A TeV-scale model for neutrino mass, DM and baryon asymmetry

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Model for extended Higgs sector: Additional singlet

Singlet is inert: dark matter candidate

m_η would be around 49-64 GeV

Neutrino masses induced by 3-loop diagrams

- no higher scale needed

Yukawa couplings: Type X (similar to Type II)

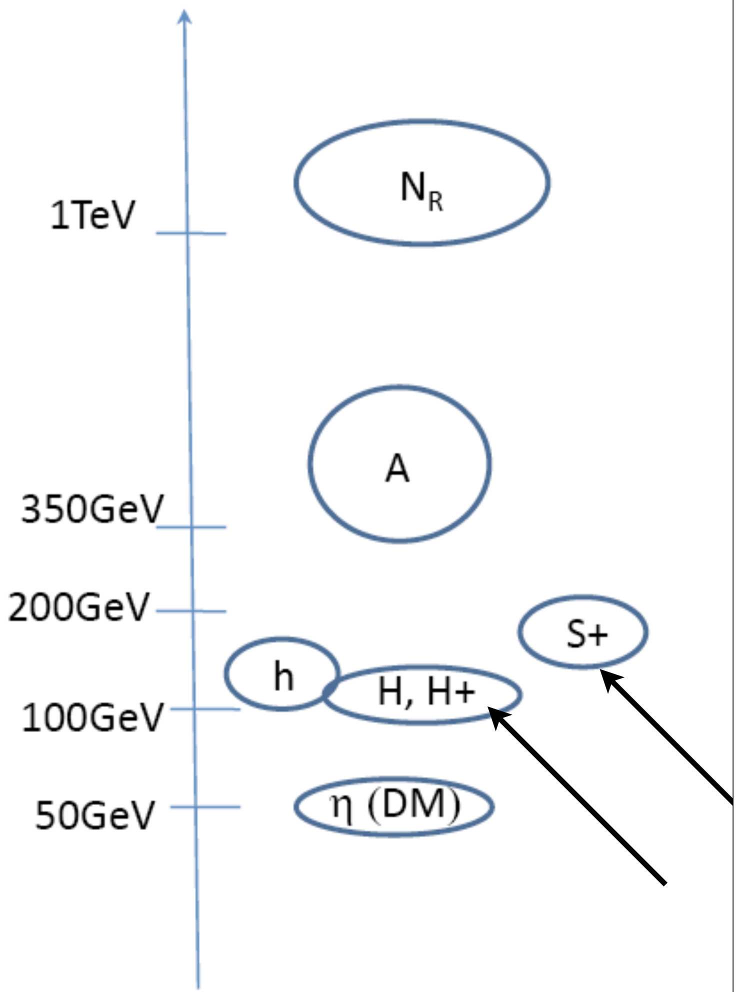
Mass Spectrum

The current data and requirement for

- LFV (μ to e γ)
- Neutrino oscillation
- Abundance of DM
- Strong 1st order EW phase transition
- LEP bounds (direct and indirect)
- b to sγ (actually no bound because of Type-X)
- Perturbative unitarity and vacuum stability

They give constraints on the masses

– η (DM candidate):	around 50 GeV
– Light H^+, H, S^+	~100 GeV
– Strong coupled A	m_A>350GeV
– RH-ν	O(1) TeV



All the masses are predicted as

O(100) GeV – O(1) TeV

Charged Higgs production in the flavored MSSM

Michael Spannowsky

In collaboration with
Stefan Dittmaier
Gudrun Hiller
Tilman Plehn

Presented by Sven

Minimal flavor violation [D'Ambrosio *et al*, 2002]

Basic principle of MFV:

The Yukawa couplings are the only sources of flavor and CP violation

Motivation of MFV:

- Success of SM predictions in FCNC processes
- Reduction of free parameters
- Phenomenologically more predictive

Resulting Squark mass matrices in MFV and NMFV (to good approximation)

$$\mathcal{M}^u_{mfv} = \begin{pmatrix} (M^2_u)^u_{LL} & 0 & 0 & \Delta^u_{LR,11} & 0 & 0 \\ & (M^2_u)^c_{LL} & 0 & 0 & \Delta^u_{LR,22} & 0 \\ & & (M^2_u)^t_{LL} & 0 & 0 & \Delta^u_{LR,33} \\ & & & (M^2_u)^u_{RR} & 0 & 0 \\ & \text{h.c.} & & & (M^2_u)^c_{RR} & 0 \\ & & & & & (M^2_u)^t_{RR} \end{pmatrix}$$

$$\mathcal{M}^u_{nmfv} = \begin{pmatrix} (M^2_u)^u_{LL} & \Delta^u_{LL,12} & \Delta^u_{LL,13} & \Delta^u_{LR,11} & \Delta^u_{LR,12} & \Delta^u_{LR,13} \\ & (M^2_u)^c_{LL} & \Delta^u_{LL,23} & \Delta^u_{LR,21} & \Delta^u_{LR,22} & \Delta^u_{LR,23} \\ & & (M^2_u)^t_{LL} & \Delta^u_{LR,31} & \Delta^u_{LR,32} & \Delta^u_{LR,33} \\ & & & (M^2_u)^u_{RR} & \Delta^u_{RR,12} & \Delta^u_{RR,13} \\ & \text{h.c.} & & & (M^2_u)^c_{RR} & \Delta^u_{RR,23} \\ & & & & & (M^2_u)^t_{RR} \end{pmatrix}$$

$$(M^2_u)^q_{LL} = M^2_{\tilde{Q},q} + m^2_q + (T^q_3 - Q_q \sin^2\theta_w)\, m^2_Z \cos 2\beta$$

$$(M^2_u)^q_{RR} = M^2_{\tilde{u},q} + m^2_q + Q_q \sin^2\theta_w m^2_Z \cos 2\beta$$

$$\Delta^u_{LR,ii} = \langle H^0_2 \rangle A^u_{ii} - m_{q_i}\mu \cot\beta$$

$$\Delta^u_{LR,ij} = \langle H^0_2 \rangle A^u_{ij}$$

$$\Delta^u_{LL,ij} = M^2_{\tilde{Q},ij} \quad i \neq j$$

$$\Delta^u_{RR,ij} = M^2_{\tilde{u},ij} \quad i \neq j$$

Results

m_{H+}	$\tan\beta$	σ_{2HDM}	$\sigma_{\text{2HDM}}^{(m_s=0)}$	σ_{MFV}	$\sigma_{\text{MFV}}^{(m_s=0)}$	$\sigma_{\text{MFV}}^{(m_q=0)}$
187 GeV	3	$2.1 \cdot 10^{-1}$	$7.5 \cdot 10^{-2}$	$1.4 \cdot 10^{-1}$	$1.9 \cdot 10^{-1}$	$6.7 \cdot 10^{-4}$
187 GeV	7	$7.8 \cdot 10^{-1}$	$4.8 \cdot 10^{-1}$	$5.3 \cdot 10^{-1}$	$5.7 \cdot 10^{-1}$	$1.5 \cdot 10^{-4}$
400 GeV	3	$3.3 \cdot 10^{-2}$	$1.3 \cdot 10^{-2}$	$2.6 \cdot 10^{-2}$	$3.0 \cdot 10^{-2}$	$4.2 \cdot 10^{-4}$
400 GeV	7	$1.3 \cdot 10^{-1}$	$7.3 \cdot 10^{-2}$	$8.8 \cdot 10^{-2}$	$1.1 \cdot 10^{-1}$	$9.1 \cdot 10^{-5}$

m_{H+}	$\tan\beta$	σ_{SUSY}	$\sigma_{\text{SUSY}}^{(m_s=0)}$	$\sigma_{\text{SUSY}}^{(m_q=0)}$
188 GeV	3	9.9	9.7	8.4
188 GeV	7	3.1	3.1	1.8
400 GeV	3	1.5	1.5	1.4
400 GeV	7	0.47	0.46	0.032

- σ_{SUSY} corresponds to $\delta^u_{LR,31} = 0.5$
- Light-flavor and bottom Yukawa have roughly the same impact $m_b V_{cb} \sim m_s V_{cs}$
- The D-Term couplings are numerically irrelevant
- NMFV can enhance cross-section by one order of magnitude for small

Charged Higgs Phenomenology in the NMSSM

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Faculté des Sciences et Techniques, Tangier, Morocco

Based on A. G. Akeroyd, A.A and Q. S. Yan, EPJC'08
A. A, K. Cheung, T. J. Hou and K. W. Song, JHEP'07

Outline

- Short review of Next-to MSSM (NMSSM)
- Very light CP-odd pseudoscalar A_1
- Higgs-gauge bosons couplings in NMSSM and sum rules
- ⇉ $H^\pm \to W^\pm A_1, W^\pm h_{1,2}$ in NMSSM
- $pp \to H^\pm h_1$, $pp \to H^\pm A_1$ vs $pp \to W^\pm h_1$
- Conclusions

cH$^\pm$arged 2008 16-19/09/2008, Uppsala University

Conclusions

- In the NMSSM, $H^\pm \to W^\pm A_1, W^\pm h_1$ dominate over $\tau^\pm \nu$ and tb channels both below and above the top-bottom threshold.
- $pp \to H^\pm A_1$ with $H^\pm \to W^\pm A_1$ can be used to search for light charged Higgs with small to moderate $\tan\beta$.
- $pp \to H^\pm A_1$ with $H^\pm \to W^\pm A_1$ and $pp \to W^\pm h_1$ with $h_1 \to A_1 A_1$ leads to same signal $W A_1 A_1 \to \{W4b, W4\tau\}$ which can be distinguished at the LHC by applying appropriate reconstruction methods.
- The interference term for $W4b$ and $W4\tau$ might not be negligible and should be taken into account in any simulation study.

CP violation in charged Higgs decays in MSSM

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Institute for Nuclear Research and Nuclear Energy, BAS, Sofia

We consider

$H^{\pm}$-decays into ordinary particles:

$$H^{\pm} \to tb$$

$$H^{\pm} \to \tau^{\pm}\nu$$

$$H^{\pm} \to W^{\pm}h^{0}$$

- decay rate asymmetries:

$$\delta^{CP} = \frac{\Gamma(H^{+}\to ...)-\Gamma(H^{-}\to ...)}{\Gamma(H^{+}\to ...)+\Gamma(H^{-}\to ...)}$$

$$\delta_{tb}, \qquad \delta_{\nu\tau}, \qquad \delta_{Wh^{0}}$$

Conclusions

CPV in MSSM: $H^\pm \to tb,\ H^\pm \to \nu\tau,\ H^\pm \to W^\pm h^0$:

$\Rightarrow$ $\tan\beta$ & m_{H^+} are unknown

$\Rightarrow$ depending on $\tan\beta$ & m_{H^+} different decay modes will play role

$\Rightarrow$ different phases will be measured

$$\delta^{CP} = \frac{\Gamma(H^+ \to ...) - \Gamma(H^- \to ...)}{\Gamma(H^+ \to ...) + \Gamma(H^- \to ...)}$$

- simple measurement – only the decay rates
- always decay modes $H^+ \to$ SUSY partls. needed for $\delta^{CP} \neq 0$
  $\Rightarrow$ this decreases $BR(H^+ \to$ ordinary partls.)
  - a simult. considr. of δ^{CP} & BR needed

Consider high masses

Uppsala University
16-19 September, 2008

CP-violation in charged Higgs boson production at LHC

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&
Institute for Nuclear Research and Nuclear Energy, BAS, Sofia

CP-violating asymmetry

- The CP-violating asymmetry is defined as:

$$A_P^{CP} = \frac{\sigma^+(pp \to \bar{t}H^+) - \sigma^-(pp \to tH^-)}{\sigma^+(pp \to \bar{t}H^+) - \sigma^-(pp \to tH^-)}$$

In our terms:

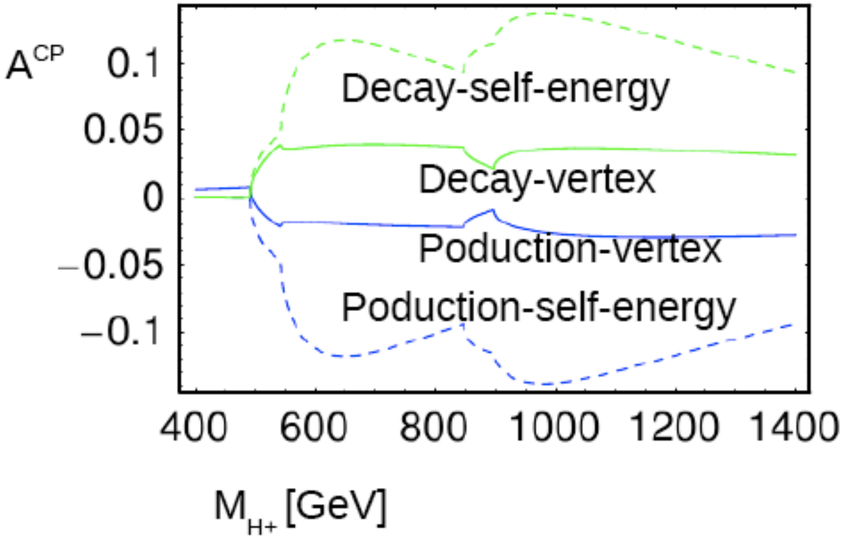
$$A_P^{CP} = \frac{\sigma^{CP}}{\sigma^{inv}} = \frac{\alpha_s}{12\sigma^{tree}} \int dx_b dx_g f_b(x_b) f_g(x_g) \frac{1}{(x_b x_g \hat{s})^2} \left\{ \frac{2\alpha_s}{3\pi} \mathcal{C}_s + \frac{3\alpha_\omega}{8\pi} \mathcal{C}_w \right\}$$

$$\mathcal{C}_s = [\mathrm{Im}(f_{RL}) y_t + \mathrm{Im}(f_{LR}) y_b] \mathcal{I}_1 + [\mathrm{Im}(f_{LL}) y_t + \mathrm{Im}(f_{RR}) y_b] \mathcal{I}_2$$

$$\mathcal{C}_\omega = \mathrm{Im}(f_{LL}) y_t \mathcal{I}_3$$

Numerical analysis

- Production and decay $pp \to tH^{\pm} \to tb$ process at parton level



$$\sqrt{\hat{s}} = 2 \text{ TeV}$$

Concern about cancellation

Tree-level Vaccum stability in THDM

R. Santos

NExT

with A. Barroso, P. Ferreira and N. Sá

Phase transitions in 2HDM

K.A.Kanishev

Institute of Theoretical Physics, University of Warsaw

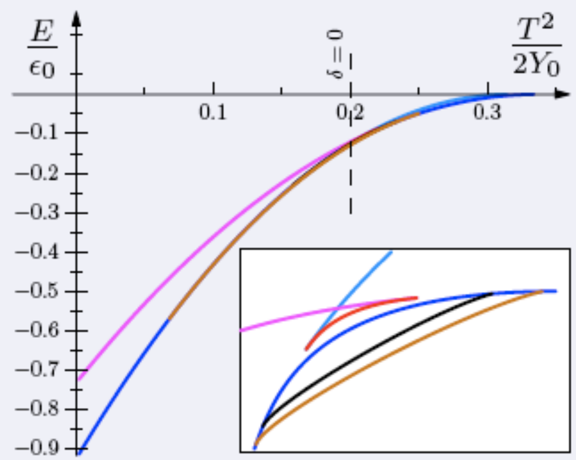
Prospects for Charged Higgs Discovery at Colliders
Uppsala University, Sweden, 16-19 September 2008

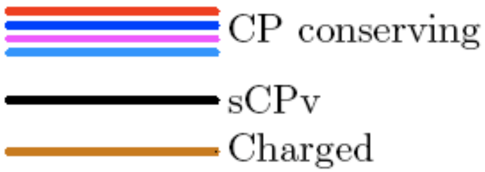
In collaboration with I.F.Ginzburg and I.P. Ivanov.

EW $\overset{II}{\rightarrow}$ CPc $\overset{II}{\rightarrow}$ Charged $\overset{II}{\rightarrow}$ CPc

Transition through charged vacuum $< \phi_2 >= \begin{pmatrix} u \\ v_2 e^{-i\xi} \end{pmatrix}$

Energies of extrema





- Electric charge is not conserved
- Four massive Higgs bosons and four massive gauge bosons without definite electric charges.
- Up and down fermions can mix.

On distinguishing the direct and spontaneous CP violation in 2HDM

Dorota Sokolowska

Institute of Theoretical Physics, University of Warsaw

"Prospects for Charged Higgs Discovery at Colliders"
Uppsala, 16-19.09.2008

based on collaboration with Maria Krawczyk and Konstantin Kanischev

Summary

- CP violation in 2HDM without fermions

→ Study of sources of CP violation with focus on distinguishing explicit and spontaneous violation

→ We found that both J_i and I_i are needed to distinguish sources

- Usual approach: CP violation $\Leftrightarrow$ mixing between states of different CP properties (true for soft violation of Z_2 symmetry)

- However, with CP conservation in the gauge interactions of scalars still possible CP violation in self-interactions
$\Rightarrow$ CP violation effects in vertices with odd number of A (eg. $A \to H^+H^-$)

Constraining the Inert Doublet Model

Maria Krawczyk, U. of Warsaw

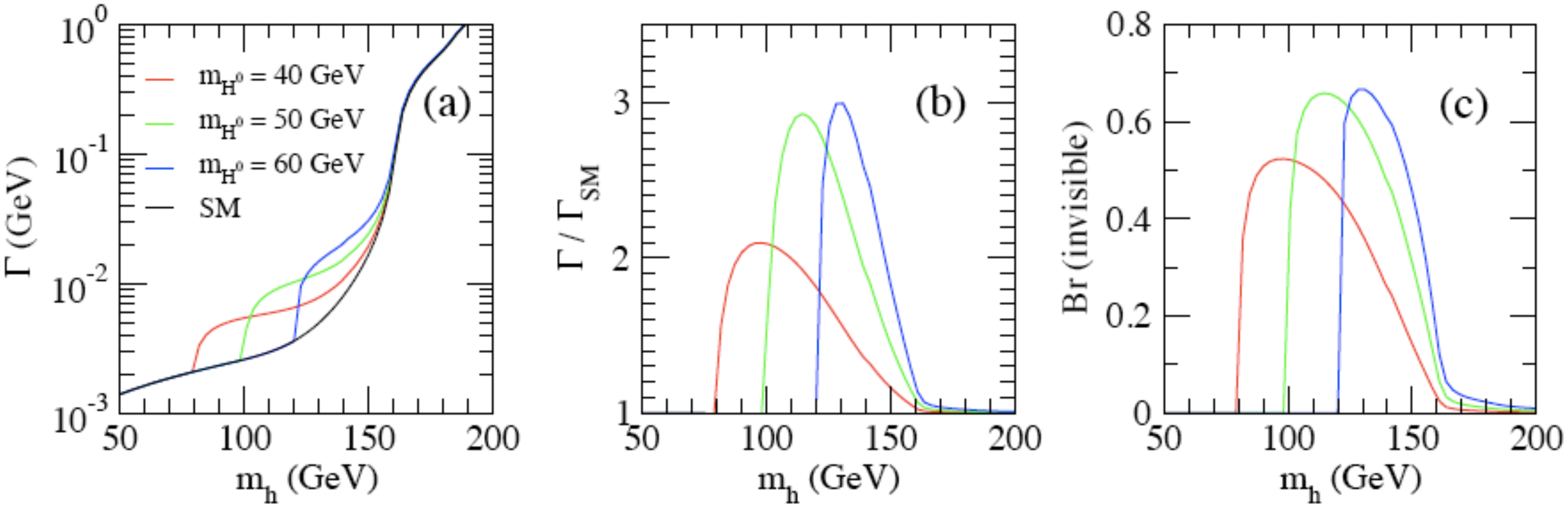
H+ Workshop, Uppsala, 16-19.09.2008

In this talk:

- Basics of the Two-Higgs-Doublet Model (2HDM)
- Role of Z_2 symmetry
- Constraints on CP conserving 2HDM (II)

- Exact Z_2 symmetry and Inert (Dark) Doublet Model
- Inert Doublet Model: standard Higgs boson and dark scalars
- The lightest dark scalar is stable → a candidate for dark matter
- Constraints - colliders and DM

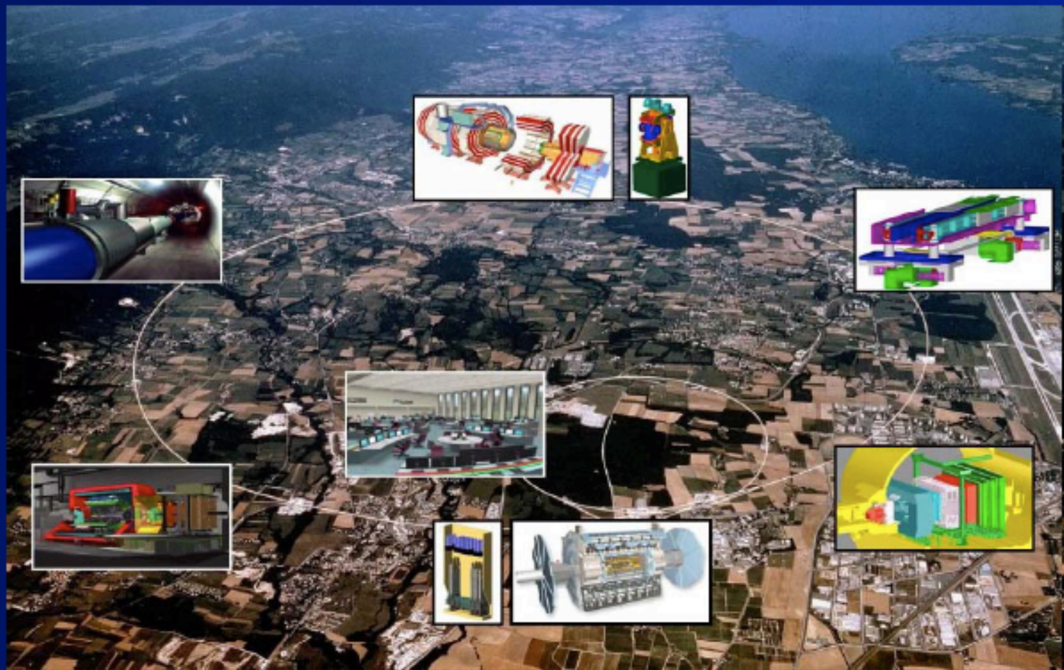
In collaboration with D. Sokołowska and K. Kanishev



Modification of the total width due to additional (dark) decay channels.

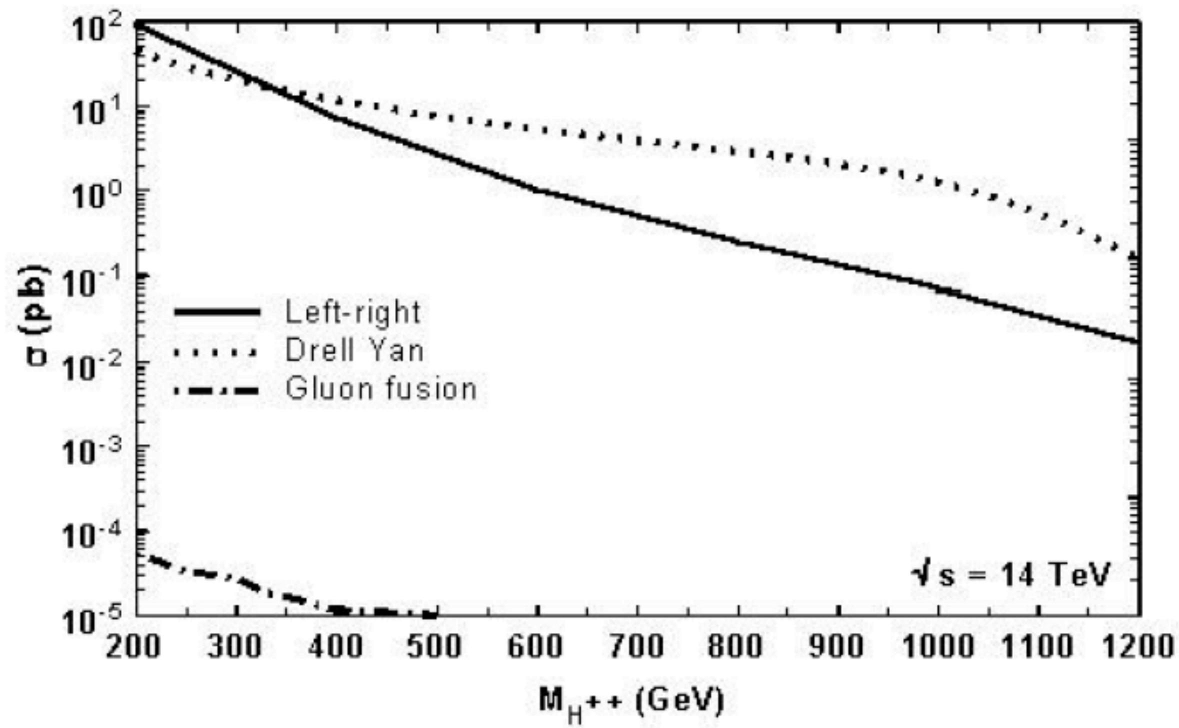
Doubly cHarged Higgs at the LHC in 3-3-1 model

Nelson V. Cortez (São Paulo Univ.)



Charged Higgs 2008,Uppsala-Se

LRSM x 331(DY) x 331(GGF)



Apologies...