Single VLQ searches

Stéphanie Beauceron
IPNL

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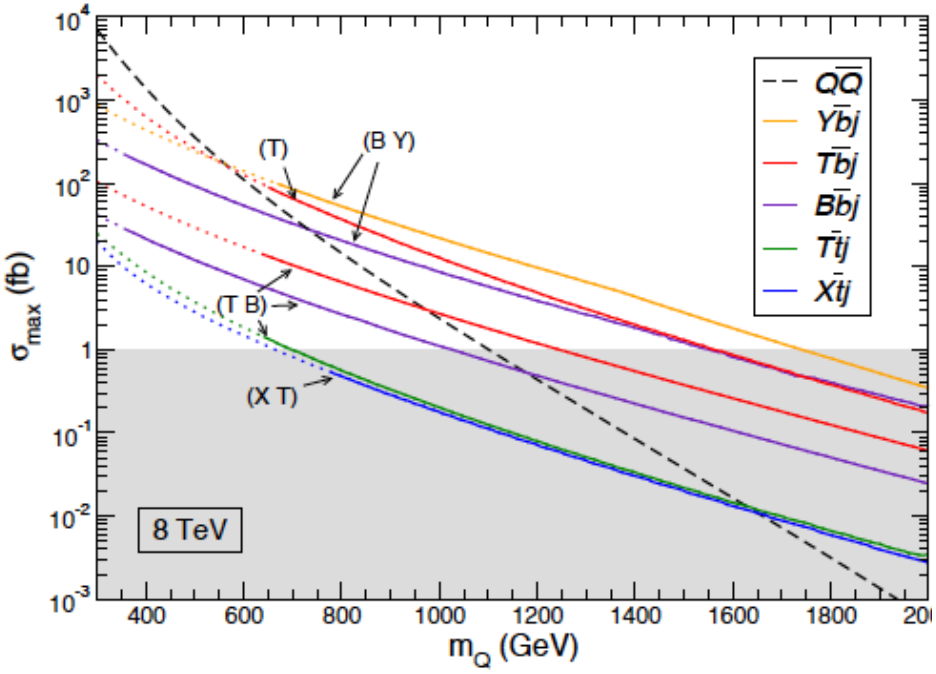
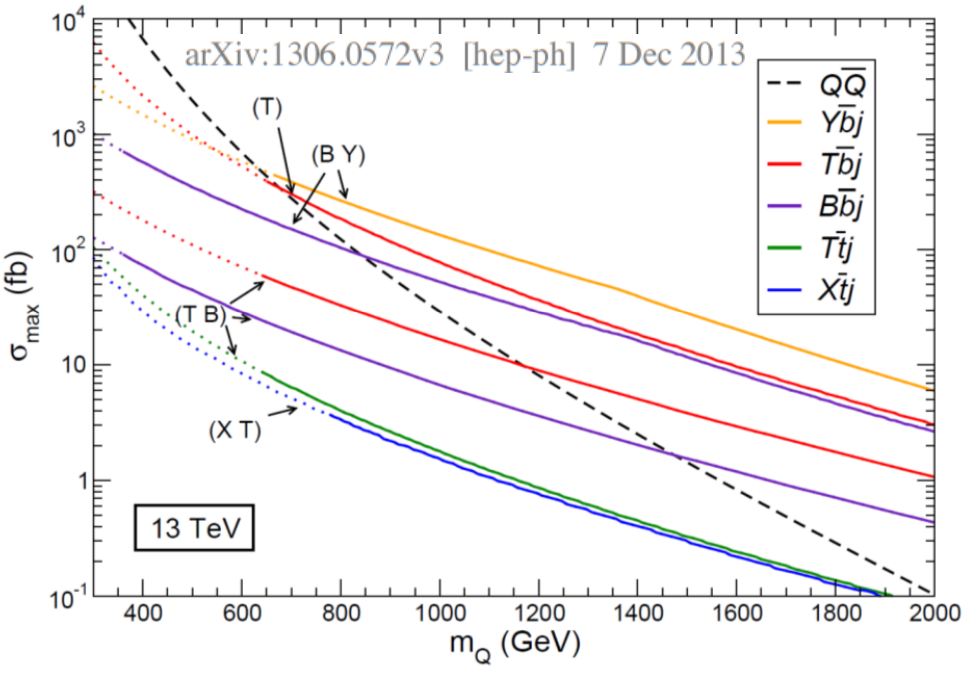
Outline

- **Summary of Run1 + 2015 results**
- **Pair vs Single production**
- **Question of Width**
- **2016 Analysis:**
  - **Atlas: $Y^{4/3}$ /T → Wb → lvb**
  - **CMS: T → Zt → ll+top**
- **Summary**

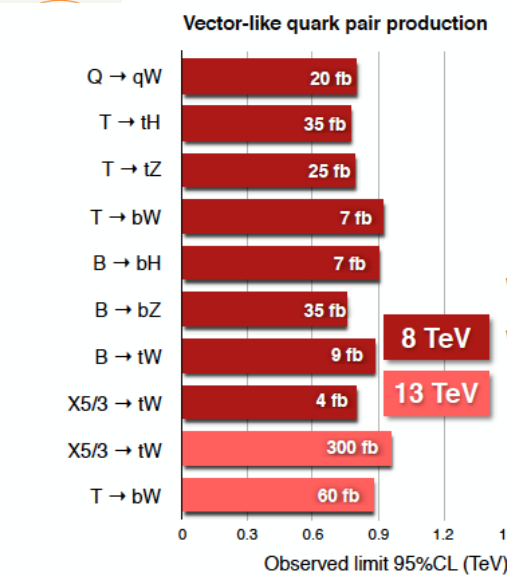
Introduction

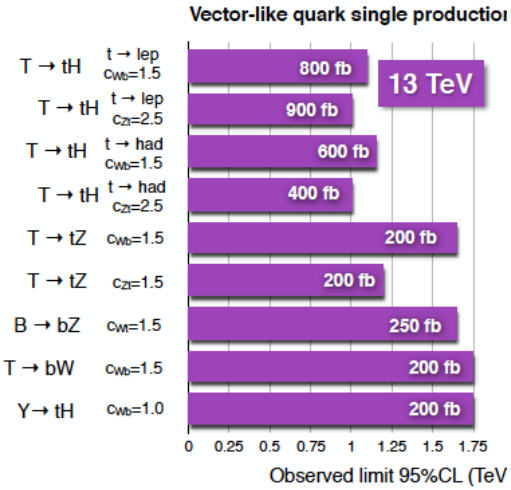




Plots above are for given benchmarks couplings but still giving an idea of what is happening…

Pair production cross section falling very rapidly and single production dominates as soon as 700 GeV for T and Y.





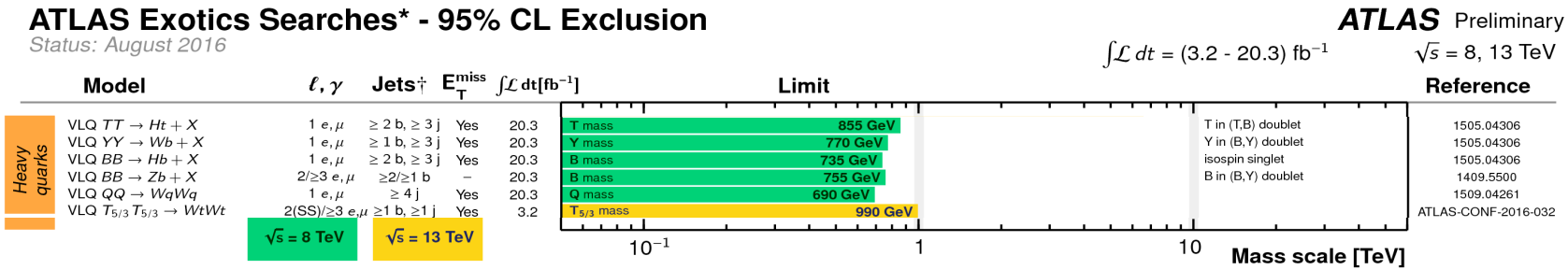
Run 1 + 2015

Atlas and CMS got two different approaches:

- **Atlas has dedicated analysis for some single VLQ channel and includes single VLQ production as additional signal while developing pair VLQ analysis**
- **CMS has dedicated analysis for single VLQ but in single VLQ, no consideration of pair production is done**

Second interesting point: pair VLQ is getting up to two order of magnitude lower in cross section than the single VLQ

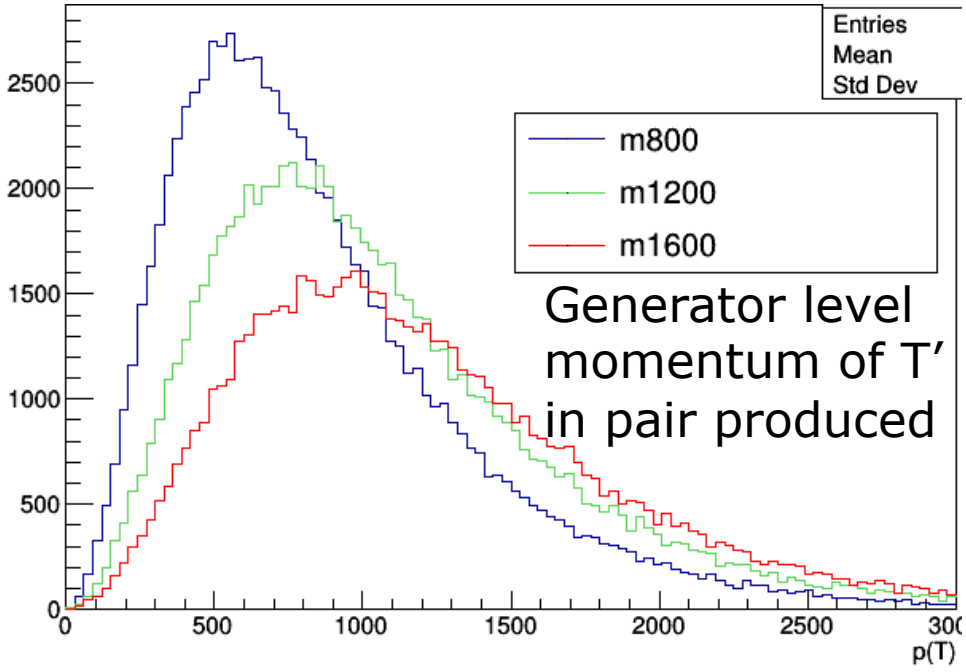
→ Counter intuitive…



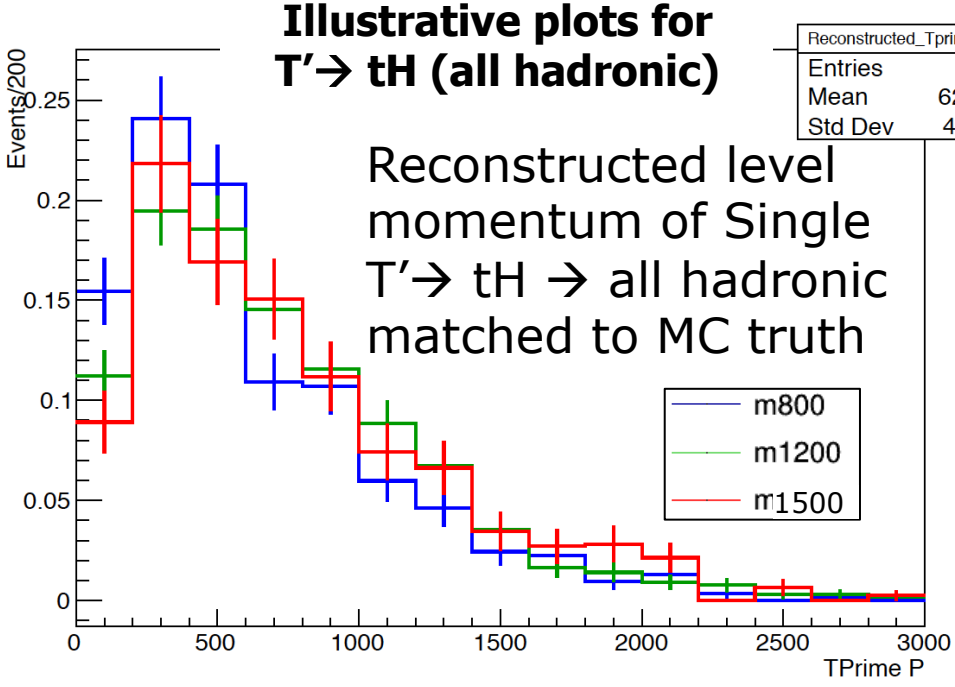
*Only a selection of the available mass limits on new states or phenomena is shown. Lower bounds are specified only when explicitly not excluded.

†Small-radius (large-radius) jets are denoted by the letter j (J).

Pair Produced=Momentum



Illustrative plots for T'→ tH (all hadronic)

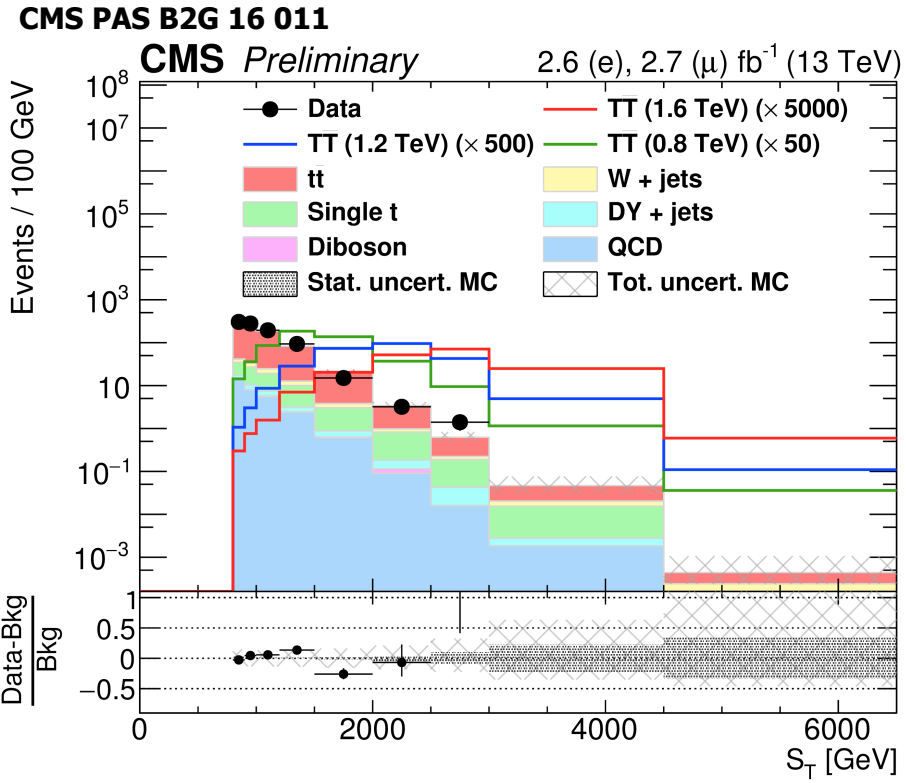


In pair production, the momentum of the produced VLQ is ~M/2, so it is increasing with mass while cross section is going down

Coming from threshold artifact linked from spin ½ (low cross section but more energy available for production)

In single production mode, the momentum does not change much with mass.

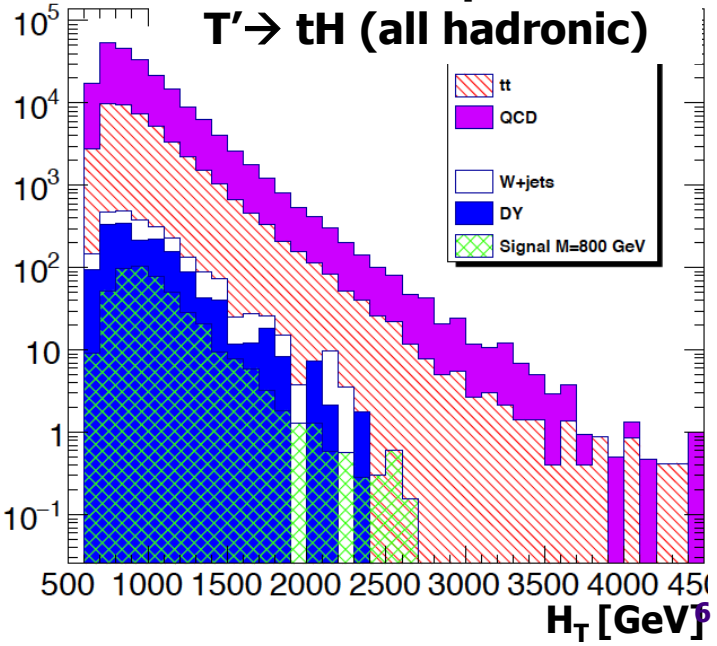
Pair Produced=Momentum



Typical background distribution in variable like scalar sum of pt of reconstructed object

→ Very quickly can be in configuration of "background" free analysis, so stronger limit can be set

Illustrative plots for T'→ tH (all hadronic)



Single VLQ will tend to remain in the bulk of the background distribution

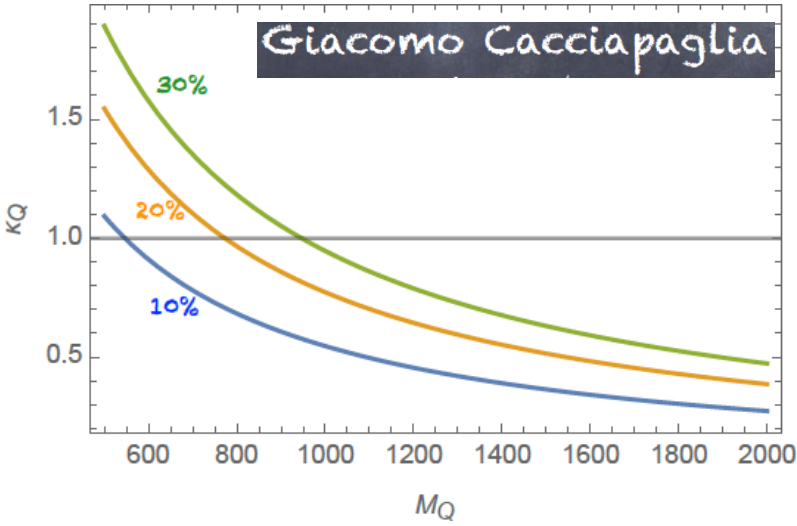
➔ Important to have dedicated analysis for single VLQ or look at single VLQ when pair production cross section is ~2 order of magnitude lower (? Can be detector dependent)

Question of Width?

Single VLQ only EW contributions and sensitive to both the VLQ mass and its mixing parameters

→ Mixing parameters entering the width of VLQ

→ Model dependent



Currently all pair analysis only doing narrow width while acceptance/analysis selection could be not optimal for large width (as 30%)

➔ Single VLQ and pair VLQ search are complementary

Run 2 (=2016) Analysis

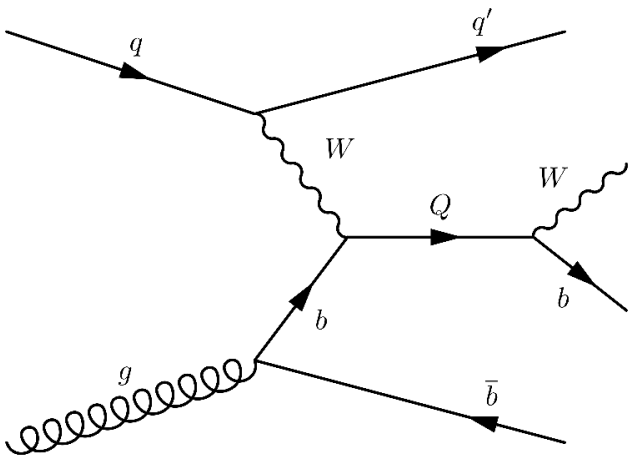
- Atlas is retuning an analysis for VLQ → Wb with width/coupling consideration
- CMS is following existing ones (T→tZ) with large width consideration (10%/20%/30%)

- Both analysis are scaling cross section to NLO but do not take potential effect of NLO on forward jet

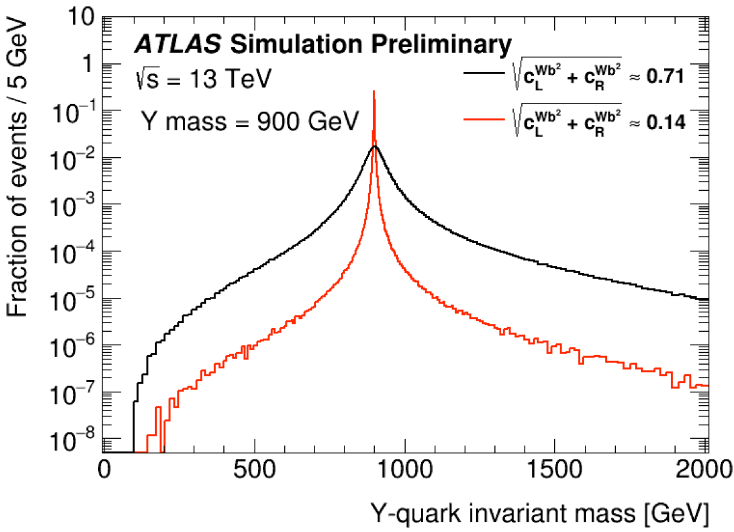
- Chirality is not presenting major differences in the final state quantities used by the analysis, so the tuning of the criteria is done over one chirality and applied to both.

Atlas: Single $Y^{4/3}/T \rightarrow Wb$

- Leading order feynman
- Interpretation as (B,Y) doublet or T singlet
- Studies made with narrow width approximation, smearing performed to study larger width
- Search performed in lvb final state with mass reconstruction (pz is minimal from real solution, if non real, then varies E_T to get real solution)
- Main background are W+jets and tt which are estimated from MC with cross check in control region
- Non prompt lepton from Matrix Method



ATLAS CONF 2016-072

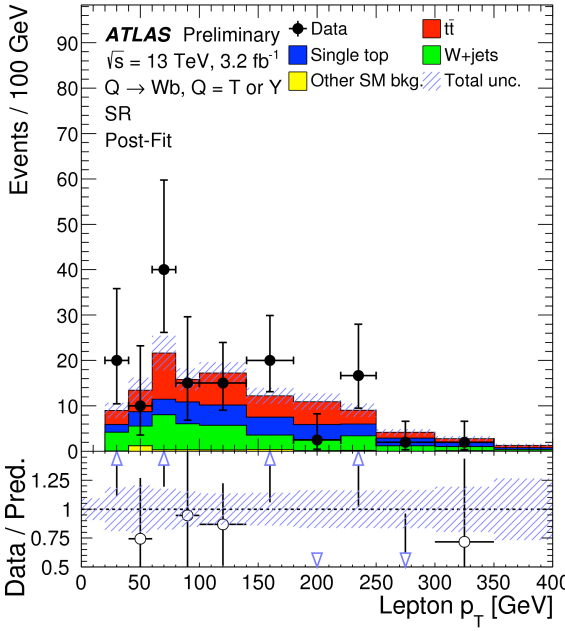


Width ~ 50 GeV (?)
So below detector resolution (?)

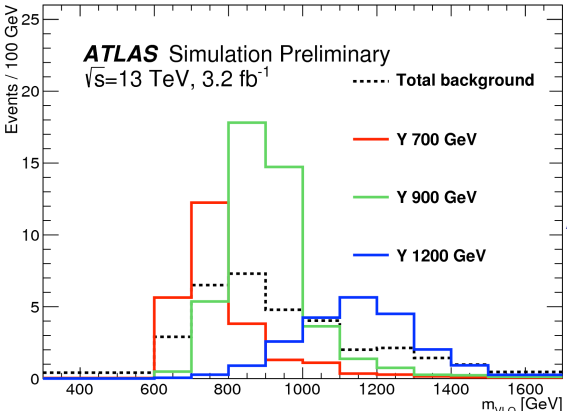
Atlas: Single $Y^{4/3}/T \rightarrow Wb$

Selection:

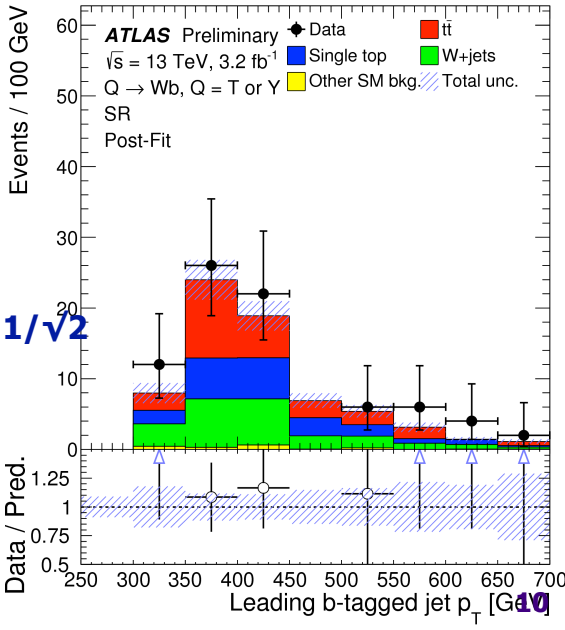
- **1 isolated e with pt >25 GeV or 1 μ with pt > 20 GeV matched to primary vertex**
- **≥ 1 b-jet with pt> 350 GeV**
- **Etmiss > 120 GeV**
- **Δφ (lepton,leading b-tagged jet)| > 2.5**
- **≥ 1 forward ak4 jet pt>40 GeV (2.5<|η|<4.5)**
- **Veto if 1 ak4 jet pt>75 GeV, |η|<2.5 and ΔR (jet, leading b-tagged jet)< 1.2 or ΔR (jet, leading b-tagged jet) > 2.7**



Region	Selection cuts: Leading jet p_T	Leading jet is b-tagged	ΔR (jet, b-tagged jet))< 1.2 or ΔR (jet, b-tagged jet) > 2.7
SR	> 350 GeV	yes	0
$t\bar{t}$ CR	> 200 GeV	yes	≥ 1
W+jets CR	> 250 GeV	no	-



For Y mass [700 GeV, 1600 GeV]
Coupling strength $\sqrt{(c^{Wb}_L)^2 + (c^{Wb}_R)^2} = 1/\sqrt{2}$
S/√B → [0.5,3.8]
Acceptance x ε = [0.3%,1.4%]



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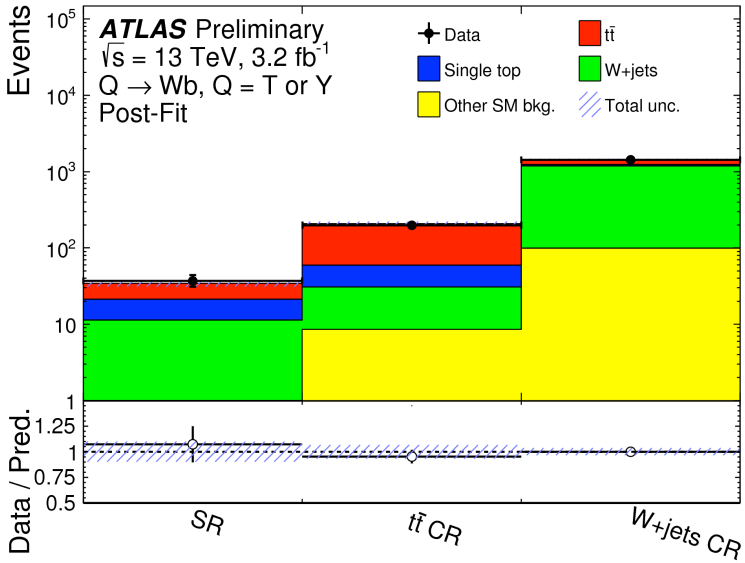
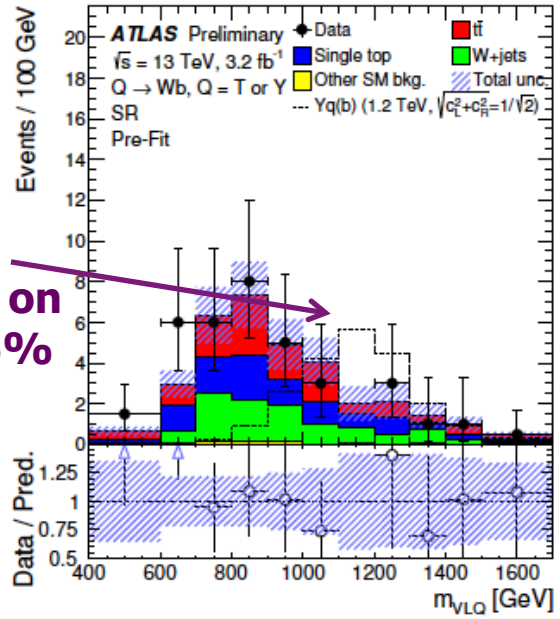
Atlas: Single $Y^{4/3}/T \rightarrow Wb$

Simultaneous fit in SR and CR

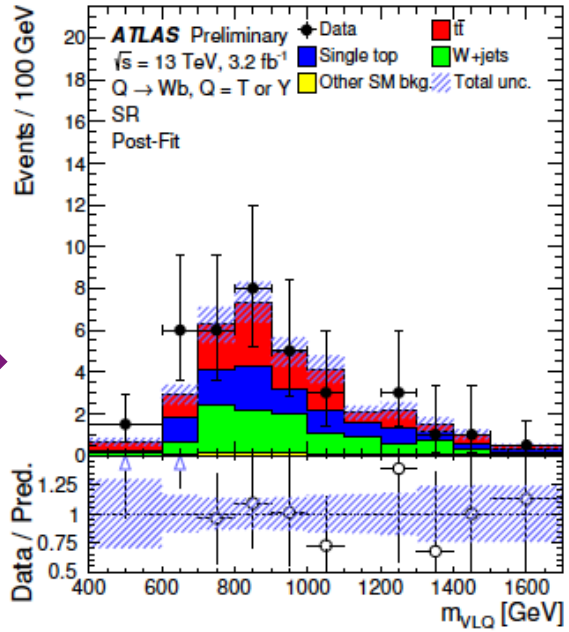


	SR	$t\bar{t}$ CR	W+jets CR
$t\bar{t}$	13.4 ± 3.4	149.8 ± 14.8	195.5 ± 38.0
single top	9.8 ± 1.5	28.5 ± 4.0	42.0 ± 7.5
W+jets	10.7 ± 2.0	22.0 ± 4.4	1093.4 ± 59.1
Multijet	0.01 ± 0.3	5.4 ± 6.4	27.0 ± 16.3
Z+jets, diboson	0.6 ± 0.2	3.2 ± 0.6	72.2 ± 5.8
Total	34.5 ± 3.6	208.9 ± 15.6	1430.1 ± 52.1
Data	37	199	1427

Mass resolution on signal > 5%



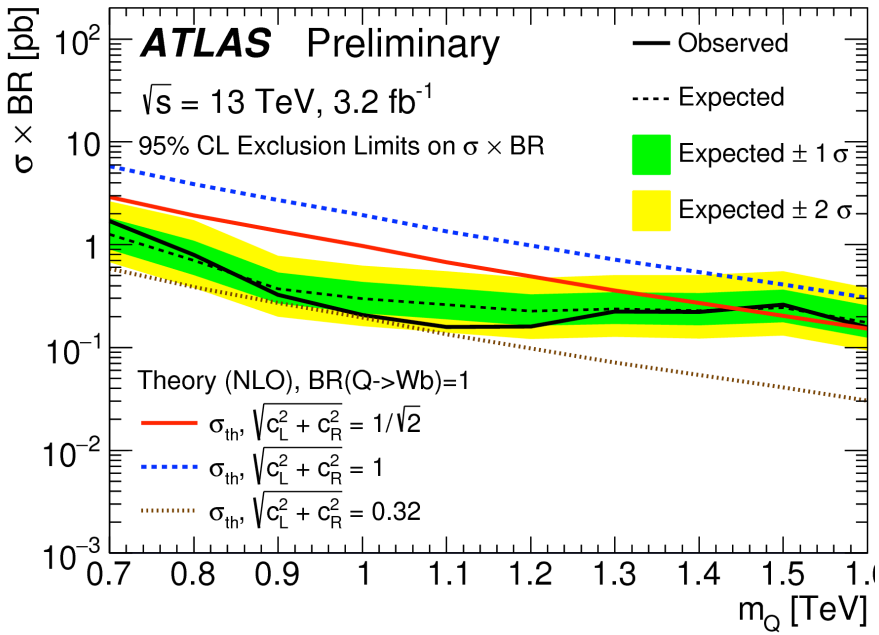
Fit

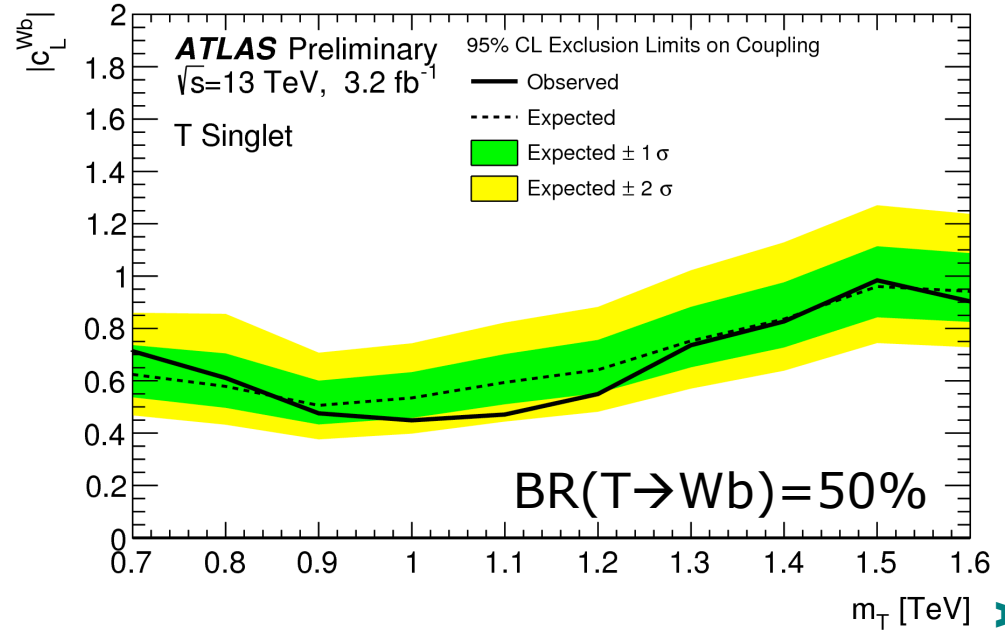


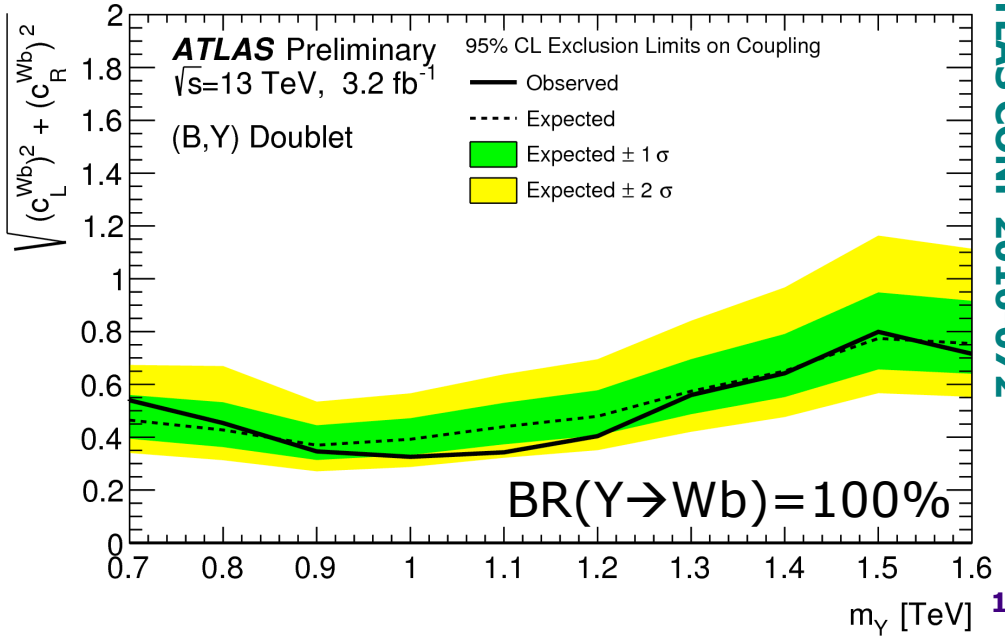
ATLAS CONF 2016-072

Atlas: Single $Y^{4/3}/T \rightarrow Wb$

Limits:







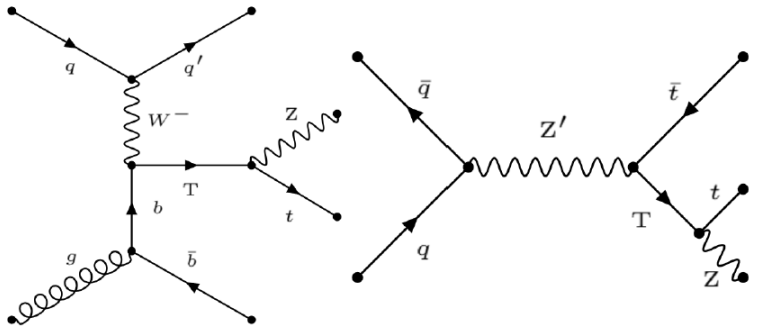
Interpretation in terms of coupling/width
Width consideration still below detector resolution

➔ Exclusion of large part of narrow width approximation

ATLAS CONF 2016-072

CMS: Single T → Zt

- Leading order feynman
- Interpretation as singlet/doublet T
- Studies made with narrow width approximation + MC produced for various width: NWA, 10%, 20%, 30%
- Search performed in ll+top final state with mass reconstruction
- Analysis performed in all regimes for top: resolved, semi-resolved, boosted
- Categorization as function of presence of a forward jet
- Main background are Z+jets and tt which are estimated from data with efficiency from MC



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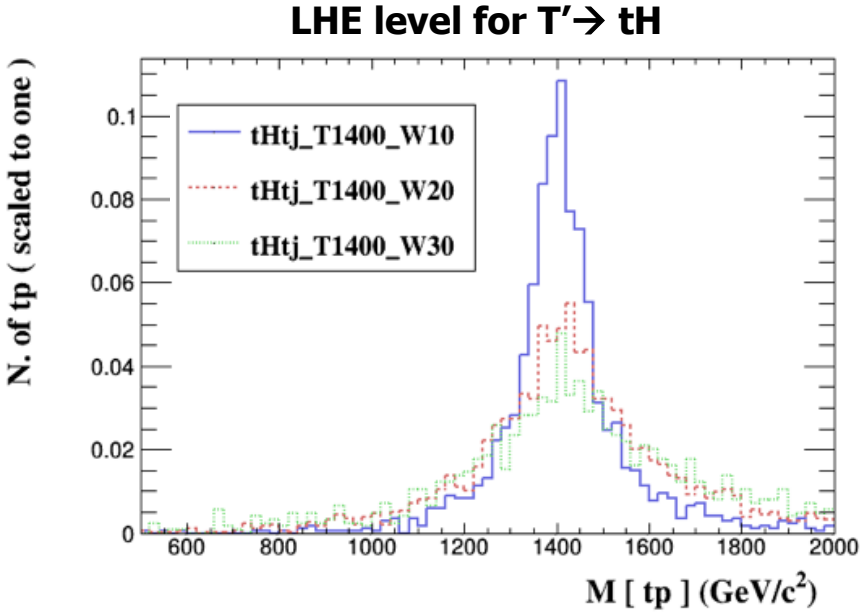


CMS: Single T → Zt

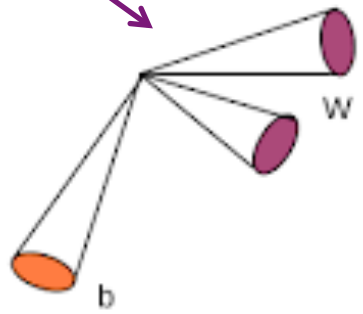
Selection:

- **2 isolated opposite sign e/μ with pt(l_1) >120 GeV and pt > 20 GeV**
- **≥ 0 forward ak4 jet pt>30 GeV (2.5<|η|<4.5)**

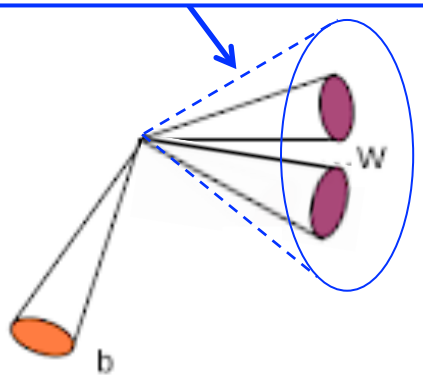
Depending on Top decay:

Jet	one top jet	one W jet one b jet	three ak4 jets (one b-tagged)
$\Delta R(\ell,\ell)$	< 1.4	< 0.6	< 0.6
N(b jet) medium WP	≥ 1	≥ 1	≥ 1

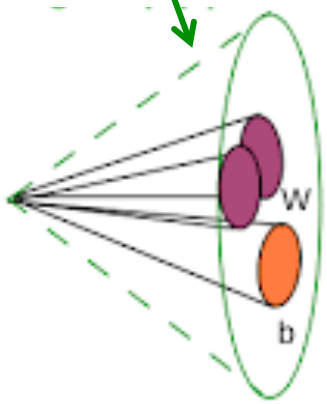
Fully resolved:
≥ 3 ak4 jets
pt>20 GeV with 1 b-tag



Partially resolved:
≥ 1 ak4 jets pt>20 GeV
b-tag + ≥ 1 ak8 W-tag
pt>180 GeV



Boosted:
≥ 1 ak8 top-tag
pt>400 GeV



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CMS: Single T → Zt

Background estimation based on: $N_{bkg}(M_{t,Z}) = N_{cr}(M_{t,Z}) \cdot \alpha(M_{t,Z})$

Control Region defined as event with no loose b-tag jets

α is measured on MC: $\alpha = \frac{M_{t,Z}(\text{passing b tag})}{M_{t,Z}(\text{failing b tag})}$

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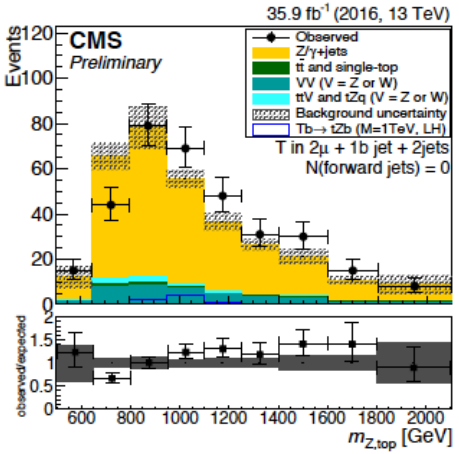
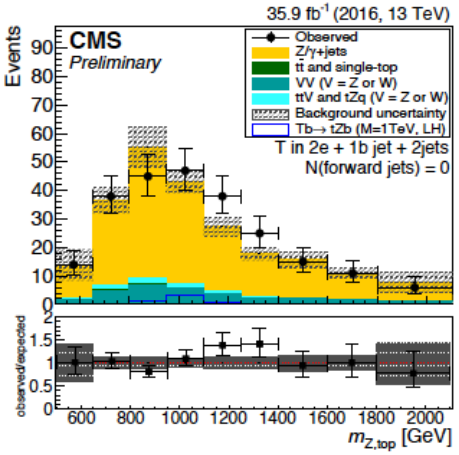
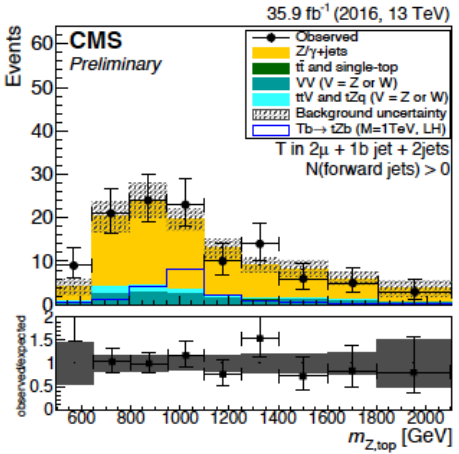
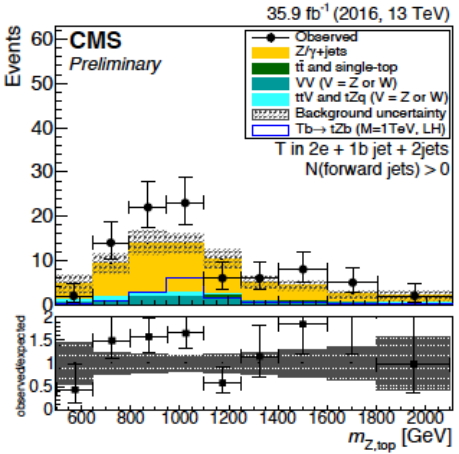
Fully resolved:

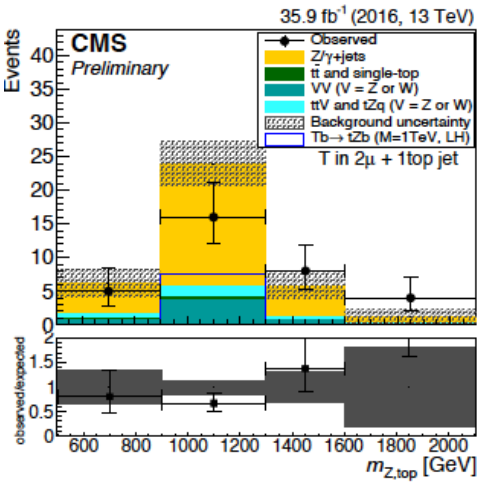


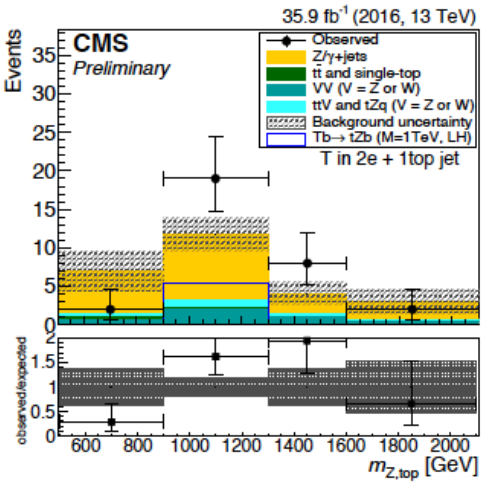






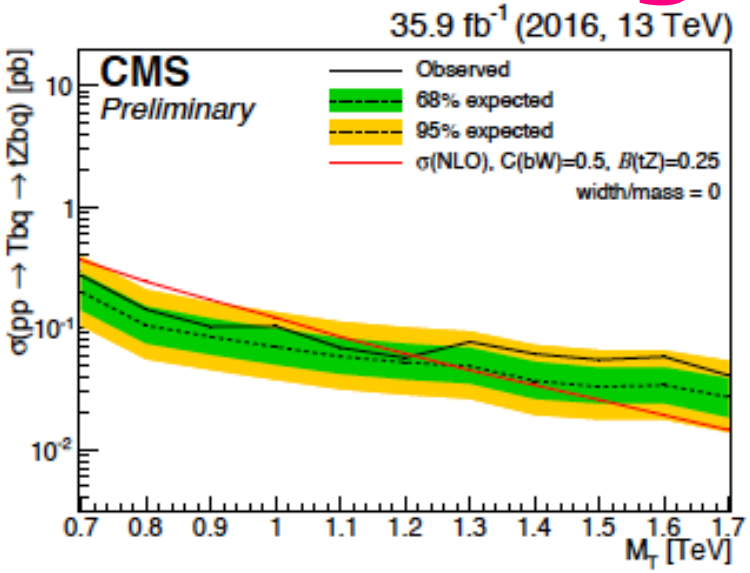
Boosted:

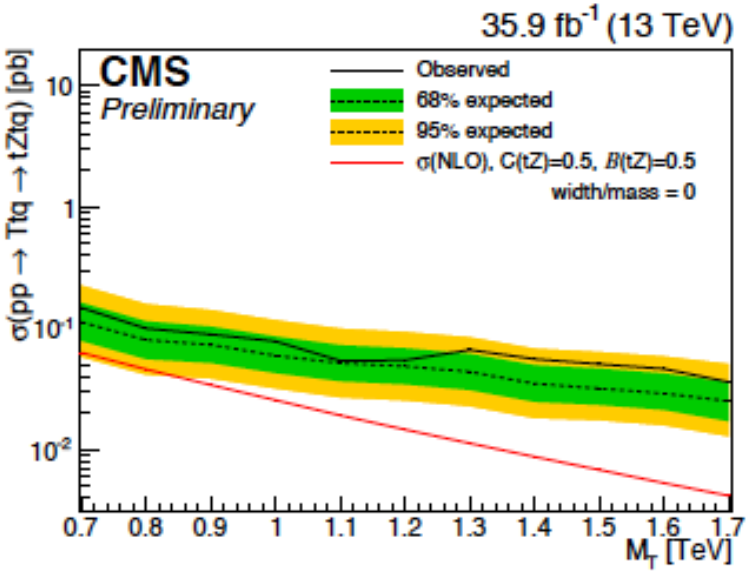


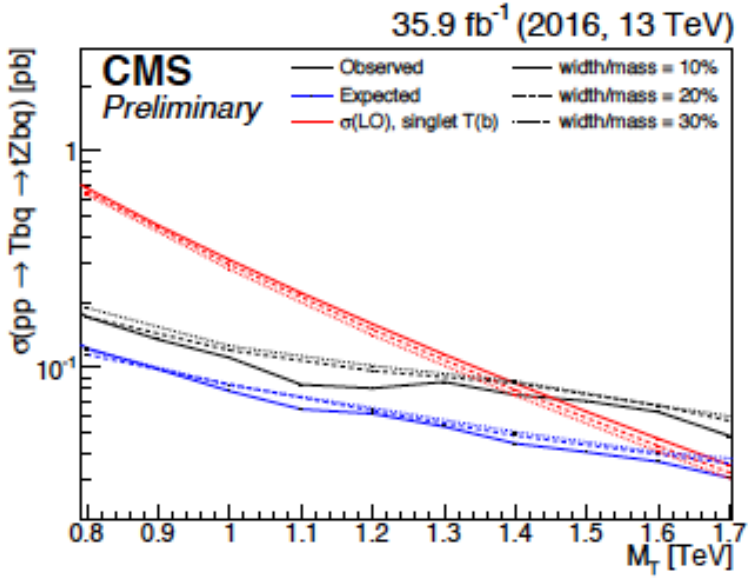


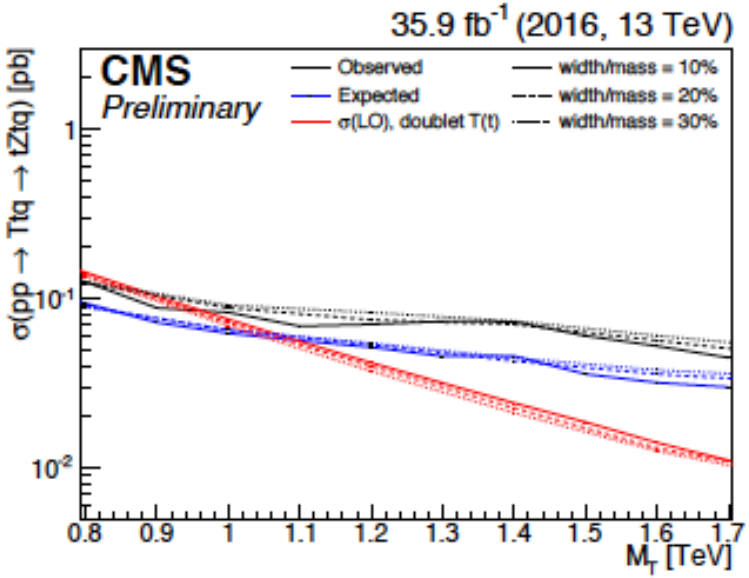
CMS: Single T → Zt

Limits:









CMS PAS B2G-17-007

Interpretation in terms of coupling/width (larger than detector resolution)
➔ Exclusion of large part of narrow width approximation

Summary

- **Single production would become the main channel but it is more difficult as really in the bulk of the background**
- **New studies on single VLQ have started: taking into account coupling which change width consideration**
- **A lot of analysis are on going on single and pair production of VLQ (with french contributions)**
- **New results are expecting soon (constraining large width/couplings)**

Alternative Summary