Searches for BSM Physics in Events with Top Quarks in ATLAS

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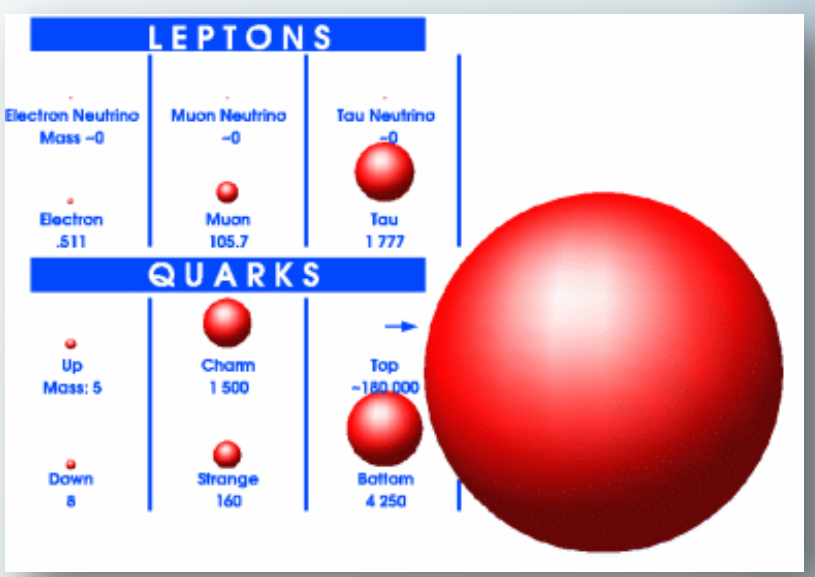
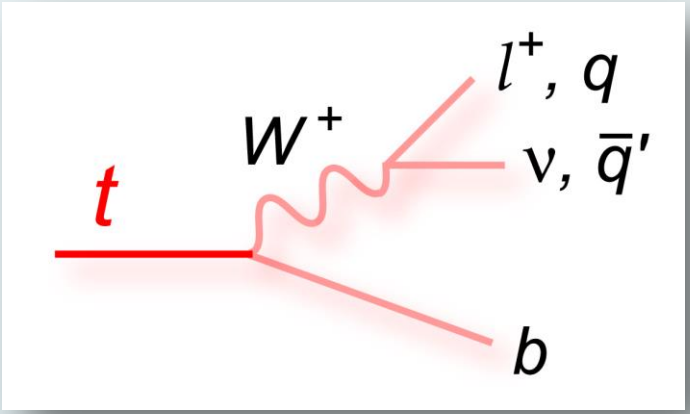
(On behalf of ATLAS collaboration)

SUSY2014, Manchester, Jul. 25, 2014

Top quarks in BSM searches

- Heaviest fundamental particle
  - Strong coupling in many BSM scenarios
  - Favorable in final states of BSM productions





- Short life time ~5x 10^{-25} s
  - Decay before hadronization
  - Unique decay modes

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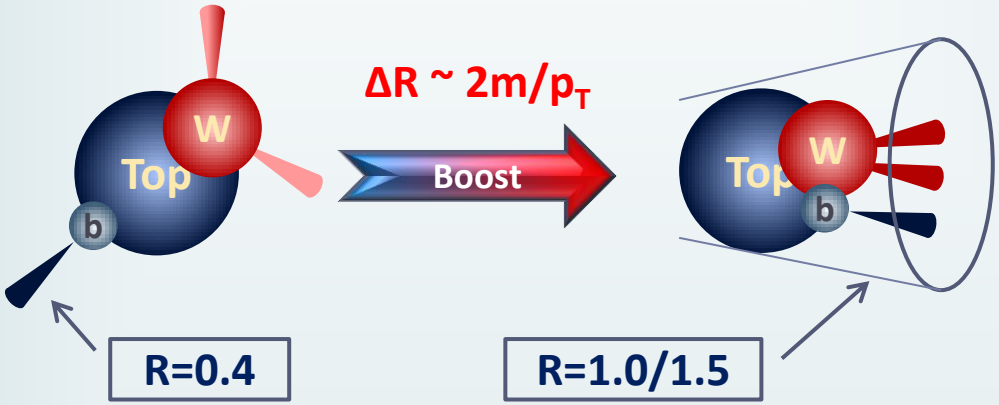
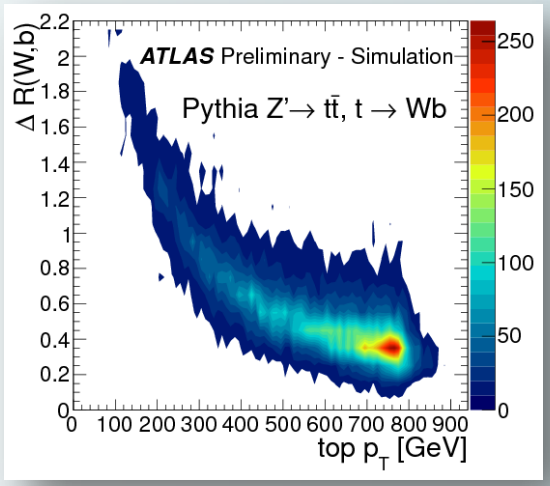
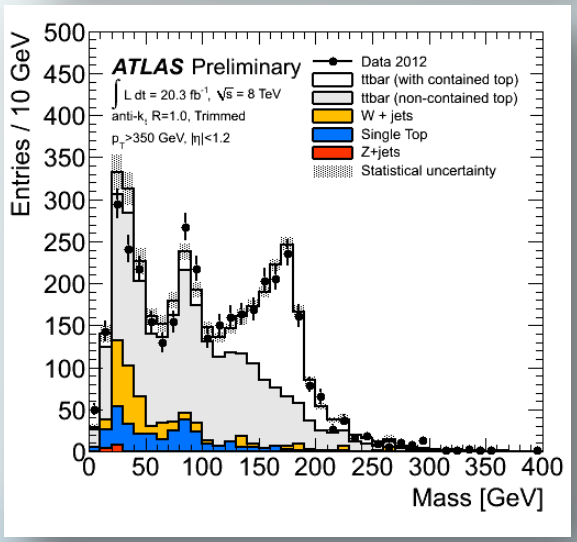
Top quarks in BSM searches

- LHC searches entering TeV-scale
  - "Boosted" top quarks from BSM signals







- Efficient **hadronic** top tagging
  - Large-radius jet as top candidate
    => less combinatorics backgrounds
  - Jet substructure can be exploited for powerful discriminants

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Searches with top quarks in ATLAS

- Heavy boson searches
  - $t\bar{t}$ resonance ATLAS-CONF-2013-052
  - $t\bar{b}$ resonance ATLAS-CONF-2013-052; EXOT-2013-14
- Vector-Like Quark (VLQ) searches
  - Zt+X ATLAS-CONF-2014-036
  - Ht+X, Same-sign di-lepton, etc
- Gluino, 3rd generation squark searches (See Monday's talk by Maria Fiascaris)

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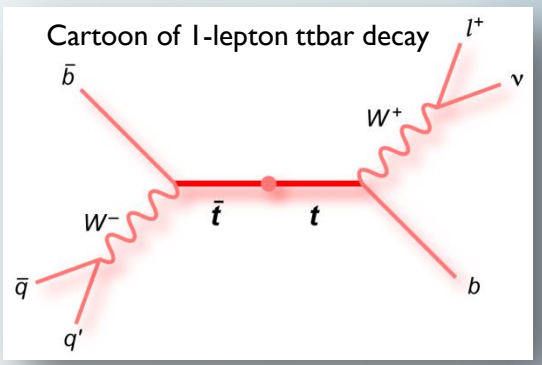
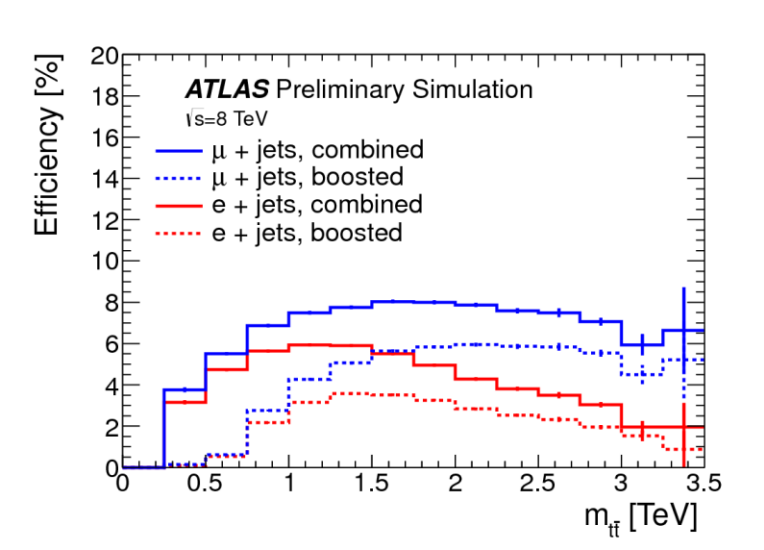
Heavy bosons -- $t\bar{t}$ resonance

ATLAS-CONF-2013-052

- Single-lepton (e/μ) final state



- Resolved + boosted selections
  - Resolved:
    Reconstruct $t\bar{t}$ with l+ν+4 small radius jets;
    Choose kinematically best combinatorics
  - Boosted:
    Leptonic top = l + ν + nearby small radius jet
    Hadronic top = large radius jet with high mass, hard substructure
  - Boosted selection attempted first; exclusive combination



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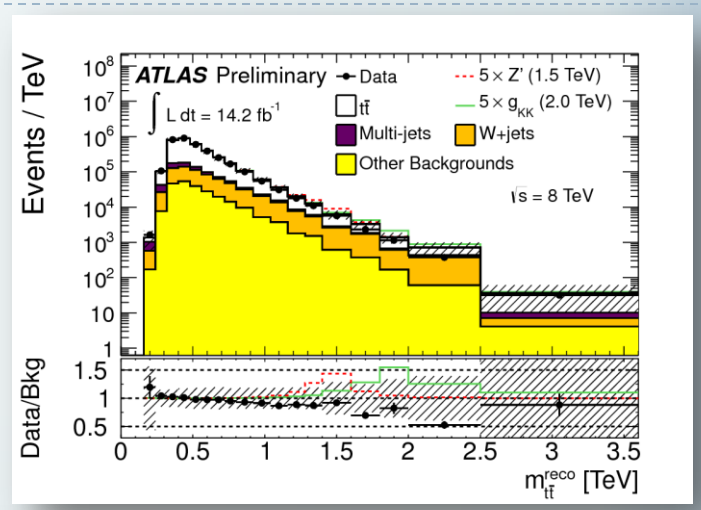
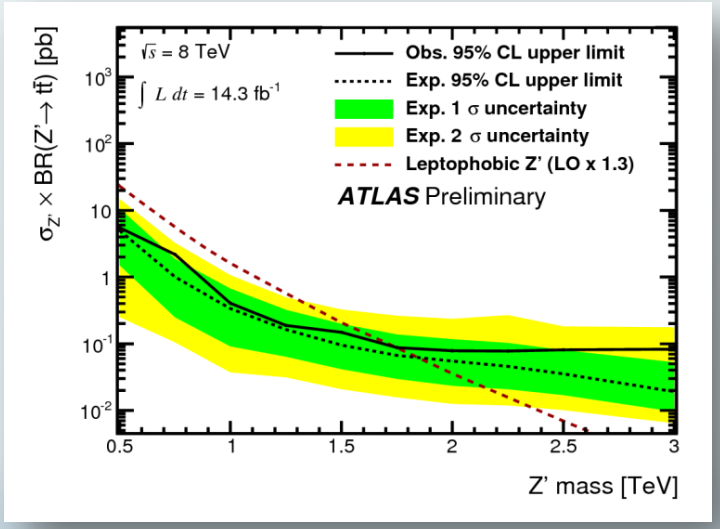
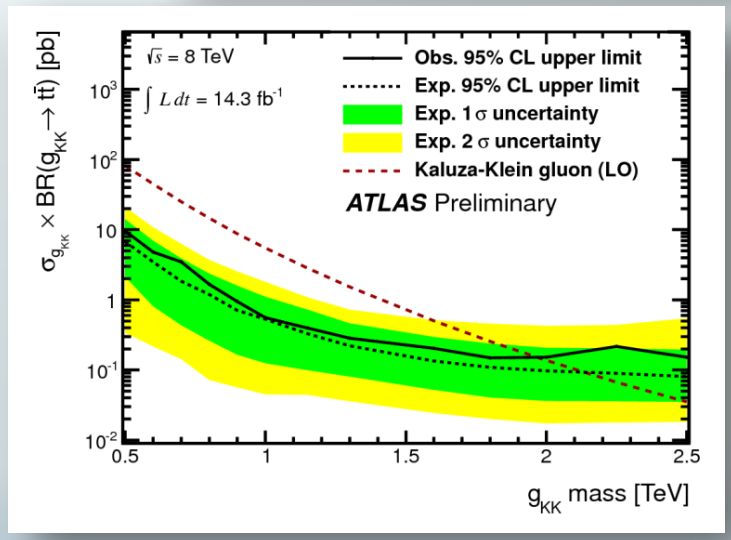
Heavy bosons -- $t\bar{t}$ resonance

ATLAS-CONF-2013-052

- Search across wide mass range
- Narrow resonance TC2 Z' (Γ=1.2%)
  - Excluded up to 1.8(1.9)TeV, obs.(exp.)
- Broad resonance g_{KK} (Γ=15.3%)
  - Excluded up to 2.0(2.1) TeV, obs.(exp.)
- Experimental resolution ~10%







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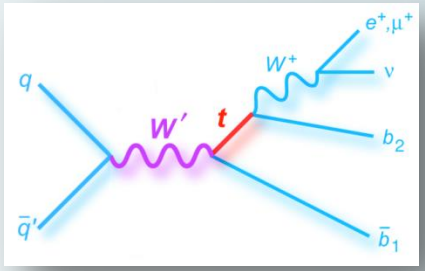
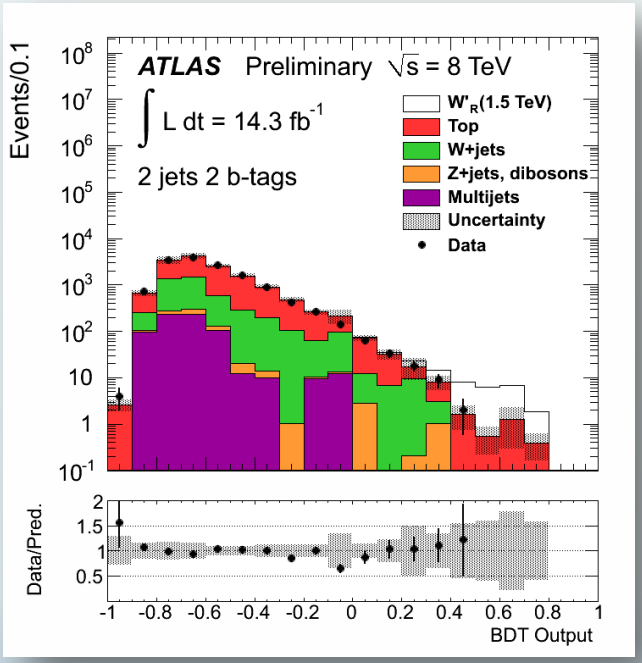
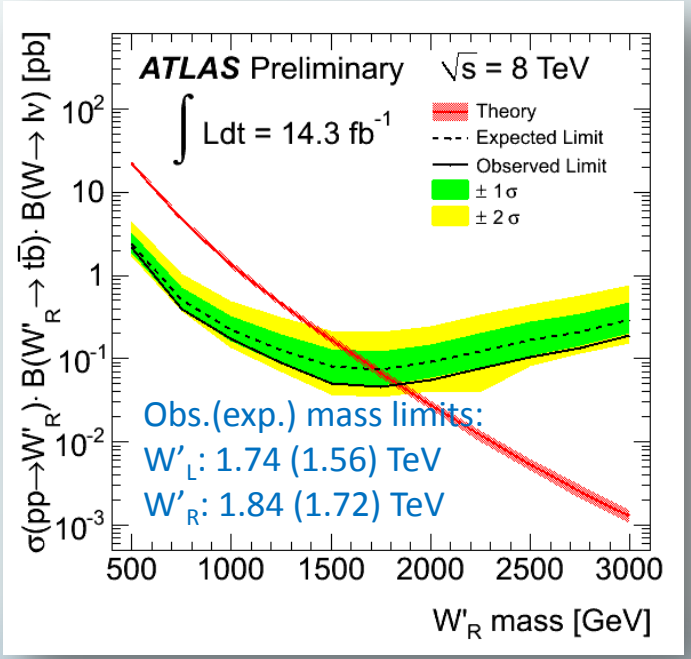
Heavy bosons --$t\bar{b}$ resonance

ATLAS-CONF-2013-050

- Single-lepton (e/μ) final state
- Missing E_T, ≥ 2 b-tagged jets (small-R)
- BDT (Boosted decision tree) as discriminant: including m(tb), p_T(t), etc







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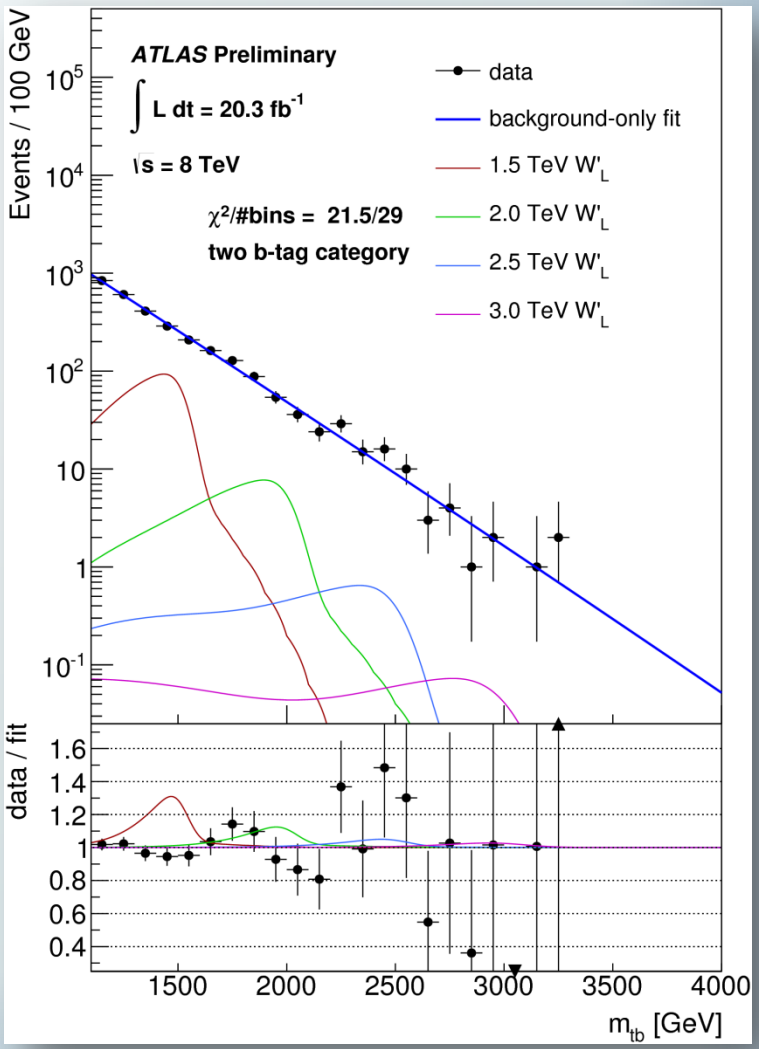
Heavy bosons --$t\bar{b}$ resonance

EXOT-2013-14 **(preliminary)**

- All hadronic (0-lep) final state
  - Exactly one **large-radius jet** "top-tagged" by **substructures**
  - Exactly one small-radius jet **b-tagged;** $\Delta R > 2.0$
  - Two categories based on b-tagging of top candidate
- Unbinned likelihood fit on m(tb)
  - Bkg estimation fully from data
- Obs.(exp.) mass limits:
  - W'_L: 1.70 (1.65) TeV
  - W'_R: 1.77 (1.86) TeV



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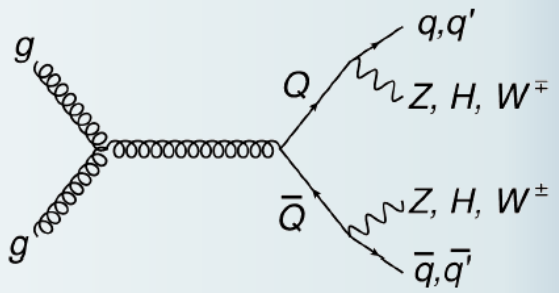
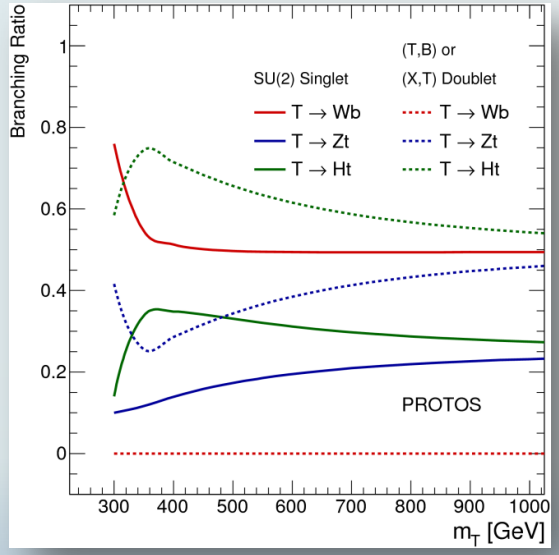
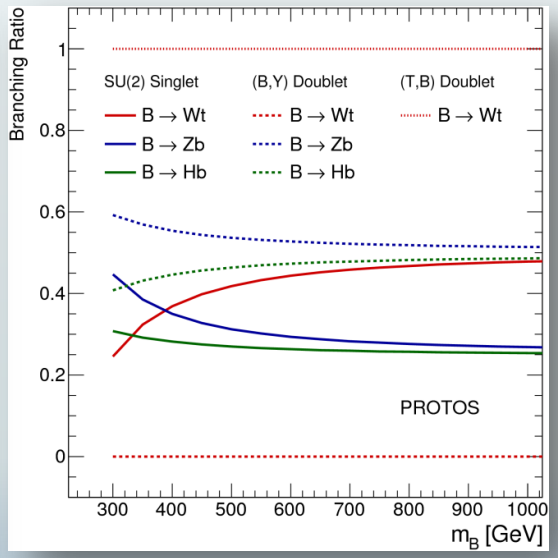
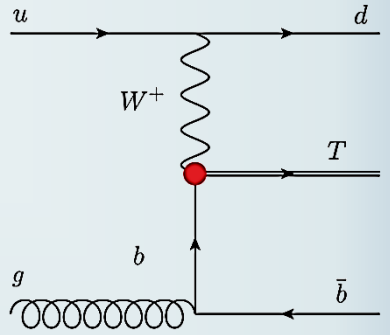
Vector-Like Quarks searches

- Pair production
  - Model-independent: xsec only rely on mass
- single production
  - Depend on EW charges/coupling
  - Higher xsec for high mass VLQ
- Decay mostly to 3rd gen quarks
  - Diverse final states









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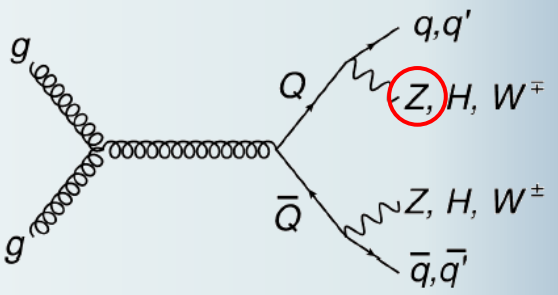
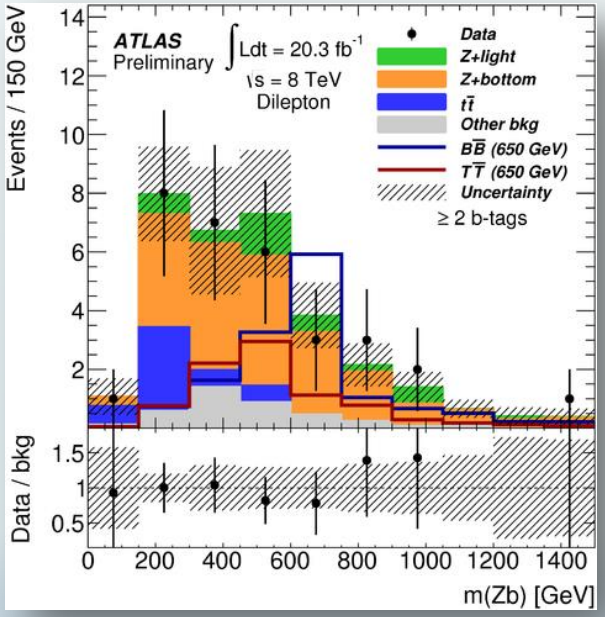
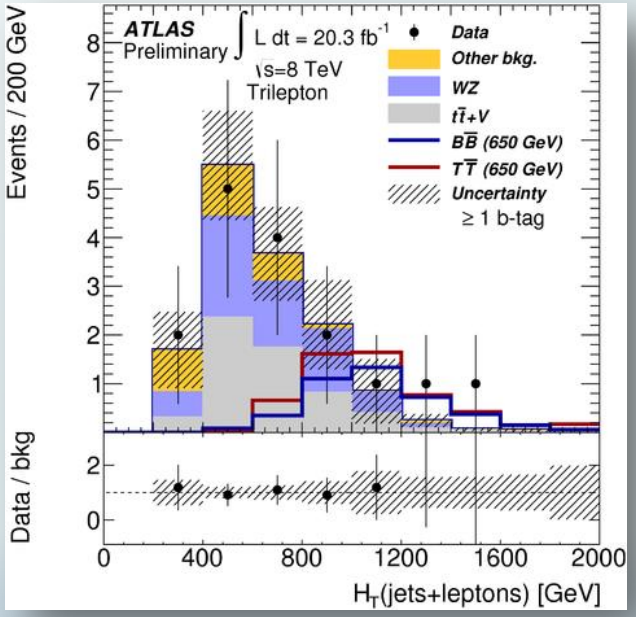
Vector-Like Quarks: Zt/b+X

ATLAS-CONF-2014-036

- High p_T (>150GeV) leptonic Z boson
- ≥2 central jets
- Various selections on leptons, b-jets and forward jets; targeting for
  - Di-lepton / tri-lepton; Pair / single production







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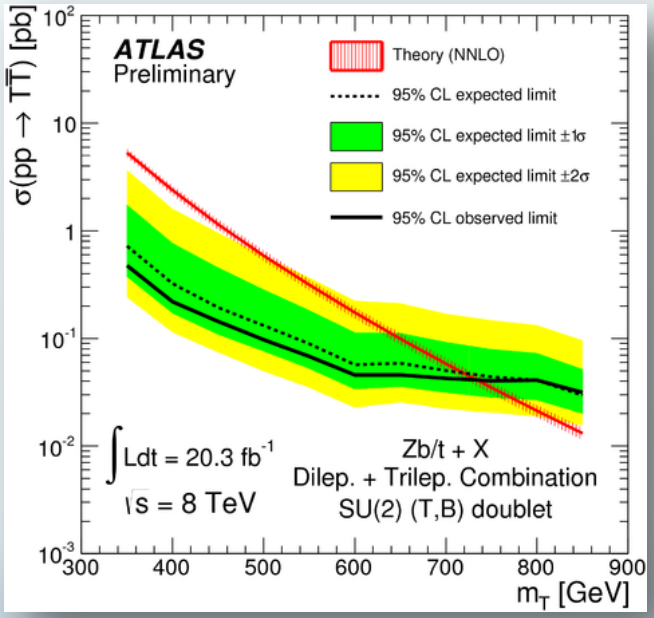
Vector-Like Quarks: Zt/b+X

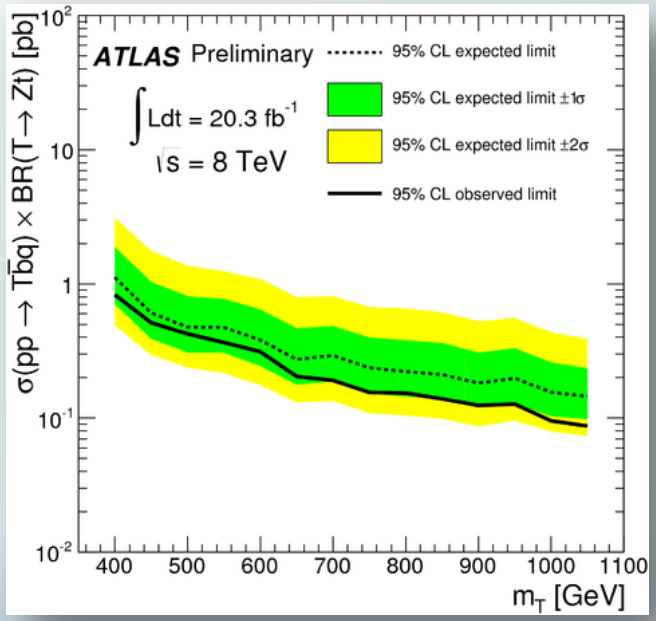
ATLAS-CONF-2014-036

- VLQ mass limits
  - $B\bar{B}$ singlet/doublet excluded to 685/755 GeV
  - $T\bar{T}$ singlet/doublet excluded to 655/735 GeV
- First LHC xsec limit on single VLQ production

$T\bar{T}$



$T\bar{b}q$



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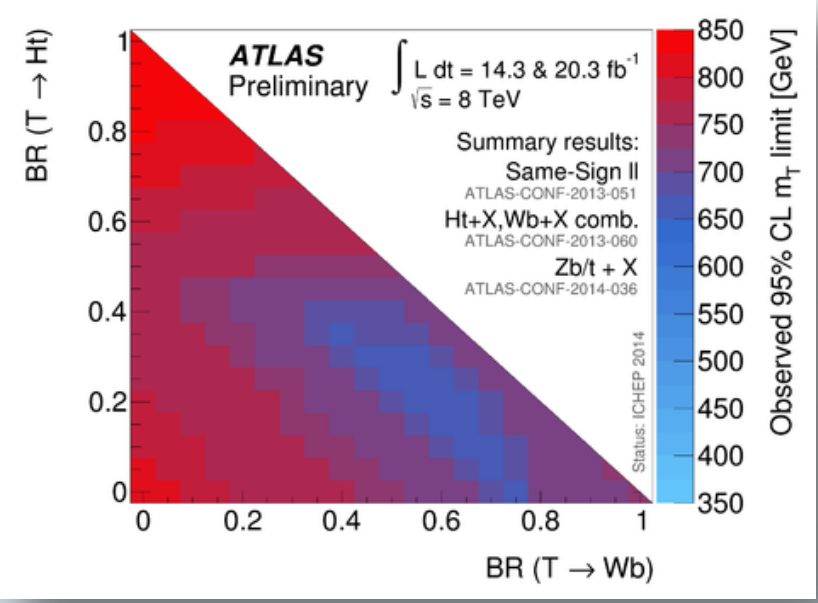
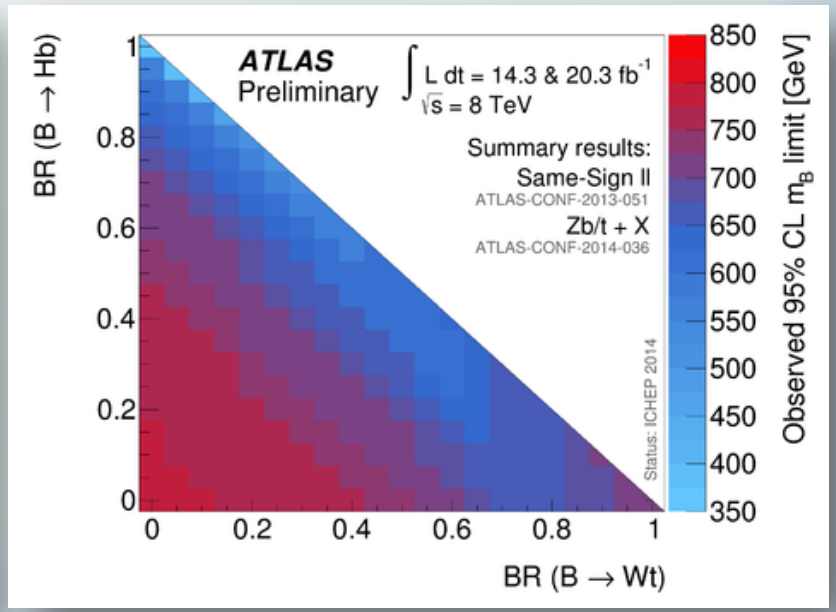
Vector-Like Quarks

- Other VLQ searches
  - Same-sign dilepton + b-jets : ATLAS-CONF-2013-051
  - Ht+X (H->bb) 1-lepton : ATLAS-CONF-2013-018
  - Wb+X 1-lepton : ATLAS-CONF-2013-060
- Best mass limit from all VLQ searches, **scan over all BRs**





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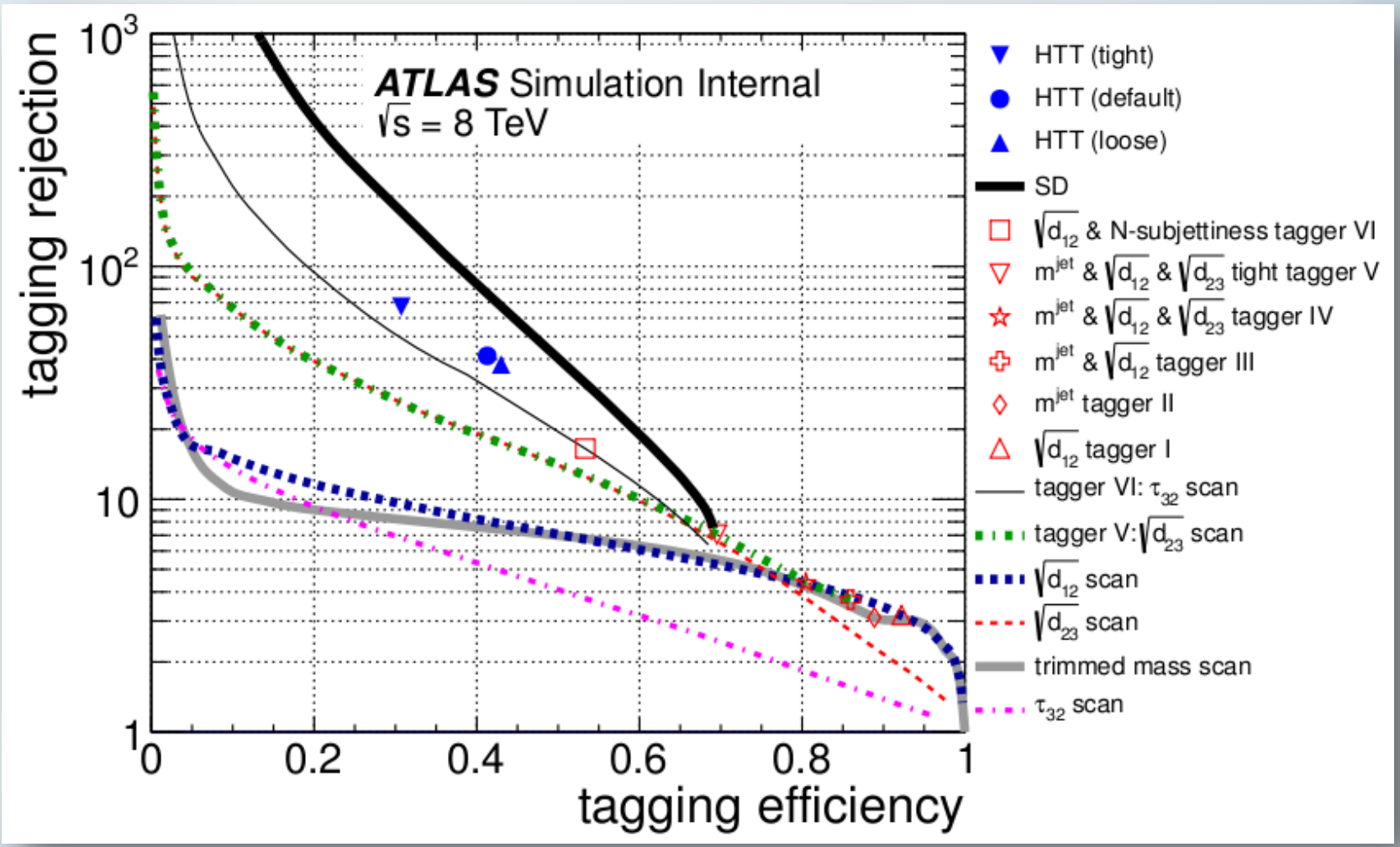
Summary

- Extensive BSM searches with top quarks in ATLAS
- Selected recent non-SUSY ATLAS results using 8TeV data
  - Results consistent with SM, so far…
  - More results to be published in the following months. Stay tuned!
- Exclusion limits mostly reaching TeV-scale
  - Boosted top tagging become powerful discriminant
  - New analysis strategies can considerably enhance sensitivity
  - Will become mainstream in LHC Run-2 program

Thanks!!

Backup: Top Tagging

ATLAS-CONF-2013-084



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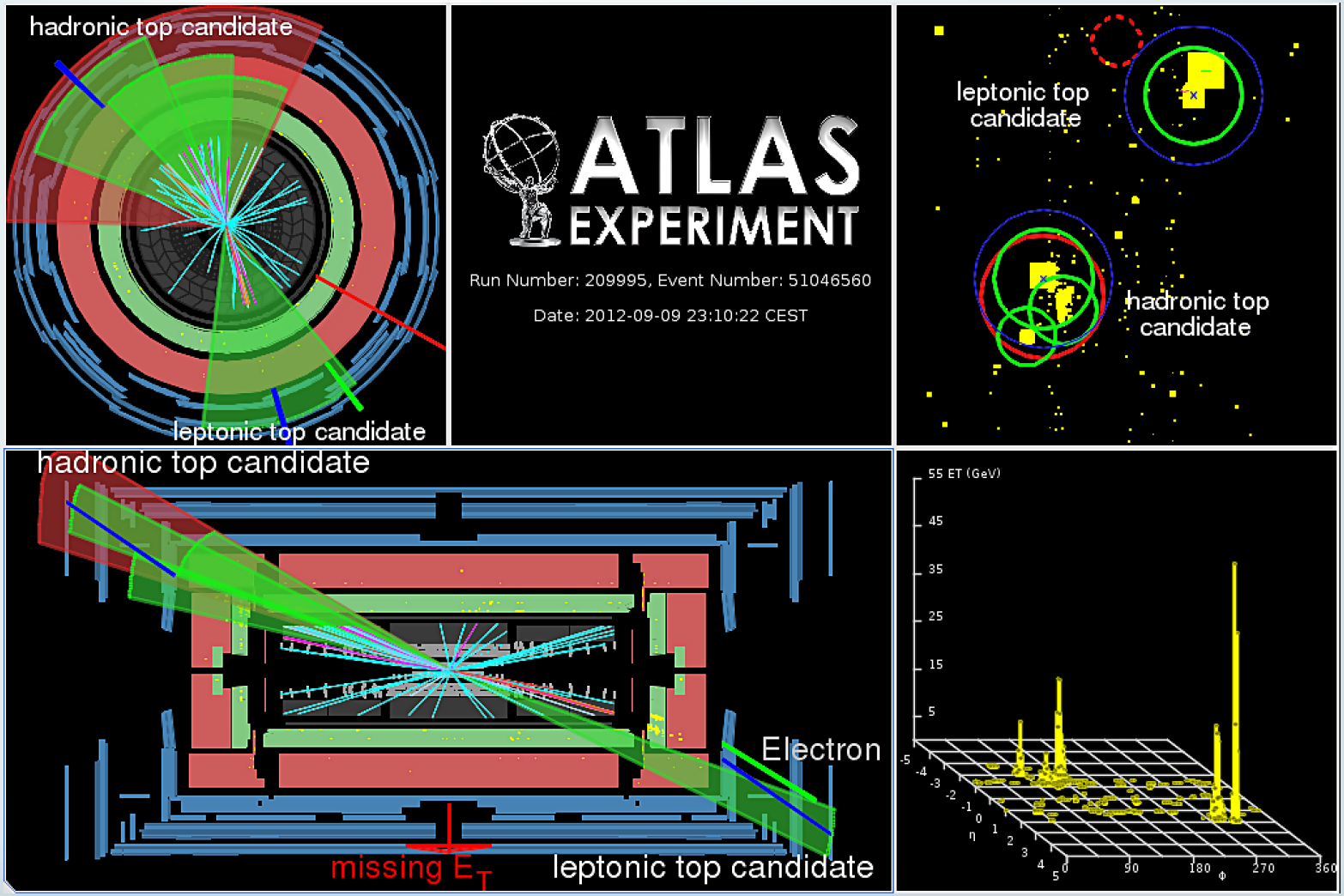
Backup: $t\bar{t}$ resonance

ATLAS-CONF-2013-052



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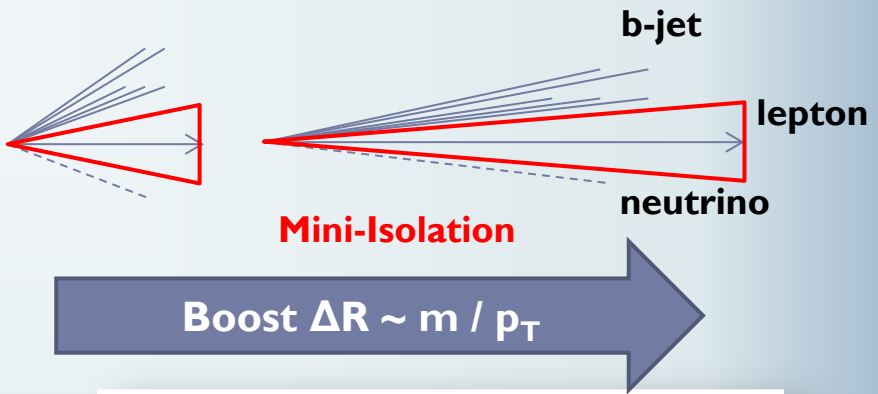
Backup: $t\bar{t}$ resonance

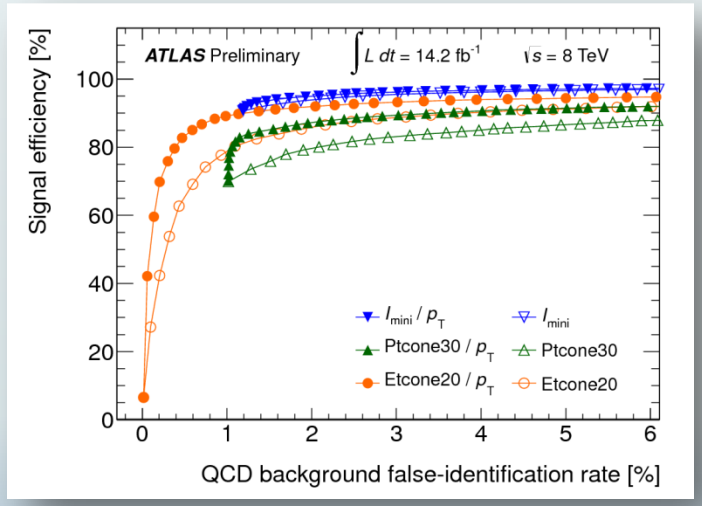
ATLAS-CONF-2013-052

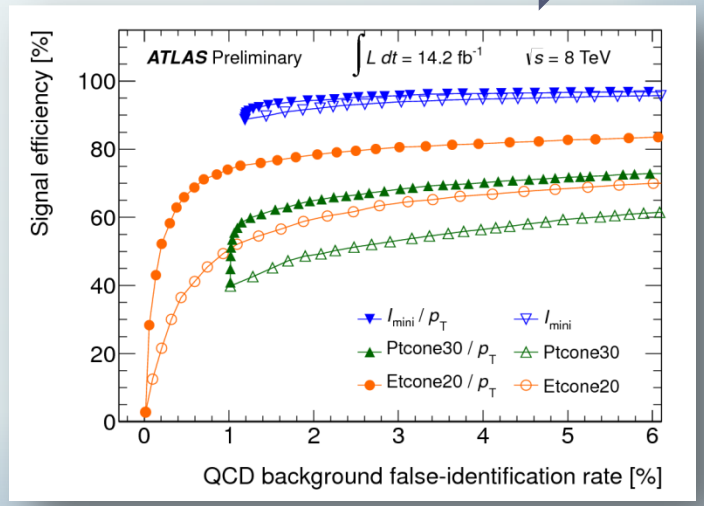
Mini-isolation *JHEP 1103:059 (2011) Rehermann, Tweedie*

- **Variable cone size: ΔR= k_T/p_T^{lepton}** , k_T=10 GeV
- $I_{mini} = \sum P_T$ of tracks within (excluding the track of the lepton)
- Require I_{mini}/p_T^{lepton} <0.05



Boost ΔR ~ m / p_T





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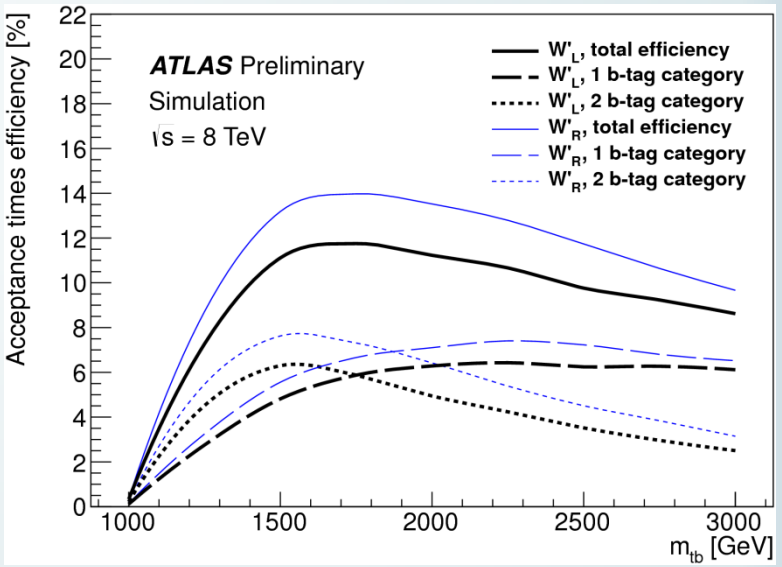
Backup: $t\bar{b}$ resonance

EXOT-2013-14 **(preliminary)**

High pt b-tagging very challenging



ATLAS Preliminary

Systematic Uncertainties [%]	W'_L		W'_R	
	One *b*-tag	Two *b*-tag	One *b*-tag	Two *b*-tag
b-tagging	+13, -20	+45, -37	+15, -21	+40, -34
W' Top-tagging	±13	± 10	± 11	± 9
Jet Energy Scale	±1.3	± 1.9	± 0.8	± 1.9
Jet Energy Resolution	<0.1	± 0.2	± 0.1	± 0.5
Theoretical	±10		+8, -10	
Luminosity	±2.8			
Background Modelling	±44 events	±28 events	±45 events	±24 events

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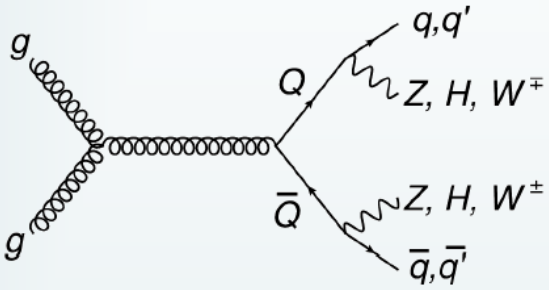
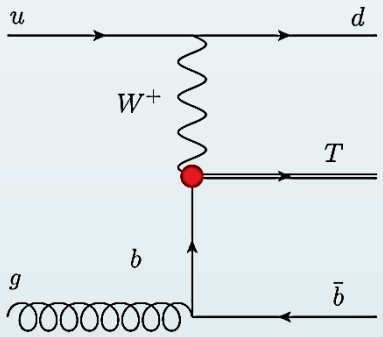
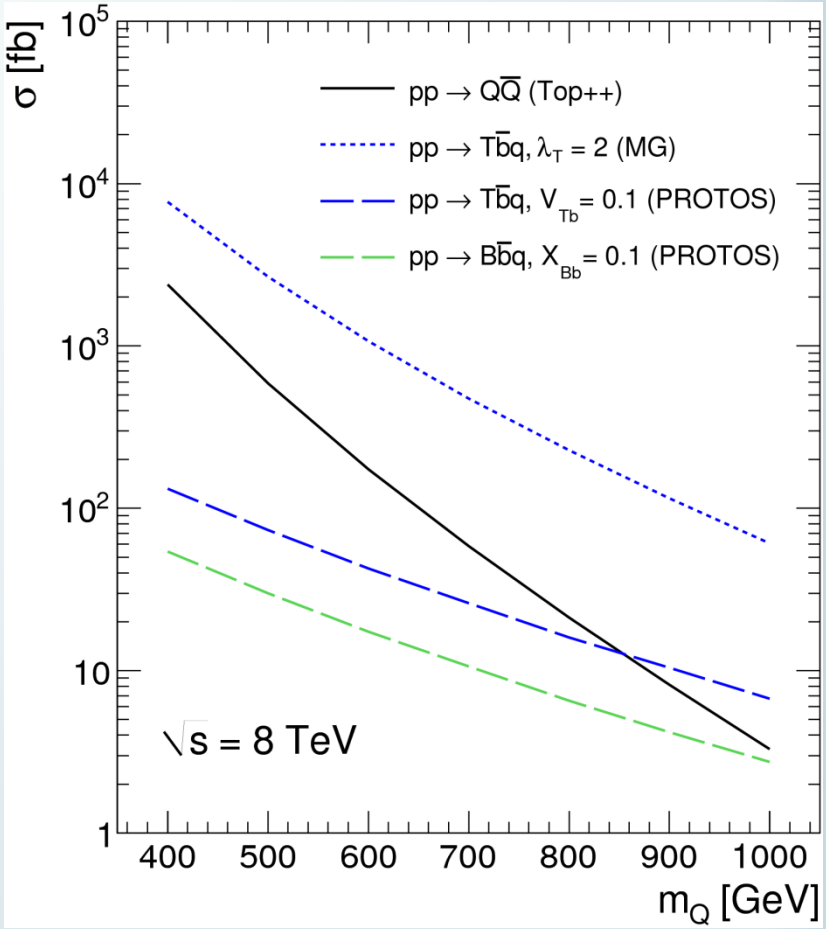
Backup: Vector-Like Quarks: Zt/b+X

ATLAS-CONF-2014-036







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Backup: Vector-Like Quarks: Zt/b+X

ATLAS-CONF-2014-036

Event selection			
Z boson candidate preselection ≥ 2 central jets $p_{\mathrm{T}}(Z) \geq 150$ GeV			
Dilepton channel		**Trilepton channel**	
$= 2$ leptons		≥ 3 leptons	
≥ 2 b-tagged jets		≥ 1 b-tagged jet	
Pair production	**Single production**	**Pair production**	**Single production**
$H_{\mathrm{T}}(\mathrm{jets}) \geq 600$ GeV	≥ 1 fwd. jet	–	≥ 1 fwd. jet
Final discriminant			
$m(Zb)$		H_{T}(jets+leptons)	

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