Instituto de Ciencias Nucleares UNAM

# Forward-Backward Multiplicity Correlation in pp collisions at LHC energies

## The 8th International Workshop on Multiple Partonic Interaction at the LHC

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# Outline

- Motivation
- Correlation history
- $b_{corr}$ Correlation definition
- Correlation on Pythia vs ALICE data
- Some correlation studies:
  - Multiplicity
  - Colour Reconnection (CR)
  - Multi-parton Interaction (MPI)
- 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 **p$\overline{\text{p}}$** in **Sp$\overline{\text{pS}}$**
  - 570 Gev, ~1983
- Collisions **Au-Au** in **RIHC**
  - 200 Gev, ~2009
- Collisions **pp** at ALICE CERN
  - 0.9 & 7 TeV  2015

Phys.Rev. D34 (1986) 3304

Nucl.Phys. B132 (1978) 15

Phys.Lett. B123 (1983) 361

Phys.Rev.Lett. 103 (2009) 172301

JHEP 05 (2015) 097]

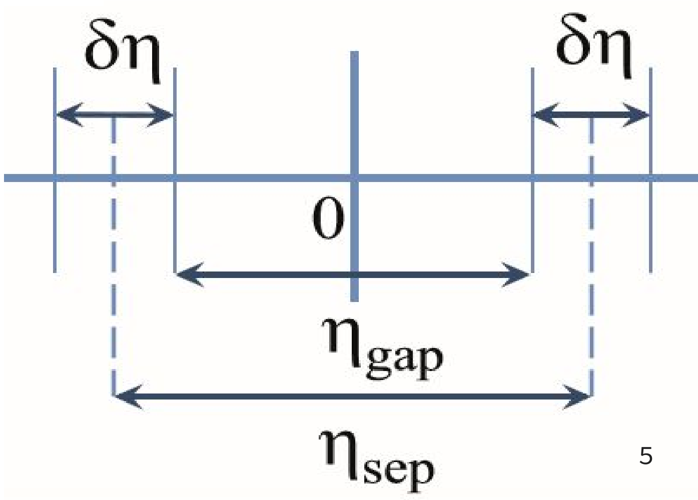
# Definition of Multiplicity correlation

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.

$$b_{Corr} = \frac{\langle n_F n_B \rangle - \langle n_F \rangle \langle n_B \rangle}{\langle n_F^2 \rangle - \langle n_F \rangle^2}$$



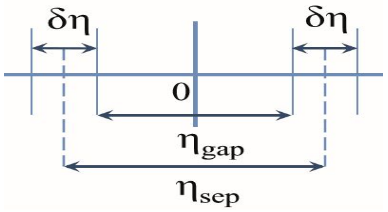
# Events Generated (PYTHIA 8)

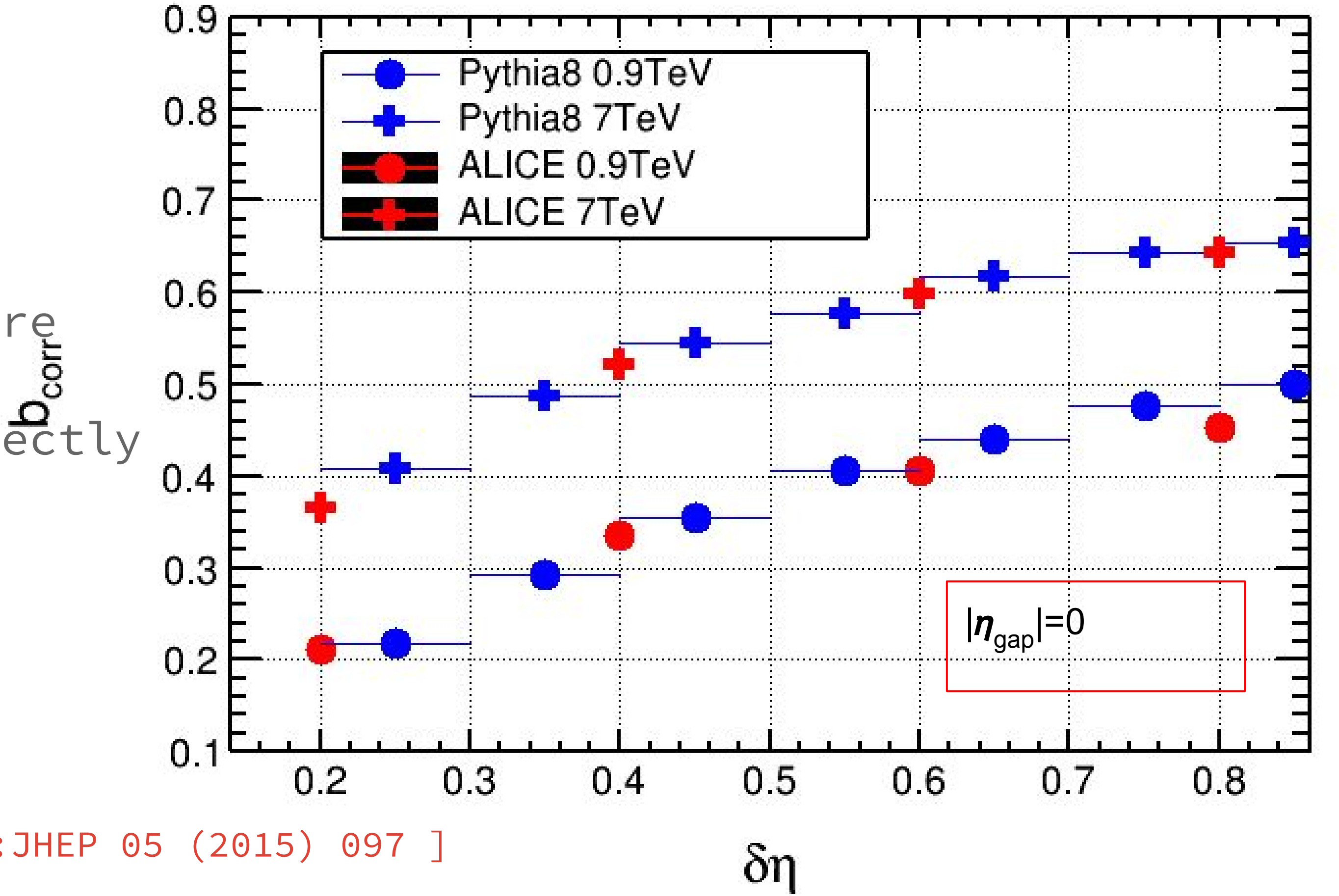
Pythia8215, with the Tune Monash2013 for pp collisions. The main initial conditions for the data sample used are:

- ❖ Cuts in $|\eta|<1$
- ❖ Cuts in 0.3GeV/c<pT<1.5GeV/c
- ❖ Charged
- ❖ Final State
- ❖ Primary Particles

# Pythia vs Alice Data

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



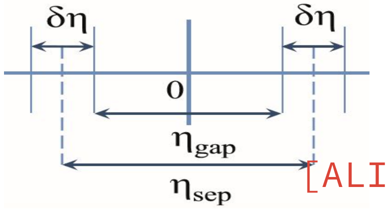



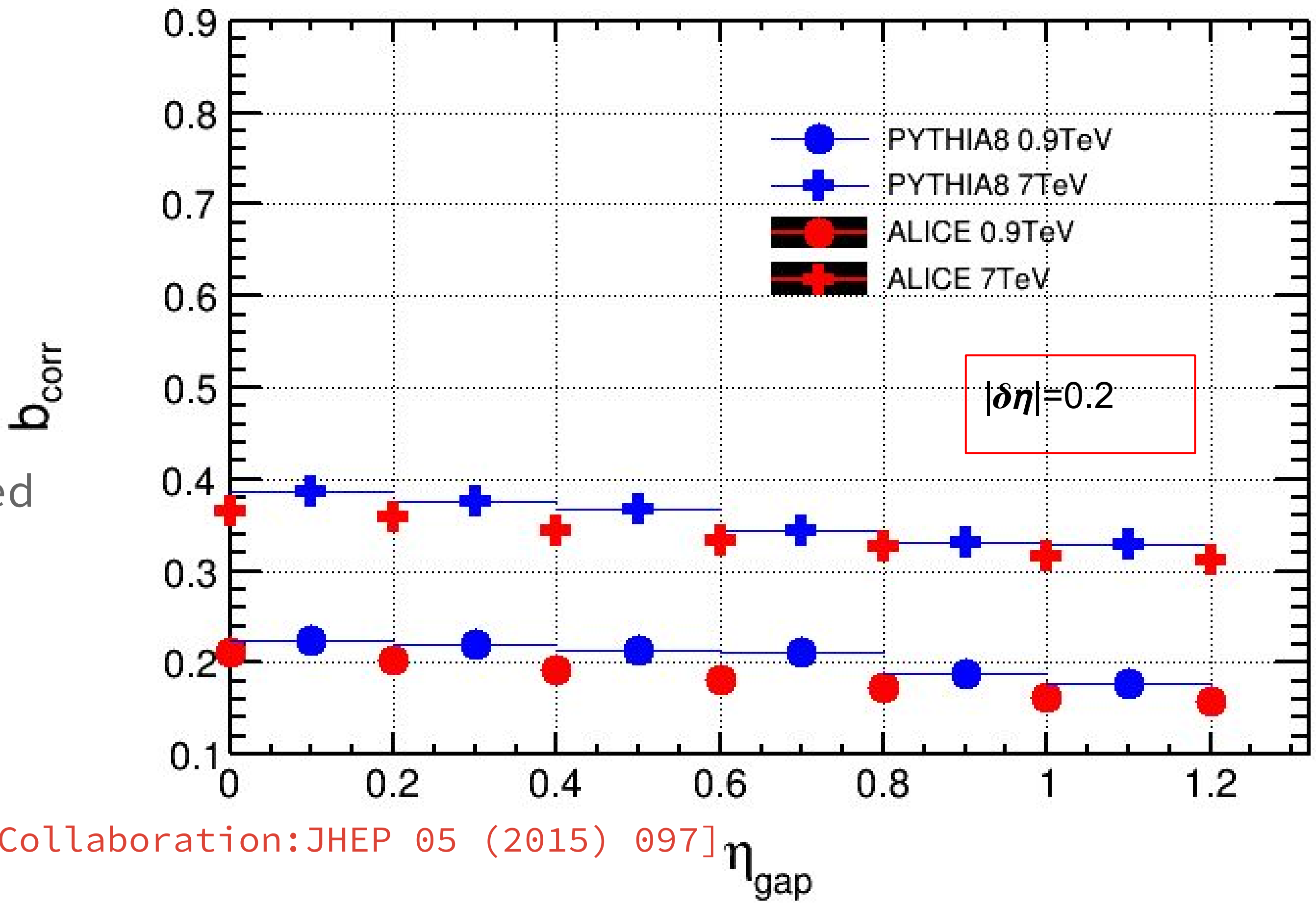

[ALICE Collaboration:JHEP 05 (2015) 097 ]

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

# Pythia vs ALICE Data

Another distribution to check, is $b_{corr}$ vs $\eta_{gap}$, generated with pythia8 Monash 2013



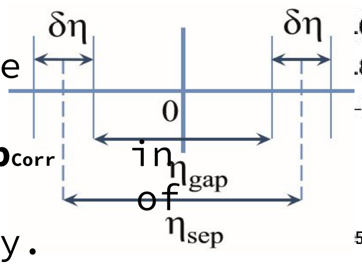



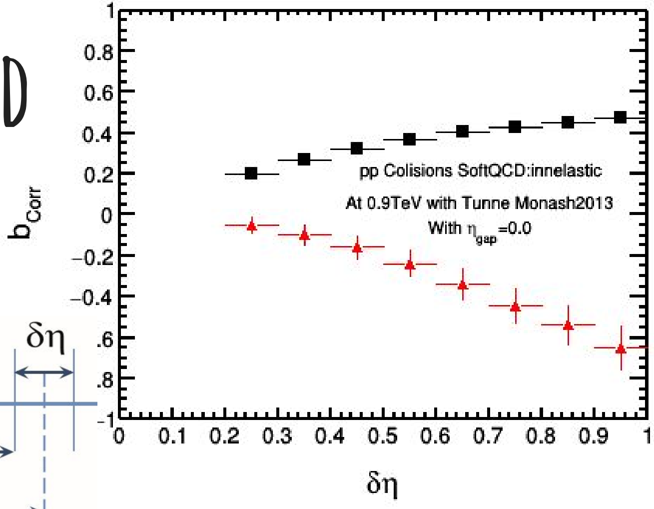

[ALICE Collaboration:JHEP 05 (2015) 097]

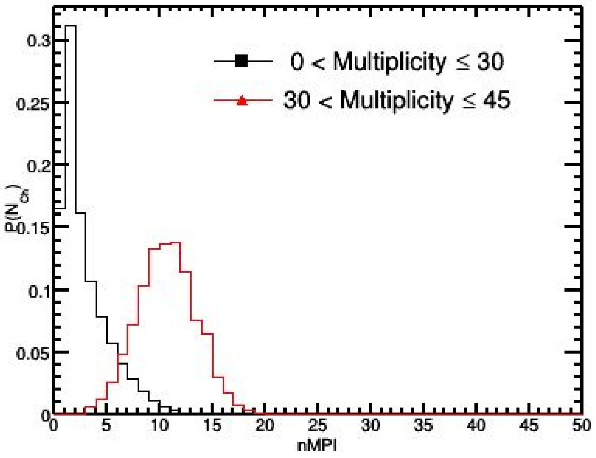
Again we reproduce well the data

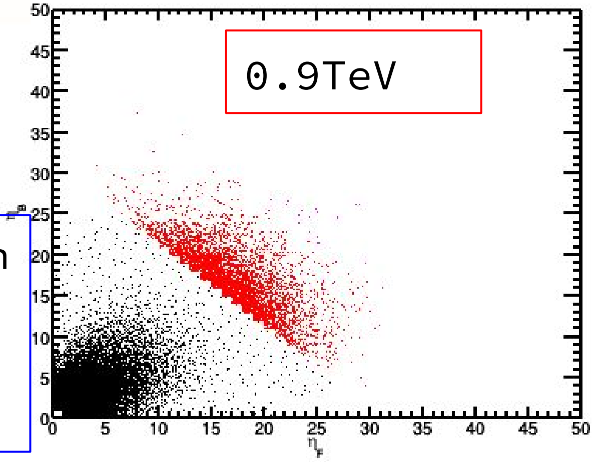
# Multiplicity and Correlation

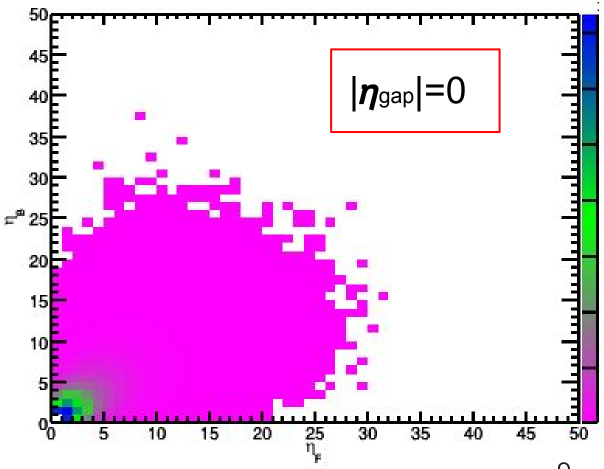
One way to characterize the events is by **b**corr in function of multiplicity.



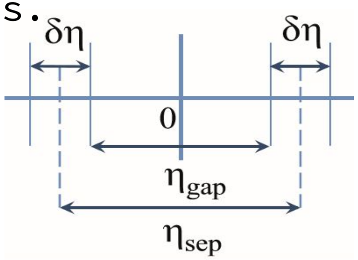



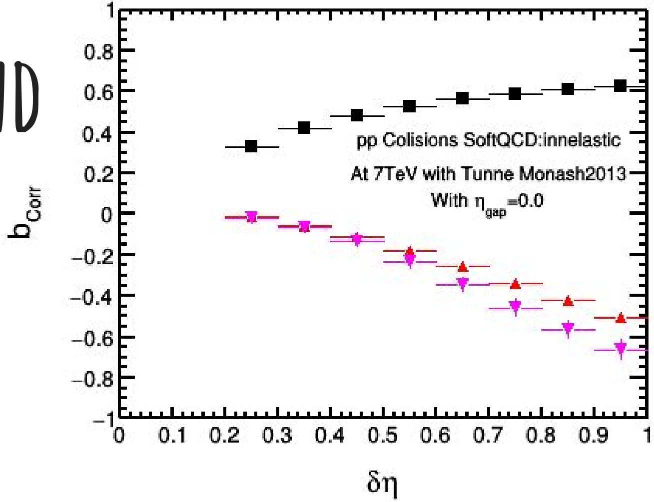



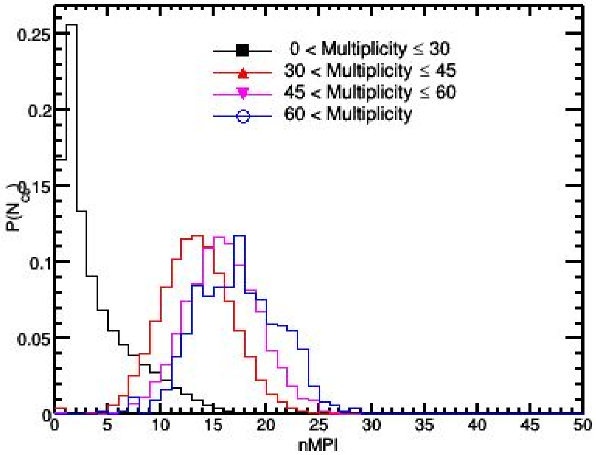

We observe strong dependence on multiplicity which is correlated with different nMPI.

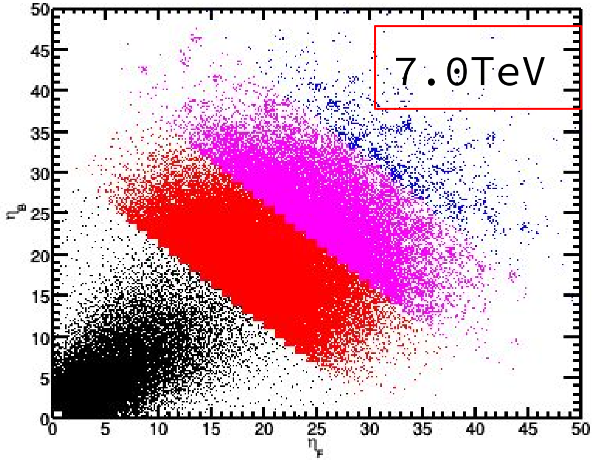
# Multiplicity and Correlation

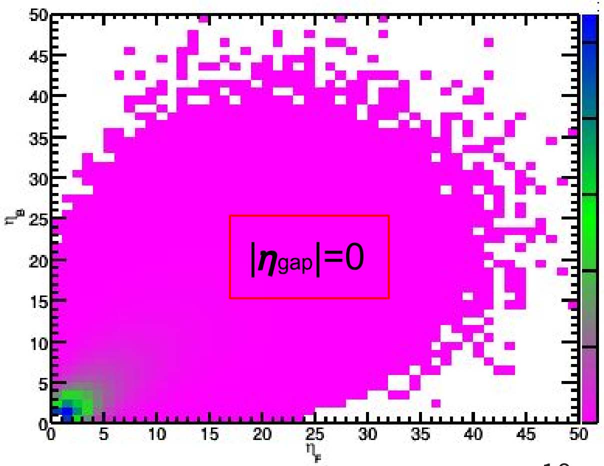
One can observe significant differences between low (0.9TeV) and high (7.0TeV) energies.



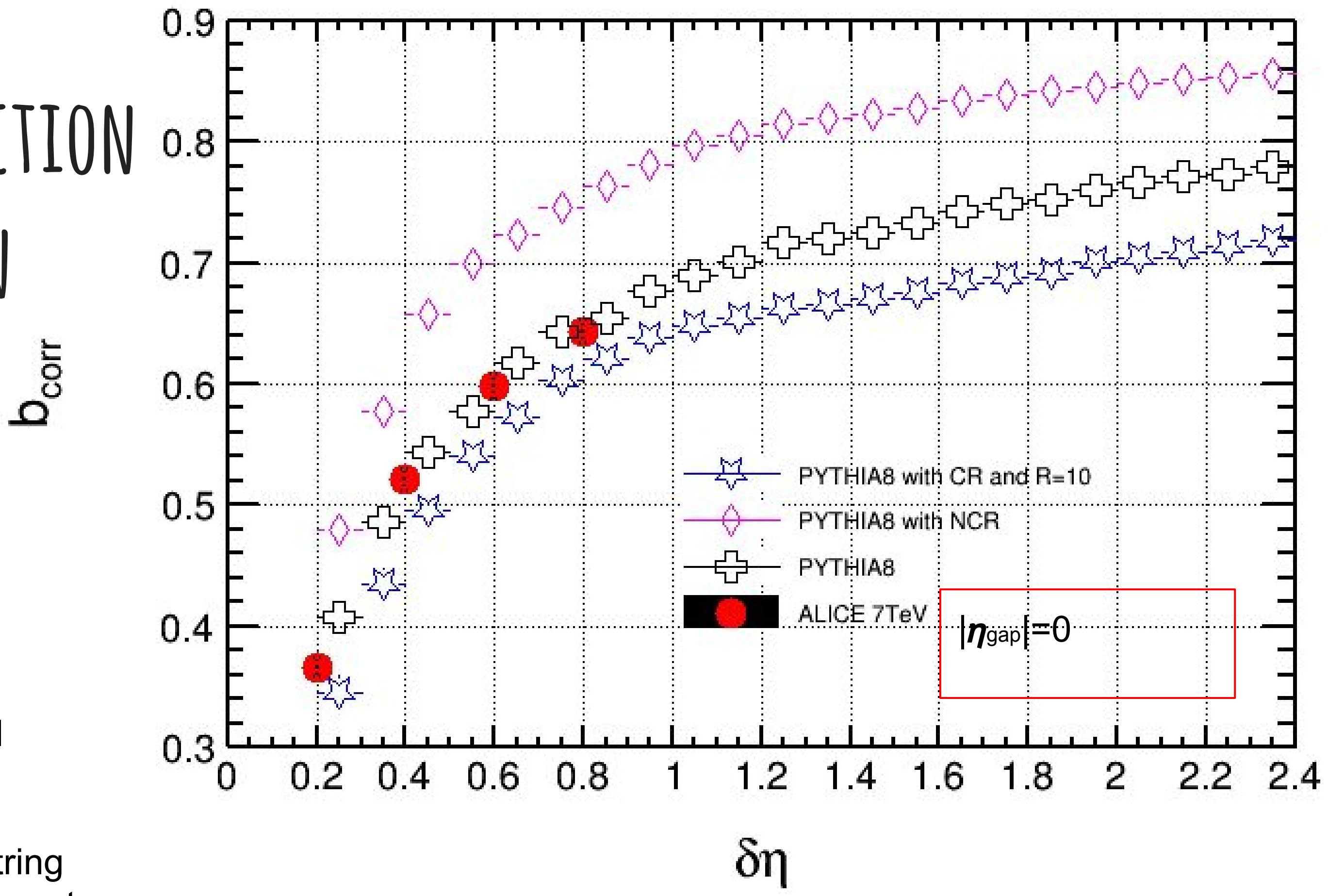



# Colour Reconnection And Correlation

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




CR: A nonperturbative model applicable to any final state.

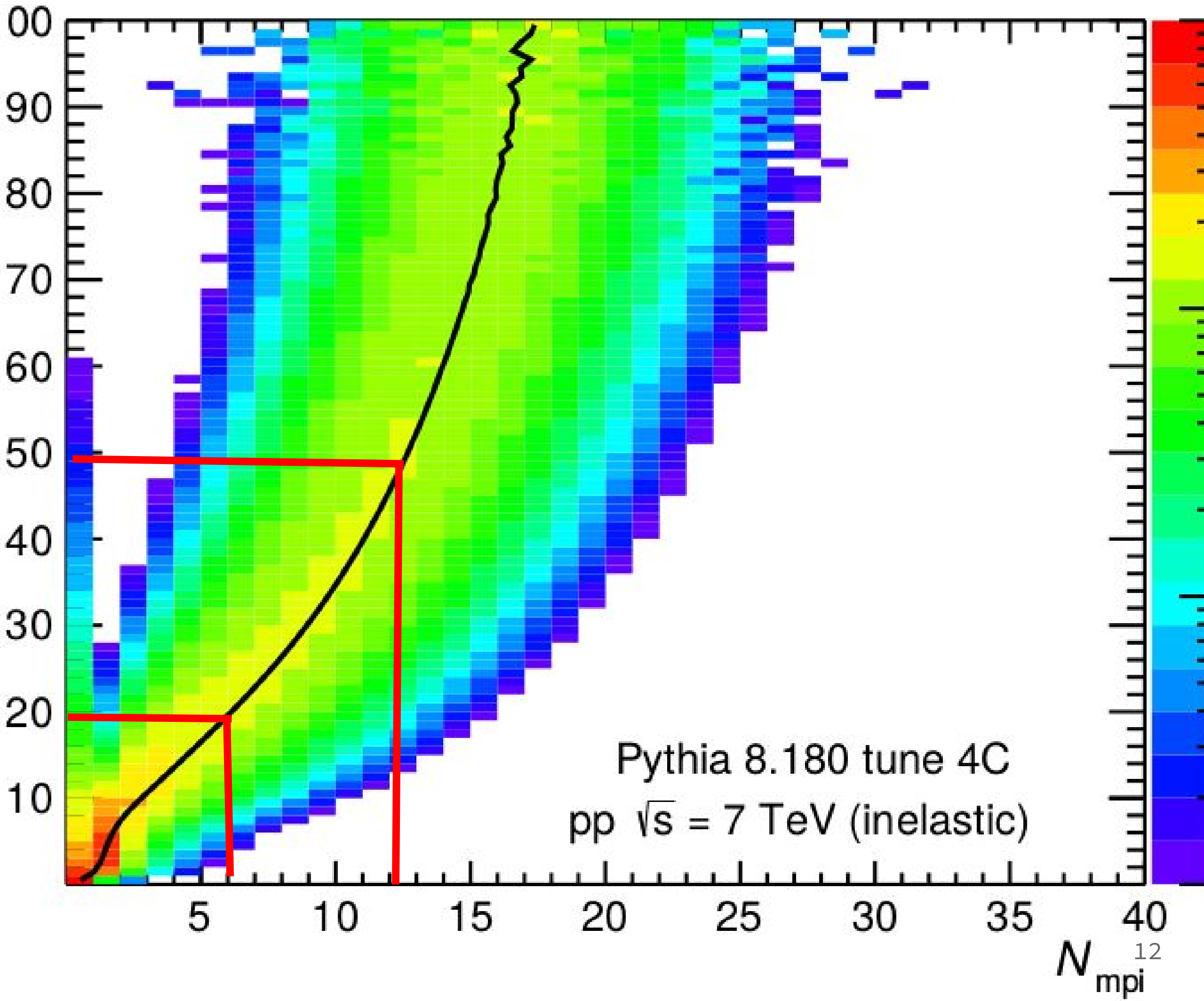
At hadronization time each string piece has a probability to interact with other string:

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

# nMPI and Multiplicity

Next distribution Shows how is the behavior of nMPI and Multiplicity

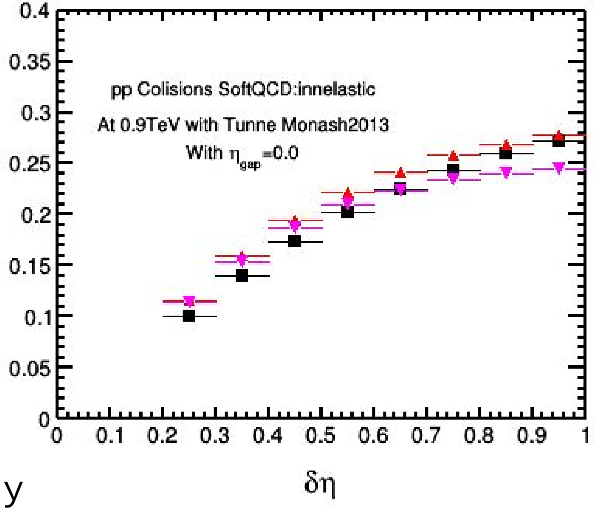
Nucl. Phys. A941, 78-86 (2015)

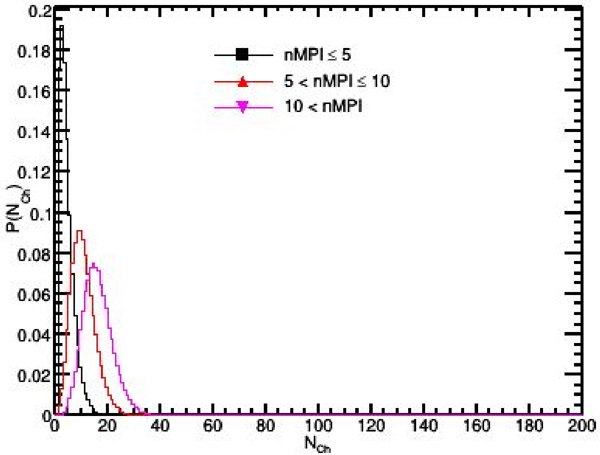


# MPI and Correlation

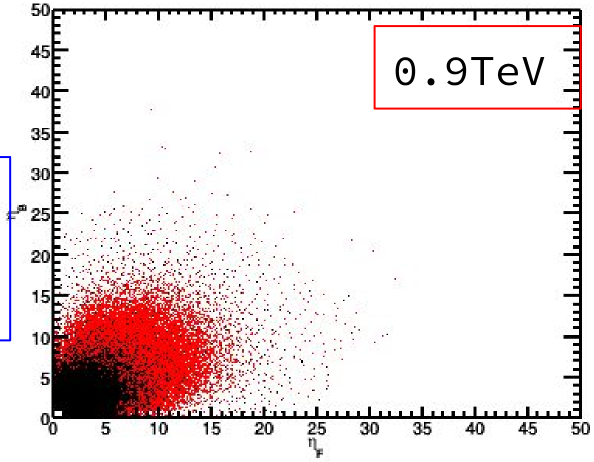
MPI produce effects on $b_{corr}$ under certain range of nMPI. Low and high nMPI range correspond to different kind of process.

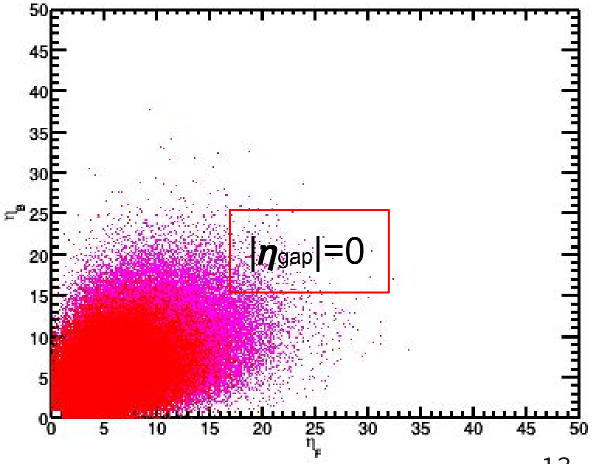
Different nMPI produce not the same multiplicity distributions.



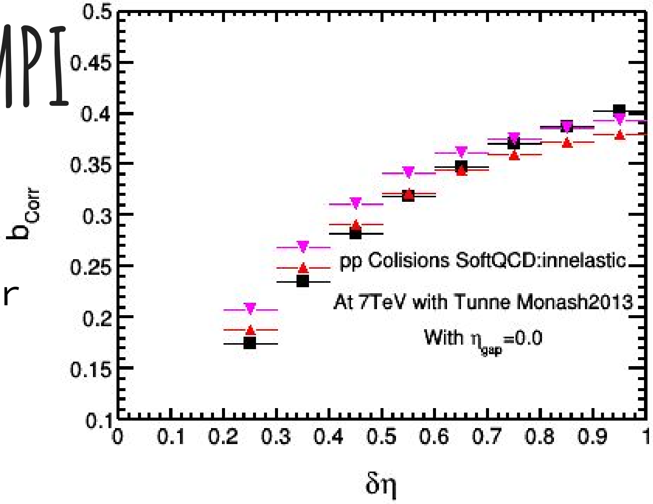



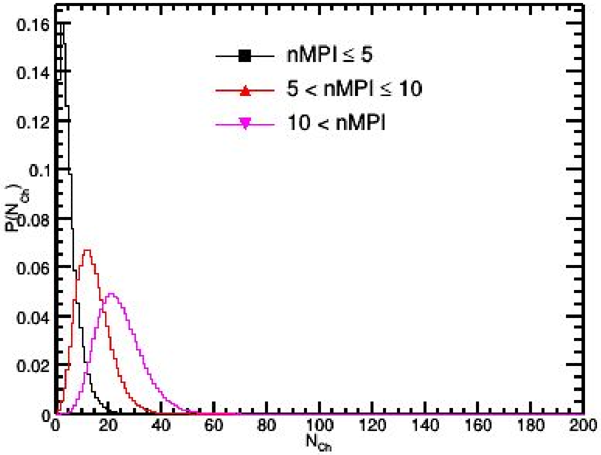

High range of nMPI means an increase Correlation at very short range of centrality, meanwhile decrease for bigger range in pseudorapidity



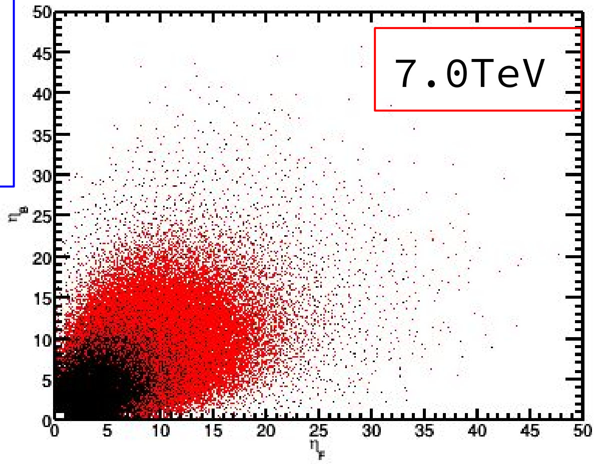
# Correlation vs nMPI

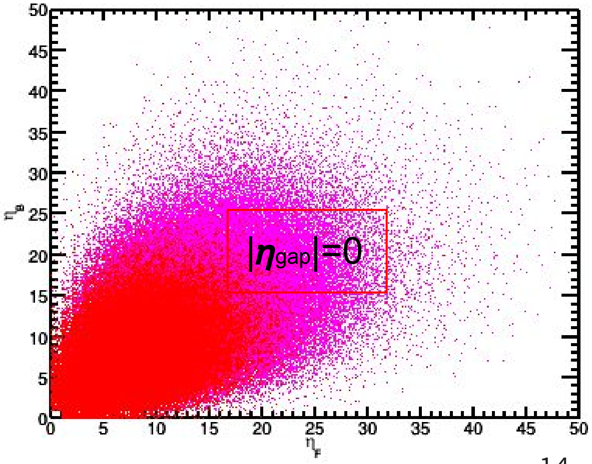


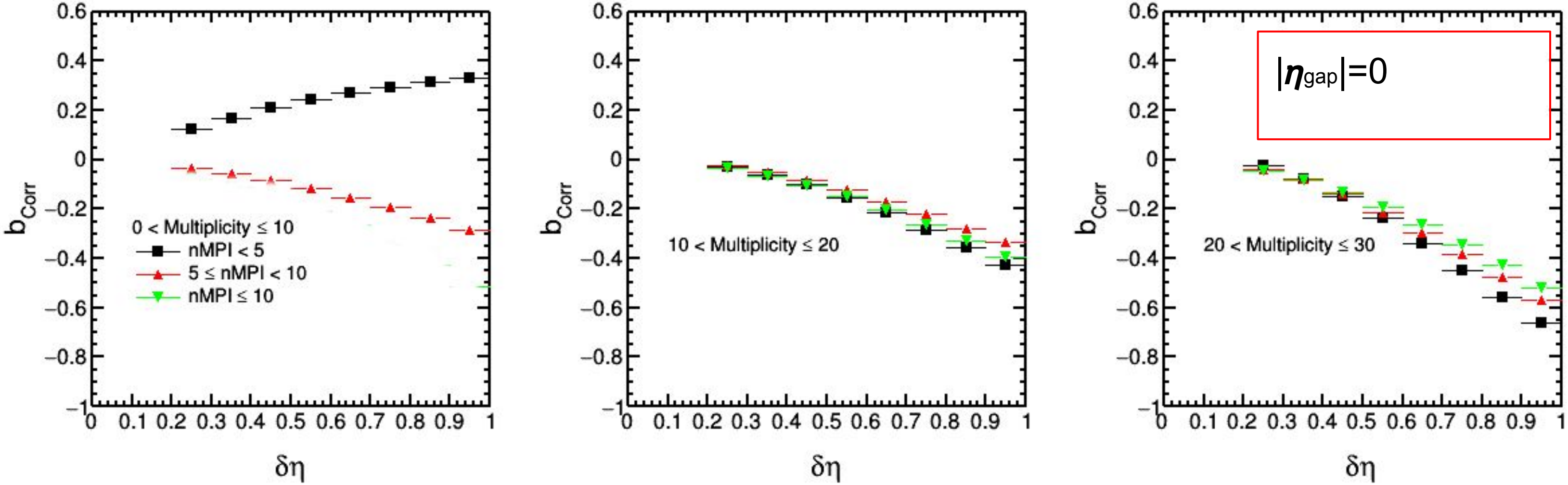




nMPI increase with the energy of collision.
Higher nMPI means bigger Correlations

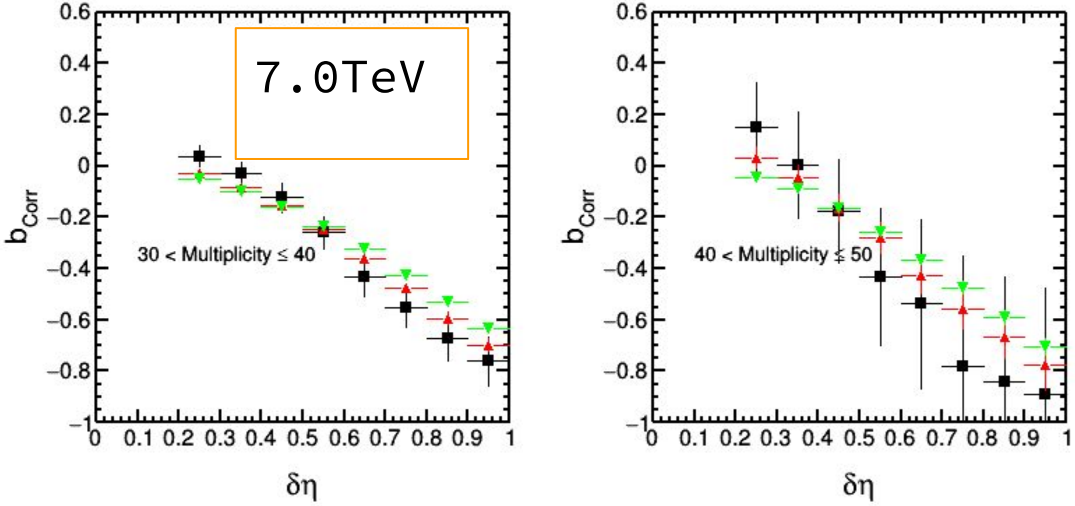
Increase of the collision energy imply larger Correlation for all range of nMPI






# Correlations vs Mult. and 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.

# Conclusion

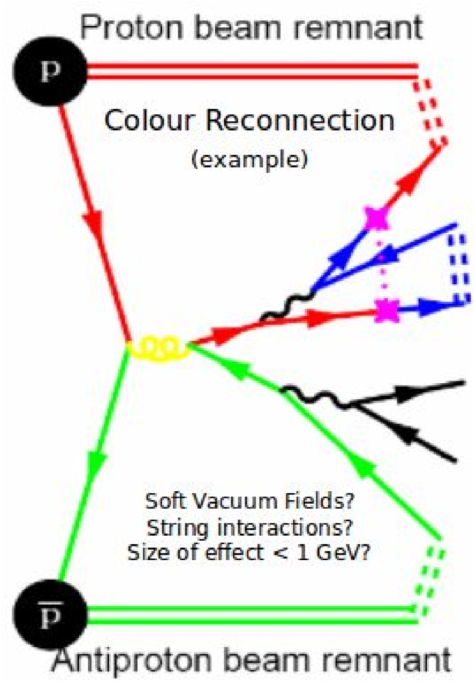
- ➔ We have analyzed Multiplicity F- B correlations using Pythia8 event generator.
  - ◆ We observe complete agreement between ALICE data and simulation.

- ➔ The excellent agreement in F-B correlations led us to study details of phenomenas 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:

$$P = 1-(1-\boldsymbol{\xi})^N$$

$$p_0 = \frac{pT_{0Rec}^2}{(pT_{0Rec}^2 + pT^2)}$$

*Probability of the lowest system, until m*

$$p_0(1-p_0)^{m-1}$$