



Search for Rare Top Quark decays and Resonances for New Physics models

Marco CARDACI
(National Central University, Taiwan)

on behalf of the
ATLAS and CMS Collaborations

Windows on the Universe 2013

14/Aug/2013

Outline

◦ Rare Top Quark decays

- $R = B(t \text{ to } Wb)/B(t \text{ to } Wq)$ (CMS)
- Flavor-Changing Neutral Current (FCNC) in top decays (ATLAS + CMS)
- Baryon Number Violating (BNV) top decays (CMS)

◦ Resonances

- Z' to $t\bar{t}$ in all hadronic (CMS)
- Z' to $t\bar{t}$ in $l + \text{jets}$ (ATLAS + CMS)
- W' to $t\bar{b}$ (ATLAS + CMS)
- T^* to $t\bar{g}$ (CMS)
- Anomalous production in SS dileptons, resonances (ATLAS)

Non-exhaustive review!

Only 2013 results!

◦ Vector-Like Quarks and other non resonant states

- Anomalous production in SS dileptons, non resonant (ATLAS)
- $T_{5/3}$ to SS dileptons (CMS)
- Search for T VLQ in single-lepton and ≥ 2 b-jet channel: T to Ht to $(bb)t$ (ATLAS)
- Search for 4th gen. t' and T VLQ in single-lepton and ≥ 1 b-jet channel: T to Wb (ATLAS)
- Search for T & B VLQs in di-lepton and ≥ 2 b-jet channel: T to Zt & B to Zb (ATLAS)
- Inclusive search for Vector-Like T Quark in single- and multi-lepton channels (CMS)

Outline

◦ Rare Top Quark decays

- $R = B(t \text{ to } Wb)/B(t \text{ to } Wq)$ (CMS)
- Flavor-Changing Neutral Current (FCNC) in top decays (ATLAS + CMS)
- Baryon Number Violating (BNV) top decays (CMS)

◦ Resonances

- Z' to $t\bar{t}$ in all hadronic (CMS)
- Z' to $t\bar{t}$ in $l + \text{jets}$ (ATLAS + CMS)
- W' to $t\bar{b}$ (ATLAS + CMS)
- T^* to $t\bar{g}$ (CMS)
- Anomalous production in SS dileptons, resonances (ATLAS)

Non-exhaustive review!

Only 2013 results!

Most recent results


◦ Vector-Like Quarks and other non resonant states

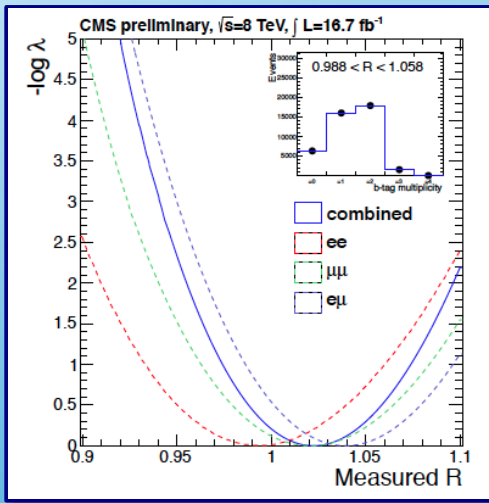
- Anomalous production in SS dileptons, non resonant (ATLAS)
- $T_{5/3}$ to SS dileptons (CMS)
- Search for T VLQ in single-lepton and ≥ 2 bjet channel: T to Ht to $(bb)t$ (ATLAS)
- Search for 4th gen. t' and T VLQ in single-lepton and ≥ 1 b-jet channel: T to Wb (ATLAS)
- Search for T & B VLQs in di-lepton and ≥ 2 b-jet channel: T to Zt & B to Zb (ATLAS)
- Inclusive search for Vector-Like T Quark in single- and multi-lepton channels (CMS)

Measurement of $R = B(t \rightarrow Wb) / B(t \rightarrow Wq)$ with $q = b, s, d$

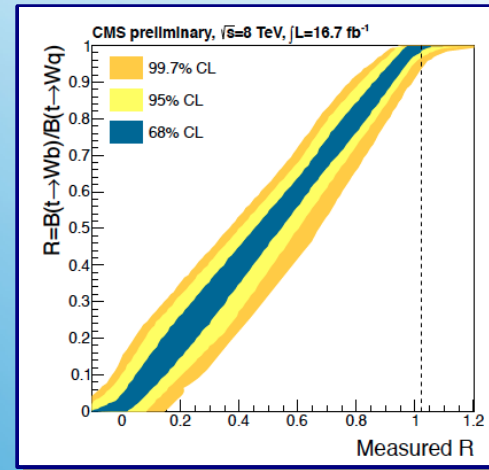
SM prediction:
$$R = \frac{B(t \rightarrow Wb)}{B(t \rightarrow Wq)} = \frac{|V_{tb}|^2}{|V_{tb}|^2 + |V_{ts}|^2 + |V_{td}|^2} = 0.99830^{+0.00006}_{-0.00009} \quad [1]$$

Indirect test of SM, which predicts:
$$|V_{tb}| = 0.999146^{+0.000021}_{-0.000046} \quad [1]$$

Tension with SM from 
$$\mathcal{R} = 0.90 \pm 0.04 \text{ (stat.+syst.)} \quad \mathcal{R}_{\ell\ell} = 0.86^{+0.041}_{-0.042} \text{ (stat)}^{+0.035}_{-0.035} \text{ (syst)} \quad [2]$$



- PLR to determine the signal purity
- Jet misassignment model obtained by randomly rotating selected leptons
- PLR taking into account signal purity, misassignment and probability of b-tagging as a function of R



Upper and lower endpoints of the confidence interval on R using the Feldman-Cousins frequentist approach based on a likelihood ratio ordering principle

$$\mathcal{R} = 1.023^{+0.036}_{-0.034}$$

Under the hypothesis of CKM matrix unitarity

$$|V_{tb}| = 1.011^{+0.018}_{-0.017} \text{ (stat+syst)}$$

Assuming $\mathcal{R} \leq 1$ obtain at 95% CL

$$\mathcal{R} > 0.945$$

Under the hypothesis of CKM matrix unitarity

$$|V_{tb}| > 0.972$$



[CMS-PAS-TOP-12-035]

Marco CARDACI

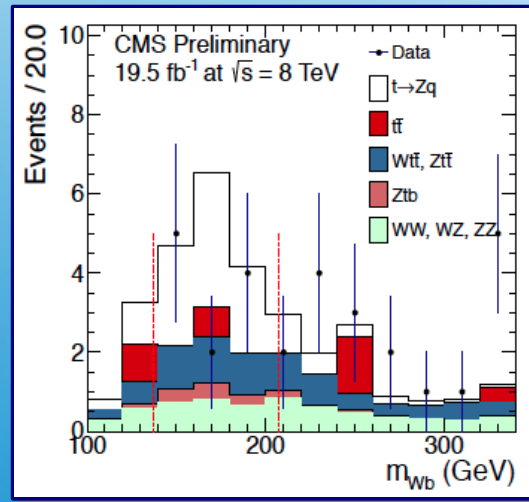
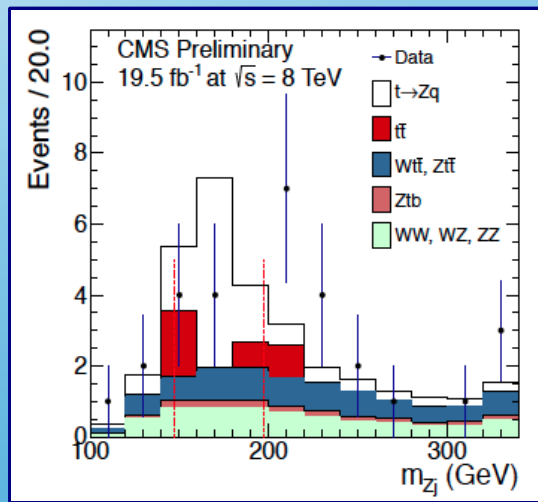
Search for FCNC in t to Zq with $q = u, c$

Highly suppressed in the SM by GIM mechanisms $\mathcal{B}(t \rightarrow Zq)$ is $\mathcal{O}(10^{-14})$ [3]

Enhanced in R-parity violating SUSY [4], top color assisted technicolor [5] models to $\mathcal{O}(10^{-4})$

Measurement in the trilepton channel:

Data-driven background:



$$\begin{pmatrix} N_{all} \\ N_{1btag} \\ N_{0btag} \end{pmatrix} = \begin{pmatrix} & & \\ & T & \\ & & \end{pmatrix} \begin{pmatrix} N_{VV} \\ N_{FCNC} \\ N_{Vtt} \end{pmatrix}$$

No excess found and 95% C.L. limit set with CLs method:

$$\mathcal{B}(t \rightarrow Zq) < 0.07\%$$



[CMS-PAS-TOP-12-037]

Marco CARDACI

7 TeV analyses:

CMS Phys. Lett. B718 (2013) 1252

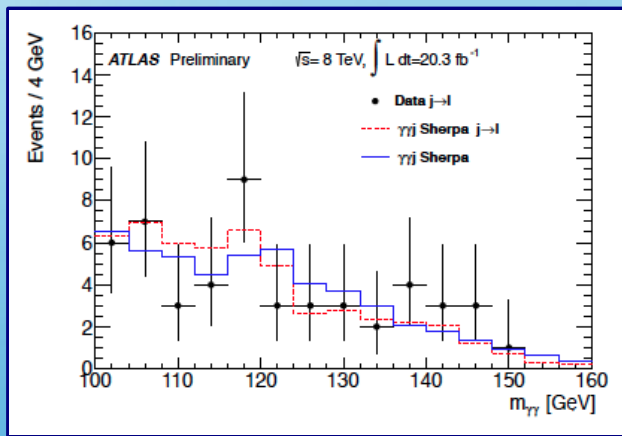
ATLAS Phys. Lett. B712 (2012) 351-369

Search for FCNC in t to $c(u)H$ with H to gamma-gamma

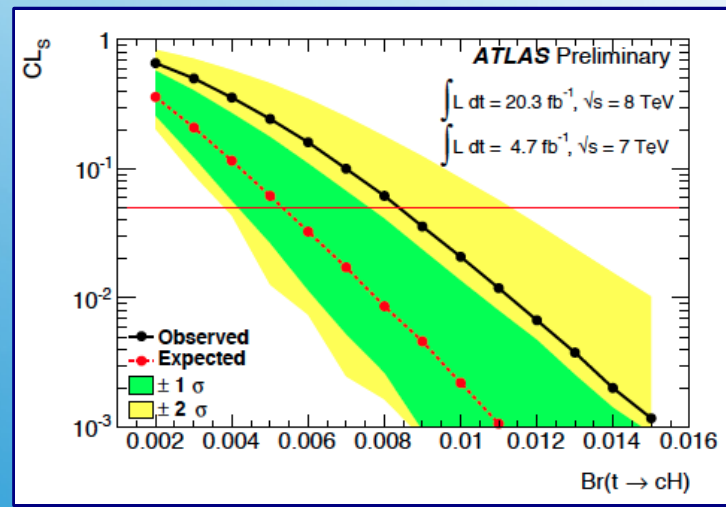
Quark-singlet model (QS) [6–8], 2HDM of type I with explicit flavour conservation (FC-2HDM), or 2HDM of type II, like MSSM [9–15], 2HDM without explicit flavour conservation (2HDM-III) [16–23]

Process	SM	QS	2HDM-III	FC-2HDM	MSSM
$t \rightarrow cH$	$3 \cdot 10^{-15}$	$4.1 \cdot 10^{-5}$	$1.5 \cdot 10^{-3}$	$\sim 10^{-5}$	10^{-5}

$tt \rightarrow (cH)(Wb) \rightarrow$ (c gamma-gamma) (lnu c)	8 TeV
$tt \rightarrow (cH)(Wb) \rightarrow$ (c gamma-gamma) (qq c)	7 TeV and 8 TeV



Single-lepton channel :
Lowest jet pT replaced by a lepton



$B(t \text{ to } cH)$

< 0.83%
observed

< 0.53%
expected



[ATLAS-CONF-2013-081]

Marco CARDACI

Search for Baryon Number Violating top decays

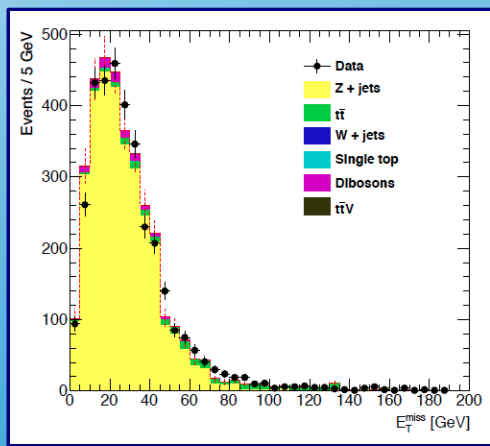
Small BNV can arise from non-perturbative effects in the SM [24]

Recent studies point to BNV top decays $t \rightarrow \bar{b} \bar{u} e^+$ ($\bar{t} \rightarrow b u e^-$) [25]

$t \rightarrow \bar{b} \bar{c} \mu^+$ ($\bar{t} \rightarrow b c \mu^-$)

Signature: 1 lepton + 5 jets + no MET

Cross check on MET modelling from $Z (\mu^+ \mu^-) + 4$ jets events



QCD background data-driven estimate:

$$N_{QCD} = R(N_{data}^{anti-iso} - N_{non-QCD}^{anti-iso})$$

from MC

$$R = f / (1 - f)$$

from DATA (fake rate)

$Z + 4$ jets $\rightarrow \mu^+ \mu^- + 4$ jets

2012 results (20 fb⁻¹ at 8 TeV):

	95% CL Upp. lim.	Exp. lim.	68% exp. lim. range
Muon ch.	0.0016	0.0029	[0.0017, 0.0042]
Electron ch.	0.0017	0.0031	[0.0018, 0.0045]
Combined	0.0015	0.0029	[0.0016, 0.0042]

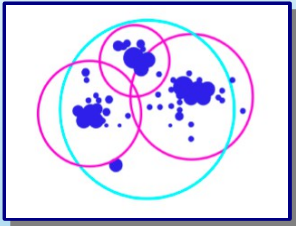


[CMS-PAS-B2G-12-023]

Marco CARDACI

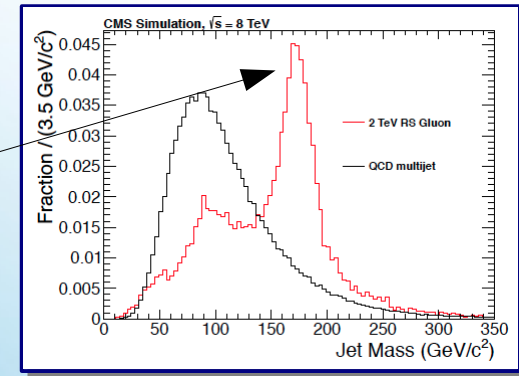
ttbar resonances in all hadronic

Highly boosted topologies - 2 fat jets in the final state:



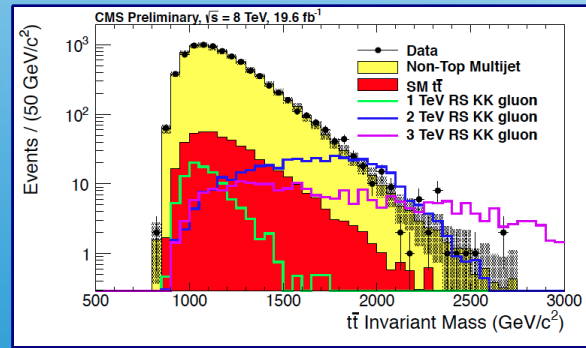
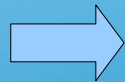
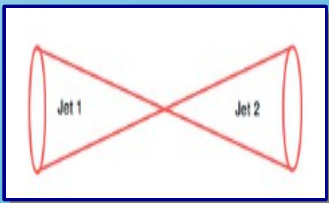
Top-tagging criteria:

- 3 or 4 subjets
- Fat-jet mass within [140, 250] GeV
- Minimum pair-wise subjet mass > 50 GeV



QCD background model from inversion of pair-wise mass cut:

Anti top-tagged jet Probe jet



to estimate mistag rate,
which is applied on 1 top-
tagged + X events

Type	Mass exclusions
Z' (10% width) [26]	< 2.7 TeV
Z' (1.2% width) [26]	< 2.1 TeV
KK-gluon [27]	< 2.5 TeV

$$\mathcal{S} = \frac{\int_{M_{t\bar{t}} > 1\text{TeV}/c^2} \frac{d\sigma_{SM+NP}}{dM_{t\bar{t}}} dM_{t\bar{t}}}{\int_{M_{t\bar{t}} > 1\text{TeV}/c^2} \frac{d\sigma_{SM}}{dM_{t\bar{t}}} dM_{t\bar{t}}}$$

$$\mathcal{S} < 1.79$$

Constraint of enhancements (i.e. top forward-backward charge asymmetry) in ttbar mass spectrum



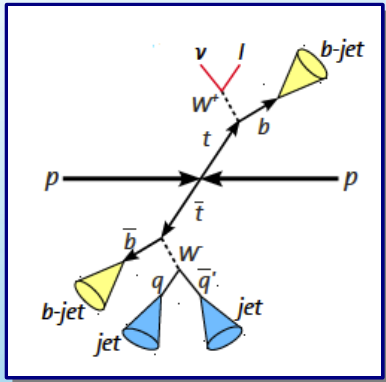
[CMS-PAS-B2G-12-005]

Marco CARDACI

$t\bar{t}$ resonances in $l + \text{jets}$

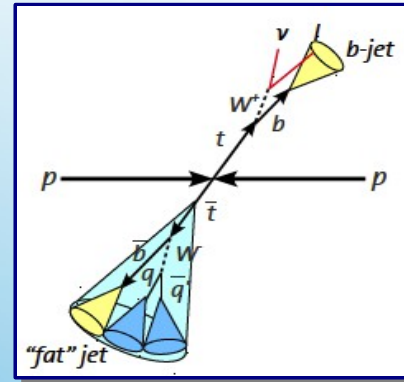
Boosted analysis

Two regimes are investigated and then merged:



Threshold analysis

- Background parametrization
- Morphing for signal model



- No isolation requirement on the lepton, instead:

$$\Delta R(\text{lepton, closest jet})$$

OR

$$p_T^{\text{rel}}(\text{lepton, closest jet}) > 25 \text{ GeV}$$

- Both analyses use χ^2 sorting for: jet assignment and neutrino disambiguation
- Both analyses apply a binned likelihood fit to the invariant mass to extract limits

Mass exclusions at 95% C.L.

Type	Mass
Z' (10% width) [26]	< 2.7 TeV
Z' (1.2% width) [26]	< 2.1 TeV
KK-gluon [27]	< 2.5 TeV

Cross section exclusions at 95% C.L.

Type \ Mass	0.5 TeV	2 TeV
Z' (10% width)	< 1.71 pb	< 0.045 pb
Z' (1.2% width)	< 1.94 pb	< 0.029 pb
KK-gluon	-	< 0.101 pb



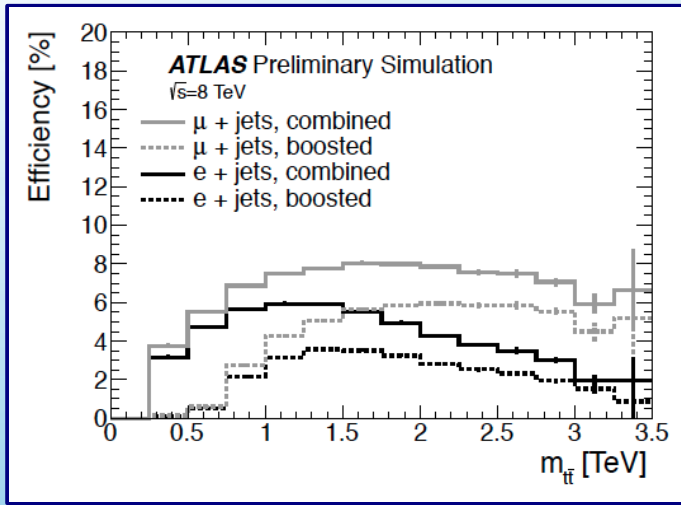
[CMS-PAS-B2G-12-006]

Marco CARDACI

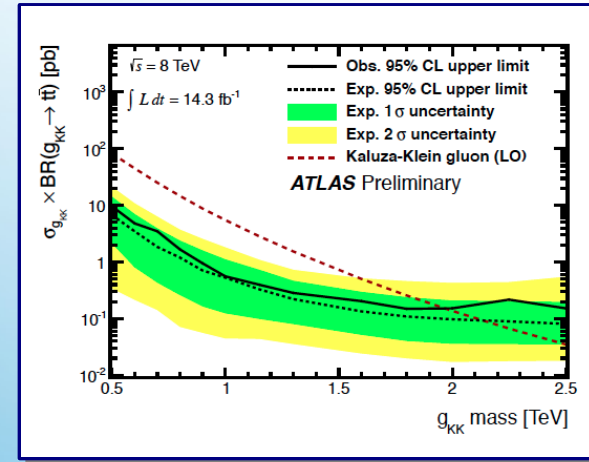
ttbar resonances in l + jets

7 TeV analysis
 Phys. Rev. D 88,
 012004 (2013)

- KK-gluon (15.3% width) [28]

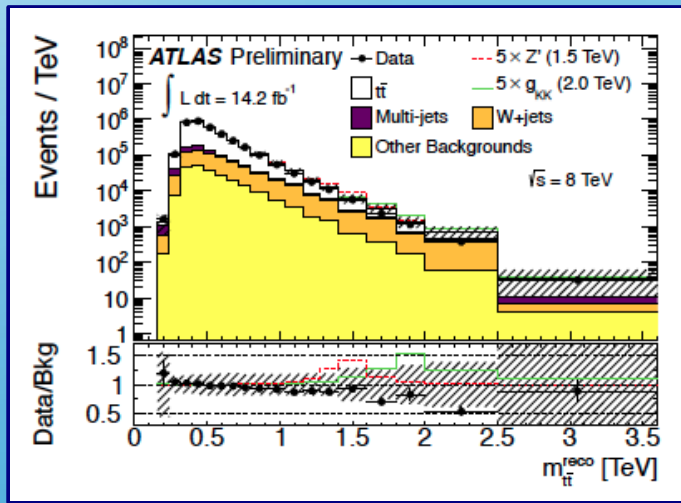


- Boosted and resolved channels considered



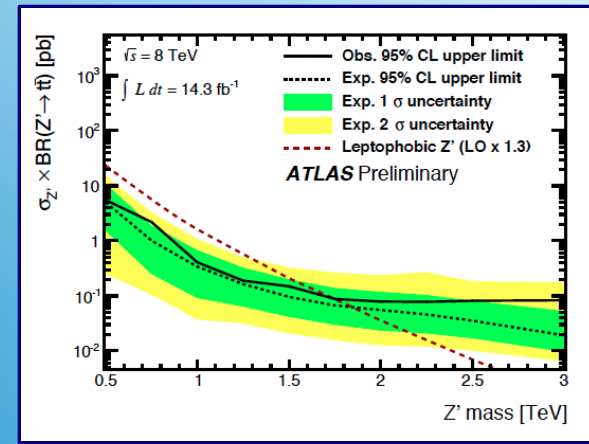
$M_{g(KK)} > 2.0$ TeV

(not directly comparable with the measurement from CMS)



- Bump hunter scan taking into account LEE

- Topocolor Z' (1.2% width) [26]



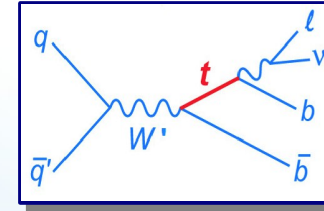
$M_{Z'} > 1.8$ TeV



[ATLAS-CONF-2013-052]

Marco CARDACI

W' to tb

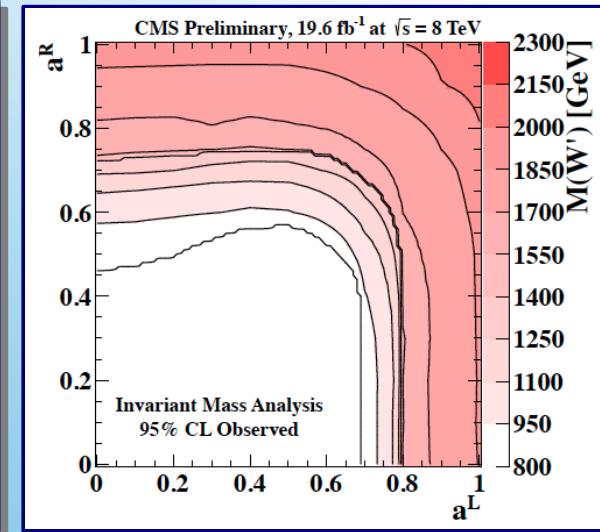
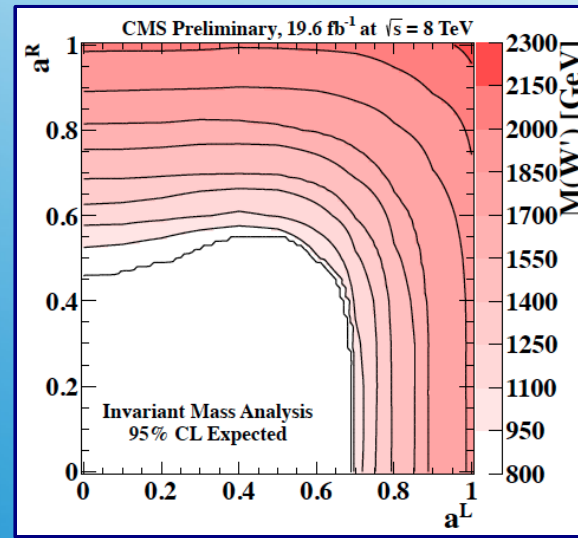
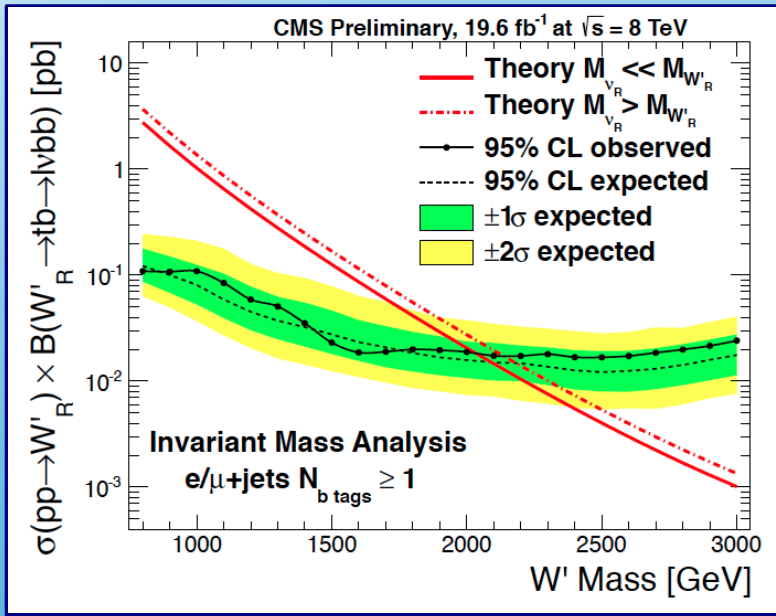


Theory motivations: Little Higgs, Extra Dimensions, Extended Technicolor, L-R Symmetry [29 - 33]

- Limits on the general couplings (left-handed component implies mixing with SM) [34]

- $M_{W'} > 2.03$ TeV for right-handed W'

$$\mathcal{L} = \frac{V_{fifj}}{2\sqrt{2}} g_w \bar{f}_i \gamma_\mu (a_{fifj}^R (1 + \gamma^5) + a_{fifj}^L (1 - \gamma^5)) W'^\mu f_j + \text{H.c.}$$



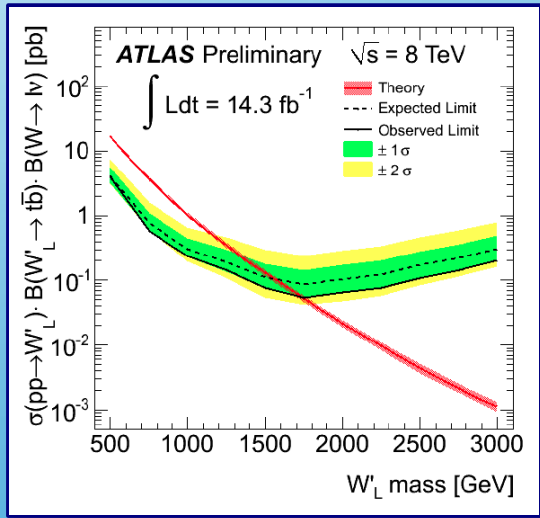
[CMS-PAS-B2G-12-010]

Marco CARDACI

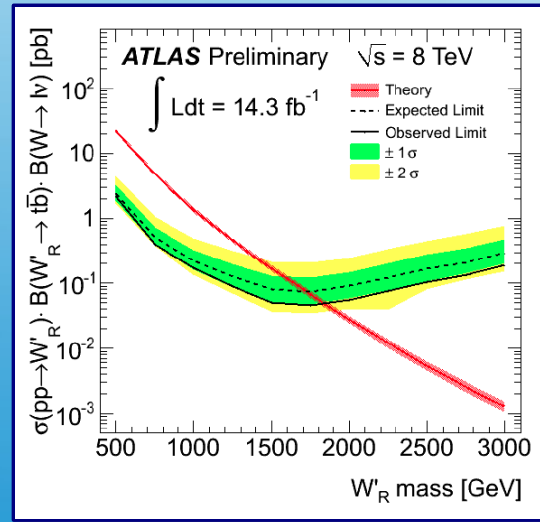
W' to tb

- Two categories: 2 jets 2 b-tags, 3 jets 2 b-tags
- Boosted Decision Tree discrimination
- Limits valid for the theoretical model (same as CMS) [34]:

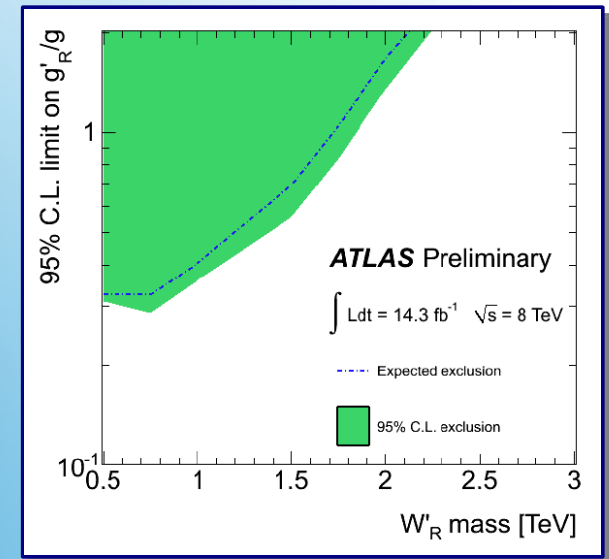
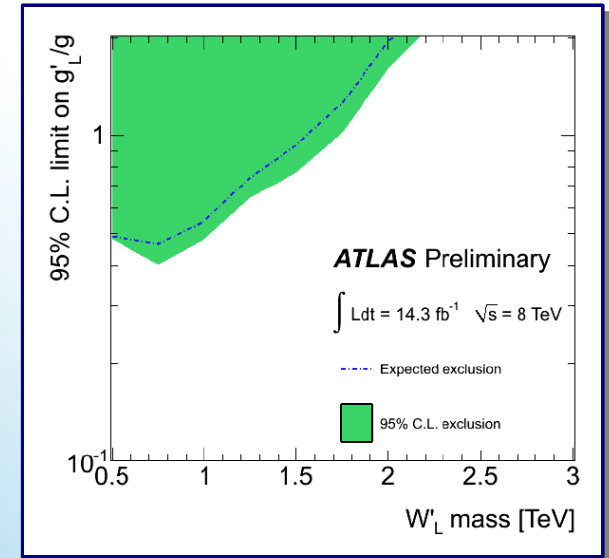
$$\mathcal{L} = \frac{V'_{ij}}{2\sqrt{2}} \bar{f}_i \gamma_\mu (g'_{Ri,j}(1 + \gamma^5) + g'_{Li,j}(1 - \gamma^5)) W'^\mu f_j + h.c.$$



$M_{W'(L)} > 1.74 \text{ TeV}$

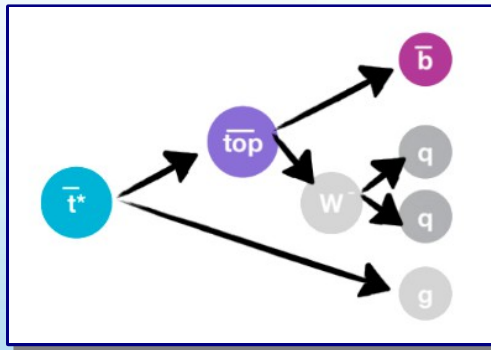
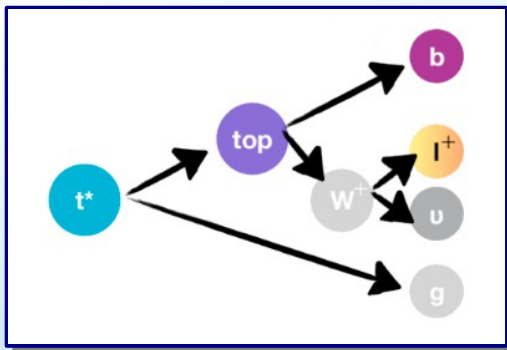


$M_{W'(R)} > 1.84 \text{ TeV}$



[ATLAS-CONF-2013-050]

Marco CARDACI



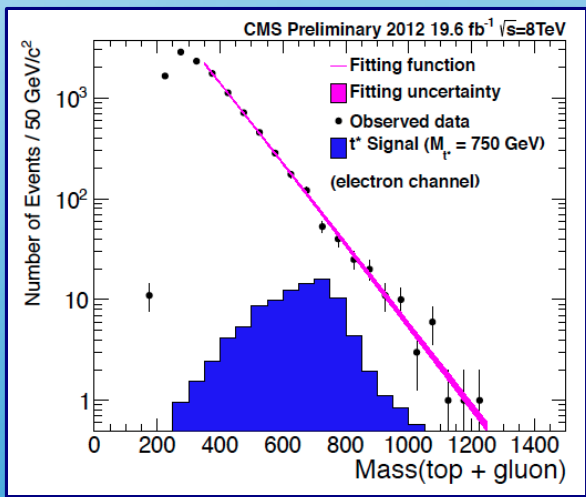
T* to top + gluon

Result given for spin 3/2 RS T* [35]

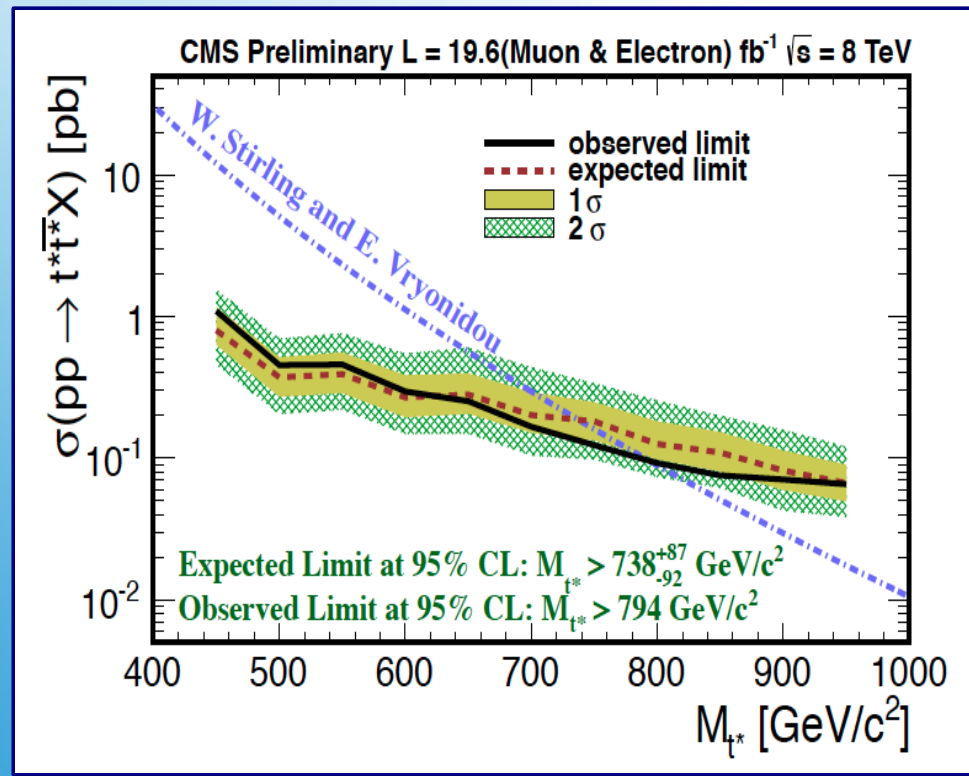
$$M_{T^*} > 794 \text{ GeV}$$

Fermi-like function modelling the SM sources

$$f(x) = \frac{a}{1 + e^{\frac{x-b}{c}}}$$



Only showing electron channel here!

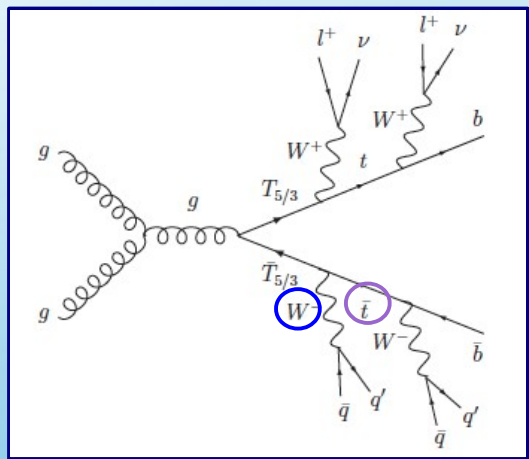


[CMS-PAS-B2G-12-014]

Marco CARDACI

Search of $T_{5/3}$ in SS dilepton

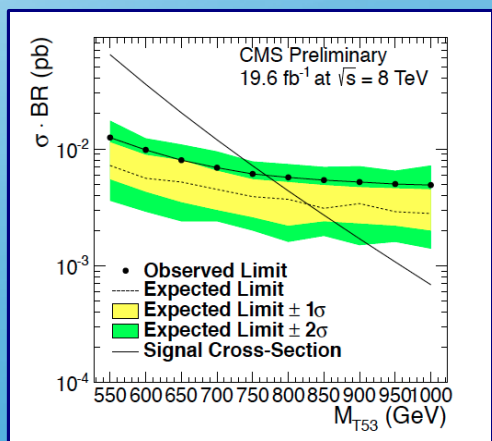
$T_{5/3}$ top partners of exotic charge [36 - 39]



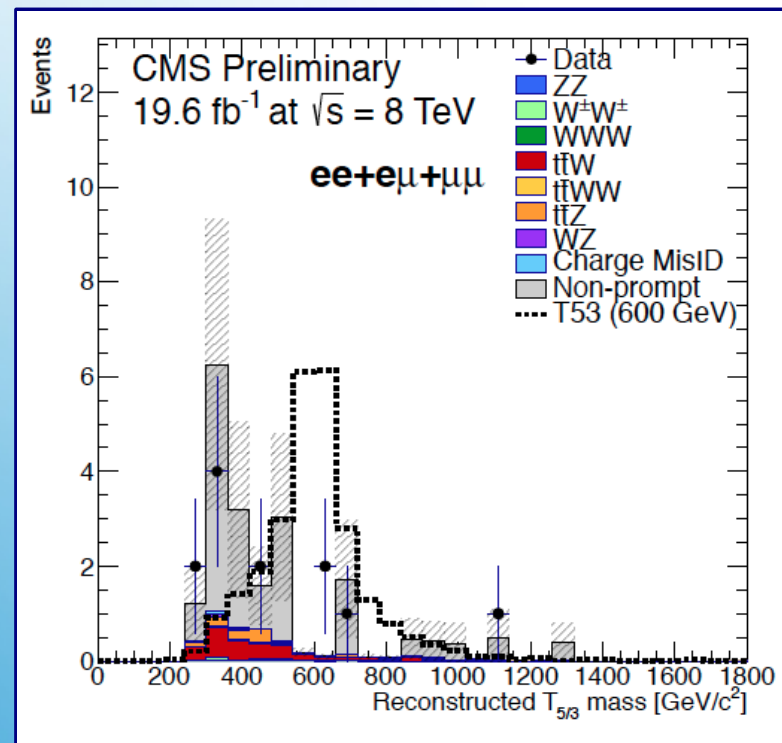
Top-tagging as in Z' analysis

W tagging:
 - 2 subjects
 - M within [60, 130] GeV

+



$M_{T(5/3)} > 770$ GeV



[CMS-PAS-B2G-12-012]

Marco CARDACI

b' [40] T, B Vector-like Quarks [41], 4 top quark production [42], sgluons [43 - 49], UED [50], positively charged top pair [51, 52]

SS dilepton searches

Selection:

- exactly 2 SS leptons (and Z veto for SF)
- 2 jets
- at least 1 b-tag
- MET > 40 GeV
- $H_T > 550$ GeV

Optimization:

- $H_T > 650$ GeV

for b' and VLQ searches

- $H_T > 650$ GeV and at least 2 b-tags

for 4 top enhancement

- Positive charge leptons

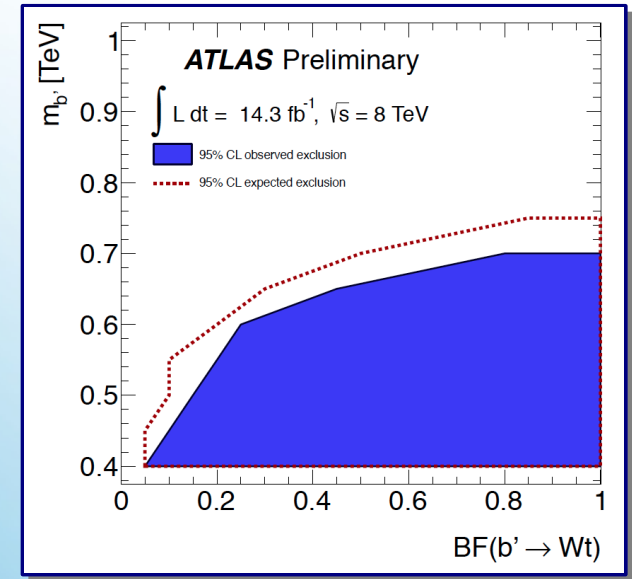
for 2 positively charged top quark production

$$BR(b' \rightarrow Wt) = 1$$

$$M_{b'} > 720 \text{ GeV}$$

$$M_{B(\text{singlet})} > 590 \text{ GeV}$$

$$M_{T(\text{singlet})} > 540 \text{ GeV}$$



Non resonant results

- 4 top quarks

$$M_{\text{sgluon}} > 800 \text{ GeV}$$

$$M_{KK} > 900 \text{ GeV}$$

(pair production)

$$m_{KK} \equiv \frac{1}{R_4}$$

- Exchange of heavy particles via s- and t-channels

$$uu \rightarrow tt$$

prevalently

Model	95% C.L. upper limit		
	$\sigma(pp \rightarrow t\bar{t}\bar{t})$ [fb]		$ C /\Lambda^2$ [TeV ⁻²]
	Expected 1σ range	Observed	Observed
Standard Model	43-89	85	—
Contact interaction	29-61	59	15

Chirality configuration	95% C.L. upper limit		
	$\sigma(pp \rightarrow tt)$ [pb]		$ C /\Lambda^2$ [TeV ⁻²]
	Expected 1σ range	Observed	Observed
Left-left	0.14-0.28	0.19	0.092
Left-right	0.15-0.30	0.20	0.271
Right-right	0.15-0.32	0.21	0.099



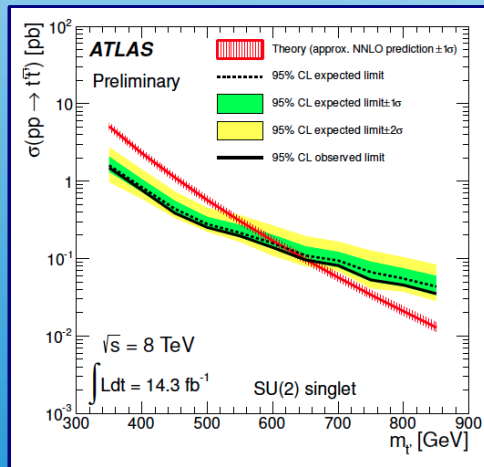
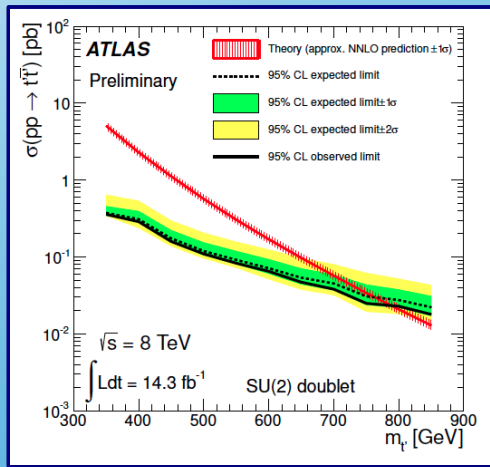
[ATLAS-CONF-2013-051]

Marco CARDACI

Search for T Vector-Like Quark

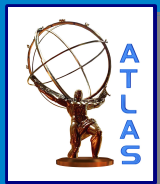
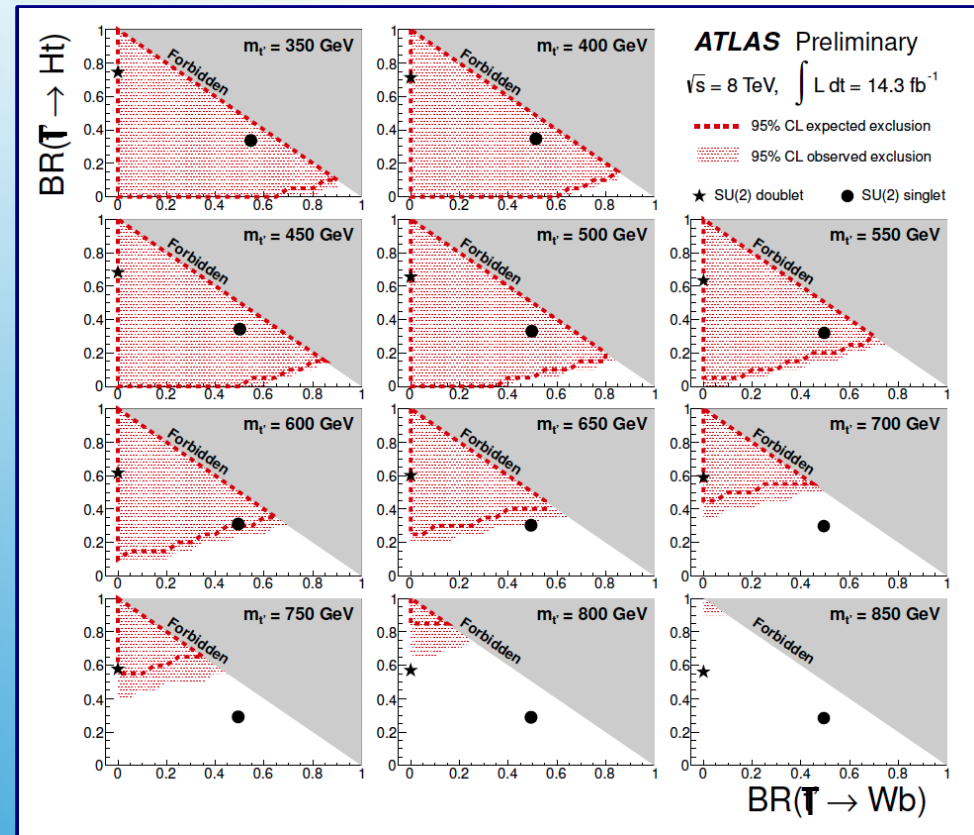
- T (singlet or doublet) to bW, tH and tZ [53] in single lepton channel and ≥ 2 b-tags: **focusing on T to Ht to (bb)**
- Fit SF of $t\bar{t}$ + LF and $t\bar{t}$ + HF for $H_T < 700$ GeV
- Backgrounds from Matrix Method and W charge asymmetry
- Log-Likelihood Ratio as test-statistics

$$LLR = -2 \log(L_{s+b}/L_b)$$



$M_{T(\text{doublet})} > 790 \text{ GeV}$

$M_{T(\text{singlet})} > 640 \text{ GeV}$

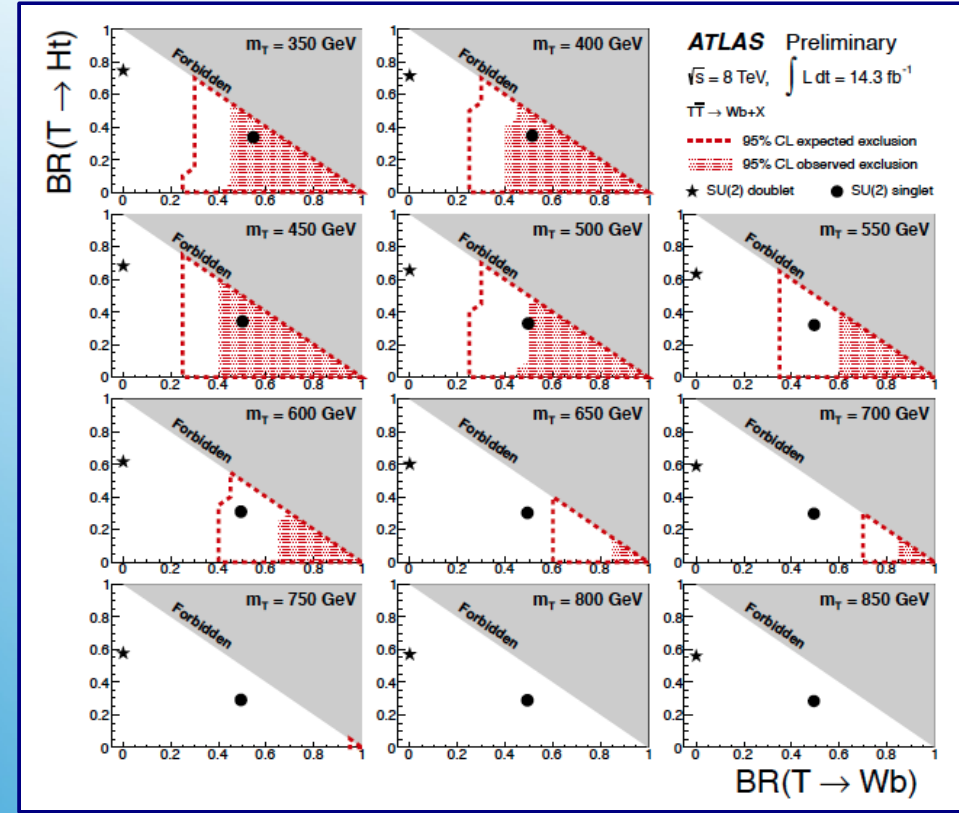
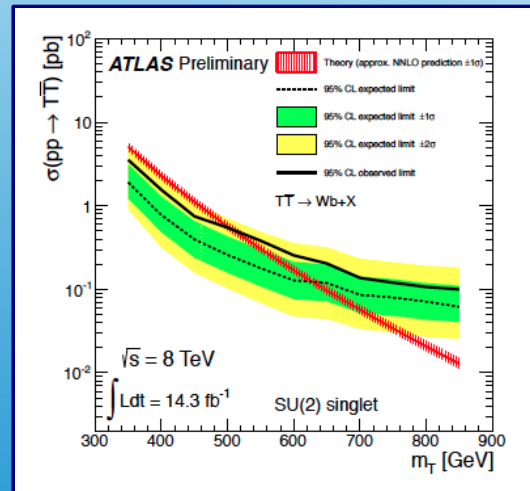
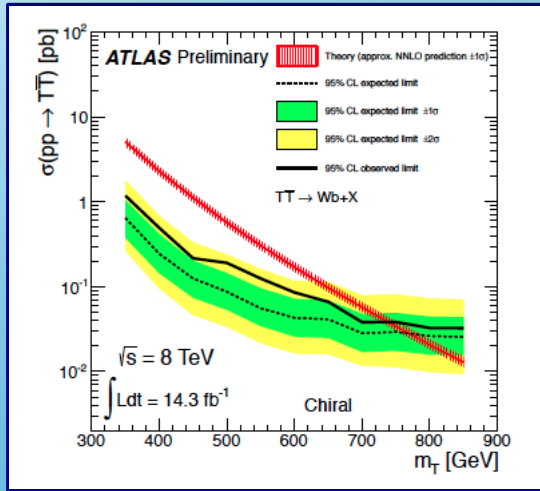


[ATLAS-CONF-2013-018]

Marco CARDACI

Search for t' Chiral 4th Gen. & T Vector-Like Quarks

- Single-lepton and 1 \geq b-jet: **focusing on T to Wb**
- Complementary to previous analysis: ≥ 6 jets and ≥ 3 b-tag
- Backgrounds from Matrix Method and W charge asymmetry
- Log-Likelihood Ratio as test-statistics



$M_{t'} > 740$ GeV [54, 55]
valid also for $Y(-4/3)$

$M_{T(\text{singlet})} > 505$ GeV



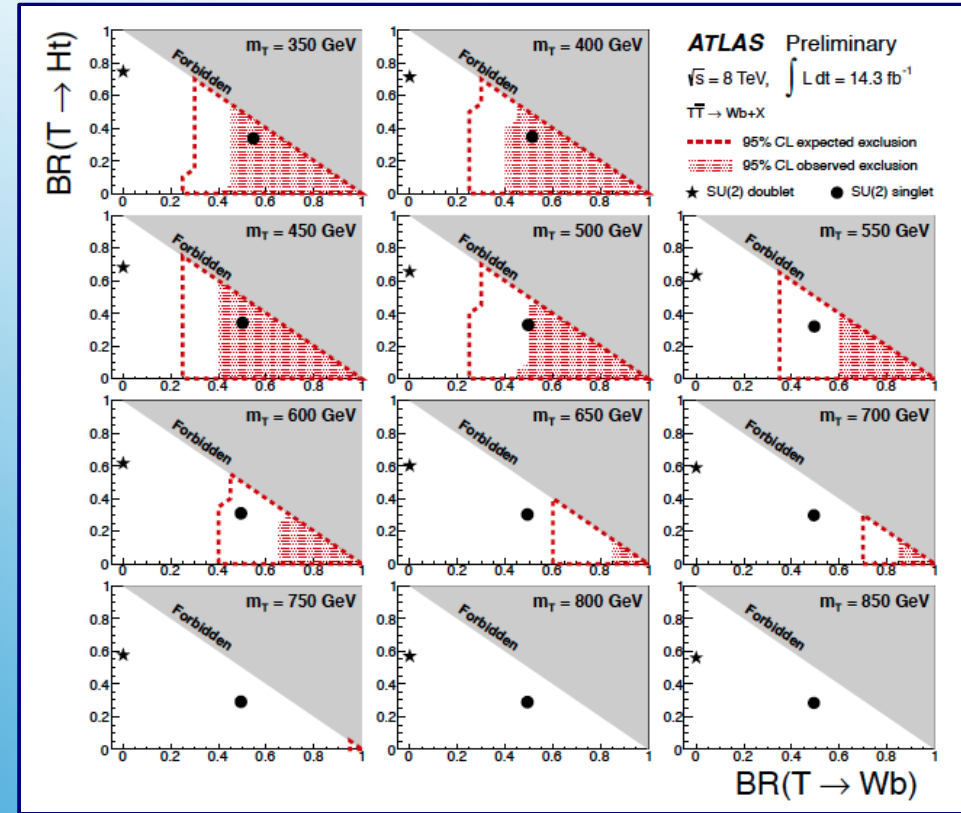
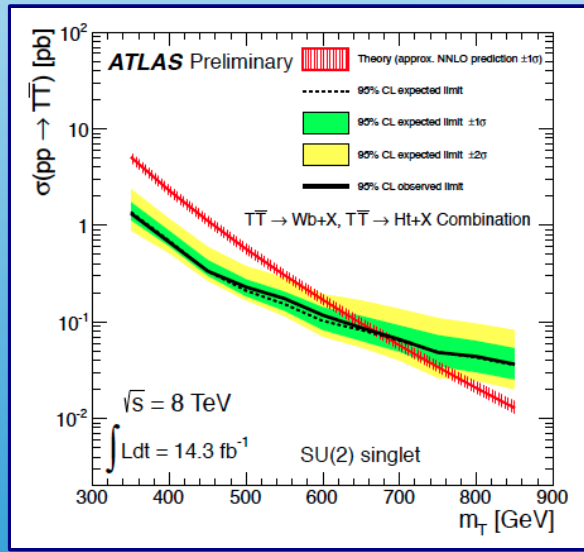
[ATLAS-CONF-2013-060]

Marco CARDACI

Search for t' Chiral 4th Gen. & T Vector-Like Quarks

- Single-lepton and 1 \geq b-jet: **focusing on T to Wb**
- Complementary to previous analysis: ≥ 6 jets and ≥ 3 b-tag
- Backgrounds from Matrix Method and W charge asymmetry
- Log-Likelihood Ratio as test-statistics

Combination
with
previous
analysis



$$M_{T(\text{singlet})} > 640 \text{ GeV [ATLAS-CONF-2013-018]}$$

$$M_{T(\text{singlet})} > 505 \text{ GeV [ATLAS-CONF-2013-060]}$$



$$M_{T(\text{singlet})} > 670 \text{ GeV}$$

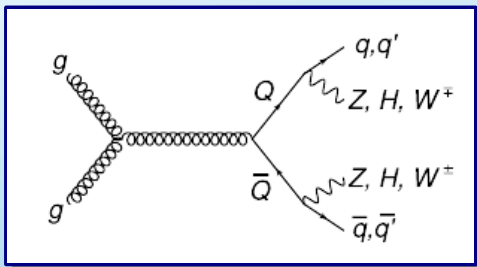


[ATLAS-CONF-2013-060]

Marco CARDACI

Search for T & B Vector-Like Quark

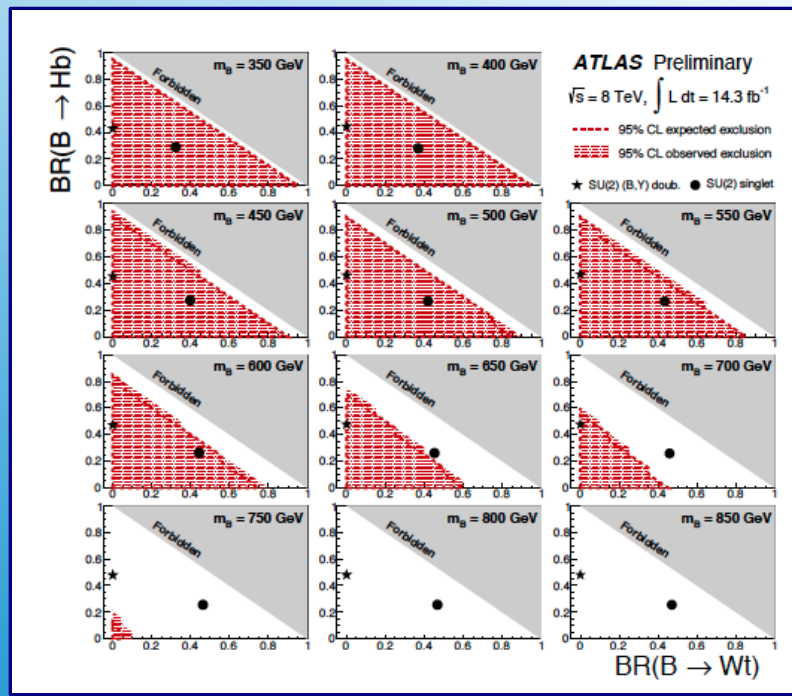
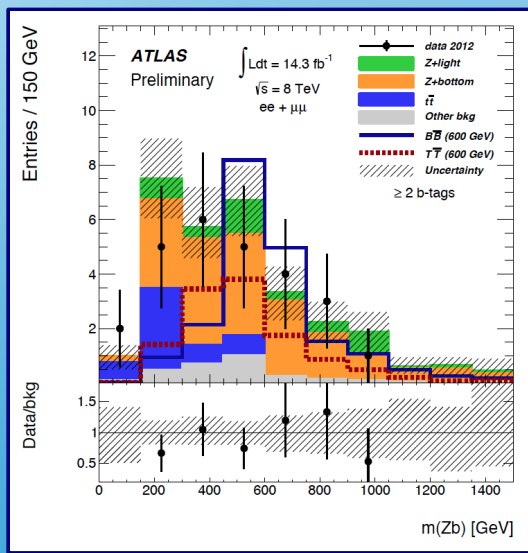
Di-lepton and ≥ 2 b-tags: focusing on T to Zt & B to Zb



	singlet	doublet (*)
M_T	> 585 GeV	> 680 GeV
M_B	> 645 GeV	> 725 GeV

(*): T of an (X, T) doublet or B of an (B, Y) doublet with $X(+5/3)$ and $Y(-4/3)$

No significant signal-like excess observed in the invariant mass distribution :



2D limits on B VLQ

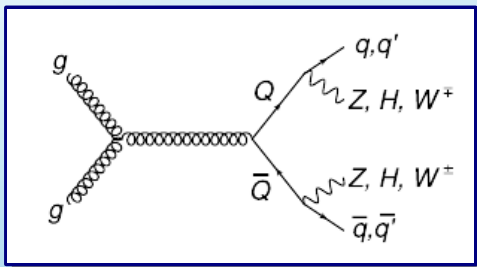


[ATLAS-CONF-2013-056]

Marco CARDACI

Search for T & B Vector-Like Quark

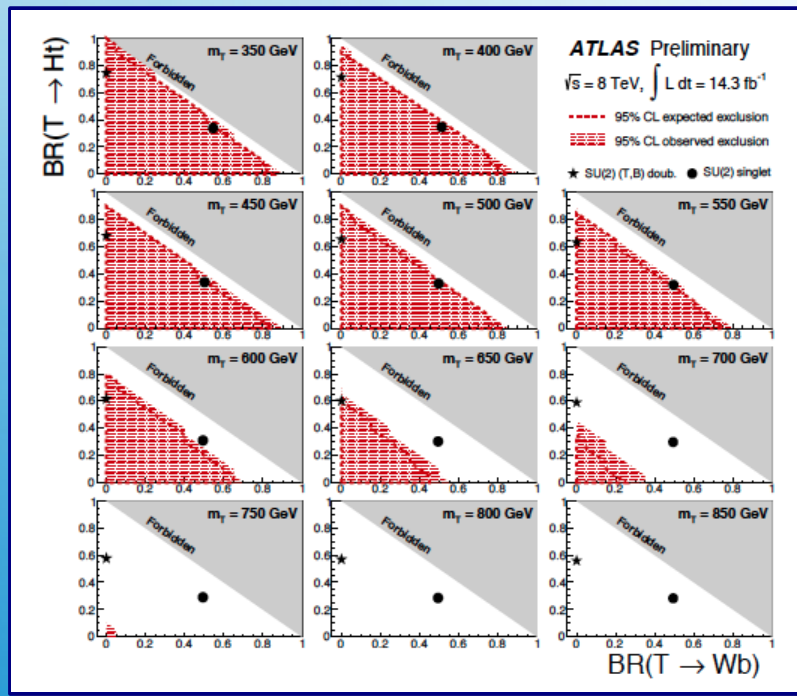
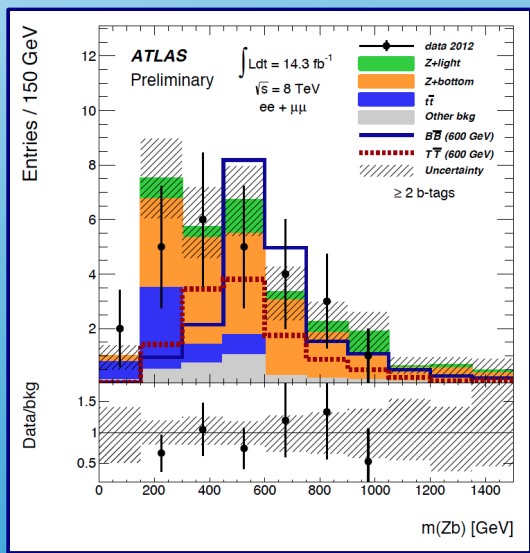
Di-lepton and ≥ 2 b-tags: focusing on T to Zt & B to Zb



	singlet	doublet (*)
M_T	> 585 GeV	> 680 GeV
M_B	> 645 GeV	> 725 GeV

(*): T of an (X, T) doublet or B of an (B, Y) doublet with $X(+5/3)$ and $Y(-4/3)$

No significant signal-like excess observed in the invariant mass distribution :



2D limits on T VLQ

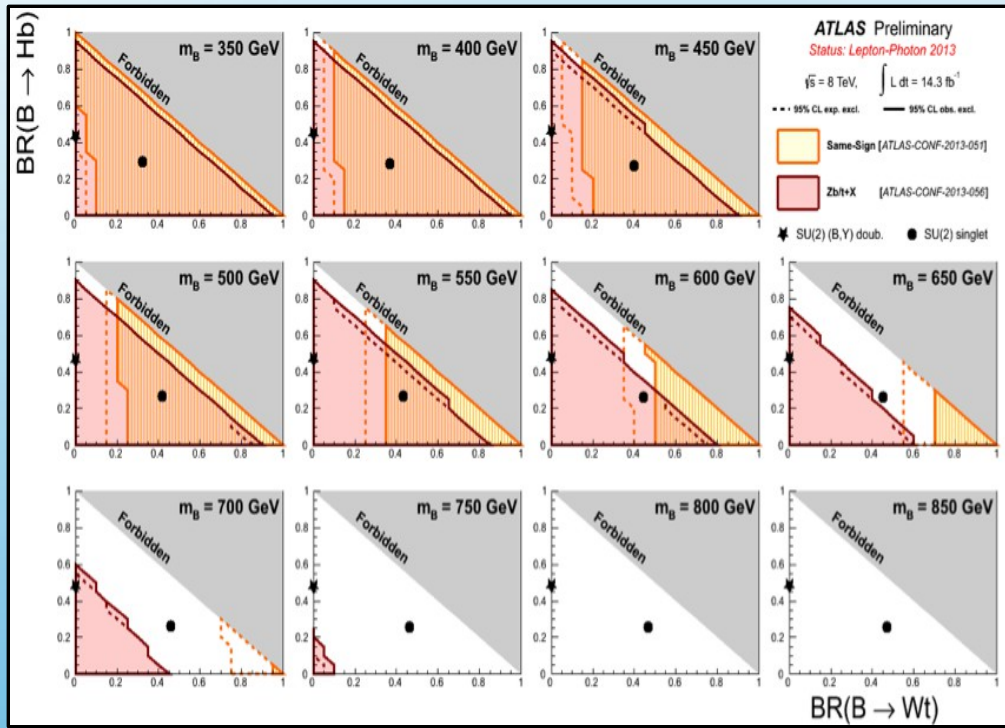


[ATLAS-CONF-2013-056]

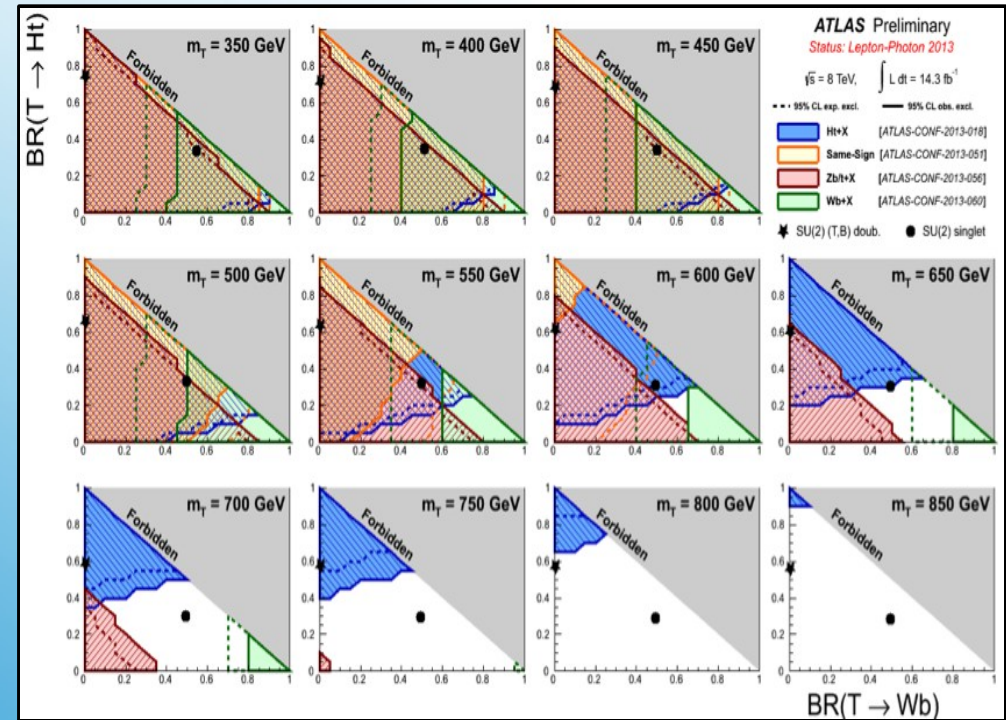
Marco CARDACI

Search for T & B Vector-Like Quark

B exclusion limits



T exclusion limits



[ATLAS-CONF-2013-018 / 51 / 56 / 60]

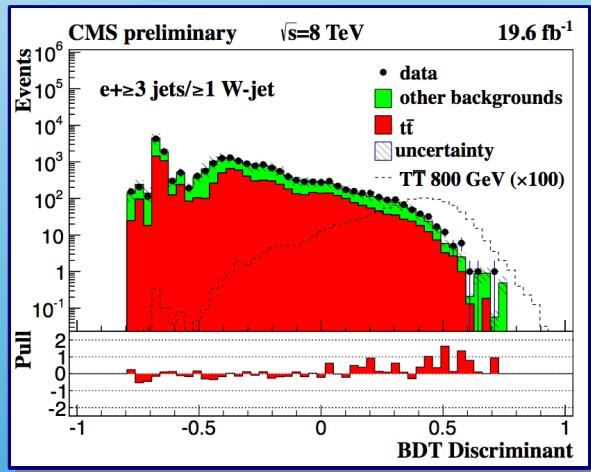
Marco CARDACI

Inclusive search for T Vector-Like Quark

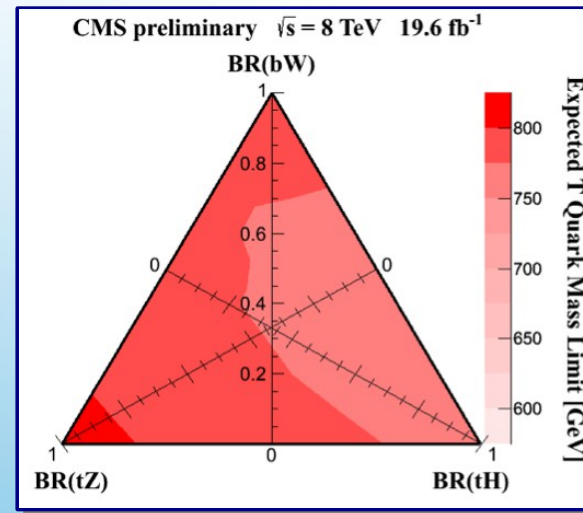
Single-lepton, OS and SS dileptons and tri-lepton channels

- Instrumental backgrounds such as non-prompt and charge mis-identified are estimated from data

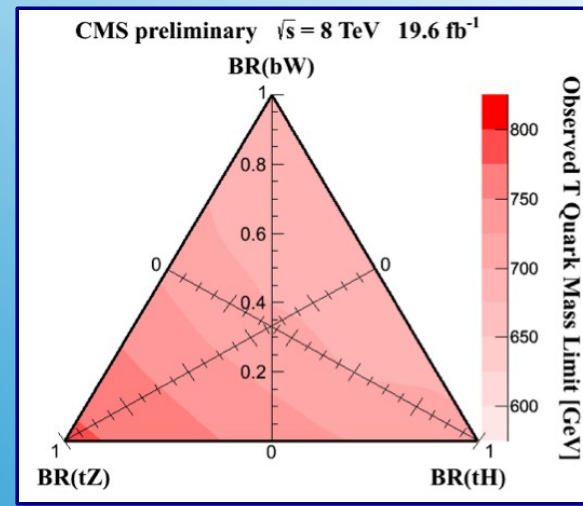
- BDT discriminant used for **single-lepton channel** based on: Jet multiplicity, b-tag multiplicity, H_T , missing p_T , lepton p_T , p_T of the 3rd jet & p_T of the 4th jet



- 4 **single-lepton** categories:
(Electron, Muon) \times (≥ 1 W-jets, 0 W-jets)
where W-jet is a CA jet that consists of 2 sub-jets



Limits computed using bayesian statistics



Observed Exclusion Limits are between:
 $M_T > 782$ GeV
 $M_T > 687$ GeV



[CMS-PAS-B2G-12-015]

Marco CARDACI

Summary

Analysis	Exp.	Result	Result
$R = B(t \text{ to } Wb) / B(t \text{ to } Wq)$	CMS	$R = 1.023 +0.036/-0.034$	$R > 0.945 (R \leq 1)$
$R = B(t \text{ to } Wb) / B(t \text{ to } Wq)$	CMS	$ V_{tb} = 1.011 +0.018/-0.017$ (CKM unitarity)	$ V_{tb} > 0.972$ (CKM unitarity)
FCNC	CMS	$B(t \text{ to } qZ) < 0.07\%$	
BNV	CMS	$B(t \text{ to } bue/bcm) < 0.15 \%$	
FCNC	ATLAS	$B(t \text{ to } cH) < 0.83\%$	
Topcolor Z' (10% width)	CMS	$M > 2.3 \text{ TeV}$ (hadronic analysis)	$M > 2.7 \text{ TeV}$ (semilep. analysis)
Topcolor Z' (1.2% width)	CMS	$M > 1.6 \text{ TeV}$ (hadronic analysis)	$M > 2.1 \text{ TeV}$ (semilep. analysis)
KK-gluon (mass dependent width)	CMS	$M > 1.8 \text{ TeV}$ (hadronic analysis)	$M > 2.5$ (semilep. analysis)
Topcolor Z' (1.2% width)	ATLAS		$M > 1.8 \text{ TeV}$ (semilep. analysis)
KK-gluon (15.3% width)	ATLAS		$M > 2 \text{ TeV}$ (semilep. analysis)
W' to tb	CMS	$M > 2.03 \text{ TeV}$ (right-handed)	
W' to tb	ATLAS	$M > 1.84 \text{ TeV}$ (right-handed)	$M > 1.74 \text{ TeV}$ (left-handed)
T^*	CMS	$M > 0.794 \text{ TeV}$	
$T_{5/3}$	CMS	$M > 0.770 \text{ TeV}$	
b'	ATLAS	$M > 0.720 \text{ TeV}$	
T	CMS	$M > 0.782 \text{ TeV}$ (singlet)	
T	ATLAS	$M > 0.670 \text{ TeV}$ (singlet)	$M > 0.790 \text{ TeV}$ (doublet)
B	ATLAS	$M > 0.645 \text{ TeV}$ (singlet)	$M > 0.725 \text{ TeV}$ (doublet)
Other non-resonant	ATLAS	$M(\text{sgluon}) > 0.800 \text{ TeV}$	$M(\text{KK mass}) > 0.900 \text{ TeV}$

References

- [1] J. Beringer and others (Particle Data Group), “Review of Particle Physics (RPP)”, Phys.Rev. D86 (2012) 010001, doi:10.1103/PhysRevD.86.010001.
- [2] D0 Collaboration, “Precision measurement of the ratio $B(t \text{ to } Wb)/B(t \text{ to } Wq)$ ”, Phys. Rev. Lett. 107 (2011) 121802, doi:10.1103/PhysRevLett.107.121802, arXiv:1106.5436.
- [3] J. A. Aguilar-Saavedra et al., “Top quark physics”, Acta Phys. Polon. B 35 (2004) 2671, arXiv:hep-ph/0410110.
- [4] J. A. Aguilar-Saavedra, “Top flavor changing neutral coupling signals at a linear collider”, Phys. Lett. B 502 (2001) 115, doi:10.1016/S0370-2693(01)00162-9, arXiv:hep-ph/0012305.
- [5] G. Lu et al., “Rare top quark decays $t \text{ to } cV$ in the topcolor assisted technicolor model”, Phys. Rev. D 68 (2003) 015002, doi:10.1103/PhysRevD.68.015002, arXiv:hep-ph/0303122.

References

- [6] J. A. Aguilar-Saavedra and B. M. Nobre, Rare top decays $t \rightarrow c\gamma$, $t \rightarrow cg$ and CKM unitarity, Phys. Lett. B553 (2003) 251–260, arXiv:hep-ph/0210360.
- [7] F. del Aguila, J. A. Aguilar-Saavedra, and R. Miquel, Constraints on top couplings in models with exotic quarks, Phys. Rev. Lett. 82 (1999) 1628, arXiv:hep-ph/9808400.
- [8] J. A. Aguilar-Saavedra, Effects of mixing with quark singlets, Phys. Rev. D67 (2003) 035003, arXiv:hep-ph/0210112. Erratum-ibid. D 69 (2004) 099901.
- [9] C. S. Li, R. J. Oakes, and J. M. Yang, Rare decay of the top quark in the minimal supersymmetric model, Phys. Rev. D49 (1994) 293–298. Erratum-ibid.D56:3156,1997.
- [10] G. M. de Divitiis, R. Petronzio, and L. Silvestrini, Flavour changing top decays in supersymmetric extensions of the standard model, Nucl. Phys. B504 (1997) 45–60, arXiv:hep-ph/9704244.
- [11] J. L. Lopez, D. V. Nanopoulos, and R. Rangarajan, New supersymmetric contributions to $t \rightarrow c\gamma$, Phys. Rev. D56 (1997) 3100–3106, arXiv:hep-ph/9702350.

References

[12] J. Guasch and J. Sola, FCNC top quark decays: A door to SUSY physics in high luminosity colliders?, Nucl. Phys. B562 (1999) 3–28, arXiv:hep-ph/9906268.

[13] D. Delepine and S. Khalil, Top flavour violating decays in general supersymmetric models, Phys. Lett. B599 (2004) 62–74, arXiv:hep-ph/0406264.

[14] J. J. Liu, C. S. Li, L. L. Yang, and L. G. Jin, $t \rightarrow c\nu$ via SUSY FCNC couplings in the unconstrained MSSM, Phys. Lett. B599 (2004) 92–101, arXiv:hep-ph/0406155.

[15] J. J. Cao et al., SUSY-induced FCNC top-quark processes at the Large Hadron Collider, Phys. Rev. D75 (2007) 075021, arXiv:hep-ph/0702264.

[16] T. P. Cheng and M. Sher, Mass Matrix Ansatz and Flavor Nonconservation in Models with Multiple Higgs Doublets, Phys. Rev. D35 (1987) 3484.

[17] B. Grzadkowski, J. F. Gunion, and P. Krawczyk, Neutral current flavor changing decays for the Z boson and the top quark in two Higgs doublet models, Phys. Lett. B268 (1991) 106–111.

References

- [18] M. E. Luke and M. J. Savage, Flavor changing neutral currents in the Higgs sector and rare top decays, *Phys. Lett. B* 307 (1993) 387, arXiv:hep-ph/9303249.
- [19] D. Atwood, L. Reina, and A. Soni, Phenomenology of two Higgs doublet models with flavor changing neutral currents, *Phys. Rev. D* 55 (1997) 3156–3176, arXiv:hep-ph/9609279.
- [20] S. Bejar, J. Guasch, and J. Sola, Loop induced flavor changing neutral decays of the top quark in a general two-Higgs-doublet model, *Nucl. Phys. B* 600 (2001) 21–38, arXiv:hep-ph/0011091.
- [21] I. Baum, G. Eilam, and S. Bar-Shalom, Scalar FCNC and rare top decays in a two Higgs doublet model “for the top”, *Phys. Rev. D* 77 (2008) 113008, arXiv:hep-ph/0802.2622.
- [22] K.-F. Chen, W.-S. Hou, C. Kao, and M. Kohda, When the Higgs meets the Top; Search for $t \rightarrow cH$ at the LHC, arXiv:hep-ph/1304.8037.
- [23] D. Atwood, S.-K. Gupta, and A. Soni, Constraining the flavor changing Higgs couplings to the top-quark at the LHC, arXiv:hep-ph/1305.2427.

References

- [24] G. 't Hooft, "Symmetry Breaking through Bell-Jackiw Anomalies", Phys. Rev. Lett. 37(1976) 8–11, doi:10.1103/PhysRevLett.37.8.
- [25] Z. Dong et al., "Baryon number violation at the LHC: the top option", Phys.Rev. D85 385 (2012) 016006, arXiv:1107.3805.
- [26] R. M. Harris, C. T. Hill, and S. J. Parke, Cross section for topcolor Z' (t) decaying to $t\bar{t}$, arXiv:9911288 [hep-ph]. R. M. Harris and S. Jain, Cross Sections for Leptophobic Topcolor Z' Decaying to Top-Antitop, Eur. Phys. J. C72 (2012) 2072, arXiv:1112.4928 [hep-ph].
- [27] K. Agashe et al., "CERN LHC signals from warped extra dimensions", Phys. Rev. D 77 (2008) 015003, doi:10.1103/PhysRevD.77.015003.
- [28] B. Lillie, L. Randall, and L.-T. Wang, The Bulk RS KK-gluon at the LHC, JHEP 09 (2007) 074, arXiv:hep-ph/0701166.
- [29] M. Schmaltz and D. Tucker-Smith, "LITTLE HIGGS THEORIES", Annual Review of Nuclear and Particle Science 55 (2005), no. 1, 229–270, doi:10.1146/annurev.nucl.55.090704.151502.

References

- [30] T. Appelquist, H.-C. Cheng, and B. A. Dobrescu, “Bounds on universal extra dimensions”, Phys. Rev. D 64 (Jun, 2001) 035002, doi:10.1103/PhysRevD.64.035002.
- [31] H.-C. Cheng et al., “Standard model in the latticized bulk”, Phys. Rev. D 64 (Aug, 2001) 065007, doi:10.1103/PhysRevD.64.065007.
- [32] R. S. Chivukula, E. H. Simmons, and J. Terning, “Limits on noncommuting extended technicolor”, Phys. Rev. D 53 (May, 1996) 5258–5267, doi:10.1103/PhysRevD.53.5258.
- [33] R. N. Mohapatra and J. C. Pati, “Left-right gauge symmetry and an ‘isoconjugate’ model of CP violation”, Phys. Rev. D 11 (Feb, 1975) 566–571, doi:10.1103/PhysRevD.11.566.
- [34] Z. Sullivan, “Fully differential W production and decay at next-to-leading order in QCD”, Phys. Rev. D 66 (2002) 075011, doi:10.1103/PhysRevD.66.075011, arXiv:hep-ph/0207290.
- [35] W. Stirling and E. Vryonidou, “Effect of spin-3/2 top quark excitation on $t\bar{t}$ production at the LHC”, JHEP 1201 (2012) 055, doi:10.1007/JHEP01(2012)055, arXiv:1110.1565. Cross sections at $\sqrt{s} = 8$ TeV obtained through private communication.

References

- [36] K. Agashe, R. Contino, L. Da Rold and A. Pomarol, A custodial symmetry for Zbb , Phys. Lett. B 641 (2006) 62 [hep-ph/0605341].
- [37] R. Contino, L. Da Rold and A. Pomarol, Light custodians in natural composite Higgs models, Phys. Rev. D 75 (2007) 055014 [hep-ph/0612048].
- [38] M.S. Carena, E. Ponton, J. Santiago and C.E.M. Wagner, Light Kaluza-Klein states in Randall-Sundrum models with custodial $SU(2)$, Nucl. Phys. B 759 (2006) 202 [hep-ph/0607106]; A.D. Medina, N.R. Shah and C.E.M. Wagner, Gauge-Higgs unification and radiative electroweak symmetry breaking in warped extra dimensions, Phys. Rev. D 76 (2007) 095010 [arXiv:0706.1281].
- [39] G. Panico, E. Ponton, J. Santiago and M. Serone, Dark matter and electroweak symmetry breaking in models with warped extra dimensions, arXiv:0801.1645.
- [40] S. Bar-Shalom, M. Geller, S. Nandi, and A. Soni, Two Higgs doublets, a 4th generation and a 125 GeV Higgs, arXiv:1208.3195 [hep-ph].
- [41] R. S. Chivukula, B. A. Dobrescu, H. Georgi, and C. T. Hill, Top quark seesaw theory of electroweak symmetry breaking, Phys.Rev. D59 (1999) 075003, arXiv:hep-ph/9809470 [hep-ph].

References

- [42] C. Degrande, J.-M. Gerard, C. Grojean, F. Maltoni, and G. Servant, Non-resonant New Physics in Top Pair Production at Hadron Colliders, JHEP 1103 (2011) 125, arXiv:1010.6304 [hep-ph].
- [43] T. Plehn and T. M. Tait, Seeking Sgluons, J.Phys. G36 (2009) 075001, arXiv:0810.3919 [hep-ph].
- [44] S. Choi, M. Drees, J. Kalinowski, J. Kim, E. Popena, et al., Color-Octet Scalars of N=2 Supersymmetry at the LHC, Phys.Lett. B672 (2009) 246–252, arXiv:0812.3586 [hep-ph].
- [45] C. Kilic, T. Okui, and R. Sundrum, Vectorlike Confinement at the LHC, JHEP 1002 (2010) 018, arXiv:0906.0577 [hep-ph].
- [46] C. Kilic, T. Okui, and R. Sundrum, Colored Resonances at the Tevatron: Phenomenology and Discovery Potential in Multijets, JHEP 0807 (2008) 038, arXiv:0802.2568 [hep-ph].
- [47] G. Burdman, B. A. Dobrescu, and E. Ponton, Resonances from two universal extra dimensions, Phys.Rev. D74 (2006) 075008, arXiv:hep-ph/0601186 [hep-ph].
- [48] S. Calvet, B. Fuks, P. Gris, and L. Valery, Searching for sgluons in multitop events at a center-of-mass energy of 8 TeV, JHEP 1304 (2013) 043, arXiv:1212.3360 [hep-ph].

References


- [49] D. Goncalves-Netto, D. Lopez-Val, K. Mawatari, T. Plehn, and I. Wigmore, Sgluon Pair Production to Next-to-Leading Order, *Phys.Rev. D* 85 (2012) 114024, arXiv:1203.6358 [hep-ph].
- [50] G. Cacciapaglia, A. Deandrea, and J. Llodra-Perez, A Dark Matter candidate from Lorentz Invariance in 6D, *JHEP* 1003 (2010) 083. [arXiv:0907.4993v1 [hep-ph]].
- [51] J. Aguilar-Saavedra and M. Perez-Victoria, No like-sign tops at Tevatron: Constraints on extended models and implications for the $t\bar{t}$ asymmetry, *Phys.Lett. B* 701 (2011) 93–100, arXiv:1104.1385 [hep-ph].
- [52] E. L. Berger, Q.-H. Cao, C.-R. Chen, C. S. Li, and H. Zhang, Top Quark Forward-Backward Asymmetry and Same-Sign Top Quark Pairs, *Phys.Rev.Lett.* 106 (2011) 201801, arXiv:1101.5625 [hep-ph].
- [53] J. A. Aguilar-Saavedra, Identifying top partners at LHC, *JHEP* 11 (2009) 030, ArXiv:0907.3155 [hep-ph].
- [54] B. Holdom et al., Four statements about the fourth generation, *PMC Physics A* 3 (2009) 4, arXiv:0904.4698 [hep-ph].
- [55] S. A. C. etin et al., Status of the Fourth Generation, arXiv:1112.2907 [hep-ex].

Back up

Measurement of $R = \mathcal{B}(t \text{ to } Wb) / \mathcal{B}(t \text{ to } Wq)$ with $q = b, s, d$

SM prediction:
$$R = \frac{\mathcal{B}(t \rightarrow Wb)}{\mathcal{B}(t \rightarrow Wq)} = \frac{|V_{tb}|^2}{|V_{tb}|^2 + |V_{ts}|^2 + |V_{td}|^2} = 0.99830^{+0.00006}_{-0.00009} \quad [1]$$

Indirect test of SM, which predicts:
$$|V_{tb}| = 0.999146^{+0.000021}_{-0.000046} \quad [1]$$

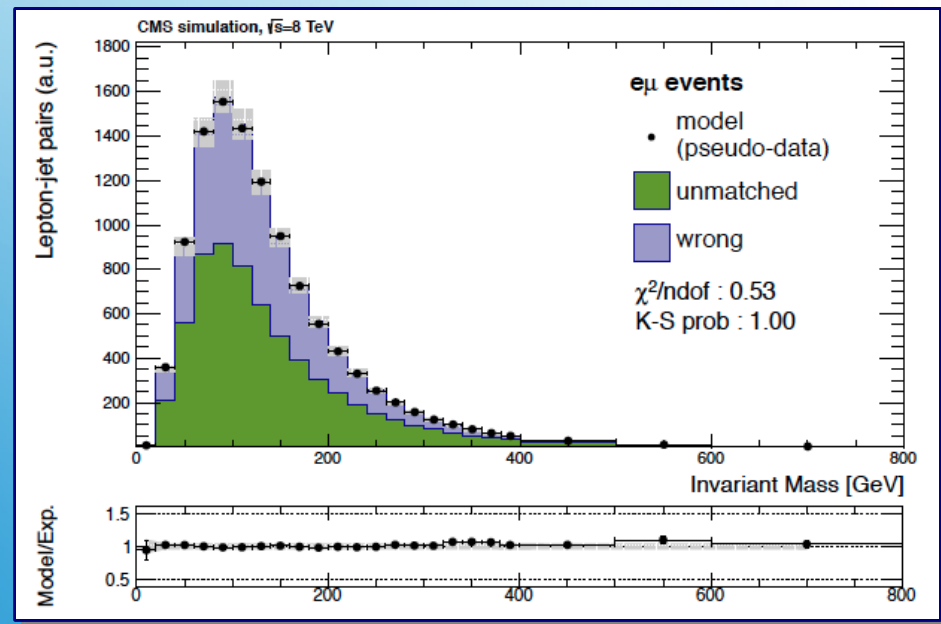
Tension with SM from 
$$\mathcal{R} = 0.90 \pm 0.04 \text{ (stat.+syst.)} \quad \mathcal{R}_{\ell\ell} = 0.86^{+0.041}_{-0.042} \text{ (stat)}^{+0.035}_{-0.035} \text{ (syst)} \quad [2]$$

Strategy in the dilepton channel:

- PLR to determine the signal purity

$$f_{\bar{t}\bar{t}} = \mu \cdot N_{\bar{t}\bar{t} \text{ exp.}} / N_{\text{obs}}$$

- Jet misassignment model obtained by randomly rotating selected leptons



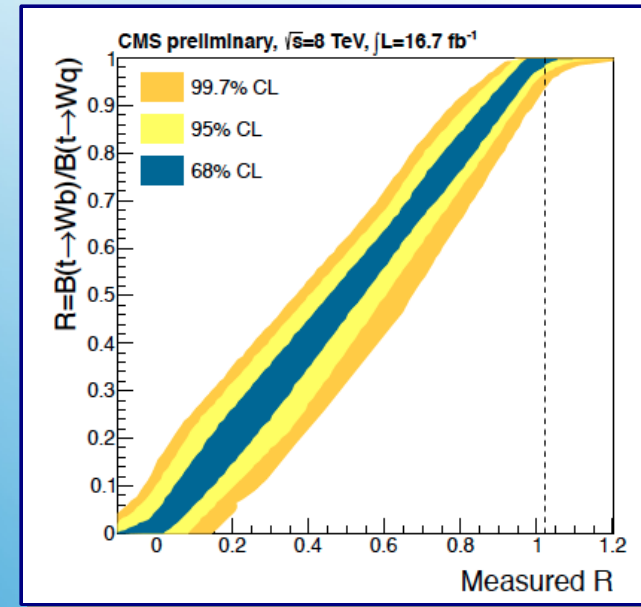
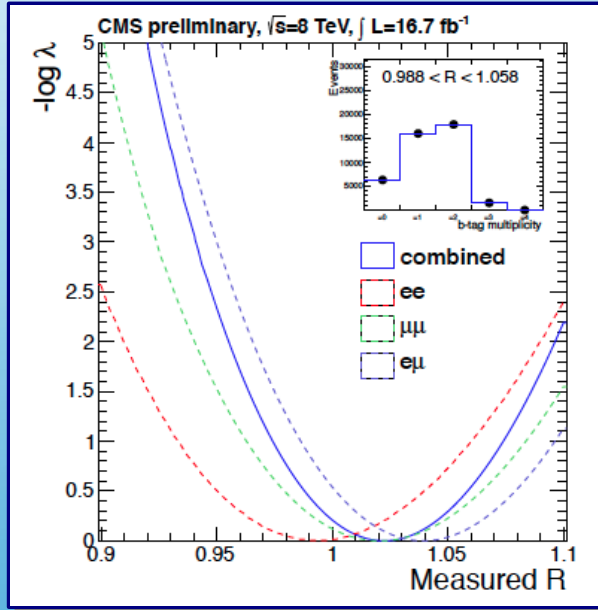
[CMS-PAS-TOP-12-035]

Marco CARDACI

Measurement of $R = B(t \text{ to } Wb) / B(t \text{ to } Wq)$ with $q = b, s, d$

PLR taking into account signal purity, misassignment and probability of b-tagging as a function of R

Upper and lower endpoints of the confidence interval on R using the Feldman-Cousins frequentist approach based on a likelihood ratio ordering principle



$$R = 1.023^{+0.036}_{-0.034}$$

Under the hypothesis of CKM matrix unitarity

$$|V_{tb}| = 1.011^{+0.018}_{-0.017} \text{ (stat+syst)}$$

Assuming $R \leq 1$
obtain at 95% CL

$$R > 0.945$$

Under the hypothesis of CKM matrix unitarity

$$|V_{tb}| > 0.972$$



[CMS-PAS-TOP-12-035]

Marco CARDACI

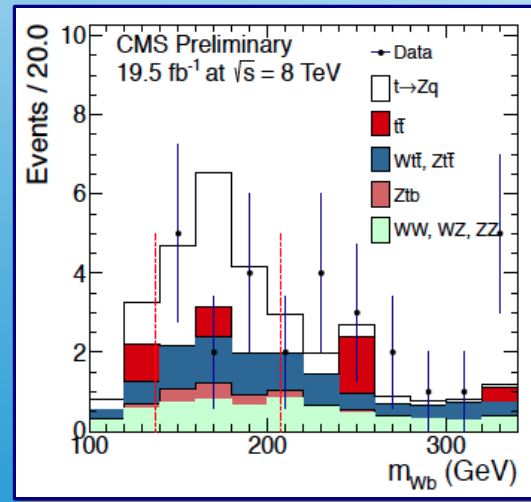
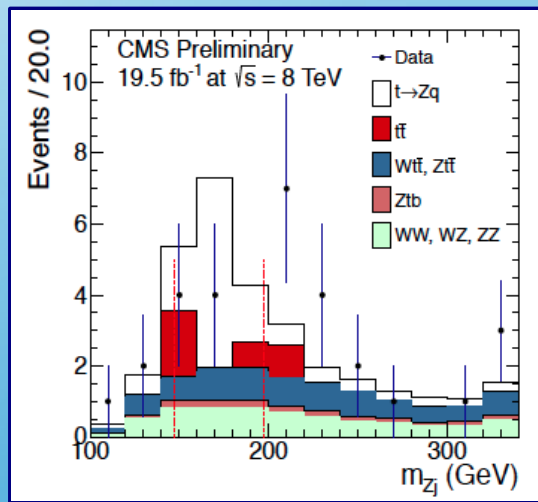
Search for FCNC in t to Zq with $q = u, c$

Highly suppressed in the SM by GIM mechanisms $\mathcal{B}(t \rightarrow Zq)$ is $\mathcal{O}(10^{-14})$ [3]

Enhanced in R-parity violating SUSY [4], top color assisted technicolor [5] models to $\mathcal{O}(10^{-4})$

Measurement in the trilepton channel:

Data-driven background:



$$\begin{pmatrix} N_{all} \\ N_{1btag} \\ N_{0btag} \end{pmatrix} = \begin{pmatrix} & & \\ & T & \\ & & \end{pmatrix} \begin{pmatrix} N_{VV} \\ N_{FCNC} \\ N_{Vtt} \end{pmatrix}$$

No excess found and 95% C.L. limit set with CLs method:

$$\mathcal{B}(t \rightarrow Zq) < 0.07\%$$



[CMS-PAS-TOP-12-037]

Marco CARDACI

7 TeV analyses:

CMS Phys. Lett. B718 (2013) 1252

ATLAS Phys. Lett. B712 (2012) 351-369

Search for Baryon Number Violating top decays

Small BNV can arise from non-perturbative effects in the SM [6]

Recent studies point to BNV top decays $t \rightarrow \bar{b} \bar{u} e^+$ ($\bar{t} \rightarrow b u e^-$) [7]

$t \rightarrow \bar{b} \bar{c} \mu^+$ ($\bar{t} \rightarrow b c \mu^-$)

Signature: 1 lepton + 5 jets + no MET

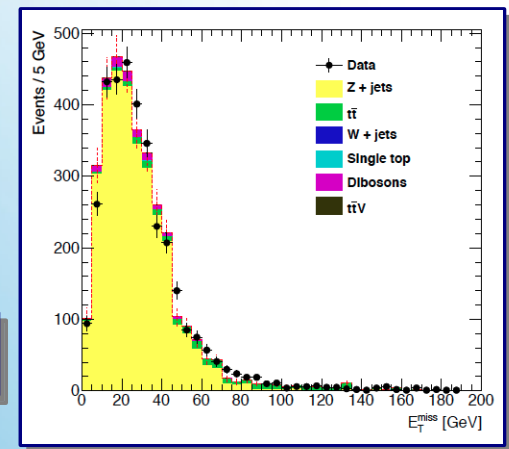
Cross check on MET modelling from Z ($\mu^+ \mu^-$) + 4 jets events

Likelihood approach based on the following equations:

$$N_{exp}^T = (N_{obs}^B - N_{bck}^B) \left[\frac{1}{1 + \frac{\sigma_{tW} \epsilon_{tW}^B(BR)}{\sigma_{tt} \epsilon_{tt}^B(BR)}} \times \frac{\epsilon_{tt}^T(BR)}{\epsilon_{tt}^B(BR)} + \frac{1}{1 + \frac{\sigma_{tW} \epsilon_{tW}^B(BR)}{\sigma_{tt} \epsilon_{tt}^B(BR)}} \times \frac{\epsilon_{tW}^T(BR)}{\epsilon_{tW}^B(BR)} \right] + N_{bck}^T$$

$$\epsilon_{tt}^X = 2BR(1 - BR)\epsilon_{BNV,SM}^X + (1 - BR)^2\epsilon_{SM,SM}^X + BR^2\epsilon_{BNV,BNV}^X$$

$$\epsilon_{tW}^X = (1 - BR)\epsilon_{SM}^X + BR\epsilon_{BNV}^X$$



which can be written after normalizing the expected event yield in the BASIC selection

- Improvement of a factor of 2.5 on the expected limit due to the normalization

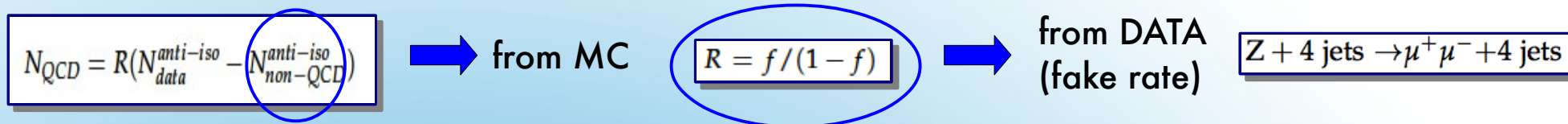


[CMS-PAS-B2G-12-023]

Marco CARDACI

Search for Baryon Number Violating top decays

QCD background data-driven estimate:



2012 results (20 fb⁻¹ at 8 TeV):

	95% CL Upp. lim.	Exp. lim.	68% exp. lim. range
Muon ch.	0.0016	0.0029	[0.0017, 0.0042]
Electron ch.	0.0017	0.0031	[0.0018, 0.0045]
Combined	0.0015	0.0029	[0.0016, 0.0042]

2011 results (5 fb⁻¹ at 7 TeV):

	95% CL Upp. lim.	Exp. lim.	68% exp. lim. range
Muon ch.	0.0076	0.0044	[0.0028, 0.0057]
Electron ch.	0.0072	0.0054	[0.0035, 0.0087]
Combined	0.0067	0.0041	[0.0027, 0.0060]

Muon channel | Electron channel

Quantity	Systematic uncertainty (%)	Systematic uncertainty (%)
$\epsilon_{SM,SM}^B$	19	19
$\epsilon_{SM,SM}^T$	20	20
$\epsilon_{BNV,SM}^B$	12	12
$\epsilon_{BNV,SM}^T$	17	17
$\epsilon_{BNV,BNV}^B$	15	15
$\epsilon_{BNV,BNV}^T$	15	15
ϵ_{SM}^B	12	12
ϵ_{SM}^T	12	12
ϵ_{BNV}^B	15	15
ϵ_{BNV}^T	14	14
N_{bck}^B	41	34
N_{bck}^T	34	30
σ_{tW}	8	8
$\sigma_{t\bar{t}}$	15	15

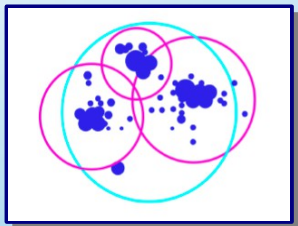


[CMS-PAS-B2G-12-023]

Marco CARDACI

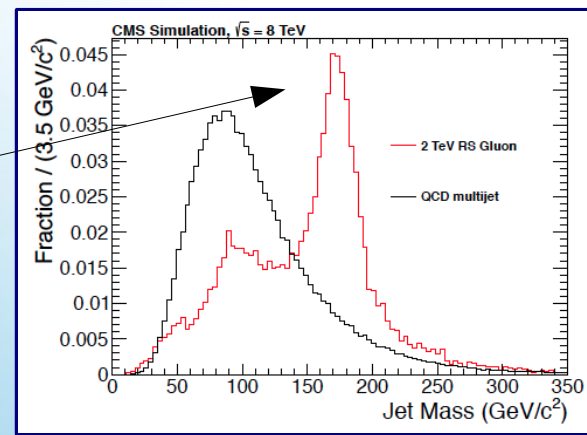
Z' to ttbar in all hadronic

Highly boosted topologies - 2 fat jets in the final state:



Top-tagging criteria:

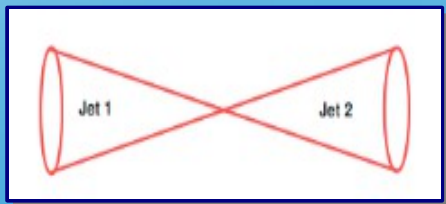
- 3 or 4 subjets
- Fat-jet mass within [140, 250] GeV
- Minimum pair-wise subjet mass > 50 GeV



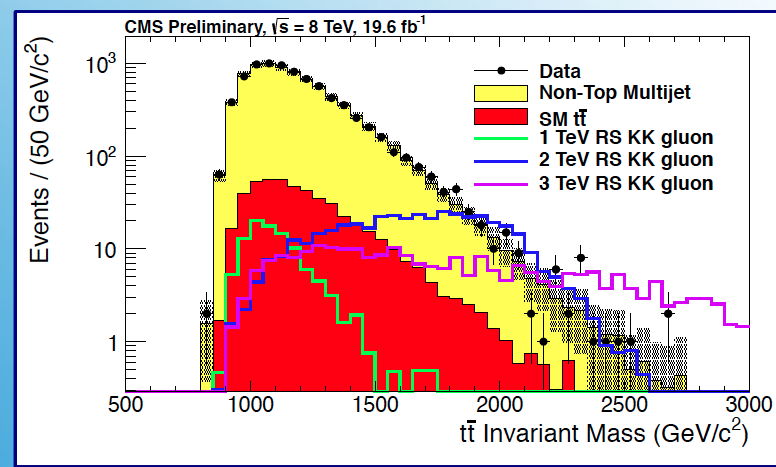
QCD background model from inversion of pair-wise mass cut:

Anti top-tagged jet

Probe jet



to estimate mistag rate, which is applied on
1 top-tagged + X events

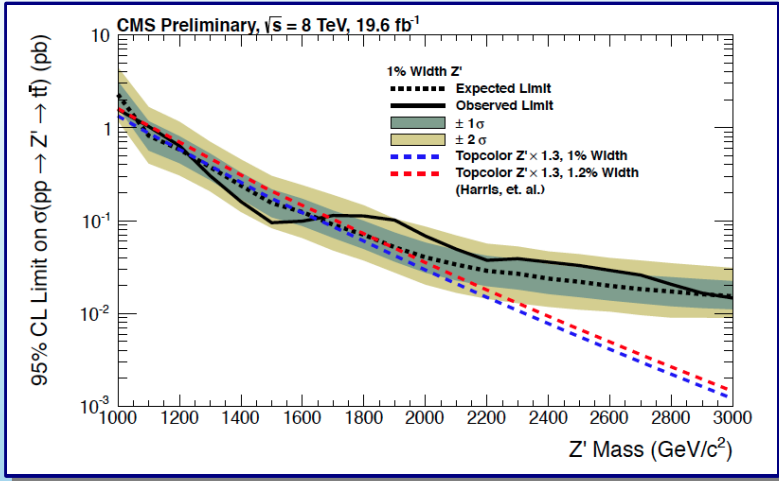


[CMS-PAS-B2G-12-005]

Marco CARDACI

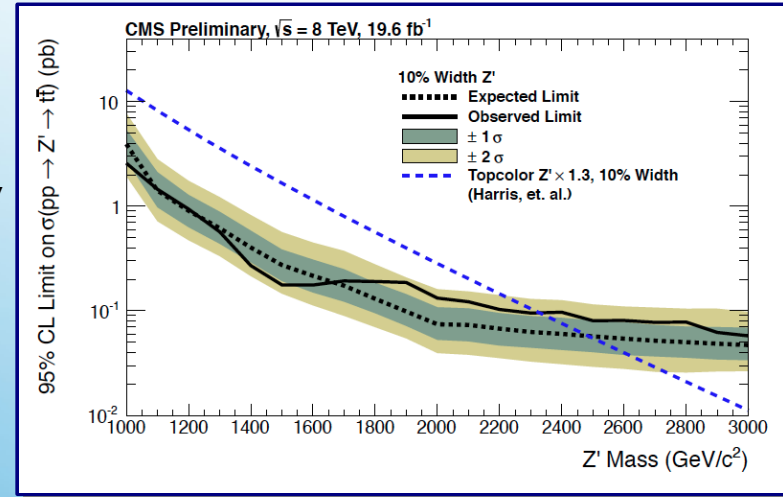
Z' to ttbar in all hadronic

Topcolor narrow (1.2%) resonance [8]



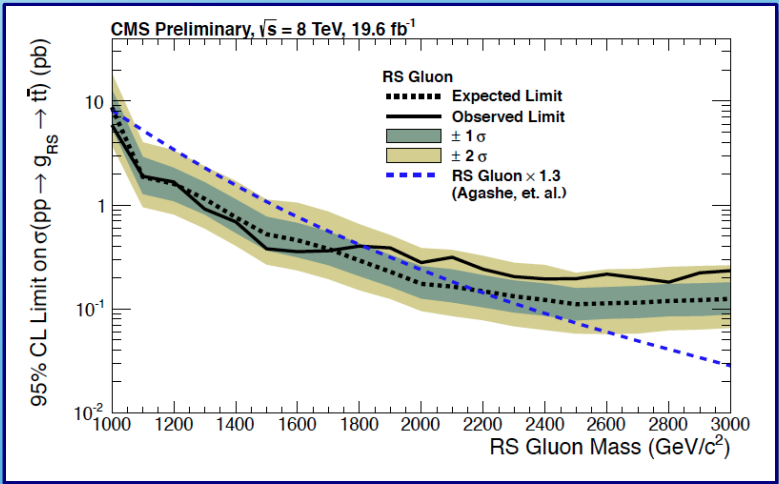
$M_{Z'} > 1.6 \text{ TeV}$

Topcolor wide (10%) resonance [8]



$M_{Z'} > 2.3 \text{ TeV}$

KK-gluon (width function of mass) [9]



$M_{g(KK)} > 1.8 \text{ TeV}$

$$S = \frac{\int_{M_{t\bar{t}} > 1\text{TeV}/c^2} \frac{d\sigma_{SM+NP}}{dM_{t\bar{t}}} dM_{t\bar{t}}}{\int_{M_{t\bar{t}} > 1\text{TeV}/c^2} \frac{d\sigma_{SM}}{dM_{t\bar{t}}} dM_{t\bar{t}}}$$

$$S < 1.79$$

Constraint of enhancements (i.e. top forward-backward charge asymmetry) in ttbar mass spectrum

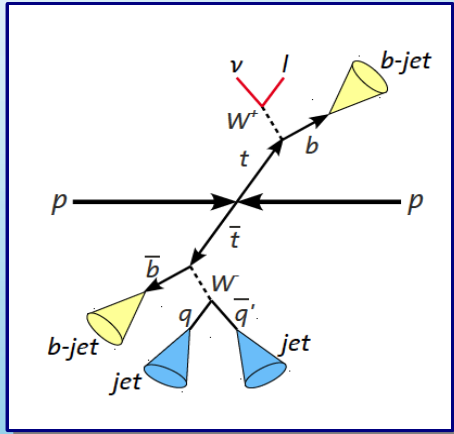


[CMS-PAS-B2G-12-005]

Marco CARDACI

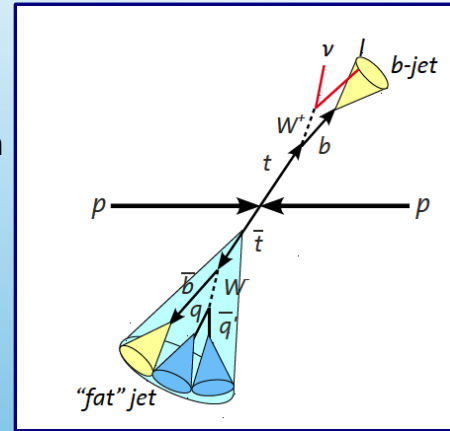
Z' to ttbar in l + jets

Two regimes are investigated and then merged:



Threshold analysis

- Background parametrization
- Morphing for signal model



Boosted analysis

- No isolation requirement on the lepton, instead:

$$\Delta R(\text{lepton, closest jet})$$

OR

$$p_T^{\text{rel}}(\text{lepton, closest jet}) > 25 \text{ GeV}$$

- Both analyses use χ^2 sorting for: jet assignment and neutrino disambiguation
- Both analyses apply a binned likelihood fit to the invariant mass to extract limits

The two regimes are "combined" choosing the transition on the base of the exp. sensitivity

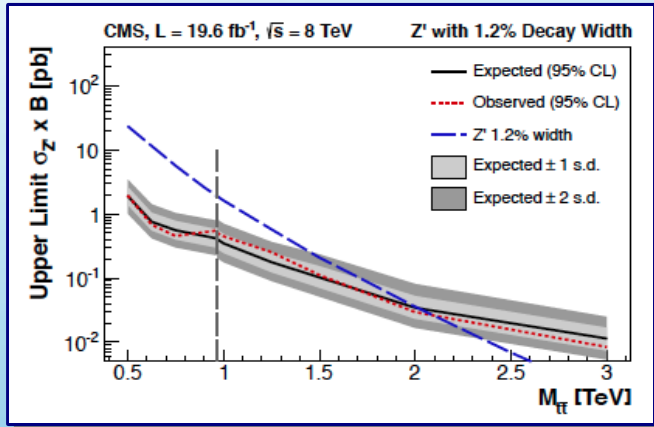


[CMS-PAS-B2G-12-006]

Marco CARDACI

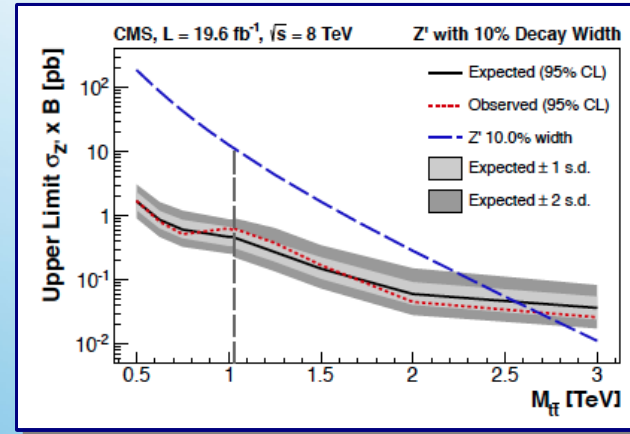
Z' to ttbar in l + jets

Topcolor narrow (1.2%) resonance [8]



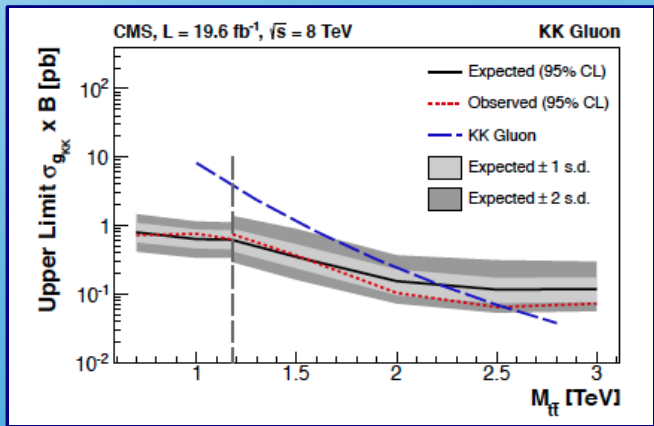
$M_{Z'} > 2.1$ TeV

Topcolor wide (10%) resonance [8]



$M_{Z'} > 2.7$ TeV

KK-gluon (width function of mass) [9]



$M_{g(KK)} > 2.5$ TeV

Cross section exclusions at 95% C.L.

Type \ Mass	0.5 TeV	2 TeV
Z' (10% width)	< 1.71 pb	< 0.045 pb
Z' (1.2% width)	< 1.94 pb	< 0.029 pb
KK-gluon	-	< 0.101 pb



[CMS-PAS-B2G-12-006]

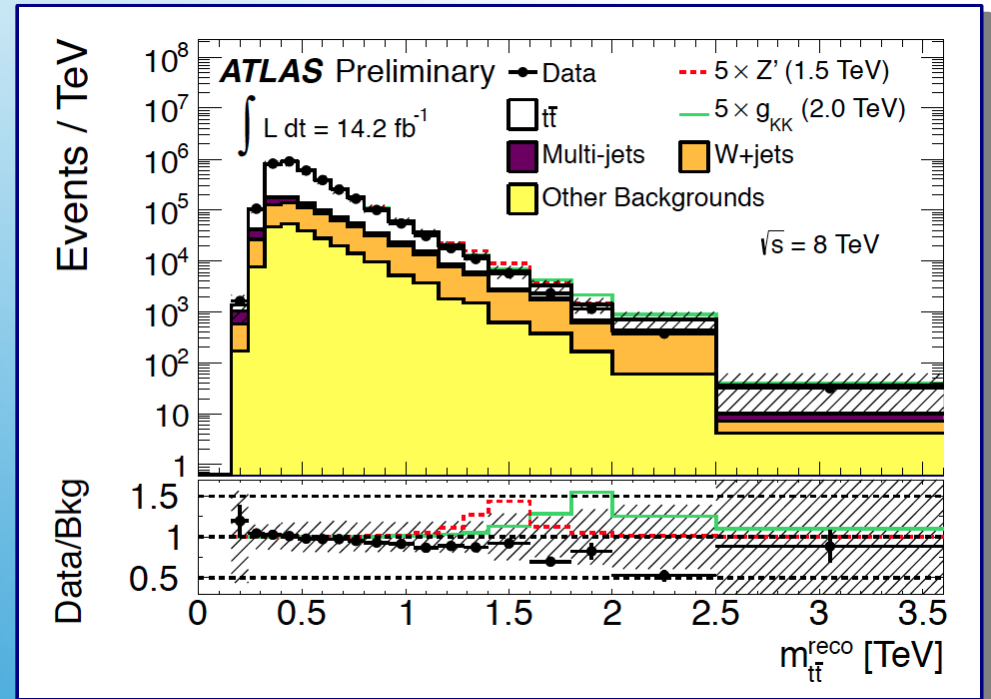
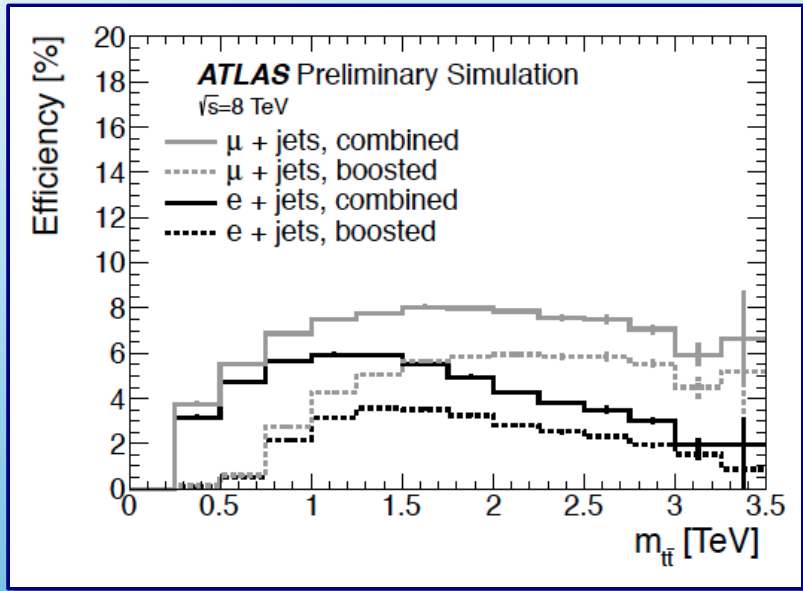
Marco CARDACI

Z' to ttbar in l + jets

7 TeV analysis
submitted to PRD
arXiv:1305.2756

- Boosted and resolved channels considered

- Bumphunter scan taking into account LEE



- No significant excess was found

$e + \mu$ Channel	Boosted	Resolved
Prediction	5600 ± 1200	283000 ± 39000
Data	5122	280251

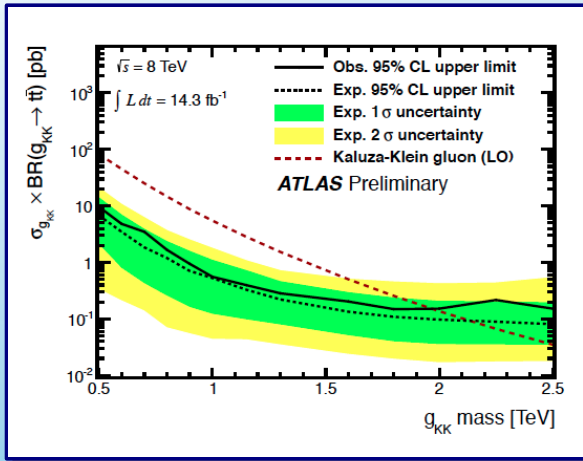


[ATLAS-CONF-2013-052]

Marco CARDACI

Z' to ttbar in l + jets

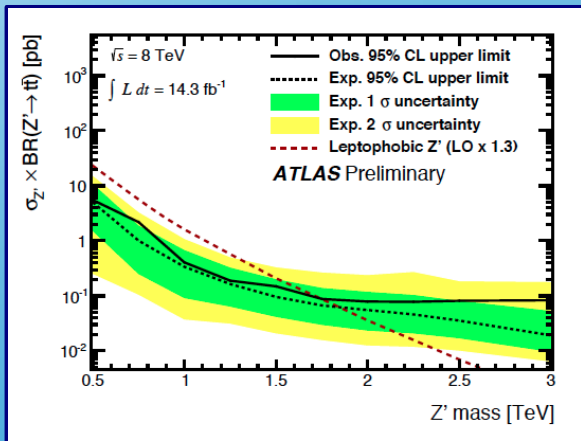
- KK-gluon (15.3% width) [10]



$M_{g(KK)} > 2.0 \text{ TeV}$

Mass (TeV)	$\sigma \times \text{BR}$ [pb]	Obs. (pb)	Exp. (pb)	-1σ (pb)	$+1\sigma$ (pb)
0.50	82.	9.62	6.73	2.15	14.1
0.60	45.	4.79	3.48	0.813	6.98
0.70	25.	3.48	1.84	0.436	3.90
0.80	15.	1.66	1.19	0.262	2.37
0.90	8.8	0.948	0.711	0.165	1.60
1.00	5.5	0.561	0.529	0.125	1.11
1.15	2.8	0.394	0.329	0.100	0.720
1.30	1.5	0.282	0.221	0.081	0.464
1.60	0.50	0.204	0.134	0.052	0.296
1.80	0.26	0.149	0.109	0.041	0.237
2.00	0.14	0.153	0.097	0.036	0.209
2.25	0.067	0.218	0.089	0.036	0.203
2.50	0.035	0.152	0.080	0.035	0.196

- Topocolor Z' (1.2% width) [8]



$M_{Z'} > 1.8 \text{ TeV}$

Mass (TeV)	$\sigma \times \text{BR} \times 1.3$ [pb]	Obs. (pb)	Exp. (pb)	-1σ (pb)	$+1\sigma$ (pb)
0.50	23.	5.30	4.99	1.50	10.7
0.75	5.6	2.17	1.00	0.249	1.87
1.00	1.6	0.406	0.335	0.091	0.674
1.25	0.57	0.187	0.160	0.064	0.323
1.50	2.1×10^{-1}	0.148	0.096	0.041	0.198
1.75		0.087	0.066	0.030	0.137
2.00	3.9×10^{-2}	0.078	0.055	0.023	0.117
2.25		0.078	0.045	0.021	0.103
2.50	6.9×10^{-3}	0.081	0.035	0.017	0.081
3.00	1.5×10^{-3}	0.083	0.019	0.010	0.053



[ATLAS-CONF-2013-052]

Marco CARDACI

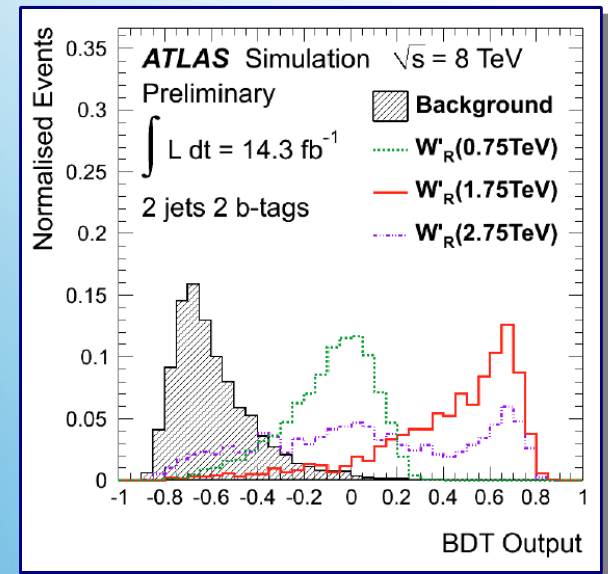
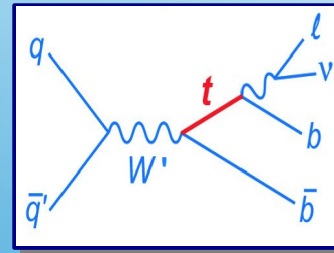
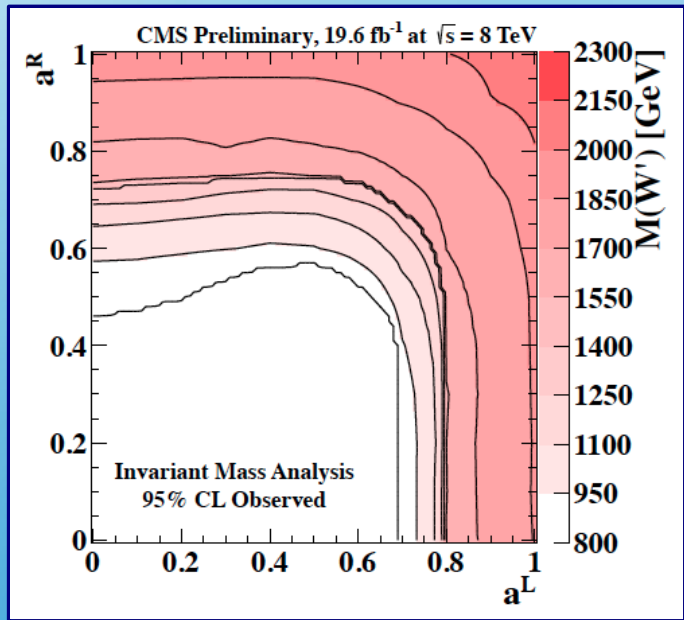
W' to tb

Theory motivations: Little Higgs, Extra Dimensions, Extended Technicolor, L-R Symmetry [11 - 15]

- $M_{W'} > 2.03$ TeV for right-handed W'
- and in addition limits on the general couplings (left-handed component implies mixing with SM) [16]

$$\mathcal{L} = \frac{V_{fifj}}{2\sqrt{2}} g_w \bar{f}_i \gamma_\mu (a_{fifj}^R (1 + \gamma^5) + a_{fifj}^L (1 - \gamma^5)) W'^\mu f_j + \text{H.c.}$$

- Two categories:
2 jets 2 b-tags
3 jets 2 b-tags
- Boosted Decision Tree discrimination



[CMS-PAS-B2G-12-010], [ATLAS-CONF-2013-050]

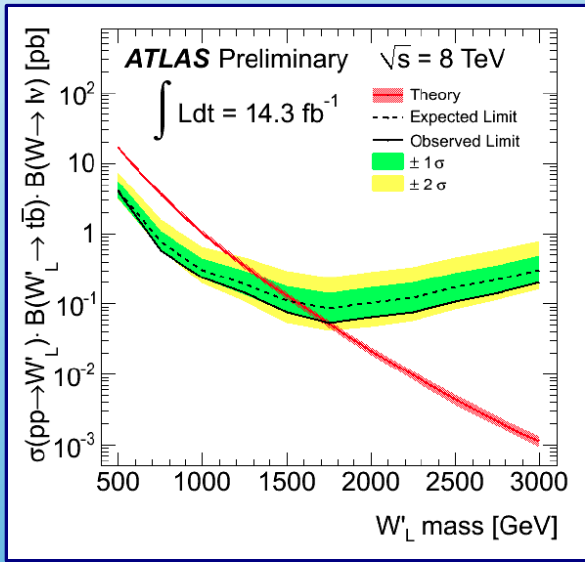
Marco CARDACI



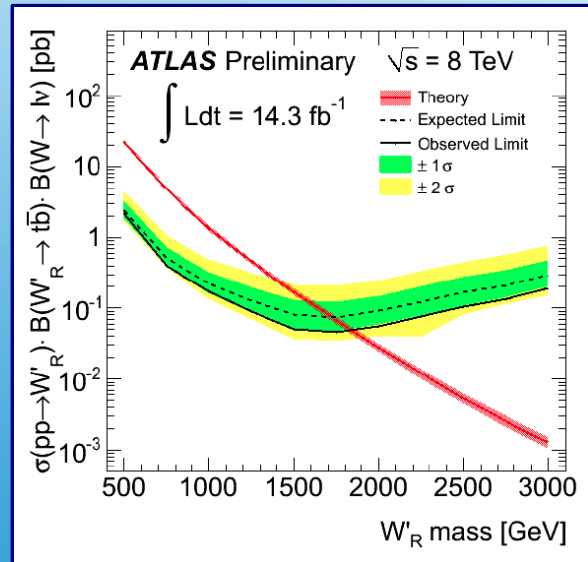
W' to tb

- Limits valid for the theoretical model (same as CMS) [16]:

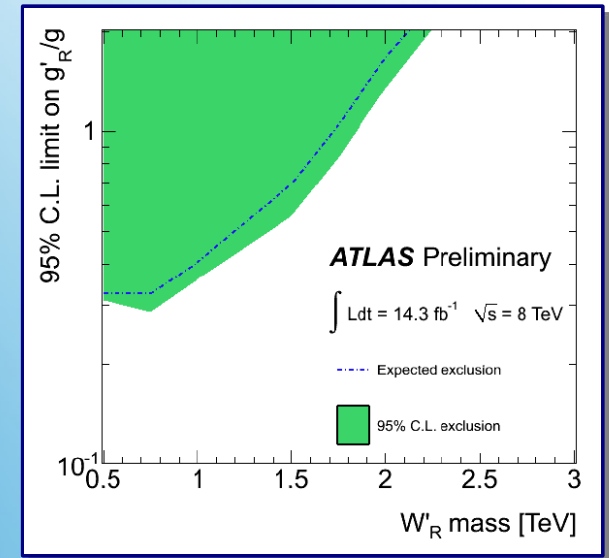
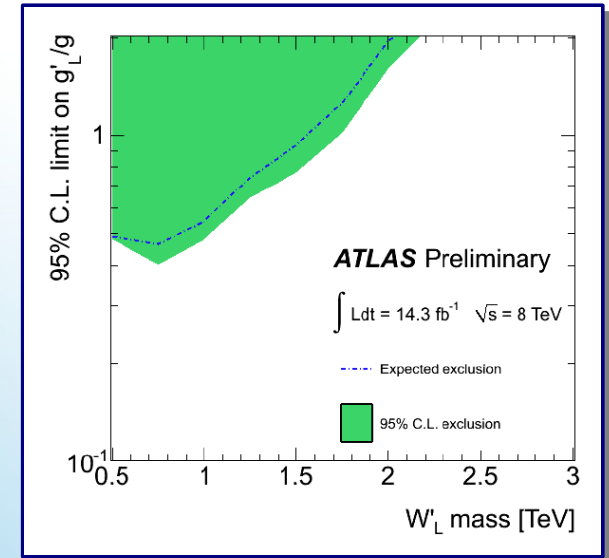
$$\mathcal{L} = \frac{V'_{ij}}{2\sqrt{2}} \bar{f}_i \gamma_\mu (g'_{R,i,j}(1 + \gamma^5) + g'_{L,i,j}(1 - \gamma^5)) W'^{\mu} f_j + h.c.$$



$M_{W'(L)} > 1.74 \text{ TeV}$

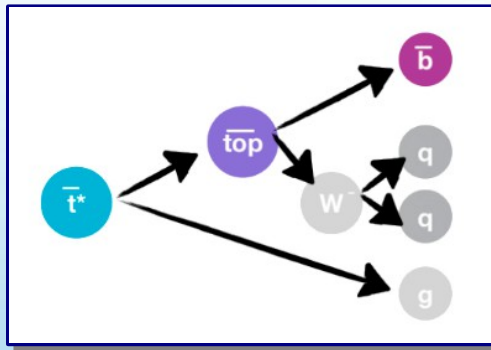
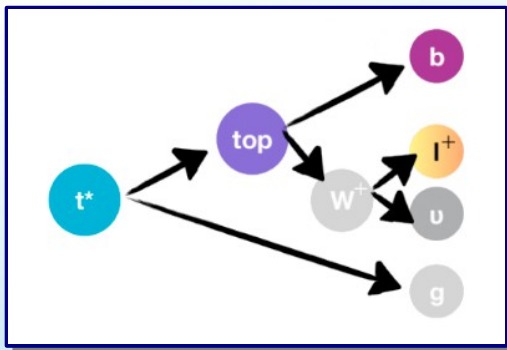


$M_{W'(R)} > 1.84 \text{ TeV}$



[ATLAS-CONF-2013-050]

Marco CARDACI



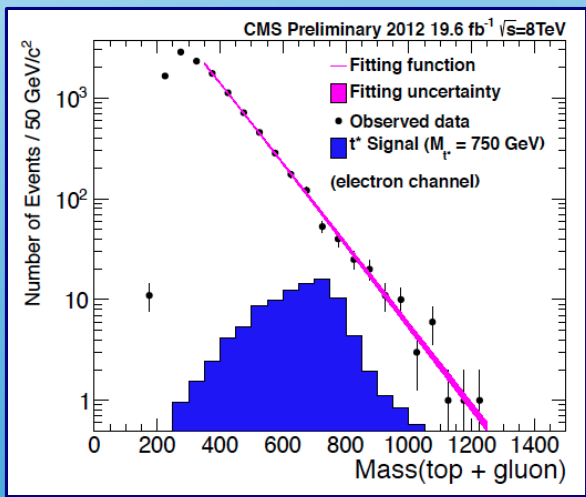
T^* to top + gluon

Result given for spin 3/2 RS T^* [17]

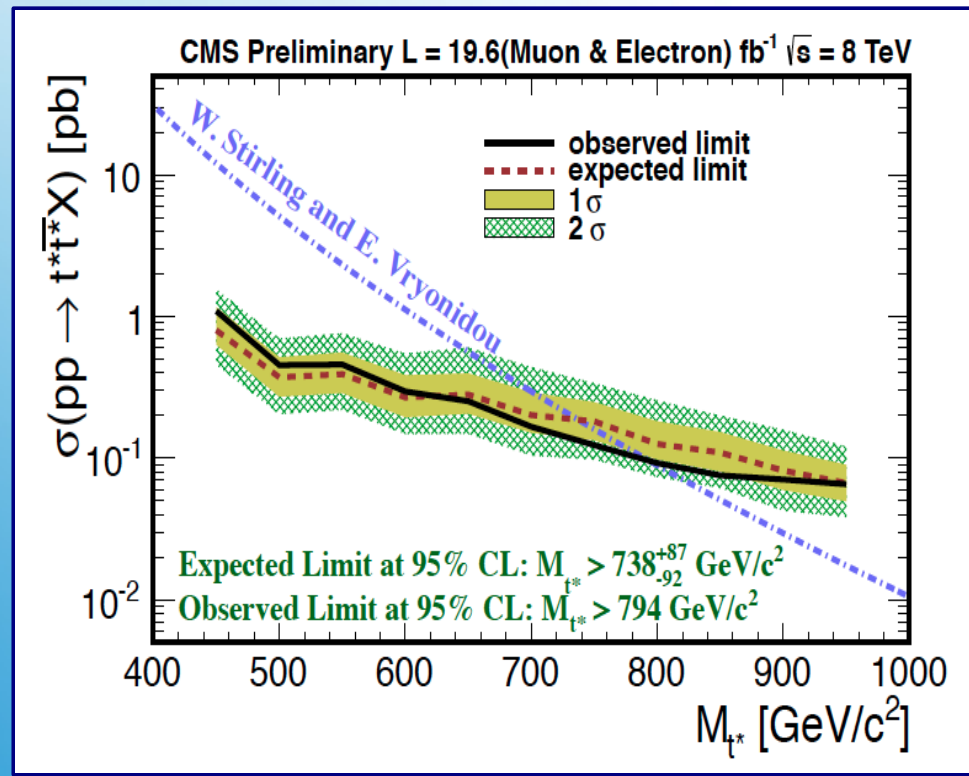
$$M_{T^*} > 794 \text{ GeV}$$

Fermi-like function modelling the SM sources

$$f(x) = \frac{a}{1 + e^{\frac{x-b}{c}}}$$



Only showing electron channel here!

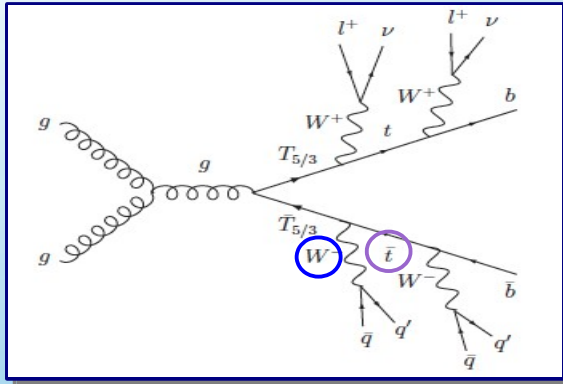


[CMS-PAS-B2G-12-014]

Marco CARDACI

SS dilepton searches

$T_{5/3}$ top partners of exotic charge [18 - 21]



Top-tagging as in Z' analysis

+

W tagging:

- 2 subjets

- M within [60, 130] GeV

b' [22] T, B Vector-like Quarks [23],
4 top quark production [24], sgluons [25 - 31],
UED [32], positively charged top pair [33, 34]

Selection:

- exactly 2 SS leptons (and Z veto for SF)
- 2 jets
- at least 1 b-tag
- MET > 40 GeV
- $H_T > 550$ GeV

Optimization:

- $H_T > 650$ GeV

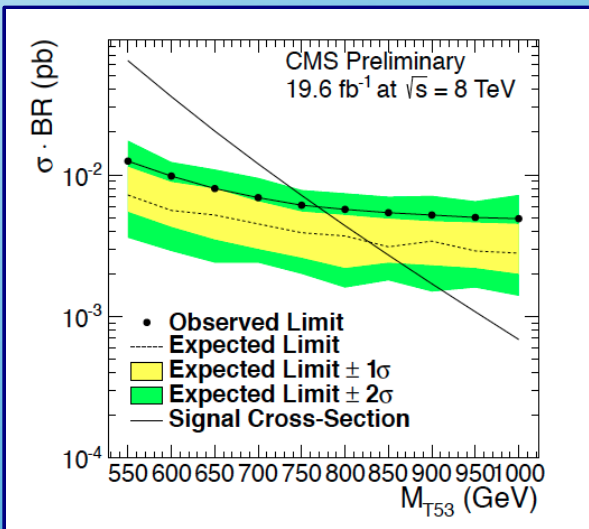
for b' and VLQ searches

- $H_T > 650$ GeV and at least 2 b-tags

for 4 top enhancement

- Positive charge leptons

for 2 positively charged top quark production



$M_{T(5/3)} > 770$ GeV

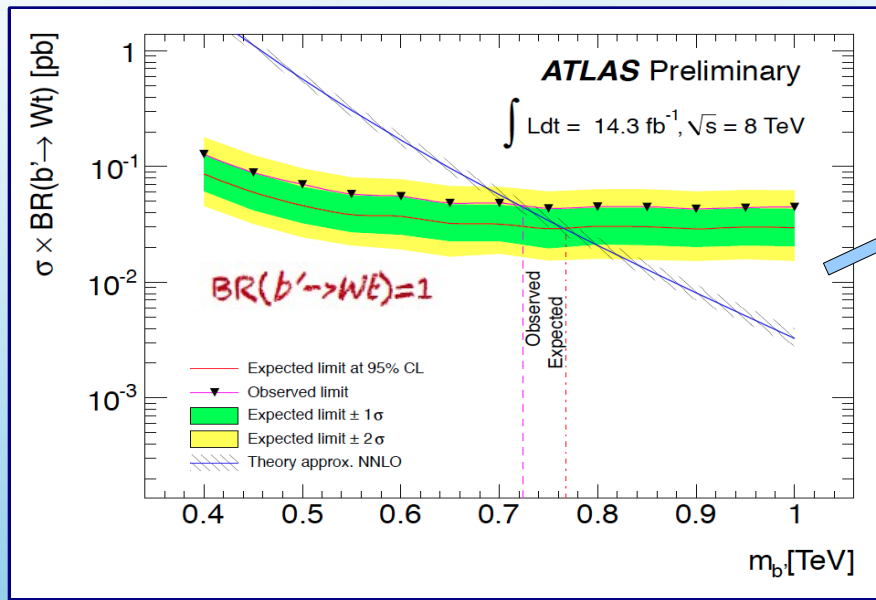
[CMS-PAS-B2G-12-012], [ATLAS-CONF-2013-051]



Marco CARDACI



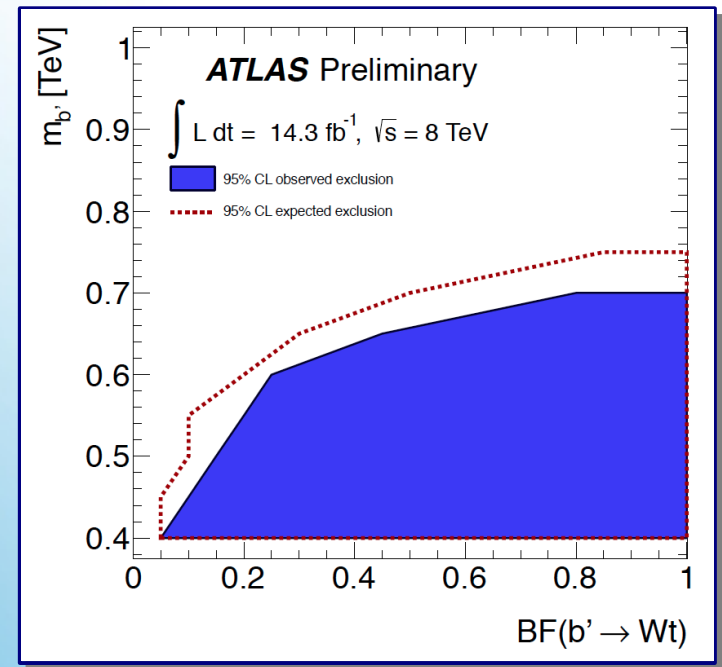
SS dilepton searches



$$M_{b'} > 720 \text{ GeV}$$

$$M_{B(\text{singlet})} > 590 \text{ GeV}$$

$$M_{T(\text{singlet})} > 540 \text{ GeV}$$



Non resonant results

$$M_{\text{sgluon}} > 800 \text{ GeV} \quad (\text{pair production})$$

$$M_{KK} > 900 \text{ GeV}$$

$$m_{KK} \equiv \frac{1}{R_4}$$

- 4 top quarks

- Exchange of heavy particles via s- and t-channels $uu \rightarrow tt$ prevalently

Model	95% C.L. upper limit		
	$\sigma(pp \rightarrow t\bar{t}\bar{t})$ [fb]		$ C /\Lambda^2$ [TeV ⁻²]
	Expected 1σ range	Observed	Observed
Standard Model	43-89	85	—
Contact interaction	29-61	59	15

Chirality configuration	95% C.L. upper limit		
	$\sigma(pp \rightarrow tt)$ [pb]		$ C /\Lambda^2$ [TeV ⁻²]
	Expected 1σ range	Observed	Observed
Left-left	0.14-0.28	0.19	0.092
Left-right	0.15-0.30	0.20	0.271
Right-right	0.15-0.32	0.21	0.099



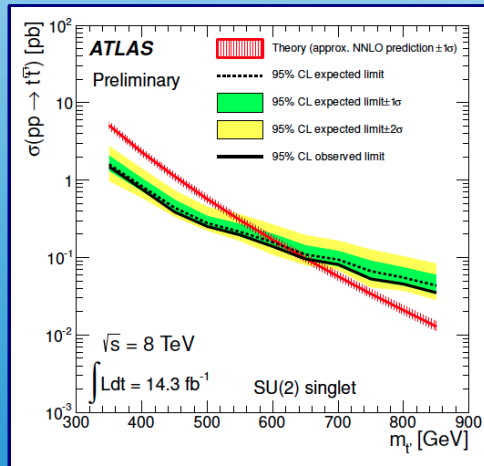
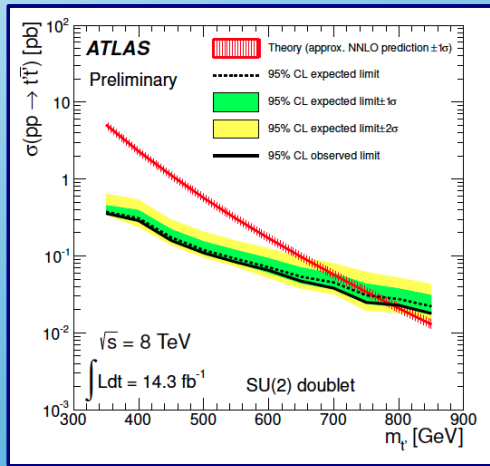
[ATLAS-CONF-2013-050]

Marco CARDACI

Search for Vector-Like t' Quark

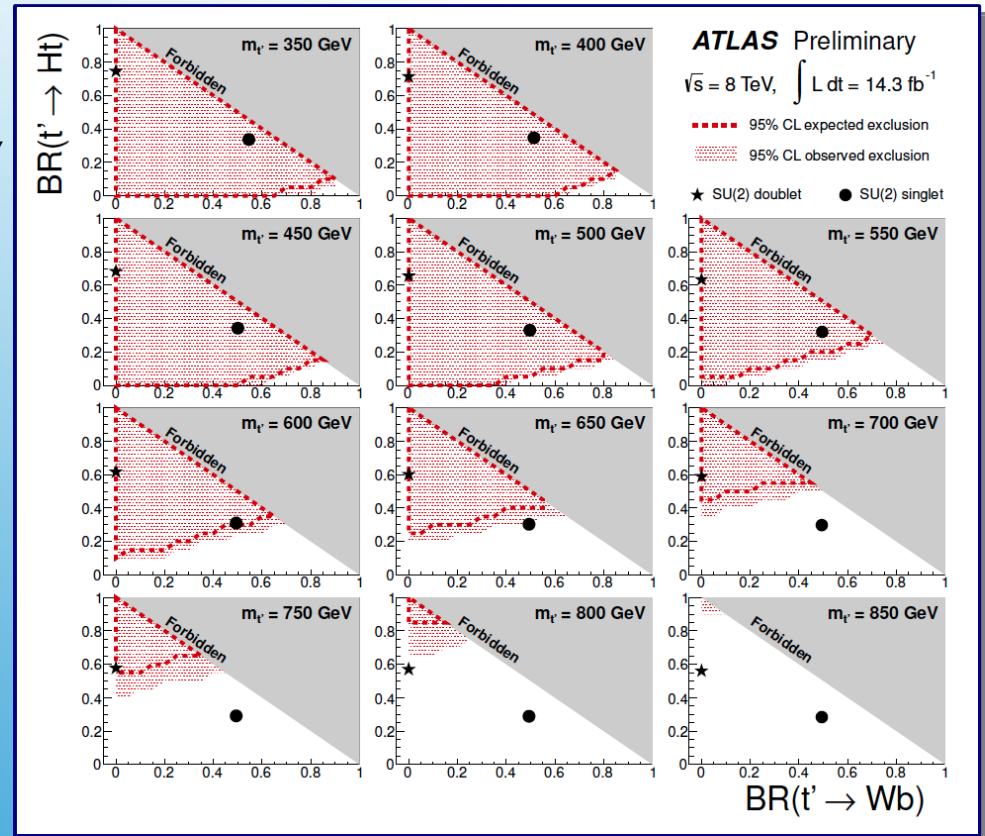
- t' (singlet or doublet) to bW , tH and tZ [35] in single lepton channel
- Fit SF of $t\bar{t}$ + LF and $t\bar{t}$ + HF for $HT < 700$ GeV
- Backgrounds from Matrix Method and W charge asymmetry
- Log-Likelihood Ratio as test-statistics

$$LLR = -2 \log(L_{s+b}/L_b)$$



$M_{t'(\text{doublet})} > 790 \text{ GeV}$

$M_{t'(\text{singlet})} > 640 \text{ GeV}$



[ATLAS-CONF-2013-018]

Marco CARDACI