Buried Higgs

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Preview

- Found a SUSY model, where:
  - Weird higgs decays automatic
  - Higgs could be below “LEP bound”
  - No little hierarchy
  - Lots of new particles at LHC, but higgs buried in QCD background
  - Could discover “fake higgs”

Outline

- The little hierarchy of the MSSM and pGB higgses
- The simplest supersymmetric pGB higgs: 5 Goldstones h+η
- h-decays and η decays: higgs could be < 114 GeV
- A “flipped” matter content: charming higgs

Little hierarchy in the MSSM

- SUSY solves hierarchy problem, but
  - Log divergences remain
  - Need a large $\Delta\lambda$ to push higgs above 114 GeV
- Generic Higgs potential

$$V(H_u, H_d) = (m_{H_u}^2 + \mu^2)|H_u|^2 + (m_{H_d}^2 + \mu^2)|H_d|^2 - B\mu(H_u H_d + \text{h.c.}) + \frac{g^2}{2}(H_u^\dagger \vec{\tau} H_u + H_d^\dagger \vec{\tau} H_d)^2 + \frac{g'^2}{2}(H_u^\dagger H_u - H_d^\dagger H_d)^2$$

- For minimum we need

$$M_Z^2 = 2\left(\frac{m_{H_d}^2 - m_{H_u}^2 \tan^2\beta}{\tan^2\beta - 1} - \mu^2\right)$$

- For large tan β $M_Z^2 \sim -2m_{H_u}^2$

$$m_{H_u}^2 = m_0^2 - \frac{3\lambda_t^2 m_{\tilde{t}}^2}{4\pi^2} \log \frac{\Lambda_{UV}^2}{m_{\tilde{t}}^2}$$

- But the expression for the Higgs mass is:

$$m_{Higgs}^2 = M_Z^2 + \frac{3m_t^2\lambda_t^2}{4\pi^2} \log \frac{m_{\tilde{t}}}{m_t}$$

- To push Higgs mass above 114 GeV: need $m_{stop} \gtrsim 1$ TeV, but then need 1% or less tuning for M_Z

- Main idea: SUSY Higgs as pseudo-Goldstone boson (=super-little Higgs, doubly protected Higgs)

(Birkedal, Chacko, Gaillard; Chankowski, Falkowski, Pokorski, Wagner)

- A global symmetry broken at f~500 GeV produces Goldstones, softens Higgs potential further

- In these models higgs potential completely finite

$$m_{H_u}^2 = -\frac{3\lambda_t^2 m_{\tilde{t}}^2}{4\pi^2} \log \frac{f^2}{m_{\tilde{t}}^2}$$

- Fine tuning reduced

- BUT: global symmetry (presence of top partners) also reduced shift in quartic

- Usually VERY difficult to achieve m_{Higgs}>114 GeV

- Models quite complicated (Berezhiani, Chankowski, Falkowski, Pokorski; Roy, Schmaltz; C.C., Marandella, Shirman, Strumia)

- Main new idea here: in simplest model (susy version of Schmaltz's simplest little Higgs) ad'l Goldstone η automatic

- $h \rightarrow \eta\eta$ decay can avoid LEP bounds, don't need to push quartic, can get simple natural model with interesting phenomenology

Higgs sector and Goldstones

•Higgses:

(Same as Schmaltz simplest LH)

	$SU(3)_C$	$SU(3)_W$	$U(1)_X$
$\mathcal{H}_u, \Phi_u$	1	3	$1/3$
$\mathcal{H}_d, \Phi_d$	1	$\bar{3}$	$-1/3$

•Assume no $\Phi\mathcal{H}$ terms in the superpotential: $SU(3)_\Phi x SU(3)_\mathcal{H}$ global symmetry

•One sector will get a VEV F~10 TeV

$$\langle \Phi_u \rangle^T = \langle \Phi_d \rangle = (0, 0, F/\sqrt{2})$$

•Embedding of hypercharge: $Y=T_8/\sqrt{3}+X$, where $T_8=1/(2\sqrt{3})\ \mathrm{diag}(1,1,-2)$

- Below F theory effectively MSSM with $SU(3)_{\mathcal{H}}$ global symmetry

- SU(3) breaking from $\langle \mathcal{H} \rangle$ ~f~400 GeV

- The parameterization of the Higgses:

$$\mathcal{H}_u = e^{i\Pi/f} f \sin\beta \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}, \quad \mathcal{H}_d = e^{-i\Pi/f} f \cos\beta \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

- Where Π is the pion matrix containing the 5 Goldstones:

$$\Pi = \left(\begin{array}{c|c} & H \\ \hline H^\dagger & \frac{\tilde{\eta}}{\sqrt{2}} \end{array} \right)$$

- The Higgs fields H can be thought of as angles between the triplet VEVs $\langle \Phi \rangle$ and $\langle \mathcal{H} \rangle$. Together SU(3)xU(1)→$U(1)_{QED}$

•The result is:

$$\mathcal{H}_{u,d} = f_{u,d} \begin{pmatrix} \sin H/f \\ e^{\pm i\frac{\eta}{f}} \cos|H|/f \end{pmatrix}$$

•In terms of the uneaten fields $\tilde{h}$ and $\tilde{\eta}$ (before shifting VEVs)

$$\mathcal{H}_u = f \sin\beta \begin{pmatrix} 0 \\ \sin(\tilde{h}/\sqrt{2}f) \\ e^{i\tilde{\eta}/\sqrt{2}f} \cos(\tilde{h}/\sqrt{2}f) \end{pmatrix} \qquad \mathcal{H}_d^T = f \cos\beta \begin{pmatrix} 0 \\ \sin(\tilde{h}/\sqrt{2}f) \\ e^{-i\tilde{\eta}/\sqrt{2}f} \cos(\tilde{h}/\sqrt{2}f) \end{pmatrix}$$

•After Higgs gets VEV $\langle\tilde{h}\rangle = \sqrt{2}\tilde{v}$ with $v_{EW} = f\sin(\tilde{v}/f)$
where v_{EW}=174 GeV
we shift fields as usual

$$\tilde{h} = \sqrt{2}\tilde{v} + h, \ \tilde{\eta} = \eta/\cos(\tilde{v}/f)$$

$h\to\eta\eta$ vs. $h\to bb$

- In order to make $h\to\eta\eta$ the leading mode need to win over λ_b: not that hard, v/f suppression OK.

- The Goldstone kinetic term contains derivative interaction

$$\mathcal{L}_{pGB} \approx \frac{1}{2}(\partial_\mu \tilde{h})^2 + \frac{1}{2}\cos^2(\tilde{h}/\sqrt{2}f)(\partial_\mu \tilde{\eta})^2$$

- After shifting VEV get cubic interaction:

$$\mathcal{L}_{h\eta^2} \approx -h(\partial_\mu \eta)^2 \frac{\tan(\tilde{v}/f)}{\sqrt{2}f}$$

(Ideas suggested by Dermisek, Gunion; Chang, Fox, Weiner;…)

•The h→$\eta\eta$ rate is:

$$\Gamma_{h\to\eta\eta} \approx \frac{1}{64\pi}\left(1-\frac{v_{EW}^2}{f^2}\right)^{-1}\frac{m_h^3 v_{EW}^2}{f^4}$$

•Compare to the usual fermionic width with extra $(1\text{-}v^2/f^2)$ suppression:

$$\Gamma_{h\to f\bar{f}} = \left(1-\frac{v_{EW}^2}{f^2}\right)\Gamma^{SM}_{h\to f\bar{f}} = c_{QCD}\frac{N_c}{16\pi}\left(1-\frac{v_{EW}^2}{f^2}\right)\frac{m_h m_f^2}{v_{EW}^2}$$

•Relevant quantity for suppression of the h→bb compared to SM is ξ^2:

$$\xi^2_{h\to b\bar{b}} \equiv \frac{\sigma(e^+e^- \to Zh)}{\sigma_{SM}(e^+e^- \to Zh)} BR(h \to b\bar{b}) = \frac{\Gamma^{SM}_{h\to b\bar{b}}}{\Gamma_{h\to\eta\eta} + \left(1 - \frac{v^2_{EW}}{f^2}\right)\sum_f \Gamma^{SM}_{h\to f\bar{f}}} \left(1 - \frac{v^2_{EW}}{f^2}\right)^2$$

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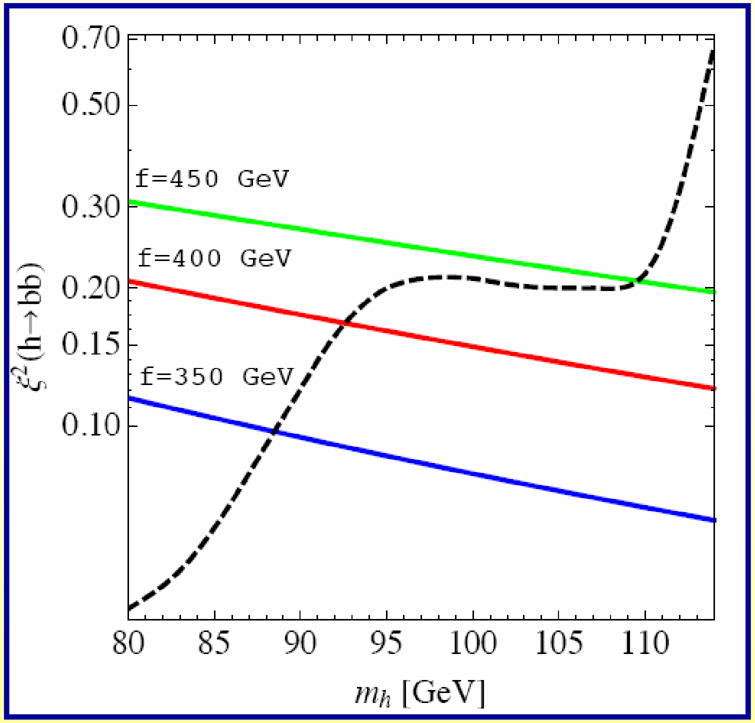

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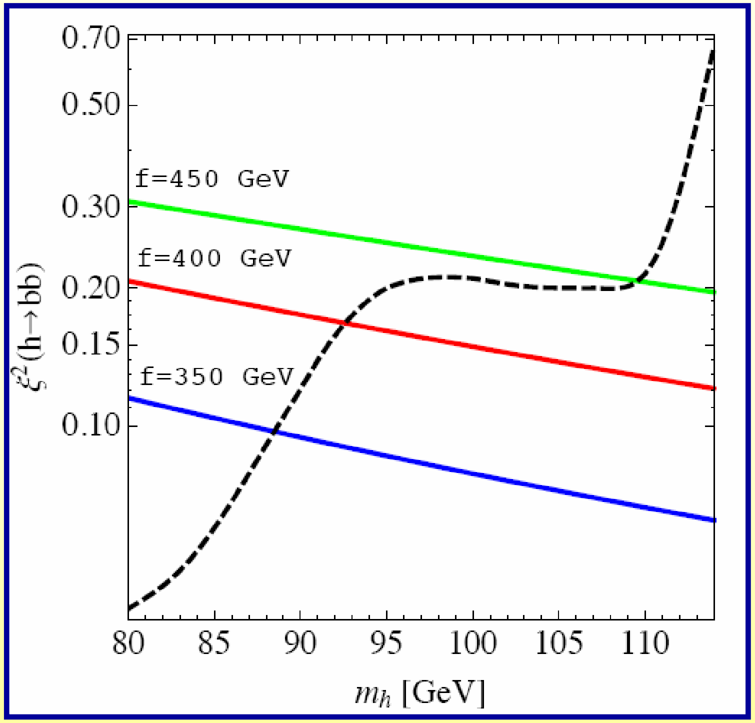

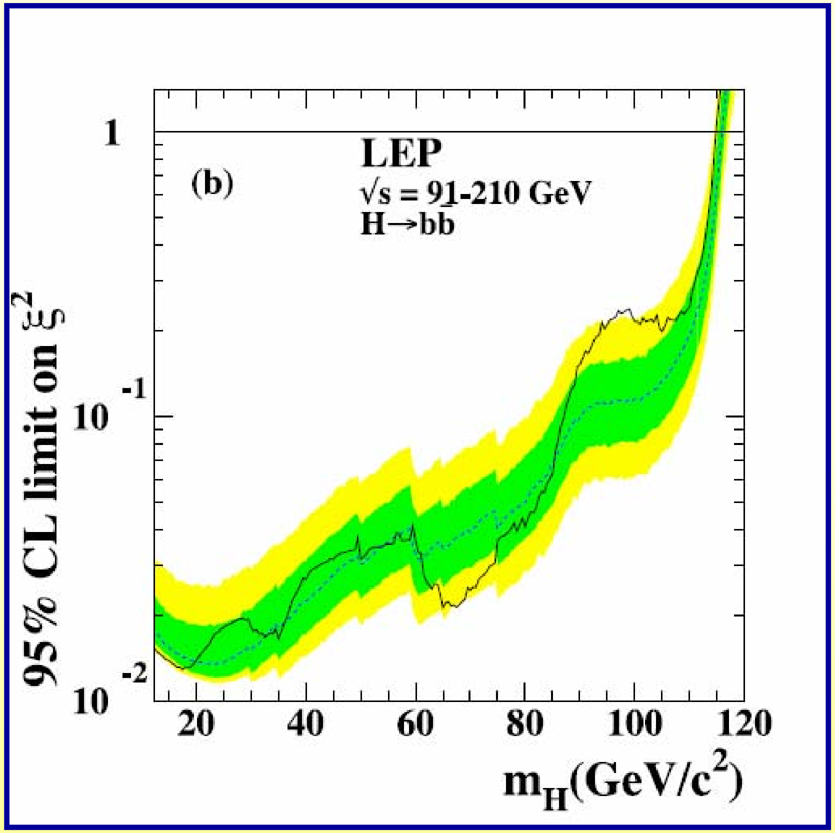

The LEP bound

•To actually hide higgs at LEP, need to make sure η decays are allowed and weird, since bounds:

Decay channel	Limit (GeV)
$h \to b\bar{b}, \tau\bar{\tau}$	115
$h \to jj$	113
$h \to \gamma\gamma$	117
$h \to WW^*, ZZ^*$	110
$h \to$ invisible	115
$h \to \eta\eta \to 4b$	110
$h \to \eta\eta \to 4\tau, 4c, 4g$	86
model indep.	82

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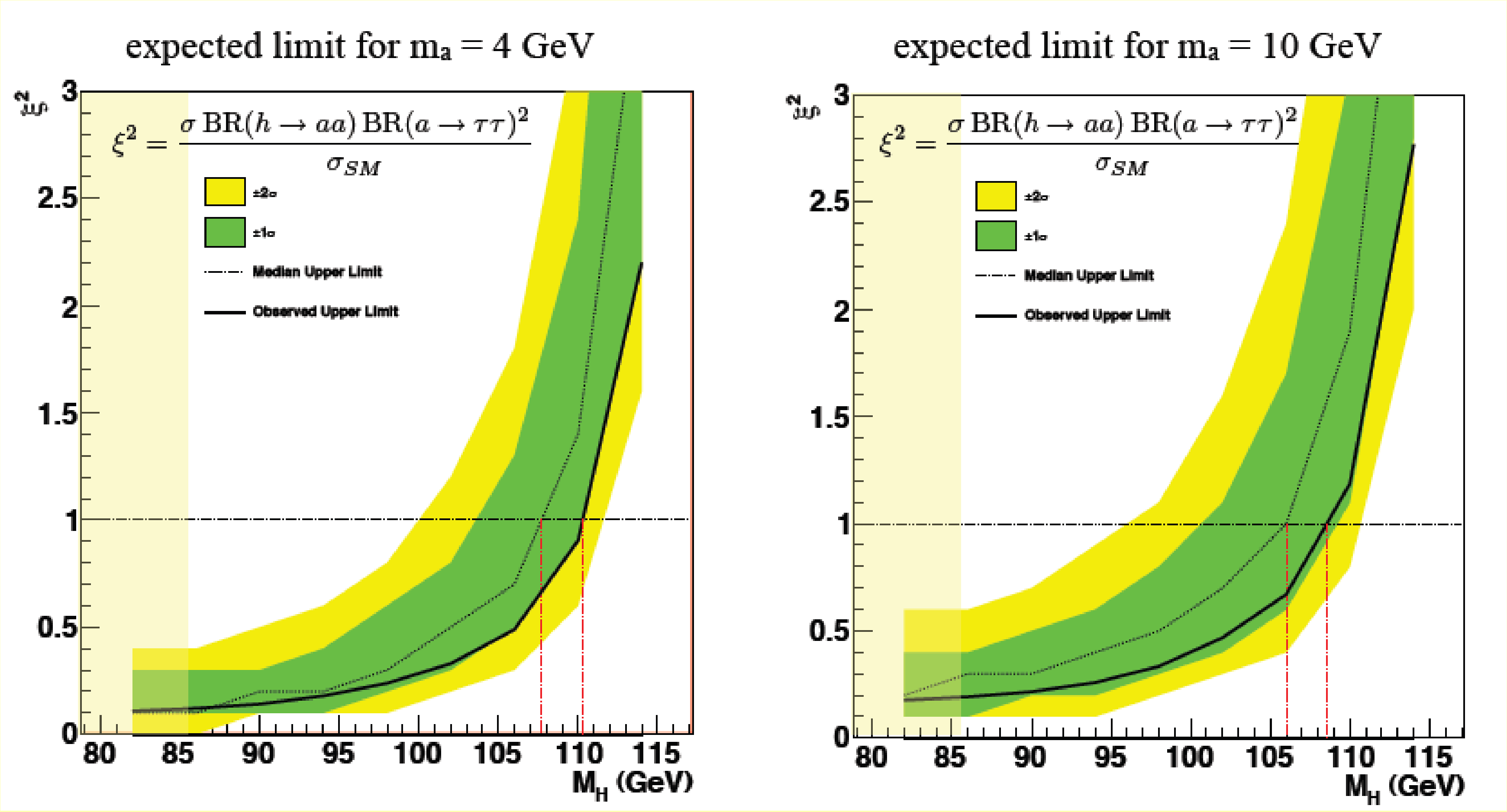
New LEP result!

ALEPH bound on h→4τ of order 105-110 GeV!



Talk by K. Cranmer on 11/3/09

(Cranmer, Yavin, Beacham, Spagnolo, ALEPH collab.)

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- To find out which case need fermion embeddings…

The matter content and Yukawas

	$SU(3)_C$	$SU(3)_W$	$U(1)_X$
$Q = (t^Q, b^Q, \hat{b}^Q)$	3	3	0
$V = (b^V, t^V, \hat{t}^V)$	3	$\bar{3}$	$1/3$
$V_c = (b_c^V, t_c^V, \hat{t}_c^V)$	$\bar{3}$	3	$-1/3$
t_c	$\bar{3}$	1	$-2/3$
$b_c^{1,2}$	$\bar{3}$	1	$1/3$
$L_{1,2} = (\tau_{1,2}^L, \nu_{1,2}^L, \hat{\nu}_{1,2}^L)$	1	$\bar{3}$	$-1/3$
$E_c = (\nu_c^E, \tau_c^E, \hat{\tau}_c^E)$	1	$\bar{3}$	$2/3$
$\nu_c^{1,2,3}$	1	1	0

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$E_c = (\nu^E_c, \tau^E_c, \hat{\tau}^E_c)$	1	$\bar{3}$	$2/3$
$\nu^{1,2,3}_c$	1	1	0

- Why?????

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- Cancels anomalies
- Contains MSSM chiral generation
- Obtain from SU(6) matter content

•Quark Yukawas (including a μ-term for VV_c):

$$y_1 t_c V \Phi_u + y_2 \mathcal{H}_u V_c Q + \mu_V V V_c + y_{b1} \Phi_d Q b_c^1 + y_{b2} \mathcal{H}_d Q b_c^2$$

•Not the most general superpotential, could also add

$$\tilde{y}_1 t_c V \mathcal{H}_u + \tilde{y}_2 \Phi_u V_c Q + \tilde{y}_{b1} \mathcal{H}_d Q b_c^1 + \tilde{y}_{b2} \Phi_d Q b_c^2$$

•Original superpotential collective

•In top sector need y_1, y_2 and μ_V to break $SU(3)_H$

$m_t \sim y_1 y_2 \mu_V$, corrections OK if $\mu_V <$ TeV.

•In bottom sector need y_{b1} and y_{b2} to break $SU(3)_H$

•Since $y_{b1}F$ is one of bottom masses, need $y_{b1} \lesssim 0.1$ to avoid large logs in higgs mass

Higgs potential, fine tuning

- Both f/F and v/f can be radiatively generated from Yukawa interactions

- f generated due to potential for triplet $\mathcal{H}_u$:

$$
\begin{aligned}
m^2_{\mathcal{H}_u} &\approx -\frac{3y_2^2 \sin^2\beta}{2\pi^2} M^2_{\rm soft} \log(\Lambda/M_T) \\
\lambda_{\mathcal{H}_u} &\approx \frac{3y_2^4 \sin^4\beta}{8\pi^2} \log((M^2_{\rm soft}+M_T^2)/M_T^2)
\end{aligned}
$$

- Here m_T top partner mass $M_T = \sqrt{\mu_V^2 + \sin^2\beta y_2^2 f^2}$

- Generates "radion" mass $m_r^2 \sim 4\lambda_{\mathcal{H}_u} f^2$

•Fine tuning from f/F hierarchy:

$$FT_3 = \frac{m_r^2/2}{|m_{\mathcal{H}_u}^2|} \sim \frac{y_2^2 f^2}{M_{soft}^2} \frac{\log \frac{M_{soft}^2 + M_T^2}{M_T^2}}{\log \frac{\Lambda^2}{M_T^2}}$$

•Similar to MSSM expression, except:

- m_r can be heavier than Higgs
- y_2 can be bigger than y_t

•Typical fine tuning 5-10%

- Usual MSSM fine tuning completely absent

$$FT_2 = \frac{m_h^2/2}{|\Delta m^2|}$$

- Higgs mass parameter shift finite

$$\Delta m^2 \approx -\frac{3m_t^2}{8\pi^2 v_{EW}^2}\left[M_T^2 \log\frac{M_{\rm soft}^2 + M_T^2}{M_T^2} + M_{\rm soft}^2 \log\frac{M_{\rm soft}^2 + M_T^2}{M_{\rm soft}^2}\right]$$

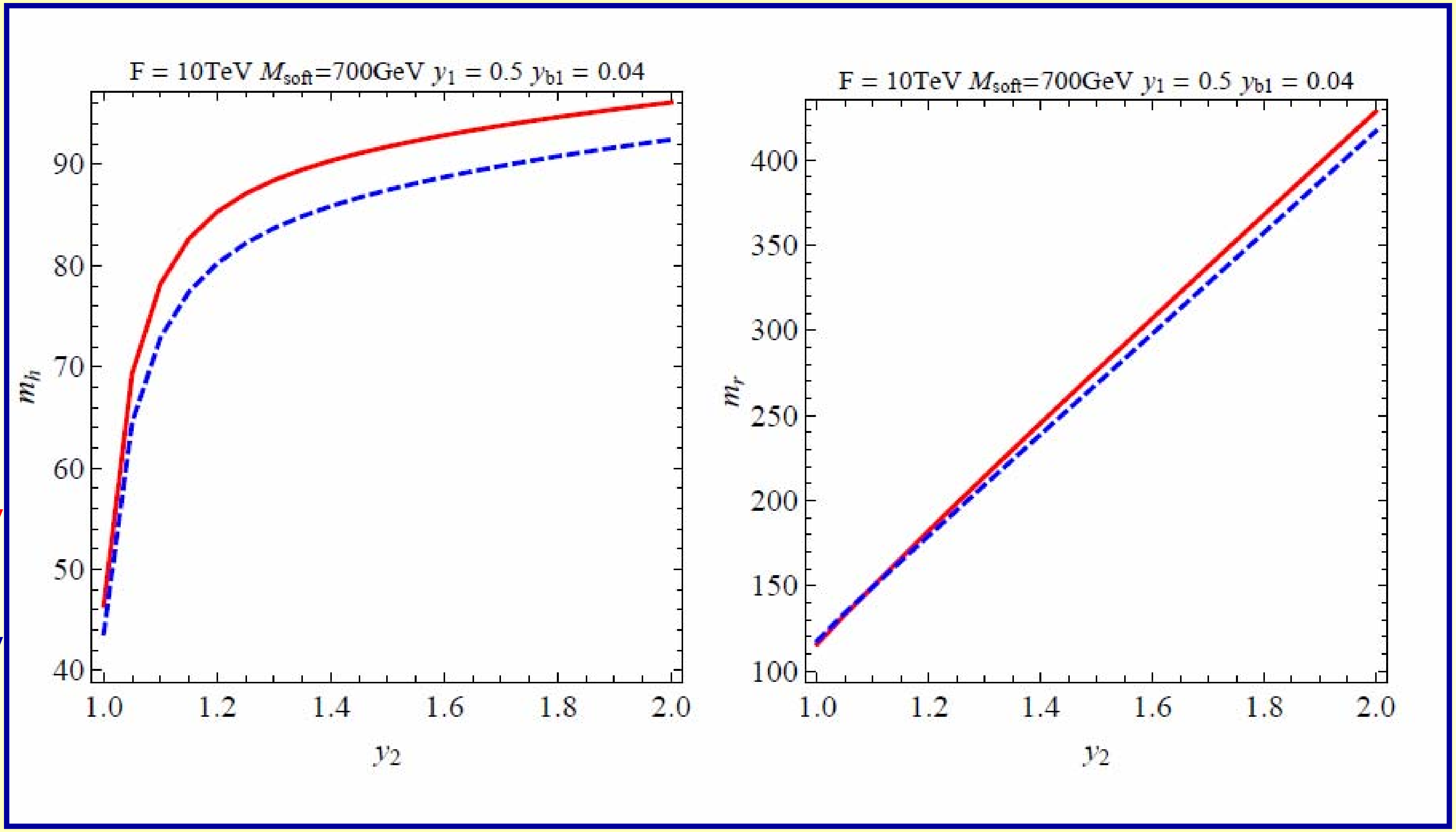
- Physical higgs mass:

$$m_h^2 = \left(1 - \frac{v_{EW}^2}{f^2}\right)\left\{m_Z^2 \cos^2(2\beta) + \frac{3m_t^4}{4\pi^2 v_{EW}^2}\left[\log\left(\frac{M_{\rm soft}^2 M_T^2}{m_t^2(M_{\rm soft}^2 + M_T^2)}\right) -2\frac{M_{\rm soft}^2}{M_T^2}\log\left(\frac{M_{\rm soft}^2 + M_T^2}{M_{\rm soft}^2}\right)\right]\right\}$$

•A slice of the higgs and radial masses

f=400 GeV

f=350 GeV



•From 1-loop Coleman Weinberg, including higgs-radial mixing

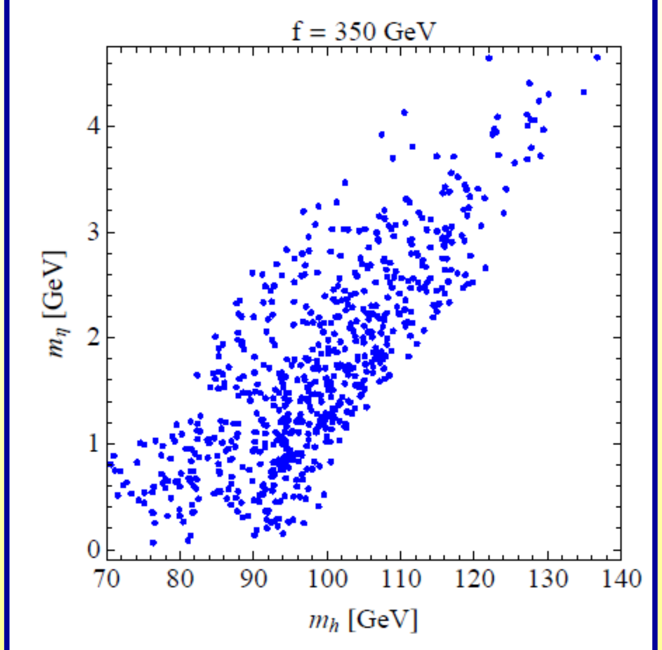
η mass

•For collective Yukawas, f/F→0 η exactly massless – can be removed by phase redefinitions

•To leading order in f/F:

$$m_\eta^2 \approx \frac{3v_{EW}^2 y_2^2}{8\pi^2}\frac{M_{\rm soft}^2}{F^2}\left[\log\left(\frac{y_{b1}^2 F^2}{2(M_T^2+M_{\rm soft}^2)}\right) - \frac{M_T^2}{M_{\rm soft}^2}\log\left(\frac{M_T^2+M_{\rm soft}^2}{M_T^2}\right)+1\right]$$

•Generates small m_η in the few GeV range:



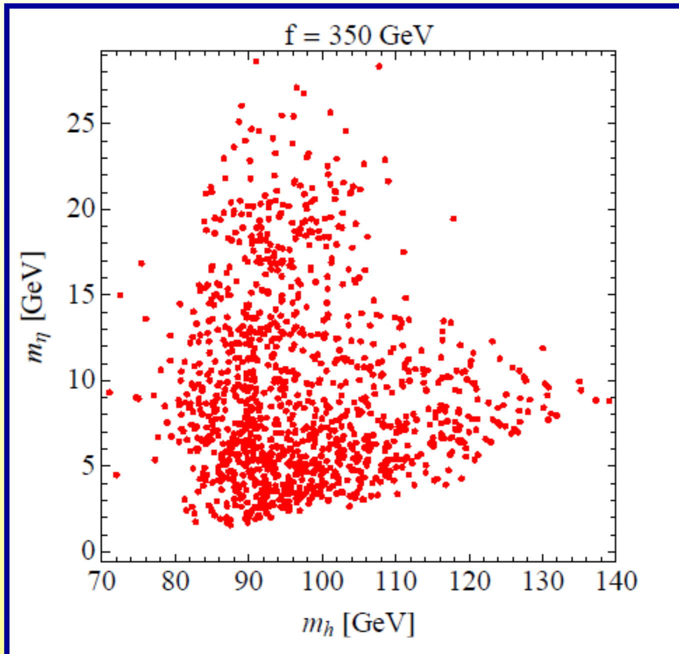
- To get bigger m_η can turn on small non-collective coupling

$$\tilde{y}_{b1}\mathcal{H}_d Q b_c^1 + \tilde{y}_{b2}\Phi_d Q b_c^2$$

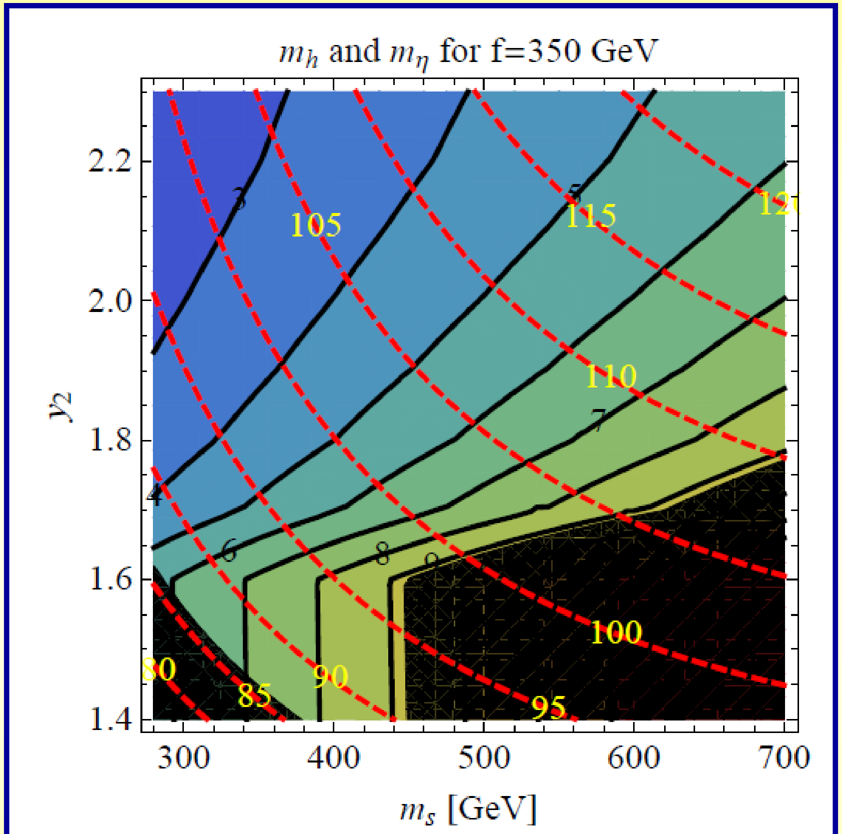
$$m_\eta^2 = \cos\beta \frac{N_c}{4\pi}\frac{F}{f}(y_{b1}\tilde{y}_{b1} + y_{b2}\tilde{y}_{b2}) M_{soft}^2 \log\frac{\Lambda}{F}$$

- A scatter plot for the achievable masses for a particular point:

$f = 350, F = \sqrt{2}\cdot 10^4, \Lambda = 10^7$ GeV for both plots, and scanned the remaining parameters in the regions $0.02 < y_1 < 0.3, 1 < y_2 < 3, 0.02 < y_{b1} < 0.12$ and $300 < M_{soft} < 1500$ GeV.



Parameter scans (f=350 GeV)



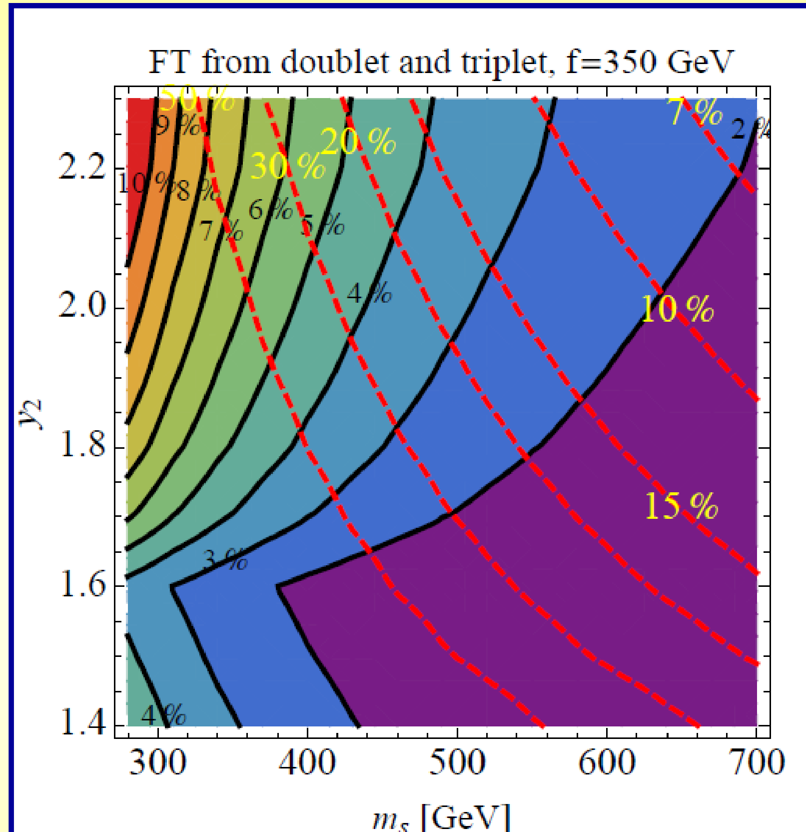
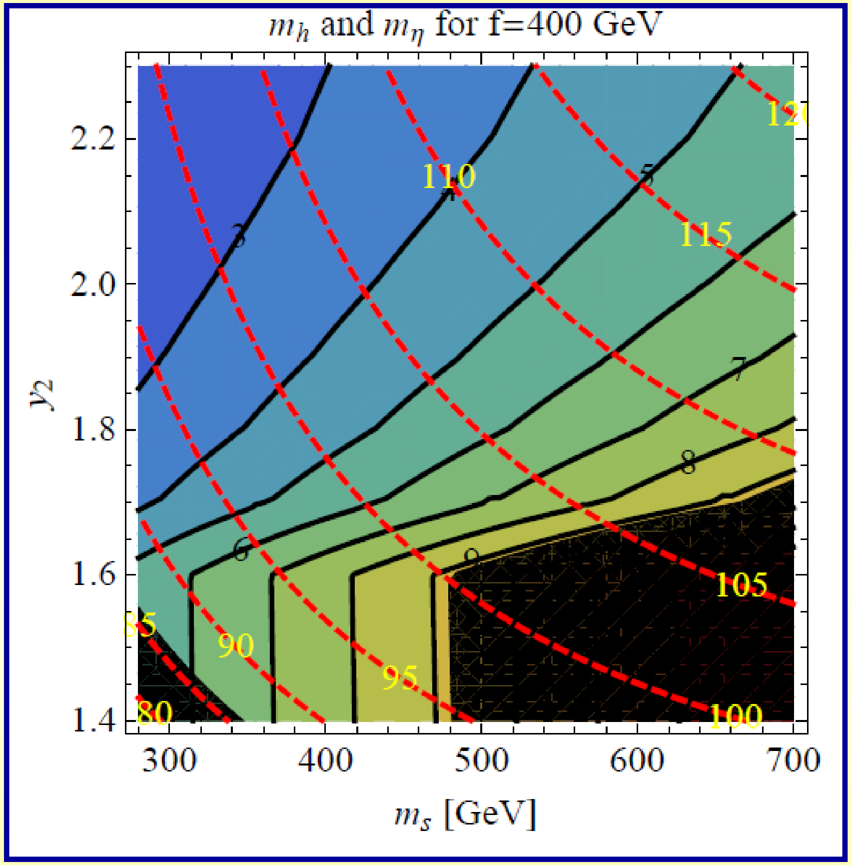
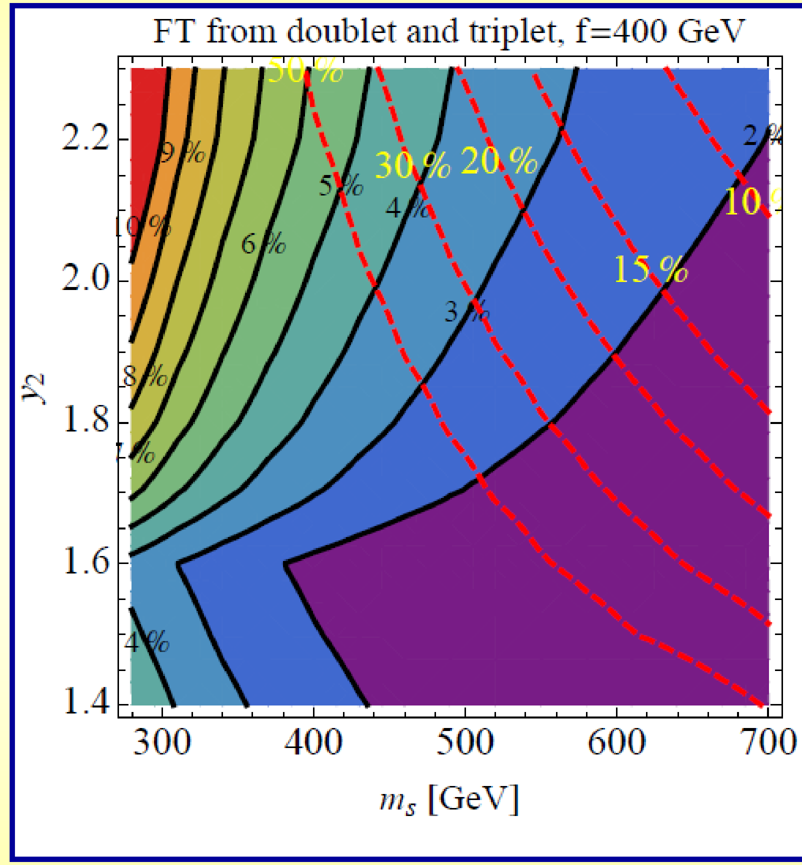


Figure 4: On the left the contours of the Higgs mass (dashed red line) and the η mass (solid black lines) as function of the universal soft breaking mass M_{soft} and the top Yukawa y_2. On the right, the necessary fine tunings FT_3 (solid black) and FT_2 (dashed red) in percent. These plots are based on the full numerical 1-loop Coleman-Weinberg potential, with $f = 350$ GeV, $y_1 = 0.29, y_{b1} = 0.1, y_{b2} = 0, \tilde{y}_{b1} = 0.001, \tan\beta = 10, F = \sqrt{2} \cdot 10^4$ and $\tilde{y}_{b2} = 0$. The region in the lower left is excluded by the LEP ξ^2 bound and in the lower right because $m_\eta > 2m_b$.

Parameter scans (f=400 GeV)





- Perturbativity: SU(3) Landau pole at $\Lambda \sim 10^8$ TeV
- For y_2=1.64 $\Lambda^{quartic}=10^8$ TeV, while for y_2=1.83 $\Lambda^{quartic}=10^4$ TeV

η decays

- If $m_\eta > 2\, m_b$ then $\eta \to bb$ will dominate. But then $h \to 4b$ which is strongly constrained by LEP ($m_h > 110$ GeV)

- Will require $m_\eta < 2\, m_b$. In this case decays to τ, c, γ or gluon are relevant.

- Decay to τ: $h \to 2\eta \to 4\tau$ from coupling

$$i\tilde{y}_\tau (\bar{\tau}\gamma_5\tau)\eta \qquad \tilde{y}_\tau \simeq \frac{m_\tau^3 f}{\sqrt{2} M_\tau^2 v_{EW}^2}$$

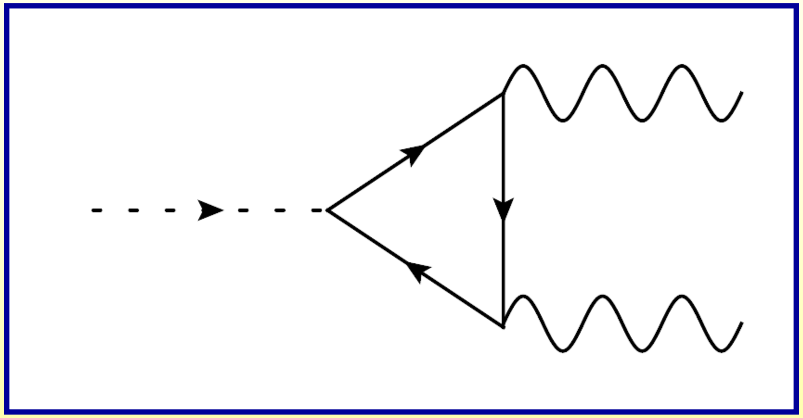
- Strongly suppressed because τ mixing $\propto m_\tau^2/M_\tau^2$

- Width for decays to τ

$$\Gamma_{\eta\to\tau\tau} \approx \frac{1}{16\pi}\sqrt{1-4m_\tau^2/m_\eta^2}\,\frac{m_\eta m_\tau^6 f^2}{v_{EW}^4 M_\tau^4}$$

- Very small ~ 10^{-13} GeV, mm decay length…

- Dominant decay will be through loops to 2g, 2γ:



- The loop induced decays:

$$\kappa^g \eta \epsilon^{\mu\nu\rho\sigma} G^a_{\mu\nu} G^a_{\rho\sigma} \,, \qquad \kappa^g = \frac{g^2}{32\pi^2} \sum_\psi \frac{\tilde{y}_\psi}{m_\psi} c_2(\psi) \tau_\psi f(\tau_\psi)$$

- f(τ) is the usual triangle function, τ=4 m_ψ^2/m_η^2:

$$f(\tau) = \begin{cases} \arcsin^2[\tau^{-1/2}] \\ -\frac{1}{4}\left(\log[(1+\sqrt{1-\tau})/(1-\sqrt{1-\tau})] - i\pi\right)^2 \end{cases}$$

- Leading term: $\eta G \tilde{G}$ ~ $\sum \tilde{y}_\psi / m_\psi \approx \mathcal{O}(1/F^2)$ vanishes due to anomaly cancellation

- Actual leading operator $\Box \eta G \tilde{G}$ ~ $\sum \tilde{y}_\psi m_\eta^2 / m_\psi^3$ dominated by bottom

- The $\eta \to gg$ decay width:

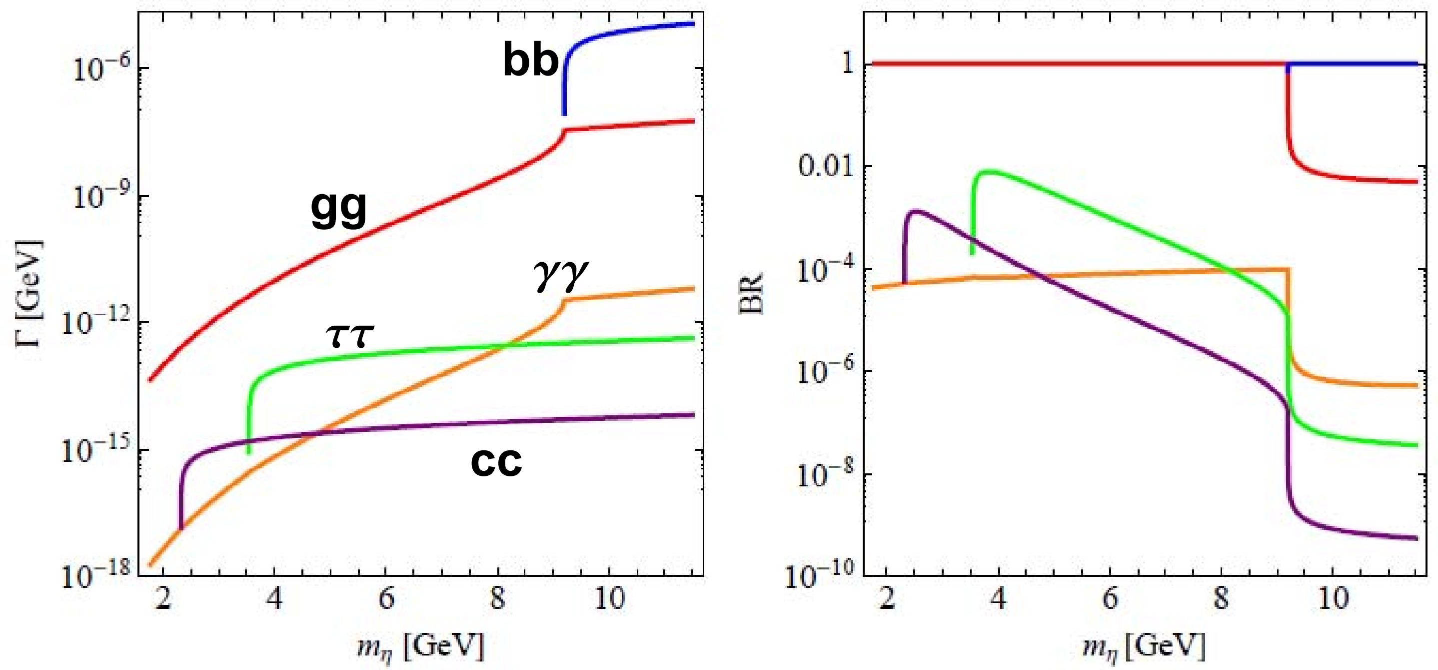
$$\kappa^g \simeq \frac{1}{12\sqrt{2}} \frac{g_s^2(m_\eta)}{64\pi^2} \frac{m_\eta^2}{m_b^2} \frac{m_t^2 f}{\mu_V^2 v_{EW}^2}$$

- Will be leading mode

- $h \to 2\eta \to 4g$ will be main decay chain

- Hard to find at hadron colliders – higgs buried under QCD background

The η decays

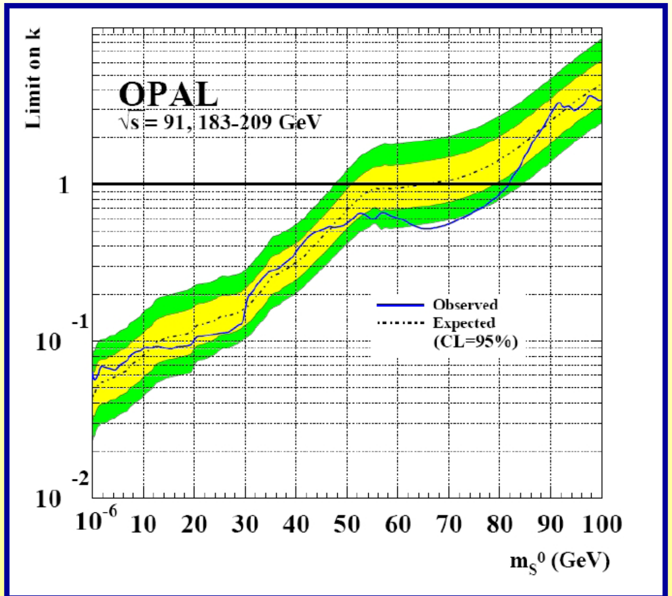


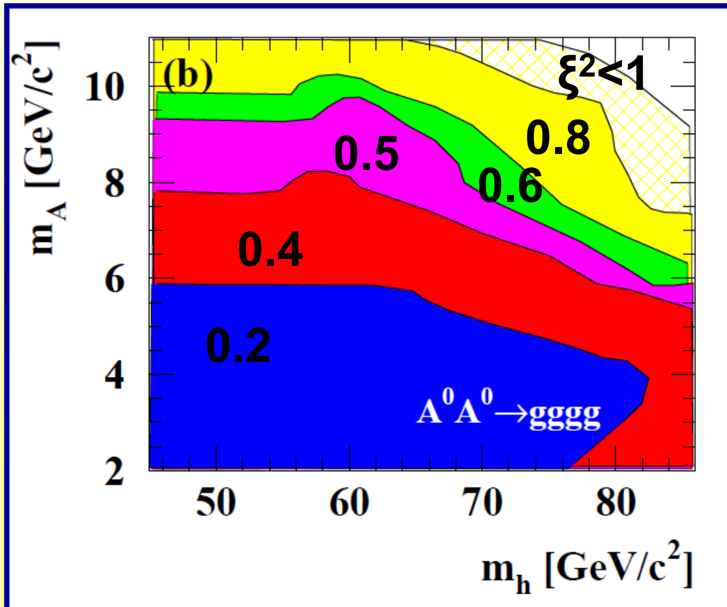
$f = 350$ GeV, $\mu_V = 500$ GeV, $M_c = 400 GeV$, $M_\tau = 200$ GeV

- h→4g almost 100 %
- h→$\gamma\gamma$gg of order 10^{-4}
- h→$\tau\tau$gg of order 10^{-3} – 10^{-5}
- h→4μ and h →$\tau\tau$μμ very suppressed…

- LEP bound: model indep. m_h>78 GeV

- OPAL h→2η→4j analysis (assuming m_h<86 GeV):



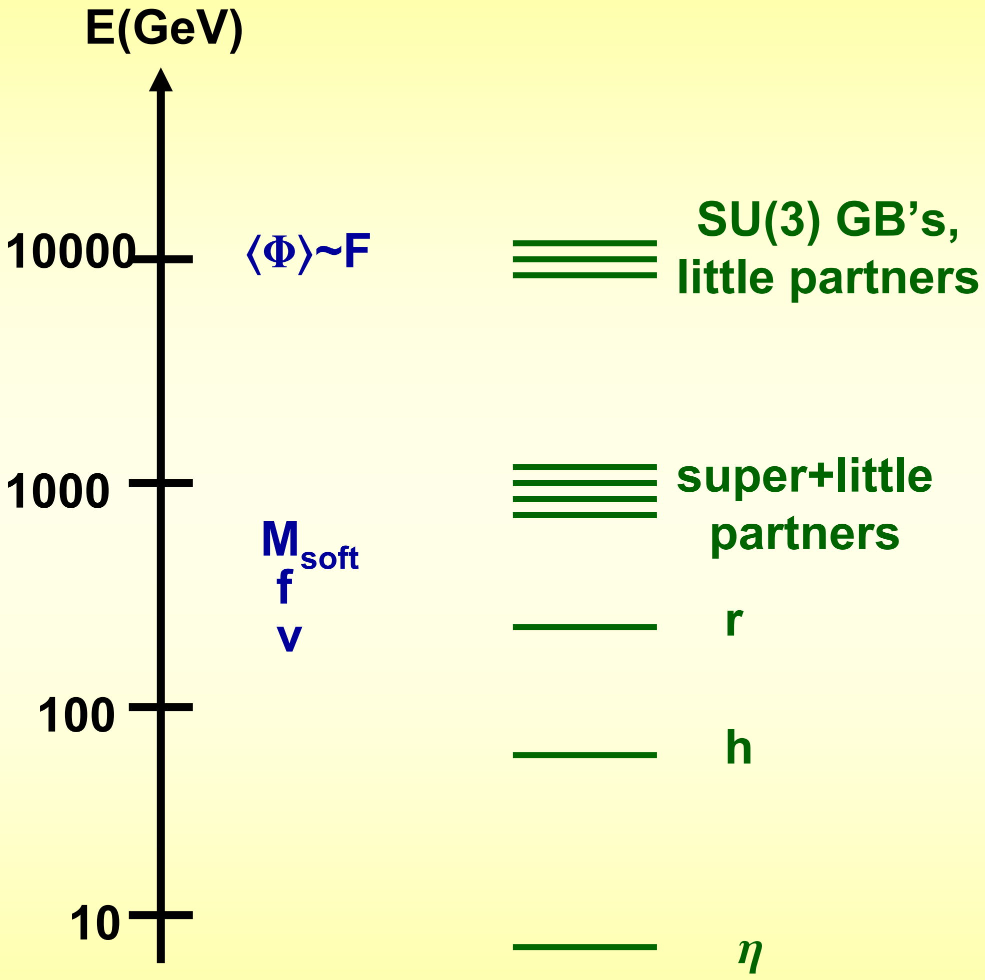


- LEP exclusion: for 78 GeV<m_h<86 GeV we need 6 GeV<m_η<9.2 GeV

- Reason: opening angle between jets ~4m_η/m_h, for very small m_η not 4 jets but 2 jets, restrictive search…

- Would need to know what genuine 4 jet analysis gives at LEP…

The particle spectrum



Radial mode, unitarity, EWP

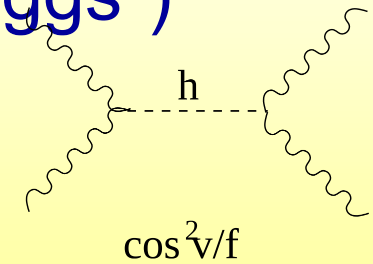
•Radial mode: m_r~ 300-400 GeV

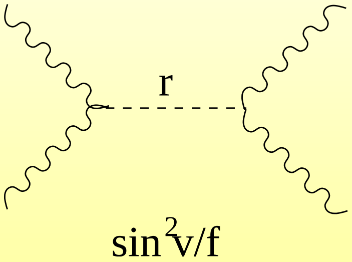
•Couples just like the higgs, with sin v/f suppression

•Should be observable in Z→Z+r→Z+ZZ→Z+4l mode, or just gluon fusion gg→r→ZZ→4l

•But will have wrong cupling for unitarity, EWP: wrong higgs ("fake higgs")

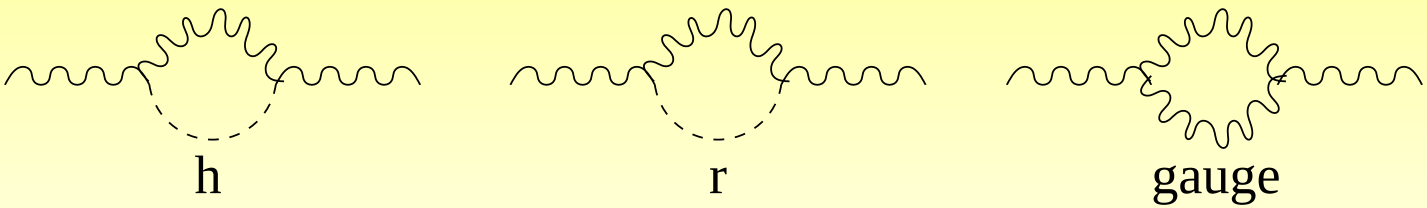
•Unitarity:





•As long as m_h, m_r < TeV unitarity OK

•Electroweak precision (S, T):



$\sim\cos^2 v/f \log m_h/\Lambda$ $\sim\sin^2 v/f \log m_r/\Lambda$ $\sim\log \Lambda/m_W$

•$m_h^{eff} = m_h \, (m_r/m_h)^{\sin^2 v/f}$ ~120 GeV

•Still within allowed region, but NOT at χ^2 minimum…

The Charming Higgs

- Simple variation of model by changing fermion matter content

- To get real little Higgs, need top partner in triplet

- Need to exchange up- and down-type quarks

- Can get another anomaly free matter content that does this!

How to get the anomaly free matter?

- Original model: SU(3)xSU(3)xU(1) $\subset$SU(6)

- SU(6) matter: $\begin{smallmatrix}\square\\ \square\end{smallmatrix}$ +2 $\bar{\square}$, just decompose to subgroup

- Another possibility: “flipped SU(N)”

	$SU(N)$	$U(1)_X$
1	$\begin{smallmatrix}\square\\ \square\end{smallmatrix}$	$N-4$
$(N-4)$	$\bar{\square}$	$-(N-2)$
$\frac{(N-4)(N-3)}{2}$	1	N

- Decomposing this (for N=6) gives new fermion matter

The flipped matter content

- Quark sector now like little Higgs (can add $\mu_V V V_c$ mass, now μ_V does not have to be ~TeV…

Gauge and global symmetry (almost) same

	$SU(3)_C$	$SU(3)_W$	$U(1)_X$
$\mathcal{H}_u, \Phi_u$	1	$\bar{3}$	1/3
$\mathcal{H}_d, \Phi_d$	1	3	−1/3

- Goldstones:

$$\mathcal{H}_u^T = f s_b \begin{pmatrix} \sin(\tilde{h}/\sqrt{2}f) \\ 0 \\ e^{i\tilde{\eta}/\sqrt{2}f} \cos(\tilde{h}/\sqrt{2}f) \end{pmatrix},$$

$$\mathcal{H}_d = f c_b \begin{pmatrix} \sin(\tilde{h}/\sqrt{2}f) \\ 0 \\ e^{-i\tilde{\eta}/\sqrt{2}f} \cos(\tilde{h}/\sqrt{2}f) \end{pmatrix}.$$

- Hypercharge $Y=-T_8/\sqrt{3}+X$

Yukawas

- Collective for quarks:

$$y_1 t_c^1 \Phi_u Q + y_2 t_c^2 \mathcal{H}_u Q + \mu_V V_c V + y_{b1} V_c Q \Phi_d + y_{b2} b_c^1 V \mathcal{H}_d$$

- μ_V large limit easy:

$$y_1 t_c^1 \Phi_u Q + y_2 t_c^2 \mathcal{H}_u Q + \frac{y_{b1} y_{b2}}{\mu_V} b_c^1 Q \Phi_d \mathcal{H}_d$$

- Top and charm mass:

$$m_t \approx \frac{s_b y_1 y_2 F}{\sqrt{(y_1 F)^2 + 2(s_b y_2 f)^2}} v_{EW}$$

$$m_c = \frac{s_b y_{c1} y_{c2} F}{\sqrt{(y_{c1} F)^2 + 2(s_b y_{c2} f)^2}} v_{EW}$$

- Bottom mass:

$$m_b \approx y_{b1} y_{b2} c_b v_{EW} F / \sqrt{2} \mu_V$$

η decays

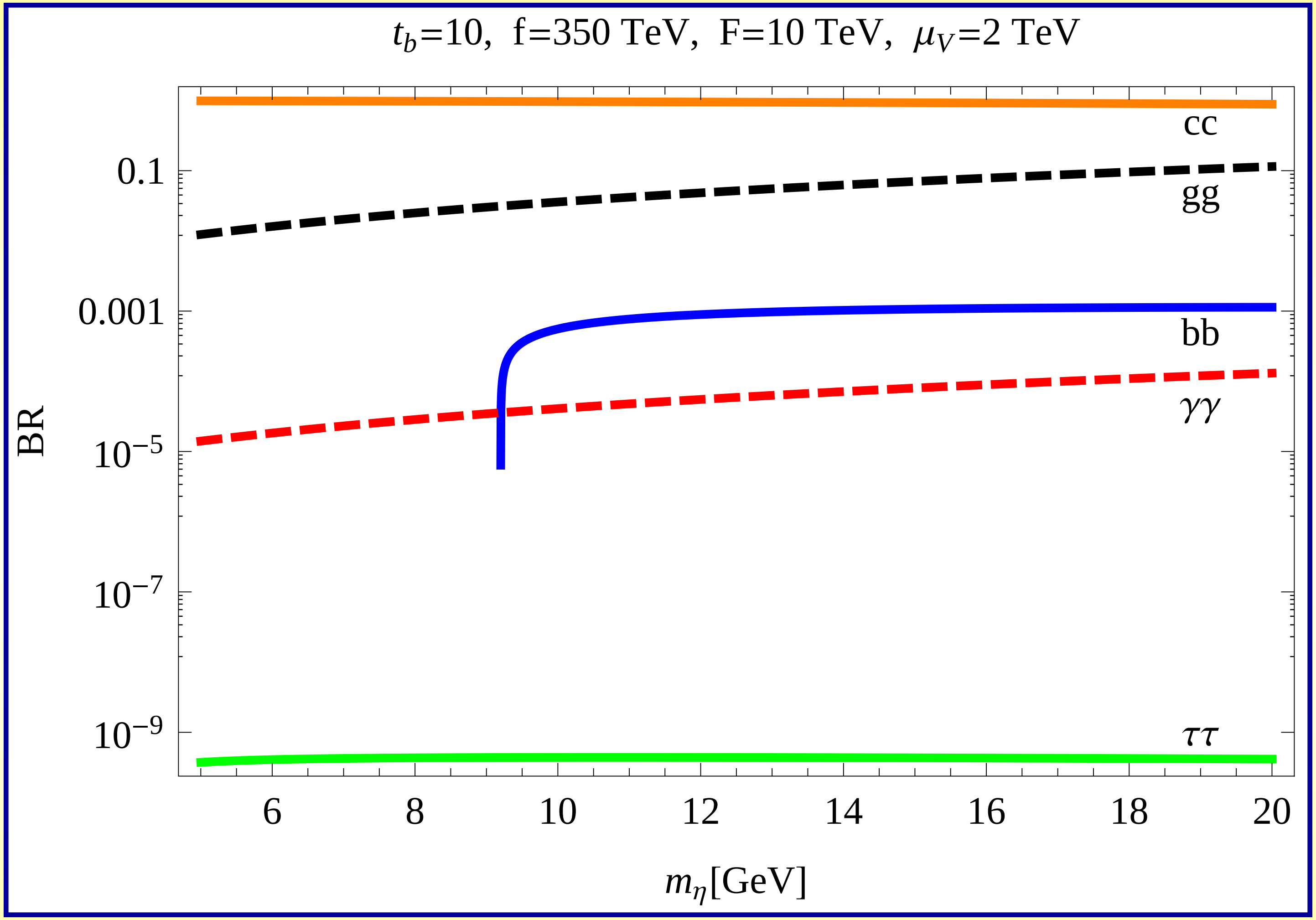
- Important difference: coupling to down-type quarks suppressed by m_b^2/μ_V^2 – very suppressed even if kinematically allowed

- τ coupling still suppressed

- will mostly decay to charm or gluon

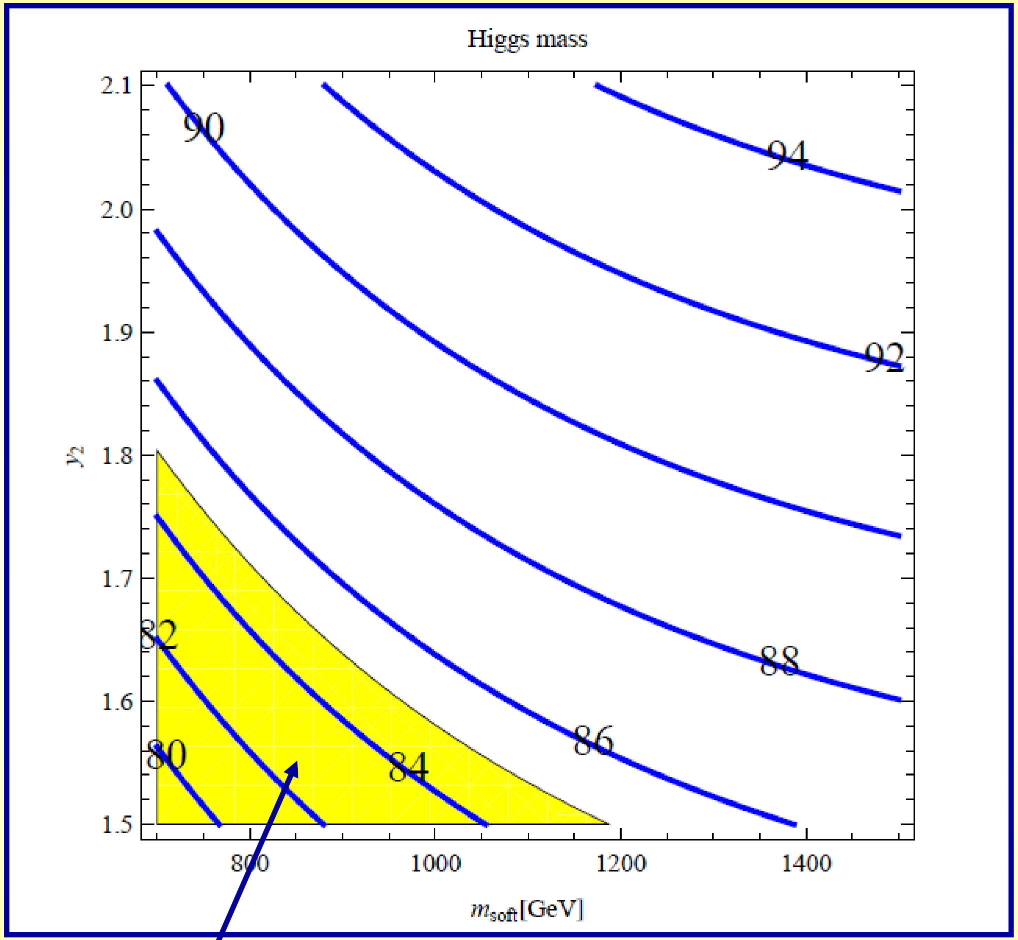
$$\tilde{y}_c \approx \frac{m_c}{\sqrt{2}f} \qquad \tilde{y}_\tau \sim \frac{m_\tau}{\sqrt{2}f}\frac{m_\tau^2}{M_\tau^2}$$

η decays



- Note: size of loop induced ηbb coupling estimated

Achievable Higgs masses



Region excluded by LEP h→bb

Summary

- An extension of the MSSM, where:
  - $h \to 2\eta \to 4j$ cascade is natural
  - higgs below LEP bound
  - no little hierarchy
  - h and η both Goldstones (little Higgs)
  - super and little partners available at LHC
  - Higgs buried (?) in QCD at LHC
  - Fake higgs readily available
  - All scales radiatively generated
- A really cool model of EWSB!