Top Quark

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  THANK YOU for 10 years of service in PDG!
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New in RPP 2006 - Review

- Major and extensive update of the top quark review
  - 9 printed pages, 115 references

Citation: W.-M. Yao *et al.* (Particle Data Group), J. Phys. G **33**, 1 (2006) (URL: http://pdg.lbl.gov)

t

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

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

THE TOP QUARK

Updated April 2006 by T. M. Liss (Illinois) and A. Quadt (Bonn, MPI Munich & Rochester/New York).

A. Introduction: The top quark is the $Q = 2/3$, $T_3 = +1/2$ member of the weak-isospin doublet containing the bottom quark (see the review on the "Standard Model of Electroweak

New in RPP 2006 - Papers

- Many new top results, mostly from Tevatron Run-II at $\sqrt{s} = 1.96$ TeV
  - 21 new papers with 29 measurements
  - including 5 top mass measurements
- And many more preliminary results ...

Preliminary Results Included in Minireview

Table 1: Cross section for $t\bar{t}$ production in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV from CDF and DØ ($m_t = 175$ GeV/c^2), and theory. Also shown are final results from Run I at $\sqrt{s} = 1.8$ TeV from CDF ($m_t = 175$ GeV/c^2) & DØ ($m_t = 172.1$ GeV/c^2). Uncertainties given are the quadrature sum of statistical and systematic uncertainties of each measurement.

$\sigma_{t\bar{t}}(pb)$	Source	$\int \mathcal{L}dt$ (pb^{-1})	Ref.		Method
$6.7^{+2.2}_{-1.7}$	DØ	230	[22]		ℓ + jets/kinematics
$8.6^{+1.7}_{-1.6}$	DØ	230	[23]		ℓ + jets/vtx b-tag
$8.1^{+1.4}_{-1.3}$	DØ	370	[24]	†	ℓ + jets/vtx b-tag
$7.9^{+1.7}_{-1.6}$	DØ	370	[25]	†	ℓ + jets/0-2 vtx b-tags
$8.6^{+3.4}_{-3.0}$	DØ	220-240	[26]		$\ell\ell$
$8.6^{+2.7}_{-2.3}$	DØ	370	[27]	†	$\ell\ell$
$11.1^{+6.0}_{-4.6}$	DØ	160	[28]	†	$e\mu$/vtx b-tag
$8.6^{+2.3}_{-2.1}$	DØ	370	[29]	†	ℓ+track/vtx b-tag + $e\mu$
$5.2^{+3.0}_{-2.7}$	DØ	350	[30]	†	all-jets/vtx b-tags
12.1 ± 6.7	DØ	360	[31]	†	all-jets/vtx b-tags
$7.1^{+1.9}_{-1.7}$	DØ	220-240	[32]	†	combined
$5.6^{+1.5}_{-1.3}$	CDF	160	[33]		ℓ + jets/vtx b-tag
8.2 ± 1.2	CDF	695	[34]	†	ℓ + jets/vtx b-tag
8.9 ± 1.5	CDF	320	[35]	†	ℓ + jets/jet prob b-tag
$5.3^{+3.5}_{-3.4}$	CDF	190	[36]		ℓ + jets/soft μ b-tag
6.6 ± 1.9	CDF	190	[37]		ℓ + jets/kinematics
6.0 ± 1.1	CDF	760	[38]	†	ℓ + jets/kinematics
6.0 ± 2.0	CDF	160	[39]		ℓ + jets/kin+vtx b-tag
$6.0^{+1.5}_{-1.4}$	CDF	310	[40]		ℓ + jets/miss.-E_T+jets
$7.0^{+2.9}_{-2.4}$	CDF	200	[41]		$\ell\ell$
8.3 ± 1.9	CDF	750	[42]	†	$\ell\ell$
10.1 ± 2.6	CDF	360	[43]	†	ℓ+track
$8.0^{+3.9}_{-3.0}$	CDF	310	[44]	†	all-jets/kin+vtx b-tags
7.3 ± 0.9	CDF	760	[45]	†	combined

Table 2: Measurements of top quark mass from CDF and DØ. $\int \mathcal{L}dt$ is given in pb^{-1}.

m_t (GeV/c^2)	Source		$\int \mathcal{L}dt$	Ref.		Method
$173.3 \pm 5.6 \pm 5.5$	DØ	Run I	125	[21]		ℓ+jets, TM
$180.1 \pm 3.6 \pm 3.9$	DØ	Run I	125	[63]	$\star\triangle$	ℓ+jets, ME
$168.4 \pm 12.3 \pm 3.6$	DØ	Run I	125	[64]	$\star\triangle$	$\ell\ell$, $\eta(\nu)/\mathcal{M}WT$
$178.5 \pm 13.7 \pm 7.7$	DØ	Run I	110	[65]		all jets
179.0 ± 5.1	DØ	Run I	110-125	[63]		DØ combined
$177.5 \pm 5.8 \pm 7.1$	DØ	Run II	160	[66]	†	ℓ+jets/topo, Ideogram
$169.9 \pm 5.8^{+7.8}_{-7.1}$	DØ	Run II	230	[67]	†	ℓ+jets/topo, TM
$170.6 \pm 4.2 \pm 6.0$	DØ	Run II	230	[67]	†	ℓ+jets/b-tag, TM
$169.2^{+5.0+1.5}_{-7.4-1.4}$	DØ	Run II	370	[10]	†	ℓ+jets/topo, ME($W \to jj$)
$170.6^{+4.0}_{-4.7} \pm 1.4$	DØ	Run II	370	[10]	† $\triangle$	ℓ+jets/b-tag, ME($W \to jj$)
$176.6 \pm 11.2 \pm 3.8$	DØ	Run II	370	[68]	† $\triangle$	$\ell\ell$/b-tag, $\mathcal{M}WT$
$175.6 \pm 10.7 \pm 6.0$	DØ	Run II	370	[69]	†	$\ell\ell$, $\eta(\nu)$
$176.1 \pm 5.1 \pm 5.3$	CDF	Run I	110	[58,70,71]	$\star\triangle$	ℓ + jets
$167.4 \pm 10.3 \pm 4.8$	CDF	Run I	110	[58]	$\star\triangle$	$\ell\ell$
$186.0 \pm 10.0 \pm 5.7$	CDF	Run I	110	[58,72]	$\star\triangle$	all jets
176.1 ± 6.6	CDF	Run I	110	[58,71]		CDF combined
$173.5^{+3.7}_{-3.6} \pm 1.3$	CDF	Run II	318	[9]	$\star$	ℓ+jets/b-tag, TM($W \to jj$)
$173.4 \pm 2.5 \pm 1.3$	CDF	Run II	680	[73]	† $\triangle$	ℓ+jets/b-tag, TM($W \to jj$)
$173.2^{+2.6}_{-2.4} \pm 3.2$	CDF	Run II	318	[9]		ℓ+jets/b-tag, DLM
$174.1 \pm 2.5 \pm 1.3$	CDF	Run II	680	[74]	†	ℓ+jets/b-tag, ME($W \to jj$)
$183.9^{+15.7}_{-13.9} \pm 5.6$	CDF	Run II	695	[56]	†	ℓ+jets/b-tag, L_{xy}
$165.2 \pm 6.1 \pm 3.4$	CDF	Run II	340	[75]	$\star$	$\ell\ell$, ME
$164.5 \pm 4.5 \pm 3.1$	CDF	Run II	750	[76]	† $\triangle$	$\ell\ell$, ME
$170.7^{+6.9}_{-6.5} \pm 4.6$	CDF	Run II	359	[59,75]		$\ell\ell$, $\eta(\nu)$
$169.7^{+8.9}_{-9.0} \pm 4.0$	CDF	Run II	340	[59,75]		$\ell\ell$, $\phi(\nu)$
$169.5^{+7.7}_{-7.2} \pm 4.0$	CDF	Run II	340	[59,75]		$\ell\ell$, $p_z(t\bar{t})$
$172.0 \pm 1.6 \pm 2.2$	CDF	Run I+II	110-750	[77]	†	CDF Combined

† = preliminary result, not published by April 2006

Top Quark Mass

- Top mass averages provided by Tevatron EWWG
  - Requested average including only published results: hep-ex/0604053

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

OUR EVALUATION of 174.2 ± 2.0 ± 2.6 GeV (TEVEWWG 06A) is an average of top mass measurements from Tevatron Run-I (1992–1996) and Run-II (2001–present) that were published at the time of preparing this *Review*. This average was provided by the Tevatron Electroweak Working Group (TEVEWWG) and takes correlated uncertainties properly into account. Our previous average of 178.0 ± 2.7 ± 3.3 GeV (TEVEWWG 04) was based on measurements from Run-I only. Including the most recent unpublished top mass measurements from Run-II, the TEVEWWG reports an average top mass of 172.5 ± 1.3 ± 1.9 GeV (TEVEWWG 06). See the note "The Top Quark" in these Quark Particle Listings.

- Latest top mass average from Tevatron EWWG as of September 16, 2006:
  - hep-ex/ 0608032: 171.4 ± 1.2 (stat) ± 1.8 (syst) GeV (1.2% precision!)
- Indirect top mass from SM EW fit (RPP 2006): 172.3 + 10.2 – 7.6 GeV

Evolution of Top Quark Mass

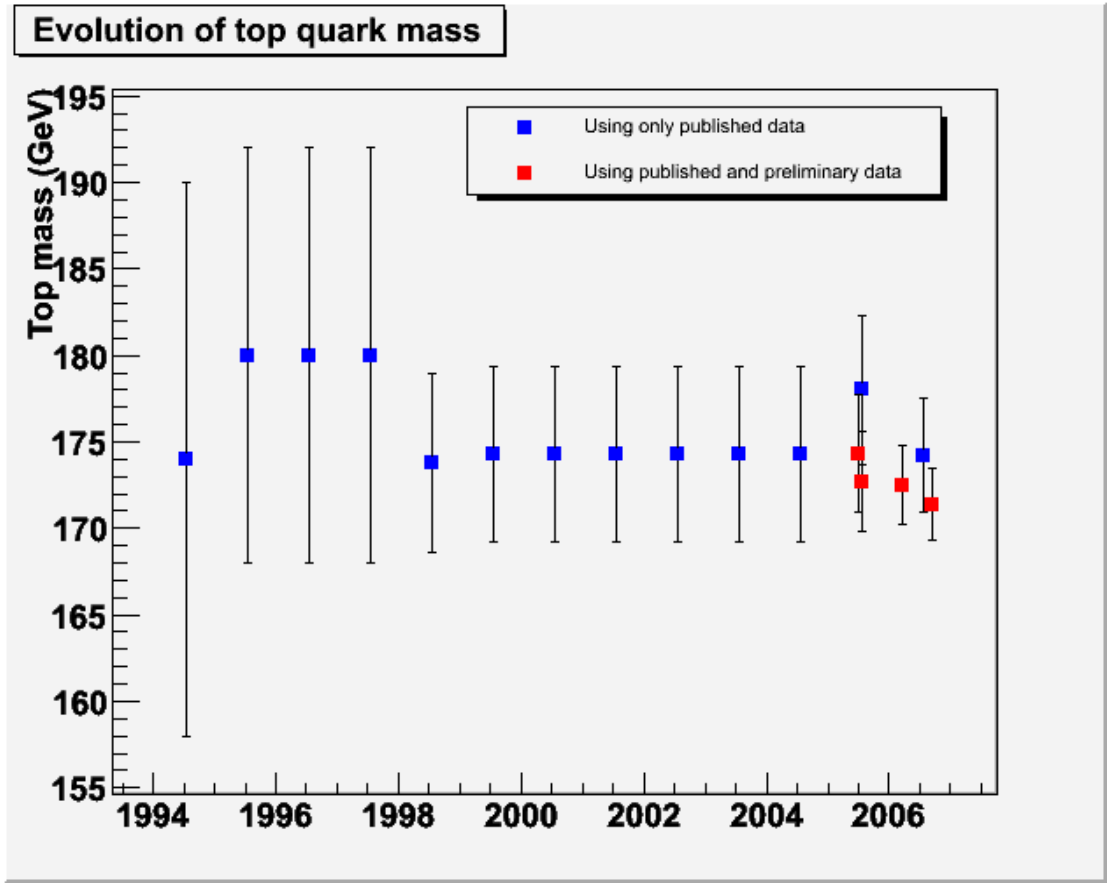
History since 1994 ***t*-Quark Mass in $p\,\bar{p}$ Collisions**

THIS FEATURE IS STILL IN BETA TESTING

WARNING: Values below are taken from the summary tables of the current and previous editions of the Review of Particle Physics. Changes in values may not only be due to changes in the available data, but also due to changes in the definition of the quantity being displayed. Please check the full listings of the past editions of RPP.

Date	Value (GeV)	Summary type
1994	174 ± 16	OUR AVERAGE
	>131	OUR BEST LIMIT
1996	180 ± 12	OUR AVERAGE
1997	180 ± 12	OUR AVERAGE
1998	173.8 ± 5.2	OUR EVALUATION
2000	174.3 ± 5.1	OUR EVALUATION
2002	174.3 ± 5.1	OUR EVALUATION
2003	174.3 ± 5.1	OUR EVALUATION
2004	174.3 ± 5.1	OUR EVALUATION
2005	178.0 ± 4.3	OUR EVALUATION
current	174.2 ± 3.3	OUR EVALUATION

This table is NOT part of any RPP edition, but rather a compilation from earlier RPPs



Encoding Style

- Up to now, there were only few top quark measurements and we could afford to give very detailed information in footnotes, e.g.:

  [63] ABAZOV 05R measures the top-quark pair production cross section at $\sqrt{s}$=1.96 TeV with 224–243 pb^{-1} of data, based on the analysis of events with two charged leptons in the final state. The first error is statistical, the second one is systematic, and the last one gives the luminosity uncertainty. The result assumes m_t = 175 GeV; the mean value changes by $(175-m_t(\text{GeV})) \times 0.08$ pb in the mass range 160 to 190 GeV.

- With today's increasing number of measurements from the Tevatron (and soon LHC) this is no longer practical
  - Detailed information is also given in the new top quark review
- Suggestion:
  - Change encoding style and adopt brevity used in the majority of the Listings
  - Use shared footnotes, split data blocks (e.g. production cross section at different energies)
  - As time permits, update existing footnotes to new style