Summary of 'CMS Collaboration, *Measurements of the* $\mathrm{t\bar{t}}$ *production cross section using events in the* $\mathrm{e}\mu$ *final state in pp collisions at* $\sqrt{s} = 13\,\mathrm{TeV}$'

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The paper describes the analysis of $\mathrm{t\bar{t}}$ events with $\mathrm{e}\mu$ final state in order to measure the $\mathrm{t\bar{t}}$ production cross section. It uses data provided by the CMS experiment from pp collisions at a center of mass energy of 13 TeV with an integrated luminosity of $2.2\,\mathrm{fb}^{-1}$. The selection of this analysis consists of having an opposite signed (OS) pair of electron and muon together with two or more jets of which at least one resulted from the decay of a b quark. The measured cross section for the $\mathrm{t\bar{t}}$ production is $815 \pm 9(\mathrm{stat}) \pm 38(\mathrm{syst}) \pm 19(\mathrm{lumi})\,\mathrm{pb}$ which is in agreement with the standard model prediction.

Measuring the $\mathrm{t\bar{t}}$ production at the CMS experiment at the LHC yields multiple beneficial information. It tests the prediction provided by the QCD and can add constrains on the parton distribution functions. Additionally, it grants information about the top quark pole mass but the most important reason precise data about the $\mathrm{t\bar{t}}$ production is necessary is the search for BSM physics since $\mathrm{t\bar{t}}$ is the dominant background in those analysis. For the analysis the full data set of 2015 from the CMS experiment is used providing a data set corresponding to an inverse luminosity of $2.2\,\mathrm{fb}^{-1}$.

The CMS experiment is an experiment at the LHC at CERN used to analyze pp collisions. The silicon pixel detector of the CMS detector covers $0 < \Phi < 2\pi$ azimuth and a pseudorapidity of $|\eta| < 2.5$. In order to detect jets and electron the lead tungstate crystal electromagnetic and the brass and scintillator hadron calorimeter. Muons can be detected using the gas-ionization detectors outside the solenoid. In order to simulate signal and background events different Monte Carlo (MC) event generators are used such as `POWHEG`,`PYTHIA`,`HERWIG++` and `MG5_aMC`. The Standard Model prediction is determined with `TOP++` for a top quark mass of $m_t = 172.5\,\mathrm{GeV}$ and is calculated to be $\sigma_{\mathrm{t\bar{t}}} = 832^{+20}_{-29}(\mathrm{scales}) \pm 35(\mathrm{PDF} + \alpha_{\mathrm{s}})\,\mathrm{pb}$. In order to suppress most background and access the desired decay channel a certain selection is chosen. The selection consists of the requirement of one isolated electron and one isolated muon with opposite electric charge, a transverse momentum $p_T > 20\,\mathrm{GeV}$ and $|\eta| < 2.4$. The isolation criteria is based on the sum of the momentum of the reconstructed particles in a cone around the lepton subtracting its contribution. Furthermore, two or more jets with $p_T > 30\,\mathrm{GeV}$ and $|\eta| < 2.4$ are necessary for a $\mathrm{t\bar{t}}$ candidate. Finally, due to the nature of the decay of $\mathrm{t\bar{t}}$ into a bottom quark + antiquark at least one jet is required to be identified as a result of the hadronisation of a b quark. This constrain reduces the amount of background events created by Drell-Yan (DY) and W+Jets events.

The main background processes for the $e\,\mu$ decay channel of $\mathrm{t\bar{t}}$ are single top quark production, Drell-Yan (DY) processes and events containing two or more prompt leptons from vector boson decays, referred to as VV events.

There are some systematic uncertainties that have to be considered due to their significant contribution. From experiments The jet energy scale (JES) Lepton efficiencies

The cross section is calculated with a event counting method using the formula

$$\sigma_{\mathrm{t\bar{t}}} = \frac{N - N_{\mathrm{B}}}{\mathcal{A}\mathcal{L}}.$$

N is the total number of events found in data after the selection is applied, N_{b} is the estimated number of background events extracted from modeling, $\mathcal{A}$ is the acceptance including the mean acceptance, the selection efficiency and the branching ratio of $\mathrm{t\bar{t}}$ into the $e^{\pm}\mu^{\mp}$ decay channel. The value of $\mathcal{A}$ is $(0.55 \pm 0.03)\,\%$ and is determined from simulation with a top quark mass of $m_t = 172.5\,\mathrm{GeV}$. Finally, the resulting measured cross section is

$$\sigma_{\mathrm{t\bar{t}}} = 815 \pm 9(\mathrm{stat}) \pm 38(\mathrm{syst}) \pm 19(\mathrm{lumi})\,\mathrm{pb}$$

which is in agreement with the Standard Model prediction within one standard deviation.

References

[1] CMS Collaboration, Measurement of the $\mathrm{t\bar{t}}$ production cross section using events in the eμ final state in pp collisions at $\sqrt{s} = 13\,\mathrm{TeV}$, Eur. Phys. J. C 77 (2017) 172.