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# Measurement of the $W^+W^-$ cross section in pp collisions at 8 TeV and limits on anomalous gauge couplings

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A measurement of the W boson pair production cross section in proton-proton collisions at $\sqrt{s}$ = 8 TeV is presented. The data collected with the CMS detector at the LHC correspond to an integrated luminosity of 19.4 $fb^{-1}$. The $W^+W^-$ candidates are selected from events with two charged leptons, electrons or muons, and large missing transverse energy. The measured $W^+W^-$ cross section is $\sigma(pp \to W^+W^-)$ = 60.1 ± 0.9 (stat.) ± 3.2 (exp.) ± 3.1(th.) ± 1.6 (lumi) pb = 60.1 ± 4.8 pb, consistent with the standard model prediction. The $W^+W^-$ cross sections are also measured in two different fiducial phase space regions. The normalized differential cross section is measured as a function of kinematic variables of the final-state charged leptons and compared with several perturbative QCD predictions. Limits on anomalous gauge couplings associated with dimension-six operators are also given in the framework of an effective field theory. The corresponding 95% confidence level intervals are $-5.7 < c_{www}/\Lambda^2 < 5.9$ $TeV^{-2}$, $-11.4 < c_w/\Lambda^2 < 5.4$ $TeV^{-2}$, $29.2 < c_B/\Lambda^2 < 23.9$ $TeV^{-2}$, in the HISZ basis.

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## 1. Introduction

The Standard Model (SM) description of electroweak and strong interactions can provide very precise calculations of the vector boson production cross section.
Vector bosons pair production is one of the most important electroweak processes at hadron colliders, and $W^+$ $W^-$ takes a special role, having a larger cross section than $W^\pm$ Z or ZZ production.
The SM description can be tested through precision measurements of $W^+$ $W^-$ production cross section at hadron colliders.
Any deviation from SM expectations in measured production rates and kinematical distributions of vector bosons decay products could provide an evidence of new physics effects beyond the SM at high energy scales.
These effects can be described by operators with mass dimension larger than four in an effective field theory (EFT) framework, that can generate anomalous trilinear gauge couplings (ATGC) [1].
The ATGC modifications of certain kinematic distributions from the SM predictions can be used to place limits on the coupling constants associated to the EFT operators, providing a model independent probe of the existence of physics beyond the SM. Moreover, $W^+$ $W^-$ production represents an important background for new particles searches [2].
We present the measurement of the $W^+$ $W^-$ production cross section with data collected by the CMS experiment [3]. The SM diagrams leading to $W^+$ $W^-$ pair production at hadron colliders are s-channel and t-channel qq annihilation and, in a minor part, gluon gluon fusion [4]. The analysis focused on the fully leptonic decay channel of the $W^+$ $W^-$ bosons.

## 2. Analysis Strategy and Results

The dataset considered in the analysis amounts to an integrated luminosity of 19.4 $\mathrm{fb}^{-1}$ collected with the CMS experiment [5].
Events are selected by requiring two high $p_T$ opposite charged and isolated leptons, and missing transverse energy due to the presence of the neutrinos.
The main background comes from the production of top quarks (tt or single top quark, like Wt). To reduce these processes, events with two or more reconstructed jets ($p_T$ above 30 GeV and $|\eta| <$ 4.7)are rejected. Moreover, events with at least one b-tagged jet are discarded.
In the case of same flavour leptons, the Drell-Yan $Z/\gamma^*$ production represent an important background due to finite resolution on the missing transverse energy and to the high cross section.
To reject these events as much as possible the invariant mass of the two leptons system is required to be more than 15 GeV away from the Z boson mass, and a dedicated MVA (multivariate analysis) is exploited.
All the backgrounds, including W + jets and multiboson processes ($W\gamma$, WZ, ZZ, triboson) are taken into account, when possible by inspecting directly data (data-driven estimation), otherwise by producing simulated samples.
The inclusive $W^+$ $W^-$ production cross section is calculated by selecting a signal region as pure as possible, and counting the signal and backgrounds successes:

$$\sigma_{W^+W^-} = \frac{N_{data} - N_{bkg}}{L \cdot \varepsilon \cdot (3 \cdot B(W \to l\bar{\nu}))^2}$$

where L is the luminosity, $\varepsilon$ is the signal efficiency and B is the branching ratio of the W $\rightarrow$ l$\nu$ process.

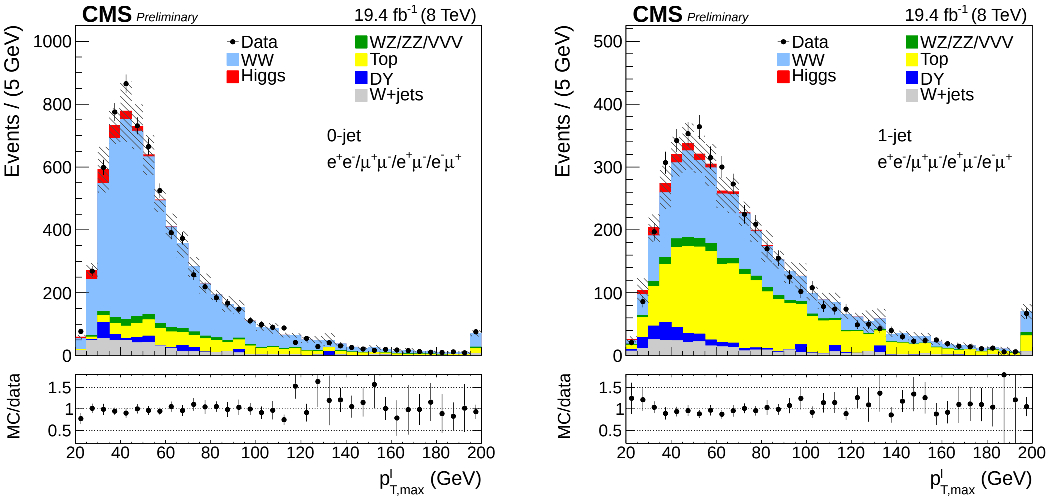


Figure 1: Transverse momentum of the leading lepton in the 0–jet bin (left) and in the 1–jet bin (right) distribution for signal and background compared to Run I data, in the different lepton flavour channel. Dashed pattern represents the montecarlo uncertainties.

The cross section is measured separately in events with same and different flavour leptons, and in events with exclusively zero or one reconstructed and identified jet. The results of the selections for the different lepton flavour channel are shown in Figure 1, where the p T of the leading lepton is drawn in the 0-jet and in the 1-jet bin. Similar distributions are obtained for the same lepton flavour channel.
The theoretical systematic uncertainties affecting the signal efficiency are due to the choice of the QCD theoretical parameters: PDFs [6] [7], $\alpha_s$ , renormalization ($\mu_R$) and factorization ($\mu_F$) scales and higher order corrections [8].
For the background an additional source of uncertainty is given by the normalization factor, when is applied. Finally, the experimental uncertainty and the one on the luminosity were considered.
The $W^+$ $W^-$ measured cross section resulted to be:
$\sigma(pp \rightarrow W^+W^-) = 60.1 \pm 0.9$ (stat.) $\pm$ 3.2 (exp.) $\pm$ 3.1(th.) $\pm$ 1.6 (lumi) pb, consistent with the NNLO theoretical prediction of: $\sigma^{NNLO}(pp \rightarrow W^+W^-) = 59.8^{+1.3}_{-1.1}$ pb.
No evidence of anomalous triple gauge-boson couplings is found, and stringent limits on their magnitude are set.

## References

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