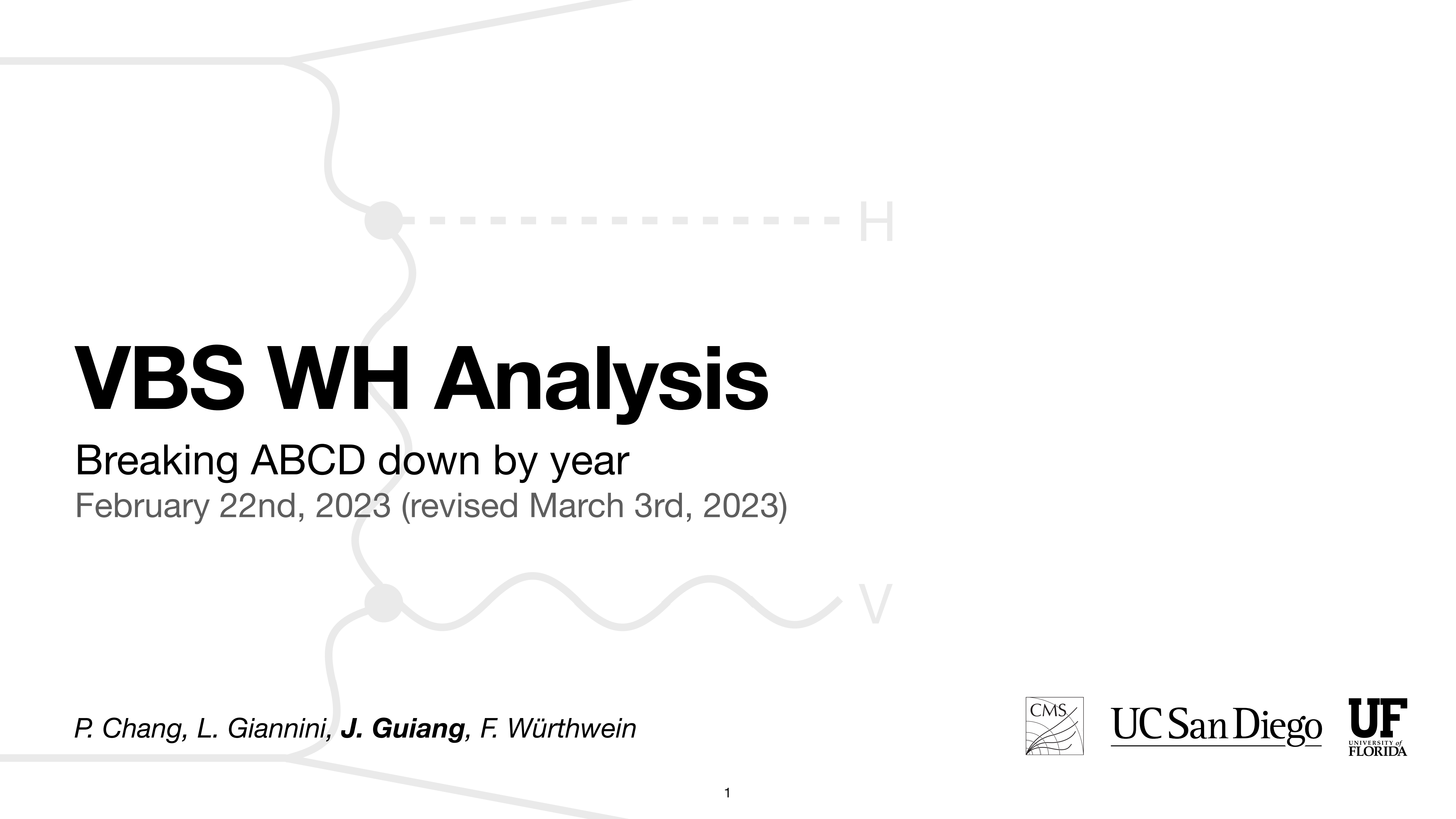


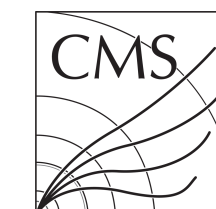


VBS WH Analysis

Breaking ABCD down by year

February 22nd, 2023 (revised March 3rd, 2023)

*P. Chang, L. Giannini, **J. Guiang**, F. Würthwein*

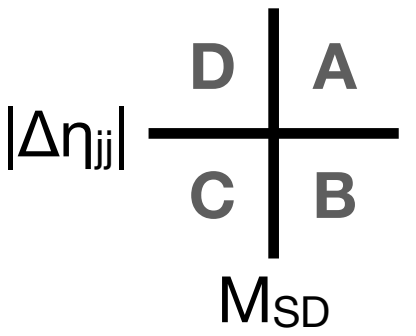


UC San Diego





ABCD: Year-by-year



Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.28	1.07	50.36	1.77	3.18	0.50	35	5.92
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.17	1.01	67.10	1.84	0.26	0.15	56	7.48
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.16	1.03	50.44	2.22	3.50	0.51	30	5.48
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	0.95	0.84	28.02	1.64	101.08	2.92	—	—

36.33 fb⁻¹

	MC	Data
A/B	0.75 ± 0.03	0.63 ± 0.13
$D_{pred} = C*(A/B)$	37.9 ± 2.37	18.8 ± 5.30
$ 1 - D_{pred}/D_{MC} $	35.1%	—
$D_{pred}/Lumi$	1.04 ± 0.07	0.52 ± 0.15

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2017 ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	—	0.84	44.93	1.54	2.80	0.67	43	6.56
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	—	0.87	65.65	3.04	0.17	0.17	68	8.25
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	—	0.89	49.76	2.17	4.90	0.89	57	7.55
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	—	0.88	33.54	2.20	112.26	4.33	—	—

41.48 fb⁻¹

	MC	Data
A/B	0.68 ± 0.04	0.63 ± 0.12
$D_{pred} = C*(A/B)$	34.1 ± 2.46	36.0 ± 8.49
$ 1 - D_{pred}/D_{MC} $	1.5%	—
$D_{pred}/Lumi$	0.82 ± 0.06	0.87 ± 0.20

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2018 ONLY)

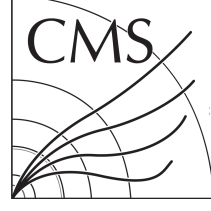
Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.20	—	77.54	2.25	6.18	1.26	64	8.00
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.15	—	109.00	4.60	0.51	0.36	77	8.77
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.13	—	80.79	3.12	8.31	1.47	83	9.11
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	1.13	—	54.77	2.68	184.10	6.91	—	—

59.83 fb⁻¹

	MC	Data
A/B	0.71 ± 0.04	0.83 ± 0.14
$D_{pred} = C*(A/B)$	57.5 ± 3.69	69.0 ± 13.91
$ 1 - D_{pred}/D_{MC} $	4.9%	—
$D_{pred}/Lumi$	0.96 ± 0.06	1.15 ± 0.23

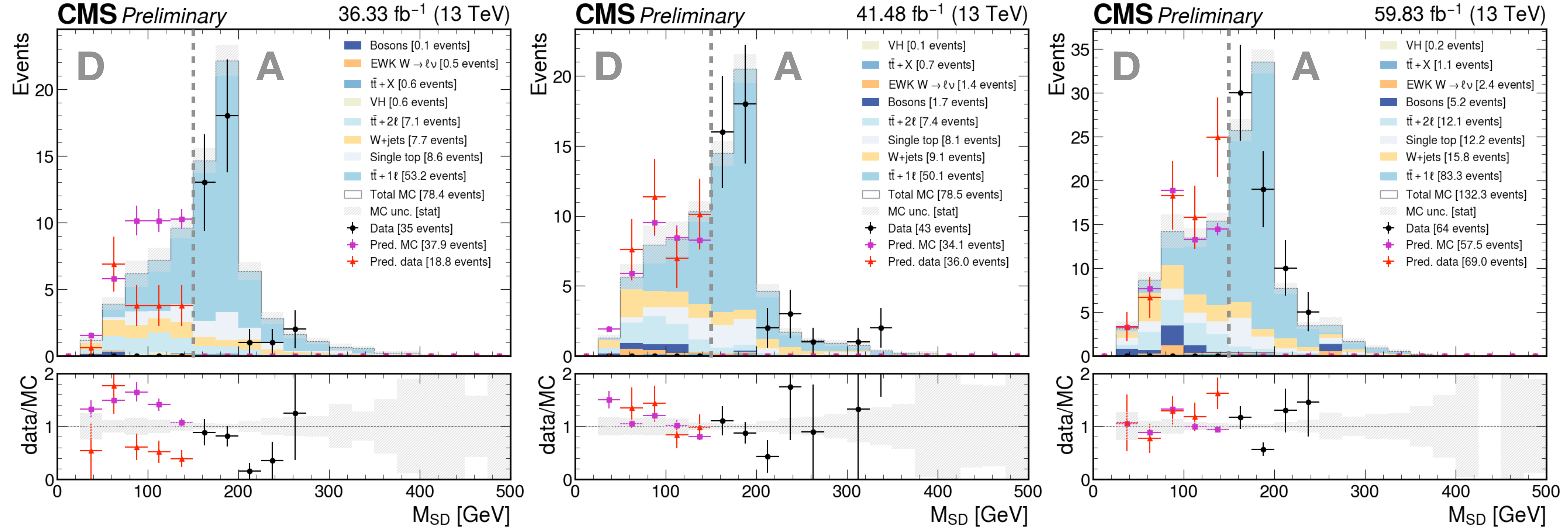
For 2018: Bkg./2017 = ((Bkg. 2018)/59.83)/((Bkg. 2017)/41.48)

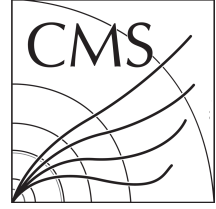
2016 accounts for almost all of the systematic on ABCD method



ABCD: Year-by-year

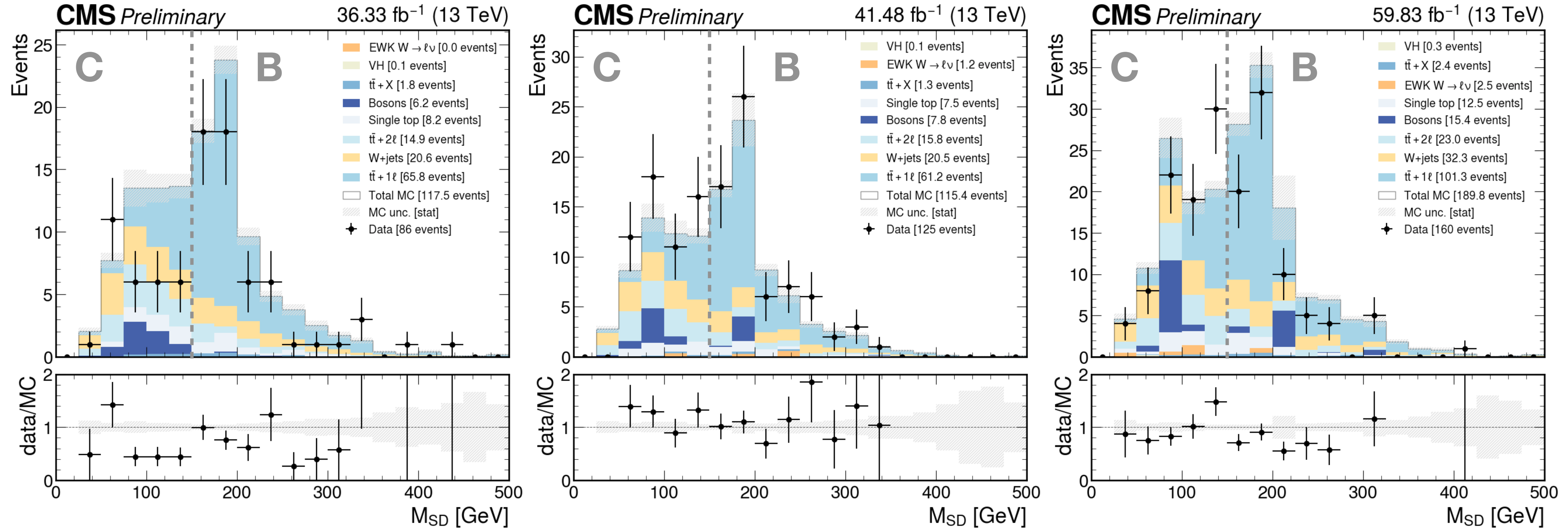
$$|\Delta\eta_{ij}| \begin{array}{c|c} \text{D} & \text{A} \\ \hline \text{C} & \text{B} \end{array} M_{SD}$$





ABCD: Year-by-year

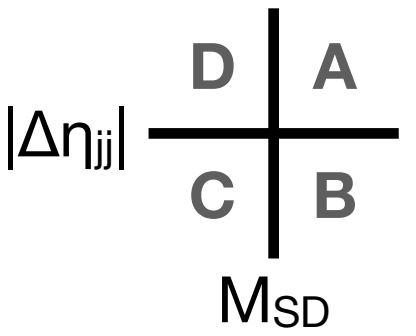
$$|\Delta\eta_{ij}| \begin{array}{c|c} \text{D} & \text{A} \\ \hline \text{C} & \text{B} \end{array} M_{SD}$$



Backup



ABCD: Year-by-year



Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 pre-VFP ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.31	1.10	27.71	1.33	1.79	0.39	17	4.12
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.11	0.97	34.36	1.30	0.26	0.15	19	4.36
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.18	1.05	27.61	1.67	1.68	0.36	18	4.24
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	0.97	0.86	15.28	1.16	54.86	2.17	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 post-VFP ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.24	1.04	22.66	1.17	1.39	0.31	18	4.24
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.23	1.07	32.74	1.30	0.00	0.00	37	6.08
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.13	1.01	22.82	1.47	1.81	0.36	12	3.46
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	0.94	0.83	12.74	1.16	46.22	1.95	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2017 ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	—	0.84	44.93	1.54	2.80	0.67	43	6.56
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	—	0.87	65.65	3.04	0.17	0.17	68	8.25
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	—	0.89	49.76	2.17	4.90	0.89	57	7.55
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	—	0.88	33.54	2.20	112.26	4.33	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2018 ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.20	—	77.54	2.25	6.18	1.26	64	8.00
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.15	—	109.00	4.60	0.51	0.36	77	8.77
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.13	—	80.79	3.12	8.31	1.47	83	9.11
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	1.13	—	54.77	2.68	184.10	6.91	—	—

For 2018: Bkg./2017 = ((Bkg. 2018)/59.83)/((Bkg. 2017)/41.48)

19.52 fb⁻¹

	MC	Data
A/B	0.81 ± 0.05	0.89 ± 0.30
$D_{\text{pred}} = C \cdot (A/B)$	22.3 ± 1.91	16.1 ± 6.58
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	45.7%	—
$D_{\text{pred}}/\text{Lumi}$	1.14 ± 0.10	0.83 ± 0.34

16.81 fb⁻¹

	MC	Data
A/B	0.69 ± 0.05	0.49 ± 0.14
$D_{\text{pred}} = C \cdot (A/B)$	15.8 ± 1.45	5.8 ± 2.38
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	24.0%	—
$D_{\text{pred}}/\text{Lumi}$	0.94 ± 0.09	0.35 ± 0.14

41.48 fb⁻¹

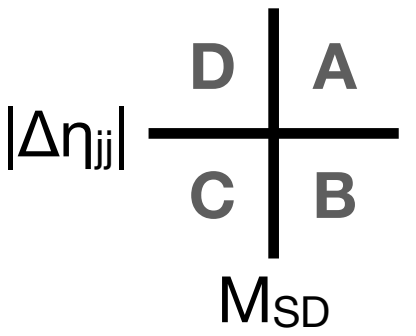
	MC	Data
A/B	0.68 ± 0.04	0.63 ± 0.12
$D_{\text{pred}} = C \cdot (A/B)$	34.1 ± 2.46	36.0 ± 8.49
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	1.5%	—
$D_{\text{pred}}/\text{Lumi}$	0.82 ± 0.06	0.87 ± 0.20

59.83 fb⁻¹

	MC	Data
A/B	0.71 ± 0.04	0.83 ± 0.14
$D_{\text{pred}} = C \cdot (A/B)$	57.5 ± 3.69	69.0 ± 13.91
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	4.9%	—
$D_{\text{pred}}/\text{Lumi}$	0.96 ± 0.06	1.15 ± 0.23



ABCD: Year-by-year



Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 pre-VFP, $t\bar{t}+1\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.34	1.11	22.22	1.10	1.87	0.40	17	4.12
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.21	1.06	25.61	1.16	0.26	0.15	19	4.36
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.19	1.01	9.02	0.68	1.63	0.35	19	4.36
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	1.08	1.05	7.46	0.65	55.21	2.17	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 post-VFP, $t\bar{t}+1\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.22	1.01	17.51	0.94	1.41	0.31	19	4.36
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.33	1.17	24.31	1.09	0.00	0.00	36	6.00
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.05	0.89	6.83	0.58	1.71	0.35	12	3.46
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	1.01	0.98	6.00	0.55	47.74	2.01	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2017, $t\bar{t}+1\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	—	0.83	35.36	1.28	3.02	0.71	45	6.71
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	—	0.88	45.13	1.39	0.17	0.17	67	8.19
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	—	0.85	16.11	0.83	4.61	0.87	58	7.62
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	—	0.98	14.72	0.82	116.15	4.44	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2018, $t\bar{t}+1\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.21	—	61.55	1.78	6.27	1.28	65	8.06
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.14	—	73.95	1.90	0.51	0.36	77	8.77
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.18	—	27.39	1.17	8.41	1.49	83	9.11
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	1.02	—	21.73	1.05	191.01	7.10	—	—

For 2018: Bkg./2017 = ((Bkg. 2018)/59.83)/((Bkg. 2017)/41.48)

19.52 fb⁻¹

	MC	Data
A/B	0.87 ± 0.06	0.89 ± 0.30
$D_{\text{pred}} = C \cdot (A/B)$	7.8 ± 0.79	17.0 ± 6.89
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	5.0%	—
$D_{\text{pred}}/\text{Lumi}$	0.40 ± 0.04	0.87 ± 0.35

16.81 fb⁻¹

	MC	Data
A/B	0.72 ± 0.05	0.53 ± 0.15
$D_{\text{pred}} = C \cdot (A/B)$	4.9 ± 0.54	6.3 ± 2.56
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	18.1%	—
$D_{\text{pred}}/\text{Lumi}$	0.29 ± 0.03	0.38 ± 0.15

41.48 fb⁻¹

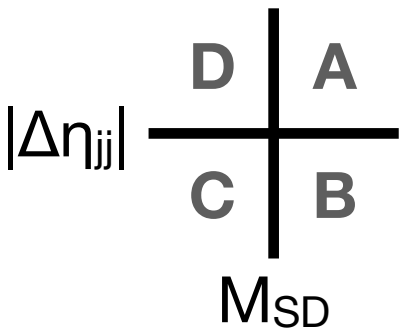
	MC	Data
A/B	0.78 ± 0.04	0.67 ± 0.13
$D_{\text{pred}} = C \cdot (A/B)$	12.6 ± 0.88	39.0 ± 9.08
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	14.2%	—
$D_{\text{pred}}/\text{Lumi}$	0.30 ± 0.02	0.94 ± 0.22

59.83 fb⁻¹

	MC	Data
A/B	0.83 ± 0.03	0.84 ± 0.14
$D_{\text{pred}} = C \cdot (A/B)$	22.8 ± 1.31	70.1 ± 14.09
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	4.9%	—
$D_{\text{pred}}/\text{Lumi}$	0.38 ± 0.02	1.17 ± 0.24



ABCD: Year-by-year



Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 pre-VFP, $t\bar{t}+2\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.98	1.72	1.11	0.22	1.87	0.40	17	4.12
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.04	0.92	2.18	0.30	0.26	0.15	19	4.36
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.19	1.24	6.38	0.53	1.63	0.35	19	4.36
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	0.98	0.86	2.84	0.36	55.21	2.17	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 post-VFP, $t\bar{t}+2\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.87	1.63	0.91	0.19	1.41	0.31	19	4.36
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	0.93	0.83	1.69	0.26	0.00	0.00	36	6.00
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.01	1.05	4.67	0.43	1.71	0.35	12	3.46
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	0.89	0.79	2.24	0.31	47.74	2.01	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2017, $t\bar{t}+2\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	—	0.87	1.19	0.20	3.02	0.71	45	6.71
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	—	0.89	4.47	0.37	0.17	0.17	67	8.19
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	—	1.04	11.35	0.61	4.61	0.87	58	7.62
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	—	0.88	6.20	0.47	116.15	4.44	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2018, $t\bar{t}+2\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.15	—	1.98	0.27	6.27	1.28	65	8.06
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.12	—	7.24	0.50	0.51	0.36	77	8.77
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	0.96	—	15.78	0.79	8.41	1.49	83	9.11
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	1.13	—	10.14	0.66	191.01	7.10	—	—

For 2018: Bkg./2017 = ((Bkg. 2018)/59.83)/((Bkg. 2017)/41.48)

19.52 fb⁻¹

	MC	Data
A/B	0.51 ± 0.12	0.89 ± 0.30
$D_{\text{pred}} = C \cdot (A/B)$	3.3 ± 0.82	17.0 ± 6.89
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	14.4%	—
$D_{\text{pred}}/\text{Lumi}$	0.17 ± 0.04	0.87 ± 0.35

16.81 fb⁻¹

	MC	Data
A/B	0.54 ± 0.14	0.53 ± 0.15
$D_{\text{pred}} = C \cdot (A/B)$	2.5 ± 0.68	6.3 ± 2.56
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	11.6%	—
$D_{\text{pred}}/\text{Lumi}$	0.15 ± 0.04	0.38 ± 0.15

41.48 fb⁻¹

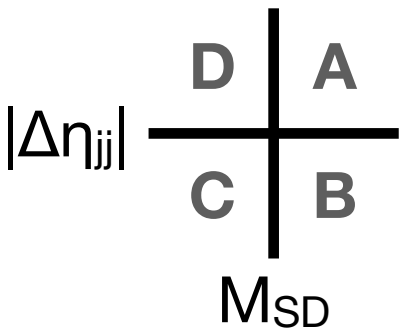
	MC	Data
A/B	0.27 ± 0.05	0.67 ± 0.13
$D_{\text{pred}} = C \cdot (A/B)$	3.0 ± 0.59	39.0 ± 9.08
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	51.1%	—
$D_{\text{pred}}/\text{Lumi}$	0.07 ± 0.01	0.94 ± 0.22

59.83 fb⁻¹

	MC	Data
A/B	0.27 ± 0.04	0.84 ± 0.14
$D_{\text{pred}} = C \cdot (A/B)$	4.3 ± 0.69	70.1 ± 14.09
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	57.4%	—
$D_{\text{pred}}/\text{Lumi}$	0.07 ± 0.01	1.17 ± 0.24



ABCD: Year-by-year



Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 pre-VFP, $t\bar{t}+1\ell$ or $t\bar{t}+2\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.36	1.13	23.34	1.12	1.87	0.40	17	4.12
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.19	1.05	27.79	1.20	0.26	0.15	19	4.36
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.19	1.09	15.40	0.86	1.63	0.35	19	4.36
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	1.05	0.99	10.30	0.74	55.21	2.17	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 post-VFP, $t\bar{t}+1\ell$ or $t\bar{t}+2\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.24	1.03	18.42	0.96	1.41	0.31	19	4.36
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.29	1.14	26.00	1.12	0.00	0.00	36	6.00
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.03	0.95	11.49	0.72	1.71	0.35	12	3.46
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	0.97	0.92	8.24	0.63	47.74	2.01	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2017, $t\bar{t}+1\ell$ or $t\bar{t}+2\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	—	0.83	36.55	1.29	3.02	0.71	45	6.71
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	—	0.88	49.59	1.44	0.17	0.17	67	8.19
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	—	0.92	27.46	1.03	4.61	0.87	58	7.62
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	—	0.95	20.92	0.94	116.15	4.44	—	—

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2018, $t\bar{t}+1\ell$ or $t\bar{t}+2\ell$ ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.20	—	63.53	1.80	6.27	1.28	65	8.06
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.14	—	81.19	1.96	0.51	0.36	77	8.77
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.09	—	43.17	1.41	8.41	1.49	83	9.11
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	1.06	—	31.87	1.24	191.01	7.10	—	—

For 2018: Bkg./2017 = ((Bkg. 2018)/59.83)/((Bkg. 2017)/41.48)

19.52 fb⁻¹

	MC	Data
A/B	0.84 ± 0.05	0.89 ± 0.30
$D_{\text{pred}} = C \cdot (A/B)$	12.9 ± 1.10	17.0 ± 6.89
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	25.6%	—
$D_{\text{pred}}/\text{Lumi}$	0.66 ± 0.06	0.87 ± 0.35

16.81 fb⁻¹

	MC	Data
A/B	0.71 ± 0.05	0.53 ± 0.15
$D_{\text{pred}} = C \cdot (A/B)$	8.1 ± 0.75	6.3 ± 2.56
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	1.2%	—
$D_{\text{pred}}/\text{Lumi}$	0.48 ± 0.04	0.38 ± 0.15

41.48 fb⁻¹

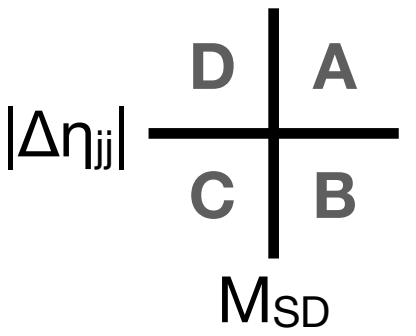
	MC	Data
A/B	0.74 ± 0.03	0.67 ± 0.13
$D_{\text{pred}} = C \cdot (A/B)$	20.2 ± 1.20	39.0 ± 9.08
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	3.3%	—
$D_{\text{pred}}/\text{Lumi}$	0.49 ± 0.03	0.94 ± 0.22

59.83 fb⁻¹

	MC	Data
A/B	0.78 ± 0.03	0.84 ± 0.14
$D_{\text{pred}} = C \cdot (A/B)$	33.8 ± 1.67	70.1 ± 14.09
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	6.0%	—
$D_{\text{pred}}/\text{Lumi}$	0.56 ± 0.03	1.17 ± 0.24



ABCD: Year-by-year



Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 pre-VFP, NOT ($t\bar{t}+1\ell$ or $t\bar{t}+2\ell$) ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.11	0.96	4.37	0.71	1.87	0.40	17	4.12
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	0.87	0.72	6.57	0.50	0.26	0.15	19	4.36
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.16	0.99	12.21	1.43	1.63	0.35	19	4.36
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	0.84	0.67	4.98	0.89	55.21	2.17	—	—

19.52 fb⁻¹

	MC	Data
A/B	0.67 ± 0.12	0.89 ± 0.30
$D_{\text{pred}} = C \cdot (A/B)$	8.1 ± 1.74	17.0 ± 6.89
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	63.0%	—
$D_{\text{pred}}/\text{Lumi}$	0.42 ± 0.09	0.87 ± 0.35

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2016 post-VFP, NOT ($t\bar{t}+1\ell$ or $t\bar{t}+2\ell$) ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.25	1.08	4.24	0.66	1.41	0.31	19	4.36
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.04	0.86	6.73	0.66	0.00	0.00	36	6.00
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.25	1.07	11.33	1.28	1.71	0.35	12	3.46
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	0.88	0.70	4.50	0.97	47.74	2.01	—	—

16.81 fb⁻¹

	MC	Data
A/B	0.63 ± 0.12	0.53 ± 0.15
$D_{\text{pred}} = C \cdot (A/B)$	7.1 ± 1.55	6.3 ± 2.56
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	58.5%	—
$D_{\text{pred}}/\text{Lumi}$	0.42 ± 0.09	0.38 ± 0.15

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2017, NOT ($t\bar{t}+1\ell$ or $t\bar{t}+2\ell$) ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	—	0.86	8.38	0.83	3.02	0.71	45	6.71
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	—	0.83	16.05	2.68	0.17	0.17	67	8.19
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	—	0.85	22.30	1.91	4.61	0.87	58	7.62
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	—	0.80	12.62	1.99	116.15	4.44	—	—

41.48 fb⁻¹

	MC	Data
A/B	0.52 ± 0.10	0.67 ± 0.13
$D_{\text{pred}} = C \cdot (A/B)$	11.6 ± 2.47	39.0 ± 9.08
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	7.8%	—
$D_{\text{pred}}/\text{Lumi}$	0.28 ± 0.06	0.94 ± 0.22

Preselection AND $M_{jj} > 600$ GeV AND $S_T > 900$ GeV AND PNet Xbb > 0.9 (2018, NOT ($t\bar{t}+1\ell$ or $t\bar{t}+2\ell$) ONLY)

Cut	Region	Bkg./2017	Bkg./2018	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$ \Delta\eta_{jj} > 4$ AND $M_{SD} \geq 150$ GeV	A	1.16	—	14.01	1.35	6.27	1.28	65	8.06
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} \geq 150$ GeV	B	1.20	—	27.81	4.16	0.51	0.36	77	8.77
$ \Delta\eta_{jj} \leq 4$ AND $M_{SD} < 150$ GeV	C	1.17	—	37.62	2.78	8.41	1.49	83	9.11
$ \Delta\eta_{jj} > 4$ AND $M_{SD} < 150$ GeV (SR)	D	1.26	—	22.89	2.37	191.01	7.10	—	—

59.83 fb⁻¹

	MC	Data
A/B	0.50 ± 0.09	0.84 ± 0.14
$D_{\text{pred}} = C \cdot (A/B)$	19.0 ± 3.66	70.1 ± 14.09
$ 1 - D_{\text{pred}}/D_{\text{MC}} $	17.2%	—
$D_{\text{pred}}/\text{Lumi}$	0.32 ± 0.06	1.17 ± 0.24

For 2018: Bkg./2017 = ((Bkg. 2018)/59.83)/((Bkg. 2017)/41.48)