Higgs BR study

ILD Analysis meeting

2011 Aug. 31

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Current status

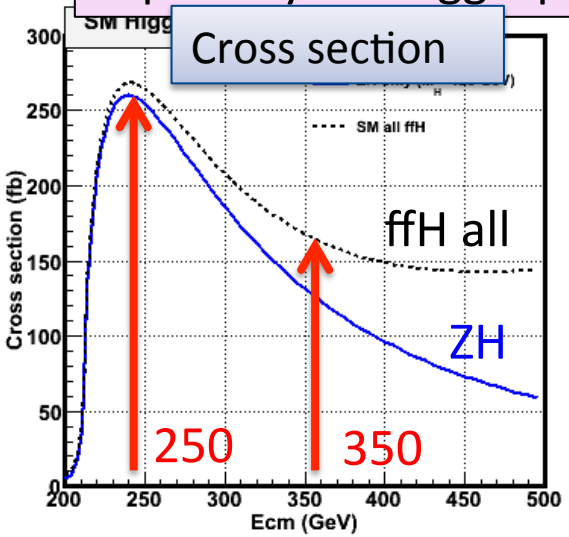
1. Higgs BR study results are summarized to publish the paper
   Checking stable final results with template fitting
2. Suppose the different masses from 120 GeV for Higgs study from the consideration of LHC results

3. DBD analysis of vvH BR at 1 TeV is also considered

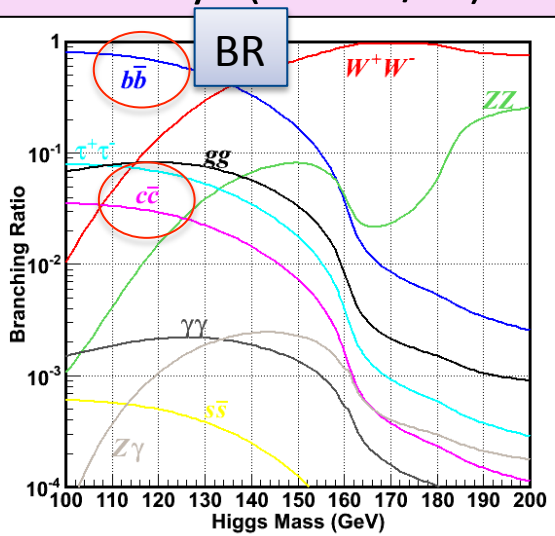
Higgs Branching Fraction study

Measurement of the branching ratio is one of the issues of ILC especially for Higgs quark decays (H→bb/cc)

Cross section



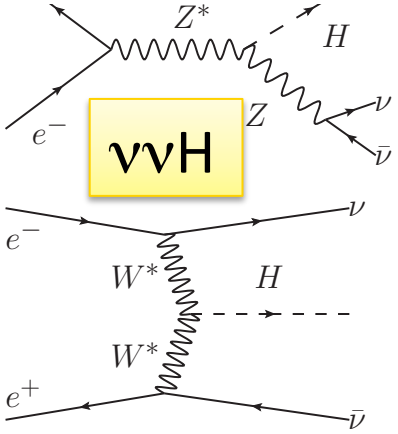
BR



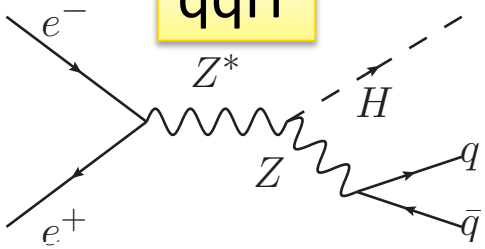
M_H=120 GeV
P(e+,e-)=(+30%, -80%) L=250fb^{-1} is assumed
with E_{cm}=250 and 350 GeV

Main background processes
WW/ZZ + qq (tt at 350 GeV)

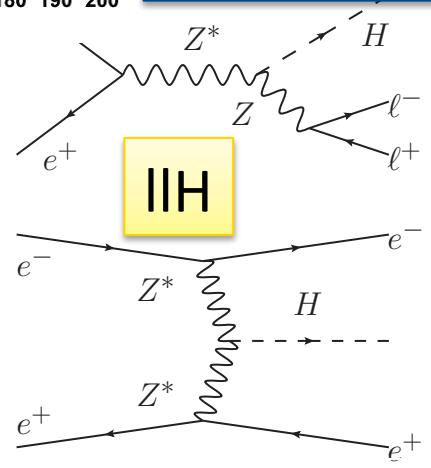
νν̄H



qqH



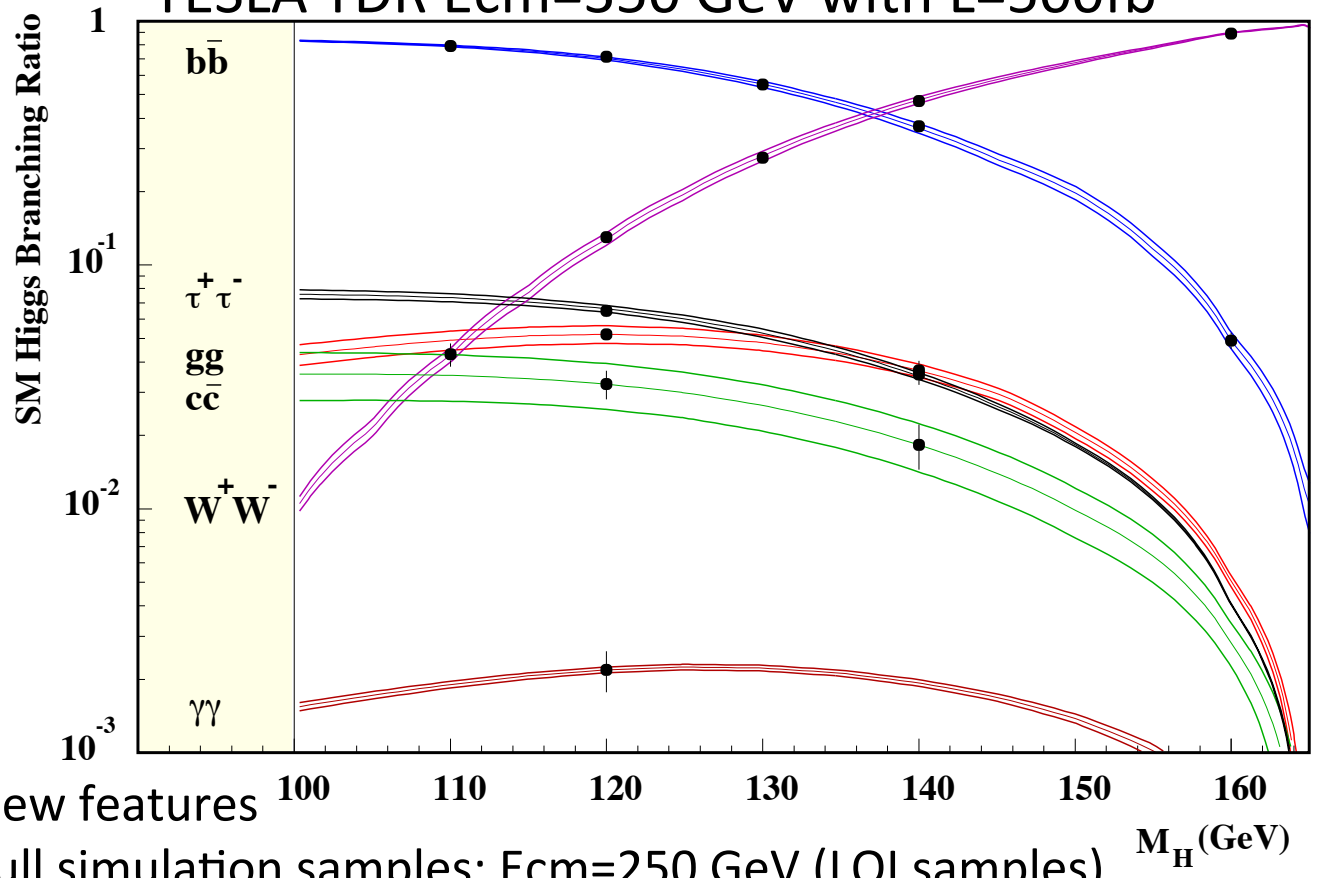
llH



Higgs BR with different masses

Aim: Update Higgs BR measurement accuracy plot after LOI

TESLA TDR Ecm=350 GeV with L=500fb^{-1}



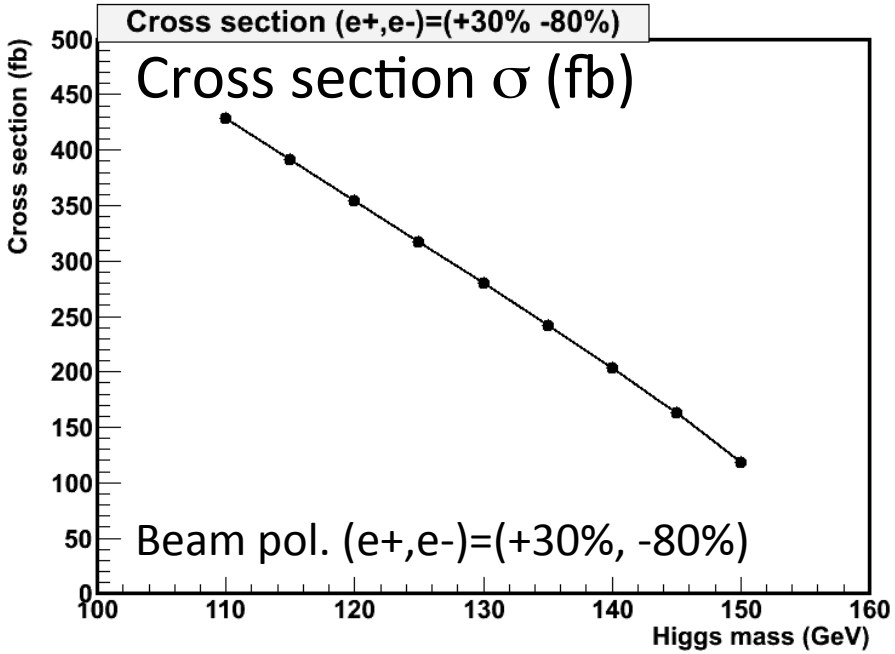
New features

Full simulation samples: Ecm=250 GeV (LOI samples)

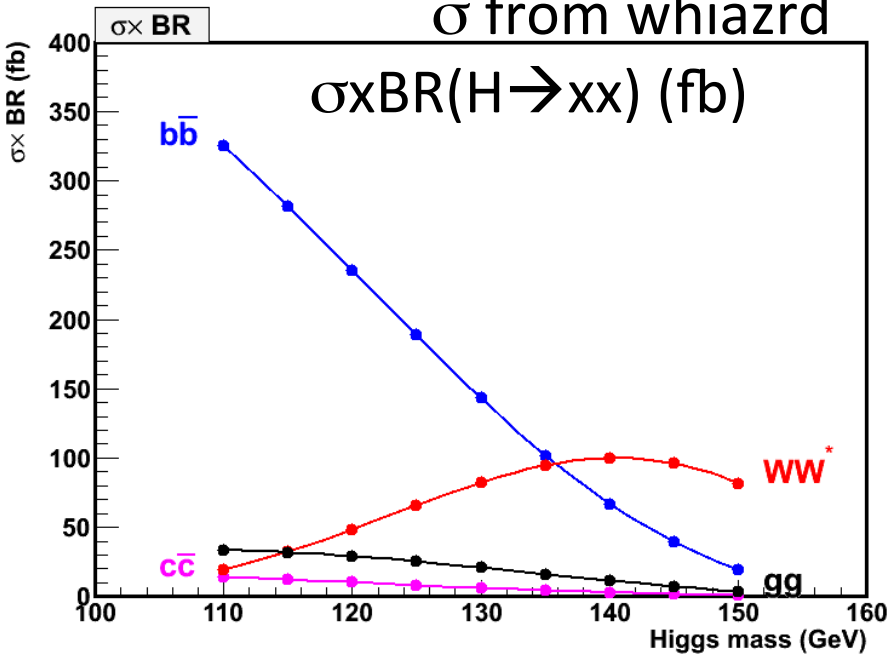
Signal : Mh=120 GeV, integrated luminosity of 250 fb^{-1}

Cross section and σ×BR

σ at E_{cm}=250 GeV with different Higgs masses from whizard
Beam pol. (e+,e-)=(+30%, -80%)



σ from whiazrd



Measurement accuracies are extrapolated from the 120 GeV results

$$\left(\frac{\Delta BR}{BR(x)}\right)_{M_h} = \left(\frac{\Delta BR}{BR(x)}\right)_{120} \cdot \sqrt{\frac{\sigma_{120}\cdot BR(x)_{120}}{\sigma_{M_h}\cdot BR(x)_{M_h}}}$$

Efficiency differences are not considered
BR is calculated by HDECAY

Summary table of Higgs BR after LOI

Ecm=250 GeV and L=250fb^{-1}, P(e+,e-)=(+30%, -80%)

Higgs mass	120 GeV					140 GeV		
Cross section	σ=354.3 fb					σ=203.1 fb		
Higgs decay	BR	σxBR	ΔBR/BR			BR	σxBR	ΔBR/BR
			ILD	SiD	Avg.			Scaled
H→bb	66.5%	235.6	2.7% (2.7%)	4.8%	3.8%	33.0%	67.1	7.1%
H→cc	2.9%	10.4	8.7% (6.7%)	8.4%	8.6%	1.5%	3.0	16.1%
H→WW*	13.6%	48.3	15.7%		15.7%	49.2%	99.8	10.9%
H→gg	8.2%	29.2		12.2%	12.2%	5.7%	11.5	19.4%
H→ττ	6.8%	24.1				3.5%	7.1	
H→ZZ*	1.5%	5.3				6.7%	13.6	

ILD results are preliminarily combined with vvH and qqH at 250 GeV ():350GeV

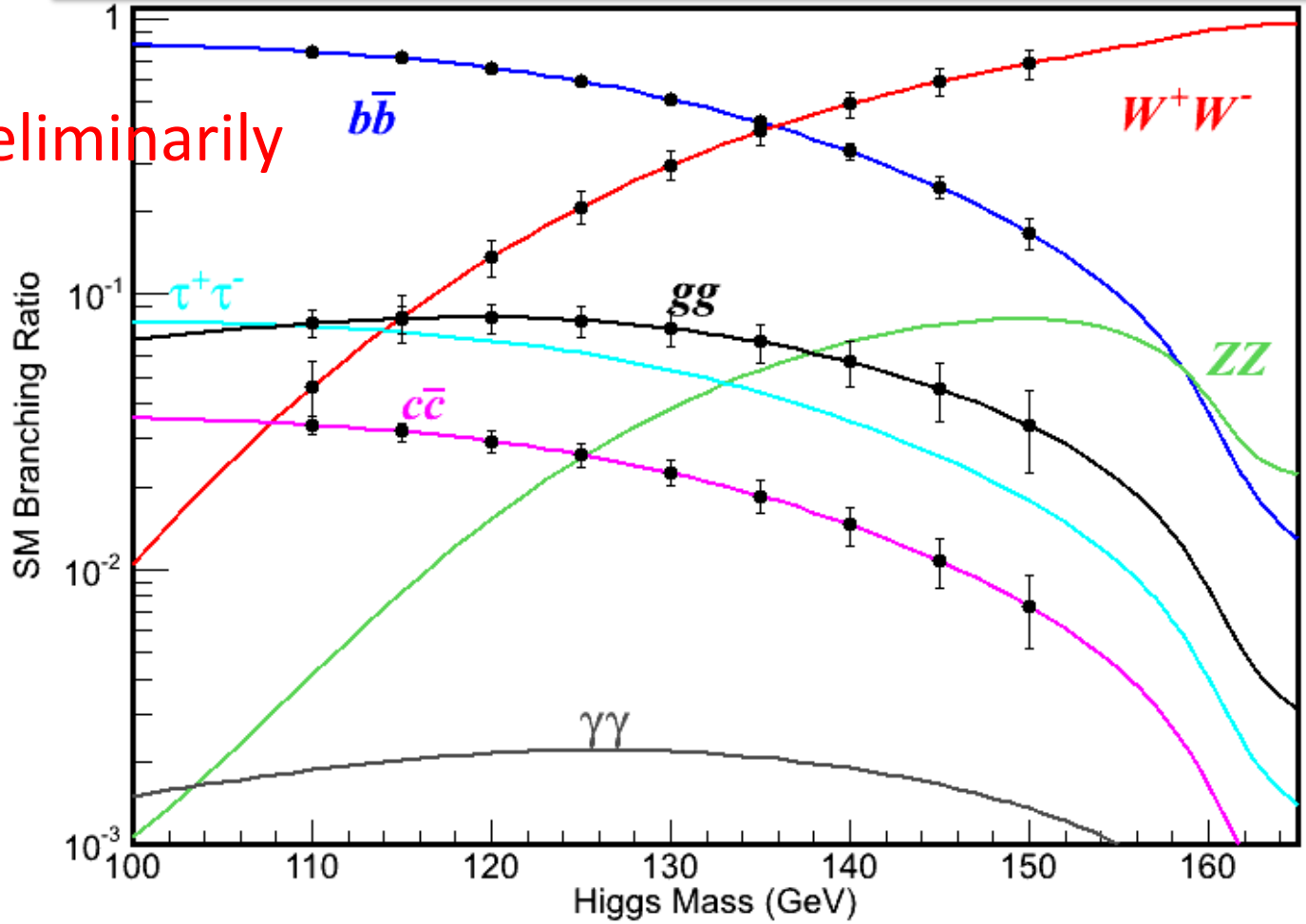
- H→WW* result is obtained from the Takubo-san's analysis at 250 GeV
- H→gg was studied at SiD (combined results of vvH and qqH) at 250 GeV
- σ_{ZH} uncertainty is also included for ILD (2.5%) and SiD (4.7%)

SiD ZH sutdy: Physical Review D 82, 03013 (2010)
H→WW* anomalous coupling 1011.5805v2

BR accuracy with different Mh

Ecm=250 GeV, L=250 fb^{-1}, Beam pol(e^+,e^-)=(+30%, -80%)

preliminarily



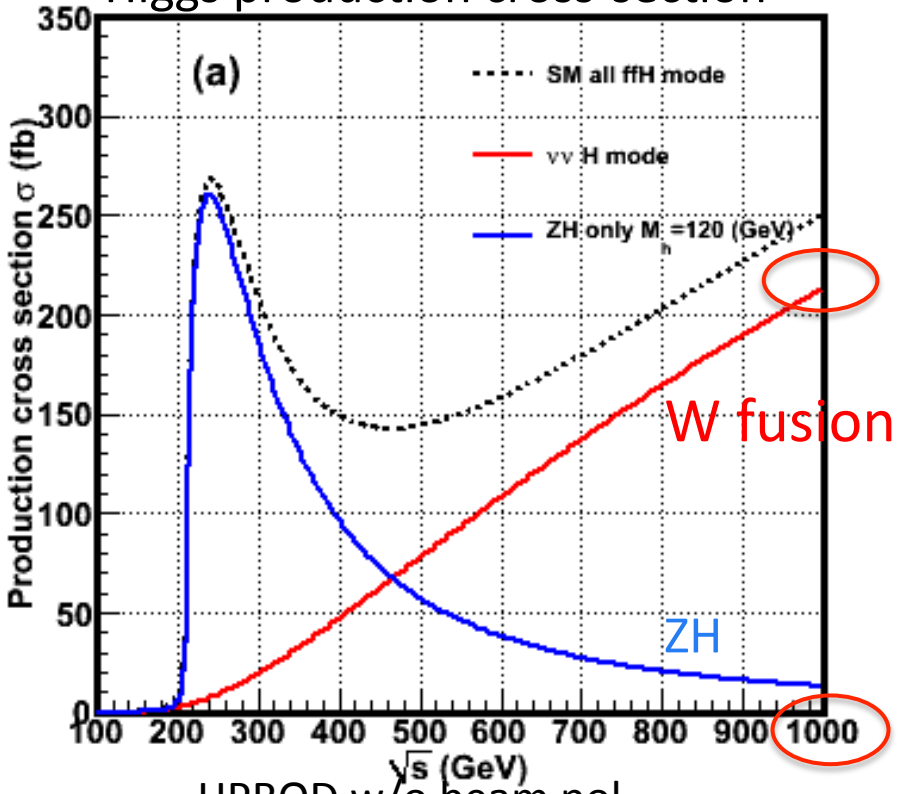
Measurement accuracies are extrapolated from Mh=120 GeV

Toward the DBD analysis

vvH @ 1 TeV for DBD

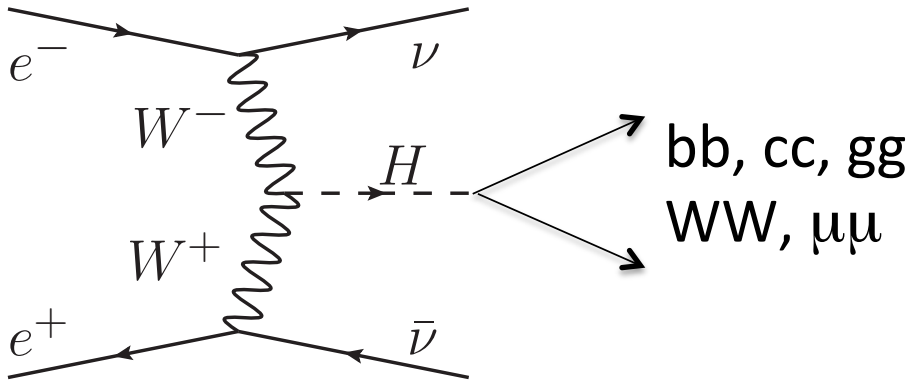
DBD benchmark process
σ*BR for H→μμ, bb, cc, WW, gg

Higgs production cross-section



HPROD w/o beam pol.

Main production process: W-fusion
(Z information is not available)



H→bb, cc, gg
Di jet reconstruction (Invariant mass)

H→μμ, WW (qqqq, lvlv, lvqq)
(Di lepton ID, W mass information)

Main backgrounds (WW,ZZ)
ll, qq (2f), WW, ZZ (4f), tt (6f)

MC samples for DBD analysis

- As minimum samples, WW and ZZ background should be prepared
- Other 2f, 4f SM (tt, qq background)
- ll for H→μμ? generation with cuts

	σ (fb)	Process
vvH	215 fb	ee→vvH
WW	2695 fb	lvqq, qqqq, llqq,vlvl
ZZ	151 fb	vvqq, qqqq, vvll, llll
qq	624 fb	qq
tt	167 fb	tt
ll	40457 fb	ll

Current signal samples in MadGraph

L=1000fb^{-1} statistics for 250 GeV
L=500fb^{-1} statistics for 350GeV

Summary

- Now summarizing Higgs BR study results to publish paper

- Mh=130, 140 GeV at Ecm=250 GeV DST samples are already produced by A. Miyamoto.
  - Need to considered H→WW study for both Mh=140 GeV case and DBD vvH@ 1TeV study.

Backup

SiD Higgs physics results

TABLE V. Results for the $H \to c\bar{c}$, $H \to b\bar{b}$, and $H \to gg$ decay modes.

		Neutrino	Hadronic	Combined
$H \to c\bar{c}$	Signal events	178	407	
	SM background events	140	673	
	Higgs background events	109	213	
	Signal efficiency	27.9	22.2	
	Signal $\sigma_{H\to c\bar{c}}$	6.8 ± 0.8 fb	6.9 ± 0.6 fb	6.86 ± 0.48 fb
	Relative uncertainty on $\sigma_{H\to c\bar{c}}$	11.6%	8.8%	7.0%
	Higgs BR	3.3 ± 0.4%	3.3 ± 0.3%	3.3 ± 0.3%
	Relative uncertainty on Higgs BR	12.5%	10.0%	8.4%
$H \to b\bar{b}$	Signal events	2833	8122	
	SM background events	220	4700	
	Higgs background events	55	423	
	Signal efficiency	24.5	26.2	
	Signal $\sigma_{H\to b\bar{b}}$	142.7 ± 2.3 fb	142.5 ± 1.9 fb	142.57 ± 1.61 fb
	Relative uncertainty on $\sigma_{H\to b\bar{b}}$	1.9%	1.4%	1.1%
	Higgs BR	68.3 ± 3.4%	68.2 ± 3.3%	68.2 ± 5.3%
	Relative uncertainty on Higgs BR	5.0%	4.9%	4.8%
$H \to gg$	Signal events	32	524	
	SM background events	0	3621	
	Higgs background events	4	1431	
	Signal efficiency	3.3	17.7	
	Signal $\sigma_{H\to gg}$	15.1 ± 1.9 fb	15.6 ± 2.6 fb	15.41 ± 1.74 fb
	Relative uncertainty on $\sigma_{H\to gg}$	18.7%	14.2%	11.3%
	Higgs BR	7.2 ± 1.4%	7.5 ± 1.1%	7.4 ± 0.9%
	Relative uncertainty on Higgs BR	19.3%	15.0%	12.2%

PHYSICAL REVIEW D 82, 033013 (2010), Yambazi Banda et.al

RDR Physics chapter

TABLE 2.1
Expected precision of the Higgs branching ratio measurements at ILC for $M_H = 120$ GeV and a luminosity of 500 fb^{-1}. Ranges of results from various studies are shown with c.m. energies of 300 GeV [8], 350 GeV [93, 94, 95] and 350/500 GeV [96].

Decay mode	Relative precision (%)	References
$b\bar{b}$	1.0–2.4	[8][93] [94][97]
$c\bar{c}$	8.1–12.3	[8][93] [94][97]
$\tau^+\tau^-$	4.6–7.1	[8] [93] [94]
gg	4.8–10	[8] [93] [94][97]
WW	3.6–5.3	[8][93] [94] [95]
$\gamma\gamma$	23–35	[94] [96]

[8] ACFA Linear Collider Working Group, K. Abe et al., hep-ph/0109166.
[93] M. Battaglia, hep-ph/9910271.
[94] J. C. Brient, LC-PHSM-2002-003.
[95] G. Borisov and F. Richard, hep-ph/9905413.
[96] E. Boos et al., Eur. Phys. J. C19, 455 (2001).
[97] T. Kuhl and K. Desch, LC-PHSM-2007-2.

RDR Physics chapter

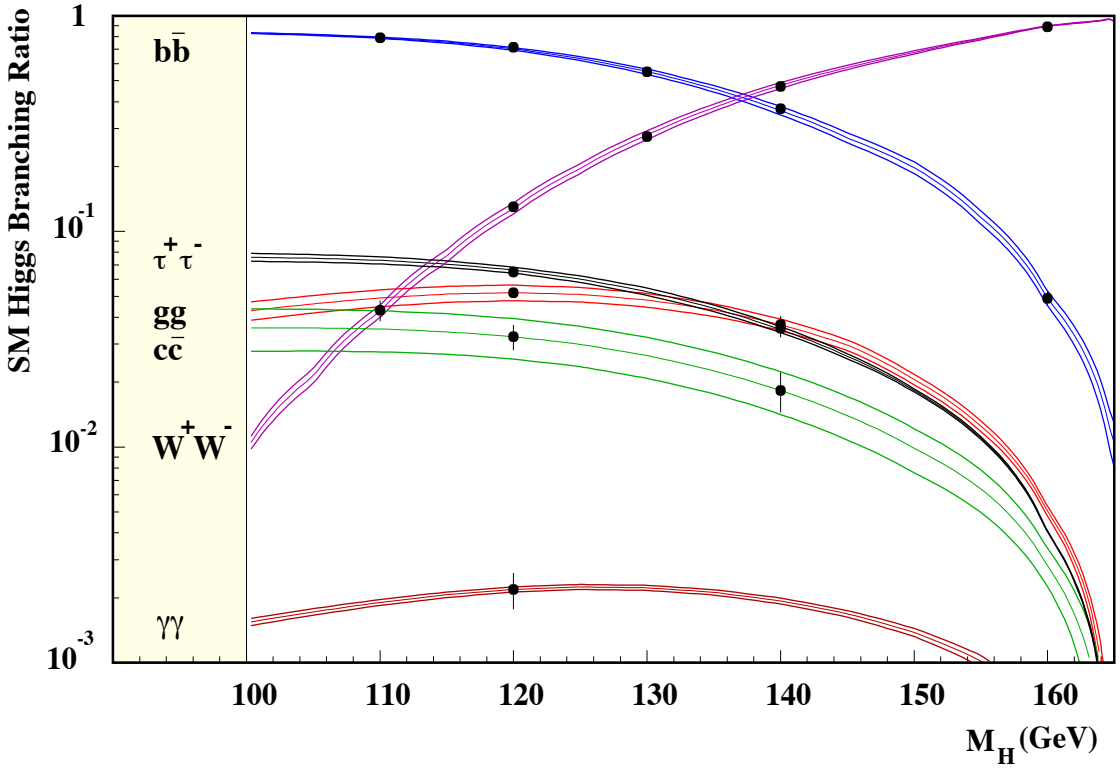


FIGURE 2.12. The branching ratio for the SM Higgs boson with the expected sensitivity at ILC. A luminosity of 500 fb^{-1} at a c.m. energy of 350 GeV are assumed; from Ref. [93].

ILDLOI summary table

Channel	$Br(\mathrm{H} \to \mathrm{b\bar{b}})$	$Br(\mathrm{H} \to \mathrm{c\bar{c}})$	$Br(\mathrm{H} \to gg)$
$\mathrm{ZH} \to \ell^+\ell^-\mathrm{q\bar{q}}$	$(2.7 \oplus 2.5)\,\%$	$(28 \oplus 2.5)\,\%$	$(29 \oplus 2.5)\,\%$
$\mathrm{ZH} \to \nu\bar{\nu}H$	$(1.1 \oplus 2.5)\,\%$	$(13.8 \oplus 2.5)\,\%$	–
$\mathrm{ZH} \to \mathrm{q\bar{q}c\bar{c}}$	–	$(30 \oplus 2.5)\,\%$	–
Combined	2.7 %	12 %	29 %

TABLE 3.3-5
Expected precision for the Higgs boson branching fraction measurements ($\sqrt{s} = 250\,\mathrm{GeV}$) for the individual Z decay channels and for the combined result. The expected $2.5\,\%$ uncertainty on the total Higgs production cross section is added in quadrature. The results are based on full simulation/reconstruction and assume an integrated luminosity of $250\,\mathrm{fb}^{-1}$. Entries marked – indicate that results are not yet available.

Analysis	$\sqrt{s}$	Observable	Precision	Comments
Higgs recoil mass	250 GeV	$\sigma(\mathrm{e^+e^-} \to \mathrm{ZH})$	$\pm 0.30\,\mathrm{fb}$ (2.5 %)	Model Independent
		m_{H}	32 MeV	Model Independent
		m_{H}	27 MeV	Model Dependent
Higgs Decay	250 GeV	$Br(\mathrm{H} \to \mathrm{b\bar{b}})$	2.7 %	includes 2.5 %
		$Br(\mathrm{H} \to \mathrm{c\bar{c}})$	12 %	from
		$Br(\mathrm{H} \to gg)$	29 %	$\sigma(\mathrm{e^+e^-} \to \mathrm{ZH})$