MC for e+e- colliders

Vrije Universiteit Brussel

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

KOBE UNIVERSITY

KEK-JAPAN

Kentarou Mawatari

LPSC Grenoble Laboratoire de Physique Subatomique et de Cosmologie

大阪大学 OSAKA UNIVERSITY

from this summer

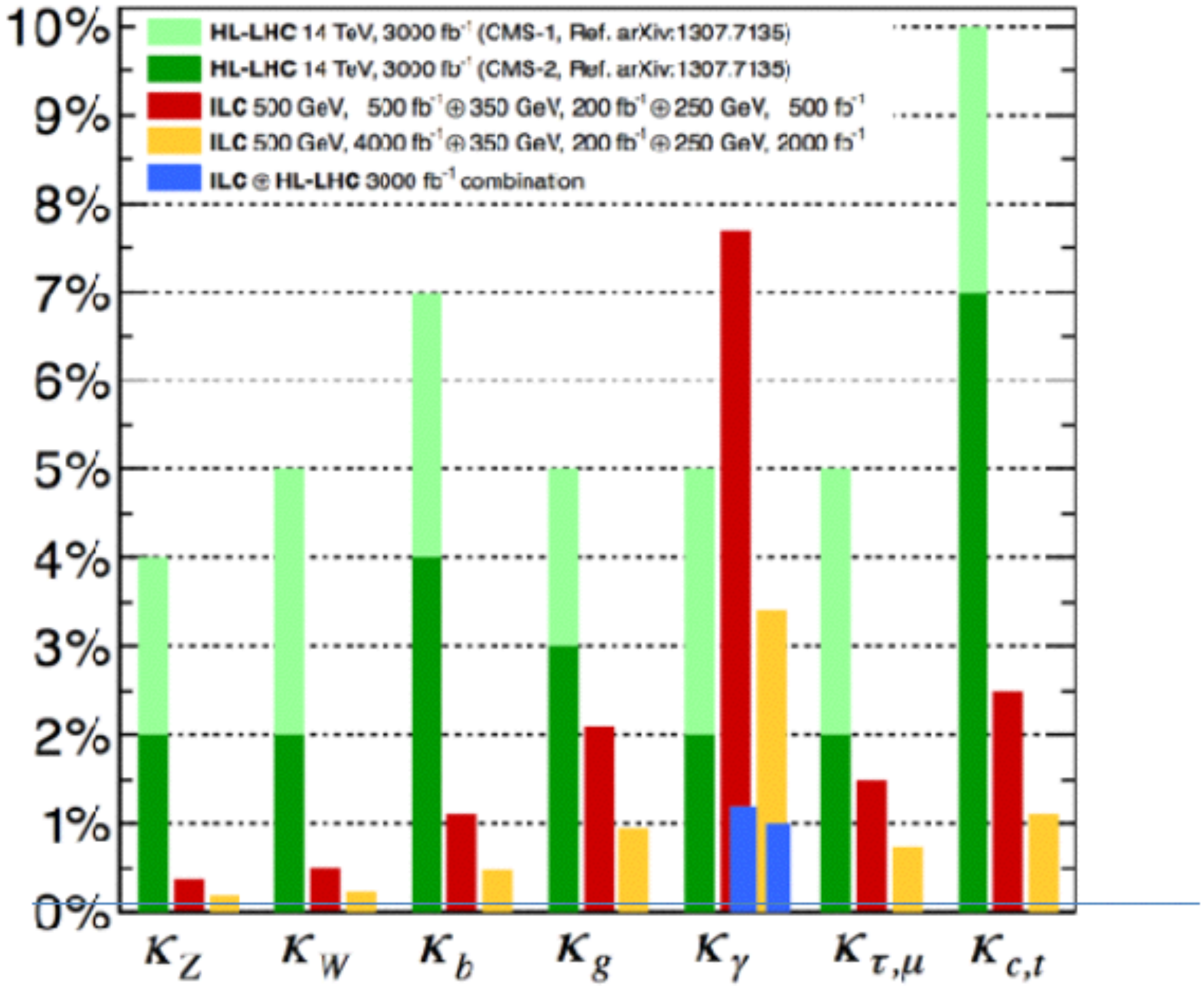
LHC

ILC, CEPC

Model-dependent ***coupling fit*** *(LHC-style 7-parameter fit)*

H20 Scenario
arXiv: 1506.05992
arXiv: 1506.07830

Σ_{SM} BR = 1



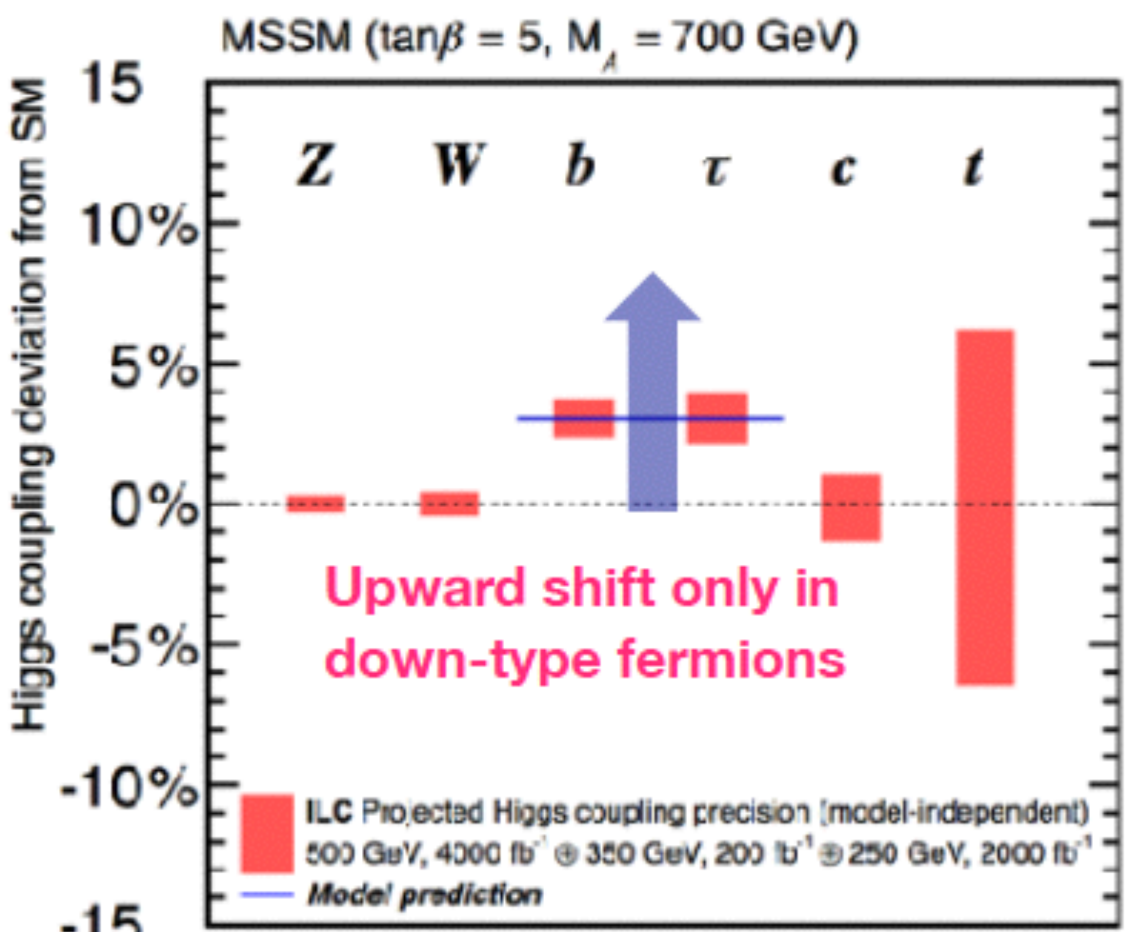
Possible to achieve precision far exceeding LHC!

H20 Scenario
arXiv: 1506.05992
arXiv: 1506.07830

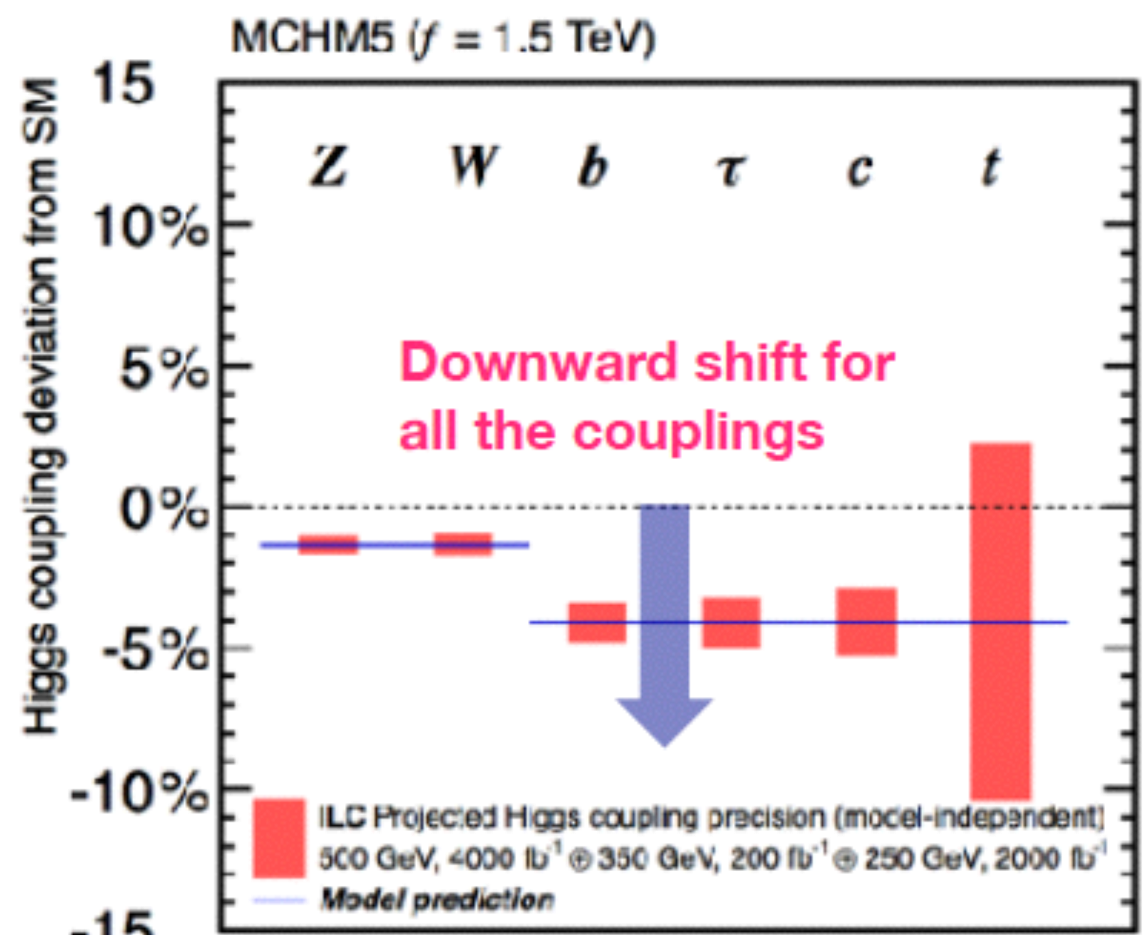
Fingerprinting

Elementary v.s. Composite?

Supersymmetry
(MSSM)



Composite Higgs
(MCHM5)



ILC 250+500 LumiUP

Complementary to direct searches at LHC: Depending on parameters, ILC's sensitivity far exceeds that of LHC!

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Summary

by Keisuke Fujii
at HPNP2017 in Toyama

- MEXT is seriously investigating various issues to be solved to host the ILC in Japan.
- KEK/JHEP is taking various actions together with the LCC to address issues pointed out by the MEXT ILC Advisory Panel.
- MEXT-DOE joint discussion group started.
- US-Japan collaborative research on cost reduction started.
- There are important political interactions happening also in Europe and Asia.
- Serious discussions on staging started.
- As Hon. Kawamura said in LCWS 2016, 2017-2018 will be a very important time for the ILC.

Monte Carlo Generator
(status)

Akiya Miyamoto, KEK

on be half of LC generator WG

Timothy Barklow (SiD, SLAC), Mikael Berggren(ILD, DESY),
Philip Roloff(clicDP, CERN), AM(ILD, KEK)

3 June 2016

ECFA LC2016

W. Kilian, T. Ohl, J. Reuter

Whizard2

- The latest, Whizard2.2.8, (Nov.2015). Whizard2.3.0 will be released soon. Whizard2 is not Whizard1.95

- Why Whizard2 ? : New features are available/under development.
  - Improved QCD treatment with shower matching.

    Whizard1.95(DBD): α_s=0 in Whizard, parton shower& hadronization by phythia.

    Whizard2 : Matching gluon from Whizard with gluons by parton shower possible.
  - Improved treatment of t-tbar threshold. NLO available.
  - Easier to use BSM models.
  - New steering language: Sindrain
  - Better CPU performance:
    Whizard1.95: 6f, very time consuming, 8f practically impossible.
    Whizard2 : now possible with “Multi-processing” option.
  - Many event output formats including LCIO
  - Beam-beam luminosity spectrum could be directly read-in to Whizard

Tauola

- Polarized tau decay is crucial for ILC physics.
- Whizard1.95, Pythia calls tauola for tau decay. This function was implemented using a user interface in Whizard1 by T.Barklow.
  - Correct single polarized tau decay in DBD sample.
  - Not for tau pair decay (H→tautau) in DBD sample.
- Whizard2 does not have such interface function.
- Possible resolution would be,
  - HepMC output by Whizard2(2.2.8) could be edited "manually" so that polarized tau decay is handled by pythia8.

    → not for a large production.

    → pythia8 tuning for e+e- physics is needed. Step2 work.
  - Port tauola interface in Whizard1.95 to Whizard2.
    - We are working together with Whizard author to implement a private interface developed from Whizard1.95 interface to the Whizard2 release.
    - Single tauola looks OK in 2.3.0_alpha release. Need extensive validation.
    - Correlation in tau pair decay is complicated and work in progress.

Summary

- Whizard2 is almost OK, expect ISR and higher multiplicity in 4q events.
  - Tauola: Single tau case is almost OK. Some work needed for H--> tau+tau-
  - Beamstrahlug with Cires2 works. Circes2 files should be prepared based ILC parameters. The files for CLIC exists
  - Standard Sindarin file is prepared. Tests with many processes and events are necessary.

- Low Pt Hadrons : for the moment we use Whizard1.95. Investigate a possibility
- Good generators for QED processes, Nγ for example, is missing.

- LC generator WG is serving as liaisons on LC generator issues. Please send your experiences and wisdoms to us for sharing among LC community. Your contributions are highly welcomed.

Status: MG5_aMC for e+e-

```
./bin/mg5_aMC
>generate e+ e- > t t~ h [QCD]
```

J. Alwall, R. Frederix, S. Frixione, V. Hirschi, F. Maltoni, O. Mattelaer, H-S. Shao, T. Stelzer, P. Torrielli, M. Zaro [1405.0301, JHEP]

Process		Syntax	Cross section (pb)			
Top quarks +bosons			LO 1 TeV		NLO 1 TeV	
j.1	$e^+e^- \to t\bar{t}H$	`e+ e- > t t~ h`	$2.018 \pm 0.003 \cdot 10^{-3}$	$^{+0.0\%}_{-0.0\%}$	$1.911 \pm 0.006 \cdot 10^{-3}$	$^{+0.4\%}_{-0.5\%}$
j.2*	$e^+e^- \to t\bar{t}Hj$	`e+ e- > t t~ h j`	$2.533 \pm 0.003 \cdot 10^{-4}$	$^{+9.2\%}_{-7.8\%}$	$2.658 \pm 0.009 \cdot 10^{-4}$	$^{+0.5\%}_{-1.5\%}$
j.3*	$e^+e^- \to t\bar{t}Hjj$	`e+ e- > t t~ h j j`	$2.663 \pm 0.004 \cdot 10^{-5}$	$^{+19.3\%}_{-14.9\%}$	$3.278 \pm 0.017 \cdot 10^{-5}$	$^{+4.0\%}_{-5.7\%}$
j.4*	$e^+e^- \to t\bar{t}\gamma$	`e+ e- > t t~ a`	$1.270 \pm 0.002 \cdot 10^{-2}$	$^{+0.0\%}_{-0.0\%}$	$1.335 \pm 0.004 \cdot 10^{-2}$	$^{+0.5\%}_{-0.4\%}$
j.5*	$e^+e^- \to t\bar{t}\gamma j$	`e+ e- > t t~ a j`	$2.355 \pm 0.002 \cdot 10^{-3}$	$^{+9.3\%}_{-7.9\%}$	$2.617 \pm 0.010 \cdot 10^{-3}$	$^{+1.6\%}_{-2.4\%}$
j.6*	$e^+e^- \to t\bar{t}\gamma jj$	`e+ e- > t t~ a j j`	$3.103 \pm 0.005 \cdot 10^{-4}$	$^{+19.5\%}_{-15.0\%}$	$4.002 \pm 0.021 \cdot 10^{-4}$	$^{+5.4\%}_{-6.6\%}$
j.7*	$e^+e^- \to t\bar{t}Z$	`e+ e- > t t~ z`	$4.642 \pm 0.006 \cdot 10^{-3}$	$^{+0.0\%}_{-0.0\%}$	$4.949 \pm 0.014 \cdot 10^{-3}$	$^{+0.6\%}_{-0.5\%}$
j.8*	$e^+e^- \to t\bar{t}Zj$	`e+ e- > t t~ z j`	$6.059 \pm 0.006 \cdot 10^{-4}$	$^{+9.3\%}_{-7.8\%}$	$6.940 \pm 0.028 \cdot 10^{-4}$	$^{+2.0\%}_{-2.6\%}$
j.9*	$e^+e^- \to t\bar{t}Zjj$	`e+ e- > t t~ z j j`	$6.351 \pm 0.028 \cdot 10^{-5}$	$^{+19.4\%}_{-15.0\%}$	$8.439 \pm 0.051 \cdot 10^{-5}$	$^{+5.8\%}_{-6.8\%}$
j.10*	$e^+e^- \to t\bar{t}W^\pm jj$	`e+ e- > t t~ wpm j j`	$2.400 \pm 0.004 \cdot 10^{-7}$	$^{+19.3\%}_{-14.9\%}$	$3.723 \pm 0.012 \cdot 10^{-7}$	$^{+9.6\%}_{-9.1\%}$
j.11*	$e^+e^- \to t\bar{t}HZ$	`e+ e- > t t~ h z`	$3.600 \pm 0.006 \cdot 10^{-5}$	$^{+0.0\%}_{-0.0\%}$	$3.579 \pm 0.013 \cdot 10^{-5}$	$^{+0.1\%}_{-0.0\%}$
j.12*	$e^+e^- \to t\bar{t}\gamma Z$	`e+ e- > t t~ a z`	$2.212 \pm 0.003 \cdot 10^{-4}$	$^{+0.0\%}_{-0.0\%}$	$2.364 \pm 0.006 \cdot 10^{-4}$	$^{+0.6\%}_{-0.5\%}$
j.13*	$e^+e^- \to t\bar{t}\gamma H$	`e+ e- > t t~ a h`	$9.756 \pm 0.016 \cdot 10^{-5}$	$^{+0.0\%}_{-0.0\%}$	$9.423 \pm 0.032 \cdot 10^{-5}$	$^{+0.3\%}_{-0.4\%}$
j.14*	$e^+e^- \to t\bar{t}\gamma\gamma$	`e+ e- > t t~ a a`	$3.650 \pm 0.008 \cdot 10^{-4}$	$^{+0.0\%}_{-0.0\%}$	$3.833 \pm 0.013 \cdot 10^{-4}$	$^{+0.4\%}_{-0.4\%}$
j.15*	$e^+e^- \to t\bar{t}ZZ$	`e+ e- > t t~ z z`	$3.788 \pm 0.004 \cdot 10^{-5}$	$^{+0.0\%}_{-0.0\%}$	$4.007 \pm 0.013 \cdot 10^{-5}$	$^{+0.5\%}_{-0.5\%}$
j.16*	$e^+e^- \to t\bar{t}HH$	`e+ e- > t t~ h h`	$1.358 \pm 0.001 \cdot 10^{-5}$	$^{+0.0\%}_{-0.0\%}$	$1.206 \pm 0.003 \cdot 10^{-5}$	$^{+0.9\%}_{-1.1\%}$
j.17*	$e^+e^- \to t\bar{t}W^+W^-$	`e+ e- > t t~ w+ w-`	$1.372 \pm 0.003 \cdot 10^{-4}$	$^{+0.0\%}_{-0.0\%}$	$1.540 \pm 0.006 \cdot 10^{-4}$	$^{+1.0\%}_{-0.9\%}$

Status: MG5_aMC for e+e-

C.T. Potter [1702.04827]

$\sqrt{s}$[GeV]	Pol.	Process	σ[pb] CEPC	σ[pb] MG5
250	none	$e^+e^- \to \mu^+\mu^-, \tau^+\tau^-$	4.40	3.50
250	none	$e^+e^- \to q\bar{q}$	50.2	11.3
250	none	$e^+e^- \to ZZ$	1.03	1.10
250	none	$e^+e^- \to WW$	15.4	16.5
250	none	$e^+e^- \to Zh$	0.212	0.240
$\sqrt{s}$[GeV]	Pol.	Process	σ[pb] ILC	σ[pb] MG5
250	$(+,-)$	$e^+e^- \to Zh$	0.319	0.356
250	$(-,+)$	$e^+e^- \to Zh$	0.206	0.240
350	$(+,-)$	$e^+e^- \to t\bar{t}$	0.286	0.378
350	$(-,+)$	$e^+e^- \to t\bar{t}$	0.137	0.166
500	$(+,-)$	$e^+e^- \to t\bar{t}$	1.08	0.921
500	$(-,+)$	$e^+e^- \to t\bar{t}$	0.470	0.436

6 Conclusion

We have described the production of fast simulation background samples for new physics studies at a future e^+e^- collider like the ILC or CEPC. Events are generated for a variety of run scenarios with approximately five times the integrated luminosity envisaged by the most optimistic run scenario for each $\sqrt{s}$. The events are generated with MG5_aMC@NLO with detector simulation performed by Delphes using the DSiD detector card. Finally, the samples are compared to the ILC background samples made for the DBD study and CEPC background samples.

Systematic uncertainties associated with the MG5_aMC@NLO samples have been estimated. These samples lack a detailed simulation of initial state radiation and beamstrahlung. The $2f$ background from radiative return events is absent, and both pileup from bunch-bunch interactions and a realistic beam energy distribution are absent. Nevertheless, these shortcomings can be ameliorated.

Mad-ee project

with Shao-Feng Ge (Max Planck Heidelberg), Kaoru Hagiwara (KEK)
+ Fabio, Olivier, …

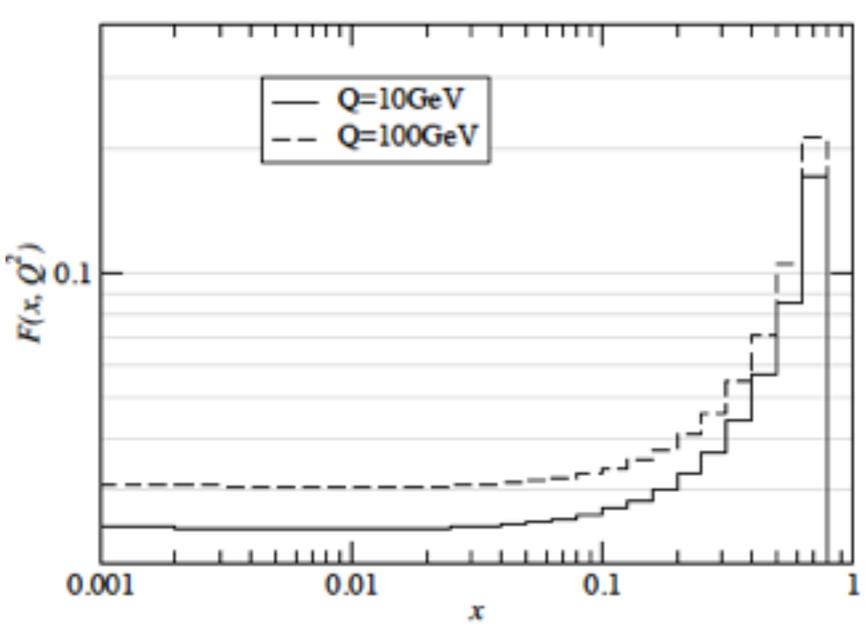
- define e- beam = e- a e+
- define e+ beam = e+ a e-
- replace the proton PDFs by the electron PDFs

$$\beta = \frac{\alpha}{\pi}(L-1), \quad \eta = \frac{\alpha}{\pi}L, \quad L = \ln\frac{Q^2}{m_e^2} \tag{1}$$

$$\begin{aligned} P_{e^-/e^-}(x,Q^2) = & \frac{e^{(-\gamma_E+\frac{3}{4})\beta}}{\Gamma(1+\beta)}\beta(1-x)^{\beta-1} \\ & -\frac{1}{2}\beta(1+x) \\ & -\frac{1}{8}\beta^2[\frac{1+3x^2}{1-x}\ln(x)+4(1+x)\ln(1-x)+5+x] \end{aligned} \tag{2}$$

$$P_{\gamma/e^-}(x,Q^2) = \frac{1}{2}\eta\frac{1+(1-x)^2}{x} \tag{3}$$

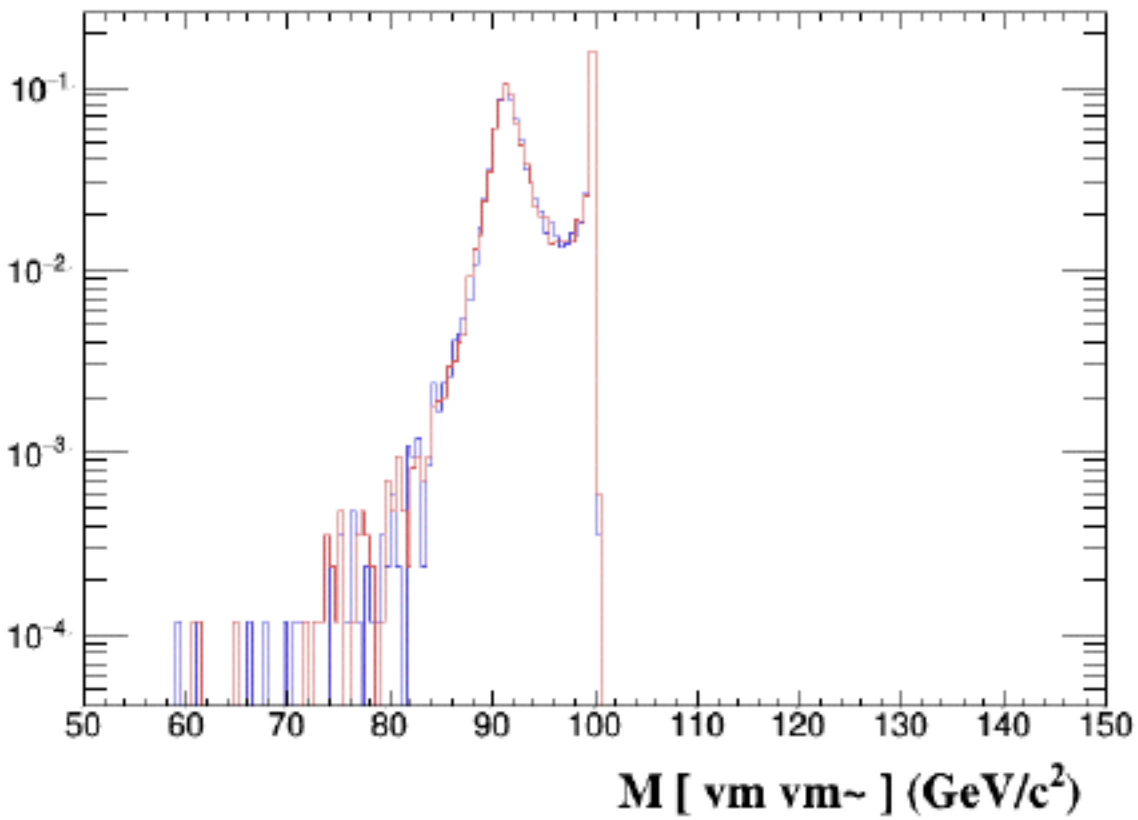
$$P_{e^+/e^-}(x,Q^2) = \frac{1}{8x}\beta^2\,[\frac{4}{3}+x-x^2-\frac{4}{3}x^3+2x(1+x)\ln(x)] \tag{4}$$

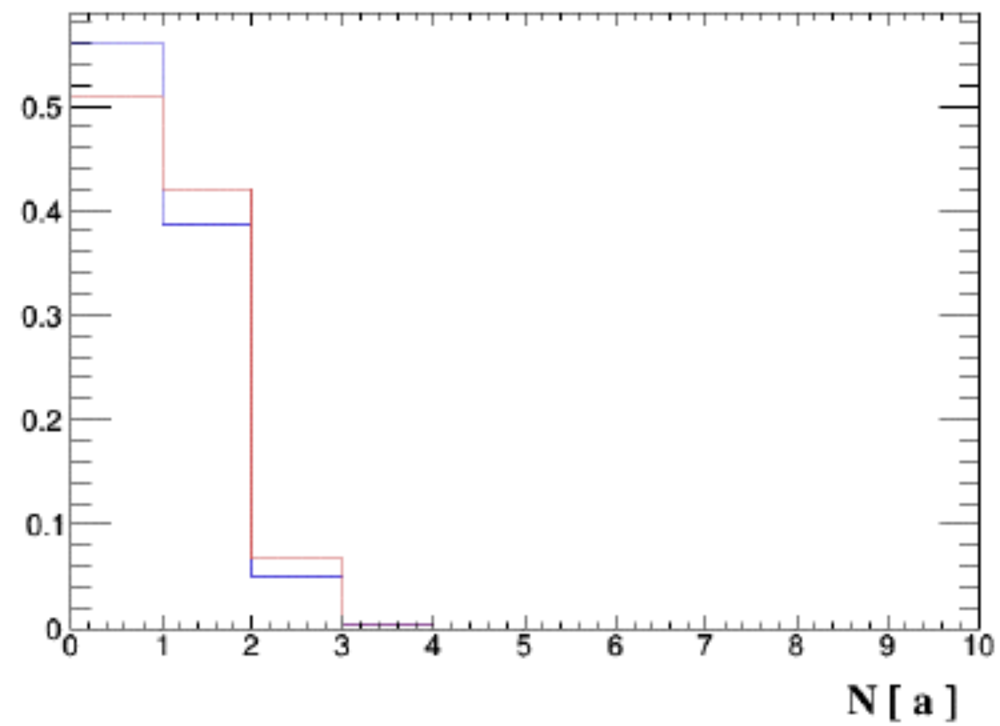


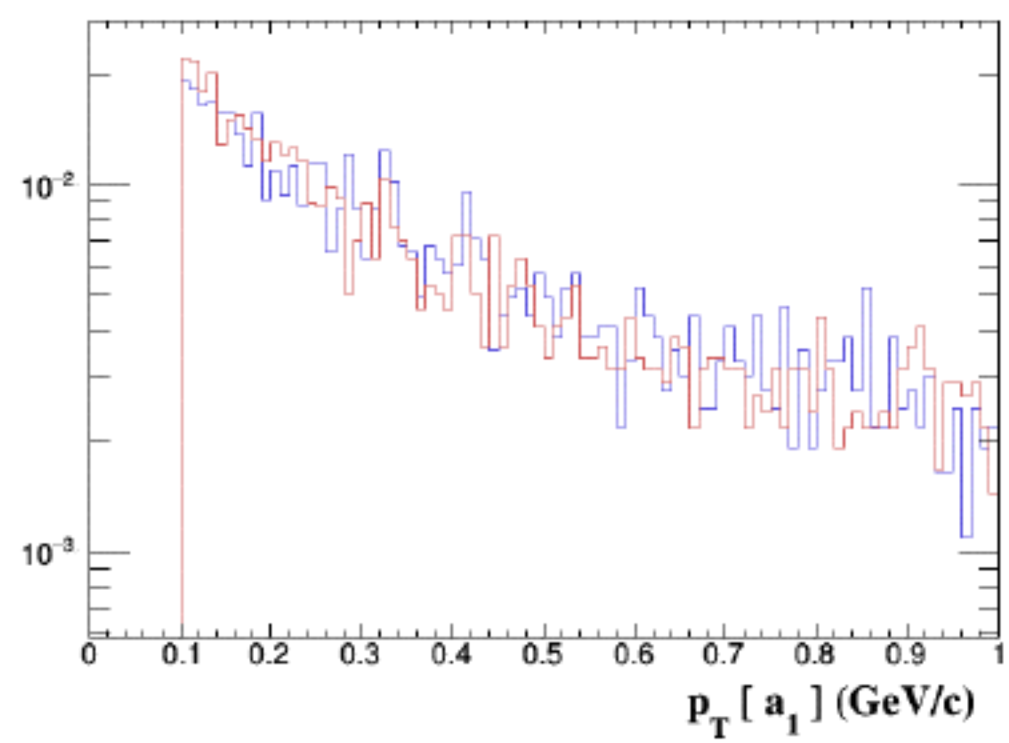

```
#*********************************************************************
# Collider type and energy                                           *
# lpp: 0=No PDF, 1=proton, -1=antiproton, 2=photon from proton,      *
#                                   3=e-/a/e+ from electron          *
#*********************************************************************
     3     = lpp1 ! beam 1 type
    -3     = lpp2 ! beam 2 type
   250.0 = ebeam1 ! beam 1 total energy in GeV
   250.0 = ebeam2 ! beam 2 total energy in GeV
```

MG5aMC+Pythia6/8

```
./bin/mg5_aMC
>generate e+ e- > vm vm~
```

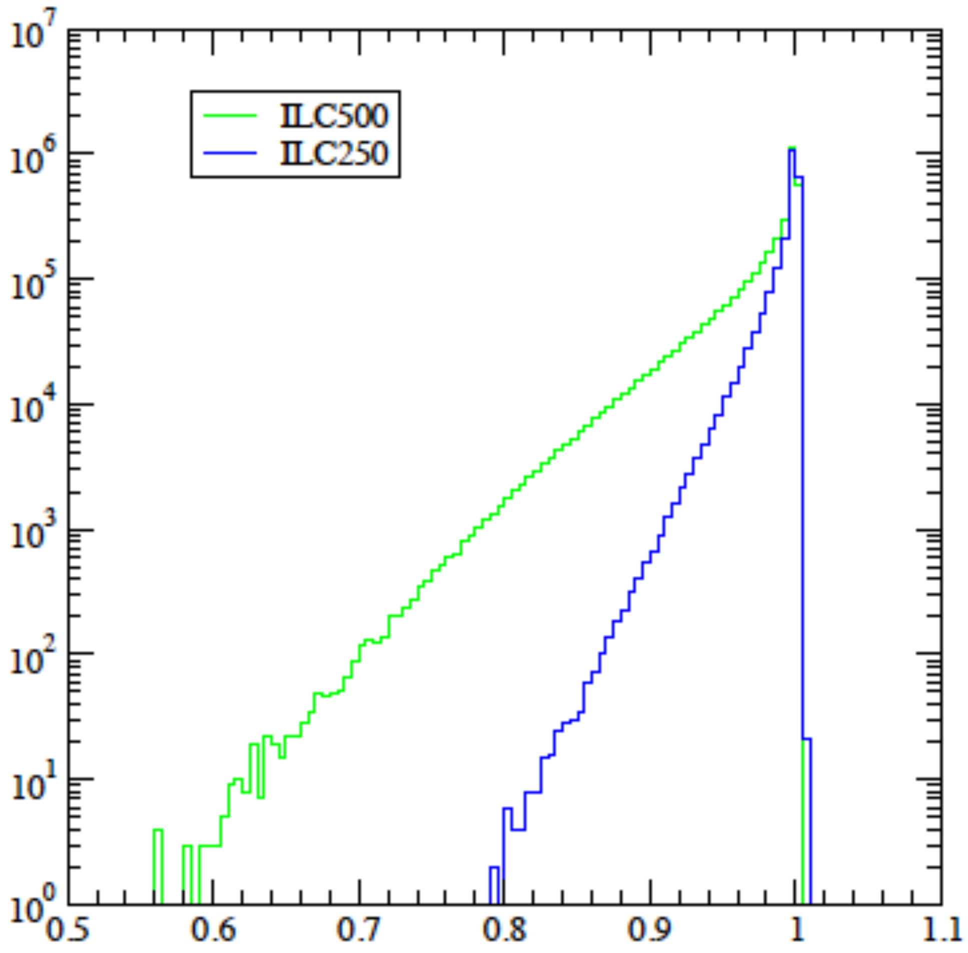






beamstrahlung

Beam-beam simulations with GUINEA-PIG



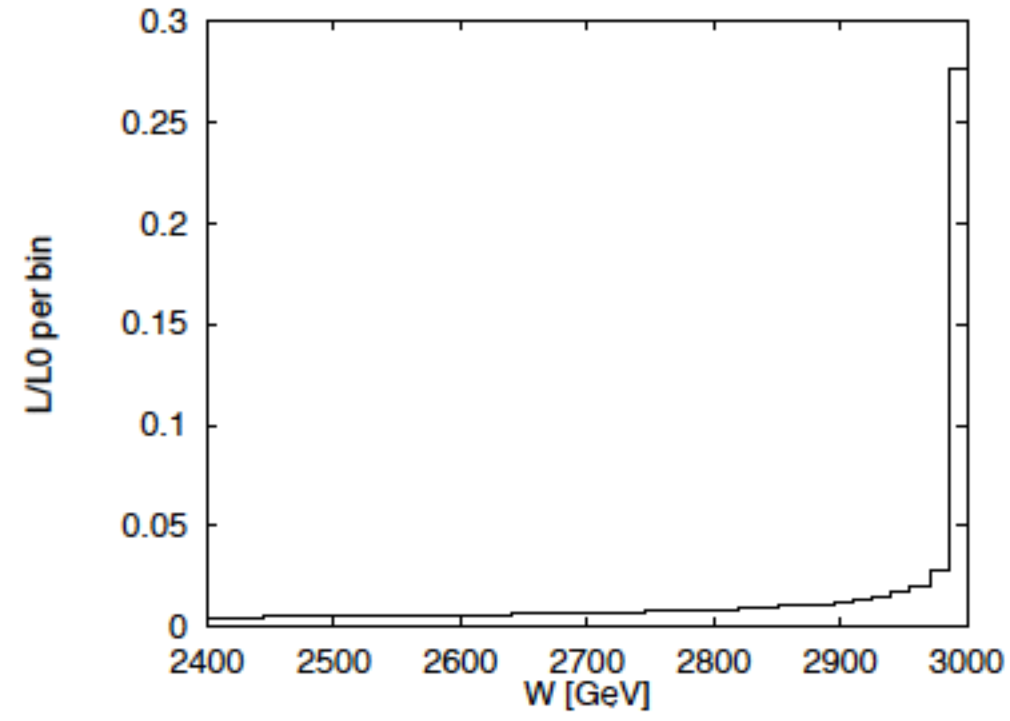


Figure 1: The luminosity spectrum for CLIC at E_{cm} 3 TeV.

Polarised beams

- We are preparing for
  - polarised PDFs
  - polarised showers
  - modification of the structure of MG5aMC (especially for photon-photon collisions).
- NLO-EW?