

Exotic Fermions and Heavy Higgs in a New Framework

Daniel Alberto Camargo Vargas

In collaboration with Alex Gomes Dias, Elmer Barreto, Alexandre Alves

UFABC

Centro de Ciências Naturais e Humanas

The 22nd International Conference on Supersymmetry
and Unification of Fundamental Interactions

England-Manchester

25/07/2014

Outline

Some Motivations

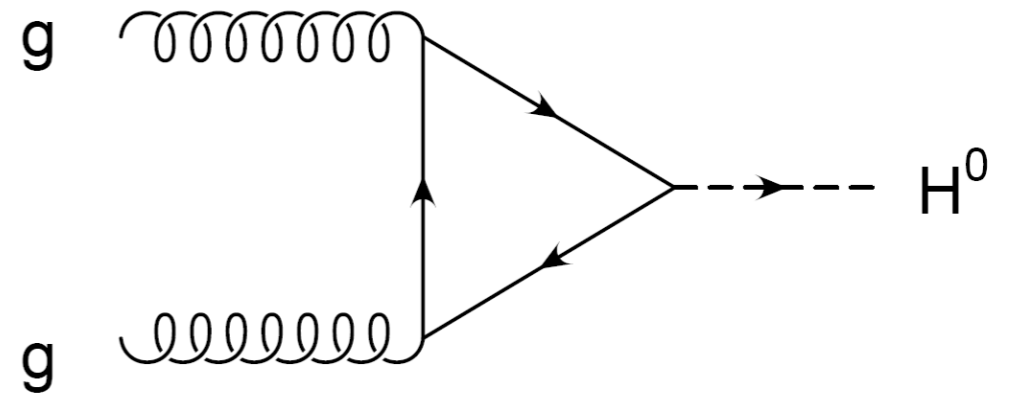
Model Overview

Heavy Higgs (Main focus of this talk)

Some Results and Prospects

Some Motivations

- Families beyond the SM?
- More Scalars?



The Heavy Higgs will be embedded into a Model with the same Gauge Group of the SM.

Models free of anomalies with New Chiral Fermions

Recent LHC searches for quarks with exotic charges

$$X^{5/3} \quad Y^{-4/3}$$

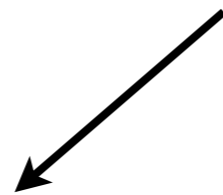
Theoretical constructions in order to look for more scalars

Higgs physics

The Model

A model with chiral quarks of electric charges $-4/3$ and $5/3$
[JHEP07 \(2013\)129](#)

Alexandre Alves, Elmer Barreto, Daniel Camargo, Alex Dias



- New fermions in the framework of SM

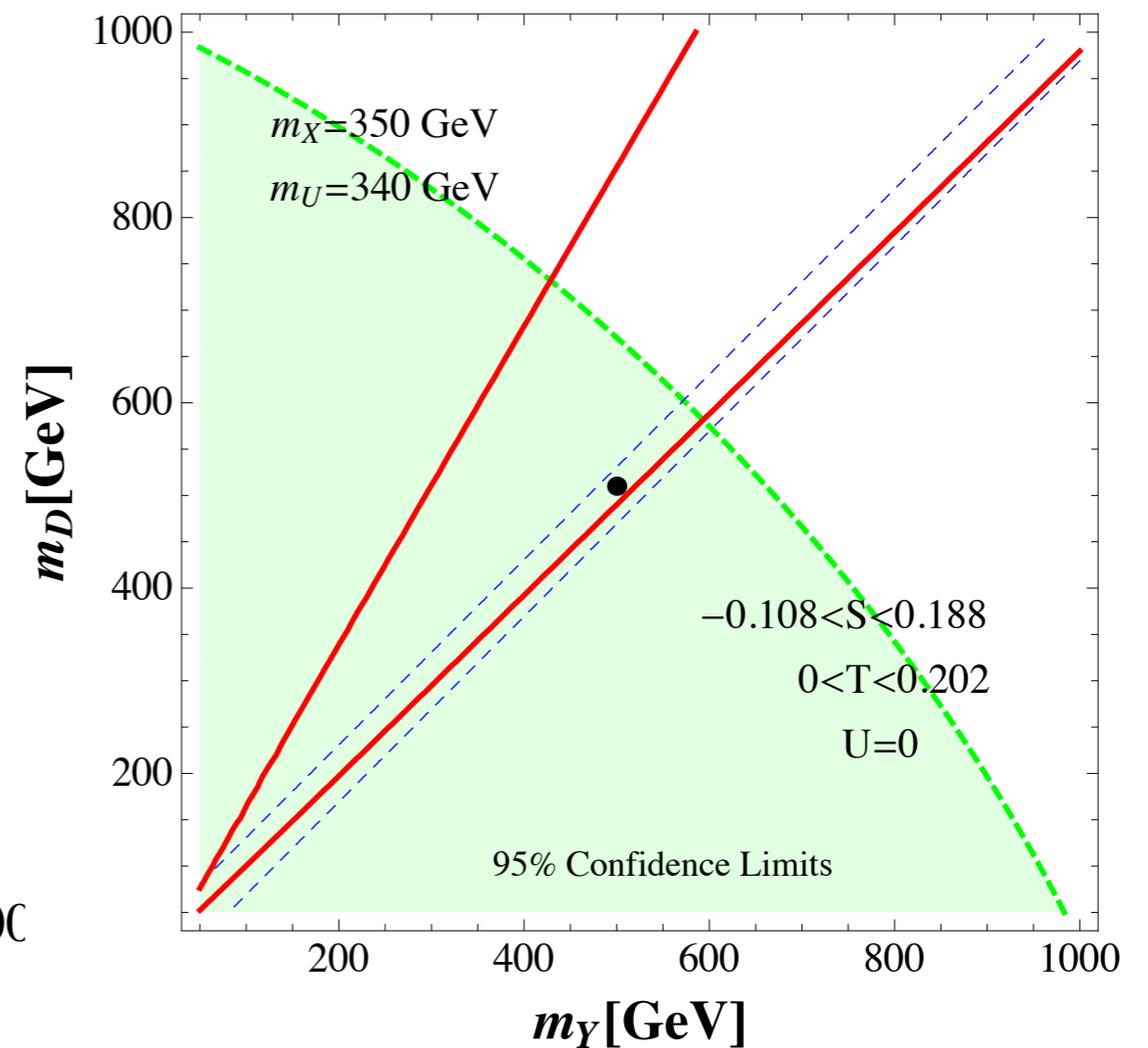
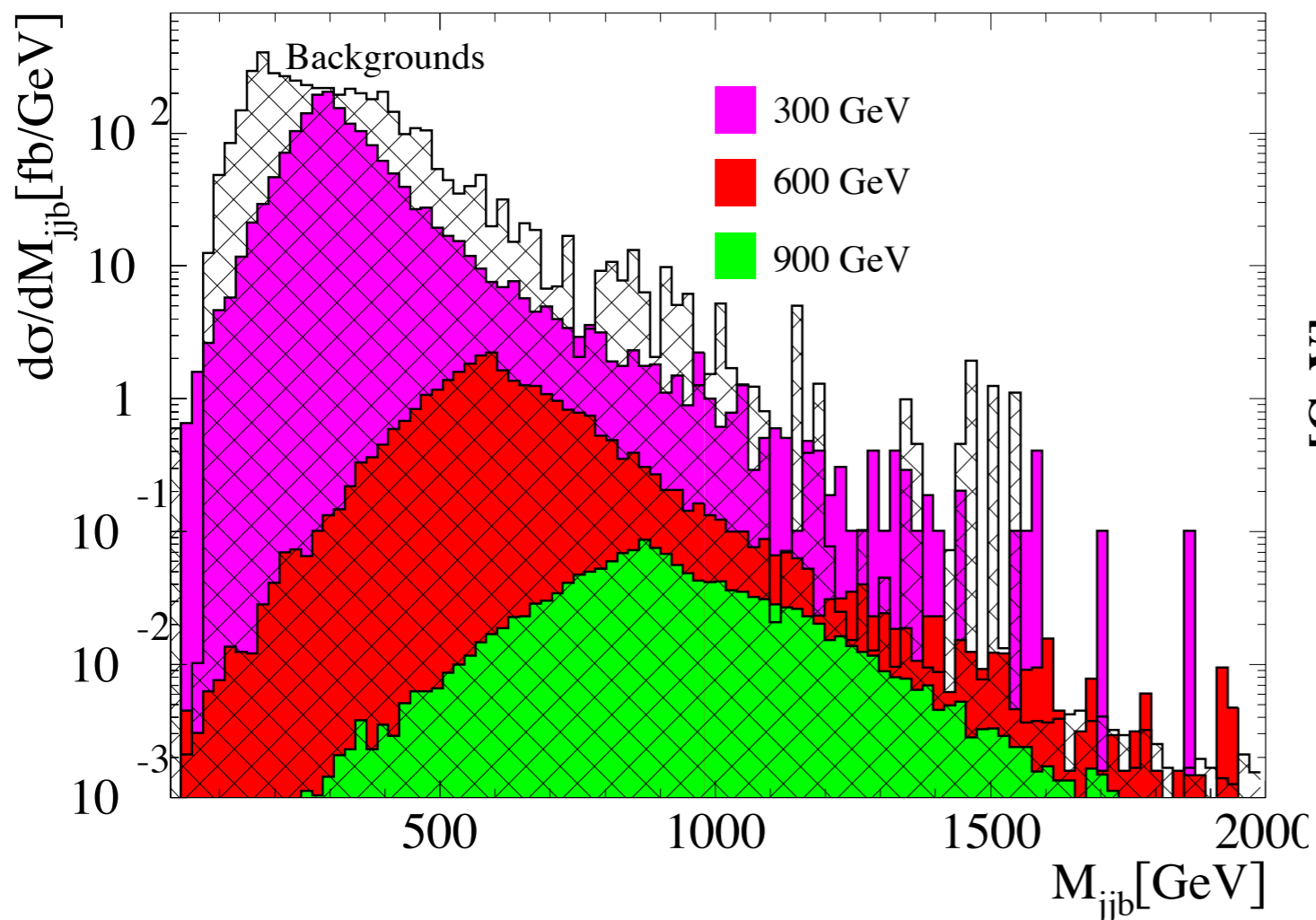
$$SU(3)_C \otimes SU(2)_L \otimes U(1)_Y \otimes Z_4$$

- Model with **exotic fermions** $X^{5/3}$ $Y^{-4/3}$

- 2HDM  $H\dots$

About the previous work

- The phenomenology for the quark $\gamma^{-4/3}$ shows that it is possible to detect it in the LHC at 8 TeV for masses between 300 and 750 GeV.



Heavy Higgs

Higgs SM discovery



Any deviation from the Standard Model predictions would be evidence of physics beyond the Standard Model.

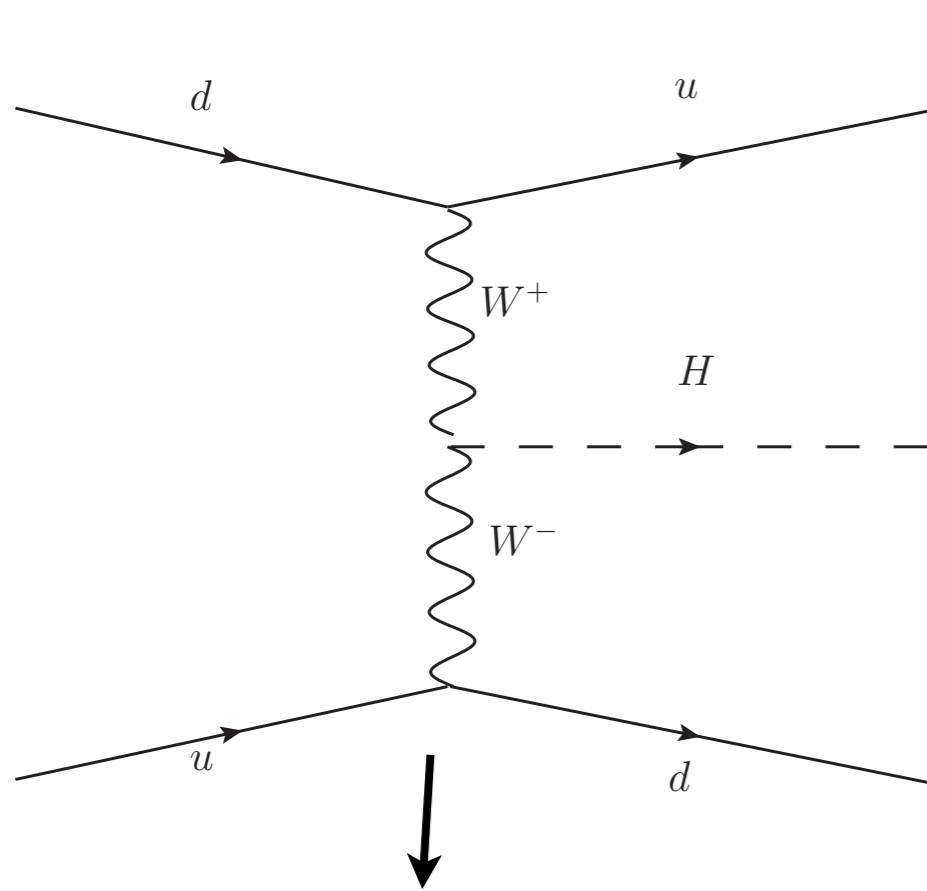
→ New CP sources, Strong CP problem among others...

★ Many extensions of SM have been proposed with the ESB sector up till now, but one of the most easy extensions is the **2HDM**.

★ Four-2HDM Types differing in the Yukawa couplings.

Z_4
SM-fermionphobic
New interactions
thus new physics

Heavy Higgs



$$\begin{aligned}
 -\mathcal{L}_Y^Q &= y_{ij}^u \overline{q_{iL}} \tilde{\phi}_1 u'_{jR} + y_{ij}^d \overline{q_{iL}} \phi_1 d'_{jR} \\
 &+ y^U \overline{\psi_L^X} \phi_2 U'_R + y^D \overline{\psi_L^Y} \tilde{\phi}_2 D'_R \\
 &+ y^X \overline{\psi_L^X} \tilde{\phi}_2 X_R + y^Y \overline{\psi_L^Y} \phi_2 Y_R + h.c.
 \end{aligned}$$

$$\begin{aligned}
 -\mathcal{L}_Y^L &= y_{ij}^e \overline{e_{iL}} \tilde{\phi}_1 e'_{jR} + y_{ij}^\nu \overline{\nu_{iL}} \phi_1 e'_{jR} \\
 &+ x^{E^+} \overline{\psi_L^N} \tilde{\phi}_2 E'^+_R + x^F \overline{\psi_L^F} \phi_2 F'^-_R \\
 &+ x^N \overline{\psi_L^N} \phi_2 N'_R + x^{E^-} \overline{\psi_L^F} \tilde{\phi}_2 F'^--_R + h.c.
 \end{aligned}$$

H-SM fermions interactions through gauge vector bosons

$$V(H_i, \phi) = V_{\mathcal{H}} + \left(f \phi_1^\dagger \phi_2 \chi + \lambda \chi^4 + h.c. \right)$$

$V_{\mathcal{H}}$ can be whichever of I,II,III,IV types of 2HDM depending of the soft breaking terms

Heavy Higgs

We consider two scenarios:

Fermiophobic



Tree-level interactions with the new fermions are suppressed by phase space (compatible with the experimental measurements)

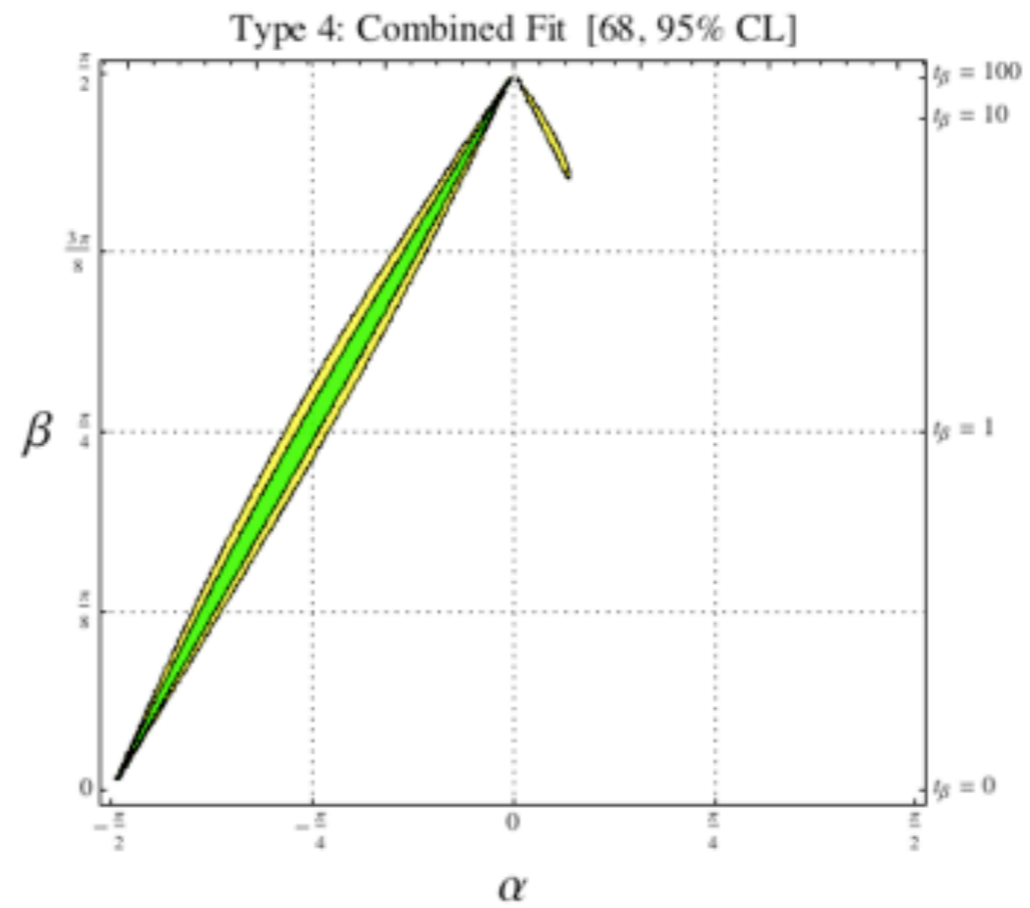
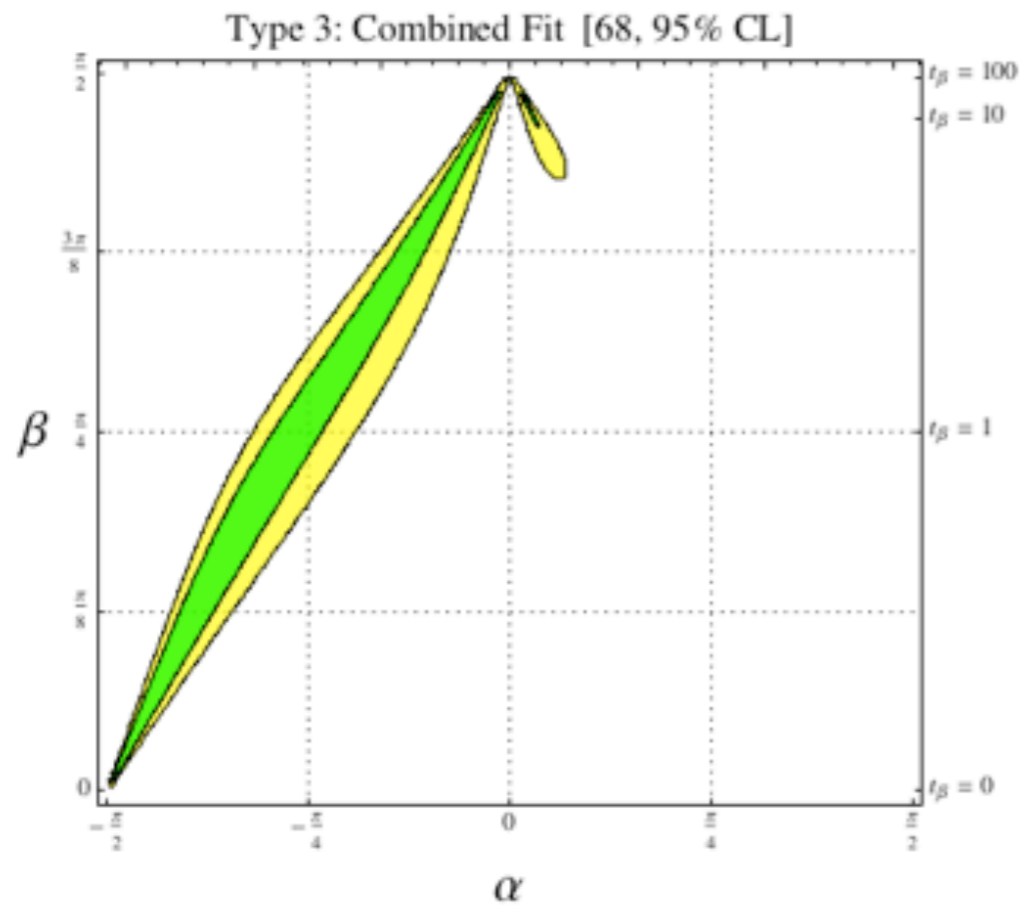
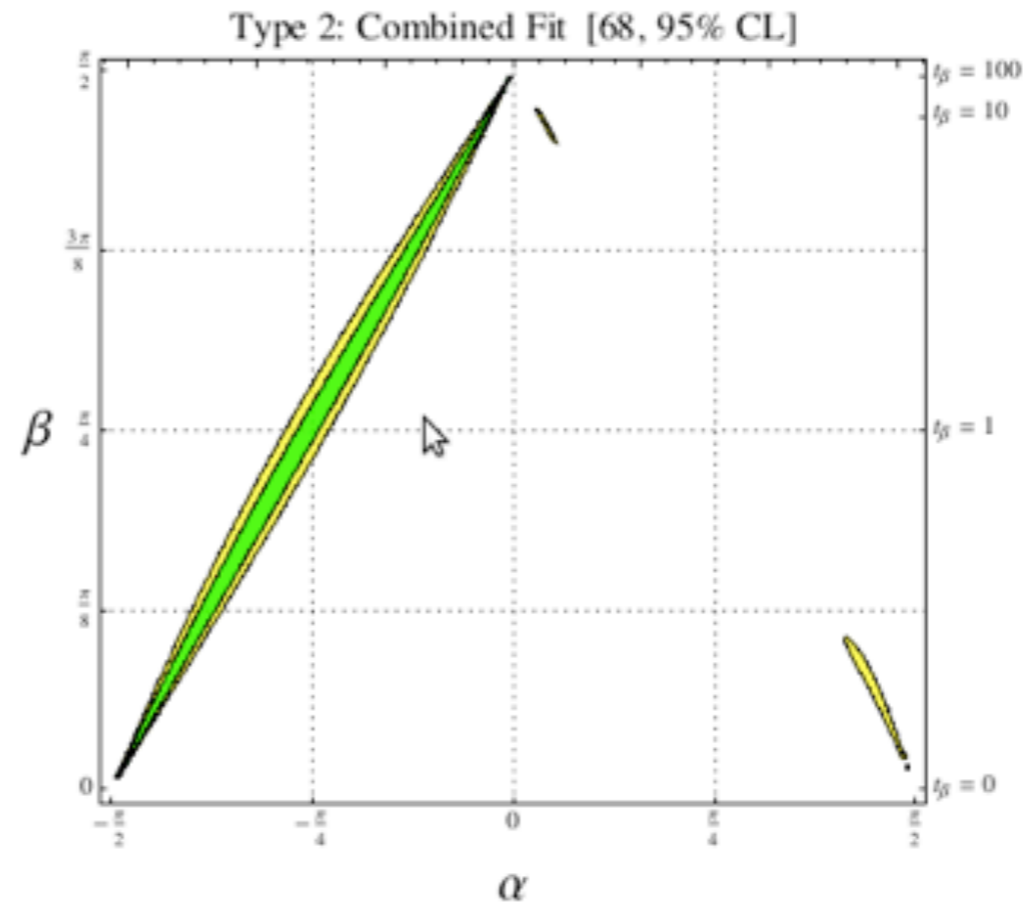
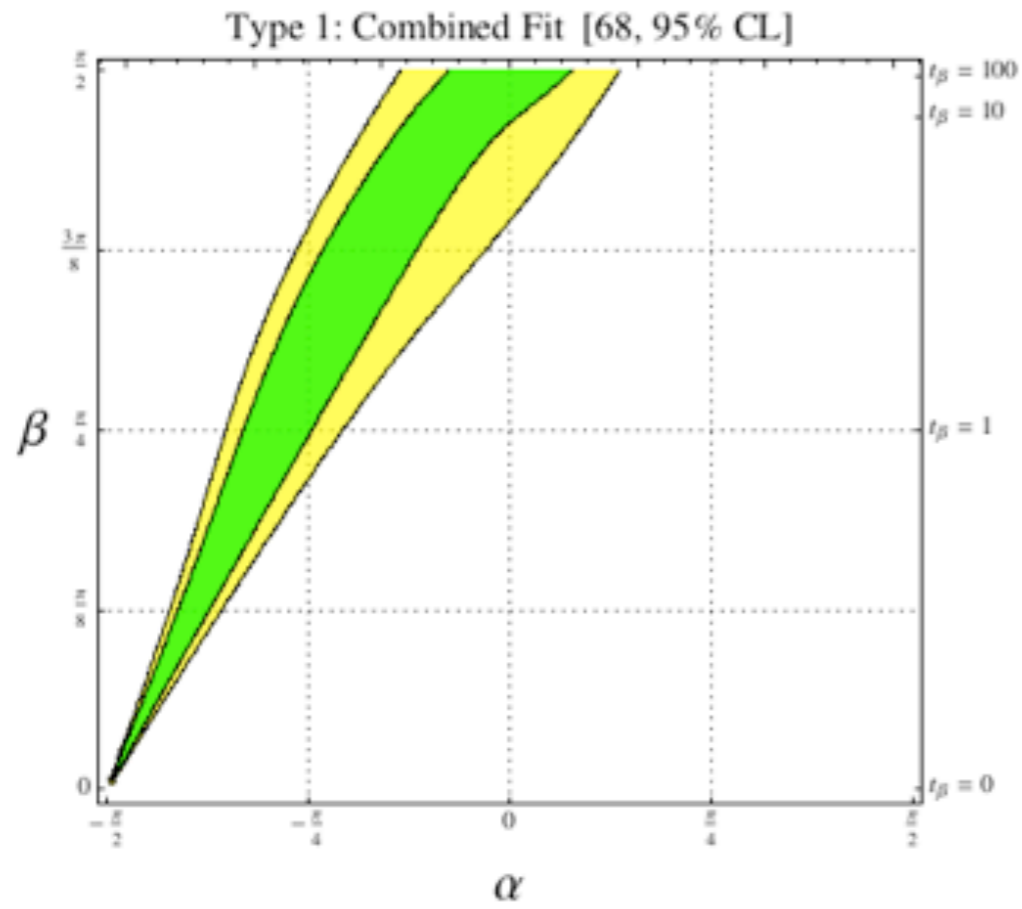
Heavy Higgs Searches and Constraints on Two Higgs Doublet Models, arxiv:1305.1624.

E-Interactions $\longrightarrow \mathcal{L} \sim \alpha \bar{L} l_{SM} V$ New Fermion-SM-Fermion interactions

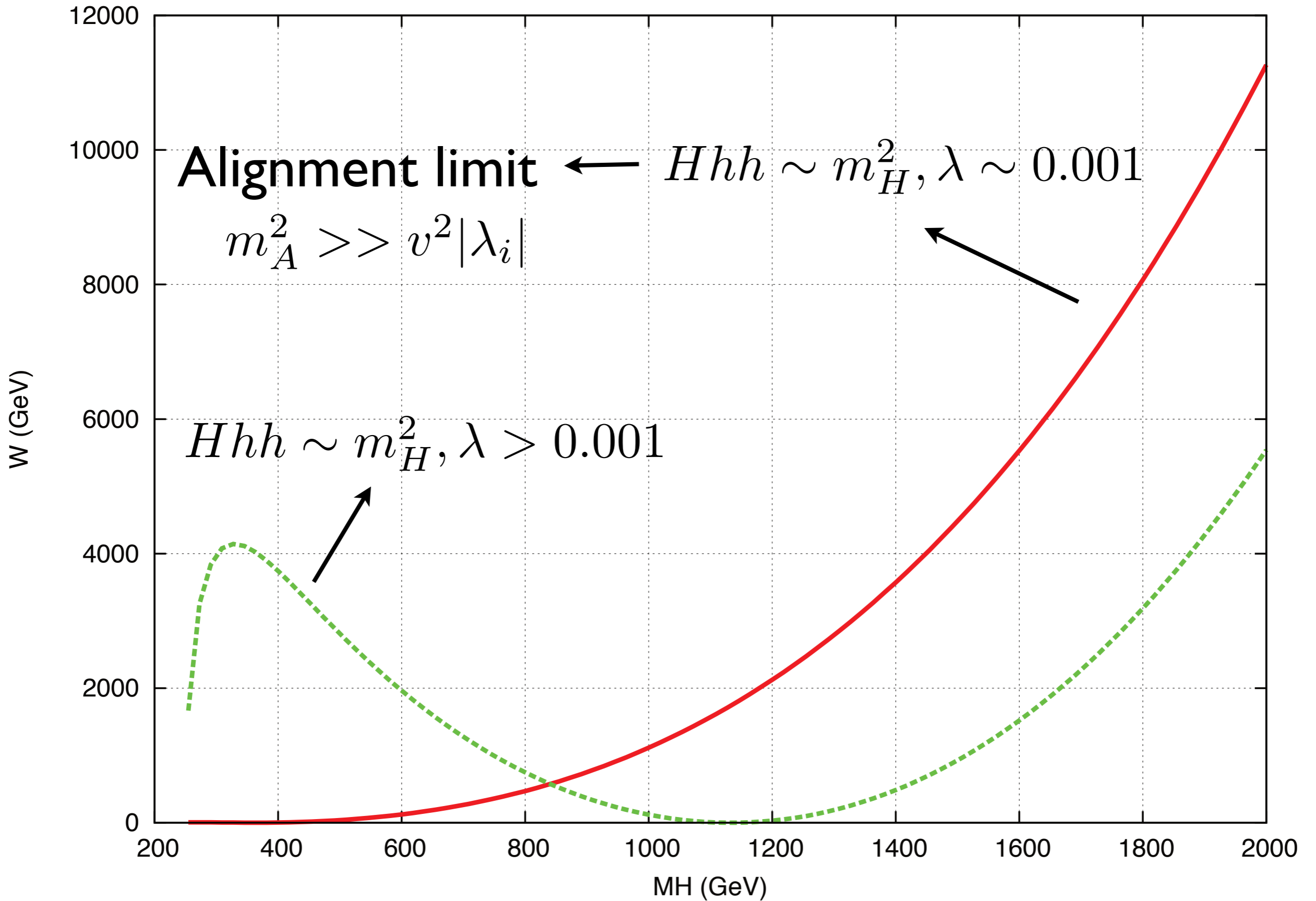
$m_H > 2m_{Q_E, L_E}$

We want to see the impact of the NF in the search of H

Heavy Higgs



Heavy Higgs



Alignment limit

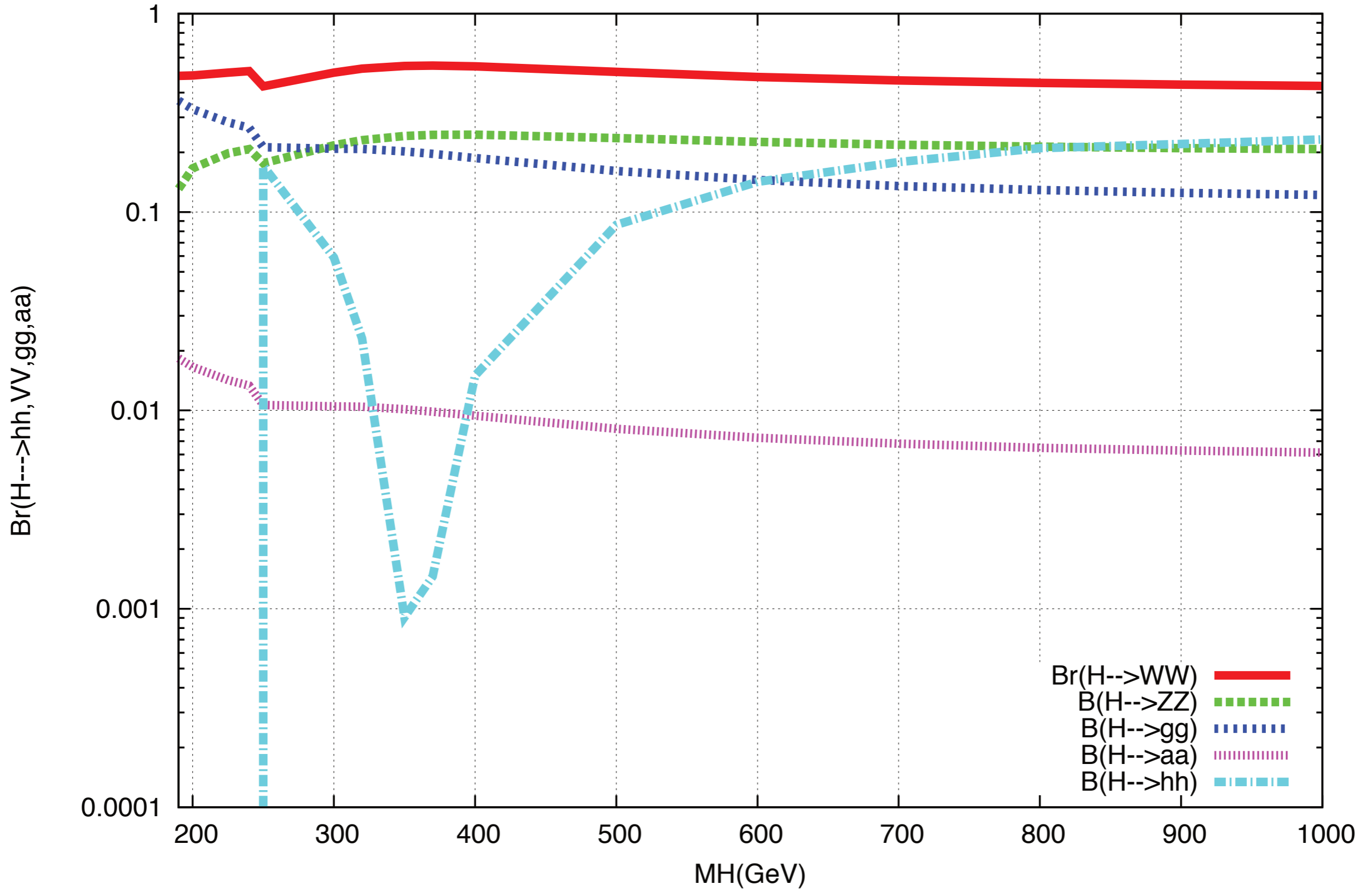
$$m_A^2 \gg v^2 |\lambda_i|$$

$$Hhh \sim m_H^2, \lambda \sim 0.001$$

$$Hhh \sim m_H^2, \lambda > 0.001$$

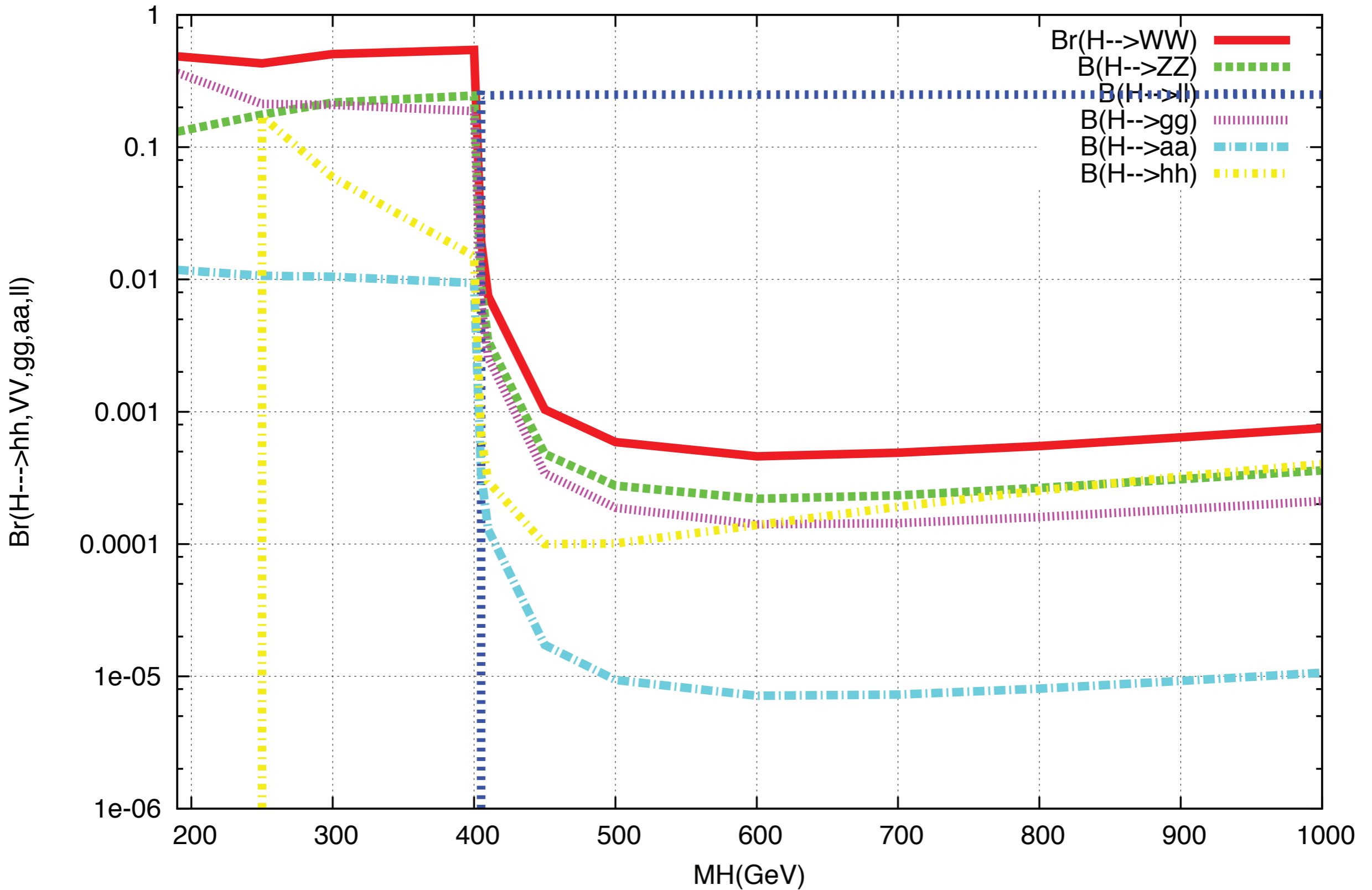
Heavy Higgs

Fermiophobic Heavy Higgs Branching-ratio near to alignment limit

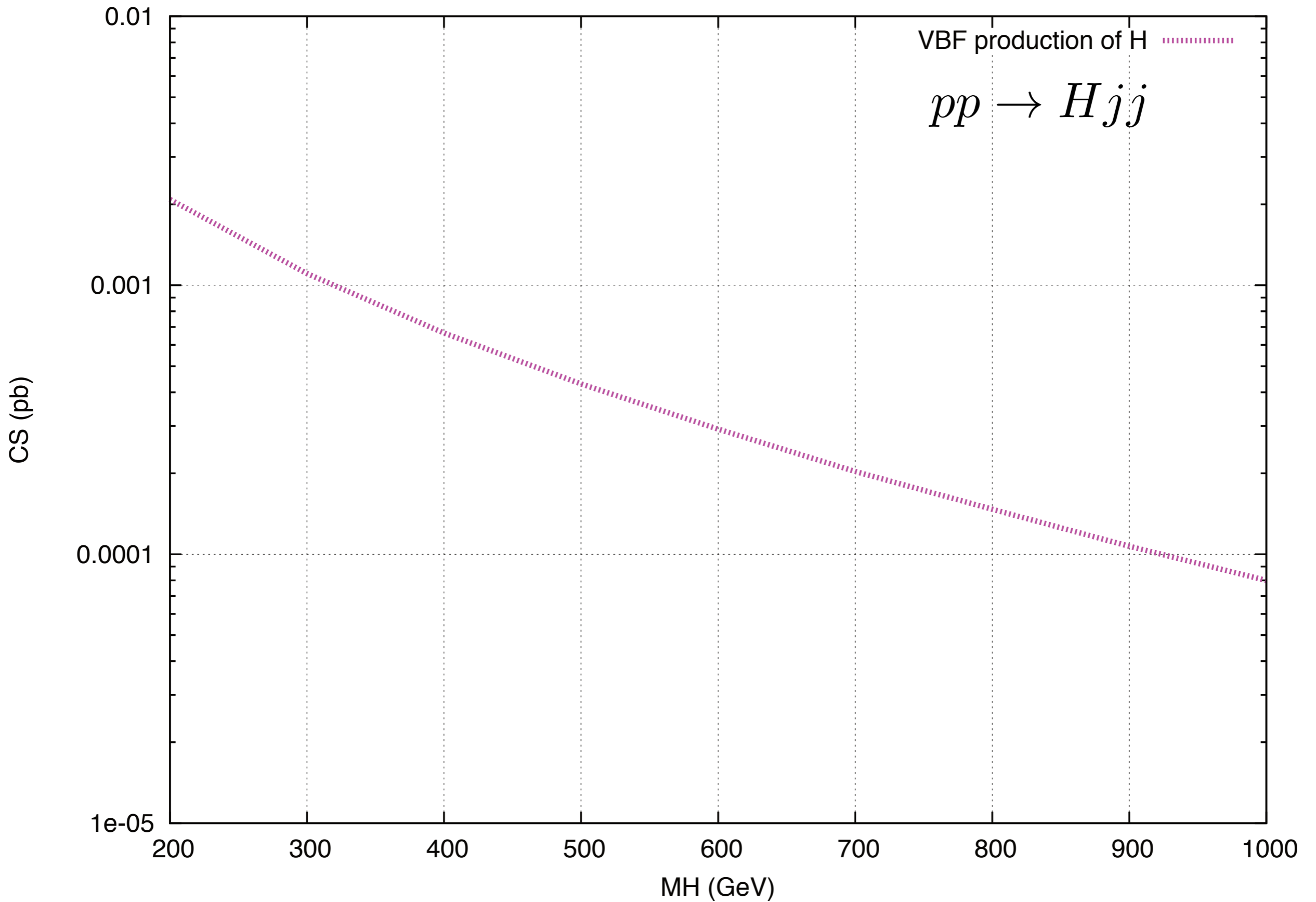


Heavy Higgs

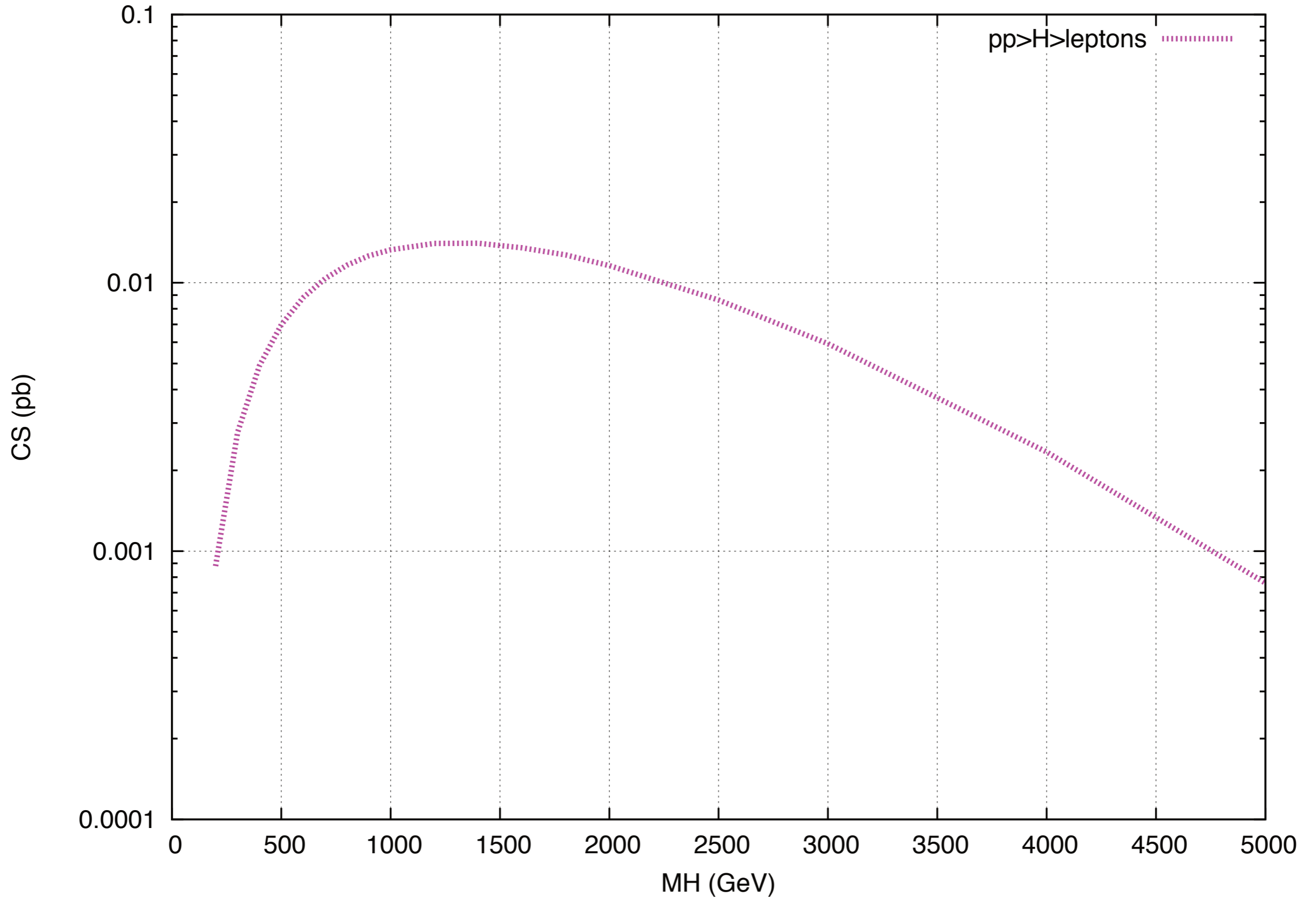
Heavy Higgs Branching-ratio near to alignment limit



Heavy Higgs



Heavy Higgs



Some Results

Alignment limit \longrightarrow

Constrains on the
free parameters

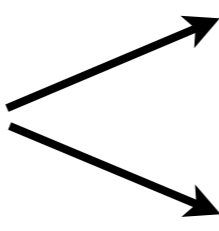
$$\lambda_i < 0.001$$

For $M_H > 800 \text{ GeV}$ \longrightarrow

Considerable
invisible H decay

The New Fermions open an important channel
in the search of H

Prospects

Look for more scenarios  $m_A, m_{H^\pm}, m_H, \lambda, Q, L$
LHC Energy

Simulation-Experiment-Reality.

Model validation.

Try to solve open problems...

Thanks