ZH Branching ratio study

ILC physics and software meeting
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Current status

- qq background at 350 GeV copy has finished
  - BDII (LDAP service) trouble was solved
  - Copy process has finished with a few days
- Re-run analysis with qq background at 350 GeV
- vvH is analyzed with template fitting
- Compare with luminosity scaling
  - beam parameter dependence is checked
- llH study
  - Di-lepton candidate + di-jet clustering re-apply for DST with Marline→ Now in progress

vvH study

vvH cut optimization

Ecm=250 GeV

1. 80<MissingMass<140GeV
2. 20<Pt<70 GeV
3. |Pl|<60 GeV
4. # of chdtrack > 10
5. Pmax<30GeV
6. Y+<0.02
7. 0.2<Y-<0.8
8. 100<Mh<130GeV

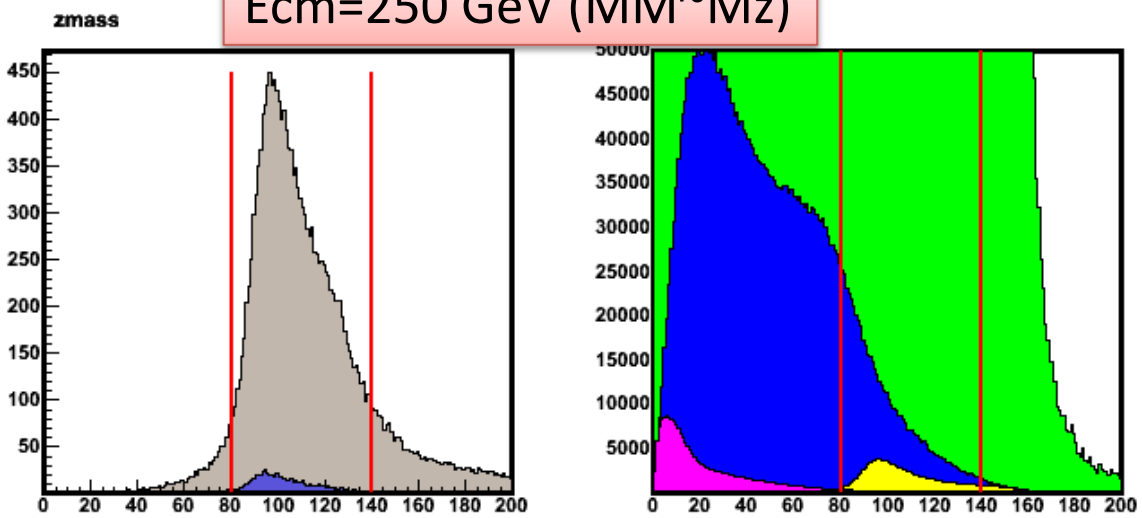
Ecm=350 GeV

1. 50<MissingMass<250GeV
2. 10<Pt<140 GeV
3. |Pl|<150 GeV
4. # of chdtrack > 10
5. Pmax<60GeV
6. Y+<0.02
7. 0.2<Y-<0.8
8. 100<Mh<130GeV

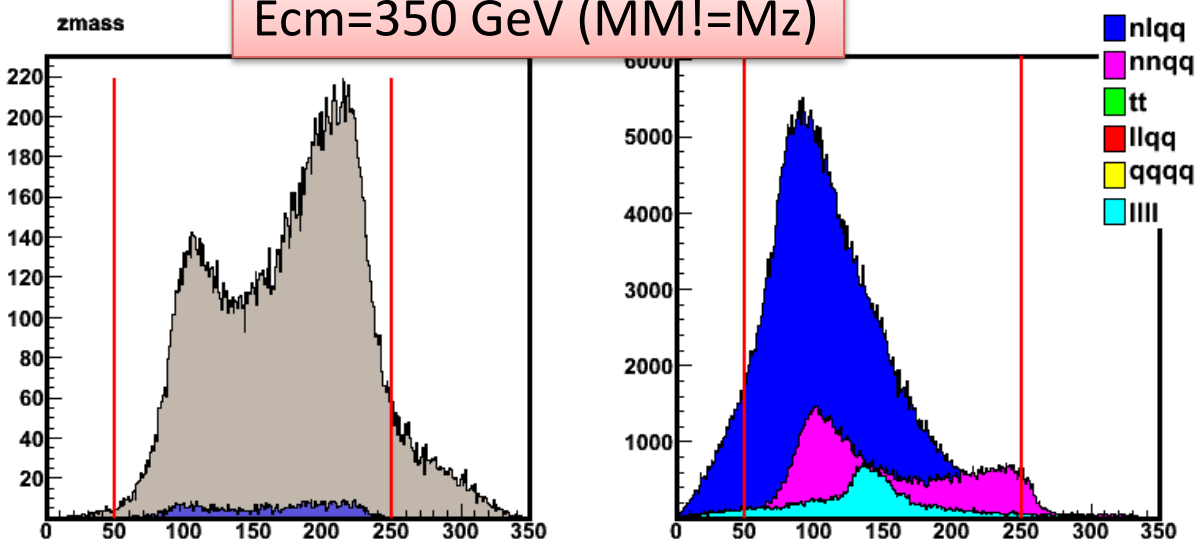
Selection criteria are optimized for vvH mode at 350 GeV

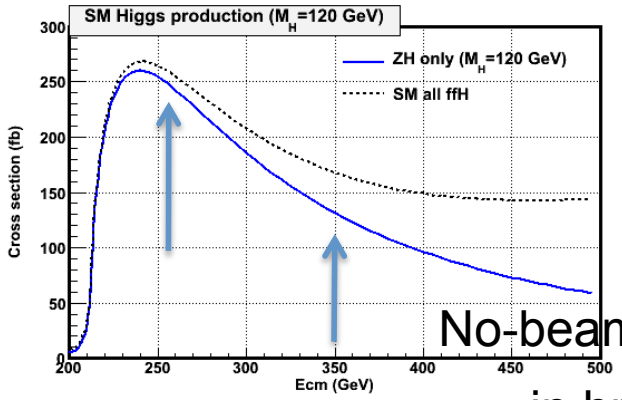
vvH cut parameter (MissingMass)

Ecm=250 GeV (MM~Mz)



Ecm=350 GeV (MM!=Mz)

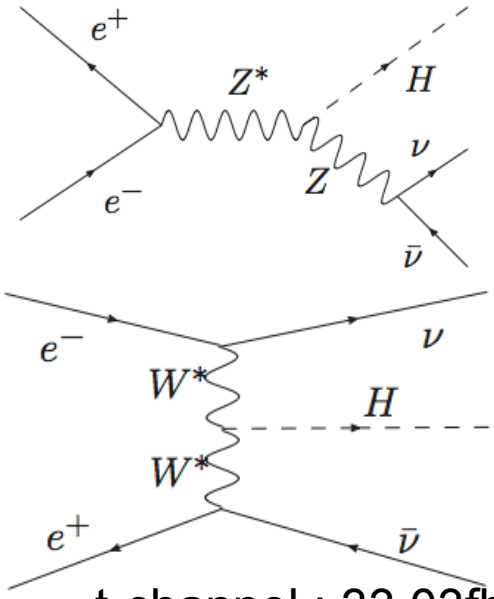




No-beampol

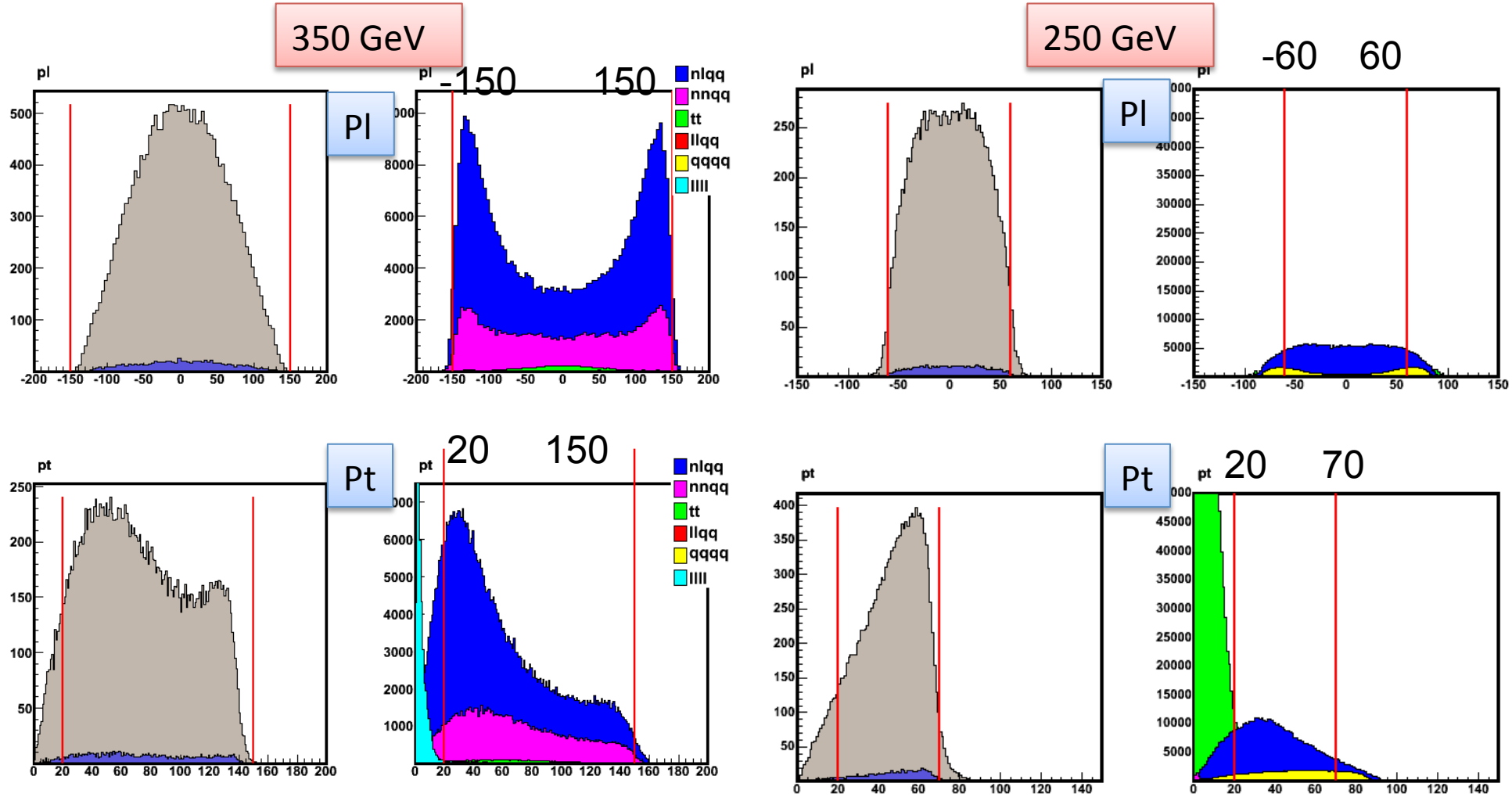
in hprod

s-channel : 131.4fb



t-channel : 33.03fb

vvH cut parameters



BG reduction summary (vvH)

250 GeV	No cuts	MM	Pt	|Pl|	nchdtrk	Pmax	Y+	Y−	Mh	Eff.
H→cc	698	635	567	553	547	476	344	329	315	45.20%
H→bb	12904	11521	10282	10014	9955	9123	6801	6510	5863	45.44%
ZH→vvH all	19124	15448	13730	13336	12920	11741	7807	7471	6731	35.20%
SM Bkg	44827141	6214068	549361	392398	374863	204988	74393	62505	19059	0.04%
$S_{cc}/\sqrt{B}$	0.10	0.25	0.76	0.88	0.89	1.05	1.26	1.31	2.28	
$S_{bb}/\sqrt{B}$	1.93	4.62	13.87	15.99	16.26	20.15	24.93	26.04	42.47	

350 GeV	No cuts	MM	Pt	|Pl|	nchdtrk	Pmax	Y+	Y−	Mh	Eff.
H→cc	930	917	892	892	878	845	678	478	442	47.59%
H→bb	17604	17298	16870	16870	16752	16291	12915	8721	7425	42.18%
ZH→vvH all	25990	23897	23303	23303	21895	21172	15447	10275	8708	33.51%
SM Bkg	18102000	4822840	1727390	1706180	1619980	973874	475892	181206	20071	0.11%
Scc/sqrt(B)	0.22	0.42	0.68	0.68	0.69	0.86	0.98	1.12	3.12	
Sbb/sqrt(B)	4.14	7.88	12.84	12.92	13.16	16.51	18.72	20.49	52.41	

Relative BR comparison (add qq BG at 350GeV)

Relative branching fraction has checked for Ecm=250, 350 GeV

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

Efficiency	Ecm=250 GeV		Ecm=350 GeV	
mode	neutrino	hadron	neutrino	hadron
e_{bb}	36.8%	39.0%	47.6%	31.7%
e_{cc}	41.8%	41.9%	42.2%	35.4%

Fitted results	Ecm=250 GeV		Ecm=350 GeV	
mode	neutrino	hadron	neutrino	hadron
rbb	0.853+-0.009	0.774+-0.013	0.853+-0.007	0.788+-0.009
rcc	0.052+-0.004	0.046+-0.005	0.051+-0.003	0.047+-0.003
BR(cc)/BR(bb)	0.054+-0.004	0.055+-0.006	0.053+-0.003	0.054+-0.003
ΔBR(cc)/BR(bb)	7.94%	10.15%	5.87%	6.48%

Very preliminary

Consider template fitting stability (Statistics)

Peak luminosity dependence

Reference value : $L_{peak}=2.0\times10^{34}cm^{-2}s^{-1}$, $L_{int}=500\ fb^{-1}$ at RDR 500 GeV

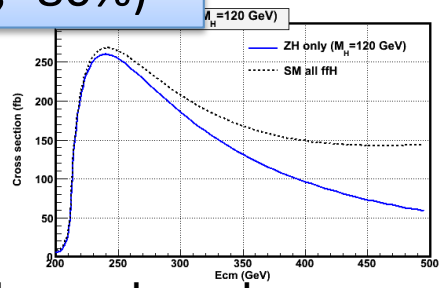
	RDR (LOI)			SB2009 w/ TF			NB w/TF		
Ecm (GeV)	250	350	500	250	350	500	250	350	500
Peak L ($10^{34}\ cm^{-2}s^{-1}$)	0.75	1.2	2.0	0.27	1.0	2.0	0.8	1.0	2.0
Integrated L (fb^{-1})	187.5	300	500	67.5	250	500	200	250	500

Compare RDR 250GeV with SB2009 w/ TF 350GeV

NB : New baseline parameter

Production cross section with beam polarization (e+,e-)=(+30%, -80%)

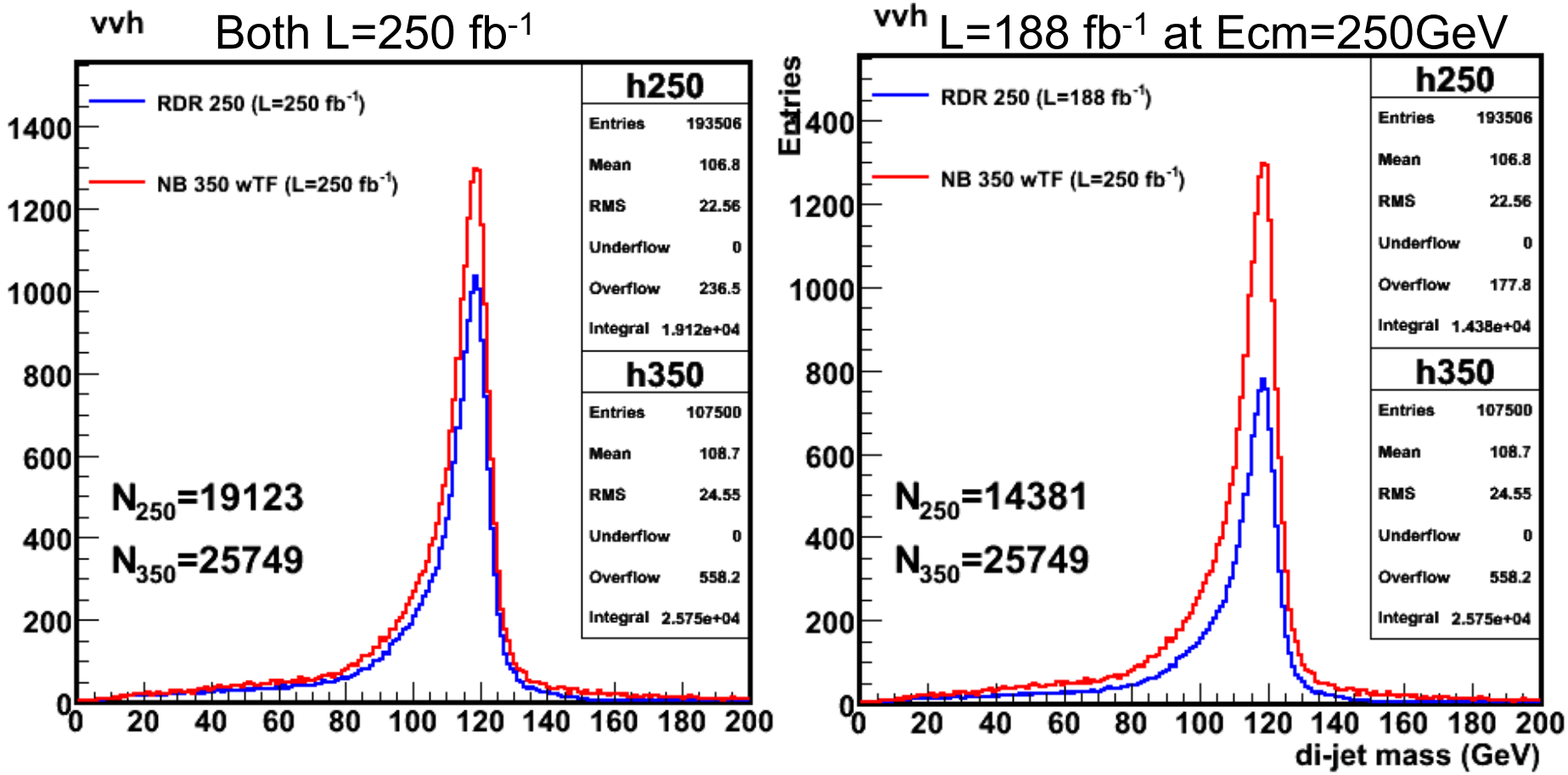
Cross section	250 GeV	350 GeV
vvH	77.44 fb	105.23 fb
qqH	210.03 fb	144.40 fb



vvH includes t-channel and larger entries at Ecm=350 GeV

vvH sample luminosity comparison

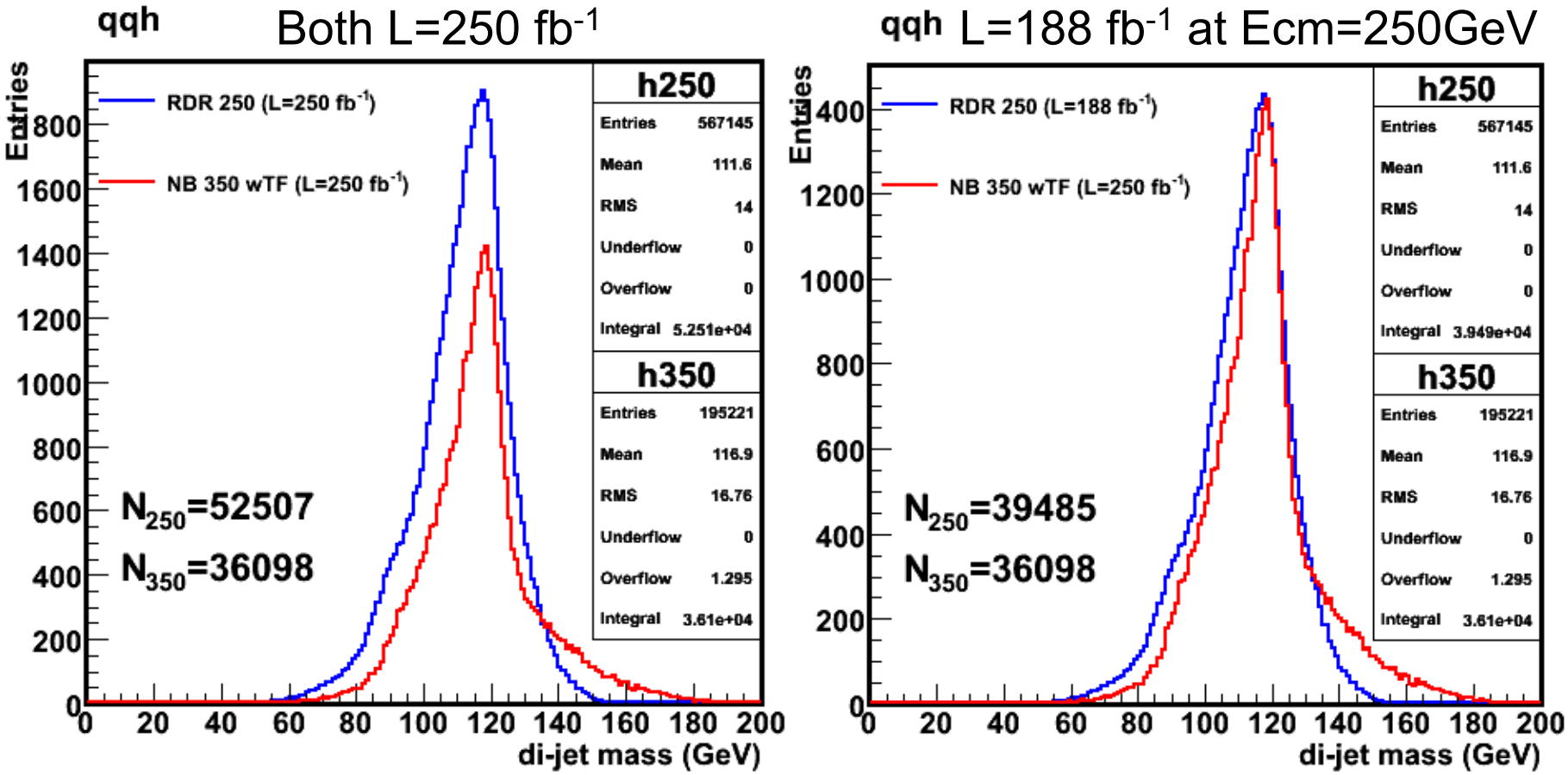
Higgs candidate di-jet mass distribution without selection criteria



Without any selections. Difference becomes large
because of increasing the t-channel contribution at 350 GeV (Larger x-sec)

qqH sample luminosity comparison

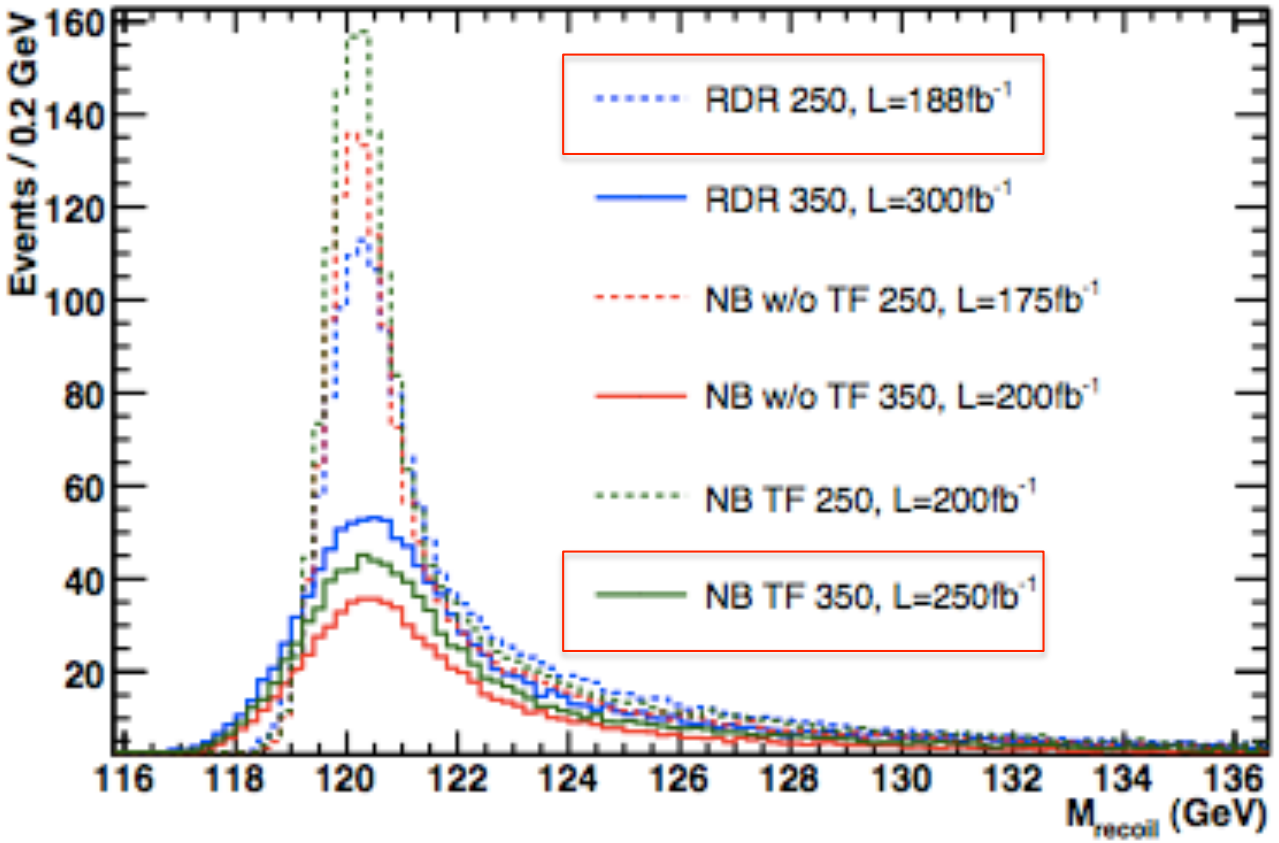
Higgs candidate di-jet mass distribution without selection criteria



Without any cuts. Next apply BR analysis with luminosity scaling

llH recoil analysis from Li's analysis

Fast simulation by Hengne Li



Cross section	250 GeV	350 GeV
μμH	11.7 fb	7.1 fb

Next step

- Still improving BR measurement accuracy at 350 GeV
  - Confirm these results with other strategy (σ*Br(bb/cc))
  - Compare 250/350 GeV with scaling different luminosity
- Consider peak luminosity difference into BR analysis
- llH analysis should be applied
  - Try to compare Hengne Li's fastsim analysis

Backup

BG reduction (ZH→νν̄H, 250 GeV)

250 GeV	No cuts	MM	Pt	|Pl|	nchdtrk	Pmax	Y+	Y−	Mh	Eff.
H→cc	698	635	567	553	547	476	344	329	315	45.20%
H→bb	12904	11521	10282	10014	9955	9123	6801	6510	5863	45.44%
νν̄H all	19124	15448	13730	13336	12920	11741	7807	7471	6731	35.20%
qqqq	4048390	3889	140	137	137	126	2	2	1	0.11%
qq	35353300	5488020	48578	15128	14913	10671	8048	7019	2475	19.18%
nlqq	4114190	560258	410528	323540	309618	153727	36918	31571	12760	66.73%
llqq	398320	10980	2964	2687	2607	1917	373	339	228	35.93%
nnqq	149979	124840	85775	49749	47584	38545	29052	23573	3594	31.20%
llll	762962	26082	1376	1156	4	2	1	1	0	0.00%
SM Bkg	44827141	6214068	549361	392398	374863	204988	74393	62505	19059	0.04%
$S_{cc}/\sqrt{B}$	0.2	0.7	0.8	0.9	0.9	1.1	1.3	1.4	2.4	
$S_{bb}/\sqrt{B}$	4.2	13.5	14.5	16.3	16.6	20.7	26.4	27.6	45.5	

BG reduction (ZH→νν̄H, 350 GeV)

350 GeV	No cuts	MM	Pt	|Pl|	nchdtrk	Pmax	Y+	Y−	Mh	Eff.
H→cc	930	917	892	892	878	845	678	478	442	47.59%
H→bb	17604	17298	16870	16870	16752	16291	12915	8721	7425	42.18%
νν̄H all	25990	23897	23303	23303	21895	21172	15447	10275	8708	33.51%
qqqq	3094510	105289	14939	14939	14939	13347	1498	871	5	0.00%
qq	9632260	2943540	199590	188661	182420	154830	131999	48260	3269	0.03%
tt	166459	52002	50641	50641	50443	44176	1726	1311	210	0.13%
nlqq	3343170	1377330	1306440	1298210	1235490	638976	240865	96615	12545	0.38%
llqq	468340	47674	15421	15305	14632	10316	2445	1381	207	0.04%
nnqq	151150	139791	131615	129852	122032	112223	97356	32767	3834	2.54%
llll	1246160	157213	8750	8572	23	6	3	1	1	0.00%
SM Bkg	18102000	4822840	1727390	1706180	1619980	973874	475892	181206	20071	0.11%
Scc/sqrt(B)	0.22	0.42	0.68	0.68	0.69	0.86	0.98	1.12	3.12	
Sbb/sqrt(B)	4.14	7.88	12.84	12.92	13.16	16.51	18.72	20.49	52.41	

BG reduction (ZH→qqH, 350 GeV)

350 GeV	No cuts	chi2	nTracks	−Log(Y34)	thrust	cosθ	θ_H	Mh	Eff.
H→cc	1296	899	672	652	599	553	516	460	35.50%
H→bb	24051	14919	11589	11275	10410	9636	8811	7623	31.70%
qqH all	36099	20203	14905	14546	13524	12523	11191	9675	26.80%
qqqq	3094510	322790	179720	167952	85560	54839	39092	27214	0.88%
qq	9631930	463312	93869	51746	29232	25431	20666	14562	0.15%
tt	166459	49314	29138	29096	28832	25962	17568	5428	3.26%
nlqq	3343060	81620	638	489	350	270	158	43	0.00%
llqq	468202	33186	235	173	90	74	51	28	0.01%
nnqq	119416	142	35	16	9	9	2	0	0.00%
llll	1074390	22722	0	0	0	0	0	0	0.00%
SM Bkg	17898000	973086	303634	249472	144073	106586	77537	47274	0.26%
Scc/sqrt(B)	0.31	0.91	1.22	1.30	1.58	1.69	1.85	2.12	
Sbb/sqrt(B)	5.69	15.12	21.03	22.57	27.43	29.52	31.64	35.06	

BG reduction (ZH→qqH, 250 GeV)

250 GeV	No cuts	chi2	nTracks	−Log(Y34)	thrust	cosθ	θ_H	Mh	Eff.
H→cc	1916	1460	1114	1102	1081	963	890	804	41.95%
H→bb	34963	24568	19542	19351	19013	16854	15488	13651	39.04%
qqH all	52507	32430	25252	25037	24656	21856	20041	17617	33.55%
qqqq	4048390	1299950	824215	818221	814909	591276	533302	430869	10.64%
qq	35353100	1220310	296152	183403	120560	104502	88475	73790	0.21%
nlqq	4114190	25981	119	112	94	83	59	18	0.00%
llqq	398319	42195	307	274	225	165	139	111	0.03%
nnqq	149979	0	0	0	0	0	0	0	0.00%
llll	761223	20168	0	0	0	0	0	0	0.00%
SM Bkg	44825201	2608604	1120793	1002011	935788	696026	621975	504788	1.13%
Scc/sqrt(B)	0.05	0.31	1.05	1.10	1.12	1.15	1.13	1.13	
Sbb/sqrt(B)	0.86	5.27	18.46	19.33	19.65	20.20	19.64	19.21	

BG reduction (qqH) L=250fb^{-1}

250 GeV	No cuts	chi2	nTracks	−Log(Y34)	thrust	cosθ	θ_H	Mh	Eff.
H→cc	1916	1460	1114	1102	1081	963	890	804	41.95%
H→bb	34963	24568	19542	19351	19013	16854	15488	13651	39.04%
qqH all	52507	32430	25252	25037	24656	21856	20041	17617	33.55%
SM Bkg	44825201	2608604	1120793	1002011	935788	696026	621975	504788	1.13%
Scc/sqrt(B)	0.05	0.31	1.05	1.10	1.12	1.15	1.13	1.13	
Sbb/sqrt(B)	0.86	5.27	18.46	19.33	19.65	20.20	19.64	19.21	

350 GeV	No cuts	chi2	nTracks	−Log(Y34)	thrust	cosθ	θ_H	Mh	Eff.
H→cc	1296	899	672	652	599	553	516	460	35.50%
H→bb	24051	14919	11589	11275	10410	9636	8811	7623	31.70%
qqH all	36099	20203	14905	14546	13524	12523	11191	9675	26.80%
SM Bkg	17898000	973086	303634	249472	144073	106586	77537	47274	0.26%
Scc/sqrt(B)	0.31	0.91	1.22	1.30	1.58	1.69	1.85	2.12	
Sbb/sqrt(B)	5.69	15.12	21.03	22.57	27.43	29.52	31.64	35.06	

No qq background in 350 GeV

Relative branching fraction has checked for Ecm=250, 350 GeV

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

Efficiency	Ecm=250 GeV		Ecm=350 GeV	
	neutrino	hadron	neutrino	hadron
ε_{bb}	36.8%	39.0%		31.7%
ε_{cc}	41.8%	41.9%		35.4%

Fitted results	Ecm=250 GeV			Ecm=350 GeV	
mode	neutrino	hadron	had w/o qq	neutrino	hadron
rbb	0.853+-0.009	0.774+-0.013	0.775+-0.014	0.853+-0.006	0.788+-0.008
rcc	0.052+-0.004	0.046+-0.005	0.046+-0.004	0.051+-0.003	0.048+-0.002
BR(cc)/BR(bb)	0.054+-0.004	0.055+-0.006	0.055+-0.005	0.053+-0.003	0.054+-0.003
ΔBR(cc)/BR(bb)	7.94%	10.15%	9.68%	5.93%	6.18%

Very preliminary