WWW Analysis Note

## WWW Analysis Team

December 11, 2018

Abstract

This contains various tables and plots used for the actual AN of WWW analysis.

1 Lost Lepton Control Region

Table 1: PUT YOUR CAPTION HERE

Bin number	$\gamma \to lepton$	Charge mis-id	Non-prompt	Lost/three lep	Irredu.	WWW	Total	Data	Ratio
ee	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	7.558 ± 0.593	0.006 ± 0.004	0.0 ± 0.0	7.564 ± 0.593	12.0 ± 3.464	1.586 ± 0.475
em	0.0 ± 0.0	0.025 ± 0.025	3.076 ± 3.017	23.539 ± 1.13	-0.133 ± 0.176	0.0 ± 0.0	26.508 ± 3.227	25.0 ± 5.0	0.943 ± 0.221
mm	0.01 ± 0.01	0.0 ± 0.0	0.2 ± 0.16	46.653 ± 1.764	0.611 ± 0.379	0.123 ± 0.123	47.474 ± 1.811	59.0 ± 7.681	1.243 ± 0.169
1SFOS	0.0 ± 0.0	0.182 ± 0.075	0.411 ± 0.228	51.697 ± 1.547	0.086 ± 0.209	0.589 ± 0.246	52.376 ± 1.579	70.0 ± 8.367	1.336 ± 0.165
2SFOS	0.0 ± 0.0	0.218 ± 0.08	5.401 ± 2.924	198.751 ± 3.11	2.809 ± 1.508	0.369 ± 0.231	207.178 ± 4.528	199.0 ± 14.107	0.961 ± 0.071
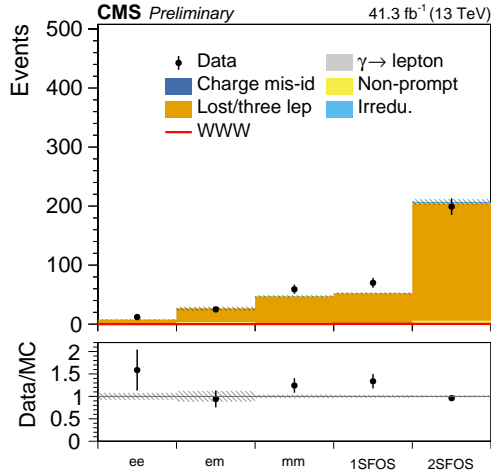
(a)

Figure 1: Lost lepton control region for 2017 data.

Table 2: PUT YOUR CAPTION HERE

Bin number	Nominal	JES	LepSF	TrigSF	BTagLF	BTagHF	Pileup	Total	Data	Ratio
ee	1.0 ± 0.0	0.197 ± 0.0	0.04 ± 0.0	0.025 ± 0.0	0.003 ± 0.0	0.002 ± 0.0	0.192 ± 0.0	1.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
em	1.0 ± 0.0	0.058 ± 0.0	0.008 ± 0.0	0.004 ± 0.0	0.002 ± 0.0	0.0 ± 0.0	0.094 ± 0.0	1.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
mm	1.0 ± 0.0	0.079 ± 0.0	0.006 ± 0.0	0.005 ± 0.0	0.006 ± 0.0	0.002 ± 0.0	0.12 ± 0.0	1.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
side-ee	1.0 ± 0.0	0.07 ± 0.0	0.021 ± 0.0	0.007 ± 0.0	0.006 ± 0.0	0.003 ± 0.0	0.13 ± 0.0	1.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
side-em	1.0 ± 0.0	0.048 ± 0.0	0.007 ± 0.0	0.008 ± 0.0	0.001 ± 0.0	0.002 ± 0.0	0.028 ± 0.0	1.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
side-mm	1.0 ± 0.0	0.075 ± 0.0	0.006 ± 0.0	0.002 ± 0.0	0.003 ± 0.0	0.0 ± 0.0	0.055 ± 0.0	1.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
1SFOS	1.0 ± 0.0	0.077 ± 0.0	0.016 ± 0.0	0.015 ± 0.0	0.001 ± 0.0	0.001 ± 0.0	0.066 ± 0.0	1.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
2SFOS	1.0 ± 0.0	0.012 ± 0.0	0.004 ± 0.0	0.013 ± 0.0	0.0 ± 0.0	0.001 ± 0.0	0.032 ± 0.0	1.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

Table 3: Some numbers for same-sign channel m_{SFOS} efficiency measurement. Equation is that eff $= b/a$ and $\text{eff}_{\text{err}} = \sqrt{(\text{eff}(1 - \text{eff})/n)}$

Bin number	lostlep eff msfos ss mc	Total	lostlep eff msfos ss data	Ratio
eff (e)	0.878 ± 0.003	0.878 ± 0.003	0.889 ± 0.03	1.013 ± 0.035
after (a)	77.75 ± 0.0	77.75 ± 0.0	96.0 ± 0.0	1.235 ± 0.0
before (b)	88.592 ± 0.0	88.592 ± 0.0	108.0 ± 0.0	1.219 ± 0.0
raw (n)	8815.0 ± 0.0	8815.0 ± 0.0	108.0 ± 0.0	0.012 ± 0.0

2 Statistical interpretation

2.1 m_{jj}-in ee

```
imax 1 number of bins
jmax * number of processes
kmax * number of nuisance parameters
---------------------------------------------------------------------------------------------------------------------------------
bin          SRSSee
observation  2.0
---------------------------------------------------------------------------------------------------------------------------------
bin                        SRSSee         SRSSee         SRSSee         SRSSee         SRSSee         SRSSee         SRSSee         SRSSee
process                    0              1              2              3              4              5              6              7
process                    www            fakes          photon         lostlep        qflip          prompt         ttw            vbsww
rate                       0.714          0.225          0.018          1.277          0.000          0.253          0.201          0.144
---------------------------------------------------------------------------------------------------------------------------------
JES                  lnN   0.9531/0.9783  -              1.0000/1.0000  -              1.0000/1.0000  1.0451/1.0367  1.0567/1.0462  1.0609/1.2065
LepSF                lnN   0.9861/0.9226  -              1.0368/0.9632  -              165904.8055/156964.0491  1.0181/0.9491  1.0150/0.9438  1.0321/0.9679
TrigSF               lnN   1.0441/0.9559  -              1.0528/0.9472  -              1.0000/1.0000  1.0399/0.9601  1.0464/0.9536  1.0367/0.9633
BTagLF               lnN   1.0259/0.9746  -              1.0331/0.9682  -              1.0000/1.0000  1.0240/0.9764  1.0242/0.9763  1.0299/0.9709
BTagHF               lnN   1.0138/0.9867  -              1.0757/0.9287  -              1.0000/1.0000  1.0411/0.9602  1.0517/0.9499  1.0095/0.9906
Pileup               lnN   0.7312/1.5909  -              0.8136/1.1911  -              1.0000/1.0000  0.8270/1.4064  0.7636/1.5322  0.8711/1.1345
FakeRateEl           lnN   -              1.0371/0.9634  -              -              -              -              -              -
FakeRateMu           lnN   -              1.0000/1.0000  -              -              -              -              -              -
FakeClosureEl        lnN   -              1.8127/0.3618  -              -              -              -              -              -
FakeClosureMu        lnN   -              1.0000/1.0000  -              -              -              -              -              -
PDF                  lnN   0.9901/1.0140  -              -              -              -              -              -              -
Qsq                  lnN   0.9956/1.0044  -              -              -              -              -              -              -
AlphaS               lnN   0.9868/0.9986  -              -              -              -              -              -              -
WZCRSSeeFull_CRstat  gmN  12  -           -              -              0.1064         -              -              -              -
MjjSyst              lnN   -              -              -              1.049          -              -              -              -
Mll1SSSyst           lnN   -              -              -              1.053          -              -              -              -
Mll13LSyst           lnN   -              -              -              -              -              -              -              -
VBSWWVR              lnN   -              -              -              -              -              -              -              1.22
VBSWWXsec            lnN   -              -              -              -              -              -              -              1.20
TTWVR                lnN   -              -              -              -              -              -              1.18           -
TTWXsec              lnN   -              -              -              -              -              -              1.20           -
GammaVR              lnN   -              -              1.50           -              -              -              -              -
QFlipSyst            lnN   -              -              -              -              1.50           -              -              -
LumSyst              lnN   1.025          -              1.025          -              1.025          1.025          1.025          1.025
www_SRSSee_stat      lnN   1.2842         -              -              -              -              -              -              -
fakes_SRSSee_stat    lnN   -              4.9924         -              -              -              -              -              -
photon_SRSSee_stat   lnN   -              -              1.5206         -              -              -              -              -
qflip_SRSSee_stat    lnN   -              -              -              -              1.0000         -              -              -
prompt_SRSSee_stat   lnN   -              -              -              -              -              1.2388         -              -
ttw_SRSSee_stat      lnN   -              -              -              -              -              -              1.1542         -
vbsww_SRSSee_stat    lnN   -              -              -              -              -              -              -              1.2590
```

Table 4: Some numbers for three-lepton channel m_{SFOS} on//off ratio measurement. Equation is that r $= p/f$

Bin number	lostlep ratio msfos 3l mc	Total	lostlep ratio msfos 3l data	Ratio
ratio (r)	16.055 ± 0.032	16.055 ± 0.032	12.0 ± 0.127	0.747 ± 0.008
on (p)	589.527 ± 4.67	589.527 ± 4.67	804.0 ± 28.355	1.364 ± 0.049
off (f)	36.719 ± 1.148	36.719 ± 1.148	67.0 ± 8.185	1.825 ± 0.23

Table 5: Some numbers for same-sign channel m_{jj} efficiency measurement. Equation is that $\text{eff} = b/a$ and $\text{eff}_{\text{err}} = \sqrt{(\text{eff}(1 - \text{eff})/n)}$

Bin number	lostlep eff mjj ss mc	Total	lostlep eff mjj ss data	Ratio
eff (e)	0.194 ± 0.005	0.194 ± 0.005	0.25 ± 0.044	1.288 ± 0.23
after (a)	15.089 ± 0.0	15.089 ± 0.0	24.0 ± 0.0	1.591 ± 0.0
before (b)	77.75 ± 0.0	77.75 ± 0.0	96.0 ± 0.0	1.235 ± 0.0
raw (n)	7707.0 ± 0.0	7707.0 ± 0.0	96.0 ± 0.0	0.012 ± 0.0

2.2 m_{jj}-in em

```
imax 1 number of bins
jmax * number of processes
kmax * number of nuisance parameters
-------------------------------------------------------------------------------------------------------------------------------
bin            SRSSem
observation    8.0
-------------------------------------------------------------------------------------------------------------------------------
bin                        SRSSem       SRSSem       SRSSem       SRSSem       SRSSem       SRSSem       SRSSem       SRSSem
process                    0            1            2            3            4            5            6            7
process                    www          fakes        photon       lostlep      qflip        prompt       ttw          vbsww
rate                       1.494        2.898        0.026        2.314        1.295        0.479        0.466        0.659
-------------------------------------------------------------------------------------------------------------------------------
JES                 lnN    0.8730/1.0163 -           1.0000/1.0956 -          1.0000/1.0000 0.8950/2.6894 0.8923/1.0524 0.8801/0.9588
LepSF               lnN    1.0255/0.9745 -           1.0317/0.9683 -          1.0330/0.9670 1.0112/0.9565 1.0102/0.9566 1.0288/0.9712
TrigSF              lnN    1.0425/0.9575 -           1.0432/0.9568 -          1.0300/0.9700 1.0483/0.9517 1.0476/0.9524 1.0453/0.9547
BTagLF              lnN    1.0314/0.9696 -           1.0440/0.9577 -          1.0247/0.9757 1.0315/0.9693 1.0314/0.9694 1.0332/0.9676
BTagHF              lnN    1.0056/0.9944 -           1.0203/0.9797 -          1.0121/0.9884 1.0433/0.9578 1.0444/0.9566 1.0027/0.9973
Pileup              lnN    0.7324/1.6743 -           0.4828/3.3636 -          0.9708/1.0079 0.7462/1.7816 0.7096/1.8654 0.7226/1.7527
FakeRateEl          lnN    -            1.0274/0.9730 -           -           -            -            -            -
FakeRateMu          lnN    -            1.1165/0.8977 -           -           -            -            -            -
FakeClosureEl       lnN    -            1.2969/0.7468 -           -           -            -            -            -
FakeClosureMu       lnN    -            1.0758/0.9265 -           -           -            -            -            -
PDF                 lnN    0.9872/1.0170 -           -           -           -            -            -            -
Qsq                 lnN    0.8734/1.1859 -           -           -           -            -            -            -
AlphaS              lnN    1.0019/1.0012 -           -           -           -            -            -            -
WZCRSSemFull_CRstat gmN 25 -            -            -            0.0925      -            -            -            -
MjjSyst             lnN    -            -            -            1.049       -            -            -            -
MllSSSyst           lnN    -            -            -            1.053       -            -            -            -
Mll3LSyst           lnN    -            -            -            -           -            -            -            -
VBSWWVR             lnN    -            -            -            -           -            -            -            1.22
VBSWWXsec           lnN    -            -            -            -           -            -            -            1.20
TTWVR               lnN    -            -            -            -           -            -            1.18         -
TTWXsec             lnN    -            -            -            -           -            -            1.20         -
GammaVR             lnN    -            -            1.50        -           -            -            -            -
QFlipSyst           lnN    -            -            -           -           1.50         -            -            -
LumSyst             lnN    1.025        -            1.025       -           1.025        1.025        1.025        1.025
www_SRSSem_stat     lnN    1.1875       -            -           -           -            -            -            -
fakes_SRSSem_stat   lnN    -            1.2954       -           -           -            -            -            -
photon_SRSSem_stat  lnN    -            -            1.4113      -           -            -            -            -
qflip_SRSSem_stat   lnN    -            -            -           -           1.8818       -            -            -
prompt_SRSSem_stat  lnN    -            -            -           -           -            1.2392       -            -
ttw_SRSSem_stat     lnN    -            -            -           -           -            -            1.1157       -
vbsww_SRSSem_stat   lnN    -            -            -           -           -            -            -            1.1301
```

2.3 m_{jj}-in mm

```
imax 1 number of bins
jmax * number of processes
kmax * number of nuisance parameters
```
---
bin		SRSSmm							
observation		8.0							
---
bin		SRSSmm	SRSSmm	SRSSmm	SRSSmm	SRSSmm	SRSSmm	SRSSmm	SRSSmm
process		0	1	2	3	4	5	6	7
process		www	fakes	photon	lostlep	qflip	prompt	ttw	vbsww
rate		2.541	2.074	0.000	3.782	0.000	1.167	0.536	0.614

JES	lnN	0.8983/0.9975	–	1.0000/1.0000	–	1.0000/1.0000	0.8904/1.0452	0.9578/1.0984	1.0429/0.9384
LepSF	lnN	1.0186/0.9814	–	1.0000/1.0000	–	1.0000/1.0000	1.0187/0.9813	1.0182/0.9818	1.0186/0.9814
TrigSF	lnN	1.0356/0.9644	–	1.0000/1.0000	–	1.0000/1.0000	1.0264/0.9736	1.0364/0.9636	1.0377/0.9623
BTagLF	lnN	1.0238/0.9767	–	1.0000/1.0000	–	1.0000/1.0000	1.0319/0.9689	1.0287/0.9719	1.0344/0.9666
BTagHF	lnN	1.0117/0.9884	–	1.0000/1.0000	–	1.0000/1.0000	1.0217/0.9787	1.0428/0.9580	1.0080/0.9921
Pileup	lnN	0.7516/1.5487	–	1.0000/1.0000	–	1.0000/1.0000	0.7073/1.6366	0.7630/1.6179	0.7761/1.4117
FakeRateEl	lnN	–	1.0000/1.0000	–	–	–	–	–	–
FakeRateMu	lnN	–	1.4131/0.6359	–	–	–	–	–	–
FakeClosureEl	lnN	–	1.0000/1.0000	–	–	–	–	–	–
FakeClosureMu	lnN	–	1.2903/0.7190	–	–	–	–	–	–
PDF	lnN	0.9978/1.0044	–	–	–	–	–	–	–
Qsq	lnN	0.9675/1.0575	–	–	–	–	–	–	–
AlphaS	lnN	0.9992/0.9982	–	–	–	–	–	–	–
WZCRSSmmFull_CRstat	gmN 59	–	–	–	0.0641	–	–	–	–
MjjSyst	lnN	–	–	–	1.049	–	–	–	–
MllSSSyst	lnN	–	–	–	1.053	–	–	–	–
Mll3LSyst	lnN	–	–	–	–	–	–	–	–
VBSWWVR	lnN	–	–	–	–	–	–	–	1.22
VBSWWXsec	lnN	–	–	–	–	–	–	–	1.20
TTWVR	lnN	–	–	–	–	–	–	1.18	–
TTWXsec	lnN	–	–	–	–	–	–	1.20	–
GammaVR	lnN	–	–	1.50	–	–	–	–	–
QFlipSyst	lnN	–	–	–	–	1.50	–	–	–
LumSyst	lnN	1.025	–	1.025	–	1.025	1.025	1.025	1.025
www_SRSSmm_stat	lnN	1.1871	–	–	–	–	–	–	–
fakes_SRSSmm_stat	lnN	–	1.3072	–	–	–	–	–	–
photon_SRSSmm_stat	lnN	–	–	1.0000	–	–	–	–	–
qflip_SRSSmm_stat	lnN	–	–	–	–	1.0000	–	–	–
prompt_SRSSmm_stat	lnN	–	–	–	–	–	1.2167	–	–
ttw_SRSSmm_stat	lnN	–	–	–	–	–	–	1.1133	–
vbsww_SRSSmm_stat	lnN	–	–	–	–	–	–	–	1.1373

2.4 m_{jj}-out ee

```
imax 1 number of bins
jmax * number of processes
kmax * number of nuisance parameters
```
---
bin		SRSSSideee							
observation		11.0							
---
bin		SRSSSideee	SRSSSideee	SRSSSideee	SRSSSideee	SRSSSideee	SRSSSideee	SRSSSideee	SRSSSideee
process		0	1	2	3	4	5	6	7
process		www	fakes	photon	lostlep	qflip	prompt	ttw	vbsww
rate		0.789	2.721	0.039	4.152	2.258	0.485	0.187	1.446

JES	lnN	1.0787/0.9852	–	0.9521/1.0000	–	1.0017/0.9338	1.0399/0.9763	1.1034/1.1176	1.0396/0.9725
LepSF	lnN	1.0338/0.9662	–	1.0371/0.9629	–	1.0439/0.9561	1.0217/0.9574	1.0055/0.9403	1.0361/0.9639
TrigSF	lnN	1.0393/0.9607	–	1.0571/0.9429	–	1.0649/0.9351	1.0327/0.9673	1.0460/0.9540	1.0506/0.9494
BTagLF	lnN	1.0267/0.9739	–	1.0345/0.9665	–	1.0457/0.9560	1.0249/0.9758	1.0240/0.9767	1.0308/0.9700
BTagHF	lnN	1.0078/0.9924	–	1.0474/0.9542	–	1.0191/0.9809	1.0198/0.9808	1.0513/0.9501	1.0045/0.9955
Pileup	lnN	0.7419/1.5560	–	0.7007/1.7343	–	0.8190/1.1774	0.8782/2.1208	0.8162/1.4629	0.7337/1.7815
FakeRateEl	lnN	–	1.0389/0.9618	–	–	–	–	–	–
FakeRateMu	lnN	–	1.0000/1.0000	–	–	–	–	–	–
FakeClosureEl	lnN	–	1.4561/0.6187	–	–	–	–	–	–
FakeClosureMu	lnN	–	1.0000/1.0000	–	–	–	–	–	–
PDF	lnN	0.9851/1.0176	–	–	–	–	–	–	–
Qsq	lnN	0.8532/1.2339	–	–	–	–	–	–	–
AlphaS	lnN	0.9911/1.0011	–	–	–	–	–	–	–
WZCRSSeeFull_CRstat	gmN 12	–	–	–	0.3460	–	–	–	–
MjjSyst	lnN	–	–	–	1.049	–	–	–	–
MllSSSyst	lnN	–	–	–	1.053	–	–	–	–
Mll3LSyst	lnN	–	–	–	–	–	–	–	–
VBSWWVR	lnN	–	–	–	–	–	–	–	1.22
VBSWWXsec	lnN	–	–	–	–	–	–	–	1.20
TTWVR	lnN	–	–	–	–	–	–	1.18	–
TTWXsec	lnN	–	–	–	–	–	–	1.20	–
GammaVR	lnN	–	–	1.50	–	–	–	–	–
QFlipSyst	lnN	–	–	–	–	1.50	–	–	–
LumSyst	lnN	1.025	–	1.025	–	1.025	1.025	1.025	1.025
www_SRSSSideee_stat	lnN	1.2980	–	–	–	–	–	–	–
fakes_SRSSSideee_stat	lnN	–	1.4461	–	–	–	–	–	–
photon_SRSSSideee_stat	lnN	–	–	1.4122	–	–	–	–	–
qflip_SRSSSideee_stat	lnN	–	–	–	–	1.7790	–	–	–
prompt_SRSSSideee_stat	lnN	–	–	–	–	–	1.5056	–	–
ttw_SRSSSideee_stat	lnN	–	–	–	–	–	–	1.1978	–
vbsww_SRSSSideee_stat	lnN	–	–	–	–	–	–	–	1.0843

2.5 m_{jj}-out em

```
imax 1 number of bins
jmax * number of processes
kmax * number of nuisance parameters
----------------------------------------------------------------------------------------------------------------------------------
bin         SRSSSideem
observation   17.0
----------------------------------------------------------------------------------------------------------------------------------
bin                       SRSSSideem    SRSSSideem    SRSSSideem    SRSSSideem    SRSSSideem    SRSSSideem    SRSSSideem    SRSSSideem
process                   0             1             2             3             4             5             6             7
process                   www           fakes         photon        lostlep       qflip         prompt        ttw           vbsww
rate                      1.986         4.522         0.009         6.107         0.245         2.546         0.539         3.748
----------------------------------------------------------------------------------------------------------------------------------
JES                 lnN   1.1590/0.9687  -            1.2821/0.7934  -            1.0000/1.0000  1.0608/0.4213  1.0619/1.0188  0.9938/1.0393
LepSF               lnN   1.0251/0.9749  -            1.0345/0.9655  -            1.0391/0.9609  1.0287/0.9690  1.0215/0.9678  1.0233/0.9682
TrigSF              lnN   1.0413/0.9587  -            1.0504/0.9496  -            1.0440/0.9560  1.0410/0.9590  1.0475/0.9525  1.0455/0.9545
BTagLF              lnN   1.0275/0.9732  -            1.0372/0.9637  -            1.0016/0.9985  1.0269/0.9737  1.0232/0.9773  1.0276/0.9730
BTagHF              lnN   1.0065/0.9935  -            1.0248/0.9752  -            1.0894/0.9158  1.0126/0.9878  1.0531/0.9486  1.0039/0.9961
Pileup              lnN   0.8510/1.3195  -            0.5422/1.6989  -            0.7455/2.5503  0.4511/2.3415  0.7135/1.6203  0.7168/1.7380
FakeRateEl          lnN   -              1.0291/0.9713  -            -            -              -              -              -
FakeRateMu          lnN   -              1.0770/0.9241  -            -            -              -              -              -
FakeClosureEl       lnN   -              1.3370/0.7112  -            -            -              -              -              -
FakeClosureMu       lnN   -              1.0973/0.9046  -            -            -              -              -              -
PDF                 lnN   0.9881/1.0140  -            -             -            -              -              -              -
Qsq                 lnN   0.9941/0.9687  -            -             -            -              -              -              -
AlphaS              lnN   0.9954/1.0003  -            -             -            -              -              -              -
WZCRSSemFull_CRstat gmN 25 -             -            -             0.2443       -              -              -              -
MjjSyst             lnN   -              -            -             1.049        -              -              -              -
Mll3SSyst           lnN   -              -            -             1.053        -              -              -              -
Mll3LSyst           lnN   -              -            -             -            -              -              -              -
VBSWWVR             lnN   -              -            -             -            -              -              -              1.22
VBSWWXsec           lnN   -              -            -             -            -              -              -              1.20
TTWVR               lnN   -              -            -             -            -              -              1.18           -
TTWXsec             lnN   -              -            -             -            -              -              1.20           -
GammaVR             lnN   -              -            1.50          -            -              -              -              -
QFlipSyst           lnN   -              -            -             -            1.50           -              -              -
LumSyst             lnN   1.025          -            1.025         -            1.025          1.025          1.025          1.025
www_SRSSSideem_stat lnN   1.2219         -            -             -            -              -              -              -
fakes_SRSSSideem_stat lnN -              1.2963       -             -            -              -              -              -
photon_SRSSSideem_stat lnN -             -            1.6306        -            -              -              -              -
qflip_SRSSSideem_stat lnN -              -            -             -            1.7056         -              -              -
prompt_SRSSSideem_stat lnN -             -            -             -            -              1.5595         -              -
ttw_SRSSSideem_stat lnN   -              -            -             -            -              -              1.1271         -
vbsww_SRSSSideem_stat lnN -              -            -             -            -              -              -              1.0547
```

2.6 m_{jj}-out mm

```
imax 1 number of bins
jmax * number of processes
kmax * number of nuisance parameters
----------------------------------------------------------------------------------------------------------------------------------
bin         SRSSSidemm
observation   13.0
----------------------------------------------------------------------------------------------------------------------------------
bin                       SRSSSidemm    SRSSSidemm    SRSSSidemm    SRSSSidemm    SRSSSidemm    SRSSSidemm    SRSSSidemm    SRSSSidemm
process                   0             1             2             3             4             5             6             7
process                   www           fakes         photon        lostlep       qflip         prompt        ttw           vbsww
rate                      1.050         1.471         0.004         6.836         0.000         0.830         0.658         3.506
----------------------------------------------------------------------------------------------------------------------------------
JES                 lnN   1.3727/0.8999  -            0.5573/1.0000  -            1.0000/1.0000  0.8767/0.9797  0.9903/0.9745  1.0175/0.9948
LepSF               lnN   1.0185/0.9815  -            1.0221/0.9779  -            1.0000/1.0000  1.0185/0.9815  1.0190/0.9810  1.0185/0.9815
TrigSF              lnN   1.0371/0.9629  -            1.0639/0.9361  -            1.0000/1.0000  1.0366/0.9634  1.0373/0.9627  1.0348/0.9652
BTagLF              lnN   1.0418/0.9596  -            1.0384/0.9626  -            1.0000/1.0000  1.0291/0.9715  1.0262/0.9744  1.0317/0.9692
BTagHF              lnN   1.0104/0.9896  -            1.0000/1.0000  -            1.0000/1.0000  1.0395/0.9620  1.0487/0.9531  1.0048/0.9952
Pileup              lnN   0.7586/2.0520  -            0.6497/1.4125  -            1.0000/1.0000  0.8366/1.3672  0.7772/1.5095  0.7104/1.7063
FakeRateEl          lnN   -              1.0000/1.0000  -            -            -              -              -              -
FakeRateMu          lnN   -              1.3444/0.6622  -            -            -              -              -              -
FakeClosureEl       lnN   -              1.0000/1.0000  -            -            -              -              -              -
FakeClosureMu       lnN   -              1.3751/0.6329  -            -            -              -              -              -
PDF                 lnN   0.9920/1.0119  -            -             -            -              -              -              -
Qsq                 lnN   1.0674/0.8927  -            -             -            -              -              -              -
AlphaS              lnN   1.0085/1.0005  -            -             -            -              -              -              -
WZCRSSmmFull_CRstat gmN 59 -             -            -             0.1159       -              -              -              -
MjjSyst             lnN   -              -            -             1.049        -              -              -              -
Mll3SSyst           lnN   -              -            -             1.053        -              -              -              -
Mll3LSyst           lnN   -              -            -             -            -              -              -              -
VBSWWVR             lnN   -              -            -             -            -              -              -              1.22
VBSWWXsec           lnN   -              -            -             -            -              -              -              1.20
TTWVR               lnN   -              -            -             -            -              -              1.18           -
TTWXsec             lnN   -              -            -             -            -              -              1.20           -
GammaVR             lnN   -              -            1.50          -            -              -              -              -
QFlipSyst           lnN   -              -            -             -            1.50           -              -              -
LumSyst             lnN   1.025          -            1.025         -            1.025          1.025          1.025          1.025
www_SRSSSidemm_stat lnN   1.3635         -            -             -            -              -              -              -
fakes_SRSSSidemm_stat lnN -              1.2753       -             -            -              -              -              -
photon_SRSSSidemm_stat lnN -             -            1.7117        -            -              -              -              -
qflip_SRSSSidemm_stat lnN -              -            -             -            1.0000         -              -              -
prompt_SRSSSidemm_stat lnN -             -            -             -            -              1.2007         -              -
ttw_SRSSSidemm_stat lnN   -              -            -             -            -              -              1.0992         -
vbsww_SRSSSidemm_stat lnN -              -            -             -            -              -              -              1.0594
```

2.7 0SFOS

```
imax 1 number of bins
jmax * number of processes
kmax * number of nuisance parameters
----------------------------------------------------------------------------------------------------------------------------------------------------
bin        SR0SFOS
observation   2.0
----------------------------------------------------------------------------------------------------------------------------------------------------
```

bin		SR0SFOS	SR0SFOS	SR0SFOS	SR0SFOS	SR0SFOS	SR0SFOS	SR0SFOS	SR0SFOS
process		0	1	2	3	4	5	6	7
process		www	fakes	photon	lostlep	qflip	prompt	ttw	vbsww
rate		2.895	0.627	0.000	0.756	0.017	0.431	0.207	0.000
JES	lnN	0.8843/0.9675	–	1.0000/1.0000	–	0.0001/1.0000	0.8125/1.2860	0.9050/1.1498	1.0000/1.0000
LepSF	lnN	0.9905/0.9363	–	1.0000/1.0000	–	1.0323/0.9677	1.0259/0.9741	1.0250/0.9750	1.0000/1.0000
TrigSF	lnN	1.0539/0.9461	–	1.0000/1.0000	–	1.0408/0.9592	1.0397/0.9603	1.0582/0.9418	1.0000/1.0000
BTagLF	lnN	1.0030/0.9971	–	1.0000/1.0000	–	1.0218/0.9785	1.0019/0.9981	1.0040/0.9960	1.0000/1.0000
BTagHF	lnN	1.0003/0.9997	–	1.0000/1.0000	–	1.0000/1.0000	1.0067/0.9933	1.0139/0.9861	1.0000/1.0000
Pileup	lnN	0.7736/1.4776	–	1.0000/1.0000	–	0.2505/6.3495	0.7079/1.5408	0.7309/1.6041	1.0000/1.0000
FakeRateEl	lnN	–	1.0014/0.9986	–	–	–	–	–	–
FakeRateMu	lnN	–	1.5930/0.5364	–	–	–	–	–	–
FakeClosureEl	lnN	–	1.0509/0.9437	–	–	–	–	–	–
FakeClosureMu	lnN	–	1.2339/0.7742	–	–	–	–	–	–
PDF	lnN	0.9944/1.0074	–	–	–	–	–	–	–
Qsq	lnN	1.0925/0.8229	–	–	–	–	–	–	–
AlphaS	lnN	1.0050/1.0013	–	–	–	–	–	–	–
MjjSyst	lnN	–	–	–	–	–	–	–	–
Mll SSSyst	lnN	–	–	–	–	–	–	–	–
Mll3LSyst	lnN	–	–	–	1.082	–	–	–	–
VBSWWVR	lnN	–	–	–	–	–	–	–	1.22
VBSWWXsec	lnN	–	–	–	–	–	–	–	1.20
TTWVR	lnN	–	–	–	–	–	–	1.18	–
TTWXsec	lnN	–	–	–	–	–	–	1.20	–
GammaVR	lnN	–	–	1.50	–	–	–	–	–
QFlipSyst	lnN	–	–	–	–	1.50	–	–	–
LumSyst	lnN	1.025	–	1.025	–	1.025	1.025	1.025	1.025
www_SR0SFOS_stat	lnN	1.1930	–	–	–	–	–	–	–
fakes_SR0SFOS_stat	lnN	–	2.1808	–	–	–	–	–	–
photon_SR0SFOS_stat	lnN	–	–	1.0000	–	–	–	–	–
qflip_SR0SFOS_stat	lnN	–	–	–	–	2.0000	–	–	–
prompt_SR0SFOS_stat	lnN	–	–	–	–	–	1.3116	–	–
ttw_SR0SFOS_stat	lnN	–	–	–	–	–	–	1.1483	–
vbsww_SR0SFOS_stat	lnN	–	–	–	–	–	–	–	1.0000

2.8 1SFOS

```
imax 1 number of bins
jmax * number of processes
kmax * number of nuisance parameters
----------------------------------------------------------------------------------------------------------------------------------------------------
bin        SR1SFOS
observation   9.0
----------------------------------------------------------------------------------------------------------------------------------------------------
```

bin		SR1SFOS	SR1SFOS	SR1SFOS	SR1SFOS	SR1SFOS	SR1SFOS	SR1SFOS	SR1SFOS
process		0	1	2	3	4	5	6	7
process		www	fakes	photon	lostlep	qflip	prompt	ttw	vbsww
rate		1.167	1.325	0.000	6.729	0.050	0.787	0.122	0.000
JES	lnN	1.0324/1.0769	–	1.0000/1.0000	–	1.0000/1.0000	0.7789/1.0161	0.7278/1.1043	1.0000/1.0000
LepSF	lnN	1.0218/0.9782	–	1.0000/1.0000	–	1.0241/0.9759	1.0246/0.9754	1.0285/0.9715	1.0000/1.0000
TrigSF	lnN	1.0509/0.9491	–	1.0000/1.0000	–	1.0833/0.9167	1.0482/0.9518	1.0585/0.9415	1.0000/1.0000
BTagLF	lnN	1.0068/0.9931	–	1.0000/1.0000	–	1.0211/0.9792	1.0169/0.9831	1.0063/0.9937	1.0000/1.0000
BTagHF	lnN	1.0071/0.9931	–	1.0000/1.0000	–	1.0000/1.0000	1.0046/0.9955	1.0294/0.9709	1.0000/1.0000
Pileup	lnN	0.7989/1.5089	–	1.0000/1.0000	–	0.6203/1.9494	0.6623/1.7953	0.6577/1.9976	1.0000/1.0000
FakeRateEl	lnN	–	1.0109/0.9892	–	–	–	–	–	–
FakeRateMu	lnN	–	1.0758/0.9205	–	–	–	–	–	–
FakeClosureEl	lnN	–	1.3360/0.7129	–	–	–	–	–	–
FakeClosureMu	lnN	–	1.0828/0.9189	–	–	–	–	–	–
PDF	lnN	0.9876/1.0167	–	–	–	–	–	–	–
Qsq	lnN	1.0591/0.8975	–	–	–	–	–	–	–
AlphaS	lnN	1.0033/1.0027	–	–	–	–	–	–	–
WZCR1SFOSFull_CRstat	gmN 70	–	–	–	0.0961	–	–	–	–
MjjSyst	lnN	–	–	–	–	–	–	–	–
Mll SSSyst	lnN	–	–	–	–	–	–	–	–
Mll3LSyst	lnN	–	–	–	1.082	–	–	–	–
VBSWWVR	lnN	–	–	–	–	–	–	–	1.22
VBSWWXsec	lnN	–	–	–	–	–	–	–	1.20
TTWVR	lnN	–	–	–	–	–	–	1.18	–
TTWXsec	lnN	–	–	–	–	–	–	1.20	–
GammaVR	lnN	–	–	1.50	–	–	–	–	–
QFlipSyst	lnN	–	–	–	–	1.50	–	–	–
LumSyst	lnN	1.025	–	1.025	–	1.025	1.025	1.025	1.025
www_SR1SFOS_stat	lnN	1.3181	–	–	–	–	–	–	–
fakes_SR1SFOS_stat	lnN	–	1.4557	–	–	–	–	–	–
photon_SR1SFOS_stat	lnN	–	–	1.0000	–	–	–	–	–
qflip_SR1SFOS_stat	lnN	–	–	–	–	1.7731	–	–	–
prompt_SR1SFOS_stat	lnN	–	–	–	–	–	1.7954	–	–
ttw_SR1SFOS_stat	lnN	–	–	–	–	–	–	1.2211	–
vbsww_SR1SFOS_stat	lnN	–	–	–	–	–	–	–	1.0000

2.9 2SFOS

```
imax 1 number of bins
jmax * number of processes
kmax * number of nuisance parameters
```

```
bin       SR2SFOS
observation  11.0
```
----

bin		SR2SFOS	SR2SFOS	SR2SFOS	SR2SFOS	SR2SFOS	SR2SFOS	SR2SFOS	SR2SFOS
process		0	1	2	3	4	5	6	7
process		www	fakes	photon	lostlep	qflip	prompt	ttw	vbsww
rate		0.849	0.336	0.000	10.640	0.166	0.036	0.057	0.000

|									
JES	lnN	0.9610/0.9775	–	1.0000/1.0000	–	0.9697/1.1283	0.6338/1.3246	0.7686/1.5497	1.0000/1.0000
LepSF	lnN	1.0267/0.9733	–	1.0000/1.0000	–	1.0303/0.9697	1.0296/0.9704	1.0277/0.9723	1.0000/1.0000
TrigSF	lnN	1.0341/0.9659	–	1.0000/1.0000	–	1.0776/0.9224	1.0473/0.9527	1.0460/0.9540	1.0000/1.0000
BTagLF	lnN	1.0112/0.9889	–	1.0000/1.0000	–	1.0047/0.9953	1.0048/0.9953	1.0102/0.9899	1.0000/1.0000
BTagHF	lnN	1.0010/0.9990	–	1.0000/1.0000	–	1.0000/1.0000	1.0199/0.9804	1.0126/0.9876	1.0000/1.0000
Pileup	lnN	0.7883/2.2668	–	1.0000/1.0000	–	0.6935/2.0882	0.6819/1.0657	0.7317/1.3945	1.0000/1.0000
FakeRateEl	lnN	–	0.9963/1.0036	–	–	–	–	–	–
FakeRateMu	lnN	–	1.7644/0.3322	–	–	–	–	–	–
FakeClosureEl	lnN	–	0.8843/1.0879	–	–	–	–	–	–
FakeClosureMu	lnN	–	1.2984/0.7104	–	–	–	–	–	–
PDF	lnN	0.9967/1.0046	–	–	–	–	–	–	–
Qsq	lnN	1.0072/1.0087	–	–	–	–	–	–	–
AlphaS	lnN	0.9986/1.0000	–	–	–	–	–	–	–
WZCR2SFOSFull_CRstat	gmN	199	–	–	–	0.0535	–	–	–	–
MjjSyst	lnN	–	–	–	–	–	–	–	–
MllSSSyst	lnN	–	–	–	–	–	–	–	–
Mll3LSyst	lnN	–	–	–	1.082	–	–	–	–
VBSWWVR	lnN	–	–	–	–	–	–	–	1.22
VBSWWXsec	lnN	–	–	–	–	–	–	–	1.20
TTWVR	lnN	–	–	–	–	–	–	1.18	–
TTWXsec	lnN	–	–	–	–	–	–	1.20	–
GammaVR	lnN	–	–	1.50	–	–	–	–	–
QFlipSyst	lnN	–	–	–	1.50	–	–	–
LumSyst	lnN	1.025	–	1.025	–	1.025	1.025	1.025	1.025
www_SR2SFOS_stat	lnN	1.3195	–	–	–	–	–	–	–
fakes_SR2SFOS_stat	lnN	–	2.0650	–	–	–	–	–	–
photon_SR2SFOS_stat	lnN	–	–	1.0000	–	–	–	–	–
qflip_SR2SFOS_stat	lnN	–	–	–	–	1.4286	–	–	–
prompt_SR2SFOS_stat	lnN	–	–	–	–	–	1.7592	–	–
ttw_SR2SFOS_stat	lnN	–	–	–	–	–	–	1.3406	–
vbsww_SR2SFOS_stat	lnN	–	–	–	–	–	–	–	1.0000
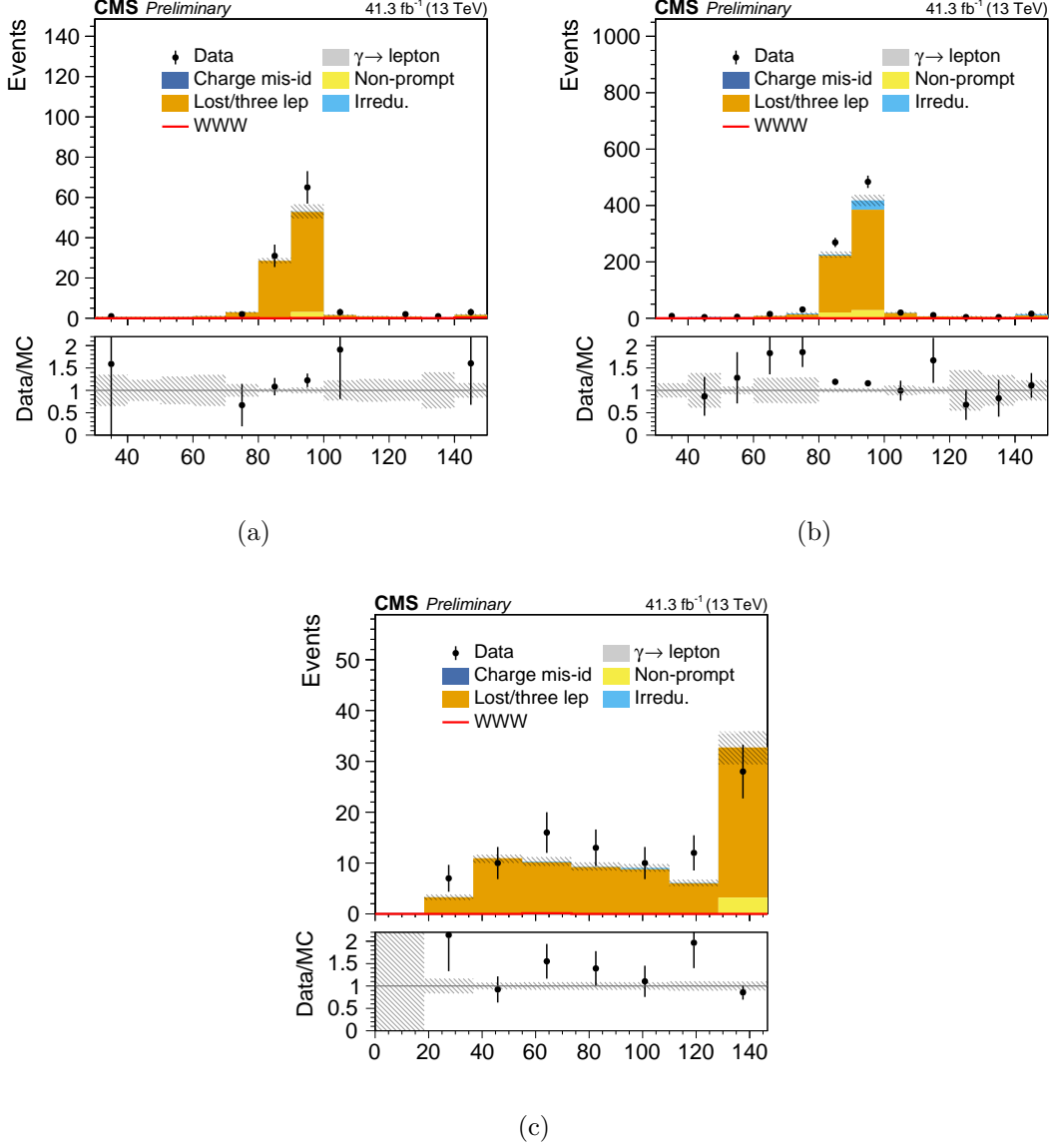
Figure 2: Lost lepton control region, efficiencies and extrapolation checks (a) The m_{SFOS} distribution in lost lepton control regions for same-sign channels. (b) The m_{SFOS} distribution in lost lepton control regions for three-lepton channels. (c) The m_{jj} distribution in lost lepton control regions for same-sign channels.