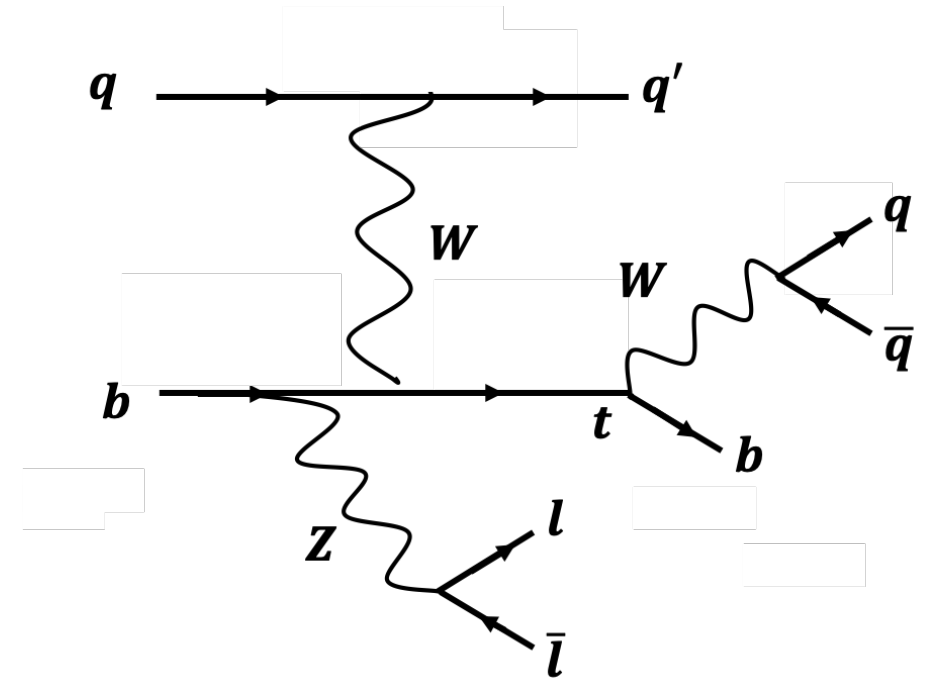


# Search for $tZq$ production in the dilepton final state using CMS nanoAOD run 2 samples

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# tZq production in the dilepton final state

- Shape-based analysis
- Motivations:
  - **Rare process** predicted by the SM
  - Top quark does not hadronise  $\Rightarrow$  **spin info** passed onto decay particles
  - Sensitive to the **tZ and WWZ couplings**
  - tZq forms an **irreducible background** to the tZ-FCNC process



# Methodology

# Events with bad luminosities were filtered using the golden json file

- The golden json file provides the run numbers and luminosity ranges of good lumisections:
  - 2016: [Cert\\_271036-284044\\_13TeV\\_PromptReco\\_Collisions16\\_JSON.txt](#)
  - 2017: [Cert\\_294927-306462\\_13TeV\\_PromptReco\\_Collisions17\\_JSON.txt](#)
  - 2018: in AFS, copy file across to where you want it  
(path: `/afs/cern.ch/cms/CAF/CMSCOMM/COMM_DQM/certification/Collisions18/13TeV/PromptReco/Cert_314472-325175_13TeV_PromptReco_Collisions18_JSON.txt`)
- PdmV twiki:
  - 2016: <https://twiki.cern.ch/twiki/bin/viewauth/CMS/PdmV2016Analysis>
  - 2017: <https://twiki.cern.ch/twiki/bin/viewauth/CMS/PdmV2017Analysis>
  - 2018: <https://twiki.cern.ch/twiki/bin/viewauth/CMS/PdmV2018Analysis>
- Twiki link is [here](#)

# Event cleaning removes events affected by known anomalies

- Primary vertex filter (Flag\_goodVertices)
- Beam halo filter (Flag\_globalSuperTightHalo2016Filter)
- HBHE noise filter (Flag\_HBHENoiseFilter)
- HBHEIso noise filter (Flag\_HBHENoiseIsoFilter)
- ECAL trigger primitive filter (Flag\_EcalDeadCellTriggerPrimitiveFilter)
- Bad PF muon filter (Flag\_BadPFMuonFilter)
- Bad charged hadron filter (Flag\_BadChargedCandidateFilter)
- Flag\_ecalBadCalibFilter
- Flag\_eeBadScFilter

Twiki page outlining the differences between years is [here](#).

# Signal Region: Event Selection using CMS nanoAOD samples for 2016 ( $35.88 \text{ fb}^{-1}$ )

- **Lepton selection** (ee and  $\mu\mu$  channels):
  - Exactly two. Opposite sign and same flavour.
  - Leading (subleading) **electrons**:  $p_T > 35$  (15) GeV,  $|\eta| < 2.4$
  - Leading (subleading) **muons**:  $p_T > 26$  (20) GeV,  $|\eta| < 2.4$
- **Jet selection**:
  - Anti- $K_T$  jets with  $\Delta R = 0.4$ .
  - Jets:  $|\eta| < 4.7$ ,  $p_T > 30$  GeV.
- **B-tagged jets**:  $|\eta| < 2.4$ . 1-2 b-jets using CSVv2 at the **medium working point**.
- **W boson candidate reconstruction**:
  - A pair of quark jets (excluding the leading b jet) with a reconstructed mass **closest to the W mass**.
  - Mass window cut of **20 GeV** is applied.
- **Top quark reconstruction**:
  - From the W boson and the leading b jet with an invariant mass **closest to that of the top quark mass**.

# Signal Region: Event Selection using CMS nanoAOD samples for 2017 ( $41.53 \text{ fb}^{-1}$ ) and 2018 ( $59.69 \text{ fb}^{-1}$ )

- Same as 2016, except for **changed cuts shown in red**:
- **Lepton selection** (ee and  $\mu\mu$  channels):
  - Exactly two. Opposite sign and same flavour.
  - Leading (subleading) **electrons**:  $p_T > 38$  (15) GeV,  $|\eta| < 2.4 \rightarrow p_T > 38$  (15) GeV,  $|\eta| < 2.5$
  - Leading (subleading) **muons**:  $p_T > 29$  (20) GeV,  $|\eta| < 2.4 \rightarrow p_T > 29$  (20) GeV,  $|\eta| < 2.5$
- **B-tagged jets**:  $|\eta| < 2.4 \rightarrow |\eta| < 2.5$ .

Increased  $p_T$  cuts due to **increased single lepton trigger thresholds** from 2016 to 2017.

Increased  $|\eta|$  cut due to **increased tracker acceptance**.

# Control Regions

- $t\bar{t}$ 
  - Lepton selection changed: exactly one tight electron and one tight muon are required with  $p_T > 25$  GeV. No additional loose leptons.
- Z+jets
  - W boson mass requirement is inverted (no pair of jets may have an invariant mass within 20 GeV of the nominal W boson mass, excluding the leading b jet). The event must have less than 50 GeV of missing transverse energy.



# Experimental blinding is carried out to apply a side-band region to data and MC. This prevents unintentionally-biased choices.

Based on  $HH \rightarrow b\bar{b}b\bar{b}$  analyses [1, 2]

$$\chi^2 = \left( \frac{m_W^{rec} - m_W}{\sigma_W} \right)^2 + \left( \frac{m_{top}^{rec} - m_{top}}{\sigma_T} \right)^2 \Rightarrow \begin{array}{l} \text{Side band region:} \\ \text{Signal region:} \end{array}$$

Where:

$m_W^{rec}$  = nominal W mass

$m_W$  = reconstructed W boson mass

$m_{top}^{rec}$  = nominal top mass

$m_{top}$  = reconstructed top boson mass

$\sigma_W$  = resolution of the reconstructed W boson mass

$\sigma_T$  = resolution of the reconstructed top quark mass

# Experimental blinding (continued)

- In the equation on the previous slide, the  $m_W^{rec}$ ,  $m_T^{rec}$ ,  $\sigma_W$  and  $\sigma_T$  values are calculated from **Gaussian fits** that have been applied to the **W and top mass distributions**.
- The  $m_W$  and  $m_T$  values are 80.385 GeV and 173.3 GeV, respectively.

# Experimental blinding (continued)

- Using MC events as input to the equation, the  $\chi^2$  is calculated for each event.
- The  $\chi^2$  range was defined so that it contained all events where the reconstructed W mass **was within  $5\sigma$**  of the known W mass. The range also contains **68% of the simulated signal events**.
- A value of 68% was chosen because anything higher would leave **too few background events** to properly model backgrounds with confidence.
- Data events were filtered with this  $\chi^2$  range. For unblinding, this filter was removed.

# Non prompt lepton (NPL) estimation

$$N_{data}^{OS_{nonprompt}} = \left( N_{data}^{SS} - N_{real+mis-ID}^{SS} \right) \cdot \underbrace{\frac{N_{MC}^{OS_{nonprompt}}}{N_{MC}^{SS_{nonprompt}}}}_{\text{Used for normalisation}}$$

where:

$N_{data}^{SS}$  = number of same sign events observed in data

$N_{real+mis-ID}^{SS}$  = expected number of real same sign events and events with charge misidentification

$N_{MC}^{OS_{nonprompt}}$  = number of opposite-sign NPLs in simulation

$N_{MC}^{SS_{nonprompt}}$  = number of same-sign NPLs in simulation

# Simulation corrections are applied to match MC with data.

- Normalisation factor
- Lepton Efficiency
  - Lepton identification, isolation, reconstruction and trigger efficiencies
- Lepton Energy Corrections
  - Electron regression, electron energy scale and electron smearing
  - Rochester corrections
- Jet Energy Corrections
  - Jet smearing
  - L1 pile up (already included in nanoAOD)
  - L2 relative and L3 absolute (already included in nanoAOD)
  - L2L3 residual (already included in nanoAOD)
- Pileup modelling
- b tagging efficiency
- Top quark  $p_T$  reweighting
- Miscalibrated Tracker APV Chips (2016 only)

# Simulation corrections – Normalisation Factor ( $w$ )

$$w = \frac{\mathcal{L}\sigma}{N}$$

$\mathcal{L}$  = integrated luminosity,  $\sigma$  = cross section,  $N$  = number of simulated events

- The  $\mathcal{L}$  is calculated using the [brilcalc tool](#)

# Simulation corrections – Lepton Efficiencies

- The muon identification (ID), isolation (ISO) and reconstruction efficiency scale factors are provided by CMS: [Twiki page for 2016](#), [Twiki page for 2017](#), [Twiki page for 2018](#)
  - ROOT files for 2016
    - [MuonID\\_EfficienciesAndSF\\_BCDEF.root](#)
    - [MuonID\\_EfficienciesAndSF\\_GH.root](#)
    - [MuonISO\\_EfficienciesAndSF\\_BCDEF.root](#)
    - [MuonISO\\_EfficienciesAndSF\\_GH.root](#)
  - ROOT files for 2017
    - [Muon\\_RunBCDEF\\_SF\\_ID.root](#)
    - [Muon\\_RunBCDEF\\_SF\\_ID\\_syst.root](#)
    - [Muon\\_RunBCDEF\\_SF\\_ISO.root](#)
    - [Muon\\_RunBCDEF\\_SF\\_ISO\\_syst.root](#)
  - ROOT files for 2018:
    - [RunABCD\\_SF\\_ID.root](#)
    - [RunABCD\\_SF\\_ISO.root](#)

# Simulation Corrections – Lepton efficiency (continued)

- A trigger scale factor is calculated for each channel ( $ee$ ,  $\mu\mu$  and  $e\mu$ ) using the cross-trigger method (from ???).
- MET samples were chosen for the cross trigger, since they are weakly correlated to tZq events.

$$\epsilon_{MC (DATA)} = \frac{\text{Number of MC (data) events that pass the MET triggers, lepton triggers and the event selection}}{\text{Number of MC (Data) events that pass the lepton triggers and event selection only}}$$

$$SF_{Trig} = \frac{\epsilon_{DATA}}{\epsilon_{MC}}$$



# Simulation Corrections – Lepton Energy Corrections

- Electron regression, energy scale and smearing corrections
  - [Link](#) to EGammaPOG Twiki page
  - [File 1 for 2016](#)
  - [File 2 for 2016](#)
  - [File 1 for 2017](#)
  - [File 2 for 2017](#)
  - [File 3 for 2017](#)
  - [File 1 for 2018](#)
  - [File 2 for 2018](#)
- Rochester corrections
  - The roccor.Run2.v3.tgz package was used for run 2
  - [Link](#) to Twiki page

The files for **2018** were downloaded from [this Twiki page](#).

# Simulation Corrections – Jet Energy Corrections

- Already applied in nanoAOD:
  - **L1 pile up** – Applied to both data and simulation, removes excess energy that arises from PU from the jet energy.
  - **L2 relative and L3 absolute** – Applied to both data and simulation, accounts for the non-uniform response of the detector for  $p_T$  and  $\eta$ .
  - **L2L3 residual** – Applied only to simulated jets, these account for any remaining discrepancies between data and simulation.
- **Jet smearing** needs to be applied (slides 19-22).

# Simulation correction – Jet Energy Smearing

- The [hybrid method](#) was used to apply the correction factor to the four momentum of the reconstructed jet. If 2 is true, 1 is used. Else, 3 is used.

1.  $C_{JER} = 1 + (S_{JER} + 1) \frac{p_T - p_T^{ptcl}}{p_T}$

2.  $\Delta R = R_{cone}/2$  and  $|p_T - p_T^{ptcl}| < 3\sigma_{JER}p_T$

3.  $C_{JER} = 1 + N(0, S_{JER}) \sqrt{\max(S_{JER}^2 - 1, 0)}$

Where:

$C_{JER}$  = correction factor  
 $S_{JER}$  = data-to-simulation core resolution factor

$\sigma_{JER}$  = transverse momentum resolution  
 $p_T$  = jet transverse momentum

$p_T^{ptcl}$  = the  $p_T$  of a generator-level jet

$N(0, S_{JER})$  = random number sampled from a normal distribution, with a mean of zero and variance of  $\sigma^2$

$\max(S_{JER}^2 - 1, 0)$  = the largest value out of  $S_{JER}^2 - 1$  or 0

# Simulation correction – Jet Energy Smearing (continued)

- $S_{JER}$  and  $\sigma_{JER}$  are read from text files.
- Text files provided by CMS:
  - $\sigma_{JER}$  [for 2016](#)
  - $\sigma_{JER}$  [for 2017](#)
  - $\sigma_{JER}$  [for 2018](#)
  - $S_{JER}$  [for 2016](#)
  - $S_{JER}$  [for 2017](#)
  - $S_{JER}$  [for 2018](#)

Explanations of the format of the  $S_{JER}$  and  $\sigma_{JER}$  text files are given on slides 21 and 22.

# Simulation correction – Jet Energy Smearing (continued)

- For  $\sigma_{JER}$ , use the  $p_T$  resolution text file e.g. for 2017 (Fall17\_V3\_MC\_PtResolution\_AK4PFchs.txt):

{2	JetEta	Rho	1	JetPt	sqrt([0]*abs([0])/(x*x)+[1]*[1]*pow(x,[3])+[2]*[2])				Resolution}	
-4.7	-3.2	0	6.37	6	15	3000	-29.87	29.84	0.1045	-1.995
-4.7	-3.2	6.37	12.4	6	15	3000	-23.2	23.09	0.1051	-1.987
-4.7	-3.2	12.4	18.42	6	15	3000	4.337	0.2253	0.06986	-0.4215

- Columns 1 and 2 = Min and max  $\eta$  values (Jet\_eta).
- Columns 3 and 4 = Min and max  $\rho$  values (fixedGridRhoFastjetAll).
- Column 5 = Just to say there are 6 more columns after this one (this column is not used).
- Columns 6 and 7 = Min and max  $p_T$  values (Jet\_pt).
- Columns 8, 9, 10 and 11 = Values you substitute into [0], [1], [2] and [3] in the equation, respectively, (where x is the input  $p_T$ )

# Simulation correction – Jet Energy Smearing (continued)

- For  $s_{JER}$  use the SF file e.g. for 2017 (Fall17\_V3\_MC\_SF\_AK4PFchs.txt)

```
{1 JetEta 0 None ScaleFactor}  
-5.191 -3.139 3 1.1542 1.0019 1.3066  
-3.139 -2.964 3 1.2696 1.1607 1.3785  
-2.964 -2.853 3 2.2923 1.9180 2.6665
```

- Columns 1 and 2 = Min and max  $\eta$  values.
- Column 3 = to tell you there are three more columns after this one (not used).
- Column 4 = central SF value.
- Column 5 = SF down (column 4 – column 5 = lower uncertainty)
- Column 6 = SF up (column 6 – column 4 = upper uncertainty)

# Simulation Correction – Pile Up Modelling

- The **number of primary vertices** (root branch name = *PV\_npvs*) in MC was reweighted.
- **ROOT files** containing the reweighted values have been created:
  - Link to the ROOT file for [2016](#)
  - Link to the ROOT file for [2017](#)
  - Link to the ROOT file for [2018](#)

# Simulation Correction – Pile up Modelling (cont.)

E.g. To make the MC PU distribution for 2018:

- The [python file](https://github.com/cms-sw/cmssw/blob/master/SimGeneral/MixingModule/python/mix_2018_25ns_JuneProjectionFull18_PoissonOOTPU_cfi.py) used by CMS for 2018 MC generation:  
[https://github.com/cms-sw/cmssw/blob/master/SimGeneral/MixingModule/python/mix\\_2018\\_25ns\\_JuneProjectionFull18\\_PoissonOOTPU\\_cfi.py](https://github.com/cms-sw/cmssw/blob/master/SimGeneral/MixingModule/python/mix_2018_25ns_JuneProjectionFull18_PoissonOOTPU_cfi.py)
- The pt bins from the above script were pasted into this script:  
[https://github.com/brunel-physics/tZq\\_analysis/blob/run\\_2/scripts/createPileUpMC2017.C](https://github.com/brunel-physics/tZq_analysis/blob/run_2/scripts/createPileUpMC2017.C)



# Simulation Correction – Pile up Modelling (cont.)

- These instructions were followed to produce the pile up profiles for data:  
<https://twiki.cern.ch/twiki/bin/viewauth/CMS/PileupJSONFileforData>
- Linux command used (in CMSSW):
  - *pileupCalc.py -i Cert\_314472-325175\_13TeV\_PromptReco\_Collisions18\_JSON.txt --inputLumiJSON pileup\_latest.txt --calcMode true --minBiasXsec 69200 --maxPileupBin 100 --numPileupBins 100 MyDataPileupHistogram2018.root*

# Simulation Correction – b Tagging Efficiency

- The b-tagging event weight,  $\omega$ , is calculated using method 1a in [this twiki](#):

$$P(MC) = \prod_{i = \text{tagged}} \epsilon_i \prod_{j = \text{not tagged}} (1 - \epsilon_j)$$

$$P(DATA) = \prod_{i = \text{tagged}} SF_i \epsilon_i \prod_{j = \text{not tagged}} (1 - SF_j \epsilon_j)$$

$\epsilon$  = the B-tagging efficiency that *you* calculate (explained on the next two slides).

$SF$  = the *CMS-calculated* b-tagging scale factor (explained on slide 21).

$$\omega = \frac{P(DATA)}{P(MC)}$$

Tagged = a b-tagged jet ( $b$ ).

Not tagged = up quark, down quark, strange quark, charm quark ( $c$ ) or a gluon ( $g$ ). The first three are collectively known as “light quarks” ( $l$ ).

# Simulation Correction – b Tagging Efficiency (continued)

For b-tagged jets:

$$\epsilon = \frac{\text{number of bjets in MC correctly identified by CSVv2}}{\text{number of bjets in MC}}$$

- Numerator = This is a 2D histogram. Find the number of events with **tight jets** that have `GenPart_pdgId == 5` && `Jet_btagCSVV2 > 0.8838` && `abs(bjet  $\eta$ ) < 2.4`. Plot a 2D histogram of the  $p_T$  versus  $\eta$  for these events.
- Denominator = same as numerator but without `Jet_btagCSVV2 > 0.8838`.

# Simulation Correction – b Tagging Efficiency (continued)

For non bjets:

$$\epsilon = \frac{\text{number of non bjets in MC correctly identified by CSVv2}}{\text{number of non bjets in MC}}$$

In the numerator,  
**GenPart Requirement** is:

- GenPart\_pdgId > 0 && GenPart\_pdgId < 4 (light jets)
- GenPart\_pdgId == 4 (charm)
- GenPart\_pdgId == 21 (gluons)

See [page 2 of this link](#) for these values.

- Numerator = This is a 2D histogram. Number of events with **tight jets** that have **GenPart Requirement** && **Jet\_btagCSVV2 > 0.8838** && **abs(bjet  $\eta$ ) < 2.4**. Plot a 2D histogram of the **p<sub>T</sub> versus  $\eta$**  for these events.
- Denominator = same as numerator but without **Jet\_btagCSVV2 > 0.8838**.

# Simulation Correction – b Tagging Efficiency (continued)

Twiki page that explains the csv file format is [here](#)

- The  $SF$  has already been calculated by CMS:
  - .csv file for 2017 (CSVv2\_94XSF\_V2\_B\_F.csv) can be downloaded [here](#)
  - Information for all years is [here](#)
- General CSV file format (explained on the next slide):

```
0, comb, central, 1, -2.5, 2.5, 20, 1000, 0, 1, "0.986369+(-(4.21155e-05*(log(x+19)*(log(x+18)*(3-(-(6.02128*log(x+18)))))))))"
0, comb, central, 0, -2.5, 2.5, 20, 1000, 0, 1, "0.986369+(-(4.21155e-05*(log(x+19)*(log(x+18)*(3-(-(6.02128*log(x+18)))))))))"
0, comb, down, 1, -2.5, 2.5, 20, 30, 0, 1, "0.986369+(-(4.21155e-05*(log(x+19)*(log(x+18)*(3-(-(6.02128*log(x+18))))))))-0.088046833872795105)"
0, comb, down, 1, -2.5, 2.5, 30, 50, 0, 1, "0.986369+(-(4.21155e-05*(log(x+19)*(log(x+18)*(3-(-(6.02128*log(x+18))))))))-0.031759314239025116)"
```

# Simulation Correction – b Tagging Efficiency (continued)

```
0, comb, central, 1, -2.5, 2.5, 20, 1000, 0, 1, "0.986369+(-(4.21155e-05*(log(x+19)*(log(x+18)*(3-(-(6.02128*log(x+18)))))))))"
0, comb, central, 0, -2.5, 2.5, 20, 1000, 0, 1, "0.986369+(-(4.21155e-05*(log(x+19)*(log(x+18)*(3-(-(6.02128*log(x+18)))))))))"
0, comb, down, 1, -2.5, 2.5, 20, 30, 0, 1, "0.986369+(-(4.21155e-05*(log(x+19)*(log(x+18)*(3-(-(6.02128*log(x+18))))))))-0.088046833872795105)"
0, comb, down, 1, -2.5, 2.5, 30, 50, 0, 1, "0.986369+(-(4.21155e-05*(log(x+19)*(log(x+18)*(3-(-(6.02128*log(x+18))))))))-0.031759314239025116)"
```

- Column 1 = CSVv2 operating point
- Column 2 = Measurement type
- Column 3 = Systematic type
- Column 4 = Jet flavour
- Columns 5 and 6 = Min and max  $\eta$  values
- Columns 7 and 8 = Min and max  $p_T$  values
- Columns 9 and 10 = CSVv2 discriminant value

Compare input values with the values in columns 1-10 and return the answer that the equation in column 11 gives if the conditions are met (where  $x$  is the transverse momentum).

More info on [this twiki](#).

# Simulation Corrections – Top $p_T$ Reweighting

- The top  $p_T$  in Standard Model  $t\bar{t}$  MC events is reweighted using the factor  $\omega$ :

$$\omega = \sqrt{SF(t)SF(\bar{t})} \text{ where } SF(p_T) = e^{-0.0615 - 0.0005 \cdot p_T}$$

- Link to the twiki page is [here](#)
- [CMS-TOP-12-028](#)

**GenPart\_pdgId == 6** for top quarks and **-6** for antitop quarks.

**GenPart\_statusFlags == 13** (isLastCopy).

# Simulation Corrections – Miscalibrated Tracker APV Chips (2016 only)



# Shape uncertainties

- Jet energy corrections (already in nanoAOD)
- Jet smearing
- Missing transverse energy (MET)
- PU reweighting
  - vary the expected minimum bias cross section in simulation by  $\pm 4.6\%$
- b tagging SFs
  - vary the SF values by  $\pm 1\sigma$
- PDFs
- Perturbative and non-perturbative factorisation and normalisation scales
- Matching threshold energy

# Shape uncertainties – Jet Smearing

- The up and down uncertainties applied to the SF are provided by CMS
- E.g. in [Fall17\\_V3\\_MC\\_SF\\_AK4PFchs.txt](#):

-5.191	-3.139	3	1.1542	1.0019	1.3066
-3.139	-2.964	3	1.2696	1.1607	1.3785
-2.964	-2.853	3	2.2923	1.9180	2.6665
-2.853	-2.500	3	1.9909	1.4225	2.5593
-2.500	-2.322	3	1.4085	1.2066	1.6105

Column 4 = nominal value

Column 5 = down

Column 6 = up

# Shape uncertainties – MET

- The MET of particle flow (PF) jets must be corrected to consider the impact of jet smearing.
  - **Up variation:** the  $\Delta x$  of the unclustered MET energy is added to the  $p_x$  and  $p_y$  of the MET four momentum.
  - **Down variation:** the  $\Delta x$  of the unclustered MET energy is subtracted from the  $p_x$  and  $p_y$  of the MET four momentum.
- [Twiki page](#)

# Shape uncertainties – Pile up reweighting

- The cross section for the MC PU profile was varied by  $\pm 4.6\%$
- E.g. Linux commands used (in CMSSW) to obtain the MC PU profiles for the up and down uncertainties for 2018:
  - **Linux command used for the up uncertainty:** `pileupCalc.py -i Cert_314472-325175_13TeV_PromptReco_Collisions18_JSON.txt --inputLumiJSON pileup_latest.txt --calcMode true --minBiasXsec 72383.2 --maxPileupBin 100 --numPileupBins 100 MyDataPileupHistogramScaleUp2018.root`
  - **Linux command used for the down uncertainty:** `pileupCalc.py -i Cert_314472-325175_13TeV_PromptReco_Collisions18_JSON.txt --inputLumiJSON pileup_latest.txt --calcMode true --minBiasXsec 66016.8 --maxPileupBin 100 --numPileupBins 100 MyDataPileupHistogramScaleDown2018.root`

# Shape uncertainties – btagging scale factors

- Provided by CMS in the csv file ([CSVv2\\_94XSF\\_V2\\_B\\_F.csv](#) for run 2)

0, comb, down, 0, -2.5, 2.5,  
0, comb, down, 0, -2.5, 2.5,  
0, comb, down, 0, -2.5, 2.5,  
0, comb, up, 1, -2.5, 2.5, 2  
0, comb, up, 1, -2.5, 2.5, 3  
0, comb, up, 1, -2.5, 2.5, 5

The method is the same as for obtaining the equation to calculate the nominal scale factor, except **column 3** must be equal to **up or down**.

# Shape uncertainties – PDFs

- The branch LHEPdfWeight was used

# Shape uncertainties – Perturbative factorisation and normalisation scales

# Shape uncertainties – Non-perturbative factorisation and normalisation scales

- In 2016, **additional samples** are provided that contain the weights
- In 2017 and 2018, **weights are stored in the nanoAOD samples** for:  $tZq$  (signal),  $t\bar{t}W$ , single top s-channel, single top t-channel top, single top t-channel anti-top,  $t\bar{t}\gamma$ ,  $t\bar{t}$  (to hadronic) and  $t\bar{t}$  (to semileptonic).
- In these samples for 2017 and 2018, the branch **PSWeight** was used:
  - PSWeight.at(0) = isr down
  - PSWeight.at(1) = fsr down
  - PSWeight.at(2) = isr up
  - PSWeight.at(3) = fsr up



# Shape uncertainties – Matching threshold energy

$$\text{POWHEG V2 matching threshold energy} = \frac{hdamp^2}{hdamp^2 + p_T^2}$$

(where *hdamp* has been tuned to  $1.58 \times m_{top}$ )

- Samples for the *hdamp* up and *hdamp* down variations have been provided by CMS for 2016, 2017 and 2018.

# With the exception of lepton efficiency scale factor uncertainties, rate uncertainties are implemented using the combine tool

- **Integrated luminosity**
  - Estimated to be 2.5% in 2016 [4], 2.3% in 2017 [5] and 2.5% in 2018 [6].
- **Cross section normalization**
  - A value of 30% was used in the trilepton search [7.], but a value of 10% was used for this dilepton analysis
- **Non prompt lepton background estimate**
  - A 30% normalisation uncertainty value was applied based on other analyses with similar background contributions.
- **Lepton efficiencies** are provided by CMS (combine tool not used to implement them). The lepton efficiency scale factors were varied by  $\pm 1\sigma$

# Multivariate analysis

- Through the tact tool, a Boosted Decision Tree (BDT) was used to separate signal-like and background-like events.

The Higgs Combine Tool was used to implement the rate uncertainties and carry out the signal extraction

# Results

# Results: Signal Region – Cutflow

# Results: Z+jets Control Region – Cutflow

# Results: $t\bar{t}$ Control Region – Cutflow



# Results: Signal Region – Event Yields

# Results: Z+jets Control Region – Event Yields

# Results: $t\bar{t}$ Control Region – Event Yields

# Results: Signal Region – Event Yields (NPL)

# Results: Z+jets Control Region – Event Yields (NPL)

# Results: $t\bar{t}$ Control Region – Event Yields (NPL)

# Results: Signal Region – Event Yield Distributions

# Results: Z+jets Control Region – Event Yield Distributions



# Results: $t\bar{t}$ Control Region – Event Yield Distributions

# Conclusions

# References

- [1] M. Aaboud et al. “Search for pair production of Higgs bosons in the  $b\bar{b}b\bar{b}$  final state using proton–proton collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector”. arXiv: 1606.04782 [hep-ex].
  
- [2] V. Khachatryan et al. “Search for resonant pair production of Higgs bosons decaying to two bottom quark–antiquark pairs in proton–proton collisions at 8 TeV”. arXiv: 1503.04114 [hep-ex].
  
- [3] <https://arxiv.org/abs/1607.03663>

- [4] <http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/LUM-17-001/index.html>
- [5] <http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/LUM-17-004/index.html>
- [6] <http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/LUM-18-002/index.html>
- [7] <https://arxiv.org/abs/1712.02825>

# Back up

# Samples 2016 (1)

Process	Sample(s)
tZq (signal)	<a href="#">/tZq ll 4f 13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOADSIM</a>
Z+jets (aMCatNLO)	<a href="#">/DYJetsToLL M-50 TuneCUETP8M1 13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext2-v1/NANOADSIM</a>  <a href="#">/DYJetsToLL M-10to50 TuneCUETP8M1 13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a>  <a href="#">/DYJetsToLL M-10to50 TuneCUETP8M1 13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOADSIM</a>
ZPlusJets (Madgraph)	<a href="#">/DYJetsToLL M-50 TuneCUETP8M1 13TeV-madgraphMLM-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOADSIM</a>  <a href="#">/DYJetsToLL M-50 TuneCUETP8M1 13TeV-madgraphMLM-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext2-v1/NANOADSIM</a>  <a href="#">/DYJetsToLL M-10to50 TuneCUETP8M1 13TeV-madgraphMLM-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a>

Process	Sample(s)
Z+jets (pT-binned)	<a href="#">/DYJetsToLL_Zpt-0To50_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv6-Nano25Oct2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-50To100_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-50To100_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext3-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-100To250_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-100To250_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-100To250_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext2-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-100To250_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext5-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-250To400_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-250To400_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-250To400_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext2-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL_Pt-250To400_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext5-v1/NANOAODSIM</a>

Process	Sample(s)
Z+jets (pT-binned)	<a href="#">/DYJetsToLL_Pt-400To650_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a>
	<a href="#">/DYJetsToLL_Pt-400To650_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOAODSIM</a>
	<a href="#">/DYJetsToLL_Pt-400To650_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext2-v1/NANOAODSIM</a>
	<a href="#">/DYJetsToLL_Pt-650ToInf_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a>
	<a href="#">/DYJetsToLL_Pt-650ToInf_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOAODSIM</a>
	<a href="#">/DYJetsToLL_Pt-650ToInf_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext2-v1/NANOAODSIM</a>



Process	Sample(s)
Single top	<p>t-channel top:  <a href="#">/ST t-channel top 4f inclusiveDecays 13TeV-powhegV2-madspin-pythia8 TuneCUETP8M1/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a></p> <p>t-channel top scale up:  <a href="#">/ST t-channel top 4f scaleup inclusiveDecays 13TeV-powhegV2-madspin-pythia8/RunIISummer16NanoAODv6-PUMoriond17 Nano25Oct2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a></p> <p>t channel top scale down:  <a href="#">/ST t-channel top 4f scaledown inclusiveDecays 13TeV-powhegV2-madspin-pythia8/RunIISummer16NanoAODv3-PUMoriond17 94X mcRun2 asymptotic v3-v1/NANOADSIM</a></p> <p>t-channel antitop scale up: <a href="#">/ST t-channel antitop 4f scaleup inclusiveDecays 13TeV-powhegV2-madspin-pythia8/RunIISummer16NanoAODv6-PUMoriond17 Nano25Oct2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a></p> <p>t-channel antitop scale down:  <a href="#">/ST t-channel antitop 4f scaledown inclusiveDecays 13TeV-powhegV2-madspin-pythia8/RunIISummer16NanoAODv6-PUMoriond17 Nano25Oct2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a></p> <p>t-channel antitop:  <a href="#">/ST t-channel antitop 4f inclusiveDecays 13TeV-powhegV2-madspin-pythia8 TuneCUETP8M1/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a></p> <p>s-channel:  <a href="#">/ST s-channel 4f InclusiveDecays 13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a></p>

# Samples 2016 (2)

Process	Sample(s)
Single top	<p>tW:</p> <p><a href="#">/ST tW top 5f inclusiveDecays 13TeV-powheg-pythia8 TuneCUETP8M1/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAOBSIM</a></p> <p>tW scale up:</p> <p><a href="#">/ST tW top 5f scaleup inclusiveDecays 13TeV-powheg-pythia8 TuneCUETP8M1/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAOBSIM</a></p> <p>tW scale down:</p> <p><a href="#">/ST tW top 5f scaledown inclusiveDecays 13TeV-powheg-pythia8 TuneCUETP8M1/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAOBSIM</a></p> <p>tW_tbar:</p> <p><a href="#">/ST tW antitop 5f inclusiveDecays 13TeV-powheg-pythia8 TuneCUETP8M1/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAOBSIM</a></p> <p>tW_tbar_ScaleUp:</p> <p><a href="#">/ST tW antitop 5f scaleup inclusiveDecays 13TeV-powheg-pythia8 TuneCUETP8M1/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAOBSIM</a></p> <p>tW_tbar_ScaleDown:</p> <p><a href="#">/ST tW antitop 5f scaledown inclusiveDecays 13TeV-powheg-pythia8 TuneCUETP8M1/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAOBSIM</a></p>

# Samples 2016 (3)

Process	Sample(s)
Single top	<p>tZq (hadronic Z, leptonic W):</p> <p>tHq:  <a href="#">/THQ_Hincl_13TeV-madgraph-pythia8_TuneCUETP8M1/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p>tWZ tLL:  <a href="#">/ST_tWll_5f_LO_13TeV-MadGraph-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p>
VVV	<p>WWW to 4F:  <a href="#">/WWW_4F_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p>WWZto4F:  <a href="#">/WWZ_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p>WZZ:  <a href="#">/WZZ_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p>ZZZ:  <a href="#">/ZZZ_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p>

# Samples 2016 (4)

Process	Sample(s)
VV	<p>ZZTo4L: <a href="#">/ZZTo4L_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOAODSIM</a></p> <p>ZZTo2L2Nu: <a href="#">/ZZTo2L2Nu_13TeV_powheg_pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p>ZZTo2L2Q: <a href="#">/ZZTo2L2Q_13TeV_amcatnloFXFX_madspin_pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p>WWTo2L2Nu: <a href="#">/WWTo2L2Nu_13TeV-powheg/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p>WZTo1L1Nu2Q: <a href="#">/WZTo1L1Nu2Q_13TeV_amcatnloFXFX_madspin_pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p>WWToLNuQQ: <a href="#">/WWToLNuQQ_13TeV-powheg/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p><a href="#">/WWToLNuQQ_13TeV-powheg/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOAODSIM</a></p> <p>WZTo3LNu: <a href="#">/WZTo3LNu_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p>WZTo2L2Q: <a href="#">/WZTo2L2Q_13TeV_amcatnloFXFX_madspin_pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p>

# Samples 2016 (5)

Process	Sample(s)
ttbar	<p>ttbar_madgraph: <a href="#">/TTJets DiLept TuneCUETP8M1 13TeV-madgraphMLM-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a></p> <p><a href="#">/TTJets DiLept TuneCUETP8M1 13TeV-madgraphMLM-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7_ext1-v1/NANOADSIM</a></p> <p>TTToHadronic: not used</p> <p>ttbar_aMCatNLO:  <a href="#">/TTJets TuneCUETP8M2T4 13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a></p> <p>ttbar 2l2nu: <a href="#">/TTTo2L2Nu TuneCP5 PSweights 13TeV-powheg-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOADSIM</a></p> <p>TTToSemileptonic: not used</p>

# Samples 2016 (6)

Process	Sample(s)
ttbar	<p>TT_hdampUP: <a href="#">/TT_hdampUP_TuneCUETP8M2T4_13TeV-powheg-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOADSIM</a></p> <p>TT_hdampUP_ext: <a href="#">/TT_hdampUP_TuneCUETP8M2T4_13TeV-powheg-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOADSIM</a></p> <p>TT_hdampDOWN: <a href="#">/TT_hdampDOWN_TuneCUETP8M2T4_13TeV-powheg-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOADSIM</a></p> <p>TT_hdampDOWN_ext: <a href="#">/TT_hdampDOWN_TuneCUETP8M2T4_13TeV-powheg-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOADSIM</a></p> <p>ST_tchannel_top_hdampup: ST_tchannel_top_hdampdown:</p> <p>ST_tchannel_top_ScaleUp: ST_tchannel_top_ScaleDown:</p>

# Samples 2016 (7)

Process	Sample(s)
ttbar	<p>TT_isr_UP: <a href="#">/TT TuneCUETP8M2T4 13TeV-powheg-isrup-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAODSIM</a></p> <p>TT_isr_DOWN: <a href="#">/TT TuneCUETP8M2T4 13TeV-powheg-isrdwn-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOAODSIM</a></p> <p>TT_isr_DOWN_ext: <a href="#">/TT TuneCUETP8M2T4 13TeV-powheg-isrdwn-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAODSIM</a></p> <p>TT_fsr_UP: <a href="#">/TT TuneCUETP8M2T4 13TeV-powheg-fsrup-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOAODSIM</a></p> <p>TT_fsr_UP_ext: <a href="#">/TT TuneCUETP8M2T4 13TeV-powheg-fsrup-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAODSIM</a></p> <p>TT_fsr_DOWN: <a href="#">/TT TuneCUETP8M2T4 13TeV-powheg-fsrdwn-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7-v1/NANOAODSIM</a></p> <p>TT_fsr_DOWN_ext: <a href="#">/TT TuneCUETP8M2T4 13TeV-powheg-fsrdwn-pythia8/RunIISummer16NanoAODv5-PUMoriond17 Nano1June2019 102X mcRun2 asymptotic v7 ext1-v1/NANOAODSIM</a></p>

# Samples 2016 (7)

Process	Samples(s)
ttbarV	<p>ttgamma: not used</p> <p>TTZToQQ:  <a href="#">/TTZToQQ_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOADSIM</a></p> <p>TTZToLL:  <a href="#">/TTZToLLNuNu_M-10_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOADSIM</a>  <a href="#">/TTZToLLNuNu_M-10_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext2-v1/NANOADSIM</a>  <a href="#">/TTZToLLNuNu_M-10_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext3-v1/NANOADSIM</a></p> <p>TTZToLLNuNu:  <a href="#">/TTZToLLNuNu_M-10_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOADSIM</a>  <a href="#">/TTZToLLNuNu_M-10_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext2-v1/NANOADSIM</a>  <a href="#">/TTZToLLNuNu_M-10_TuneCUETP8M1_13TeV-amcatnlo-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext3-v1/NANOADSIM</a></p> <p>ttWJetsToLNu:  <a href="#">/TTWJetsToLNu_TuneCUETP8M1_13TeV-amcatnloFXFX-madspin-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext1-v1/NANOADSIM</a>  <a href="#">/TTWJetsToLNu_TuneCUETP8M1_13TeV-amcatnloFXFX-madspin-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext2-v1/NANOADSIM</a></p> <p>ttWJetsToQQ:  <a href="#">/TTWJetsToQQ_TuneCUETP8M1_13TeV-amcatnloFXFX-madspin-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOADSIM</a></p> <p>ttHTobb: <a href="#">/ttHTobb_M125_TuneCUETP8M2_ttHtranche3_13TeV-powheg-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOADSIM</a></p> <p>ttHToNonbb:  <a href="#">/ttHToNonbb_M125_TuneCUETP8M2_ttHtranche3_13TeV-powheg-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOADSIM</a></p>



# Samples 2016 (7)

Process	Sample(s)
W+jets	<p>W Jets To L Nu:</p> <p><a href="#">/WJetsToLNu_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7-v1/NANOAODSIM</a></p> <p><a href="#">/WJetsToLNu_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16NanoAODv5-PUMoriond17_Nano1June2019_102X_mcRun2_asymptotic_v7_ext2-v1/NANOAODSIM</a></p>
Data	<p>Double Muon:</p> <p><a href="#">/DoubleMuon/Run2016B_ver2-Nano14Dec2018_ver2-v1/NANOAOD</a></p> <p><a href="#">/DoubleMuon/Run2016C-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleMuon/Run2016D-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleMuon/Run2016E-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleMuon/Run2016F-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleMuon/Run2016G-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleMuon/Run2016H-Nano25Oct2019-v1/NANOAOD</a></p> <p>Double electron:</p> <p><a href="#">/DoubleEG/Run2016B-22Aug2018_ver2-v1/NANOAOD</a></p> <p><a href="#">/DoubleEG/Run2016C-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleEG/Run2016D-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleEG/Run2016E-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleEG/Run2016F-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleEG/Run2016G-Nano25Oct2019-v1/NANOAOD</a></p> <p><a href="#">/DoubleEG/Run2016H-Nano25Oct2019-v1/NANOAOD</a></p>

# Samples 2017 (1)

Process	Sample(s)
tZq (signal)	<a href="#">/tZq ll 4f ckm NLO TuneCP5 PSweights 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv4-PU2017 12Apr2018 Nano14Dec2018 new pmx 102X mc2017 realistic v6-v1/NANOAOBSIM</a>
Z+jets	<a href="#">/DYJetsToLL M-50 TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOAOBSIM</a>  <a href="#">/DYJetsToLL M-50 TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7 ext1-v1/NANOAOBSIM</a>  <a href="#">/DYJetsToLL M-10to50 TuneCP5 13TeV-madgraphMLM-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOAOBSIM</a>
Single top	<p>t-channel top:  <a href="#">/ST t-channel top 4f InclusiveDecays TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOAOBSIM</a> </p> <p>t-channel antitop:  <a href="#">/ST t-channel antitop 4f InclusiveDecays TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOAOBSIM</a> </p> <p>s-channel:  <a href="#">/ST s-channel 4f leptonDecays TuneCP5 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOAOBSIM</a> </p> <p>tW:  <a href="#">/ST tW top 5f inclusiveDecays TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOAOBSIM</a> </p>

# Samples 2017 (2)

Process	Sample(s)
Single top	<p>tbarW:  <a href="#">/ST tW antitop 5f inclusiveDecays TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>tZq (hadronic Z, leptonic W):  <a href="#">/tZq W lept Z hadron 4f ckm NLO 13TeV amcatnlo pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>tHq:  <a href="#">/THQ 4f Hinc 13TeV madgraph pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>tWZ tLL:/  <a href="#">ST tWll 5f LO TuneCP5 PSweights 13TeV-madgraph-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7_ext1-v1/NANOADSIM</a></p>
VVV	<p>WWW to 4F:  <a href="#">/WWW 4F TuneCP5 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>WWZTo4F:  <a href="#">/WWZ 4F TuneCP5 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>WZZ:  <a href="#">/WZZ TuneCP5 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>ZZZ:/ZZZ TuneCP5 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</p>

# Samples 2017 (3)

Process	Sample(s)
VV	<p>ZZTo4L:  <a href="#">/ZZTo4L 13TeV powheg pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOAOBSIM</a></p> <p>ZZTo2L2Nu:  <a href="#">/ZZTo2L2Nu 13TeV powheg pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOAOBSIM</a></p> <p>ZZTo2L2Q:  <a href="#">/ZZTo2L2Q 13TeV amcatnloFXFX madspin pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOAOBSIM</a></p> <p>WWTo2L2Nu:  <a href="#">/WWTo2L2Nu NNPDF31 TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7 ext1-v1/NANOAOBSIM</a></p> <p>WWTo1L1Nu2Q:  <a href="#">/WWTo1L1Nu2Q 13TeV amcatnloFXFX madspin pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOAOBSIM</a></p> <p>WWToLNUQQ:  <a href="#">/WWToLNUQQ NNPDF31 TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7 ext1-v1/NANOAOBSIM</a></p> <p>WWInuQQ: <a href="#">/WWToLNUQQ NNPDF31 TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7 ext1-v1/NANOAOBSIM</a></p> <p>WZTo3LNU:  <a href="#">/WZTo3LNU TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOAOBSIM</a></p> <p>WZTo2L2Q:  <a href="#">/WZTo2L2Q 13TeV amcatnloFXFX madspin pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOAOBSIM</a></p> <p>WZTo1L1Nu2Q: <a href="#">/WZTo1L1Nu2Q 13TeV amcatnloFXFX madspin pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOAOBSIM</a></p>

# Samples 2017 (4)

Process	Sample(s)
ttbar	<p>ttbar_madgraph:  <a href="#">/TTJets TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOAODSIM</a></p> <p>TTToHadronic:  <a href="#">/TTToHadronic TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOAODSIM</a></p> <p>ttbar_aMCatNLO:  <a href="#">/TTJets TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOAODSIM</a></p> <p>ttbar 2l2nu  <a href="#">/TTTo2L2Nu TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOAODSIM</a></p> <p>TTToSemileptonic:  <a href="#">/TTToSemiLeptonic TuneCP5 PSweights 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOAODSIM</a></p>

# Samples 2017 (5)

Process	Samples(s)
ttbarV	<p>ttgamma: <a href="#">/TTGamma Dilept TuneCP5 PSweights 13TeV madgraph pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>TTZToQQ: <a href="#">/TTZToQQ TuneCP5 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>TTZToQQ_ext: <a href="#">/TTZToQQ TuneCP5 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7_ext1-v1/NANOADSIM</a></p> <p>TTZToLL: <a href="#">/TTZToLL M-1to10 TuneCP5 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>TTZToLLNuNu: <a href="#">/TTZToLLNuNu M-10 TuneCP5 13TeV-amcatnlo-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>ttWJetsToLNu: <a href="#">/TTWJetsToLNu TuneCP5 PSweights 13TeV-amcatnloFXFX-madspin-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>ttWJetsToQQ: <a href="#">/TTWJetsToQQ TuneCP5 13TeV-amcatnloFXFX-madspin-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>ttHTobb: <a href="#">/ttHTobb M125 TuneCP5 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOADSIM</a></p> <p>ttHToNonbb: <a href="#">/ttHToNonbb M125 TuneCP5 13TeV-powheg-pythia8/RunIIFall17NanoAODv5-PU2017 12Apr2018 Nano1June2019 new pmx 102X mc2017 realistic v7-v1/NANOADSIM</a></p>

# Samples 2017 (6)

Process	Sample(s)
W+jets	W Jets To L Nu: <a href="#">/WJetsToLNu_TuneCP5_13TeV-madgraphMLM-pythia8/RunIIFall17NanoAODv5-PU2017_12Apr2018_Nano1June2019_new_pmx_102X_mc2017_realistic_v7-v1/NANOADSIM</a>
Data	<p>Double Muon:</p> <p><a href="#">/DoubleMuon/Run2017B-Nano14Dec2018-v1/NANOAO</a> <a href="#">/DoubleMuon/Run2017C-Nano14Dec2018-v1/NANOAO</a> <a href="#">/DoubleMuon/Run2017D-Nano14Dec2018-v1/NANOAO</a> <a href="#">/DoubleMuon/Run2017E-Nano14Dec2018-v1/NANOAO</a> <a href="#">/DoubleMuon/Run2017F-Nano14Dec2018-v1/NANOAO</a></p> <p>Double electron:</p> <p><a href="#">/DoubleEG/Run2017B-Nano14Dec2018-v1/NANOAO</a> <a href="#">/DoubleEG/Run2017C-Nano14Dec2018-v1/NANOAO</a> <a href="#">/DoubleEG/Run2017D-Nano14Dec2018-v1/NANOAO</a> <a href="#">/DoubleEG/Run2017E-Nano14Dec2018-v1/NANOAO</a> <a href="#">/DoubleEG/Run2017F-Nano14Dec2018-v1/NANOAO</a></p>

# Samples 2018 (1)

Process	Sample(s)
tZq (signal)	<a href="#">/tZq ll 4f ckm NLO TuneCP5 13TeV-madgraph-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOAODSIM</a>
Z+jets (M50)	<a href="#">/DYJetsToLL M-50 TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL M-50 TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext2-v1/NANOAODSIM</a>
Z+jets (M10to50)	<a href="#">/DYJetsToLL M-10to50 TuneCP5 13TeV-madgraphMLM-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOAODSIM</a>  <a href="#">/DYJetsToLL M-10to50 TuneCP5 13TeV-madgraphMLM-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOAODSIM</a>
Single top	<p>t-channel top: <a href="#">/ST t-channel top 4f InclusiveDecays TuneCP5 13TeV-powheg-madspin-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOAODSIM</a></p> <p>t-channel antitop: <a href="#">/ST t-channel antitop 4f InclusiveDecays TuneCP5 13TeV-powheg-madspin-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOAODSIM</a></p> <p>s-channel: <a href="#">/ST s-channel 4f leptonDecays TuneCP5 13TeV-madgraph-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOAODSIM</a></p> <p>tW: <a href="#">/ST tW top 5f inclusiveDecays TuneCP5 13TeV-powheg-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOAODSIM</a></p>



# Samples 2018 (2)

Process	Sample(s)
Single top	<p>tbarW: <a href="#">/ST tW antitop 5f inclusiveDecays TuneCP5 13TeV-powheg-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOADSIM</a></p> <p>tZq (hadronic Z, leptonic W): <a href="#">/tZq Zhad Wlept 4f ckm NLO TuneCP5 PSweights 13TeV-amcatnlo-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOADSIM</a></p> <p>tHq: <a href="#">/THQ 4f Hincl 13TeV madgraph pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOADSIM</a></p> <p>tWZ tLL: <a href="#">/ST tWll 5f LO TuneCP5 PSweights 13TeV-madgraph-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOADSIM</a></p>
VVV	<p>WWW to 4F: <a href="#">/WWW 4F TuneCP5 13TeV-amcatnlo-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOADSIM</a></p> <p>WWZTo4F: <a href="#">/WWZ TuneCP5 13TeV-amcatnlo-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOADSIM</a></p> <p>WZZ: <a href="#">/WZZ TuneCP5 13TeV-amcatnlo-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOADSIM</a></p> <p>ZZZ: <a href="#">/ZZZ TuneCP5 13TeV-amcatnlo-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOADSIM</a></p>

# Samples 2018 (3)

Process	Sample(s)
VV	<p>ZZTo4L: <a href="#">/ZZTo4L TuneCP5 13TeV powheg pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext2-v1/NANOAODSIM</a></p> <p>ZZTo2L2Nu: <a href="#">/ZZTo2L2Nu TuneCP5 13TeV powheg pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOAODSIM</a></p> <p><a href="#">/ZZTo2L2Nu TuneCP5 13TeV powheg pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext2-v1/NANOAODSIM</a></p> <p>ZZTo2L2Q: <a href="#">/ZZTo2L2Q 13TeV amcatnloFXFX madspin pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOAODSIM</a></p> <p>WWTo2L2Nu: <a href="#">/WWTo2L2Nu NNPDF31 TuneCP5 13TeV-powheg-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOAODSIM</a></p> <p>WWTo1L1Nu2Q: <a href="#">/WWToLNUQQ NNPDF31 TuneCP5 13TeV-powheg-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOAODSIM</a></p> <p>WWToLNUQQ: Not in 2018</p> <p>WZTo3LNU: <a href="#">/WZTo3LNU TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOAODSIM</a></p> <p><a href="#">/WZTo3LNU TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19 ext1-v1/NANOAODSIM</a></p> <p>WZTo2L2Q: <a href="#">/WZTo2L2Q 13TeV amcatnloFXFX madspin pythia8/RunIIAutumn18NanoAODv5-Nano1June2019 102X upgrade2018 realistic v19-v1/NANOAODSIM</a></p> <p>WZTo1L1Nu2Q:</p>

# Samples 2018 (4)

Process	Sample(s)
ttbar	<p>ttbar_madgraph: <a href="#">/TTJets_DiLept_TuneCP5_13TeV-madgraphMLM-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOAODSIM</a></p> <p>TTToHadronic: <a href="#">/TTToHadronic_TuneCP5_13TeV-powheg-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOAODSIM</a></p> <p>ttbar_aMCatNLO: <a href="#">/TTJets_TuneCP5_13TeV-amcatnloFXFX-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19_ext1-v1/NANOAODSIM</a></p> <p>ttbar 2l2nu: <a href="#">/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOAODSIM</a></p> <p>TTToSemileptonic: <a href="#">/TTToSemiLeptonic_TuneCP5_13TeV-powheg-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOAODSIM</a></p>

# Samples 2018 (5)

Process	Samples(s)
ttbarV	<p>ttgamma: <a href="#">/TTGamma_Dilept_TuneCP5_13TeV-madgraph-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOADSIM</a></p> <p><a href="#">/TTGamma_Dilept_TuneCP5_13TeV_madgraph_pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19_ext1-v1/NANOADSIM</a></p> <p>TTZToQQ: <a href="#">/TTZToQQ_TuneCP5_13TeV-amcatnlo-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOADSIM</a></p> <p>TTZToQQ_ext: <a href="#">/TTZToQQ_TuneCP5_13TeV-amcatnlo-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19_ext1-v1/NANOADSIM</a></p> <p>TTZToLL: <a href="#">/TTZToLL_M-1to10_TuneCP5_13TeV-amcatnlo-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOADSIM</a></p> <p>TTZToLLNuNu: <a href="#">/TTZToLLNuNu_M-10_TuneCP5_13TeV-amcatnlo-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19_ext1-v1/NANOADSIM</a></p> <p>ttWJetsToLNu: <a href="#">/TTWJetsToLNu_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19_ext1-v1/NANOADSIM</a></p> <p>ttWJetsToQQ: <a href="#">/TTWJetsToQQ_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOADSIM</a></p> <p>ttHTobb: <a href="#">/ttHTobb_M125_TuneCP5_13TeV-powheg-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOADSIM</a></p> <p>ttHTNonbb: <a href="#">/ttHTNonbb_M125_TuneCP5_13TeV-powheg-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOADSIM</a></p>

# Samples 2018 (6)

Process	Sample(s)
W+jets	W Jets To L Nu: <a href="#">/WJetsToLNu_TuneCP5_13TeV-madgraphMLM-pythia8/RunIIAutumn18NanoAODv5-Nano1June2019_102X_upgrade2018_realistic_v19-v1/NANOADSIM</a>
Data	<p>Single Muon: <a href="#">/SingleMuon/Run2018B-Nano25Oct2019-v1/NANOAOB</a> <a href="#">/SingleMuon/Run2018C-Nano25Oct2019-v1/NANOAOB</a> <a href="#">/SingleMuon/Run2018D-Nano25Oct2019-v1/NANOAOB</a></p> <p>Double Muon: <a href="#">/DoubleMuon/Run2018B-Nano14Dec2018-v1/NANOAOB</a> <a href="#">/DoubleMuon/Run2018C-Nano14Dec2018-v1/NANOAOB</a> <a href="#">/DoubleMuon/Run2018D-Nano25Oct2019_ver2-v1/NANOAOB</a></p> <p>Single and double electron: <a href="#">/EGamma/Run2018B-Nano25Oct2019-v1/NANOAOB</a> <a href="#">/EGamma/Run2018C-Nano25Oct2019-v1/NANOAOB</a> <a href="#">/EGamma/Run2018D-Nano25Oct2019-v1/NANOAOB</a></p>

# Samples for trigger SF calculations (2016)

Process	Sample(s)
ttbar	
MET	

# Samples for trigger SF calculations (2017)

Process	Sample(s)
ttbar	
MET	

# Samples for trigger SF calculations (2018)

Process	Sample(s)
ttbar	
MET	



# Results – Normalisation Factors 2016 (1)

Sample	Number of simulated events	Cross section	Normalisation factor
<a href="#">tZq</a>	13656784	0.0758	0.000199163
<a href="#">Z+jets (M 50 aMCatNLO)</a>	120777245	5941.0	1.76507
<a href="#">Z+jets (M10To50 aMCatNLO)</a>	67942840	18810.0	9.93422
<a href="#">Z+jets (M10To50 ext aMCatNLO)</a>	40154170	18810.0	16.8092
<a href="#">Z+jets (M50 Madgraph)</a>	49748967	4963.0	3.57972
<a href="#">Z+jets (M50 Madgraph ext)</a>	96531428	4963.0	1.84486
<a href="#">Z+jets (M10To50 Madgraph)</a>	35114961	16270.0	16.6259

# Results – Normalisation Factors 2016 (2)

Sample	Number of simulated events	Cross section	Normalisation factor
Z+jets ( <a href="#">pt binned, 0-50</a> )	37458375	5352.57924	5.12747
Z+jets ( <a href="#">pt binned, 50-100</a> )	21847075	363.81428	59755.1
Z+jets ( <a href="#">pt binned, 50-100 ext</a> )	108670239	363.81428	0.120132
Z+jets ( <a href="#">pt binned, 100-250</a> )	2046961	84.014804	1.47277
Z+jets ( <a href="#">pt binned, 100-250 ext1</a> )	2805972	84.014804	1.07439
Z+jets ( <a href="#">pt binned, 100-250 ext2</a> )	2991815	84.014804	1.00765
Z+jets ( <a href="#">pt binned, 100-250 ext5</a> )	76440229	84.014804	0.0394387

# Results – Normalisation Factors 2016 (2)

Sample	Number of simulated events	Cross section	Normalisation factor
Z+jets ( <a href="#">pt-binned, 250-400</a> )	423976	3.228256512	0.273222
Z+jets ( <a href="#">pt-binned, 250-400 ext1</a> )	590806	3.228256512	0.19607
Z+jets ( <a href="#">pt-binned, 250-400 ext2</a> )	594317	3.228256512	0.194912
Z+jets ( <a href="#">pt-binned, 250-400 ext5</a> )	19567800	3.228256512	0.00591991
Z+jets ( <a href="#">pt-binned, 400To650</a> )	432056	0.436041144	0.036214
Z+jets ( <a href="#">pt-binned, 400To650 ext1</a> )	589842	0.436041144	0.0265265
Z+jets ( <a href="#">pt-binned, 400To650 ext2</a> )	604038	0.436041144	0.0259031

# Results – Normalisation Factors 2016 (3)

Sample	Number of simulated events	Cross section	Normalisation factor
Z+jets ( <a href="#">pt-binned, 600ToInf</a> )	430691	0.040981055	0.00341433
Z+jets ( <a href="#">pt-binned, 600ToInf ext1</a> )	599665	0.040981055	0.00245224
Z+jets ( <a href="#">pt-binned, 600ToInf ext2</a> )	597526	0.040981055	0.00246102
ttbar ( <a href="#">inc</a> )	76857480	730.6	
<a href="#">ttbar (madgraph)</a>	6068369	56.86	0.33622
<a href="#">ttbar (madgraph ext)</a>	24767666	56.86	0.0823779

# Results – Normalisation Factors 2016 (4)

Sample	Number of simulated events	Cross section	Normalisation factor
ttbar (TT to hadronic)	Not used	Not used	Not used
ttbar (TT to semileptonic)	Not used	Not used	Not used
ttbar ( <a href="#">aMCatNLO</a> )	43768838	722.8	0.592573
Single top ( <a href="#">t-channel, top</a> )	67105876	136.02	0.0727329
Single top ( <a href="#">t-channel, top, scale up</a> )	5992440	136.02	0.814494
Single top ( <a href="#">t-channel, top, scale down</a> )	64352832	136.02	0.0758445
Single top ( <a href="#">t-channel, antitop</a> )	38811017	80.95	0.0748429
Single top ( <a href="#">t-channel, antitop, scale up</a> )	3970546	80.95	0.731569
Single top ( <a href="#">t-channel, antitop, scale down</a> )	37359247	80.95	0.731569
Single top ( <a href="#">s-channel</a> )	2989199	10.12	0.121483

# Results – Normalisation Factors 2016 (5)

Sample	Number of simulated events	Cross section	Normalisation factor
ttbar ( <a href="#">hdamp up</a> )	29833668	730.6	0.878743
ttbar ( <a href="#">hdamp up ext</a> )	28855428	730.6	0.908533
ttbar ( <a href="#">hdamp down</a> )	29047858	730.7	0.902638
ttbar ( <a href="#">hdamp down ext</a> )	29229088	730.7	0.897042
Single top ( <a href="#">tchannel, top, hdampup</a> )			
Single top ( <a href="#">tchannel, top, hdampdown</a> )			

# Results – Normalisation Factors 2016 (6)

Sample	Number of simulated events	Cross section	Normalisation factor
ttbar ( <a href="#">TT_isr_UP</a> )	58977100	730.6	0.444513
ttbar ( <a href="#">TT_isr_DOWN</a> )	28409782	730.6	0.922785
ttbar ( <a href="#">TT_isr_DOWN_ext</a> )	29915551	730.6	0.876337
ttbar ( <a href="#">TT_fsr_UP</a> )	29632372	730.6	0.884712
ttbar ( <a href="#">TT_fsr_UP_ext</a> )	29501065	730.6	0.88865
ttbar ( <a href="#">TT_fsr_DOWN</a> )	29571600	730.6	0.88653
ttbar ( <a href="#">TT_fsr_DOWN_ext</a> )	29571600	730.6	0.88653

# Results – Normalisation Factors 2016 (7)

Sample	Number of simulated events	Cross section	Normalisation factor
Single top ( <a href="#">tW</a> )	6952830	38.09	0.196579
Single top ( <a href="#">tW, scale up</a> )	997880	38.09	1.36969
Single top ( <a href="#">tW, scale down</a> )	993640	38.09	1.37553
Single top ( <a href="#">t bar W</a> )	6933094	38.06	0.196984
Single top ( <a href="#">t bar W, scale up</a> )	1000000	38.06	1.36571
Single top ( <a href="#">t bar W, scale down</a> )	999068	38.06	1.36698
Single top ( <a href="#">tHq</a> )	3495799	0.2609	0.00267804
Single top (tZq, W lept Z had)	Not used	Not used	Not used
Single top ( <a href="#">tWZ tWLL</a> )	50000	0.01104	0.00792297
Diboson ( <a href="#">ZZ to 2L2Nu</a> )	8931750	0.5644	0.00226746
Diboson (ZZ to 2L2Nu ext)	Doesn't exist	Doesn't exist	Doesn't exist
Diboson ( <a href="#">ZZ to 2L2Q</a> )	15462693	3.222	0.00747703



# Results – Normalisation Factors 2016 (8)

Sample	Number of simulated events	Cross section	Normalisation factor
Diboson ( <a href="#">ZZ to 4L</a> )	10711278	1.204	0.00403342
Diboson (WW1nuqq)	Not used	Not used	Not used
Diboson ( <a href="#">WZ to 2L2Q</a> )	26517272	5.606	0.007586
Diboson ( <a href="#">WZ to 3LNu</a> )	1959179	4.688	0.0858622
Diboson ( <a href="#">WZ to 1L1Nu2Q</a> )	24311445	10.73	0.0158372
Diboson ( <a href="#">WW to 2L2Nu</a> )	1999000	10.48	0.188121

# Results – Normalisation Factors 2016 (9)

Sample	Number of simulated events	Cross section	Normalisation factor
Diboson ( <a href="#">WW to LNuQQ</a> )	1999200	43.53	0.781306
Diboson ( <a href="#">WW to LNuQQ ext</a> )	6655400	43.53	0.234695
Diboson (WG to LNuG)	Not used	Not used	Not used
Diboson (ZG to LLG)	Not used	Not used	Not used
Triboson ( <a href="#">WWW to 4F</a> )	240000	0.2086	0.0311883
Triboson ( <a href="#">WWZ to 4F</a> )	250000	0.1651	0.0236971
Triboson ( <a href="#">WZZ</a> )	246800	0.05565	0.00809112
Triboson ( <a href="#">ZZZ</a> )	249237	0.01398	0.00201272

# Results – Normalisation Factors 2016 (10)

Sample	Number of simulated events	Cross section	Normalisation factor
<a href="#">W+jets</a>	22533326	60430.0	96.2312
<a href="#">W+jets (ext)</a>	237263153	60430.0	9.13926
ttbarV ( <a href="#">ttW jets to LNu</a> )	2160168	0.2001	0.0033239
ttbarV ( <a href="#">ttW jets to LNu ext</a> )	3120397	0.2001	0.00230105
ttbarV ( <a href="#">ttW jets to QQ</a> )	833298	0.405	0.0174399
ttbarV ( <a href="#">ttZ to LL</a> )	1992438	0.2529	0.00455463
ttbarV ( <a href="#">ttZ to LL ext2</a> )	5837781	0.2529	0.0015545
ttbarV ( <a href="#">ttZ to LL ext3</a> )	5934228	0.2529	0.00152923
ttbarV ( <a href="#">ttZ to QQ</a> )	749400	0.5297	
ttbarV (ttgamma)	Not used	Not used	Not used
ttbarV ( <a href="#">ttH to bb</a> )	3872944	0.5638	0.00522363
ttbarV ( <a href="#">ttH to nonbb</a> )	3981250	0.5638	0.00508153

# Results – Normalisation Factors 2017 (1)

Sample	Number of simulated events	Cross section	Normalisation factor
<a href="#">tZq</a>	13276146	0.07358	0.000230159
<a href="#">Z+jets (M 50)</a>	27529915	6529.0	9.84879
<a href="#">Z+jets (M50 ext)</a>	182104014	6529.0	1.48891
<a href="#">Z+jets (M10To50)</a>	316134	15810	2076.83
ttbar ( <a href="#">2l2nu</a> )	69098644	88.29	0.0530619
ttbar ( <a href="#">madgraph</a> )	6094476	56.86	0.120653

# Results – Normalisation Factors 2017 (2)

Sample	Number of simulated events	Cross section	Normalisation factor
ttbar ( <a href="#">TT to hadronic</a> )	130091218	377.96	0.137907
ttbar ( <a href="#">TT to semileptonic</a> )	110014744	365.34	0.194558
ttbar ( <a href="#">aMCatNLO</a> )	154280331	722.8	0.387446
Single top ( <a href="#">t-channel, top</a> )	122630600	136.02	0.000464558
Single top ( <a href="#">t-channel, antitop</a> )	63620800	80.95	0.0460622
Single top ( <a href="#">s-channel</a> )	9883805	3.74	0.0528395

# Results – Normalisation Factors 2017 (3)

Sample	Number of simulated events	Cross section	Normalisation factor
Single top ( <a href="#">tW</a> )	7945242	34.91	0.0157141
Single top ( <a href="#">t bar W</a> )	7745276	34.97	0.182467
Single top ( <a href="#">tHq</a> )	3381548	0.3184	0.187499
Single top ( <a href="#">tZq, W lept Z had</a> )	1000000	0.1573	0.0039102
Single top ( <a href="#">tWZ tWLL</a> )	986000	0.01103	0.00653235
Diboson ( <a href="#">ZZ to 2L2Nu</a> )	8744768	0.5644	0.00268028
Diboson ( <a href="#">ZZ to 2L2Q</a> )	27611672	3.222	0.00484589

# Results – Normalisation Factors 2017 (4)

Sample	Number of simulated events	Cross section	Normalisation factor
Diboson ( <a href="#">ZZ to 4L</a> )	6964071	1.256	0.00748975
Diboson ( <a href="#">WW1nuqq</a> )	8785360	45.99	
Diboson ( <a href="#">WZ to 1L2Nu2Q</a> )	4997672	45.68	0.379577
Diboson ( <a href="#">WZ to 2L2Q</a> )	27582164	5.606	0.00844045
Diboson ( <a href="#">WZ to 3LNu</a> )	10987679	5.052	0.0190941
Diboson ( <a href="#">WW to 1L1Nu2Q</a> )	4997672	45.68	0.379577
Diboson ( <a href="#">WW to 2L2Nu</a> )	2000000	11.08	0.230065

# Results – Normalisation Factors 2017 (5)

Sample	Number of simulated events	Cross section	Normalisation factor
Diboson ( <a href="#">WW to LNuQQ</a> )	8785360	45.99	0.217393
Diboson (WG to LNuG)	6283083	405.27	2.67863
Diboson (ZG to LLG)	30490034	51.50	0.070144
Triboson ( <a href="#">WWW to 4F</a> )	232300	0.2086	0.0372912
Triboson ( <a href="#">WWZ to 4F</a> )	250000	0.1651	0.0274251
Triboson ( <a href="#">WZZ</a> )	250000	0.05565	0.00924413
Triboson ( <a href="#">ZZZ</a> )	250000	0.01398	0.00232225



# Results – Normalisation Factors 2017 (6)

Sample	Number of simulated events	Cross section	Normalisation factor
<a href="#">W+jets</a>	30008250	52940.0	73.2629
ttbarV ( <a href="#">ttW jets to LNu</a> )	4908905	0.2198	0.00185945
ttbarV ( <a href="#">ttW jets to QQ</a> )	811306	0.4316	0.0220921
ttbarV ( <a href="#">ttgamma</a> )	4642344	0.5804	0.00519196
ttbarV ( <a href="#">ttZ to LL</a> )	250000	0.05324	0.0088438
ttbarV ( <a href="#">ttH to bb</a> )	8000000	0.5269	0.00273514
ttbarV ( <a href="#">ttH to nonbb</a> )	7966779	0.5638	0.00293889

# Results – Normalisation Factors 2017 (7)

Sample	Number of simulated events	Cross section	Normalisation factor
ttbarV ( <a href="#">ttZ to LLNuNu</a> )	7563490	0.2432	0.00133531
ttbarV ( <a href="#">ttZ to QQ</a> )	750000	0.5104	0.0282612
ttbarV ( <a href="#">ttZ to QQ ext</a> )	8940000	0.5104	0.00237091

# Results – Normalisation Factors 2018 (1)

Sample	Number of simulated events	Cross section	Normalisation factor
<a href="#">tZq</a>	13736000	0.07358	0.000319732
<a href="#">Z+jets (M 50)</a>	997561	6529.0	390.656
<a href="#">Z+jets (M50 ext)</a>	193094040	6529.0	2.0182
<a href="#">Z+jets (M10To50)</a>	39392062	15810	23.9558
<a href="#">Z+jets (M10To50 ext)</a>	46976952	15810	20.0879
<a href="#">ttbar (2l2nu)</a>	64310000	88.29	0.0819445
<a href="#">ttbar (madgraph)</a>	28701360	54.23	0.112778

# Results – Normalisation Factors 2018 (2)

Sample	Number of simulated events	Cross section	Normalisation factor
ttbar ( <a href="#">TT to hadronic</a> )	133664000	377.96	0.168779
ttbar ( <a href="#">TT to semileptonic</a> )	101550000	365.34	0.214736
ttbar ( <a href="#">aMCatNLO</a> )	142155064	831.76	0.349239
Single top ( <a href="#">t-channel, top</a> )	154307600	136.02	0.0526141
Single top ( <a href="#">t-channel, antitop</a> )	79090800	80.95	0.0610911
Single top ( <a href="#">s-channel</a> )	19965000	3.74	0.0111812

# Results – Normalisation Factors 2018 (3)

Sample	Number of simulated events	Cross section	Normalisation factor
Single top ( <a href="#">tW</a> )	9598000	34.91	0.217098
Single top ( <a href="#">t bar W</a> )	7623000	34.97	0.273815
Single top ( <a href="#">tHq</a> )	3375995	0.3184	0.00562935
Single top ( <a href="#">tZq, W lept Z had</a> )	4977000	0.1518	0.0018205
Single top ( <a href="#">tWZ tWLL</a> )	248600	0.01103	0.00264826
Diboson ( <a href="#">ZZ to 2L2Nu</a> )	8382600	0.5644	0.00401879
Diboson ( <a href="#">ZZ to 2L2Nu ext</a> )	48046000	0.5644	0.00070116
Diboson ( <a href="#">ZZ to 2L2Q</a> )	27900469	3.222	0.00689289

# Results – Normalisation Factors 2018 (4)

Sample	Number of simulated events	Cross section	Normalisation factor
Diboson ( <a href="#">ZZ to 4L</a> )	99009000	1.256	0.000757185
Diboson ( <a href="#">WZ to 1L2Nu2Q</a> )	18901469	10.73	0.0118683
Diboson ( <a href="#">WZ to 2L2Q</a> )	28193648	5.606	0.0280525
Diboson ( <a href="#">WZ to 3LNu</a> )	10749269	5.052	0.0338837
Diboson ( <a href="#">WZ to 3LNu ext</a> )	11248318	5.502	0.0852367
Diboson ( <a href="#">WW to 1L1Nu2Q</a> )	19199100	45.68	0.142014
Diboson ( <a href="#">WW to 2L2Nu</a> )	7758900	11.08	3.96022

# Results – Normalisation Factors 2018 (5)

Sample	Number of simulated events	Cross section	Normalisation factor
Diboson (WW to LNuQQ)	Not sample	No sample	No sample
Diboson ( <a href="#">WG to LNuG</a> )	6108186	405.27	0.220411
Diboson ( <a href="#">ZG to LLG</a> )	13946364	51.50	0.0518788
Triboson ( <a href="#">WWW to 4F</a> )	240000	0.2086	0.039418
Triboson ( <a href="#">WWZ to 4F</a> )	250000	0.1651	0.0132865
Triboson ( <a href="#">WZZ</a> )	250000	0.05565	0.00326613
Triboson ( <a href="#">ZZZ</a> )	250000	0.01398	44.4886

# Results – Normalisation Factors 2018 (6)

Sample	Number of simulated events	Cross section	Normalisation factor
<a href="#">W+jets</a>	71026861	52940.0	00.00261138
ttbarV ( <a href="#">ttW jets to LNu</a> )	4911941	0.2149	0.030841
ttbarV ( <a href="#">ttW jets to QQ</a> )	835296	0.4316	0.030841
ttbarV ( <a href="#">ttZ to ll</a> )	250000	0.05324	0.0127112
ttbarV ( <a href="#">ttZ to QQ</a> )	750000	0.5104	
ttbarV ( <a href="#">ttZ to QQ ext</a> )	8891000	0.5104	
ttbarV ( <a href="#">ttgamma</a> )	5968000	0.5804	0.00580478
ttbarV ( <a href="#">ttgamma ext</a> )	4940000	0.5804	0.00701274
ttbarV ( <a href="#">ttH to bb</a> )	9580000	0.5269	0.00328284
ttbarV ( <a href="#">ttH to nonbb</a> )	7525991	0.5638	0.00447145



# More useful links

- NanoAOD twiki page is [here](#)
- Documentation for the description of nanoAOD branches can be found [here](#).
- [CMS Top Quark Group Twiki](#)
- [Top systematics twiki](#)
- [Top systematics twiki \(Run 2\)](#)
- [CMS Top Approval Procedure](#)
- [Info for each year](#) (change the year in the URL for 2017 and 2018)
- [Jet energy smearing twiki](#)
- JECs:
  - [Twiki page](#)
  - Text files for [2016](#) and [2017](#)
  - Recommended JECs and uncertainties for data and MC [twiki](#)
  - Link to [the paper](#)

# Editing the analysis note (in lxplus)

- Example commands:  
[https://twiki.cern.ch/twiki/pub/CMS/Internal/TdrProcessing/lxplus\\_git\\_example.txt](https://twiki.cern.ch/twiki/pub/CMS/Internal/TdrProcessing/lxplus_git_example.txt)
- When typing the commands given in the above text file, change “alverson” to your CERN username. Also change:

*git clone --recursive https://:@gitlab.cern.ch:8443/tdr/papers/AN-18-280.git*

to

*git clone --recursive https://:@gitlab.cern.ch:8443/tdr/**notes/AN-18-280**.git*

# Editing the analysis note (in lxplus)

- Twiki page:  
<https://twiki.cern.ch/twiki/bin/viewauth/CMS/Internal/TdrProcessing>

# Setting up a grid certificate

- Step 1: <https://twiki.cern.ch/twiki/bin/viewauth/CMS/DQMGUIGridCertificate>
- Step 2: <https://cafiles.cern.ch/cafiles/certificates/Grid.aspx>
- Step 3 (to double check): <https://ca.cern.ch/ca/Help/?kbid=040110>

# EPR

- Rules: <https://twiki.cern.ch/twiki/bin/view/Main/EprRulesExplained>
- Manpower needs (tracker DPG):  
<https://twiki.cern.ch/twiki/bin/viewauth/CMS/TrackerDPGManpowerNeeds>