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# Higgs working group report

Yoshiaki Yasui

Higgs Selfcoupling

Top Yukawa

Heavy Higgs

# What we can do at LC (after LHC)?

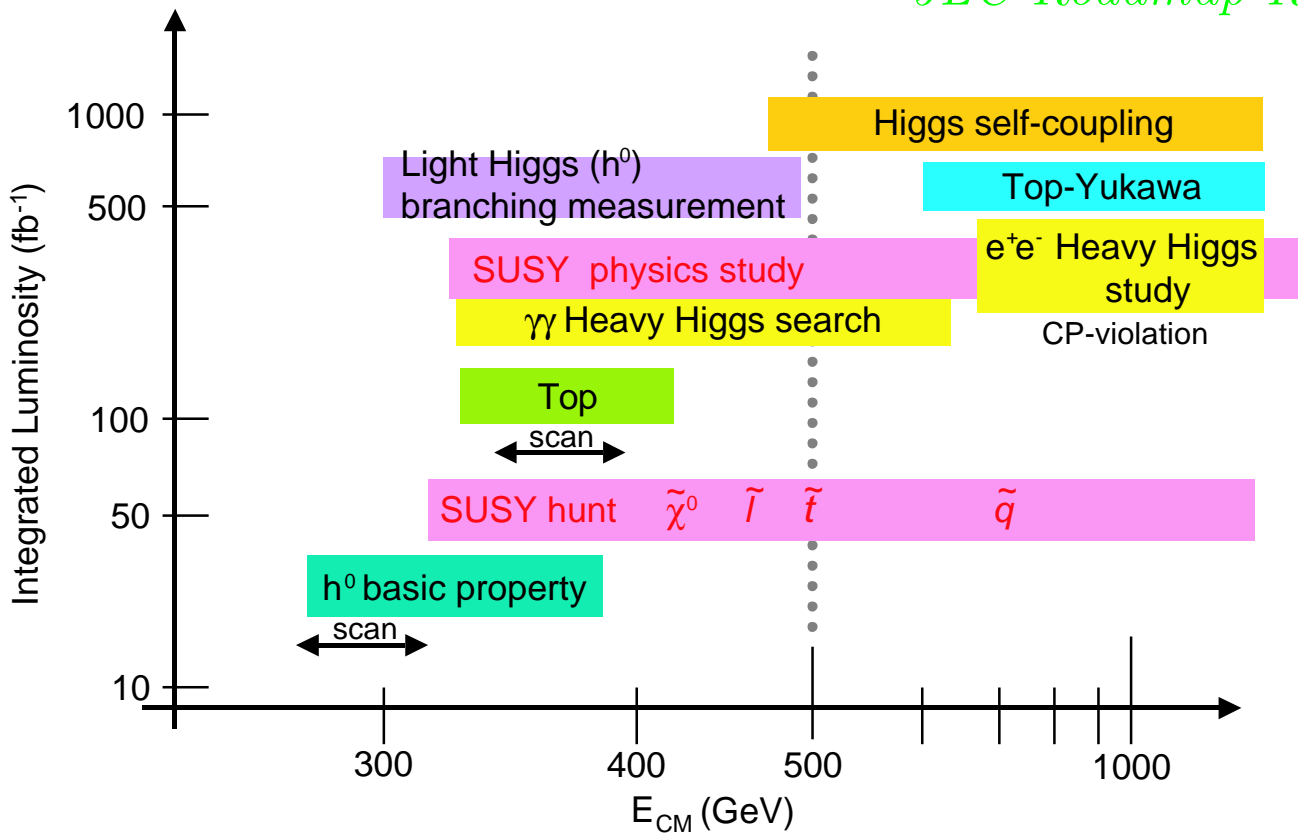
Expected Scenario  $\leftarrow$  Higgs boson is relatively light in SM

LHC Higgs boson discovery

$\Rightarrow$  LC Precise measurement of Higgs sector

Potential of LC

*JLC Roadmap Report*



$\sqrt{s} = 500$  GeV Single Higgs production  $\sim \mathcal{O}(100) fb$

$\Rightarrow$  TeV scale  $\dots$  Multi Higgs, Top Yukawa, Heavy Higgs

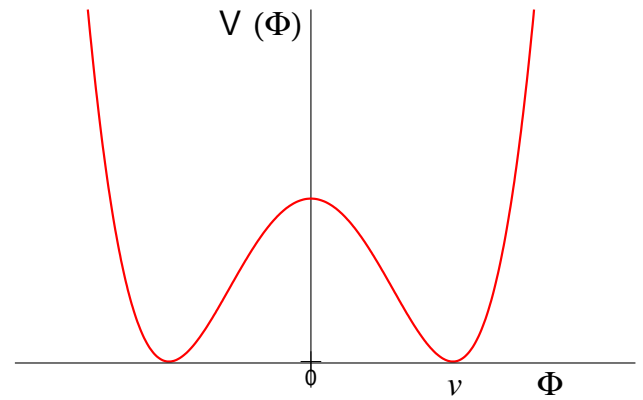
# Higgs Self coupling measurement

## ↓ Higgs potential and SSB

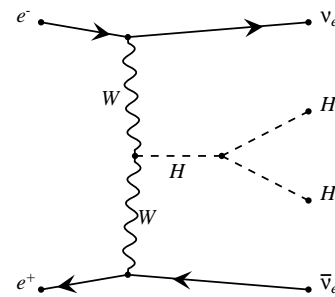
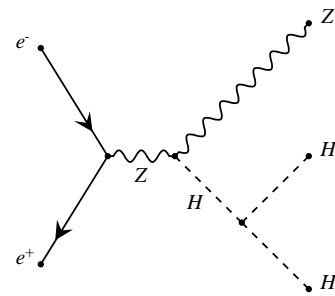
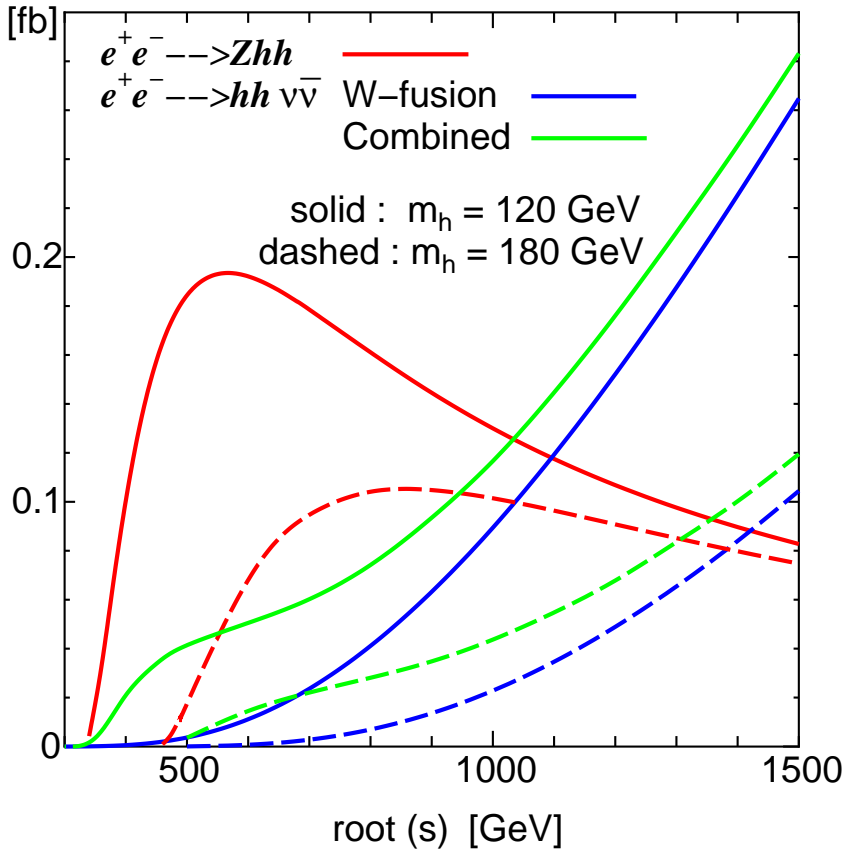
$$V(\Phi) = -\mu^2 \Phi^\dagger \Phi + \lambda (\Phi^\dagger \Phi)^2$$

$$\Phi = \frac{1}{\sqrt{2}} \begin{pmatrix} i\xi_1 + \xi_2 \\ v + h - i\xi_3 \end{pmatrix}$$

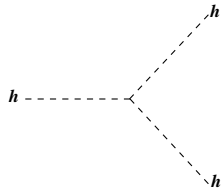
$$m_h^2 = 2\lambda v^2 \text{ at tree}$$



total cross section



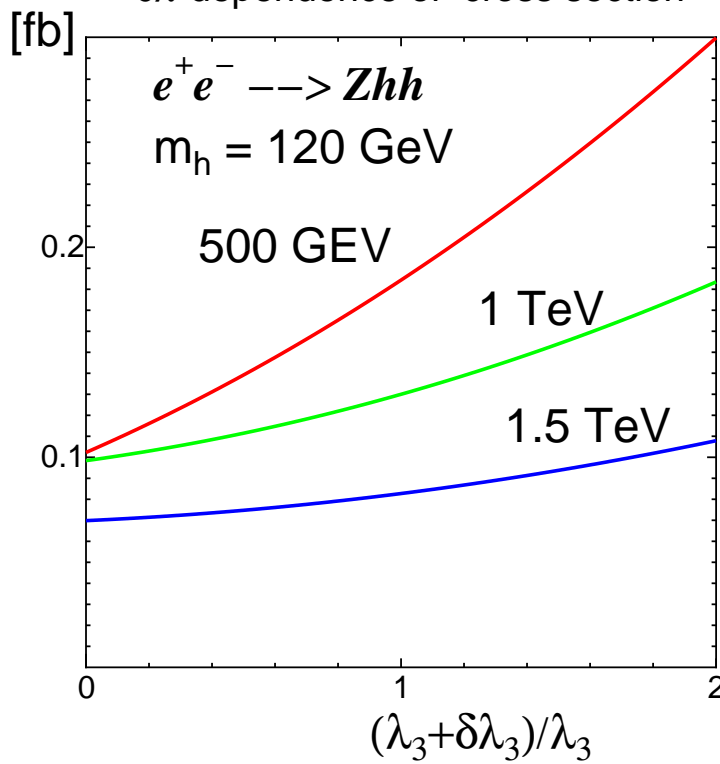
## Triple Higgs coupling $\lambda_3$



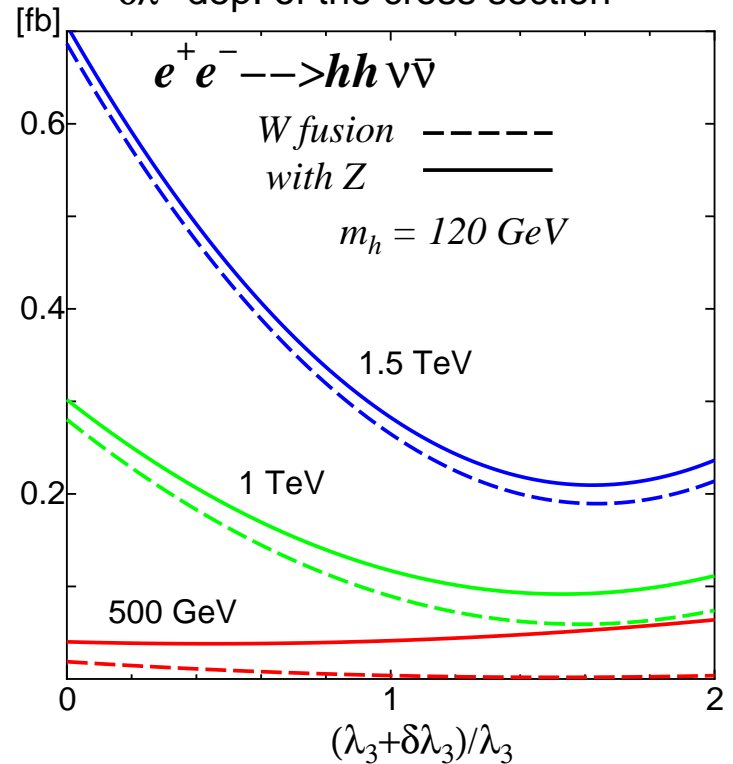
triple-Higgs coupling

$$\lambda_3 hhh \implies (\lambda_3 + \delta\lambda_3) hhh$$

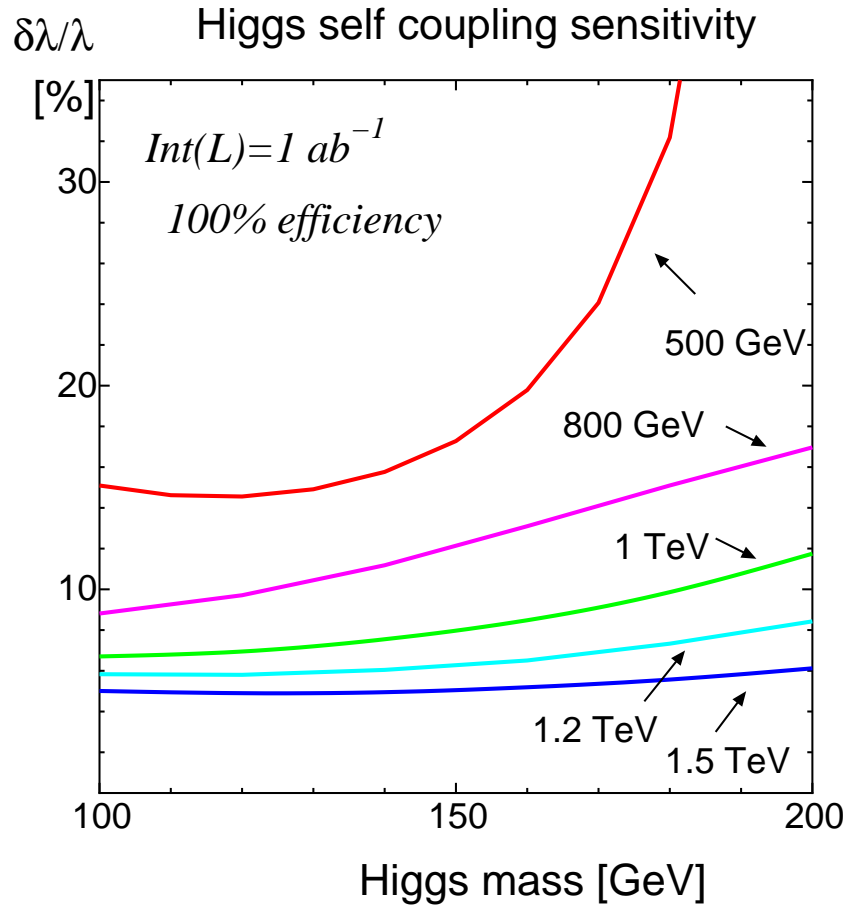
$\delta\lambda$  dependence of cross section



$\delta\lambda$ -dep. of the cross section



by GRACE and CompHEP



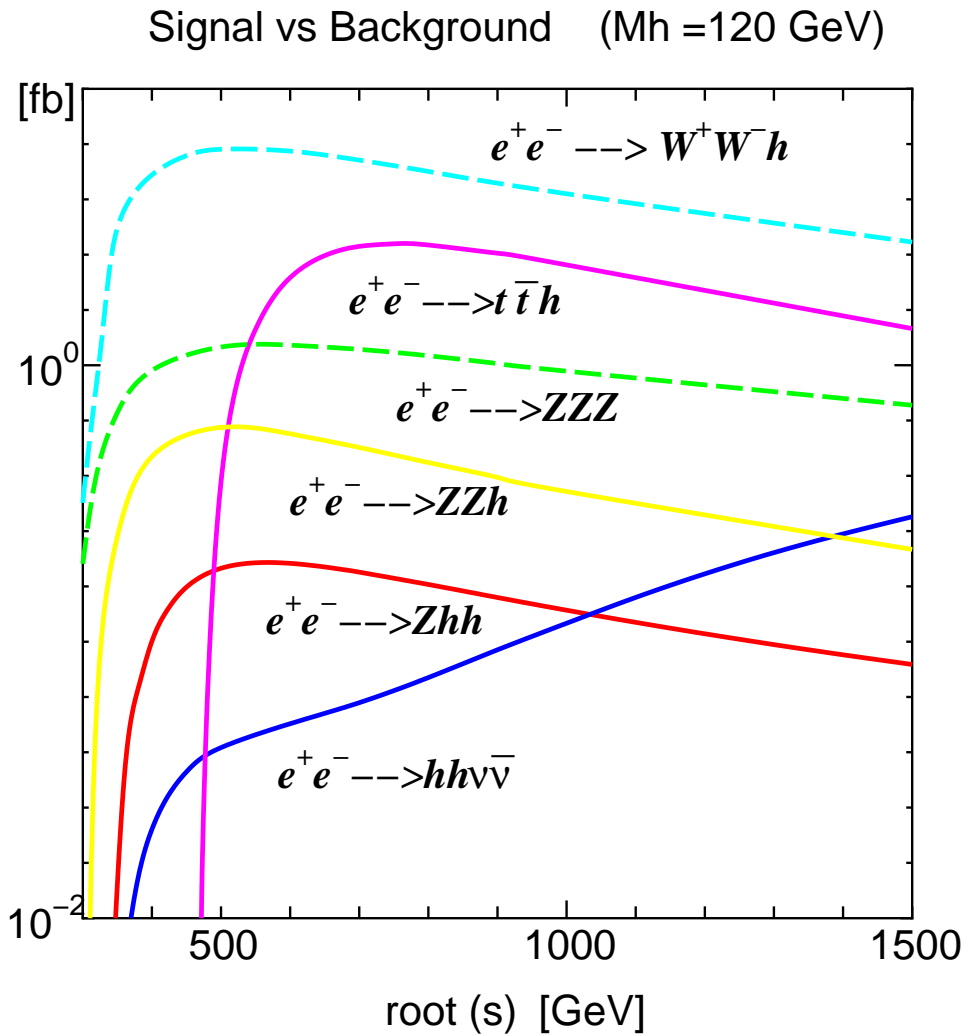
★  $\sqrt{s} = 500\ \text{GeV} \dots Zhh$  channel is dominant

⇒  $m_h \lesssim 150\ \text{GeV}: \delta\lambda_3/\lambda_3 \simeq 15\%$

⇒  $m_h \gtrsim 150\ \text{GeV}: \delta\lambda_3/\lambda_3 > 20\%$

★  $\sqrt{s} > 1\ \text{TeV} \dots W$  fusion is dominant

⇒  $\delta\lambda_3/\lambda_3 < 10\%$



GRACE → PYTHIA/JETSET → Simulation

Miyamoto

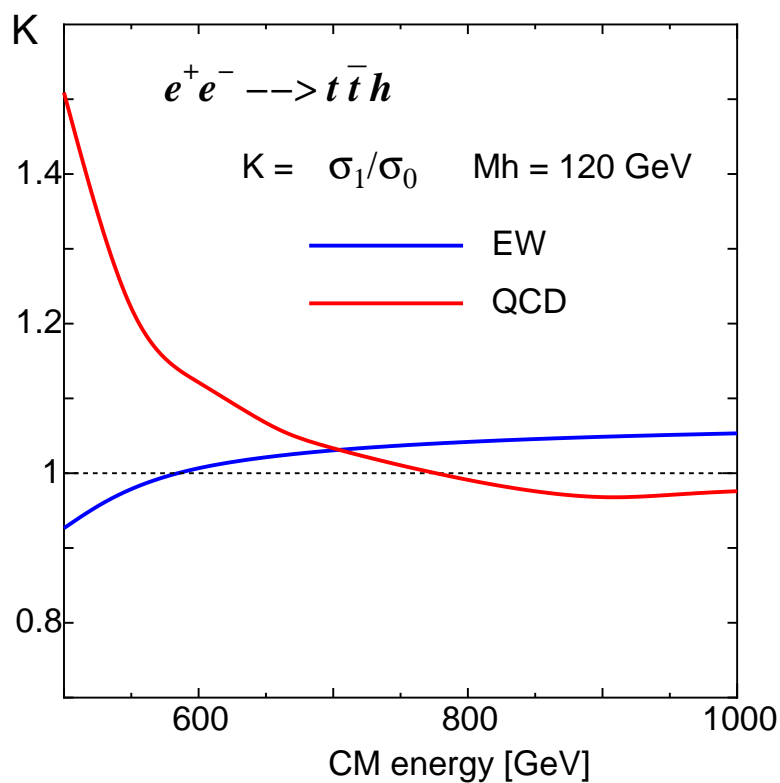
Ex.  $m_t = 170 \text{ GeV}$ ,  $M_h = 100 \text{ GeV}$

...  $\sigma \sim 3 \text{ fb}$  at  $\sqrt{s} = 700 \text{ GeV} \Rightarrow \Delta Y_t / Y_t \sim 7\%$  for  $100 \text{ fb}^{-1}$

## Theoretical uncertainty

large radiative correction

- QCD [Dittmaier-Krämer-Liao-Spira-Zerwas, Dawaon-Reina](#)
- Electro-Weak (Top Yukawa) [by Minami Tateya group](#)



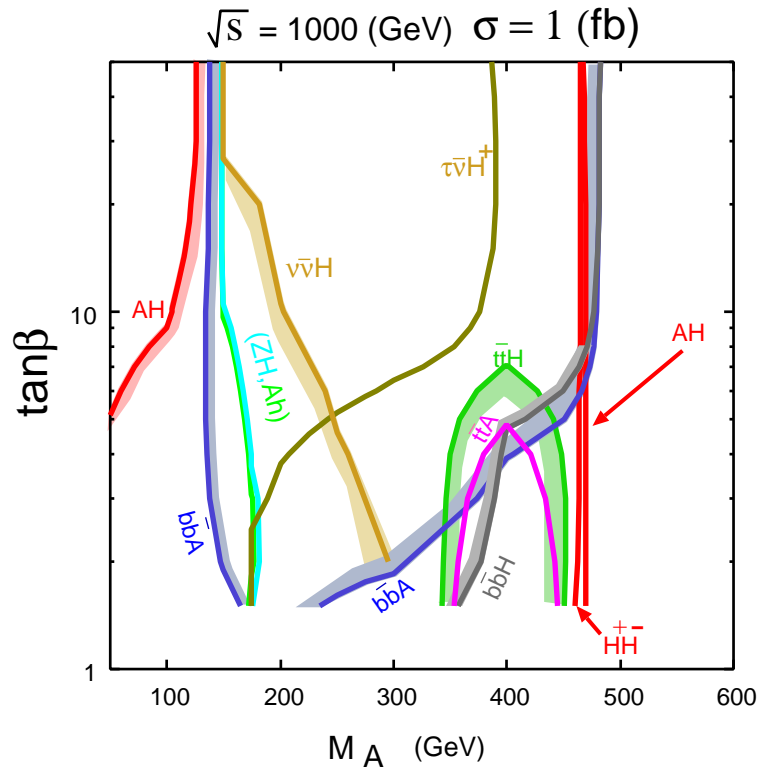
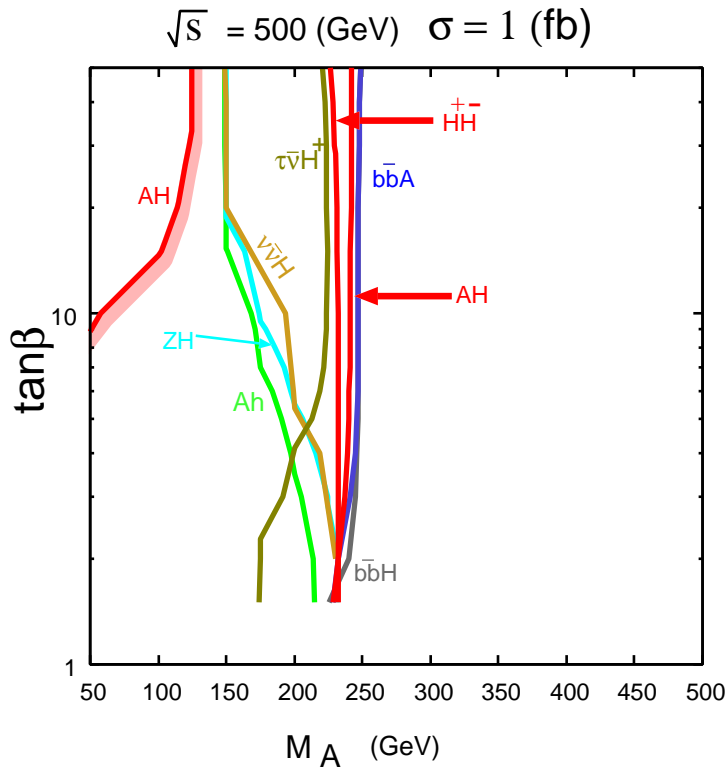
# Heavy Higgs in MSSM

$$e^+e^- \rightarrow ZH, Ah, AH, H^+H^-, W^\pm H^\mp$$

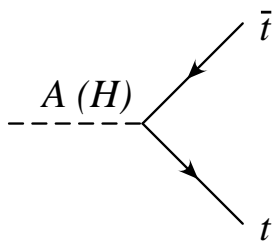
$$e^+e^- \rightarrow b\bar{b}A, b\bar{b}H, t\bar{t}A, t\bar{t}H, \nu\bar{\nu}H, \tau\bar{\tau}H, \tau\bar{\tau}A$$

HDECAY, FeynHiggs, SUSY-GRACE

$W^\pm H^\mp$  (loop induced) by Kanemura-Moretti-Odagiri

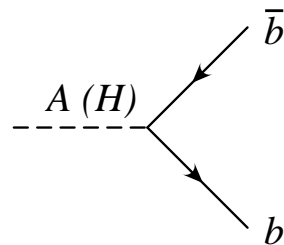


$\tan \beta$  dep. for  $e^+e^- \rightarrow t\bar{t}A, t\bar{t}H, b\bar{b}A, b\bar{b}H$



$$\sim \cot \beta (\sim 1/\sin \beta)$$

$\tan \beta$   
Small  $\iff$  Large



$$\sim \tan \beta (\sim 1/\cos \beta)$$

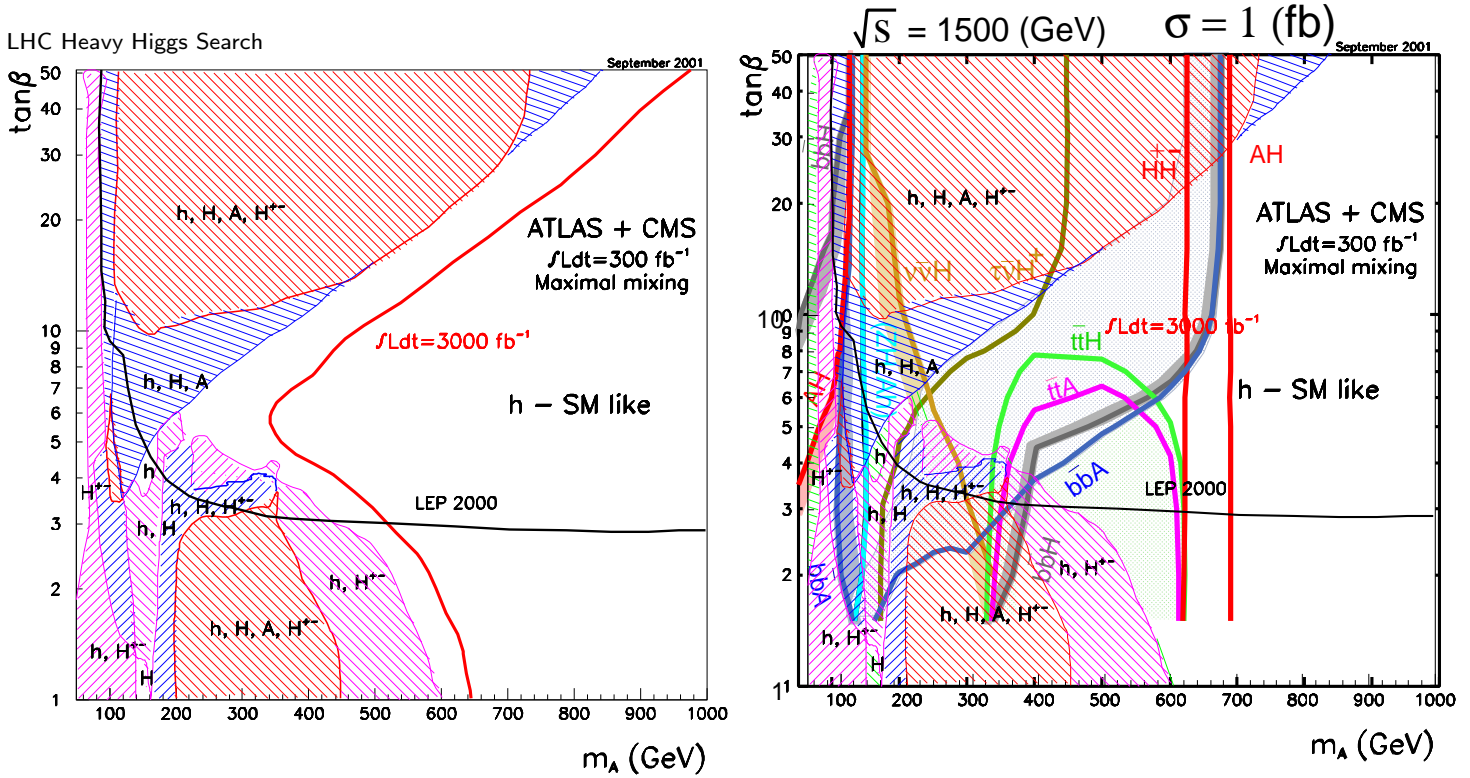


## Heavy Higgs Search at LC

TeV class LC has the potential of the Higgs bosons search.

★ If  $\sqrt{s} \sim 1$  (1.5) TeV,

LC cover the region of  $\tan \beta \lesssim 10$  (20),  $M_A \lesssim \sqrt{s}/2$



## Higgs physics at LC

Origin of the Electroweak symmetry breaking ←GOAL



Structure of the Higgs potential



500 GeV: Higgs mass, branching ratio, etc.

1TeV: Self coupling, Top Yukawa, Heavy Higgs, etc.



LHC : Higgs discovery ←START

## Future prospect

★ Background analysis (by GRACE)

⇒ ○  $M_h \sim 120 - 130 \text{ GeV}$   $h \rightarrow b\bar{b}$

⇒ ×  $M_h > 140 \text{ GeV}$   $h \rightarrow W^+W^-$

★ Event generator

○ GRACE → PYTHIA/JETSET, etc.

★ Full simulation