

Search for vector-like quarks

J. P. Araque, J. Santiago, N. F. Castro
T. Vale, A. Peixoto, J. R. Correia, A. Amorim

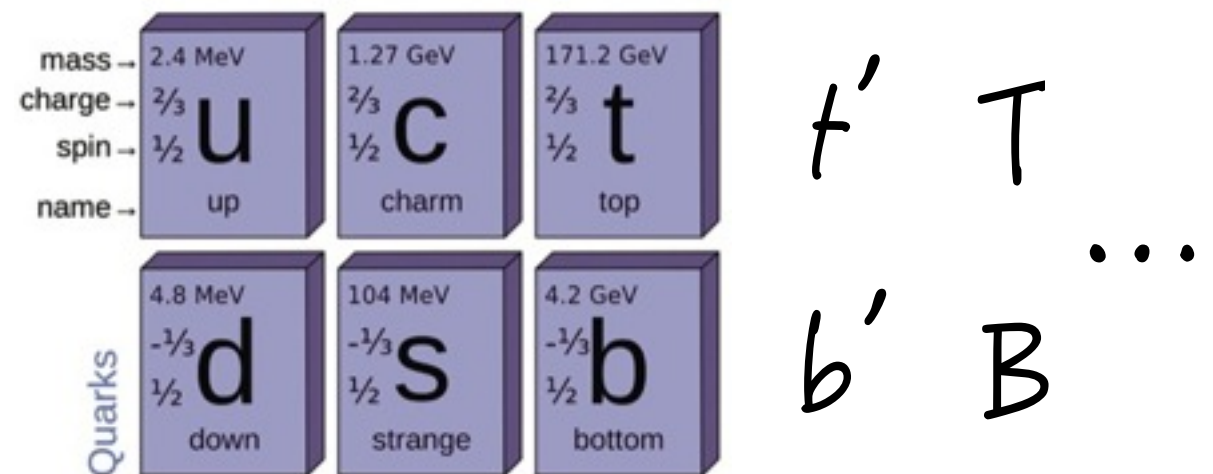


Introduction

$$\begin{aligned} \mathcal{L} = & -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} \\ & + i \bar{\psi} \not{D} \psi + h.c. \\ & + \chi_i^\dagger Y_{ij} \chi_j \phi + h.c. \\ & + |D_\mu \phi|^2 - V(\phi) \end{aligned}$$

- **Standard Model**: best description of particle physics to date.
- Outstanding precision for different observables.
- Completed with the Higgs discovery.

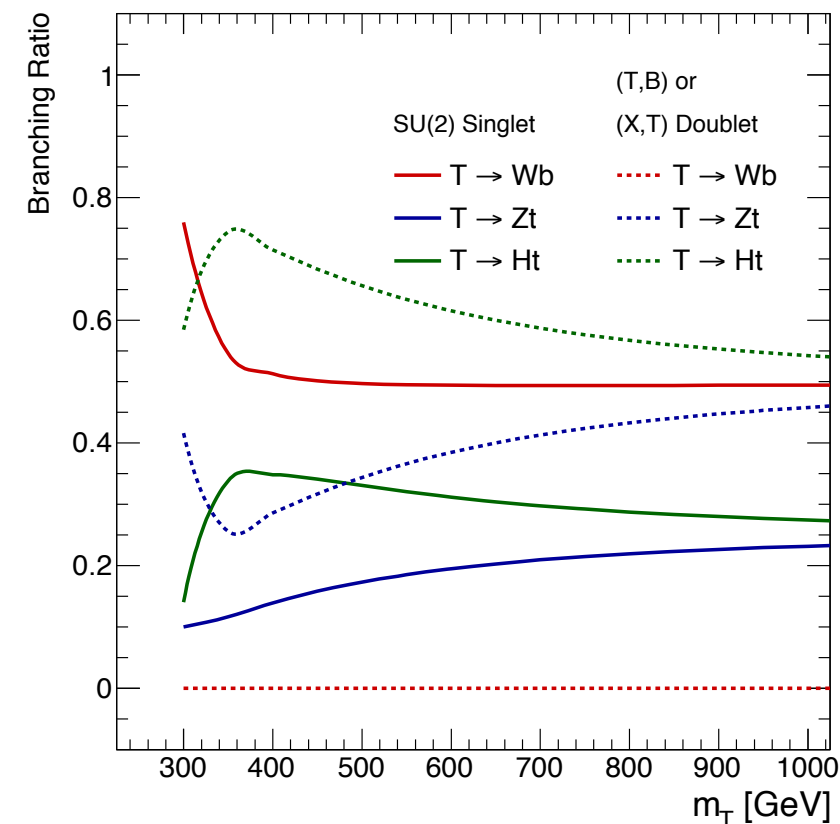
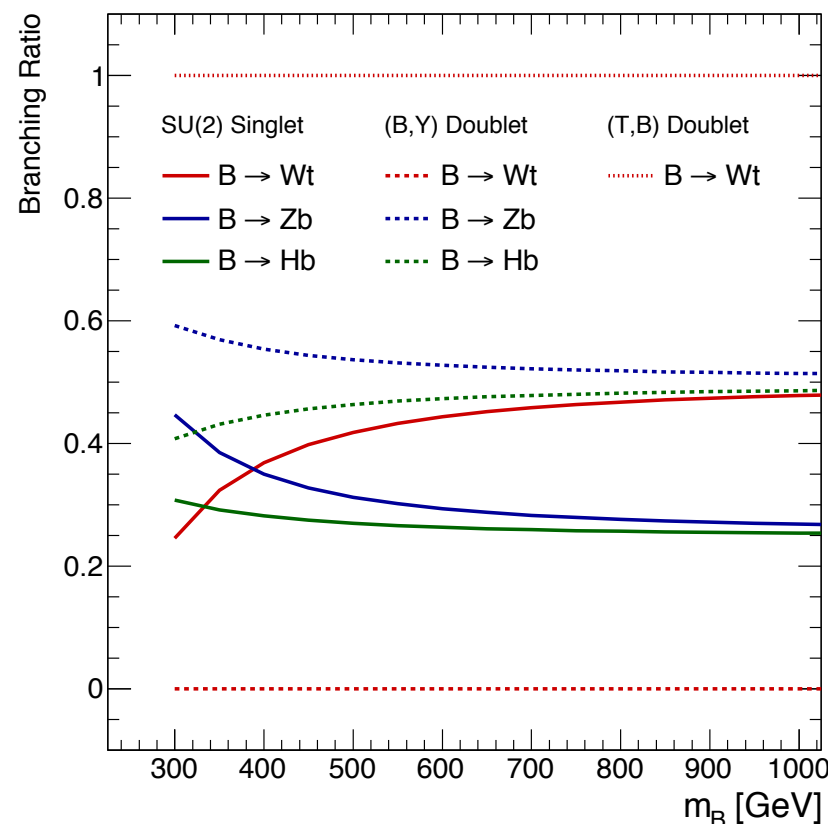
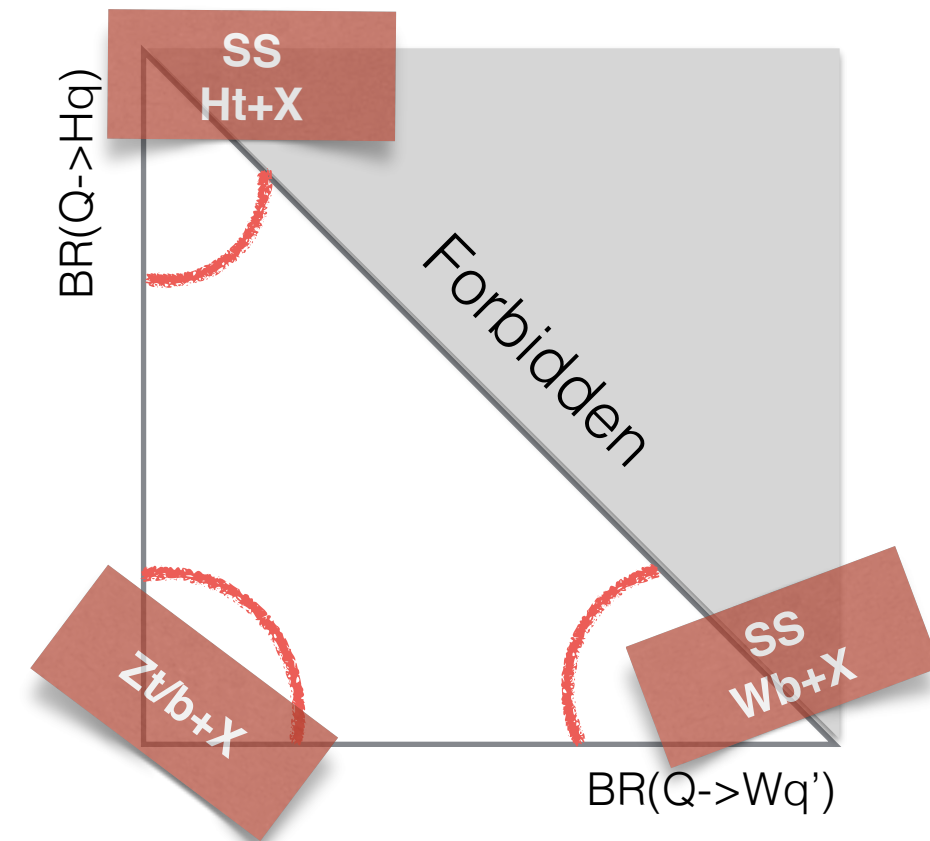
- Open questions:
 - Hierarchy problem.
 - Mass of neutrinos.
 - Number of fermion families.
 - ...



Singlet		Doublet			Triplet	
$T_{L,R}$	$B_{L,R}$	$\begin{pmatrix} U \\ D \end{pmatrix}_{L,R}$	$\begin{pmatrix} X \\ T \end{pmatrix}_{L,R}$	$\begin{pmatrix} B \\ Y \end{pmatrix}_{L,R}$	$\begin{pmatrix} X \\ T \\ B \end{pmatrix}_{L,R}$	$\begin{pmatrix} T \\ B \\ Y \end{pmatrix}_{L,R}$

VLQ Searches in ATLAS

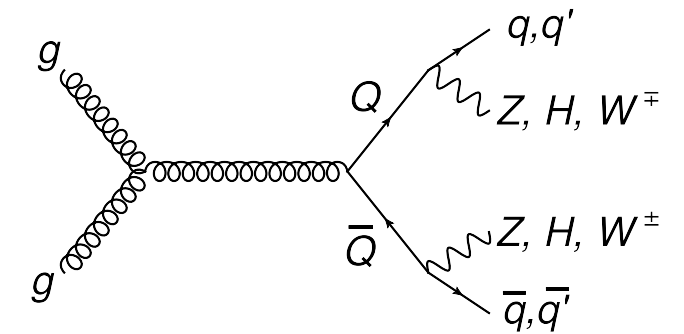
- Several analyses in ATLAS target production of vector-like quarks with different topologies and final states.
 - Cover the maximum phase-space possible.
 - Target the three different possible VLQ decays channel:
 - Same-Sign (SS)
 - Wt+X [PRD91,112011(2015)]
 - Wb+X [JHEP08(2015)105]
 - Ht+X [JHEP08(2015)105]
 - Zt/b+X [JHEP11(2014)104]
- Pair production
- Pair and single production



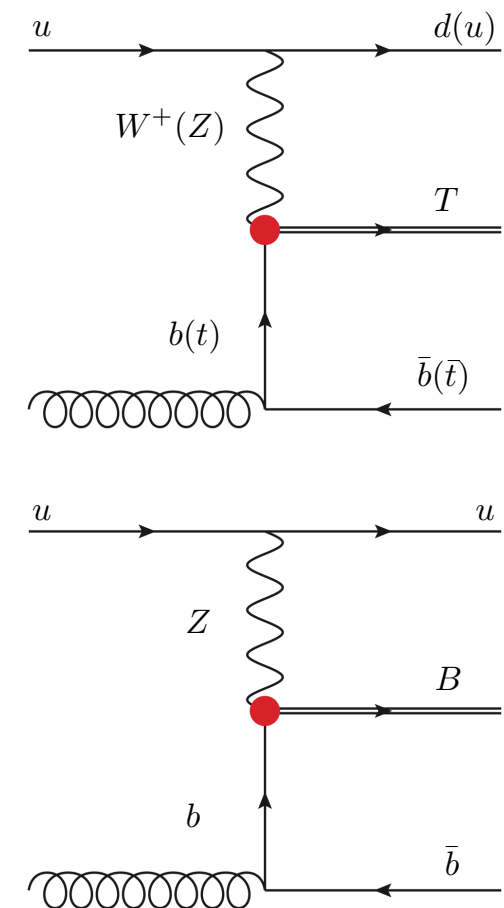
The VLQ Zt/b+X analysis

- This analysis searches for pair and single production of a vector-like quark with at least one of them decaying to a Z boson.
 - Pair production: QCD process like top pair production, rather model independent.
 - Single production: model dependent and a composite Higgs model has been used as benchmark for vector-like T and the singlet model for vector-like B.

Pair production

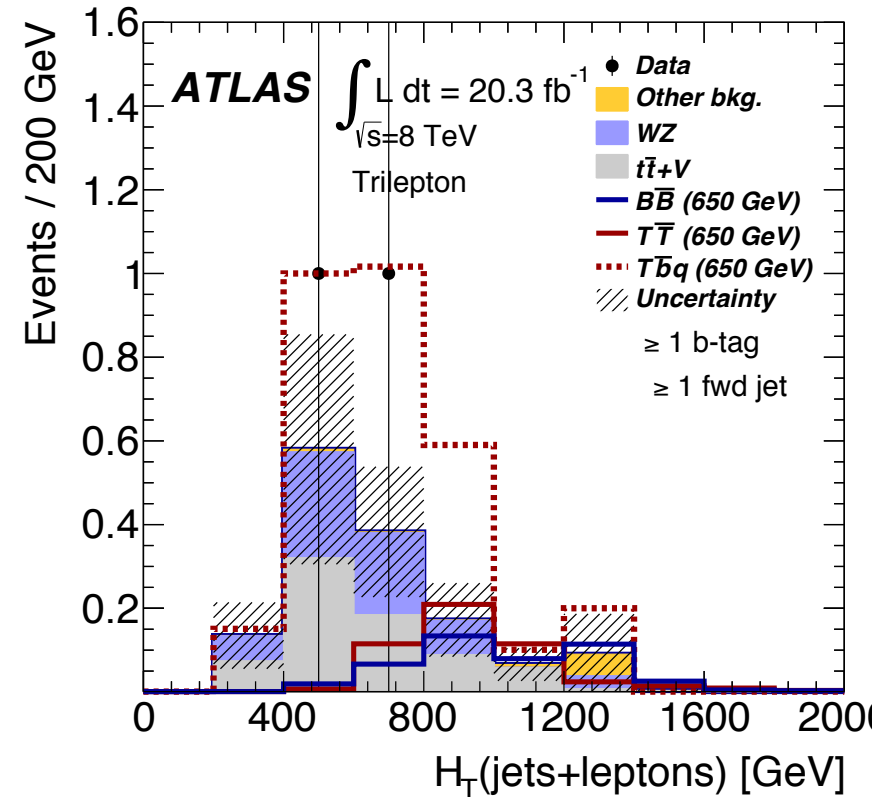
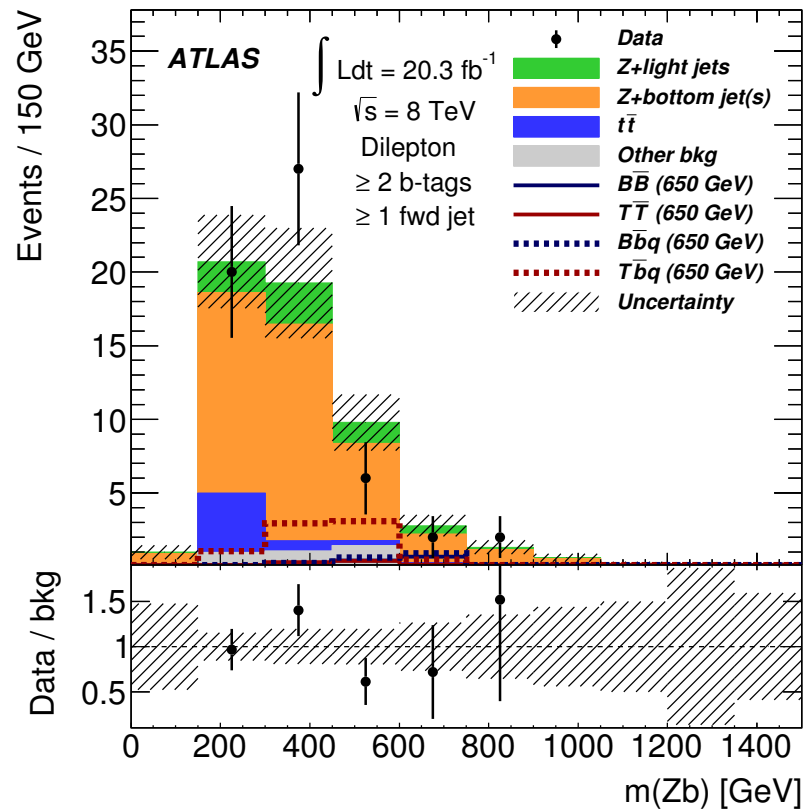
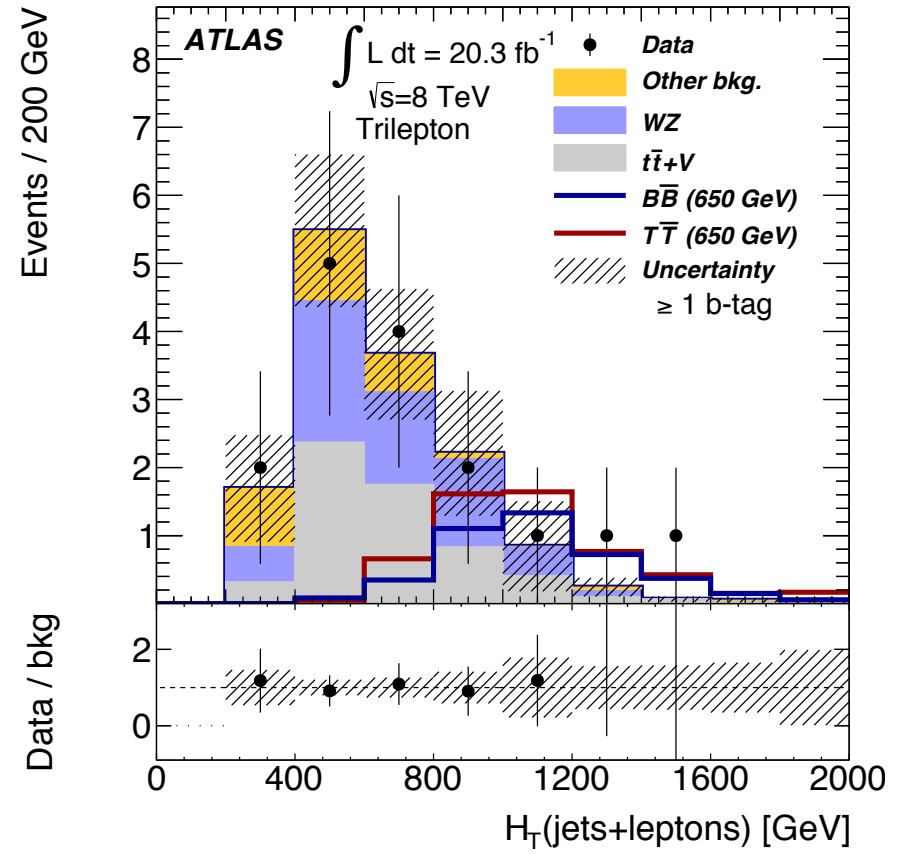
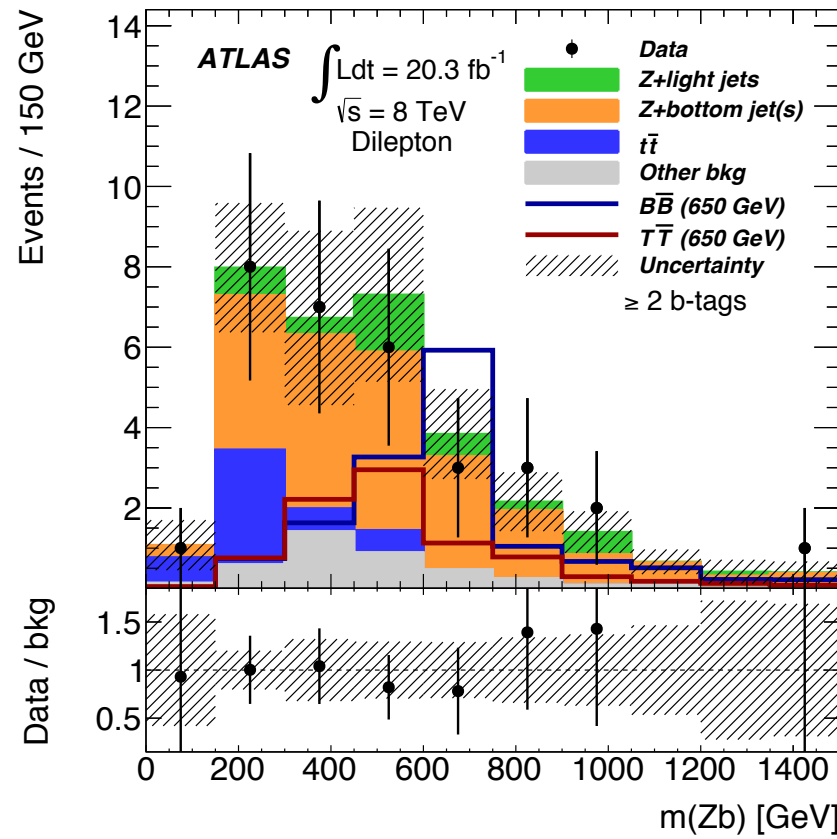


Single production

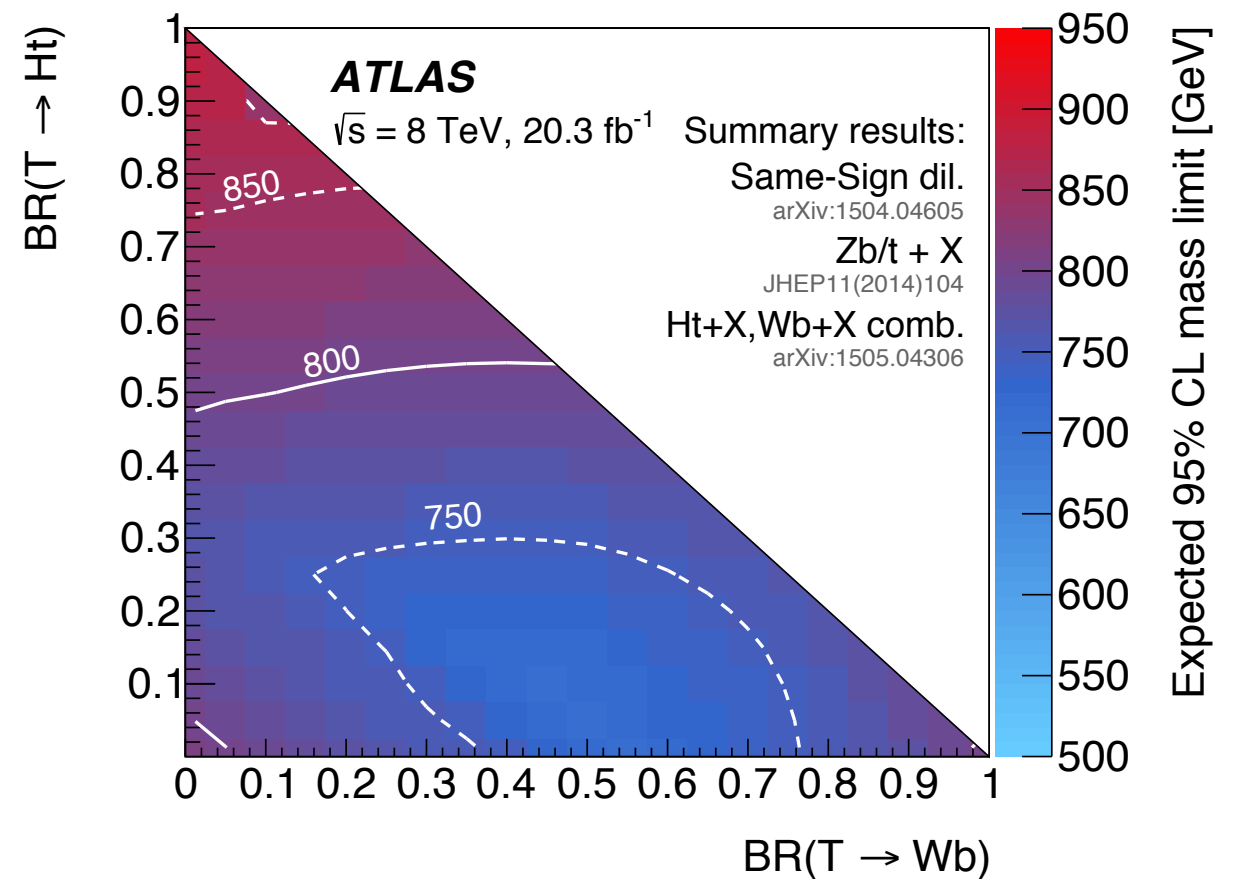
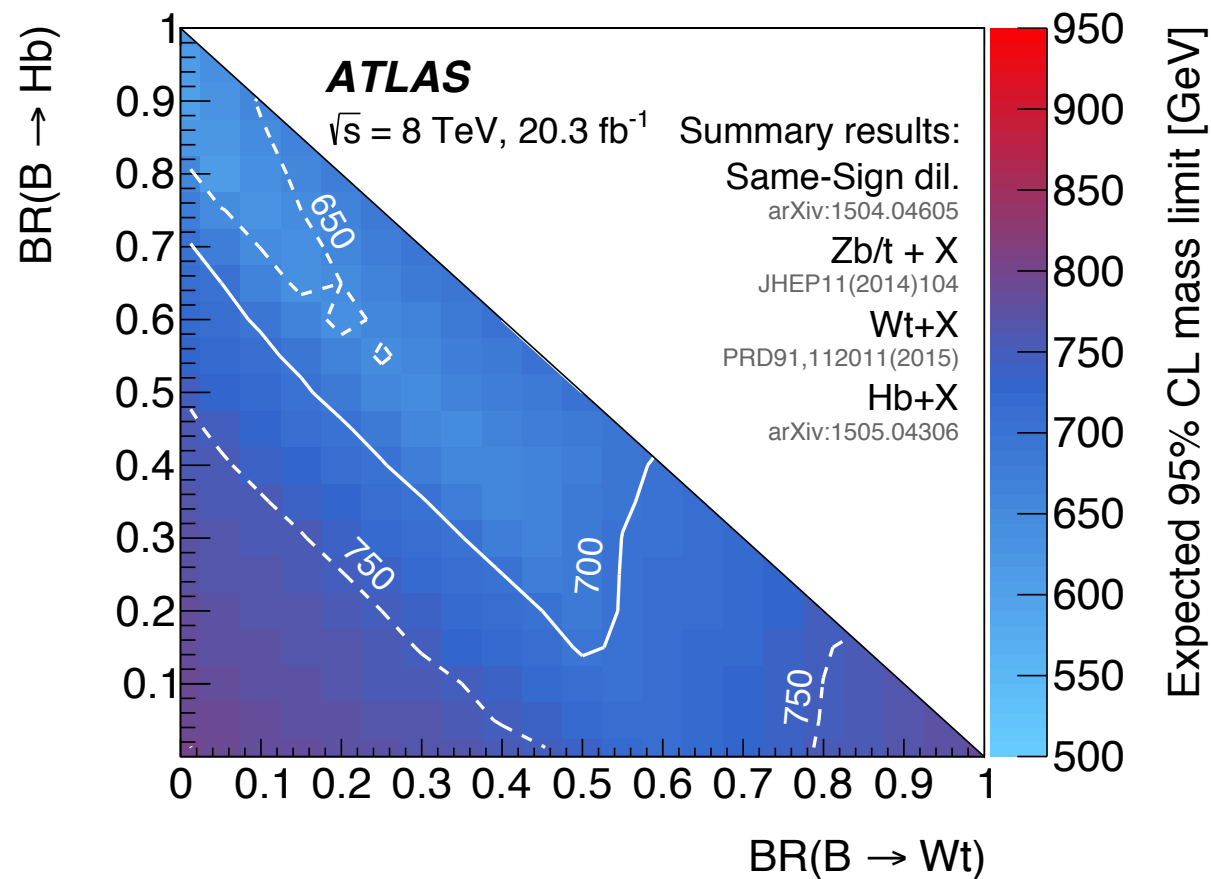
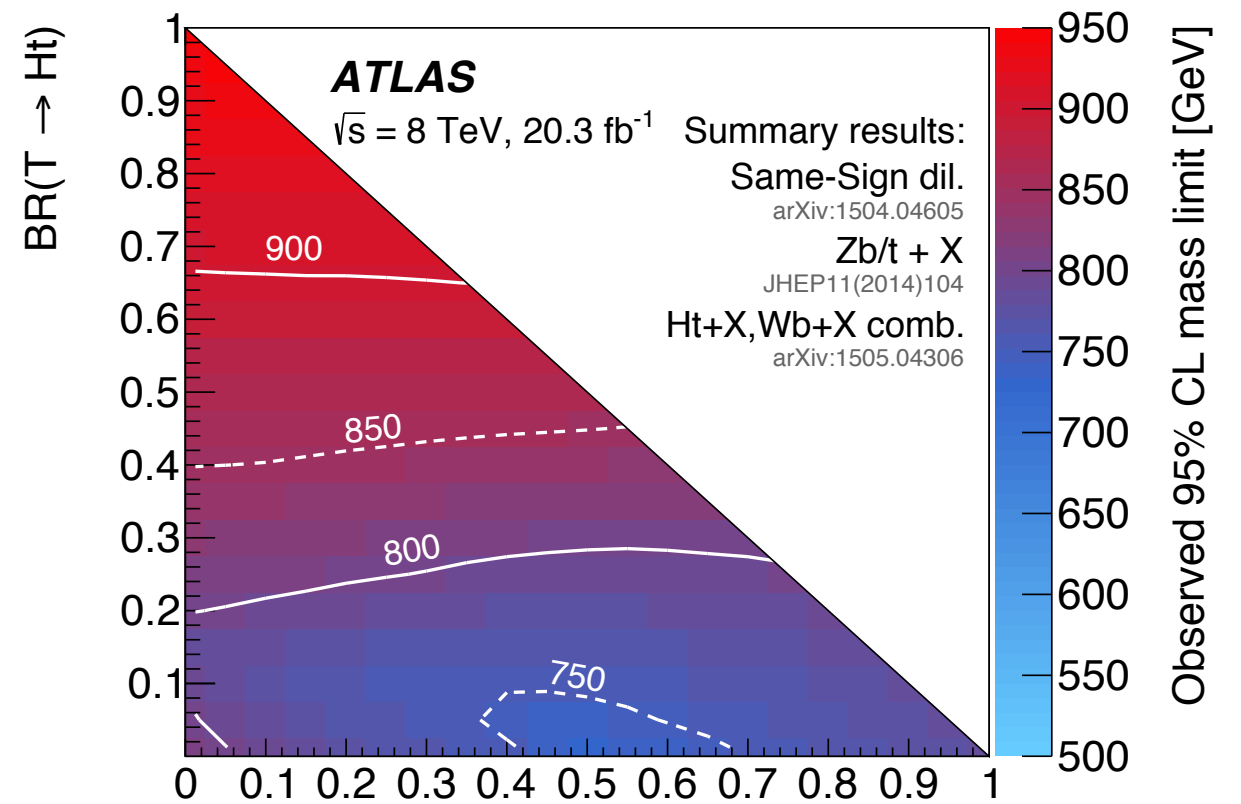
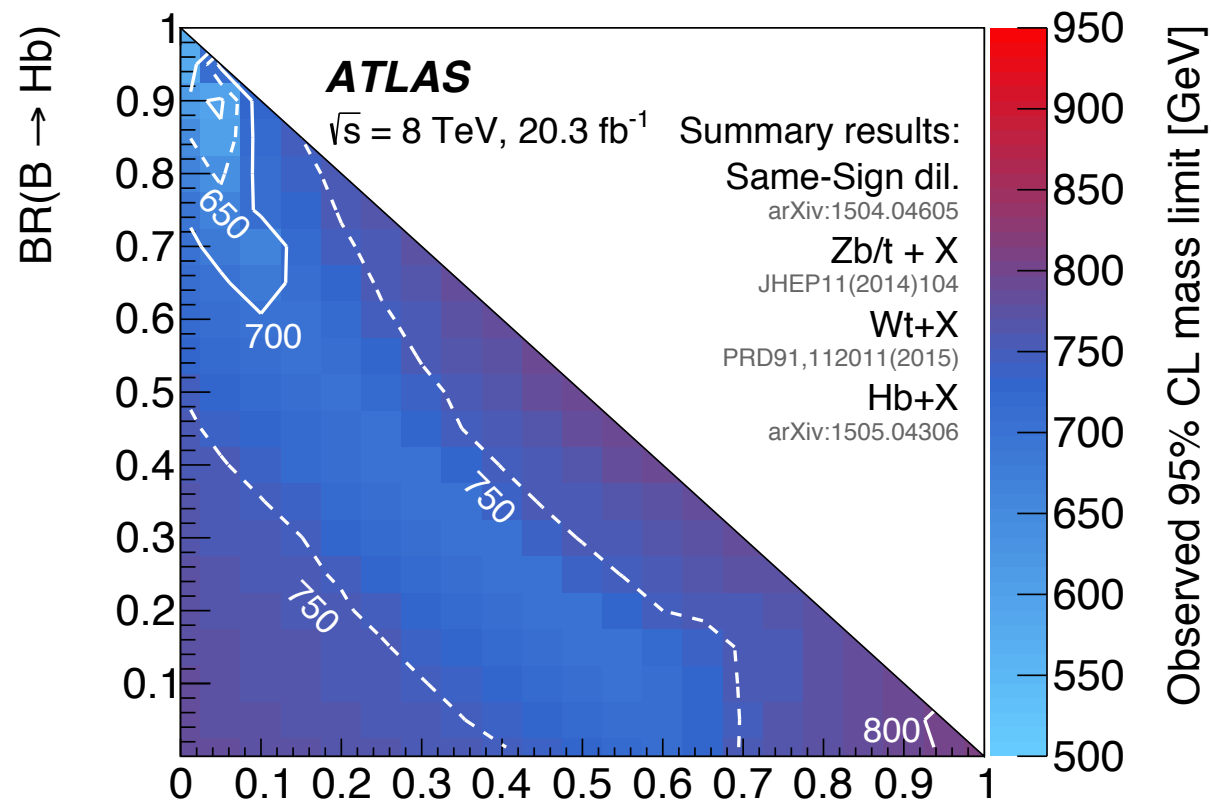


Event selection			
Z boson candidate preselection			
≥ 2 central jets			
$p_T(Z) \geq 150$ GeV			
Dilepton channel		Trilepton channel	
$= 2$ leptons		≥ 3 leptons	
≥ 2 b-tagged jets		≥ 1 b-tagged jet	
Pair production	Single production	Pair production	Single production
$H_T(\text{jets}) \geq 600$ GeV	≥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

Final discriminants

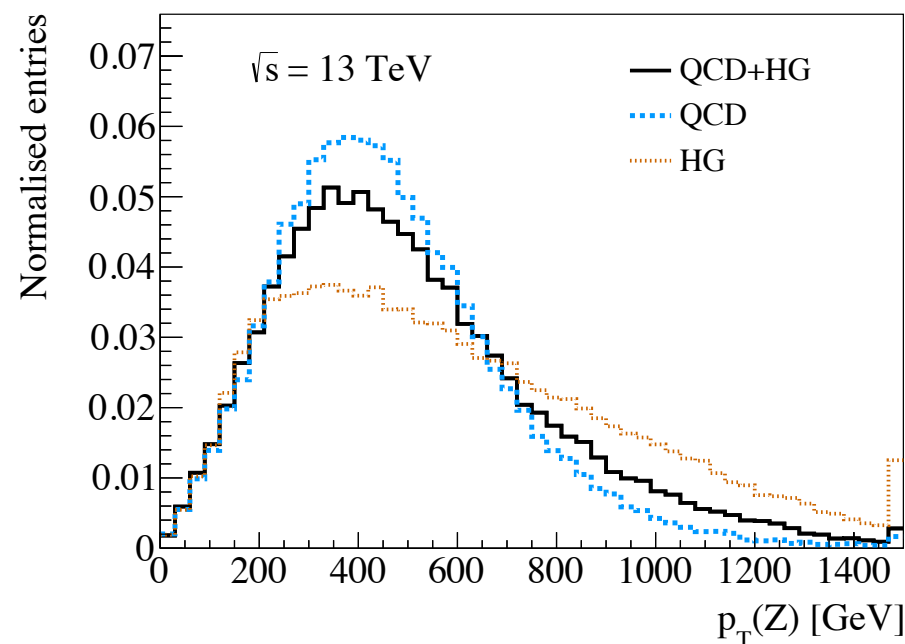
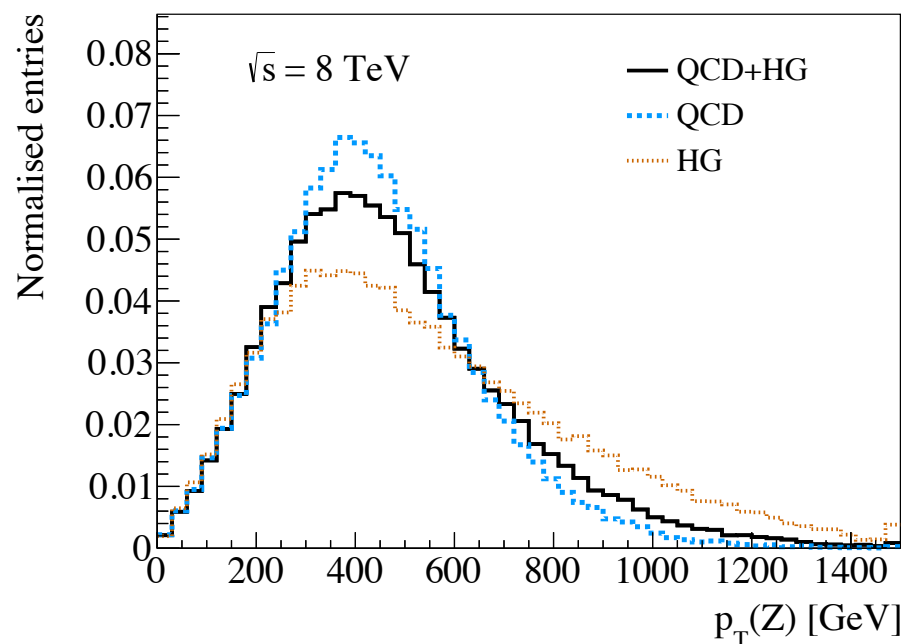


ATLAS summary results

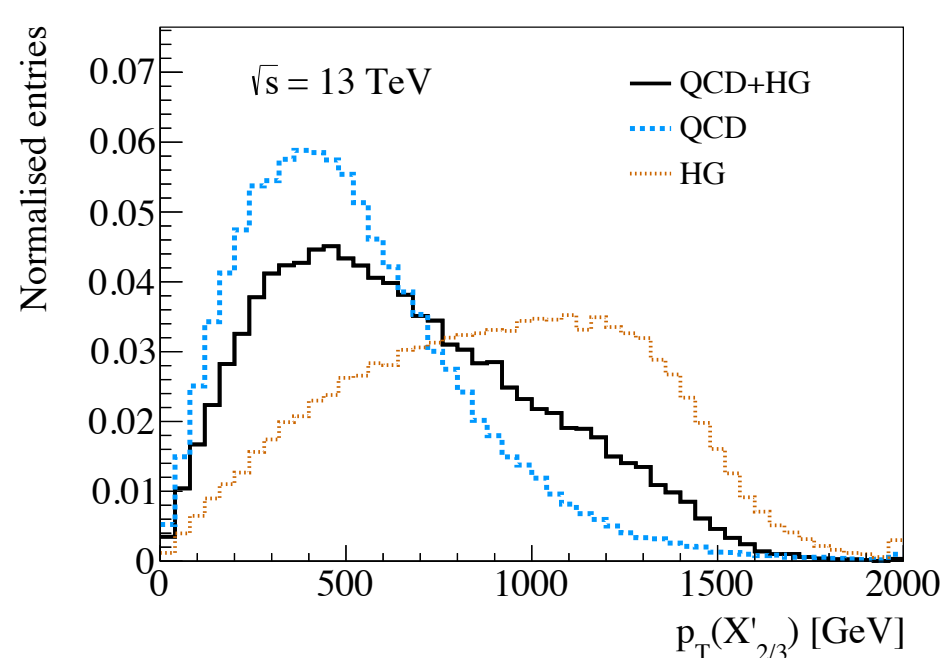
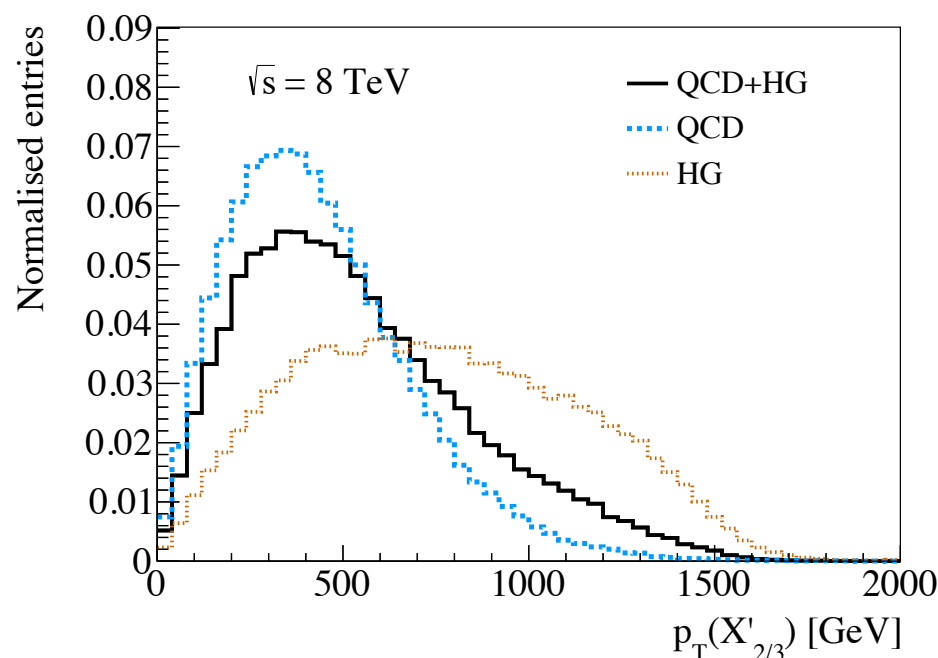


VLQ including heavy gluon contribution

- In composite-Higgs models a new massive color octet can be introduced.
- This new heavy gluon will modify the usual QCD pair production of VLQs.
- Study the kinematical impact of heavy gluons in VLQ production and evaluate whether or not a typical analysis would be sensitive.



**Visible differences
at parton level**

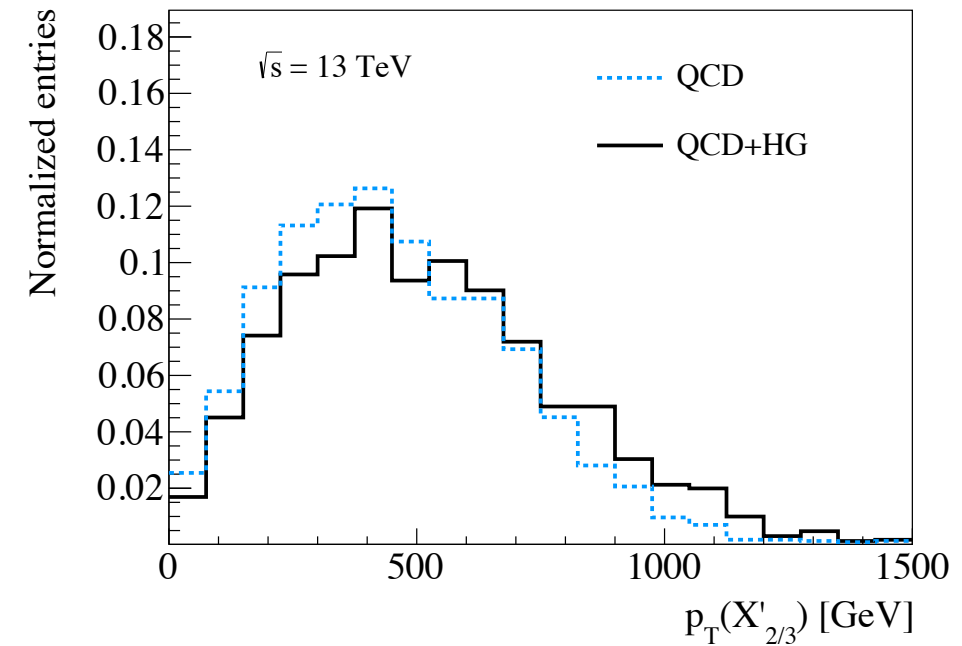
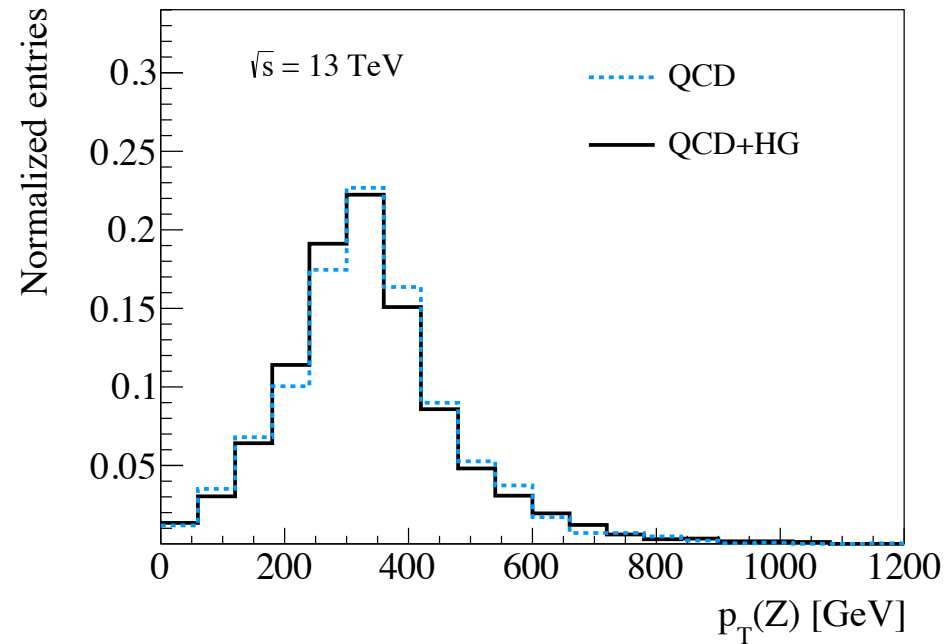


[JHEP11(2015)120]

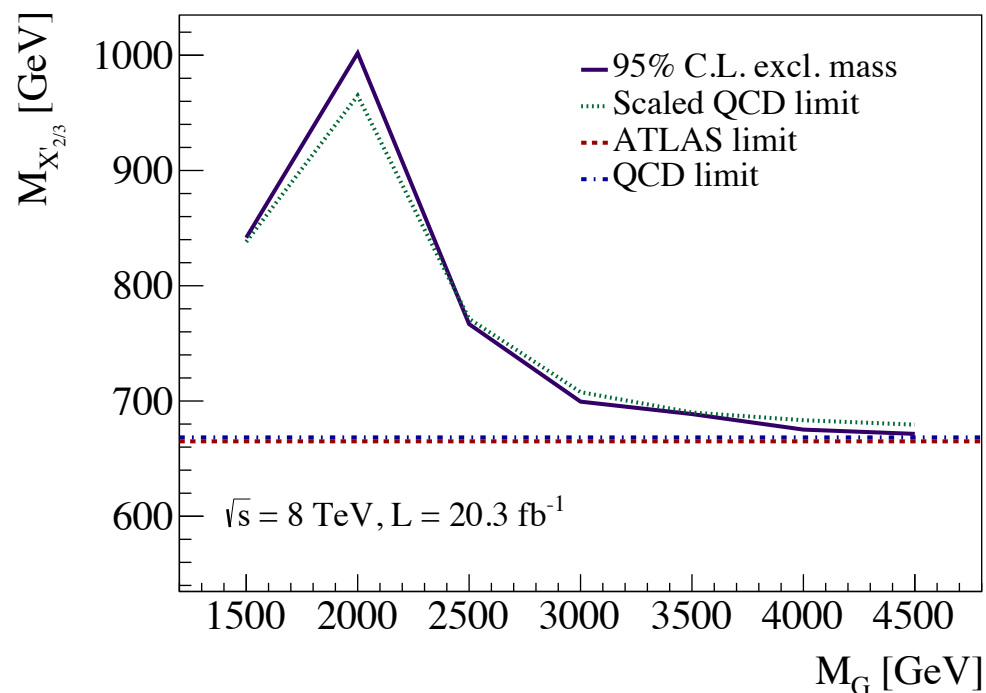
VLQ including heavy gluon contribution

Differences vanish at reco level

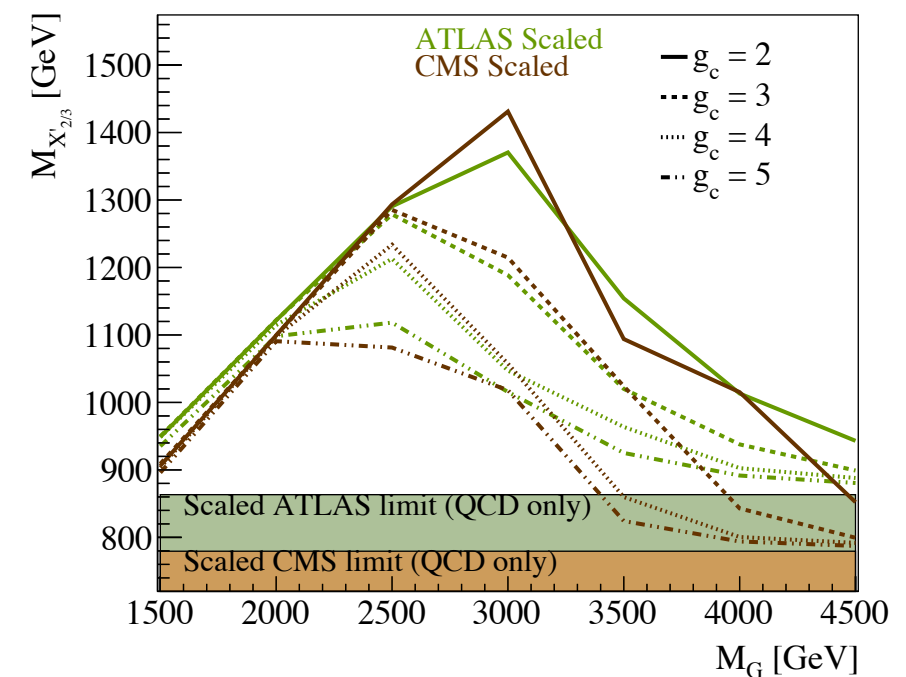
(Zt/b analysis was replicated with dedicated T reconstruction)



Improved analysis with neural network



Excluded masses using latest published results



Conclusion

- ATLAS Analysis:
 - VLQ production both via single and pair production have been studied.
 - The Zt/b analysis is part of the global search for VLQ in ATLAS.
 - Dilepton and trilepton channels are studied.
 - Most stringent exclusion limits for high BR to the Z boson.
- Heavy gluon impact in VLQ searches:
 - The kinematical impact of a heavy gluon in the context of composite Higgs models has been evaluated.
 - No significant impact has been found when using resolved analysis.
 - Given that no differences in efficiencies is found when only QCD and QCD+heavy gluon production are compared, current limits can be used to derive limits on the mass of the heavy gluon and VLQ in this context.