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t-Quark Mass in $p\overline{p}$ Collisions

OUR EVALUATION is an AVERAGE done by the Tevatron Electroweak Working Group and was reported in TEVEWWG 04. The present average of 178.0 ± 2.7 ± 3.3 GeV includes the most recent CDF and DØ measurements in each channel as available in 2004. The change compared to the previous average of 174.3 ± 3.2 ± 4.0 GeV from DEMORTIER 99 is essentially due to the re-analysis of the DØ data in the lepton + jets channel (ABAZOV 04G).

For earlier search limits see the *Review of Particle Physics*, Phys. Rev. **D54**,1 (1996).

VALUE (GeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
178.0± 4.3 OUR EVALUATION				
178.5±13.7± 7.7	[1,2] ABAZOV	05	D0	6 or more jets
180.1± 3.6± 3.9	[3,4] ABAZOV	04G	D0	lepton + jets
176.1± 5.1± 5.3	[5] AFFOLDER	01	CDF	lepton + jets
167.4±10.3± 4.8	[6,7] ABE	99B	CDF	dilepton
168.4±12.3± 3.6	[4] ABBOTT	98D	D0	dilepton
186 ±10 ± 5.7	[6,8] ABE	97R	CDF	6 or more jets
• • • We do not use the following data for averages, fits, limits, etc. • • •				
176.1± 6.6	[9] AFFOLDER	01	CDF	lepton + jets, dileptons, all-jets
172.1± 5.2± 4.9	[10] ABBOTT	99G	D0	di-lepton, lepton+jets
176.0± 6.5	[7,11] ABE	99B	CDF	dilepton, lepton+jets, and all jets
173.3± 5.6± 5.5	[4,12] ABBOTT	98F	D0	lepton + jets
175.9± 4.8± 5.3	[6,13] ABE	98E	CDF	lepton + jets
161 ±17 ±10	[6] ABE	98F	CDF	dilepton
172.1± 5.2± 4.9	[14] BHAT	98B	RVUE	dilepton and lepton+jets
173.8± 5.0	[15] BHAT	98B	RVUE	dilepton, lepton+jets, and all jets
173.3± 5.6± 6.2	[4] 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

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

[2] ABAZOV 05 result is 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.

[3] This result is 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.

[4] Result is based on 125 ± 7 pb^{-1} of data at $\sqrt{s}$ = 1.8 TeV.

[5] AFFOLDER 01 result uses lepton + jets topology. It is based on ∼ 106 pb^{-1} of data at $\sqrt{s}$= 1.8 TeV.

[6] Result is based on 109 ± 7 pb^{-1} of data at $\sqrt{s}$ = 1.8 TeV.

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

[8] ABE 97R result is based on the first observation of all hadronic decays of $t\bar{t}$ 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.

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

[10] ABBOTT 99G result is 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).

[11] ABE 99B result is 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.

[12] See ABAZOV 04G.

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

[14] BHAT 98B result is 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.

[15] BHAT 98B result is 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.

Indirect *t*-Quark Mass from Standard Model Electroweak Fit

"OUR EVALUATION" below is from the fit to electroweak data described in the "Electroweak Model and Constraints on New Physics" section of this Review. This fit result does not include direct measurements of m_t.

The RVUE values are based on the data described in the footnotes. RVUE's published before 1994 and superseded analyses are now omitted. For more complete listings of earlier results, see the 1994 edition (Physical Review **D50** 1173 (1994)).

VALUE (GeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
$178.1^{+10.4}_{-8.3}$ OUR EVALUATION				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$162 \pm 15 \ ^{+25}_{-5}$	[16] ABBIENDI	01A	OPAL	Z parameters
170.7 ± 3.8	[17] FIELD	00	RVUE	Z parameters without *b*-jet + Direct
$171.2^{+3.7}_{-3.8}$	[18] FIELD	99	RVUE	Z parameters without *b* jet + Direct
$172.0^{+5.8}_{-5.7}$	[19] DEBOER	97B	RVUE	Electroweak + Direct
$157 \ ^{+16}_{-12}$	[20] ELLIS	96C	RVUE	Z parameters, m_W, low energy
$175 \pm 11 \ ^{+17}_{-19}$	[21] ERLER	95	RVUE	Z parameters, m_W, low energy
$180 \pm 9^{+19}_{-21} \mp 2.6 \pm 4.8$	[22] MATSUMOTO	95	RVUE	
$157 \ ^{+36}_{-48} \ ^{+19}_{-20}$	[23] ABREU	94	DLPH	Z parameters
$158 \ ^{+32}_{-40} \pm 19$	[24] ACCIARRI	94	L3	Z parameters

$190 \begin{array}{l}+39\\-48\end{array} \begin{array}{l}+12\\-14\end{array}$		[25] ARROYO	94	CCFR	ν_μ iron scattering
$184 \begin{array}{l}+25\\-29\end{array} \begin{array}{l}+17\\-18\end{array}$		[26] BUSKULIC	94	ALEP	Z parameters
153 ± 15		[27] ELLIS	94B	RVUE	Electroweak
$177 \pm 9 \begin{array}{l}+16\\-20\end{array}$		[28] GURTU	94	RVUE	Electroweak
$174 \begin{array}{l}+11\\-13\end{array} \begin{array}{l}+17\\-18\end{array}$		[29] MONTAGNA	94	RVUE	Electroweak
$171 \pm 12 \begin{array}{l}+15\\-21\end{array}$		[30] NOVIKOV	94B	RVUE	Electroweak
$160 \begin{array}{l}+50\\-60\end{array}$		[31] ALITTI	92B	UA2	m_W, m_Z

[16] ABBIENDI 01A result is from fit with free α_s when m_H is fixed to 150 GeV. The second errors are for m_H= 90 GeV (lower) and 1000 GeV (upper). The fit also finds α_s= $0.125 \pm 0.005^{+0.004}_{-0.001}$.

[17] FIELD 00 result updates FIELD 99 by using the 1998 EW data (CERN-EP/99-15). Only the lepton asymmetry data are used together with the direct measurement constraint m_t=173.8 ± 5.0 GeV, $\alpha_s(m_Z)$ = 0.12, and $1/\alpha(m_Z)$ = 128.896. The result is from a two parameter fit with free m_t and m_H, yielding also m_H=$38.0^{+30.5}_{-19.8}$ GeV.

[18] FIELD 99 result is from the two-parameter fit with free m_t and m_H, yielding also m_H= $47.2^{+29.8}_{-24.5}$ GeV. Only the lepton and charm-jet asymmetry data are used together with the direct measurement constraint m_t= 173.8 ± 5.0 GeV, and $1/\alpha(m_Z)$= 128.896.

[19] DEBOER 97B result is from the five-parameter fit which varies m_Z, m_t, m_H, α_s, and $\alpha(m_Z)$ under the constraints: m_t=175 ± 6 GeV, $1/\alpha(m_Z)$=128.896 ± 0.09. They found m_H=$141^{+140}_{-\ 77}$ GeV and $\alpha_s(m_Z)$=0.1197 ± 0.0031.

[20] ELLIS 96C result is a the two-parameter fit with free m_t and m_H, yielding also m_H=$65^{+117}_{-\ 37}$ GeV.

[21] ERLER 95 result is from fit with free m_t and $\alpha_s(m_Z)$, yielding $\alpha_s(m_Z)$ = 0.127(5)(2).

[22] MATSUMOTO 95 result is from fit with free m_t to Z parameters, M_W, and low-energy neutral-current data. The second error is for $m_H = 300^{+700}_{-240}$ GeV, the third error is for $\alpha_s(m_Z)$ = 0.116 ± 0.005, the fourth error is for $\delta\alpha_{\text{had}}$ = 0.0283 ± 0.0007.

[23] ABREU 94 value is for $\alpha_s(m_Z)$ constrained to 0.123 ± 0.005. The second error corresponds to $m_H = 300^{+700}_{-240}$ GeV.

[24] ACCIARRI 94 value is for $\alpha_s(m_Z)$ constrained to 0.124 ± 0.006. The second error corresponds to $m_H = 300^{+700}_{-240}$ GeV.

[25] ARROYO 94 measures the ratio of the neutral-current and charged-current deep inelastic scattering of ν_μ on an iron target. By assuming the SM electroweak correction, they obtain $1-m^2_W/m^2_Z = 0.2218 \pm 0.0059$, yielding the quoted m_t value. The second error corresponds to $m_H = 300^{+700}_{-240}$ GeV.

[26] BUSKULIC 94 result is from fit with free α_s. The second error is from m_H=300^{+700}_{-240} GeV.

[27] ELLIS 94B result is fit to electroweak data available in spring 1994, including the 1994 A_{LR} data from SLD. m_t and m_H are two free parameters of the fit for $\alpha_s(m_Z)$ = 0.118 ± 0.007 yielding m_t above, and $m_H = 35^{+70}_{-22}$ GeV. ELLIS 94B also give results for fits including constraints from CDF's direct measurement of m_t and CDF's and DØ 's production cross-section measurements. Fits excluding the A_{LR} data from SLD are also given.

[28] GURTU 94 result is from fit with free m_t and $\alpha_s(m_Z)$, yielding m_t above and $\alpha_s(m_Z) = 0.125 \pm 0.005^{+0.003}_{-0.001}$. The second errors correspond to $m_H = 300^{+700}_{-240}$ GeV. Uses LEP, M_W, νN, and SLD electroweak data available in spring 1994.

[29] MONTAGNA 94 result is from fit with free m_t and $\alpha_s(m_Z)$, yielding m_t above and $\alpha_s(m_Z) = 0.124$. The second errors correspond to $m_H = 300^{+700}_{-240}$ GeV. Errors in $\alpha(m_Z)$ and m_b are taken into account in the fit. Uses LEP, SLC, and M_W/M_Z data available in spring 1994.

[30] NOVIKOV 94B result is from fit with free m_t and $\alpha_s(m_Z)$, yielding m_t above and $\alpha_s(m_Z) = 0.125 \pm 0.005 \pm 0.002$. The second errors correspond to $m_H = 300^{+700}_{-240}$ GeV. Uses LEP and CDF electroweak data available in spring 1994.

[31] ALITTI 92B assume $m_H = 100$ GeV. The 95%CL limit is $m_t < 250$ GeV for $m_H <$ 1 TeV.

t DECAY MODES

	Mode			Fraction (Γ_i/Γ)	Confidence level
Γ_1	$W q (q = b, s, d)$				
Γ_2	$W b$				
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]	$< 5.9 \times 10^{-3}$	95%

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

	Mode			Fraction (Γ_i/Γ)	Confidence level
Γ_6	$Z q (q=u,c)$	*T1*	[d]	< 13.7 %	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 $\Gamma(t \to \gamma q)/\Gamma(t \to W b)$.

[d] 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

VALUE	*DOCUMENT ID*		*TECN*
$\mathbf{0.94^{+0.26}_{-0.21}{}^{+0.17}_{-0.12}}$	[32] AFFOLDER	01C	CDF

[32] 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	[33] ABE	98X	CDF

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

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

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

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

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.0132	95	[35] AKTAS	04	H1	$B(t \to \gamma u)$
<0.0059	95	[36] CHEKANOV	03	ZEUS	$B(t \to \gamma u)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.0465	95	[37] ABDALLAH	04C	DLPH	$B(\gamma c$ or $\gamma u)$
<0.041	95	[38] ACHARD	02J	L3	$B(t \to \gamma c$ or $\gamma u)$
<0.032	95	[39] ABE	98G	CDF	$t\overline{t} \to (Wb)(\gamma c$ or $\gamma u)$

[35] 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 $B(\gamma c) = B(Zu) = B(Zc) = 0$, is from private communication, E. Perez, May 2005.

[36] 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 $B(\gamma c)$=$B(Zq)$=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.

[37] 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 $B(t \to \gamma q)$, where q is a u or a c quark, for m_t = 175 GeV when $B(t \to Zq)$=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.

[38] 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 $B(\gamma q)$, 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.

[39] 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 $\Gamma(\gamma q)/\Gamma(Wb)$.

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

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.159	95	[40] ABDALLAH	04C	DLPH	$e^+e^- \to \overline{t}c$ or $\overline{t}u$
<0.137	95	[41] ACHARD	02J	L3	$e^+e^- \to \overline{t}c$ or $\overline{t}u$
<0.14	95	[42] HEISTER	02Q	ALEP	$e^+e^- \to \overline{t}c$ or $\overline{t}u$
<0.137	95	[43] 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. • • •					

<0.17	95	[44] BARATE	00S	ALEP	$e^+ e^- \to \overline{t} c$ or $\overline{t} u$
<0.33	95	[45] ABE	98G	CDF	$t \overline{t} \to (W b)(Z c$ or $Z u)$

[40] 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($t \to Z q$), 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.

[41] 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($Z q$), 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.

[42] 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($Z q$), 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.

[43] 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($Z q$) 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.

[44] 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.

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

t Decay Vertices

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.91±0.37±0.13	[46] AFFOLDER	00B	CDF	$F_0 = W_L/(W_L+W_T)$
0.11±0.15	[46] AFFOLDER	00B	CDF	B($t \to W_+ b$)

[46] 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. The first error is statistical and the second systematic. 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.

Single *t*-Quark Production Cross Section in $p\overline{p}$ Collisions

Direct probes of the $t b W$ coupling and possible new physics

VALUE (pb)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				

<18	95	[47] ACOSTA	02	CDF	$p\overline{p} \rightarrow tb + X$
<13	95	[48] ACOSTA	02	CDF	$p\overline{p} \rightarrow tqb + X$
<17	95	[49,50] ABAZOV	01C	D0	$p\overline{p} \rightarrow tb + X$
<22	95	[50,51] ABAZOV	01C	D0	$p\overline{p} \rightarrow tqb + X$
<39	95	[49] ABBOTT	01B	D0	$p\overline{p} \rightarrow tb + X$
<58	95	[51] ABBOTT	01B	D0	$p\overline{p} \rightarrow tqb + X$

[47] ACOSTA 02 bounds the cross section for single top-quark production via the *s*-channel *W*-exchange process, $q'\overline{q} \rightarrow t\overline{b}$. It is based on $\sim$ 106 pb^{-1} of data at $\sqrt{s}$=1.8 TeV.

[48] ACOSTA 02 bounds the cross section for single top-quark production via the *t*-channel *W*-exchange process, $q'g \rightarrow qt\overline{b}$. It is based on $\sim$ 106 pb^{-1} of data at $\sqrt{s}$=1.8 TeV.

[49] Result bounds the cross section for single top-quark production via the *s*-channel process $q'\overline{q} \rightarrow W' \rightarrow tb$. It is based on $\sim$ 90 pb^{-1} of data at $\sqrt{s}$= 1.8 TeV.

[50] ABAZOV 01C results updates those of ABBOTT 01B by making use of arrays of neural networks to separate signals from backgrounds.

[51] Result bounds the cross section for single top-quark production via the *t*-channel *W*-exchange process $q'g \rightarrow qtb$. It is based on $\sim$ 90 pb^{-1} of data at $\sqrt{s}$= 1.8 TeV.

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. • • •					
0.55	95	[52] AKTAS	04	H1	$e^{\pm}p \rightarrow e^{\pm}tX$

[52] 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 $\sigma(ep \rightarrow etX) = 0.29^{+0.15}_{-0.14}$ pb at $\sqrt{s} = 319$ GeV gives the quoted upper bound if the observed events are due to statistical fluctuation.

t-Quark REFERENCES

ABAZOV	05	PL B606 25	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	04G	NAT 429 638	V.M. Abazov *et al.*	(D0 Collab.)
ABDALLAH	04C	PL B590 21	J. Abdallah *et al.*	(DELPHI Collab.)
AKTAS	04	EPJ C33 9	A. Aktas *et al.*	(H1 Collab.)
TEVEWWG	04	hep-ex/0404010	CDF, D0 Collab., Tevatron Electroweak Working Group	
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.)
ABAZOV	01C	PL B517 282	V.M. Abazov *et al.*	(D0 Collab.)
ABBIENDI	01A	EPJ C19 587	G. Abbiendi *et al.*	(OPAL Collab.)
ABBIENDI	01T	PL B521 181	G. Abbiendi *et al.*	(OPAL Collab.)
ABBOTT	01B	PR D63 031101	B. Abbott *et al.*	(D0 Collab.)
AFFOLDER	01	PR D63 032003	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.)
FIELD	00	PR D61 013010	J.H. Field	
ABBOTT	99G	PR D60 052001	B. Abbott *et al.*	(D0 Collab.)
ABE	99B	PRL 82 271	F. Abe *et al.*	(CDF Collab.)
Also	99G	PRL 82 2808 (erratum)	F. Abe *et al.*	(CDF Collab.)
DEMORTIER	99	FNAL-TM-2084	L. Demortier *et al.*	(CDF/D0 Working Group)
FIELD	99	MPL A14 1815	J.H. Field	
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.)
ABE	98X	PRL 80 2773	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.)
DEBOER	97B	ZPHY C75 627	W. de Boer *et al.*	
ELLIS	96C	PL B389 321	J. Ellis, G.L. Fogli, E. Lisi	(CERN, BARI)
ABACHI	95	PRL 74 2632	S. Abachi *et al.*	(D0 Collab.)
ABE	95F	PRL 74 2626	F. Abe *et al.*	(CDF Collab.)
ERLER	95	PR D52 441	J. Erler, P. Langacker	(PENN)
MATSUMOTO	95	MPL A10 2553	S. Matsumoto	(KEK)
ABE	94E	PR D50 2966	F. Abe *et al.*	(CDF Collab.)
Also	94F	PRL 73 225	F. Abe *et al.*	(CDF Collab.)
ABREU	94	NP B418 403	P. Abreu *et al.*	(DELPHI Collab.)
ACCIARRI	94	ZPHY C62 551	M. Acciarri *et al.*	(L3 Collab.)
ARROYO	94	PRL 72 3452	C.G. Arroyo *et al.*	(COLU, CHIC, FNAL+)
BUSKULIC	94	ZPHY C62 539	D. Buskulic *et al.*	(ALEPH Collab.)
ELLIS	94B	PL B333 118	J. Ellis, G.L. Fogli, E. Lisi	(CERN, BARI)
GURTU	94	MPL A9 3301	A. Gurtu	(TATA)
MONTAGNA	94	PL B335 484	G. Montagna *et al.*	(INFN, PAVI, CERN+)
NOVIKOV	94B	MPL A9 2641	V.A. Novikov *et al.*	(GUEL, CERN, ITEP)
PDG	94	PR D50 1173	L. Montanet *et al.*	(CERN, LBL, BOST+)
ALITTI	92B	PL B276 354	J. Alitti *et al.*	(UA2 Collab.)