Higgs-Tquark NJL 3-State System:
A Detailed History of Observations

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Abstract:

The Consensus view of the Physics Community is that the Standard Model has one Higgs mass state at 125 GeV and one Tquark mass state at 174 GeV.

E8 Physics (viXra 1602.0319, 1701.0495, 1701.0496) views Higgs as a Nambu-Jona-Lasinio (NJL) type Tquark -Tantiquark Condensate with 3 mass states for Higgs and Tquark:

Low-mass - 125 GeV Higgs and 130 GeV Tquark
Middle-mass - 200 GeV Higgs and 174 GeV Tquark
High-mass - 240 GeV Higgs and 220 GeV Tquark

This paper is a chronological listing of observations of Higgs and Tquark mass states by experiments such as (descriptions from Wikipedia):

ARGUS - a particle physics experiment at the electron-positron collider DORIS II at DESY in Hamburg -
commissioned in 1982 - operated until 1992.
HERA - DESY's largest synchrotron and storage ring for electrons and positrons -
began operation in 1990 - started taking data in 1992 - closed in 2007 -
detectors H1 and ZEUS
FERMILAB - site of Tevatron proton-antiproton collider at Batavia, Illinois -
Tevatron was completed in 1983 and closed in 2011 -
detectors CDF and D0
LEP - electron-positron collider at CERN in Geneva used from 1989 until 2000
LHC - proton-proton collider at CERN re-using the LEP tunnel - the largest single machine on Earth -
built between 1998 and 2008 - detectors CMS and ATLAS -
first research run at 7 to 8 TeV was from 2010 to 2013 -
restarted at 13 TeV in 2015 - by the end of 2016 had 36 fb(-1) at 13 TeV -
during 2017 had collected an additional 45 fb(-1) at 13 TeV
for a total of 80 fb(-1) = 80 x 100 Trillion = 8 Quadrillion = 8 x 10^15 events.

ATLAS analysis of Higgs -> ZZ* -> 4l of 2016 LHC run was in ATLAS-CONF-2017-058 saying: "... proton–proton collision data at a centre-of-mass energy of 13 TeV ...[with]... an integrated luminosity of 36.1 fb-1 collected ... during 2015 and 2016 at the [LHC]... **excess ...[is]... observed ...around 240 ... GeV ... with local significance 3.6 sigma**.
CMS disagrees with ATLAS. CMS PAS HIG-17-012 (2017/12/08) says "... in the mass range from 130 GeV to 3 TeV ...
No significant excess of events is observed ..."

If CMS is right, then Our Universe is MetaStable (see page 26).
If CMS is wrong due to misuse of Look Elsewhere Effect (LEE),
then Higgs and Tquark form a 3-State NJL type System (see page 28).

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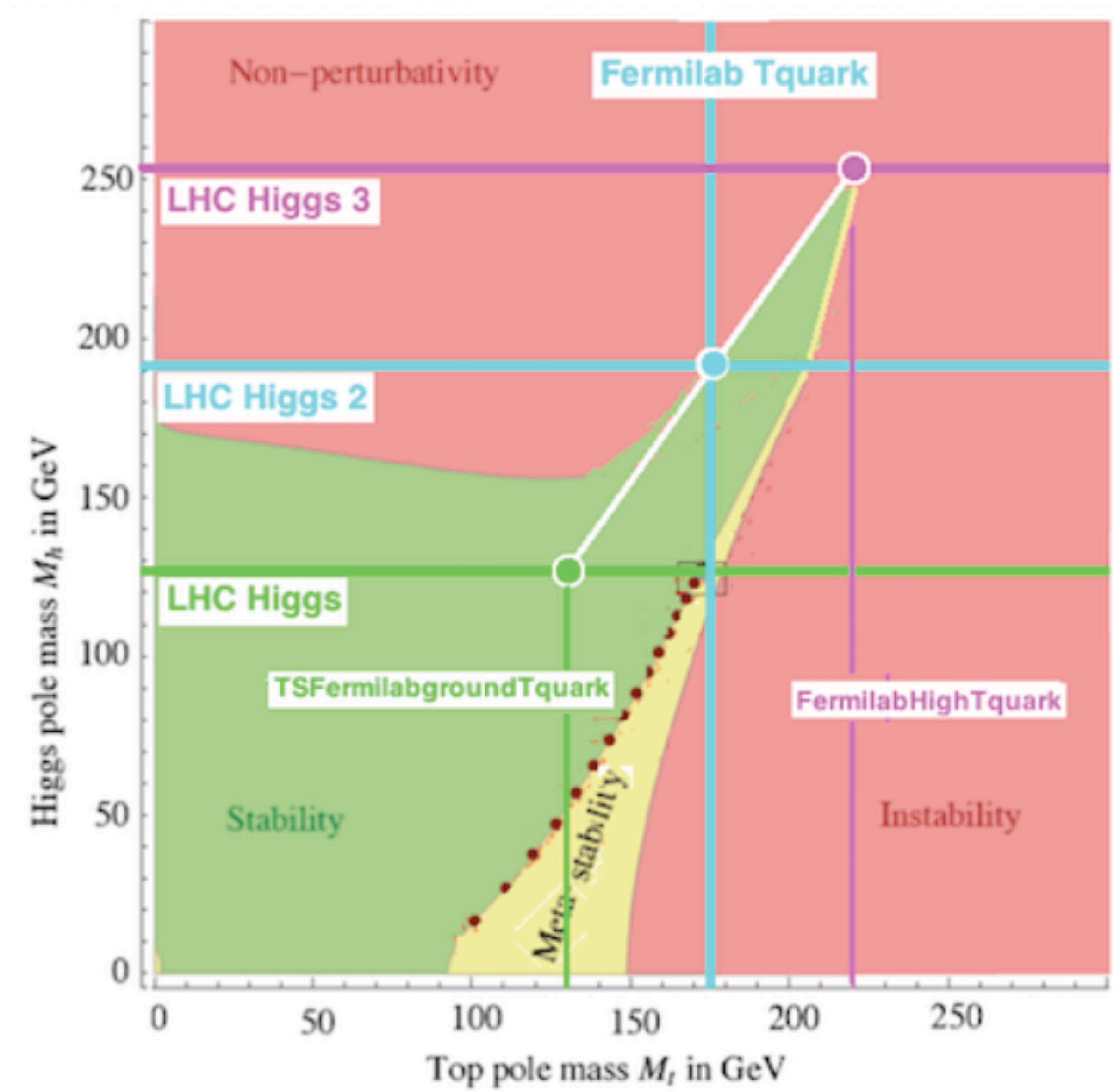
For an overall History of Our Universe see viXra 1711.0476

For details of how E8 leads to 3-state Higgs-Tquark System see viXra 1701.0496

In the **Cl(1,25) E8 model** (viXra 1602.0319) the **Higgs is seen as a Nambu-Jona-Lasinio (NJL) type fermionic condensate with a 3-state Higgs-Tquark System**.



The Green Dot where the White Line originates in our Ordinary Phase is the **Low-mass state of a 130 GeV Truth Quark and a 125 GeV Higgs.**

The 130 GeV Tquark mass is also predicted by Connes's NCG (NonCommutative Geometry) by the formula Mt = sqrt(8/3) Mw

The Cyan Dot where the White Line hits the Triviality Boundary leaving the Ordinary Phase is the **Middle-mass state of a 174 GeV Truth Quark and Higgs around 200 GeV**. It corresponds to the Higgs mass calculated by Hashimoto, Tanabashi, and Yamawaki in hep-ph/0311165 where they say:
"... We perform the most attractive channel (MAC) analysis in the top mode standard model with TeV-scale extra dimensions, where the standard model gauge bosons and the third generation of quarks and leptons are put in D(=6,8,10,...) dimensions. In such a model, bulk gauge couplings rapidly grow in the ultraviolet region. In order to make the scenario viable, only the attractive force of the top condensate should exceed the critical coupling, while other channels such as the bottom and tau condensates should not. We then find that the top condensate can be the MAC for D=8 ... We predict masses of the top (m_t) and the Higgs (m_H) ... based on the renormalization group for the top Yukawa and Higgs quartic couplings with the compositeness conditions at the scale where the bulk top condenses ... for ...[Kaluza-Klein type]... dimension... D=8 ...
m_t = 172-175 GeV and m_H=176-188 GeV ...".
As to composite Higgs and the Triviality boundary, Pierre Ramond says in his book Journeys Beyond the Standard Model (Perseus Books 1999) at pages 175-176: "... The Higgs quartic coupling has a complicated scale dependence. It evolves according to d lambda / d t = (1 / 16 pi^2) beta_lambda where the one loop contribution is given by beta_lambda = 12 lambda^2 - ... - 4 H ... The value of lambda at low energies is related [to] the physical value of the Higgs mass according to the tree level formula m_H = v sqrt(2 lambda) while the vacuum value is determined by the Fermi constant ... for a fixed vacuum value v, let us assume that the Higgs mass and therefore lambda is large. In that case, beta_lambda is dominated by the lambda^2 term, which drives the coupling towards its Landau pole at higher energies.
Hence the higher the Higgs mass, the higher lambda is and the close[r] the Landau pole to experimentally accessible regions.
This means that for a given (large) Higgs mass, we expect the standard model to enter a strong coupling regime at relatively low energies, losing in the process our ability to calculate. This does not necessarily mean that the theory is incomplete,
only that we can no longer handle it ... it is natural to think that this effect is caused by new strong interactions, and that the Higgs actually is a composite ...
The resulting bound on lambda is sometimes called the triviality bound.
The reason for this unfortunate name (the theory is anything but trivial)
stems from lattice studies where the coupling is assumed to be finite everywhere;
in that case the coupling is driven to zero, yielding in fact a trivial theory.
In the standard model lambda is certainly not zero. ...".

The Magenta Dot at the end of the White Line is the **High-mass state of a 220 GeV Truth Quark and a 240 GeV Higgs**. It is at the critical point of the Higgs-Tquark System with respect to Vacuum Instability and Triviality. It corresponds to the description in hep-ph/9603293 by Koichi Yamawaki of the Bardeen-Hill-Lindner model:
"... the BHL formulation of the top quark condensate ... is based on the RG equation combined with the compositeness condition ... start[s] with the SM Lagrangian which includes explicit Higgs field at the Lagrangian level ...
BHL is crucially based on the perturbative picture ...[which]... breaks down at high energy near the compositeness scale /\ ...[10^19 GeV]...
there must be a certain matching scale /_Matching such that
the perturbative picture (BHL) is valid for mu < /_Matching, while only the nonperturbative picture (MTY) becomes consistent for mu > /_Matching ...
However, thanks to the presence of a quasi-infrared fixed point,
BHL prediction is numerically quite stable against ambiguity at high energy region, namely, rather independent of whether this high energy region is replaced by MTY or something else. ... Then we expect mt = mt(BHL) = ... = 1/(sqrt(2)) ybart v within 1-2%, where ybart is the quasi-infrared fixed point given by Beta(ybart) = 0 in ... the one-loop RG equation ...
The composite Higgs loop changes ybart^2 by roughly the factor Nc/(Nc +3/2) = 2/3 compared with the MTY value, i.e., 250 GeV -> 250 x sqrt(2/3) = 204 GeV, while the electroweak gauge boson loop with opposite sign pulls it back a little bit to a higher value. The BHL value is then given by mt = 218 +/- 3 GeV, at /\ = 10^19 GeV.
The Higgs boson was predicted as a tbar-t bound state
with a mass MH = 2mt based on the pure NJL model calculation.
Its mass was also calculated by BHL through the full RG equation ...
the result being ... MH / mt = 1.1) at /.\ = 10^19 GeV ...
... the top quark condensate proposed by Miransky, Tanabashi and Yamawaki (MTY) and by Nambu independently ... entirely replaces the standard Higgs doublet by a composite one formed by a strongly coupled short range dynamics (four-fermion interaction) which triggers the top quark condensate.
The Higgs boson emerges as a tbar-t bound state and hence is deeply connected with the top quark itself. ... MTY introduced explicit four-fermion interactions responsible for the top quark condensate in addition to the standard gauge couplings. Based on the explicit solution of the ladder SD equation, MTY found that even if all the dimensionless four-fermion couplings are of O(1), only the coupling larger than the critical coupling yields non-zero (large) mass ... The model was further formulated in an elegant fashion by Bardeen, Hill and Lindner (BHL) in the SM language, based on the RG equation and the compositenes condition.
BHL essentially incorporates 1/Nc sub-leading effects such as those of the composite Higgs loops and ... gauge boson loops which were disregarded by the MTY formulation. We can explicitly see that BHL is in fact equivalent to MTY at 1/Nc-leading order. Such effects turned out to reduce the above MTY value 250 GeV down to 220 GeV ...".

Here is a History of Observations of the Higgs-Tquark NJL 3-State System:

1988 - Tquark - Nir, Nuclear Physics B306 (1988) 14 -
ARGUS B-Bbar experiments set limits on the Mass of the Truth Quark, showing it to be between 43 GeV and 180 GeV, and likely to be between **83 GeV and 180 GeV**.

1992 - Low-mass Tquark - **Dalitz, Goldstein**, Phys. Lett. B 287 (1992) 225-230) -
A simple idealized procedure is proposed for the analysis of individual top-antitop quark pair production and dilepton decay events, in terms of the top quark mass. This procedure is illustrated by its application to the CDF candidate event.
If this event really represents top-antitop production and decay, then the top quark mass would be **131 +22 -11 GeV**.

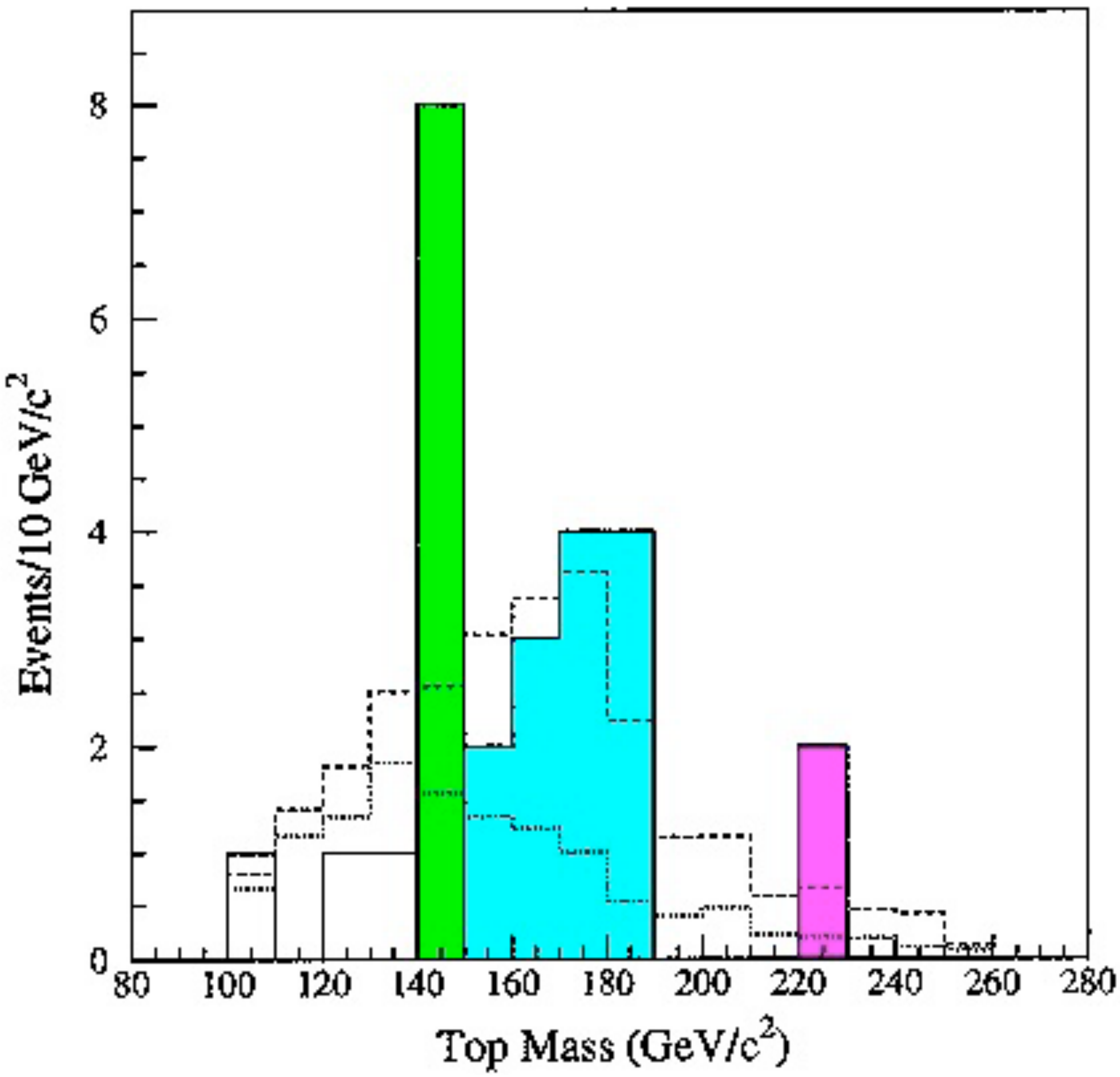
1993-Low-mass Tquark- **Kondo, Chikamatsu, Kim** J. Phys. Soc. Japan 62: 1177-82 - the dilepton candidate found during the Fermilab 1988-89 run can be interpreted as from the top antitop pair

1993 - Low-mass Tquark - **Dalitz, Goldstein**, hep-ph/9308345 -
Now that LEP experiments have measured with high accuracy many quantities related with the electroweak interactions, these measurements can be compared with the corrected theoretical predictions in order to draw some conclusions concerning the top quark and any other particles of high mass. ... With the LEP data updated to July 1992, Ellis et al. have given the value ... $m_t = 124(27)$GeV, (2.1) using α_S $(M_Z^2) = 0.118(8)$.
...
One good ($\mu^- e^+$) candidate event has ... been published by the CDF collaboration ...

A second (μe) candidate was shown by the CDF collaboration in their report given at the November 1992 Chicago Meeting of the Division of Particles and Fields of the American Physical Society, although no measurement details were released.
It was well known at that meeting that the DO collaboration also had their first (μe) candidate. Although the integrated luminosities IL are not known to us precisely, a value of about 20 pb^{-1} for CDF (including IL=4.7 pb^{-1} from their 1989 paper) and 10 pb^{-1} for DO would appear plausible estimates, at least of the right order of magnitude. ...
On the assumption that these three (μe) candidates do stem from top-antitop production, and that the integrated luminosity up to November 1992 was about 30 pb^{-1}, the probability distribution for m_t ... peak is at **120 GeV**, the one-deviation limits being **109 and 135 GeV**. ... the peak value thus determined for m_t is not strongly dependent on our estimate for IL, nor on the number of μe events. ...".

1994 - Low-mass Tquark - 4 April - Abachi et al -
We have searched for evidence of top quark production in *pp*¯ collisions at √*s* =1.8 TeV using the ***D*0** detector at the Fermilab Tevatron collider. ... We discuss the properties of an event for which expected backgrounds are small ... it is a dilepton e-mu event in a relatively low background region with a likelihood distribution that is maximized for a Tquark mass of about **145 GeV/c^2**.

1994 - Low, Middle, High-mass Tquark - 26 April - **FERMILAB-PUB-94/097-E** -
A semileptonic histogram showed **all three states of the T-quark**:



The green bar represents a bin in the **140-150 GeV** range containing Semileptonic events considered by me to represent the Truth Quark.
The cyan bar represents a broader peak in the **160-180 GeV** range
that includes the 174 GeV Truth Quark at the Triviality Boundary of the H-Tq System.
The magenta bar represents a bin in the **220-230 GeV** range
of the Truth Quark at the Critical Point of the Higgs - Truth Quark System.

1995 - Middle-mass Tquark - **CDF** hep-ex/9503002 -
analyzing about 50 pb-1 of data, mostly Semileptonic events
gets a T-quark mass of about **176 GeV**

1995 - Middle-mass Tquark - **D0** hep-ex/9503003 -
analyzing about 50 pb-1 of data, mostly Semileptonic events
gets a T-quark mass of about **199 GeV**

1995 - Low, Middle-mass Tquark - **Dalitz, Goldstein** hep-ph/9506232 -
analyze the recent seven L(+/-)4jet events and, in accord with CDF,
get a mass estimate of about **175 GeV** for those events.
Their analysis of e(+/-)mu(+/-)2jet events gives
a somewhat lower peak t-quark mass (about **156 GeV**).
When they consider the CDF event 45047/104393 to
be a dilepton event with both leptons hard, and combining two jets into a single jet,
they get a good fit as a t-tbar event with t-quark mass **136 (+18 -14) GeV**.

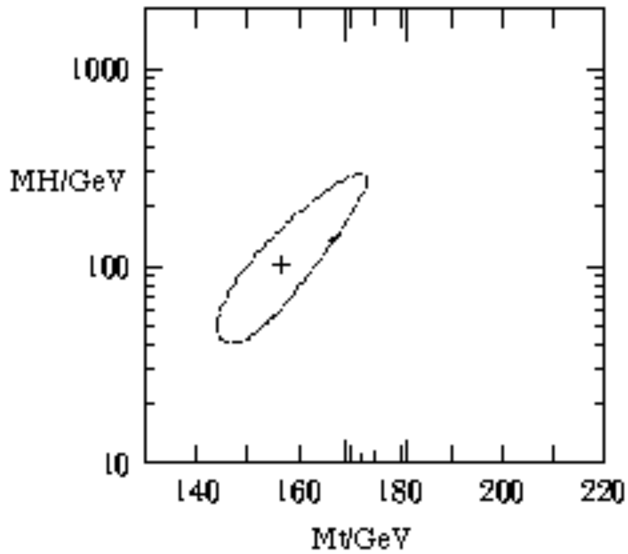
1995 - Low-mass Tquark -**Kondo** Oral History Interview by K. Staley 10 October 1995 -
the dilepton candidate found during the Fermilab 1988-89 run could be reconstructed as decay of a top-antitop pair with top mass of around **130 GeV/c2** with a very broad error.

1996 - Low-mass Tquark - **Goldstein** hep-ph/9611314 -
Top-antitop quark pairs produced at the Tevatron have a sizeable spin correlation. That correlation feeds into the angular distribution of the decay products, particularly in the dilepton channel. Including the expected correlation in an overall analysis of a handful of actual dilepton events continues to favor a lower top mass (centered on **155 GeV**) than the single lepton events.

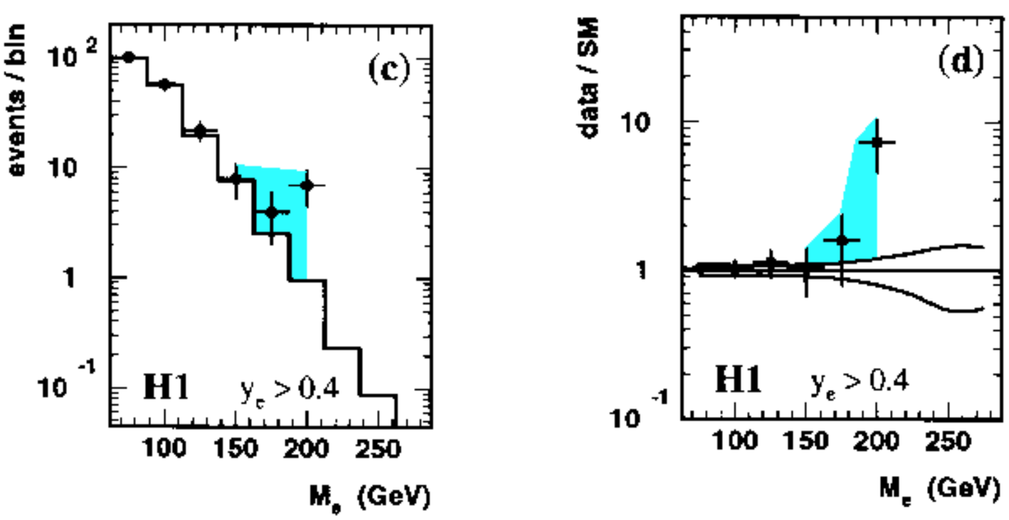
1996 - Low, Middle-mass Tquark - **Heinson** hep-ex/9601006 -
results on top quark physics from the DZero collaboration since the discovery of the top quark in March 1995 with about 50 pb^(-1) of data from 1992 to 1995:
For Semi-Leptonic Lepton + Jets events: Mt = **199 +24 -30 GeV**;
For Dilepton events: Mt = **145 +/- 32 GeV**.

1996 - Low, Middle-mass Tquark - **Campagnari, Franklin** hep-ex/9608003 -
For Semi-Leptonic Lepton + Jets events:
CDF kinematic result: Mt = **180 +/- 12(stat) (+19/-15)(syst) GeV**;
CDF mass reconstruction result: Mt = **176 +/- 9 GeV**;
D0 mass reconstruction result: Mt = **170 +/- 18 GeV**.
For Dilepton events:
CDF kinematic result:
Mt = **159 (+24/-22)(stat) +/- 17(syst) GeV**;
D0 mass reconstruction result:
Mt = **145 +/- 25(stat) +/- 20(syst) GeV**.

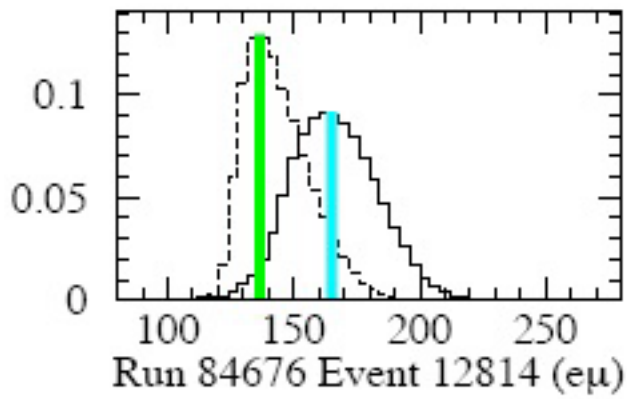
1996 - Low-mass Tquark, Low-mass Higgs - **Dittmaier, Schildknecht**
hep-ph/9609488 -
implications of 1996 electroweak data on the Higgs and T-quark masses -
If the LEP value of the Weinberg angle s2w = 0.23200 is used,
and the SLD value s2w = 0.23165 is excluded
then, approximately, Mt = **155 GeV** and MH = **100 GeV**:



1997 - Middle-mass Tquark - **HERA H1** hep-ex/9702012 -
The following histograms show that the HERA H1 events begin to appear with unusual frequency at the **150-200 GeV** and compare the HERA H1 observed data with the 1-sigma deviation line from the standard NC DIS expected data



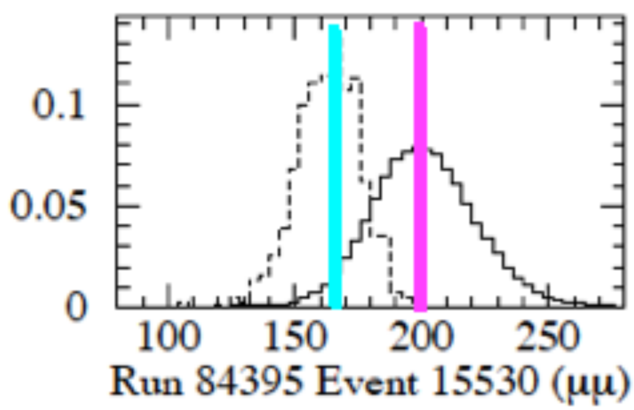
1997 - Low, Middle, High-mass Tquark - **Varnes** U. C. Berkeley Ph.D. Thesis
FERMILAB-THESIS-1997-28
https://www-d0.fnal.gov/results/publications_talks/thesis/varnes/thesis.ps
In his 1997 Ph.D. thesis Erich Ward Varnes (page 159) said:
"... distributions for the dilepton candidates. For events with more than two jets, the dashed curves show the results of considering only the two highest ET jets in the reconstruction ...



...” (colored bars added by me)

The event for all 3 jets (solid curve) seems to me to correspond to
decay of a middle (cyan) T-quark state
with one of the 3 jets corresponding to
decay from the Triviality boundary to the Normal Stable Region (green) T-quark state,
whose immediately subsequent decay corresponds to the 2-jet (dashed curve) event at the low (green) energy level.

In the Varnes thesis there is one dilepton event with 3 jets (solid curve)



that seems to me to correspond to decay of a high (magenta) T-quark state
with one of the 3 jets corresponding to
decay from the Critical Point down to the Triviality Boundary (cyan) T-quark state,
whose immediately subsequent decay corresponds to the 2-jet (dashed curve) event.

Dilepton data are described by Erich Ward Varnes in Chapter 8 of his 1997 UC Berkeley PhD thesis about D0 data at Fermilab:
"… there are six t-tbar candidate events in the dilepton final states … Three of the events contain three jets, and in these cases the results of the fits using only the leading two jets and using all combinations of three jets are given …".
There being only 6 dilepton events in Figure 8.1 of Varnes's PhD thesis

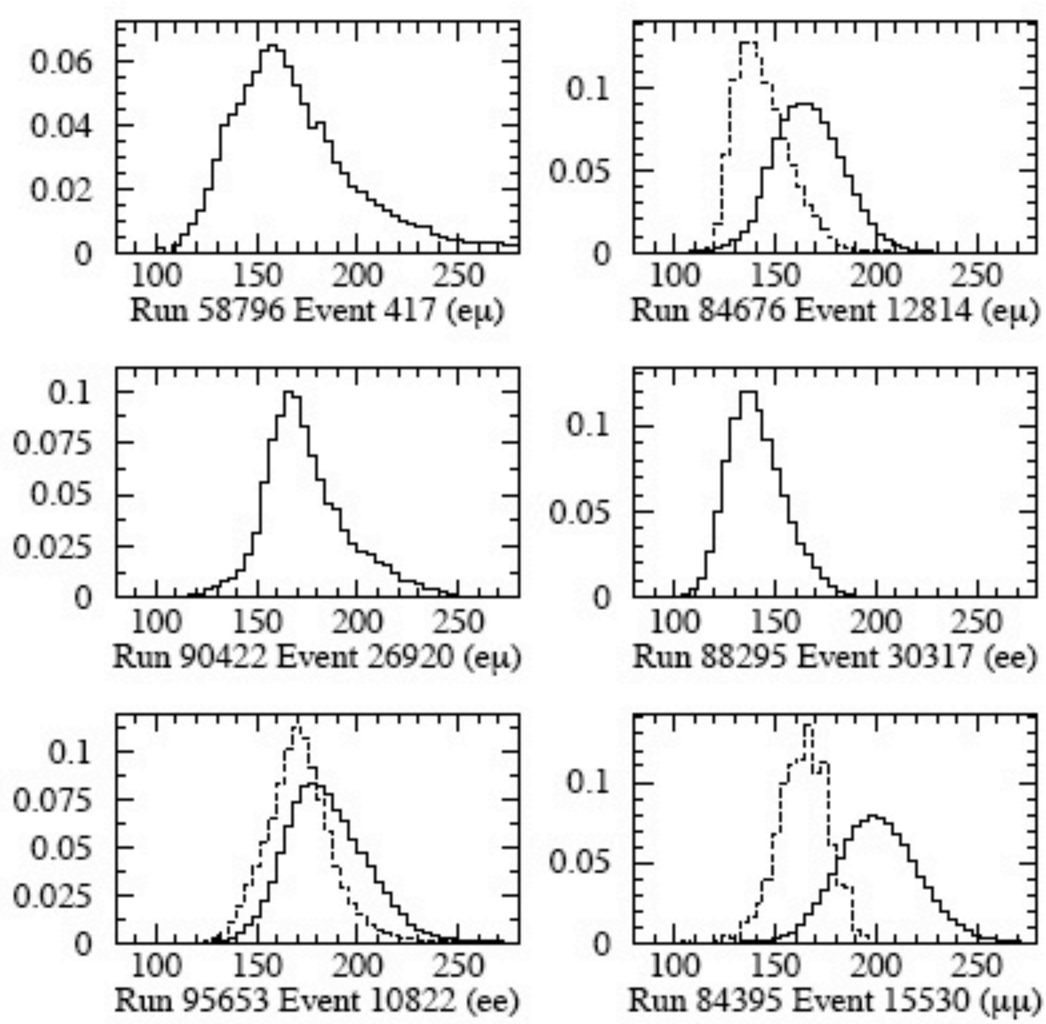


Figure 8.1: $\mathcal{W}(m_t)$ distributions for the dilepton candidates. For events with more than two jets, the dashed curves show the results of considering only the two highest E_T jets in the reconstruction.

it is reasonable to discuss each of them,
so (mass is roughly estimated by me looking at the histograms) here they are:

Run 58796 Event 417 (e mu) - 2 jets - **160 GeV**
Run 90422 Event 26920 (e mu) - 2 jets - **170 GeV**
Run 88295 Event 30317 (e e) - 2 jets - **135 GeV**

Run 84676 Event 12814 (e mu) - more than 2 jets - **165 GeV** -
highest 2 jets - **135 GeV**
Run 95653 Event 10822 (e e) - more than 2 jets - **180 GeV** - highest 2 jets - **170 GeV**
Run 84395 Event 15530 (mu mu) - more than 2 jets - **200 GeV** -
highest 2 jets - **165 GeV**

In terms of 3 Truth Quark mass states - High around 220 GeV or so -
Middle around 174 GeV or so - Low around 130-145 GeV or so - those look like:

Run 58796 Event 417 (e mu) - direct 2-jet decay of Middle
Run 90422 Event 26920 (e mu) - direct 2-jet decay of Middle
Run 88295 Event 30317 (e e) - direct 2-jet decay of Low
Run 84676 Event 12814 (e mu) - decay of Middle to Low then 2-jet decay of Low
Run 95653 Event 10822 (e e) - decay of High to Middle then 2-jet decay of MIddle
Run 84395 Event 15530 (mu mu) - decay of High to MIddle then 2-jet decay of Middle

The 1997 UC Berkeley PhD thesis of Erich Ward Varnes says:
"... 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 $\not{E}_T^{\text{cal}}$ > 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)

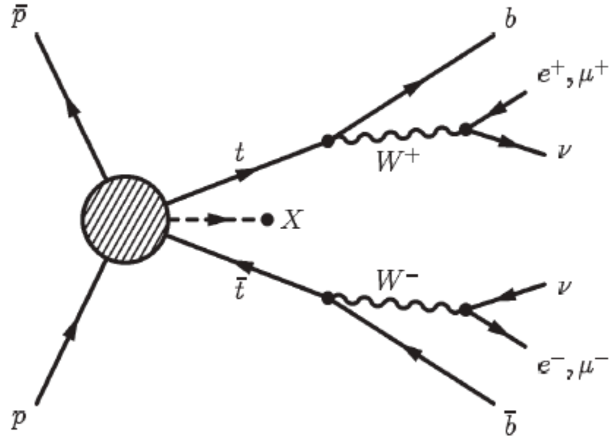


Figure 6.1: Schematic representation of $t\bar{t}$ production and decay in the dilepton channels.

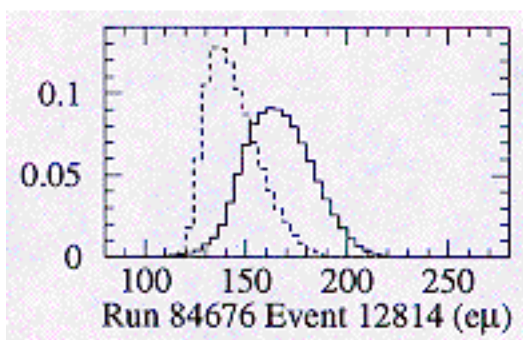
so that the final state is completely specified by knowledge of the energy four-vectors of these six particles ... there are ... kinematic constraints:

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.

...

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 ...

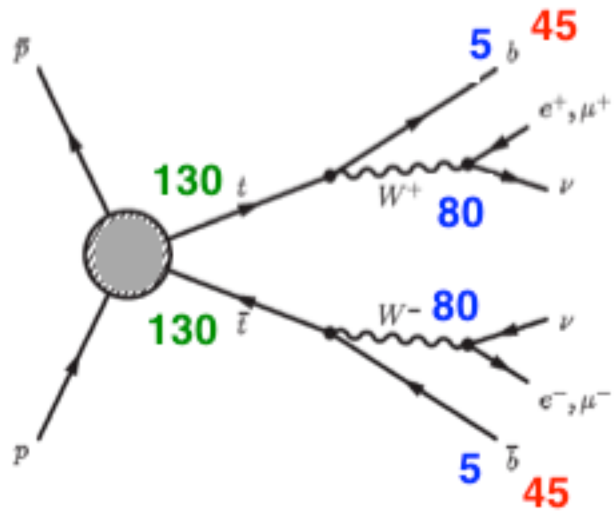


...

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)		

...”.

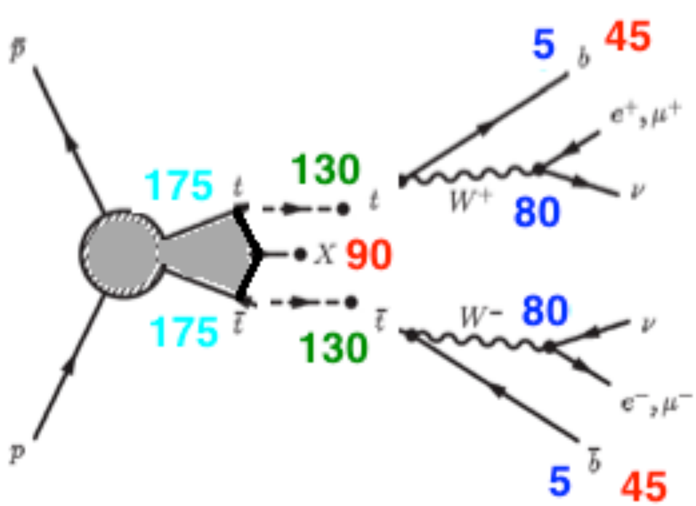
If the t and tbar are both in the 130 GeV mass state then the decay is simple with 2 jets:



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.

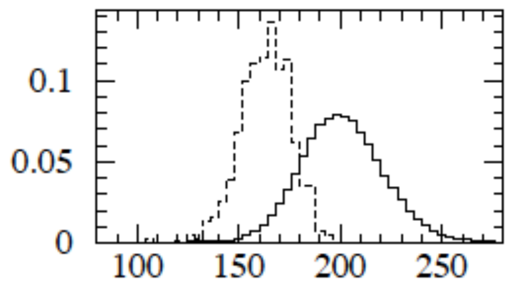
(In these two diagrams I have indicated energies only approximately for t and tbar mass states (cyan and green) and W and b-quark (blue) and jets (red). Actual kinematic data may vary from the idealized numbers on the diagrams, but they should give similar physics results.)

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

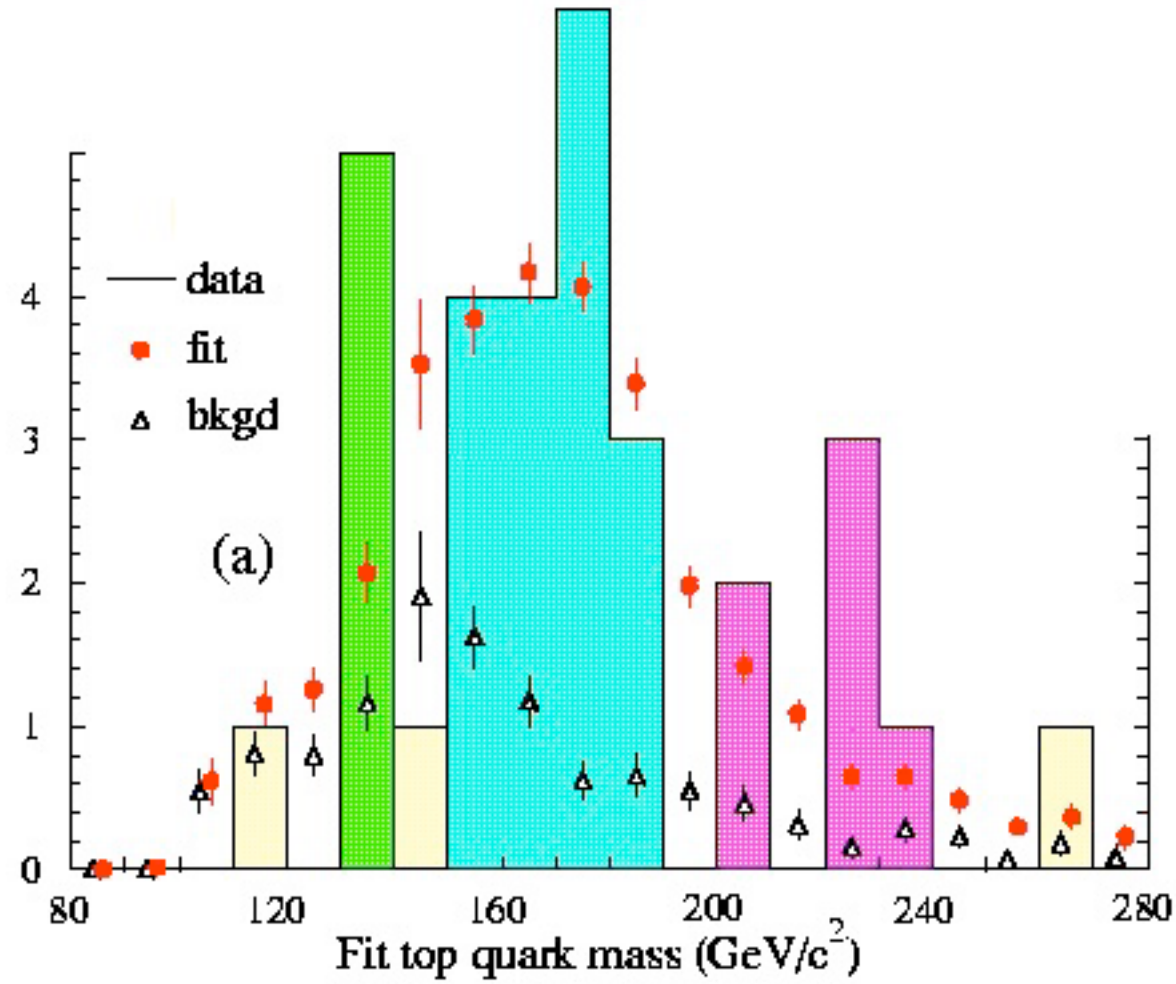


Run 84395 Event 15530 (μμ)

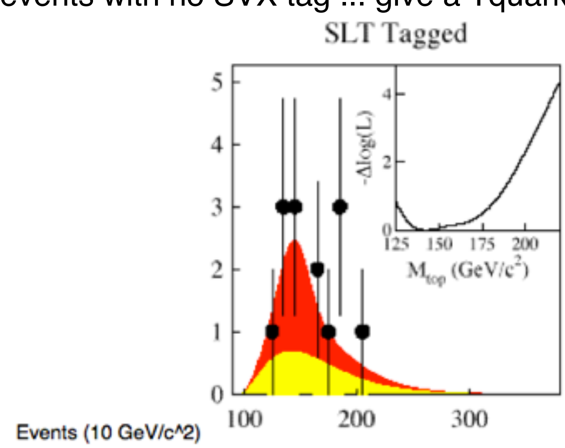
Run 84395 Event 15530					z vertex: 5.9 cm		
Object	E	E_x	E_y	E_z	E_T	η	ϕ
Muon 1	68.6	-63.9	12.7	-21.4	65.1	-0.32	2.94
Muon 2	34.9	-16.0	31.0	1.9	34.9	0.05	2.05
$\not{E}_T$	–	71.2	53.2	–	88.9	–	0.64
Jet 1	146.1	32.1	-98.2	-102.4	103.3	-0.88	5.03
	(153.5)	(33.8)	(-103.1)	(-107.6)	(108.5)		
Jet 2	35.1	-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.

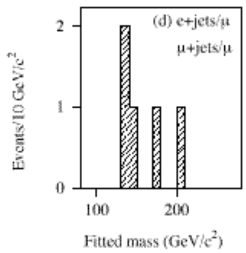
1997 - Low, Middle, High-mass Tquark - **D0** hep-ex/9703008 -
A semileptonic histogram showed **all three states of the T-quark**:



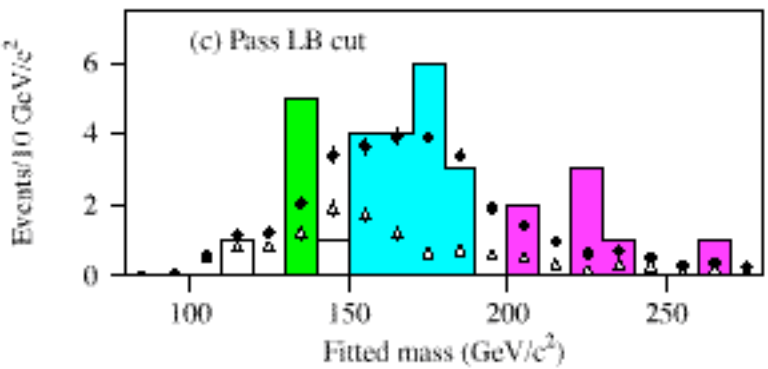
1998 - Low, Middle-mass Tquark - **CDF** hep-ex/9801014 -
based on lepton + 4 jet events that were either SVX tagged, SVX double tagged, or untagged ... the top quark mass is **175.9 +/- 4.8(stat.) +/- 4.9(syst.) GeV/c^2**
14 SLT tagged events with no SVX tag ... give a Tquark Mass of **142 GeV (+33, -14)**



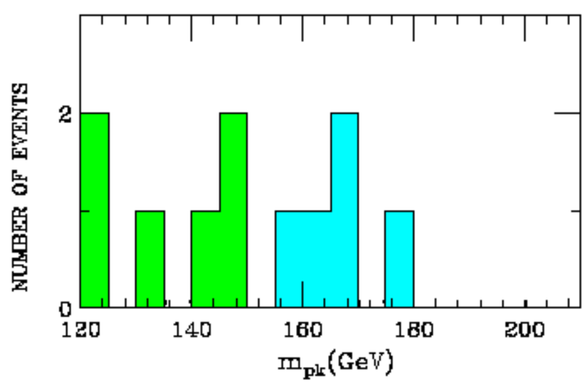
1998 - Low, Middle, High-mass Tquark - **D0** hep-ex/9801025 -
5 tagged lepton + jets give Tquark mass **130-150 GeV** for 3 of the events



of the total of 91 candidate events, 31 survived Chi-squared less than 10 cut
and also survived the Low Bias selection cut, **all three Tquark states** observed:

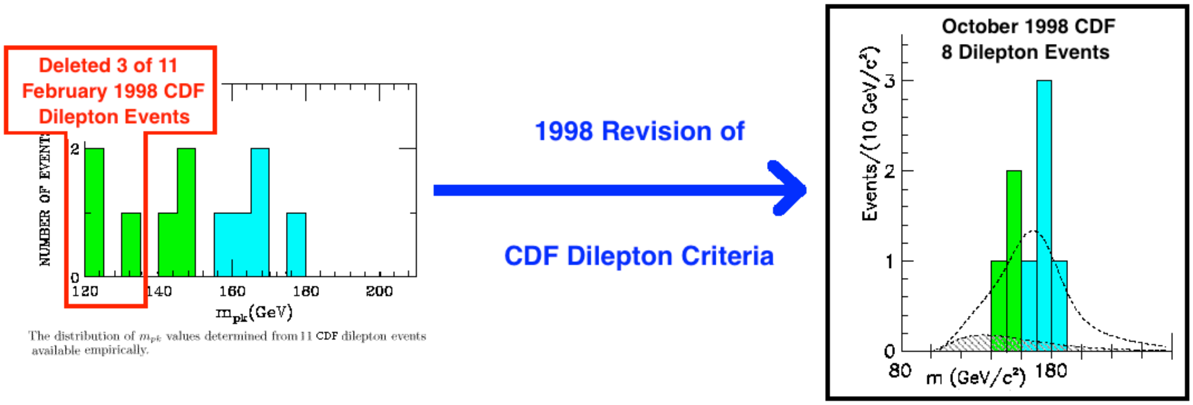


1998 - Low, Middle-mass Tquark - **Dalitz, Goldstein** hep-ph/9802249 -
11 additional CDF dilepton events which have become available since the 1997
Electron-Photon conference in Hamburg are **Low and Middle-mass Tquark states**:



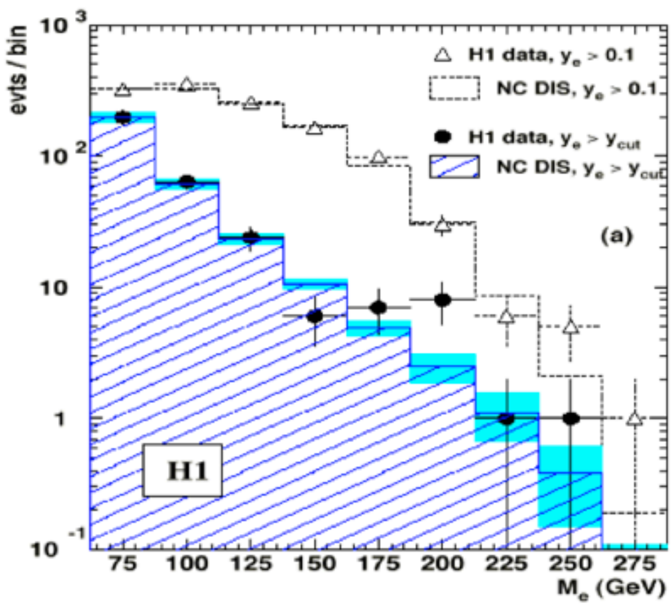
The distribution of m_{pk} values determined from 11 CDF dilepton events
available empirically.

1998 - Low, Middle-mass Tquark - **CDF** hep-ex/9810029 -
CDF “present[s] a new measurement of the top quark mass ...
[that] supersedes [CDF’s] previously reported result in the dilepton channel”
which revision seems to me to be cutting the lowest 3 of the 11 original events

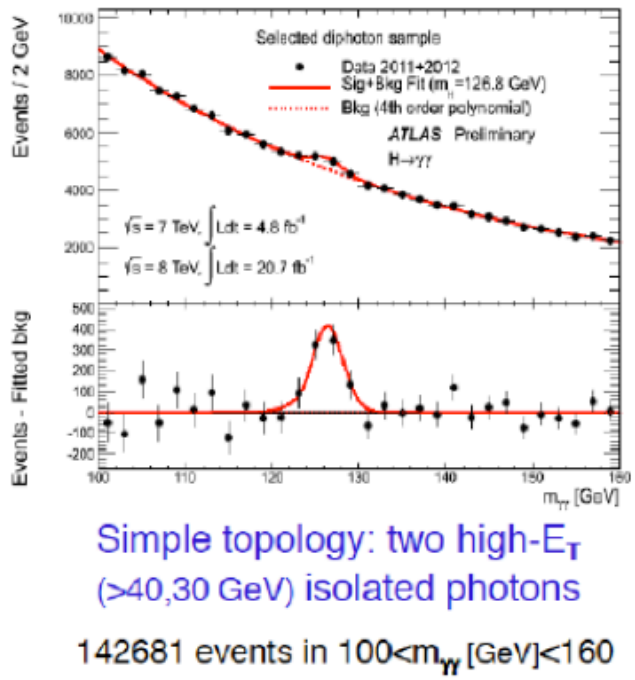


as part of a Fermilab policy of ignoring the Low-mass Tquark state.

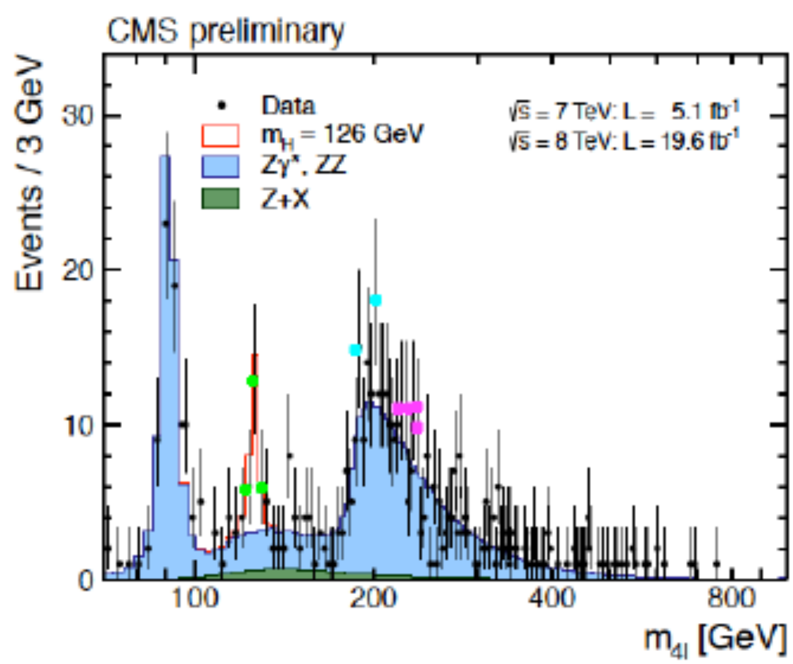
1999 - Middle, High-mass Tquark - **HERA H1, ZEUS** hep-ex/9910012 -
The excess in the H1 data is still present at Me = **200 GeV** but has not been corroborated by the 1997 data. Also ZEUS observes an excess at Mej **> 200 GeV**



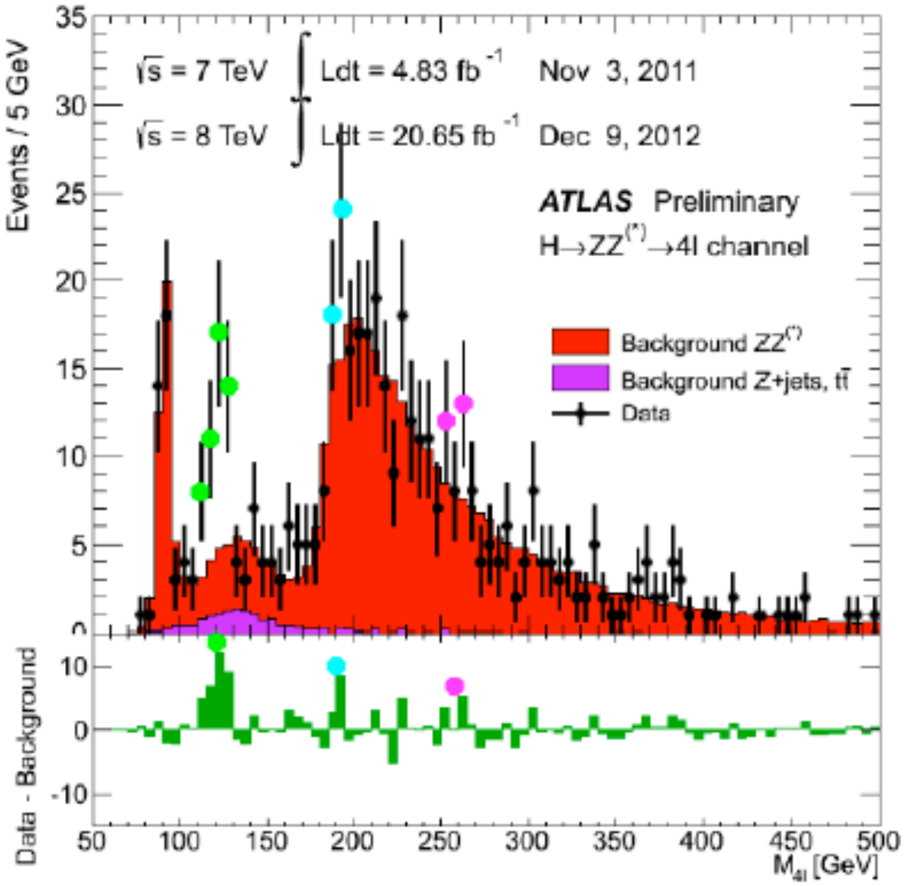
2013 - Low, Middle, High-mass Higgs - **ATLAS, CMS** Moriond 2013 -
In the 25/fb of data collected through the LHC run ending with the long shutdown at the end of 2012, the LHC has observed a 126 GeV (about 133 proton masses) Low-mass state of the Standard Model Higgs boson. The digamma histogram for ATLAS clearly shows only one peak below 160 GeV and it is around 126 GeV



A CMS histogram (some colors added by me) for the Golden Channel Higgs to ZZ to 4l shows the peak around 126 GeV (green dots - Low Higgs mass state. The CMS histogram also indicates other excesses around 200 GeV (cyan dots - Middle Higgs mass state) and around 240 GeV (magenta dots - High Higgs mass state).

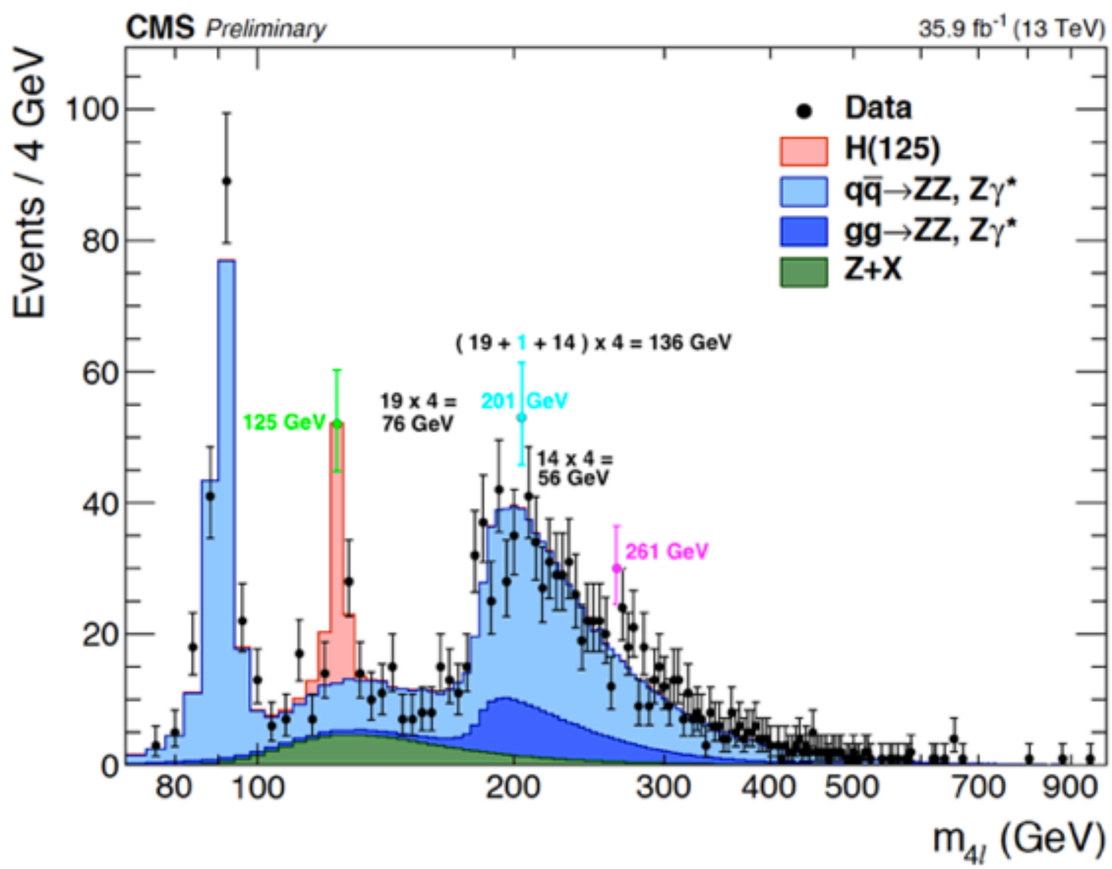


An ATLAS ZZ to 4l histogram (some colors added by me) show the peak around 126 GeV (green dots - Low Higgs mass state. The ATLAS histogram also indicates other excesses around 200 GeV (cyan dots -Middle Higgs mass state) and around 240 GeV (magenta dots - High Higgs mass state) .

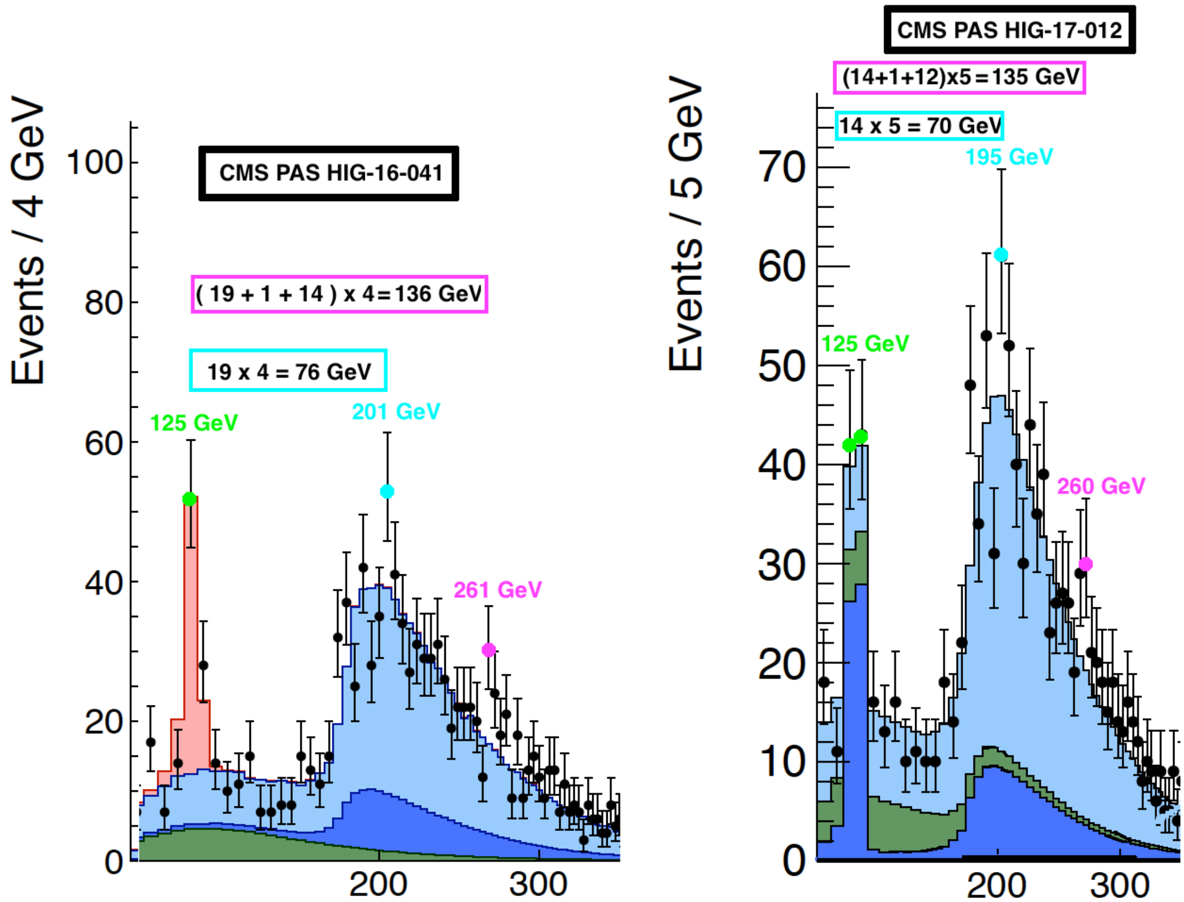


2016 - Low, Middle, High-mass Higgs - **CMS, ATLAS**
CMS PAS HIG-16-041, CMS PAS HIG-17-012,
ATLAS-CONF-2017-058

CMS PAS HIG-16-041 (2017/04/13) histogram (Figure 3) for Higgs -> ZZ* -> 4l of **2016 LHC run** shows clearly **all three Higgs mass states**:



CMS PAS HIG-17-012 (2017/12/08) histogram (Figure 2) for Higgs -> ZZ* -> 4l untagged
of **2016 LHC run** also shows clearly **all three Higgs mass states**



however
CMS PAS HIG-17-012 says "... in the mass range from 130 GeV to 3 TeV ...
No significant excess of events is observed ...".

It is clear to me that there are two excess peaks: **195-201 GeV** and **260-261 GeV**

As to why CMS says that those two peaks are not there, perhaps CMS is taking a global view of their mass range from 130 GeV to 3 TeV using Look Elsewhere Effect (LEE).

Since those two peaks have been predicted by my E8 physics model to be around 200 GeV and around 250 GeV, application of the LEE to get a global significance is NOT valid. The local obvious excess peaks ARE valid.

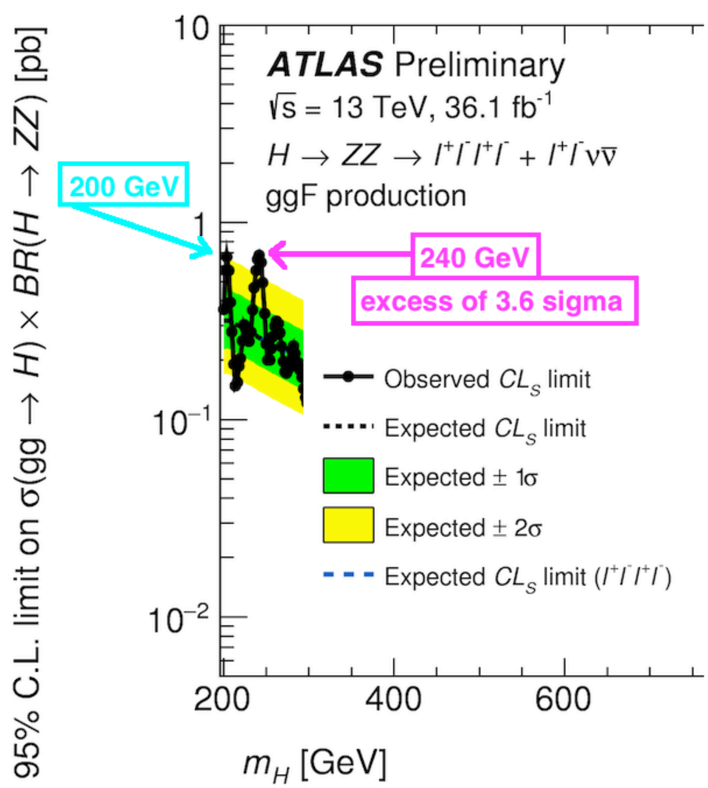
ATLAS-CONF-2017-058 (5 July 2017) (Figure 6) analysis of Higgs -> ZZ* -> 4l
of 2016 LHC run says:
"... A search for heavy resonances decaying into a pair of Z bosons leading to l+ l- l+ l- ... final state... where l stands for either an electron or a muon, is presented.

[that includes the Higgs -> ZZ* -> 4l channel]

The search uses proton–proton collision data at a centre-of-mass energy of 13 TeV corresponding to an integrated luminosity of 36.1 fb-1 collected with the ATLAS detector during 2015 and 2016 at the Large Hadron Collider ...

excess ...[is]... observed in the data for m4l around 240 ... GeV ...
with a local significance of 3.6 sigma ...

The global significance is of 2.2 sigma ...



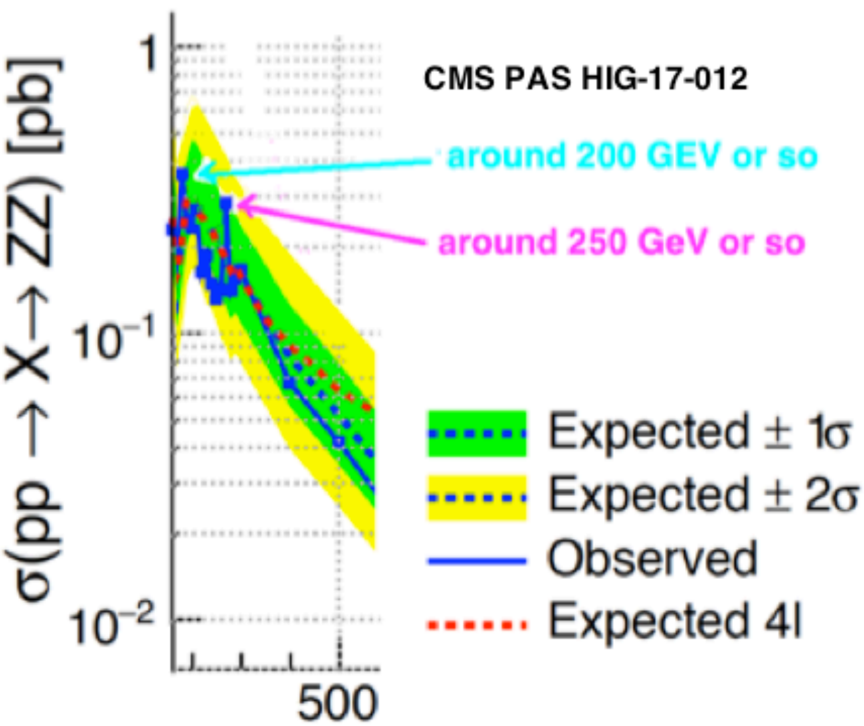
...".

However, **CMS PAS HIG-17-012** (2017/12/08) says (see Figure 9)
... in the mass range from 130 GeV to 3 TeV ...
No significant excess of events is observed ...".

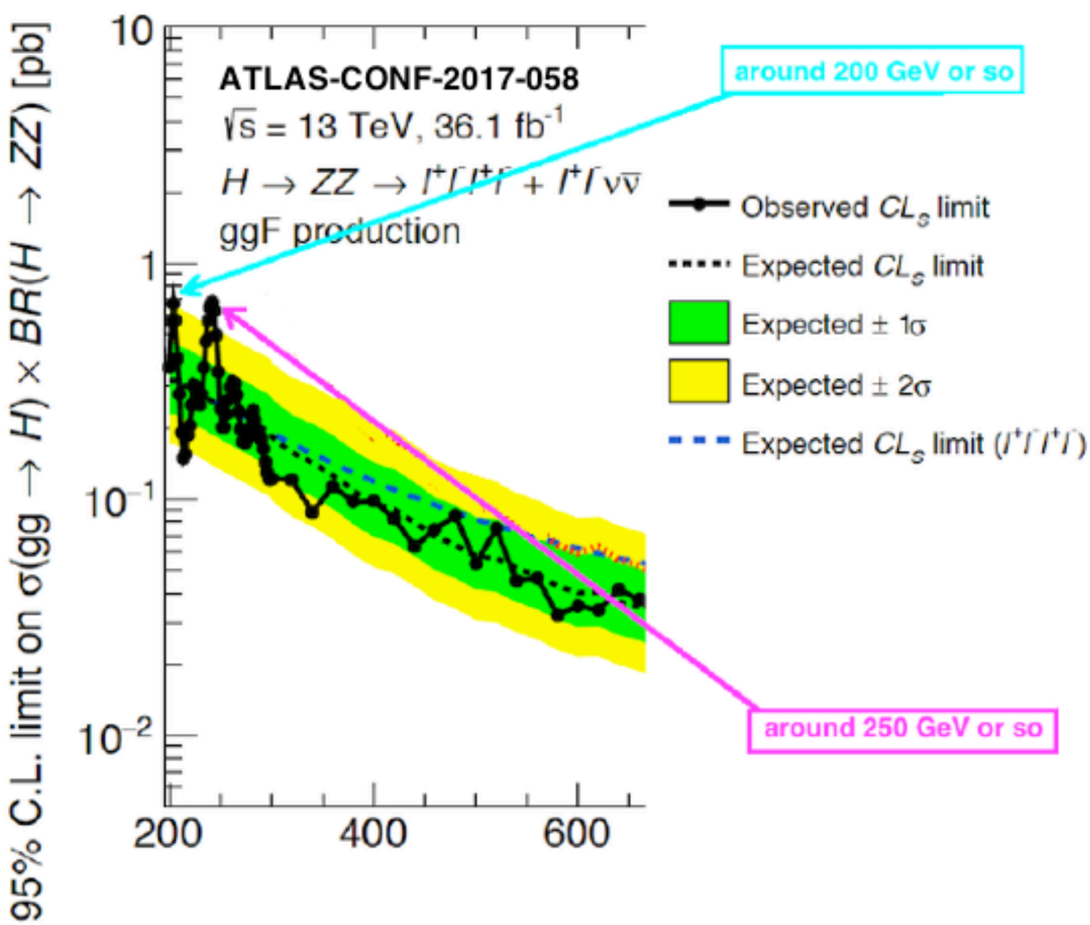
Comparison ATLAS Figure 6 and CMS Figure 9 shows that the data points are similar but the green/yellow Brazil Bands are not. That may be because

CMS uses a global view with LEE to get a low (2.2 sigma or so) significance
and
ATLAS uses a local (no LEE) significance of 3.6 sigma.

My E8 physics model predicted the excess locations including around 240 GeV so the CMS LEE dismissal is NOT VALID.



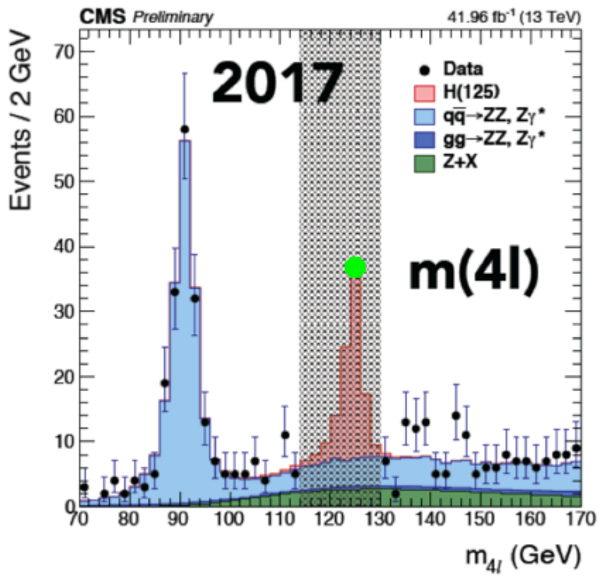
CMS PAS HIG-17-012
around 200 GEV or so
around 250 GeV or so
Expected ± 1σ
Expected ± 2σ
Observed
Expected 4l
σ(pp → X → ZZ) [pb]
1
10^-1
10^-2
500



ATLAS-CONF-2017-058
√s = 13 TeV, 36.1 fb^-1
H → ZZ → l+l-l+l- + l+l-νν
ggF production
around 200 GeV or so
around 250 GeV or so
Observed CLs limit
Expected CLs limit
Expected ± 1σ
Expected ± 2σ
Expected CLs limit (l+l-l+l-)
95% C.L. limit on σ(gg → H) × BR(H → ZZ) [pb]
10
1
10^-1
10^-2
200
400
600

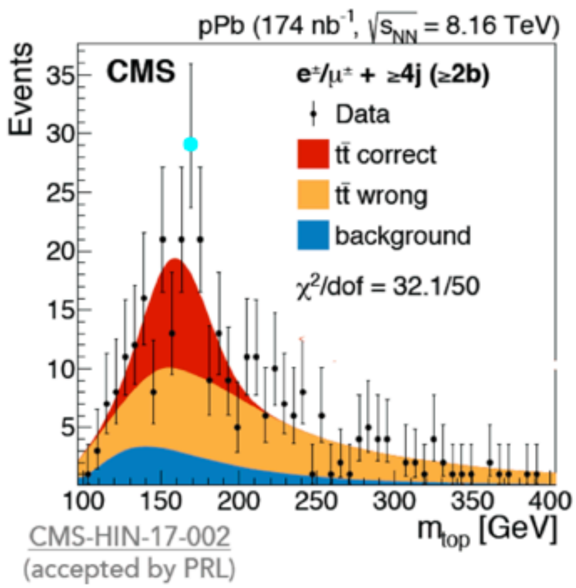
2017 - Low, Middle, High-mass Higgs - CMS, ATLAS

CMS at LHC 25 Year Symposium on 15 December 2017 showed slide saying
"... analyses of 2017 data ... ongoing ...



...

1st observation of tops in proton-lead collisions ...



...".

CMS analysis of the 2017 LHC data is that there exists

one Higgs state at 125 GeV

and

one Tquark state at 172 GeV

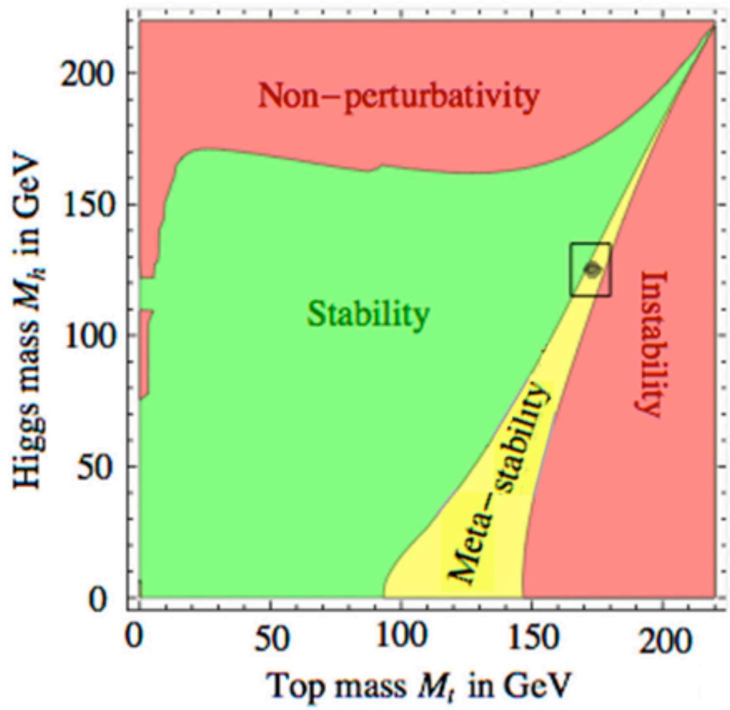
What are the consequences of

one Higgs state at 125 GeV

and

one Tquark state at 172 GeV ?

Fermilab (http://news.fnal.gov/2014/09/epic-facepalm/) 11 September 2014 said:
"... Whether our universe is in a stable configuration, an unstable configuration or a metastable one depends on the mass of the Higgs boson and the mass of the top quark. The dot shows tells us the value of those parameters in our universe ...
[according to the CMS view of one Higgs at 125 GeV and one Tquark at 172 GeV]
... t**he universe appears to be metastable** ...



...".

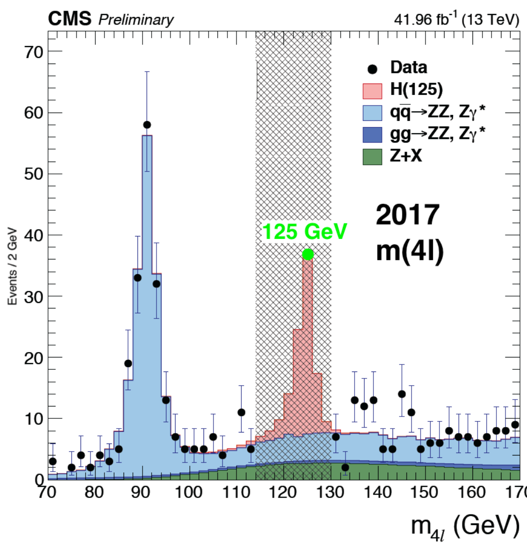
Is Our Universe really MetaStable, or could CMS be wrong ?

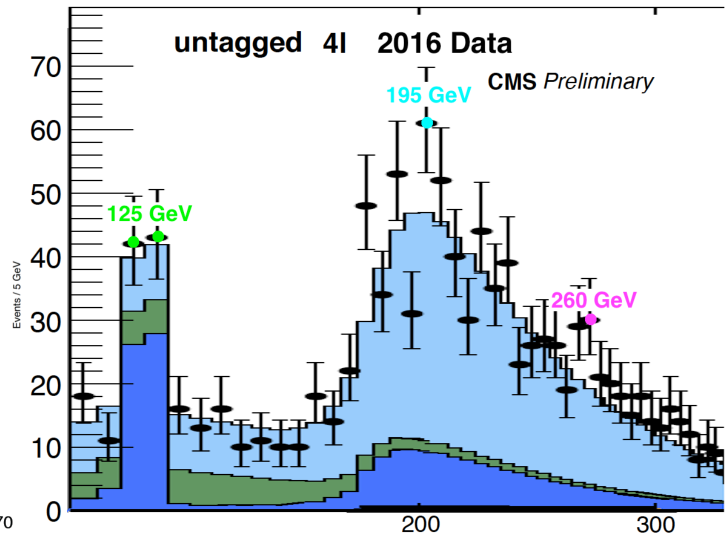
CMS may be wrong in its disagreement with ATLAS
about 2016 LHC data in the Higgs -> ZZ* -> 4l channel in which
CMS PAS HIG-17-012 (2017/12/08) says "... in the mass range
from 130 GeV to 3 TeV ... **No significant excess of events is observed** ..."
while **ATLAS-CONF-2017-058** says
"... **excess ...[is]... observed in the data for m4l around 240 ... GeV** ...
with a local significance of 3.6 sigma ..."

because

CMS uses a global view with LEE to get a low (2.2 sigma or so) significance
and **ATLAS uses a local (no LEE) significance of 3.6 sigma**.
Since my E8 physics model predicted excess locations (including around 240 GeV)
the CMS LEE dismissal of excesses is NOT VALID.

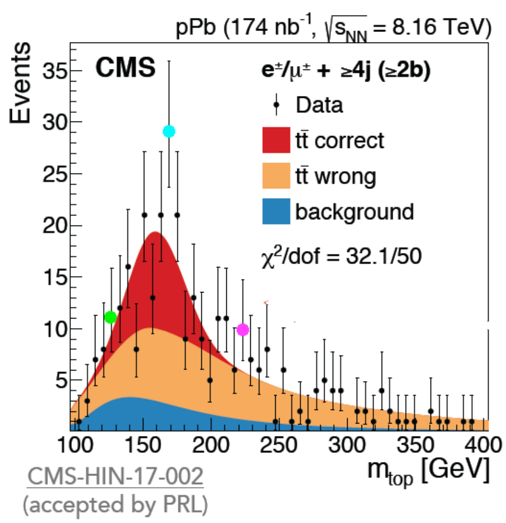
If the ATLAS 2016 data excess is right and CMS is wrong
then there may be a Higgs mass state around 240 GeV
that was not seen by CMS in 2017 data.
CMS only showed at the LHC 25 Year Symposium on 15 December 2017
a Higgs -> ZZ* -> 4l histogram for the mass region 70 GeV to 170 GeV.
CMS did NOT show any histogram for 170 GeV to 300 GeV
If the 2017 data is like the 2016 data

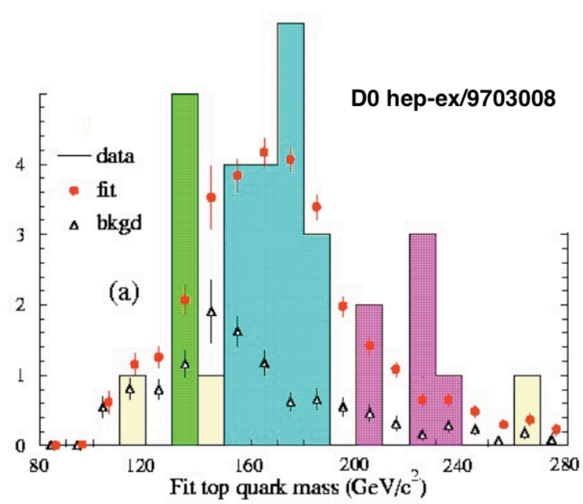




then **a CMS histogram for 100 GeV to 300 GeV will show**
not only the 125 GeV Higgs Mass State
but also the Higgs Mass States predicted by my E8 physics model
around 200 GeV and around 250 GeV

Further, **if CMS accumulates more Tquark data**
and it evolves to resemble the 1997 D0 Fermilab data





then **that will indicate a 3-Mass-State NJL Higgs-Tquark System**
The Low-Mass States (Higgs 125 GeV, Tquark 130 GeV) are in the Normal Stable region of a Higgs Mass - Tquark Mass phase diagram.

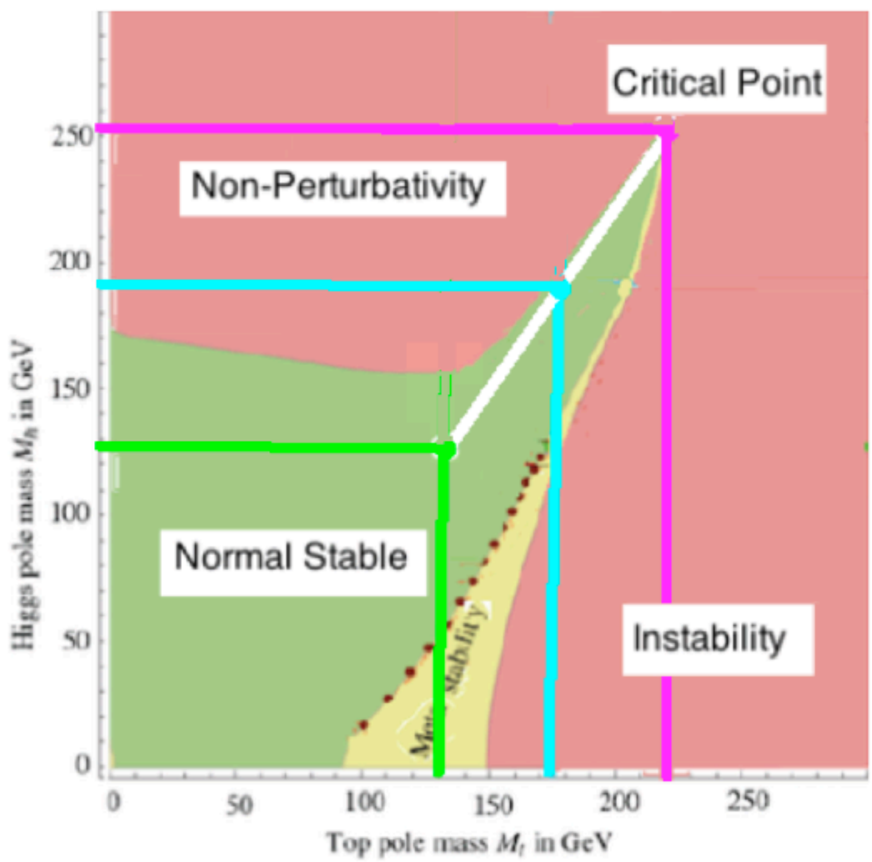
The Tquark ground-state Low-Mass State 130 GeV is also predicted by Non-Commutative Geometry (NCG).

Adding Energy moves the States up along the white line until it intersects the boundary of Normal Stability with Non-Perturbativity at which point are the Middle-Mass States (Higgs around 200 GeV, Tquark 174 GeV).

Experiments in this region should tell us a lot about Non-Perturbativity of Compositeness and 8-dim Kaluza-Klein M4 x CP2 Structure.

Adding further Energy moves up along the white line to the Critical Point at the High-Mass States (Higgs around 250 GeV, Tquark 220 GeV).

Experiments in this region should tell us about the Critical Intersection of Normal Stability, Non-Perturbativity of Compositeness, and 8-dim Kaluza-Klein M4 x CP2 Structure, and Vacuum Instability.



Adding Energy beyond the Critical Point will go into the Massless Realm of Unbroken Electroweak Symmetry where the Higgs Mechanism no longer gives Mass to Particles.