Measurement of multiparton interactions through forward-backward multiplicity correlations in jets

Edgar Dominguez Rosas
Eleazar Cuautle Flores

Instituto de Ciencias Nucleares UNAM

May 11, 2021

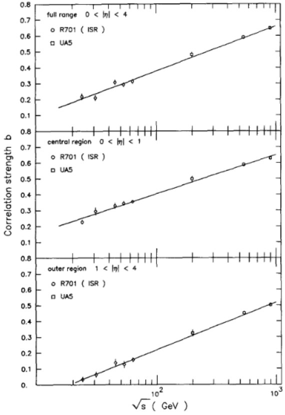
Outline

- Motivation & Background.
- Jets & Forward-Backward correlation.
- Phenomenological effects.
    - Colour reconnection, multiple parton interaction.
- Results.
- Conclusions.

Motivation and background

- Using the Forward-Backward multiplicity correlation approach, it is possible to examine string configurations and their interactions along the η-range, accessible in an experiment.
- The study of low and high energetic jets gives insight into the soft and hard QCD processes, as well as the number of multiple parton interactions (nMPI).
- Correlation ($\eta < 1$) are induced by various short-range effects like decays of clusters or resonances, **jet and mini-jet**.
- Previous works have explored these phenomenological effects on the hadrons systems. However, none of the studies have calculated the **number** $\langle nMPI \rangle$ in terms of the **number of jets**.

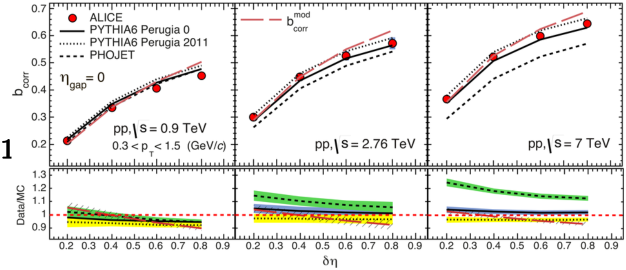
Motivation and Background



- Since experimental results not allow to determine directly the nMPI, we need to find alternative methods: Forward-Backward Correlation.
- The **UA5** measure a lineal increase in terms of the energy, and confirmed later on in **E735**. **ALICE** found that the correlation was weak for the Short-Range component while it is was strong for the Long-Range component.

↑ **Z.Phys.C37(1988) 191**

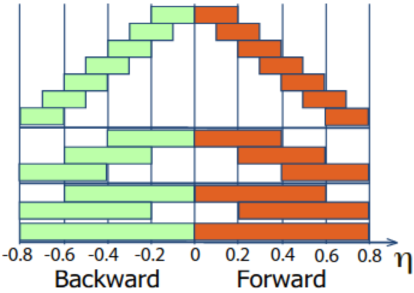
JHEP 05 (2015) 097→



Defined by:

$$b_{Corr}(\delta\eta) = \frac{\langle n_F n_B \rangle - \langle n_F \rangle \langle n_B \rangle}{\langle n_F^2 \rangle - \langle n_F \rangle^2}$$

where n_F and n_B are the charged multiplicity in two symmetrically window width $\delta\eta$, separated by a central pseudorapidity gap, $\Delta\eta$.



ALICE ilustration. JHEP 05 (2015) 097↑

A jet is defined as multiple collimated hadrons created by the hadronization of quarks or gluons produced in hard collisions. The topology of the jet cone, where the hadrons inside a phase space defined by a cone with radius:

$$R = \sqrt{\Delta\eta + \Delta\phi},$$

and a minimum of energy is require to declare the jet.

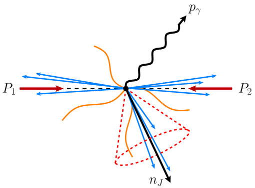


Figure: Jet topology ilustred by Matthew D. Schwartz

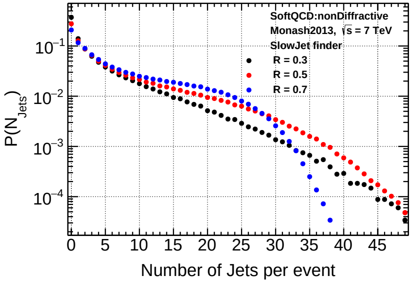


Figure: Probability distribution for the number of jets in the event.

Multiple parton interaction: The $\langle nMPI \rangle$ indicate how many collisions between partons occur in an event as a function of p_T. An average nMPI per event, is related to the cross section given by:

$$\langle n_{MPI}(p_{T,min}) \rangle = \frac{\sigma_{int}(p_{T,min})}{\sigma_{nd}}$$

where σ_{nd} and $\sigma_{int}(p_{T,min})$ correspond to cross section for non diffractive events and the integrated one.

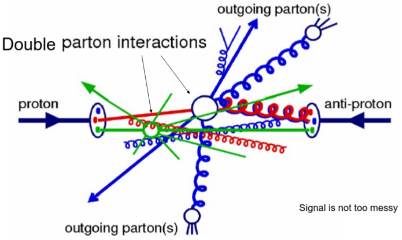


Figure: Illustration from $D\varnothing$ Collaboration.

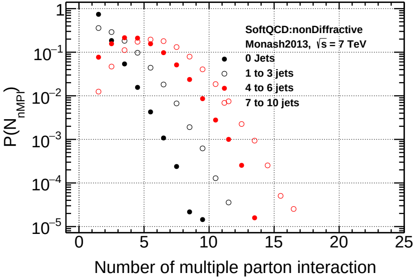


Figure: nMPI distribution in terms of number of jets per event.

Phenomenological effects

Colour reconnection:
The hadronization process contributes from the interaction probability among different partons before and after the dispersion parton-parton in hadron-hadron collisions. This interaction probability between two partons gives the probability to combine partons to form a hadron; This is called reconnection probability and is given by

$$P_{rec}(p_T) = \frac{(R_{rec}\, p_{T0})^2}{(R_{rec}\, p_{T0})^2 + p_T^2}$$

where the range of color reconnection (R_{rec}) is $0 \leq R_{rec} \leq 10$, it is a phenomenological parameter and p_{T0} is the energy dependent parameter used to damp the low p_T divergence of the $2 \to 2$ QCD cross section.

Results in correlations

Eur. Phys. J. C 79, 626 (2019)$\rightarrow$:

- The Correlation simulated at 7 TeV by pythia, and agreed with ALICE at two different energy with his respective range of nMPI.
- A prediction is made for higher energy values (13 TeV).
- $b_{corr} = a + b\, ln\sqrt{(\delta\eta)}$.

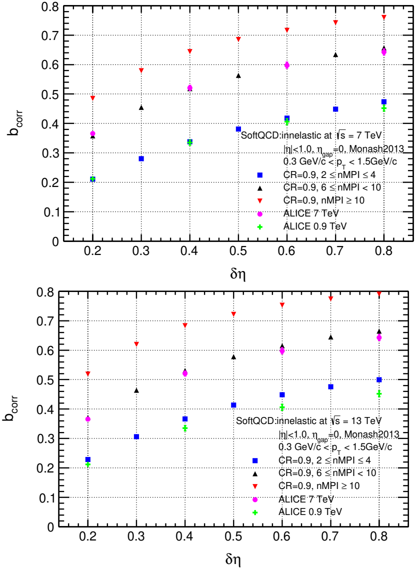


Figure: b_{corr} in terms of nMPI and CR for pp collision at $\sqrt{s} = 7$ TeV and 13 TeV, and ALICE.

Work in progress→:

- Colour reconnection produce a higher reduction in multiplicity with higher range of number of jets.
- Multiplicity show ascendance in terms of the number of jets.
- Higher range of number of jets implies higher average multiplicity.

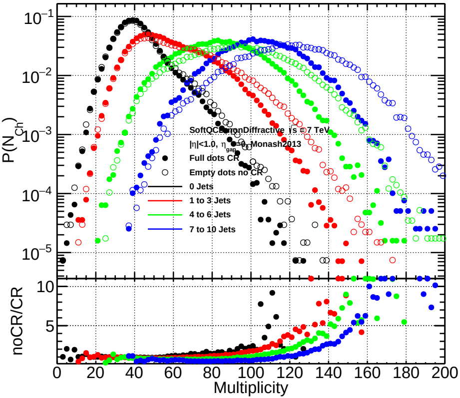


Figure: Multiplicity distribution with and without CR as a function of number of jets.

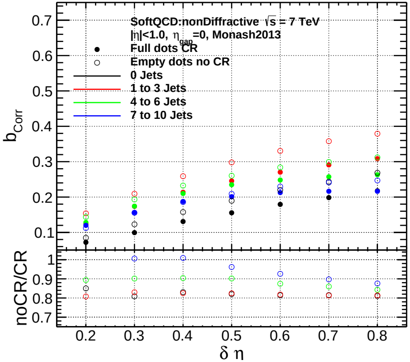


Figure: b_{corr} for ranges of number of jets with and without CR

- The correlation strength shows dependance on the event class (number of a jets in an event).

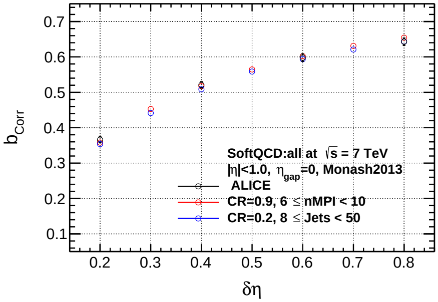


Figure: b_{corr} comparison between ALICE and PYTHIA with different selection.

- Different event classes reproduce the best fit to data.

Conclusion

- $\langle nMPI \rangle$ was extracted from F-B multiplicity correlations, and predicted for energy not yet measured.
- Large numbers of jets also mean more extensive average multiplicity, which implies lower strength of the correlation.
- The average number of multiple parton interactions have a relationship with the number of jets in an event.
- From experimental point of view it is not possible the direct extraction of $\langle nMPI \rangle$, in this work we show that is possible to get it from F-B multiplicity correlations selecting event class according to the number of jets and consequently we get a better understanding of the proton-proton collisions.

Backup