Forward-backward correlations between event-mean p_T in Pb-Pb collisions

Igor Altsybeev (Saint Petersburg State University) for the ALICE Collaboration

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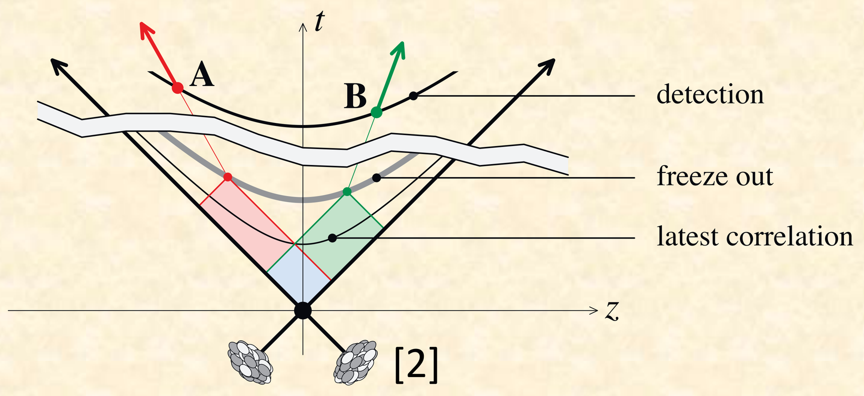
Motivation

Soft and semi-hard parts of the multi-particle production in pp collisions at high energy are successfully described in terms of colour strings stretched between the projectile and target. The hadronization of these strings produces the observed hadrons. In the case of nuclear collisions, the number of strings grows with the growing energy and the number of nucleons of colliding nuclei, and one has to take into account the interaction between strings in the form of their fusion and/or percolation. The possible experimental observation of the string interaction phenomenon as an intermediate process, leading to the QGP formation, is extremely interesting. Forward-backward (FB) correlations between mean p_T in two separated pseudorapidity intervals were proposed as the main tool to study this phenomenon [1].

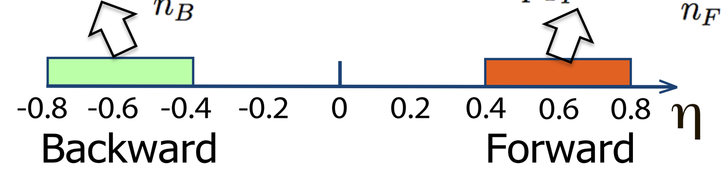


Observable and data analysis

FB correlations are usually measured between observables obtained in an event-by-event analysis in two separated η-intervals. The conventional observable for the FB correlations analysis is the charged particle *multiplicity* (**n-n correlations**). In the present study, instead of the multiplicity, we took an intensive observable, namely the *event-averaged transverse momentum* of particles measured in each of the two pseudorapidity intervals, and call it **mean-p_T correlations**. The strength of the correlation (b_{corr}) between observables F and B is determined by expression below:

$$b_{corr} = \frac{\langle FB\rangle - \langle F\rangle\langle B\rangle}{\langle F^2\rangle - \langle F\rangle^2}$$

$$B \equiv \overline{p_T}_B = \frac{\sum_{i=1}^{n_B} p_T^{(i)}}{n_B} \qquad F \equiv \overline{p_T}_F = \frac{\sum_{j=1}^{n_F} p_T^{(j)}}{n_F}$$



FB correlations are measured in Pb-Pb collisions at $\sqrt{s_{NN}}$=**2.76** and **5.02 TeV** with the ALICE detector. Particle reconstruction was performed using Inner Tracker System (ITS) and Time Projection Chamber (TPC). Kinematic range is $|\eta|<0.8$, **p_T range 0.2-2.0 GeV/*c***. Systematic uncertainties for b_{corr} are about 3-5%. Centrality estimators used in the analysis are V0 detector (which consists of two arrays of scintillators V0C $-3.7 < \eta < -1.7$ and V0A $2.8 < \eta < 5.1$) and zero-degree calorimeter ZDC.

Notations: η_{gap} – distance between FB intervals, $\delta\eta$ – interval width (taken as 0.4 for this analysis).

Evolution with centrality

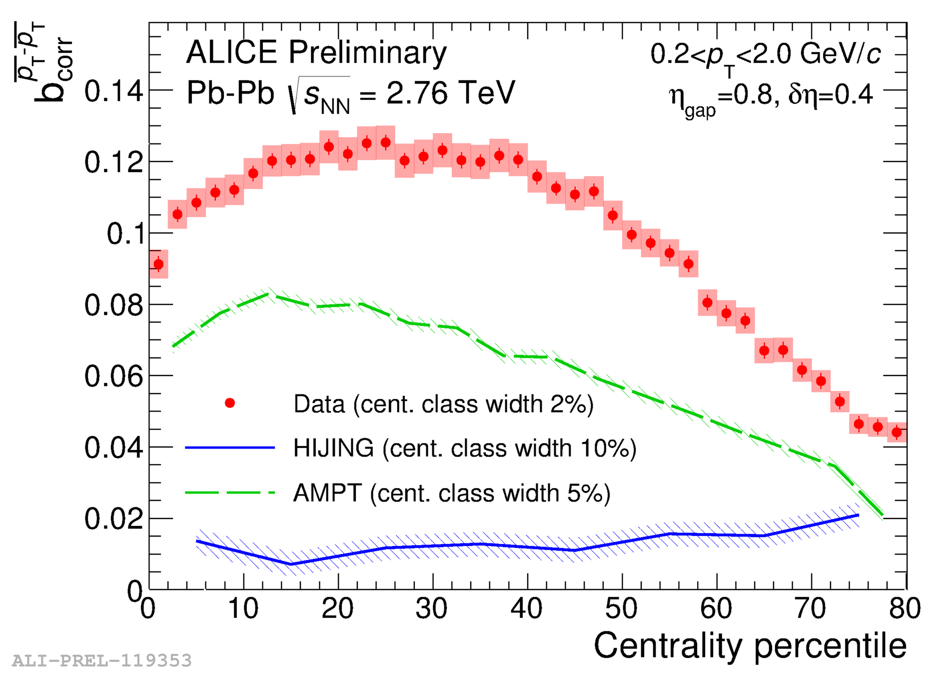


Fig.1 FB mean-p_T correlation strength as a function of centrality in comparison with calculations from AMPT and HIJING.

- ✧ The magnitude of the FB mean-p_T correlation strength rises from peripheral to mid-central and drops towards central collisions (Figure 1).
- ✧ Monte-Carlo event generators generally do not describe this centrality evolution: HIJING provides too weak correlations with no dependence on centrality, while AMPT shows significant correlations but does not quantitatively or qualitatively agree with the data.
- ✧ Calculations in other MC generators are shown in Figure 2 (with different kinematic cuts). It can be seen that only the string fusion model [3] qualitatively describes the behavior of b_{corr} observed in data.

One of the possible explanations of the decline of the mean-p_T correlation coefficient for most central collisions was obtained in the model with quark-gluon string fusion on the transverse lattice [4]. It was shown that this decline can be explained by the attenuation of color field fluctuations due to the string fusion processes at large string density, which can be gained only at LHC energy (at energies above RHIC). Note that in this simple model there is no azimuthal flow. This qualitative explanation is confirmed by the results [5, 6], obtained in a more realistic dipole-based Monte Carlo string fusion model [7, 8].

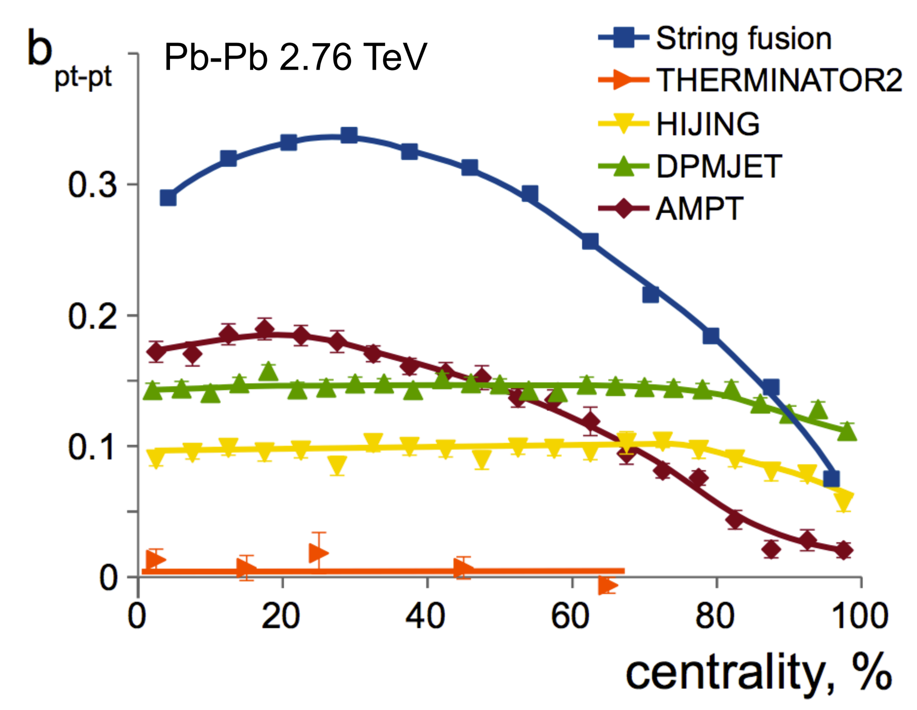


Fig.2 FB mean-p_T correlations in different monte-carlo models [5]. Kinematic cuts are different than in Fig.1.

Comparison with multiplicity correlations

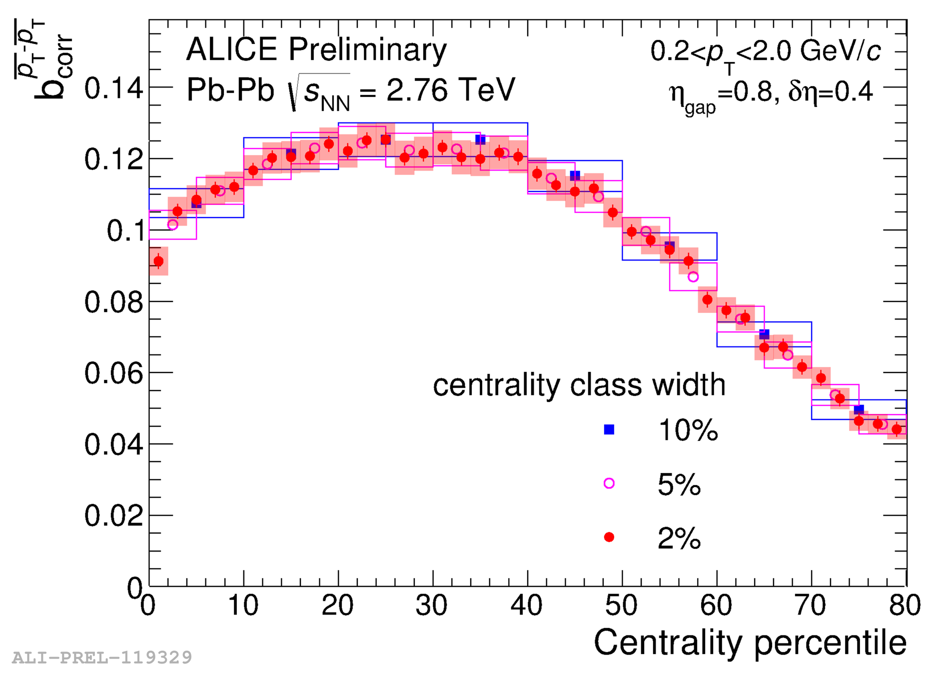


Fig.3 FB mean-p_T correlation strength as a function of centrality, in centrality classes of the widths 10, 5 and 2% determined by V0M estimator.

Event-mean transverse momenta correlations are robust against volume fluctuations and thus the centrality determination methods (see Figure 3), which provides higher sensitivity of this quantity to the properties of the initial state and evolution of the medium created in AA collisions.

In contrast, FB *multiplicity* correlations strongly depend on the size of centrality class and type of centrality estimator (see Figure 4 to the right), so any physical conclusions should be made very carefully. The reason is that the FB multiplicity correlation is a correlation between *extensive* observables, whereas the FB mean-p_T correlation is a correlation between *intensive* observables, which are not influenced by trivial "volume" fluctuations.

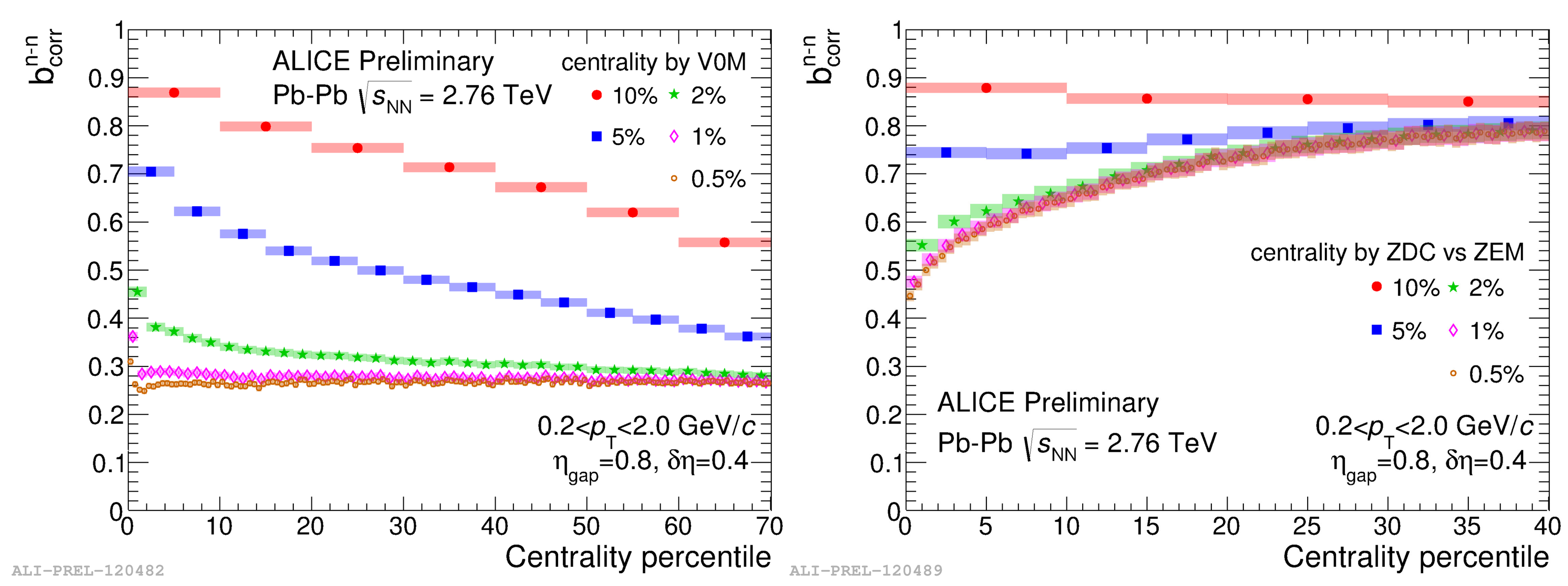


Fig.4 FB multiplicity correlation strength as a function of centrality, in centrality classes of the widths 10, 5, 2, 1 and 0.5% determined by V0M estimator (left plot) and by ZDC (right plot).

Dependence on η-gap between windows

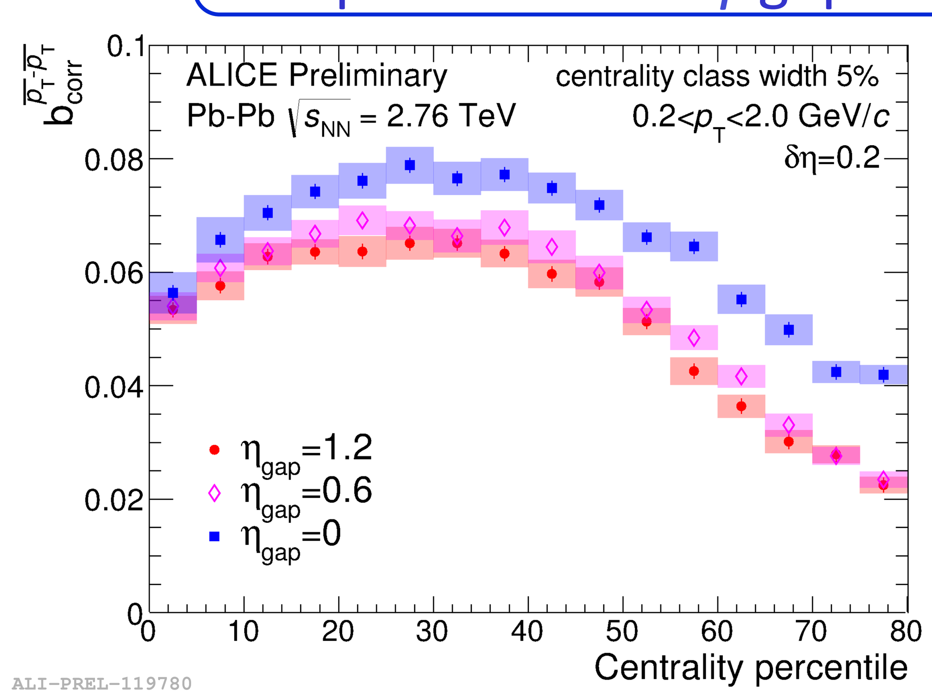


Fig.5 The magnitude of the FB correlation strength is obtained for different gaps between pseudorapidity intervals. Size of F and B intervals on this plot is $\delta\eta$=0.2.

At all η gaps, the shape of the centrality dependence of b_{corr} is the same, however, values are higher at η gap=0 due to short-range contributions from resonance decays and mini-jets.

Compare results at two energies

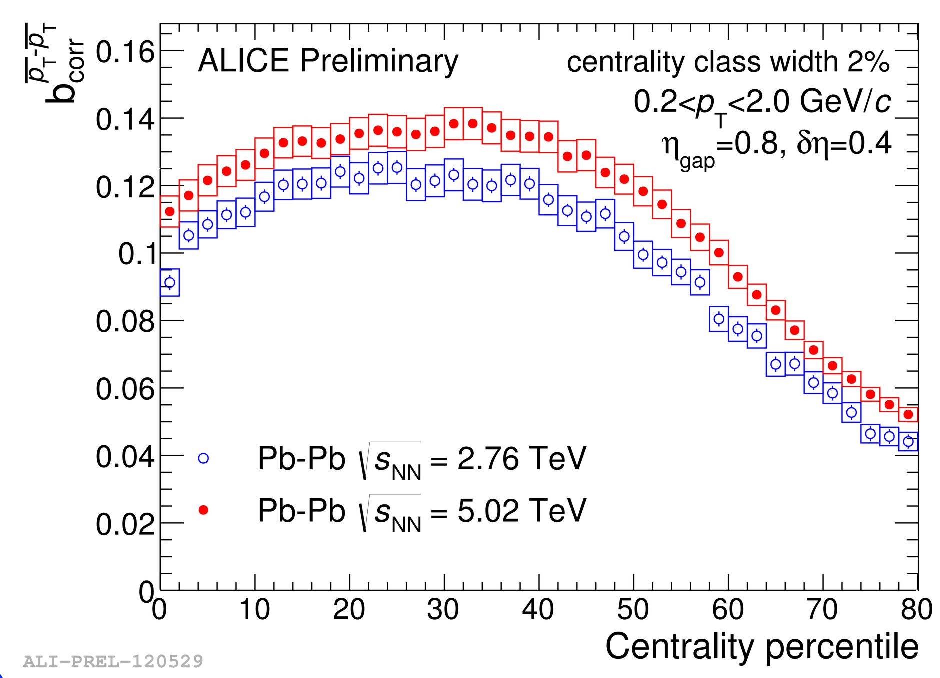


Fig.6 FB mean-p_T correlation strength as a function of centrality at $\sqrt{s_{NN}}$=2.76 and 5.02 TeV.

- ✧ similar behavior with centrality at both energies
- ✧ higher b_{corr} values at 5.02 TeV (by 10-25%)

Conclusions

- Forward-backward correlations between event-mean transverse momenta in two separated windows have been measured with ALICE at 2.76 and 5.02 TeV in p_T range 0.2-2.0 GeV/*c*
- These correlations are robust against volume fluctuations and thus the centrality determination methods
  - ✧higher sensitivity to the properties of the initial state and medium evolution
- Correlation coefficient b_{corr} rises from peripheral to mid-central and then falls for central events
- Behavior is not reproduced by MC generators, but string fusion model provides reasonable description
- Behavior at different η gaps between FB windows is similar
- Centrality dependence of b_{corr} at 5.02 TeV is similar to 2.76 TeV, with slightly higher values
- FB *multiplicity* correlations are shown to be heavily dependent on centrality selection (type of estimator, class width), so any physical conclusions should be made very carefully

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