Supersymmetry in Hadronic Final States

Workshop on Collider and Dark Matter Physics

Mitchell Institute
Texas A&M University

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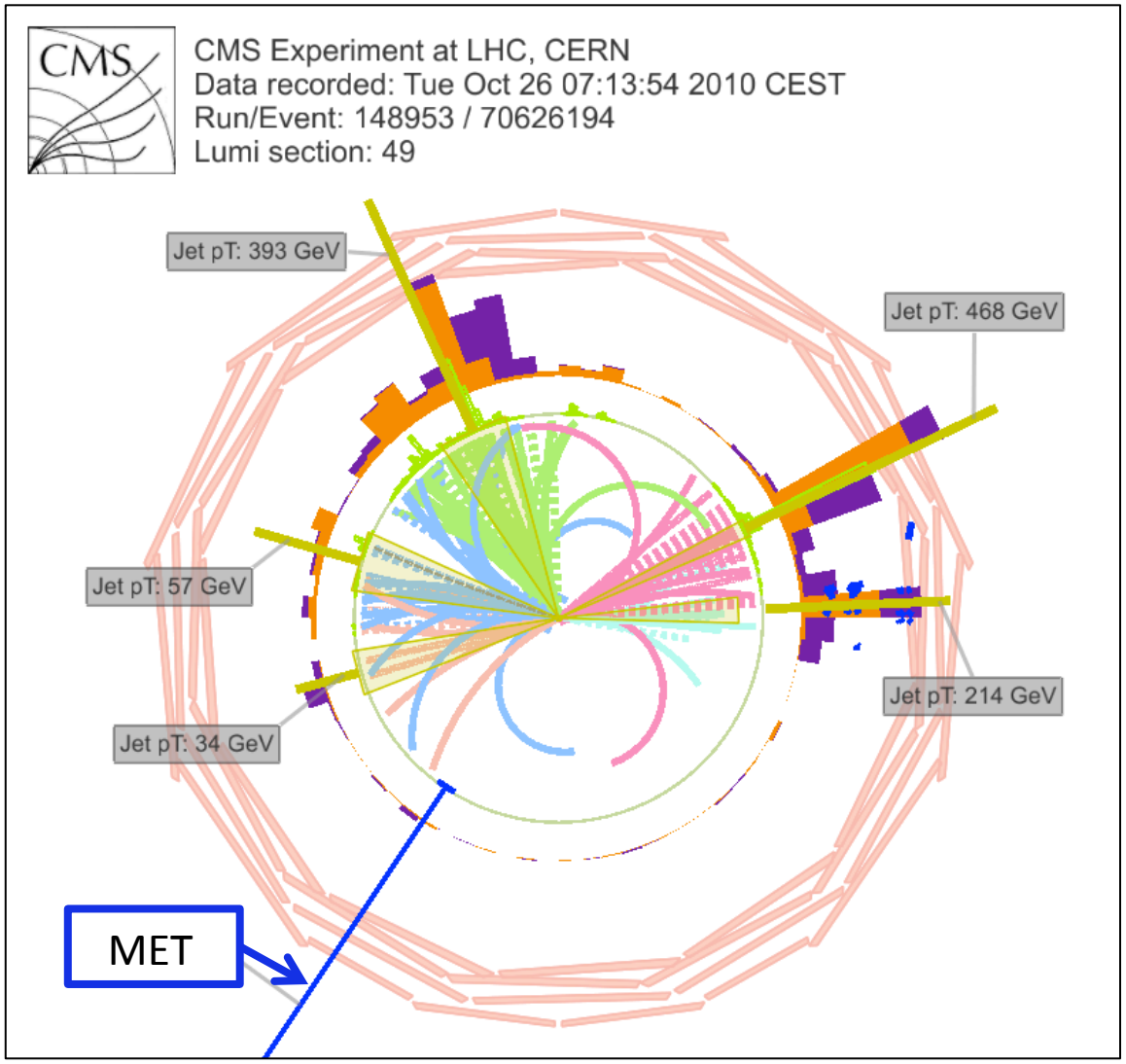
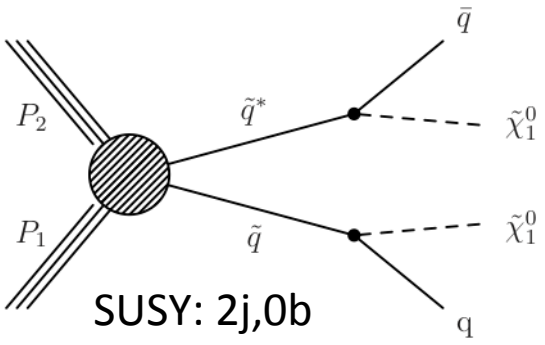
A classic SUSY signature

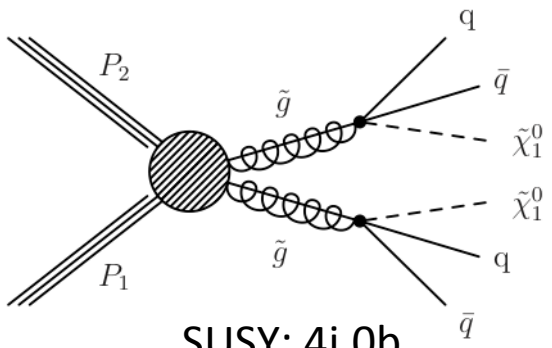
- Jets + MET is bread and butter physics for a hadron collider
- This talk:
  - Give flavor of state of the art
  - Explore what's next



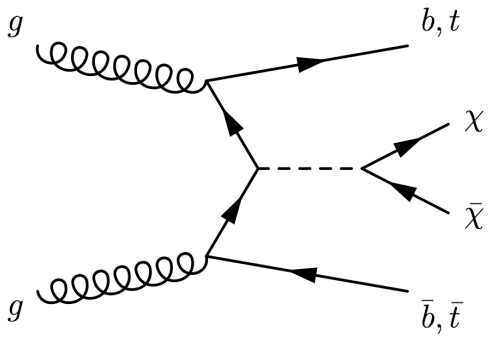
Wide range of models



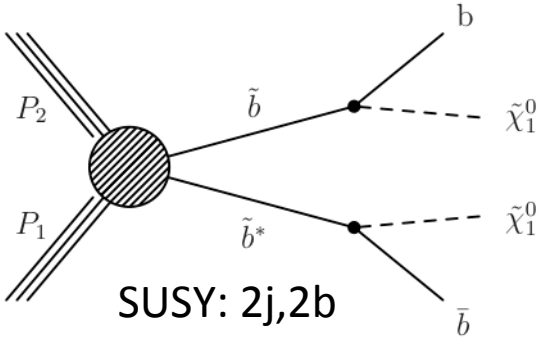
SUSY: 2j,0b



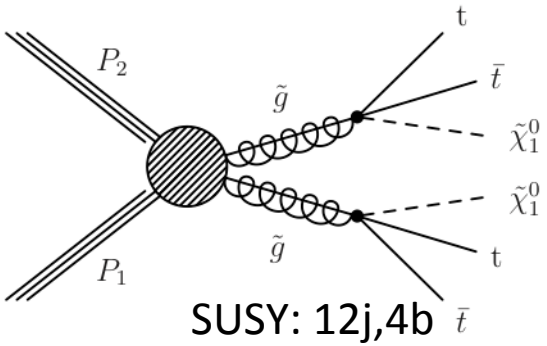
SUSY: 4j,0b



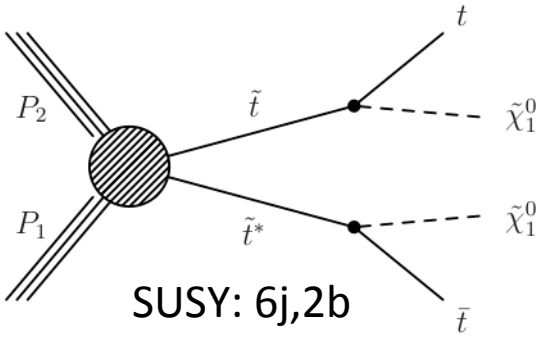
Direct DM: 2j,2b



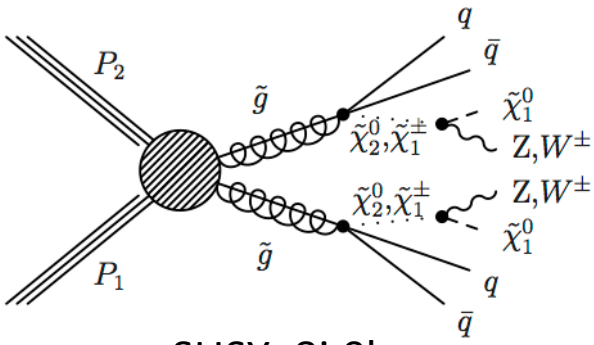
SUSY: 2j,2b



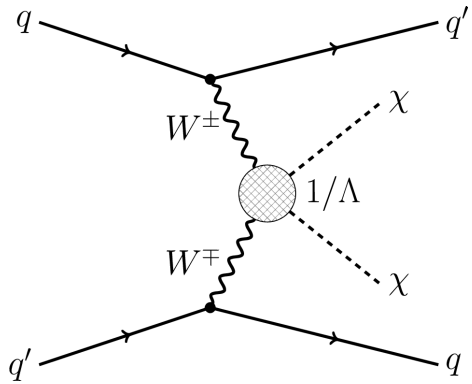
SUSY: 12j,4b



SUSY: 6j,2b

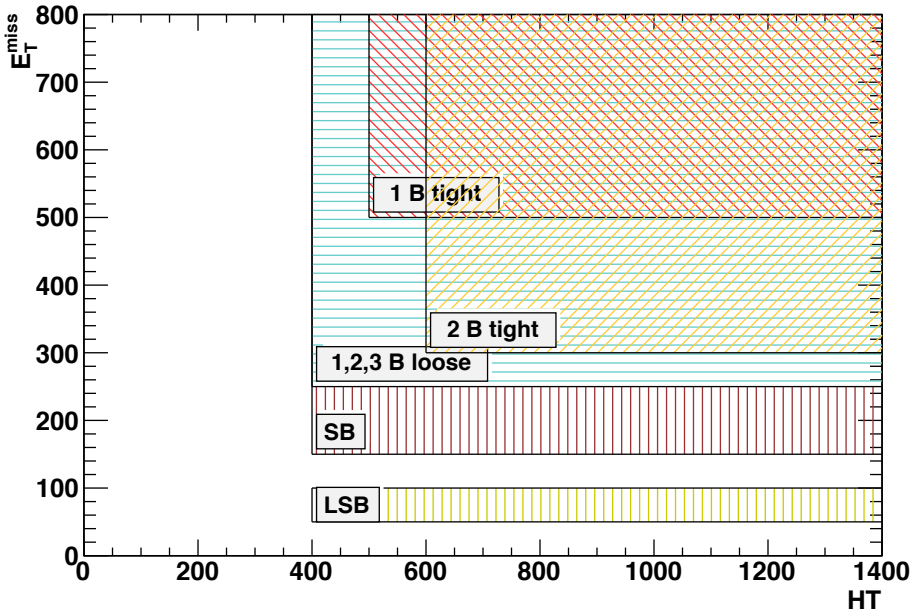


SUSY: 8j,0b

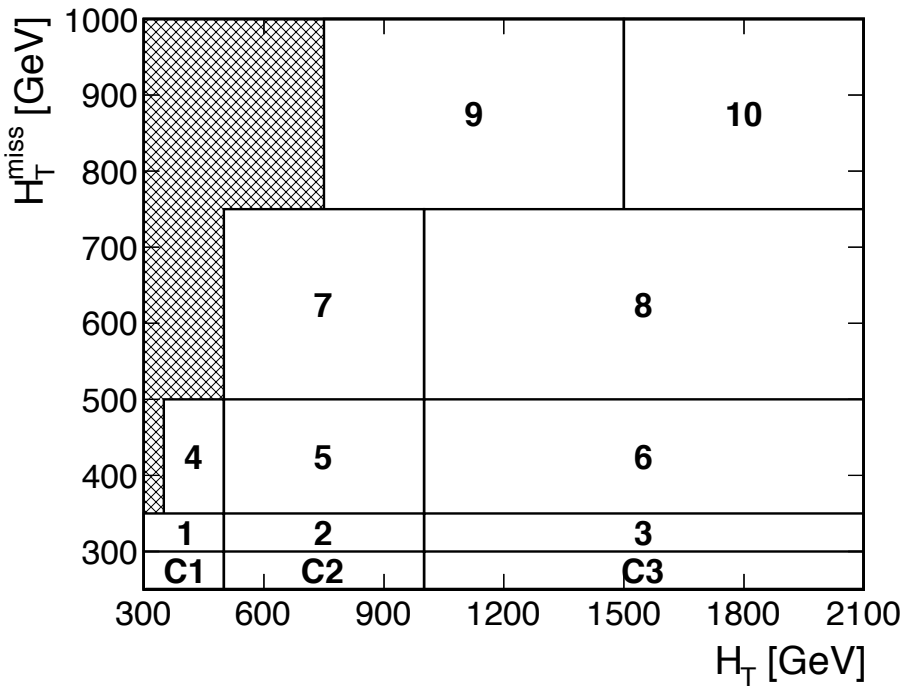


Direct DM: 2j,0b

Aiming for inclusiveness



PRD 86, 072010 (2012)

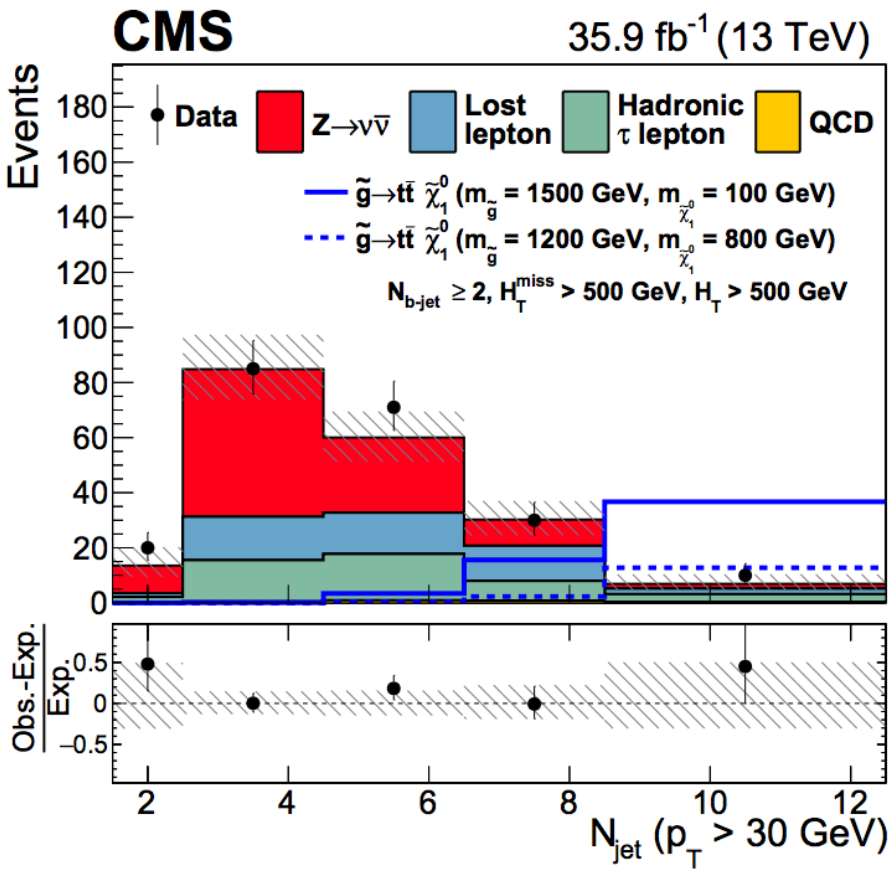


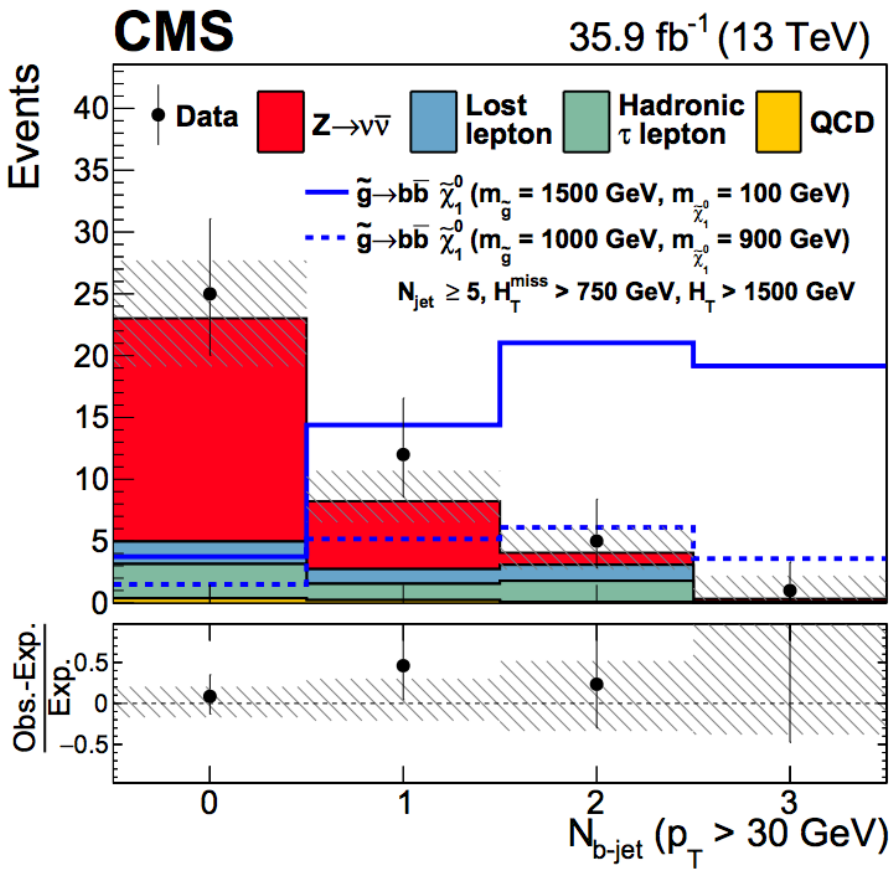
1704.07781 (2017)

- Binning in sensitive variables instead of cutting
  - Helps preserve sensitivity to less extreme kinematics signals
  - Improves signal/background in tighter regions, too

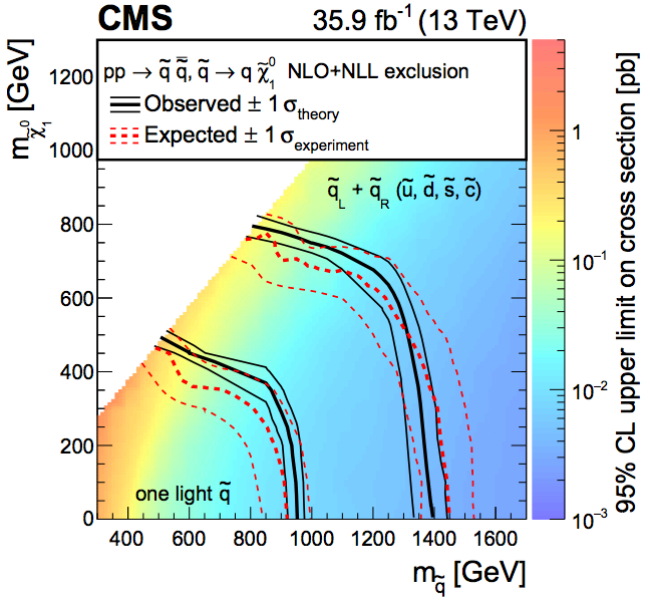
Bin in everything!

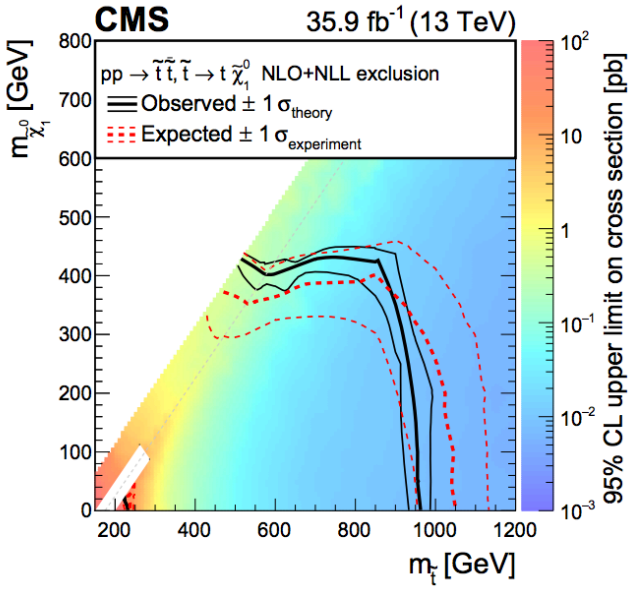
- Also gain by binning in number of jets and number of b-jets, where different models peak in different places

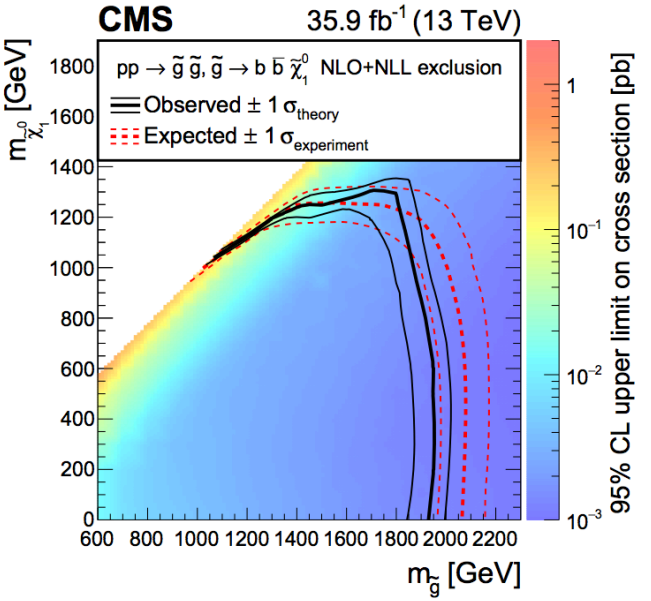


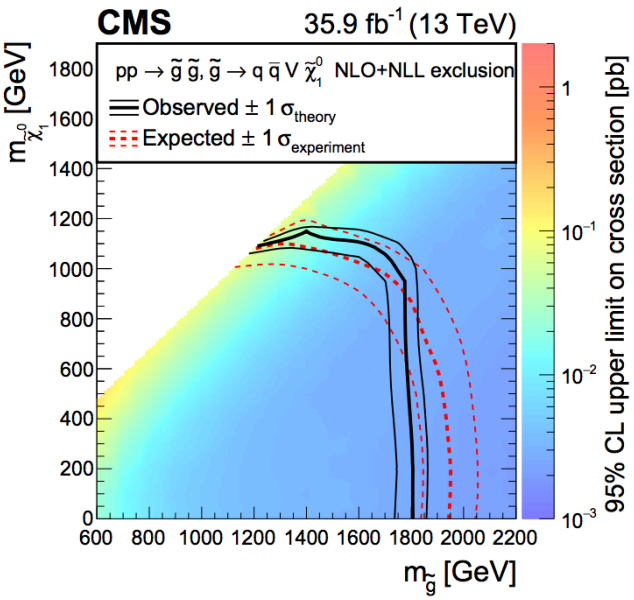


Sensitive to wide range of models

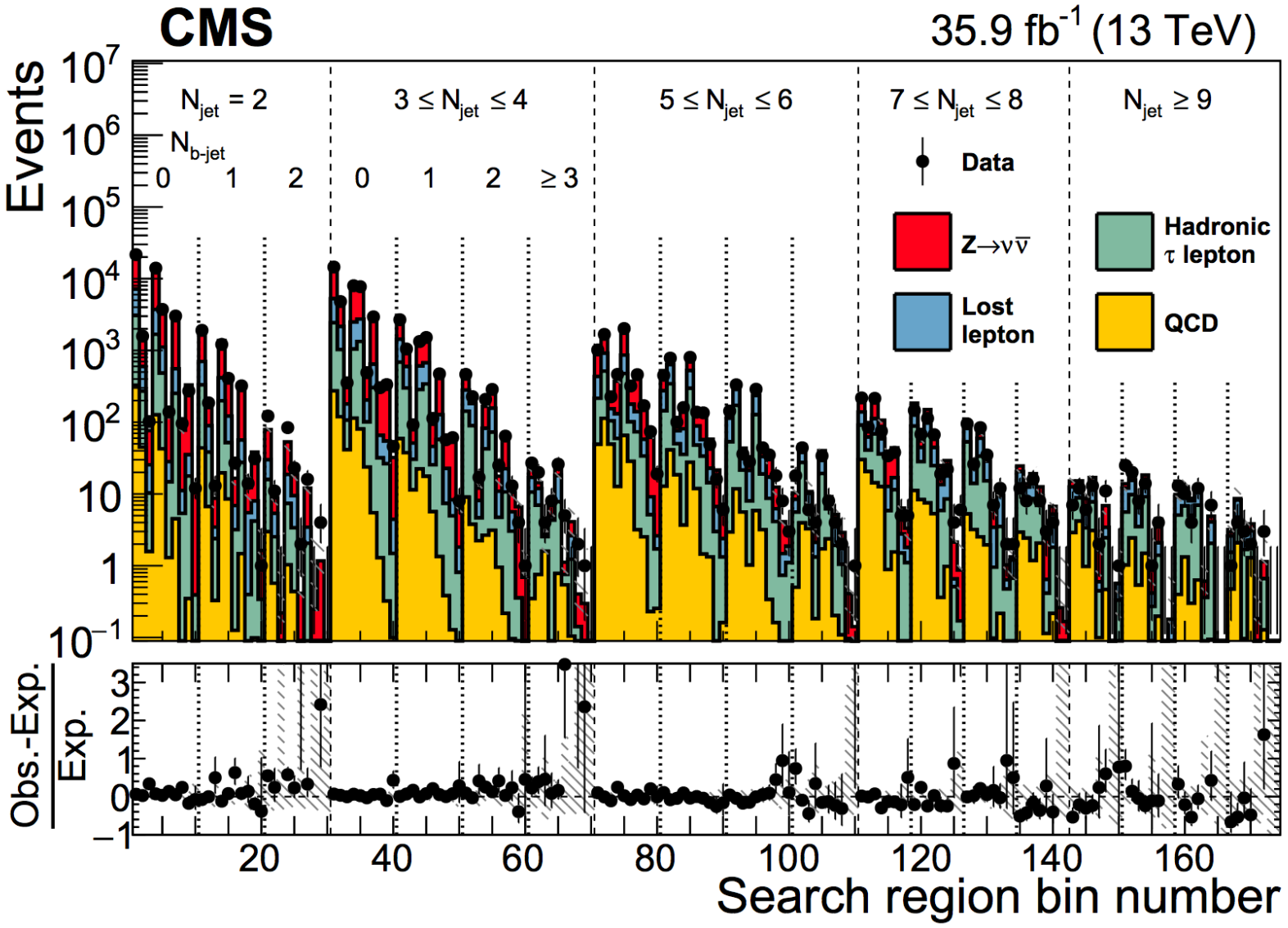








But end up with lots of bins!



But end up with lots of bins!

Table B.1: Observed numbers of events and prefit background predictions in the $N_{jet} = 2$ search regions. The first uncertainty is statistical and second systematic.

Bin	H_T^{miss} [GeV]	H_T [GeV]	N_{jet}	$N_{b\text{-}jet}$	Lost-e/μ	$\tau \to$ had	$Z \to \nu\bar{\nu}$	QCD	Total pred.	Obs.
1	300–350	300–500	2	0	$4069^{+67+320}_{-67-320}$	$2744^{+37+510}_{-37-500}$	$13231^{+67+760}_{-66-740}$	$326^{+12+170}_{-12-120}$	$20370^{+120+980}_{-120-960}$	21626
2	300–350	500–1000	2	0	326^{+22+36}_{-22-36}	226^{+11+43}_{-11-42}	944^{+18+55}_{-18-54}	45^{+2+24}_{-2-17}	1541^{+37+82}_{-37-79}	1583
3	300–350	>1000	2	0	$15.2^{+5.8+2.3}_{-5.1-2.3}$	$8.7^{+2.1+2.1}_{-2.0-2.1}$	$50.9^{+4.5+4.4}_{-4.1-3.8}$	$1.57^{+0.16+0.84}_{-0.16-0.61}$	$76.3^{+9.1+5.5}_{-8.2-5.0}$	102
4	350–500	350–500	2	0	$2049^{+46+160}_{-46-160}$	$1553^{+27+290}_{-27-290}$	$9347^{+57+540}_{-57-520}$	126^{+4+67}_{-4-48}	$13076^{+93+630}_{-93-620}$	14019
5	350–500	500–1000	2	0	631^{+25+54}_{-25-54}	439^{+14+84}_{-14-84}	$2502^{+30+150}_{-30-140}$	43^{+7+22}_{-7-16}	$3615^{+49+180}_{-49-170}$	3730
6	350–500	>1000	2	0	$13.5^{+4.9+1.9}_{-4.3-1.9}$	$13.4^{+2.4+2.6}_{-2.3-2.6}$	$94.0^{+6.2+7.9}_{-5.8-6.9}$	$1.30^{+0.06+0.68}_{-0.06-0.49}$	$122.1^{+9.5+8.6}_{-8.8-7.6}$	139
7	500–750	500–1000	2	0	303^{+17+29}_{-17-29}	247^{+10+48}_{-10-47}	$2328^{+30+170}_{-29-160}$	$4.5^{+0.1+2.4}_{-0.1-1.7}$	$2883^{+40+180}_{-40-170}$	3018
8	500–750	>1000	2	0	$5.8^{+2.7+1.5}_{-2.2-1.5}$	$5.3^{+1.4+1.3}_{-1.3-1.3}$	$66.2^{+5.4+5.3}_{-5.0-5.1}$	$0.03^{+0.02+0.02}_{-0.02-0.01}$	$77.3^{+6.8+5.7}_{-6.1-5.4}$	96
9	>750	750–1500	2	0	$17.3^{+4.5+3.0}_{-4.1-3.0}$	$17.4^{+2.5+4.5}_{-2.4-4.5}$	295^{+11+41}_{-11-38}	$0.35^{+0.06+0.18}_{-0.06-0.13}$	330^{+13+42}_{-12-38}	272
10	>750	>1500	2	0	$0.0^{+1.8+0.0}_{-0.0-0.0}$	$0.38^{+0.54+0.09}_{-0.29-0.09}$	$12.6^{+3.0+2.1}_{-2.4-1.9}$	$0.01^{+0.01+0.00}_{-0.01-0.00}$	$13.0^{+3.8+2.1}_{-2.5-1.9}$	12
11	300–350	300–500	2	1	370^{+21+31}_{-21-31}	288^{+11+63}_{-11-63}	1361^{+7+140}_{-7-140}	44^{+6+25}_{-6-17}	$2063^{+33+160}_{-33-160}$	1904
12	300–350	500–1000	2	1	51^{+10+7}_{-10-7}	$31.6^{+4.2+7.2}_{-4.2-7.2}$	97^{+2+10}_{-2-10}	$6.7^{+2.7+3.7}_{-2.7-2.5}$	186^{+15+15}_{-14-14}	186
13	300–350	>1000	2	1	$1.1^{+2.3+0.2}_{-1.1-0.0}$	$2.0^{+1.1+0.5}_{-1.0-0.5}$	$5.23^{+0.46+0.63}_{-0.42-0.59}$	$0.33^{+0.02+0.18}_{-0.02-0.13}$	$8.7^{+3.4+0.9}_{-2.1-0.8}$	13
14	350–500	350–500	2	1	215^{+16+19}_{-16-19}	179^{+9+39}_{-9-39}	962^{+6+99}_{-6-98}	20^{+2+11}_{-2-8}	$1376^{+26+110}_{-26-110}$	1212
15	350–500	500–1000	2	1	$69.8^{+9.9+7.5}_{-9.8-7.5}$	$43.3^{+4.4+9.7}_{-4.4-9.6}$	257^{+3+27}_{-3-26}	$8.5^{+3.0+4.8}_{-3.0-3.2}$	379^{+15+30}_{-15-29}	409
16	350–500	>1000	2	1	$3.7^{+2.5+0.7}_{-1.9-0.7}$	$3.1^{+1.1+0.9}_{-1.0-0.9}$	$9.7^{+0.6+1.2}_{-0.6-1.1}$	$0.13^{+0.04+0.07}_{-0.04-0.05}$	$16.6^{+3.7+1.6}_{-3.0-1.6}$	27
17	500–750	500–1000	2	1	$28.9^{+5.8+3.3}_{-5.6-3.3}$	$26.0^{+2.9+5.8}_{-2.9-5.8}$	240^{+3+27}_{-3-26}	$1.48^{+0.18+0.83}_{-0.18-0.56}$	296^{+9+28}_{-9-27}	321
18	500–750	>1000	2	1	$5.1^{+6.2+1.6}_{-4.1-1.6}$	$0.36^{+0.55+0.12}_{-0.30-0.12}$	$6.81^{+0.56+0.80}_{-0.52-0.78}$	$0.03^{+0.03+0.02}_{-0.03-0.00}$	$12.3^{+6.8+1.8}_{-4.5-1.7}$	14
19	>750	750–1500	2	1	$3.8^{+2.2+0.8}_{-1.7-0.8}$	$4.1^{+1.5+1.1}_{-1.4-1.1}$	$30.4^{+1.1+5.0}_{-1.1-4.7}$	$0.10^{+0.03+0.06}_{-0.03-0.04}$	$38.4^{+3.9+5.1}_{-3.3-4.8}$	31
20	>750	>1500	2	1	$0.0^{+1.4+0.0}_{-0.0-0.0}$	$0.34^{+0.51+0.13}_{-0.22-0.13}$	$1.29^{+0.31+0.24}_{-0.25-0.23}$	$0.00^{+0.01+0.00}_{-0.00-0.00}$	$1.6^{+2.0+0.3}_{-0.3-0.3}$	1
21	300–350	300–500	2	2	$14.1^{+4.5+2.6}_{-4.0-2.6}$	$12.9^{+2.3+2.8}_{-2.2-2.8}$	49^{+0+17}_{-0-17}	$3.0^{+0.8+3.6}_{-0.8-2.1}$	79^{+7+18}_{-6-18}	122
22	300–350	500–1000	2	2	$2.8^{+2.4+0.9}_{-1.7-0.9}$	$2.0^{+1.1+1.0}_{-0.9-1.0}$	$3.5^{+0.1+1.2}_{-0.1-1.2}$	$0.57^{+0.17+0.69}_{-0.17-0.40}$	$8.9^{+3.5+2.0}_{-2.6-1.9}$	11
23	300–350	>1000	2	2	$0.0^{+2.2+0.0}_{-0.0-0.0}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.19^{+0.02+0.07}_{-0.01-0.07}$	$0.03^{+0.01+0.04}_{-0.01-0.02}$	$0.2^{+2.6+0.1}_{-0.0-0.1}$	0
24	350–500	350–500	2	2	$11.4^{+4.5+2.5}_{-3.9-2.5}$	$6.3^{+1.7+2.1}_{-1.6-2.1}$	35^{+0+12}_{-0-12}	$1.0^{+0.5+1.2}_{-0.5-0.6}$	53^{+6+13}_{-6-13}	84
25	350–500	500–1000	2	2	$6.1^{+2.9+1.5}_{-2.4-1.5}$	$2.9^{+1.2+0.8}_{-1.1-0.8}$	$9.3^{+0.1+3.3}_{-0.1-3.3}$	$0.44^{+0.05+0.52}_{-0.05-0.39}$	$18.7^{+4.1+3.8}_{-3.5-3.7}$	23
26	350–500	>1000	2	2	$0.0^{+1.1+0.0}_{-0.0-0.0}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.35^{+0.02+0.13}_{-0.02-0.13}$	$0.06^{+0.04+0.08}_{-0.04-0.02}$	$0.4^{+1.5+0.1}_{-0.0-0.1}$	2
27	500–750	500–1000	2	2	$1.4^{+2.9+0.4}_{-1.4-0.0}$	$2.03^{+0.84+0.61}_{-0.70-0.61}$	$8.6^{+0.1+3.1}_{-0.1-3.1}$	$0.03^{+0.01+0.04}_{-0.01-0.03}$	$12.1^{+3.7+3.2}_{-2.1-3.2}$	16
28	500–750	>1000	2	2	$0.0^{+2.2+0.0}_{-0.0-0.0}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.24^{+0.02+0.09}_{-0.02-0.09}$	$0.00^{+0.01+0.00}_{-0.00-0.00}$	$0.2^{+2.7+0.1}_{-0.0-0.1}$	0
29	>750	750–1500	2	2	$0.0^{+1.6+0.0}_{-0.0-0.0}$	$0.07^{+0.46+0.07}_{-0.04-0.06}$	$1.09^{+0.04+0.41}_{-0.04-0.41}$	$0.01^{+0.01+0.01}_{-0.01-0.00}$	$1.2^{+2.1+0.4}_{-0.1-0.4}$	4
30	>750	>1500	2	2	$0.0^{+2.0+0.0}_{-0.0-0.0}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.05^{+0.01+0.02}_{-0.01-0.02}$	$0.00^{+0.01+0.00}_{-0.00-0.00}$	$0.0^{+2.5+0.0}_{-0.0-0.0}$	0

Table B.2: Observed numbers of events and prefit background predictions in the $3 \leq N_{jet} \leq 4$ search regions. The first uncertainty is statistical and second systematic.

Bin	H_T^{miss} [GeV]	H_T [GeV]	N_{jet}	$N_{b\text{-}jet}$	Lost-e/μ	$\tau \to$ had	$Z \to \nu\bar{\nu}$	QCD	Total pred.	Obs.
31	300–350	300–500	3–4	0	$2830^{+45+200}_{-45-200}$	$2152^{+29+160}_{-29-150}$	$8353^{+52+480}_{-52-470}$	$273^{+68+120}_{-68-100}$	$13608^{+110+560}_{-110-540}$	14520
32	300–350	500–1000	3–4	0	$1125^{+25+120}_{-25-120}$	$909^{+18+100}_{-18-100}$	$2487^{+29+140}_{-28-140}$	119^{+8+51}_{-8-45}	$4640^{+52+220}_{-52-210}$	4799
33	300–350	>1000	3–4	0	$72.7^{+7.1+6.1}_{-7.1-6.1}$	$65.3^{+5.2+6.4}_{-5.2-6.3}$	176^{+8+14}_{-8-12}	41^{+2+18}_{-2-16}	356^{+15+24}_{-15-22}	354
34	350–500	350–500	3–4	0	$1439^{+37+110}_{-37-110}$	$930^{+19+120}_{-19-110}$	$5014^{+41+280}_{-41-280}$	114^{+6+48}_{-6-43}	$7496^{+70+330}_{-69-320}$	7973
35	350–500	500–1000	3–4	0	$1402^{+27+140}_{-27-140}$	$1253^{+22+120}_{-22-120}$	$4811^{+40+270}_{-40-260}$	80^{+9+34}_{-9-31}	$7547^{+65+330}_{-64-320}$	7735
36	350–500	>1000	3–4	0	103^{+8+11}_{-8-11}	$77.0^{+5.9+7.6}_{-5.9-7.5}$	303^{+11+24}_{-10-21}	24^{+1+10}_{-1-9}	506^{+18+30}_{-17-26}	490
37	500–750	500–1000	3–4	0	339^{+15+33}_{-15-33}	297^{+10+26}_{-10-26}	$2143^{+28+150}_{-28-140}$	$5.5^{+0.2+2.3}_{-0.2-2.1}$	$2785^{+37+160}_{-37-150}$	2938
38	500–750	>1000	3–4	0	$33.8^{+4.4+3.6}_{-4.3-3.6}$	$30.5^{+3.4+2.9}_{-3.4-2.9}$	219^{+10+16}_{-9-15}	$1.29^{+0.53+0.55}_{-0.53-0.49}$	284^{+12+17}_{-12-16}	303
39	>750	750–1500	3–4	0	$28.2^{+4.4+3.7}_{-4.3-3.7}$	$26.0^{+2.9+3.4}_{-2.9-3.4}$	319^{+11+44}_{-11-40}	$0.32^{+0.03+0.14}_{-0.03-0.12}$	373^{+14+44}_{-13-41}	334
40	>750	>1500	3–4	0	$2.9^{+2.0+0.7}_{-1.5-0.7}$	$1.38^{+0.66+0.17}_{-0.48-0.17}$	$27.8^{+3.9+4.1}_{-3.5-3.8}$	$0.10^{+0.01+0.04}_{-0.01-0.04}$	$32.2^{+4.8+4.2}_{-4.0-3.9}$	46
41	300–350	300–500	3–4	1	746^{+25+55}_{-25-55}	627^{+15+48}_{-15-47}	1235^{+8+130}_{-8-120}	59^{+4+24}_{-4-22}	$2667^{+41+150}_{-41-150}$	2677
42	300–350	500–1000	3–4	1	296^{+15+25}_{-15-25}	262^{+9+27}_{-9-27}	385^{+4+39}_{-4-39}	38^{+4+15}_{-4-14}	981^{+24+56}_{-24-56}	1048
43	300–350	>1000	3–4	1	$20.8^{+4.1+2.1}_{-4.0-2.1}$	$19.0^{+2.6+1.8}_{-2.5-1.8}$	$27.6^{+1.3+3.2}_{-1.2-3.0}$	$11.4^{+0.8+4.7}_{-0.8-4.4}$	$78.8^{+6.9+6.3}_{-6.6-6.0}$	92
44	350–500	350–500	3–4	1	321^{+17+25}_{-17-25}	263^{+10+22}_{-10-21}	738^{+6+74}_{-6-74}	$22.3^{+1.4+9.1}_{-1.4-8.5}$	1343^{+28+82}_{-28-81}	1332
45	350–500	500–1000	3–4	1	329^{+14+26}_{-14-26}	324^{+11+26}_{-11-26}	737^{+6+74}_{-6-74}	$17.6^{+3.4+7.2}_{-3.4-6.7}$	1407^{+26+83}_{-26-83}	1515
46	350–500	>1000	3–4	1	$20.4^{+4.0+2.0}_{-3.8-2.0}$	$19.9^{+2.9+1.8}_{-2.9-1.7}$	$47.5^{+1.7+5.5}_{-1.6-5.1}$	$5.7^{+0.5+2.3}_{-0.5-2.2}$	$93.4^{+7.1+6.5}_{-6.9-6.2}$	113
47	500–750	500–1000	3–4	1	$69.7^{+7.4+6.6}_{-7.3-6.6}$	$56.0^{+4.1+5.0}_{-4.1-4.9}$	322^{+4+35}_{-4-35}	$1.34^{+0.10+0.55}_{-0.10-0.51}$	449^{+12+36}_{-12-36}	472
48	500–750	>1000	3–4	1	$15.3^{+3.4+1.9}_{-3.3-1.9}$	$7.0^{+1.4+0.7}_{-1.4-0.7}$	$34.4^{+1.5+3.8}_{-1.4-3.8}$	$0.38^{+0.14+0.16}_{-0.14-0.15}$	$57.0^{+5.1+4.4}_{-4.9-4.3}$	57
49	>750	750–1500	3–4	1	$3.3^{+1.5+0.5}_{-1.3-0.5}$	$4.8^{+1.3+0.8}_{-1.2-0.8}$	$48.5^{+1.7+7.9}_{-1.7-7.3}$	$0.13^{+0.01+0.05}_{-0.01-0.05}$	$56.8^{+3.3+7.9}_{-3.0-7.4}$	61
50	>750	>1500	3–4	1	$1.0^{+1.2+0.3}_{-0.7-0.3}$	$0.77^{+0.75+0.16}_{-0.59-0.16}$	$4.40^{+0.62+0.75}_{-0.55-0.71}$	$0.03^{+0.01+0.01}_{-0.01-0.01}$	$6.2^{+2.0+0.8}_{-1.4-0.8}$	8
51	300–350	300–500	3–4	2	137^{+11+11}_{-11-11}	133^{+7+11}_{-7-11}	145^{+1+26}_{-1-26}	$9.0^{+1.1+3.9}_{-1.1-3.4}$	424^{+18+31}_{-17-31}	464
52	300–350	500–1000	3–4	2	$92.3^{+9.1+9.5}_{-9.0-9.5}$	$85.6^{+5.7+7.5}_{-5.7-7.4}$	$53.0^{+0.6+9.6}_{-0.6-9.6}$	$3.8^{+1.2+1.6}_{-1.2-1.4}$	235^{+15+16}_{-15-15}	227
53	300–350	>1000	3–4	2	$3.4^{+2.2+0.8}_{-1.7-0.8}$	$2.41^{+0.91+0.50}_{-0.78-0.50}$	$3.95^{+0.18+0.75}_{-0.17-0.73}$	$2.23^{+0.18+0.96}_{-0.18-0.86}$	$12.0^{+3.1+1.6}_{-2.5-1.5}$	17
54	350–500	350–500	3–4	2	$39.6^{+6.1+3.8}_{-5.9-3.8}$	$39.8^{+3.9+3.8}_{-3.8-3.8}$	84^{+1+15}_{-1-15}	$2.7^{+0.6+1.1}_{-0.6-1.0}$	166^{+10+16}_{-10-16}	208
55	350–500	500–1000	3–4	2	$83.9^{+8.2+7.8}_{-8.1-7.8}$	$69.4^{+4.9+5.9}_{-4.9-5.8}$	97^{+1+18}_{-1-17}	$3.1^{+0.2+1.3}_{-0.2-1.2}$	254^{+13+20}_{-13-20}	286
56	350–500	>1000	3–4	2	$6.2^{+4.0+1.0}_{-3.6-1.0}$	$3.8^{+1.1+0.6}_{-1.0-0.6}$	$6.8^{+0.2+1.3}_{-0.2-1.3}$	$0.95^{+0.16+0.41}_{-0.16-0.36}$	$17.7^{+5.2+1.8}_{-4.6-1.8}$	25
57	500–750	500–1000	3–4	2	$11.8^{+3.3+2.0}_{-3.1-2.0}$	$10.5^{+1.8+1.6}_{-1.7-1.6}$	$39.7^{+0.5+7.4}_{-0.5-7.3}$	$0.22^{+0.04+0.09}_{-0.04-0.08}$	$62.1^{+5.1+7.8}_{-4.8-7.7}$	64
58	500–750	>1000	3–4	2	$2.6^{+2.3+0.6}_{-1.6-0.6}$	$2.9^{+1.5+0.6}_{-1.5-0.6}$	$4.90^{+0.21+0.92}_{-0.21-0.91}$	$0.10^{+0.03+0.04}_{-0.03-0.04}$	$10.5^{+3.8+1.2}_{-3.1-1.2}$	13
59	>750	750–1500	3–4	2	$0.0^{+1.1+0.0}_{-0.0-0.0}$	$0.32^{+0.48+0.09}_{-0.13-0.09}$	$6.3^{+0.2+1.4}_{-0.2-1.3}$	$0.03^{+0.02+0.01}_{-0.02-0.01}$	$6.6^{+1.6+1.4}_{-0.3-1.3}$	4
60	>750	>1500	3–4	2	$0.0^{+1.1+0.0}_{-0.0-0.0}$	$0.03^{+0.46+0.01}_{-0.02-0.01}$	$0.65^{+0.09+0.15}_{-0.08-0.14}$	$0.01^{+0.01+0.01}_{-0.01-0.00}$	$0.7^{+1.6+0.1}_{-0.1-0.1}$	1
61	300–350	300–500	3–4	≥3	$6.4^{+2.8+0.7}_{-2.3-0.7}$	$10.3^{+1.9+2.7}_{-1.9-2.7}$	$5.0^{+0.0+2.8}_{-0.0-2.8}$	$0.35^{+0.18+0.42}_{-0.18-0.16}$	$22.0^{+4.7+3.9}_{-4.2-3.9}$	27
62	300–350	500–1000	3–4	≥3	$4.9^{+2.7+0.6}_{-2.2-0.6}$	$6.2^{+1.4+1.7}_{-1.3-1.7}$	$2.5^{+0.0+1.4}_{-0.0-1.4}$	$0.75^{+0.52+0.90}_{-0.52-0.24}$	$14.4^{+4.2+2.4}_{-3.6-2.2}$	20
63	300–350	>1000	3–4	≥3	$0.0^{+1.1+0.0}_{-0.0-0.0}$	$0.94^{+0.87+0.44}_{-0.74-0.44}$	$0.21^{+0.01+0.12}_{-0.01-0.12}$	$1.6^{+0.2+1.9}_{-0.2-1.4}$	$2.7^{+2.0+2.0}_{-0.8-1.5}$	4
64	350–500	350–500	3–4	≥3	$0.6^{+1.2+0.1}_{-0.6-0.0}$	$4.2^{+1.5+1.3}_{-1.4-1.3}$	$2.5^{+0.0+1.4}_{-0.0-1.4}$	$0.09^{+0.04+0.11}_{-0.04-0.05}$	$7.4^{+2.6+1.9}_{-1.9-1.9}$	8
65	350–500	500–1000	3–4	≥3	$10.2^{+6.3+2.1}_{-5.7-2.1}$	$7.0^{+1.5+1.9}_{-1.5-1.9}$	$4.3^{+0.0+2.4}_{-0.0-2.4}$	$0.78^{+0.18+0.94}_{-0.18-0.60}$	$22.3^{+7.9+3.8}_{-7.2-3.7}$	26
66	350–500	>1000	3–4	≥3	$0.0^{+1.1+0.0}_{-0.0-0.0}$	$0.21^{+0.49+0.13}_{-0.16-0.13}$	$0.36^{+0.01+0.20}_{-0.01-0.20}$	$0.54^{+0.15+0.65}_{-0.15-0.39}$	$1.1^{+1.6+0.7}_{-0.2-0.5}$	5
67	500–750	500–1000	3–4	≥3	$1.4^{+2.9+0.4}_{-1.4-0.0}$	$1.13^{+0.74+0.45}_{-0.58-0.45}$	$1.50^{+0.02+0.83}_{-0.02-0.83}$	$0.10^{+0.10+0.13}_{-0.10-0.00}$	$4.1^{+3.6+1.0}_{-2.0-0.9}$	0
68	500–750	>1000	3–4	≥3	$0.00^{+0.95+0.00}_{-0.00-0.00}$	$0.12^{+0.46+0.09}_{-0.06-0.09}$	$0.26^{+0.01+0.15}_{-0.01-0.15}$	$0.02^{+0.03+0.02}_{-0.02-0.00}$	$0.4^{+1.4+0.2}_{-0.1-0.2}$	2
69	>750	750–1500	3–4	≥3	$0.00^{+0.97+0.00}_{-0.00-0.00}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.29^{+0.01+0.16}_{-0.01-0.16}$	$0.01^{+0.02+0.01}_{-0.01-0.00}$	$0.3^{+1.4+0.2}_{-0.0-0.2}$	1
70	>750	>1500	3–4	≥3	$0.0^{+1.4+0.0}_{-0.0-0.0}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.04^{+0.01+0.02}_{-0.00-0.02}$	$0.01^{+0.03+0.02}_{-0.01-0.00}$	$0.0^{+1.8+0.0}_{-0.0-0.0}$	0

Table B.3: Observed numbers of events and prefit background predictions in the $5 \leq N_{jet} \leq 6$ search regions. The first uncertainty is statistical and second systematic.

Bin	H_T^{miss} [GeV]	H_T [GeV]	N_{jet}	$N_{b\text{-}jet}$	Lost-e/μ	$\tau \to$ had	$Z \to \nu\bar{\nu}$	QCD	Total pred.	Obs.
71	300–350	300–500	5–6	0	217^{+11+22}_{-11-22}	166^{+6+27}_{-6-27}	489^{+12+42}_{-12-39}	49^{+5+21}_{-5-19}	922^{+21+58}_{-21-56}	1015
72	300–350	500–1000	5–6	0	397^{+13+37}_{-13-37}	403^{+9+36}_{-9-36}	772^{+16+61}_{-15-57}	113^{+4+47}_{-4-43}	1686^{+27+93}_{-27-88}	1673
73	300–350	>1000	5–6	0	$49.6^{+4.5+5.4}_{-4.5-5.4}$	$55.1^{+3.8+8.3}_{-3.8-8.3}$	$100.0^{+6.4+8.2}_{-6.0-7.1}$	49^{+1+21}_{-1-19}	254^{+11+24}_{-10-22}	226
74	350–500	350–500	5–6	0	71^{+7+11}_{-6-11}	47^{+3+16}_{-3-16}	242^{+9+20}_{-9-19}	$12.7^{+2.3+5.3}_{-2.3-4.8}$	372^{+13+29}_{-13-28}	464
75	350–500	500–1000	5–6	0	384^{+12+33}_{-12-33}	412^{+11+32}_{-11-32}	1110^{+19+84}_{-19-78}	65^{+2+27}_{-2-25}	1971^{+30+99}_{-29-93}	2018
76	350–500	>1000	5–6	0	$76.9^{+6.4+8.9}_{-6.4-8.9}$	$72.4^{+4.8+9.3}_{-4.8-9.3}$	170^{+8+14}_{-8-12}	28^{+1+12}_{-1-11}	347^{+14+22}_{-14-21}	320
77	500–750	500–1000	5–6	0	$66.7^{+5.1+7.3}_{-5.0-7.3}$	$70.1^{+4.3+6.1}_{-4.2-6.0}$	302^{+10+23}_{-10-22}	$3.2^{+0.1+1.3}_{-0.1-1.2}$	442^{+14+25}_{-14-24}	460
78	500–750	>1000	5–6	0	$23.9^{+2.9+4.5}_{-2.9-4.5}$	$31.2^{+3.1+4.0}_{-3.1-4.0}$	$123.5^{+7.3+9.4}_{-6.9-8.9}$	$2.5^{+0.1+1.1}_{-0.1-1.0}$	181^{+10+11}_{-9-11}	170
79	>750	750–1500	5–6	0	$4.0^{+1.2+0.7}_{-1.1-0.7}$	$4.90^{+0.89+0.52}_{-0.76-0.52}$	$52.2^{+4.6+7.5}_{-4.2-6.8}$	$0.23^{+0.04+0.10}_{-0.04-0.09}$	$61.3^{+5.0+7.5}_{-4.6-6.9}$	74
80	>750	>1500	5–6	0	$0.90^{+0.61+0.19}_{-0.45-0.19}$	$1.46^{+0.67+0.16}_{-0.49-0.16}$	$16.5^{+2.9+2.7}_{-2.5-2.5}$	$0.25^{+0.06+0.11}_{-0.06-0.10}$	$19.1^{+3.2+2.7}_{-2.7-2.5}$	19
81	300–350	300–500	5–6	1	130^{+8+11}_{-8-11}	131^{+6+17}_{-6-17}	133^{+3+19}_{-3-19}	$12.8^{+2.8+5.2}_{-2.8-4.9}$	407^{+15+29}_{-15-28}	450
82	300–350	500–1000	5–6	1	290^{+11+25}_{-11-25}	302^{+8+25}_{-8-25}	218^{+4+31}_{-4-30}	41^{+4+17}_{-4-16}	851^{+20+50}_{-20-49}	781
83	300–350	>1000	5–6	1	$25.8^{+3.4+2.5}_{-3.4-2.5}$	$31.6^{+2.9+5.9}_{-2.9-5.9}$	$29.0^{+1.8+4.1}_{-1.7-4.0}$	$18.4^{+0.8+7.5}_{-0.8-7.1}$	105^{+7+11}_{-6-10}	100
84	350–500	350–500	5–6	1	$45.4^{+5.5+5.4}_{-5.4-5.4}$	32^{+3+11}_{-3-11}	$65.1^{+2.4+9.3}_{-2.3-9.1}$	$3.7^{+0.5+1.5}_{-0.5-1.4}$	146^{+9+16}_{-8-16}	160
85	350–500	500–1000	5–6	1	228^{+10+20}_{-10-20}	269^{+8+21}_{-8-21}	310^{+5+43}_{-5-42}	28^{+3+11}_{-3-11}	834^{+19+53}_{-19-52}	801
86	350–500	>1000	5–6	1	$40.5^{+5.5+4.2}_{-5.4-4.2}$	$36.0^{+3.3+4.3}_{-3.3-4.2}$	$49.4^{+2.3+7.0}_{-2.2-6.7}$	$11.9^{+0.7+4.8}_{-0.7-4.5}$	138^{+9+10}_{-9-10}	138
87	500–750	500–1000	5–6	1	$23.4^{+3.5+2.6}_{-3.4-2.6}$	$32.1^{+2.8+3.3}_{-2.8-3.3}$	84^{+3+12}_{-3-12}	$1.45^{+0.11+0.59}_{-0.11-0.55}$	141^{+7+13}_{-7-12}	135
88	500–750	>1000	5–6	1	$8.5^{+1.8+1.1}_{-1.7-1.1}$	$13.0^{+1.8+1.5}_{-1.7-1.5}$	$35.3^{+2.1+4.9}_{-2.0-4.8}$	$1.33^{+0.17+0.54}_{-0.17-0.51}$	$58.0^{+4.1+5.3}_{-3.9-5.2}$	49
89	>750	750–1500	5–6	1	$3.7^{+1.4+0.7}_{-1.2-0.7}$	$2.9^{+1.0+0.4}_{-0.9-0.4}$	$14.9^{+1.3+2.8}_{-1.2-2.6}$	$0.07^{+0.01+0.03}_{-0.01-0.03}$	$21.6^{+2.8+2.9}_{-2.5-2.7}$	16
90	>750	>1500	5–6	1	$1.06^{+0.74+0.26}_{-0.56-0.26}$	$1.16^{+0.73+0.18}_{-0.57-0.18}$	$4.79^{+0.85+0.96}_{-0.73-0.92}$	$0.16^{+0.07+0.07}_{-0.07-0.06}$	$7.2^{+1.7+1.0}_{-1.3-1.0}$	6
91	300–350	300–500	5–6	2	$60.1^{+7.1+6.0}_{-7.0-6.0}$	$50.2^{+3.3+4.9}_{-3.3-4.9}$	$23.8^{+0.6+7.1}_{-0.6-7.1}$	$2.9^{+0.9+1.1}_{-0.9-1.1}$	137^{+10+11}_{-10-11}	143
92	300–350	500–1000	5–6	2	137^{+9+13}_{-9-13}	160^{+6+14}_{-6-14}	39^{+1+12}_{-1-11}	$11.8^{+1.8+4.6}_{-1.8-4.5}$	347^{+15+22}_{-15-22}	332
93	300–350	>1000	5–6	2	$16.9^{+3.8+2.0}_{-3.7-2.0}$	$15.9^{+2.1+2.1}_{-2.1-2.1}$	$5.1^{+0.3+1.5}_{-0.3-1.5}$	$5.6^{+0.4+2.2}_{-0.4-2.2}$	$43.5^{+5.9+3.9}_{-5.8-3.9}$	36
94	350–500	350–500	5–6	2	$13.3^{+3.1+1.9}_{-2.9-1.9}$	$7.0^{+1.1+2.3}_{-1.0-2.3}$	$11.7^{+0.4+3.5}_{-0.4-3.5}$	$1.02^{+0.54+0.40}_{-0.54-0.39}$	$32.9^{+4.3+4.6}_{-4.0-4.6}$	28
95	350–500	500–1000	5–6	2	$107.5^{+7.6+9.6}_{-7.6-9.6}$	$121.2^{+5.8+9.9}_{-5.8-9.8}$	55^{+1+16}_{-1-16}	$5.9^{+1.0+2.3}_{-1.0-2.2}$	290^{+14+22}_{-13-21}	288
96	350–500	>1000	5–6	2	$14.2^{+2.8+1.8}_{-2.7-1.8}$	$15.7^{+2.2+2.0}_{-2.1-2.0}$	$8.7^{+0.4+2.6}_{-0.4-2.6}$	$3.2^{+0.1+1.2}_{-0.1-1.2}$	$41.8^{+5.0+4.0}_{-4.8-3.9}$	44
97	500–750	500–1000	5–6	2	$8.4^{+2.3+1.1}_{-2.2-1.1}$	$8.3^{+1.3+1.0}_{-1.2-1.0}$	$15.0^{+0.5+4.4}_{-0.5-4.4}$	$0.34^{+0.05+0.13}_{-0.05-0.13}$	$32.1^{+3.7+4.7}_{-3.4-4.7}$	35
98	500–750	>1000	5–6	2	$2.1^{+1.3+0.3}_{-1.0-0.3}$	$4.0^{+1.1+0.6}_{-1.0-0.6}$	$6.2^{+0.4+1.9}_{-0.3-1.8}$	$0.16^{+0.05+0.06}_{-0.05-0.06}$	$12.5^{+2.4+2.0}_{-2.0-2.0}$	18
99	>750	750–1500	5–6	2	$0.74^{+0.87+0.22}_{-0.53-0.22}$	$0.68^{+0.64+0.16}_{-0.45-0.16}$	$2.64^{+0.23+0.85}_{-0.21-0.83}$	$0.05^{+0.05+0.02}_{-0.05-0.00}$	$4.1^{+1.5+0.9}_{-1.0-0.9}$	8
100	>750	>1500	5–6	2	$0.77^{+0.65+0.24}_{-0.45-0.24}$	$1.07^{+0.72+0.33}_{-0.56-0.33}$	$0.84^{+0.15+0.28}_{-0.13-0.27}$	$0.03^{+0.03+0.01}_{-0.03-0.00}$	$2.7^{+1.4+0.5}_{-1.0-0.5}$	3
101	300–350	300–500	5–6	≥3	$2.8^{+1.5+0.3}_{-1.2-0.3}$	$5.1^{+1.0+0.8}_{-0.9-0.8}$	$2.0^{+0.0+1.1}_{-0.0-1.1}$	$0.50^{+0.37+0.57}_{-0.37-0.13}$	$10.4^{+2.5+1.5}_{-2.1-1.4}$	18
102	300–350	500–1000	5–6	≥3	$17.0^{+3.2+1.6}_{-3.1-1.6}$	$23.5^{+2.4+3.2}_{-2.3-3.2}$	$4.2^{+0.1+2.3}_{-0.1-2.3}$	$3.9^{+2.3+4.5}_{-2.3-1.6}$	$48.7^{+6.0+6.2}_{-5.9-4.5}$	44
103	300–350	>1000	5–6	≥3	$4.4^{+2.1+0.6}_{-1.8-0.6}$	$2.50^{+0.86+0.47}_{-0.73-0.47}$	$0.65^{+0.04+0.35}_{-0.04-0.35}$	$3.3^{+0.4+3.7}_{-0.4-2.8}$	$10.8^{+3.0+3.8}_{-2.6-3.0}$	6
104	350–500	350–500	5–6	≥3	$0.8^{+1.7+0.2}_{-0.8-0.0}$	$1.14^{+0.75+0.33}_{-0.59-0.33}$	$0.87^{+0.03+0.47}_{-0.03-0.47}$	$0.18^{+0.08+0.21}_{-0.08-0.10}$	$3.0^{+2.4+0.6}_{-1.4-0.6}$	4
105	350–500	500–1000	5–6	≥3	$15.2^{+2.6+1.5}_{-2.6-1.5}$	$17.6^{+2.2+2.7}_{-2.1-2.7}$	$5.7^{+0.1+3.1}_{-0.1-3.1}$	$1.7^{+0.1+1.9}_{-0.1-1.6}$	$40.2^{+4.8+4.8}_{-4.7-4.6}$	34
106	350–500	>1000	5–6	≥3	$1.9^{+1.1+0.3}_{-0.8-0.3}$	$3.8^{+1.1+0.7}_{-1.0-0.7}$	$1.14^{+0.05+0.62}_{-0.05-0.62}$	$2.4^{+0.3+2.7}_{-0.3-2.1}$	$9.2^{+2.2+2.8}_{-1.9-2.3}$	8
107	500–750	500–1000	5–6	≥3	$1.8^{+1.1+0.3}_{-0.8-0.3}$	$1.71^{+0.77+0.67}_{-0.61-0.67}$	$1.48^{+0.05+0.81}_{-0.05-0.80}$	$0.20^{+0.04+0.23}_{-0.04-0.17}$	$5.2^{+1.8+1.1}_{-1.5-1.1}$	4
108	500–750	>1000	5–6	≥3	$1.13^{+0.96+0.25}_{-0.66-0.25}$	$0.94^{+0.67+0.27}_{-0.49-0.27}$	$0.73^{+0.04+0.40}_{-0.04-0.40}$	$0.11^{+0.03+0.12}_{-0.03-0.08}$	$2.9^{+1.6+0.6}_{-1.1-0.6}$	2
109	>750	750–1500	5–6	≥3	$0.00^{+0.72+0.00}_{-0.00-0.00}$	$0.07^{+0.46+0.04}_{-0.06-0.04}$	$0.31^{+0.03+0.17}_{-0.03-0.17}$	$0.02^{+0.04+0.03}_{-0.02-0.00}$	$0.4^{+1.2+0.2}_{-0.1-0.2}$	0
110	>750	>1500	5–6	≥3	$0.00^{+0.63+0.00}_{-0.00-0.00}$	$0.03^{+0.46+0.01}_{-0.02-0.01}$	$0.11^{+0.02+0.06}_{-0.02-0.06}$	$0.00^{+0.02+0.01}_{-0.00-0.00}$	$0.1^{+1.1+0.1}_{-0.0-0.1}$	1

Table B.4: Observed numbers of events and prefit background predictions in the $7 \leq N_{jet} \leq 8$ search regions. The first uncertainty is statistical and second systematic.

Bin	H_T^{miss} [GeV]	H_T [GeV]	N_{jet}	$N_{b\text{-}jet}$	Lost-e/μ	$\tau \to$ had	$Z \to \nu\bar{\nu}$	QCD	Total pred.	Obs.
111	300–350	500–1000	7–8	0	$48.0^{+3.9+5.4}_{-3.8-5.4}$	$60.8^{+3.4+6.0}_{-3.4-6.0}$	76^{+5+11}_{-5-10}	30^{+2+12}_{-2-11}	215^{+9+18}_{-9-17}	218
112	300–350	>1000	7–8	0	$21.2^{+2.9+2.3}_{-2.9-2.3}$	$20.3^{+2.2+2.8}_{-2.1-2.8}$	$23.9^{+3.3+2.8}_{-2.9-2.5}$	$20.5^{+0.5+8.5}_{-0.5-7.8}$	$85.9^{+6.1+9.6}_{-5.8-9.0}$	85
113	350–500	500–1000	7–8	0	$43.2^{+3.9+4.9}_{-3.9-4.9}$	$54.2^{+3.6+5.7}_{-3.5-5.7}$	89^{+6+11}_{-5-10}	$14.3^{+1.9+5.9}_{-1.9-5.4}$	201^{+10+14}_{-9-14}	215
114	350–500	>1000	7–8	0	$22.5^{+2.8+2.7}_{-2.7-2.7}$	$23.3^{+2.5+2.3}_{-2.4-2.3}$	$48.3^{+4.7+5.4}_{-4.3-4.8}$	$12.6^{+0.7+5.2}_{-0.7-4.8}$	$106.7^{+7.1+8.3}_{-6.7-7.7}$	75
115	500–750	500–1000	7–8	0	$6.9^{+1.8+1.4}_{-1.7-1.4}$	$4.96^{+0.95+0.77}_{-0.84-0.77}$	$26.5^{+3.6+3.3}_{-3.2-3.0}$	$0.88^{+0.10+0.36}_{-0.10-0.34}$	$39.2^{+4.5+3.7}_{-4.1-3.5}$	34
116	500–750	>1000	7–8	0	$5.4^{+1.1+0.9}_{-1.0-0.9}$	$9.9^{+1.6+1.7}_{-1.5-1.7}$	$27.2^{+3.7+3.1}_{-3.2-2.8}$	$1.56^{+0.12+0.64}_{-0.12-0.59}$	$44.1^{+4.5+3.7}_{-4.1-3.5}$	38
117	>750	750–1500	7–8	0	$1.26^{+0.70+0.50}_{-0.58-0.50}$	$1.44^{+0.74+0.24}_{-0.57-0.24}$	$3.6^{+1.4+0.7}_{-1.0-0.6}$	$0.07^{+0.02+0.03}_{-0.02-0.03}$	$6.4^{+2.0+0.9}_{-1.5-0.8}$	5
118	>750	>1500	7–8	0	$0.69^{+0.47+0.16}_{-0.35-0.16}$	$1.03^{+0.69+0.15}_{-0.51-0.15}$	$1.5^{+1.2+0.3}_{-0.7-0.3}$	$0.07^{+0.01+0.03}_{-0.01-0.03}$	$3.3^{+1.7+0.4}_{-1.1-0.4}$	5
119	300–350	500–1000	7–8	1	$64.7^{+5.1+6.4}_{-5.1-6.4}$	$77.0^{+3.9+7.5}_{-3.8-7.4}$	$31.7^{+2.1+8.6}_{-1.9-8.4}$	$11.2^{+0.5+4.7}_{-0.5-4.3}$	184^{+9+14}_{-9-14}	146
120	300–350	>1000	7–8	1	$16.3^{+2.4+1.7}_{-2.4-1.7}$	$19.9^{+2.2+2.1}_{-2.1-2.1}$	$10.3^{+1.4+2.7}_{-1.2-2.6}$	$8.3^{+0.2+3.5}_{-0.2-3.2}$	$54.8^{+4.8+5.2}_{-4.7-5.0}$	68
121	350–500	500–1000	7–8	1	$46.9^{+4.4+5.0}_{-4.4-5.0}$	$58.6^{+3.7+5.7}_{-3.7-5.7}$	$37.0^{+2.4+9.7}_{-2.2-9.5}$	$7.5^{+0.4+3.2}_{-0.4-2.9}$	150^{+8+13}_{-8-12}	113
122	350–500	>1000	7–8	1	$19.5^{+2.5+2.1}_{-2.4-2.1}$	$19.5^{+2.3+2.0}_{-2.3-2.0}$	$21.0^{+2.0+5.4}_{-1.9-5.3}$	$5.3^{+0.5+2.2}_{-0.5-2.0}$	$65.3^{+5.2+6.5}_{-5.1-6.4}$	67
123	500–750	500–1000	7–8	1	$7.6^{+2.0+1.4}_{-1.9-1.4}$	$5.5^{+1.1+0.8}_{-1.1-0.8}$	$11.5^{+1.6+3.0}_{-1.4-3.0}$	$0.36^{+0.04+0.15}_{-0.04-0.14}$	$24.9^{+3.5+3.4}_{-3.3-3.4}$	19
124	500–750	>1000	7–8	1	$9.3^{+2.1+1.3}_{-2.0-1.3}$	$7.5^{+1.5+0.8}_{-1.4-0.8}$	$11.4^{+1.5+3.0}_{-1.4-2.9}$	$0.98^{+0.12+0.41}_{-0.12-0.37}$	$29.2^{+3.9+3.3}_{-3.7-3.3}$	22
125	>750	750–1500	7–8	1	$0.14^{+0.30+0.05}_{-0.14-0.00}$	$0.44^{+0.51+0.10}_{-0.22-0.10}$	$1.48^{+0.56+0.44}_{-0.42-0.43}$	$0.07^{+0.03+0.03}_{-0.03-0.03}$	$2.14^{+0.99+0.46}_{-0.56-0.45}$	4
126	>750	>1500	7–8	1	$0.00^{+0.47+0.00}_{-0.00-0.00}$	$0.14^{+0.47+0.02}_{-0.08-0.02}$	$0.70^{+0.55+0.22}_{-0.34-0.21}$	$0.03^{+0.01+0.01}_{-0.01-0.01}$	$0.9^{+1.1+0.2}_{-0.3-0.2}$	6
127	300–350	500–1000	7–8	2	$34.7^{+3.5+3.6}_{-3.5-3.6}$	$47.7^{+3.0+4.4}_{-3.0-4.4}$	$8.1^{+0.5+3.6}_{-0.5-3.5}$	$5.3^{+0.5+2.1}_{-0.5-2.1}$	$95.8^{+6.6+7.1}_{-6.5-7.0}$	95
128	300–350	>1000	7–8	2	$9.0^{+2.1+1.2}_{-2.1-1.2}$	$10.8^{+1.4+1.3}_{-1.4-1.3}$	$2.4^{+0.3+1.0}_{-0.3-1.0}$	$3.2^{+0.1+1.3}_{-0.1-1.3}$	$25.4^{+3.6+2.4}_{-3.4-2.4}$	26
129	350–500	500–1000	7–8	2	$26.2^{+3.0+2.9}_{-3.0-2.9}$	$31.0^{+2.5+3.3}_{-2.5-3.2}$	$9.6^{+0.6+4.1}_{-0.6-4.1}$	$2.5^{+0.2+1.0}_{-0.2-1.0}$	$69.3^{+5.6+6.1}_{-5.5-6.1}$	84
130	350–500	>1000	7–8	2	$13.3^{+2.5+1.5}_{-2.4-1.5}$	$13.3^{+1.8+1.3}_{-1.7-1.3}$	$4.7^{+0.5+2.0}_{-0.4-2.0}$	$1.95^{+0.13+0.78}_{-0.13-0.75}$	$33.3^{+4.3+3.0}_{-4.2-2.9}$	35
131	500–750	500–1000	7–8	2	$2.5^{+1.4+0.5}_{-1.2-0.5}$	$0.86^{+0.50+0.21}_{-0.18-0.21}$	$2.6^{+0.3+1.1}_{-0.3-1.1}$	$0.10^{+0.01+0.04}_{-0.01-0.04}$	$6.0^{+1.9+1.3}_{-1.4-1.3}$	7
132	500–750	>1000	7–8	2	$6.0^{+2.3+1.0}_{-2.2-1.0}$	$3.3^{+1.0+0.6}_{-0.9-0.6}$	$2.9^{+0.4+1.2}_{-0.3-1.2}$	$0.22^{+0.06+0.09}_{-0.06-0.08}$	$12.4^{+3.4+1.7}_{-3.1-1.7}$	12
133	>750	750–1500	7–8	2	$0.16^{+0.34+0.08}_{-0.16-0.00}$	$0.44^{+0.56+0.15}_{-0.32-0.15}$	$0.39^{+0.15+0.18}_{-0.11-0.18}$	$0.03^{+0.01+0.01}_{-0.01-0.01}$	$1.03^{+0.91+0.25}_{-0.49-0.23}$	2
134	>750	>1500	7–8	2	$0.53^{+0.62+0.20}_{-0.38-0.20}$	$0.61^{+0.57+0.22}_{-0.33-0.22}$	$0.13^{+0.10+0.06}_{-0.06-0.06}$	$0.06^{+0.02+0.02}_{-0.02-0.02}$	$1.3^{+1.2+0.3}_{-0.7-0.3}$	2
135	300–350	500–1000	7–8	≥3	$8.1^{+1.8+1.0}_{-1.7-1.0}$	$9.4^{+1.4+1.3}_{-1.3-1.3}$	$4.1^{+0.3+2.3}_{-0.2-2.3}$	$2.9^{+0.6+3.3}_{-0.6-2.3}$	$24.6^{+3.2+4.3}_{-3.1-3.7}$	12
136	300–350	>1000	7–8	≥3	$4.7^{+2.0+0.7}_{-1.8-0.7}$	$5.4^{+1.2+0.8}_{-1.1-0.8}$	$1.51^{+0.21+0.85}_{-0.18-0.84}$	$2.4^{+0.3+2.7}_{-0.3-2.1}$	$13.9^{+3.2+3.0}_{-2.9-2.5}$	8
137	350–500	500–1000	7–8	≥3	$5.9^{+1.9+0.8}_{-1.7-0.8}$	$7.4^{+1.4+1.2}_{-1.3-1.2}$	$4.7^{+0.3+2.7}_{-0.3-2.7}$	$1.2^{+0.1+1.3}_{-0.1-1.1}$	$19.2^{+3.2+3.3}_{-3.1-3.2}$	16
138	350–500	>1000	7–8	≥3	$2.6^{+1.1+0.3}_{-1.0-0.3}$	$4.8^{+1.3+0.7}_{-1.2-0.7}$	$3.1^{+0.3+1.8}_{-0.3-1.8}$	$2.1^{+0.3+2.3}_{-0.3-1.8}$	$12.6^{+2.5+3.0}_{-2.2-2.6}$	8
139	500–750	500–1000	7–8	≥3	$0.23^{+0.48+0.08}_{-0.23-0.00}$	$0.30^{+0.48+0.10}_{-0.13-0.10}$	$1.70^{+0.23+0.96}_{-0.20-0.96}$	$0.11^{+0.04+0.12}_{-0.04-0.08}$	$2.34^{+0.99+0.98}_{-0.41-0.96}$	3
140	500–750	>1000	7–8	≥3	$3.4^{+2.4+0.7}_{-2.1-0.7}$	$1.59^{+0.83+0.49}_{-0.69-0.49}$	$1.51^{+0.20+0.85}_{-0.18-0.85}$	$0.22^{+0.08+0.24}_{-0.08-0.14}$	$6.7^{+3.2+1.2}_{-2.7-1.2}$	4
141	>750	750–1500	7–8	≥3	$0.00^{+0.56+0.00}_{-0.00-0.00}$	$0.05^{+0.46+0.02}_{-0.03-0.02}$	$0.19^{+0.07+0.11}_{-0.05-0.11}$	$0.03^{+0.04+0.03}_{-0.03-0.00}$	$0.3^{+1.0+0.1}_{-0.1-0.1}$	0
142	>750	>1500	7–8	≥3	$0.00^{+0.72+0.00}_{-0.00-0.00}$	$0.04^{+0.46+0.02}_{-0.02-0.02}$	$0.12^{+0.10+0.07}_{-0.06-0.07}$	$0.01^{+0.03+0.01}_{-0.01-0.00}$	$0.2^{+1.2+0.1}_{-0.1-0.1}$	0

Table B.5: Observed numbers of events and prefit background predictions in the $N_{jet} \geq 9$ search regions. The first uncertainty is statistical and second systematic.

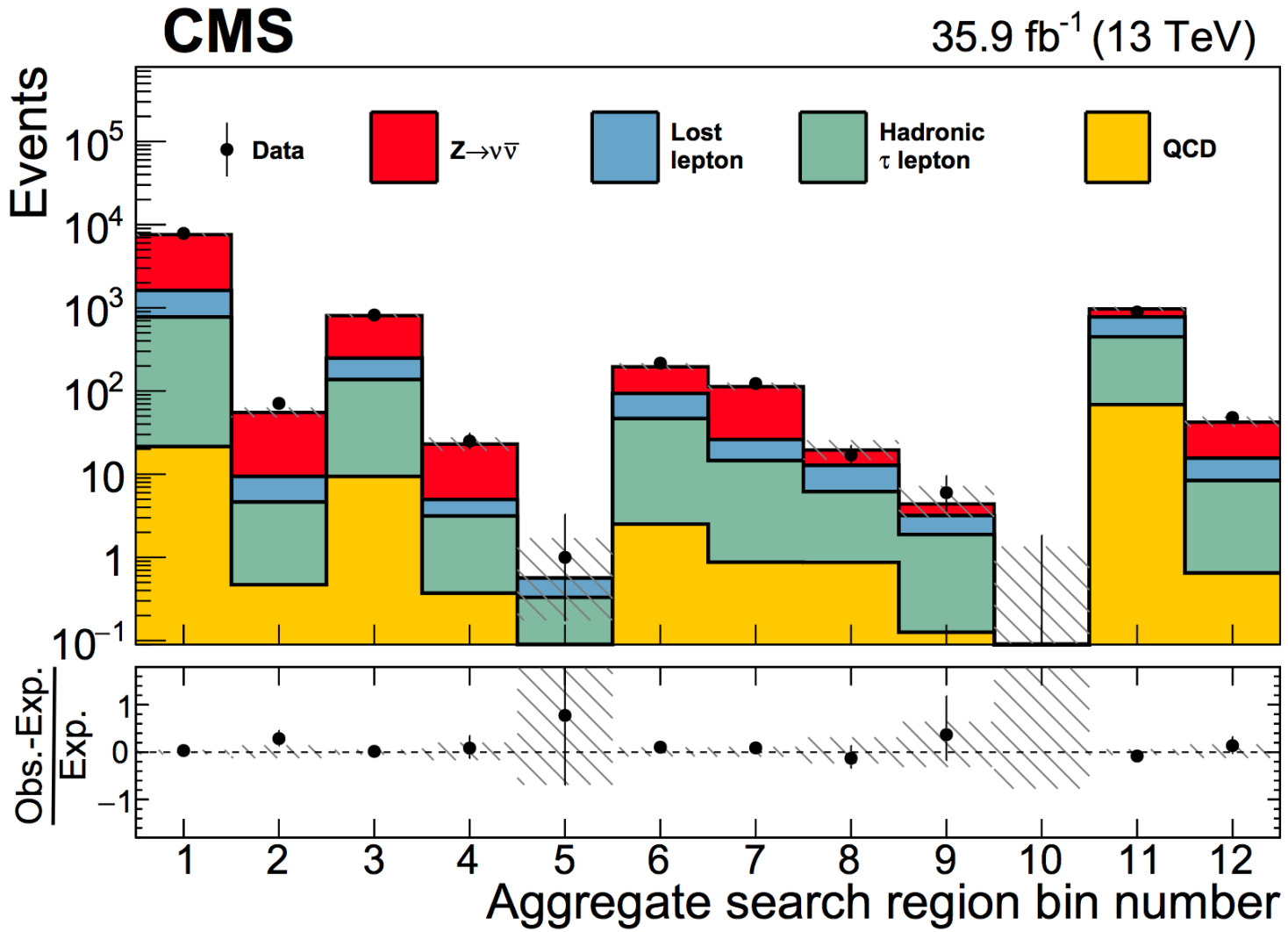
Bin	H_T^{miss} [GeV]	H_T [GeV]	N_{jet}	$N_{b\text{-}jet}$	Lost-e/μ	$\tau \to$ had	$Z \to \nu\bar{\nu}$	QCD	Total pred.	Obs.
143	300–350	500–1000	≥9	0	$6.2^{+2.7+1.7}_{-2.6-1.7}$	$3.46^{+0.89+0.59}_{-0.77-0.59}$	$2.6^{+1.2+0.7}_{-0.9-0.7}$	$2.9^{+0.3+1.3}_{-0.3-1.1}$	$15.1^{+3.8+2.3}_{-3.5-2.2}$	7
144	300–350	>1000	≥9	0	$3.5^{+1.2+0.6}_{-1.1-0.6}$	$4.6^{+1.0+0.6}_{-0.9-0.6}$	$3.0^{+1.4+0.6}_{-1.0-0.6}$	$4.2^{+0.3+1.9}_{-0.3-1.6}$	$15.2^{+2.7+2.1}_{-2.3-1.9}$	12
145	350–500	500–1000	≥9	0	$2.39^{+0.99+0.69}_{-0.89-0.69}$	$2.39^{+0.86+0.48}_{-0.73-0.48}$	$2.9^{+1.3+0.7}_{-0.9-0.6}$	$0.97^{+0.08+0.43}_{-0.08-0.37}$	$8.6^{+2.3+1.2}_{-1.9-1.1}$	6
146	350–500	>1000	≥9	0	$3.7^{+1.1+0.6}_{-1.1-0.6}$	$4.6^{+1.0+0.6}_{-0.9-0.6}$	$5.5^{+1.9+1.0}_{-1.5-0.9}$	$3.1^{+0.2+1.4}_{-0.2-1.2}$	$17.0^{+2.9+1.9}_{-2.5-1.7}$	13
147	500–750	500–1000	≥9	0	$0.15^{+0.32+0.10}_{-0.15-0.00}$	$0.35^{+0.55+0.12}_{-0.30-0.12}$	$1.0^{+1.3+0.4}_{-0.7-0.4}$	$0.10^{+0.05+0.04}_{-0.05-0.04}$	$1.6^{+1.6+0.5}_{-0.8-0.4}$	2
148	500–750	>1000	≥9	0	$0.98^{+0.50+0.26}_{-0.41-0.26}$	$1.98^{+0.74+0.30}_{-0.58-0.30}$	$3.5^{+1.6+0.7}_{-1.1-0.7}$	$0.47^{+0.05+0.21}_{-0.05-0.18}$	$6.9^{+2.0+0.8}_{-1.5-0.8}$	11
149	>750	750–1500	≥9	0	$0.00^{+0.44+0.00}_{-0.00-0.00}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.00^{+0.64+0.00}_{-0.00-0.00}$	$0.01^{+0.02+0.00}_{-0.01-0.00}$	$0.0^{+1.1+0.0}_{-0.0-0.0}$	0
150	>750	>1500	≥9	0	$0.23^{+0.27+0.16}_{-0.17-0.16}$	$0.28^{+0.50+0.08}_{-0.21-0.08}$	$0.00^{+0.82+0.00}_{-0.00-0.00}$	$0.05^{+0.03+0.02}_{-0.03-0.02}$	$0.6^{+1.1+0.2}_{-0.4-0.2}$	1
151	300–350	500–1000	≥9	1	$6.5^{+1.8+1.1}_{-1.7-1.1}$	$4.57^{+0.93+0.77}_{-0.81-0.77}$	$1.83^{+0.84+0.68}_{-0.60-0.74}$	$1.02^{+0.06+0.42}_{-0.06-0.40}$	$13.9^{+2.8+1.5}_{-2.6-1.6}$	25
152	300–350	>1000	≥9	1	$5.7^{+1.6+0.7}_{-1.5-0.7}$	$7.3^{+1.3+1.1}_{-1.2-1.1}$	$2.08^{+0.95+0.69}_{-0.68-0.77}$	$2.43^{+0.06+0.99}_{-0.06-0.94}$	$17.5^{+3.0+1.8}_{-2.8-1.8}$	20
153	350–500	500–1000	≥9	1	$2.92^{+0.94+0.57}_{-0.84-0.57}$	$2.96^{+0.77+0.60}_{-0.61-0.60}$	$2.00^{+0.91+0.71}_{-0.65-0.78}$	$0.53^{+0.05+0.22}_{-0.05-0.21}$	$8.4^{+1.9+1.1}_{-1.6-1.2}$	8
154	350–500	>1000	≥9	1	$5.4^{+1.4+0.7}_{-1.3-0.7}$	$7.7^{+1.4+1.1}_{-1.3-1.1}$	$3.9^{+1.3+1.3}_{-1.0-1.4}$	$1.48^{+0.05+0.60}_{-0.05-0.57}$	$18.4^{+3.1+1.9}_{-2.8-2.0}$	14
155	500–750	500–1000	≥9	1	$0.14^{+0.30+0.08}_{-0.14-0.00}$	$0.24^{+0.49+0.21}_{-0.18-0.16}$	$0.71^{+0.94+0.35}_{-0.46-0.36}$	$0.03^{+0.03+0.01}_{-0.03-0.00}$	$1.1^{+1.2+0.4}_{-0.6-0.4}$	1
156	500–750	>1000	≥9	1	$0.68^{+0.58+0.12}_{-0.41-0.12}$	$1.20^{+0.64+0.21}_{-0.44-0.21}$	$2.4^{+1.1+0.8}_{-0.8-0.9}$	$0.20^{+0.02+0.08}_{-0.02-0.07}$	$4.5^{+1.6+0.8}_{-1.2-0.9}$	4
157	>750	750–1500	≥9	1	$0.00^{+0.73+0.00}_{-0.00-0.00}$	$0.04^{+0.46+0.02}_{-0.04-0.00}$	$0.00^{+0.45+0.00}_{-0.00-0.00}$	$0.01^{+0.01+0.00}_{-0.01-0.00}$	$0.1^{+1.3+0.0}_{-0.0-0.0}$	0
158	>750	>1500	≥9	1	$0.13^{+0.27+0.06}_{-0.13-0.00}$	$0.03^{+0.46+0.01}_{-0.02-0.01}$	$0.00^{+0.57+0.00}_{-0.00-0.00}$	$0.02^{+0.01+0.01}_{-0.01-0.01}$	$0.18^{+0.93+0.06}_{-0.15-0.01}$	0
159	300–350	500–1000	≥9	2	$4.1^{+1.3+0.7}_{-1.2-0.7}$	$4.68^{+0.92+0.85}_{-0.80-0.85}$	$0.64^{+0.29+0.34}_{-0.21-0.36}$	$0.40^{+0.06+0.24}_{-0.06-0.21}$	$9.8^{+2.2+1.2}_{-2.0-1.2}$	13
160	300–350	>1000	≥9	2	$5.2^{+1.6+0.7}_{-1.5-0.7}$	$5.5^{+1.2+1.0}_{-1.1-1.0}$	$0.73^{+0.33+0.37}_{-0.24-0.39}$	$1.32^{+0.15+0.68}_{-0.15-0.58}$	$12.7^{+2.8+1.4}_{-2.6-1.4}$	10
161	350–500	500–1000	≥9	2	$3.01^{+0.91+0.63}_{-0.82-0.63}$	$4.7^{+1.1+0.9}_{-1.0-0.9}$	$0.70^{+0.32+0.36}_{-0.23-0.39}$	$0.30^{+0.08+0.14}_{-0.08-0.12}$	$8.7^{+2.0+1.1}_{-1.8-1.1}$	4
162	350–500	>1000	≥9	2	$4.4^{+1.1+0.6}_{-1.1-0.6}$	$6.3^{+1.4+0.8}_{-1.3-0.8}$	$1.35^{+0.47+0.67}_{-0.36-0.72}$	$0.63^{+0.03+0.32}_{-0.03-0.27}$	$12.7^{+2.6+1.3}_{-2.4-1.3}$	12
163	500–750	500–1000	≥9	2	$0.00^{+0.39+0.00}_{-0.00-0.00}$	$0.35^{+0.49+0.17}_{-0.18-0.17}$	$0.25^{+0.33+0.15}_{-0.16-0.16}$	$0.01^{+0.01+0.01}_{-0.01-0.00}$	$0.61^{+0.95+0.23}_{-0.24-0.23}$	0
164	500–750	>1000	≥9	2	$2.0^{+1.1+0.4}_{-0.9-0.4}$	$1.95^{+0.87+0.45}_{-0.73-0.45}$	$0.84^{+0.39+0.43}_{-0.28-0.46}$	$0.09^{+0.02+0.04}_{-0.02-0.04}$	$4.9^{+2.0+0.7}_{-1.7-0.7}$	7
165	>750	750–1500	≥9	2	$0.00^{+0.60+0.00}_{-0.00-0.00}$	$0.01^{+0.46+0.01}_{-0.00-0.00}$	$0.00^{+0.16+0.00}_{-0.00-0.00}$	$0.00^{+0.01+0.00}_{-0.00-0.00}$	$0.0^{+1.1+0.0}_{-0.0-0.0}$	0
166	>750	>1500	≥9	2	$0.00^{+0.38+0.00}_{-0.00-0.00}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.00^{+0.20+0.00}_{-0.00-0.00}$	$0.01^{+0.02+0.00}_{-0.01-0.00}$	$0.01^{+0.87+0.00}_{-0.01-0.00}$	0
167	300–350	500–1000	≥9	≥3	$1.06^{+0.63+0.27}_{-0.50-0.27}$	$1.06^{+0.57+0.29}_{-0.34-0.29}$	$0.37^{+0.17+0.26}_{-0.12-0.28}$	$0.47^{+0.13+0.56}_{-0.13-0.34}$	$3.0^{+1.2+0.7}_{-0.9-0.6}$	1
168	300–350	>1000	≥9	≥3	$3.5^{+1.7+0.5}_{-1.5-0.5}$	$2.6^{+1.0+0.7}_{-0.9-0.7}$	$0.42^{+0.19+0.29}_{-0.14-0.31}$	$2.1^{+0.3+2.4}_{-0.3-1.8}$	$8.6^{+2.7+2.6}_{-2.4-2.0}$	4
169	350–500	500–1000	≥9	≥3	$1.03^{+0.60+0.30}_{-0.47-0.30}$	$1.58^{+0.71+0.43}_{-0.55-0.43}$	$0.40^{+0.18+0.28}_{-0.13-0.31}$	$0.10^{+0.03+0.11}_{-0.03-0.07}$	$3.1^{+1.3+0.6}_{-1.0-0.6}$	3
170	350–500	>1000	≥9	≥3	$0.81^{+0.56+0.14}_{-0.41-0.14}$	$0.96^{+0.54+0.16}_{-0.27-0.16}$	$0.77^{+0.27+0.53}_{-0.20-0.58}$	$1.3^{+0.2+1.5}_{-0.2-1.1}$	$3.8^{+1.1+1.6}_{-0.7-1.3}$	2
171	500–750	500–1000	≥9	≥3	$0.00^{+0.43+0.00}_{-0.00-0.00}$	$0.03^{+0.46+0.03}_{-0.02-0.03}$	$0.14^{+0.19+0.11}_{-0.09-0.11}$	$0.01^{+0.02+0.01}_{-0.01-0.00}$	$0.18^{+0.91+0.11}_{-0.09-0.11}$	0
172	500–750	>1000	≥9	≥3	$0.00^{+0.48+0.00}_{-0.00-0.00}$	$0.53^{+0.56+0.13}_{-0.31-0.13}$	$0.48^{+0.22+0.33}_{-0.16-0.37}$	$0.13^{+0.14+0.15}_{-0.13-0.00}$	$1.1^{+1.1+0.4}_{-0.4-0.4}$	3
173	>750	750–1500	≥9	≥3	$0.00^{+0.50+0.00}_{-0.00-0.00}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.00^{+0.09+0.00}_{-0.00-0.00}$	$0.01^{+0.05+0.02}_{-0.01-0.00}$	$0.01^{+0.97+0.02}_{-0.01-0.00}$	0
174	>750	>1500	≥9	≥3	$0.00^{+0.42+0.00}_{-0.00-0.00}$	$0.00^{+0.46+0.00}_{-0.00-0.00}$	$0.00^{+0.11+0.00}_{-0.00-0.00}$	$0.02^{+0.05+0.02}_{-0.02-0.00}$	$0.02^{+0.89+0.02}_{-0.02-0.00}$	0

How to make this tractable?

- Go back to the original idea of single count search regions: "Aggregate regions"
  - Lose some in statistical sensitivity, but gain in intuition

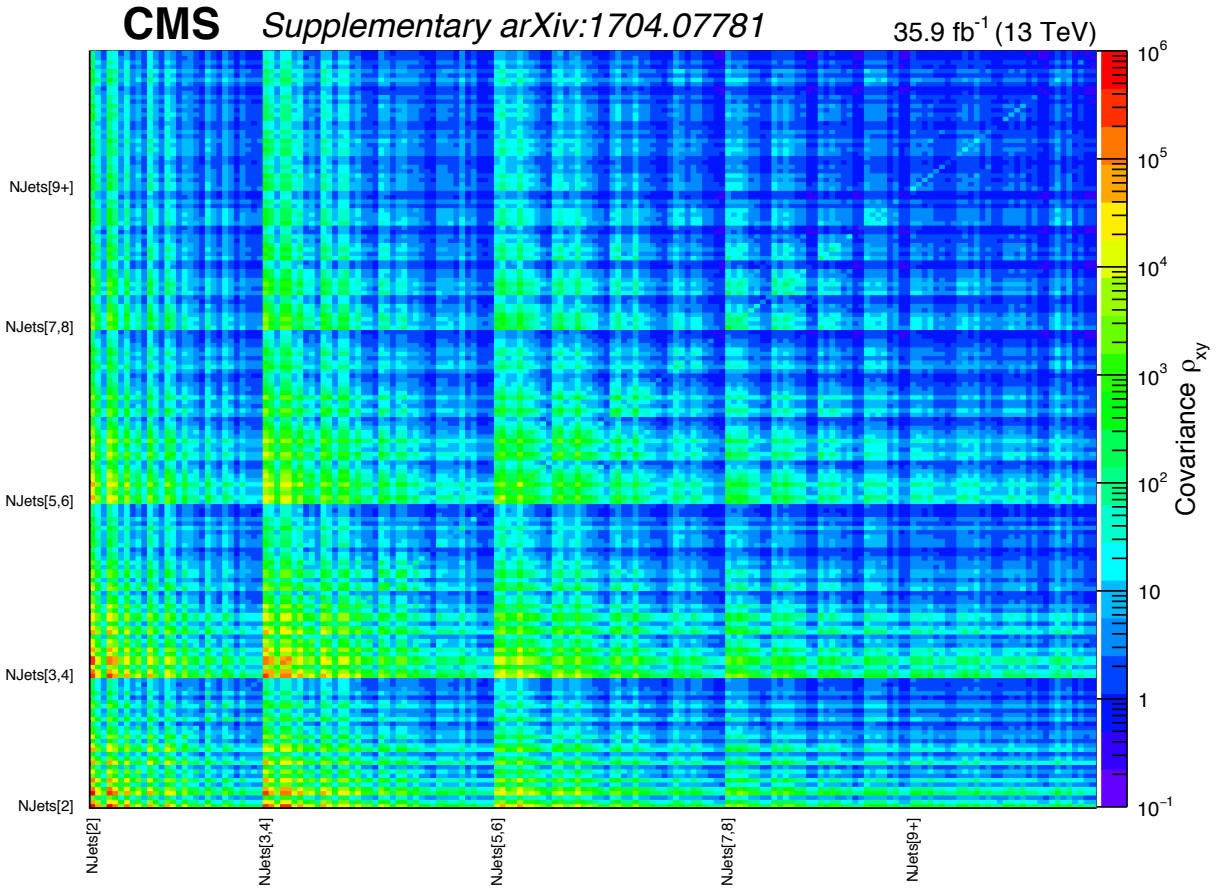
Region	N_{jet}	$N_{\text{b-jet}}$	H_{T} [GeV]	$H_{\text{T}}^{\text{miss}}$ [GeV]	Parton multiplicity	Heavy flavor ?	Δm
1	≥ 2	0	≥ 500	≥ 500	Low	No	Small
2	≥ 3	0	≥ 1500	≥ 750	Low	No	Large
3	≥ 5	0	≥ 500	≥ 500	Medium	No	Small
4	≥ 5	0	≥ 1500	≥ 750	Medium	No	Large
5	≥ 9	0	≥ 1500	≥ 750	High	No	All
6	≥ 2	≥ 2	≥ 500	≥ 500	Low	Yes	Small
7	≥ 3	≥ 1	≥ 750	≥ 750	Low	Yes	Large
8	≥ 5	≥ 3	≥ 500	≥ 500	Medium	Yes	Small
9	≥ 5	≥ 2	≥ 1500	≥ 750	Medium	Yes	Large
10	≥ 9	≥ 3	≥ 750	≥ 750	High	Yes	All
11	≥ 7	≥ 1	≥ 300	≥ 300	Medium high	Yes	Small
12	≥ 5	≥ 1	≥ 750	≥ 750	Medium	Yes	Large

Aggregate region results



What if you want it all?

- Now provide full covariance matrix for background predictions in all 174 bins
- Allows for complete reinterpretation for any model



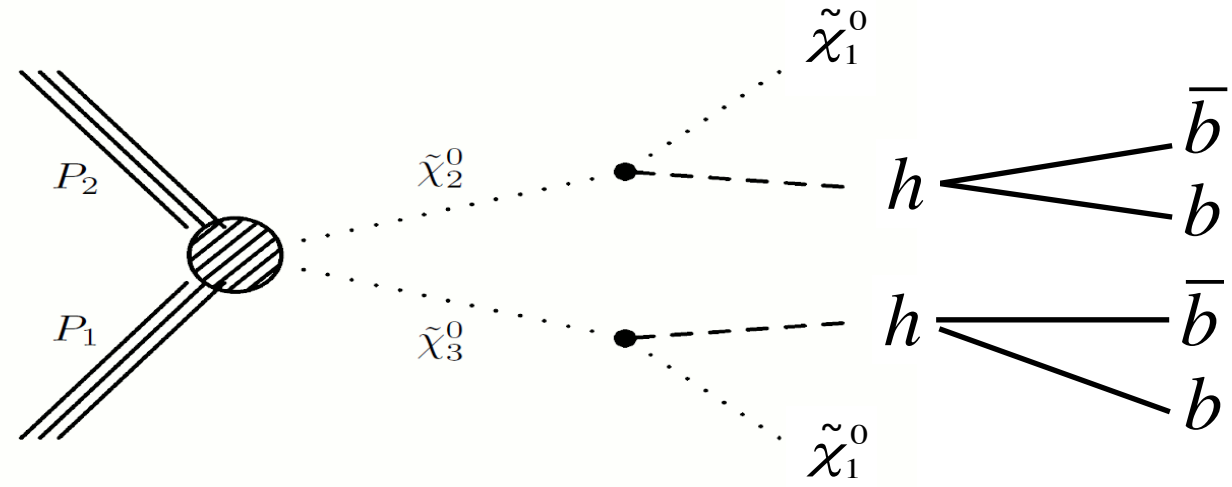
The future of hadronic SUSY searches

- Inclusive hadronic SUSY searches are now very mature
  - Strong background measurement techniques
  - Very inclusive approach
  - Adding luminosity helps, but only slow gains at this point
- Most fruitful approach at this point is to probe new corners of search space
  - Compressed signatures (ex. R. Castello)
  - Electroweak production (ex. L. Shchutska)
  - Boosted searches (ex. Z. Wu)

Hadronic EW search

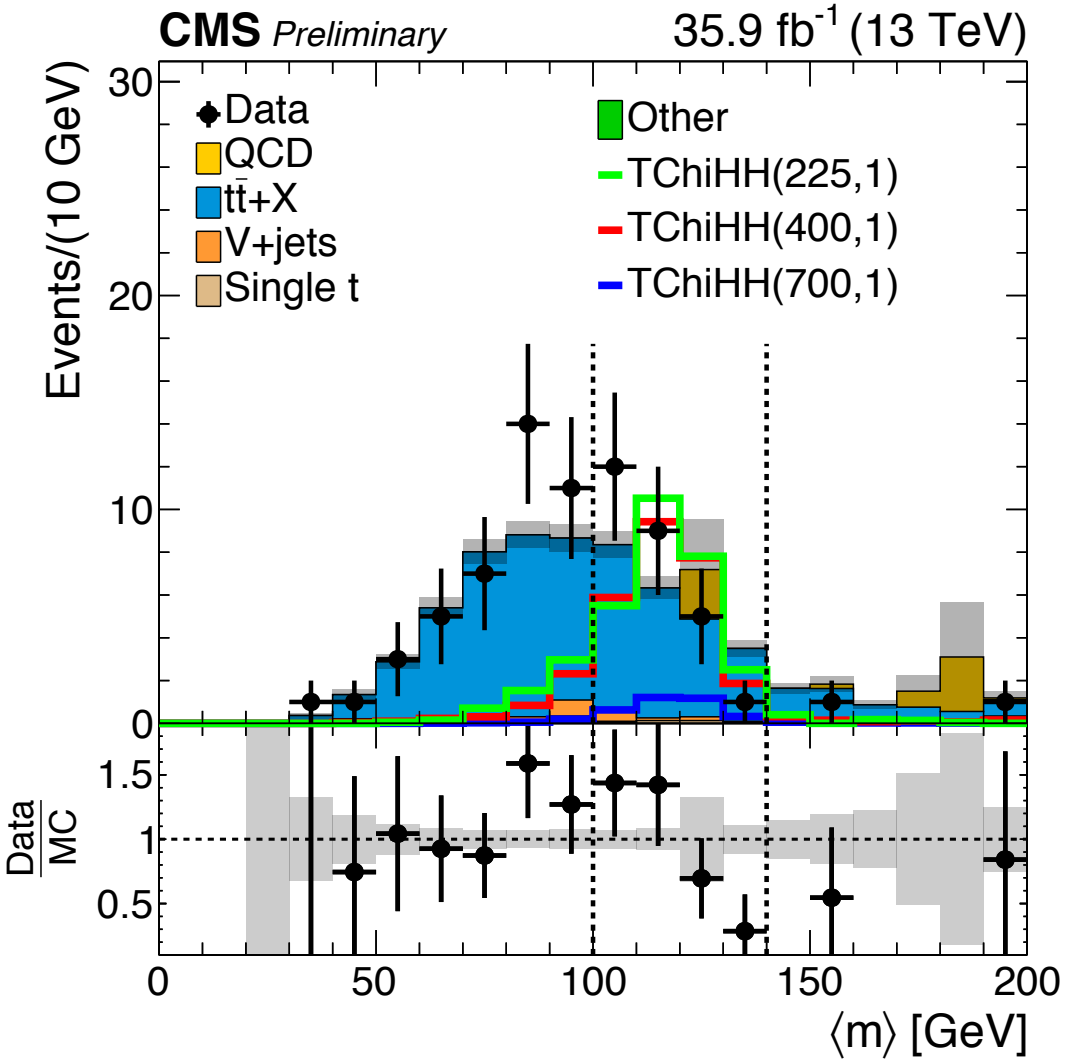
- Electroweak SUSY typically dominated by final states with leptons from W or Z decays
- But the new EW boson in town likes to decay to jets
- "Yesterday's discovery is today's background, and tomorrow's calibration"

Higgsino pair production → 4b + MET



Higgsino search

- Select pairs of b-jets with small mass difference
- Can exploit peaking Higgs mass for signal to reject background
- 4b signature dominated by tt with fake b-tags



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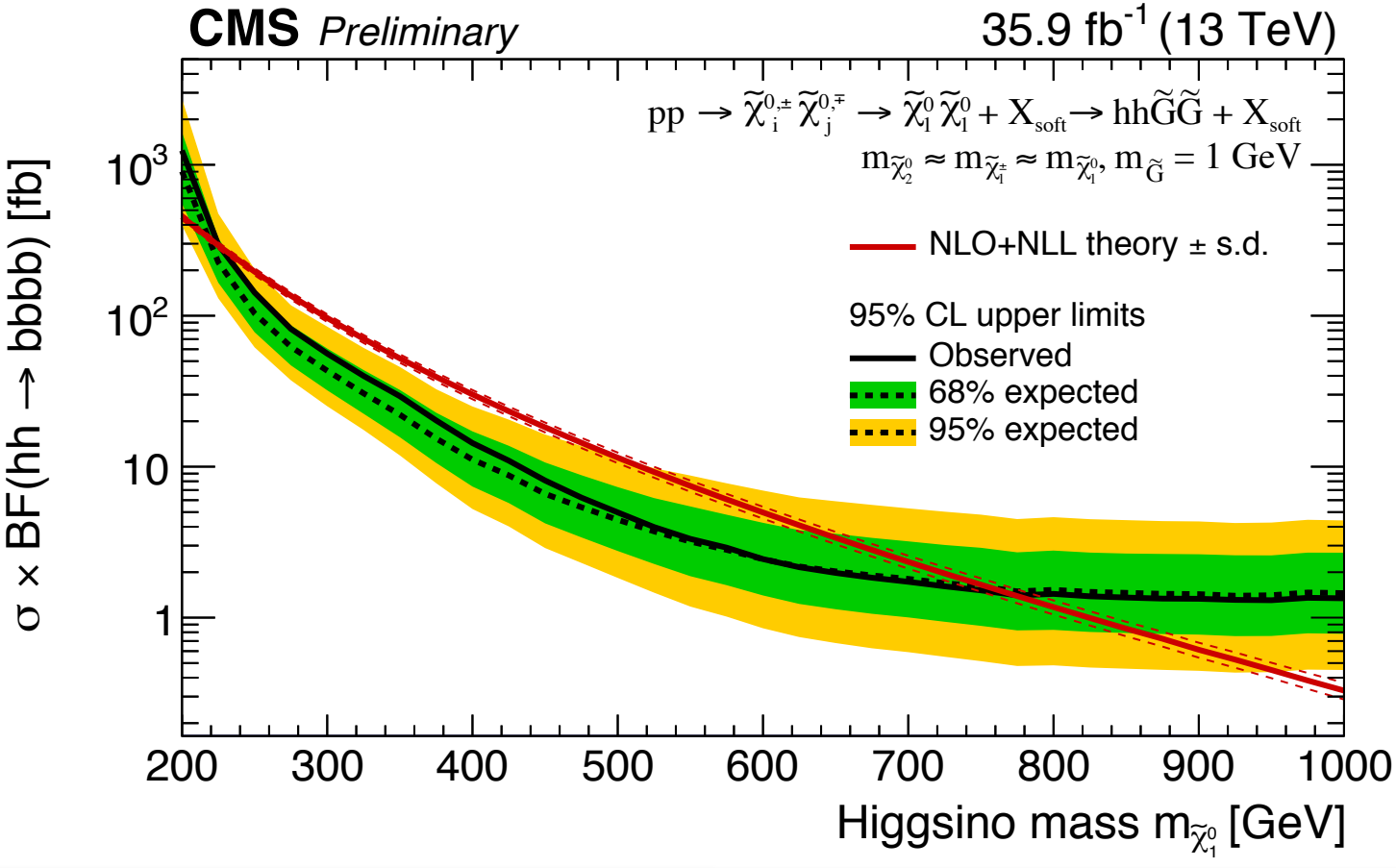
Higgsino exclusion

- Exclude wide range of Higgsino masses
  - Standard SMS caveats: assuming 100% BF to H,LSP and presence of light Goldstino



Conclusions

- Hadronic SUSY searches are a real workhorse for LHC physics program
- Sensitivity to many new physics models, yet no signs of beyond-SM contributions yet
- Next steps are to move into corners not yet explored…
- … and there are many more corners to explore!