

ZHH Progress Report

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Bryan Bliewert

Hadron Channel (preliminary)

	$\sigma[\text{fb}]$	N_{exp}	N_{gen}
$ZHH \rightarrow qqHH$	0.155	311	$2 \cdot 10^6$

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$qqqqH$	5.30	10600	$2 \cdot 10^6$

signal	$\sigma [\text{fb}]$	$N_{exp} [\text{evts}]$	fraction	$N_{gen} [\text{evts}]$
$llHH (llbbbb)$	0.02 (0.007)	40.5 (14.3)	10% (3.6%)	$3.45 \cdot 10^5$
$\nu\nu HH (\nu\nu bbbb)$	0.04 (0.014)	80.1 (28.5)	20% (7.2%)	$3.91 \cdot 10^5$
$qqHH (qqbbbb)$	0.14 (0.049)	273.1 (99.5)	70% (25.0%)	$1.13 \cdot 10^6$

background	$\sigma [\text{fb}]$	$N_{exp} [\text{evts}]$	$N_{gen} [\text{evts}]$
ZZH (total)	0.63	1259.4	$8.76 \cdot 10^5$
$\rightarrow llqqH$	0.08	150.9	$1.91 \cdot 10^5$
$\rightarrow \nu\nu qqH$	0.22	447.0	$2.96 \cdot 10^5$
$\rightarrow qqqqH$	0.33	662.6	$3.89 \cdot 10^5$

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Difference due to more inclusive production (?)
 Previously **only ZZH**, now also including WWH

Current analysis

UH



	qqqqH	bbbbqq	bbbb	bbqqqq	lvbbqq	Total background	qqHH (non-bbbb)	(qqHH bbbb)	(bbHH bbbb)	Total signal
σ [fb]	5.3	0.0732	12.2	326	339	$3.18 \cdot 10^4$	0.103	0.0418	0.0109	0.155
expected	$1.06 \cdot 10^4$	146	$2.44 \cdot 10^4$	$6.52 \cdot 10^5$	$6.78 \cdot 10^5$	$6.36 \cdot 10^7$	205	83.6	21.9	311
$N_{iso.leptons} = 0$	$9.47 \cdot 10^3$	144	$2.37 \cdot 10^4$	$6.42 \cdot 10^5$	$2.20 \cdot 10^5$	$4.68 \cdot 10^7$	148	82.2	21.5	252
$b_{max4} \geq 0.16$	$1.11 \cdot 10^3$	120	$2.10 \cdot 10^4$	$1.57 \cdot 10^4$	$3.72 \cdot 10^4$	$1.10 \cdot 10^6$	30.0	67.8	21.4	119
$p_t^{miss}/GeV \leq 100.0$	$1.10 \cdot 10^3$	120	$2.10 \cdot 10^4$	$1.57 \cdot 10^4$	$2.50 \cdot 10^4$	$1.02 \cdot 10^6$	28.6	67.7	21.4	118
$thrust \leq 0.9$	$1.09 \cdot 10^3$	119	$8.75 \cdot 10^3$	$1.57 \cdot 10^4$	$2.43 \cdot 10^4$	$3.86 \cdot 10^5$	28.6	67.6	21.4	118
$40.0 \leq m_Z/GeV \leq 120.0$	$1.09 \cdot 10^3$	119	$7.48 \cdot 10^3$	$1.56 \cdot 10^4$	$2.01 \cdot 10^4$	$5.30 \cdot 10^4$	28.1	67.4	21.3	117
$85.0 \leq m_{H1}/GeV \leq 155.0$	$1.09 \cdot 10^3$	118	$7.07 \cdot 10^3$	$1.55 \cdot 10^4$	$1.82 \cdot 10^4$	$4.90 \cdot 10^4$	28.0	67.4	21.3	117
$60.0 \leq m_{H2}/GeV \leq 180.0$	$1.08 \cdot 10^3$	118	$6.90 \cdot 10^3$	$1.55 \cdot 10^4$	$1.77 \cdot 10^4$	$4.78 \cdot 10^4$	27.9	67.2	21.2	116

2014 analysis

	qqqqH	qqbbbbb	bbbb	bbcsc	bbsdu	bbuddu	lvbbqq	ttZ	ttbb	Background	qqHH (qqbbbbb)
σ [fb]	0.33	0.07	20.12	77.95	156	78.07	370	1.09	1.05	704.8	0.137
expected events	662.6	140.5	$4.02 \cdot 10^4$	$1.56 \cdot 10^5$	$3.12 \cdot 10^5$	$1.56 \cdot 10^5$	$7.40 \cdot 10^5$	2197	2109	$1.4 \cdot 10^6$	273.1 (99)
Preselection Cuts											
$N_{isolep} = 0$	583 ± 1.4	137 ± 0.4	$3.9 \cdot 10^4 \pm 53$	$1.5 \cdot 10^5 \pm 174$	$3.0 \cdot 10^5 \pm 270$	$1.5 \cdot 10^5 \pm 198$	$2.4 \cdot 10^4 \pm 222$	1322 ± 6	1271 ± 6	$6.7 \cdot 10^5 \pm 440$	214 ± 0.3 (82.0)
$btag > 0.16$	114 ± 0.6	84 ± 0.4	$2.4 \cdot 10^4 \pm 41$	$1.3 \cdot 10^4 \pm 51$	6167 ± 38	568 ± 12	$1.6 \cdot 10^4 \pm 57$	166 ± 2	429 ± 33	$6.0 \cdot 10^4 \pm 101$	81.7 ± 0.2 (59.7)
Additional Precuts											
$60 < M_{H1} < 180$	112 ± 0.6	82 ± 0.3	$2.2 \cdot 10^4 \pm 39$	$1.2 \cdot 10^4 \pm 50$	5955 ± 38	549 ± 12	$1.5 \cdot 10^4 \pm 55$	160 ± 2	412 ± 3	$5.6 \cdot 10^4 \pm 93$	80.5 ± 0.2 (59.0)
$60 < M_{H2} < 180$	109 ± 0.6	79 ± 0.3	$2.0 \cdot 10^4 \pm 36$	$1.2 \cdot 10^4 \pm 49$	5765 ± 37	526 ± 12	$1.2 \cdot 10^4 \pm 47$	156 ± 2	380 ± 3	$5.2 \cdot 10^4 \pm 86$	78.9 ± 0.2 (58.4)
missing $p_T < 70$	109 ± 0.6	79 ± 0.3	$1.9 \cdot 10^4 \pm 36$	$1.2 \cdot 10^4 \pm 49$	5752 ± 37	526 ± 12	7596 ± 37	143 ± 2	337 ± 3	$4.6 \cdot 10^4 \pm 82$	77.4 ± 0.2 (58.2)
thrust < 0.9	109 ± 0.6	78 ± 0.4	6492 ± 21	$1.2 \cdot 10^4 \pm 49$	5742 ± 37	525 ± 12	7437 ± 37	143 ± 2	337 ± 3	$3.3 \cdot 10^4 \pm 76$	77.3 ± 0.2 (58.2)

	qqqqH	bbbbqq	bbbb	bbqqqq	lvbbqq	Total background	qqHH (non-bbbb)	(qqHH bbbb)	(bbHH bbbb)	Total signal
σ [fb]	5.3	0.0732	12.2	326	339	$3.18 \cdot 10^4$	0.103	0.0418	0.0109	0.155
expected	$1.06 \cdot 10^4$	146	$2.44 \cdot 10^4$	$6.52 \cdot 10^5$	$6.78 \cdot 10^5$	$6.36 \cdot 10^7$	205	83.6	21.9	311
$N_{iso.leptons} = 0$	$9.47 \cdot 10^3$	144	$2.37 \cdot 10^4$	$6.42 \cdot 10^5$	$2.20 \cdot 10^5$	$4.68 \cdot 10^7$	148	82.2	21.5	252
$b_{max4} \geq 0.16$	$1.11 \cdot 10^3$	120	$2.10 \cdot 10^4$	$1.57 \cdot 10^4$	$3.72 \cdot 10^4$	$1.10 \cdot 10^6$	30.0	67.8	21.4	119
$p_t^{miss}/GeV \leq 100.0$	$1.10 \cdot 10^3$	120	$2.10 \cdot 10^4$	$1.57 \cdot 10^4$	$2.50 \cdot 10^4$	$1.02 \cdot 10^6$	28.6	67.7	21.4	118
$thrust \leq 0.9$	$1.09 \cdot 10^3$	119	$8.75 \cdot 10^3$	$1.57 \cdot 10^4$	$2.43 \cdot 10^4$	$3.86 \cdot 10^5$	28.6	67.6	21.4	118
$40.0 \leq m_Z/GeV \leq 120.0$	$1.09 \cdot 10^3$	119	$7.48 \cdot 10^3$	$1.56 \cdot 10^4$	$2.01 \cdot 10^4$	$5.30 \cdot 10^4$	28.1	67.4	21.3	117
$85.0 \leq m_{H1}/GeV \leq 155.0$	$1.09 \cdot 10^3$	118	$7.07 \cdot 10^3$	$1.55 \cdot 10^4$	$1.82 \cdot 10^4$	$4.90 \cdot 10^4$	28.0	67.4	21.3	117
$60.0 \leq m_{H2}/GeV \leq 180.0$	$1.08 \cdot 10^3$	118	$6.90 \cdot 10^3$	$1.55 \cdot 10^4$	$1.77 \cdot 10^4$	$4.78 \cdot 10^4$	27.9	67.2	21.2	116
$(P_{qqHHbbbb} \geq 0.7145 \wedge P_{others} \leq 0.7848) \vee (P_{bbHHbbbb} \geq 0.6493 \wedge P_{others} \leq 0.6903)$	57.2	2.82	11.9	17.0	0.867	91.1	0.783	12.9	11.7	25.3

	qqqqH	qqbbbb	bbbb	bbcsc	bbsdu	bbuddu	lvbbqq	μZ	μbb	Background	qqHH (qqbbbb)
expected events	662.6	140.5	$4.02 \cdot 10^4$	$1.56 \cdot 10^5$	$3.12 \cdot 10^5$	$1.56 \cdot 10^5$	$7.40 \cdot 10^5$	2197	2109	$1.4 \cdot 10^6$	273.1 (99)
preselection	109 ± 0.6	78 ± 0.4	6492 ± 21	$1.2 \cdot 10^4 \pm 49$	5742 ± 37	525 ± 12	7487 ± 37	143 ± 2	337 ± 3	$3.3 \cdot 10^4 \pm 76$	77.3 ± 0.2 (58.2)
bbHH dominant Selection											
$btagZ > 0.54$	15 ± 0.2	14 ± 0.4	648 ± 6.8	242 ± 7	87 ± 5	11 ± 1.7	166 ± 6	16 ± 0.6	35 ± 0.9	1233 ± 12.7	18.8 ± 0.1 (16.1)
$bdtg(bbbbb)>0.9$	11 ± 0.2	7 ± 0.1	25 ± 1.3	177 ± 6	65 ± 4	8 ± 1.5	16 ± 2	13 ± 0.6	25 ± 0.8	348 ± 7.8	15.7 ± 0.1 (13.7)
$bdtg(bbqqqq) > 0.28$	10 ± 0.2	6 ± 0.1	22 ± 1.3	111 ± 5	45 ± 3	6 ± 1.2	12 ± 2	13 ± 0.6	23 ± 0.8	246 ± 6.5	14.6 ± 0.1 (13.0)
$bdtg(qqbbbb) > -0.25$	9 ± 0.2	5 ± 0.1	20 ± 1.2	105 ± 5	41 ± 3	5 ± 1.1	11 ± 2	12 ± 0.6	22 ± 0.7	231 ± 6.4	14.1 ± 0.1 (12.6)
$bmax3 + bmax4 > 1.22$	4 ± 0.1	2 ± 0.1	6 ± 0.6	4 ± 1	0	1 ± 0.3	0	2 ± 0.2	3 ± 0.3	22 ± 1.3	8.5 ± 0.1 (8.0)
Light qqHH dominant Selection											
$btagZ < 0.54$	94 ± 0.6	65 ± 0.3	5845 ± 20.4	$1.2 \cdot 10^4 \pm 48$	5654 ± 37	514 ± 11.6	7321 ± 38.8	128 ± 1.8	302 ± 2.8	$3.1 \cdot 10^4 \pm 75.6$	58.5 ± 0.2 (42.1)
$bdtg(bbbbb)>0.9$	71 ± 0.5	36 ± 0.2	208 ± 3.9	8571 ± 42	4219 ± 32	396 ± 10.2	521 ± 10.3	113 ± 1.7	244 ± 2.5	$1.4 \cdot 10^4 \pm 54.8$	48.5 ± 0.2 (36.5)
$bdtg(bbqqqq) > 0.61$	42 ± 0.4	17 ± 0.2	80 ± 2.4	1599 ± 18	909 ± 15	98 ± 5.1	83 ± 4.1	71 ± 1.3	121 ± 1.8	3019 ± 24.4	32.5 ± 0.1 (25.5)
$bdtg(qqbbbb) > 0.17$	28 ± 0.3	8 ± 0.1	60 ± 2.1	1341 ± 16	746 ± 13	81 ± 4.6	70 ± 3.8	63 ± 1.3	102 ± 1.6	2499 ± 21.8	29.8 ± 0.1 (23.3)
$bmax3 + bmax4 > 1.18$	17 ± 0.2	5 ± 0.1	41 ± 1.7	57 ± 3	54 ± 4	16 ± 2.0	3 ± 0.8	27 ± 0.8	42 ± 1.0	261 ± 5.6	19.5 ± 0.1 (16.6)
$bmax3 > 0.85$	15 ± 0.2	5 ± 0.1	38 ± 1.6	36 ± 3	40 ± 3	13 ± 1.8	3 ± 0.7	24 ± 0.8	36 ± 1.0	209 ± 5.2	17.9 ± 0.1 (15.4)
$40 < M_Z < 110$	13 ± 0.2	4 ± 0.1	27 ± 1.4	27 ± 2	30 ± 3	7 ± 1.3	3 ± 0.7	15 ± 0.6	25 ± 0.8	151 ± 4.3	15.7 ± 0.1 (13.8)
$90 < M_{H1} < 140$	8 ± 0.2	2 ± 0.1	16 ± 1.0	13 ± 2	17 ± 2	5 ± 1.1	2 ± 0.4	7 ± 0.5	14 ± 0.6	84 ± 3.2	13.0 ± 0.1 (11.9)
$90 < M_{H2} < 140$	7 ± 0.2	2 ± 0.1	10 ± 0.8	8 ± 1	9 ± 1	4 ± 0.9	2 ± 0.4	5 ± 0.3	8 ± 0.5	55 ± 2.0	12.6 ± 0.1 (10.9)