Evidences of CP violation in the minimal supersymmetric model at modern and future colliders

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E.A., M.Dolgopolov, M.Dubinin Higgs Bosons in the Two-Doublet Model with CP Violation // Phys.Rev.D V.71 N7 2005

Online

- *Introduction*
- *MSSM with CP violation:*
- *Higgs bosons masses, intense-coupling regime*
- *Decay widths*
- *Summary*

Effective THDM potential with explicit CP violation

The most general renormalized SU(2)xU(1) invariant potential

$$U(\Phi_1,\Phi_2) = -\mu_1^2(\Phi_1^\dagger\Phi_1) - \mu_2^2(\Phi_2^\dagger\Phi_2) - \mu_{12}^2(\Phi_1^\dagger\Phi_2) - \overset{*}{\mu_{12}^2}(\Phi_2^\dagger\Phi_1) +$$

$$+\frac{\lambda_1}{2}(\Phi_1^\dagger\Phi_1)^2 + \frac{\lambda_2}{2}(\Phi_2^\dagger\Phi_2)^2 + \lambda_3(\Phi_1^\dagger\Phi_1)(\Phi_2^\dagger\Phi_2) + \lambda_4(\Phi_1^\dagger\Phi_2)(\Phi_2^\dagger\Phi_1) +$$

$$+\frac{\lambda_5}{2}(\Phi_1^\dagger\Phi_2)(\Phi_1^\dagger\Phi_2) + \frac{\overset{*}{\lambda_5}}{2}(\Phi_2^\dagger\Phi_1)(\Phi_2^\dagger\Phi_1) +$$

$$+\lambda_6(\Phi_1^\dagger\Phi_1)(\Phi_1^\dagger\Phi_2) + \overset{*}{\lambda_6}(\Phi_1^\dagger\Phi_1)(\Phi_2^\dagger\Phi_1) +$$

$$+\lambda_7(\Phi_2^\dagger\Phi_2)(\Phi_1^\dagger\Phi_2) + \overset{*}{\lambda_7}(\Phi_2^\dagger\Phi_2)(\Phi_2^\dagger\Phi_1)$$

$$\Phi_1^\dagger\Phi_2 \xrightarrow{CP} \Phi_2^\dagger\Phi_1$$

$$\lambda_{5,6,7} \xrightarrow{CP} \overset{*}{\lambda}_{5,6,7}$$

μ_{12}^2,
$\lambda_5, \lambda_6, \lambda_7$
complex

***U* *is* *CP*-invariant at the M_{SUSY} scale,**
because $\overset{*}{\lambda}_{5,6,7}$ = 0

CP U_{eff}

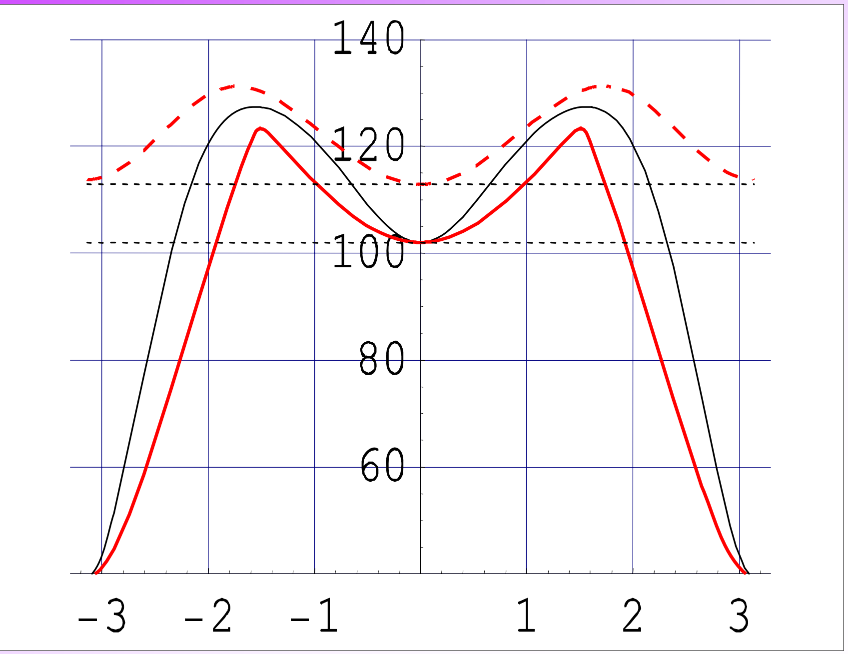
m_{top} M_{SUSY}

μ - mass-energy scale

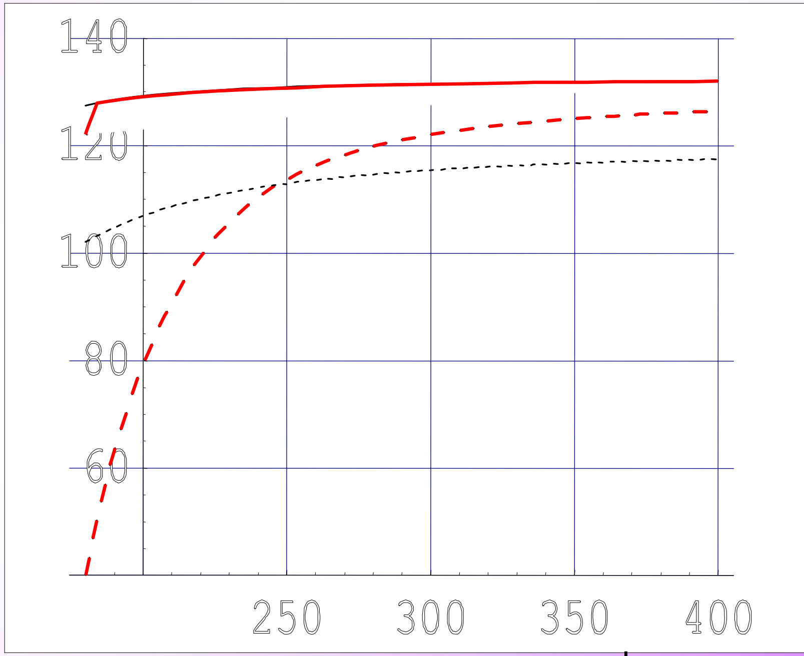
Eff. potential method

φ=arg($\lambda_{6,7}$)=arg(λ_5)/2

Mass of the light Higgs boson



m_{h1}, GeV



φ=arg(μA) [rad]

$m_H^{\pm}$ **[GeV]**

solid line $m_{H^\pm}$ =180 GeV

dashed line $m_{H^\pm}$ =250 GeV

solid line $\varphi = \frac{\pi}{2}$

dashed line $\varphi = \pi$

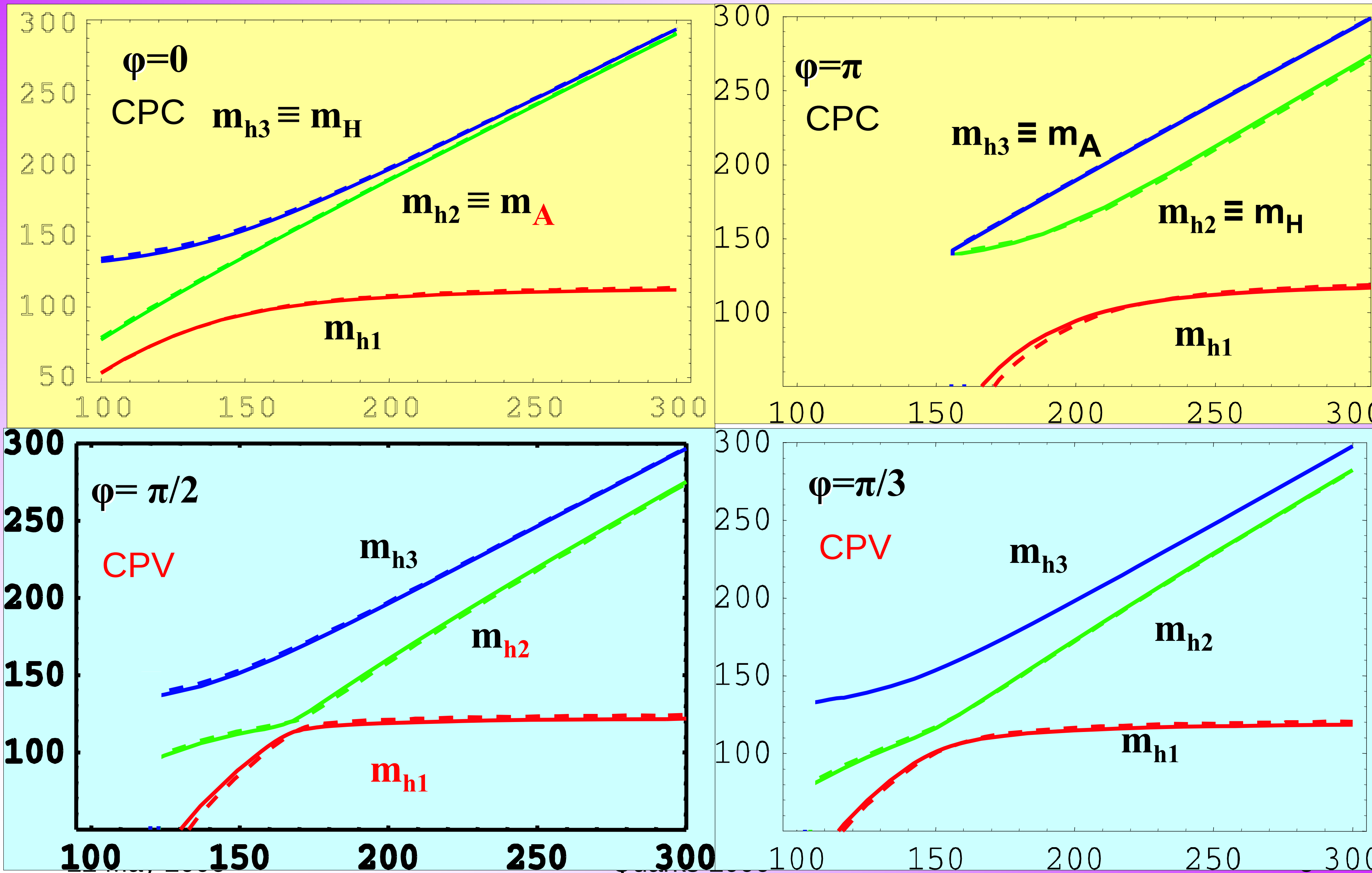
μ = 2 ТэВ, A_t=A_b= 1 ТэВ, tg β =5, M_{SUSY} =0.5 ТэВ

The maximum effects of CP mixing are in the CPX scenario

[Carena et al., Phys.Lett B495 155(2000)]

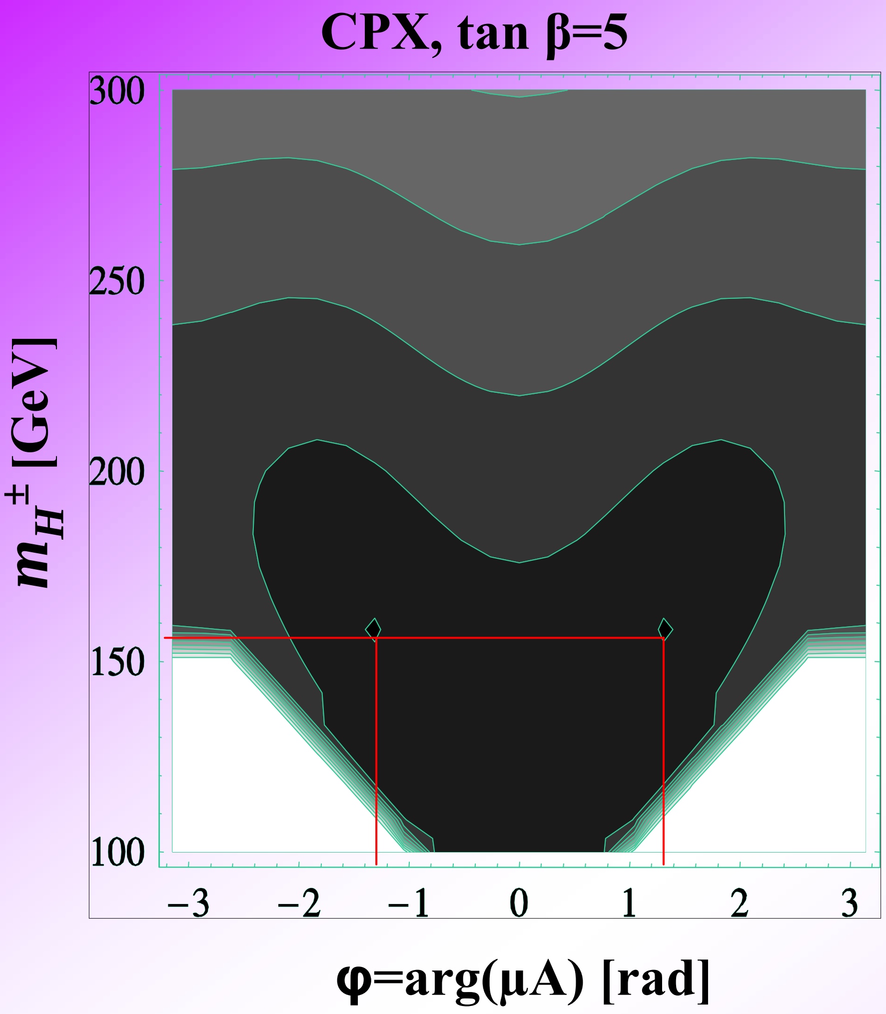
arg(A_t)=arg(A_b)=arg(M_{gluino})=90^0, large ratio |μ A_t|/M_{SUSY}

Higgs boson masses (m_{h_i}, GeV) vs m_{H^+} [GeV] at different phases at tanβ=5: intense-coupling regime and CP-even/CP-odd mixing (2-loop)

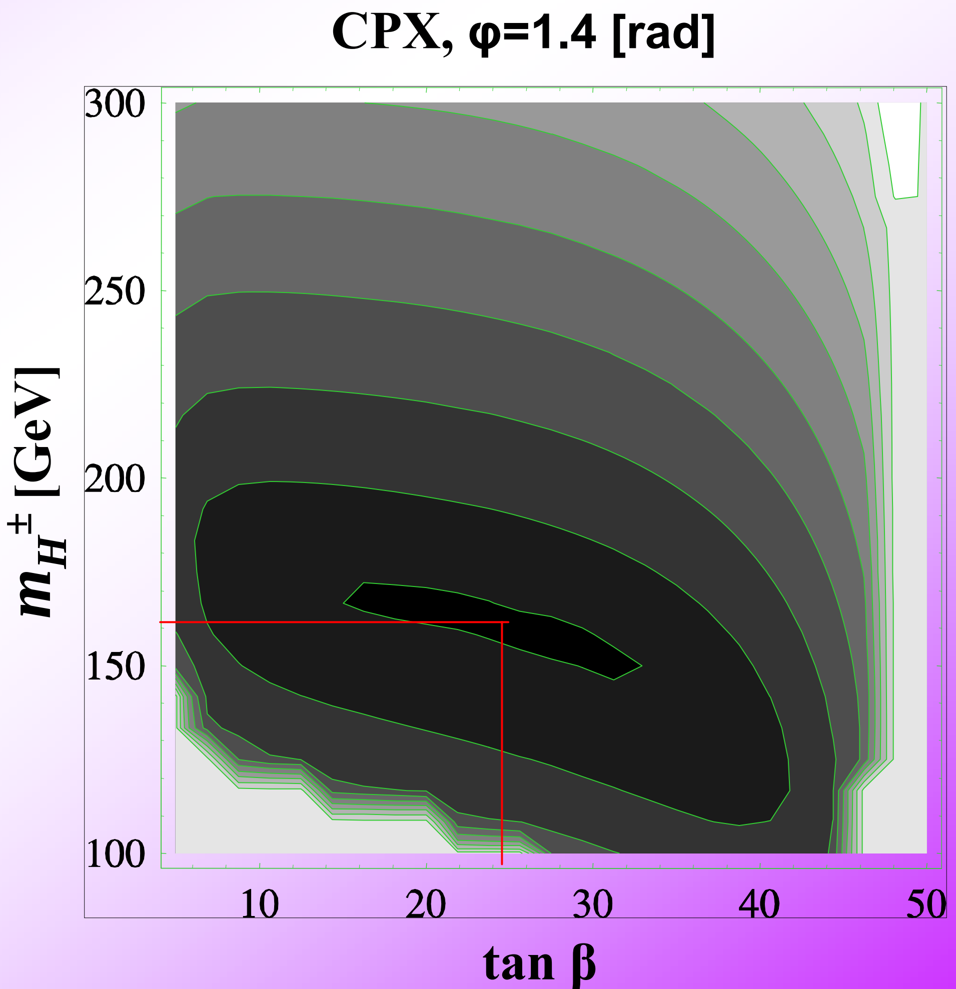


E.Boos, A.Djouadi, A.Nikitenko, Phys. Lett. **B578**, 384 (2004), [hep-ph/0307079].

(mh2+mh3)/2-mh1



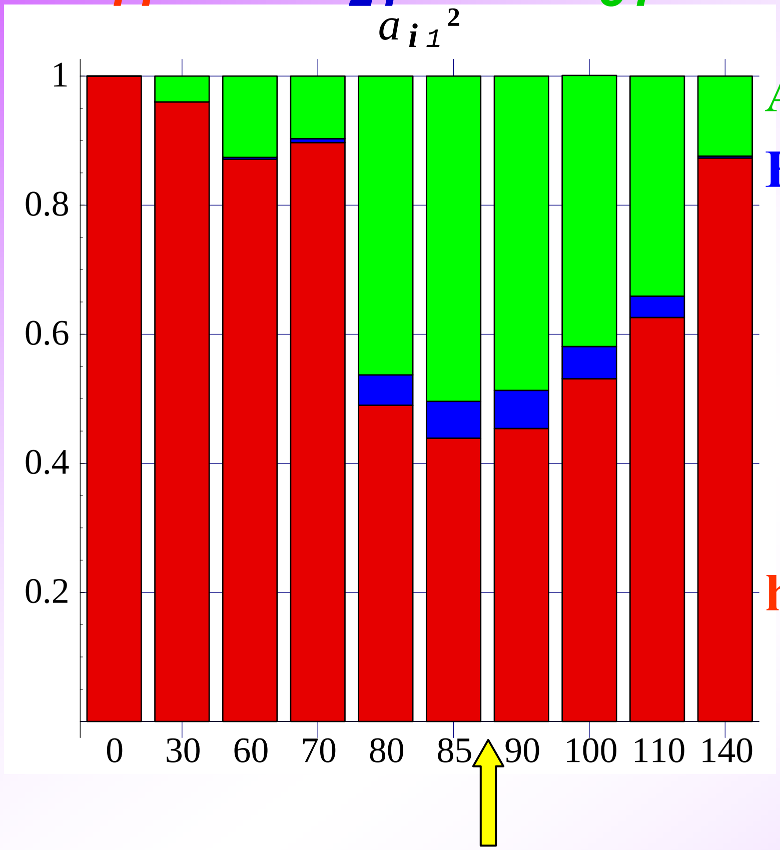
CPX, tan β=5
300
250
200
150
100
−3
−2
−1
0
1
2
3
$m_{H^{\pm}}$ [GeV]
φ=arg(μA) [rad]

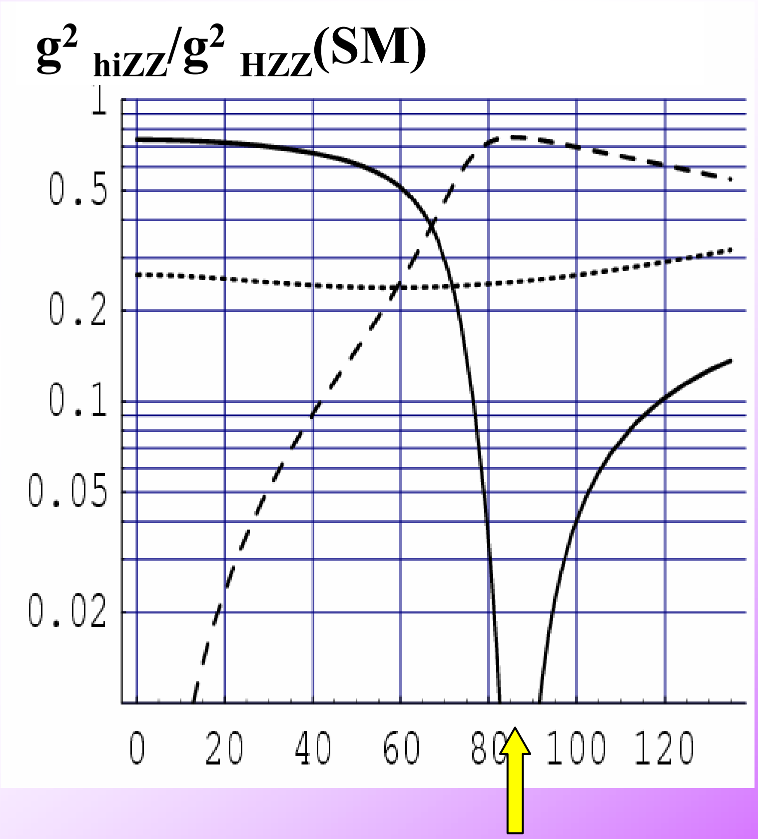


CPX, φ=1.4 [rad]
300
250
200
150
100
10
20
30
40
50
$m_{H^{\pm}}$ [GeV]
tan β

Matrix elements a_{i1} and coupling with Z-boson

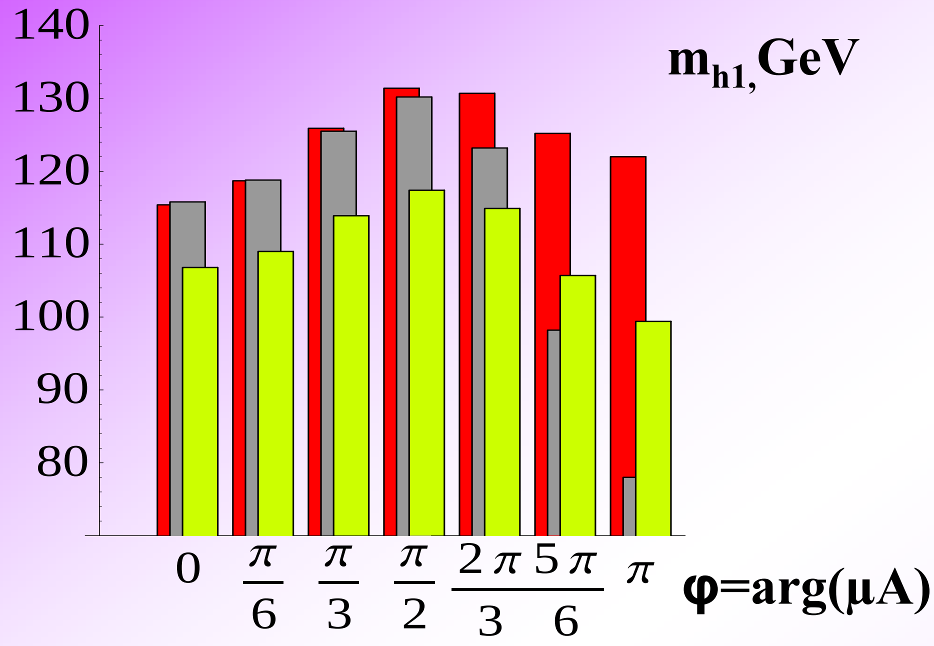
$h_1 = a_{11}\, h + a_{21}\, H + a_{31}\, A$

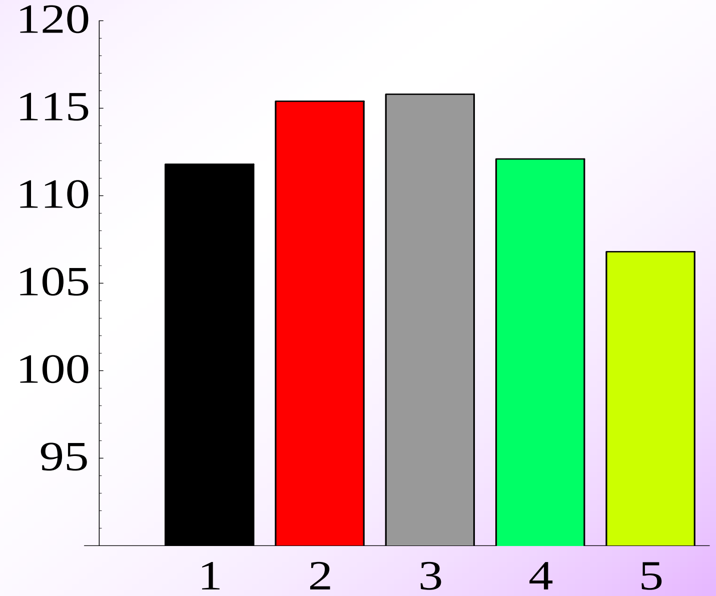




μ = 2 ТэВ, A_t=A_b= 1 ТэВ, tg β =5, M_{SUSY} =0.5 ТэВ, $m_H\pm$=150 ГэВ

Mass of the lightest Higgs boson





- our
- FeynHiggs
- CPsuperH

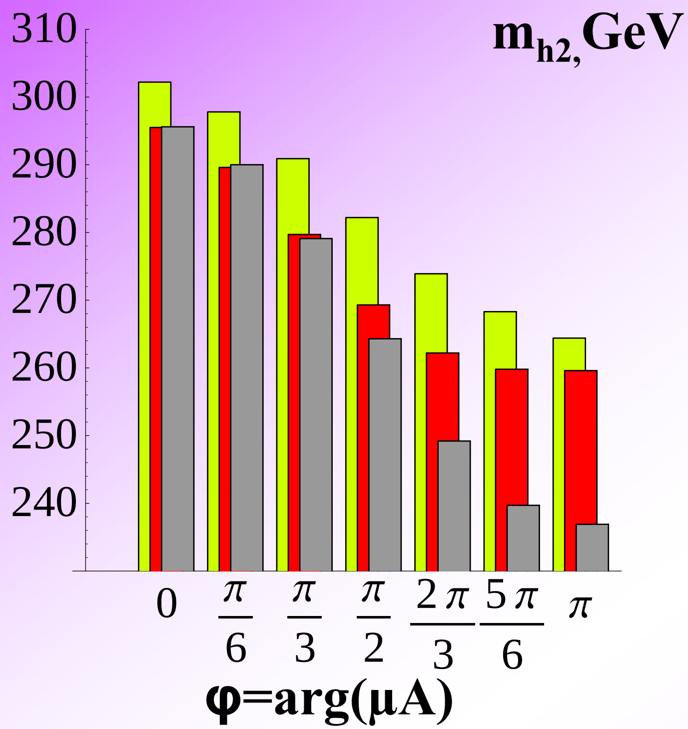
μ = 2 ТэВ, A_t=A_b= 1 ТэВ,

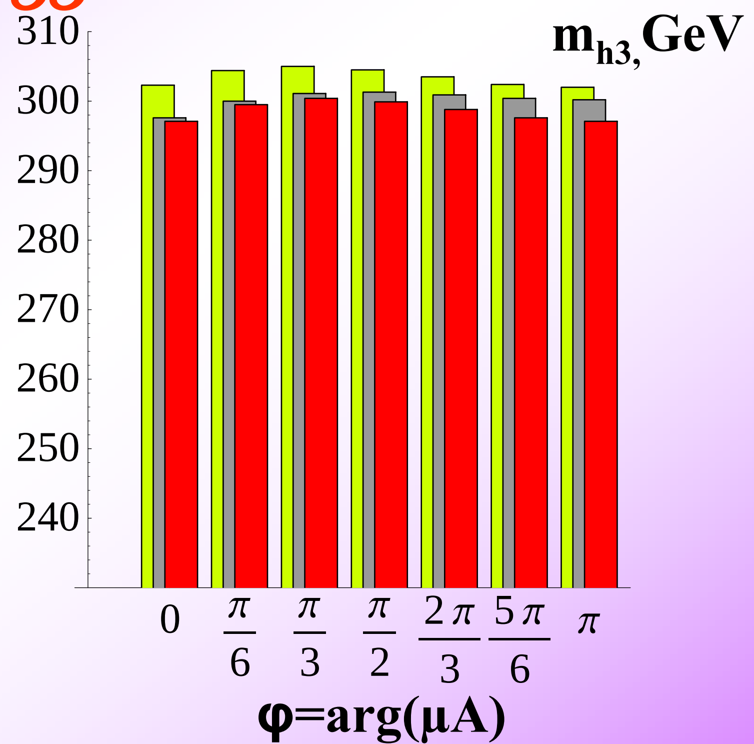
tg β =5, M_{SUSY} =0.5 ТэВ

[1] M.Frank, S.Heinemeyer, W.Hollik, G.Weiglein //hep-ph/0212037

[2] J.S. Lee, A.Pilaftsis, M.Carena, et.al. CPsuperH. (2004)

Mass of the Higgs bosons





our

FeynHiggs

CPsuperH

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Decay widths $h_1 \to gg$ and $h_1 \to \gamma\gamma$

The most promising channel for the Higgs bosons detection with mass 110–140GeV on collider LHC

$$pp \to h + X \to \gamma\gamma + X$$

$$\Gamma(h_i \to gg) = \frac{m_{h_i}^3 \alpha_S^2}{32\pi^3 v^2}\left[K_H^g \, |S_i^g(m_{h_i})|^2 + K_A^g \, |P_i^g(m_{h_i})|^2 \right]$$

$$\Gamma(h_i \to \gamma\gamma) = \frac{m_{h_i}^3 \alpha^2}{256\pi^3 v^2}\left[|S_i^\gamma(m_{h_i})|^2 + |P_i^\gamma(m_{h_i})|^2 \right]$$

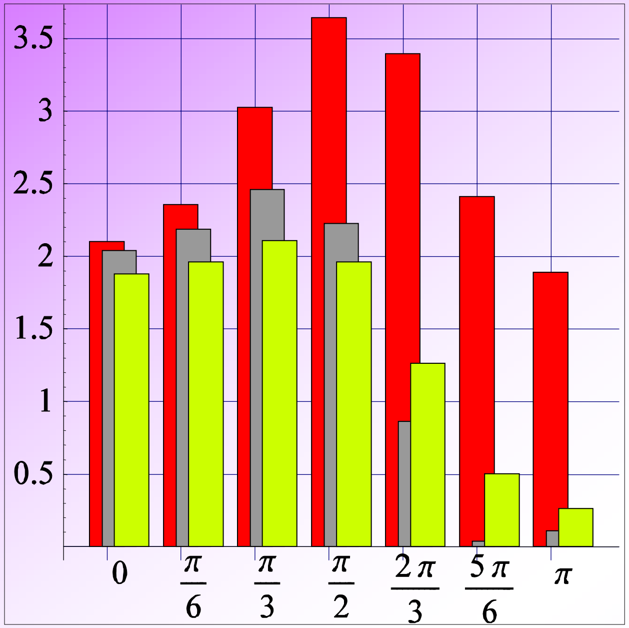
$h_1 \to b\bar{b} \quad (10^{-3} GeV)$ $h_1 \to gg \quad (10^{-4} GeV)$ $h_1 \to \tau\bar{\tau} \quad (10^{-4} GeV)$

$h_1 \to \gamma\gamma \quad (10^{-5} GeV)$ $h_1 \to c\bar{c} \quad (10^{-4} GeV)$ $h_1 \to s\bar{s} \quad (10^{-5} GeV)$

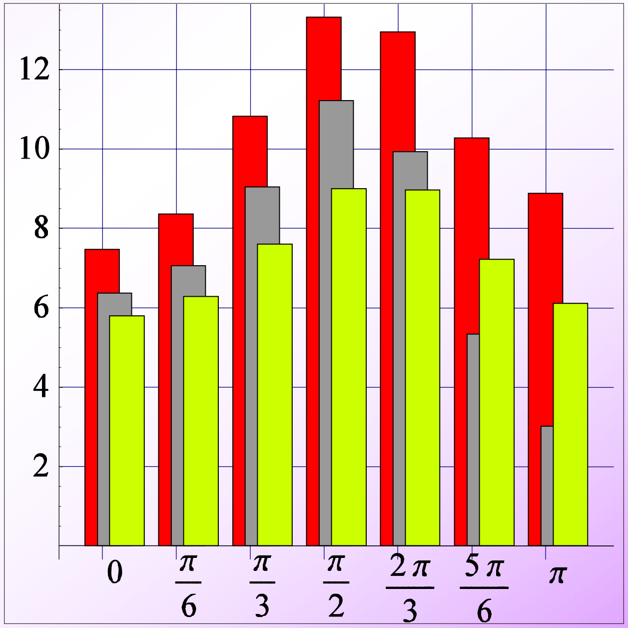
[1] J.S.Lee, A.Pilaftsis et al. Comput. Phys. Commun. 156 (2004)
[2] M.Spira. DESY 95-073 (hep-ph/9504339)
[3] E.Akhmetzyanova, M.Dolgopolov, M.Dubinin, Phys.Rev, D71 (2005) 075008

Decay widths $h_1 \to gg$ and $h_1 \to \gamma\gamma$

$\Gamma(h_1 \to gg)(GeV) \times 10^4$



$\Gamma(h_1 \to \gamma\gamma)(GeV) \times 10^6$



φ=arg(μA)

Our results **FeynHiggs** **CPsuperH**

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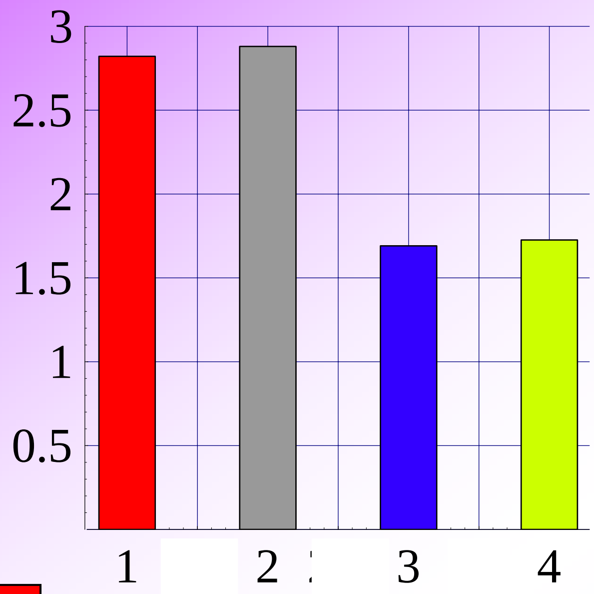
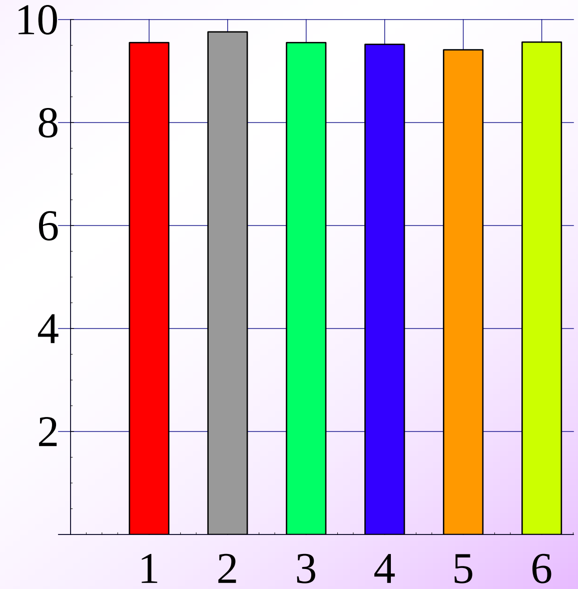


$\Gamma(h_1 \to \gamma\gamma)(\mathrm{GeV}) \times 10^6$



total

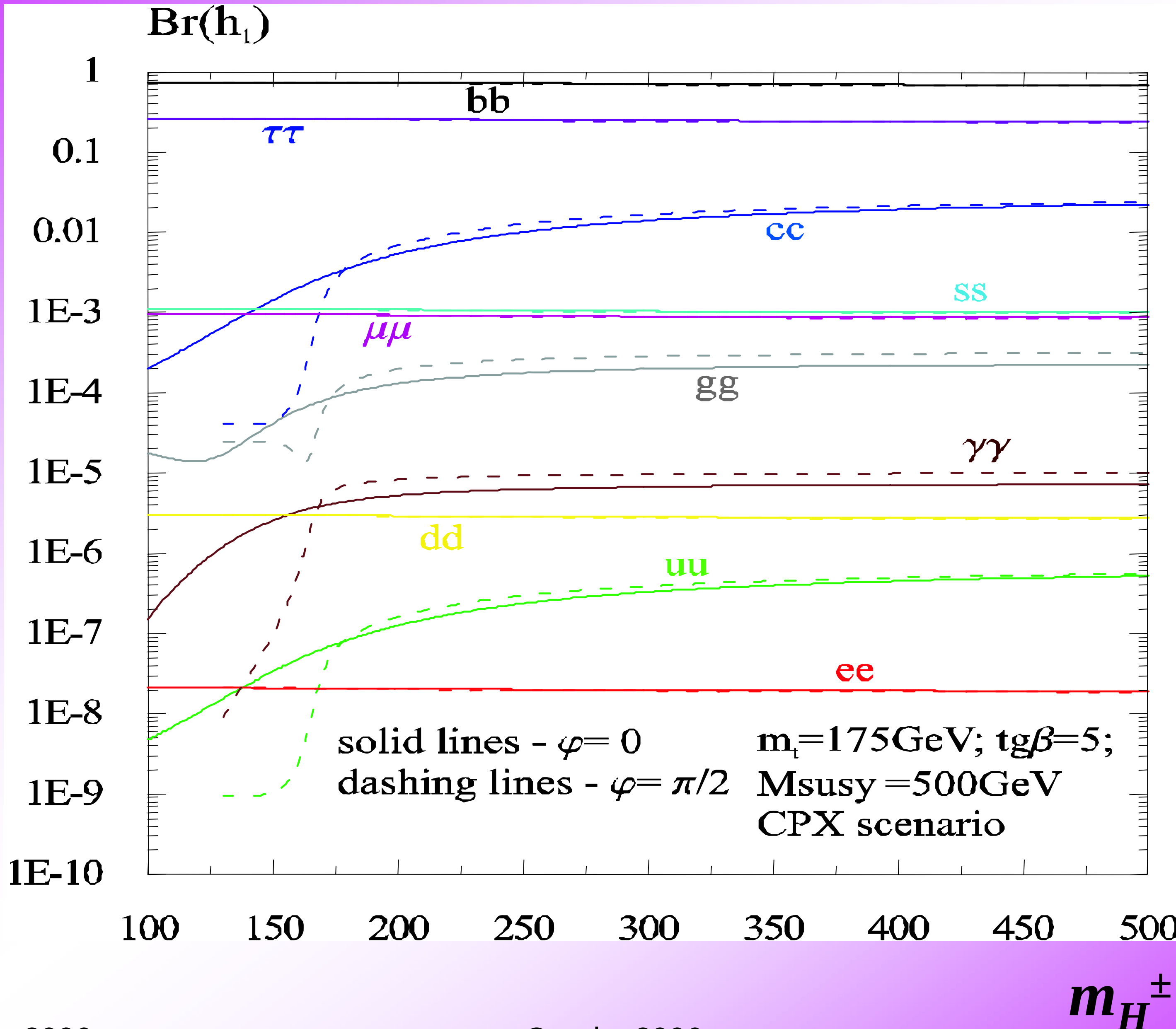
sfemions

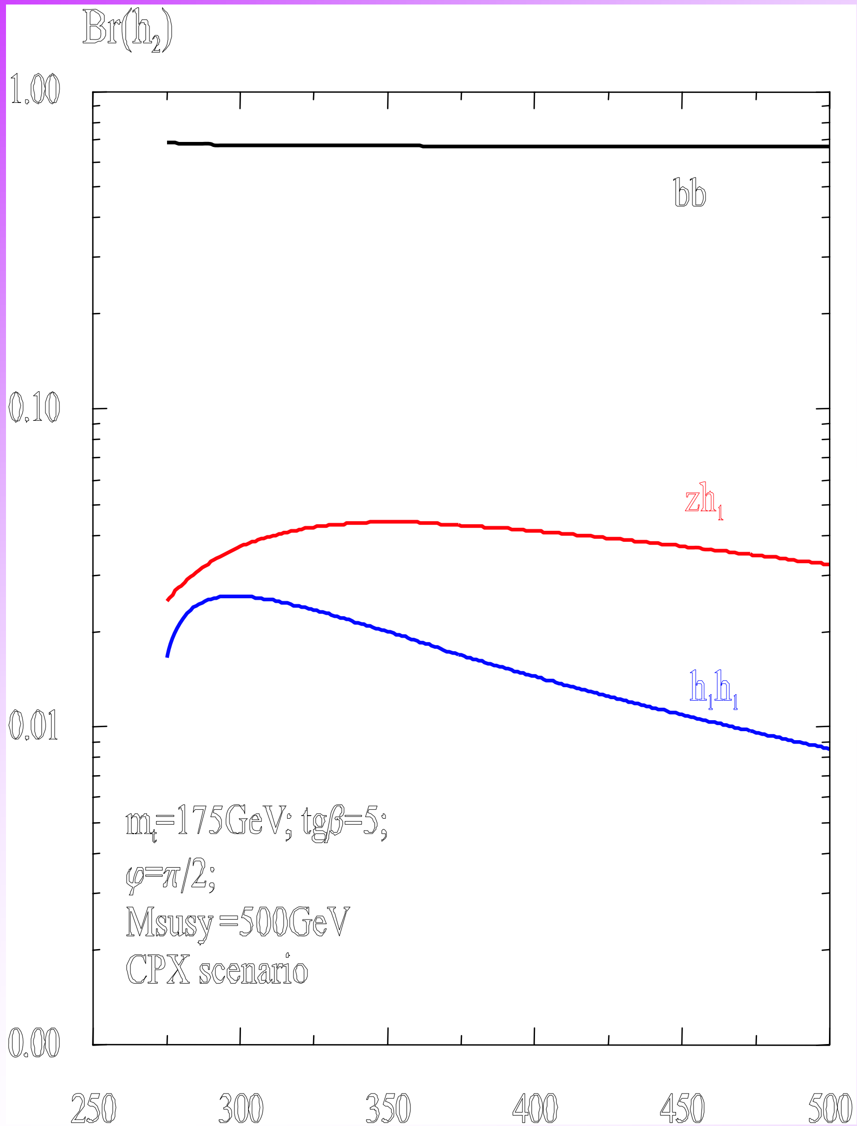
***K*, *J*- factors**

H^+H^-

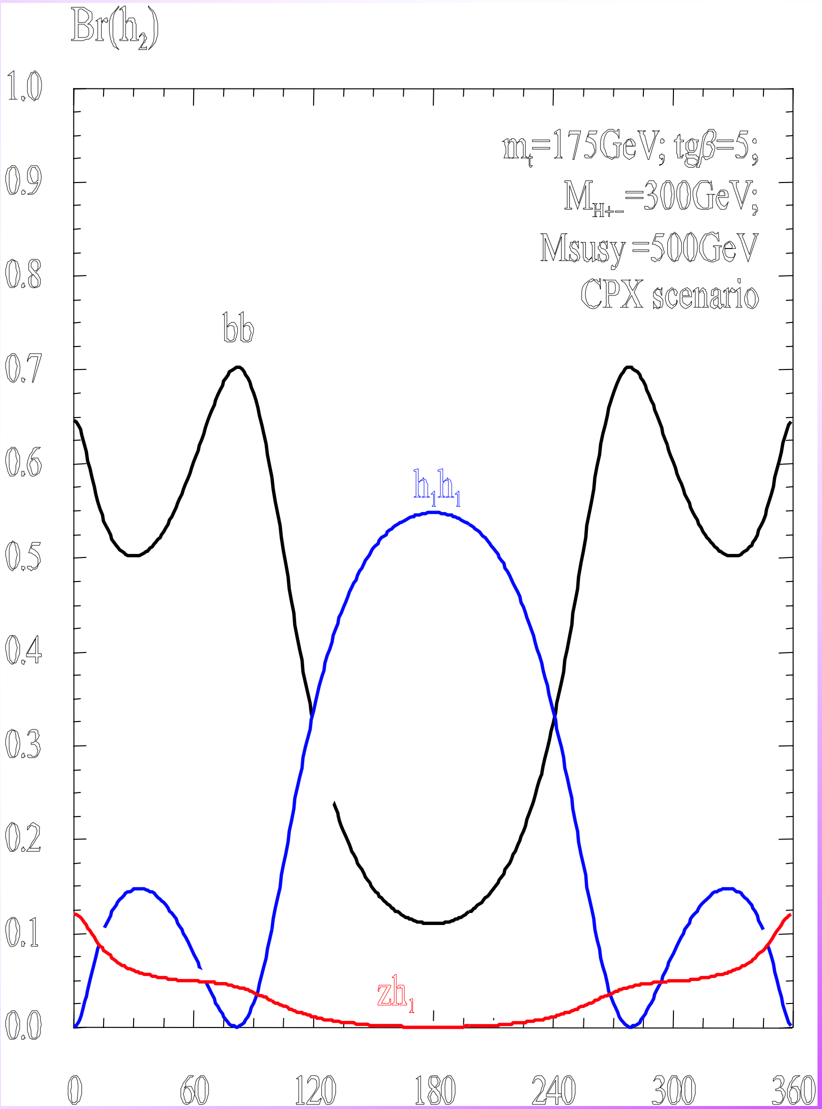
Charged SUSY particles

SM contributions


Br(h₁)
1
0.1
0.01
1E-3
1E-4
1E-5
1E-6
1E-7
1E-8
1E-9
1E-10
100
150
200
250
300
350
400
450
500
bb
ττ
cc
ss
μμ
gg
γγ
dd
uu
ee
solid lines - φ= 0
dashing lines - φ= π/2
m_t=175GeV; tgβ=5;
Msusy =500GeV
CPX scenario
m_H±


Br(h2)
1.00
0.10
0.01
0.00
bb
zh1
h1h1
mt=175GeV; tgβ=5;
φ=π/2;
Msusy=500GeV
CPX scenario
250
300
350
400
450
500

$m_{H^{\pm}}$


Br(h2)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
mt=175GeV; tgβ=5;
MH+-=300GeV;
Msusy=500GeV
CPX scenario
bb
h1h1
zh1
0
60
120
180
240
300
360

φ=arg(μA)

Summary

1. **The potential of the THDM in the general case is not CP-invariant and the parameters $\lambda_{5,6,7}$ of the two-doublet MSSM sector should be taken complex.**

2. **The deviations of the observable effects in the scenario with CP-violation from the phenomenology of the standard scenario can be substantial mainly due to changed masses in comparison with CP conserving theory.**

3. **The deviations are particularly strong if the power terms $|\mu A_t|/M_{SUSY}$ are large and the charged Higgs boson mass does not exceed 150-200 GeV, being rather weakly dependent on the value of tan β.**

4. **Such models could lead in principle to a reconsideration of the experimental properties for the signal of the Higgs boson production at the modern and future colliders.**