: Centrality Bin Width and Factorial moments.

I wondering if this work can be considered for the paper in preparation.

Thank you for your attention [1].

[1] Special thanks to Eleazar Cuautle