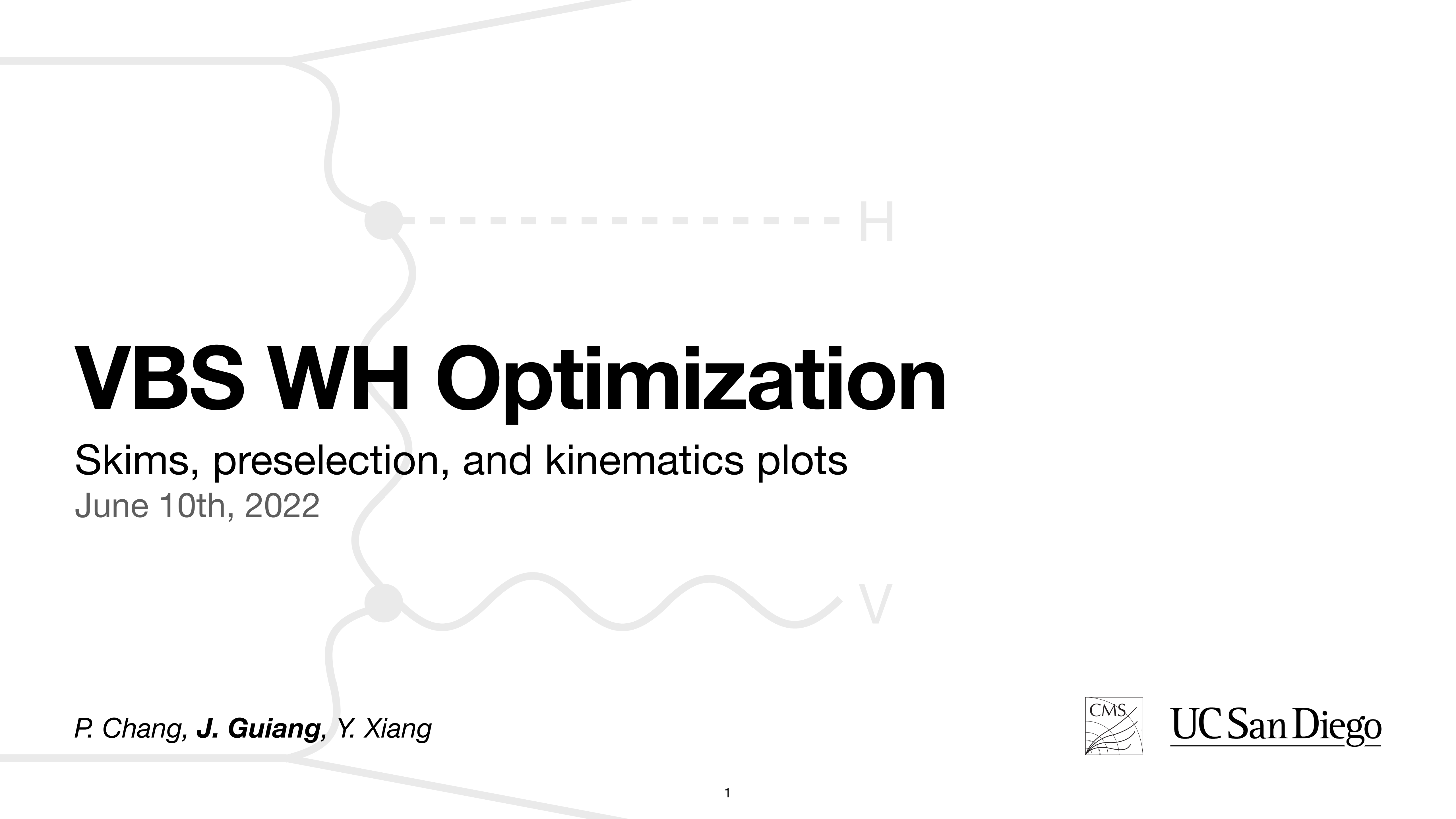


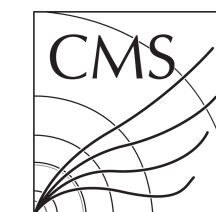


VBS WH Optimization

Skims, preselection, and kinematics plots

June 10th, 2022

P. Chang, J. Guiang, Y. Xiang



UC San Diego



VBS WH Skims

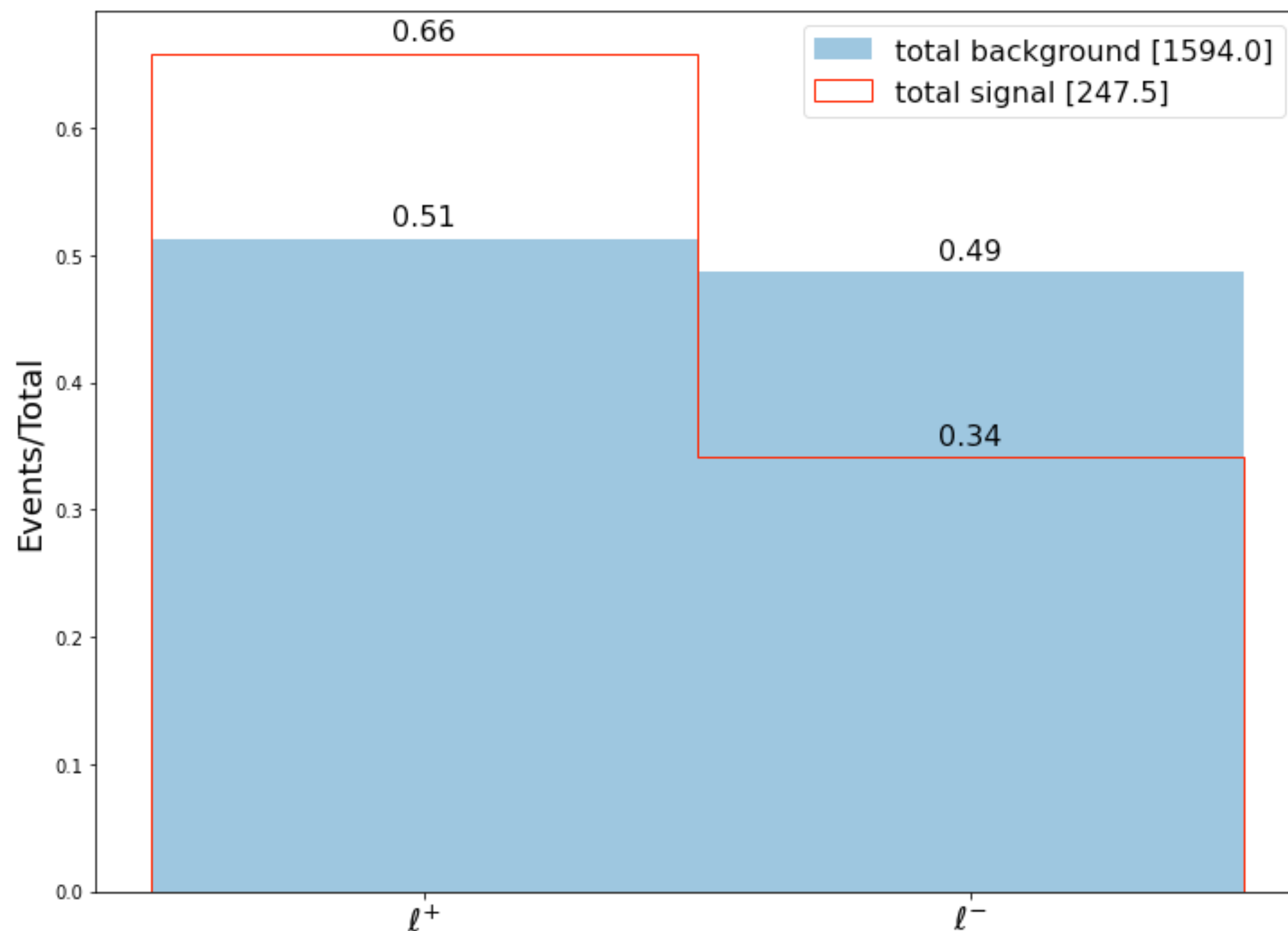
Object	Primary Skim	Post-skim
Leptons (μ , e)	≥ 1 veto	$== 1$ loose AND $== 1$ tight
Fat Jets	≥ 1 w/ $p_T > 200$ GeV AND mass > 10 GeV AND $M_{SD} > 10$ GeV AND $\Delta R(\text{fat jet, any veto lepton}) > 0.8$	≥ 1 w/ $p_T > 250$ GeV AND mass > 25 GeV AND $M_{SD} > 25$ GeV AND Hbb vs. QCD > 0.5 AND $\Delta R(\text{fat jet, tight lepton}) > 0.8$
Jets	≥ 1 w/ $p_T > 20$ GeV AND $\Delta R(\text{jet, any veto lepton}) > 0.4$	—

VBS WH Preselection

Cut	VHToNonbb	VV/VVV/VBSWZ	W+Jets	TTbar+X	TTbar1L	TTbar2L	TotalBkg	Eff.*	VBSWH (kW < 0)	Eff.*
Skim AND Postskim	167.20	1682.82	32662.10	3676.56	430420.00	34119.54	502728.22	—	59617.33	—
$p_T(\ell) > 40$ GeV	134.51	1328.10	26056.77	2744.54	331902.50	25374.77	387541.19	23%	9070.38	85%
≥ 1 fat jet* w/ $p_T > 250$ GeV AND mass > 50 GeV AND $M_{SD} > 40$ GeV	134.75	1310.99	25501.66	2707.36	329709.20	23536.49	382900.44	1%	3280.86	64%
max(PNet Hbb vs. QCD) > 0.9	52.86	692.78	5851.26	1005.57	114900.90	9552.56	132055.94	66%	1344.23	59%
2 VBS jets** (max E)	16.38	220.91	3224.48	899.00	87069.10	6693.48	98123.35	26%	929.23	31%
$M_{jj} > 500$ AND $\Delta\eta_{jj} > 3$	0.21	7.43	87.64	5.53	1342.52	150.77	1594.10	98%	247.51	73%

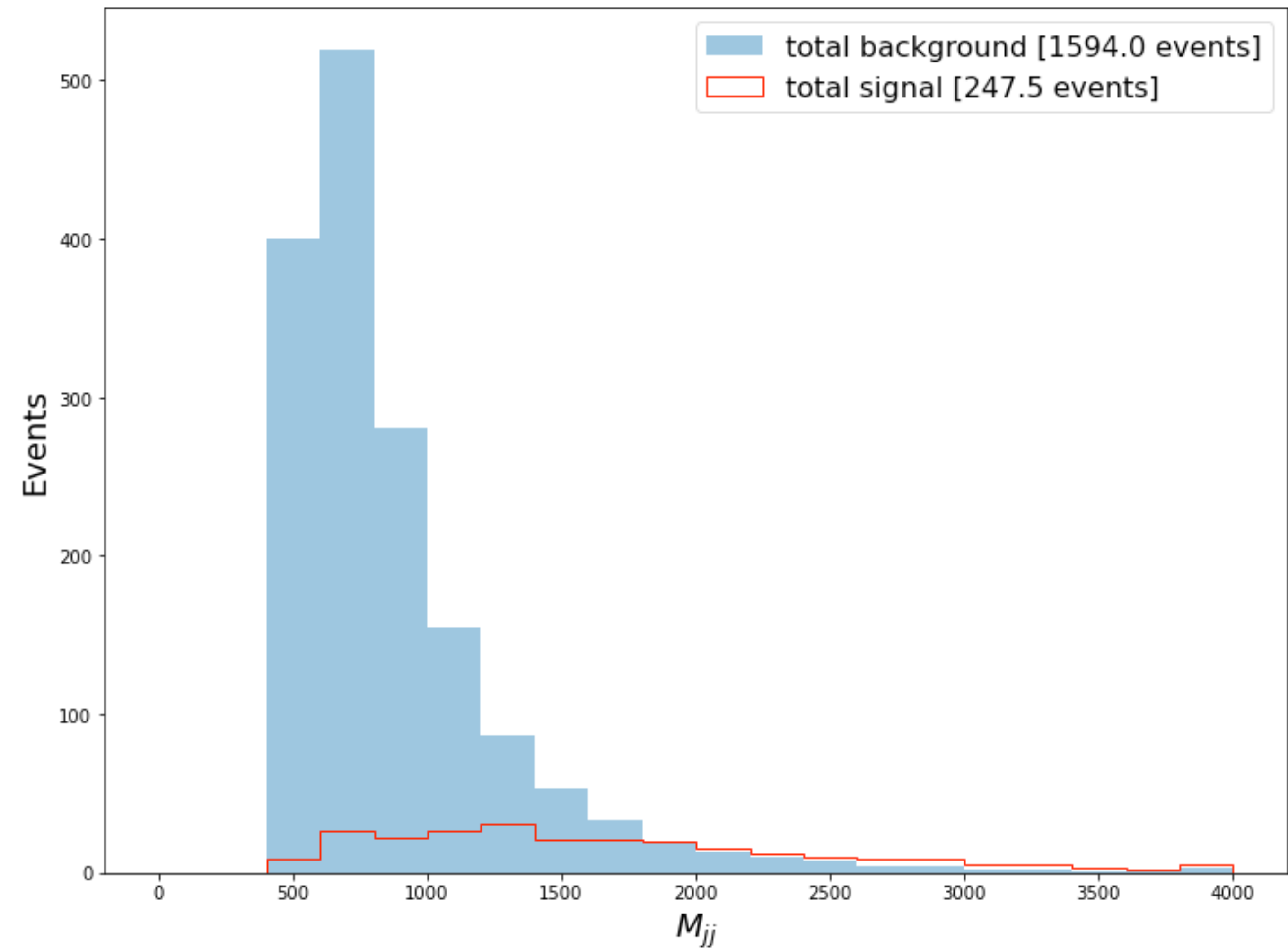
- Ak8 jet passing selection w/ max(PNet Hbb vs. QCD) is selected as the Hbb jet
- Variables left to play with (next slides):
 - VBS kinematics: M_{jj} , $\Delta\eta_{jj}$
 - WH kinematics: $L_T = p_T(\ell) + \text{MET}$, $S_T = L_T + p_T(\text{Hbb fat jet})$, Hbb vs. QCD ParticleNet score

Lepton Charge Asymmetry



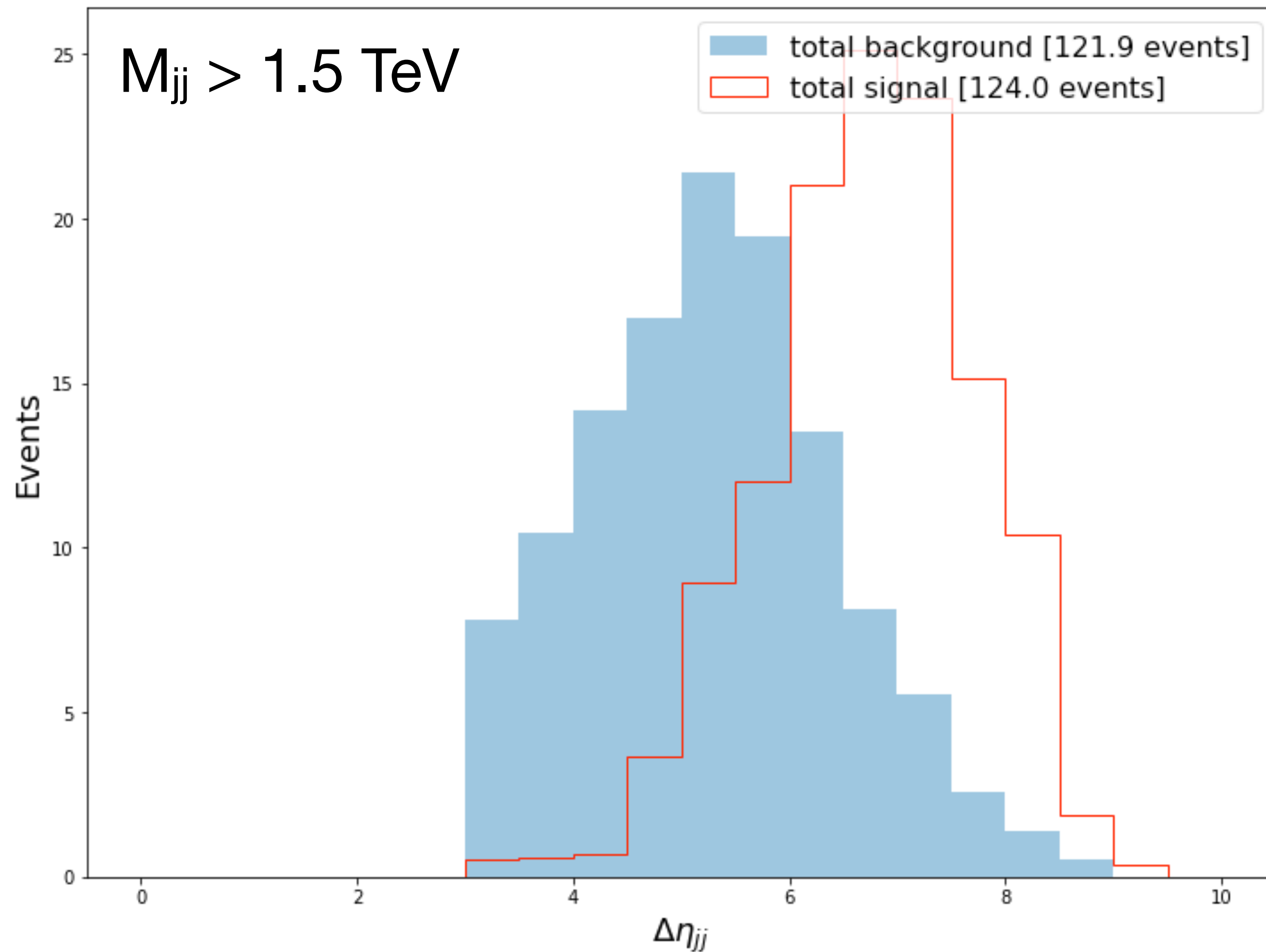
Similar to SS VBS WWH analysis
⇒ separate into e^+ , μ^+ , ℓ^- channels?

VBS Kinematics: M_{jj}



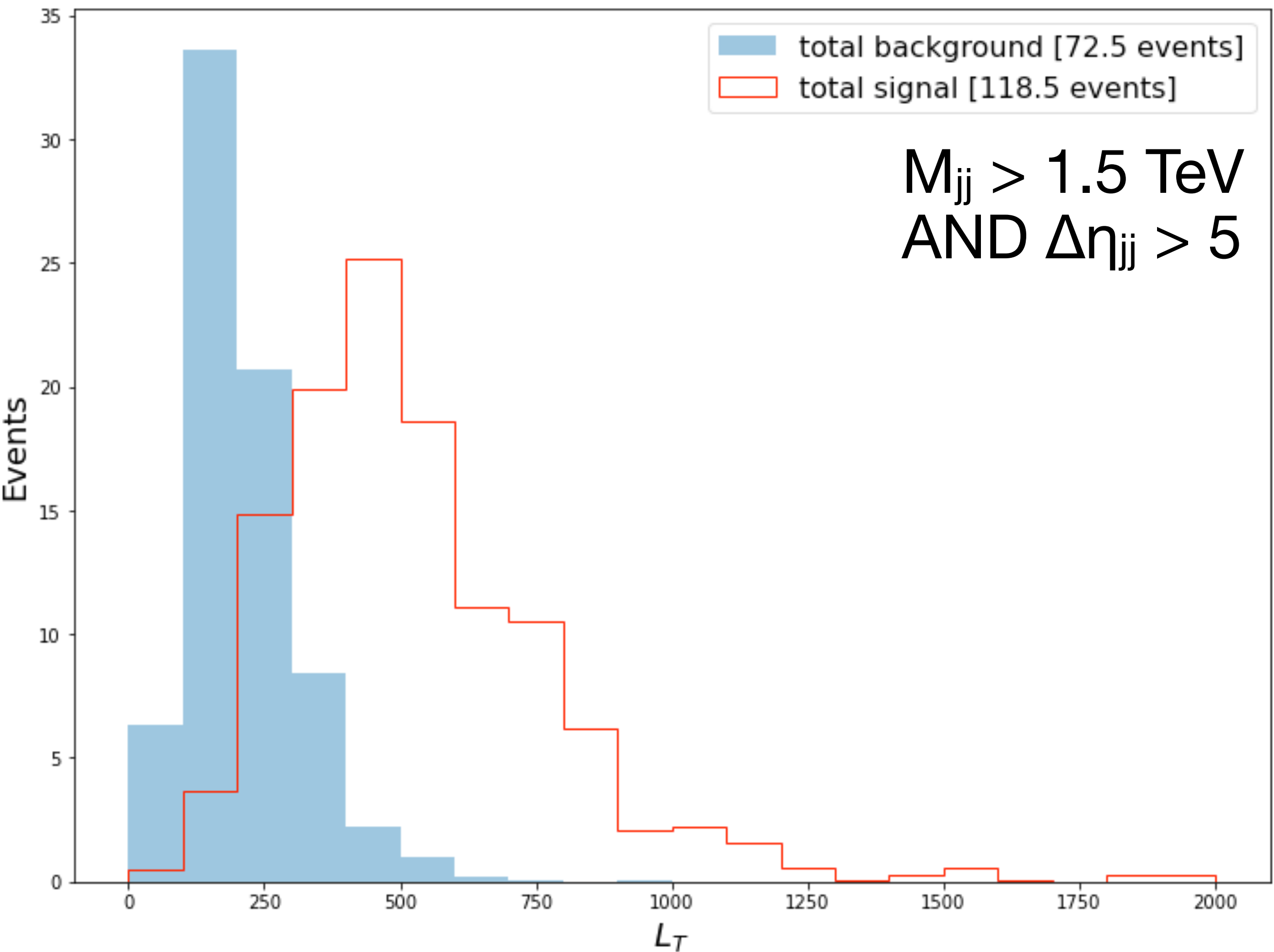
Cut	VBSWH (kW < 0)	TotalBkg	S/ $\sqrt{B}$
Preselection	247.51	1594.10	6.20
$M_{jj} > 1 \text{ TeV}$	190.41	393.43	9.60
$M_{jj} > 1.5 \text{ TeV}$	123.97	121.90	11.23
$M_{jj} > 2 \text{ TeV}$	73.39	45.70	10.86
$M_{jj} > 2.5 \text{ TeV}$	41.22	19.41	9.36

VBS Kinematics: $\Delta\eta_{jj}$



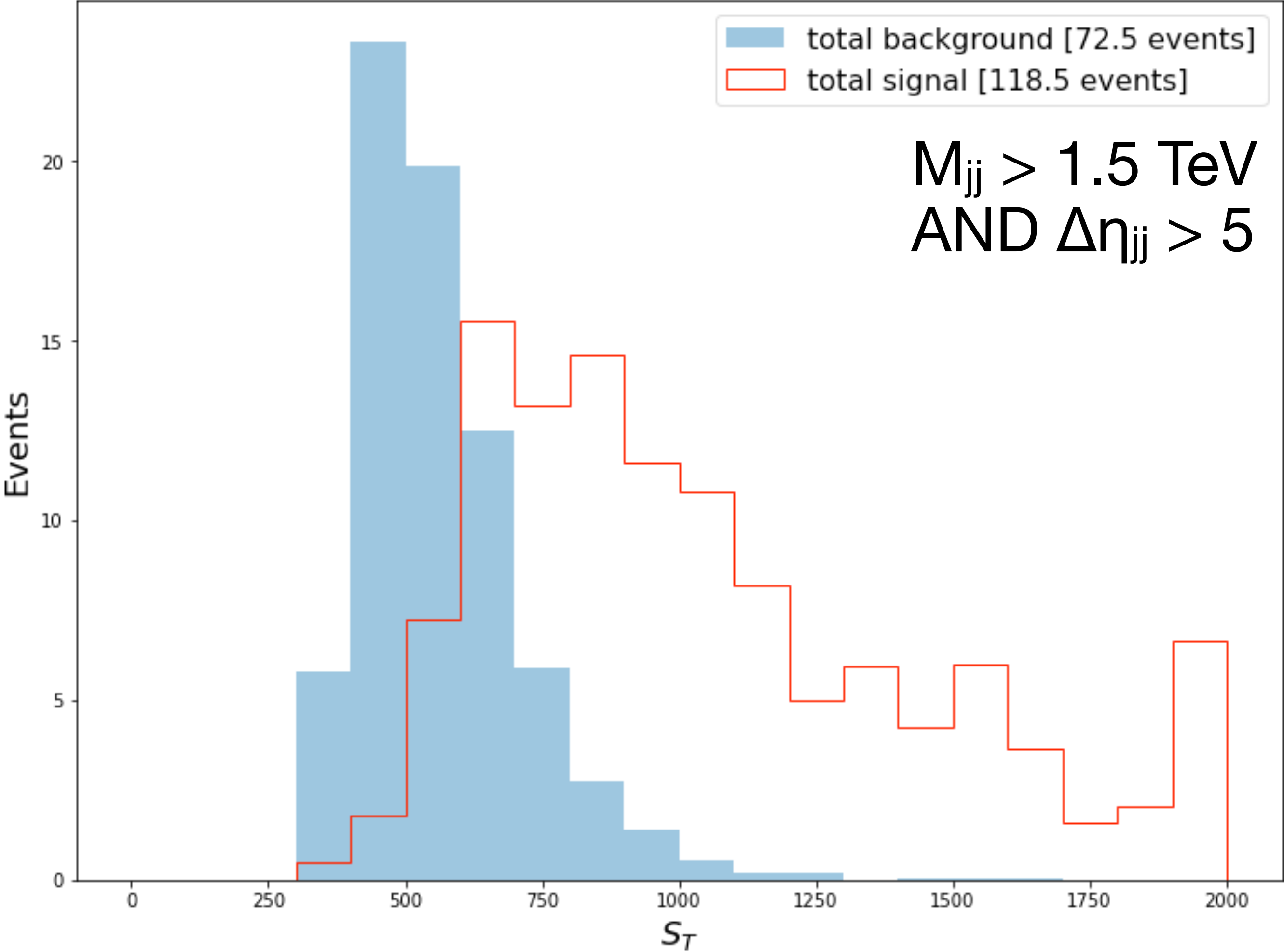
Cut	VBSWH (kW < 0)	TotalBkg	S/ $\sqrt{B}$
$M_{jj} > 1.5 \text{ TeV}$	123.97	121.90	11.23
$\Delta\eta_{jj} > 3.5$	123.46	114.07	11.56
$\Delta\eta_{jj} > 4$	122.86	103.65	12.07
$\Delta\eta_{jj} > 4.5$	122.18	89.49	12.91
$\Delta\eta_{jj} > 5$	118.53	72.50	13.92
$\Delta\eta_{jj} > 5.5$	109.61	51.13	15.33
$\Delta\eta_{jj} > 6$	97.58	31.70	17.33
$\Delta\eta_{jj} > 6.5$	76.56	18.16	17.96
$\Delta\eta_{jj} > 7$	51.42	10.04	16.23

WH Kinematics: $L_T = p_T(\ell) + \text{MET}$



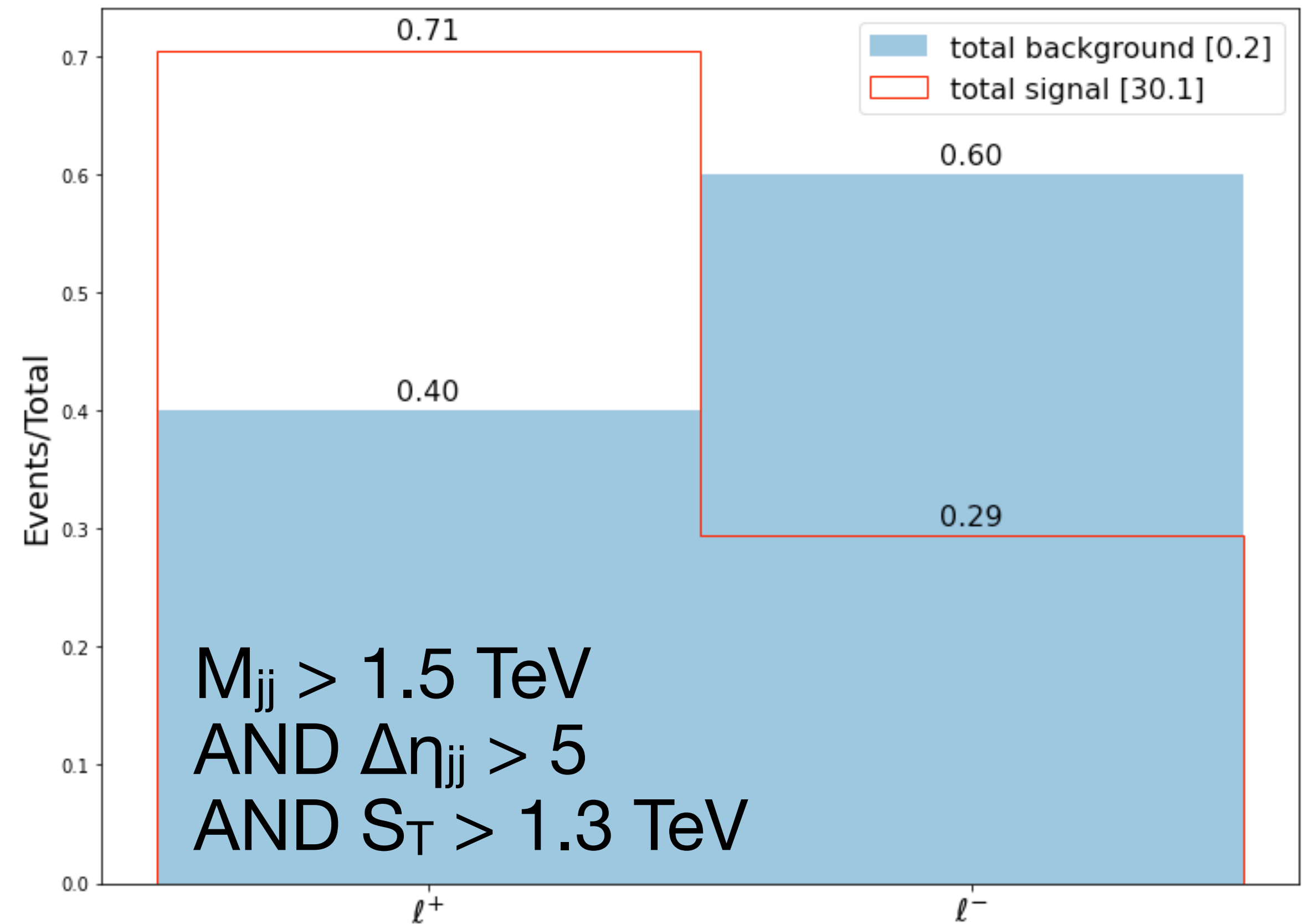
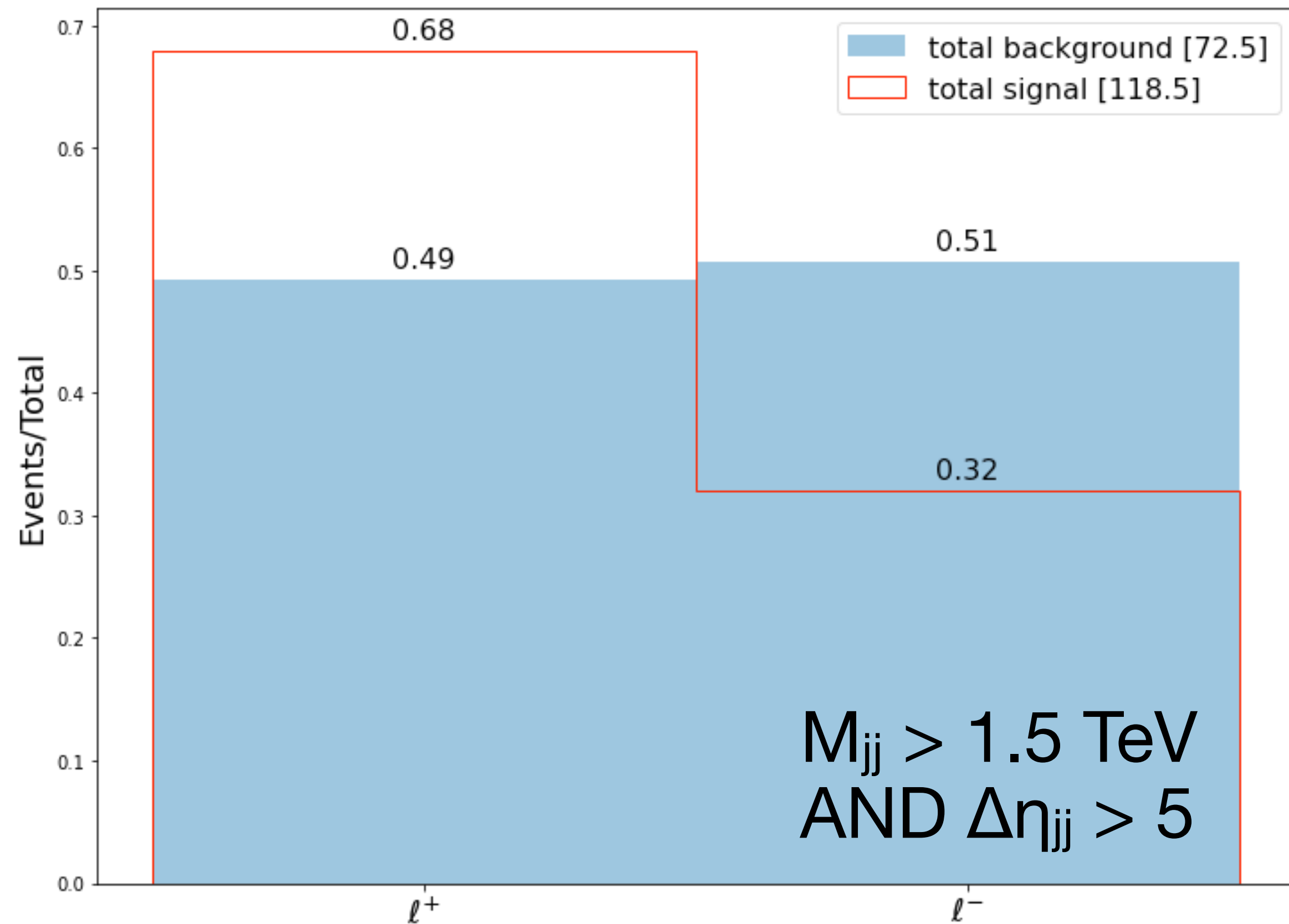
Cut	VBSWH (kW < 0)	TotalBkg	S/ $\sqrt{B}$
$M_{jj} > 1.5 \text{ TeV}$ AND $\Delta\eta_{jj} > 5$	118.53	72.50	13.92
$L_T > 100 \text{ GeV}$	118.02	66.18	14.51
$L_T > 200 \text{ GeV}$	114.37	32.57	20.04
$L_T > 300 \text{ GeV}$	99.53	11.91	28.84
$L_T > 400 \text{ GeV}$	79.62	3.51	42.52
$L_T > 500 \text{ GeV}$	54.48	1.28	48.17
$L_T > 600 \text{ GeV}$	35.90	0.29	66.40
$L_T > 700 \text{ GeV}$	24.83	0.11	76.56
$L_T > 800 \text{ GeV}$	14.29	0.06	58.66
$L_T > 900 \text{ GeV}$	8.07	0.05	36.62
$L_T > 1 \text{ TeV}$	5.96	0.00	239.16

WH Kinematics: $S_T = L_T + p_T(\text{Hbb Ak8 jet})$



Cut	VBSWH (kW < 0)	TotalBkg	S/ $\sqrt{B}$
$M_{jj} > 1.5 \text{ TeV}$ $\text{AND } \Delta\eta_{jj} > 5$	118.53	72.50	13.92
$S_T > 1 \text{ TeV}$	54.13	1.10	51.63
$S_T > 1.1 \text{ TeV}$	43.33	0.58	56.70
$S_T > 1.2 \text{ TeV}$	35.12	0.37	57.74
$S_T > 1.3 \text{ TeV}$	30.11	0.17	72.36
$S_T > 1.4 \text{ TeV}$	24.15	0.16	59.83
$S_T > 1.5 \text{ TeV}$	19.90	0.11	58.76
$S_T > 1.6 \text{ TeV}$	13.93	0.06	59.22
$S_T > 1.7 \text{ TeV}$	10.28	0.00	412.26
$S_T > 1.8 \text{ TeV}$	8.67	0.00	540.82
$S_T > 1.9 \text{ TeV}$	6.62	0.00	413.10

Lepton Charge Asymmetry

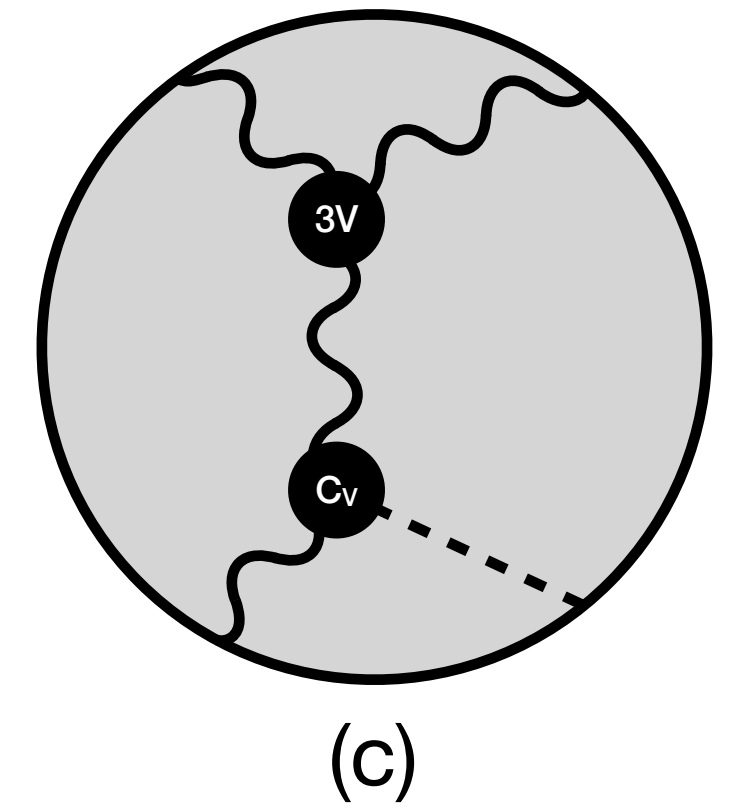
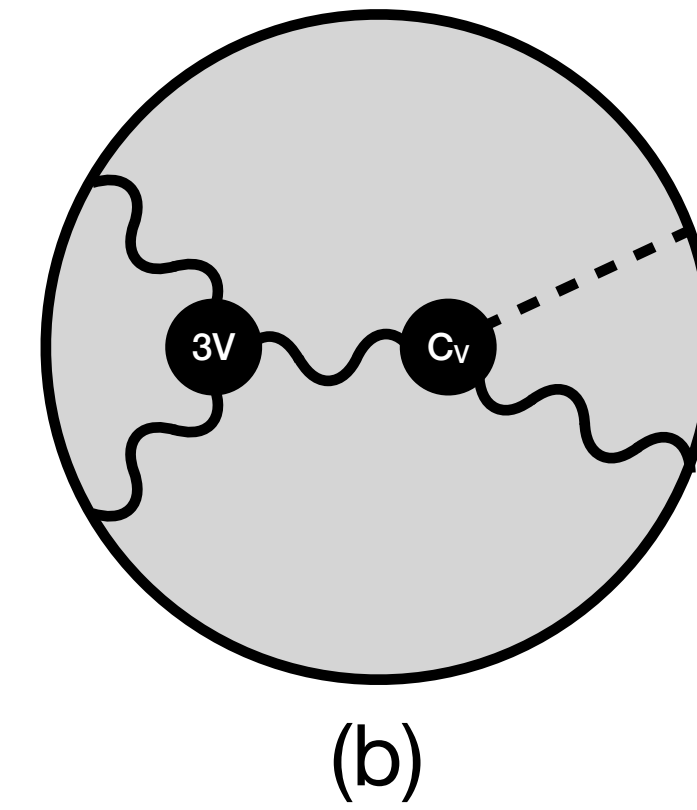
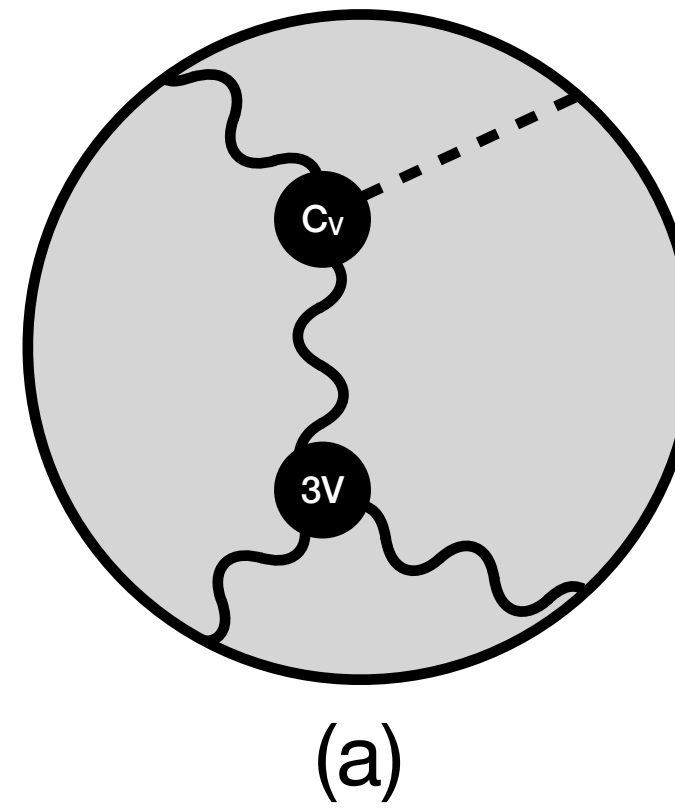
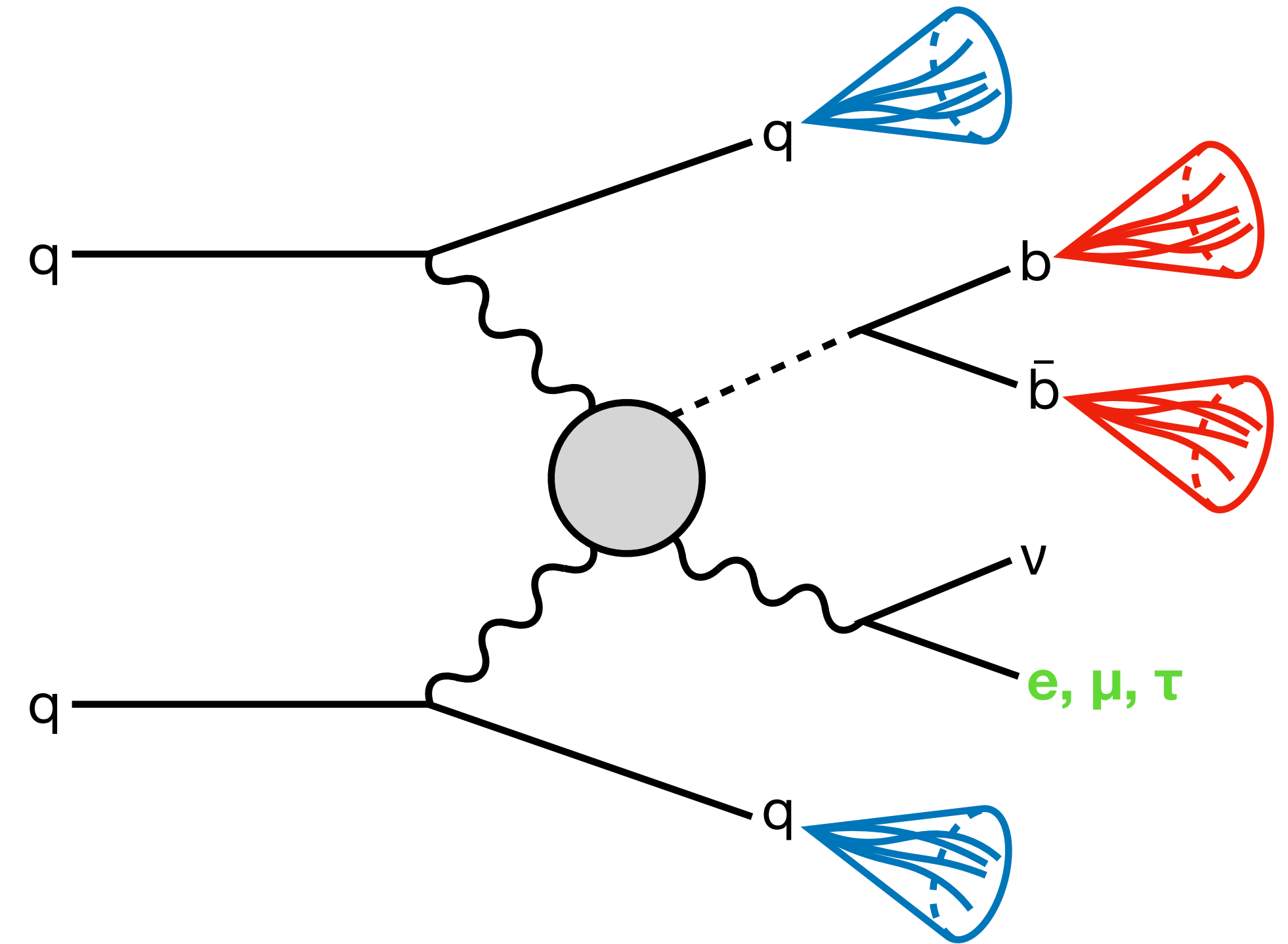


More background with ℓ^- after tighter cuts

Backup

Target Final State

- Targeting **VBS** $WH \rightarrow \ell \nu b \bar{b}$
- Sensitive to $\kappa_V \rightarrow \lambda_{WZ} = \kappa_Z/\kappa_W$
 - Handle for ruling out $\lambda_{WZ} < 0$ (BSM)
- VBS WH BSM kinematics:
 - High- p_T H and W (high S_T)
 - VBS jets with large $\Delta\eta_{jj}$, M_{jj}

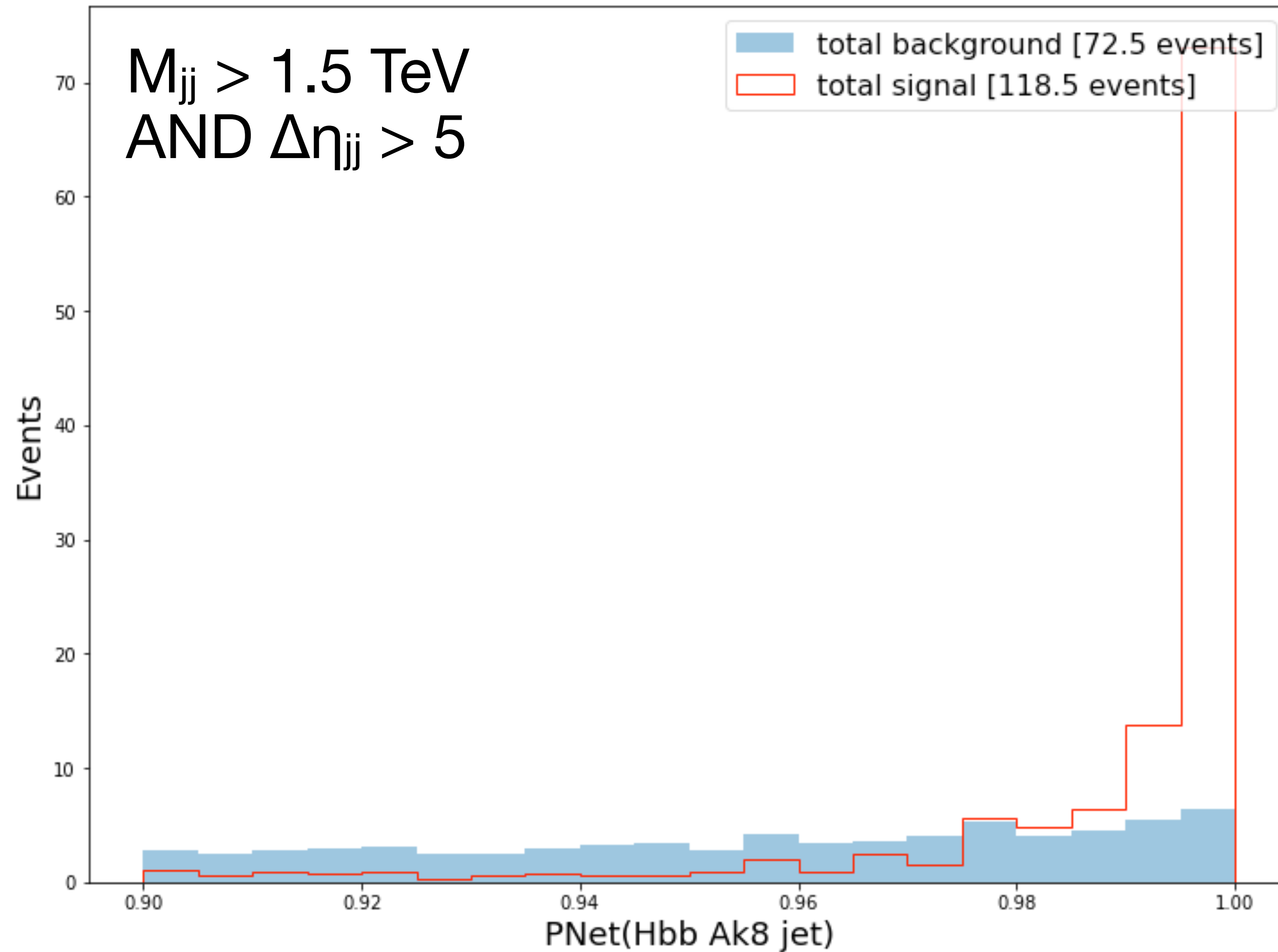




VBS WH Cutflow

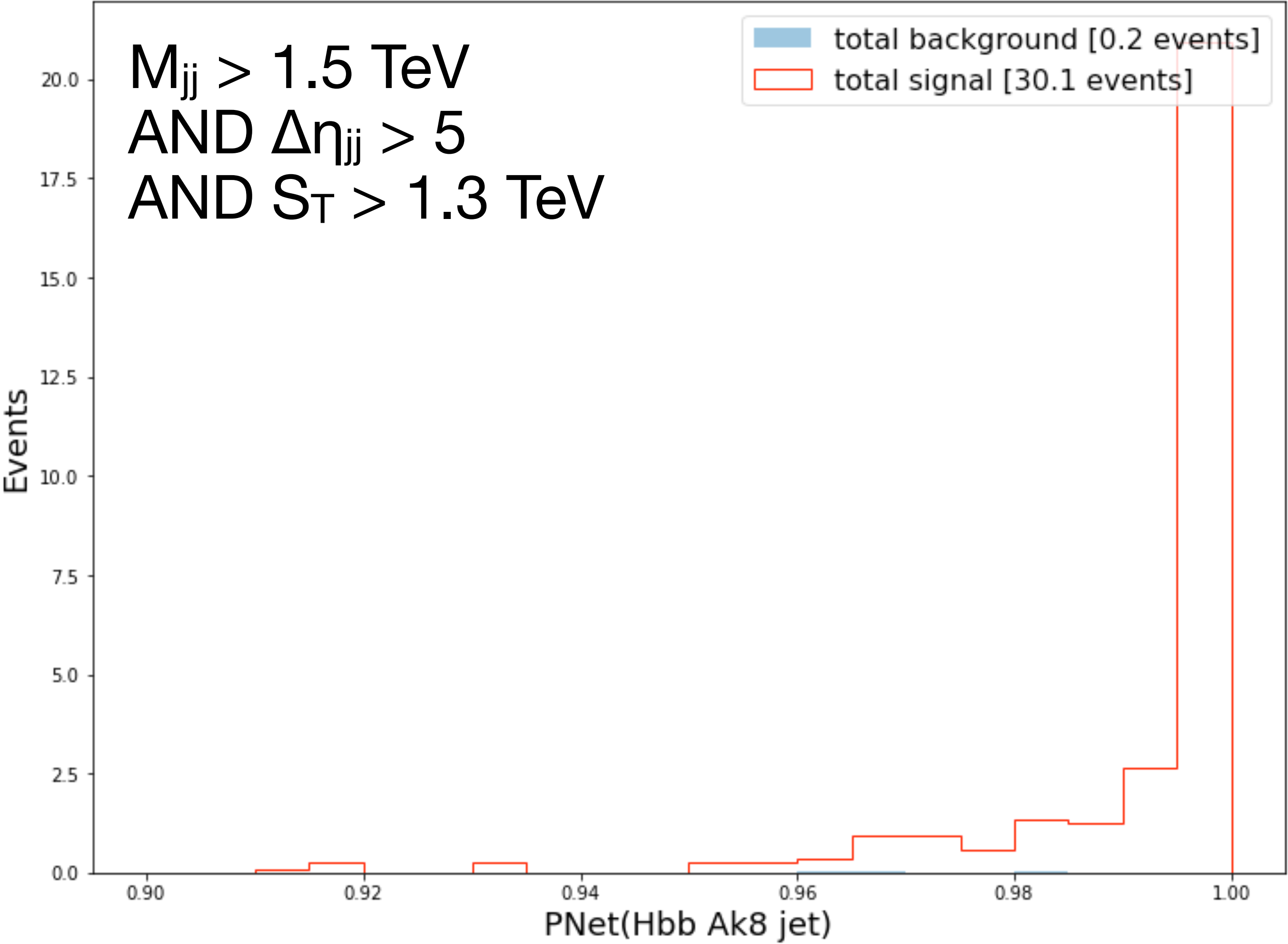
	VHToNonbb		VV/VVV/VBSWZ		W+Jets		TTbar+X		TTbar1L		TTbar2L		TotalBkg		VBSWH (kW < 0)	
cut	raw	wgt	raw	wgt	raw	wgt	raw	wgt	raw	wgt	raw	wgt	raw	wgt	raw	wgt
Bookkeeping	1637	167.20	296595	1682.82	430128	32662.10	2960671	3676.56	9439330	430420.00	962161	34119.54	14090522	502728.22	399989	59617.33
SelectLeptons	1637	167.20	296595	1682.82	430128	32662.10	2960671	3676.56	9439330	430420.00	962161	34119.54	14090522	502728.22	399989	59617.33
Has1TightLep	1637	167.20	296595	1682.82	430128	32662.10	2960671	3676.56	9439330	430420.00	962161	34119.54	14090522	502728.22	73481	10992.67
LepPtGt40	1330	134.51	236196	1328.10	331677	26056.77	2229901	2744.54	7315482	331902.50	717050	25374.77	10831636	387541.19	60719	9070.38
SelectFatJets	1330	134.51	236196	1328.10	331677	26056.77	2229901	2744.54	7315482	331902.50	717050	25374.77	10831636	387541.19	60719	9070.38
Geq1FatJet	1317	134.75	232351	1310.99	324702	25501.66	2195215	2707.36	7268198	329709.20	665489	23536.49	10687272	382900.44	22019	3280.86
SelectHbbFatJet	1317	134.75	232351	1310.99	324702	25501.66	2195215	2707.36	7268198	329709.20	665489	23536.49	10687272	382900.44	22019	3280.86
PNetHbbScoreGt0p9	524	52.86	99990	692.78	81022	5851.26	849107	1005.57	2544585	114900.90	270367	9552.56	3845595	132055.94	8992	1344.23
SelectJetsNoHbbOverlap	524	52.86	99990	692.78	81022	5851.26	849107	1005.57	2544585	114900.90	270367	9552.56	3845595	132055.94	8992	1344.23
SelectVBSJetsMaxE	232	16.38	68999	220.91	61298	3224.48	759911	899.00	1926126	87069.10	188949	6693.48	3005515	98123.35	6209	929.23
MjjGt500detajjGt3	5	0.21	954	7.43	1392	87.64	4722	5.53	30145	1342.52	4316	150.77	41534	1594.10	1661	247.51

WH Kinematics: ParticleNet Hbb vs. QCD



Cut	VBSWH (kW < 0)	TotalBkg	S/ $\sqrt{B}$
$M_{jj} > 1.5 \text{ TeV}$ AND $\Delta\eta_{jj} > 5$	118.53	72.50	13.92
PNet(Hbb Ak8 jet) > 0.91	116.91	67.28	14.25
PNet(Hbb Ak8 jet) > 0.92	115.27	61.54	14.69
PNet(Hbb Ak8 jet) > 0.93	114.17	56.06	15.25
PNet(Hbb Ak8 jet) > 0.94	112.89	50.64	15.86
PNet(Hbb Ak8 jet) > 0.95	111.70	43.93	16.85
PNet(Hbb Ak8 jet) > 0.96	108.89	36.97	17.91
PNet(Hbb Ak8 jet) > 0.97	105.49	29.89	19.29
PNet(Hbb Ak8 jet) > 0.98	98.26	20.49	21.71
PNet(Hbb Ak8 jet) > 0.99	86.93	11.81	25.29

WH Kinematics: ParticleNet Hbb vs. QCD



Cut	VBSWH (kW < 0)	TotalBkg	S/ $\sqrt{B}$
$M_{jj} > 1.5 \text{ TeV}$ $\text{AND } \Delta\eta_{jj} > 5$ $\text{AND } S_T > 1.3 \text{ TeV}$	30.11	0.17	72.36
PNet(Hbb Ak8 jet) > 0.91	30.11	0.17	72.36
PNet(Hbb Ak8 jet) > 0.92	29.77	0.17	71.92
PNet(Hbb Ak8 jet) > 0.93	29.77	0.16	74.19
PNet(Hbb Ak8 jet) > 0.94	29.52	0.15	76.08
PNet(Hbb Ak8 jet) > 0.95	29.52	0.15	76.08
PNet(Hbb Ak8 jet) > 0.96	29.01	0.15	74.82
PNet(Hbb Ak8 jet) > 0.97	27.73	0.05	129.80
PNet(Hbb Ak8 jet) > 0.98	26.20	0.05	122.65
PNet(Hbb Ak8 jet) > 0.99	23.58	0.00	971.72