

Latest cross section measurements of the tW process at CMS

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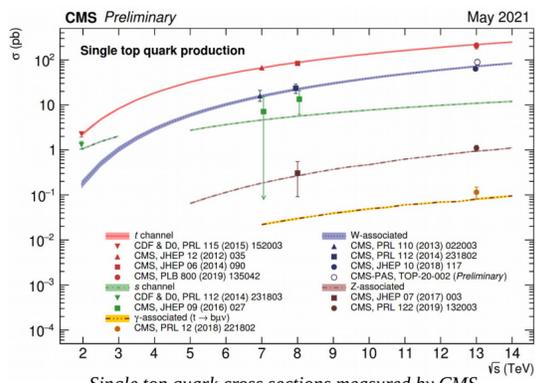
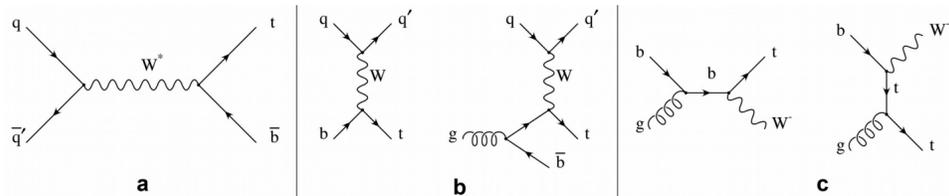


Single top quark production

- Top quarks at the LHC are produced predominantly via QCD with \bar{t} partner,
- Can be produced singly via EW interactions.

Why do we study them?

- Direct probes of V_{tb} and therefore sensitive to new physics,
- Background to many searches,
- Can constrain PDFs,
- Provides measurements of top quark properties.



tW production

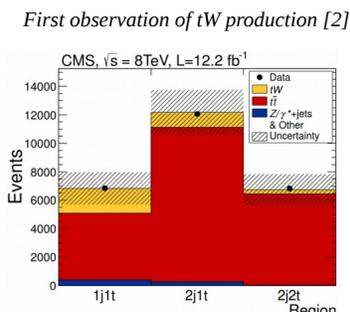
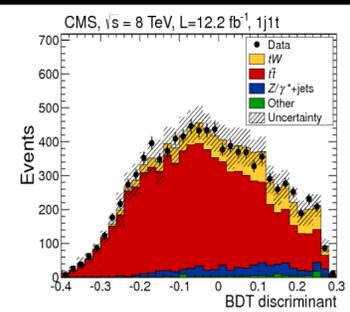
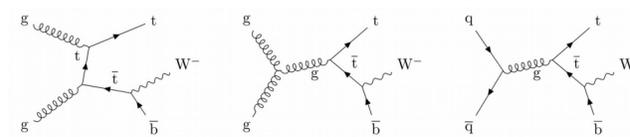
The associated production of a single top quark with a W boson
SM cross section (at³LO): $79.5^{+1.9}_{-1.8}$ (scale) $^{+2.0}_{-1.4}$ (PDF) [1]

Major backgrounds

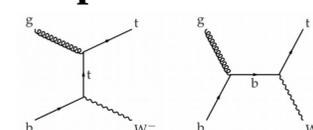
- $t\bar{t}$ – shares diagrams with tW at NLO (see below),
- Drell-Yan (dilepton channel),
- QCD and W+jets (lepton + jets channel).

Diagram Removal vs Diagram Subtraction

- tW at NLO interferes with $t\bar{t}$ and makes simulation difficult,
- DR (default scheme) removes diagrams from signal definition,
- DS (treated as a systematic) subtracts a gauge invariant term.



Dilepton channel



Event signature

- 2 leptons (muon/electron),
- Associated MET,
- 1 jet from a b quark.

Analysis strategy

- 36 fb⁻¹ pp collision data collected in 2016 by CMS at $\sqrt{s} = 13$ TeV,
- Using most sensitive $e\mu$ channel,
- BDT to discriminate between tW and $t\bar{t}$ background in 1j1t and 2j1t regions,
- Binned likelihood fit on BDT output and subleading jet p_T in 2j2b region to extract tW production cross section.

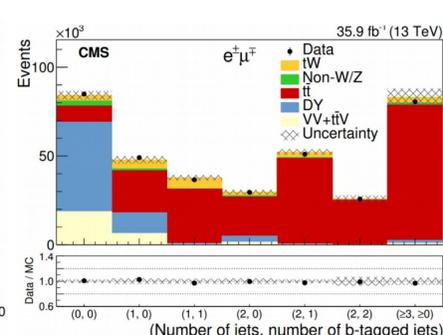
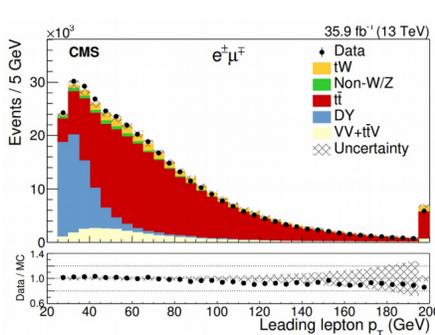


Table 1: Definition of the fiducial region.

Number of leptons	≥ 2
$p_T(\ell_1)$	> 25 GeV
$m_{\ell\ell}$	> 20 GeV
Number of jets	1
Number of loose jets	0
Number of b jets	1

A fiducial region is defined enriched in tW signal to extract differential measurements.

Inclusive cross section JHEP10(2018)117

Region	Prefit		Postfit	
	tW	$t\bar{t}$	tW	$t\bar{t}$
1j1b	6147 ± 442	30622 ± 1862	5440 ± 604	30592 ± 582
2j1b	3125 ± 294	48484 ± 1984	2888 ± 321	47436 ± 612
2j2b	725 ± 85	25052 ± 2411	719 ± 88	25114 ± 281

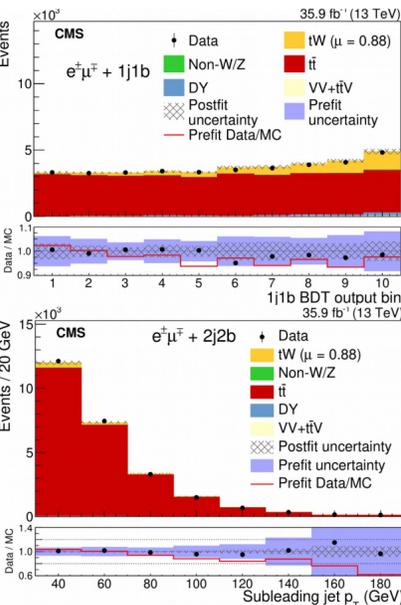
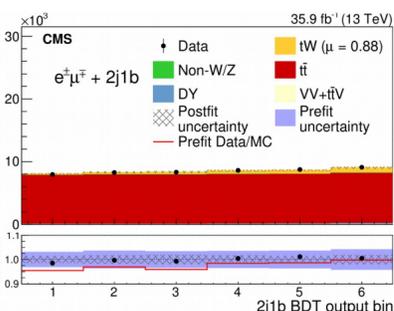
Selected events pre- and postfit

Measured cross section:

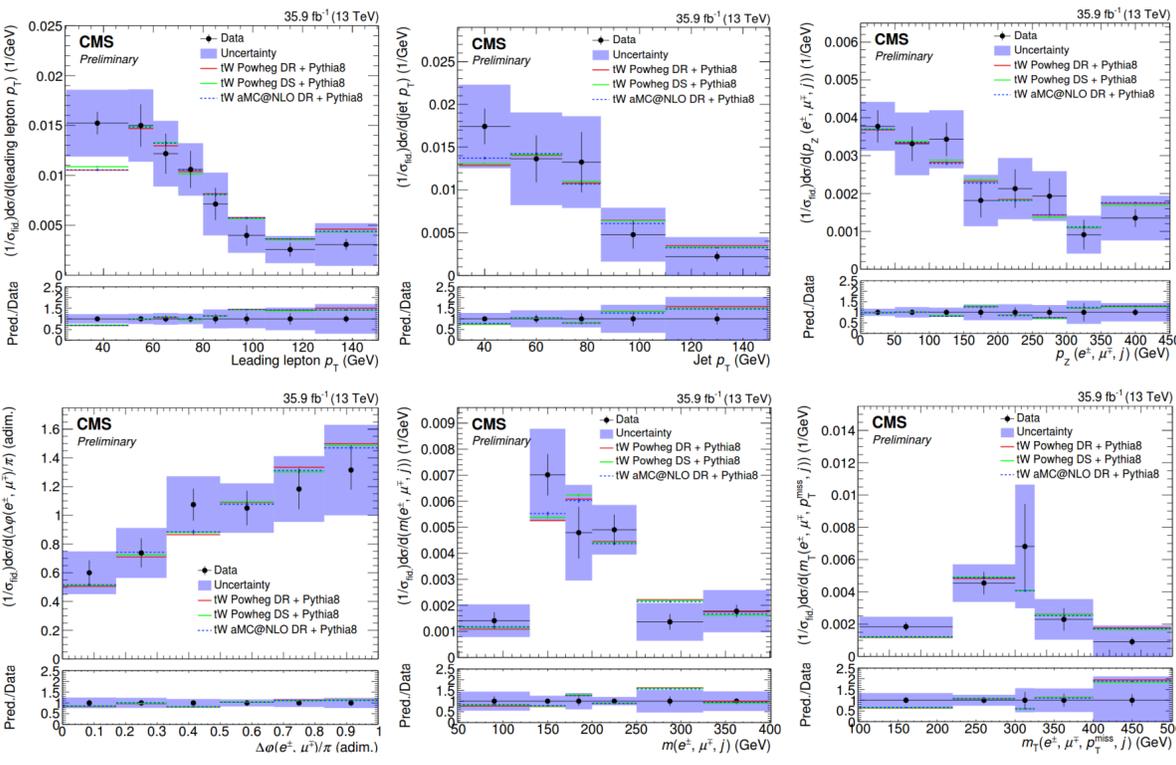
$$63.1 \pm 1.8 \text{ (stat)} \pm 6.4 \text{ (syst)} \pm 2.1 \text{ (lumi)} \text{ pb}$$

Leading uncertainties:

- JES/JER,
- Object selection and reconstruction efficiencies,
- $t\bar{t}$ simulation

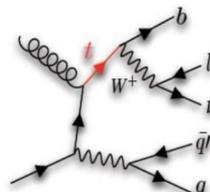


Differential cross sections CMS PAS TOP-19-003 - CDS record 2712818



Lepton plus jets channel JHEP11(2021)111

JHEP11(2021)111

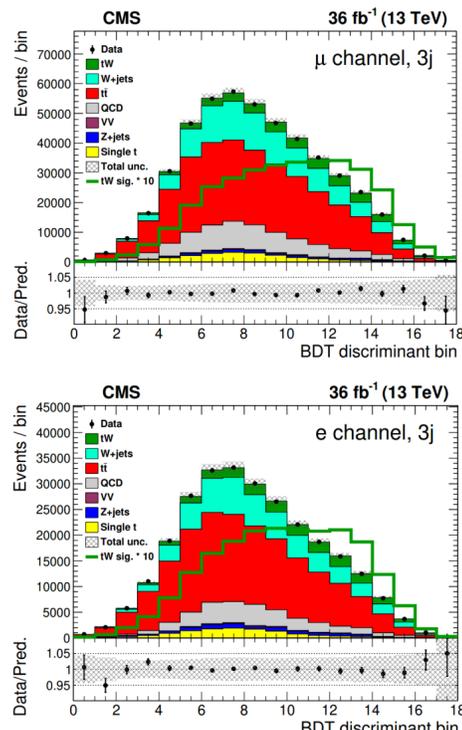


Event signature

- 1 lepton (muon or electron),
- Associated MET,
- 3 jets, 1 from a b quark.

Analysis strategy

- 36 fb⁻¹ pp collision data collected in 2016 by CMS at $\sqrt{s} = 13$ TeV,
- Data-driven estimation used for QCD background,
- BDT to discriminate between tW and $t\bar{t}$ background,
- Binned likelihood fit on BDT output to extract tW production cross section.



Result

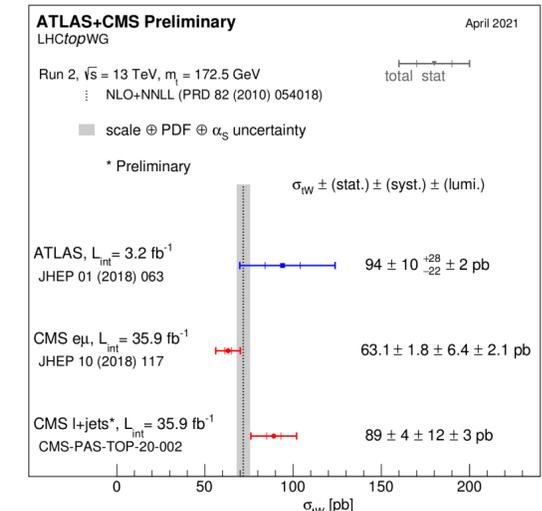
Measured cross section:

$$89 \pm 4 \text{ (stat)} \pm 12 \text{ (syst)} \text{ pb}$$

First observation of tW in the l+jets channel

Leading uncertainties:

- JES, data-driven background estimations, $t\bar{t}$ simulation



Source	Relative uncertainty (%)
Experimental	
Jet energy scale	6
b tagging efficiency	4
Luminosity	3
Lepton energy scale	2
Trigger efficiency	1
Jet energy resolution	1
b tagging misidentification rate	<1
Unclustered energy	<1
Pileup	<1
Normalization	
QCD multijet normalization	7
W+jets normalization	6
Z+jets normalization	3
Single t normalization	1
$t\bar{t}$ normalization	1
VV normalization	<1
Modelling	
h_{damp}	4
Diagram removal/diagram subtraction	3
Underlying event tune	3
Colour reconnection model	1
Parton distribution function	1
Matrix element/parton shower matching	1
Final-state radiation	<1
Initial-state radiation	<1
Total systematic uncertainty	14
Statistical uncertainty	5
Total uncertainty	15