# Extracting SUSY Parameters from the Higgs Boson Properties

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collaboration with
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- $m_A$ determination from the ratio,

$$\frac{Br(h \to c\bar{c}) + Br(h \to gg)}{Br(h \to b\bar{b})} .$$

- $h b\bar{b}$ coupling and the Yukawa structure of the effective theory.
- Experimental & theoretical errors.
- Numerical results.
- Conclusion.

## $m_A$ determination from the ratio,

$$R_{br} = \frac{Br(h \to c\bar{c}) + Br(h \to g\bar{g})}{Br(h \to b\bar{b})}$$

| $h \to b\bar{b}$ | $h \to c\bar{c}$ |
|---|---|
| $f_b \bar{b} Q \cdot H_d$ | $f_c \bar{c} Q \cdot H_u$ |
| $\frac{m_b \cdot \sin\alpha}{v \cdot \cos\beta} \bar{b}_L b_R h$ | $\frac{m_c \cdot \cos\alpha}{v \cdot \sin\beta} \bar{c}_L c_R h$ |
| $Br(h \to b\bar{b}) \propto \left(\frac{\sin\alpha}{\cos\beta}\right)^2$ | $Br(h \to c\bar{c}) \propto \left(\frac{\cos\alpha}{\sin\beta}\right)^2$ |

$$R = \frac{Br(h \to c\bar{c})}{Br(h \to b\bar{b})} \propto \frac{(\cos\alpha/\sin\beta)^2}{(\sin\alpha/\cos\beta)^2} = \left(\frac{1}{\tan\alpha \cdot \tan\beta}\right)^2$$

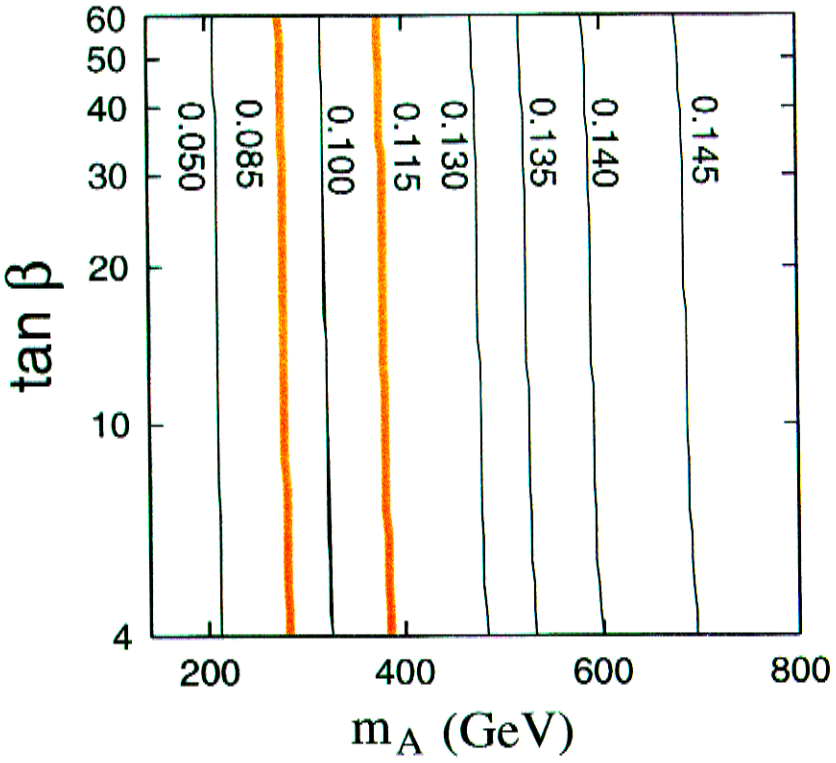
$$\left(\frac{1}{\tan\alpha \cdot \tan\beta}\right) = \frac{m_h^2 - m_A^2}{m_Z^2 + m_A^2}\left(1 + \frac{m_h^2 - m_Z^2}{m_h^2 + m_A^2} \cdot \frac{1}{\tan^2\beta}\right)$$

$$\sim \frac{m_h^2 - m_A^2}{m_Z^2 + m_A^2} \qquad (m_A > m_h \sim m_Z)$$

$$\boxed{R \simeq R(m_A)}$$

Kamoshita-
Okada-
Tanaka

$$R_{c\bar{c}+gg\,/\,b\bar{b}} = \frac{B(h\to c\bar{c}) + B(h\to gg)}{B(h\to b\bar{b})}$$




$m_h = 120$ GeV  At=0  $\mu = 500$GeV

$$R_{c\bar{c}+gg\,/\,b\bar{b}} = \frac{B(h\to c\bar{c}) + B(h\to gg)}{B(h\to b\bar{b})} \; ; \; 15\%$$

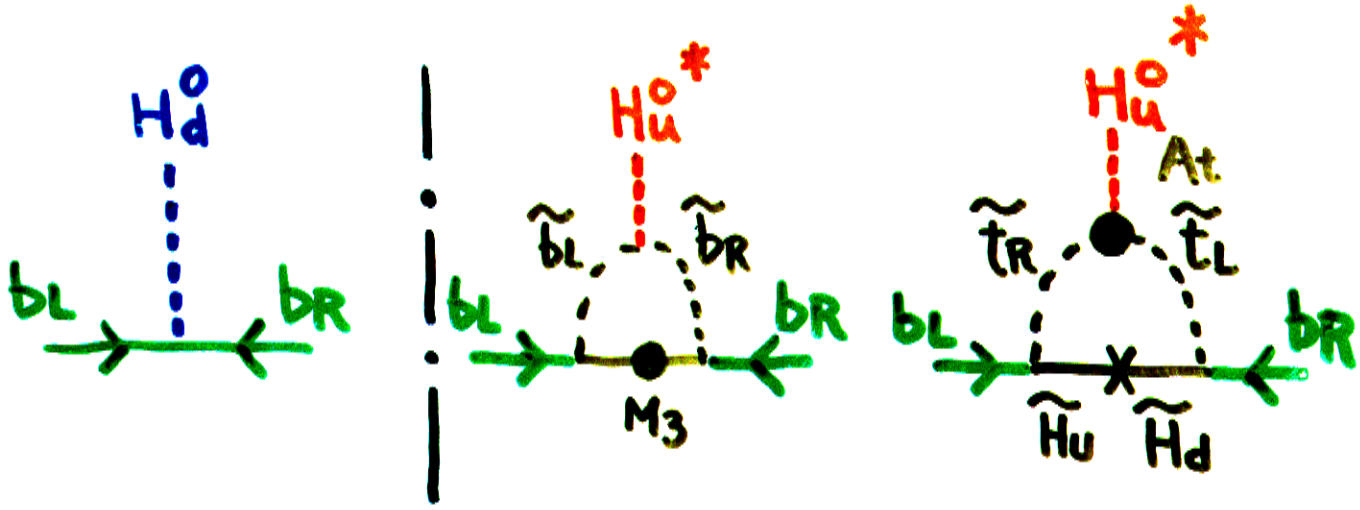
for the SM Higgs boson with a mass of 120GeV(100fb^-1).

J.Kamoshita,Y.Okada,M.Tanaka, LCWS95 & PLB391(97)124

I.Nakamura, Kawagoe, LCWS95 & PRD54(96)3634, I.Nakamura, LCWS99

## ● $h b \bar{b}$ coupling and the Yukawa structure of the effective theory.

The corrections due to the ~~SUSY~~ violate the Type II structure of the Yukawa interactions of the MSSM.




$f_b \bar{b}_L b_R H_d^0 \qquad f_b \epsilon_b \bar{b}_L b_R H_u^{0*}$

$$\epsilon_b = \frac{2\alpha_s}{3\pi} \mu M_3 f(M_3^2, m_{\tilde{b}_L}^2, m_{\tilde{b}_R}^2) + \frac{f_t^2}{16\pi^2} \mu A_t f(\mu^2, m_{\tilde{t}_L}^2, m_{\tilde{t}_R}^2)$$

$\sim O(1\%)$ Babu-Kolda, Eberl et.al. Logan et.al.

- $m_b = f_b v_d + f_b \epsilon_b v_u = f_b(1+\epsilon_b \tan\beta) \times v\cos\beta$

- $\mathcal{L}_{hb\bar{b}} = -\frac{m_b \cdot \sin\alpha}{v\cdot\cos\beta}\underbrace{\left(\frac{1-\epsilon_b/\tan\alpha}{1+\epsilon_b\tan\beta}\right)}$

$$\sim \left\{1 - 2\frac{m_t^2}{m_A^2}\frac{\epsilon_b\tan\beta}{1+\epsilon_b\tan\beta}\right\}$$

The effect of $\epsilon_b$ on the b-quark mass becomes significant when $\tan\beta$ is large.

$$\frac{Br(h\to c\bar{c})}{Br(h\to b\bar{b})} = \frac{m_c^2}{m_b^2}\cdot\frac{1}{(\tan\alpha\tan\beta)^2}\left[\frac{1+\epsilon_b\tan\beta}{1-\epsilon_b/\tan\alpha}\right]^2$$

$$\frac{Br(h\to \tau^+\tau^-)}{Br(h\to b\bar{b})} = \frac{m_\tau^2}{3m_b^2}\left[\frac{1+\epsilon_b\tan\beta}{1-\epsilon_b/\tan\alpha}\right]^2$$

Effective theory below Msusy is the general 2HDM.

Note:

$$\frac{Br(h\to c\bar{c})}{Br(h\to \tau^+\tau^-)} = \frac{3m_c^2}{m_\tau^2}\times\frac{1}{(\tan\alpha\cdot\tan\beta)^2}$$

$\cdots \epsilon_b$ independent.

# Experimental & Theoretical errors.

- Nakamura - Kawagoe

  PRD 54.3634, LCWS99

  the S.M. Higgs boson (120 GeV)

- $\hat{\alpha}_s(M_Z)$ : 0.1181 ± 0.002

  $\hat{m}_b(m_b)$ : 4.20 ± 0.13 GeV (±3%)

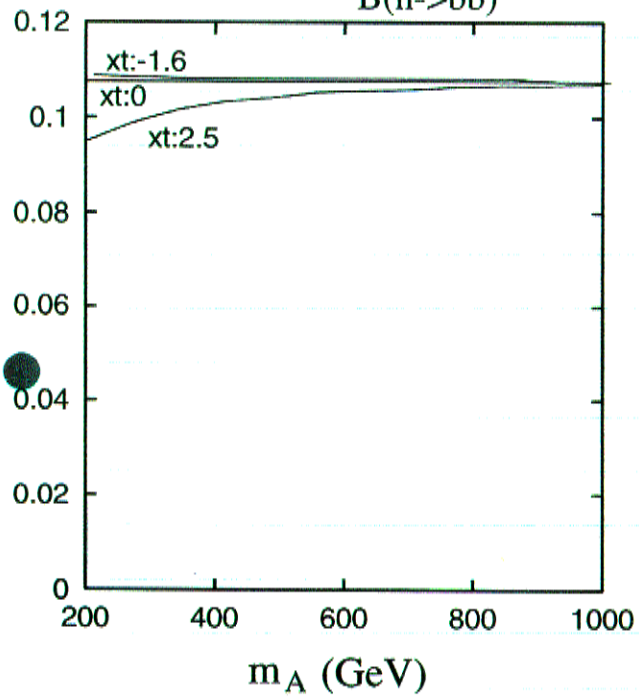
  $\hat{m}_c(m_c)$ : 1.25 ± 0.06 GeV (±5%)

| | Exp. (%) | Th. (%) | Total (%) |
|---|---|---|---|
| $\frac{Br(h\to c\bar{c})+Br(h\to gg)}{Br(h\to b\bar{b})}$ | 15.0 / 6.7 | 8.6 | 17.3 / 10.9 |
| $\frac{Br(h\to \tau^+\tau^-)}{Br(h\to b\bar{b})}$ | 10.0 / 4.5 | 7.6 | 12.6 / 8.8 |
| $\frac{Br(h\to c\bar{c})+Br(h\to gg)}{Br(h\to \tau^+\tau^-)}$ | 19.5 / 8.7 | 4.1 | 19.9 / 9.6 |
| | 100 / 500 fb$^{-1}$ | | 100 / 500 fb$^{-1}$ |

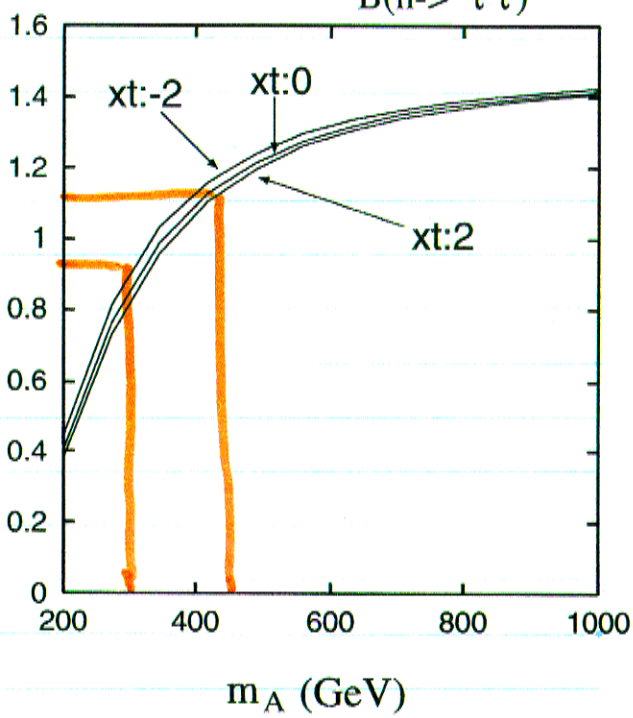
# $\tan\beta = 10$



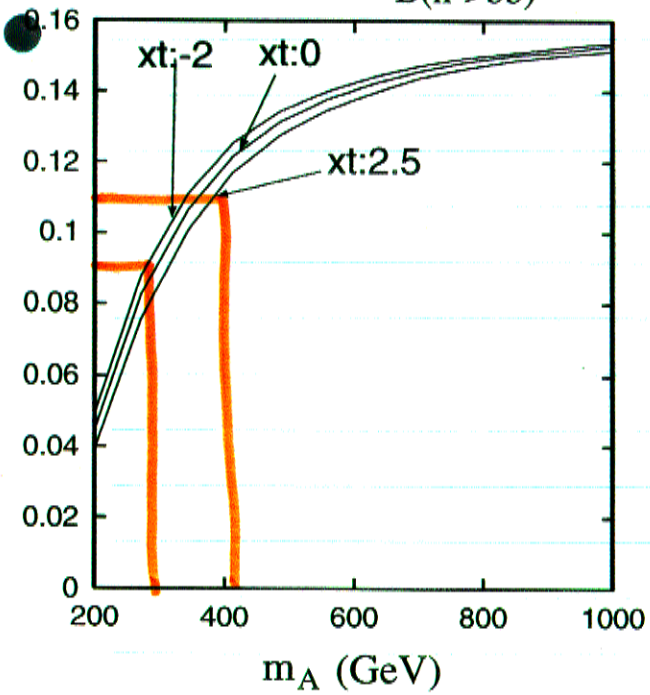
$$R_{\tau^+\tau^-/\,b\bar{b}} = \frac{B(h\to\ \tau^+\tau^-)}{B(h\to b\bar{b})}$$




$$R_{c\bar{c}+gg\,/\,\tau^+\tau^-} = \frac{B(h\to c\bar{c}) + B(h\to gg)}{B(h\to\ \tau^+\tau^-)}$$




$$R_{c\bar{c}+gg\,/\,b\bar{b}} = \frac{B(h\to c\bar{c}) + B(h\to gg)}{B(h\to b\bar{b})}$$




$xt = At / M_{Susy}$

$M^2_{SUSY} := m^2_{\tilde{t}_L} = m^2_{\tilde{t}_R} = m^2_{\tilde{t}_R}$

$m_h = 120$ GeV

$\tan\beta = 10$

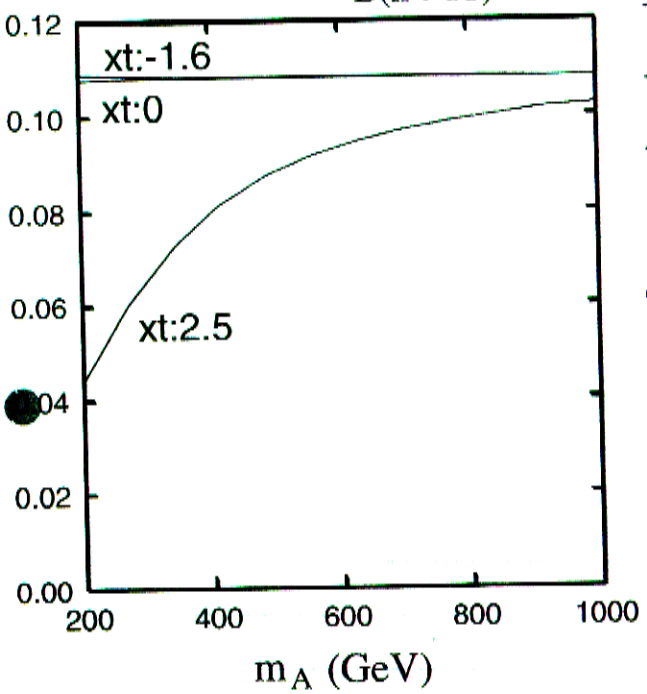
M3 = 300GeV

$\mu$ = 300GeV

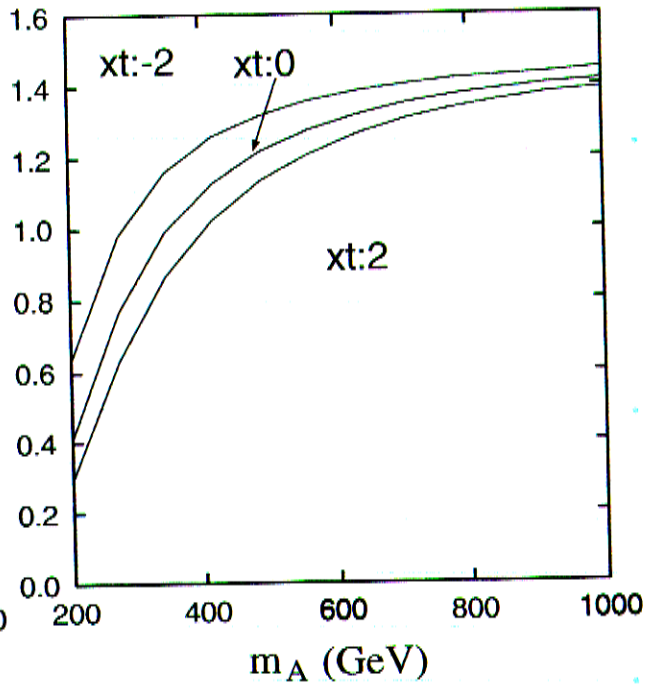
We chose Msusy such that $m_h$ became 120GeV for each $m_A$ with fixing the ratio Xt

# tanβ = 30

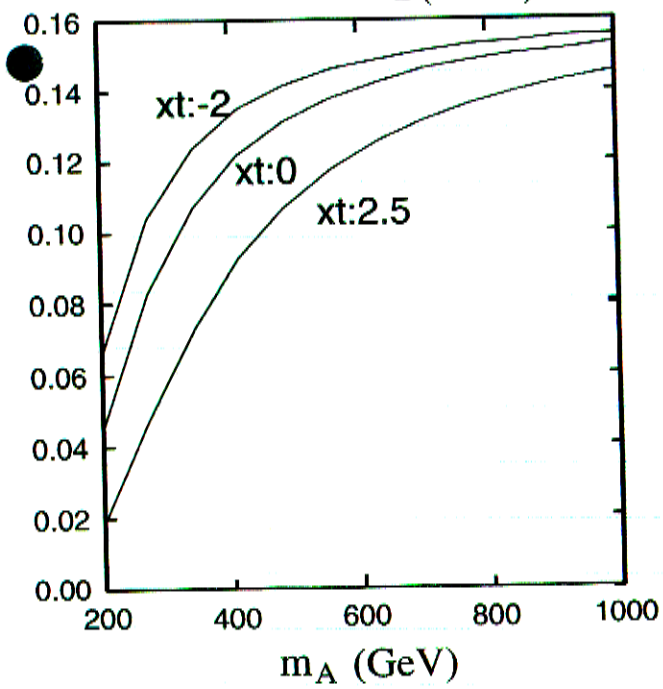
$$R_{\tau^+\tau^-/\,b\bar{b}} = \frac{B(h\to \tau^+\tau^-)}{B(h\to b\bar{b})}$$




$$R_{c\bar{c}+gg\,/\,\tau^+\tau^-} = \frac{B(h\to c\bar{c}) + B(h\to gg)}{B(h\to \tau^+\tau^-)}$$




$$R_{c\bar{c}+gg\,/\,b\bar{b}} = \frac{B(h\to c\bar{c}) + B(h\to gg)}{B(h\to b\bar{b})}$$




$xt = At / M_{Susy}$

$m_h = 120$ GeV

$\tan\beta = 30$

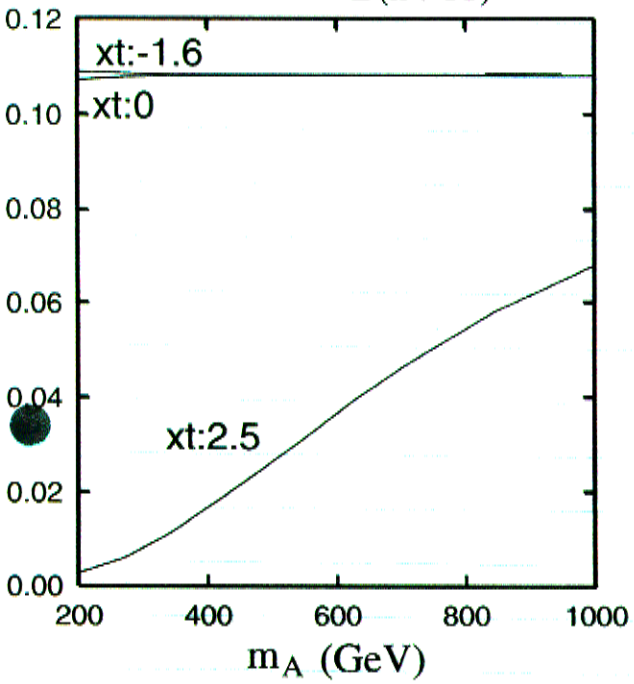
M3 = 300GeV

μ = 300GeV

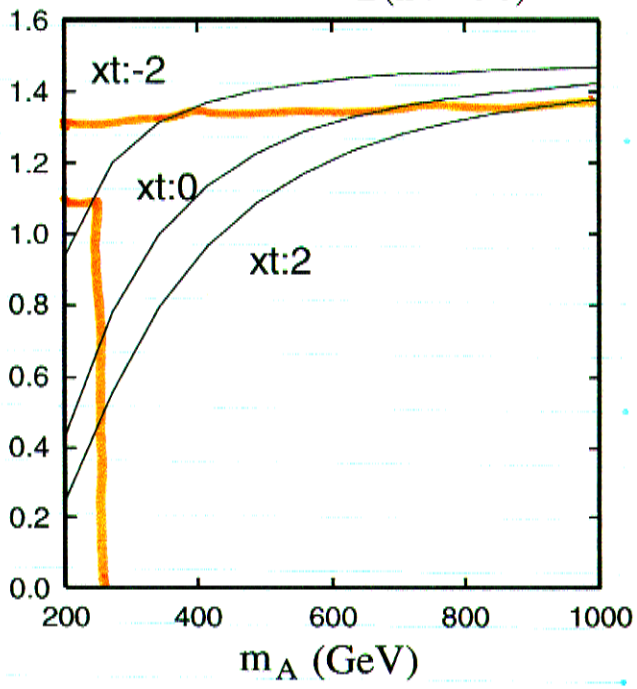
# $\tan\beta = 50$

DATE No

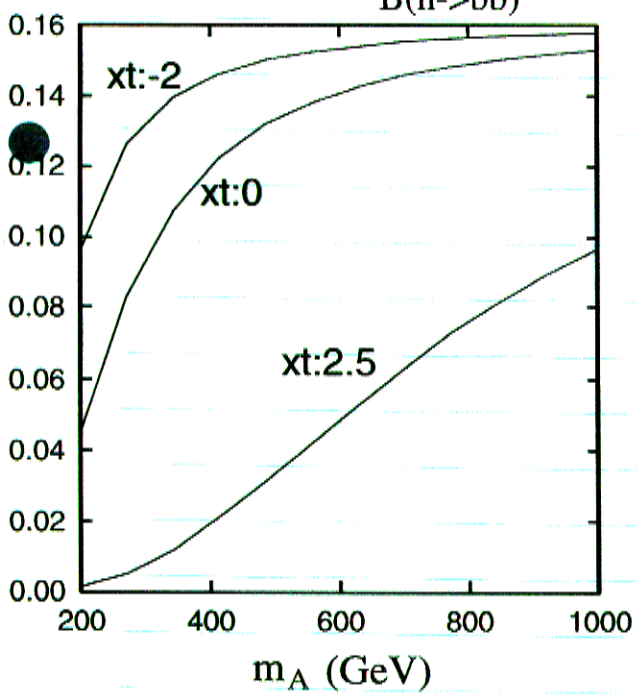
$$R_{\tau^+\tau^-/\,b\bar{b}} = \frac{B(h\to \tau^+\tau^-)}{B(h\to b\bar{b})}$$




$$R_{c\bar{c}+gg\,/\,\tau^+\tau^-} = \frac{B(h\to c\bar{c}) + B(h\to gg)}{B(h\to \tau^+\tau^-)}$$




$$R_{c\bar{c}+gg\,/\,b\bar{b}} = \frac{B(h\to c\bar{c}) + B(h\to gg)}{B(h\to b\bar{b})}$$




$$Xt = At / M_{Susy}$$

$m_h = 120$ GeV

$\tan\beta = 50$

M3 = 300GeV

$\mu$ = 300GeV

# Conclusion.

We estimated the theoretical uncertainties due to the SUSY-loop corrections on the double ratios between the branching fractions of the lightest Higgs boson.

- $\tan\beta \lesssim 10$ .... We can constrain the range of the CP-odd Higgs mass from
  $\frac{Br(h\to c\bar{c})+Br(h\to gg)}{Br(h\to b\bar{b})}$ and
  $\frac{Br(h\to c\bar{c})+Br(h\to gg)}{Br(h\to \tau^+\tau^-)}$.
- $\tan\beta \gtrsim 30$ .... We can set the lower bound for the CP-odd Higgs mass from the double ratio. $\frac{Br(h\to c\bar{c})+Br(h\to gg)}{Br(h\to \tau^+\tau^-)}$.