New physics in single-top signatures: experimental summary

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Outline

One Top in the final state:

- **W′ → tb**
- **Monotop**
- **Stop**

"Single production" mode with top

- **Single B′ VLQ**
- **Single T′ VLQ**

Conclusion

Over the talk:

Atlas results, CMS results

One Top quark

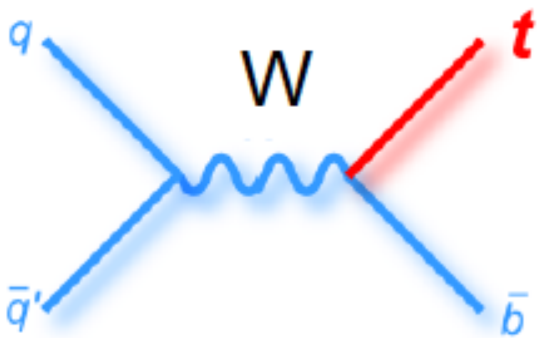
W'→tb

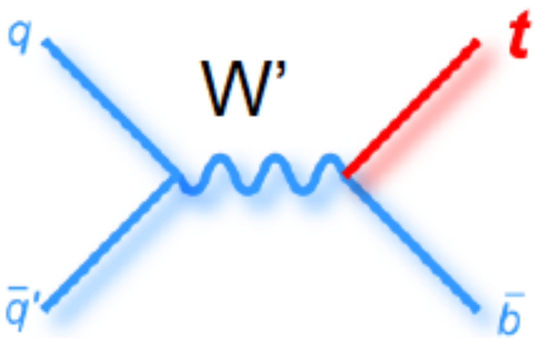
W' searched in direct lepton + neutrino decay
→ No access to right-handed sector (only hadronic decay)
Most of the models have stronger coupling to third generation of quarks.

Lagrangian:

$$\mathcal{L} = \frac{V_{f_i f_j}}{2\sqrt{2}} g_w \overline{f}_i \gamma_\mu \left(a^{\mathrm{R}}_{f_i f_j} (1+\gamma^5) + a^{\mathrm{L}}_{f_i f_j} (1-\gamma^5) \right) \mathrm{W}'^{\mu} f_j + \mathrm{h.c.},$$

Non-0 → interference with SM





Similar production to single top

src:Z.Sullivan, Phys.Rev.D 66 075011

W'→tb Semi Leptonic

CERN-PH-EP-2014-232 CERN-PH-EP-2014-11

Atlas and CMS: lνbb (l=e,μ), luminosity: 20.3fb^{-1}, 19.5 fb^{-1}

Selection:

Single lepton trigger

Isolated lepton with p_T>30 GeV , 50 GeV

Missing E_T >35 GeV , >20 GeV

Jets with p_T>25 GeV, (sub-)leading p_T>120 (40) GeV

B-tagging: 2 b-tag jets using neural-network b-tagging (ε=70%),
1 or 2 b-tag with CSVM (ε= 70%)

Reconstruction/Analysis:

Both: Full reconstruction of the final state (neutrino solved via W-mass constraint) [CMS 83% correct neutrino assignment for W']

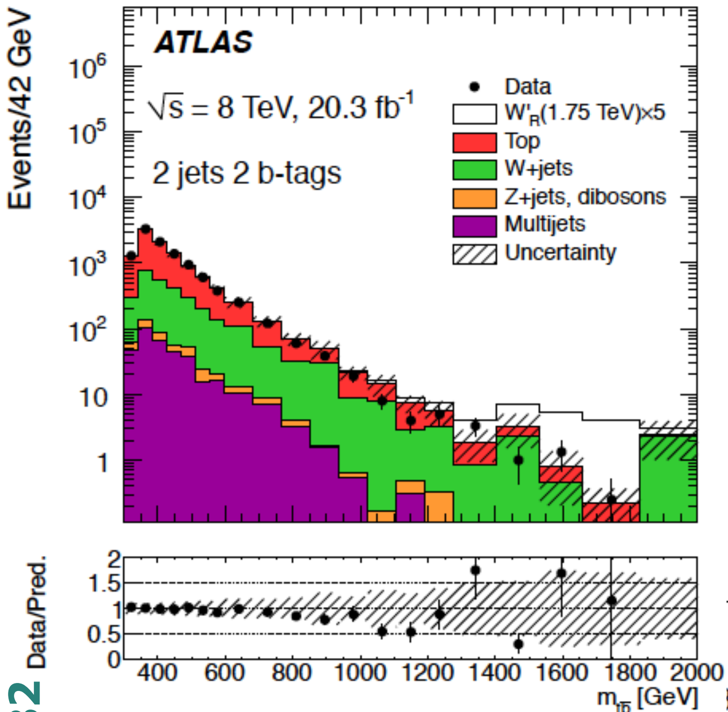
Atlas: MT(W) +Met>60 GeV, studies performed in 2 or 3 jets bin; BDT used with 11 input variables changing in case of the jet bin as well as left-handed/right-handed case, no cut on BDT.

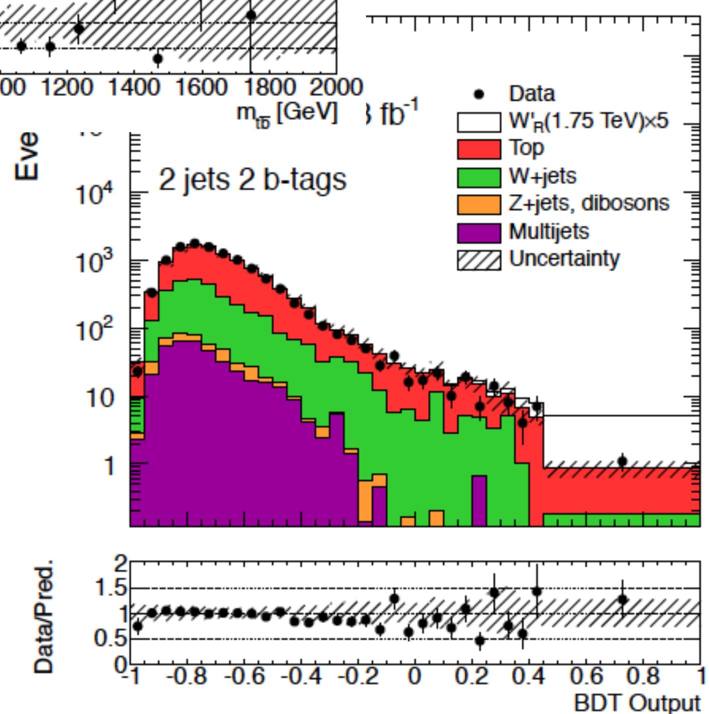
CMS: cut based: p_T(top)> 85 GeV, p_T(vect(jet1+jet2))>140 GeV, 130<M(top)<210 GeV. Work in one or two b-tag categories.

Except the 2b-tag, looser selection in Atlas case.

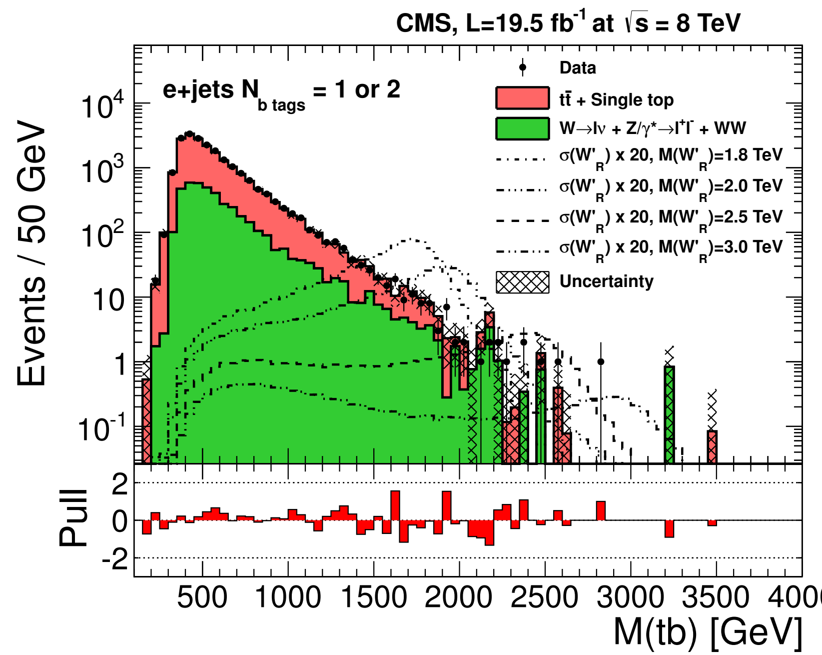
W'→tb→lνbb - Results

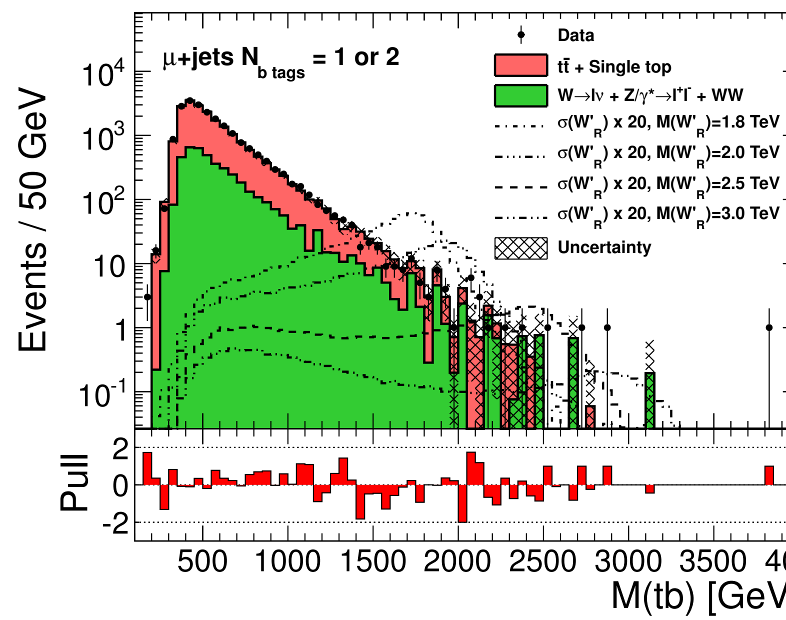
CERN-PH-EP-2014-232





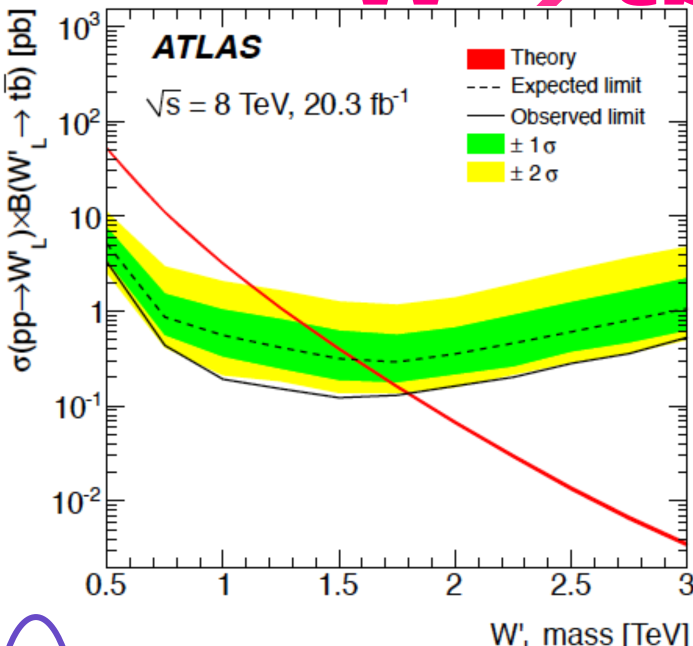
Less events in Atlas at high masses





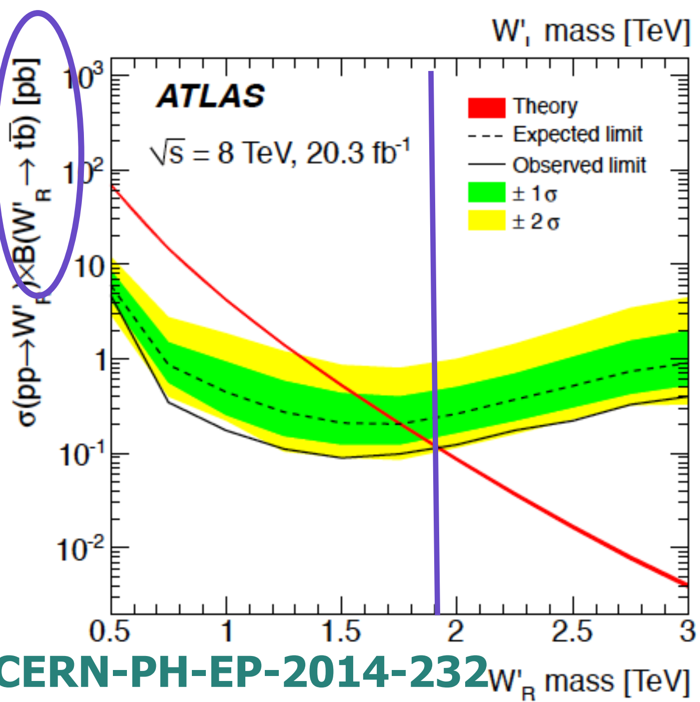
CERN-PH-EP-2014-11

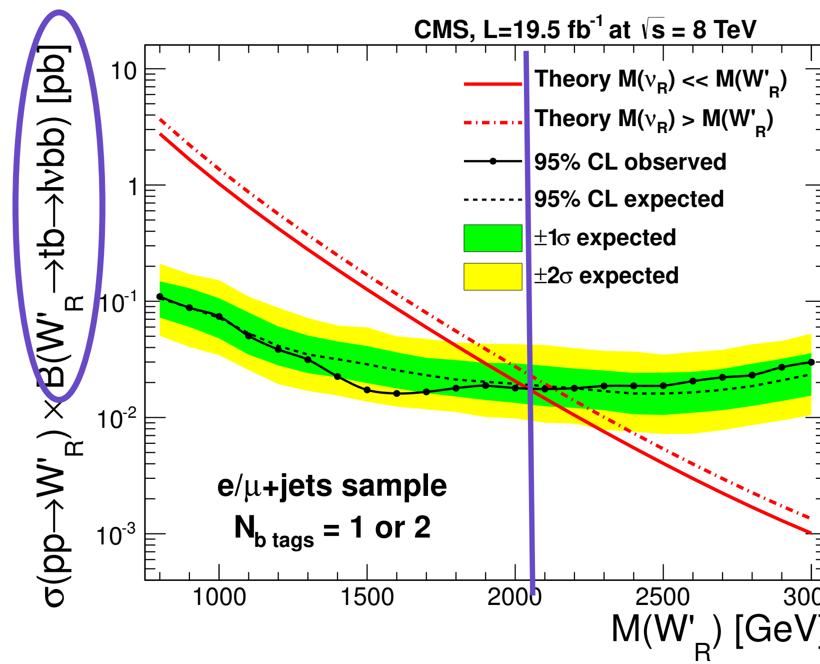
W'→tb→lνbb - Limits



CMS limit plots only for WR

Stronger limit from CMS mainly coming the fact that CMS has higher expected signal events.





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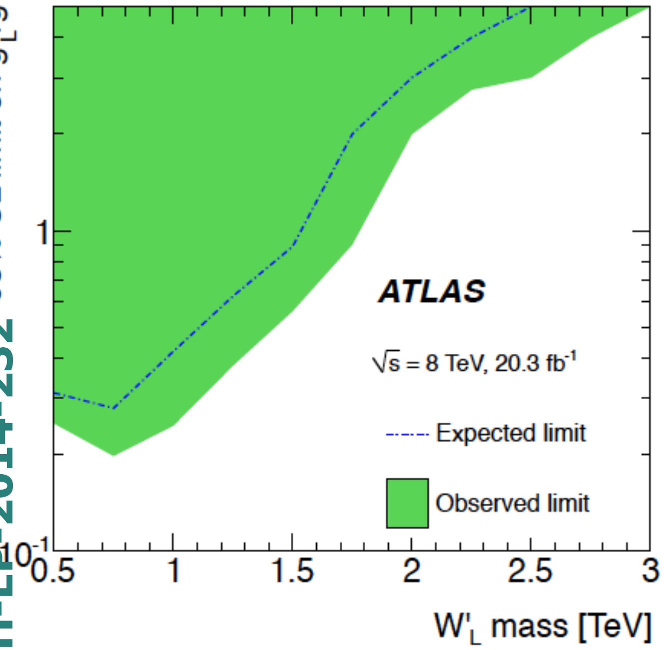
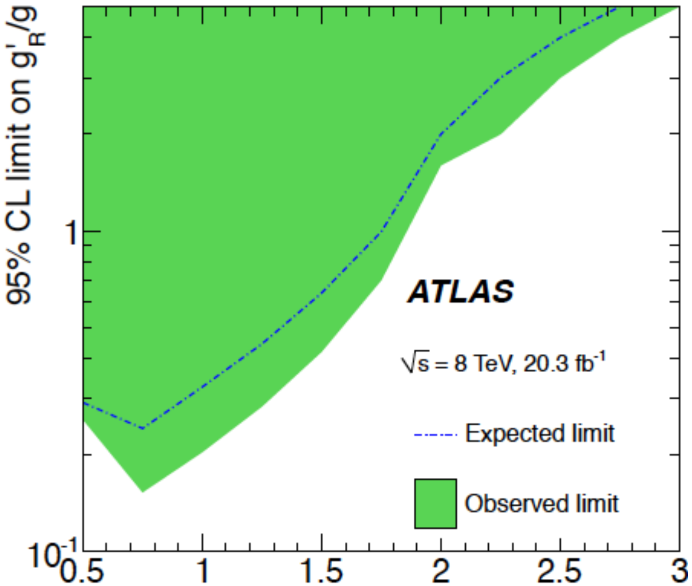
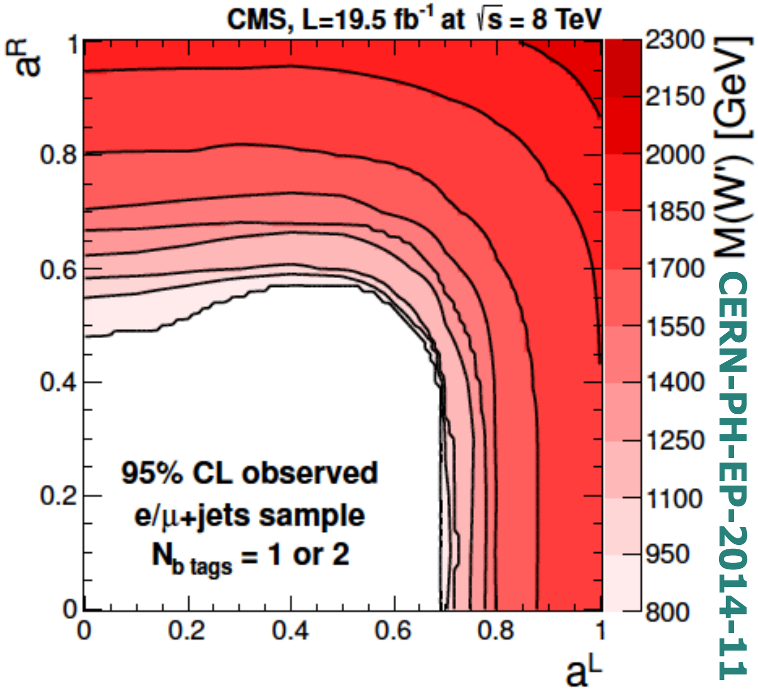
W'→tb→lνbb - Limits





CERN-PH-EP-2014-232

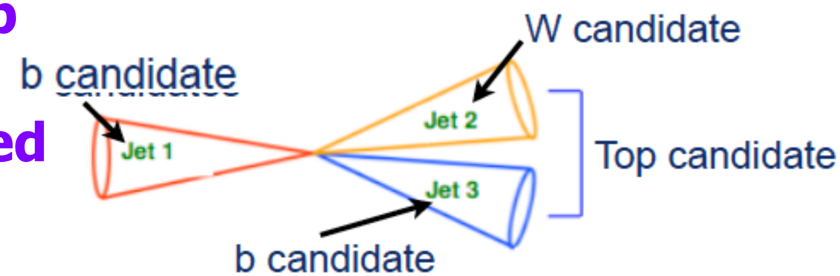
Different way of presenting the results...



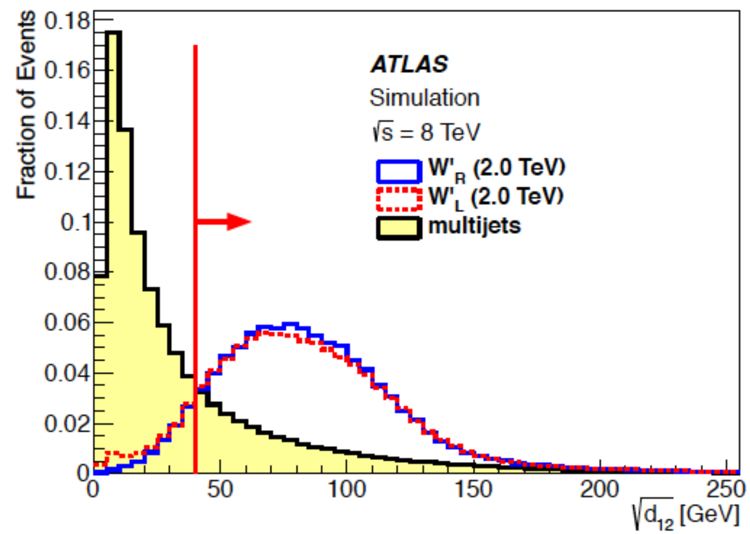
CERN-PH-EP-2014-11

W'→tb Full hadronic

Atlas: Top + b : Boosted regime for Top
Top – tagging algorithm used:
Anti Kt "large R-radius" = 1.0 - Trimmed



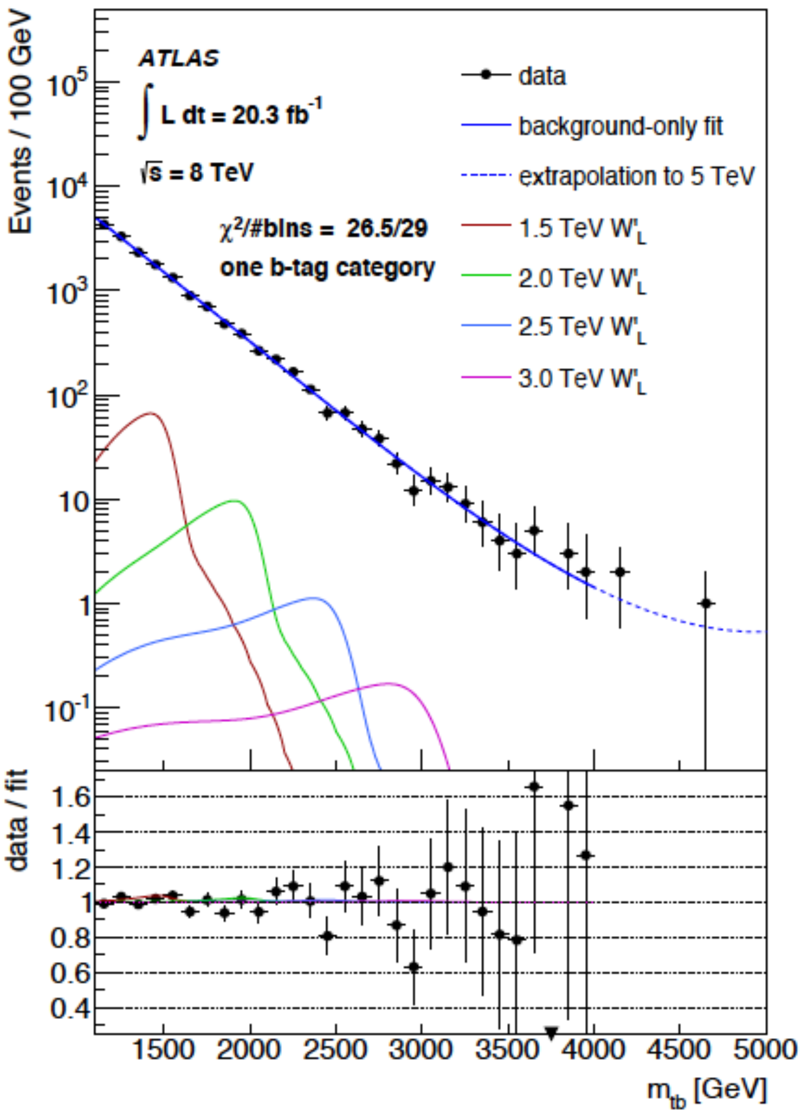
Selection:
Trigger sum E_T caloTowers>700 GeV
== 1 Large-R jet p_T>350 GeV with
$\sqrt{(d_{12})}$>40 GeV, τ_{32}<0.65 and 0.4<τ_{21}<0.9
DR between two jets >2.0
M(jj) > 1.1 TeV

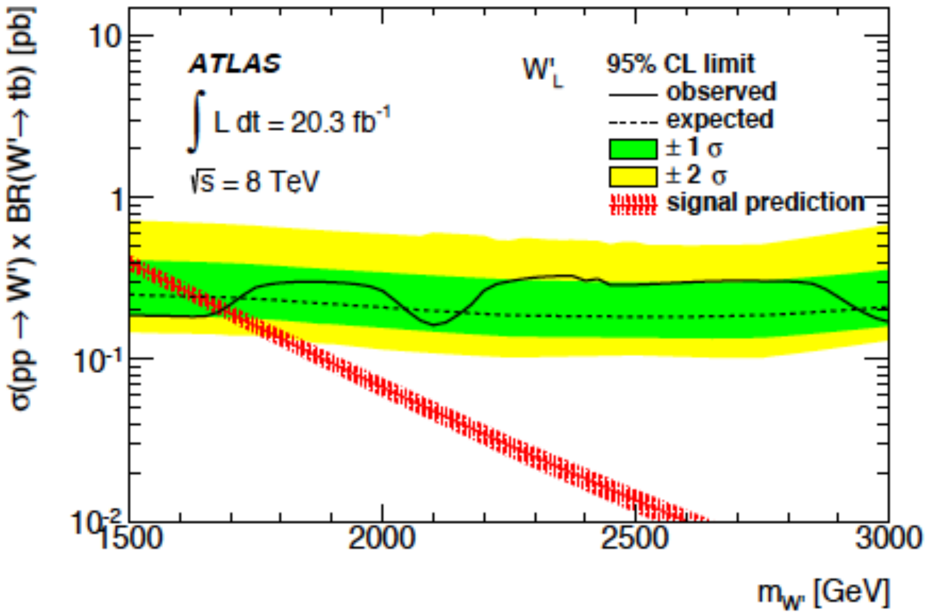


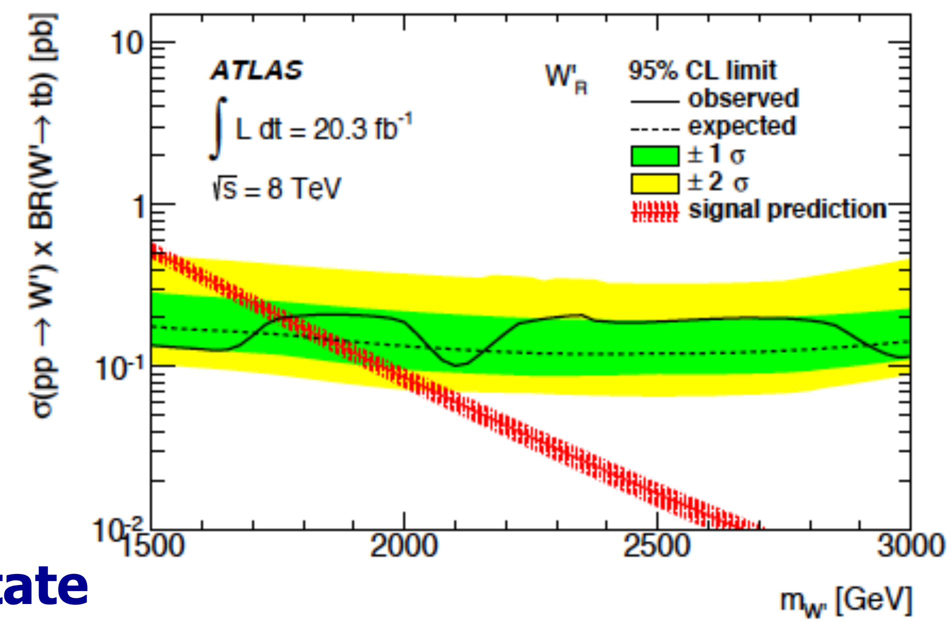
Selection of the analysis:
Full hadronic final state → direct reconstruction of W' mass
Consider 2 categories: 1 b-tag, 2 b-tag (second b-tag is close by the Large-R jet [Top tag one])

W'→tb Full hadronic

CERN-PH-EP-2014-152







Lower limits than in l+jets final state

Monotop

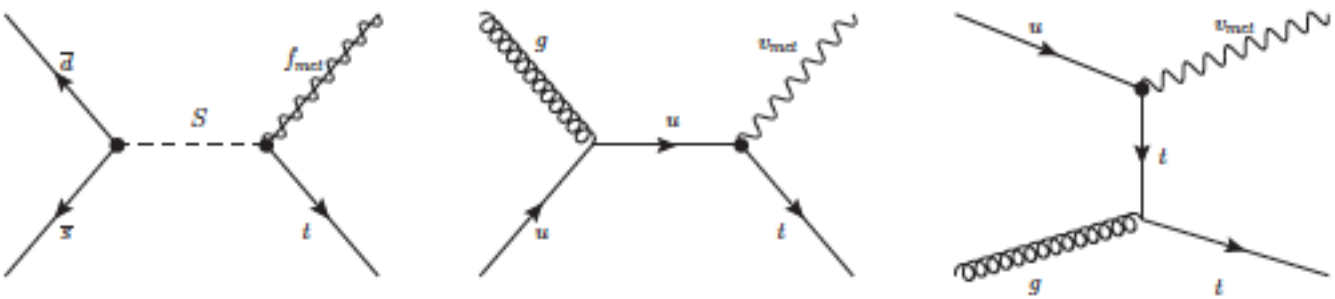
CERN-PH-EP-2014-231 CERN-PH-EP-2014-225

Production of particle decaying in top quark and either a neutral boson (non resonant) which do not interact or a neutral fermion (resonant).
Assumption: both neutral particle have BR~1 to decay in hidden sector or to have decay length is long enough to not be detected inside detector
→ Search for single Top quark + large missing Et

Lagrangian:

$$\mathcal{L} = \mathcal{L}_{\mathrm{SM}} + \mathcal{L}_{\mathrm{kin}} + a^{0}_{\mathrm{FC}}\phi\bar{u}u + a^{1}_{\mathrm{FC}}v_{\mu}\bar{u}\gamma^{\mu}u + \mathrm{h.c.},$$

$a^{0,1}_{\mathrm{FC}}$ two 3×3 matrices in flavor space

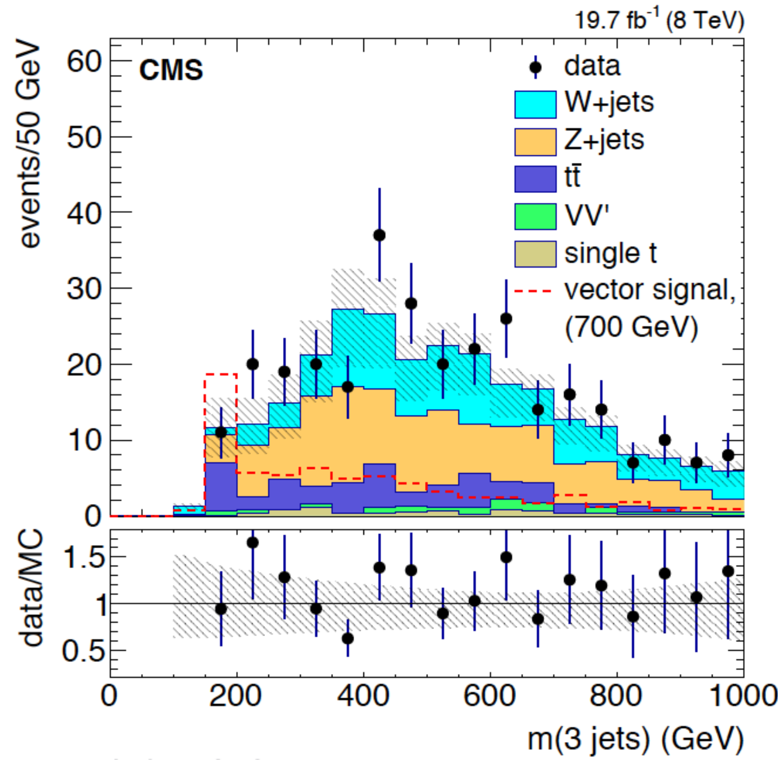


CMS used $a^{0,1}_{FC}$ =0.1 (for non 0-terms), Atlas: 0.2 (0.5, 1.0)

Monotop - Analysis - CMS

All Hadronic final state → Full reconstruction of Top

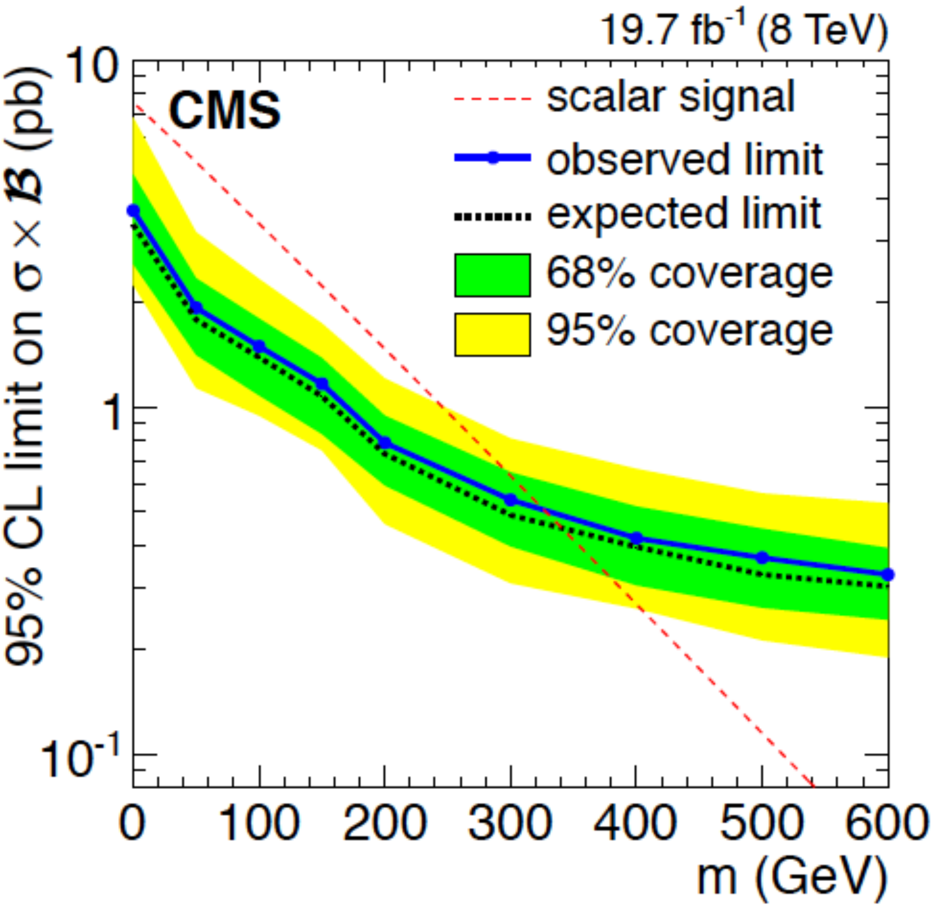
Selection:
Trigger: Missing E_T>150 GeV
3 jets p_T>40 GeV, 2 jets p_T> 60 GeV,
veto events if additional jet p_T> 35 GeV
M(jjj) < 250 GeV
1 b-tag jet (ε=70%)
Veto on isolated e/mu>20/10 GeV
Missing E_T> 350 GeV

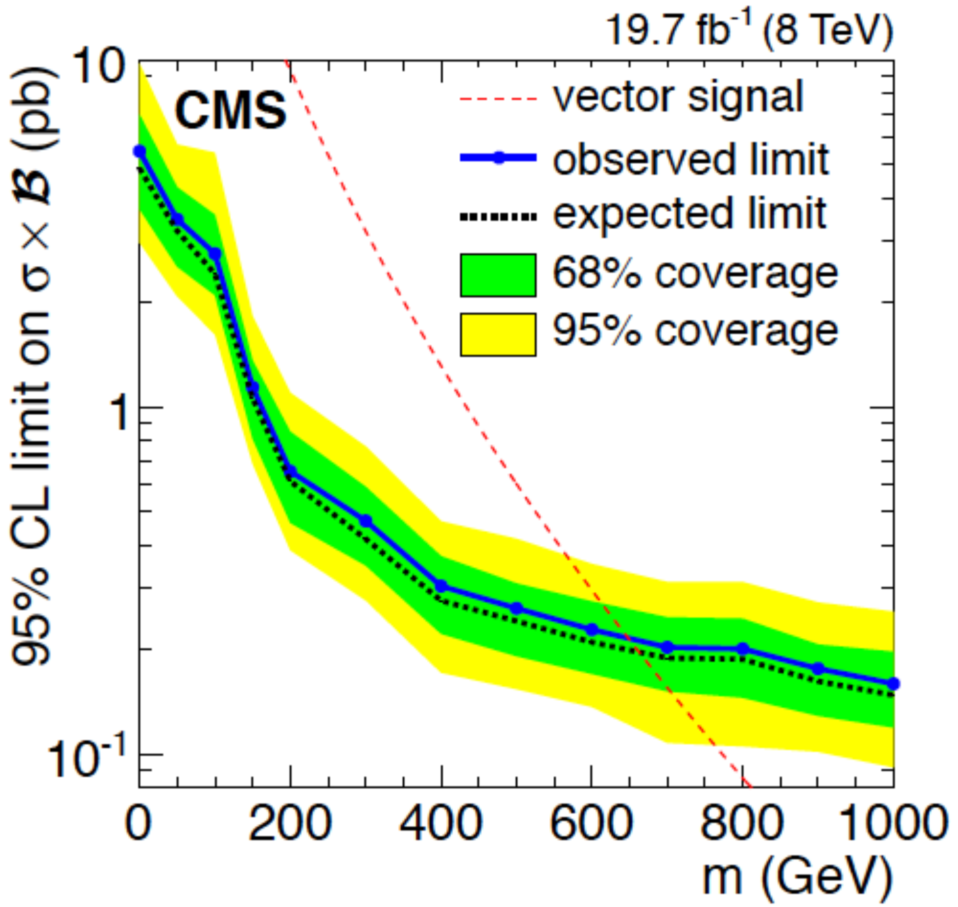


CERN-PH-EP-2014-225

Difficulty:
Using 3 control samples to derived multijet, Z(→νν) + jets and W(→lν)+jets [lepton outside of detector acceptance] from data.

Monotop - Results - CMS

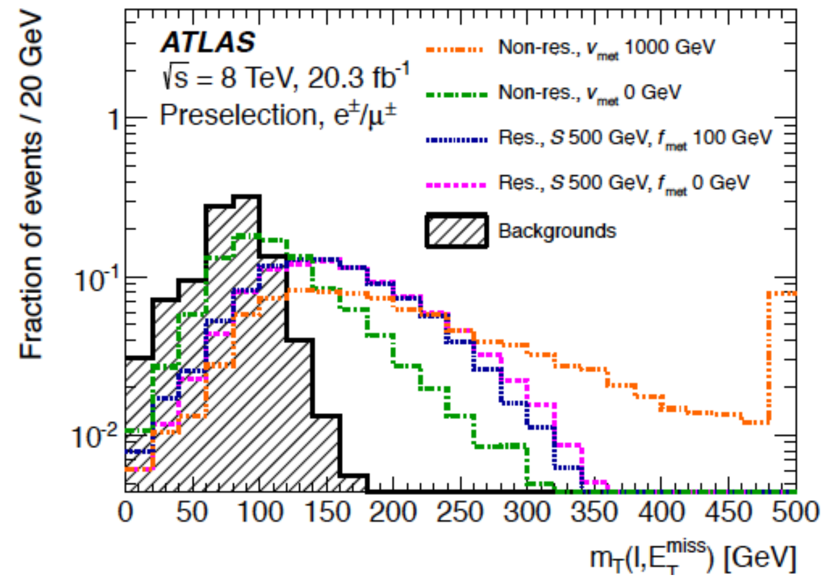




CERN-PH-EP-2014-225

Monotop – Analysis - Atlas

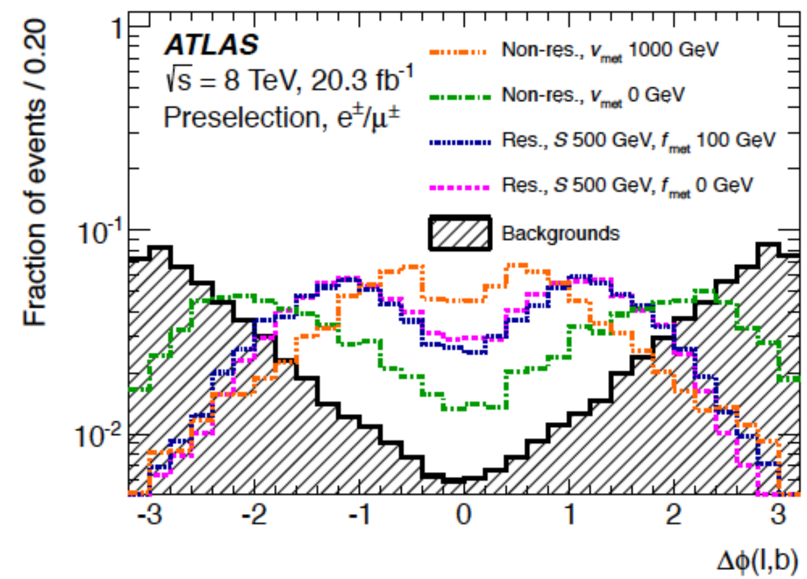
Atlas: lνb (l=e,μ)
Selection:
Single lepton trigger
Isolated lepton with p_T>30 GeV
Missing E_T >35 GeV
== 1 jet with p_T>25 GeV
B-tagging:
1 b-tag jets (ε=57%, ε_light=0.2%)



Reconstruction/Analysis:
M_T(W) +ME_T>60 GeV
M_T(W) >150 GeV
Work in region of M_T(W) and | Δφ(l,b)|

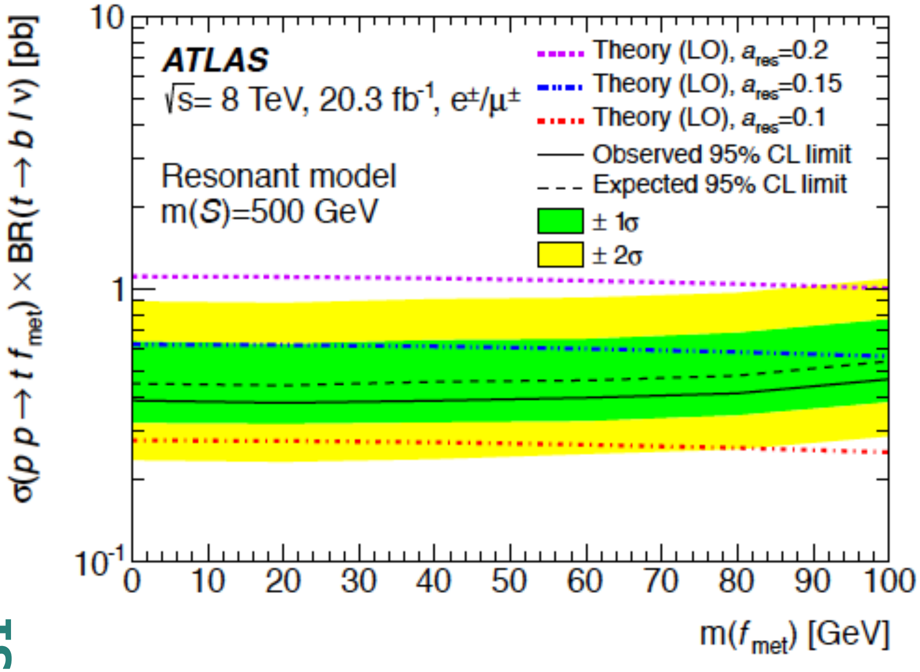
Signal will stand at M_T(W)>200 GeV

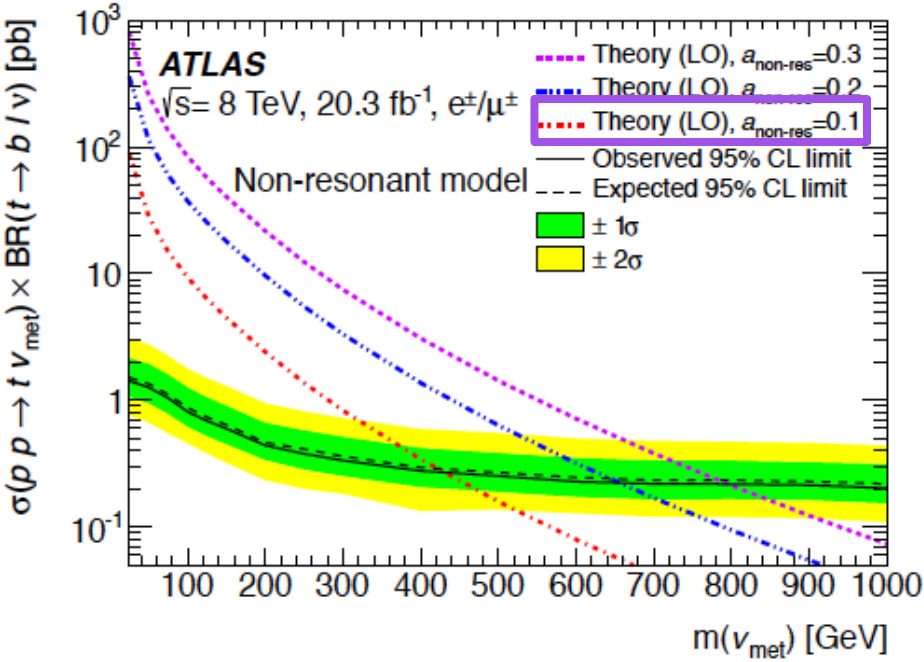
Defined 3 control samples to validate simulated background in W+jets enriched , multijet and ttbar enriched.



CERN-PH-EP-2014-231

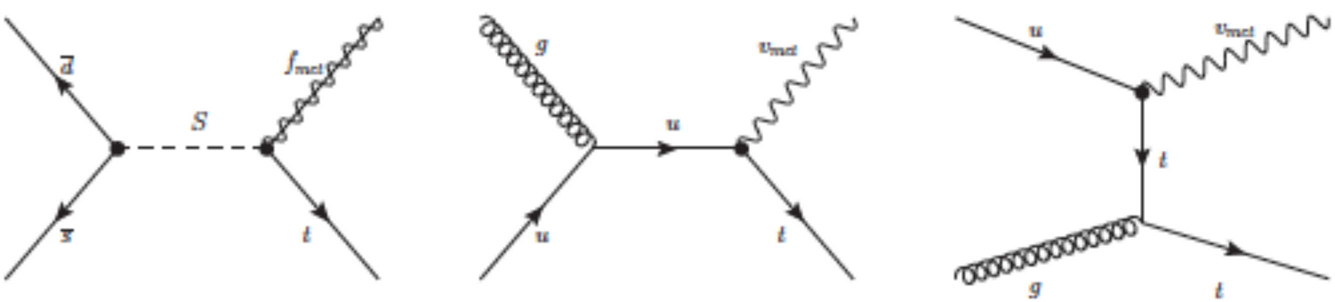
Monotop - Results - Atlas



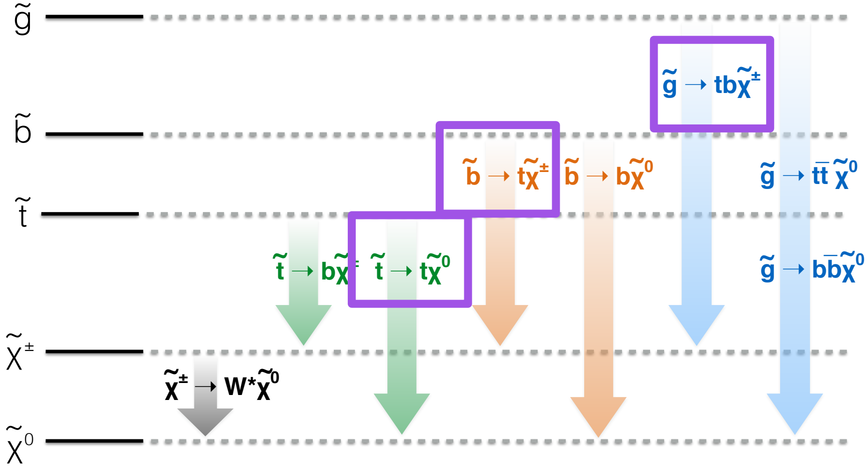


CERN-PH-EP-2014-231

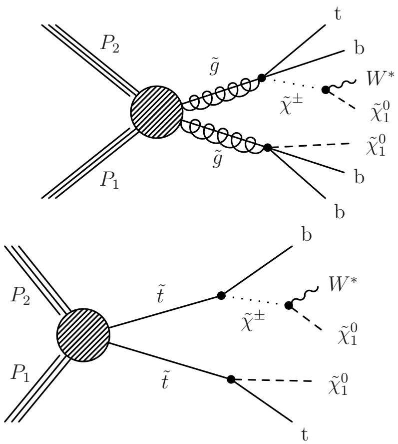
Not exactly the same model than in Atlas…



Stop searches



Generic analysis mainly performed in pair of stop produced
→ Could have only one top in the final state if second object decaying in other mode



Analysis not really taking into account the Top presence by reconstructing the object, only working via "boxes" following the variables:

$$M_R \equiv \sqrt{(|\vec{p}^{j_1}|+|\vec{p}^{j_2}|)^2-(p_z^{j_1}+p_z^{j_2})^2}\,,$$

$$M_T^R \equiv \sqrt{\frac{E_T^{miss}(p_T^{j_1}+p_T^{j_2})-\vec{E}_T^{miss}\cdot(\vec{p}_T^{j_1}+\vec{p}_T^{j_2})}{2}}\,,$$

$$R \equiv \frac{M_T^R}{M_R}\,.$$

Box	Lepton	b-tag	Kinematic	Jet
Two-lepton boxes				
MuEle	$\geq$ 1 tight electron and $\geq$ 1 loose muon			
MuMu	$\geq$ 1 tight muon and $\geq$ 1 loose muon	$\geq$ 1 b-tag	($M_R > 300$ GeV and $R^2 > 0.15$) and ($M_R > 350$ GeV or $R^2 > 0.2$)	$\geq$ 2 jets
EleEle	$\geq$ 1 tight electron and $\geq$ 1 loose electron			
Single-lepton boxes				
MuMultiJet	1 tight muon	$\geq$ 1 b-tag	($M_R > 300$ GeV and $R^2 > 0.15$) and ($M_R > 350$ GeV or $R^2 > 0.2$)	$\geq$ 4 jets
EleMultiJet	1 tight electron			
MuJet	1 tight muon			2 or 3 jets
EleJet	1 tight electron			
Hadronic boxes				
MultiJet	none	$\geq$ 1 b-tag	($M_R > 400$ GeV and $R^2 > 0.25$) and ($M_R > 450$ GeV or $R^2 > 0.3$)	$\geq$ 4 jets
$\geq$ 2 b-tagged jet	none	$\geq$ 2 b-tag		2 or 3 jets

The table's top header reads "Requirements" and spans the Lepton, b-tag, Kinematic and Jet columns.

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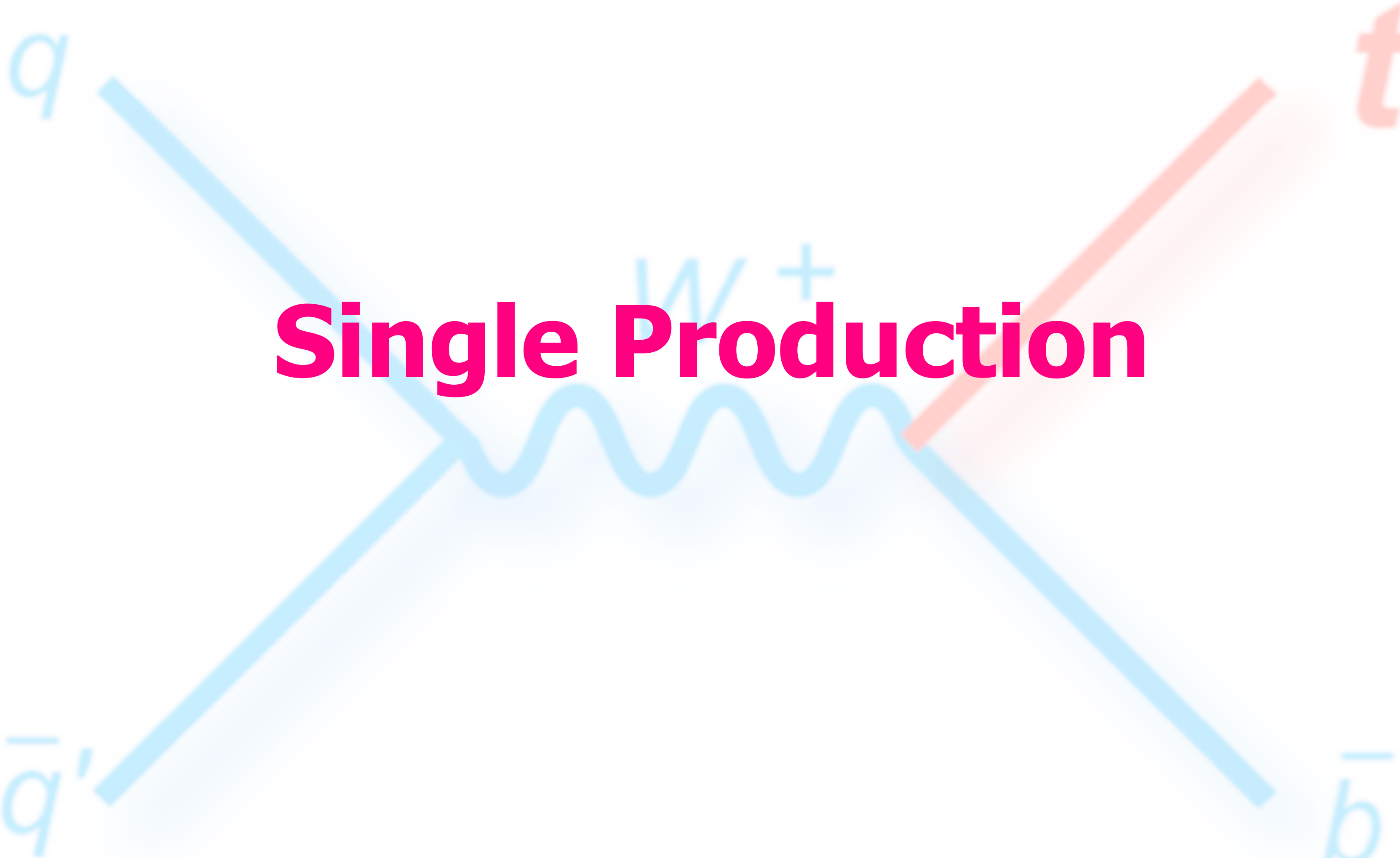
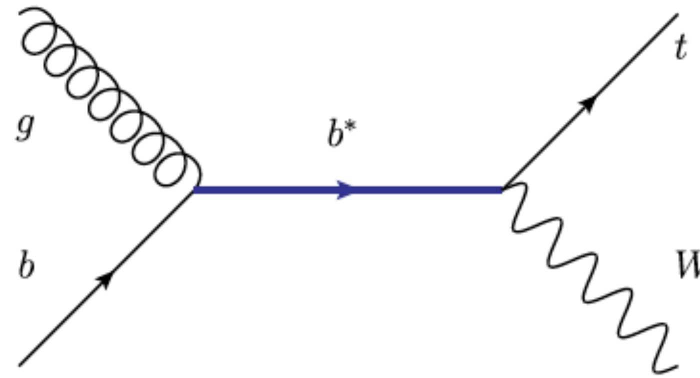
Single Production



Single b*/′ production (7 TeV)

Atlas: lνbjj (l=e,μ) or lνlνb

2 cases: excited b-quark (b*), vector like quark (VLQ) (b′)



Lagrangians:

$$\mathcal{L} = \frac{g_s}{2\Lambda} G_{\mu\nu} \bar{b}\, \sigma^{\mu\nu} (\kappa_L^b P_L + \kappa_R^b P_R) b^* + \text{h.c.},$$

$$\mathcal{L} = \frac{g_2}{\sqrt{2}} W_\mu^+ \bar{t} \gamma^\mu (g_L P_L + g_R P_R) b^* + \text{h.c.},$$

Selection:

Single lepton trigger

Isolated lepton with p_T>25 GeV

Jets with p_T>30 (25) GeV (l+jets)

B-tagging: b-tag jets (ε=70%)

Reconstruction/Analysis:

L+jets: 1 μ + ME_T>25 GeV
or 1e + ME_T>30 GeV

M_T(W) +ME_T>60 GeV

M_T(W) >30 GeV

>=3 jets

==1 b-jet

Dilepton:

2 opposite charge lepton

|Z_{mass} – m(ll)|>10 GeV

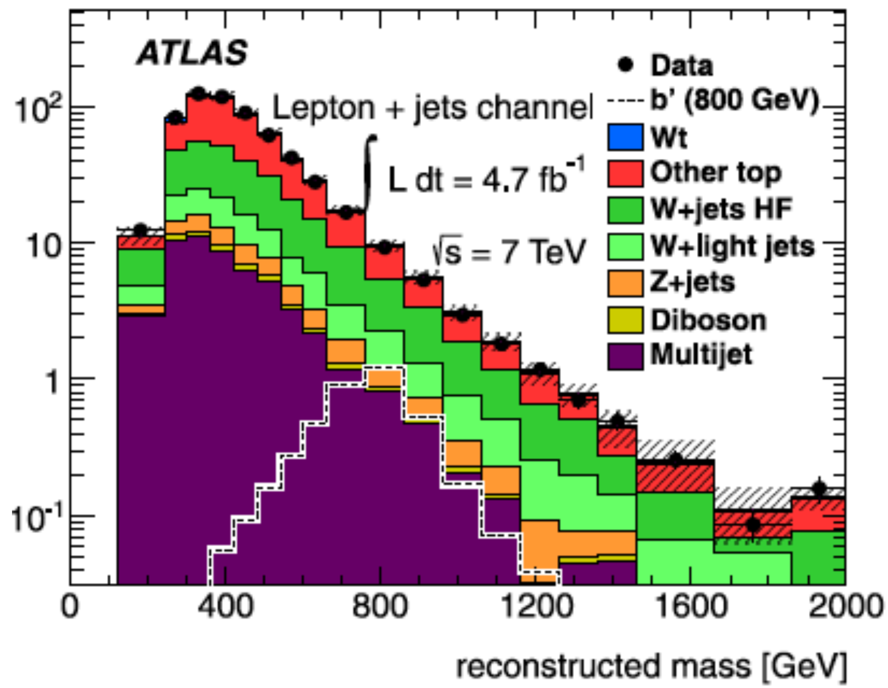
ME_T>50 GeV

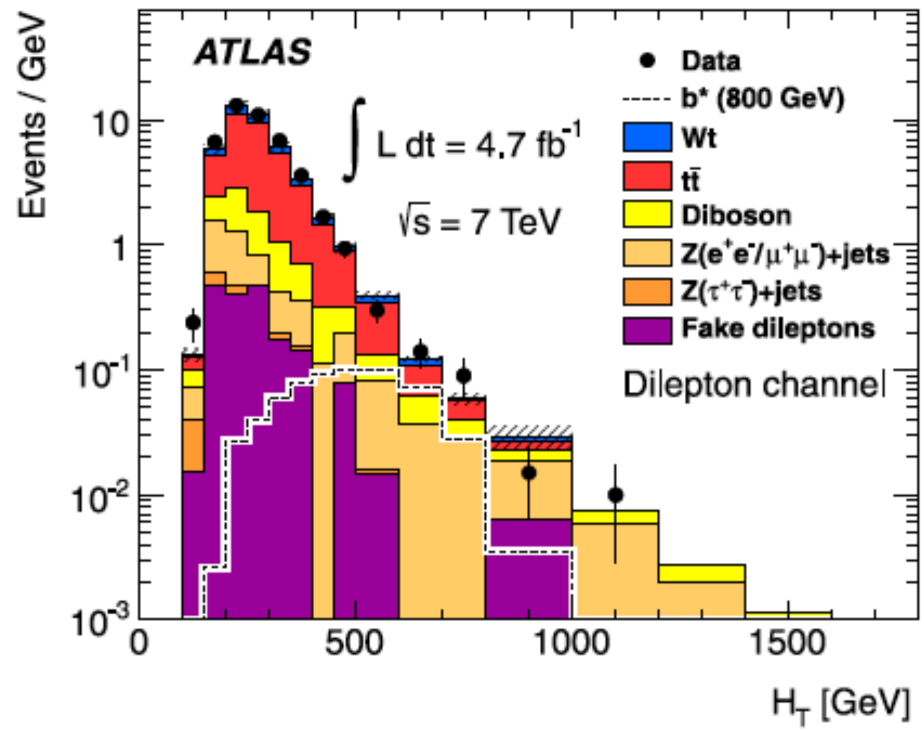
| Δφ(l,ME_T)|<2.5 rad

==1 b-jet

Physics Letters B 721 (2013) 171–189

Single b*/′ production - Results





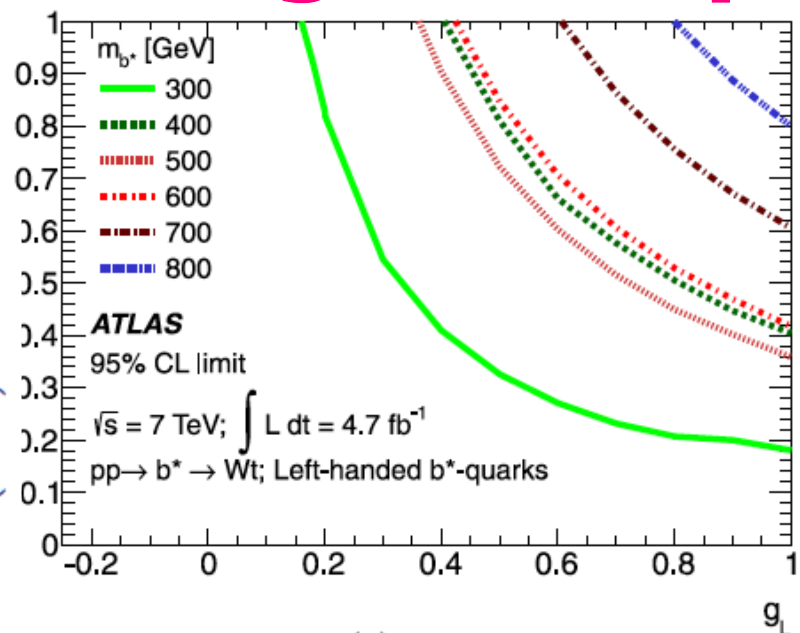
Physics Letters B 721 (2013) 171–189

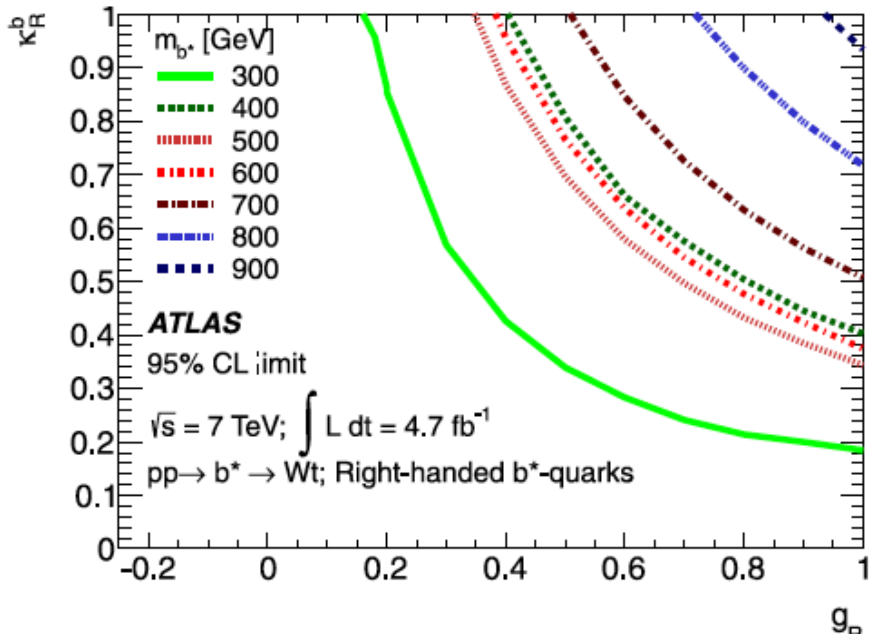
In Lepton + jets channel:
Full mass reconstructed by considering ME_T pz=0

In Dilepton channel:
HT is the main discriminative variable

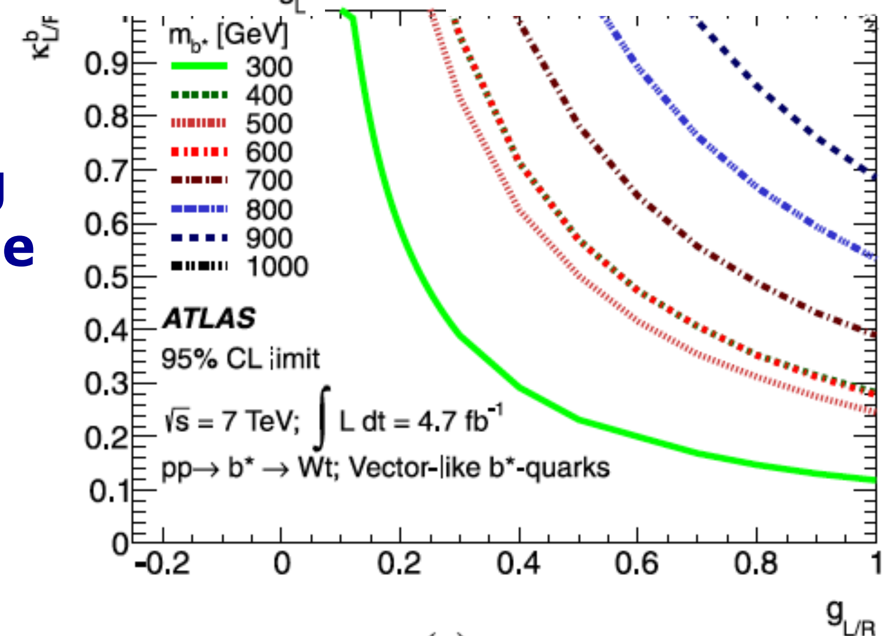
Single b*/′ production - Limits

Physics Letters B 721 (2013) 171–189



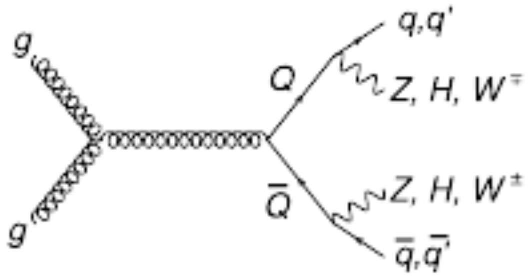


Limits on the various coupling depending on the model.

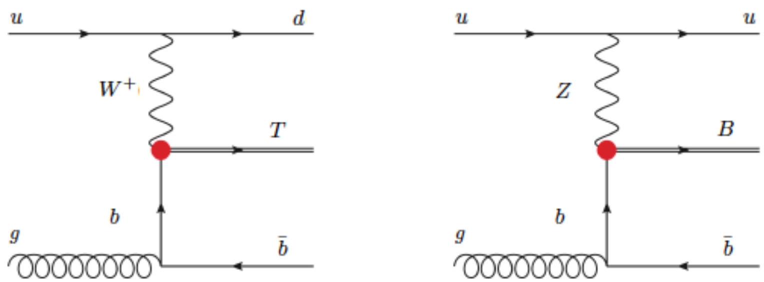


Single B′/T′ production

Vector Like Quark B′/T′, so far CMS looked for pair production, but single production can be interesting too…



Higher cross section for single production mode than pair production



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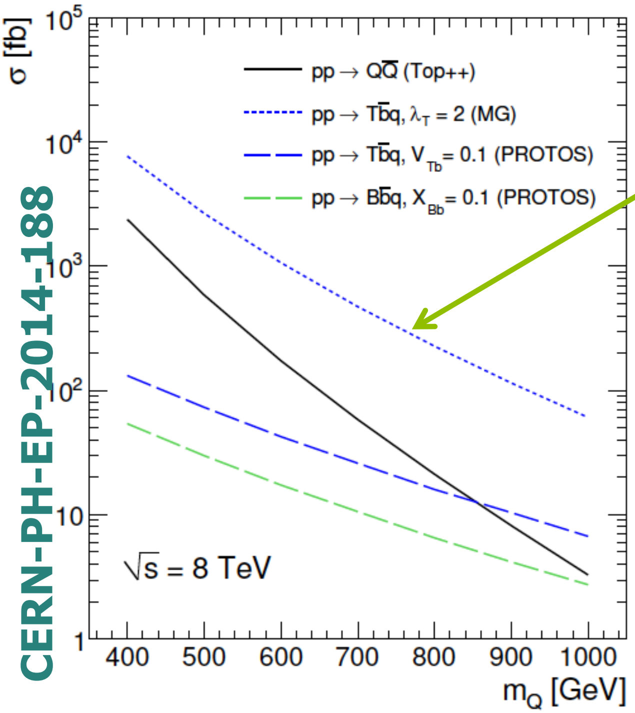
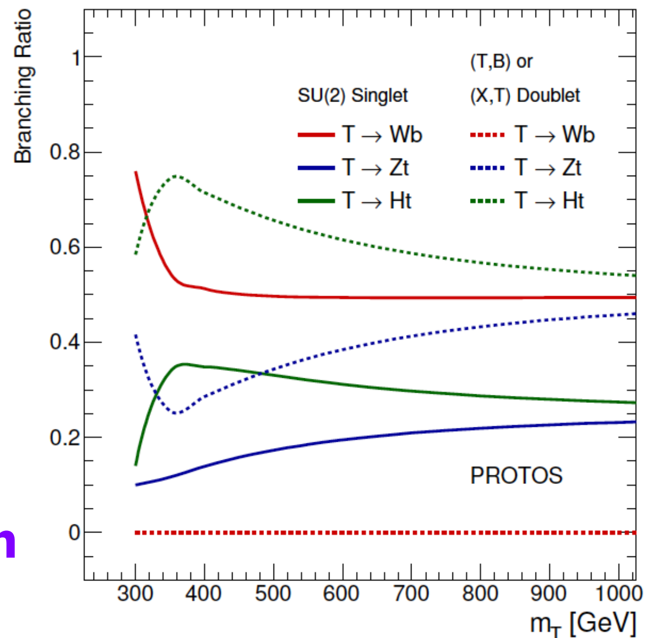
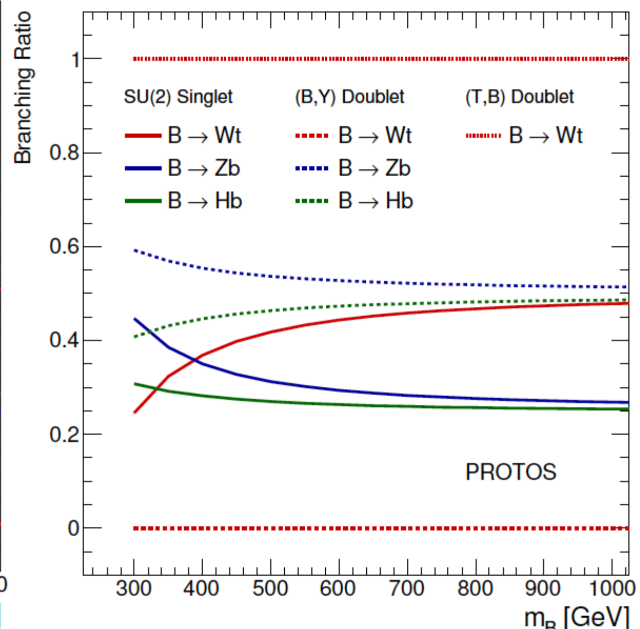






Atlas analysis looking at pair and single production in Zt/Zb final states

Single B'/T' production

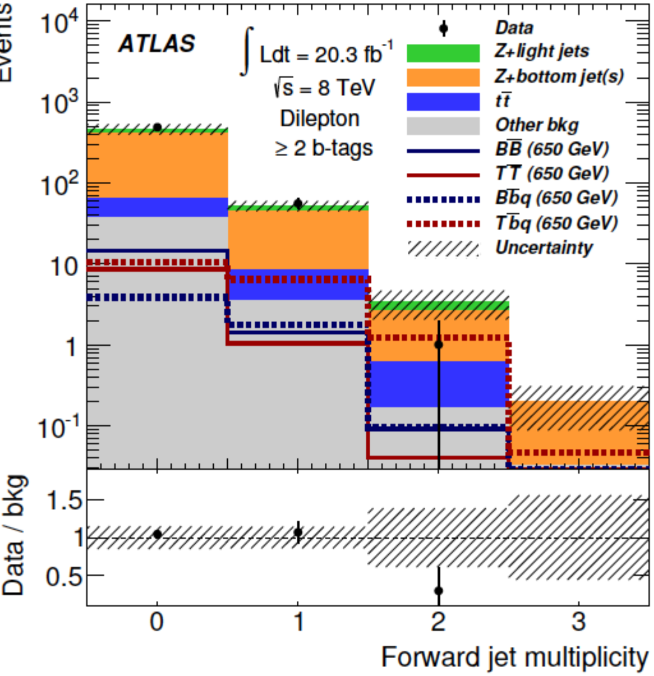
Containing a Z in the final state → use lepton decay (full mass reconstruction)
Triggers: single lepton triggers
2 leptons opposite charge same flavor
$|Z_{mass} - m(ll)| < 10$ GeV

CERN-PH-EP-2014-188

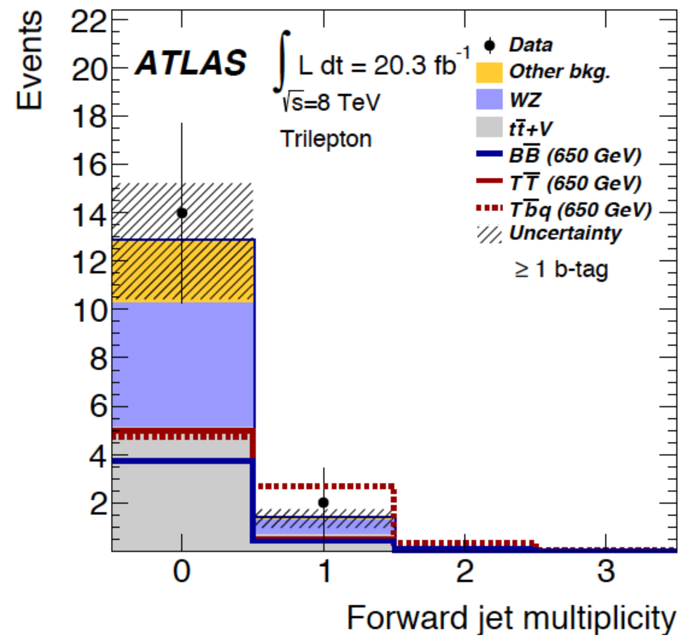
Event selection			
Z boson candidate preselection ≥ 2 central jets $p_T(Z) \geq 150$ GeV			
Dilepton channel		**Trilepton channel**	
$= 2$ leptons		≥ 3 leptons	
≥ 2 b-tagged jets		≥ 1 b-tagged jet	
Pair production	**Single production**	**Pair production**	**Single production**
$H_T(\text{jets}) \geq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

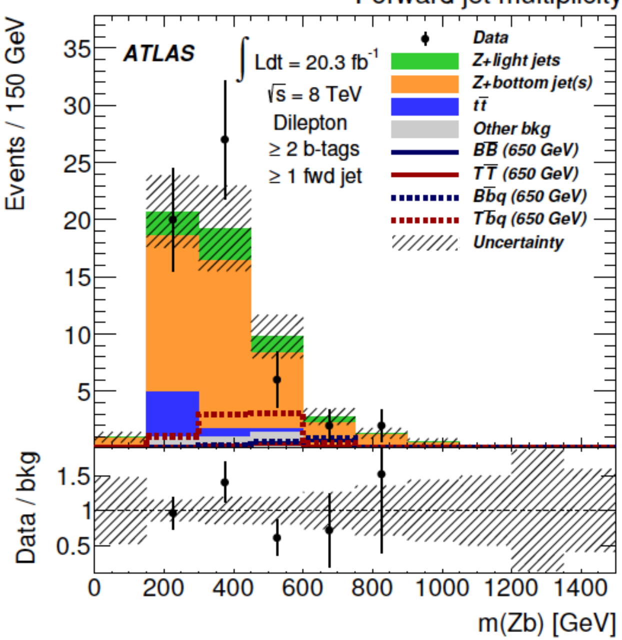
Forward jets: pt>20 GeV and $2.5<|\eta|<4.5$

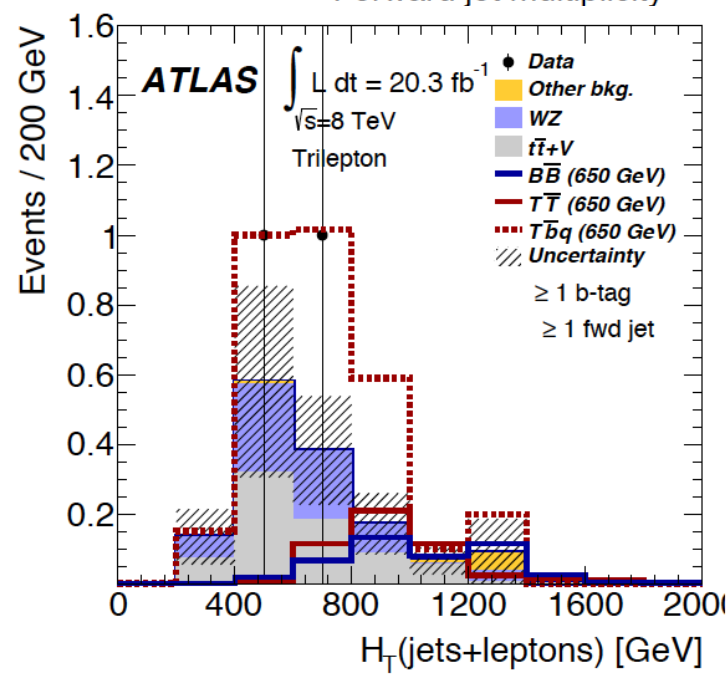
Single B'/T' production



Using fully the properties of the single production mode in the selection.







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Single B′/T′ production

Presenting limits only on the "single production mode" of B′/T′.

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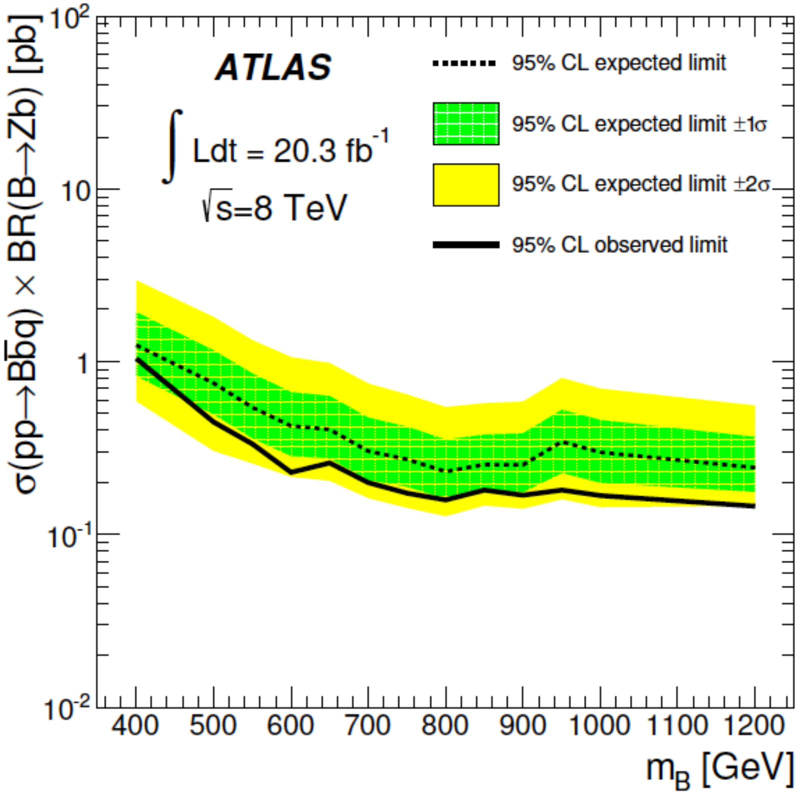
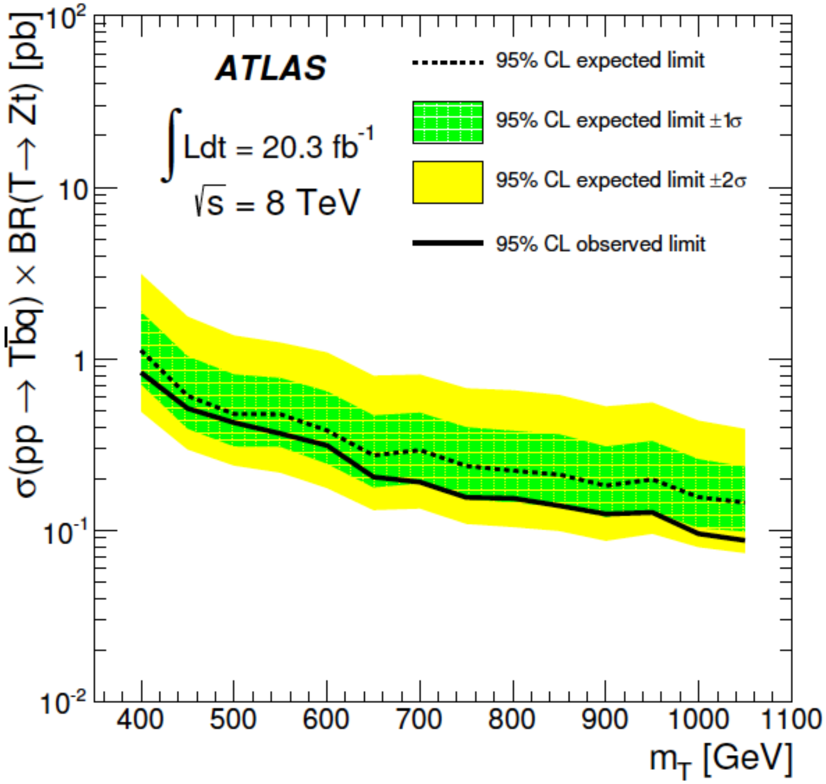
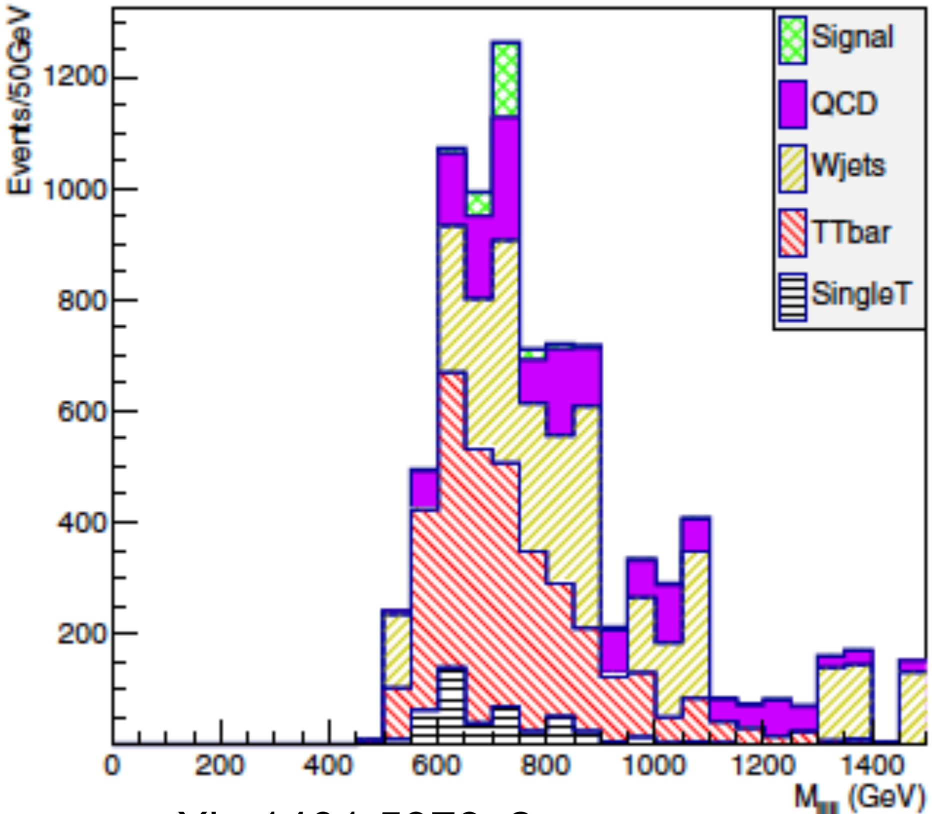




Single T' production in CMS

First look on going (samples just got produced at 8 TeV):
On going analysis (no public results yet) in tH final state
Look for full hadronic mode for the moment, following pheno studies, signal can be extracted thanks to full reconstruction of the events (relying on top and Higgs presence to decrease background).



arXiv:1401.5979v2

Conclusion

A lot of varieties of analysis have top quark in the final state:

Top is the most massive quark so far, its decay is used to select the events (either b-quark or lepton from the W)

Other particles produced in single production mode
→ Start to use forward jet, expertise from single Top

→ A lot of more analysis to start with 13 TeV data to push limit forward!