CMS LHC Run 2 - Higgs and Truth Quark

Frank Dodd (Tony) Smith, Jr. - 2019

Abstract

CMS histogram for 2016+2017+2018 LHC Run 2 at 13 TeV supports
3 mass states of the Higgs at about 125 GeV, 200 GeV, and 250 GeV
with Higgs and Truth Quark forming a Nambu-Jona-Lasinio System.

ATLAS (afaik) has not studied the mass range of 200 GeV and 250 GeV
since ATLAS-CONF-2017-058 which saw excess in 2015-2016 13 TeV data
around 240 GeV with local significance 3.6 sigma.

Fermilab CDF and D0 have, in addition to the Truth Quark 174 GeV state,
seen indications of Truth Quark mass states around 130 GeV and 220 GeV
but the Fermilab Consensus has dismissed them as statistical fluctuations.

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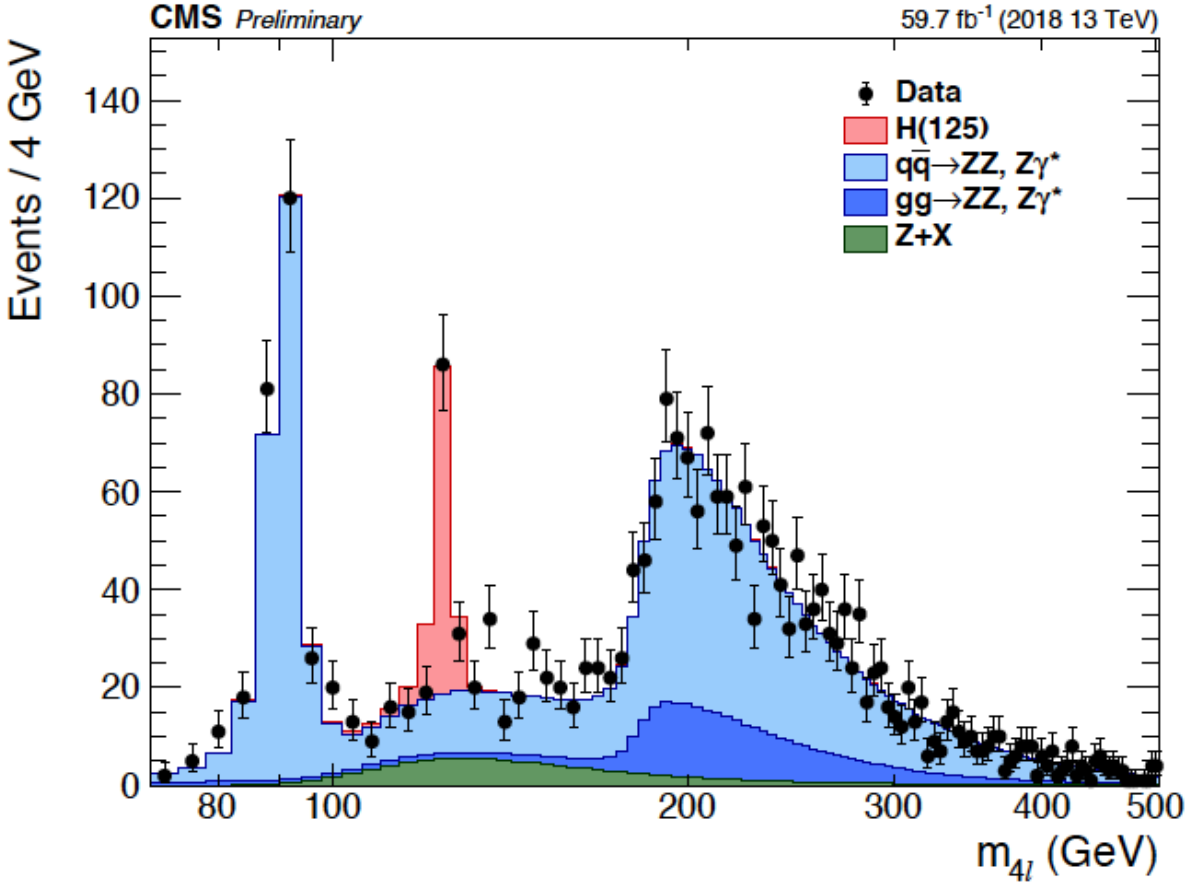
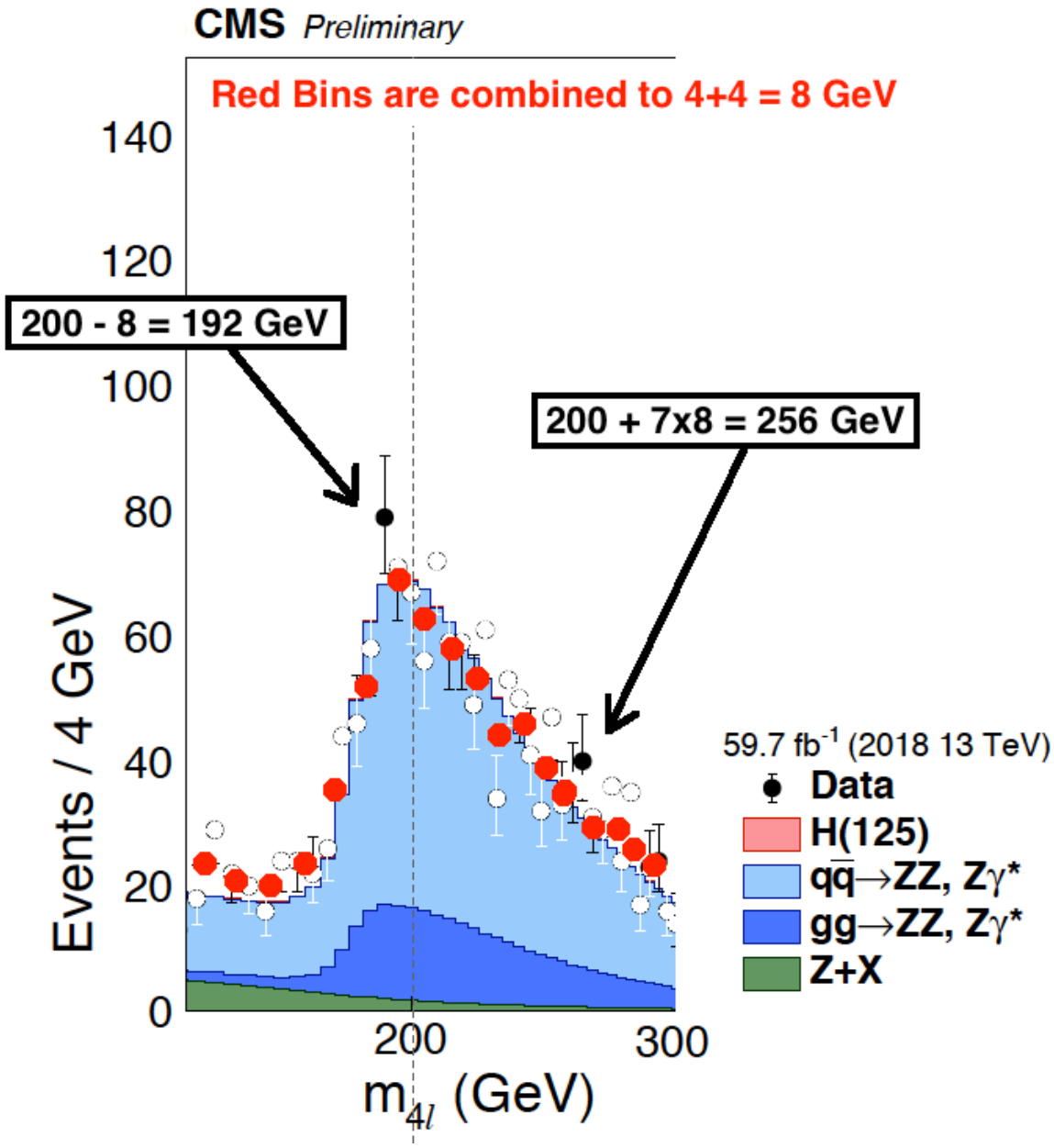
CMS Higgs -> ZZ* -> 4l LHC Run 2 of 59.7 fb-1 (2018 13 TeV)

CMS HIG-19-001-pas dated 2019/03/22 figure 6 (left) shows
"... Distribution of the reconstructed four-lepton invariant mass m4l
up to 500 GeV ... 59.7 fb-1 (2018 13 TeV) ... Events / 4 GeV ...

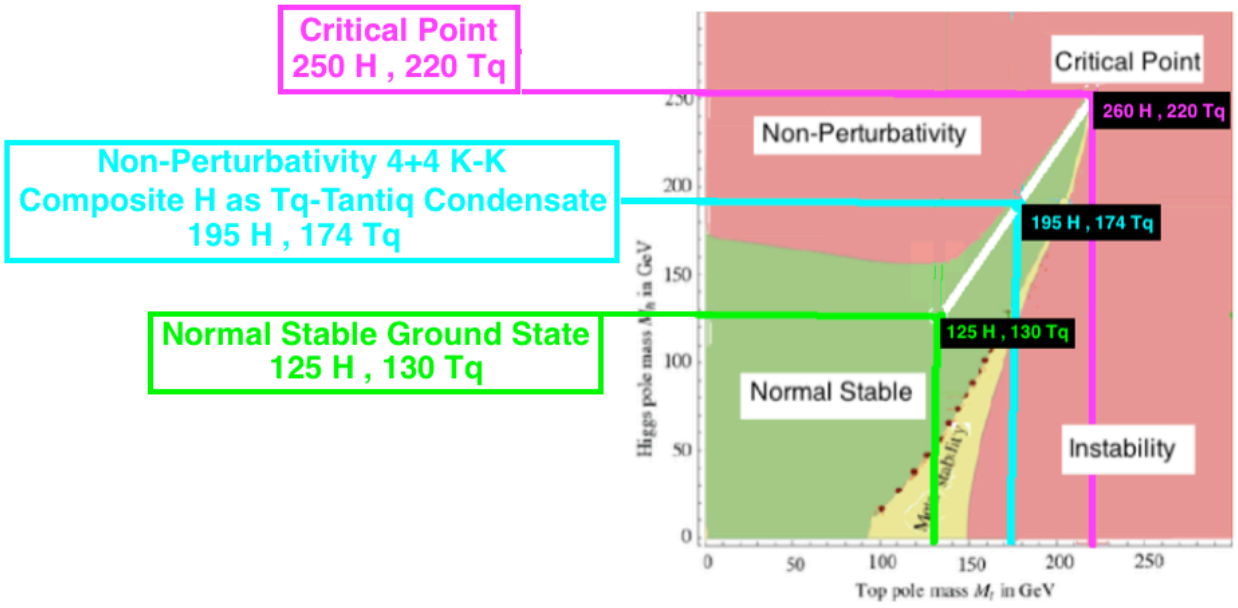


...". In my view there are two Higgs mass peaks in addition to the prominent one at 125 GeV:
one at l92 GeV and another at 256 GeV
but
with the narrow 4 GeV bin size used by CMS the data points have so much random fluctuation that, as Tommaso Dorigo said in a 16 May 2011 blog post, "... might distract the user's attention from the important features of the distribution ...". As Lubos Motl commented on that blog post "... the main trade-off here is clear. ...
If the bins are too narrow, you lose the information about the y-coordinates **-** the number of events / objects in each bin becomes too fluctuating ...
It's always possible to merge bins into bigger ones **...**"

I left the 4 GeV bins for 192 GeV and 256 GeV as is
and, in the range of about 150 GeV to about 300 GeV,
combined the other 4 GeV bins pairwise with their neighbors to get 8 GeV bins
with the combined bin data points shown as red dots.
It is then very clear to me that the two black-dot 4 GeV bin peakis at 192 and 256 GeV
are shown by the 2018 LHC Run 2 at 13 TeV to be real


CMS Preliminary
Red Bins are combined to 4+4 = 8 GeV
200 - 8 = 192 GeV
200 + 7x8 = 256 GeV
Events / 4 GeV
m4l (GeV)
59.7 fb-1 (2018 13 TeV)
Data
H(125)
qq̄→ZZ, Zγ*
gg→ZZ, Zγ*
Z+X

The reality of the 192 GeV and 256 GeV peaks means that the Higgs and the Truth Quark form a Nambu-Jona-Lasinio type system with three mass states:



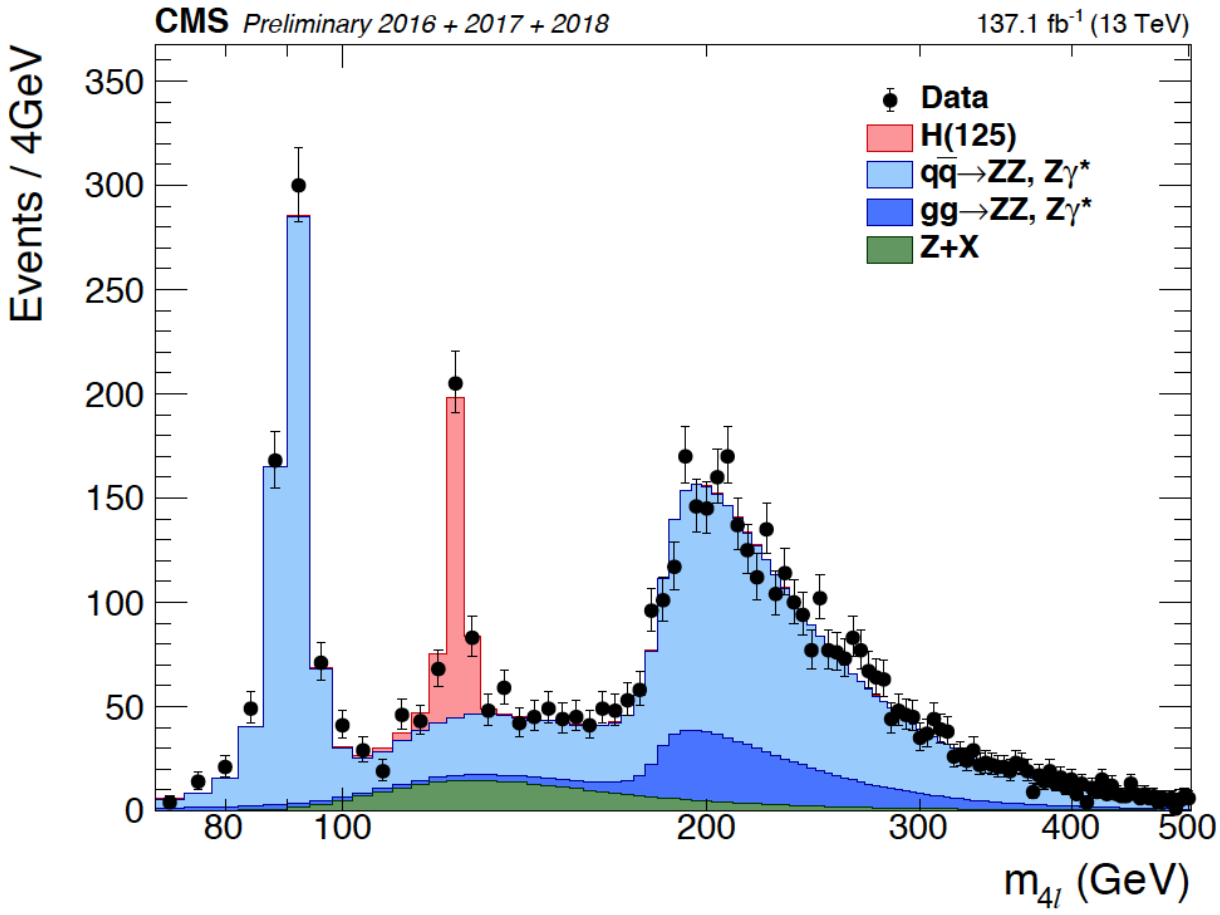
The Green Dot where the White Line originates in our Ordinary Phase is the **Low-mass state of a 130 GeV Truth Quark and a 125 GeV Higgs**.

The **130 GeV Truth Quark 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 ... We then find that the top condensate can be the MAC for D=8 ... We predict masses ... 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 ...".
Pierre Ramond says in his book Journeys Beyond the Standard Model (pp. 175-176):
"... The Higgs quartic coupling has a complicated scale dependence ... it is natural to think that ... the Higgs actually is a composite ...".

The Magenta Dot at the end of the White Line is the **High-mass state of a 220 GeV Truth Quark and a 250 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.

CMS HIG-19-001-pas dated 2019/03/22 figure 7 (left) shows
"... Distribution of the reconstructed four-lepton invariant mass m4l up to 500 GeV ...
with full Run 2 data. ... 137.1 fb-1 2016+2017+2018 (13 TeV) ... Events / 4 GeV ...

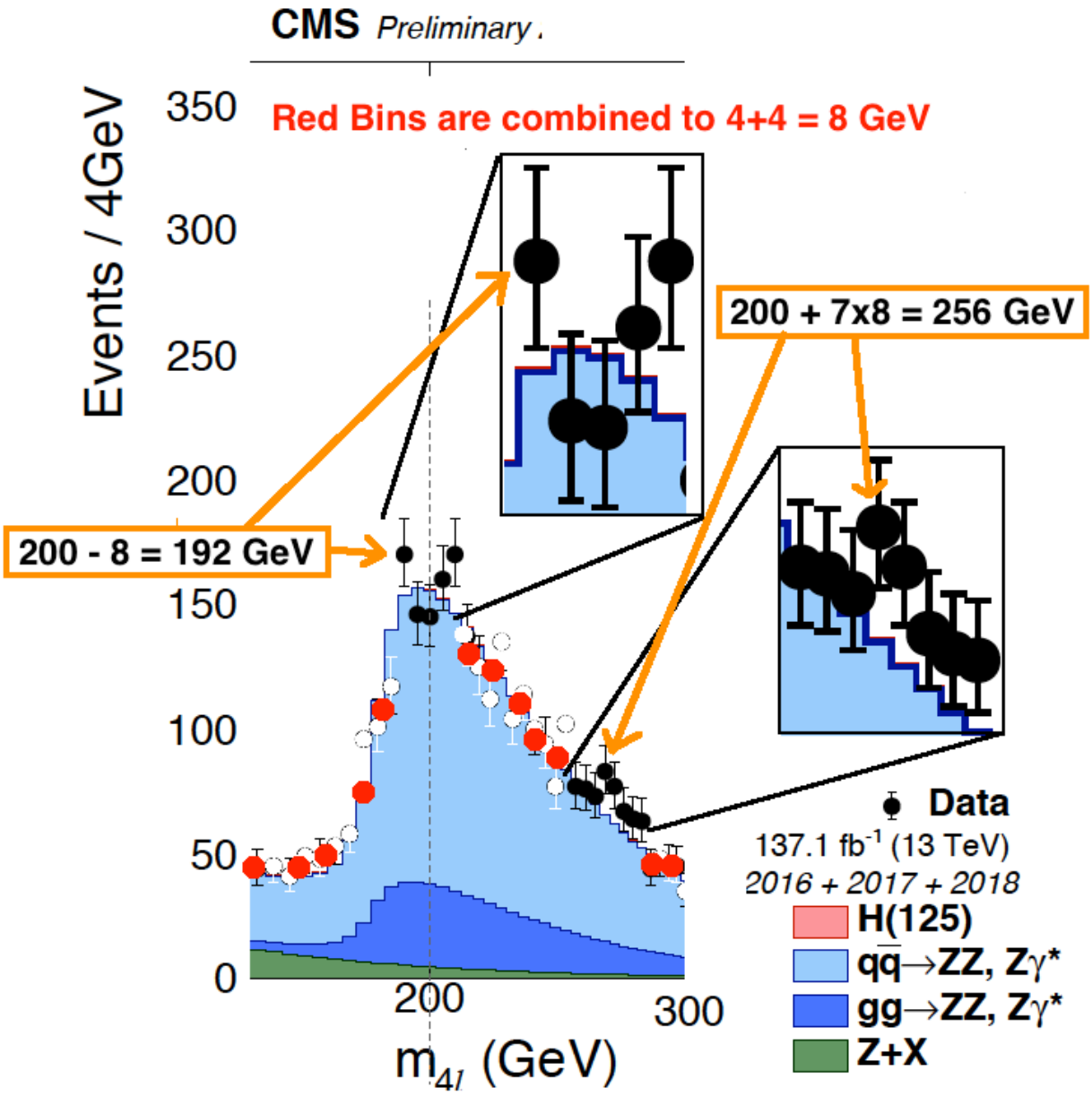


In my view the Higgs mass peaks at l92 GeV and 256 GeV
are also shown in the full Run 2 histogram
but
the analysis is complicated by combining data from 2016 and 2017 with 2018
as there seem to be some differences in the way data was processed and analyzed.

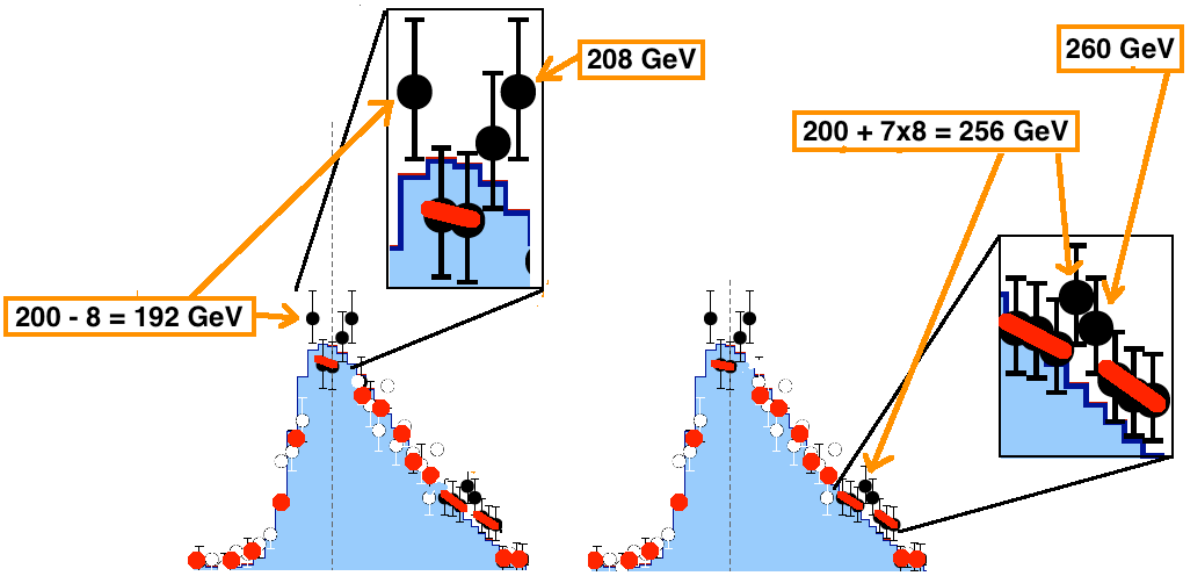
The first things to take into account are the facts that
the 192 GeV bin (4 GeV) seems to be part of a cluster of 5 bins (4 GeV each)
and
the 256 GeV bin (4 GeV) seems to be part of a cluster of 8 bins (4 GeV each)

so

I did pairwise combination of 4 GeV bins to 8 GeV bins (as for the 2018 histogram)
in the range from about 150 GeV to about 300 GeV for 4 GeV bins outside those clusters
with the combined bin data points shown as red dots
with the result that the two clusters are clearly exceptional
and the red-dot background is nice and smooth



The next steps are to analyze the two clusters in detail.



The cluster with the 192 GeV peak has 5 bins (4 GeV each).
The 192 GeV bin is the peak seen in the 2018 histogram.
The 196 GeV and 200 GeV bins are consistent with pure background.
The 204 GeV and 208 GeV bins are consistent with
the 205 GeV peak in Figure 2 (upper left) of the CMS paper at arXiv 1804.01939

The cluster with the 256 GeV peak has 8 bins (4 GeV each).
The 244 GeV and 248 and 252 GeV bins are consistent with pure background.
The 256 GeV bin is the peak seen in the 2018 histogram.
The 260 GeV bin is consistent with
the 265 GeV peak in Figure 2 (upper left) of the CMS paper at arXiv 1804.01939
The 264 GeV and 268 GeV and 272 GeV bins are consistent with pure background.

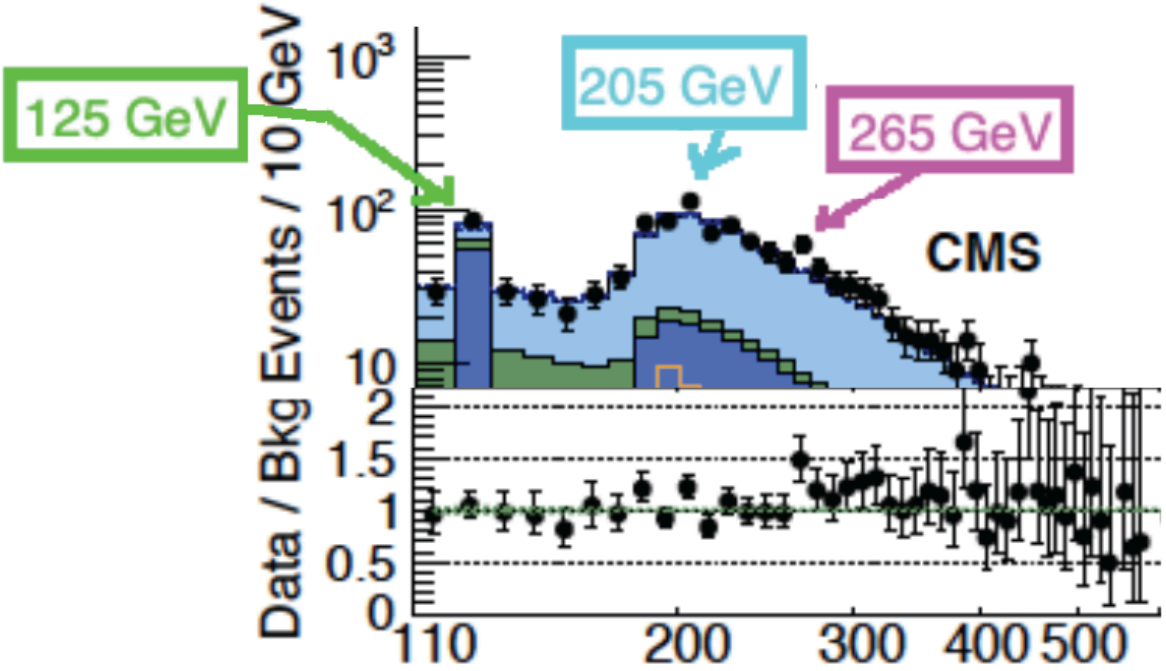
Therefore, taking into account
the need to combine 4 GeV bins into 8 GeV bins to get a smooth background
and
the fact that the 2016+2017+2018 histogram must deal with possibly varying
methods of data collection and analysis for 35.9 fb-1 from 2016 and 58.7 fb-1 from 2018
plus 2017 data, all to be combined into 137.1 fb-1 for the 2016+2017+2018 histogram,

it seems to me that the CMS 137.1 fb-1 2016+2017+2018 histogram also supports
the Higgs and the Truth Quark
as a Nambu-Jona-Lasinio type system with three mass states

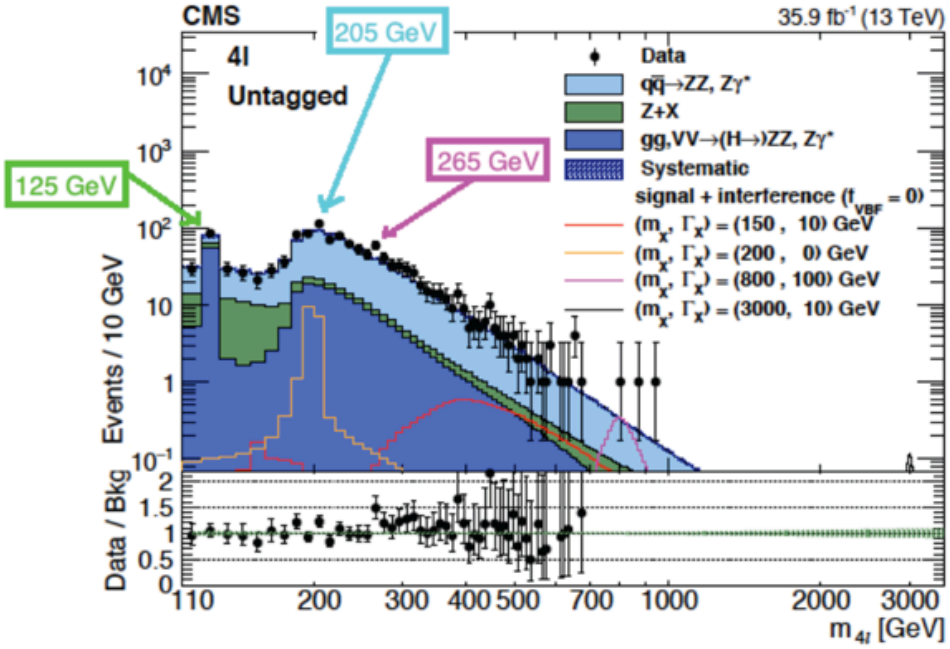
The next page shows detail of the CMS 2016 histogram for 35.9 fb-1.
It used 10 GeV bins and got a very smooth background.
Even with its log scale for Number of Events,
the two peaks (205 GeV and 265 GeV) are clearly real.

35.9 fb-1 at 13 TeV for 2016

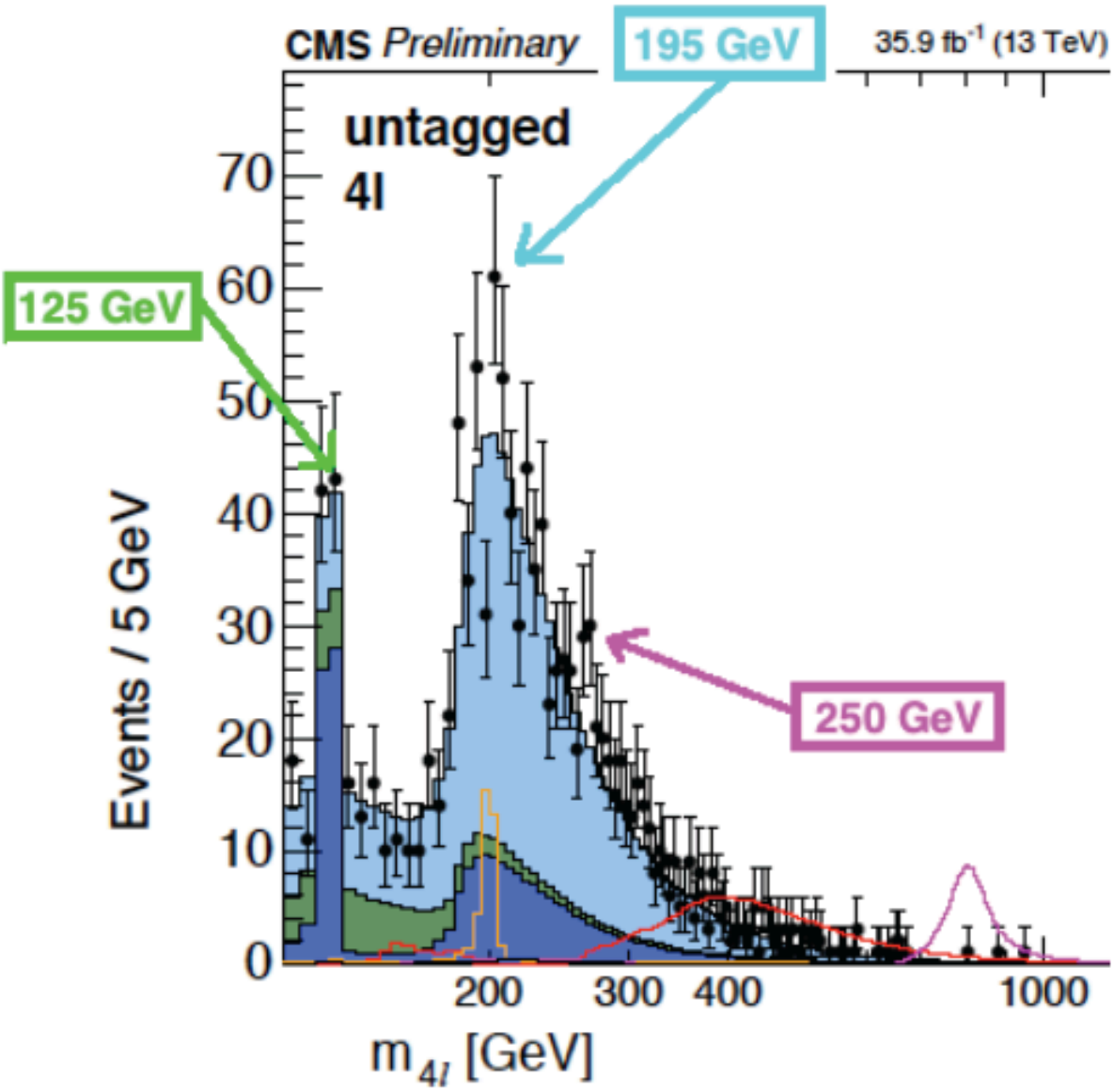
CMS in arXiv 1804.01939 showed a 4 lepton log scale histogram with 10 GeV bins
As you can see, with 10 GeV bins the background is very smooth
and the two peaks at 205 GeV and 265 GeV are obviously there
but shifted with respect to the 2018 histogram from 192 GeV and 256 GeV.



Here is the full histogram from arXiv 1804.01939

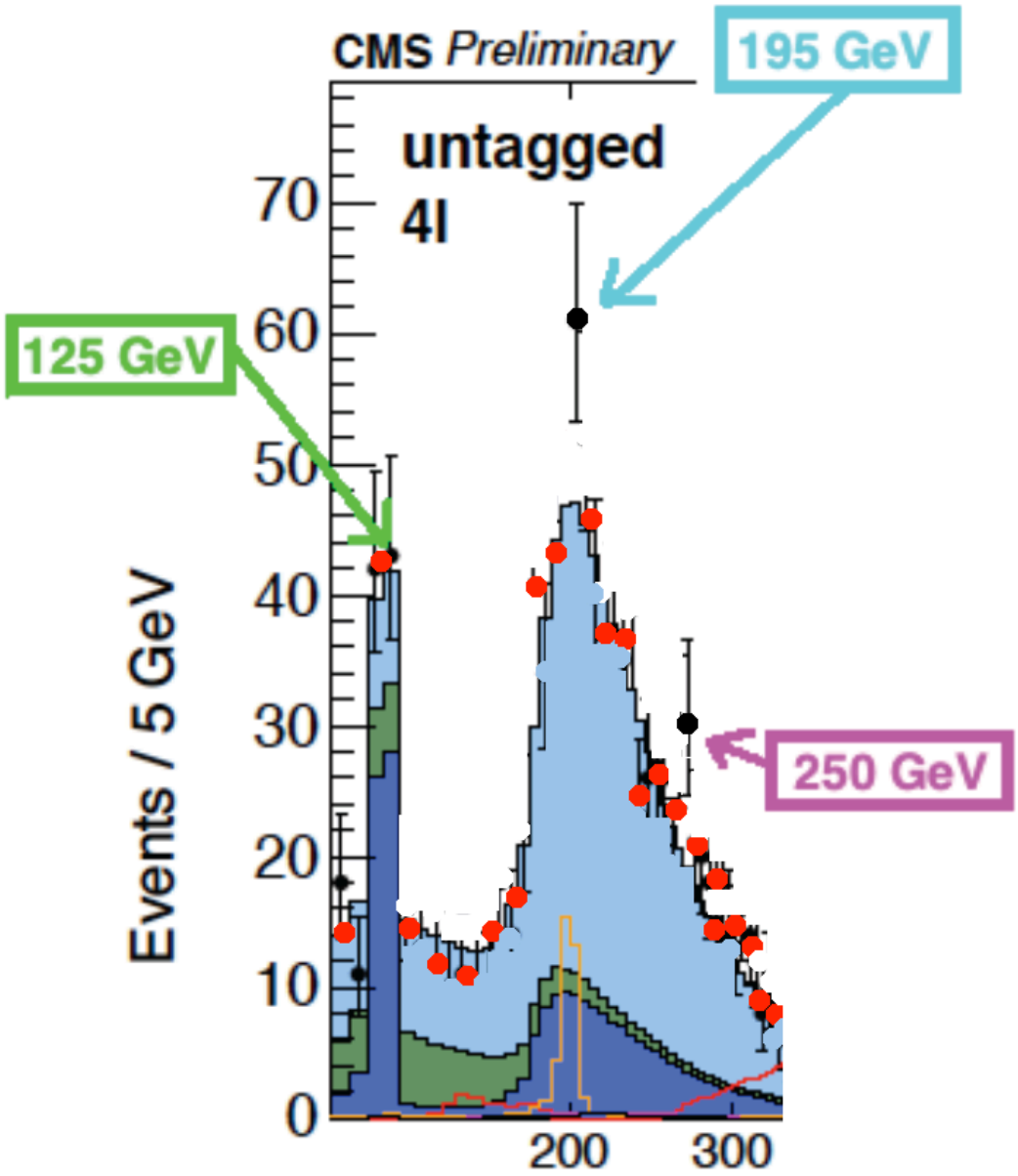


For the same 35.9 fb-1 2016 data
CMS PAS HIG-17-012 showed a 4 lepton linear scale histogram with 5 GeV bins
As you can see, with 5 GeV bins the background has a lot of fluctuations
that not only make the background seem noisy
but also obscures the 205 GeV and 245 GeV peaks of the 2016 histogram
and shifts them from 205 GeV to 195 GeV and from 265 GeV to 250 GeV



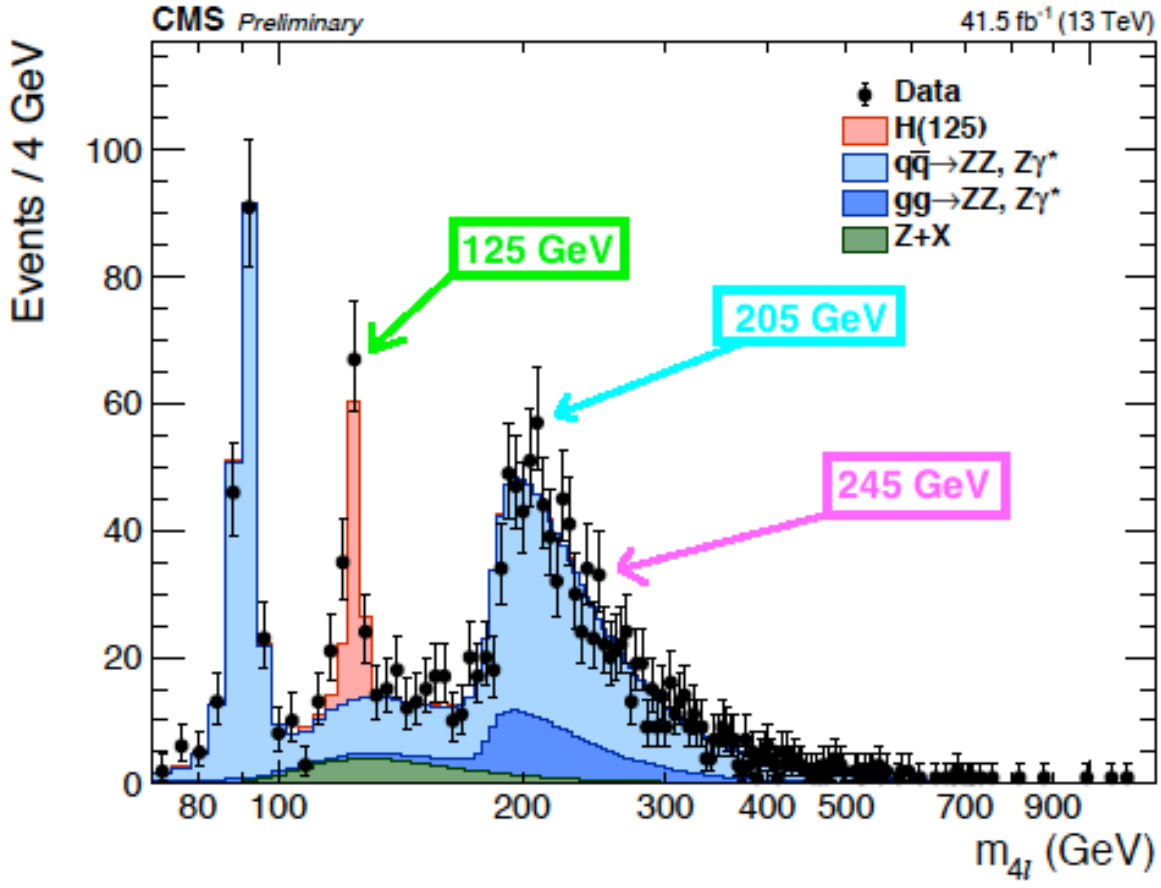
Also, note what happens when you combine 5 GeV bins pairwise to 10 GeV bins
for all bins except the peak bins at 195 GeV and 250 GeV of the 2016 linear histogram
which have been shifted with respect to the 2018 histogram
from 192 GeV to 195 GeV and from 256 GeV to 250 GeV

The background becomes smooth (just like CMS showed when it used 10 GeV bins)
and the peaks at 195 GeV and 250 GeV become obvious
and
even the 125 GeV peak seems to be naturally a 10 GeV pair of bins
instead of a single 5 GeV bin.



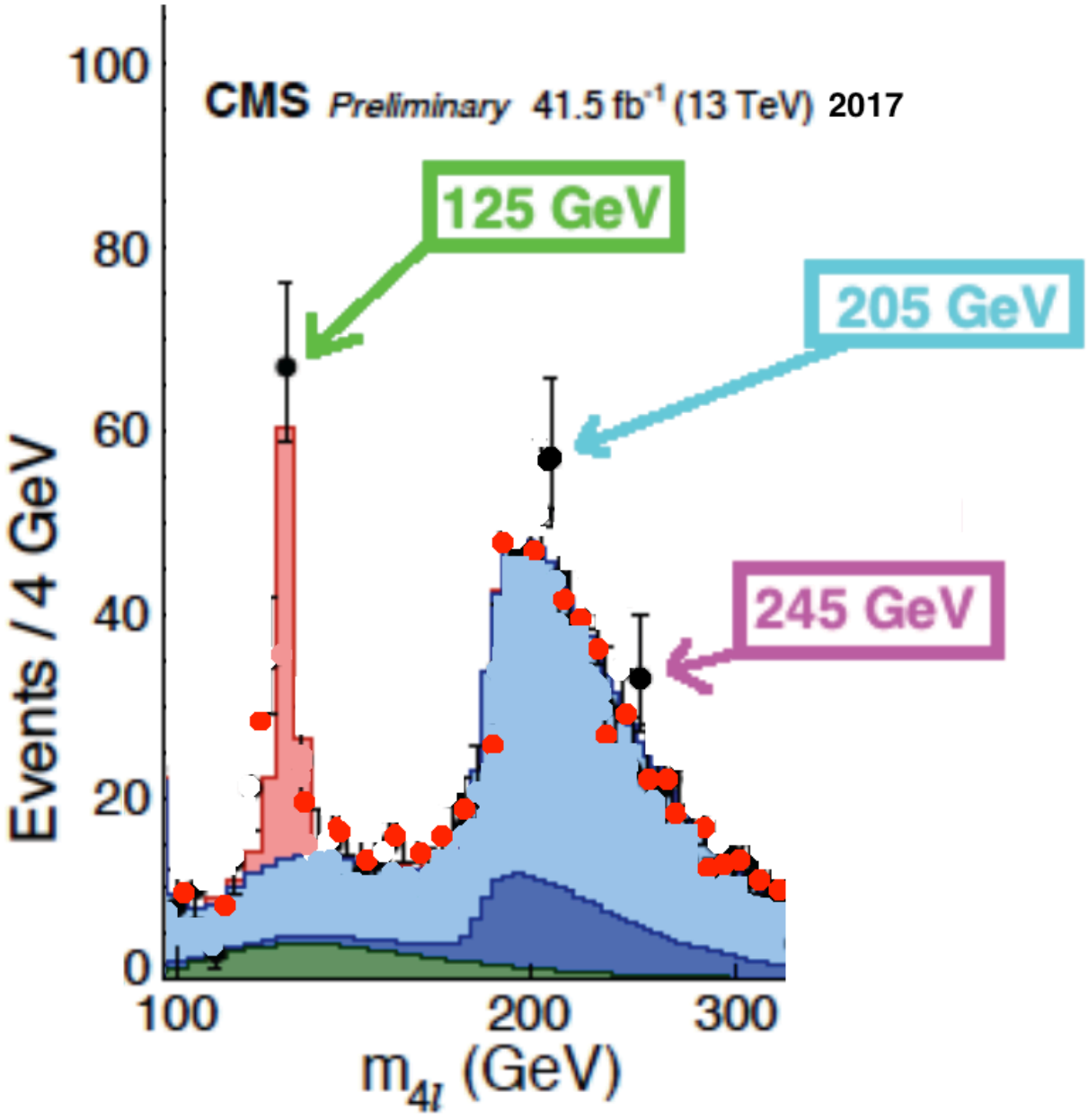
41.5 fb-1 at 13 TeV for 2017

CMS-PAS-HIG-18-001 showed a 4 lepton histogram with 4 GeV bins
As you can see, with 4 GeV bins the background has a lot of fluctuations
that not only make the background seem noisy
but also obscures the 205 GeV and 245 GeV peaks of the 2017 histogram
which have been shifted with respect to the 2018 histogram
from 192 GeV to 205 GeV and from 256 GeV to 245 GeV



Note what happens when you combine 4 GeV bins pairwise 8 GeV bins
for all bins except the peak bins at 205 GeV and 245 GeV of the 2017 histogram
which have been shifted with respect to the 2018 histogram
from 192 GeV to 205 GeV and from 256 GeV to 245 GeV

The background becomes smooth (just like CMS showed when it used 10 GeV bins) and the peaks at 205 GeV and 245 GeV become obvious



What about ATLAS ?

ATLAS reported in ATLAS-CONF-2017-058 for H -> ZZ -> 4l channel that 2015-2016 13 TeV data showed

"... excess ... observed ... around 240 ... GeV ... with local significance 3.6 sigma ...".

However,

I do not know of more recent analyses by ATLAS of Higgs mass states around 200 GeV and 250 GeV.

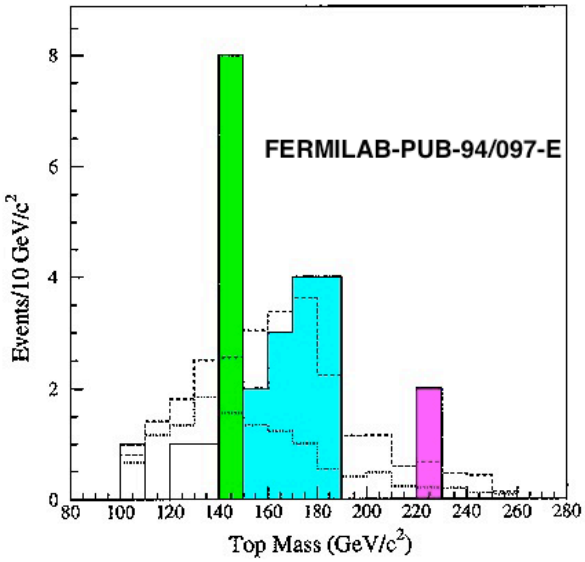
For example,
ATLAS-CONF-2018-018 said that it

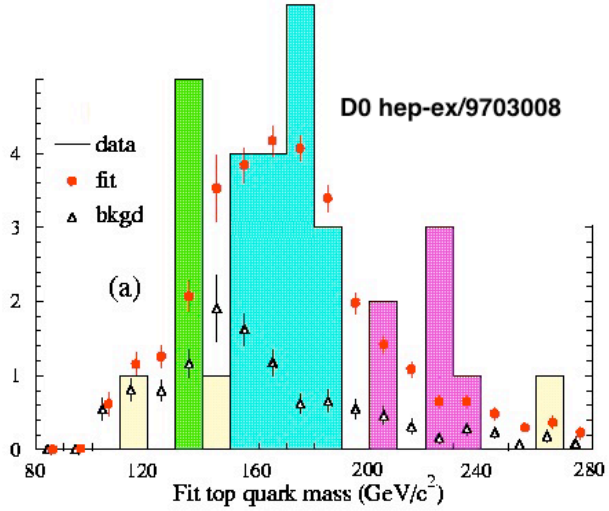
"selected ... Higgs boson candidates within a mass window of 115 GeV < 4l < 130 GeV"

thus ignoring anaalyses of Higgs mass states around 200 GeV and 250 GeV.

What about the Truth Quark ?

The Official Consensus of Fermilab is that
the low-mass green peaks of the CDF and D0 semi-leptonic histograms
(and the high-mass magenta peaks which are indeed less prominent)
are only statistical fluctuations.





Tommaso Dorigo said that

the significance of such similar green peaks
being seen by both CDF and D0,
consistent with my model prediction,
is 4 sigma.

In light of that, and other details of Fermilab data analysis
that I have described in viXra 1804.0121 and other papers,

I think that accurate analysis of Fermilab data will support
a Truth Quark - Higgs 3-mass-state Nambu-Jona-Lasinio System.