Higgs-Radion Mixing in the RS and LHC Higgs-like Excesses

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Is what we are seeing a Higgs-like chameleon?
Higgs-like LHC Excesses

Or is it THE Higgs?
Given that the mass(es) is(are) of order $125$ GeV, the MSSM or the much more attractive NMSSM extension thereof is a natural candidate theory.

After all, SUSY solves the hierarchy problem, predicts gauge coupling unification at the GUT scale and so forth.

However:

- A SM-like Higgs with mass as large as $125$ GeV is a bit of a stretch. Even in the NMSSM $125$ GeV is “on the edge” for semi-universal (NUHM) GUT boundary conditions (and not possible for full CNMSSM b.c.).
- This is aggravated if the signal is $> \text{SM}$.
- And, even more problematically, there may be more than one ’excess’ in the data (cf. CMS data).

The only other really attractive alternate solution to the hierarchy problem that provides a self-contained ultraviolet complete framework is to allow extra dimensions.

One particular implementation is the Randall Sundrum model in which there is a warped 5th dimension.
The background RS metric that solves Einstein’s equations takes the form [1]

\[ ds^2 = e^{-2m_0b_0|y|} \eta_{\mu\nu} dx^\mu dx^\nu - b_0^2 dy^2 \]  \hspace{1cm} (1)

where \( y \) is the coordinate for the 5th dimension with \(|y| \leq 1/2\).

The graviton and radion fields, \( h_{\mu\nu}(x, y) \) and \( \phi_0(x) \), are the quantum fluctuations relative to the background metric \( \eta_{\mu\nu} \) and \( b_0 \), respectively.

In the simplest case, only gravity propagates in the bulk while the SM is located on the infrared (or TeV) brane at \( y = 1/2 \) and

\[ \mathcal{L}_{\text{int}} = -\frac{1}{\Lambda_W} \sum_{n \neq 0} h_{\mu\nu}^n T_{\mu\nu} - \frac{\phi_0}{\Lambda_\phi} T_\mu^\mu \]  \hspace{1cm} (2)
where \( h_{\mu\nu}^n(x) \) are the Kaluza-Klein (KK) modes (with mass \( m_n \)) of the graviton field \( h_{\mu\nu}(x, y) \).

- The parameters:

\[
\hat{\Lambda}_W \simeq \sqrt{2} m_{Pl} \Omega_0, \text{ where } \Omega_0 = e^{-\frac{1}{2}m_0b_0}, \text{ and } \Lambda_\phi = \sqrt{3} \hat{\Lambda}_W.
\]

- If matter propagates in the bulk then the interactions of gravitons and radion with matter are controlled by the overlap of appropriate extra-dimensional profiles and corrections to (2) appear.

- In addition to the radion, the model contains a conventional Higgs boson, \( h_0 \).

- The RS model provides a simple solution to the hierarchy problem if the Higgs is placed on the TeV brane at \( y = 1/2 \) by virtue of the fact that the 4D electro-weak scale \( v_0 \) is given in terms of the \( \mathcal{O}(m_{Pl}) \) 5D Higgs vev, \( \hat{v} \), by:

\[
v_0 = \Omega_0 \hat{v} = e^{-\frac{1}{2}m_0b_0} \hat{v} \sim 1 \text{ TeV} \quad \text{for } \frac{1}{2}m_0b_0 \sim 35. \quad (3)
\]
To solve the hierarchy problem, $\Lambda_\phi = \sqrt{6} m_{Pl} \Omega_0 \lesssim 1 - 10$ TeV needed.

- $m_0/m_{Pl}$ is a particularly crucial parameter that characterizes the 5-dimensional curvature.

$m_0/m_{Pl} \gtrsim 0.5$ is favored for fitting the LHC Higgs excesses and by bounds on FCNC and PEW constraints.

Views on $m_0/m_{Pl}$ are changing:

- Original: $R_5/M_5^2 < 1$ ($M_5$ being the 5D Planck scale and $R_5 = 20m_0^2$ the size of the 5D curvature) is needed to suppress higher curvature terms in the 5D action: $\Rightarrow m_0/m_{Pl} \lesssim 0.15$.

- New: [9] argues that $R_5/\Lambda^2$ ($\Lambda$ = energy scale at which the 5D gravity theory becomes strongly coupled, with NDA estimate of $\Lambda \sim 2\sqrt{3}\pi M_5$), is the appropriate measure, $\Rightarrow m_0/m_{Pl} < \sqrt{3\pi^3/(5\sqrt{5})} \sim 3$ acceptable.

- Note: the mass of 1st KK graviton excitation ($G^1$) is related to $m_0/m_{Pl}$
and $\Lambda_\phi$ by

$$m_1^{KK} = \left(\frac{m_0}{m_{Pl}}\right)x_1^{KK} \sqrt{6} \Lambda_\phi,$$

(4)

where $x_1^{KK} \sim 3.83$.

$\Rightarrow$ large $m_0/m_{Pl}$ if the lower bound on $m_1^{KK}$ is large and $\Lambda_\phi \sim 1$ TeV.

• In the simplest RS scenario, the SM fermions and gauge bosons are confined to the brane.

Now regarded as highly problematical:

– Higher-dimensional operators in the 5D effective field theory are suppressed only by $\text{TeV}^{-1}$, $\Rightarrow$ FCNC processes and PEW observable corrections are predicted to be much too large.

$\Rightarrow$ no explanation of the flavor hierarchies.

• Must move fermions and gauge bosons (but not Higgs) off the brane

[2][3][4][5][6][7][8][9]
The SM particles = zero-modes of the 5D fields and the profile of a SM fermion in the extra dimension can be adjusted using a mass parameter.

Two possibilities:

1. If 1st and 2nd generation fermion profiles peak near the Planck brane then FCNC operators and PEW corrections will be suppressed by scales $\gg$ TeV.

Even with this arrangement it is estimated that the $g^1, W^1$ and $Z^1$ masses must be larger than about 3 TeV (see the summary in [9]).

2. Use fairly flat profiles for the 1st and 2nd generation fermions in the 5th dimension.

$\Rightarrow$ the coupling of light quarks to $g^1, W^1, Z^1$, proportional to the integral of the square of the fermion profile multiplied by the gauge boson profile, will be very small, implying small FCNC.

PEW constraints would still be very problematical unless a special 5D GIM mechanism is employed [11].

In either case, the interactions of Eq. (2) are greatly modified when gauge bosons and fermions are allowed to propagate in the bulk,
• If the gauge bosons and fermions do not propagate in the bulk, then the strongest limits on $\Lambda_\phi$ come, via Eq. (4), from the lower bound placed by the LHC on the first graviton KK excitation (see, for example, [13] and [14] for the ATLAS and CMS limits).

• However, when the fermions propagate in the bulk, the couplings of light fermion pairs to $G^1$ are greatly reduced and these limits do not apply.

• When gauge bosons propagate in the bulk, a potentially important experimental limit on the model comes from lower bounds on the 1st excitation of the gluon, $g^1$.

In the model of [12], in which light fermion profiles peak near the Planck brane, there is a universal component to the light quark coupling $q\bar{q}g^1$ that is roughly equal to the SM coupling $g$ times a factor of $\zeta^{-1}$, where $\zeta \sim \sqrt{\frac{1}{2}m_0b_0} \sim 5 - 6$.

The suppression is due to the fact that the light quarks are localized near the Planck brane whereas the KK gluon is localized near the TeV brane.
Even with such suppression, the LHC $g^1$ production rate due to $u\bar{u}$ and $d\bar{d}$ collisions is large.

Further, the $t_R\bar{t}_R g^1$ coupling is large since the $t_R$ profile peaks near the TeV brane – the prediction of [12] is $g_{t_R\bar{t}_R g^1} \sim \zeta g$.

$\Rightarrow g^1 \to t\bar{t}$ decays dominant.

$\Rightarrow$ lower bound of $m^g_1 \gtrsim 1.5$ TeV [15] using an update of the analysis of [12]. ([16] gives a weaker bound of $m^g_1 > 0.84$ TeV.)

- In terms of $\Lambda_\phi$, we have the following relations:

$$
\frac{m_0}{m_{Pl}} = \sqrt{6} \frac{m^g_1}{x^g_1 \Lambda_\phi} \simeq \frac{m^g_1}{\Lambda_\phi}, \quad \text{and} \quad \frac{1}{2} m_0 b_0 = - \log \left( \frac{\Lambda_\phi}{\sqrt{6} m_{Pl}} \right) \tag{5}
$$

where $x^g_1 = 2.45$ is the 1st zero of an appropriate Bessel function.

If the model really solves the hierarchy problem then $\hat{\Lambda}_W$ in Eq. (2) cannot be much larger than 1 TeV. Let us take $\hat{\Lambda}_W \lesssim 5.5$ TeV as an extreme possibility, which implies $\Lambda_\phi = \sqrt{3} \hat{\Lambda}_W \lesssim 10$ TeV.
If we adopt the CMS limit of $m^g_1 > 1.5$ TeV then (5) implies a lower limit on the 5-dimensional curvature of $m_0/m_{Pl} \gtrsim 0.15$.

Thus, a significant lower bound on $m^g_1$ implies that only relatively large values for $m_0/m_{Pl}$ are allowed. ⇒ probably ok given latest ideas.

- Another approach:
  
  Take light fermion profiles to be flat in 5th dimension. ⇒ $q\bar{q}g^1, \ldots$ couplings are small.
  
  ⇒ FCNC ok and PEW ok if introduce a 5D GIM mechanism [11].
  
  ⇒ no direct experimental bound on $m^g_1$.

$\Lambda_{\phi}$?

if $\Lambda_{\phi} = 1$ TeV, for $m_0/m_{Pl} = 0.01, 0.1$ Eq. (5) implies $m^g_1 = 10, 100$ GeV.

Could the $g^1$ really have escaped discovery for such low masses?

If there is no firm bound on $m^g_1$ ⇒ discuss the phenomenology for fixed $\Lambda_{\phi}$. We will consider $\Lambda_{\phi} = 1$ TeV and 1.5 TeV.
Higgs-Radion Mixing

- Since the radion and higgs fields have the same quantum numbers, they can mix. [17]

\[ S_\xi = \xi \int d^4x \sqrt{g_{\text{vis}}} R(g_{\text{vis}}) \hat{H}^\dagger \hat{H}, \]  

(6)

The physical mass eigenstates, \( h \) and \( \phi \), are obtained by diagonalizing and canonically normalizing the kinetic energy terms.

The diagonalization procedures and results for the \( h \) and \( \phi \) using our notation can be found in [10] (see also [17][18]).

In the end, one finds

\[ h_0 = dh + c\phi - \phi_0 = a\phi + bh, \]  

where

\[ d = \cos \theta - t \sin \theta, \quad c = \sin \theta + t \cos \theta, \quad a = -\frac{\cos \theta}{Z}, \quad b = \frac{\sin \theta}{Z}, \]  

(7)

with

\[ t = 6\xi \gamma / Z, \quad Z^2 = 1 + 6\xi \gamma^2 (1 - 6\xi), \quad \tan 2\theta = \frac{12\xi \gamma Z m_{h_0}^2}{m_{\phi_0}^2 - m_{h_0}^2 [Z^2 - 36\xi^2 \gamma^2]}. \]  

(8)
Here $m^2_{h_0}$ and $m^2_{\phi_0}$ are the Higgs and radion masses before mixing.

Consistency of the diagonalization imposes strong restrictions on the possible $\xi$ values as a function of the final eigenstate masses $m_h$ and $m_\phi$, which restrictions depend strongly on the ratio $\gamma \equiv v_0/\Lambda_\phi$ ($v_0 = 246$ GeV).

- The full Feynman rules after mixing for the $h$ and $\phi$ interactions with gauge bosons and fermions located in the bulk were derived in [19].

Of particular note are the anomaly terms associated with the $\phi_0$ interactions before mixing. After mixing we find

$$g_h = (d + \gamma b) \quad g_\phi = (c + \gamma a) \quad g^r_h = \gamma b \quad g^r_\phi = \gamma a.$$  \hspace{1cm} (9)

$$c^{h,\phi}_g = -\frac{\alpha_s}{4\pi v} \left[ g_{h,\phi} \sum_i F_{1/2}(\tau_i) - 2 (b_3 + \frac{2\pi}{\alpha_s \frac{1}{2} m_0 b_0}) g^r_{h,\phi} \right]$$

$$c^{h,\phi}_\gamma = -\frac{\alpha}{2\pi v} \left[ g_{h,\phi} \sum_i e_i^2 N_c^i F_i(\tau_i) - (b_2 + b_Y + \frac{2\pi}{\alpha \frac{1}{2} m_0 b_0}) g^r_{h,\phi} \right]$$  \hspace{1cm} (10)
New relative to old on-the-brane results are the $2\pi \ldots$ corrections to the $g^r$ terms. They can be significant when $m_0/m_{Pl}$ is small.

- There are also modifications to the $WW$ and $ZZ$ couplings of the $h$ and $\phi$ relative to old on-the-brane results.

Without bulk propagation, these couplings were simply given by SM couplings (proportional to the metric tensor $\eta^{\mu\nu}$) times $g_h$ or $g_\phi$.

For the bulk propagation case, there are additional terms in the interaction Lagrangian that lead to Feynman rules that have terms not proportional to $\eta^{\mu\nu}$, see [19].

For example, for the $W$ we have (before mixing)

$$\mathcal{L} \ni h_0 \frac{2m_W^2}{v} W_\mu^\dagger W^\mu - \phi_0 \frac{2m_W^2}{\Lambda_\phi} \left[ W_\mu^\dagger W^\mu (1 - \kappa_W) + W_\mu^\dagger W_{\mu\nu} \frac{1}{4m_W^2(\frac{1}{2}m_0b_0)} \right]$$

(11)
After mixing, this becomes, for example for the \( h \) interaction

\[
\mathcal{L} \ni \equiv h \frac{2m_w^2}{v} g^W h \left[ W^\dagger_\mu W^\mu + \eta^W h W^\dagger_\mu_\nu W^{\mu\nu} \right]
\]

with a similar result for the \( \phi \).

Here,

\[
g^V_{h,\phi} \equiv g_{h,\phi} - g^r_{h,\phi} \kappa^V, \quad \eta^V_{h,\phi} \equiv \frac{g^r_{h,\phi}}{g^V_{h,\phi}} \frac{1}{4m_v^2 (\frac{1}{2}m_0 b_0)}.
\]

Net Feynman rule for the \( hWW \):

\[
igm_w g^W_h \left[ \eta_{\mu\nu} (1 - 2k^+ \cdot k^- \eta^W_h) + 2\eta^W_h k^+_{\mu} k^-_{\nu} \right]
\]

where \( k^+, k^- \) are the momenta of the \( W^+, W^- \), respectively.

- For the fermions, we assume profiles such that there are no corrections to the \( h_0 \) and \( \phi_0 \) couplings due to propagation in the bulk.

This is a very good approximation for the top quark quark which must be localized near the TeV brane.
Also for the bottom quark the approximation is better than 20%, see [19].

Even though the approximation is not necessarily good for light quarks, it is only the heavy quarks that impact the phenomenology of the higgs-radion system.
• In the context of the higgs-radion model, positive signals can only arise for two masses.

• If more than two excesses were to ultimately emerge, then a more complicated Higgs sector will be required than the single $h_0$ case we study here.

Certainly, one can consider including extra Higgs singlets or doublets.

For the moment, we presume that there are at most two excesses. In this case, it is sufficient to pursue the single Higgs plus radion model.
We will consider a few cases. Errors quoted for the excesses are $\pm 1\sigma$.

1. ATLAS:
   - $125$ GeV: $\gamma\gamma$ excess of $2^{+0.8}_{-0.8} \times SM$
   - $125$ GeV: $4\ell$ excess of $1.5^{+1.5}_{-1} \times SM$

2. CMSA:
   - $124$ GeV: $\gamma\gamma$ excess of $1.7^{+0.8}_{-0.7} \times SM$
   - $124$ GeV: $4\ell$ excess of $0.5^{+1.1}_{-0.7} \times SM$
   - $120$ GeV: $4\ell$ excess of $\sim 2^{+1.5}_{-1} \times SM$ but $\gamma\gamma$ rate $< 0.5 \times SM$.

3. CMSB:
   - $124$ GeV: as above
   - $137$ GeV: $\gamma\gamma$ excess of $1.5^{+0.8}_{-0.8} \times SM$
   - $137$ GeV: $4\ell < 0.2 \times SM$

Notes:
- For plots use $125$ GeV always: no change if $125$ GeV $\rightarrow$ $124$ GeV.

- As discussed, consider two different kinds models:
  1. lower bound on $m_1^g$ of $1.5$ TeV
  2. fixed $\Lambda_\phi$
Lower bound of $m_1^g = 1.5$ TeV

- Recall that $\Lambda_\phi$ will be correlated with $m_0/m_{Pl}$.

$$\frac{m_0}{m_{Pl}} \simeq \frac{m_1^g}{\Lambda_\phi} \quad (15)$$

$\Rightarrow$

For small $m_0/m_{Pl}$, $\Lambda_\phi$ is too large, so only solve hierarchy if $m_0/m_{Pl}$ is $\gtrsim 0.2$.

- Only have time for a limited selection of situations.
Figure 1: We plot $\gamma\gamma$ and $ZZ$ relative to SM vs $\xi$. 

$h\rightarrow\gamma\gamma$: solid red; $h\rightarrow ZZ$: blue dashes; $\phi\rightarrow\gamma\gamma$: green dots; $\phi\rightarrow ZZ$: cyan long dashes.
Only 125 GeV excess

• If want no excesses at \( \sim 120 \) GeV, but \( \gamma\gamma \) excess at 125 GeV of order \( \gtrsim 1.5 \times \text{SM} \), then \( m_0/m_{Pl} = 0.4 \) and \( \xi \sim -0.09 \) are good choices.

4\ell signal at 125 GeV is \( > \gamma\gamma \) but still within error.

• For the reversed assignments of \( m_h = 120 \) GeV and \( m_\phi = 125 \) GeV, no decent description of the ATLAS 125 GeV excesses with signals at 120 GeV being sufficiently suppressed.

Excesses at 125 GeV and 120 GeV

• Higgs-radion scenario fails.

In the regions of \( \xi \) for which appropriate signals are present at 125 GeV from the \( h \), the 4\ell and \( \gamma\gamma \) rates at 120 GeV are either both suppressed or it is the \( \gamma\gamma \) rate that is enhanced more than the 4\ell rate at 120 GeV. This phenomenon persists at higher \( m_0/m_{Pl} \) values.
Figure 2: $\gamma\gamma$ and $ZZ$ relative to SM vs $\xi$. 

$h \rightarrow \gamma\gamma$: solid red; $h \rightarrow ZZ$: blue dashes; $\phi \rightarrow \gamma\gamma$: green dots; $\phi \rightarrow ZZ$: cyan long dashes.
Signals at 125 GeV and 137 GeV

- In Fig. 2 (previous page): \( m_0/m_{Pl} = 0.5 \) and \( \xi = 0 \Rightarrow \)

  - 125 GeV: \( \gamma\gamma \sim 1 \times \text{SM} \) and \( 4\ell \sim 1 \times \text{SM} \)
  - 137 GeV: \( \gamma\gamma \sim 1 \times \text{SM} \) and \( 4\ell \) very small

  These rates are consistent within \( 1\sigma \) with the CMS observations.
Figure 3: We plot $\gamma\gamma$ and $ZZ$ relative to SM vs $\xi$.
There are two choices, \( m_h = 125 \text{ GeV} \) with \( m_\phi = 500 \text{ GeV} \) or reverse. Let us discuss the reverse. Fig. 3.

Large \( \xi > 0 \Rightarrow \gamma\gamma \sim 2 \times \text{SM} \ \gamma\gamma \) signal and \( 4\ell \sim 1 \times \text{SM} \) signal at \( m_\phi = 125 \text{ GeV} \) for \( m_0/m_{Pl} = 0.4 \) and 0.5.

\( h \rightarrow 4\ell \) signal at 500 GeV \( \sim \text{SM} \).

\( \gamma\gamma \) signal at 500 GeV enhanced, but SM rate small, and thus almost surely unobservable.

\( 4\ell \) rates at 500 GeV? ATLAS and CMS disagree.

Probably, the heavy \( h \) in this scenario would have to be placed beyond LHC reach (for which the \( m_\phi = 125 \text{ GeV} \) signals shown would be unchanged).
Fixed $\Lambda_\phi$

- If fermionic profiles are quite flat, couplings of light quarks to the gauge excitations are very small. $\Rightarrow$ no bounds on $m^g_1$ or $\Lambda_\phi$.

We choose to examine the phenomenology for (low) values of $\Lambda_\phi = 1$ TeV and $\Lambda_\phi = 1.5$ TeV.

- When fermions and, in particular, gauge bosons propagate in the bulk the phenomenology does not depend on $\Lambda_\phi$ alone — at fixed $\Lambda_\phi$ there is strong dependence on $m_0/m_{Pl}$ when $m_0/m_{Pl}$ is small.

- Only for large $m_0/m_{Pl} \gtrsim 0.5$ is the phenomenology determined almost entirely by $\Lambda_\phi$.

But, not the same as when all fields are on the TeV brane.

- Once again, we step through the various possible mass locations for the
Higgs and radion that are motivated by the LHC excesses in the $\gamma\gamma$ and/or $4\ell$ channels.

**Single resonance at 125 GeV**

- The choice of $\Lambda_{\phi} = 1$ TeV with $m_{\phi} = 125$ GeV and $m_h = 120$ GeV gives a reasonable description of the ATLAS excesses at 125 GeV with no visible signals at 120 GeV in either the $\gamma\gamma$ or $4\ell$ channels. (figure not shown)

  A good choice of parameters is $m_0/m_{Pl} = 1$ and $\xi = -0.015$.

- In contrast, for $\Lambda_{\phi} = 1.5$ TeV the 125 GeV predicted $\gamma\gamma$ and $4\ell$ excesses are below $1\times$SM and thus would not provide a good description of the ATLAS excesses.

- For the reversed assignments of $m_h = 125$ GeV and $m_{\phi} = 120$ GeV, any choice of parameters that gives a good description of the 125 GeV signals always yields a highly observable 120 GeV signal, not appropriate for ATLAS, see next figure.
Figure 4: We plot $\gamma\gamma$ and $ZZ$ relative to SM vs $\xi$ taking $\Lambda_\phi$ fixed at 1 TeV.
For CMS we want:

125 GeV: $\gamma\gamma \sim 1.7 \times \text{SM}$ and $4\ell < 1.6 \times \text{SM}$.

and

120 GeV: $4\ell \sim 2 \times \text{SM}$ and $\gamma\gamma < 0.4 \times \text{SM}$.

Fig. 4: for $m_h = 125$ GeV, $m_\phi = 137$ GeV, $\xi = \max$ and $m_0/m_{Pl} = 1.1$

$\Rightarrow$

125 GeV: $\gamma\gamma \sim 1.3 \times \text{SM}$ and $4\ell \sim 0.8 \times \text{SM}$, i.e. within $-1\sigma$

120 GeV: $4\ell \sim 2 \times \text{SM}$ and $\gamma\gamma \sim 0.3 \times \text{SM}$, so ok.

With the reversed assignments of $m_h = 120$ GeV and $m_\phi = 125$ GeV a satisfactory description of the two CMS excesses is not possible.
Signals at 125 GeV and 137 GeV

- CMS data want:
  
  125 GeV: $\gamma\gamma \sim 1.7 \times $SM and $4\ell < 1.6 \times $SM.
  
  137 GeV: $\gamma\gamma \sim 1.5 \times $SM and $4\ell \sim small$.

- For $\Lambda_\phi = 1$ TeV, $m_h = 125$ GeV, $m_\phi = 137$ GeV get rough description at $m_0/m_{Pl} = 0.6$ and $\xi = -0.05$

- For $\Lambda_\phi = 1.5$ TeV, can do better.

  Fig. 5 (next page) shows results for $m_h = 125$ GeV and $m_\phi = 137$ GeV.
  
  For $m_0/m_{Pl} = 0.25$ and $\xi \sim -0.1 \Rightarrow$
  
  125 GeV: $\gamma\gamma \sim 2 \times $SM and $4\ell \sim 1.5 \times $SM. signals
  
  137 GeV: $\gamma\gamma \sim 2 \times $SM and $4\ell$ very suppressed.

- For $\Lambda_\phi = 1$ TeV or 1.5 TeV, the reverse configuration of $m_h = 137$ GeV and $m_\phi = 125$ GeV is not good.
Figure 5: $\gamma\gamma$ and $ZZ$ rates relative to SM vs $\xi$ taking $\Lambda_\phi$ fixed at 1.5 TeV.
For $\Lambda_\phi = 1.5$ TeV,

With $m_h = 125$ GeV and $m_\phi = 500$ GeV there are $m_0/m_{Pl}$ and $\xi$ choices such that the predicted 125 GeV excesses in $\gamma\gamma$ and 4$\ell$ are at the level of $(1.5 - 2) \times $ SM.

However, for these parameter choices the 500 GeV signals for 4$\ell$ are at a level of $\sim 3 \times $ SM and thus pretty much ruled out.

For the reverse case of $m_h = 500$ GeV and $m_\phi = 125$ GeV there again are $m_0/m_{Pl}$ and $\xi$ choices that give excesses of $(1.5 - 2) \times $ SM in both $\gamma\gamma$ and 4$\ell$, but the 500 GeV excesses are far to large.

Thus, for $\Lambda_\phi = 1.5$ TeV if one of either the radion or the higgs is heavy and one at 125 GeV, the heavy higgs must be beyond LHC reach to avoid conflict with data at large mass if reasonable consistency with the 125 GeV excesses is to be maintained.
• For $\Lambda_{\phi} = 1$ TeV,

If $m_h = 125$ GeV and $m_{\phi} = 500$ GeV then excesses in $4\ell$ and $\gamma\gamma$ at 125 GeV of order $2 \times SM$ are possible at large $\xi$, but the 500 GeV $4\ell$ signal is far too big.

In the reverse case of $m_h = 500$ GeV and $m_{\phi} = 125$ GeV, one can obtain $\gamma\gamma$ and $4\ell$ signals at 125 GeV of order $2 \times SM$ and $0.8 \times SM$ with a $4\ell$ excess at 500 GeV of order $2 \times SM$.

This not in disagreement with CMS observation in this mass region, but ATLAS has a deficit.

One can, of course, choose to describe only the 125 GeV excesses by taking $m_h > 1$ TeV (which leaves the $m_{\phi} = 125$ GeV excess prediction unchanged) to avoid any possible conflict with the 500 GeV region data.
Conclusions

It seems likely that the Higgs responsible for EWSB is not buried. Perhaps, other Higgs-like objects are emerging. But, must never assume we have un-buried all the Higgs.
Certainly, I will continue watching and waiting
References


[24] ATLAS Collaboration, Combination of Higgs Boson Searches with up to 4.9 fb$^{-1}$ of pp Collisions Data Taken at a center-of-mass energy of 7 TeV with the ATLAS Experiment at the LHC, ATLAS-CONF-2011-163.

[26] ATLAS Collaboration, Search for the Standard Model Higgs boson in the decay channel $H \rightarrow ZZ^{(*)} \rightarrow 4\ell$ at $\sqrt{s} = 7$ TeV.

[27] CMS Collaboration, Search for a Higgs boson produced in the decay channel 4l, CMS-PAS-HIG-11-025.