New Diphoton Resonace of Mass 750 GeV Interpreted as 6 Top + 6 Anti top Bound state

We long worked on a picture based on the Standard Model alone, but involving a bound state of 6 top + 6 antitop quarks bound by Higgs exchange and helped by gluon exchange.

Main Content of Talk on the Diphoton being the 6 top + 6 antitop Bound State

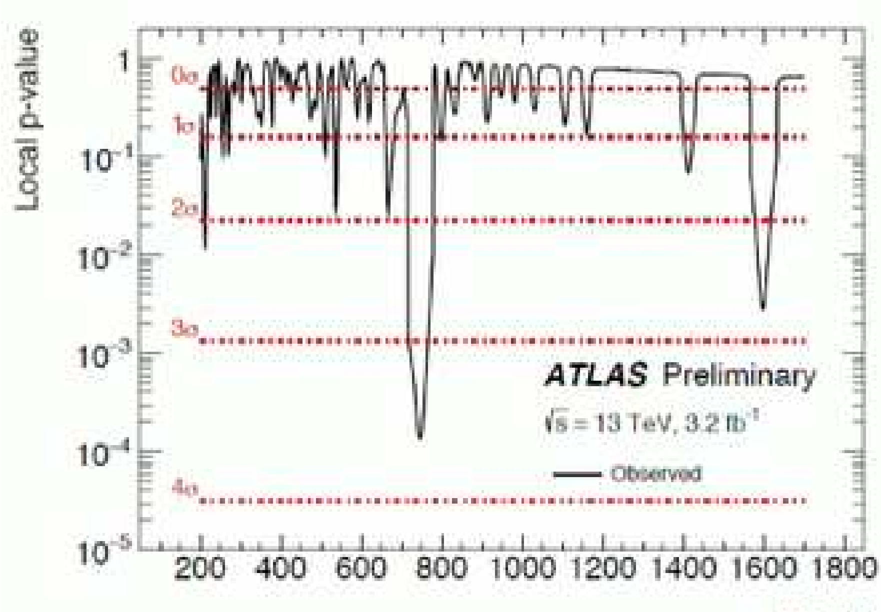
- In this scenario it is possible/natural, that the diphoton resonace of mass 750 GeV has not yet been seen in other channels; but it is very close, and at the $\sqrt{s} = 13 TeV$ soon to be investigated it can no longer be hidden, if we are right!
- Laperashvili, Das and I calculated a little correction to the observed Higgs mass relative to the one connected to the effective Higgs potoential $V_{eff}(\phi_H)$. By an appropriate mass (and radius) of this bound state "diphoton"- particle the observed Higgs mass of 125 GeV could be just compatible with the high Higgs-field vacuum having just the same energy density as the present/physical vacuum, in which we live. Fitting the mass of the bound state to this only barely instability of vacuum leads to a mass compatible with 750 GeV!

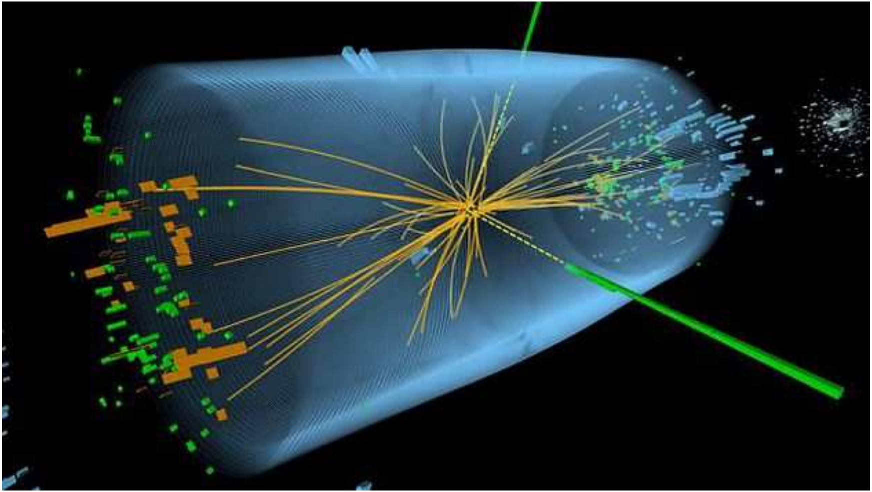
Plan of Talk on "New Resonance ?"

- Intro Introduction about main thesis: New Particle is Bound State of 6 top + 6 antitop.
- New Reviewing a bit doubtfull peaks from recent LHC experiments.
- 12tops Foroggatts and mine crude estimates of the decay and production of our speculated bound state.
- MPP Our long proposed new law of nature of several degenerate vacua.
- MPPmass Our calculations using MPP to get mass predictions for the new peak, and for Higgs itself.
- Conclusion Conclude, that you ought to believe in our long proposed but otherwise new law of nature, MPP (="Multiple Point Principle").

New Particle or Statistical Fluctuations?

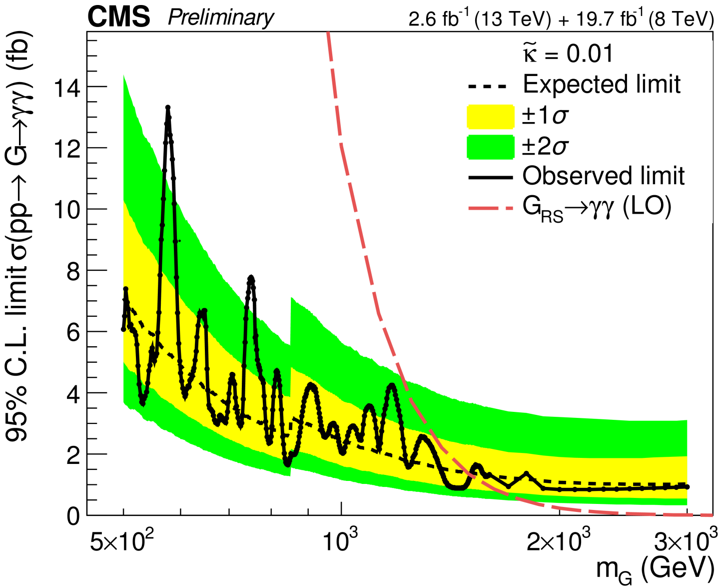
The quite new particle - December 2015 - is a seemingly new particle , which decays into two photons and has a mass 750 GeV/c^2 just found at ATLAS and also seen by CMS. We shall interprete it as a bound state of 6 top + 6 anti top quark, but nobody knows at present, what kind of particle it is even, if it is not a statisical fluctuation.


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



There are a couple of further presumably fluctuations or resonaces?

The newest and most trustworthy deviation from the Standard Model - but nevertheless probably just a statistical fluctuation - is a little top/excess in the number of pairs of photons that comes out of the LHC collissions, when this number is plotted versus the collected mass of the two photons.
The mass of the peak is 750 GeV/c^2.


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)
14
12
10
8
6
4
2
0
5×10^2
10^3
2×10^3
3×10^3
mG (GeV)

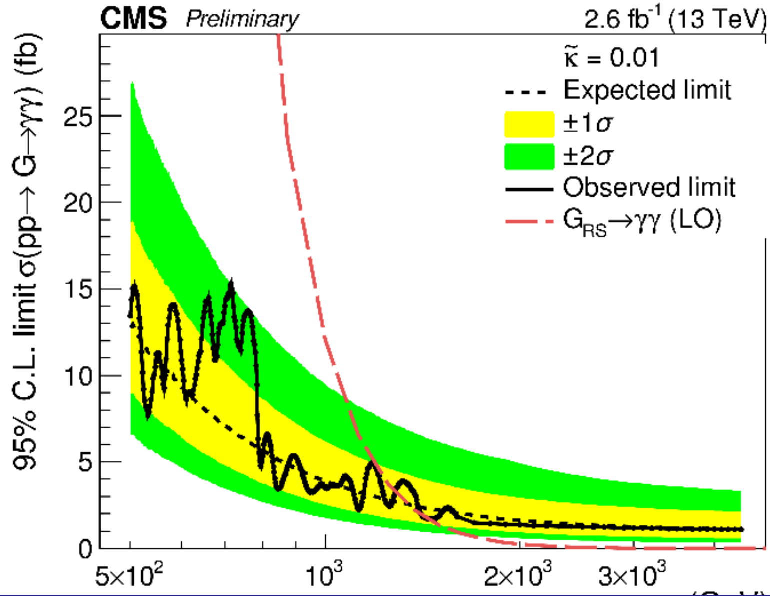
Has LHC shown anything in excess of the Standard Model ? Not convincing, But there are Statistical Fluctuations, or is it New Physics ???

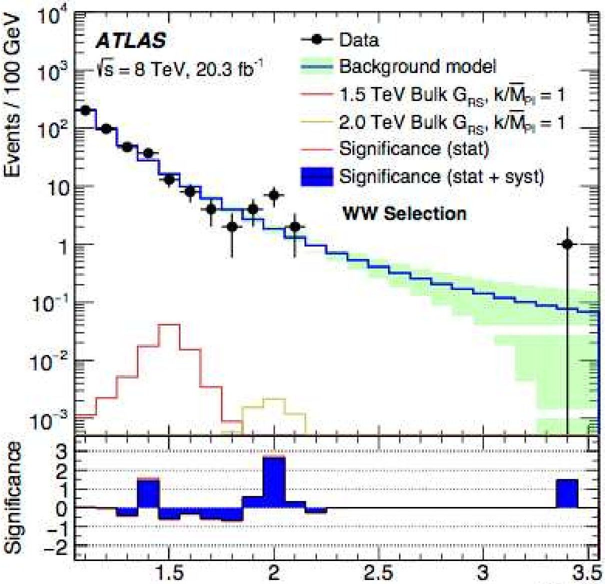
a couple of may be new physics observations

- **A Resonance with mass 1.8 TeV to 2 TeV** ca. 3 σ
- **A Resonance (or something else) Decaying into e.g. two Higgs bosons of W's ...** It is a single bin with an exceptional high number of events at a bit under 0.3 TeV in mass. It is for decay to two particles that could be Higgs's or W's or Z's This particle could easily be the particle which Colin Froggatt and I imagined as a bound state consisting of 6 top + 6 antitop quarks. (but now we shifted our hope to the 750 Gev excess)

An early Deviation from Standard Model

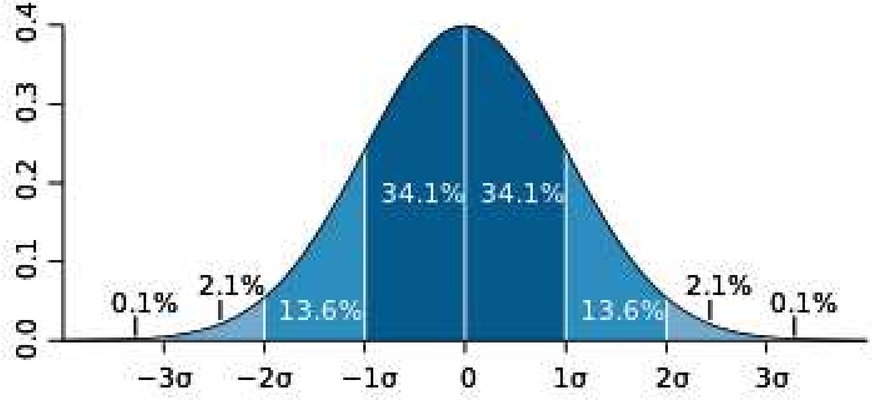
- **A excess of Higgs decay to $\gamma\gamma$ at ATLAS** The first deviation found from Standard Model was that ATLAS found a bit higher number of Higgs decays to two photons than predicted from Standard Model But CMS did not confirm that.
- The very newest is a resonance $-- > \gamma\gamma$ with mass 750 to 760 GeV.


CMS Preliminary
2.6 fb^{-1} (13 TeV)
$\tilde{\kappa}$ = 0.01
Expected limit
±1σ
±2σ
Observed limit
$G_{RS}\to\gamma\gamma$ (LO)
95% C.L. limit σ(pp→ G→γγ) (fb)
0
5
10
15
20
25
5×10^2
10^3
2×10^3
3×10^3

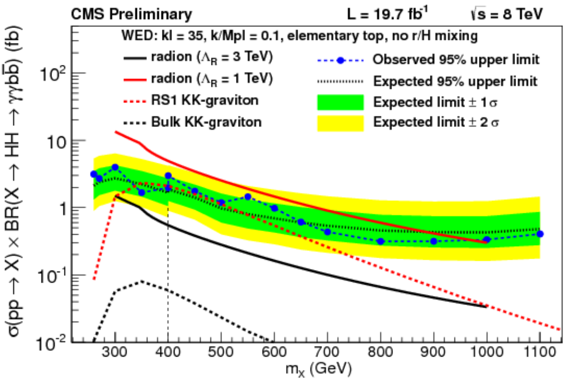


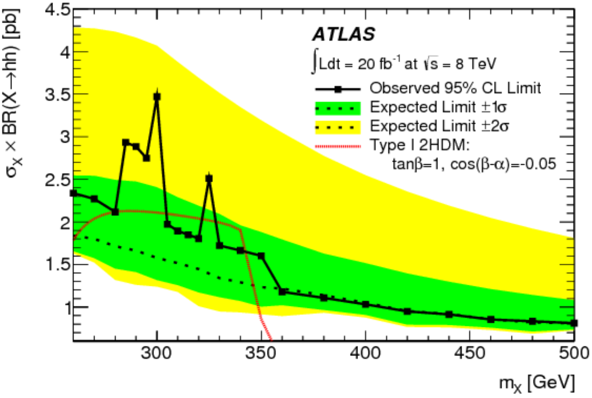
ATLAS
√s = 8 TeV, 20.3 fb⁻¹
Data
Background model
1.5 TeV Bulk G_RS, k/M̄_Pl = 1
2.0 TeV Bulk G_RS, k/M̄_Pl = 1
Significance (stat)
Significance (stat + syst)
WW Selection
Events / 100 GeV
Significance

This Atlas plot shows the mass spectrum for pairs of particles WW, WZ or ZZ.
således at, hvis der fandtes en If the little relative increase in the number of events - i.e. of numbers of WW, WZ, or ZZ pairs - at 1.8 TeV were stastically significant. But it is only 3 standard deviations. Our/my ? hope is that we can identify this 1.8 TeV heavy peak as a resonance in two of the 750 GeV ones, but this may be too early to talk about now. We have calculated more on the 750 GeV peaks so far.


0.4
0.3
0.2
0.1
0.0
34.1% 34.1%
13.6% 13.6%
2.1% 2.1%
0.1% 0.1%
−3σ −2σ −1σ 0 1σ 2σ 3σ

In the following two one look for the collectuve mass but seek to look for decays into two Higgses $b\bar{b}$ and to $\gamma\gamma$.


CMS Preliminary
L = 19.7 fb^{-1}
$\sqrt{s}$ = 8 TeV
WED: kl = 35, k/Mpl = 0.1, elementary top, no r/H mixing
radion (Λ_R = 3 TeV)
radion (Λ_R = 1 TeV)
RS1 KK-graviton
Bulk KK-graviton
Observed 95% upper limit
Expected 95% upper limit
Expected limit ± 1σ
Expected limit ± 2σ
$\sigma(pp \to X) \times BR(X \to HH \to \gamma\gamma b\bar{b})$ (fb)
m_X (GeV)


ATLAS
∫Ldt = 20 fb⁻¹ at √s = 8 TeV
Observed 95% CL Limit
Expected Limit ±1σ
Expected Limit ±2σ
Type I 2HDM:
tanβ=1, cos(β-α)=-0.05
σX × BR(X→hh) [pb]
mX [GeV]
4.5
4
3.5
3
2.5
2
1.5
1
300
350
400
450
500

If you want to illustrate the main result of LHC that the Standard Model works perfectly almost one can show the two following not so easy to overview tabels just expressing that there are now good bounds for many theoretical hopes for new physics, and nothing seen so far. Typically the new physics scale of energy would have to be at least about 1 TeV, if it shall not be excluded already.

ATLAS Long-lived Particle Searches* - 95% CL Exclusion
Status: July 2015
ATLAS Preliminary
∫L dt = (18.4 - 20.3) fb⁻¹
√s = 8 TeV
Model
Signature
∫L dt[fb⁻¹]
Lifetime limit
Reference
SUSY
RPV χ₁⁰ → eeν/eμν/μμν | displaced lepton pair | 20.3 | χ₁⁰ lifetime | 7-740 mm | m(g̃) = 1.3 TeV, m(χ₁⁰) = 1.0 TeV | 1504.05162
GGM χ₁⁰ → ZG̃ | displaced vtx + jets | 20.3 | χ₁⁰ lifetime | 6-480 mm | m(g̃) = 1.1 TeV, m(χ₁⁰) = 1.0 TeV | 1504.05162
AMSB pp → χ₁±χ₁⁰, χ₁⁺χ₁⁻ | disappearing track | 20.3 | χ₁± lifetime | 0.22-3.0 m | m(χ₁±) = 450 GeV | 1310.3675
AMSB pp → χ₁±χ₁⁰, χ₁⁺χ₁⁻ | large pixel dE/dx | 18.4 | χ₁± lifetime | 1.31-9.0 m | m(χ₁±) = 450 GeV | 1506.05332
GMSB | non-pointing or delayed γ | 20.3 | χ₁⁰ lifetime | 0.08-5.4 m | SPS8 with Λ = 200 TeV | 1409.5542
Stealth SUSY | 2 ID/MS vertices | 19.5 | S̃ lifetime | 0.12-90.6 m | m(g̃) = 500 GeV | 1504.03634
Higgs BR = 10%
Hidden Valley H → πᵥπᵥ | 2 low-EMF trackless jets | 20.3 | πᵥ lifetime | 0.41-7.57 m | m(πᵥ) = 25 GeV | 1501.04020
Hidden Valley H → πᵥπᵥ | 2 ID/MS vertices | 19.5 | πᵥ lifetime | 0.31-25.4 m | m(πᵥ) = 25 GeV | 1504.03634
FRVZ H → 2γd + X | 2 e−, μ−, π−jets | 20.3 | γd lifetime | 14-140 mm | H → 2γd + X, m(γd) = 400 MeV | 1409.0746
FRVZ H → 4γd + X | 2 e−, μ−, π−jets | 20.3 | γd lifetime | 15-260 mm | H → 4γd + X, m(γd) = 400 MeV | 1409.0746
Higgs BR = 5%
Hidden Valley H → πᵥπᵥ | 2 low-EMF trackless jets | 20.3 | πᵥ lifetime | 0.6-5.0 m | m(πᵥ) = 25 GeV | 1501.04020
Hidden Valley H → πᵥπᵥ | 2 ID/MS vertices | 19.5 | πᵥ lifetime | 0.43-18.1 m | m(πᵥ) = 25 GeV | 1504.03634
FRVZ H → 4γd + X | 2 e−, μ−, π−jets | 20.3 | γd lifetime | 28-160 mm | H → 4γd + X, m(γd) = 400 MeV | 1409.0746
300 GeV scalar
Hidden Valley Φ → πᵥπᵥ | 2 low-EMF trackless jets | 20.3 | πᵥ lifetime | 0.29-7.9 m | σ×BR = 1 pb, m(πᵥ) = 50 GeV | 1501.04020
Hidden Valley Φ → πᵥπᵥ | 2 ID/MS vertices | 19.5 | πᵥ lifetime | 0.19-31.9 m | σ×BR = 1 pb, m(πᵥ) = 50 GeV | 1504.03634
900 GeV scalar
Hidden Valley Φ → πᵥπᵥ | 2 low-EMF trackless jets | 20.3 | πᵥ lifetime | 0.15-4.1 m | σ×BR = 1 pb, m(πᵥ) = 50 GeV | 1501.04020
Hidden Valley Φ → πᵥπᵥ | 2 ID/MS vertices | 19.5 | πᵥ lifetime | 0.11-18.3 m | σ×BR = 1 pb, m(πᵥ) = 50 GeV | 1504.03634
Other
HV Z′(1 TeV) → qᵥqᵥ | 2 ID/MS vertices | 20.3 | πᵥ lifetime | 0.1-4.9 m | σ×BR = 1 pb, m(πᵥ) = 50 GeV | 1504.03634
HV Z′(2 TeV) → qᵥqᵥ | 2 ID/MS vertices | 20.3 | πᵥ lifetime | 0.1-10.1 m | σ×BR = 1 pb, m(πᵥ) = 50 GeV | 1504.03634
0.01
0.1
1
10
100
cτ [m]
√s = 8 TeV
*Only a selection of the available lifetime limits on new states is shown.

ATLAS Exotics Searches* - 95% CL Exclusion

Status: July 2015

ATLAS Preliminary

$\int \mathcal{L}\, dt = (4.7 - 20.3)\ \mathrm{fb}^{-1}$ $\sqrt{s} = 7,\ 8$ TeV

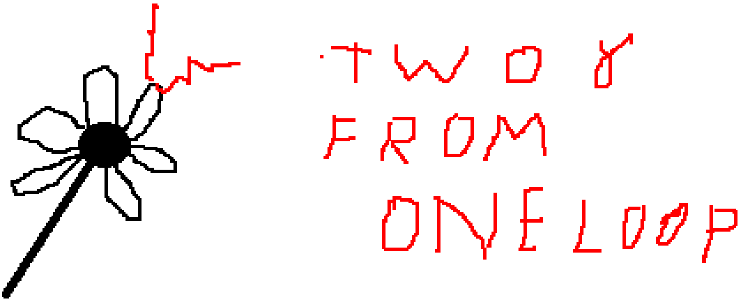
	Model	ℓ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\mathrm{fb}^{-1}]$	Limit		Reference
Extra dimensions	ADD $G_{KK} + g/q$	–	≥ 1 j	Yes	20.3	M_D 5.25 TeV	$n = 2$	1502.01518
	ADD non-resonant $\ell\ell$	2e, μ	–	–	20.3	M_S 4.7 TeV	$n = 3$ HLZ	1407.2410
	ADD QBH $\to \ell q$	1 e, μ	1 j	–	20.3	M_{th} 5.2 TeV	$n = 6$	1311.2006
	ADD QBH	–	2 j	–	20.3	M_{th} 5.82 TeV	$n = 6$	1407.1376
	ADD BH high N_{trk}	2 μ (SS)	–	–	20.3	M_{th} 4.7 TeV	$n = 6$, $M_D = 3$ TeV, non-rot BH	1308.4075
	ADD BH high $\sum p_T$	≥ 1 e, μ	≥ 2 j	–	20.3	M_{th} 5.8 TeV	$n = 6$, $M_D = 3$ TeV, non-rot BH	1405.4254
	ADD BH high multijet	–	≥ 2 j	–	20.3	M_{th} 5.8 TeV	$n = 6$, $M_D = 3$ TeV, non-rot BH	1503.08988
	RS1 $G_{KK} \to \ell\ell$	2 e, μ	–	–	20.3	G_{KK} mass 2.68 TeV	$k/\overline{M}_{Pl} = 0.1$	1405.4123
	RS1 $G_{KK} \to \gamma\gamma$	2 γ	–	–	20.3	G_{KK} mass 2.66 TeV	$k/\overline{M}_{Pl} = 0.1$	1504.05511
	Bulk RS $G_{KK} \to ZZ \to qq\ell\ell$	2 e, μ	2 j / 1 J	–	20.3	G_{KK} mass 740 GeV	$k/\overline{M}_{Pl} = 1.0$	1409.6190
	Bulk RS $G_{KK} \to WW \to qq\ell\nu$	1 e, μ	2 j / 1 J	Yes	20.3	W' mass 760 GeV	$k/\overline{M}_{Pl} = 1.0$	1503.04677
	Bulk RS $G_{KK} \to HH \to b\bar{b}b\bar{b}$	–	4 b	–	19.5	G_{KK} mass 500-720 GeV	$k/\overline{M}_{Pl} = 1.0$	1506.00285
	Bulk RS $g_{KK} \to t\bar{t}$	1 e, μ	≥ 1 b, ≥ 1J/2j	Yes	20.3	g_{KK} mass 2.2 TeV	BR = 0.925	1505.07018
	2UED / RPP	2 e, μ (SS)	≥ 1 b, ≥ 1 j	Yes	20.3	KK mass 960 GeV		1504.04605
Gauge bosons	SSM $Z' \to \ell\ell$	2 e, μ	–	–	20.3	Z' mass 2.9 TeV		1405.4123
	SSM $Z' \to \tau\tau$	2 τ	–	–	19.5	Z' mass 2.02 TeV		1502.07177
	SSM $W' \to \ell\nu$	1 e, μ	–	Yes	20.3	W' mass 3.24 TeV		1407.7494
	EGM $W' \to WZ \to \ell\nu\ell'\ell'$	3 e, μ	–	Yes	20.3	W' mass 1.52 TeV		1406.4456
	EGM $W' \to WZ \to qq\ell\ell$	2 e, μ	2 j / 1 J	–	20.3	W' mass 1.59 TeV		1409.6190
	EGM $W' \to WZ \to qqqq$	–	2 J	–	20.3	W' mass 1.3-1.5 TeV		1506.00962
	HVT $W' \to WH \to \ell\nu bb$	1 e, μ	2 b	Yes	20.3	W' mass 1.47 TeV	$g_V = 1$	1503.08089
	LRSM $W'_R \to t\bar{b}$	1 e, μ	2 b, 0-1 j	Yes	20.3	W' mass 1.92 TeV		1410.4103
	LRSM $W'_R \to t\bar{b}$	0 e, μ	≥ 1 b, 1 J	–	20.3	W' mass 1.76 TeV		1408.0886
CI	CI $qqqq$	–	2 j	–	17.3	Λ 12.0 TeV	$\eta_{LL} = -1$	1504.00357
	CI $qq\ell\ell$	2 e, μ	–	–	20.3	Λ 21.6 TeV	$\eta_{LL} = -1$	1407.2410
	CI $uutt$	2 e, μ (SS)	≥ 1 b, ≥ 1 j	Yes	20.3	Λ 4.3 TeV	$\lvert C_{LL}\rvert = 1$	1504.04605
DM	EFT D5 operator (Dirac)	0 e, μ	≥ 1 j	Yes	20.3	M_* 974 GeV	at 90% CL for $m(\chi) < 100$ GeV	1502.01518
	EFT D9 operator (Dirac)	0 e, μ	1 J, ≤ 1 j	Yes	20.3	M_* 2.4 TeV	at 90% CL for $m(\chi) < 100$ GeV	1309.4017
LQ	Scalar LQ 1st gen	2 e	≥ 2 j	–	20.3	LQ mass 1.05 TeV	$\beta = 1$	Preliminary
	Scalar LQ 2nd gen	2 μ	≥ 2 j	–	20.3	LQ mass 1.0 TeV	$\beta = 1$	Preliminary
	Scalar LQ 3rd gen	1 e, μ	≥1 b, ≥3 j	Yes	20.3	LQ mass 640 GeV	$\beta = 0$	Preliminary
Heavy quarks	VLQ $TT \to Ht + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	T mass 855 GeV	T in (T,B) doublet	1505.04306
	VLQ $YY \to Wb + X$	1 e, μ	≥ 1 b, ≥ 3 j	Yes	20.3	Y mass 770 GeV	Y in (B,Y) doublet	1505.04306
	VLQ $BB \to Hb + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	B mass 735 GeV	isospin singlet	1505.04306
	VLQ $BB \to Zb + X$	2/≥3 e, μ	≥2/≥1 b	–	20.3	B mass 755 GeV	B in (B,Y) doublet	1409.5500
	$T_{5/3} \to Wt$	1 e, μ	≥ 1 b, ≥ 5 j	Yes	20.3	$T_{5/3}$ mass 840 GeV		1503.05425
Excited fermions	Excited quark $q^* \to q\gamma$	1 γ	1 j	–	20.3	q* mass 3.5 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1309.3230
	Excited quark $q^* \to qg$	–	2 j	–	20.3	q* mass 4.09 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1407.1376
	Excited quark $b^* \to Wt$	1 or 2 e, μ	1 b, 2 j or 1 j	Yes	4.7	b* mass 870 GeV	left-handed coupling	1301.1583
	Excited lepton $\ell^* \to \ell\gamma$	2 e, μ, 1 γ	–	–	13.0	ℓ* mass 2.2 TeV	$\Lambda = 2.2$ TeV	1308.1364
	Excited lepton $\nu^* \to \ell W, \nu Z$	3 e, μ, τ	–	–	20.3	ν* mass 1.6 TeV	$\Lambda = 1.6$ TeV	1411.2921
Other	LSTC $a_T \to W\gamma$	1 e, μ, 1 γ	–	Yes	20.3	a_T mass 960 GeV		1407.8150
	LRSM Majorana ν	2 e, μ	2 j	–	20.3	N^0 mass 2.0 TeV	$m(W_R) = 2.4$ TeV, no mixing	1506.06020
	Higgs triplet $H^{\pm\pm} \to \ell\ell$	2 e, μ (SS)	–	–	20.3	$H^{\pm\pm}$ mass 551 GeV	DY production, BR($H_L^{\pm\pm} \to \ell\ell$)=1	1412.0237
	Higgs triplet $H^{\pm\pm} \to \ell\tau$	3 e, μ, τ	–	–	20.3	$H^{\pm\pm}$ mass 400 GeV	DY production, BR($H_L^{\pm\pm} \to \ell\tau$)=1	1411.2921
	Monotop (non-res prod)	1 e, μ	1 b	Yes	20.3	spin-1 invisible particle mass 657 GeV	$a_{non-res} = 0.2$	1410.5404
	Multi-charged particles	–	–	–	20.3	multi-charged particle mass 785 GeV	DY production, $\lvert q\rvert = 5e$	1504.04188
	Magnetic monopoles	–	–	–	7.0	monopole mass 1.34 TeV	DY production, $\lvert g\rvert = 1 g_D$, spin 1/2	Preliminary

$\sqrt{s} = 7$ TeV $\sqrt{s} = 8$ TeV

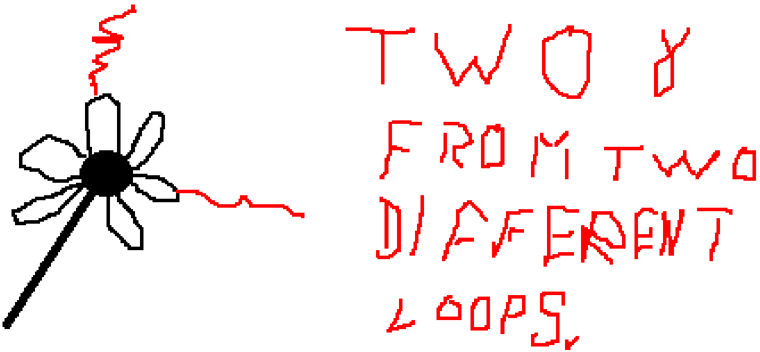
Mass scale [TeV] (10^{-1}, 1, 10)

*Only a selection of the available mass limits on new states or phenomena is shown.

From same top-loop



From TWO differnt loops of tops



Final st. f	Bound	Relative prediction	$\frac{\Gamma(S\to f)}{\Gamma(S\to\gamma\gamma)}$	Comt.
$\gamma\gamma$	$< 0.8(r/5)$	$(4\alpha/9)^2 = 1.2 * 10^{-5}$	1	
gl + gl	$< 1300 \cdot \frac{r}{5}$	$8\alpha_s/6)^2 = 2.3 * 10^{-3}$	190	
H + H	$< 20(r/5)$	$\alpha_h^2/4 = 3 * 10^{-4}$	25	Higgs
ZZ	$< 6(r/5)$	$\alpha_h^2/4 = 3 * 10^{-4}$	25	longtl.
WW	$< 20(r/5)$	$\alpha_h^2/2 = 6 * 10^{-4}$	50	longtl.
$Z\gamma$	$< 2(r/5)$	$2(4\alpha/9)^2 * 0.92$	1.8	
ZZ	$< 6(r/5)$	$(4\alpha/9)^2 * (0.92)^2$	0.8	tran.
WW	$< 20(r/5)$	$2(0.54\alpha)^2 = 3.5 * 10^{-5}$	3	tran.
t + $\bar{t}$	$< 300(r/5)$	$3\alpha_{t\bar{t}}^2 T_2 = 6.5 * 10^{-5}$	5	
		$\Gamma_{total}(S)/\Gamma(S \to \gamma\gamma)$:	302	

Table: Assuming dominance of *one* top anti top pair giving the final state, relative predictions are given for the partial decay widths of S and for the branching ratios relative to the diphoton decay width compared to the experimental upper bounds.

Photon and transverse Z. The electric charge of the top quark is $q = 2e/3$ and the effective coupling for of the photon to the $t\bar{t}$ loop is $4\alpha/9$.
The corresponding effective coupling of Z to the $t\bar{t}$ loop is

$$\frac{\alpha}{2\sin^2\theta_W \cos^2\theta_W}\left[\left(\frac{1}{2}-\frac{2}{3}\sin^2\theta_W\right)^2+\left(-\frac{2}{3}\sin^2\theta_W\right)^2\right] = \quad (1)$$

We take $\alpha = 1/129$ and the Weinberg angle to be given by $\sin^2\theta_W = 0.23$.

Gluon. The vertex for a gluon of color i coupling to a top quark is $g_s \lambda^i/2$. Averaging over the colors of the top quark, the effective coupling of the gluon to the $t\bar{t}$ loop becomes

$$\frac{\alpha_s}{3} Tr \left(\frac{\lambda^i}{2}\right)^2 = \frac{\alpha_s}{6}. \tag{2}$$

We take $\alpha_s = 0.1$ and then sum over the 8 color states of the gluon.

Higgs and longitudinal $W^{\pm}$ and Z^0. According to the Goldstone Boson Equivalence Theorem [?], in the high energy limit the couplings of the longitudinal $W^{\pm}$ and Z^0 become equal to those of the corresponding eaten Higgs fields. The Higgs field coupling to the $t\bar{t}$ loop is

$$\alpha_h = \frac{g_t^2/2}{4\pi} = 0.035 \qquad (3)$$

where g_t is the top quark Yukawa coupling constant.

Transverse $W^{\pm}$. The $W^{\pm}$ gauge fields are formed from two real fields, W_1 and W_2, lying in the adjoint representation of SU(2). So their effective coupling to the $t\bar{t}$ loop is

$$\frac{1}{2} * \frac{\alpha}{\sin^2\theta_W}\left(\left(\frac{\sigma^i}{2}\right)^2\right)_{t_L t_L} = \frac{\alpha}{8\sin^2\theta_W} = 0.54\alpha, \quad (4)$$

where the extra factor of $1/2$ is due to $W^{\pm}$ only interacting with left-handed top quarks. The final sum over $i = 1, 2$ gives a factor of 2 in the decay rate.

Fin. f	Bound	Relative pred.	$\frac{\Gamma(S\to f)}{\Gamma(S\to\gamma\gamma)}$	Com.
$\gamma\gamma$	$< 0.8(r/5)$	$(0.236\alpha)^2 = 3.35 * 10^{-6}$	1	
gl + gl	$< 1300 \cdot \frac{r}{5}$	$8(\alpha_s/18)^2 = 2.5 * 10^{-4}$	74	
H + H	$< 20(r/5)$	$\alpha_h^4/(4T_2) = 3.4 * 10^{-5}$	10	Higgs
ZZ	$< 6(r/5)$	$\alpha_h^4/(4T_2) = 3.4 * 10^{-5}$	10	longtn.
WW	$< 20(r/5)$	$\alpha_h^4/(2T_2) = 6.8 * 10^{-5}$	20	longtn.
$Z\gamma$	$< 2(r/5)$	$2(0.236\alpha)^2 \tan^2\theta_W$	0.6	
ZZ	$< 6(r/5)$	$(0.236\alpha)^2 \tan^2\theta_W$	0.09	transv.
WW	$< 20(r/5)$	$2(0.54\alpha)^4/T_2 = 6 * 10^{-8}$	0.02	transv.
t + $\bar{t}$	$< 300(r/5)$	$3\alpha_{t\bar{t}}^4/T_2 = 1.06 * 10^{-3}$	316	
		$\Gamma_{total}(S)/\Gamma(S\to\gamma\gamma)$:	432	

Table: Assuming dominance of *two* top anti top pairs giving the final state, relative predictions are given for the partial decay widths of S and for the branching ratios relative to the diphoton decay width compared to the experimental upper bounds(Francecini).

Photon and transverse Z. The hypercharge coupled superposition of the photon and Z^0 is described by the field $B_\mu = \cos\theta_W A_\mu - \sin\theta_W Z_\mu$. It couples with an average squared charge $[(2/3)^2 + (1/6)^2]/2 = 0.236$ to a top quark. The two loop diphoton decay is dominated by the production of this B_μ component and so the effective coupling for the photon is 0.236α.

The corresponding effective coupling of Z is $0.236\alpha \tan\theta_W$.

Gluon. Averaging over the colors of the two (anti)top pairs, the effective coupling of a gluon of color i for the "crossed" diagram is

$$\frac{\alpha_s}{9} Tr\left(\frac{\lambda^i}{2}\right)^2 = \frac{\alpha_s}{18}. \tag{5}$$

Higgs, longitudinal Z^0, $W^{\pm}$, top antitop. We use the same effective couplings as in the one loop case.

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	$< 300(r/5)$	208	
$\Gamma_{total}(S)/\Gamma(S\to\gamma\gamma)$:		387	

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. [?].

Production

We assume the production rate to be of an order calculated analogous to the production of a fourth family just taking into account that our bound state consist of 12 quarks. Using our decay ratio estimates the rate for $S \rightarrow \gamma\gamma$ is order of magnitude o.k.

Multiple Point Principle

In general, a quantum field theory allows an existence of several minima of the effective potential, which is a function of a scalar field.

If all vacua, corresponding to these minima, are degenerate, having zero cosmological constants, then we can speak about the existence of a multiple critical point (MCP) in the phase diagram.

See:

D.L. Bennett and H.B. Nielsen,
Int. J. Mod. Phys. **A9**, 5155 (1994); arXiv:hep-ph/9311321,

postulated a Multiple Point Principle (MPP) for many degenerate vacua

Multiple Point Principle

The Multiple Point Model (MPM) of the Universe evokes simply the Standard Model up to the scale $\sim 10^{18}$ GeV.

If the MPP is very accurate, we may have a new law of Nature, that can help us to restrict coupling constants from theoretical principles.

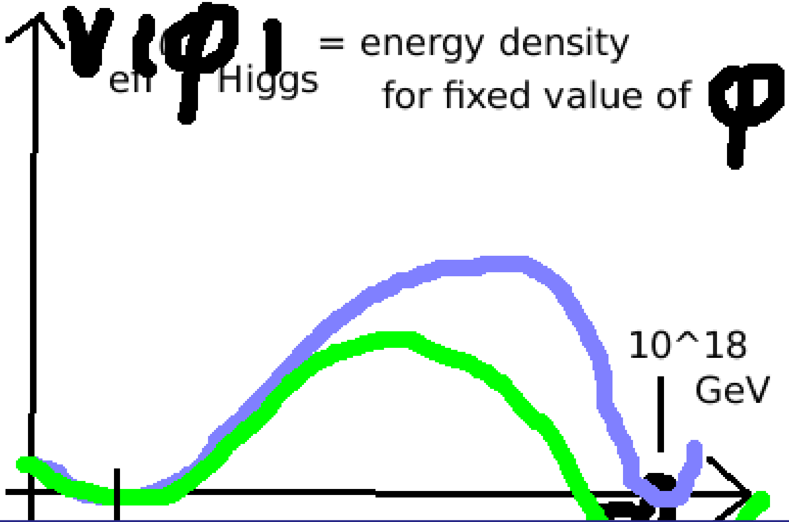
Assuming the existence of two degenerate vacua in the SM:

1. the Electroweak vacuum at $v = 246$ GeV, and
2. the Planck scale vacuum at $v_2 \simeq 10^{18}$ GeV,

C.D. Froggatt and H.B. Nielsen,
Phys. Lett. **B368**, 96 (1996); arXiv:hep-ph/9511371,

predicted the top-quark and Higgs boson masses:

Multiple Point Principle



Multiple Point Principle

The tree-level Higgs potential with the standard "Electroweak minimum" at $\phi_{min\,1} = v$ is given by:

$$V_1 = \frac{\lambda}{4}\left(\phi^2 - v\right)^2 + C_1.$$

The new minimum at the Planck scale:

$$V_2 = V_{eff}(\text{at Planck scale}) = \frac{\lambda_{run}}{4}\left(\phi^2 - v_2\right)^2 + C_2,$$

can be higher or lower than the Electroweak one, showing a stable Electroweak vacuum (in the first case), or metastable one (in the second case).

In accordance with cosmological measurements, Froggatt and Nielsen assumed that cosmological constants C_1 and C_2 for both vacua are equal to zero (or approximately zero): $C_{1,\,2} = 0$, or

Multiple Point Principle

The following requirements must be satisfied in order to, the effective potential have two degenerate minima:

$$V_{eff}(\phi^2_{min\ 1}) = V_{eff}(\phi^2_{min\ 2}) = 0,$$

and

$$V'_{eff}(\phi^2_{min\ 1}) = V'_{eff}(\phi^2_{min\ 2}) = 0,$$

where,

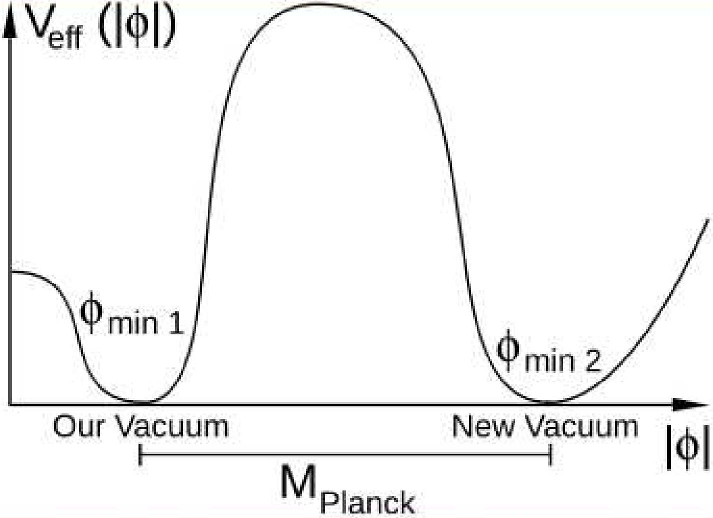
$$V'(\phi^2) = \frac{\partial V}{\partial \phi^2}$$

C.D. Froggatt and H.B. Nielsen,
Phys. Lett. **B368**, 96 (1996); arXiv:hep-ph/9607302.

Multiple Point Principle postulates:

There are many vacua with the same energy density, or

Multiple Point Principle



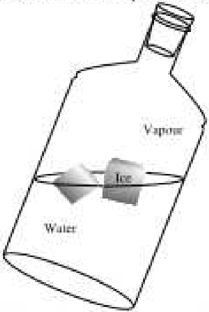
Multiple Point Principle

If several vacua are degenerate, then the phase diagram contains a special point – the Multiple Critical Point (MCP), at which the corresponding phases assembly together.

Multiple Point Principle

Here it is useful to remind you a triple point of water analogy.

It is well known in the thermal physics that in the range of fixed extensive quantities: volume, energy and a number of moles, the degenerate phases of water (namely, ice, water and vapour, presented in this figure) exist on the phase diagram (P, T):

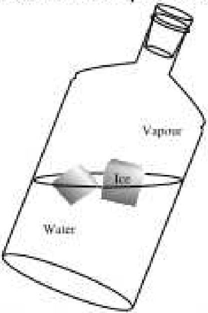


At the finetuned values of the intensive variables pressure P and

Multiple Point Principle

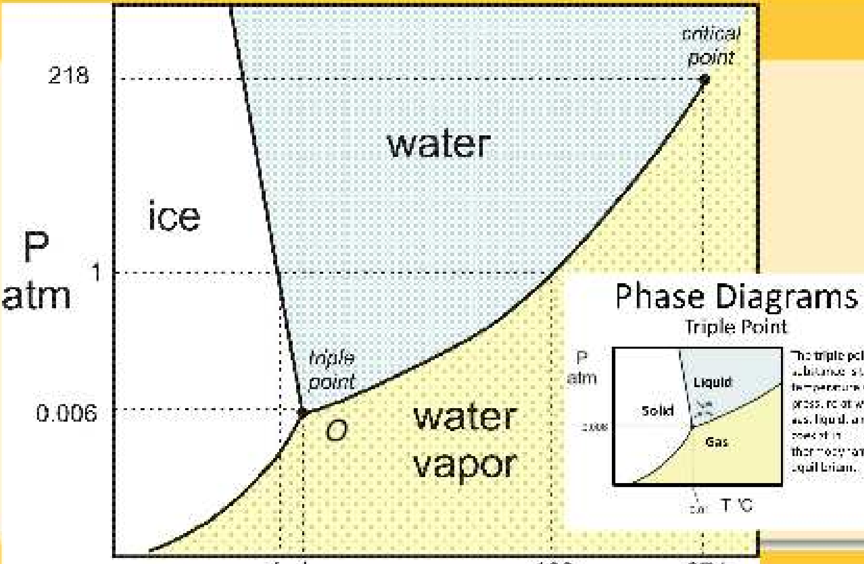
Here it is useful to remind you a triple point of water analogy.

It is well known in the thermal physics that in the range of fixed extensive quantities: volume, energy and a number of moles, the degenerate phases of water (namely, ice, water and vapour, presented in this figure) exist on the phase diagram (P, T):



At the finetuned values of the intensive variables pressure P and

Multiple Point Principle



Mutiple Point Principle

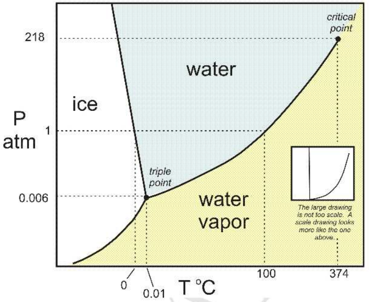
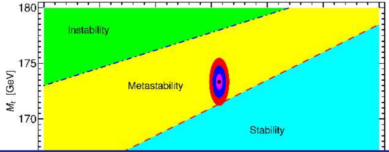


Fig. 5: The phase diagram $(P,\ T)$ of water analogy. The triple point O with $T_c = 0.01^C$ and $P_c = 4.58\ mm\ Hg$ is shown in Fig. 4.



Multiple Point Principle

At the finetuned values of the variables pressure P and temperature T – we have:

$$T_c \approx 0.01^o\mathrm{C}, \; P_c \approx 4.58 \; \mathrm{mm \; Hg},$$

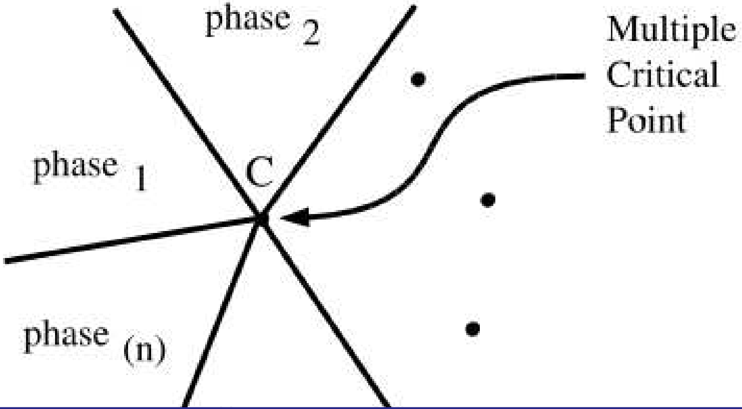
giving the critical (triple) point O shown in the previous figure.

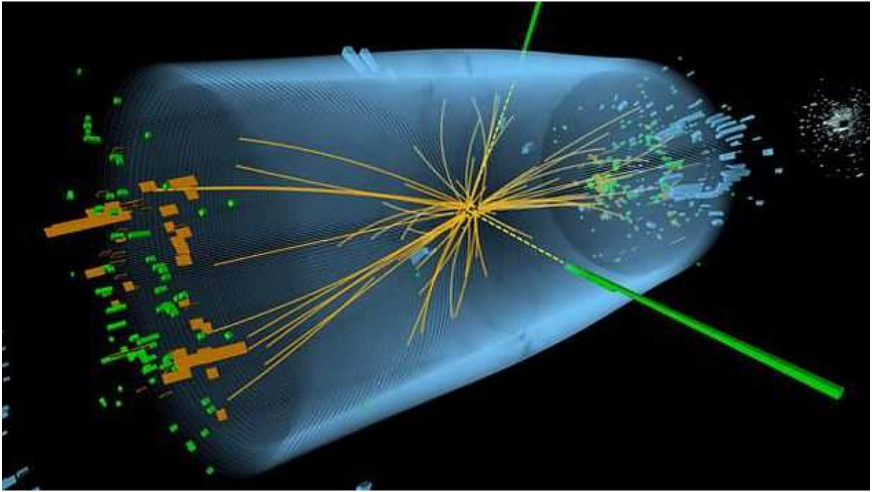
This is a triple point of water analogy.

The idea of the Multiple Point Principle has its origin from the lattice investigations of gauge theories. In particular, Monte Carlo simulations of $U(1)$, $SU(2)$ and $SU(3)$ gauge theories on lattice, indicate the existence of the triple critical point.

Multiple Point Principle

If several vacua are degenerate, then the phase diagram contains a special point – the Multiple Critical Point (MCP), at which the corresponding phases assembly together:





Post/Pre- dicting Masses from Mutiple Point Principle

Claim 3 Post or Pre-dictions of Masses from MPP

We use/assume three diffent "vacua" which we may name: "physical", "Higg Higgs" and "S condensate":

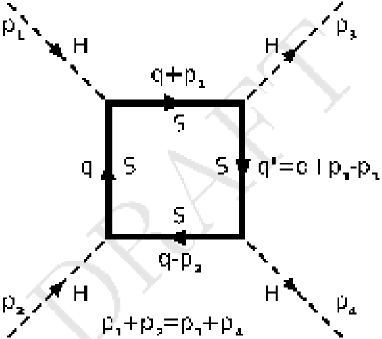
- 1.Mass of Higgs from degeneracy of "physical" and "High Higgs" **Prediction !**
- 2. Mass of the new resonance S of 750 GeV from degeneracy of "physical" and "Higgs Higgs" with improved accuracy. (postdiction only, but...)
- 3. Mass of the new 750 GeV resonance from degeneracy of "physical" and "S condensate".(now postdiction) (Actually Colin Froggatt and I made this calculation as PREdiction to 285 GeV for the mass, but without attaching much belief to it.)

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

Lars Andersen

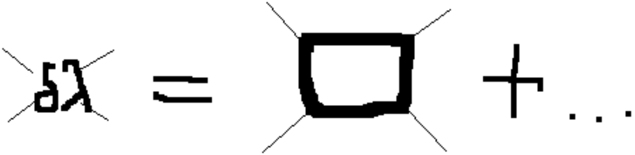
Historiemaler Portrætmaler Provokunstner Om Lars Andersen CV/omtale Kontakt

Higgs-Mass Correction



Higgs-Mass Correction

$$m_H^2 = 2(\delta\lambda + \lambda)v^2$$



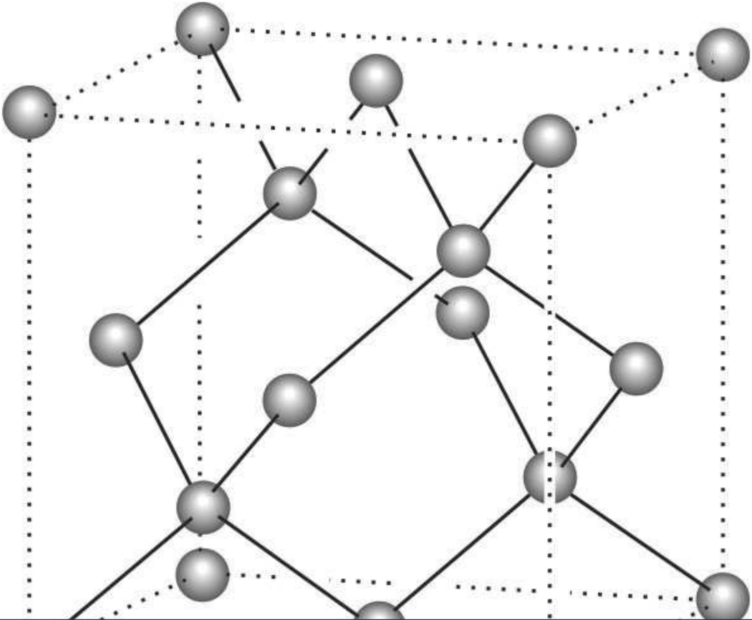
3. Getting the Bound state S Mass from Requiring Degeneracy of Vacua "Physical" and "S Condensate" to 4 m_t

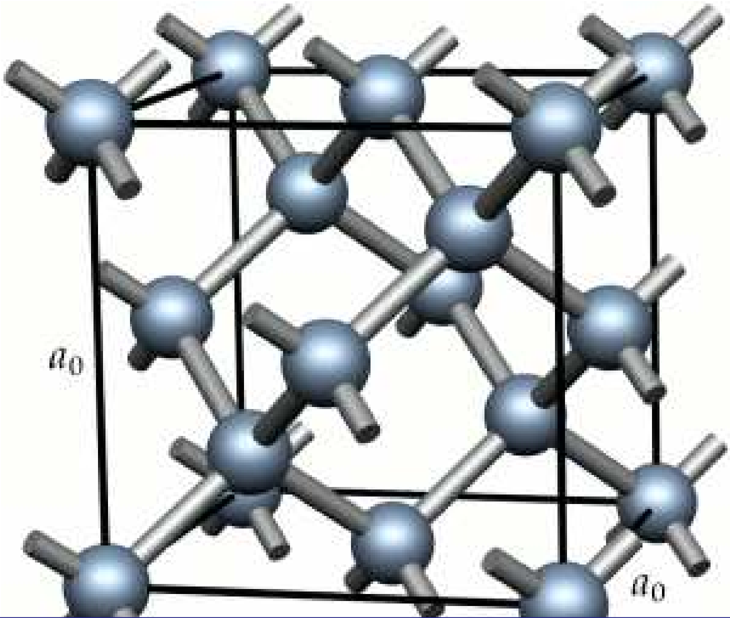
With the right not so obvious approximations one gets in a very simple way that the bound state S shall have the mass $m_S = 12m_t/3 = 4m_t$. Thes assumptions:

- The "S condensate" vacuum is a lattice of same structure as diamond chrystal.
- We can count the binding energy as if the neighboring S-states in the chrystal have there constituent top and anti tops in the n=2 level of the surrounded S.

Assumptions continued:

- We can ignore the effective Higgs mass for the exchange up to the n=2 level, but from n=3 and on the Higgs mass may be taken infinite.
- The MPP - degeneracy of "physical" and "S condensate" vacua - requires the binding in the chrystal to just cancel the Einstein masses of the S particles.
- We can take the S's in the "S condensate " vacuum as at rest.




a_0
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3. Mass from MPP of S-condensate

We want to estimate the condition in a non-relativistic ansatz for the vacuum with the S-condensate as a diamond-structure pattern of S-bound states. The binding energy between the neighbors in this pattern is estimated by assuming that the four nearest neighbors S's to a certain S have their top and anti tops effectively filling up the 4 n=2 states surrounding the S considered. Since n=2 states in the Bohr atom have a binding $1/n^2 = 1/4$ times that in the n=1 states, we take it that the binding per quark of a neighboring S to a given one is in the Higgs mass zero approximation just 1/4 times that binding of one of the constituent quarks inside its S. Thus the binding of an S to its neighbor must be with a potential 1/4 of the binding energy of an S from its constituents.

3. Mass from MPP of S-condensate

In the assumed diomond lattice each carbon atom has 4 nearest neighbors, but each “binding-link” is attached to two carbon atoms. So the number of “binding-links” is twise as large as the number of carbon atoms. If we therefore as argued have one quarter of the binding energy in these “binding links” as in the S’s or the carbon atoms in the analogue, there will be $2/4 = 1/2$ as much binding in the “binding -links” as in the S’s themselves.

3. Mass from MPP for S-condensate

If the Einstein energy $E = mc^2$ of a sample of bound states S consisting of top and anti tops shall be just compensated by the binding energy between these quarks, then the total binding energy per quark must add up to this Einstein energy numerically. Such compensation is required by our new law of nature "Multiple point principle".

If the bindings in the "binding-links" make up 1/2 of the binding of the constituents inside their respective S bound states, the latter must make up 2/3 of the Einstein energy. The a priori Einstein energy of the twelve top or anti top quarks in an S bound state is of course 12 m_t. The binding energy the S-bound state should thus from MPP be 12 m_t * 2/3. Thus the left over mass of the S bound state shall be 12 m_t - 2/3 *12m_t = 12/3 m_t = 4 m_t, which is indeed very close to the observed mass $m_S = 750 GeV$. In fact $4m_t = 4 * 173 GeV = 692 GeV$.

Conclusion

- We have argued for that in our interpretation of the diphoton peak as a bound state of $6t + 6\bar{t}$ bound state ther are two arguments using the “multiple point principle” that independently lead to the bound state having a mass near the 750 GeV:
  - A. The correction to the to be observed Higgs mass needed to make degeneracy (MPP) of the physical and the high Higgs vacua is close to requiring the bound state mass 760 GeV.
  - B. To have the degeneracy (MPP) of the S-condensate vacuum with the physical one an S mass of $\sim 4m_t$ is needed.

Conclusion(continued)

- Even ignoring the little correction from the bound state S to the relation between the Higgs mass and the energy density of the high Higgs vacuum is so well approximately in correspondance with the MPP-required degeneracy of the physical and the high higgs vacua that we - Colin Froggatt and I - PREdited the Higgs mass correctly within 10 GeV!
- That the 750 GeV peak is so far only seen in the diphoton channel is so far barely consistent with the bounds from LHC, because one has not yet analysed the other relevant channels at 13 TeV.
- The production rate is in crude agreement with our estimate.