UNIVERSITÀ DEGLI STUDI
DI MILANO

The quest for Natural SUSY

ATLAS searches

IFAE 2013 - Cagliari, 3 Aprile 2013

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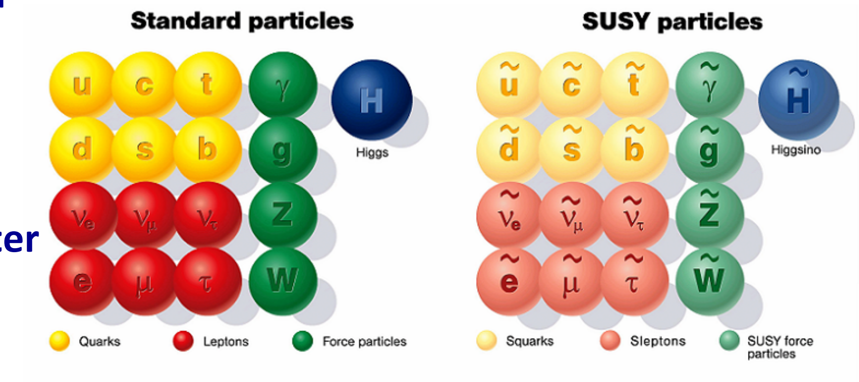
Supersymmetry and MSSM

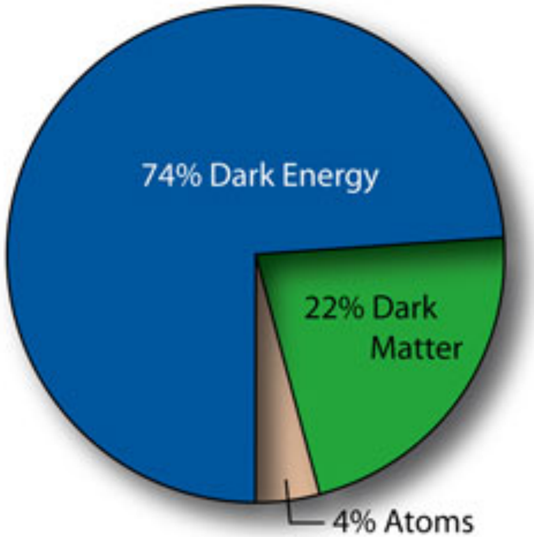
The Standard Model (SM) is a powerful and successful description of fundamental interactions, but:

- Has an **high-level of fine-tuning** (quadratically divergent corrections to the Higgs boson mass)
- Doesn't provide an explanation for the **Dark Matter**
- Doesn't provide an **unification** of QCD and EW coupling constants



Supersymmetry (SUSY) can extend the SM

- New physics at TeV scale
- SUSY relates each SM particle to another, known as *superpartner*, that differs by half unit of spin.
- SUSY is broken: sparticle masses are function of the breaking terms.
- **R-parity** $R = (-1)^{3B+L+2S}$ is a discrete multiplicative symmetry.
  - **SUSY particles must be produced in pairs**
  - The Lightest Supersymmetric Particle (LSP) is stable (dark matter candidate)



Natural SUSY

Naturalness provides a useful criterion to address the status of SUSY at the electroweak scale.

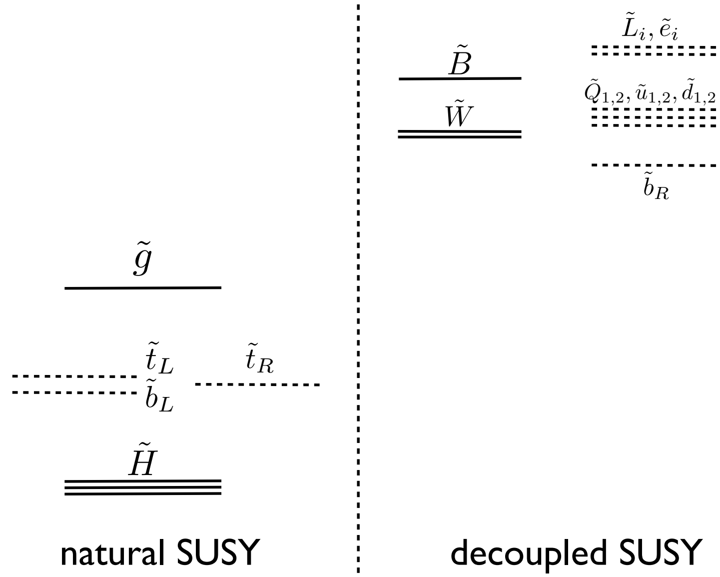
- **The naturalness requirement is summarized by the following relation in the Minimal Supersymmetric Standard Model (MSSM)**

$$-\frac{m_Z^2}{2} = |\mu|^2 + m_H^2$$

If the superpartners are too heavy, contributions to the right-hand side must be tuned against each other to achieve electroweak symmetry breaking at the observed energy scale.

$$\delta m_H^2\Big|_{stop} \cong -\frac{3y_t^2}{8\pi^2}\left(m_{Q_3}^2 + m_{U_3}^2 + |A_t|^2\right)\ln\left(\frac{\Lambda}{TeV}\right)$$

$$\delta m_H^2\Big|_{gluino} \cong -\frac{2y_t^2}{\pi^2}\left(\frac{\alpha_s}{\pi}\right)|M_3|^2 \ln^2\left(\frac{\Lambda}{TeV}\right)$$



M.Papucci, J.Ruderman, A. Weiler
hep-ph:1110.6926

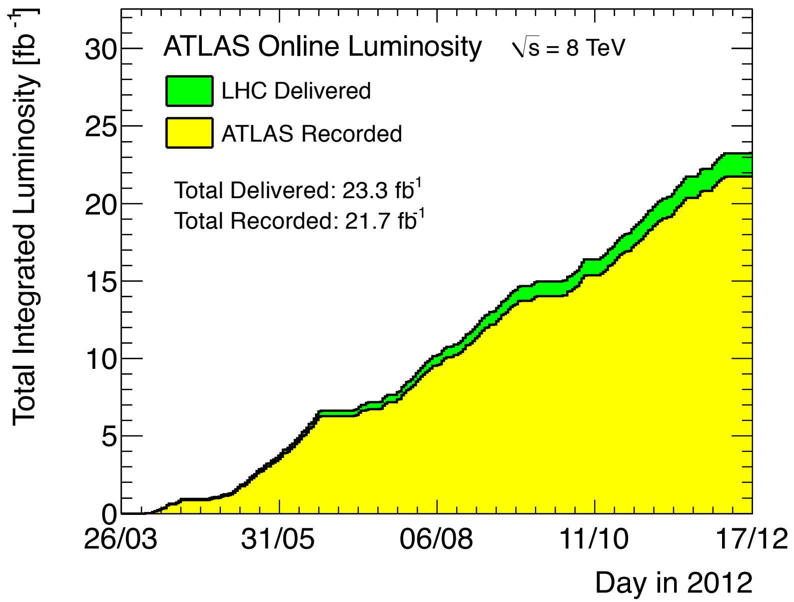
The following particles are required to be light:

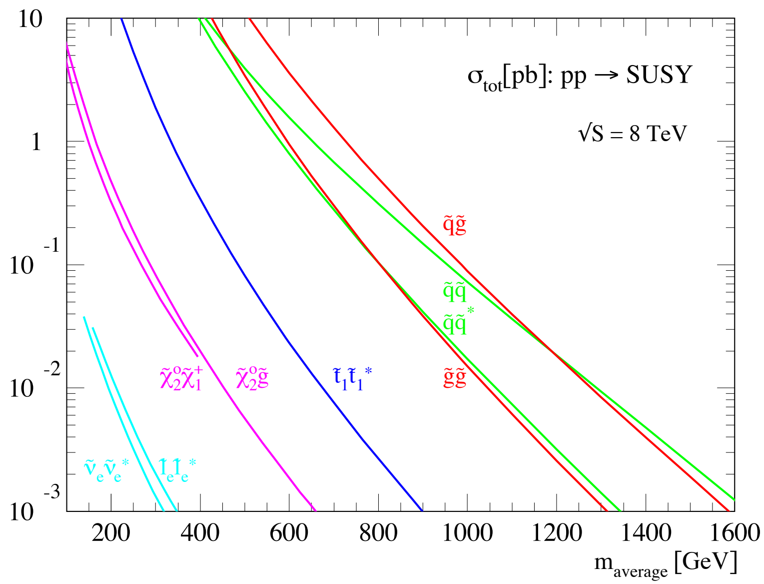
- Two *higgsinos*, i.e. one chargino and two neutralinos below 350 GeV ($\mu \cong m_Z$ at tree level)
- ***stop* and *sbottoms*** up to 700 GeV (1-loop radiative corrections)
- *Gluinos* up to 1.5 TeV (2-loop radiative corrections)

Collected data and process sensitivity

The results shown in the following are based up to 21 fb^{-1} of data, collected between March and December 2012.

Only events satisfying good data quality cuts (i.e. collisions with all detectors in satisfactory working conditions) are considered for the analysis





Considering the available integrated luminosity

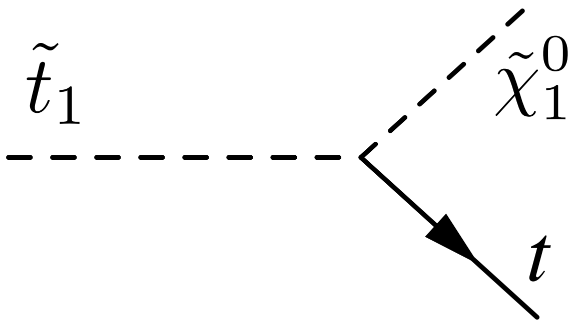
- *squarks* and *gluinos* accessible well over the TeV scale with large branching fractions and efficiencies.
- direct *stop* up to 700 GeV
- *charginos* and *neutralinos* up to 400 GeV
- *sleptons* up to 150 GeV

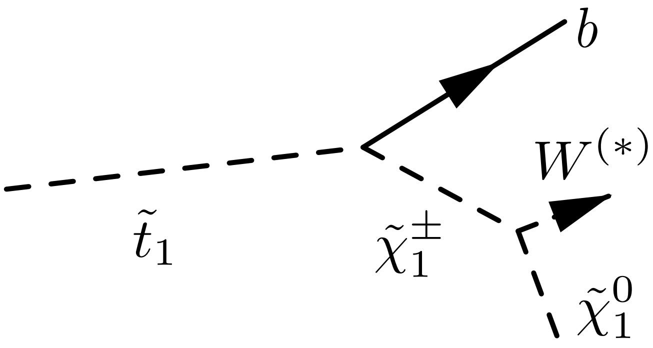
Common analysis strategies

The analyses presented in the following slides share a common approach:

- Define a *Signal Region* (SR) based on signal kinematic features
- Estimate the Standard Model processes in the SR:
  - **Data-driven** reducible backgrounds (QCD multijet backgrounds)
  - **Semi data-driven** major irreducible backgrounds
    - Define a *control region* (CR) for each of the backgrounds
    - Normalise MC yields to data
    - Apply transfer factor from CR to SR
  - Minor backgrounds are taken from **MC simulation** only
- Check background estimation against data in *Validation Regions* (VR)
- Look at the observed data in the SR

$$N(\mathrm{SR}) = \left(N^{\mathrm{Data}}(\mathrm{CR}) - N_{\mathrm{others}}(\mathrm{CR})\right) \frac{N^{\mathrm{MC}}(\mathrm{SR})}{N^{\mathrm{MC}}(\mathrm{CR})}$$





- Fully hadronic final state
- One lepton final state
- Two leptons final state

DIRECT SCALAR TOP SEARCHES

Scalar top: fully hadronic

This analysis looks for events where each of the **stops** decays **into a top quark +** $\tilde{\chi}_1^0$.

$$\tilde{t}\tilde{t} \rightarrow t\tilde{\chi}_1^0 t\tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0 bqq\, \tilde{\chi}_1^0 bqq$$

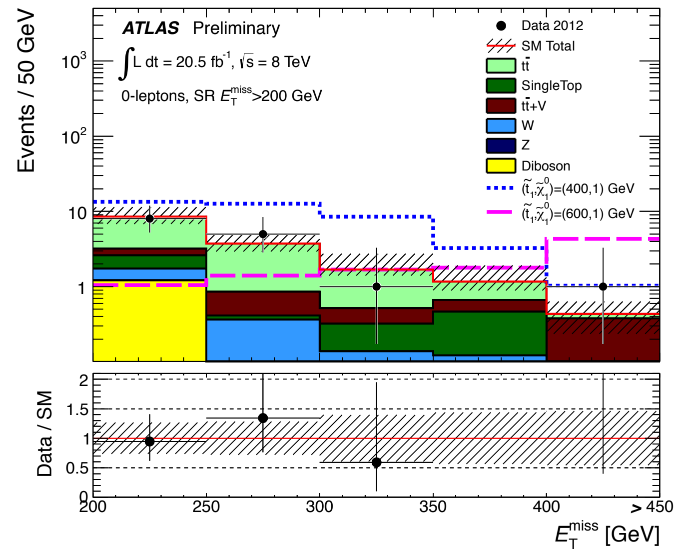
The final state for this search is therefore six or more jets and E_T^{miss}.

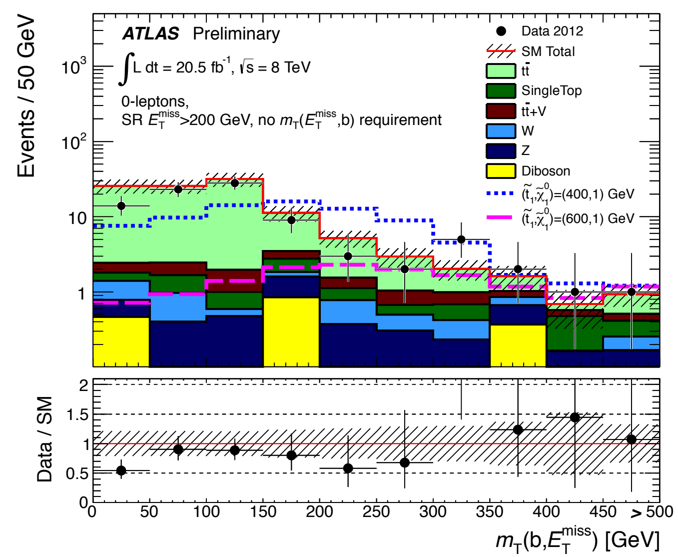
Six or more jets are required (plus lepton veto)

- 2 b-tags, $p_T^{jet1,2} > 80$ GeV, $p_T^{jet3+} > 35$ GeV
- $\Delta\phi(E_T^{miss}, jet_{1,2,3}) > 0.2\pi$
- $\Delta\phi(E_T^{miss}, E_T^{miss,track}) < \pi/3$ ($E_T^{miss,track} > 30$ GeV)
- Tau-jet veto

Final selection on

- **$m_T(E_T^{miss}$, b-jet$_{closest}) > 175$ GeV**
- **$E_T^{miss} > 200, 300, 350$ GeV**





ATLAS-CONF-2013-024

Scalar top: fully hadronic

This analysis looks for events where each of the **stops** decays **into a top quark +** $\tilde{\chi}_1^0$.

$$\tilde{t}\tilde{t} \rightarrow t\tilde{\chi}_1^0 t\tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0 bqq\, \tilde{\chi}_1^0 bqq$$

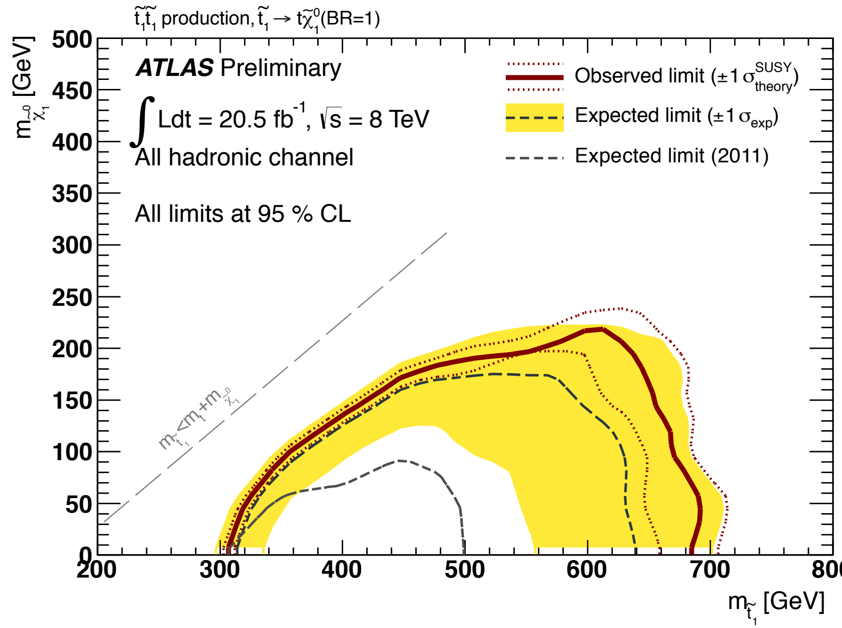
The final state for this search is therefore six or more jets and E_T^{miss}.

Six or more jets are required (plus lepton veto)

- 2 b-tags, $p_T^{jet1,2}$ > 80 GeV, p_T^{jet3+} > 35 GeV
- $\Delta\phi(E_T^{miss}, jet_{1,2,3}) > 0.2\pi$
- $\Delta\phi(E_T^{miss}, E_T^{miss,track}) < \pi/3$
- Tau-jet veto

Final selection on

- **$m_T(E_T^{miss}$, b-jet) > 175 GeV**
- **E_T^{miss} > 200, 300, 350 GeV**



ATLAS-CONF-2013-024

Number of events	SR1	SR2	SR3
Observed	15	2	1
Expected background	17.5 ± 3.2	4.7 ± 1.5	2.7 ± 1.2
Expected $t\bar{t}$	9.8 ± 2.6	1.9 ± 1.3	0.9 ± 0.7
Expected $t\bar{t} + W/Z$	1.7 ± 1.0	0.7 ± 0.4	0.51 ± 0.30
Expected Z+jets	2.1 ± 1.0	1.2 ± 0.5	0.8 ± 0.4
Expected W+jets	1.2 ± 0.8	0.32 ± 0.29	$0.19^{+0.23}_{-0.19}$
Expected single-top	1.5 ± 0.9	0.5 ± 0.4	$0.3^{+0.5}_{-0.3}$
Expected multijet	0.12 ± 0.12	0.01 ± 0.01	< 0.01
Expected diboson	1.2 ± 1.2	< 0.22	< 0.22
Fit input expectation $t\bar{t}$	9.9	1.7	0.6

Scalar top: 1 lepton

NEW!

This analysis looks for events where each of the **stops** decays either **into a bottom quark +** $\tilde{\chi}_1^{\pm}$, or **into a top quark +** $\tilde{\chi}_1^0$**.**

$$\tilde{t}\tilde{t} \rightarrow t\tilde{\chi}_1^0 t\tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0 bl\nu\, \tilde{\chi}_1^0 bqq$$

$$\tilde{t}\tilde{t} \rightarrow b\tilde{\chi}^{\pm} b\tilde{\chi}^{\mp} \rightarrow \tilde{\chi}_1^0 bl\nu\, \tilde{\chi}_1^0 bqq$$

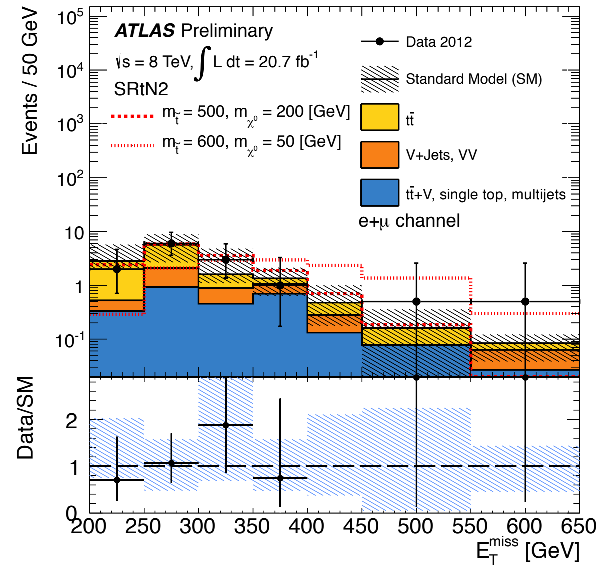
High E_T^{miss} for the signal because of $\tilde{\chi}_1^0$ in the final state.

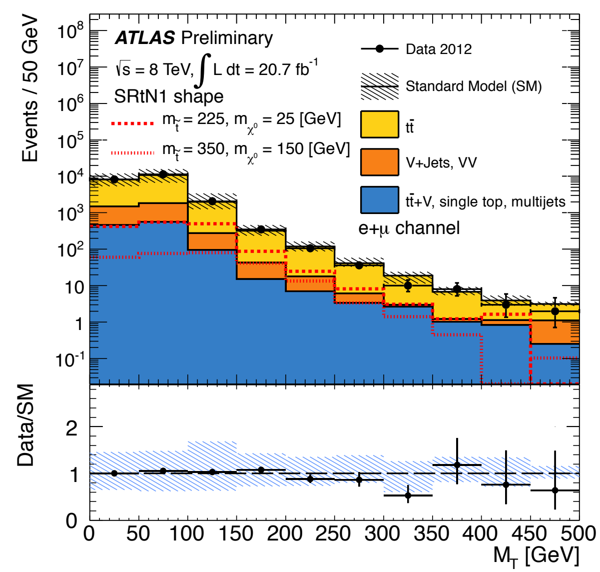
Multiple signal regions (see backup):

- relying mostly on **a harsh selection on** E_T^{miss} and m_T

$$m_T = \sqrt{2 p_T^{\ell} E_T^{miss} \left(1 - \cos\Delta\phi\left(E_T^{miss}, \ell\right)\right)}$$

- tag one b-jet, **reconstruct one hadronic top mass**
- 5 cut & count signal regions, 1 signal region with E_T^{miss} and m_T shape fit





ATLAS-CONF-2013-037

NEW!

Scalar top: 1 lepton

This analysis looks for events where each of the **stops** decays either **into a bottom quark +** $\tilde{\chi}_1^{\pm}$, or **into a top quark +** $\tilde{\chi}_1^0$.

$$\tilde{t}\tilde{t} \rightarrow t\tilde{\chi}_1^0 t\tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0 bl\nu\, \tilde{\chi}_1^0 bqq$$

$$\tilde{t}\tilde{t} \rightarrow b\tilde{\chi}^{\pm} b\tilde{\chi}^{\mp} \rightarrow \tilde{\chi}_1^0 bl\nu\, \tilde{\chi}_1^0 bqq$$

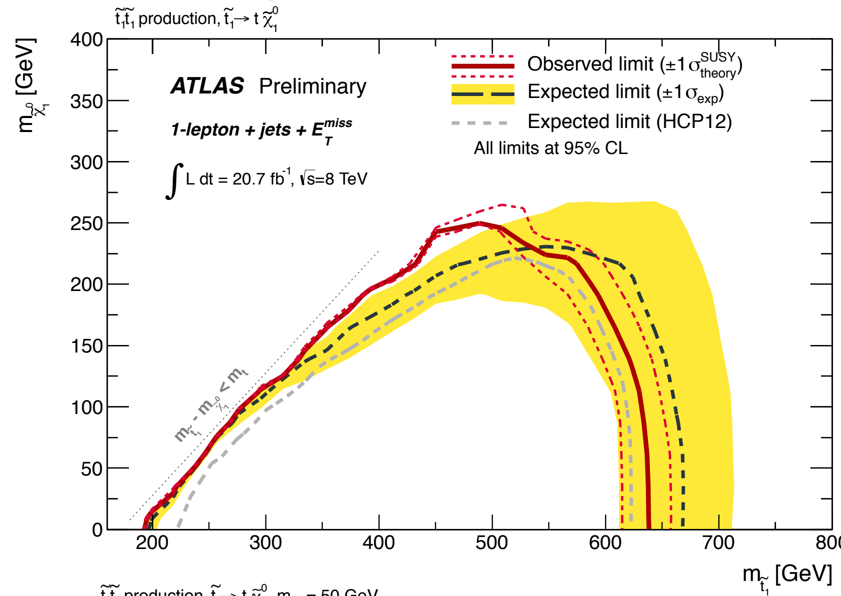
High E_T^{miss} for the signal because of $\tilde{\chi}_1^0$ in the final state.

Multiple signal regions (see backup):

- relying mostly on **a harsh selection on** $\mathbf{E_T^{miss}}$ and $\mathbf{m_T}$

$$m_T = \sqrt{2 p_T^{\ell} E_T^{miss}\left(1-\cos\Delta\phi\left(E_T^{miss},\ell\right)\right)}$$

- tag one b-jet, **reconstruct one hadronic top mass**
- 5 cut & count signal regions, 1 signal region with E_T^{miss} and m_T shape fit



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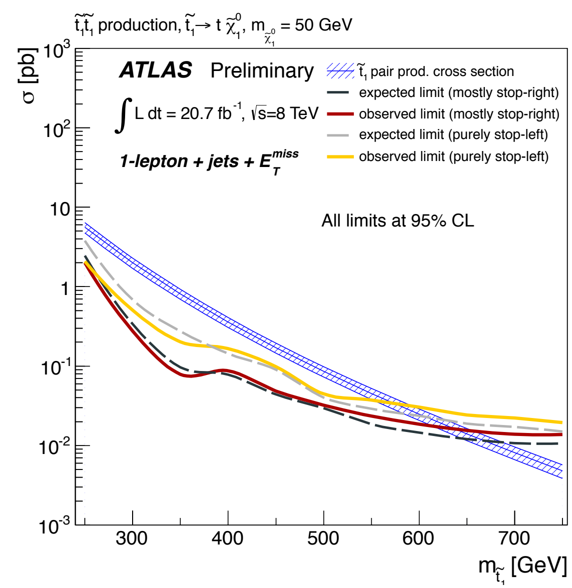


Dependency on the stop chirality.

If the *stop* **is left handed,** results are **penalised** by lepton **decreased acceptance**

Scalar top: 2 leptons

This analysis looks for events where each of the **stops** decays **into a bottom quark +** $\tilde{\chi}_1^{\pm}$.

$$\tilde{t}\tilde{t} \rightarrow b\tilde{\chi}^{\pm} b\tilde{\chi}^{\mp} \rightarrow \tilde{\chi}_1^0 bl\nu\, \tilde{\chi}_1^0 bl\nu$$

Use of the ***m_{T2}* variable** to discriminate the signal from the background

$$m_{T2}\left(\vec{p}_T^{\,1},\vec{p}_T^{\,1},\vec{p}\!\!\!/_T\right) = \min_{\vec{q}_T^{\,1}+\vec{q}_T^{\,2}=\vec{p}\!\!\!/_T}\left\{\max\left[m_T^2\left(p_T^1,\vec{q}_T^{\,1}\right), m_T^2\left(p_T^2,\vec{q}_T^{\,2}\right)\right]\right\}$$

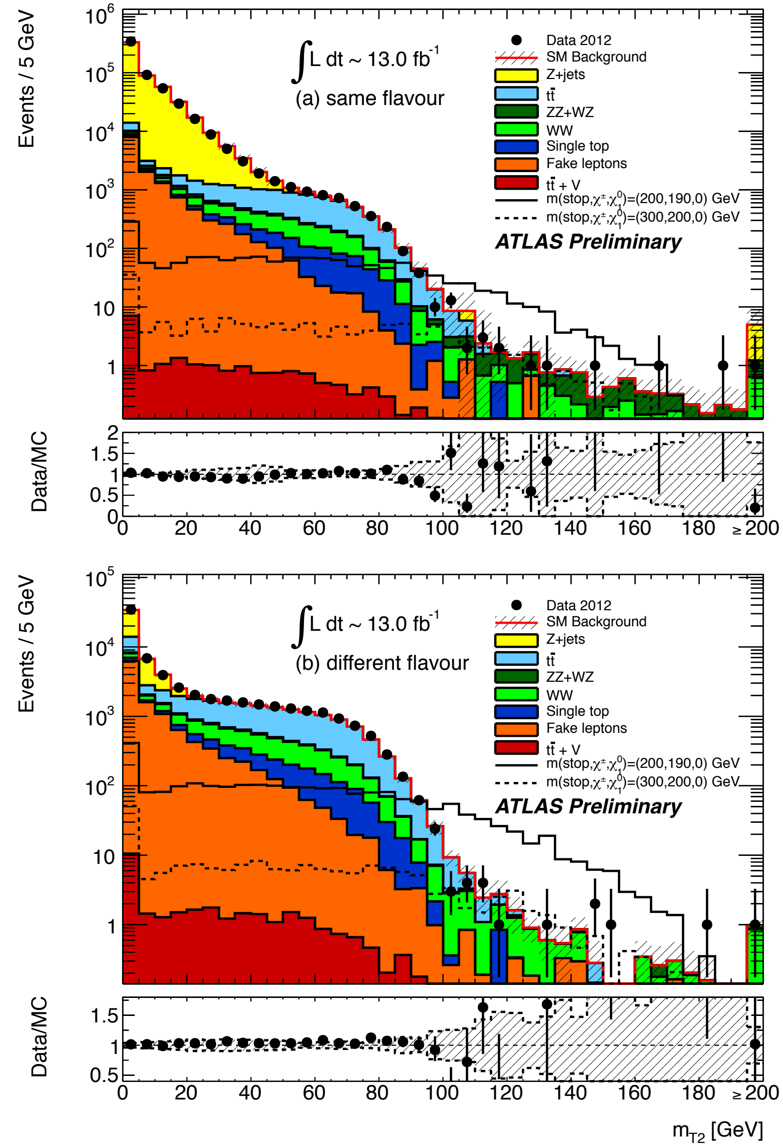
Exactly two **opposite sign** high-p_T leptons (e or μ, veto a third)

Two channels: **Different Flavour** ***DF*** (eμ)
Same Flavour ***SF*** (ee , μμ)

- $\Delta\phi(E_T^{miss}$, closest jet) > 1.0
- $\Delta\phi_b$ $(E_T^{miss}, p_b^{ll}) < 1.5$
- **M_{T2} > 90, 100, 110 GeV**

SF candidates only

- Veto 71 GeV < m_{ll} < 111 GeV



ATLAS-CONF-2012-167

Scalar top: 2 leptons

This analysis looks for events where each of the **stops** decays **into a bottom quark +** $\tilde{\chi}_1^{\pm}$.

$$\tilde{t}\tilde{t} \rightarrow b\tilde{\chi}^{\pm}b\tilde{\chi}^{\mp} \rightarrow \tilde{\chi}_1^0 bl\nu\, \tilde{\chi}_1^0 bl\nu$$

Use of the ***m_{T2}* variable** to discriminate the signal from the background

$$m_{T2}\left(\vec{p}_T^{\,1},\vec{p}_T^{\,1},\vec{p}\!\!\!/_T\right) = \min_{\vec{q}_T^{\,1}+\vec{q}_T^{\,2}=\vec{p}\!\!\!/_T}\left\{\max\left[m_T^2\left(p_T^1,\vec{q}_T^{\,1}\right), m_T^2\left(p_T^2,\vec{q}_T^{\,2}\right)\right]\right\}$$

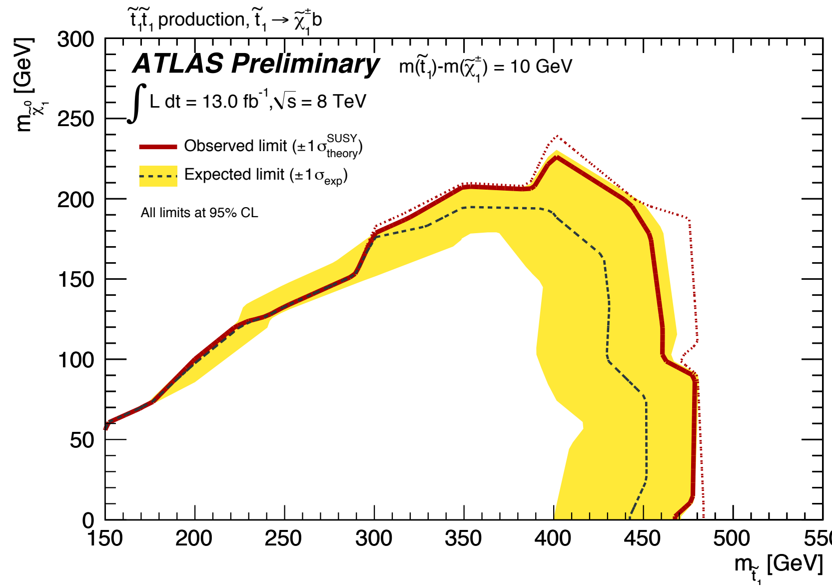
Exactly two **opposite sign** high-p_T leptons (e or μ, veto a third)

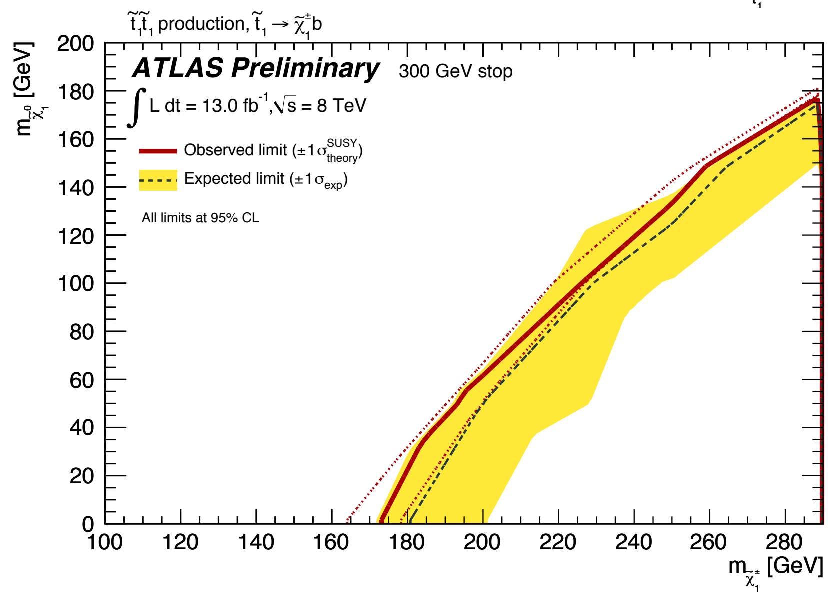
Two channels: **Different Flavour** ***DF*** (eμ)
Same Flavour ***SF*** (ee , $\mu\mu$)

- $\Delta\phi(E_T^{miss}$, closest jet$) > 1.0$
- $\Delta\phi_b\ (E_T^{miss}, p_b^{ll}) < 1.5$
- **M_{T2} > 90, 100, 110 GeV**

SF candidates only

- Veto 71 GeV < m_{ll} < 111 GeV

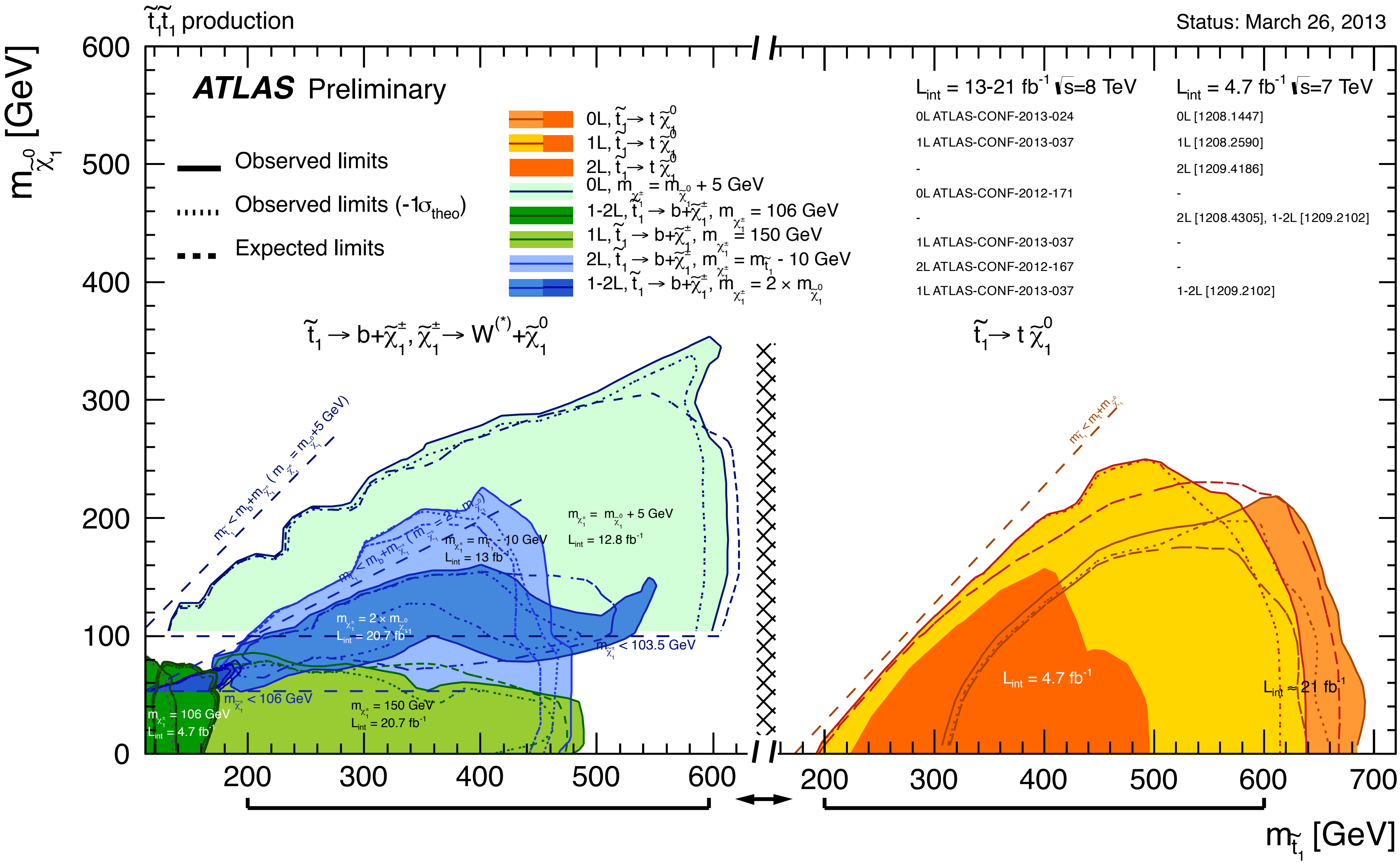


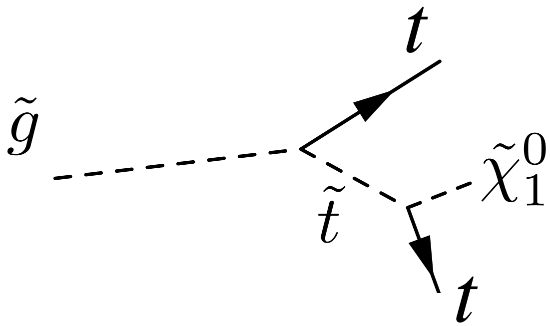


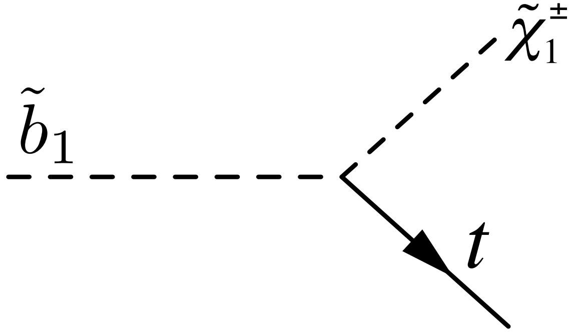
ATLAS-CONF-2012-167

NEW!

Direct Stop searches summary







- 2 Same Sign leptons
- 3 leptons

OTHER NATURAL SUSY SEARCHES

2 SS leptons search

A search utilizes **same-sign electron and muon pairs** (*ee*, *e*μ, μμ), missing transverse momentum, *b*-quark jets (*b*-jets) and multiple high-p_T jets.

- Final state sensitive to many possible signal processes.

$\tilde{g} \to b\, \tilde{b}_1$

$\tilde{g} \to t\, \tilde{t}_1$

- $\to t\, \tilde{\chi}_1^{\pm}$ / $\to b\, \tilde{\chi}_1^{\pm}$: Gluino-stop ($b\tilde{\chi}_1^{\pm}$) degenerate ($m_{\tilde{\chi}_1^{\pm}}, m_{\tilde{\chi}_1^0}$); Gluino-stop ($b\tilde{\chi}_1^{\pm}$) on-shell
- $\to t\, \tilde{\chi}_1^0$: Gluino-stop ($t\tilde{\chi}_1^0$) off-shell ($m_{\tilde{g}} < m_{\tilde{t}} + m_t$); Gluino-stop ($t\tilde{\chi}_1^0$) on-shell ($m_{\tilde{g}} > m_{\tilde{t}} + m_t$)
- $\to$ b s: Gluino-stop (bs) RPV

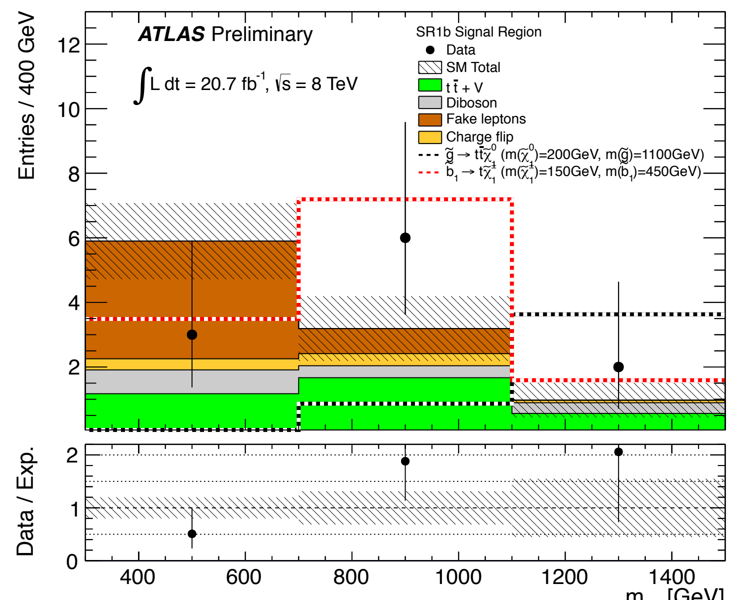
$\tilde{b}_1 \to t\, \tilde{\chi}_1^{\pm}$

- $\to W^{\pm(*)} \tilde{\chi}_1^0$: direct sbottom ($t\tilde{\chi}_1^{\pm}$) fixed $m_{\tilde{\chi}_1^0}$; direct sbottom ($t\tilde{\chi}_1^{\pm}$) varied $m_{\tilde{\chi}_1^0}$

ATLAS-CONF-2013-007

N_{b-jets}	Signal cuts (discovery case)	Signal cuts (exclusion case)
0	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV, $m_{eff} > 400$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV, binned shape fit in m_{eff} for $m_{eff} > 300$ GeV
≥1	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV, $m_{eff} > 700$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV, binned shape fit in m_{eff} for $m_{eff} > 300$ GeV
≥3	$N_{jets} \geq 4$ -	$N_{jets} \geq 5$, $E_T^{miss} < 150$ GeV or $m_T < 100$ GeV

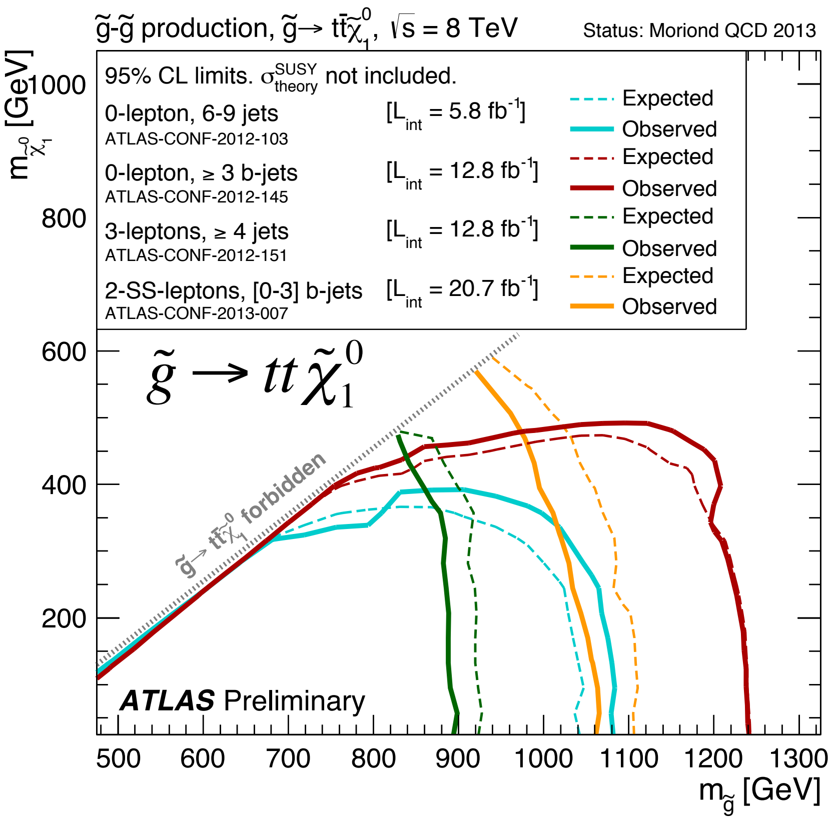
$$m_{eff} = \sum_j p_T^j + \sum_\ell p_T^\ell + E_T^{miss}$$



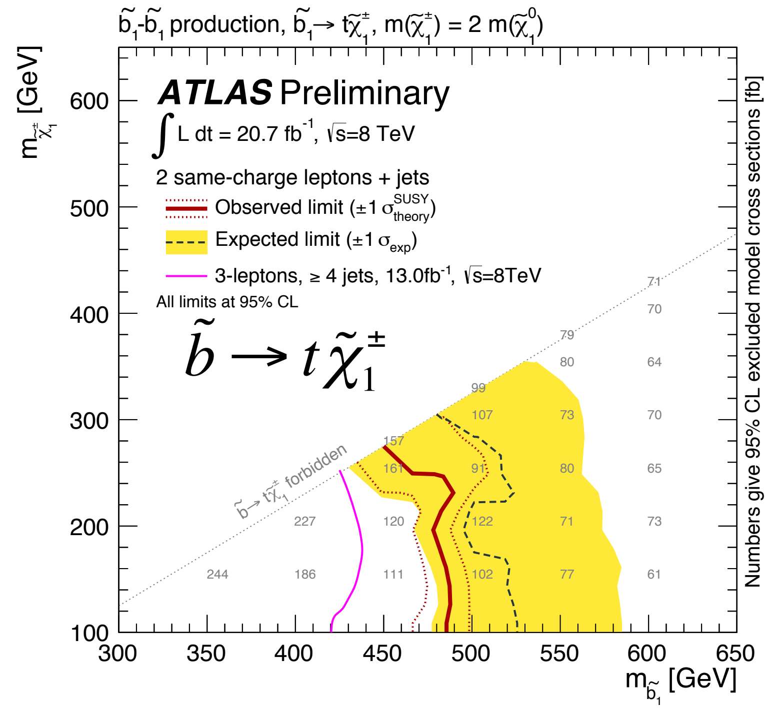
Slightly different cuts have been applied for

- model independent limits (discovery case)
- model dependent exclusion limits (exclusion case)

2 SS leptons search



Results interpreted in both *gluino* and *sbottom* decay scenarios.



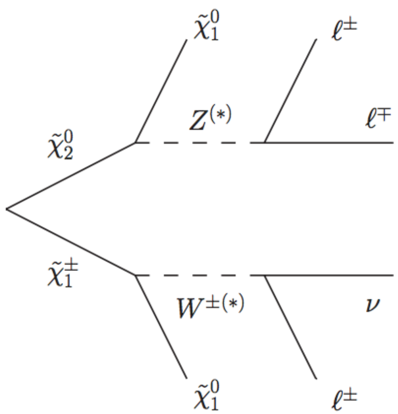
ATLAS-CONF-2013-007

Signal regions	$\langle\epsilon\sigma\rangle^{95}_{\rm obs}$ [fb]	$S^{95}_{\rm obs}$	$S^{95}_{\rm exp}$
SR0b	0.33	6.7	$7.9^{+2.6}_{-2.0}$
SR1b	0.53	11.0	$6.8^{+2.6}_{-1.5}$
SR3b	0.34	7.0	$5.9^{+2.4}_{-1.3}$

NEW!

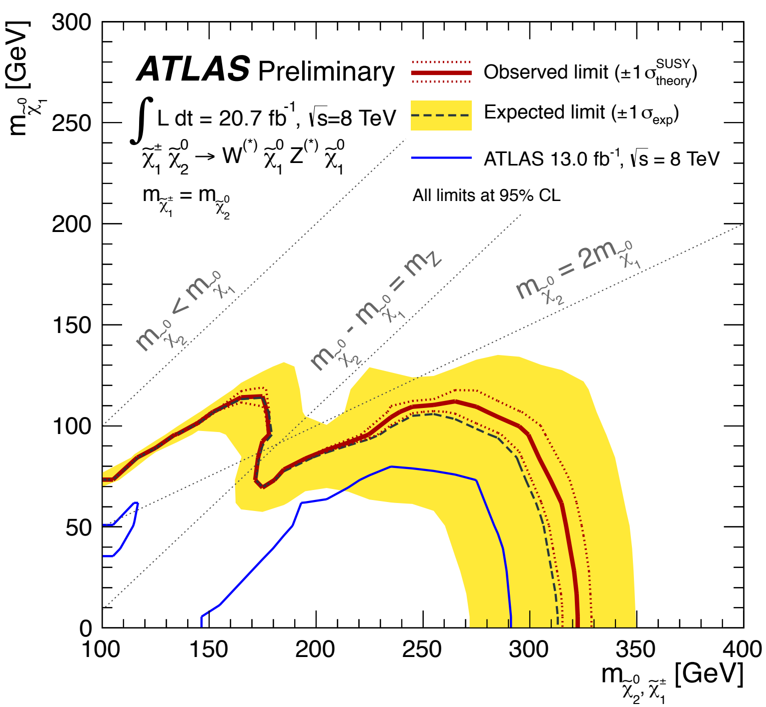
Direct gaugino search: 3 leptons

ATLAS-CONF-2013-035



Direct electroweak production of gauginos gives rise to **multi-lepton final states:**

- Very **low SM background** expected
- Decays through **sleptons** (BR to leptons 100%) or **WZ-like** (challenging) decays assumed



	Z depleted			Z enriched		
Selection	SRnoZa	SRnoZb	SRnoZc	SRZa	SRZb	SRZc
m_{SFOS} [GeV]	<60	60–81.2	<81.2 or >101.2	81.2–101.2	81.2–101.2	81.2–101.2
E_T^{miss} [GeV]	>50	>75	>75	75–120	75–120	>120
m_T [GeV]	–	–	>110	<110	>110	>110
p_T 3rd ℓ [GeV]	>10	>10	>30	>10	>10	>10
SR veto	SRnoZc	SRnoZc	–	–	–	–
Target	Low mass splitting	No slepton Off-shell Z	Slepton bulk	WZ-like	No slepton On-shell Z	No slepton bulk

Results interpretation (simplified models) assumes **wino-like** $\tilde{\chi}_2^0$ and $\tilde{\chi}_1^\pm$ and a **bino-like** $\tilde{\chi}_1^0$

- $\tilde{\chi}_2^0$ and $\tilde{\chi}_1^\pm$ are assumed to be mass-degenerate

Conclusions and Outlook

The analysis of the 2012 data of ATLAS has yielded lots of results:

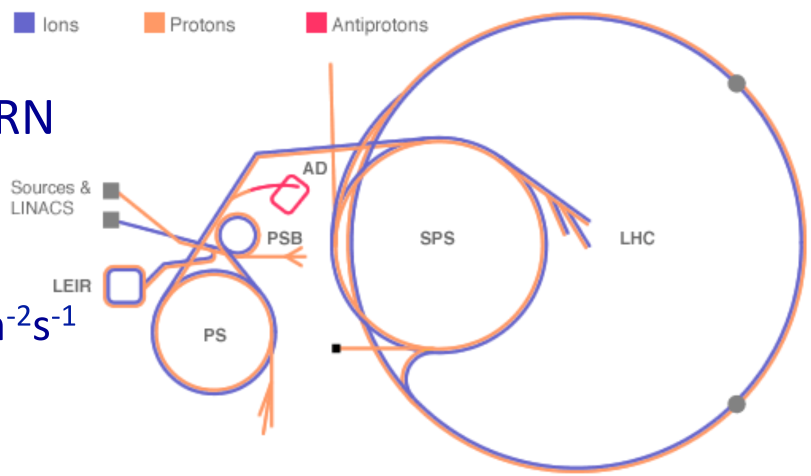
- 95% CL exclusion limits are set within various phenomenological assumptions
- the parameter space given by the naturalness argument is being filled up

Even if the results have been found consistent with Standard Model expectations, the search continues: in particular for implementations of supersymmetry leading to more subtle signals at LHC

- The third generation of scalar quarks is crucial for naturalness and an high priority in ongoing searches.
- More to come with 8 TeV data: expect new results soon!

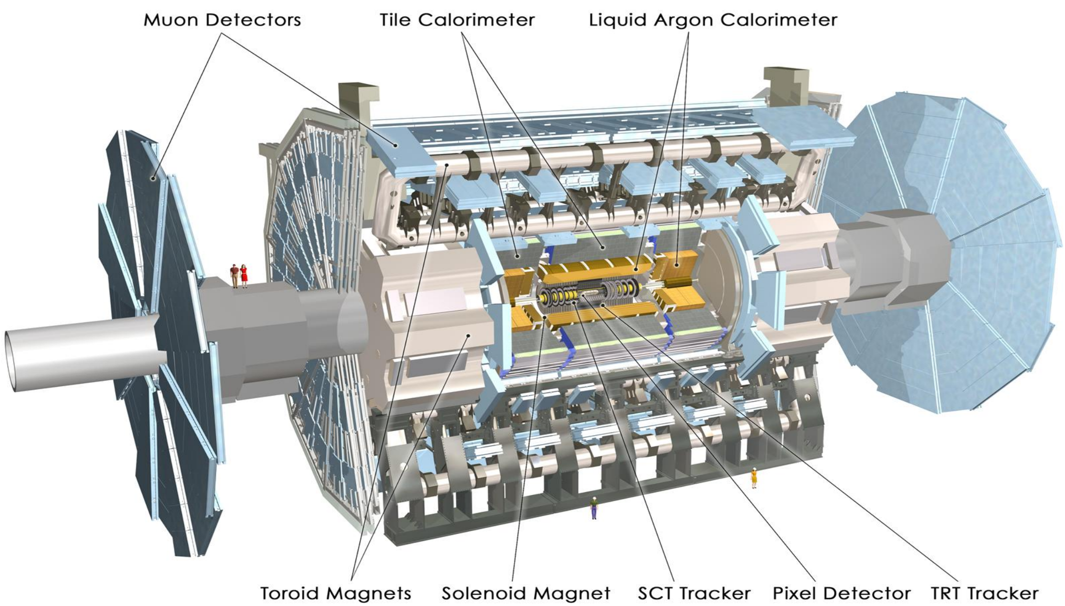
THANKS FOR YOUR ATTENTION!

LHC and ATLAS



LHC is a proton-proton collider situated at CERN

- Collisions at $\sqrt{s}$ = 7 TeV (2010-2011)
- Collisions at $\sqrt{s}$ = 8 TeV (2012)
- High instantaneous luminosities L = 6×10^{33} $cm^{-2}s^{-1}$
- More than 21 fb^{-1} of data delivered before LS1



ATLAS is a multi-purpose detector composed by:

- An inner tracking system (silicon + gaseous)
- Two sampling calorimeter systems (Electromagnetic and Hadronic)
- An *in-air* muon spectrometer

Common background estimation strategies

The analyses presented here share some common techniques to estimate the backgrounds:

- QCD multijet backgrounds (data-driven)
  - *Hadronic searches*: Estimated smearing a sample of jets from a control region (CR) with a function taken from a simulated dijet sample
  - *Leptonic searches*: Fake rate measured in a CR with relaxed lepton identification criteria and used to estimate the rate in the signal region (SR)
- Major backgrounds (semi data-driven)
  - Define a control region for each of the backgrounds kinematically close to signal region
  - Normalise MC yields to data
  - Apply transfer factor from CR to SR subtracting other backgrounds in the region

$$N(\mathrm{SR}) = (N^{\mathrm{Data}}(\mathrm{CR}) - N_{\mathrm{others}}(\mathrm{CR}))\,\frac{N^{\mathrm{MC}}(\mathrm{SR})}{N^{\mathrm{MC}}(\mathrm{CR})}$$

- Minor backgrounds are taken from MC simulation only

Scalar top: fully hadronic

Model independent result interpretation

Signal region	$\langle \epsilon\sigma \rangle^{95}_{\mathrm{obs}}$[fb]	S^{95}_{obs}	S^{95}_{exp}
SR1	0.49	10.0	$10.6^{+5.5}_{-1.7}$
SR2	0.17	3.6	$5.3^{+3.2}_{-1.7}$
SR3	0.19	3.9	$4.5^{+1.9}_{-0.7}$

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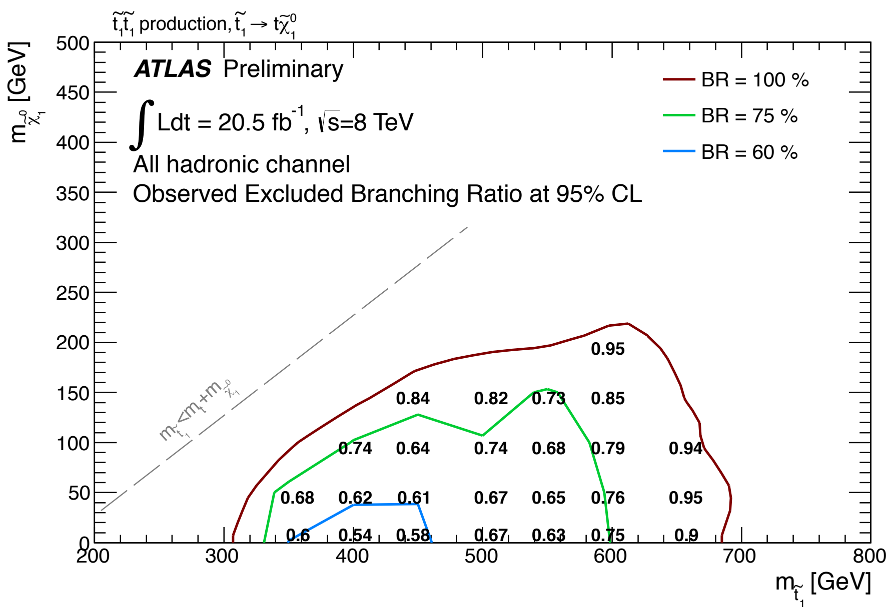
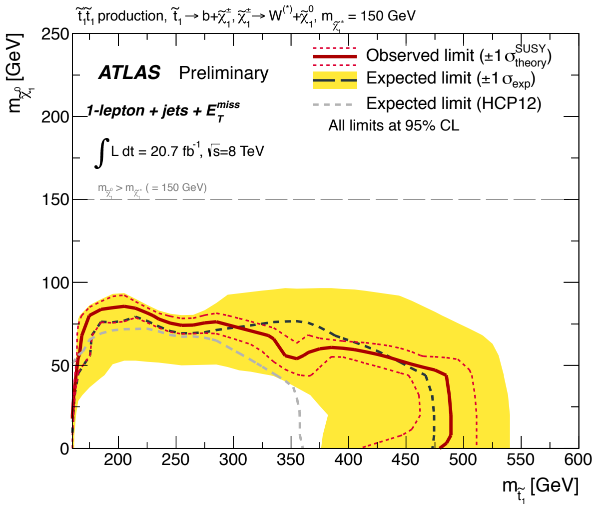
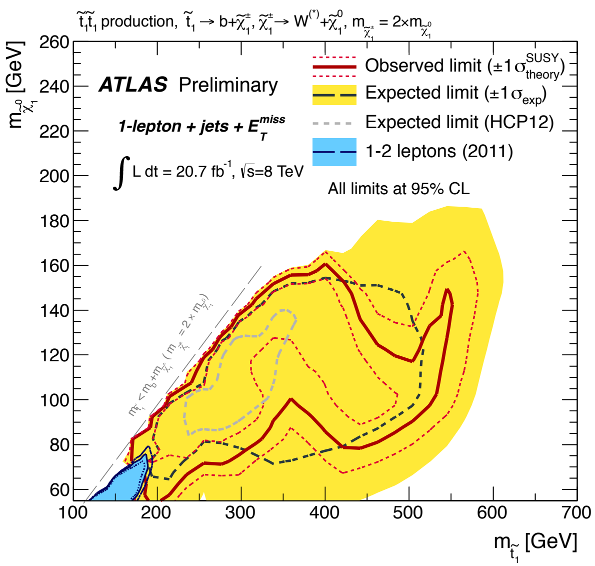
Limit dependence on BR to selected final state (top + neutralino 1), assuming that the competing decay modes are outside the sensitivity of the analysis



Scalar top: 1 lepton





Requirement	SRtN1_shape	SRtN2	SRtN3	SRbC1	SRbC2	SRbC3
$\Delta\varphi(\text{jet}_1, \vec{p}_T^{\text{miss}}) >$	0.8	-	0.8	0.8	0.8	0.8
$\Delta\varphi(\text{jet}_2, \vec{p}_T^{\text{miss}}) >$	0.8	0.8	0.8	0.8	0.8	0.8
E_T^{miss} [GeV] >	$100^{(\star)}$	200	275	150	160	160
$E_T^{\text{miss}} / \sqrt{H_T}$ [GeV$^{1/2}$] >	5	13	11	7	8	8
m_T [GeV] >	$60^{(\star)}$	140	200	120	120	120
m_{eff} [GeV] >	-	-	-	-	550	700
am_{T2} [GeV] >	-	170	175	-	175	200
m_{T2}^{τ} [GeV] >	-	-	80	-	-	-
m_{jjj}	Yes	Yes	Yes	-	-	-
$N^{\text{iso-trk}} = 0$	-	-	-	Yes	Yes	Yes
Number of b-jets ≥	1	1	1	1	2	2
p_T (leading b-jet) [GeV] >	25	25	25	25	100	120
p_T (second b-jet) [GeV] >	-	-	-	-	50	90

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- *Table*: signal region definition
- *Top plot*: bottom + chargino decay mode result interpretation with fixed C1 mass = 150 GeV
- *Bottom plot*: bottom + chargino decay mode result interpretation in gaugino unification scenario

Scalar top: 2 leptons

Cut & count results + model independent result interpretation

Process	$SR90$	$SR100$	$SR110$
$t\bar{t}$ events	134 ± 24	21 ± 9	3.8 ± 1.8
(MC prediction)	(131 ± 30)	(21 ± 9)	(3.7 ± 2.1)
WW events	51 ± 11	23 ± 7	15 ± 5
(MC prediction)	(42 ± 5)	(19 ± 4)	(12 ± 3)
$WZ - ZZ$ events	8.4 ± 1.9	6.3 ± 1.8	4.7 ± 1.4
(MC prediction)	(13 ± 4)	(10 ± 4)	(7 ± 3)
Z+jets	8 ± 6	7 ± 5	4 ± 6
$t\bar{t}V$ events	1.5 ± 0.3	0.9 ± 0.2	0.6 ± 0.2
Wt events	11 ± 5	1.8 ± 1.9	1.4 ± 0.8
Events with fake leptons	9.6 ± 2.8	3.7 ± 1.4	1.4 ± 0.8
Total bkg events	224 ± 31	64 ± 13	31 ± 8
(MC prediction)	(215 ± 34)	(62 ± 13)	(30 ± 8)
Signal, m($\tilde{t}_1, \tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0$) = (200,190,1) GeV	594 ± 92	405 ± 64	252 ± 41
Signal, m($\tilde{t}_1, \tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0$) = (300,200,1) GeV	52 ± 17	35 ± 14	24 ± 11
Observed events	178	44	22
95% CL limit on σ_{vis}^{obs}[fb]	3.29	1.39	1.18
95% CL limit on σ_{vis}^{exp}[fb]	5.39	2.39	1.58

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Scalar top: 2 leptons

Systematic uncertainties breakdown

	$SR90$	$SR100$	$SR110$
JES	2%	3%	3%
JER	4%	1%	9%
cluster energy scale	2%	2%	8%
cluster energy resolution	0%	0%	9%
pileup	7%	6%	1%
diboson generator	2%	9%	15%
top generator	8%	5%	3%
top ISRFSR	4%	3%	1%
top parton shower	3%	11%	4%
MC stat	3%	8%	13%
$t\bar{t}$ normalization	3%	1%	1%
WW normalization	4%	6%	8%
WZ/ZZ normalization	1%	2%	3%
Fake-lepton uncertainties	1%	1%	1%
Total uncertainty	14%	20%	28%

ATLAS-CONF-2012-167

2 SS leptons

Cut & count results. p_0 denotes the *p*-value of the observed events for the background only hypothesis.

A) Discovery case	**SR0b**	**SR1b**	**SR3b**
Observed events	5	8	4
Expected background events	7.5 ± 3.3	3.7 ± 1.6	3.1 ± 1.6
Expected $t\bar{t} + V$ events	0.5 ± 0.4	2.2 ± 1.0	1.7 ± 0.8
Expected diboson events	3.4 ± 1.0	0.7 ± 0.4	0.1 ± 0.1
Expected fake lepton events	3.4 ± 3.1	$0.3^{+1.1}_{-0.3}$	$0.9^{+1.4}_{-0.9}$
Expected charge mis-measurement events	0.1 ± 0.1	0.5 ± 0.2	0.4 ± 0.1
p_0	0.50	0.11	0.36

B) Exclusion case	**SR0b**	**SR1b**	**SR3b**
Observed events	5	11	1
Expected background events	7.5 ± 3.2	10.1 ± 3.9	1.8 ± 1.3
Expected $t\bar{t} + V$ events	0.5 ± 0.4	3.4 ± 1.5	0.6 ± 0.4
Expected diboson events	3.4 ± 1.1	1.4 ± 0.7	< 0.1
Expected fake lepton events	3.4 ± 2.9	4.4 ± 3.1	1.0 ± 1.1
Expected charge mis-measurement events	0.2 ± 0.1	0.8 ± 0.3	0.1 ± 0.1
p_0	0.5	0.39	0.5

ATLAS-CONF-2013-007

Direct sbottom search: 2 b-jets

$E_{\mathrm{T}}^{\mathrm{miss}}$	> 150 GeV	> 200 GeV	> 150 GeV	> 250 GeV
Leading jet $p_{\mathrm{T}}(j_1)$	> 130 GeV, $\lvert\eta\rvert < 2.8$	> 60 GeV, $\lvert\eta\rvert < 2.8$	> 130 GeV, $\lvert\eta\rvert < 2.8$	> 150 GeV, $\lvert\eta\rvert < 2.8$
Second jet $p_{\mathrm{T}}(j_2)$	> 50 GeV, $\lvert\eta\rvert < 2.8$	> 60 GeV, $\lvert\eta\rvert < 2.8$	> 30 GeV, < 110 GeV, $\lvert\eta\rvert < 2.8$	
Third jet $p_{\mathrm{T}}(j_3)$	veto event if $p_{\mathrm{T}}(j_3) > 50$ GeV, $\lvert\eta\rvert < 2.8$		> 30 GeV, $\lvert\eta\rvert < 2.8$	
$\Delta\phi(E_{\mathrm{T}}^{\mathrm{miss}}, j_1)$	-		> 2.5	
jet b-tagging ($\lvert\eta\rvert < 2.5$)	j_1 and j_2 tagged		j_1 anti-tagged, j_2 and j_3 tagged	
$\Delta\phi_{\mathrm{min}}(n)$	> 0.4 ($n = 2$)		> 0.4 ($n = 3$)	
$E_{\mathrm{T}}^{\mathrm{miss}}/\mathrm{m_{eff}}(j_1, j_2, j_3)$	> 0.25			
m_{CT}	$> 150, 200, 250, 300$ GeV	> 100 GeV	-	
$H_{\mathrm{T},x}$	-	< 50 GeV, $x = 2$	< 50 GeV, $x = 3$	

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Direct sbottom production has been probed in events with 2 final state b-tagged jets.

- Many signal regions have been defined to improve sensitivity on the $\tilde{b} - \tilde{\chi}_1^0$ plane depending on the mass difference $\Delta m = m_{\tilde{b}} - m_{\tilde{\chi}_1^0}$

$$H_{T,x} = \sum_{all\ jets} p_T^{jet} - \sum_{leading\ x\ jets} p_T^{jet}$$

- Two SRs exploiting ISR recoil