Lepton flavor violation search at ATLAS detector

Xiangke Zhang

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Overview

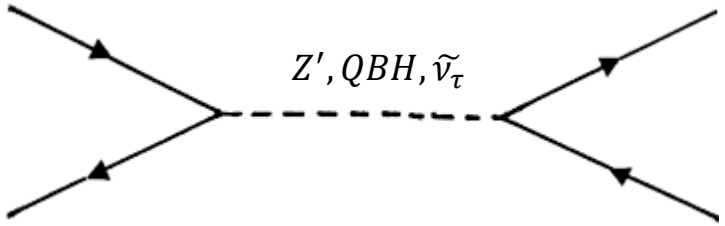
- Introduction
  - motivation and strategy
- Overview
  - LFV($Z', \widetilde{\nu_\tau} \rightarrow e\mu, e\tau, \mu\tau$) search (20.3 fb^{-1}) in pp collision at 8 TeV
  - LFV($Z', \widetilde{\nu_\tau}, QBH \rightarrow e\mu, e\tau, \mu\tau$) search (36.1 fb^{-1}) in pp collision at 13 TeV
  - LFV(Z $\rightarrow e\tau, \mu\tau$) search (139 fb^{-1}) in pp collision at 13 TeV
- Current LFV search
  - LFV($Z', \widetilde{\nu_\tau}, QBH \rightarrow e\mu, e\tau, \mu\tau$) search (139 fb^{-1}) in pp collision at 13 TeV
- Summary

Introduction: motivation & strategy

- Direct charged-lepton flavor violation (LFV) is forbidden in the Standard Model

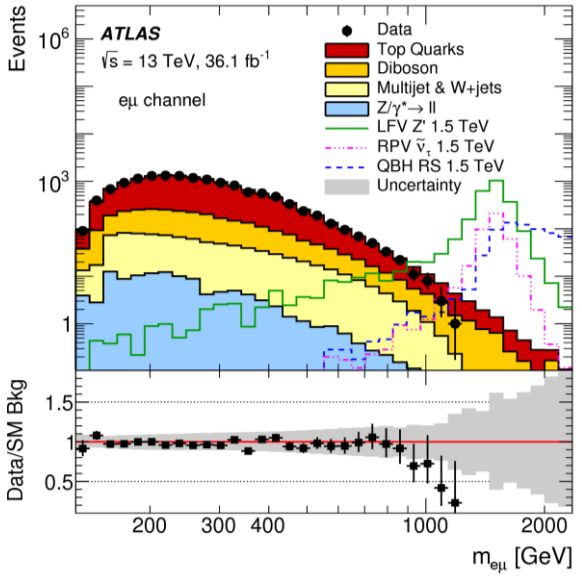
But it's allowed in hypothetic new physics models

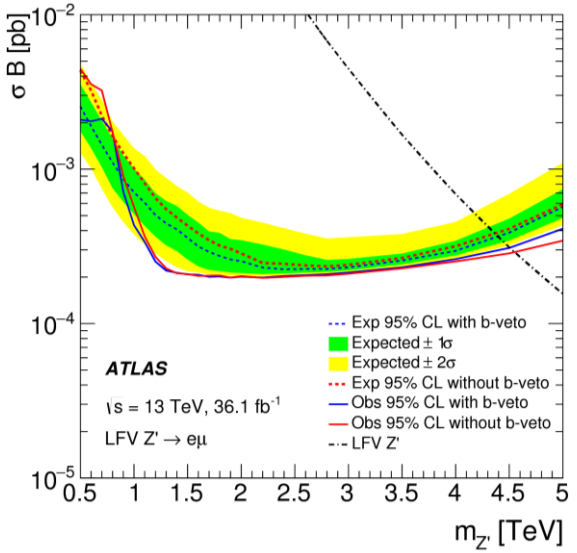
models / Production & reason	SM	models with additional gauge symmetries	R-parity violating(RPV) SUSY	quantum black hole QBH
lepton pairs with different flavor (LFV)	Not allowed	allowed	allowed	allowed
Reason	LFC	Z'	sneutrino τ resonance	$pp \rightarrow QBH \rightarrow l^{\mp}l'^{\pm}$
Final state		$e\mu$, $e\tau$, $\mu\tau$		



Introduction: motivation & strategy

- Aim of LFV analysis
  - search for a new resonance with two leptons of different flavor ($e\mu$, $e\tau$, $\mu\tau$) in high mass region
  - otherwise, set limits on the parameters of physics models
- Clear experimental signature
  - low background from SM processes
  - the invariant mass of the heavy neutral particle can be reconstructed



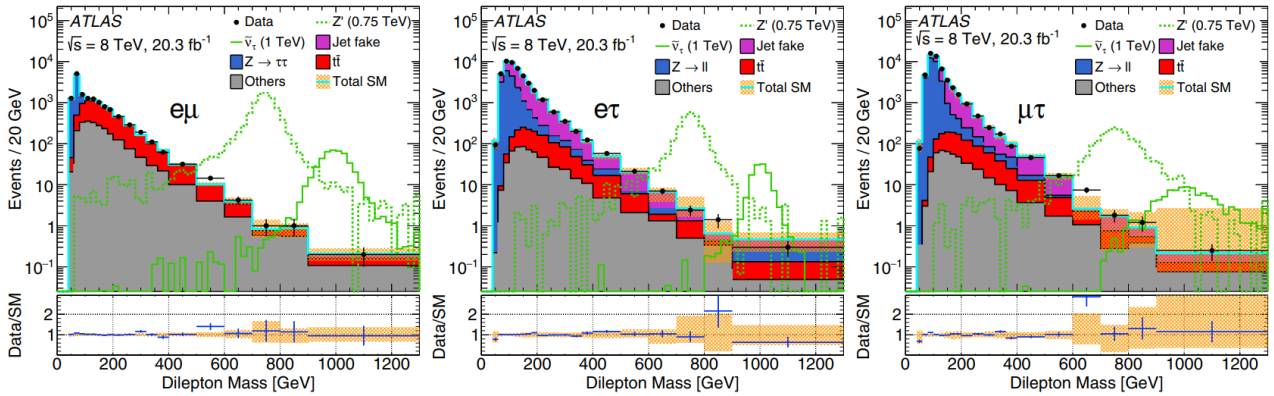


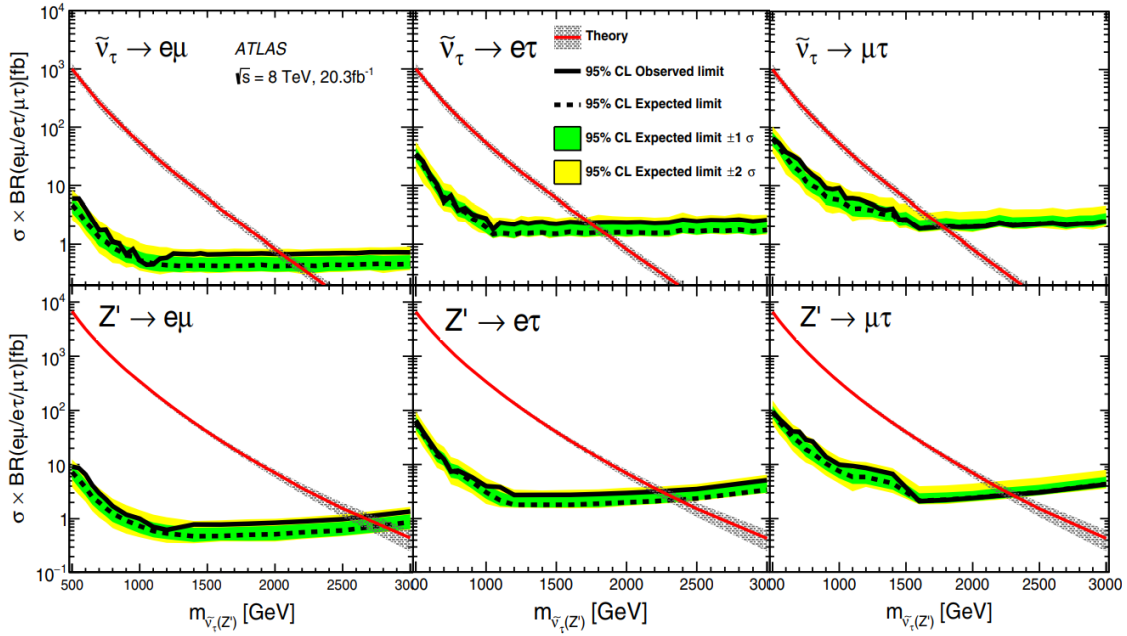
LFV search at 8 TeV

$Z', \tilde{\nu}_\tau \to e\mu, e\tau, \mu\tau$

The data set has a total integrated luminosity of 20.3 fb^{-1}

Process	$m_{\ell\ell'} < 200$ GeV			$m_{\ell\ell'} > 200$ GeV		
	$N_{e\mu}$	$N_{e\tau_{had}}$	$N_{\mu\tau_{had}}$	$N_{e\mu}$	$N_{e\tau_{had}}$	$N_{\mu\tau_{had}}$
$Z/\gamma^* \to \tau\tau$	6000 ± 400	11000 ± 900	11200 ± 700	28 ± 12	72 ± 21	99 ± 33
$Z/\gamma^* \to ee$	—	6100 ± 1100	—	—	430 ± 70	—
$Z/\gamma^* \to \mu\mu$	—	—	19500 ± 1300	—	—	410 ± 80
$t\bar{t}$	4220 ± 290	690 ± 60	580 ± 50	1640 ± 120	700 ± 60	550 ± 40
Diboson	1440 ± 80	321 ± 29	258 ± 17	474 ± 30	197 ± 17	141 ± 11
Single top quark	470 ± 40	87 ± 11	60 ± 7	202 ± 17	90 ± 10	73 ± 8
W + jets	54 ± 18	17000 ± 4000	14000 ± 4000	8 ± 4	3600 ± 700	2800 ± 600
Multijet	227 ± 32	4800 ± 1000	700 ± 800	58 ± 12	340 ± 210	100 ± 190
Total	12400 ± 600	40400 ± 2900	46000 ± 4000	2400 ± 130	5400 ± 500	4200 ± 400
Data	12954	41304	48304	2474	5336	4184

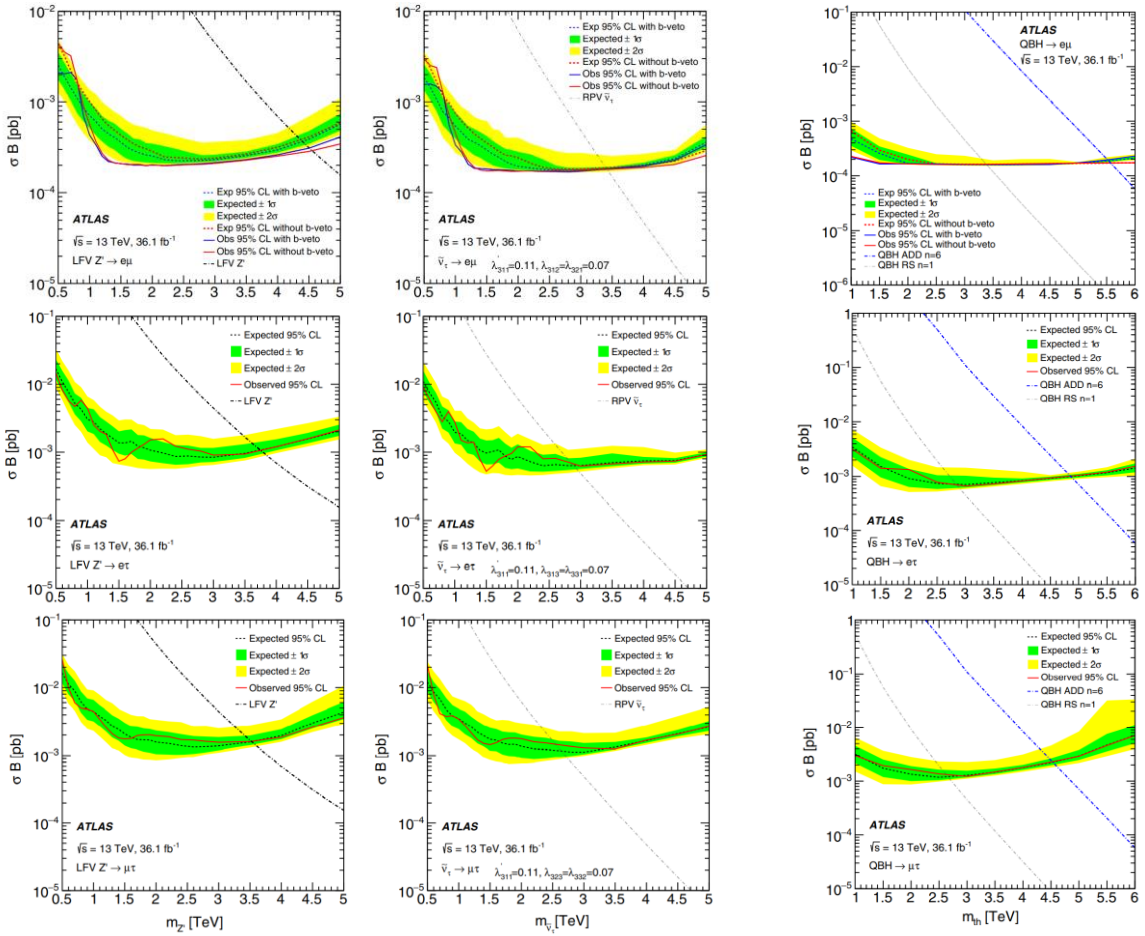


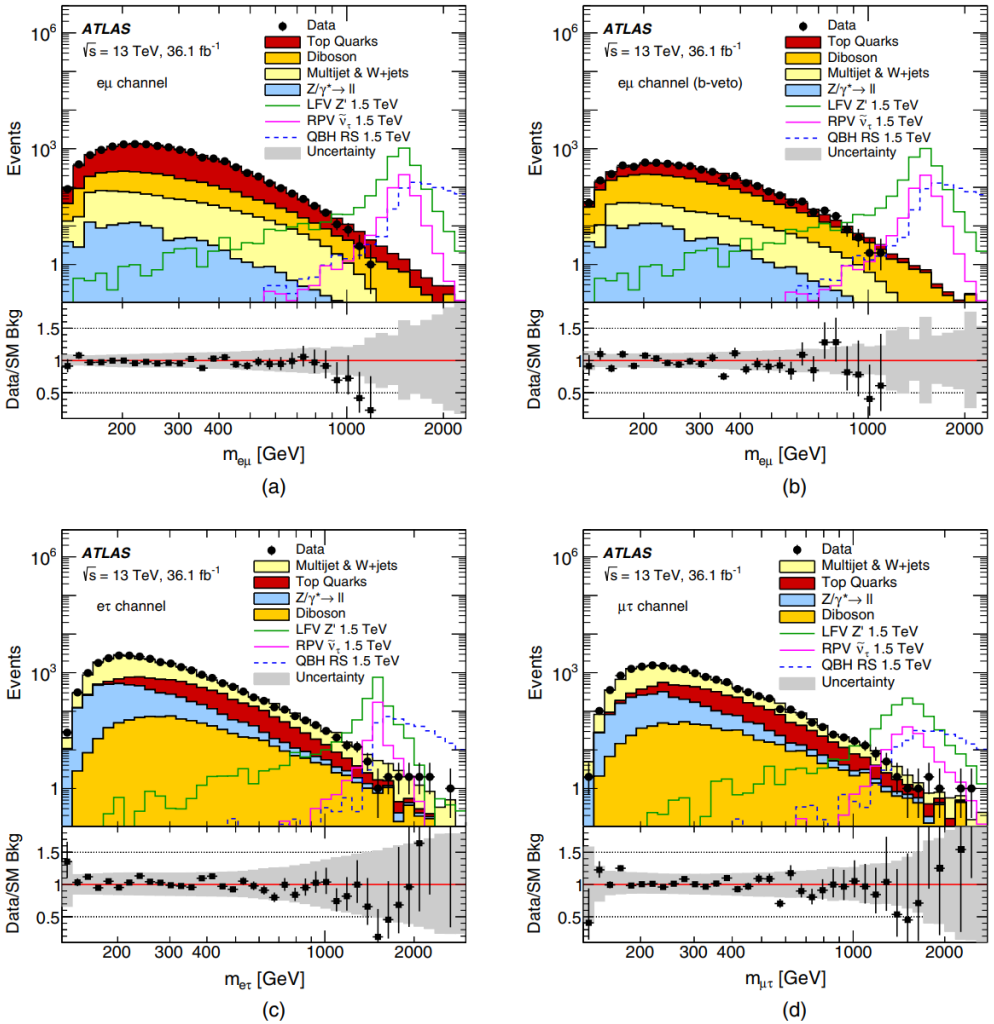


LFV search at 13 TeV

$Z', \tilde{\nu}_\tau, QBH \rightarrow e\mu, e\tau, \mu\tau$

The data set has a total integrated luminosity of 36.1 fb^{-1}



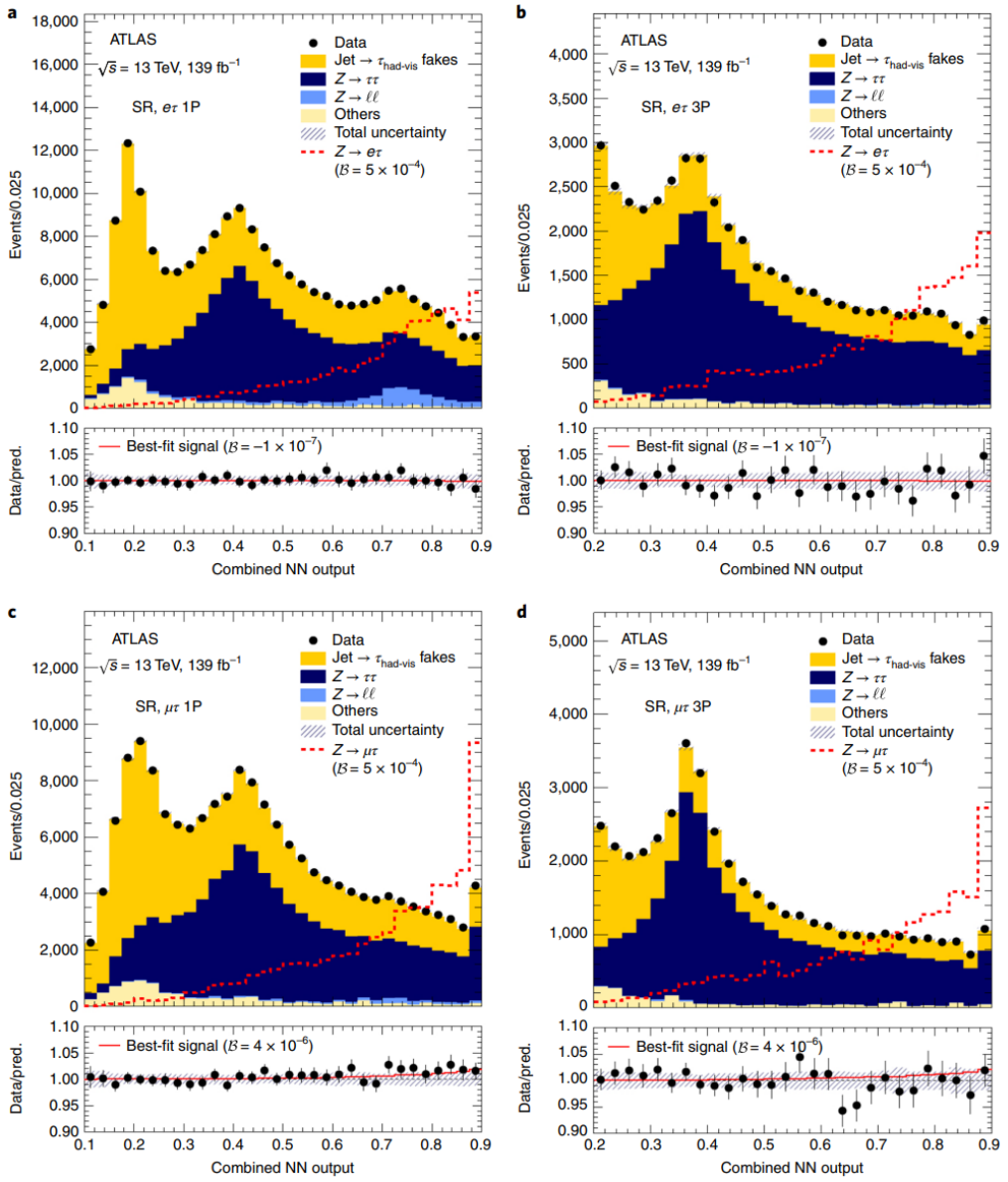


LFV search at 13 TeV

Standard model: $Z \to e\tau, \mu\tau$

The data set has a total integrated luminosity of 139 fb^{-1}

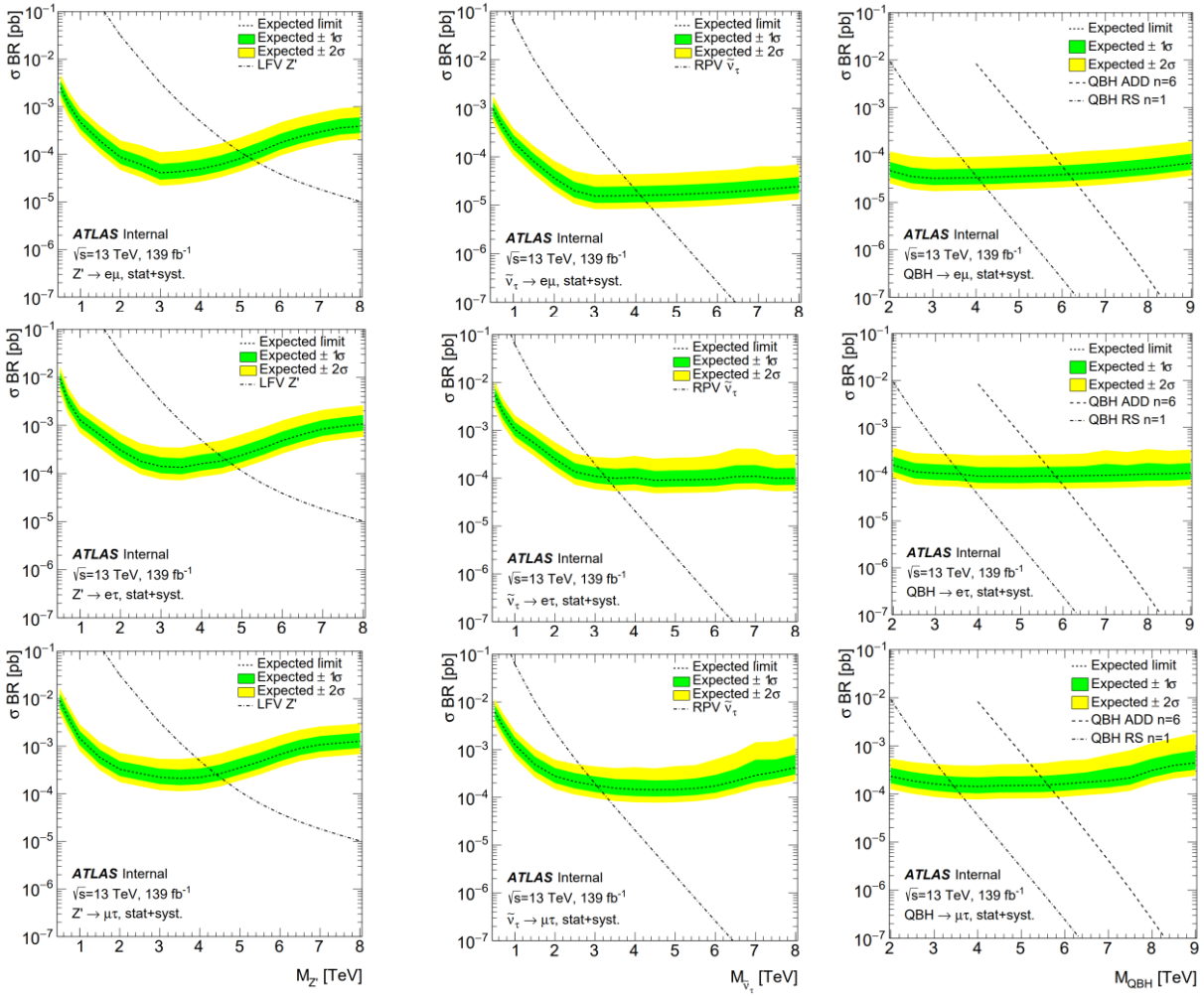
Experiment, polarization assumption	**Observed (expected) upper limit on $\mathcal{B}(Z \to \ell\tau)$ (×10^{-6})**	
	$e\tau$	$\mu\tau$
ATLAS Run 2, unpolarized τ	8.1 (8.1)	9.9 (6.3)
ATLAS Run 2, left-handed τ	8.2 (8.6)	9.5 (6.7)
ATLAS Run 2, right-handed τ	7.8 (7.6)	10 (5.8)
ATLAS Run 1, unpolarized τ[17]		17 (26)
ATLAS Run 1 + Run 2 combination, unpolarized τ		9.5 (6.1)
LEP OPAL, unpolarized τ[10]	9.8	17
LEP DELPHI, unpolarized τ[11]	22	12

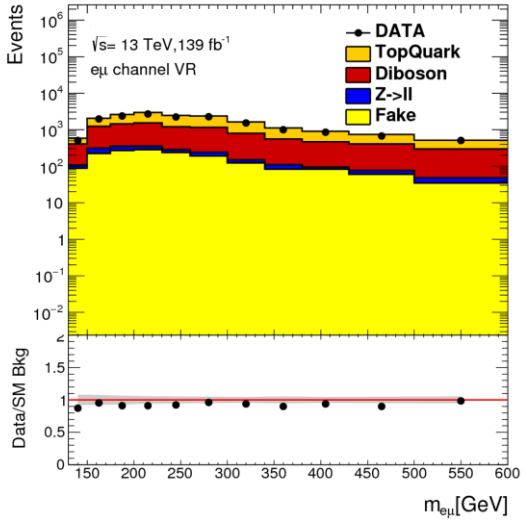


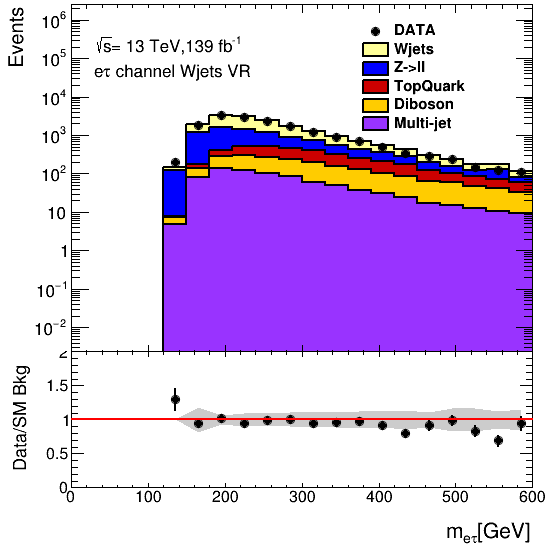
LFV search at 13 TeV (ongoing)

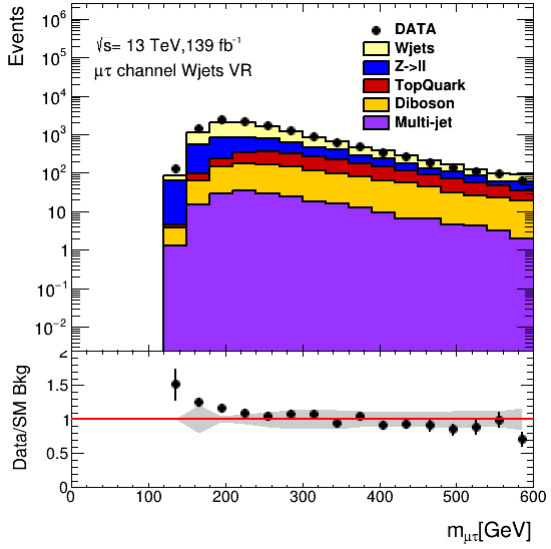
$Z', \tilde{\nu}_\tau, QBH \rightarrow e\mu, e\tau, \mu\tau$

The data set has a total integrated luminosity of 139 fb^{-1}









Summary

- LFV finished
  - LFV at 8 TeV
    - Z' upper limit $e\mu$: 2.7 TeV, $e\tau$: 2.3 TeV, $\mu\tau$: 2.3 TeV
    - $\tilde{\upsilon_\tau}$ upper limit $e\mu$: 2.1 TeV, $e\tau$: 1.7 TeV, $\mu\tau$: 1.7 TeV
  - LFV at 13 TeV

Model	Expected limit [TeV]				Observed limit [TeV]			
	$e\mu$	$e\mu$ (b-veto)	$e\tau$	$\mu\tau$	$e\mu$	$e\mu$ (b-veto)	$e\tau$	$\mu\tau$
LFV Z'	4.3	4.3	3.7	3.5	4.5	4.4	3.7	3.5
RPV SUSY $\tilde{\nu}_\tau$	3.4	3.4	2.9	2.6	3.4	3.4	2.9	2.6
QBH ADD $n = 6$	5.6	5.5	4.9	4.5	5.6	5.5	4.9	4.5
QBH RS $n = 1$	3.3	3.4	2.8	2.7	3.4	3.4	2.9	2.6

  - Standard Z decay at 13TeV
    - Z decay to $e\tau$,$\mu\tau$: ~10^{-6}
- LFV ongoing
  - Z' upper limit $e\mu$: 5 TeV, $e\tau$: 4.5 TeV, $\mu\tau$: 4.2 TeV
  - $\tilde{\upsilon_\tau}$ upper limit $e\mu$: 4 TeV, $e\tau$: 3.2 TeV, $\mu\tau$: 3.0 TeV
  - QBH upper limit RS(ADD) $e\mu$: 4(6.2) TeV, $e\tau$: 3.6(6.0) TeV, $\mu\tau$: 3.4(5.5) TeV