Searches for vector-like quarks with the ATLAS detector

Antonella Succurro

on behalf of
the ATLAS collaboration

EPS 2013, Stockholm, July 18th-24th
Outline

Introduction

General Strategy

$T\bar{T} \rightarrow Ht + X$

Same-sign dileptons

$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$

$T\bar{T} \rightarrow Wb + X$

Conclusions
Standard Model as an effective theory

The Standard Model does not provide answers to the following questions

- Where does the baryon asymmetry come from?
- What is Dark Matter?
- How to solve the hierarchy problem?

Supersymmetry is not the only possible solution... Extra-dimensions [1], composite Higgs [2] models with new heavy quarks predicted [3]

- Not chiral\(^{(a)}\): chiral 4th generation would change the Higgs SM cross section and B.R.
- Vector-like: left and right components transform the same under \(SU(2) \times U(1)\)
- Weak-isospin singlets, doublets or triplets

\[\text{not naturally solve the hierarchy problem, like a stop squark in SUSY}\]

\(^{(a)}\) still, some models allow for a chiral fourth generation, see e.g. [4]
Heavy quark production

from [5]

Pair-production via strong interaction
Heavy quark production

Pair-production via strong interaction

EW single production could dominate at high mass
Outline

Introduction

General Strategy

$T\bar{T} \rightarrow Ht + X$

Same-sign dileptons

$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$

$T\bar{T} \rightarrow Wb + X$

Conclusions
Heavy quark decay modes

B.R.s are very model dependent

- most analyses optimized for specific decay channels

![Graphs showing branching ratios for T and B quarks](image)
Heavy quark decay modes

B.R.s are very model dependent

- most analyses optimized for specific decay channels
Heavy quark decay modes

B.R.s are very model dependent

- most analyses optimized for specific decay channels

**T**

- SU(2) Singlet
- (T,B) or (X,T) Doublet

**B**

- SU(2) Singlet
- (B,Y) Doublet
- (T,B) Doublet

---

A Succurro, IFAE Barcelona

EPS 2013, Stockholm, July 18th-24th

6/23
Heavy quark decay modes

B.R.s are very model dependent

- most analyses optimized for specific decay channels
Heavy quark decay modes

B.R.s are very model dependent

- most analyses optimized for specific decay channels
Model Independent Strategy \ldots since Oct 2012 [8]!

- Build a 2-dim plane to scan model mixing

\[
\begin{align*}
\text{BR}(T \rightarrow Wb) \\
\text{BR}(B \rightarrow Wt)
\end{align*}
\]
Model Independent Strategy  ... since Oct 2012 [8]!

- Build a 2-dim plane to scan model mixing

\[ BR(T \rightarrow Wb) \]
\[ BR(B \rightarrow Wt) \]

\[ BR(B \rightarrow Hb) \]
\[ BR(T \rightarrow Ht) \]

Forbidden

\[ \text{Sum of BRs is 1} \]

\[ (a) \]
\[ (a) \]

\[ BR(T/B \rightarrow Zt/b) = 1 - BR(T/B \rightarrow Ht/b) - BR(T/B \rightarrow Wb/t) \]

Different analyses are sensitive to different areas

\[ Ht(b) \]
\[ Zt(b) \]
\[ Wb(t) \]

Set exclusion using CLs technique [6, 7]

Using 14.3 fb\(^{-1}\) of 2012 data

Updating 7 TeV results
Model Independent Strategy  ... since Oct 2012 [8]!

- Build a 2-dim plane to scan model mixing
- Sum of BRs is \(1^{(a)}\)

\[
\begin{align*}
\text{BR}(T \rightarrow Wb) & \quad \text{BR}(B \rightarrow Wb) \\
\text{BR}(T \rightarrow Ht) & \quad \text{BR}(B \rightarrow Hb)
\end{align*}
\]

\[(a) \text{BR}(T/B \rightarrow Zt/b) = 1 - \text{BR}(T/B \rightarrow Ht/b) - \text{BR}(T/B \rightarrow Wb/t)\]
Model Independent Strategy … since Oct 2012 [8]!

- Build a 2-dim plane to scan model mixing
- Sum of BRs is \(1^{(a)}\)
- Different analyses are sensitive to different areas

\[ (a) \text{BR}(T/B \to Zt/b) = 1 - \text{BR}(T/B \to Ht/b) \]
\[ - \text{BR}(T/B \to Wb/t) \]
Model Independent Strategy … since Oct 2012 [8]!

- Build a 2-dim plane to scan model mixing
- Sum of BRs is $1^{(a)}$
- Different analyses are sensitive to different areas

\[(a) \text{BR}(T/B \rightarrow Zt/b) = 1 - \text{BR}(T/B \rightarrow Ht/b) - \text{BR}(T/B \rightarrow Wb/t)\]
Model Independent Strategy  ... since Oct 2012 [8]!

- Build a 2-dim plane to scan model mixing
- Sum of BRs is $1^{(a)}$
- Different analyses are sensitive to different areas

$$\begin{align*}
\text{BR}(B \rightarrow Wb) &< \text{BR}(T \rightarrow Ht) \\
\text{BR}(B \rightarrow Wt) &< \text{BR}(T \rightarrow Ht) \\
\text{BR}(T \rightarrow Zt) &< \text{BR}(B \rightarrow Wt) \\
\text{BR}(T \rightarrow Wb) &< \text{BR}(B \rightarrow Wt) \\
\end{align*}$$

$$(a) \text{BR}(T/B \rightarrow Zt/b) = 1 - \text{BR}(T/B \rightarrow Ht/b) - \text{BR}(T/B \rightarrow Wb/t)$$
Model Independent Strategy … since Oct 2012 [8]!

- Build a 2-dim plane to scan model mixing
- Sum of BRs is 1\(^{(a)}\)
- Different analyses are sensitive to different areas
- Set exclusion using \(CL_s\) technique [6, 7]
- Using 14.3 fb\(^{-1}\) of 2012 data

\[
\text{BR}(T \rightarrow Wb) + \text{BR}(B \rightarrow Wt) = 1 - \text{BR}(T \rightarrow Ht) - \text{BR}(T \rightarrow Zt) = \text{BR}(T \rightarrow Zt) + \text{BR}(B \rightarrow Ht) \]

\(^{(a)}\)
Model Independent Strategy ... since Oct 2012 [8]!

- Build a 2-dim plane to scan model mixing
- Sum of BRs is 1\(^{(a)}\)
- Different analyses are sensitive to different areas
- Set exclusion using \(CL_s\) technique [6, 7]

\[^{(a)}\]BR(T/B \rightarrow Zt/b) = 1 - BR(T/B \rightarrow Ht/b) - BR(T/B \rightarrow Wb/t)

Using 14.3 fb\(^{-1}\) of 2012 data

Updating 7 TeV results
Outline

Introduction

General Strategy

$T \bar{T} \rightarrow Ht + X$

Same-sign dileptons

$B \bar{B}(T \bar{T}) \rightarrow Zb(t) + X$

$T \bar{T} \rightarrow Wb + X$

Conclusions
\( \bar{T}T \rightarrow Ht + X \)

Channel with high jet and \( b \)-tagged jet multiplicity \((H \rightarrow bb, t \rightarrow Wb)\)

Three channels:
\[
= 2, \ = 3, \geq 4 \text{ } b\text{-tagged jets}
\]

**Discriminant variable:**
\[
H_T = \sum_j p_T(j) + p_T(l) + E_{\text{miss}}^T
\]

- At least 6 jets with \( p_T > 25 \text{ GeV} \)
- Exactly one well reconstructed, isolated lepton (\( e \) or \( \mu \))
- \( E_T^{\text{miss}} > 20 \text{ GeV} \)
- \( E_T^{\text{miss}} + \)\( m_T(W) > 60 \text{ GeV} \)

\( \int L dt = 14.3 \text{ fb}^{-1} \)
$T \bar{T} \rightarrow H_t + X$

T exclusion plane [10] I

$\text{BR}(T \rightarrow H_t)$

$m_T = 350 \text{ GeV}$
$m_T = 400 \text{ GeV}$
$m_T = 450 \text{ GeV}$
$m_T = 500 \text{ GeV}$
$m_T = 550 \text{ GeV}$
$m_T = 600 \text{ GeV}$
$m_T = 650 \text{ GeV}$
$m_T = 700 \text{ GeV}$
$m_T = 750 \text{ GeV}$
$m_T = 800 \text{ GeV}$
$m_T = 850 \text{ GeV}$

$\sqrt{s} = 8 \text{ TeV}, \quad \int L \, dt = 14.3 \text{ fb}^{-1}$

[95% CL exp. exc.]

[95% CL obs. exc.]

[ATLAS:CONF-2013-018]

[$\star$ SU(2) (T,B) doub.]

[$\bullet$ SU(2) singlet]
Outline

Introduction

General Strategy

$T\bar{T} \rightarrow Ht + X$

Same-sign dileptons

$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$

$T\bar{T} \rightarrow Wb + X$

Conclusions
Same-sign dileptons

Channel with very small contamination from SM backgrounds: sensitive to many possible new physics signals like vector-like $B$ and $T$, $\tilde{t}\tilde{t}$, $\tilde{g}$

- Exactly 2 leptons ($e$ or $\mu$) with same electric charge
- $\geq 2$ jets with $p_T > 25$ GeV
- $E_T^{\text{miss}} > 40$ GeV
- $H_T^{(1)} > 650$ GeV
- $Z$ veto in $ee$ and $\mu\mu$ channels
- $\geq 1$ $b$-tagged jet
- $\geq 2$ jets with $p_T > 25$ GeV
- $E_T^{\text{miss}} > 40$ GeV
- $H_T^{(1)} > 650$ GeV

<table>
<thead>
<tr>
<th>Backgrounds</th>
<th>ee</th>
<th>$e\mu$</th>
<th>$\mu\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge misidentification</td>
<td>0.6 ± 0.1 ± 0.2</td>
<td>0.9 ± 0.1 ± 0.3</td>
<td>—</td>
</tr>
<tr>
<td>Fakes</td>
<td>0.8 ± 0.4 ± 0.3</td>
<td>0.2 ± 0.4 ± 0.1</td>
<td>&lt; 1.1</td>
</tr>
<tr>
<td>Diboson</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$WZ/ZZ$+jets</td>
<td>0.3 ± 0.2 ± 0.1</td>
<td>0.3 ± 0.1$^{+0.4}_{-0.2}$</td>
<td>0.4 ± 0.2 ± 0.1</td>
</tr>
<tr>
<td>$W^\pm W^\pm$+2 jets</td>
<td>0.17 ± 0.09 ± 0.05</td>
<td>0.3 ± 0.2 ± 0.1</td>
<td>0.2 ± 0.1 ± 0.1</td>
</tr>
<tr>
<td>$tt + W/Z$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t\bar{t}W$(+jet(s))</td>
<td>0.6 ± 0.2 ± 0.3</td>
<td>1.9 ± 0.2 ± 0.6</td>
<td>1.3 ± 0.2 ± 0.4</td>
</tr>
<tr>
<td>$t\bar{t}Z$(+jet(s))</td>
<td>0.18 ± 0.03 ± 0.06</td>
<td>0.66 ± 0.05 ± 0.22</td>
<td>0.31 ± 0.04 ± 0.10</td>
</tr>
<tr>
<td>$t\bar{t}W^+W^-$</td>
<td>0.024 ± 0.003$^{+0.010}_{-0.007}$</td>
<td>0.072 ± 0.005$^{+0.028}_{-0.020}$</td>
<td>0.055 ± 0.004$^{+0.022}_{-0.016}$</td>
</tr>
<tr>
<td>Total expected background</td>
<td>2.7 ± 0.5 ± 0.4</td>
<td>4.4 ± 0.5$^{+0.9}_{-0.7}$</td>
<td>2.3 ± 1.2 ± 0.5</td>
</tr>
<tr>
<td>Observed</td>
<td>3</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

$$H_T = \sum_j p_T(j) + p_T(l_1) + p_T(l_2)$$
Same-sign dileptons

\section*{Same-sign dileptons}

**$T$ exclusion plane [10] II**

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figures.png}
\caption{Exclusion plots for $T$ production with different masses ($m_T$) in the BR($T \rightarrow Ht$) vs. BR($T \rightarrow Wb$) plane. The plots show the allowed and excluded regions for the process, with different colors indicating the significance of the exclusion.}
\end{figure}
Same-sign dileptons

\textbf{B exclusion plane [10] I}

\begin{itemize}
\item $m_B = 350$ GeV
\item $m_B = 400$ GeV
\item $m_B = 450$ GeV
\item $m_B = 500$ GeV
\item $m_B = 550$ GeV
\item $m_B = 600$ GeV
\item $m_B = 650$ GeV
\item $m_B = 700$ GeV
\item $m_B = 750$ GeV
\item $m_B = 800$ GeV
\item $m_B = 850$ GeV
\end{itemize}

\textit{ATLAS Preliminary}

\textit{Status: Lepton-Photon 2013}

\( \sqrt{s} = 8 \text{ TeV}, \quad \int L dt = 14.3 \text{ fb}^{-1} \)

- 95\% CL exp. excl.
- 95\% CL obs. excl.

- Same-Sign [ATLAS-CONF-2013-051]

\(<\star>\text{SU(2) (B,Y) doub.}\quad <\bullet>\text{SU(2) singlet}\)
Outline

Introduction

General Strategy

$T\bar{T} \rightarrow Ht + X$

Same-sign dileptons

$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$

$T\bar{T} \rightarrow Wb + X$

Conclusions
**Exploit ability to reconstruct Z bosons from OS dileptons (e and μ)**

- Exactly two same flavor, opposite charge leptons
- Dilepton mass in a 15 GeV mass window around $m(Z)$
- At least two $b$-tagged jets

$m(Zb)$ is the final test variable: invariant mass of the $Z$ candidate paired with the highest $p_T$ $b$-tagged jet.
$B\bar{B}(t\bar{t}) \rightarrow Zb(t) + X$

$T$ exclusion plane [10] III

**ATLAS** Preliminary
Status: Lepton-Photon 2013

$\sqrt{s} = 8$ TeV, \( L \) dt = 14.3 fb$^{-1}$

- 95\% CL exp. exc.
- 95\% CL obs. exc.

- Ht+X [ATLAS-CONF-2013-019]
- Same-Sign [ATLAS-CONF-2013-051]
- Zb(t)+X [ATLAS-CONF-2013-056]

- SU(2) (T,B) doub.
- SU(2) singlet
$B \bar{B}(T \bar{T}) \rightarrow Zb(t) + X$

**B exclusion plane [10] II**

\[ m_B = 350 \text{ GeV} \]

\[ m_B = 400 \text{ GeV} \]

\[ m_B = 450 \text{ GeV} \]

\[ m_B = 500 \text{ GeV} \]

\[ m_B = 550 \text{ GeV} \]

\[ m_B = 600 \text{ GeV} \]

\[ m_B = 650 \text{ GeV} \]

\[ m_B = 700 \text{ GeV} \]

\[ m_B = 750 \text{ GeV} \]

\[ m_B = 800 \text{ GeV} \]

\[ m_B = 850 \text{ GeV} \]

**BR(B → Hb)**

**ATLAS Preliminary**

Status: Lepton-Photon 2013

$\sqrt{s} = 8 \text{ TeV}, \quad \int dt = 14.3 \text{ fb}^{-1}$

- 95% CL exp. excl.
- 95% CL obs. excl.

- Same-Sign [ATLAS:CONF-2013-051]
- Zb/t+X [ATLAS:CONF-2013-056]

- SU(2) (B,Y) doub.
- SU(2) singlet
Outline

Introduction

General Strategy

$T\bar{T} \rightarrow Ht + X$

Same-sign dileptons

$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$

$T\bar{T} \rightarrow Wb + X$

Conclusions
$T\bar{T} \rightarrow Wb + X$

**Exploit $T$’s boosted kinematics to reconstruct $W$ bosons**

- $W_{\text{type I had}}$: single merged jet
  $(p_T > 250$ GeV,
  $m_j \in [60, 110]$ GeV)

- $W_{\text{type II had}}$: two close-by jets
  $(\Delta R(j,j) < 0.8, p_T > 150$ GeV,
  $m_{jj} \in [60, 110]$ GeV)

\[ \Delta R(l, \nu) < 1.2 \]
\[ \min(\Delta R(l, b_{1,2})) > 1.4 \]
\[ \min(\Delta R(W_{\text{had}}, b_{1,2})) > 1.4 \]

The reconstructed $W$ boson is matched to the $b$-tagged jets that gives the lowest mass difference between the leptonical and hadronical leg.
$T \bar{T} \to W_b + X$

**$T$ exclusion plane [10] IV**

![Graphs showing exclusion limits for $m_T$ ranging from 350 to 850 GeV, with BR($T \to H_t$) on the y-axis and BR($T \to W_b$) on the x-axis. Each graph represents a different mass value with shaded regions indicating forbidden parameter space.](image_url)
Outline

Introduction

General Strategy

$T\bar{T} \rightarrow Ht + X$

Same-sign dileptons

$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$

$T\bar{T} \rightarrow Wb + X$

Conclusions
Using 14 fb^{-1} of \sqrt{s} = 8 TeV 2012 LHC data, ATLAS performed four preliminary model independent and complementary searches for heavy quarks.

- Updating \sqrt{s} = 7 TeV analyses

Considering a few benchmark points, at 95% CL we exclude:

- Singlet T with mass up to 670 GeV [9, 15]
- Singlet B with mass up to 645 GeV [13]
- Doublet T with mass up to 790 GeV [9]
- Doublet B with mass up to 725 GeV [13]
References I

TASI lectures on extra dimensions and branes.

Little Higgs models and their phenomenology.

Identifying top partners at LHC.

Status of the Fourth Generation: A Brief Summary of B3SM-III Workshop in Four Parts.
References II


Search for heavy top-like quarks decaying to a higgs boson and a top quark in the lepton plus jets final state in $pp$ collisions at $\sqrt{s} = 8$ tev with the atlas detector. 


Search for anomalous production of events with same-sign dileptons and $b$ jets in 14.3 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ tev with the atlas detector. 

Search for exotic same-sign dilepton signatures ($b'$ quark, $T_{5/3}$ and four top quarks production) in 4.7/fb of pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector. 
References IV

Search for pair production of new heavy quarks that decay to a $Z$ boson and a third generation quark in $pp$ collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector.  

Search for pair production of a new quark that decays to a $Z$ boson and a bottom quark with the ATLAS detector.  

Search for pair production of heavy top-like quarks decaying to a high-pT $W$ boson and a $b$ quark in the lepton plus jets final state in $pp$ collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector.  
Event pre-selection

ATLAS working groups defined standard object definitions analyses use in general these definitions, as well as common selections

Object definitions

- **Jets**: Topological clusters reconstructed with the AntikT4 algorithm ($p_T > 25$ GeV, $|\eta| < 2.5$, JVF $> 0.5^{(a)}$)
- **Electrons**: Well isolated calo object matched to track ($E_T > 25$ GeV, $|\eta|$ in $[0,2.47]$ removing $[1.37,1.52]$, $z_0 < 2$ mm$(b)$)
- **Muons**: Segment in the tracker and muon detector, isolated track ($p_T > 25$ GeV, $|\eta| < 2.5$, $z_0 < 2$ mm$(b)$)

If jets within $\Delta R < 0.2$ of an electron, the closest jet is discarded; Leptons within $\Delta R < 0.4$ of a jet are removed

Event pre-selection

- $\geq 5$ tracks from the Primary Vertex (Cosmics and Pileup rejection)
- If more vertices, choose the one with largest sum of $p_T^2$
- Single lepton triggers: isolated electron with $p_T > 24$ GeV OR electron with $p_T > 60$ GeV OR isolated muon with $p_T > 24$ GeV OR muon with $p_T > 36$ GeV

If the analysis requires one or more leptons, at least one of them must match the single lepton trigger

$(a)$ the jet vertex fraction is defined as the fraction of summed $p_T (> 0.5$ GeV) of tracks associated to the jet that come from the primary vertex

$(b)$ $z_0$ is the longitudinal impact parameter of the track wrt the primary vertex
$T\bar{T} \rightarrow Ht + X$ [9]

Three channels:

$= 2$, $= 3$, $\geq 4$ $b$-tagged jets
$T\bar{T} \rightarrow Ht + X$ [9]

ATLAS Preliminary

$\sqrt{s} = 8$ TeV, $\int L \, dt = 14.3$ fb$^{-1}$

- 95% CL expected exclusion
- 95% CL observed exclusion

SU(2) doublet \hspace{1cm} SU(2) singlet

$\text{BR}(t' \rightarrow Wb)$
Same-sign dileptons [11]
Same-sign dileptons [11]

\[ \int L \, dt = 14.3 \text{ fb}^{-1}, \sqrt{s} = 8 \text{ TeV} \]
Same-sign dileptons [11]

**ATLAS Preliminary**

\( \sqrt{s} = 8 \text{ TeV}, \int L \, dt = 14.3 \text{ fb}^{-1} \)

- **95\% CL expected exclusion**
- **95\% CL observed exclusion**

- \( m_B = 350 \text{ GeV} \)
- \( m_B = 400 \text{ GeV} \)
- \( m_B = 450 \text{ GeV} \)
- \( m_B = 500 \text{ GeV} \)
- \( m_B = 550 \text{ GeV} \)
- \( m_B = 600 \text{ GeV} \)
- \( m_B = 650 \text{ GeV} \)
- \( m_B = 700 \text{ GeV} \)
- \( m_B = 750 \text{ GeV} \)
- \( m_B = 800 \text{ GeV} \)
- \( m_B = 850 \text{ GeV} \)

- SU(2) doublet
- SU(2) singlet

\( \text{BR}(B \rightarrow Hb) \)

\( \text{BR}(B \rightarrow Wt) \)
Same-sign dileptons [11]

 ATLAS Preliminary
\( s = 8 \text{ TeV}, \int L \, dt = 14.3 \text{ fb}^{-1} \)

- 95% CL expected exclusion
- 95% CL observed exclusion

SU(2) doublet \quad SU(2) singlet
$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$ [13]
$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$ [13]

\[ \text{BR}(B \rightarrow Hb) = \text{BR}(B \rightarrow Wt) \]

**ATLAS** Preliminary

\( \sqrt{s} = 8 \text{ TeV, } \int L \, dt = 14.3 \text{ fb}^{-1} \)

- 95% CL expected exclusion
- 95% CL observed exclusion

- SU(2) (B,Y) doub.  
- SU(2) singlet

A Succurro, IFAE Barcelona

EPS 2013, Stockholm, July 18th-24th
$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$ [13]
$B\bar{B}(T\bar{T}) \rightarrow Zb(t) + X$ [13]
\( T\bar{T} \rightarrow Wb + X [15] \)

- one lepton (e or \( \mu \)), \( E_{T}^{\text{miss}} > 20 \text{ GeV}, \)
  \( E_{T}^{\text{miss}} + m_{T}(W) > 60 \text{ GeV} \)
- \( \geq 3 \) jets and one \( W^{\text{typeI}}_{\text{had}} \)
  
  OR
- \( \geq 4 \) jets and one \( W^{\text{typeII}}_{\text{had}} \) and no \( W^{\text{typeI}}_{\text{had}} \)
- \( \geq 1 \) btagged jet (consider also the 2nd highest b-tag weight jet)
- \( H_T^{(a)} > 800 \text{ GeV} \)
- \( p_T(b_1) > 160 \text{ GeV}, p_T(b_2) > 80 \text{ GeV} \)
- \( \Delta R(l, \nu) < 1.2 \)
- \( \min(\Delta R(l, b_{1,2})) > 1.4 \)
- \( \min(\Delta R(W_{\text{had}}, b_{1,2})) > 1.4 \)

\[(a)\ H_T = p_T(j_1) + p_T(j_2) + p_T(j_3) + p_T(j_4) + p_T(l) + E_{T}^{\text{miss}}\]
**$T\bar{T} \to Wb + X$ [15]**

**ATLAS** Preliminary

$v_S = 8$ TeV, $\int L \, dt = 14.3$ fb$^{-1}$

$T\bar{T} \to Wb+X$

- 95% CL expected exclusion
- 95% CL observed exclusion

SU(2) doublet  SU(2) singlet

* $m_T = 350$ GeV
* $m_T = 400$ GeV
* $m_T = 450$ GeV
* $m_T = 500$ GeV
* $m_T = 550$ GeV
* $m_T = 600$ GeV
* $m_T = 650$ GeV
* $m_T = 700$ GeV
* $m_T = 750$ GeV
* $m_T = 800$ GeV
* $m_T = 850$ GeV

__A Succurro, IFAE Barcelona__

EPS 2013, Stockholm, July 18th-24th
combining $T\bar{T} \to Ht + X$ [9] and $T\bar{T} \to Wb + X$ [15]

**ATLAS** Preliminary

$\sqrt{s} = 8$ TeV, $\int L \, dt = 14.3$ fb$^{-1}$

$T\bar{T} \to Wb + X$, $T\bar{T} \to Ht + X$ Combination

- 95% CL expected exclusion
- 95% CL observed exclusion

SU(2) doublet  SU(2) singlet
Results on chiral quarks: $b' \rightarrow Wt$ (100%) [11]
Results on chiral quarks: $t' \rightarrow Wb$ (100%) [15]
The ATLAS Detector

A general purpose experiment

- vertex detector and central tracker
- superconducting solenoid
- electromagnetic and hadronic calorimeters
- muon spectrometer
- superconducting toroids
- high hermeticity (full $\phi$ and $|\eta| < 5$)
The ATLAS Detector

A general purpose experiment
- vertex detector and central tracker
- superconducting solenoid
- electromagnetic and hadronic calorimeters
- muon spectrometer
- superconducting toroids
- high hermeticity (full $\phi$ and $|\eta| < 5$)

In 2012 21.7 fb$^{-1}$ collected at $\sqrt{s} = 8$ TeV!

See ATLAS public page

Will present results obtained with 14.3 fb$^{-1}$ of 2012 data