Can vanilla new physics illuminate the Higgs boson?

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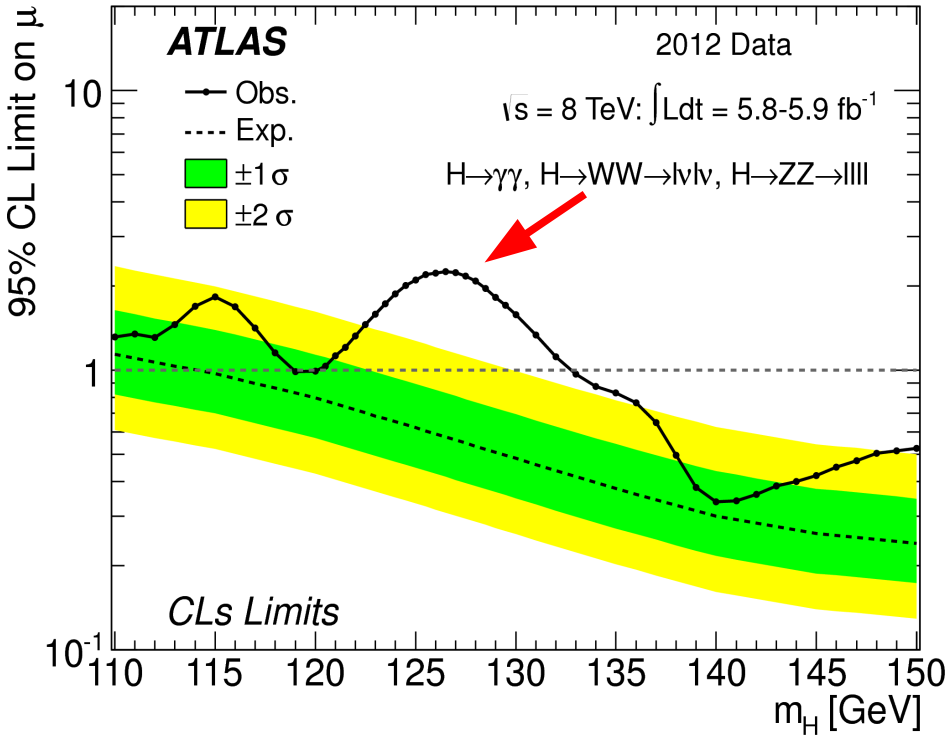
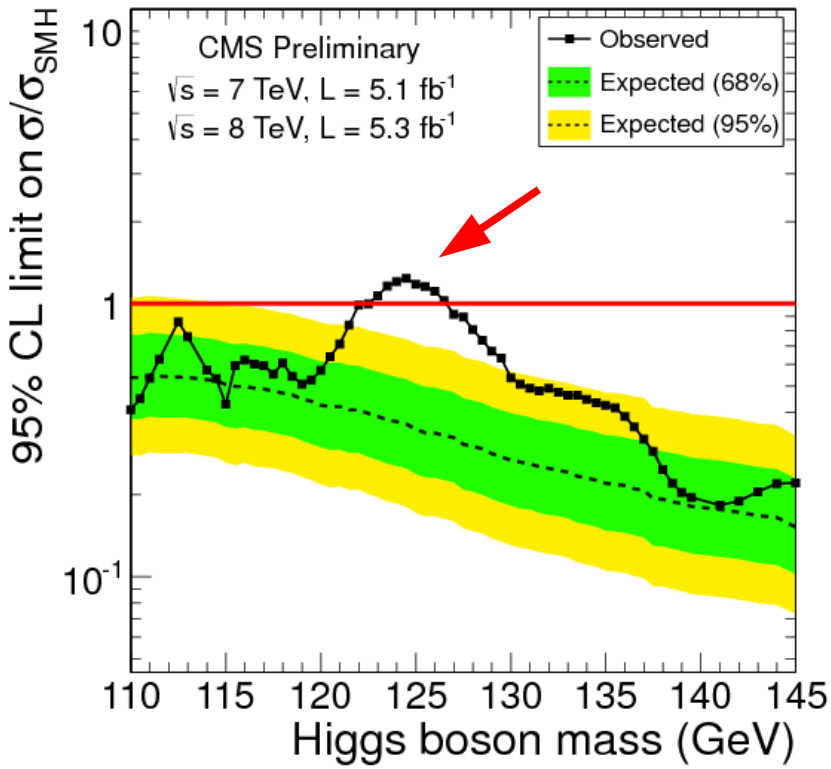
05/11/2012

July 4th, celebration day

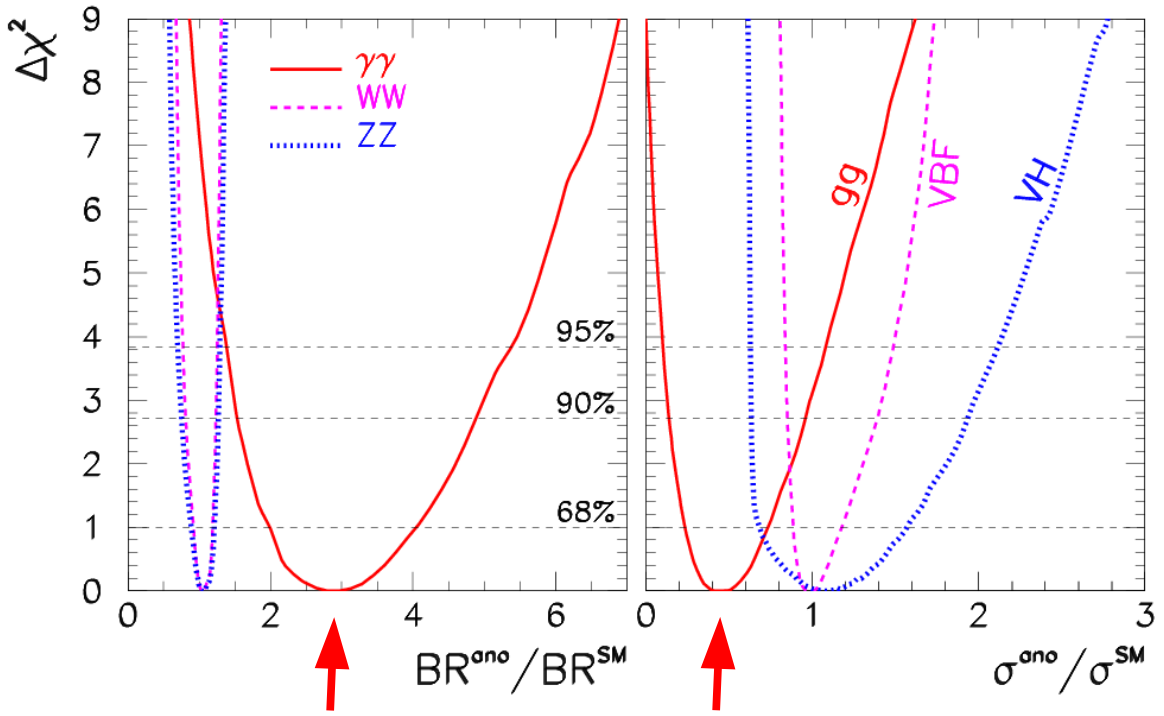




Next step: what's the shape of the Higgs?

Everything consistent with the SM @ 95% C.L.

However...



Corbett, Eboli, Gonzalez-Fraile, Gonzalez-Garcia 1207.1344

General message

$$\mathrm{h} \to VV \simeq \text{SM}$$

$$\mathrm{h} \to \gamma\gamma \gtrsim \text{SM}$$

$$\mathrm{GG} \to h \lesssim \text{SM}$$

@ loop level in the SM

IS THIS NEW PHYSICS?

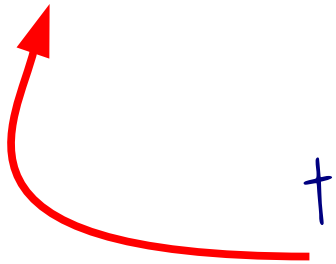
In this talk:

SM

+

vector-like fermions

not mixed with SM fermions



to avoid problems with flavor and precision measurements

Why vector-like?

$$R_{\gamma\gamma} = \frac{\Gamma(h \to \gamma\gamma)}{\Gamma(h \to \gamma\gamma)_{SM}}$$

$$R_{GG} = \frac{\sigma(GG \to h)}{\sigma(GG \to h)_{SM}}$$

Why vector-like?

$$R_{\gamma\gamma} = \left|1 + \sum_i \delta^i_C + \sum_j \delta^j_{NC}\right|^2$$

$$R_{GG} = \left|1 - 9.7 \sum_i \frac{t^i_c}{N^i_c Q^2_i} \delta^i_C\right|^2$$

$$\delta^i_{C,NC} = \frac{N^i_c Q^2_i \frac{2 g_{hii}}{m_i} A_i\left(\frac{m^2_h}{4 m^2_i}\right)}{\mathcal{A}_W + \mathcal{A}_t}$$

A closer look

Ellis et al '76
Shifman et al '79

all mass from EWSB $\rightsquigarrow \frac{2g_{hff}}{m_f} = \frac{d}{dv}\log m_f^2 \propto \frac{1}{v}$

↓

non-decoupling
(4^{th} generation like)

Too large production
X-sec (9 times)

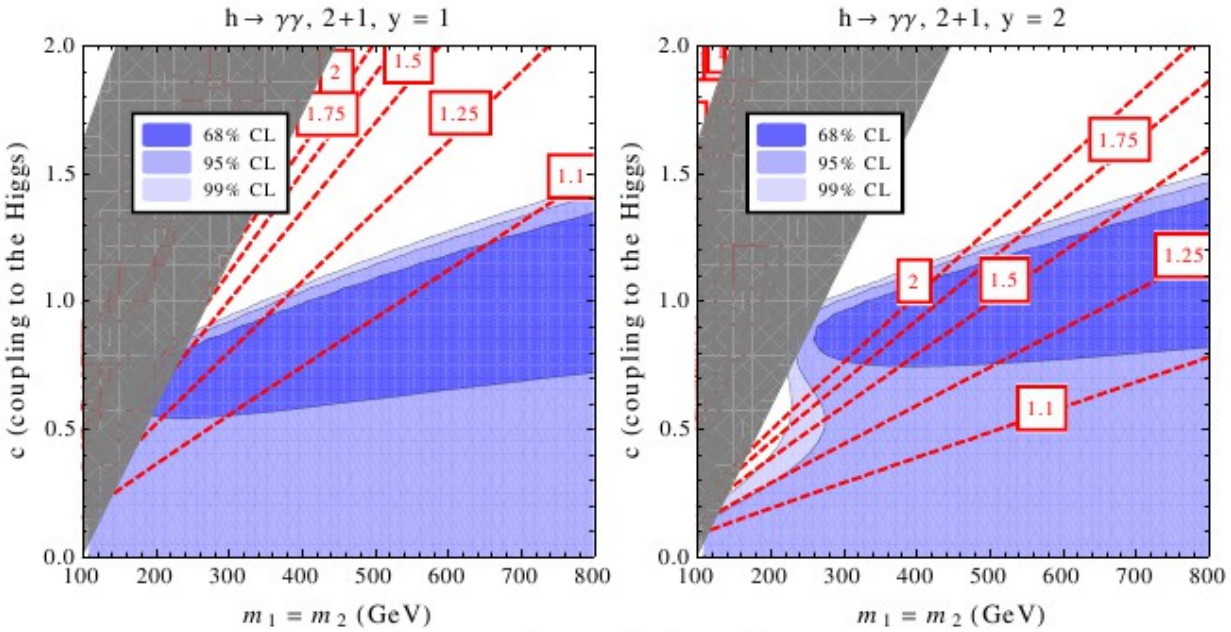
A closer look

NOT all mass from EWSB ⇝ Vector-like fermions with vev-dependent mixing

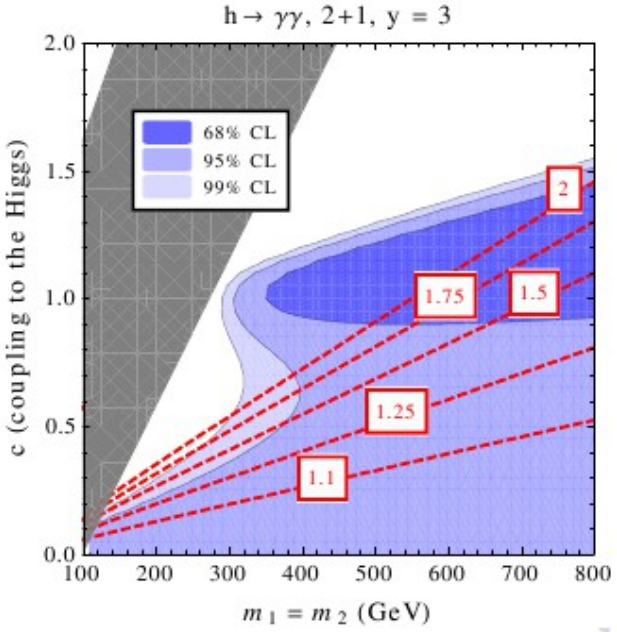
Two models

$\mathrm{SU(2)_L}$		$\mathrm{U(1)_Y}$	$SU(3)_c$
$2+1$	$3+2$		
$D_{L,R}=2$	$T_{L,R}=3$	$\hat{y}=y-\frac{1}{2}$	$1,\,3,\,8$
$S_{L,R}=1$	$D_{L,R}=2$	y	$1,\,3,\,8$

2+1

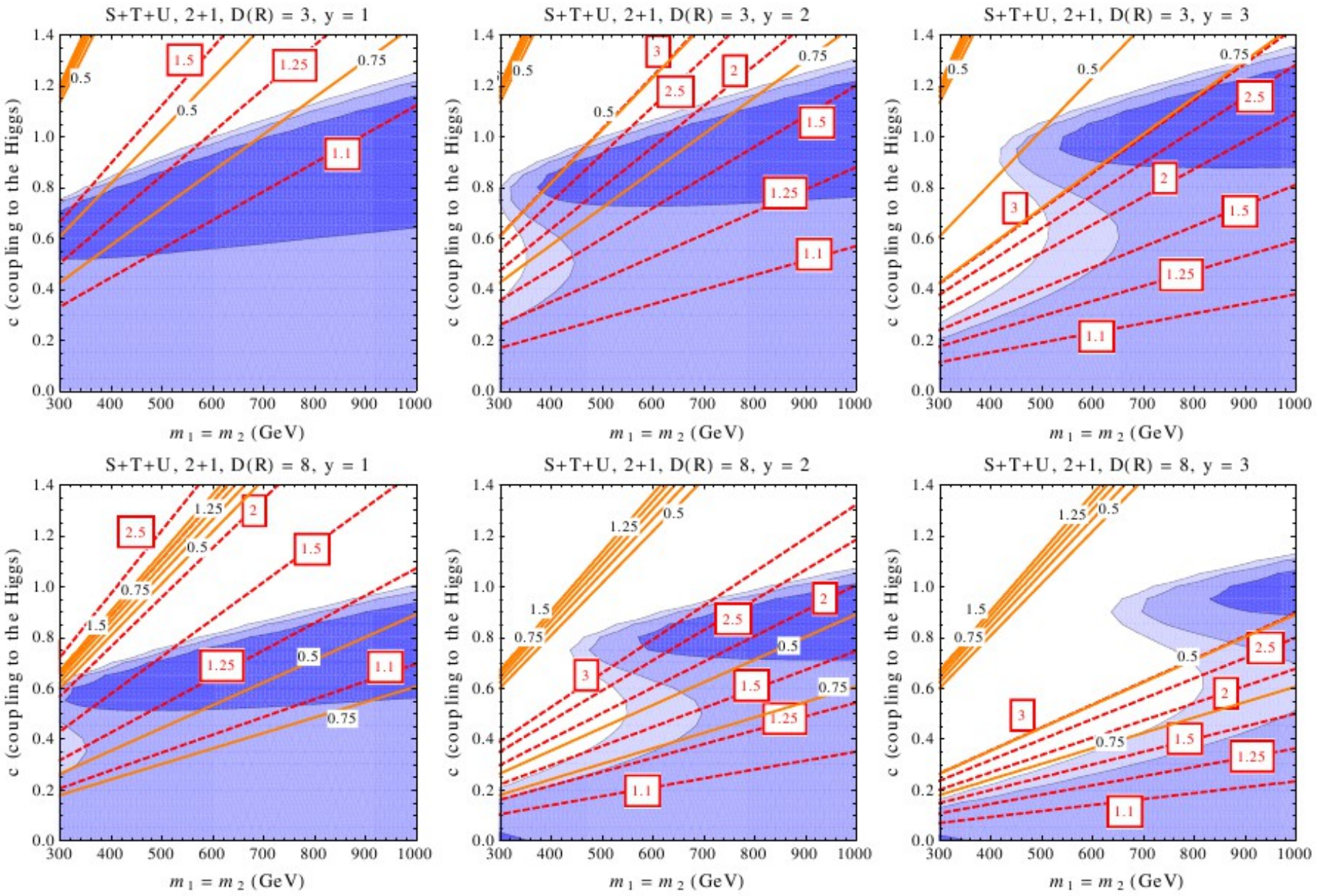

h → γγ, 2+1, y = 1
c (coupling to the Higgs)
$m_1 = m_2$ (GeV)
68% CL
95% CL
99% CL
2
1.75
1.5
1.25
1.1

h → γγ, 2+1, y = 2
c (coupling to the Higgs)
$m_1 = m_2$ (GeV)
68% CL
95% CL
99% CL
1.75
2
1.5
1.25
1.1


h → γγ, 2+1, y = 3
c (coupling to the Higgs)
$m_1 = m_2$ (GeV)
68% CL
95% CL
99% CL
2
1.75
1.5
1.25
1.1

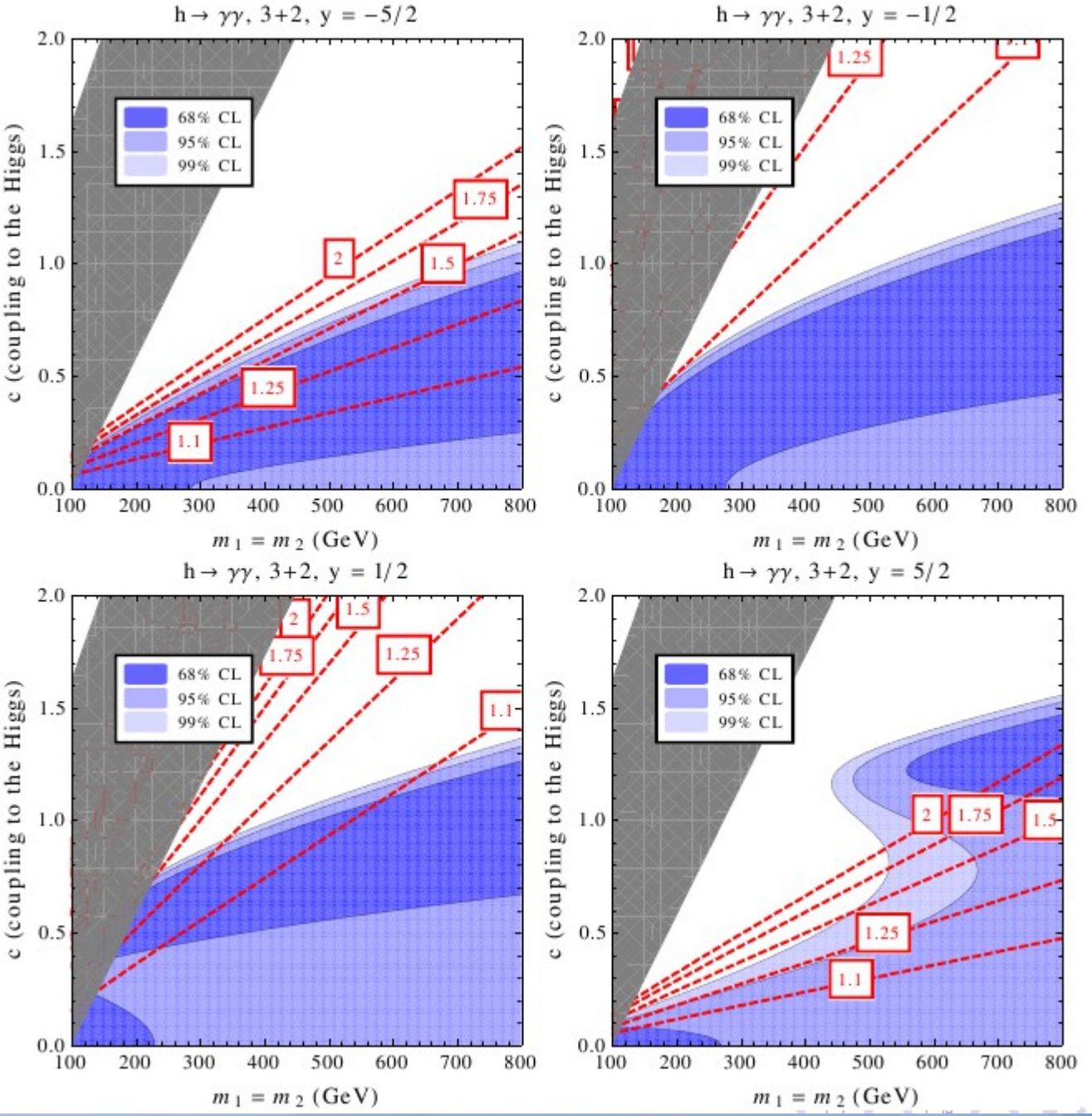
γγ

2+1: color


S+T+U, 2+1, D(R) = 3, y = 1
S+T+U, 2+1, D(R) = 3, y = 2
S+T+U, 2+1, D(R) = 3, y = 3
S+T+U, 2+1, D(R) = 8, y = 1
S+T+U, 2+1, D(R) = 8, y = 2
S+T+U, 2+1, D(R) = 8, y = 3
c (coupling to the Higgs)
m 1 = m 2 (GeV)

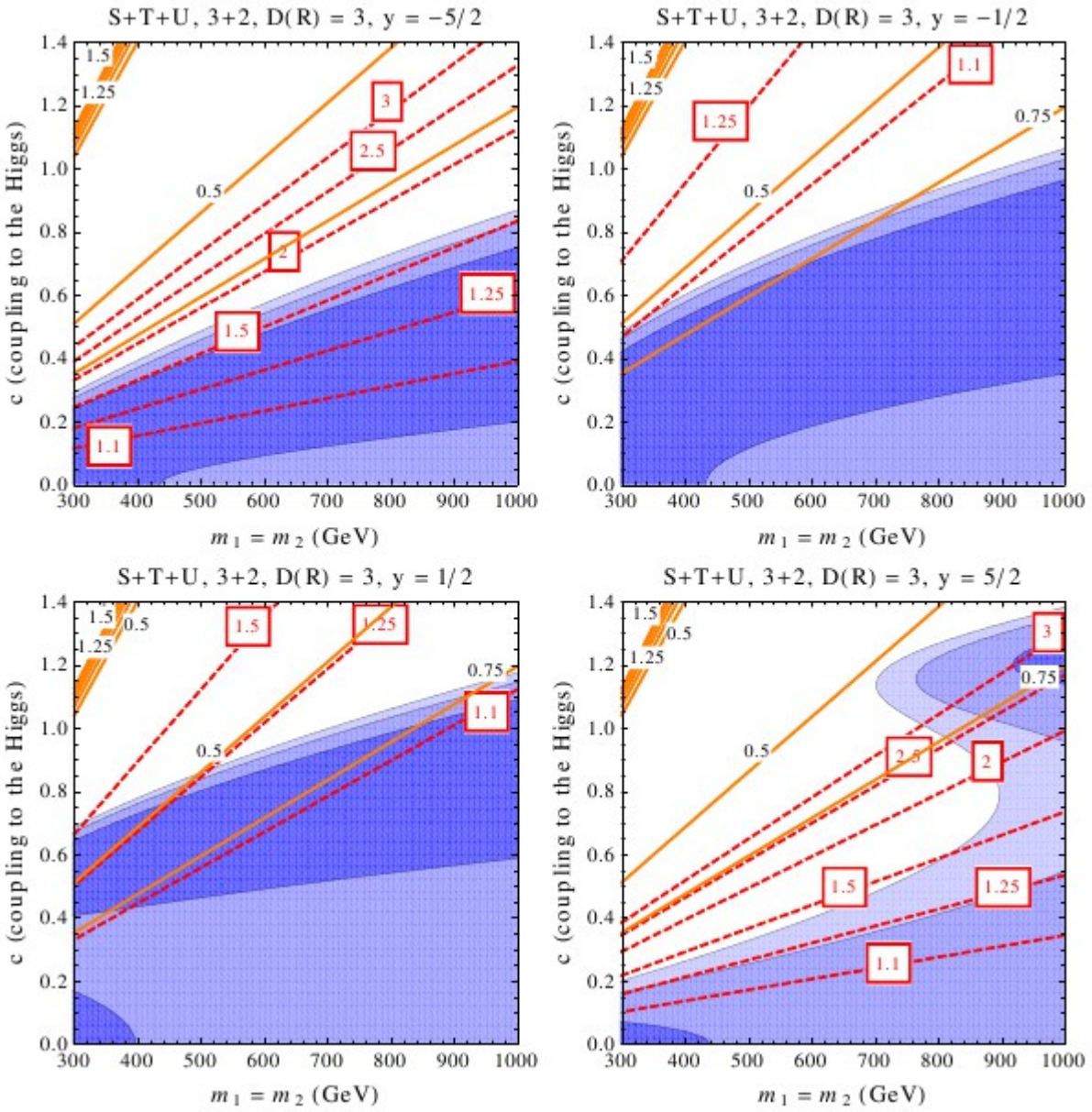
3+2

$\gamma\gamma$



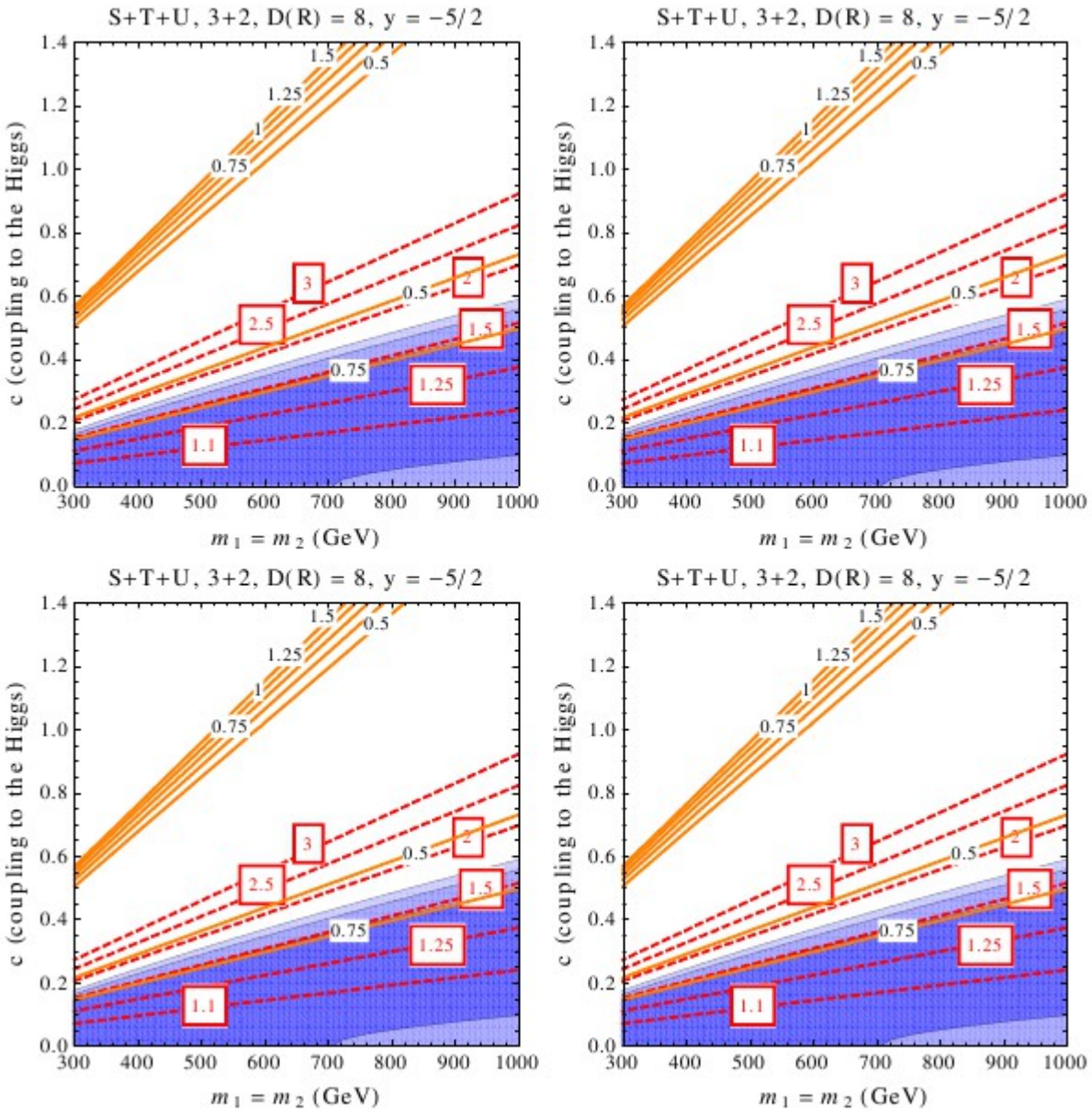
3+2: colored 3

$\gamma\gamma$
GG



3+2: colored 8

$\gamma\gamma$
GG



Conclusions

- Modest $\gamma\gamma$ & GG modifications (10–20%) easily obtained without spoiling EWPM
- Large $\gamma\gamma$ enhancement requires $Q \geq 2$
- Large GG modification requires $N_c=8$, but more difficult to pass EWPM
- Theory needs to be completed

Completion of the theory

$$\frac{d\lambda}{d\log Q} = -\frac{N_c}{8\pi^2}c^4$$ RGE Higgs' quartic

$$\rightsquigarrow \quad \lambda(3m_{light}) \lesssim 0$$

New scalars or vectors
should enter to postpone
vacuum instability