Machine Learning and Multi-Parton Interactions in pp collisions from RHIC to LHC energies

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Given the composite nature of hadrons, several parton-parton interactions (MPI) can occur within the same proton-proton collision.

At the LHC energies the hard cross section exceeds the total proton-proton cross section.

Multi-parton interactions help to describe charge-multiplicity distributions and flow-like patterns observed in pp collisions.

In this work, for the first time we extract the MPI activity from pp data.

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Training and testing using MC

- We have used multivariate regression technique based on boosted decision trees (BDT).
- The extraction of $N_{\text{mpi}}$ is a regression problem in which one gives input variables and obtain a target variable that in this case is the $N_{\text{mpi}}$.
- Training for the MPI-activity estimation is performed on simulated samples of pp collisions at 13 TeV using PYTHIA 8.244 event generator (tune 4C).
- Within uncertainties, the method reproduces the energy dependence of $N_{\text{mpi}}$.
- When MPI are off on the simulations, the method gives a value that is consistent with unity within uncertainties.
- Within uncertainties, $N_{\text{mpi}}$ given by the regression is independent of color reconnection.

In this analysis, we have used the published ALICE data on $p_T$ spectra as a function of event multiplicity. The data are available for $pp$ collisions at 5.02, 7 and 13 TeV.
For \( N_{ch} < 3 \) \( \langle N_{ch} \rangle \) the self normalized \( N_{mpi} \) increases linearly with the event multiplicity.

For higher multiplicities, we observe a deviation of the self normalized \( N_{mpi} \) with respect to the linear trend. This result is fully compatible with the so-called “mini-jet analysis” ALICE Collaboration, JHEP09, 049 (2013).
Summary

- MPI can help to describe charge-multiplicity distributions as well as the flow like patterns in pp collisions

- We have applied machine learning to extract MPI from data, the method was successfully tested with MC

- The minimum-bias data supports the presence of MPI in pp collisions

- For higher multiplicities, the self normalized $N_{\text{mpi}}$ has a deviation with respect to the linear trend. This result is compatible with the so-called “mini-jet analysis”

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