ATLAS search for EWK SUSY in a three lepton final state

RAMP #6 Seminar:
Auxiliary Material Presentation

25th October 2021

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UNIVERSITY OF SUSSEX

ATLAS EXPERIMENT

CERN

Introduction

- ATLAS search for **chargino-neutralino** pair production with ***WZ/Wh* boson-mediated** decays to **three-lepton final state** in $\sqrt{s}$ = 13 TeV pp collision data
  - Paper recently **accepted to EPJC**
  - Useful links: **Twiki**, **arXiv**, **InspireHEP**, **HEPData**

- Outline:
  - Analysis target and strategy
  - Results overview
  - Recursive Jigsaw Reconstruction (RJR) Run 2 follow-up
  - Available HEPData material

EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

Submitted to: EPJC

CERN-EP-2021-059
4th June 2021

Search for chargino–neutralino pair production in final states with three leptons and missing transverse momentum in $\sqrt{s}$ = 13 TeV pp collisions with the ATLAS detector

The ATLAS Collaboration

A search for chargino–neutralino pair production in three-lepton final states with missing transverse momentum is presented. The study is based on a dataset of $\sqrt{s}$ = 13 TeV pp collisions recorded with the ATLAS detector at the LHC, corresponding to an integrated luminosity of 139 fb^{-1}. No significant excess relative to the Standard Model predictions is found in data. The results are interpreted in simplified models of supersymmetry, and statistically combined with results from a previous ATLAS search for compressed spectra in two-lepton final states. Various scenarios for the production and decay of charginos ($\tilde{\chi}_1^\pm$) and neutralinos ($\tilde{\chi}_2^0$) are considered. For pure higgsino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ pair-production scenarios, exclusion limits at 95% confidence level are set on $\tilde{\chi}_2^0$ masses up to 210 GeV. Limits are also set for pure wino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ pair production, on $\tilde{\chi}_2^0$ masses up to 640 GeV for decays via on-shell W and Z bosons, up to 300 GeV for decays via off-shell W and Z bosons, and up to 190 GeV for decays via W and Standard Model Higgs bosons.

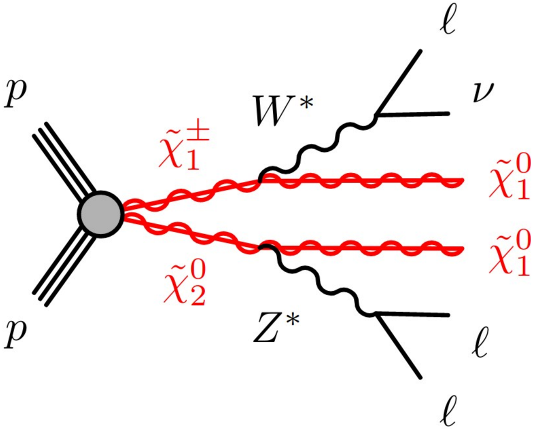
Targeted signal models: *Wino-Bino(+)* scenario

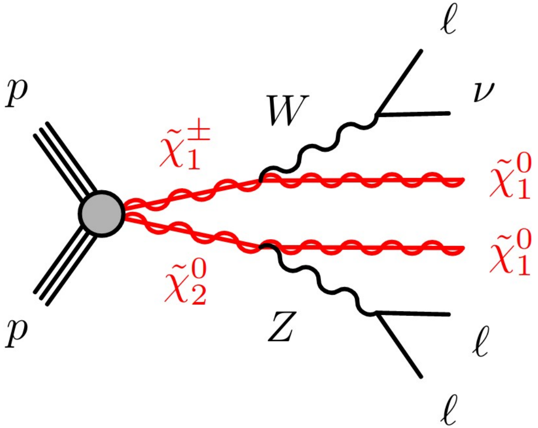
Simplified models assumptions:

- **MSSM**
- EWK direct production of **Chargino-Neutralino**
- **Wino-Bino** scenario: $|M_1| < |M_2| \ll |\mu|$
- $m_{\text{eig}}(\tilde{\chi}_2^0) \times m_{\text{eig}}(\tilde{\chi}_1^0) > 0$ → ***Wino-Bino(+)***
- $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0 \rightarrow$ **Wino-like** and **mass-degenrate**
- **R-parity conserving** decay to **Bino-like**, stable LSP = $\tilde{\chi}_1^0$
- **SM gauge-** and **SM Higgs-mediated** decays (100% B.R.)
- **Final state**: **three leptons** (e or μ) + E_T^{miss} + **light jets**

"Off-shell WZ"

$\Delta m(\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0, \tilde{\chi}_1^0) < m_Z$



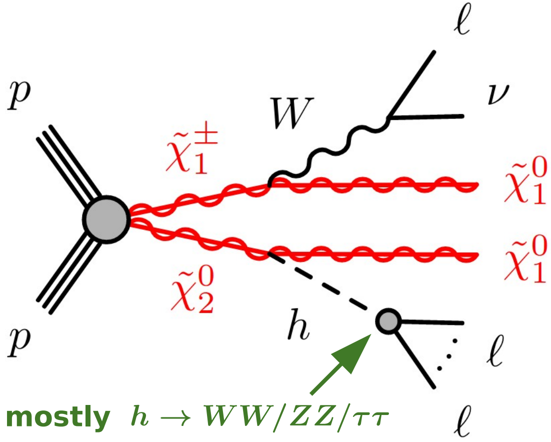


"On-shell WZ"

$\Delta m(\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0, \tilde{\chi}_1^0) \gtrsim m_Z$

"On-shell Wh"

$\Delta m(\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0, \tilde{\chi}_1^0) > m_h$



Models Reinterpretations & Combination

- ***Wino-Bino(+) Off-shell WZ*** model → reinterpreted in the context of :

  → ***Wino-Bino(–)*** scenario:

  - Same simplified model assumptions except for: $m_{\text{eig}}(\tilde{\chi}_2^0) \times m_{\text{eig}}(\tilde{\chi}_1^0) < 0$
  - **Different mass lineshape of *Z*** boson from $\tilde{\chi}_2^0$ decay → mainly for ***Δm < m*$_Z$ *(off-shell)***
  - *Wino-Bino(+)* signal samples reweighted based on m_{Z^*}

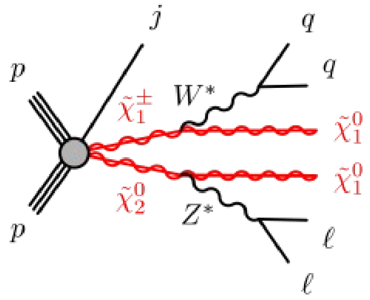
  → ***Higgsino*** scenario:

  - $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0, \tilde{\chi}_1^0$ → purely **higgsino** states
  - $m(\tilde{\chi}_1^\pm) = \dfrac{m(\tilde{\chi}_2^0) + m(\tilde{\chi}_1^0)}{2}$

- Results in the ***WZ-mediated*** scenario(s):

  - **Statistically combined together** and with a **previous ATLAS search** (**Phys. Rev. D 101 (2020) 052005**) in **two-lepton** final state:

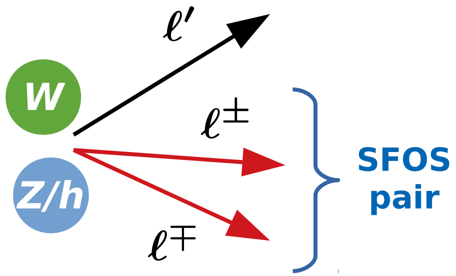
    - ***"Compressed"***
    - Model interpretations considered: ***Wino-Bino(+/–)*** and ***Higgsino*** scenarios



Analysis strategy: *On-shell WZ* and *Wh*

- Trigger strategy: **di-lepton** → $p_T^{\ell_1}, p_T^{\ell_3}, p_T^{\ell_3} \geq 25,\ 20,\ 10\,\mathrm{GeV}$ → trigger efficiency plateau
- Event selection based on the presence of a **Same-Flavour Opposite-Sign (SFOS)** lepton pair + **one extra lepton**

$n_{SFOS} \geq 1$



- If $\left|m_{\ell\ell}^{\mathrm{SFOS}} - m_Z\right| < 15\,\mathrm{GeV}$

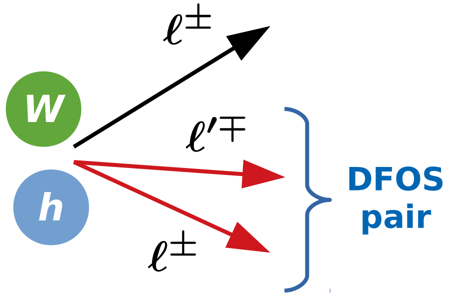
  → Target = ***On-shell WZ***

- If $\left|m_{\ell\ell}^{\mathrm{SFOS}} - m_Z\right| \geq 15\,\mathrm{GeV}$

  → Target = ***On-shell Wh***

- **Binned Signal Regions (SRs)** approach (see *back-up*):
  - **Enhance sensitivity** for different $\Delta m(\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0,\ \tilde{\chi}_1^0)$ scenarios
  - Better control over main SM backgrounds (**e.g. *WZ→3l***)
  - Exploit **topologies** with jets from **Initial State Radiation**

$n_{SFOS} = 0$



- **Different-Flavour Opposite Sign (DFOS)** lepton pair from SM Higgs decay
- Background suppression with requirements on:
  - Angular separation b/w DFOS leptons
  - High E_T^{miss} significance (due to $\tilde{\chi}_1^0$)
  - Binning in light jet multiplicity

- $E_T^{miss} \geq 50\,\mathrm{GeV}$ (suppression of *Z+jets* background) and **b-tagged jet veto** (suppression of top-related backgrounds)

Analysis strategy: *Off-shell WZ*

- Trigger strategy: **multi-lepton** and E_T^{miss} **triggers** → different p_T^{ℓ}, / E_T^{miss} thresholds → trigger efficiency plateau
- **n_{SFOS} ≥1 SFOS lepton pair**
  - If n_{SFOS}>1 → consider the SFOS pair with lowest invariant mass ($m_{\ell\ell}^{\min}$)
- Event selection based on $m_{\ell\ell}^{\min}$ to maximally **suppress combinatorial background from on-shell *Z* boson**:

$$1\,\mathrm{GeV} \leq m_{\ell\ell}^{\min} \leq m_{\ell\ell}^{\max} < 75\,\mathrm{GeV}$$

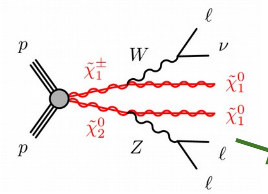
- **SRs binned** in $m_{\ell\ell}^{\min}$ (see *back-up*):
  → to target different $\Delta m(\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0, \tilde{\chi}_1^0)$ scenarios
  → veto on *J/Ψ* and Υ resonances

+

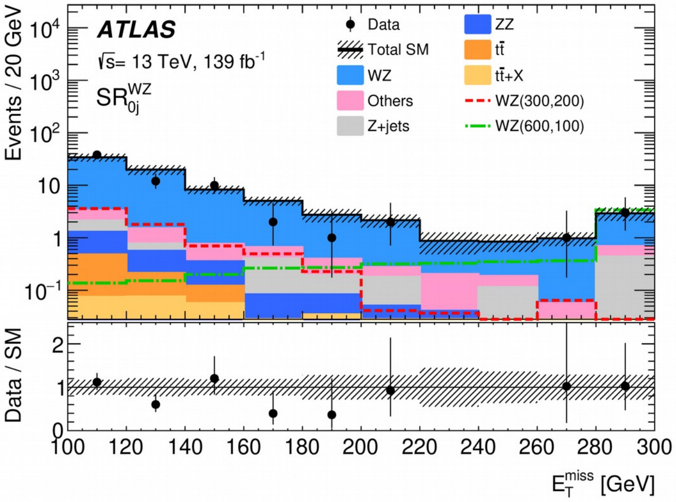
- **Four different categories** for SRs based on:
  → Jet multiplicity (=0 and ≥1)
  → Low and High E_T^{miss}

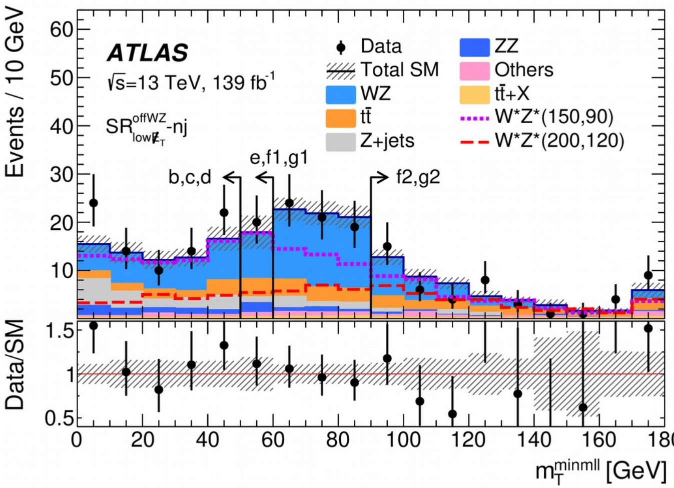
- SRs **further optimised individually** by means of other kinematics constraints
- Dedicated multi-variate, **Boosted Decision Tree (BDT)-based isolation requirement** on the **softest lepton**
  → suppression of **backgrounds from SM *Z+jets*** in which softest lepton likelier to be **“fake/non-prompt”**
- **b-tagged jet veto**

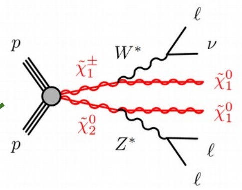
Standard Model backgrounds



On-shell WZ

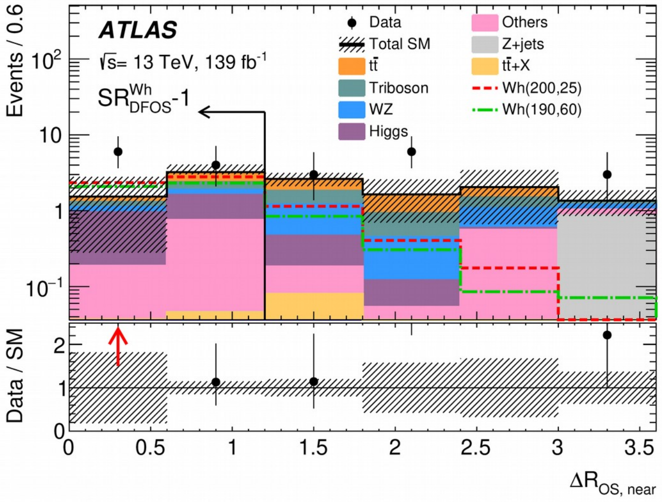


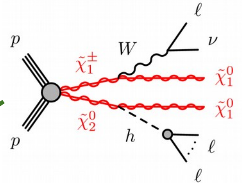




Off-shell WZ

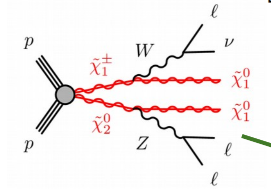
- **Irreducible** backgrounds from:
  - SM ***WZ→3l*** (mainly in SFOS SRs) → MC normalised to data in a Control Region (CR)
  - SM ***Higgs*** and ***Triboson*** processes (mainly in DFOS SRs)
- **Reducible** backgrounds with “fake/non-prompt” leptons from SM ***Z+jets*** (estimated from data) and $\boldsymbol{t\bar{t}}$
- Final background estimate from ***profile log-likelihood fit***, simultaneous in all (orthogonal) CRs and SRs



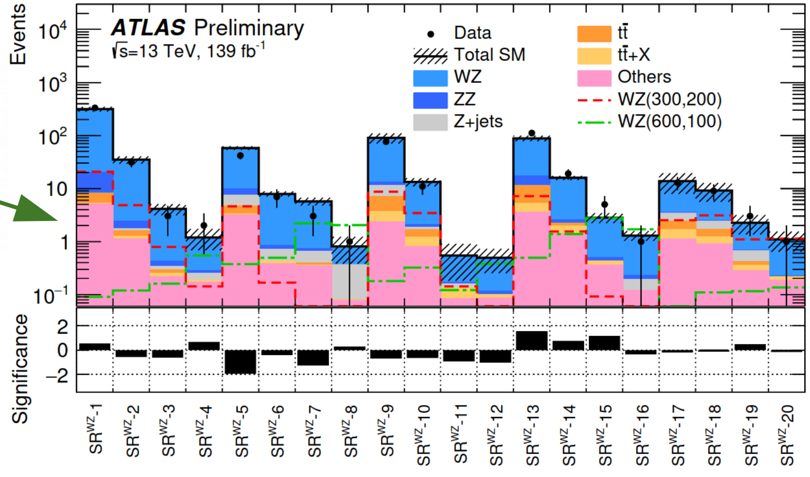


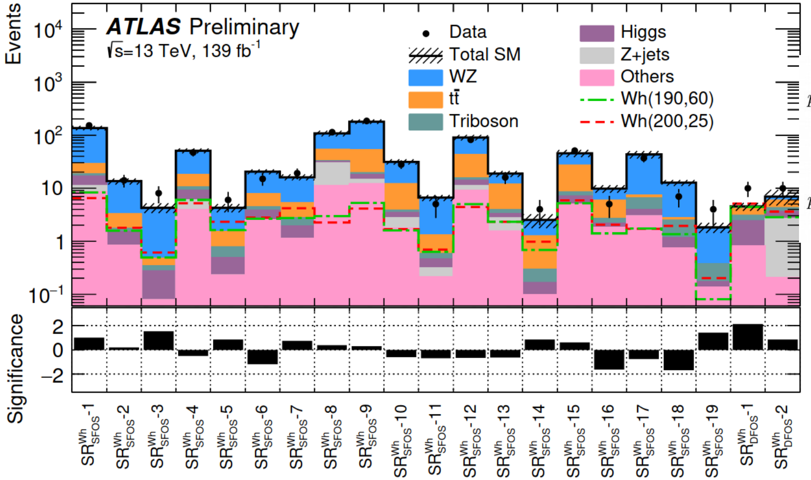
On-shell Wh

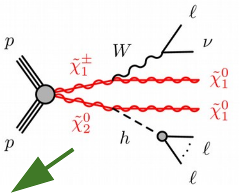
Results



On-shell WZ

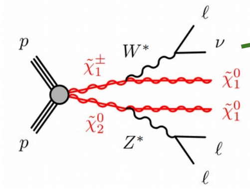


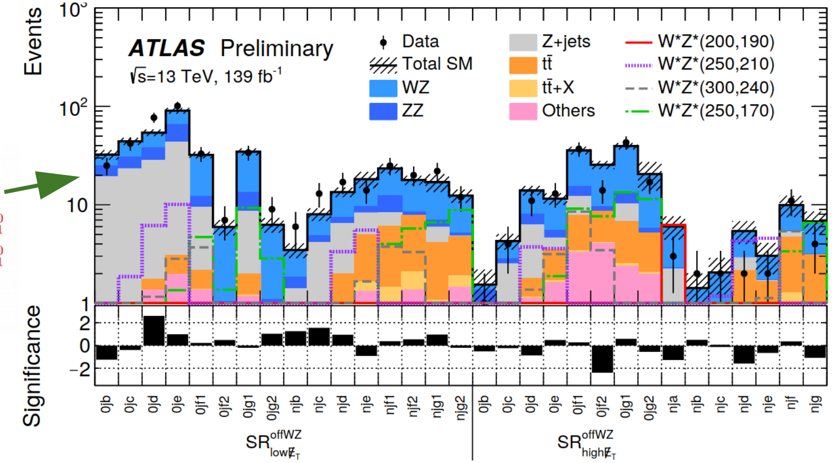




On-shell Wh

Off-shell WZ





- **No significant deviation from SM** prediction observed

Model-independent limits & Discovery *p*-values

On-shell WZ

SR	N_{obs}	N_{exp}	σ^{95}_{vis} [fb]	S^{95}_{obs}	S^{95}_{exp}	CL_b	$p(s=0)$ (Z)
incSR^{WZ}-1	34	38 ± 5	0.10	14	16^{+7}_{-4}	0.32	0.50 (0.00)
incSR^{WZ}-2	2	1.2 ± 0.5	0.04	5.0	$4.0^{+1.6}_{-0.7}$	0.76	0.23 (0.73)
incSR^{WZ}-3	4	6.5 ± 1.1	0.03	4.8	$6.5^{+2.6}_{-1.8}$	0.19	0.50 (0.00)
incSR^{WZ}-4	25	31 ± 6	0.09	12	15^{+6}_{-4}	0.25	0.50 (0.00)
incSR^{WZ}-5	1	5.2 ± 1.1	0.03	3.9	$5.8^{+2.2}_{-1.4}$	0.03	0.50 (0.00)
incSR^{WZ}-6	23	16.4 ± 1.4	0.12	17.0	$10.3^{+3.9}_{-3.0}$	0.93	0.07 (1.48)
$\text{incSR}^{\text{Wh}}_{\text{SFOS}}$-7	174	150 ± 14	0.41	58	38^{+15}_{-11}	0.90	0.10 (1.27)
$\text{incSR}^{\text{Wh}}_{\text{SFOS}}$-8	53	55 ± 5	0.12	17	18^{+7}_{-5}	0.42	0.50 (0.00)
$\text{incSR}^{\text{Wh}}_{\text{SFOS}}$-9	34	36 ± 4	0.10	14	15^{+6}_{-4}	0.40	0.50 (0.00)
$\text{incSR}^{\text{Wh}}_{\text{SFOS}}$-10	56	55 ± 7	0.16	22	21^{+8}_{-6}	0.55	0.41 (0.22)
$\text{incSR}^{\text{Wh}}_{\text{SFOS}}$-11	41	45 ± 6	0.11	16	18^{+7}_{-5}	0.34	0.50 (0.00)
$\text{incSR}^{\text{Wh}}_{\text{DFOS}}$-12	18	11.5 ± 4.1	0.12	17.0	$10.5^{+4.2}_{-2.7}$	0.92	0.07 (1.48)

Off-shell WZ

SR	N_{obs}	N_{exp}	σ^{95}_{vis} [fb]	S^{95}_{obs}	S^{95}_{exp}	CL_b	$p(s=0)$ (Z)
$\text{incSR}^{\text{offWZ}}_{\text{high}\not{E}_T}$-nja	3	6.0 ± 1.6	0.03	4.6	$6.3^{+2.4}_{-2.0}$	0.16	0.50 (0.00)
$\text{incSR}^{\text{offWZ}}_{\text{high}\not{E}_T}$-njb	2	1.4 ± 0.6	0.03	4.8	$4.0^{+1.6}_{-0.7}$	0.71	0.30 (0.53)
$\text{incSR}^{\text{offWZ}}_{\text{high}\not{E}_T}$-njc1	7	9.5 ± 2.2	0.05	7.0	$8.4^{+2.9}_{-2.2}$	0.28	0.50 (0.00)
$\text{incSR}^{\text{offWZ}}_{\text{high}\not{E}_T}$-njc2	2	2.1 ± 0.8	0.03	4.7	$4.6^{+1.8}_{-1.1}$	0.52	0.50 (0.00)
$\text{incSR}^{\text{offWZ}}_{\text{low}\not{E}_T}$-b	31	36 ± 4	0.09	12	15^{+6}_{-4}	0.25	0.50 (0.00)
$\text{incSR}^{\text{offWZ}}_{\text{high}\not{E}_T}$-b	3	3.0 ± 0.9	0.04	5.4	$5.2^{+2.0}_{-1.3}$	0.53	0.50 (0.00)
$\text{incSR}^{\text{offWZ}}_{\text{low}\not{E}_T}$-c	86	88 ± 7	0.17	23	24^{+9}_{-7}	0.44	0.50 (0.00)
$\text{incSR}^{\text{offWZ}}_{\text{high}\not{E}_T}$-c	9	9.3 ± 1.5	0.06	7.7	$7.7^{+3.4}_{-1.8}$	0.50	0.50 (0.00)
$\text{incSR}^{\text{offWZ}}$-d	202	184 ± 12	0.37	51	37^{+14}_{-11}	0.84	0.16 (0.99)
$\text{incSR}^{\text{offWZ}}$-e1	332	308 ± 17	0.49	68	49^{+19}_{-15}	0.84	0.16 (1.00)
$\text{incSR}^{\text{offWZ}}$-e2	298	269 ± 15	0.50	69	46^{+17}_{-14}	0.90	0.10 (1.29)
$\text{incSR}^{\text{offWZ}}$-f1	479	457 ± 22	0.56	78	63^{+22}_{-20}	0.77	0.23 (0.75)
$\text{incSR}^{\text{offWZ}}$-f2	277	272 ± 13	0.33	46	42^{+17}_{-12}	0.60	0.37 (0.34)
$\text{incSR}^{\text{offWZ}}$-g1	620	593 ± 28	0.69	96	74^{+29}_{-22}	0.77	0.21 (0.79)
$\text{incSR}^{\text{offWZ}}$-g2	418	408 ± 20	0.46	64	57^{+23}_{-15}	0.65	0.32 (0.47)
$\text{incSR}^{\text{offWZ}}$-g3	288	285 ± 16	0.35	48	47^{+19}_{-12}	0.55	0.38 (0.30)
$\text{incSR}^{\text{offWZ}}$-g4	141	136 ± 10	0.25	35	31^{+13}_{-8}	0.64	0.35 (0.39)

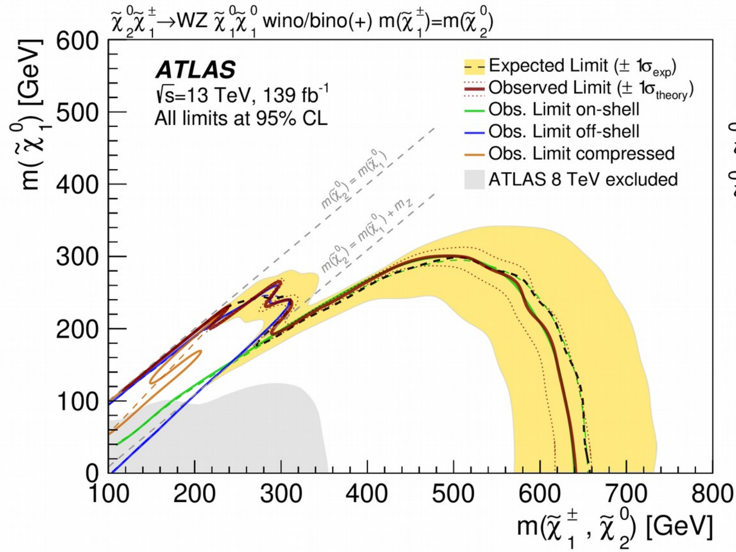
- **Discovery fits**, with pseudo-data, performed on **inclusive SRs** (see *back-up*):
  - Logical OR between nominal SRs (even overlapping) → capture various (signal) kinematics → based on best expected discovery sensitivity
- 95% CL upper-limits on: **observed** and **expected number** of BSM events, **visible cross section** of a BSM process
- ***p*-value** and **significance (*Z*)** on background-only hypothesis

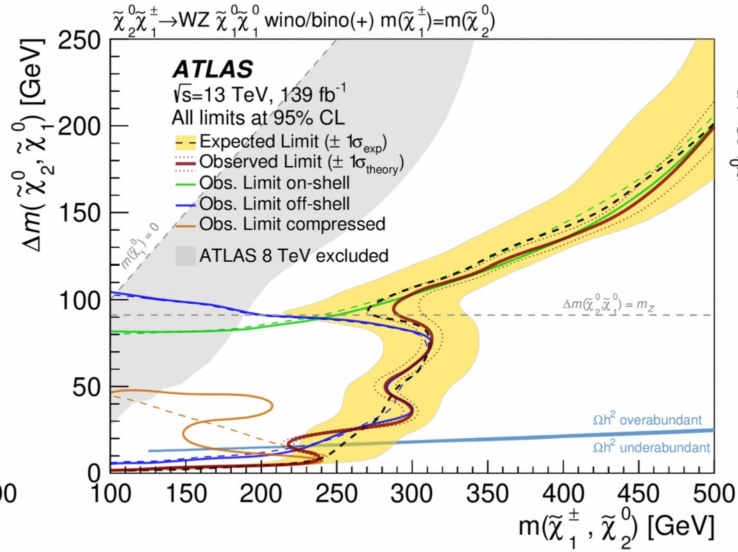
Model-dependent limits: *Wino-Bino(+)* scenario

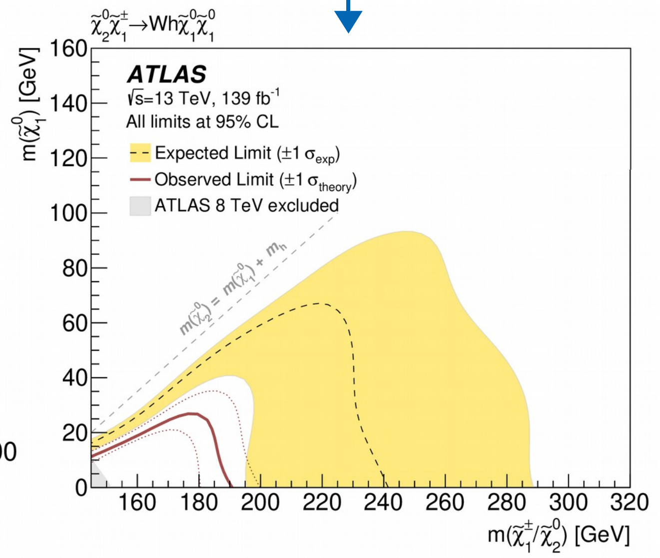
Wino-Bino(+) scenario: (Compressed + Off- + On-shell) WZ

Combination (see *back-up*)

Wino-Bino(+) scenario: On-shell Wh

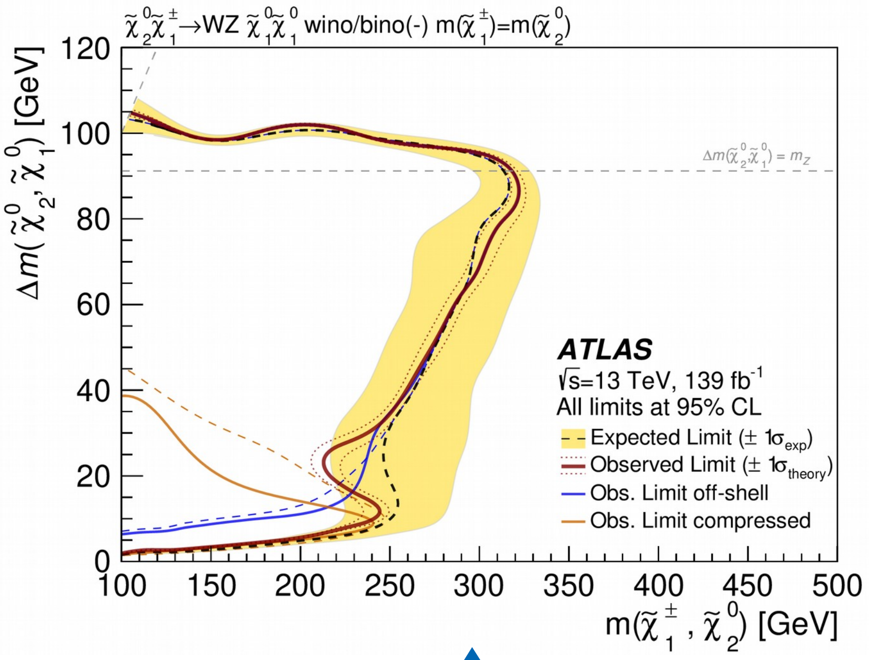






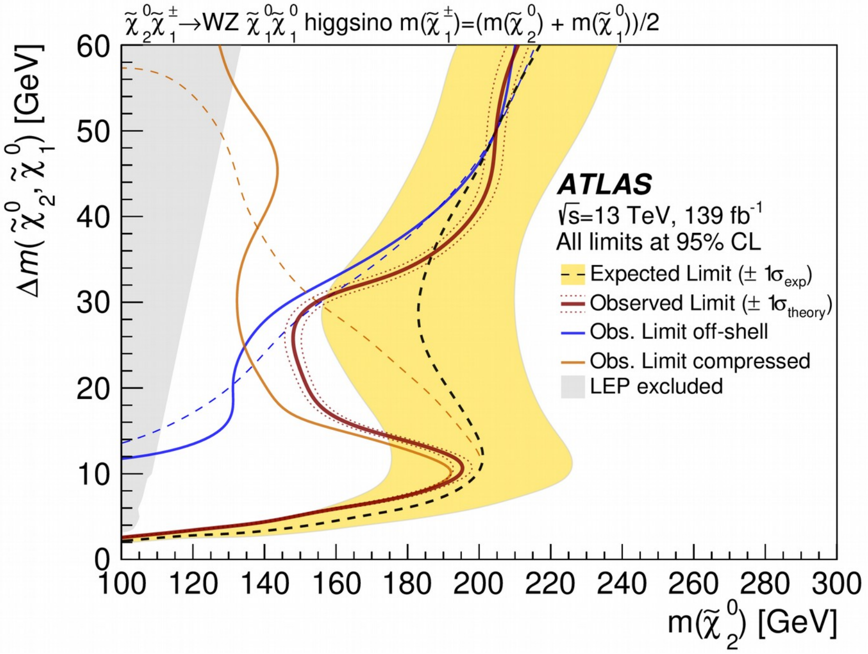
- **95% Confidence Level (CL) upper-limits** on $m(\tilde{\chi}_1^\pm/\tilde{\chi}_2^0)$ and $m(\tilde{\chi}_1^0)$ using the CL_s prescription
  - For ***WZ*-mediated** models: $m(\tilde{\chi}_1^\pm/\tilde{\chi}_2^0)$ excluded up to 640 GeV for $m(\tilde{\chi}_1^0) = 0$, and up to 300 GeV for low $\Delta m(\tilde{\chi}_1^\pm/\tilde{\chi}_2^0, \tilde{\chi}_1^0)$
  - For ***Wh*-mediated** model: $m(\tilde{\chi}_1^\pm/\tilde{\chi}_2^0)$ excluded up to 185 GeV for $m(\tilde{\chi}_1^0)$ < 20 GeV

Model-dependent limits: *Wino-Bino(–) & Higgsino*

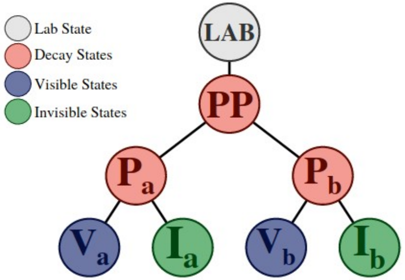


Wino-Bino(–) scenario: (Compressed + Off-shell) WZ

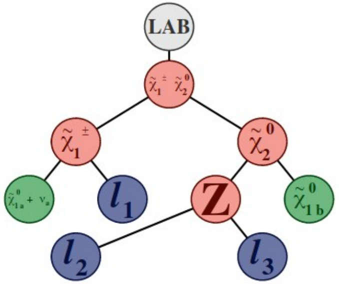
Higgsino scenario: (Compressed + Off-shell) WZ

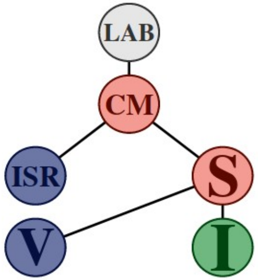


RJR follow-up with full Run 2 data



- **Follow-up** on 2015-2016 analysis (link) with **full Run 2 data** (139 fb^{-1})
  - An excess was observed with 36.1 fb^{-1} data
- **RJR technique**: define decay trees (intermediate states matching signal hypothesis)
  - Kinematic variables built from a set of different reference frames
- **SRs** targeting **Standard** (0 jets → SR3l-Low) and **ISR** (≥ 1 jets → SR3l-ISR) approach
- **No significant deviation from SM** observed with full Run 2 data





Standard approach

ISR approach

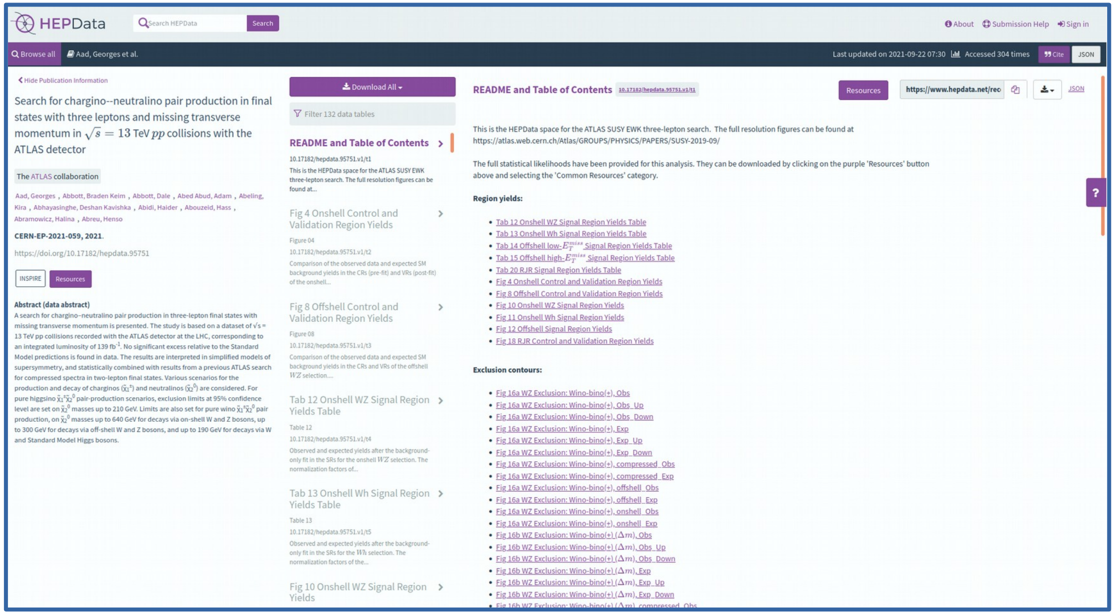
Region	SR3ℓ-Low	SR3ℓ-ISR
Observed	53	25
Fitted SM	49 ± 14	17 ± 4
Diboson	47 ± 14	16 ± 4
FNP leptons	1.36 ± 0.29	0.83 ± 0.27
Triboson	0.40 ± 0.14	0.14 ± 0.06
Others	0.052 ± 0.029	0.41 ± 0.21

SRs yields

Model independent/discovery fit results

SR	σ^{95}_{vis} [fb]	S^{95}_{obs}	S^{95}_{exp}	CL_b	$p(s=0)$ (Z)
SR3ℓ-Low	0.24	33	30^{+10}_{-8}	0.61	0.39 (0.28)
SR3ℓ-ISR	0.14	19	12^{+5}_{-4}	0.89	0.09 (1.32)

HEPData material

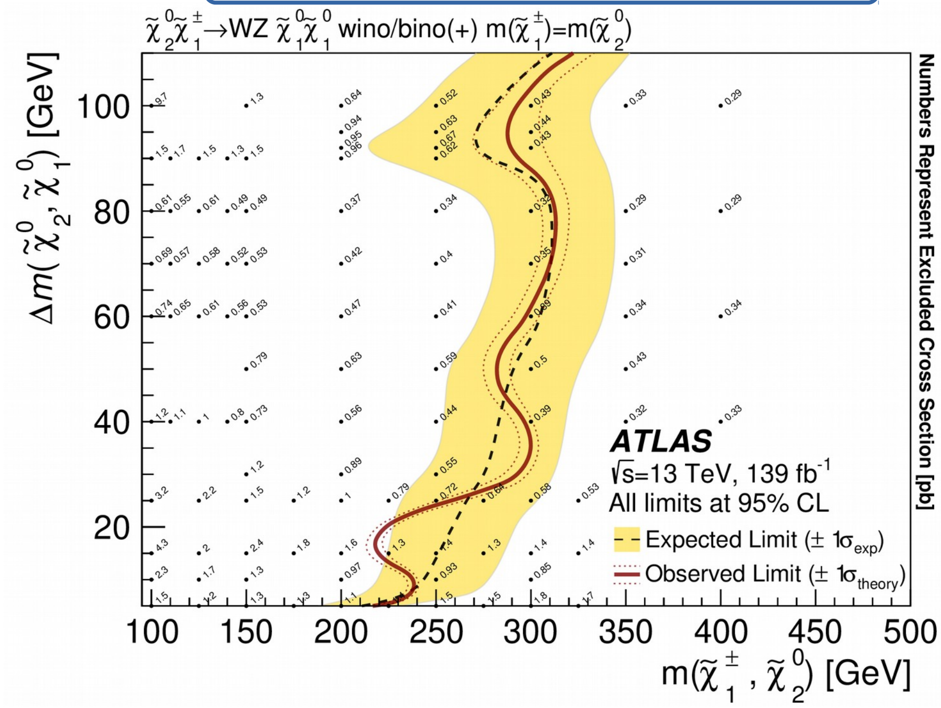


- ***Resources* → *Common Resources*** buttons:
  - **SimpleAnalysis** code snippets for *on-/off-shell*
  - **SLHA files** for signals used in cutflows
  - Full ***likelihoods in HistFactory JSON format***:
    - Can be used in **PyHF**
    - **Background** info & **patchsets** for signal models, including **combination with compressed** analysis (see *back-up*)
    - **README** for instructions
- **Tables** and **figures** for **SRs/CRs/VRs yields**
- **Exclusion limits** curves
- **Observed/Expected upper limits** on cross section for every signal point
- **Discovery fits** tables (see slide 11)
- **Kinematic distributions** plots (e.g. see slide 7)
- Detailed **cutflow tables**
- **Acceptance** & **Efficiency** maps

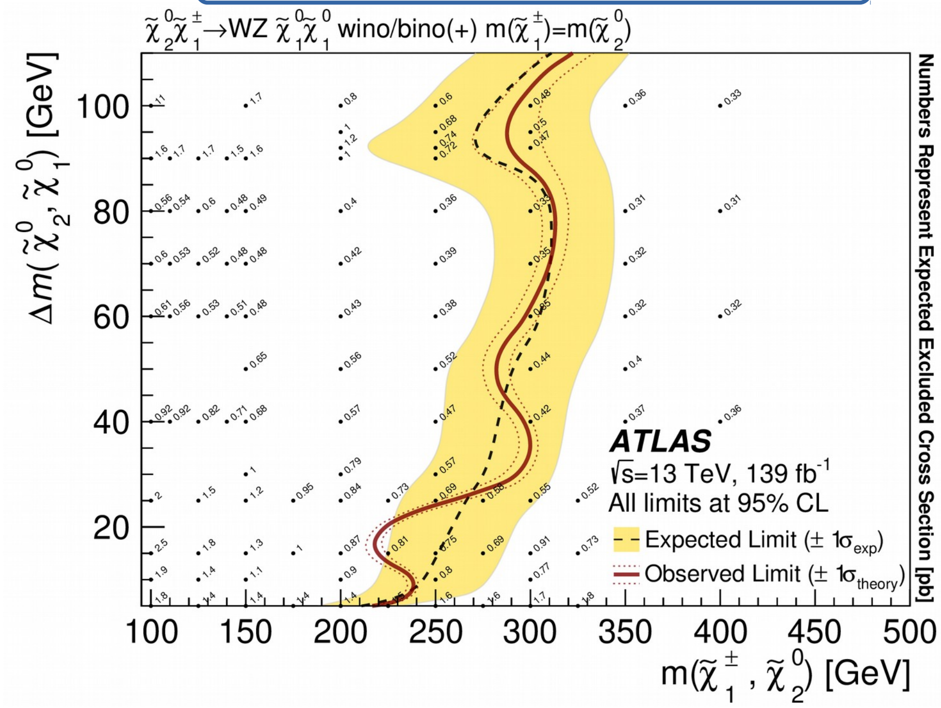
Upper limits on signal cross section

Wino-Bino(+) scenario:
(Compressed + Off- + On-shell) WZ

Numbers = Observed Upper Limits



Numbers = Expected Upper Limits



- **Expected** and **Observed Upper Limits** on signal cross sections for **every signal point** and for **all reinterpretations**, including **combination with compressed** analysis

Yields tables

- Detailed **yields tables** showing **observed data** and fitted SM **background events** for:
  - All **SRs/CRs/VRs** for every model: *Off-shell WZ*, *On-shell WZ*, *On-shell Wh*
  - Breakdown of main SM background processes

On-shell WZ SRs

Regions	SR^{WZ}-1	SR^{WZ}-2	SR^{WZ}-3	SR^{WZ}-4	SR^{WZ}-5	SR^{WZ}-6	SR^{WZ}-7
Observed	331	31	3	2	42	7	3
Fitted SM	314 ± 33	35 ± 6	4.1 ± 1.0	1.2 ± 0.5	58 ± 5	8.0 ± 0.9	5.8 ± 1.0
WZ	294 ± 31	32 ± 5	3.7 ± 0.9	0.9 ± 0.5	48 ± 4	7.1 ± 0.8	5.0 ± 0.9
ZZ	12.1 ± 3.1	0.66 ± 0.35	0.08 ± 0.04	0.04 ± 0.02	2.3 ± 0.6	0.12 ± 0.04	0.08 ± 0.03
$t\bar{t}$	2.8 ± 0.8	0.36 ± 0.26	0.04 ± 0.01	$0.00\pm^{0.01}_{0.00}$	1.4 ± 0.4	$0.00\pm^{0.01}_{0.00}$	0.04 ± 0.02
Z+jets	0.01 ± 0.01	0.14 ± 0.14	0.05 ± 0.06	0.06 ± 0.04	2.8 ± 2.3	0.3 ± 0.4	0.26 ± 0.17
$t\bar{t}+X$	0.16 ± 0.06	0.13 ± 0.05	0.03 ± 0.04	0.01 ± 0.01	0.10 ± 0.06	0.05 ± 0.03	0.01 ± 0.01
Others	5.1 ± 0.8	1.1 ± 0.4	0.21 ± 0.06	0.17 ± 0.06	3.2 ± 0.5	0.38 ± 0.11	0.34 ± 0.10

Regions	SR^{WZ}-8	SR^{WZ}-9	SR^{WZ}-10	SR^{WZ}-11	SR^{WZ}-12	SR^{WZ}-13	SR^{WZ}-14
Observed	1	77	11	0	0	111	19
Fitted SM	0.8 ± 0.4	90 ± 20	13.4 ± 2.4	0.5 ± 0.4	0.49 ± 0.24	89 ± 11	16.0 ± 1.4
WZ	0.44 ± 0.32	77 ± 19	11.3 ± 2.4	0.37 ± 0.31	0.38 ± 0.22	72 ± 9	13.4 ± 1.3
ZZ	0.01 ± 0.01	1.9 ± 0.9	0.24 ± 0.13	0.01 ± 0.01	0.01 ± 0.01	5.8 ± 2.8	0.39 ± 0.18
$t\bar{t}$	$0.00\pm^{0.01}_{0.00}$	3.3 ± 0.9	0.45 ± 0.28	$0.00\pm^{0.01}_{0.00}$	$0.00\pm^{0.01}_{0.00}$	6.0 ± 1.4	0.24 ± 0.17
Z+jets	0.28 ± 0.20	4 ± 5	0.2 ± 0.4	0.02 ± 0.03	0.02 ± 0.03	0.02 ± 0.03	0.02 ± 0.03
$t\bar{t}+X$	0 ± 0	1.3 ± 0.4	0.40 ± 0.14	0.05 ± 0.04	0.02 ± 0.01	1.6 ± 0.5	0.56 ± 0.16
Others	0.08 ± 0.06	2.3 ± 0.5	0.79 ± 0.22	0.08 ± 0.05	0.08 ± 0.03	3.5 ± 0.7	1.37 ± 0.33

Regions	SR^{WZ}-15	SR^{WZ}-16	SR^{WZ}-17	SR^{WZ}-18	SR^{WZ}-19	SR^{WZ}-20
Observed	5	1	13	9	3	1
Fitted SM	2.8 ± 0.6	1.30 ± 0.27	13.7 ± 2.6	9.2 ± 1.3	2.3 ± 0.4	1.09 ± 0.13
WZ	2.3 ± 0.6	1.07 ± 0.24	10.2 ± 1.9	6.7 ± 0.8	1.58 ± 0.24	0.87 ± 0.12
ZZ	0.07 ± 0.04	0.04 ± 0.03	0.13 ± 0.06	0.10 ± 0.04	0.02 ± 0.01	0.02 ± 0.01
$t\bar{t}$	$0.00\pm^{0.01}_{0.00}$	$0.00\pm^{0.01}_{0.00}$	0.77 ± 0.32	0.45 ± 0.26	$0.00\pm^{0.01}_{0.00}$	$0.00\pm^{0.01}_{0.00}$
Z+jets	0.02 ± 0.02	0.07 ± 0.08	1 ± 1	0.7 ± 1.0	0.25 ± 0.34	0.02 ± 0.02
$t\bar{t}+X$	0.07 ± 0.03	$0.00\pm^{0.03}_{0.00}$	0.53 ± 0.17	0.33 ± 0.10	0.07 ± 0.04	0.03 ± 0.02
Others	0.37 ± 0.11	0.12 ± 0.04	1.1 ± 0.8	0.9 ± 0.7	0.27 ± 0.07	0.18 ± 0.05

Cutflow tables

On-shell WZ

Selection	$m(\tilde{\chi}_2^0, \tilde{\chi}_1^0)$ [GeV] (300, 200)	(600, 100)
$\mathcal{L} \times \sigma$	53784	2799
$\mathcal{L} \times \sigma \times$ BF	1760	92
$\mathcal{L} \times \sigma \times$ BF $\times$ filt. eff.	1322	69
3 isolated lepton selection, lepton $p_T^{1,2,3} > 25, 20, 10$ GeV, $E_T^{miss} > 50$ GeV	227	23.9
$n_{SFOS} \geq 1$	226	23.7
Trigger selection	222	23.3
$n_{b-jets} = 0$	209	21.9
Resonance veto $m_{\ell\ell} > 12$ GeV	209	21.9
$\lvert m_{3\ell} - m_Z \rvert > 15$ GeV	203	21.7
$m_{\ell\ell} \in [75, 105]$ GeV	196	20.1
with MC to data weight	186	19.2
$n_{jets} = 0$	76.4	7.72
with MC to data weight	73.3	7.45
$m_T \in [100, 160]$ GeV	26.7	0.90
$\mathrm{SR}^{\mathtt{WZ}}$-1	20.9	0.09
$\mathrm{SR}^{\mathtt{WZ}}$-2	4.86	0.11
$\mathrm{SR}^{\mathtt{WZ}}$-3	0.78	0.16
$\mathrm{SR}^{\mathtt{WZ}}$-4	0.14	0.54
$m_T > 160$ GeV	5.80	5.11
$\mathrm{SR}^{\mathtt{WZ}}$-5	4.64	0.37
$\mathrm{SR}^{\mathtt{WZ}}$-6	0.16	0.49
$\mathrm{SR}^{\mathtt{WZ}}$-7	0	2.21
$\mathrm{SR}^{\mathtt{WZ}}$-8	0	2.14
$\mathrm{SR}^{\mathtt{WZ}}_{\mathtt{0j}}$ ($\mathrm{SR}^{\mathtt{WZ}}$-1 to 8)	31.4	6.11
$n_{jets} > 0$, $H_T < 200$ GeV	97.5	9.90
with MC to data weight	91.8	9.54
$m_T \in [100, 160]$ GeV	29.6	1.19
$\mathrm{SR}^{\mathtt{WZ}}$-9	8.75	0.17
$\mathrm{SR}^{\mathtt{WZ}}$-10	3.46	0.32
$\mathrm{SR}^{\mathtt{WZ}}$-11	0.54	0.15
$\mathrm{SR}^{\mathtt{WZ}}$-12	0	0.38
$m_T > 160$ GeV	9.50	6.80
$\mathrm{SR}^{\mathtt{WZ}}$-13	7.19	0.49
$\mathrm{SR}^{\mathtt{WZ}}$-14	1.53	1.37
$\mathrm{SR}^{\mathtt{WZ}}$-15	0.09	2.77
$\mathrm{SR}^{\mathtt{WZ}}$-16	0	1.69
$n_{jets} > 0$, $H_T > 200$ GeV	22.2	2.40
$H_T^{lep} < 350$ GeV	20.9	0.65
with MC to data weight	19.3	0.58
$m_T > 100$ GeV	10.8	0.47
$\mathrm{SR}^{\mathtt{WZ}}$-17	2.53	0.02
$\mathrm{SR}^{\mathtt{WZ}}$-18	3.12	0.11
$\mathrm{SR}^{\mathtt{WZ}}$-19	1.09	0.12
$\mathrm{SR}^{\mathtt{WZ}}$-20	1.13	0.13
$\mathrm{SR}^{\mathtt{WZ}}_{\mathtt{nj}}$ ($\mathrm{SR}^{\mathtt{WZ}}$-9 to 20)	29.4	7.8

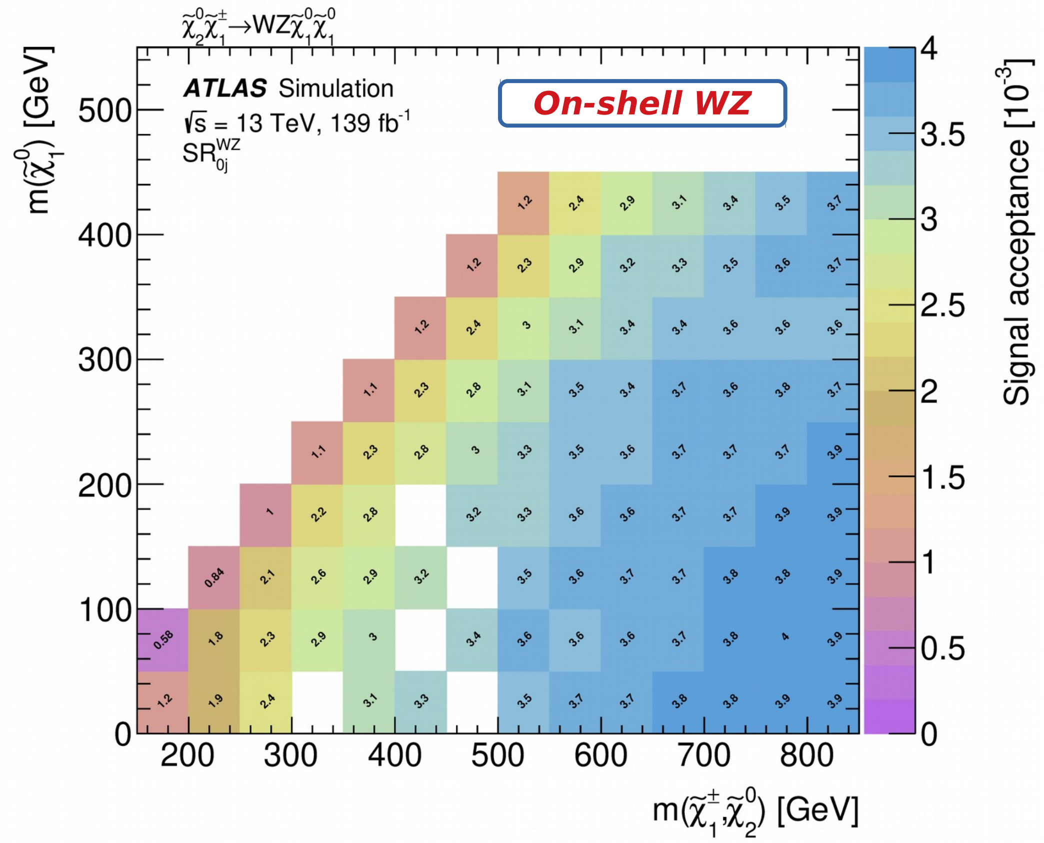
Wino-Bino(+)
Off-shell WZ

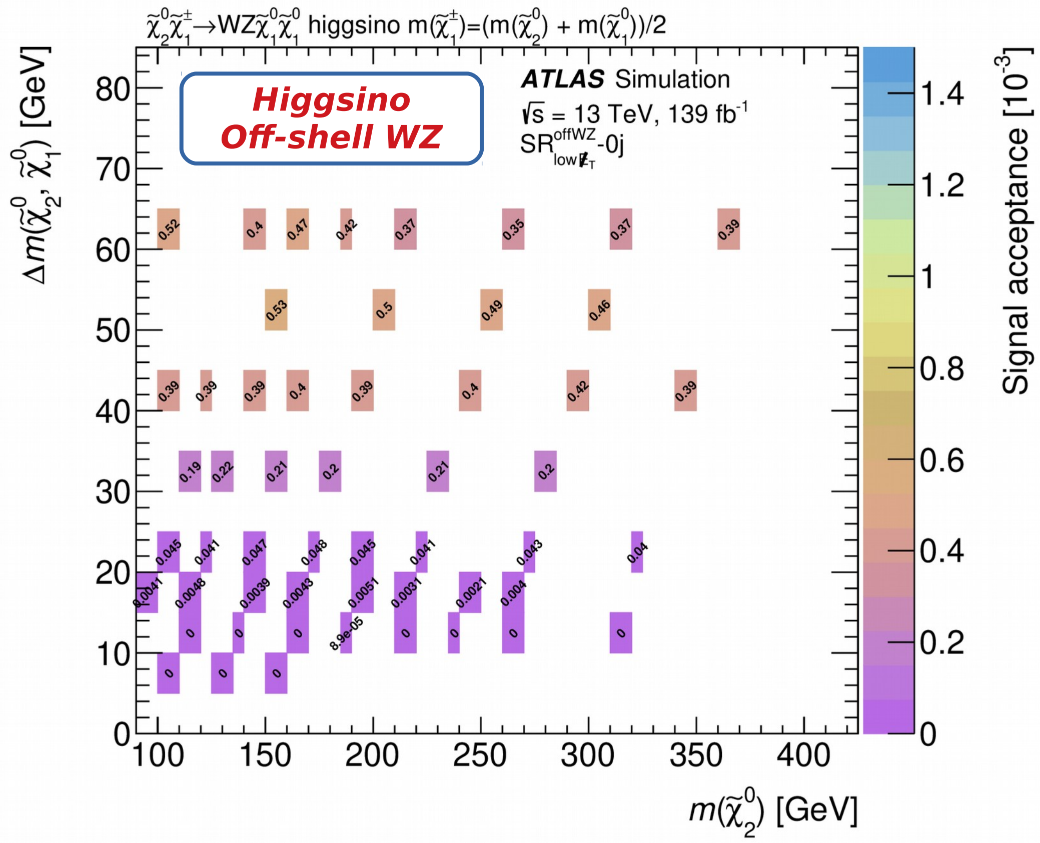
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to WZ\tilde{\chi}_1^0\tilde{\chi}_1^0$ wino/bino (+) — $m(\tilde{\chi}_2^0, \tilde{\chi}_1^0)$ = (125, 85) GeV

	a	b	c	d	e	f1	f2	g1	g2	a through g2
Common cuts										
$\mathcal{L} \times \sigma$					1394866					1394866
$\mathcal{L} \times \sigma \times$ BF					45634					45634
$\mathcal{L} \times \sigma \times$ BF $\times$ filt. eff.					16811					16811
3 isolated lepton selection					2.66e+03					2.66e+03
b-veto					2.55e+03					2.55e+03
Trigger selection					1.81e+03					1.81e+03
$m_{\ell\ell}$, $m_{\ell\ell}^{max}$ [GeV]					[< 75] 1.79e+03					1.79e+03
Common cuts $\mathrm{SR}^{\mathtt{offWZ}}_{\mathtt{low}E_T}$										
$m_{\ell\ell}^{min}$ [GeV]	-		[∈ [12, 40]] 1.70e+03				[∈ [40, 75]] 14.6			1.71e+03
lepton $p_T^{1,2,3}$ [GeV]	-		[> 10] 1.44e+03				[> 15] 7.74			1.45e+03
FNP lepton cleaning (conversions)	-		1.12e+03				5.92			1.12e+03
$m_{\ell\ell}^{max}$ [GeV]	-		[< 60] 1.02e+03				5.92			1.03e+03
$m_{\ell\ell}^{min}$ [GeV]	-	[∈ [12, 15]] 47.0	[∈ [15, 20]] 119	[∈ [20, 30]] 406	[∈ [30, 40]] 452	[∈ [40, 60]] 5.92		[∈ [60, 75]] 0		1.03e+03
m_{T2}^{100} [GeV]	-	[< 115] 19.4	[< 120] 74.7	[< 130] 374	452	5.92		0		926
minΔR	-	[< 1.6] 19.4	[< 1.6] 73.2	[< 1.6] 295	452	5.92		0		846
Cuts $\mathrm{SR}^{\mathtt{offWZ}}_{\mathtt{low}E_T}$-0j										
$n_{jets}^{p_T>30\,GeV}$	-	[= 0] 12.2	[= 0] 49.5	[= 0] 186	[= 0] 291	[= 0] 3.28		[= 0] 0		542
E_T^{miss} [GeV]	-	[< 50] 11.2	[< 50] 42.9	[< 50] 147	[< 50] 242	[< 50] 2.62		[< 50] 0		446
E_T^{miss} signif.	-	[> 1.5] 8.57	[> 1.5] 34.7	[> 1.5] 123	[> 1.5] 182	[> 1.5] 1.91		[> 1.5] 0		350
$m_{3\ell}$ [GeV]	-	8.57	34.7	123	182	[> 100] 0.656		[> 100] 0		349
m_T^{minmll} [GeV]	-	[< 50] 8.16	[< 50] 32.6	[< 50] 97.8	[< 60] 158	[< 60] 0.560	[> 90] 0	[< 60] 0	[> 90] 0	297
p_T^{lep}/E_T^{miss}	-	[< 1.1] 5.27	[< 1.1] 22.7	[< 1.1] 64.3	[< 1.3] 138	[< 1.4] 0.560	[< 1.4] 0	[< 1.4] 0	[< 1.4] 0	231
MC-to-data eff. weights	-	4.77	20.2	59.3	126	0.525	0	0	0	211
Cuts $\mathrm{SR}^{\mathtt{offWZ}}_{\mathtt{low}E_T}$-nj										
$n_{jets}^{p_T>30\,GeV}$	-	[> 0] 7.20	[> 0] 23.8	[> 0] 110	[> 0] 161	[> 0] 2.64		[> 0] 0		304
E_T^{miss} [GeV]	-	[< 200] 6.52	[< 200] 21.3	[< 200] 102	[< 200] 150	[< 200] 2.64		[< 200] 0		282
E_T^{miss} signif.	-	[> 3.0] 4.72	[> 3.0] 16.1	[> 3.0] 76.3	[> 3.0] 106	[> 3.0] 1.70		[> 3.0] 0		205
m_T^{minmll} [GeV]	-	[< 50] 2.85	[< 50] 10.7	[< 50] 42.9	[< 60] 65.7	[< 60] 1.41	[> 90] 0	[< 60] 0	[> 90] 0	124
p_T^{lep}/E_T^{miss}	-	[< 1.0] 2.54	[< 1.0] 10.6	[< 1.0] 36.5	[< 1.0] 59.9	[< 1.2] 1.34	[< 1.2] 0	[< 1.2] 0	[< 1.2] 0	111
MC-to-data eff. weights	-	2.31	9.82	33.7	53.0	1.25	0	0	0	100
Cuts $\mathrm{SR}^{\mathtt{offWZ}}_{\mathtt{high}E_T}$-0j										
lepton $p_T^{1,2,3}$ [GeV]					[> 25, 15, 10] 1.17e+03					1.17e+03
$m_{\ell\ell}^{min}$ [GeV]	-	[∈ [12, 15]] 44.0	[∈ [15, 20]] 120	[∈ [20, 30]] 422	[∈ [30, 40]] 541	[∈ [40, 60]] 11.1		[∈ [60, 75]] 0.148		1.14e+03
m_{T2}^{100} [GeV]	-	[< 115] 19.1	[< 120] 76.3	[< 130] 388	[< 140] 540	[< 160] 11.1		[< 175] 0.148		1.03e+03
$n_{jets}^{p_T>30\,GeV}$	-	[= 0] 11.6	[= 0] 49.6	[= 0] 239	[= 0] 341	[= 0] 7.28		[= 0] 0.148		649
E_T^{miss} [GeV]	-	[> 50] 2.05	[> 50] 10.3	[> 50] 50.8	[> 50] 67.0	[> 50] 1.08		[> 50] 0		131
E_T^{miss} signif.	-	[> 3.0] 1.80	[> 3.0] 9.37	[> 3.0] 46.1	[> 3.0] 60.5	[> 3.0] 0.805		[> 3.0] 0		119
m_T^{minmll} [GeV]	-	[< 50] 1.74	[< 50] 8.84	[< 60] 43.3	[< 60] 52.4	[< 70] 0.805	[> 90] 0	[< 70] 0	[> 90] 0	107
MC-to-data eff. weights	-	1.84	8.03	40.2	48.6	0.760	0	0	0	99.5
Cuts $\mathrm{SR}^{\mathtt{offWZ}}_{\mathtt{high}E_T}$-nj										
lepton $p_T^{1,2,3}$ [GeV]					[>4.5,3] 1.79e+03					1.79e+03
						f		g		
$m_{\ell\ell}^{min}$ [GeV]	[∈ [1, 12]] 78.4	[∈ [12, 15]] 83.5	[∈ [15, 20]] 207	[∈ [20, 30]] 661	[∈ [30, 40]] 746	[∈ [40, 60]] 14.5		[∈ [60, 75]] 0.148		1.79e+03
m_{T2}^{100} [GeV]	[< 112] 25.2	[< 115] 34.8	[< 120] 131	[< 130] 607	[< 140] 744	[< 160] 14.5		[< 175] 0.148		1.56e+03
$n_{jets}^{p_T>30\,GeV}$	[> 0] 9.71	[> 0] 15.8	[> 0] 52.7	[> 0] 252	[> 0] 287	[> 0] 5.24		[> 0] 0		622
E_T^{miss} [GeV]	[> 200] 0.713	[> 200] 2.09	[> 200] 5.85	[> 200] 22.3	[> 200] 24.1	[> 200] 7.10e-02		[> 200] 0		55.1
E_T^{miss} signif.	[> 3.0] 0.713	[> 3.0] 2.09	[> 3.0] 5.85	[> 3.0] 22.3	[> 3.0] 24.1	[> 3.0] 7.10e-02		[> 3.0] 0		55.1
p_T^{lep}/E_T^{miss}	[< 0.2] 0.611	[< 0.2] 1.99	[< 0.3] 5.39	[< 0.3] 14.6	[< 0.3] 13.8	[< 1.0] 7.10e-02		[< 1.0] 0		36.4
MC-to-data eff. weights	0.594	1.92	4.94	13.4	12.6	7.20e-02		0		33.5

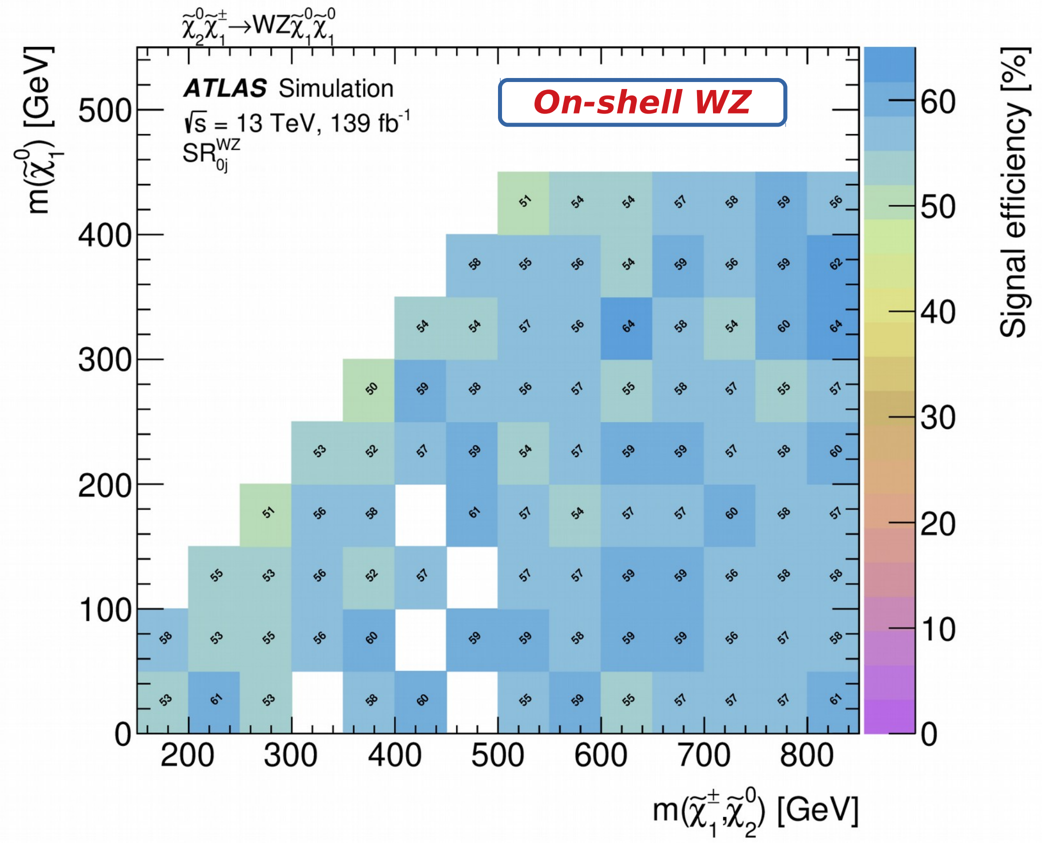
- **Detailed cutfows** provided for **each SR** (and **inclusive SRs** ←) and some of the **most representative signal mass points** (for *off-shell WZ*, this includes ***Wino-Bino(-)*** and ***Higgsino*** reinterpretations)

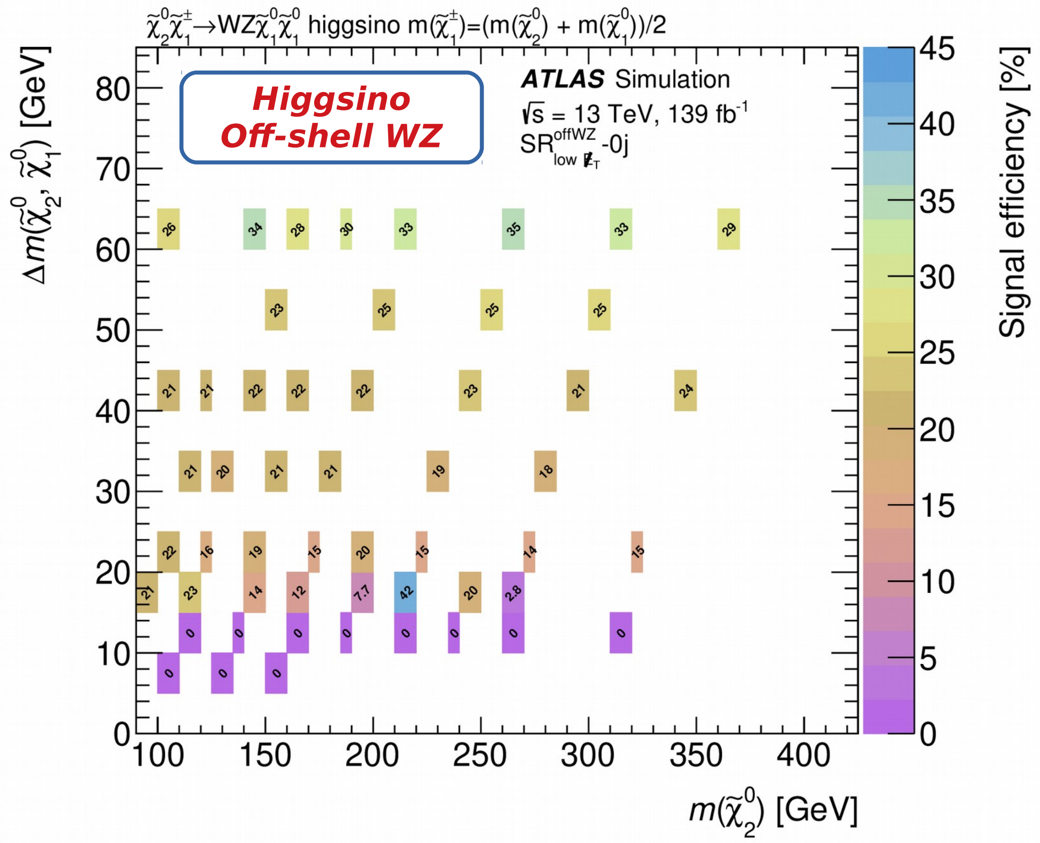
Acceptance





- **Truth-level acceptances** with respect to total sparticle production for **all mass points** and **inclusive SRs** in **every scenario and reinterpretation**





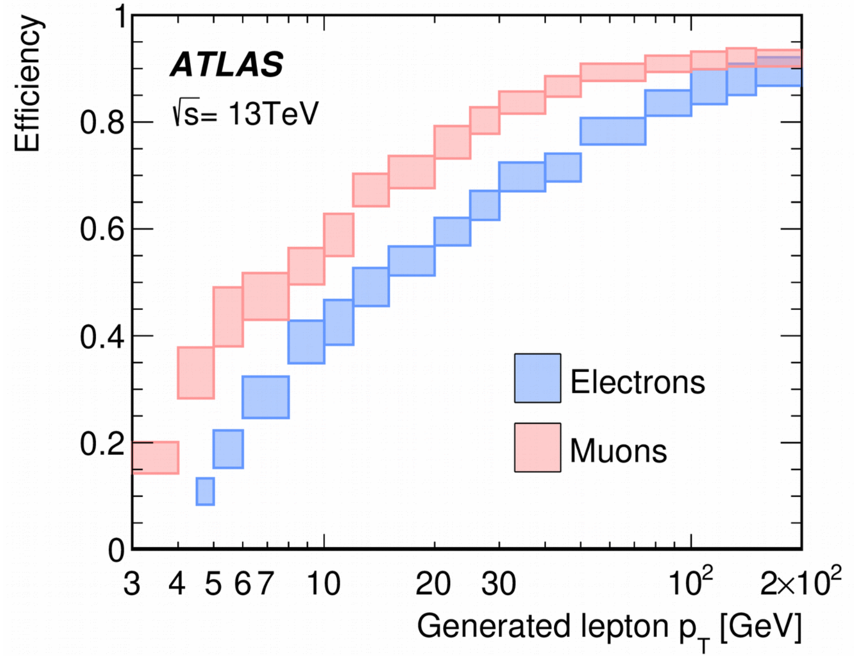
- **Reconstruction efficiencies** (= full signal selection / accepted events) for **all mass points** and **inclusive SRs** in **every scenario and reinterpretation**

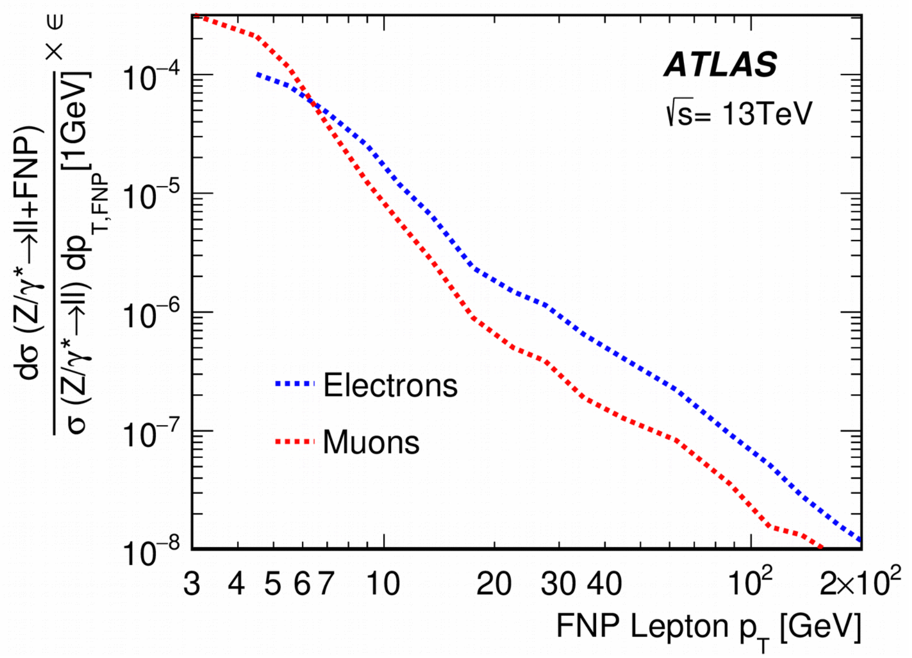
Conclusions

- ATLAS search for the production of **chargino-neutrelino** decaying **via *WZ***, ***W*Z**** and ***Wh*** into **three light-flavour leptons**
  - ***Off-shell WZ*** also **reinterpreted** in the context of ***Wino-Bino(-)*** and ***Higgsino*** scenarios
  - Data **compatible with SM prediction**
  - Results **combined** with **each other** and with previous ATLAS **compressed** search in two leptons
  - Full Run 2 follow-up on RJR search → no excess found with respect to SM prediction
- **All results and material** provided as part of the recently released **HEPData**
  - Efforts made to ensure the material provided to be **suitably preserved** and **usable for reinterpretations** and any follow-up studies

Back-up

Lepton selection efficiency and fake rejection





- Selection efficiency for signal, lowest-p_T lepton in a three baseline off-shell WZ selection
- Probability for a SM Z+jets event to be accompanied by a fake/non-prompt lepton in a region with ≥2 signal leptons
- Non-prompt lepton BDT selection designed to keep 70%-90% efficiency for real leptons ($p_T \leq 20$ GeV), with a rejection factor of 2-3 for fake/non-prompt leptons passing the isolation criteria

On-shell WZ/Wh SR definitions

Variable	SR^{WZ}	SR^{Wh}_{SFOS}	SR^{Wh}_{DFOS}
	Preselection requirements		
$n_{lep}^{baseline}$, n_{lep}^{signal}		= 3	
Trigger		dilepton	
$p_T^{\ell_1}, p_T^{\ell_2}, p_T^{\ell_3}$ [GeV]		> 25, 20, 10	
E_T^{miss} [GeV]		> 50	
$n_{b\text{-jets}}$		= 0	
Resonance veto $m_{\ell\ell}$ [GeV]	> 12	> 12	-
n_{SFOS}	≥ 1	≥ 1	= 0
$m_{\ell\ell}$ [GeV]	∈ [75, 105]	∉ [75, 105]	-
$\|m_{3\ell} - m_Z\|$ [GeV]	> 15	> 15	-

Selection requirements			
$m_{\ell\ell} \leq 75$ GeV, $n_{jets} = 0$			
m_T [GeV]	E_T^{miss} [GeV]		
[0, 100]	SR^{Wh}_{SFOS}-1: [50, 100]	SR^{Wh}_{SFOS}-2: [100, 150]	SR^{Wh}_{SFOS}-3 > 150
[100, 160]	SR^{Wh}_{SFOS}-4: [50, 100]	SR^{Wh}_{SFOS}-5: > 100	
> 160	SR^{Wh}_{SFOS}-6: [50, 100]	SR^{Wh}_{SFOS}-7: > 100	
$m_{\ell\ell} \leq 75$ GeV, $n_{jets} > 0$, $H_T < 200$ GeV			
m_T [GeV]	E_T^{miss} [GeV]		
[0, 50]	SR^{Wh}_{SFOS}-8: [50, 100]		
[50, 100]	SR^{Wh}_{SFOS}-9: [50, 100]		
[0, 100]	SR^{Wh}_{SFOS}-10: [100, 150]		SR^{Wh}_{SFOS}-11: > 150
[100, 160]	SR^{Wh}_{SFOS}-12: [50, 100]	SR^{Wh}_{SFOS}-13: [100, 150]	SR^{Wh}_{SFOS}-14: > 150
> 160	SR^{Wh}_{SFOS}-15: [50, 150]	SR^{Wh}_{SFOS}-16: > 150	
$m_{\ell\ell} \geq 105$ GeV, $n_{jets} = 0$			
m_T [GeV]	E_T^{miss} [GeV]		
> 100	SR^{Wh}_{SFOS}-17: [50, 100]	SR^{Wh}_{SFOS}-18: [100, 200]	SR^{Wh}_{SFOS}-19: > 200

Selection requirements				
$n_{jets} = 0$				
m_T [GeV]	E_T^{miss} [GeV]			
[100, 160]	SR^{WZ}-1: [50, 100]	SR^{WZ}-2: [100, 150]	SR^{WZ}-3: [150, 200]	SR^{WZ}-4: > 200
> 160	SR^{WZ}-5: [50, 150]	SR^{WZ}-6: [150, 200]	SR^{WZ}-7: [200, 350]	SR^{WZ}-8: > 350
$n_{jets} > 0$, $H_T < 200$ GeV				
m_T [GeV]	E_T^{miss} [GeV]			
[100, 160]	SR^{WZ}-9: [100, 150]	SR^{WZ}-10: [150, 250]	SR^{WZ}-11: [250, 300]	SR^{WZ}-12: > 300
> 160	SR^{WZ}-13: [50, 150]	SR^{WZ}-14: [150, 250]	SR^{WZ}-15: [250, 400]	SR^{WZ}-16: > 400
$n_{jets} > 0$, $H_T > 200$ GeV, $H_T^{lep} < 350$ GeV				
m_T [GeV]	E_T^{miss} [GeV]			
> 100	SR^{WZ}-17: [150, 200]	SR^{WZ}-18: [200, 300]	SR^{WZ}-19: [300, 400]	SR^{WZ}-20: > 400

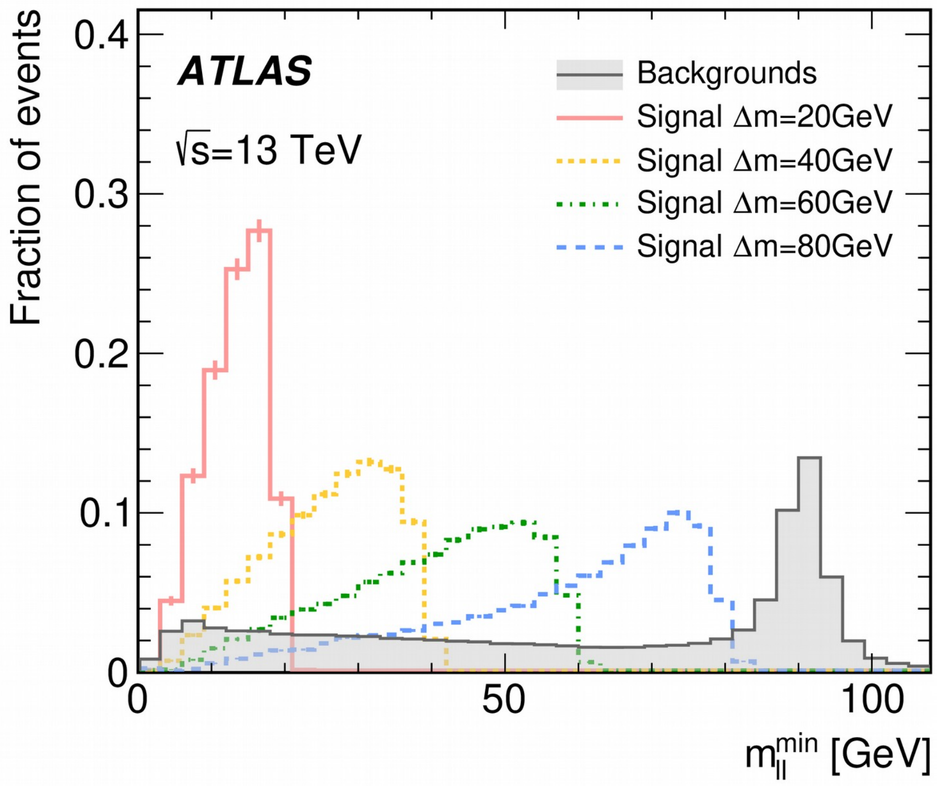
Variable	SR^{Wh}_{DFOS}-1	SR^{Wh}_{DFOS}-2
	Selection requirements	
n_{jets}	= 0	∈ [1, 2]
E_T^{miss} significance	> 8	> 8
$p_T^{\ell_3}$ [GeV]	> 15	> 20
$\Delta R_{OS,near}$	< 1.2	< 1.0

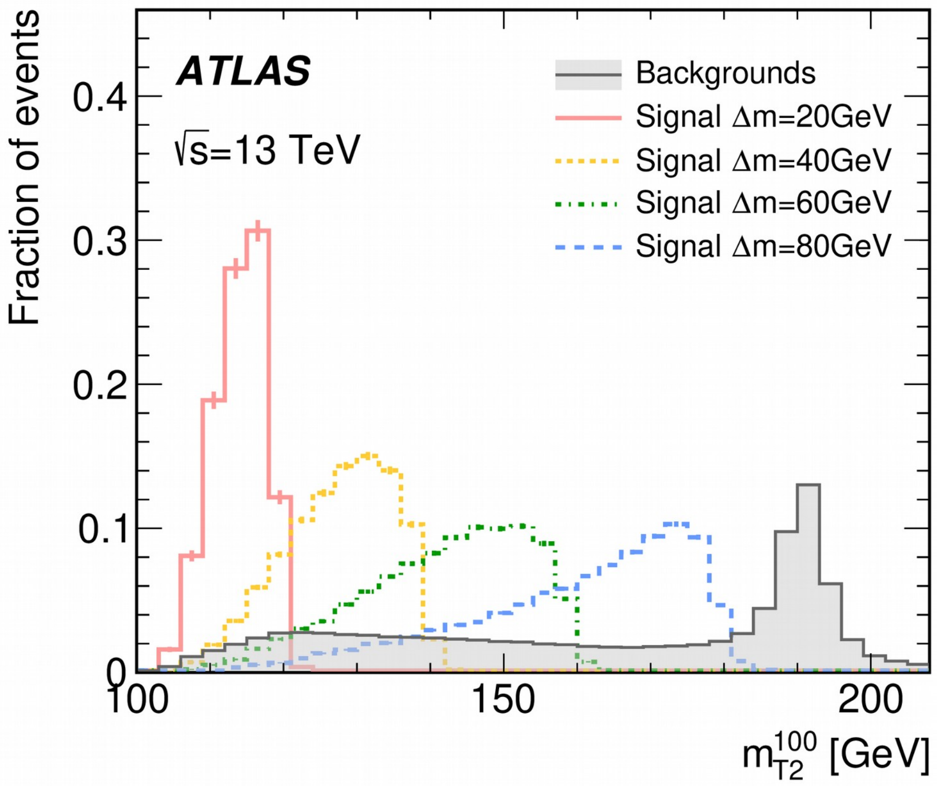
Off-shell WZ SR definitions

Variable	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_T}$-0j	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_T}$-nj	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_T}$-0j	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_T}$-nj
	Preselection requirements			
$n_{\mathrm{lep}}^{\mathrm{baseline}}$, $n_{\mathrm{lep}}^{\mathrm{signal}}$	$= 3$			
n_{SFOS}	≥ 1			
$m_{\ell\ell}^{\mathrm{max}}$ [GeV]	< 75			
$m_{\ell\ell}^{\mathrm{min}}$ [GeV]	$\in [1, 75]$			
$n_{b\text{-jets}}$	$= 0$			
min $\Delta R_{3\ell}$	> 0.4			
Resonance veto $m_{\ell\ell}^{\mathrm{min}}$ [GeV]	$\notin [3, 3.2]$, $\notin [9, 12]$			-
Trigger	(multi-)lepton		((multi-)lepton $\Vert$ E_T^{miss})	
$n_{\mathrm{jets}}^{30\ \mathrm{GeV}}$	$= 0$	≥ 1	$= 0$	≥ 1
E_T^{miss} [GeV]	< 50	< 200	> 50	> 200
E_T^{miss} significance	> 1.5	> 3.0	> 3.0	> 3.0
$p_T^{\ell_1}$, $p_T^{\ell_2}$, $p_T^{\ell_3}$ [GeV]	> 10			$> 4.5(3.0)$ for $e(\mu)$
$\lvert m_{3\ell} - m_Z \rvert$ [GeV]	> 20 ($\ell_W = e$ only)		-	
min ΔR_{SFOS}	$[0.6, 2.4]$ ($\ell_W = e$ only)		-	

Variable	a	b	c	d	e	f1	f2	g1	g2
	Selection requirements								
$m_{\ell\ell}^{\mathrm{min}}$ [GeV]	[1, 12]	[12, 15]	[15, 20]	[20, 30]	[30, 40]	[40, 60]		[60, 75]	
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_T}$ common								
$m_{\ell\ell}^{\mathrm{max}}$ [GeV]	$\times$	< 60	< 60	< 60	< 60	-	-	-	-
m_T^{mllmin} [GeV]	$\times$	< 50	< 50	< 50	< 60	< 60	> 90	< 60	> 90
m_{T2}^{100} [GeV]	$\times$	< 115	< 120	< 130	-	-	-	-	-
min ΔR_{SFOS}	$\times$	< 1.6	< 1.6	< 1.6	-	-	-	-	-
$p_T^{\ell_1}$,$p_T^{\ell_2}$,$p_T^{\ell_3}$ [GeV]	$\times$	> 10	> 10	> 10	> 10	> 15	> 15	> 15	> 15
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_T}$-0j								
$\lvert \mathbf{p}_T^{\mathrm{lep}} \rvert / E_T^{\mathrm{miss}}$	$\times$	< 1.1	< 1.1	< 1.1	< 1.3	< 1.4	< 1.4	< 1.4	< 1.4
$m_{3\ell}$ [GeV]	$\times$	-	-	-	-	> 100	> 100	> 100	> 100
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_T}$-nj								
$\lvert \mathbf{p}_T^{\mathrm{lep}} \rvert / E_T^{\mathrm{miss}}$	$\times$	< 1.0	< 1.0	< 1.0	< 1.0	< 1.2	< 1.2	< 1.2	< 1.2
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_T}$ common								
m_{T2}^{100} [GeV]	< 112	< 115	< 120	< 130	< 140	< 160	< 160	< 175	< 175
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_T}$-0j								
$p_T^{\ell_1}$,$p_T^{\ell_2}$,$p_T^{\ell_3}$ [GeV]	$\times$	$> 25, > 15, > 10$							
m_T^{mllmin} [GeV]	$\times$	< 50	< 50	< 60	< 60	< 70	> 90	< 70	> 90
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_T}$-nj								
						f		g	
$p_T^{\ell_1}$,$p_T^{\ell_2}$,$p_T^{\ell_3}$ [GeV]	> 4.5 (3.0) for e (μ)								
$\lvert \mathbf{p}_T^{\mathrm{lep}} \rvert / E_T^{\mathrm{miss}}$	< 0.2	< 0.2	< 0.3	< 0.3	< 0.3	< 1.0		< 1.0	

Off-shell WZ SRs: m_{ll} and m_{T2}^{100} binning





Inclusive SR definitions

	$\mathrm{SR}^{\mathrm{WZ}}$ ($m_{\ell\ell} \in [75, 105]$ GeV)			
	$n_{\mathrm{jets}} = 0$		$n_{\mathrm{jets}} > 0$	
m_{T} [GeV]	$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]			
[100, 160]	$\mathrm{incSR}^{\mathrm{WZ}}$-1: [100, 200]	$\mathrm{incSR}^{\mathrm{WZ}}$-2: > 200	$\mathrm{incSR}^{\mathrm{WZ}}$-3: [150, 250]	$\mathrm{incSR}^{\mathrm{WZ}}$-4: > 250
> 160	$\mathrm{incSR}^{\mathrm{WZ}}$-5: > 200		$\mathrm{incSR}^{\mathrm{WZ}}$-6: > 200	

	$\mathrm{SR}^{\mathrm{Wh}}_{\mathrm{SFOS}}$ ($m_{\ell\ell} \leq 75$ GeV)	
	$n_{\mathrm{jets}} = 0$	$n_{\mathrm{jets}} > 0$
m_{T} [GeV]	$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	
[0, 100]	$\mathrm{incSR}^{\mathrm{Wh}}_{\mathrm{SFOS}}$-7: > 50	-
[100, 160]	$\mathrm{incSR}^{\mathrm{Wh}}_{\mathrm{SFOS}}$-8: > 50	$\mathrm{incSR}^{\mathrm{Wh}}_{\mathrm{SFOS}}$-9: > 75
> 160	$\mathrm{incSR}^{\mathrm{Wh}}_{\mathrm{SFOS}}$-10: > 50	$\mathrm{incSR}^{\mathrm{Wh}}_{\mathrm{SFOS}}$-11: > 75

	$\mathrm{SR}^{\mathrm{Wh}}_{\mathrm{DFOS}}$
	$\mathrm{incSR}^{\mathrm{Wh}}_{\mathrm{DFOS}}$-12: $n_{\mathrm{jets}} \in [0, 2]$, $\Delta R_{\mathrm{OS,near}} < 1.2$, 3rd lepton p_{T} >20 GeV

	$\mathrm{incSR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj			
	a	b	c1	c2
$m_{\ell\ell}^{\mathrm{min}}$ [GeV]	[1, 12]	[12, 15]	[1, 20]	[15, 20]
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[a]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[b]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[a-c]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[c]

	$\mathrm{incSR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$		$\mathrm{incSR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$	
	b	c	b	c
$m_{\ell\ell}^{\mathrm{min}}$ [GeV]	[12, 15]	[12, 20]	[12, 15]	[12, 20]
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[b], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[b]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[b-c], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[b-c]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[b], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[b]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[b-c], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[b-c]

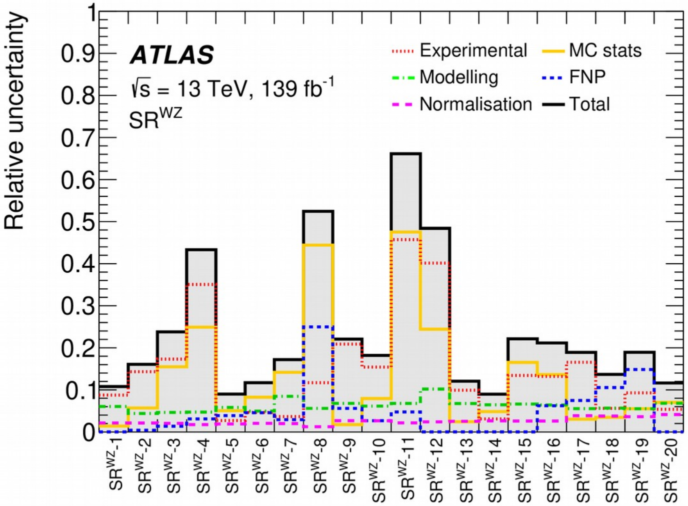
	$\mathrm{incSR}^{\mathrm{offWZ}}$				
	d	e1	e2	f1	f2
$m_{\ell\ell}^{\mathrm{min}}$ [GeV]	[12, 30]	[12, 40]	[20, 40]	[12, 60]	[30, 60]
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[b-d], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[b-d], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[b-d], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[b-d]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[b-e], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[b-e], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[b-e], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[b-e]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[c-e], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[c-e], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[c-e], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[c-e]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[c-f2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[c-f2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[c-f2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[c-f]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[e-f2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[e-f2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[e-f2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[e-f]

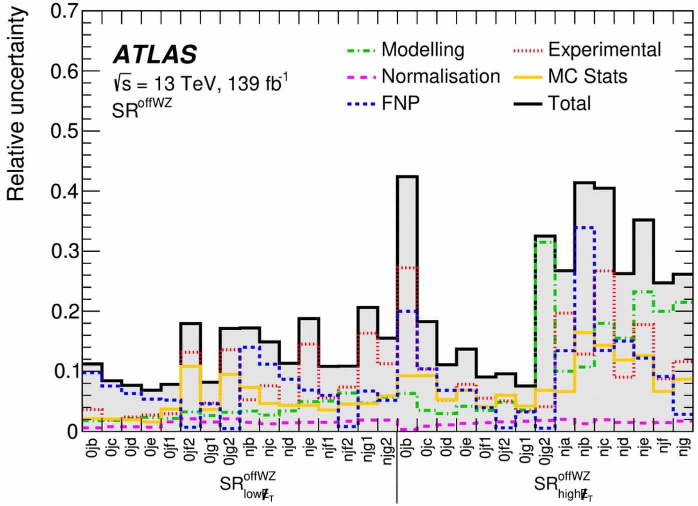
	$\mathrm{incSR}^{\mathrm{offWZ}}$			
	g1	g2	g3	g4
$m_{\ell\ell}^{\mathrm{min}}$ [GeV]	[12, 75]	[30, 75]	[40, 75]	[60, 75]
	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[b-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[b-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[b-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[b-g]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[e-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[e-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[e-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[e-g]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[f1-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[f1-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[f1-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[f1-g]	$\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-0j[g1-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{low}\not{E}_{T}}$-nj[g1-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-0j[g1-g2], $\mathrm{SR}^{\mathrm{offWZ}}_{\mathrm{high}\not{E}_{T}}$-nj[g]

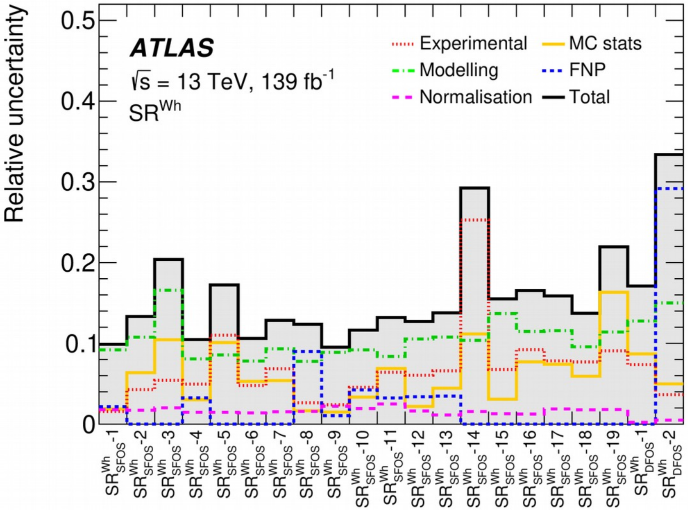
RJR regions definitions

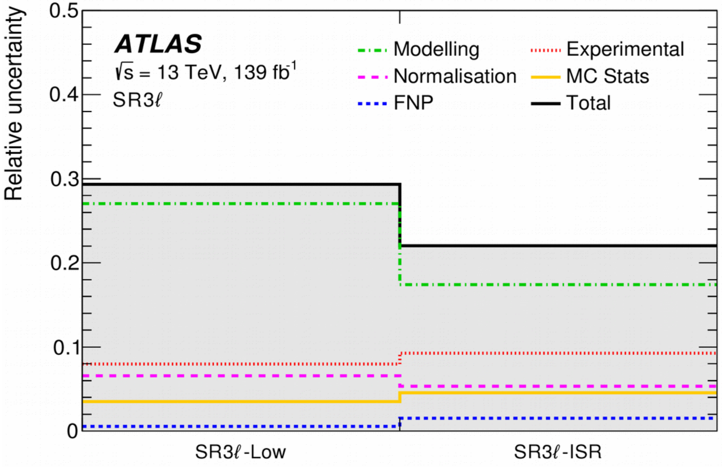
Variable	Selection requirements					
	CR3ℓ-VV	VR3ℓ-VV	SR3ℓ-Low	CR3ℓ-ISR-VV	VR3ℓ-ISR-VV	SR3ℓ-ISR
n_{lep}		$= 3$			$= 3$	
n_{jets}		$= 0$		≥ 1	≥ 1	$\in [1, 3]$
$n_{b\text{-jets}}$		$= 0$			$= 0$	
$p_{\text{T}}^{\ell_1}, p_{\text{T}}^{\ell_2}, p_{\text{T}}^{\ell_3}$ [GeV]		$> 60, 40, 30$			$> 25, 25, 20$	
$m_{\ell\ell}$ [GeV]		$\in [75, 105]$			$\in [75, 105]$	
m_{T} [GeV]	$\in (0, 70)$	$\in (70, 100)$	> 100	< 100	> 60	> 100
$H_{3,1}^{\text{PP}}$ [GeV]	> 250	> 250	> 250		-	
$p_{\text{T}}^{\text{PP,lab}}/(p_{\text{T}}^{\text{PP,lab}} + H_{\text{T}\,3,1}^{\text{PP}})$	< 0.2	< 0.2	< 0.05		-	
$H_{\text{T}\,3,1}^{\text{PP}}/H_{3,1}^{\text{PP}}$	> 0.75	> 0.75	> 0.9		-	
$\Delta\phi_{\text{ISR,I}}^{\text{CM}}$		-			> 2.0	
R_{ISR}		-			$\in (0.55, 1.0)$	
$p_{\text{T,ISR}}^{\text{CM}}$ [GeV]		-		> 80	> 80	> 100
$p_{\text{T,I}}^{\text{CM}}$ [GeV]		-		> 60	> 60	> 80
p_{T}^{CM} [GeV]		-		< 25	> 25	< 25

Systematics breakdown plots

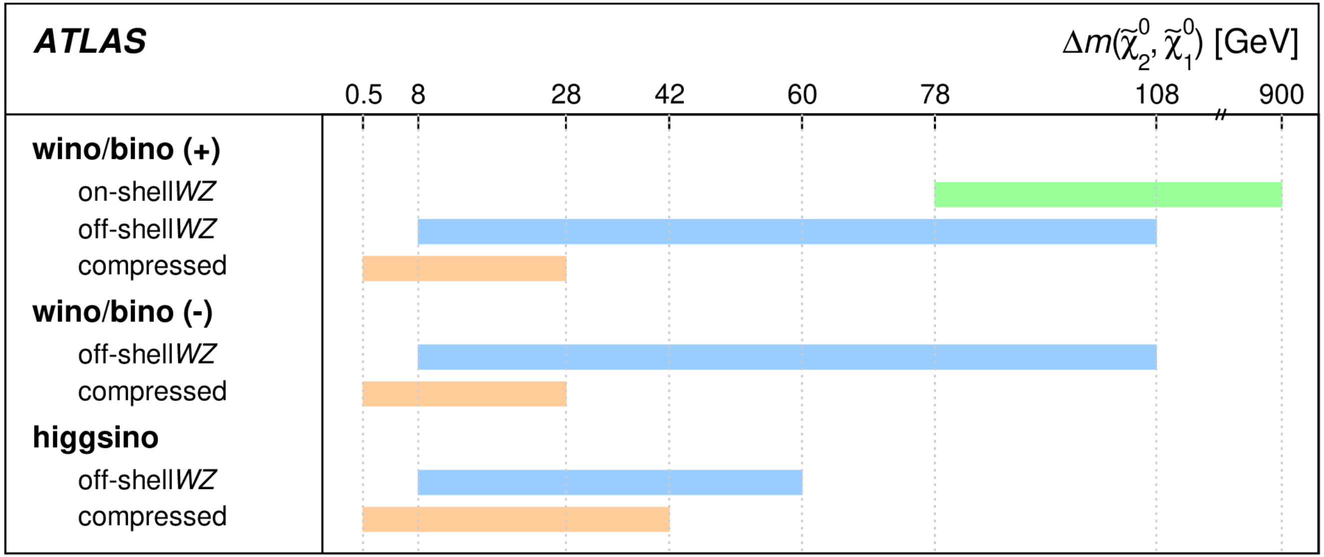








Composition scheme used for combination



- Overlapping areas represent the signal points where the corresponding combination has been taken into account

PyHF patchsets

```
README.md
~/.cache/.fr-K9BQhH/statistical_models

# HistFactory Likelihoods for the ATLAS SUSY Electroweak
The HistFactory likelihoods of the three-lepton searches are serialised in JSON.
The likelihoods can be provided as input or manipulated with [pyhf](https://iris-hep.org/projects/pyhf.html).

For each analysis channel (on-shell, off-shell) a background-only workspace is provided
(bkg_onshell.json, bkg_offshell.json). Information relative to the signal models
is contained in files called 'patchsets'. Patchsets are provided for
each analysis channel and for each SUSY Electroweak scanario considered:
wino/bino (+) for the on-shell channel and wino/bino (+), wino/bino (-) and higgsino for
the off-shell channel.

### Performing a fit

In order to perform a fit, a background workspace has to be applied a patch.
For example, if the desired signal point is defined by m($\chi^{\pm} _{1}$) = 250 GeV and m($\chi^{0} _{1}$) = 50 GeV, the likelihood including the on-shell regions is built with:
```
pyhf patchset apply --name CN_WZ_250_50_harmonised_onshell bkg_onshell.json onshell_winobino_plus_patchset.json --output-file CN_WZ_250_50_onshell_from_patch.json
```
The string following the --name option is the patch name.
All patches are called following the pattern:
```
CN_WZ_{chargino mass}_{neutralino mass}_harmonised_{channel = onshell or offshell}
```
The adjective 'harmonised' appearing in the patch name remarks the fact that the onshell and offshell likelihoods share the same conventions for the naming of parameters.

The exclusion fit can be run with:
```
pyhf cls CN_WZ_250_50_onshell_from_patch.json
```

### Combined fits

For the wino/bino (+) scenario, the signal points with  m($\chi^{\pm} _{1}$)  -  m($\chi^{0} _{1}$) between 78 and 108 GeV are in common between the on-shell and the off-shell channels, allowing for a combined
fit.

To permorm a combined fit:

* create the workspaces using the patchsets:
```
pyhf patchset apply --name CN_WZ_200_100_harmonised_onshell bkg_onshell.json onshell_winobino_plus_patchset.json --output-file CN_WZ_200_100_onshell_from_patch.json
```
```
pyhf patchset apply --name CN_WZ_200_100_harmonised_offshell bkg_offshell.json offshell_winobino_plus_patchset.json --output-file CN_WZ_200_100_offshell_from_patch.json
```
* combine the workspaces
```
pyhf combine --join outer CN_WZ_200_100_onshell_from_patch.json CN_WZ_200_100_offshell_from_patch.json --output-file combined_CN_WZ_200_100.json
```
* run the fit
```
pyhf cls combined_CN_WZ_200_100.json
```

### Combination with the 2L compressed workspaces

The likelihoods of the [2L compressed analysis](https://doi.org/10.1103/PhysRevD.101.052005) can be downloaded at https://www.hepdata.net/record/ins1767649.
To perform a combination the parameters have to be renamed according to the mapping specified in `compressed_mapping.py`.
### Additional Notes

`pyhf` v0.6.2+ is recommended to use these patchsets. See [scikit-hep/pyhf#1488](https://github.com/scikit-hep/pyhf/pull/1488) for more details.
```

- **PyHF patchsets** available in HEPData's Resources
- **All models** and **reinterpretations**
- Full **instructions in README** on how to run PyHF
  - + instructions on how to **perform the combination**
- Link to **download compressed likelihoods** + instructions to include compressed in the **combination**