Disentangling the soft and hard components of the pp collisions
(study the effects on the p_T spectra of identified hadrons)

E. Cuautle, R. T. Jiménez, I. A. Maldonado, **A. Ortiz***, G. Paic and E. Pérez
Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México. Apartado Postal 70-543, México Distrito Federal 04510, México.
*antonio.ortiz@nucleares.unam.mx

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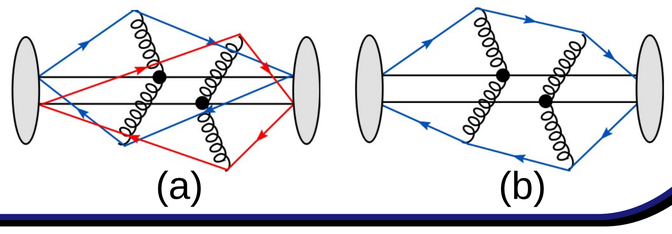
Abstract
We present a new method based on the use of the event shapes to split the data into enhanced soft and hard event samples corresponding to large and low numbers of multi-parton interactions (MPI), respectively. The study was done for inelastic pp collisions at √s =7 and 13 TeV simulated with Pythia 8.180[1]. We study the identified particle transverse momentum, p_T, spectra and their ratios for two extreme event classes.

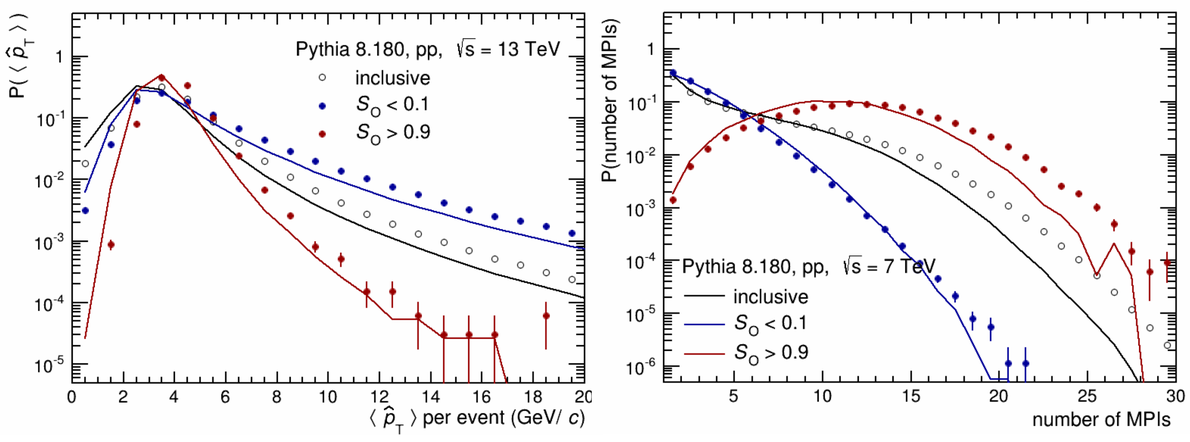
Introduction
Some similarities among the different colliding systems at the LHC have been found when the analyses are performed as a function of the event multiplicity, N_{ch}[2,3]. However, the same N_{ch} corresponds to a very different collision regime[4]. Hence, multiplicity is not a good quantity to compare results from different systems. In this work we investigate the event shapes and find that they can be used to separate soft and hard events. This would allow to compare the same event classes in pp and p-Pb, models could be tested in soft and hard events and radial flow effects could be enhanced[5,6].

In Pythia, color reconnection, CR, produces radial flow. Figure (a) b shows the case when CR is (not) activated.



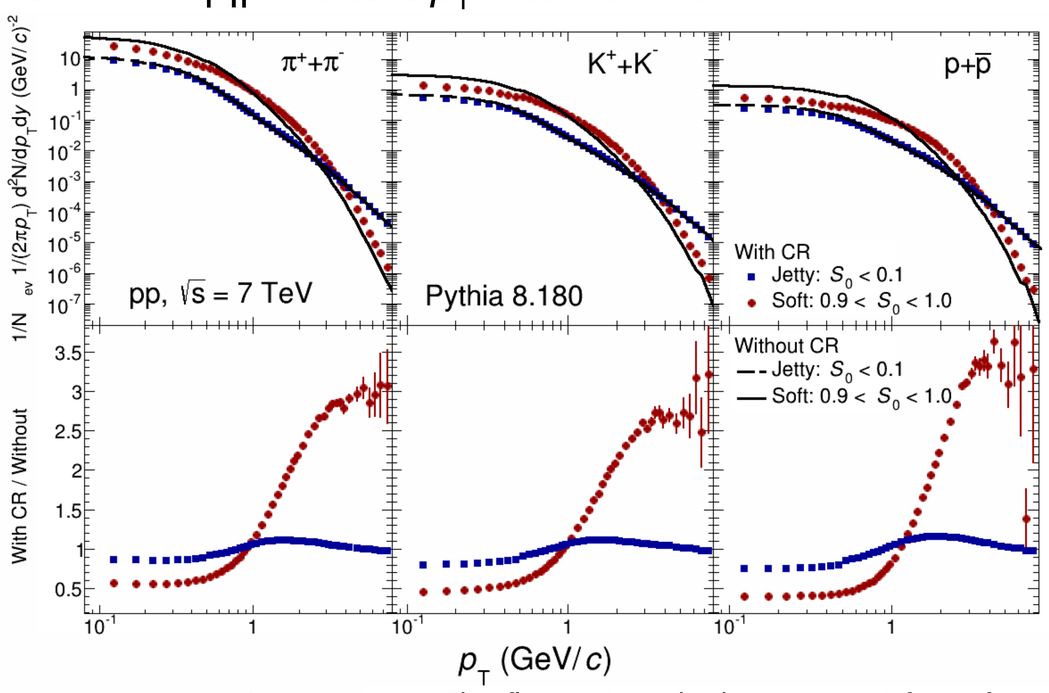
Spherocity
Transverse spherocity, S_O, is defined for a unit transverse vector which minimizes the ratio[7]:

$$S_O = \min_{\vec{n}_T} \frac{\pi^2}{4} \left(\frac{\sum_i^{N_{ch}} \left| \vec{p}_{T_i} \times \vec{n}_T \right|}{\sum_i^{N_{ch}} \left| \vec{p}_{T_i} \right|} \right)^2$$



Isotropic events ~ soft events (S_O>0.9): large number (~12 MPI) of soft partonic interactions.
Pencil-like events ~ hard events (S_O<0.1): low number of MPI (~2), the events are harder than in MB.

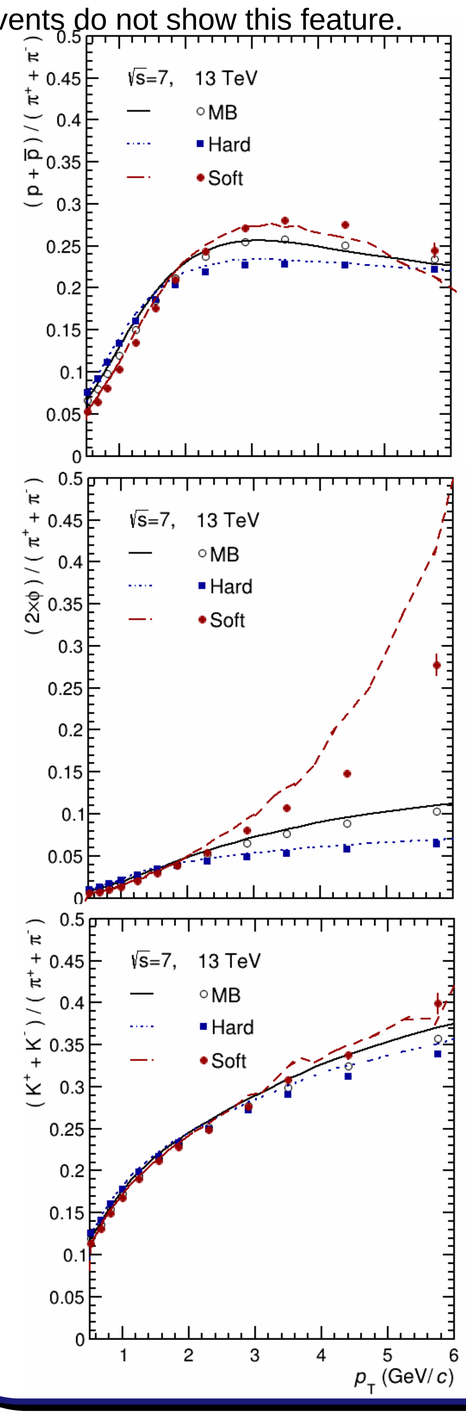
Results
The p_T distributions of π/K/p at |y|<0.5 for pp collisions were obtained for soft and hard events. The computation of S_O required more than two charged hadrons in |η|<0.8 and p_T > 0.5 GeV/*c*.



Transverse momentum spectra. The flow pattern is the strongest for soft events (red markers), around 2 GeV/*c* the spectra become harder with the hadron mass increase. Spectra without CR and for hard events do not show this feature.

The **particle ratios**, *i.e.*, the yields of protons, kaons and phi-mesons normalized to those for pions were studied. For soft and hard events the ratios were found different with respect to the MB ones. In spite of flow patterns are visible in MB events, they are small, but these can be increased in soft events. On the other hand, for hard events the effects are much smaller. The ratio φ/π exhibits a stronger effect at high p_T, this is a factor 2.7 higher in soft events with respect to MB.

The **energy dependence** on the particle ratios is the strongest for soft events. For instance, in this event class the maximum of the p/π ratio is shifted to higher p_T than in MB, this is due to the larger number of MPIs which increases the radial flow. Furthermore, φ/π is almost a factor 2 higher at p_T=5 GeV/*c* going from √s= 7 to 13 TeV.



References
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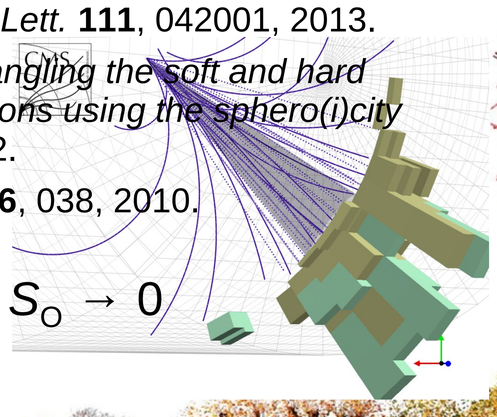

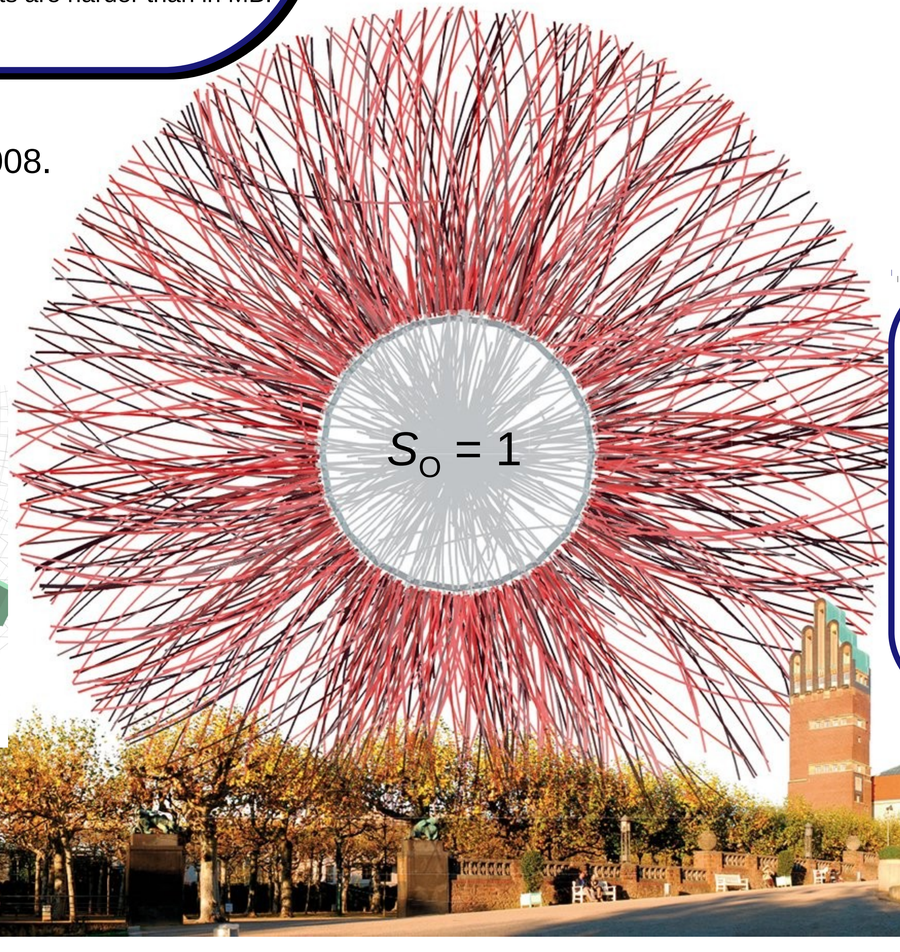

Conclusion
Using Pythia we demonstrated that **spherocity** is an observable which allows the separation of the pp collisions into soft and hard events. The shapes of the p_T distributions were found strongly affected in soft events.