Multi-Higgs models in four and more dimensions

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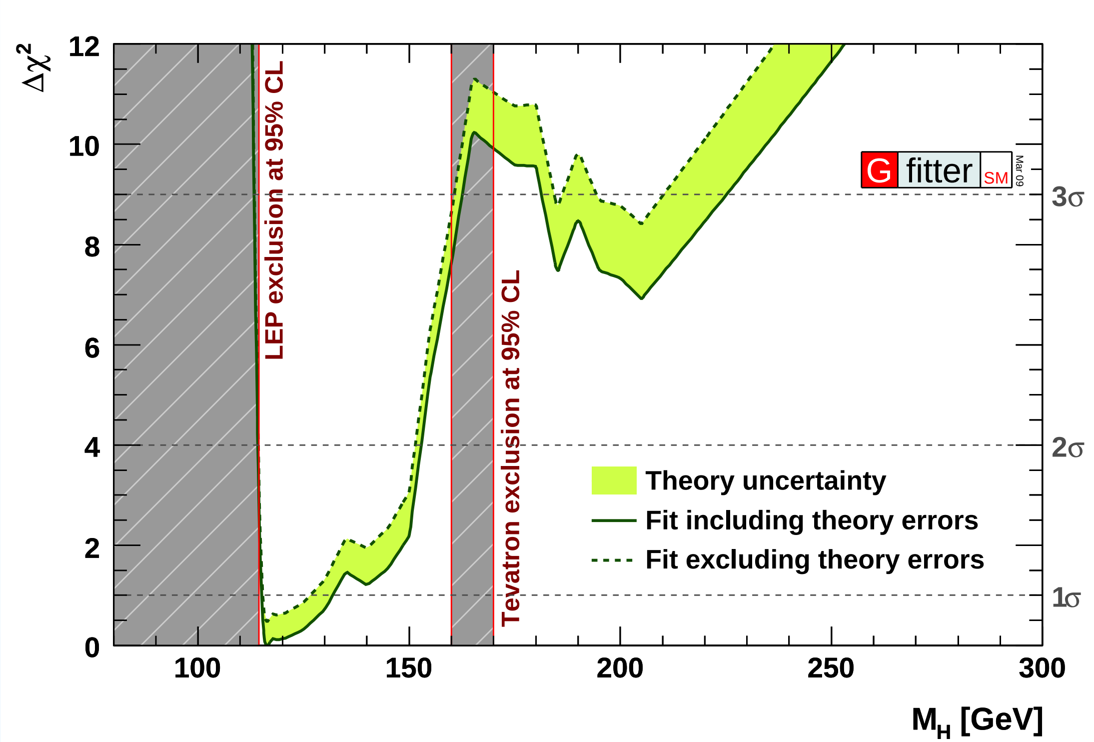
Outline

1. SM and Multi-Higgs models
2. Weakly Int. Higgs sector: MSSM/THDM
   - The THDM-III (with Textures)
   - Low Energy Constraints of $H^{\pm}$
   - Colliders Signals of $H^{\pm}$
3. Strongly Int. Higgs sector: Composite/XD Higgs
   - Composite PGB Higgs boson
   - RS Higgs sector
4. Conclusions.

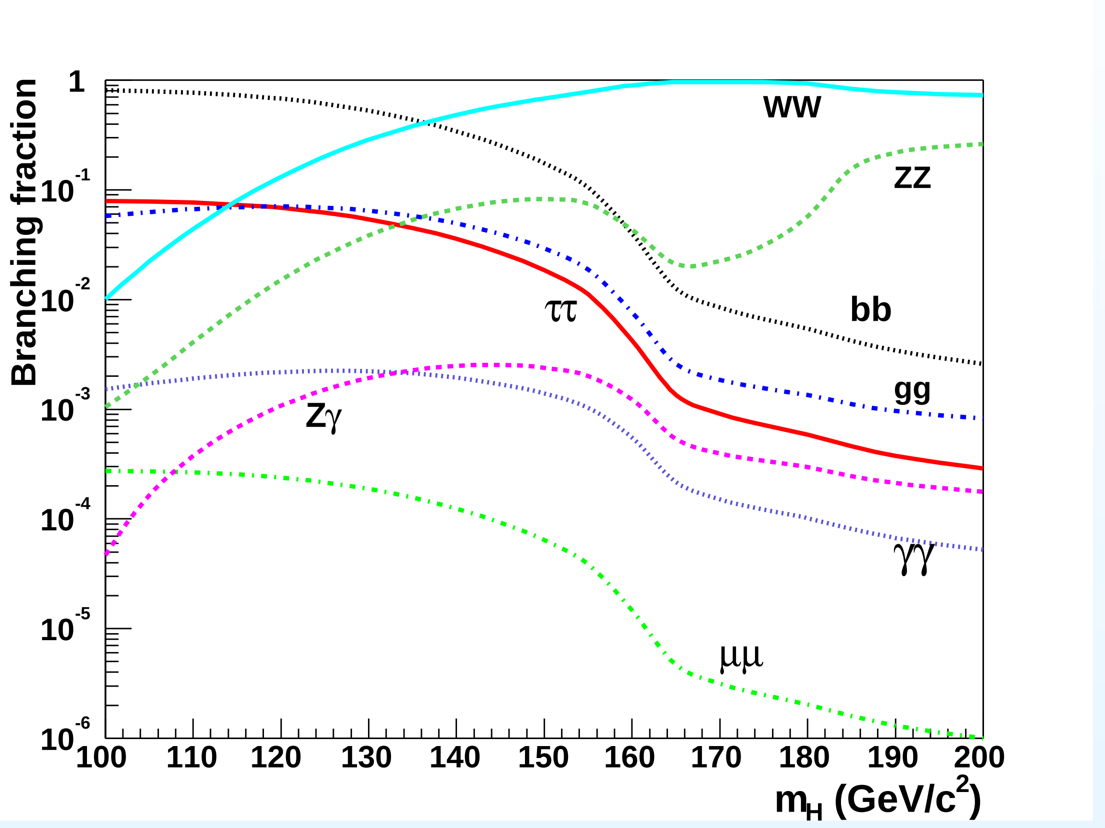
1.1 SM Higgs

- Minimal Model: $\Phi = (\phi^+, \phi^0)$,
- SSB induces $SU(2)_L \times U(1)_Y \to U(1)_{em}$,
- $W^\pm, Z$ and fermions aquire their masses (Yukawa),
- Remmant of SSB: $\Phi \to h$, the Higgs boson.
- Higgs boson couples to mass $\to$
  Relevant couplings: hWW, hZZ, $ht\bar{t}$, $hb\bar{b}$, $h\tau\tau$
- Rad. Corrs. prefere a light Higgs, with a mass of order of the EW scale ($m_{\phi_{SM}} \simeq v$).
- LHC will probe the Higgs sector soon,

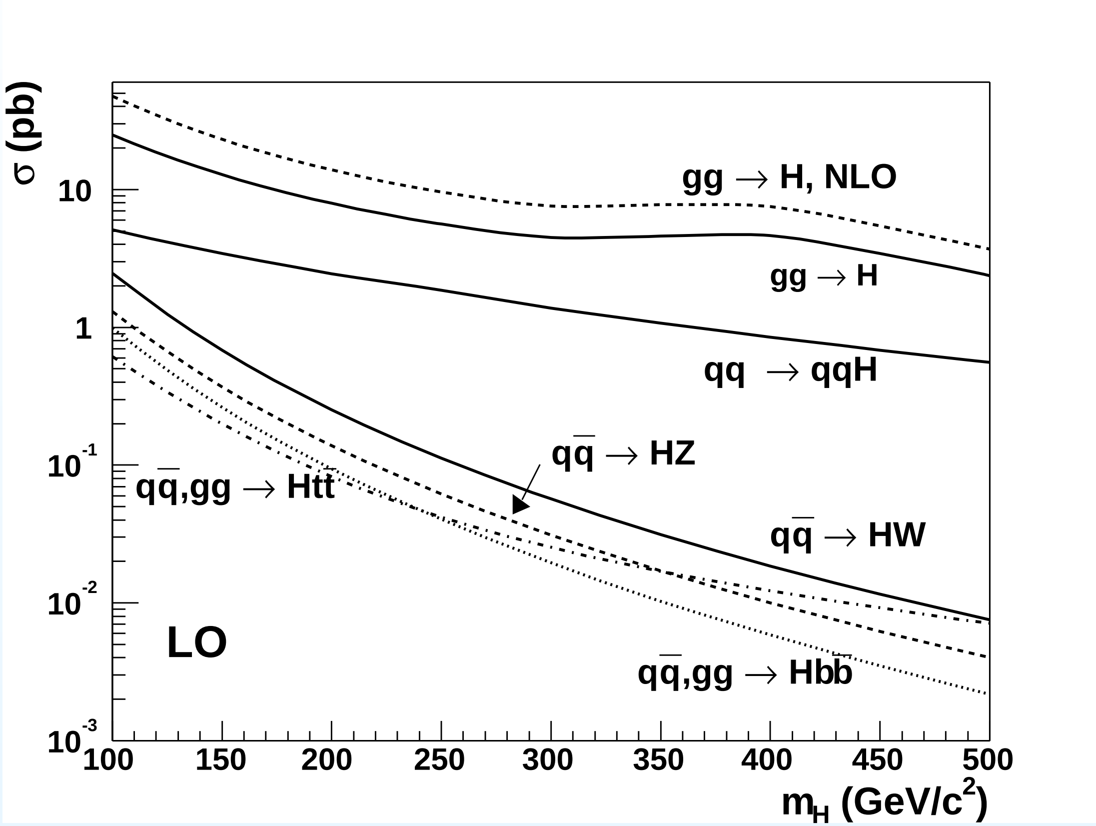
1.2 Higgs mass limits



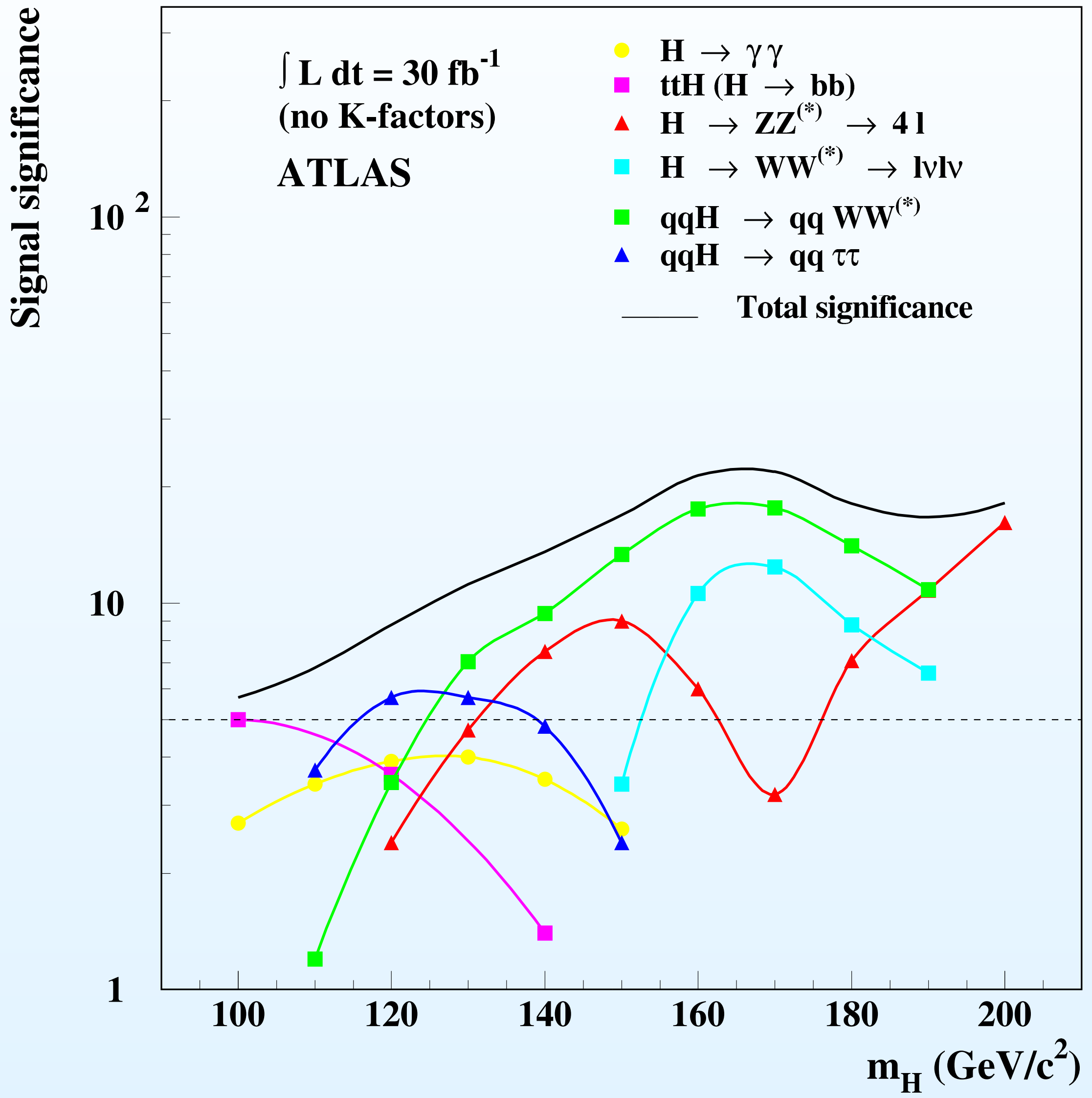
1.2b Higgs B.R.'s



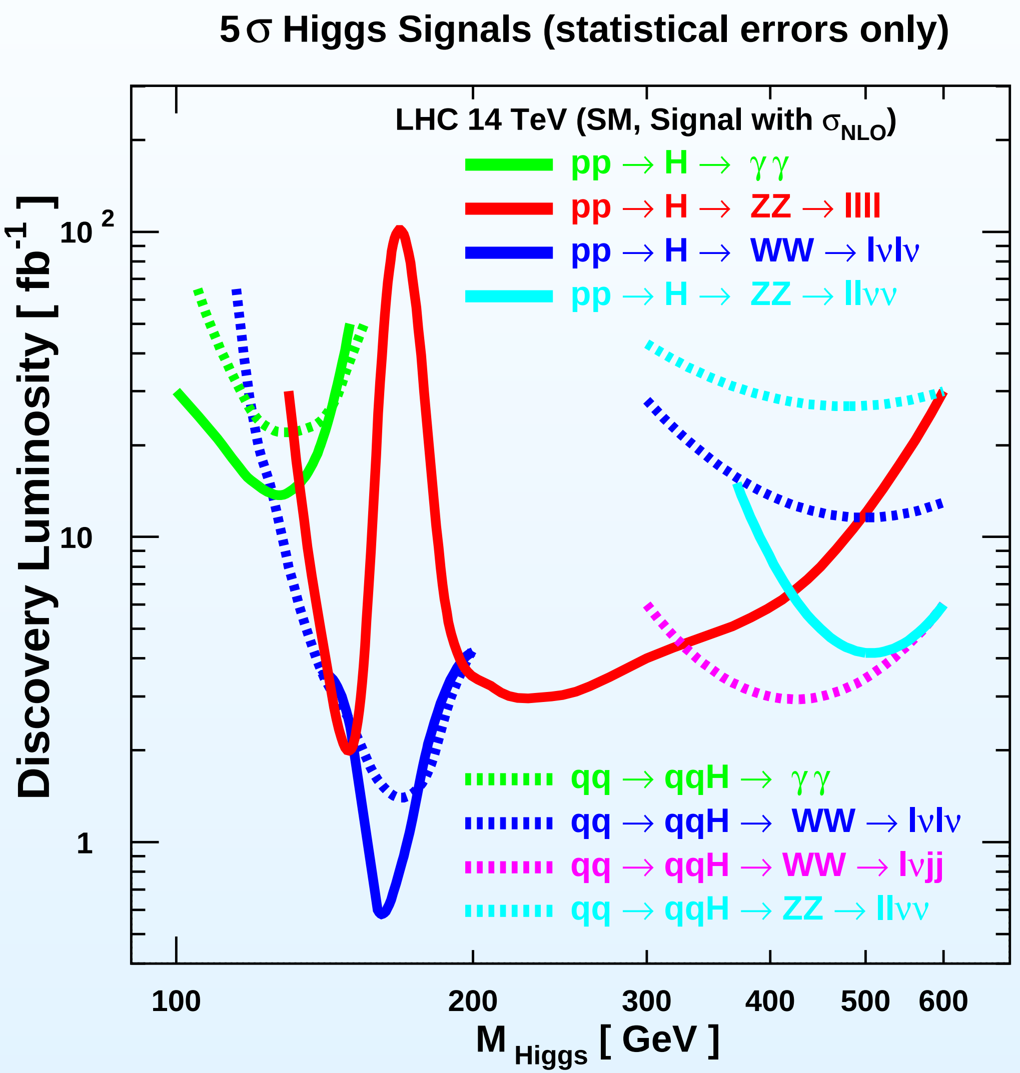
1.2c Higgs cross sections



1.2d Higgs search at LHC - ATLAS



1.2e Higgs search at LHC - CMS



1.3 Scenarios of New Physics

Open problems in the SM suggest the need for New Physics:

- Large/Little hierarchy problem,
- Neutrino masses,
- Strong CP problem,
- Dark Matter,
- Cosmological constant (Dark energy),
- Some deviations from the SM (a few std. dev.),
  e.g. Δa_μ, etc.
- Aesthetical questions,

1.3b Proposals for EWSB-Hierarchy problem

- Weakly interacting EWSB:

  Need a symmetry to stabilize elementary Higgs boson

  e.g. SUSY $\rightarrow$ MSSM $\rightarrow$ mSUGRA, ...

- Strongly Interacting EWSB:

  Composite $W^{\pm}, Z^{0} \rightarrow$ e.g. Technicolor, ETC,WTC...

  Composite Higgs models $\rightarrow$ e.g. PGB Higgs (4D)

Another possibility: Accidental Cancellacion,

$$\lambda = y_t^2 - \frac{1}{8}[3g^2 + g'^2] \tag{1}$$

1.3c Scenarios of New Physics

Models of New Physics often $\longrightarrow$ Multi-Scalar models:

- Hierarchy problem
  $\longrightarrow$ SUSY $\longrightarrow$ Two-Higgs doublet model
- Neutrino masses
  $\longrightarrow$ Radiative $\longrightarrow$ Higgs triplets
  $\longrightarrow$ LR models $\longrightarrow$ Higgs triplets, doublets and bi-doublets
- Strong CP problem
  $\longrightarrow$ PQ $\longrightarrow$ Two-Higgs doublet model
- Dark Matter
  $\longrightarrow$ MDM $\longrightarrow$ Scalar DM,

2.1 Weakly Int. Higgs sector

SUSY is one case widely studied, but why is it attractive?

- Offers the possibility to stabilize the Higgs mass and EWSB,
- Improves Unification and o.k. with proton decay,
- Favors a light Higgs boson, in agreement with EWPT, i.e. $m_h \leq 180$ GeV,
- New sources of flavor and CP violation may help to get the right BAU,
- LSP is stable and Dark matter candidate.

2.1b The MSSM

The minimal extension of the SM consistent with SUSY, is based on:

- SM Gauge Group ($\longrightarrow$ gauge bosons and gauginos),
- 3 families of fermions and sfermions,
- Two Higgs doublets,
- Soft-breaking of SUSY,
- R-parity distinguish SM and their superpartners
  $\longrightarrow$ LSP is stable and DM candidate.

2.1c The MSSM particle content

	SM	Superpartners
SM Bosons	$W^{\pm}, Z, \gamma$ gluon Higgs bosons	Wino,Zino, Photino gluino Higgsinos
SM Fermions	quarks leptons neutrinos	squarks sleptons sneutrinos

Mixing of gauginos and Higgsinos $\longrightarrow$
Charginos ($\chi_i^{\pm}$, $i = 1, 2$) and
Neutralinos (χ_j^0, $j = 1, 4$),

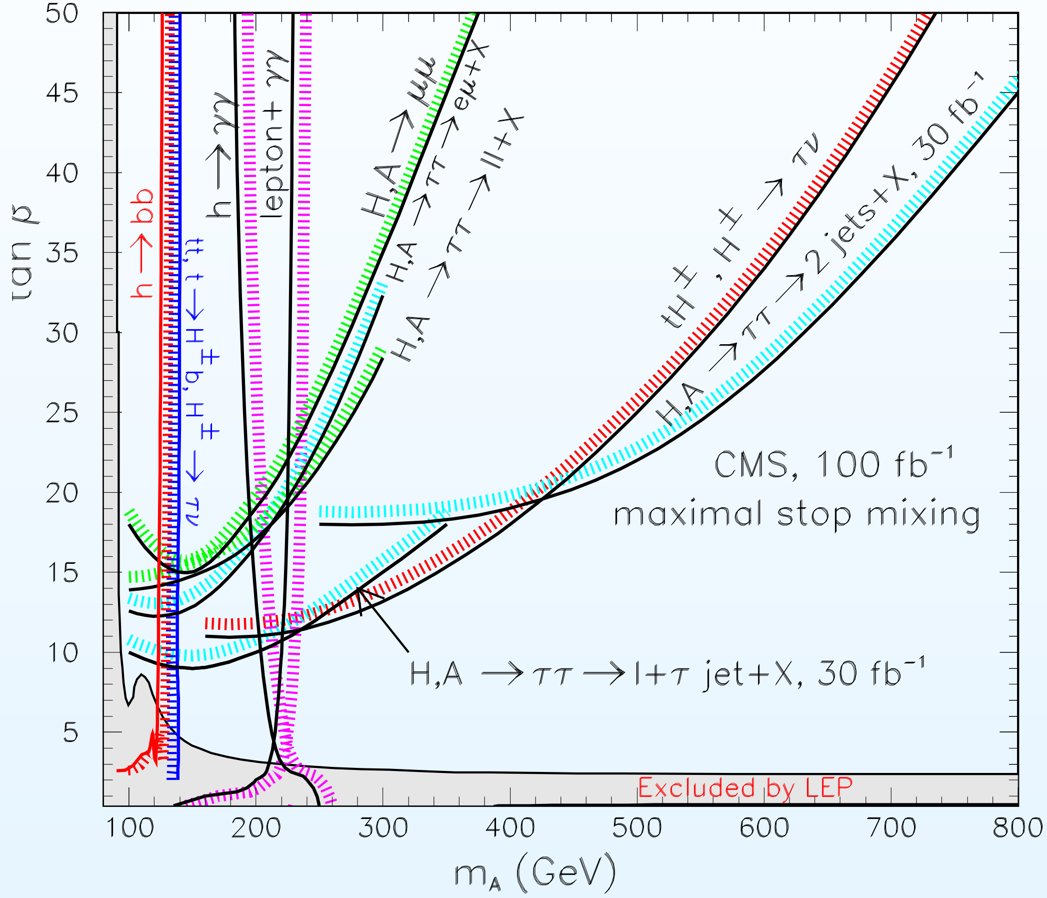
Gravitino may also play a role.

2.4 The MSSM Higgs sector

At tree-level MSSM Higgs sector is a THDM of type-II, i.e. each doublet couples only to one type (u or d) quark.

- CP-even neutral Higgs bosons h^0, H^0, with $m_h < m_Z$,
- CP-odd neutral Higgs A^0 with $m_H^2 = m_A^2 + m_Z^2 \sin^2 2\beta$,
- Charged Higgs $H^\pm$, with $m_{H^+}^2 = m_A^2 + m_W^2$,
- Masses and mixing angles fixed with:
  m_A and $tan\beta = v_2/v_1$,
- When $m_A \leq \tilde{m}$, Higgs search uses SM techniques.
- But $H^0, A^0, H^\pm$ may decay into SUSY modes;
  LHC search gets more complicated!,

2.4b MSSM Higgs search at LHC



2.5 Problems in the MSSM

- To satisfy LEP limits ($m_h > 114$ GeV), one needs to include stop-top loops, with a SUSY mass scale $\tilde{m} = O(1)$ TeV,
- But with such large masses, fine-tunning may be back,
- SUSY breaking is still a dark cloud,
- Generic soft terms lead to (too large) FCNC,
- MSSM involves 105 New Parameters!,
- Loop effects make the MSSM Higgs sector to become a THDM of type III

It may be worth to study THDM as a generic model,

2.5 The THDM

THDM (1,2,3) is usefull, cheap, economical.....and takes you almost everywhere.

2.5b THDM neutral Higgs couplings:

- $(hVV):\quad \frac{2m_V^2}{v}\cos(\beta-\alpha),\quad v^2=v_1^2+v_2^2,$
- $(huu):\quad \frac{m_u}{v}\left(\frac{\cos\alpha}{\sin\beta}\right),$
- $(hdd):\quad \frac{m_d}{v}\left(\frac{\sin\alpha}{\cos\beta}\right),$
- $(hll):\quad \frac{m_l}{v}\left(\frac{\sin\alpha}{\cos\beta}\right),$
- $(hhhh):\quad \simeq \lambda_i.$

Similar expressions hold for H^0, A^0.

2.6 Charged Higgs-Fermions coupling

- Charged state $H^{\pm}$ has $m_{H^{\pm}} > m_W$
- Its couplings with fermions is given by:

$$\mathcal{L}_{H^+\bar{u}_i d_j} = -\frac{ig}{2\sqrt{2}M_W}(S_{ij} + P_{ij}\gamma_5),$$

where:

$$S_{ij} = (V_{CKM})_{il}\, m_{d_l}\, X_{lj} + m_{u_i}\, Y_{il}(V_{CKM})_{lj}$$
$$P_{ij} = (V_{CKM})_{il}\, m_{d_l}\, X_{lj} - m_{u_i}\, Y_{il}(V_{CKM})_{lj}.$$

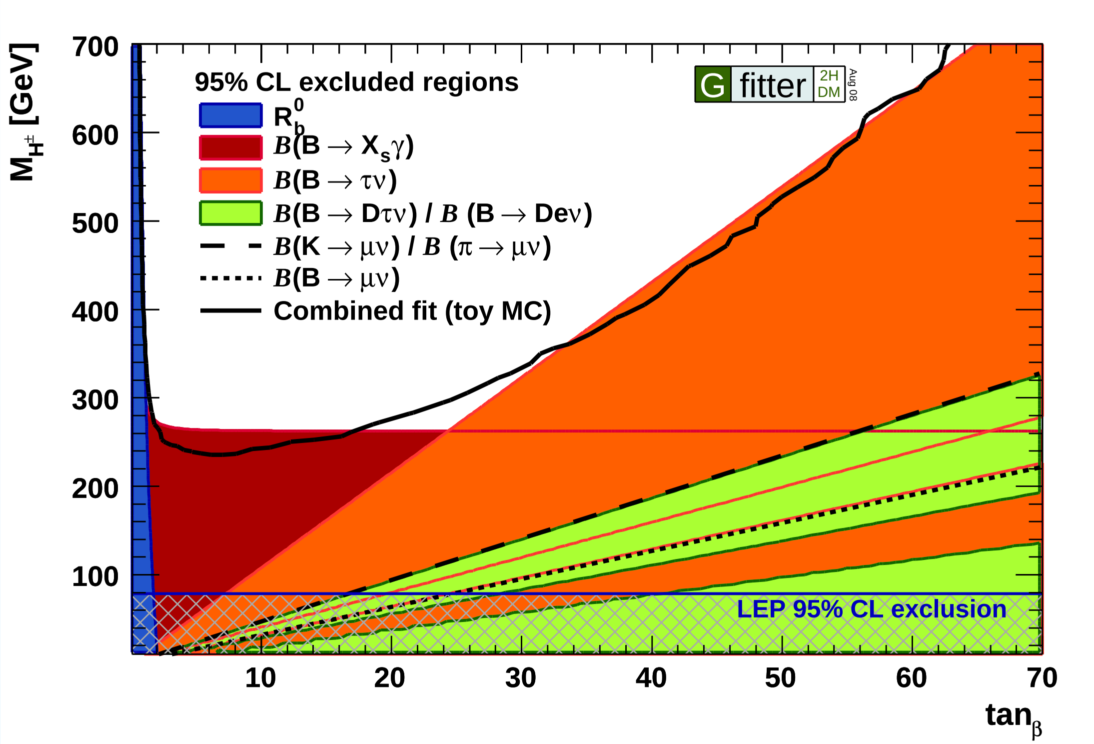
with $\quad X_{lj} = \tan\beta\delta_{lj}, \quad Y_{il} = \cot\beta\delta_{il}.$

2.7 Higgs and Flavor

Rare B decays have been used to constrain the Neutral and Charged Higgs sector in THDM (and BSM)

- $B.R.(B \rightarrow X_s + \gamma)_{exp.} = (3.55 \pm 0.24)x10^{-4}$:
  (SM prediction: $B.R. = (3.15 \pm 0.23)x10^{-4}$)
- $B.R.(B_s \rightarrow \mu\mu)_{exp.} \leq 5.8x10^{-8}$:
  (SM prediction:$B.R.(B_s \rightarrow \mu\mu) = 3x10^{-9}$)
- $B \rightarrow \tau\nu$, $B \rightarrow \mu\nu$,
- $B \rightarrow D\tau\nu$
- $\tau \rightarrow \mu\nu\nu$

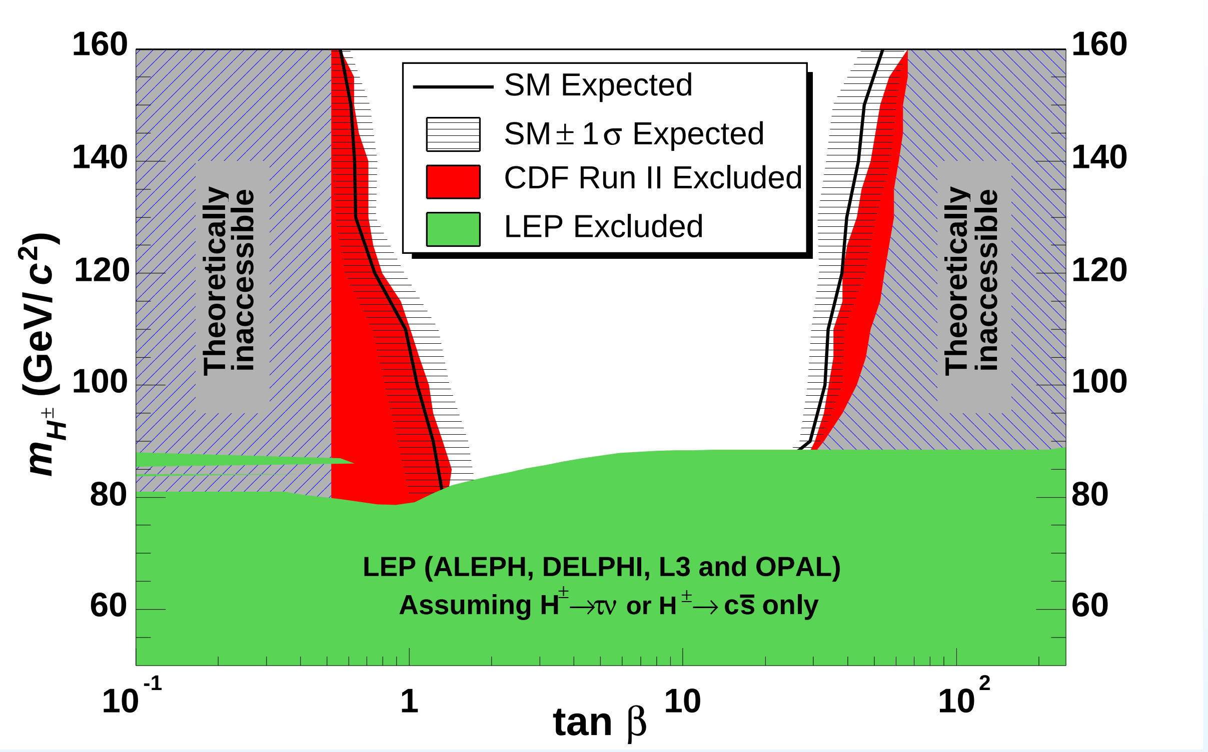
2.8 Flavor and Higgs



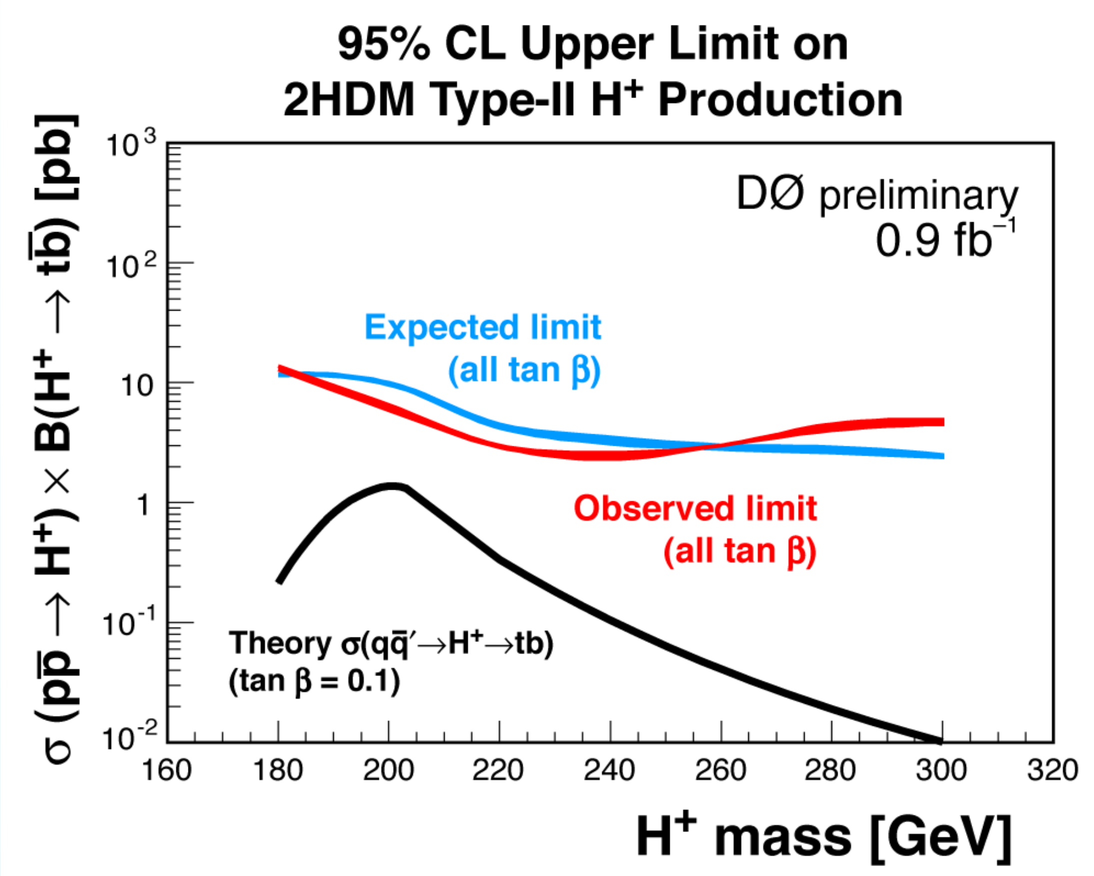
2.9 Charged Higgs at Colliders

- Tevatron has searched for the decay $t \longrightarrow bH^+$, its non-observation implies $m_{H^\pm} > m_t - m_b$, which is satisfied for some regions of MSSM params.,
- More recently, Tevatron has searched for $qq' \longrightarrow H^+ \longrightarrow tb$, but its sensitivity only probes some region of params.
- LHC will be able to search for a charged Higgs,
- Interesting to study how to distinguish MSSM charged Higgs from THDM-II,

2.9b Top decay to $H^{\pm} + b$ at Tevatron



2.9c Charged Higgs search at Tevatron



2.10 Charged Higgs within the THDM-III

[a]

In THDM-III $\Phi_{1,2}$ couple to both d- and u-type quarks:

- FC Neutral Higgs interactions are induced at tree-level,
- Fermion mass textures keep under control FCNC,
  A four-texture THDM3 satisfies all constraints, i.e.
  Higgs-fermion coupling $Y_{ij} \simeq \frac{(m_i m_j)^{1/2}}{v}$ (Cheng-Sher)
- Interesting to study Charged Higgs III (flavor and LHC), because MSSM-THDM2 becomes a THDM3 after rad. corrs.

[a] With Dorados de Villa/DUAL-CP

2.10b THDM-III Lagrangian

When both $\Phi_{1,2}$ couple to u- and d-type quarks, the charged Higgs-fermion interaction becomes:

$$\mathcal{L} = Y_1^u \bar{Q}_L \tilde{\Phi}_1 u_R + Y_2^u \bar{Q}_L \tilde{\Phi}_2 u_R + Y_1^d \bar{Q}_L \Phi_1 d_R + Y_2^d \bar{Q}_L \Phi_2 d_R,$$

where
$\Phi_{1,2} = (\phi^+_{1,2}, \phi^0_{1,2})^T$ refer to the two Higgs doublets,
$\tilde{\Phi}_{1,2} = i\sigma_2 \Phi^*_{1,2}$;
Q_L is the left-handed fermion doublet, u_R and d_R are the right-handed singlets,
$Y^{u,d}_{1,2}$ denote the (3×3) Yukawa matrices.

2.10c THDM-III Lagrangian

Consider Yukawa matrices with four-Hermitic-texture form (Fritzsch-Xing):

(2) $$M^q = \begin{pmatrix} 0 & C_q & 0 \\ C_q^* & \tilde{B}_q & B_q \\ 0 & B_q^* & A_q \end{pmatrix} \qquad (q = u, d) \; ,$$

To diagonalize them, use matrices O_q and P_q:

(3) $$\bar{M}^q = O_q^T \, P_q \, M^q \, P_q^\dagger \, O_q$$

Then, write $\tilde{Y}_n^q = O_q^T \, P_q \, Y_n^q \, P_q^\dagger \, O_q$, in the form,

(4) $$\left[\tilde{Y}_n^q\right]_{ij} = \frac{\sqrt{m_i^q m_j^q}}{v} \, [\tilde{\chi}_n^q]_{ij} = \frac{\sqrt{m_i^q m_j^q}}{v} \, [\chi_n^q]_{ij} \; e^{i\vartheta_{ij}^q}$$

2.10d THDM-III Lagrangian

Then, $\bar{u}_i d_j H^+$ and $u_i \bar{d}_j H^-$ couplings are written in terms of:

$$
\begin{aligned}
S_{ij} &= (V_{CKM})_{il}\, m_{d_l}\, X_{lj} + m_{u_i}\, Y_{il} (V_{CKM})_{lj} \\
P_{ij} &= (V_{CKM})_{il}\, m_{d_l}\, X_{lj} - m_{u_i}\, Y_{il} (V_{CKM})_{lj}.
\end{aligned}
$$

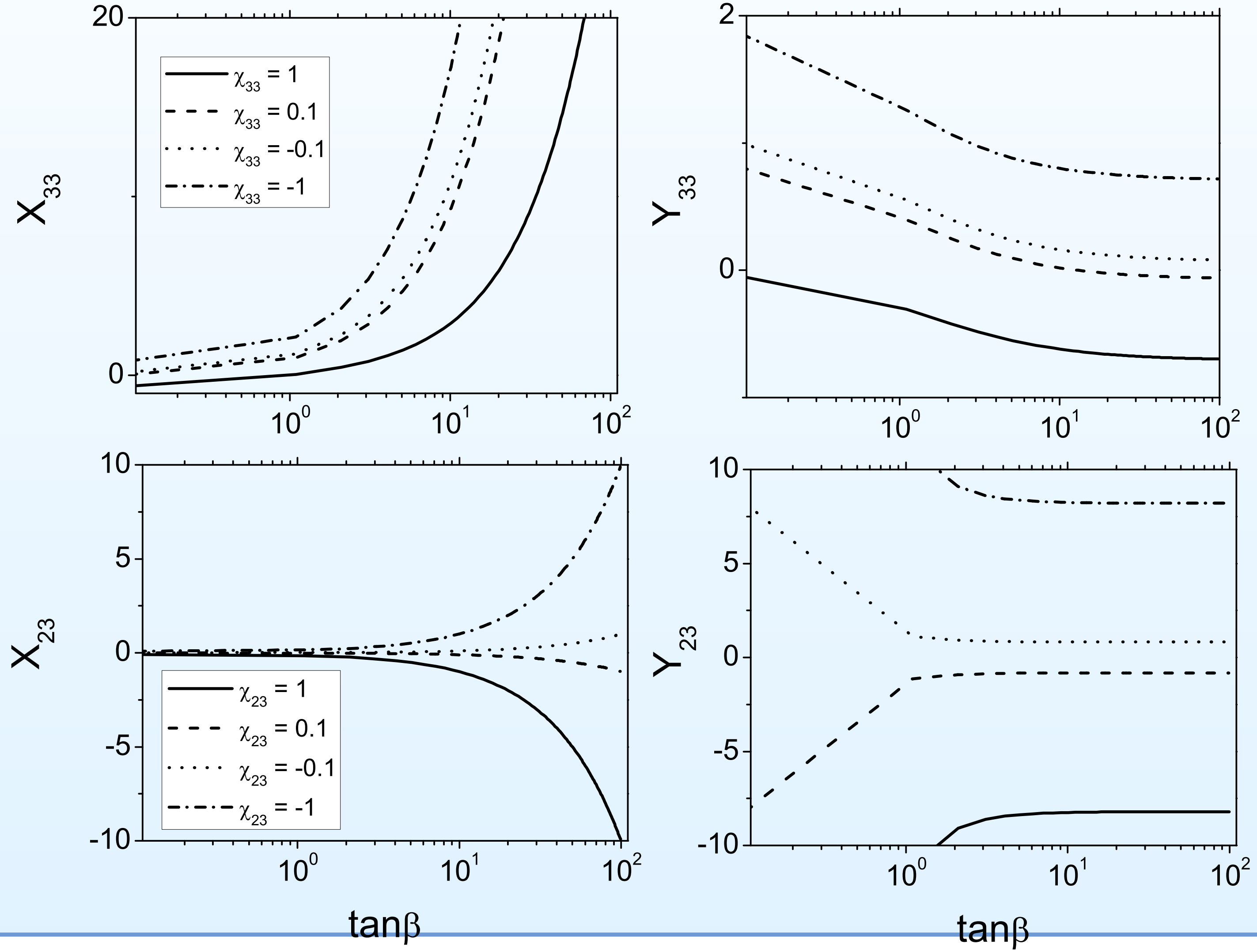
$$
\begin{aligned}
X_{lj} &= \left[\tan\beta\, \delta_{lj} - \frac{\sec\beta}{\sqrt{2}} \sqrt{\frac{m_{d_j}}{m_{d_l}}}\, \tilde{\chi}^d_{lj} \right], \\
Y_{il} &= \left[\cot\beta\, \delta_{il} - \frac{\csc\beta}{\sqrt{2}} \sqrt{\frac{m_{u_l}}{m_{u_i}}}\, \tilde{\chi}^u_{il} \right].
\end{aligned}
$$

The 33 elements are the parameters $X = X_{33}$, $Y = Y_{33}$, and $Z = Z_{33}$, used in literature.

2.11 THDM-III Lagrangian

- Based on the analysis of $B \to X_s \gamma$ (Borzumati and Greub), it is claimed that $X \leq 20$ and $Y \leq 1.7$ for $m_{H^+} > 250$ GeV (Xiao-Guo), while for a lighter charged Higgs boson mass $m_{H^+} \sim 200$ GeV, one gets: $(X, Y) \leq (18, 0.5)$.
- Next Figure shows (X, Y) as a function of $\tan\beta$ within our model.
- Then, we find the bounds: $|\chi_{33}^{u,d}| \leq 1$ for $0.1 \leq \tan\beta \leq 70$.
- In summary, we find that low energy constraints still allow to have $\tilde{\chi}_{ij}^{q} = O(0.1 - 1.)$.

2.11b THDM-III Lagrangian



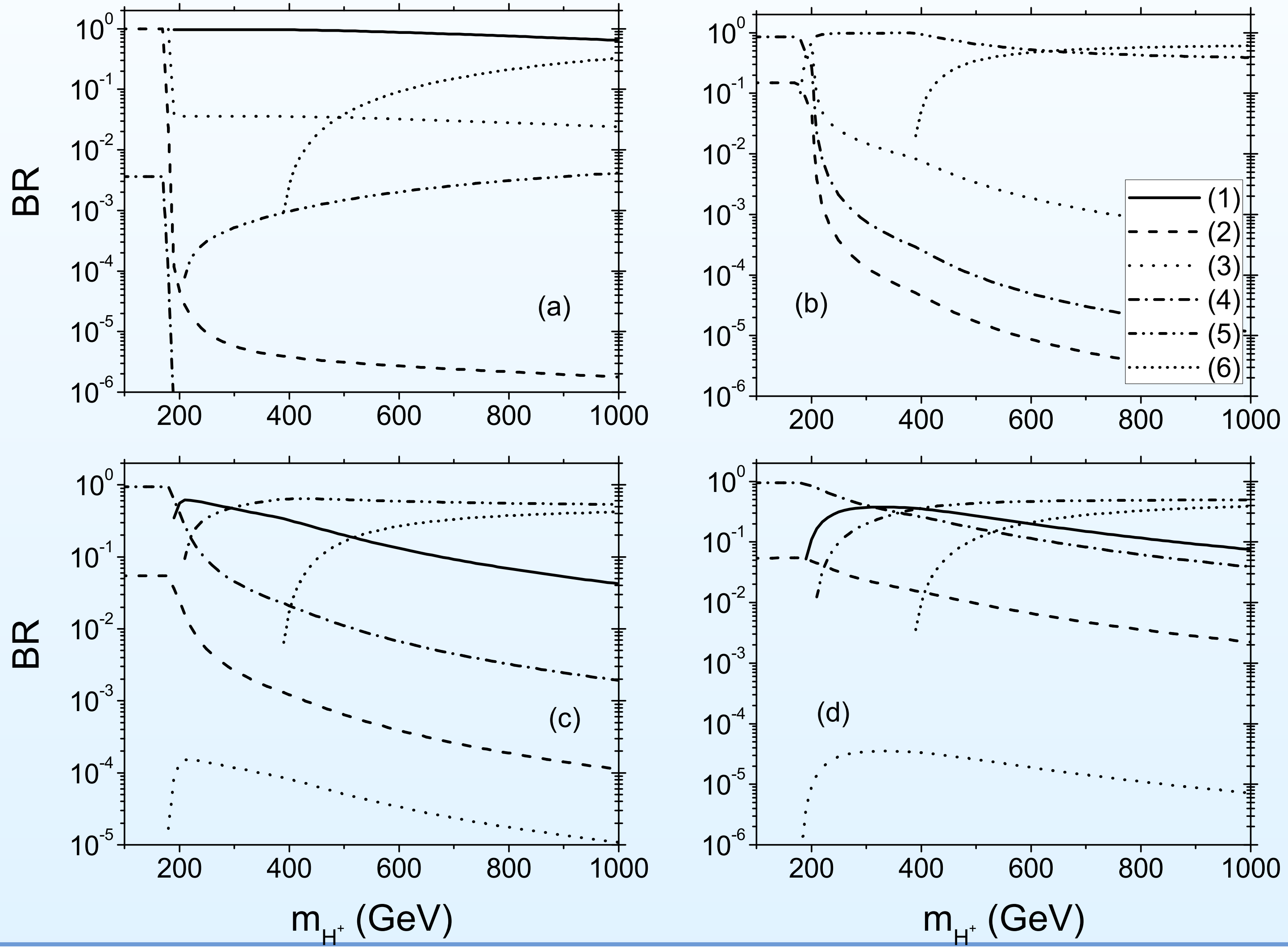
2.12 Charged Higgs decays

We shall refer to four benchmark scenarios, namely.

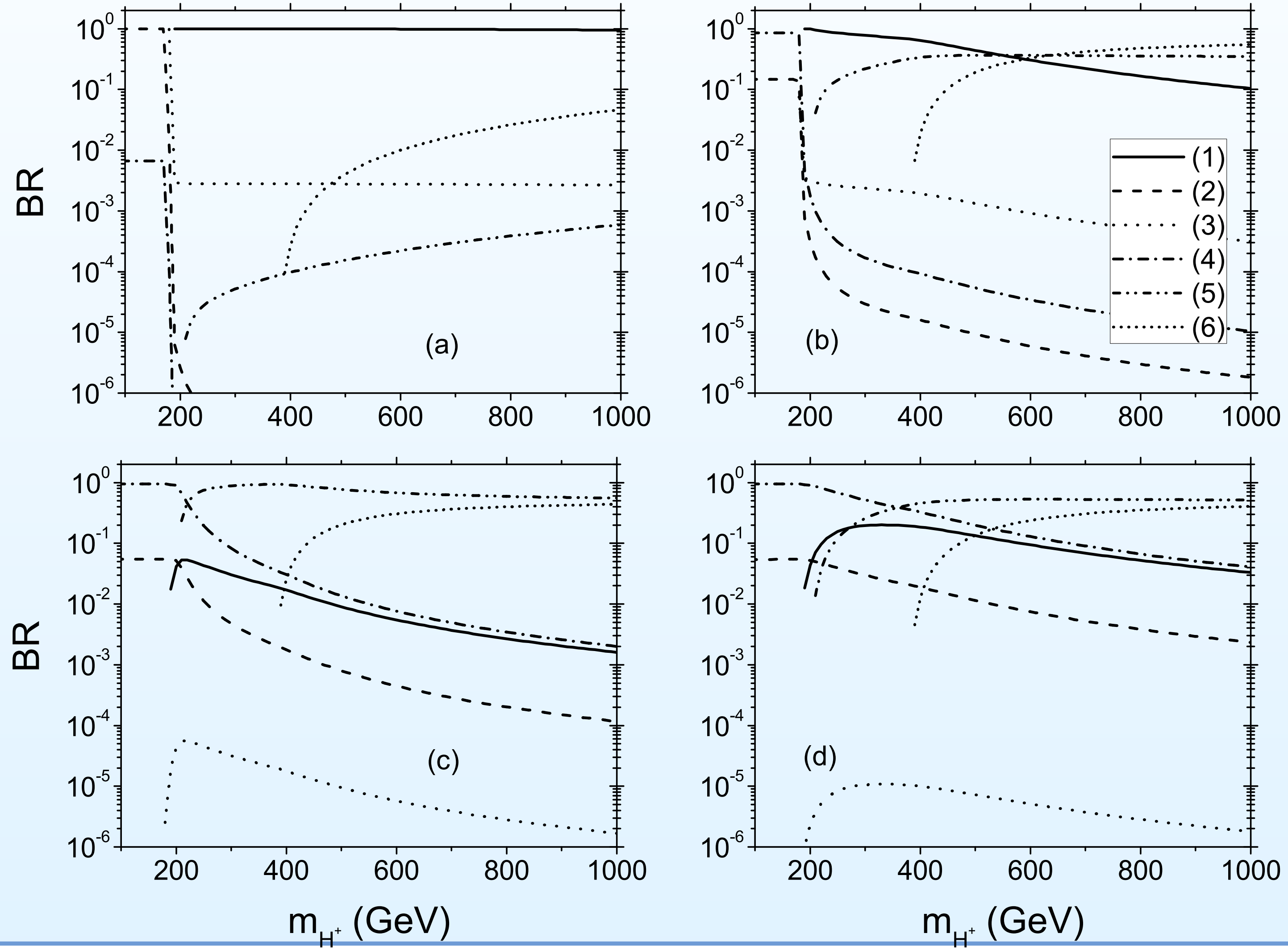
- **Scenario A**: $\tilde{\chi}^u_{ij} = 1$, $\tilde{\chi}^d_{ij} = 1$;
- **Scenario B**: $\tilde{\chi}^u_{ij} = 0.1$, $\tilde{\chi}^d_{ij} = 1$;
- **Scenario C**: $\tilde{\chi}^u_{ij} = 1$, $\tilde{\chi}^d_{ij} = 0.1$;
- **Scenario D**: $\tilde{\chi}^u_{ij} = 0.1$, $\tilde{\chi}^d_{ij} = 0.1$.

For the numerical results of $H^\pm$ decays we take:
$\tan\beta = 0.1,\ 1,\ 15,\ 70$, 100 GeV $\leq m_{H^\pm} \leq$ 1000 GeV, and fixing $m_{h^0} = 120$ GeV, $m_{A^0} = 300$ GeV and the mixing angle $\alpha = \pi/2$.

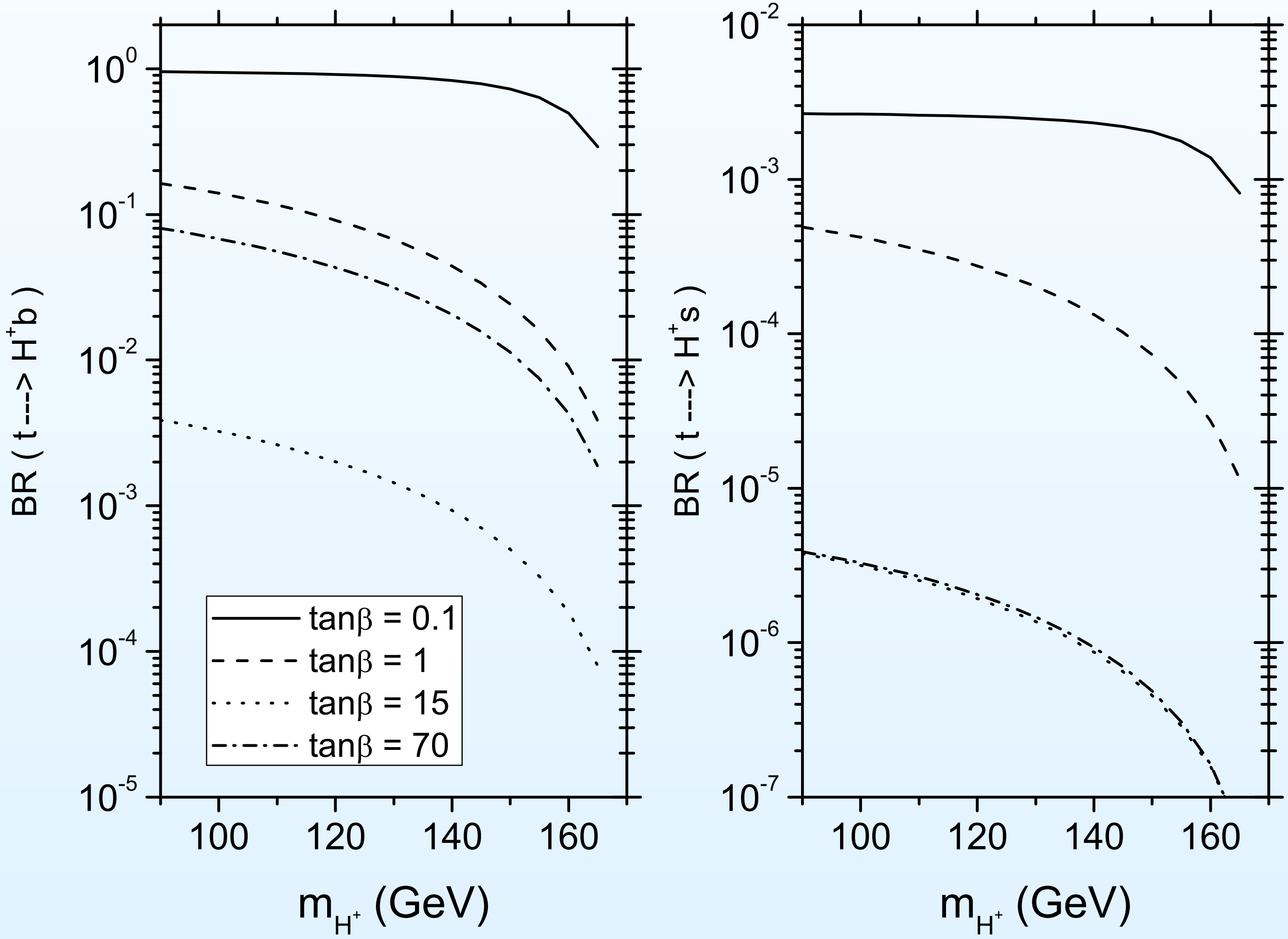
2.12b Charged Higgs decays



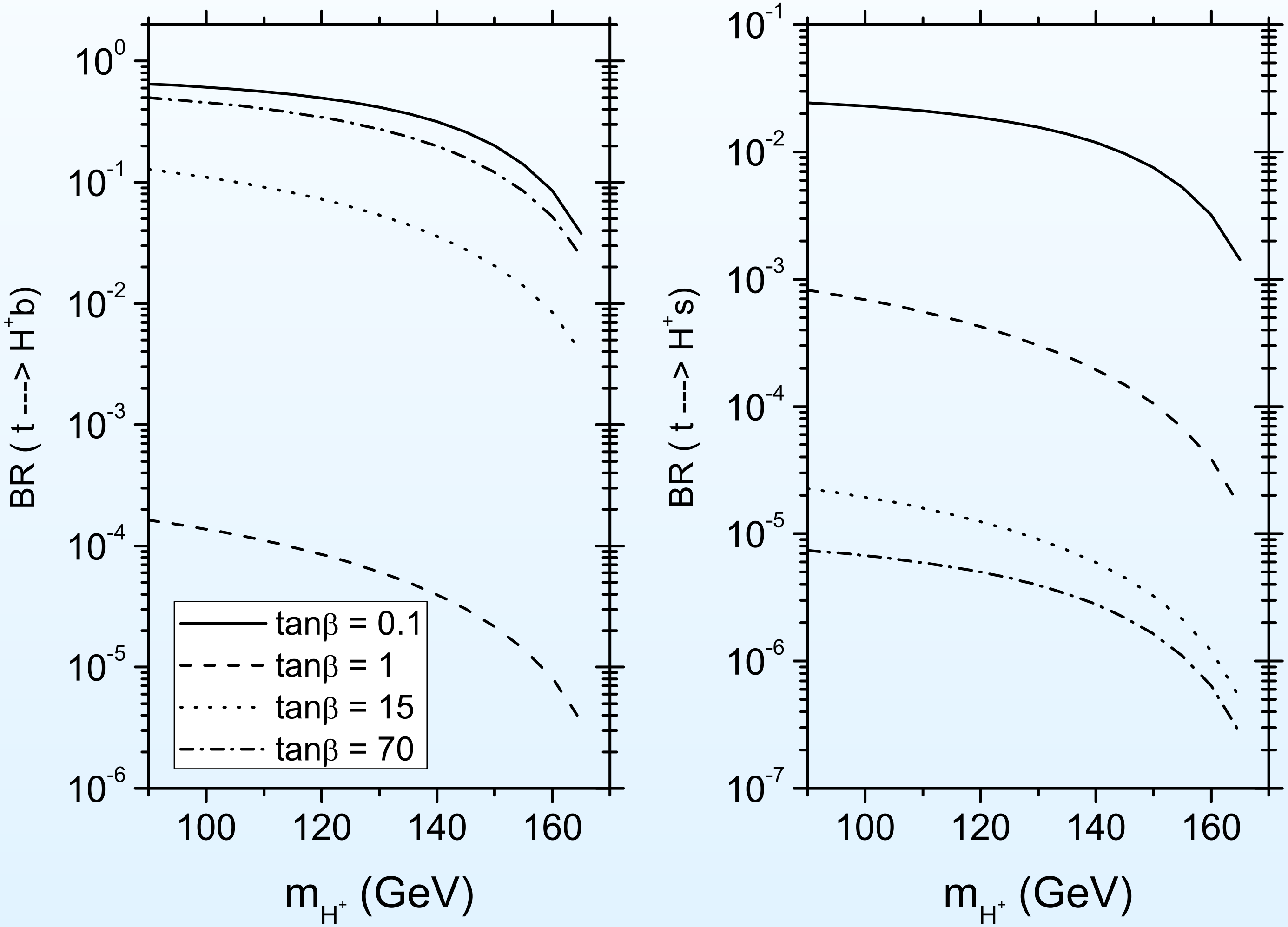
2.12c Charged Higgs decays



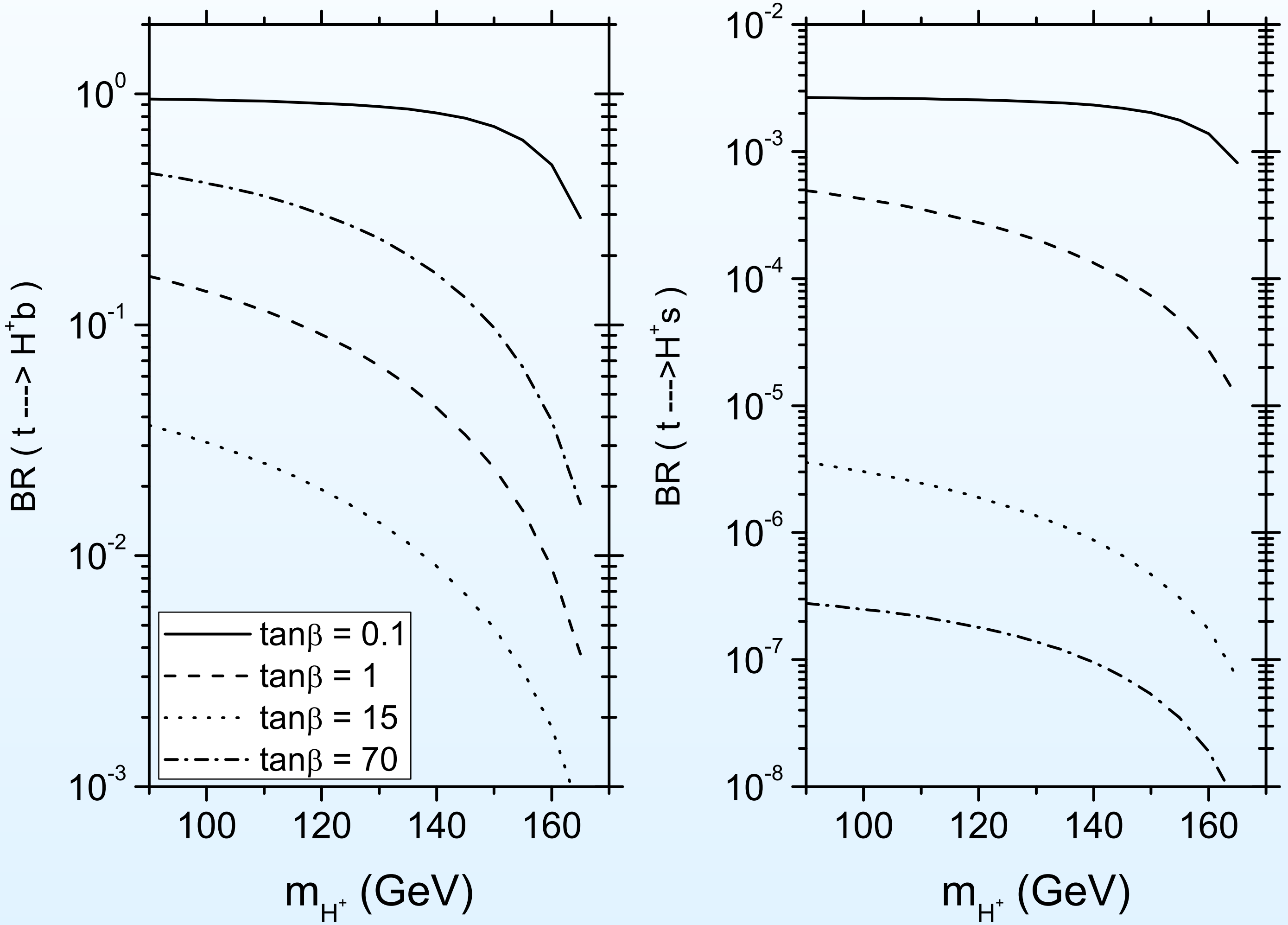
2.12d Top decay into H^+



2.12e Top decay into H^+



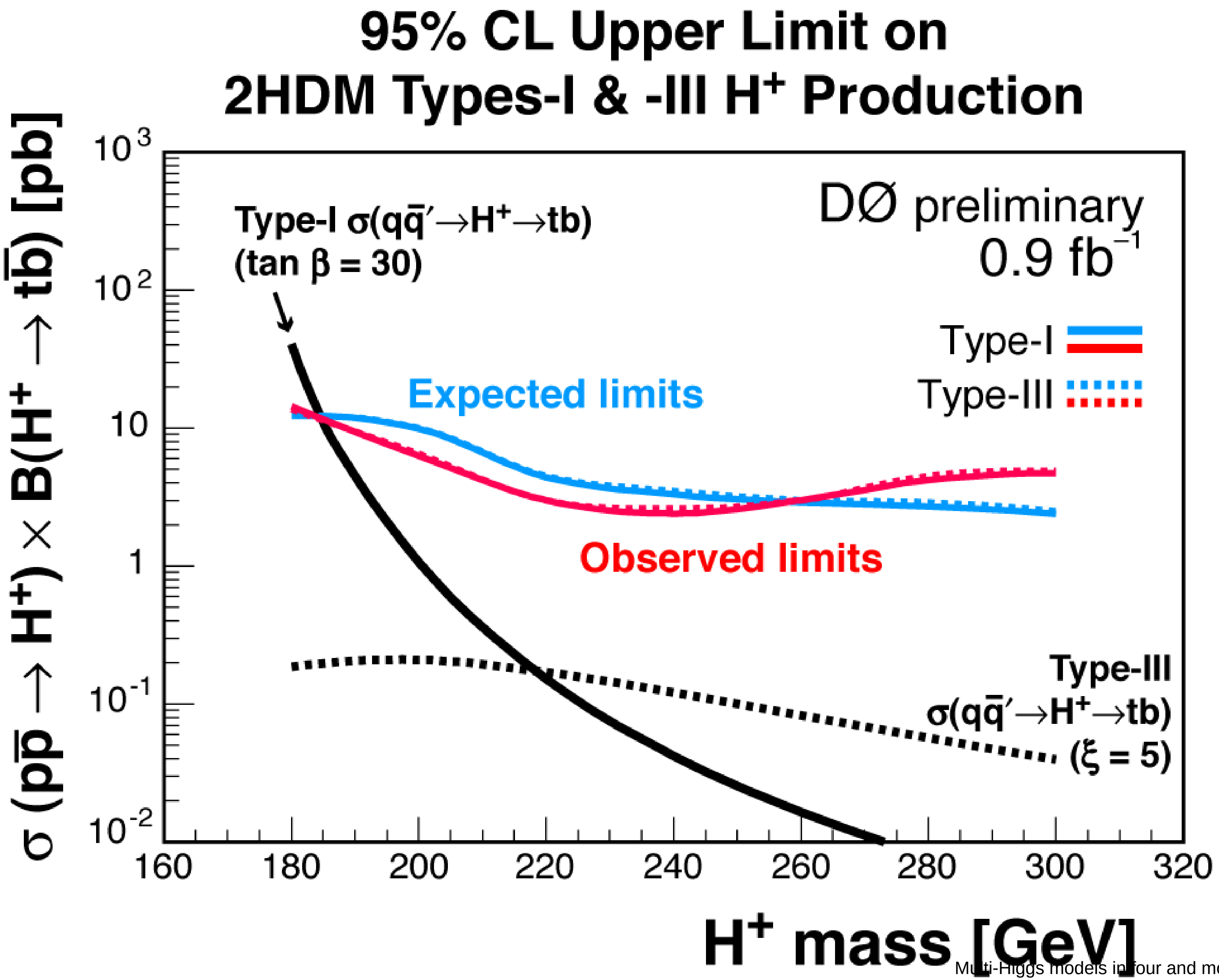
2.12f Top decay into H^+



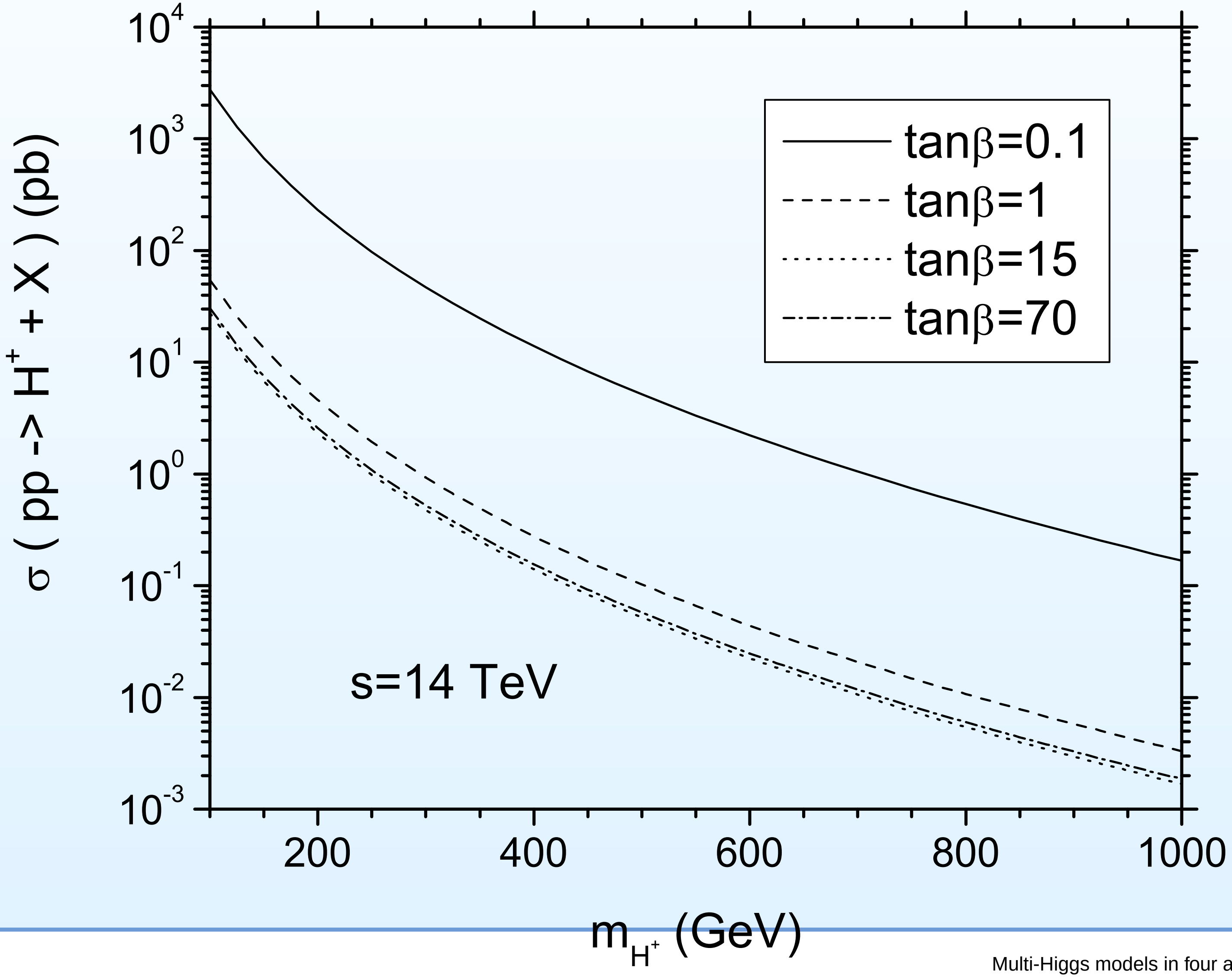
2.13 s-channel Charged Higgs production

- Because in THDM3 the coupling Hcb can be enhanced, it can affect the reaction $cb \to H^+$.
- This reaction has been searched at Tevatron, with $H^+ \to tb$,
- We have studied this s-channel reaction at LHC,
- At LHC other decay modes could be searched, e.g. $H^+ \to Wh$.

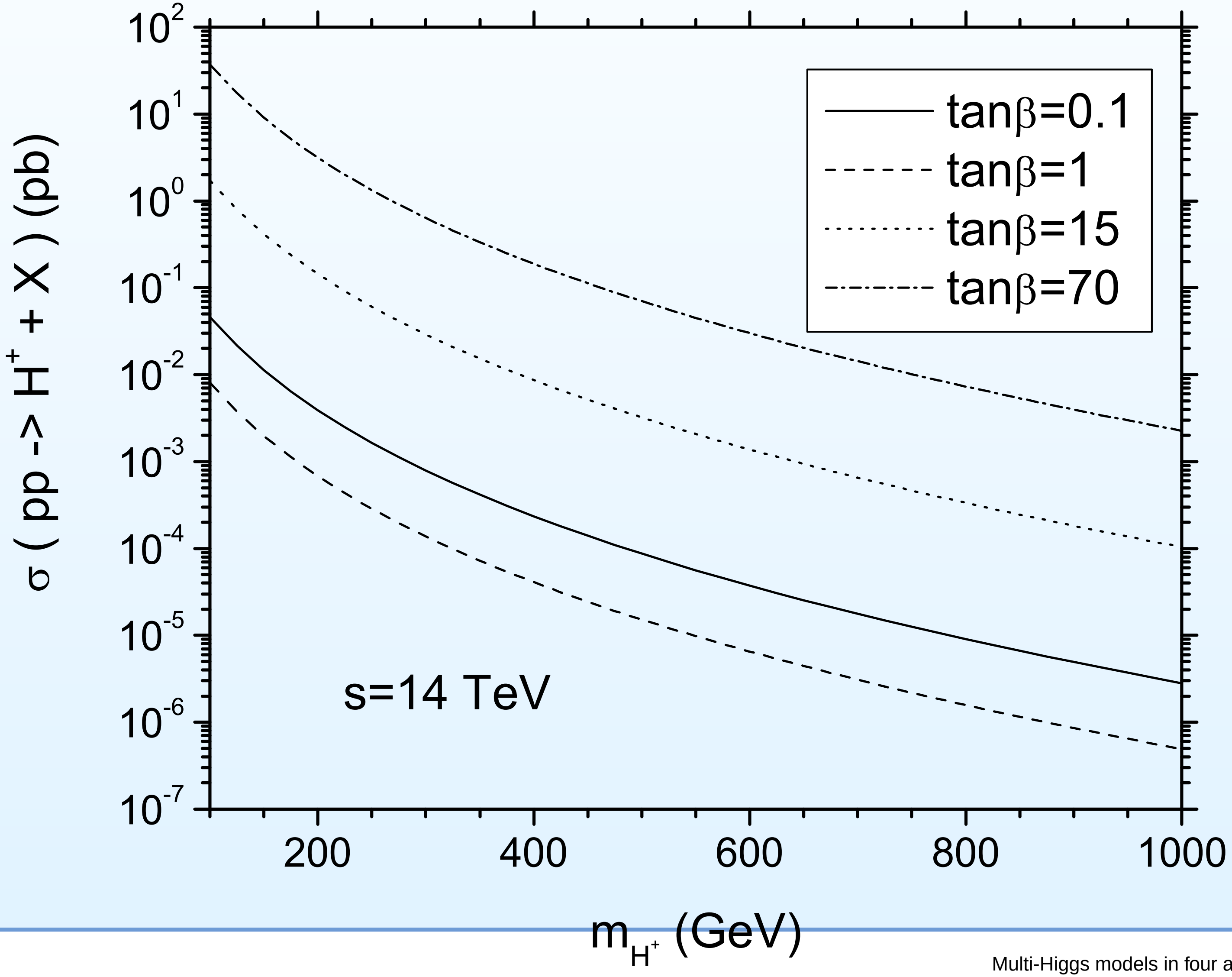
2.13b Charged Higgs search at Tevatron



2.13c s-channel Charged Higgs production at LHC



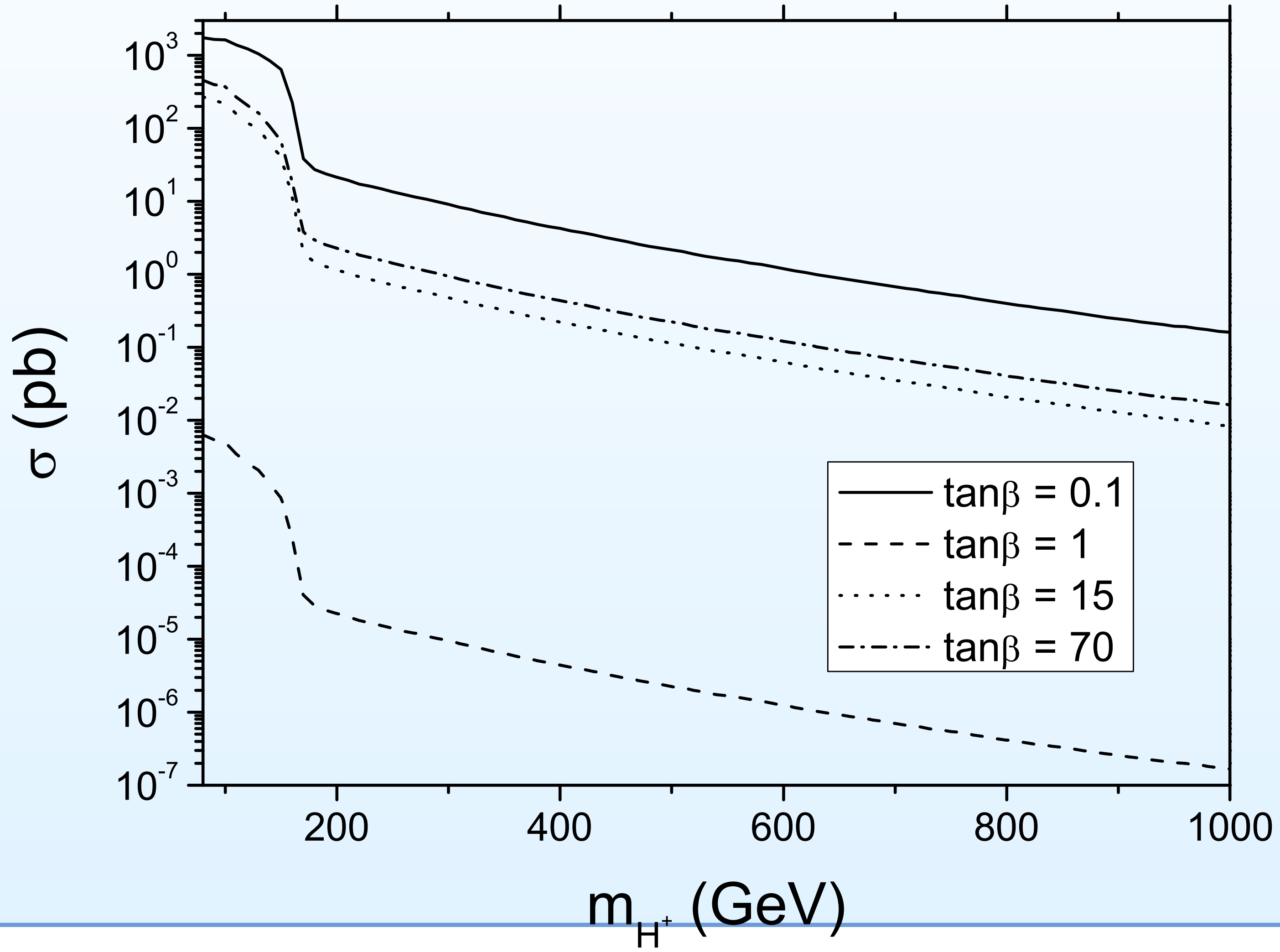
2.13d s-channel Charged Higgs production at LHC



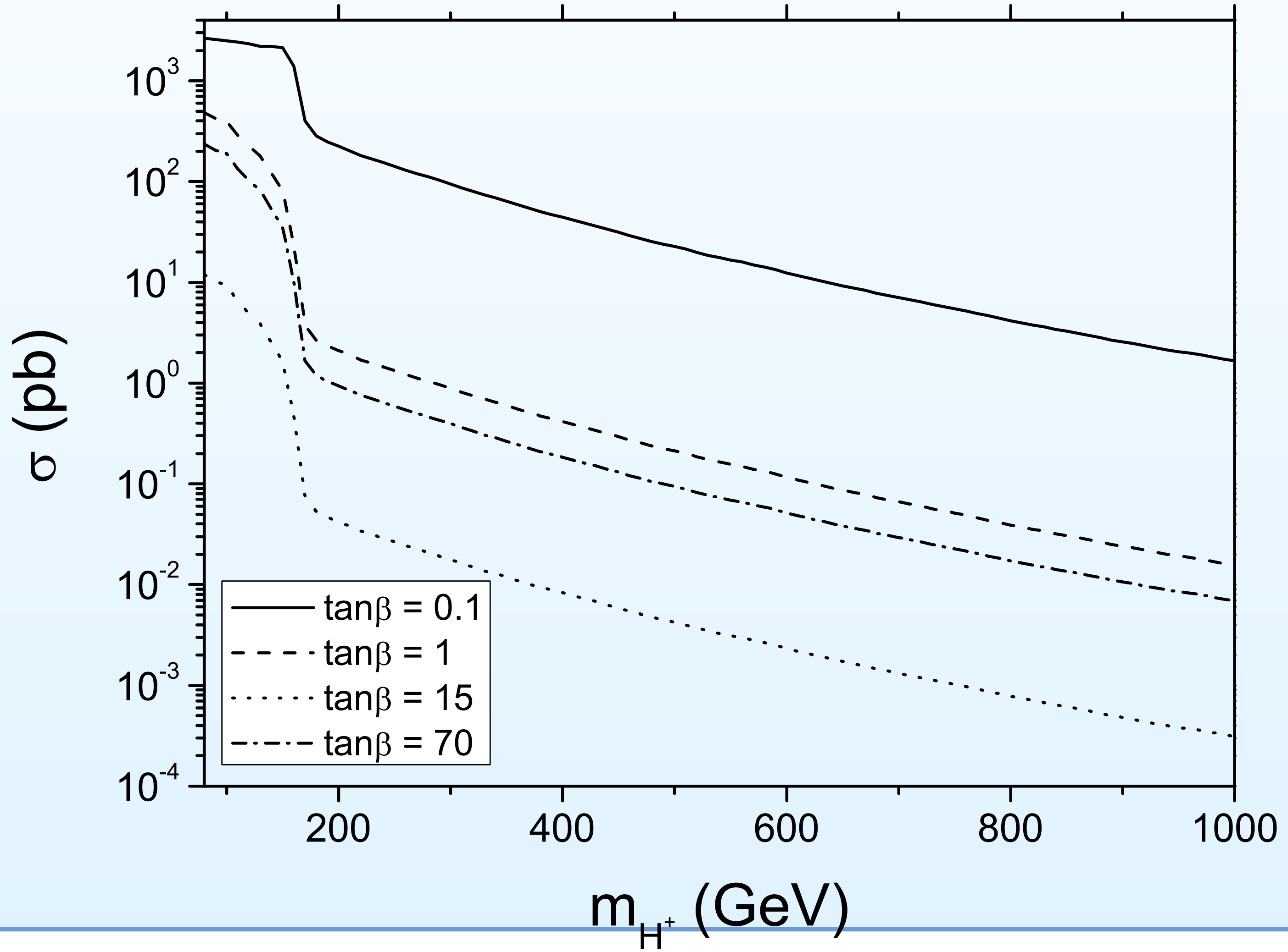
2.14 Associated Charged Higgs production at LHC

- if the charged Higgs boson mass $m_{H^\pm}$ satisfies $m_{H^\pm} < m_t - m_b$, $H^\pm$ could be produced in the decay of on-shell (i.e., $\Gamma_t \to 0$) top (anti-)quarks $t \to bH^+$,
- We denote such a $H^\pm$ production channel as $q\bar{q}$, $gg \to t\bar{t} \to t\bar{b}H^-$ + c.c. (i.e., if due to (anti-)top decays) whilst we use the notation $q\bar{q}$, $gg \to t\bar{b}H^-$ + c.c.
- Charged Higgs bosons could also be produced at and beyond the kinematic top decay threshold.

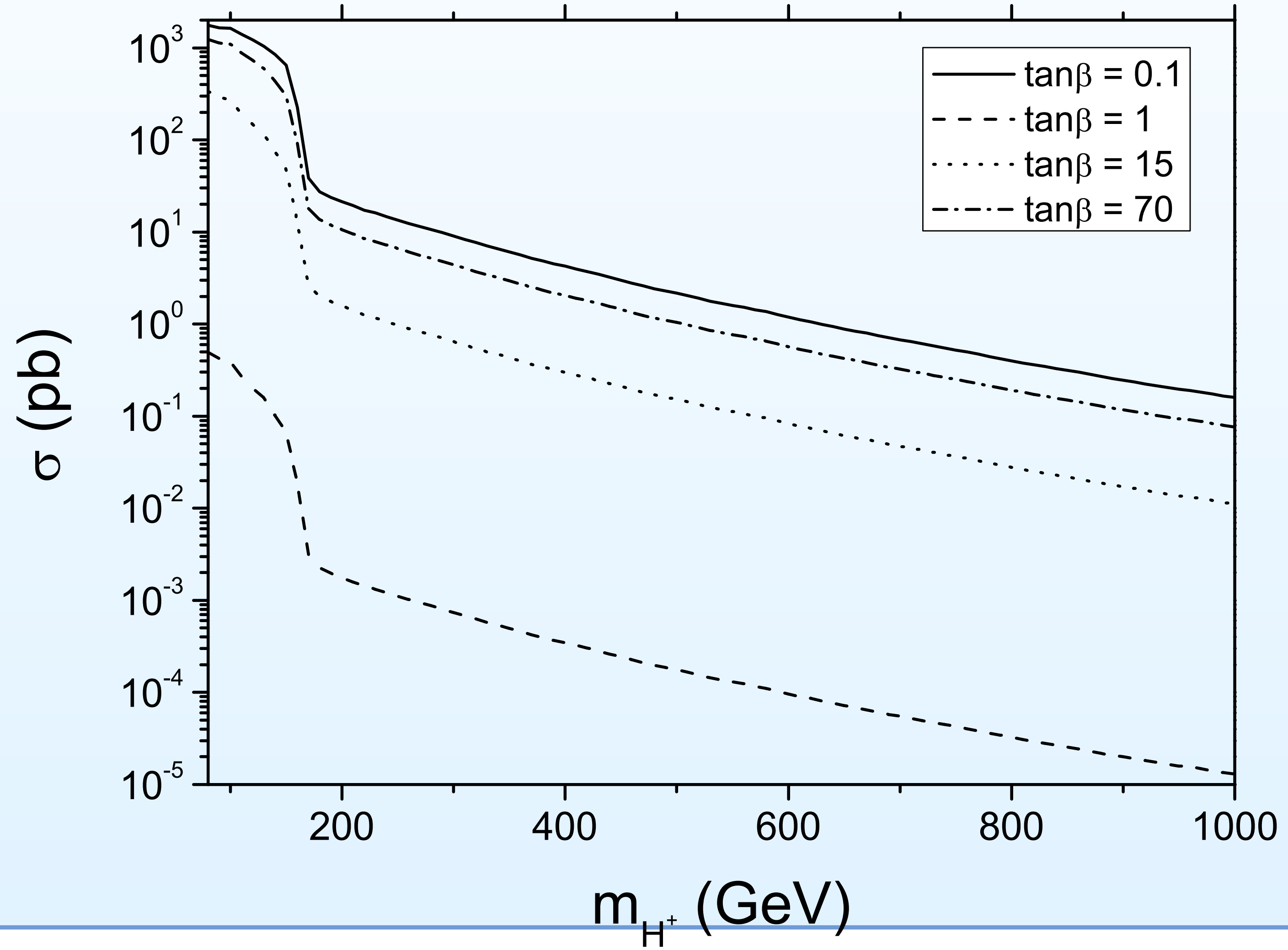
2.14b Associated Charged Higgs production at LHC



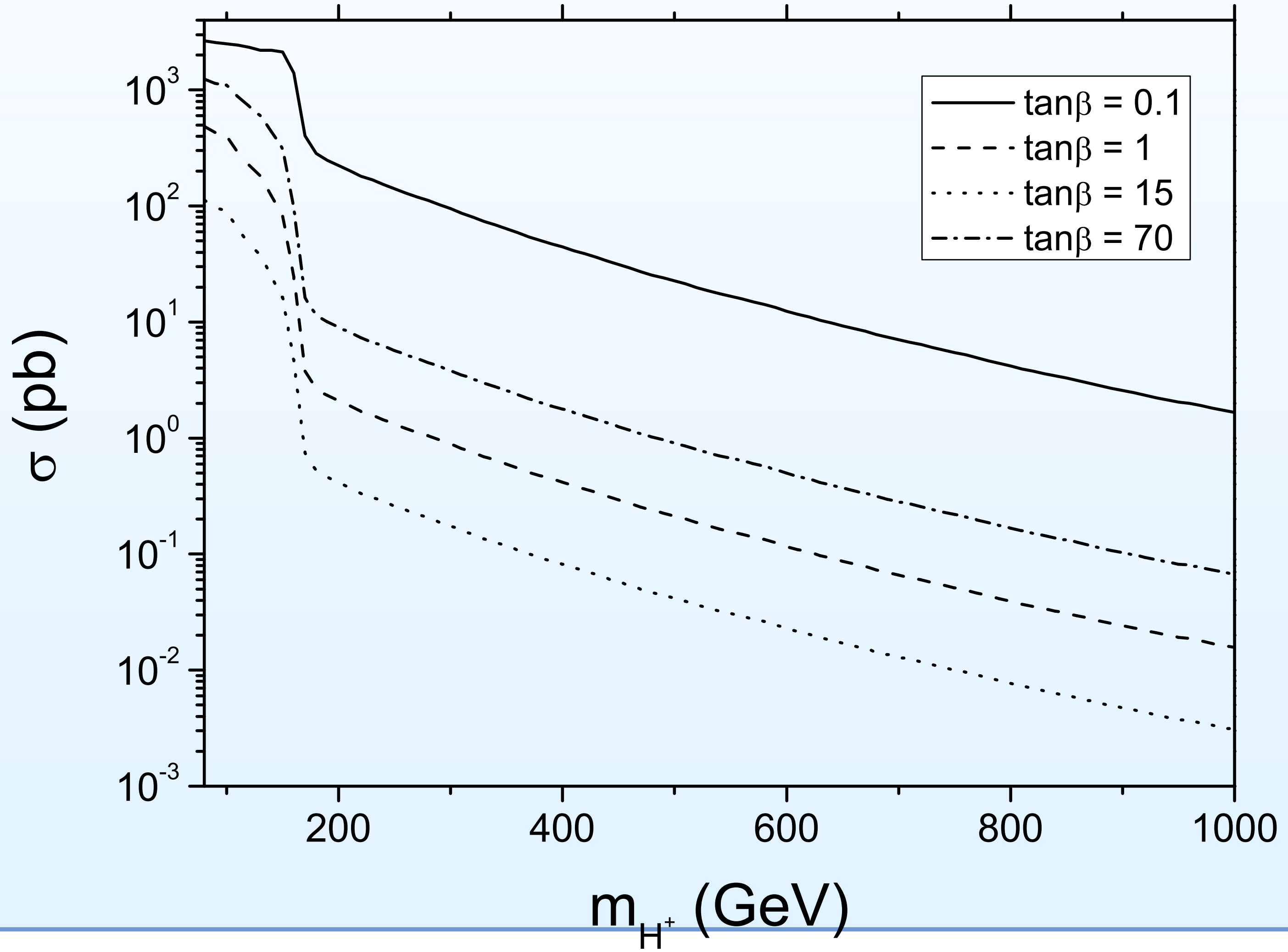
2.14c Associated Charged Higgs production at LHC



2.14d Associated Charged Higgs production at LHC



2.14e Associated Charged Higgs production at LHC



3.1 Composite Higgs (AdS/CFT)

- Composite Higgs models were proposed in early 80's. (Georgi et al $\longrightarrow$ Higgs as a PGB)
- HHM [a] are composite Higgs models, which admit a dual description:
- From 4D perspective are bound states of conformal sector, and arises as PGB.
- From 5D perspective HHM can be interpreted as GH unified models.
- 5D helps to calculate Higgs properties.

[a] 1) R. Contino, Y. Nomura and A. Pomarol, Nucl. Phys. B **671**, 148 (2003). [arXiv:hep-ph/0306259].
2) K. Agashe, R. Contino and A. Pomarol, Nucl. Phys. B **719**, 165 (2005). [arXiv:hep-ph/0412089].

3.2 Holograhic Higgs models: 4D

- HHM contains: SM and strong sectors:
- SM sector includes gauge and most SM fermions (g denotes SM couplings),
- Strongly int. sector has global symmetry G ($\rightarrow g_*$ and scale M_R),
- Global symmetry G breaks $\rightarrow H$. Higgs doublet arises as PGB ($\rightarrow f_\pi$) and $M_R \simeq 4\pi f_\pi$,
- Higgs potential vanishes at tree-level because of G,
- SM interactions induce the Higgs potential and EWSB,
- Corrs. to EW observables depends on $\epsilon = \frac{v}{f_\pi} \leq 1$,

3.2b Holograhic Higgs models: 4D

Global symmetry G breaks $\rightarrow H$, [a], e.g.,

- Model I (Minimal): $G = SO(5) \rightarrow H = SO(4)$, contains One Higgs doublet (Φ),
- Model II: $G = SO(6) \rightarrow H = SO(5)$, contains One Higgs doublet (Φ) + 1 singlet (η),
- Model III: $G = SO(6) \rightarrow H = SO(4)$, contains Two Higgs doublet ($\Phi_{1,2}$),
- Another option: one composite Higgs doublet + extra fundamental scalars (Diaz-Cruz et al.),

[a] Pomarol et al,ArXive:0902.1483 [hep-ph]

3.3 Other Composite Higgs models

Strongly interacting Higgs models have been proposed recently.

- Little Higgs (Deconstructed XD),
- Higgsless models (RS),
- Effective lagrangian (4D) approach: very usefull.

These models have solved some of the problems that old approaches faced (S, T params., FCNC).

3.4 Gauge-Higgs Unification (XD)

- Basic idea: Identify the Higgs as a component of a higher dimensional gauge field
- In general

$$A_M \rightarrow \begin{array}{l} A_\mu = 4\text{D gauge bosons} \\ A_i = 4\text{D scalars} \end{array}$$

- **5D Models**
  Generally predict a very small Higgs mass
- **6D Models**
  Quartic coupling present at tree level
  Higgs mass prediction is better
- Fermion gauge ints. $\bar{\psi}\Gamma^M A_M \psi$ become Yukawa couplings for $M \rightarrow i$.

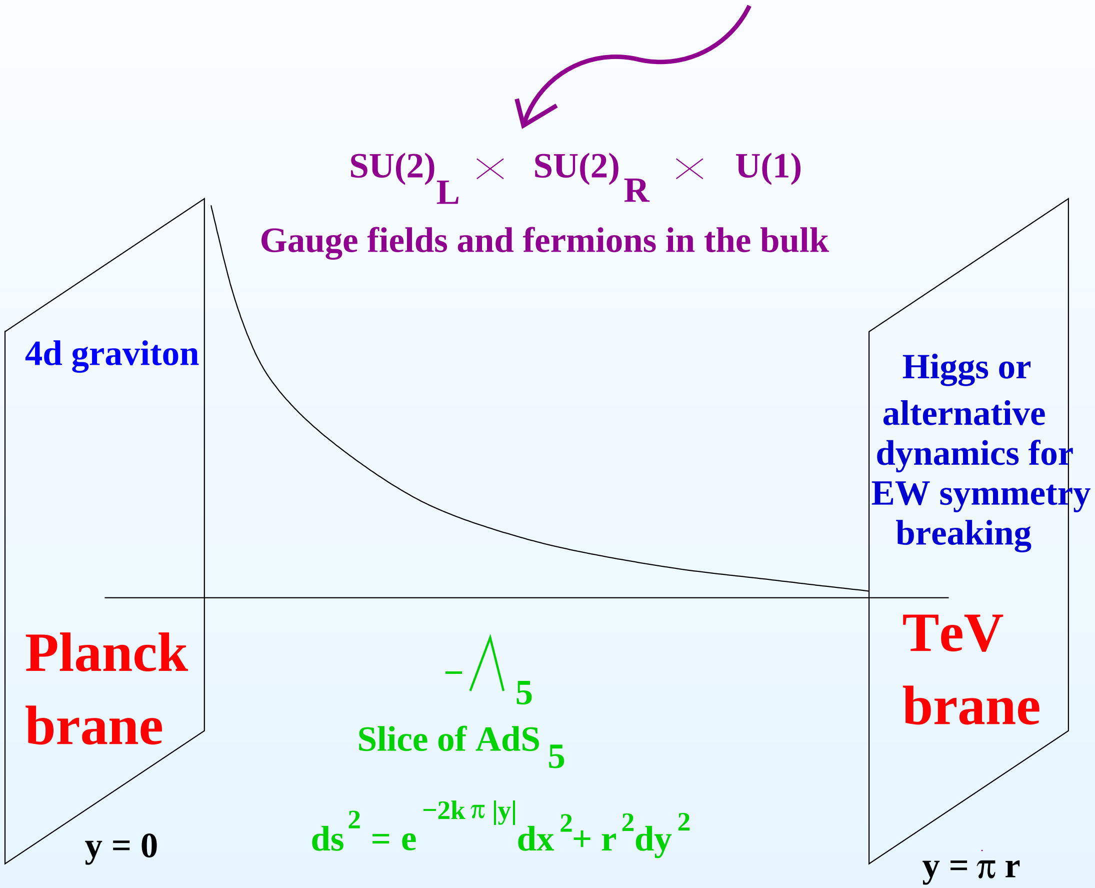
4.1 Holographic Higgs models: 5D RS-SM

- RS is defined on 5D AdS, with two branes: Planck and TeV.
- Hierarchy problem is solved if Higgs doublet lives in TeV (IR) brane,
- Gauge bosons can live in the bulk,
- Most SM fermions also live in the bulk,
- Top quark (b?) lives near TeV brane (at $z = L_1 \simeq 1/TeV$).
- The Higgs mass is calculable,

(5) $$m_h^2 \simeq \frac{1}{16\pi^2} \frac{c}{L_1^2},$$

- Higher-dims. operators affect Higgs properties, and could be tested at LHC/ILC.

4.2 Randall-Sundrum Model (AdS)



4.3 Higgs and Fermions in Randall-Sundrum

[a]

- In 5D there are no chiral fermions. The 5D fermions Ψ are vector like, and have a Dirac mass of the form

$$\mathcal{L}_D = -i \sum_{\Psi} m_\Psi \left(\overline{\Psi}_L \Psi_R + \overline{\Psi}_R \Psi_L\right) \tag{6}$$

$$\Psi = \mathcal{Q}, \mathcal{U}, \mathcal{D} \tag{7}$$

- The Dirac mass can be parameterized by $m_\Psi = c_\Psi \sigma'$, with $\sigma = k\,|y|$.

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[a] Diaz-Cruz, Diaz-Furlong

4.4 Higgs in Randall-Sundrum

- In this case the Kaluza-Klein descomposition is

$$\Psi_{L,R}\left(x^{\mu},y\right)=\frac{e^{2\sigma}}{\sqrt{2\pi R}}\sum_{n=0}^{\infty}\Psi_{L,R}^{(n)}\left(x^{\mu}\right)f_{L,R}^{(n)}\left(y\right) \tag{8}$$

- and fermionic KK modes are:

$$f_{L,R}^{(0)} = \sqrt{\frac{\left(1\mp 2c\right)\pi kR}{e^{(1\mp 2c)\pi kR}-1}}e^{\mp c\sigma}$$

$$f_{L}^{(n)}\left(y\right) = \frac{e^{\sigma/2}}{N_n}\left[J_{\alpha}\left(\frac{M_n}{k}e^{\sigma}\right)+b_{\alpha}\left(m_n\right)Y_{\alpha}\left(\frac{M_n}{k}e^{\sigma}\right)\right]$$

- with $M_n>0$ the mass of the KK excitations $\Psi^{(n)}$, y J_{α}, Y_{α} are Bessel functions of order $\alpha=|c\pm 1/2|$, the signs $\pm$ correspond to $f_{L,R}^{(n)}$

4.5 Higgs in Randall-Sundrum

- In the limit $M_n \ll k$, and $kR \gg 1$,

(9)
$$M_n \simeq \left(n + \frac{\alpha}{2} - \frac{3}{4}\right) \pi k e^{-\pi k R}$$

- For values of $c_{L(R)}$ larger (smaller) than 1 / 2 (-1 / 2), the zero mode is localized near the UV brane, while for values $c_{L(R)} < 1/2 \ (> -1/2)$, implies that the zero mode is localized near the IR brane. KK modes ($n > 0$) is localized near the IR brane.

4.6 Higgs in Randall-Sundrum

- The 5D action which contains the Yukawa interactions can be written as

$$S_{Yuk} = -i \int d^4x \int dy \sqrt{-g} \left[\begin{array}{c} \lambda_{ij}^{u(5)} \overline{\mathcal{Q}}_i (x,y) \mathcal{U}_j (x,y) \widetilde{\phi}(x) \\ +\lambda_{ij}^{d(5)} \overline{\mathcal{Q}}_i (x,y) \mathcal{D}_j (x,y) \phi(x) \end{array} \right] \cdot \delta (y - \pi R) \qquad (10)$$

- with $\phi(x) = (\phi^+, \phi^0)$ and $\widetilde{\phi}(x) = (-\phi^{0*}, \phi^-)$

4.7 Higgs in Randall-Sundrum

- Expanding the 5D fields in their KK modes and integrating over the extra dimension, after SSB the 4D mass Lagrangian takes the form:

$$
\begin{aligned}
i\mathcal{L}^{4D}_{masa} &= \sum_{n,m=0}^{\infty} \left[\lambda^{u(n,m)}_{ij} \overline{u}^{(n)i}_{L} u^{(m)j}_{R} + \lambda^{d(n,m)}_{ij} \overline{d}^{(n)i}_{L} d^{(m)j}_{R} \right] + h.c. \\
&+ \sum_{n=0}^{\infty} \left[\begin{array}{c} M^{Q(n)}_{i} \left(\begin{array}{c} \overline{u}^{(n)i}_{L} \widehat{u}^{(n)j}_{R} + \overline{\widehat{u}}^{(n)i}_{R} u^{(n)j}_{L} \\ + \overline{d}^{(n)i}_{L} \widehat{d}^{(n)j}_{R} + \overline{\widehat{d}}^{(n)i}_{R} d^{(n)j}_{L} \end{array} \right) \\ + M^{u(n)}_{i} \left(\overline{\widehat{u}}^{(n)i}_{L} u^{(n)j}_{R} + \overline{u}^{(n)i}_{R} \widehat{u}^{(n)j}_{L} \right) \\ + M^{d(n)}_{i} \left(\overline{\widehat{d}}^{(n)i}_{L} d^{(n)j}_{R} + \overline{d}^{(n)i}_{R} \widehat{d}^{(n)j}_{L} \right) \end{array} \right]
\end{aligned}
$$

4.8 Higgs in Randall-Sundrum

- The "Yukawa couplings" are

$$\lambda_{ij}^{u(n,m)} = \lambda_{ij}^{u(5)} \frac{v}{\sqrt{2}} e^{\pi kR} \frac{f_{QL}^{(n)i}(\pi R)\, f_{uR}^{(m)j}(\pi R)}{2\pi} = \lambda_{ij}^{u} a_Q^{(n)i} a_u^{(m)j}$$

$$\lambda_{ij}^{d(n,m)} = \lambda_{ij}^{d(5)} \frac{v}{\sqrt{2}} e^{\pi kR} \frac{f_{QL}^{(n)i}(\pi R)\, f_{dR}^{(m)j}(\pi R)}{2\pi} = \lambda_{ij}^{d} a_Q^{(n)i} a_d^{(m)j}$$

- with $v \simeq 246$ GeV, and

$$\lambda_{ij}^{u,d} = \lambda_{ij}^{u,d(5)} \frac{v}{\sqrt{2}},$$

$$a_Q^{(n)i} = e^{\frac{\pi kR}{2}} \frac{f_{QL}^{(n)i}(\pi R)}{\sqrt{2\pi}},\, a_{u,d}^{(m)j} = e^{\frac{\pi kR}{2}} \frac{f_{u,dL}^{(m)i}(\pi R)}{\sqrt{2\pi}}$$

4.10 Higgs in Randall-Sundrum

- Taking $c_{Q_3} = -0.47$, $c_{u_3} = 0.34$,
- $\lambda_t^{(5)} = 0.42$
- The following results are obtained for M^u (in GeV),

(11) $$M_{11} << M_{22} << M_{33}$$

5. Conclusions

- Worth studying generic THDM's (indep. of SUSY).
- Rare B decays have been used to constrain the Neutral and Charged Higgs sector in SUSY,THDM (and BSM),
- Charged Higgs in THDM3 gives particular signatures,
- Very interesting signal: $cb \to H^+ \to W + h^0$. THDM-III rates can be very large, and thus the discovery potential in ATLAS and CMS can be substantial.
- Multi-Higgs models in RS under construction.