Forward-backward multiplicity correlations in pp collisions at √s = 0.9, 2.76 and 7 TeV

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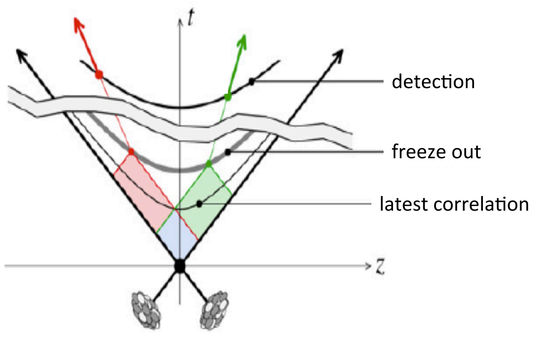
Overview

Causality requires appearance of long-range correlations at the very early stages between particles detected in separated rapidity intervals in any type of collisions (pp, pA, AA).

This report is devoted to the correlations between charged particle multiplicities in backward (B) and forward (F) rapidity windows, where n_F and n_B are the corresponding multiplicities.



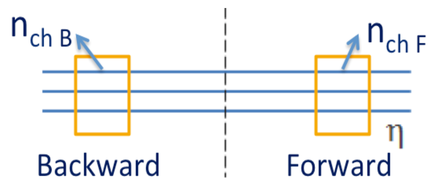
Motivation:

- String percolation picture of pp collisions at LHC energies (P. Brogueira, J. Dias de Deus, and C. Pajares, Phys. Lett. B 675 (2009) 308)
- CGC predictions for pp collisions at the LHC (E.Levin and Amir H. Rezaeia, "Gluon saturation and inclusive hadron production at LHC", PRD82, 014022 (2010), arXiv:1005.0631)
- Color string fusion phenomenon (SFM) (M.A.Braun and C.Pajares, Phys. Lett. B287 (1992) 154; Nucl. Phys. B390 (1993) 542, 549)
- "Twisted correlations" as a tool to tune color reconnection and MPI in PYTHIA (K. Wraight and P. Skands, Eur. Phys. J., C 71 (2011) 1628).

The FB correlation strength b_{corr} is determined by:

1) linear regression: $\langle n_B \rangle_{n_F} = a + b_{corr} \cdot n_F$

2) by alternative formula: $b_{corr} = \frac{\langle n_B n_F \rangle - \langle n_B \rangle \langle n_F \rangle}{\langle n_F^2 \rangle - \langle n_F \rangle^2}$



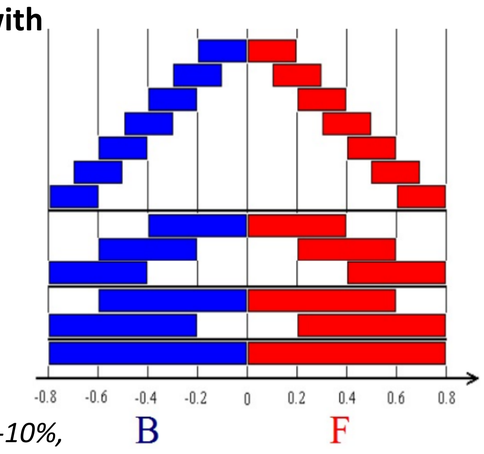
Determination of the FB multiplicity correlations with the ALICE detector

***η*-window pairs** used in ALICE are shown in the Figure.
Notations:

- η_{gap} – distance between windows,
- $\delta\eta$ – windows width.

Particle reconstruction was performed using Inner Tracker (ITS) and Time Projection Chamber (TPC).
Kinematic range is $|\eta|<0.8$, p_T range 0.3-1.5 GeV/*c*.

Correction factors for b_{corr} are found to be of the order of *5-10%*, systematic uncertainties are of the order *2-5%*.



ALICE results for pp collisions

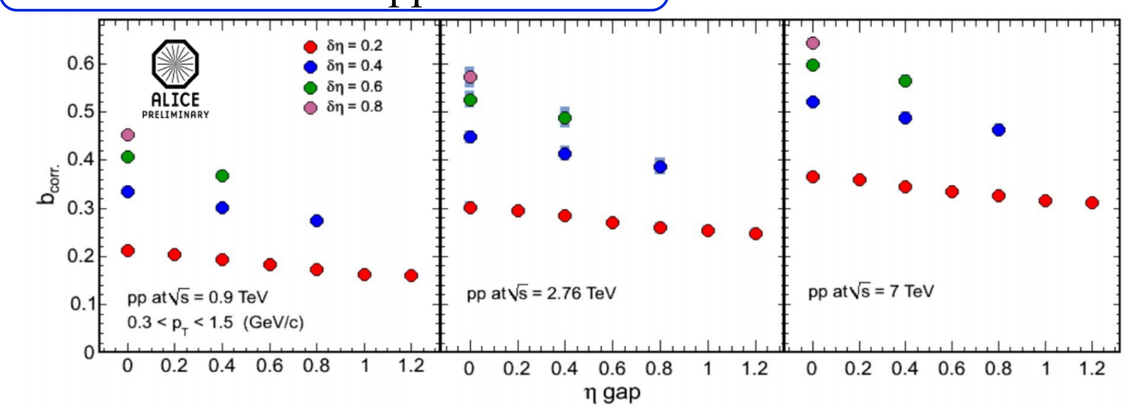


Fig.1: FB multiplicity correlation strength as a function of *η*-distance between the windows, for different width (*δη*) of the windows.

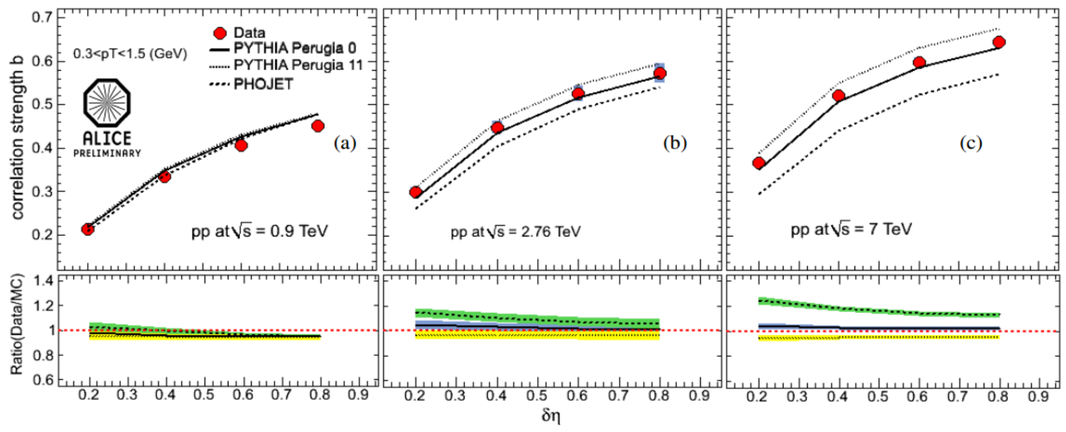


Fig.2: FB multiplicity correlations as a function of *δη*.
The comparison to the PYTHIA6 and PHOJET is shown.

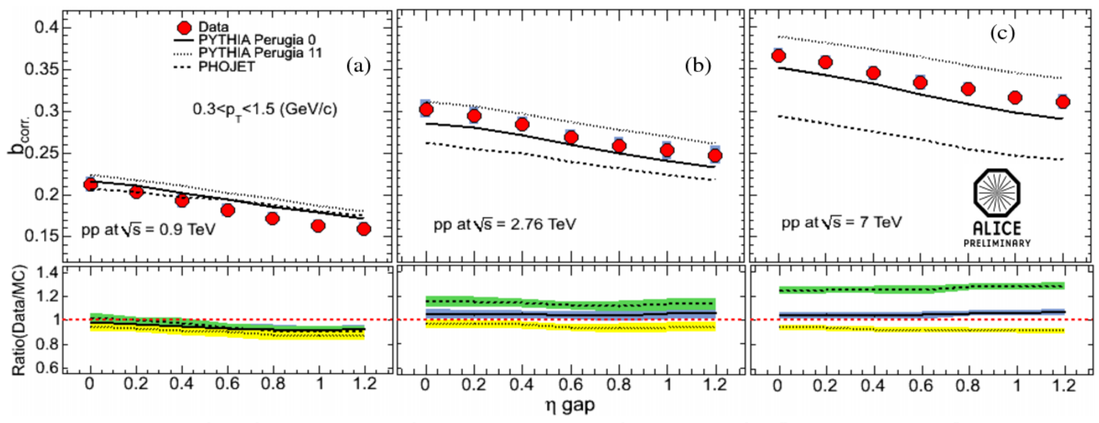


Fig.3: FB multiplicity correlations in windows with *δη*=0.2 as a function of *η*-distance, in comparison to the PYTHIA6 and PHOJET.

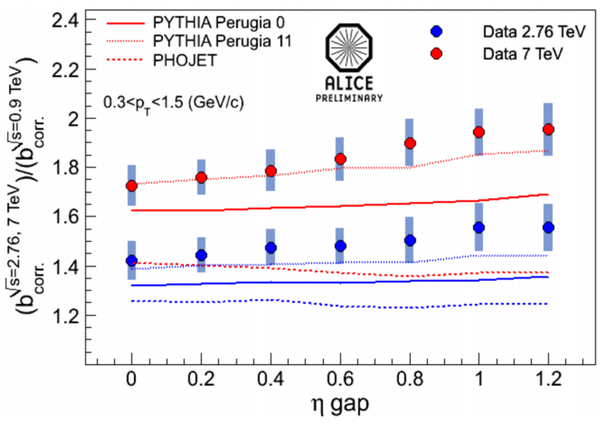


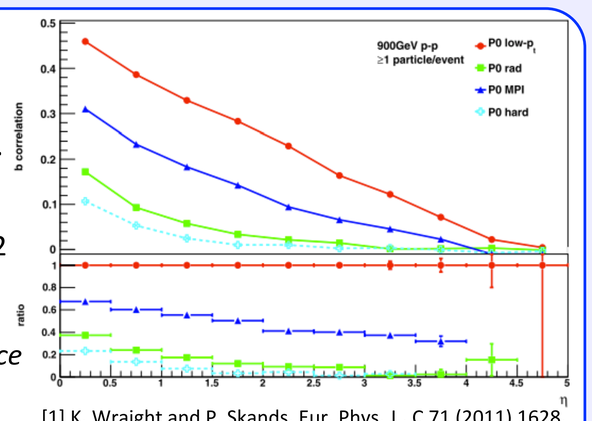
Fig.4: b_{corr} ratio for 2.76 (blue circles) and 7 TeV (red circles) with respect to 0.9 TeV vs. η_{gap}.
Lines are for MC generators: PYTHIA6 Perugia0 (solid), Perugia2011 (dotted) and PHOJET (dashed), for 2.76 TeV (blue) and 7 TeV (red).

FB correlations in models

- Influence of the MPI on the FB multiplicity correlations

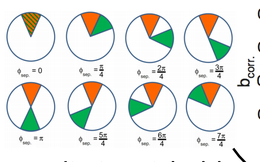
FB correlations were studied with different PYTHIA6 parameterizations [1].

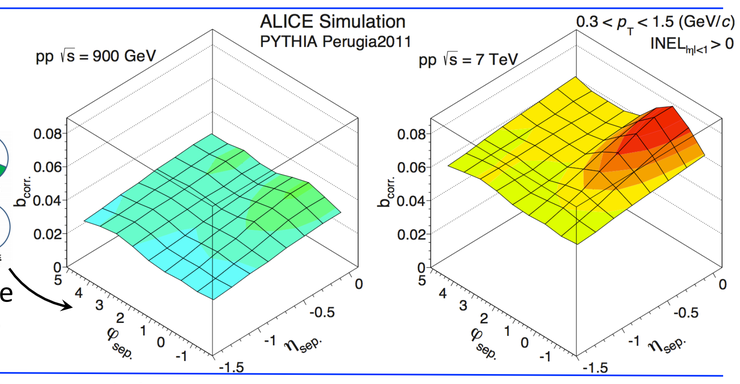
Figure: b_{corr} for tune Perugia 0 particle production mechanisms.
The green and cyan lines correspond to samples with single partonic 2-to-2 interaction without Multiple Parton Interactions (MPI):
HARD: no MPI, no parton showers; RAD: no MPI, with parton showers.
In both cases it could be seen, that switching off the MPI causes *the absence of correlations* at large *η* distances.



[1] K. Wraight and P. Skands, Eur. Phys. J., C 71 (2011) 1628.

- FB multiplicity correlations in PYTHIA6 (Perugia 2011) with additional *φ*-binning of the windows:





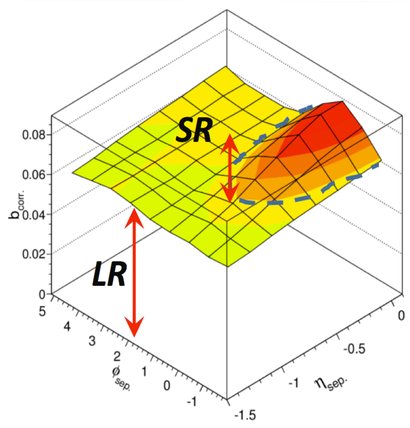
The following features were observed:
- short-range and long-range contributions are distinguishable
- non-zero plateau is observed and increases with the energy

- FB multiplicity correlations in the parametric string model (results interpretation)

Introduce $\delta a = \delta\eta\,\delta\phi/2\pi$ - *acceptance* of the forward and backward windows.
For windows with small acceptances in rapidity and azimuth situated in a mid rapidity region: $b_{corr} = b^{LR} + b^{SR}$, where:

$$b^{LR} = \frac{\omega_N \mu_0 \delta a}{1 + [\omega_N + \Lambda(0,0)]\mu_0 \delta a}, \quad b^{SR} = \frac{\mu_0 \delta a}{1 + [\omega_N + \Lambda(0,0)]\mu_0 \delta a}\Lambda(\eta_{sep}, \phi_{sep})$$

ω_N is the event-by-event scaled variance of the number of strings,
μ_0 is the average rapidity density of the charged particles produced by one string,
$\Lambda(\eta,\phi)$ is the pair correlation function of a single string.



References:
1) V.V. Vechernin, arXiv: 1305.0857, 2013
2) M.A. Braun, R.S. Kolevatov, C. Pajares, V.V. Vechernin, Eur. Phys. J. C32, 535 (2004).

Conclusions

ALICE results

- Forward-backward multiplicity correlations were measured for minimum bias pp events in windows separated in *η* for charged particles with transverse momenta 0.3-1.5 GeV/*c*.
- A considerable increase of the FB correlation strength b_{corr} with the growth of the collision energy is observed.
  It can be shown that the increase of b_{corr} with the energy can not be explained only by the increase of the mean multiplicity.
- b_{corr} increases with the width of pseudorapidity windows but decreases only slightly with the gap between the windows.
- PYTHIA and PHOJET underestimate the experimental ratios and demonstrate a flatter η_{gap} dependence.

Model analysis and interpretation

- PYTHIA and PHOJET MC event generators and the model based on the string picture of hadronic interactions indicate that the behavior of b_{corr} collisions in azimuth and rapidity is compatible with the multiparticle production by independent string emitters.
- Analysis of b_{corr} for various configurations of azimuthal sectors enables to separate the short-range (SR) and long-range (LR) effects:
  - the LR part arises due to event-by-event fluctuation of the number of emitters,
  - the SR part is due to pair correlation between particles produced by the same emitter.
- The LR part reveals itself as a common pedestal increasing with the collision energy.
- Experimental results for *η-φ* windows are upcoming.