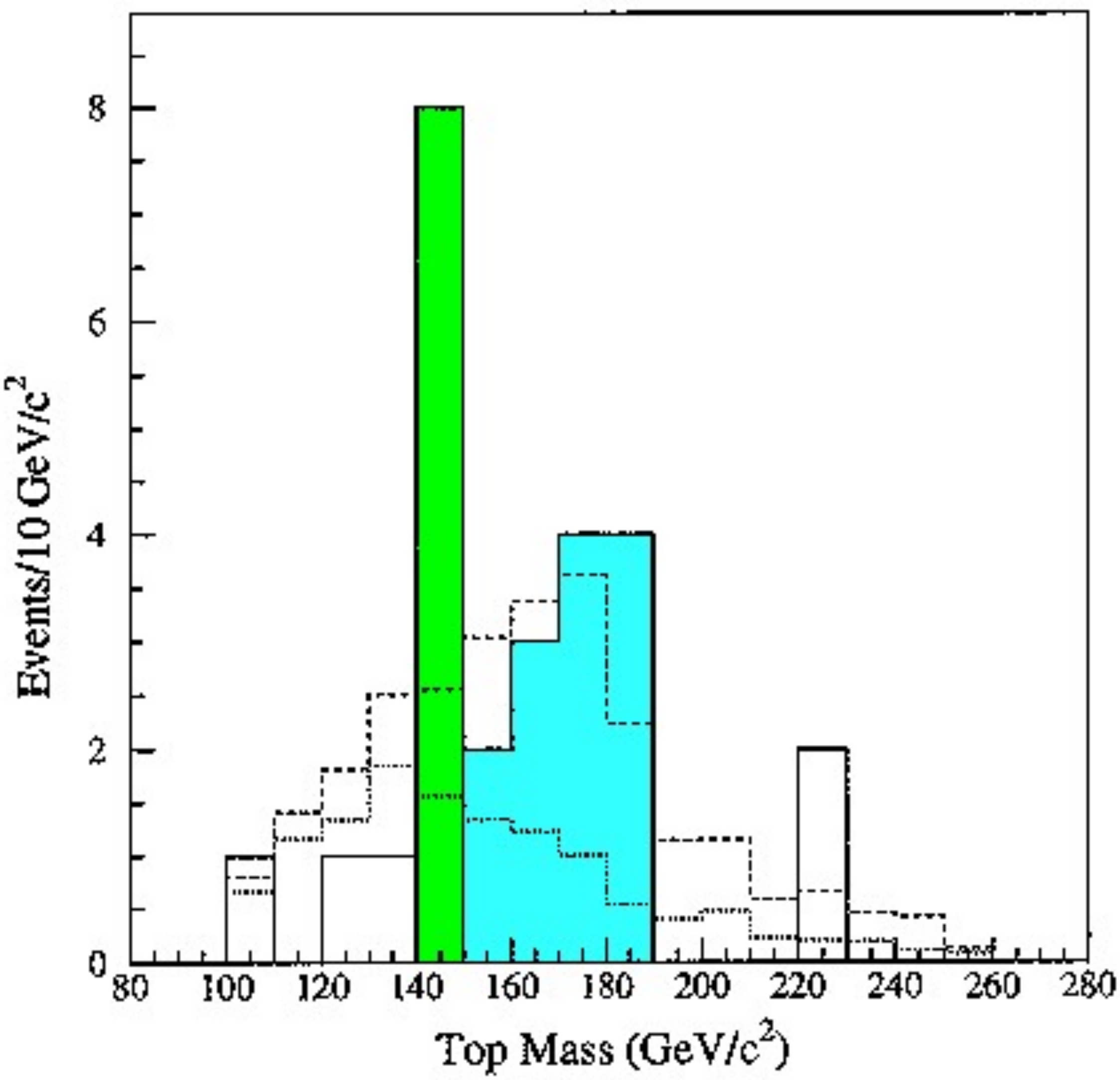
T-quark Widths for 3 Mass States

Frank Dodd (Tony) Smith, Jr. - 2015 - vixra 1511.xxxx

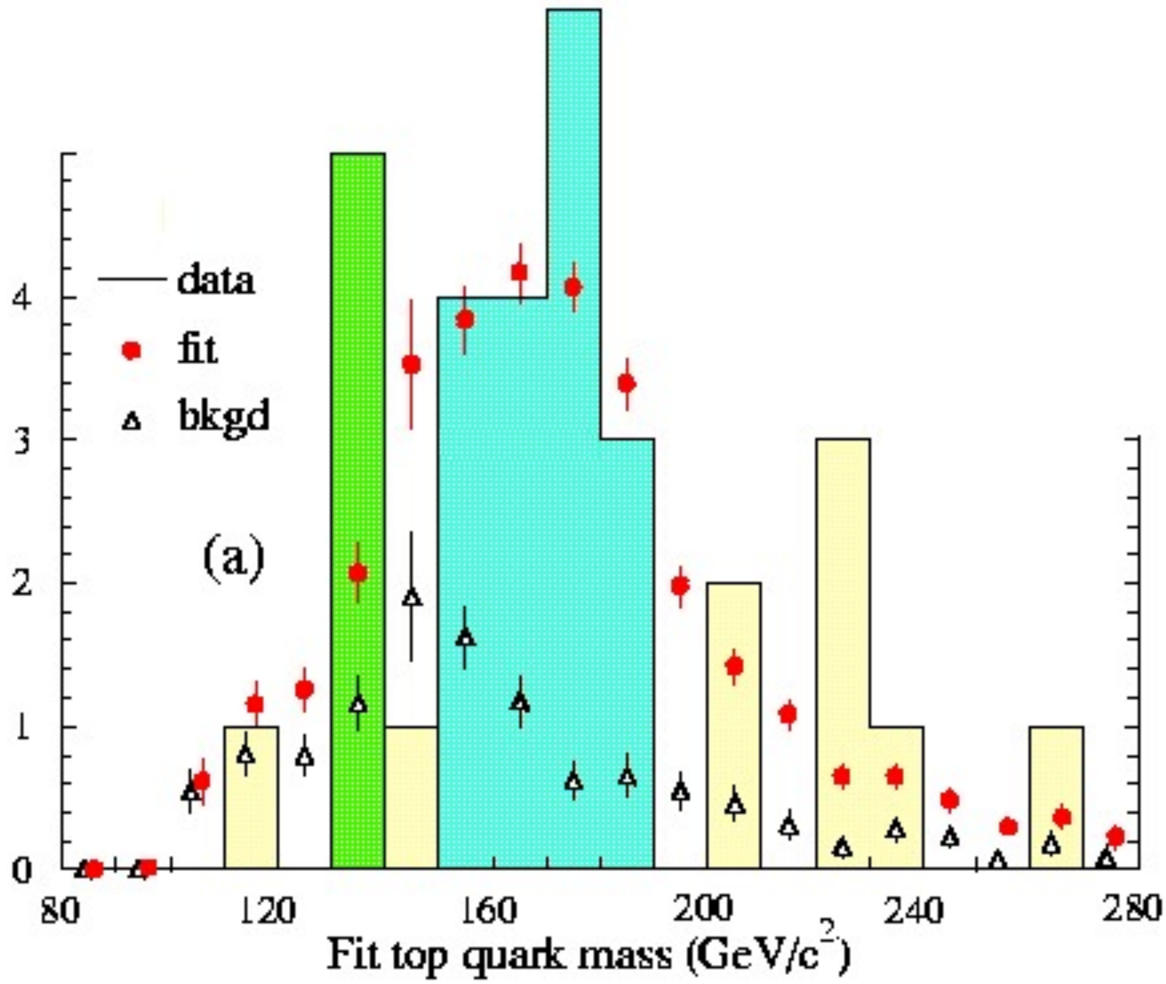
During Run 1 of the Fermilab Tevatron Collider, CDF claimed discovery of the T-quark in FERMILAB-PUB-94/097-E, dated 26 April 1994, with this Semileptonic event histogram:



The cyan bars represent bins in the 150-190 GeV range interpreted as Truth Quarks by CDF. I agree that they do correspond to a T-quark mass state around 174 GeV.

The green bars represent a bin in the 140-150 GeV range containing Semileptonic events considered by me to represent the Truth Quark, but as to which **CDF said** "... **We assume the mass combinations in the 140 to 150 GeV/c^2 bin represent a statistical fluctuation since their width is narrower than expected for a top signal**. ...". **I disagree**. I think they correspond to a low-energy T-quark mass state that in my E8 Physics model (viXra 1508.0157) is due to a Green's Function Pole around 130 GeV.

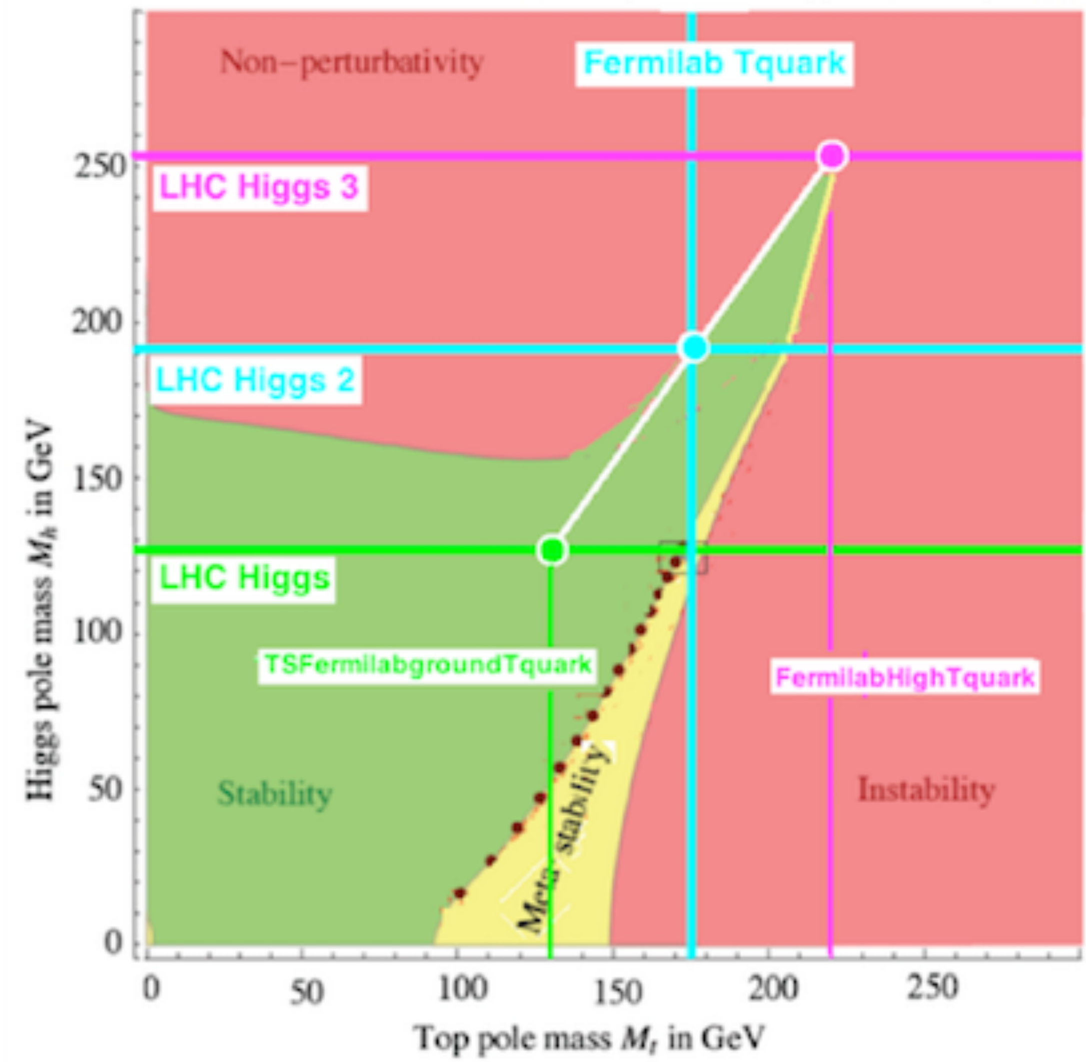
In 1997, D0 reported T-quarks in hep-ex/9703008, with this Semileptonic event histogram:



Again, the cyan bars represent bins in the 150-190 GeV range containing Semileptonic events interpreted as Truth Quarks by D0 and, again, I agree that they do correspond to a T-quark mass state around 174 GeV.

Similarly to the CDF histogram, the green bars represent a bin in the 130-140 GeV range containing Semileptonic events deemed insignificant by D0,
but,
when they are considered together with the independent CDF 1994 histogram,
the result is **a 4-sigma signal of a T-quark mass state in the 130 to 150 GeV range, with a very Narrow Width.**
I think that those peaks correspond to a low-energy T-quark mass state that in E8 Physics (viXra 1508.0157) is due to a Green's Function Pole around 130 GeV and
that the 1997 D0 bin calibration of the peak at 130-140 GeV is more realistic than the older 1994 CDF bin calibration of the peak at 140-150 GeV.

Here is an overview of the Higgs-T-quark system of E8 Physics (viXra 1508.0157)



in which there is a high-mass state at the critical point where the normal Stable region and the Non-Perturbative region and the Vacuum Instability region all come together where the Higgs mass state reaches the Higgs VeV level around 250 GeV and where the T-quark mass state is only weakly indicated in the CDF and D0 histograms and

the middle-mass state (T-quark mass around 174 GeV) is on the boundary of the Non-Perturbativity region where the composite nature of Higgs as T-quark Condensate becomes manifest, as does the 8-dim nature of Kaluza-Klein spacetime M4 x CP2 with M4 Physical Spacetime and CP2 Internal Symmetry Space where CP2 = SU(3) / SU(2)xU(1) has symmetries of the Standard Model Gauge Groups and

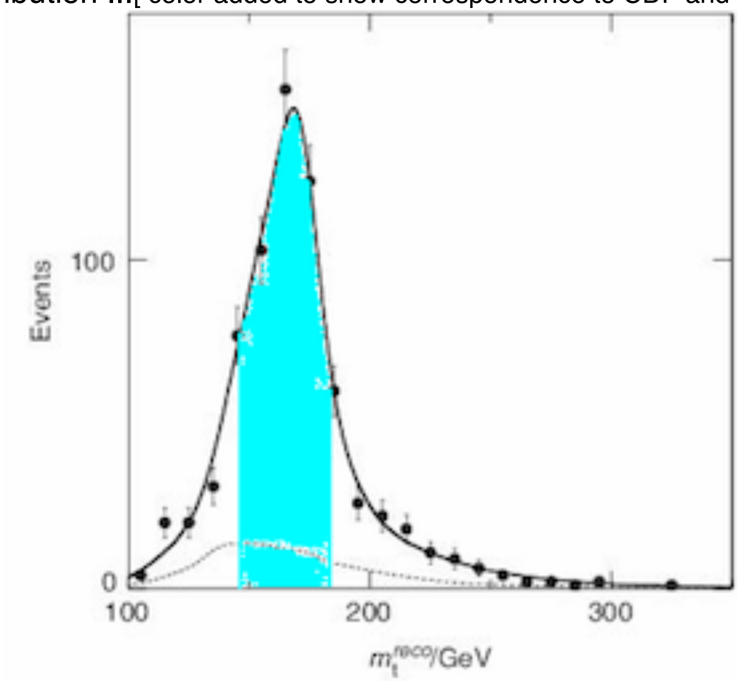
the low-mass state (T-quark mass around 130 GeV) is in the normal Stable region in which the T-quark is represented by a Schwinger Source in M4 Physical Spacetime which Schwinger Source has Green's Function structure based on Kernel Functions of Bounded Symmetric Domains whose symmetry is that of the T-quark.

As to the T-quark width for the 174 GeV mass state, which appears
in the 1994 CDF and 1997 D0 semileptonic histograms to be about 40 GeV,
which is 4 of the 10 GeV histogram bins,
Mark Thomson, in “Modern Particle Physics” (Cambridge 2013) says:
“... Decay of the top quark ... The total decay rate is ...

$$\Gamma(t \to bW^+) = \frac{G_F m_t^3}{8\sqrt{2}\pi}\left(1 - \frac{m_W^2}{m_t^2}\right)^2\left(1 + \frac{2m_W^2}{m_t^2}\right),$$

... For ... mt = 173 GeV ... the lowest-order calculation of the total decay width of the top quark gives Γ t = 1.5 GeV ...

The total width of the top quark is measured to be Γ t = 2.0 +/- 0.6 GeV.
The top width is determined much less precisely than the top quark mass because the width of the distribution ...[color added to show correspondence to CDF and D0 histograms]...



... is dominated by the experimental resolution. ...”.

The T-quark total width Γ t = 2 GeV is much smaller than the 40 GeV width
experimentally observed at Fermilab and would, except for experimental resolution,
fit well within one single bin in the 1994 CDF and 1997 D0 semileptonic histograms.

As to the T-quark width for the 130 GeV mass state,
which appears in the 1994 CDF and 1997 D0 semileptonic histograms
to be less than the 10 GeV histogram bin width,
using the total width formula from Mark Thomson's book and paraphrasing:

"... For mt = 130 GeV ... the lowest-order calculation
of the total decay width of the top quark gives Γt = about 0.5 GeV ...".

I think that the CDF explanation
for the low mass T-quark peak in a single 10 GeV bin

"... We assume the mass combinations in the ... bin represent a statistical fluctuation since their width is narrower than expected for a top signal. ...".

is highly unlikely since
a similar low mass single 10 GeV bin T-quark mass peak was observed by the independent D0 detector.

The mt = 130 GeV width of 0.5 GeV is only 1/20 of the 10 GeV bin width of that peak.
The 20:1 = 10 : 0.5 observed width : actual width ratio for mt = 130 GeV
is the same as
the 20:1 = 40 : 2.0 observed width : actual width ratio for mt = 173 GeV.

What differences between the mt = 130 GeV and mt = 173 GeV states
might affect their relative experimental resolutions ?

The mt = 130 GeV peak is in the normal Stable region
in which the T-quark is represented by a Schwinger Source in M4 Physical Spacetime
which Schwinger Source has Green's Function structure based on Kernel Functions
of Bounded Symmetric Domains whose symmetry is that of the T-quark.
Since it is a simple Schwinger Source it has simple W - b - 2 jet decay.

The mt = 173 GeV peak is on the boundary
of the Non-Perturbativity region where the composite nature of Higgs as T-quark
Condensate becomes manifest, as does the 8-dim nature of Kaluza-Klein spacetime
M4 x CP2 with M4 Physical Spacetime and CP2 Internal Symmetry Space where
CP2 = SU(3) / SU(2)xU(1) has symmetries of the Standard Model Gauge Groups.
Its decay scheme is more complicated, with 2 stages:

175 to 130 GeV, a process of the Higgs - T-quark condensate system of E8 Physics
and
simple W - b - 2 jet decay of the 130 GeV intermediate state.

The wider width of the 173 GeV decay peak
is due to the Higgs - T-quark condensate process.

The 1997 UC Berkeley PhD thesis of Erich Ward Varnes gives details of some D0 events and analysis, based on the Standard Model view of one T-quark mass state:
“... the leptonic decays of the t tbar events are divided into two broad categories:
the lepton plus jets and dilepton channels.
The former has the advantage of a large branching ratio, accounting for about 30% of all t tbar decays, with the disadvantage that electroweak processes or detector misidentification of fina-state particle can mimic the t tbar signal relatiely frequently.
Conversely,
the dilepton channels have lower backgrounds, but account for only 5% of all decays.
...
The kinematic selection of dilepton events is summarized in Table 5.2 ...

	ee	$e\mu$	$\mu\mu$
Leptons	E_T> 20 GeV $\lvert\eta\rvert < 2.5$	$E_T(e) > 15$ Gev, $p_T(\mu) > 15$ GeV/c $\lvert\eta(e)\rvert < 2.5$	$p_T(\mu) > 15$ GeV/c
Jets	≥ 2 with E_T> 20 GeV and $\lvert\eta\rvert < 2.5$		
$\not{E}_T$	> 25 GeV	$\not{E}_T$> 20 GeV $\not{E}_T^{cal} > 10$ GeV	N/A
H_T^e	> 120 GeV	> 120 GeV	> 100 GeV

Table 5.2: Kinematic cuts for the dilepton event selection. The cut used in place of $\not{E}_T$ to reject $Z \to \mu\mu$ events is described in the text, as is the H_T^e variable. Also, the muon η cut is run-dependent, as detailed in Chapter 4.

...
In the dilepton channels, one expects the final state to consist of two charged leptons, two neutrinos, and two b jets (see Fig. 6.1)

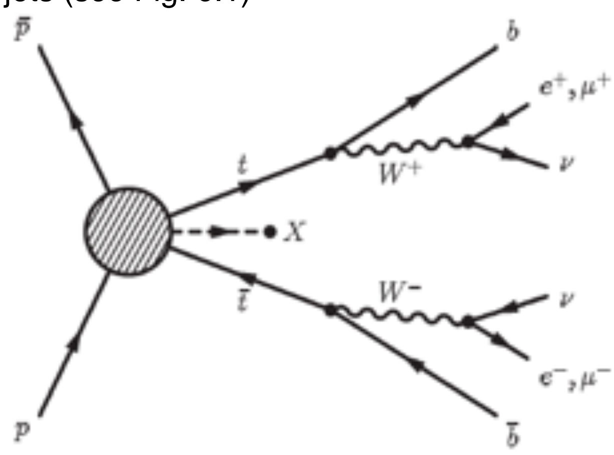


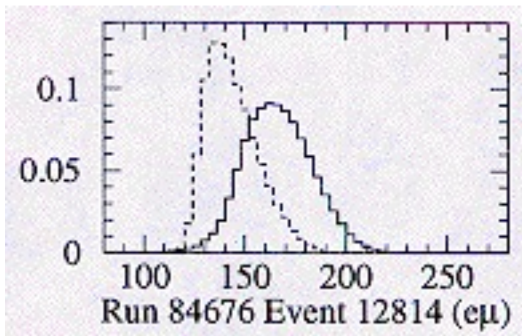
Figure 6.1: Schematic representation of $t\bar{t}$ production and decay in the dilepton channels.

so that the final state is completely specified by knowledge of the energy four-vectors of these six particles ... there are ... kinematic constraints:

The invariant mass of each lepton and neutrino pair is equal to the W mass.
The masses of the reconstructed t and tbar in the event are equal.

...
The result of reconstructing the top quark mass for a dilepton event is the distribution W(mt), which is evaluaed for 50 values of the top quark mass ... the intrinsic resolution of the dilepton mass reconstruction is much broader than the 4 GeV/c2 interval between assumed top quark masses ... the RMS of the typical W(mt) distribution ... typically lies between 35 and 40 GeV/c2 ...

...
Figure 8.1: W(mt) distributions for the dilepton candidates. For events with more than two jets, the dashed curves show the results of considering only the two highest ET jets in the reconstruction ...



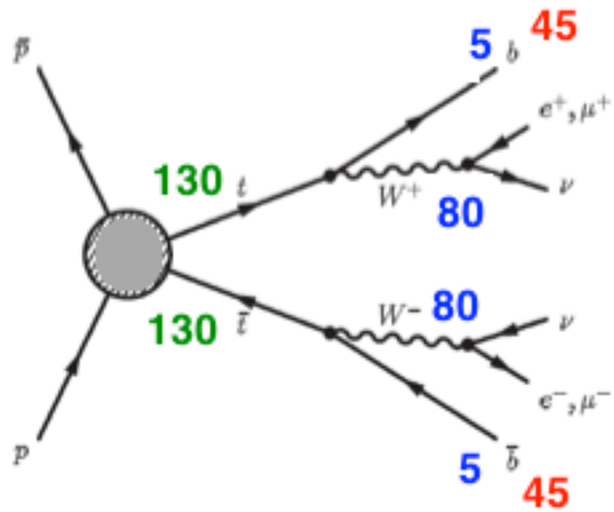
...

Run 84676 Event 12814					z vertex: -6.17 cm		
Object	E	E_x	E_y	E_z	E_T	η	ϕ
Electron	81.3	-75.4	-1.1	-30.2	74.5	-0.39	3.16
Muon	30.2	-25.2	10.6	-12.8	27.4	-0.45	2.75
$\not{E}_T$	–	62.0	5.2	–	62.3	–	0.08
Jet 1	93.8	38.0	-83.7	-15.6	91.9	-0.17	5.14
	(95.9)	(38.9)	(-85.6)	(-16.0)	(94.0)		
Jet 2	37.8	13.9	32.3	-11.2	35.2	-0.31	1.17
	(38.8)	(14.2)	(33.1)	(-11.4)	(36.0)		
Jet 3	31.4	-1.6	28.6	11.6	28.7	0.39	1.63
	(32.2)	(-1.6)	(29.3)	(11.9)	(29.4)		

...”.

In E8 Physics (viXra 1508.0157) there are, as stated above, three T-quark mass states, so in order to keep the kinematic constraint
“The masses of the reconstructed t and tbar in the event are equal”
the t and tbar must be in the same mass state, which is physically realistic because the t and tbar are created together in the same collider collision event.

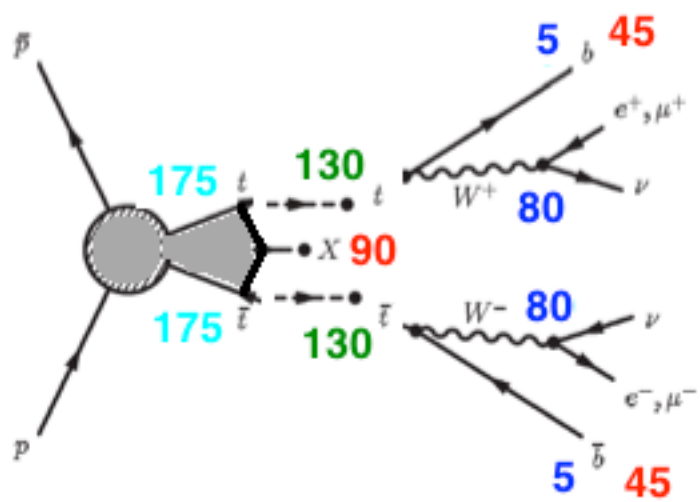
If the t and tbar are both in the 130 GeV mass state then the decay is simple with 2 jets:



and both jets are highly constrained as being related to the W - b decay process so it is reasonable to expect that the 130 GeV decay events would fall in the narrow width of a single 10 GeV histogram bin.

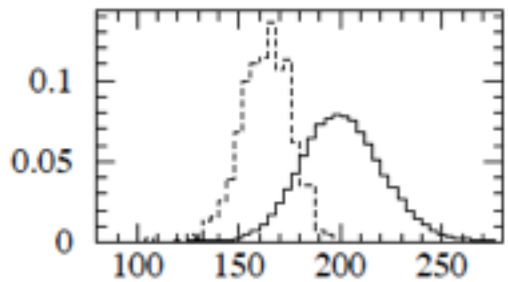
(In these two diagrams I have indicated energies only approximately for t and tbar mass states (cyan and green) and W and b-quark (blue) and jets (red). Actual kinematic data may vary from the idealized numbers on the diagrams, but they should give similar physics results.)

If the t and tbar are both in the 173 GeV mass state
(as, for example, in Run 84676 Event 12814 (e mu) described above)
the decay has two stages and 3 jets:



First, the 175 GeV t and tbar both decay to the 130 GeV state, emitting a jet.
Then, the 130 GeV t and tbar decay by the simple 2-jet process.
The first jet is a process of the Higgs - T-quark condensate system of E8 Physics and is not a W -b decay process so it is not so highly constrained and it is reasonable to expect that the 175 GeV decay events would appear to have a larger (on the order of 40 GeV) width.

As to t and tbar being the high T-quark mass state (around 225 GeV) there would be a third stage for decay from 225 GeV to 175 GeV with a fourth jet carrying around 100 GeV of decay energy.
In the Varnes thesis there is one dilepton event



Run 84395 Event 15530 (μμ)

Run 84395 Event 15530					z vertex: 5.9 cm		
Object	E	E_x	E_y	E_z	E_T	η	ϕ
Muon 1	68.6	-63.9	12.7	-21.4	65.1	-0.32	2.94
Muon 2	34.9	-16.0	31.0	1.9	34.9	0.05	2.05
$\not{E}_T$	–	71.2	53.2	–	88.9	–	0.64
Jet 1	146.1	32.1	-98.2	-102.4	103.3	-0.88	5.03
	(153.5)	(33.8)	(-103.1)	(-107.6)	(108.5)		
Jet 2	35.1	-8.6	21.4	26.2	23.1	0.97	1.95
	(37.2)	(-9.1)	(22.7)	(27.7)	(24.5)		
Jet 3	47.1	-7.6	-16.8	43.0	18.4	1.58	4.29
	(52.3)	(-8.4)	(-18.6)	(47.8)	(20.5)		

that seems me to represent that third stage of decay from 225 GeV to 175 GeV.
Since it is described as a 3-jet event and not a 4-jet event as I would have expected, my guess is that the third and fourth jets of my model were not distinguished by the experiment so that they appeared to be one third jet.