Wjj excess from a Higgs boson, Composite States

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Abstract

The newly found dijet peak in the 120 GeV - 160 GeV mass region produced in co-production with W ISR actually a Higgs boson in spite of the expectation of a different decay pattern for most Higgses. Our point, however, is that the bound state of $6t + 6\bar{t}$, which we have put forward already in several articles [4–11], easily could be lighter – possibly even much lighter – than half a Higgs mass. Since this bound state, if it existed should certainly couple strongly to the Higgs, the Higgs would in this case decay dominantly to two of our bound states. If these bound states were indeed very light (say $\approx 10$ GeV mass) their decay products into hadrons would look like two jets, one for each bound state. That even a very small mass for our bound state is not unexpected insofar as it is a part of our model that especially the top-quark-Yukawa coupling is being tuned in so as to make precisely this bound state of $6t + 6\bar{t}$ become (approximately) massless. This tuning is a consequence of our Multiple Point Principle (MPP) [12–14] which states that realized parameter/couplings values correspond to having a maximally set of degenerate vacua.

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1 Introduction

Recently there has been seen a three standard deviation “peak” \[1\] in the mass spectrum of dijets in co-production with a $W$-boson. The mass of around 144 GeV would be perfect for it being a Higgs boson in the Standard Model, actually agreeing even with our own prediction for the Higgs mass of 135 GeV \[2\], or a bit lower \[3\]. However, the decay into $b + \bar{b}$ which is the decay channel that would show up as a dijet-decay should only provide 12 fb of the events observed rather than the about $\sim 4$ pb actually making up the possible peak observed. Thus the Tevatron collaboration \[1\] asserts that the new particle is not the Higgs.

Previously we have already discussed in several articles \[4–11\] a model in which a cluster of $6t + 6\bar{t}$ is kept together by Higgs exchange and helped by gluon exchange to form a bound state with a mass tuned in to be very small, compared say to 12 top masses. Crudely this bound state should couple as strongly to the Higgs as 12 top-quarks. Even if this should be a strong overestimate, it is hard to see that the decay of the Higgs into a pair of such bound states should not dominate the usually expected decay modes for the Higgs, at least as long as we compare to decays involving the rather small bottom-Yukawa-coupling (squared in the rate) $g_b$, – as for the $b + \bar{b}$ decay – or decays into virtual $Z$ or $W$’s. Now the decay of the Higgs into a couple of our bound states would – if these bound states are sufficiently light and that could easily happen, since they in our model are finetuned\[^{2}\] to be light – look like the Higgs decaying into two jets. So if our bound state is appreciably lighter than the Higgs mass, it will cause the Higgs to decay dominantly into a couple of hadronic jets, i.e. a dijet.

The peak observed by CDF should in our model – assuming the bound state to be indeed tuned light – consist of almost all the Higgses produced with an associated event of the type selected, rather than only of the sub-sample decaying via $b + \bar{b}$ as usually assumed. Very crudely we could say that the decay into the $b + \bar{b}$ channel is suppressed by a factor of the order of the bottom-quark-Yukawa coupling $g_b$ squared, $g_b^2$, compared to a channel with coupling of “order unity” as we should expect our two bound states channel to have. Since the bottom-Yukawa-coupling is of the order of $g_b \approx 1/30$ our decay rate of the Higgs into bound state pairs would be of the order of $1/g_b^2 \approx 900$ times bigger than the decay rate into $b + \bar{b}$. Thus an expected into $b + \bar{b}$ decaying cross-section $\sigma \cdot P(b + \bar{b}) \approx 12$ fb would potentially allow for a cross-section into bound states - which we suggest is what is observed – of the order of $900 \cdot 12$ fb $\approx 10$ pb. But that would be an over estimate, because in our model the branching ratio for Higgs into $b + \bar{b}$ would likely be appreciably diminished compared to the usual picture (i.e. without our bound state). Even the cross-section for the peak observed $\approx 4$ pb may be a bit high for Higgs production at all.

Really the problem is that whole cross-section for Higgs in co-production with $W$ etc.

\[^{2}\]This finetuning comes from our by now old idea of MPP \[12–14\] which more recently can be weakly connected to the idea of a complex action \[14, 15\]. The latter is in turn forerun by idea more generally of non-locality \[16–18\], which we indeed invented trying to find an argument for MPP. Further C.D. Froggatt and I established that the existence of a light bound state is supported by calculations \[4, 6, 7, 10\] while our calculation is disputed in Refs. \[19–23\]. The idea of couplings being finetuned was also found in Baby Universe theory \[24-28\].
or $Z$ is more like 0.1 pb than the needed of the order of 4 pb even if all were observed. In the range of interesting, Higgs masses say crudely 100 GeV to 200 Gev the cross-section for co-production with $W$ falls from about 0.25 pb to 0.02 pb in the usually assumed Standard Model production mechanism.

With our bound state, or even better other particles in the family of our $6t + 6\bar{t}$ bound state presented as a virtual particle in possible mechanisms for Higgs production, a somewhat increased cross-section for Higgs production compared to the conventional picture is not excluded. 

With such an increased uncertainty in the up-going direction for the Higgs cross-section in our model compared to the conventional estimates the cross-section found for the peak observed of $\approx 4$ pb should be comprehensible.

I thus strongly suggest that what has been seen by CDF IS the Higgs, where the Higgs dominantly decays into two very light bound states looking like jets and therefore does not match with usual theoretical expectations for a Higgs.

In the following section we discuss a couple of arguments against that the observed peak should be due to a Standard Model Higgs. In the last section I shall conclude and resume stressing that our model with the bound state was indeed developed quite without any indication of the Higgs decaying into hadrons rather than in the conventional way with $W$ etc. except perhaps that there were some indications that the Higgs seen by LEP were effectively broad [29, 30].

2 Discussion of arguments against the peak being a Higgs

The Tevatron group investigated whether the dijets in the peak were more rich in b-jets than the surrounding mass regions as would have been the case, if the peak were due to $b + \bar{b}$ decay (of a conventional Higgs). There were NO significant excess of b-jets. If the jets are really decay products of our $6t + 6\bar{t}$ bound states, the question of finding an excess of b-jets – as was said not to have been found – would depend on whether the decay of our bound state would go preferentially to b-quarks. In the approximation of strong interactions dominating so that only gluons cause the annihilation of the several pairs of

\[ \text{In the family of bound states related to our most important} \quad 6t + 6\bar{t} \text{ state we have e.g. a bound} \]
\[ \text{state which is the same one but with one of the top quarks replaced by a (left) bottom-quark, or we} \]
\[ \text{may consider this related state as a resonance in the scattering of a W and our almost zero mass state} \]
\[ 6t + 6\bar{t}. \]  

This resonance we predict to have a mass in the region 400 GeV to 800 GeV. It could be used to enhance the effective $WWH$-vertex (i.e. the vertex between two $W$'s and one Higgs) compared to the Standard Model as usually assumed. This could come about by the two $W$'s exchanging this resonance in the 400 to 800 GeV range whereby they then become a pair of the light $6t + 6\bar{t}$-bound state virtually. Such a virtual pair couples very strongly to combine to become a Higgs. In this way we could obtain a loop diagram involving propagators in the loop corresponding to our bound states renormalizing the $WWH$-vertex relevant for the co-production of Higgs ($H$) with $W$.

Even if we say that the full $WWH$-vertex is measured effectively by the $W$-mass for Higgs four momentum being zero, there is still the possibility that the suggested loop part of the vertex could have so much four momentum dependence that a larger coupling at the four momentum for an on-shell Higgs is possible. Thus such a correction diagram could at least make the prediction of the rate of Higgs production with our bound states included more uncertain.

\[ \]
$t\bar{t}$ in the bound state there would be no special $b$-excess. So in this first approximation –
gluon dominance – our model agrees with the lack of $b$-excess in the peak. If, however,
$W$-exchanges should play a role in the disappearance of the top and anti-top quarks in
the bound states, an excess of bottom quarks in the decay is expected because of the
dominant weak ($W$) transition from top to bottom.

The genuine $b + \bar{b}$ decay which also looks like a dijet would as we crudely estimated
be down by a factor 900 and would hardly be observable in data.

Another argument against that the data with the peak revealing the Higgs is that a
neural network program has already looked for Higgses and generally careful Higgs studies
have also been done. However, neural networks looking for Higgses will likely look mainly
for decays that are with the characteristic lepton and missing transverse energy. Thus
such programs trained to look for the conventional Higgses will presumably not accept the
dijet decaying Higgs as a very promising candidate. Actually for the conventional Higgs
only the channel $b + \bar{b}$ with relatively small branching ratio, with lots of background will
be of the dijet type. If there are no signs of $b$-quarks the neural network will presumably
rank the chance that a dijet decay be a Higgs as very small.

The conventional Higgs decay modes will presumably be strongly reduced by the
Higgses decaying into pairs of our bound states. So we predict that the conventional Higgs
searches will have only little success.

3 Conclusion: Higgs found by CDF decay mainly into
two jet-like bound states!

In the present article I have pointed to that provided our bound state of $6t + 6\bar{t}$ [4–11] is
very light in accordance with our finetuning principle, “multiple point principle” (MPP)
[12–14], it is no longer a problem that the newly found particle co-produced with $W$ could
be a Higgs! Indeed our point is that the very light – exceptionally finetuned to be light –
bound state of $6 + \bar{t}$ couples strongly to the Higgs. Therefore the Higgs decays dominantly
into a pair of such bound states and likely shows up as decaying into two jets. Thereby
usually believed Higgs decays will not be able to compete (in branching ratio) and a
conventional Higgs search might lead to very few results. Of course, also a broader Higgs
width is expected in our model. Possibly the width seen in the observed peak extending
from around 120 GeV to 160 GeV could easily in our model reflect the genuine decay rate
rather than uncertainties in the mass measurement.

It should be stressed that the model with a six top plus six anti-top bound state
propagated in the present article were NOT made up for the purpose of the CDF-dijet-
mass-peak. Rather we have speculated and published our bound state idea as an extension
of our Multiple Point Principle (MPP) originally put in Refs. [12–14] as a fundamental law
stating that Nature seeks out values of parameters/couplings that correspond to having
maximally degenerate vacua. As the transition between the phases corresponding to the
various vacua are first order, our MPP also embodies a finetuning mechanism (due to
having finite heats of melting and fusion if one thinks in terms of the somewhat analogous
phase diagram for water).

Subsequently MPP has been used to explain the low weak scale [6, 31], or originally
to fit gauge coupling constants [12–14], and to provide a model for dark matter [11], and
to understand the value of the cosmological constant [32, 33]. Putting into our already
published model with the 6 top + 6 anti-top bound state the option that the mass of it is
lower than half the Higgs mass leads immediately to the purely hadronic and likely dijet
decay of the otherwise Standard Model Higgs. It should be stressed that our model is –
or at least could be – purely Standard Model in the sense that no new fields in addition
to those of the Standard Model go into our model. The only deviation is not truly a
deviation, but rather the addition of extra information:

We postulate that the coupling constants in the Standard Model are tuned to obey
relations between them guaranteeing that not only one, but rather three different vacua
shall have their vacuum-energy densities (or cosmological constants) be very small (es-
tentially zero).

One of these three vacua is supposed – in our model [4–11] – to be one deviating
from another in which we live by having a Boson condensate of our above discussed bound
state. It is the tuning of e.g. the top-Yukawa-coupling to make the vacua with and without
this condensate energetically degenerate that is supposed also to lead to the bound state
mass being small.

Contrary to the general belief that it is not possible to understand dark matter
without extending the Standard Model, our model can incorporate dark matter in the
form of pea-sized white dwarf stars – or of similarly strongly compressed matter – in
which the vacuum with the Bose-condensate of the very particle coming out of the main
Higgs decay in the prevailing vacuum inside the sea.

A potential further project might be to fit the CDF-peak discussed together with
the LEP findings [29, 30] as a tail of now assumed broad Higgs.

A possible way to confirm our model would be in the CDF-data to look for whether
the jets in the dijet should have a mass peak, i.e. for the jets for which total mass of
the jet of hadrons can be calculated sufficiently accurately over an abundance of jets with
a certain mass (of course, the mass of our NBS bound state, which we estimate to be
extremely narrow).

4 Acknowledgement

It is pleasure to thank Ivan Andric (Rudjer Boskovic Institute) for the first information
about the discussed CDF-peak and for further discussions during my visit to Zagreb. I
thank Larisa Jonke for funds. Also I thank my collaborators on the work about the bound
state from which almost all the present article could have been extracted, in particular,
Roman Nevzorov (Hawaii Univ.) for telephone conversations about the Higgs decaying
into our bound state at a very early stage in our developments of the bound state theory.
I am thankful of Don Bennett, C.R. Das and Larisa Laperashvili for some corrections
during the proof-reading. Also I want to thank Li Shi-Yuan (School of Physics, Shandong
University) and P.R. China for the collaboration long ago in ca 2000 on the question of
the decay of our 6t + 6t bound state.
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