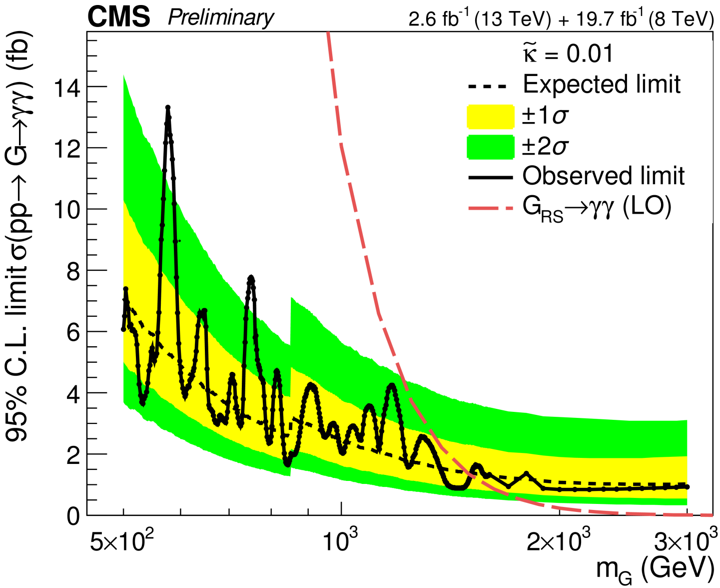
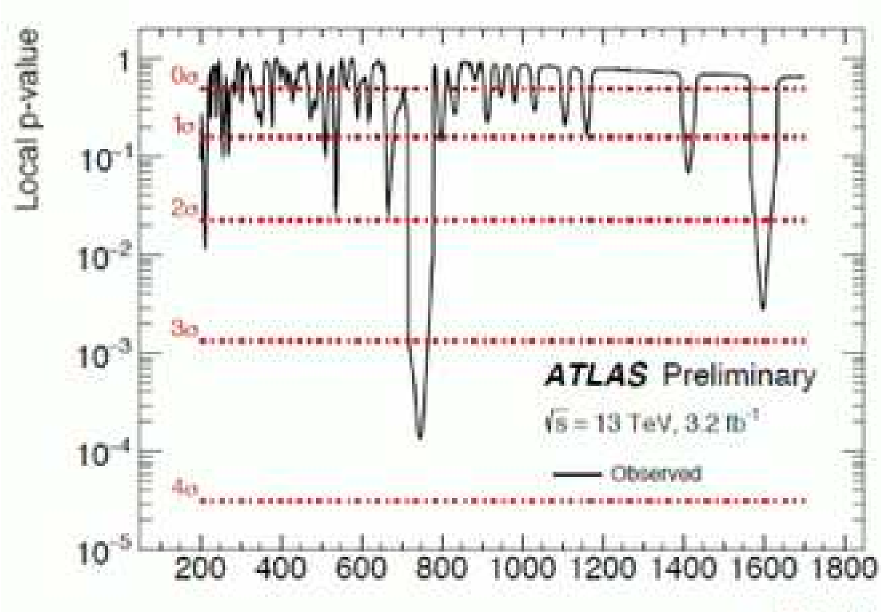
Interpretation of a newly found excess of diphoton decays in LHC as a bound state of 6 top + 6 anti top quarks.

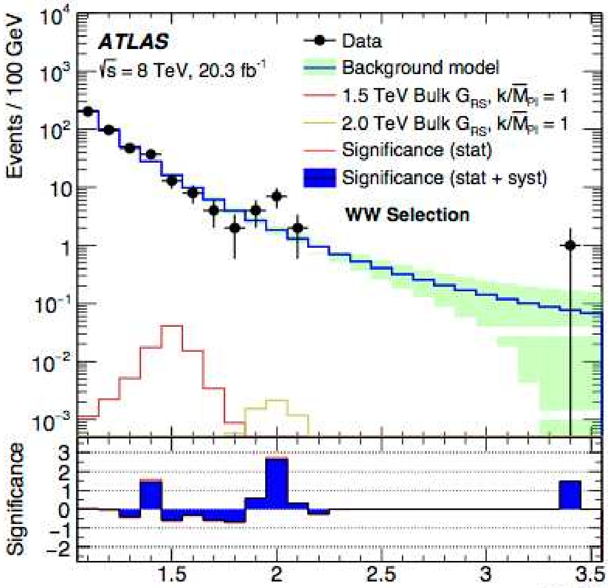
Last December (2015) the "Large Hadron Collider" at CERN(= Cooperation Europeene de Research Nucleaire) found some presumably not statistically significant enough to survive peak/excess in the spectrum of masses of two photons in proton + proton collissions with energy together $\sqrt{s} = 13 TeV$ (TeV means terra electron volts, i.e. energy achieved by a charge quantum by passing a potential difference of 10^9 volts) at the mass-value $\sim$ 750 GeV = 0.75 TeV for the potentially existing "new" particle.


CMS Preliminary
2.6 fb-1 (13 TeV) + 19.7 fb-1 (8 TeV)
κ̃ = 0.01
Expected limit
±1σ
±2σ
Observed limit
GRS→γγ (LO)
95% C.L. limit σ(pp→ G→γγ) (fb)
mG (GeV)
0
2
4
6
8
10
12
14
5×10^2
10^3
2×10^3
3×10^3


Local p-value
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0σ
1σ
2σ
3σ
4σ
ATLAS Preliminary
$\sqrt{s}$ = 13 TeV, 3.2 fb^{-1}
Observed
200 400 600 800 1000 1200 1400 1600 1800

“Diphoton”

Since the perhaps exisitng new particle with mass 750 GeV = 0.75 TeV is seen to become a pare of lightquanta /photons we call it “diphoton”. An unstable particle we typically call resonance.
We call it “new” because it seems - and my colleagues believe - that there is no place to understand inside the at so phantastically well functioning quantum field theory “The Standard Model” for the observed 750 GeV resonance. It namely then in principle signals that the true theory / the true model must be another one than this Standard Model.
Only I and my collaborators see this resonance as being inside the Standard model!


ATLAS
√s = 8 TeV, 20.3 fb-1
Data
Background model
1.5 TeV Bulk G_RS, k/M_Pl = 1
2.0 TeV Bulk G_RS, k/M_Pl = 1
Significance (stat)
Significance (stat + syst)
WW Selection
Events / 100 GeV
Significance
1.5
2
2.5
3
3.5

Standard Model

The Standard Model is a quantum field theory.
When using it one almost allways uses *perturbation* approximation, which means that one assumes that a series of parameters in the model(such as the Standard Model) called coupling constants are so small that we can expand in them.
But especially what concerns the part of the Standard Model involved with the gluons and the quarks has some effective coupling constant to be used in the energy range og a few GeVs which is *not* small. This gives raise to the regime of *strong interactions* and of hadrons which *cannot* be treated alone by perturbation theory.
So one supplements by speculative approximations, confinement ...
Actually the main message of my interpretation of the "new" resonance(s) (there is actually also one with mass 1.8 TeV) is as a non-perturbative effect - a bound state - inside the Standard Model!

Our (= Froggatt's, Laperashvili's, and mine (etc.s?)) Main Point:

In spite of the hopes of my colleagues, that the new resonances represent *new fundamental particles* and thus shows the way to the model behind the Standard Model *we* claim that we can speculate these resonances to **exist inside the pure Standard Model**, so that **no new physics is needed!**

Well, Not Quite though:

We developped our bound state ideas long before the recent experimental potential finding of "our bound state"(s) under the extra assumption of a **new law of nature**, which we (Bennett (and Brene), me and Froggatt) proposed and call "Multiple Point Principle".

Our New Law of Nature, "Multipel Point Principle"

Myself and my collaborators - mainly Donald Bennett og Colin D. Froggatt (and at very early stage N. Brene involved)- propose a new law of nature (Multipel Point Principle):
There are several vacua(=states of empty space) with very very small energy densities (=cosmological constants= dark energies). It is a situation analogous to a combination of e.g. ice and water. A situation, which enforces just the temperature 0^0 Celsius. That such a combination in spite of the temperature being special is rather common is supported by the fact that we have a special word for such a mixture "slud".

“Multipel Point Principle” (Our Own Law of Nature) Predicted Something

Our own speculative law of nature in fact *predicted*:

- The number of families In a very speculative and presumably too complicated model - with multipel point principle built into it (even though we did not talk about that at that time) we (Niels Brene, Don Bennett, ...and me) fitted the finestructure constants, parameters/coupling constants analoguos to the electric elementary charge squared (divided by 4π), and used the number of families as a parameter (=e.g. antallet af electron-analogous charged particles: electron, μ og τ). We fitted 3 and *later* it were found that there were indeed 3 families. Hurra!

Predictions continued:

- The mass of the Higgs boson Under use of pure Standard Model (the best for the time being for accelerator physics) and of Multipel Point Principle Colin Froggatt and I *pre*dicted the Higgs-boson mass to be $135 GeV/c^2 \pm 10 GeV/c^2$. At that time the Higgs-boson were only theory. It was first found in 2012, $\sim$ 20 years later, and even after I had been painted together with the Danish member of cabinet Mogens Lykketoft and the predicted Higgs mass behind his head.

kunstmaler lars andersen http://www.23.dk/skak.htm

Lars Andersen

Historiemaler Portrætmaler Provokunstner Om Lars Andersen CV/omtale Kontakt

Plan for
"Interpretation of a newly found excess of diphoton decays in LHC as a bound state of 6 top + 6 anti top quarks."

QFT, Standard Model

The situation in high energy physics research for the moment is:

- Experiment The for the time being accelerator most at the front is LHC(=Large Hadron Collider), but there are many other types of experiments, such as neutrinoes being searched in the ice at the south pole...
- Theory For the accelerator experiments the "Standard Model" works perfectly so far; but for neutrino experiments reason as well as for theoretical and astronomical reasons it has severe *problems*.
- Standard Model is QFT The Standard Model is a special Quantum Field Theory, and such theories, I would say, have in themselves at least some philosophical problems.

Classical Fields Standard Model

The Standard Model is always meant to be a *quantum* field theory, but for putting it forward I would like to first present the corresponding theory with *classical fields*:
This classical model is constructed as a trivial vector (fiber) bundle with fiber being cross product with in total 90 complex-dimensional Grassmanian odd vector space and a two complex-dimensional (the Higgs). Then in addition there is a connection with the structure group/gauge group $S(U(2) \times U(3)) \sim U(1) \times SU(2) \times SU(3)$.

Standard Model

The gauge (= structure) group is $S(U(2) \times U(3))$, which has the same Lie *algebra* as $\mathbf{R} \times SU(2) \times SU(3)$. (The group $S(U(2) \times U(3))$ could be defined as this covering group divided by a $\mathbf{Z}$-isomorfic discrete subgroup of the center generated by the element $(2\pi, -\mathbf{1}, \exp(i\frac{2\pi}{3})\mathbf{1}))$. The connection is described by a gauge (four vector) field taking values in the Lie algebra. So it needs a special assignment of meaning, if you make sense of the Standard Model having a specific gauge-*group*. (Any representations for the vector bundle fields could be allowed for the covering group, but some possible representations for the Lie algebra would not be allowed for a specific group with the same Lie algebra as e.g. the *Lie group* $S(U(2) \times U(3))$). O'Raifaitaigh takes the phenomenological gauge *group* to be the one compatible with the representations/the fields of fermions and Higgses having *minimal* set of representations.

Standard Model (continued)

Could define a "phenomenological gauge *group*" (with emphasis on group) by saying, it is that group that can be represented on all the representations - all the fields - of the gauge Lie algebra present in the model(say the Standard Model) and which has the fewest representations among these allowed groups. (the various groups have infnite numbers of (linear) representations, but there is of course an ordering on the sets of representations by inclusion). Such a definition of "the" gauge-*group* for the Standard Model is the basis for declaring, that it is $S(U(2) \times U(3))$ rather than any other Lie group with the same Lie algebra as
$U(1) \times SU(2) \times SU(3)$.
Part of the success of the "grand unification theories" with e.g. $SU(5)$ as the grand unification group is that we as group have $S(U(2) \times U(3)) \subset SU(5)$, so that there in the Standard Model only occur those representations, that could also be in $SU(5)$.

Matter Fields of Standard Model

With the by Nature - so to speak - selected Gauge group $S(U(2) \times U(3))$ the vector bundle has of course to have fibers which are representations of this group. There are two types of fields (=sections) 1) fermionic and 2) bosonic. The representations are in notation for representation of $U(1) \times SU(2) \times SU(3)$ and the charge for $U(1)$ denoted $y/2$:

- Fermionic 3 (it was this 3 we PREdicted) times left handed Weyl fermions of each of the five irreducible representations:

$$q_L = (y/2 = 1/6, \mathbf{2}, \mathbf{3}) \quad , \quad \bar{u}_L = (y/2 = -2/3, \mathbf{1}, \bar{\mathbf{3}}), \quad (1)$$

$$\bar{d}_L = (y/2 = 1/3, \mathbf{1}, \bar{\mathbf{3}}) \quad ; \quad (2)$$

$$l_L = (y/2 = 1/2, \mathbf{2}, \mathbf{1}) \quad , \quad \bar{e}_L = (y/2 = 1, \mathbf{1}, \mathbf{1}) \quad (3)$$

- Bosonic

$$Higgs = (y/2 = 1/2, \mathbf{2}, \mathbf{1}) \quad (4)$$

Standard Model Fundamental Particles (and Fields)

Gauge Group

What I think has come a bit as a surprise to the physicists, is how much it is Yang Mills theories/ gauge theories/ connections that play the major role in the Stanrd Model, which step by step has been found to be the right one for the time being.
In a way the gauge group corresponding to the Standard Model - the successful one - seems to me just a rather random Lie group a priori. But I claim "characteristically small faithful representations"!

Problems for Standard Model

- 1. It is *only* “renormalizable” i.e.:If one calcualtes naively on it one gets divergences/nonsense results (of the type of meanigsless integrals $\int \frac{d^4q}{q^4}$ eller 1+2+3+...). The ca. 20 parameters get meaningless/divergente/infiite, but measurable quantities come out o.k. *at the end*.
- 2. If adding gravity it is not even “renormalizable”, i.e. even mausurable quantities do not come out in principle o.k. any longer. [But practically it goes well, because gravity is so weak (for few particles.)]

Standard Modell Problems Continued

- 3. Standard Model $\rightarrow m_{\nu_e} = 0; \quad m_{\nu_\mu} = 0; \quad m_{\nu_\tau} = 0;$ *but* neutrinos ν have (very small) masses *different from zero*!

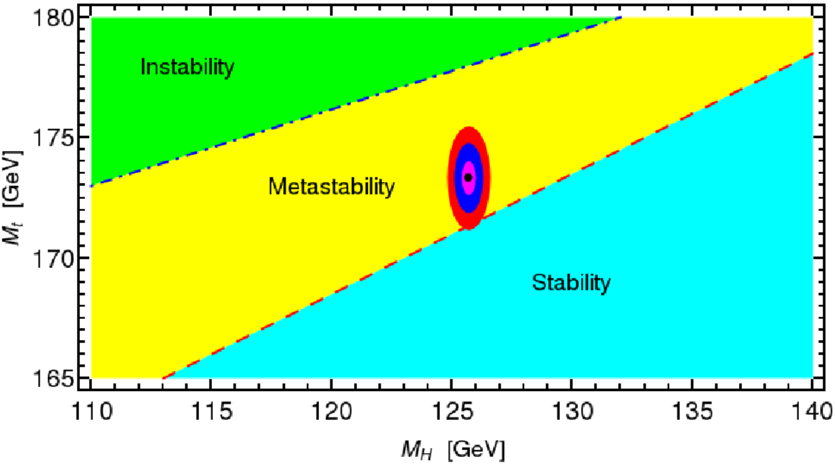
Astronmical Cosmological Problems

- 4. Colleagues say: The cold dark matter *not* possible in pure Standard Model. (Except though I and Colin Froggatt,etc.... has a dark-matter-model *inside* the Standard-model)
- 5. The Inflation-era requires likely a field not in Standard-Model.
- 6. The nucleons, of which the material consists would in pure Standard-model have disappeared in the early universe, because of an "anomaly", an unexpected effect, which is computed in quantum mecanics.

Yet more Problems for Standard Model

Finetuning-problems:

- 7. Why is the mass of the Higgs partikle masse (and so the weak scale of energy) so little compared to a supposed fundamental mass, the Planck-mass M_{Planck}, in fact $m_{Higgs} \sim 10^{-17} M_{Planck}$?
- 8. Why is correspondingly the energy density of empty space so immensely little ?


Instability
Metastability
Stability
180
175
170
165
110
115
120
125
130
135
140
M_t [GeV]
M_H [GeV]

In the notation of $\vec{r}$ being the position of a consituent quark relative to thee center of mass of the bound state S

$$< \vec{r}^2 > = 3r_0^2, \quad (5)$$

$$r_0 = \frac{b}{m_t}, \quad (6)$$

we obtain a theoretical estimate

$$b = \sqrt{\frac{< \vec{r}^2 >}{3}} m_t \approx 2.34, \quad (7)$$

and by a slightly different calculation /estimate The parameter b is just the radius of the bound state S is units of top-quark Compton wave length $1/m_t$

How little is Vacuum Unstable, due to High Higgs Field One

If the "high Higgs-field vacuum" following our Multiple Point Principle should be very accurately degenerate in energy-density with the present vacuum, then the renormalization-group running self-coupling of the Higgs $\lambda(\mu)$ taken as a function of the (scale given by) the Higgs field $\mu = \phi$ must go very accurately to 0 for the value of the Higgs field $\phi_{\text{"high field"}}$ for the "high Higgs field vacuum". However, it is not quite so small as to give degeneracy corresponding to the energy density in the vacuum, we live in, and the by best calculation in (naive) Standard Model gives for the running self-coupling at the "high Higgs field vacuum" (close to Planck scale)

$$\lambda(\phi_{\text{"high field"}}) = -0.01 \pm 0.002. \tag{8}$$

It is the value of this running $\lambda(\mu)$ but for $\mu \sim$ weak scale, say 100 GeV, that determines the Higgs mass - which is now measured to 125 GeV - in terms of the Higgs field expectation value which is measured as related to the weak interaction strength, or the masses of Z and W. So if we impose that we want MPP we get the Higgs mass changed a bit to 129.4 GeV $\pm 1.8 GeV$ (slightly, by 3 standard deviations) disgreeing with the 125 GeV (the uncertainty now $\sim$ 0.2 GeV).

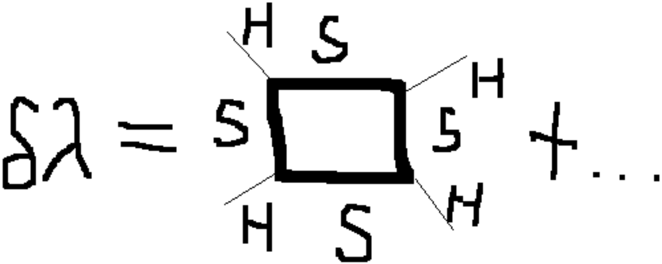
Correction of Higgs-mass from MPP from the bound state S

A strongly bound state, such as our bound state S of 6 top + 6 anti top, gives an extra contributions in perturbation theory and e.g. gives a correction to the Higgs mass, which experiment should observe, by there being an extra effective term $\lambda_S = \delta\lambda$ given by various perturbation diagrams in the expression for the Higgs selfcoupling at the weak scale - i.e. correct $\lambda(m_z) \rightarrow \lambda(m_Z) + \lambda_S$. The dominant diagram/correction is

$$\lambda_S \approx \frac{1}{\pi^2}\left(\frac{6g_t}{b}\frac{m_t}{m_S}\right)^4$$

where we have the estimated or measured values

$$g_t = 0.935;\ m_t = 173 GeV;\ b \approx 2.34 or 2.43$$


δλ =
H
S
H
S
S
H
H
S
+ . . .

The Needed Mass for the Bound State S

Using the after all rather small deviation from perfect MPP

$$\lambda_{\text{high field}} = -0.01 \pm 0.002$$

and requiring it to be cancelled by the correction from the bound state we get the requirement

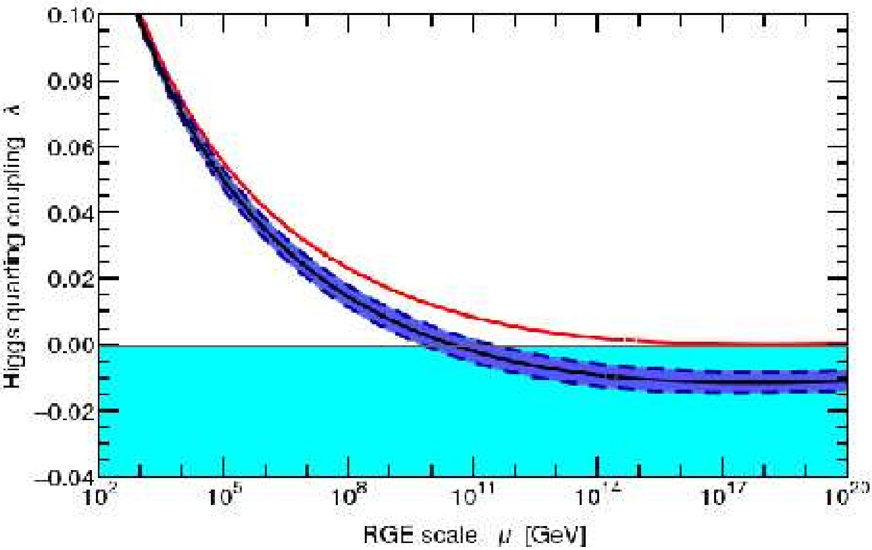
$$\lambda_S = \frac{1}{\pi^2}\left(\frac{6g_t}{b} * \frac{m_t}{m_S}\right)^4 * (\sim 2) \approx 0.01 \pm 0.002, \qquad (9)$$

where $g_t = .935$, $m_t = 173 GeV$, $b \approx 2.43$ and the factor "(~ 2)" were taken in to approximtesome neglected diagrams.

The solution w.r.t. the mass of the bound state m_S gives

$$m_S \approx \frac{6 g_t m_t}{b}\left(\frac{\sim 2}{\pi^2 * 0.01 \pm 0.002}\right) 1.3^{1/4}$$

$$\approx 2.31 * 173 GeV * 2.1 = 4.9 * 173 GeV = 850 GeV \pm 20\%$$


0.10
0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
Higgs quartic coupling λ
10^2
10^5
10^8
10^11
10^14
10^17
10^20
RGE scale μ [GeV]

Yet a MPP-determination of the Bound State S Mass

Also crudely estimate, what mass m_S the bound state should have to make third vacuum, "condensate of S's vacuum", have very accurately zero energy density. For this use diamond-like model for structure with the S's as the carbon atoms and the binding of the neighboring S-bound states to each other as if having the quarks and antiquarks of the neighbors in the atomic orbit n=2 of the neighboring "atom" with binding 1/4 of that of the n=1 orbit. We assume - as seems crudely true - that an exchage of W's and Z's compensate for the effect of "screening" : half the quarks and anti quarks are further out from center than a considered quark, so that the strength of attracktion gets down by a factor 2. Having really four Higgses at short dinstance brings it up again.

$$\text{Binding per S in "diamond" vac.} \approx \frac{4}{2} * \frac{1}{4}(12m_t - m_S) = \frac{1}{2}(12m_t - m_s) \tag{10}$$

Having

$$\text{Binding per S in “diamond” vac. of the S's} \approx \qquad (11)$$
$$\approx \frac{4}{2} * \frac{1}{4} \text{Binding of constituents in S} = \qquad (12)$$
$$= \frac{1}{2}(12m_t - m_s) \qquad (13)$$

we get

$$m_S \approx \frac{12m_t}{3} = 4m_t = 4 * 173GeV = 692GeV(\pm 40\%\text{say}) \qquad (14)$$

also close to the 750 GeV. (we assumed the screening just cancelled)

Three Degenerate Vacuua give Three Parameters Specified

Each time one by our Multiple Point Principle assume a vacuum to have zero (or exceedingly small) energy density one fix one relation between the parameters of the theory(of the Standard Model), but instead of using it that way you can fix some quantities you in prinicple but not in reality can calculate such as e.g. the bound state mass(using then the experimental values for the parameters). In this way we got even two calculations for the bound state mass - using in addition crude estimation -

$$m_S(\text{from "high field vacuum"}) \approx 850 GeV \pm 30\% \quad (15)$$

$$m_S(\text{"condensate vac."} \approx 692 GeV \pm 40\% \quad (16)$$

The agreement of the two is encourraging, even if the diphoton resonance found in LHC with mass 750 GeV should wash out.

Decays of S to Other Channels May Not have been seen, But it is Close

Crude estimates by Colin Froggatt and me suggests that the decay rates to other channels than the diphoton one, say to top + anti top or to two jets(gluons),WW, or ZZ etc. , are typically appreciably larger than to the only observed channel $\gamma + \gamma$ the back ground in these alternative channels and the so far performed analysis make that the observation of the there even to expected bigger number of events should not yet have been seen. But it is very close, and if one does not rather soon see other decay channels of the same particle S, then our hypotesis about what it is gets falcified.

Final state f	Bound	$\frac{\Gamma(S\to f)}{\Gamma(S\to\gamma\gamma)}$	Comment
$\gamma\gamma$	$< 0.8(r/5)$	1	
gluon + gluon	$< 1300(r/5)$	117	
Higgs + Higgs	$< 20(r/5)$	15	Higgs-particles
ZZ	$< 6(r/5)$	15	longitudinal
WW	$< 20(r/5)$	30	longitudinal
$Z\gamma$	$< 2(r/5)$	1.0	
ZZ	$< 6(r/5)$	0.3	transverse
WW	$< 20(r/5)$	1.1	transverse
top + anti top	$< 300(r/5)$	378	
$\Gamma_{total}(S)/\Gamma(S\to\gamma\gamma)$:		558	

Table: Benchmark model with $\epsilon^2 = 0.15$. Predictions are given for the decay branching ratios of S relative to the diphoton decay width and compared to the experimental upper bounds from ref. [?]. In our model $r \simeq 10$.

The Mass = 1.8 TeV Fluctuation/Particle

Actually before the 750 GeV peak were found LHC had found an also very doubtfull peak corresponding to a resonance decaying into weak gauge bosons WW with a mass 1.2 TeV. This is not very far from double the mass of the as bound state of 6 top + 6 anti top suggested S ($2 * 750 GeV = 1.5 TeV \approx 1.8$), and so t s very suggestive that this 1.8 TeV could bea resonance in scattering of two S's against each other.

Such a pair of S's should to fit one of our calculations - namely the one for the "condensate vacuum" with the diamond-like structure model be bound with a binding energy $m_S/2$ because

- There are effectively $2 = 4/2$ S-S (neighboring)bindings per S in the "diamond modelled" structure.
- This two bindings must together cancel the mass-energy of the S in the "condensate vacuum".

Simple Story on 1.8 TeV Resonance Mass

If the binding between the two S's I suggest the 1.8 TeV resonance to consists of were the same as in the "condensate vacuum" arranged to get the energy density of it be 0, then the mass of the 1.8 TeV would have to be
$2m_S - m_S/2 = 3M_S/2 = 3 * 0.75/2 TeV = 1.12_5 TeV$. But now we expect the effective mass of the Higgs to be smaller inside the "condensate vacuum" than in more free space such as is the situation in the two S system that is hoped to be the 1.8 TeV observation.
If indeed the effective Higgs mass would be essentaially zero in the "condensate vacuum" but nevertheless big eneough to to essentially remove the interaction by simple Higgs exchange in the S-S system, then we would roughly get the sign of the mass correction shifted and we would get for "1.8 TeV" the mass
$2m_S + m_S/2 = 5m_S/2 = 5 * 0.75 TeV/2 = 1.87_5 TeV$.

Effect on SS-state Mass of Removing Higgs-attracktion between Two S-particles

in the massless Higgs approximation one has virial theorem argument telling that the potential energy in an eigensate is just -2 times the kinetic. If one removes the potential energy by letting the exchanged Higgs get a big mass so that the binding between the two S's due to simple Higgs exchange vanish the original bound state with binding enegy $m_S/2$ get shifted up in mass by twise this amount, and thus ends up having an amount of mass $m_S/2$ over the sum of the two S-masses (of the consituents). So if indeed the effective Higgs mass in resonance consisting of two S's is effectivel small for the purpose of binding the quarks together to S but huge for the purpose of binding the S's to each other, then the mass of the resonance formed from two S's becomes

$$m_{\text{“}1.8\text{ TeV}''} = 2m_S + m_S/2 = \frac{5}{2} * m_S = 2.5 * 0.75\,TeV = 1.88\,TeV$$

Conclusion Resume

- In spite of some doubtful resonances observed with masses $m_S = 0.75$ TeV ("seen" in two intersections) and $m_{\text{"}1.8TeV''} = 1.8TeV$, we claim that pure Standard Model is sufficient !
- Because these resonances may be explained as *bound states* of respectively 6 top + 6 anti top and of two of the first type, i.e. as 2 S's interacting with each other.
- We long had speculations on the S before it were potentially found in a scenario having as an ingredient also:
- The Multiple Point Principle, a by us proposed new law of nature saying that there are several (we say in Standard Model 3) all having very very small energy densities/cosmological constants.

Conclusion (Continued)

- We made mass estimates mainly based on this Multiple Point Principle and found by very crude calculational technique

$$m_S \approx 4m_t \text{ and } m_{\text{“}1.8\,TeV\text{''}} \approx \frac{5}{2} m_S$$

.

- We even got the mass for the diphoton resonance in two different ways, namely using to different vacua, “high field vacuum” and “condensate vacuum”, to be required to have same energy density (i.e. very small) as the vacuum we live in.
- It has also been one of the most remarkably results of the running of the accelerator LHC so far that it has found only limits supporting non-existence of anything new relative to the Standard Model (“Rosner Bjorken Nightmare”)

Conclusion (Yet continued)

- In spite of its success the Standard Model has of the order of 8 problems suggesting that something more is needed.
- I also mentioned that at first it looks quite accidental why Nature should chosen just the gauge group, the structure group $S(U(2) \times U(3))$ as the group relevant for the Standard Model that works so almost surprisingly well ? I have some idea of that it in a sense which is made precise in a may be special way has the smallest possible faithful representations relative to the "adjoint" representation. A sort of averaged and generalized Dynkin index is what selects the group deserving to be the right one for physics.