VBS WH Analysis

A closer look at ABCD systematics

February 10th, 2023

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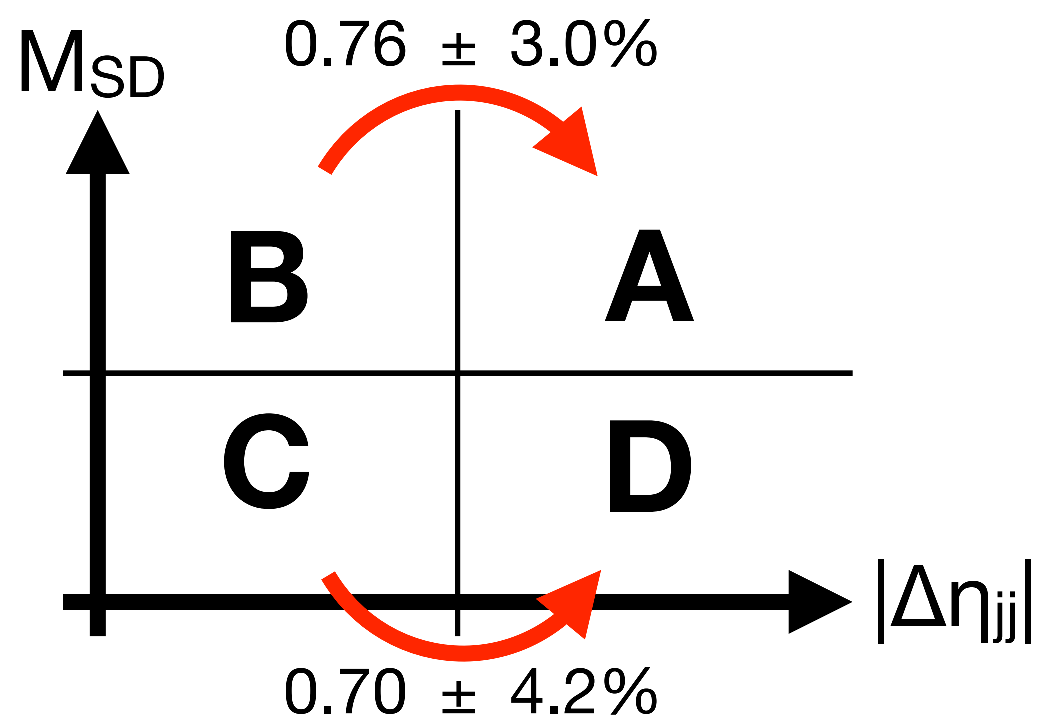
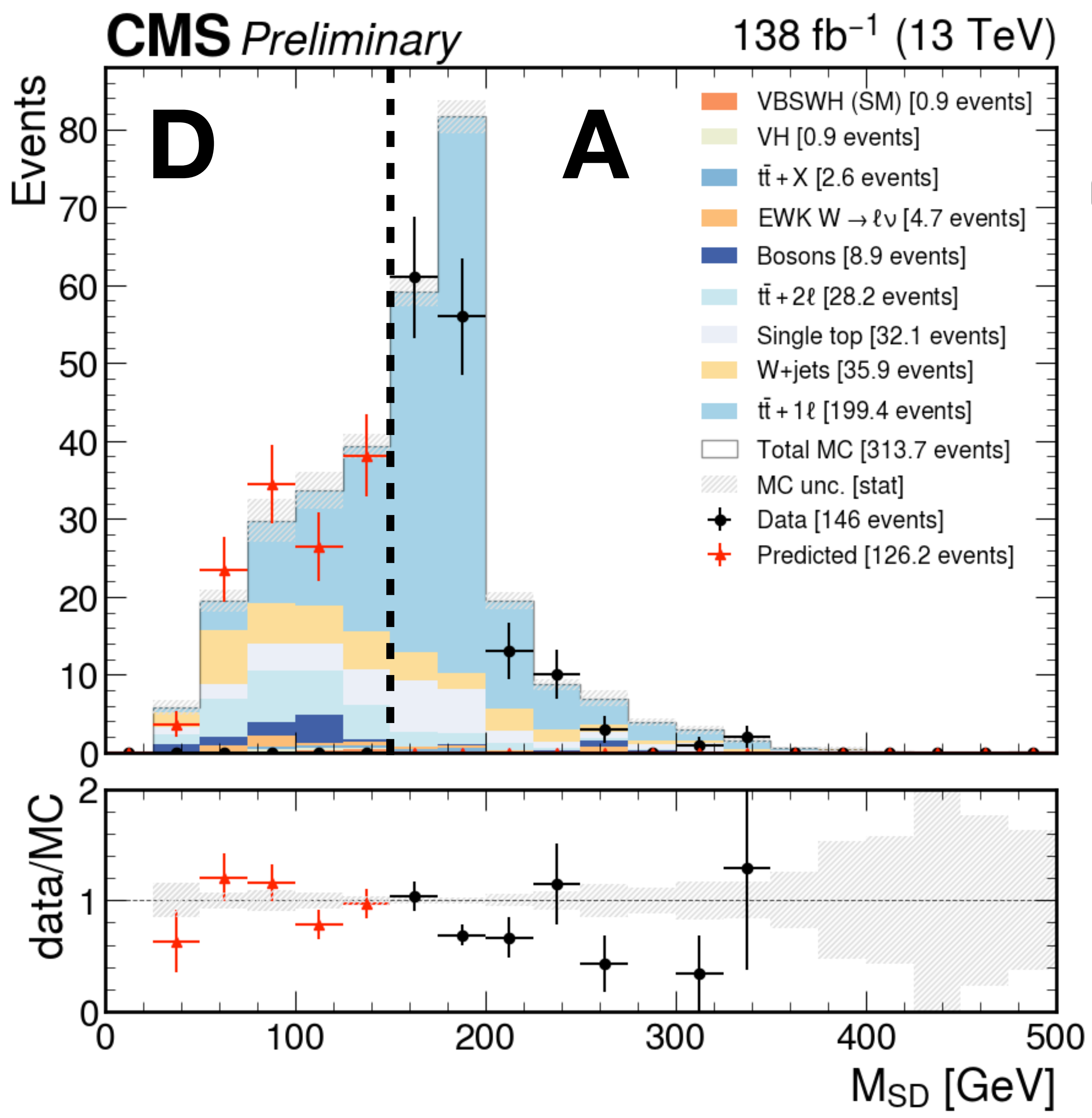
ABCD: $\Delta\eta_{jj}$ vs. M_{SD}

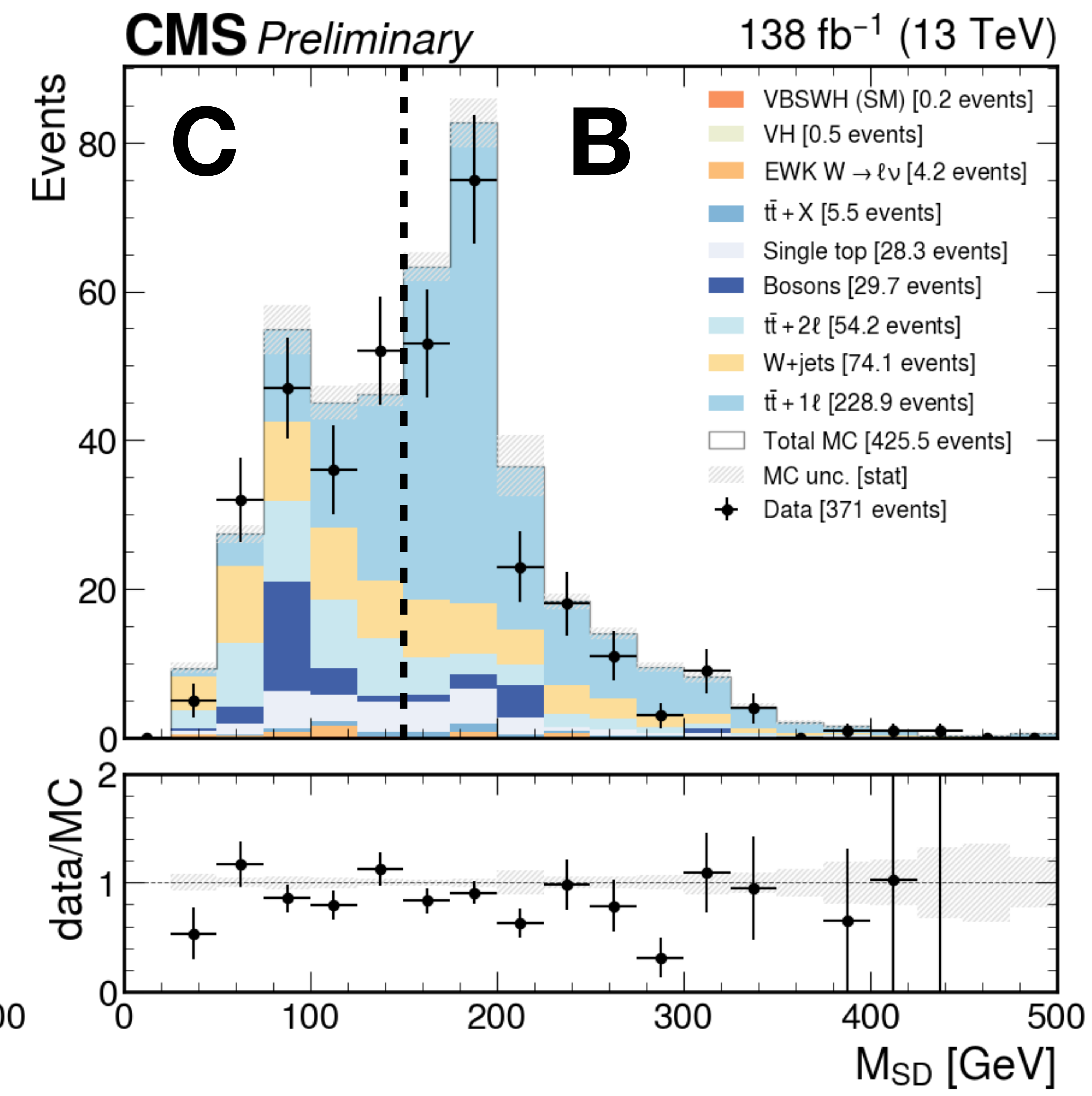
Preselection AND M_{jj} > 600 GeV AND S_T > 900 GeV AND PNet Xbb > 0.9

Cut	Region	Bkg. (wgt)	Bkg. Err.*	Sig. (wgt)	Sig. Err.*	Data	Data Err.*
$\|\Delta\eta_{jj}\|$ > 4 AND M_{SD} ≥ 150 GeV	A	185.64	3.40	12.57	1.55	146	12.08
$\|\Delta\eta_{jj}\|$ ≤ 4 AND M_{SD} ≥ 150 GeV	B	242.73	5.86	0.94	0.42	199	14.11
$\|\Delta\eta_{jj}\|$ ≤ 4 AND M_{SD} < 150 GeV	C	182.62	4.54	16.35	1.80	172	13.11
$\|\Delta\eta_{jj}\|$ > 4 AND M_{SD} < 150 GeV (SR)	D	127.13	4.23	410.10	8.88	—	—



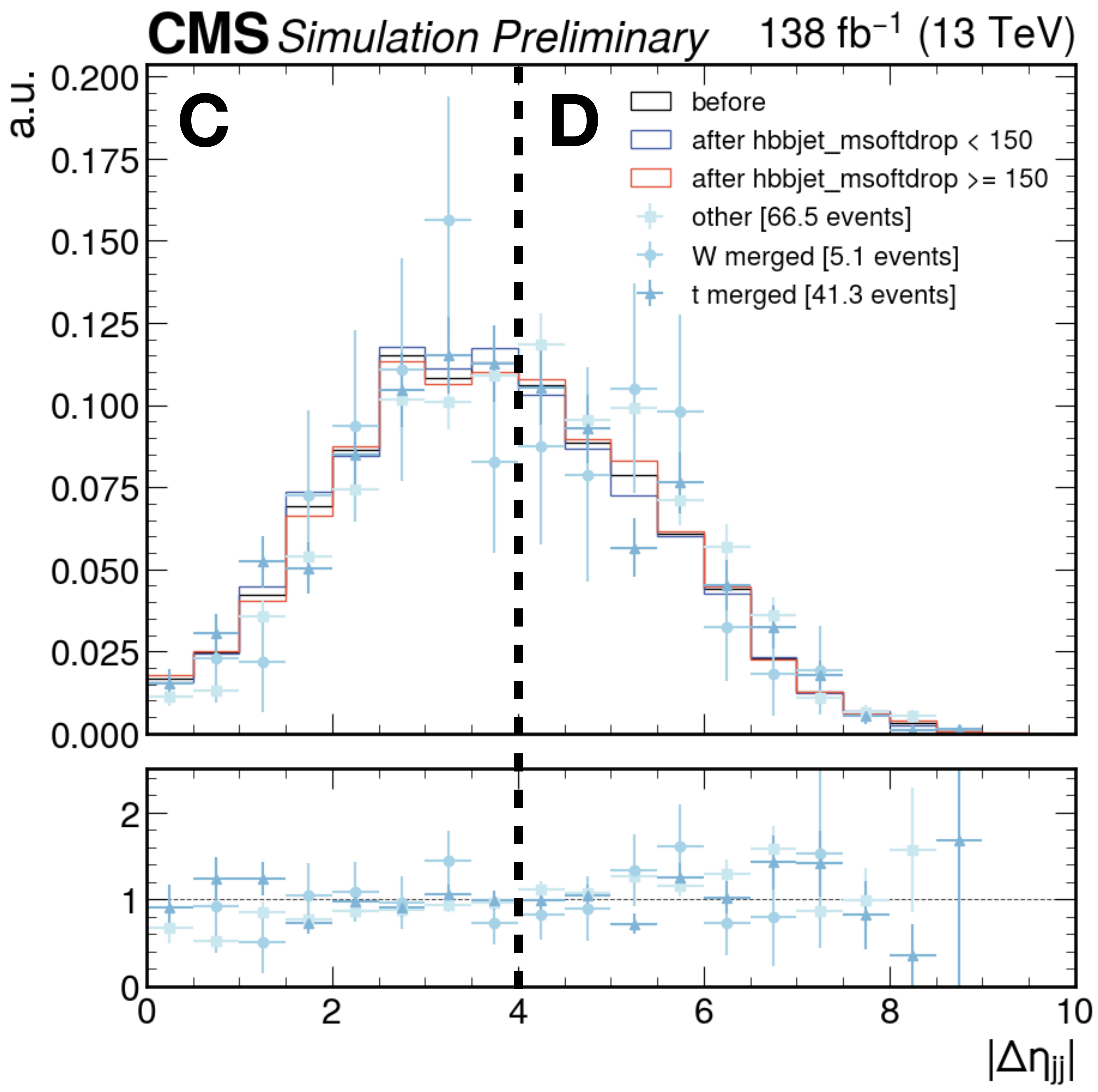
- Concern from Loukas:
  - AB likely has mostly t-merged fake Hbb fat jet
  - CD likely has more W-merged fake Hbb fat jet
  - Can we faithfully apply A→B transfer factor to take C→D if the physics is different?

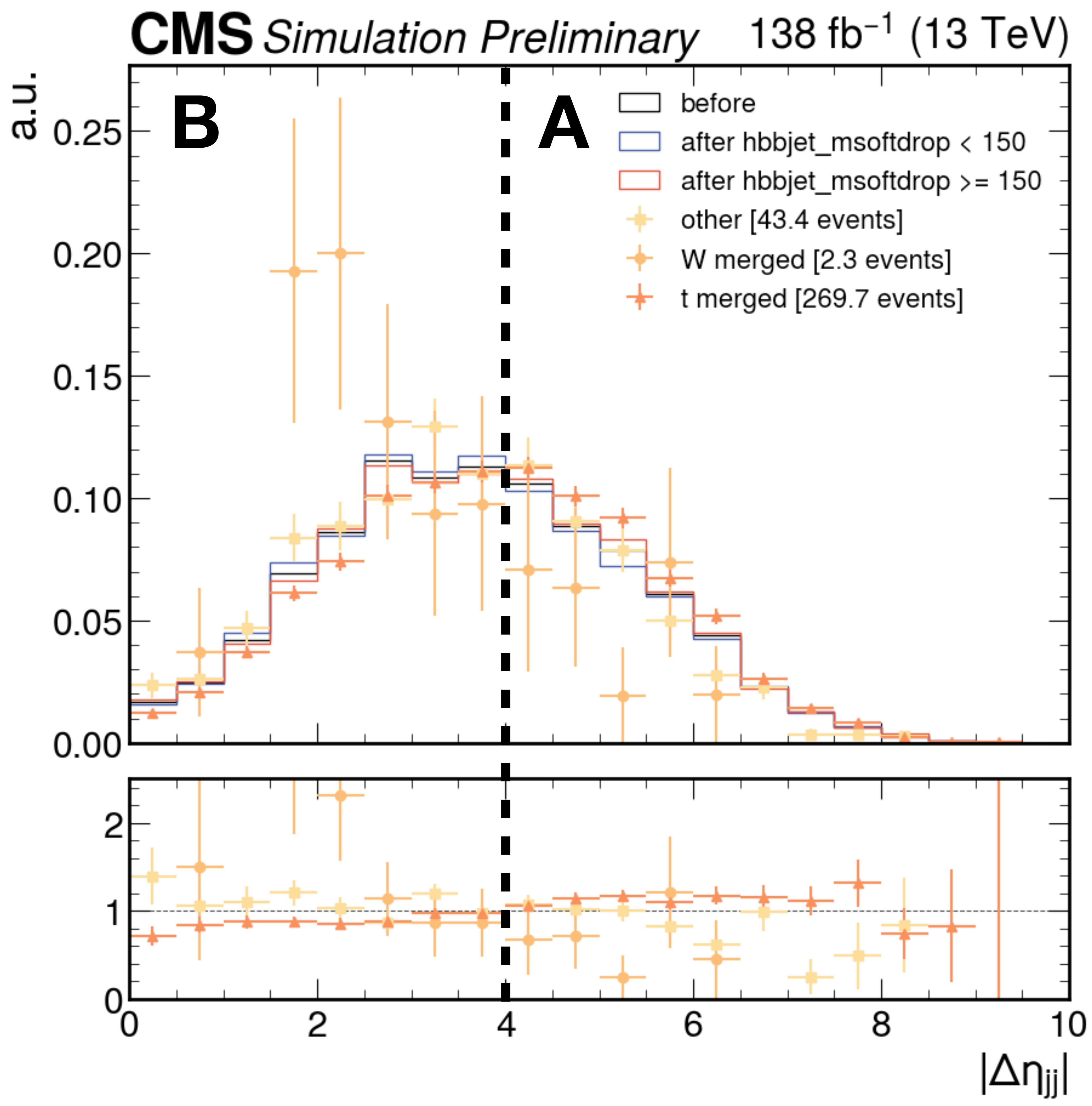


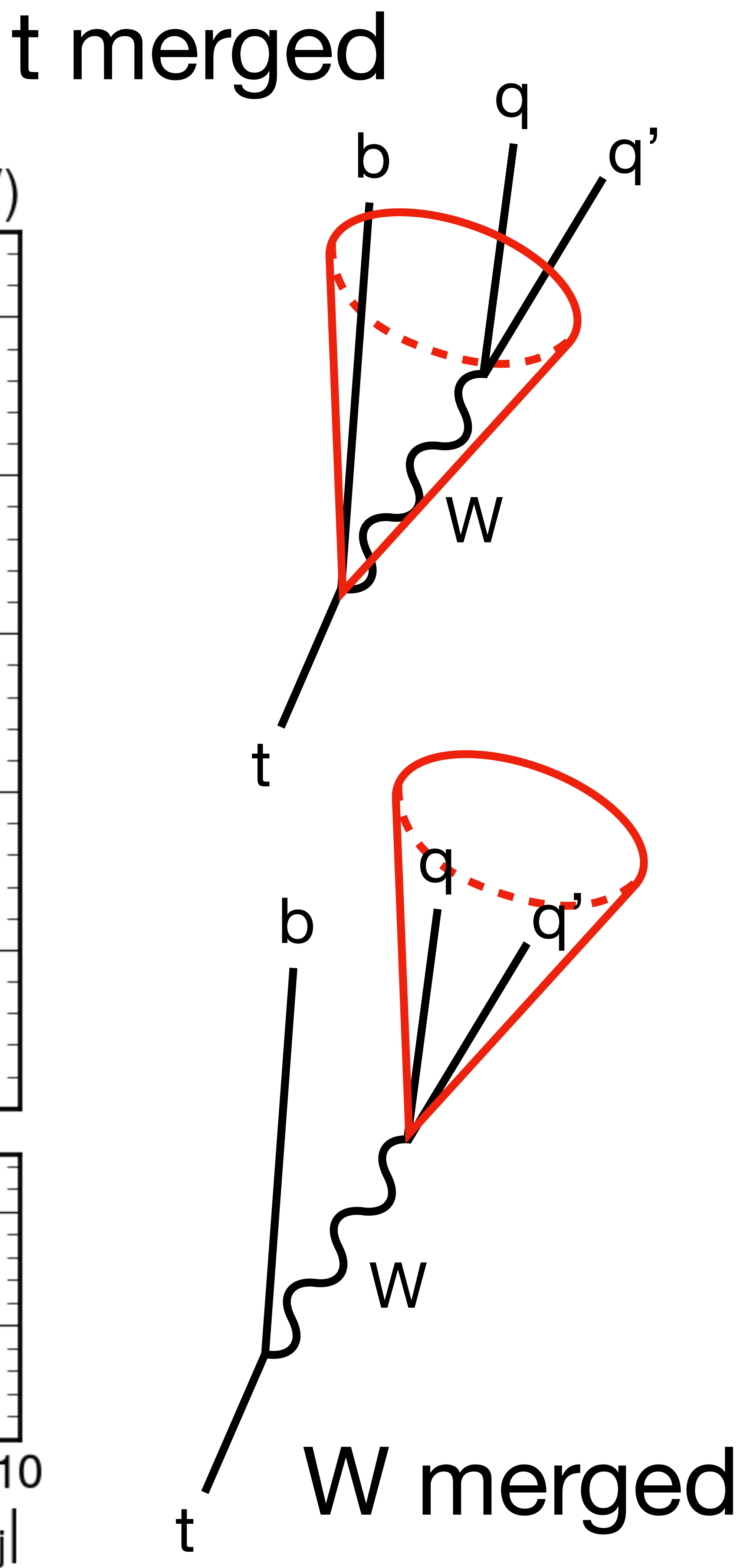


*err = $\sqrt{(\Sigma_i w_i^2)}$ for MC, $\sqrt{(\text{count})}$ for data

ABCD: Splitting ttbar+1ℓ







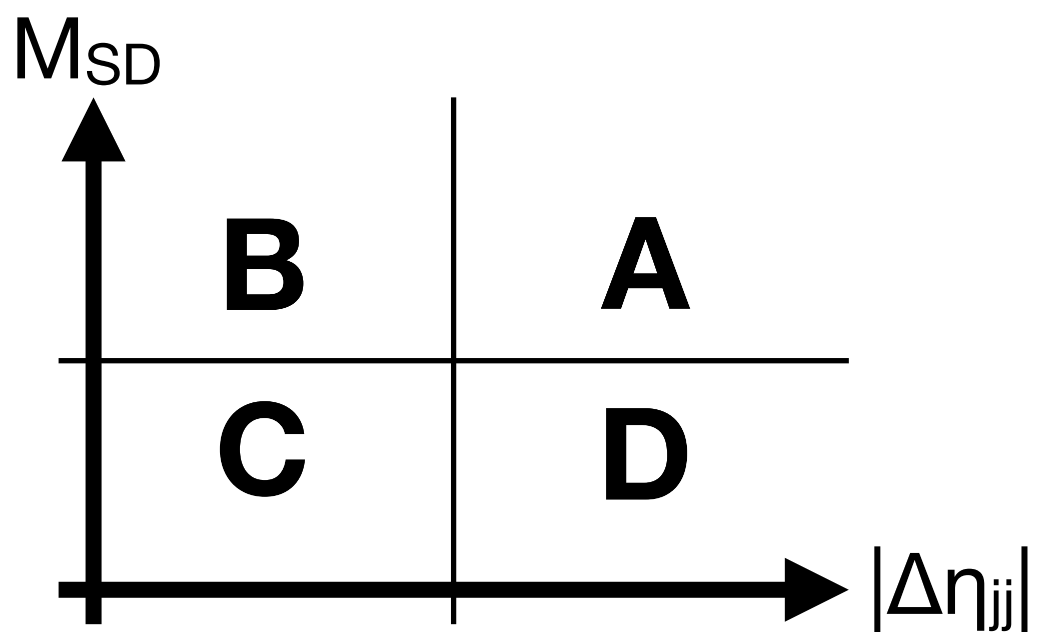
Some difference across B→A for W-merged $t\bar{t}$+1ℓ events (only 2 events)

UC San Diego

ABCD: Splitting ttbar+1ℓ

Could assign a larger systematic by adding systs for each sample in quadrature

Sample	A	B	C	A/B	D_{pred} = C*A/B	D	D - D_{pred}
Bosons	1.08	8.00	21.74	0.14	2.94 ± 0.89	7.85 ± 3.03	4.91
Single top	17.75	13.59	14.71	1.31	19.21 ± 0.17	14.36 ± 1.44	4.85
$t\bar{t}$+X	1.57	3.74	1.79	0.42	0.75 ± 0.12	1.00 ± 0.11	0.25
$t\bar{t}$+1ℓ	145.99	169.37	59.48	0.86	51.28 ± 0.04	53.41 ± 1.65	2.13
$t\bar{t}$+1ℓ (t-merged)	128.41	141.29	23.36	0.91	21.23 ± 0.05	17.94 ± 0.96	3.29
$t\bar{t}$+1ℓ (W-merged)	0.57	1.73	2.84	0.33	0.93 ± 0.35	2.23 ± 0.34	1.29
$t\bar{t}$+1ℓ (other)	17.02	26.35	33.28	0.65	21.50 ± 0.08	33.24 ± 1.30	11.75
$t\bar{t}$+2ℓ	5.39	15.63	38.55	0.35	13.30 ± 0.10	22.85 ± 0.97	9.55
VH	0.03	0.02	0.44	1.59	0.70 ± 0.55	0.90 ± 0.41	0.20
W+jets	12.17	30.94	43.18	0.39	16.98 ± 0.07	23.74 ± 1.41	6.76
EWK W→ℓν	1.65	1.45	2.73	1.14	3.12 ± 0.78	3.02 ± 0.88	0.10
Total	185.64	242.73	182.62	0.76	139.67	127.13	12.55



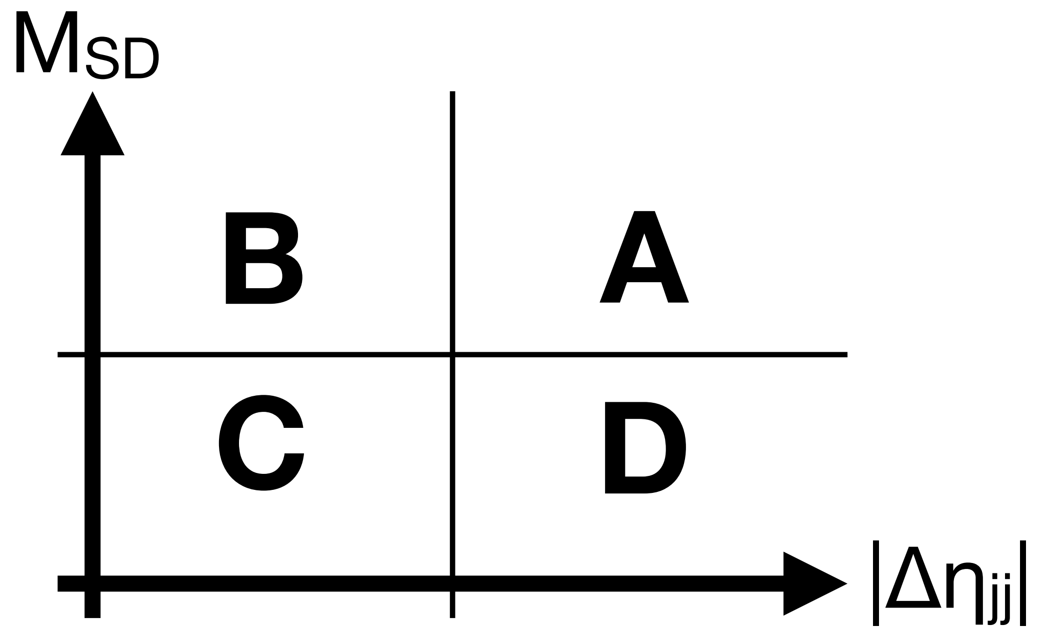
Current syst: 9.9%

Sample-split syst: 10.8%

Sample-split ($t\bar{t}$+1ℓ split) syst: 14.4%

Summary

- There is indeed some difference across B→A for W-merged “Hbb” fat jets in $t\bar{t}$+1ℓ
  - Only 2 events, though, so not a significant effect
  - t-merged and W-merged look fine
- To address future concerns about applying ABCD to all backgrounds, could assign a larger systematic
  - Does not matter much in the end and is probably overkill



Backup

MC Samples: 2016

Process	Sample Name	σ [pb]
SingleTop	/ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8[0]	136.02
	/ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8[0]	19.559
	/ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8[0]	19.559
	/ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8[0]	80.95
TTbar1L	/TTToSemiLeptonic_TuneCP5_13TeV-powheg-pythia8[0]	373.9093904
TTbar2L	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8[0]	94.936764
TTX	/TTToHadronic_TuneCP5_13TeV-powheg-pythia8[0]	367.825066
	/TTWJetsToLNu_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8[1]	0.2043
	/TTZToLLNuNu_M-10_TuneCP5_13TeV-amcatnlo-pythia8[0]	0.2529
	/ttHTobb_M125_TuneCP5_13TeV-powheg-pythia8[1]	0.1279
	/ttHToNonbb_M125_TuneCP5_13TeV-powheg-pythia8[1]	0.215
	/TTWZ_TuneCP5_13TeV-madgraph-pythia8[0]	0.003884
	/TTWW_TuneCP5_13TeV-madgraph-pythia8[0]	0.0115
	/TTbb_4f_TTTo2L2Nu_TuneCP5-Powheg-Openloops-Pythia8[0]	0.04
	/TTbb_4f_TTToSemiLeptonic_TuneCP5-Powheg-Openloops-Pythia8[0]	0.62
WJets	/WJetsToLNu_HT-70To100_TuneCP5_13TeV-madgraphMLM-pythia8[0]	1310.78
	/WJetsToLNu_HT-100To200_TuneCP5_13TeV-madgraphMLM-pythia8[0]	1325.9
	/WJetsToLNu_HT-200To400_TuneCP5_13TeV-madgraphMLM-pythia8[0]	348.5703
	/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8[0]	47.308275
	/WJetsToLNu_HT-600To800_TuneCP5_13TeV-madgraphMLM-pythia8[0]	11.358487
	/WJetsToLNu_HT-800To1200_TuneCP5_13TeV-madgraphMLM-pythia8[0]	5.2086934
	/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8[0]	1.1880809
	/WJetsToLNu_HT-2500ToInf_TuneCP5_13TeV-madgraphMLM-pythia8[1]	0.024098031
Bosons	/DYJetsToLL_M-10to50_TuneCP5_13TeV-madgraphMLM-pythia8[0]	20657.0
	/DYJetsToLL_M-50_TuneCP5_13TeV-madgraphMLM-pythia8[0]	6198.0
	/EWKWplus2Jets_WToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[0]	10.67
	/EWKWminus2Jets_WToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[0]	10.67
	/EWKZ2Jets_ZToLL_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	6.22
	/EWKZ2Jets_ZToNuNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[1]	10.72
	/EWKZ2Jets_ZToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[0]	10.67
	/WWTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	49.997
	/WWTolnulnu_TuneCP5_13TeV-madgraph-pythia8[0]	12.178
	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8[0]	12.178
	/WZTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	49.997
	/WZTo1L3Nu_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	3.054024
	/WZTo2Q2L_mllmin4p0_TuneCP5_13TeV-amcatnloFXFX-pythia8[1]	5.6
	/WZTo3LNu_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	4.42965
	/ZZTo2Q2L_mllmin4p0_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	3.28
	/ZZTo2L2Nu_TuneCP5_13TeV_powheg_pythia8[0]	0.564
	/ZZTo4L_M-1toInf_TuneCP5_13TeV_powheg_pythia8[0]	1.256
	/WWW_4F_TuneCP5_13TeV-amcatnlo-pythia8[2]	0.2086
	/WWZ_4F_TuneCP5_13TeV-amcatnlo-pythia8[2]	0.1651
	/WZZ_TuneCP5_13TeV-amcatnlo-pythia8[2]	0.05565
	/ZZZ_TuneCP5_13TeV-amcatnlo-pythia8[2]	0.01398
	/WWJJToLNuLNu_EWK_noTop_TuneCP5_13TeV-madgraph-pythia8[0]	0.284
	/WZJJ_EWK_InclusivePolarization_TuneCP5_13TeV_madgraph-madspin-pythia8[0]	0.01701
	/ZZJJTo4L_TuneCP5_13TeV-madgraph-pythia8[1]	0.00884
EWKWLep	/EWKWPlus2Jets_WToLNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	39.33
	/EWKWMinus2Jets_WToLNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	32.26
VH	/VHToNonbb_M125_TuneCP5_13TeV-amcatnloFXFX_madspin_pythia8[1]	2.207
	/WminusH_HToBB_WToLNu_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.04901236122
	/WplusH_HToBB_WToLNu_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.08487599411
	/ZH_HToBB_ZToLL_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.02627486511
	/ggZH_HToBB_ZToLL_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.002461395396

[0] /RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
[1] /RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM
[2] /RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext1-v1/NANOAODSIM

Table 1: Background MC samples used in this analysis, corresponding to 2016preVFP detector conditions (UL), with their respective cross sections in picobarns.

Process	Sample Name	σ [pb]
SingleTop	/ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8[0]	80.95
	/ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8[0]	136.02
	/ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8[1]	19.559
	/ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8[1]	19.559
TTbar1L	/TTToSemiLeptonic_TuneCP5_13TeV-powheg-pythia8[0]	373.9093904
TTbar2L	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8[0]	94.936764
TTX	/TTToHadronic_TuneCP5_13TeV-powheg-pythia8[0]	367.825066
	/TTWJetsToLNu_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8[0]	0.2043
	/TTZToLLNuNu_M-10_TuneCP5_13TeV-amcatnlo-pythia8[0]	0.2529
	/ttHTobb_M125_TuneCP5_13TeV-powheg-pythia8[1]	0.1279
	/ttHToNonbb_M125_TuneCP5_13TeV-powheg-pythia8[1]	0.215
	/TTWZ_TuneCP5_13TeV-madgraph-pythia8[0]	0.003884
	/TTWW_TuneCP5_13TeV-madgraph-pythia8[0]	0.0115
	/TTbb_4f_TTTo2L2Nu_TuneCP5-Powheg-Openloops-Pythia8[0]	0.04
	/TTbb_4f_TTToSemiLeptonic_TuneCP5-Powheg-Openloops-Pythia8[0]	0.62
WJets	/WJetsToLNu_HT-70To100_TuneCP5_13TeV-madgraphMLM-pythia8[0]	1283.91
	/WJetsToLNu_HT-100To200_TuneCP5_13TeV-madgraphMLM-pythia8[0]	1303.06
	/WJetsToLNu_HT-200To400_TuneCP5_13TeV-madgraphMLM-pythia8[0]	341.046
	/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8[0]	45.4362
	/WJetsToLNu_HT-600To800_TuneCP5_13TeV-madgraphMLM-pythia8[0]	11.0051
	/WJetsToLNu_HT-800To1200_TuneCP5_13TeV-madgraphMLM-pythia8[0]	4.94177
	/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8[0]	1.15544
	/WJetsToLNu_HT-2500ToInf_TuneCP5_13TeV-madgraphMLM-pythia8[1]	0.0216234
Bosons	/DYJetsToLL_M-10to50_TuneCP5_13TeV-madgraphMLM-pythia8[0]	20657.0
	/DYJetsToLL_M-50_TuneCP5_13TeV-madgraphMLM-pythia8[0]	6198.0
	/EWKWplus2Jets_WToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[0]	10.67
	/EWKWminus2Jets_WToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[0]	10.67
	/EWKZ2Jets_ZToLL_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	6.22
	/EWKZ2Jets_ZToNuNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[1]	10.72
	/EWKZ2Jets_ZToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[0]	10.67
	/WWTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	49.997
	/WWTolnulnu_TuneCP5_13TeV-madgraph-pythia8[0]	12.178
	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8[0]	12.178
	/WZTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	49.997
	/WZTo1L3Nu_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	3.054024
	/WZTo2Q2L_mllmin4p0_TuneCP5_13TeV-amcatnloFXFX-pythia8[1]	5.6
	/WZTo3LNu_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	4.42965
	/ZZTo2Q2L_mllmin4p0_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	3.28
	/ZZTo2L2Nu_TuneCP5_13TeV_powheg_pythia8[0]	0.564
	/ZZTo4L_M-1toInf_TuneCP5_13TeV_powheg_pythia8[0]	1.256
	/WWW_4F_TuneCP5_13TeV-amcatnlo-pythia8[2]	0.2086
	/WWZ_4F_TuneCP5_13TeV-amcatnlo-pythia8[2]	0.1651
	/WZZ_TuneCP5_13TeV-amcatnlo-pythia8[2]	0.05565
	/ZZZ_TuneCP5_13TeV-amcatnlo-pythia8[2]	0.01398
	/WWJJToLNuLNu_EWK_noTop_TuneCP5_13TeV-madgraph-pythia8[0]	0.284
	/WZJJ_EWK_InclusivePolarization_TuneCP5_13TeV_madgraph-madspin-pythia8[0]	0.01701
	/ZZJJTo4L_TuneCP5_13TeV-madgraph-pythia8[1]	0.00884
EWKWLep	/EWKWPlus2Jets_WToLNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	39.33
	/EWKWMinus2Jets_WToLNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	32.26
VH	/VHToNonbb_M125_TuneCP5_13TeV-amcatnloFXFX_madspin_pythia8[1]	2.207
	/WminusH_HToBB_WToLNu_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.04901236122
	/WplusH_HToBB_WToLNu_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.08487599411
	/ZH_HToBB_ZToLL_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.02627486511
	/ggZH_HToBB_ZToLL_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.002461395396

[0] /RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM
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[2] /RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17_ext1-v1/NANOAODSIM

Table 2: Background MC samples used in this analysis, corresponding to 2016postVFP detector conditions (UL), with their respective cross sections in picobarns.

DRAFT

MC Samples: 2017, 2018

Process	Sample Name	σ [pb]
SingleTop	/ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8[0]	136.02
	/ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8[0]	80.95
	/ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8[1]	19.559
	/ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8[1]	19.559
TTbar1L	/TTToSemiLeptonic_TuneCP5_13TeV-powheg-pythia8[0]	373.9093904
TTbar2L	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8[0]	94.936764
TTX	/TTToHadronic_TuneCP5_13TeV-powheg-pythia8[0]	367.825066
	/TTWJetsToLNu_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8[0]	0.2043
	/TTZToLLNuNu_M-10_TuneCP5_13TeV-amcatnlo-pythia8[0]	0.2529
	/ttHTobb_M125_TuneCP5_13TeV-powheg-pythia8[1]	0.1279
	/ttHToNonbb_M125_TuneCP5_13TeV-powheg-pythia8[1]	0.215
	/TTWZ_TuneCP5_13TeV-madgraph-pythia8[0]	0.003884
	/TTWW_TuneCP5_13TeV-madgraph-pythia8[0]	0.0115
	/TTbb_4f_TTTo2L2Nu_TuneCP5-Powheg-Openloops-Pythia8[0]	0.04
	/TTbb_4f_TTToSemiLeptonic_TuneCP5-Powheg-Openloops-Pythia8[0]	0.62
WJets	/WJetsToLNu_HT-70To100_TuneCP5_13TeV-madgraphMLM-pythia8[0]	1319.76
	/WJetsToLNu_HT-100To200_TuneCP5_13TeV-madgraphMLM-pythia8[0]	1334.74
	/WJetsToLNu_HT-200To400_TuneCP5_13TeV-madgraphMLM-pythia8[0]	350.435
	/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8[0]	46.5726
	/WJetsToLNu_HT-600To800_TuneCP5_13TeV-madgraphMLM-pythia8[0]	11.1485
	/WJetsToLNu_HT-800To1200_TuneCP5_13TeV-madgraphMLM-pythia8[2]	5.02246
	/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8[0]	1.183
	/WJetsToLNu_HT-2500ToInf_TuneCP5_13TeV-madgraphMLM-pythia8[1]	0.0258083
Bosons	/DYJetsToLL_M-10to50_TuneCP5_13TeV-madgraphMLM-pythia8[0]	20657.0
	/DYJetsToLL_M-50_TuneCP5_13TeV-madgraphMLM-pythia8[0]	6198.0
	/EWKWplus2Jets_WToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[0]	10.67
	/EWKWminus2Jets_WToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[0]	10.67
	/EWKZ2Jets_ZToLL_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[1]	6.22
	/EWKZ2Jets_ZToNuNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[1]	10.72
	/EWKZ2Jets_ZToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[0]	10.67
	/WWTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	49.997
	/WWTolnulnu_TuneCP5_13TeV-madgraph-pythia8[0]	12.178
	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8[1]	12.178
	/WZTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	49.997
	/WZTo1L3Nu_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	3.054024
	/WZTo2Q2L_mllmin4p0_TuneCP5_13TeV-amcatnloFXFX-pythia8[1]	5.6
	/WZTo3LNu_TuneCP5_13TeV-amcatnloFXFX-pythia8[1]	4.42965
	/ZZTo2Q2L_mllmin4p0_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	3.28
	/ZZTo2L2Nu_TuneCP5_13TeV_powheg_pythia8[0]	0.564
	/ZZTo4L_M-1toInf_TuneCP5_13TeV_powheg_pythia8[0]	1.256
	/WWZ_4F_TuneCP5_13TeV-amcatnlo-pythia8[0]	0.1651
	/WZZ_TuneCP5_13TeV-amcatnlo-pythia8[3]	0.05565
	/ZZZ_TuneCP5_13TeV-amcatnlo-pythia8[3]	0.01398
	/WWJJToLNuLNu_EWK_noTop_TuneCP5_13TeV-madgraph-pythia8[0]	0.284
	/WZJJ_EWK_InclusivePolarization_TuneCP5_13TeV_madgraph-madspin-pythia8[0]	0.01701
	/ZZJJTo4L_TuneCP5_13TeV-madgraph-pythia8[1]	0.00884
	/WWW_4F_TuneCP5_13TeV-amcatnlo-pythia8[3]	0.2086
EWKWLep	/EWKWPlus2Jets_WToLNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[1]	39.33
	/EWKWMinus2Jets_WToLNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[1]	32.26
VH	/VHToNonbb_M125_TuneCP5_13TeV-amcatnloFXFX_madspin_pythia8[1]	2.207
	/WminusH_HToBB_WToLNu_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.04901236122
	/WplusH_HToBB_WToLNu_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.08487599411
	/ZH_HToBB_ZToLL_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.02627486511
	/ggZH_HToBB_ZToLL_M-125_TuneCP5_13TeV-powheg-pythia8[0]	0.002461395396

[0] /RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v1/NANOAODSIM
[1] /RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOAODSIM
[2] /RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v3/NANOAODSIM
[3] /RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9_ext1-v2/NANOAODSIM

Table 3: Background MC samples used in this analysis, corresponding to 2017 detector conditions (UL), with their respective cross sections in picobarns.

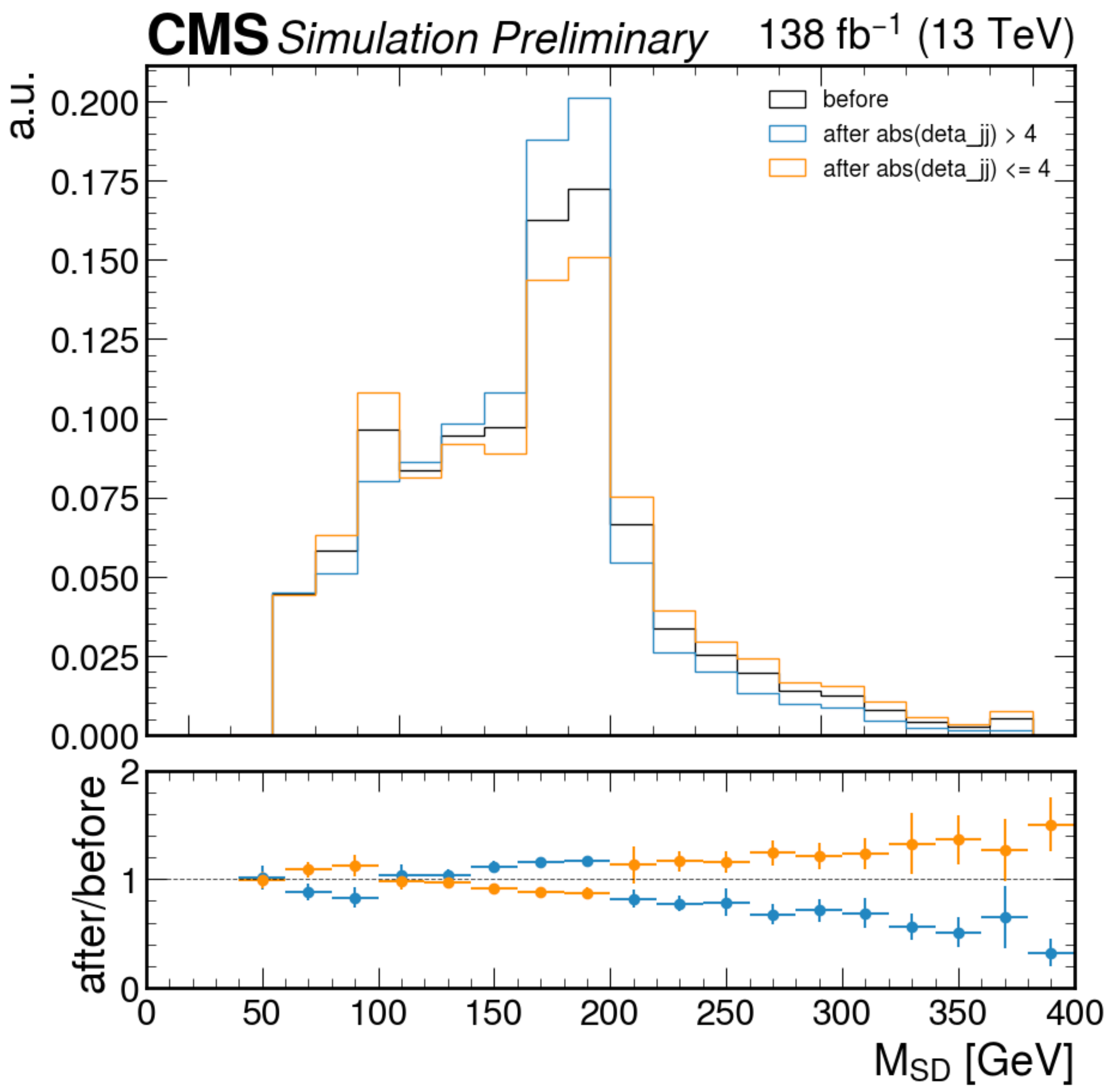
Process	Sample Name	σ [pb]
SingleTop	/ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8[0]	19.559
	/ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8[2]	136.02
	/ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8[2]	80.95
	/ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8[0]	19.559
TTbar1L	/TTToSemiLeptonic_TuneCP5_13TeV-powheg-pythia8[2]	373.9093904
TTbar2L	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8[2]	94.936764
TTX	/TTToHadronic_TuneCP5_13TeV-powheg-pythia8[2]	367.825066
	/TTWJetsToLNu_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8[2]	0.2043
	/TTZToLLNuNu_M-10_TuneCP5_13TeV-amcatnlo-pythia8[2]	0.2529
	/ttHTobb_M125_TuneCP5_13TeV-powheg-pythia8[0]	0.1279
	/ttHToNonbb_M125_TuneCP5_13TeV-powheg-pythia8[0]	0.215
	/TTWZ_TuneCP5_13TeV-madgraph-pythia8[2]	0.003884
	/TTWW_TuneCP5_13TeV-madgraph-pythia8[2]	0.0115
	/TTbb_4f_TTTo2L2Nu_TuneCP5-Powheg-Openloops-Pythia8[2]	0.04
	/TTbb_4f_TTToSemiLeptonic_TuneCP5-Powheg-Openloops-Pythia8[2]	0.62
WJets	/WJetsToLNu_HT-70To100_TuneCP5_13TeV-madgraphMLM-pythia8[2]	1321.16
	/WJetsToLNu_HT-100To200_TuneCP5_13TeV-madgraphMLM-pythia8[2]	1335.7
	/WJetsToLNu_HT-200To400_TuneCP5_13TeV-madgraphMLM-pythia8[2]	351.689
	/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8[2]	47.1663
	/WJetsToLNu_HT-600To800_TuneCP5_13TeV-madgraphMLM-pythia8[2]	11.4196
	/WJetsToLNu_HT-800To1200_TuneCP5_13TeV-madgraphMLM-pythia8[2]	5.12389
	/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8[2]	1.18295
	/WJetsToLNu_HT-2500ToInf_TuneCP5_13TeV-madgraphMLM-pythia8[0]	0.0255202
Bosons	/WWW_4F_TuneCP5_13TeV-amcatnlo-pythia8[1]	0.2086
	/DYJetsToLL_M-10to50_TuneCP5_13TeV-madgraphMLM-pythia8[2]	20657.0
	/DYJetsToLL_M-50_TuneCP5_13TeV-madgraphMLM-pythia8[2]	6198.0
	/EWKWplus2Jets_WToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[2]	10.67
	/EWKWminus2Jets_WToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[2]	10.67
	/EWKZ2Jets_ZToLL_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	6.22
	/EWKZ2Jets_ZToNuNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	10.72
	/EWKZ2Jets_ZToQQ_dipoleRecoilOn_TuneCP5_13TeV-madgraph-pythia8[2]	10.67
	/WWTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[2]	49.997
	/WWTolnulnu_TuneCP5_13TeV-madgraph-pythia8[2]	12.178
	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8[0]	12.178
	/WZTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[2]	49.997
	/WZTo1L3Nu_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8[2]	3.054024
	/WZTo2Q2L_mllmin4p0_TuneCP5_13TeV-amcatnloFXFX-pythia8[2]	5.6
	/WZTo3LNu_TuneCP5_13TeV-amcatnloFXFX-pythia8[0]	4.42965
	/ZZTo2Q2L_mllmin4p0_TuneCP5_13TeV-amcatnloFXFX-pythia8[2]	3.28
	/ZZTo2L2Nu_TuneCP5_13TeV_powheg_pythia8[2]	0.564
	/ZZTo4L_M-1toInf_TuneCP5_13TeV_powheg_pythia8[2]	1.256
	/WWZ_4F_TuneCP5_13TeV-amcatnlo-pythia8[1]	0.1651
	/WZZ_TuneCP5_13TeV-amcatnlo-pythia8[1]	0.05565
	/ZZZ_TuneCP5_13TeV-amcatnlo-pythia8[1]	0.01398
	/WWJJToLNuLNu_EWK_noTop_TuneCP5_13TeV-madgraph-pythia8[2]	0.284
	/WZJJ_EWK_InclusivePolarization_TuneCP5_13TeV_madgraph-madspin-pythia8[2]	0.01701
	/ZZJJTo4L_TuneCP5_13TeV-madgraph-pythia8[0]	0.00884
EWKWLep	/EWKWPlus2Jets_WToLNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	39.33
	/EWKWMinus2Jets_WToLNu_M-50_TuneCP5_withDipoleRecoil_13TeV-madgraph-pythia8[0]	32.26
VH	/VHToNonbb_M125_TuneCP5_13TeV-amcatnloFXFX_madspin_pythia8[0]	2.207
	/WminusH_HToBB_WToLNu_M-125_TuneCP5_13TeV-powheg-pythia8[2]	0.04901236122
	/WplusH_HToBB_WToLNu_M-125_TuneCP5_13TeV-powheg-pythia8[2]	0.08487599411
	/ZH_HToBB_ZToLL_M-125_TuneCP5_13TeV-powheg-pythia8[2]	0.02627486511
	/ggZH_HToBB_ZToLL_M-125_TuneCP5_13TeV-powheg-pythia8[2]	0.002461395396

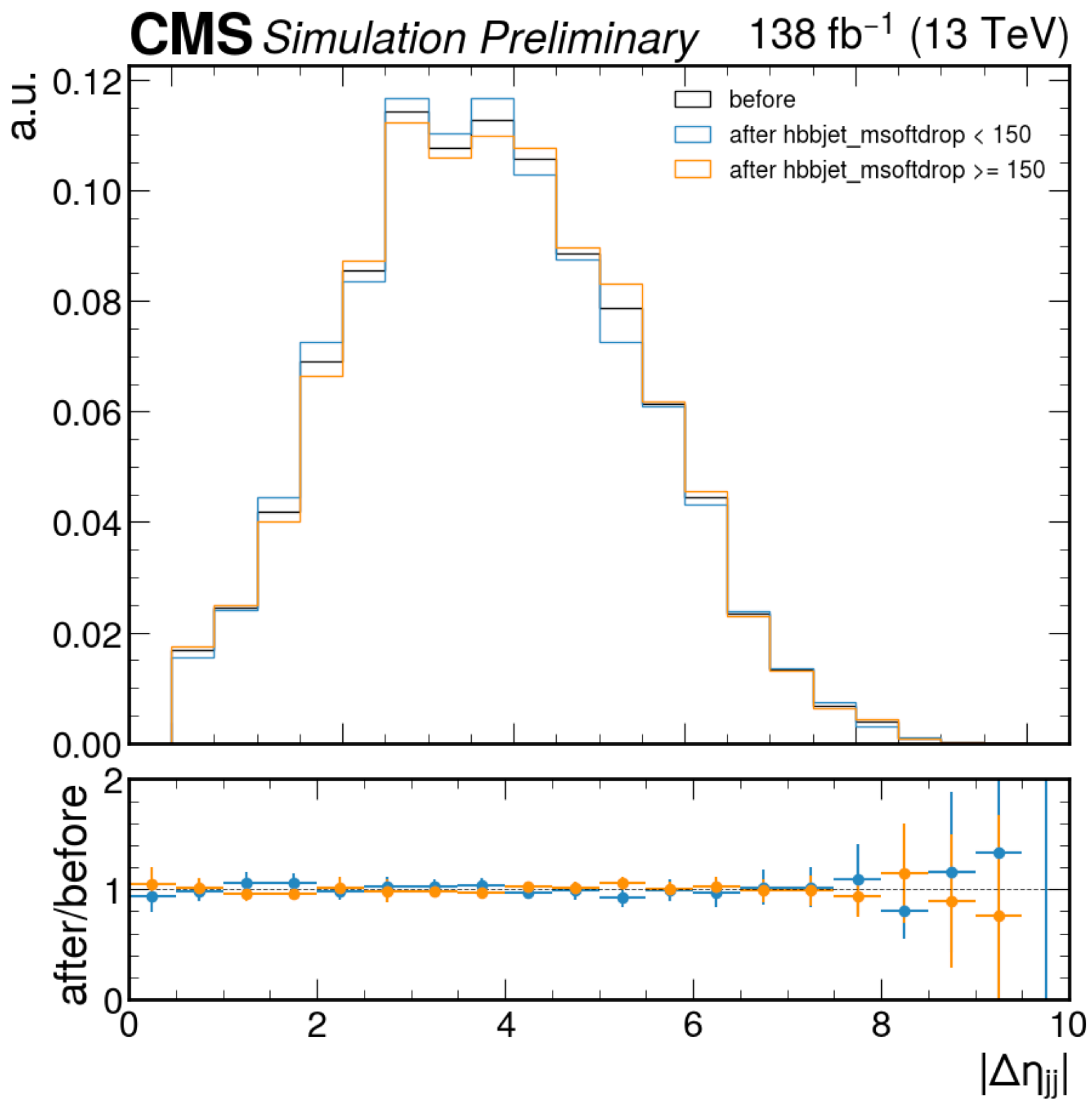
[0] /RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM
[1] /RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v2/NANOAODSIM
[2] /RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM

Table 4: Background MC samples used in this analysis, corresponding to 2018 detector conditions (UL), with their respective cross sections in picobarns.

SR1 ABCD: $\Delta\eta_{jj}$ vs. M_{SD} Correlations

Preselection AND M_{jj} > 600 GeV AND S_T > 900 GeV AND PNet Xbb > 0.9





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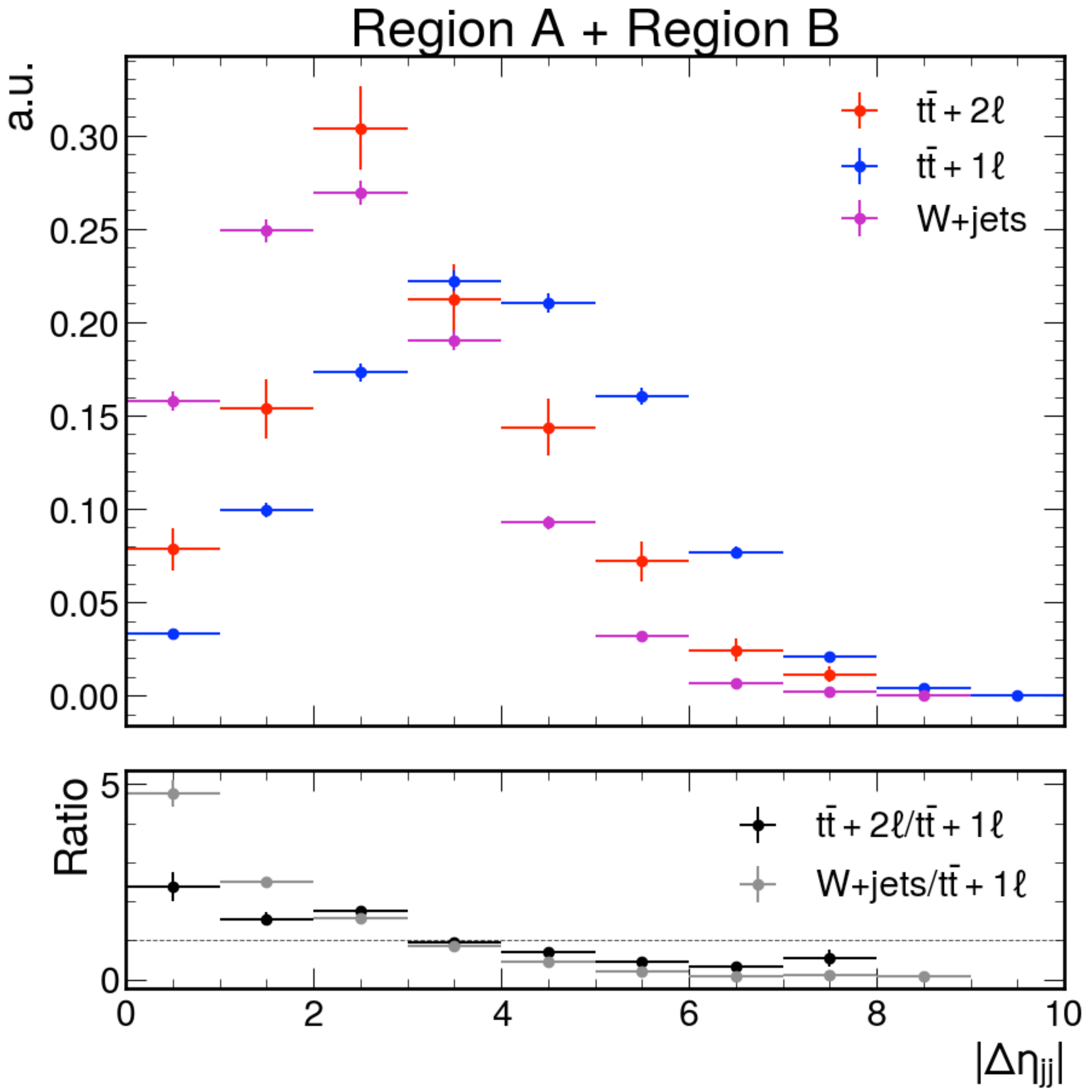
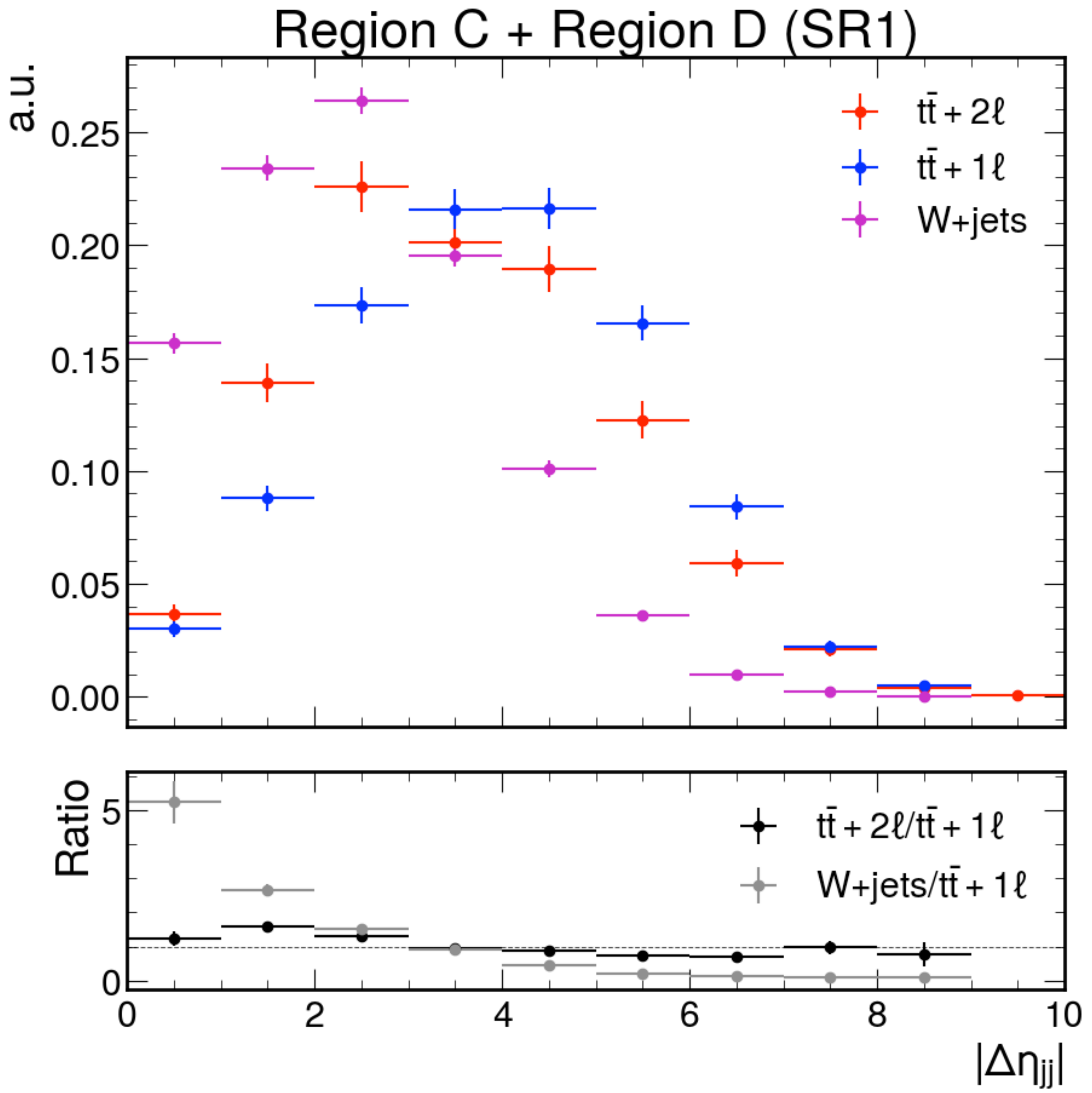
SR1 ABCD: W+jets Composition

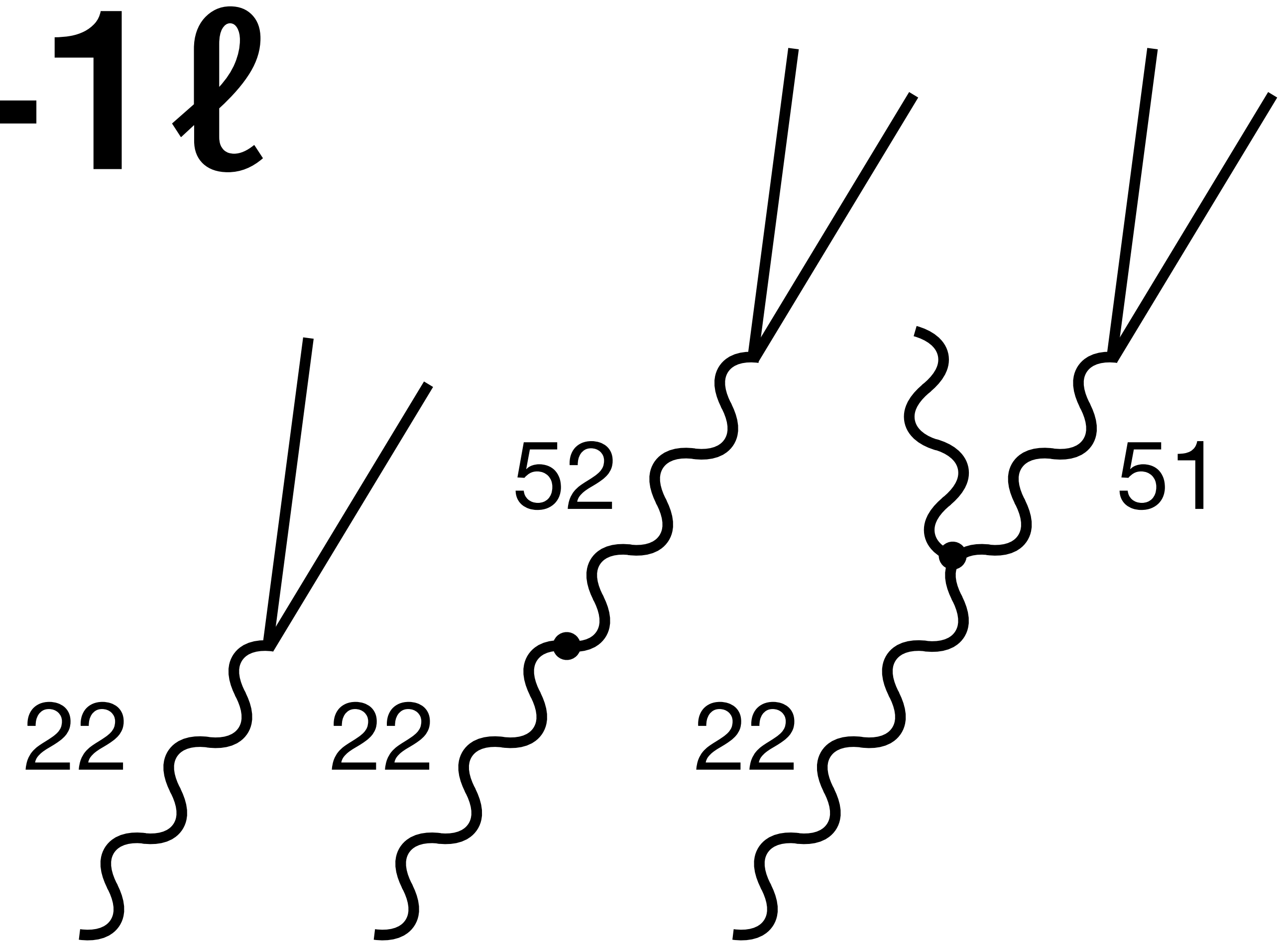




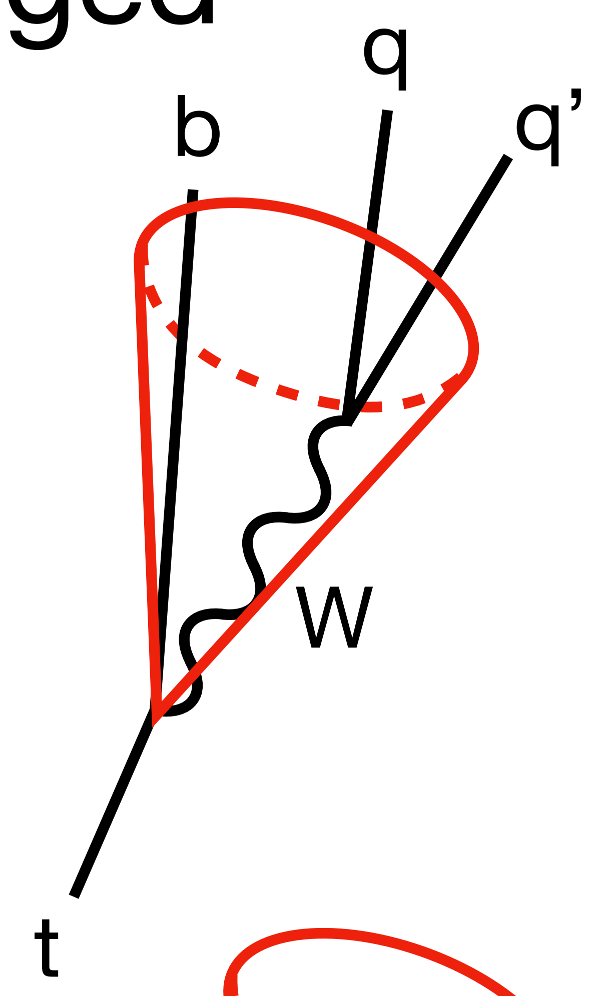
TT1L & TT2L $|\Delta\eta_{jj}|$ shapes roughly consistent, W+Jets is much different

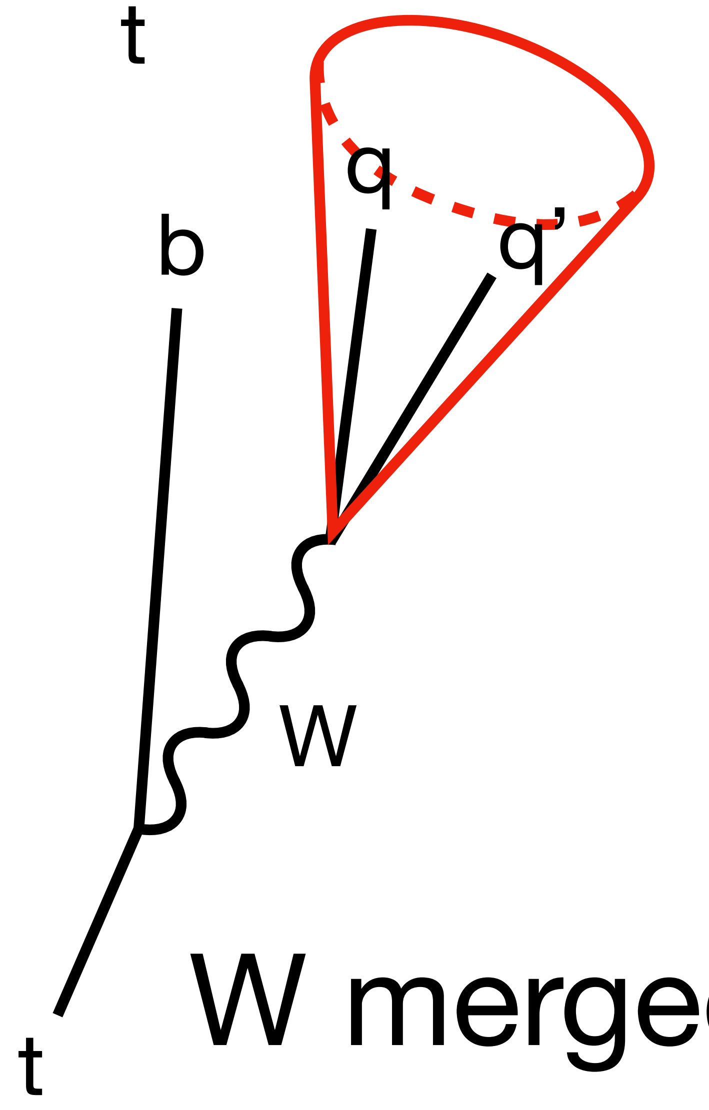
ABCD: Splitting ttbar+1ℓ

- First find top quarks:
    - Status == 62
- Next, find W bosons from top quarks:
    - Mother == one of the top quarks, status == 22
    - OR Mother == W boson, status == 52 or 51
- Finally, look at outgoing quarks: (status == 23)
    - Find b quarks from one of the top quarks
    - Find q, q’ from W→hadrons



t merged





W merged

CMS

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