Higgs BR with ZH→ννH & ZH→llH

LCWS2010 & ILC10

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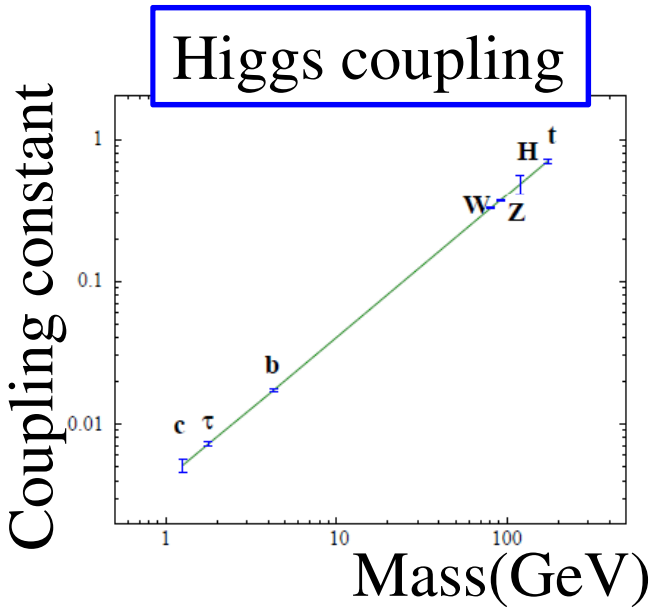
Introduction

Higgs branching ratio

- The key to verify the Higgs mechanism.
- Higgs coupling is proportional to the mass of particle.
- $Br(H \rightarrow cc)/BR(H \rightarrow bb) = m_c^2/m_b^2$



The study of Higgs BR with ILD detector

- ZH→ννH (K.Yoshida)
- ZH→llH (K.Yoshida)
- ZH→qqH (H.Ono) → Next talk!

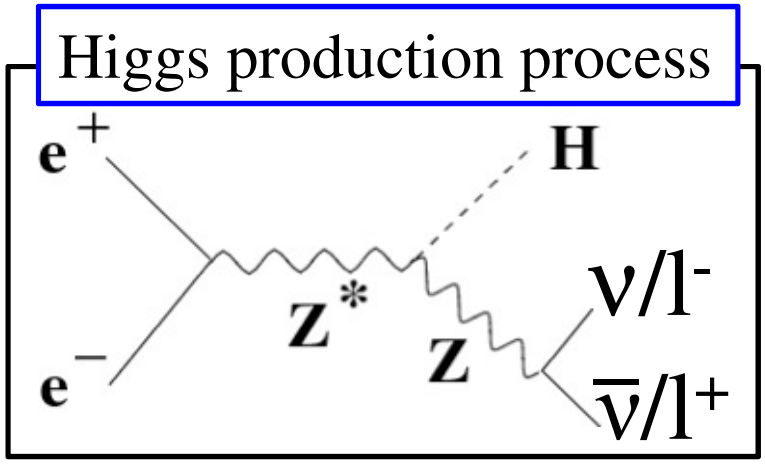
→The current status of ZH→ννH and llH will be reported in this talk.

Simulation setup

Setup

- $E_{C.M.}$: 250 GeV
- Luminosity : 250 fb^{-1}
- Polarization : $(e^-, e^+) = (-80\%, +30\%)$
- M_H : 120 GeV

Higgs production process



Software

- Detector simulation : Mokka
- Reconstruction : Marlin

Data

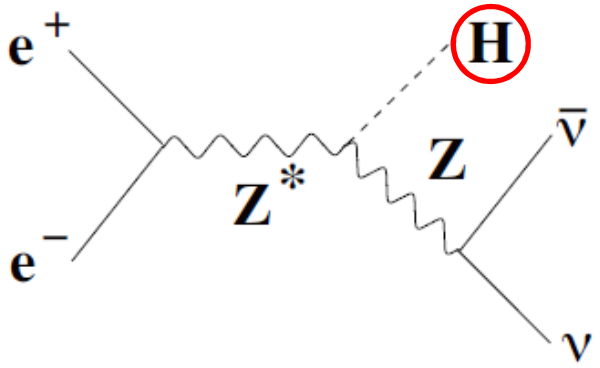
Signal		Background	
ZH→ννH	77.4fb	ννll, νlqq, qqqq, ννqq, llqq, llll	42400fb
ZH→llH	31.9fb	llqq, νlqq	18100fb

*ZH→eeH(11.1fb): e-channel, ZH→μμH(10.4fb): μ-channel

$ZH \rightarrow \nu\nu H$

Selection criteria

All events are reconstructed as 2jets.



Selection criteria

- **Z boson selection**
  - $80<M_{miss}<140GeV$
- **Higgs selection**
  - $20<P_T<70GeV$, $|P_L|<60GeV$, $100<M_{jj}<130GeV$
- **leptonic mode rejection**
  - # of charged tracks>10
- **$\nu_\tau\tau qq$ rejection**
  - P_{max} in event<30GeV, $Y_+<0.02$
- **WW,ZZ rejection**
  - $0.2<Y_-<0.8$

Y_+

- Threshold of y-value to reconstruct 2~3 jets

Y_-

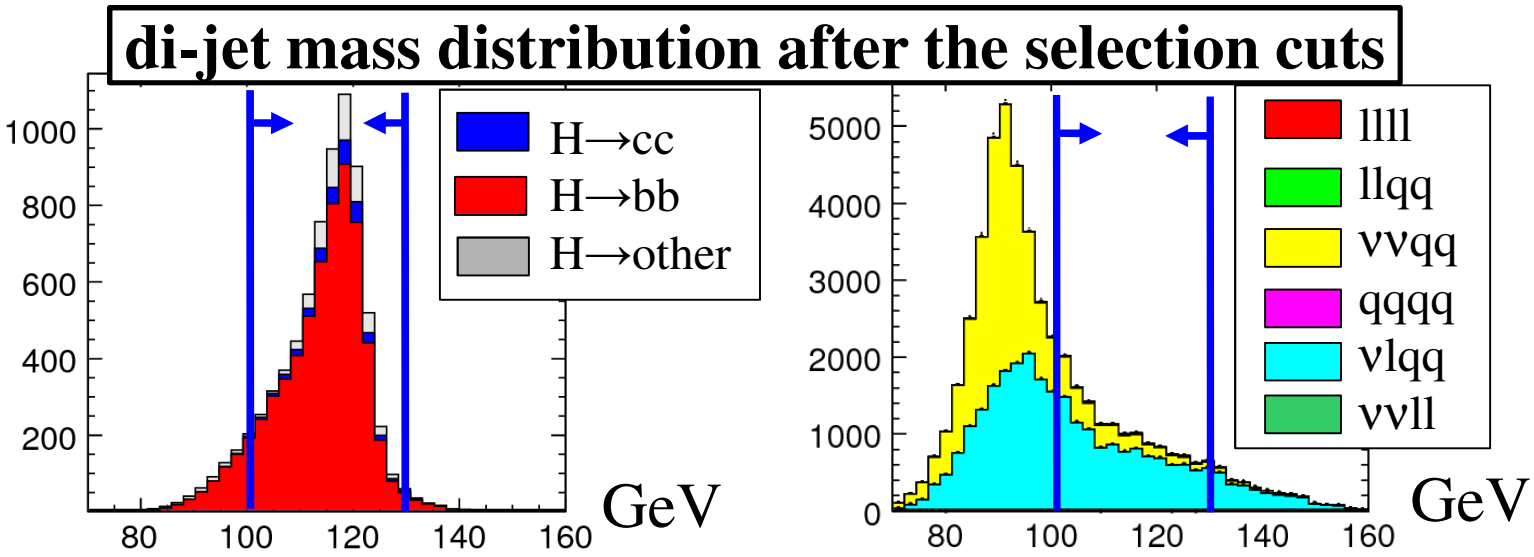
- Threshold of y-value to reconstruct 1~2 jets

Higgs 2jet mass distribution

Higgs di-jet mass distribution was checked after the selection cuts.

- Background was rejected efficiently.
- Efficiency

ZH→νvcc	ZH→νvbb	Background
43.22%	44.48%	< 2.5%



Estimation of Higgs BR

- The ratio of BR(H→cc) to BR(H→bb) is estimated.

$$\frac{BR(H \to cc)}{BR(H \to bb)} = \frac{r_{cc}/\varepsilon_{cc}}{r_{bb}/\varepsilon_{bb}}$$

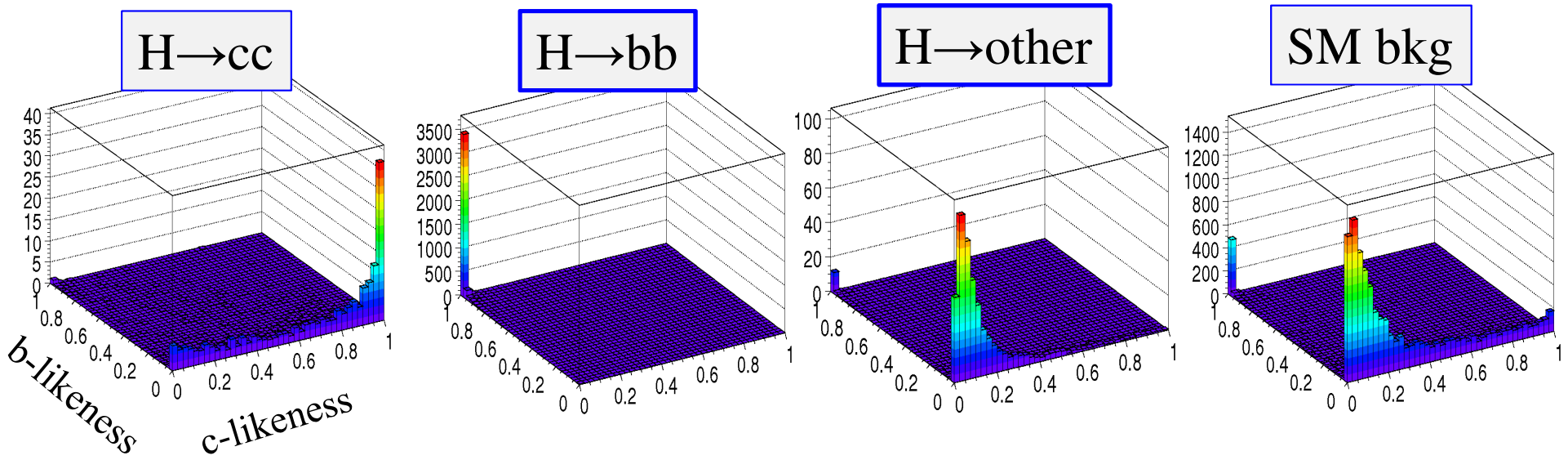
  - ε_{cc},ε_{bb} are the selection efficiency.
    - ε_{cc}: 0.4322
    - ε_{bb}: 0.4448
  - r_{cc},r_{bb} are the ratio of ZH→Zcc,Zbb to ZH after the selection cuts.

r_{cc},r_{bb} are evaluated by 3D template fitting (b,c,bc-likeness)

Template fit

Template fit

- Template: 3D histogram (b-likeness vs c-likeness vs bc-likeness)
  - H→cc, H→bb, H→other, SM bkg
- Data is prepared by fluctuating the template histogram with statistical error of 250fb^{-1}.
- Scale factor: r_{cc},r_{bb},r_{oth},r_{bkg}



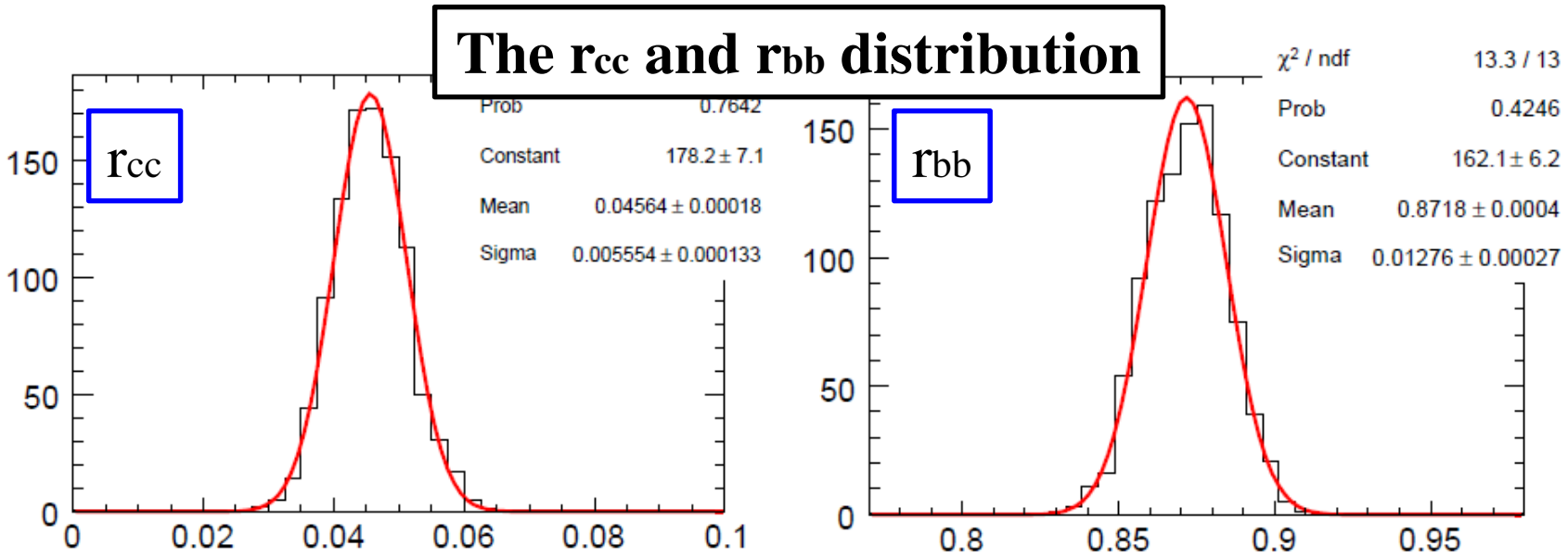
Result

Template fitting was done 1000 times.

Result

- r_{cc}: 0.0456 +/- 0.0056(true: 0.046)
- r_{bb}: 0.872 +/- 0.013(true: 0.87)

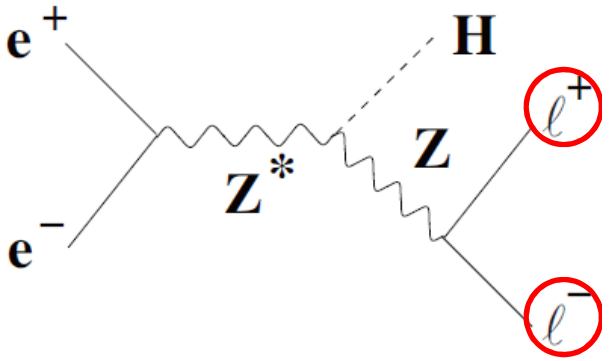
→ BR(H→cc)/BR(H→bb)= 0.0539±0.0066(12.26%)



$ZH \rightarrow llH$

Lepton identification

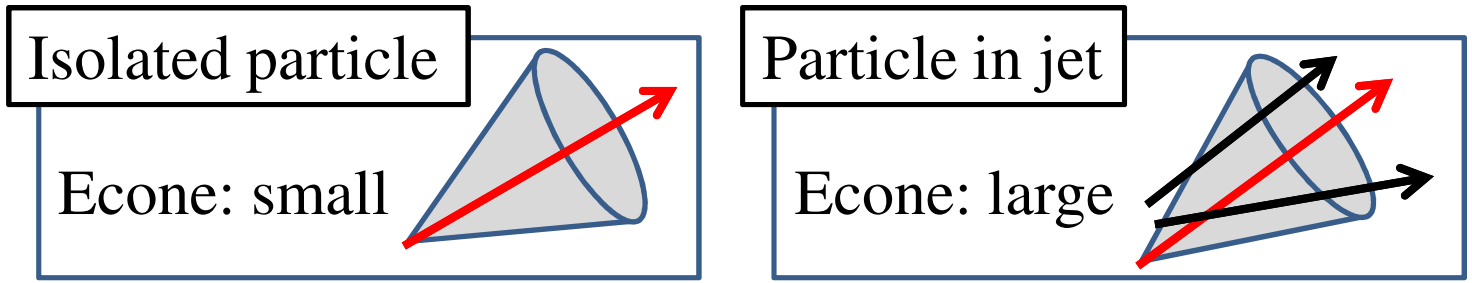
Two leptons should be identified.



1. Electron(muon)-like particles are selected.

	e-ID	μ-ID
$E_{ECAL}/(E_{ECAL}+E_{HCAL})$	> 0.9	< 0.5
$(E_{ECAL}+E_{HCAL})/P$	> 0.7 && < 1.2	< 0.4

2. Particles in jet are rejected.
   - 10<E<90GeV && Econe<20GeV
   - Econe: Sum of the energy within 10 degree around a track



3. #lepton candidates ≥ 3

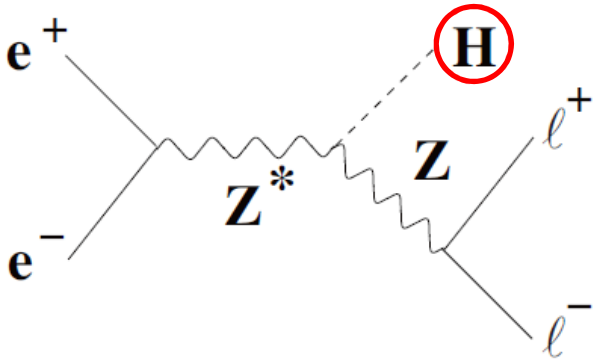
→The pair is selected to have the nearest invariant mass with Mz.

di-lepton recoil mass distribution

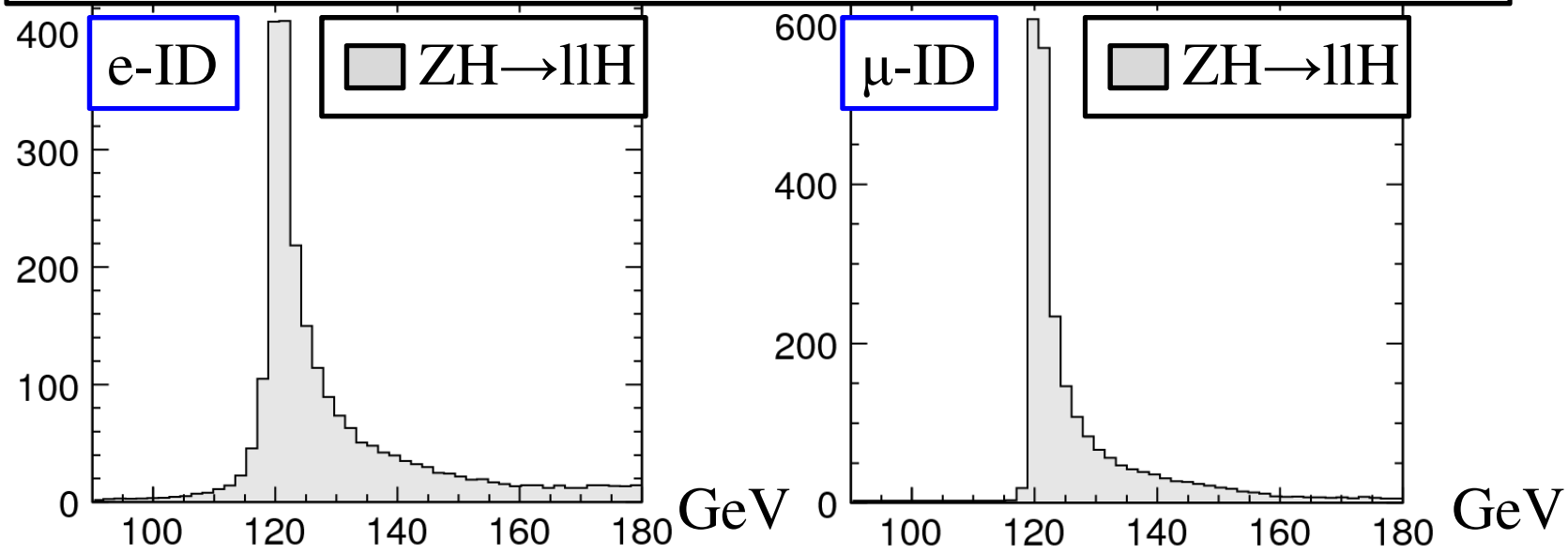
di-lepton recoil mass distribution was checked.

- Signal has a peak at M_H(120GeV).

Performance	e-ID	μ-ID
Efficiency	88.3%	96.4%
Purity	82.9%	95%



The di-lepton recoil mass distribution after the lepton ID

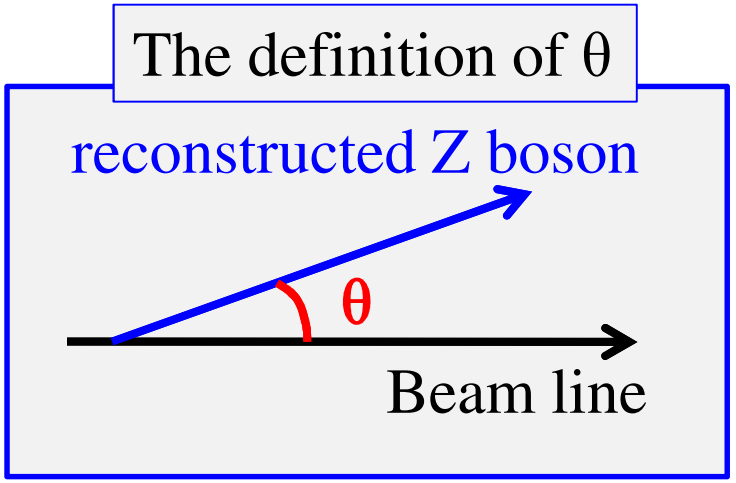


Selection criteria

All events are reconstructed as 2leptons+2jets.

Selection criteria

- **Selection of ZH→llH**
  - #leptons≥2, Evis>140GeV
- **Z boson selection**
  - $70<M_{ee}<110$GeV(e)
  - $80<M_{\mu\mu}<100$GeV(μ)
- **t-channel background rejection**
  - $|\cos\theta|<0.8$(e,μ)
- **Higgs selection**
  - $100<M_{jj}<140$GeV && $110<M_{recoil}<140$GeV(e)
  - $100<M_{jj}<140$GeV && $115<M_{recoil}<140$GeV(μ)

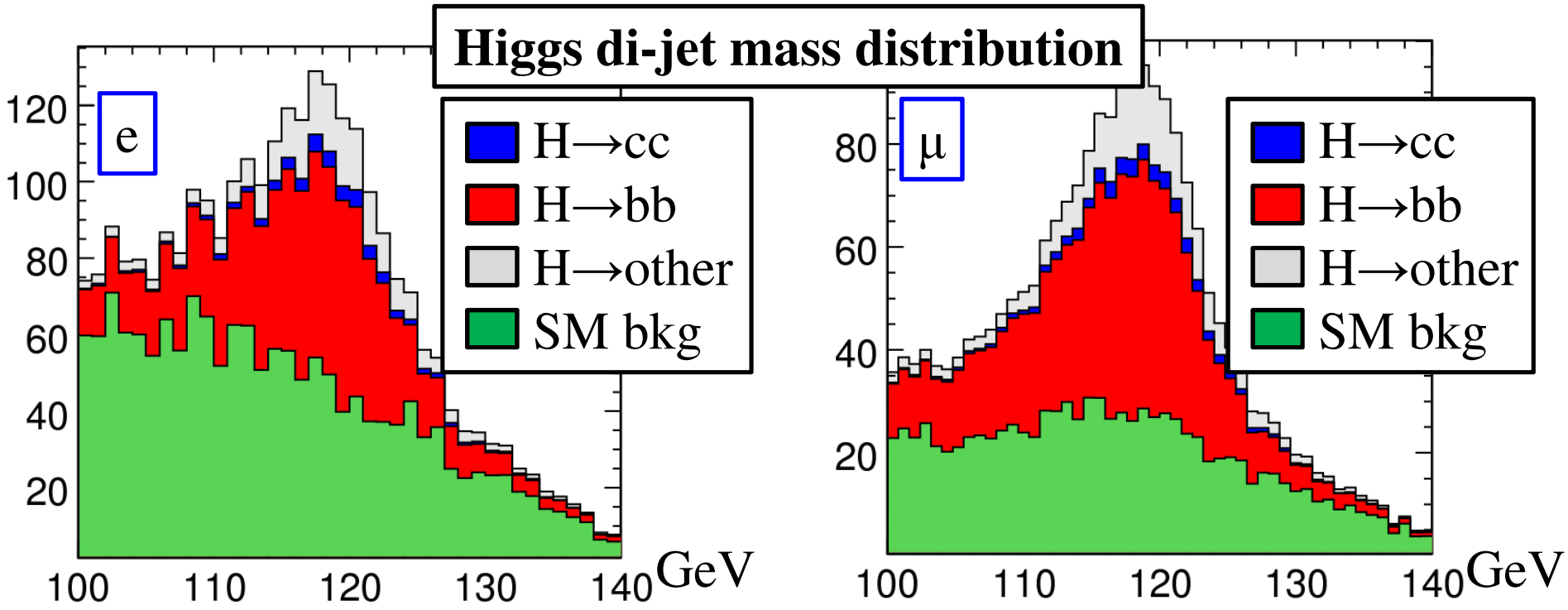


Higgs 2jet mass distribution

Higgs di-jet mass distribution was checked after the selection cuts.

- # of Signal ≈ # of Background

Efficiency	ZH→llcc	ZH→llbb	SM bkg
e-ch	54.05%	47.93%	< 1%
μ-ch	60.91%	54.1%	< 1%



Estimation of Higgs BR

The same procedure as ZH→ννH was applied.

Fitting result of template fitting

	e-channel	**μ-channel**
r_{cc} (true r_{cc})	0.0461 +/- 0.0164(0.047)	0.0445 +/- 0.0149(0.045)
r_{bb} (true r_{bb})	0.759 +/- 0.023(0.76)	0.759 +/- 0.022(0.76)

BR(H→cc)/BR(H→bb)

	e-channel	**μ-channel**	**Combined**
Relative BR	0.0518+/-0.0185	0.0517+/-0.0174	0.0517+/-0.0127
Stat. Accuracy	35.78%	33.67%	24.6%

Summary

- BR(H→cc)/BR(H→bb) was estimated with ILD detector.
  - $E_{C.M.}$: 250GeV
  - Luminosity: 250fb-1

	ZH→ννH	**ZH→eeH**	**ZH→μμH**
Relative BR	0.0539±0.0066	0.0518±0.0185	0.0517±0.0174
Stat. Accuracy	12.26%	35.78%	33.67%

ZH→llH
0.0517+/-0.0127
24.6%