

Two Higgs doublets, a 4th generation and a 125 GeV Higgs

Based on:

M.G. , S. Bar-Shalom, G. Eilam, A. Soni PRD 2012
M.G. , S. Bar-Shalom, S. Nandi , A. Soni AHEP 2013

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4G2HDM: a 2HDM framework with new heavy fermions

Motivation

- An alternative to standard 4G approaches:

- The SM4 (SM+4th generation) Higgs is not compatible with the 125 GeV Higgs results.

- The bounds on the 4th generation quarks in the SM4 (700-800 GeV) exceed the perturbative limit.

- An effective low-energy realization for a dynamical symmetry breaking scenario with heavy fermions:

- Condensation of heavy-fermions is still a viable option: M.G. , S. Bar-Shalom, A. Soni arXiv:1302.2915

- Chiral 4G with extended Higgs sectors: possible but severely constrained.

- Vector-like 4G quarks are not excluded, and have a strong theoretical motivation

Little Higgs Models: N. Arkani-Hamed, et al, JHEP 2002
Top Seesaw: B. A. Dobrescu, C. T. Hill, PRL 1998

The Model - 4G2HDM

S. Bar-Shalom, S. Nandi, A. Soni PRD 2011

- Φ_h couples to the heavy fermions.

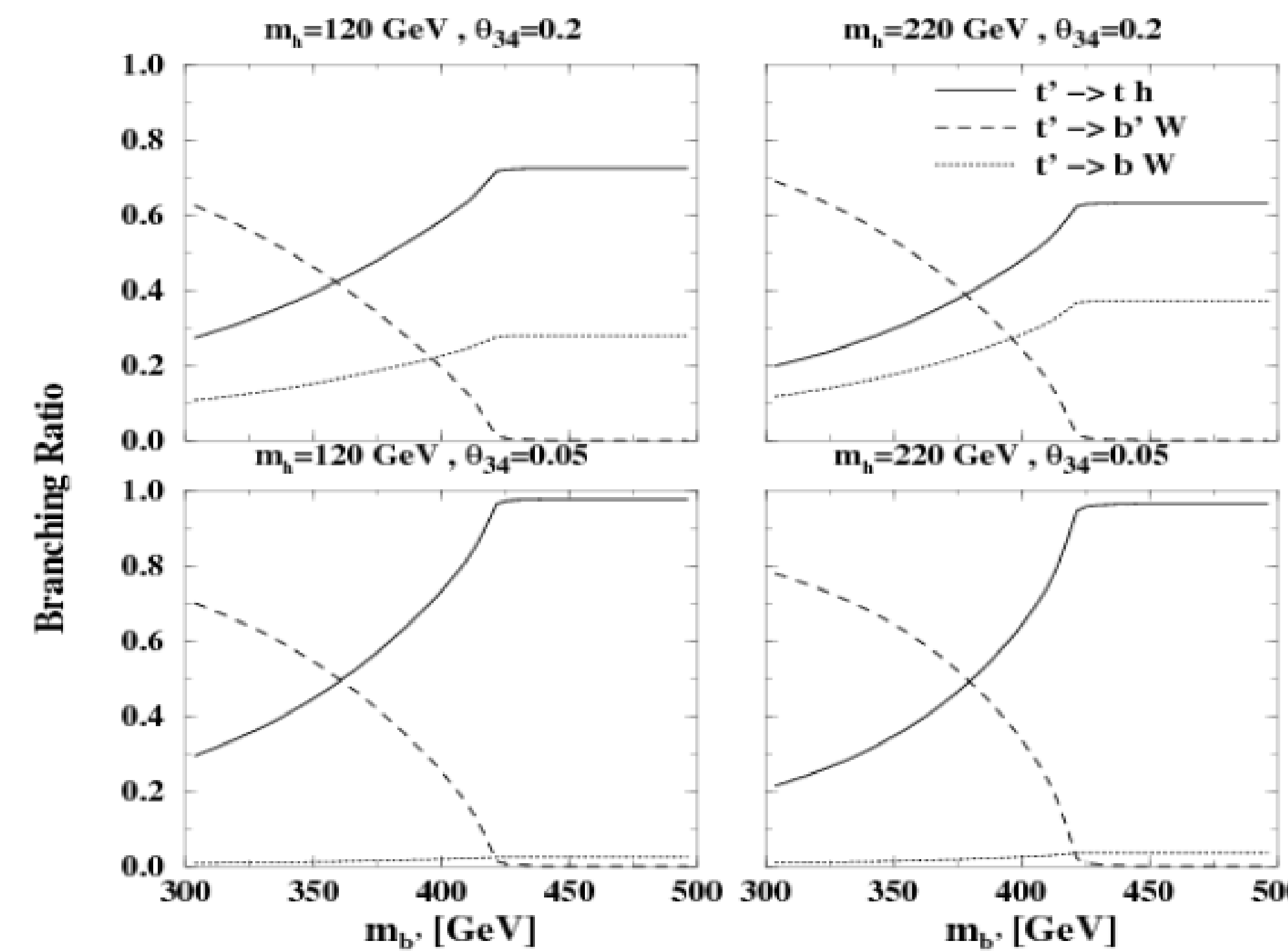
- Φ_ℓ couples to all the other (light) fermions.

$$L_Y = -\bar{Q}_L \left(\Phi_\ell F \begin{pmatrix} d_R \\ s_R \\ b_R \\ 0 \end{pmatrix} + \Phi_h F \begin{pmatrix} 0 \\ 0 \\ 0 \\ b'_R \end{pmatrix} \right) - \bar{Q}_L \left(\tilde{\Phi}_\ell G \begin{pmatrix} u_R \\ c_R \\ t_R \\ 0 \end{pmatrix} + \tilde{\Phi}_h G \begin{pmatrix} 0 \\ 0 \\ 0 \\ t'_R \end{pmatrix} \right) + h.c$$

FCNC are allowed only among the 4G and 3rd gen. quarks and are governed by a new mixing parameter ϵ_t

4G Quark Pheno. in the 4G2HDM

• Leading decays: $t' \rightarrow ht$, $t' \rightarrow Wb$, $t' \rightarrow Wb'$:

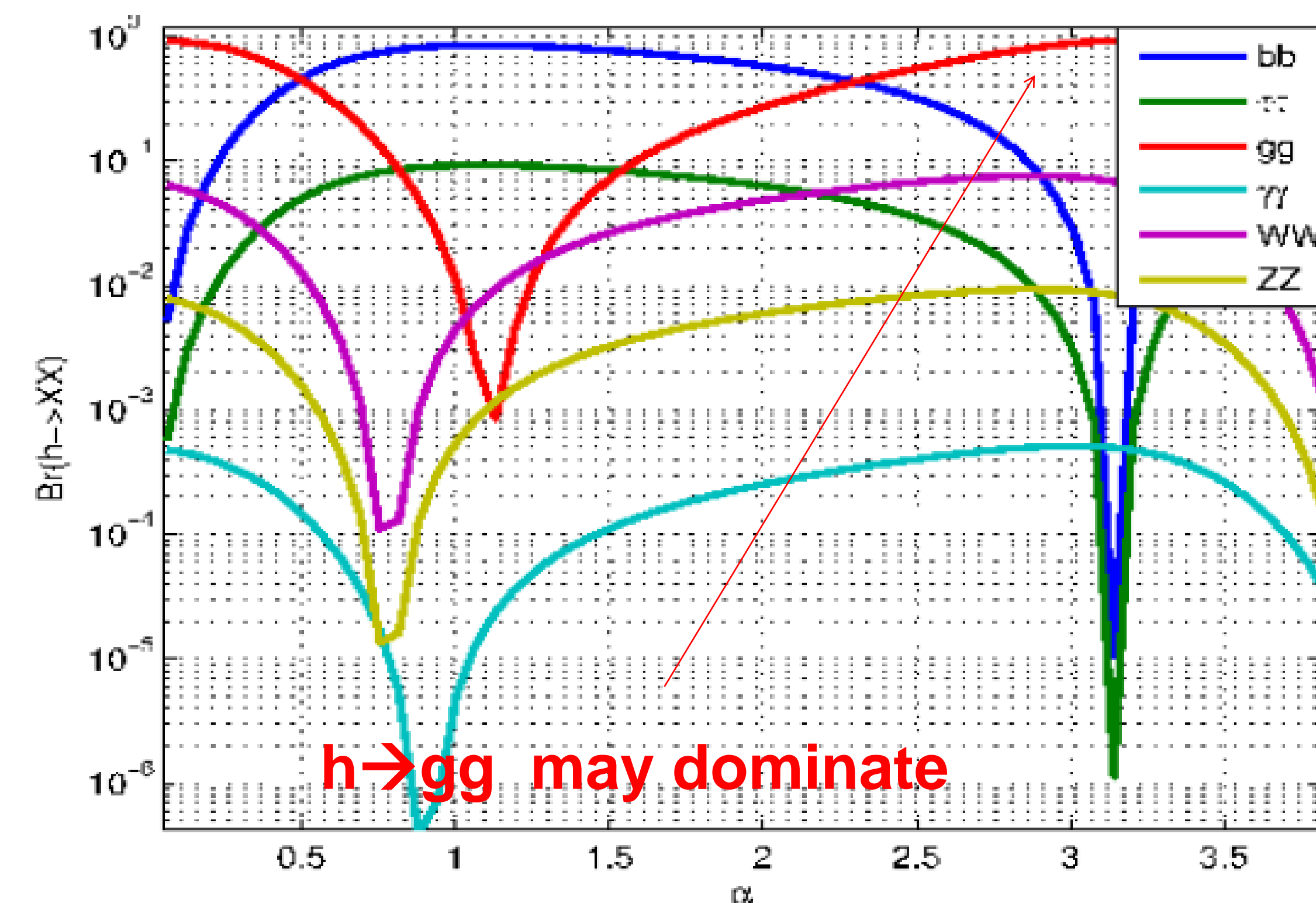


- A variety of possible new signatures for direct searches (recall “standard” SM4 signature $pp \rightarrow t't' \rightarrow 2b+2W$):

- $pp \rightarrow t't' \rightarrow htht \rightarrow bbtbbt \rightarrow 6b+2W$
- $pp \rightarrow t't' \rightarrow htht \rightarrow ggtggt \rightarrow 4g+2b+2W$ (see below)
- $pp \rightarrow t't' \rightarrow Wb'Wb' \rightarrow WWtWWt \rightarrow 6W+2b$
- $pp \rightarrow b'b' \rightarrow hbhb \rightarrow 6b$

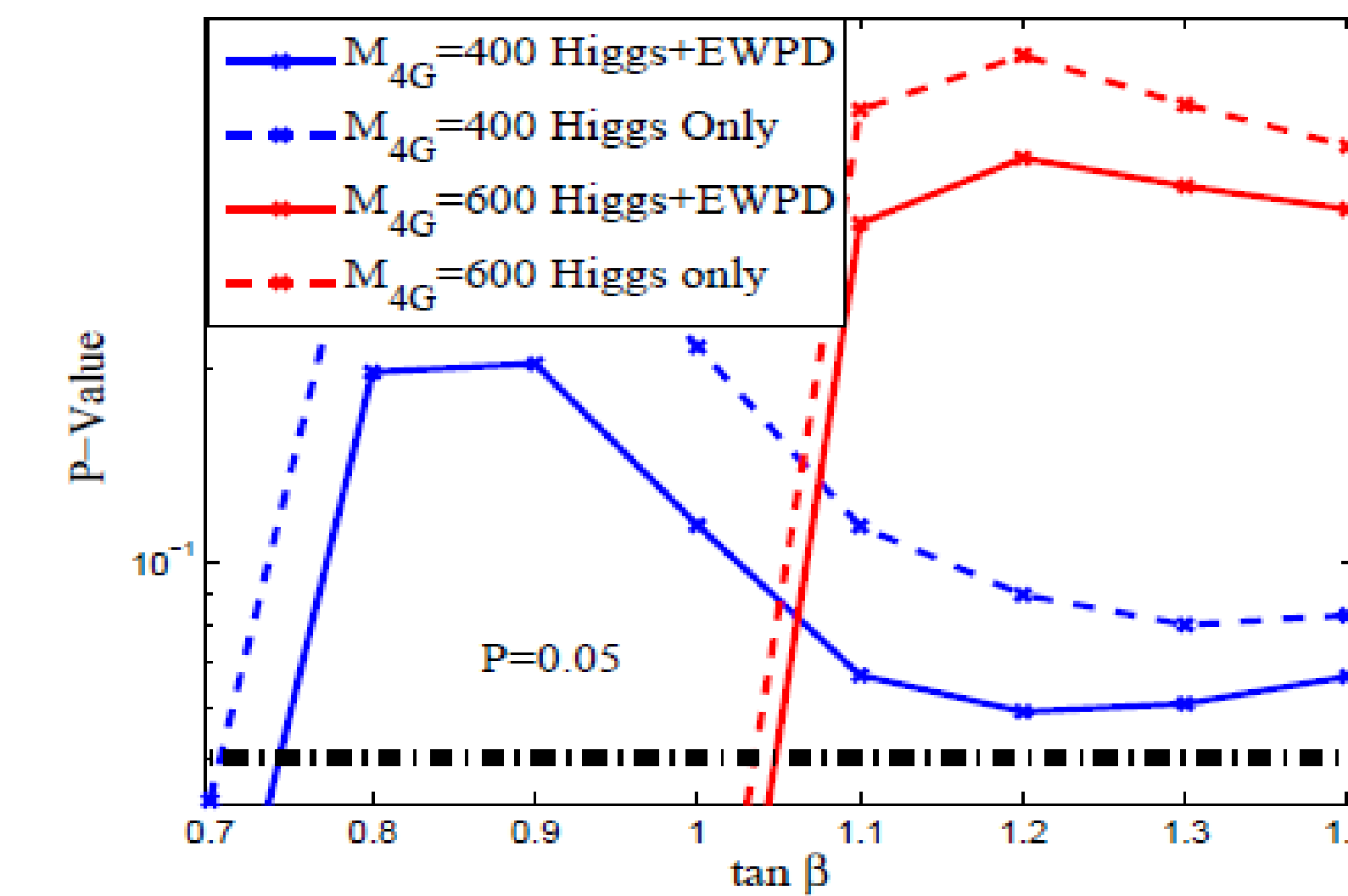
Higgs Pheno. in the 4G2HDM

- Three neutral scalars: h,H and A
- New couplings depend on $\tan\beta$, α and ϵ_t
- Branching ratios:

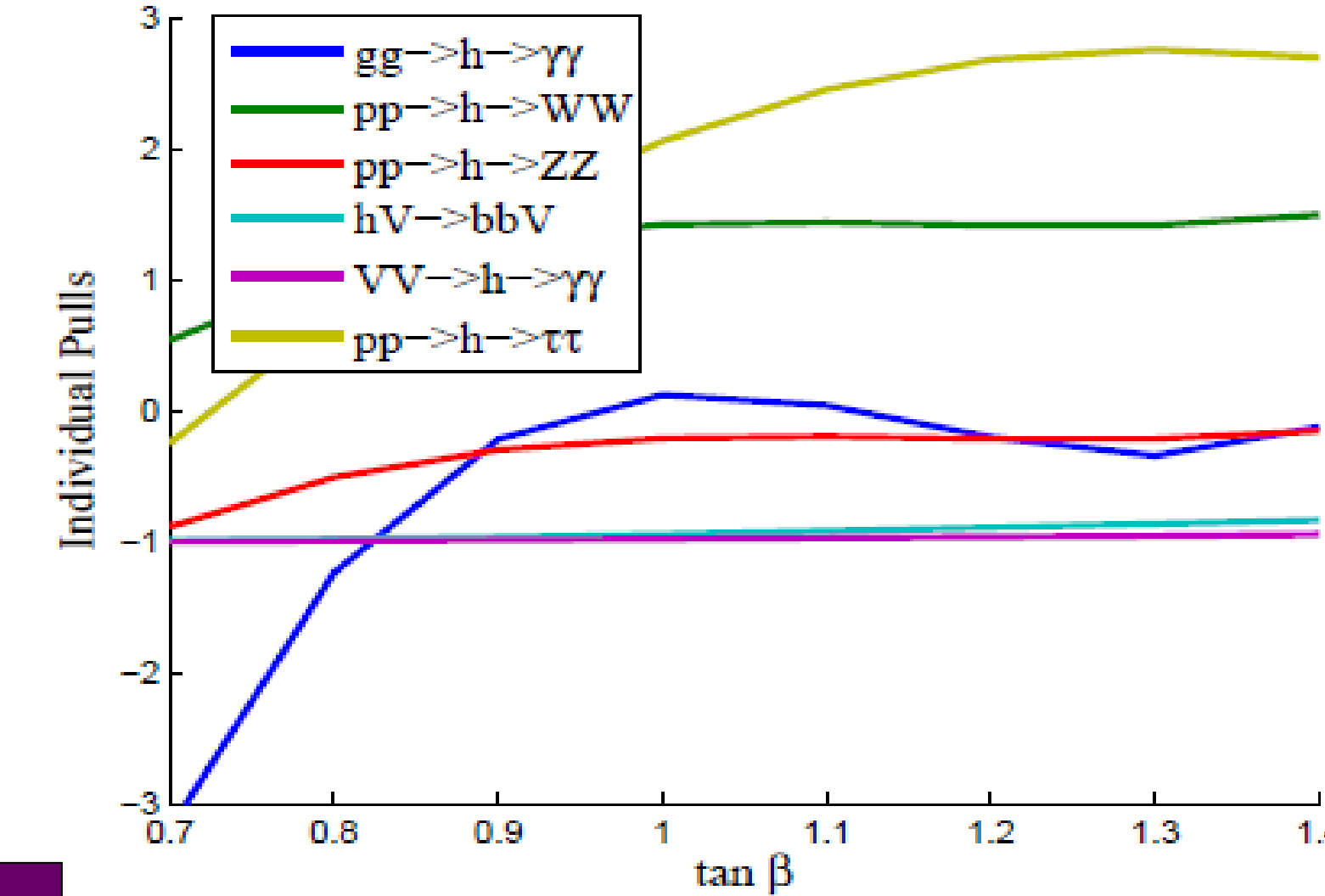


Fits to Higgs Signals

Optimized P Values



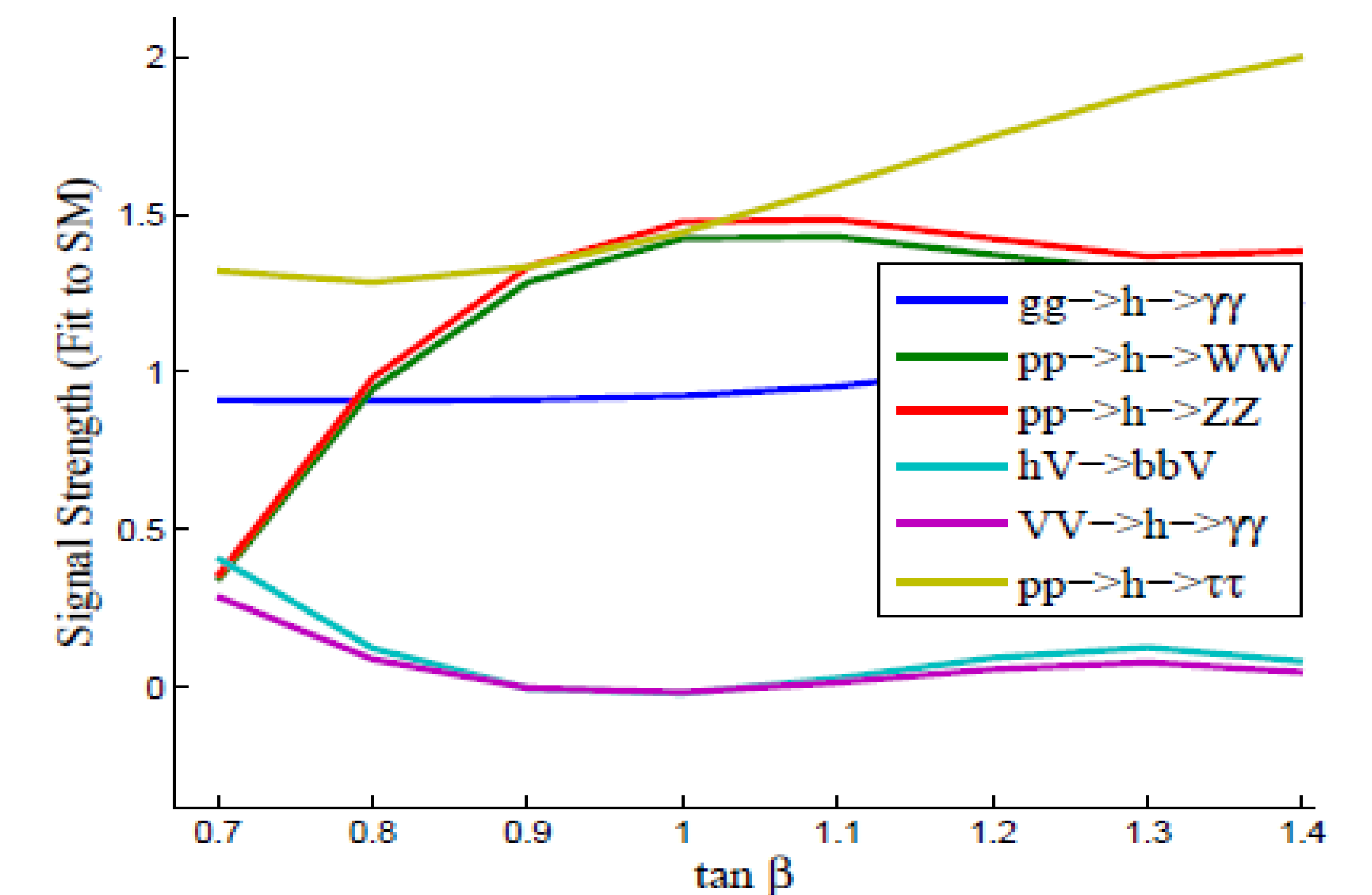
The Individual Channels



The lightest Higgs in the 4G2HDM is consistent with the data.

Predictions of the 4G2HDM

- Smaller signal in the EW productions Channels: e.g., $\sigma(W \rightarrow h \rightarrow W/\gamma\gamma) \sim 0.1 \times \sigma_{SM}$
- Increased production in the $gg \rightarrow h \rightarrow \tau\tau$ channel: $\sigma(gg \rightarrow h \rightarrow \tau\tau) \sim 1.5 \times \sigma_{SM}$



• Predictions for the other neutral scalars

- The CP-even H scalar is excluded up to 500 GeV
- The CP-odd A can be as light as 130 GeV with no contradiction to the current data.