Search for direct top squark pair production in events with a Higgs or Z boson

Claudia Merlassino

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ATLAS EXPERIMENT

SUSY and the top squark

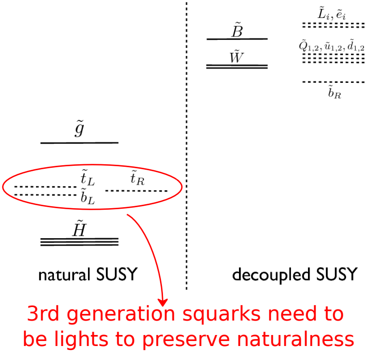
For decades the Standard Model has been subject to experimental scrutiny and has been found to be in agreement with experimental measurements.

Still, some open questions:

- Higgs mass not natural,
- Dark Matter. . .

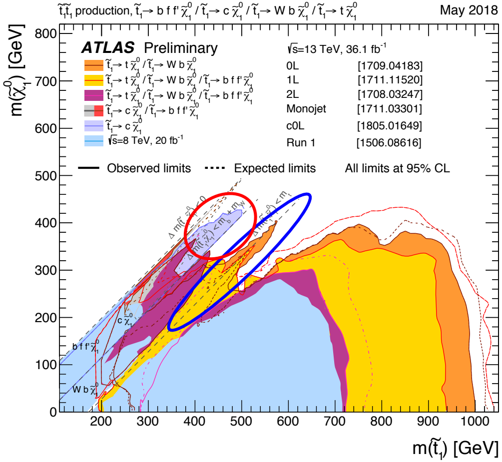
Supersymmetry can solve these problems by adding a new set of particles one for each of the Standard Model's ones

We haven't seen these particles yet $\rightarrow$ the symmetry must be broken



$\rightarrow$ comprehensive program of top squark searches at the LHC

Exclusion limits often presented through simplified models:
most popular $\tilde{t}_1 \to t\tilde{\chi}_1^0$

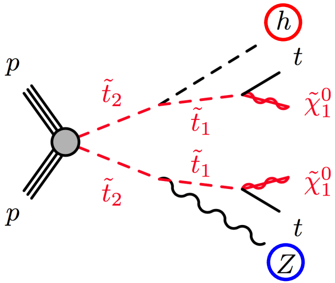


Some regions hard to cover due to experimental limits:

- $\Delta m(\tilde{t}_1, \tilde{\chi}_1^0) = m(t)$
  signal very similar to the $t\bar{t}$ background
- compressed area
  (small $\Delta m(\tilde{t}_1, \tilde{\chi}_1^0)$)
  soft decay products and low $E_{\mathrm{T}}^{\mathrm{miss}}$

Complex decay chains: $\tilde{t}_2$ pair production

When the $\tilde{t}_1 \to t + \tilde{\chi}_1^0$ becomes difficult to tackle
it can be convenient to pass through the $\tilde{t}_2$



Two main selections,
to target the two different bosons
3 leptons + 1 b jet ($Z \to \ell^+\ell^-$)
1 or 2 leptons + 4 b jets ($h \to b\bar{b}$)

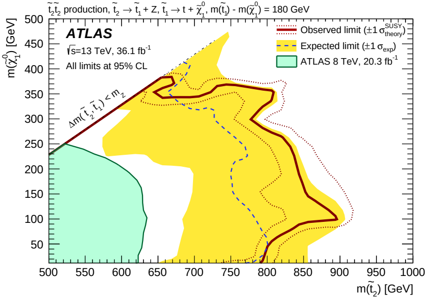
Pros:

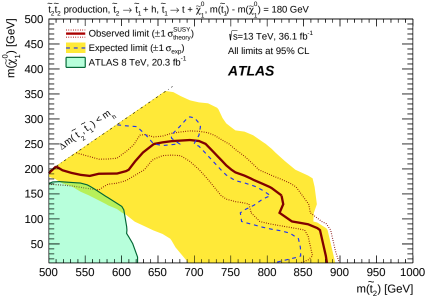
- busy final state
  - reduce the most common SM backgrounds
  - no need to rely on the $\tilde{t}_1$ decays products

Cons:

- higher masses
- lower cross sections
- more free parameters
  $\to$ a choice must be made
  $\Delta m(\tilde{t}_1, \tilde{\chi}_1^0) = m(t)$

First results with 2015/16 dataset



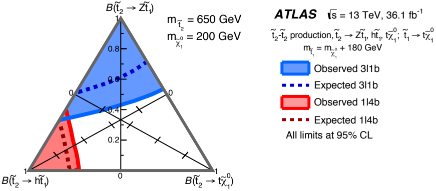


No significant excess has been found

↓

Results used to put limits on

$\tilde{t}_1$, $\tilde{t}_2$ and $\tilde{\chi}_1^0$ masses

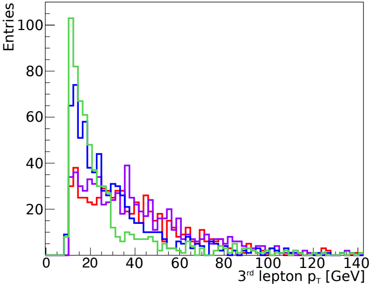


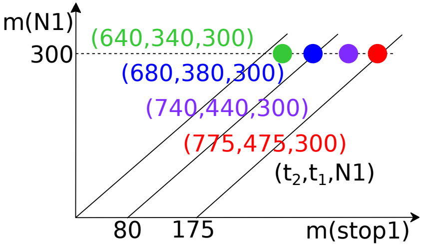
arxiv:1706.03986

Compress scenarios

Plan to target also the compressed scenarios with the full datasets

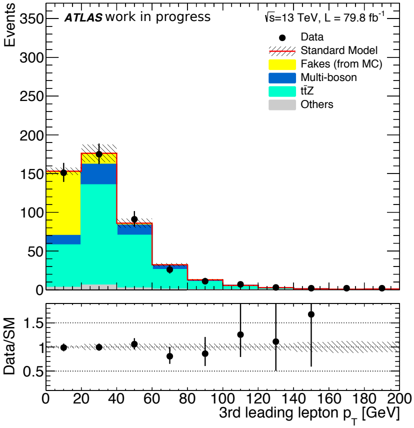
- a different phase space results in different kinematic distributions
- softer leptons ad b-jets
- a new selection will be developed



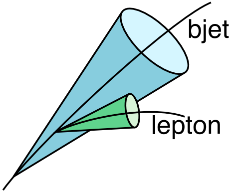


Soft leptons and fakes

The new selections will come with new challenges



- events with non-prompt leptons become dominant at low p_T
  - coming from b decays
- re-definition of candidate leptons
- isolation is the key!



Conclusions

Long decay chains can be considered to target more realistic models and experimentally complex phase space regions

- pair production of heavy stops allows to investigate such regions
- Z or h boson are present in the decay chain
  - $3\ell + 1b$ selection
  - $1/2\ell + 4b$ selection
- the ATLAS search with the intermediate Run 2 dataset allows to exclude up to 800-900 GeVof $\tilde{t}_2$ mass (depending on mass splitting and BR assumptions)
- plan to cover also very small $\Delta m(\tilde{t}_1, \tilde{\chi}_1^0)$ with the full dataset

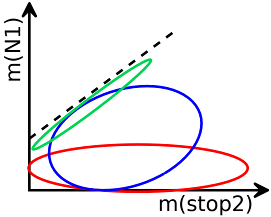
Stay tuned for the new results!

Backup slides

Decay chains with the Z: $3\ell + 1b$ selection

3 signal regions targeting different mass splitting

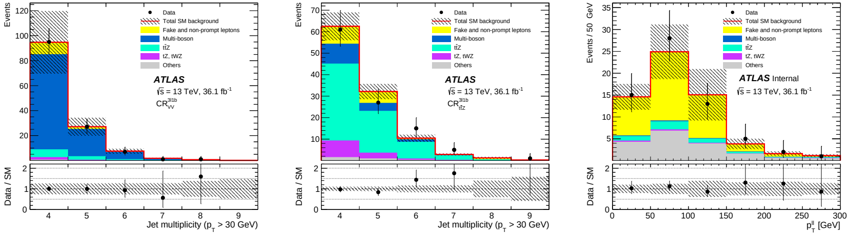
Requirement / Region	$\mathrm{SR}^{3\ell 1b}_{\mathrm{A}}$	$\mathrm{SR}^{3\ell 1b}_{\mathrm{B}}$	$\mathrm{SR}^{3\ell 1b}_{\mathrm{C}}$
$\lvert m_{\ell\ell} - m_Z \rvert$ [GeV]	< 15	< 15	< 15
Leading jet p_{T} [GeV]	> 250	> 80	> 60
Leading b-tagged jet p_{T} [GeV]	> 40	> 40	> 30
n_{jets} ($p_{\mathrm{T}} > 30$ GeV)	≥ 6	≥ 6	≥ 5
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 100	> 180	> 140
$p_{\mathrm{T}}^{\ell\ell}$ [GeV]	> 150	–	< 80



Main backgrounds:

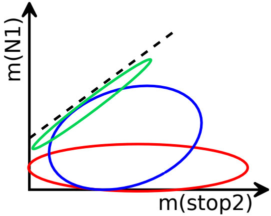
ttZ and diboson (Monte Carlo normalised in control regions)

fakes and non prompt lepton (data-driven estimation)



3 signal regions targeting different mass splitting

Requirement / Region	$\mathrm{SR}_{\mathrm{A}}^{1\ell 4b}$	$\mathrm{SR}_{\mathrm{B}}^{1\ell 4b}$	$\mathrm{SR}_{\mathrm{C}}^{1\ell 4b}$
m_{T} [GeV]	–	>150	>125
H_{T} [GeV]	> 1000	–	–
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 120	> 150	> 150
Leading b-tagged jet p_{T} [GeV]	–	–	<140
m_{bb} [GeV]	95–155	–	–
p_{T}^{bb} [GeV]	> 300	–	–
n_{jets} (p_{T} >60 GeV)	≥ 6	≥ 5	–
n_{jets} (p_{T} >30 GeV)	–	–	≥ 7



Main background:
$t\bar{t} + b\bar{b}$ production
Monte Carlo normalised in 3 control regions kinematically close to the signal regions