Multiplicity Correlation nMPI and CR

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Outline

- Definition of Correlation
- Motivation
  - Multiple Parton interactions and Colour Reconnection
- Initial Conditions
- Generated Events
  - Soft and Hard QCD process
  - Multiple Parton Interaction (nMPI)
  - Colour Reconnection (CR)
- Conclusions

Definition of the F-B Correlation

The Correlation is theoretically defined event by event, comparing the integrad density of particles produced in different ranges of pseudorapidity;

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

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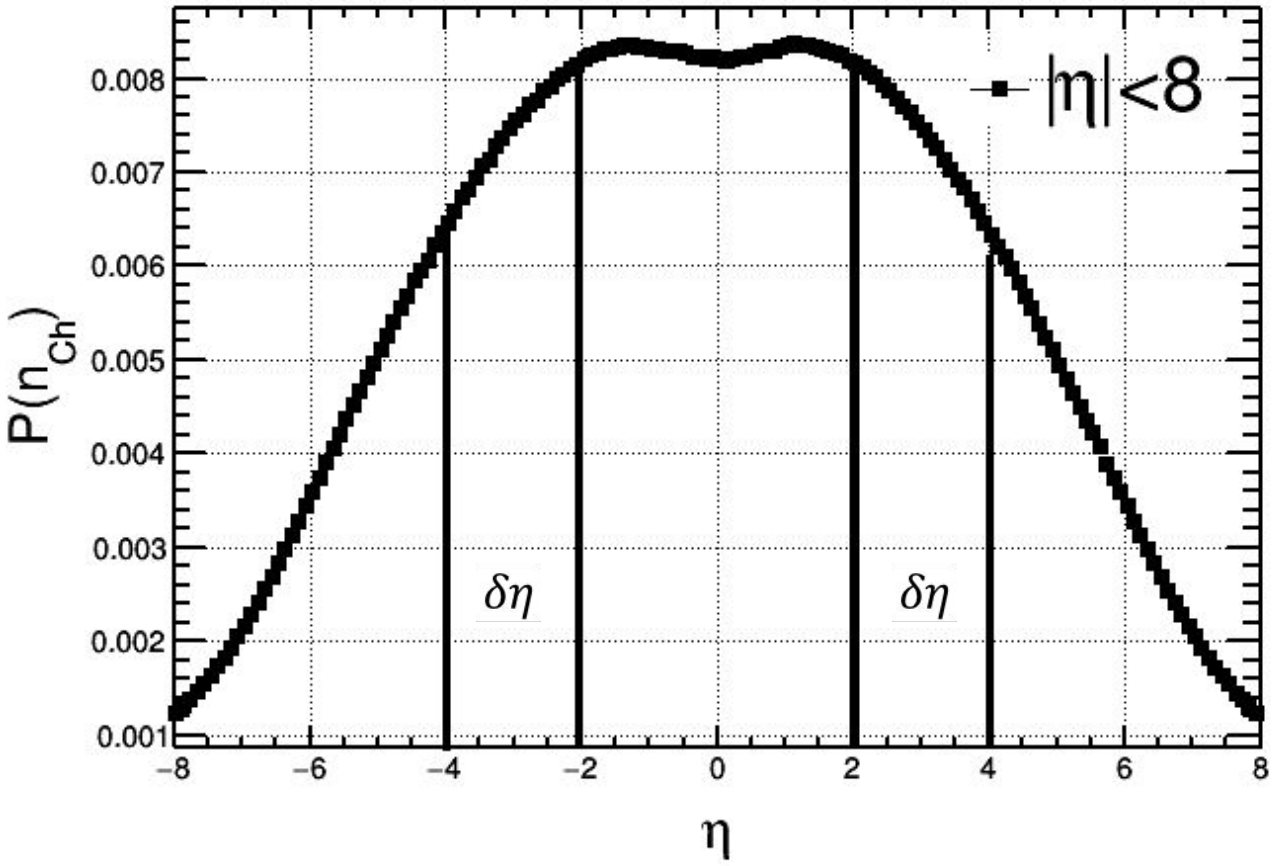


Motivation: Modeling Multiple parton interactions

The original idea was proposed by T. Sjostrand and M. Van Zijl, Phys. Rev. D 36 (1987) 2019:

- There is a theoretical fact: differential cross section $2 \rightarrow 2$ diverges as $p_T \rightarrow 0$.
- The solution is introduce a cut-off (p_{T0}) to ensure finite and calculable

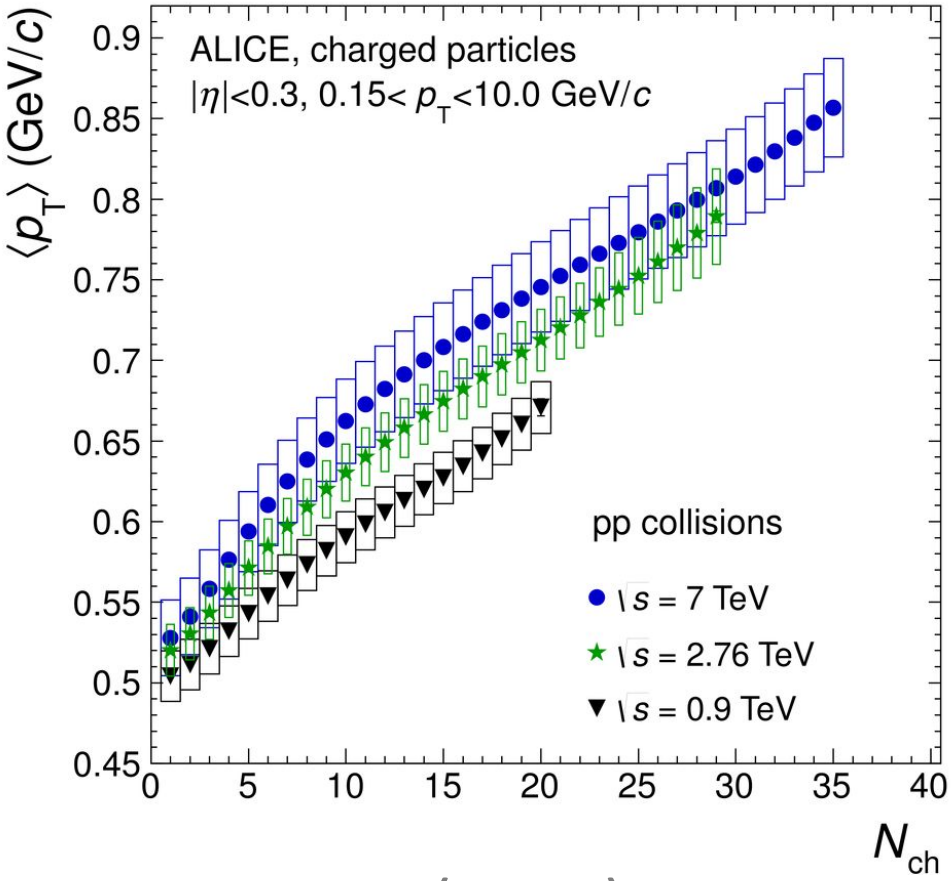
$$\frac{d\sigma}{dp_T^2} \propto \frac{\alpha_s^2(p_T^2)}{p_T^4} \rightarrow \frac{\alpha_s^2(p_T^2 + p_{T0}^2)}{(p_T^2 + p_{T0}^2)^2}$$

This solution implies:

- nMPI independent, which leads to a Poisson process, with minimal 1 interaction . arXiv:1410.3012
- All event generators use this model, but they differ in the choice of p_{T0} and also in the subsequent shower.

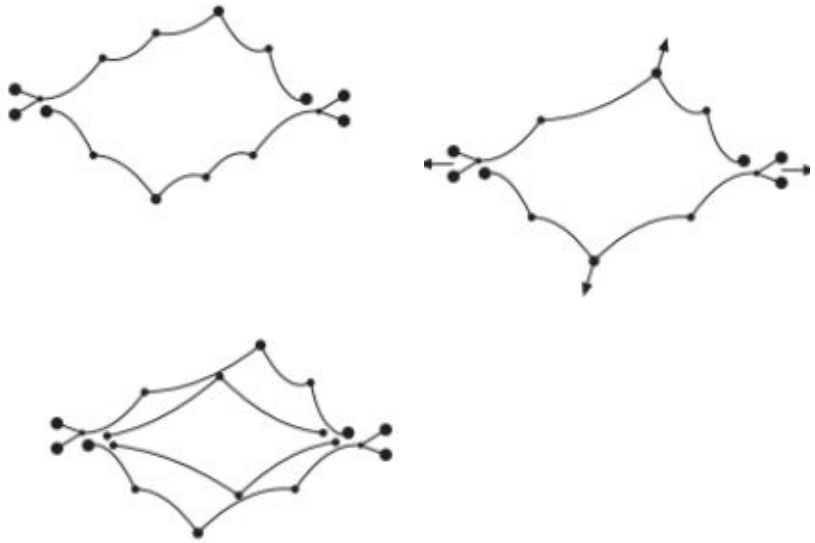
Motivation: Modeling Colour Reconnection

- There is an experimental fact: We can not explain the behavior of $\langle p_T \rangle$ *vs* N_{Ch}.



Phys. Lett. B 727 (2013) 371-380

- Solution? Many solutions, one of them is CR!



Phys.Lett. B209 (1988) 90-94

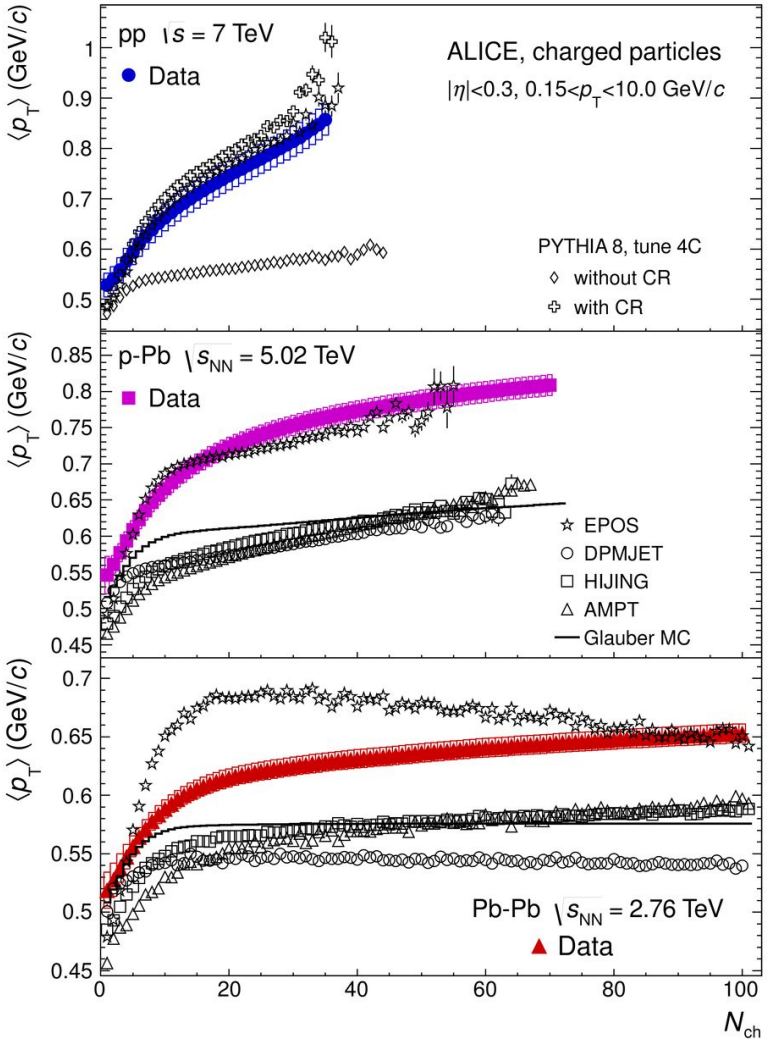
Motivation: Modeling Colour Reconnection

Models of Color Reconnection:

There are different models of CR, one of them is based in the scheme of parton interaction. They are classified by which nMPI system they belong to in function of the transverse moment. The strength of reconnection is defined by,

$$P_{rec}(p_T) = \frac{(R_{rec}p_T)^2}{(R_{rec}p_T)^2 + {p_T}^2}$$

$$p_T \downarrow \Longrightarrow \; P_{rec} \uparrow$$



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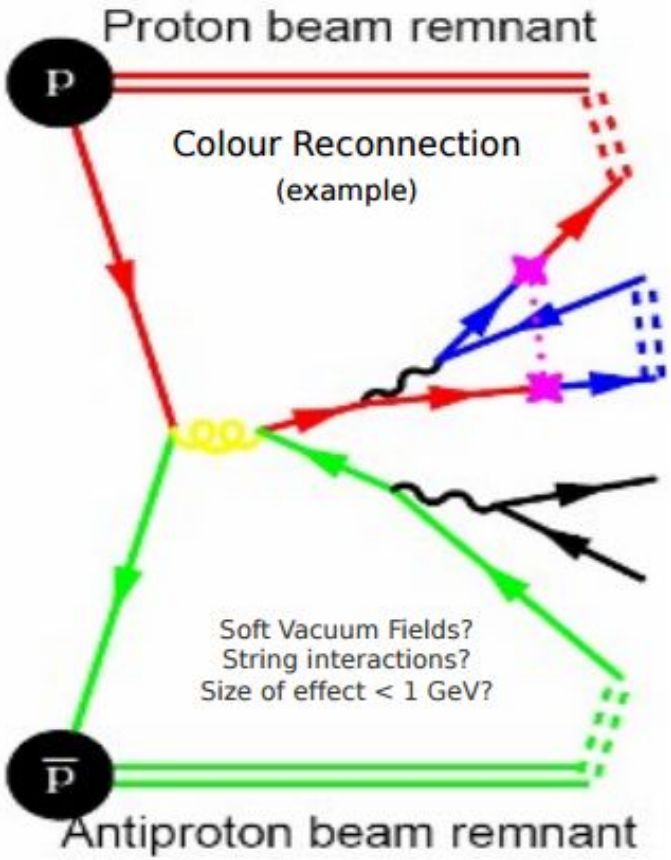
Motivation: Modeling Colour Reconnection

There are two more CR models that we use. One is based in QCD and the other in Gluon-move, the idea from this two models is to reduce the string length (lambda).

$$\lambda \sim \langle n_{hadrons} \rangle$$



CR-QCD model takes into account the hadronization based in the colour rules of SU(3) to determine if two strings are colour compatible using a junction structure.

arXiv1507.02091

Gluon-move is a Toy Model, in which it is tried to reduce λ by moving a gluon between a pair.

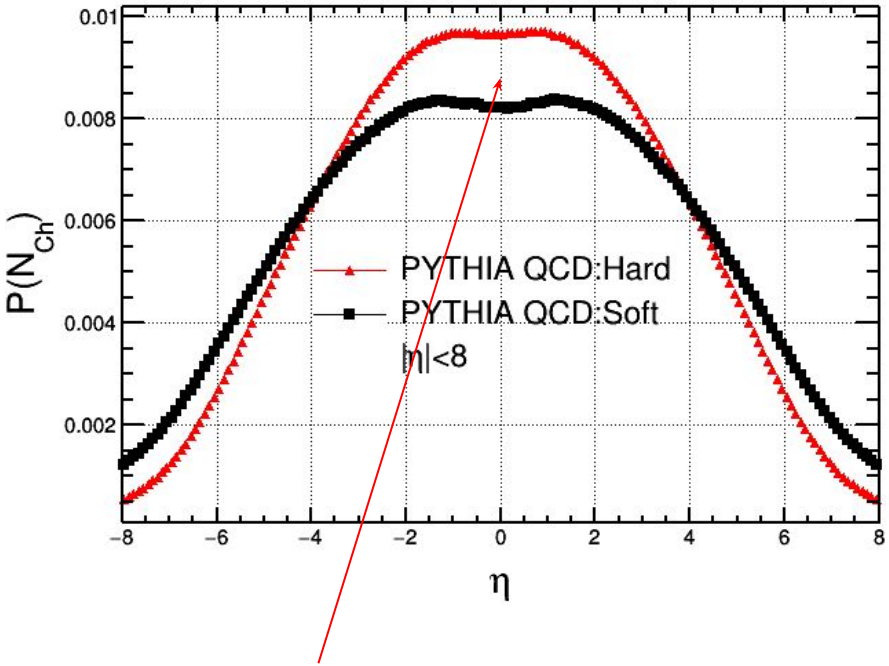
arXiv1407.6653

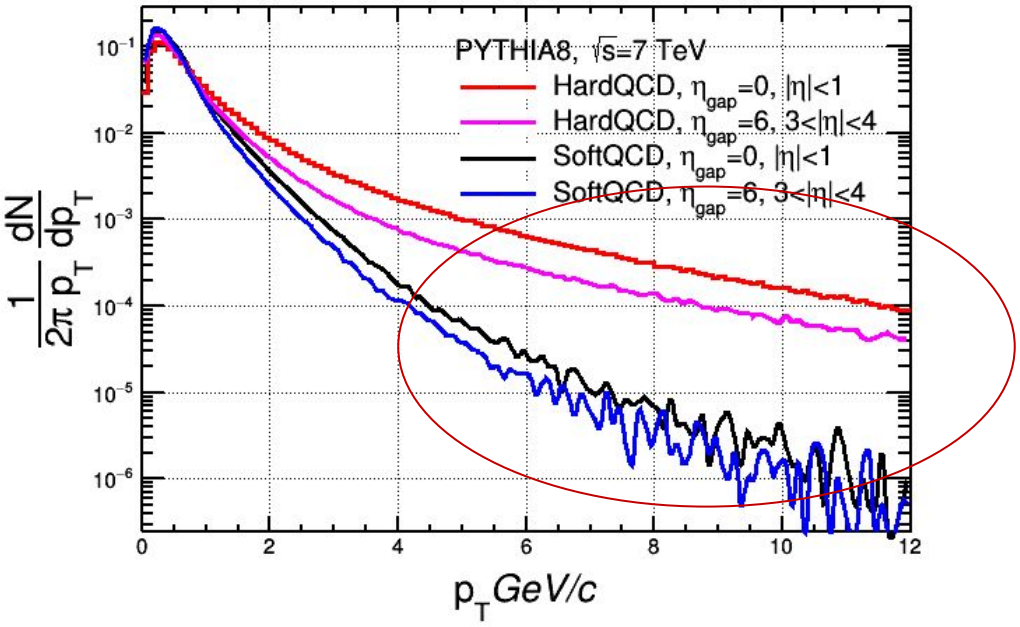
PYTHIA event generator

PYTHIA is a package program based on QCD process. In this case we use the perturbative QCD for higher p_T and QCD non perturbative for lower p_T. In our case we are going to use this initial condition for our data sample:

- Simulation in PYTHIA 8.216
- Proton-proton collision at 0.9 and $7\ TeV$ energies
- $25{,}000{,}000$ events (for each model)
- Soft and Hard events
- Charge particles
- Primary particles
- Final state

Pseudorapidity and p_T for Soft and Hard

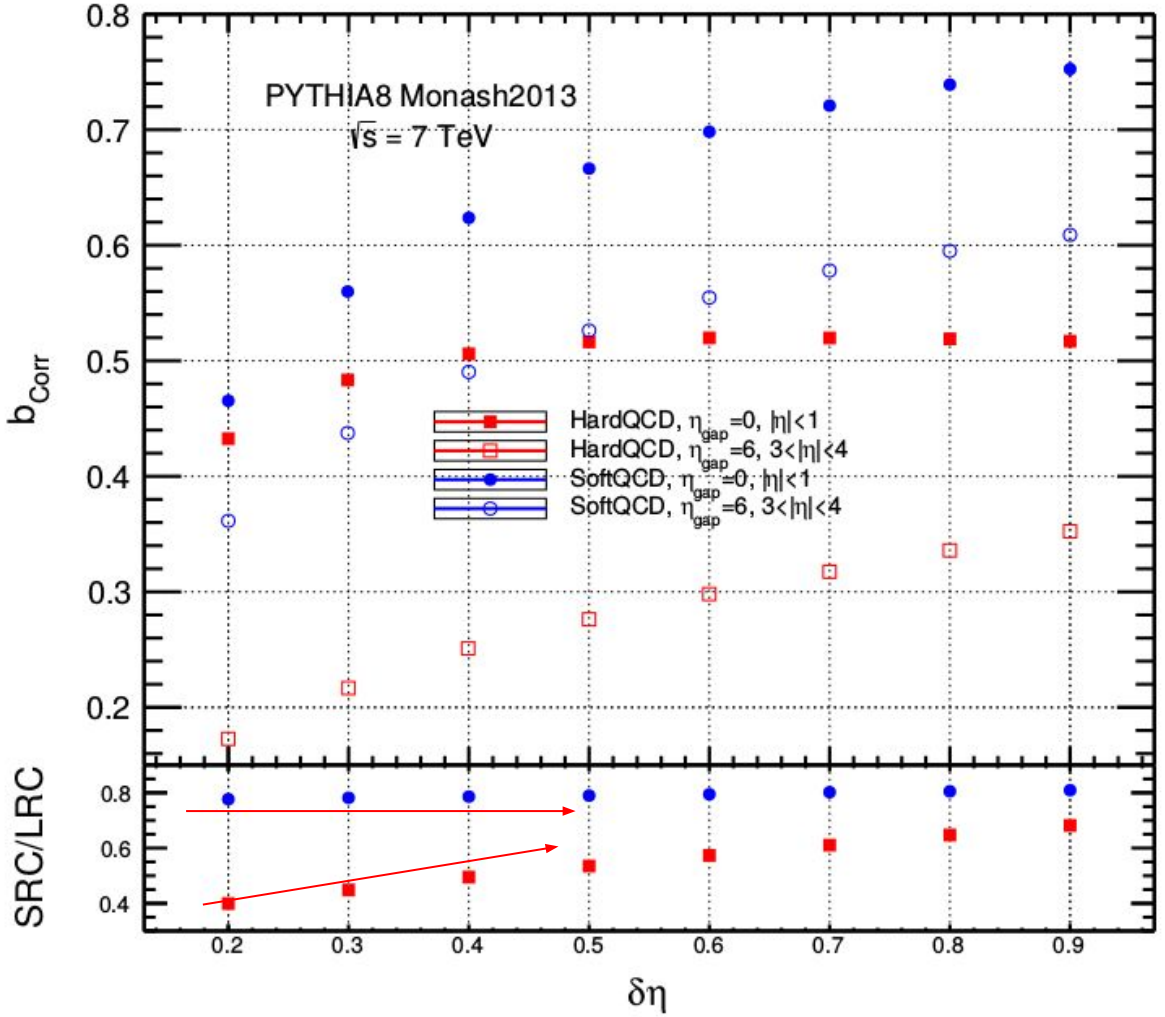




- Hard processes has an enhancement in the central region
- Differences on pseudorapidity distributions means different kind of QCD processes

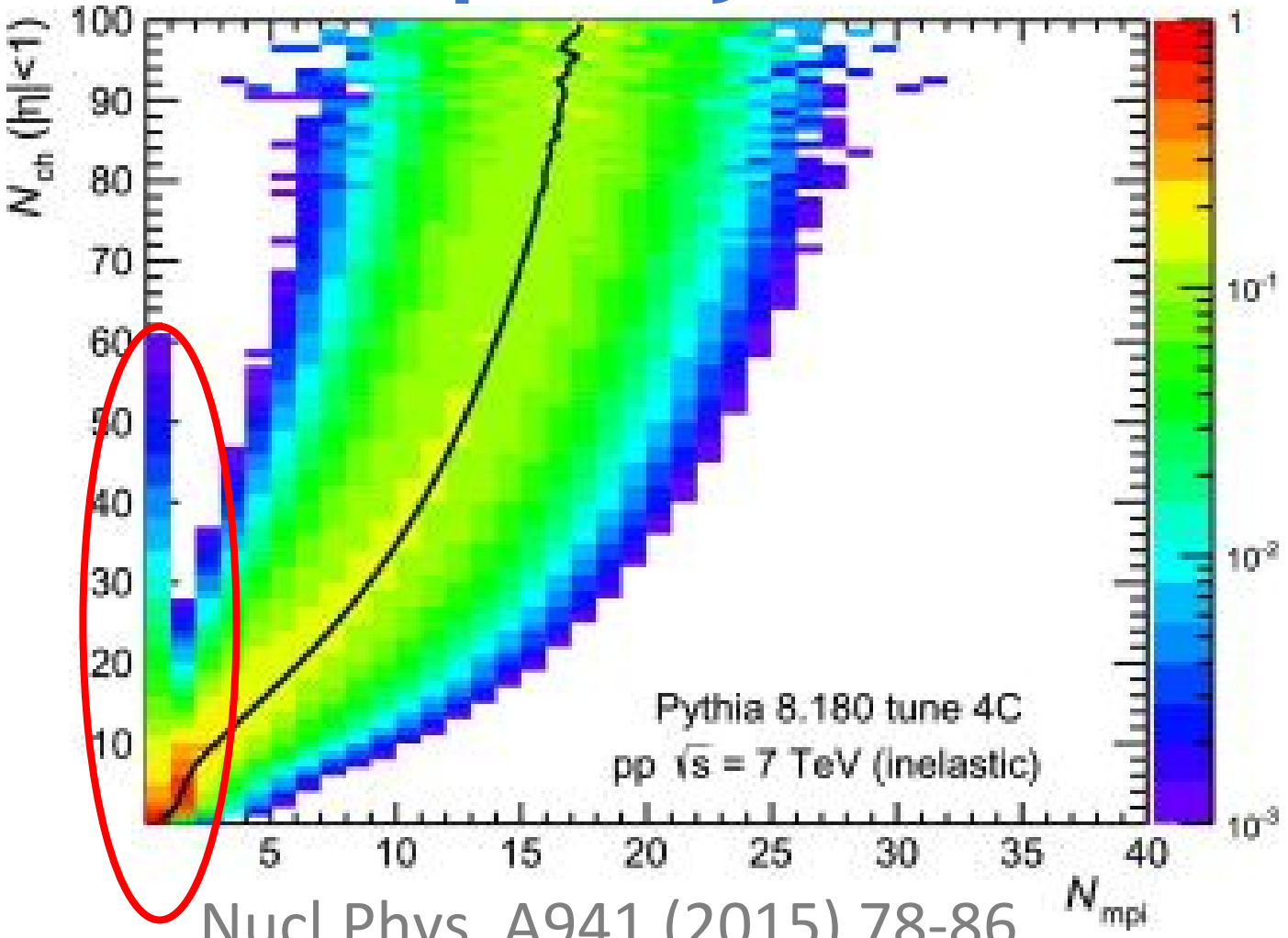
- p_T spectra shape allow classify Hard and Soft QCD processes.
- Going from central to the fragmentation pseudorapidity region we are going from Hard to Soft processes.

Short and Long range correlations



- In central pseudorapidity b_{Corr} is harder that for fragmentation region.
- For Soft QCD process: Short and Long range correlation are scaled as function of $\delta\eta$, but not for the Hard.
- For Soft process we have stronger correlation than for Hard ones.

Multiplicity vs nMPI

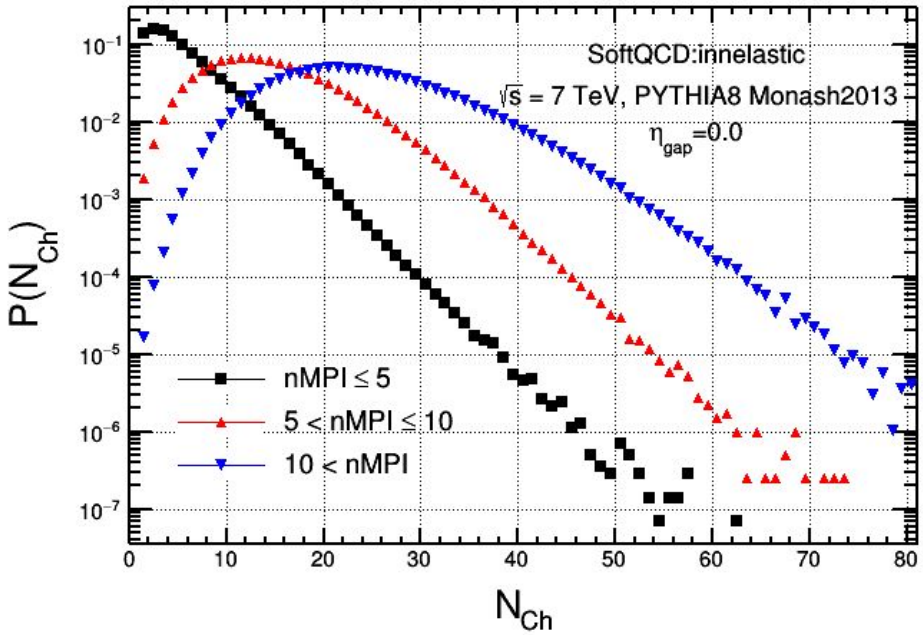


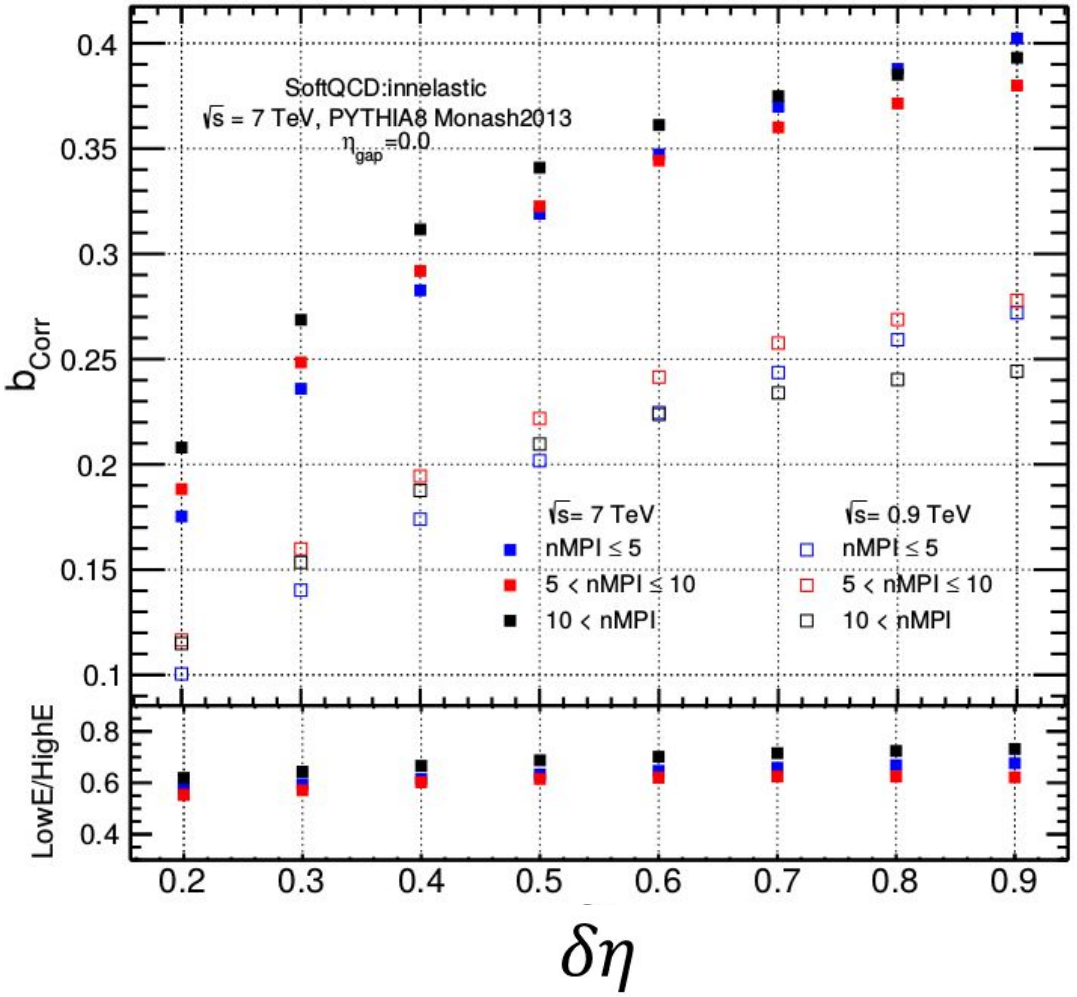
Nucl.Phys. A941 (2015) 78-86

- There is a relationship between nMPI and multiplicity, this indicate that the number of nMPI saturated. This result brings consequences in b_{Corr}

- The inelastic process produce and enchantment in multiplicity at lower nMPI.

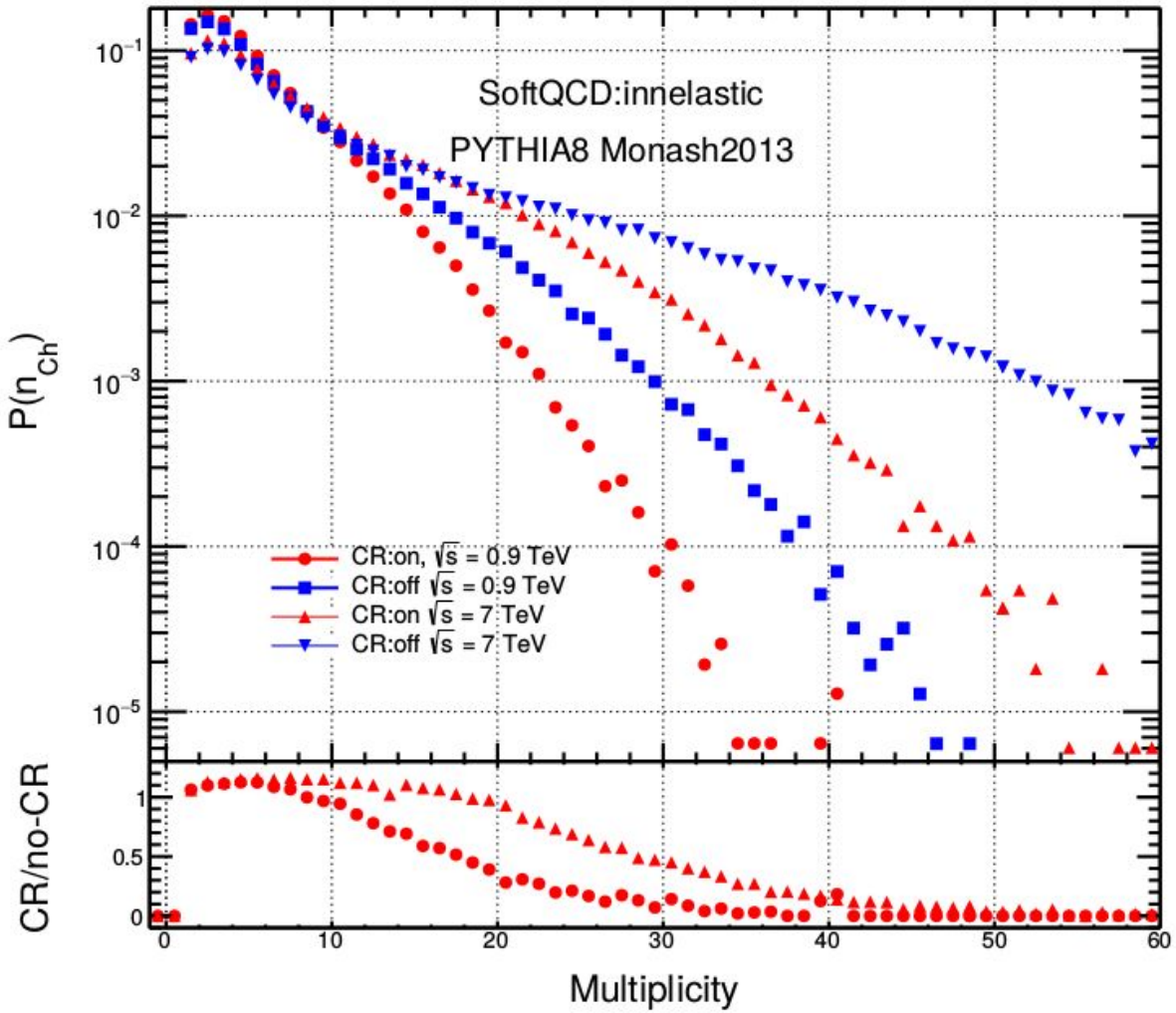
Correlations as function nMPI and energy





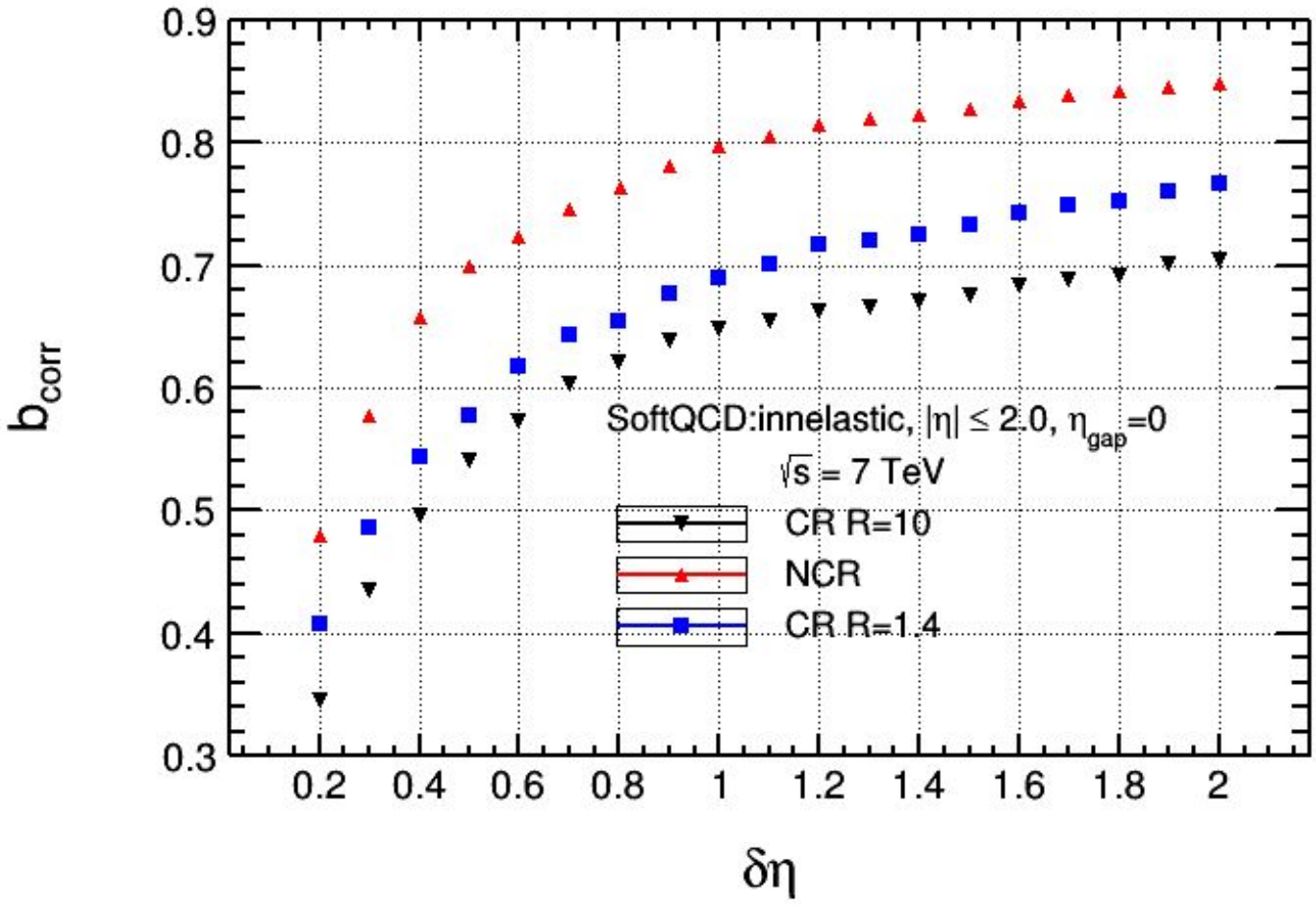
- Higher nMPI produce a shift in the of multiplicity.
- Taking different range on nMPI, af the multiplicity and consequent b_{Co}
- Higher nMPI ranges produce a little enhancement as function of the energy.

Correlations and Colour Reconnection (nMPI-model)



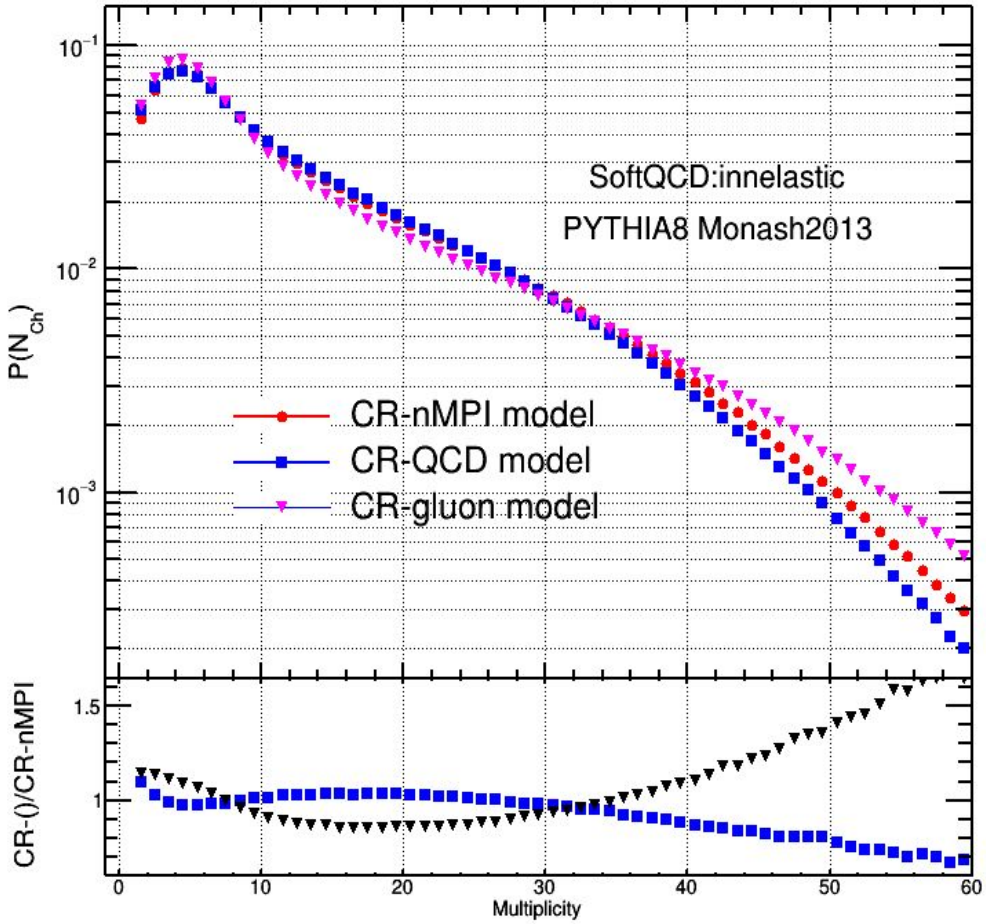
- The multiplicity is reduced by the influence of CR-nMPI.
- The effect of CR-nMPI increase as the energy does.
- The effect of CR-nMPI affects high multiplicity.

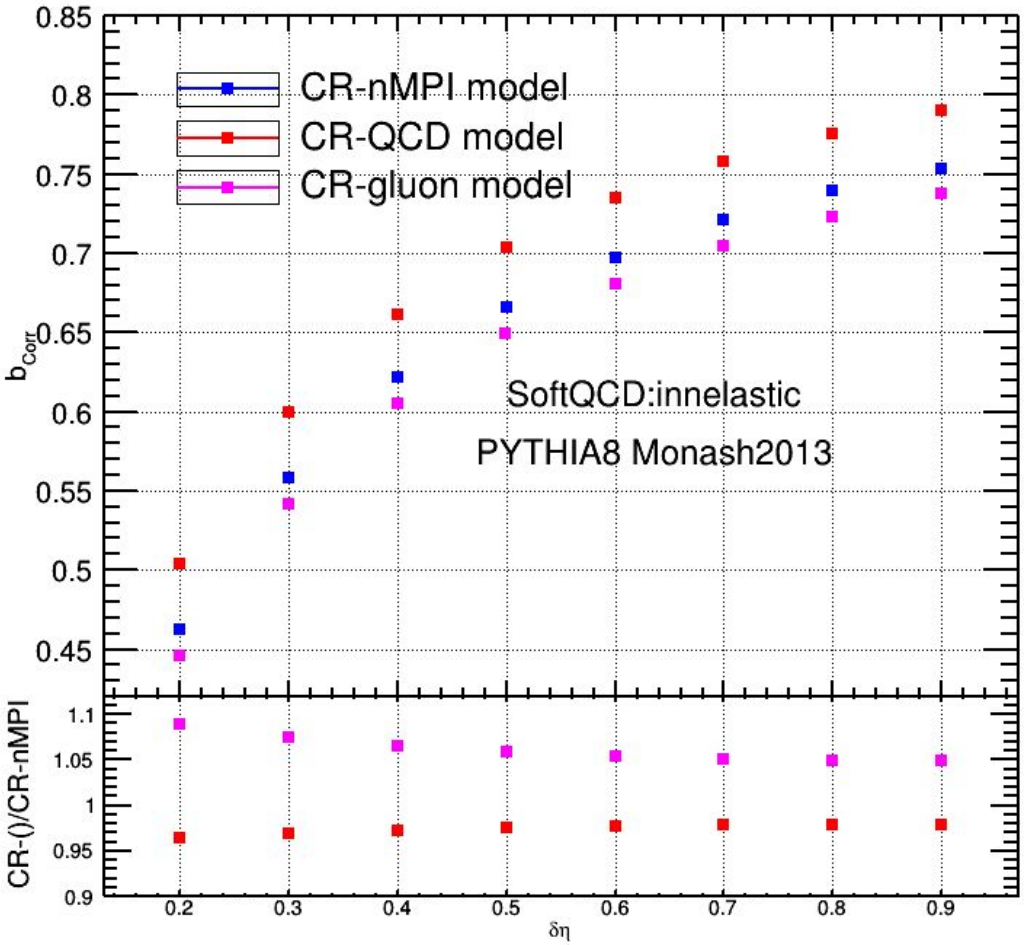
Correlations and Colour Reconnection (nMPI-model)



- The correlation decrease in not a linear way with the increase of CR.
- The correlation tends to a saturated with the increase of the window of analysis.

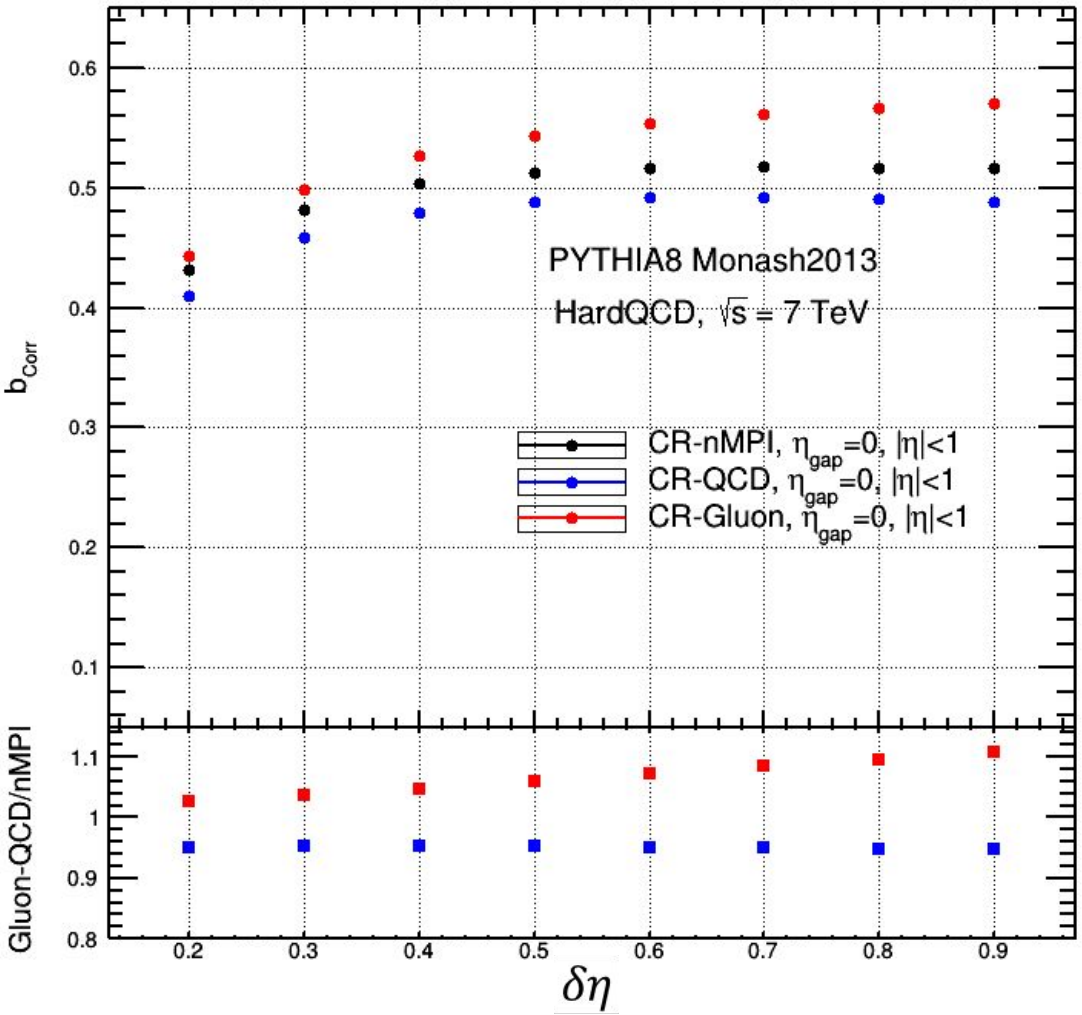
Correlation and models of CR

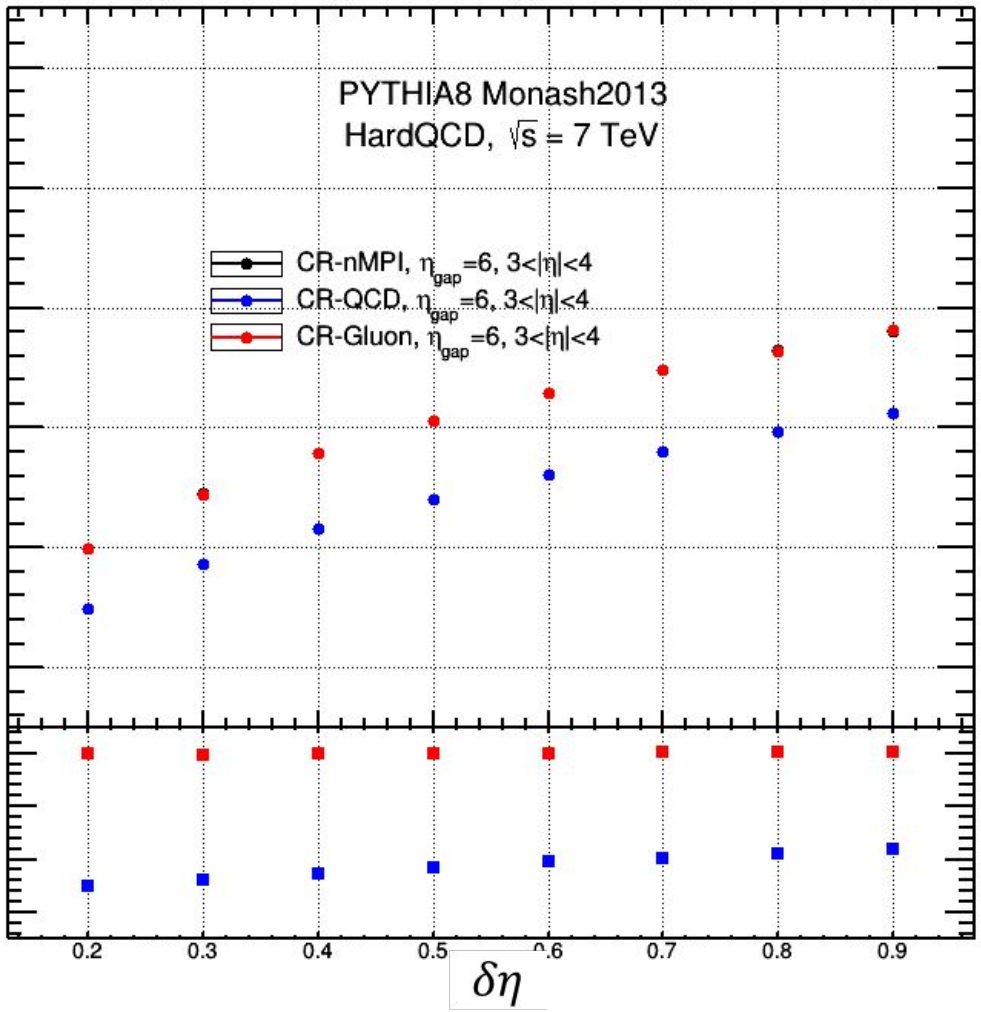




- The models for CR produce different multiplicity distribution.
- CR models produce different $\langle p_T \rangle$.
- b_{Corr} is different for the *three* models, the main difference is at lower $\delta\eta$.
- The most significant differences are between the Gluon and QCD models.

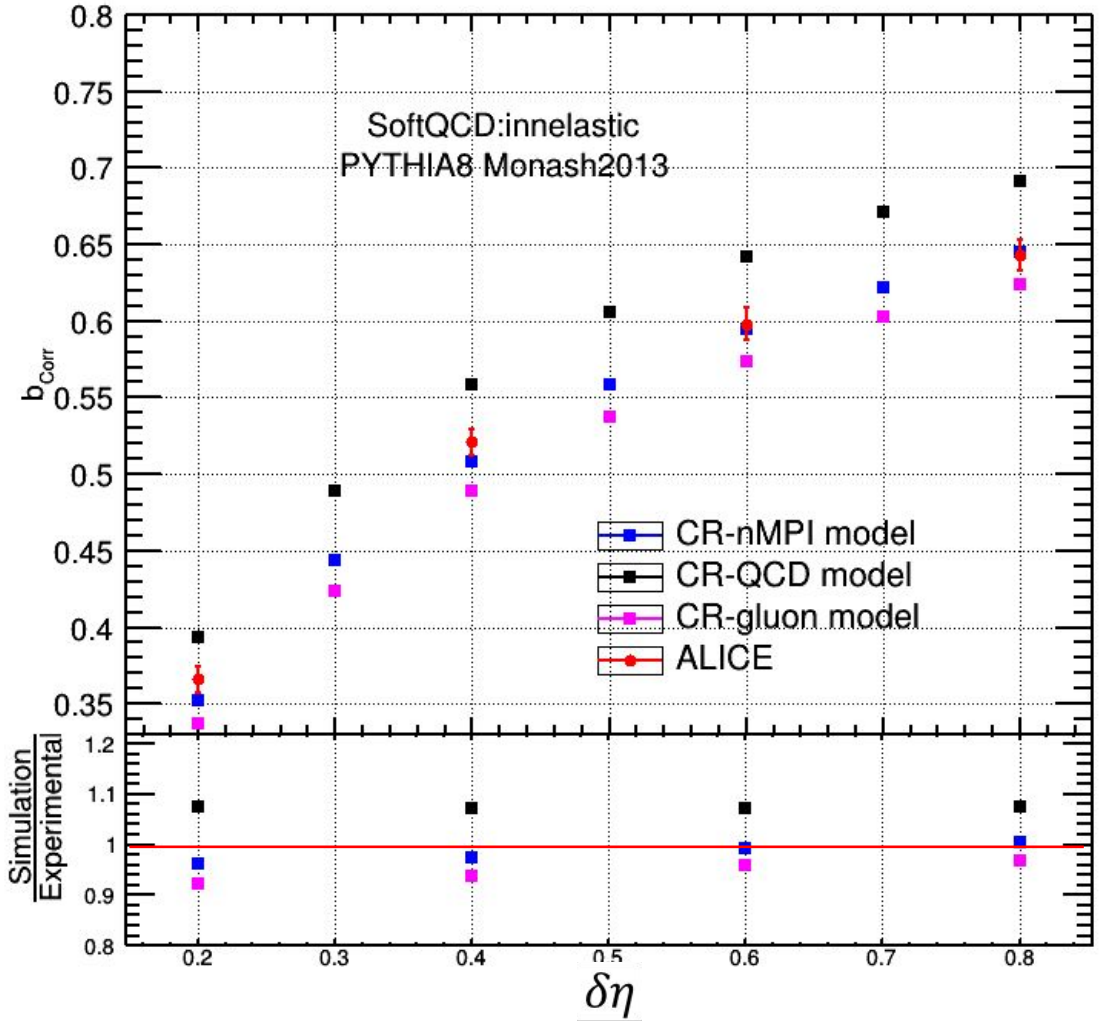
SRC and LRC for CR models





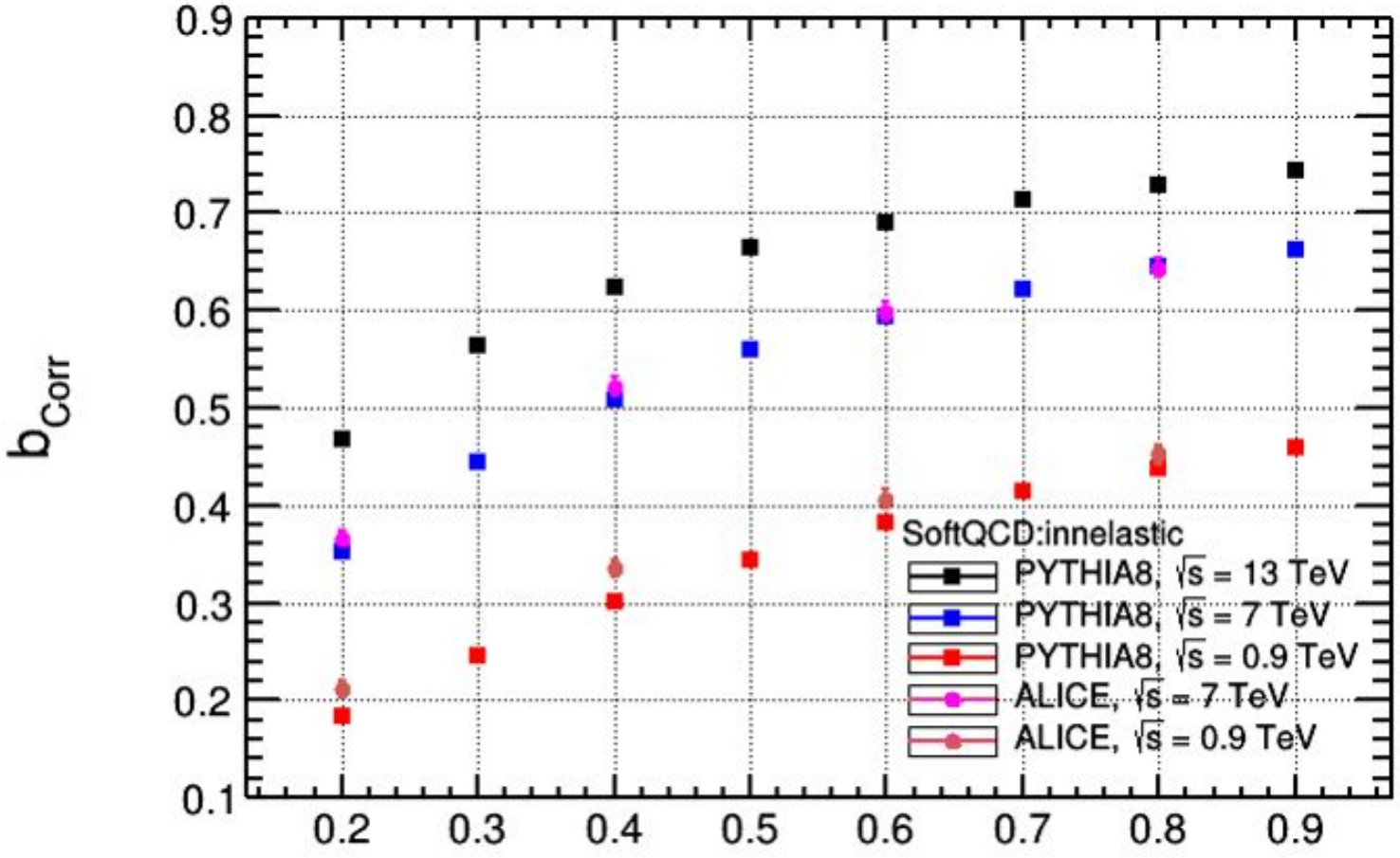
- CR-nMPI and CR-QCD models produce *a* b_{Corr} scale for the central pseudorapidity region.
- CR-nMPI and CR-Gluon models produce the same correlation at fragmentation region.

Correlations from models vs data



- The results show that nMPI model of CR gets better agreement with experimental data.
- CR-QCD models produce higher b_{Corr} compared with data, while CR-Gluon produce lower values.

Correlation for higher energy



CR range 1.4 is the best value (Tune Monash 1.8) to reproduce the data, along with all values of nMPI, within the range $0.3 < p_T < 1.5$, and $|\eta| < 0.9$.

$\delta\eta$

- We can even make prediction for the correlation at higher energies.
- The scale of b_{Corr} for the different energy will not be lineal.

Conclusions

Using PYTHIA event generator, we have analyzed Soft and Hard QCD processes to compute the forward-backward multiplicity correlation (b_{Corr}) and the effects on it due to CR and nMPI.

- Soft QCD process are more correlated than the Hard ones.
- Correlation decrease as CR increase. ↑CR⇒↓ b_{Corr}⇒↓Collectivity?
- The CR models produce different shape of b_{Corr}, the larger discrepancy among them are about 20%
- Higher nMPI produce a higher multiplicity mean, however the correlation produce a small change on the shape of b_{Corr}.
- The correlation increase as the energy does, It just not at scaled.

There is a relationship between N_{ch} , nMPI and CR, so measuring the first one and computing the b_{Corr} , one could extract physical information of pp events.