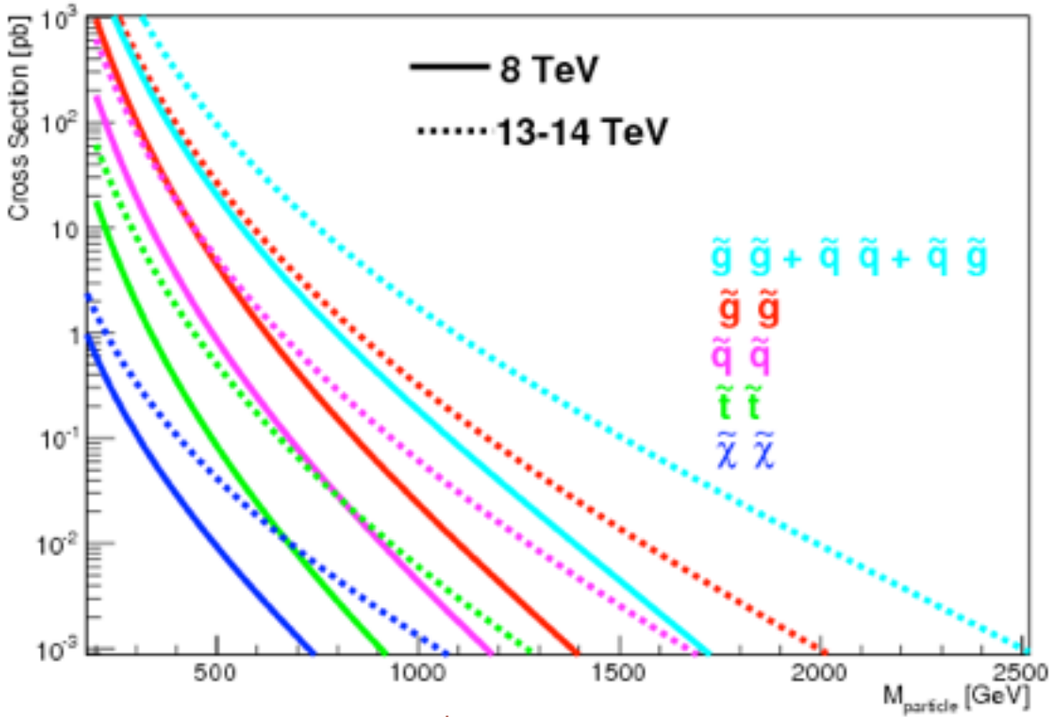
Search for direct stop and sbottom pair production with the ATLAS detector

Silvia Fracchia (IFAE Barcelona)
on behalf of the ATLAS Collaboration

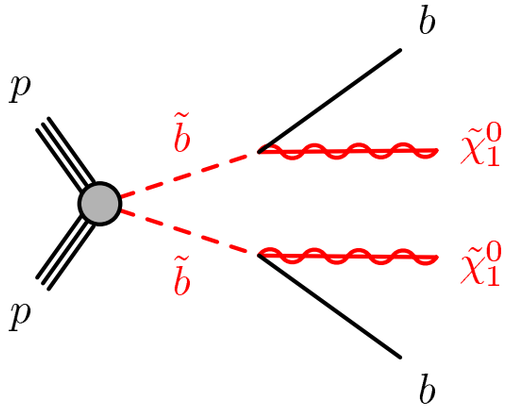
SUSY 2016 — July 5th, 2016

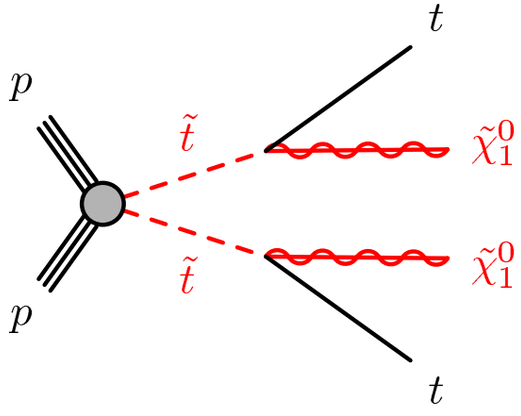
Direct stop and sbottom searches in ATLAS

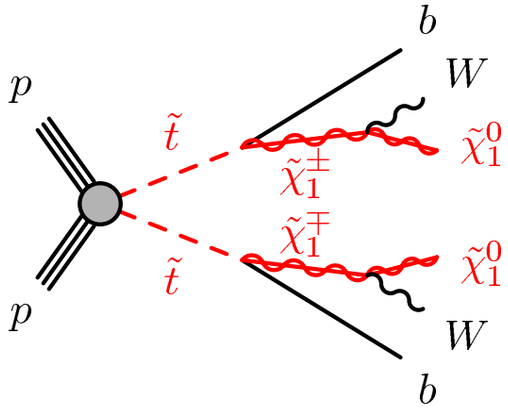
- Large cross section increase with increase of center-of-mass energy for direct stop and sbottom pair production
- Common strategy is to optimise for a specific signature and interpret the results for simplified models (generally with 100% B.R.)

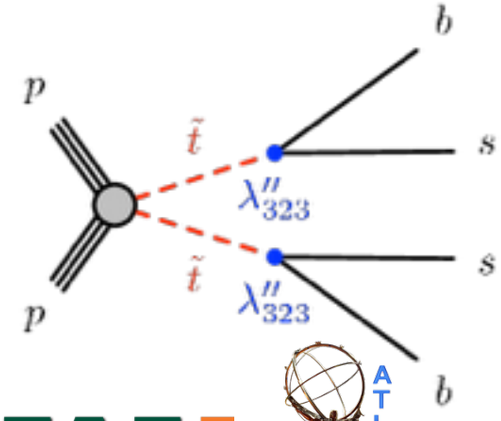


- Searches in ATLAS with results at $\sqrt{s}$=13 TeV, using 3.2 fb^{-1} of integrated luminosity corresponding to the data collected in 2015
  - Direct sbottom pair production: arXiv:1606.08772
  - Direct stop pair production
    - 1 lepton: arXiv:1606.03903
    - 2 leptons: ATLAS-CONF-2016-009
    - RPV stop: ATLAS-CONF-2016-022









The sbottom analysis

Analysis strategy

arXiv:1606.08772

Final state:

0 leptons, large E_T^{miss}, 2 b-jets

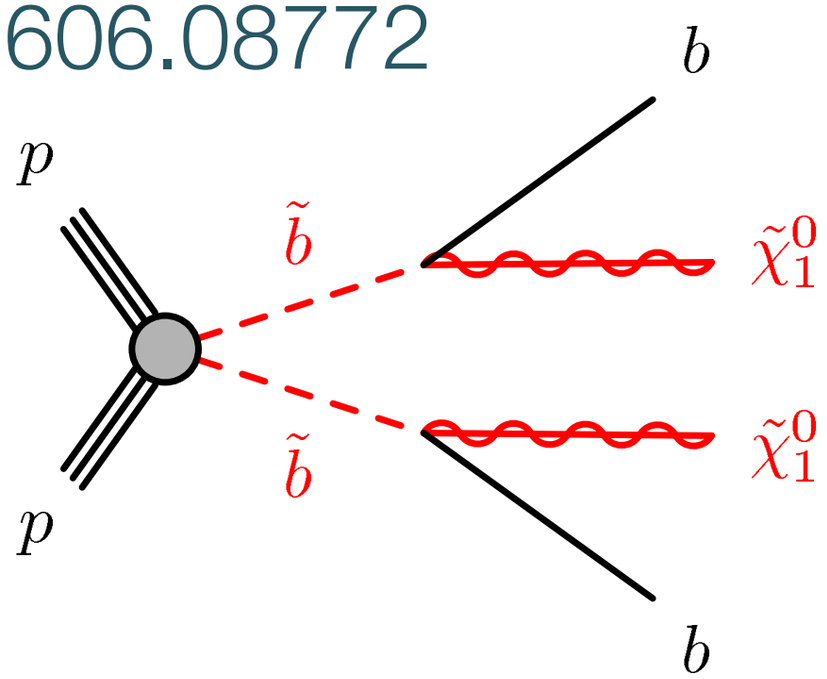
Two sets of signal regions:

SRA: targeting models with large $\Delta M(\tilde{b}_1, \tilde{\chi}_1^0)$

- m_{CT}(bb) is the main discriminating variable

SRB: targeting models with small $\Delta M(\tilde{b}_1, \tilde{\chi}_1^0)$

- High p_T ISR jet recoiling against $\tilde{b}\tilde{b}$ system



$$\tilde{b}_1\tilde{b}_1 \rightarrow bb\tilde{\chi}_1^0\tilde{\chi}_1^0$$

100% B.R.

Variable	SRA	SRB
Event cleaning	Common to all SR	
Lepton veto	No e/μ with $p_T > 10$ GeV after overlap removal	
E_T^{miss} [GeV]	> 250	> 400
n(jets) $p_T > 35$ GeV	2–4	3–4
1st jet $p_T(j_1)$ [GeV]	> 130	> 300
2nd jet $p_T(j_2)$ [GeV]	> 50	> 50
4th jet	Vetoed if $p_T(j_4) > 50$ GeV	
$\Delta\phi^j_{min}$	> 0.4	> 0.4
$\Delta\phi(j_1, E_T^{miss})$	-	> 2.5
b-tagging	j_1 and j_2	j_2 and (j_3 or j_4)
E_T^{miss}/m_{eff}	> 0.25	> 0.25
m_{CT} [GeV]	> 250, 350, 450	-
m_{bb} [GeV]	> 200	-

Contransverse mass

$$m_{CT}^2 = [E_T(v1) + E_T(v2)]^2 + - [\mathbf{p_T}(v1) - \mathbf{p_T}(v2)]^2$$

It has kinematical endpoint

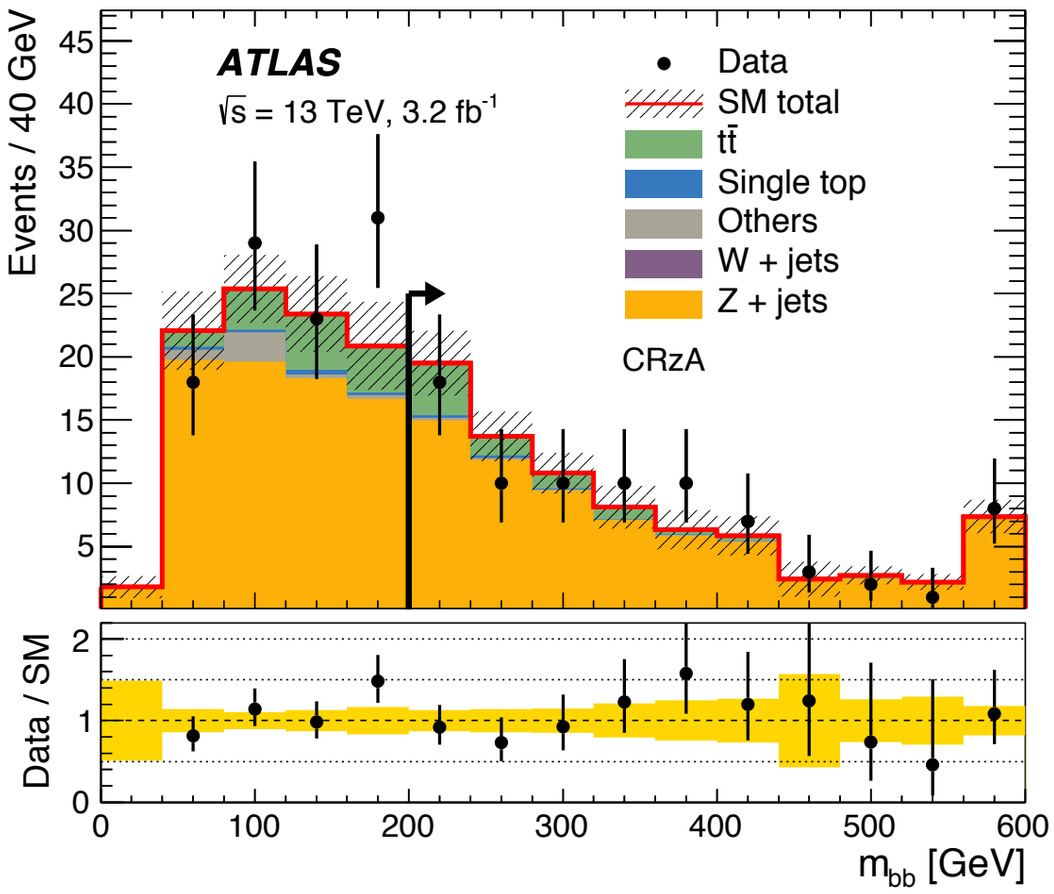
$t\bar{t}$ background:135 GeV

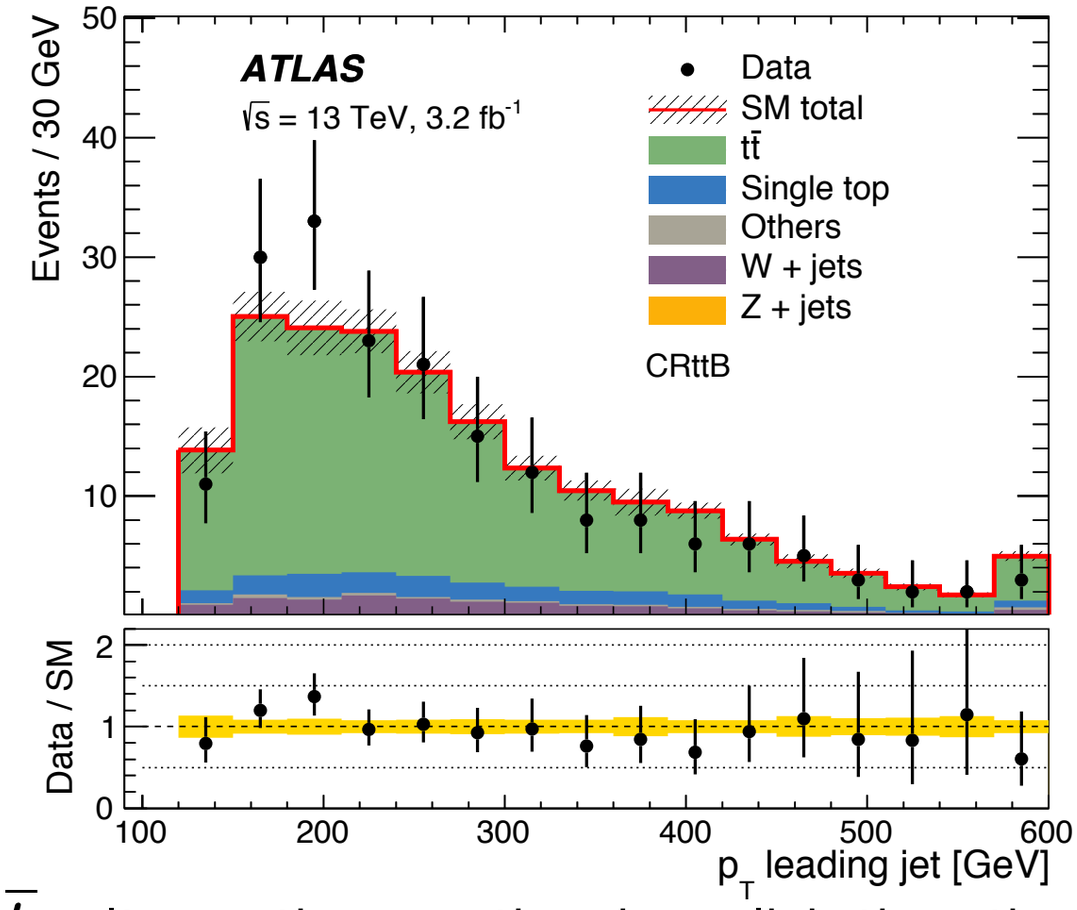
signal: $m_{CT}^{max} = (m_{\tilde{b}_1}^2 - m_{\tilde{\chi}_1^0}^2)/m_{\tilde{b}_1}$

The sbottom analysis

Background estimation

- Z(—>vv)+jets is the dominant background in SRA
  - Constrained in 2 leptons control region
  - $t\bar{t}$, single top and W+jets also have dedicated 1 lepton control regions
- $t\bar{t}$ and Z(—>vv)+jets are the dominant background in SRB
  - Both constrained in dedicated control regions with 1 and 2 leptons, respectively



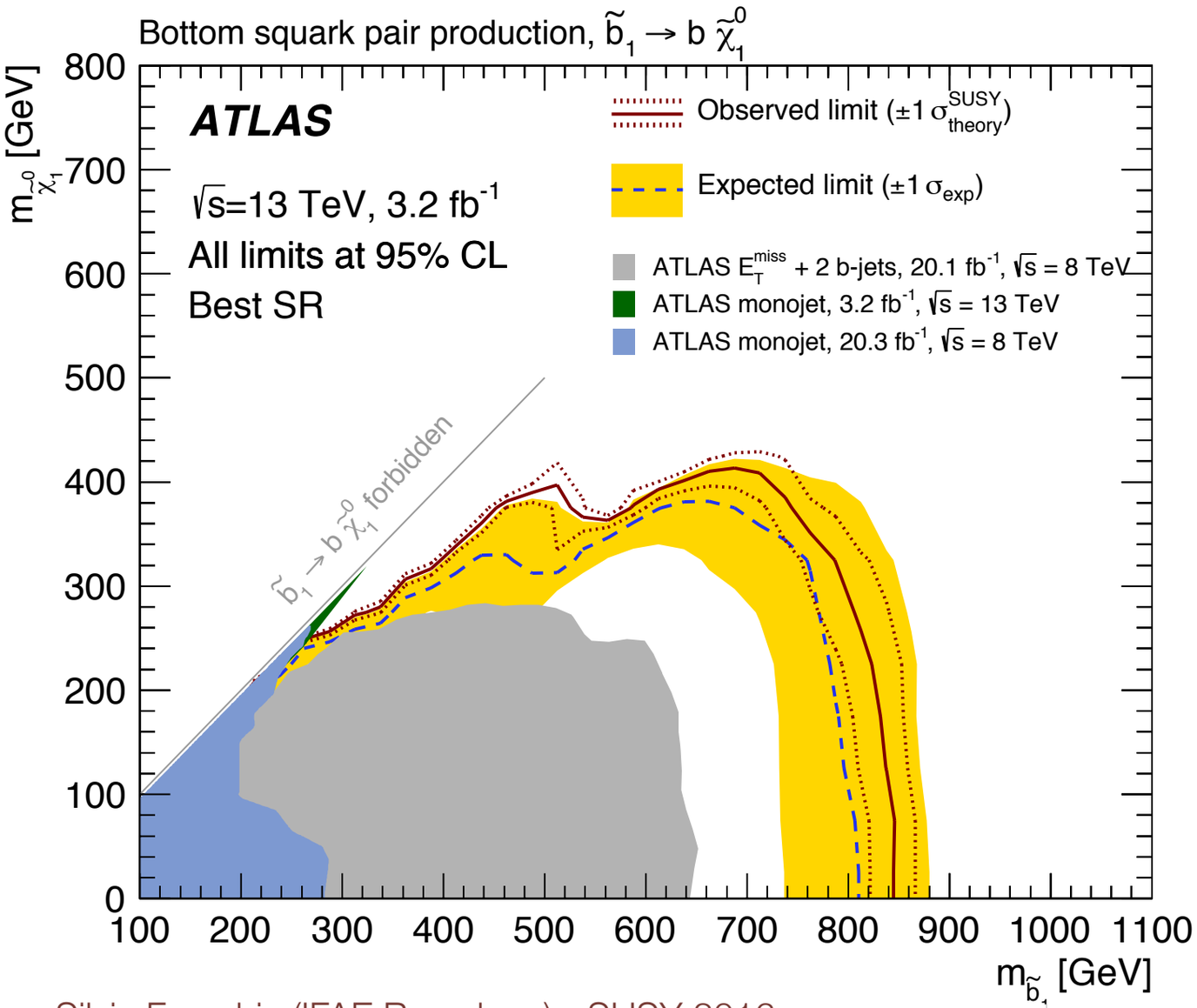


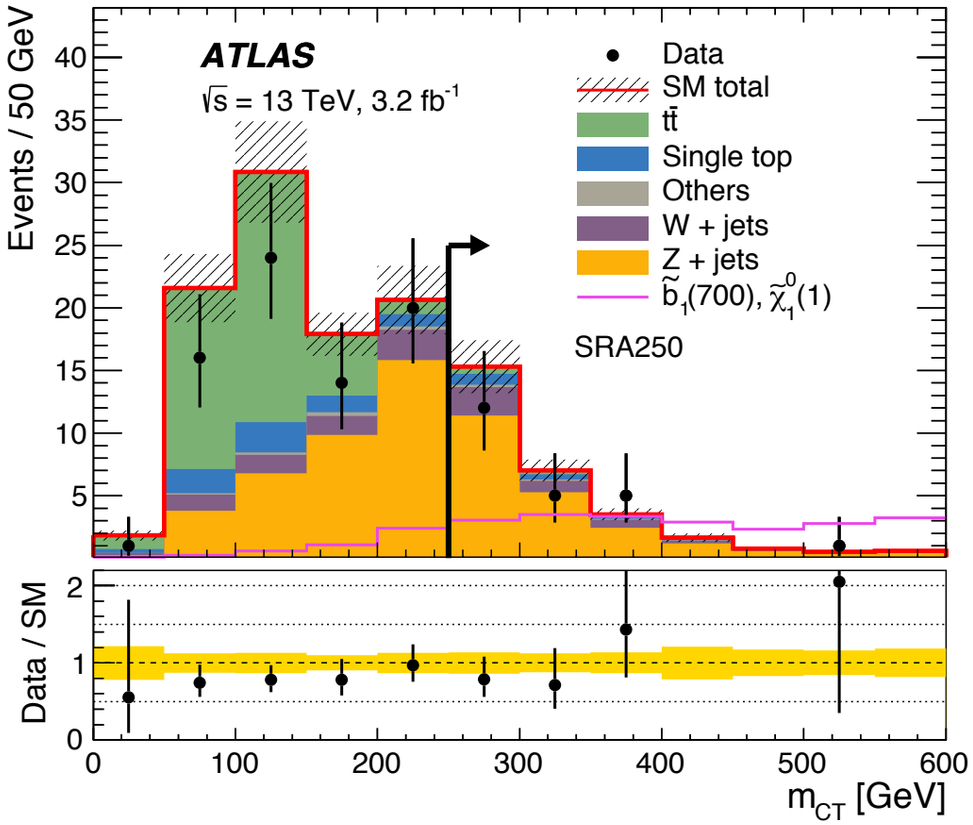
- Validation regions for Z+jets and $t\bar{t}$, alternative methods validating the Z +jets estimation

The sbottom analysis

Results

- No excess is observed with respect to the SM prediction
- Exclusion limits at 95% CL derived in the direct sbottom pair production models, expanding the Run-1 limits

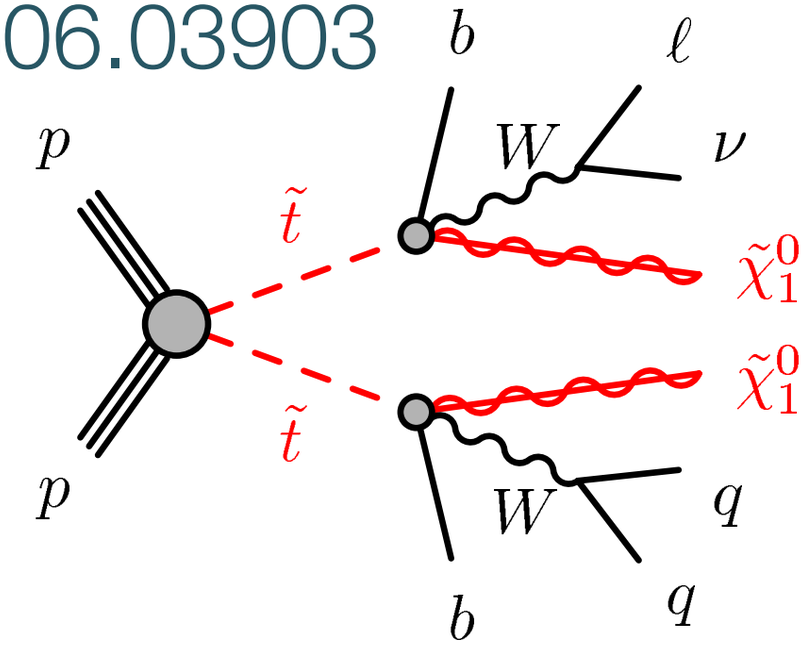




The stop 1 lepton analysis

Analysis strategy (1)

arXiv:1606.03903



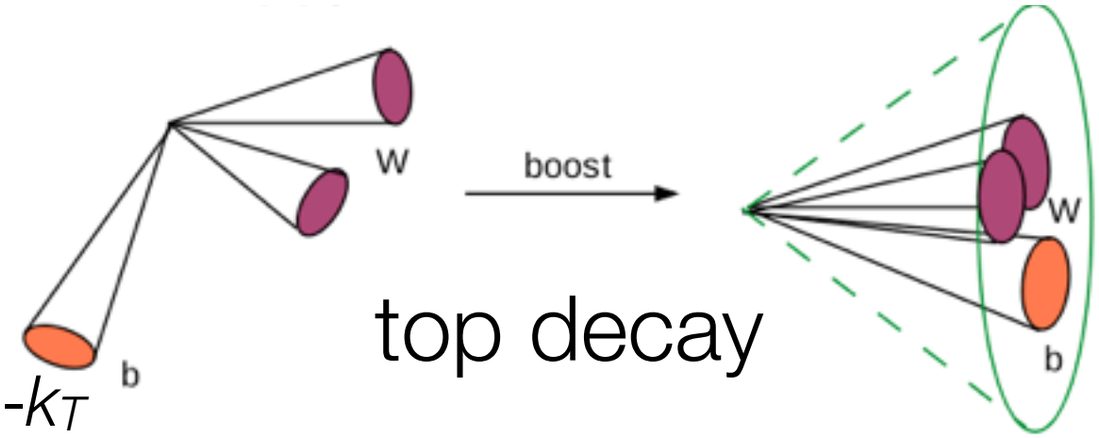
$\tilde{t}_1\tilde{t}_1 \rightarrow tt\tilde{\chi}_1^0\tilde{\chi}_1^0$

B.R. 100%

- 1 lepton (electron or muon), large E_T^{miss}, large jet multiplicity, ≥1 b-jets, veto on hadronic taus
- Analysis targeting gluino mediated stop pair production and direct stop pair production
- 3 signal regions (SR1, SR2, SR3) characterised by increasing E_T^{miss} requirements (260, 350, 380 GeV, respectively)
  - SR1 optimised for direct stop model with (600, 260) GeV
  - SR2, SR3 more boosted regimes

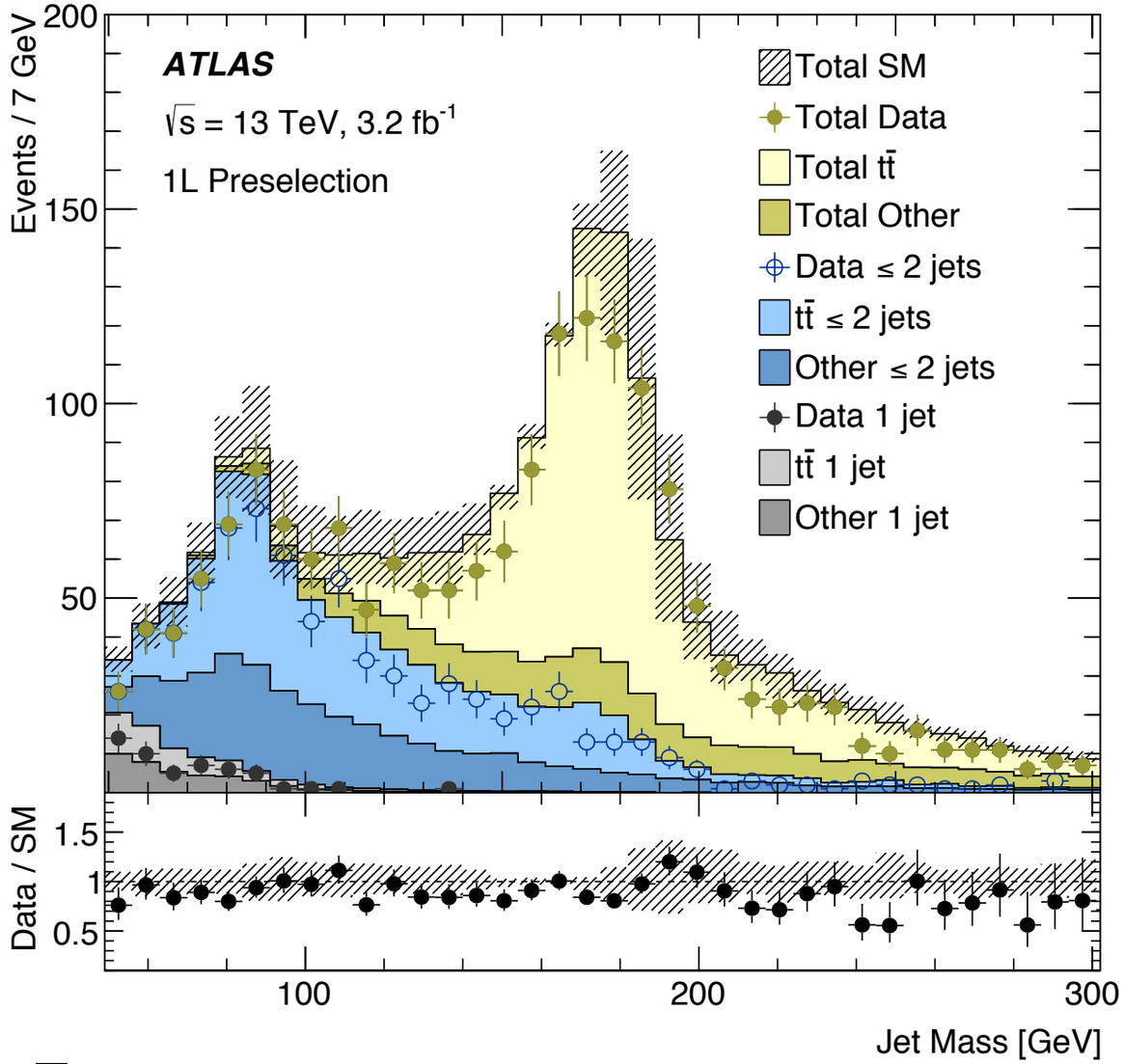
The stop 1 lepton analysis

Analysis strategy (2)



- m^{χ}_{top} as discriminant variable in SR1
  - Invariant mass of the 3 small-radius (anti-k_T R=0.4) jet candidates from top hadronic decay selected with χ^2-minimization

- Large-radius jets from re-clustering of anti-k_T R=0.4 jets as top candidates in SR2, SR3
  - Optimal radius is found to be R=1.2 for SR2 and R=1.0 for SR3
  - Plot showing large-radius jet mass (R = 1.2), decomposed into the number of small-radius jet constituents

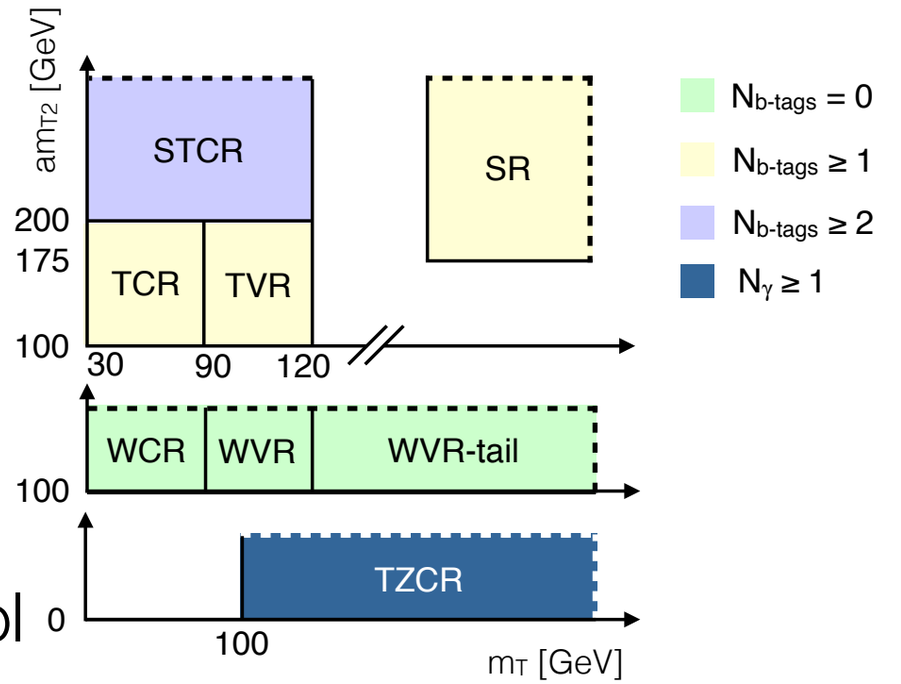


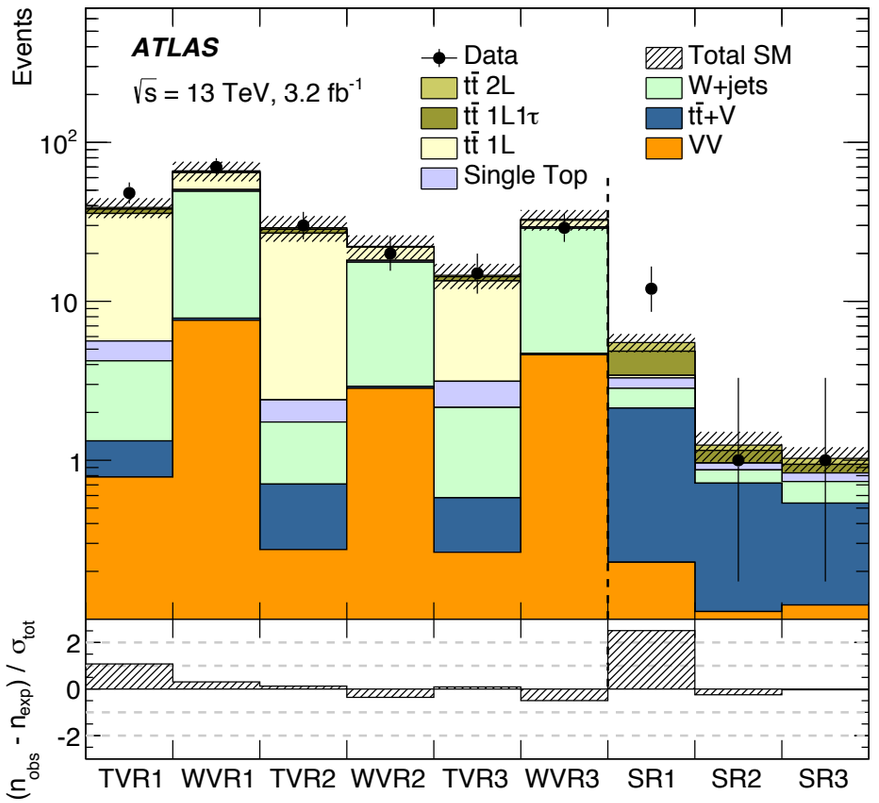
- More variables used to reject dileptonic $t\bar{t}$: m_T (signal lepton, E_T^{miss}), am_{T2}, topness (from χ^2-type function minimization)

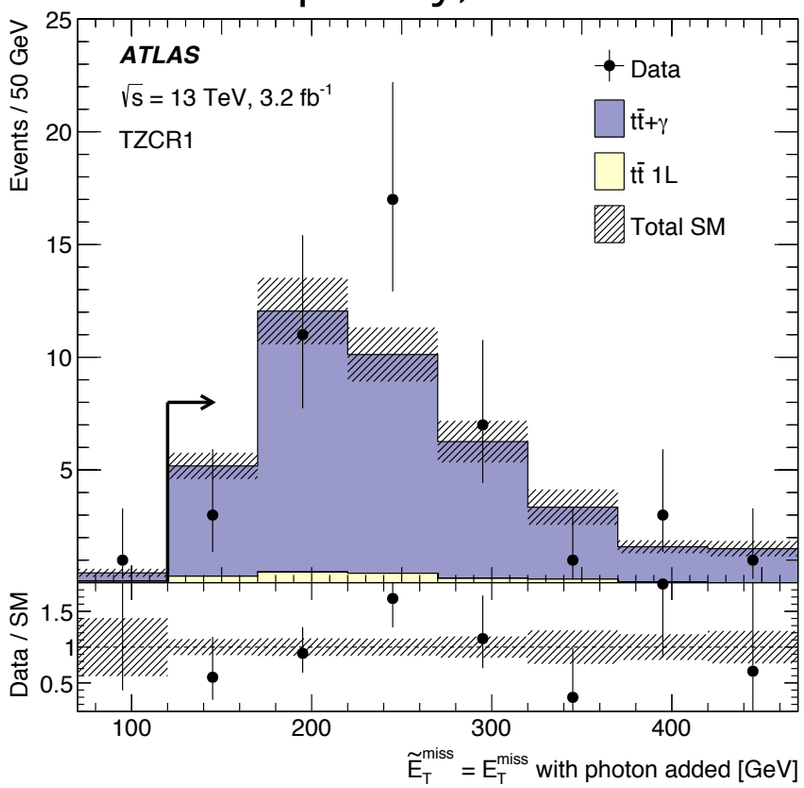
The stop 1 lepton analysis

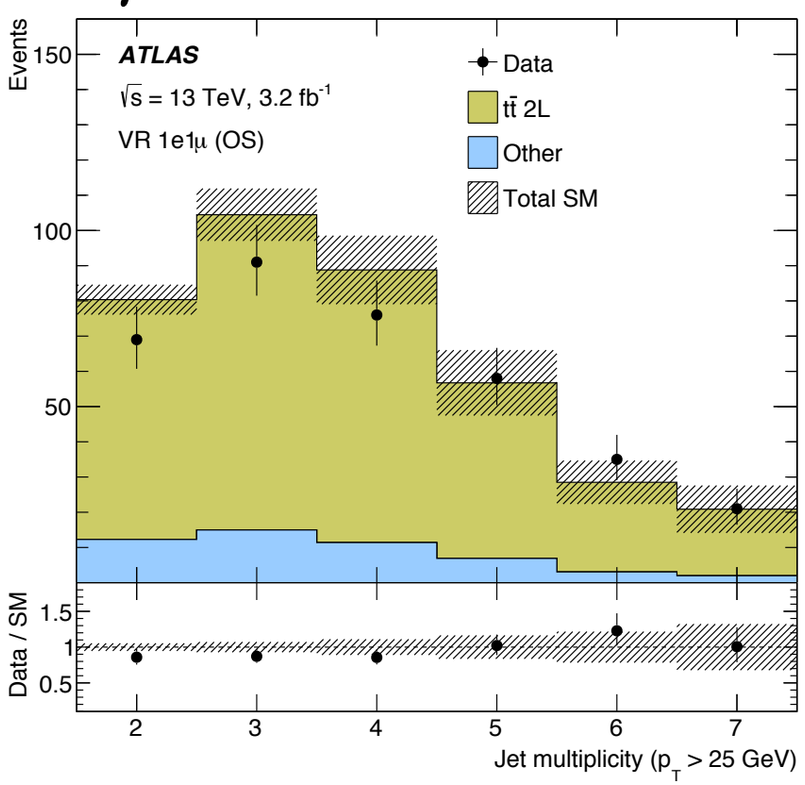
Background estimation

- Dominant backgrounds: dileptonic $t\bar{t}$ and $t\bar{t}$+Z(—>vv), less relevant contributions from W+jets and Wt single top
- Background normalisation from dedicated control regions for $t\bar{t}$, W+jets, single top and $t\bar{t}$ +W/Z (for each signal region)
- Inverted m_T requirements, extrapolation on b-jet multiplicity, $t\bar{t}$+Z from $t\bar{t}$+γ







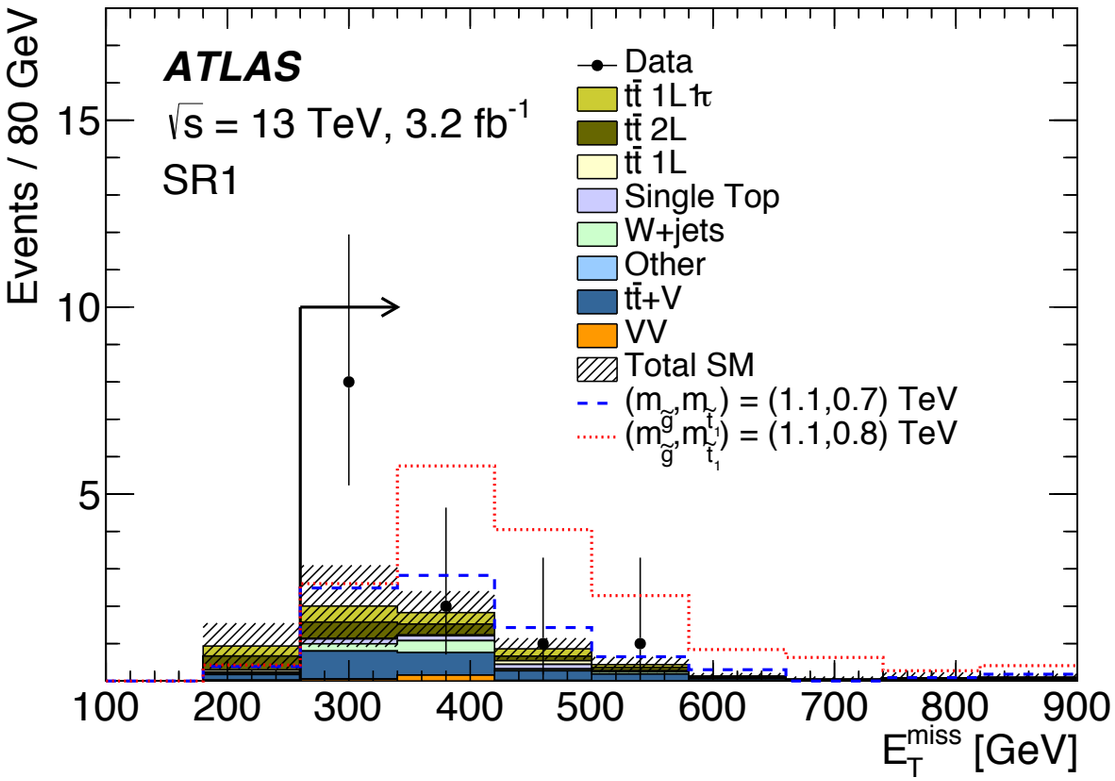


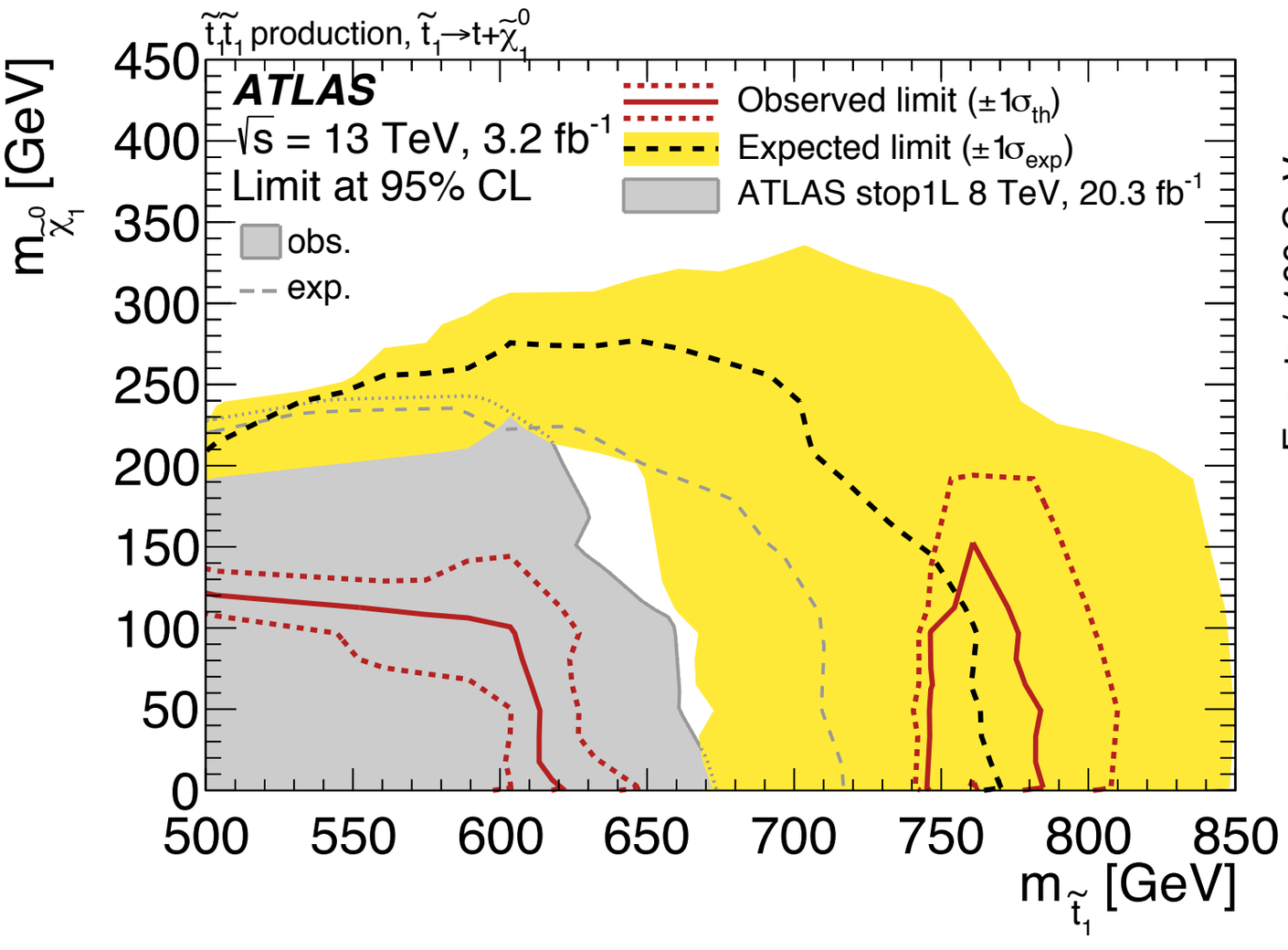
Modelling of extra jets (not from $t\bar{t}$ decay) monitored in dedicated validation regions

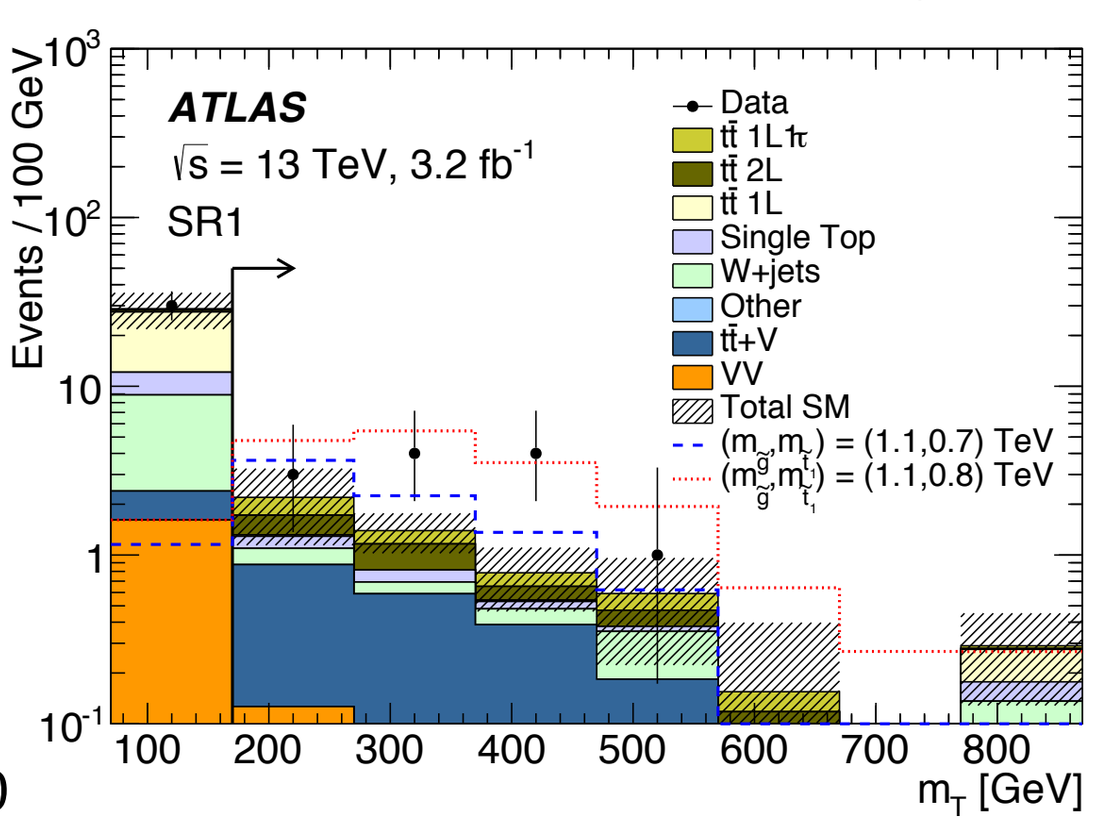
The stop 1 lepton analysis

Results

- Small excess (2.3σ) in the most inclusive signal region (SR1)
- Exclusion limits at 95% CL derived in the stop (and gluino) pair production models, expanding the Run-1 limits





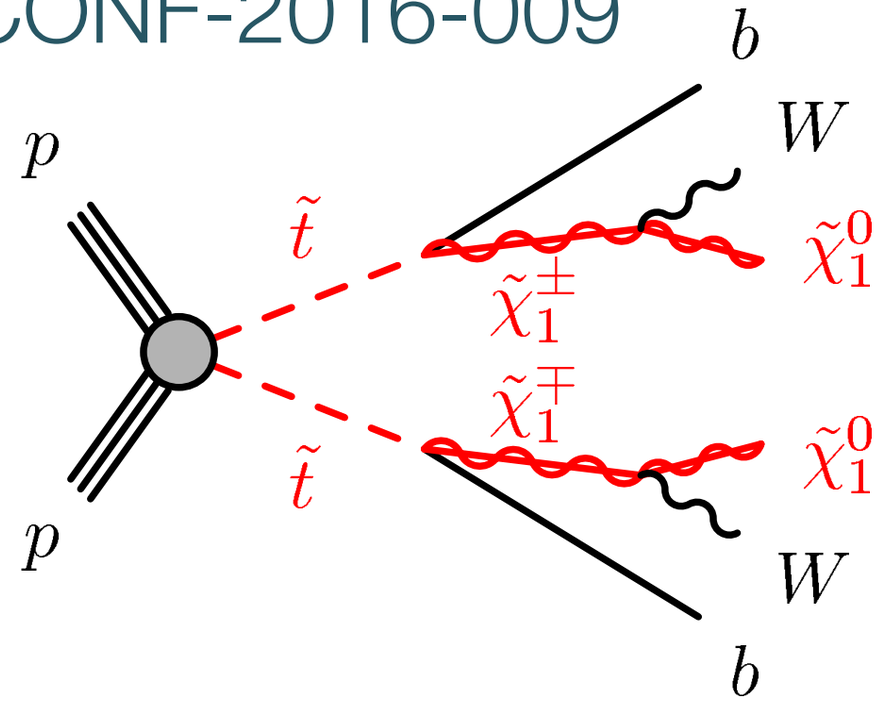


The stop 2 leptons analysis

Analysis strategy

ATLAS-CONF-2016-009

- Considering fully leptonic final state
- Direct stop pair production resulting in final state with 2 opposite charge leptons (electron or muon) and large E_T^{miss}
- Analysis targeting $m(\tilde{\chi}_1^{\pm}) - m(\tilde{\chi}_1^0) > m_W$
- 2 orthogonal signal regions for
  - different flavour (DF) lepton pairs
  - same flavour (SF) lepton pairs



$\tilde{t}_1\tilde{t}_1 \rightarrow bb\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\pm} \rightarrow bbWW\tilde{\chi}_1^0\tilde{\chi}_1^0$

B.R. 100%

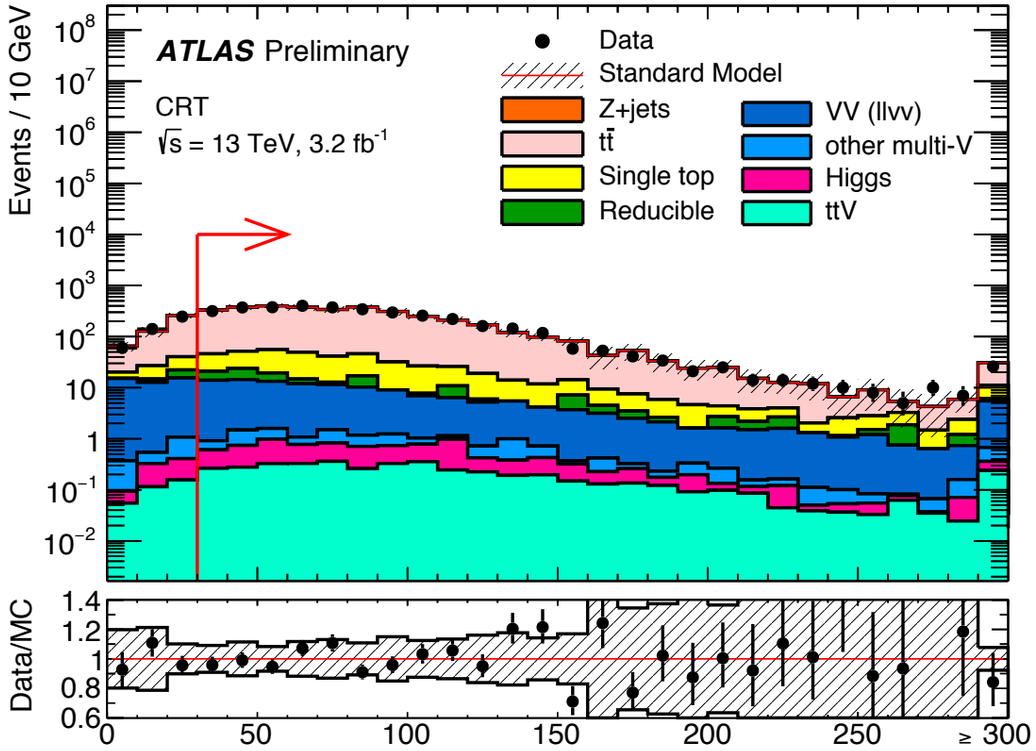
- Requirements on dilepton invariant mass m_{ll}, leptonic stransverse mass m_{T2} (bounded from above for WW and $t\bar{t}$) and R1=E_T^{miss}/m_{eff}

Signal Region	DF	SF
leading lepton p_T [GeV]	> 25	
sub-leading lepton p_T [GeV]	> 15	
additional lepton (veto) p_T [GeV]	> 10	
$m_{\ell\ell}$ [GeV]	>20	(>20 and < 71) or > 111
m_{T2} [GeV]	> 145	
R1	> 0.3	

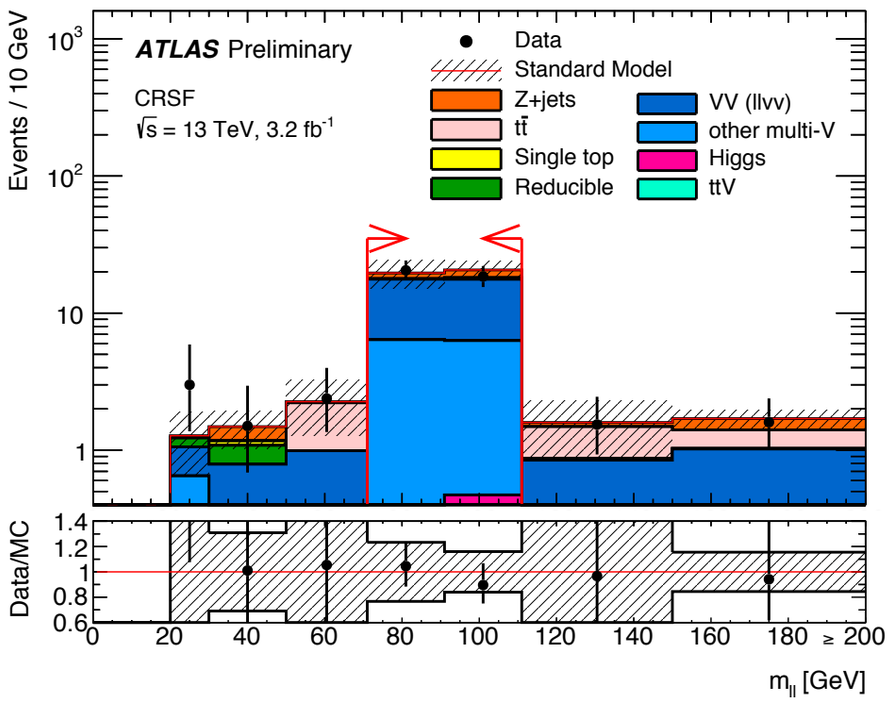
The stop 2 leptons analysis

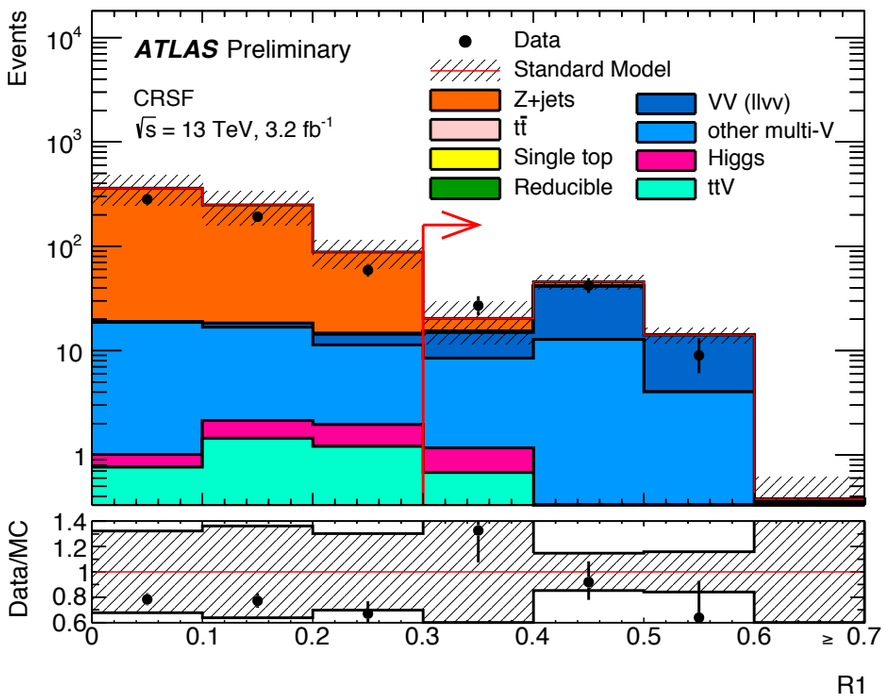
Background estimation

- Dominant backgrounds: diboson production (llvv), $t\bar{t}$
  - They both have a dedicated control region
- The magnitude of the variable $\mathbf{p_{Tb}^{ll} = p_T^{miss} + p_T^{l_1} + p_T^{l_2}}$ is used to discriminating between $t\bar{t}$ and diboson production in the control regions



- Other background sources are Wt, Z/γ^*+jets, $t\bar{t}$ +W/Z and "reducible" background (fake/non-prompt lepton background from semi-leptonic $t\bar{t}$, s and t-channel single top, W+jets, multijet)
- The reducible background is estimated from data by considering the event count in the signal region with two sets of lepton identification criteria

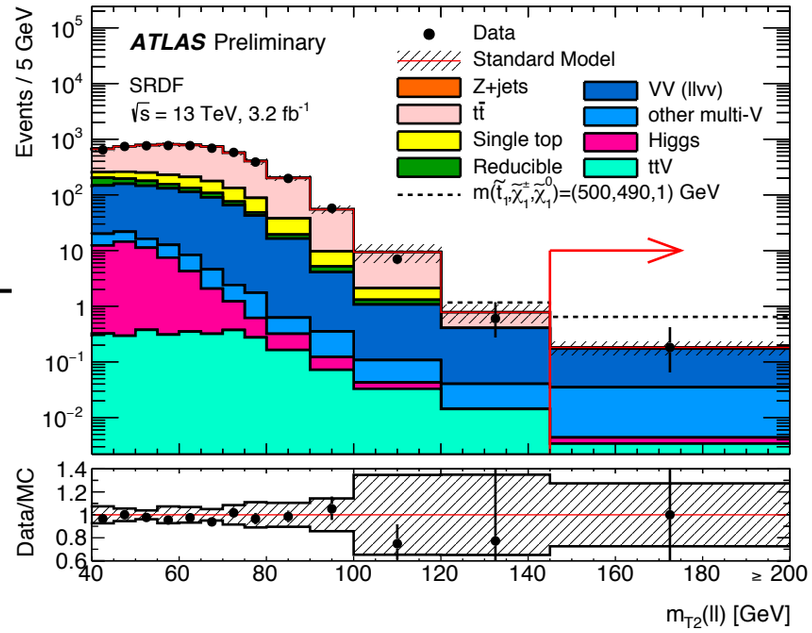


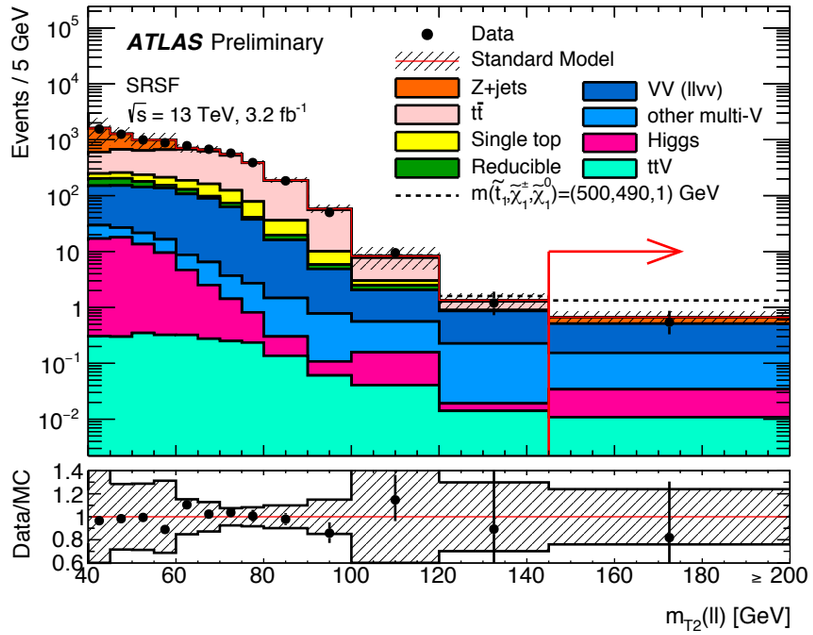


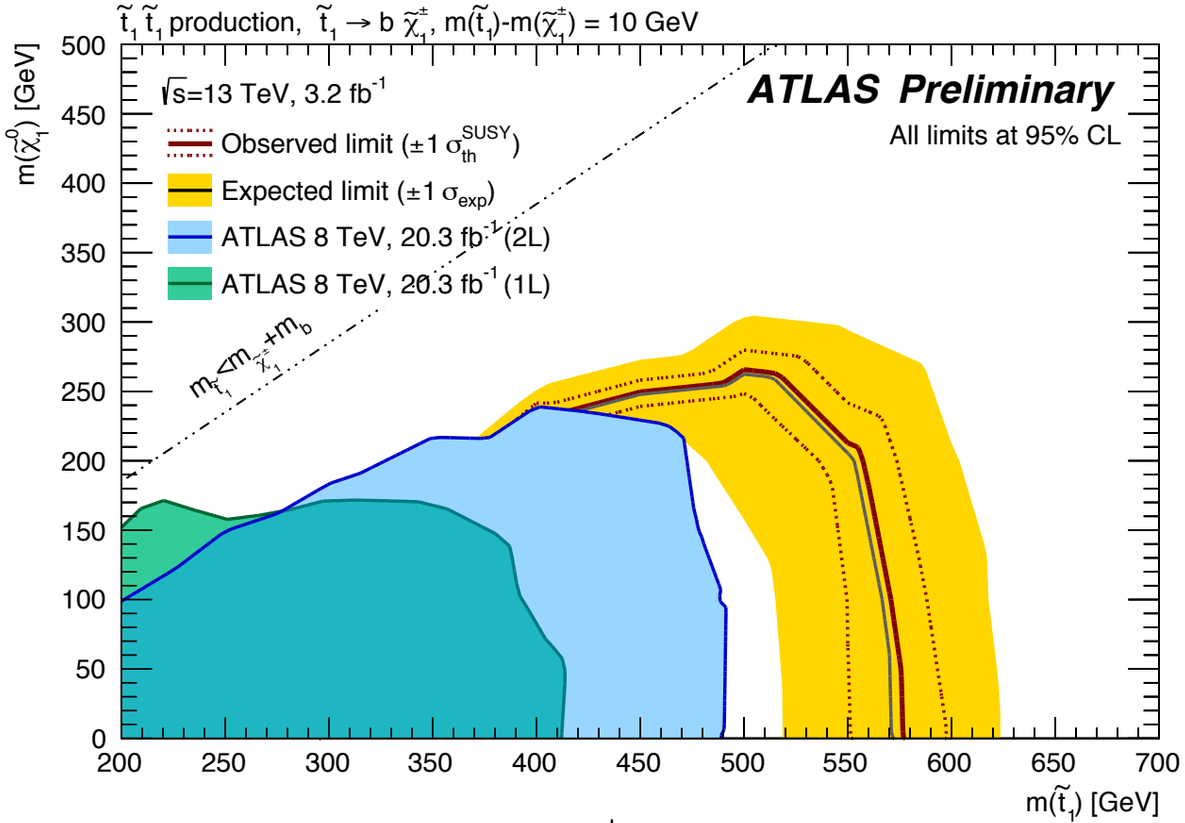
The stop 2 leptons analysis

Results

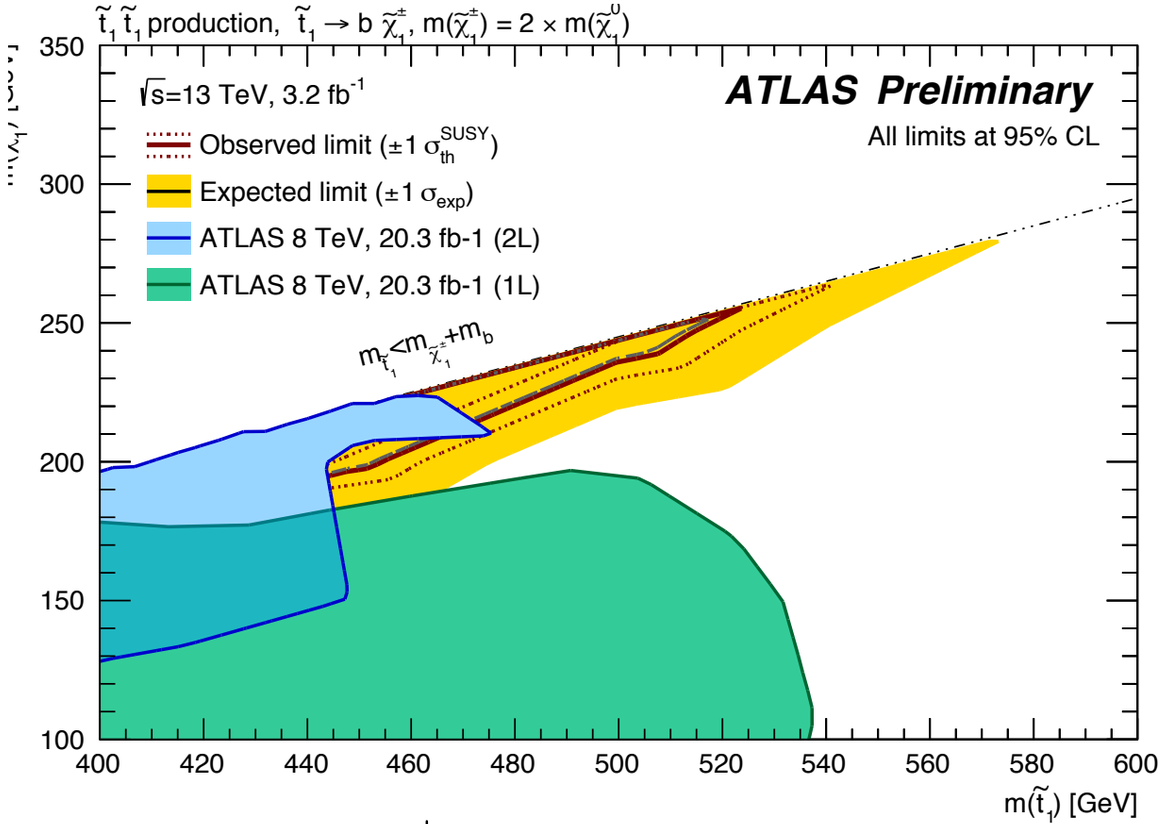
- Good agreement with SM expectations
- Exclusion limits at 95% CL derived for 2 assumptions of chargino and neutralino masses, expanding the Run-1 limits







$$m(\tilde{t}_1) - m(\tilde{\chi}_1^{\pm}) = 10 \text{ GeV}$$



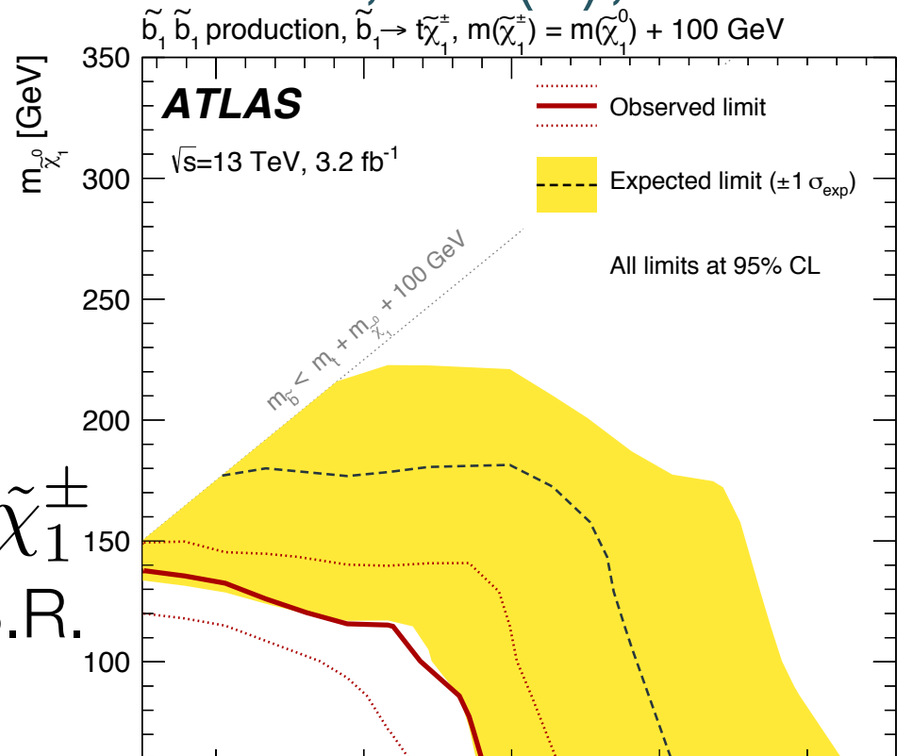
$$m(\tilde{\chi}_1^{\pm}) = 2 \times m(\tilde{\chi}_1^0)$$

Non-RPV direct sbottom and stop pair production

Results from other analyses

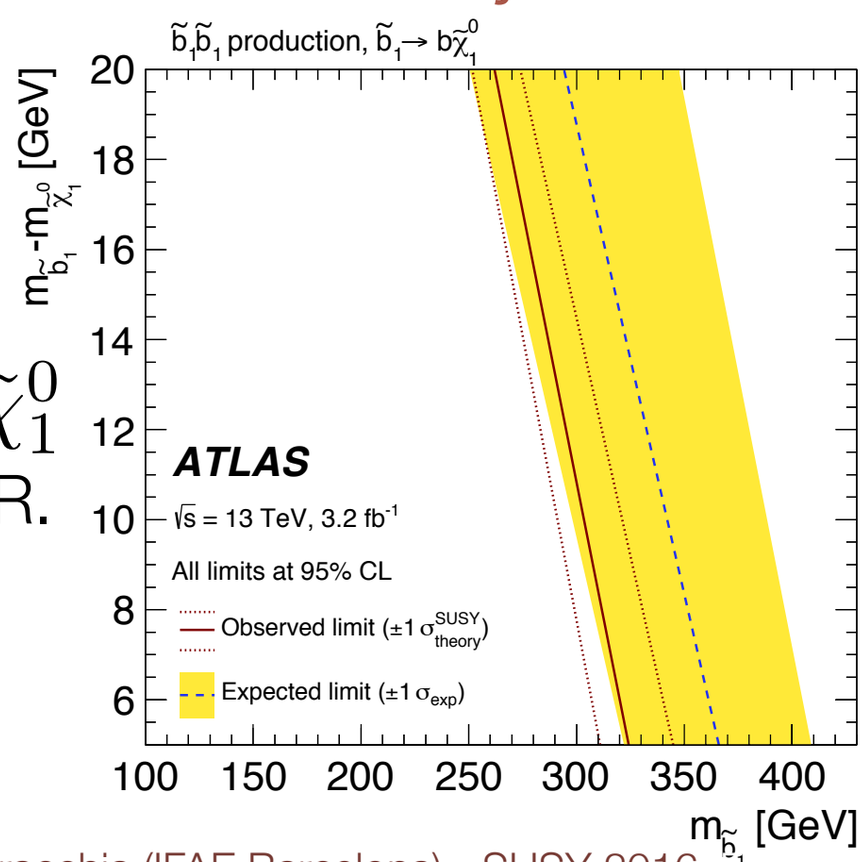
SS/3L: EPJ C, 76(5), 1-26

- Direct sbottom/stop pair production interpretations also in
  - Monojet analysis (no leptons), sensitive to compressed spectra (more about this analysis in Laser Seymour Kaplan's talk)
  - 2 same sign leptons or 3 leptons analysis (see Moritz Backes' talk)

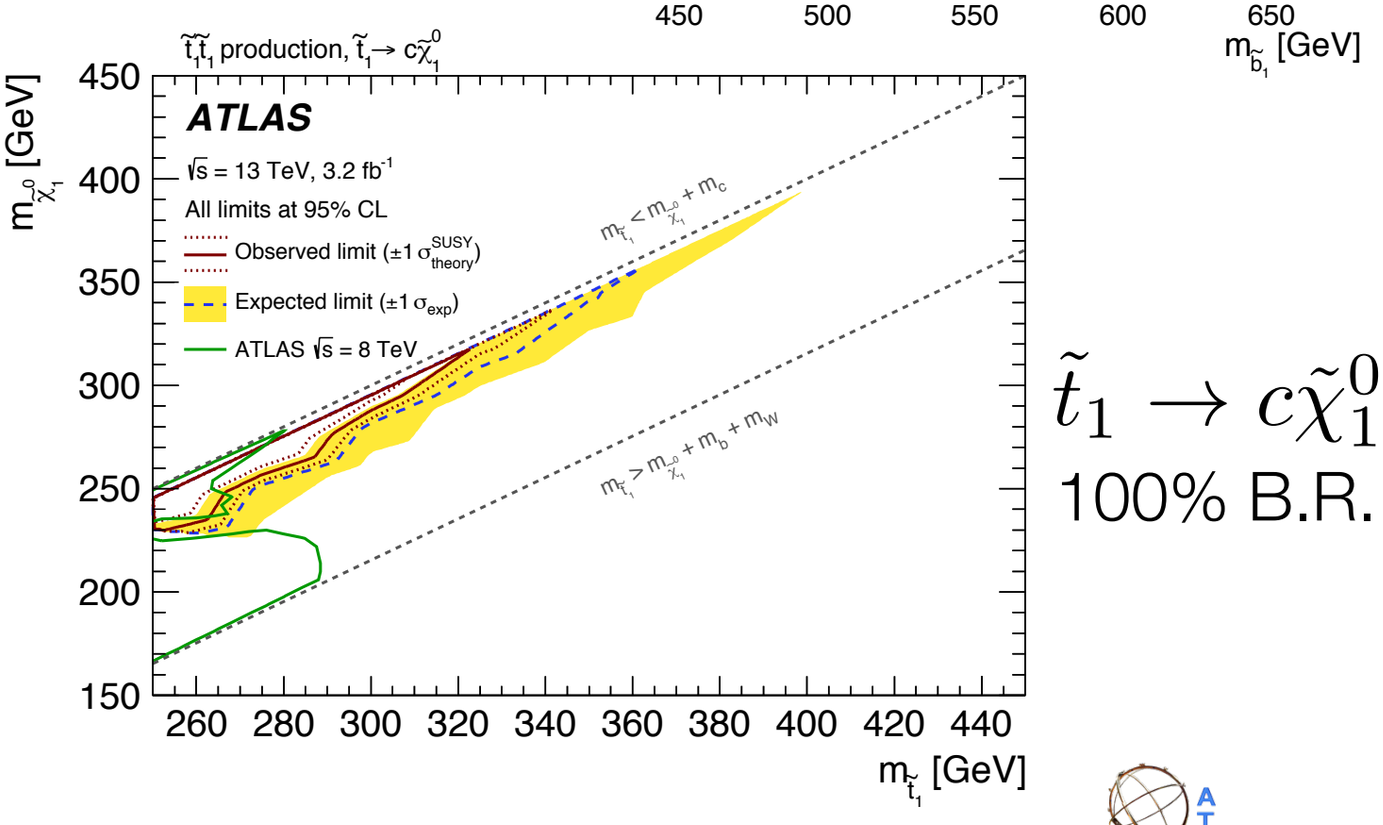


$\tilde{b}_1 \rightarrow t\tilde{\chi}_1^{\pm}$
100% B.R.

Monojet: arXiv:1604.07773



$\tilde{b}_1 \rightarrow b\tilde{\chi}_1^0$
100% B.R.



$\tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$
100% B.R.

The RPV stop analysis

Analysis strategy

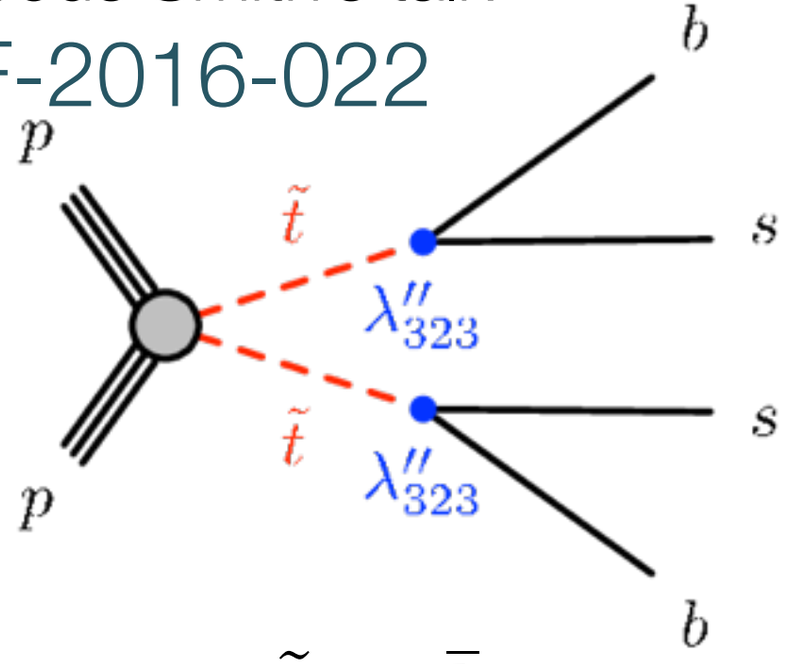
See also Russel Woods Smith's talk

ATLAS-CONF-2016-022

- Targeting high stop masses, decay products expected to be close-by in ΔR
- Candidate resonances constructed by pairing the four leading jets in the event, by minimising

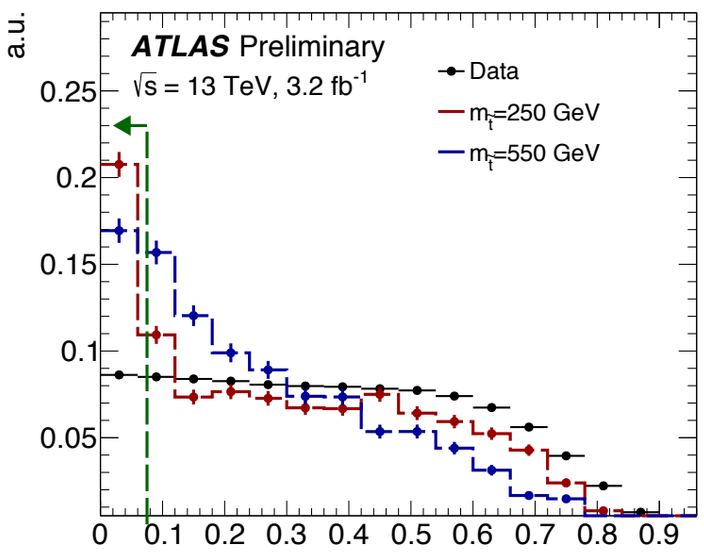
$$\Delta R_{min} = \sum_{i=1,2} | \Delta R_i - 1.0 |$$

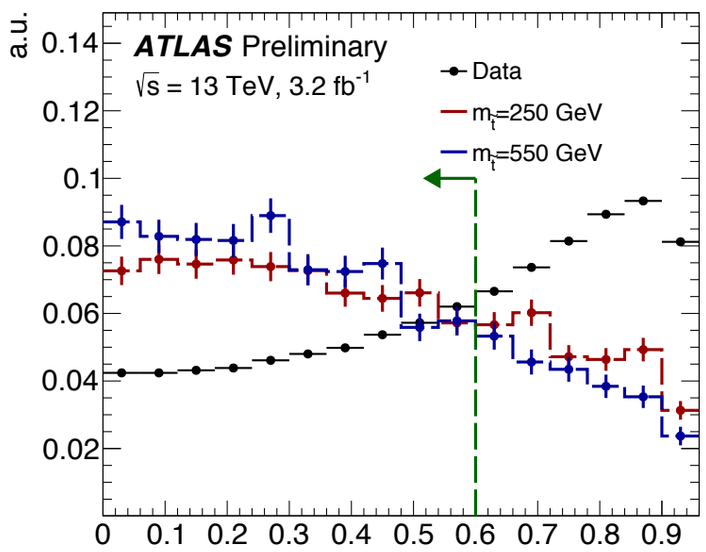
- Additional selections on the stop pair production angle, the mass asymmetry of the resonances, b-jets multiplicity
- The final analysis discriminant is the average mass of the two resonances (m_{avg})

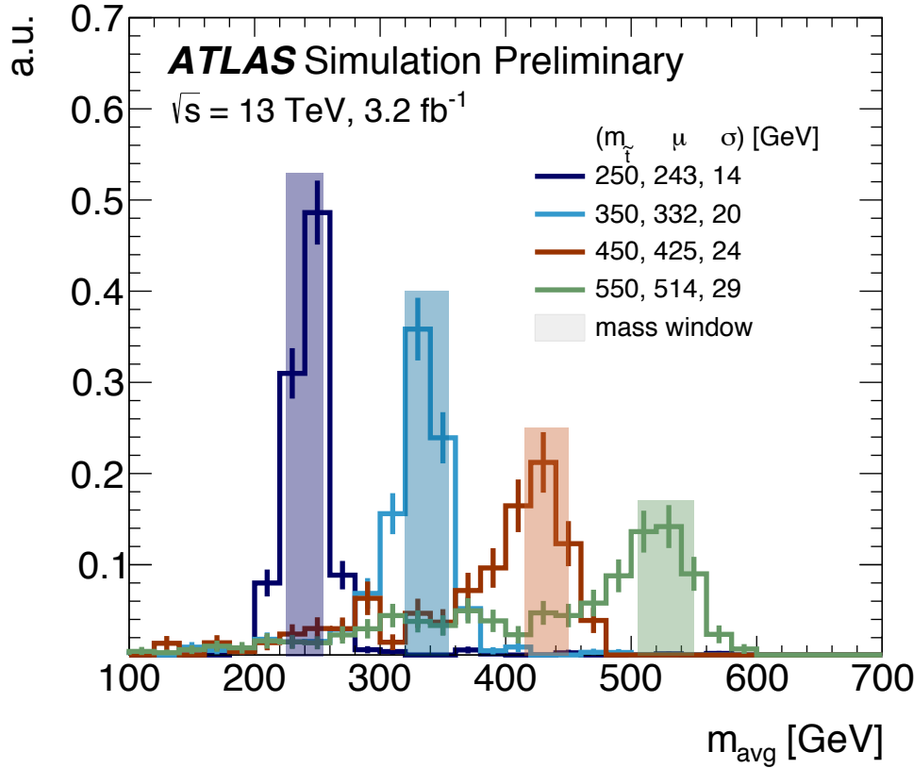


$\tilde{t} \to \bar{b}\bar{s}$

100% B.R.



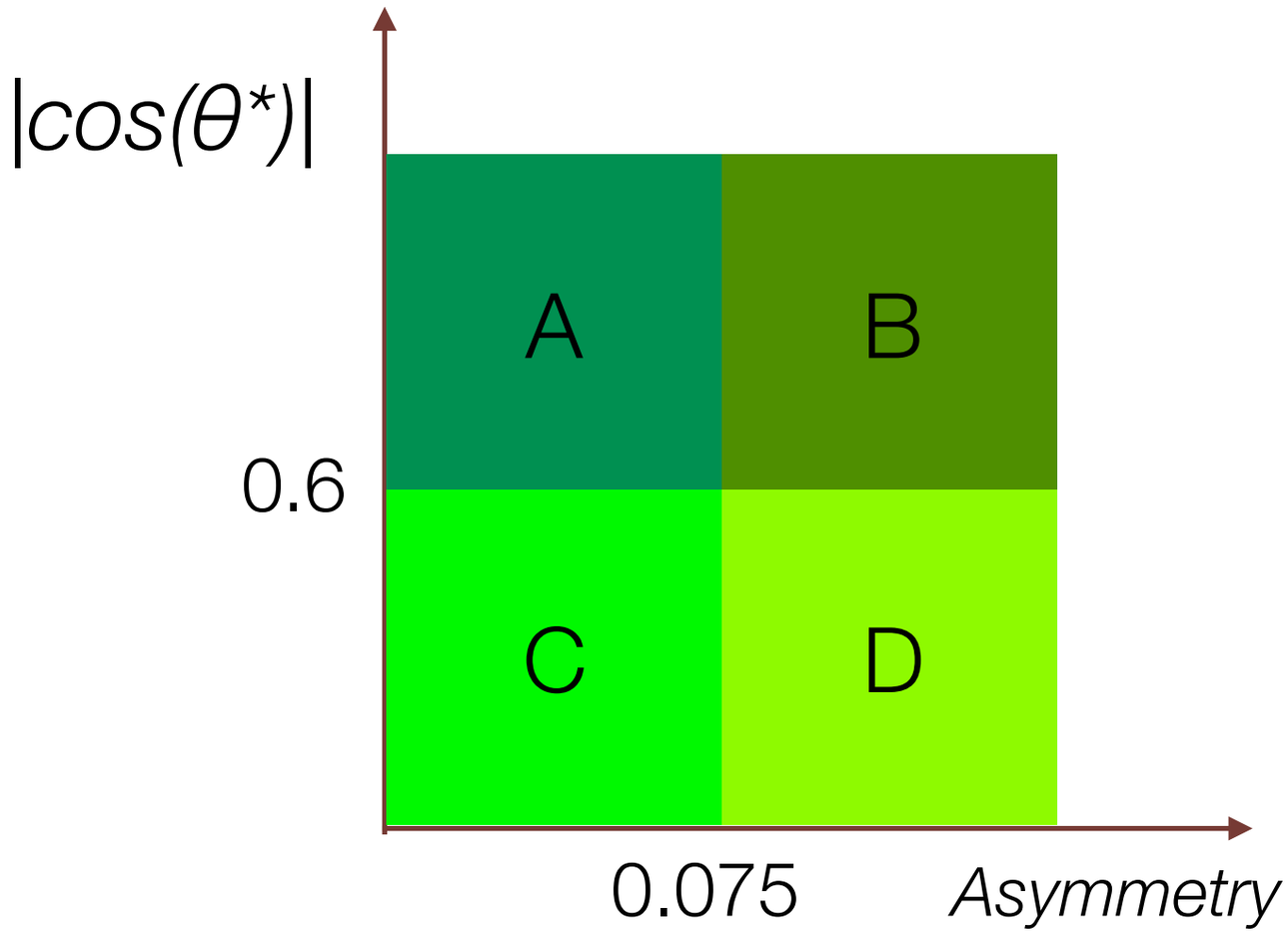




The RPV stop analysis

Background estimation (1)

- Dominant background is SM multijet production
- Data-driven estimation of normalisation and shape of m_{avg} distribution
  - m_{avg} spectrum predicted in a 0 b-tag region with an ABCD method



A,B,C background dominated

Signal selection applied in D

Stop mass asymmetry and pair production angle uncorrelated

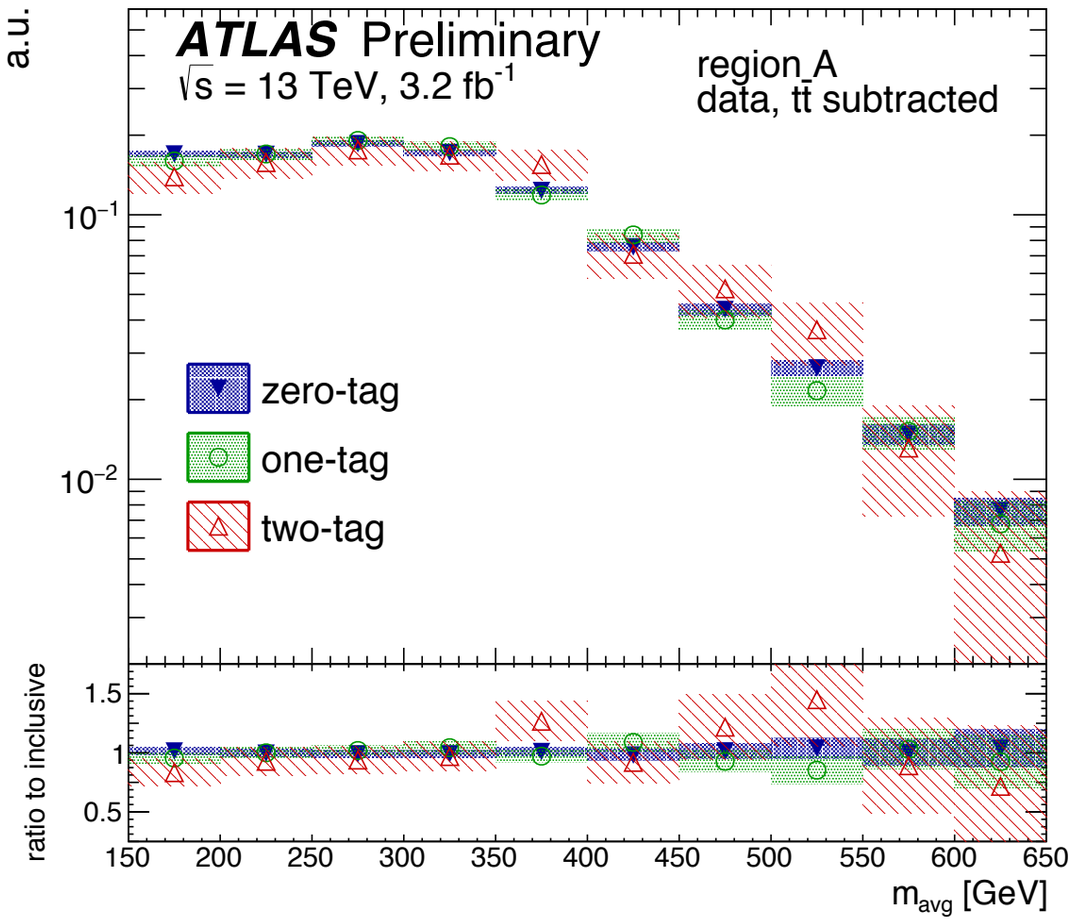
Background in D predicted from data in A,B,C as $N_D = N_B \times N_C/N_A$

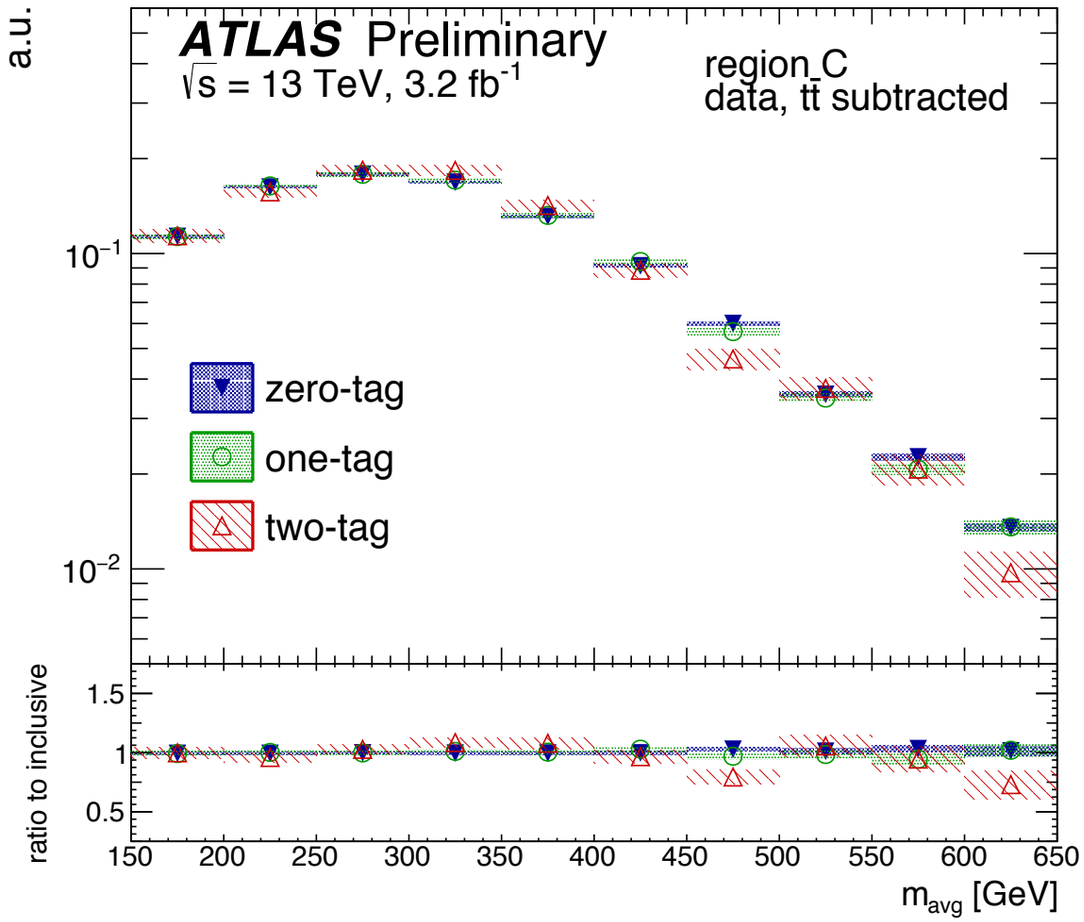
Closure test to validate 0-tag prediction in region D to assign a systematic uncertainty

The RPV stop analysis

Background estimation (2)

- Assumption is that m_{avg} shape in background is invariant across b-tag multiplicities





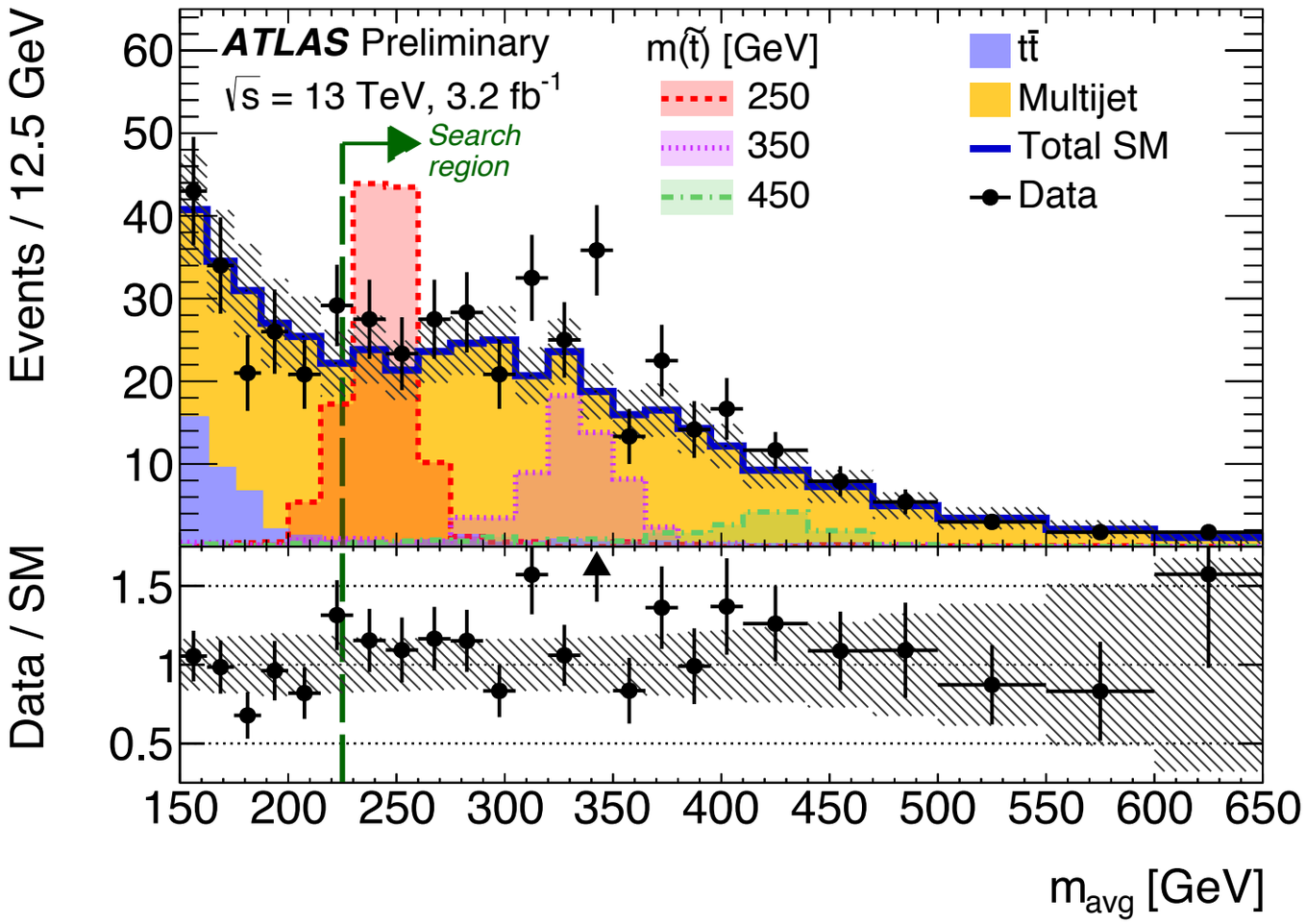
- Then extrapolation to signal region with at least 2 b-jets

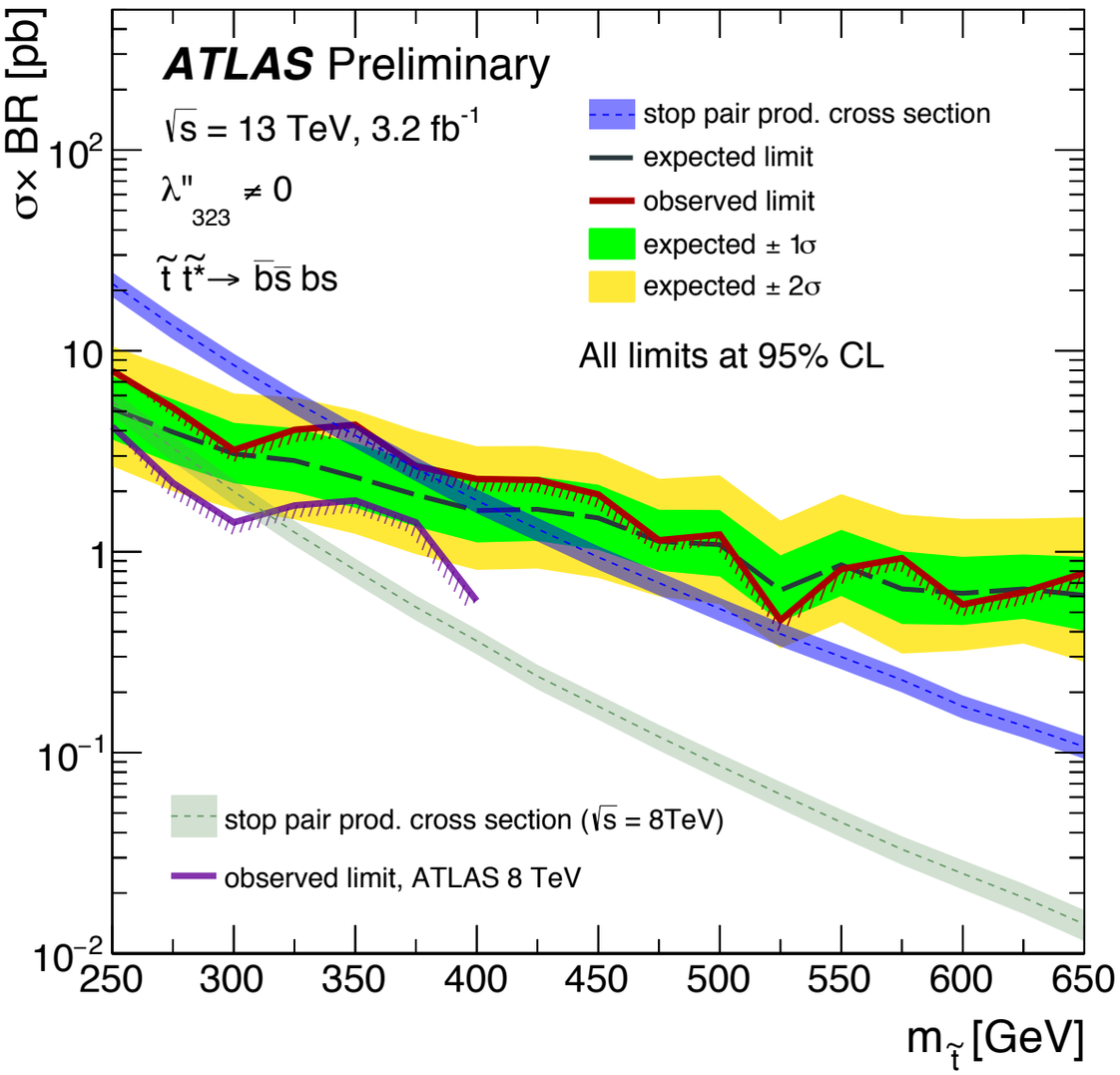
- Data-driven method validated in data by projecting m_{avg} shape from 0-tag to 1-tag validation region

The RPV stop analysis

Results

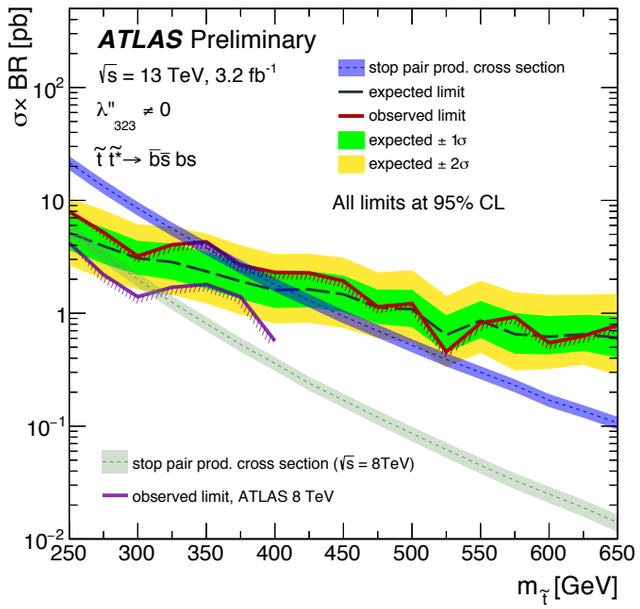
- No significant deviation from SM expectation
- Exclusion limits at 95% CL derived, extending the Run-1 limits

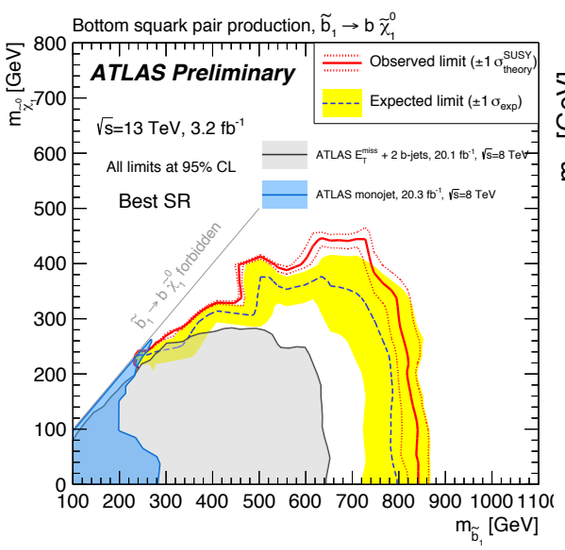


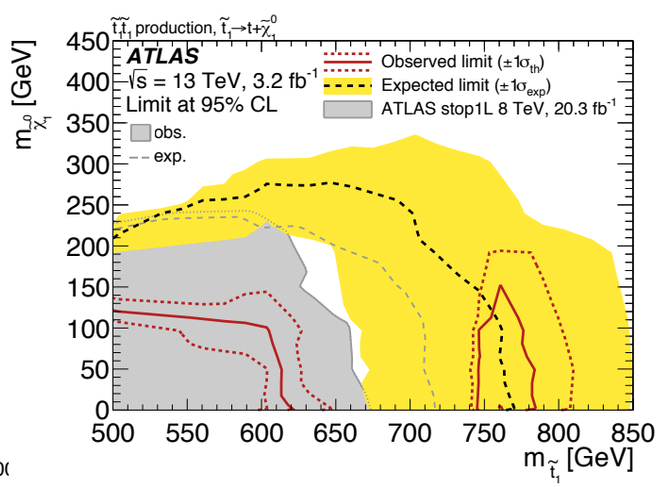


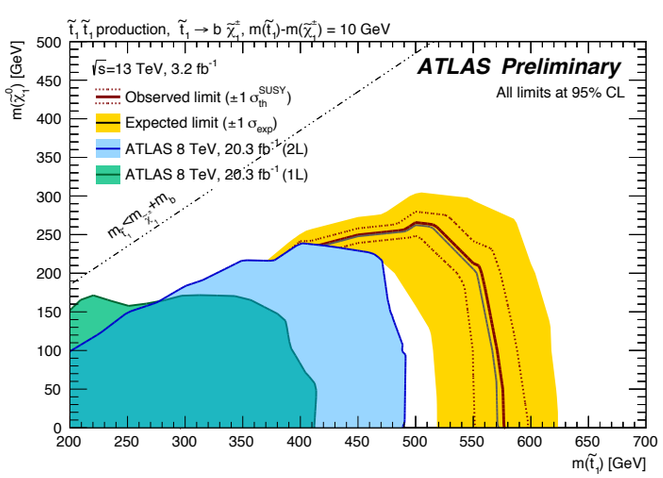
Conclusions

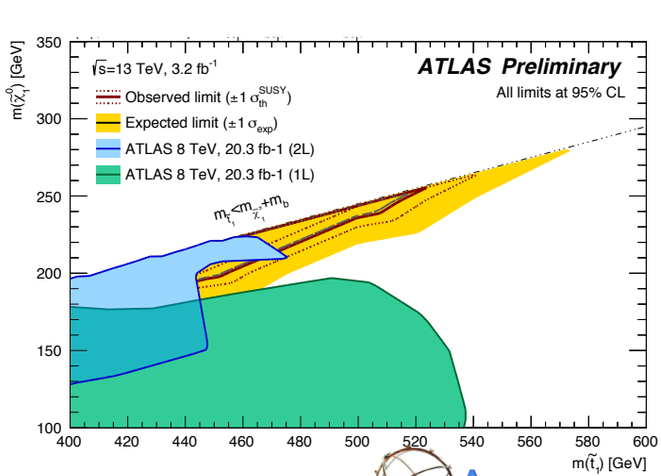
- Overview of the first Run-2 results from the searches for direct stop and sbottom pair production in ATLAS, using data collected in 2015 at $\sqrt{s}$=13 TeV, corresponding to 3.2 fb^{-1} of integrated luminosity
- No significant deviation from Standard Model predictions has been observed so far
- Run-1 limits have been significantly improved
- Great LHC performance in 2016 so far!
- Many new results expected soon with 2016 data
  - Stay tuned!!!







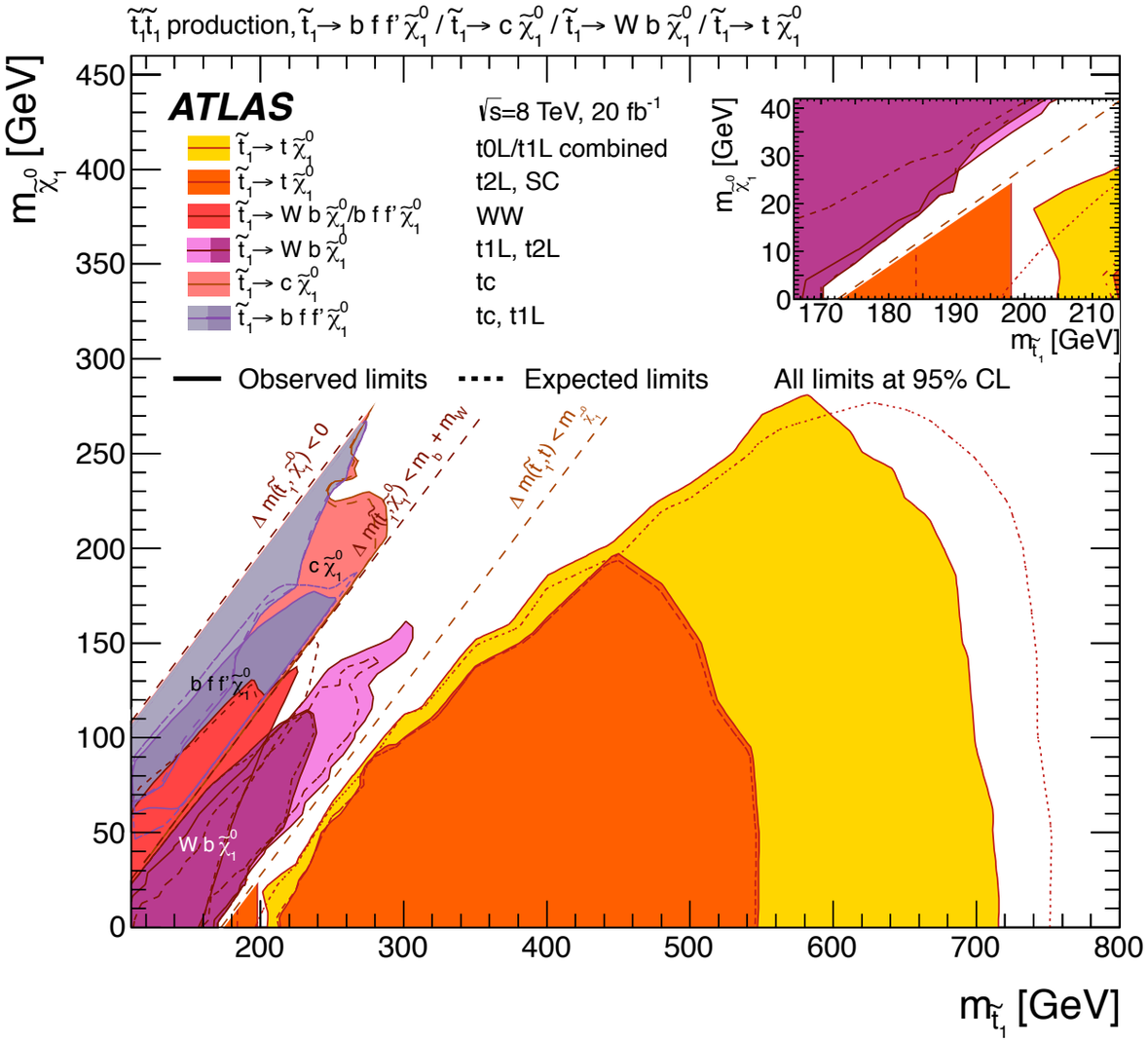




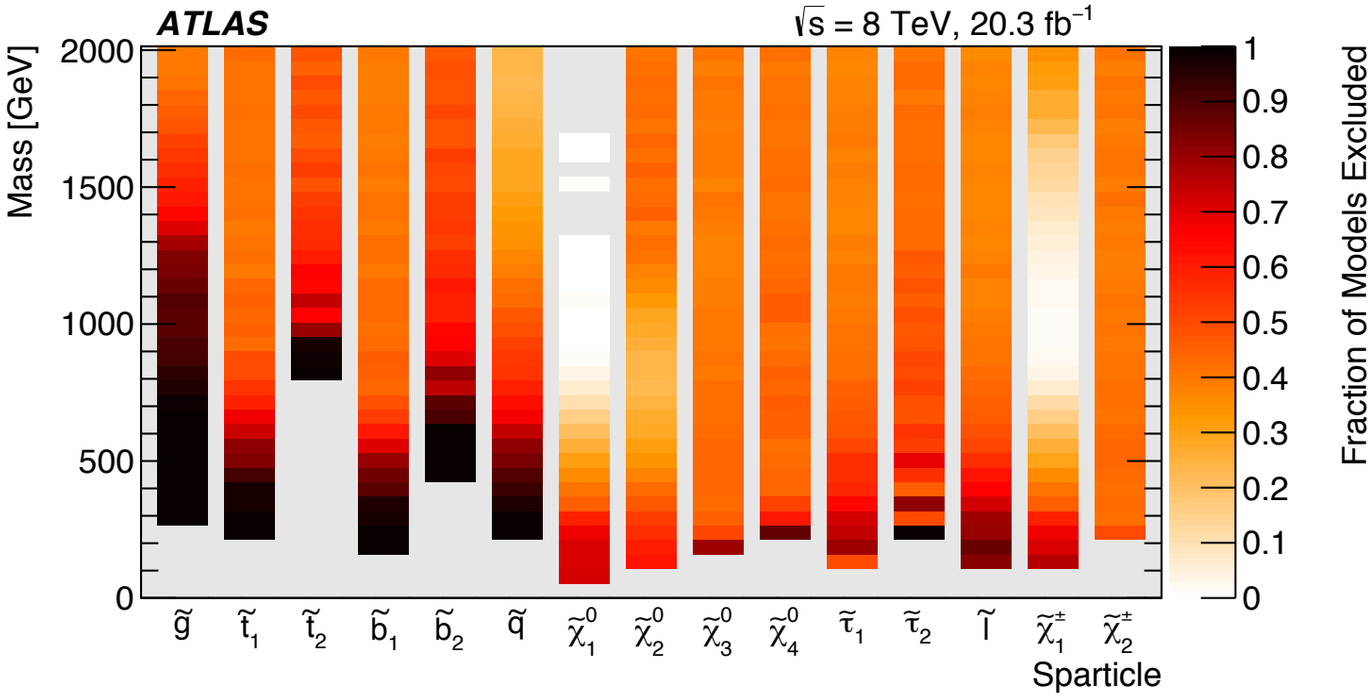
BACKUP

Run-1 summary plots

Combined limits for stop pair production



pMSSM summary



The sbottom analysis

Control regions definition

Variable	CRzA	CRttA	CRstA	CRwA	CRzB	CRttB
Number of leptons	2 SFOS	1	1	1	2 SFOS	1
1st lepton p_T [GeV]	> 90	> 26	> 26	> 26	> 26	> 26
2nd lepton p_T [GeV]	> 20	-	-	-	> 20	-
$m_{\ell\ell}$ [GeV]	[76, 106]	-	-	-	[76, 106]	-
m_T [GeV]	-	-	-	> 30	-	-
n(jets) p_T > 35 GeV	2–4	2–4	2–4	2–4	3–4	3–4
1st jet $p_T(j_1)$ [GeV]	> 50	> 130	> 50	> 130	> 50	> 130
2nd jet $p_T(j_2)$ [GeV]	> 50	> 50	> 50	> 50	> 50	> 50
4th jet	Vetoed if $p_T(j_4)$ > 50 GeV				Vetoed if $p_T(j_4)$ > 50 GeV	
b-tagged jets	j_1 and j_2	j_1 and j_2	j_1 and j_2	j_1	j_2 and (j_3 or j_4)	
E_T^{miss} [GeV]	< 100	> 100	> 100	> 100	< 70	> 200
$E_T^{miss,cor}$ [GeV]	> 100	-	-	-	> 100	-
m_{bb} [GeV]	> 200	< 200	> 200	(m_{bj}) > 200	-	-
m_{CT} [GeV]	-	> 150	> 150	> 150	-	-
$m_{b\ell}^{min}$ [GeV]	-	-	> 170	-	-	-
$\Delta\phi(j_1, E_T^{miss})$	-	-	-	-	> 2.0	> 2.5

The sbottom analysis

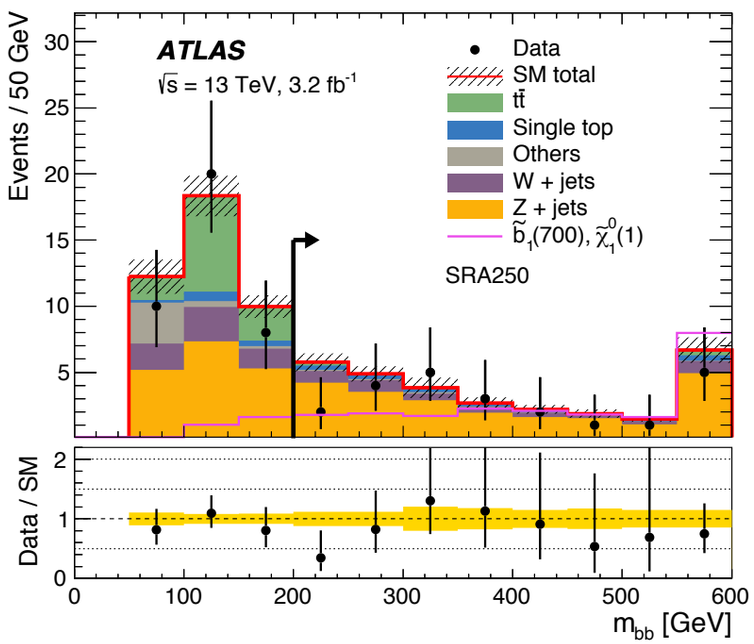
Results (control regions)

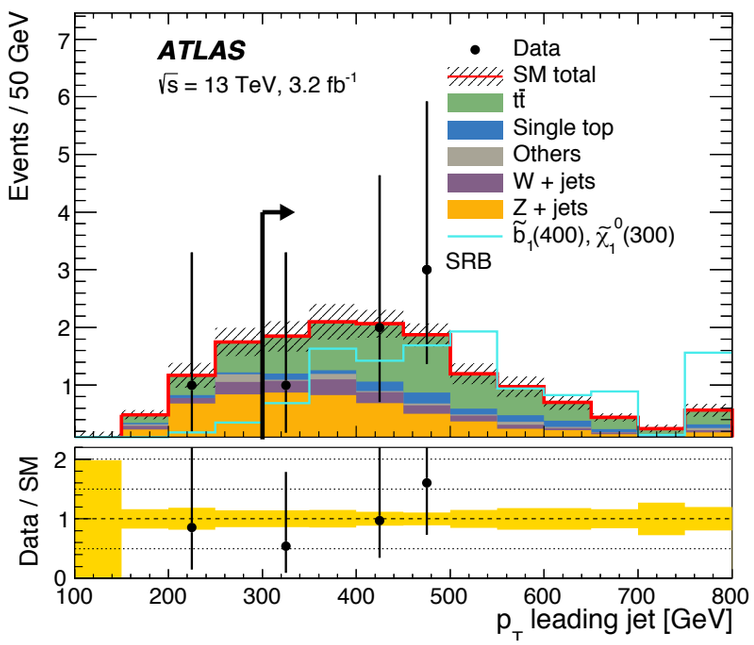
Control Region	CRzA	CRwA	CRttA	CRstA	CRzB	CRttB
Observed	78	543	260	56	59	188
Total background (fit)	78 ± 9	543 ± 23	260 ± 16	56 ± 7	59 ± 8	188 ± 14
$t\bar{t}$	9.0 ± 1.6	153 ± 26	181 ± 23	11.1 ± 2.1	14.6 ± 2.0	156 ± 15
Single top	0.8 ± 0.4	50 ± 23	27 ± 13	23 ± 10	0.42 ± 0.07	16.6 ± 2.0
W+jets	-	327 ± 43	45 ± 14	20 ± 6	-	13 ± 5
Z+jets	68 ± 9	3.8 ± 0.6	1.4 ± 0.2	0.9 ± 0.2	42 ± 8	0.3 ± 0.1
"Other"	0.9 ± 0.1	8.1 ± 1.1	5.8 ± 0.7	0.6 ± 0.1	1.6 ± 0.4	2.3 ± 0.2
Total background (MC exp.)	61	503	267	57	46	191
$t\bar{t}$	9.4	161	190	12	15	159
Single top	1.1	60	33	27	0.4	16
W+jets	-	270	37	17	-	12.9
Z+jets	50	2.8	1.0	0.7	29	0.2
"Other"	0.9	8.1	5.8	0.6	1.6	2.3

The sbottom analysis

Results (signal regions) + model independent limits

Signal region	SRA250	SRA350	SRA450	SRB
Observed	23	6	1	6
Total background (fit)	29 ± 5	7.0 ± 1.2	1.8 ± 0.4	12.0 ± 2.5
$t\bar{t}$	1.0 ± 0.4	0.17 ± 0.08	0.04 ± 0.02	5.5 ± 2.0
Single top	1.8 ± 1.0	0.53 ± 0.30	0.13 ± 0.07	1.0 ± 0.4
W+jets	4.4 ± 1.3	1.2 ± 0.4	0.30 ± 0.10	1.1 ± 0.6
Z+jets	22 ± 4	5.0 ± 1.1	1.3 ± 0.4	4.1 ± 1.3
"Other"	0.45 ± 0.06	0.14 ± 0.04	0.04 ± 0.04	0.3 ± 0.1
Total background (MC exp.)	23	5.6	1.5	11
$t\bar{t}$	1.1	0.18	0.04	5.6
Single top	2.2	0.6	0.15	1.0
W+jets	3.6	1.0	0.25	1.1
Z+jets	16	3.7	1.0	2.8
"Other"	0.45	0.14	0.04	0.3



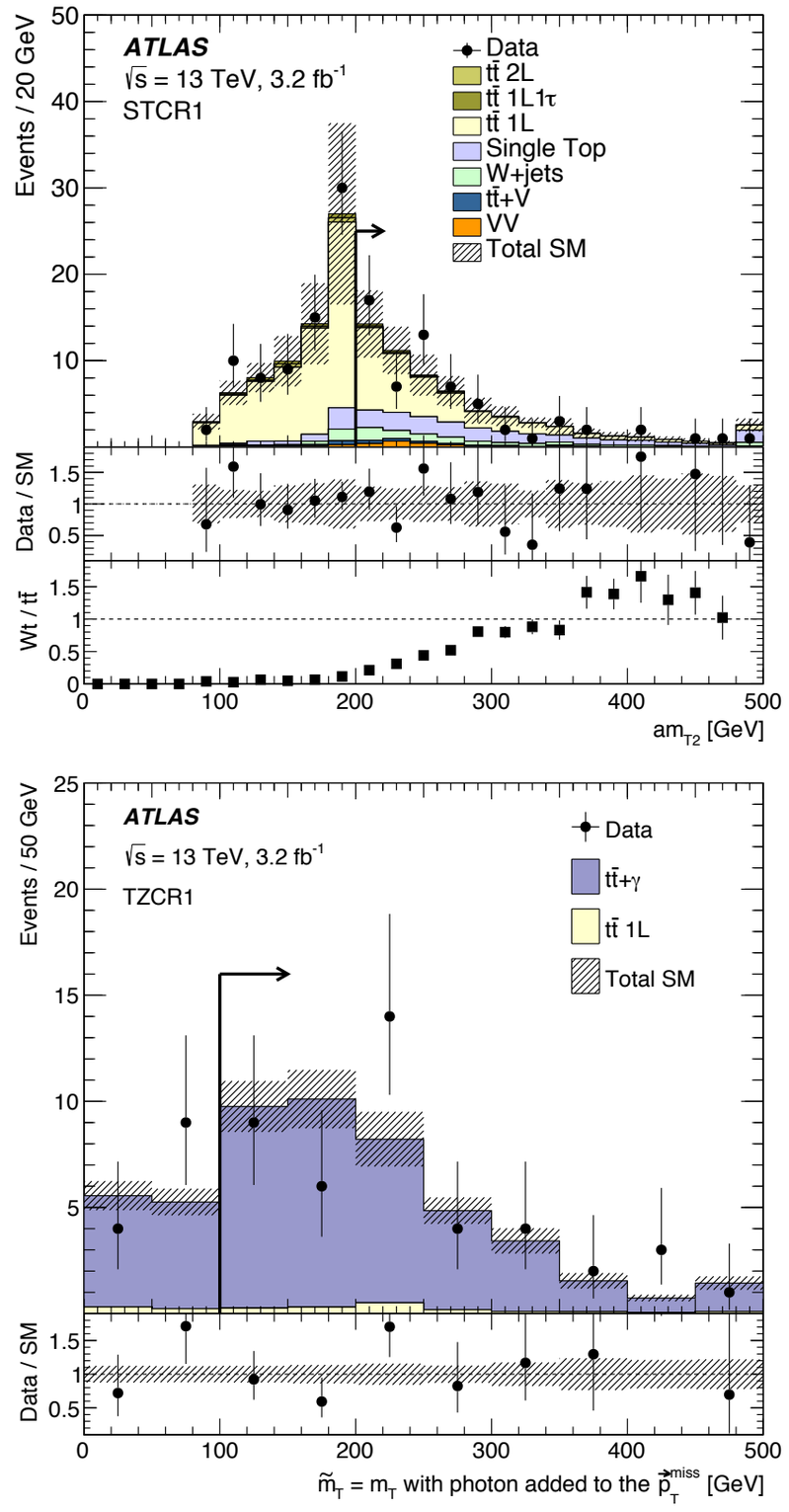


Signal channel	$\langle \epsilon A \sigma \rangle^{95}_{\text{obs}}$[fb]	S^{95}_{obs}	S^{95}_{exp}
SRA250	3.42	11.0	$13.8^{+6.0}_{-3.2}$
SRA350	1.93	6.2	$6.6^{+3.1}_{-1.1}$
SRA450	1.23	3.9	$4.1^{+1.9}_{-0.6}$
SRB	1.89	6.1	$8.7^{+3.1}_{-2.5}$

The stop 1 lepton analysis

Signal and control regions definition

Common event selection			
Trigger	$E_{\mathrm{T}}^{\mathrm{miss}}$ trigger		
Lepton	exactly one signal lepton (e, μ), no additional baseline leptons		
Jets	at least four signal jets, and $\lvert\Delta\phi(\mathrm{jet}_i, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})\rvert > 0.4$ for $i \in \{1,2\}$		
Hadronic τ	veto events with a hadronic τ decay and $m_{\mathrm{T2}}^{\tau} < 80$ GeV		
Variable	SR1	TCR1 / WCR1	STCR1
≥4 jets with p_{T} > [GeV]	(80 50 40 40)	(80 50 40 40)	(80 50 40 40)
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 260	> 200	> 200
$H_{\mathrm{T,sig}}^{\mathrm{miss}}$	> 14	> 5	> 5
m_{T} [GeV]	> 170	[30,90]	[30,120]
am_{T2} [GeV]	> 175	[100, 200] / > 100	> 200
topness	> 6.5	> 6.5	> 6.5
m_{top}^{χ} [GeV]	< 270	< 270	< 270
$\Delta R(b, \ell)$	< 3.0	–	–
$\Delta R(b_1, b_2)$	–	–	> 1.2
Number of b-tags	≥ 1	≥ 1 / = 0	≥ 2
	SR2	TCR2 / WCR2	STCR2
≥4 jets with p_{T} > [GeV]	(120 80 50 25)	(120 80 50 25)	(120 80 50 25)
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 350	> 250	> 200
$H_{\mathrm{T,sig}}^{\mathrm{miss}}$	> 20	> 15	> 5
m_{T} [GeV]	> 200	[30,90]	[30,120]
am_{T2} [GeV]	> 175	[100, 200] / > 100	> 200
$\Delta R(b, \ell)$	< 2.5	–	–
$\Delta R(b_1, b_2)$	–	–	> 1.2
Number of b-tags	≥ 1	≥ 1 / = 0	≥ 2
Leading large-R jet p_{T} [GeV]	> 200	> 200	> 200
Leading large-R jet mass [GeV]	> 140	> 140	> 0
$\Delta\phi(\vec{p}_{\mathrm{T}}^{\mathrm{miss}}, 2^{\mathrm{nd}}\text{large-R jet})$	> 1.0	> 1.0	> 1.0
	SR3	TCR3 / WCR3	STCR3
≥4 jets with p_{T} > [GeV]	(120 80 50 25)	(120 80 50 25)	(120 80 50 25)
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 480	> 280	> 200
$H_{\mathrm{T,sig}}^{\mathrm{miss}}$	> 14	> 8	> 5
m_{T} [GeV]	> 190	[30,90]	[30,120]
am_{T2} [GeV]	> 175	[100, 200] / > 100	> 200
topness	> 9.5	> 0	> 9.5
$\Delta R(b, \ell)$	< 2.8	–	–
$\Delta R(b_1, b_2)$	–	–	> 1.2
Number of b-tags	≥ 1	≥ 1 / = 0	≥ 2
Leading large-R jet p_{T} [GeV]	> 280	> 200	> 200
Leading large-R jet mass [GeV]	> 70	> 70	> 70



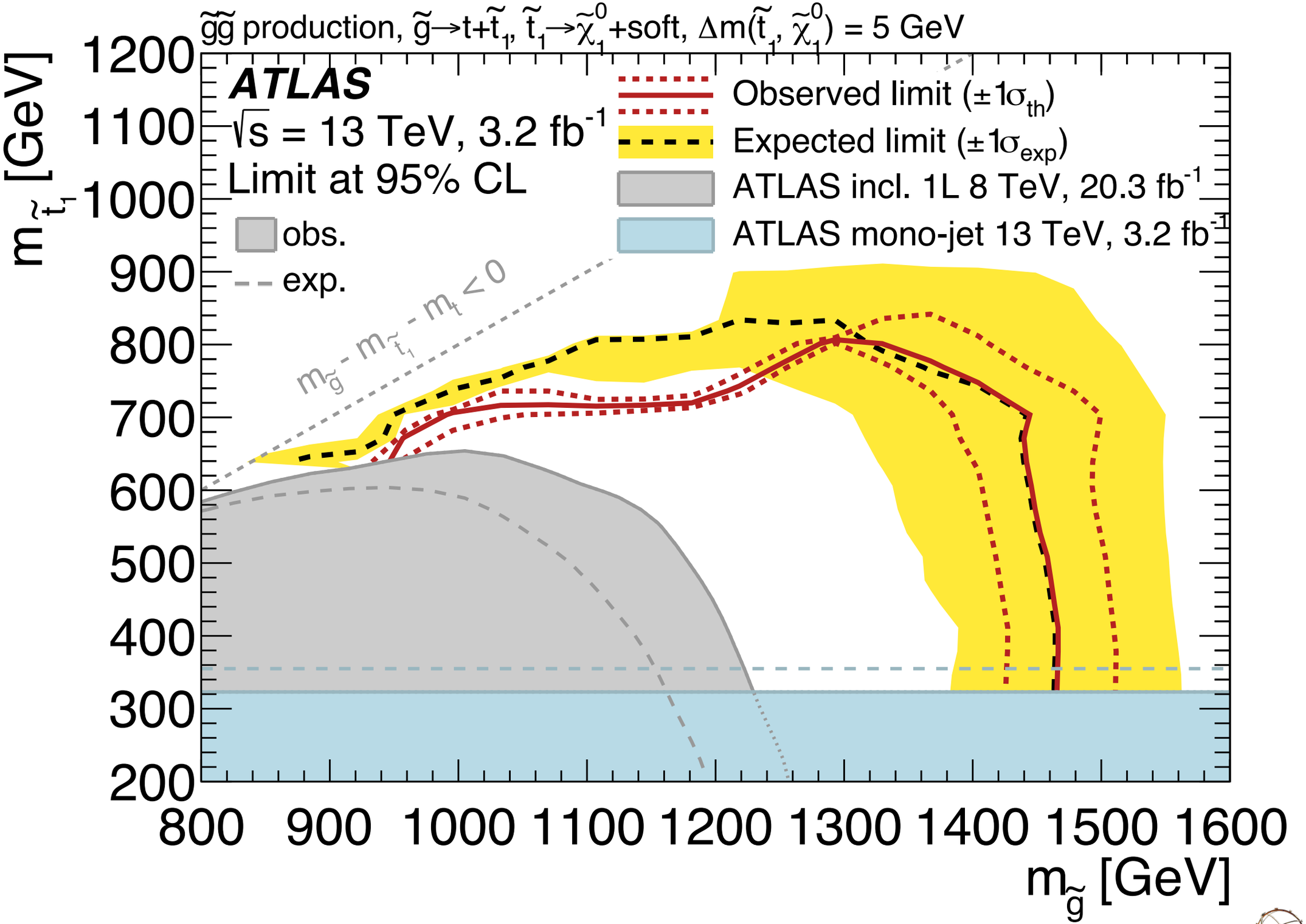
The stop 1 lepton analysis

Results

Signal region	SR1	SR2	SR3
Observed	12	1	1
Total background	5.50 ± 0.72	1.25 ± 0.26	1.03 ± 0.18
$t\bar{t}$	2.21 ± 0.60	0.29 ± 0.10	0.20 ± 0.07
(1L, 1L1τ, 2L) in %	(6, 48, 46)	(0, 58, 42)	(0, 36, 64)
Single top	0.46 ± 0.39	0.09 ± 0.08	0.10 ± 0.09
W+jets	0.71 ± 0.43	$0.15^{+0.19}_{-0.15}$	0.20 ± 0.09
$t\bar{t} + V$	1.90 ± 0.42	0.61 ± 0.14	0.41 ± 0.10
Diboson	0.23 ± 0.15	0.11 ± 0.07	0.12 ± 0.07
$t\bar{t}$ NF	1.10 ± 0.14	1.06 ± 0.14	0.80 ± 0.13
Single top NF	0.62 ± 0.46	0.65 ± 0.49	0.71 ± 0.42
W+jets NF	0.75 ± 0.12	0.78 ± 0.15	0.93 ± 0.12
$t\bar{t} + W/Z$ NF	1.42 ± 0.24	1.45 ± 0.24	1.46 ± 0.24
p_0	0.012 $(2.3\,\sigma)$	0.50 $(0.0\,\sigma)$	0.50 $(0.0\,\sigma)$
$N^{\text{limit}}_{\text{non-SM}}$ exp. (95% CL)	$6.4^{+3.2}_{-2.0}$	$3.6^{+2.3}_{-1.3}$	$3.5^{+2.2}_{-1.2}$
$N^{\text{limit}}_{\text{non-SM}}$ obs. (95% CL)	13.3	3.4	3.4

The stop 1 lepton analysis

Limits for gluino mediated stop pair production



The stop 2 leptons analysis

Results (control regions)

Region	CRT	CRSF	VRDF	VRSF
Observed events	3718	78	222	267
Total (constrained) SM events	3718 ± 61	78.0 ± 8.8	217 ± 33	269 ± 89
Fit output, $t\bar{t}$ events	3206 ± 90	$0.5^{+1.4}_{-0.5}$	68 ± 16	43.8 ± 9.1
Fit output, $\ell\ell\nu\nu$ events	124 ± 38	44 ± 15	118 ± 17	100 ± 39
Total expected SM events	3960 ± 110	76 ± 14	222 ± 35	267 ± 81
Fit input, expected $t\bar{t}$ events	3449 ± 84	$1.1^{+2.5}_{-1.1}$	73 ± 18	47 ± 10
Fit input, expected $\ell\ell\nu\nu$ events	124 ± 39	41.1 ± 4.7	118 ± 17	94 ± 10
Expected Wt events	309 ± 38	$0.07^{+0.10}_{-0.07}$	17.7 ± 4.4	12.5 ± 2.9
Expected other multi-V events	6.5 ± 1.6	23.9 ± 1.6	2.50 ± 0.55	11.7 ± 2.3
Expected Higgs events	5.92 ± 0.82	0.52 ± 0.48	1.77 ± 0.33	1.04 ± 0.72
Expected Z/γ^*+jets events	$0.8^{+1.5}_{-0.8}$	9^{+11}_{-9}	$0.32^{+0.70}_{-0.32}$	92 ± 78
Expected $t\bar{t}$ +V events	4.7 ± 2.4	0.99 ± 0.52	0.03 ± 0.02	0.02 ± 0.02
Expected events with fake and non-prompt leptons	61 ± 31	–	8.3 ± 4.2	8.6 ± 4.3

The stop 2 leptons analysis

Results (signal regions) + model independent limits

Signal Region	DF	SF
Observed events	2	6
Total (constrained) SM events	2.01 ± 0.62	6.5 ± 1.7
Fit output, $t\bar{t}$ events	0.04 ± 0.04	0.06 ± 0.06
Fit output, $\ell\ell\nu\nu$ events	1.52 ± 0.54	3.82 ± 1.5
Total expected SM events	2.01 ± 0.62	6.3 ± 1.2
Fit input, expected $t\bar{t}$ events	0.04 ± 0.04	0.06 ± 0.06
Fit input, expected $\ell\ell\nu\nu$ events	1.52 ± 0.54	3.59 ± 0.69
Expected other multi-V events	0.34 ± 0.12	1.31 ± 0.47
Expected Higgs events	$0.01^{+0.19}_{-0.01}$	0.26 ± 0.21
Expected Z/γ^*+jets events	–	0.91 ± 0.73
Expected $t\bar{t}$ + V events	0.04 ± 0.03	0.12 ± 0.07
Expected events with fake and non-prompt leptons	0.06 ± 0.03	–

Signal Region	DF	SF
$\langle \epsilon\sigma \rangle^{95}_{\text{obs}}$ [fb]	1.3	2.1
S^{95}_{obs}	4.3	6.7
S^{95}_{exp}	$4.3^{+2.5}_{-1.5}$	$7.0^{+3.4}_{-2.2}$

The RPV stop analysis

ABCD regions definition and results

Region	$\mathcal{A}$	$\lvert\cos(\theta^*)\rvert$
A	< 0.075	≥ 0.6
B	≥ 0.075	≥ 0.6
C	≥ 0.075	< 0.6
D	< 0.075	< 0.6

$m(\tilde{t})$ [GeV]	Window [GeV]	Signal ($\pm$ stat. $\pm$ sys.)	Expected background ($\pm$ stat. $\pm$ sys.)	Data	p_0
250	[225 - 255]	$102 \pm 6 \pm 12$	$53.8 \pm 2.5 \pm 8.7$	68	0.10
275	[250 - 280]	$80 \pm 6 \pm 11$	$54.6 \pm 2.5 \pm 8.2$	62	0.25
300	[275 - 305]	$66 \pm 4 \pm 8$	$59.5 \pm 2.7 \pm 8.9$	59	0.50
325	[295 - 330]	$52 \pm 5 \pm 7$	$61.0 \pm 2.7 \pm 9.5$	73	0.19
350	[320 - 355]	$44.6 \pm 3.4 \pm 7.2$	$57.7 \pm 2.6 \pm 9.5$	80	0.07
375	[345 - 375]	$27.7 \pm 2.2 \pm 3.7$	$39.7 \pm 2.0 \pm 7.0$	48	0.27
400	[365 - 400]	$25.1 \pm 1.3 \pm 3.6$	$41.8 \pm 2.1 \pm 8.0$	52	0.25
425	[390 - 425]	$15.6 \pm 1.9 \pm 1.8$	$31.9 \pm 1.7 \pm 6.8$	40	0.23
450	[415 - 450]	$10.9 \pm 1.3 \pm 1.5$	$24.3 \pm 1.4 \pm 5.8$	30	0.27
475	[435 - 475]	$10.3 \pm 1.1 \pm 1.3$	$23.5 \pm 1.4 \pm 6.2$	23	0.50
500	[460 - 500]	$7.5 \pm 0.8 \pm 1.4$	$18.1 \pm 1.2 \pm 5.5$	20	0.45
525	[485 - 525]	$6.0 \pm 0.6 \pm 0.9$	$13.7 \pm 1.0 \pm 4.7$	7	0.50
550	[505 - 550]	$3.8 \pm 0.4 \pm 0.7$	$9.9 \pm 0.9 \pm 3.9$	9	0.50
575	[530 - 575]	$4.0 \pm 0.4 \pm 0.8$	$8.3 \pm 0.8 \pm 3.7$	13	0.28
600	[555 - 600]	$2.42 \pm 0.26 \pm 0.46$	$7.3 \pm 0.8 \pm 3.8$	5	0.50
625	[580 - 625]	$1.82 \pm 0.20 \pm 0.28$	$5.7 \pm 0.7 \pm 3.4$	5	0.50
650	[600 - 650]	$1.64 \pm 0.17 \pm 0.34$	$4.4 \pm 0.6 \pm 3.0$	7	0.25