Forward-Backward Multiplicity Correlation in pp collisions at LHC energies

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Outline

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- Correlation history
- $b_{corr}$ Correlation definition
- Correlation on Pythia vs ALICE data
- Some correlation studies:
  - Multiplicity
  - Colour Reconnection (CR)
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- Remarks and Conclusions
Motivation

- Characterization and extraction of information on hadronic processes using F-B correlations.
- Analysis of Colour Reconnection and MPI using F-B.
Correlation History

- Collisions $e^+e^-$ in ISR, PETRA
  - 29 Gev, ~1989
- Collisions $pp$ in ISR
  - 56 Gev, ~1978
- Collisions $pp \bar{p}$ in Spp$\bar{p}$
  - 570 Gev, ~1983
- Collisions $Au-Au$ in RIHC
  - 200 Gev, ~2009
- Collisions $pp$ at ALICE CERN
  - 0.9 & 7 TeV 2015

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Definition of Multiplicity Correlation

Correlation is obtained from the multiplicity event by event in intervals of pseudorapidity.

\[
\langle n_B \rangle_{n_F} = a + b_{Corr} \cdot n_F
\]

Under the assumption of a linear correlation between the average Multiplicity in forward and backward.

\[
b_{Corr} = \frac{\langle n_F n_B \rangle - \langle n_F \rangle \langle n_B \rangle}{\langle n_F^2 \rangle - \langle n_F \rangle^2}
\]
Events Generated (PYTHIA 8)

Pythia8215, with the Tune Monash2013 for pp collisions. The main initial conditions for the data sample used are:

- Cuts in $|\eta|<1$
- Cuts in 0.3GeV/c<$p_T<$1.5GeV/c
- Charged
- Final State
- Primary Particles
Pythia vs Alice Data

We need to be sure that we are calculating correctly the correlation

\[ \eta_{\text{gap}} = 0 \]

We observe a good agreement with the published data at two energies.

[ALICE Collaboration: JHEP 05 (2015) 097]
Another distribution to check, is $b_{\text{corr}}$ vs $\eta_{\text{gap}}$, generated with pythia8 Monash 2013.

Again we reproduce well the data

[ALICE Collaboration: JHEP 05 (2015) 097]
One way to characterize the events is by \( b_{\text{corr}} \) in function of multiplicity. We observe strong dependence on multiplicity which is correlated with different nMPI.
One can observe significant differences between low (0.9 TeV) and high (7.0 TeV) energies.
**Colour Reconnection and Correlation**

CR mechanics could be study, through the measurements of $b_{\text{corr}}$. (Here $|\eta|<2.4$)

CR: A nonperturbative model applicable to any final state.

At hadronization time each string piece has a probability to interact with other string:

Here we can see the effects of CR on the correlation factor. Increase of CR range imply decrease of $b_{\text{corr}}$. 

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nMPI and Multiplicity

Next distribution
Shows how is the behavior of nMPI and Multiplicity

MPI and Correlation

MPI produce effects on $b_{\text{corr}}$ under certain range of nMPI. Low and high nMPI range correspond to different kind of process.

Different nMPI produce not the same multiplicity distributions.

High range of nMPI means an increase Correlation at very short range of centrality, meanwhile decrease for bigger range in pseudorapidity.
nMPI increase with the energy of collision. Higher nMPI means bigger Correlations.

Increase of the collision energy imply larger Correlation for all range of nMPI.
We observe that the increase of the multiplicity and low nMPI the $b_{corr}$ goes to even more negative, and for bigger nMPI the behavior is opposite.
We have analyzed Multiplicity F-B correlations using Pythia8 event generator. We observe complete agreement between ALICE data and simulation.

The excellent agreement in F-B correlations led us to study details of phenomena like CR, nMPI and its relations to the multiplicity. We have observed:

- Increase the strength of correlation with the energy
- Increase the correlation with the width of pseudorapidity, meanwhile decrease with the gap increment between the windows.
- CR range produce smaller correlation factor.
- Correlation factor increase with nMPI
- Interesting behaviour of the correlations for hard QCD processes. This kind of analysis could be use to understand this phenomena on Jet and UE.

It will be interesting to see comparison of FB Correlation with Hydro
COLOR RECONNECTIONS MECHANISM

A nonperturbative model applicable to any final state.

At hadronization time each string piece has a probability to interact with other string:

\[ P = 1 - (1 - \xi)^N \]

\[ p_0 = \frac{pT_{0\text{Rec}}^2}{(pT_{0\text{Rec}}^2 + pT^2)} \]

Probability of the lowest system, until \( m \)

\[ p_0(1 - p_0)^{m-1} \]