

ZH Branching ratio study

ILC physics and software meeting

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Current status

- IIH mode analysis is conducted
 - $\mu\mu H$, $\tau\tau H$ cross section difference was pointed out
 - Difference comes from the LOI samples and bremsstrahlung effect corrected sample pointed out from IDAG
 - Only signal samples ($eeH/\mu\mu H$) exist
No $\tau\tau H$ corrected sample exists

Mode	$E_{cm}=250\text{GeV}$	$E_{cm}=350\text{GeV}$
IIH (lepton) ($eeH/\mu\mu H/\tau\tau H$)	34.60 fb (12.55/ 11.66 / 10.39 fb)	25.25 fb (10.96/7.16/7.14 fb)

DST01-06_ppr004_e2e2h_w29423_250_ILD_00_LCP_ep+1.0_em-1.0_Slac_250_SM_IDAG

DST01-06_ppr004_e3e3h_w20621_250_ILD_00_LCP_ep+1.0_em-1.0_Slac_250_SM

Comparison with recoil study

Refer with the study on recoil mass ID performance in LOI

On LCWS2010 slide

Electron ID

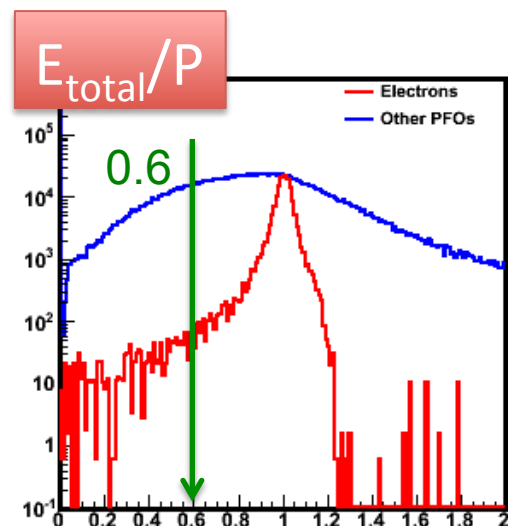
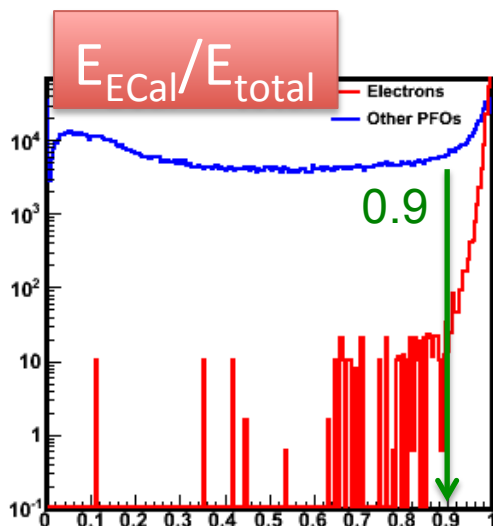
Muon ID

$$\begin{aligned} E_{\text{ECal}}/E_{\text{total}} &> 0.6 \\ E_{\text{total}}/P &> 0.9 \end{aligned}$$



$$\begin{aligned} E_{\text{ECal}}/E_{\text{total}} &> 0.9 \\ E_{\text{total}}/P &> 0.6 \end{aligned}$$

$$\begin{aligned} E_{\text{ECal}}/E_{\text{total}} &< 0.5 \\ E_{\text{total}}/P &< 0.3 \end{aligned}$$



Efficiency	Electron	Muon
Ecm=250 GeV	98.5%	95.5%
Ecm=350 GeV	97.3%	95.4%
Recoil mass @250 GeV	98.8 %	95.4 %

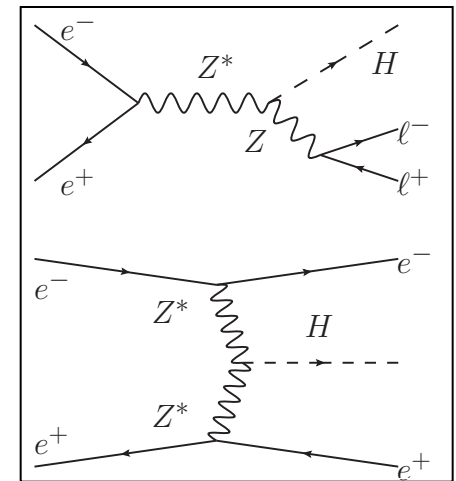
Consistent performance with recoil efficiency with same criteria

BG reduction for lH mode

BG selections

1. ee/ $\mu\mu$ ID tracks ≥ 2
2. Z mass cut
(eeh : $70 < M_z < 110$ GeV, $\mu\mu h$: $80 < M_z < 100$ GeV)
3. Z $\cos\theta$ ($-0.8 < \cos\theta < 0.8$)
4. Mh ($100 < M_h < 140$ GeV)
5. Recoil Mass
($110 < M_{rec} < 140$ GeV, $\mu\mu h$: $115 < M_h < 140$ GeV)

$e^+e^- \rightarrow ZH \rightarrow llH$



$e^+e^- \rightarrow e^+e^-H$

No significant differences are observed

Apply the same selection criteria for 250 and 350 GeV for now

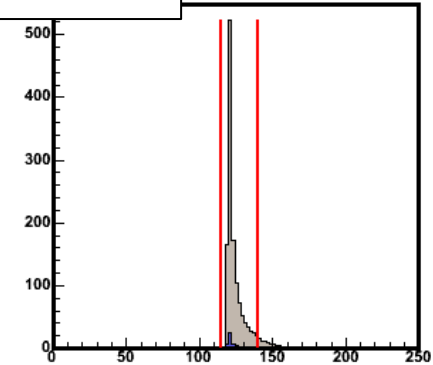
Signal : eeH/ $\mu\mu$ H
BG : llh, llqq, vlqq

Mode	$E_{cm}=250\text{GeV}$	$E_{cm}=350\text{GeV}$
llH (eeH/ $\mu\mu$ H/ $\tau\tau$ H)	34.60 fb (12.55/11.66/10.39 fb)	25.25 fb (10.96/7.16/7.14 fb)

BG reduction ($\mu\mu H$) $L=250\text{fb}^{-1}$

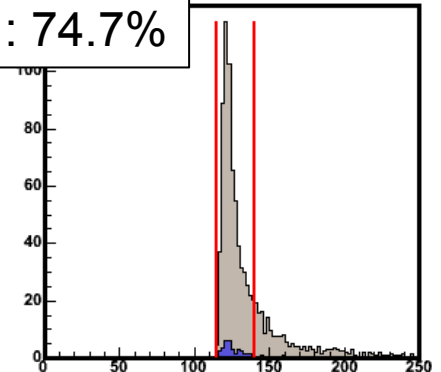
250 GeV	No cuts	eID	Mz	zcos	Mh	RecM	Eff.
$H \rightarrow cc$	93	84	76	63	60	56	60.62%
$H \rightarrow bb$	1742	1595	1388	1141	995	938	53.86%
$\mu\mu H$ all	2601	2389	2033	1671	1313	1237	47.55%
SM Bkg	4517890	28325	12928	8059	1960	980	0.02%
S_{cc}/\sqrt{B}	0.04	0.50	0.67	0.71	1.35	1.79	
S_{bb}/\sqrt{B}	0.82	9.47	12.21	12.71	22.47	29.96	

Recoil Eff.
cc : 93.3%
bb : 94.3%



350 GeV	No cuts	eID	Mz	zcos	Mh	RecM	Eff.
$H \rightarrow cc$	69	61	57	47	43	35	51.04%
$H \rightarrow bb$	1186	1082	950	815	641	479	40.41%
$\mu\mu H$ all	1789	1631	1405	1202	855	639	35.70%
SM Bkg	3826930	23607	13296	6268	1195	465	0.01%
S_{cc}/\sqrt{B}	0.04	0.40	0.49	0.59	1.23	1.63	
S_{bb}/\sqrt{B}	0.61	7.04	8.23	10.29	18.55	22.22	

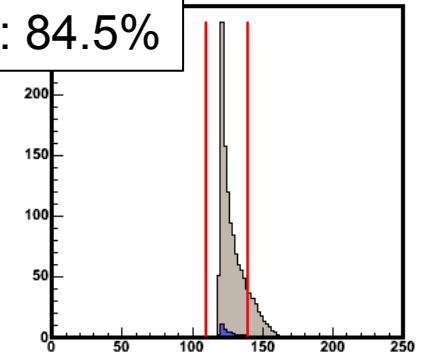
Recoil Eff.
cc : 81.3%
bb : 74.7%



BG reduction (eeH) $L=250\text{fb}^{-1}$

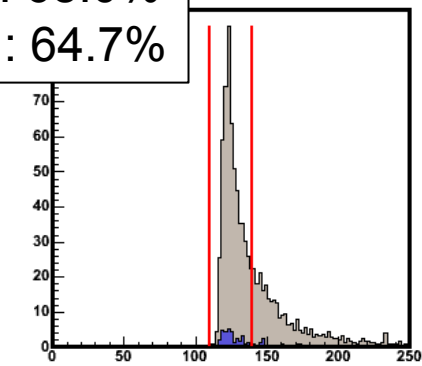
250 GeV	No cuts	eID	Mz	zcos	Mh	RecM	Eff.
H→cc	102	86	74	61	57	49	47.82%
H→bb	1851	1577	1323	1084	939	793	42.85%
eeH All	2777	2392	1940	1587	1238	1045	37.65%
SM Bkg	4517710	204764	34158	21610	2735	1610	0.04%
S_{cc}/\sqrt{B}	0.05	0.19	0.40	0.41	1.10	1.22	
S_{bb}/\sqrt{B}	0.87	3.49	7.16	7.37	17.95	19.78	

Recoil Eff.
cc : 86.0%
bb : 84.5%



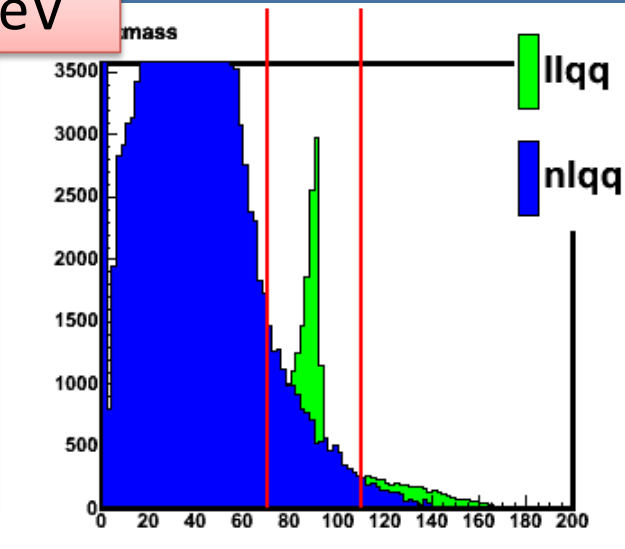
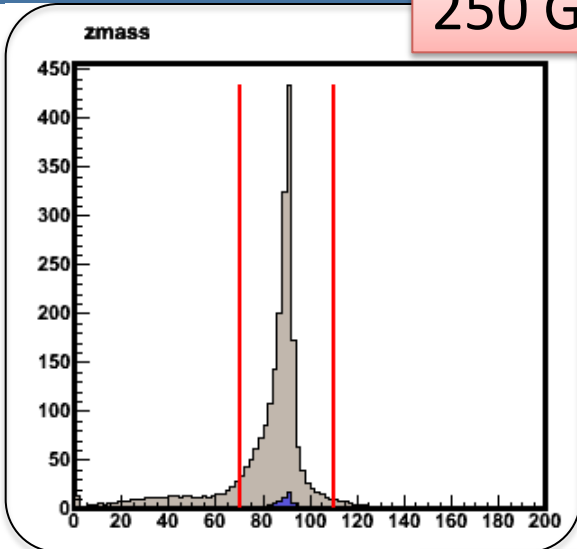
350 GeV	No cuts	eID	Mz	zcos	Mh	RecM	Eff.
H→cc	99	83	58	53	50	34	34.34%
H→bb	1787	1457	944	792	634	416	23.30%
eeH all	2740	2271	1426	1194	866	567	20.68%
SM Bkg	3825980	179602	51372	20897	2010	581	0.02%
S_{cc}/\sqrt{B}	0.05	0.20	0.26	0.37	1.12	1.42	
S_{bb}/\sqrt{B}	0.91	3.44	4.17	5.48	14.14	17.28	

Recoil Eff.
cc : 68.0%
bb : 64.7%

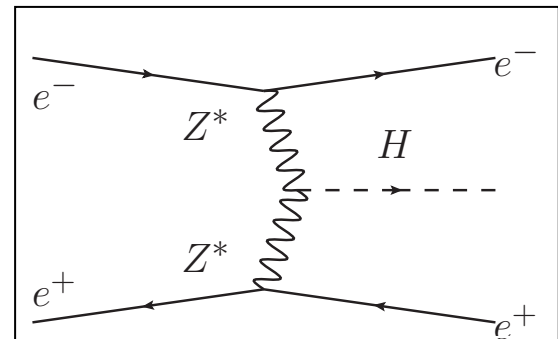
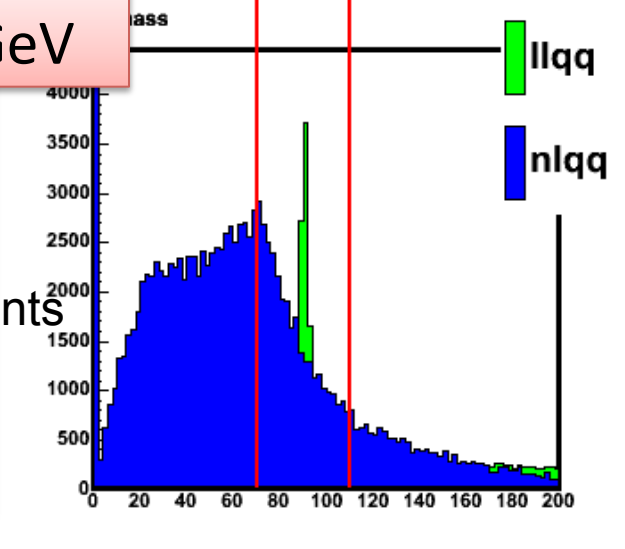
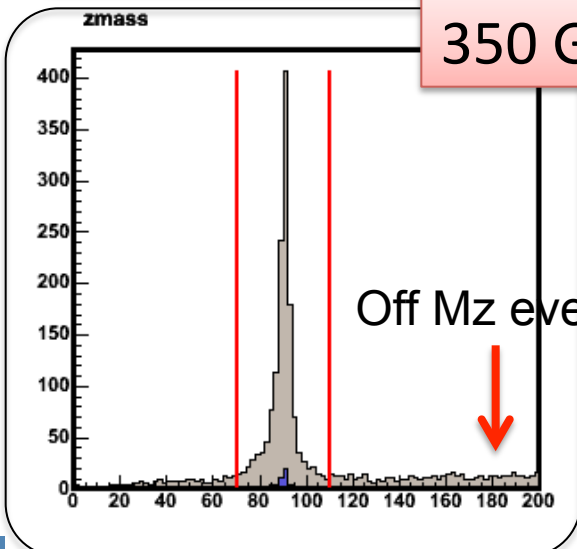


eeH reconstructed Z mass distribution

250 GeV



350 GeV



t-channel di-lepton mass does not make M_z peak

Next step

- Need to optimize selection criteria for IH mode
- Compare BR measurement accuracy between 250 GeV with 350 GeV including integrated luminosity diff.

Relative BR comparison

Relative branching fraction has checked for $E_{cm}=250, 350$ GeV

Relative branching ratio is calculated from following formula

$$\frac{Br(H \rightarrow c\bar{c})}{Br(H \rightarrow b\bar{b})} = \frac{r_{cc} / \epsilon_{cc}}{r_{bb} / \epsilon_{bb}} \quad r_{xx} = N_{xx} / N_{ZH \rightarrow xx} \text{ after BG reduction}$$

BG reduction efficiency summary

mode	Neutrino($\nu\nu H$)		Hadron (qqH)		Muon ($\mu\mu H$)		Electron (eeH)	
	250	350	250	350	250	350	250	350
e_{bb}	45.5%	65.1%	39.0%	31.7%	53.9%	40.4%	47.8%	23.3%
e_{cc}	45.2%	59.4%	41.9%	35.4%	60.6%	51.4%	42.9%	34.3%

r_{bb}/r_{cc} are obtained from the template fitting

Measurement accuracy of BR

Ecm=250 GeV	Fitted results			
mode	neutrino	hadron	muon	electron
rbb	0.871±0.008	0.774±0.013	0.758±0.018	0.758±0.019
rcc	0.0470±0.004	0.046±0.005	0.045±0.008	0.047±0.008
BR(cc)/BR(bb)	0.054±0.004	0.055±0.006	0.053±0.009	0.055±0.010
ΔBR(cc)/BR(bb)	7.75%	10.15%	17.08%	18.15%

IIH mode analysis has some inconsistency between significance and BR measurement accuracy

Ecm=350 GeV	Fitted results			
mode	neutrino	hadron	muon	electron
rbb	0.853±0.007	0.788±0.009	0.750±0.019	0.736±0.021
rcc	0.051±0.003	0.047±0.003	0.055±0.009	0.060±0.010
BR(cc)/BR(bb)	0.053±0.003	0.054±0.003	0.057±0.009	0.056±0.010
ΔBR(cc)/BR(bb)	5.87%	6.48%	16.54%	17.49%

In template fitting, binning dependence should be evaluated (Statistics error only)

Very preliminary