Forward-backward correlations and multiplicity fluctuations in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV from ALICE at the LHC

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Motivation: Why do we study correlations and fluctuations?

The aim of the analysis:
→ Forward-backward correlation coefficient $b_{\text{corr}}$
→ Strongly intensive quantity sigma $\Sigma$
Forward-backward correlations $b_{\text{corr}}$

$$b_{\text{corr}} = \frac{\text{Cov}(n_F, n_B)}{\sqrt{\text{Var}(n_F) \text{Var}(n_B)}}$$

- Dependence on centrality estimator;
- Drop of the value of $b_{\text{corr}}$ (reduced fluctuations of $N_{\text{part}}$).
Strongly intensive quantity $\Sigma$ for a symmetric collision, like Pb-Pb:

$$\Sigma \approx \omega (1 - b_{corr})$$

Scaled variance = \frac{\text{variance}}{\text{mean}}

$\Sigma$ does:

$\rightarrow$ not depend on centrality estimator;
$\rightarrow$ not depend on centrality bin width.
Strongly intensive quantity $\Sigma$

**MC simulations**

ALICE Simulation
Hijing generated
Pb-Pb $|s_{NN}| = 2.76$ TeV
$\rho_\perp > 0.2$ GeV/c
$\Delta \eta = 1.2$, $\delta \eta = 0.2$, $\varphi \in (0, 2\pi)$

Centrality via impact parameter

Centrality via V0

**Experimental data**

ALICE Preliminary
Pb-Pb $|s_{NN}| = 2.76$ TeV
$\rho_\perp > 0.2$ GeV/c
$\Delta \eta = 1.2$, $\delta \eta = 0.2$, $\varphi \in (0, 2\pi)$

Centrality via ZDCvsZEM

Centrality via V0

$\sigma = \text{Cov}(n_F, n_B)\sqrt{\text{Var}(n_F)\text{Var}(n_B)}$

Different ordering of the values of $\Sigma$ with centrality $\rightarrow$ possible hint about the early dynamics?
1. Data on forward-backward correlations ($b_{\text{corr}}$) and first experimental data on strongly intensive ($\Sigma$) quantity in Pb-Pb collisions at $\sqrt{s_{\text{NN}}}=2.76$ TeV:

$\rightarrow b_{\text{corr}}$: large dependence on centrality bin width and estimator!

$\rightarrow b_{\text{corr}}$: information on early dynamics is mixed with trivial geometrical fluctuations.

$\rightarrow \Sigma$: does not depend on centrality selection method nor on centrality bin width

$\rightarrow$ these are properties of a strongly intensive quantity!

2. The comparison between experimental data and MC simulations for the strongly intensive quantity $\Sigma$ shows different ordering of the values of $\Sigma$ with centrality $\rightarrow$ possible hint about the early dynamics?

Thank you!
The Analysis: ALICE Experiment

Pb-Pb @ $\sqrt{s_{NN}} = 2.76$ TeV

**TPC → main tracking detector**

**ZDC → Centrality 0-40%.**
*Estimator:* energy of spectators
*most forward detector* ZDC vs ZEM

**V0 → Centrality 0-80%.**
*Estimator:* energy deposition by charged particles
Strongly intensive quantity $\Sigma$

Intensive quantities do not depend on system volume.

Scaled variance:
\[ \omega_{B(F)} = \frac{\text{Var}(n_{B(F)})}{\langle n_{B(F)} \rangle} \]

Strongly intensive quantities do not depend on system volume nor system volume fluctuations (i.e. $\text{Var}(N_s,\omega_s) \rightarrow \Sigma$)

\[ \Sigma = \frac{1}{\langle n_B \rangle + \langle n_F \rangle} \left[ \langle n_F \rangle \omega_B + \langle n_B \rangle \omega_F - 2 \text{Cov}(n_F, n_B) \right] \]

For a symmetric collision, like Pb-Pb:
\[ \omega_B = \omega_F \text{ and } \langle n_F \rangle = \langle n_B \rangle \]
\[ \Sigma \approx \omega(1-b_{\text{corr}}) \]

For Poisson distribution: $\omega=1$ & $b_{\text{corr}}=0 \rightarrow \Sigma=1$