Higgs Branching ratio study

ILD Analysis meeting

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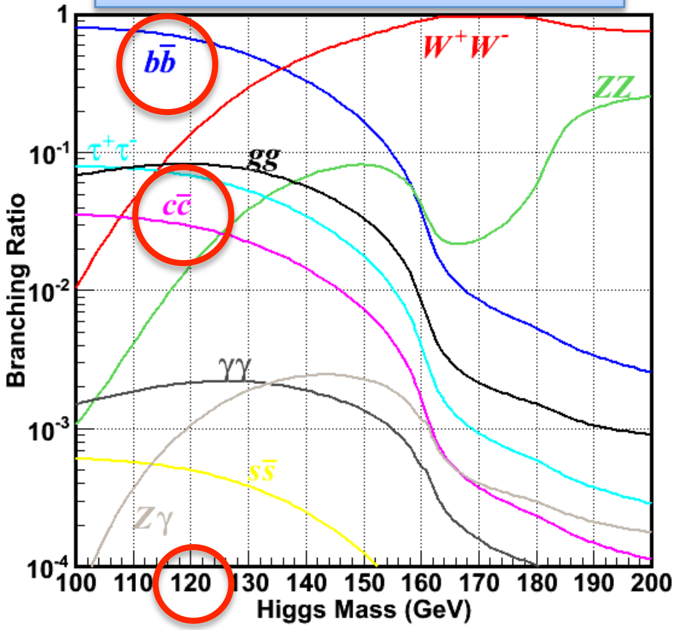
Higgs Branching Ratio measurement

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

BR at M_H=120 GeV

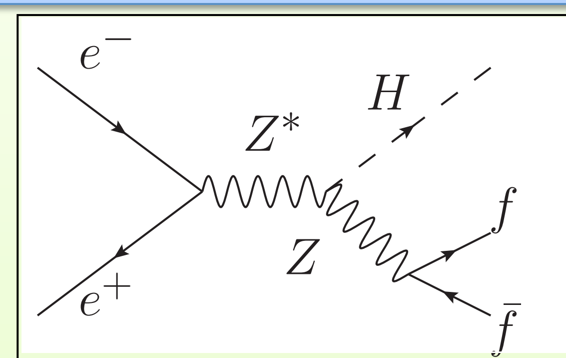


H→xx	BR
H→bb	65.7%
H→WW	15.0%
H→ττ	7.9%
H→gg	5.5%
H→cc	3.6%

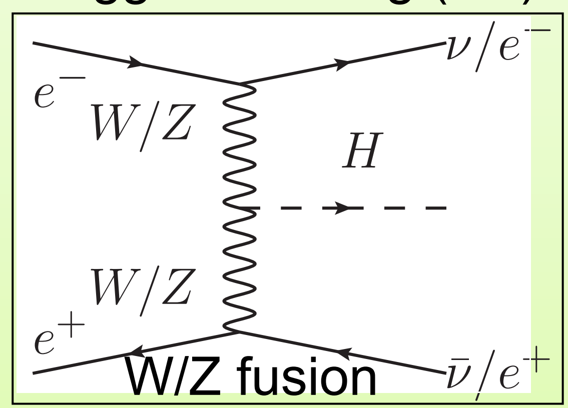
(in pythia)

M_H=120 GeV is assumed with Ecm=250 and 350 GeV

Higgs production processes



Higgs-strahlung (ZH)



W/Z fusion

Higgs study with different Ecm

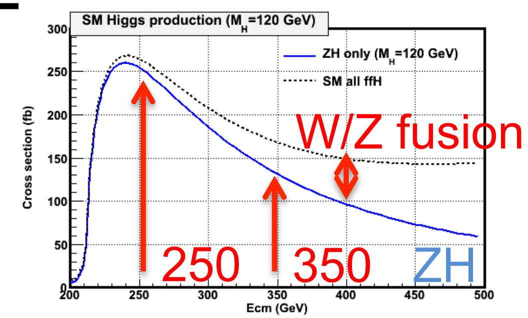
Ecm=250 GeV (ZH production threshold around 230 GeV at Mh=120 GeV)

- ZH Largest production cross-section with Z/H almost at rest
  Suit for mass and cross-section measurement with recoil study
- Higgs-strahlung (ZH) process dominant

Ecm=350 GeV

- Reduce cross-section and Z/H will be boosted
- Increase W/Z fusion process contribution
- tt background should be considered

→ Higher peak luminosity, better S/N, with top study



	RDR (LOI)			SB2009 w/ TF			NB w/ TF		
Ecm (GeV)	250	350	500	250	350	500	250	350	500
Peak L (10^{34} $cm^{-2}s^{-1}$)	0.75	1.2	2.0	0.27	1.0	2.0	0.8	1.0	2.0
Integrated L (fb^{-1})	188	300	500	67.5	250	500	200	250	500

Evaluate the effect of different Ecm for BR study

NB : New baseline parameter
TF : beam traveling focus

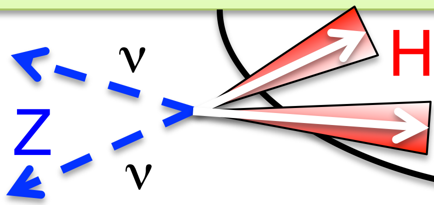
ZH BR analysis procedure

ZH→ννH (neutrino) | ZH→qqH (hadron) | ZH→llH (lepton)

Categorized with Z decay

Study at Bonne Univ.

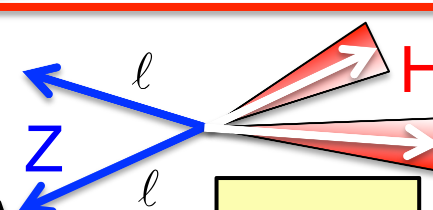
2 jet clustering | 4 jet clustering | di-lepton ID



Z/H combination | 2 jet clustering

Background reduction

ε_{bb}, ε_{cc}



Simple flavor cut

Check consistency with template fitting

Template fitting

r_{bb}, r_{cc}

Relative BR

$$\frac{BR(H \to c\bar{c})}{BR(H \to b\bar{b})}$$

Background reduction

Neutrino (vvH) channel analysis

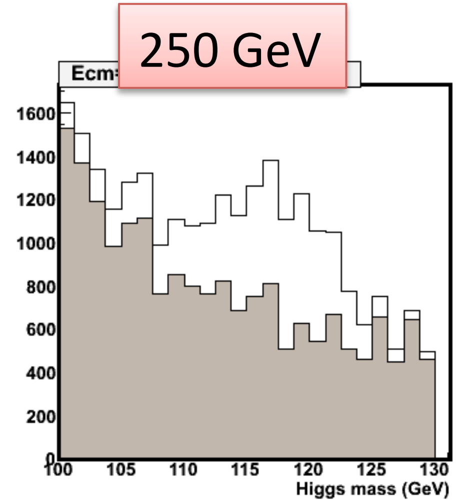
Selection criteria

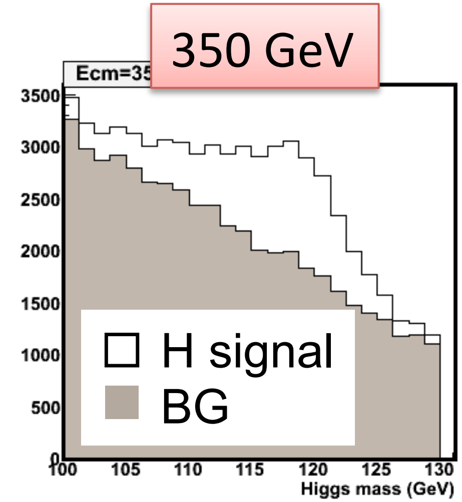
1. Missing mass (Mz)
   (80<MM<140 or 50<MM<240)
2. Transverse momentum
   (20<Pt<70 or 10<Pt<140)
3. Longitudinal momentum
   (|Pl|<60 or 130)
4. # of charged tracks (N<10)
5. Maximum momentum
   (Pm<30 or 60)
6. Y value (Y_{23}<0.02, 0.2<Y_{12}<0.8)
7. Di-jet mass (M_H) (100<M_H<130)

4f, 2f background is considered
tt is also considered at 350 GeV

Better signal significance is obtained at 350 GeV

Di-jet mass after all cuts w/o b-tag





		Generated	After cut	S/√(S+B)
250 GeV	Sig	19360 (14520)	6731 (5048)	41.91 (36.3)
	BG	44827100 (33811100)	19059 (14294)	
350 GeV	Sig	26307	12338	49.03
	BG	18991000	50993	

(): L=188fb^{-1} at 250 GeV

Hadronic (qqH) channel analysis

Selection criteria

1. Jet paring χ^2 (χ^2 <10)
2. # of charged tracks in jet (N<4)
3. Y_{34} (3→4 Jet paring Y threshold) (Y_{34}<2.7)
4. Thrust (<0.9 or <0.85)
5. Thrust angle ($|\cos\theta|$<0.9)
6. H jets angle (105<θ<160 or 70<θ<120)
7. Fitted Z mass (85<M_Z<100)
8. Fitted H mass (105<M_H<130)

5 Constraints fit is tried

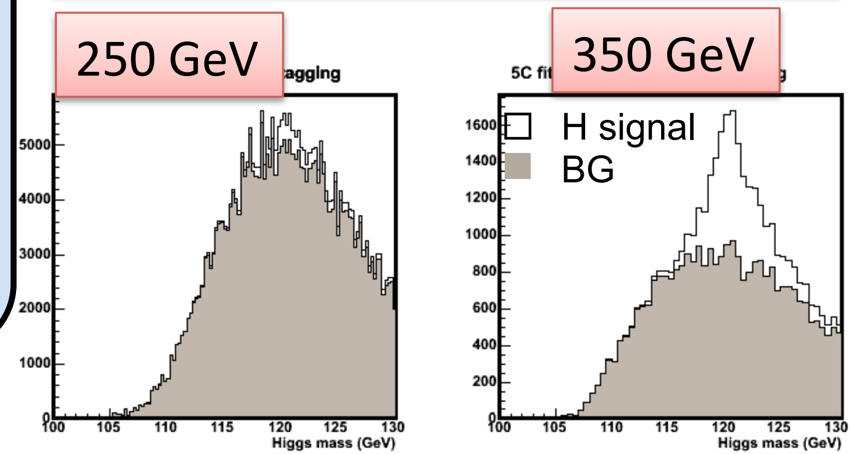
- $\Sigma P_i = 0$
- $\Sigma E_i - E_{cm} = 0$
- $|M_{12} - M_{34}| = |M_Z - M_H|$

Jet pair combination from 4 jets

$$\chi^2 = \left(\frac{M_{12} - M_Z}{\sigma_Z}\right)^2 + \left(\frac{M_{34} - M_H}{\sigma_H}\right)^2$$

Minimum χ^2 pairs are selected

Higgs mass after all cuts w/o b-tag

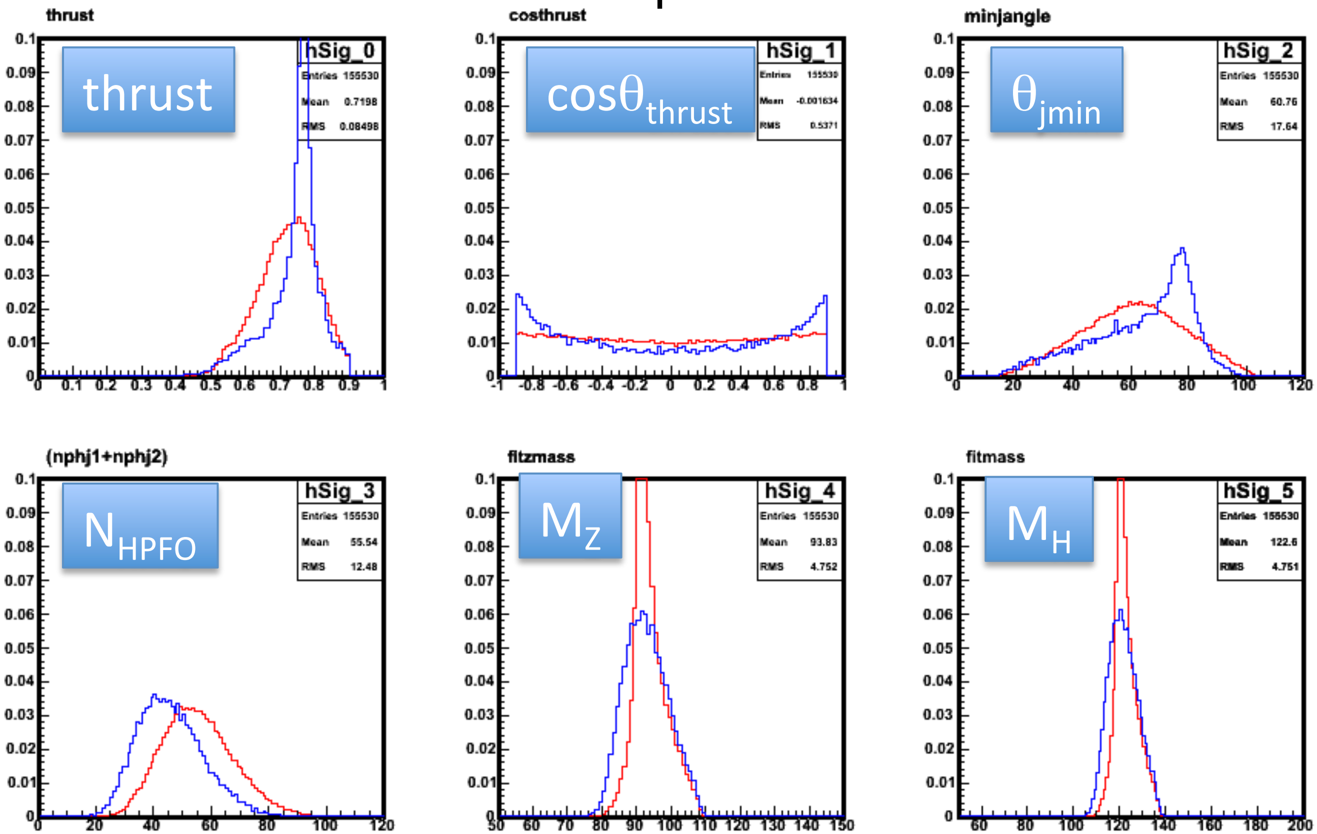


Better signal significance has obtained at 350 GeV

Likelihood variable cut for qqH 250 GeV

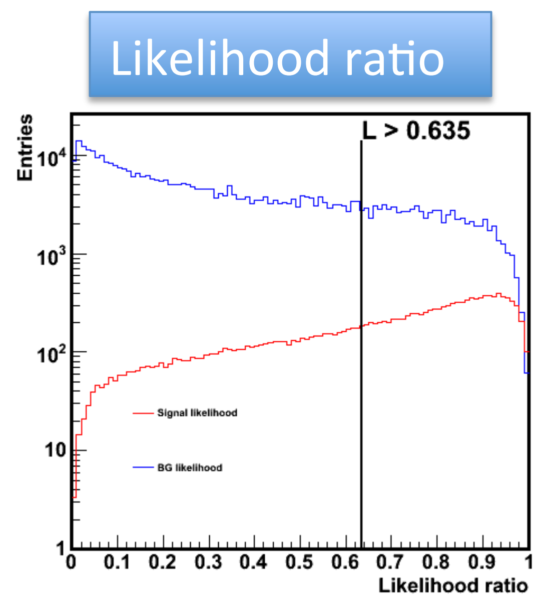
Likelihood variable cut is tried to improve the background reduction

Likelihood input variables

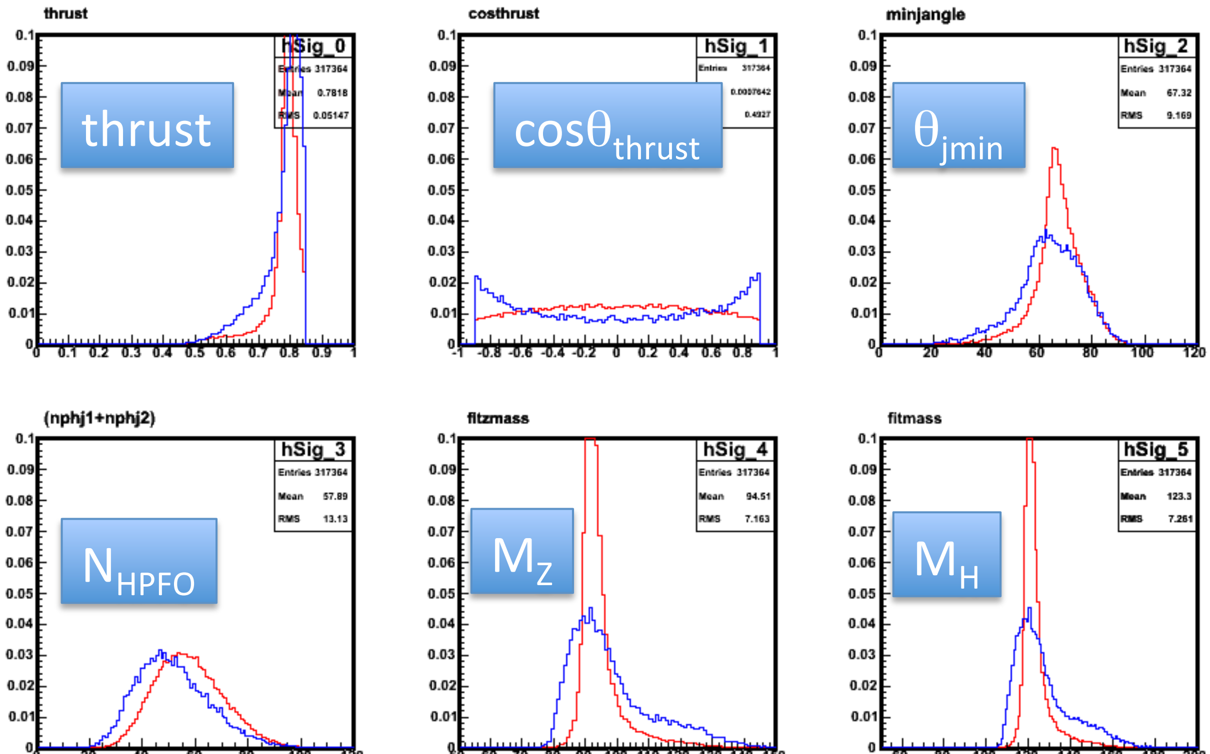


$L = P_S/(P_S+P_B)$

L cut position is defined as significance maximum

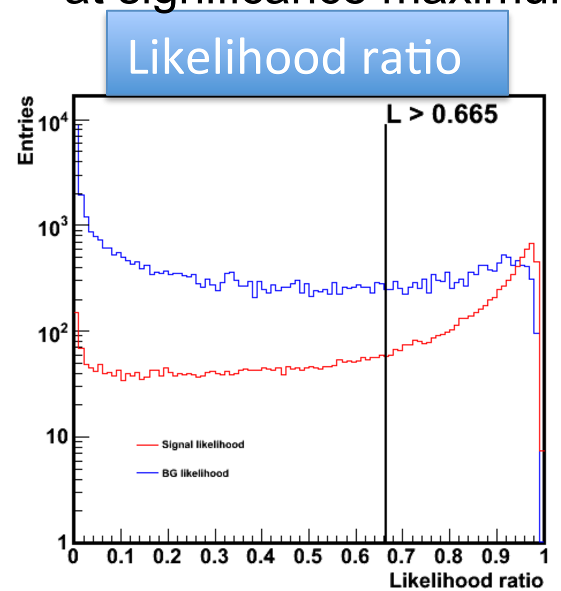


Likelihood variable cut at 350 GeV



Likelihood input variables

L cut position is defined at significance maximum

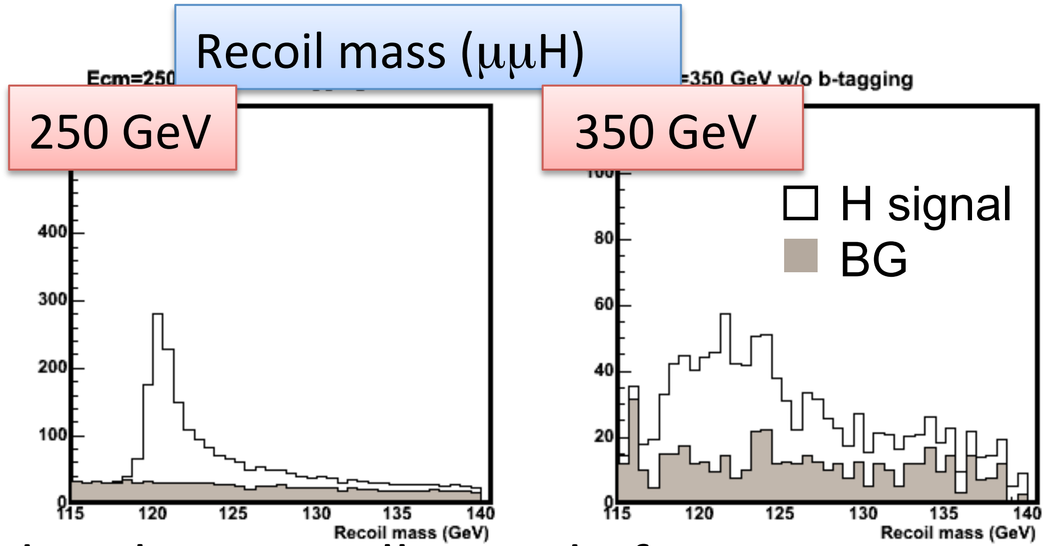


		Generated	After cut	LR cut	S/√(S+B)
250 GeV	Sig	52507	16350	10101	25.0→33.8
	BG	44827100	411785	79401	
350 GeV	Sig	36099	9447	6396	40.7→48.8
	BG	20544400	44395	10789	

Lepton mode (llH) background reduction

BG reduction

1. ee/μμ ID
2. Z mass cut
3. Z cosθ
4. Mh
5. Recoil Mass



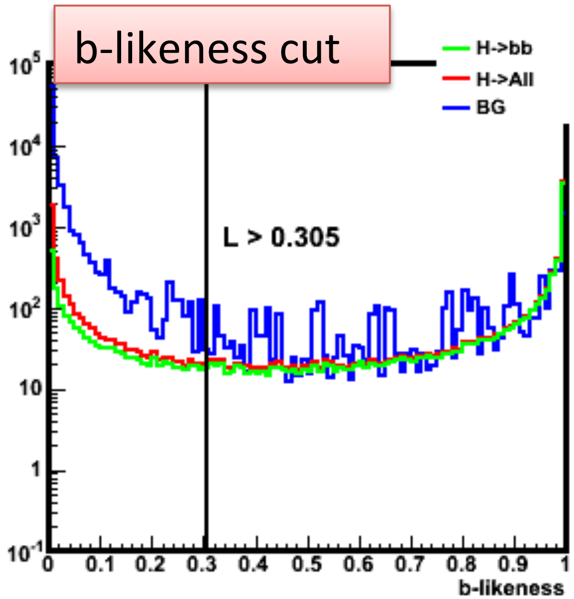
Narrow recoil mass distribution in llH mode from
better momentum resolution at Ecm=250 GeV

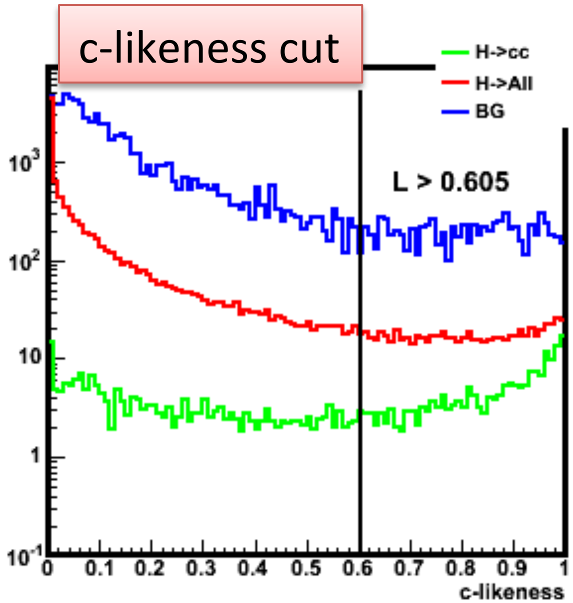
Better signal significance can be achieved
at Ecm=250 GeV from narrower recoil mass distribution

Now this channel is studied by Nina Herder, Bonne Univ.
Please see her status report

Simple cut for qqH channel

Simple flavor tagging cut test with likelihood ratio cut





qqH w/o LR cut	Δσbb/σbb	Δσcc/σcc
Ecm=250 GeV	1.81%	58.2%
Ecm=350 GeV	1.87%	30.6%

→

qqH w/ LR cut	Δσbb/σbb	Δσcc/σcc
Ecm=250 GeV	1.79%	49.2%
Ecm=350 GeV	1.71%	24.1%

Measurement accuracy can improve with LR cut.
Next test with template fitting

Measurement accuracy of BR

Relative BR with template fitting

To improve the flavor cut efficiency and measurement accuracy of BR template fitting has applied and evaluate the relative branching fraction

Relative branching fraction

$$\frac{Br(H \to c\bar{c})}{Br(H \to b\bar{b})} = \frac{r_{cc}/\varepsilon_{cc}}{r_{bb}/\varepsilon_{bb}}$$

r_{xx} : N_{xx}/N_{Hall} fraction after BG reduction
ε_{xx} : BG reduction efficiency

r_{bb}/r_{cc} are extracted with the template fitting as fit parameter

Poisson statistics are considered for each template sample bin

$$p_{ijk} = \frac{\mu^X e^{-\mu}}{X!} \quad X = N_{ijk}^{data} \quad \mu = N_{ijk}^{template} = \sum_{s=bb,cc,others} r_s \left(\frac{N^{Hall}}{N^s} \right) N_{ijk}^s + r_{bkg} N_{ijk}^{bkg}$$

$$L = -\log P = -\log\left(\prod_{i,j,k} P_{ijk} \right) = -\sum_{i,j,k} \left(\log P_{ijk} \right)$$

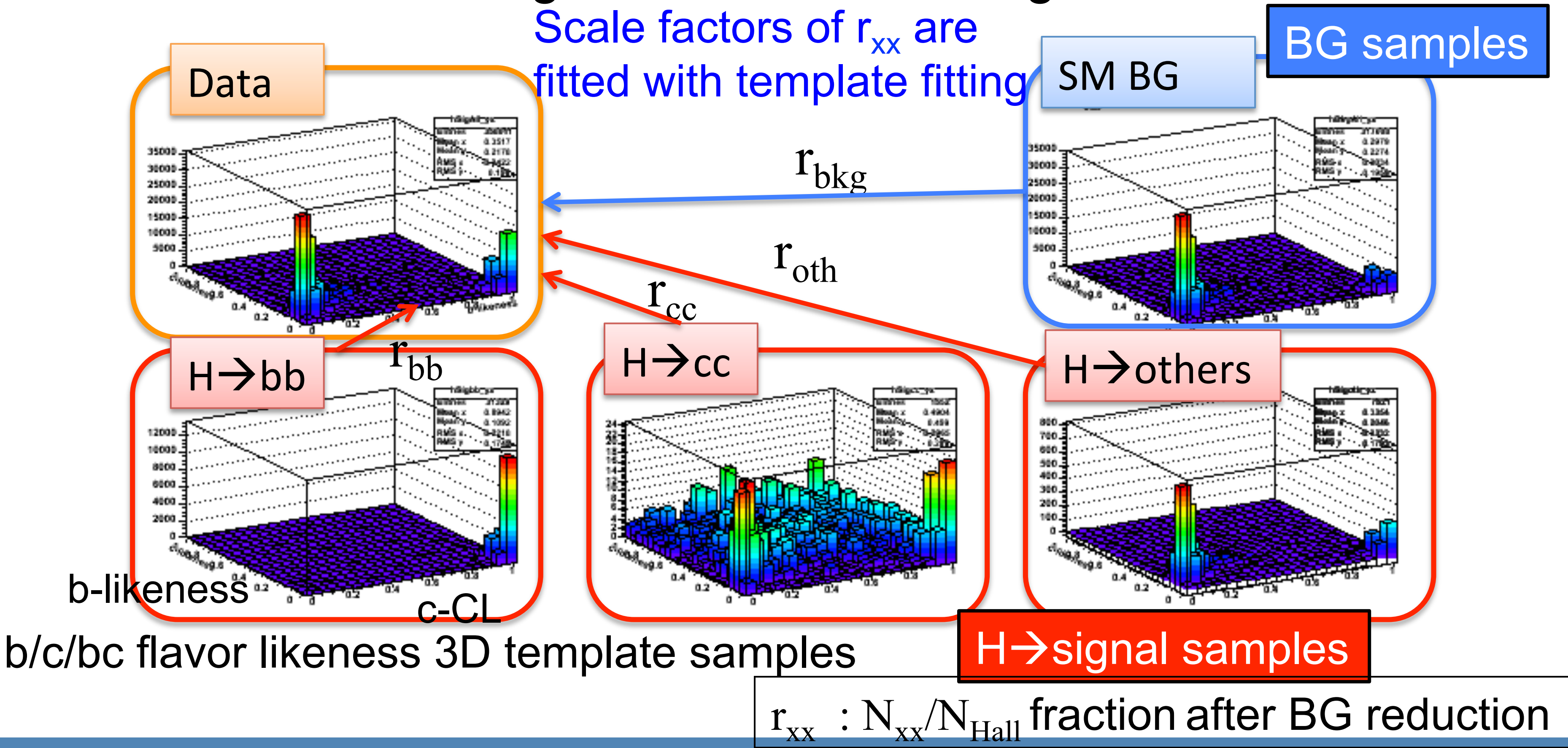
Template fitting has applied with minimizing L

3D template samples histogram

Apply 1,000 times Toy MC and evaluate relative errors

From the MC sample statistics limitation,

low statistic bins are ignored from the fitting



Template fitting results

From the template fitting analysis for 250 and 350 GeV, better measurement accuracy has obtained at Ecm=350 GeV
→<u>From the better signal significance</u>

Preliminary results

	Ecm	ΔBR(cc)/BR(bb)
Neutrino (nnH)	250	20.7%(28.9%)
	350	14.2%
Hadron (qqH)	250	23.0%→18.7% (31.3%→26.0%)
	350	16.4%→16.6%
Muon (mmH)	250	39.5%(45.3%)
	350	43.9%
Electron (eeH)	250	47.5%(50.9%)
	350	37.8%
Combined	250	13.7%(18.0%)
	350	10.0%

Absolute value of the accuracy of relative BR has changed from IWLC2010 because low statistics bins are ignored to suppress the over estimation

- ~25% becomes better in accuracy at <u>Ecm=350 GeV</u> with vvH, qqH mode.
- Luminosity reduction makes accuracy worse ~25% as same as luminosity scaling
- llH modes are relatively worse accuracy from the smaller entries

→Accuracy is improved with LR cut at 250 GeV, check the reason at 350 GeV case.

(): L=188fb^{-1} scaled as RDR250

Statistical error only

Summary and next steps

- BR measurement accuracy has improved at the Ecm=350 GeV about 25%.
- ~25% degradation with $L=188fb^{-1}$ (RDR250 parameter) as same fraction as peak luminosity reduction

- tt background contribution looks not so large at the 350 GeV (set just 1GeV above the threshold in this sample)

- Recoil mass resolution is much better at <u>Ecm=250 GeV</u>

Backups