# Studying the effects of multi-parton interactions on typical heavy-ion observables

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## Abstract

Recent measurements performed in high-multiplicity proton-proton (pp) and proton-lead (p-Pb) collisions have shown features that are reminiscent of those observed in lead--lead (Pb-Pb) collisions. The origin of these features is, however, still controversial, with collectivity, initial state effects and multipartonic correlations all possibly contributing. The pp measurements have in the past been successfully modeled by mechanisms such as multi-parton interactions and color reconnection. We now have an opportunity to investigate if these effects can mimic collectivity in a high multiplicity regime. In this work, we use the PYTHIA event generator to investigate how typical heavy-ion observables are affected in a scenario in which a large number of partonic interactions took place. Observables related to the event shape and identified particle production, including strange particles and resonances, are studied.

## Introduction

Recently, traces of heavy-ion collision phenomenology have been observed in high multiplicity pp and p-Pb collisions [1]. Some of these features have been successfully modeled by mechanisms such as multi-parton interactions (MPI) [2] and more recently with colour reconnection (CR) [3].

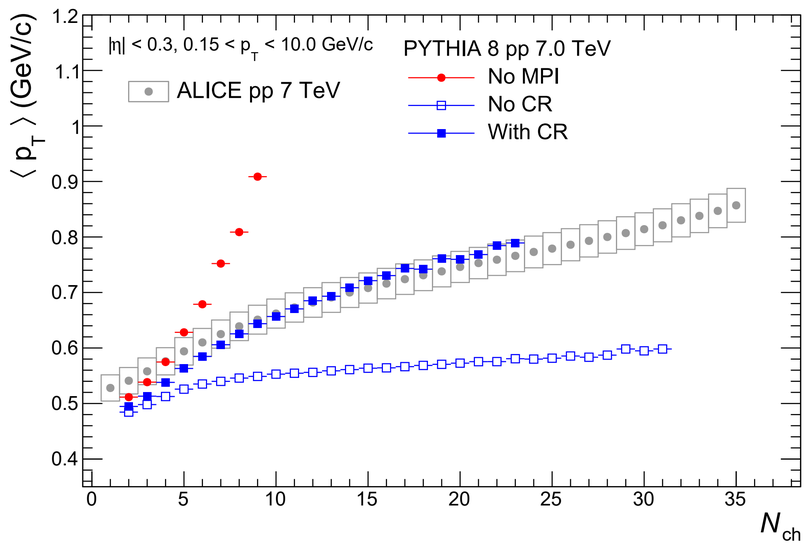


**Figure 1**: Mean transverse momentum of charged particles as a function of charged particle density. ALICE DATA from [6].

- CR changes the particle spectra, increasing their ⟨ $p_T$ ⟩.

In this work we study how CR affects the multiplicity dependence of event shapes and relative resonance production. To do this we use the PYTHIA 8 event generator [4] to simulate pp collisions without MPI, collisions with MPI but without CR and with the new CR mechanism (More QCD based Scheme) [5] in the non-diffractive event class.

## Event Shape

To observe if the spectra modification that CR generates also modifies the topology of the events we use here the 2nd order cumulant $c_2\{2\}$ [7].

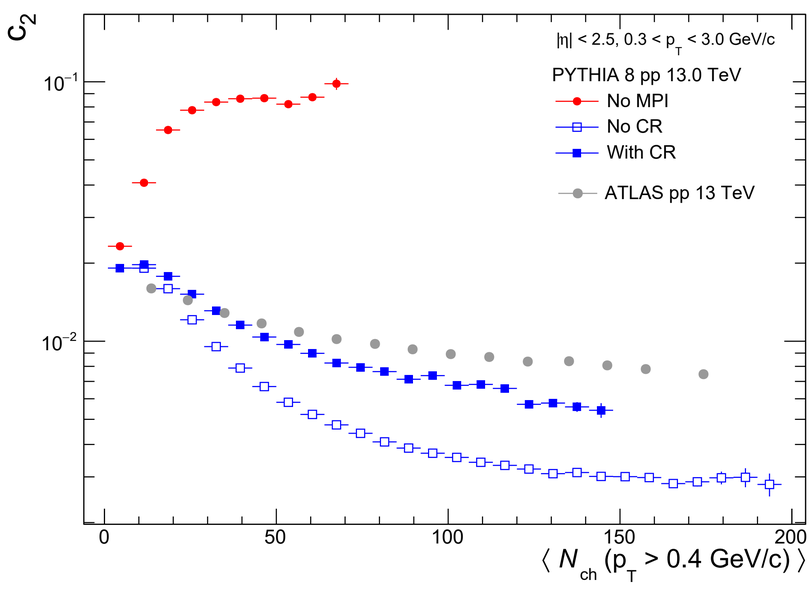


**Figure 2**: The second order cumulant $c_2\{2\}$ as a function of charged particle density . ATLAS DATA from [8].

- Events without MPI have an elevated $c_2$ due to momentum conservation (jet--like events);
- CR makes the events more anisotropic, increasing $c_2$.

**Figure 3**: Two-particle cumulant $c_2\{2\}$ as a function of transverse momentum of charged particles for high multplicity events.




- The increase of $c_2$ is not only a consequence of an increase of the mean $p_T$ but is also seen in the $p_T$-differential $c_2$;

## Identified Particle Ratios

In this section we study some ratios of identified particles as a function of the event activity emphasizing resonance to non-resonance ratios.

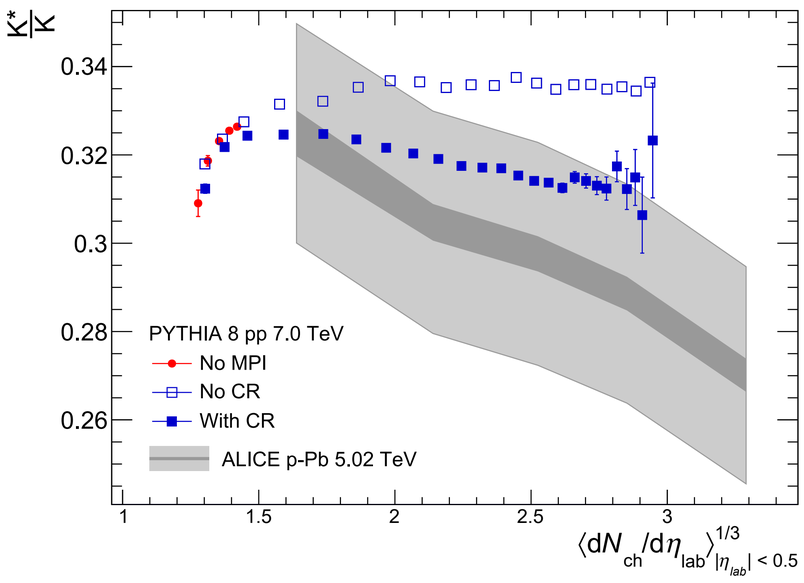


**Figure 4**: $K^*$ to K ratio as a function of charged particle density. ALICE data from [9].

- The relative $K^*$ production is supressed in events in which CR is allowed to take place.
- The decrease of $K^*/K$ with increasing multiplicity is similar to the one observed in p-Pb by the ALICE collaboration [9,10].

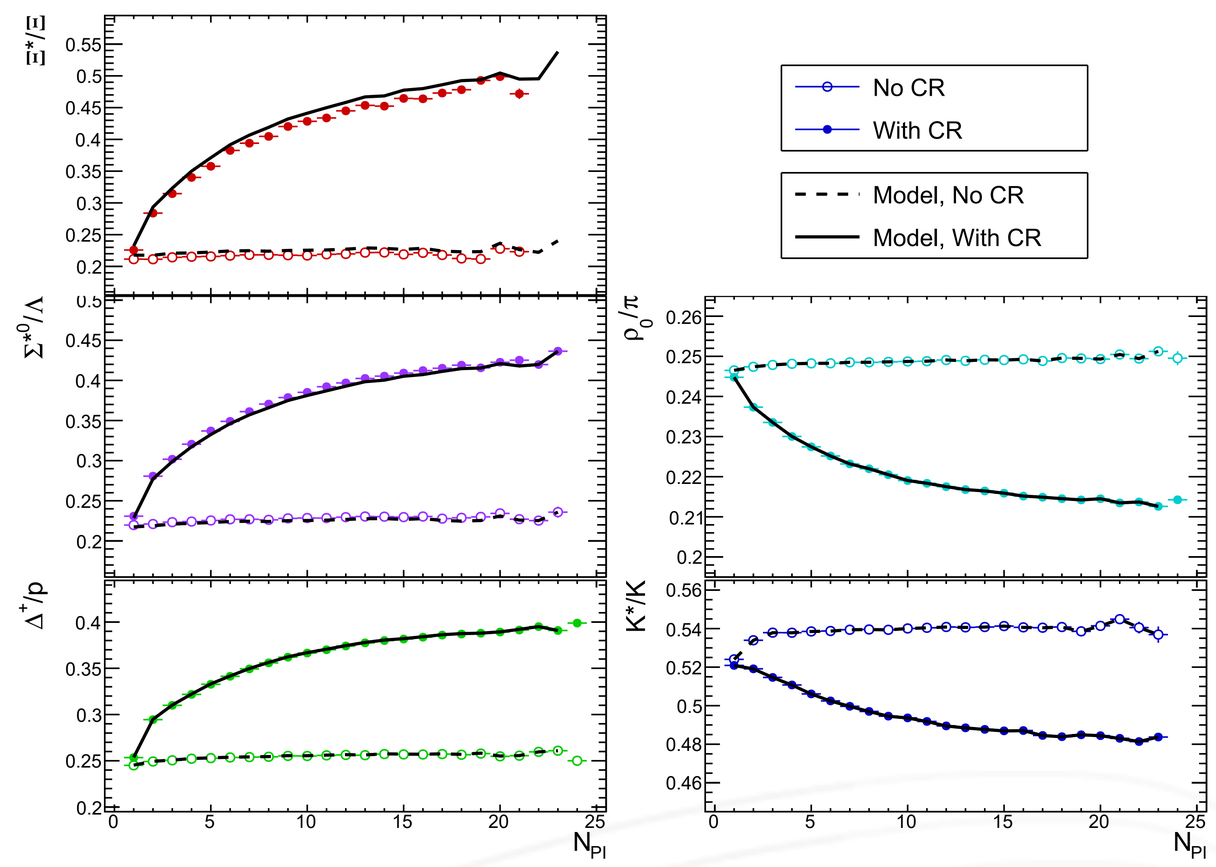


**Figure 5**: Resonance to non-resonance particle ratios as a function of the number of partonic interactions ($N_{PI}$). Particle ratios do not include any decay products. The model parametrization is from [11].

- The production of spin 3/2 baryons is enhanced if CR is allowed to take place.
- Resonance to non-resonanace ratios in PYTHIA 8 can be described with a Markov process-inspired parametrization [11];

## Conclusion

- CR predicts a multiplicity-dependent $c_2$ that is in better agreement with data;
- The majority of the increase of $c_2$ comes from a increase in the $p_T$-differential $c_2$ as opposed to an increase of the mean $p_T$;
- CR also suppresses relative vector meson production in high multiplicity events, which is in qualitative agreement with data;
- A simple phenomenological model inspired by markovian processes can describe the particle ratios from PYTHIA;

Acknowledgments

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## References

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