

## Measurement of single top production in $pp$ collisions at 7 TeV with the CMS detector

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**Abstract.** The measurement of  $t$ -channel single top cross-section in proton–proton collisions at the Large Hadron Collider (LHC) at a centre-of-mass energy of 7 TeV, using data collected with the Compact Muon Solenoid (CMS) experiment during the year 2010 is presented. Both the electron-neutrino and muon-neutrino decay channels of  $W$  boson from top decay are considered. Two complementary multivariate analysis methods to separate signal and background and to extract the cross-section for the single top produced in  $t$ -channel are explored. The result is compared with the most precise Standard Model theory predictions.

**Keywords.** Single top; CMS; 2010.

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### 1. Introduction

The theory of electroweak interactions predicts three different production mechanisms for single top quarks in hadron–hadron collisions:  $t$  channel,  $s$  channel, and  $tW$  (or  $W$ -associated). In this article, we show the first evidence for  $t$ -channel single top quark production in  $pp$  collisions and perform the first measurement of this cross-section in  $pp$  collisions at  $\sqrt{s} = 7$  TeV provided by the LHC. The results are based on the data sample corresponding to an integrated luminosity of  $35.9 \pm 1.4$  pb<sup>-1</sup> recorded by the CMS experiment [1], incorporating data taken up to November 2010.

This analysis treats the  $t$ -channel production mode as signal, including the other two in the definition of background and utilizes the leptonic decay channels in which the  $W$  boson from the top quark decays further into a muon or an electron and a neutrino with a branching ratio  $\text{BR}(t \rightarrow b \ell \nu) = (10.80 \pm 0.09)\%$ , where  $\ell = e/\mu$ .

### 2. Analysis

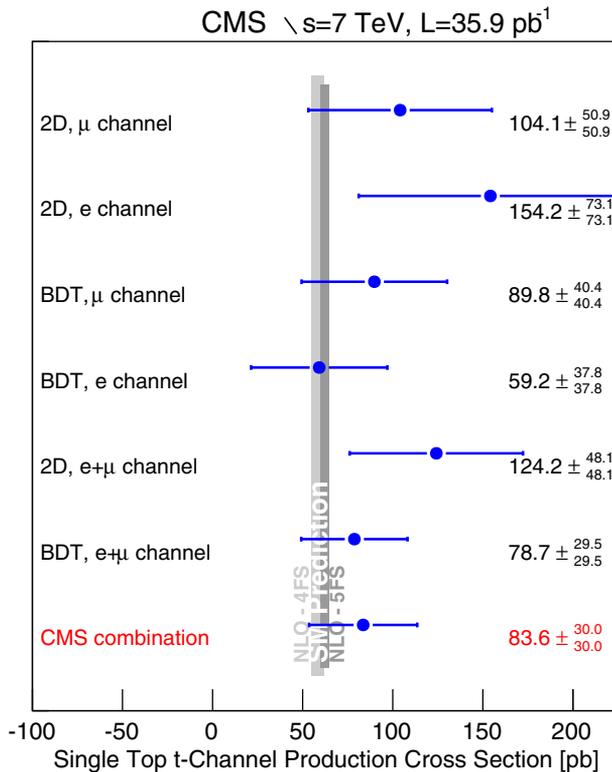
We apply a dedicated event selection, and then perform two complementary measurements. In our first approach, we exploit a data-driven method using two angular properties

specific to  $t$ -channel top quark production: the non-central pseudorapidity distribution of the light jet recoiling against the single top and the cosine of the angle, in the reconstructed top quark rest frame, between this jet and the final-state lepton. In our second method, we probe the overall compatibility of the signal event candidates with the Standard Model expectations of electroweak top quark production by using a multivariate analysis technique. In the following, these analyses will be referred to as 2 dimension (2D)-analysis and boosted decision tree (BDT)-analysis, respectively.

The BDT-analysis combines a given set of observables into a single classifier variable  $bdt$ . A total of 37 observables have been chosen. The most discriminant ones are the lepton momentum, the mass of the system formed by the reconstructed  $W$  boson and the two jets, the  $p_T$  of the system formed by the two jets, the  $p_T$  of the jet passing tight  $b$ -tagging requirements, and the reconstructed top-quark mass.

### 3. Results and combination

The cross-sections measured in 2D- and BDT-analyses are combined with the BLUE technique [2], considering all the uncertainties fully correlated with few exceptions: the



**Figure 1.** Comparison of the cross-section measurements in all channels in the 2D- and BDT-analyses, and theoretical calculations under the Standard Model assumption.

statistical error (51% correlation), the  $W$ +light partons normalization and shape (data-driven in the 2D-analysis and taken from theory in the BDT-analysis), and the QCD normalization. The correlation of the latter component is poorly known. Therefore, we consider a 50% correlation and treat the uncertainty on this correlation as an additional systematic (within 0% and 100%), whose impact is found to be negligible.

Figure 1 compares the  $t$ -channel cross-section extractions in muon and electron decay channels from 2D- and BDT-analyses as well as the combined 2D and BDT measurements.

The combination of 2D and BDT measurements yields the following cross-section measurement combined in muon and electron channels:

$$\sigma = 83.6 \pm 29.8(\text{stat.} + \text{syst.}) \pm 3.3(\text{lumi.}) \text{ pb} \quad \text{combined}, \quad (1)$$

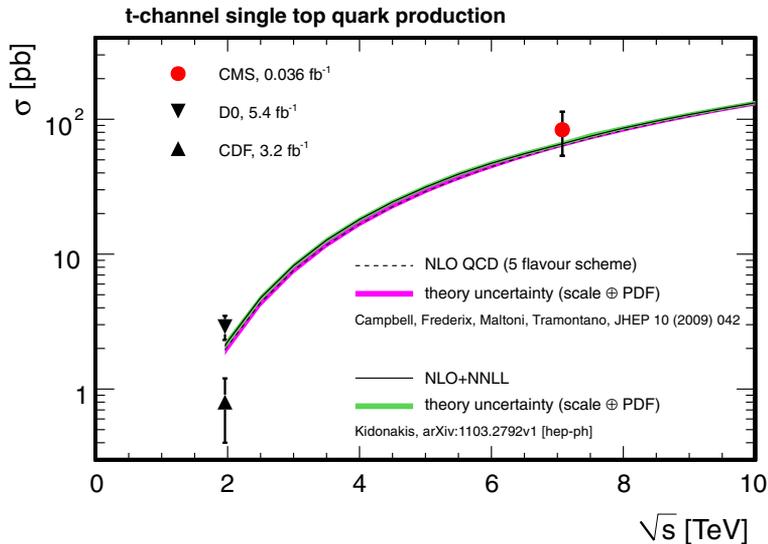
where the BDT-analysis, being more precise, contributes with a larger weight (89%) with respect to the 2D-analysis.

Figure 2 compares the combined measurement [3] with the dedicated  $t$ -channel cross-section extractions at Tevatron [4,5], demonstrating the large increase due to the higher centre-of-mass energy.

Under the assumption that  $|V_{td}|$  and  $|V_{ts}|$  are much smaller than  $|V_{tb}|$ , we extract the latter quantity as

$$|V_{tb}| = \sqrt{\frac{\sigma^{\text{exp}}}{\sigma^{\text{th}}}} = 1.16 \pm 0.22(\text{exp}) \pm 0.02(\text{th}), \quad (2)$$

where  $\sigma^{\text{exp}}$  is taken from eq. (1) and  $\sigma^{\text{th}} = 62.3_{-2.4}^{+2.3}$  pb is the NLO prediction in the 5-flavour scheme [6].



**Figure 2.** Single top cross-section in the  $t$  channel vs. centre-of-mass energy, comparing our measurement with the dedicated  $t$ -channel cross-section measurements at Tevatron [4,5] and with the NLO QCD expectation computed with MCFM in the 5-flavour scheme [7].

## References

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