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DPS cross-section measurement from $ssWW$ bosons production in p-p collisions at CMS

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Summary. — The status of the search for same-sign WW production via double-parton scatttering is presented, based on the study on proton-proton collision data using dimuon and electron-muon final states within the CMS experiment Both the results from the 8 and 13 TeV measurements will be shown.

1. – What is double parton scattering?

An interaction where two hard scatters between two independent partons occur within the same proton-proton collision is indicated as double parton scattering (DPS) [1, 2]. In the case of two identical processes and in the assumption of no longitudinal correlation, the DPS cross-section can be written as $\sigma_{DPS} = \frac{1}{2}\frac{\sigma_{incl}^2}{\sigma_{eff}}$, where σ_{incl} is the inclusive cross-section of the single interaction (SPS) and σ_{eff} contains all the information propagated in the orthogonal plane [3]. The experimental signature for a DPS event is the absence of angular and momentum correlations between the objects in the final state.

Many measurements have been performed on different final states and different center-of-mass energy values [4-7]. The same-sign WW production is considered a golden channel for the DPS study since the two W bosons are produced independently of each other and without any associated jet (with respect to the topology of the SPS production), furthermore leptonic decay is reconstructed in order to ensure a clear identification of the final state [8].

2. – DPS in $ssWW$ measurements

The first attempt measuring the DPS in the $ssWW$ final state has been done on data collected by CMS in 2012 at $\sqrt{s} = 8\,\text{TeV}$ ($L = 19.7\,\text{fb}^{-1}$) [9]. Both the $\mu^{\pm}\mu^{\pm}$ and $e^{\pm}\mu^{\pm}$ final states have been analysed. Events were selected if they satisfied a baseline selection and then a boosted decision tree (BDT) has been used to enhance the signal against the

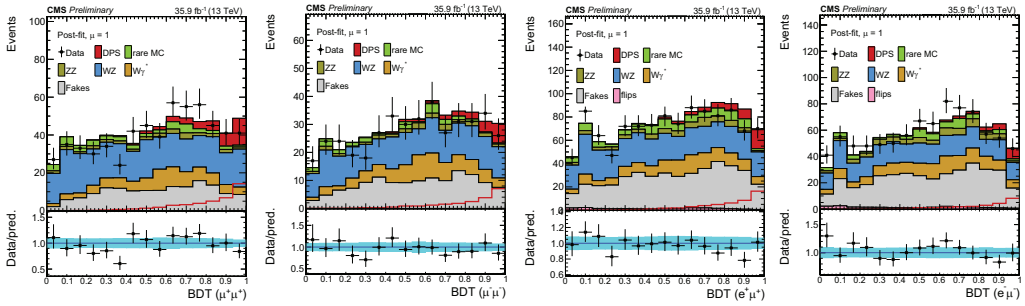

Fig. 1. – The BDT output classifiers are reported here for $\mu^+\mu^+$, $\mu^-\mu^-$, $e^+\mu^+$ and $e^-\mu^-$ final states from left to right. Data points are compared to different Monte Carlo models for signal and background processes.

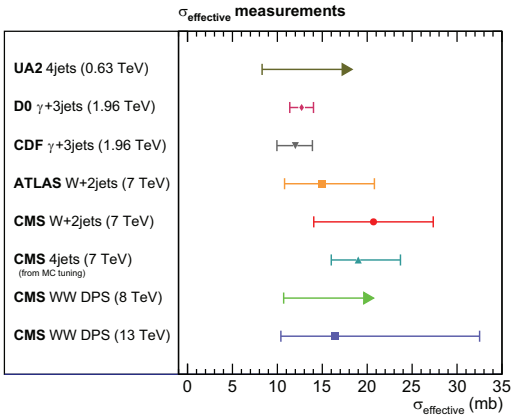

Fig. 2. – The state of the art for the σ_{eff} measurements in the vector-boson final states is reported here.

main background processes. Both the event selection and the BDT input variables are deeply discussed in this paper.

The available statistic was not enough for a direct measurement, thus only an upper limit could be set for the DPS cross-section, $\sigma_{DPS} < 0.32\%$ pb with a 95% CL which corresponds to $\sigma_{eff} > 12.2$ mb, in agreement with the previous measurements.

The analysis has been repeated, in an independent way, using $35.9\,\text{fb}^{-1}$ 2016 data collected at $\sqrt{s} = 13$ TeV. In addition to the increase of the statistics, also some improvements to the analysis strategy and event selection have been introduced, in particular regarding the lepton isolation and identification. The details of the analysis can be found in ref. [10]. A BDT has been trained against the main background, WZ, in order to get a better signal discrimination. Results are reported in fig. 1 divided for lepton flavour and charge.

A cross-section of $\sigma_{DPS} = 1.09^{+0.50}_{-0.49}$ has been extracted for the inclusive WW double parton scattering process, which corresponds to $\sigma_{eff} = 16.39^{+13.88}_{-5.16}$ mb. This is the most precise measurement on DPS in the $ssWW$ final state so far, with an observed sensitivity of 2.23σ.

3. – Conclusion

The strategy developed analysing data collected by CMS at a center-of-mass energy of $\sqrt{s} = 8\,\text{TeV}$ allowed to provide a first deep study and characterisation of the double parton scattering on the $ssWW$ final state putting a lower limit on the $\sigma_{\mathit{eff}} > 12.2\,\text{mb}$. Using a larger statistic at higher center-of-mass energy, $\sqrt{s} = 13\,\text{TeV}$ collected in 2016, and improving the event selection it was possible to provide a first hint of direct measurement for the DPS in $ssWW$, with a measurement of $\sigma_{\mathit{eff}} = 16.39^{+13.88}_{-5.16}\,\text{mb}$. The state of the art of the σ_{eff} measurements in the vector-boson final states from different experiments, final states and center-of-mass energies is reported in fig. 2.

A great work has been done so far but a deep understanding is still needed.

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