

Searches for new phenomena in final states involving leptons and jets using the ATLAS detector

Adriana Milic

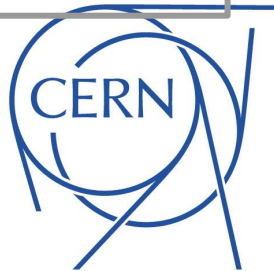
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On behalf of the ATLAS collaboration



UNIVERSITY OF
TORONTO



- Final states including jets and leptons are used to investigate a wide range of phenomena.
 - Selection of newest results from ATLAS is presented.
 - Data from LHC Run 2 at 13 TeV proton-proton collisions used. Selected analyses include data from 2015, 2016, and 2017 ($36 - 80 \text{ fb}^{-1}$).
- Presented today
 - Search for excited electrons
 - Searches for third-generation scalar leptoquarks
 - Search for a right-handed gauge boson decaying to a right-handed heavy neutrino

Search for excited electrons

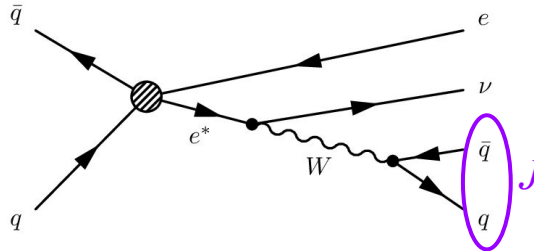
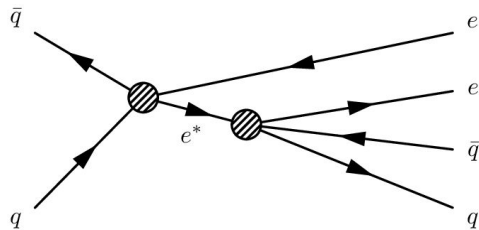
- Excited *electrons* appear in various **composite models**.
- Composite models introduce particles called *preons* that bind at a *high scale* Λ to form SM fermions and their excited states.
- Excited fermions form vector-like states (SU(2) doublets and singlets) that acquire masses on the order of Λ .

Theory

- Search is divided into two channels:

$pp \rightarrow ee^* \rightarrow eeqq = \text{eejj channel}$

$pp \rightarrow ee^* \rightarrow evW = \text{evJ channel}$

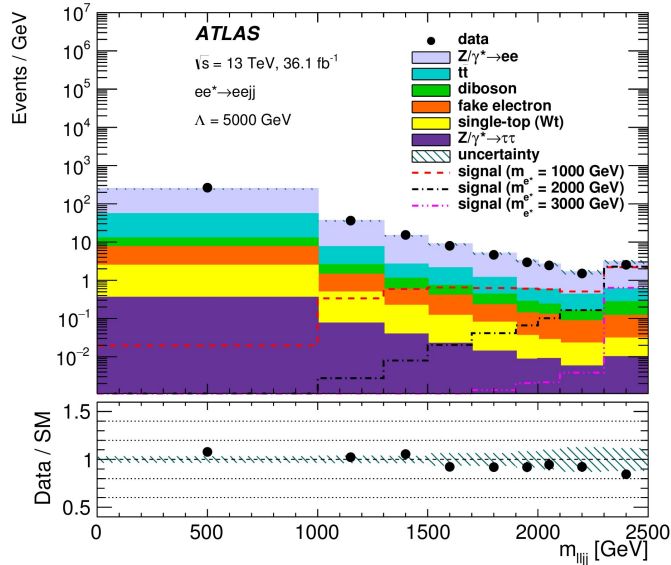


Main backgrounds:

- Z/γ^* (*eejj channel*)
- $W+\text{jets}$ (*evJ channel*)
- *t*bar, single top, diboson (both channels)

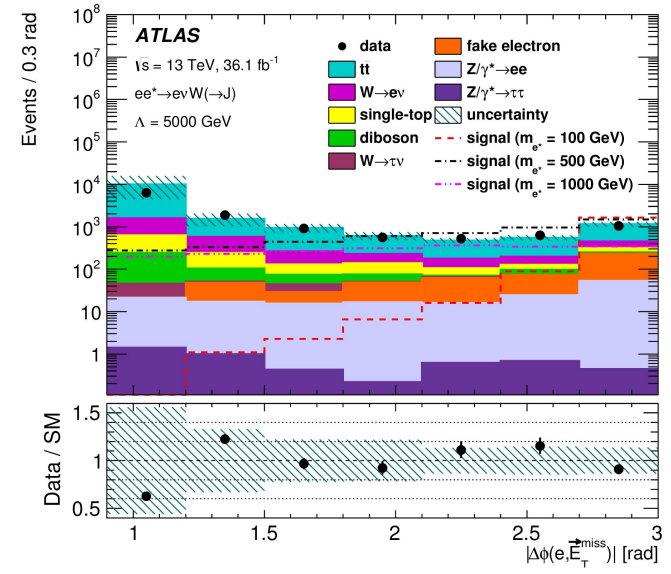
Search for excited electrons

- Signal region $eejj$ constrained with three kinematic variables:
 - **Invariant mass** m_{ll} of electron pair
 - **Scalar sum** S_T of transverse momenta of two electrons and two jets with highest p_T
 - Invariant mass m_{lljj} of two electrons and two jets.



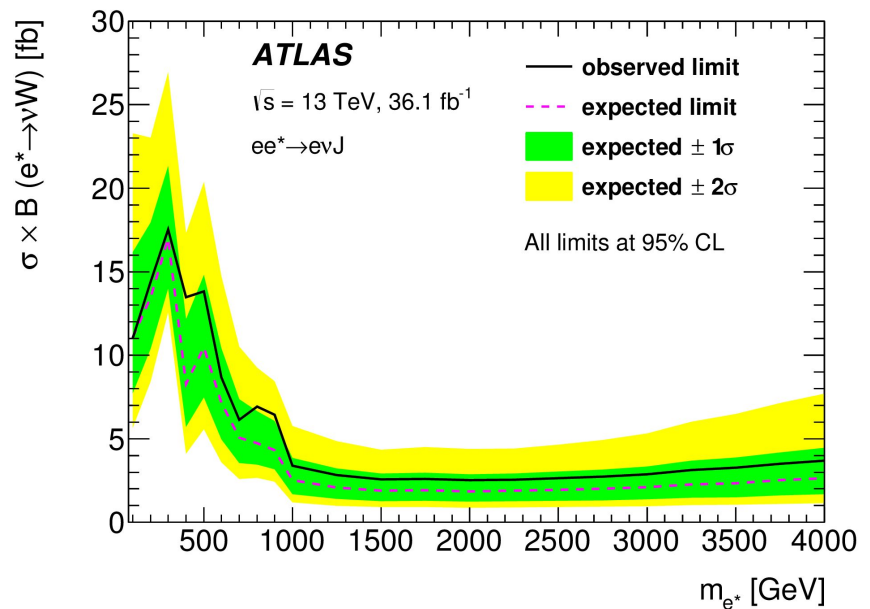
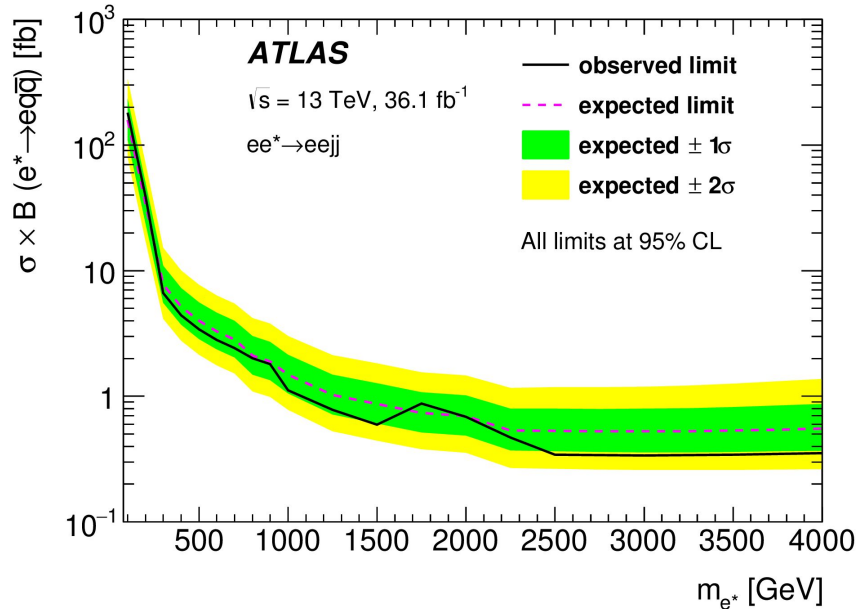
Normalization for $Z+jets$, $t\bar{t}$, and $W+jets$ extracted from control regions.

- In signal region evJ significance optimized for each e^* using
 - Transverse mass m_T^{vW}
 - $|\Delta\phi(e, E_T^{miss})|$



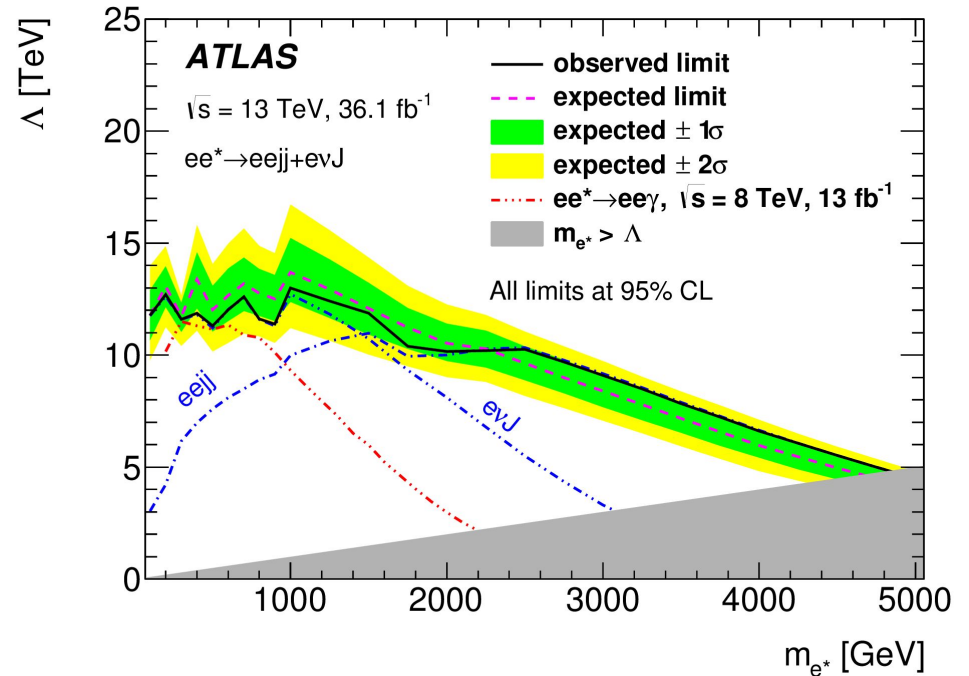
Search for excited electrons

- Binned likelihood fit performed on yields in two control regions and the signal regions.
- Limits set on $\sigma \times B$ as function of m_{e^*} .



Search for excited electrons

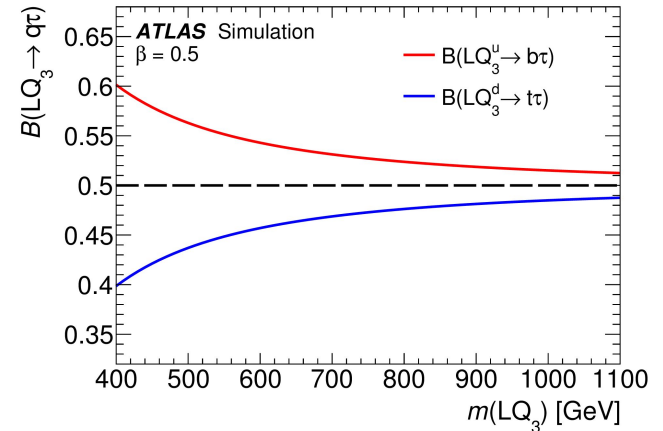
- Unified likelihood function for both channels constructed in order to set **combined limit on compositeness scale Λ** .
- Λ excluded up to 13 TeV in the low mass region.
- The limits for $m_e^* > 4$ TeV are the result of extrapolation.



Search for third gen. scalar leptoquarks

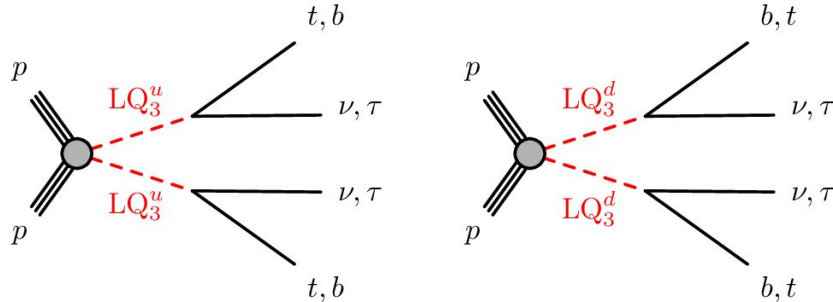
- Search for **pair production of scalar leptoquarks (LQ s)** decaying into third generation quarks (t, b) and a lepton (τ, ν).
- LQ s couple to lepton-quark pair via Yukawa interaction. Coupling determined by
 - **Model parameter β**
 - **Coupling parameter λ**
- Search carried out for an **up-type ($LQ_3^u \rightarrow \tau\nu/b\tau$)** and a **down-type ($LQ_3^d \rightarrow b\nu/t\tau$) LQ .**

Theory



β is not equal to the branching ratio for third-generation LQ s due to the relatively large *top-quark mass*.

→ Results presented as a function of the LQ mass and B into charged leptons.



Search for third gen. scalar leptoquarks

$b\tau b\tau$ channel split in

- $\tau_{lep} \tau_{had}$
- $\tau_{had} \tau_{had}$
- Events with one or two b -jets.

$tt + E_T^{miss}$ with one lepton channel where

- $t_{lep} t_{had}$
- = 1 *isolated* electron/muon
- ≥ 4 jets, ≥ 1 b-jet
- E_T^{miss}

$tt + E_T^{miss}$ with *no lepton* channel

- $t_{had} t_{had}$
- 0 leptons
- ≥ 4 jets, ≥ 1 b-jet
- E_T^{miss}

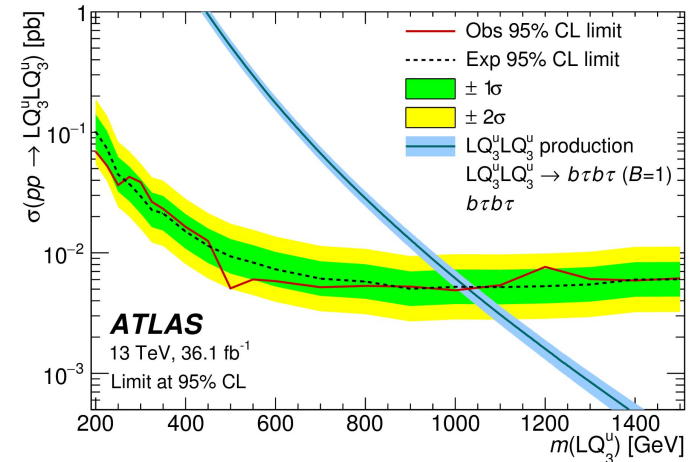
$\tau\tau b + E_T^{miss}$ channel split in

- $\tau_{lep} \tau_{had}$
- $\tau_{had} \tau_{had}$
- E_T^{miss}

$bb + E_T^{miss}$ channel split in

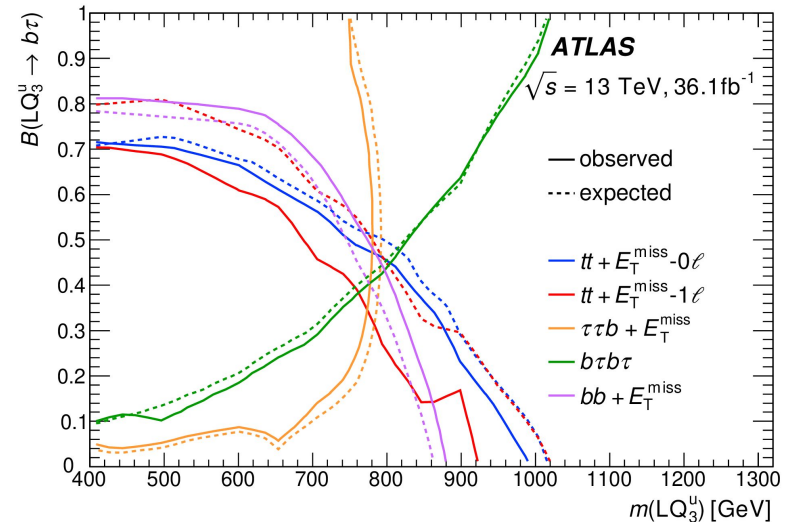
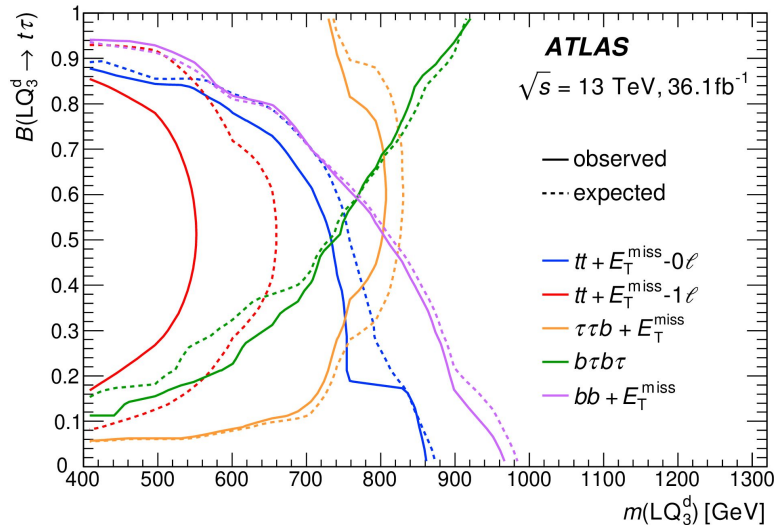
- Zero or one lepton
- = 2 b -jets
- E_T^{miss}

- Each analysis set **upper limits on cross-section** for a **fixed value of B** that is expected to have the highest sensitivity for the respective analysis.
- **Strongest limits** for $B = 1$ ($b\tau b\tau$) and $B = 0$ ($tt + E_T^{miss}$) channels.



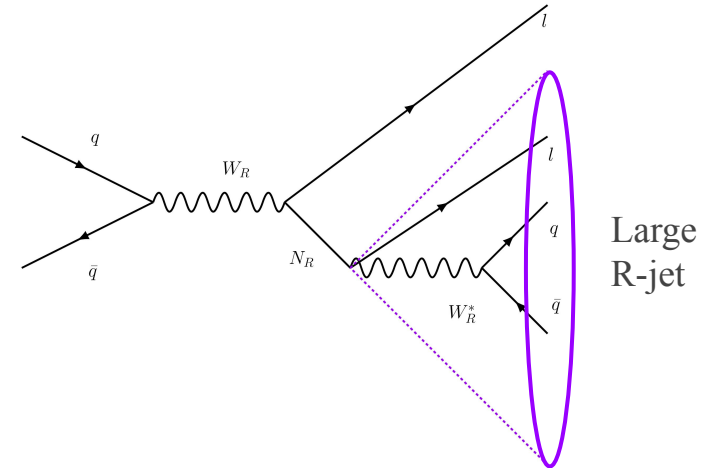
Search for third gen. scalar leptoquarks

- Based on **theoretical prediction for the LQ pair production cross-section**, these cross-section limits can be converted to **lower limits on the LQ mass**.
- Excluding *LQ masses* < 800 GeV (independently of B), and < 1000 GeV for $B = 1$ or $B = 0$.



Search for a right-handed gauge boson

- Search for a right-handed gauge boson W_R , decaying into a *boosted right-handed heavy neutrino* N_R .
- Small neutrino masses explained through **Seesaw mechanism**. In this analysis **Left-Right Symmetric Model (LRSM)** considered that postulates **SM-singlet heavy neutrino** N_R .



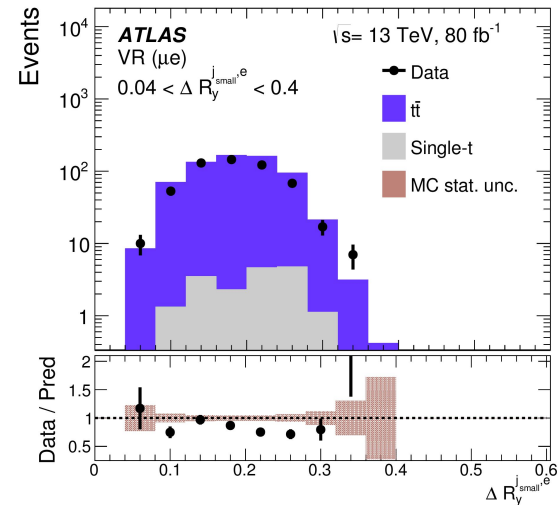
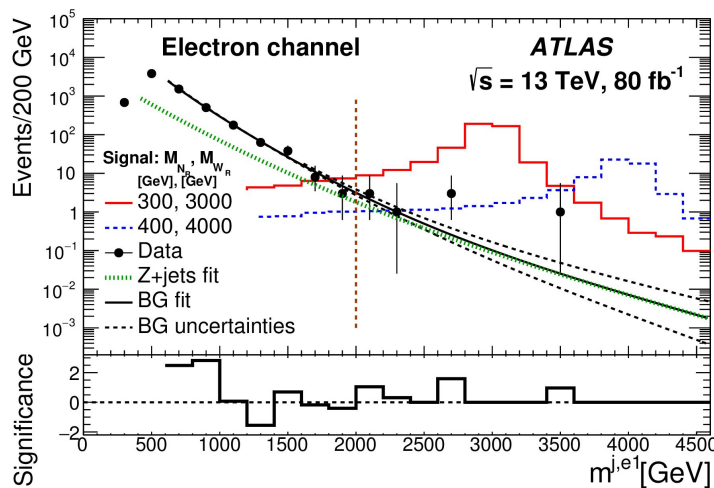
Signature

- *Lepton* and *large R-jet* back to back.
- N_R boosted \rightarrow *Subleading lepton* should be inside jet and *isolated*.
- *Same flavor leptons* required.
- Analysis split into *electron* and *muon* channel.

Search for a right handed gauge boson

- Dominating backgrounds
 - $t\bar{t}$
 - $Z+jets$
- $Z+jets$ fitted in MC in full range.
- $t\bar{t}$ fit in CR in data with $Z+jets$ fixed to value obtained from MC.
- VR used to assess *electron identification performance* inside jet
→ add 30% uncertainty to cover for mismodeling.

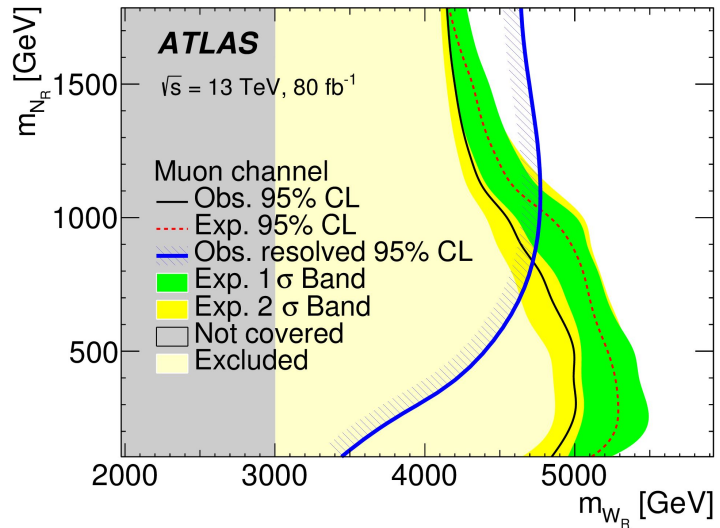
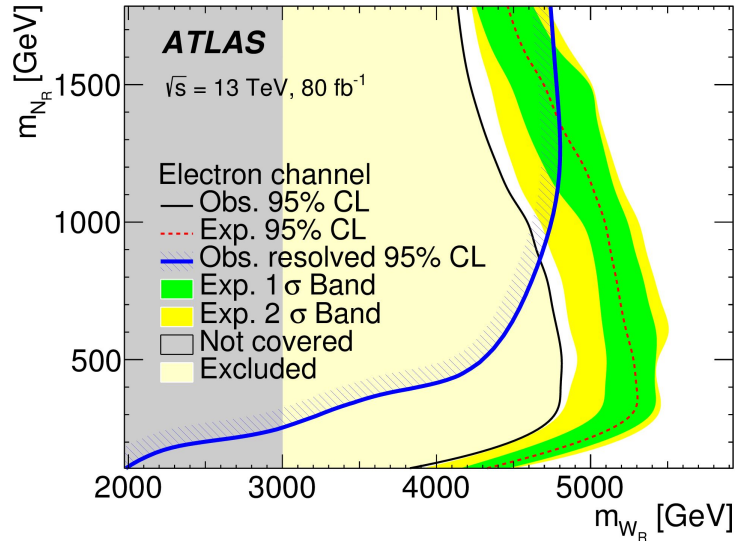
Region	Range of $m_{W_R}^{reco}$	Lepton flavour
Signal region (SR)	> 2 TeV	Same flavour
Control region (CR)	< 2 TeV	Same flavour
Validation region (VR)	All	Mixed flavour (leading: muon; subleading: electron)



Search for a right handed gauge boson

- One-binned likelihood fit performed to obtain limits on the mass of N_R and W_R .

	Electron	Muon
Expected background	$2.8^{+0.5}_{-0.7}$	$1.9^{+0.5}_{-0.7}$
Observed events	8	4
Significance	2.4σ	1.2σ



- **Excited electrons**

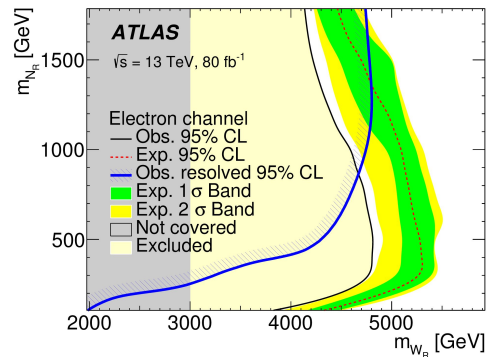
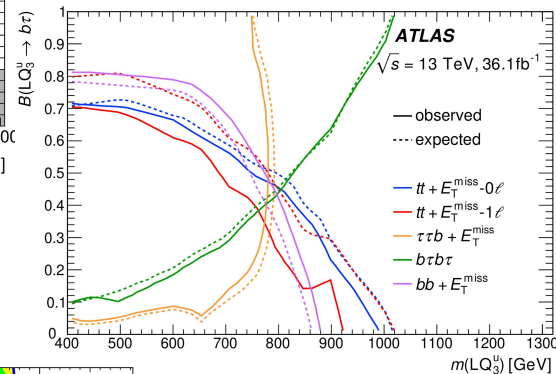
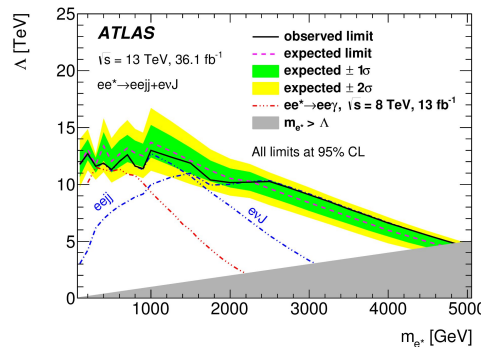
- Λ excluded up to 13 TeV for $m_e^* < 2$ TeV.

- **Third generation scalar LQ**

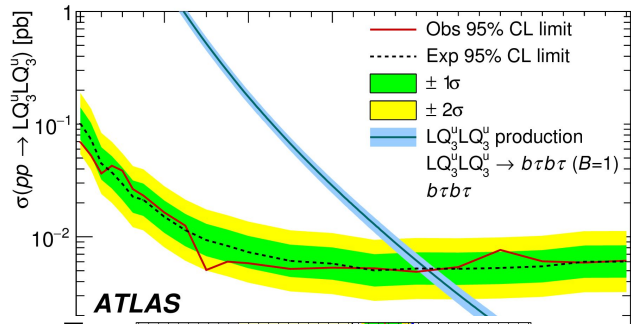
- Excluding LQ masses < 800 GeV (independently of B), and < 1000 GeV for $B = 1$ or $B = 0$.

- **Right-handed gauge boson**

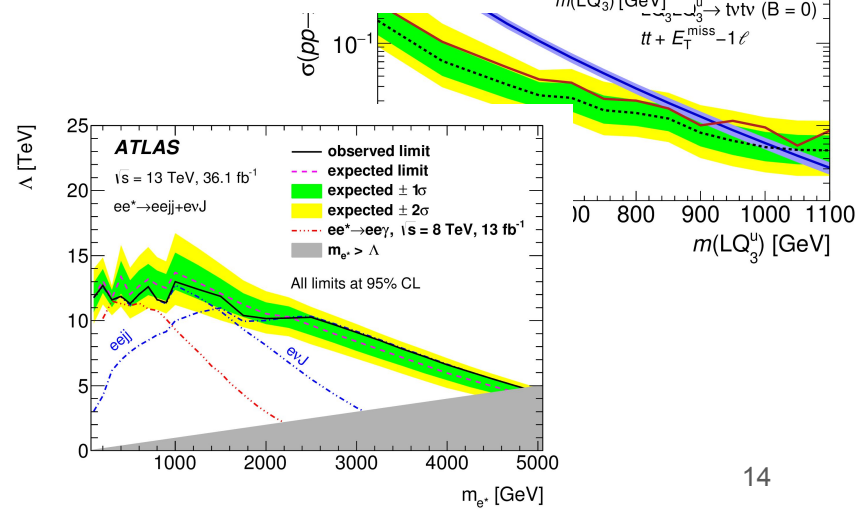
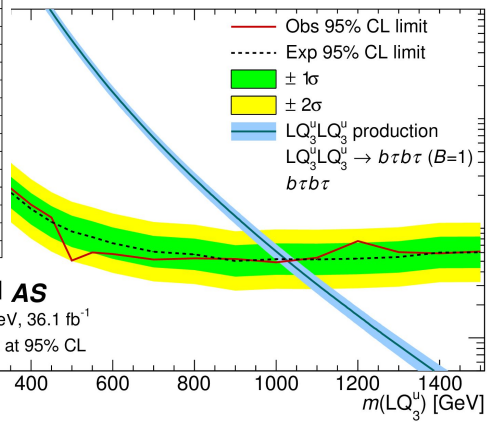
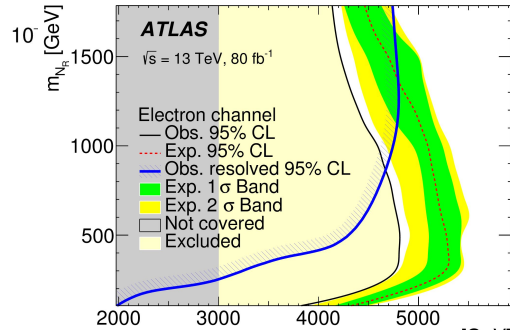
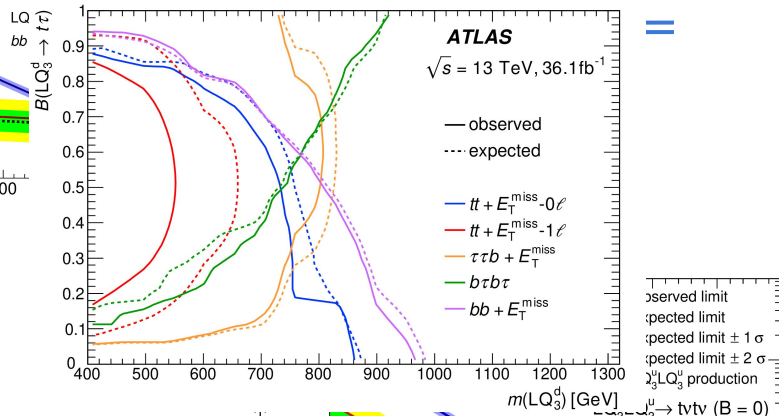
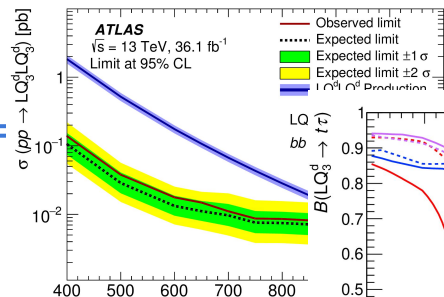
- W_R excluded for $m_{WR} < 5$ TeV



Limits, limits, limits ...



No BSM (yet?)



Backup