Search for supersymmetric particle pair production in final states with two oppositely charged leptons and large missing transverse momentum in proton-proton collisions

PABLO MATORRAS-CUEVAS

Instituto de Fisica de Cantabria (CSIC-Universidad de Cantabria)

On behalf of the CMS collaboration

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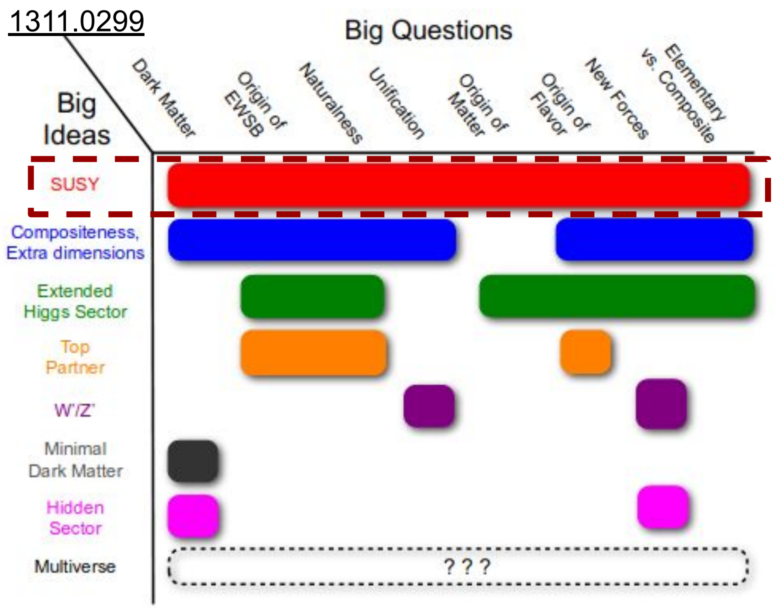
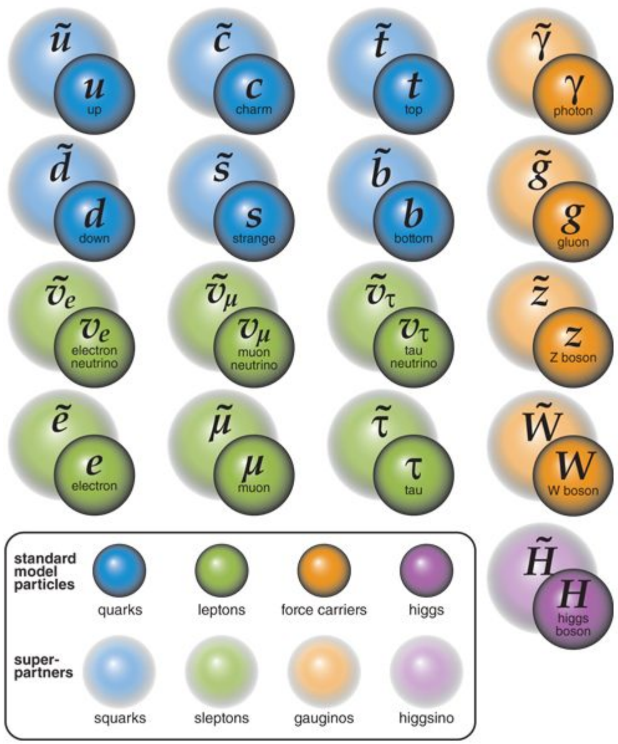
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

UNIVERSIDAD DE CANTABRIA

Supersymmetry in a nutshell



- Supersymmetry (**SUSY**) can solve multiple open questions both theoretical (great unification theory) or experimental (dark matter (DM) candidate)

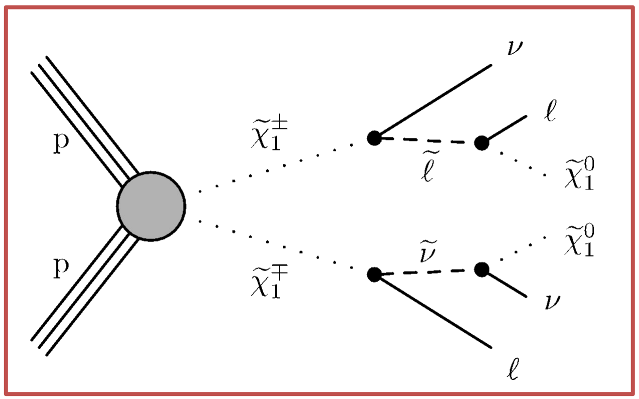


- A new space time symmetry ➞ one superpartner companion per standard model (SM) particle.
- If R parity conserved ➞ produced in pairs, Lightest supersymmetric particle stable
- Naturalness ➞ gluinos, top squark (stop), and electroweakinos (charginos or neutralinos) at TeV scale

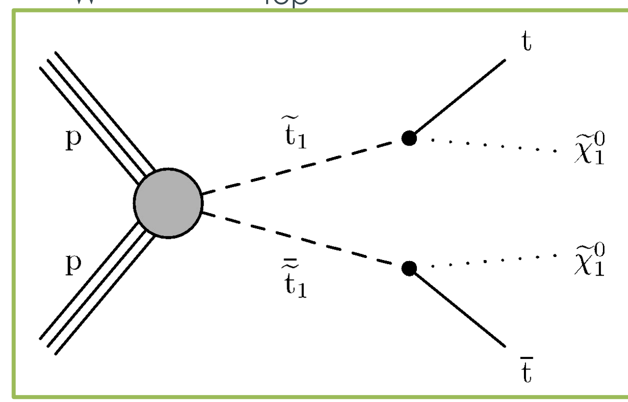
Target of the Analysis

- Search for direct chargino pair production and stop pair production in final states with two oppositely charged leptons:

TChipmSlepSnu

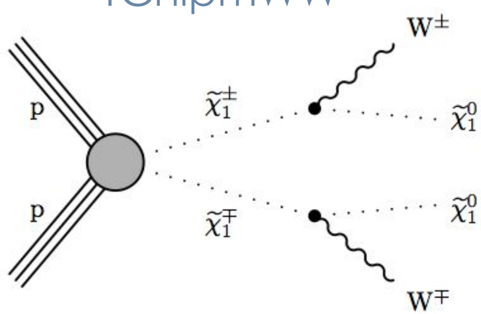


T2tt with $m_W < \Delta m < m_{top}$ (three-body decays)

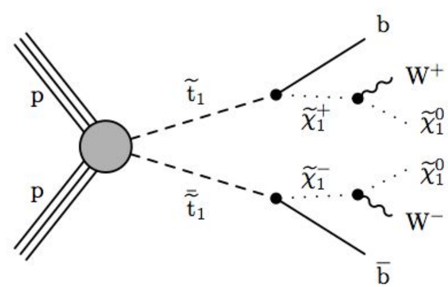


- Additional interpretations:

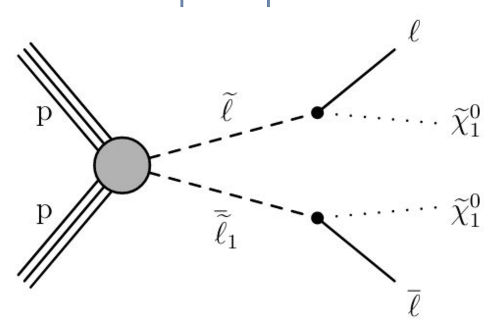
TChipmWW



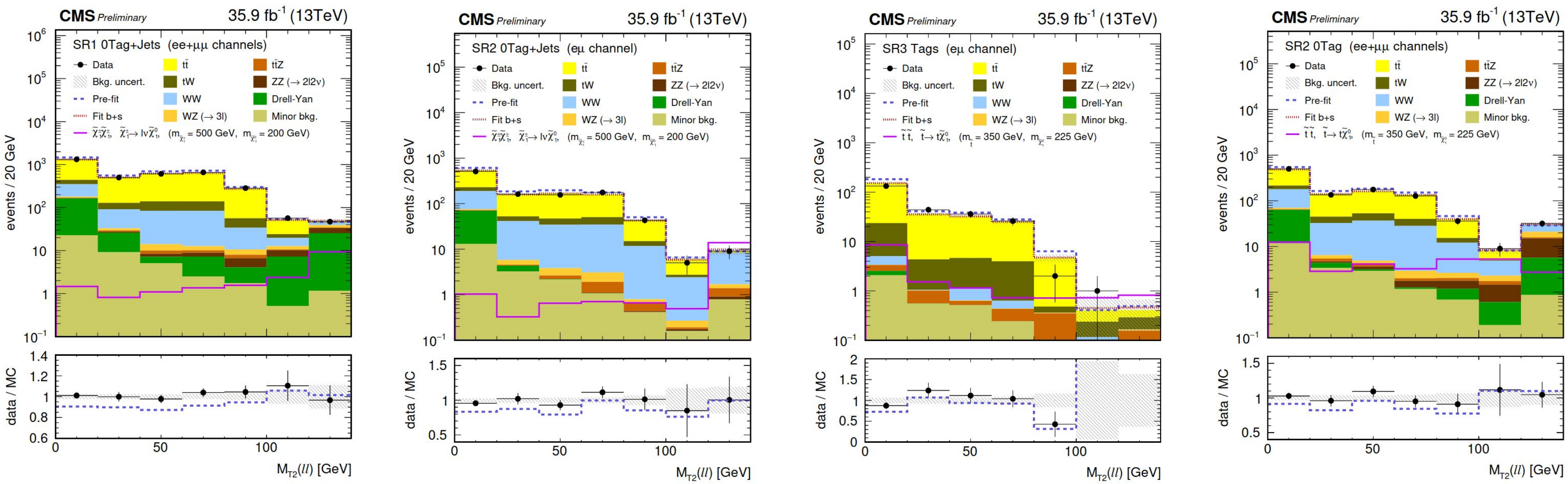
T2bW



TSlepSlep



Analysis Strategy



- Signal extraction strategy:
  - Selecting events with two oppositely charged leptons and high p_T^{miss}
  - Search regions (SRs) defined according to p_T^{miss} bins, b-tag content, and lepton flavour channels
  - Simultaneous fit to observed m_{T2} distribution in all the SRs
  - Main backgrounds from top and WW production normalized at low m_{T2}

Optimized Search Regions

- Chargino general search regions (TChipmSlepSnu, TChipmWW, TSlepSlep)

	$SR1^{0jet}_{0tag}$	$SR1^{jets}_{0tag}$	$CR1_{tags}$	$SR2^{0jet}_{0tag}$	$SR2^{jets}_{0tag}$	$CR2_{tags}$	$SR3_{0tag}$	$CR3_{tags}$	$SR4_{0tag}$	$CR4_{tags}$
p_T^{miss} [GeV]	160–220	160–220	160–220	220–280	220–280	220–280	280–380	380–380	≥380	≥380
$N_{b\ jets}$	0	0	≥1	0	0	≥1	0	≥1	0	≥1
N_{jets}	0	≥1	≥1	0	≥1	≥1	≥0	≥1	≥0	≥1
Channels	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF
$m_{T2}(\ell\ell)$	0–20, 20–40, 40–60, 60–80, 80–100, 100–160, 160–240, 240–370. ≥370 GeV									

- Stop general search regions (T2tt, T2bW)

	$SR1_{0tag}$	$SR1_{tags}$	$SR2_{0tag}$	$SR2_{tags}$	$SR3_{0tag}$	$SR3_{tags}$	$SR4^{ISR}_{0tag}$	$SR4^{ISR}_{tag}$
p_T^{miss} [GeV]	160–220	160–220	220–280	220–280	280–380	280–380	≥380	≥380
$N_{b\ jets}$	0	≥1	0	≥1	0	≥1	0	≥1
N_{jets}	≥0	≥1	≥0	≥1	≥0	≥1	≥1	≥2
ISR jets	≥0	≥0	≥0	≥0	≥0	≥0	≥1	≥1
Channels	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF
$m_{T2}(\ell\ell)$	0–20, 20–40, 40–60, 60–80, 80–100, 100–160, ≥160 GeV							

- We further merge the last m_{T2} bins dependent on the p_T^{miss} bin for the chargino SRs in order to avoid having no meaningful m_{T2} bins.

Background Estimation in CRs

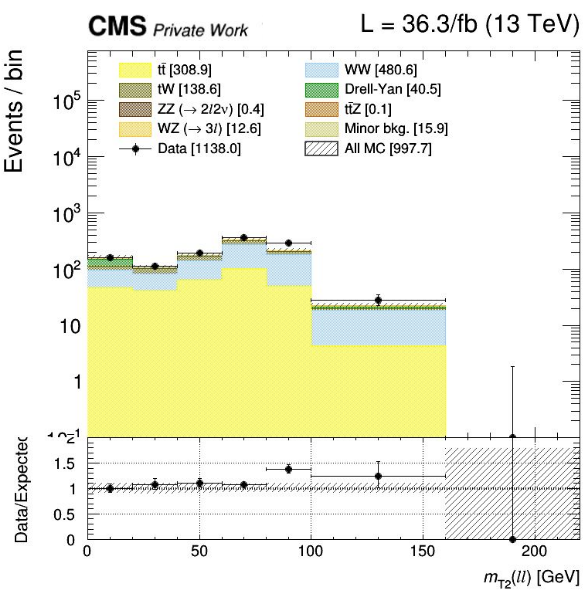
- Control regions (CRs) for the validation of the m_{T2} tails in processes with m_W endpoint (top and WW):
  - Events with $100 < p_T^{miss} < 140$ GeV
  - Effect of jet mismeasurement at high p_T^{miss}:
    - $WZ \rightarrow 3L$ events, p_T of one Z's leptons added to p_T^{miss}
  - Non-prompt leptons:
    - rate tested in same-sign events
    - m_{T2} shape validated in events with a third (looser) lepton
- Control regions for sub-leading Z+X backgrounds (no m_W endpoint):
  - WZ normalization: events with three leptons and p_T^{miss} in SR threshold
  - ZZ: reconstructed $ZZ \rightarrow 4L$ events, one Z's p_T added to p_T^{miss}
  - ttZ: from $ttZ \rightarrow 4L$ events, Z's p_T added to p_T^{miss}
  - DY: same flavour events with $|m_{ll} - m_Z| < 15$ GeV

CRs: $100<p_T^{miss}<140$ GeV

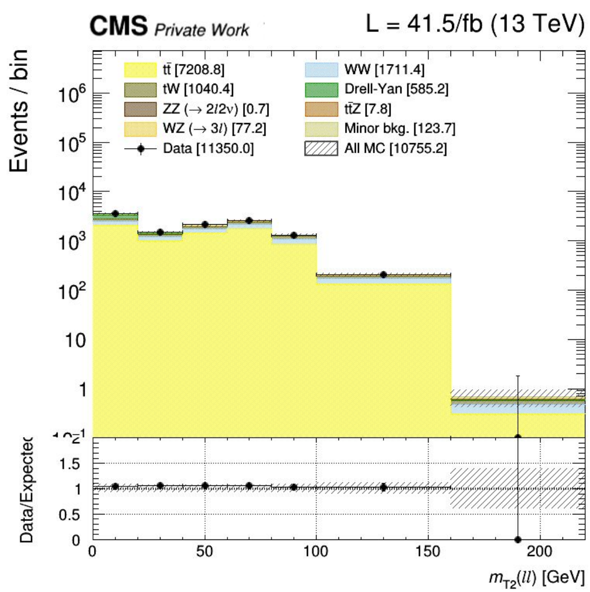
For each year, we study events with:

- $100<p_T^{miss}<140$ GeV
- split in terms of its b jet content,
- eμ channel

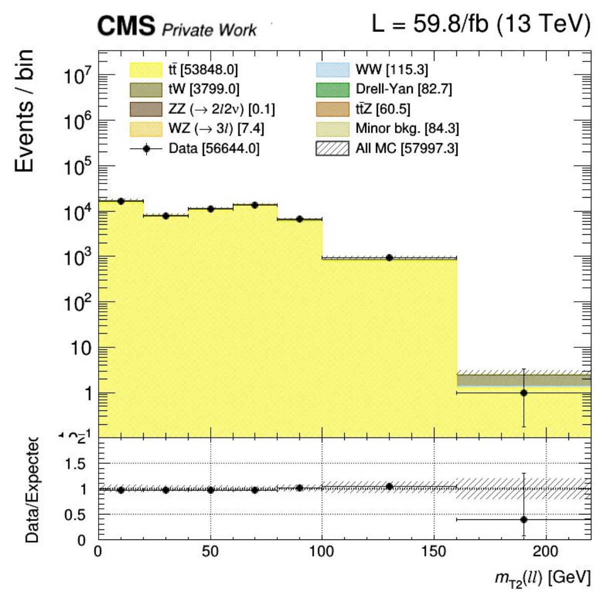
2016, $n_{bjets}=0$, $n_{jets}=0$



2017, $n_{bjets}=0$, $n_{jets}>0$

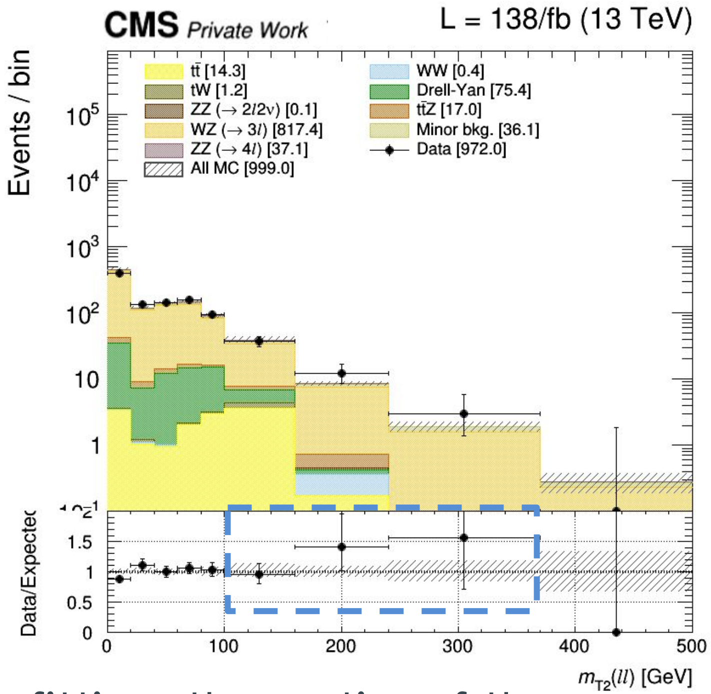


2018, $n_{bjets}>0$



CRs: High p_T^{miss}

- We check the description of the tails of the m_{T2} distributions at high p_T^{miss} for backgrounds with m_W endpoint in WZ events:
  - Event selected with three leptons
  - Candidate Z with $|m_{ll}-m_Z|<15$ GeV
  - Adding to p_T^{miss} the p_T of the Z lepton with same charge as the third lepton
  - Selecting events with p_T^{miss}>160 GeV
  - m_{T2} is computed with the other two leptons



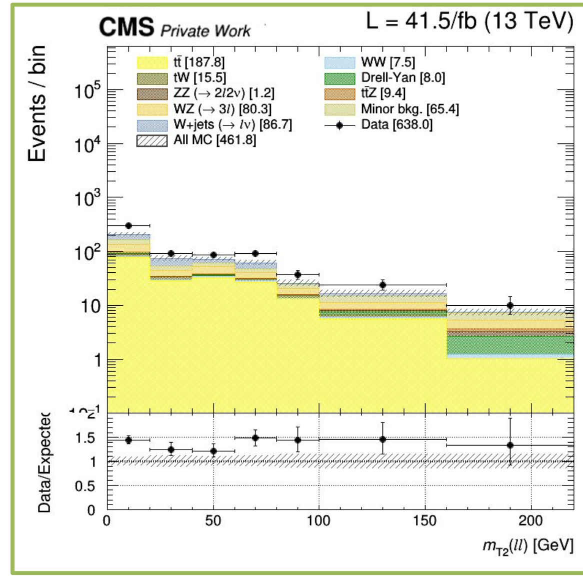
Slight excess in the last bins quantified by fitting the ratio of the (background-subtracted) observed events
to the expected WZ events, using a linear function.

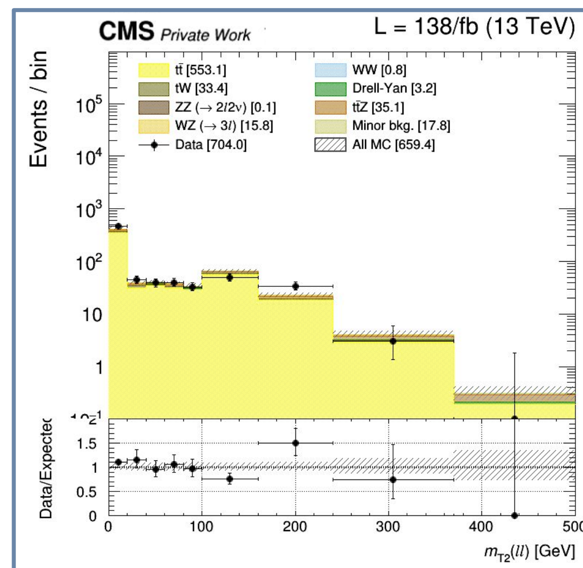
Non-prompt Lepton Rate

- Rate of non-prompt leptons tested in same-sign events for each year.
  - Around 10-40% excess in data
  - Uncertainty calculated by taking the largest difference from the central value of a linear fit on several variables (jet-p_T, n_{jets} $n_{b\text{-}jets}$, or p_T^{miss}…)

year		value
2016	HIPM	1.18 ±0.30
	noHIPM	1.10 ±0.40
2017		1.38 ±0.29
2018		1.36 ±0.25

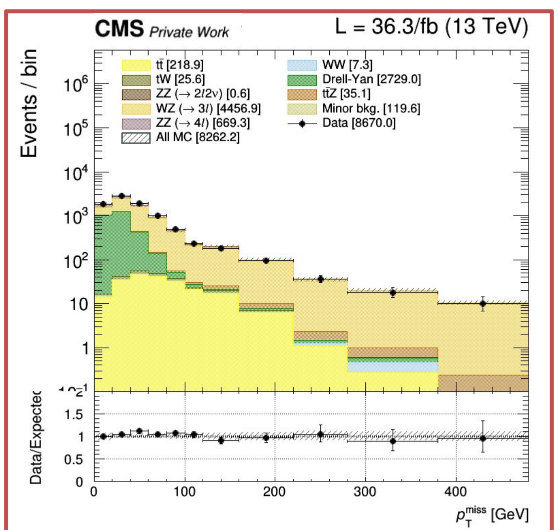
- m_{T2} shape validated in events with a third "looser" lepton and p_T^{miss}>160 GeV:
  - Swapping the loose lepton with one of the two "tight" ones and recomputing m_{T2}
  - Reasonable agreement between the recomputed m_{T2} shape in data and simulations



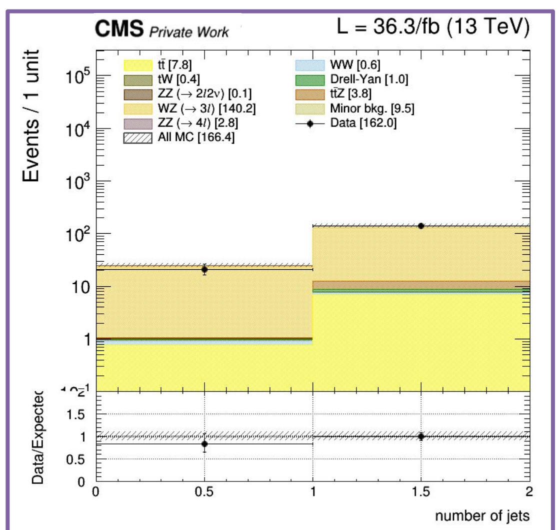


WZ Production (Normalization)

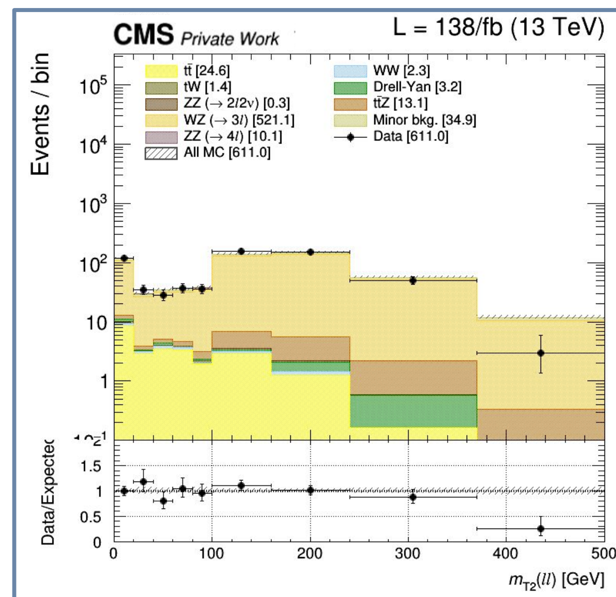
- WZ background is probed in events with three leptons and p_T^{miss}>160 GeV:
  - To constrain its normalisation, regions are included to the fit used for the signal, with the same p_T^{miss} and jet multiplicity bins.
- Shapes are validated by looking at m_{T2} distributions:
  - To prevent normalisation bias, WZ events are normalized to data in the same CR bins used in the fit
  - Hint for slight background overprediction at very high m_{T2} values
  - → A systematic uncertainty is added to cover from this effect



p_T^{miss}

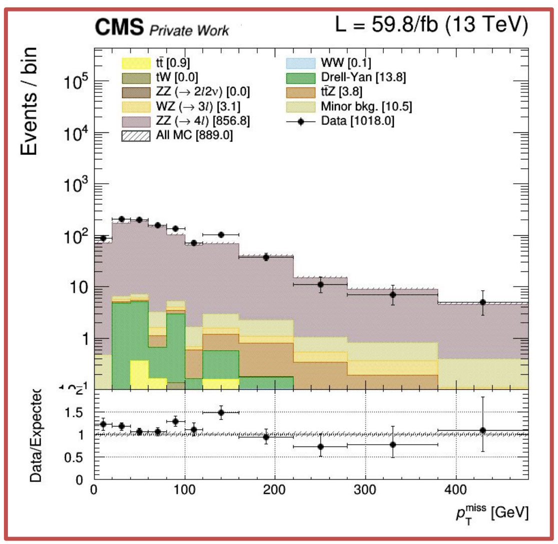


njets (p_T^{miss}>160 GeV)

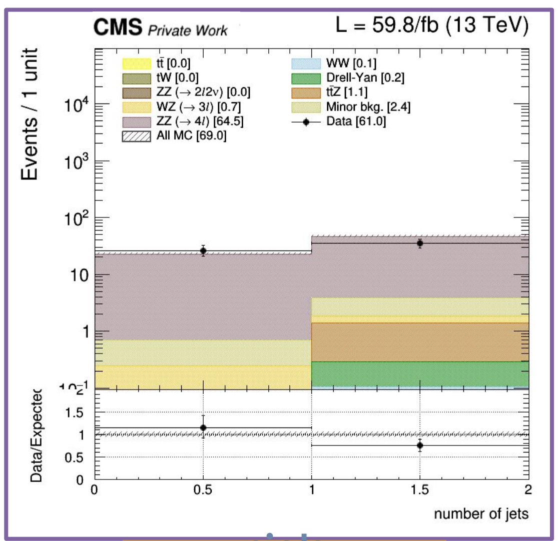


ZZ Production (Normalization)

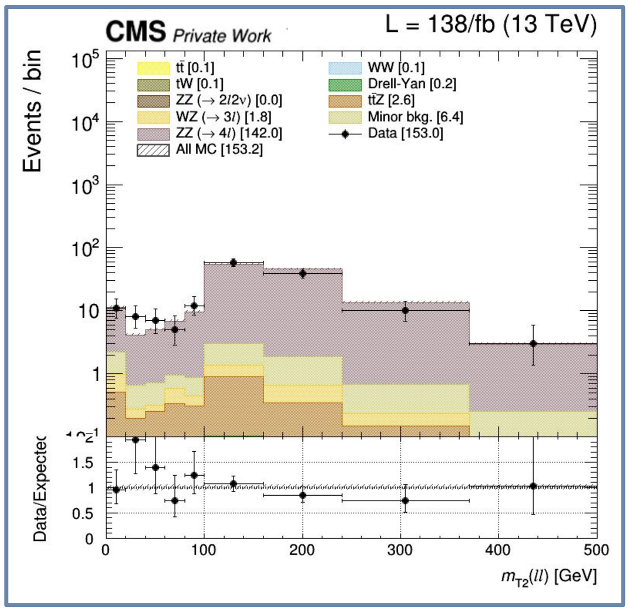
- Modeling of events from ZZ → 2L2ν process tested reconstructing ZZ → 4L events, and adding one Z boson's p_T to the p_T^{miss}
  - MC to data normalisation studied year by year in p_T^{miss} and n_{jet} variables, similarly to the WZ case
- The variable m_{T2} has been validated using ZZ→2L2v events and p_T^{miss}>160 GeV, for the combination of the three years.
  - As for the WZ, the ZZ events are normalized to data.
  - Good agreement within the limited statistics



p_T^{miss}

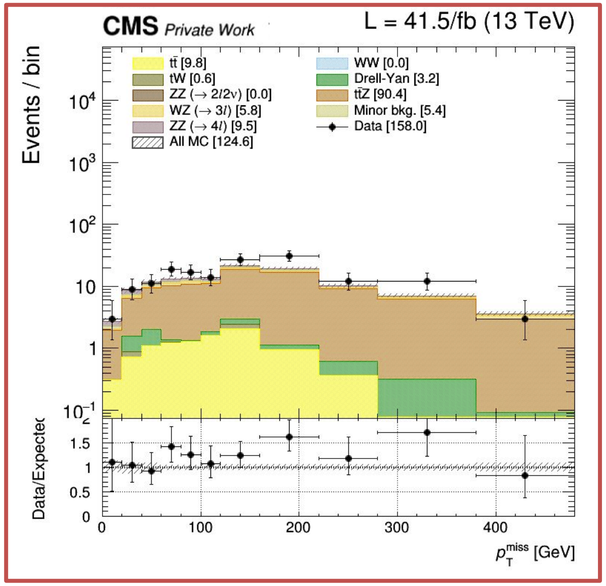


njets (p_T^{miss}>160 GeV)

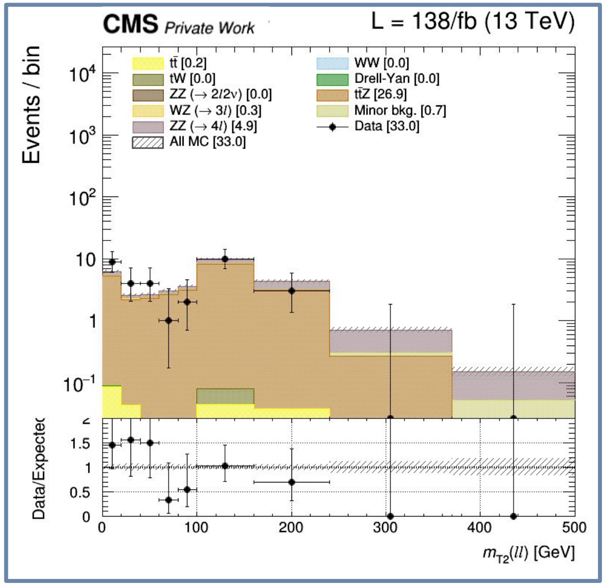


ttZ Events

- Control region for normalisation taken from ttZ with $Z \to L\nu$ events, with at least 3 leptons, two of them within the Z window, and at least one b-tagged jet (2 if exactly 3 leptons), year by year.
  - MC found to underpredict data
  - → Introduced in the ML fit in p_T^{miss} bins.



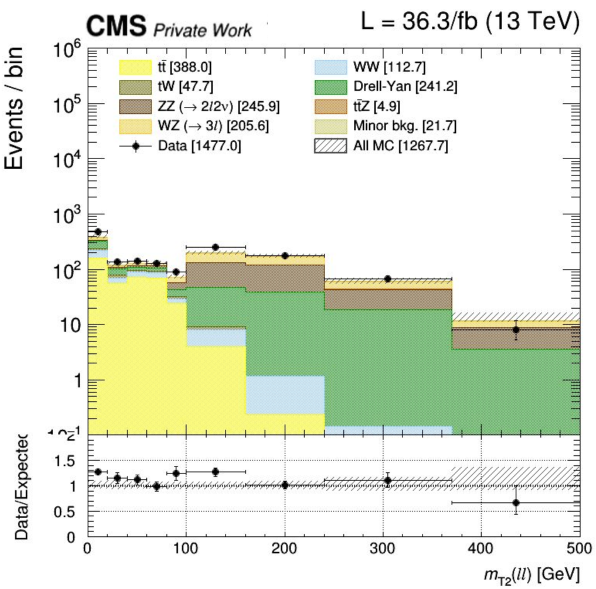
- m_{T2} shape description tested in events with 4 leptons and no b-tagged jets:
  - p_T from reconstructed candidate Z added to p_T^{miss}
  - No bias observed within the limited statistics



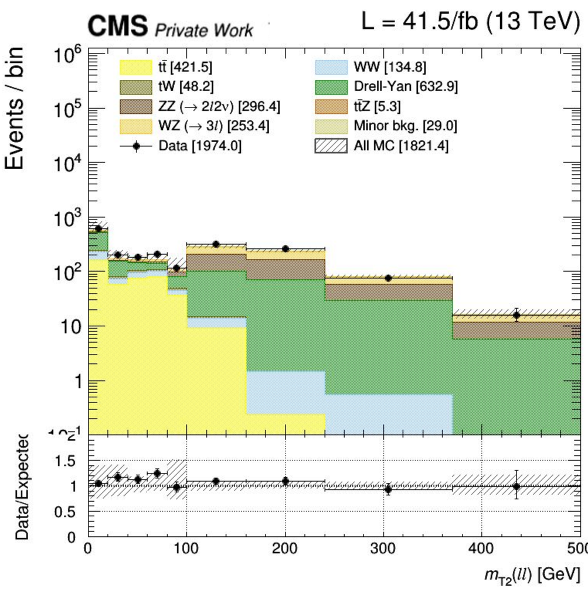
Drell-Yan Production

Testing modeling of Drell-Yan production by reversing the Z veto in SF events year by year:

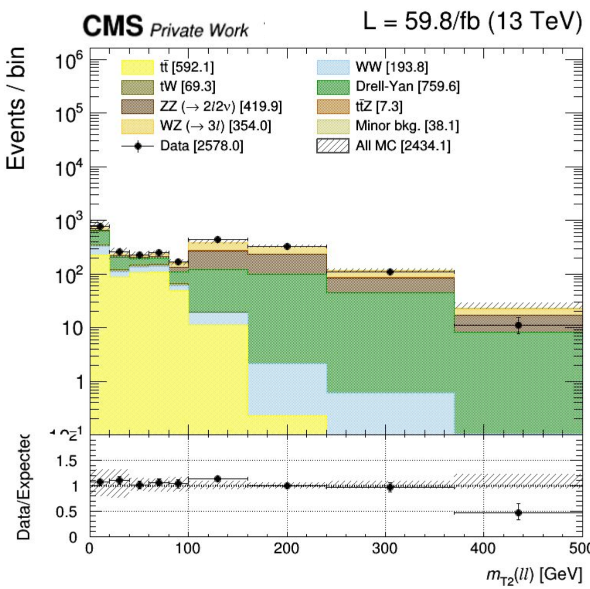
2016



2017

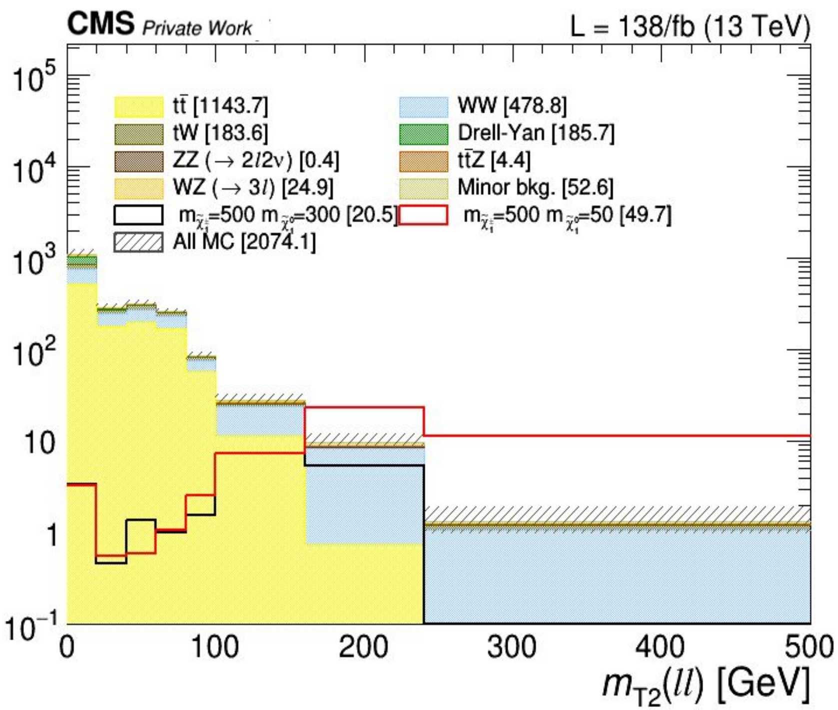


2018

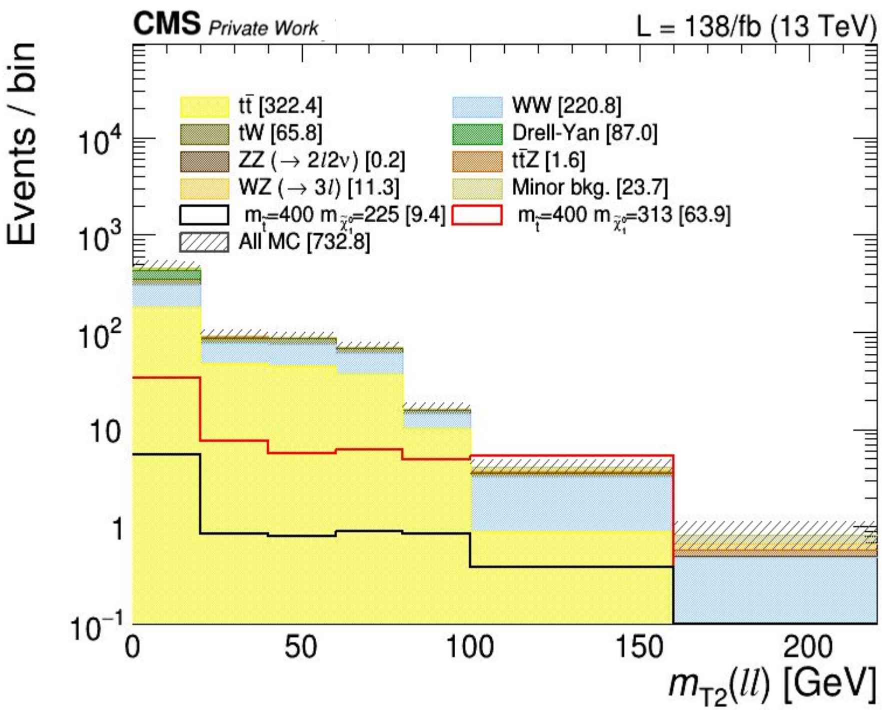


Yields in the Search Regions

- Example expected signal and background yields in some of the studied SRs



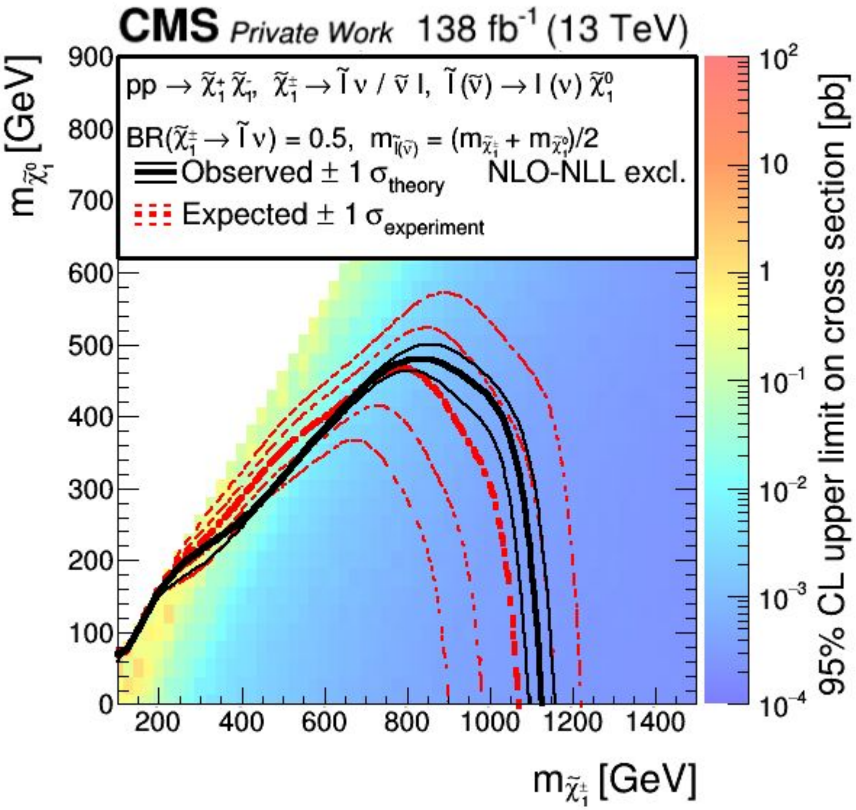
SR2 NoJet eμ (TChipmSlepSnu)



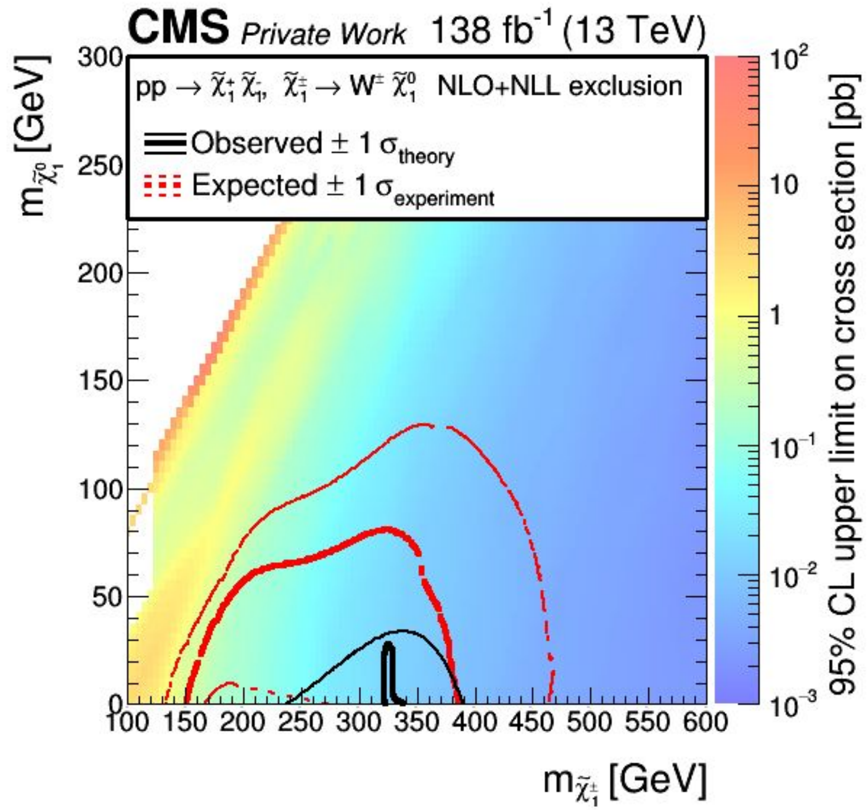
SR3 Veto eμ (T2tt)

RunII observed Limits: **Chargino**

- Observed and expected limits from 2016, 2017 and 2018 combination



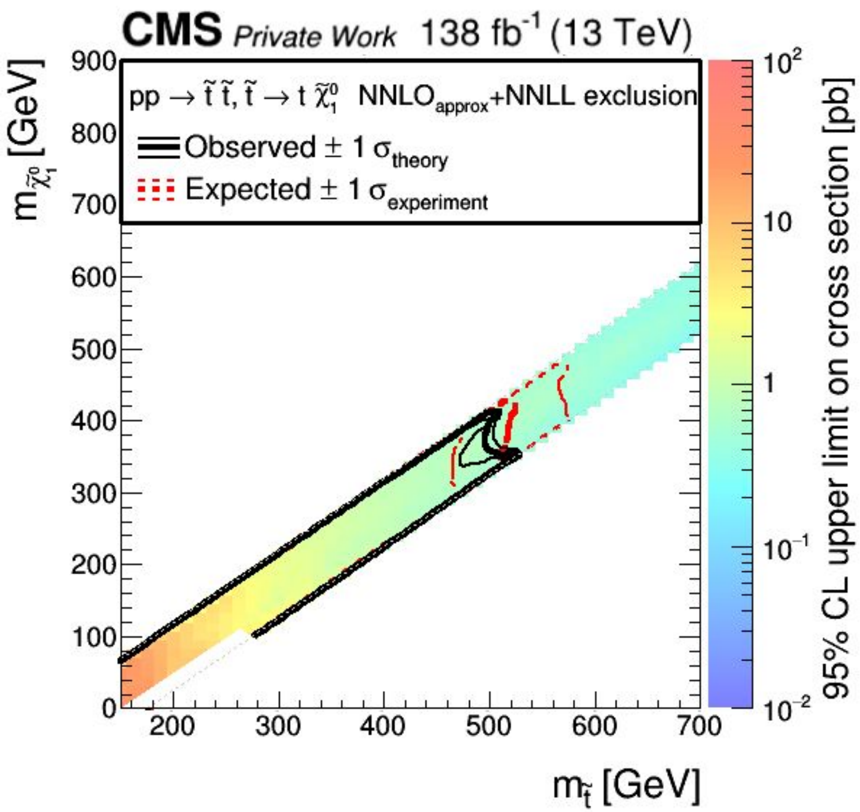
TChipmSlepSnu



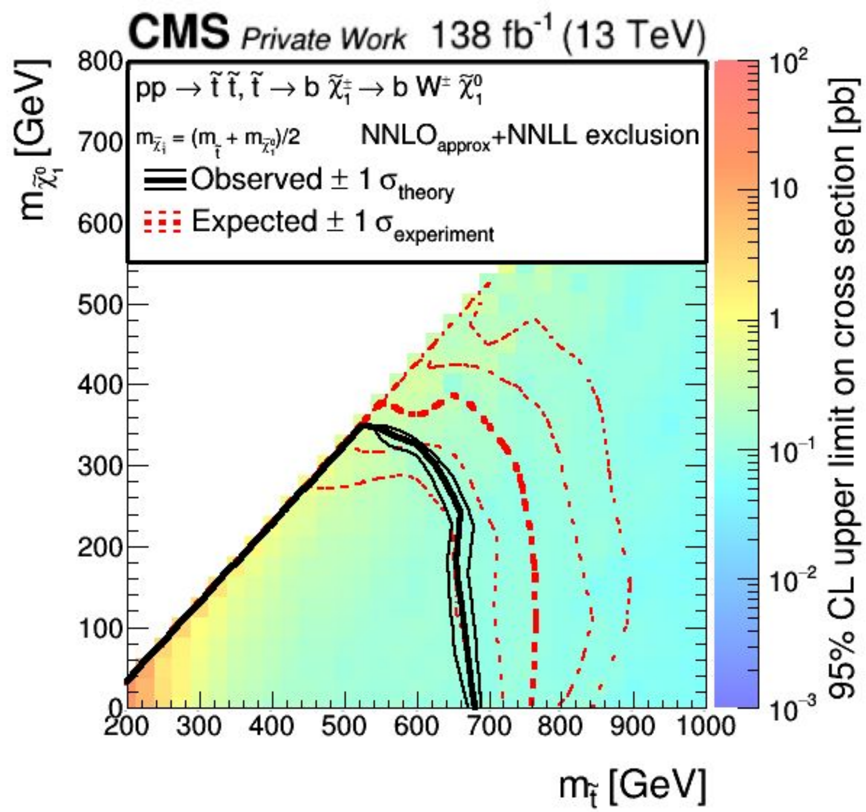
TChipmWW

RunII observed Limits: **Stop**

- Observed and expected limits from 2016, 2017 and 2018 combination



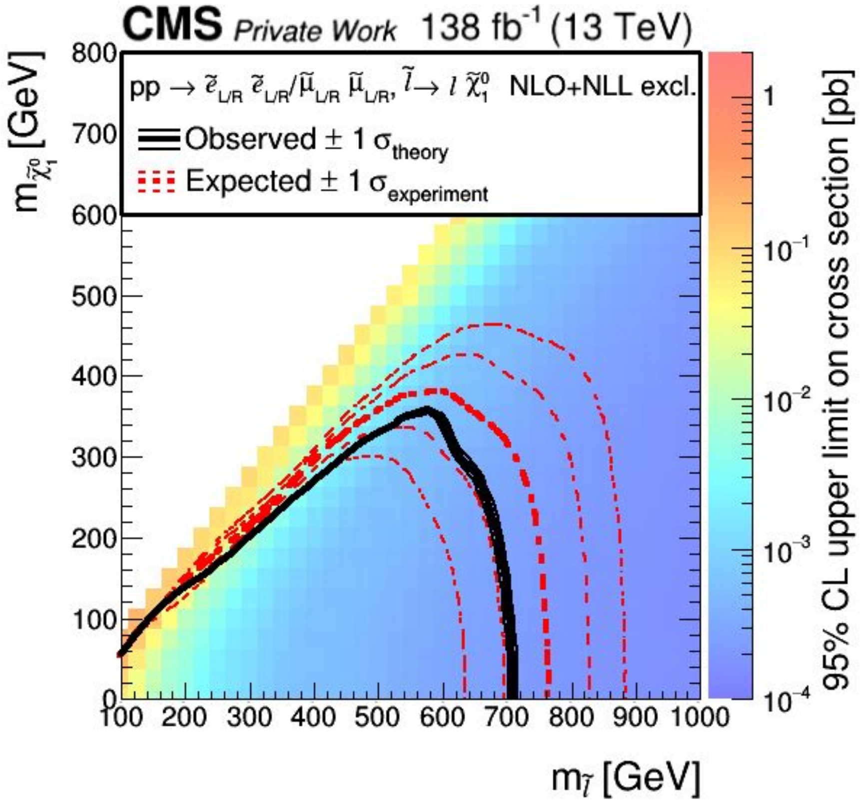
T2tt



T2bW

RunII observed Limits: **TSlepSlep**

- Observed and expected limits from 2016, 2017 and 2018 combination



TSlepSlep

Summary and Future Steps

- An analysis probing for several SUSY models is in place:
  - Signal regions are optimised.
  - Backgrounds well understood
  - Results obtained for several SUSY models.
    - → No significant deviations found with respect to expectation
- Currently going through the last steps of the CMS' internal reviewing process.
  - → Targeting the summer conferences (ICHEP)

Backup Material

Full list of triggers

2016 HIPM

Data set	Run range	HLT path
MuonEG	[271036,278272]	HLT_Mu8_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_v*
		HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL_v*
	[278273,278807]	HLT_Mu12_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_DZ_v*
		HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL_DZ_v*
DoubleMuon	[271036,278807]	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_v*
		HLT_Mu17_TrkIsoVVL_TkMu8_TrkIsoVVL_v*
DoubleEG	[271036,278807]	HLT_Ele23_Ele12_CaloIdL_TrackIdL_IsoVL_DZ_v*
SingleMuon	[271036,278807]	HLT_IsoMu24_v*
		HLT_IsoTkMu24_v*
SingleElectron	[271036,278807]	HLT_Ele27_WPTight_Gsf_v*
		HLT_Ele25_eta2p1_WPTight_Gsf_v*

2016 noHIPM

Data set	Run range	HLT path
MuonEG	[278769,284044]	HLT_Mu12_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_DZ_v*
		HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL_DZ_v*
DoubleMuon	[278769,281612]	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_v*
		HLT_Mu17_TrkIsoVVL_TkMu8_TrkIsoVVL_v*
	[281613,284044]	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_DZ_v*
		HLT_Mu17_TrkIsoVVL_TkMu8_TrkIsoVVL_DZ_v*
DoubleEG	[278769,284044]	HLT_Ele23_Ele12_CaloIdL_TrackIdL_IsoVL_DZ_v*
SingleMuon	[278769,284044]	HLT_IsoMu24_v*
		HLT_IsoTkMu24_v*
SingleElectron	[278769,284044]	HLT_Ele27_WPTight_Gsf_v*
		HLT_Ele25_eta2p1_WPTight_Gsf_v*

2017

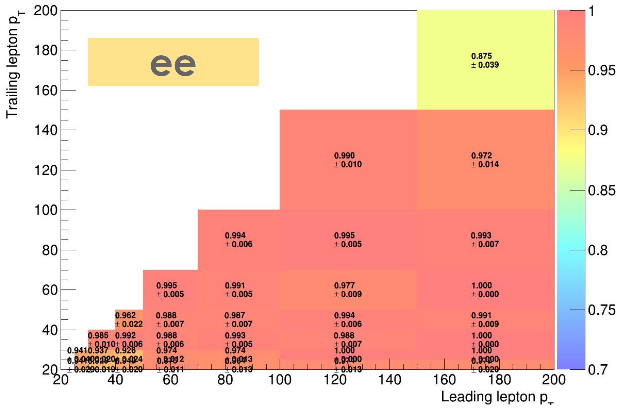
Data set	Run range	HLT path
MuonEG	[297046,299329]	HLT_Mu12_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_DZ_v*
		HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL_DZ_v*
	[299368,306462]	HLT_Mu12_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_DZ_v*
		HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL_v*
DoubleMuon	[297046,299329]	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_DZ_v*
	[299368,306462]	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_DZ_Mass8_v*
DoubleEG	[297046,306462]	HLT_Ele23_Ele12_CaloIdL_TrackIdL_IsoVL_v*
SingleMuon	[297046,306462]	HLT_IsoMu27_v*
SingleElectron	[297046,306462]	HLT_Ele35_WPTight_Gsf_v*

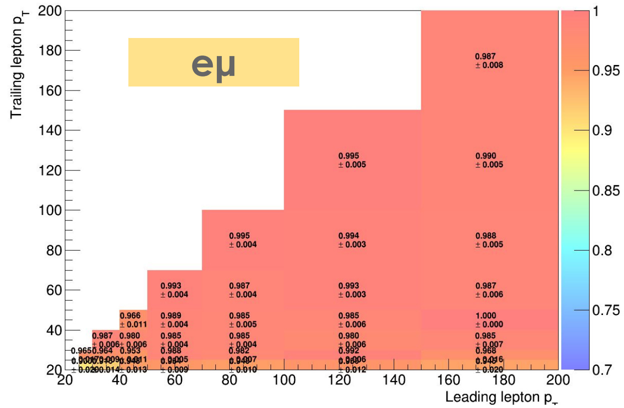
2018

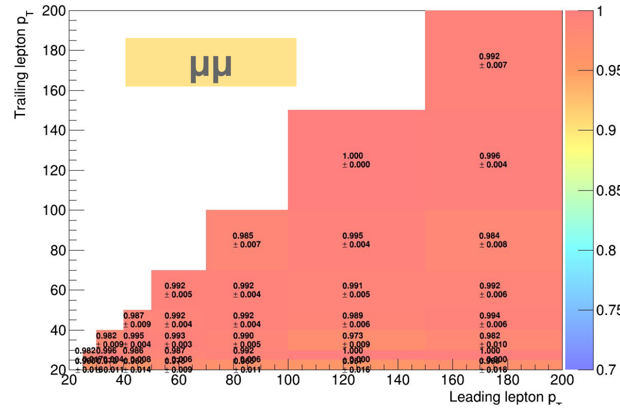
Data set	Run range	HLT path
MuonEG	[315252,325175]	HLT_Mu12_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_DZ_v*
		HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL_v*
DoubleMuon	[315252,325175]	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_DZ_Mass3p8_v*
EGamma	[315252,325175]	HLT_Ele23_Ele12_CaloIdL_TrackIdL_IsoVL_v*
		HLT_Ele32_WPTight_Gsf_v*
SingleMuon	[315252,325175]	HLT_IsoMu24_v*

Trigger efficiencies

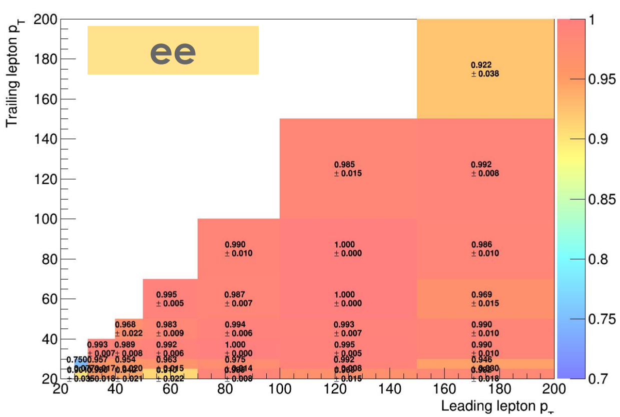
2016HIPM

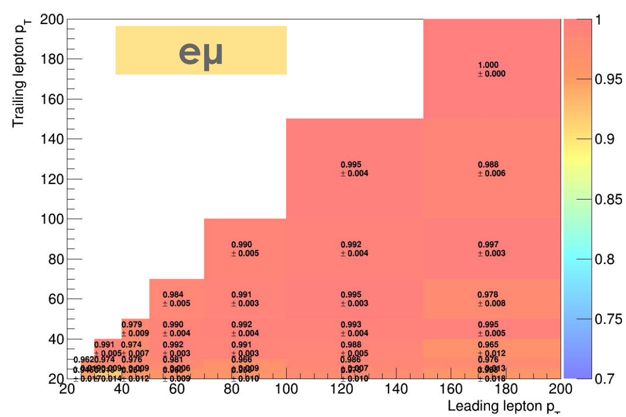


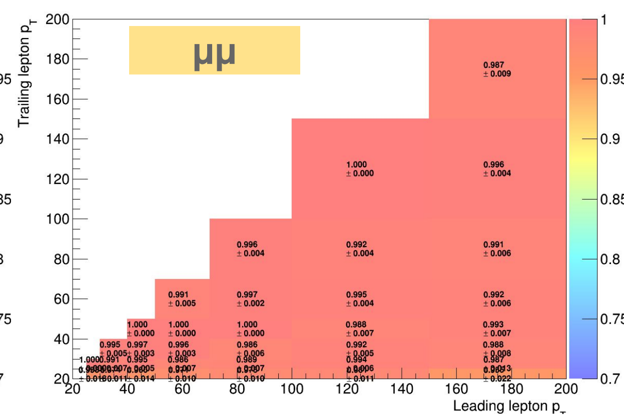




2016noHIPM

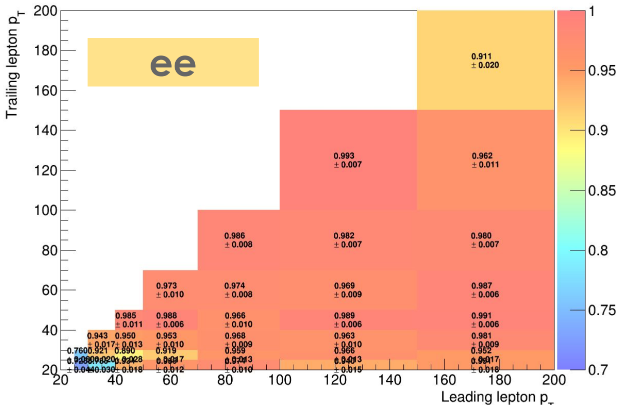


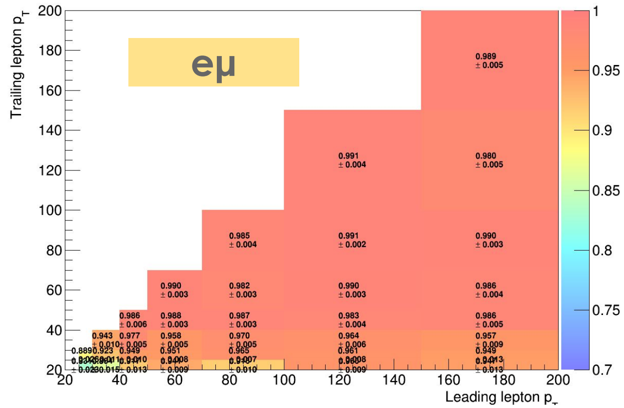


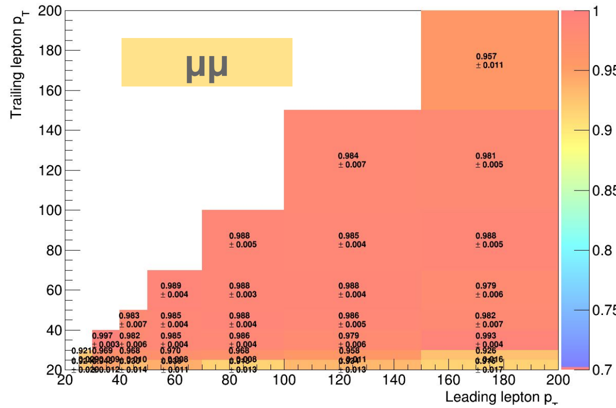


Trigger efficiencies

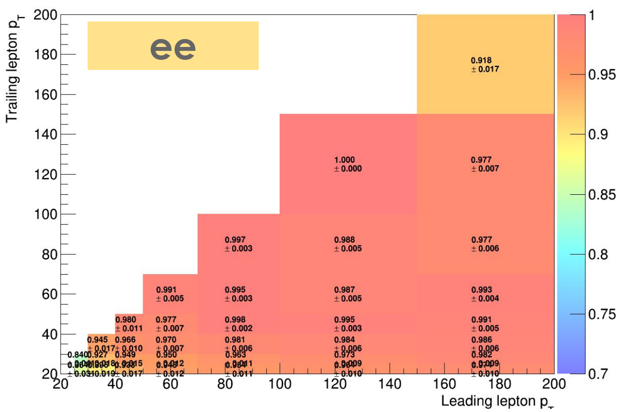
2017

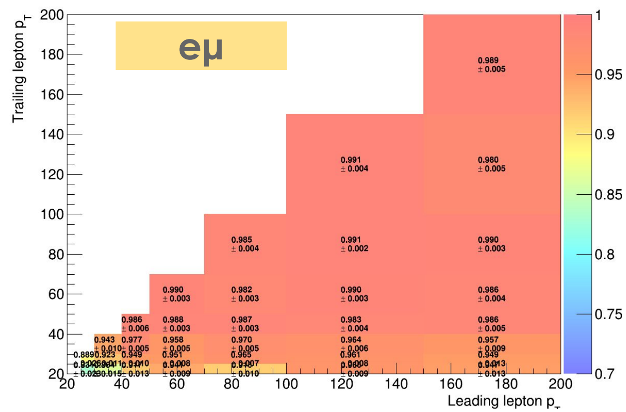


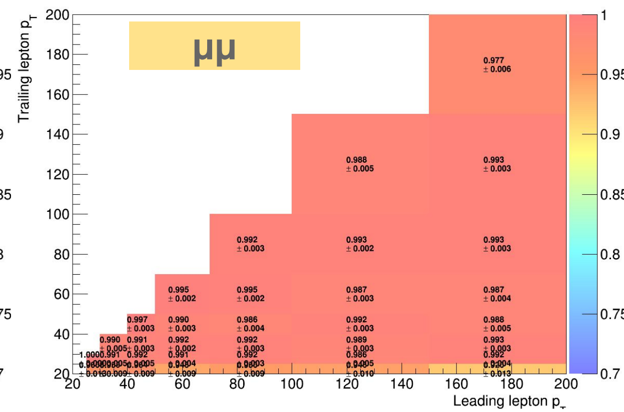




2018







Lepton scale factors

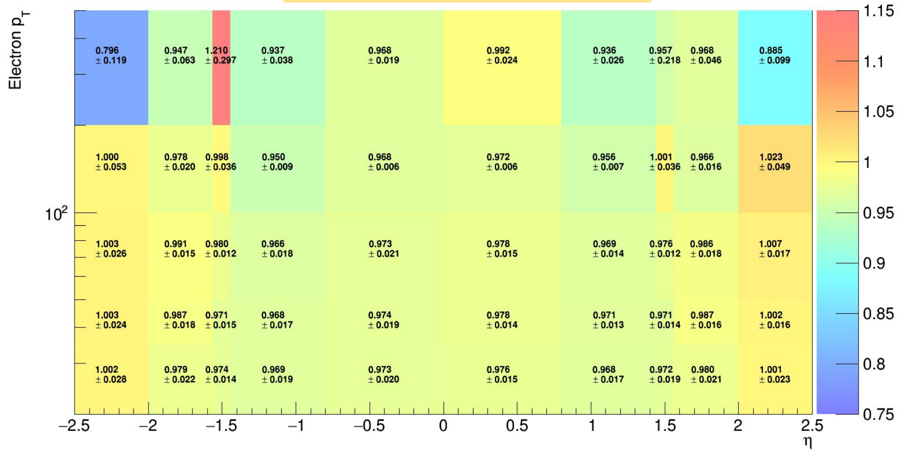
Table with selection cuts applied per lepton for the lepton scale factors obtained from the Tag and Probe method

	Electrons	Muons
Event selection	$60 < m_{\ell\ell} < 120\,\mathrm{GeV}$ HLT_Ele35(27/32)_WPTight_Gsf	$70 < m_{\ell\ell} < 130\,\mathrm{GeV}$ HLT_IsoMu27(24)
Tag lepton	analysis electron match trigger primitive	analysis muon match trigger primitive
Probe lepton	cut based medium ID	medium ID and $I_{\mathrm{rel}} < 0.15$
Cuts to probe	$\lvert d_0 \rvert < 0.05\,\mathrm{cm}$, $\lvert d_z \rvert < 0.10\,\mathrm{cm}$, $S^{\mathrm{d}}_{\mathrm{3D}} < 4$, $N^{inn.tracker}_{\mathrm{miss.\ hits}} = 0$	$\lvert d_0 \rvert < 0.05\,\mathrm{cm}$, $\lvert d_z \rvert < 0.10\,\mathrm{cm}$, $S^{\mathrm{d}}_{\mathrm{3D}} < 4$
Varying cuts for systematics	tag MVA Iso wp90 ID $p_{\mathrm{T}}^{\mathrm{miss}} < 50\,\mathrm{GeV}$ $N_{\mathrm{jets}} = 0$	tag $I_{\mathrm{rel}} < 0.1$, $I_{\mathrm{rel}} < 0.3$ $p_{\mathrm{T}}^{\mathrm{miss}} < 50\,\mathrm{GeV}$ $N_{\mathrm{jets}} = 0$ $75 < m_{\ell\ell} < 140\,\mathrm{GeV}$, $65 < m_{\ell\ell} < 120\,\mathrm{GeV}$

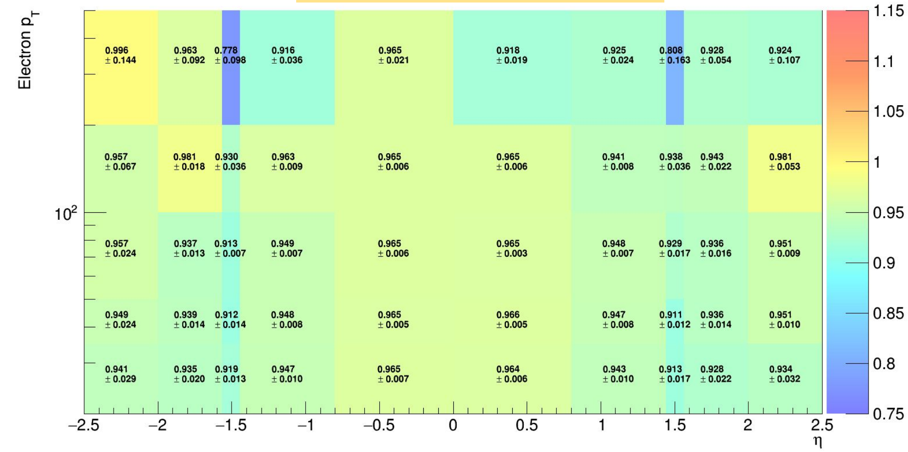
Lepton Additional Scale Factors

Electrons

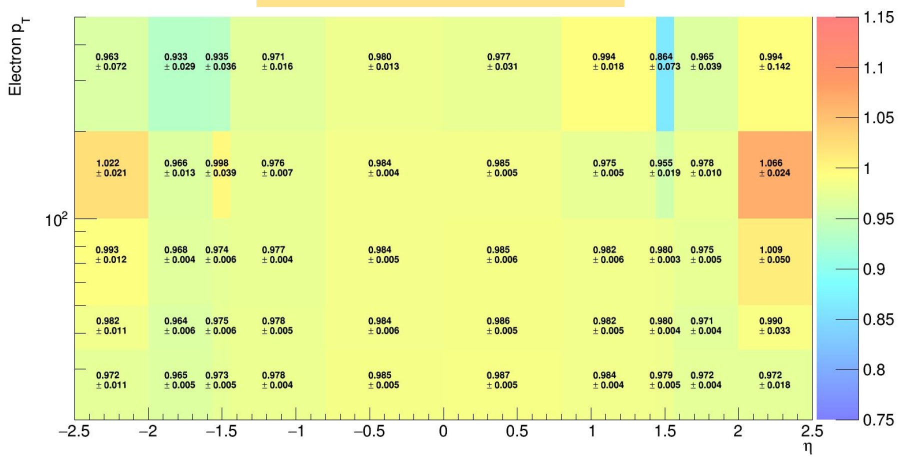
2016-HIPM



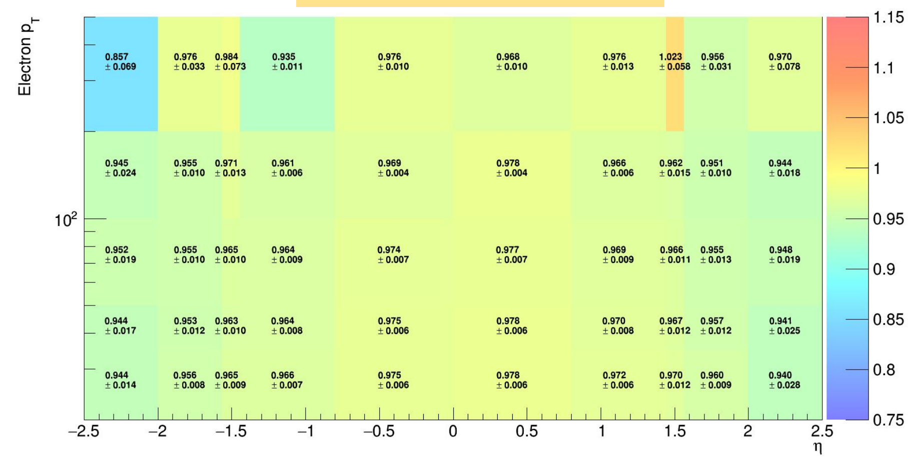
2016-noHIPM



2017



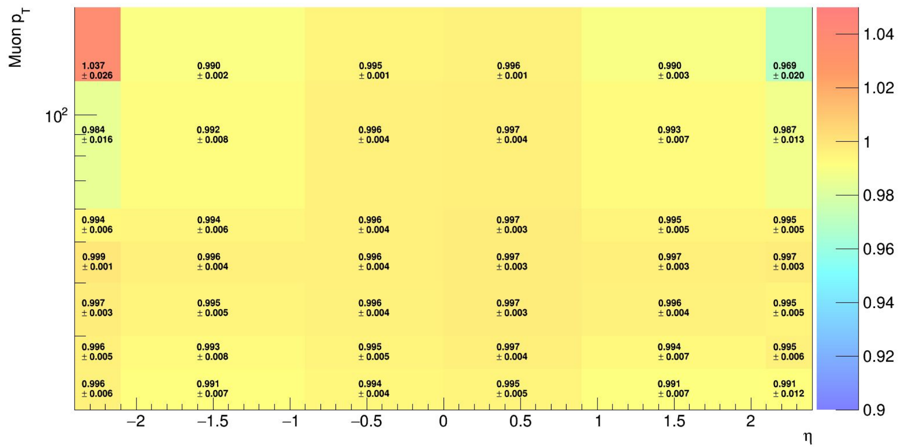
2018



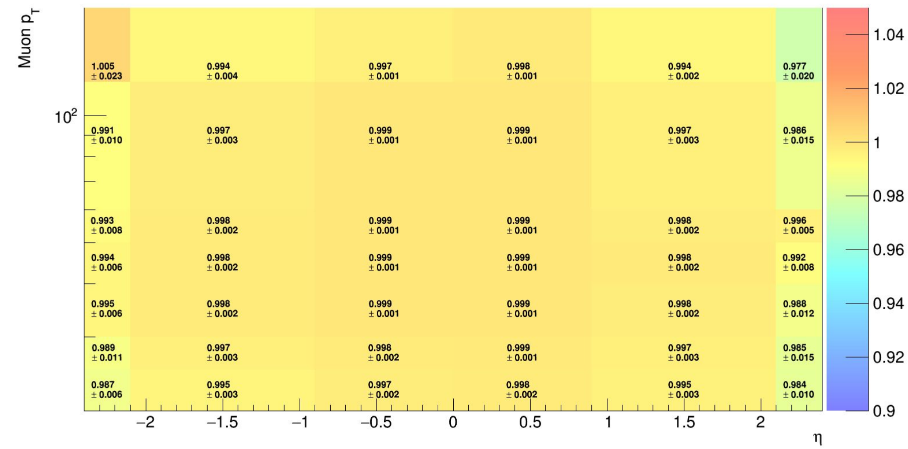
Lepton Additional Scale Factors

Muons

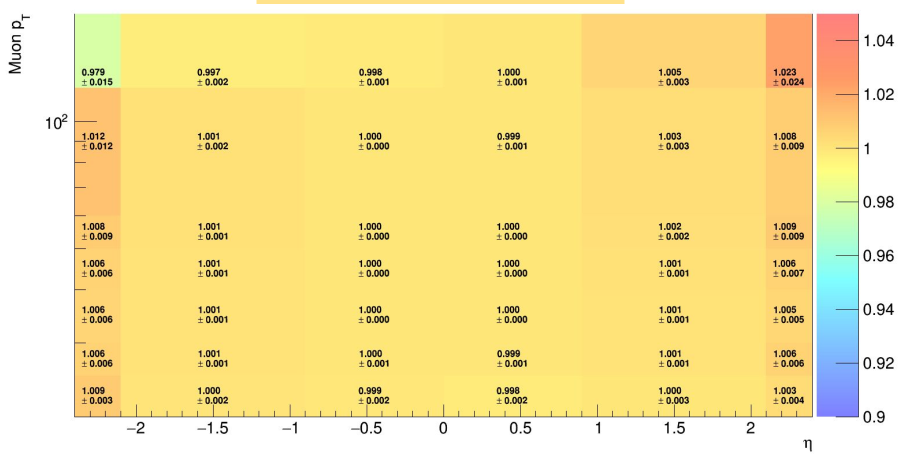
2016-HIPM



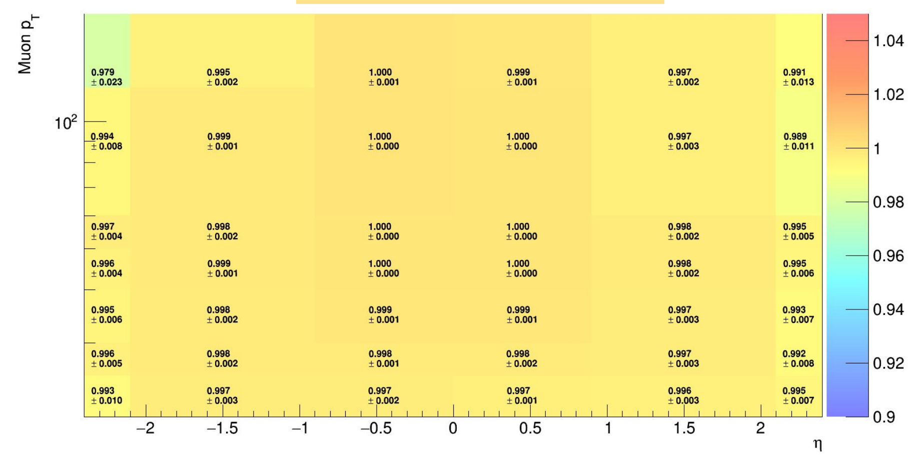
2016-noHIPM



2017



2018

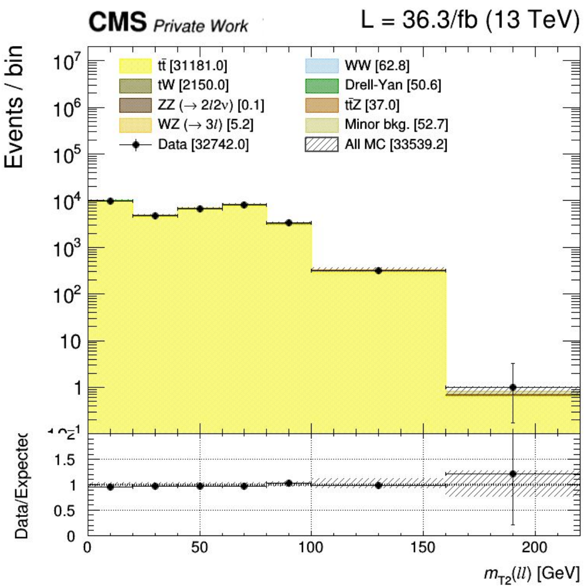


CRs: $100<p_T^{miss}<140$ GeV

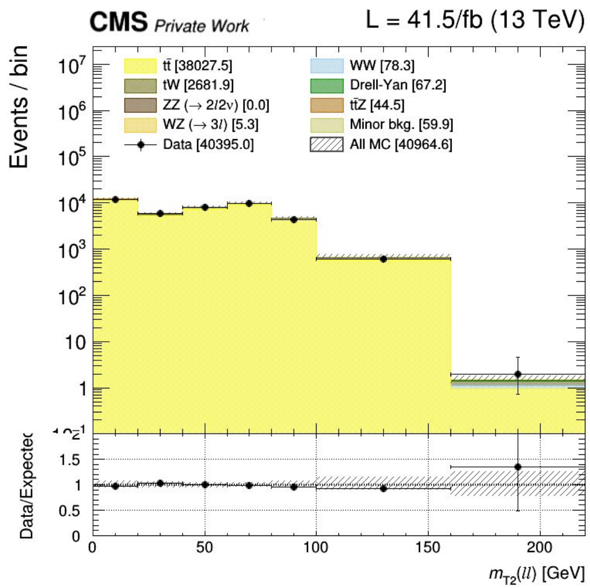
Events with:

- $100<p_T^{miss}<140$ GeV
- ≥1 b-tagged jets,   eμ channel

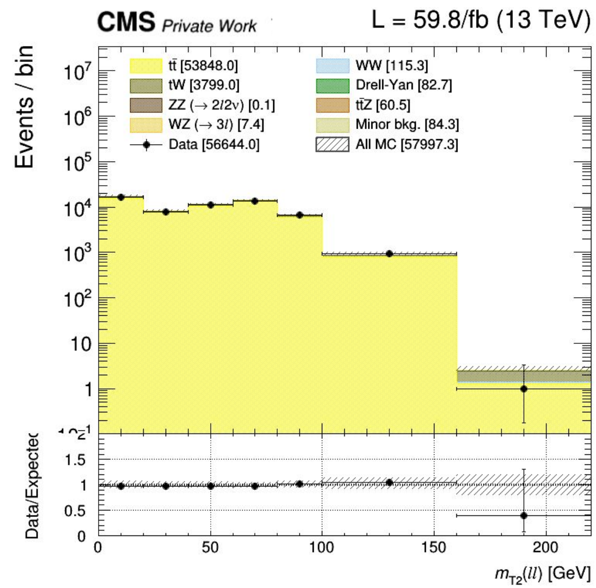
2016



2017



2018

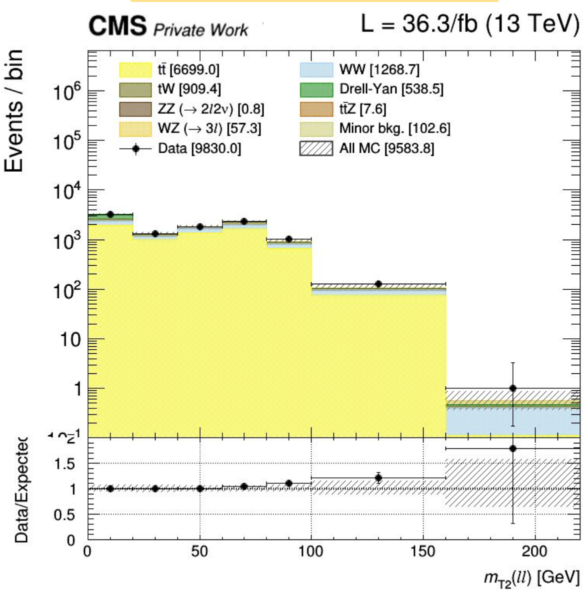


CRs: $100<p_T^{miss}<140$ GeV

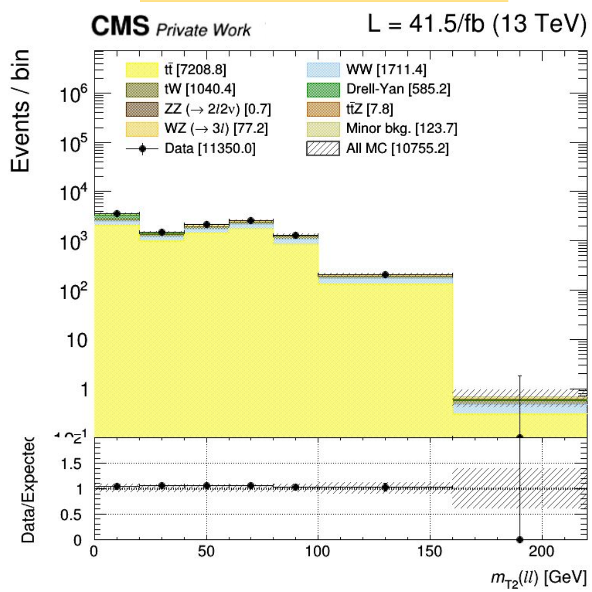
Events with:

- $100<p_T^{miss}<140$ GeV
- ≥1jets but 0 b-tagged jets, eμ channel

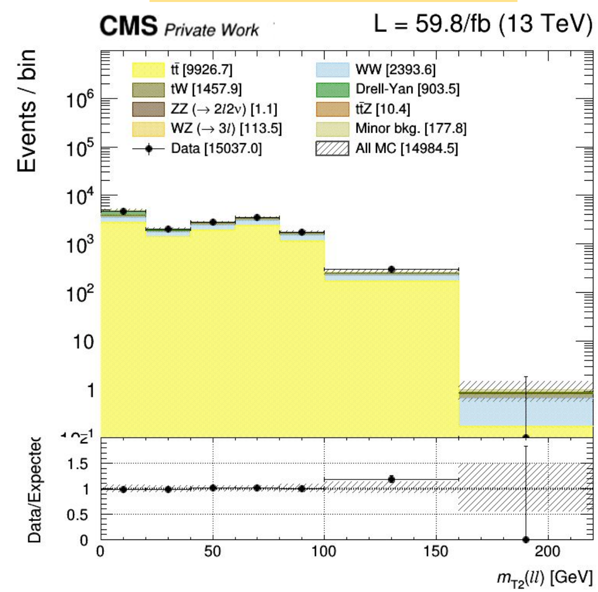
2016



2017



2018

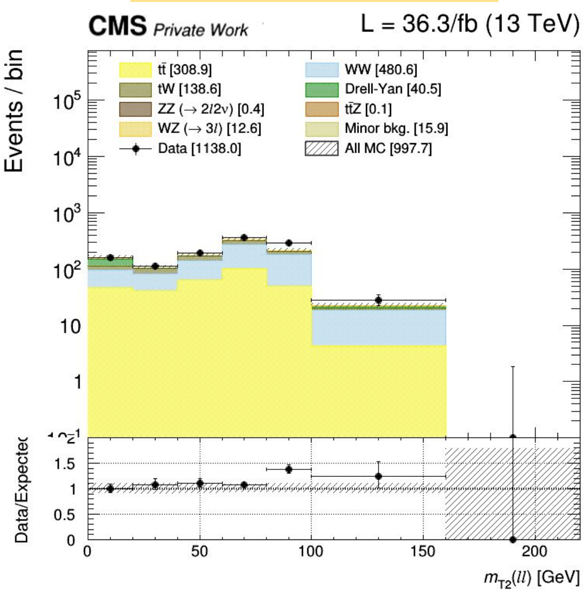


CRs: $100<p_T^{miss}<140$ GeV

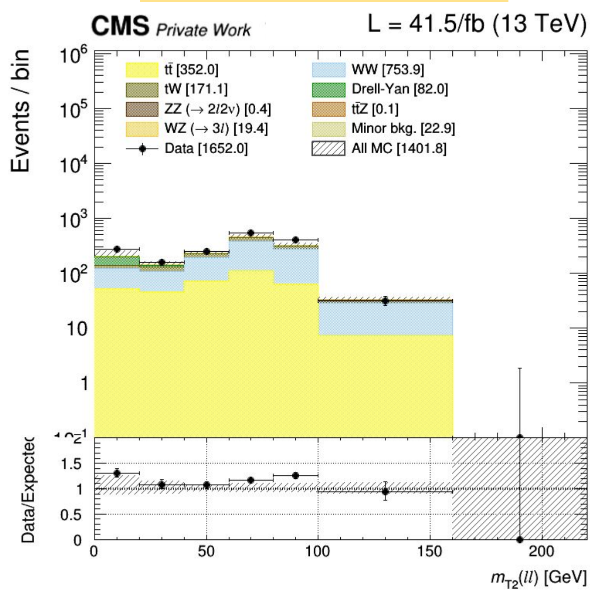
Events with:

- $100<p_T^{miss}<140$ GeV
- no jets, eμ channel

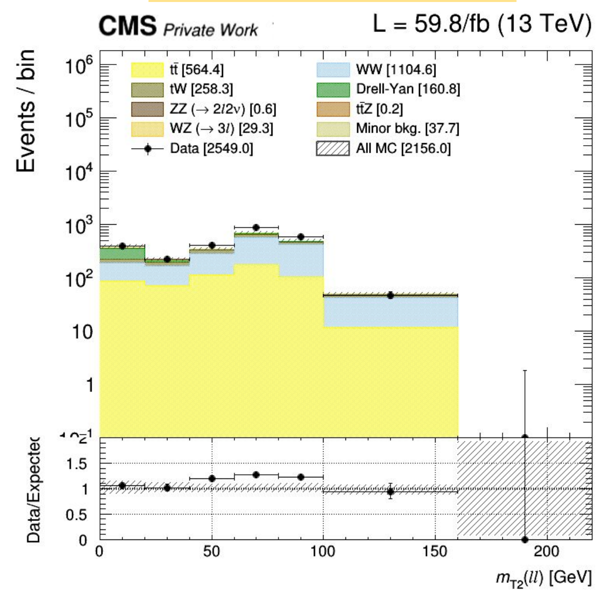
2016



2017



2018



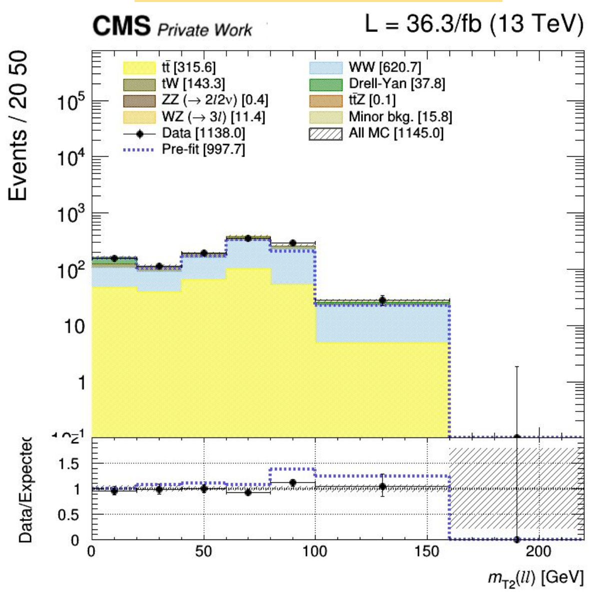
CRs: $100<p_T^{miss}<140$ GeV

Events with:

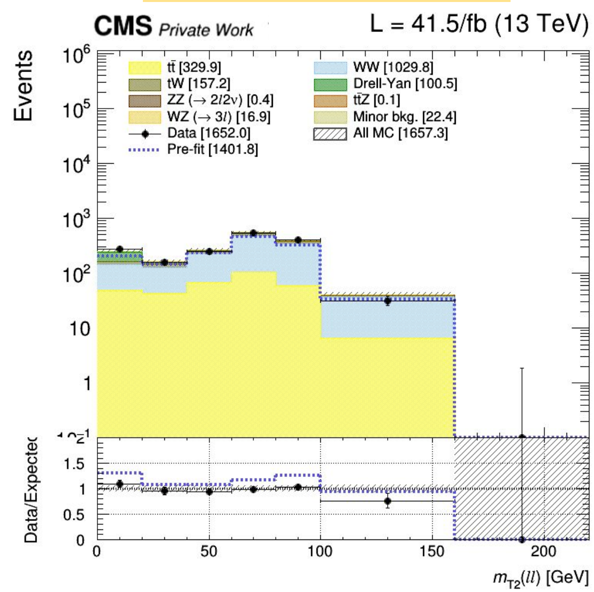
- $100<p_T^{miss}<140$ GeV
- no jets, eμ channel

Postfit

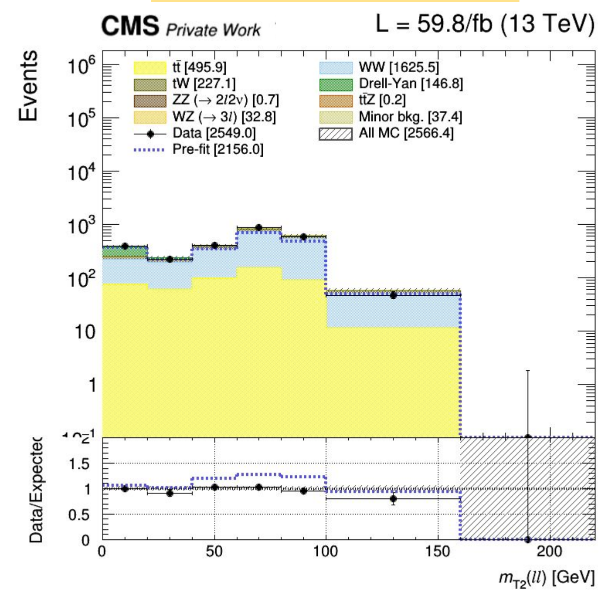
2016



2017



2018



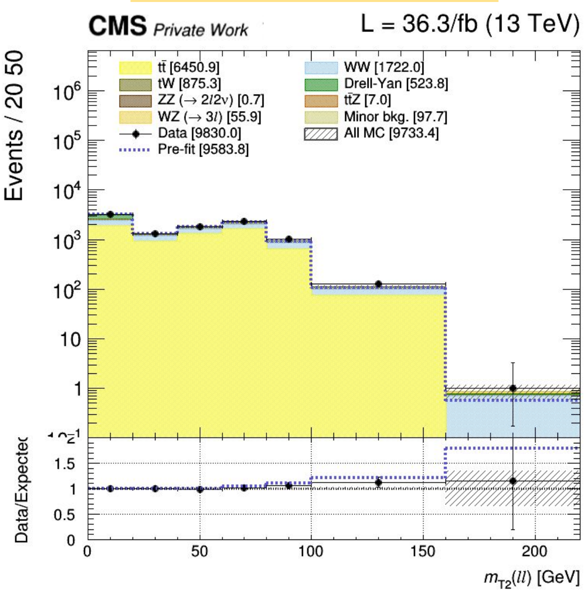
CRs: $100<p_T^{miss}<140$ GeV

Events with:

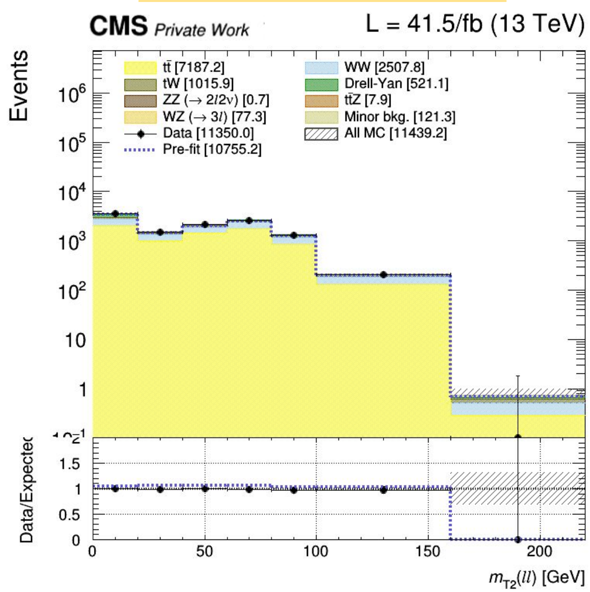
- $100<p_T^{miss}<140$ GeV
- ≥1jets but 0 b-tagged jets, eμ channel

Postfit

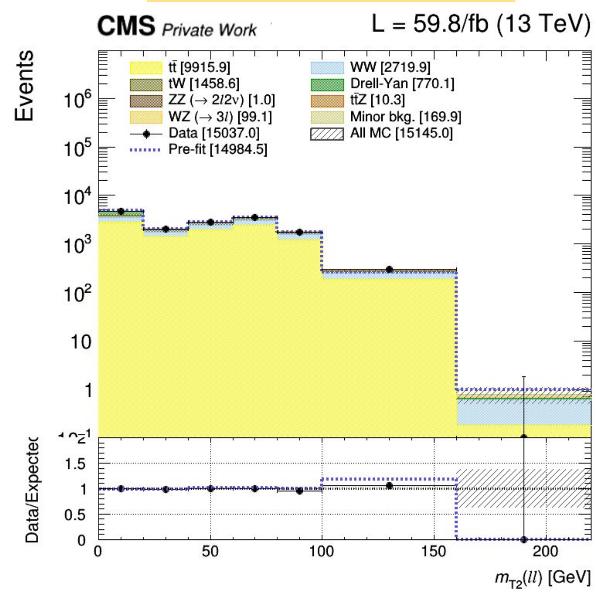
2016



2017



2018



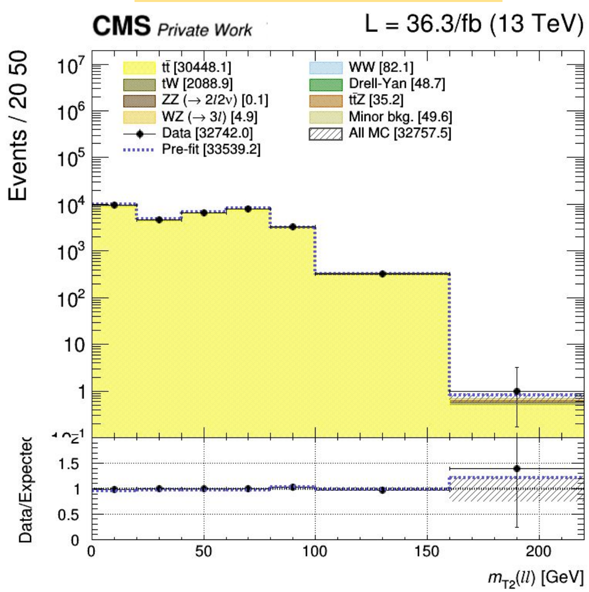
CRs: $100<p_T^{miss}<140$ GeV

Events with:

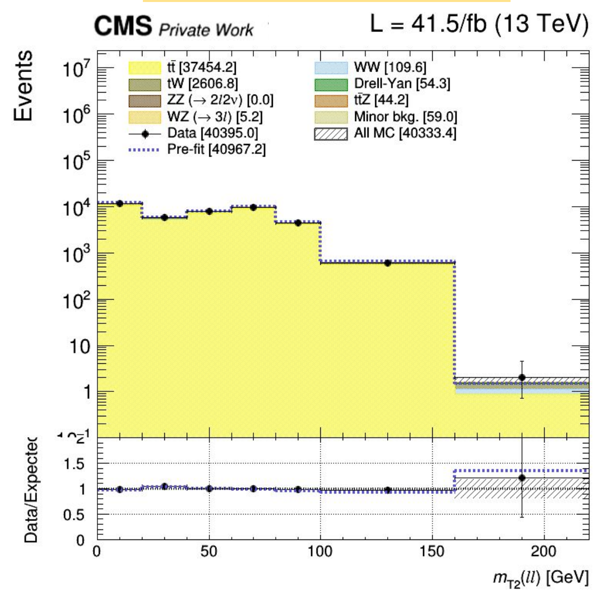
- $100<p_T^{miss}<140$ GeV
- ≥1jets, eμ channel

Postfit

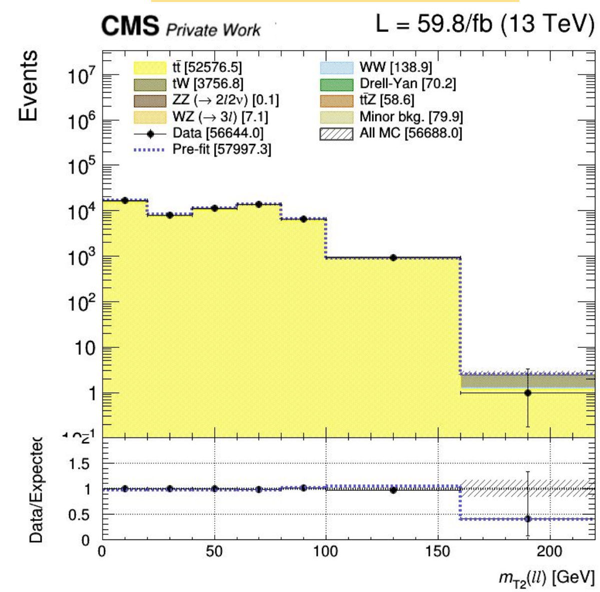
2016



2017



2018



Summary of Included Systematics (Stop)

Source of uncertainty	SR1 $160 \leq p_T^{miss} < 220\,GeV$ Yields	$m_{T2}(\ell\ell)$ shape	SR2 $220 \leq p_T^{miss} < 280\,GeV$ Yields	$m_{T2}(\ell\ell)$ shape	SR3 $280 \leq p_T^{miss} < 380\,GeV$ Yields	$m_{T2}(\ell\ell)$ shape	SR4 $p_T^{miss} \geq 380\,GeV$ Yields	$m_{T2}(\ell\ell)$ shape
Integrated luminosity	1–3%	—	1–3%	—	1–3%	—	1–3%	—
Trigger efficiency	2%	< 1%	2%	< 1%	2%	< 1%	2%	< 1%
Pileup	≤ 2%	3–9%	≤ 1%	2–12%	≤ 1%	2–20%	< 1%	3–18%
Jet energy scale	3–8%	3–10%	3–7%	2–8%	3–6%	2–5%	3–6%	3–7%
Jet energy resolution	1–2%	2–8%	1–2%	2–8%	1–2%	2–5%	1–2%	2–8%
Unclustered energy	1–2%	5–10%	1–2%	3–7%	1–2%	2–11%	1–2%	3–13%
Prefiring	< 1%	≤ 1%	1%	< 1%	< 1%	< 1%	< 1%	≤ 1%
Lepton reconstruction	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Lepton ident./isolation	2–4%	≤ 2%	2–3%	≤ 3%	1–3%	1–5%	2–4%	1–15%
Lepton additional cuts	1%	≤ 1%	1%	< 1%	1%	< 1%	1%	≤ 1%
b tagging	1–4%	≤ 4%	1–5%	≤ 4%	≤ 5%	≤ 2%	≤ 3%	≤ 6%
b tagging (light jets)	< 1%	≤ 2%	< 1%	≤ 3%	< 1%	≤ 1%	< 1%	≤ 2%
Simulated samples statistics	< 1%	4–18%	≤ 2%	5–21%	1–2%	12–29%	1–3%	18–37%
Renorm./fact. scales	2–3%	1–15%	5–6%	2–7%	10–16%	2–5%	13–23%	2–13%
PDFs	< 1%	≤ 1%	< 1%	≤ 2%	< 1%	≤ 2%	≤ 2%	≤ 9%
Drell–Yan normalization	≤ 5%	≤ 26%	≤ 6%	≤ 16%	≤ 7%	≤ 8%	≤ 7%	≤ 7%
tW normalization	< 1%	≤ 2%	1%	≤ 1%	1%	≤ 1%	1–2%	1–3%
Minor bkg. normalization	< 1%	1–5%	≤ 1%	1–8%	≤ 2%	1–3%	1–3%	1–5%
$m_{T2}(\ell\ell)$ tails (m_W endpoint)	1–2%	5–14%	1%	6–16%	< 1%	5–14%	< 1%	5–20%
$m_{T2}(\ell\ell)$ tails (WZ)	—	< 1%	< 1%	< 1%	—	—	< 1%	≤ 7%
Nonprompt leptons	< 1%	≤ 8%	< 1%	≤ 7%	< 1%	≤ 2%	< 1%	≤ 3%
$t\bar{t}$ p_T reweighting	1–2%	2–3%	2–4%	2–6%	2–4%	1–3%	2–6%	1–4%

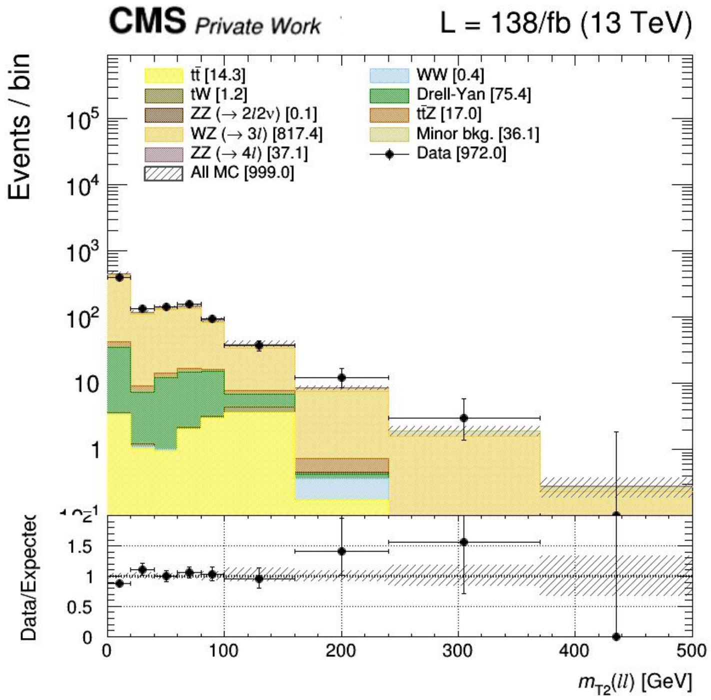
Systematic uncertainties for SM processes in the stop SRs

Source of uncertainty	SR1 $160 \leq p_T^{miss} < 220\,GeV$ Yields	$m_{T2}(\ell\ell)$ shape	SR2 $220 \leq p_T^{miss} < 280\,GeV$ Yields	$m_{T2}(\ell\ell)$ shape	SR3 $280 \leq p_T^{miss} < 380\,GeV$ Yields	$m_{T2}(\ell\ell)$ shape	SR4 $p_T^{miss} \geq 380\,GeV$ Yields	$m_{T2}(\ell\ell)$ shape
Integrated luminosity	1–3%	—	1–3%	—	1–3%	—	1–3%	—
Trigger efficiency	2%	< 1%	2%	< 1%	2%	< 1%	2%	< 1%
Pileup	≤ 1%	1–3%	≤ 2%	1–7%	≤ 2%	1–7%	≤ 2%	≤ 7%
Jet energy scale	≤ 4%	1–4%	≤ 5%	2–6%	≤ 4%	2–6%	≤ 4%	2–7%
Jet energy resolution	< 1%	1–4%	< 1%	1–4%	≤ 1%	1–3%	< 1%	1–5%
Unclustered energy	< 1%	1–4%	< 1%	1–7%	≤ 1%	2–6%	< 1%	1–7%
Prefiring	< 1%	< 1%	1%	< 1%	< 1%	< 1%	< 1%	≤ 1%
Lepton reconstruction	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Lepton ident./isolation	1–3%	≤ 2%	1–3%	≤ 3%	1–4%	≤ 2%	1–3%	1–6%
Lepton additional cuts	1%	< 1%	1%	< 1%	1%	< 1%	1%	< 1%
b tagging	1%	< 1%	1%	< 1%	1%	< 1%	≤ 1%	< 1%
b tagging (light jets)	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Simulated samples statistics	1–3%	4–7%	2–4%	6–13%	3–5%	8–16%	3–5%	10–16%
Renorm./fact. scales	< 1%	< 1%	1%	< 1%	1–2%	< 1%	2%	≤ 1%
Nonprompt leptons	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
ISR reweighting	2–3%	2–3%	4–5%	1–3%	5–6%	≤ 2%	6–8%	≤ 4%
Lepton ident./isolation (FastSim)	4.0%	—	4.0%	—	4.0%	—	4.0%	—
b tagging (FastSim)	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
p_T^{miss} (FastSim)	≤ 5%	2–8%	≤ 6%	≤ 14%	≤ 5%	3–18%	4–8%	4–15%

Systematic uncertainties for stop pair production (m_S=400 GeV, m_X=275GeV)

CRs: High p_T^{miss}

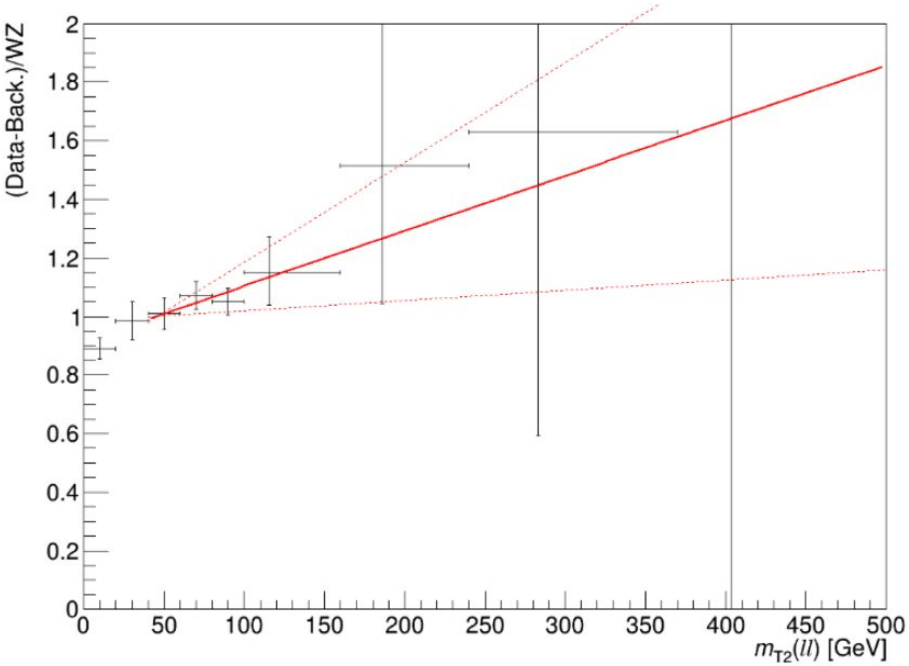
- We check the description of the tails of the m_{T2} distributions at high p_T^{miss} for backgrounds with mW endpoint in WZ events:
  - Event selected with three leptons
  - Candidate Z with $|m_{ll}-m_Z|<15$ GeV
  - Adding to p_T^{miss} the p_T of the Z lepton with same charge as the third lepton
  - Selecting events with $p_T^{miss}>160$ GeV
  - m_{T2} is computed with the other two leptons



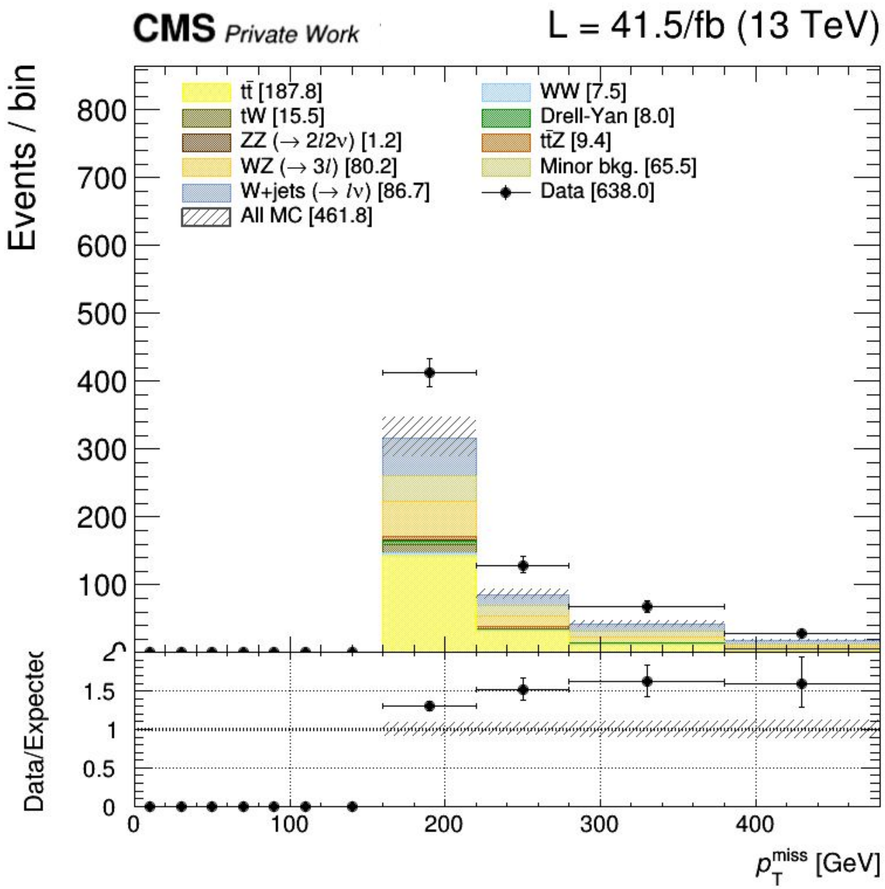
CRs: High p_T^{miss}

Slight excess in the last bins quantified by fitting the ratio of the (background-subtracted) observed events
to the expected WZ events, using a linear function.

- Result of the fit taken to correct m_{T2} modelling of WZ events
- Errors in the fit taken as uncertainties in the correction



Nonprompt Lepton Rate

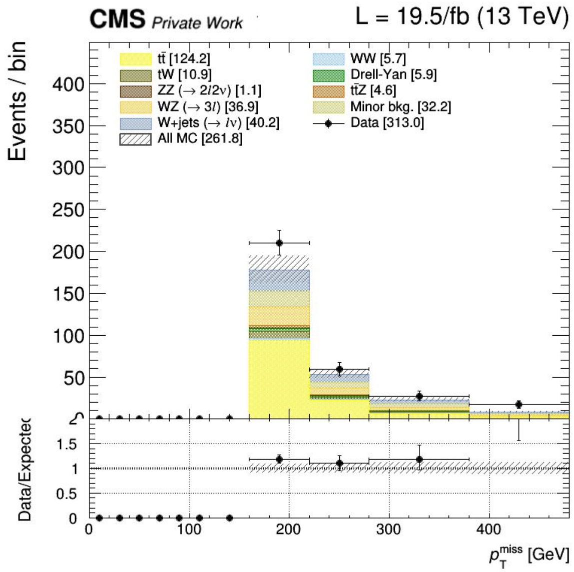


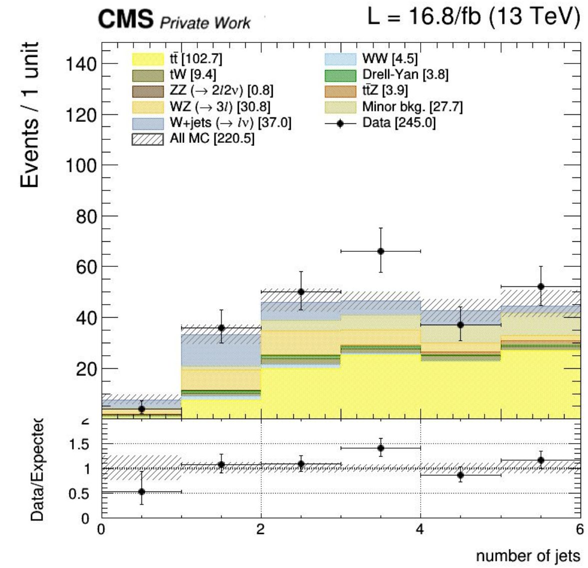
year		value
2016	HIPM	1.18 ±0.30
	noHIPM	1.10 ±0.40
2017		1.38 ±0.29
2018		1.36 ±0.25

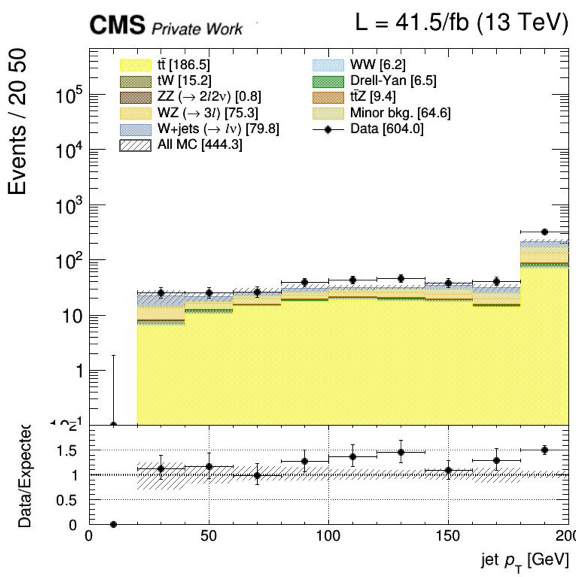
- Rate of nonprompt leptons tested in same-sign events
  - Around 10-40% excess in data

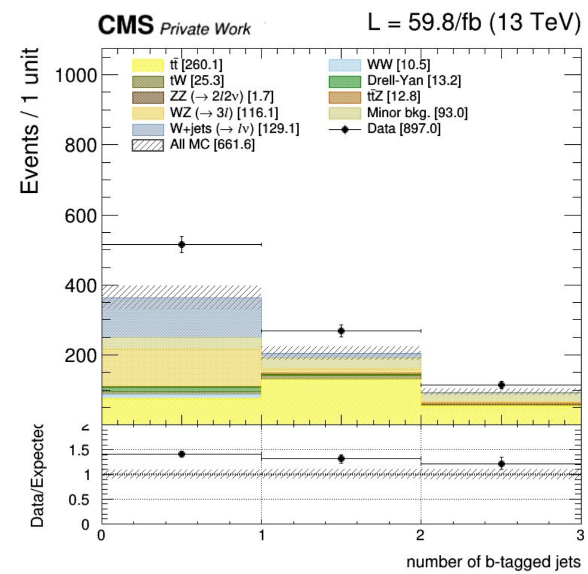
- Uncertainty calculated by taking the largest difference from the central value of a linear fit vs several kinematic variables

Nonprompt Lepton Rate
Example distributions





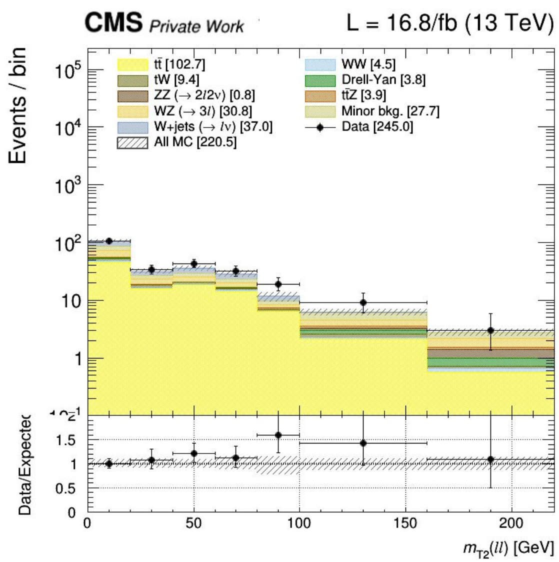




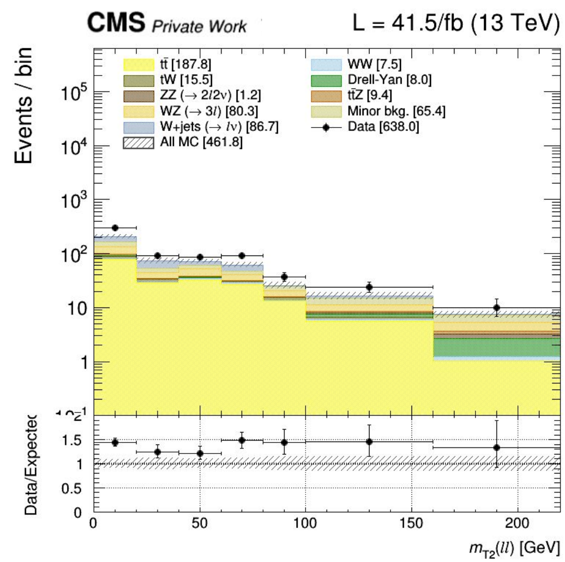
Non-Prompt Scale Factors

- Plots for the non-prompt scale factors split by year:

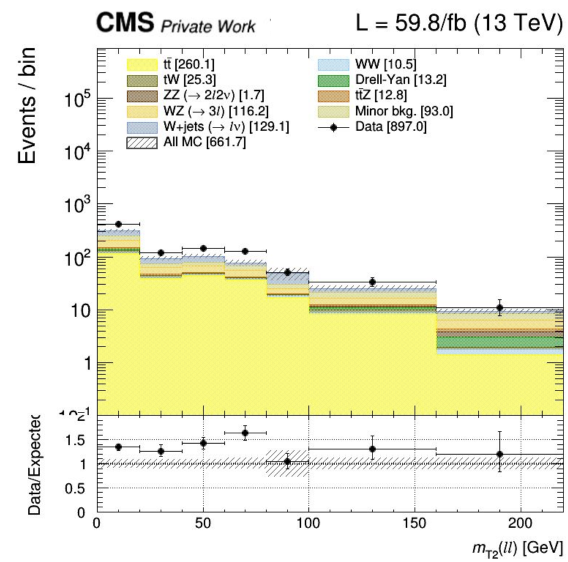
2016-noHIPM



2017

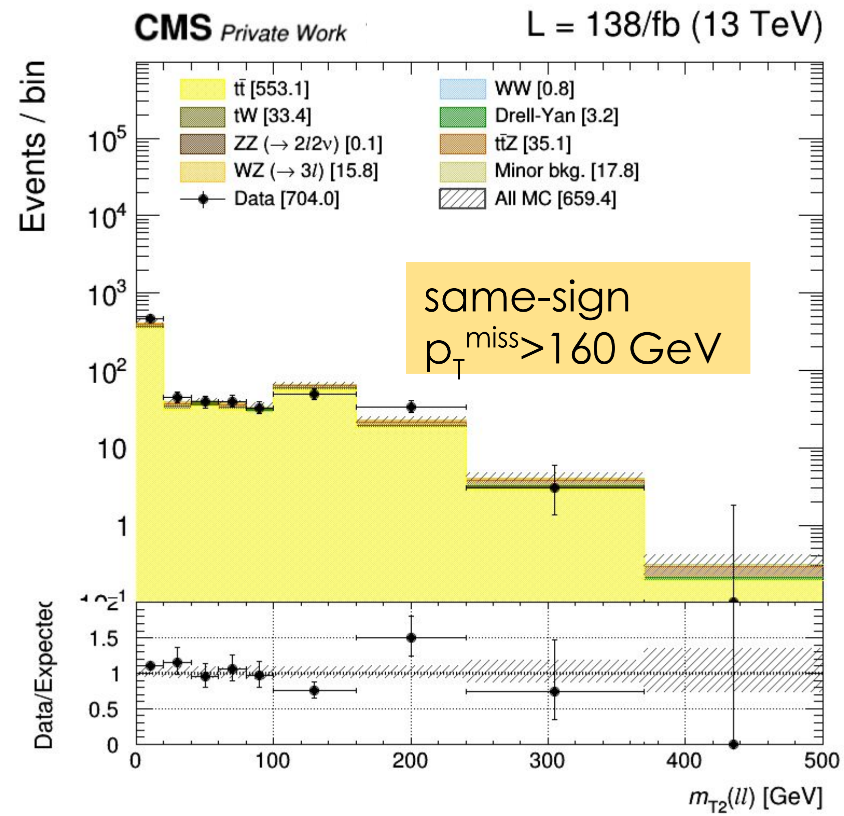


2018



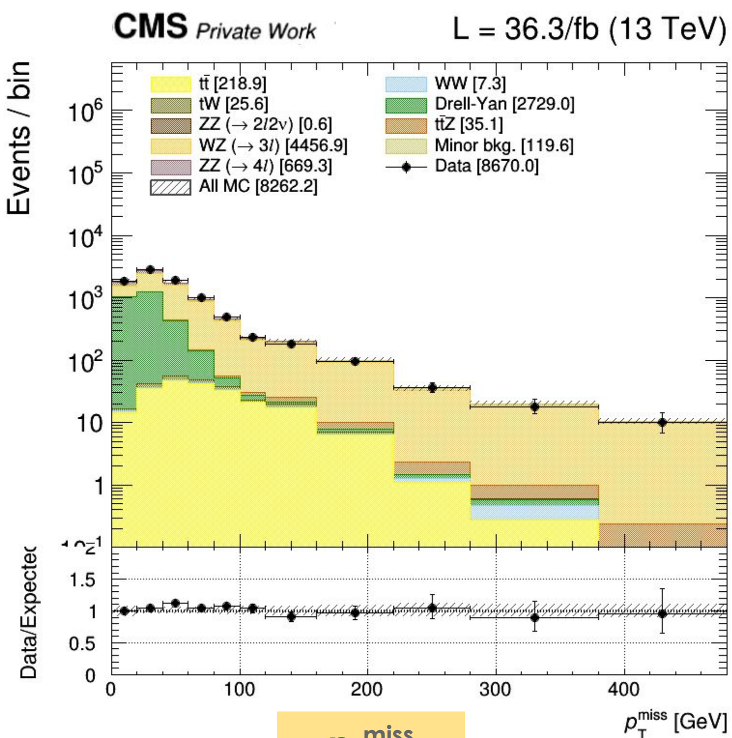
M_{T2} Shape Nonprompt Lepton

- Modelling of nonprompt leptons in m_{T2} shape validated in events with a third “looser” lepton:
  - Swapping the loose lepton with one of the two “tight” ones and recomputing m_{T2}
  - Reasonable agreement between the recomputed m_{T2} shape in data and simulations



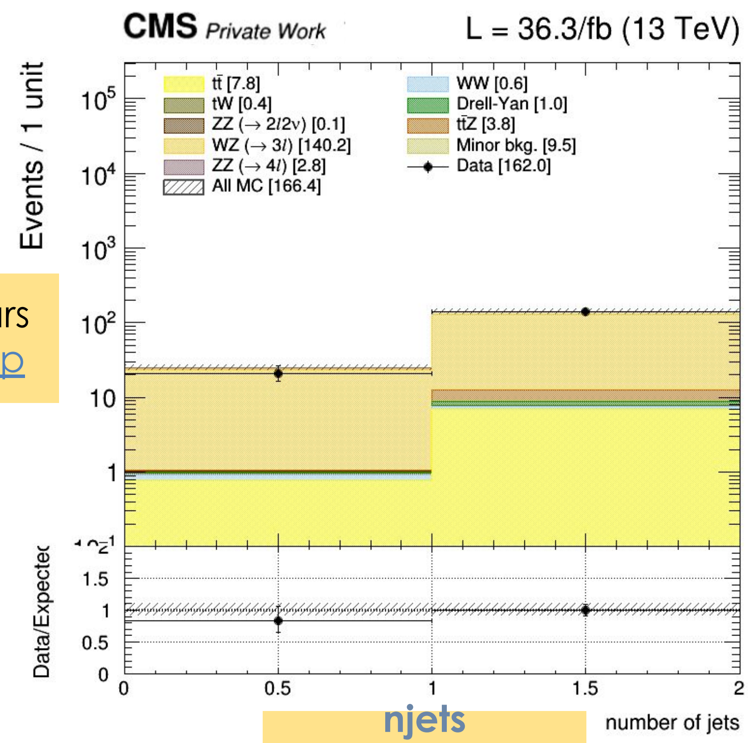
WZ Production (Normalization)

- WZ background is probed in events with three leptons and p_T^{miss}>160 GeV:
  - To constrain its normalisation, regions are included to the fit used for the signal, with the same p_T^{miss} and jet multiplicity bins.



p_T^{miss}

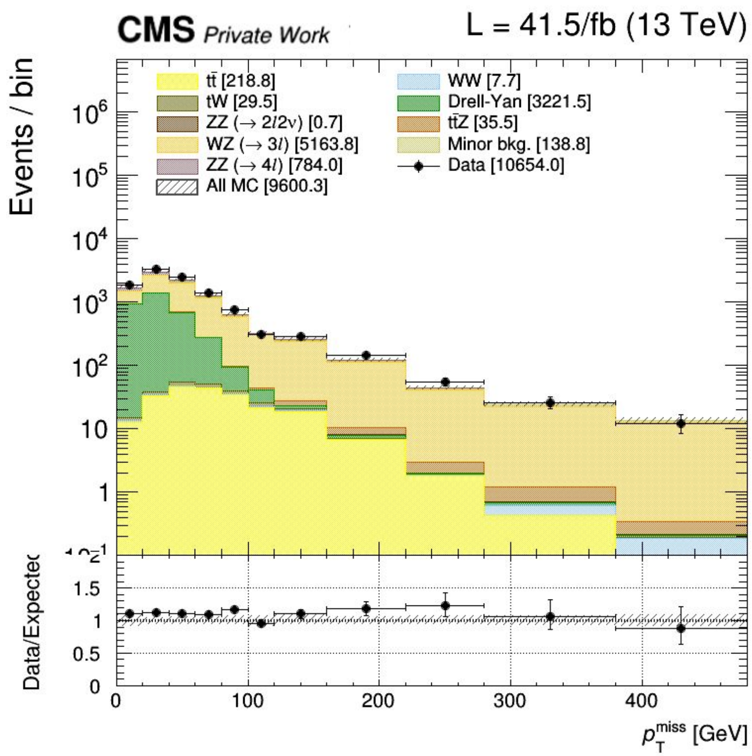
Other years on [backup](#)

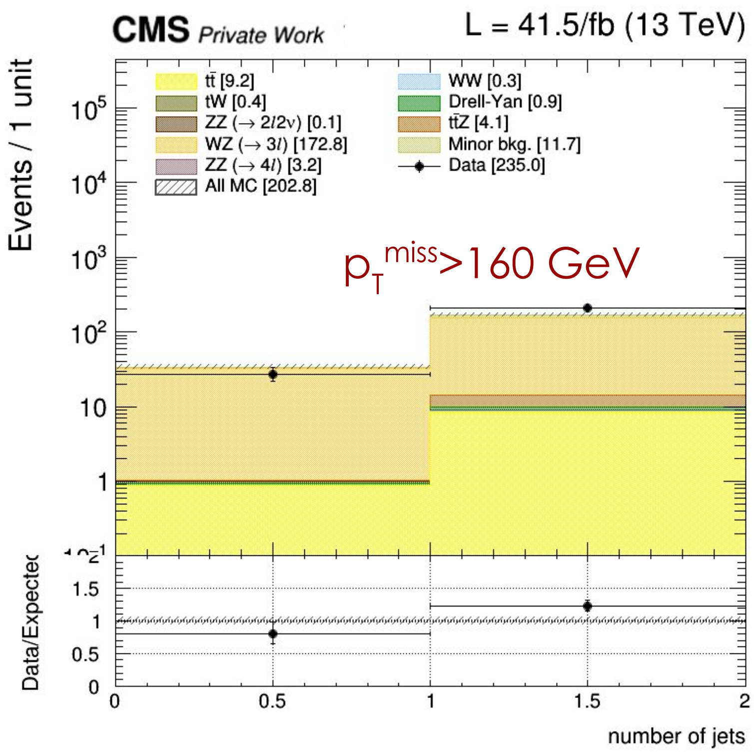


njets (p_T^{miss}>160 GeV)

WZ Production (Normalization)

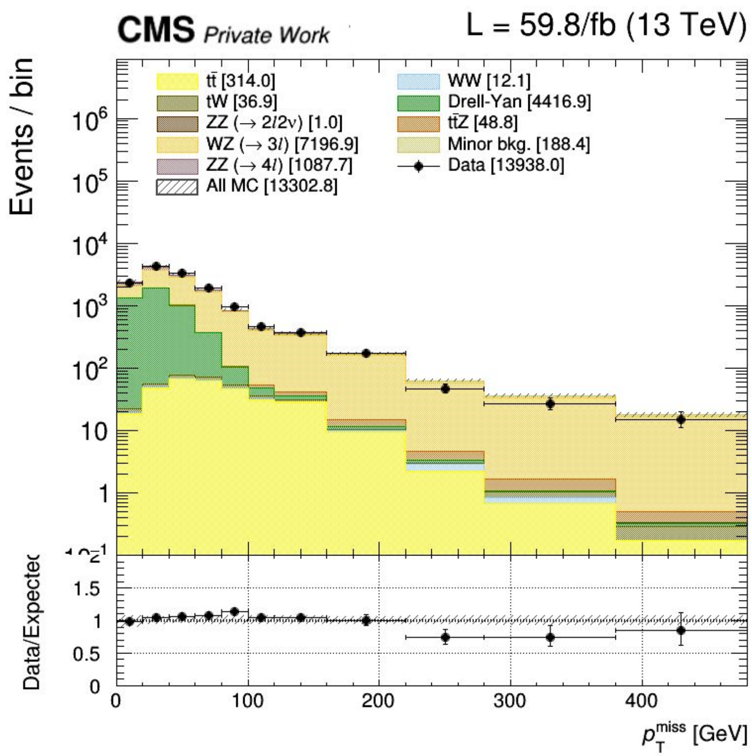
- Plots for WZ scale factors (**2017**):

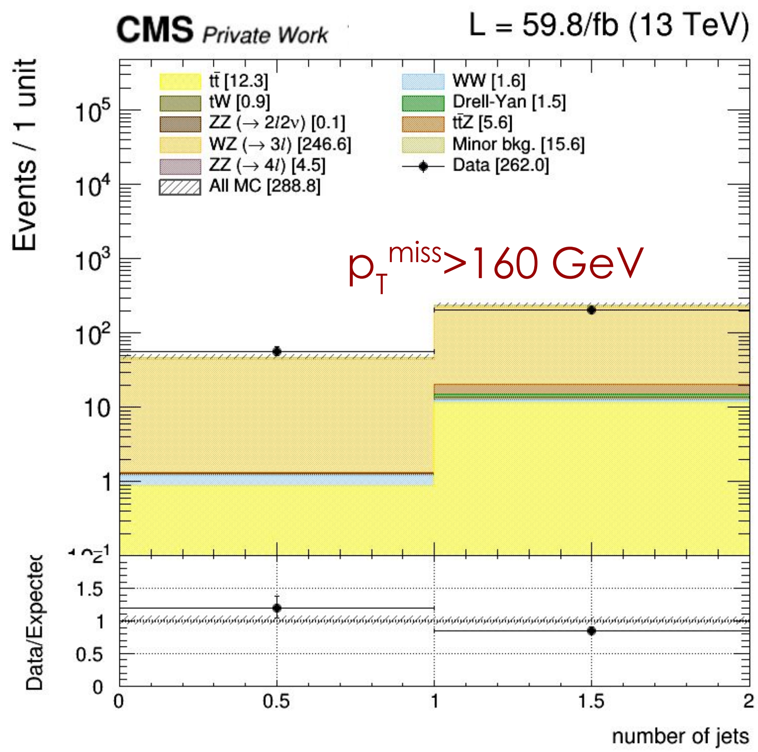




WZ Production (Normalization)

- Plots for WZ scale factors (**2018**):

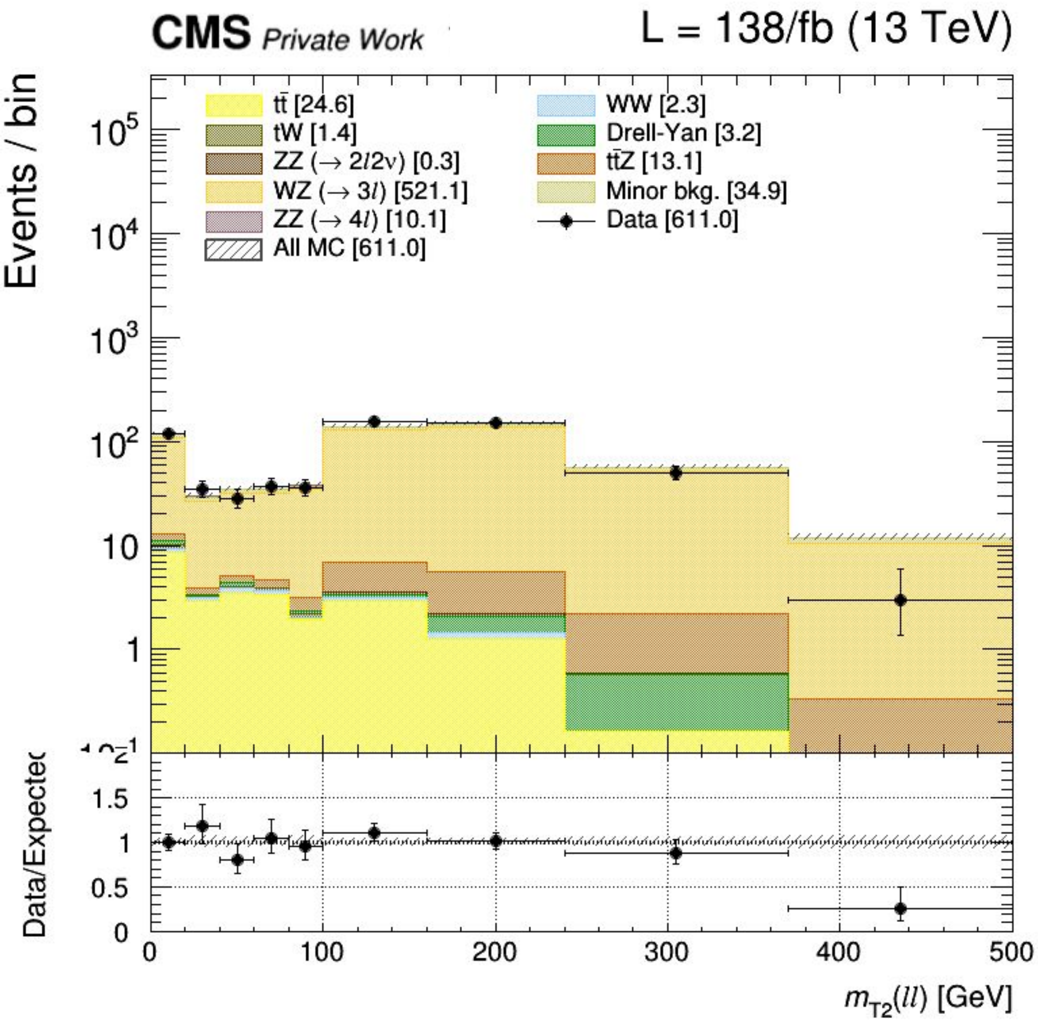




WZ Production (m_{T2} Shape)

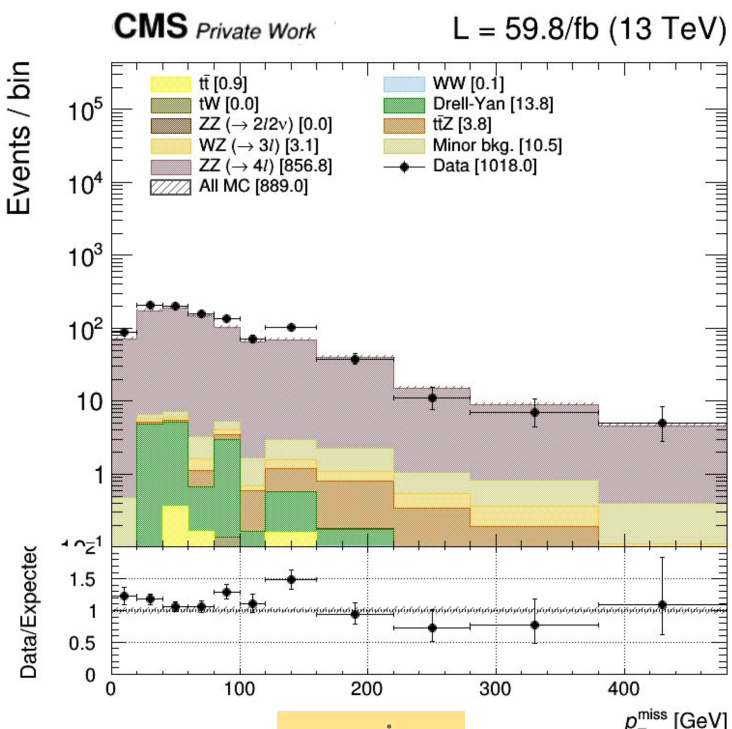
- We look at m_{T2} distribution:
  - To prevent normalisation bias, WZ events are normalized to data in the same CR bins used in the fit

- Hint for background overprediction at very high m_{T2} values
  - → A systematic uncertainty is added to cover from this effect



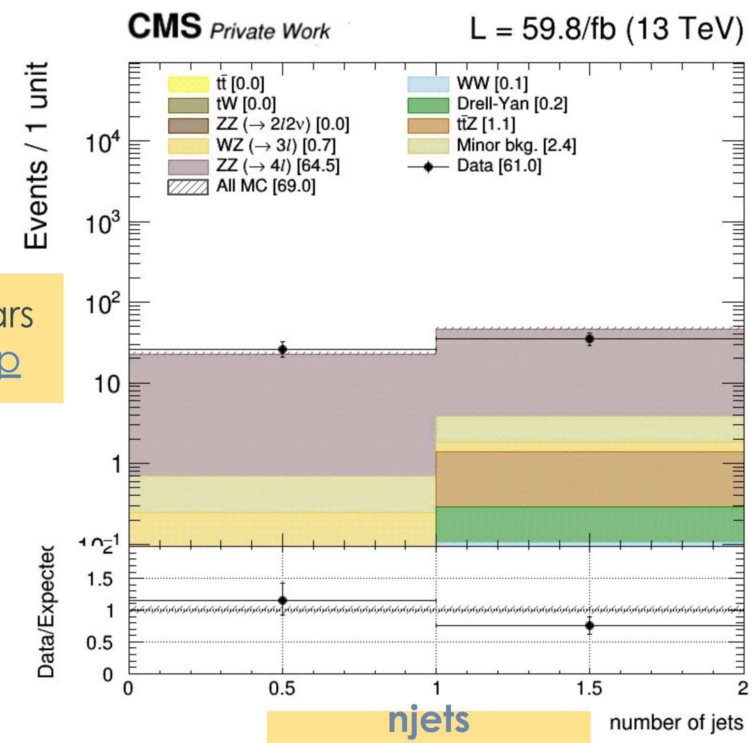
ZZ Production (Normalization)

- Modeling of events from ZZ → 2L2Nu process tested reconstructing ZZ → 4L events, and adding one Z boson's p_T to the p_T^{miss}
  - MC to data normalisation studied year by year in p_T^{miss} and njet variables, similarly to the WZ case :



p_T^{miss}

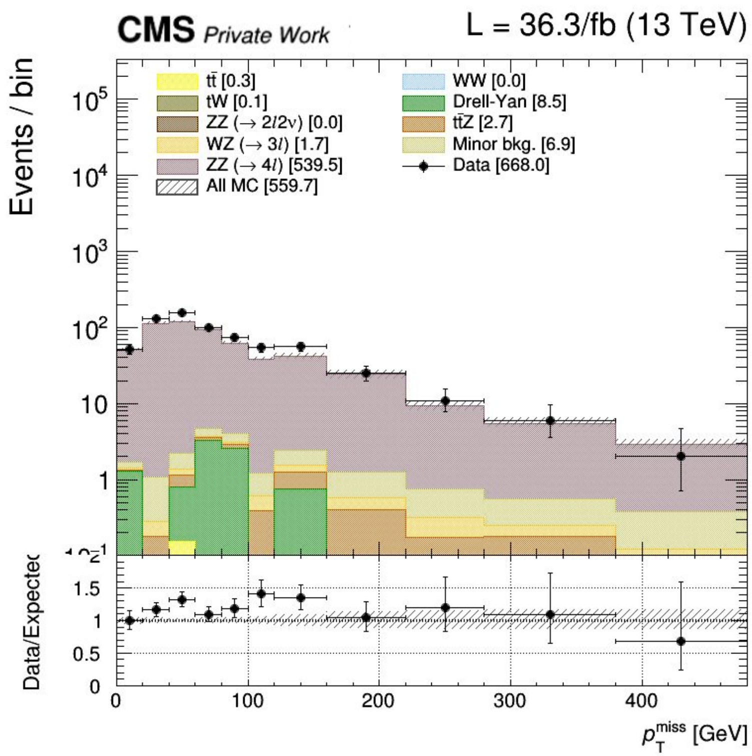
Other years in [backup]

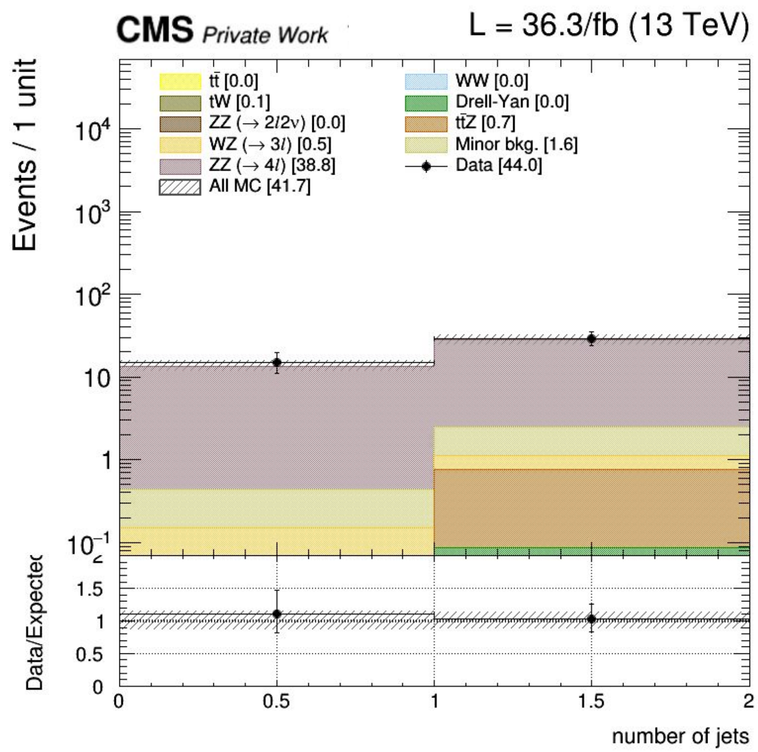


njets (p_T^{miss}>160 GeV)

ZZ Production (Normalization)

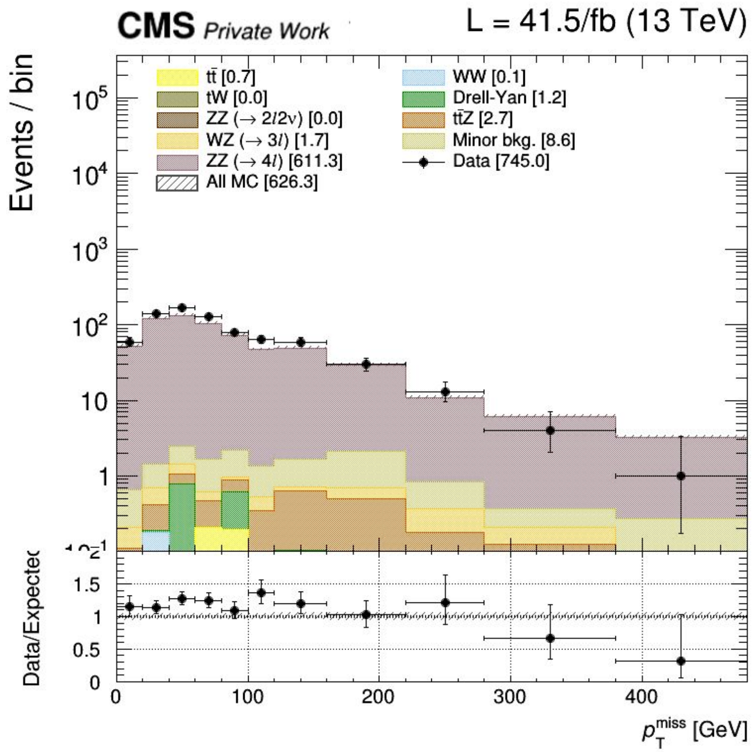
- Plots for ZZ scale factors (**2016**):

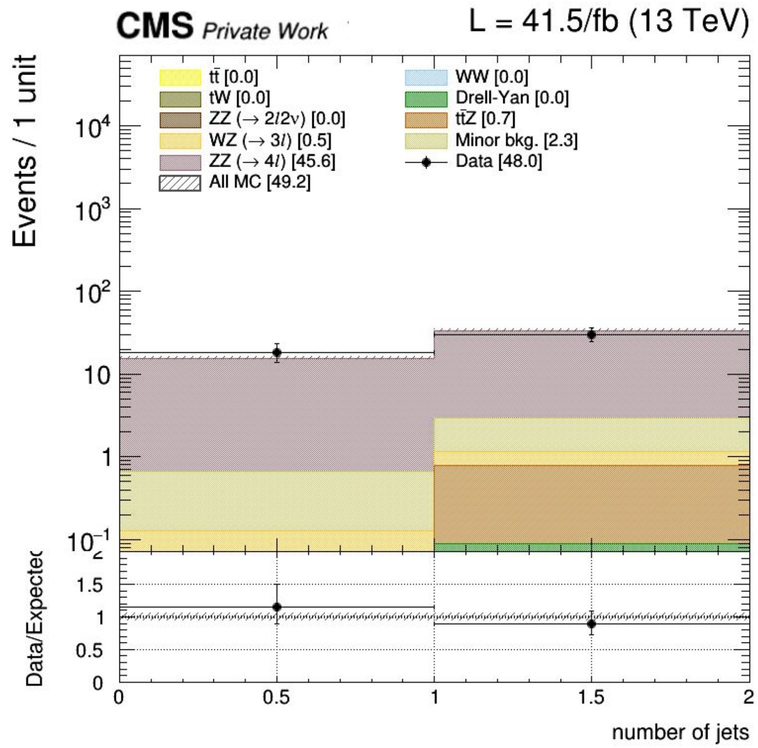




ZZ Production (Normalization)

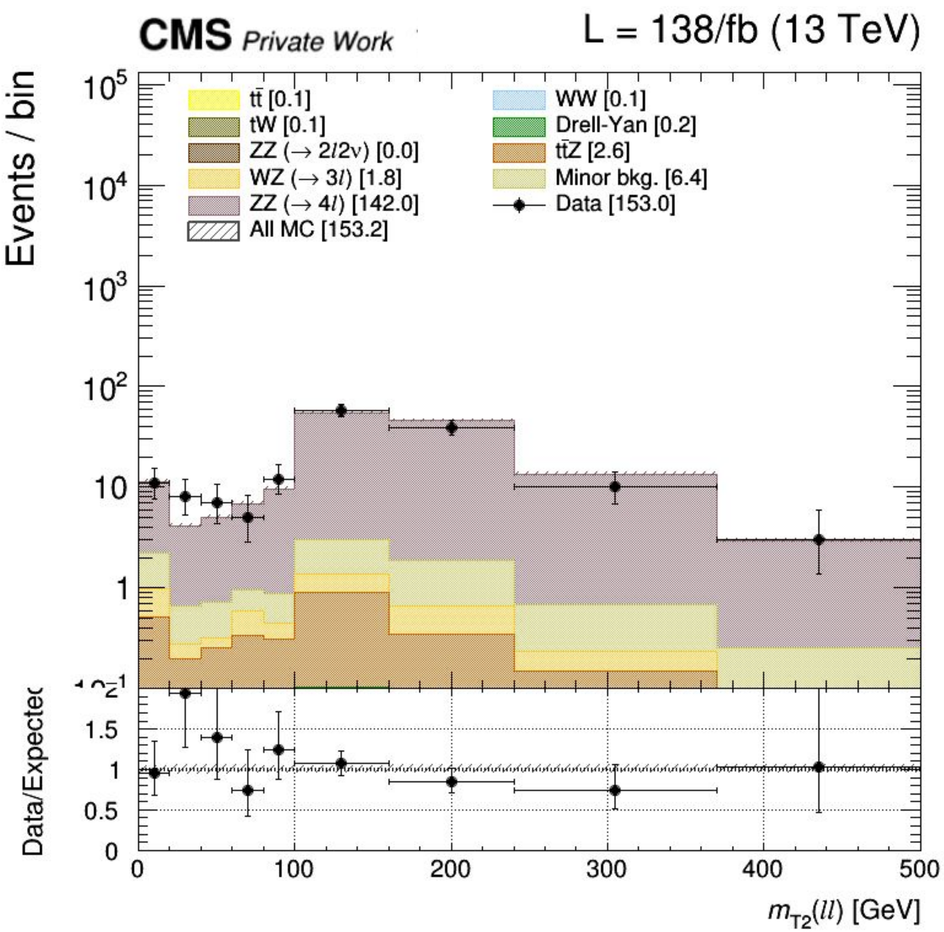
- Plots for ZZ scale factors (**2017**):





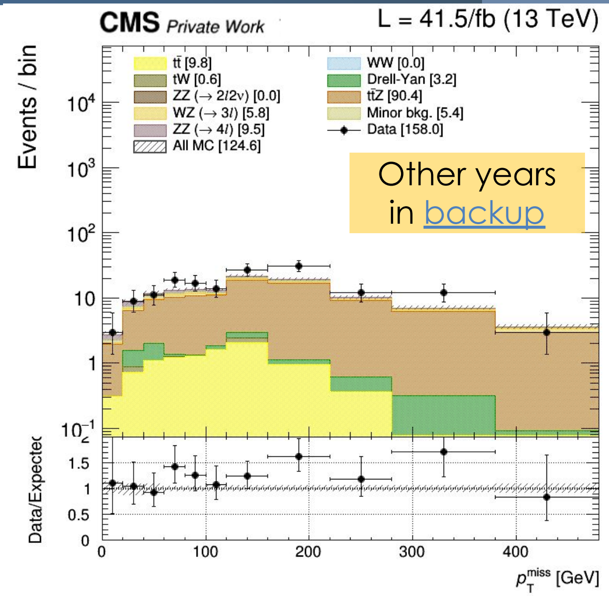
ZZ Production (m_{T2} Shape)

- The variable m_{T2} has been checked for ZZ→2l2ν events and p_T^{miss}>160, for the three year combination.
  - Similarly to the WZ, the ZZ events are normalized to data.
  - Good agreement within the limited statistics

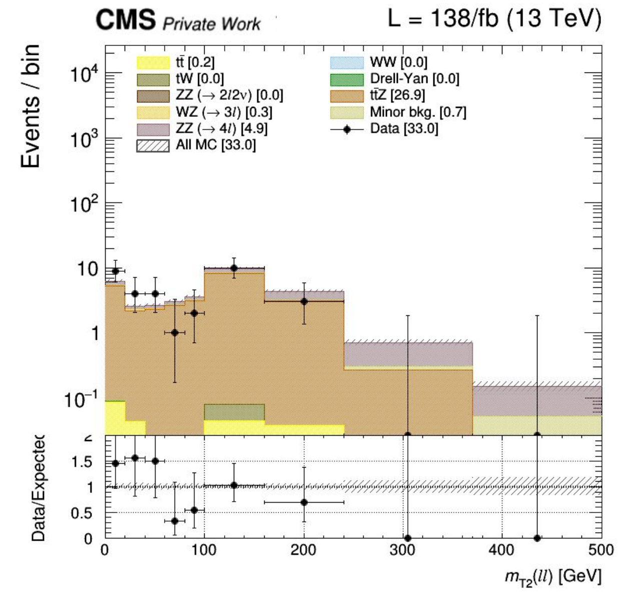


ttZ Events

- Control region for normalisation taken from: ttZ with Z→lν, with at least 3 leptons, two of them within the Z window, and at least one b-tagged jet (two if exactly three leptons)
  - MC underpredicts the data → introduced in the ML fit in p_T^{miss} bins.

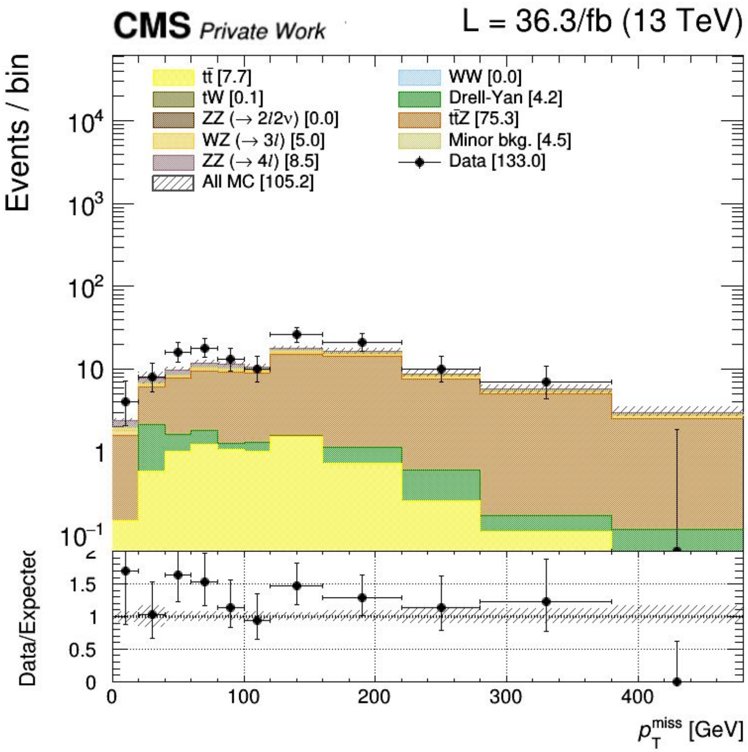


- m_{T2} shape description tested in events with 4 leptons and no b-tagged jets:
  - p_T from reconstructed candidate Z added to p_T^{miss}
  - No bias observed within the limited statistics

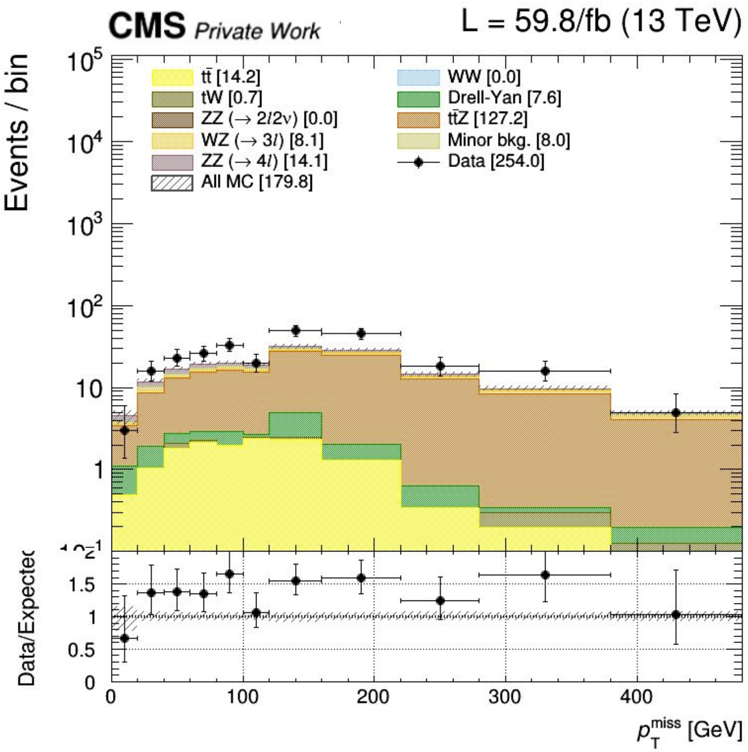


ttZ Events

- Plots for the rest of ttZ scale factors:



2016



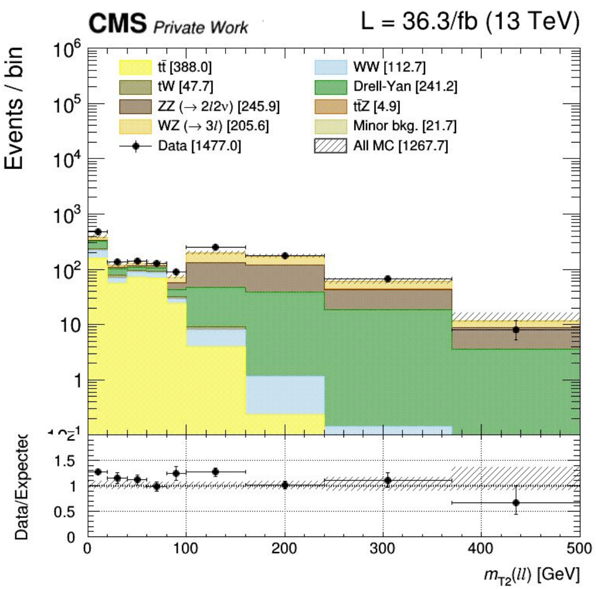
2018

Drell-Yan Production

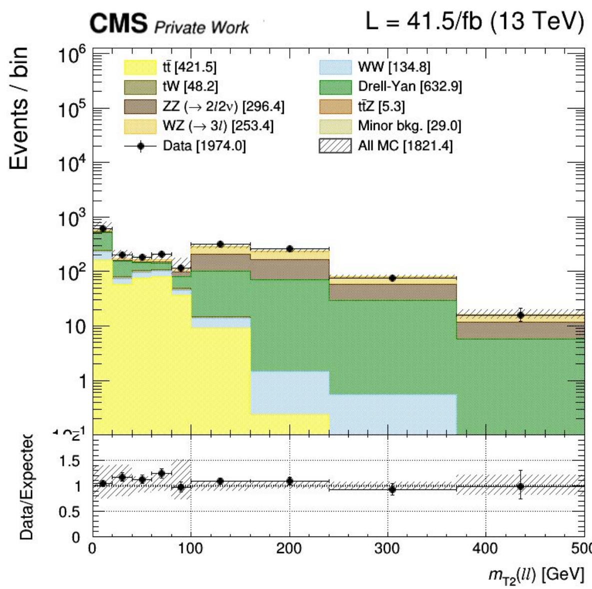
Testing modeling of Drell-Yan production by reversing the Z veto in SF events:

- Mismodeling found for 2017 EOY no longer found in UL.

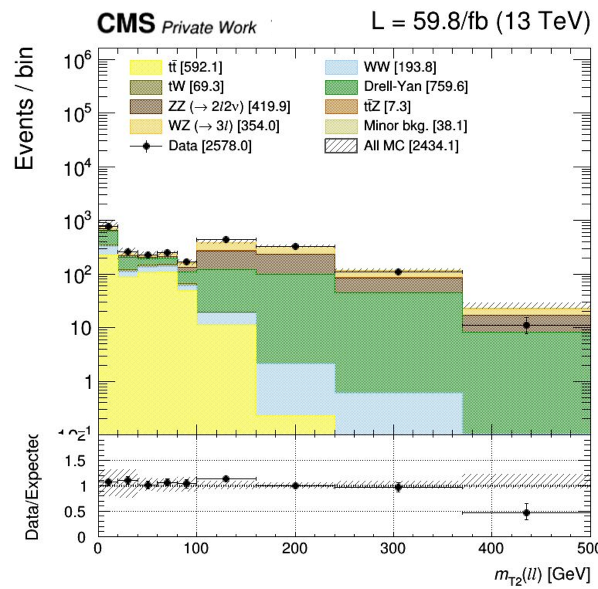
2016



2017



2018

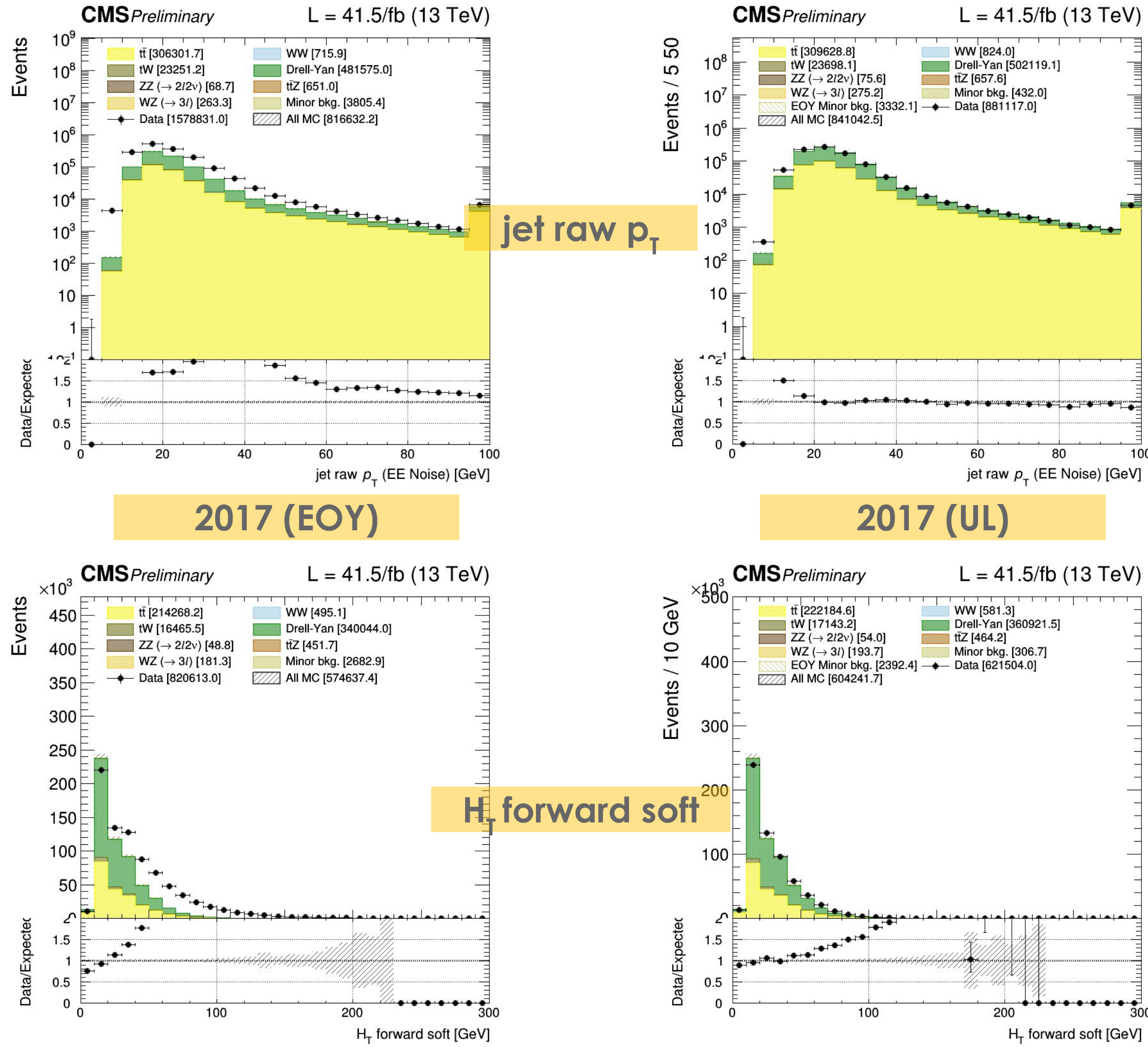


EE Noise in 2017 data (UL vs EOY)

- EE Noise found in 2017 data greatly reduced in UL

- We still find some mismodelling, as shown in the H_T (with $n_{bjets} \geq 1$)
  - ➜ Veto H_T>60 GeV

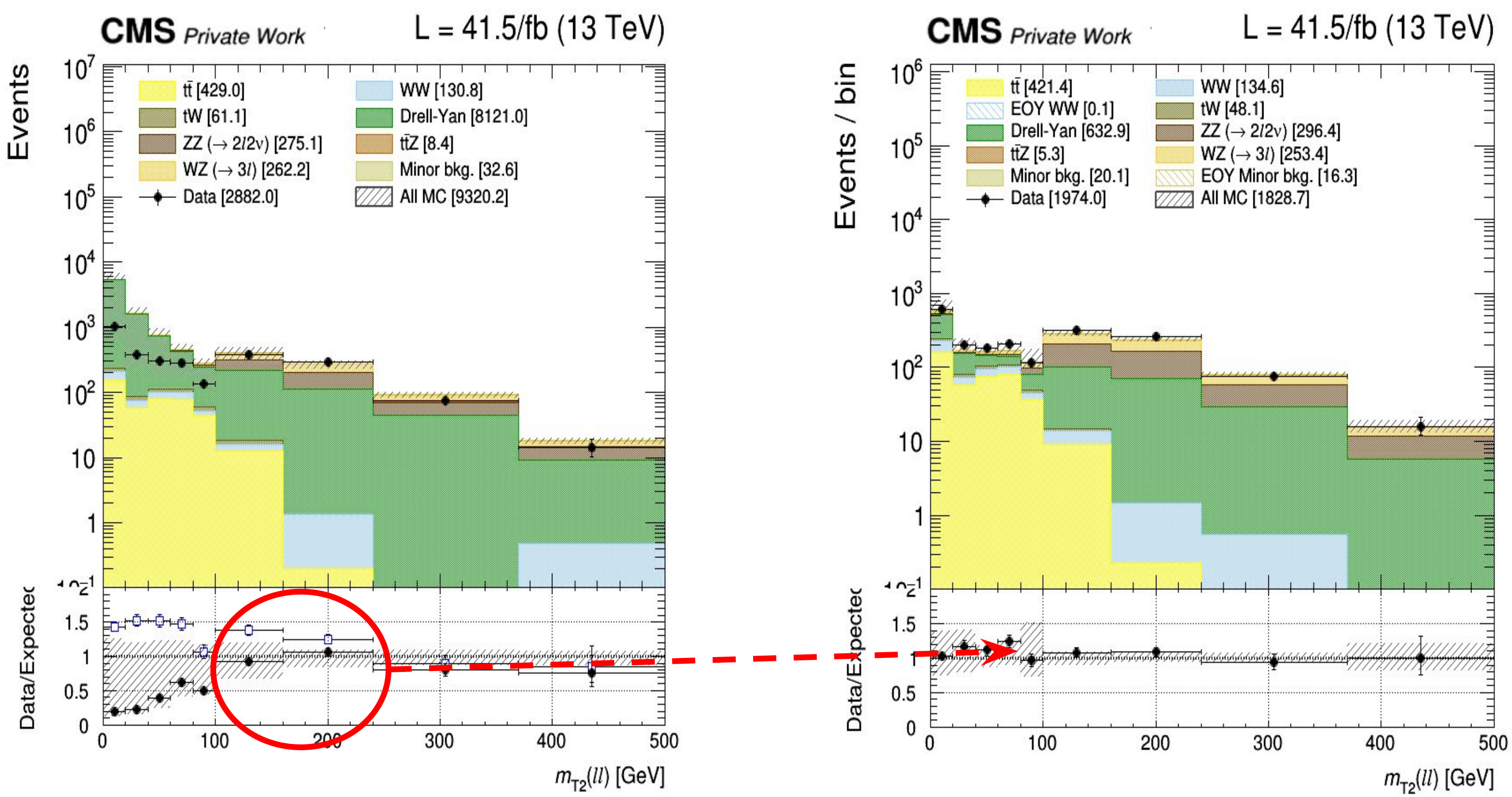
N.b. H_T forward soft = Sum of jet p_T's, for jets with $2.650 < |\eta_{jet}| < 3.139$ and raw p_T<50 GeV



EOY vs UL Drell-Yan Production

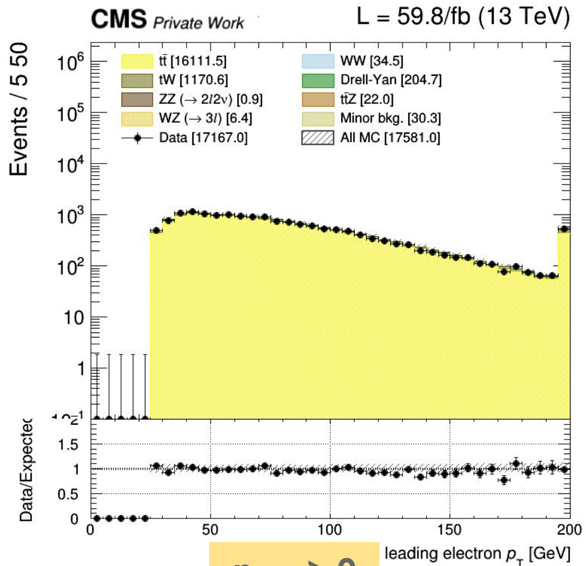
- Mismodeling found for 2017 EOY no longer found in UL.

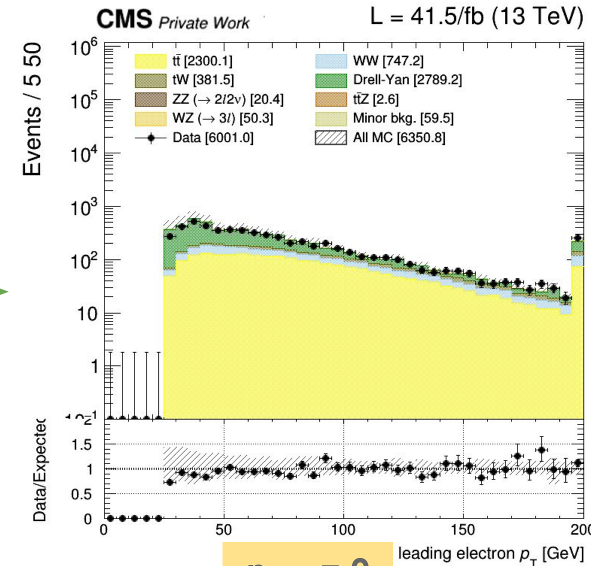
2017 (EOY) **2017 (UL)**



Electrons in $100<p_T^{miss}<160$ GeV Sideband region

+all plots here

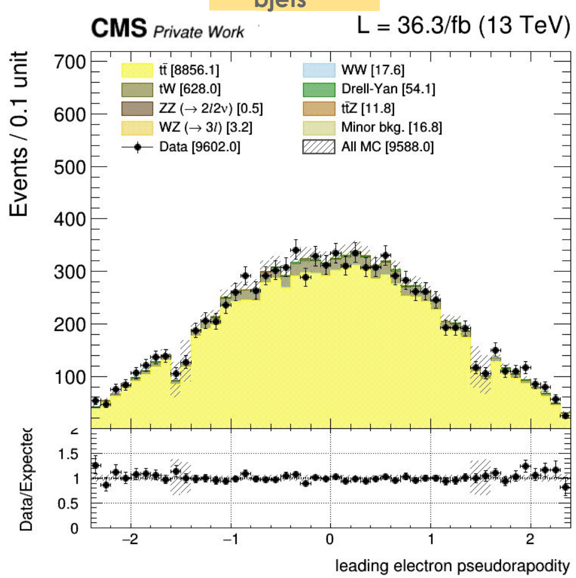


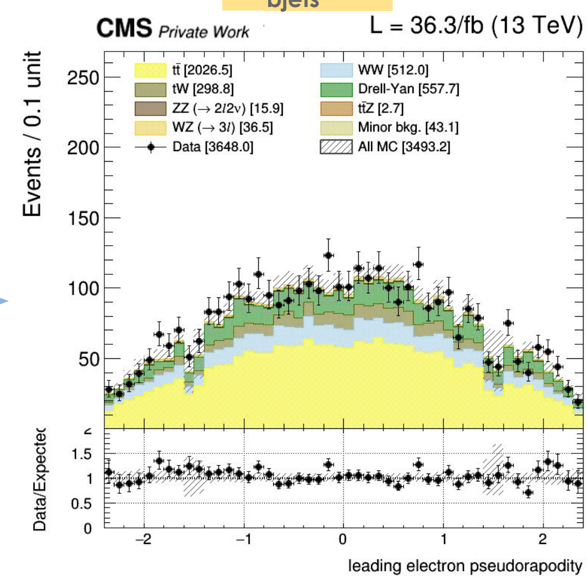


leading electron p_T

$n_{bjets} > 0$

$n_{bjets} = 0$

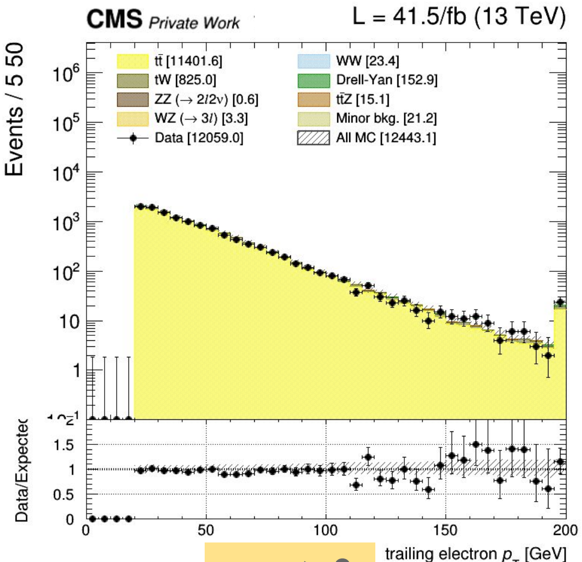




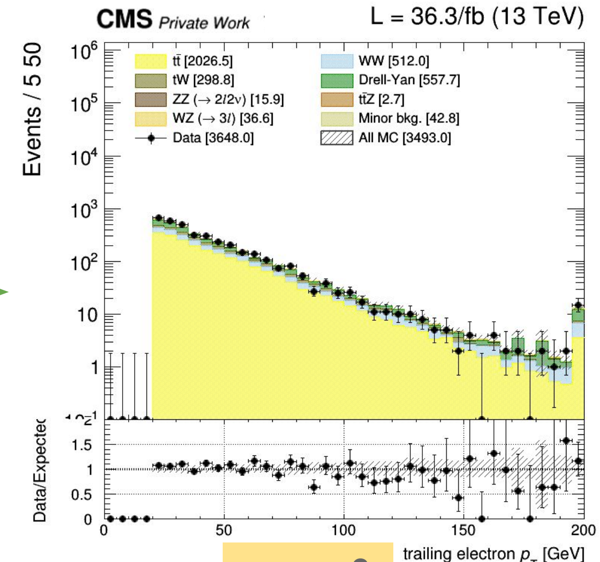
trailing electron's η

Electrons in $100<p_T^{miss}<160$ GeV Sideband region

+all plots here

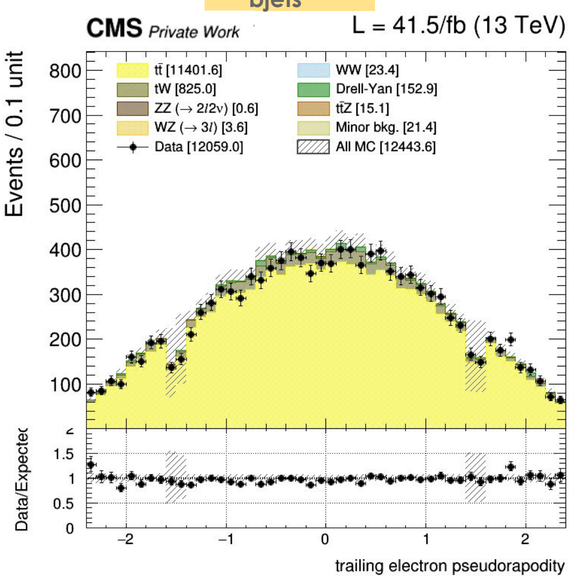


trailing electron p_T

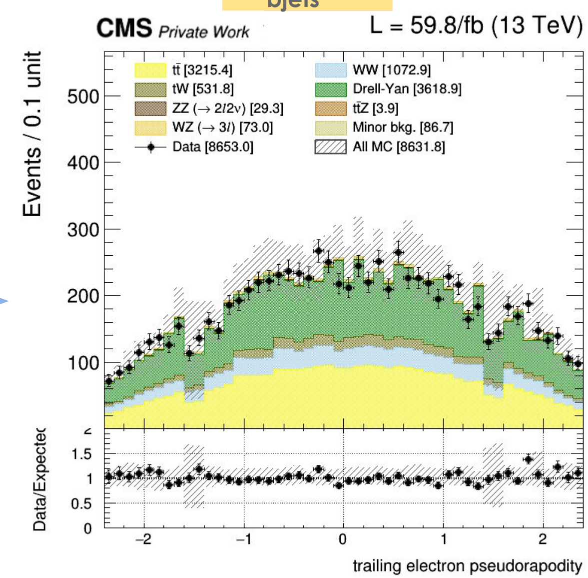


$n_{bjets} > 0$

$n_{bjets} = 0$

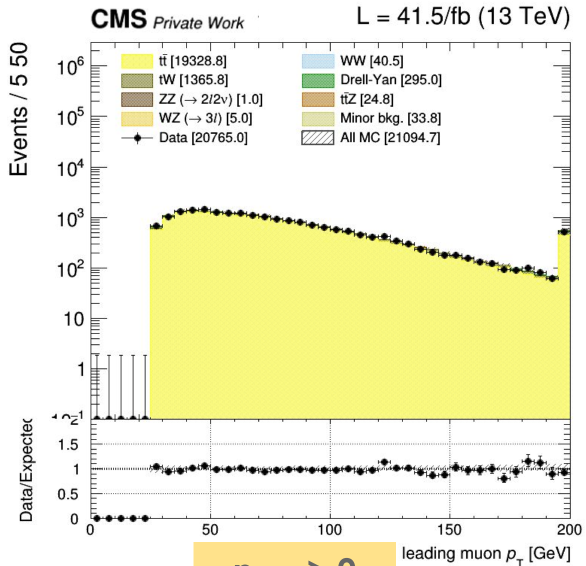


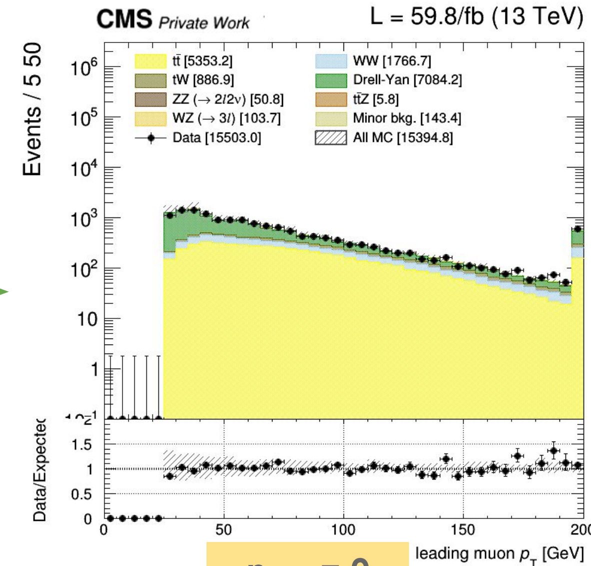
trailing electron's η



Muons in 100<p_T^{miss}<160 GeV
Sideband region

+all plots here

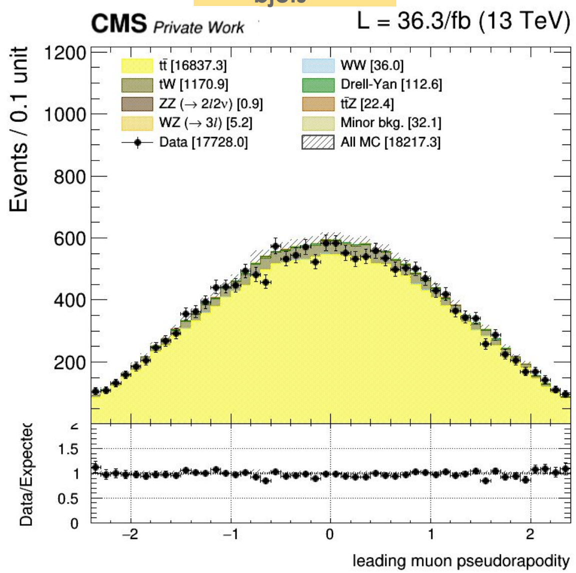




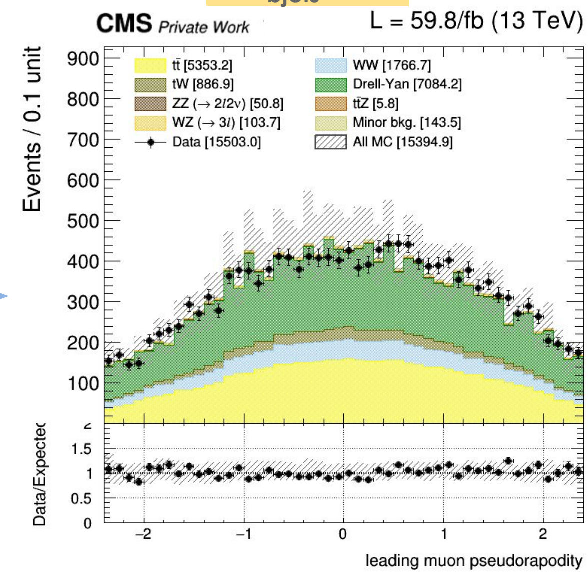
leading muon's p_T

$n_{bjets} > 0$

$n_{bjets} = 0$

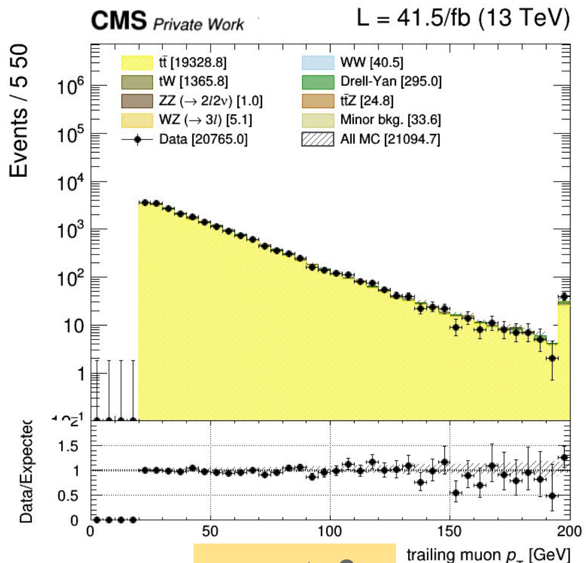


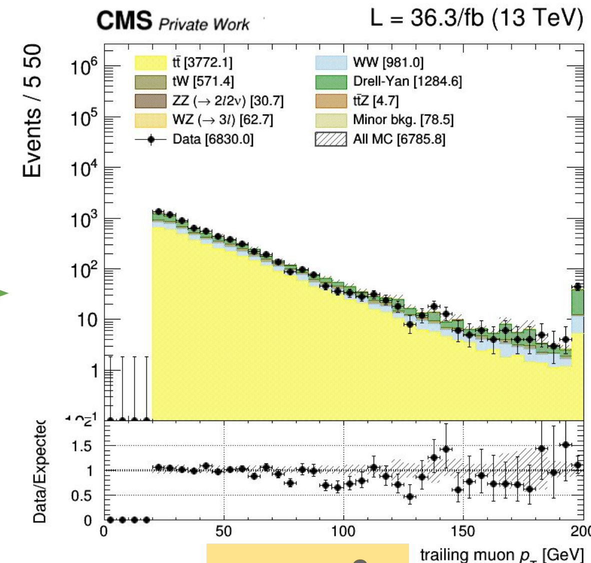
leading muon's η



Muons in 100<p_T^{miss}<160 GeV
Sideband region

+all plots here

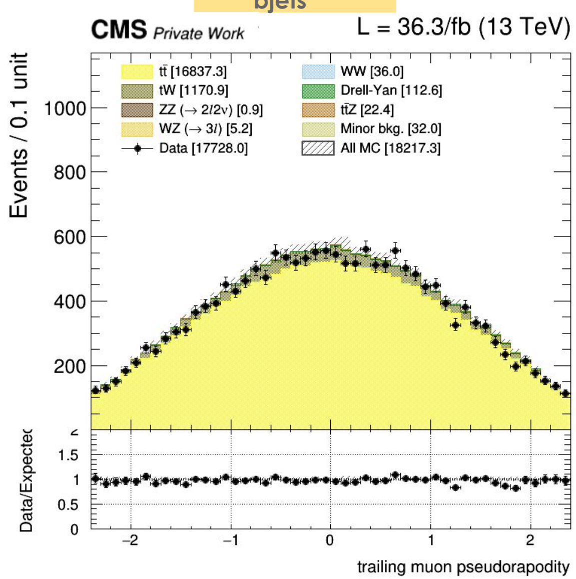


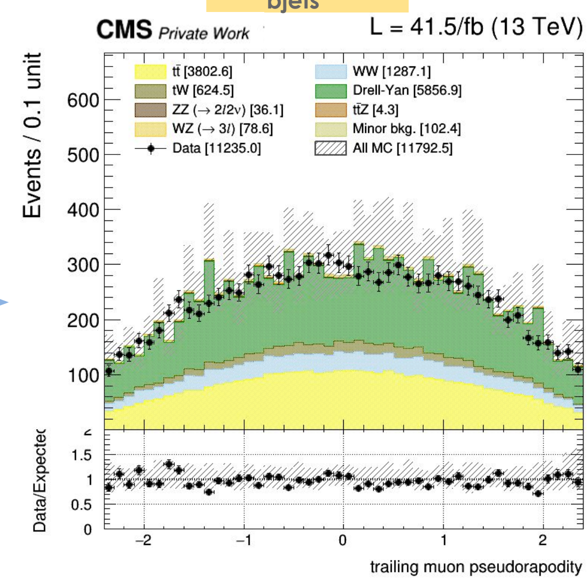


trailing muon's p_T

$n_{bjets} > 0$

$n_{bjets} = 0$





trailing muon's η

Summary of included systematics (Chargino SRs)

Source of uncertainty	SR1 $160 \le p_T^{miss} < 220$ GeV Yields	SR1 $m_{T2}(\ell\ell)$ shape	SR2 $220 \le p_T^{miss} < 280$ GeV Yields	SR2 $m_{T2}(\ell\ell)$ shape	SR3 $280 \le p_T^{miss} < 380$ GeV Yields	SR3 $m_{T2}(\ell\ell)$ shape	SR4 $p_T^{miss} \ge 380$ GeV Yields	SR4 $m_{T2}(\ell\ell)$ shape
Integrated luminosity	1–3%	—	1–3%	—	1–3%	—	1–3%	—
Trigger efficiency	2%	< 1%	2%	≤ 1%	2%	< 1%	2%	≤ 2%
Pileup	≤ 4%	3–9%	≤ 3%	3–19%	≤ 1%	2–13%	< 1%	5–13%
Jet energy scale	1–6%	3–10%	≤ 6%	2–10%	3–5%	2–8%	3–4%	2–9%
Jet energy resolution	1–5%	2–6%	1–3%	2–7%	1–2%	1–5%	1–2%	2–8%
Unclustered energy	1–5%	5–8%	2–5%	3–7%	1%	2–4%	1–2%	4–6%
Prefiring	1%	< 1%	1–2%	≤ 3%	1%	< 1%	≤ 1%	1–2%
Lepton reconstruction	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Lepton ident./isolation	2–5%	≤ 5%	2–4%	1–5%	2–3%	1–5%	2–4%	1–11%
Lepton additional cuts	1–2%	< 1%	1–2%	≤ 1%	1%	≤ 2%	1%	≤ 2%
b tagging	3–5%	2–4%	3–5%	2–5%	2–4%	2–4%	2–3%	2–3%
b tagging (light jets)	< 1%	< 1%	< 1%	≤ 6%	< 1%	< 1%	< 1%	≤ 2%
Simulated samples statistics	≤ 6%	4–22%	1–10%	11–58%	1–2%	11–27%	2–3%	15–46%
Renorm./fact. scales	2–4%	1–4%	4–6%	3–12%	9%	5–6%	12–13%	8–10%
PDFs	≤ 1%	1–2%	1–2%	1–5%	1%	1–3%	2%	2–4%
Drell–Yan normalization	1–7%	3–22%	≤ 6%	2–23%	4–7%	4–11%	4–7%	4–8%
tW normalization	1%	≤ 2%	1–2%	1–2%	1%	1%	1%	1–2%
Minor bkg. normalization	1–2%	1–3%	1–3%	1–9%	2%	1–3%	2–3%	1–6%
$m_{T2}(\ell\ell)$ tails (m_W endpoint)	1–3%	4–14%	1–5%	5–21%	1%	8–22%	1–2%	11–35%
$m_{T2}(\ell\ell)$ tails (WZ)	—	< 1%	< 1%	≤ 1%	< 1%	≤ 2%	< 1%	≤ 16%
Nonprompt leptons	< 1%	≤ 2%	< 1%	≤ 3%	< 1%	≤ 6%	< 1%	≤ 2%
$t\bar{t}$ p_T reweighting	1%	1–3%	1–2%	2–4%	2%	4%	2%	4–5%

Systematic uncertainties for SM processes in the chargino SRs

Systematic uncertainties for chargino pair production (m_C=800 GeV, m_X=200GeV)

Source of uncertainty	SR1 $160 \le p_T^{miss} < 220$ GeV Yields	SR1 $m_{T2}(\ell\ell)$ shape	SR2 $220 \le p_T^{miss} < 280$ GeV Yields	SR2 $m_{T2}(\ell\ell)$ shape	SR3 $280 \le p_T^{miss} < 380$ GeV Yields	SR3 $m_{T2}(\ell\ell)$ shape	SR4 $p_T^{miss} \ge 380$ GeV Yields	SR4 $m_{T2}(\ell\ell)$ shape
Integrated luminosity	1–3%	—	1–3%	—	1–3%	—	1–3%	—
Trigger efficiency	2%	< 1%	2%	< 1%	2%	< 1%	2%	< 1%
Pileup	1–4%	1–4%	≤ 3%	1–4%	≤ 2%	≤ 2%	≤ 3%	1–3%
Jet energy scale	1–5%	1–10%	1–5%	1–9%	≤ 2%	1–6%	≤ 3%	≤ 6%
Jet energy resolution	≤ 3%	1–10%	≤ 2%	1–12%	< 1%	1–14%	< 1%	≤ 5%
Unclustered energy	≤ 2%	2–10%	≤ 3%	2–8%	< 1%	1–8%	< 1%	≤ 3%
Prefiring	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Lepton reconstruction	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Lepton ident./isolation	2–6%	1–2%	2–6%	≤ 3%	3–6%	≤ 1%	3–7%	≤ 3%
b tagging	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
b tagging (light jets)	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Simulated samples statistics	6–14%	9–21%	5–15%	9–22%	3–7%	8–16%	3–6%	6–21%
Renorm./fact. scales	< 1%	< 1%	≤ 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Nonprompt leptons	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
ISR reweighting	1–2%	≤ 2%	1–2%	≤ 5%	≤ 2%	1–4%	≤ 2%	1–5%
Lepton ident./isolation (FASTSIM)	4.0%	—	4.0%	—	4.0%	—	4.0%	—
b tagging (FASTSIM)	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
p_T^{miss} (FASTSIM)	≤ 11%	2–24%	≤ 7%	≤ 13%	1–2%	≤ 9%	≤ 2%	1–8%

Summary of Included Systematics (Stop)

Source of uncertainty	SR1 $160 \leq p_T^{miss} < 220$ GeV Yields	SR1 $m_{T2}(\ell\ell)$ shape	SR2 $220 \leq p_T^{miss} < 280$ GeV Yields	SR2 $m_{T2}(\ell\ell)$ shape	SR3 $280 \leq p_T^{miss} < 380$ GeV Yields	SR3 $m_{T2}(\ell\ell)$ shape	SR4 $p_T^{miss} \geq 380$ GeV Yields	SR4 $m_{T2}(\ell\ell)$ shape
Integrated luminosity	1–3%	—	1–3%	—	1–3%	—	1–3%	—
Trigger efficiency	2%	< 1%	2%	< 1%	2%	< 1%	2%	< 1%
Pileup	≤ 2%	3–9%	≤ 1%	2–12%	≤ 1%	2–20%	< 1%	3–18%
Jet energy scale	3–8%	3–10%	3–7%	2–8%	3–6%	2–5%	3–6%	3–7%
Jet energy resolution	1–2%	2–8%	1–2%	2–8%	1–2%	2–5%	1–2%	2–8%
Unclustered energy	1–2%	5–10%	1–2%	3–7%	1–2%	2–11%	1–2%	3–13%
Prefiring	< 1%	≤ 1%	1%	< 1%	< 1%	< 1%	< 1%	≤ 1%
Lepton reconstruction	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Lepton ident./isolation	2–4%	≤ 2%	2–3%	≤ 3%	1–3%	1–5%	2–4%	1–15%
Lepton additional cuts	1%	≤ 1%	1%	< 1%	1%	< 1%	1%	≤ 1%
b tagging	1–4%	≤ 4%	1–5%	≤ 4%	≤ 5%	≤ 2%	≤ 3%	≤ 6%
b tagging (light jets)	< 1%	≤ 2%	< 1%	≤ 3%	< 1%	≤ 1%	< 1%	≤ 2%
Simulated samples statistics	< 1%	4–18%	≤ 2%	5–21%	1–2%	12–29%	1–3%	18–37%
Renorm./fact. scales	2–3%	1–15%	5–6%	2–7%	10–16%	2–5%	13–23%	2–13%
PDFs	< 1%	≤ 1%	< 1%	≤ 2%	< 1%	≤ 2%	≤ 2%	≤ 9%
Drell–Yan normalization	≤ 5%	≤ 26%	≤ 6%	≤ 16%	≤ 7%	≤ 8%	≤ 7%	≤ 7%
tW normalization	< 1%	≤ 2%	1%	≤ 1%	1%	≤ 1%	1–2%	1–3%
Minor bkg. normalization	< 1%	1–5%	≤ 1%	1–8%	≤ 2%	1–3%	1–3%	1–5%
$m_{T2}(\ell\ell)$ tails (m_W endpoint)	1–2%	5–14%	1%	6–16%	< 1%	5–14%	< 1%	5–20%
$m_{T2}(\ell\ell)$ tails (WZ)	—	< 1%	< 1%	< 1%	—	—	< 1%	≤ 7%
Nonprompt leptons	< 1%	≤ 8%	< 1%	≤ 7%	< 1%	≤ 2%	< 1%	≤ 3%
$t\bar{t}$ p_T reweighting	1–2%	2–3%	2–4%	2–6%	2–4%	1–3%	2–6%	1–4%

Systematic uncertainties for SM processes in the stop SRs

Source of uncertainty	SR1 $160 \leq p_T^{miss} < 220$ GeV Yields	SR1 $m_{T2}(\ell\ell)$ shape	SR2 $220 \leq p_T^{miss} < 280$ GeV Yields	SR2 $m_{T2}(\ell\ell)$ shape	SR3 $280 \leq p_T^{miss} < 380$ GeV Yields	SR3 $m_{T2}(\ell\ell)$ shape	SR4 $p_T^{miss} \geq 380$ GeV Yields	SR4 $m_{T2}(\ell\ell)$ shape
Integrated luminosity	1–3%	—	1–3%	—	1–3%	—	1–3%	—
Trigger efficiency	2%	< 1%	2%	< 1%	2%	< 1%	2%	< 1%
Pileup	≤ 1%	1–3%	≤ 2%	1–7%	≤ 2%	1–7%	≤ 2%	≤ 7%
Jet energy scale	≤ 4%	1–4%	≤ 5%	2–6%	≤ 4%	2–6%	≤ 4%	2–7%
Jet energy resolution	< 1%	1–4%	< 1%	1–4%	≤ 1%	1–3%	< 1%	1–5%
Unclustered energy	< 1%	1–4%	< 1%	1–7%	≤ 1%	2–6%	< 1%	1–7%
Prefiring	< 1%	< 1%	1%	< 1%	< 1%	< 1%	< 1%	≤ 1%
Lepton reconstruction	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Lepton ident./isolation	1–3%	≤ 2%	1–3%	≤ 3%	1–4%	≤ 2%	1–3%	1–6%
Lepton additional cuts	1%	< 1%	1%	< 1%	1%	< 1%	1%	< 1%
b tagging	1%	< 1%	1%	< 1%	1%	< 1%	≤ 1%	< 1%
b tagging (light jets)	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Simulated samples statistics	1–3%	4–7%	2–4%	6–13%	3–5%	8–16%	3–5%	10–16%
Renorm./fact. scales	< 1%	< 1%	1%	< 1%	1–2%	< 1%	2%	≤ 1%
Nonprompt leptons	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
ISR reweighting	2–3%	2–3%	4–5%	1–3%	5–6%	≤ 2%	6–8%	≤ 4%
Lepton ident./isolation (FASTSIM)	4.0%	—	4.0%	—	4.0%	—	4.0%	—
b tagging (FASTSIM)	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
p_T^{miss} (FASTSIM)	≤ 5%	2–8%	≤ 6%	≤ 14%	≤ 5%	3–18%	4–8%	4–15%

Systematic uncertainties for stop pair production (m_S=400 GeV, m_X=275GeV)

UL vs EOY yields in the Search Regions

- We compared expected backgrounds yields in EOY and UL
  - Generally, UL has slightly higher estimates at low mt2ll
  - Comparable estimates at large mt2ll

Table 38: Expected yields in the search region with $220 \leq p_{\mathrm{T}}^{\mathrm{miss}} < 280\,\mathrm{GeV}$ for events with two OC DF leptons, at least one jet, and no b-tagged jets in 2018 data.

$m_{\mathrm{T2}}(\ell\ell)$ bin	0-20	20-40	40-60	60-80	80-100	100-160	160-240	240-370	≥ 370
ZZ ($\rightarrow 2\ell 2\nu$)	0.05 ± 0.01	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.06 ± 0.01	0.03 ± 0.00	0.01 ± 0.00	0.00 ± 0.00
WW	103 ± 6	29.0 ± 2.5	30.9 ± 3.3	25.8 ± 2.0	7.9 ± 1.0	5.3 ± 0.7	2.8 ± 0.5	0.40 ± 0.27	0.00 ± 0.00
Drell–Yan	65.0 ± 54.0	2.6 ± 2.1	0.23 ± 0.45	0.03 ± 0.03	0.01 ± 0.01	0.06 ± 0.05	0.01 ± 0.02	0.00 ± 0.00	0.00 ± 0.00
EOY VZ ($\rightarrow 2\ell 2$q)	1.1 ± 0.1	0.07 ± 0.05	0.01 ± 0.02	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
$\mathrm{t\bar{t}Z}$	0.73 ± 0.09	0.24 ± 0.03	0.20 ± 0.02	0.21 ± 0.02	0.11 ± 0.02	0.26 ± 0.03	0.11 ± 0.01	0.01 ± 0.01	0.00 ± 0.00
VVV	4.0 ± 2.0	1.1 ± 0.6	1.2 ± 0.6	1.0 ± 0.5	0.31 ± 0.21	0.31 ± 0.19	0.14 ± 0.07	0.01 ± 0.03	0.00 ± 0.00
EOY H $\rightarrow$ WW/$\tau\tau$	0.98 ± 0.13	0.41 ± 0.04	0.30 ± 0.07	0.07 ± 0.01	0.00 ± 0.01	0.00 ± 0.00	0.04 ± 0.01	0.01 ± 0.02	0.00 ± 0.00
$\mathrm{t\bar{t}W}$	1.4 ± 0.6	0.37 ± 0.17	0.29 ± 0.13	0.29 ± 0.13	0.08 ± 0.10	0.12 ± 0.06	0.06 ± 0.03	0.01 ± 0.01	0.00 ± 0.00
WZ ($\rightarrow 3\ell\nu$)	4.9 ± 0.5	2.0 ± 0.5	1.2 ± 0.3	1.0 ± 0.3	0.26 ± 0.18	0.15 ± 0.13	0.09 ± 0.08	0.00 ± 0.01	0.00 ± 0.00
$\mathrm{t\bar{t}}$	218 ± 43	72.6 ± 10.5	84.4 ± 12.5	70.0 ± 8.0	25.0 ± 5.0	5.3 ± 1.3	0.37 ± 0.17	0.04 ± 0.11	0.00 ± 0.00
H $\rightarrow$ WW/$\tau\tau$	4.2 ± 2.5	1.1 ± 0.6	0.68 ± 0.44	0.06 ± 0.05	0.00 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
tW	38.7 ± 6.7	11.3 ± 1.8	13.4 ± 2.0	10.4 ± 1.5	3.2 ± 0.7	0.64 ± 0.17	0.04 ± 0.03	0.00 ± 0.00	0.00 ± 0.00
EOY WW	0.85 ± 0.11	0.31 ± 0.05	0.63 ± 0.15	0.55 ± 0.14	0.12 ± 0.04	0.11 ± 0.05	0.05 ± 0.01	0.03 ± 0.03	0.00 ± 0.00
EOY VVV	1.2 ± 0.3	0.45 ± 0.21	0.24 ± 0.17	0.13 ± 0.07	0.09 ± 0.04	0.09 ± 0.04	0.24 ± 0.13	0.00 ± 0.00	0.00 ± 0.00
SM Processes	446 ± 96	122 ± 15	134 ± 17	110 ± 11	37.2 ± 6.1	12.5 ± 2.0	4.0 ± 0.6	0.51 ± 0.32	0.00 ± 0.00
SM Processes (EOY)	433 ± 78	111 ± 15	130 ± 14	112 ± 14	37.4 ± 7.8	12.5 ± 2.6	4.4 ± 0.5	0.83 ± 0.39	0.00 ± 0.24
$m_{\tilde{\chi}_1^\pm} = 300, m_{\tilde{\chi}_1^0} = 1$	3.4 ± 0.9	2.5 ± 1.4	3.6 ± 1.0	2.7 ± 1.6	2.5 ± 2.2	25.7 ± 6.1	37.4 ± 6.5	2.0 ± 1.6	0.00 ± 0.00
$m_{\tilde{\chi}_1^\pm} = 500, m_{\tilde{\chi}_1^0} = 50$	1.8 ± 0.3	0.16 ± 0.12	0.29 ± 0.14	0.48 ± 0.35	0.69 ± 0.14	3.4 ± 0.5	9.6 ± 1.1	4.4 ± 0.8	0.00 ± 0.00
$m_{\tilde{\chi}_1^\pm} = 400, m_{\tilde{\chi}_1^0} = 225$	3.5 ± 0.8	0.58 ± 0.26	1.8 ± 0.5	0.89 ± 0.86	1.8 ± 0.5	6.7 ± 1.6	1.8 ± 0.8	0.00 ± 0.00	0.00 ± 0.00
$m_{\tilde{\chi}_1^\pm} = 300, m_{\tilde{\chi}_1^0} = 175$	11.1 ± 4.4	2.6 ± 2.1	2.1 ± 1.3	2.6 ± 2.5	2.1 ± 2.1	4.5 ± 3.0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
$m_{\tilde{\chi}_1^\pm} = 650, m_{\tilde{\chi}_1^0} = 350$	0.36 ± 0.03	0.12 ± 0.06	0.11 ± 0.06	0.09 ± 0.07	0.26 ± 0.08	1.0 ± 0.3	3.0 ± 0.5	0.45 ± 0.13	0.00 ± 0.00