Update and future plan of H→cc

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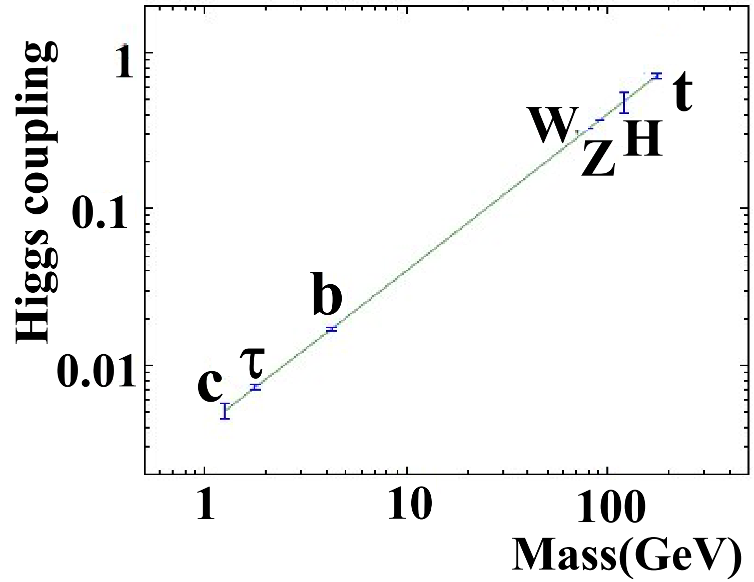
Introduction

Higgs branching ratio

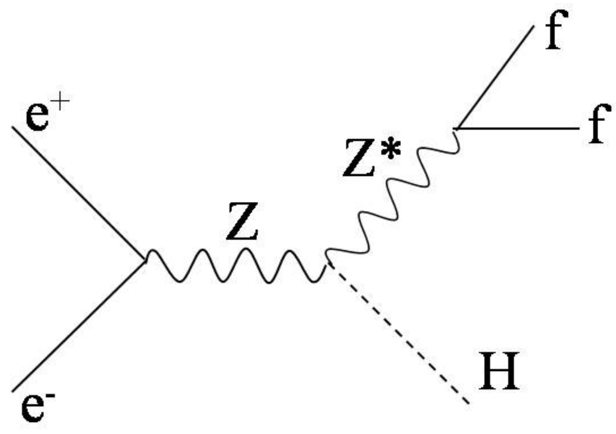
- The measurement is essential to confirm Higgs mechanism.
- Estimation of measurement accuracy of H→cc with e^+e^-→ZH is required for LOI.
    - Optionally, H→μμ

Mass v.s. Higgs coupling



Analysis mode

- ZH→qqcc : Wenbiao → Hiroaki
- ZH→ννcc : Yoshida
- ZH→llqq : Roberval → Yoshida



The status of the analysis and future plan are shown.

Simulation setup

Simulation condition

- Higgs mass: 120 GeV
- E_{CM} : 250 GeV (with Beamstrahlung, ISR, and FSR)
- Integrated luminosity: 250 fb^{-1}
- Beam energy spread: 0.28% (e^-) and 0.18% (e^+)
- Beam polarization: 80% left-handed for e^- and 30% right-handed for e^+

Signal v.s. BG

- Signal: ZH→qqcc, ννcc, llcc
  - σ(ZH): 387fb
  - BR(H→cc): 3.6%
- BG: qqqq, qq, qqll, ….

Analysis procedure

- Selection of ZH events from SM-BG.
  - There are large SM-BG from ZZ, WW, and etc..
  - The kinematical selection cut is necessary.
- Identification of H→cc and H→bb in ZH events.
  - H→bb is large BG for H→cc.
  - LCFIVertex is used for the flavor tagging.
- Estimation of BR(H→cc)
  - ILD: Template fitting with 3D histogram of b/c/bc-likeness.
    - ✓ The same method as SiD was used for ZH→qqcc in LOI.
  - SiD: Statistical evaluation assuming knowledge of ZH xsec and Higgs branching ratio other than H→cc.

Result in LOI and ALCPG09

LOI

	ILD	SiD
• ZH→ννcc :	13.8%	10.3%
• ZH→qqcc :	30.0%	5.8%
• ZH→llcc :	28.0%	
• ZH→qqμμ :		1.1σ

ALCPG09

	ILD	SiD
• ZH→ννcc :	13.8%	11.6%
• ZH→qqcc :	16.6%	8.8%
• ZH→llcc :	20.8%	
• ZH→qqμμ :		1.1σ

Remarks

- The measurement accuracy of ZH→ννcc becomes consist with ILD and SiD.
- There are still large difference for ZH→qqcc.

→ The consistency check with SiD and current status of the analysis for ZH→qqcc are shown.

Result of ZH→qqcc in LOI

In LOI, we have large difference of the selection efficiency with SiD.

<u># of events after selection cut</u>

ILD

- Signal: 37
- ZH BG: 24
- SM BG: 97

SiD

- Signal : 814
- ZH BG : 547
- SM BG : 569

For the comparison, Wenbiao tries to apply the same pre-selection cut as SiD after LOI submission.

Pre-selection with SiD cut

	ZH→qqcc	ZH-BG	SM-BG
Nocut	1915	50590	3.94×10^7
Evis > 170GeV	1915	48057	1.62×10^7
thrust < 0.95	1912	47979	1.24×10^7
$\lvert\cos\theta_{thrust}\rvert < 0.96$	1819	45695	8361181
$75 < \theta_{Hjj} < 165$ deg.	1702	42686	7331015
$50 < \theta_{Zjj} < 150$ deg.	1528	38309	6060228
$95 < M_H < 145$ GeV	1408	33967	3289201
$45 < M_Z < 105$ GeV	1404	33879	3276026
$-\log_{10}(Y_{34}) < 2.7$	1380	33345	2592239
Ntrk>1, Npfo>5	1351	30868	2113206
$E_\gamma < 10$GeV	697	17403	906180
SiD:	947	15687	967312

- After LOI, Wenbiao used the same cut as SiD.
- However, some cut values were different.

SiD cut:

← $105 < \theta_{Hjj} < 165$ deg

← $70 < \theta_{Zjj} < 160$ deg

← $110 < M_H < 140$ GeV

← $80 < M_Z < 110$ GeV

Still inconsistent.

At first, we checked consistency within ILD.

Consistency check within ILD

	ZH→qqcc		ZH-BG		SM-BG	
	Hiroaki	Wenbiao	Hiroaki	Wenbiao	Hiroaki	Wenbiao
Nocut	2914	1915	76927	50590	4.38×10^9	3.94×10^7
Decay mode selection	1693	1915	38273	48057	2.41×10^9	1.62×10^7
# of charged track > 4	1238	1864	27925	43256	3323060	7060154
$-\log_{10}(Y_{34}) < 2.7$	1218	1826	27563	42572	2635920	4792438
thrust < 0.95	1217	1825	27551	42545	2584510	4674499
$\lvert\cos\theta_{thrust}\rvert < 0.95$	1157					
$105 < \theta_{Hjj} < 165$ deg.	1080					
$70 < \theta_{Zjj} < 160$ deg.	1028					
$110 < M_H < 140$ GeV	982	1142	22076	24712	1209100	1118000
$80 < M_Z < 110$ GeV	982	1142	22074	24711	1206570	1117958
$E_\gamma < 10$GeV	515	582	12601	13758	570479	485898

The number of events after SiD cut became consistent within ILD.

→ Let's compare with SiD.

Comparison with SiD

	ZH→qqcc		ZH-BG		SM-BG	
	ILD	SiD	ILD	SiD	ILD	SiD
Nocut	2914	2869	76927	76910	4.38×10^9	9.28×10^9
Decay mode selection	1693	1837	38273	41016	2.41×10^9	3.94×10^7
# of charged track > 4	1238	1143	27925	30125	3323060	18601753
$-\log_{10}(Y_{34}) < 2.7$	1218	1101	27563	29478	2635920	13921271
thrust < 0.95	1217	1047	27551	27065	2584510	8737017
$\lvert\cos\theta_{thrust}\rvert < 0.95$	1157	1017	26258	26322	2295690	7943851
$105 < \theta_{Hjj} < 165$ deg.	1080	[illegible]	[illegible]	[illegible]	8300	5871237
$70 < \theta_{Zjj} < 160$ deg.	1028	[illegible]	[illegible]	[illegible]	6150	4898312
$110 < M_H < 140$ GeV	982	966	22076	22533	1209100	1917231
$80 < M_Z < 110$ GeV	982	963	22074	21877	1206570	1561432
$E_\gamma < 10$GeV	515	947	12601	15687	570479	967312

The performance of E_γ cut is much different.

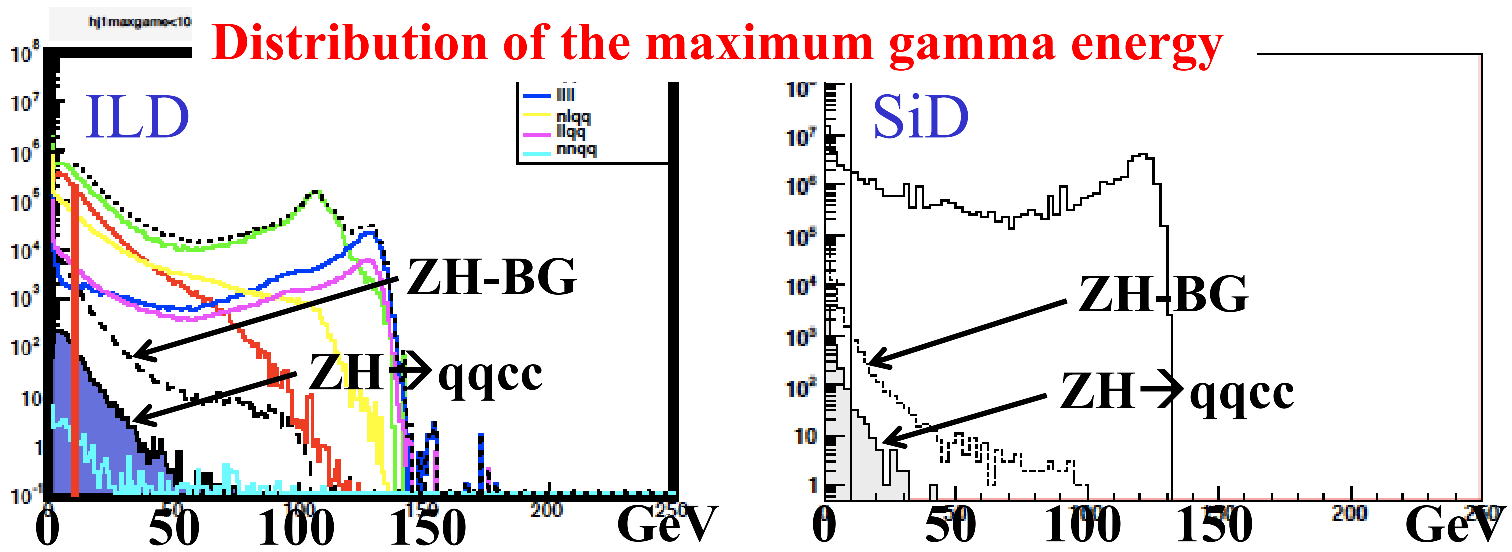
Optimization of E_γ cut

- E_γ distribution for ILD is wider than SiD.
- E_γ<20GeV is required for ILD. (SiD: E_γ<10GeV)

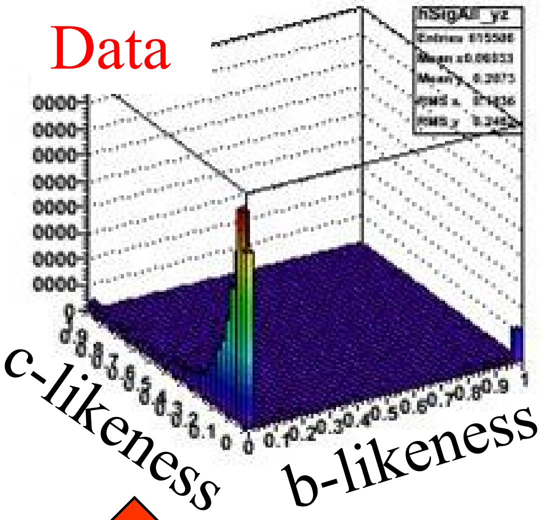
ZH→qqcc	ZH-BG	SM-BG
• ILD: 895	• ILD: 20351	• ILD: 1036990
• SiD: 947	• SiD: 15687	• SiD: 967312

The cut results became almost consistent with SiD.

→ We study to derive Higgs BR.



Optimization of template fit

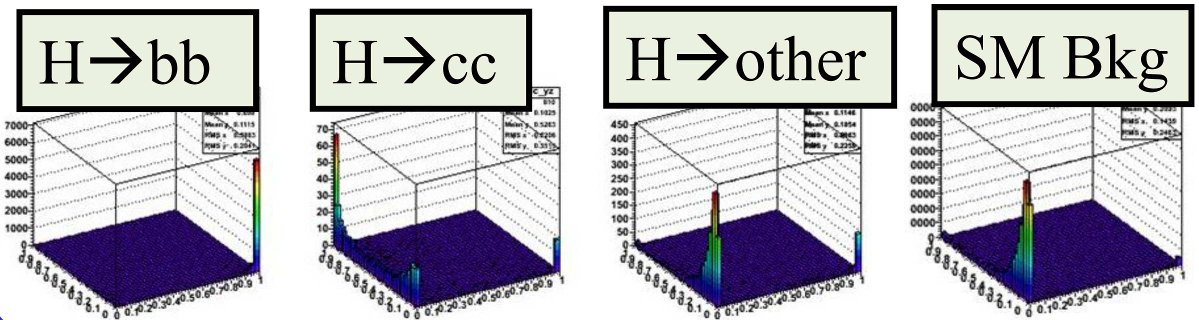


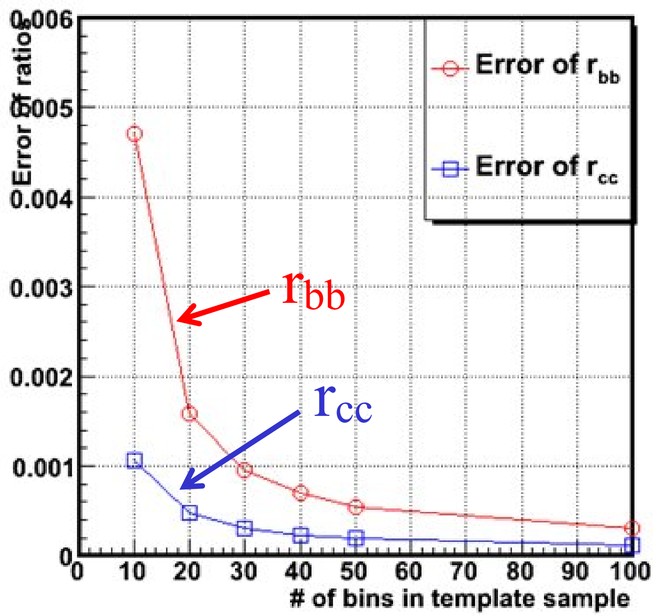
- Higgs-BR is derived by using the template fitting.
  - Template: 3D histogram of b/bc/c-likeness
- The accuracy of BR depends on the binning of the template by statistical bias of the template.
  - The smoothing of the template is ongoing.

The analysis will be finished by LCWS10.

Fit with $\chi^2(r_{bb}, r_{cc}, r_{other}, r_{SM})$

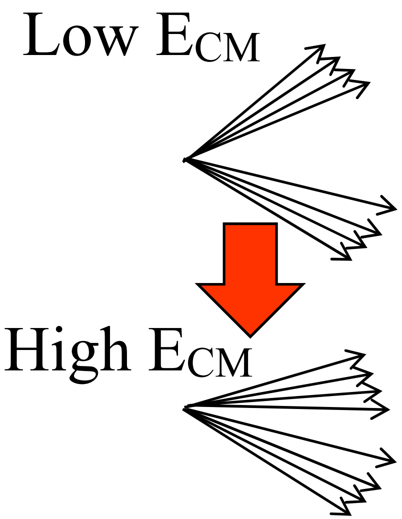
Template

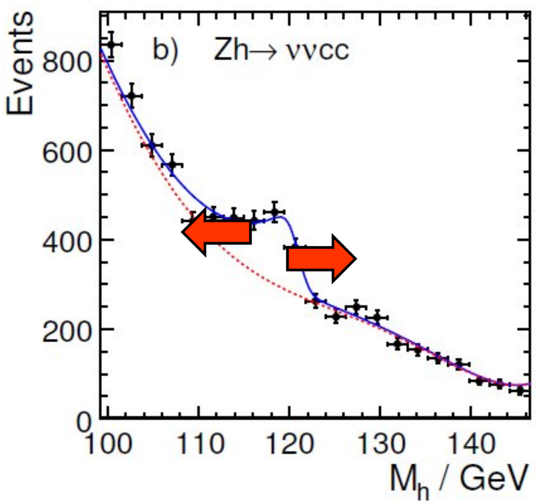


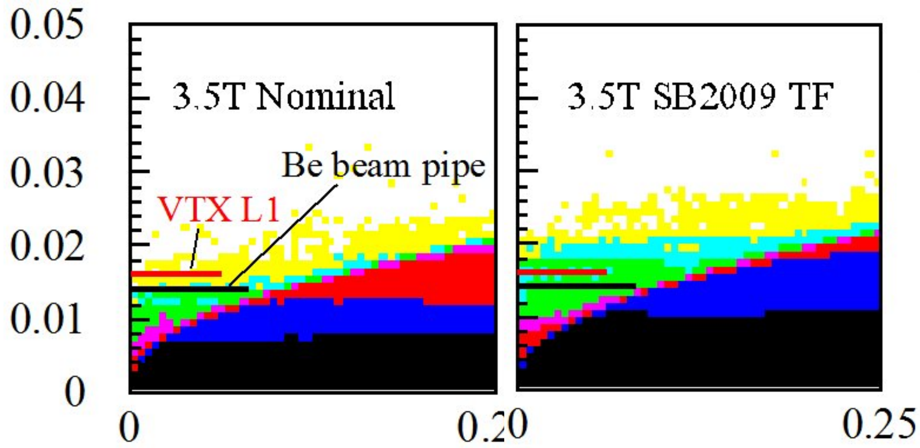


Future plan for H→cc study

- The sensitivity to Higgs BR must be evaluated as a function of E_{CM}.
  - It is not trivial because the performance of flavor tagging depends on the jet-clustering.
  - The selection efficiency also depends on the jet-clustering.
- The effect of the radius of the VTX inner most layer should be checked.
  - Depending the accelerator design, the VTX inner most layer might be put at larger distance from IP.







Summary

- After LOI, we try to check consistency of Higgs BR analysis with SiD.
- We had consistent number of events after selection cut with SiD and ILD before ALCPG.
- There is a large discrepancy of the measurement accuracy of Higgs-BR with SiD.
- The measurement accuracy of the Higgs-BR depends on the binning of the template.
    - The problem will be solved soon.
- The sensitivity to Higgs BR must be evaluated as a function of E_{CM} and the radius of VTX layer.