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Measurements of the top quark pair production cross section at 7 TeV

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Summary. — We present several measurements of the cross section for the production of top quark pairs in proton-proton collisions at the LHC at a centre-of-mass energy of 7 TeV. We use data collected with the CMS experiment during the year 2010, and amounting to a total integrated luminosity of $36\,\mathrm{pb}^{-1}$. Measurements are presented in the lepton+jets final state, where events are selected which contain exactly one isolated, highly energetic muon or electron, and at least four jets. In addition, the di-lepton final state, which consists of two leptons, at least two jets, and significant missing transverse energy is explored. We use b-jet identification in order to increase the purity of the selection. Important backgrounds are estimated using data-driven techniques, and systematic uncertainties are estimated. The results are compared with theory predictions.

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1. – Introduction

In the standard model, a top quark decays nearly 100% of the time to a W boson and a b quark. The decay of a $t\bar{t}$ pair is categorized by the decay of the W bosons produced by the pair. Thus the channel in which both W bosons decay to leptons is referred to as the *dilepton* channel, and the channel in which one W decays to leptons and the other to quark jets is the *lepton+jets* channel. The channel in which both W bosons decay to jets is called the *all hadronic* channel.

The cross section for top quark-antiquark pair production has been measured with the CMS detector [1] in proton-proton collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ using a sample corresponding to $36\,\mathrm{pb}^{-1}$ of integrated luminosity. Here is presented the measurement of the cross section of $t\bar{t}$ pair production using both *dilepton* [2] and *leptons+jets* [3, 4] samples.

2. – Measurement of the cross section in the *dilepton* channel

The *dilepton* cross section measurement is performed by requiring two isolated leptons and the presence of large missing E_T, where E_T is the transverse energy. In the

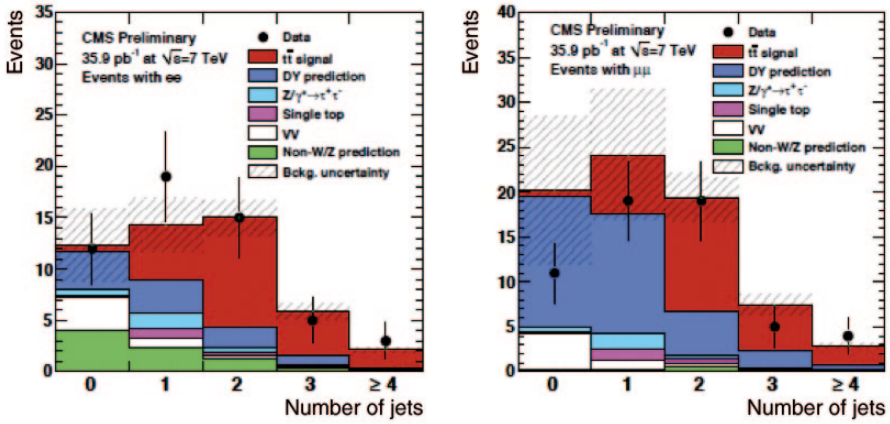

Fig. 1. – Jet multiplicity for events passing full dilepton selection criteria without b-tagging, less the requirement on the number of jets compared to signal expectations from simulation, Drell-Yan and non-W/Z lepton backgrounds estimated in data, and remaining backgrounds estimated from simulation. The total uncertainty on the background contribution is displayed by the shaded area.

dielectron+jets channel the 2 electrons are required to have an E_T greater than 30 GeV and to be in a region of pseudorapidity $|\eta|$ less than 2.5. While muons selected in the dimuon+jets channel are required to have transverse momentum p_T greater than 20 GeV and to be in $|\eta|$ less than 2.1. In both channels the selected jets are required to have a p_T greater than 30 GeV. The background and signal expectations compared to the number of events selected in data in different jet multiplicity bins are shown in fig. 1 for events without a b-tagging requirement.

To maximize separation with background the analysis is performed in jet multiplicity bins, where in each jet bin a separate selection and background estimation from Drell-Yan and QCD contributions is performed. Uncertainties result from the lepton reconstruction and resolution, as well as the b-tag efficiency and modelling of the signal shape. Combining the measurements in all the three *dilepton* channels ($ee, \mu\mu, e\mu$) results in a cross section of

$$\sigma_{t\bar{t}} = 168 \pm 18(stat) \pm 14(syst) \pm 7(lumi)\,\text{pb}\,.$$

3. – Measurement of the cross section in the *lepton+jets* channel

The measurement in the *lepton+jets* channel is performed through two methods by requiring a single high-p_T lepton and either three or more jets or the presence of a b-tag. In the instance where there is a b-tag, the yield is determined by fitting in three dimensions the vertex mass distribution of the b-tagged jet, the jet multiplicity and the number of b-tagged jets. The fit simultaneously floats the jet energy scale, the b-tag efficiency, and the W+jets Q^2 scale so as to reduce the systematic uncertainty. This method is additionally performed simultaneously in lepton flavor(e and μ). The method where three or more jets are utilized is performed by simultaneously fitting the missing E_T and the mass of the three jets. The fit is performed in both the electron and muon plus jets channel while separately floating the single top, W, Z, electron QCD and muon

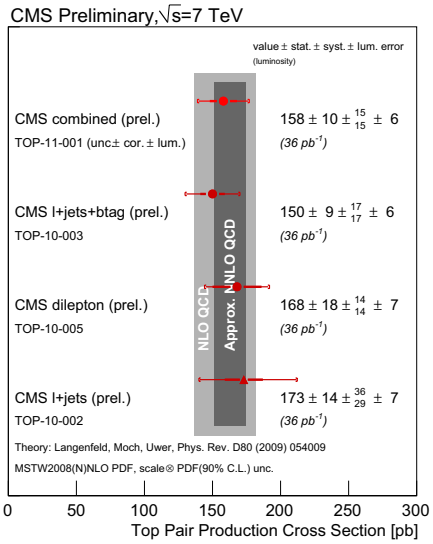

Fig. 2. – Summary of various inclusive $t\bar{t}$ production cross sections. The inner error bars of the data points correspond to the statistical uncertainty. The thin error bars incorporate the systematic uncertainties and the brackets incorporate the luminosity uncertainty.

QCD contributions. The measurement parallels the cross section measurement where a b-tag is applied. The cross section resulting by combining the two different methods is

$$\sigma_{t\bar{t}} = 158 \pm 10(stat) \pm 15(syst) \pm 6(lumi)\,\mathrm{pb}\,.$$

4. – Conclusions

We presented the measurements of the cross section for the production of top quark pairs using data collected with the CMS experiment, amounting to a total integrated luminosity of $36\,\mathrm{pb}^{-1}$. All the measurements are in agreement with each other and with the theoretical predictions (fig. 2).

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