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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."

OUR EVALUATION of 173.5 ± 0.6 ± 0.8 GeV is an average of published top mass measurements from Tevatron Run-I (1992–1996) and Run-II (2001−present) and of the LHC. The Tevatron average (173.4 ± 0.6 ± 0.8 GeV) was provided by the Tevatron Electroweak Working Group (TEVEWWG). It takes correlated uncertainties into account and has a χ^2 of 8.5 for 11 degrees of freedom. We include in OUR EVALUATION the measurement from CHATRCHYAN 11F assuming uncorrelated systematic uncertainties. The average would be 173.4 ± 0.6 ± 0.8 GeV if we assumed fully correlated systematics between the Tevatron average and CHATRCHYAN 11F.

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.

VALUE (GeV)	DOCUMENT ID		TECN	COMMENT
173.5 ± 0.6 ± 0.8	**OUR EVALUATION**			See comments in the header above.
172.3 ± 2.4 ± 1.0	[1] AALTONEN	11AK	CDF	$\not{E}_T + \geq 4$ jets (≥ 1 b-tag)
172.1 ± 1.1 ± 0.9	[2] AALTONEN	11E	CDF	$\ell +$ jets and dilepton
174.94 ± 0.83 ± 1.24	[3] ABAZOV	11P	D0	$\ell + \not{E}_T + 4$ jets (≥ 1 b-tag)
174.0 ± 1.8 ± 2.4	[4] ABAZOV	11R	D0	dilepton $+ \not{E}_T + \geq 2$ jets
175.5 ± 4.6 ± 4.6	[5] CHATRCHYAN	11F	CMS	dilepton $+ \not{E}_T +$ jets
173.0 ± 1.2	[6] AALTONEN	10AE	CDF	$\ell + \not{E}_T + 4$ jets (≥ 1 b-tag), ME method
170.7 ± 6.3 ± 2.6	[7] AALTONEN	10D	CDF	$\ell + \not{E}_T + 4$ jets (b-tag)
174.8 ± 2.4 $^{+1.2}_{-1.0}$	[8] AALTONEN	10E	CDF	≥ 6 jets, vtx b-tag
180.1 ± 3.6 ± 3.9	[9,10] ABAZOV	04G	D0	lepton + jets
176.1 ± 5.1 ± 5.3	[11] AFFOLDER	01	CDF	lepton + jets
167.4 ± 10.3 ± 4.8	[12,13] ABE	99B	CDF	dilepton
168.4 ± 12.3 ± 3.6	[10] ABBOTT	98D	D0	dilepton
186 ± 10 ± 5.7	[12,14] ABE	97R	CDF	6 or more jets

• • • We do not use the following data for averages, fits, limits, etc. • • •

172.4 ± 1.4 ± 1.3	[15]	AALTONEN	11AC	CDF	$\ell + \not\!\!E_T$ + 4 jets (≥ 1 b-tag)
176.9 ± 8.0 ± 2.7	[16]	AALTONEN	11T	CDF	$\ell + \not\!\!E_T$ + 4 jets (≥ 1 b-tag), $p_T(\ell)$ shape
169.3 ± 2.7 ± 3.2	[17]	AALTONEN	10C	CDF	dilepton + b-tag (MT2+NWA)
180.5 ±12.0 ± 3.6	[18]	AALTONEN	09AK	CDF	$\ell + \not\!\!E_T$ + jets (soft μ b-tag)
172.7 ± 1.8 ± 1.2	[19]	AALTONEN	09J	CDF	$\ell + \not\!\!E_T$ + 4 jets (b-tag)
171.1 ± 3.7 ± 2.1	[20]	AALTONEN	09K	CDF	6 jets, vtx b-tag
171.9 ± 1.7 ± 1.1	[21]	AALTONEN	09L	CDF	ℓ + jets, $\ell\ell$ + jets
171.2 ± 2.7 ± 2.9	[22]	AALTONEN	09O	CDF	dilepton
165.5 $^{+3.4}_{-3.3}$ ± 3.1	[23]	AALTONEN	09X	CDF	$\ell\ell + \not\!\!E_T$ ($\nu\phi$ weighting)
174.7 ± 4.4 ± 2.0	[24]	ABAZOV	09AH	D0	dilepton + b-tag (νWT+MWT)
170.7 $^{+4.2}_{-3.9}$ ± 3.5	[25,26]	AALTONEN	08C	CDF	dilepton, $\sigma_{t\overline{t}}$ constrained
171.5 ± 1.8 ± 1.1	[27]	ABAZOV	08AH	D0	$\ell + \not\!\!E_T$ + 4 jets
177.1 ± 4.9 ± 4.7	[28,29]	AALTONEN	07	CDF	6 jets with ≥ 1 b vtx
172.3 $^{+10.8}_{-9.6}$ ±10.8	[30]	AALTONEN	07B	CDF	≥ 4 jets (b-tag)
174.0 ± 2.2 ± 4.8	[31]	AALTONEN	07D	CDF	≥ 6 jets, vtx b-tag
170.8 ± 2.2 ± 1.4	[32,33]	AALTONEN	07I	CDF	lepton + jets (b-tag)
173.7 ± 4.4 $^{+2.1}_{-2.0}$	[29,34]	ABAZOV	07F	D0	lepton + jets
176.2 ± 9.2 ± 3.9	[35]	ABAZOV	07W	D0	dilepton (MWT)
179.5 ± 7.4 ± 5.6	[35]	ABAZOV	07W	D0	dilepton (νWT)
164.5 ± 3.9 ± 3.9	[33,36]	ABULENCIA	07D	CDF	dilepton
180.7 $^{+15.5}_{-13.4}$ ± 8.6	[37]	ABULENCIA	07J	CDF	lepton + jets
170.3 $^{+4.1}_{-4.5}$ $^{+1.2}_{-1.8}$	[33,38]	ABAZOV	06U	D0	lepton + jets (b-tag)
173.2 $^{+2.6}_{-2.4}$ ± 3.2	[39,40]	ABULENCIA	06D	CDF	lepton + jets
173.5 $^{+3.7}_{-3.6}$ ± 1.3	[26,39]	ABULENCIA	06D	CDF	lepton + jets
165.2 ± 6.1 ± 3.4	[33,41]	ABULENCIA	06G	CDF	dilepton
170.1 ± 6.0 ± 4.1	[26,42]	ABULENCIA	06V	CDF	dilepton
178.5 ±13.7 ± 7.7	[43,44]	ABAZOV	05	D0	6 or more jets
176.1 ± 6.6	[45]	AFFOLDER	01	CDF	dilepton, lepton+jets, all-jets
172.1 ± 5.2 ± 4.9	[46]	ABBOTT	99G	D0	di-lepton, lepton+jets
176.0 ± 6.5	[13,47]	ABE	99B	CDF	dilepton, lepton+jets, all-jets
173.3 ± 5.6 ± 5.5	[10,48]	ABBOTT	98F	D0	lepton + jets
175.9 ± 4.8 ± 5.3	[12,49]	ABE	98E	CDF	lepton + jets
161 ±17 ±10	[12]	ABE	98F	CDF	dilepton
172.1 ± 5.2 ± 4.9	[50]	BHAT	98B	RVUE	dilepton and lepton+jets
173.8 ± 5.0	[51]	BHAT	98B	RVUE	dilepton, lepton+jets, all-jets
173.3 ± 5.6 ± 6.2	[10]	ABACHI	97E	D0	lepton + jets
199 $^{+19}_{-21}$ ±22		ABACHI	95	D0	lepton + jets
176 ± 8 ±10		ABE	95F	CDF	lepton + b-jet
174 ±10 $^{+13}_{-12}$		ABE	94E	CDF	lepton + b-jet

t-Quark $\overline{\text{MS}}$ Mass from Cross-Section Measurements

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

VALUE (GeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
$160.0^{+4.8}_{-4.3}$	[52] ABAZOV	11S	D0	$\sigma(t\overline{t})$ + theory

• • • We do not use the following data for averages, fits, limits, etc. • • •

	[53] ABAZOV	09AG	D0	cross sects, theory + exp
	[54] ABAZOV	09R	D0	cross sects, theory + exp

[1] 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 ℓ + jets and all hadronic channels while being sensitive to those events with a τ lepton in the final state. Supersedes AALTONEN 07B.

[2] 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 ± 1.2 ± 0.9 GeV while the dilepton channel yields 170.3 ± 2.0 ± 3.1 GeV. The results are combined. OUR EVALUATION includes the measurement in the dilepton channel only.

[3] Based on 3.6 fb^{-1} in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. ABAZOV 11P reports 174.94 ± 0.83 ± 0.78 ± 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.

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

[5] 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.

[6] 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 ± 0.7(stat) ± 0.6(JES) ± 0.9(syst) GeV, for a total uncertainty of 1.2 GeV.

[7] 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 lenght 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) ± 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.

[8] Based on 2.9 fb^{-1} in $p\overline{p}$ 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.

[9] 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.

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

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

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

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

[14] 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.

[15] 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 ± 0.3(stat).

[16] 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.

[17] Based on 3.4 fb^{-1} in $p\overline{p}$ 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) ± 2.9(syst) GeV with smaller systematic error due to small JES uncertainty.

[18] 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.

[19] 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.

[20] 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.

[21] 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 ± 2.2 GeV, and dilepton data only give $m_t = 171.2^{+5.3}_{-5.1}$ GeV.

[22] 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.

[23] 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.

[24] 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 ± 4.8 ± 2.1 GeV and the MWT (Matrix-element Weighting Technique) result of 173.2 ± 4.9 ± 2.0 GeV.

[25] Reports measurement of $170.7^{+4.2}_{-3.9}$ ± 2.6 ± 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 $169.7^{+5.2}_{-4.9}$ ± 3.1 GeV is obtained.

[26] Template method.

[27] 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.

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

[29] Ideogram method.

[30] 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.

[31] Based on 1.02 fb^{-1} of data at $\sqrt{s}$ = 1.96 TeV.

[32] 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.

[33] Matrix element method.

[34] 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).

[35] 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.

[36] 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.

[37] 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.

[38] 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.

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

[40] Dynamical likelihood method.

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

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

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

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

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

[46] 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).

[47] 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.

[48] See ABAZOV 04G.

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

[50] 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.

[51] 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.

[52] 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 $\overline{\text{MS}}$ 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 $m_t^{\overline{\text{MS}}} = 154.5^{+5.0}_{-4.3}$ GeV.

[53] 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).

[54] 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).

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

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

VALUE (GeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
−1.4±2.0 OUR AVERAGE	Error includes scale factor of 1.6.			
−3.3±1.4±1.0	[1] AALTONEN	11K	CDF	$\ell + \not\!\!E_T$ + 4 jets
0.8±1.8±0.5	[2] ABAZOV	11T	D0	$\ell + \not\!\!E_T$ + 4 jets (≥ 1 *b*-tag)
• • • We do not use the following data for averages, fits, limits, etc. • • •				
3.8±3.4±1.2	[3] ABAZOV	09AA	D0	$\ell + \not\!\!E_T$ + 4 jets (≥ 1 *b*-tag)

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

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

[3] 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*
$\mathbf{1.99^{+0.69}_{-0.55}}$		[1] ABAZOV	11B	D0	$\Gamma(t \to Wb)/B(t \to Wb)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
> 1.21	95	[1] ABAZOV	11B	D0	$\Gamma(t \to Wb)$
< 7.6	95	[2] AALTONEN	10AC	CDF	ℓ + jets, direct
<13.1	95	[3] AALTONEN	09M	CDF	m_t(rec) distribution

[1] 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.

[2] 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< Γ_t < 4.4 GeV for m_t = 172.5 GeV.

[3] 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	$Wq(q = b, s, d)$			
Γ_2	Wb			
Γ_3	$\ell \nu_\ell$ anything	[a,b]	(9.4±2.4) %	
Γ_4	$\tau \nu_\tau b$			
Γ_5	$\gamma q (q{=}u,c)$	[c]	< 5.9 × 10^{-3}	95%

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

Γ_6	$Z q (q=u,c)$	$T1$	[d] < 3.2	%	95%

[a] ℓ means e or μ decay mode, not the sum over them.

[b] Assumes lepton universality and W-decay acceptance.

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

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

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
0.91±0.04 OUR AVERAGE				
0.90 ± 0.04	[1] ABAZOV	11X	D0	
$1.12^{+0.21}_{-0.19}{}^{+0.17}_{-0.13}$	[2] ACOSTA	05A	CDF	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$0.97^{+0.09}_{-0.08}$	[3] ABAZOV	08M	D0	ℓ + n jets with 0,1,2 b-tag
$1.03^{+0.19}_{-0.17}$	[4] ABAZOV	06K	D0	
$0.94^{+0.26}_{-0.21}{}^{+0.17}_{-0.12}$	[5] AFFOLDER	01C	CDF	

[1] 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 ℓ + 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.

[2] ACOSTA 05A result is from the analysis of lepton + jets and di-lepton + jets final states of $t\bar{t}$ 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.

[3] 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).

[4] ABAZOV 06K result is from the analysis of $t\bar{t} \rightarrow \ell\nu + \geq 3$ 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.

[5] 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.

$\Gamma(\ell \nu_\ell \text{anything})/\Gamma_{\text{total}}$ — Γ_3/Γ

VALUE	DOCUMENT ID		TECN
0.094±0.024	[1] ABE	98X	CDF

[1] ℓ means e or μ decay mode, not the sum. Assumes lepton universality and W-decay acceptance.

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

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] ABULENCIA	06R	CDF	$\ell\tau$ + jets
	[2] ABE	97V	CDF	$\ell\tau$ + jets

[1] 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 $\Gamma(t \rightarrow \tau\nu q)$ / $\Gamma_{SM}(t \rightarrow \tau\nu q) < 5.2$.

[2] 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.

$\Gamma(\gamma q(q{=}u,c))/\Gamma_{total}$ Γ_5/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<$0.0064	95	[1] AARON	09A	H1	$t \rightarrow \gamma u$
$<$0.0059	95	[2] CHEKANOV	03	ZEUS	B($t \rightarrow \gamma u$)
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<$0.0465	95	[3] ABDALLAH	04C	DLPH	B(γc or γu)
$<$0.0132	95	[4] AKTAS	04	H1	B($t \rightarrow \gamma u$)
$<$0.041	95	[5] ACHARD	02J	L3	B($t \rightarrow \gamma c$ or γu)
$<$0.032	95	[6] ABE	98G	CDF	$t\overline{t} \rightarrow (W b)$ (γc or γu)

[1] 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.

[2] CHEKANOV 03 looked for single top production via FCNC in the reaction $e^{\pm} p \rightarrow e^{\pm}$ (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.

[3] 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.

[4] 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.

[5] 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.

[6] 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 $\Gamma(\gamma q)/\Gamma(W b)$.

$\Gamma(Zq(q{=}u,c))/\Gamma_{total}$ Γ_6/Γ

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.032	95	[1] ABAZOV	11M	D0	$t \to Zq$ ($q = u$, c)
<0.037	95	[2] AALTONEN	08AD	CDF	$t \to Zq$ ($q = u$, c)
<0.159	95	[3] ABDALLAH	04C	DLPH	$e^+e^- \to \overline{t}c$ or $\overline{t}u$
<0.137	95	[4] ACHARD	02J	L3	$e^+e^- \to \overline{t}c$ or $\overline{t}u$
<0.14	95	[5] HEISTER	02Q	ALEP	$e^+e^- \to \overline{t}c$ or $\overline{t}u$
<0.137	95	[6] ABBIENDI	01T	OPAL	$e^+e^- \to \overline{t}c$ or $\overline{t}u$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.083	95	[7] AALTONEN	09AL	CDF	$t \to Zq$ (q=c)
<0.17	95	[8] BARATE	00S	ALEP	$e^+e^- \to \overline{t}c$ or $\overline{t}u$
<0.33	95	[9] ABE	98G	CDF	$t\overline{t} \to (Wb)(Zc$ or $Zu)$

[1] 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.

[2] 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.

[3] 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.

[4] 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) $\neq$0 are given in Fig. 5 and Table 7. Table 6 gives constraints on t-c-e-e four-fermi contact interactions.

[5] 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.

[6] 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.

[7] 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.

[8] 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.

[9] 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 $\Gamma(Zq)/\Gamma(Wb)$.

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.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$(V_{tb}\,f_2^L)^2$ < 0.13	95	[1] ABAZOV	12E	D0	Single-top
$(V_{tb}\,f_1^R)^2$ < 0.93	95	[1] ABAZOV	12E	D0	Single-top
$(V_{tb}\,f_2^R)^2$ < 0.06	95	[1] ABAZOV	12E	D0	Single-top
$0.669 \pm 0.078 \pm 0.065$		[2] ABAZOV	11C	D0	$F_0 = B(t \to W_0 b)$
$0.023 \pm 0.041 \pm 0.034$		[2] ABAZOV	11C	D0	$F_+ = B(t \to W_+ b)$
$0.70 \pm 0.07 \pm 0.04$		[3] AALTONEN	10Q	CDF	$F_0 = B(t \to W_0 b)$
$-0.01 \pm 0.02 \pm 0.05$		[3] AALTONEN	10Q	CDF	$F_+ = B(t \to W_+ b)$
$0.62 \pm 0.10 \pm 0.05$		[4] AALTONEN	09Q	CDF	$F_0 = B(t \to W_0 b)$
$-0.04 \pm 0.04 \pm 0.03$		[4] AALTONEN	09Q	CDF	$F_+ = B(t \to W_+ b)$
$\lvert f_1^R \rvert^2$ < 1.01	95	[5] ABAZOV	09J	D0	$\lvert f_1^L\rvert = 1$, $\lvert f_2^L\rvert = \lvert f_2^R\rvert = 0$
$\lvert f_2^L \rvert^2$ < 0.28	95	[5] ABAZOV	09J	D0	$\lvert f_1^L\rvert = 1$, $\lvert f_1^R\rvert = \lvert f_2^R\rvert = 0$
$\lvert f_2^R \rvert^2$ < 0.23	95	[5] ABAZOV	09J	D0	$\lvert f_1^L\rvert = 1$, $\lvert f_1^R\rvert = \lvert f_2^L\rvert = 0$
$\lvert f_1^R \rvert^2$ < 2.5	95	[6] ABAZOV	08AI	D0	$\lvert f_1^L\rvert^2 = 1.8^{+1.0}_{-1.3}$
$\lvert f_2^L \rvert^2$ < 0.5	95	[6] ABAZOV	08AI	D0	$\lvert f_1^L\rvert^2 = 1.4^{+0.6}_{-0.5}$
$\lvert f_2^R \rvert^2$ < 0.3	95	[6] ABAZOV	08AI	D0	$\lvert f_1^L\rvert^2 = 1.4^{+0.9}_{-0.8}$
$0.425 \pm 0.166 \pm 0.102$		[7] ABAZOV	08B	D0	$F_0 = B(t \to W_0 b)$
$0.119 \pm 0.090 \pm 0.053$		[7] ABAZOV	08B	D0	$F_+ = B(t \to W_+ b)$
$0.056 \pm 0.080 \pm 0.057$		[8] ABAZOV	07D	D0	$F_+ = B(t \to W_+ b)$
$-0.06 \pm 0.22 \pm 0.12$		[9] ABULENCIA	07G	CDF	$F_{V+A} = B(t \to W b_R)$
$<$ 0.29	95	[9] ABULENCIA	07G	CDF	$F_{V+A} = B(t \to W b_R)$
$0.85\ ^{+0.15}_{-0.22} \pm 0.06$		[10] ABULENCIA	07I	CDF	$F_0 = B(t \to W_0 b)$
$0.05\ ^{+0.11}_{-0.05} \pm 0.03$		[10] ABULENCIA	07I	CDF	$F_+ = B(t \to W_+ b)$
$<$ 0.26	95	[10] ABULENCIA	07I	CDF	$F_+ = B(t \to W_+ b)$
$0.74\ ^{+0.22}_{-0.34}$		[11] ABULENCIA	06U	CDF	$F_0 = B(t \to W_0 b)$
$<$ 0.27	95	[11] ABULENCIA	06U	CDF	$F_+ = B(t \to W_+ b)$
0.56 ± 0.31		[12] ABAZOV	05G	D0	$F_0 = B(t \to W_0 b)$
$0.00 \pm 0.13 \pm 0.07$		[13] ABAZOV	05L	D0	$F_+ = B(t \to W_+ b)$
$<$ 0.25	95	[13] ABAZOV	05L	D0	$F_+ = B(t \to W_+ b)$
$<$ 0.80	95	[14] ACOSTA	05D	CDF	$F_{V+A} = B(t \to W b_R)$
$<$ 0.24	95	[14] ACOSTA	05D	CDF	$F_+ = B(t \to W_+ b)$
$0.91 \pm 0.37 \pm 0.13$		[15] AFFOLDER	00B	CDF	$F_0 = B(t \to W_0 b)$
0.11 ± 0.15		[15] AFFOLDER	00B	CDF	$F_+ = B(t \to W_+ b)$

[1] 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.

[2] 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.

[3] 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.

[4] 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 $F_+ = -0.03 \pm 0.06 \pm 0.03$.

[5] 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 tbW 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.

[6] 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 tbW 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, $f_1^L = V_{tb}^*$.

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

[8] 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.

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

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

[11] 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.

[12] 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.

[13] 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.

[14] 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).

[15] 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.

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

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. • • •				
0.85 ± 0.29	[1] ABAZOV	12B	D0	f ($\ell\ell + \geq 2$ jets, $\ell + \geq 4$ jets)
$1.15^{+0.42}_{-0.43}$	[2] ABAZOV	12B	D0	f ($\ell + \not{E}_T + \geq 4$ jets)
$0.60^{+0.50}_{-0.16}$	[3] AALTONEN	11AR	CDF	κ ($\ell + \not{E}_T + \geq 4$ jets)
$0.74^{+0.40}_{-0.41}$	[4] ABAZOV	11AE	D0	f ($\ell\ell + \not{E}_T + \geq 2$ jets)
0.10 ± 0.45	[5] ABAZOV	11AF	D0	C ($\ell\ell + \not{E}_T + \geq 2$ jets)

[1] 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.

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

[3] 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 $\kappa \approx 0.40$.

[4] 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.

[5] 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.

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. • • •					
<0.013	95	[1] ABAZOV	10K	D0	κ^{tug}/Λ
<0.057	95	[1] ABAZOV	10K	D0	κ^{tcg}/Λ
<0.018	95	[2] AALTONEN	09N	CDF	κ^{tug}/Λ ($\kappa^{tcg} = 0$)
<0.069	95	[2] AALTONEN	09N	CDF	κ^{tcg}/Λ ($\kappa^{tug} = 0$)
<0.037	95	[3] ABAZOV	07V	D0	κ^{utg}/Λ
<0.15	95	[3] ABAZOV	07V	D0	κ^{ctg}/Λ

[1] 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.

[2] 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.

[3] 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.

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 $\sim 106\ \mathrm{pb}^{-1}$ 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 $\sim 106\ \mathrm{pb}^{-1}$ 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 $\sim 106\ \mathrm{pb}^{-1}$ 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
$\mathbf{2.7^{+0.6}_{-0.5}}$ **OUR AVERAGE** Error includes scale factor of 1.2.					
$3.43^{+0.73}_{-0.74}$		[1] ABAZOV	11AD	D0	s- + t-channels
$2.3^{+0.6}_{-0.5}$		[2] AALTONEN	09AT	CDF	s- + t-channel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.98 ± 0.63		[3] ABAZOV	11AA	D0	s-channel
2.90 ± 0.59		[3] ABAZOV	11AA	D0	t-channel
$1.8^{+0.7}_{-0.5}$		[4] AALTONEN	10AB	CDF	s-channel
0.8 ± 0.4		[4] AALTONEN	10AB	CDF	t-channel
$4.9^{+2.5}_{-2.2}$		[5] AALTONEN	10U	CDF	$\not{E}_T$ + jets decay
$3.14^{+0.94}_{-0.80}$		[6] ABAZOV	10	D0	t-channel
1.05 ± 0.81		[6] ABAZOV	10	D0	s-channel
< 7.3	95	[7] ABAZOV	10J	D0	τ + jets decay
3.94 ± 0.88		[8] ABAZOV	09Z	D0	s- + t-channel
$2.2^{+0.7}_{-0.6}$		[9] AALTONEN	08AH	CDF	s- + t-channel
4.7 ± 1.3		[10] ABAZOV	08I	D0	s- + t-channel
4.9 ± 1.4		[11] ABAZOV	07H	D0	s- + t-channel
< 6.4	95	[12] ABAZOV	05P	D0	$p\overline{p} \rightarrow tb + X$
< 5.0	95	[12] ABAZOV	05P	D0	$p\overline{p} \rightarrow tqb + X$
<10.1	95	[13] ACOSTA	05N	CDF	$p\overline{p} \rightarrow tqb + X$
<13.6	95	[13] ACOSTA	05N	CDF	$p\overline{p} \rightarrow tb + X$
<17.8	95	[13] ACOSTA	05N	CDF	$p\overline{p} \rightarrow tb + X$, $tqb + X$

[1] 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 $0 < |V_{tb}|^2 < 1$.

[2] Based on 3.2 fb^{-1} of data. Events with isolated $\ell + \not\!\!E_T$ + 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.

[3] 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.

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

[5] 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).

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

[7] 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.

[8] Based on 2.3 fb^{-1} of data. Events with isolated $\ell + \not\!\!E_T + \geq 2$ 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.

[9] Result is based on 2.2 fb^{-1} of data. Events with isolated $\ell + \not\!\!E_T$ + 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.

[10] Result is based on 0.9 fb^{-1} of data. Events with isolated $\ell + \not\!\!E_T$ + 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.

[11] 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.

[12] 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.

[13] 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.

Single t-Quark 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
83.6±29.8±3.3	[1] CHATRCHYAN 11R	CMS	t-channel

[1] 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 ± 0.22(exp)±0.02(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 $0 < |V_{tb}|^2 < 1$.

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	$e^{\pm} p \to e^{\pm} t X$
<0.55	95	[2] AKTAS	04	H1	$e^{\pm} p \to e^{\pm} t X$
<0.225	95	[3] CHEKANOV	03	ZEUS	$e^{\pm} p \to e^{\pm} t X$

[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 ± 0.22 events are expected from the Standard Model background. No excess was found for the hadronic channel. The observed cross section of $\sigma(ep \to etX) = 0.29^{+0.15}_{-0.14}$ 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±1.21±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. • • •				
8.5 ±0.6 ±0.7	[1] AALTONEN	11D	CDF	$\ell + \not{E}_T$ + jets (≥ 1b-tag)
7.64±0.57±0.45	[2] AALTONEN	11W	CDF	$\ell + \not{E}_T$ + jets (≥ 1b-tag)
7.99±0.55±0.76±0.46	[3] AALTONEN	11Y	CDF	$\not{E}_T$ + ≥ 4jets (0,1,2 b-tag)
$7.78^{+0.77}_{-0.64}$	[4] ABAZOV	11E	D0	$\ell + \not{E}_T$ + ≥ 2 jets
$7.56^{+0.63}_{-0.56}$	[5] ABAZOV	11Z	D0	Combination

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

[1] Based on 1.12 fb^{-1} and assumes m_t = 175 GeV, where the cross section changes by $\pm$0.1 pb for every $\mp$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.

[2] 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.

[3] 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.

[4] 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.

[5] 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.

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

[7] 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.

[8] 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.

[9] 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.

[10] 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.

[11] Based on 1 fb^{-1}. The result is for m_t = 170 GeV. For m_t = 175 GeV, the result is $6.3^{+1.2}_{-1.1}\text{(stat)}\pm0.7\text{(syst)}\pm0.4\text{(lumi)}$ 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.

[12] Based on 1.1 fb^{-1}. The result is for $\text{B}(W \rightarrow \ell\nu)$ = 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 $t\overline{t}$ decays into dileptons including $\ell = \tau$. The result is based on the candidate event samples with and without vertex b-tag.

[13] 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.

[14] 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 $\text{R}^{\ell\ell/\ell j} = 0.86^{+0.19}_{-0.17}$ and $\text{R}^{\ell\tau/\ell\ell-\ell j} = 0.97^{+0.32}_{-0.29}$, consistent with the SM expectation of R = 1. This leads to the upper bound of $\text{B}(t \rightarrow bH^+)$ as a function of m_{H^+}. Results are shown in their Fig. 1 for $\text{B}(H^+ \rightarrow \tau\nu) = 1$ and $\text{B}(H^+ \rightarrow c\overline{s}) = 1$ 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.

[15] 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 $7.6^{+4.9}_{-4.3}{}^{+3.5}_{-3.4}{}^{+1.4}_{-0.9}$ pb and the $\ell\ell$ channel gives $7.5^{+1.2}_{-1.1}{}^{+0.7}_{-0.6}{}^{+0.7}_{-0.5}$ pb.

[16] 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].

[17] 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 $\ell +$ 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.

[18] 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 $t\overline{t}$, $W^+ W^-$, and $Z \rightarrow \tau^+ \tau^-$ production processes simultaneously. The other cross sections are given in Table IV.

[19] 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.

[20] 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.

[21] 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.

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

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

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

[25] 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 $W \rightarrow \tau\nu$ mode.

[26] ABULENCIA,A 06E measures the $t\overline{t}$ 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.

[27] 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.

[28] 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.

[29] 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.

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

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

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

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

[34] 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.

[35] 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 $t\overline{t}\gamma$ to $t\overline{t}$ 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 + $\not{E}_T$ + ≥ 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 ± 0.005. The absolute production cross section is measured to be 0.18 ± 0.08 fb. The statistical significance is 3.0 standard deviations.

$t\overline{t}$ 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. • • •				
$177 \pm 20 \pm 14 \pm 7$	[1] AAD	12B	ATLS	$\ell\ell + \not{E}_T + \geq 2$j
$145 \pm 31 ^{+42}_{-27}$	[2] AAD	11A	ATLS	$\ell + \not{E}_T + \geq 4$j, $\ell\ell + \not{E}_T + \geq 2$j
$173 ^{+39}_{-32} \pm 7$	[3] CHATRCHYAN	11AA	CMS	$\ell + \not{E}_T + \geq 3$ jets
$168 \pm 18 \pm 14 \pm 7$	[4] CHATRCHYAN	11F	CMS	$\ell\ell + \not{E}_T$ + jets
$154 \pm 17 \pm 6$	[5] CHATRCHYAN	11Z	CMS	Combination
$194 \pm 72 \pm 24 \pm 21$	[6] KHACHATRY...	11A	CMS	$\ell\ell + \not{E}_T + \geq 2$ jets

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

[2] 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.

[3] 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.

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

[5] 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 $150 \pm 9 \pm 17 \pm 6$ pb.

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

$gg \rightarrow t\overline{t}$ fraction in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV

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

[1] Result is based on 0.96 fb^{-1} of data. The contribution of the subprocesses $gg \rightarrow t\overline{t}$ and $q\overline{q} \rightarrow t\overline{t}$ 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 ($\lvert\eta\rvert < 1.1$).

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

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-11.6 ± 15.3	[1] AALTONEN	11F	CDF	$m_{t\overline{t}} < 450$ GeV
47.5 ± 11.4	[1] AALTONEN	11F	CDF	$m_{t\overline{t}} > 450$ GeV
$19.6\pm\ 6.5$	[2] ABAZOV	11AH	D0	$\ell + \not{E}_T + \geq 4$ jets($\geq 1b$-tag)
$17\ \pm\ 8$	[3] AALTONEN	08AB	CDF	$p\overline{p}$ frame
$24\ \pm14$	[3] AALTONEN	08AB	CDF	$t\overline{t}$ frame
$12\ \pm\ 8\ \pm1$	[4] ABAZOV	08L	D0	$\ell + \not{E}_T + \geq 4$ jets

[1] 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.

[2] 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)%.

[3] 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 ($\leq\ 2\ \sigma$) with the SM predictions.

[4] 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
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] AALTONEN	10S	CDF	
	[2] ABAZOV	07C	D0	fraction of $|q|$=4e/3 pair

[1] 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.

[2] ABAZOV 07C reports an upper limit $\rho < 0.80$ (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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ABAZOV	12E	PL B708 21	V.M. Abazov *et al.*	(D0 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.)
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ABAZOV	11C	PR D83 032009	V.M. Abazov *et al.*	(D0 Collab.)
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ABAZOV	11S	PL B703 422	V.M. Abazov *et al.*	(D0 Collab.)
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CHATRCHYAN	11AA	EPJ C71 1721	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	11F	JHEP 1107 049	S. Chatrchyan *et al.*	(CMS Collab.)
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KHACHATRY...	11A	PL B695 424	V. Khachatryan *et al.*	(CMS Collab.)
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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 031102R	T. Aaltonen *et al.*	(CDF Collab.)
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AALTONEN	10E	PR D81 052011	T. Aaltonen *et al.*	(CDF Collab.)
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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.*	(MANZ, HEIDH)
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AALTONEN	09AK	PR D80 051104R	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09AL	PR D80 052001	T. Aaltonen *et al.*	(CDF Collab.)
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AALTONEN	09M	PRL 102 042001	T. Aaltonen *et al.*	(CDF Collab.)
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AARON	09A	PL B678 450	F.D. Aaron *et al.*	(H1 Collab.)
ABAZOV	09AA	PRL 103 132001	V.M. Abazov *et al.*	(D0 Collab.)
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ABAZOV	07P	PR D76 072007	V.M. Abazov *et al.*	(D0 Collab.)
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ABAZOV	06U	PR D74 092005	V.M. Abazov *et al.*	(D0 Collab.)
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ABAZOV	05G	PL B617 1	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	05L	PR D72 011104R	V.M. Abazov *et al.*	(D0 Collab.)
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ACOSTA	05T	PR D72 052003	D. Acosta *et al.*	(CDF Collab.)

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