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Multi parton interactions with CMS detector at LHC

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Summary. — Multi parton interactions (MPI) are experiencing a growing popularity and are widely invoked to account for observations that cannot be explained otherwise: the activity of the Underlying Event, the rates for multiple heavy flavour production, the survival probability of large rapidity gaps in hard diffraction, etc. The definition, implementation and tuning of MPI models in Monte Carlo generators plays an important role for the LHC physics: a better definition of the collision dynamics and a better definition of background processes. CMS was involved into the MPI characterization from the beginning of the LHC data-taken, starting from the Underlying Event measurements in Minimum Bias events. With the large integrated luminosity available, the Double Parton Scattering (DPS) measurements (2 hard events in the same proton-proton collision) can be performed in different final states and at different energy scales. The proposed contribution is intended to review past and ongoing studies on MPI with the CMS detector, providing a common interpretation.

PACS 13.87.-a – Jets in large-Q^2 scattering.
PACS 13.85.Hd – Inelastic scattering: many-particle final states.
PACS 13.75.Cs – Nucleon-nucleon interactions.

1. – Introduction

In a proton-proton scattering the hadronic final state can be described as the superposition of different contributions. One of the most important contribution is due to the Multi Parton Interactions as shown in [1,2]. For this reason a correct modelling of MPI will result in more precise predictions in LHC physics searches.

LHC probes small values of the momentum fraction x carried by the colliding partons and the large densities at small-x values increase the probability of having two simultaneous parton-parton scatterings producing two independently-identifiable hard scatterings in a single interaction. Double parton scattering can also contribute sizeably at larger x if the second process occurs with a large rate, as is the case in W+2 jets [3]. Experimental searches for the occurrence of double parton scattering (DPS) processes have been proposed in double Drell-Yan, four jets, and same-sign WW productions, as well as in
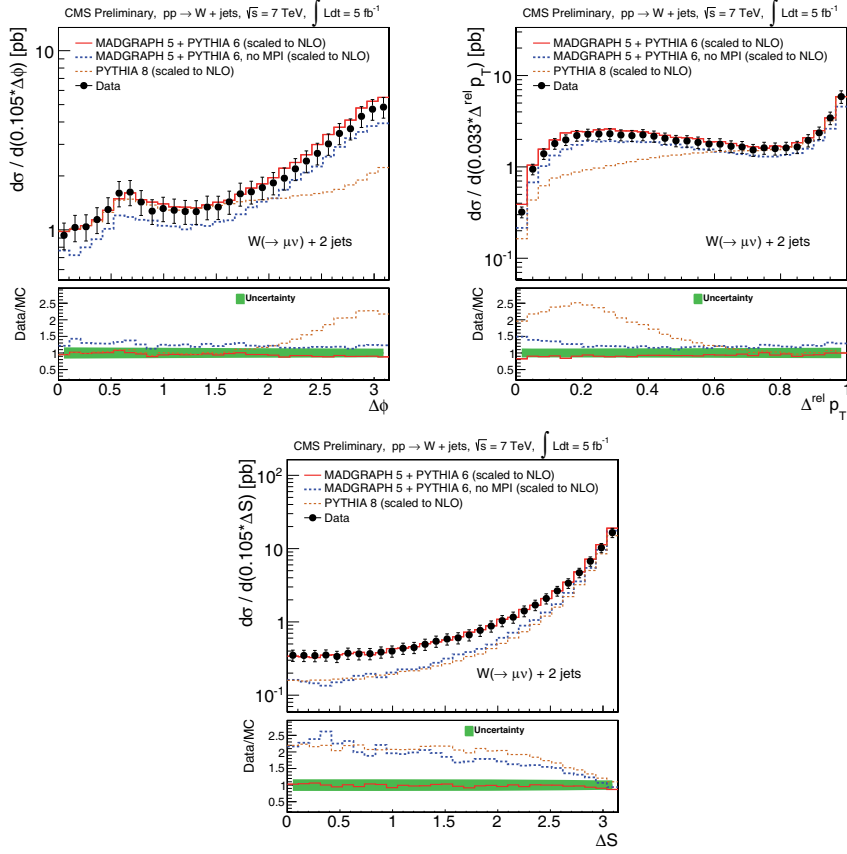
Fig. 1. – Fully corrected differential cross sections for various DPS-sensitive observables for exactly 2 jets: $\Delta\phi$(left), $\Delta^{rel}p_T$ (right), ΔS(bottom). The bottom pad shows the ratio of data over simulations. The green band represents the total uncertainty in the experimental distribution.

W production associated with jets. The large integrated luminosity available from 2012 data taking allows to study the double hard interactions. A preliminary overview on W+2 jets final state will be presented, where specific kinematic observables, supposed to be sensitive to DPS contribution, have been analysed.

2. – Double Parton Scattering at LHC

It is possible, in W+2 jets final state, to define several observables which are sensitive to discriminate DPS events from the Single Parton Scattering (SPS) ones. The analysed data correspond to an integrated luminosity of $5\,\mathrm{fb}^{-1}$ at a centre-of-mass energy of $7\,\mathrm{TeV}$.

Observables $\Delta\phi$, $\Delta^{rel}p_T$ and ΔS (as defined in [3]) for exclusive (exactly two jets) (fig. 1) and inclusive (at least two jets) (fig. 2) W+2 jets events has been studied.

Corrected distributions are compared with particle-level predictions of MADGRAPH [4] MC sample. This sample includes W+jets (up to 4 partons) hard processes from the matrix element calculation which are showered and hadronized using PYTHIA-6 [5]
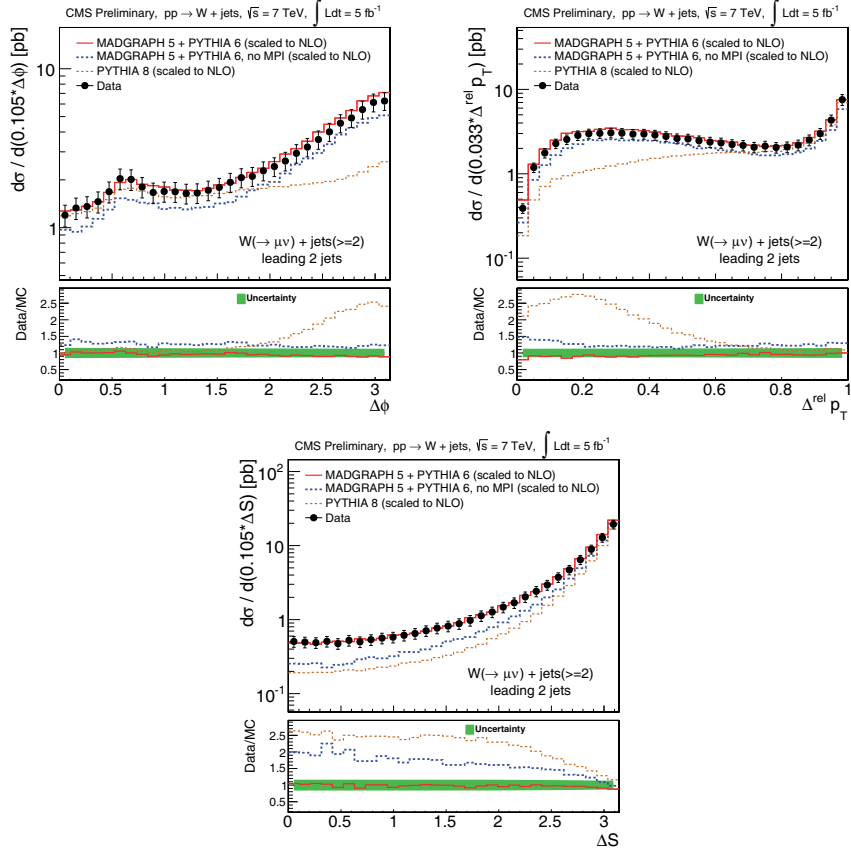
Fig. 2. – Fully corrected differential cross sections for various DPS-sensitive observables for at least two jets with the leading two jets used to calculation: $\Delta\phi$ (left), $\Delta^{rel}p_T$ (right), ΔS(bottom). The bottom pad shows the ratio of data over simulations. The green band represents the total uncertainty in the experimental distribution.

Z2* tune. Events are generated using the CTEQ6L1 [6] parton distribution functions (PDFs). To see the effects of multiple-parton interactions, similar events are produced but switching off multiple-parton interactions during showering and hadronization with PYTHIA. Measurements are also compared with the predictions by PYTHIA 8.165 [7]. PYTHIA-8 events are generated using 4C [8] tune and using the CTEQ6L1 PDFs. For comparison with the measurements MC events are scaled to next-to-leading order cross section.

3. – Conclusion

By comparison of the simulation with and without MPI, it is observed that different observables have different sensitivity in identifying DPS contribution. The availability of such fully corrected distributions provides a first step towards the upcoming extraction of the underlying DPS fraction in p-p collisions at LHC energies.

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