Status of Higgs self-coupling analysis

Junping Tian (KEK)

Nov. 28 @ ILD Analysis Meeting

status

From LCWS12

- llHH and ννHH modes analyzed
- qqHH mode updated (more backgrounds)
- vvHH (fusion) @ 1TeV, samples ongoing
- update Higgs self-coupling section of DBD

$e^+ + e^- \to ZHH \to (\nu\bar{\nu})(b\bar{b})(b\bar{b}) \to \nu\bar{\nu} + 4$ bjets

full simulation @ 500GeV

- ✦generator: Whizard 1.95
- ✦simulation: ilcsoft-v01-14-01
- ✦reconstruction: ilcsoft-v01-16
- ✦flavor tagging: LCFIPlus

pre-selection:

- no isolated-charged-leptons
- 4-jets clustering (LCFIPlus, Durham)
- combine the six jets by minimizing

$$\chi^2 = \frac{(M(b,\bar{b}) - M_H)^2}{\sigma_{H_1}^2} + \frac{(M(b,\bar{b}) - M_H)^2}{\sigma_{H_2}^2}$$

requirement implied in the pre-selection:

- 3rd-largest b-likeness > 0.2

final selection:

- train the neural-nets, each event is also reconstructed as from ZZ, tt-bar, ZZZ and ZZH, and various variables are input to NN
- optimize cuts on NN-output and b-tagging

reduction table (vvHH)

Polarization: (e-,e+)=(-0.8,+0.3) $E_{\rm cm} = 500{\rm GeV}, M_H = 120{\rm GeV}$ $\int Ldt = 2{\rm ab}^{-1}$

normalized	expected	MC	pre-selection	Evis-0.83MissPt <360 MissMass > 60	NpfosMin>=8 MassCut	MLP_bbbb>0.83	MLP_lvbbqq>0.56	MLP_vvbbbb>0.61	Bmax3+Bmax4 >1.14
νvhh(νvbbbb)	103(42.8)	7.06×10^5	45.0(37.0)	43.6(35.8)	26.0(23.7)	22.7(20.7)	20.6(18.9)	17.1(15.7)	8.47(8.42)
BG			1.33×10^5	33619	5887	4650	1176	887	7.86
νvbbbb	97.1	8.22×10^4	82.1	80.5	10.1	6.90	5.66	2.03	0.87
νvqqH(ZZH)	469	7.41×10^4	82.1	79.0	21.5	17.5	13.0	5.86	1.93
bbqqqq	6.24×10^5	3.88×10^6	58457	1212	178	71.5	38.6	37.2	0
bbbb	4.02×10^4	7.06×10^5	30826	3684	350	13.2	9.82	7.87	2.99
νvbb	2.73×10^5	4.79×10^5	861	758	9.17	4.25	4.25	3.02	0
evbbqq	2.48×10^5	1.51×10^6	3884	2126	504	451	72.6	54.9	0
μvbbqq	2.46×10^5	1.48×10^6	1637	951	223	195	72.8	52.1	0
τvbbqq	2.46×10^5	1.59×10^6	37440	24728	2591	3890	959	724	2.07

nS = 8.5, nB = 7.9 $\sim 2.1\sigma$

update of qqHH

- ZZH, ttz and ttg(ttbb) added (physsim as generator, with DBD beam spectrum and ISR)
- re-tuned the neural-nets and optimization.
- bbHH mode decrease significantly, qqHH slightly

Status of DBD analysis

preliminary

P(e-,e+)=(-0.8,0.3)

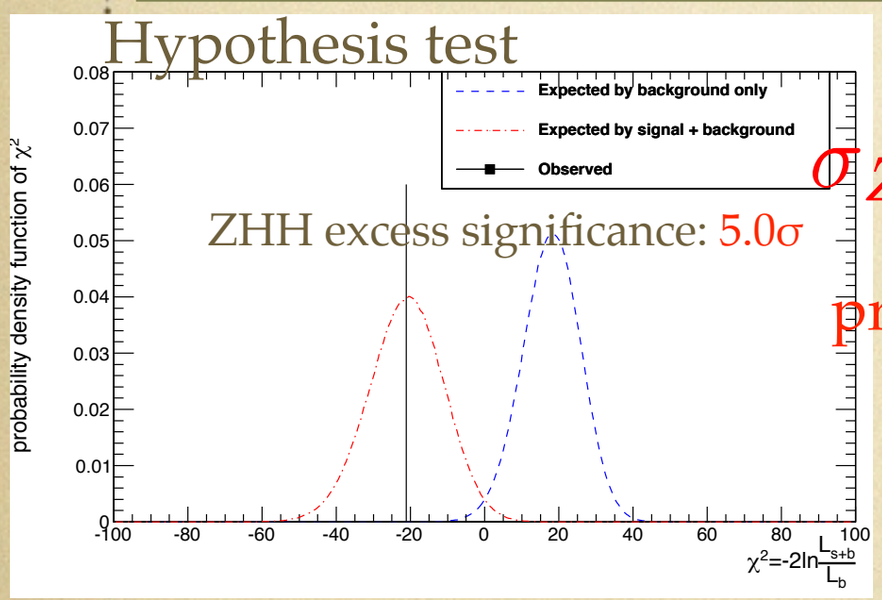
$e^+ + e^- \to ZHH$

$M(H) = 120\text{GeV}$

$\int Ldt = 2\text{ab}^{-1}$

Energy (GeV)	Modes	signal	background	significance	
				excess (I)	measurement (II)
500	$ZHH \to (l\bar{l})(b\bar{b})(b\bar{b})$	3.7	4.3	1.5σ	1.1σ
		4.5	6.0	1.5σ	1.2σ
500	$ZHH \to (\nu\bar{\nu})(b\bar{b})(b\bar{b})$	8.5	7.9	2.5σ	2.1σ
500	$ZHH \to (q\bar{q})(b\bar{b})(b\bar{b})$	13.6	30.7	2.2σ	2.0σ
		18.8	90.6	1.9σ	1.8σ

Hypothesis test

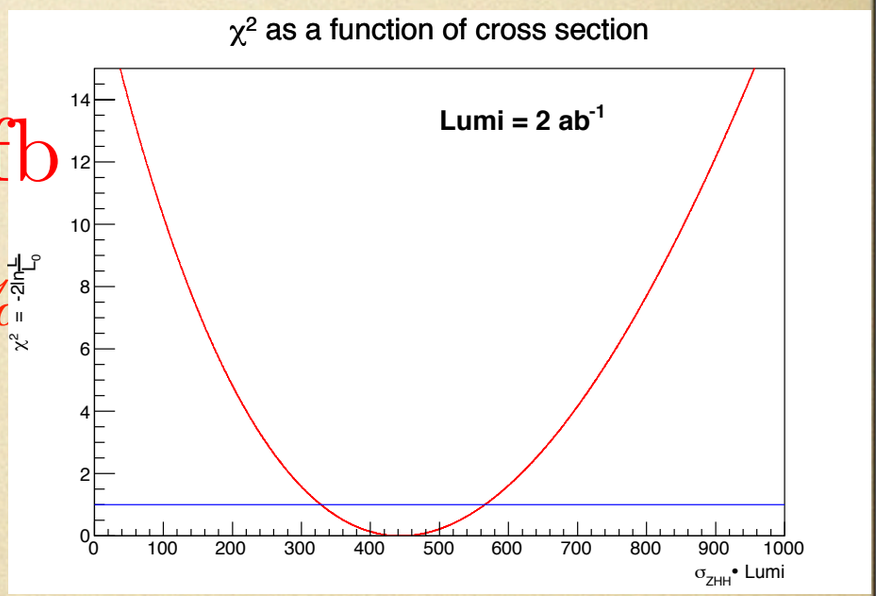


ZHH excess significance: 5.0σ

$\sigma_{ZHH} = 0.22 \pm 0.06$ fb

precision of cross section: **26.7%**

Higgs self-coupling: **48%**



after using weighting, would be: $\frac{\delta\lambda}{\lambda} = 44\%$

backup

preliminary reduction table (probZ1+probZ2 > 0.56)

P(e-,e+)=(-0.8,+0.3)

$E_{\rm cm} = 500{\rm GeV}, M_H = 120{\rm GeV}$ $\int Ldt = 2{\rm ab}^{-1}$

normalized	expected	MC	pre-selection	probZ1+probZ2>0.56	MissPt < 60	MLP_bbbb>0.74	MLP_bbqqqq>0.34	MLP_qqbbbb>0.0	Bmax3>0.82 Bmax4>0.21
qqhh(qqbbbb)	310(129)	3.73×10^5	111(85.3)	26.7(23.0)	25.9(22.8)	20.6(18.8)	20.1(18.4)	20.0(18.3)	12.4(11.8)
bbbb	4.02×10^4	7.19×10^5	22889	2289	2253	9.04	8.06	7.94	3.32
lvbbqq	7.40×10^5	3.56×10^6	17240	357	172	8.47	6.69	6.69	0.03
qqbbbb	140	3.03×10^4	82.3	13.6	13.5	7.43	6.96	3.94	2.36
bbuddu	1.56×10^5	8.87×10^5	565	11.2	11.2	8.82	6.73	6.73	0.73
bbcsdu	3.12×10^5	1.26×10^6	6109	86.8	86.4	61.6	44.6	44.1	2.41
bbcssc	1.56×10^5	1.17×10^6	12456	256	254	177	126	125	4.71
qqqqH(ZZH)	381	not available yet							
ttqq	2169	not available yet							
BG			59342	3013	2790	273	199	197	11.0

bbHH dominant: $nS = 12.4, nB = 11.0 \quad \sim 2.7\sigma$

samples of ZZH and ttqq are already available, to be added soon

preliminary reduction table (probZ1+probZ2 < 0.56)

P(e-,e+)=(-0.8,+0.3)

$E_{\rm cm} = 500{\rm GeV}, M_H = 120{\rm GeV}$ $\int Ldt = 2{\rm ab}^{-1}$

normalized	expected	MC	pre-selection	probZ1+probZ2<0.56	MissPt < 60	MLP_bbbb>0.63	MLP_bbqqqq>0.55	MLP_qqbbbb>0.15	Bmax3>0.85 Bmax4>0.43
qqhh(qqbbbb)	310(129)	3.73×10^5	111(85.3)	84.3(62.3)	80.9(61.8)	66.9(53.5)	45.9(37.7)	44.5(36.6)	21.4(18.6)
bbbb	4.02×10^4	7.19×10^5	22889	20600	20282	152	62.9	53.5	25.6
lvbbqq	7.40×10^5	3.56×10^6	17240	16884	7937	536	115	105	1.36
qqbbbb	140	3.03×10^4	82.3	68.7	68.3	42.5	20.7	14.9	7.03
bbuddu	1.56×10^5	8.87×10^5	565	554	550	434	105	99.2	11.3
bbcsdu	3.12×10^5	1.26×10^6	6109	6022	5987	4559	977	917	25.4
bbcssc	1.56×10^5	1.17×10^6	12456	12200	12115	9181	1655	1556	19.2
qqqqH(ZZH)	381	not available yet							
ttqq	2169	not available yet							
BG			59342	56329	46939	14906	2936	2745	89.9

light qqHH dominant: $nS = 21.4, nB = 89.9 \quad \sim 2.0\sigma$