Search of the top quark heaviest supersymmetric partner with the ATLAS detector

<S|P|S> Annual meeting 2016 Lugano

Geoffrey Mullier
Bern University Laboratory for High Energy Physics
25th August 2016

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ATLAS EXPERIMENT

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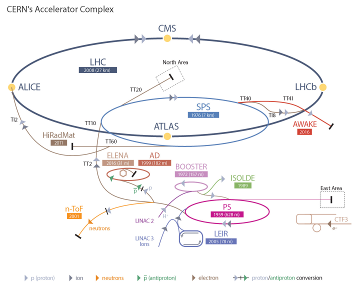
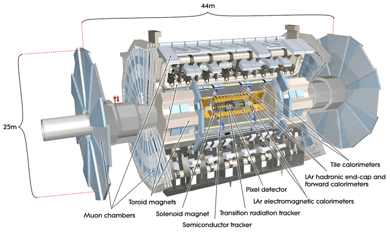
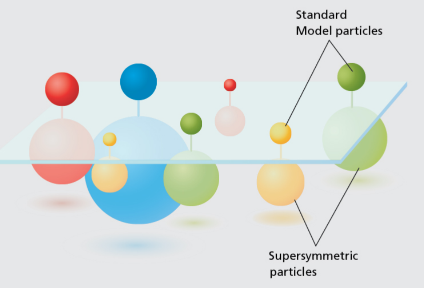
The Large Hadron Collider & ATLAS – A Toroidal Lhc ApparatuS





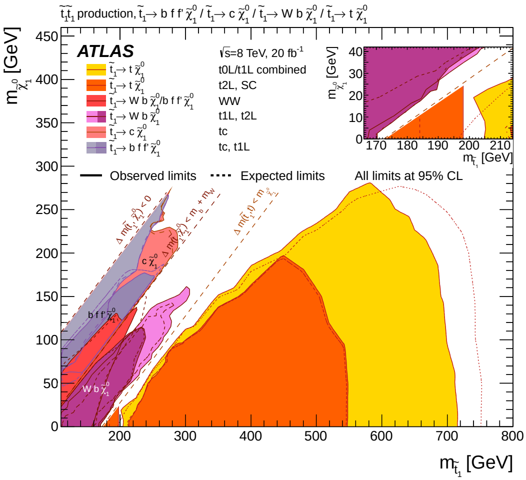
- LHC
  - Circular p–p collider with center of mass energy of 13 TeV at collision rate of 40 MHz.
  - Design instantaneous luminosity of 10^{34} cm^{-2} s^{-1} with maximum instantaneous luminosity this year $1.16\ 10^{34}$ cm^{-2} s^{-1}.
  - More than 22.1 fb^{-1} delivered so far.
- ATLAS
  - Cylindrical symmetry, 4π coverage multi purpose detector aimed at generic searches.
  - Build to withstand the LHC design instantaneous luminosity of the LHC.

SUSY – SUperSYmmetry in short



- Extension of the Standard Model adding a super partner for each Standard Model particle.
- "Natural" R-Parity conserving SUSY provides an interesting framework giving solutions to
  - Hierarchy problem thanks to contribution of SUSY particles to the Higgs mass, especially the stop.
  - Dark matter candidate thanks to a stable WIMP.
  - Provides potential forces unification.

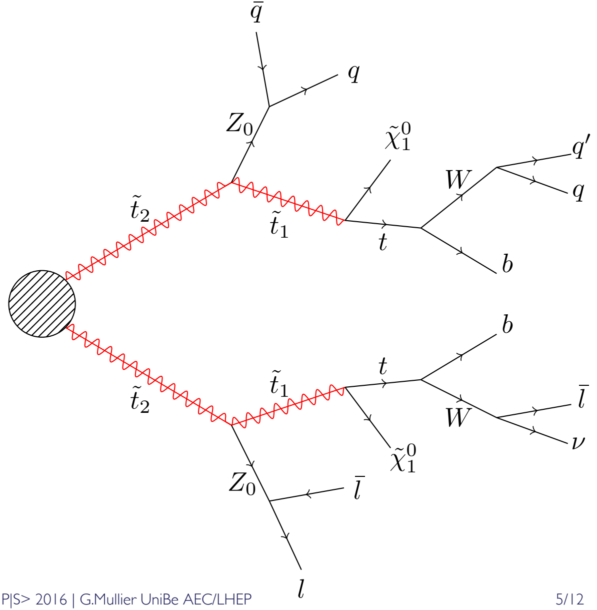
Searches for top quark Super-Partner



- Naturalness arguments constrain the stop mass to be less or the around the TeV.
- Interesting to look along the diagonal considering the $\tilde{t}_1$ as a decay product.
- Simplified models are an efficient way to interpret results.

Direct $\tilde{t}_2$ Process Overview

- Simplified model with direct $\tilde{t}_2$ pair production to $\tilde{t}_1$ and Z_0.
- Decay of $\tilde{t}_1$ to t and $\tilde{\chi}_1^0$.
- Assuming a "stealth" $\tilde{t}_1$ meaning $\tilde{t}_1 - \chi_1^0 \approx m_t$.
- Final state with three leptons, jets and missing transverse momentum.
- Making use of the Z_0 as a handle to reduce background.



Definition of signal regions

- Signal regions

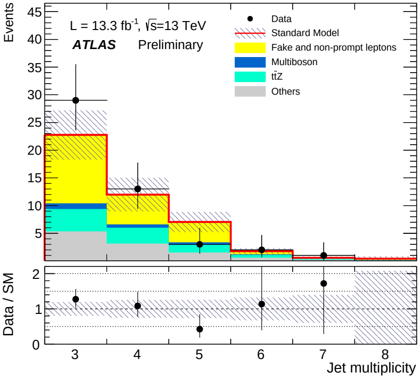
  SRH : High Mass splitting between $\tilde{t}_2$ and $\tilde{t}_1$.
  SRL : Low Mass splitting between $\tilde{t}_2$ and $\tilde{t}_1$.
  SRE : Optimization for intermediate mass splittings.

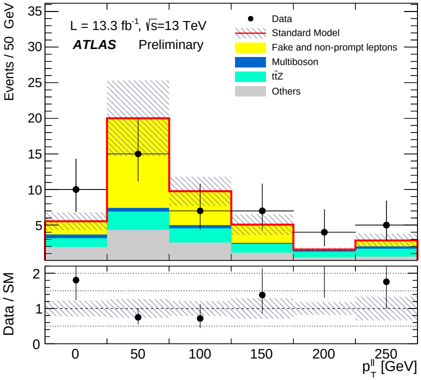
- $\ell_1, \ell_2 \equiv \ell_1\ \ell_2 \ \in$ SFOS leptons | min $|m_{\ell_1 \ell_2} - m_Z|$

Var/Region	SRL	SRH	SRE
$m_{\ell\ell}$ [GeV]	$76.2 - 106.2$	$76.2 - 106.2$	$76.2 - 106.2$
Leading lepton p_T [GeV]	> 40	> 40	> 40
Leading jet p_T [GeV]	> 60	> 100	> 80
n_{b-jets}	≥ 1	≥ 1	≥ 1
n_{jets}	≥ 6	≥ 5	≥ 5
MET [GeV]	> 100	> 100	> 100
$p_T^{\ell\ell}$ [GeV]	–	> 200	> 100

Background : Fake leptons & Matrix Method in a nutshell

- Data driven fake lepton estimation via Matrix Method.
- Associating the requirements on the leptons "quality" to the rate of identification and misidentification of leptons
- In Plots : Z veto | p_T leading lepton > 40 GeV | p_T leading jet > 60 GeV

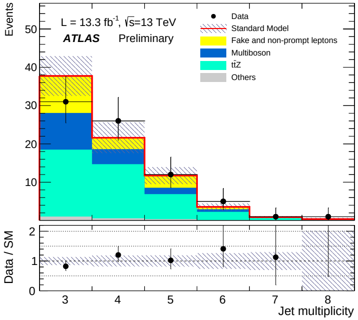


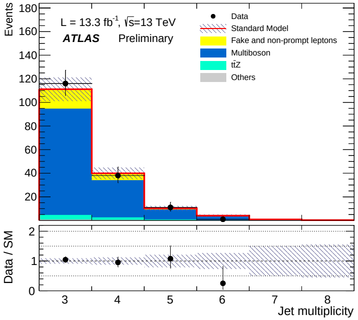


Major prompt background

- Dominating background coming from $t\bar{t}Z$.
- Following main contribution by VV.
- Other minor contribution by $t\bar{t}$H.
- Definition of two control regions CRTZ ($t\bar{t}Z$) and CRVV (VV) where fit is performed.

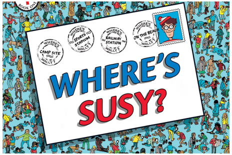
Var/Region	CRTZ	CRVV
$m_{\ell\ell}$ [GeV]	76.2–106.2	76.2–106.2
Leading lepton p_T [GeV]	> 40	> 40
Leading jet p_T [GeV]	> 60	> 60
$n_{b-\text{jets}}$	≥ 1	0
$n_{\text{jets}}(p_T > 30$ GeV$)$	≥ 3	≥ 3
MET [GeV]	< 100	–

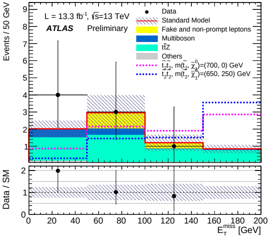




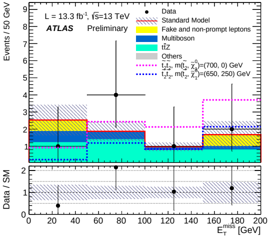
Results

Yields 13.3 fb^{-1}	SRE	SRL	SRH
Observed events	5	1	3
Fitted bkg events	4.2 ± 1.1	2.05 ± 0.63	2.48 ± 0.82
Fitted VV, VVV events	0.51 ± 0.20	0.10 ± 0.07	0.40 ± 0.15
Fitted $t\bar{t}Z$ events	2.99 ± 0.90	1.42 ± 0.47	1.55 ± 0.47
Fake and non prompt lepton events	$0.59^{+0.70}_{-0.59}$	$0.34^{+0.39}_{-0.34}$	$0.50^{+0.65}_{-0.50}$
Fitted Others events	0.12 ± 0.06	0.19 ± 0.06	0.04 ± 0.03
MC exp. VV, VVV events	0.50 ± 0.24	0.09 ± 0.08	0.39 ± 0.19
MC exp. $t\bar{t}Z$ events	3.45 ± 0.50	1.64 ± 0.33	1.79 ± 0.28
$\tilde{t}_2\tilde{t}_2$ $m(\tilde{t}_2, \tilde{t}_1, \tilde{\chi}^0_1) = (700, 180, 0)$GeV events	7.17 ± 0.77	4.76 ± 0.69	5.83 ± 0.83
$\tilde{t}_2\tilde{t}_2$ $m(\tilde{t}_2, \tilde{t}_1, \tilde{\chi}^0_1) = (650, 430, 250)$GeV events	6.78 ± 0.97	5.1 ± 1.1	2.98 ± 0.93

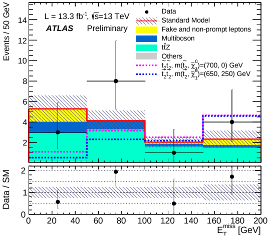




SRL

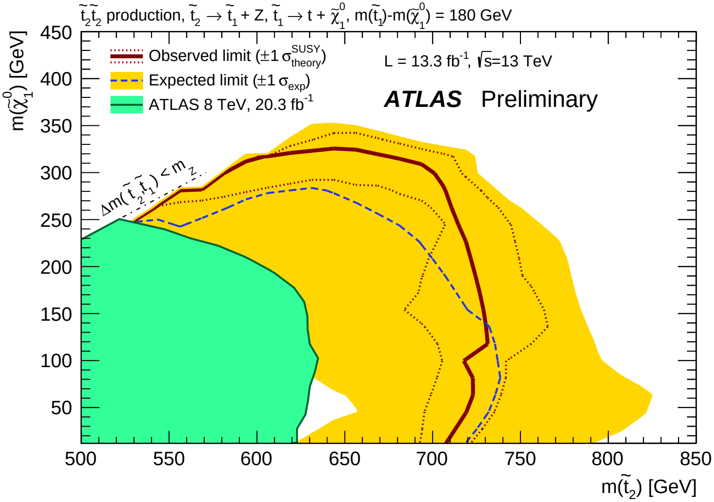


SRH



SRE

Exclusion contour



- In this $m(\tilde{t}_2)$ $m(\tilde{\chi}_1^0)$ exclusion contour we assume that
  - $m(\tilde{t}_2) - m(\tilde{\chi}_1^0) = 180$ GeV
  - BR $(\tilde{t}_2 \to Z\tilde{t}_1) = 1$
- Extending exclusion contours from Run I from $\tilde{t}_2 \approx 620$ GeV to ≈ 720 GeV and $m_{\tilde{\chi}_1^0}$ up to ≈ 300 GeV

Conclusions

- We performed a search for the heavy supersymmetric heavy top squark with a simplified model assuming $\tilde{t}_2 \rightarrow \tilde{t}_1 Z$ with 100% branching ratio to $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$ with 13.3 fb^{-1} of data with the ATLAS detector.
- The data recorded and analyzed is compatible with standard model prediction.
- Extending exclusion contours from Run 1 to $\tilde{t}_2$ squark masses up to 740 GeV at 95% confidence level for a $\tilde{\chi}_1^0$ of $70 - 100$ GeV and $\tilde{\chi}_1^0$ mass up to 270 GeV are excluded for $\tilde{t}_2$ squark masses below 650 GeV.
- All results in the ICHEP 2016 conference note ATLAS-CONF-2016-038.

Thank you for your attention!

STOPZ