Recent $t\bar{t}$ and single top inclusive cross section results in CMS

ICHEP 2020

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on behalf of the CMS Collaboration

July 28, 2020

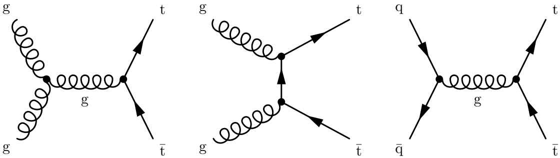
Outline

- Top quark production at the LHC
- CMS $t\bar{t}$ inclusive cross section measurements
  - $t\bar{t}$ dilepton (ee, eμ, $\mu\mu$): EPJC 79 (2019) 368
  - $t\bar{t}$ $\tau + e/\mu$: JHEP 02 (2020) 191
- CMS single top inclusive cross section measurements
  - *t* channel: PLB 800 (2020) 135042
  - tW-associated: JHEP 10 (2018) 117
- ATLAS+CMS combination Run 1 single top:
  JHEP 05 (2019) 088

Differential CMS $t\bar{t}$ and single top cross section measurements:
see talk from Georgios Bakas

Top quark production at the LHC

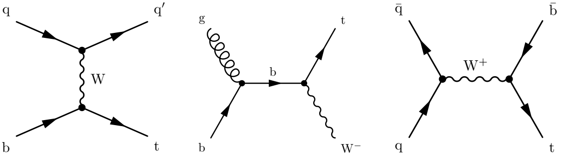
Dominant: QCD production of $\mathbf{t\bar{t}}$ pairs (@13 TeV: ≈ 90% gg fusion, ≈ 10% $q\bar{q}$ annihilation)



$\sigma_{t\bar{t}} \approx 830$ pb

⇒ **135M $t\bar{t}$ pairs!**

Single top production: probing EWK sector of SM



⇒ **50M single top quarks!**

t channel: $\sigma_{t\text{-ch}} \approx 220$ pb

tW-associated: $\sigma_{tW} \approx 70$ pb

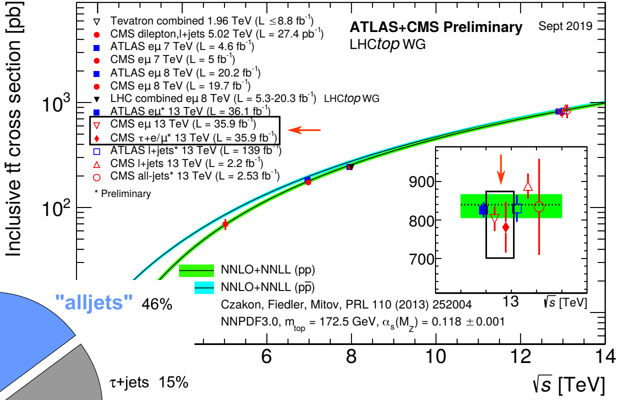
s channel: $\sigma_{s\text{-ch}} \approx 10$ pb

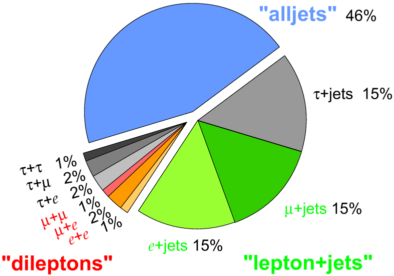
$t\bar{t}$ inclusive cross section

Constrain PDFs, α_S, m_t^{pole}

Main bkg contribution for many BSM analyses

$$\sigma_{t\bar{t}}^{theo} = 832^{+20}_{-29}\,(\text{scale}) \pm 35\,(\text{PDF} + \alpha_S)\text{ pb (NNLO+NNLL)}$$





In this talk:

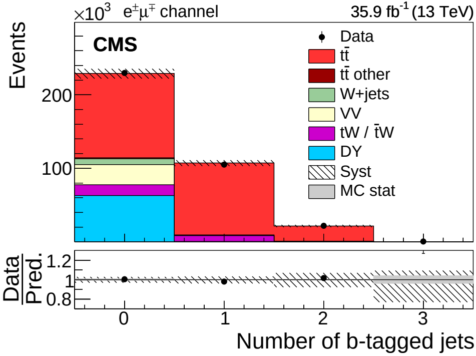
2 dilepton analyses, 1 of them with τ's

$\Rightarrow$ only $\approx$ 9% of all $t\bar{t}$ decays

$\Rightarrow$ probe of lepton universality

Dilepton channel

EPJC 79 (2019) 368

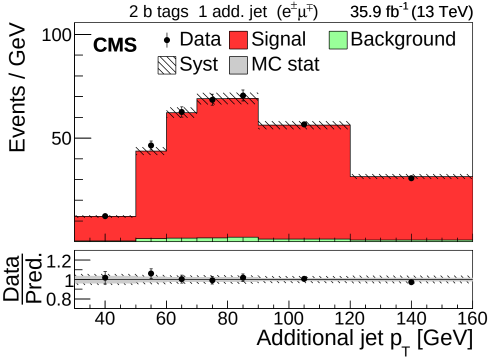


- Select events with isolated $e\mu$, ee, and $\mu\mu$ of opposite sign
- Categorize events according to multiplicity of jets with $p_T > 30$ GeV (n_j) and multiplicity of b-tagged jets (n_b) $\Rightarrow$ 28 event categories
- Extract cross section through profile LH ratio (PLR) fit in fiducial region and extrapolation to full phase space

Dilepton channel

EPJC 79 (2019) 368

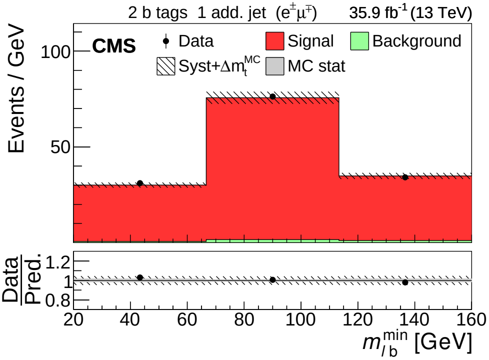
- Observables used in fit: p_T of additional untagged jet of each event category
- Dominant uncertainties: int. lumi, lepton efficiencies, PDF
- With m_t^{MC} =172.5 GeV: **$\sigma_{t\bar{t}}$ = 803 ± 2 (stat) ± 25 (syst) ± 20 (lumi) pb** ⇒ 4.0% total unc., precision beyond theory prediction (5.2%)



Dilepton channel

EPJC 79 (2019) 368

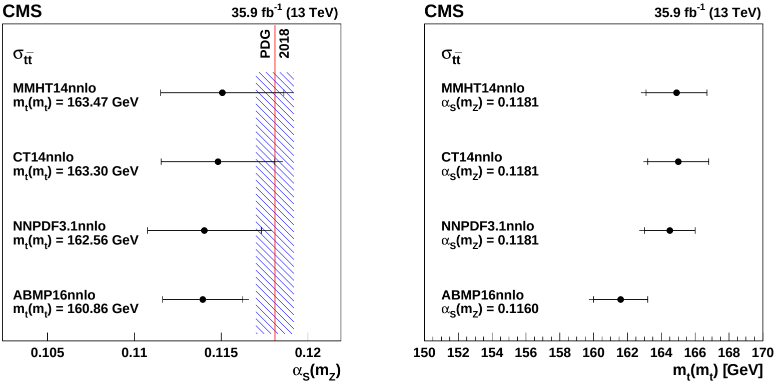
- In addition: fit performed for simultaneous extraction of $\sigma_{t\bar{t}}$ and m_t^{MC}, using same event categories of eμ channel as in main measurement
- Fit observable to maximize sensitivity on m_t^{MC}: minimum invariant mass $m_{\ell b}$
- Dominant unc.: int. lumi, lepton eff., NLO generator
- $\sigma_{t\bar{t}} = 815 \pm 2\,(\text{stat}) \pm 29\,(\text{syst}) \pm 20\,(\text{lumi})$ pb $\Rightarrow$ 4.3% total unc.
- $m_t^{MC} = 172.33 \pm 0.14\,(\text{stat})^{+0.66}_{-0.72}\,(\text{syst})$ GeV



Dilepton channel

EPJC 79 (2019) 368

Use $\sigma_{t\bar{t}}$ result from simultaneous fit of $\sigma_{t\bar{t}}$ and m_t^{MC} to extract m_t and $\alpha_S(m_Z)$ in $\overline{MS}$ scheme with different PDF sets

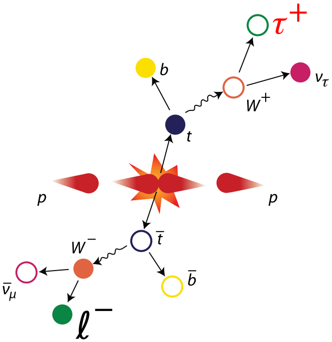


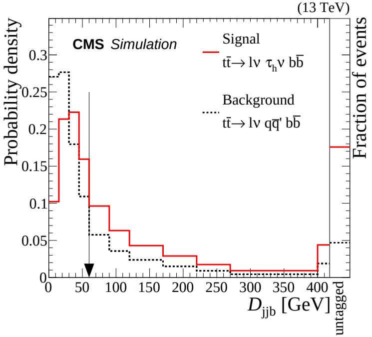
PDG 2018: $\alpha_S(m_Z) = 0.1181 \pm 0.0011$

$\tau + e/\mu$ channel

JHEP 02 (2020) 191

- Important process for lepton universality check in $t\bar{t}$
- Bkg contribution for BSM Higgs searches, e. g. $H^{\pm} \rightarrow \tau^{\pm}\nu_{\tau}$
- Event selection:
  1 e/μ, 1 hadronic τ with OS, $\geq$2 jets ($\geq$1 b-tagged)
- Define signal and bkg category using kinematic jet properties
  - Jet triplets for each combo of 1 b-tagged and 2 untagged jets
  - Distance parameter
    $D_{\text{jjb}} = \sqrt{(m_{\text{W}} - m_{\text{jj}})^2 + (m_{\text{t}} - m_{\text{jjb}})^2}$
  - Signal event: $D_{\text{jjb}}^{\text{min}} > 60$ GeV *OR* only 1 untagged jet





$\tau + e/\mu$ channel

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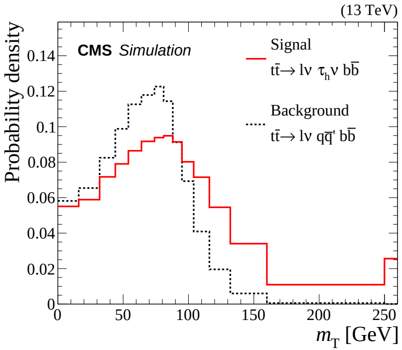
- PLR fit to transverse mass $m_T(\ell, p_T^{miss}) = \sqrt{2|\vec{p}_T^{\ell}||\vec{p}_T^{miss}|(1-\cos\Delta\phi)}$ in signal-like and bkg-like event category, separately for $e\tau$ and $\mu\tau$ final state
- Main bkg contribution: $t\bar{t}$ ℓ+jets $\Rightarrow$ one jet misidentified as τ_h

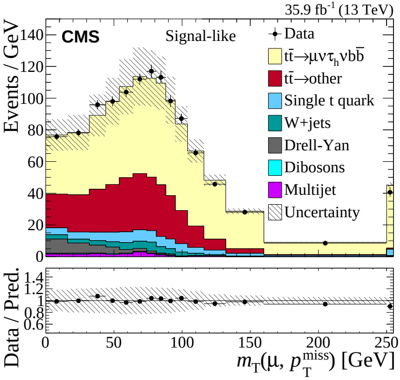


- Other sources of misidentified τ_h: W+jets, QCD multijet
- Bkgs with genuine τ_h: single top tW, DY

$\tau + e/\mu$ channel – Results

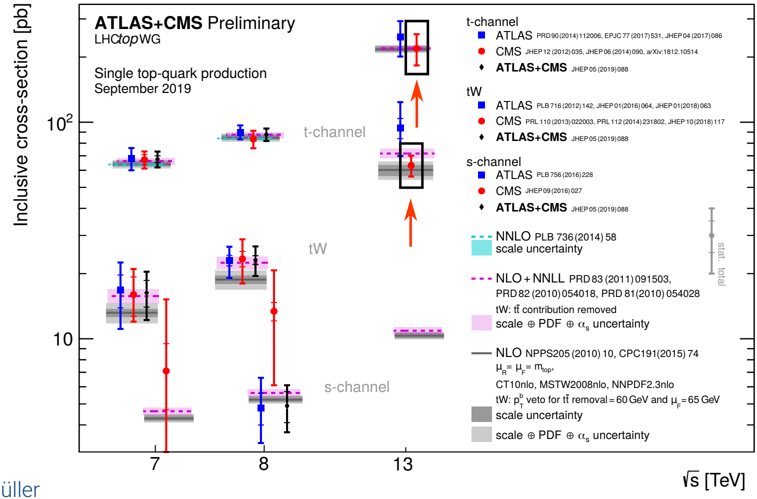
JHEP 02 (2020) 191

- Dominant syst. unc.: τ_h misidentification, int. lumi, b quark fragmentation
- $\sigma_{t\bar{t}} = 781 \pm 7\,(\text{stat}) \pm 62\,(\text{syst}) \pm 20\,(\text{lumi})$ pb
  $\Rightarrow$ 8.3% total unc.
- Check for lepton universality using $t\bar{t}$ dilepton result (EPJC 79 (2019) 368):
  $R_{\ell\tau_h/\ell\ell} = 0.973 \pm 0.009\,(\text{stat}) \pm 0.066\,(\text{syst})$
  $\Rightarrow$ compatible to unity, lepton universality conserved



Single top inclusive cross section

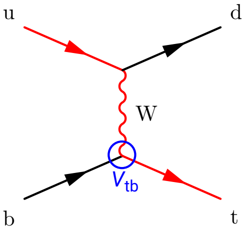
Direct measurement of $|V_{tb}|$
Probing PDFs via cross section ratio between top quark and top antiquark production

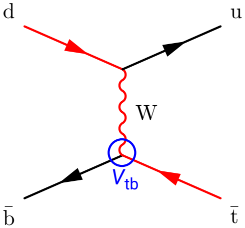


t channel

PLB 800 (2020) 135042

- Most dominant production mode at LHC
- Asymmetric production of top quarks and top antiquarks
  ⇒ cross section ratio $R_{t\text{-ch}}$
  - Sensitive to flavor of initial quarks and to different PDF predictions
  - Reduced systematic uncertainties
- Direct measurement of CKM matrix element $|V_{tb}|$ in production
- Final state: Leptonically decaying W boson and b quark from top quark decay, light quark preferably in forward direction





t channel

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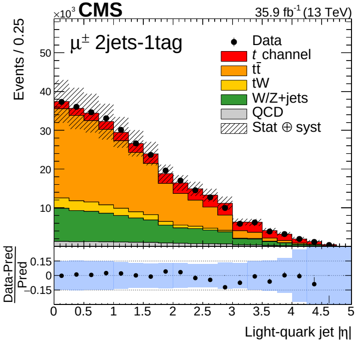
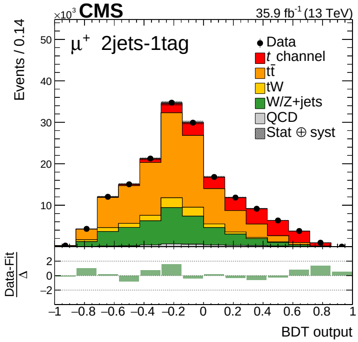
- Events with 1 isolated e/μ and jets and b-tagged jets with $p_T > 40$ GeV selected
- Define 3 event categories according to #jets (j) and #b jets (t): 2j1t (signal) and 3j1t, 3j2t ($t\bar{t}$ bkg)
- Event classification: BDT with 12 variables, trained in 2j1t category
- Most important input variables: Light-quark jet $|\eta|$, reconstructed m_t, inv. dijet mass m_{qb}





t channel

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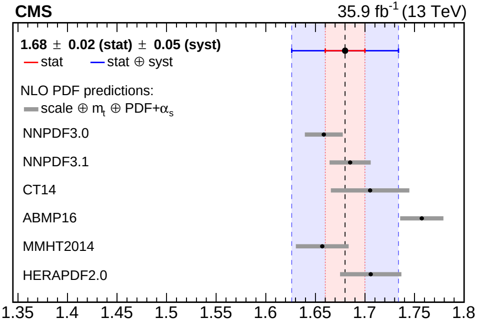
$\sigma_{t\text{-ch}}^{\text{theo}} = 217^{+7}_{-5}\,(\text{scale}) \pm 6\,(\text{PDF} + \alpha_S)$ pb (NLO, HATHOR v2.1)

- Max LH fit to BDT output in all categories to extract $\sigma_{t\text{-ch},\text{t}}$, $\sigma_{t\text{-ch},\bar{\text{t}}}$, and $R_{t\text{-ch}}$
- Systematic uncertainties: either nuisance parameters (profiled) or varied templates (nonprofiled)



$\sigma_{t\text{-ch}} = 207 \pm 1\,(\text{stat}) \pm 31\,(\text{syst})$ pb 15.0%

Improvement of $R_{t\text{-ch}}$ precision (3.0%) compared to 2015 analysis (12.9%)

Use total cross section to extract V_{tb}:

$|f_{\text{LV}} V_{\text{tb}}| = \sqrt{\sigma_{\text{meas}}/\sigma_{\text{theo}}} =$
$0.98 \pm 0.07\,(\text{exp}) \pm 0.02\,(\text{theo})$ 7.4%

- Dominant uncertainties:
  - Cross sections: PS scale, ME-PS matching of signal (nonprof.)
  - Ratio: PDF of signal (nonprofiled), MC sample size (prof.)

tW-associated

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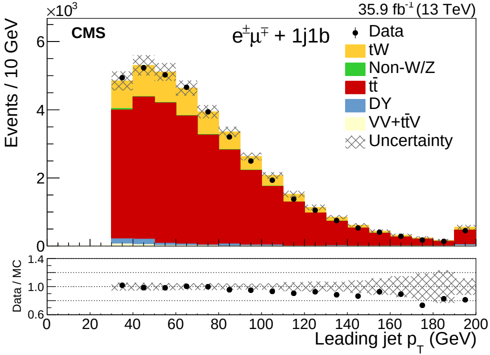
- Events with 1 e and 1 μ of opposite sign and jets with $p_T > 30$ GeV selected
- Define event categories using #jets (j) and # b jets (b): 1j1b (signal), 2j1b and 2j2b (bkg)
- Diagram removal scheme used to account for interference of NLO tW with $t\bar{t}$



- 2 BDTs trained in 1j1b and 2j1b category to discriminate tW against $t\bar{t}$

tW-associated

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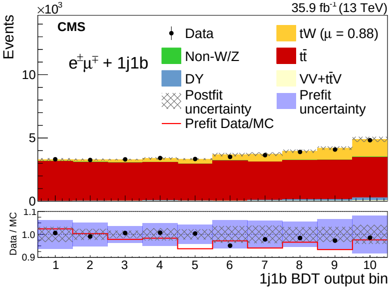
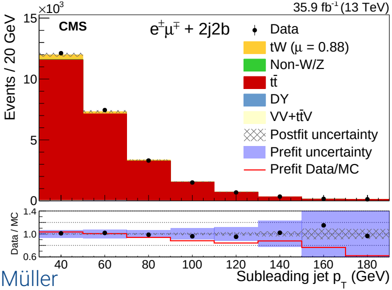
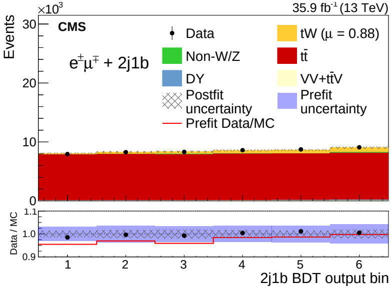
$$\sigma_{tW}^{theo} = 72 \pm 2\,(\text{scale}) \pm 3\,(\text{PDF} + \alpha_S)\text{ pb (approx. NNLO)}$$

- Max LH fit to BDT outputs in 1j1b and 2j1b categories and to p_T of subleading jet in 2j2b category
- Dominant systematic uncertainties: pileup, int. lumi, JES
- $\sigma_{tW} = 63.1 \pm 1.8\,(\text{stat}) \pm 6.4\,(\text{syst}) \pm 2.1\,(\text{lumi})$ **pb** 11.0%







Single top: ATLAS and CMS combination Run 1

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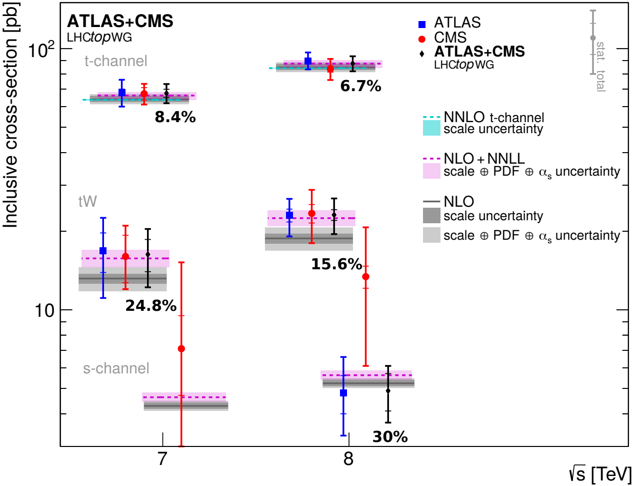
Combine 7 and 8 TeV ATLAS and CMS cross section measurements with BLUE method (assumption: $m_t = 172.5$ GeV)



Single top: ATLAS and CMS combination Run 1

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- Uncertainty sources grouped into different categories
- Assumptions about correlation between similar sources of uncertainties in different measurements

$\sigma_{t\text{-chan.}}$, $\sqrt{s} = 8$ TeV		
Combined cross-section	87.7 pb	
Uncertainty category	Uncertainty	
	[%]	[pb]
Data statistical	1.3	1.1
Simulation statistical	0.6	0.5
Integrated luminosity	1.7	1.5
Theory modelling	5.3	4.7
Background normalisation	1.2	1.1
Jets	2.6	2.3
Detector modelling	1.8	1.6
Total syst. unc. (excl. lumi.)	6.3	5.5
Total syst. unc. (incl. lumi.)	6.5	5.7
Total uncertainty	6.7	5.8

Single top: ATLAS and CMS combination Run 1

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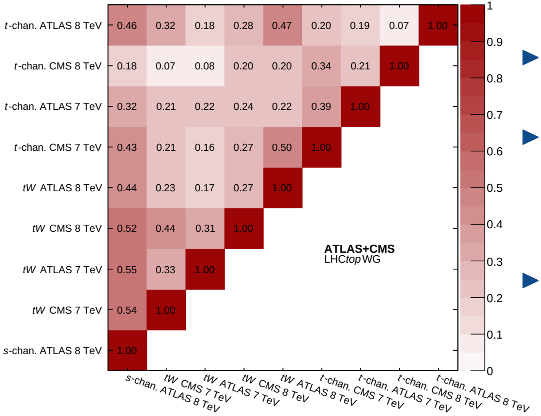

- Measure V_{tb} using $\sigma_{\text{meas}} \propto |f_{LV} V_{tb}|^2$
- Include theoretical cross section uncertainties as well as impact of ± 1 GeV m_t variation
- Correlations between input measurements in combination all below 0.6

Single top: ATLAS and CMS combination Run 1

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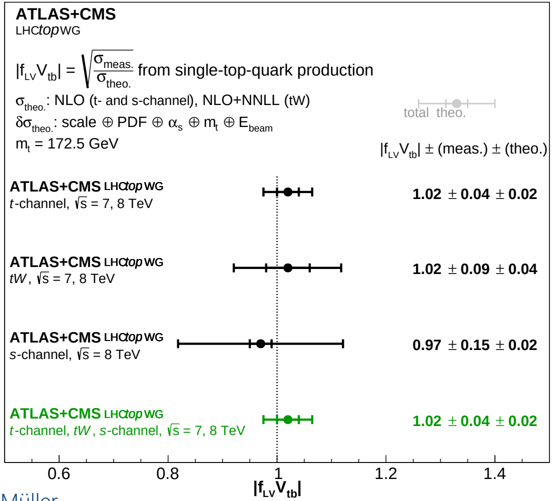
8 TeV *t* channel contributes the most

Dominant uncertainties: theory modeling and theoretical cross section



3.9%

8.4%

15.0%

3.7%

Latest *t*-ch. V_{tb} Run 2 result: see Giulia Negro's talk!

Comparison with Tevatron: $1.02^{+0.06}_{-0.05}$ (5.4%)

Conclusion

- CMS $t\bar{t}$ and single top inclusive cross section measurements in Run 2 (2016 data) presented
  - Precision era reached, can now challenge with theory predictions
  - $t\bar{t}$ dilepton $\tau + e/\mu$ and $ee/e\mu/\mu\mu$ analyses: probe of lepton universality $\Rightarrow$ conserved
  - Single top *t* channel: cross section ratio $R_{t\text{-ch}}$ $\Rightarrow$ helps constraining different PDF predictions
- ATLAS and CMS combination of Run 1 single top cross section results
  - Extraction of V_{tb}: no hint for anomalous Wtb couplings
- Results with full Run 2 data in preparation

Backup

$\tau + e/\mu$ channel

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Event selection:

- 1 isolated e/μ with $p_T > 30/26$ GeV, $|\eta| < 2.4$
- $\geq$2 jets with $p_T > 30$ GeV, $|\eta| <$2.5
  - $\geq$1 b-tagged jet (66% eff., 1% misid. prob.)
- 1 τ_h candidate (1-prong, 1-prong 1-strip, 1-prong 2-strips, 3-prongs) with $p_T > 30$ GeV, $|\eta| < 2.4$
- Opposite sign (OS) $\tau_h \leftrightarrow \ell$
- Veto on additional loose e/μ

Data-driven QCD multijet:

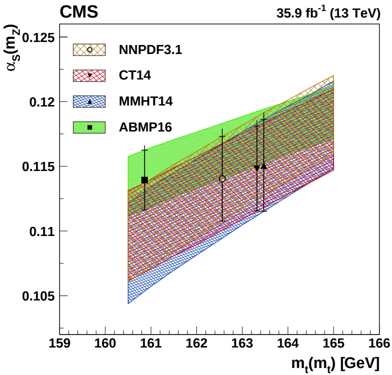
- Modeling via data sideband with 1 ℓ and 1 τ_h of same sign (SS)
- Correction factor for normalization: $f_{OS}/f_{SS} = \mathbf{1.05 \pm 0.05}$ (stat+syst) from control region with relaxed τ_h id. and inverted ℓ iso. requirement

Source	Uncertainty [%]				
	$e\tau_h$	$\mu\tau_h$	Combined	Dileptons	Correlation
Experimental uncertainties					
τ_h jet identification	4.7	4.5	4.5	—	0
τ_h jet misidentification	2.2	2.3	2.3	—	0
Pileup	2.5	2.2	2.3	0.1	1
Lepton identification and isolation	1.8	1.1	1.2	2.0	1
btagging efficiency	1.1	1.2	0.9	0.4	1
τ_h energy scale	0.7	0.8	0.8	0.0	0
Trigger efficiency	2.3	0.6	0.7	0.3	0
Drell–Yan background	0.4	0.4	0.6	0.9	1
$t\bar{t}$ background	1.0	0.8	0.6	0.2	0
tW background	0.6	0.5	0.5	1.1	1
W+jets background	0.1	0.4	0.5	0.2	0
Multijet background	0.1	0.5	0.4	<0.1	0
Jet energy scale	0.1	0.2	0.4	0.4	1
Jet energy resolution	0.6	0.3	0.1	0.4	1
Electron momentum scale	0.1	0.1	0.1	0.1	1
Muon momentum scale	0.1	0.1	0.1	0.1	1
Diboson background	<0.1	<0.1	<0.1	0.2	1
Theoretical uncertainties					
bfragmentation	2.3	2.0	2.4	0.7	1
Top quark p_T modelling	2.7	2.3	2.2	0.5	1
$t\bar{t}$ FSR scale	1.7	1.9	1.7	0.8	1
tW FSR scale	<0.1	<0.1	<0.1	0.1	1
$t\bar{t}$ ISR scale	1.7	1.6	1.5	0.4	1
tW ISR scale	<0.1	<0.1	<0.1	0.1	1
$t\bar{t}$ ME scale	1.1	1.2	1.1	0.2	1
tW ME scale	<0.1	<0.1	<0.1	0.2	1
Drell–Yan ME scale	<0.1	<0.1	<0.1	0.1	1
Semileptonic bhadron branching fraction	0.8	0.6	0.7	0.1	1
Underlying event	0.5	0.5	0.6	0.3	1
ME-PS matching	0.4	0.4	0.5	0.2	1
Colour reconnection	<0.1	<0.1	<0.1	0.3	1
PDFs	1.5	1.5	1.6	1.1	1
Normalization uncertainties					
Statistical	1.4	1.1	0.9	0.2	0
MC statistical	2.0	1.6	1.6	1.1	0
Integrated luminosity	2.5	2.5	2.5	2.5	1
Extrapolation uncertainties					
$t\bar{t}$ ME scale	0.3	0.4	0.3	0.3	0
PDFs	1.2	1.4	1.3	1.0	0
Top quark p_T modelling	1.0	1.1	1.1	0.5	0
$t\bar{t}$ ISR scale	0.5	0.3	0.3	0.1	0
$t\bar{t}$ FSR scale	1.9	2.0	1.9	0.1	0
Underlying event	0.3	0.2	0.2	<0.1	0

Dilepton channel

EPJC 79 (2019) 368

Use $\sigma_{t\bar{t}}$ result from simultaneous fit of $\sigma_{t\bar{t}}$ and m_t^{MC} to extract m_t and $\alpha_S(m_Z)$ in $\overline{MS}$ scheme with different PDF sets



Extraction of m_t repeated in pole mass scheme using Top++ 2.0 program and NNLO+NNLL $\sigma_{t\bar{t}}$ prediction

PDF set	m_t^{pole} [GeV]
ABMP16	169.9 ± 1.8 (fit + PDF + α_S) $^{+0.8}_{-1.2}$ (scale)
NNPDF3.1	173.2 ± 1.9 (fit + PDF + α_S) $^{+0.9}_{-1.3}$ (scale)
CT14	173.7 ± 2.0 (fit + PDF + α_S) $^{+0.9}_{-1.4}$ (scale)
MMHT14	173.6 ± 1.9 (fit + PDF + α_S) $^{+0.9}_{-1.4}$ (scale)

t channel

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	$\Delta R_{t\text{-ch}}/R_{t\text{-ch}}$	$\Delta\sigma/\sigma(\mathrm{t})$	$\Delta\sigma/\sigma(\bar{\mathrm{t}})$
Nonprofiled uncertainties			
μ_R/μ_F scale *t* channel	1.5	6.1	5.0
ME-PS scale matching *t* channel	0.5	7.1	7.8
PS scale *t* channel	0.9	10.1	9.6
PDF *t* channel	3.0	3.1	5.8
Luminosity	—	2.5	2.5
Profiled uncertainties			
JES	0.9	1.5	1.8
JER	0.2	< 0.1	0.2
Unclustered energy	< 0.1	0.1	0.2
b tagging	0.1	1.1	1.2
Muon and electron efficiencies	0.2	0.8	0.6
Pileup	0.1	0.9	1.0
QCD bkg. normalization	< 0.1	0.1	0.1
MC sample size	2.5	2.2	3.2
$\mathrm{t\bar{t}}$ bkg. model and normalization	0.2	0.6	0.6
Top quark p_T	< 0.1	< 0.1	< 0.1
tW bkg. normalization	0.1	0.5	0.6
W/Z+jets bkg. normalization	0.3	0.6	0.9
μ_R/μ_F scale $\mathrm{t\bar{t}}$, tW, W/Z+jets	0.1	0.2	0.3
PDF $\mathrm{t\bar{t}}$, W/Z+jets	< 0.1	0.2	0.2

tW-associated

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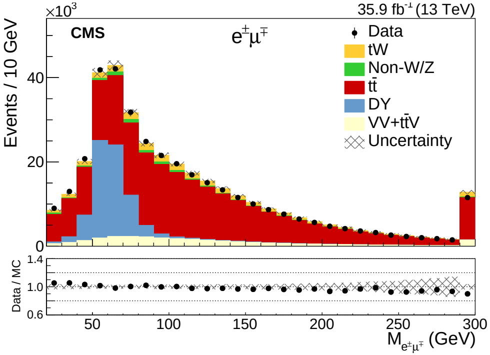

Source	Uncertainty (%)
Experimental	
Trigger efficiencies	2.7
Electron efficiencies	3.2
Muon efficiencies	3.1
JES	3.2
Jet energy resolution	1.8
b tagging efficiency	1.4
Mistag rate	0.2
Pileup	3.3
Modeling	
$t\bar{t}$ μ_R and μ_F scales	2.5
tW μ_R and μ_F scales	0.9
Underlying event	0.4
Matrix element/PS matching	1.8
Initial-state radiation	0.8
Final-state radiation	0.8
Color reconnection	2.0
B fragmentation	1.9
Semileptonic B decay	1.5
PDFs	1.5
DR-DS	1.3
Background normalization	
$t\bar{t}$	2.8
VV	0.4
Drell–Yan	1.1
Non-W/Z leptons	1.6
$t\bar{t}V$	0.1
MC finite sample size	1.6
Full phase space extrapolation	2.9
Total systematic (excluding integrated luminosity)	10.1
Integrated luminosity	3.3
Statistical	2.8
Total	11.1

Single top: ATLAS and CMS combination Run 1

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Cross section measurements of ATLAS and CMS, Run 1:

		ATLAS		CMS	
$\sqrt{s}$	Process	σ [pb]	Lumi. [fb^{-1}]	σ [pb]	Lumi. [fb^{-1}]
7 TeV	t-channel	68 ± 8	4.59	67.2 ± 6.1	1.17–1.56
	tW	16.8 ± 5.7	2.05	16^{+5}_{-4}	4.9
	s-channel	—	—	7.1 ± 8.1	5.1
8 TeV	t-channel	$89.6^{+7.1}_{-6.3}$	20.2	83.6 ± 7.8	19.7
	tW	$23.0^{+3.6}_{-3.9}$	20.3	23.4 ± 5.4	12.2
	s-channel	$4.8^{+1.8}_{-1.5}$	20.3	13.4 ± 7.3	19.7

Single top: ATLAS and CMS combination Run 1

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Uncertainties in combined $|f_{LV} V_{tb}|^2$ measurement

Combined $\|f_{LV} V_{tb}\|^2$	1.05	
Uncertainty category	Uncertainty	
	[%]	$\Delta\|f_{LV} V_{tb}\|^2$
Data statistical	1.8	0.02
Simulation statistical	0.9	0.01
Integrated luminosity	1.3	0.01
Theory modelling	4.5	0.05
Background normalisation	1.3	0.01
Jets	2.6	0.03
Detector modelling	1.6	0.02
Top-quark mass	0.7	0.01
Theoretical cross-section	4.3	0.04
Total syst. unc. (excl. lumi.)	7.1	0.07
Total syst. unc. (incl. lumi.)	7.2	0.08
Total uncertainty	7.4	0.08

	t-channel ATLAS 8 TeV	t-channel CMS 8 TeV	t-channel ATLAS 7 TeV	t-channel CMS 7 TeV	tW ATLAS 8 TeV	tW CMS 8 TeV	tW ATLAS 7 TeV	tW CMS 7 TeV	s-channel ATLAS 8 TeV
$\|f_{\mathrm{LV}} V_{tb}\|^2$	1.06	0.99	1.06	1.05	1.03	1.05	1.07	1.02	0.92
Uncertainties:									
Data statistical	0.01	0.03	0.03	0.06	0.06	0.09	0.18	0.21	0.15
Simulation statistical	0.01	0.01	0.02	0.02	0.01	0.03	0.02	–	0.11
Integrated luminosity	0.02	0.03	0.02	0.02	0.05	0.03	0.07	0.04	0.05
Theory modelling									
ISR/FSR, ren./fact. scale	0.04	0.02	0.03	0.04	0.09	0.13	0.05	0.03	0.06
NLO match., generator	0.03	0.05	0.02	0.04	0.03	–	0.11	–	0.10
Parton shower	0.02	–	–	0.01	0.02	0.15	0.16	0.10	0.02
PDF	0.01	0.02	0.03	0.01	0.01	0.02	0.02	0.02	0.03
DS/DR scheme	–	–	–	–	0.04	0.02	–	0.06	–
Top-quark p_{T} rew.	–	–	–	–	–	<0.01	–	–	–
Background normalisation									
Top-quark bkg.	<0.01	0.02	0.02	0.01	0.02	0.02	0.06	0.06	0.05
Other bkg. from sim.	0.01	<0.01	<0.01	0.03	0.02	0.03	0.09	0.04	0.05
Bkg. from data	<0.01	0.02	0.01	0.01	<0.01	–	0.02	–	0.01
Jets									
JES common	0.03	0.04	0.08	0.01	0.05	0.04	0.17	0.15	0.05
JES flavour	<0.01	–	0.02	–	0.02	–	–	–	0.01
JetID	<0.01	–	0.01	–	<0.01	–	0.05	–	0.01
JER	<0.01	0.01	0.02	<0.01	0.07	0.01	0.02	0.04	0.11
Detector modelling									
Leptons	0.02	0.01	0.03	0.04	0.03	0.02	0.07	0.05	0.02
HLT (had. part)	–	–	–	0.02	–	–	–	–	–
$E_{\mathrm{T}}^{\mathrm{miss}}$ scale	<0.01	<0.01	0.03	<0.01	0.06	<0.01	–	0.03	0.01
$E_{\mathrm{T}}^{\mathrm{miss}}$ res.	<0.01	–	–	–	<0.01	–	–	–	0.01
b-tag	0.01	0.02	0.04	0.02	0.01	0.01	–	0.02	0.07
Pile-up	<0.01	0.01	<0.01	0.01	0.03	<0.01	0.11	0.01	0.01
Top-quark mass	0.01	<0.01	0.01	–	0.05	0.05	–	–	–
Theoretical cross-section									
PDF+α_{s}	0.03	0.03	0.04	0.04	0.06	0.07	0.08	0.07	0.03
Ren./fact. scale	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
Top-quark mass	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
E_{beam}	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total systematic uncertainty	0.09	0.09	0.13	0.10	0.18	0.23	0.34	0.24	0.24
Total uncertainty	0.09	0.10	0.13	0.12	0.19	0.24	0.38	0.32	0.28