1 Page 1

- What calculation was done?
  `GRACE` system[1] provides
  - Calculation of the helicity amplitudes,
  - Integration of the total cross section,
  - Event generation,
  - Up to tree and 1-loop process,
  - Physics Models available are SM and MSSM.
- Sample diagram or 2
  Example of tree process :$e^+e^- \to b\bar{b}u\bar{d}\mu^-\bar{\nu}_\mu$, 232 tree graphs[2]. (Fig. 1)
  Example of 1-loop process :$e^+e^- \to t\bar{t}$, 52 1-loop graphs[3]. (Fig. 2, 3, 4)
- Which tool was used
  `GRACE` system includes
  - `grc`[4] for Feynman graph generation,
  - `BASES/SPRING`[5]for Monte Carlo integration and event generation.
- How long did it take

  CPU time required for the integration of total cross section are shown in Table 1.

  $e^+e^- \to W^+W^-\gamma$ process ($\sqrt{s} = 1$Tev, `ncall` =50000, ncall is a number of sample points used in Monte Carlo integration)
- Who did it
  Minami-Tateya Collaboration
- Abstract number if presented at ACAT 2000
  - Talk in SPS "A Feynman-graph selection tool in GRACE system (SPS103)"
  - Talk in VLSC "Integration of GRACE and PYTHIA (VLSC103)"
  - Talk in VLSC "Parton shower method for QED radiative correction (VLSC104)"

2 Page 2

- Motivation - why is this calculation interesting to physics
  `GRACE` provides
  - Automatic generation of Feynman graphs,
  - Automatic generation of a helicity amplitude corresponding to each of graphs,
  - Phase space integration of the squared amplitude,
  - Event generation for the data analysis.

  We can obtain the theoretical predictions for a larger class of physical processes in the current and future accelerator projects.
- One or two interesting technique or physics observations
  - Numerical approach to helicity amplitudes (`CHANEL`[6] Library)
  - Numerical approach to Feynman integrals[7] (Loop Library).
- The results (or some of the results) Event generation packages
  - `grc4f`[9] for LEPII,
  - `susy23`[10] for LEPII,
  - `GRAPE`[11] for HERA.
- What same group is working on next
  Hadron Collider Physics
- url for further information
  http://www-sc.kek.jp/minami/

References

[1] MINAMI-TATEYA group, `GRACE` manual. KEK Report 92-19.;
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[2] F.Yuasa, Y.Kurihara and S.Kawabata, Phys. Letters **414B**(1997) 178.

[3] J.Fujimoto and K.Kato, *Proc. of Tennessee International Symposium on Radiative corrections:Status and Outlook*, Gatlinburg, 1994, 100-108.

[4] T.Kaneko, Compt. Phys. Commun. **92**(1995) 127.

[5] S.Kawabata, Compt. Phys. Commun. **88**(1995) 309.

[6] H.Tanaka, Compt. Phys. Commun. **58**(1990) 153;
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[8] S.Kawabata, Compt. Phys. Commun. **88**(1995) 309.

[9] J.Fujimoto, T.Ishikawa, T.Kaneko, K.Kato, S.Kawabata, Y.Kurihara, T.Munehisa, D.Perret-Gallix, Y.Shimizu and H.Tanaka
Compt. Phys. Commun. **100**(1997), 128–156.

[10] J.Fujimoto *et al.*, Compt. Phys. Commun. **109**(1998) 1.

[11] T.Abe *et al.*, in *Proceedings of workshop(1998/1999) on "Monte Carlo Generators for HERA Physics"*, DESY 1999. 566.

Table 1: Comparison of CPU time required for the integration of the total cross section ($e^+e^- \to W^+W^-\gamma$process)

Machine	cpu time	comment
Hitachi SR8000/F1	00:00:06.47	4node
Hitachi SR8000/F1	00:00:21.28	1node
FUJITSU VPP	00:01:04.94	4cpu
Compaq ES40:1 21264,500MHz	00:03:24.28	true64
FUJITSU VPP	00:03:26.05	1cpu
Pentium III 500Mhz	00:11:00.03	linux
ap3000 UltraSparc 360MHz	00:11:51.73	solaris
HP 9000: 1 PA8000,195MHz	00:17:20.48	hpux
OSF1 V3.0 358 alpha	00:44:47:04	dec
HI-UX 04.00_B U 3500 2	00:51:15.48	hiux
DELL i586 150MHz	02:16.17.80	linux
IRIX 5.3 11091811 IP19 mips	02:28:56.81	sgi
HP-UX A.09.05 E 9000/755	02:36:55.94	hpux

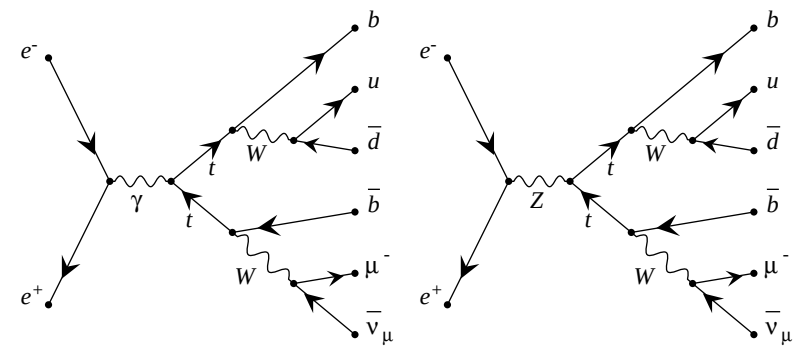

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Figure 1: A part of Feynman diagrams for the $e^+e^- \to b\bar{b}u\bar{d}\mu^-\bar{\nu}_\mu$ process. Diagrams with the $t\bar{t}$ production are shown.

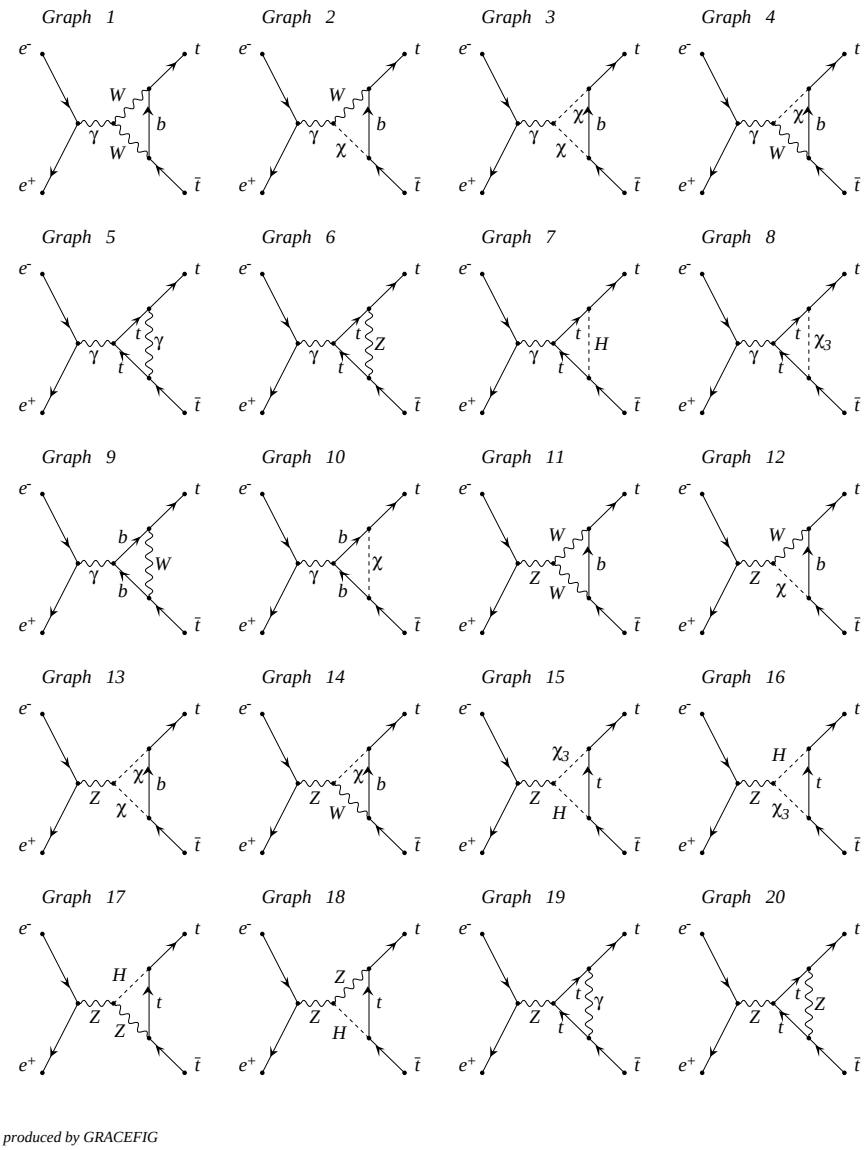


Figure 2: Feynman diagrams for the $e^+e^- \to t\bar{t}$ process (Part 1).

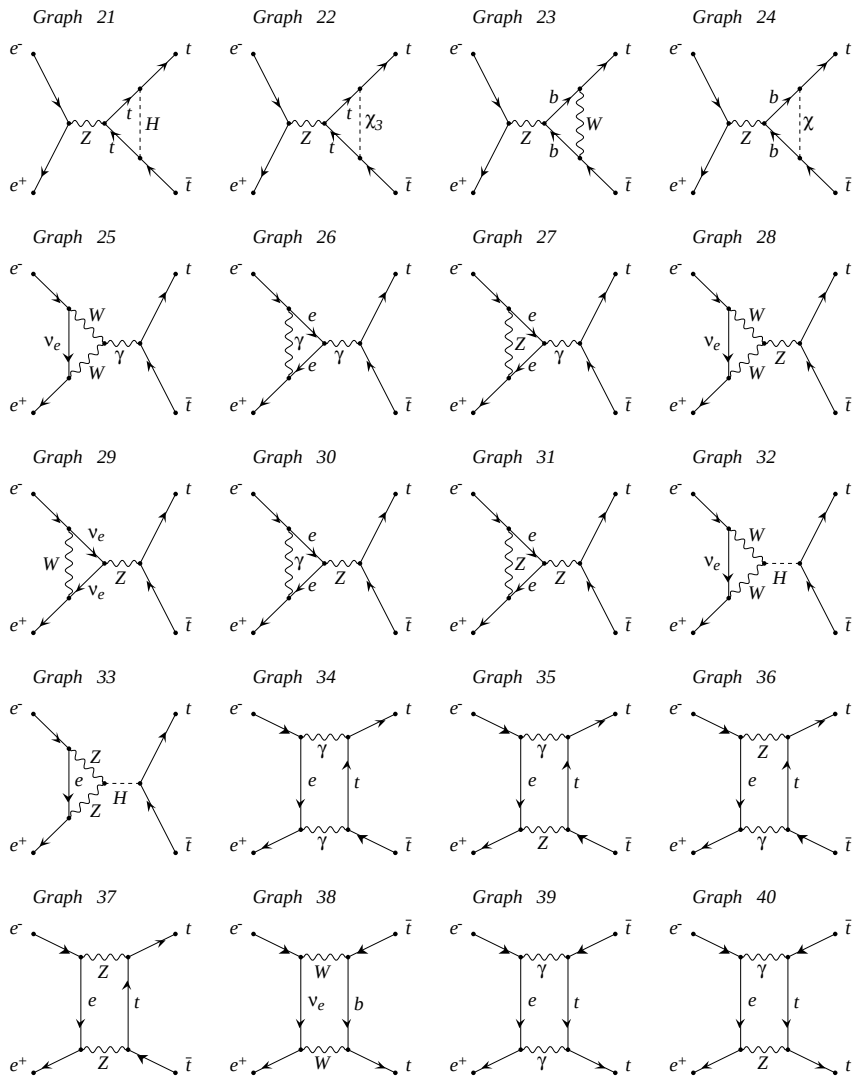


Figure 3: Feynman diagrams for the $e^+e^- \to t\bar{t}$ process (Part 2).

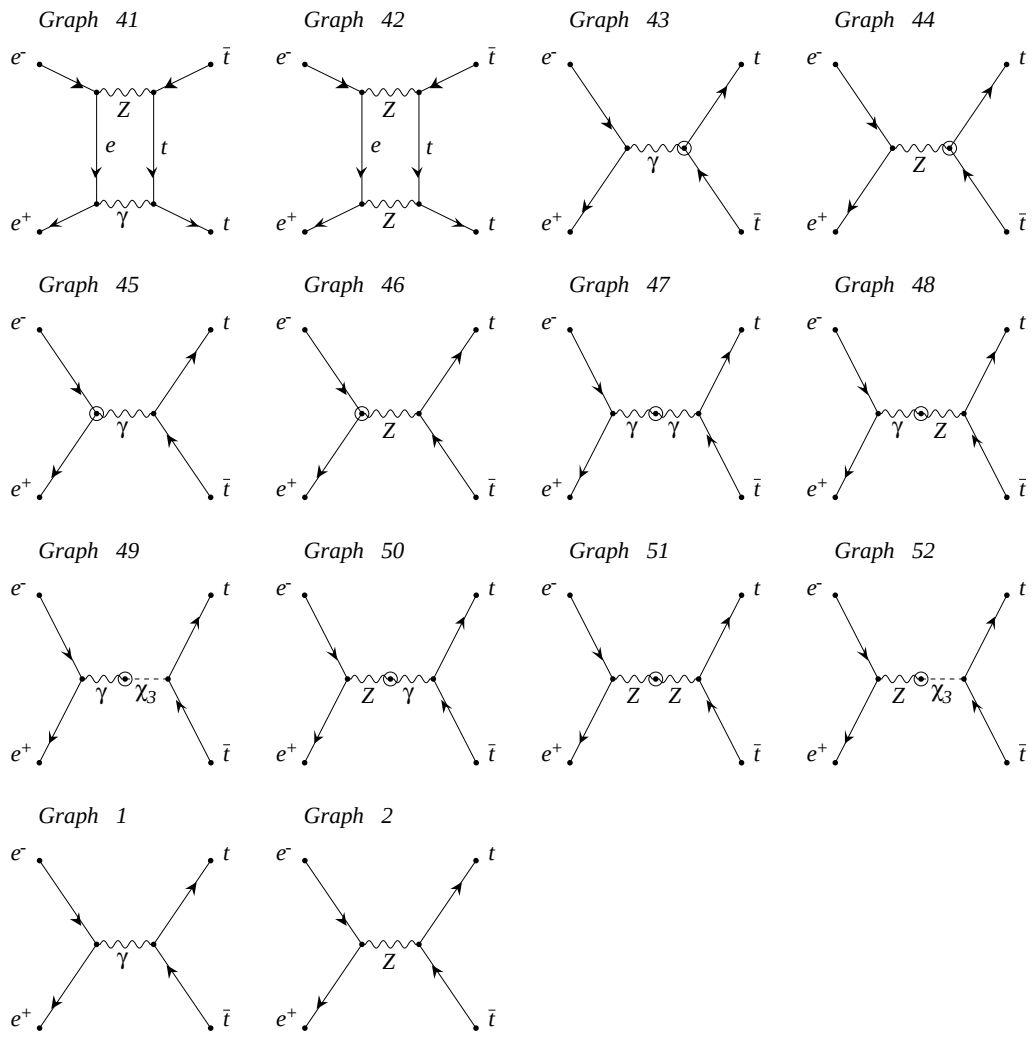


Figure 4: Feynman diagrams for the $e^+e^- \to t\bar{t}$ process (Part 3).

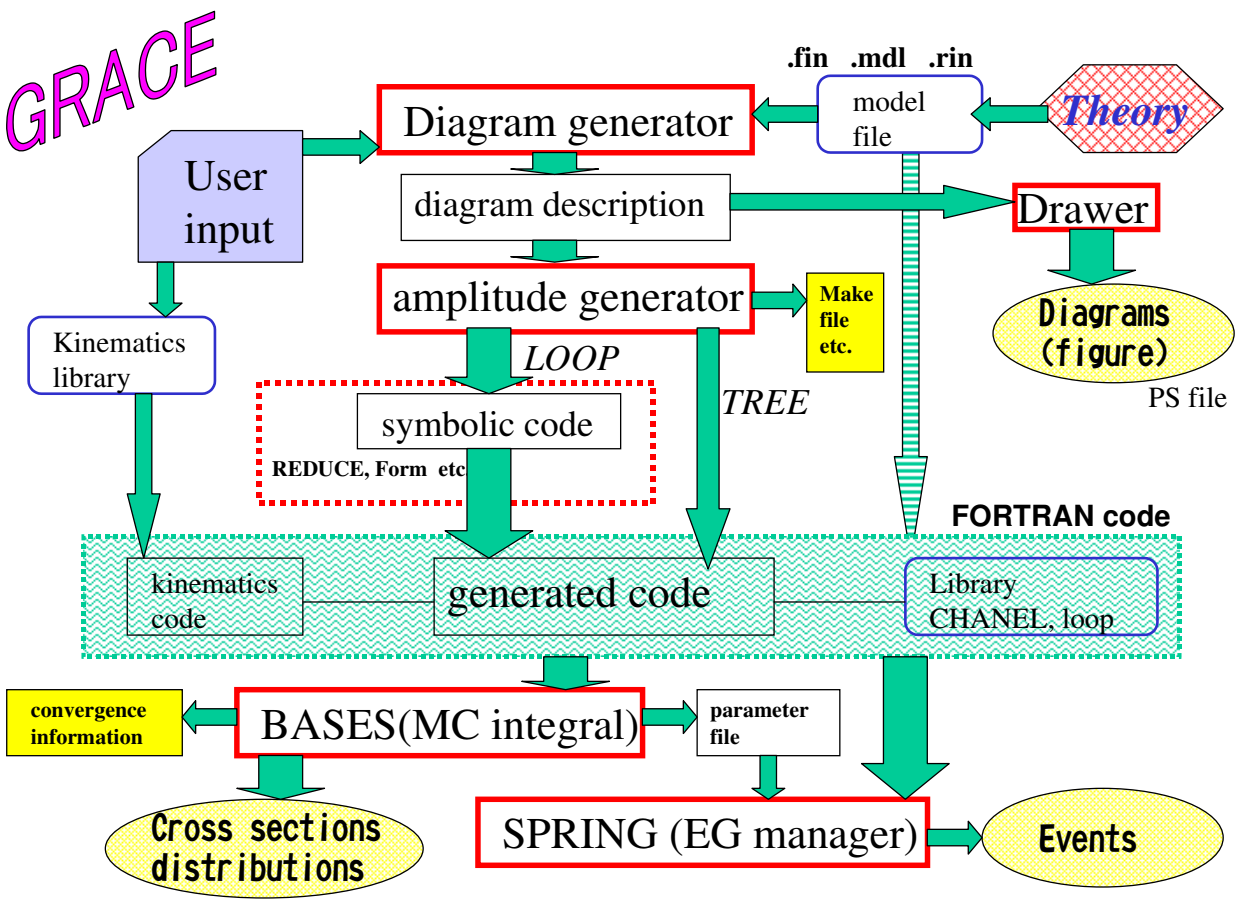
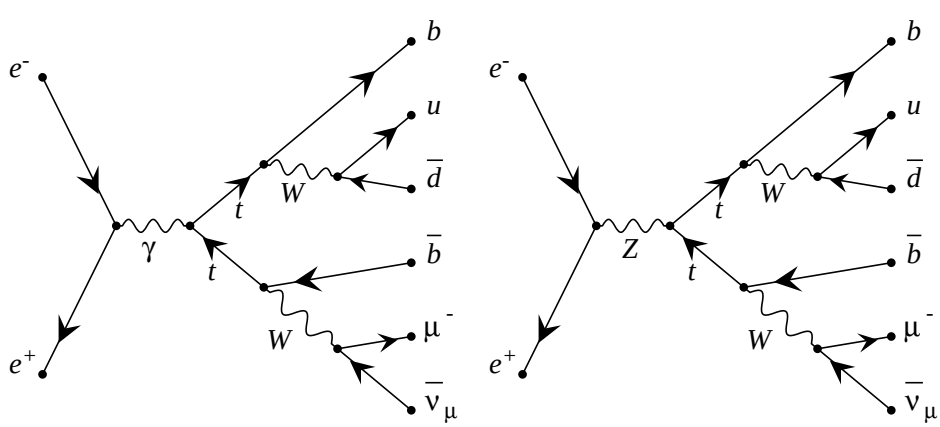


Figure 5: Program Flow of GRACE



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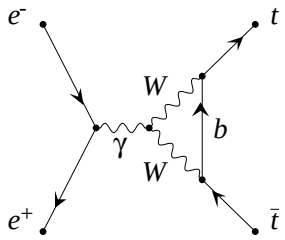
Graph 1



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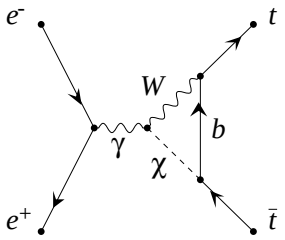

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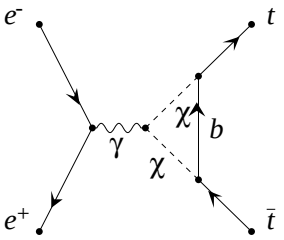

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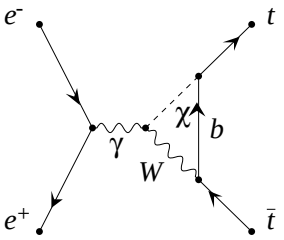

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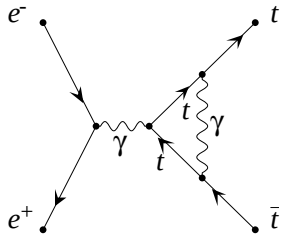

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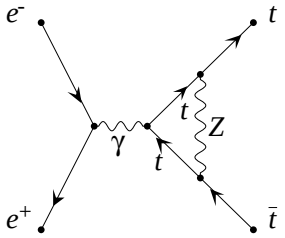

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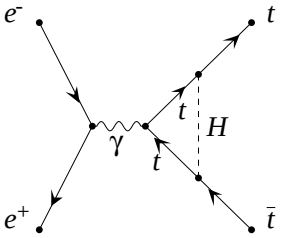

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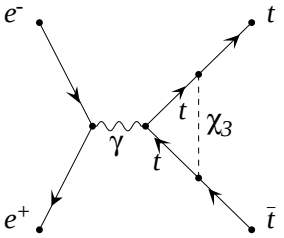

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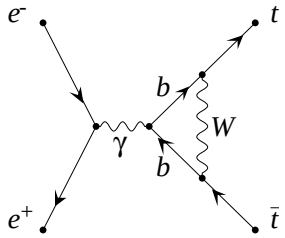

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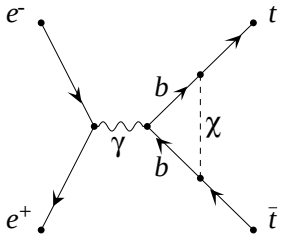

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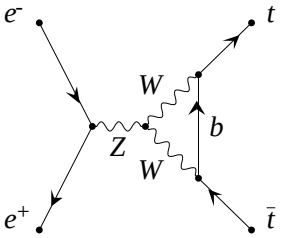

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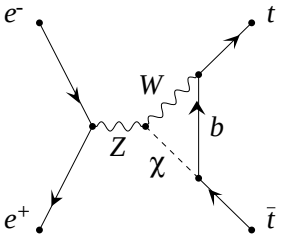

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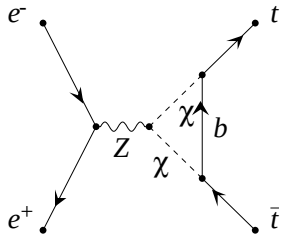

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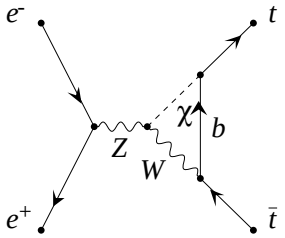

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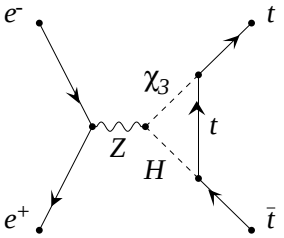

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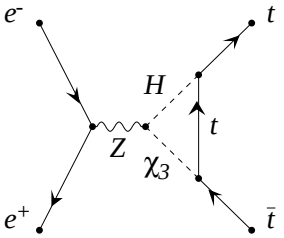

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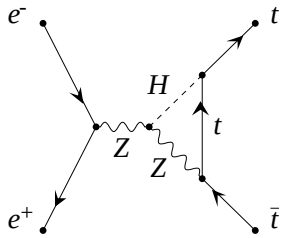

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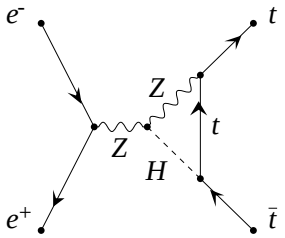

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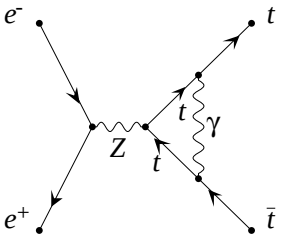

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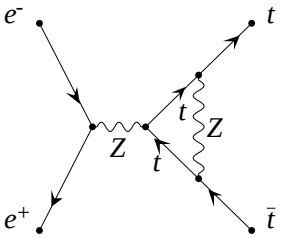

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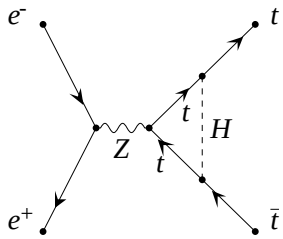

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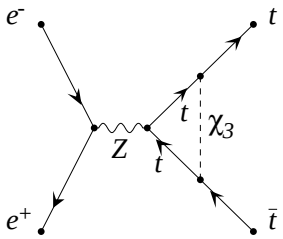

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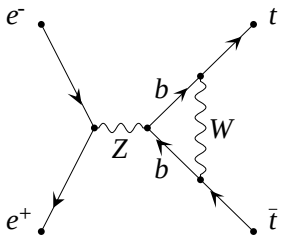

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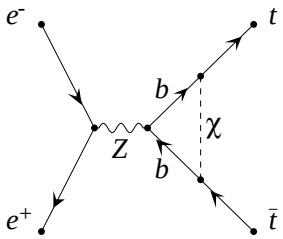

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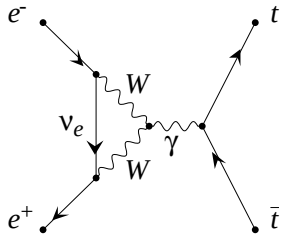

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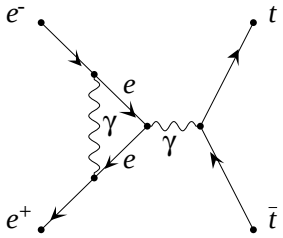

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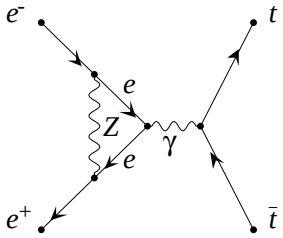

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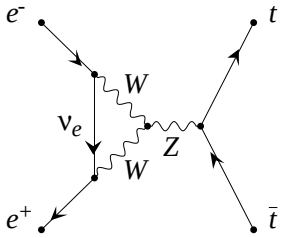

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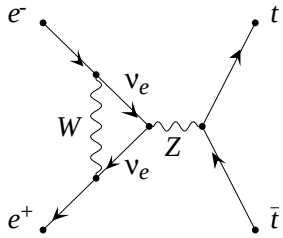

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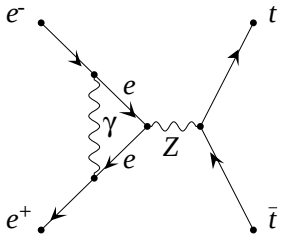

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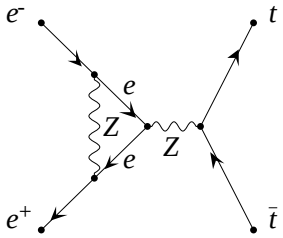

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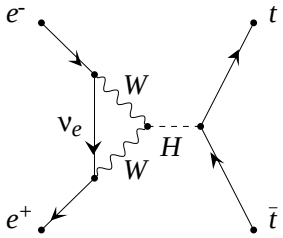

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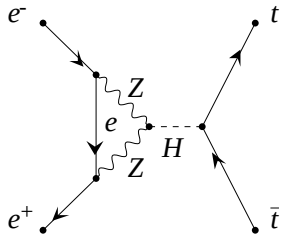

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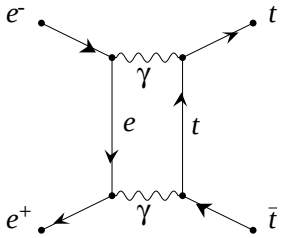

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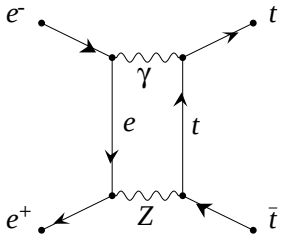

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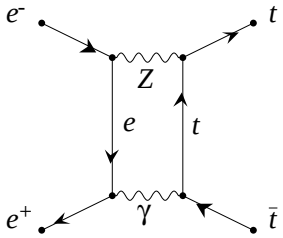

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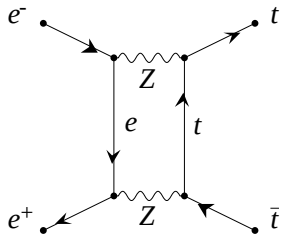

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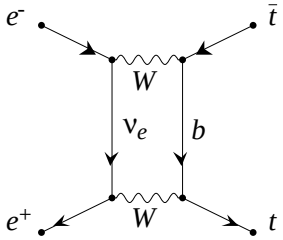

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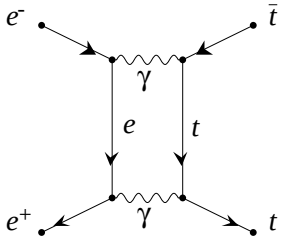

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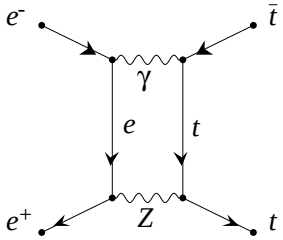

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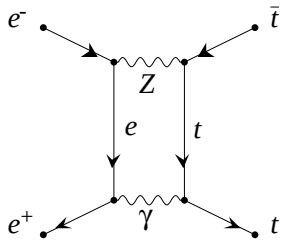
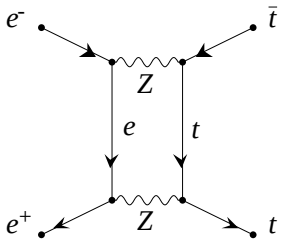
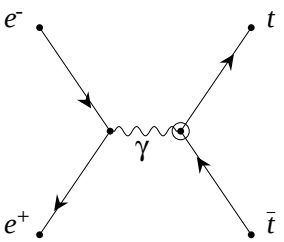


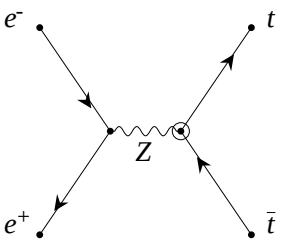
Graph 42



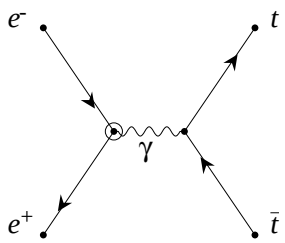
Graph 43



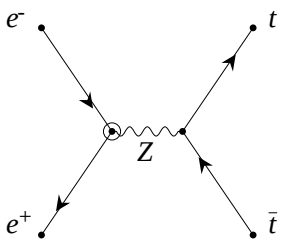
Graph 44



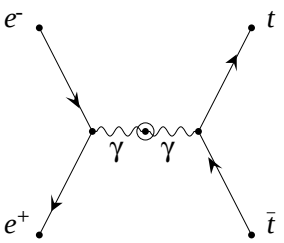
Graph 45



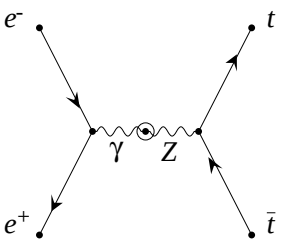
Graph 46



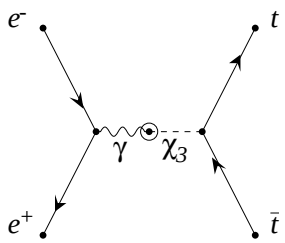
Graph 47



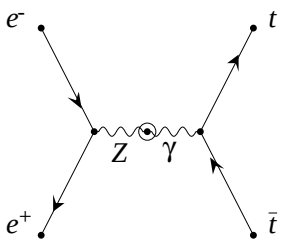
Graph 48



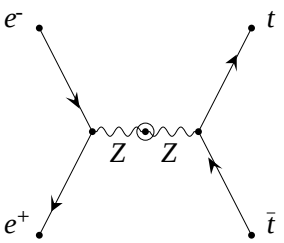
Graph 49



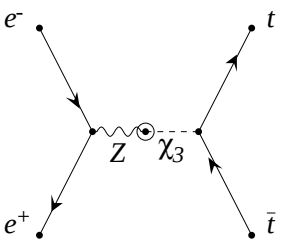
Graph 50



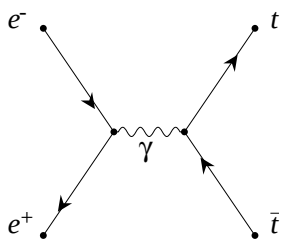
Graph 51



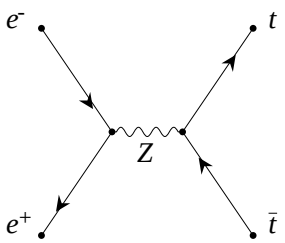
Graph 52



Graph 1



Graph 2



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