SUSY search with same-sign or 3 leptons at ATLAS

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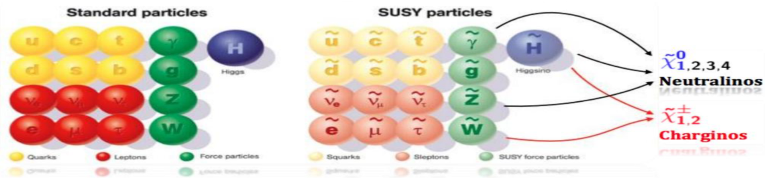
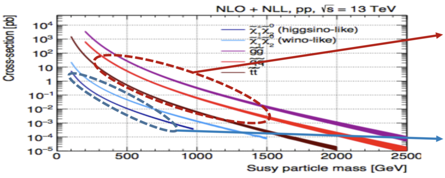
Introduction:



- The Supersymmetry is a well motivated and favored extension of the Stand Model (SM):
  - ◇ Solves hierarchy problem, provides dark matter candidate, helps with the GUT...
- Basically have 2 production ways:



SUSY strong production:
- Squark & gluino production
- Relative larger cross-section
- Larger SUSY particle mass

ElecktroWeak sector (EWK):
- Chargino & sleptons production
- Smaller cross-section
- Lower hadronic background

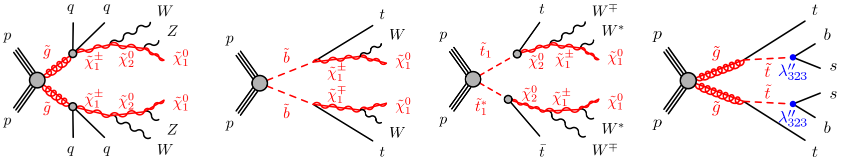
- This talk will focus on the public results of SUSY search with SS/3L+jets, (arXiv: 1909.08457) at ATLAS during run2 with $\mathcal{L} = 139$ fb^{-1}

Analysis Overview:

- Signature: same-sign(SS) or three leptons (electrons or muons) and jets in the final state, decay from squarks and gluinos
- Advantage:
  - Low SM background contamination
  - Cover a wide range of BSM scenarios (RPV and RPC)
  - Can probe the compressed scenarios
- Major contributions from SM processes to the SRs arise from WZ+jets and $t\bar{t}V$ depending on b-tagged jet multiplicity, MC estimation directly, VRs are designed to validate them.
- Reducible backgrounds like “charge-flip” and fake or non-prompt leptons (“F/NP”) are estimated via dedicated data-driven methods
- Both model dependent and independent statistical interpretation are derived in the end

Signal Regions:

- We chose to illustrate the analysis versatility by evaluating its sensitivity to:
  - three R-parity-conserving (RPC) SUSY scenarios, featuring gluino, bottom or top squark pair production with various exclusive decay modes
  - one R-parity-violating (RPV) SUSY scenario with gluino or neutralino decays via violating λ'' couplings



- Five signal regions (SRs) are built to isolate signatures of hypothetical supersymmetric signal processes from the SM and reducible backgrounds:

SR	n_ℓ	n_b	n_j	E_T^{miss} [GeV]	m_{eff} [GeV]	E_T^{miss}/m_{eff}	SUSY
Rpv2L	≥ 2 ($\ell^\pm\ell^\pm$)	≥ 0	≥ 6 ($p_T > 40$ GeV)	–	> 2600	–	$\tilde{g} \to t\bar{t}\tilde{\chi}_1^0,\ \tilde{\chi}_1^0 \to 3q$ ($\lambda'' \neq 0$) $\tilde{g} \to q\bar{q}\tilde{\chi}_1^0,\ \tilde{\chi}_1^0 \to qq'\ell$ ($\lambda' \neq 0$) $\tilde{g} \to t\bar{t}_1^*,\ \tilde{t}_1^* \to qq'$ ($\lambda'' \neq 0$)
Rpc2L1b	≥ 2 ($\ell^\pm\ell^\pm$)	≥ 1	≥ 6 ($p_T > 40$ GeV)	–	–	> 0.25	$\tilde{b}_1 \to tW\tilde{\chi}_1^0$
Rpc2L2b	≥ 2 ($\ell^\pm\ell^\pm$)	≥ 2	≥ 6 ($p_T > 25$ GeV)	> 300	> 1400	> 0.14	$\tilde{b}_1 \to tW\tilde{\chi}_1^0$ $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$
Rpc2L0b	≥ 2 ($\ell^\pm\ell^\pm$)	$= 0$	≥ 6 ($p_T > 40$ GeV)	> 200	> 1000	> 0.2	$\tilde{g} \to q\bar{q}'WZ\tilde{\chi}_1^0$
Rpc3LSS1b	≥ 3 ($\ell^\pm\ell^\pm\ell^\pm$)	≥ 1	no cut but veto $81 < m_{e^\pm e^\pm} < 101$ GeV			> 0.14	$\tilde{t}_1 \to tW^\pm(W^*)\tilde{\chi}_1^0$

Standard Model backgrounds I:

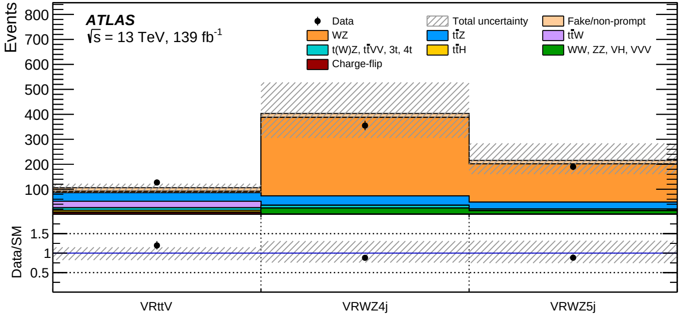
- Major contributions from SM processes to the SRs arise from WZ+jets and $t\bar{t}V$ depending on b-tagged jet multiplicity
- Others coming from ZZ and $W^{\pm}W^{\pm}jj$
- systematics from simulated samples are categorized into two part:
  - experimental uncertainty:
    - ⋆ uncertainties on simulation of the detector (all kinds of scale factors)
    - ⋆ uncertainties from luminosity and trigger
  - theoretical uncertainty:
    - ⋆ uncertainties on cross-section
    - ⋆ uncertainties on the choice of factorization and renormalization scales
    - ⋆ uncertainties on the PDFs
    - ⋆ overall, contribute 35 – 45% for $t\bar{t}W$, 25 – 45% for $t\bar{t}Z$, and 40 – 45% for WZ

Background & Generator	Cross Section	PDF & α_s	QCD scale	PS, Resummation & CKKW matching
WZ (Sherpa)	6%	LHE3 weights	on-the-fly weights	Variation Sample
ZZ, WW (Sherpa)	6%			
VVV (Sherpa)	20%			
$t\bar{t}Z$ (MGPythia)	12%	LHE3 weights	on-the-fly weights	Variation Samples
$t\bar{t}W$ (MGPythia)	13%			
$t\bar{t}H$ (Powheg+Py8)	10%	LHE3 weights	on-the-fly weights	on-the-fly weights
$t\bar{t}WW$, tWZ, tZ, 3t, 4t	50%			

Standard Model backgrounds II:

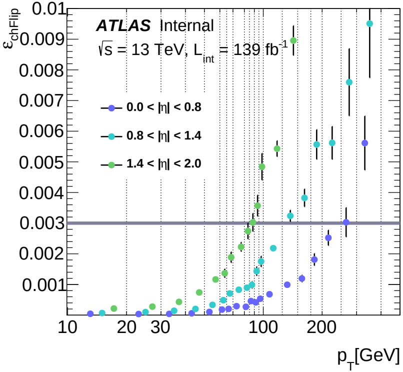
- 3 dedicated designed validation regions for WZ+jets (`VRWZ4j`, `VRWZ5j`) and $t\bar{t}V$ (`VRttV`) are set to validate this method

	n_ℓ	n_b	n_j	m_{eff} [GeV]	Other requirements
`VRWZ4j`	$=3$, $=1$ SFOS pair	$=0$	≥ 4 ($p_T > 25$ GeV)	> 600	$81 < m_{SFOS} < 101$ GeV, $E_T^{miss} > 50$ GeV, no fourth baseline lepton
`VRWZ5j`		$=0$	≥ 5 ($p_T > 25$ GeV)	> 400	
`VRttV`	≥ 2, ≥ 1 SS pair	≥ 1	≥ 3 ($p_T > 40$ GeV)	> 600	$p_T > 30$ GeV for SS leptons, $\sum \lvert p_T^b \rvert > 0.4 \sum \lvert p_T^j \rvert$, $E_T^{miss} > 0.1 m_{eff}$, min $\Delta R_\eta(\ell_1, j) > 1.1$
All VRs	$m_{eff} < 1.5$ TeV, $E_T^{miss} < 250$ GeV; veto `Rpc2L1b`, `Rpc2L2b`, `Rpc2L0b` and `Rpv2L` signal regions.				



Reducible background I:

- Other SM processes may also contribute to SRs via misidentification of the reconstructed objects
- "charge-flip":
  - mis-ID the charge of a lepton due to the interaction with detector material (effect on muon is negligible)
  - minor contribution to SRs due to the use of "ECIDS" tool
  - estimated via a data-driven method: $w_{flip} = \xi_1(1-\xi_2) + (1-\xi_1)\xi_2$
  - $\xi(\eta, p_T)$ was measured in simulated $t\bar{t}$ events and corrected by comparison the measurement in data



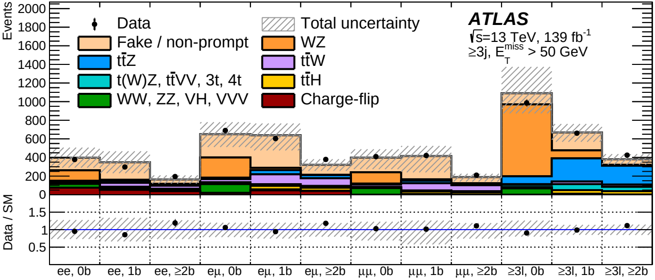
- The probabilities grow up to $\mathcal{O}(0.1\%)$ at $p_T = 100\,\text{GeV}$ for central electrons ($|\eta| < 1.4$), and are about fives times larger at higher $|\eta|$
- Systematic uncertainties are assessed by propagating the measurement uncertainties, leading to a $70-90\%$ uncertainty in the predicted SR yields

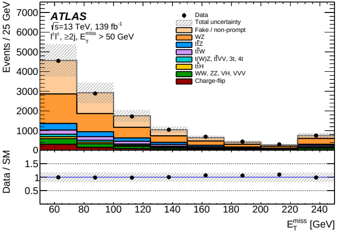
Reducible background II:

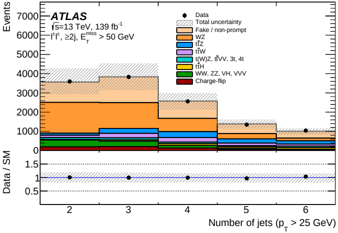
- fake or non-prompt leptons (“F/NP”)
  - may come from various sources e.g: EWK decays of hadrons, single pion, in-flight decays of kaons or conversion of photons and etc ...
  - in SRs mainly contribute from $t\bar{t}$
  - matrix method was used to estimate this background in SRs: $\mathcal{S} = \varepsilon (1 - \mathcal{F}) + \zeta \mathcal{F}$
  - prompt lepton rates:
    - ⋆ obtained directly from $t\bar{t}$ simulation as function of p_T and $|\eta|$, typically above 82% (85%) for electron (muon)
    - ⋆ uncertainties measured as a function of p_T and proximity to the closest jet
  - fake lepton rates:
    - ⋆ measured in data in regions enriched in F/NP leptons produced by $t\bar{t}$ processes
    - ⋆ measured according to p_T, multiplicity of b-tagged jets and electrons fired or not fired triggers
    - ⋆ $\sim$ 10% for leptons up to $p_T \sim 35$ GeV, 20% (35%) for electrons (muons) with $p_T > 60$ GeV, twice for events with two b-tagged jets
  - systematics:
    - ⋆ propagate from fake/prompt rates
    - ⋆ possible different in the sources of F/NP or in the environment, assessed with $t\bar{t}$

Reducible background III:

- validated by comparing the observed data to the prediction of backgrounds
- good agreement between data and predicted backgrounds
- cross-checked with “ABCD” method

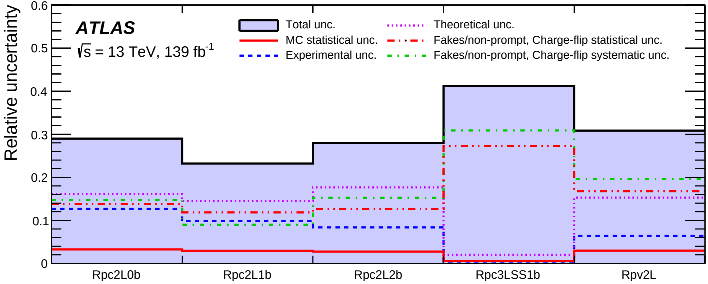






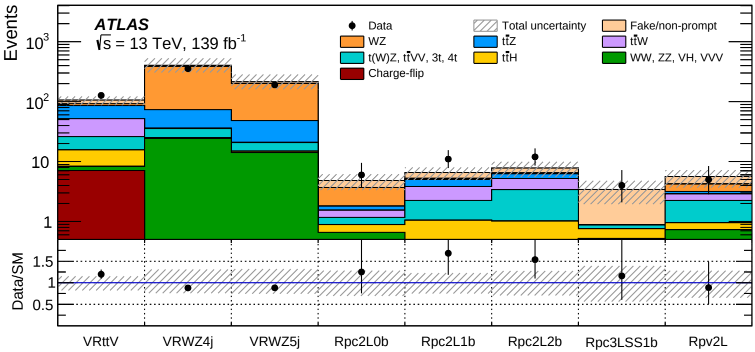
Systematics:

- all sources of uncertainties from both reducible and irreducible backgrounds described above are taken into account
- These range from 23% to 41%, and are always smaller than the statistical uncertainties in the observed data yields



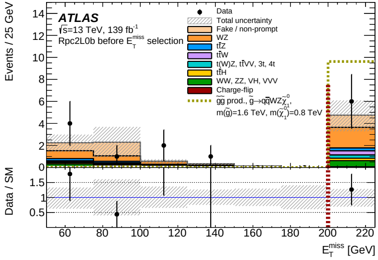
Results I:

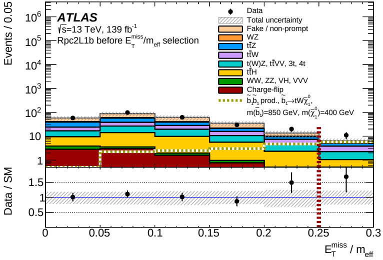
- data agrees well with predicted backgrounds
- no significant excess observed

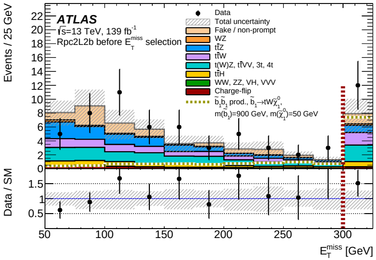


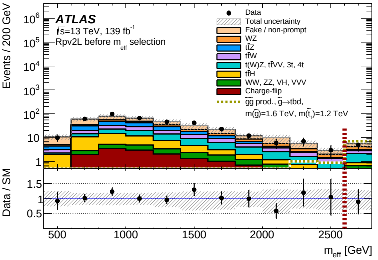
Results II:

- Distributions of E_T^{miss}, m_{eff} or the E_T^{miss}/m_{eff} ratio near the SRs
- good agreement between data and predicted backgrounds



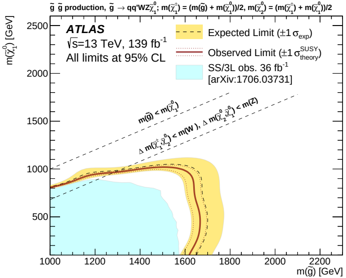




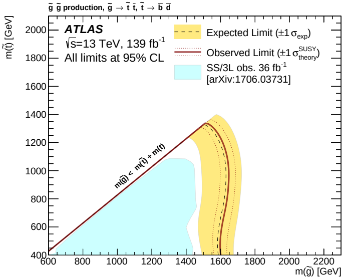


Results III:

- 95% confidence level exclusion limits on the production of pairs of gluinos
- reaching up to 1.6 TeV for gluinos



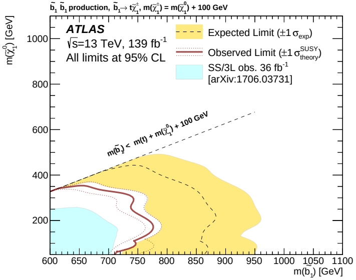
Rpc2L0b: $\tilde{g} \to q\bar{q}WZ\tilde{\chi}_1^0$



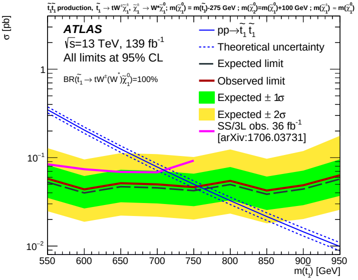
Rpv2L: $\tilde{g} \to t\bar{b}\bar{d}$

Results IV:

- 95% confidence level exclusion limits on the production of pairs of third-generation squarks
- reaching up to 750 GeV bottom and top squarks



Rpc2L1b+Rpc2L2b: $\tilde{b}_1 \rightarrow tW\tilde{\chi}_1^0$



Rpc3LSS1b: $\tilde{t}_1 \rightarrow tW^{\mp}\tilde{\chi}_1^{\pm}$

Results V:

- Model-independent limits on the cross-section of possible BSM signal contributions to the SRs are also established

Signal region	σ_{vis} [fb]	S^{95}_{obs}	S^{95}_{exp}	$p(s = 0)$
`Rpc2L0b`	0.05	7.5	$6.4^{+3.2}_{-2.0}$	0.33
`Rpc2L1b`	0.08	11.6	$7.3^{+3.6}_{-2.3}$	0.09
`Rpc2L2b`	0.09	12.4	$8.7^{+4.0}_{-2.7}$	0.14
`Rpc3LSS1b`	0.04	6.2	$5.7^{+2.9}_{-1.8}$	0.41
`Rpv2L`	0.05	6.6	$7.0^{+3.2}_{-2.1}$	0.50

Conclusion:

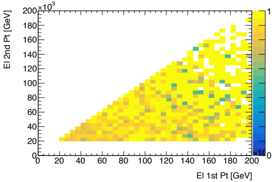
- Data agrees well with predicted SM backgrounds in all SRs, no significant excess observed in any of SRs
- Lower limits on particle masses are derived at 95% confidence level for these models, reaching up to 1.6 TeV for gluinos and 750 GeV bottom and top squarks
- Significantly extending the previous exclusion limits
- Model-independent limits on the cross-section of possible BSM signal contributions to the SRs are also established

BACK UP

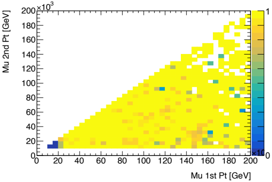
Trigger strategy:

- 2015 data:
  - $E_T^{miss} < 250$ GeV: logical `or` of the following dilepton triggers: `HLT_2e12_lhloose_L12EM10VH`, `HLT_e17_lhloose_mu14`, `HLT_mu18_mu8noL1`
  - $E_T^{miss} > 250$ GeV: logical `or` of the dilepton triggers and `HLT_xe70`
- 2016 data:
  - $E_T^{miss} < 250$ GeV: logical `or` of the following dilepton triggers: `HLT_2e17_lhvloose_nod0`, `HLT_e17_lhloose_nod0_mu14`, `HLT_mu22_mu8noL1`
  - $E_T^{miss} > 250$ GeV: logical `or` of the dilepton triggers, `HLT_xe90_mht_L1XE50` (period A–D3), `HLT_xe100_mht_L1XE50` (period D4–F1) and `HLT_xe110_mht_L1XE50` (period F2–open)
- 2017 data:
  - $E_T^{miss} < 250$ GeV: logical `or` of the following dilepton triggers: `HLT_2e24_lhvloose_nod0`, `HLT_e17_lhloose_nod0_mu14`, `HLT_mu22_mu8noL1`
  - $E_T^{miss} > 250$ GeV: logical `or` of the dilepton triggers and `HLT_xe110_pufit_L1XE55`
- 2018 data:
  - $E_T^{miss} < 250$ GeV: logical `or` of the following dilepton triggers: `HLT_2e24_lhvloose_nod0`, `HLT_e17_lhloose_nod0_mu14`, `HLT_mu22_mu8noL1`
  - $E_T^{miss} > 250$ GeV: logical `or` of the dilepton triggers and `HLT_xe110_pufit_xe70_L1XE50`

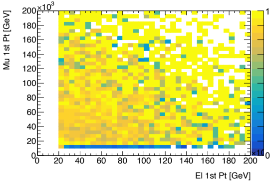
Trigger turn-on curve:



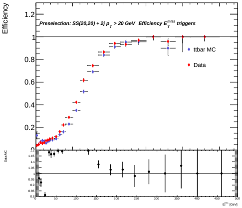
Dielectron triggers



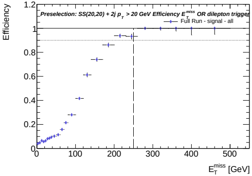
Dimuon triggers



Electron-muon triggers



E_T^{miss} triggers



Logical OR E_T^{miss} and dilepton triggers ($E_T^{miss} > 250\,GeV$)

Object definitions:

Pre-selected jet	
Collection	AntiKt4EMTopo
Acceptance	$p_T > 20\,\text{GeV}, \lvert\eta\rvert < 2.8$
Overlap	see section 4.4
Jet vertex tagger	if $\lvert\eta\rvert < 2.4$, reject jets with $p_T < 120$ GeV and JVT<0.59 (Medium WP) else if $\lvert\eta\rvert < 2.5$, reject jets with $p_T < 120$ GeV, and JVT<0.11 (Loose WP)
b-jets	
Acceptance	$p_T > 20\,\text{GeV}$, $\lvert\eta\rvert < 2.5$
b-tagging	MV2c10 algorithm 70% OP MV2c10 algorithm 85% OP for overlap removal
Jet vertex tagger	reject b-jets with $p_T < 60$ GeV, $\lvert\eta\rvert < 2.4$ and JVT<0.59

	Pre-selected Electron	**Pre-selected Muon**
Acceptance	$p_T > 10\,\text{GeV}, \lvert\eta^{\text{clust}}\rvert < 2.47$ except $1.37 < \lvert\eta^{\text{clust}}\rvert < 1.52$	$p_T > 10\,\text{GeV}, \lvert\eta\rvert < 2.5$
Quality	LooseAndBLayerLLH	xAOD::Muon::Medium
ℓ-jet Isolation	see section 4.4	
Impact parameter	$\lvert d_0/\sigma(d_0)\rvert < 5.0$ $\lvert z_0 \cdot \sin(\theta)\rvert < 0.5\,\text{mm}$	$\lvert z_0 \cdot \sin(\theta)\rvert < 0.5\,\text{mm}$
	Signal Electron	**Signal Muon**
Quality	MediumLH $\lvert\eta\rvert < 2.0$ [a] ElectronChargeIDSelector tool, 97% OP [b]	- - -
Isolation	"FCTight "	"FCTightTrackOnly"
Impact parameter		$\lvert d_0/\sigma(d_0)\rvert < 3.0$

[a,b] Cuts applied on all electrons, even in events with three leptons.

Signal region definition:

- Significance in the RPC SRs defined. The fake/non-prompt and detector backgrounds are taken from $t\bar{t}$ and V+jets MC simulations. The truth-lepton matching for Rpc3LSS1b is not applied here. These results are obtained for 139 fb^{-1}, with AB 21.2.70 ntuples.

SR	Signal Point	Signal Ev.	Bkg Ev.	Z (Z,ROOT)	Purity
Rpc2L1b	$\tilde{b}_1 \to t\tilde{\chi}_1^{\pm}$: $m_{\tilde{b}_1} = 750$ GeV, $m_{\tilde{\chi}_1^{\pm}} = 540$ GeV, $m_{\tilde{\chi}_1^0} = 440$ GeV	7.24	6.65	1.83 (1.64)	0.52
	$\tilde{b}_1 \to t\tilde{\chi}_1^{\pm}$: $m_{\tilde{b}_1} = 850$ GeV, $m_{\tilde{\chi}_1^{\pm}} = 500$ GeV, $m_{\tilde{\chi}_1^0} = 400$ GeV	5.52		1.45 (1.26)	0.45
Rpc2L2b	$\tilde{b}_1 \to t\tilde{\chi}_1^{\pm}$: $m_{\tilde{b}_1} = 900$ GeV, $m_{\tilde{\chi}_1^{\pm}} = 150$ GeV, $m_{\tilde{\chi}_1^0} = 50$ GeV	7.22	8.27	1.61 (1.42)	0.47
Rpc2L0b	$\tilde{g} \to q\bar{q}'WZ\tilde{\chi}_1^0$: $m_{\tilde{g}} = 1400$ GeV, $m_{\tilde{\chi}_2^{\pm}} = 1100$ GeV, $m_{\tilde{\chi}_2^0} = 950$ GeV, $m_{\tilde{\chi}_1^0} = 800$ GeV	21.38	4.02	5.41 (5.26)	0.84
	$\tilde{g} \to q\bar{q}'WZ\tilde{\chi}_1^0$: $m_{\tilde{g}} = 1600$ GeV, $m_{\tilde{\chi}_2^{\pm}} = 1200$ GeV, $m_{\tilde{\chi}_2^0} = 1000$ GeV, $m_{\tilde{\chi}_1^0} = 800$ GeV	9.34		2.93 (2.74)	0.70
	$\tilde{g} \to q\bar{q}'WZ\tilde{\chi}_1^0$: $m_{\tilde{g}} = 1800$ GeV, $m_{\tilde{\chi}_2^{\pm}} = 1100$ GeV, $m_{\tilde{\chi}_2^0} = 750$ GeV, $m_{\tilde{\chi}_1^0} = 400$ GeV	3.33		1.24 (1.03)	0.45
Rpc3LSS1b	$\tilde{t} \to tW^{\pm}(W^*)\tilde{\chi}_1^0$: $m_{\tilde{t}} = 550$ GeV, $m_{\tilde{\chi}_2^0} = 375$ GeV, $m_{\tilde{\chi}_1^0} = 275$ GeV	40.09	3.03	9.11 (8.99)	0.93
	$\tilde{t} \to tW^{\pm}(W^*)\tilde{\chi}_1^0$: $m_{\tilde{t}} = 750$ GeV, $m_{\tilde{\chi}_2^0} = 575$ GeV, $m_{\tilde{\chi}_1^0} = 475$ GeV	6.90		2.62 (2.43)	0.69
	$\tilde{t} \to tW^{\pm}(W^*)\tilde{\chi}_1^0$: $m_{\tilde{t}} = 850$ GeV, $m_{\tilde{\chi}_2^0} = 675$ GeV, $m_{\tilde{\chi}_1^0} = 575$ GeV	3.40		1.45 (1.24)	0.53
Rpv2L	$\tilde{g} \to tbd$ ($\lambda''_{331} \neq 0$: $m_{\tilde{g}} = 1600$ GeV, $m_{\tilde{t}} = 1200$ GeV	7.06	4.85	2.12 (1.94)	0.60
	$\tilde{g} \to tbd$ ($\lambda''_{331} \neq 0$: $m_{\tilde{g}} = 1600$ GeV, $m_{\tilde{t}} = 800$ GeV	8.04		2.37 (2.18)	0.62
	$\tilde{g} \to tbd$ ($\lambda''_{331} \neq 0$: $m_{\tilde{g}} = 1600$ GeV, $m_{\tilde{t}} = 400$ GeV	6.52		2.00 (1.80)	0.57

prompt bkg estimation:

- Estimated via simulated samples
- experimental and theoretical uncertainties are taken into account
- Total theoretical uncertainties for the VV, VVV, $t\bar{t}$V and $t\bar{t}$H processes, in all signal and validations regions. These results are obtained for 139 fb^{-1}, with AB 21.2.70 ntuples

Region	WZ		ZZ		WW		VVV	
	Yields	Unc. [%]	Yields	Unc. [%]	Yields	Unc. [%]	Yields	Unc. [%]
VR_ttV	5.58	+32.40/-25.48	0.17	+50.00/-50.00	0.71	+28.10/-21.95	0.33	+27.20/-25.99
VR_WZ4j	317.81	+36.48/-27.19	10.5	+34.84/-26.36	0.0	–	14.27	+31.28/-26.62
VR_WZ5j	155.4	+37.44/-28.10	6.83	+35.69/-27.25	0.0	–	7.44	+31.70/-27.48
Rpc2L0b	1.86	+40.93/-35.19	0.02	+50.00/-50.00	0.35	+42.68/-34.77	0.19	+30.89/-30.89
Rpc2L1b	0.27	+42.22/-35.90	0.0	–	0.06	+36.38/-36.38	0.02	+50.00/-50.00
Rpc2L2b	0.2	+37.03/-41.78	0.0	–	0.02	+50.00/-50.00	0.03	+38.87/-38.87
Rpv2L	1.05	+45.44/-39.90	0.05	+50.00/-50.00	0.26	+49.44/-41.11	0.24	+31.47/-28.88

(a) Global theory uncertainties for diboson and triboson background processes.

	ttZ		ttW	
Region	Yields	Unc. [%]	Yields	Unc. [%]
VR_ttV	33.07	+22.44/-22.55	25.15	+19.28/-19.74
VR_WZ4j	37.46	+21.14/-21.79	0.4	+30.93/-25.00
VR_WZ4j	27.52	+23.54/-24.35	0.32	+33.99/-30.98
Rpc2L0b	0.26	+28.45/-22.99	0.38	+47.32/-42.55
Rpc2L1b	1.16	+32.98/-33.13	1.59	+37.47/-34.38
Rpc2L2b	1.02	+23.61/-21.37	1.82	+38.67/-30.93
RpcSS3L	0.66	+38.80/-37.47	0.54	+30.17/-30.95
Rpv2L	0.27	+44.98/-41.16	0.63	+45.34/-42.62

(b) Total uncertainties for $t\bar{t}V$ background processes.

Region	Yields	Unc [%]
VR_ttV	8.41	+11.98/-14.33
VR_WZ4j	1.09	+17.81/-17.74
VR_WZ4j	0.98	+18.11/-17.41
Rpc2L0b	0.27	+35.96/-32.56
Rpc2L1b	1.08	+24.91/-24.35
Rpc2L2b	0.9	+30.14/-22.93
RpcSS3L	0.53	+14.99/-15.10
Rpv2L	0.27	+40.96/-37.83

(c) Total uncertainties for $t\bar{t}H$ background processes.

prompt bkg estimation:

- Comparison of the event yields for the $t\bar{t}W$ background processes between aMC@NLO (default generator) and Sherpa 2.2.1 multileg–NLO samples in the most relevant VRs and SRs, as well as their relative difference. For completeness, the yields obtained with the available Sherpa 2.2.5 samples are also shown. Only the statistical uncertainties are displayed. These results are obtained for 139 fb^{-1}, with AB 21.2.70 ntuples

Region	aMC@NLO	Sherpa 2.2.1 multileg–NLO	Relative diff.	Sherpa 2.2.5 inc–NLO (Sherpa 2.2.5 multileg–NLO)
VRTTV	25.77 ± 0.47	23.60 ± 0.45	8%	31.12 ± 0.43 (32.93 ± 0.57)
Rpc2L1b	1.56 ± 0.12	1.56 ± 0.11	0%	1.64 ± 0.09 (1.83 ± 0.14)
Rpc2L2b	1.81 ± 0.13	1.85 ± 0.14	2%	2.12 ± 0.10 (2.53 ± 0.17)
Rpv2L	0.64 ± 0.07	0.47 ± 0.06	27%	0.68 ± 0.05 (0.53 ± 0.07

prompt bkg estimation:

- TopRareDecay: may also contribute extra leptons which will further goes into our final selections
  - estimated via estimating the contributions directly, with PHOTOS++ pkg
  - Checks using LO MC16 $t\bar{t}$ samples

selections	Events	Fraction
Total	10000000	100%
With extra leptons	13232	0.13%
pass ΔR(bjet,extra lepton)	13077	0.13%
pass ΔR(lepton,extra lepton)	9961	0.10%
pass ΔISO(extra lepton)	6191	0.062%
Extra lepton $p_T > 10$ GeV	466	0.0047%
Extra lepton $p_T > 15$ GeV	184	0.0018%
Extra lepton $p_T > 20$ GeV	47	0.00047%
2 pass ΔR(bjet,extra lepton)	12718	0.13%
2 pass ΔR(lepton,extra lepton)	8952	0.09%
2 pass ΔISO(extra lepton)	698	0.007%
2 Extra lepton $p_T > 10$ GeV	44	0.000444%
2 Extra lepton $p_T > 15$ GeV	3	3e-05%
2 Extra lepton $p_T > 20$ GeV	1	1e-05%

	VRTTV	VRWZ4j	VRWZ5j
$t\bar{t}$, 410470	12.61 ± 2.21	4.60 ± 1.67	3.07 ± 1.02
$t\bar{t}$, HTslices	7.82 ± 0.80	1.43 ± 0.32	0.60 ± 0.20
$t\bar{t}$, METslices	1.01 ± 0.16	0.30 ± 0.10	0.21 ± 0.09
$t\bar{t}$, Rare Decay	0.57 ± 0.07	0.08 ± 0.03	0.09 ± 0.03

(a) Validation regions:

	Rpc2L0b	Rpc2L1b	Rpc2L2b	Rpc3LSS1b	Rpv2L
$t\bar{t}$, 410470	0.00 ± 0.00	1.19 ± 0.60	0.41 ± 0.30	0.97 ± 0.63	0.14 ± 0.14
$t\bar{t}$, HTslices	0.33 ± 0.11	1.20 ± 0.29	1.24 ± 0.12	0.01 ± 0.01	0.57 ± 0.07
$t\bar{t}$, METslices	0.44 ± 0.08	1.35 ± 0.16	1.13 ± 0.10	0.04 ± 0.03	0.49 ± 0.16
$t\bar{t}$, Rare Decay	0.01 ± 0.01	0.06 ± 0.02	0.02 ± 0.01	0.10 ± 0.03	0.02 ± 0.01

(b) Signal regions:

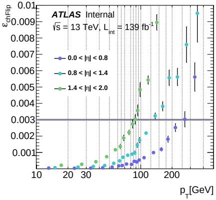
Charge-flip estimation:

- a data-driven method was used

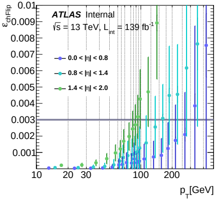
$$w_{\text{flip}} = \xi_1(1-\xi_2) + (1-\xi_1)\xi_2$$

- rely on the correct measurement on $\xi(p_T, \eta)$, cross-checked with the ones obtained using the (likelihood-based) method

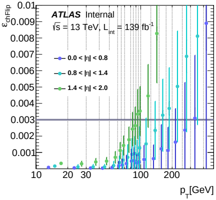
$$\xi_{\text{Data}} = \xi_{\text{True}} \times \text{SF}; \qquad (\text{SF} = \frac{\xi_{\text{Data}}}{\xi_{\text{MC}}})$$



True Rates, $t\bar{t}$



True Rates $\times$ SFs, $t\bar{t}$



True Rates $\times$ SFs, Zjets

Charge-flip estimation:

- Systematics coming from propagating uncertainties from charge-flip rate and p_T shift caused by bremsstrahlung
- variations of the charge-flip rate are obtained by:

$$\xi^{syst}_{Data} = \text{fabs}(\xi^{UP}_{Data} - \xi_{Data})$$

  where ξ^{UP}_{Data} obtained via UP variation of the SFs
- p_T shift effects accessed via shifting down the transverse momentum of one electron (the one with largest η) in all OS events used for the charge-flip background estimate
- effects are negligible

Rpc2L0b	Rpc2L1b	Rpc2L2b	Rpc3LSS1b	Rpv2L	VR-TTV
2%	2%	0%	0%	−0.5%	−4%

Fake/non-prompt events estimation:

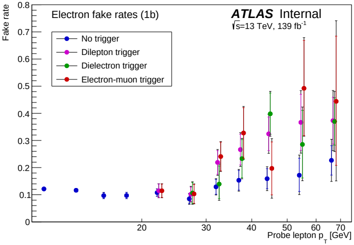
- matrix method was used, highly rely on fake/true lepton rates (ξ/ϵ)
- inputs to this method is slightly different from the nominal inputs used in our analysis:

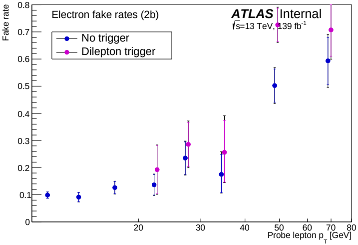
Channel	$e^{\pm}e^{\pm}$	$\mu^{\pm}e^{\pm}$	$e^{\pm}\mu^{\pm}$	$\mu^{\pm}\mu^{\pm}$	$\ell^{\pm}\ell'^{\mp}e^{\mp}$	$\ell^{\pm}\ell'^{\mp}\mu^{\mp}$
Event selection	≥ 1 b-jet, ≥ 2 jets ($p_T > 25$ GeV), $E_T^{miss} > 30$ GeV $E_T^{miss} < 150$ GeV, $m_{eff} < 1.5$ TeV no extra baseline lepton					
Extras	≥ 3 jets				no OSSF pair with $m \in [81, 101]$ GeV	
Tag lepton	Lead. e	μ	e	Lead. μ	ℓ'	ℓ'
Probe lepton	Sublead. e	e	μ	Sublead. μ	e	μ
Tag cuts	$p_T > p_T^{probe} + 20$ GeV, signal lepton selection, $\mathsf{max}\{\text{ptvarcone40}, \text{topoetcone40}\} < 0.02 \times p_T$ + tag electrons must also satisfy tightLH PID					
Trigger (*)	di-e || single-e	e-μ || single-μ	e-μ || single-e	di-μ || single-μ	same as ℓ'e	same as $\ell'\mu$
	+ the tag lepton must be trigger-matched when the event was acquired with the single-ℓ trigger					

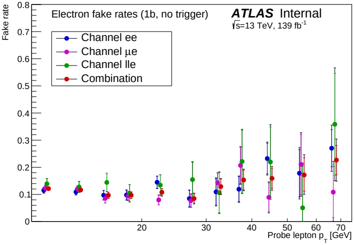
(*) the trigger chains used for 2015 data are respectively e24_lhmedium_iloose_L1EM20VH (single-e), mu20_iloose_L1MU15 (single-μ), e17_lhloose_mu14 (e-μ), mu18_mu8noL1 (di-μ) and 2e12_lhloose_L12EM10VH – and similar unprescaled chains for 2016–2018 data (in particular 2e24_lhvloose_nod0 for 2017–2018).

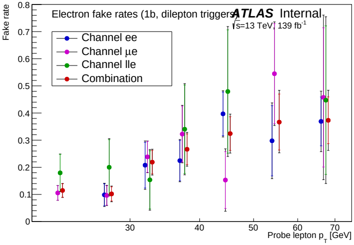
Fake/non-prompt events estimation:

- Fake rate measurement:
  - obtained by data in regions enriched with fakes produced by $t\bar{t}$ using "tag-and-probe" method
  - strong dependence on lepton flavor, b-tagged jets multiplicity, and triggers



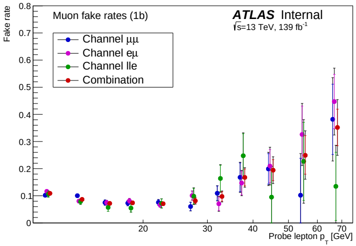


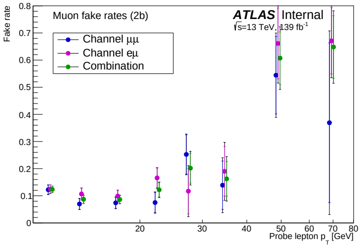




Fake/non-prompt events estimation:

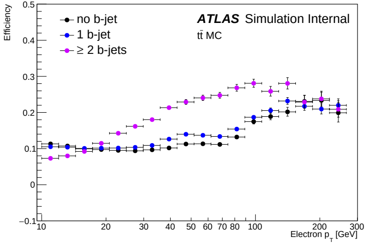
- Fake rate measurement:
  - obtained by data in regions enriched with fakes produced by $t\bar{t}$ using "tag-and-probe" method
  - strong dependence on lepton flavor, b-tagged jets multiplicity, and triggers

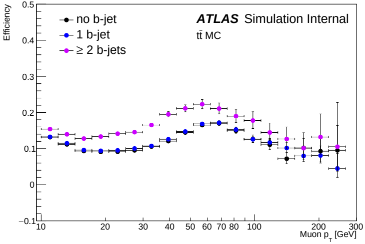


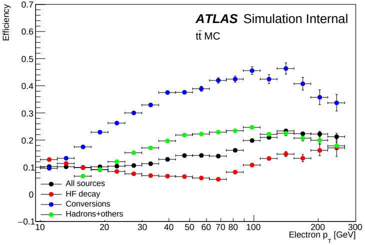


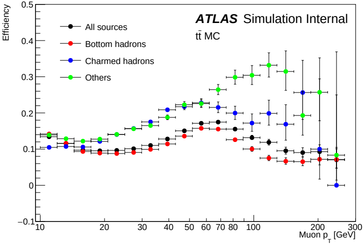
Fake/non-prompt events estimation:

- Fake rate measurement:
    - uncertainties coming from statistical, reduction of prompt SM processes,









Fake/non-prompt events estimation:

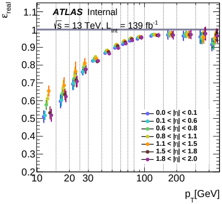
- Fake rate measurement:
  - uncertainties coming from statistical, reduction of prompt SM processes, b-tagged jets multiplicity, different sources of fakes, and busy environment

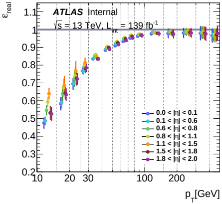
Channel	Electrons	Muons
Events with $= 0$b	$\pm 15\%$	$\pm 15\%$
Extrapolation to higher p_T	0% (covered by measurement uncertainties and/or next item)	
Underlying jet kinematics / event topology	$\pm 30\%$ for $p_T < 100$ GeV $\pm 50\%$ for $p_T > 100$ GeV	$\pm 30\%$ for $p_T < 30$ GeV $^{+30\%}_{-50\%}$ for $30 < p_T < 50$ GeV $^{+30\%}_{-80\%}$ for $p_T > 50$ GeV

Fake/non-prompt events estimation:

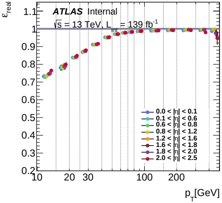
- real lepton rate measurement:
  - obtained via simulated $t\bar{t}$ samples, cross-checked with $Z \rightarrow ee$ data and MC events

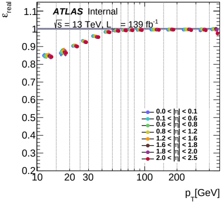
$$\varepsilon_{\mathrm{Data}} = \varepsilon_{\mathrm{True}} \times \frac{\mathrm{SF}^{\mathrm{tight}}}{\mathrm{SF}^{\mathrm{loose}}}$$





True e Rates × SFs, $t\bar{t}$ True e Rates × SFs, Zjets





Fake/non-prompt events estimation:

- real lepton rate measurement:
  - uncertainties coming from the variations of SFs

$$\varepsilon^{\mathrm{syst}}_{\mathrm{Data}} = \mathrm{fabs}(\varepsilon^{\mathrm{UP}}_{\mathrm{Data}} - \varepsilon_{\mathrm{Data}}); \quad (\varepsilon^{\mathrm{UP}}_{\mathrm{Data}} = \varepsilon_{\mathrm{True}} \times \frac{\mathrm{SF}^{\mathrm{tight,UP}}}{\mathrm{SF}^{\mathrm{loose,UP}}}).$$

  - uncertainties also coming from extrapolation to busy environments, obtained by comparing the efficiency measured in Gtt samples (as function of $\mathrm{p_T}$ and $\Delta\mathrm{R}(\ell, \mathrm{j})$), to the nominal one

$$\varepsilon^{\mathrm{Syst,BusyTopo}}_{\mathrm{Data}}(\mathrm{p_T}, \Delta\mathrm{R}(\ell,\mathrm{j})) = \int \varepsilon_{\mathrm{Data,tt}}(\mathrm{p_T}, \eta) \frac{\partial \mathrm{N_{Gtt}}}{\partial \eta}(\mathrm{p_T}, \Delta\mathrm{R}) \mathrm{d}\eta - \varepsilon_{\mathrm{Data,Gtt}}(\mathrm{p_T}, \Delta\mathrm{R}(\ell,\mathrm{j}))$$

p_T bin [GeV]	$0 < \Delta R(l,j) < 0.4$	$0.4 < \Delta R(l,j) < 0.6$	$\Delta R(l,j) > 0.6$
$10 < p_T < 15$ GeV	0.32 ± 0.05 (stat, $t\bar{t}$) ± 1.00 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	−0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)
$15 < p_T < 20$ GeV	0.32 ± 0.04 (stat, $t\bar{t}$) ± 0.19 (stat, Gtt)	0.11 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	−0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)
$20 < p_T < 25$ GeV	0.32 ± 0.04 (stat, $t\bar{t}$) ± 0.29 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)
$25 < p_T < 30$ GeV	0.32 ± 0.04 (stat, $t\bar{t}$) ± 0.24 (stat, Gtt)	0.12 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)
$30 < p_T < 40$ GeV	0.32 ± 0.01 (stat, $t\bar{t}$) ± 0.07 (stat, Gtt)	0.10 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)
$40 < p_T < 50$ GeV	0.24 ± 0.01 (stat, $t\bar{t}$) ± 0.03 (stat, Gtt)	0.10 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.03 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$50 < p_T < 60$ GeV	0.18 ± 0.01 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.04 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$60 < p_T < 70$ GeV	0.16 ± 0.01 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.09 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.07 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$70 < p_T < 80$ GeV	0.15 ± 0.01 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.07 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$80 < p_T < 100$ GeV	0.18 ± 0.01 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$100 < p_T < 150$ GeV	0.16 ± 0.01 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.07 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.10 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$150 < p_T < 200$ GeV	0.13 ± 0.01 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.13 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$200 < p_T < 300$ GeV	0.12 ± 0.02 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.14 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$300 < p_T < 400$ GeV	0.21 ± 0.06 (stat, $t\bar{t}$) ± 0.03 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.14 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$p_T > 400$ GeV	0.25 ± 0.12 (stat, $t\bar{t}$) ± 0.05 (stat, Gtt)	0.05 ± 0.01 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.14 ± 0.01 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)

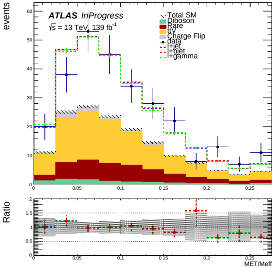
(a) Electrons

p_T bin	$0 < \Delta R(l,j) < 0.4$	$0.4 < \Delta R(l,j) < 0.5$	$0.5 < \Delta R(l,j) < 0.6$	$\Delta R(l,j) > 0.6$
$10 < p_T < 15$ GeV	0.38 ± 0.03 (stat, $t\bar{t}$) ± 0.22 (stat, Gtt)	0.36 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.19 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	−0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)
$15 < p_T < 20$ GeV	0.38 ± 0.02 (stat, $t\bar{t}$) ± 0.26 (stat, Gtt)	0.33 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.18 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	−0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)
$20 < p_T < 25$ GeV	0.38 ± 0.02 (stat, $t\bar{t}$) ± 0.22 (stat, Gtt)	0.32 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.16 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)
$25 < p_T < 30$ GeV	0.38 ± 0.02 (stat, $t\bar{t}$) ± 0.18 (stat, Gtt)	0.30 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.19 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)
$30 < p_T < 40$ GeV	0.38 ± 0.00 (stat, $t\bar{t}$) ± 0.03 (stat, Gtt)	0.27 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.14 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.03 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$40 < p_T < 50$ GeV	0.30 ± 0.00 (stat, $t\bar{t}$) ± 0.02 (stat, Gtt)	0.14 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.08 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$50 < p_T < 60$ GeV	0.21 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.09 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.04 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.03 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$60 < p_T < 70$ GeV	0.16 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.07 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.03 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$70 < p_T < 80$ GeV	0.12 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.06 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.03 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$80 < p_T < 100$ GeV	0.09 ± 0.00 (stat, $t\bar{t}$) ± 0.01 (stat, Gtt)	0.03 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$100 < p_T < 150$ GeV	0.05 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$150 < p_T < 200$ GeV	0.03 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$200 < p_T < 300$ GeV	0.02 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$300 < p_T < 400$ GeV	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	−0.00 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.00 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)
$p_T > 400$ GeV	0.00 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.00 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	−0.00 ± 0.01 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)	0.01 ± 0.00 (stat, $t\bar{t}$) ± 0.00 (stat, Gtt)

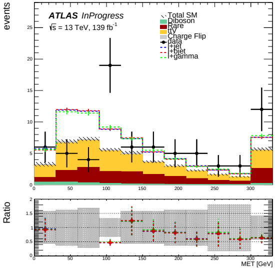
(b) Muons

Fake/non-prompt events estimation:

- ABCD method (used to cross-check:)
  - $N^{\ell^\pm\ell^\pm}_{\text{fakes,SR}} = \frac{N^{\ell+X}_{\text{data, SR}}}{N^{\ell+X}_{\text{data, CR}}}\left(N^{\ell^\pm\ell^\pm}_{\text{data, CR}} - N^{\text{prompt}}_{\text{MC, CR}} - N^{\text{charge-flip}}_{\text{data-driven, CR}}\right)$



Rpc2L1b, ABCD method



Rpc2L2b, ABCD method

Fake/non-prompt events estimation:

- ABCD method (used to cross-check:)
  - uncertainties only on statistical and m_{eff} related uncertainties are taken into account

Region	Fakes(ℓ+Jet)	Fakes(ℓ+BJet)	Fakes($\ell + \gamma$)
Rpc2L0b	1.353±0.749 ± 0.101	1.310±0.725 ± 0.389	1.389±0.778 ± 0.279
Rpc2L1b	2.619±0.355 ± 0.534	2.640±0.359 ± 1.403	2.524±0.379 ± 1.652
Rpc2L2b	1.795±0.670 ± 0.111	1.784±0.670 ± 0.204	2.044±0.790 ± 0.492
Rpc3LSS1b	2.501±2.551 ± 0.786	1.757±1.793 ± 0.642	1.925±1.968 ± 1.102
Rpv2L	0.414±0.049 ± 0.035	0.267±0.033 ± 0.102	0.675±0.113 ± 0.199

Region	Matrix method	ABCD method
Rpc2L0b	1.1 ± 0.7 (stat)$^{+0.5}_{-0.9}$ (syst)	1.4 ± 0.7 (stat)
Rpc2L1b	1.3 ± 0.8 (stat)$^{+0.4}_{-0.8}$ (syst)	2.6 ± 0.4 (stat)
Rpc2L2b	1.4 ± 1.0 (stat)$^{+1.0}_{-1.4}$ (syst)	1.9 ± 0.7 (stat)
Rpc3LSS1b	2.6 ± 0.9 (stat)$^{+0.9}_{-1.1}$ (syst)	2.5 ± 2.6 (stat)
Rpv2L	1.4 ± 0.9 (stat)$^{+0.8}_{-1.4}$ (syst)	0.4 ± 0.1 (stat)

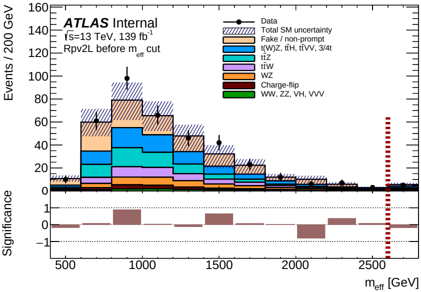
N-1 plots:

- SRs involving an effective mass cut: it is relaxed together with the E_T^{miss} cut to avoid indirectly tightening requirements on the visible leptonic and hadronic contributions to m_{eff} for low values of E_T^{miss}; the m_{eff} requirement is therefore changed to:

$$m_{eff} > \left(m_{eff}^{SR\ cut}\right) - \max\left[\left(E_T^{miss,\ SR\ cut}\right) - E_T^{miss}, 0\right]$$

- SRs involving a cut on the E_T^{miss}/m_{eff} ratio: it is relaxed together with the E_T^{miss} cut to allow populating the low E_T^{miss} tail of the distributions:

$$\frac{E_T^{miss}}{m_{eff}} > \left(\frac{E_T^{miss}}{m_{eff}}\right)^{SR\ cut} \times \min\left[\frac{E_T^{miss}}{\left(E_T^{miss,\ SR\ cut}\right)^{SR\ cut}}, 1\right]$$



pull plots:

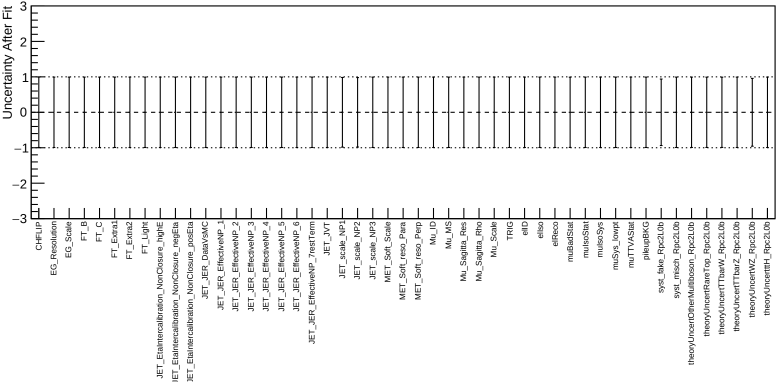


Figure 2: After fit parameter values for Rpc2L0b

pull plots:

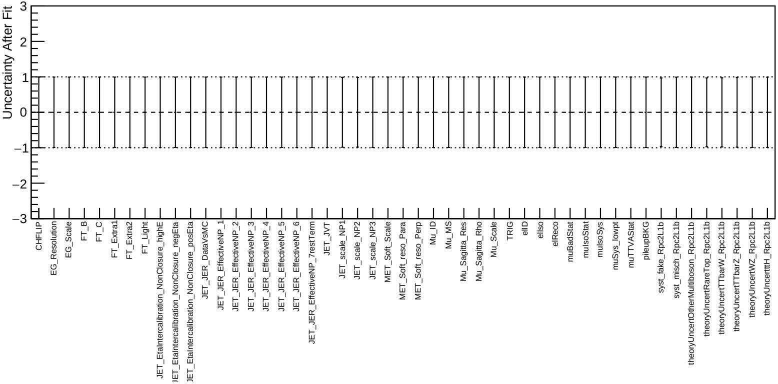


Figure 3: After fit parameter values for Rpc2L1b

pull plots:

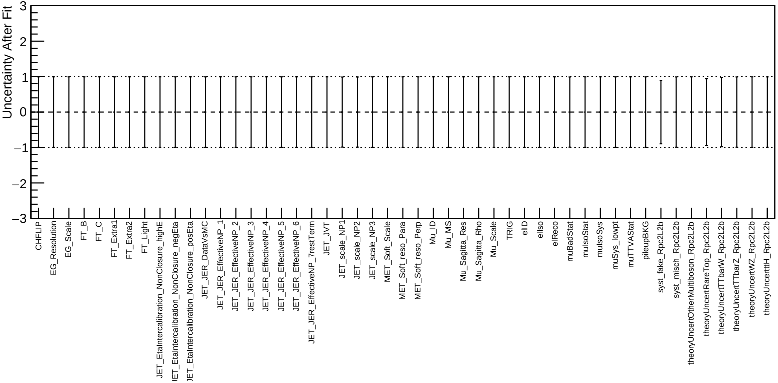


Figure 4: After fit parameter values for Rpc2L2b

pull plots:

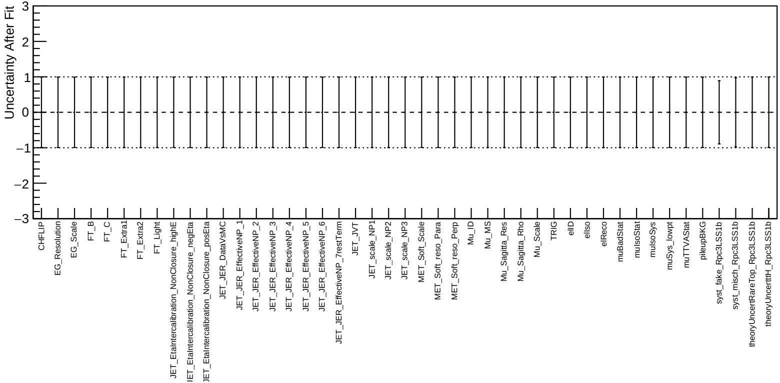


Figure 5: After fit parameter values for Rpc3LSS1b

pull plots:

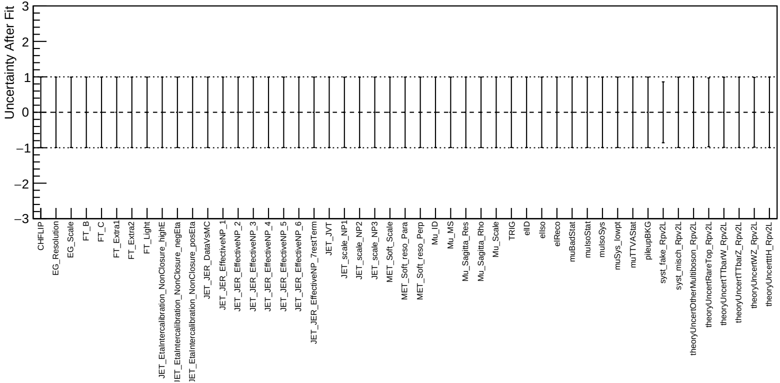


Figure 6: After fit parameter values for Rpv2L

pull plots:

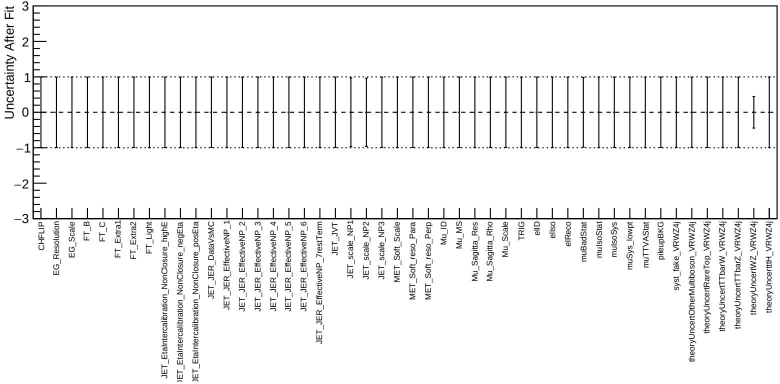


Figure 7: After fit parameter values for VRWZ4j

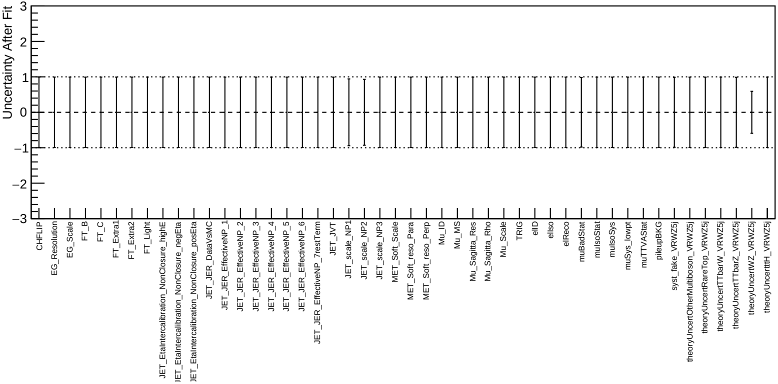


Figure 8: After fit parameter values for VRWZ5j

pull plots:

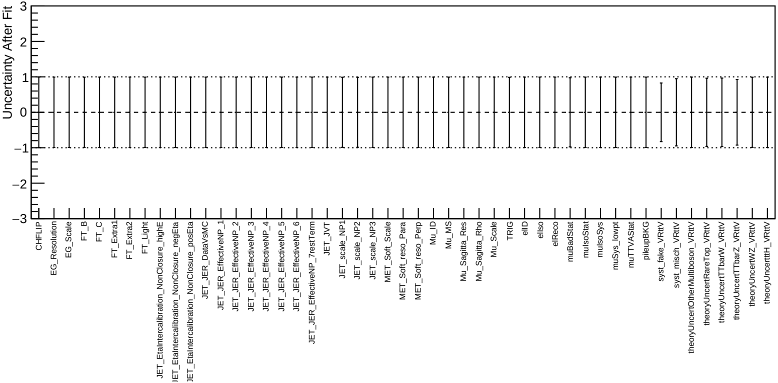
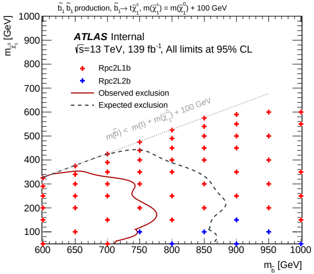
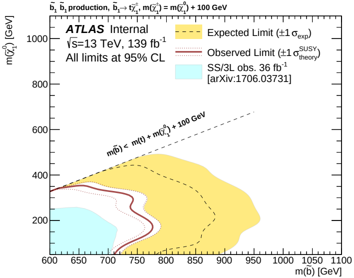
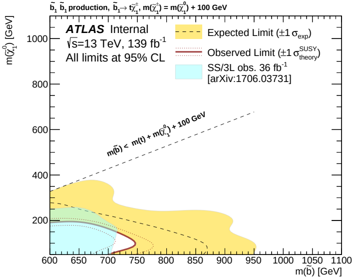


Figure 9: After fit parameter values for VRttV

limits:


b̃₁ b̃₁ production, b̃₁→ tχ̃±₁, m(χ̃±₁) = m(χ̃⁰₁) + 100 GeV
ATLAS Internal
√s=13 TeV, 139 fb-1, All limits at 95% CL
Rpc2L1b
Rpc2L2b
Observed exclusion
Expected exclusion
m(b̃) < m(t) + m(χ̃⁰₁) + 100 GeV
m_χ̃⁰₁ [GeV]
m_b̃ [GeV]


b̃₁ b̃₁ production, b̃₁→ tχ̃±₁, m(χ̃±₁) = m(χ̃⁰₁) + 100 GeV
ATLAS Internal
√s=13 TeV, 139 fb-1
All limits at 95% CL
Expected Limit (±1 σexp)
Observed Limit (±1 σSUSY theory)
SS/3L obs. 36 fb-1
[arXiv:1706.03731]
m(b̃) < m(t) + m(χ̃⁰₁) + 100 GeV
m(χ̃⁰₁) [GeV]
m(b̃) [GeV]


b̃₁ b̃₁ production, b̃₁→ tχ̃±₁, m(χ̃±₁) = m(χ̃⁰₁) + 100 GeV
ATLAS Internal
√s=13 TeV, 139 fb-1
All limits at 95% CL
Expected Limit (±1 σexp)
Observed Limit (±1 σSUSY theory)
SS/3L obs. 36 fb-1
[arXiv:1706.03731]
m(b̃) < m(t) + m(χ̃⁰₁) + 100 GeV
m(χ̃⁰₁) [GeV]
m(b̃) [GeV]

THE END