Study of HγZ coupling at the ILC

Yumi Aoki(SOKENDAI)
Tian Junping, Keisuke Fujii, Sunghoon Jung,
Junghwan Lee, Hiroshi Yokoya
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0.Background

International Linear Collider

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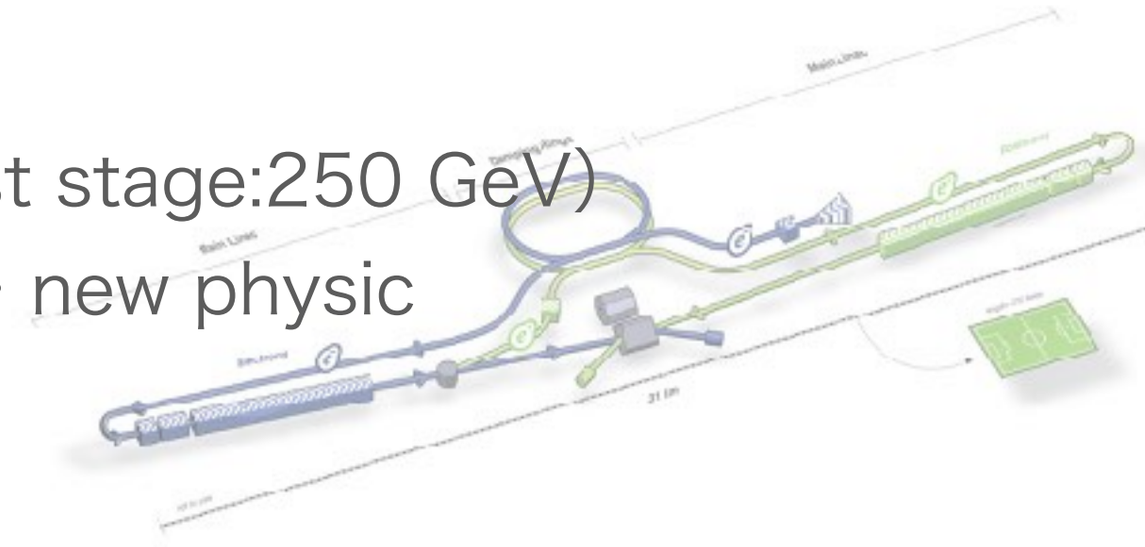
electron-positron collider（First stage:250 GeV）

for finding（new particle）・new physic

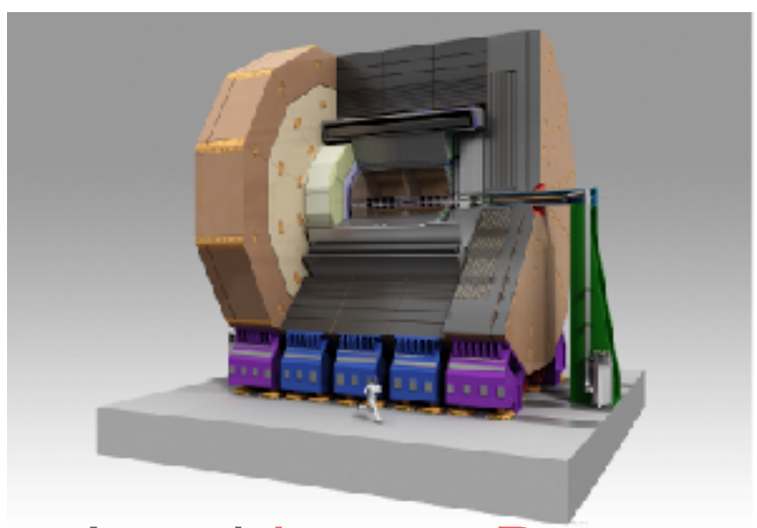


Advantage of ILC

・Beam polarization for +-80% for electron , +-30% for positron

Advantage of ILD

・Based on Particle Flow Analysis, we can detect all particles without overlap.

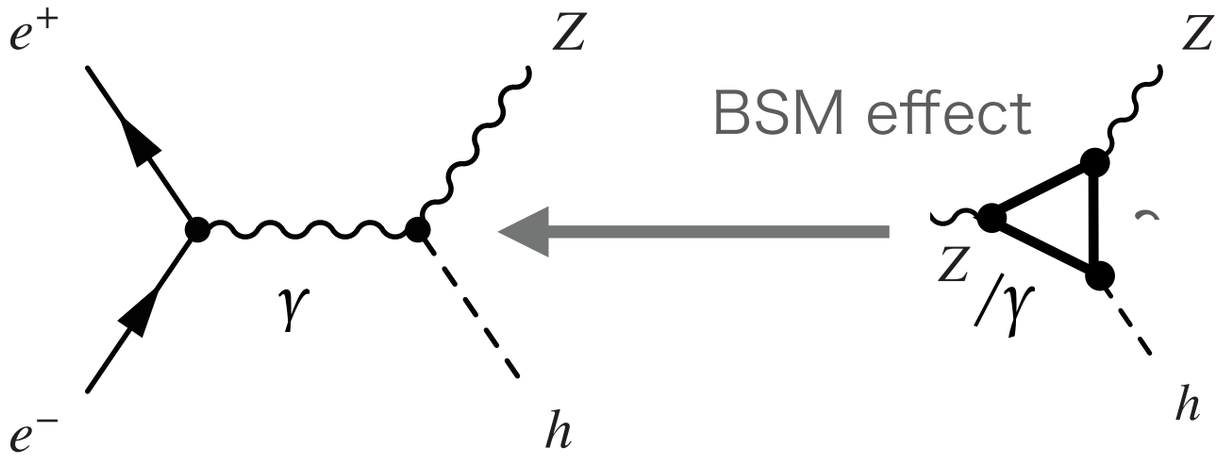


International Large Detector

1.Motivation

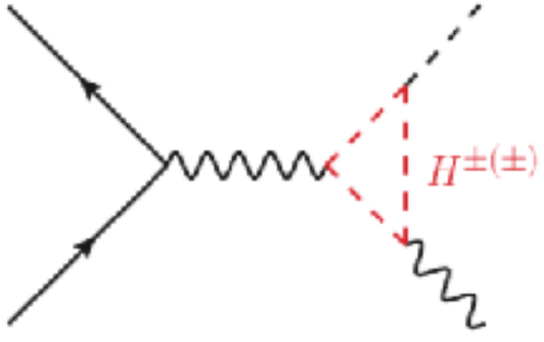
Find new physics via H$\gamma\gamma$ and HγZ couplings

Higgs to γZ coupling in the Standard Model (SM) is a loop induced coupling.

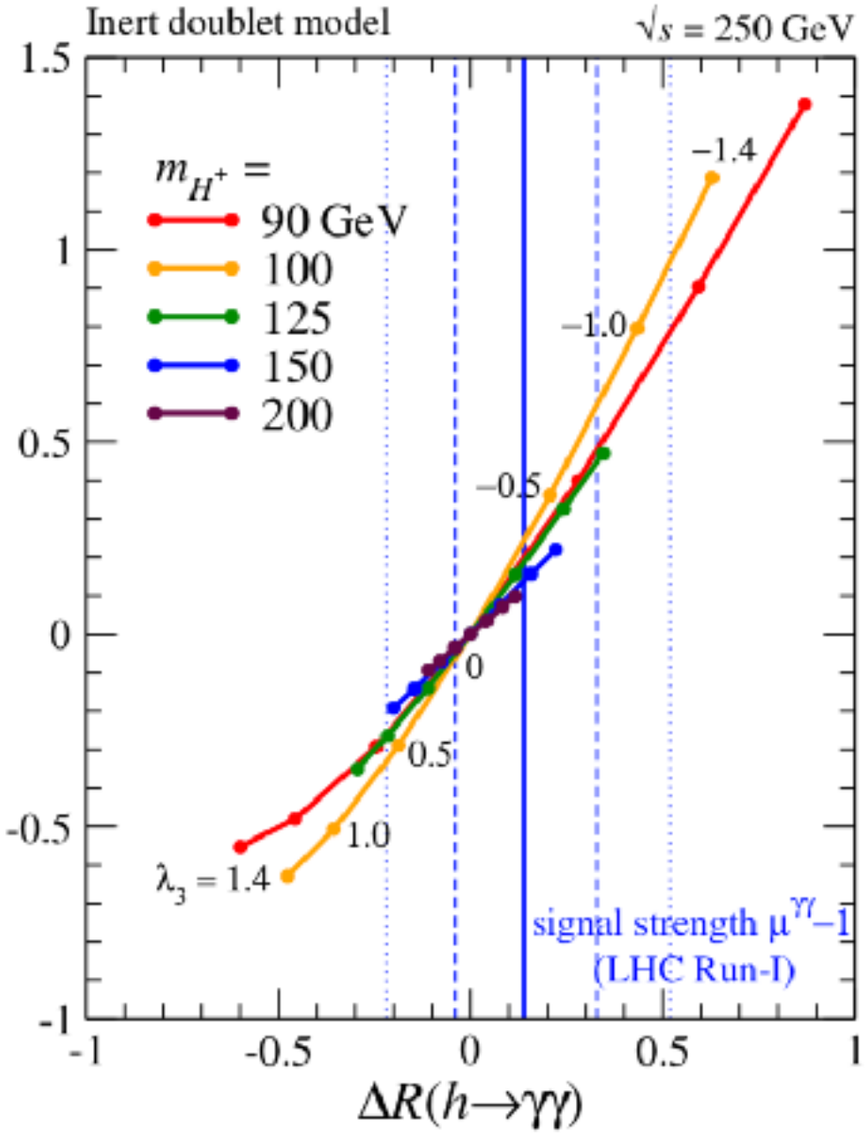


If we get different values of coupling constants with regard to SM, we get a key to new physics.

Ex： Inert Doublet Model



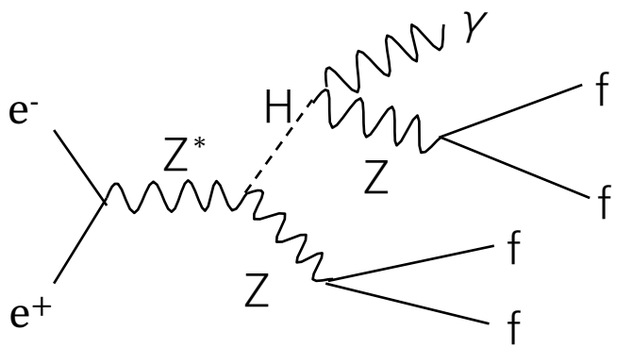
Mawatari, et al, arXiv:1808.10268



3.Experimental Method

higgs decay

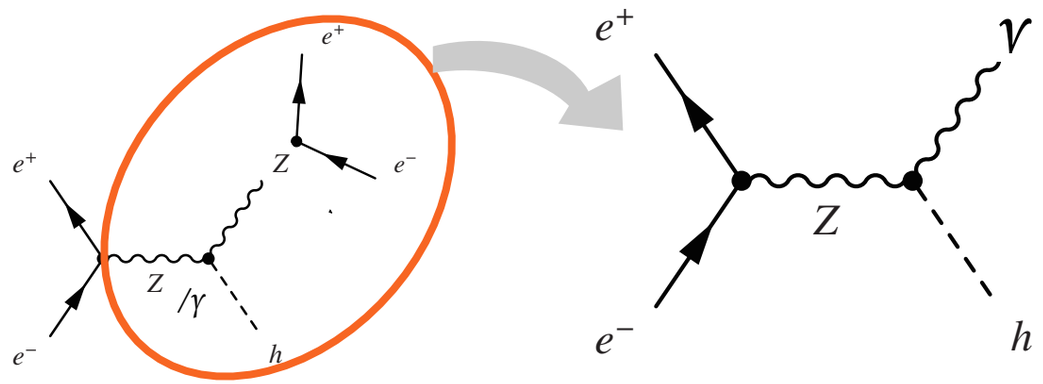
BR(h to gamma Z)



final state	Branching ratio
mmqqg	4.7%
eeqqg	4.7%
nnqqg	28.0%
qqqqg	48.9%
others	13.7%

by Kazuki Fujii at LCWS2018

higgs production



e+e-→hγ

h->bb

arXiv:1902.06029v1
[hep-ex]

h->WW*

fully hadronic

semi leptonic

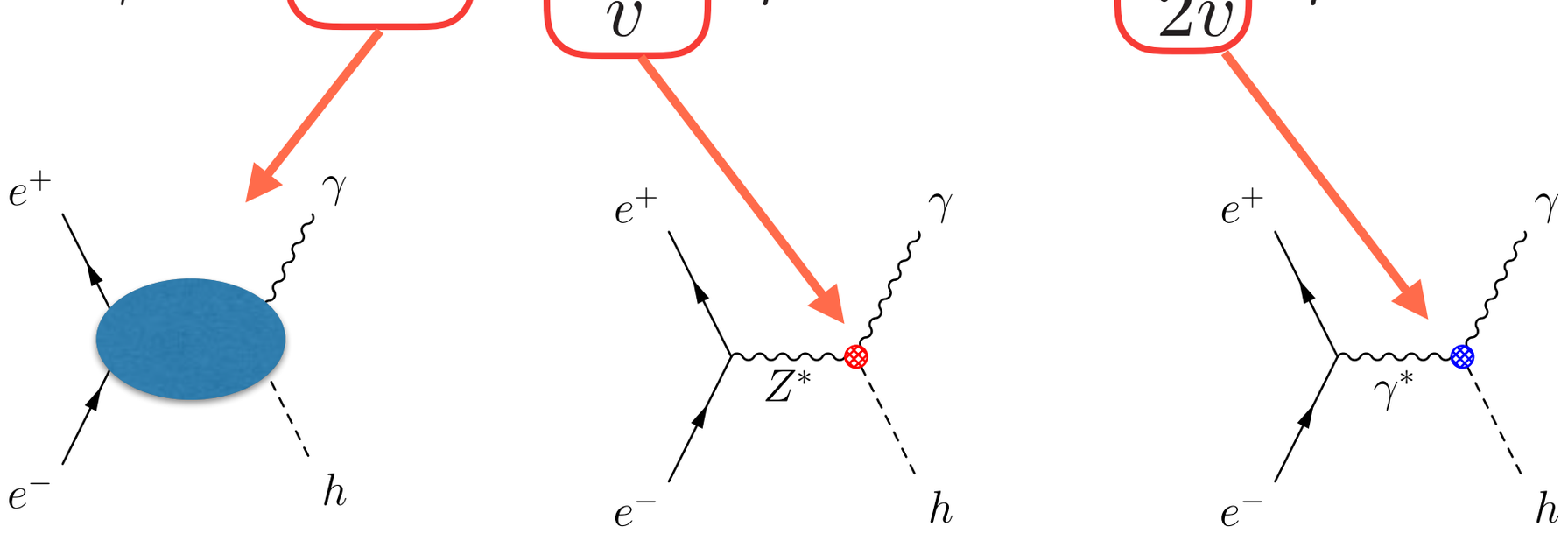
2. Theoretical framework for our analysis

The effective Lagrangian to include new physics contributions to the e+e- to hγ cross section model-independently

effective h γ Z coupling

effective h γ γ coupling

$$L_{\gamma H} = L_{\mathrm{SM}} + \frac{\zeta_{AZ}}{v} A_{\mu\nu} Z^{\mu\nu} H + \frac{\zeta_A}{2v} A_{\mu\nu} A^{\mu\nu} H$$



ζ_{AZ} : effective coupling between Higgs and γZ

ζ_A : effective coupling between Higgs and γγ

Aμν, Zμν : field strength tensors

v: vacuum expectation value

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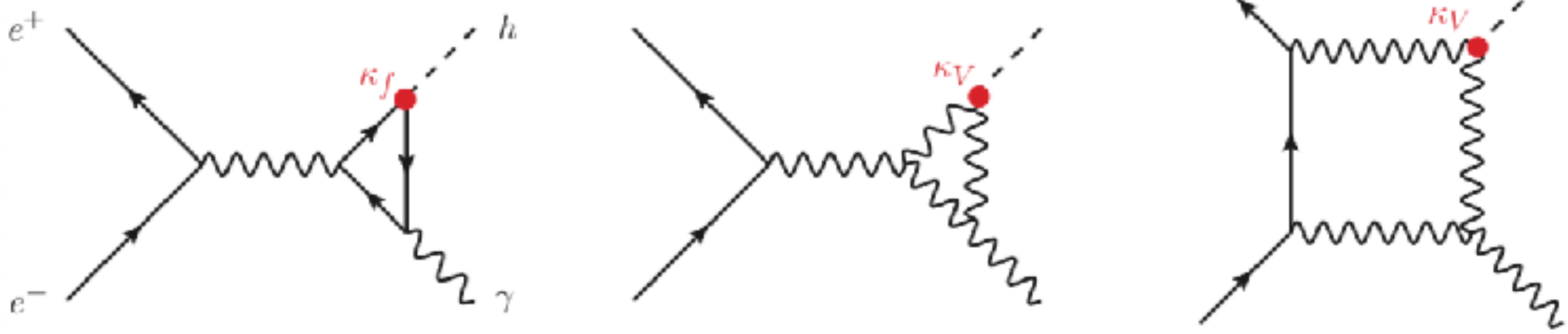
SM one-loop predictions

e+e- ->h gamma is a loop induced process in SM

The main Feynman diagrams

Mawatari, et al, arXiv:1808.10268



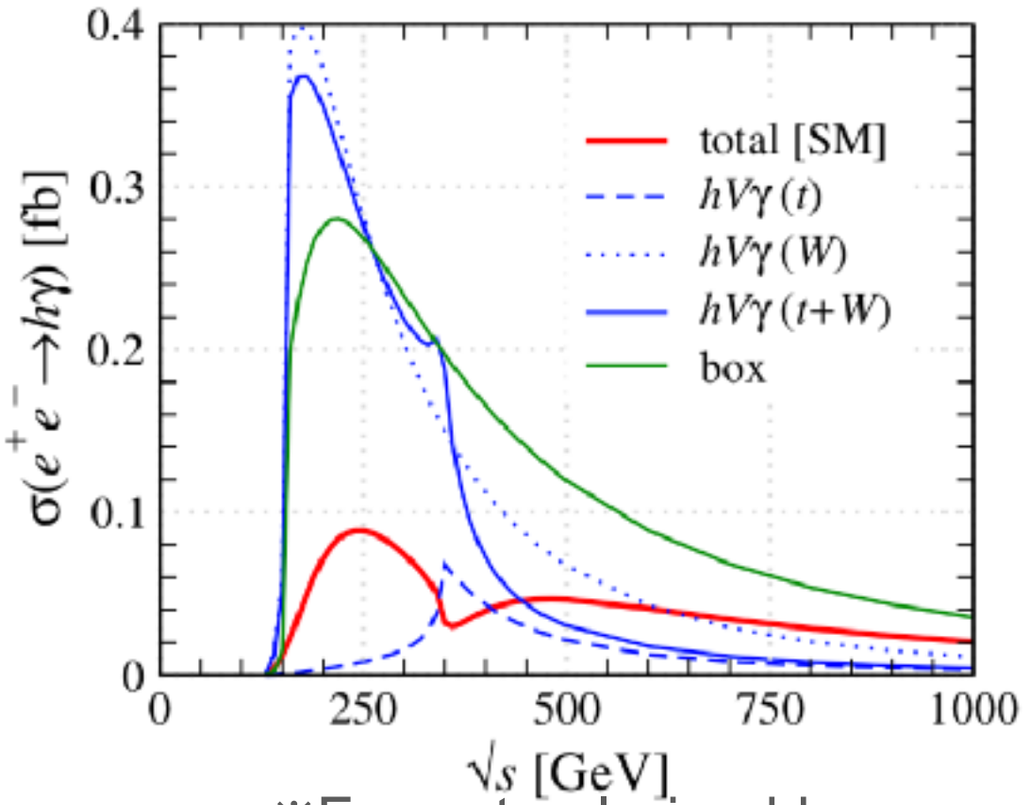
The cross sections by one loop calculation

$e-$ $e+$

σ_{SM}=0.35 fb for (-100%,+100%)

σ_{SM}=0.016 fb for (+100%,-100%)

σ_{SM}=0.20 fb for (-80%,+30%)

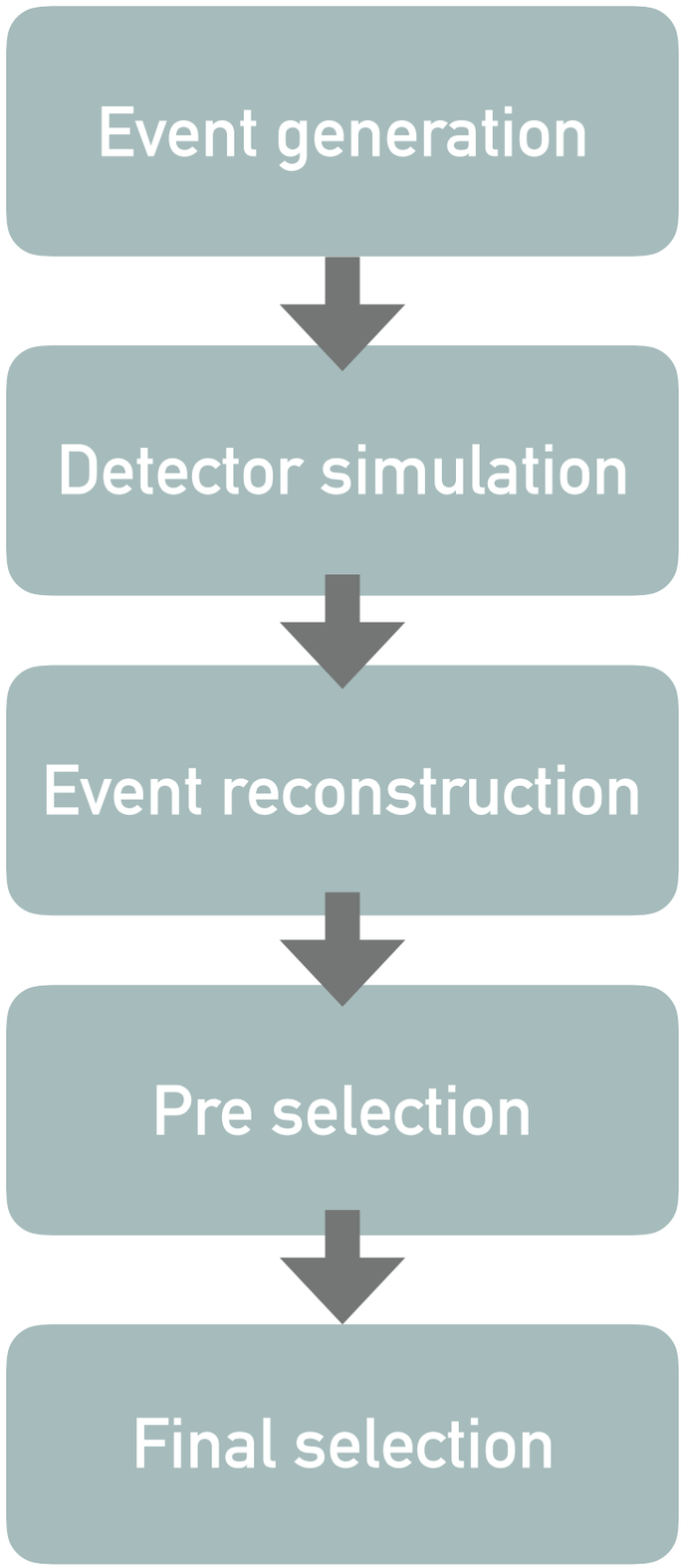


$\sqrt{s}$ = 250 GeV

※For not polarized beam

Destructive interferences

4.Simulation framework



- Physsim
  - √s=250 GeV
  - Integrated Luminosity: 2000 fb^{-1}
  - back ground : DBD sample
- ILD full simulation (Mokka)
- iLCSoft v01-16-02
  - MarlinReco, PandoraPFA,
  - LCFI+, Isolated photon finder, jet clustering
- ISR and Beamsstralung effects are included

5. Event selection

Signal: $e^+e^- \rightarrow \gamma H \rightarrow \gamma(b\bar{b})$

Signal signatures

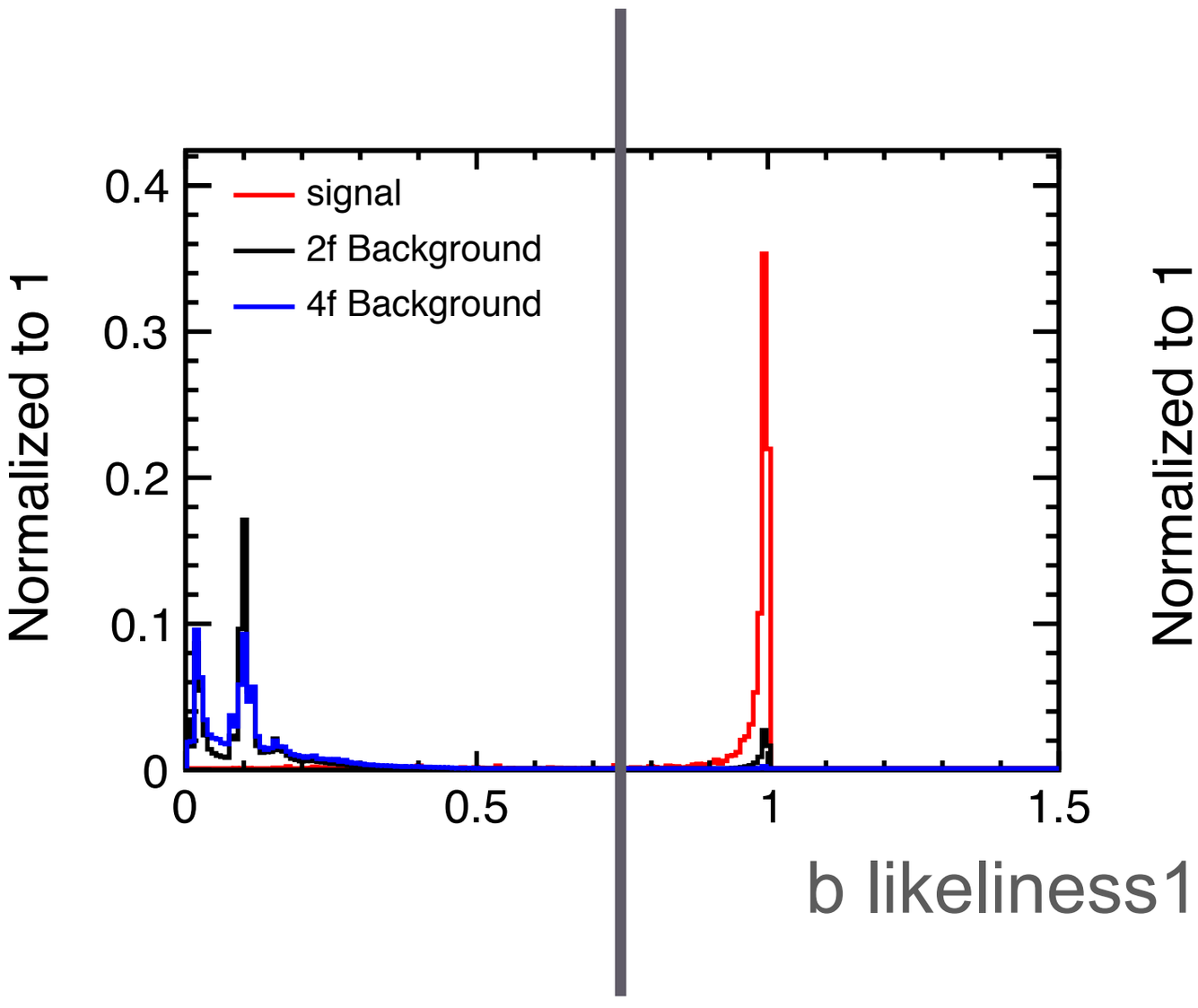
1. Isolated monochromatic photon with energy 93 GeV
2. 2 b jets
3. m(bb) (invariant mass) = higgs mass

Main backgrounds

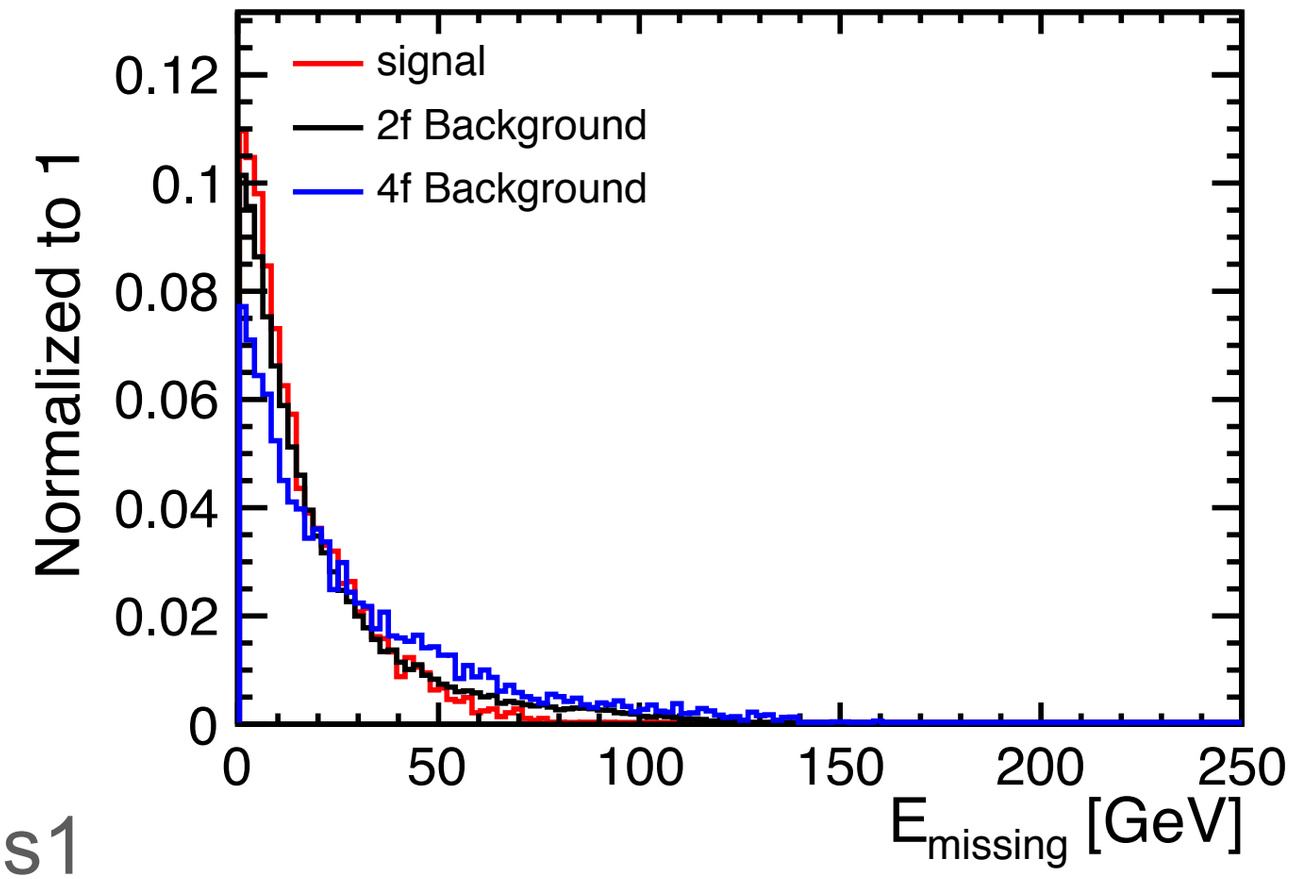
e+e- ->γqq(bar) dominated by e+e- → γZ (radiative return)

Final selection

-Cut 1:b likeliness1>0.77



-Cut 2: missing energy<35 GeV



※I tried Multivariate Data Analysis

6. Result

$$significance = \frac{N_s}{\sqrt{N_s + N_B}}$$

Reduction table Preliminary

N_s:Number of signal
N_B:Number of back ground

	Signal	background	Significance
Expected	237	3.14×10^{8}	0.01
Pre selection	222	6.54×10^{7}	0.02
btag>0.8	200	4.96×10^{6}	0.09
E_{mis}<35	182	4.30×10^{6}	0.09
mvabdt > 0.0126	75	1.98×10^{4}	0.53

6. Result

$$L_{\gamma H} = L_{\mathrm{SM}} + \frac{\zeta_{AZ}}{v} A_{\mu\nu} Z^{\mu\nu} H + \frac{\zeta_{A}}{2v} A_{\mu\nu} A^{\mu\nu} H$$

1.64

→95% C.L upper limit $\sigma = \frac{1.64}{significance} \sigma_{SM}$

Significance = 0.53 for SM

= 3.09 × 0.35 [fb]

=1.08 [fb] (Left handed)

3.09> $\frac{\sigma_{\gamma H}}{\sigma_{SM}} = 1 - 201\zeta_A - 273\zeta_{AZ}$ >0

asume ζ_A =0

-0.0077> ζ_{AZ} >0.0037

7. Combined result

higgs decay

$$Significance = \sqrt{1.00^2 + 0.78^2 + 1.54^2 + 1.15^2}$$
$$= 2.31 \pm 0.03$$

higgs production (h->bb)

Significance = 0.53 for SM

-0.0077> ζ_{AZ} >0.0037

8. Summary

・I simulated and analyzed e+e- -> h gamma process

・Significance for e+e- ->hγ process

~ 0.53σ for SM at $\sqrt{s}$=250 GeV, 2000 fb^{-1}

・model independent upper limit for cross section : $\sigma_{\gamma H}$< 1.08 fb(95% C.L.)

・Corresponding bounds : -0.0077> ζ_{AZ} >0.0037

Next step

・try h->WW* channel（on going）

・Understand the role of this measurement in one global EFT analysis