

# Suppression of resonance production in high multiplicity pp events due to color reconnection effects in PYTHIA8



R. Acconcia, D.D. Chinellato, R. Derradi de Souza, J. Takahashi, G. Torrieri  
"Gleb Wataghin" Institute of Physics - University of Campinas (UNICAMP) – Brazil



## ABSTRACT

Measurement of short-lived hadronic resonances in high energy heavy ion collisions is an important observable to investigate the properties of the created system and the observed suppression of resonance to non-resonance yields towards central heavy ion collisions has been interpreted as being due to re-scattering of decay daughters in the final hadronic phase of the system evolution. However, hints of suppression in the resonance to non-resonance ratio have also been recently observed for high multiplicity events in collisions of small systems, such as pp and p-Pb. We explore the effects of color reconnection (CR) mechanisms, such as the new more QCD-based scheme, in hadronic resonance production in high multiplicity pp collisions using the PYTHIA8 event generator. Our studies show that the inclusion of CR leads to a suppression of hadronic resonance production with respect to non-resonance states, observed in the evolution of the ratios of  $K^*/K$ ,  $\rho/\pi$  and  $\eta'/\pi$  as a function of the event activity. These results bring an alternative possible explanation for the phenomenon in small system collisions. We also discuss another heavy-ion observable that is affected by the CR, the two particle correlation  $2^{\text{nd}}$  order cumulant.

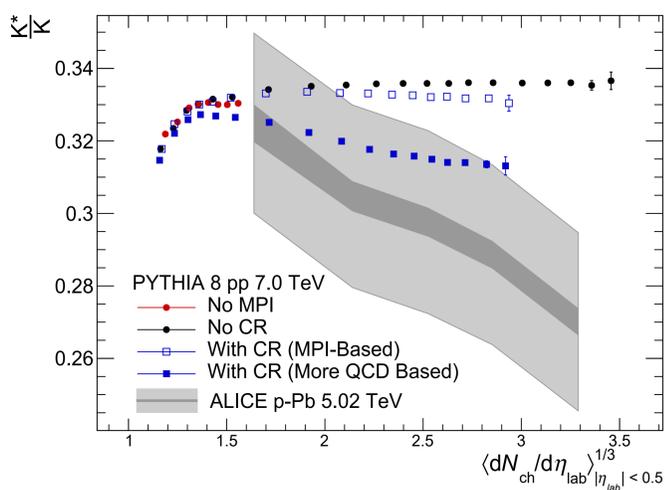
## INTRODUCTION AND PHYSICS MOTIVATION

Recently, traces reminiscent of heavy-ion phenomenology have been observed in high multiplicity proton-proton (pp) and proton-lead (p-Pb) collisions [1]. Some of these features have been successfully modeled by mechanisms such as multiparton interactions (MPI) [2] and with color reconnection (CR) [3].

In this work we study the effects of MPI and CR on the hadrochemistry of pp collisions with special focus on the production of hadronic resonances.

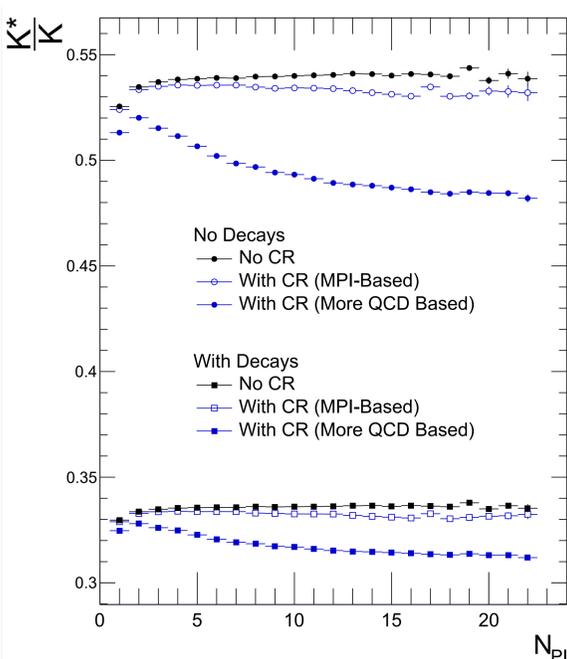
The PYTHIA 8 event generator [4] was used to simulate pp collisions with and without MPI and two variants of CR mechanisms. Results were compared to recent experimental measurements.

### → Resonance suppression in small systems



- A suppression of  $K^*/K$  with increasing charged particle multiplicity has been observed in p-Pb collisions by the ALICE Collaboration [5]
- The inclusion of the More QCD-based CR scheme [6] in PYTHIA8 produce a suppression of the relative production of hadronic resonances which is in qualitative agreement with the experimental observations

## ISOLATING THE EFFECT

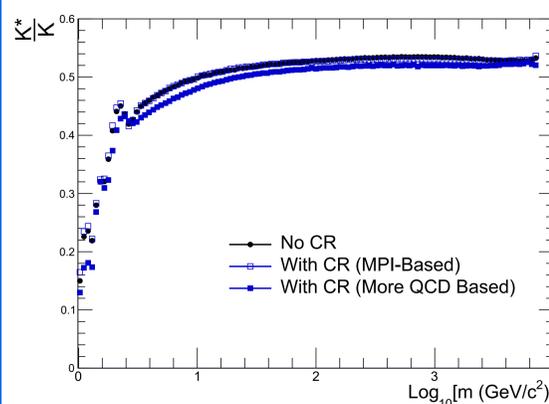


- $N_{PI}$ , number of partonic interactions
- A significant fraction of the charged kaons in the denominator of the ratio comes from resonances decays
- Could the suppression be due to extra kaons from decays?

The suppression due to CR is still present even after removing the contribution from decays

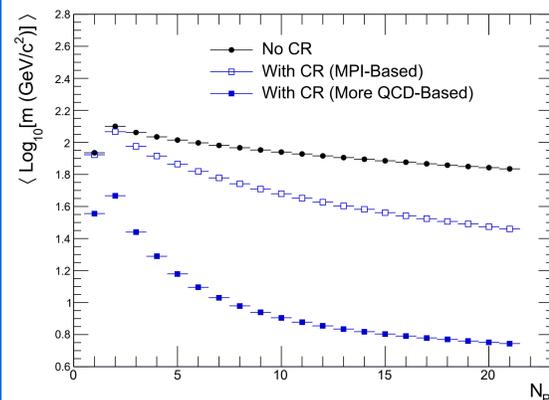
## STRING HADRONIZATION STUDY

To understand the origin of the resonance suppression introduced by CR, we studied the properties of the strings produced in the collision process.



- $K^*/K$  ratio vs string invariant mass
- Shorter strings produce relatively less  $K^*$  compared to  $K$
- Similar behavior is observed also for  $\rho/\pi$  and  $\eta'/\pi$  [7]

How does the invariant mass of the strings depend on  $N_{PI}$ ?



- Mean string inv. mass vs  $N_{PI}$
- Mean invariant mass of strings decreases with increasing  $N_{PI}$
- Effect is more pronounced for the More QCD-based CR scheme
- The decreasing invariant mass of strings for events with high  $N_{PI}$  leads to a suppression of the relative resonance production

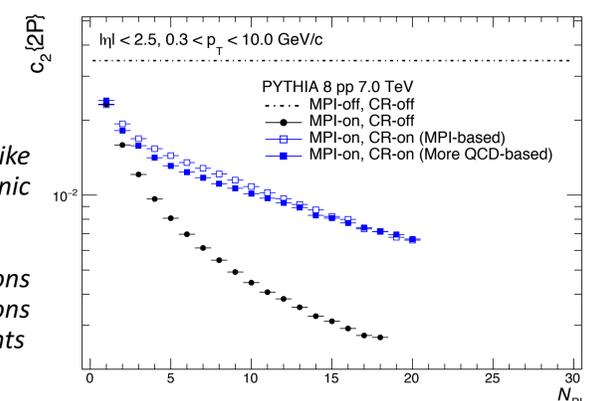
## EVENT SHAPE STUDY

Since CR introduces correlation between different partonic interactions by reconnecting the initial strings, it may also affects the final event topology.

In order to evaluate possible effects, we studied the  $p_T$ -integrated  $2^{\text{nd}}$  order cumulant of charged particles for different CR mechanisms.

### → $c_2\{2\}$ vs the number of partonic interactions

- MPI dilutes the initial jet-like correlation of single partonic interactions
- CR introduces correlations between partonic interactions leading to less isotropic events



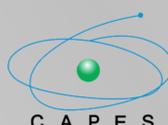
## CONCLUSION

- CR leads to shorter, less energetic strings, which hadronize preferentially into particles with lower masses, leading to a relative suppression of resonances
- CR can be an alternative explanation for the observed resonance suppression in pp collisions, commonly explained via rescattering in a hadronic phase
- Initial studies with observables associated with collectivity, such as  $c_2\{2\}$ , suggest that CR also affects the final event topology

## REFERENCES

- [1] Nature Physics 13, 535-539 (2017)
- [2] Phys. Rev. D36, 2019-2041 (1987)
- [3] Phys. Rev. Lett. 111, 042001 (2013)
- [4] Comput. Phys. Commun. 191, 159-177 (2015)
- [5] Eur. Phys. J. C76, 245 (2016)
- [6] JHEP 1508, 003 (2015)
- [7] Phys. Rev. D97, 036010 (2018)

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