Searches for New Phenomena in Leptonic or Hadronic Final States using the ATLAS Detector

Avik Roy
on behalf of the ATLAS Collaboration

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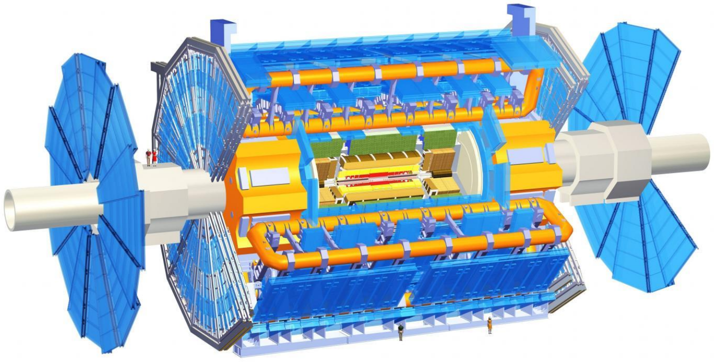
Introduction

- ATLAS collected 139 fb^{-1} pp data for physics analyses in run-2 (2015-2018)
- A large number of analyses are analyzing this data for precision measurements and BSM searches
- Relatively recent analyses with hadronic/leptonic final states covered here



Vector-like Quark: B→bH(bb)

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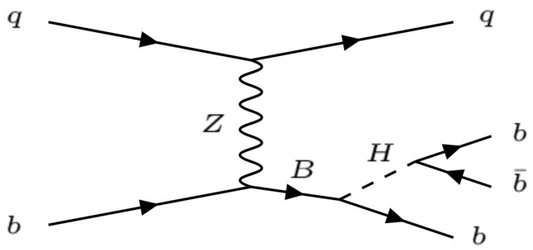
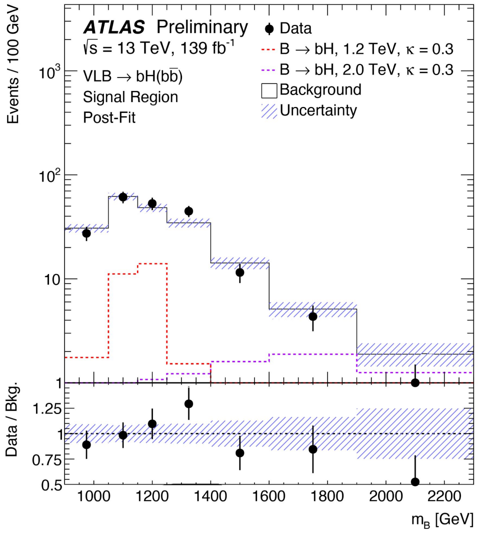
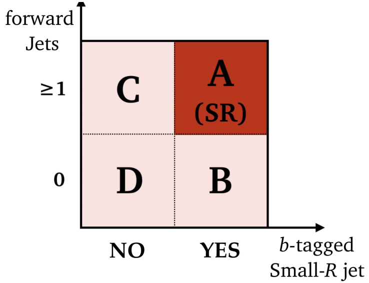
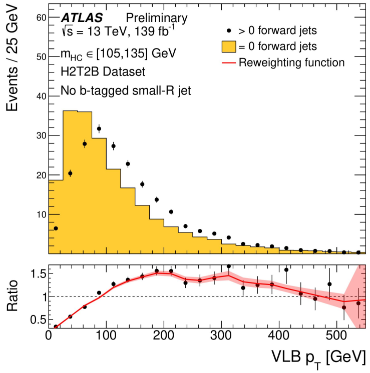


- Search for -⅓ charged VLB quark decaying to H + b with H → bb
- All hadronic final state: reconstructed Higgs Candidate (HC) based on large-R jet pT, mass, and associated b-tagged track jets
- Fitted on reconstructed VLB mass: mB = m(HC + jet) with dR(jet, HC) > 2.5
- Data driven estimation for QCD multijet background using ABCD method

$$N_A = N_B \times (N_C / N_D)$$

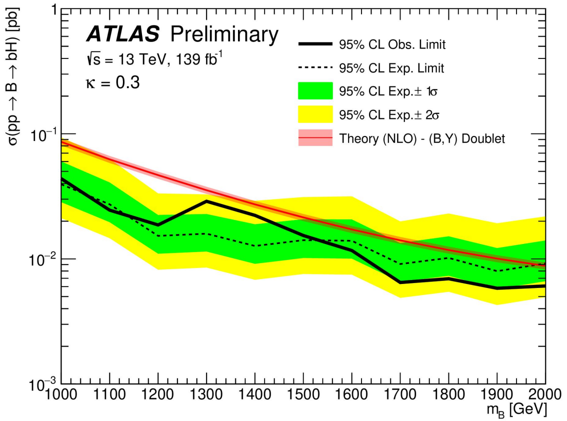


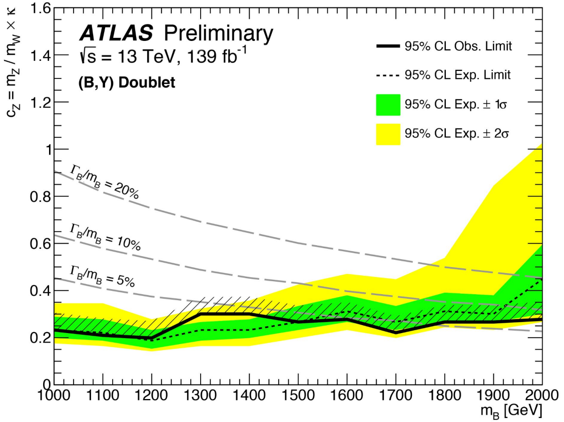




Vector-like Quark: B→bH(bb)

- Excludes VLBs up to 2 TeV in doublet representations for moderate and higher couplings
- Interpretation: Limits on coupling as a function of VLB mass for doublet representation





Multi b-jet Resonance Search

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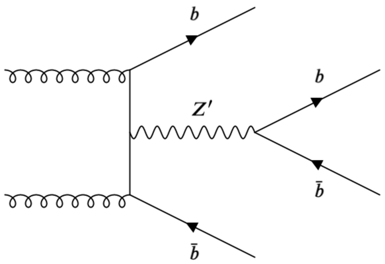
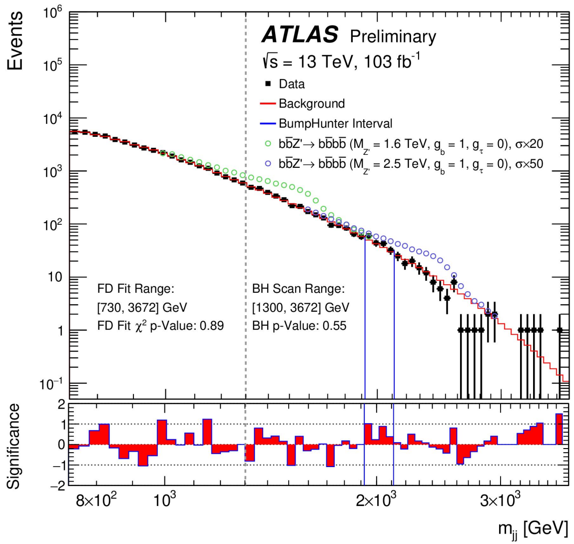
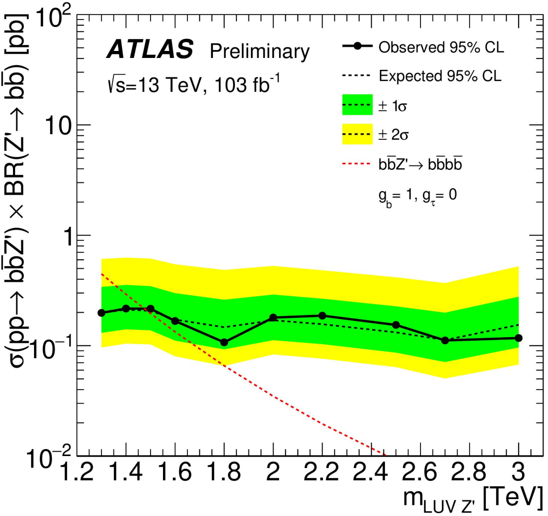


- Search for resonances decaying to a pair of b jets: fully hadronic final state
- Dedicated tri-jet trigger with asymmetric thresholds - data cannot be modelled by usual empirical functional forms
- Background estimation based on functional decomposition with exponential basis functions
- Z' mass excluded up to 1.45 TeV

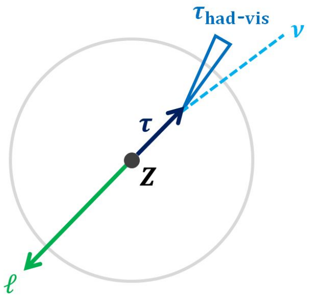




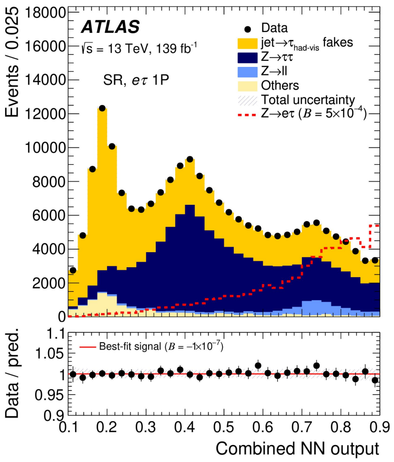
LFV: $Z \to \tau + e/\mu$

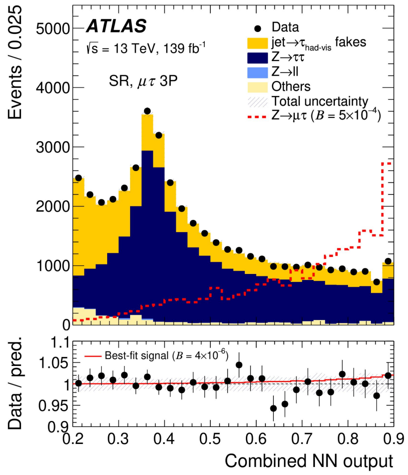
arxiv:2010.02566

- Single lepton (e/μ) final state with hadronic τ candidate
- Reconstructed τ from 1 or 3 matched jet tracks (1 prong / 3 prong taus)
- Multiple neural networks trained to classify signal against W+jets, $Z \to \tau\tau$, and $Z \to ll$
- Combined NN output is determined by a weighted mean squared value of the NN outputs
- Limits on LFV BRs supercede the previous bounds from LEP



$BR(Z \to \mu\tau) < 9.5 \times 10^{-6}$
$BR(Z \to e\tau) < 8.1 \times 10^{-6}$

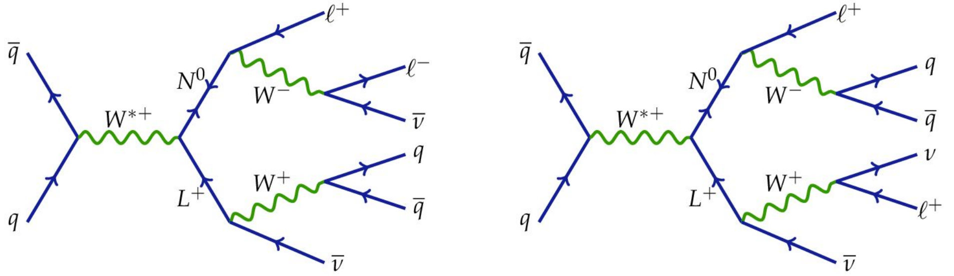




Type III Seesaw Heavy Leptons

arXiv:2008.07949

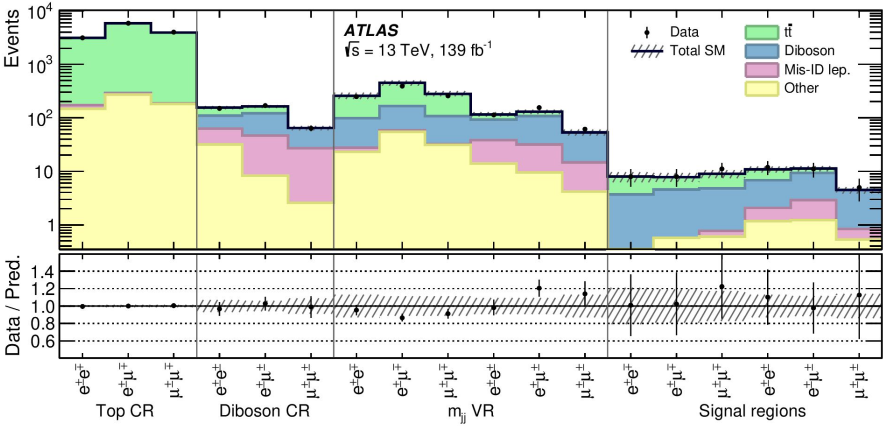
- Di-lepton (e/μ) + inclusive di-jet final state
- Opposite sign and same sign signatures
- Control, validation, and signal regions defined according to the OS/SS category along with the lepton flavor combination

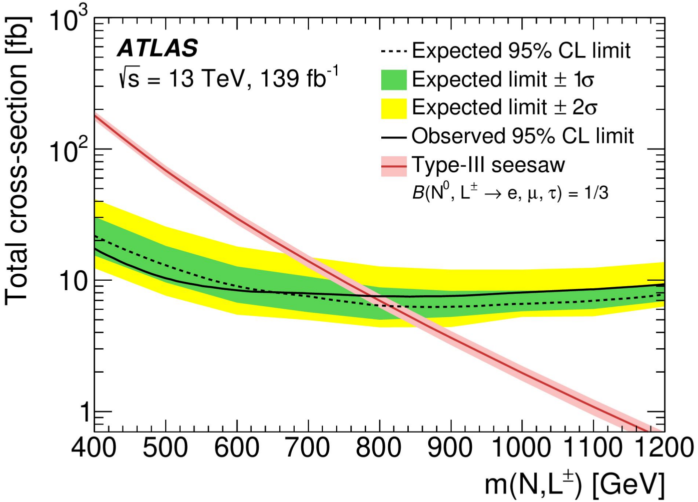


	OS ($\ell^+\ell^- = e^+e^-, e^\pm\mu^\mp, \mu^+\mu^-$) Top CR	m_{jj} VR	SR	SS ($\ell^\pm\ell^\pm = e^\pm e^\pm, e^\pm\mu^\pm, \mu^\pm\mu^\pm$) Diboson CR	m_{jj} VR	SR
N(jet)	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2
N(b-jet)	≥ 2	0	0	0	0	0
m_{jj} [GeV]	$(60, 100)$	$(35, 60) \cup (100, 125)$	$(60, 100)$	$(0, 60) \cup (100, 300)$	$(0, 60) \cup (100, 300)$	$(60, 100)$
$m_{\ell\ell}$ [GeV]	≥ 110	≥ 110	≥ 110	≥ 100	≥ 100	≥ 100
$\mathcal{S}(E_{\mathrm{T}}^{\mathrm{miss}})$	≥ 5	≥ 10	≥ 10	≥ 5	≥ 5	≥ 7.5
$\Delta\phi(E_{\mathrm{T}}^{\mathrm{miss}}, \ell)_{\mathrm{min}}$	—	—	≥ 1	—	—	—
$p_{\mathrm{T}}(jj)$ [GeV]	—	—	≥ 100	—	—	≥ 60
$p_{\mathrm{T}}(\ell\ell)$ [GeV]	—	—	≥ 100	—	—	≥ 100
$H_{\mathrm{T}} + E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	≥ 300	≥ 300	≥ 300	$(300, 500)$	≥ 500	≥ 300

Type III Seesaw Heavy Leptons

- Data-driven estimation of misidentified leptons and fake
- Binned likelihood fitting of H_T (scalar sum of jet and lepton p_T) + MET
- Excludes masses up to ~800 GeV for doublet masses

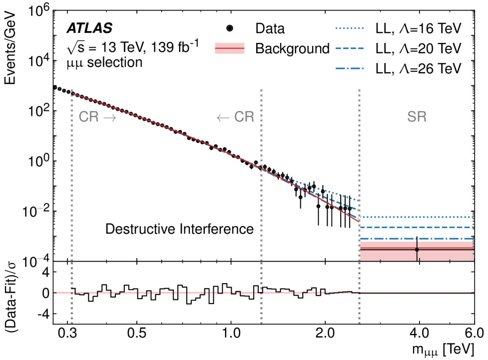


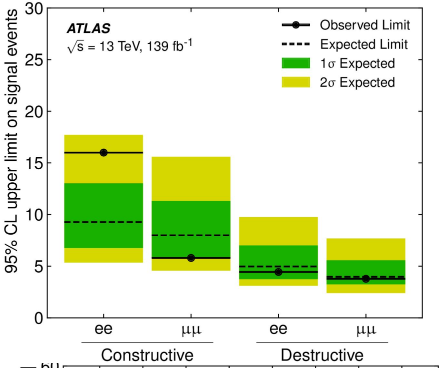


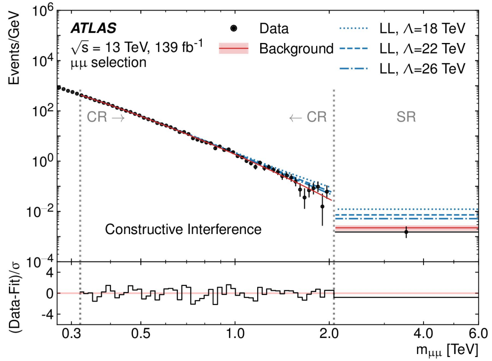
Non-resonant Dilepton Search

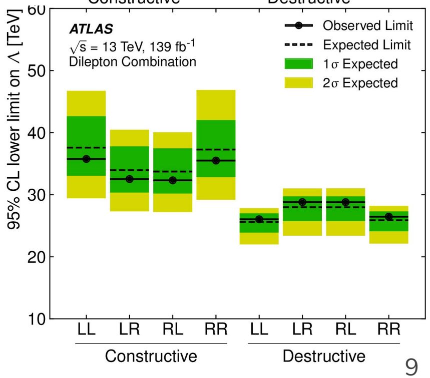
[arxiv:2006.12946](https://arxiv.org/abs/2006.12946)

- Model-independent non-resonant search with control and signal regions defined based on interference pattern according to Contact Interactions (CI) model
- Background fitted against a smoothly falling functional form in CR and extrapolated in the SR
- Limits interpreted in terms of compositeness energyscale (Λ) for all combinations of dilepton chirality structure and interference type





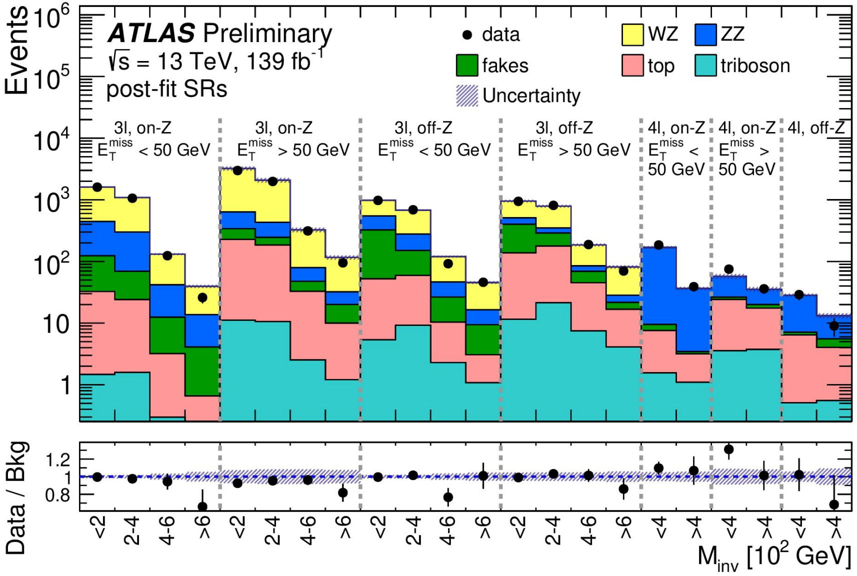




Three and Four Lepton Final States

ATLAS-CONF-2021-011

- 22 signal regions based on invariant mass of leptons, on/off-shell Z and MET threshold
- Additional WZ and ZZ control regions for 3l and 4l selections
- Fakes estimated by determining data-driven fake factors in dedicated regions and propagating them to CR/SRs
- Cross-section upper limits calculated in each SR (appended in backup)



Summary

- Recent ATLAS results setting strong constraints on model-specific and model-independent BSM searches

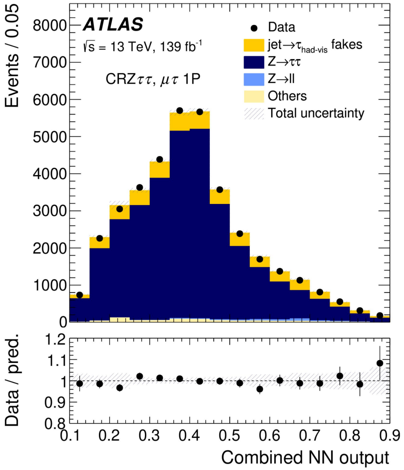
- ATLAS continues work on BSM searches with the Run 2 dataset. More results are in the pipeline

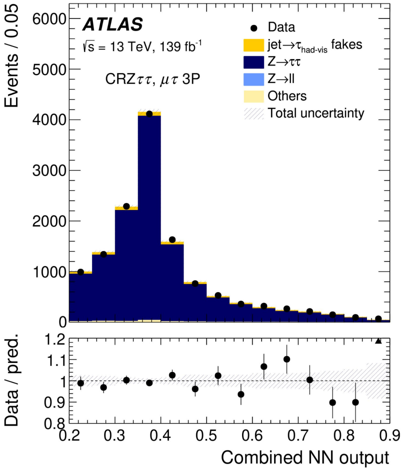
- Additional ATLAS results presented in dedicated LQ, Higgs pair production talks

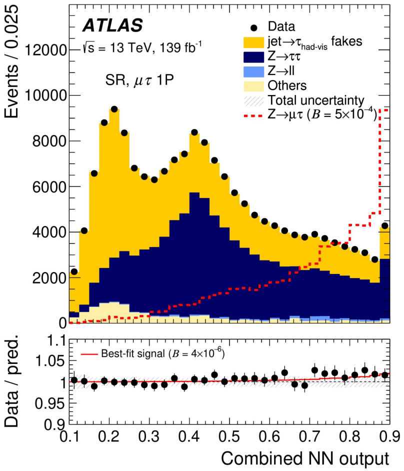
Backup Slides

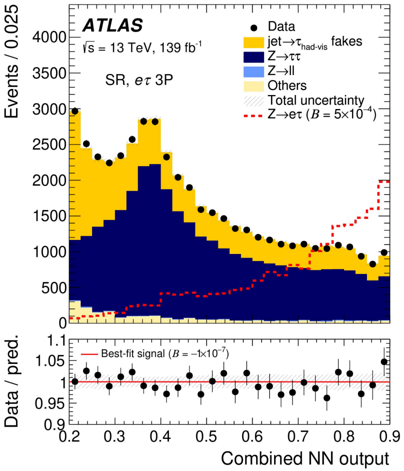
LFV: $Z \to \tau + e/\mu$

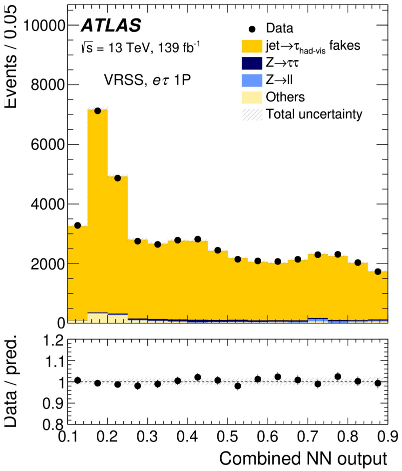
[Link to Results]

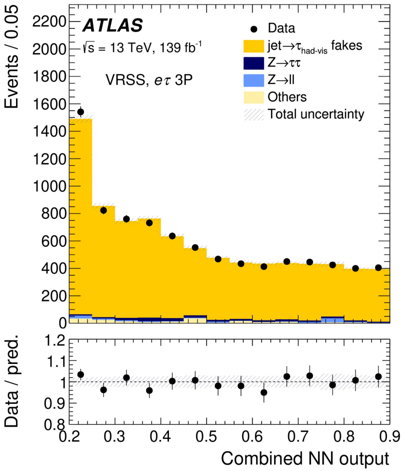












Three and Four Lepton Final States

Link to Results

Mass Range	N_{95} (exp.)	N_{95} (obs.)	σ_{vis} [fb] (exp.)	σ_{vis}[fb] (obs.)
3ℓ, On-Z, E_T^{miss} < 50 GeV				
<200 GeV	96^{+38}_{-27}	90	$0.69^{+0.27}_{-0.19}$	0.65
200-400 GeV	77^{+30}_{-21}	61	$0.55^{+0.22}_{-0.15}$	0.44
400-600 GeV	25^{+10}_{-7}	21	$0.18^{+0.08}_{-0.05}$	0.15
>600 GeV	14^{+6}_{-4}	7	$0.10^{+0.04}_{-0.03}$	0.05
3ℓ, On-Z, E_T^{miss} > 50 GeV				
<200 GeV	406^{+144}_{-114}	284	$2.9^{+1.0}_{-0.8}$	2.0
200-400 GeV	311^{+109}_{-87}	251	$2.2^{+0.8}_{-0.6}$	1.8
400-600 GeV	61^{+23}_{-17}	52	$0.44^{+0.16}_{-0.12}$	0.37
>600 GeV	27^{+11}_{-8}	16	$0.19^{+0.08}_{-0.05}$	0.11
3ℓ, Off-Z, E_T^{miss} < 50 GeV				
<200 GeV	72^{+29}_{-20}	69	$0.52^{+0.21}_{-0.15}$	0.50
200-400 GeV	60^{+24}_{-17}	67	$0.43^{+0.17}_{-0.12}$	0.48
400-600 GeV	25^{+10}_{-7}	12	$0.18^{+0.07}_{-0.05}$	0.08
>600 GeV	15^{+7}_{-4}	16	$0.11^{+0.05}_{-0.03}$	0.11

Mass Range	N_{95} (exp.)	N_{95} (obs.)	σ_{vis} [fb] (exp.)	σ_{vis}[fb] (obs.)
3ℓ, Off-Z, E_T^{miss} > 50 GeV				
<200 GeV	104^{+39}_{-29}	96	$0.75^{+0.28}_{-0.21}$	0.69
200-400 GeV	96^{+36}_{-27}	109	$0.69^{+0.26}_{-0.19}$	0.79
400-600 GeV	34^{+13}_{-9}	35	$0.24^{+0.10}_{-0.07}$	0.25
>600 GeV	21^{+9}_{-6}	14	$0.15^{+0.06}_{-0.04}$	0.10
4ℓ, On-Z, E_T^{miss} < 50 GeV				
<400 GeV	32^{+13}_{-9}	45	$0.23^{+0.09}_{-0.06}$	0.32
>400 GeV	14^{+6}_{-4}	16	$0.10^{+0.04}_{-0.03}$	0.11
4ℓ, On-Z, E_T^{miss} > 50 GeV				
<400 GeV	20^{+8}_{-6}	35	$0.14^{+0.06}_{-0.04}$	0.25
>400 GeV	14^{+6}_{-4}	15	$0.10^{+0.04}_{-0.03}$	0.11
4ℓ, Off-Z				
<400 GeV	12^{+5}_{-3}	13	$0.09^{+0.04}_{-0.02}$	0.09
>400 GeV	9^{+4}_{-3}	6	$0.065^{+0.030}_{-0.018}$	0.044