t

$I(J^P) = 0(\frac{1}{2}^+)$

Charge = $\frac{2}{3}$ e Top = +1

See the related review(s):

Top Quark

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t-QUARK MASS

We first list the direct measurements of the top quark mass which employ the event kinematics and then list the measurements which extract a top quark mass from the measured $t\overline{t}$ cross-section using theory calculations. A discussion of the definition of the top quark mass in these measurements can be found in the review "The Top Quark."

For earlier search limits see PDG 96, Physical Review **D54** 1 (1996). We no longer include a compilation of indirect top mass determinations from Standard Model Electroweak fits in the Listings (our last compilation can be found in the Listings of the 2007 partial update). For a discussion of current results see the reviews "The Top Quark" and "Electroweak Model and Constraints on New Physics."

t-Quark Mass (Direct Measurements)

The following measurements extract a t-quark mass from the kinematics of $t\overline{t}$ events. They are sensitive to the top quark mass used in the MC generator that is usually interpreted as the pole mass, but the theoretical uncertainty in this interpretation is hard to quantify. See the review "The Top Quark" and references therein for more information.

OUR AVERAGE of 172.57 ± 0.29 GeV is an average of top mass measurements from LHC and Tevatron Runs. The latest Tevatron average, 174.30 ± 0.35 ± 0.54 GeV, was provided by the Tevatron Electroweak Working Group (TEVEWWG).

VALUE (GeV)	DOCUMENT ID		TECN	COMMENT
172.57± 0.29 OUR AVERAGE	Error includes scale factor of 1.5. See the ideogram below.			
174.41± 0.39± 0.71	[1] AAD	23N	ATLS	leptonic invariant mass in ℓ+jets channel
171.77± 0.37	[2] TUMASYAN	23BB	CMS	$\ell + \geq 4$j (2b)
173.06± 0.24± 0.80	[3] TUMASYAN	23Z	CMS	boosted top; ℓ+jets channel
$172.13^{+0.76}_{-0.77}$	[4] TUMASYAN	21G	CMS	t-channel single top production
172.6 ± 2.5	[5] SIRUNYAN	20AR	CMS	jet mass from boosted top
172.69± 0.25± 0.41	[6] AABOUD	19AC	ATLS	7, 8 TeV ATLAS combination
172.34± 0.20± 0.70	[7] SIRUNYAN	19AP	CMS	≥ 6 jets ($\geq 2b$)
$172.33 \pm 0.14^{+0.66}_{-0.72}$	[8] SIRUNYAN	19AR	CMS	dilepton channel ($e\mu$, 2e, 2μ)
172.44± 0.13± 0.47	[9] KHACHATRY...	16AK	CMS	7, 8 TeV CMS combination
174.30± 0.35± 0.54	[10] TEVEWWG	16	TEVA	Tevatron combination
• • • We do not use the following data for averages, fits, limits, etc. • • •				
172.08± 0.39± 0.82	[11] AABOUD	19AC	ATLS	$\ell + \geq 4$j (2b)
172.26± 0.07± 0.61	[12] SIRUNYAN	19AP	CMS	lepton+jets, all-jets channels
172.25± 0.08± 0.62	[13] SIRUNYAN	18DE	CMS	$\ell + \geq 4$j (2b)

$173.72 \pm 0.55 \pm 1.01$	[14] AABOUD	17AH	ATLS	≥ 5 jets ($2b$)
$174.95 \pm 0.40 \pm 0.64$	[15] ABAZOV	17B	D0	ℓ + jets and dilepton channels
$172.95 \pm 0.77 {}^{+0.97}_{-0.93}$	[16] SIRUNYAN	17L	CMS	t-channel single top production
170.8 ± 9.0	[17] SIRUNYAN	17N	CMS	jet mass in highly-boosted $t\overline{t}$ events
$172.22 \pm 0.18 {}^{+0.89}_{-0.93}$	[18] SIRUNYAN	17O	CMS	Dilepton channel
$172.99 \pm 0.41 \pm 0.74$	[19] AABOUD	16T	ATLS	dilepton channel
$172.84 \pm 0.34 \pm 0.61$	[20] AABOUD	16T	ATLS	combination of ATLAS
$173.32 \pm 1.36 \pm 0.85$	[21] ABAZOV	16	D0	$\ell\ell + \not{E}_T + \geq 2$j ($\geq 2b$)
$173.93 \pm 1.61 \pm 0.88$	[22] ABAZOV	16D	D0	$\ell\ell + \not{E}_T + \geq 2$j ($\geq 2b$)
$172.35 \pm 0.16 \pm 0.48$	[23,24] KHACHATRY...	16AK	CMS	$\ell + \geq 4$j ($2b$)
$172.32 \pm 0.25 \pm 0.59$	[23,24] KHACHATRY...	16AK	CMS	≥ 6 jets ($2b$)
$172.82 \pm 0.19 \pm 1.22$	[23,25] KHACHATRY...	16AK	CMS	$(ee/\mu\mu)+\not{E}_T+ \geq 2b$,$e\mu+ \geq 2b$
$173.68 \pm 0.20 {}^{+1.58}_{-0.97}$	[26] KHACHATRY...	16AL	CMS	semi- + di-leptonic channels
$173.5 \pm 3.0 \pm 0.9$	[27] KHACHATRY...	16CB	CMS	$t \rightarrow (W \rightarrow \ell\nu)(b \rightarrow J/\psi X \rightarrow \mu^+\mu^- X)$
$175.1 \pm 1.4 \pm 1.2$	[28] AAD	15AW	ATLS	small $\not{E}_T$, ≥ 6 jets ($2b$-tag)
$172.99 \pm 0.48 \pm 0.78$	[29] AAD	15BF	ATLS	ℓ + jets and dilepton
$171.5 \pm 1.9 \pm 2.5$	[30] AALTONEN	15D	CDF	$\ell\ell + \not{E}_T + \geq 2$j
$175.07 \pm 1.19 {}^{+1.55}_{-1.58}$	[31] AALTONEN	14N	CDF	small $\not{E}_T$, 6–8 jets ($\geq 1b$-tag)
$174.98 \pm 0.58 \pm 0.49$	[32] ABAZOV	14C	D0	$\ell + \not{E}_T$ + 4 jets (≥ 1 b-tag)
$173.49 \pm 0.69 \pm 1.21$	[33] CHATRCHYAN	14C	CMS	≥ 6 jets (≥ 2 b-tag)
$173.93 \pm 1.64 \pm 0.87$	[34] AALTONEN	13H	CDF	$\not{E}_T + \geq 4$ jets (≥ 1 b)
$173.9 \pm 0.9 {}^{+1.7}_{-2.1}$	[35] CHATRCHYAN	13S	CMS	$\ell\ell+\not{E}_T+ \geq 2b$-tag (MT2$_{(T)}$)
$174.5 \pm 0.6 \pm 2.3$	[36] AAD	12I	ATLS	$\ell+\not{E}_T+ \geq 4$ jets (≥ 1 b), MT
$172.85 \pm 0.71 \pm 0.85$	[37] AALTONEN	12AI	CDF	$\ell+\not{E}_T+ \geq 4$j (0,1,2b) template
$172.7 \pm 9.3 \pm 3.7$	[38] AALTONEN	12AL	CDF	$\tau_h + \not{E}_T$ +4j ($\geq 1b$)
$173.18 \pm 0.56 \pm 0.75$	[39] AALTONEN	12AP	TEVA	CDF, D0 combination
$172.5 \pm 1.4 \pm 1.5$	[40] AALTONEN	12G	CDF	6–8 jets with ≥ 1 b
$173.7 \pm 2.8 \pm 1.5$	[41] ABAZOV	12AB	D0	$\ell\ell + \not{E}_T + \geq 2$ j (νWT)
$173.9 \pm 1.9 \pm 1.6$	[42] ABAZOV	12AB	D0	$\ell\ell+\not{E}_T+ \geq 2$j ($\nu$WT+MWT)
$172.5 \pm 0.4 \pm 1.5$	[43] CHATRCHYAN	12BA	CMS	$\ell\ell+\not{E}_T+ \geq 2$j ($\geq 1b$), AMWT
$173.49 \pm 0.43 \pm 0.98$	[44] CHATRCHYAN	12BP	CMS	$\ell+\not{E}_T+ \geq 4$j ($\geq 2b$)
$172.4 \pm 1.4 \pm 1.3$	[45] AALTONEN	11AC	CDF	$\ell + \not{E}_T$ + 4 jets (≥ 1 b-tag)
$172.3 \pm 2.4 \pm 1.0$	[46] AALTONEN	11AK	CDF	Repl. by AALTONEN 13H
$172.1 \pm 1.1 \pm 0.9$	[47] AALTONEN	11E	CDF	ℓ + jets and dilepton
$176.9 \pm 8.0 \pm 2.7$	[48] AALTONEN	11T	CDF	$\ell + \not{E}_T$ + 4 jets (≥ 1 b-tag), $p_T(\ell)$ shape
$174.94 \pm 0.83 \pm 1.24$	[49] ABAZOV	11P	D0	$\ell + \not{E}_T$ + 4 jets (≥ 1 b-tag)
$174.0 \pm 1.8 \pm 2.4$	[50] ABAZOV	11R	D0	dilepton + $\not{E}_T + \geq 2$ jets
$175.5 \pm 4.6 \pm 4.6$	[51] CHATRCHYAN	11F	CMS	dilepton + $\not{E}_T$ + jets
$173.0 \pm 0.9 \pm 0.9$	[52] AALTONEN	10AE	CDF	$\ell + \not{E}_T$ + 4 jets (≥ 1 b-tag), ME method
$169.3 \pm 2.7 \pm 3.2$	[53] AALTONEN	10C	CDF	dilepton + b-tag (MT2+NWA)
$170.7 \pm 6.3 \pm 2.6$	[54] AALTONEN	10D	CDF	$\ell + \not{E}_T$ + 4 jets (b-tag)
$174.8 \pm 2.4 {}^{+1.2}_{-1.0}$	[55] AALTONEN	10E	CDF	≥ 6 jets, vtx b-tag
$180.5 \pm 12.0 \pm 3.6$	[56] AALTONEN	09AK	CDF	$\ell + \not{E}_T$ + jets (soft μ b-tag)
$172.7 \pm 1.8 \pm 1.2$	[57] AALTONEN	09J	CDF	$\ell + \not{E}_T$ + 4 jets (b-tag)

171.1 $\pm$ 3.7 $\pm$ 2.1	[58] AALTONEN	09K	CDF	6 jets, vtx b-tag
171.9 $\pm$ 1.7 $\pm$ 1.1	[59] AALTONEN	09L	CDF	ℓ + jets, $\ell\ell$ + jets
171.2 $\pm$ 2.7 $\pm$ 2.9	[60] AALTONEN	09O	CDF	dilepton
165.5 $^{+3.4}_{-3.3}$ $\pm$ 3.1	[61] AALTONEN	09X	CDF	$\ell\ell + \not\!\!E_T$ ($\nu\phi$ weighting)
174.7 $\pm$ 4.4 $\pm$ 2.0	[62] ABAZOV	09AH	D0	dilepton + b-tag (νWT+MWT)
170.7 $^{+4.2}_{-3.9}$ $\pm$ 3.5	[63,64] AALTONEN	08C	CDF	dilepton, $\sigma_{t\overline{t}}$ constrained
171.5 $\pm$ 1.8 $\pm$ 1.1	[65] ABAZOV	08AH	D0	$\ell + \not\!\!E_T$ + 4 jets
177.1 $\pm$ 4.9 $\pm$ 4.7	[66,67] AALTONEN	07	CDF	6 jets with ≥ 1 b vtx
172.3 $^{+10.8}_{-9.6}$ $\pm$10.8	[68] AALTONEN	07B	CDF	≥ 4 jets (b-tag)
174.0 $\pm$ 2.2 $\pm$ 4.8	[69] AALTONEN	07D	CDF	≥ 6 jets, vtx b-tag
170.8 $\pm$ 2.2 $\pm$ 1.4	[70,71] AALTONEN	07I	CDF	lepton + jets (b-tag)
173.7 $\pm$ 4.4 $^{+2.1}_{-2.0}$	[67,72] ABAZOV	07F	D0	lepton + jets
176.2 $\pm$ 9.2 $\pm$ 3.9	[73] ABAZOV	07W	D0	dilepton (MWT)
179.5 $\pm$ 7.4 $\pm$ 5.6	[73] ABAZOV	07W	D0	dilepton (νWT)
164.5 $\pm$ 3.9 $\pm$ 3.9	[71,74] ABULENCIA	07D	CDF	dilepton
180.7 $^{+15.5}_{-13.4}$ $\pm$ 8.6	[75] ABULENCIA	07J	CDF	lepton + jets
170.3 $^{+4.1}_{-4.5}$ $^{+1.2}_{-1.8}$	[71,76] ABAZOV	06U	D0	lepton + jets (b-tag)
173.2 $^{+2.6}_{-2.4}$ $\pm$ 3.2	[77,78] ABULENCIA	06D	CDF	lepton + jets
173.5 $^{+3.7}_{-3.6}$ $\pm$ 1.3	[64,77] ABULENCIA	06D	CDF	lepton + jets
165.2 $\pm$ 6.1 $\pm$ 3.4	[71,79] ABULENCIA	06G	CDF	dilepton
170.1 $\pm$ 6.0 $\pm$ 4.1	[64,80] ABULENCIA	06V	CDF	dilepton
178.5 $\pm$13.7 $\pm$ 7.7	[81,82] ABAZOV	05	D0	6 or more jets
180.1 $\pm$ 3.6 $\pm$ 3.9	[83,84] ABAZOV	04G	D0	lepton + jets
176.1 $\pm$ 5.1 $\pm$ 5.3	[85] AFFOLDER	01	CDF	lepton + jets
176.1 $\pm$ 6.6	[86] AFFOLDER	01	CDF	dilepton, lepton+jets, all-jets
172.1 $\pm$ 5.2 $\pm$ 4.9	[87] ABBOTT	99G	D0	di-lepton, lepton+jets
176.0 $\pm$ 6.5	[88,89] ABE	99B	CDF	dilepton, lepton+jets, all-jets
167.4 $\pm$10.3 $\pm$ 4.8	[89,90] ABE	99B	CDF	dilepton
168.4 $\pm$12.3 $\pm$ 3.6	[84] ABBOTT	98D	D0	dilepton
173.3 $\pm$ 5.6 $\pm$ 5.5	[84,91] ABBOTT	98F	D0	lepton + jets
175.9 $\pm$ 4.8 $\pm$ 5.3	[90,92] ABE	98E	CDF	lepton + jets
161 $\pm$17 $\pm$10	[90] ABE	98F	CDF	dilepton
172.1 $\pm$ 5.2 $\pm$ 4.9	[93] BHAT	98B	RVUE	dilepton and lepton+jets
173.8 $\pm$ 5.0	[94] BHAT	98B	RVUE	dilepton, lepton+jets, all-jets
173.3 $\pm$ 5.6 $\pm$ 6.2	[84] ABACHI	97E	D0	lepton + jets
186 $\pm$10 $\pm$ 5.7	[90,95] ABE	97R	CDF	6 or more jets
199 $^{+19}_{-21}$ $\pm$22	ABACHI	95	D0	lepton + jets
176 $\pm$ 8 $\pm$10	ABE	95F	CDF	lepton + b-jet
174 $\pm$10 $^{+13}_{-12}$	ABE	94E	CDF	lepton + b-jet

[1] AAD 23N based on 36.1 fb^{-1} of pp data at $\sqrt{s}$ = 13 TeV. The second error is the sum of systematic ($\pm$0.66) and that from changing parton-shower gluon recoil scheme ($\pm$0.25) uncertainties. The distribution of the invariant mass $m_{\ell\mu}$ (ℓ from W and μ from b-hadron decay) is used, which is less sensitive to jet energy uncertainties and top production modelling.

[2] TUMASYAN 23BB based on 36.3 fb^{-1} of pp data at $\sqrt{s}=13$ TeV. For each event, the mass is reconstructed from a kinematic fit of the decay products to a $t\overline{t}$ hypothesis. A profile likelihood method is applied using up to four observables per event.

[3] TUMASYAN 23Z based on 138 fb^{-1} of pp data at $\sqrt{s}=13$ TeV. The second error is the sum of experimental ($\pm$0.61), model ($\pm$0.47), and theoretical ($\pm$0.23) uncertainties. The products of the hadronic decay of a top quark with $p_T > 400$ GeV, in the ℓ + jets channel of $t\overline{t}$, are reconstructed as a single jet. The top quark mass is determined from the normalized differential cross section measurement in the m_{jet} distribution.

[4] TUMASYAN 21G based on 35.9 fb^{-1} of pp data at $\sqrt{s}=13$ TeV. Events are selected by requiring 1ℓ + 2jets($1b$ jet) final state.

[5] SIRUNYAN 20AR based on 35.9 fb^{-1} of pp data at $\sqrt{s}=13$ TeV. The products of the hadronic decay of a top quark with $p_T > 400$ GeV, in the ℓ + jets channel of $t\overline{t}$ are reconstructed as a single jet. The top quark mass is determined from the normalized differential cross section measurement in the m_{jet} distribution.

[6] AABOUD 19AC is an ATLAS combination of 7 and 8 TeV top-quark mass determination in the dilepton, lepton + jets, and all jets channels.

[7] SIRUNYAN 19AP based on 35.9 fb^{-1} of pp data at $\sqrt{s}=13$ TeV. A kinematical fit is applied to each event assuming the signal event topology. m_t is determined simultaneously with a jet energy scale factor (JSF). The second error represents stat.+JSF. Modeling uncertainties are larger than in the measurements at $\sqrt{s}=7$ and 8 TeV because of the use of new alternative color reconnection models.

[8] SIRUNYAN 19AR based on 35.9 fb^{-1} of pp data at $\sqrt{s}=13$ TeV. Obtained from a simultaneous fit of the cross section and the top quark mass in the POWHEG simulation. The cross section is used also to extract the $\overline{\text{MS}}$ mass and the strong coupling constant for different PDF sets.

[9] KHACHATRYAN 16AK based on 19.7 fb^{-1} of pp data at $\sqrt{s}=8$ TeV. Combination of the three top mass measurements in KHACHATRYAN 16AK and with the CMS results at $\sqrt{s}=7$ TeV.

[10] TEVEWWG 16 is the latest Tevatron average (July 2016) provided by the Tevatron Electroweak Working Group. It takes correlated uncertainties into account and has a χ^2 of 10.8 for 11 degrees of freedom.

[11] AABOUD 19AC based on 20.2 fb^{-1} in pp collisions at $\sqrt{s}=8$ TeV. Uses optimized event selection to suppress less-well-reconstructed events and template fits to determine m_t together with a global jet energy scale factor and a relative b-to-light-jet energy scale factor.

[12] SIRUNYAN 19AP based on 35.9 fb^{-1} of pp data at $\sqrt{s}=13$ TeV. A combined measurement using the lepton+jets and all-jets channels through a single likelihood function. See SIRUNYAN 18DE.

[13] SIRUNYAN 18DE based on 35.9 fb^{-1} of pp data at $\sqrt{s}=13$ TeV. m_t is determined simultaneously with an overall jet energy scale factor constrained by the mass of the hadronically decayed W. Compared to the Run 1 analysis a more advanced treatment of modeling uncertainties are employed, in particular concerning color-reconnection models. Superseded by TUMASYAN 23BB.

[14] AABOUD 17AH based on 20.2 fb^{-1} of pp data at $\sqrt{s}=8$ TeV. Uses template fits to the ratio of the masses of three-jets (from t candidate) and dijets (from W candidate), to suppress jet energy scale uncertainty. Large QCD background is modelled using a data-driven method.

[15] ABAZOV 17B is a combination of measurements of the top quark mass by D0 in the lepton+jets and dilepton channels, using all data collected in Run I (1992–1996) at $\sqrt{s}$ = 1.8 TeV and Run II (2001–2011) at $\sqrt{s}=1.96$ TeV of the Tevatron, corresponding to integrated luminosities of 0.1 fb^{-1} and 9.7 fb^{-1}, respectively.

[16] SIRUNYAN 17L based on 19.7 fb^{-1} of pp data at $\sqrt{s}=8$ TeV. m_t is reconstructed from a fit to the invariant mass distribution of $\mu\nu b$, where p_T^{miss} and W mass constraint are used to reconstruct ν momentum. The number of events for various contributions, except for the t-channel single top one, are fixed to the values extracted from simulation. Superseded by TUMASYAN 21G.

[17] SIRUNYAN 17N based on 19.7 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. The fully hadronic decay of a highly-boosted t is reconstructed in the ℓ+jets channel and unfolded at the particle level. The sensitivity of the peak position of the m_{jet} distribution is used to test quality of the modelling by the simulation.

[18] SIRUNYAN 17O based on 19.7 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. Analysis is based on the kinematical observables $M(b\ell)$, M_{T2} and $M(b\ell\nu)$. A fit is performed to determine m_t and an overall jet energy scale factor simultaneously.

[19] AABOUD 16T based on 20.2 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. The analysis is refined using the p_T and invariant mass distributions of ℓ+b-jet system. A combination with measurements from $\sqrt{s} = 7$ TeV data in the dilepton and lepton+jets channels gives 172.84 $\pm$ 0.34 $\pm$ 0.61 GeV.

[20] AABOUD 16T is an ATLAS combination of 8 TeV top-quark mass in the dilepton channel with previous measurements from $\sqrt{s} = 7$ TeV data in the dilepton and lepton + jets channels.

[21] ABAZOV 16 based on 9.7 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. Employs improved fit to minimize statistical errors and improved jet energy calibration, using lepton + jets mode, which reduces error of jet energy scale. Based on previous determination in ABAZOV 12AB with increased integrated luminosity and improved fit and calibrations.

[22] ABAZOV 16D based on 9.7 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV, using the matrix element technique. Based on previous determination in ABAZOV 11R with increased integrated luminosity. There is a strong correlation with the determination in ABAZOV 16. (See ABAZOV 17B.)

[23] KHACHATRYAN 16AK based on 19.7 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. Combination of the three top mass measurements in KHACHATRYAN 16AK and with the CMS results at $\sqrt{s} = 7$ TeV gives 172.44 $\pm$ 0.13 $\pm$ 0.47 GeV.

[24] The top mass and jet energy scale factor are determined by a fit.

[25] Uses the analytical matrix weighting technique method.

[26] KHACHATRYAN 16AL based on 19.7 fb^{-1} in pp collisions at $\sqrt{s} = 8$ TeV. Determined from the invariant mass distribution of leptons and reconstructed secondary vertices from b decays using only charged particles. The uncertainty is dominated by modeling of b fragmentation and top p_T distribution.

[27] KHACHATRYAN 16CB based on 666 candidate reconstructed events corresponding to 19.7 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. The measurement exploits correlation of m_t with $M(J/\psi\ell)$ in the same top quark decay, using a high-purity event sample. A study on modeling of b-quark fragmentation is given in Sec.3.3.

[28] AAD 15AW based on 4.6 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. Uses template fits to the ratio of the masses of three-jets (from t candidate) and dijets (from W candidate). Large background from multijet production is modeled with data-driven methods.

[29] AAD 15BF based on 4.6 fb^{-1} in pp collisions at $\sqrt{s} = 7$ TeV. Using a three-dimensional template likelihood technique the lepton plus jets ($\geq 1b$-tagged) channel gives 172.33 $\pm$ 0.75 $\pm$ 1.02 GeV, while exploiting a one dimensional template method using $m_{\ell b}$ the dilepton channel (1 or 2b-tags) gives 173.79 $\pm$ 0.54 $\pm$ 1.30 GeV. The results are combined.

[30] AALTONEN 15D based on 9.1 fb^{-1} of $p\overline{p}$ data at $\sqrt{s} = 1.96$ TeV. Uses a template technique to fit a distribution of a variable defined by a linear combination of variables sensitive and insensitive to jet energy scale to optimize reduction of systematic errors. b-tagged and non-b-tagged events are separately analyzed and combined.

[31] Based on 9.3 fb^{-1} of $p\overline{p}$ data at $\sqrt{s} = 1.96$ TeV. Multivariate algorithm is used to discriminate signal from backgrounds, and templates are used to measure m_t.

[32] Based on 9.7 fb^{-1} of $p\overline{p}$ data at $\sqrt{s} = 1.96$ TeV. A matrix element method is used to calculate the probability of an event to be signal or background, and the overall jet energy scale is constrained *in situ* by m_W. See ABAZOV 15G for further details.

[33] Based on 3.54 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. The mass is reconstructed for each event employing a kinematic fit of the jets to a ttbar hypothesis. The combination with the pervious CMS measurements in the dilepton and the lepton+jets channels gives 173.54 $\pm$ 0.33 $\pm$ 0.96 GeV.

[34] Based on 8.7 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. Events with an identified charged lepton or small $\not{E}_T$ are rejected from the event sample, so that the measurement is statistically independent from those in the $\ell +$ jets and all hadronic channels while being sensitive to those events with a τ lepton in the final state.

[35] Based on 5.0 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. CHATRCHYAN 13S studied events with di-lepton + $\not{E}_T$ + ≥ 2 b-jets, and looked for kinematical endpoints of MT2, MT2$_T$, and subsystem variables.

[36] AAD 12I based on 1.04 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. Uses 2d-template analysis (MT) with m_t and jet energy scale factor (JSF) from m_W mass fit.

[37] Based on 8.7 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV. The JES is calibrated by using the dijet mass from the W boson decay.

[38] Use the ME method based on 2.2 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV.

[39] Combination based on up to 5.8 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV.

[40] Based on 5.8 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV the quoted value is m_t = 172.5 $\pm$ 1.4(stat)$\pm$1.0(JES)$\pm$1.1(syst) GeV. The measurement is performed with a liklihood fit technique which simultaneously determines m_t and JES (Jet Energy Scale).

[41] Based on 4.3 fb^{-1} of data in p-pbar collisions at 1.96 TeV. The measurement reduces the JES uncertainty by using the single lepton channel study of ABAZOV 11P.

[42] Combination with the result in 1 fb^{-1} of preceding data reported in ABAZOV 09AH as well as the MWT result of ABAZOV 11R with a statistical correlation of 60%.

[43] Based on 5.0 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. Uses an analytical matrix weighting technique (AMWT) and full kinematic analysis (KIN).

[44] Based on 5.0 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. The first error is statistical and JES combined, and the second is systematic. Ideogram method is used to obtain 2D liklihood for the kinematical fit with two parameters mtop and JES.

[45] Based on 3.2 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. The first error is from statistics and JES combined, and the latter is from the other systematic uncertainties. The result is obtained using an unbinned maximum likelihood method where the top quark mass and the JES are measured simultaneously, with Δ_{JES} = 0.3 $\pm$ 0.3(stat).

[46] Based on 5.7 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. Events with an identified charged lepton or small $\not{E}_T$ are rejected from the event sample, so that the measurement is statistically independent from those in the $\ell +$ jets and all hadronic channels while being sensitive to those events with a τ lepton in the final state. Supersedes AALTONEN 07B.

[47] AALTONEN 11E based on 5.6 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. Employs a multi-dimensional template likelihood technique where the lepton plus jets (one or two b-tags) channel gives 172.2 $\pm$ 1.2 $\pm$ 0.9 GeV while the dilepton channel yields 170.3 $\pm$ 2.0 $\pm$ 3.1 GeV. The results are combined. OUR EVALUATION includes the measurement in the dilepton channel only.

[48] Uses a likelihood fit of the lepton p_T distribution based on 2.7 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV.

[49] Based on 3.6 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. ABAZOV 11P reports 174.94 $\pm$ 0.83$\pm$0.78$\pm$0.96 GeV, where the first uncertainty is from statistics, the second from JES, and the last from other systematic uncertainties. We combine the JES and systematic uncertainties. A matrix-element method is used where the JES uncertainty is constrained by the W mass. ABAZOV 11P describes a measurement based on 2.6 fb^{-1} that is combined with ABAZOV 08AH, which employs an independent 1 fb^{-1} of data.

[50] Based on a matrix-element method which employs 5.4 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. Superseded by ABAZOV 12AB.

[51] Based on 36 pb^{-1} of pp collisions at $\sqrt{s} = 7$ TeV. A Kinematic Method using b-tagging and an analytical Matrix Weighting Technique give consistent results and are combined. Superseded by CHATRCHYAN 12BA.

[52] Based on 5.6 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. The likelihood calculated using a matrix element method gives m_t = 173.0 $\pm$ 0.7(stat)$\pm$0.6(JES)$\pm$0.9(syst) GeV, for a total uncertainty of 1.2 GeV.

[53] Based on 3.4 fb^{-1} of $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. The result is obtained by combining the MT2 variable method and the NWA (Neutrino Weighting Algorithm). The MT2 method alone gives $m_t = 168.0^{+4.8}_{-4.0}$(stat)$\pm$2.9(syst) GeV with smaller systematic error due to small JES uncertainty.

[54] Based on 1.9 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. The result is from the measurement using the transverse decay length of b-hadrons and that using the transverse momentum of the W decay muons, which are both insensitive to the JES (jet energy scale) uncertainty. OUR EVALUATION uses only the measurement exploiting the decay length significance which yields $166.9^{+9.5}_{-8.5}$(stat)$\pm$2.9 (syst) GeV. The measurement that uses the lepton transverse momentum is excluded from the average because of a statistical correlation with other samples.

[55] Based on 2.9 fb^{-1} of $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. The first error is from statistics and JES uncertainty, and the latter is from the other systematics. Neural-network-based kinematical selection of 6 highest E_T jets with a vtx b-tag is used to distinguish signal from background. Superseded by AALTONEN 12G.

[56] Based on 2 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. The top mass is obtained from the measurement of the invariant mass of the lepton (e or μ) from W decays and the soft μ in b-jet. The result is insensitive to jet energy scaling.

[57] Based on 1.9 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. The first error is from statistics and jet energy scale uncertainty, and the latter is from the other systematics. Matrix element method with effective propagators.

[58] Based on 943 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV. The first error is from statistical and jet-energy-scale uncertainties, and the latter is from other systematics. AALTONEN 09K selected 6 jet events with one or more vertex b-tags and used the tree-level matrix element to construct template models of signal and background.

[59] Based on 1.9 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. The first error is from statistical and jet-energy-scale (JES) uncertainties, and the second is from other systematics. Events with lepton + jets and those with dilepton + jets were simultaneously fit to constrain m_t and JES. Lepton + jets data only give $m_t = 171.8 \pm 2.2$ GeV, and dilepton data only give $m_t = 171.2^{+5.3}_{-5.1}$ GeV.

[60] Based on 2 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. Matrix Element method. Optimal selection criteria for candidate events with two high p_T leptons, high $\not{E}_T$, and two or more jets with and without b-tag are obtained by neural network with neuroevolution technique to minimize the statistical error of m_t.

[61] Based on 2.9 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. Mass m_t is estimated from the likelihood for the eight-fold kinematical solutions in the plane of the azimuthal angles of the two neutrino momenta.

[62] Based on 1 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. Events with two identified leptons, and those with one lepton plus one isolated track and a b-tag were used to constrain m_t. The result is a combination of the νWT (ν Weighting Technique) result of $176.2 \pm 4.8 \pm 2.1$ GeV and the MWT (Matrix-element Weighting Technique) result of $173.2 \pm 4.9 \pm 2.0$ GeV.

[63] Reports measurement of $170.7^{+4.2}_{-3.9} \pm 2.6 \pm 2.4$ GeV based on 1.2 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. The last error is due to the theoretical uncertainty on $\sigma_{t\overline{t}}$. Without the cross-section constraint a top mass of $169.7^{+5.2}_{-4.9} \pm 3.1$ GeV is obtained.

[64] Template method.

[65] Result is based on 1 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. The first error is from statistics and jet energy scale uncertainty, and the latter is from the other systematics.

[66] Based on 310 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV.

[67] Ideogram method.

[68] Based on 311 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV. Events with 4 or more jets with $E_T >$ 15 GeV, significant missing E_T, and secondary vertex b-tag are used in the fit. About 44% of the signal acceptance is from $\tau\nu$ + 4 jets. Events with identified e or μ are vetoed to provide a statistically independent measurement.

[69] Based on 1.02 fb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. Superseded by AALTONEN 12G.

[70] Based on 955 pb^{-1} of data $\sqrt{s}$ = 1.96 TeV. m_t and JES (Jet Energy Scale) are fitted simultaneously, and the first error contains the JES contribution of 1.5 GeV.

[71] Matrix element method.

[72] Based on 425 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. The first error is a combination of statistics and JES (Jet Energy Scale) uncertainty, which has been measured simultaneously to give JES = 0.989 ± 0.029(stat).

[73] Based on 370 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. Combined result of MWT (Matrix-element Weighting Technique) and νWT (ν Weighting Technique) analyses is 178.1 ± 6.7 ± 4.8 GeV.

[74] Based on 1.0 fb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. ABULENCIA 07D improves the matrix element description by including the effects of initial-state radiation.

[75] Based on 695 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. The transverse decay length of the b hadron is used to determine m_t, and the result is free from the JES (jet energy scale) uncertainty.

[76] Based on ∼ 400 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. The first error includes statistical and systematic jet energy scale uncertainties, the second error is from the other systematics. The result is obtained with the b-tagging information. The result without b-tagging is $169.2^{+5.0}_{-7.4}{}^{+1.5}_{-1.4}$ GeV. Superseded by ABAZOV 08AH.

[77] Based on 318 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV.

[78] Dynamical likelihood method.

[79] Based on 340 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV.

[80] Based on 360 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV.

[81] Based on 110.2 ± 5.8 pb^{-1} at $\sqrt{s}$ = 1.8 TeV.

[82] Based on the all hadronic decays of $t\overline{t}$ pairs. Single b-quark tagging via the decay chain $b \to c \to \mu$ was used to select signal enriched multijet events. The result was obtained by the maximum likelihood method after bias correction.

[83] Obtained by re-analysis of the lepton + jets candidate events that led to ABBOTT 98F. It is based upon the maximum likelihood method which makes use of the leading order matrix elements.

[84] Based on 125 ± 7 pb^{-1} of data at $\sqrt{s}$ = 1.8 TeV.

[85] Based on ∼ 106 pb^{-1} of data at $\sqrt{s}$= 1.8 TeV.

[86] Obtained by combining the measurements in the lepton + jets [AFFOLDER 01], all-jets [ABE 97R, ABE 99B], and dilepton [ABE 99B] decay topologies.

[87] Obtained by combining the D0 result m_t (GeV) = 168.4 ± 12.3 ± 3.6 from 6 di-lepton events (see also ABBOTT 98D) and m_t (GeV) = 173.3 ± 5.6 ± 5.5 from lepton+jet events (ABBOTT 98F).

[88] Obtained by combining the CDF results of m_t (GeV)=167.4 ± 10.3 ± 4.8 from 8 dilepton events, m_t (GeV)=175.9 ± 4.8 ± 5.3 from lepton+jet events (ABE 98E), and m_t (GeV)=186.0 ± 10.0 ± 5.7 from all-jet events (ABE 97R). The systematic errors in the latter two measurements are changed in this paper.

[89] See AFFOLDER 01 for details of systematic error re-evaluation.

[90] Based on 109 ± 7 pb^{-1} of data at $\sqrt{s}$ = 1.8 TeV.

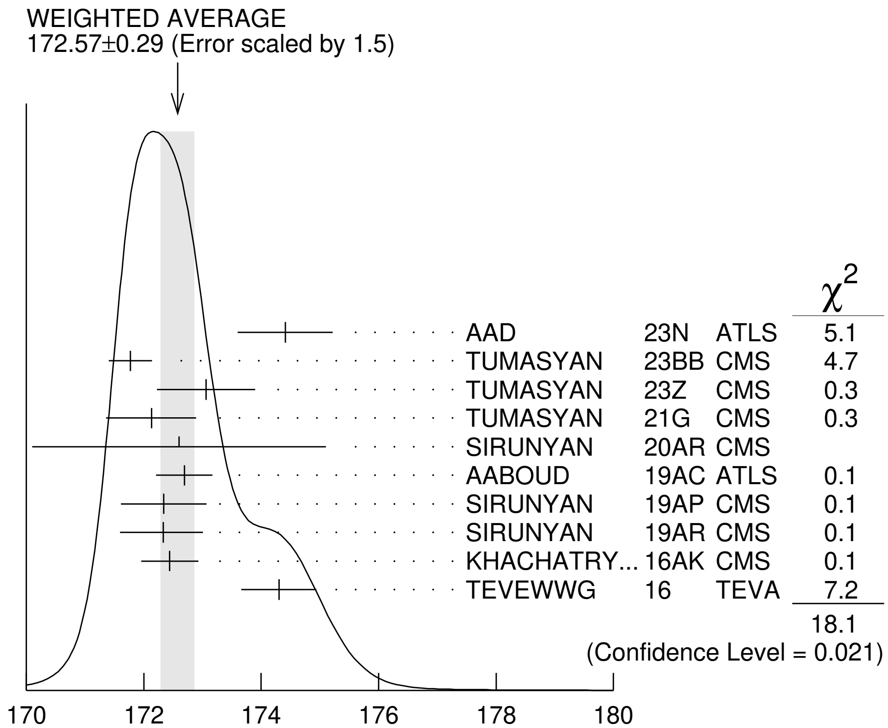
[91] See ABAZOV 04G.

[92] The updated systematic error is listed. See AFFOLDER 01, appendix C.

[93] Obtained by combining the DØ results of m_t(GeV)=168.4 ± 12.3 ± 3.6 from 6 dilepton events and m_t(GeV)=173.3 ± 5.6 ± 5.5 from 77 lepton+jet events.

[94] Obtained by combining the DØ results from dilepton and lepton+jet events, and the CDF results (ABE 99B) from dilepton, lepton+jet events, and all-jet events.

[95] Based on the first observation of all hadronic decays of $t\overline{t}$ pairs. Single b-quark tagging with jet-shape variable constraints was used to select signal enriched multi-jet events. The updated systematic error is listed. See AFFOLDER 01, appendix C.



t-Quark Mass (Direct Measurements) (GeV)

t-Quark Mass from Cross-Section Measurements

The top quark $\overline{\mathrm{MS}}$ or pole mass can be extracted from a measurement of $\sigma(t\overline{t})$ by using theory calculations. We quote below the $\overline{\mathrm{MS}}$ mass. See the review "The Top Quark" and references therein for more information.

VALUE (GeV)	*DOCUMENT ID*	*TECN*	*COMMENT*
$\mathbf{162.5^{+2.1}_{-1.5}}$ **OUR AVERAGE**			
$162.9\pm0.5\pm1.0^{+2.1}_{-1.2}$	[1] AAD 19G	ATLS	$\ell+\not{E}_T+\ \geq 5\ j\ (2b\text{-}j)$
$160.0^{+4.8}_{-4.3}$	[2] ABAZOV 11S	D0	$\sigma(t\overline{t})$ + theory
• • • We do not use the following data for averages, fits, limits, etc. • • •			
	[3] ABAZOV 09AG	D0	cross sects, theory + exp
	[4] ABAZOV 09R	D0	cross sects, theory + exp

[1] AAD 19G based on 20.2 fb^{-1} of data in pp collisions at $\sqrt{s}$ = 8 TeV. Normalized $t\overline{t}$ + 1-jet differential cross section as a function of $t\overline{t}j$ invariant mass is measured in the ℓ + jets mode. The unfolded parton-level distribution is compared with the NLO QCD prediction. The three errors are from statitics, systematics, and theory.

[2] Based on 5.3 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. ABAZOV 11S uses the measured $t\overline{t}$ production cross section of $8.13^{+1.02}_{-0.90}$ pb [ABAZOV 11E] in the lepton plus jets channel to obtain the top quark $\overline{\mathrm{MS}}$ mass by using an approximate NNLO computation (MOCH 08, LANGENFELD 09). The corresponding top quark pole mass is $167.5^{+5.4}_{-4.9}$ GeV. A different theory calculation (AHRENS 10, AHRENS 10A) is also used and yields $m_t^{\overline{\mathrm{MS}}} = 154.5^{+5.0}_{-4.3}$ GeV.

[3] Based on 1 fb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. Uses the ℓ + jets, $\ell\ell$, and $\ell\tau$ + jets channels. ABAZOV 09AG extract the pole mass of the top quark using two different

calculations that yield $169.1^{+5.9}_{-5.2}$ GeV (MOCH 08, LANGENFELD 09) and $168.2^{+5.9}_{-5.4}$ GeV (KIDONAKIS 08).

[4] Based on 1 fb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. Uses the $\ell\ell$ and $\ell\tau$ + jets channels. ABAZOV 09R extract the pole mass of the top quark using two different calculations that yield $173.3^{+9.8}_{-8.6}$ GeV (MOCH 08, LANGENFELD 09) and $171.5^{+9.9}_{-8.8}$ GeV (CACCIARI 08).

t-Quark Pole Mass from Cross-Section Measurements

VALUE (GeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
172.4 ±0.7 OUR AVERAGE				
$173.4\ ^{+1.8}_{-2.0}$	[1] AAD	23AY	LHC	$e^{\pm}\mu^{\mp}$ pair; ATLAS+CMS combined
172.93±1.36	[2] TUMASYAN	23R	CMS	$t\bar{t}$+jet; $\ell^{\pm}\ell^{\mp}$ mode
$173.1\ ^{+2.0}_{-2.1}$	[3] AAD	20Q	ATLS	$e + \mu$ + 1 or 2 b-jets
$171.1\ \pm0.4\ \pm0.9^{+0.7}_{-0.3}$	[4] AAD	19G	ATLS	ℓ+$\not\!\!E_T$+ $\geq$ 5 j (2b-j)
170.6 ±2.7	[5] SIRUNYAN	17W	CMS	ℓ + $\geq$ 1j
$172.8\ \pm1.1\ ^{+3.3}_{-3.1}$	[6] ABAZOV	16F	D0	$\ell\ell$, ℓ+jets channels
$173.7\ ^{+2.3}_{-2.1}$	[7] AAD	15BW	ATLS	ℓ+$\not\!\!E_T$+ $\geq$ 5j (2b-tag)
• • • We do not use the following data for averages, fits, limits, etc. • • •				
170.5 ±0.8	[8] SIRUNYAN	20BV	CMS	$t\bar{t}$ normalized multi-differential cross sections
173.2 ±0.9 ±0.8±1.2	[9] AABOUD	17BC	ATLS	$e + \mu + \geq 1b$ jets
$173.8\ ^{+1.7}_{-1.8}$	[10] KHACHATRY...	16AW	CMS	$e + \mu + \not\!\!E_T$ + $\geq$ 0j
$172.9\ ^{+2.5}_{-2.6}$	[11] AAD	14AY	ATLS	pp at $\sqrt{s}$ = 7, 8 TeV
$176.7\ ^{+3.0}_{-2.8}$	[12] CHATRCHYAN	14	CMS	pp at $\sqrt{s}$ = 7 TeV

[1] AAD 23AY based on 5 fb^{-1} and 20 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV and 8 TeV, respectively. The result is obtained from the combined inclusive cross section measurements and the NNLO+NNLL predictions fixing $\alpha_s(m_Z)$ = 0.118.

[2] TUMASYAN 23R based on 36.3 fb^{-1} of data in pp collisions at $\sqrt{s}$ = 13 TeV. Normalized $t\bar{t}$ + 1-jet differential cross section as a function of $t\bar{t}j$ invariant mass is measured in the dilepton mode. The unfolded parton-level distribution is compared with the NLO QCD prediction. The result depends on the PDF and ABMP16NLO is used.

[3] AAD 20Q based on 36.1 fb^{-1} of pp data at $\sqrt{s}$ = 13 TeV. The result is obtained from the inclusive cross section measurement and the NNLO+NNLL prediction.

[4] AAD 19G based on 20.2 fb^{-1} of data in pp collisions at $\sqrt{s}$ = 8 TeV. Normalized $t\bar{t}$ + 1-jet differential cross section as a function of $t\bar{t}j$ invariant mass is measured in the ℓ + jets mode. The unfolded parton-level distribution is compared with the NLO QCD prediction. The three errors are from statitics, systematics, and theory.

[5] SIRUNYAN 17W based on 2.2 fb^{-1} of pp data at $\sqrt{s}$ = 13 TeV. Events are categorized according to the jet multiplicity and the number of b-tagged jets. The pole mass is obtained from the inclusive cross section measurement and the NNLO prediction.

[6] ABAZOV 16F based on 9.7 fb^{-1} of data in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. The result is obtained from the inclusive cross section measurement and the NNLO+NNLL prediction.

[7] AAD 15BW based on 4.6 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. Uses normalized differential cross section for $t\bar{t}$ + 1 jet as a function of the inverse of the invariant mass of the $t\bar{t}$ + 1 jet system. The measured cross section is corrected to the parton level. Then a fit to the data using NLO + parton shower prediction is performed.

[8] SIRUNYAN 20BV based on 35.9 fb^{-1} of pp data at $\sqrt{s} = 13$ TeV. The error accounts for both experimental and theoretical uncertainties. Events containing two oppositely charged leptons are used. The pole mass is particularly sensitive to the $t\overline{t}$ invariant mass distribution close to the threshold. However, the Coulomb and soft gluon resummation effects are not taken into account, hence, an additional theoretical uncertainty of order +1 GeV is assumed.

[9] AABOUD 17BC based on 20.2 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. The pole mass is extracted from a fit of NLO predictions to eight single lepton and dilepton differential distributions, while simultaneously constraining uncertainties due to PDFs and QCD scales. The three reported uncertainties come from statistics, experimental systematics, and theoretical sources.

[10] KHACHATRYAN 16AW based on 5.0 fb^{-1} of pp collisions at 7 TeV and 19.7 fb^{-1} at 8 TeV. The 7 TeV data include those used in CHATRCHYAN 14. The result is obtained from the inclusive cross sections.

[11] AAD 14AY used $\sigma(t\overline{t})$ for $e\mu$ events. The result is a combination of the measurements $m_t = 171.4 \pm 2.6$ GeV based on 4.6 fb^{-1} of data at 7 TeV and $m_t = 174.1 \pm 2.6$ GeV based on 20.3 fb^{-1} of data at 8 TeV.

[12] CHATRCHYAN 14 used $\sigma(t\overline{t})$ from pp collisions at $\sqrt{s} = 7$ TeV measured in CHATRCHYAN 12AX to obtain m_t(pole) for $\alpha_s(m_Z) = 0.1184 \pm 0.0007$. The errors have been corrected in KHACHATRYAN 14K.

$m_t - m_{\overline{t}}$

Test of *CPT* conservation. OUR AVERAGE assumes that the systematic uncertainties are uncorrelated.

VALUE (GeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.15±0.20 OUR AVERAGE	Error includes scale factor of 1.1.			
$0.83^{+1.79}_{-1.35}$	[1] TUMASYAN	21G	CMS	*t*-channel single top production
−0.15±0.19±0.09	[2] CHATRCHYAN	17	CMS	$\ell + \not{E}_T + \geq 4$j (≥ 1b j)
0.67±0.61±0.41	[3] AAD	14	ATLS	$\ell + \not{E}_T + \geq 4$j (≥ 2 *b*-tags)
−1.95±1.11±0.59	[4] AALTONEN	13E	CDF	$\ell + \not{E}_T + \geq 4$j (0,1,2 b-tags)
−0.44±0.46±0.27	[5] CHATRCHYAN	12Y	CMS	$\ell + \not{E}_T + \geq 4$j
0.8 ±1.8 ±0.5	[6] ABAZOV	11T	D0	$\ell + \not{E}_T + 4$ jets (≥ 1 *b*-tag)
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−3.3 ±1.4 ±1.0	[7] AALTONEN	11K	CDF	Repl. by AALTONEN 13E
3.8 ±3.4 ±1.2	[8] ABAZOV	09AA	D0	$\ell + \not{E}_T + 4$ jets (≥ 1 *b*-tag)

[1] TUMASYAN 21G based on 35.9 fb^{-1} of pp data at $\sqrt{s} = 13$ TeV. Events are selected by requiring 1ℓ + 2jets($1b$ jet) final state. An average top mass of $172.13^{+0.76}_{-0.77}$ GeV/c^2 is obtained.

[2] CHATRCHYAN 17 based on 19.6 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV and an average top mass of 172.84 ± 0.10 (stat) GeV is obtained.

[3] Based on 4.7 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV and an average top mass of 172.5 GeV/c^2.

[4] Based on 8.7 fb^{-1} of $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV and an average top mass of 172.5 GeV/c^2.

[5] Based on 4.96 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. Based on the fitted m_t for ℓ^+ and ℓ^- events using the Ideogram method.

[6] Based on a matrix-element method which employs 3.6 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} =$ 1.96 TeV.

[7] Based on a template likelihood technique which employs 5.6 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV.

[8] Based on 1 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV.

t-quark DECAY WIDTH

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
$1.42^{+0.19}_{-0.15}$ OUR AVERAGE		Error includes scale factor of 1.4.			
$1.76 \pm 0.33 ^{+0.79}_{-0.68}$		[1] AABOUD	18AZ	ATLS	$\ell + \not\!\!E_T + \geq 4j$ (≥ 1 b)
$1.36 \pm 0.02 ^{+0.14}_{-0.11}$		[2] KHACHATRY...	14E	CMS	$\ell\ell + \not\!\!E_T$+2-4jets (0-2b-tag)
$2.00 ^{+0.47}_{-0.43}$		[3] ABAZOV	12T	D0	$\Gamma(t \to bW)/B(t \to bW)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 6.38	95	[4] AALTONEN	13Z	CDF	$\ell + \not\!\!E_T + \geq 4j$ (≥ 0 b), direct
$1.99 ^{+0.69}_{-0.55}$		[5] ABAZOV	11B	D0	Repl. by ABAZOV 12T
> 1.21	95	[5] ABAZOV	11B	D0	$\Gamma(t \to Wb)$
< 7.6	95	[6] AALTONEN	10AC	CDF	ℓ + jets, direct
< 13.1	95	[7] AALTONEN	09M	CDF	m_t(rec) distribution

[1] Based on 20.2 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. Γ_t is measured using a template fit to the reconstructed invariant mass of the b-jet of the semileptonically decaying top quark and the corresponding lepton, and the angular distance between j_b and j_l in hadronic top decay. Signal templates are generated by reweighting events at parton-level to Breit-Wigner distribution with different Γ_t hypotheses for $m_t = 172.5$ GeV. The result is consistent with the NNLO SM prediction of 1.322 GeV.

[2] Based on 19.7 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. The result is obtained by combining the measurement of $R = \Gamma(t \to Wb)/\Gamma(t \to Wq\ (q=b,s,d))$ and a previous CMS measurement of the t-channel single top production cross section of CHATRCHYAN 12BQ, by using the theoretical calculation of $\Gamma(t \to Wb)$ for $m_t = 172.5$ GeV.

[3] Based on 5.4 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV. $\Gamma(t \to bW) = 1.87^{+0.44}_{-0.40}$ GeV is obtained from the observed t-channel single top quark production cross section, whereas $B(t \to bW) = 0.90 \pm 0.04$ is used assuming $\sum_q B(t \to qW) = 1$. The result is valid for $m_t = 172.5$ GeV. See the paper for the values for $m_t = 170$ or 175 GeV.

[4] Based on 8.7 fb^{-1} of data. The two sided 68% CL interval is 1.10 GeV $< \Gamma_t < 4.05$ GeV for $m_t = 172.5$ GeV.

[5] Based on 2.3 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. ABAZOV 11B extracted Γ_t from the partial width $\Gamma(t \to Wb) = 1.92^{+0.58}_{-0.51}$ GeV measured using the t-channel single top production cross section, and the branching fraction br$t \to Wb = 0.962^{+0.068}_{-0.066}$(stat)$^{+0.064}_{-0.052}$(syst). The $\Gamma(t \to Wb)$ measurement gives the 95% CL lowerbound of $\Gamma(t \to Wb)$ and hence that of Γ_t.

[6] Results are based on 4.3 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. The top quark mass and the hadronically decaying W boson mass are reconstructed for each candidate events and compared with templates of different top quark width. The two sided 68% CL interval is 0.3 GeV$< \Gamma_t < 4.4$ GeV for $m_t = 172.5$ GeV.

[7] Based on 955 pb^{-1} of $p\overline{p}$ collision data at $\sqrt{s} = 1.96$ TeV. AALTONEN 09M selected $t\overline{t}$ candidate events for the $\ell + \not\!\!E_T$ + jets channel with one or two b-tags, and examine the decay width dependence of the reconstructed m_t distribution. The result is for m_t =175 GeV, whereas the upper limit is lower for smaller m_t.

t DECAY MODES

	Mode		Fraction (Γ_i/Γ)	Confidence level
Γ_1	$W q (q = b, s, d)$			
Γ_2	$W b$			
Γ_3	$e \nu_e b$		(11.10 ± 0.30) %	
Γ_4	$\mu \nu_\mu b$		(11.40 ± 0.20) %	
Γ_5	$\tau \nu_\tau b$		(10.7 ± 0.5) %	
Γ_6	$q \overline{q} b$		(66.5 ± 1.4) %	
Γ_7	$\gamma q (q=u,c)$		[a] $< 4.5 \times 10^{-5}$	95%
Γ_8	$H^+ b,\ H^+ \to \tau \nu_\tau$			

$\Delta T = 1$ weak neutral current ($T1$) modes

	Mode		Fraction (Γ_i/Γ)	Confidence level
Γ_9	$Z q (q=u,c)$	$T1$	[b] $< 1.2 \times 10^{-4}$	95%
Γ_{10}	$H u$	$T1$	$< 1.9 \times 10^{-4}$	95%
Γ_{11}	$H c$	$T1$	$< 4.3 \times 10^{-4}$	95%
Γ_{12}	$\ell^+ \overline{q} \overline{q}' (q=d,s,b;\ q'=u,c)$	$T1$	$< 1.6 \times 10^{-3}$	95%

Lepton Family number (LF) violating modes

	Mode		Fraction (Γ_i/Γ)	Confidence level
Γ_{13}	$e^\pm \mu^\mp c$	LF	$< 8.9 \times 10^{-7}$	
Γ_{14}	$e^\pm \mu^\mp u$	LF	$< 7 \times 10^{-8}$	

[a] This limit is for $\Gamma(t \to \gamma q)/\Gamma(t \to W b)$.

[b] This limit is for $\Gamma(t \to Z q)/\Gamma(t \to W b)$.

t BRANCHING RATIOS

$\Gamma(W b)/\Gamma(W q(q = b, s, d))$ — Γ_2/Γ_1

OUR AVERAGE assumes that the systematic uncertainties are uncorrelated.

VALUE	DOCUMENT ID		TECN	COMMENT
0.957±0.034 OUR AVERAGE	Error includes scale factor of 1.5. See the ideogram below.			
0.87 ± 0.07	[1] AALTONEN	14G	CDF	$\ell\ell + \not\!\!E_T + \geq 2$j (0,1,2 b-tag)
$1.014 \pm 0.003 \pm 0.032$	[2] KHACHATRY...	14E	CMS	$\ell\ell + \not\!\!E_T$ + 2,3,4j (0–2b-tag)
0.94 ± 0.09	[3] AALTONEN	13G	CDF	$\ell + \not\!\!E_T + \geq 3$jets ($\geq 1b$-tag)
0.90 ± 0.04	[4] ABAZOV	11X	D0	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$0.97 {}^{+0.09}_{-0.08}$	[5] ABAZOV	08M	D0	ℓ + n jets with 0,1,2 b-tag
$1.03 {}^{+0.19}_{-0.17}$	[6] ABAZOV	06K	D0	
$1.12 {}^{+0.21}_{-0.19} {}^{+0.17}_{-0.13}$	[7] ACOSTA	05A	CDF	Repl. by AALTONEN 13G
$0.94 {}^{+0.26}_{-0.21} {}^{+0.17}_{-0.12}$	[8] AFFOLDER	01C	CDF	

[1] Based on 8.7 fb^{-1} of data. This measurement gives $|V_{tb}| = 0.93 \pm 0.04$ and $|V_{tb}| > 0.85$ (95% CL) in the SM.

[2] Based on 19.7 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. The result is obtained by counting the number of b jets per $t\overline{t}$ signal events in the dilepton channel. The $t\overline{t}$ production cross section is measured to be $\sigma(t\overline{t}) = 238 \pm 1 \pm 15$ pb, in good agreement with the SM prediction and the latest CMS measurement of CHATRCHYAN 14F. The measurement gives $R > 0.995$ (95% CL), or $|V_{tb}| > 0.975$ (95% CL) in the SM, requiring $R \leq 1$.

[3] Based on 8.7 fb^{-1} of $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. Measure the fraction of $t \to W b$ decays simultaneously with the $t\overline{t}$ cross section. The correlation coefficient between those two measurements is -0.434. Assume unitarity of the 3×3 CKM matrix and set $|V_{tb}| > 0.89$ at 95% CL.

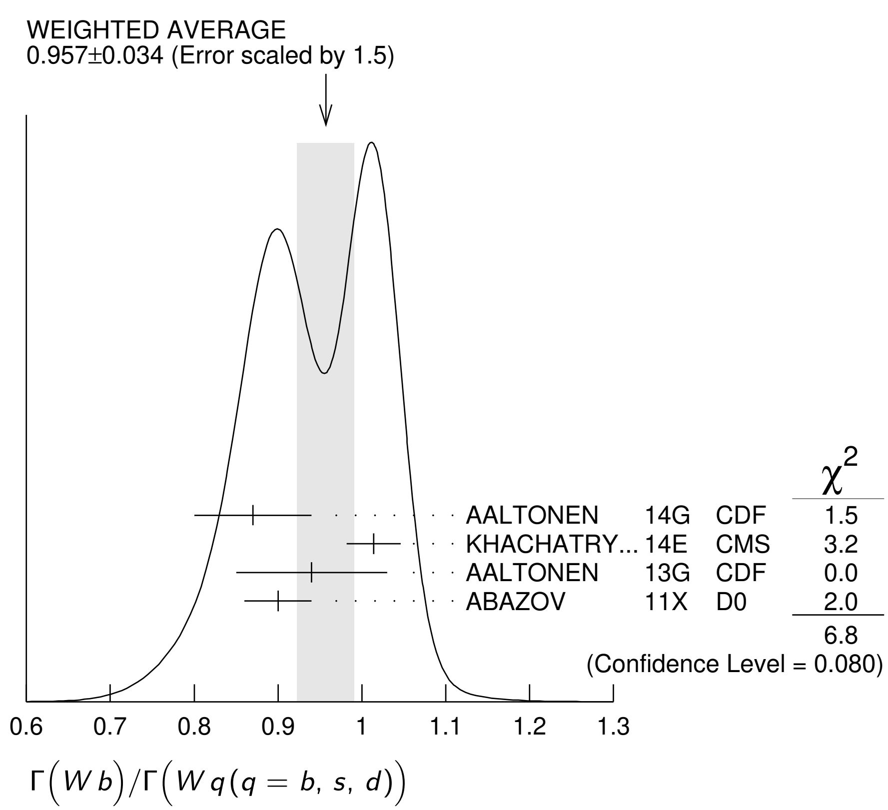
[4] Based on 5.4 fb^{-1} of data. The error is statistical and systematic combined. The result is a combination of 0.95 ± 0.07 from $\ell +$ jets channel and 0.86 ± 0.05 from $\ell\ell$ channel. $|V^{tb}| = 0.95 \pm 0.02$ follows from the result by assuming unitarity of the 3x3 CKM matrix.

[5] Result is based on 0.9 fb^{-1} of data. The 95% CL lower bound $R > 0.79$ gives $|V_{tb}| > 0.89$ (95% CL).

[6] ABAZOV 06K result is from the analysis of $t\overline{t} \to \ell\nu + \geq 3$ jets with 230 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV. It gives $R > 0.61$ and $|V_{tb}| > 0.78$ at 95% CL. Superseded by ABAZOV 08M.

[7] ACOSTA 05A result is from the analysis of lepton + jets and di-lepton + jets final states of $t\overline{t}$ candidate events with $\sim$ 162 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV. The first error is statistical and the second systematic. It gives $R > 0.61$, or $|V_{tb}| > 0.78$ at 95% CL.

[8] AFFOLDER 01C measures the top-quark decay width ratio $R = \Gamma(W b)/\Gamma(W q)$, where q is a d, s, or b quark, by using the number of events with multiple b tags. The first error is statistical and the second systematic. A numerical integration of the likelihood function gives $R > 0.61$ (0.56) at 90% (95%) CL. By assuming three generation unitarity, $|V_{tb}| = 0.97^{+0.16}_{-0.12}$ or $|V_{tb}| > 0.78$ (0.75) at 90% (95%) CL is obtained. The result is based on 109 pb^{-1} of data at $\sqrt{s} = 1.8$ TeV.



$\Gamma(e \nu_e b)/\Gamma_{total}$ Γ_3/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.111±0.003	[1] AAD	15CC	ATLS	ℓ+jets, $\ell\ell$+jets, $\ell\tau_h$+jets

[1] AAD 15CC based on 4.6 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. The original value is given by $13.3 \pm 0.4 \pm 0.5\%$, which includes electrons from the decay of τ leptons. It is assumed that the top branching ratios to leptons and jets add up to one and that only SM processes contribute to the background. The event selection criteria are optimized for the $\ell\tau_h$ + jets channel. We have converted the original value to eliminate contributions of electrons from τ's, by using the AAD 15CC measurements of the branching ratios to μ and τ channels, as well as the PDG values of τ branching ratios into e and μ channels.

$\Gamma(\mu \nu_\mu b)/\Gamma_{total}$ Γ_4/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.114±0.002	[1] AAD	15CC	ATLS	ℓ+jets, $\ell\ell$+jets, $\ell\tau_h$+jets

[1] AAD 15CC based on 4.6 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. The original value is given by $13.4 \pm 0.3 \pm 0.5\%$, which includes muons from the decay of τ leptons. It is assumed that the top branching ratios to leptons and jets add up to one and that only SM processes contribute to the background. The event selection criteria are optimized for the $\ell\tau_h$ + jets channel. We have converted the original value to eliminate contributions of muons from τ's, by using the AAD 15CC measurements of the branching ratios to μ and τ channels, as well as the PDG values of τ branching ratios into e and τ channels.

$\Gamma(\tau \nu_\tau b)/\Gamma_{total}$ Γ_5/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.107 ±0.005 OUR AVERAGE				
0.1050±0.0009±0.0071	[1] SIRUNYAN	20V	CMS	$\ell\tau_h$ + $\geq$ 3 jets ($\geq$ 1b-tag)
0.112 ±0.009	[2] AAD	15CC	ATLS	ℓ+jets, $\ell\ell$+jets, $\ell\tau_h$+jets
0.096 ±0.028	[3] AALTONEN	14A	CDF	ℓ+τ_h+ $\geq$ 2jets ($\geq$ 1b-tag)
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[4] ABULENCIA	06R	CDF	$\ell\tau$ + jets
	[5] ABE	97V	CDF	$\ell\tau$ + jets

[1] SIRUNYAN 20V based on 35.9 fb^{-1} of pp data at $\sqrt{s} = 13$ TeV. $t\overline{t}$ events are selected in the $t\overline{t} \rightarrow (\ell\nu_\ell)(\tau_h\nu_\tau)b\overline{b}$ mode, where τ_h refers to the hadronic decays of τ. The branching ratio is determined with respect to the $t\overline{t}$ inclusive cross section extrapolated from the light dilepton mode. The ratio of the $t\overline{t}$ production cross sections in the $\ell\tau_h$ and $\ell\ell$ channels yields $0.973 \pm 0.009 \pm 0.066$, consistent with lepton universality.

[2] AAD 15CC based on 4.6 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. The original value is given by $7.0 \pm 0.3 \pm 0.5\%$, which includes only the hadronic decay of τ leptons. It is assumed that the top branching ratios to leptons and jets add up to one and that only SM processes contribute to the background. The event selection criteria are optimized for the $\ell\tau_h$ + jets channel. We have converted the original value to include leptonic decays of τ's, by using the AAD 15CC measurements of the branching ratios to e and μ channels, as well as the PDG values of τ branching ratios into e and μ channels.

[3] Based on 9 fb^{-1} of data. The measurement is in the channel $t\overline{t} \rightarrow (b\ell\nu)(b\tau\nu)$, where τ decays into hadrons (τ_h), and ℓ (e or μ) include ℓ from τ decays (τ_ℓ). The result is consistent with lepton universality.

[4] ABULENCIA 06R looked for $t\overline{t} \rightarrow (\ell\nu_\ell)(\tau\nu_\tau)b\overline{b}$ events in 194 pb^{-1} of $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. 2 events are found where 1.00 ± 0.17 signal and 1.29 ± 0.25 background events are expected, giving a 95% CL upper bound for the partial width ratio $\Gamma(t \rightarrow \tau\nu q) / \Gamma_{SM}(t \rightarrow \tau\nu q) < 5.2$.

[5] ABE 97V searched for $t\overline{t} \rightarrow (\ell\nu_\ell)(\tau\nu_\tau)b\overline{b}$ events in 109 pb^{-1} of $p\overline{p}$ collisions at $\sqrt{s} = 1.8$ TeV. They observed 4 candidate events where one expects ~ 1 signal and ~ 2 background events. Three of the four observed events have jets identified as b candidates.

$\Gamma(q\overline{q}b)/\Gamma_{total}$ — Γ_6/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.665±0.004±0.013	[1] AAD	15CC	ATLS	ℓ+jets, $\ell\ell$+jets, $\ell\tau_h$+jets

[1] AAD 15CC based on 4.6 fb^{-1} of pp data at $\sqrt{s}=7$ TeV. Branching ratio of top quark into b and jets. It is assumed that the top branching ratios to leptons and jets add up to one and that only SM processes contribute to the background. The event selection criteria are optimized for the $\ell\tau_h$ + jets channel.

$\Gamma(\gamma q(q=u,c))/\Gamma_{total}$ — Γ_7/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.85 × 10^{-5}	95	[1] AAD	23	ATLS	B($t \to \gamma u$), left-handed $t u \gamma$ coupling
<4.2 × 10^{-5}	95	[1] AAD	23	ATLS	B($t \to \gamma c$), left-handed $t c \gamma$ coupling
<1.2 × 10^{-5}	95	[1] AAD	23	ATLS	B($t \to \gamma u$), right-handed $t u \gamma$ coupling
<4.5 × 10^{-5}	95	[1] AAD	23	ATLS	B($t \to \gamma c$), right-handed $t c \gamma$ coupling
<1.3 × 10^{-4}	95	[2] KHACHATRY...	16AS	CMS	B($t \to \gamma u$)
<1.7 × 10^{-3}	95	[2] KHACHATRY...	16AS	CMS	B($t \to \gamma c$)
<5.9 × 10^{-3}	95	[3] CHEKANOV	03	ZEUS	B($t \to \gamma u$)
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<2.8 × 10^{-5}	95	[4] AAD	20B	ATLS	B($t \to \gamma u$), left-handed $t u \gamma$ coupling, Repl. by AAD 23
<6.1 × 10^{-5}	95	[4] AAD	20B	ATLS	B($t \to \gamma u$), right-handed $t u \gamma$ coupling, Repl. by AAD 23
<2.2 × 10^{-4}	95	[4] AAD	20B	ATLS	B($t \to \gamma c$), left-handed $t c \gamma$ coupling, Repl. by AAD 23
<1.8 × 10^{-4}	95	[4] AAD	20B	ATLS	B($t \to \gamma c$), right-handed $t c \gamma$ coupling, Repl. by AAD 23
<0.0064	95	[5] AARON	09A	H1	$t \to \gamma u$
<0.0465	95	[6] ABDALLAH	04C	DLPH	B(γc or γu)
<0.0132	95	[7] AKTAS	04	H1	B($t \to \gamma u$)
<0.041	95	[8] ACHARD	02J	L3	B($t \to \gamma c$ or γu)
<0.032	95	[9] ABE	98G	CDF	$t\overline{t} \to (W b)(\gamma c$ or $\gamma u)$

[1] AAD 23 based on 139 fb^{-1} of data in pp collisions at $\sqrt{s}=13$ TeV. Anomalous FCNC left-handed and right-handed couplings are searched for through the single top production in association with a photon and in the decay of a top quark in the $t\overline{t}$ production. The SM predictions of the corresponding branching ratios are of the order of 10^{-14}.

[2] KHACHATRYAN 16AS based on 19.8 fb^{-1} of data in pp collisions at $\sqrt{s}=8$ TeV. FCNC through single top production in association with a photon is searched for in the mode $\mu+\gamma+\not{E}_T+\geq$ 1j (0,1b). Bounds on the anomalous FCNC couplings are given by $\kappa_{t u \gamma} < 0.025$ and $\kappa_{t c \gamma} < 0.091$.

[3] CHEKANOV 03 looked for single top production via FCNC in the reaction $e^{\pm} p \to e^{\pm}$ (t or $\overline{t}$) X in 130.1 pb^{-1} of data at $\sqrt{s}$=300–318 GeV. No evidence for top production and its decay into bW was found. The result is obtained for m_t=175 GeV when B(γc)=B(Zq)=0, where q is a u or c quark. Bounds on the effective t-u-γ and t-u-Z couplings are found in their Fig. 4. The conversion to the constraint listed is from private communication, E. Gallo, January 2004.

[4] AAD 20B based on 81 fb^{-1} of data in pp collisions at $\sqrt{s}=13$ TeV. FCNC through single top production in association with a photon is searched for in the mode $\ell\gamma+\not{E}_T$

$+$ 1j (b-tag). Anomalous FCNC left-handed and right-handed couplings are searched for, which result in different kinematical properties of top decay such as the lepton distribution. Limits are set on the $tq\gamma$ couplings in an effective field theory.

[5] AARON 09A looked for single top production via FCNC in $e^{\pm}p$ collisions at HERA with 474 pb^{-1}. The upper bound of the cross section gives the bound on the FCNC coupling $\kappa_{tu\gamma}/\Lambda < 1.03$ TeV^{-1}, which corresponds to the result for $m_t = 175$ GeV.

[6] ABDALLAH 04C looked for single top production via FCNC in the reaction $e^+e^- \rightarrow \overline{t}c$ or $\overline{t}u$ in 541 pb^{-1} of data at $\sqrt{s}$=189–208 GeV. No deviation from the SM is found, which leads to the bound on B($t \rightarrow \gamma q$), where q is a u or a c quark, for m_t = 175 GeV when B($t \rightarrow Zq$)=0 is assumed. The conversion to the listed bound is from private communication, O. Yushchenko, April 2005. The bounds on the effective t-q-γ and t-q-Z couplings are given in their Fig. 7 and Table 4, for m_t = 170–180 GeV, where most conservative bounds are found by choosing the chiral couplings to maximize the negative interference between the virtual γ and Z exchange amplitudes.

[7] AKTAS 04 looked for single top production via FCNC in $e^{\pm}$ collisions at HERA with 118.3 pb^{-1}, and found 5 events in the e or μ channels. By assuming that they are due to statistical fluctuation, the upper bound on the $tu\gamma$ coupling $\kappa_{tu\gamma} < 0.27$ (95% CL) is obtained. The conversion to the partial width limit, when B(γc) = B(Zu) = B(Zc) = 0, is from private communication, E. Perez, May 2005.

[8] ACHARD 02J looked for single top production via FCNC in the reaction $e^+e^- \rightarrow \overline{t}c$ or $\overline{t}u$ in 634 pb^{-1} of data at $\sqrt{s}$= 189–209 GeV. No deviation from the SM is found, which leads to a bound on the top-quark decay branching fraction B(γq), where q is a u or c quark. The bound assumes B(Zq)=0 and is for m_t= 175 GeV; bounds for m_t=170 GeV and 180 GeV and B(Zq) $\neq$ 0 are given in Fig. 5 and Table 7.

[9] ABE 98G looked for $t\overline{t}$ events where one t decays into $q\gamma$ while the other decays into bW. The quoted bound is for $\Gamma(\gamma q)/\Gamma(Wb)$.

$\Gamma(H^+b,\ H^+ \rightarrow \tau\nu_\tau)/\Gamma_{total}$ Γ_8/Γ

VALUE (%)	CL%	DOCUMENT ID		TECN
<0.25	95	[1] AABOUD	18BW	ATLS

[1] AABOUD 18BW based on 36.1 fb^{-1} of pp data at $\sqrt{s}$ = 13 TeV. In the mass range of m_{H^+} = 90–160 GeV, assuming the SM cross section for the $t\overline{t}$ production, the upper limit for the branching fraction B($t \rightarrow bH^+$) $\times$ B($H^+ \rightarrow \tau\nu_\tau$) ranges between 0.25% and 0.031%.

$\Gamma(Zq(q=u,c))/\Gamma_{total}$ Γ_9/Γ

Test for ΔT=1 weak neutral current. Allowed by higher-order electroweak interaction.

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
< 0.062	95	[1] AAD	23AS	ATLS	B($t \rightarrow Zu$), left-handed tuZ coupling
< 0.13	95	[1] AAD	23AS	ATLS	B($t \rightarrow Zc$), left-handed tcZ coupling
< 0.066	95	[1] AAD	23AS	ATLS	B($t \rightarrow Zu$), right-handed tuZ coupling
< 0.12	95	[1] AAD	23AS	ATLS	B($t \rightarrow Zc$), right-handed tcZ coupling
< 0.22	95	[2] SIRUNYAN	17E	CMS	$t \rightarrow Zu$
< 0.49	95	[2] SIRUNYAN	17E	CMS	$t \rightarrow Zc$
< 0.7	95	[3] AAD	16D	ATLS	$t \rightarrow Zq$ ($q = u$, c)
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 0.17	95	[4] AABOUD	18AT	ATLS	$t \rightarrow Zu$
< 0.24	95	[4] AABOUD	18AT	ATLS	$t \rightarrow Zc$

$<$ 0.6		95	[5] CHATRCHYAN	14S	CMS	$t \to Zq$ ($q = u, c$)
$<$ 0.5		95	[6] CHATRCHYAN	14S	CMS	$t \to Zq$ ($q = u, c$)
$<$ 2.1		95	[7] CHATRCHYAN	13F	CMS	$t \to Zq$ ($q = u, c$)
$<$ 7.3		95	[8] AAD	12BT	ATLS	$t\overline{t} \to \ell^+ \ell^- \ell'^\pm + \not{E}_T$ + jets
$<$32		95	[9] ABAZOV	11M	D0	$t \to Zq$ ($q = u, c$)
$<$83		95	[10] AALTONEN	09AL	CDF	$t \to Zq$ (q=c)
$<$37		95	[11] AALTONEN	08AD	CDF	$t \to Zq$ ($q = u, c$)
$<$ 1.59	$\times 10^2$	95	[12] ABDALLAH	04C	DLPH	$e^+ e^- \to \overline{t}c$ or $\overline{t}u$
$<$ 1.37	$\times 10^2$	95	[13] ACHARD	02J	L3	$e^+ e^- \to \overline{t}c$ or $\overline{t}u$
$<$ 1.4	$\times 10^2$	95	[14] HEISTER	02Q	ALEP	$e^+ e^- \to \overline{t}c$ or $\overline{t}u$
$<$ 1.37	$\times 10^2$	95	[15] ABBIENDI	01T	OPAL	$e^+ e^- \to \overline{t}c$ or $\overline{t}u$
$<$ 1.7	$\times 10^2$	95	[16] BARATE	00S	ALEP	$e^+ e^- \to \overline{t}c$ or $\overline{t}u$
$<$ 3.3	$\times 10^2$	95	[17] ABE	98G	CDF	$t\overline{t} \to (Wb)(Zc$ or $Zu)$

[1] AAD 23AS based on 139 fb^{-1} of data in pp collisions at $\sqrt{s}$ = 13 TeV. Anomalous FCNC left-handed and right-handed couplings are searched for through the single top production in association with a Z boson and in the decay of a top quark in the $t\overline{t}$ production. Events with $3\ell + \geq 1$ jet(s) (1b-tagged) + $\not{E}_T$ are used. The SM predictions of the corresponding branching ratios are of the order of 10^{-14}.

[2] SIRUNYAN 17E based on 19.7 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. The final states $t\overline{t} \to \ell^+ \ell^- \ell'^\pm \nu$ + jets (ℓ, ℓ' = e, μ) are investigated and the cross section $\sigma(pp \to tZq \to \ell\nu b\ell^+\ell^- q) = 10^{+8}_{-7}$ fb is measured, giving no sign of FCNC decays of the top quark.

[3] AAD 16D based on 20.3 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. The FCNC decay is searched for in $t\overline{t}$ events in the final state $(bW)(qZ)$ when both W and Z decay leptonically, giving 3 charged leptons.

[4] Based on 36.1 fb^{-1} of pp data at $\sqrt{s}$ = 13 TeV. The final states $t\overline{t} \to \ell^+ \ell^- \ell'^\pm \nu$ + jets (ℓ, ℓ' = e, μ) are investigated and no significant excess over the SM background contributions is observed.

[5] Based on 19.7 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. The flavor changing decay is searched for in $t\overline{t}$ events in the final state $(bW)(qZ)$ when both W and Z decay leptoically, giving 3 charged leptons.

[6] CHATRCHYAN 14S combined search limit from this and CHATRCHYAN 13F data.

[7] Based on 5.0 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. Search for FCNC decays of the top quark in $t\overline{t} \to \ell^+ \ell^- \ell'^\pm \nu$ + jets (ℓ, ℓ' = e, μ) final states found no excess of signal events.

[8] Based on 2.1 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV.

[9] Based on 4.1 fb^{-1} of data. ABAZOV 11M searched for FCNC decays of the top quark in $t\overline{t} \to \ell^+ \ell^- \ell'^\pm \nu$ + jets (ℓ, ℓ' = e, μ) final states, and absence of the signal gives the bound.

[10] Based on $p\overline{p}$ data of 1.52 fb^{-1}. AALTONEN 09AL compared $t\overline{t} \to WbWb \to \ell\nu bjjb$ and $t\overline{t} \to ZcWb \to \ell\ell cjjb$ decay chains, and absence of the latter signal gives the bound. The result is for 100% longitudinally polarized Z boson and the theoretical $t\overline{t}$ production cross section The results for different Z polarizations and those without the cross section assumption are given in their Table XII.

[11] Result is based on 1.9 fb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. $t\overline{t} \to WbZq$ or $ZqZq$ processes have been looked for in $Z + \geq 4$ jet events with and without b-tag. No signal leads to the bound B($t \to Zq$) $<$ 0.037 (0.041) for m_t = 175 (170) GeV.

[12] ABDALLAH 04C looked for single top production via FCNC in the reaction $e^+ e^- \to \overline{t}c$ or $\overline{t}u$ in 541 pb^{-1} of data at $\sqrt{s}$=189–208 GeV. No deviation from the SM is found, which leads to the bound on B($t \to Zq$), where q is a u or a c quark, for m_t = 175 GeV when B($t \to \gamma q$)=0 is assumed. The conversion to the listed bound is from private communication, O. Yushchenko, April 2005. The bounds on the effective t-q-γ and t-q-Z couplings are given in their Fig. 7 and Table 4, for m_t = 170–180 GeV, where most conservative bounds are found by choosing the chiral couplings to maximize the negative interference between the virtual γ and Z exchange amplitudes.

[13] ACHARD 02J looked for single top production via FCNC in the reaction $e^+ e^- \to \overline{t} c$ or $\overline{t} u$ in 634 pb^{-1} of data at $\sqrt{s}$= 189–209 GeV. No deviation from the SM is found, which leads to a bound on the top-quark decay branching fraction B(Zq), where q is a u or c quark. The bound assumes B(γq)=0 and is for m_t= 175 GeV; bounds for m_t=170 GeV and 180 GeV and B(γq) ≠0 are given in Fig. 5 and Table 7. Table 6 gives constraints on t-c-e-e four-fermi contact interactions.

[14] HEISTER 02Q looked for single top production via FCNC in the reaction $e^+ e^- \to \overline{t} c$ or $\overline{t} u$ in 214 pb^{-1} of data at $\sqrt{s}$= 204–209 GeV. No deviation from the SM is found, which leads to a bound on the branching fraction B(Zq), where q is a u or c quark. The bound assumes B(γq)=0 and is for m_t= 174 GeV. Bounds on the effective t- (c or u)-γ and t- (c or u)- Z couplings are given in their Fig. 2.

[15] ABBIENDI 01T looked for single top production via FCNC in the reaction $e^+ e^- \to \overline{t} c$ or $\overline{t} u$ in 600 pb^{-1} of data at $\sqrt{s}$= 189–209 GeV. No deviation from the SM is found, which leads to bounds on the branching fractions B(Zq) and B(γq), where q is a u or c quark. The result is obtained for m_t= 174 GeV. The upper bound becomes 9.7% (20.6%) for m_t= 169 (179) GeV. Bounds on the effective t- (c or u)-γ and t- (c or u)-Z couplings are given in their Fig. 4.

[16] BARATE 00S looked for single top production via FCNC in the reaction $e^+ e^- \to \overline{t} c$ or $\overline{t} u$ in 411 pb^{-1} of data at c.m. energies between 189 and 202 GeV. No deviation from the SM is found, which leads to a bound on the branching fraction. The bound assumes B(γq)=0. Bounds on the effective t- (c or u)-γ and t- (c or u)-Z couplings are given in their Fig. 4.

[17] ABE 98G looked for $t\overline{t}$ events where one t decays into three jets and the other decays into qZ with $Z \to \ell\ell$. The quoted bound is for $\Gamma(Zq)/\Gamma(Wb)$.

$\Gamma(Hu)/\Gamma_{total}$ Γ_{10}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
< 1.9	95	[1] TUMASYAN	22A	CMS	$t \to Hu$ ($H \to \gamma\gamma$)
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 3.8	95	[2] AAD	23CJ	ATLS	$pp \to tH$ or $t \to Hu$ ($H \to \gamma\gamma$)
< 4.0	95	[3] AAD	23CJ	ATLS	$pp \to tH$ or $t \to Hu$ (combined with $H \to \gamma\gamma$, $H \to bb$, $H \to \tau\tau$)
< 6.9	95	[4] AAD	23H	ATLS	$pp \to tH$ or $t \to Hu$ ($H \to \tau\tau$)
< 7.9	95	[5] TUMASYAN	22K	CMS	$t \to Hu$ ($H \to bb$)
<52	95	[6] AABOUD	19S	ATLS	$t \to Hu$ ($H \to bb$)
<17	95	[7] AABOUD	19S	ATLS	$t \to Hu$ ($H \to \tau\tau$)
<12	95	[8] AABOUD	19S	ATLS	combination of $t \to Hu$ ($H \to WW, ZZ, \tau\tau, \gamma\gamma, b\overline{b}$)
<19	95	[9] AABOUD	18X	ATLS	$t \to Hu$ ($H \to WW, ZZ, \tau\tau$)
<47	95	[10] SIRUNYAN	18BC	CMS	$t \to Hu$ ($H \to bb$)
<24	95	[11] AABOUD	17AV	ATLS	$t \to Hu$ ($H \to \gamma\gamma$)
<55	95	[12] KHACHATRY...	17I	CMS	$t \to Hu$ ($H \to WW, ZZ, \tau\tau, \gamma\gamma, b\overline{b}$)
<61	95	[13] AAD	15CO	ATLS	$t \to Hu$ ($H \to bb$)
<79	95	[14] AAD	14AA	ATLS	$t \to Hq$ (q=u,c; $H \to \gamma\gamma$)

[1] TUMASYAN 22A based on 137 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. The processes considered include both the associated production of a single top quark with a Higgs boson and the decay $t \to Hu$ in $t\overline{t}$ production using $H \to \gamma\gamma$.

[2] AAD 23CJ based on 139 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. The processes considered include both the associated production of a single top quark with a Higgs boson and the decay $t \to Hu$ in $t\overline{t}$ production using $H \to \gamma\gamma$. Limits on the SMEFT Wilson coefficients are derived.

[3] AAD 23CJ based on 139 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. The results are combined with searches in the $H \to \gamma\gamma$, $H \to bb$, and $H \to \tau\tau$ final states. Limits on the SMEFT Wilson coefficients are also derived.

[4] AAD 23H based on 139 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Uses events with one or two hadronically decaying τ and multiple jets. The limit corresponds to $(3.5^{+1.5}_{-1.0}) \times 10^{-4}$ measurement.

[5] TUMASYAN 22K based on 137 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Uses events with one isolated lepton and multiple jets (including $\geq$ 2b-jets). Deep neural networks are used for kinematical event reconstruction.

[6] AABOUD 19S based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Uses events with one isolated lepton and multiple jets (several of them b-tagged with high purity). A multivariate analysis is performed to distinguish the signal from backgrounds.

[7] AABOUD 19S based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Uses events with one or two hadronically decaying τ and multiple jets. A multivariate analysis is performed to distinguish the signal from backgrounds.

[8] AABOUD 19S based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. The searches using $H \to bb$ and $H \to \tau_h\tau_h$ are combined with searches in diphoton and multilepton final states. The upper limit on the Yukawa coupling $|Y_{tuH}| < 0.066$ (95% CL) is obtained.

[9] AABOUD 18X based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. $\ell\ell$(same sign) $+ \geq$ 4j mode and $\ell\ell\ell + \geq$ 2j mode are targeted and specialized boosted decision trees are used to distinguish signals from backgrounds.

[10] SIRUNYAN 18BC based on 35.9 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Two channels $pp \to tH$ and $pp \to t\overline{t}$ in final states with one isolated lepton and >=3 jets with >=2 b jets are considered assuming a single tHu FCNC coupling. Reconstructed kinematical variables are fed into a multivariate analysis and no significant deviation is observed from the predicted background.

[11] AABOUD 17AV based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Search for $t\overline{t}$ events, where the other top quark decays hadronically or semi-leptonically.

[12] KHACHATRYAN 17I based on 19.7 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV, using the topologies $t\overline{t} \to Hq+Wb$, where q=u, c.

[13] AAD 15CO based on 20.3 fb^{-1} at $\sqrt{s}$ = 8 TeV of pp data. Searches for $t\overline{t}$ events, where the other top quark decays semi-leptonically. Exploits high multiplicity of b-jets and uses a likelihood discriminant. Combining with other ATLAS searches for different Higgs decay modes, B($t \to Hc$) < 0.46% and B($t \to Hu$) < 0.45% are obtained.

[14] AAD 14AA based on 4.7 fb^{-1} at $\sqrt{s}$ = 7 TeV and 20.3 fb^{-1} at $\sqrt{s}$ = 8 TeV of pp data. The upper-bound is for the sum of Br($t \to Hc$) and Br($t \to Hu$). Search for $t\overline{t}$ events, where the other top quark decays hadronically or semi-leptonically. The upper bound constrains the H-t-c Yukawa couplings $\sqrt{|Y^H_{tc_L}|^2 + |Y^H_{tc_R}|^2} < 0.17$ (95% CL).

$\Gamma(Hc)/\Gamma_{\text{total}}$ — Γ_{11}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
< 4.3	95	[1] AAD	23CJ	ATLS	$pp \to tH$ or $t \to Hc$ ($H \to \gamma\gamma$)
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 5.8	95	[2] AAD	23CJ	ATLS	$pp \to tH$ or $t \to Hc$ (combined with $H \to \gamma\gamma$, $H \to bb$, $H \to \tau\tau$)
< 9.4	95	[3] AAD	23H	ATLS	$pp \to tH$ or $t \to Hc$ ($H \to \tau\tau$)

$<$ 7.3	95	[4] TUMASYAN	22A	CMS	$t \to Hc$ ($H \to \gamma\gamma$)
$<$ 9.4	95	[5] TUMASYAN	22K	CMS	$t \to Hc$ ($H \to bb$)
$<$11	95	[6] AABOUD	19S	ATLS	combination of $t \to Hc$ ($H \to WW, ZZ, \tau\tau, \gamma\gamma, b\overline{b}$)
$<$42	95	[7] AABOUD	19S	ATLS	$t \to Hc$ ($H \to bb$)
$<$19	95	[8] AABOUD	19S	ATLS	$t \to Hc$ ($H \to \tau\tau$)
$<$16	95	[9] AABOUD	18X	ATLS	$t \to Hc$ ($H \to WW, ZZ, \tau\tau$)
$<$47	95	[10] SIRUNYAN	18BC	CMS	$t \to Hc$ ($H \to bb$)
$<$22	95	[11] AABOUD	17AV	ATLS	$t \to Hc$ ($H \to \gamma\gamma$)
$<$40	95	[12] KHACHATRY...	17I	CMS	$t \to Hc$ ($H \to WW, ZZ, \tau\tau, \gamma\gamma, b\overline{b}$)
$<$56	95	[13] AAD	15CO	ATLS	$t \to Hc$ ($H \to bb$)
$<$79	95	[14] AAD	14AA	ATLS	$t \to Hq$ (q=u,c; $H \to \gamma\gamma$)
$< 1.3 \times 10^2$	95	[15] CHATRCHYAN	14R	CMS	$t \to Hc$ ($H \to \geq 2\ \ell$)
$<$56	95	[16] KHACHATRY...	14Q	CMS	$t \to Hc$ ($H \to \gamma\gamma$ or leptons)

[1] AAD 23CJ based on 139 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. The processes considered include both the associated production of a single top quark with a Higgs boson and the decay $t \to Hc$ in $t\overline{t}$ production using $H \to \gamma\gamma$. Limits on the SMEFT Wilson coefficients are derived.

[2] AAD 23CJ based on 139 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. The results are combined with searches in the $H \to \gamma\gamma$, $H \to bb$, and $H \to \tau\tau$ final states. Limits on the SMEFT Wilson coefficients are also derived.

[3] AAD 23H based on 139 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Uses events with one or two hadronically decaying τ and multiple jets. The limit corresponds to $(4.8^{+2.2}_{-1.4}) \times 10^{-4}$ measurement.

[4] TUMASYAN 22A based on 137 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. The processes considered include both the associated production of a single top quark with a Higgs boson and the decay $t \to Hc$ in $t\overline{t}$ production using $H \to \gamma\gamma$.

[5] TUMASYAN 22K based on 137 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Uses events with one isolated lepton and multiple jets (including $\geq$ 2b-jets). Deep neural networks are used for kinematical event reconstruction.

[6] AABOUD 19S based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. The searches using $H \to bb$ and $H \to \tau_h\tau_h$ are combined with searches in diphoton and multilepton final states. The upper limit on the Yukawa coupling $|Y_{tcH}| <$ 0.064 (95% CL) is obtained.

[7] AABOUD 19S based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Uses events with one isolated lepton and multiple jets (several of them b-tagged with high purity). A multivariate analysis is performed to distinguish the signal from backgrounds.

[8] AABOUD 19S based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Uses events with one or two hadronically decaying τ and multiple jets. A multivariate analysis is performed to distinguish the signal from backgrounds.

[9] AABOUD 18X based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. $\ell\ell$(same sign) $+ \geq$ 4j mode and $\ell\ell\ell + \geq$ 2j mode are targeted and specialized boosted decision trees are used to distinguish signals from backgrounds.

[10] SIRUNYAN 18BC based on 35.9 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Two channels $pp \to tH$ and $pp \to t\overline{t}$ in final states with one isolated lepton and >=3 jets with >=2 b jets are considered assuming a single tHc FCNC coupling. Reconstructed kinematical variables are fed into a multivariate analysis and no significant deviation is observed from the predicted background.

[11] AABOUD 17AV based on 36.1 fb^{-1} at $\sqrt{s}$ = 13 TeV of pp data. Search for $t\overline{t}$ events, where the other top quark decays hadronically or semi-leptonically. The upper bound on the H-t-c Yukawa couplings is 0.090 (95% CL).

[12] KHACHATRYAN 17I based on 19.7 fb^{-1} of pp data at $\sqrt{s}=8$ TeV, using the topologies $t\overline{t} \rightarrow Hq+Wb$, where $q=u$, c.

[13] AAD 15CO based on 20.3 fb^{-1} at $\sqrt{s}=8$ TeV of pp data. Searches for $t\overline{t}$ events, where the other top quark decays semi-leptonically. Exploits high multiplicity of b-jets and uses a likelihood discriminant. Combining with other ATLAS searches for different Higgs decay modes, B($t \rightarrow Hc$) < 0.46% and B($t \rightarrow Hu$) < 0.45% are obtained.

[14] AAD 14AA based on 4.7 fb^{-1} at $\sqrt{s}=7$ TeV and 20.3 fb^{-1} at $\sqrt{s}=8$ TeV of pp data. The upper-bound is for the sum of Br($t \rightarrow Hc$) and Br($t \rightarrow Hu$). Search for $t\overline{t}$ events, where the other top quark decays hadronically or semi-leptonically. The upper bound constrains the H-t-c Yukawa couplings $\sqrt{|Y^H_{tc_L}|^2+|Y^H_{tc_R}|^2} < 0.17$ (95% CL).

[15] Based on 19.5 fb^{-1} of pp data at $\sqrt{s}=8$ TeV. Search for final states with 3 or more isolated high E_T charged leptons ($\ell = e$, μ) bounds the $t \rightarrow Hc$ decay in $t\overline{t}$ events when H decays contain a pair of leptons. The upper bound constrains the H-t-c Yukawa couplings $\sqrt{|Y^H_{tc_L}|^2+|Y^H_{tc_R}|^2} < 0.21$ (95% CL).

[16] KHACHATRYAN 14Q based on 19.5 fb^{-1} at $\sqrt{s}=8$ TeV of pp data. Search for final states with ≥ 3 isolated charged leptons or with a photon pair accompanied by ≥ 1 lepton(s).

$\Gamma(\ell^+\overline{q}\overline{q}'(q=d,s,b;\,q'=u,c))/\Gamma_{total}$ — Γ_{12}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<1.6 × 10^{-3}	95	[1] CHATRCHYAN 14O	CMS	μ + dijets
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<1.7 × 10^{-3}	95	[1] CHATRCHYAN 14O	CMS	e + dijets

[1] Based on 19.5 fb^{-1} of pp data at $\sqrt{s}=8$ TeV. Baryon number violating decays of the top quark are searched for in $t\overline{t}$ production events where one of the pair decays into hadronic three jets.

$\Gamma(e^{\pm}\mu^{\mp}c)/\Gamma_{total}$ — Γ_{13}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
<8.9 × 10^{-7}	[1] TUMASYAN 22Z	CMS	pp at 13 TeV

[1] TUMASYAN 22Z analysis includes both the production ($c \rightarrow e\mu t$) and decay ($t \rightarrow e\mu c$) modes of the top quark through CFLV interactions. With no significant excess over the standard model expectation, the limits are set at 95% CL on the B($t \rightarrow e\mu c$) of 1.31×10^{-6}, 0.89×10^{-6}, 2.59×10^{-6} for vector-, scalar-, and tensor-like CLFV four-fermion effective interactions, respectively.

$\Gamma(e^{\pm}\mu^{\mp}u)/\Gamma_{total}$ — Γ_{14}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
<7 × 10^{-8}	[1] TUMASYAN 22Z	CMS	pp at 13 TeV

[1] TUMASYAN 22Z analysis includes both the production ($u \rightarrow e\mu t$) and decay ($t \rightarrow e\mu u$) modes of the top quark through CFLV interactions. With no significant excess over the standard model expectation, the limits are set at 95% CL on the B($t \rightarrow e\mu u$) of 0.13×10^{-6}, 0.07×10^{-6}, 0.25×10^{-6} for vector-, scalar-, and tensor-like CLFV four-fermion effective interactions, respectively.

t-quark EW Couplings

W helicity fractions in top decays. F_0 is the fraction of longitudinal and F_+ the fraction of right-handed W bosons. F_{V+A} is the fraction of $V+A$ current in top decays. The effective Lagrangian (cited by ABAZOV 08AI) has terms f_1^L and f_1^R for $V-A$ and $V+A$ couplings, f_2^L and f_2^R for tensor couplings with b_R and b_L respectively.

F_0

VALUE	DOCUMENT ID		TECN	COMMENT
0.693±0.013 OUR AVERAGE				
0.693±0.009±0.011	[1] AAD	20Y	LHC	ATLAS+CMS combined
0.726±0.066±0.067	[2] AALTONEN	13D	CDF	F_0 = B($t \to W_0 b$)
0.682±0.030±0.033	[3] CHATRCHYAN	13BH	CMS	F_0 = B($t \to W_0 b$)
0.67 ±0.07	[4] AAD	12BG	ATLS	F_0 = B($t \to W_0 b$)
0.722±0.062±0.052	[5] AALTONEN	12Z	TEVA	F_0 = B($t \to W_0 b$)
0.669±0.078±0.065	[6] ABAZOV	11C	D0	F_0 = B($t \to W_0 b$)
0.91 ±0.37 ±0.13	[7] AFFOLDER	00B	CDF	F_0 = B($t \to W_0 b$)
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.70 ±0.05	[8] AABOUD	17BB	ATLS	$F_0 = 1 - f_1$, Repl by AAD 20Y
0.681±0.012±0.023	[9] KHACHATRY...	16BU	CMS	F_0 = B($t \to W_0 b$), Repl by AAD 20Y
0.70 ±0.07 ±0.04	[10] AALTONEN	10Q	CDF	Repl. by AALTONEN 12Z
0.62 ±0.10 ±0.05	[11] AALTONEN	09Q	CDF	Repl. by AALTONEN 10Q
0.425±0.166±0.102	[12] ABAZOV	08B	D0	Repl. by ABAZOV 11C
0.85 $^{+0.15}_{-0.22}$ ±0.06	[13] ABULENCIA	07I	CDF	F_0 = B($t \to W_0 b$)
0.74 $^{+0.22}_{-0.34}$	[14] ABULENCIA	06U	CDF	F_0 = B($t \to W_0 b$)
0.56 ±0.31	[15] ABAZOV	05G	D0	F_0 = B($t \to W_0 b$)

[1] AAD 20Y based on about 20 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV for each experiment. The first error stands for the sum of the statistical and background uncertainties, and the second error for the remaining systematic uncertainties. The measurements used events with one lepton and different jet multiplicities in the final state. The result is consistent with the NNLO SM prediction of 0.687 ± 0.005 for m_t = 172.8 ± 1.3 GeV.

[2] Based on 8.7 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV using $t\overline{t}$ events with $\ell + \not{E}_T + \geq 4$ jets($\geq 1\ b$), and under the constraint $F_0 + F_+ + F_- = 1$. The statstical errors of F_0 and F_+ are correlated with correlation coefficient $\rho(F_0,F_+) = -0.69$.

[3] Based on 5.0 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. CHATRCHYAN 13BH studied tt events with large $\not{E}_T$ and $\ell + \geq 4$ jets using a constrained kinematic fit.

[4] Based on 1.04 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. AAD 12BG studied tt events with large $\not{E}_T$ and either $\ell + \geq 4$j or $\ell\ell + \geq 2$j. The uncertainties are not independent, $\rho(F_0,F_-) = -0.96$.

[5] Based on 2.7 and 5.1 fb^{-1} of CDF data in ℓ + jets and dilepton channels, and 5.4 fb^{-1} of D0 data in ℓ + jets and dilepton channels. $F_0 = 0.682 \pm 0.035 \pm 0.046$ if $F_+ = 0.0017(1)$, while $F_+ = -0.015 \pm 0.018 \pm 0.030$ if $F_0 = 0.688(4)$, where the assumed fixed values are the SM prediction for $m_t = 173.3 \pm 1.1$ GeV and $m_W = 80.399 \pm 0.023$ GeV.

[6] Results are based on 5.4 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV, including those of ABAZOV 08B. Under the SM constraint of $f_0 = 0.698$ (for m_t = 173.3 GeV, m_W = 80.399 GeV), $f_+ = 0.010 \pm 0.022 \pm 0.030$ is obtained.

[7] AFFOLDER 00B studied the angular distribution of leptonic decays of W bosons in $t \to W b$ events. The ratio F_0 is the fraction of the helicity zero (longitudinal) W bosons

in the decaying top quark rest frame. $B(t \to W_+ b)$ is the fraction of positive helicity (right-handed) positive charge W bosons in the top quark decays. It is obtained by assuming the Standard Model value of F_0.

[8] AABOUD 17BB based on 20.2 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. Triple-differential decay rate of top quark in the t-channel single-top production is used to simultaneously determine five generalized Wtb couplings as well as the top polarization. No assumption is made for the other couplings. See this paper for constraints on other couplings not included here. The paper reported f_1, and we converted it to F_0.

[9] KHACHATRYAN 16BU based on 19.8 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV using $t\overline{t}$ events with $\ell + \not{E}_T + \geq 4$ jets(≥ 2 b). The errors of F_0 and F_- are correlated with a correlation coefficient $\rho(F_0, F_-) = -0.87$. The result is consistent with the NNLO SM prediction of 0.687 $\pm$ 0.005 for m_t = 172.8 $\pm$ 1.3 GeV.

[10] Results are based on 2.7 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. F_0 result is obtained by assuming $F_+ = 0$, while F_+ result is obtained for $F_0 = 0.70$, the SM value. Model independent fits for the two fractions give $F_0 = 0.88 \pm 0.11 \pm 0.06$ and $F_+ = -0.15 \pm 0.07 \pm 0.06$ with correlation coefficient of -0.59. The results are for m_t = 175 GeV.

[11] Results are based on 1.9 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. F_0 result is obtained assuming $F_+ = 0$, while F_+ result is obtained for $F_0 = 0.70$, the SM values. Model independent fits for the two fractions give $F_0 = 0.66 \pm 0.16 \pm 0.05$ and $F_+ = -0.03 \pm 0.06 \pm 0.03$.

[12] Based on 1 fb^{-1} at $\sqrt{s}$ = 1.96 TeV.

[13] Based on 318 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV.

[14] Based on 200 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. $t \to Wb \to \ell\nu b$ ($\ell = e$ or μ). The errors are stat + syst.

[15] ABAZOV 05G studied the angular distribution of leptonic decays of W bosons in $t\overline{t}$ candidate events with lepton + jets final states, and obtained the fraction of longitudinally polarized W under the constraint of no right-handed current, $F_+ = 0$. Based on 125 pb^{-1} of data at $\sqrt{s}$ = 1.8 TeV.

F_-

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
0.315±0.010 OUR AVERAGE					
0.315±0.006±0.009		[1] AAD	20Y	LHC	ATLAS+CMS combined
0.310±0.022±0.022		[2] CHATRCHYAN	13BH	CMS	$F_- = B(t \to W_- b)$
0.32 ±0.04		[3] AAD	12BG	ATLS	$F_- = B(t \to W_- b)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
> 0.264 ± 0.044	95	[4] AABOUD	17BB	ATLS	$F_- = f_1(1 - f_1^+)$, Repl. by AAD 20Y
0.323±0.008±0.014		[5] KHACHATRY...	16BU	CMS	$F_- = B(t \to W_- b)$, Repl. by AAD 20Y

[1] AAD 20Y based on about 20 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV for each experiment. The first error stands for the sum of the statistical and background uncertainties, and the second error for the remaining systematic uncertainties. The measurements used events with one lepton and different jet multiplicities in the final state. The result is consistent with the NNLO SM prediction of 0.311 $\pm$ 0.005 for m_t = 172.8 $\pm$ 1.3 GeV.

[2] Based on 5.0 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. CHATRCHYAN 13BH studied tt events with large $\not{E}_T$ and $\ell + \geq 4$ jets using a constrained kinematic fit.

[3] Based on 1.04 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. AAD 12BG studied tt events with large $\not{E}_T$ and either $\ell + \geq$ 4j or $\ell\ell + \geq$ 2j. The uncertainties are not independent, $\rho(F_0,F_-) = -0.96$.

[4] AABOUD 17BB based on 20.2 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. Triple-differential decay rate of top quark in the t-channel single-top production is used to simultaneously determine five generalized Wtb couplings as well as the top polarization. No assumption is made for the other couplings. The authors reported $f_1 = 0.30 \pm 0.05$ and $f_1^+ < 0.120$ which we converted to $F_- = f_1(1 - f_1^+)$. See this paper for constraints on other couplings not included here.

[5] KHACHATRYAN 16BU based on 19.8 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV using $t\overline{t}$ events with $\ell + \not{E}_T + \geq 4$ jets(≥ 2 b). The errors of F_0 and F_- are correlated with a correlation coefficient $\rho(F_0, F_-) = -0.87$. The result is consistent with the NNLO SM prediction of 0.311 ± 0.005 for m_t = 172.8 ± 1.3 GeV.

F_+

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
−0.005±0.007 OUR AVERAGE					
−0.008±0.005±0.006		[1] AAD	20Y	LHC	ATLAS+CMS combined
−0.045±0.044±0.058		[2] AALTONEN	13D	CDF	$F_+ = B(t \to W_+ b)$
0.008±0.012±0.014		[3] CHATRCHYAN	13BH	CMS	$F_+ = B(t \to W_+ b)$
0.01 ±0.05		[4] AAD	12BG	ATLS	$F_+ = B(t \to W_+ b)$
0.023±0.041±0.034		[5] ABAZOV	11C	D0	$F_+ = B(t \to W_+ b)$
0.11 ±0.15		[6] AFFOLDER	00B	CDF	$F_+ = B(t \to W_+ b)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 0.036 ± 0.006	95	[7] AABOUD	17BB	ATLS	$F_+ = f_1 f_1^+$, Repl. by AAD 20Y
−0.004±0.005±0.014		[8] KHACHATRY...	16BU	CMS	$F_+ = B(t \to W_+ b)$, Repl. by AAD 20Y
−0.033±0.034±0.031		[9] AALTONEN	12Z	TEVA	$F_+ = B(t \to W_+ b)$
−0.01 ±0.02 ±0.05		[10] AALTONEN	10Q	CDF	Repl. by AALTONEN 13D
−0.04 ±0.04 ±0.03		[11] AALTONEN	09Q	CDF	Repl. by AALTONEN 10Q
0.119±0.090±0.053		[12] ABAZOV	08B	D0	Repl. by ABAZOV 11C
0.056±0.080±0.057		[13] ABAZOV	07D	D0	$F_+ = B(t \to W_+ b)$
0.05 $^{+0.11}_{-0.05}$ ±0.03		[14] ABULENCIA	07I	CDF	$F_+ = B(t \to W_+ b)$
< 0.26	95	[14] ABULENCIA	07I	CDF	$F_+ = B(t \to W_+ b)$
< 0.27	95	[15] ABULENCIA	06U	CDF	$F_+ = B(t \to W_+ b)$
0.00 ±0.13 ±0.07		[16] ABAZOV	05L	D0	$F_+ = B(t \to W_+ b)$
< 0.25	95	[16] ABAZOV	05L	D0	$F_+ = B(t \to W_+ b)$
< 0.24	95	[17] ACOSTA	05D	CDF	$F_+ = B(t \to W_+ b)$

[1] AAD 20Y based on about 20 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV for each experiment. The first error stands for the sum of the statistical and background uncertainties, and the second error for the remaining systematic uncertainties. The measurements used events with one lepton and different jet multiplicities in the final state. The result is estimated from the measurements of F_0 and F_- assuming unitarity. The value is consistent with the NNLO SM prediction of 0.0017 ± 0.0001 for m_t = 172.8 ± 1.3 GeV.

[2] Based on 8.7 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV using $t\overline{t}$ events with $\ell + \not{E}_T + \geq 4$ jets(≥ 1 b), and under the constraint $F_0 + F_+ + F_- = 1$. The statstical errors of F_0 and F_+ are correlated with correlation coefficient $\rho(F_0,F_+) = -0.69$.

[3] Based on 5.0 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. CHATRCHYAN 13BH studied tt events with large $\not{E}_T$ and $\ell + \geq 4$ jets using a constrained kinematic fit.

[4] Based on 1.04 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. AAD 12BG studied tt events with large $\not{E}_T$ and either $\ell + \geq 4$j or $\ell\ell + \geq 2$j.

[5] Results are based on 5.4 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV, including those of ABAZOV 08B. Under the SM constraint of $f_0 = 0.698$ (for $m_t = 173.3$ GeV, $m_W = 80.399$ GeV), $f_+ = 0.010 \pm 0.022 \pm 0.030$ is obtained.

[6] AFFOLDER 00B studied the angular distribution of leptonic decays of W bosons in $t \rightarrow Wb$ events. The ratio F_0 is the fraction of the helicity zero (longitudinal) W bosons in the decaying top quark rest frame. B($t \rightarrow W_+ b$) is the fraction of positive helicity (right-handed) positive charge W bosons in the top quark decays. It is obtained by assuming the Standard Model value of F_0.

[7] AABOUD 17BB based on 20.2 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. Triple-differential decay rate of top quark in the t-channel single-top production is used to simultaneously determine five generalized Wtb couplings as well as the top polarization. No assumption is made for the other couplings. The authors reported $f_1 = 0.30 \pm 0.05$ and $f_1^+ < 0.120$ which we converted to $F_+ = f_1\ f_1^+$. See this paper for constraints on other couplings not included here.

[8] KHACHATRYAN 16BU based on 19.8 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV using $t\overline{t}$ events with $\ell + \not{E}_T + \geq 4$ jets(≥ 2 b). The result is consistent with the NNLO SM prediction of 0.0017 ± 0.0001 for $m_t = 172.8 \pm 1.3$ GeV.

[9] Based on 2.7 and 5.1 fb^{-1} of CDF data in ℓ + jets and dilepton channels, and 5.4 fb^{-1} of D0 data in ℓ + jets and dilepton channels. $F_0 = 0.682 \pm 0.035 \pm 0.046$ if $F_+ = 0.0017(1)$, while $F_+ = -0.015 \pm 0.018 \pm 0.030$ if $F_0 = 0.688(4)$, where the assumed fixed values are the SM prediction for $m_t = 173.3 \pm 1.1$ GeV and $m_W = 80.399 \pm 0.023$ GeV.

[10] Results are based on 2.7 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. F_0 result is obtained by assuming $F_+ = 0$, while F_+ result is obtained for $F_0 = 0.70$, the SM value. Model independent fits for the two fractions give $F_0 = 0.88 \pm 0.11 \pm 0.06$ and $F_+ = -0.15 \pm 0.07 \pm 0.06$ with correlation coefficient of -0.59. The results are for $m_t = 175$ GeV.

[11] Results are based on 1.9 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. F_0 result is obtained assuming $F_+ = 0$, while F_+ result is obtained for $F_0 = 0.70$, the SM values. Model independent fits for the two fractions give $F_0 = 0.66 \pm 0.16 \pm 0.05$ and $F_+ = -0.03 \pm 0.06 \pm 0.03$.

[12] Based on 1 fb^{-1} at $\sqrt{s} = 1.96$ TeV.

[13] Based on 370 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV, using the ℓ + jets and dilepton decay channels. The result assumes $F_0 = 0.70$, and it gives $F_+ < 0.23$ at 95% CL.

[14] Based on 318 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV.

[15] Based on 200 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV. $t \rightarrow Wb \rightarrow \ell\nu b$ ($\ell = e$ or μ). The errors are stat + syst.

[16] ABAZOV 05L studied the angular distribution of leptonic decays of W bosons in $t\overline{t}$ events, where one of the W's from t or $\overline{t}$ decays into e or μ and the other decays hadronically. The fraction of the "+" helicity W boson is obtained by assuming $F_0 = 0.7$, which is the generic prediction for any linear combination of V and A currents. Based on 230 ± 15 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV.

[17] ACOSTA 05D measures the $m^2_{\ell+b}$ distribution in $t\overline{t}$ production events where one or both W's decay leptonically to $\ell = e$ or μ, and finds a bound on the V+A coupling of the tbW vertex. By assuming the SM value of the longitudinal W fraction $F_0 = $ B($t \rightarrow W_0 b$) = 0.70, the bound on F_+ is obtained. If the results are combined with those of AFFOLDER 00B, the bounds become $F_{V+A} < 0.61$ (95% CL) and $F_+ < 0.18$ (95 %CL), respectively. Based on 109 ± 7 pb^{-1} of data at $\sqrt{s} = 1.8$ TeV (run I).

F_{V+A}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
< 0.29	95	[1] ABULENCIA	07G	CDF	F_{V+A} = B($t \rightarrow W b_R$)
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.06 \pm 0.22 \pm 0.12$		[1] ABULENCIA	07G	CDF	F_{V+A} = B($t \rightarrow W b_R$)
< 0.80	95	[2] ACOSTA	05D	CDF	F_{V+A} = B($t \rightarrow W b_R$)

[1] Based on 700 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV.

[2] ACOSTA 05D measures the $m^2_{\ell+b}$ distribution in $t\overline{t}$ production events where one or both W's decay leptonically to $\ell = e$ or μ, and finds a bound on the V+A coupling of the $t b W$ vertex. By assuming the SM value of the longitudinal W fraction F_0 = B($t \rightarrow W_0 b$) = 0.70, the bound on F_+ is obtained. If the results are combined with those of AFFOLDER 00B, the bounds become F_{V+A} < 0.61 (95% CL) and F_+ < 0.18 (95 %CL), respectively. Based on 109 ± 7 pb^{-1} of data at $\sqrt{s}$ = 1.8 TeV (run I).

f_1^R

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.11 < f_1^R < 0.16$	95	[1] AAD	20Y	LHC	ATLAS+CMS combined
$\lvert f_1^R/f_2^L \rvert < 0.37$	95	[2] AABOUD	17BB	ATLS	t-channel single top
$\lvert f_1^R \rvert < 0.16$	95	[3] KHACHATRY...	17G	CMS	t-channel single-t prod.
$-0.20 < \mathrm{Re}(V_{tb}\, f_1^R) < 0.23$	95	[4] AAD	12BG	ATLS	Constr. on $W t b$ vtx
$(V_{tb}\, f_1^R)^2 < 0.93$	95	[5] ABAZOV	12E	D0	Single-top
$\lvert f_1^R \rvert^2 < 0.30$	95	[6] ABAZOV	12I	D0	single-t + W helicity
$\lvert f_1^R \rvert^2 < 1.01$	95	[7] ABAZOV	09J	D0	$\lvert f_1^L \rvert = 1$, $\lvert f_2^L \rvert = \lvert f_2^R \rvert = 0$
$\lvert f_1^R \rvert^2 < 2.5$	95	[8] ABAZOV	08AI	D0	$\lvert f_1^L \rvert^2 = 1.8^{+1.0}_{-1.3}$

[1] AAD 20Y based on about 20 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV for each experiment. The measurements used events with one lepton and different jet multiplicities in the final state. The measurements of F_0 and F_- are used to set the limit. The limit is obtained by assuming the other couplings to have their SM values.

[2] AABOUD 17BB based on 20.2 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. Triple-differential decay rate of top quark is used to simultaneously determine five generalized $W t b$ couplings as well as the top polarization. No assumption is made for the other couplings. See this paper for constraints on other couplings not included here.

[3] KHACHATRYAN 17G based on 5.0 and 19.7 fb^{-1} of pp data at $\sqrt{s}$ = 7 and 8 TeV, respectively. A Bayesian neural network technique is used to discriminate between signal and backgrounds. This is a 95% CL exclusion limit obtained by a three-dimensional fit with simultaneous variation of (f_1^L, f_1^R, f_2^R).

[4] Based on 1.04 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. AAD 12BG studied tt events with large $\not\!\!E_T$ and either $\ell + \geq$ 4j or $\ell\ell + \geq$ 2j.

[5] Based on 5.4 fb^{-1} of data. For each value of the form factor quoted the other two are assumed to have their SM value. Their Fig. 4 shows two-dimensional posterior probability density distributions for the anomalous couplings.

[6] Based on 5.4 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV. Results are obtained by combining the limits from the W helicity measurements and those from the single top quark production.

[7] Based on 1 fb^{-1} of data at $p\overline{p}$ collisions $\sqrt{s}$ = 1.96 TeV. Combined result of the W helicity measurement in $t\overline{t}$ events (ABAZOV 08B) and the search for anomalous $t b W$ couplings in the single top production (ABAZOV 08AI). Constraints when f_1^L and one of

the anomalous couplings are simultaneously allowed to vary are given in their Fig. 1 and Table 1.

[8] Result is based on 0.9 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. Single top quark production events are used to measure the Lorentz structure of the $t b W$ coupling. The upper bounds on the non-standard couplings are obtained when only one non-standard coupling is allowed to be present together with the SM one, $f_1^L = V_{tb}^*$.

f_2^L

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.08 < f_2^L < 0.05$	95	[1] AAD	20Y	LHC	ATLAS+CMS combined
$\lvert f_2^L/f_1^L \rvert < 0.29$	95	[2] AABOUD	17BB	ATLS	t-channel single top
$\lvert f_2^L \rvert < 0.057$	95	[3] KHACHATRY...	17G	CMS	t-channel single-t prod.
$-0.14 < \mathrm{Re}(f_2^L) < 0.11$	95	[4] AAD	12BG	ATLS	Constr. on $W t b$ vtx
$(V_{tb}\, f_2^L)^2 < 0.13$	95	[5] ABAZOV	12E	D0	Single-top
$\lvert f_2^L \rvert^2 < 0.05$	95	[6] ABAZOV	12I	D0	single-t + W helicity
$\lvert f_2^L \rvert^2 < 0.28$	95	[7] ABAZOV	09J	D0	$\lvert f_1^L \rvert = 1$, $\lvert f_1^R \rvert = \lvert f_2^R \rvert = 0$
$\lvert f_2^L \rvert^2 < 0.5$	95	[8] ABAZOV	08AI	D0	$\lvert f_1^L \rvert^2 = 1.4^{+0.6}_{-0.5}$

[1] AAD 20Y based on about 20 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV for each experiment. The measurements used events with one lepton and different jet multiplicities in the final state. The measurements of F_0 and F_- are used to set the limit. The limit is obtained by assuming the other couplings to have their SM values.

[2] AABOUD 17BB based on 20.2 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV. Triple-differential decay rate of top quark is used to simultaneously determine five generalized $W t b$ couplings as well as the top polarization. No assumption is made for the other couplings. See this paper for constraints on other couplings not included here.

[3] KHACHATRYAN 17G based on 5.0 and 19.7 fb^{-1} of pp data at $\sqrt{s} = 7$ and 8 TeV, respectively. A Bayesian neural network technique is used to discriminate between signal and backgrounds. This is a 95% CL exclusion limit obtained by a three-dimensional fit with simultaneous variation of (f_1^L, f_2^L, f_2^R).

[4] Based on 1.04 fb^{-1} of pp data at $\sqrt{s} = 7$ TeV. AAD 12BG studied tt events with large $\not{E}_T$ and either $\ell + \geq 4$j or $\ell\ell + \geq 2$j.

[5] Based on 5.4 fb^{-1} of data. For each value of the form factor quoted the other two are assumed to have their SM value. Their Fig. 4 shows two-dimensional posterior probability density distributions for the anomalous couplings.

[6] Based on 5.4 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV. Results are obtained by combining the limits from the W helicity measurements and those from the single top quark production.

[7] Based on 1 fb^{-1} of data at $p\overline{p}$ collisions $\sqrt{s} = 1.96$ TeV. Combined result of the W helicity measurement in $t\overline{t}$ events (ABAZOV 08B) and the search for anomalous $t b W$ couplings in the single top production (ABAZOV 08AI). Constraints when f_1^L and one of the anomalous couplings are simultaneously allowed to vary are given in their Fig. 1 and Table 1.

[8] Result is based on 0.9 fb^{-1} of data at $\sqrt{s} = 1.96$ TeV. Single top quark production events are used to measure the Lorentz structure of the $t b W$ coupling. The upper bounds on the non-standard couplings are obtained when only one non-standard coupling is allowed to be present together with the SM one, $f_1^L = V_{tb}^*$.

f_2^R

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.04 < f_2^R < 0.02$	95	[1] AAD	20Y	LHC	ATLAS+CMS combined
$-0.12 < \mathrm{Re}(f_2^R/f_1^L) < 0.17$	95	[2] AABOUD	17BB	ATLS	t-channel single top
$-0.07 < \mathrm{Im}(f_2^R/f_1^L) < 0.06$	95	[2] AABOUD	17BB	ATLS	t-channel single top
$-0.18 < \mathrm{Im}(f_2^R) < 0.06$	95	[3] AABOUD	17I	ATLS	t-channel single top
$-0.049 < f_2^R < 0.048$	95	[4] KHACHATRY...	17G	CMS	t-channel single top
$-0.36 < \mathrm{Re}(f_2^R/f_1^L) < 0.10$	95	[5] AAD	16AK	ATLS	Single-top
$-0.17 < \mathrm{Im}(f_2^R/f_1^L) < 0.23$	95	[5] AAD	16AK	ATLS	Single-top
$-0.08 < \mathrm{Re}(f_2^R) < 0.04$	95	[6] AAD	12BG	ATLS	Constr. on $W t b$ vtx
$(V_{tb}\, f_2^R)^2 < 0.06$	95	[7] ABAZOV	12E	D0	Single-top
$\lvert f_2^R\rvert^2 < 0.12$	95	[8] ABAZOV	12I	D0	single-t + W helicity
$\lvert f_2^R\rvert^2 < 0.23$	95	[9] ABAZOV	09J	D0	$\lvert f_1^L\rvert=1$, $\lvert f_1^R\rvert=\lvert f_2^L\rvert=0$
$\lvert f_2^R\rvert^2 < 0.3$	95	[10] ABAZOV	08AI	D0	$\lvert f_1^L\rvert^2 = 1.4^{+0.9}_{-0.8}$

[1] AAD 20Y based on about 20 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV for each experiment. The measurements used events with one lepton and different jet multiplicities in the final state. The measurements of F_0 and F_- are used to set the limit. The limit is obtained by assuming the other couplings to have their SM values.

[2] AABOUD 17BB based on 20.2 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. Triple-differential decay rate of top quark is used to simultaneously determine five generalized $W t b$ couplings as well as the top polarization. No assumption is made for the other couplings. See this paper for constraints on other couplings not included here.

[3] AABOUD 17I based on 20.2 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. A cut-based analysis is used to discriminate between signal and backgrounds. All anomalous couplings other than $\mathrm{Im}(f)_2^R$ are assumed to be zero. See this paper for a number of other asymmetries and measurements that are not included here.

[4] KHACHATRYAN 17G based on 5.0 and 19.7 fb^{-1} of pp data at $\sqrt{s}$ = 7 and 8 TeV, respectively. A Bayesian neural network technique is used to discriminate between signal and backgrounds. This is a 95% CL exclusion limit obtained by a three-dimensional fit with simultaneous variation of (f_1^L, f_2^L, f_2^R).

[5] AAD 16AK based on 4.6 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. The results are obtained from an analysis of angular distributions of the decay products of single top quarks, assuming f_1^R=f_2^L=0. The fraction of decays containing transversely polarized W is measured to be $F_+ + F_- = 0.37 \pm 0.07$.

[6] Based on 1.04 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. AAD 12BG studied tt events with large $\not{E}_T$ and either $\ell + \geq$ 4j or $\ell\ell + \geq$ 2j.

[7] Based on 5.4 fb^{-1} of data. For each value of the form factor quoted the other two are assumed to have their SM value. Their Fig. 4 shows two-dimensional posterior probability density distributions for the anomalous couplings.

[8] Based on 5.4 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV. Results are obtained by combining the limits from the W helicity measurements and those from the single top quark production.

[9] Based on 1 fb^{-1} of data at $p\overline{p}$ collisions $\sqrt{s}$ = 1.96 TeV. Combined result of the W helicity measurement in $t\overline{t}$ events (ABAZOV 08B) and the search for anomalous $t b W$ couplings in the single top production (ABAZOV 08AI). Constraints when f_1^L and one of the anomalous couplings are simultaneously allowed to vary are given in their Fig. 1 and Table 1.

[10] Result is based on 0.9 fb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. Single top quark production events are used to measure the Lorentz structure of the $t\,b\,W$ coupling. The upper bounds on the non-standard couplings are obtained when only one non-standard coupling is allowed to be present together with the SM one, $f_1^L = V_{tb}^*$.

$|f_{LV} V_{tb}|$

Assumed that the top-quark-related CKM matrix elements obey the relation $|V_{td}|$, $|V_{ts}| \ll |V_{tb}|$ and a form factor f_{LV} is determined for each production mode and centre-of-mass energy.

VALUE	DOCUMENT ID		TECN	COMMENT
0.995±0.021 OUR AVERAGE				
0.988±0.024	[1] SIRUNYAN	20AZ	CMS	13 TeV, t-channel single top
1.02 ±0.04 ±0.02	[2] AABOUD	19R	LHC	ATLAS + CMS at 7, 8 TeV

[1] SIRUNYAN 20AZ based on 35.9 fb^{-1} of $p\,p$ data at $\sqrt{s}$ = 13 TeV. Final states enriched in single top quark t-channel events are used. Several theories beyond the standard model are considered, and by releasing all constraints among the involved parameters. Under the standard model assumption of CKM unitarity, the values are found to be $|V_{tb}| > 0.970$ and $|V_{td}|^2 + |V_{ts}|^2 < 0.057$, both at 95% CL.

[2] The combination of single-top production cross-section measurements in the t-channel, $t\,W$, and s-channel production modes from ATLAS and CMS at $\sqrt{s}$ = 7 and 8 TeV.

$|f_{LV}\sqrt{|V_{td}|^2 + |V_{ts}|^2}|$

Assumed that the top-quark-related CKM matrix elements obey the relation $|V_{td}|$,$|V_{ts}| \ll |V_{tb}|$ and a form factor f_{LV} is determined for each production mode andcentre-of-mass energy.

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.24±0.12	[1] SIRUNYAN	20AZ	CMS	t-channel single top

[1] We report the square root of SIRUNYAN 20AZ result based on 35.9 fb^{-1} of $p\,p$ data at $\sqrt{s}$ = 13 TeV measured $|V_{td}|^2 + |V_{ts}|^2$ = 0.06 ± 0.06 using final states enriched in single top quark t-channel events by releasing all constraints from unitarity of the CKM matrix within the SM. Under the standard model assumption of CKM unitarity,the values are found to be $|V_{tb}| > 0.970$ and $|V_{td}|^2 + |V_{ts}|^2 < 0.057$, both at 95% CL.

Chromo-magnetic dipole moment $\mu_t = g_s \hat{\mu}_t / m_t$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.024^{+0.013}_{-0.009}{}^{+0.016}_{-0.011}$		[1] SIRUNYAN	20AM	CMS	ℓ+jets
$-0.014 < \hat{\mu}_t < 0.004$	95	[2] SIRUNYAN	19BX	CMS	$\ell\ell + \geq 2$j ($\geq 1b$)
$-0.053 < \text{Re}(\hat{\mu}_t) < 0.026$	95	[3] KHACHATRY...	16AI	CMS	$\ell\ell + \geq 2$j ($\geq 1b$)

[1] SIRUNYAN 20AM based on 35.9 fb^{-1} of $p\,p$ data at $\sqrt{s}$ = 13 TeV. $t\,\overline{t}$ with low and high boosts are reconstructed through a fit of the kinematic distributions. The $q\,\overline{q}$ initial subprocess is separated using different dependencies of the distributions on the initial states, and the linearized forward-backward asymmetry is measured to be $A_{FB}^{(1)} = 0.048^{+0.095}_{-0.087}{}^{+0.020}_{-0.029}$.

[2] SIRUNYAN 19BX based on 35.9 fb^{-1} of $p\,p$ data at $\sqrt{s}$ = 13 TeV. A set of parton-level normalized differential cross sections is measured to extract coefficients of the spin-dependent $t\,\overline{t}$ production density matrix. The coefficients are compared with the NLO MC simulations and with the NLO QCD calculation including EW corrections.

[3] KHACHATRYAN 16AI based on 19.5 fb^{-1} of $p\,p$ data at $\sqrt{s}$ = 8 TeV, using lepton angular distributions as a function of the $t\,\overline{t}$-system kinematical variables.

Chromo-electric dipole moment $d_t = g_s \hat{d}_t / m_t$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$\lvert\hat{d}_t\rvert < 0.015$	95	[1] TUMASYAN	23J	CMS	ℓ+jets
$-0.014 < \hat{d}_t < 0.027$	95	[2] TUMASYAN	23U	CMS	dilepton channel; $\epsilon(p_t p_{\overline{t}} p_{\ell^+} p_{\ell^-})$
$-0.019 < \hat{d}_t < 0.019$	95	[2] TUMASYAN	23U	CMS	dilepton channel; $\epsilon(p_b p_{\overline{b}} p_{\ell^+} p_{\ell^-})$
$\lvert\hat{d}_t\rvert < 0.03$	95	[3] SIRUNYAN	20AM	CMS	ℓ+jets
$-0.020 < \hat{d}_t < 0.012$	95	[4] SIRUNYAN	19BX	CMS	$\ell\ell + \geq 2$j ($\geq 1b$)
$-0.068 < \mathrm{Im}(\hat{d}_t) < 0.067$	95	[5] KHACHATRY...	16AI	CMS	$\ell\ell + \geq 2$j ($\geq 1b$)

[1] TUMASYAN 23J based on 138 fb^{-1} of pp data at $\sqrt{s} = 13$ TeV. Four T-odd triple products of momenta of the final-state particles are measured to constrain the dimensionless chromoelectric top quark dipole moment. No evidence of CP-violating effects is found, which is consistent with the SM expectation.

[2] TUMASYAN 23U based on 35.9 fb^{-1} of pp data at $\sqrt{s} = 13$ TeV. CP-odd Lorentz pseudo-scalar products $O_1 = \epsilon(p_t p_{\overline{t}} p_{\ell^+} p_{\ell^-})$ and $O_3 = \epsilon(p_b p_{\overline{b}} p_{\ell^+} p_{\ell^-})$ constructed from the momenta of t, $\overline{t}$, ℓ^+, ℓ^- and of b, $\overline{b}$, ℓ^+, ℓ^-, respectively, are measured and used to constrain the dimensionless chromoelectric top quark dipole moment. No evidence for CP-violating effects is found, which is consistent with the SM expectation.

[3] SIRUNYAN 20AM based on 35.9 fb^{-1} of pp data at $\sqrt{s} = 13$ TeV. $t\overline{t}$ with low and high boosts are reconstructed through a fit of the kinematic distributions. The $q\overline{q}$ initial subprocess is separated using different dependences of the distributions on the initial states, and the linearized forward-backward asymmetry is measured to be $A^{(1)}_{FB} = 0.048^{+0.095}_{-0.087}{}^{+0.020}_{-0.029}$.

[4] SIRUNYAN 19BX based on 35.9 fb^{-1} of pp data at $\sqrt{s} = 13$ TeV. A set of parton-level normalized differential cross sections is measured to extract coefficients of the spin-dependent $t\overline{t}$ production density matrix and constrain the anomalous chromomagnetic and chromoelectric dipole moments of the top quark. The coefficients are compared with the NLO MC simulations and with the NLO QCD calculation including EW corrections.

[5] KHACHATRYAN 16AI based on 19.5 fb^{-1} of pp data at $\sqrt{s} = 8$ TeV, using lepton angular distributions as a function of the $t\overline{t}$-system kinematical variables.

Spin Correlation in $t\overline{t}$ Production in $p\overline{p}$ Collisions

C is the correlation strength parameter, f is the ratio of events with correlated t and $\overline{t}$ spins (SM prediction: f = 1), and κ is the spin correlation coefficient. See "The Top Quark" review for more information.

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.89 ± 0.22	[1] ABAZOV	16A	D0	f ($\ell\ell + \geq 2$ jets, $\ell + \geq 4$ jets)
0.85 ± 0.29	[2] ABAZOV	12B	D0	f ($\ell\ell + \geq 2$ jets, $\ell + \geq 4$ jets)
$1.15^{+0.42}_{-0.43}$	[3] ABAZOV	12B	D0	f ($\ell + \not{E}_T + \geq 4$ jets)
$0.60^{+0.50}_{-0.16}$	[4] AALTONEN	11AR	CDF	κ ($\ell + \not{E}_T + \geq 4$ jets)
$0.74^{+0.40}_{-0.41}$	[5] ABAZOV	11AE	D0	f ($\ell\ell + \not{E}_T + \geq 2$ jets)
0.10 ± 0.45	[6] ABAZOV	11AF	D0	C ($\ell\ell + \not{E}_T + \geq 2$ jets)

[1] ABAZOV 16A based on 9.7 fb^{-1} of data. A matrix element method is used. It corresponds to evidence of spin correlation at 4.2σ and is in agreement with the NLO SM prediction $0.80^{+0.01}_{-0.02}$.

[2] This is a combination of the lepton + jets analysis presented in ABAZOV 12B and the dilepton measurement of ABAZOV 11AE. It provides a 3.1 σ evidence for the $t\overline{t}$ spin correlation.

[3] Based on 5.3 fb^{-1} of data. The error is statistical and systematic combined. A matrix element method is used.

[4] Based on 4.3 fb^{-1} of data. The measurement is based on the angular study of the top quark decay products in the helicity basis.The theory prediction is $\kappa \approx 0.40$.

[5] Based on 5.4 fb^{-1} of data using a matrix element method. The error is statistical and systematic combined. The no-correlation hypothesis is excluded at the 97.7% CL.

[6] Based on 5.4 fb^{-1} of data. The error is statistical and systematic combined. The NLO QCD prediction is C = 0.78 ± 0.03. The neutrino weighting method is used for reconstruction of kinematics.

Spin Correlation in $t\overline{t}$ Production in pp Collisions

Spin correlation, f_{SM}, measures the strength of the correlation between the spins of the pair produced $t\overline{t}$. f_{SM} =1 for the SM, while f_{SM} =0 for no spin correlation.

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.90 \pm 0.07 \pm 0.09 \pm 0.01$	[1] SIRUNYAN 19BX	CMS	C_{kk} in $\ell\ell + \geq 2$j ($\geq 1b$)
$1.13 \pm 0.32 \pm 0.32 ^{+0.10}_{-0.13}$	[1] SIRUNYAN 19BX	CMS	C_{rr} in $\ell\ell + \geq 2$j ($\geq 1b$)
$1.01 \pm 0.04 \pm 0.05 \pm 0.01$	[1] SIRUNYAN 19BX	CMS	C_{nn} in $\ell\ell + \geq 2$j ($\geq 1b$)
$0.94 \pm 0.17 \pm 0.26 \pm 0.01$	[1] SIRUNYAN 19BX	CMS	$C_{rk}+C_{kr}$ in $\ell\ell + \geq 2$j ($\geq 1b$)
$0.98 \pm 0.03 \pm 0.04 \pm 0.01$	[1] SIRUNYAN 19BX	CMS	$(C_{kk}+C_{rr}+C_{nn})/3$ in $\ell\ell + \geq 2$j ($\geq 1b$)
$0.74 \pm 0.07 \pm 0.19 ^{+0.06}_{-0.08}$	[1] SIRUNYAN 19BX	CMS	$A^{lab}_{cos\phi}$ in $\ell\ell + \geq 2$j ($\geq 1b$)
$1.05 \pm 0.03 \pm 0.08 ^{+0.09}_{-0.12}$	[1] SIRUNYAN 19BX	CMS	$A_{\lvert\Delta\phi(\ell\ell)\rvert}$ in $\ell\ell + \geq 2$j ($\geq 1b$)
$1.12 ^{+0.12}_{-0.15}$	[2] KHACHATRY...16AI	CMS	$\ell\ell + \geq 2$j ($\geq 1b$)
$0.72 \pm 0.08 ^{+0.15}_{-0.13}$	[3] KHACHATRY...16X	CMS	μ + 4,5j
$1.20 \pm 0.05 \pm 0.13$	[4] AAD 15J	ATLS	$\Delta\phi(\ell\ell)$ in $\ell\ell + \geq 2$j($\geq 1b$)
$1.19 \pm 0.09 \pm 0.18$	[5] AAD 14BB	ATLS	$\Delta\phi(\ell\ell)$ in $\ell\ell + \geq 2$j events
$1.12 \pm 0.11 \pm 0.22$	[5] AAD 14BB	ATLS	$\Delta\phi(\ell j)$ in $\ell + \geq 4$j events
$0.87 \pm 0.11 \pm 0.14$	[5,6] AAD 14BB	ATLS	S-ratio in $\ell\ell + \geq 2$j events
$0.75 \pm 0.19 \pm 0.23$	[5,7] AAD 14BB	ATLS	$\cos\theta(\ell^+)\cos\theta(\ell^-)$ in $\ell\ell + \geq 2$j events
$0.83 \pm 0.14 \pm 0.18$	[5,8] AAD 14BB	ATLS	$\cos\theta(\ell^+)\cos\theta(\ell^-)$ in $\ell\ell + \geq 2$j events

[1] SIRUNYAN 19BX based on 35.9 fb^{-1} of pp data at $\sqrt{s}$ = 13 TeV. A set of parton-level normalized differential cross sections sensitive to coefficients of the spin-dependent $t\overline{t}$ production density matrix is measured. The distributions and coefficients are compared with the NLO MC simulations and with the NLO QCD calculation including EW corrections. Three errors are from statistics, experimental systematics, and theory.

[2] KHACHATRYAN 16AI based on 19.5 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV, using lepton angular distributions as a function of the $t\overline{t}$-system kinematical variables.

[3] KHACHATRYAN 16X based on 19.7 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. Uses a template fit method. Spin correlation strength in the helicity basis is given by $A_{\rm hel} = 0.23 \pm 0.03 ^{+0.05}_{-0.04}$.

[4] AAD 15J based on 20.3 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. Uses a fit including a linear superposition of $\Delta\phi$ distribution from the SM NLO simulation with coefficient f_{SM} and from $t\overline{t}$ simulation without spin correlation with coefficient $(1 - f_{SM})$.
[5] Based on 4.6 fb^{-1} of pp data at $\sqrt{s}$ =7 TeV. The results are for m_t = 172.5 GeV.
[6] The S-ratio is defined as the SM spin correlation in the like-helicity gluon-gluon collisions normalized to the no spin correlation case; see eq.(6) for the LO expression.
[7] The polar angle correlation along the helicity axis.
[8] The polar angle correlation along the direction which maximizes the correlation.

t-quark FCNC Couplings κ^{utg}/Λ and κ^{ctg}/Λ

VALUE (TeV^{-1})	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] AAD	22T	ATLS	$ug \rightarrow t$, $cg \rightarrow t$
<0.0041	95	[2] KHACHATRY...	17G	CMS	$\lvert\kappa^{tug}\rvert/\Lambda$
<0.018	95	[2] KHACHATRY...	17G	CMS	$\lvert\kappa^{tcg}\rvert/\Lambda$
<0.010	95	[3] AAD	16AS	ATLS	κ^{tug}/Λ
<0.023	95	[3] AAD	16AS	ATLS	κ^{tcg}/Λ
<0.0069	95	[4] AAD	12BP	ATLS	t^{tug}/Λ ($t^{tcg} = 0$)
<0.016	95	[4] AAD	12BP	ATLS	t^{tcg}/Λ ($t^{tug} = 0$)
<0.013	95	[5] ABAZOV	10K	D0	κ^{tug}/Λ
<0.057	95	[5] ABAZOV	10K	D0	κ^{tcg}/Λ
<0.018	95	[6] AALTONEN	09N	CDF	κ^{tug}/Λ ($\kappa^{tcg} = 0$)
<0.069	95	[6] AALTONEN	09N	CDF	κ^{tcg}/Λ ($\kappa^{tug} = 0$)
<0.037	95	[7] ABAZOV	07V	D0	κ^{utg}/Λ
<0.15	95	[7] ABAZOV	07V	D0	κ^{ctg}/Λ

[1] AAD 22T based on 139 fb^{-1} of pp data at $\sqrt{s}$ = 13 TeV. The results are obtained from the 95% CL upper limits on the single top-quark productions $\sigma(ug \rightarrow t)\cdot$B$(t \rightarrow bW)\cdot$B$(W \rightarrow \ell\nu) <$ 3.0 pb and $\sigma(cg \rightarrow t)\cdot$B$(t \rightarrow bW)\cdot$B$(W \rightarrow \ell\nu) <$ 4.7 pb. These are interpreted as limits on couplings in an EFT $\lvert C^{ut}_{uG}\rvert/\Lambda^2 <$ 0.057 TeV^{-2} and $\lvert C^{ct}_{uG}\rvert/\Lambda^2 <$ 0.14 TeV^{-2}. The results also correspond to B$(t \rightarrow ug) < 6.1 \times 10^{-5}$ and B$(t \rightarrow cg) < 3.7 \times 10^{-4}$.
[2] KHACHATRYAN 17G based on 5.0 and 19.7 fb^{-1} of pp data at $\sqrt{s}$ = 7 and 8 TeV, respectively. t-channel single top production is used. The result corresponds to B$(t \rightarrow ug) < 2.0 \times 10^{-5}$ or B$(t \rightarrow cg) < 4.1 \times 10^{-4}$.
[3] AAD 16AS based on 20.3 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV. The results are obtained from the 95% CL upper limit on the single top-quark production $\sigma(qg \rightarrow t)\cdot$B$(t \rightarrow bW)B(W \rightarrow l\nu) <$ 2.9 pb, B$(t \rightarrow ug) < 4.0 \times 10^{-5}$ and B$(t \rightarrow cg) < 20 \times 10^{-5}$.
[4] Based on 2.05 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. The results are obtained from the 95% CL upper limit on the single top-quark production $\sigma(qg \rightarrow t)\cdot$B$(t \rightarrow bW) <$ 3.9 pb, for q=u or q=c, B$(t \rightarrow ug) < 5.7 \times 10^{-5}$ and B$(t \rightarrow ug) < 2.7 \times 10^{-4}$.
[5] Based on 2.3 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. Upper limit of single top quark production cross section 0.20 pb and 0.27 pb via FCNC t-u-g and t-c-g couplings, respectively, lead to the bounds without assuming the absence of the other coupling. B$(t \rightarrow u + g) < 2.0 \times 10^{-4}$ and B$(t \rightarrow c + g) < 3.9 \times 10^{-3}$ follow.
[6] Based on 2.2 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. Upper limit of single top quark production cross section $\sigma(u(c) + g \rightarrow t) <$ 1.8 pb (95% CL) via FCNC t-u-g and t-c-g couplings lead to the bounds. B$(t \rightarrow u + g) < 3.9 \times 10^{-4}$ and B$(t \rightarrow c + g) < 5.7 \times 10^{-3}$ follow.
[7] Result is based on 230 pb^{-1} of data at $\sqrt{s}$ = 1.96 TeV. Absence of single top quark production events via FCNC t-u-g and t-c-g couplings lead to the upper bounds on the dimensioned couplings, κ^{utg}/Λ and κ^{ctg}/Λ, respectively.

t-Quark Yukawa Coupling from $t\overline{t}$ Kinematic Distributions in pp Collisions

The ratio of t-quark Yukawa coupling to its standard model predicted value.

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$1.16^{+0.24}_{-0.35}$	[1] SIRUNYAN 20BH	CMS	$\ell\ell$ (ℓ=e,μ) + jets ($\geq 2b$j) + $\not\!\!E_T$
$1.07^{+0.34}_{-0.43}$	[2] SIRUNYAN 19BY	CMS	ℓ+jets, $t\overline{t}$ threshold

[1] SIRUNYAN 20BH based on 137 fb^{-1} of data at $\sqrt{s}$ = 13 TeV. Kinematic distributions of $t\overline{t}$ are compared with predictions by different values of the top Yukawa coupling in loop corrections, where the scaling of the SM coupling is used within the κ-framework. The $\not\!\!E_T$ cut applies only to the same-flavor dilepton, not $e\mu$ events.

[2] SIRUNYAN 19BY based on 35.8 fb^{-1} of data at $\sqrt{s}$ = 13 TeV. Experimental sensitivity is enhanced in the low $M_{t\overline{t}}$ region. The distributions of $M_{t\overline{t}}$, $|y_t - y_{\overline{t}}|$, and the number of reconstructed jets are compared with predictions by different Yukawa couplings which include NNLO QCD and NLO EW corrections.

$\sigma(Ht\overline{t})$ /$\sigma(Ht\overline{t})_{SM}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$1.43^{+0.33}_{-0.31}{}^{+0.21}_{-0.15}$		[1] AAD 20Z	ATLS	$Ht\overline{t}$ ($H \to \gamma\gamma$)
$1.38^{+0.29}_{-0.27}{}^{+0.21}_{-0.11}$		[2] SIRUNYAN 20AS	CMS	$Ht\overline{t}$ ($H \to \gamma\gamma$)
$0.72\pm0.24\pm0.38$		[3] SIRUNYAN 19R	CMS	$Ht\overline{t}$ ($H \to b\overline{b}$, $t\overline{t} \to$ ℓ+jets or dilepton)
$0.9 \pm0.7 \pm1.3$		[4] SIRUNYAN 18BD	CMS	$Ht\overline{t}$ ($H \to b\overline{b}$, $t\overline{t} \to$ all jets)
$1.26^{+0.31}_{-0.26}$		[5] SIRUNYAN 18L	CMS	combination of CMS
<6.7	95	[6] AAD 15	ATLS	$Ht\overline{t}$; $H \to \gamma\gamma$
2.8 ± 1.0		[7] KHACHATRY...14H	CMS	$H \to b\overline{b}$, $\tau_h\tau_h$, $\gamma\gamma$, WW/ZZ(leptons)

[1] AAD 20Z based on 139 fb^{-1} of pp data at 13 TeV. Assuming a CP-even coupling the $t\overline{t}H$ process is observed with a significance of 5.2 σ, and the measured $\sigma_{t\overline{t}H} \cdot B_{\gamma\gamma} = 1.64^{+0.38}_{-0.36}{}^{+0.17}_{-0.14}$ fb. A CP-mixing angle $|\alpha| > 43°$ is excluded at 95% CL.

[2] SIRUNYAN 20AS based on 137 fb^{-1} of pp data at 13 TeV. The $t\overline{t}H$ process is observed with a significance of 6.6 σ, and the measured $\sigma_{t\overline{t}H} \cdot B_{\gamma\gamma} = 1.56^{+0.33}_{-0.30}{}^{+0.09}_{-0.08}$ fb. The fractional contribution of the CP-odd component is measured to be $f^{t\overline{t}H}_{CP} = 0.00 \pm 0.33$.

[3] SIRUNYAN 19R based on 35.9 fb^{-1} of pp data at 13 TeV. Multivariate techniques are employed to separate the signal from the dominant $t\overline{t}$+jets background. The result is for m_H = 125 GeV. The measured ratio corresponds to a signal significance of 1.6σ above the background-only hypothesis.

[4] SIRUNYAN 18BD based on 35.9 fb^{-1} of pp data at 13 TeV. A combined fit of signal and background templates to data is performed in six event categories separated by jet and b-jet multiplicities. An upper limit of 3.8 is obtained for the cross section ratio.

[5] SIRUNYAN 18L based on up to 5.1, 19.7, and 35.9 fb^{-1} of pp data at 7, 8, and 13 TeV, respectively. An excess of events is observed, with a significance of 5.2 standard deviations, over the expectation from the background-only hypothesis. The result is for the Higgs boson mass of 125.09 GeV.

[6] Based on 4.5 fb^{-1} of data at 7 TeV and 20.3 fb^{-1} at 8 TeV. The result is for m_H = 125.4 GeV. The measurement constrains the top quark Yukawa coupling strength parameter $\kappa_t = Y_t/Y_t^{SM}$ to be $-1.3 < \kappa_t < 8.0$ (95% CL).

[7] Based on 5.1 fb^{-1} of pp data at 7 TeV and 19.7 fb^{-1} at 8 TeV. The results are obtained by assuming the SM decay branching fractions for the Higgs boson of mass 125.6 GeV. The signal strength for individual Higgs decay channels are given in Fig. 13, and the preferred region in the (κ_V, κ_f) space is given in Fig. 14.

Single t-Quark Production Cross Section in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV

Direct probe of the tbW coupling and possible new physics at $\sqrt{s}$ = 1.8 TeV.

VALUE (pb)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<24	95	[1] ACOSTA	04H	CDF	$p\overline{p} \rightarrow tb + X$, $tqb + X$
<18	95	[2] ACOSTA	02	CDF	$p\overline{p} \rightarrow tb + X$
<13	95	[3] ACOSTA	02	CDF	$p\overline{p} \rightarrow tqb + X$

[1] ACOSTA 04H bounds single top-quark production from the s-channel W-exchange process, $q'\overline{q} \rightarrow t\overline{b}$, and the t-channel W-exchange process, $q'g \rightarrow qt\overline{b}$. Based on $\sim$ 106 pb^{-1} of data.

[2] ACOSTA 02 bounds the cross section for single top-quark production via the s-channel W-exchange process, $q'\overline{q} \rightarrow t\overline{b}$. Based on $\sim$ 106 pb^{-1} of data.

[3] ACOSTA 02 bounds the cross section for single top-quark production via the t-channel W-exchange process, $q'g \rightarrow qt\overline{b}$. Based on $\sim$ 106 pb^{-1} of data.

Single t-Quark Production Cross Section in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.96 TeV

Direct probes of the tbW coupling and possible new physics at $\sqrt{s}$ = 1.96 TeV.

OUR AVERAGE assumes that the systematic uncertainties are uncorrelated.

VALUE (pb)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$3.53^{+1.25}_{-1.16}$		[1] AALTONEN	16	CDF	s- + t-channels ($0\ell+\not{E}_T$ + 2,3j ($\geq 1b$-tag))
$2.25^{+0.29}_{-0.31}$		[2] AALTONEN	15H	TEVA	t-channel
$3.30^{+0.52}_{-0.40}$		[2,3] AALTONEN	15H	TEVA	s- + t-channels
$1.12^{+0.61}_{-0.57}$		[4] AALTONEN	14K	CDF	s-channel ($0\ell+\not{E}_T$+2,3j ($\geq 1b$-tag))
$1.41^{+0.44}_{-0.42}$		[5] AALTONEN	14L	CDF	s-channel ($\ell+\not{E}_T$+2j ($\geq 1b$-tag))
$1.29^{+0.26}_{-0.24}$		[6] AALTONEN	14M	TEVA	s-channel (CDF + D0)
$3.04^{+0.57}_{-0.53}$		[7] AALTONEN	14O	CDF	$s + t + Wt$ ($\ell + \not{E}_T$ + 2 or 3 jets ($\geq 1b$-tag))
$1.10^{+0.33}_{-0.31}$		[8] ABAZOV	13O	D0	s-channel
$3.07^{+0.54}_{-0.49}$		[8] ABAZOV	13O	D0	t-channel
$4.11^{+0.60}_{-0.55}$		[8] ABAZOV	13O	D0	s- + t-channels
0.98 ± 0.63		[9] ABAZOV	11AA	D0	s-channel
2.90 ± 0.59		[9] ABAZOV	11AA	D0	t-channel
$3.43^{+0.73}_{-0.74}$		[10] ABAZOV	11AD	D0	s- + t-channels
$1.8^{+0.7}_{-0.5}$		[11] AALTONEN	10AB	CDF	s-channel

0.8 ± 0.4		[11] AALTONEN	10AB	CDF	t-channel
$4.9\ ^{+2.5}_{-2.2}$		[12] AALTONEN	10U	CDF	$\not{E}_T$ + jets decay
$3.14^{+0.94}_{-0.80}$		[13] ABAZOV	10	D0	t-channel
1.05 ± 0.81		[13] ABAZOV	10	D0	s-channel
<7.3	95	[14] ABAZOV	10J	D0	τ + jets decay
$2.3\ ^{+0.6}_{-0.5}$		[15] AALTONEN	09AT	CDF	s- + t-channel
3.94 ± 0.88		[16] ABAZOV	09Z	D0	s- + t-channel
$2.2\ ^{+0.7}_{-0.6}$		[17] AALTONEN	08AH	CDF	s- + t-channel
$4.7\ \pm1.3$		[18] ABAZOV	08I	D0	s- + t-channel
$4.9\ \pm1.4$		[19] ABAZOV	07H	D0	s- + t-channel
<6.4	95	[20] ABAZOV	05P	D0	$p\overline{p} \rightarrow tb + X$
<5.0	95	[20] ABAZOV	05P	D0	$p\overline{p} \rightarrow tqb + X$
<10.1	95	[21] ACOSTA	05N	CDF	$p\overline{p} \rightarrow tqb + X$
<13.6	95	[21] ACOSTA	05N	CDF	$p\overline{p} \rightarrow tb + X$
<17.8	95	[21] ACOSTA	05N	CDF	$p\overline{p} \rightarrow tb + X$, $tqb + X$

[1] AALTONEN 16 based on 9.5 fb^{-1} of data. This includes, as a part, the result of AALTONEN 14K. Combination of this result with that of AALTONEN 14O gives a s + t cross section of $3.02^{+0.49}_{-0.48}$ pb and $|V_{tb}| > 0.84$ (95% CL).

[2] AALTONEN 15H based on 9.7 fb^{-1} of data per experiment. The result is for m_t = 172.5 GeV, and is a combination of the CDF measurements (AALTONEN 16) and the D0 measurements (ABAZOV 13O) on the t-channel single t-quark production cross section. The result is consistent with the NLO+NNLL SM prediction and gives $|V_{tb}| = 1.02^{+0.06}_{-0.05}$ and $|V_{tb}| > 0.92$ (95% CL).

[3] AALTONEN 15H is a combined measurement of s-channel single top cross section by CDF + D0. AALTONEN 14M is not included.

[4] Based on 9.45 fb^{-1} of data, using neural networks to separate signal from backgrounds. The result is for m_t = 172.5 GeV. Combination of this result with the CDF measurement in the 1 lepton channel AALTONEN 14L gives $1.36^{+0.37}_{-0.32}$ pb, consistent with the SM prediction, and is 4.2 sigma away from the background only hypothesis.

[5] Based on 9.4 fb^{-1} of data, using neural networks to separate signal from backgrounds. The result is for m_t = 172.5 GeV. The result is 3.8 sigma away from the background only hypothesis.

[6] Based on 9.7 fb^{-1} of data per experiment. The result is for m_t = 172.5 GeV, and is a combination of the CDF measurements AALTONEN 14L, AALTONEN 14K and the D0 measurement ABAZOV 13O on the s-channel single t-quark production cross section. The result is consistent with the SM prediction of 1.05 ± 0.06 pb and the significance of the observation is of 6.3 standard deviations.

[7] Based on 7.5 fb^{-1} of data. Neural network is used to discriminate signals (s-, t- and Wt-channel single top production) from backgrounds. The result is consistent with the SM prediction, and gives $|V_{tb}| = 0.95 \pm 0.09(\text{stat} + \text{syst}) \pm 0.05(\text{theory})$ and $|V_{tb}| > 0.78$ (95% CL). The result is for m_t = 172.5 GeV.

[8] Based on 9.7 fb^{-1} of data. Events with $\ell + \not{E}_T$ + 2 or 3 jets (1 or 2 b-tag) are analysed, assuming m_t = 172.5 GeV. The combined s- + t-channel cross section gives $|V_{tb}\ f_1^L| = 1.12^{+0.09}_{-0.08}$, or $|V_{tb}| > 0.92$ at 95% CL for $f_1^L = 1$ and a flat prior within $0 \leq |V_{tb}|^2 \leq 1$.

[9] Based on 5.4 fb^{-1} of data. The error is statistical + systematic combined. The results are for m_t = 172.5 GeV. Results for other m_t values are given in Table 2 of ABAZOV 11AA.

[10] Based on 5.4 fb^{-1} of data and for m_t = 172.5 GeV. The error is statistical + systematic combined. Results for other m_t values are given in Table III of ABAZOV 11AD. The result is obtained by assuming the SM ratio between $t\,b$ (s-channel) and $t\,q\,b$ (t-channel) productions, and gives $|V_{tb}\ f_1^L| = 1.02^{+0.10}_{-0.11}$, or $|V_{tb}| > 0.79$ at 95% CL for a flat prior within $0 < |V_{tb}|^2 < 1$.

[11] Based on 3.2 fb^{-1} of data. For combined s- + t-channel result see AALTONEN 09AT.

[12] Result is based on 2.1 fb^{-1} of data. Events with large missing E_T and jets with at least one b-jet without identified electron or muon are selected. Result is obtained when observed 2.1 σ excess over the background originates from the signal for m_t = 175 GeV, giving $|V_{tb}| = 1.24^{+0.34}_{-0.29} \pm 0.07$(theory).

[13] Result is based on 2.3 fb^{-1} of data. Events with isolated ℓ + $\not\!\!E_T$ + 2 ,3, 4 jets with one or two b-tags are selected. The analysis assumes m_t = 170 GeV.

[14] Result is based on 4.8 fb^{-1} of data. Events with an isolated reconstructed tau lepton, missing E_T + 2, 3 jets with one or two b-tags are selected. When combined with ABAZOV 09Z result for e + μ channels, the s- and t-channels combined cross section is $3.84^{+0.89}_{-0.83}$ pb.

[15] Based on 3.2 fb^{-1} of data. Events with isolated ℓ + $\not\!\!E_T$ + jets with at least one b-tag are analyzed and s- and t-channel single top events are selected by using the likelihood function, matrix element, neural-network, boosted decision tree, likelihood function optimized for s-channel process, and neural-networked based analysis of events with $\not\!\!E_T$ that has sensitivity for $W \rightarrow \tau\nu$ decays. The result is for m_t = 175 GeV, and the mean value decreases by 0.02 pb/GeV for smaller m_t. The signal has 5.0 sigma significance. The result gives $|V_{tb}| = 0.91 \pm 0.11$ (stat+syst)± 0.07 (theory), or $|V_{tb}| > 0.71$ at 95% CL.

[16] Based on 2.3 fb^{-1} of data. Events with isolated ℓ + $\not\!\!E_T$ + $\geq$ 2 jets with 1 or 2 b-tags are analyzed and s- and t-channel single top events are selected by using boosted decision tree, Bayesian neural networks and the matrix element method. The signal has 5.0 sigma significance. The result gives $|V_{tb}| = 1.07 \pm 0.12$, or $|V_{tb}| > 0.78$ at 95% CL. The analysis assumes m_t = 170 GeV.

[17] Result is based on 2.2 fb^{-1} of data. Events with isolated ℓ + $\not\!\!E_T$ + 2, 3 jets with at least one b-tag are selected, and s- and t-channel single top events are selected by using likelihood, matrix element, and neural network discriminants. The result can be interpreted as $|V_{tb}| = 0.88^{+0.13}_{-0.12}$(stat + syst)$\pm$0.07(theory), and $|V_{tb}| > 0.66$ (95% CL) under the $|V_{tb}| < 1$ constraint.

[18] Result is based on 0.9 fb^{-1} of data. Events with isolated ℓ + $\not\!\!E_T$ + 2, 3, 4 jets with one or two b-vertex-tag are selected, and contributions from W + jets, $t\overline{t}$, s- and t-channel single top events are identified by using boosted decision trees, Bayesian neural networks, and matrix element analysis. The result can be interpreted as the measurement of the CKM matrix element $|V_{tb}| = 1.31^{+0.25}_{-0.21}$, or $|V_{tb}| > 0.68$ (95% CL) under the $|V_{tb}| < 1$ constraint.

[19] Result is based on 0.9 fb^{-1} of data. This result constrains V_{tb} to $0.68 < |V_{tb}| \leq 1$ at 95% CL.

[20] ABAZOV 05P bounds single top-quark production from either the s-channel W-exchange process, $q'\overline{q} \rightarrow t\overline{b}$, or the t-channel W-exchange process, $q'g \rightarrow q\,t\,\overline{b}$, based on $\sim$ 230 pb^{-1} of data.

[21] ACOSTA 05N bounds single top-quark production from the t-channel W-exchange process ($q'g \rightarrow q\,t\,\overline{b}$), the s-channel W-exchange process ($q'\overline{q} \rightarrow t\overline{b}$), and from the combined cross section of t- and s-channel. Based on $\sim$ 162 pb^{-1} of data.

t-channel Single t Production Cross Section in pp Collisions at $\sqrt{s}$ = 7 TeV

Direct probe of the tbW coupling and possible new physics at $\sqrt{s}$ = 7 TeV.

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
67.5 ± 5.7	[1] AABOUD	19R	LHC	combination of ATLAS+CMS
$68 \pm 2 \pm 8$	[2] AAD	14BI	ATLS	$\ell + \not{E}_T$ + 2j or 3j
$83 \pm 4 \ {}^{+20}_{-19}$	[3] AAD	12CH	ATLS	t-channel $\ell + \not{E}_T$ + (2,3)j (1b)
67.2 ± 6.1	[4] CHATRCHYAN	12BQ	CMS	t-channel $\ell + \not{E}_T + \geq$ 2j (1b)
$83.6\pm29.8\pm 3.3$	[5] CHATRCHYAN	11R	CMS	t-channel

[1] AABOUD 19R based on 1.17 to 5.1 fb^{-1} of data from ATLAS and CMS at 7 TeV.

[2] Based on 4.59 fb^{-1} of data, using neural networks for signal and background separation. $\sigma(tq) = 46 \pm 1 \pm 6$ pb and $\sigma(\overline{t}q) = 23 \pm 1 \pm 3$ pb are separately measured, as well as their ratio $R = \sigma(tq)/\sigma(\overline{t}q) = 2.04 \pm 0.13 \pm 0.12$. The results are for m_t = 172.5 GeV, and those for other m_t values are given by eq.(4) and Table IV. The measurements give $|V_{tb}| = 1.02 \pm 0.07$ or $|V_{tb}| > 0.88$ (95% CL).

[3] Based on 1.04 fb^{-1} of data. The result gives $|V_{tb}| = 1.13^{+0.14}_{-0.13}$ from the ratio σ(exp)/σ(th), where σ(th) is the SM prediction for $|V_{tb}| = 1$. The 95% CL lower bound of $|V_{tb}| > 0.75$ is found if $|V_{tb}| < 1$ is assumed. $\sigma(t) = 59^{+18}_{-16}$ pb and $\sigma(\overline{t}) = 33^{+13}_{-12}$ pb are found for the separate single t and $\overline{t}$ production cross sections, respectively. The results assume m_t = 172.5 GeV for the acceptance.

[4] Based on 1.17 fb^{-1} of data for $\ell = \mu$, 1.56 fb^{-1} of data for $\ell = e$ at 7 TeV collected during 2011. The result gives $|V_{tb}| = 1.020 \pm 0.046$(meas)$\pm0.017$(th). The 95% CL lower bound of $|V_{tb}| > 0.92$ is found if $|V_{tb}| < 1$ is assumed. The results assume m_t = 172.5 GeV for the acceptance.

[5] Based on 36 pb^{-1} of data. The first error is statistical + systematic combined, the second is luminosity. The result gives $|V_{tb}| = 1.114 \pm 0.22(exp)\pm0.02$(th) from the ratio σ(exp)/σ(th), where σ(th) is the SM prediction for $|V_{tb}| = 1$. The 95% CL lower bound of $|V_{tb}| > 0.62$ (0.68) is found from the 2D (BDT) analysis under the constraint $0 < |V_{tb}|^2 < 1$.

t-channel Single t Production Cross Section in pp Collisions at $\sqrt{s}$ = 8 TeV

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
87.7 ± 5.8	[1] AABOUD	19R	LHC	combination of ATLAS+CMS
$89.6^{+7.1}_{-6.3}$	[2] AABOUD	17T	ATLS	$\ell+\not{E}_T$+2 j (1b j)
$83.6\pm2.3\pm7.4$	[3] KHACHATRY...	14F	CMS	$\ell+\not{E}_T+\geq$ 2 j (1,2 b, 1 forward j)

[1] AABOUD 19R based on 12.2 to 20.3 fb^{-1} of data from ATLAS and CMS at 8 TeV.

[2] AABOUD 17T based on 20.2 fb^{-1} of data. A maximum-likelihood fit to neural-network discriminant distributions is used to separate signal and background events. Individual cross sections are measured as $\sigma(tq) = 56.7^{+4.3}_{-3.8}$ pb and $\sigma(\overline{t}q) = 32.9^{+3.0}_{-2.7}$ pb, while their ratio is given by $\sigma(tq)/\sigma(\overline{t}q) = 1.72 \pm 0.09$. A lower limit $|V_{tb}| > 0.92$ (95% CL) is obtained. Measured total and differential cross sections are described well by the SM.

[3] Based on 19.7 fb^{-1} of data. The t and $\overline{t}$ production cross sections are measured separately as $\sigma_{t-ch.}(t) = 53.8 \pm 1.5 \pm 4.4$ pb and $\sigma_{t-ch.}(\overline{t}) = 27.6 \pm 1.3 \pm 3.7$ pb, respectively, as well as their ratio $R_{t-ch} = \sigma_{t-ch.}(t)/\sigma_{t-ch.}(\overline{t}) = 1.95 \pm 0.10 \pm 0.19$, in agreement with the SM predictions. Combination with a previous CMS result at $\sqrt{s}$ = 7 TeV [CHATRCHYAN 12BQ] gives $|V_{tb}| = 0.998 \pm 0.038 \pm 0.016$. Also obtained is the ratio $R_{8/7} = \sigma_{t-ch.}(8\text{TeV})/\sigma_{t-ch.}(7\text{TeV}) = 1.24 \pm 0.08 \pm 0.12$.

s-channel Single t Production Cross Section in pp Collisions at $\sqrt{s}$ = 8 TeV

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
4.9 ± 1.4	[1] AABOUD	19R	LHC	ATLAS + CMS
$4.8 \pm 0.8 ^{+1.6}_{-1.3}$	[2] AAD	16U	ATLS	$\ell + \not\!\!E_T + 2b$
13.4 ± 7.3	[3] KHACHATRY...	16AZ	CMS	$\ell + \not\!\!E_T + 2b$
5.0 ± 4.3	[4] AAD	15A	ATLS	$\ell + \not\!\!E_T + 2b$

[1] AABOUD 19R based on 12.2 to 20.3 fb^{-1} of data from ATLAS and CMS at 8 TeV.
[2] AAD 16U based on 20.3 fb^{-1} of data, using a maximum-likelihood fit of a matrix element method discriminant. The same data set as in AAD 15A is used. The result corresponds to an observed significance of 3.2σ.
[3] KHACHATRYAN 16AZ based on 19.7 fb^{-1} of data, using a multivariate analysis to separate signal and backgrounds. The same method is applied to 5.1 fb^{-1} of data at $\sqrt{s}$ = 7 TeV, giving 7.1 $\pm$ 8.1 pb. Combining both measurements, the observed significance is 2.5σ. A best fit value of 2.0 $\pm$ 0.9 is obtained for the combined ratio of the measured values and SM expectations.
[4] AAD 15A based on 20.3 fb^{-1} of data, using a multivariate analysis to separate signal and backgrounds. The 95% CL upper bound of the cross section is 14.6 pb. The results are consistent with the SM prediction of 5.61 $\pm$ 0.22 pb at approximate NNLO.

t-channel Single t Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$130 \pm 1 \pm 19$	[1] SIRUNYAN	20D	CMS	$\sigma(t q)$, $\ell + \not\!\!E_T + \geq 2 j$
$77 \pm 1 \pm 12$	[1] SIRUNYAN	20D	CMS	$\sigma(\overline{t} q)$, $\ell + \not\!\!E_T + \geq 2 j$
$156 \pm 5 \pm 27 \pm 3$	[2] AABOUD	17H	ATLS	$\sigma(t q)$, $\ell + \not\!\!E_T$+2 j (1b, 1 forward j)
$91 \pm 4 \pm 18 \pm 2$	[2] AABOUD	17H	ATLS	$\sigma(\overline{t} q)$, $\ell + \not\!\!E_T$+2 j (1b, 1 forward j)
$154 \pm 8 \pm 9 \pm 19 \pm 4$	[3] SIRUNYAN	17AA	CMS	$\sigma(t q)$, $\mu + \geq$ 2 j (1b)
$85 \pm 10 \pm 4 \pm 11 \pm 2$	[3] SIRUNYAN	17AA	CMS	$\sigma(\overline{t} q)$, $\mu + \geq$ 2 j (1b)

[1] SIRUNYAN 20D based on 35.9 fb^{-1} of data. Different categories of jet and b jet multiplicity and multivariate discriminators are used to separate signal and background events. The cross section ratio is measured to be $\sigma(t q)/\sigma(\overline{t} q)$ = 1.68 $\pm$ 0.02 $\pm$ 0.05. CKM matrix element is obtained as $|f_{LV} V_{tb}|$ = 0.98 $\pm$ 0.07(exp)$\pm$0.02(theo) where f_{LV} is an anomalous form factor. All results are in agreement with the SM.
[2] AABOUD 17H based on 3.2 fb^{-1} of data. A maximum-likelihood fit to neural-network discriminant distributions is used to separate signal and background events. The third error is for luminosity. The cross section ratio is measured to be $\sigma(t q)/\sigma(\overline{t} q)$ = 1.72 $\pm$ 0.09 $\pm$ 0.18. A lower limit $|V_{tb}|$ > 0.84 (95% CL) is obtained. All results are in agreement with the SM.
[3] SIRUNYAN 17AA based on 2.2 fb^{-1} of data. A multivariate discriminator is used to separate signal and background events. The four errors are from statitics, experimental systematics, theory, and luminosity. The cross section ratio is measured to be $\sigma(t q)/\sigma(\overline{t} q)$ = 1.81 $\pm$ 0.18 $\pm$ 0.15. CKM matrix element is obtained as $|V_{tb}|$ = 1.05 $\pm$ 0.07(exp)$\pm$0.02(theo). All results are in agreement with the SM.

s-channel Single t Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$8.2 ^{+3.5}_{-2.9}$	[1] AAD	23E	ATLS	$\ell + \not\!\!E_T + 2b$

[1] AAD 23E based on 139 fb^{-1} of data. The signal significance is 3.3σ over the background-only hypothesis. The result is consistent with the NLO SM prediction of $10.32 ^{+0.40}_{-0.36}$ pb.

$t\bar{t}H$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (fb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$33\pm31^{+22}_{-17}$	[1] AAD	22Q	ATLS	$H \to \tau\tau$
$670\pm90^{+110}_{-100}$	[2] AABOUD	18BK	ATLS	$H \to b\bar{b}$, WW^* $\tau\tau$, $\gamma\gamma$, ZZ^*

[1] AAD 22Q based on 139 fb^{-1} of data. The measured value includes B($H \to \tau\tau$) and corresponds to the rapidity range $|y_H|$ <2.5. The value is consistent with the SM prediction, where B($H \to \tau\tau$) = 6.3% for m_H = 125.09 GeV.

[2] AABOUD 18BK based on 79.8 fb^{-1} of data. The observed significance is 5.8σ relative to the background-only hypothesis. The measurement is consistent with the NLO SM prediction of 507^{+35}_{-50} fb. See Table 3 and Fig. 5 for measurements of individual modes. Combined with the measurements at 7 and 8 TeV, the observed significance is 6.3σ.

Wt Production Cross Section in pp Collisions at $\sqrt{s}$ = 7 TeV

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
16.3±4.1	[1] AABOUD	19R	LHC	ATLAS + CMS combined
16^{+5}_{-4}	[2] CHATRCHYAN	13C	CMS	$t+W$ channel, $2\ell+\not{E}_T+1b$

[1] AABOUD 19R based on 1.17 to 5.1 fb^{-1} of data from ATLAS and CMS at 7 TeV.

[2] Based on 4.9 fb^{-1} of data. The result gives $V_{tb} = 1.01^{+0.16}_{-0.13}(exp)^{+0.03}_{-0.04}$(th). V_{tb} > 0.79 (95% CL) if V_{tb} < 1 is assumed. The results assume m_t = 172.5 GeV for the acceptance.

Wt Production Cross Section in pp Collisions at $\sqrt{s}$ = 8 TeV

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
26 ±7	[1] AAD	21AT	ATLS	$\ell+\geq 3$j
23.1±3.6	[2] AABOUD	19R	LHC	ATLAS + CMS combined
$23.0\pm1.3^{+3.2}_{-3.5}\pm1.1$	[3] AAD	16B	ATLS	$2\ell+\not{E}_T+1b$
23.4±5.4	[4] CHATRCHYAN	14AC	CMS	$t+W$ channel, $2\ell+\not{E}_T+1b$

[1] AAD 21AT based on 20.2 fb^{-1} of data. In this single lepton channel, only single neutrino is emitted, so that both W and t can be reconstructed. A neural network is trained to separate signal from background. The measured cross section agrees with the NLO+NNLL SM prediction of 22.4 ± 0.6(scale)±1.4(PDF) pb.

[2] AABOUD 19R based on 12.2 to 20.3 fb^{-1} of data from ATLAS and CMS at 8 TeV.

[3] AAD 16B based on 20.3 fb^{-1} of data. The result gives $|V_{tb}| = 1.01\pm0.10$ and $|V_{tb}|$ > 0.80 (95% CL) without assuming unitarity of the CKM matrix. The results assume m_t = 172.5 GeV for the acceptance.

[4] Based on 12.2 fb^{-1} of data. Events with two oppositely charged leptons, large $\not{E}_T$ and a b-tagged jet are selected, and a multivariate analysis is used to separate the signal from the backgrounds. The result is consistent with the SM prediction of 22.2 ± 0.6(scale)±1.4(PDF) pb at approximate NNLO.

Wt Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$79.2\pm0.9^{+7.7}_{-8.0}\pm1.2$	[1] TUMASYAN	23T	CMS	$e^{\pm}\mu^{\mp}$ + $\geq$ 1j(b-tag)
89 ± 4 ±12	[2] TUMASYAN	21E	CMS	1ℓ + jets

$94 \pm 10 \ {}^{+28}_{-22} \pm 2$	[3] AABOUD	18H ATLS	$\ell^+ \ell^- + \geq 1$j
$63.1 \pm 1.8 \pm 6.4 \pm 2.1$	[4] SIRUNYAN	18DL CMS	$e^\pm \mu^\mp + \geq 1$j(b-tag)

[1] TUMASYAN 23T based on 138 fb^{-1} of data. The result is consistent with the NNLO SM prediction. The differential cross sections are measured as a function of six kinematical variables and are consistent with the NLO SM prediction.

[2] TUMASYAN 21E based on 36 fb^{-1} of data. A boosted decision tree is used to separate the signal from the dominant $t\bar{t}$ backgrounds. The result corresponds to an observation with a significance exceeding 5 σ and is consistent with the NNLO QCD prediction of 71.7 $\pm$ 1.8(scale) $\pm$ 3.4(PDF) pb or with the approximate NNNLO SM prediction of $79.5^{+1.9}_{-1.8}$(scale) ${}^{+2.0}_{-1.4}$(PDF) pb.

[3] AABOUD 18H based on 3.2 fb^{-1} of data. The last error is from luminosity. A multivariate analysis is used to separate the signal from the backgrounds. The result is consistent with the NLO+NNLL SM prediction of 71.7 $\pm$ 1.8(scale) $\pm$ 3.4(PDF) pb.

[4] SIRUNYAN 18DL based on 35.9 fb^{-1} of data. The last error is from luminosity. A multivariate analysis is used to separate the signal from the backgrounds. The result is consistent with the NLO+NNLL SM prediction of 71.7 $\pm$ 1.8(scale) $\pm$ 3.4(PDF) pb.

Zt Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (fb)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$87.9^{+7.5}_{-7.3}{}^{+7.3}_{-6.0}$	[1] TUMASYAN	22L CMS	$3\ell + \geq 2$j ($\geq 1b$j)
$97 \pm 13 \pm 7$	[2] AAD	20AB ATLS	3ℓ + 1,2j + 1bj
$111 \pm 13 \ {}^{+11}_{-9}$	[3] SIRUNYAN	19BF CMS	$3\ell + \geq 2$j ($\geq 1b$j)
$600 \pm 170 \pm 140$	[4] AABOUD	18AE ATLS	3ℓ + 1j + 1bj
$123 \ {}^{+33}_{-31} \ {}^{+29}_{-23}$	[5] SIRUNYAN	18Z CMS	3ℓ + 1j + 1bj

[1] TUMASYAN 22L based on 138 fb^{-1} of data at 13 TeV. The result is for a dilepton invariant masses above 30 GeV. It agrees with the NLO SM prediction of $94.2^{+1.9}_{-1.8}$(scale)$\pm$2.5(PDF) fb. The ratio of t and $\bar{t}$ production cross sections is measured as $2.37^{+0.56}_{-0.42}{}^{+0.27}_{-0.13}$. The spin asymmetry is measured to be 0.54 $\pm$ 0.16 $\pm$ 0.06. Both measurements are in agreement with the SM predictions.

[2] AAD 20AB based on 139 fb^{-1} of data at 13 TeV. Neural networks are used to discriminate tZq signal from backgrounds. The result is for the cross section $\sigma(pp \to t\ell^+\ell^- q)$, including non-resonant dilepton pairs, for dilepton invariant masses above 30 GeV and is consistent with the NLO SM prediction of 102^{+5}_{-2} fb.

[3] SIRUNYAN 19BF based on 77.4 fb^{-1} of data. Two BDT's are used in the analysis: one to discriminate prompt leptons from non-prompt ones; and one to discriminate tZq signal from backgrounds. The result is for the cross section $\sigma(pp \to tZq \to t\ell^+\ell^- q)$ for dilepton invariant masses above 30 GeV and is consistent with the NLO SM prediction of 94.2 $\pm$ 3.1 fb.

[4] AABOUD 18AE based on 36.1 fb^{-1} of data. A multivariate analysis is used to separate the signal from the backgrounds. The result is consistent with the NLO SM prediction of 800 fb with a scale uncertainty of ${}^{+6.1}_{-7.4}$%.

[5] SIRUNYAN 18Z based on 35.9 fb^{-1} of data. A multivariate analysis is used to separate the signal from the backgrounds. The result is for the cross section $\sigma(pp \to tZq \to Wb\ell^+\ell^- q)$ and is consistent with the NLO SM prediction of $94.2^{+1.9}_{-1.8}$(scale) $\pm$ 2.5(PDF) fb. Superseded by SIRUNYAN 19BF.

γt Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (fb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] AAD	23BN	ATLS	$\gamma + \ell +$ jets $+ \not{E}_T$

[1] AAD 23BN measured fiducial cross section for $pp \rightarrow t\gamma$ at 13 TeV with 139 fb^{-1} of data. The measured cross section is 688 $\pm$ 23$^{+75}_{-71}$ fb, to be compared with the NLO SM prediction of 515$^{+36}_{-42}$ fb.

Single t-Quark Production Cross Section in ep Collisions

VALUE (pb)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.25	95	[1] AARON	09A	H1	$e^{\pm} p \rightarrow e^{\pm} t X$
<0.55	95	[2] AKTAS	04	H1	$e^{\pm} p \rightarrow e^{\pm} t X$
<0.225	95	[3] CHEKANOV	03	ZEUS	$e^{\pm} p \rightarrow e^{\pm} t X$

[1] AARON 09A looked for single top production via FCNC in $e^{\pm} p$ collisions at HERA with 474 pb^{-1} of data at $\sqrt{s}$ = 301–319 GeV. The result supersedes that of AKTAS 04.
[2] AKTAS 04 looked for single top production via FCNC in $e^{\pm}$ collisions at HERA with 118.3 pb^{-1}, and found 5 events in the e or μ channels while 1.31 $\pm$ 0.22 events are expected from the Standard Model background. No excess was found for the hadronic channel. The observed cross section of $\sigma(e p \rightarrow e t X) = 0.29^{+0.15}_{-0.14}$ pb at $\sqrt{s}$ = 319 GeV gives the quoted upper bound if the observed events are due to statistical fluctuation.
[3] CHEKANOV 03 looked in 130.1 pb^{-1} of data at $\sqrt{s}$ = 301 and 318 GeV. The limit is for $\sqrt{s}$ = 318 GeV and assumes m_t = 175 GeV.

$t\overline{t}$ Production Cross Section in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV

Only the final combined $t\overline{t}$ production cross sections obtained from Tevatron Run I by the CDF and D0 experiments are quoted below.

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
5.69$\pm$1.21$\pm$1.04	[1] ABAZOV	03A	D0	Combined Run I data
6.5 $^{+1.7}_{-1.4}$	[2] AFFOLDER	01A	CDF	Combined Run I data

[1] Combined result from 110 pb^{-1} of Tevatron Run I data. Assume m_t = 172.1 GeV.
[2] Combined result from 105 pb^{-1} of Tevatron Run I data. Assume m_t = 175 GeV.

$t\overline{t}$ Production Cross Section in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.96 TeV

Unless otherwise noted the first quoted error is from statistics, the second from systematic uncertainties, and the third from luminosity. If only two errors are quoted the luminosity is included in the systematic uncertainties.

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
7.26$\pm$0.13$^{+0.57}_{-0.50}$	[1] ABAZOV	16F	D0	$\ell\ell$, ℓ+jets channels
8.1 $\pm$2.1	[2] AALTONEN	14A	CDF	$\ell + \tau_h + \geq$ 2jets ($\geq 1b$-tag)
7.60$\pm$0.20$\pm$0.29$\pm$0.21	[3] AALTONEN	14H	TEVA	$\ell\ell$, ℓ+jets, all-jets channels
8.0 $\pm$0.7 $\pm$0.6 $\pm$0.5	[4] ABAZOV	14K	D0	$\ell + \not{E}_T + \geq$ 4 jets ($\geq 1b$-tag)
7.09$\pm$0.84	[5] AALTONEN	13AB	CDF	$\ell\ell + \not{E}_T + \geq$ 2 jets
7.5 $\pm$1.0	[6] AALTONEN	13G	CDF	$\ell + \not{E}_T + \geq$ 3jets ($\geq 1b$-tag)
8.8 $\pm$3.3 $\pm$2.2	[7] AALTONEN	12AL	CDF	$\tau_h + \not{E}_T$ +4j ($\geq 1b$)

$8.5 \pm0.6 \pm0.7$	[8] AALTONEN	11D	CDF	$\ell + \not{E}_T$ + jets ($\geq 1b$-tag)
$7.64\pm0.57\pm0.45$	[9] AALTONEN	11W	CDF	$\ell + \not{E}_T$ + jets ($\geq 1b$-tag)
$7.99\pm0.55\pm0.76\pm0.46$	[10] AALTONEN	11Y	CDF	$\not{E}_T + \geq$ 4jets (0,1,2 b-tag)
$7.78^{+0.77}_{-0.64}$	[11] ABAZOV	11E	D0	$\ell + \not{E}_T + \geq 2$ jets
$7.56^{+0.63}_{-0.56}$	[12] ABAZOV	11Z	D0	Combination
$6.27\pm0.73\pm0.63\pm0.39$	[13] AALTONEN	10AA	CDF	Repl. by AALTONEN 13AB
$7.2 \pm0.5 \pm1.0 \pm0.4$	[14] AALTONEN	10E	CDF	≥ 6 jets, vtx b-tag
$7.8 \pm2.4 \pm1.6 \pm0.5$	[15] AALTONEN	10V	CDF	$\ell + \geq 3$ jets, soft-e b-tag
7.70 ± 0.52	[16] AALTONEN	10W	CDF	$\ell + \not{E}_T + \geq 3$ jets + b-tag, norm. to $\sigma(Z \rightarrow \ell\ell)_{TH}$
6.9 ± 2.0	[17] ABAZOV	10I	D0	≥ 6 jets with 2 b-tags
$6.9 \pm1.2 {}^{+0.8}_{-0.7} \pm0.4$	[18] ABAZOV	10Q	D0	τ_h + jets
$9.6 \pm1.2 {}^{+0.6}_{-0.5} \pm0.6$	[19] AALTONEN	09AD	CDF	$\ell\ell + \not{E}_T$ / vtx b-tag
$9.1 \pm1.1 {}^{+1.0}_{-0.9} \pm0.6$	[20] AALTONEN	09H	CDF	$\ell + \geq 3$ jets+$\not{E}_T$/soft μ b-tag
$8.18^{+0.98}_{-0.87}$	[21] ABAZOV	09AG	D0	ℓ + jets, $\ell\ell$ and $\ell\tau$ + jets
$7.5 \pm1.0 {}^{+0.7}_{-0.6} {}^{+0.6}_{-0.5}$	[22] ABAZOV	09R	D0	$\ell\ell$ and $\ell\tau$ + jets
$8.18^{+0.90}_{-0.84}\pm0.50$	[23] ABAZOV	08M	D0	ℓ + n jets with 0,1,2 b-tag
7.62 ± 0.85	[24] ABAZOV	08N	D0	ℓ + n jets + b-tag or kinematics
$8.5 {}^{+2.7}_{-2.2}$	[25] ABULENCIA	08	CDF	$\ell^+\ell^-$ ($\ell = e, \mu$)
$8.3 \pm1.0 {}^{+2.0}_{-1.5} \pm0.5$	[26] AALTONEN	07D	CDF	≥ 6 jets, vtx b-tag
$7.4 \pm1.4 \pm1.0$	[27] ABAZOV	07O	D0	$\ell\ell$ + jets, vtx b-tag
$4.5 {}^{+2.0}_{-1.9} {}^{+1.4}_{-1.1} \pm0.3$	[28] ABAZOV	07P	D0	≥ 6 jets, vtx b-tag
$6.4 {}^{+1.3}_{-1.2} \pm0.7 \pm0.4$	[29] ABAZOV	07R	D0	$\ell + \geq 4$ jets
$6.6 \pm0.9 \pm0.4$	[30] ABAZOV	06X	D0	ℓ + jets, vtx b-tag
$8.7 \pm0.9 {}^{+1.1}_{-0.9}$	[31] ABULENCIA	06Z	CDF	ℓ + jets, vtx b-tag
$5.8 \pm1.2 {}^{+0.9}_{-0.7}$	[32] ABULENCIA,A	06C	CDF	missing E_T + jets, vtx b-tag
$7.5 \pm2.1 {}^{+3.3}_{-2.2} {}^{+0.5}_{-0.4}$	[33] ABULENCIA,A	06E	CDF	6–8 jets, b-tag
$8.9 \pm1.0 {}^{+1.1}_{-1.0}$	[34] ABULENCIA,A	06F	CDF	$\ell + \geq 3$ jets, b-tag
$8.6 {}^{+1.6}_{-1.5} \pm0.6$	[35] ABAZOV	05Q	D0	ℓ + n jets
$8.6^{+3.2}_{-2.7} \pm 1.1 \pm 0.6$	[36] ABAZOV	05R	D0	di-lepton + n jets
$6.7 {}^{+1.4}_{-1.3} {}^{+1.6}_{-1.1} \pm0.4$	[37] ABAZOV	05X	D0	ℓ + jets / kinematics
$5.3 \pm3.3 {}^{+1.3}_{-1.0}$	[38] ACOSTA	05S	CDF	ℓ + jets / soft μ b-tag
$6.6 \pm1.1 \pm1.5$	[39] ACOSTA	05T	CDF	ℓ + jets / kinematics
$6.0 {}^{+1.5}_{-1.6} {}^{+1.2}_{-1.3}$	[40] ACOSTA	05U	CDF	ℓ + jets/kinematics + vtx b-tag
$5.6 {}^{+1.2}_{-1.1} {}^{+0.9}_{-0.6}$	[41] ACOSTA	05V	CDF	ℓ + n jets
$7.0 {}^{+2.4}_{-2.1} {}^{+1.6}_{-1.1} \pm0.4$	[42] ACOSTA	04I	CDF	di-lepton + jets + missing ET

[1] ABAZOV 16F based on 9.7 fb^{-1} of data. The result is for $m_t = 172.5$ GeV, and the m_t dependence is shown in Table V and Fig. 9. The result agrees with the NNLO+NNLL SM prediction of $7.35^{+0.23}_{-0.27}$ pb.

[2] Based on 9 fb^{-1} of data. The measurement is in the channel $t\overline{t} \rightarrow (b\ell\nu)(b\tau\nu)$, where τ decays into hadrons (τ_h), and ℓ (e or μ) include ℓ from τ decays (τ_ℓ). The result is for $m_t = 173$ GeV.

[3] Based on 8.8 fb^{-1} of data. Combination of CDF and D0 measurements given, respectively, by $\sigma(t\overline{t}$; CDF$) = 7.63 \pm 0.31 \pm 0.36 \pm 0.16$ pb, $\sigma(t\overline{t}$; D0$) = 7.56 \pm 0.20 \pm 0.32 \pm 0.46$ pb. All the results are for $m_t = 172.5$ GeV. The m_t dependence of the mean value is parametrized in eq. (1) and shown in Fig. 2.

[4] Based on 9.7 fb^{-1} of data. Differential cross sections with respect to m_{tt}, $|y(\text{top})|$, $E_T(\text{top})$ are shown in Figs. 9, 10, 11, respectively, and are compared to the predictions of MC models.

[5] Based on 8.8 fb^{-1} of $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV.

[6] Based on 8.7 fb^{-1} of $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. Measure the $t\overline{t}$ cross section simultaneously with the fraction of $t \rightarrow Wb$ decays. The correlation coefficient between those two measurements is -0.434. Assume unitarity of the 3×3 CKM matrix and set $|V_{tb}| > 0.89$ at 95% CL.

[7] Based on 2.2 fb^{-1} of data in $p\overline{p}$ collisions at 1.96 TeV. The result assumes the acceptance for $m_t = 172.5$ GeV.

[8] Based on 1.12 fb^{-1} and assumes $m_t = 175$ GeV, where the cross section changes by ± 0.1 pb for every ∓ 1 GeV shift in m_t. AALTONEN 11D fits simultaneously the $t\overline{t}$ production cross section and the b-tagging efficiency and find improvements in both measurements.

[9] Based on 2.7 fb^{-1}. The first error is from statistics and systematics, the second is from luminosity. The result is for $m_t = 175$ GeV. AALTONEN 11W fits simultaneously a jet flavor discriminator between b-, c-, and light-quarks, and find significant reduction in the systematic error.

[10] Based on 2.2 fb^{-1}. The result is for $m_t = 172.5$ GeV. AALTONEN 11Y selects multi-jet events with large $\not\!\!E_T$, and vetoes identified electrons and muons.

[11] Based on 5.3 fb^{-1}. The error is statistical + systematic + luminosity combined. The result is for $m_t = 172.5$ GeV. The results for other m_t values are given in Table XII and eq.(10) of ABAZOV 11E.

[12] Combination of a dilepton measurement presented in ABAZOV 11Z (based on 5.4 fb^{-1}), which yields $7.36^{+0.90}_{-0.79}$ (stat+syst) pb, and the lepton + jets measurement of ABAZOV 11E. The result is for $m_t = 172.5$ GeV. The results for other m_t values is given by eq.(5) of ABAZOV 11A.

[13] Based on 2.8 fb^{-1}. The result is for $m_t = 175$ GeV.

[14] Based on 2.9 fb^{-1}. Result is obtained from the fraction of signal events in the top quark mass measurement in the all hadronic decay channel.

[15] Based on 1.7 fb^{-1}. The result is for $m_t = 175$ GeV. AALTONEN 10V uses soft electrons from b-hadron decays to suppress W+jets background events.

[16] Based on 4.6 fb^{-1}. The result is for $m_t = 172.5$ GeV. The ratio $\sigma(t\overline{t} \rightarrow \ell\text{+jets}) / \sigma(Z/\gamma^* \rightarrow \ell\ell)$ is measured and then multiplied by the theoretical $Z/\gamma^* \rightarrow \ell\ell$ cross section of $\sigma(Z/\gamma^* \rightarrow \ell\ell) = 251.3 \pm 5.0$ pb, which is free from the luminosity error.

[17] Based on 1 fb^{-1}. The result is for $m_t = 175$ GeV. 7.9 ± 2.3 pb is found for $m_t = 170$ GeV. ABAZOV 10I uses a likelihood discriminant to separate signal from background, where the background model was created from lower jet-multiplicity data.

[18] Based on 1 fb^{-1}. The result is for $m_t = 170$ GeV. For $m_t = 175$ GeV, the result is $6.3^{+1.2}_{-1.1}$(stat)± 0.7(syst)± 0.4(lumi) pb. Cross section of $t\overline{t}$ production has been measured in the $t\overline{t} \rightarrow \tau_h +$ jets topology, where τ_h denotes hadronically decaying τ leptons. The result for the cross section times the branching ratio is $\sigma(t\overline{t}) \cdot \text{B}(t\overline{t} \rightarrow \tau_h + \text{jets}) = 0.60^{+0.23}_{-0.22}{}^{+0.15}_{-0.14} \pm 0.04$ pb for $m_t = 170$ GeV.

[19] Based on 1.1 fb^{-1}. The result is for B($W \to \ell\nu$) = 10.8% and m_t = 175 GeV; the mean value is 9.8 for m_t = 172.5 GeV and 10.1 for m_t = 170 GeV. AALTONEN 09AD used high p_T e or μ with an isolated track to select $t\bar{t}$ decays into dileptons including $\ell = \tau$. The result is based on the candidate event samples with and without vertex b-tag.

[20] Based on 2 fb^{-1}. The result is for m_t = 175 GeV; the mean value is 3% higher for m_t = 170 GeV and 4% lower for m_t = 180 GeV.

[21] Result is based on 1 fb^{-1} of data. The result is for m_t = 170 GeV, and the mean value decreases with increasing m_t; see their Fig. 2. The result is obtained after combining ℓ + jets, $\ell\ell$, and $\ell\tau$ final states, and the ratios of the extracted cross sections are $R^{\ell\ell/\ell j} = 0.86^{+0.19}_{-0.17}$ and $R^{\ell\tau/\ell\ell-\ell j} = 0.97^{+0.32}_{-0.29}$, consistent with the SM expectation of R = 1. This leads to the upper bound of B($t \to bH^+$) as a function of m_{H^+}. Results are shown in their Fig. 1 for B($H^+ \to \tau\nu$) = 1 and B($H^+ \to c\bar{s}$) = 1 cases. Comparison of the m_t dependence of the extracted cross section and a partial NNLO prediction gives $m_t = 169.1^{+5.9}_{-5.2}$ GeV.

[22] Result is based on 1 fb^{-1} of data. The result is for m_t = 170 GeV, and the mean value changes by -0.07 [m_t(GeV)-170] pb near the reference m_t value. Comparison of the m_t dependence of the extracted cross section and a partial NNLO QCD prediction gives $m_t = 171.5^{+9.9}_{-8.8}$ GeV. The $\ell\tau$ channel alone gives $7.6^{+4.9+3.5+1.4}_{-4.3-3.4-0.9}$ pb and the $\ell\ell$ channel gives $7.5^{+1.2+0.7+0.7}_{-1.1-0.6-0.5}$ pb.

[23] Result is based on 0.9 fb^{-1} of data. The first error is from stat + syst, while the latter error is from luminosity. The result is for m_t=175 GeV, and the mean value changes by -0.09 pb$\cdot$[m_t(GeV)-175].

[24] Result is based on 0.9 fb^{-1} of data. The cross section is obtained from the $\ell + \geq 3$ jet event rates with 1 or 2 b-tag, and also from the kinematical likelihood analysis of the ℓ + 3, 4 jet events. The result is for m_t= 172.6 GeV, and its m_t dependence shown in Fig. 3 leads to the constraint $m_t = 170 \pm 7$ GeV when compared to the SM prediction.

[25] Result is based on 360 pb^{-1} of data. Events with high p_T oppositely charged dileptons $\ell^+\ell^-$ ($\ell = e, \mu$) are used to obtain cross sections for $t\bar{t}$, W^+W^-, and $Z \to \tau^+\tau^-$ production processes simultaneously. The other cross sections are given in Table IV.

[26] Based on 1.02 fb^{-1} of data. Result is for m_t = 175 GeV. Secondary vertex b-tag and neural network selections are used to achieve a signal-to-background ratio of about 1/2.

[27] Based on 425 pb^{-1} of data. Result is for m_t = 175 GeV. For m_t = 170.9 GeV, 7.8 $\pm$ 1.8(stat + syst) pb is obtained.

[28] Based on 405 $\pm$ 25 pb^{-1} of data. Result is for m_t = 175 GeV. The last error is for luminosity. Secondary vertex b-tag and neural network are used to separate the signal events from the background.

[29] Based on 425 pb^{-1} of data. Assumes m_t = 175 GeV.

[30] Based on $\sim$ 425 pb^{-1}. Assuming m_t = 175 GeV. The first error is combined statistical and systematic, the second one is luminosity.

[31] Based on $\sim$ 318 pb^{-1}. Assuming m_t = 178 GeV. The cross section changes by $\pm$0.08 pb for each $\mp$ GeV change in the assumed m_t. Result is for at least one b-tag. For at least two b-tagged jets, $t\bar{t}$ signal of significance greater than 5σ is found, and the cross section is $10.1^{+1.6+2.0}_{-1.4-1.3}$ pb for m_t = 178 GeV.

[32] Based on $\sim$ 311 pb^{-1}. Assuming m_t = 178 GeV. For m_t = 175 GeV, the result is $6.0 \pm 1.2^{+0.9}_{-0.7}$. This is the first CDF measurement without lepton identification, and hence it has sensitivity to the $W \to \tau\nu$ mode.

[33] ABULENCIA,A 06E measures the $t\bar{t}$ production cross section in the all hadronic decay mode by selecting events with 6 to 8 jets and at least one b-jet. S/B = 1/5 has been achieved. Based on 311 pb^{-1}. Assuming m_t = 178 GeV.

[34] Based on $\sim$ 318 pb^{-1}. Assuming m_t = 178 GeV. Result is for at least one b-tag. For at least two b-tagged jets, the cross section is $11.1^{+2.3}_{-1.9}{}^{+2.5}_{-1.9}$ pb.

[35] ABAZOV 05Q measures the top-quark pair production cross section with $\sim$ 230 pb^{-1} of data, based on the analysis of W plus n-jet events where W decays into e or μ plus neutrino, and at least one of the jets is b-jet like. The first error is statistical and systematic, and the second accounts for the luminosity uncertainty. The result assumes m_t = 175 GeV; the mean value changes by (175$-m_t$(GeV)) $\times$ 0.06 pb in the mass range 160 to 190 GeV.

[36] ABAZOV 05R measures the top-quark pair production cross section with 224–243 pb^{-1} of data, based on the analysis of events with two charged leptons in the final state. The result assumes m_t = 175 GeV; the mean value changes by (175$-m_t$(GeV)) $\times$ 0.08 pb in the mass range 160 to 190 GeV.

[37] Based on 230 pb^{-1}. Assuming m_t = 175 GeV.

[38] Based on 194 pb^{-1}. Assuming m_t = 175 GeV.

[39] Based on 194 $\pm$ 11 pb^{-1}. Assuming m_t = 175 GeV.

[40] Based on 162 $\pm$ 10 pb^{-1}. Assuming m_t = 175 GeV.

[41] ACOSTA 05V measures the top-quark pair production cross section with $\sim$ 162 pb^{-1} data, based on the analysis of W plus n-jet events where W decays into e or μ plus neutrino, and at least one of the jets is b-jet like. Assumes m_t = 175 GeV.

[42] ACOSTA 04I measures the top-quark pair production cross section with 197 $\pm$ 12 pb^{-1} data, based on the analysis of events with two charged leptons in the final state. Assumes m_t = 175 GeV.

Ratio of the Production Cross Sections of $t\bar{t}\gamma$ to $t\bar{t}$ at $\sqrt{s}$ = 1.96 TeV

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.024±0.009	[1] AALTONEN	11Z	CDF	$E_T(\gamma) > 10$ GeV, $\lvert\eta(\gamma)\rvert < 1.0$

[1] Based on 6.0 fb^{-1} of data. The error is statistical and systematic combined. Events with lepton + $\not\!\!E_T$ + $\geq$ 3 jets($\geq 1b$) with and without central, high E_T photon are measured. The result is consistent with the SM prediction of 0.024 $\pm$ 0.005. The absolute production cross section is measured to be 0.18 $\pm$ 0.08 fb. The statistical significance is 3.0 standard deviations.

tt Production Cross Section in pp Collisions at $\sqrt{s}$ = 7 TeV

VALUE (pb)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.7	95	[1] AAD	12BE	ATLS	$\ell^+\ell^+ + \not\!\!E_T + \geq$ 2j +HT

[1] Based on 1.04 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV. The upper bounds are the same for LL, LR and RR chiral components of the two top quarks.

$t\bar{t}$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 5.02 TeV

Unless otherwise noted the first quoted error is from statistics, the second from systematic uncertainties, and the third from luminosity. If only two errors are quoted the luminosity is included in the systematic uncertainties.

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
67.5±0.9±2.6	[1] AAD	23J	ATLS	dilepton + single ℓ channels
60.7±5.0±2.8±1.1	[2] TUMASYAN	22T	CMS	$e + \mu + \geq$ 2 jets
63.0±4.1±3.0	[3] TUMASYAN	22T	CMS	combination of $e + \mu + \geq$ 2 jets, ℓ+jets

$69.5 \pm 6.1 \pm 5.6 \pm 1.6$	[4] SIRUNYAN	18AQ	CMS	ℓ+jets, $\ell\ell$+jets

[1] AAD 23J based on 257 pb^{-1} of data from pp collisions. The second error is the sum of systematics (± 2.3), luminosity(± 1.1) and beam energy (± 0.2) uncertainties. The result agrees with the NNLO+NNLL SM prediction of $68.2^{+5.2}_{-5.3}$ pb.

[2] TUMASYAN 22T based on 302 pb^{-1} of data from pp collisions at $\sqrt{s}$ = 5.02 TeV. The errors are from statistics, systematics and luminosity.

[3] Combination of the measurement by TUMASYAN 22T and the measurement in the ℓ+jets channel by SIRUNYAN 18AQ. The errors are from statistics and systematics + luminosity. The result is in agreement with the NNLO+NNLL SM prediction $66.8^{+2.9}_{-3.1}$ pb.

[4] SIRUNYAN 18AQ based on 27.4 pb^{-1} of data from pp collisions at $\sqrt{s}$ = 5.02 TeV. The result is in agreement with the NNLO SM prediction $68.9^{+1.9}_{-2.3}$(scale)± 2.3(PDF)$^{+1.4}_{-1.0}(\alpha_s)$ pb.

$t\bar{t}$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 7 TeV

Unless otherwise noted the first quoted error is from statistics, the second from systematic uncertainties, and the third from luminosity. If only two errors are quoted the luminosity is included in the systematic uncertainties.

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$168.5 \pm 0.7^{+6.2}_{-5.9}{}^{+3.4}_{-3.2}$	[1] AABOUD	23	ATLS	$1\ell + \not\!\!E_T + \geq 3$j (0,1,2 b-tagged j)
178.5 ± 4.7	[2] AAD	23AY	LHC	$e^{\pm}\mu^{\mp}$ pair; ATLAS+CMS combined
$161.7 \pm 6.0 \pm 12.0 \pm 3.6$	[3] KHACHATRY...	17B	CMS	$\ell + \not\!\!E_T + \geq 4$j ($\geq 1b$)
$173.6 \pm 2.1^{+4.5}_{-4.0} \pm 3.8$	[4] KHACHATRY...	16AW	CMS	$e + \mu + \not\!\!E_T + \geq 0$j
$181.2 \pm 2.8^{+10.8}_{-10.6}$	[5] AAD	15BO	ATLS	$e + \mu + \not\!\!E_T + \geq 0$j
$178 \pm 3 \pm 16 \pm 3$	[6] AAD	15CC	ATLS	ℓ+jets, $\ell\ell$+jets, $\ell\tau_h$+jets
	[7] AAIJ	15R	LHCB	$\mu + \geq 1$j(b-tag) forward region
$182.9 \pm 3.1 \pm 6.4$	[8] AAD	14AY	ATLS	$e + \mu$ + 1 or 2b jets
$194 \pm 18 \pm 46$	[9] AAD	13X	ATLS	$\tau_h + \not\!\!E_T + \geq 5$j ($\geq 2b$)
$139 \pm 10 \pm 26$	[10] CHATRCHYAN	13AY	CMS	≥ 6 jets with 2 b-tags
$158.1 \pm 2.1 \pm 10.8$	[11] CHATRCHYAN	13BB	CMS	$\ell + \not\!\!E_T$ + jets(≥ 1 b-tag)
$152 \pm 12 \pm 32$	[12] CHATRCHYAN	13BE	CMS	$\tau_h + \not\!\!E_T + \geq 4$ jets (≥ 1 b)
$177 \pm 20 \pm 14 \pm 7$	[13] AAD	12B	ATLS	Repl. by AAD 12BF
$176 \pm 5 ^{+14}_{-11} \pm 8$	[14] AAD	12BF	ATLS	$\ell\ell + \not\!\!E_T + \geq 2$j
$187 \pm 11 ^{+18}_{-17} \pm 6$	[15] AAD	12BO	ATLS	$\ell + \not\!\!E_T + \geq 3$j with b-tag
$186 \pm 13 \pm 20 \pm 7$	[16] AAD	12CG	ATLS	$\ell + \tau_h + \not\!\!E_T + \geq 2$j ($\geq 1b$)
$143 \pm 14 \pm 22 \pm 3$	[17] CHATRCHYAN	12AC	CMS	$\ell + \tau_h + \not\!\!E_T + \geq 2$j ($\geq 1b$)
$161.9 \pm 2.5^{+5.1}_{-5.0} \pm 3.6$	[18] CHATRCHYAN	12AX	CMS	$\ell\ell + \not\!\!E_T + \geq 2b$
$145 \pm 31 ^{+42}_{-27}$	[19] AAD	11A	ATLS	$\ell + \not\!\!E_T + \geq 4$j, $\ell\ell + \not\!\!E_T + \geq 2$j
$173 ^{+39}_{-32} \pm 7$	[20] CHATRCHYAN	11AA	CMS	$\ell + \not\!\!E_T + \geq 3$ jets
$168 \pm 18 \pm 14 \pm 7$	[21] CHATRCHYAN	11F	CMS	$\ell\ell + \not\!\!E_T$ + jets

154 ±17 ± 6	[22] CHATRCHYAN 11Z	CMS	Combination
194 ±72 ±24 ±21	[23] KHACHATRY...11A	CMS	$\ell\ell + \not\!\!E_T + \geq 2$ jets

[1] AABOUD 23 based on 4.6 fb^{-1} of data. The measurement is performed using a multivariate event classifier based on a binary learning algorithm which differentiates $t\overline{t}$ events from backgrounds in a three-dimensional space. The result is in agreement with the NNLO+NNLL SM prediction of 177^{+5}_{-6}(scale)$\pm$9(PDF+α_s) pb for m_t = 172.5 GeV. Compared to the measured cross section using the dilepton mode of AAD 14AY, significance of discrepancy is between 1.9σ to 2.1σ.

[2] AAD 23AY based on 5 fb^{-1} of data using m_t = 172.5 GeV. The ratio of the combined cross section at $\sqrt{s}$ = 8 TeV to this one at $\sqrt{s}$ = 7 TeV is determined as 1.363 $\pm$ 0.032. The values of the cross sections as well as the ratio are consistent with the NNLO+NNLL SM predictions.

[3] KHACHATRYAN 17B based on 5.0 fb^{-1} of data, using a binned likelihood fit of templates to the data. Also the ratio $\sigma(t\overline{t}$; 8 TeV$)/\sigma(t\overline{t}$; 7 TeV$) = 1.43 \pm 0.04 \pm 0.07 \pm 0.05$ is reported. The results are in agreement with NNLO SM predictions.

[4] KHACHATRYAN 16AW based on 5.0 fb^{-1} of data, using a binned likelihood fit to differential distributions of b-tagged and non-b-tagged jets. The result is in good agreement with NNLO SM predictions.

[5] Based on 4.6 fb^{-1} of data. Uses a template fit to distributions of $\not\!\!E_T$ and jet multiplicities to measure simultaneously $t\overline{t}$, WW, and $Z/\gamma^* \rightarrow \tau\tau$ cross sections, assuming m_t = 172.5 GeV.

[6] AAD 15CC based on 4.6 fb^{-1} of data. The event selection criteria are optimized for the $\ell\tau_h$ + jets channel. Using only this channel 183 $\pm$ 9 $\pm$ 23 $\pm$ 3 pb is derived for the cross section.

[7] AAIJ 15R, based on 1.0 fb^{-1} of data, reports 0.239 $\pm$ 0.053 $\pm$ 0.033 $\pm$ 0.024 pb cross section for the forward fiducial region $p_T(\mu) > 25$ GeV, $2.0 < \eta(\mu) < 4.5$, 50 GeV $< p_T(b) < 100$ GeV, $2.2 < \eta(b) < 4.2$, $\Delta R(\mu,b) > 0.5$, and $p_T(\mu+b) > 20$ GeV. The three errors are from statistics, systematics, and theory. The result agrees with the SM NLO prediction.

[8] AAD 14AY reports 182.9 $\pm$ 3.1 $\pm$ 4.2 $\pm$ 3.6 $\pm$ 3.3 pb value based on 4.6 fb^{-1} of data. The four errors are from statistics, systematic, luminosity, and the 0.66% beam energy uncertainty. We have combined the systematic uncertainties in quadrature. The result is for m_t = 172.5GeV; for other m_t, $\sigma(m_t) = \sigma(172.5\text{GeV})\times[1-0.0028\times(m_t - 172.5\text{GeV})]$. The result is consistent with the SM prediction at NNLO.

[9] Based on 1.67 fb^{-1} of data. The result uses the acceptance for m_t = 172.5 GeV.

[10] Based on 3.54 fb^{-1} of data.

[11] Based on 2.3 fb^{-1} of data.

[12] Based on 3.9 fb^{-1} of data.

[13] Based on 35 pb^{-1} of data for an assumed top quark mass of m_t = 172.5 GeV.

[14] Based on 0.70 fb^{-1} of data. The 3 errors are from statistics, systematics, and luminosity. The result uses the acceptance for m_t = 172.5 GeV.

[15] Based on 35 pb^{-1} of data. The 3 errors are from statistics, systematics, and luminosity. The result uses the acceptance for m_t = 172.5 GeV and 173 $\pm$ 17^{+18}_{-16} $\pm$ 6 pb is found without the b-tag.

[16] Based on 2.05 fb^{-1} of data. The hadronic τ candidates are selected using a BDT technique. The 3 errors are from statistics, systematics, and luminosity. The result uses the acceptance for m_t = 172.5 GeV.

[17] Based on 2.0 fb^{-1} and 2.2 fb^{-1} of data for $\ell = e$ and $\ell = \mu$, respectively. The 3 errors are from statistics, systematics, and luminosity. The result uses the acceptance for m_t = 172.5 GeV.

[18] Based on 2.3 fb^{-1} of data. The 3 errors are from statistics, systematics, and luminosity. The result uses the profile likelihood-ratio (PLB) method and an assumed m_t of 172.5 GeV.

[19] Based on 2.9 pb^{-1} of data. The result for single lepton channels is $142 \pm 34^{+50}_{-31}$ pb, while for the dilepton channels is $151^{+78}_{-62}{}^{+37}_{-24}$ pb.

[20] Result is based on 36 pb^{-1} of data. The first uncertainty corresponds to the statistical and systematic uncertainties, and the second corresponds to the luminosity.

[21] Based on 36 pb^{-1} of data. The ratio of $t\bar{t}$ and Z/γ^* cross sections is measured as $\sigma(pp \to t\bar{t})/\sigma(pp \to Z/\gamma^* \to e^+e^-/\mu^+\mu^-) = 0.175 \pm 0.018(\text{stat}) \pm 0.015(\text{syst})$ for $60 < m_{\ell\ell} < 120$ GeV, for which they use an NNLO prediction for the denominator cross section of 972 ± 42 pb.

[22] Result is based on 36 pb^{-1} of data. The first error is from statistical and systematic uncertainties, and the second from luminosity. This is a combination of a measurement in the dilepton channel (CHATRCHYAN 11F) and the measurement in the ℓ + jets channel (CHATRCHYAN 11Z) which yields 150 ± 9 ± 17 ± 6 pb.

[23] Result is based on 3.1 ± 0.3 pb^{-1} of data.

$t\bar{t}$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 8 TeV

Unless otherwise noted the first quoted error is from statistics, the second from systematic uncertainties, and the third from luminosity. If only two errors are quoted the luminosity is included in the systematic uncertainties.

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$243.3^{+6.0}_{-5.9}$	[1] AAD	23AY	LHC	$e^\pm \mu^\mp$ pair; ATLAS+CMS combined
$248.3 \pm 0.7 \pm 13.4 \pm 4.7$	[2] AABOUD	18BH	ATLS	$\ell + \not{E}_T + \geq 4j$ ($\geq 1b$)
$239 \pm 4 \pm 28 \pm 5$	[3] AABOUD	17Z	ATLS	$\tau_h + \not{E}_T + \geq 2j$ ($\geq 2b$)
$228.5 \pm 3.8 \pm 13.7 \pm 6.0$	[4] KHACHATRY...	17B	CMS	$\ell + \not{E}_T + \geq 4j$ ($\geq 1b$)
$242.9 \pm 1.7 \pm 8.6$	[5] AAD	16BK	ATLS	$e + \mu$ + 1 or 2b jets
$244.9 \pm 1.4^{+6.3}_{-5.5} \pm 6.4$	[6] KHACHATRY...	16AW	CMS	$e + \mu + \not{E}_T + \geq 0j$
$275.6 \pm 6.1 \pm 37.8 \pm 7.2$	[7] KHACHATRY...	16BC	CMS	$\geq 6j$ ($\geq 2b$)
$260 \pm 1 {}^{+24}_{-25}$	[8] AAD	15BP	ATLS	$\ell + \not{E}_T + \geq 3j$ ($\geq 1b$)
	[9] AAIJ	15R	LHCB	$\mu + \geq 1j$(b-tag) forward region
$242.4 \pm 1.7 \pm 10.2$	[10] AAD	14AY	ATLS	$e + \mu$ + 1 or 2b jets
$239 \pm 2 \pm 11 \pm 6$	[11] CHATRCHYAN	14F	CMS	$\ell\ell + \not{E}_T + \geq 2j$ (≥ 1 b-tag)
$257 \pm 3 \pm 24 \pm 7$	[12] KHACHATRY...	14S	CMS	$\ell + \tau_h + \not{E}_T + \geq 2j$ ($\geq 1b$)

[1] AAD 23AY based on 20 fb^{-1} of data using m_t = 172.5 GeV. The ratio of this cross section at $\sqrt{s}$ = 8 TeV to the combined cross section at $\sqrt{s}$ = 7 TeV is determined as 1.363 ± 0.032. The values of cross sections as well as their ratio are consistent with the NNLO+NNLL SM predictions.

[2] AABOUD 18BH based on 20.2 fb^{-1} of data. The result is for m_t = 172.5 GeV. To reduce effects of uncertainties in the jet energy scale and b-tagging efficiency, they are included as nuisance parameters in the fit of discriminant distributions, after separating selected events into three regions. Furthermore the W+jets background distribution is modelled using Z+jets event data.

[3] AABOUD 17Z based on 20.2 fb^{-1} of data, using the mode $t\bar{t} \to \tau\nu q'\bar{q}b\bar{b}$ with τ decaying hadronically. Single prong and 3 prong decays of τ are separately analyzed. The result is consistent with the SM. The third quoted uncertainty is due to luminosity.

[4] KHACHATRYAN 17B based on 19.6 fb^{-1} of data, using a binned likelihood fit of templates to the data. Also the ratio $\sigma(t\bar{t}$; 8 TeV$)/\sigma(t\bar{t}$; 7 TeV$) = 1.43 \pm 0.04 \pm 0.07 \pm 0.05$ is reported. The results are in agreement with NNLO SM predictions.

[5] AAD 16BK is an update of the value from AAD 14AY using the improved luminosity calibration. The value 242.9 ± 1.7 ± 5.5 ± 5.1 ± 4.2 pb is reported, where we have combined the systematic uncertainties in quadrature. Also the ratio $\sigma(t\bar{t}$; 8TeV$)/\sigma(t\bar{t}$;

7TeV) = 1.328 ± 0.024 ± 0.015 ± 0.038 ± 0.001 has been updated. The former result is consistent with the SM predictions at NNLO, while the latter result is 2.1 σ below the expectation.

[6] KHACHATRYAN 16AW based on 19.7 fb^{-1} of data, using a binned likelihood fit to differential distributions of b-tagged and non-b-tagged jets. The result is in good agreement with NNLO SM predictions.

[7] KHACHATRYAN 16BC based on 18.4 fb^{-1} of data. The last uncertainty is due to luminosity. Cuts on kinematical fit probability and $\Delta R(b,b)$ are imposed. The major QCD background is determined from the data. The result is for m_t = 172.5 GeV and in agreement with the SM prediction. The top quark p_T spectra, also measured, are significantly softer than theoretical predictions.

[8] AAD 15BP based on 20.3 fb^{-1} of data. The result is for m_t = 172.5 GeV and in agreement with the SM prediction 253^{+13}_{-15} pb at NNLO+NNLL. Superseded by AABOUD 18BH.

[9] AAIJ 15R, based on 2.0 fb^{-1} of data, reports 0.289 ± 0.043 ± 0.040 ± 0.029 pb cross section for the forward fiducial region $p_T(\mu) > 25$ GeV, $2.0 < \eta(\mu) < 4.5$, 50 GeV $< p_T(b) <$ 100 GeV, $2.2 < \eta(b) < 4.2$, $\Delta R(\mu,b) > 0.5$, and $p_T(\mu+b) > 20$ GeV. The three errors are from statistics, systematics, and theory. The result agrees with the SM NLO prediction.

[10] AAD 14AY reports 242.4 ± 1.7 ± 5.5 ± 7.5 ± 4.2 pb value based on 20.3 fb^{-1} of data. The four errors are from statistics, systematic, luminosity, and the 0.66% beam energy uncertainty. We have combined the systematic uncertainties in quadrature. The result is for m_t = 172.5GeV; for other m_t, $\sigma(m_t) = \sigma(172.5\text{GeV})\times[1-0.0028\times(m_t - 172.5\text{GeV})]$. Also measured is the ratio $\sigma(t\overline{t};\ 8\text{TeV})/\sigma(t\overline{t};\ 7\text{TeV})$ = 1.326 ± 0.024 ± 0.015 ± 0.049 ± 0.001. The results are consistent with the SM predictions at NNLO.

[11] Based on 5.3 fb^{-1} of data. The result is for m_t = 172.5 GeV, and a parametrization is given in eq.(6.1) for the mean value at other m_t values. The result is in agreement with the SM prediction $252.9^{+6.4}_{-8.6}$ pb at NNLO.

[12] Based on 19.6 fb^{-1} of data. The measurement is in the channel $t\overline{t} \to (b\ell\nu)(b\tau\nu)$, where τ decays into hadrons (τ_h). The result is for m_t = 172.5 GeV. For m_t = 173.3 GeV, the cross section is lower by 3.1 pb.

$t\overline{t}$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (pb)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
829 ± 1 ±15.4	[1] AAD	23S	ATLS	$e^{\pm}\mu^{\mp}$ + 1 or 2 b-jets
791 ± 1 ±21 ±14	[2] TUMASYAN	21J	CMS	1ℓ + jets
830 ± 0.4±36 ±14	[3] AAD	20AH	ATLS	$\ell + \geq 4$ jets ($\geq 1b$-tag)
826.4± 3.6±11.5±15.8	[4] AAD	20Q	ATLS	$e\mu$ + 1 or 2 b-jets
781 ± 7 ±62 ±20	[5] SIRUNYAN	20V	CMS	$\ell\tau_h + \geq 3$ jets ($\geq 1b$-tag)
803 ± 2 ±25 ±20	[6] SIRUNYAN	19AR	CMS	dilepton channel ($e\mu$,2e,2μ)
	[7] SIRUNYAN	19P	CMS	dilepton channel
815 ± 9 ±38 ±19	[8] KHACHATRY...	17N	CMS	$e\mu + \geq 2$j ($\geq$ 1b j)
888 ± 2 $^{+26}_{-28}$ ±20	[9] SIRUNYAN	17W	CMS	$\ell + \geq 1$j
818 ± 8 ±35	[10] AABOUD	16R	ATLS	$e + \mu$ + 1 or 2b jets
746 ±58 ±53 ±36	[11] KHACHATRY...	16J	CMS	$e + \mu + \geq 2$j

[1] AAD 23S based on 140 fb^{-1} of data at 13 TeV. The second error is the sum of systematic effects (±13), luminosity (±8), and beam energy (±2) uncertainties. This measurement supersedes that of AAD 20Q. The result is in good agreement with the NNLO+NNLL SM prediction.

[2] TUMASYAN 21J result is based on 137 fb^{-1} of data. The last uncertainty is due to the beam luminosity. The result is in agreement with the SM prediction of 832^{+40}_{-46} pb at NNLO+NNLL. Measurements of differential and double-differential cross sections are also presented.

[3] AAD 20AH based on 139 fb^{-1} of data. The last quoted uncertainty is due to the beam luminosity. The result is for m_t = 172.5 GeV and in agreement with the SM prediction of 832^{+20}_{-29}(scale)$\pm$35(PDF+α(s)) pb at NNLO+NNLL.

[4] AAD 20Q reports 826.4 $\pm$ 3.6 $\pm$ 11.5 $\pm$ 15.7 $\pm$ 1.9 pb based on 36.1 fb^{-1} of data at 13 TeV. The four errors stem from statistics, systematic effects, luminosity, and beam energy, respectively. We have combined luminosity and beam energy uncertainties in quadrature. The result is in agreement with the SM prediction 832^{+20}_{-29}(scale)$\pm$35(PDF+α(s)) pb at NNLO+NNLL for m_t = 172.5 GeV .

[5] SIRUNYAN 20V based on 35.9 fb^{-1} of pp data at $\sqrt{s}$ = 13 TeV. The last uncertainty is due to beam luminosity. The $t\overline{t}$ production cross section is measured in the $t\overline{t} \rightarrow (\ell\nu_\ell)(\tau_h\nu_\tau)b\overline{b}$ final state, where τ_h refers to the hadronic decays of τ. The result is for m_t = 172.5 GeV and in agreement with the SM prediction at NNLO+NNLL.

[6] SIRUNYAN 19AR based on 35.9 fb^{-1} of data. Obtained from the visible cross section measured using a template fit to multidifferential distributions categorized according to the b-tagged jet multiplicity. The result is for m_t = 172.5 GeV and in agreement with the SM prediction at NNLO+NNLL.

[7] SIRUNYAN 19P reports differential $t\overline{t}$ cross sections measured using dilepton events at 13 TeV with 35.9 fb^{-1} and compared to NLO predictions.

[8] KHACHATRYAN 17N based on 2.2 fb^{-1} of data. The last quoted uncertainty is due to the beam luminosity. This measurement supersedes that of KHACHATRYAN 16J.

[9] SIRUNYAN 17W based on 2.2 fb^{-1} of pp data at $\sqrt{s}$ = 13 TeV. Events are categorized according to the jet multiplicity and the number of b-tagged jets. A likelihood fit is performed to the event distributions to compare to the NNLO+NNLL prediction.

[10] AABOUD 16R reported value 818 $\pm$ 8 $\pm$ 27 $\pm$ 19 $\pm$ 12 pb based on 3.2 fb^{-1} of data. The four errors are from statistics, systematic, luminosity, and beam energy. We have combined the systematic uncertainties in quadrature. The result is in agreement with the SM prediction 832^{+20}_{-29}(scale)$\pm$35(PDF+α(s)) pb at NNLO+NNLL for m_t = 172.5 GeV .

[11] KHACHATRYAN 16J based on 43 pb^{-1} of data. The last uncertainty is due to luminosity. The result is for m_t = 172.5 GeV and in agreement with the SM prediction 832^{+20}_{-29}(scale)$\pm$35(PDF+α(s)) pb at NNLO+NNLL.

$t\overline{t}$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 13.6 TeV

VALUE (pb)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
850$\pm$3$\pm$27	[1] AAD	24	ATLS	$e^\pm\mu^\mp$ + 1 or 2 b-jets

[1] AAD 24 based on 29 fb^{-1} of data. The last error includes the luminosity uncertainty of $\pm$20 pb. The result is for m_t = 172.5 GeV and in agreement with the SM prediction of 924^{+32}_{-40} (scale+PDF+α_s) pb. The ratio of the $t\overline{t}$ to the Z production cross section is also measured as 1.145 $\pm$ 0.003 $\pm$ 0.021 $\pm$ 0.002, which is consistent with the SM prediction of $1.238^{+0.063}_{-0.071}$ (scale+PDF+α_s). The uncertainties of luminosity and lepton efficiency largely cancel in the ratio.

$t\bar{t}$ Production Cross Section in Nucleus-Nucleus Collisions

VALUE (μbarn)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$2.03^{+0.71}_{-0.64}$	[1] SIRUNYAN 20BC	CMS	Pb-Pb collisions, dilepton + b-jets
$2.54^{+0.84}_{-0.74}$	[2] SIRUNYAN 20BC	CMS	Pb-Pb collisions, dilepton only

[1] SIRUNYAN 20BC based on (1.7 ± 0.1) nb^{-1} of lead-lead collision data at a nucleon-nucleon c.m. energy of 5.02 TeV. It makes use of the final-state dilepton kinematic properties together with requirements on the number of b-jets. The measured value is compatible with QCD predictions.

[2] SIRUNYAN 20BC based on (1.7 ± 0.1) nb^{-1} of lead-lead collision data at a nucleon-nucleon c.m. energy of 5.02 TeV. It makes use of the final-state dilepton kinematic properties alone. The measured value is compatible with QCD predictions.

$t\bar{t}\,t\bar{t}$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 8 TeV

VALUE (fb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<23	95	[1] AAD 15AR	ATLS	$\ell + \not{E}_T + \geq 5$j ($\geq 2$ b)
<70	95	[2] AAD 15BY	ATLS	$\geq 2\ell + \not{E}_T + \geq 2$j ($\geq 1$ b)
<32	95	[3] KHACHATRY... 14R	CMS	$\ell + \not{E}_T + \geq 6$j ($\geq 2$ b)

[1] AAD 15AR based on 20.3 fb^{-1} of data. A fit to H_T distributions in multi-channels classified by the number of jets and of b-tagged jets is performed.

[2] AAD 15BY based on 20.3 fb^{-1} of data. A same-sign lepton pair is required. An excess over the SM prediction reaches 2.5σ for hypotheses involving heavy resonances decaying into $t\bar{t}t\bar{t}$.

[3] Based on 19.6 fb^{-1} of data, using a multivariate analysis to separate signal from backgrounds. About $\sigma(t\bar{t}t\bar{t}) = 1$ fb is expected in the SM.

$t\bar{t}\,t\bar{t}$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (fb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$22.5^{+6.6}_{-5.5}$		[1] AAD 23BC	ATLS	(same-sign 2ℓ) or $\geq 3\ell$
$17.7^{+3.7+2.3}_{-3.5-1.9}$		[2] HAYRAPETY... 23B	CMS	(same-sign 2ℓ), 3ℓ, 4ℓ
36^{+12}_{-11}		[3] TUMASYAN 23AQ	CMS	(0,1 ℓ) + ($\ell^{\pm}\ell^{\mp}$) channels
$17 \pm 4 \pm 3$		[4] TUMASYAN 23AQ	CMS	CMS combined
26^{+17}_{-15}		[5] AAD 21BC	ATLS	ℓ or $\ell^+\ell^-$ + jets
24^{+7}_{-6}		[6] AAD 21BC	ATLS	combination of $1\ell/2\ell$(OS) and 2ℓ(SS)/3ℓ
24^{+7}_{-6}		[7] AAD 20AR	ATLS	(same-sign 2ℓ) or $\geq 3\ell$ + jets
$12.6^{+5.8}_{-5.2}$		[8] SIRUNYAN 20C	CMS	(same-sign 2ℓ) or 3ℓ + jets
<47	95	[9] AABOUD 19AP	ATLS	$\ell + \ell^+\ell^-$ channels

<49	95	[10] AABOUD	19AP ATLS	combination of ATLAS
$13\ {+11 \atop -\ 9}$		[11] SIRUNYAN	19CN CMS	combination of CMS
<48	95	[12] SIRUNYAN	19CN CMS	ℓ+jets, $\ell^+\ell^-$+jets channels
<69	95	[13] AABOUD	18CE ATLS	$\geq 2\ell$(same sign) + $\not\!\!E_T$ + $\geq 1b$j
$16.9^{+13.8}_{-11.4}$		[14] SIRUNYAN	18BU CMS	$t\overline{t}t\overline{t} \rightarrow$ (same sign 2ℓ or $\geq 3\ell$) + ≥ 4 j ($\geq 2b$)
<94	95	[15] SIRUNYAN	17AB CMS	ℓ+jets, $\ell^+\ell^-$+jets channels
<42	95	[16] SIRUNYAN	17S CMS	(same sign 2ℓ)+$\not\!\!E_T$+ $\geq$ 2j

[1] AAD 23BC result is based on 140 fb^{-1} of data. The result corresponds to observed significance of 6.1 σ.

[2] HAYRAPETYAN 23B based on 138 fb^{-1} of data. Improvements include the identification of leptons and jets from b hadrons, and from the revised analysis strategy for the signal-background separation by application of machine learning techniques. The result corresponds to the observed significance of 5.6 σ and is in agreement with the NLO (QCD+EW) SM prediction of $13.4^{+1.0}_{-1.8}$ fb including soft-gluon emission corrections at the next-to-leading logarithmic accuracy.

[3] TUMASYAN 23AQ based on up to 138 fb^{-1} of data. The all-hadronic final state is included for the first time.

[4] TUMASYAN 23AQ based on up to 138 fb^{-1} of data. It combines earlier CMS results, giving the observed significance of 4.0σ.

[5] AAD 21BC result is based on 139 fb^{-1} of data. The events are categorized according to the number of jets and how likely to contain b-hadrons and a multivariate analysis is used to discriminate the signal from backgrounds. The result corresponds to observed significance of 1.9 σ.

[6] AAD 21BC combines the results of the four-top-quark production cross section measured from the 1ℓ/opposite-sign 2ℓ channel with that from the same-sign $2\ell/3\ell$ channel (AAD 20AR). The result corresponds to observed significance of 4.7 σ and is consistent within 2.0 σ with the NLO (QCD+EW) SM prediction of 12.0 $\pm$ 2.4 fb.

[7] AAD 20AR based on 139 fb^{-1} of data. Jet multiplicity, jet flavor and event kinematics are used in a multivariate analysis to discriminate the signal from backgrounds. The result corresponds to observed significance of 4.3σ and is consistent within 1.7σ with the NLO (QCD+EW) SM prediction of 12.0 $\pm$ 2.4 fb.

[8] SIRUNYAN 20C based on 137 fb^{-1} of data. Both cut-based and multivariate approaches are taken to discriminate the signal from backgrounds. The result is in agreement with the NLO (QCD+EW) SM prediction of $12.0^{+2.2}_{-2.5}$ fb. The measurement constrains the top quark Yukawa coupling strength parameter to be $|Y_t/Y_t^{SM}| < 1.7$ (95% CL). It is also used to constrain an oblique parameter of the Higgs boson. Superseded by HAYRAPETYAN 23B.

[9] AABOUD 19AP based on 36.1 fb^{-1} of data. The upper limit corresponds to 5.1 times the NLO SM cross section.

[10] AABOUD 19AP limit from data combined with AABOUD 18CE. The upper limit corresponds to 5.3 times the NLO SM cross section. Also a limit on the four-top-quark contact interaction of $|C_{4t}|/\Lambda^2 < 1.9$ TeV^{-2} (95% CL) is obtained in an EFT model.

[11] SIRUNYAN 19CN based on 35.8 fb^{-1} of data, combined with SIRUNYAN 18BU. The results are also interpreted in the effective field theory framework.

[12] SIRUNYAN 19CN based on 35.8 fb^{-1} of data. A multivariate analysis using global event and jet propoerties is performed to discriminate from $t\overline{t}$ background.

[13] AABOUD 18CE based on 36.1 fb^{-1} of proton-proton data taken at $\sqrt{s} = 13$ TeV. Events including a same-sign lepton pair are used. The result is consistent with the NLO SM cross section of 9.2 fb.

[14] SIRUNYAN 18BU based on 35.9 fb^{-1} of proton-proton data taken at $\sqrt{s} = 13$ TeV. Yields from signal regions and control regions defined based on N_{jets}, N_b and N_l are

combined in a maximum-likelihood fit. The result is in agreement with the NLO SM prediction $9.2^{+2.9}_{-2.4}$ fb. The measurement constrains the top quark Yukawa coupling strength parameter to be $\left|Y_t/Y_t^{SM}\right| < 2.1$ (95% CL).

[15] SIRUNYAN 17AB based on 2.6 fb^{-1} of data. A multivariate analysis is used to discriminate between $t\bar{t}t\bar{t}$ signal and $t\bar{t}$ background. A combination with a previous search (CMS, KHACHATRYAN 16BJ) in the same-sign dilepton channel gives an upper limit of 69 fb (95% CL), corresponding to 7.4·(SM prediction).

[16] SIRUNYAN 17S based on 35.9 fb^{-1}. The limit is in agreement with the NLO SM prediction $9.2^{+2.9}_{-2.4}$ fb. Superseded by SIRUNYAN 18BU. The signal events are also used to constrain various new physics models.

$t\bar{t}W$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 8 TeV

VALUE (fb)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$170^{+90}_{-80}\pm70$	[1] KHACHATRY...14N	CMS	$t\bar{t}W \to$ same sign dilepton + $\not{E}_T$ + jets

[1] Based on 19.5 fb^{-1} of data. The result is consistent with the SM prediction of $\sigma(t\bar{t}W) = 206^{+21}_{-23}$ fb.

$t\bar{t}W$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (pb)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.868\pm0.040\pm0.051$	[1] TUMASYAN 23AN	CMS	2 or 3 ℓ + $\not{E}_T$ + jets
$0.87\pm0.13\pm0.14$	[2] AABOUD 19AR	ATLS	2,3,4ℓ + $\not{E}_T$ + jets
$0.77\ ^{+0.12}_{-0.11}\ ^{+0.13}_{-0.12}$	[3] SIRUNYAN 18BS	CMS	$t\bar{t}W \to$ same sign dilepton + $\not{E}_T$ + jets

[1] TUMASYAN 23AN result is based on 138 fb^{-1} of proton-proton data. The $t\bar{t}W^+$ and $t\bar{t}W^-$ production cross sections, respectively, are measured as $0.553\pm0.030\pm0.030$ pb and $0.343\pm0.026\pm0.025$ pb. The results are within 2σ deviations from the NLO FxFx SM predictions, $0.592^{+0.155}_{-0.097}$ pb ($t\bar{t}W$), $0.384^{+0.053}_{-0.033}$ pb ($t\bar{t}W^+$) and $0.198^{+0.026}_{-0.017}$ pb ($t\bar{t}W^-$).

[2] AABOUD 19AR result is based on 35.9 fb^{-1} of data. $t\bar{t}W$ and $t\bar{t}Z$ cross sections are simultaneously measured using a combined fit to the events divided into multiple regions. The result is consistent with the SM prediction at NLO $0.60^{+0.08}_{-0.07}$ pb. It is also used to constrain the Wilson coefficients for dimension-six operators which modify the $t\bar{t}Z$ vertex.

[3] SIRUNYAN 18BS result is based on 35.9 fb^{-1} of proton-proton data taken at $\sqrt{s}$ = 13 TeV. The result is consistent with the SM prediction and is used to constrain the Wilson coefficients for dimension-six operators describing new interactions. The result is consistent with the SM prediction at NLO 0.628 ± 0.082 pb.

$t\bar{t}Z$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 8 TeV

VALUE (fb)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$200^{+80}_{-70}{}^{+40}_{-30}$	[1] KHACHATRY...14N	CMS	$t\bar{t}Z \to$ 3,4 ℓ + $\not{E}_T$ + jets

[1] Based on 19.5 fb^{-1} of data. The result is consistent with the SM prediction of $\sigma(t\bar{t}Z) = 197^{+22}_{-25}$ fb.

$t\overline{t}Z$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (pb)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.99 \pm 0.05 \pm 0.08$	[1] AAD 21AS	ATLS	$3{,}4\ell$ + jets
$0.95 \pm 0.05 \pm 0.06$	[2] SIRUNYAN 20AB	CMS	$3{,}4\ell$ + jets
$0.95 \pm 0.08 \pm 0.10$	[3] AABOUD 19AR	ATLS	$2{,}3{,}4\ell + \not{E}_T$ + jets
$0.99^{+0.09}_{-0.08}{}^{+0.12}_{-0.10}$	[4] SIRUNYAN 18BS	CMS	$t\overline{t}Z \rightarrow 3{,}4\ \ell + \not{E}_T$ + jets

[1] AAD 21AS based on 139 fb^{-1} of data. The result is consistent with the SM prediction of $0.88^{+0.09}_{-0.10}$ pb which includes NLO QCD+EW corrections. Also overall the differential cross sections are in good agreement with the SM predictions.

[2] SIRUNYAN 20AB based on 77.5 fb^{-1} of data at 13 TeV. The result is consistent with the NLO SM prediction of 0.84 ± 0.10 pb. Differential cross sections are measured and used to constrain the anomalous couplings and Wilson coefficients for the $t\overline{t}Z$ interaction.

[3] AABOUD 19AR based on 35.9 fb^{-1} of data. $t\overline{t}W$ and $t\overline{t}Z$ cross sections are simultaneously measured using a combined fit to the events divided into multiple regions. The result is consistent with the SM prediction at NLO $0.88^{+0.09}_{-0.11}$ pb. It is also used to constrain the Wilson coefficients for dimension-six operators which modify the $t\overline{t}Z$ vertex.

[4] Based on 35.9 fb^{-1} of proton-proton data taken at $\sqrt{s}$ = 13 TeV. The result is consistent with the SM prediction and is used to constrain the Wilson coefficients for dimension-six operators describing new interactions. The result is consistent with the SM prediction at NLO 0.839 ± 0.101 pb.

$t\overline{t}\gamma$ Production Cross Section in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (pb)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
	[1] TUMASYAN 22W	CMS	$1\gamma+\ell^+\ell^- + \geq 1bj$
	[2] TUMASYAN 21H	CMS	$pp \rightarrow t\overline{t}\gamma$
	[3] AABOUD 19AD	ATLS	$pp \rightarrow t\overline{t}\gamma$

[1] TUMASYAN 22W measured fiducial inclusive and differential cross-sections for $pp \rightarrow t\overline{t}\gamma$ at 13 TeV with 138 fb^{-1} of data. The results are in agreement with the SM predictions. The results are used to constrain anomalous couplings of the top quark in the SMEFT framework.

[2] TUMASYAN 21H measured fiducial inclusive and differential cross-sections for $pp \rightarrow t\overline{t}\gamma$ at 13 TeV with 137 fb^{-1} of data. The results are in agreement with the SM predictions. The results are used to constrain anomalous couplings of the top quark in the SMEFT framework.

[3] AABOUD 19AD measured fiducial inclusive and differential cross-sections for $pp \rightarrow t\overline{t}\gamma$ at 13 TeV with 36.1 fb^{-1} of data. The results are in agreement with the theoretical predictions.

f(Q_0): $t\overline{t}$ Fraction of Events with a Veto on Additional Central Jet Activity in pp Collisions at $\sqrt{s}$ = 7 TeV

Q_0 denotes the threshold of the additional jet p_T.

VALUE (%)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$80.0 \pm 1.1 \pm 1.6$	[1] CHATRCHYAN 14AE	CMS	Q_0 = 75 GeV ($\lvert y \rvert$ <2.4)
$92.0 \pm 0.7 \pm 0.8$	[1] CHATRCHYAN 14AE	CMS	Q_0= 150 GeV ($\lvert y \rvert$ <2.4)
$98.0 \pm 0.3 \pm 0.3$	[1] CHATRCHYAN 14AE	CMS	Q_0= 300 GeV ($\lvert y \rvert$ <2.4)

$56.4 \pm 1.3 ^{+2.6}_{-2.8}$	[2] AAD	12BL	ATLS	Q_0 = 25 GeV (|y| <2.1)
$84.7 \pm 0.9 \pm 1.0$	[2] AAD	12BL	ATLS	Q_0 = 75 GeV (|y| <2.1)
$95.2 ^{+0.5}_{-0.6} \pm 0.4$	[2] AAD	12BL	ATLS	Q_0= 150 GeV (|y| <2.1)

[1] CHATRCHYAN 15 based on 5.0 fb^{-1} of data. The $t\overline{t}$ events are selected in the dilepton and lepton + jets decay channels. For other values of Q_0 see Table 5.

[2] Based on 2.05 fb^{-1} of data. The $t\overline{t}$ events are selected in the dilepton decay channel with two identified *b*-jets.

Fraction of $t\overline{t}$ + multi-jet Events in pp Collisions at $\sqrt{s}$ = 7 TeV

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] AAD	15D	ATLS	$\ell + \not{E}_T$ + nj (n=3 to 8)
0.332±0.090	[2] CHATRCHYAN	14AE	CMS	$t\overline{t}(\ell\ell)$ + 0 jet ($E_T >$ 30GeV)
0.436±0.098	[2] CHATRCHYAN	14AE	CMS	$t\overline{t}(\ell\ell)$ + 1 jet ($E_T >$ 30GeV)
0.232±0.125	[2] CHATRCHYAN	14AE	CMS	$t\overline{t}(\ell\ell)$ + $\geq$ 2 jet ($E_T >$ 30GeV)

[1] Based on 4.6 fb^{-1} of data. Fiducial $t\overline{t}$ production cross section is presented as a function of the jet multiplicity for up to eight jets with the jet p_T threshold of 25, 40, 60, and 80 GeV, and as a function of jet p_T up to the 5th jet. MC models can be discriminated by using data for high jet multiplicity and by p_T distributions of the leading and 5th jet.

[2] Based on 5.0 fb^{-1} of data. Events with two oppositely charged leptons, large $\not{E}_T$ and jets with at least 1 *b*-tag are used to measure the fraction of $t\overline{t}$ plus additional jets. The gap fraction (n=0 jet rate) as a function of the jet p_T and that of H_T, the scalar sum of the p_T's of additional jets, is shown in Fig. 8.

$t\overline{t}$ Charge Asymmetry (A_C) in pp Collisions at $\sqrt{s}$ = 7 TeV

A_C = (N(Δ|y| >0) − N(Δ|y| <0)) / (N(Δ|y| >0) + N(Δ|y| <0)) where Δ|y| = $|y_t|$ − $|y_{\overline{t}}|$ is the difference between the absolute values of the top and antitop rapidities and N is the number of events with Δ|y| positive or negative.

VALUE (%)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.5±0.7±0.6	[1] AABOUD	18AM	LHC	ATLAS+CMS combination (lepton + jets)
2.1±2.5±1.7	[2] AAD	15AJ	ATLS	$\ell\ell + \not{E}_T + \geq$ 2j
0.6±1.0	[3] AAD	14I	ATLS	$\ell + \not{E}_T + \geq$ 4j ($\geq$ 1b)
−1.0±1.7±0.8	[4] CHATRCHYAN	14D	CMS	$\ell\ell + \not{E}_T + \geq$ 2j ($\geq$ 1b)
−1.9±2.8±2.4	[5] AAD	12BK	ATLS	$\ell + \not{E}_T + \geq$ 4j ($\geq$ 1b)
0.4±1.0±1.1	[6] CHATRCHYAN	12BB	CMS	$\ell + \not{E}_T + \geq$ 4j ($\geq$ 1b)
$-1.3 \pm 2.8 ^{+2.9}_{-3.1}$	[7] CHATRCHYAN	12BS	CMS	$\ell + \not{E}_T + \geq$ 4j ($\geq$ 1b)

[1] ATLAS and CMS combination based on the data of AAD 14I and CHATRCHYAN 12BB. It takes into account the correlations of the measurements and systematic errors. The result is in agreement with the SM prediction (NLO QCD + NLO EW).

[2] AAD 15AJ based on 4.6 fb^{-1} of data. After kinematic reconstruction the top quark momenta are corrected for detector resolution and acceptance effects by unfolding, using parton level information of the MC generators. The lepton charge asymmetry is measured as A^{ℓ}_C = 0.024 ± 0.015 ± 0.009. All the measurements are consistent with the SM predictions.

[3] Based on 4.7 fb^{-1} of data. The result is consistent with the SM prediction of A_C = 0.0123 ± 0.0005. The asymmetry is 0.011 ± 0.018 if restricted to those events where $\beta_Z(t\bar{t}) > 0.6$, which is also consistent with the SM prediction of $0.020^{+0.006}_{-0.007}$.

[4] Based on 5.0 fb^{-1} of data. The lepton charge asymmetry is measured as $A_C^{\ell} = 0.009 \pm 0.0010 \pm 0.006$. A_C^{ℓ} dependences on $m_{t\bar{t}}$, $|y(t\bar{t})|$, and $p_T(t\bar{t})$ are given in Fig. 5. All measurements are consistent with the SM predictions.

[5] Based on 1.04 fb^{-1} of data. The result is consistent with $A_C = 0.006 \pm 0.002$ (MC at NLO). No significant dependence of A_C on $m_{t\bar{t}}$ is observed.

[6] Based on 5.0 fb^{-1} of data at 7 TeV.

[7] Based on 1.09 fb^{-1} of data. The result is consistent with the SM predictions.

$t\bar{t}$ Charge Asymmetry (A_C) in pp Collisions at $\sqrt{s} = 8$ TeV

VALUE (%)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.55±0.23±0.25	[1] AABOUD	18AM	LHC	ATLAS+CMS combination (lepton + jets)
2.1 ±1.6	[2] AAD	16AE	ATLS	$\ell\ell + \not\!\!E_T + \geq 2j$
0.9 ±0.5	[3] AAD	16AZ	ATLS	$\ell + \not\!\!E_T + \geq 4$j
4.2 ±3.2	[4] AAD	16T	ATLS	$m_{t\bar{t}}$ >0.75 TeV, $\left\|\,\|y_t\| - \|y_{\bar{t}}\|\,\right\|$ <2, $\ell + \not\!\!E_T$ + jets
1.1 ±1.1 ±0.7	[5] KHACHATRY...	16AD	CMS	$\ell\ell + \not\!\!E_T + \geq 2$j ($\geq$ 1b)
0.33±0.26±0.33	[6] KHACHATRY...	16AH	CMS	$\ell + \not\!\!E_T + \geq 4$j ($\geq$ 1b)
0.10±0.68±0.37	[7] KHACHATRY...	16T	CMS	$\ell + \not\!\!E_T + \geq 4$j ($\geq$ 1b)

[1] ATLAS and CMS combination based on the data of AAD 16AZ and KHACHATRYAN 16AH. It takes into account the correlations of the measurements and systematic errors. A combination of the differential measurements of the charge asymmetry is also presented. The results are in agreement with the SM prediction (NNLO QCD + NLO EW).

[2] AAD 16AE is based on 20.3 fb^{-1} of data. After kinematic reconstruction, the top quark momenta are corrected for detector resolution and acceptance effects by unfolding, using parton level information of the MC generators. The lepton charge asymmetry is measured as $A_C^{\ell\ell} = 0.008 \pm 0.006$. All the measurements are consistent with the SM predictions.

[3] AAD 16AZ based on 20.3 fb^{-1} of data. All the differential and inclusive measurements are statistically limited and consistent with the SM predictions.

[4] AAD 16T based on 20.3 fb^{-1} of data. Uses reconstruction techniques for the decay topology of highly boosted top quarks. The observed asymmetry is transformed by unfolding to a parton-level result in the shown fiducial region. The result is consistent with the NLO SM prediction.

[5] KHACHATRYAN 16AD based on 19.5 fb^{-1} of data. The lepton charge asymmetry is measured as $A_C^{\ell\ell} = 0.003 \pm 0.006 \pm 0.003$. All the measurements are consistent with the SM predictions.

[6] KHACHATRYAN 16AH based on 19.6 fb^{-1} of data. The same data set as in KHACHATRYAN 16T is used. A template technique is used, which is sensitive to the charge anti-symmetric component of the $t\bar{t}$ rapidity distributions and statistically advantageous. The result is consistent with the SM predictions.

[7] KHACHATRYAN 16T based on 19.7 fb^{-1} of data. The same data set as in KHACHATRYAN 16AH is used. After kinematic reconstruction the top quark momenta are corrected for detector resolution and acceptance effects by unfolding, using parton level information of the MC generators. All the measurements are consistent with the SM predictions.

$t\bar{t}$ Charge Asymmetry (A_C) in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE (%)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.68 ± 0.15	[1] AAD 23BA	ATLS	single lepton + dilepton channels
$0.42^{+0.64}_{-0.69}$	[2] TUMASYAN 23BD	CMS	$M_{t\bar{t}} > 750$GeV, single-ℓ channel

[1] AAD 23BA is based on 139 fb^{-1} of data. Inclusive $t\bar{t}$ charge asymmetry is measured to be nonzero with 4.7σ significance. Also differential $t\bar{t}$ as well as lepton charge asymmetries are measured. All the results are consistent with the SM predictions which include NNLO QCD + NLO EW corrections.

[2] TUMASYAN 23BD is based on 138 fb^{-1} of data. $t\bar{t}$ charge asymmetry for highly Lorentz-boosted top quarks is measured and is in agreement with the NNLO QCD + NLO EW corrected SM prediction of $0.94^{+0.05}_{-0.07}$%. The event selection is optimized for highly-boosted top quarks.

$t\bar{t}W$ leptonic Charge Asymmetry (A_C^ℓ) in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$-0.12\pm0.14\pm0.05$	[1] AAD 23AA	ATLS	$\ell\ell\ell+\geq 1b$

[1] AAD 23AA is based on 139 fb^{-1} of data. The charge-asymmetry in a fiducial volume at particle level is also reported at $-0.11 \pm 0.17 \pm 0.05$. All the results are consistent with the SM predictions which include NLO QCD + NLO EW corrections.

$t\bar{t}\gamma$ Charge Asymmetry (A_C) in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.003 ± 0.029	[1] AAD 23AW	ATLS	$\gamma\ell + \geq$ 4j ($\geq 1b$)

[1] AAD 23AW is based on 139 fb^{-1} of data. The measurement is in agreement with the Standard Model expectation.

t-quark Polarization in $t\bar{t}$ Events in $p\bar{p}$ Collisions at $\sqrt{s}$ = 1.96 TeV

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.070 ± 0.055	[1] ABAZOV 17	D0	$\ell+\not{E}_T+\geq$ 3j($\geq 1b$)
-0.102 ± 0.061	[2] ABAZOV 17	D0	$\ell+\not{E}_T+\geq$ 3j($\geq 1b$)
0.040 ± 0.035	[3] ABAZOV 17	D0	$\ell+\not{E}_T+\geq$ 3j($\geq 1b$)
$0.113\pm0.091\pm0.019$	[4] ABAZOV 15K	D0	A^ℓ_{FB} in $\ell\ell+\not{E}_T+\geq$ 2j($\geq 1b$)

[1] ABAZOV 17 based on 9.7 fb^{-1} of data. The value is top quark polarization times spin analyzing power in the beam basis. Combination with the result of ABAZOV 15K yields 0.081 $\pm$ 0.048. This result together with the helicity polarization is shown in a 2-dimensional plot in Fig.4. These results are consistent with the SM prediction.

[2] ABAZOV 17 based on 9.7 fb^{-1} of data. The value is top quark polarization times spin analyzing power in the helicity basis. The result is consistent with the SM prediction. This result together with the beam polarization is shown in a 2-dimensional plot in Fig.4.

[3] ABAZOV 17 based on 9.7 fb^{-1} of data. The value is top quark polarization times spin analyzing power in the transverse basis. The result is consistent with the SM prediction.

[4] ABAZOV 15K based on 9.7 fb^{-1} of data. The value is top quark polarization times spin analyzing power in the beam basis. The result is consistent with the SM prediction of -0.0019 ± 0.0005.

t-quark Polarization in $t\overline{t}$ Events in pp Collisions at $\sqrt{s}$ = 7 TeV

The double differential distribution in polar angles, θ_1 (θ_2) of the decay particle of the top (anti-top) decay products, is parametrized as $(1/\sigma)d\sigma/(d\cos\theta_1\ d\cos\theta_2)$ = (1/4) (1 + $A_t \cos\theta_1$ + $A_{\overline{t}} \cos\theta_2$ − C $\cos\theta_1 \cos\theta_2$). The charged lepton is used to tag t or $\overline{t}$. The coefficient A_t and $A_{\overline{t}}$ measure the average helicity of t and $\overline{t}$, respectively. $A_{CPC} = A_t = A_{\overline{t}}$ assumes CP conservation, whereas $A_{CPV} = A_t = -A_{\overline{t}}$ corresponds to maximal CP violation.

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$-0.035 \pm 0.014 \pm 0.037$	[1] AAD	13BE	ATLS	A_{CPC}
$0.020 \pm 0.016 {}^{+0.013}_{-0.017}$	[1] AAD	13BE	ATLS	A_{CPV}

[1] Based on 4.7 fb^{-1} of data using the final states containing one or two isolated electrons or muons and jets with at least one b-tag.

t-quark Polarization in $t\overline{t}$ Events in pp Collisions at $\sqrt{s}$ = 8 TeV

A_t, $A_{\overline{t}}$, A_{CPC}, A_{CPV}, and A_C are defined in header texts in the subsections, just above.

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$-0.044 \pm 0.038 \pm 0.027$	[1] AABOUD	17G	ATLS	A_t
$-0.064 \pm 0.040 \pm 0.027$	[1] AABOUD	17G	ATLS	$A_{\overline{t}}$
$0.296 \pm 0.093 \pm 0.037$	[1] AABOUD	17G	ATLS	A_C
-0.022 ± 0.058	[2] KHACHATRY...	16AI	CMS	A_{CPC}
0.000 ± 0.016	[2] KHACHATRY...	16AI	CMS	A_{CPV}

[1] AABOUD 17G based on 20.2 fb^{-1} of pp data, using events with two leptons and two or more jets with at least one b-tag. Determined from measurements of 15 top quark spin observables. The second error corresponds to a variation of m_t about 172.5 GeV by 0.7 GeV. The values are consistent with the NLO SM predictions.

[2] KHACHATRYAN 16AI based on 19.5 fb^{-1} of pp data at $\sqrt{s}$ = 8 TeV, using events with two leptons and two or more jets with at least one b-tag. Determined from the lepton angular distributions as a function of the $t\overline{t}$-system kinematical variables.

t-quark Polarization in Single Top Events in pp Collisions at $\sqrt{s}$ = 8 TeV

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>0.72	95	[1] AABOUD	17BB	ATLS	$\alpha_\ell P$; t-channel
$0.97 \pm 0.05 \pm 0.11$		[2] AABOUD	17I	ATLS	$\alpha_\ell P$; t-channel
$0.25 \pm 0.08 \pm 0.14$		[3] AABOUD	17I	ATLS	$(F_+ + F_-)P$; t-channel
$0.26 \pm 0.03 \pm 0.10$		[4] KHACHATRY...	16BO	CMS	$(\alpha_\mu P)/2$; t-channel

[1] AABOUD 17BB based on 20.2 fb^{-1} of pp data. Triple-differential decay rate of top quark is used to simultaneously determine five generalized $W t b$ couplings as well as the top polarization. α_ℓ denotes the spin analyzing power of charged lepton, and the spin axis of the top polarization P is taken along the spectator-quark momentum in the top rest frame. The value is compatible with the SM prediction of about 0.9.

[2] AABOUD 17I based on 20.2 fb^{-1} of pp data. A cut-based analysis is used to discriminate between signal and backgrounds. α_ℓ denotes the spin analyzing power of charged lepton, and the spin axis of the top polarization P is taken along the spectator-quark momentum in the top rest frame. See this paper for a number of other asymmetries and measurements that are not included here.

[3] AABOUD 17I based on 20.2 fb^{-1} of pp data. A cut-based analysis is used to discriminate between signal and backgrounds. $F_{\pm}$ denotes W helicity fraction, and the spin axis of the top polarization P is taken along the spectator-quark momentum in the top rest frame. See this paper for a number of other asymmetries and measurements that are not included here.

[4] KHACHATRYAN 16BO based on 19.7 fb^{-1} of data. A high-purity sample with a muon is selected by a multivariate analysis. The value is the top spin asymmetry, given by one half of the spin analyzing power α_{μ} (=1 at LO of SM) times the top polarization, P, where the spin axis is defined as the direction of the untagged jet in the top rest frame. The value is compatible with the SM prediction of 0.44 with a 2.0σ deviation.

t-quark Polarization in Single Top Events in pp Collisions at $\sqrt{s}$ = 13 TeV

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.01 ±0.18	[1] AAD	22Z	ATLS	$P_{x'}$ (t, transverse component)
−0.029±0.027	[1] AAD	22Z	ATLS	$P_{y'}$ (t, normal component)
0.91 ±0.10	[1] AAD	22Z	ATLS	$P_{z'}$ (t, parallel component)
−0.02 ±0.20	[1] AAD	22Z	ATLS	$P_{x'}$ ($\overline{t}$, transverse component)
−0.007±0.051	[1] AAD	22Z	ATLS	$P_{y'}$ ($\overline{t}$, normal component)
−0.79 ±0.16	[1] AAD	22Z	ATLS	$P_{z'}$ ($\overline{t}$, parallel component)
0.440±0.070	[2] SIRUNYAN	20R	CMS	($\alpha_{\ell}P$)/2; t-channel

[1] AAD 22Z based on 139 fb^{-1} of data. Three components of t or $\overline{t}$ polarization vector (defined in the t or $\overline{t}$ rest frame) are measured in t-channel single top production using ℓ momentum distribution in the ℓ + $\not{E}_T$ + 2j (with 1 of them b-jet) channel. The measured values are in agreement with NNLO SM prediction. Constraints on the Wilson coefficients of SMEFT are obtained as -0.9 < C_{tW} < 1.4 and -0.8 < C_{itW} < 0.2.

[2] SIRUNYAN 20R based on 36.1 fb^{-1} of data. Differential cross sections for t-channel single top production are measured using 1ℓ + 2,3-jet mode and found to be in good agreement with SM predictions. The value is the top spin asymmetry, given by 1/2 of the spin analyzing power α_{ℓ} (=1 at LO of SM) times the top polarization P, where the spin axis is defined as the direction of the spectator quark in the top rest frame at the parton level. It is in good agreement with the NLO SM prediction of 0.436.

$gg \to t\overline{t}$ Fraction in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.96 TeV

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.33	68	[1] AALTONEN	09F	CDF	$t\overline{t}$ correlations
0.07±0.14±0.07		[2] AALTONEN	08AG	CDF	low p_T number of tracks

[1] Based on 955 pb^{-1}. AALTONEN 09F used differences in the $t\overline{t}$ production angular distribution and polarization correlation to descriminate between $gg \to t\overline{t}$ and $q\overline{q} \to t\overline{t}$ subprocesses. The combination with the result of AALTONEN 08AG gives $0.07^{+0.15}_{-0.07}$.

[2] Result is based on 0.96 fb^{-1} of data. The contribution of the subprocesses $gg \to t\overline{t}$ and $q\overline{q} \to t\overline{t}$ is distinguished by using the difference between quark and gluon initiated jets in the number of small p_T (0.3 GeV < p_T < 3 GeV) charged particles in the central region ($|\eta|$ < 1.1).

A_{FB} of $t\overline{t}$ in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.96 TeV

A_{FB} = Forward-backward asymmetry.

VALUE (%)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
12.8± 2.1±1.4	[1] AALTONEN	18	TEVA	CDF, D0 combination
17.5± 5.6±3.1	[2] ABAZOV	15K	D0	A^{ℓ}_{FB} in $\ell\ell$+$\not{E}_T$+ ≥ 2j(≥ 1b)

7.2± 6.0	[3] AALTONEN	14F	CDF	A^{ℓ}_{FB} in dilepton channel ($\ell\ell+\not{E}_T+\geq 2$j)
7.6± 8.2	[3] AALTONEN	14F	CDF	$A^{\ell\ell}_{FB}$ in dilepton channel ($\ell\ell+\not{E}_T+\geq 2$j)
4.2± $2.3^{+1.7}_{-2.0}$	[4] ABAZOV	14G	D0	A^{ℓ}_{FB} ($\ell+\not{E}_T+\geq 3$j (0,1 $\geq 2b$))
10.6± 3.0	[5] ABAZOV	14H	D0	A_{FB} ($\ell+\not{E}_T+\ \geq 3$j ($\geq 1b$))
20.1± 6.7	[6] AALTONEN	13AD	CDF	a_1/a_0 in $\ell+\not{E}_T+\geq 4$j ($\geq 1b$)
− 0.2± 3.1	[6] AALTONEN	13AD	CDF	a_3,a_5,a_7 in $\ell+\not{E}_T+\geq 4$j ($\geq 1b$)
16.4± 4.7	[7] AALTONEN	13S	CDF	$\ell+\not{E}_T+\geq 4$ jets($\geq 1b$-tag)
$9.4^{+3.2}_{-2.9}$	[8] AALTONEN	13X	CDF	$\ell+\not{E}_T+\ \geq 4$ jets (≥ 1 b-tag)
11.8± 3.2	[9] ABAZOV	13A	D0	$\ell\ell$ & $\ell+$ jets comb.
−11.6±15.3	[10] AALTONEN	11F	CDF	$m_{t\overline{t}}$ < 450 GeV
47.5±11.4	[10] AALTONEN	11F	CDF	$m_{t\overline{t}}$ > 450 GeV
19.6± 6.5	[11] ABAZOV	11AH	D0	$\ell+\not{E}_T+\geq 4$ jets($\geq 1b$-tag)
17 ± 8	[12] AALTONEN	08AB	CDF	$p\overline{p}$ frame
24 ±14	[12] AALTONEN	08AB	CDF	$t\overline{t}$ frame
12 ± 8 ±1	[13] ABAZOV	08L	D0	$\ell+\not{E}_T+\ \geq 4$ jets

[1] AALTONEN 18 based on 9–10 fb^{-1} of $p\overline{p}$ data at $\sqrt{s}$ = 1.96 TeV. The value is the asymmetry in the number of reconstructed $t\overline{t}$ events with rapidity $y_t > y_{\overline{t}}$ and those with $y_t < y_{\overline{t}}$. The combined fits to CDF and D0 single lepton and $\ell\ell$ asymmetries give A^{ℓ}_{FB} = 0.073 ± 0.016 ± 0.012 and $A^{\ell\ell}_{FB}$ = 0.108 ± 0.043 ± 0.016, respectively. The results are consistent with the SM predictions.

[2] ABAZOV 15K based on 9.7 fb^{-1} of data. The result is consistent with the SM predictions. By combining with the previous D0 measurement in the ℓ + jet channel ABAZOV 14H, A^{ℓ}_{FB} = 0.118 ± 0.025 ± 0.013 is obtained.

[3] AALTONEN 14F based on 9.1 fb^{-1} of data. A^{ℓ}_{FB} and $A^{\ell\ell}_{FB}$ denote, respectively, the asymmetries ($N(x>0)-N(x<0))/N_{tot}$ for $x=q_\ell\eta_\ell$ (q_ℓ is the charge of ℓ) and $x=\eta_{\ell^+}-\eta_{\ell^-}$. Both results are consistent with the SM predictions. By combining with the previous CDF measurement in the ℓ+jet channel AALTONEN 13X, $A^{\ell}_{FB} = 0.098^{+0.028}_{-0.026}$ is obtained. The combined result is about two sigma larger than the SM prediction of A^{ℓ}_{FB} = 0.038 ± 0.003.

[4] Based on 9.7 fb^{-1} of $p\overline{p}$ data at $\sqrt{s}$ = 1.96 TeV. The asymmetry is corrected for the production level for events with $|y_l| < 1.5$. Asymmetry as functions of $E_T(\ell)$ and $|y_l|$ are given in Figs. 7 and 8, respectively. Combination with the asymmetry measured in the dilepton channel [ABAZOV 13P] gives $A^{\ell}_{FB} = 4.2 \pm 2.0 \pm 1.4$ %, in agreement with the SM prediction of 2.0%.

[5] Based on 9.7 fb^{-1} of data of $p\overline{p}$ data at $\sqrt{s}$=1.96 TeV. The measured asymmetry is in agreement with the SM predictions of 8.8 ± 0.9 % [BERNREUTHER 12], which includes the EW effects. The dependences of the asymmetry on $|y(t)-y(\overline{t})|$ and $m_{t\overline{t}}$ are shown in Figs. 9 and 10, respectively.

[6] Based on 9.4 fb^{-1} of data. Reported A_{FB} values come from the determination of a_i coefficients of $d\sigma/d(\cos\theta_t) = \Sigma_i\ a_i P_i(\cos(\theta_t))$ measurement. The result of a_1/a_0 = (40 ± 12)% seems higher than the NLO SM prediction of (15^{+7}_{-3})%.

[7] Based on 9.4 fb^{-1} of data. The quoted result is the asymmetry at the parton level.

[8] Based on 9.4 fb^{-1} of data. The observed asymmetry is to be compared with the SM prediction of A^{ℓ}_{FB} = 0.038 ± 0.003.

[9] Based on 5.4 fb^{-1} of data. ABAZOV 13A studied the dilepton channel of the $t\overline{t}$ events and measured the leptonic forward-backward asymmetry to be $A^{\ell}_{FB} = 5.8 \pm 5.1 \pm 1.3$%,

which is consistent with the SM (QCD+EW) prediction of 4.7 ± 0.1%. The result is obtained after combining the measurement (15.2 ± 4.0%) in the ℓ + jets channel ABAZOV 11AH. The top quark helicity is measured by using the neutrino weighting method to be consistent with zero in both dilepton and ℓ + jets channels.

10 Based on 5.3 fb^{-1} of data. The error is statistical and systematic combined. Events with lepton + $\not{E}_T$ + $\geq$ 4jets($\geq$ 1b) are used. AALTONEN 11F also measures the asymmetry as a function of the rapidity difference $|y_t - y_{\overline{t}}|$. The NLO QCD predictions [MCFM] are (4.0 ± 0.6)% and (8.8 ± 1.3)% for $m_{t\overline{t}}$ < 450 and > 450 GeV, respectively.

11 Based on 5.4 fb^{-1} of data. The error is statistical and systematic combined. The quoted asymmetry is obtained after unfolding to be compared with the MC@NLO prediction of (5.0 ± 0.1)%. No significant difference between the $m_{t\overline{t}}$ < 450 and > 450 GeV data samples is found. A corrected asymmetry based on the lepton from a top quark decay of (15.2 ± 4.0)% is measured to be compared to the MC@NLO prediction of (2.1 ± 0.1)%.

12 Result is based on 1.9 fb^{-1} of data. The FB asymmetry in the $t\overline{t}$ events has been measured in the ℓ + jets mode, where the lepton charge is used as the flavor tag. The asymmetry in the $p\overline{p}$ frame is defined in terms of cos(θ) of hadronically decaying t-quark momentum, whereas that in the $t\overline{t}$ frame is defined in terms of the t and $\overline{t}$ rapidity difference. The results are consistent ($\leq$ 2 σ) with the SM predictions.

13 Result is based on 0.9 fb^{-1} of data. The asymmetry in the number of $t\overline{t}$ events with $y_t > y_{\overline{t}}$ and those with $y_t < y_{\overline{t}}$ has been measured in the lepton + jets final state. The observed value is consistent with the SM prediction of 0.8% by MC@NLO, and an upper bound on the $Z' \rightarrow t\overline{t}$ contribution for the SM Z-like couplings is given in in Fig. 2 for 350 GeV < $m_{Z'}$ < 1 TeV.

t-Quark Electric Charge

VALUE	DOCUMENT ID		TECN	COMMENT
0.64±0.02±0.08	[1] AAD	13AY	ATLS	ℓ+$\not{E}_T$+ $\geq$ 4 jets ($\geq$ 1 b)
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[2] ABAZOV	14D	D0	ℓ+$\not{E}_T$+ $\geq$ 4 jets ($\geq$ 2 b)
	[3] AALTONEN	13J	CDF	$p\overline{p}$ at 1.96 TeV
	[4] AALTONEN	10S	CDF	Repl. by AALTONEN 13J
	[5] ABAZOV	07C	D0	fraction of $|q|$=4e/3 pair

1 AAD 13AY result is based on 2.05 fb^{-1} of pp data at $\sqrt{s}$ = 7 TeV, the result is obtained by reconstructing $t\overline{t}$ events in the lepton + jets final state, where b-jet charges are tagged by the jet-charge algorithm. This measurement excludes the charge −4/3 assignment to the top quark at more than 8 standard deviations.

2 ABAZOV 14D result is based on 5.3 fb^{-1} of $p\overline{p}$ data at $\sqrt{s}$=1.96 TeV. The electric charge of $b + W$ system in $t\overline{t}$ candidate events is measured from the charges of the leptons from W decay and in b jets. Under the assumption that the $b + W$ system consists of the sum of the top quark and the charge −4/3 quark b'(-4/3) of the same mass, the top quark fraction is found to be f = 0.88 ± 0.13 (stat)±0.11 (syst), or the upper bound for the b'(-4/3) contamination of 1 − f < 0.46 (95% CL).

3 AALTONEN 13J excludes the charge −4/3 assignment to the top quark at 99% CL, using 5.6 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. Result is obtained by reconstructing $t\overline{t}$ events in the lepton + jets final state, where b-jet charges are tagged by the jet-charge algorithm.

4 AALTONEN 10S excludes the charge −4/3 assignment for the top quark [CHANG 99] at 95%CL, using 2.7 fb^{-1} of data in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. Result is obtained by reconstructing $t\overline{t}$ events in the lepton + jets final state, where b-jet charges are tagged by the SLT (soft lepton tag) algorithm.

5 ABAZOV 07C reports an upper limit ρ < 0.80 (90% CL) on the fraction ρ of exotic quark pairs $Q\overline{Q}$ with electric charge $|q|$ = 4e/3 in $t\overline{t}$ candidate events with high p_T

lepton, missing E_T and ≥ 4 jets. The result is obtained by measuring the fraction of events in which the quark pair decays into $W^- + b$ and $W^+ + \overline{b}$, where b and $\overline{b}$ jets are discriminated by using the charge and momenta of tracks within the jet cones. The maximum CL at which the model of CHANG 99 can be excluded is 92%. Based on 370 pb^{-1} of data at $\sqrt{s} = 1.96$ TeV.

t-Quark REFERENCES

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AALTONEN	14L	PRL 112 231804	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	14M	PRL 112 231803	T. Aaltonen *et al.*	(CDF and D0 Collab.)
AALTONEN	14N	PR D90 091101	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	14O	PRL 113 261804	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	14C	PRL 113 032002	V.M. Abazov *et al.*	(D0 Collab.)
Also		PR D91 112003	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	14D	PR D90 051101	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	14G	PR D90 072001	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	14H	PR D90 072011	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	14K	PR D90 092006	V.M. Abazov *et al.*	(D0 Collab.)
CHATRCHYAN	14	PL B728 496	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14AC	PRL 112 231802	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14AE	EPJ C74 3014	S. Chatrchyan *et al.*	(CMS Collab.)
Also		EPJ C75 216 (errat.)	S. Chatrchyan *et al.*	(CMS Collab.)

CHATRCHYAN	14C	EPJ C74 2758	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14D	JHEP 1404 191	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14F	JHEP 1402 024	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14O	PL B731 173	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14R	PR D90 032006	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14S	PRL 112 171802	S. Chatrchyan *et al.*	(CMS Collab.)
KHACHATRY...	14E	PL B736 33	V. Khachartryan *et al.*	(CMS Collab.)
KHACHATRY...	14F	JHEP 1406 090	V. Khachartryan *et al.*	(CMS Collab.)
KHACHATRY...	14H	JHEP 1409 087	V. Khachartryan *et al.*	(CMS Collab.)
KHACHATRY...	14K	PL B738 526 (errat.)	S. Chatrchyan *et al.*	(CMS Collab.)
KHACHATRY...	14N	EPJ C74 3060	V. Khachartryan *et al.*	(CMS Collab.)
KHACHATRY...	14Q	PR D90 112013	V. Khachatryan *et al.*	(CMS Collab.)
KHACHATRY...	14R	JHEP 1411 154	V. Khachartryan *et al.*	(CMS Collab.)
KHACHATRY...	14S	PL B739 23	V. Khachartryan *et al.*	(CMS Collab.)
AAD	13AY	JHEP 1311 031	G. Aad *et al.*	(ATLAS Collab.)
AAD	13BE	PRL 111 232002	G. Aad *et al.*	(ATLAS Collab.)
AAD	13X	EPJ C73 2328	G. Aad *et al.*	(ATLAS Collab.)
AALTONEN	13AB	PR D88 091103	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13AD	PRL 111 182002	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13D	PR D87 031104	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13E	PR D87 052013	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13G	PR D87 111101	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13H	PR D88 011101	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13J	PR D88 032003	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13S	PR D87 092002	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13X	PR D88 072003	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13Z	PRL 111 202001	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	13A	PR D87 011103	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	13O	PL B726 656	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	13P	PR D88 112002	V.M. Abazov *et al.*	(D0 Collab.)
CHATRCHYAN	13AY	JHEP 1305 065	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13BB	PL B720 83	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13BE	EPJ C73 2386	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13BH	JHEP 1310 167	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13C	PRL 110 022003	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13F	PL B718 1252	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13S	EPJ C73 2494	S. Chatrchyan *et al.*	(CMS Collab.)
AAD	12B	PL B707 459	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BE	JHEP 1204 069	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BF	JHEP 1205 059	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BG	JHEP 1206 088	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BK	EPJ C72 2039	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BL	EPJ C72 2043	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BO	PL B711 244	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BP	PL B712 351	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BT	JHEP 1209 139	G. Aad *et al.*	(ATLAS Collab.)
AAD	12CG	PL B717 89	G. Aad *et al.*	(ATLAS Collab.)
AAD	12CH	PL B717 330	G. Aad *et al.*	(ATLAS Collab.)
AAD	12I	EPJ C72 2046	G. Aad *et al.*	(ATLAS Collab.)
AALTONEN	12AI	PRL 109 152003	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12AL	PRL 109 192001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12AP	PR D86 092003	T. Aaltonen *et al.*	(CDF, D0 Collab.)
AALTONEN	12G	PL B714 24	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12Z	PR D85 071106	T. Aaltonen *et al.*	(CDF, D0 Collab.)
ABAZOV	12AB	PR D86 051103	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	12B	PRL 108 032004	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	12E	PL B708 21	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	12I	PL B713 165	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	12T	PR D85 091104	V.M. Abazov *et al.*	(D0 Collab.)
BERNREUTH...	12	PR D86 034026	W. Bernreuther, Z.-G. Si	(AACH, SHDN)
CHATRCHYAN	12AC	PR D85 112007	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12AX	JHEP 1211 067	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12BA	EPJ C72 2202	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12BB	PL B717 129	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12BP	JHEP 1212 105	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12BQ	JHEP 1212 035	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12BS	PL B709 28	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12Y	JHEP 1206 109	S. Chatrchyan *et al.*	(CMS Collab.)
AAD	11A	EPJ C71 1577	G. Aad *et al.*	(ATLAS Collab.)
AALTONEN	11AC	PR D84 071105	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	11AK	PRL 107 232002	T. Aaltonen *et al.*	(CDF Collab.)

AALTONEN	11AR	PR D83 031104	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	11D	PR D83 071102	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	11E	PR D83 111101	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	11F	PR D83 112003	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	11K	PRL 106 152001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	11T	PL B698 371	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	11W	PR D84 031101	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	11Y	PR D84 032003	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	11Z	PR D84 031104	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	11A	PL B695 88	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11AA	PL B705 313	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11AD	PR D84 112001	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11AE	PRL 107 032001	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11AF	PL B702 16	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11AH	PR D84 112005	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11B	PRL 106 022001	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11C	PR D83 032009	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11E	PR D84 012008	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11M	PL B701 313	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11P	PR D84 032004	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11R	PRL 107 082004	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11S	PL B703 422	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11T	PR D84 052005	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11X	PRL 107 121802	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11Z	PL B704 403	V.M. Abazov *et al.*	(D0 Collab.)
CHATRCHYAN	11AA	EPJ C71 1721	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	11F	JHEP 1107 049	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	11R	PRL 107 091802	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	11Z	PR D84 092004	S. Chatrchyan *et al.*	(CMS Collab.)
KHACHATRY...	11A	PL B695 424	V. Khachatryan *et al.*	(CMS Collab.)
AALTONEN	10AA	PR D82 052002	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10AB	PR D82 112005	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10AC	PRL 105 232003	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10AE	PRL 105 252001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10C	PR D81 031102	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10D	PR D81 032002	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10E	PR D81 052011	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10Q	PRL 105 042002	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10S	PRL 105 101801	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10U	PR D81 072003	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10V	PR D81 092002	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	10W	PRL 105 012001	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	10	PL B682 363	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	10I	PR D82 032002	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	10J	PL B690 5	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	10K	PL B693 81	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	10Q	PR D82 071102	V.M. Abazov *et al.*	(D0 Collab.)
AHRENS	10	JHEP 1009 097	V. Ahrens *et al.*	(MAINZ, HEIDH)
AHRENS	10A	NPBPS 205-206 48	V. Ahrens *et al.*	(MAINZ, HEIDH)
AALTONEN	09AD	PR D79 112007	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09AK	PR D80 051104	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09AL	PR D80 052001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09AT	PRL 103 092002	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09F	PR D79 031101	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09H	PR D79 052007	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09J	PR D79 072001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09K	PR D79 072010	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09L	PR D79 092005	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09M	PRL 102 042001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09N	PRL 102 151801	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09O	PRL 102 152001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09Q	PL B674 160	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09X	PR D79 072005	T. Aaltonen *et al.*	(CDF Collab.)
AARON	09A	PL B678 450	F.D. Aaron *et al.*	(H1 Collab.)
ABAZOV	09AA	PRL 103 132001	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	09AG	PR D80 071102	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	09AH	PR D80 092006	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	09J	PRL 102 092002	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	09R	PL B679 177	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	09Z	PRL 103 092001	V.M. Abazov *et al.*	(D0 Collab.)
LANGENFELD	09	PR D80 054009	U. Langenfeld, S. Moch, P. Uwer	

AALTONEN	08AB	PRL 101 202001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	08AD	PRL 101 192002	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	08AG	PR D78 111101	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	08AH	PRL 101 252001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	08C	PRL 100 062005	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	08AH	PRL 101 182001	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	08AI	PRL 101 221801	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	08B	PRL 100 062004	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	08I	PR D78 012005	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	08L	PRL 100 142002	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	08M	PRL 100 192003	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	08N	PRL 100 192004	V.M. Abazov *et al.*	(D0 Collab.)
ABULENCIA	08	PR D78 012003	A. Abulencia *et al.*	(CDF Collab.)
CACCIARI	08	JHEP 0809 127	M. Cacciari *et al.*	
KIDONAKIS	08	PR D78 074005	N. Kidonakis, R. Vogt	
MOCH	08	PR D78 034003	S. Moch, P. Uwer	(BERL, KARLE)
AALTONEN	07	PRL 98 142001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	07B	PR D75 111103	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	07D	PR D76 072009	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	07I	PRL 99 182002	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	07C	PRL 98 041801	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	07D	PR D75 031102	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	07F	PR D75 092001	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	07H	PRL 98 181802	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	07O	PR D76 052006	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	07P	PR D76 072007	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	07R	PR D76 092007	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	07V	PRL 99 191802	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	07W	PL B655 7	V.M. Abazov *et al.*	(D0 Collab.)
ABULENCIA	07D	PR D75 031105	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA	07G	PRL 98 072001	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA	07I	PR D75 052001	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA	07J	PR D75 071102	A. Abulencia *et al.*	(CDF Collab.)
ABAZOV	06K	PL B639 616	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	06U	PR D74 092005	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	06X	PR D74 112004	V.M. Abazov *et al.*	(D0 Collab.)
ABULENCIA	06D	PRL 96 022004	A. Abulencia *et al.*	(CDF Collab.)
Also		PR D73 032003	A. Abulencia *et al.*	(CDF Collab.)
Also		PR D73 092002	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA	06G	PRL 96 152002	A. Abulencia *et al.*	(CDF Collab.)
Also		PR D74 032009	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA	06R	PL B639 172	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA	06U	PR D73 111103	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA	06V	PR D73 112006	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA	06Z	PRL 97 082004	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA,A	06C	PRL 96 202002	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA,A	06E	PR D74 072005	A. Abulencia *et al.*	(CDF Collab.)
ABULENCIA,A	06F	PR D74 072006	A. Abulencia *et al.*	(CDF Collab.)
ABAZOV	05	PL B606 25	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	05G	PL B617 1	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	05L	PR D72 011104	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	05P	PL B622 265	V.M. Abazov *et al.*	(D0 Collab.)
Also		PL B517 282	V.M. Abazov *et al.*	(D0 Collab.)
Also		PR D63 031101	B. Abbott *et al.*	(D0 Collab.)
Also		PR D75 092007	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	05Q	PL B626 35	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	05R	PL B626 55	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	05X	PL B626 45	V.M. Abazov *et al.*	(D0 Collab.)
ACOSTA	05A	PRL 95 102002	D. Acosta *et al.*	(CDF Collab.)
ACOSTA	05D	PR D71 031101	D. Acosta *et al.*	(CDF Collab.)
ACOSTA	05N	PR D71 012005	D. Acosta *et al.*	(CDF Collab.)
ACOSTA	05S	PR D72 032002	D. Acosta *et al.*	(CDF Collab.)
ACOSTA	05T	PR D72 052003	D. Acosta *et al.*	(CDF Collab.)
ACOSTA	05U	PR D71 072005	D. Acosta *et al.*	(CDF Collab.)
ACOSTA	05V	PR D71 052003	D. Acosta *et al.*	(CDF Collab.)
ABAZOV	04G	NAT 429 638	V.M. Abazov *et al.*	(D0 Collab.)
ABDALLAH	04C	PL B590 21	J. Abdallah *et al.*	(DELPHI Collab.)
ACOSTA	04H	PR D69 052003	D. Acosta *et al.*	(CDF Collab.)
ACOSTA	04I	PRL 93 142001	D. Acosta *et al.*	(CDF Collab.)
AKTAS	04	EPJ C33 9	A. Aktas *et al.*	(H1 Collab.)
ABAZOV	03A	PR D67 012004	V.M. Abazov *et al.*	(D0 Collab.)

CHEKANOV	03	PL B559 153	S. Chekanov *et al.*	(ZEUS Collab.)
ACHARD	02J	PL B549 290	P. Achard *et al.*	(L3 Collab.)
ACOSTA	02	PR D65 091102	D. Acosta *et al.*	(CDF Collab.)
HEISTER	02Q	PL B543 173	A. Heister *et al.*	(ALEPH Collab.)
ABBIENDI	01T	PL B521 181	G. Abbiendi *et al.*	(OPAL Collab.)
AFFOLDER	01	PR D63 032003	T. Affolder *et al.*	(CDF Collab.)
AFFOLDER	01A	PR D64 032002	T. Affolder *et al.*	(CDF Collab.)
AFFOLDER	01C	PRL 86 3233	T. Affolder *et al.*	(CDF Collab.)
AFFOLDER	00B	PRL 84 216	T. Affolder *et al.*	(CDF Collab.)
BARATE	00S	PL B494 33	S. Barate *et al.*	(ALEPH Collab.)
ABBOTT	99G	PR D60 052001	B. Abbott *et al.*	(D0 Collab.)
ABE	99B	PRL 82 271	F. Abe *et al.*	(CDF Collab.)
Also		PRL 82 2808 (errat.)	F. Abe *et al.*	(CDF Collab.)
CHANG	99	PR D59 091503	D. Chang, W. Chang, E. Ma	
ABBOTT	98D	PRL 80 2063	B. Abbott *et al.*	(D0 Collab.)
ABBOTT	98F	PR D58 052001	B. Abbott *et al.*	(D0 Collab.)
ABE	98E	PRL 80 2767	F. Abe *et al.*	(CDF Collab.)
ABE	98F	PRL 80 2779	F. Abe *et al.*	(CDF Collab.)
ABE	98G	PRL 80 2525	F. Abe *et al.*	(CDF Collab.)
BHAT	98B	IJMP A13 5113	P.C. Bhat, H.B. Prosper, S.S. Snyder	
ABACHI	97E	PRL 79 1197	S. Abachi *et al.*	(D0 Collab.)
ABE	97R	PRL 79 1992	F. Abe *et al.*	(CDF Collab.)
ABE	97V	PRL 79 3585	F. Abe *et al.*	(CDF Collab.)
PDG	96	PR D54 1	R. M. Barnett *et al.*	(PDG Collab.)
ABACHI	95	PRL 74 2632	S. Abachi *et al.*	(D0 Collab.)
ABE	95F	PRL 74 2626	F. Abe *et al.*	(CDF Collab.)
ABE	94E	PR D50 2966	F. Abe *et al.*	(CDF Collab.)
Also		PRL 73 225	F. Abe *et al.*	(CDF Collab.)