Branching ratio study of H→bb/cc/gg

ILC Physics WG general meeting

2015 Sep. 05

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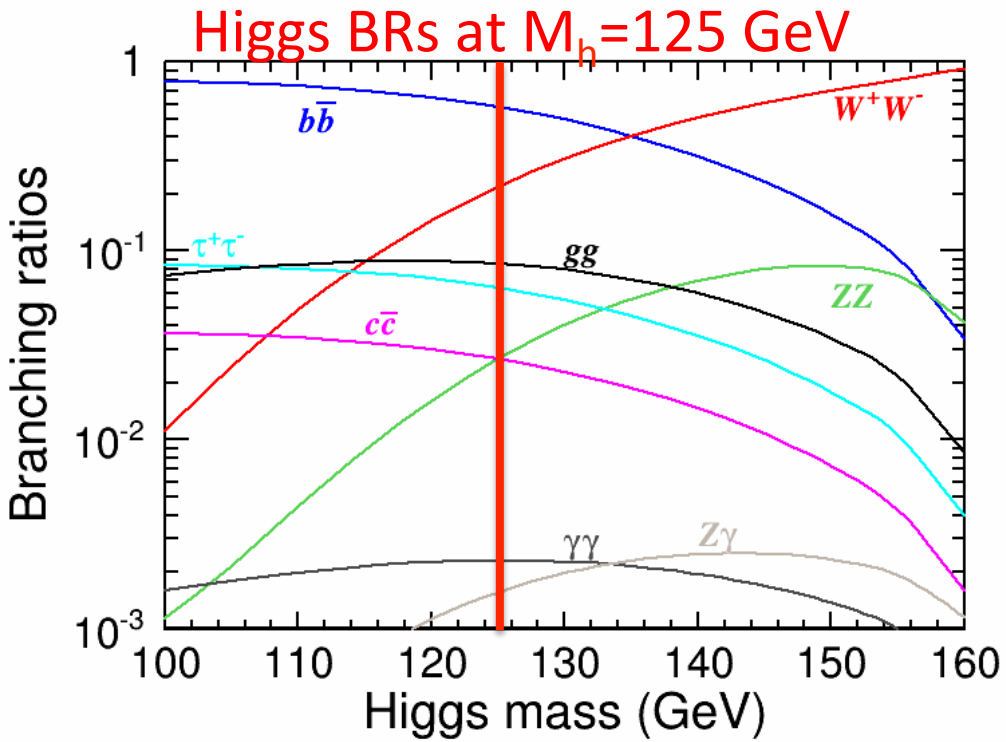
Current status

- Sorry for pending my analysis
  - Due to other hardware work and university business
- Considering following analysis
  - Template fitting stability check and update at 250 GeV (Felix considered at 350 GeV)
  - 500 GeV h→cc with Mh=125 GeV full simulation
  - TMVA approach instead of template fitting (SiD analysis strategy in DBD)

Higgs BR study in ILC

- Determine **absolute Higgs BR** (σ_{Zh} model independent measurement)
- Complementary study with LHC in **Higgs hadronic decay channel**



High precision measurement in **Higgs hadronic decay channel**

h→bb obtain best precision in ILC with largest BR, B-tagging

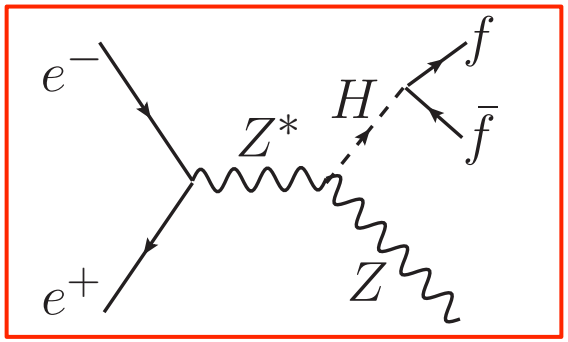
h→cc, gg are expected to measure in ILC with c-tagging

BR	Mh	bb	cc	gg	ττ	WW	ZZ	γγ	Zγ	μμ
LHCXSWG	125 GeV	57.8%	2.7%	8.6%	6.4%	21.6%	2.7%	0.2%	0.2%	0.02%

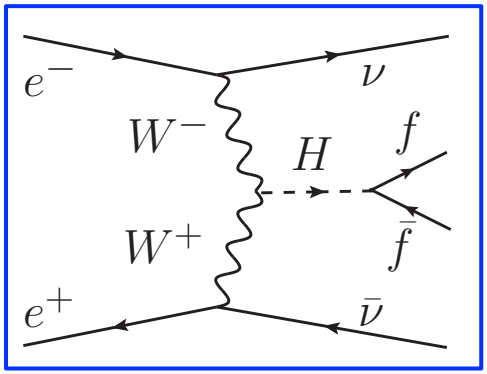
Higgs production in ILC

σxBR and σ (recoil) results extract BRs related to the coupling strength

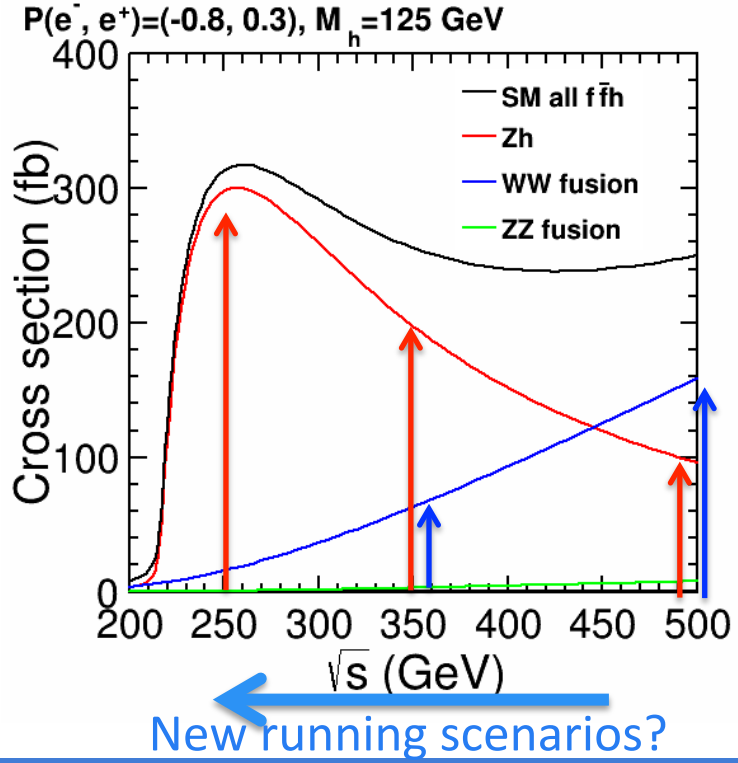
250 GeV: Zh (Higgs-strahlung) dominant (σ_{Zh}xBR)
350 GeV: Zh + WW-fusion (($\sigma_{Zh}+\sigma_{WW}$)xBR)
500 GeV: WW-fusion + Zh(($\sigma_{WW}+\sigma_{Zh}$)xBR)



Zh (Higgs-strahlung)



WW-fusion



500 GeV will be better condition for ($\sigma_{WW}+\sigma_{Zh}$)xBR measurement in terms of the statistics

New running scenarios?

Expected Higgs signal events

Mh=125 GeV	250 GeV	350 GeV	500 GeV
Luminosity (fb^{-1})	250	330	500
Beam pol.	P(-0.8, +0.3)	P(-0.8, +0.3)	P(-0.8, +0.3)
Higgs xsec	$\sigma_{Zh} >> \sigma_{WW}$	$\sigma_{Zh} > \sigma_{WW}$	$\sigma_{Zh} < \sigma_{WW}$
vvh (Zh+WW)	77.5	98.7	169.1
qqh (Zh)	210.2	138.9	67.1
llh (Zh+WW)	31.7	24.0	18.1
Total	319.4	261.5	254.4
# of events	79,850	86,295	127,179
Ratios to 250 GeV	1.00	1.08	1.59

500 GeV measurement also prefer for BR study (γγ→hadron increase though)

Full simulation study for Higgs BRs

Mh=125 GeV	250	350	500
σ (Recoil llh)	Jacqueline Watanuki	Jacqueline	Jacqueline
σ (Recoil qqh)	Tomita	Mark?	?
σxBR	Ono (Zh)	Felix (DESY) Zh+WW-fusion	?

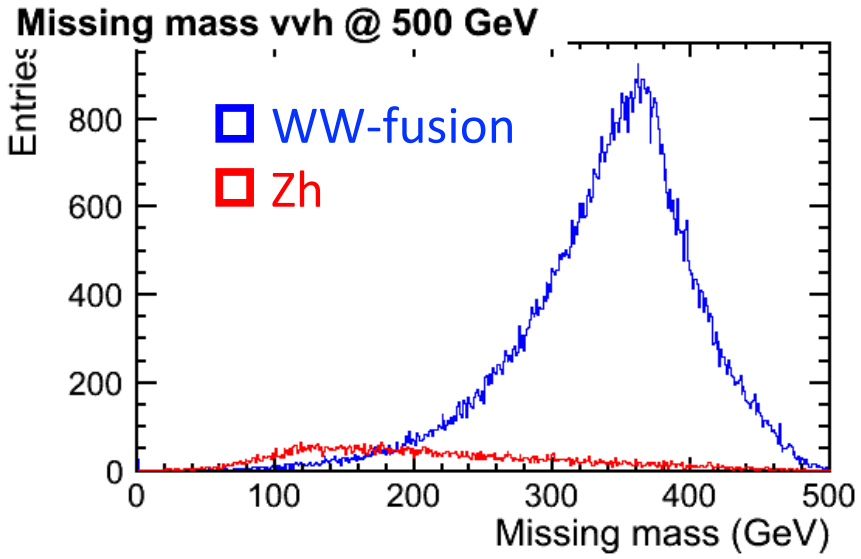
Mh=120 GeV (LOI)	250	350	500
σ (Recoil llh)	LOI	LOI	?
σ (Recoil qqh)	?	?	?
σxBR	Post LOI (Zh)	Post LOI (Zh)	Post LOI (WW-fusion)

I guess we use extrapolation from 120 GeV results some parts
Hopefully switch to real full simulation results

500 GeV analysis just started

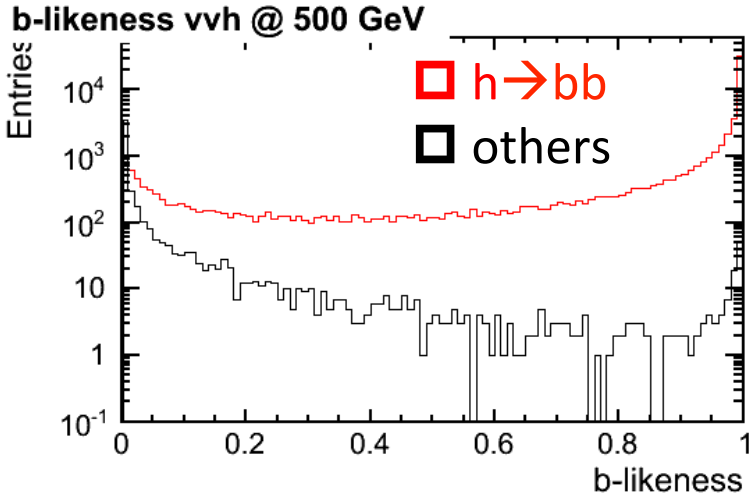
kt jet clustering has applied (R=1.4)

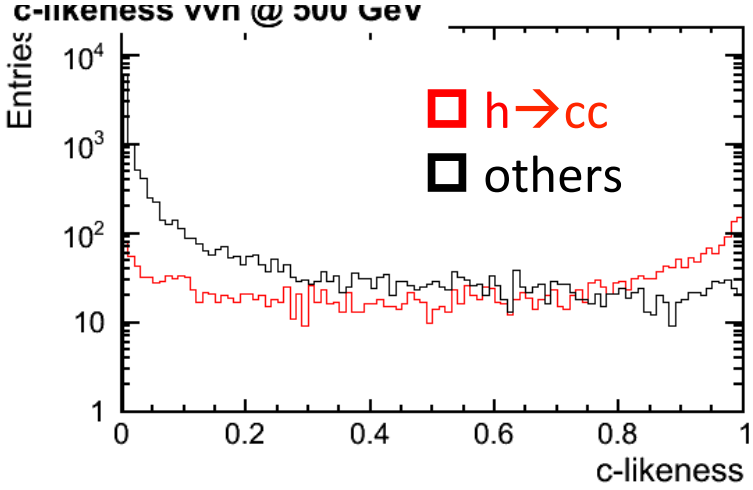
vvh @500 GeV (500 fb^{-1}) P(-0.8, +0.3)



Separation of missing mass is required for σ_{Zh} and σ_{WW}
Felix input missing mass into template at 350 GeV

vvh @500 GeV signal only



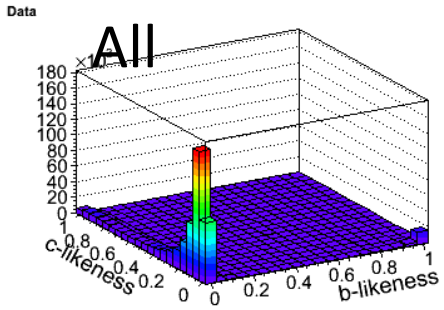


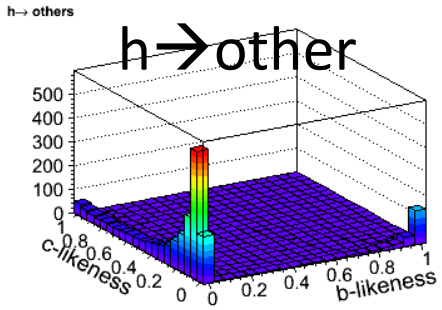
Template fitting stability

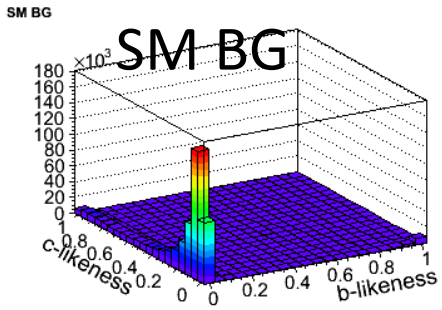
- Tiny binning treatment has problem for stability especially for h→cc, gg
  - Separation power vs low statistics bins
  - My case is just remove 1 entry bins from template ← biased
  - Felix try to solve these problem by increasing statistics
- Template smoothing or variable binning width will be tried again

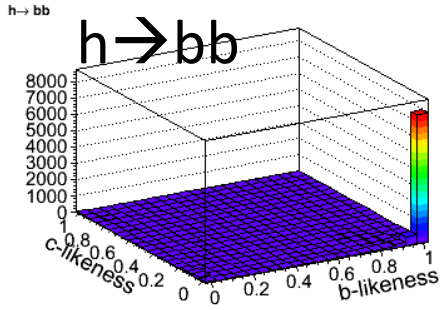
Not yet touched but need to clarify these issue

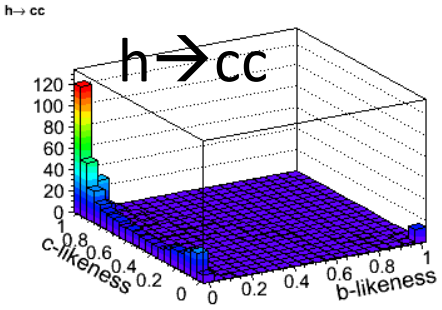
Current template fitting

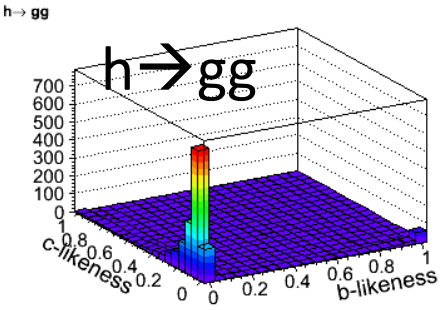




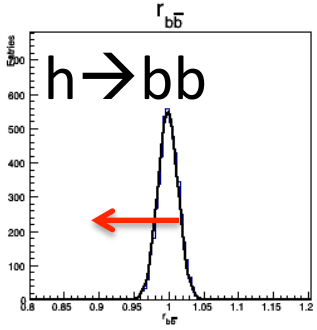


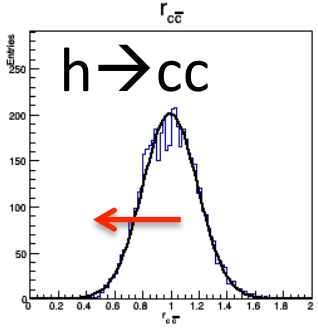


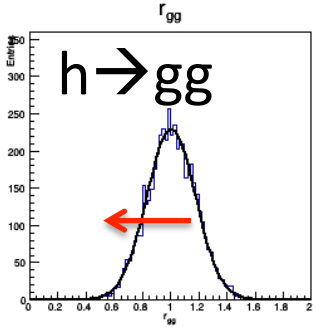




Apply 5,000 times template fitting Toy MC → Extract accuracy of sigma X BR





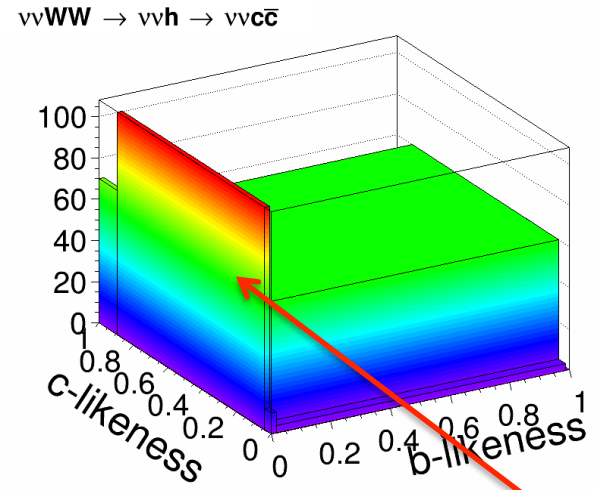


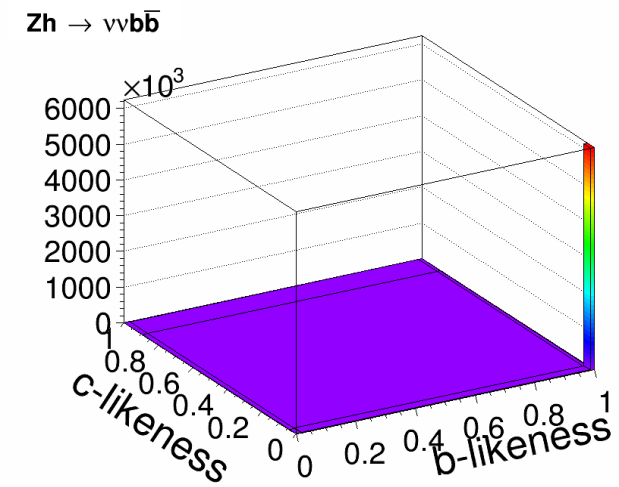
$$\sigma\mathrm{BR}(\mathrm{s}) = \mathrm{r_s} \times \sigma\mathrm{BR}^{\mathrm{SM}}(\mathrm{s})$$

Small statistics bin suppression makes bias to shift from 1

Variable binning template

Variable binning template is tested by Felix (DESY)





Results degrade

This part shape will be important to separate h→cc and h→gg
(Almost same as c-likeness distribution)
I guess it become much worse than simple cut

I will also test his strategy
But I think slightly finer binning is required for the separation between h→cc and h→gg

→ smoothing or shape fitting is another way to solve these binning problem

→ SiD analysis used 2D neuralnet for LOI

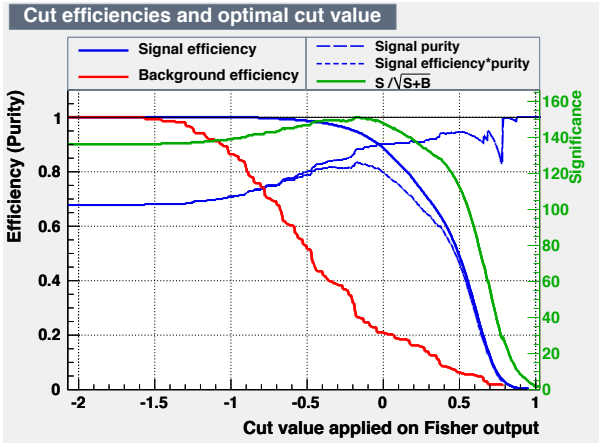
Felix Muller ILD analysis meeting May 13, 2015

Request for more statistics

- Every template should contain ~10^4 entries
- Selection efficiency ~50% -> $2*10^4$ events
- From BR: $2*10^4$ H->cc events would mean $42*10^4$ H->bb events
  - Even worse: I would like to have $2*10^4$ events for h->cc from higgs strahlung and WW-fusion
- Suggestion: production of the single Higgs decays
  - e+e- -> nnH -> nnbb Pol(e+,e-)=(-1,1) 20000 events
  - e+e- -> nnH -> nncc Pol(e+,e-)=(-1,1) 20000 events
  - e+e- -> nnH -> nngg Pol(e+,e-)=(-1,1) 20000 events
  - e+e- -> nnH -> nnbb Pol(e+,e-)=(1,-1) 40000 events
  - e+e- -> nnH -> nncc Pol(e+,e-)=(1,-1) 40000 events
  - e+e- -> nnH -> nngg Pol(e+,e-)=(1,-1) 40000 events
  - Total 180000 events
- Either way: new generator files needed

Other strategy

- TMVA classification for each flavors
  - Same procedure with SiD analysis in DBD



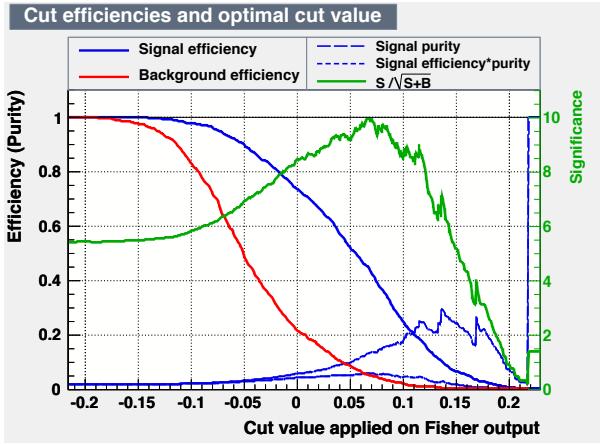


Figure 11.2.7: Efficiency and significance curves vs. cuts on the MVA Fisher discriminant output for the $h \to b\bar{b}$ (left) and $c\bar{c}$ selections (right).

h→bb and h→cc flavor MVA to separate events

SiD DBD

Summary

- Just keep progress as soon as possible
- Template fitting stability analysis and consider TMVA base analysis as comparison
- 250 GeV analysis results summarize

Breakdown of each process

E_{cm}	250 GeV	350 GeV	500 GeV
xsec	σ (-0.8,+0.3)		
νν̄h	77.5	98.7	157.0
qq̄h	210.2	138.9	67.1
ee̅h	10.9	10.2	11.3
μμ̅h	10.4	6.9	3.4
ττ̅h	10.4	6.9	3.4
Total	319.4	261.5	242.2

# of events	250 GeV	350 GeV	500 GeV
Lumi (fb^{-1})	250 fb^{-1}	330 fb^{-1}	500 fb^{-1}
νν̄h	19,383	32,555	78,483
qq̄h	52,547	45,837	33,550
ll̄h	7,931	7,910	9,073
Total	79,850	86,295	121,106

Breakdown of each process

Ecm	250 GeV	350 GeV	500 GeV
SM BGs	σ (-0.8,+0.3)		
2f	1.2×10^5	7.2×10^4	4.4×10^3
4f	4.1×10^5	3.1×10^4	1.8×10^4
6f	Ignore	1.4×10^2	
1f_3f	1.3×10^6	1.6×10^6	
aa_2f/4f	5.8×10^5	9.6×10^5	
tt	None	827.3	

# of events	250 GeV	350 GeV	500 GeV
Lumi (fb^{-1})	250 fb^{-1}	330 fb^{-1}	500 fb^{-1}
BG all	5.1×10^8	8.8×10^8	