WWW SNT Internal Note

SNT WWW Team

December 12, 2018

Abstract

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

1 TODOs

- Lost lepton background estimation
  - Lost lepton transfer factor JES needs to be updated.
  - Lost lepton m_{SFOS} uncertainty of 19.9% OK?
- Non-prompt background estimation
  - N.B. Currently, the scale factors are fitted, and the errors on SFs what is varied to obtain the fakerate errors.
- VBS $W^{\pm}W^{\pm}$ validation region
  - Update the m_{jj} variable to be the same as what was used in 2016 analysis note.
  - I am not sure if we can say (22%) like last time...
  - $Z\gamma$ sample is missing however...
- $t\bar{t}W$ validation region
  - Create a similar table done for 2016
- $\gamma \rightarrow$ lepton validation region
  - **Can't do this without $V\gamma$ MC sample! Still not ready AFAIK.**
- Charge flip validation region
  - Need opposite sign babies. (half a day time for baby production.) But shouldn't be difficult.

  - Smearing function is probably crucial?

- Other random loose ends
  - Pre-firing checks for 2017?
- Signal region yields
  - The plot and table only contains statistical uncertainties.
- Statistical interpretation
  - Some of it comes from 2016. Still needs some updates.
  - Several systematics table needs to be updated properly.

2 Lost Lepton Control Region

Table 1: Lost lepton control region yields.

	$\gamma \to lepton$	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

Table 2: Lost lepton transfer factor systematic variations.

	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 $\text{eff}_{\text{err}} = \sqrt{(\text{eff}(1-\text{eff})/n)}$

	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

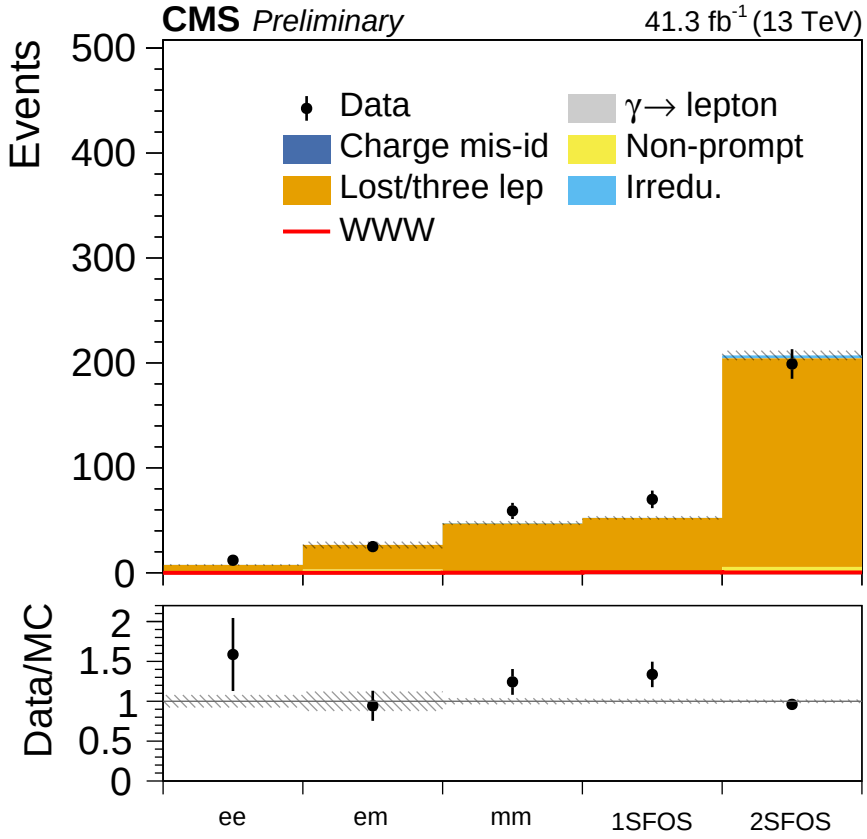


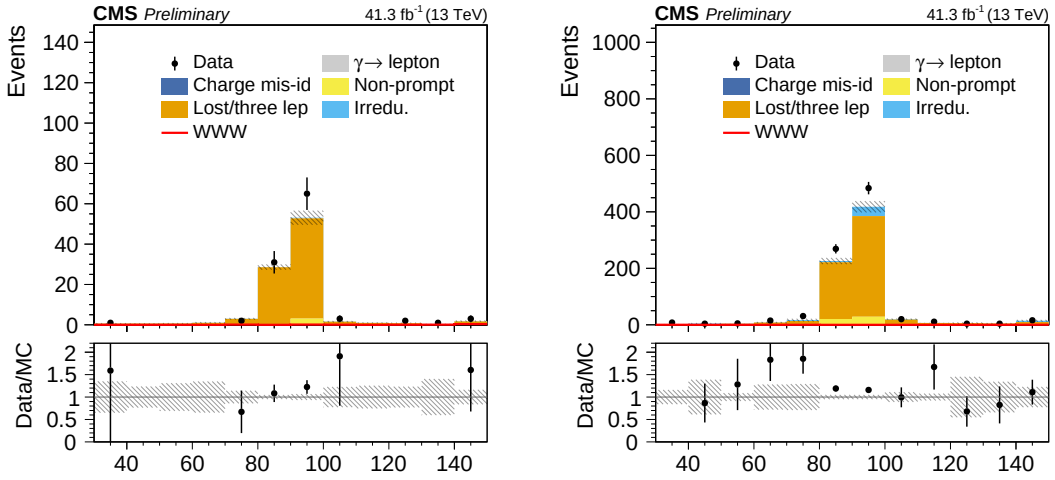
Figure 1: Lost lepton control region for 2017 data.

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

	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

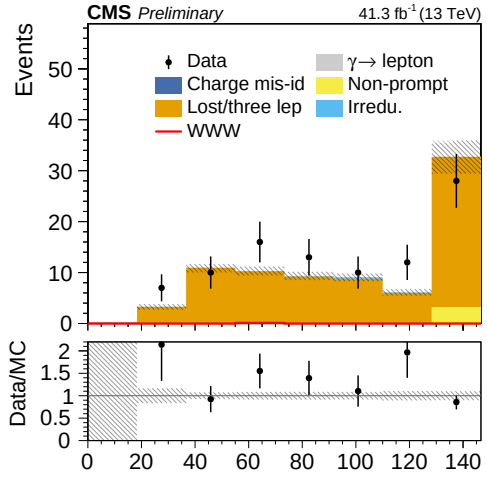
Table 5: Some numbers for same-sign channel m_{jj} efficiency measurement. Equation is that eff $= b/a$ and $\text{eff}_{\text{err}} = \sqrt{(\text{eff}(1-\text{eff})/n)}$

	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



(a)

(b)



(c)

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.

3 Non-prompt backgrounds

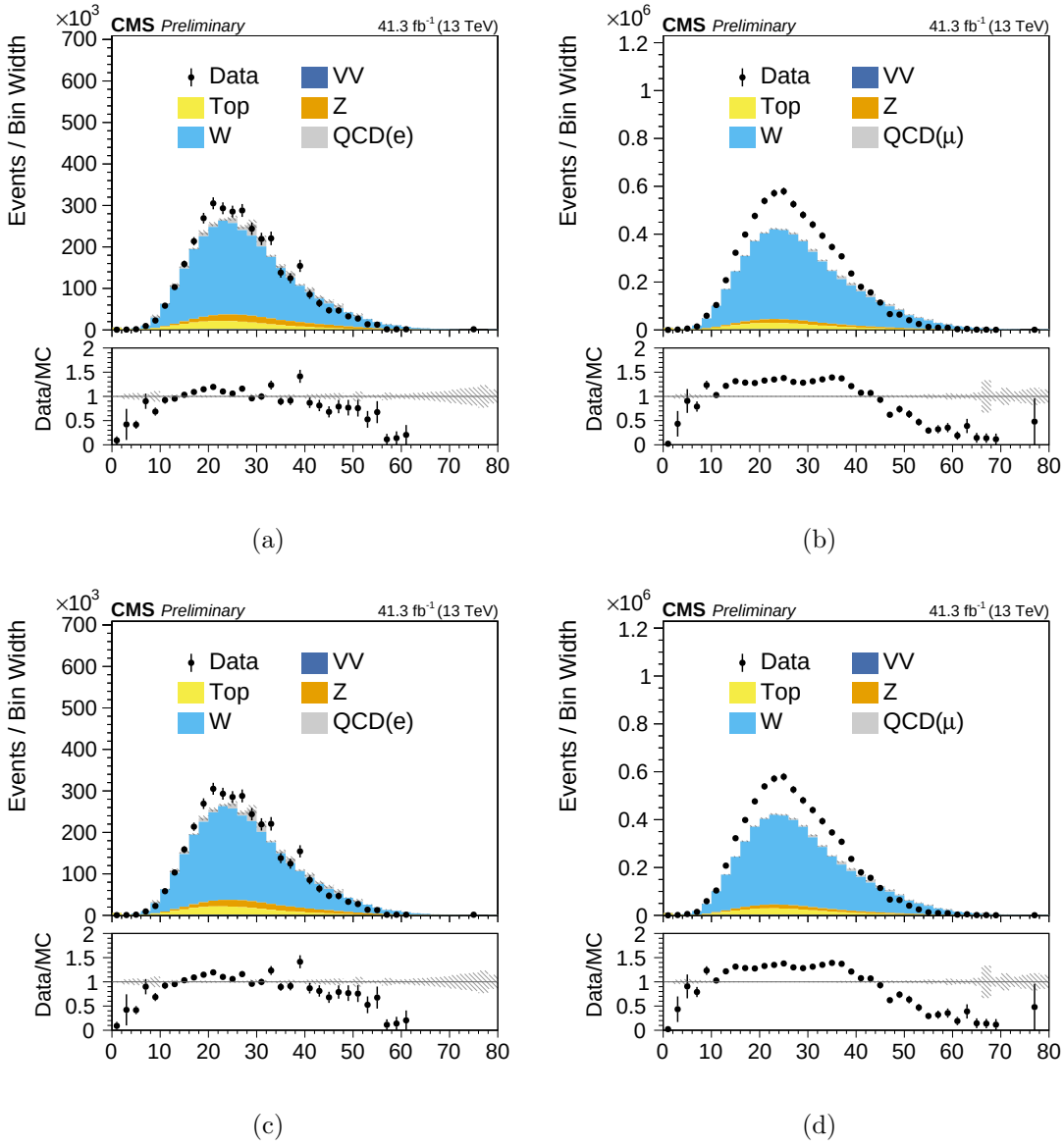


Figure 3: Checking number of vertex distribution after applying prescales. (a) The number of vertex distribution in one lepton control region for same-sign electron ID. (b) The number of vertex distribution in one lepton control region for same-sign muon ID. (c) The number of vertex distribution in one lepton control region for three-lepton electron ID. (d) The number of vertex distribution in one lepton control region for three-lepton muon ID.

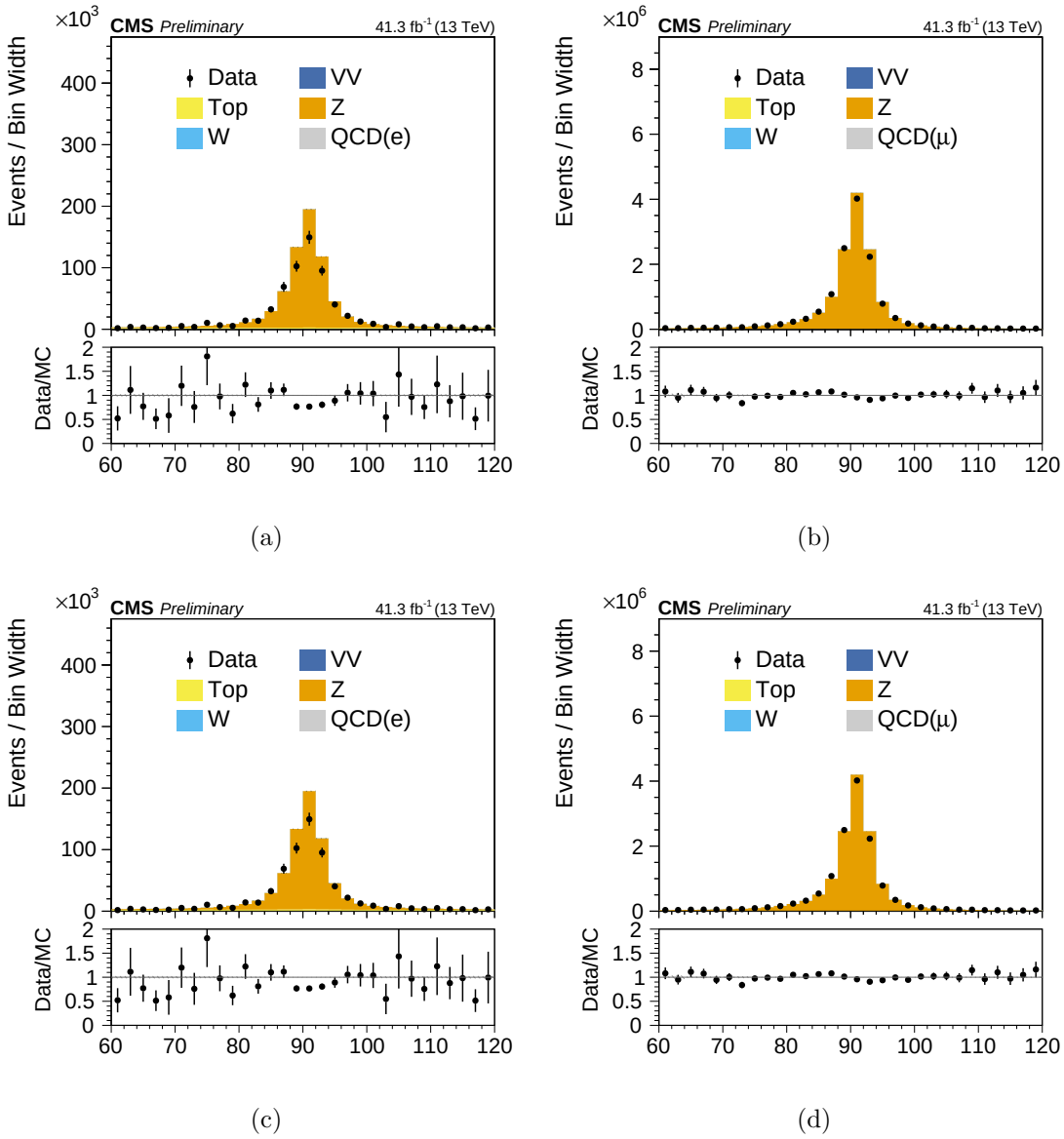
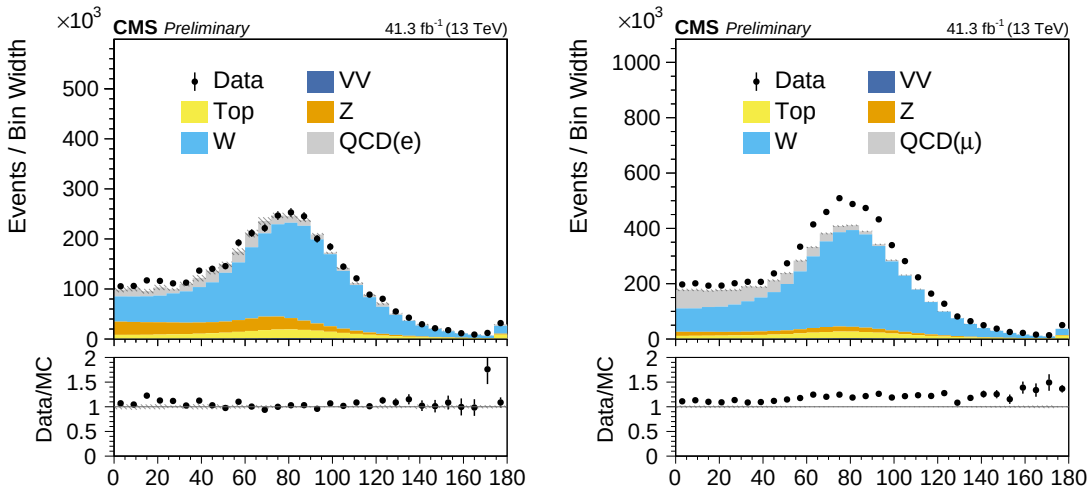
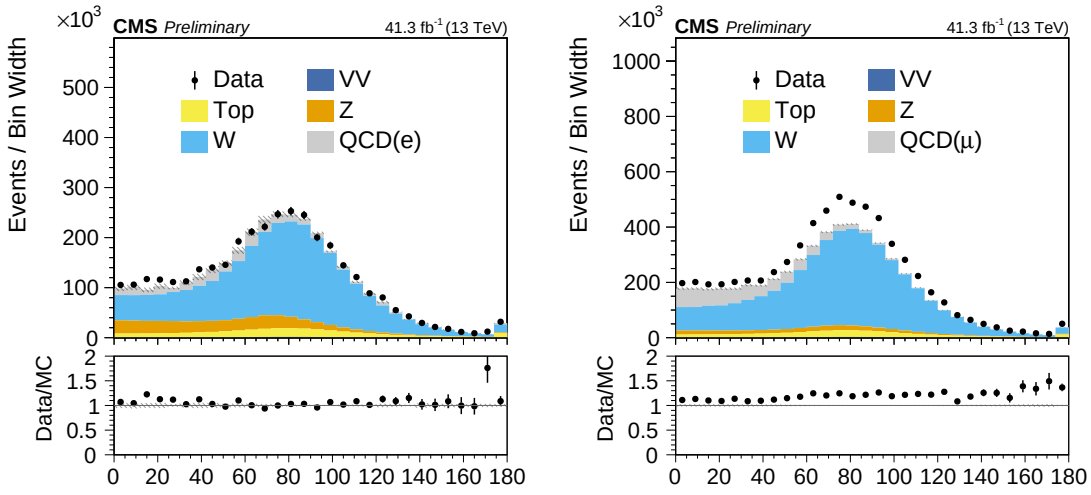


Figure 4: Even after applying prescale, some residual difference is corrected by obtaining a scale factor by comparing the expected MC yields to Z boson events from data. (a) The m_{ll} distribution in two leptons control region with same-sign electron ID. (b) The m_{ll} distribution in two leptons control region with same-sign muon ID. (c) The m_{ll} distribution in two leptons control region with three-lepton electron ID. (d) The m_{ll} distribution in two leptons control region with three-lepton muon ID.

4 VBS Validation Region



(a) (b)



(c) (d)

Figure 5: The m_T distribution in high MET region where the window of 80 GeV $< m_T <$ 120 GeV is used as a control region to obtain scale factors to apply to the prompt lepton contribution in the measurement region where the fake rate is derived. (a) The m_T distribution in one lepton control region for same-sign electron ID. (b) The m_T distribution in one lepton control region for same-sign muon ID. (c) The m_T distribution in one lepton control region for three-lepton electron ID. (d) The m_T distribution in one lepton control region for three-lepton muon ID.

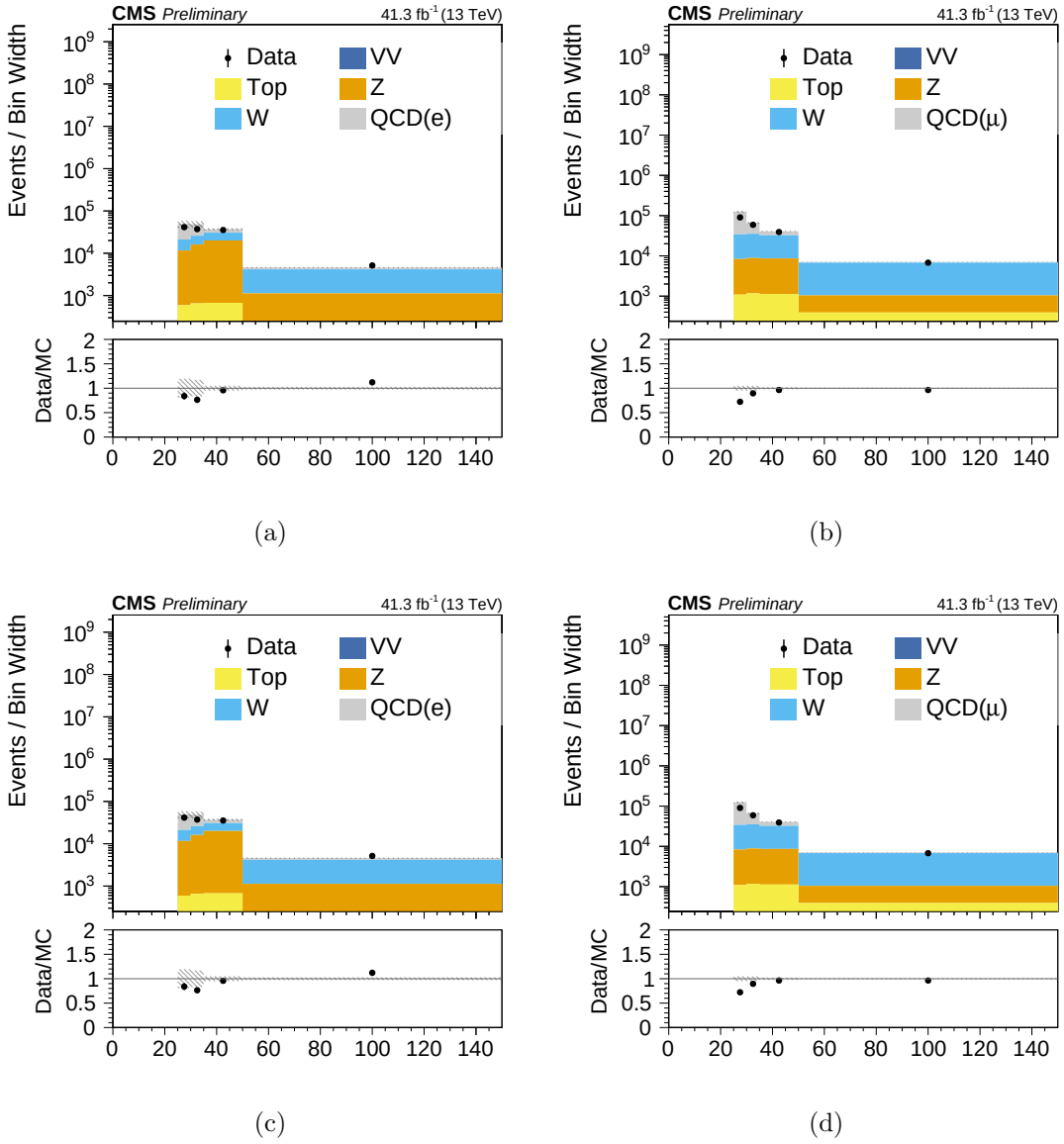


Figure 6: The $p_{T,corr}$ distribution in measurement region with one tight lepton. (a) The $p_{T,corr}$ one lepton tight measurement region for same-sign electron ID. (b) The $p_{T,corr}$ one lepton tight measurement region for same-sign muon ID. (c) The $p_{T,corr}$ one lepton tight measurement region for three-lepton electron ID. (d) The $p_{T,corr}$ one lepton tight measurement region for three-lepton muon ID.

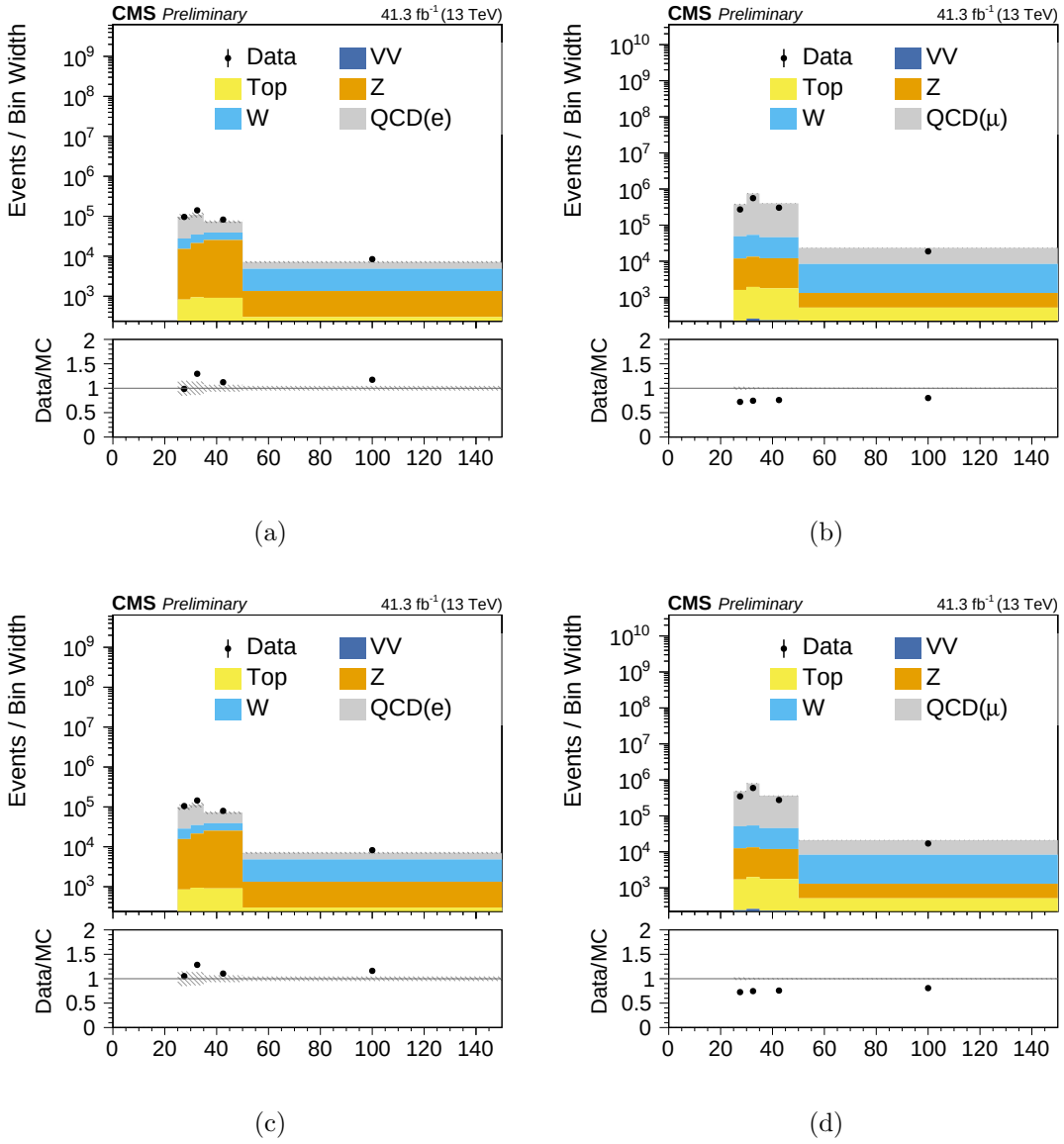
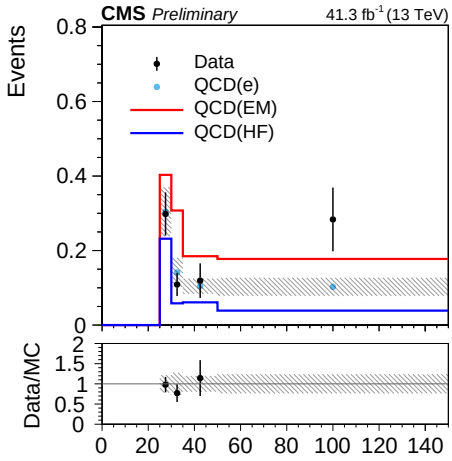
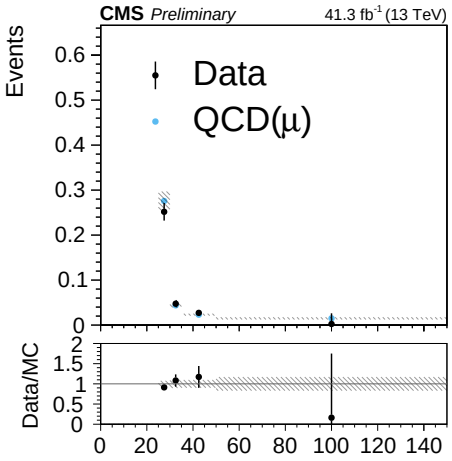


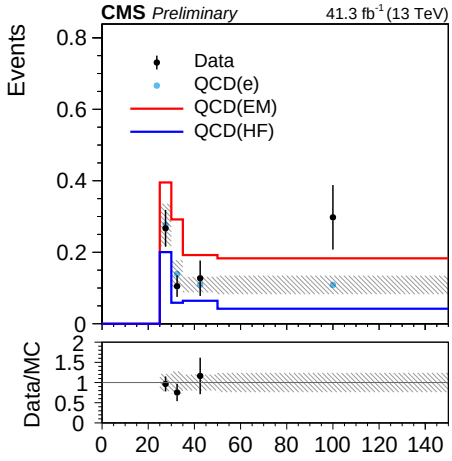
Figure 7: The $p_{T,corr}$ distribution in measurement region with one loose lepton. (a) The $p_{T,corr}$ one lepton loose measurement region for same-sign electron ID. (b) The $p_{T,corr}$ one lepton loose measurement region for same-sign muon ID. (c) The $p_{T,corr}$ one lepton loose measurement region for three-lepton electron ID. (d) The $p_{T,corr}$ one lepton loose measurement region for three-lepton muon ID.



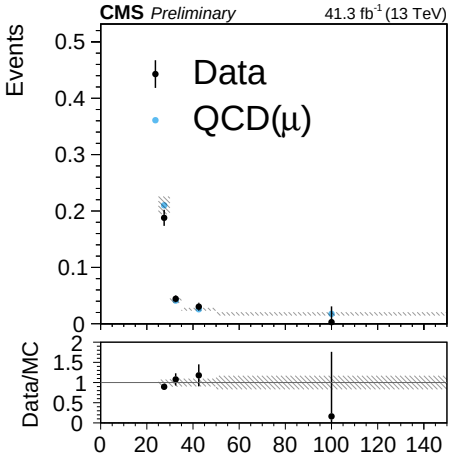
(a)



(b)



(c)



(d)

Figure 8: Fake rate measured as a function of $p_{T,corr}$. (a) The fake rate for same-sign electron ID. (b) The fake rate for same-sign muon ID. (c) The fake rate for three-lepton electron ID. (d) The fake rate for three-lepton muon ID.

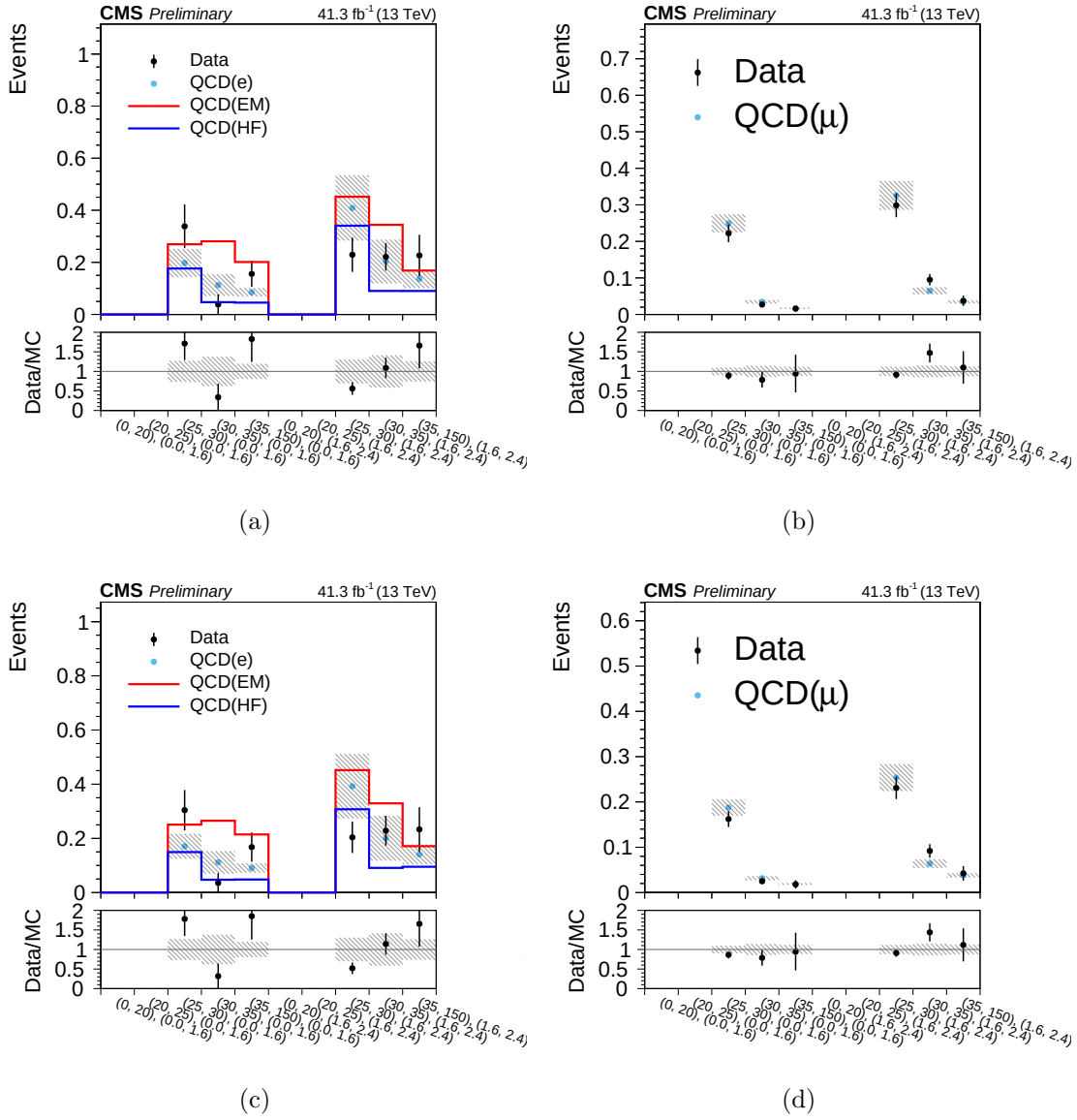


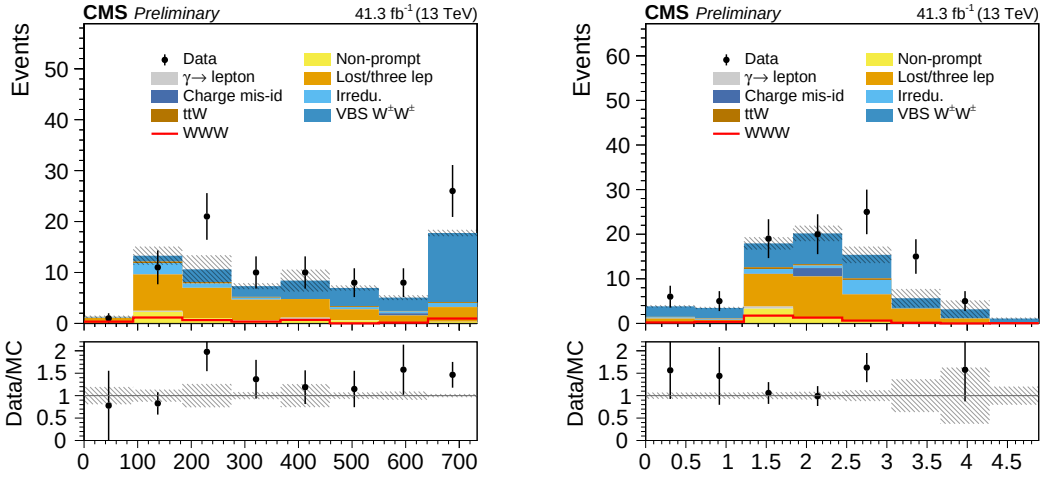
Figure 9: Fake rate measured as a function of $p_{T,corr}$ and $|\eta|$. Each bin is labeled by its phase-space. The first pair of numbers indicate the $p_{T,corr}$ phase space boundaries, and the second pair of numbers indicate the $|\eta|$ phase space boundaries. (a) The fake rate for same-sign electron ID. (b) The fake rate for same-sign muon ID. (c) The fake rate for three-lepton electron ID. (d) The fake rate for three-lepton muon ID.

Table 6: Scale factors used for same-sign channel

type of scale factors	scale factor values
Prescale e	1.16
Prescale μ	1.02
e prompt SF	1.07 ± 0.02
μ prompt SF	1.24 ± 0.01

Table 7: Scale factors used for three-lepton channel

type of scale factors	scale factor values
Prescale e	1.16
Prescale μ	1.02
e prompt SF	1.07 ± 0.02
μ prompt SF	1.24 ± 0.01



(a) (b)

Figure 10: VBS $W^{\pm}W^{\pm}$ control region plots. (a) **This isn't the same variable as 2016 analysis note.** The invariant mass of the two leading jets across all η region. (b) The Δ_{jj} of two leading jets within central regions.

5 $t\bar{t}W$ Validation Region

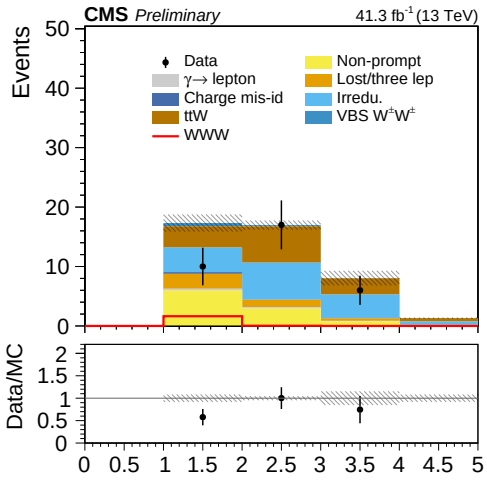


Figure 11: The n_b distribution in $t\bar{t}W$ validation region.

6 Signal Region Yields

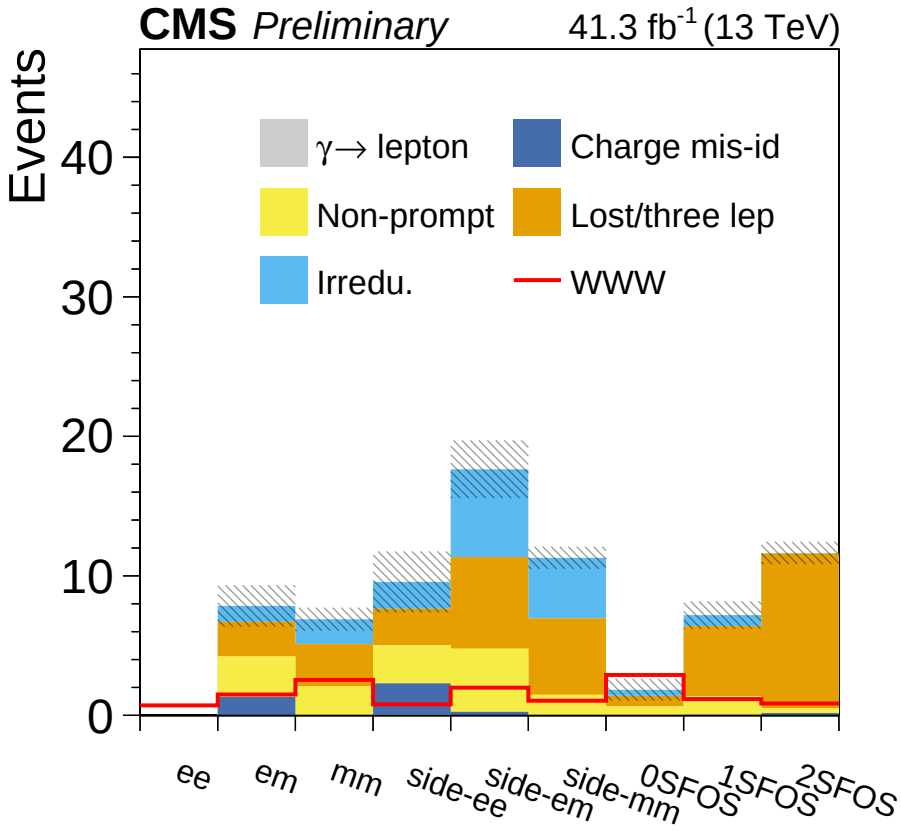


Figure 12: Signal region yields after applying background estimation methods. The uncertainty band only includes statistical uncertainties.

Table 8: Signal region yields with each process set to its background estimation method's prediction.

	$\gamma \rightarrow lepton$	Charge mis-id	Non-prompt	Lost/three lep	Irredu.	WWW	Total	Data	Ratio
ee	0.018 ± 0.009	-2.919 ± 3.084	0.225 ± 0.897	0.805 ± 0.192	0.397 ± 0.071	0.714 ± 0.203	-1.474 ± 3.219	0.0 ± 0.0	-0.0 ± 0.0
em	0.026 ± 0.01	1.295 ± 1.142	2.898 ± 0.856	2.489 ± 0.387	1.138 ± 0.143	1.494 ± 0.28	7.845 ± 1.486	0.0 ± 0.0	0.0 ± 0.0
mm	-0.002 ± 0.002	0.0 ± 0.0	2.074 ± 0.637	3.033 ± 0.465	1.781 ± 0.267	2.541 ± 0.475	6.886 ± 0.833	0.0 ± 0.0	0.0 ± 0.0
side-ee	0.039 ± 0.016	2.258 ± 1.759	2.721 ± 1.214	2.618 ± 0.37	1.932 ± 0.274	0.789 ± 0.235	9.567 ± 2.186	0.0 ± 0.0	0.0 ± 0.0
side-em	0.009 ± 0.006	0.245 ± 0.173	4.522 ± 1.34	6.569 ± 0.626	6.294 ± 1.439	1.986 ± 0.441	17.64 ± 2.071	0.0 ± 0.0	0.0 ± 0.0
side-mm	0.004 ± 0.003	0.0 ± 0.0	1.471 ± 0.405	5.482 ± 0.633	4.336 ± 0.267	1.05 ± 0.382	11.293 ± 0.797	0.0 ± 0.0	0.0 ± 0.0
0SFOS	0.0 ± 0.0	0.017 ± 0.017	0.627 ± 0.74	0.756 ± 0.215	0.431 ± 0.134	2.895 ± 0.559	1.83 ± 0.783	0.0 ± 0.0	0.0 ± 0.0
1SFOS	0.0 ± 0.0	0.05 ± 0.038	1.325 ± 0.604	5.022 ± 0.471	0.787 ± 0.626	1.167 ± 0.371	7.185 ± 0.99	0.0 ± 0.0	0.0 ± 0.0
2SFOS	0.0 ± 0.0	0.166 ± 0.071	0.336 ± 0.358	11.101 ± 0.719	0.036 ± 0.028	0.849 ± 0.271	11.64 ± 0.807	0.0 ± 0.0	0.0 ± 0.0

7 Statistical interpretation

7.1 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           -               -               -               -
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_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
```

7.2 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
```

7.3 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

7.4 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

7.5 m_{jj}-out em

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

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	-	-	-	-
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_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

7.6 m_{jj}-out mm

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

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	-	-	-	-
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_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

7.7 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	-	-	-	-	-	-	-	-
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_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

7.8 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	-	-	-	-	-	-	-	-
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_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

7.9 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