

Radiative Corrections to Higgs Production Processes at LC with GRACE-loop

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What is GRACE

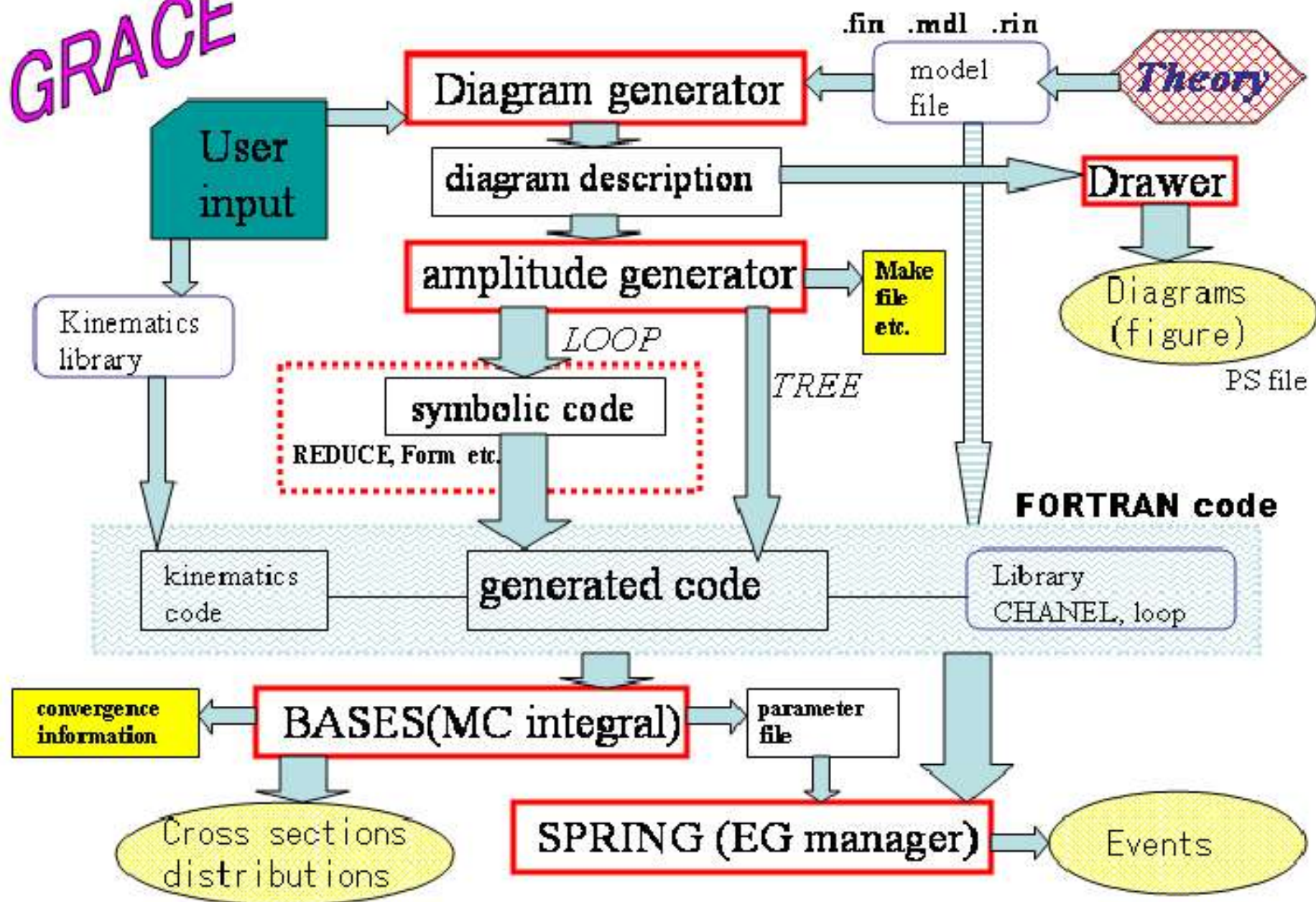
★ **GRACE is the computer code which performs the automatic calculation of the Feynman amplitudes**

- SM and MSSM
- GRACE was successfully tested at TRISTAN, LEP, LEP 2
- It is also useful for GLC, LHC study.

★ **What we can do with GRACE?**

- **Generate Feynman diagrams automatically**
- **Create FORTRAN source codes for amplitudes**
- **Calculate cross sections** ⇐ **BASES (MC integral)**
- **Generate parton events for simulation study (Spring)**

GRACE



GRACE-loop

★ Full one-loop EW radiative corrections

- On-mass shell renormalization scheme
- Dimensional regularization $n=4-2\varepsilon$
- Checks on calculation (in numerical way)
 - Ultraviolet Finiteness ($C_{UV}=1/\varepsilon$)
 - Quadruple precision \Rightarrow 30 digits
 - Infrared Finiteness (λ :photon mass)
 - Gauge parameter dependence
 - Non-linear gauge

Non-linear gauge

$$\mathcal{L}_{GF} = -\frac{1}{\xi_W} F^+ F^- - \frac{1}{\xi_Z} (F^Z)^2 - \frac{1}{2\xi_A} (F^A)^2$$

$$F^\pm \equiv (\partial_\mu \mp ie\tilde{\alpha} A_\mu \mp igc_W \tilde{\beta} Z_\mu) W^{\mu\pm} + \xi_W \frac{g}{2} (v + \tilde{\delta} H \mp i\tilde{\kappa} \chi_3) \chi^\pm$$

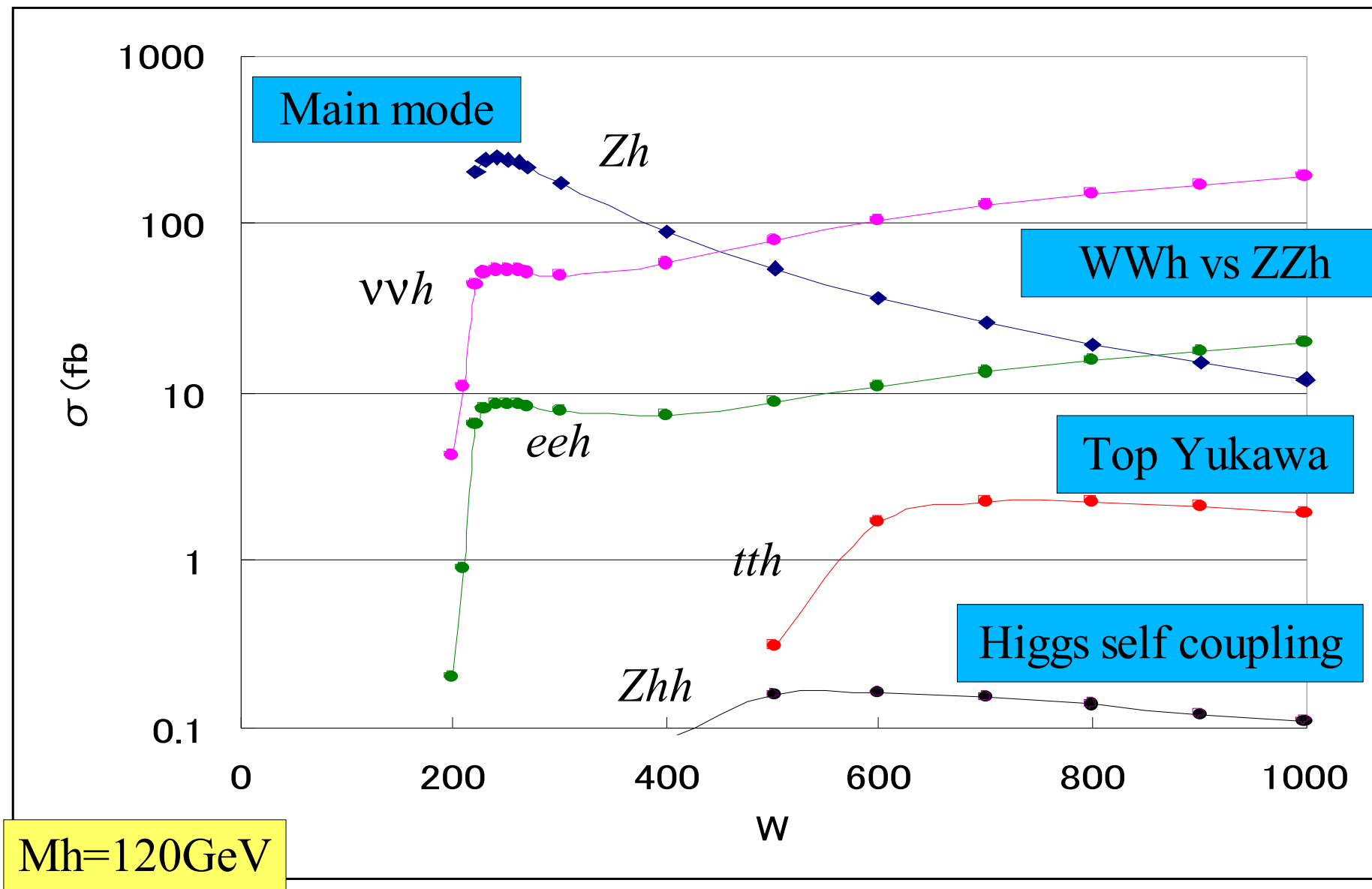
$$F^Z \equiv (\partial \cdot Z + \xi_Z \frac{g}{2c_W} (v + \tilde{\varepsilon} H) \chi_3)^2$$

$$F^A \equiv \partial \cdot A$$

Choose t'Hooft-Feynman gauge ($\xi_W = \xi_Z = \xi_A = 1$)

Vary parameters $\zeta = (\alpha, \beta, \delta, \kappa, \varepsilon)$

Higgs Physics at LC



Higgs study with GRACE-loop

★ Single Higgs production

→ $e^+e^- \rightarrow Zh$

→ $e^+e^- \rightarrow \nu\nu h$ *Phys.Lett. B559 (2003) 252-262*

→ $e^+e^- \rightarrow e^+e^- h$ *New results*

★ top Yukawa

→ $e^+e^- \rightarrow tth$ *Phys.Lett. B571 (2003) 163-172*

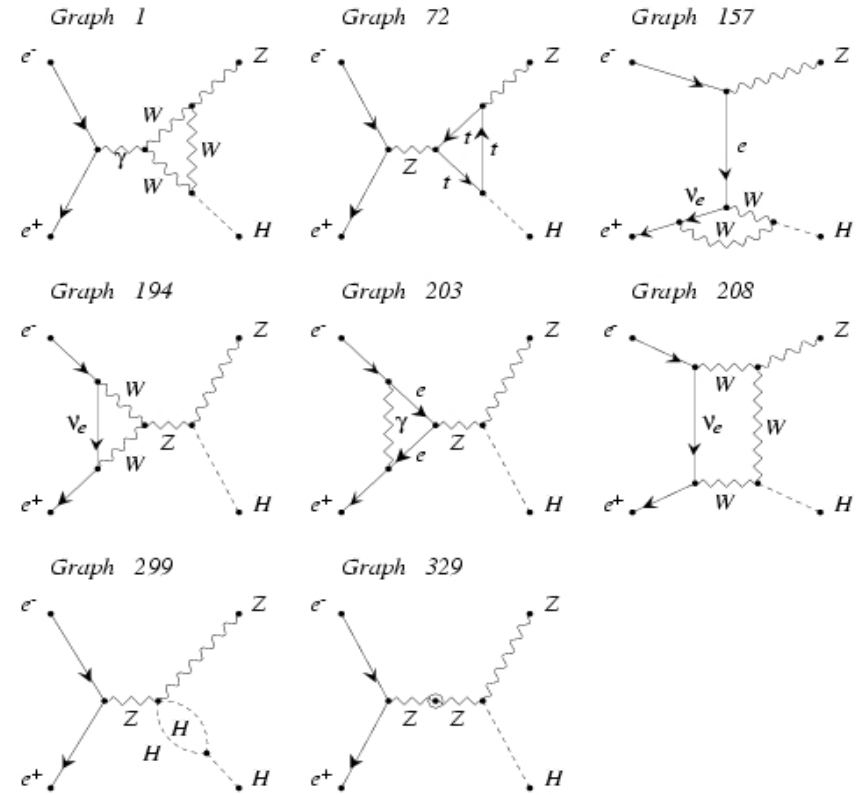
★ Multi Higgs production

→ $e^+e^- \rightarrow Zh h$ *Phys.Lett. B576 (2003) 152-164*

→ $e^+e^- \rightarrow \nu\nu h h$

$$e^+ e^- \rightarrow Zh$$

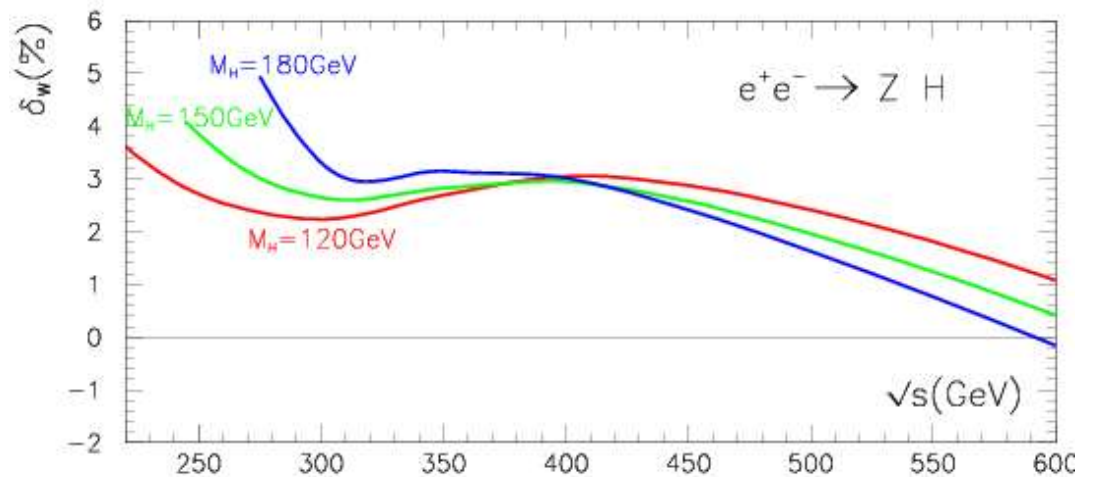
$e^+ e^- \rightarrow ZH$		GRACE-loop δ [%]	DKMB δ [%]
$\sqrt{s} = 500\text{GeV}$	$M_H = 100\text{GeV}$	4.15239	4.1524
$\sqrt{s} = 500\text{GeV}$	$M_H = 300\text{GeV}$	6.90166	6.9017
$\sqrt{s} = 1000\text{GeV}$	$M_H = 100\text{GeV}$	-2.16561	-2.1656
$\sqrt{s} = 1000\text{GeV}$	$M_H = 300\text{GeV}$	-2.49949	-2.4995
$\sqrt{s} = 1000\text{GeV}$	$M_H = 800\text{GeV}$	26.10942	26.1094
$\sqrt{s} = 2000\text{GeV}$	$M_H = 100\text{GeV}$	-11.54131	-11.5414
$\sqrt{s} = 2000\text{GeV}$	$M_H = 300\text{GeV}$	-12.82256	-12.8226
$\sqrt{s} = 2000\text{GeV}$	$M_H = 800\text{GeV}$	11.24680	11.2468



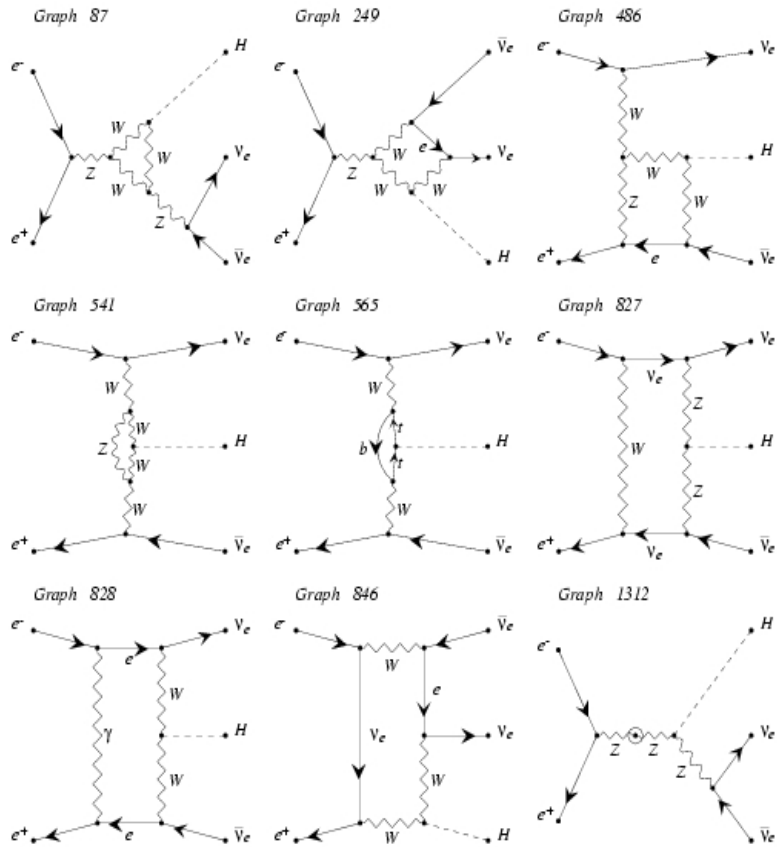
produced by GRACEFIG

DKMB:
Denner-Kublbeck-Mertg-Bohm
Z.Phys C56(1996)

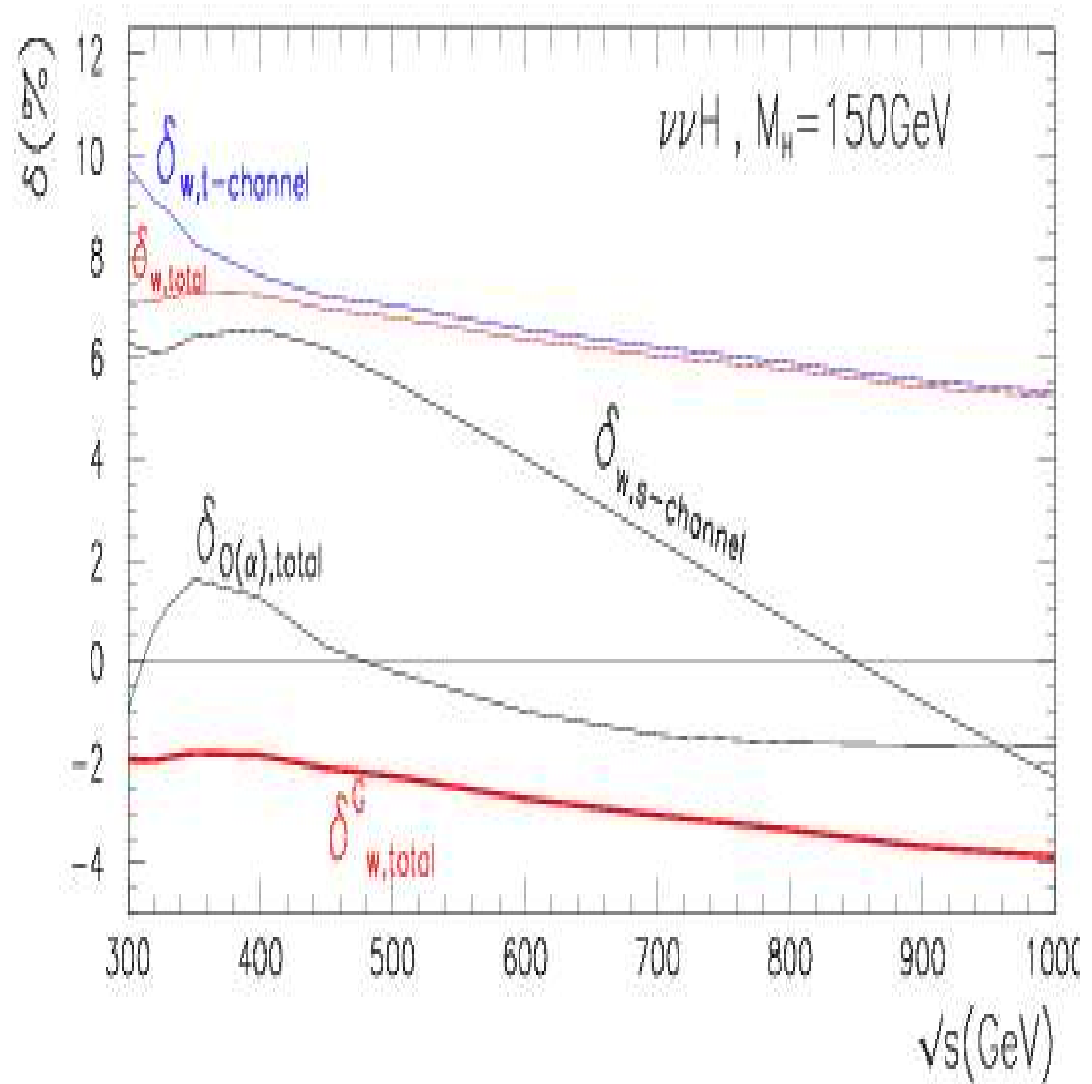
$$\begin{aligned} \sigma &= \sigma_0 (1 + \delta) \\ &= \sigma_0 (1 + \delta_{\text{QED}} + \delta_{\text{W}}) \end{aligned}$$



$$e^+ e^- \rightarrow \nu \nu h$$



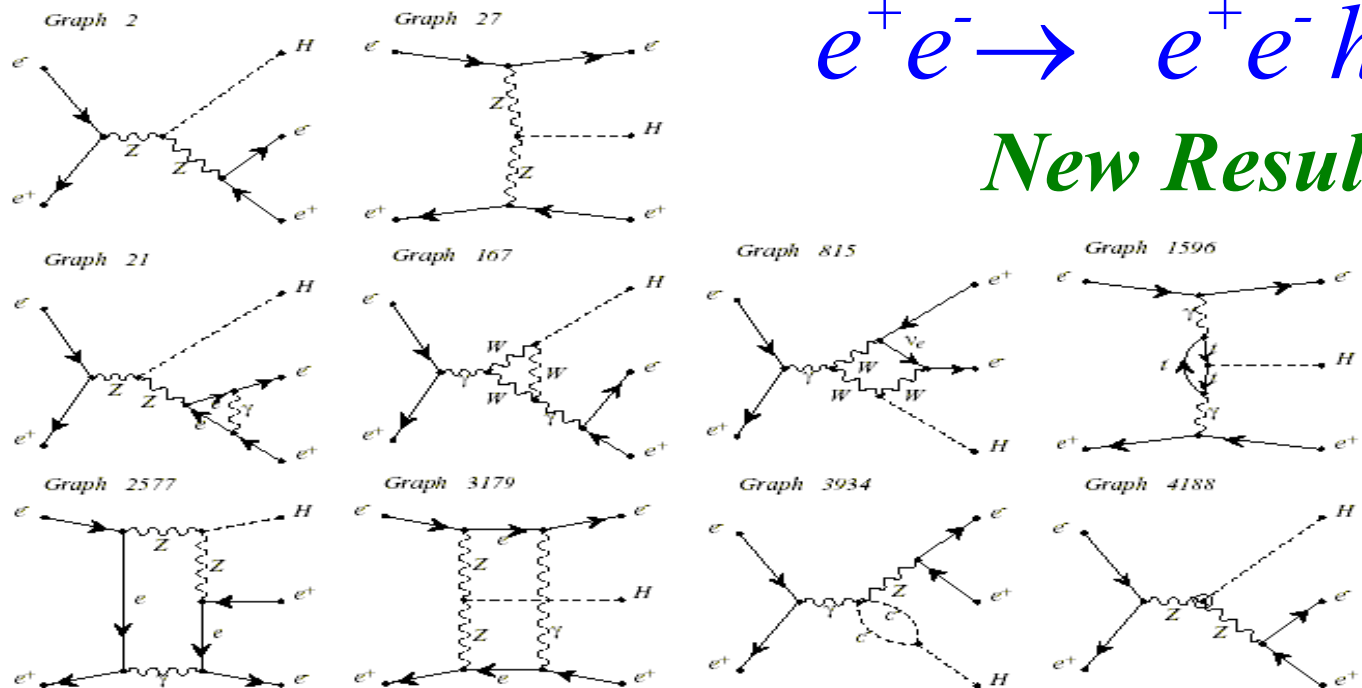
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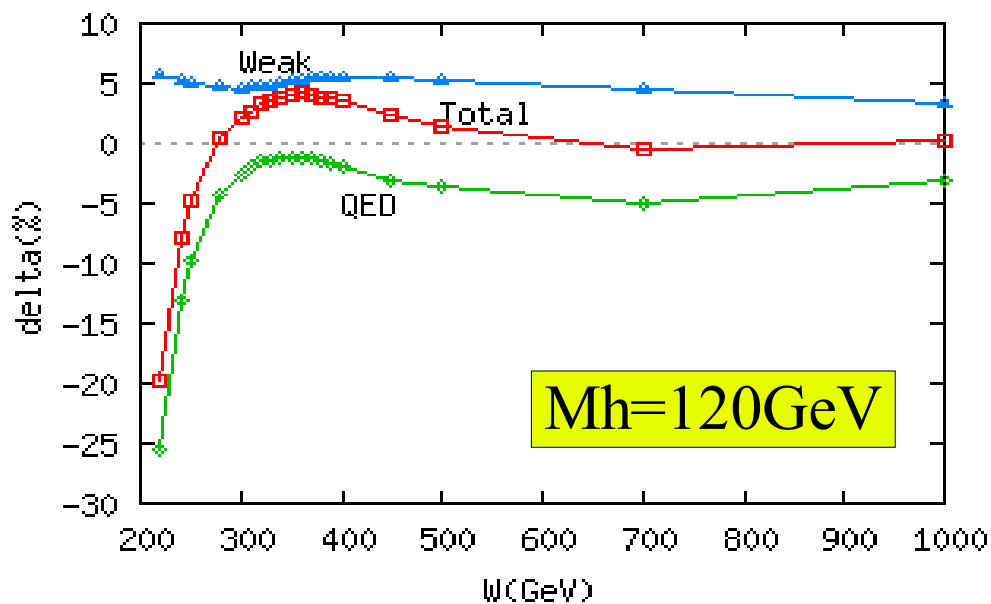
GRACE Phys.Lett.B559(2003)252
Denner et al. Nucl.Phys.B660(2003)289

$$e^+e^- \rightarrow e^+e^-h$$

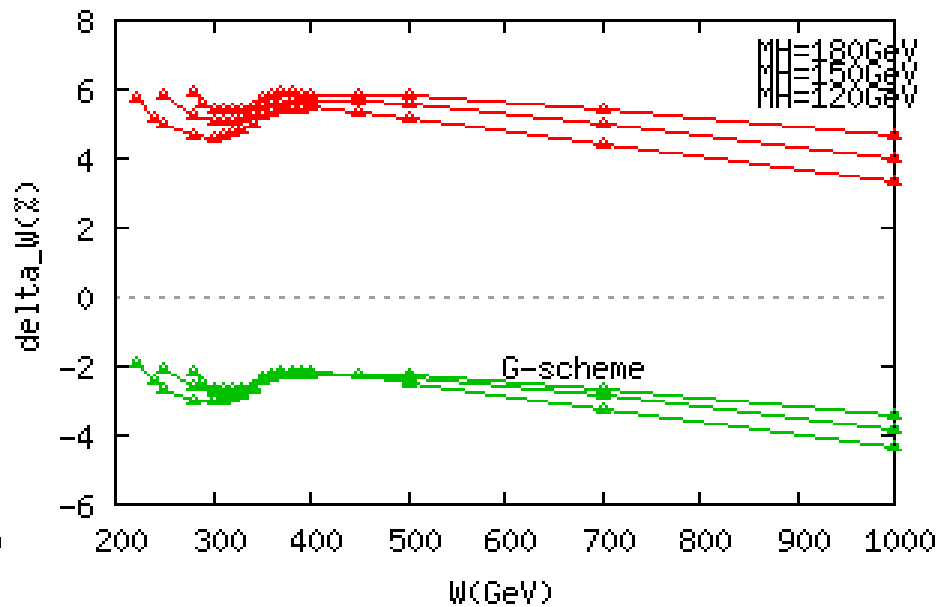
New Results



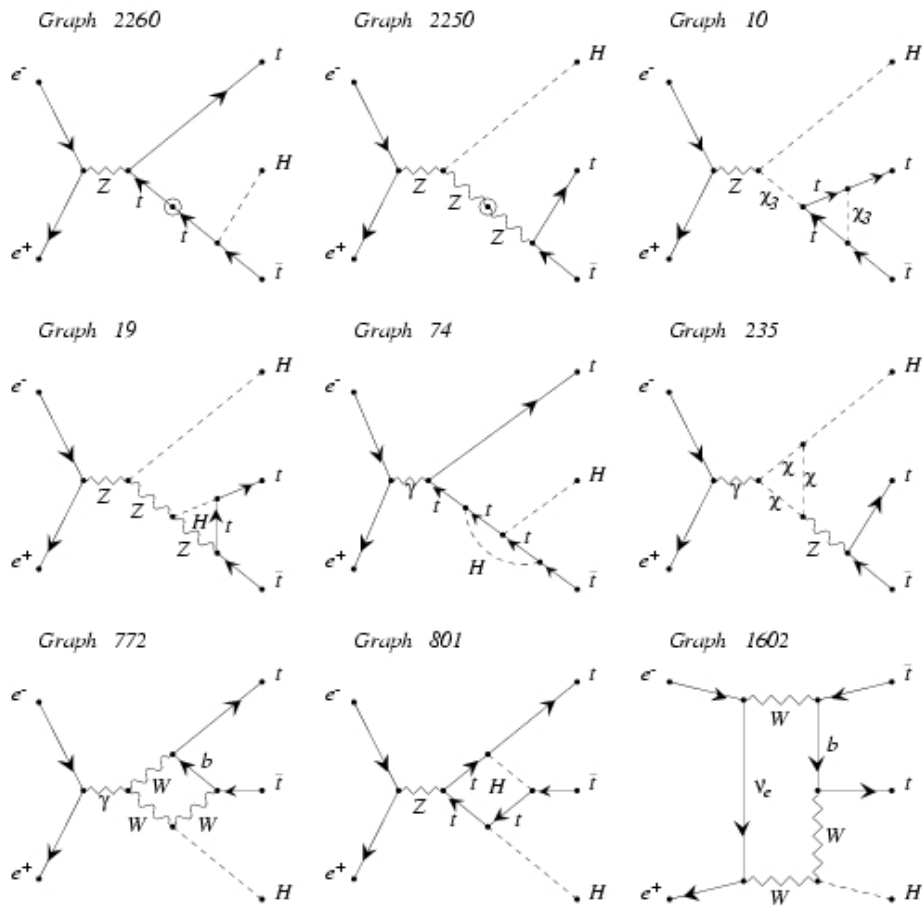
eeeeH, 1-loop



eeeeH, 1-loop

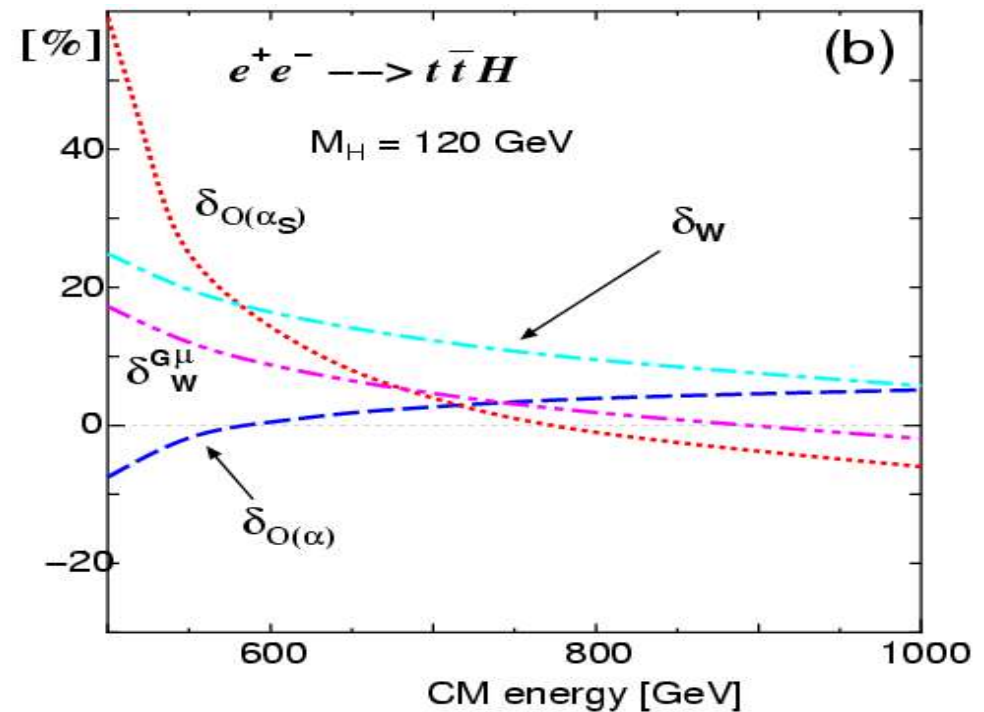
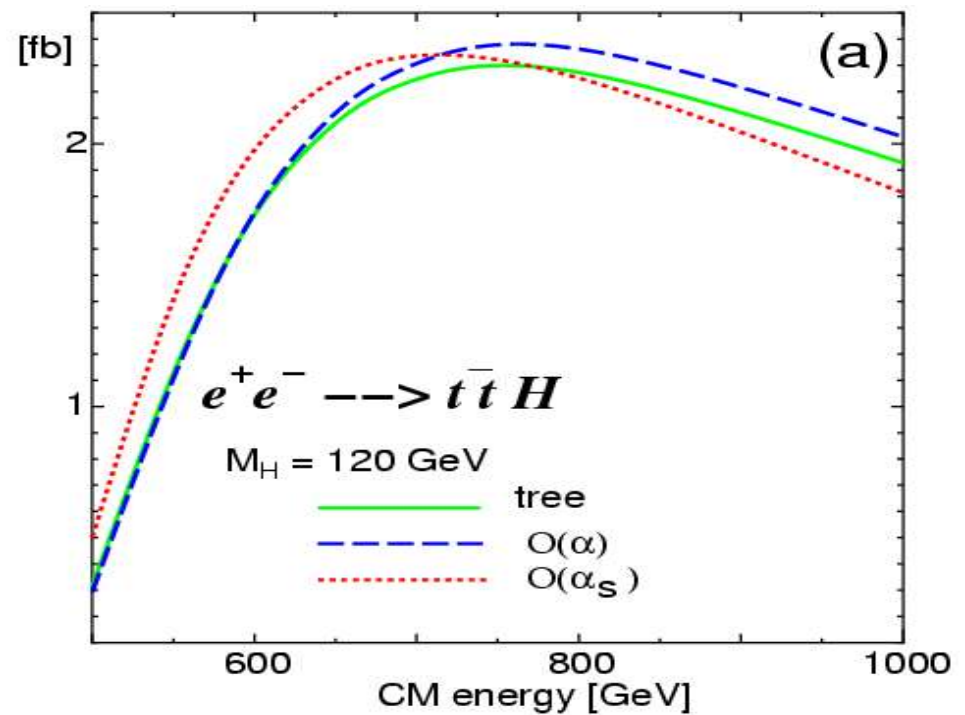


$$e^+ e^- \rightarrow t t h$$

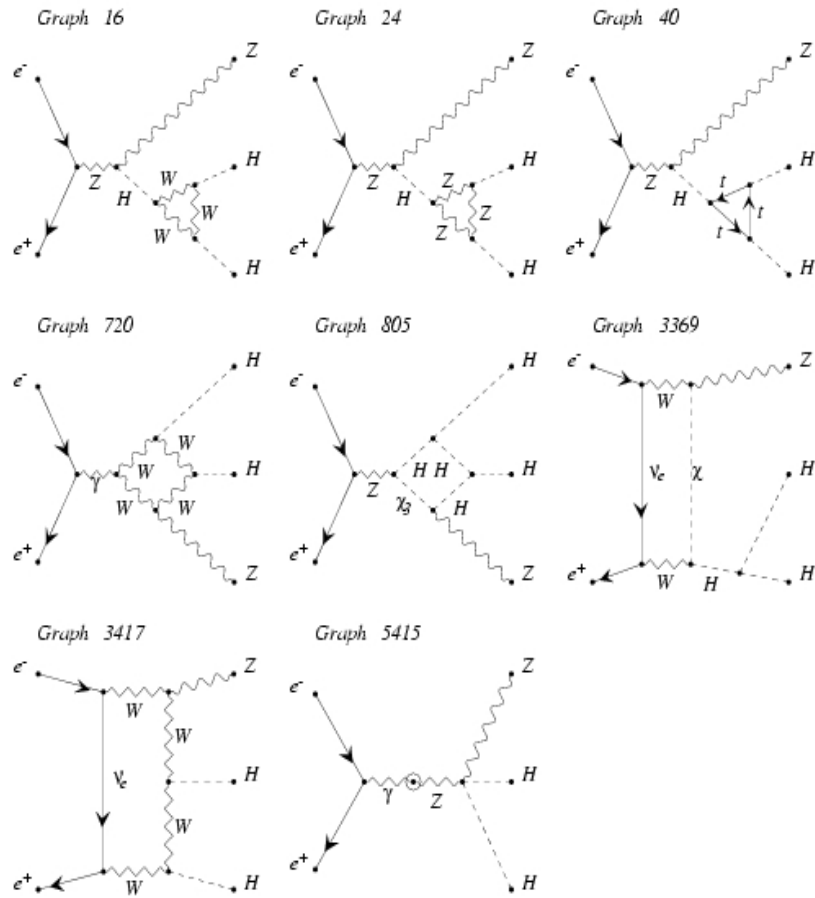


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You et al. Phys.Lett.B571(2003)85 ?
GRACE Phys.Lett.B571(2003)163
Denner et al. Phys.Lett.B575(2003)290

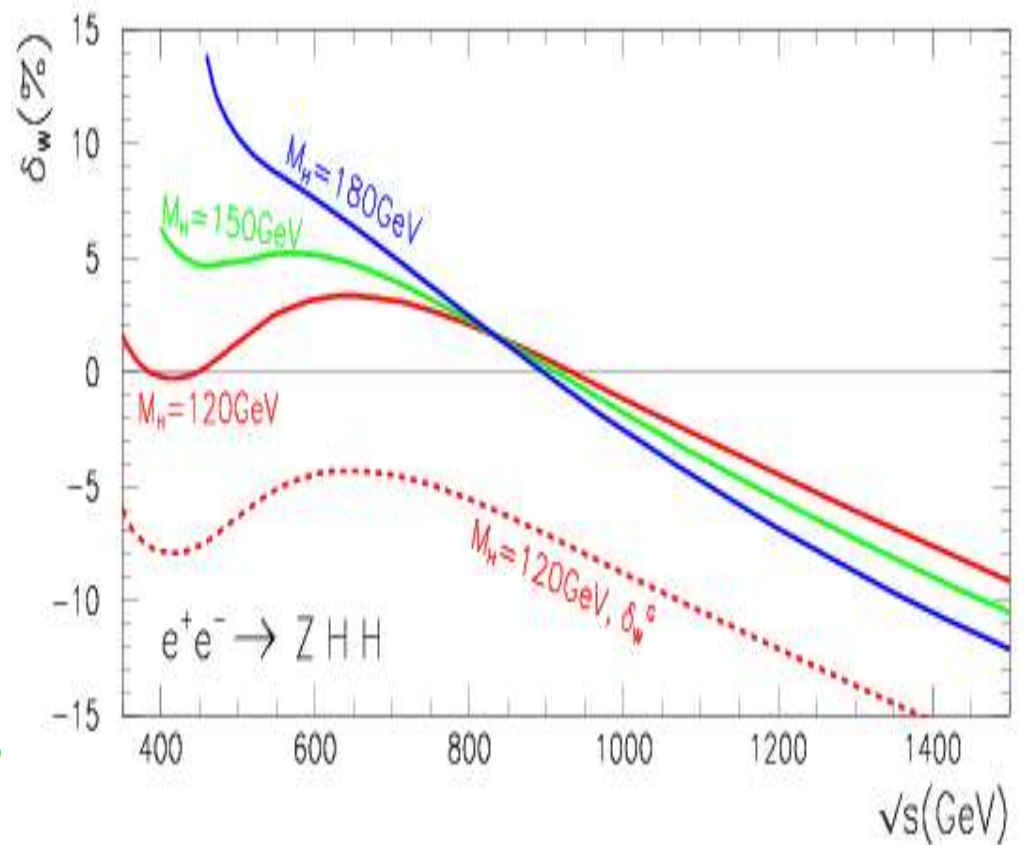
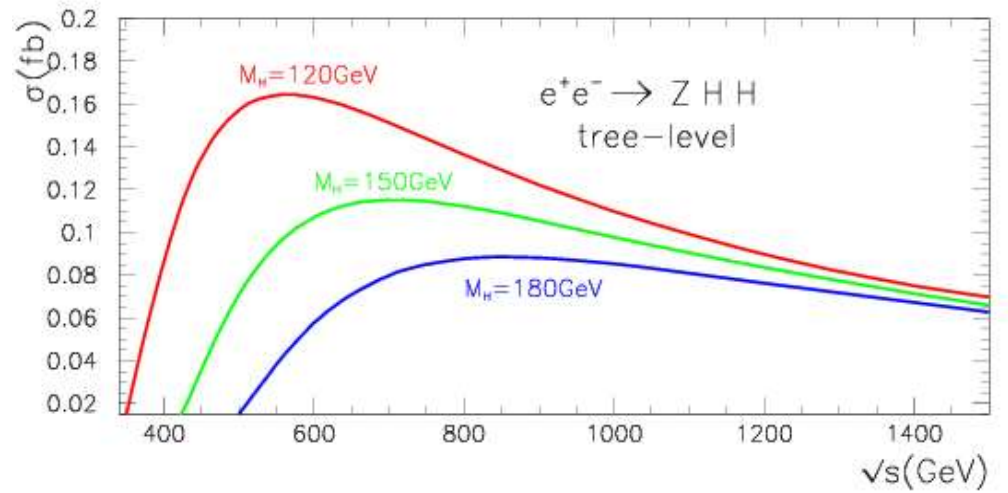


$$e^+ e^- \rightarrow Zh h$$



produced by GRACEFIG

GRACE Phys.Lett.B576(2003)152
Zhang et al. Phys.Lett.B578(2004)349



Summary of GRACE-loop

★ GRACE-loop

- **Full EW one-loop calculations are well under control for $2 \rightarrow 2$ and $2 \rightarrow 3$ processes in SM ($2 \rightarrow 2$ in MSSM)**
- **NLG is powerful to confirm the gauge invariance**

★ Higgs study

- **Systematic study of the RC for Higgs physics at LC**
- **EW corrections are sizable**
 - $e^+e^- \rightarrow tth, e^+e^- \rightarrow Zh h$ 5-10%