

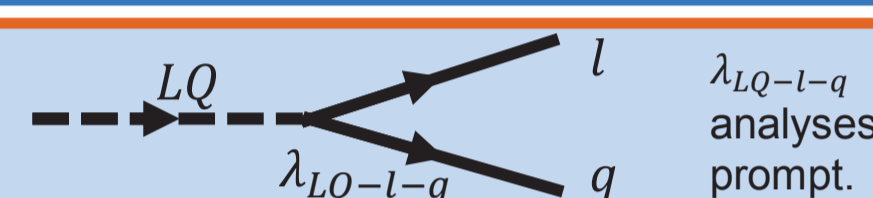
Search for scalar leptoquarks in pp collisions at $\sqrt{s} = 8$ TeV with ATLAS detector

Abstract

The poster is dedicated to a search for pair-produced scalar leptoquarks using 20.3 fb⁻¹ of data recorded by the ATLAS detector at $\sqrt{s} = 8$ TeV. Leptoquarks are hypothetical particles with non-zero lepton and baryon numbers, predicted by many extensions of the Standard Model, and can provide an explanation for the similarity between the quark and lepton sectors. Searches for pair-produced scalar leptoquarks have been performed with final states including leptons. Thereby the new limits on the leptoquarks mass were set at 95% Confidence Level [arXiv:1508.04735](https://arxiv.org/abs/1508.04735) [hep-ex].

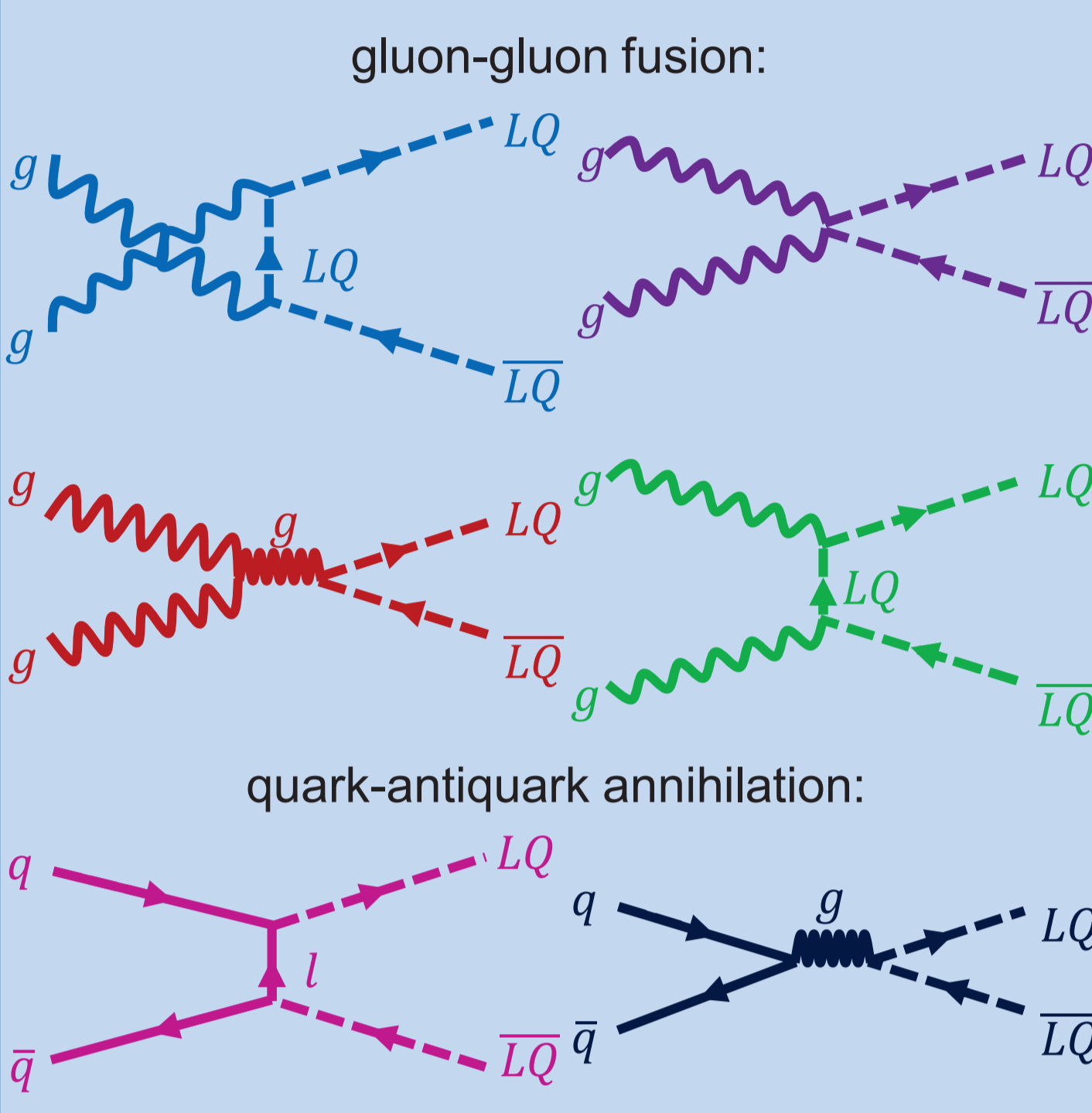
Model outlines

- Leptoquarks (LQs) are predicted by several theories of physics beyond Standard Model: *Grand Unification Theories* (SU(5), Constrained SU(5), SU(15)), *Pati Salam model* SU(4), *Superstring model*, *Composite model*, *Technicolor model*;
- They carry:
 - both **leptonic** and **baryonic** charges;
 - fractional **electrical** charge;
- LQs are grouped into **three generations** as leptons and quarks;
- $LQ\bar{L}Q$ pair-production cross-section in pp collisions:
 - depends on strong coupling constant α_s ($\Rightarrow M_{LQ}$);
 - doesn't depend on the unknown fermionic LQ-lepton-quark coupling constant λ_{LQ-l-q} ;
- LQs and it's decay products - lepton and quark - are restricted to be of the same **generation** (diagonal coupling), to prevent the proton decay;
- LQs appear as mediators of quark-lepton transitions;



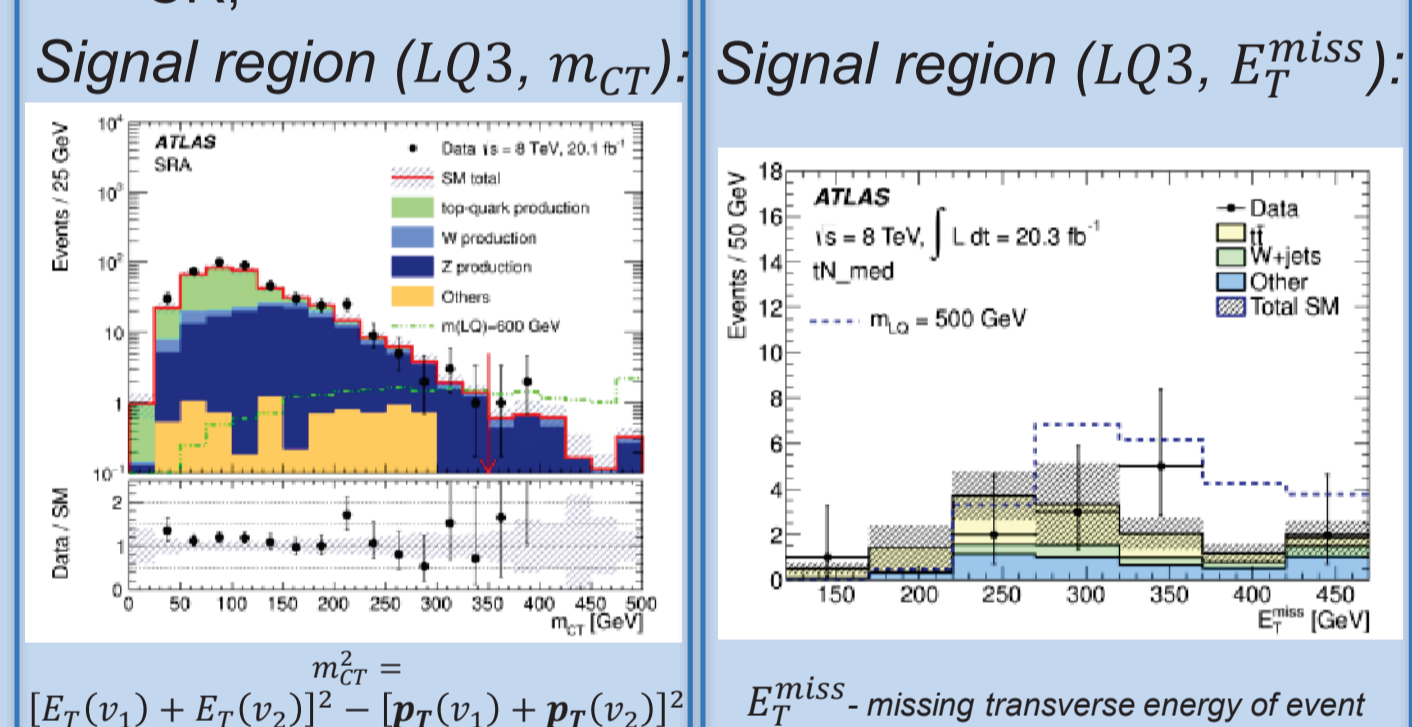
λ_{LQ-l-q} is limited by previous analyses in HERA \rightarrow decay is prompt.

Leptoquarks pair-production



Backgrounds

- LQ3 ($b\nu_\tau b\nu_\tau$):**
 - Major backgrounds:
 - $Z/\gamma^* \rightarrow \nu\nu + b\bar{b}$ (dominant); MC + CR of opposite sign di-leptons;
 - $t\bar{t}$ quark production: MC + CR of 1 lepton;
 - W boson + heavy flavor quarks: MC + CR;
- LQ3 ($\nu_\tau \nu_\tau \nu_\tau$):**
 - Major backgrounds:
 - $t\bar{t}$ MC + CR via transverse mass m_T and b-tagged jets requirements;
 - $W(\rightarrow l\nu) + jets$: MC + CR via transverse mass m_T requirement and b-tagged jets veto;



Baseline selections:

	LQ1 ($eejj$)	LQ2 ($\mu\mu jj$)
Lepton requirement	Exactly 2 electrons: <ul style="list-style-type: none"> Asymmetric p_T requirement: $p_T > 40$ GeV for leading electron, $p_T > 30$ GeV for sub-leading one; $\eta < 2.47$, excluding crack region between barrel and endcap calorimeters $1.37 < \eta < 1.52$. 	Exactly 2 muons: <ul style="list-style-type: none"> $p_T > 40$ GeV; $\eta < 2.4$;
Jet requirement	At least 2 jets (2 leading are considered finally): <ul style="list-style-type: none"> $p_T > 30$ GeV; $\eta < 2.8$; Not overlapped with leptons in $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} < 0.4$ cone; 	
	LQ3 ($b\nu_\tau b\nu_\tau$)	LQ3 ($\nu_\tau \nu_\tau \nu_\tau$)
Lepton requirement	Absence of a lepton: <ul style="list-style-type: none"> Events with one or more electrons (muons) with $p_T > 7$ (6) GeV are vetoed; 	Exactly 1 electron (muon): <ul style="list-style-type: none"> $p_T > 25$ GeV; $\eta < 2.47$ (2.4);
Jet requirement	Exactly 2 b-tagged jets: <ul style="list-style-type: none"> $p_T > 20$ GeV; $\eta < 2.5$; 	At least 4 jets: <ul style="list-style-type: none"> $p_T > 25$ GeV; $\eta < 2.5$; At least 1 of these is the b-tagged jet;
Missing transverse energy E_T^{miss} requirement	$E_T^{miss} > 150$ GeV;	$E_T^{miss} > 100$ GeV;

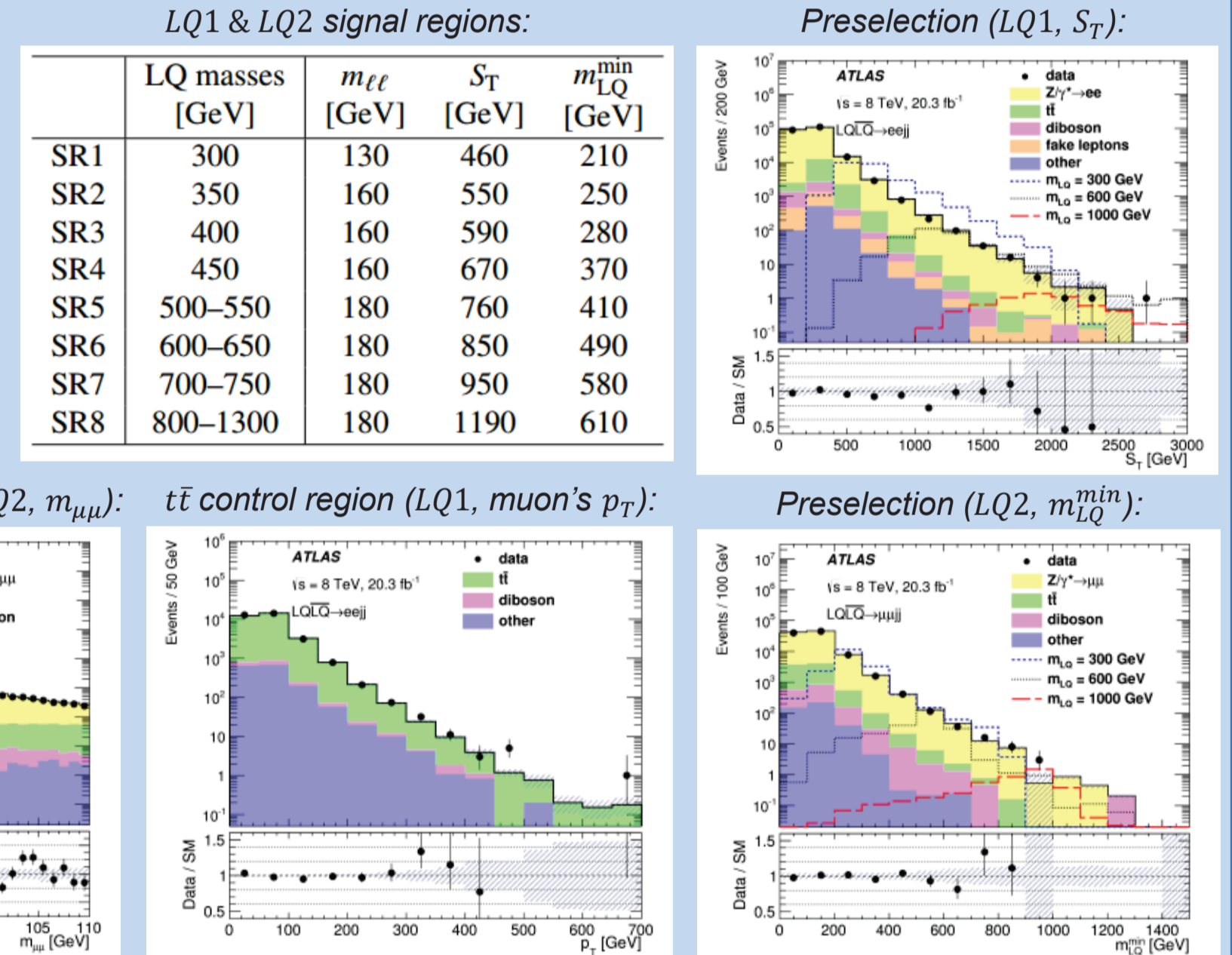
Systematic uncertainties

- Experimental uncertainties**
 - Trigger efficiency;
 - Leptons-related:
 - Identification;
 - Reconstruction;
 - Isolation (LQ1);
 - Jets-related:
 - Jets energy scale (15 components);
 - Jets energy resolution;
 - B-tagging procedure (LQ3);
 - Fake leptons estimation (LQ1);
- Theoretical uncertainties**
 - Parton Density Function uncertainty impact on cross-section and acceptance;
 - Strong coupling constant's normalization and factorization scales variation impact on the cross-section and acceptance;
 - Background modelling (data-driven);

Statistical analysis

The search is provided in optimized **Signal Regions** (cut-based) for each LQ's mass point:

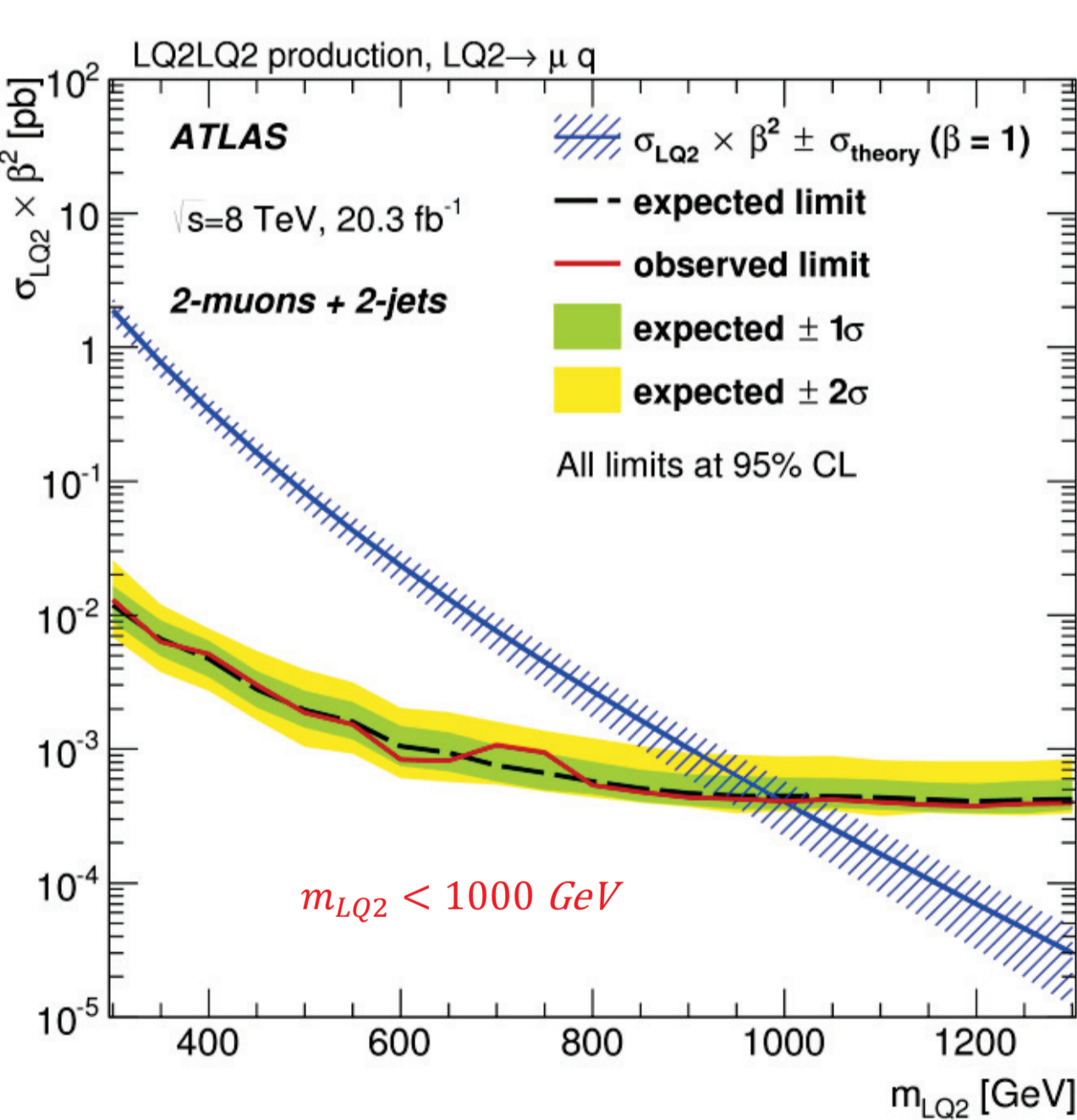
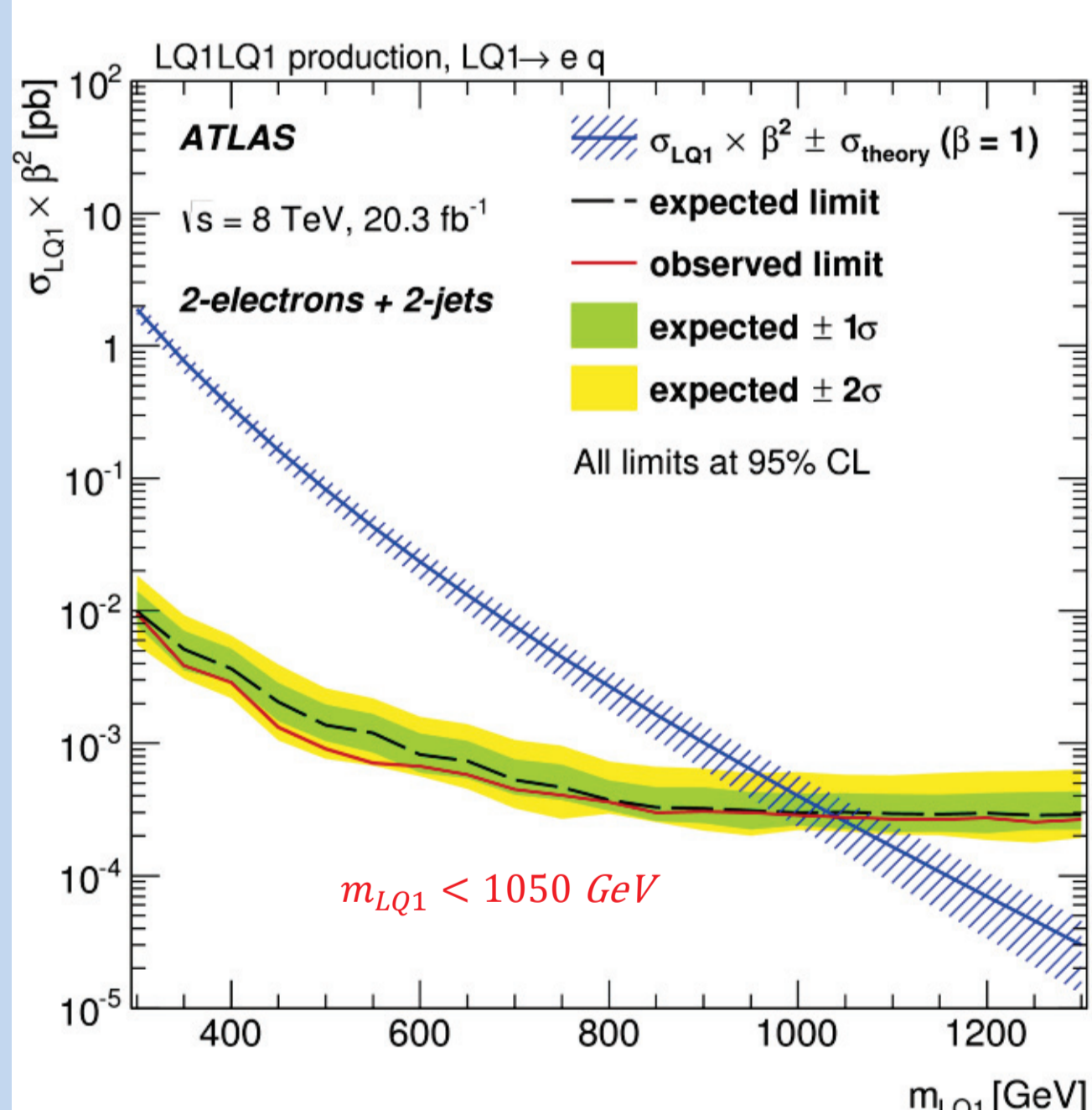
- LQ1 ($eejj$) and LQ2 ($\mu\mu jj$):** optimized cuts on the 3 discriminative variables:
 - m_{ll} - dilepton invariant mass;
 - $S_T = p_T^{lepton1} + p_T^{lepton2} + p_T^{jet1} + p_T^{jet2}$;
 - $m_{LQ}^{min} = \min\{m_{LQ1}, m_{LQ2}\}$;
- LQ3 ($b\nu_\tau b\nu_\tau$) and LQ3 ($\nu_\tau \nu_\tau \nu_\tau$):** optimized cuts on the set of background-sensitive variables;
- Major backgrounds are supplied with **CRs** - to effectively constrain corresponding yields and variations in Signal Regions;
- Joint likelihood model is used to test the hypotheses;
- CLs method is applied for signal cross-section limits extraction;



σ VS m_{LQ} exclusion

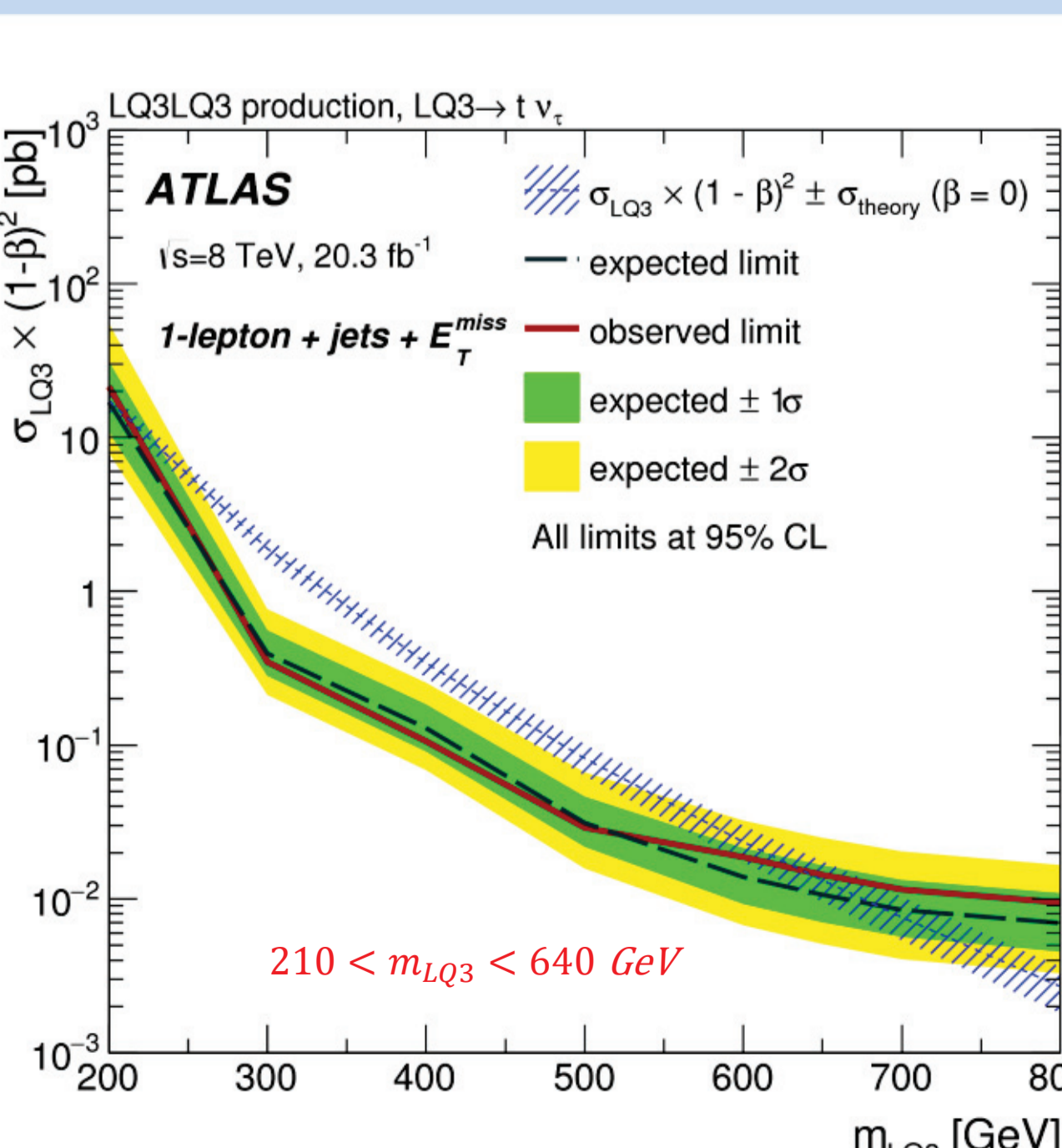
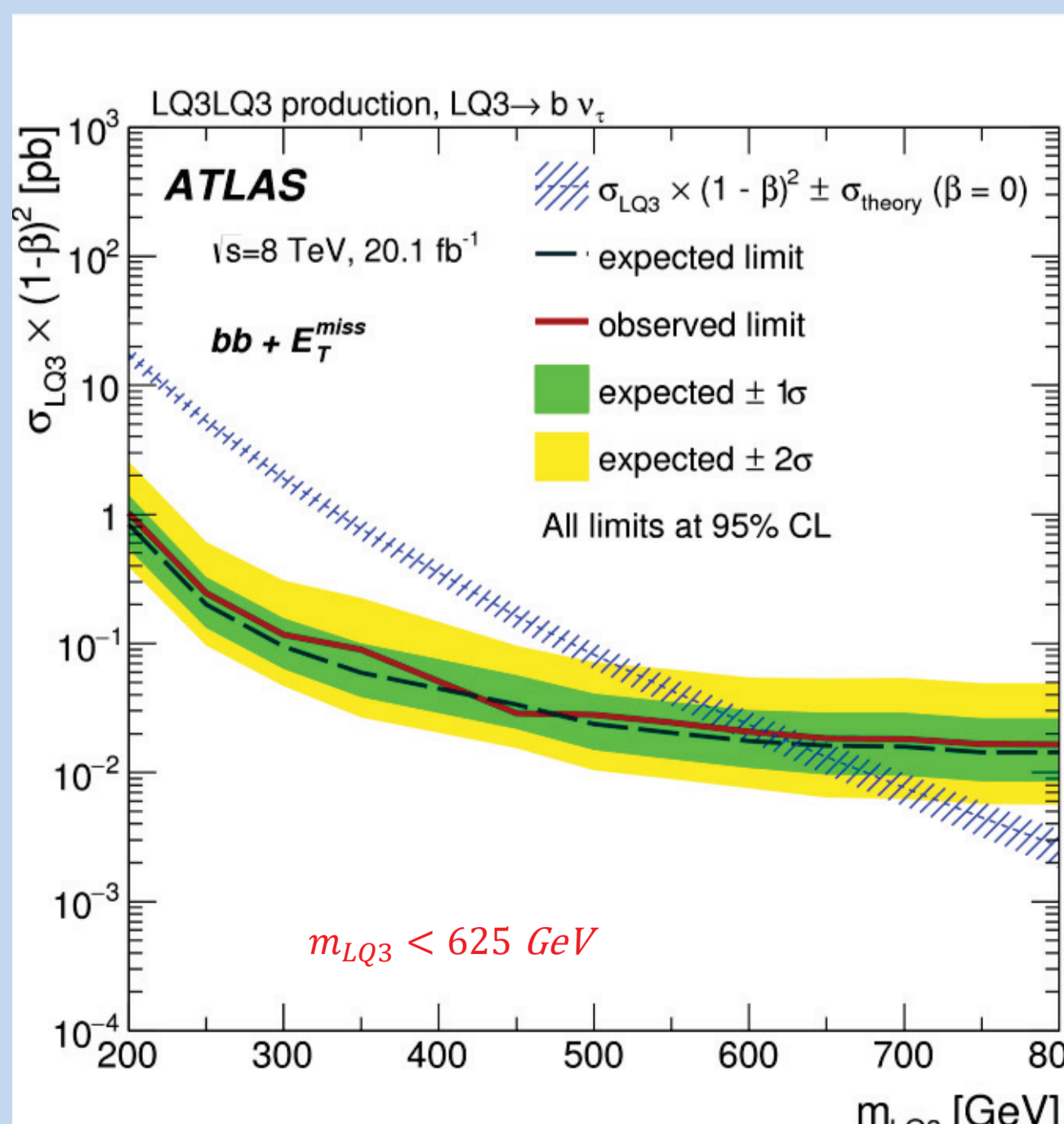
LQ1 ($eejj$) channel:

LQ2 ($\mu\mu jj$) channel:



LQ3 ($\nu\nu b\bar{b}$) channel:

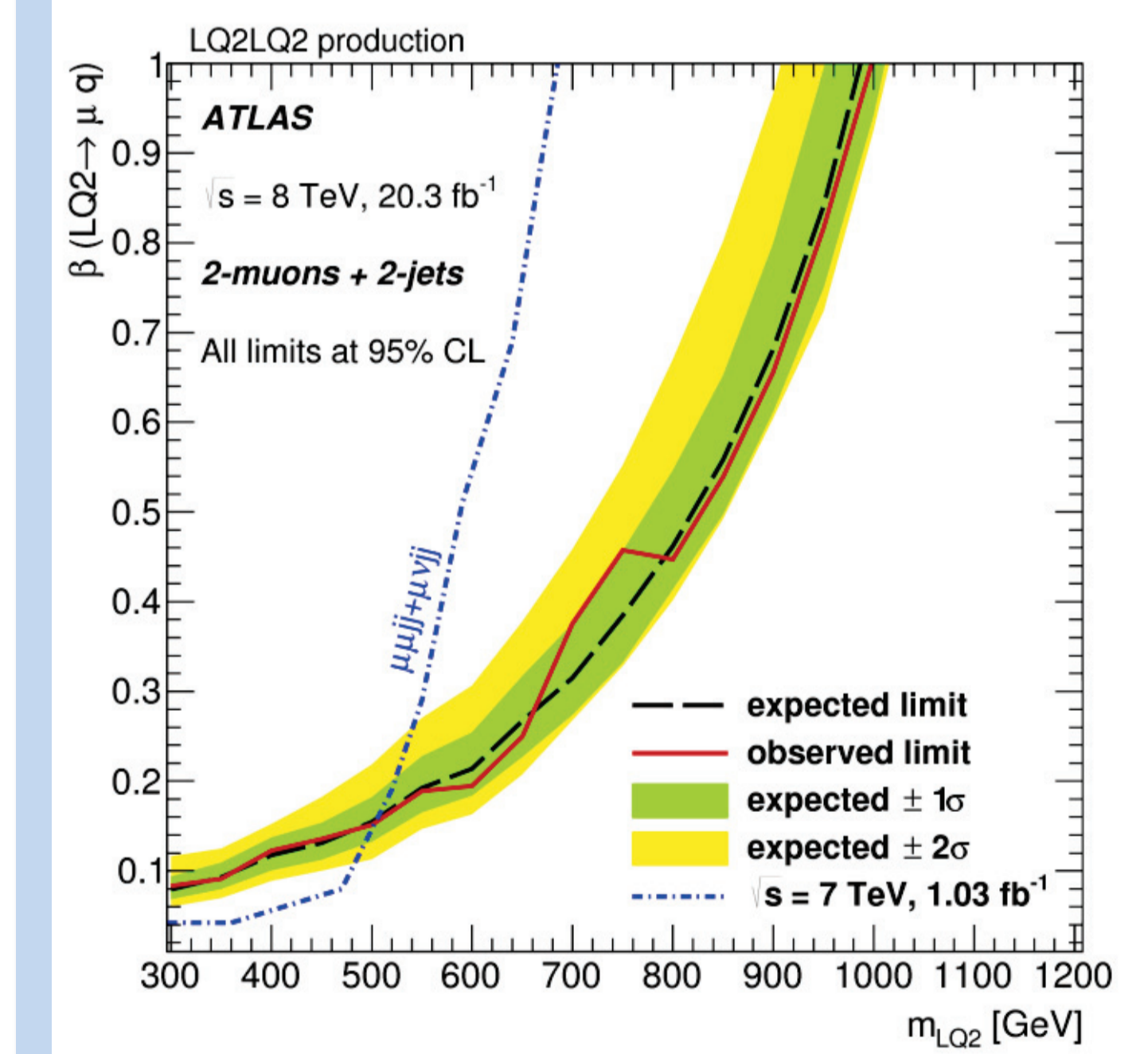
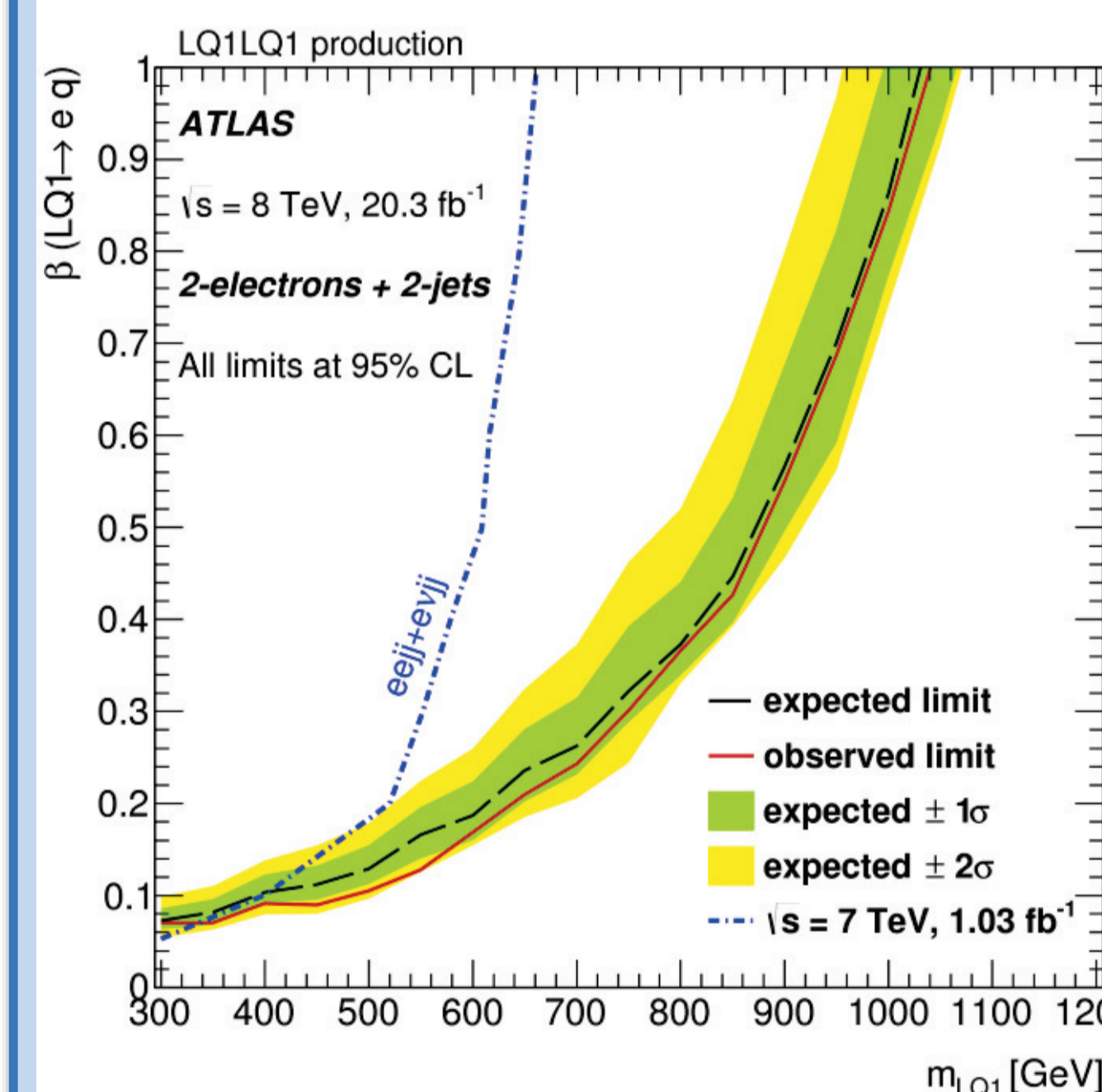
LQ3 ($\nu\nu t\bar{t}$) channel:



β VS m_{LQ} exclusion

LQ1 ($eejj$) channel:

LQ2 ($\mu\mu jj$) channel:



SUMMARY

Latest ATLAS results ($\sqrt{s} = 8$ TeV) for scalar leptoquarks search:

- Excluded leptoquark's mass ranges at 95% CL under $BR(LQ \rightarrow lq)=1$ for first, second and third generation:

Channel	Excluded leptoquark's mass range (95% CL, $BR(LQ \rightarrow lq)=1$), [GeV]
$eejj$	$m_{LQ1} < 1050$
$\mu\mu jj$	$m_{LQ2} < 1000$
$\nu_\tau \nu_\tau b\bar{b}$	$m_{LQ3} < 625$
$\nu_\tau \nu_\tau t\bar{t}$	$210 < m_{LQ3} < 640$

- Limits in terms of β (branching fraction of the LQ decay into a charge lepton and a quark) VS m_{LQ} are set for first and second generations.