A search for R-parity violating supersymmetry through top squark pair production in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS experiment

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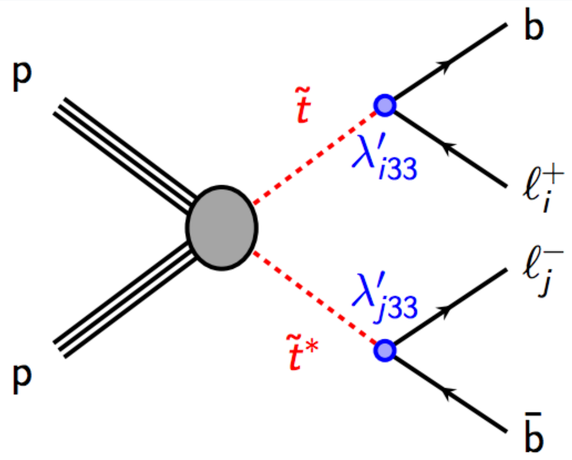
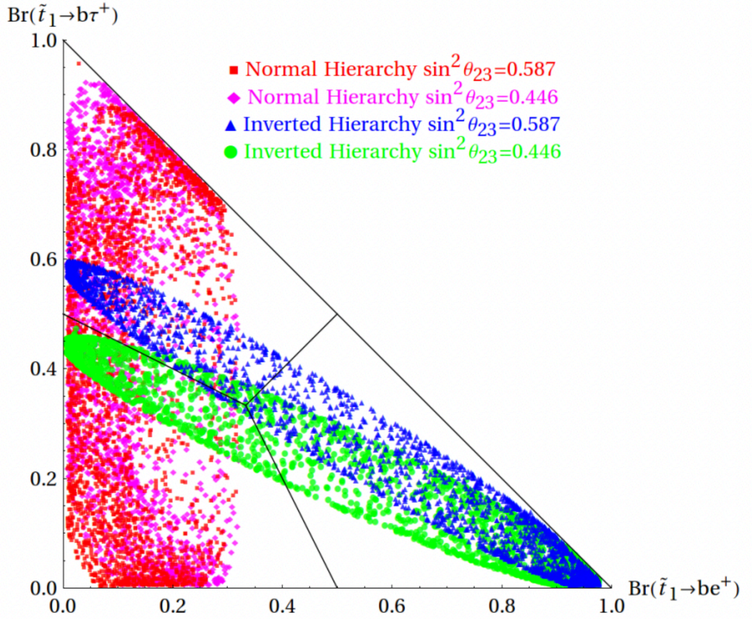
ATLAS
EXPERIMENT

Motivation

- R-parity conservation often invoked in SUSY to prevent Baryon # violating and Lepton # violating terms; also to preserve stability of the proton
- If R parity is violated → LSP allowed to decay into only standard model particles (proton still stable)
- Examine R-parity violating SUSY → stop squark as LSP
- B-L Model motivated by University of Pennsylvania theorists; Marshall, Ovrut, Purves, Spinner, PLB 732 (2014) 325-329 arxiv

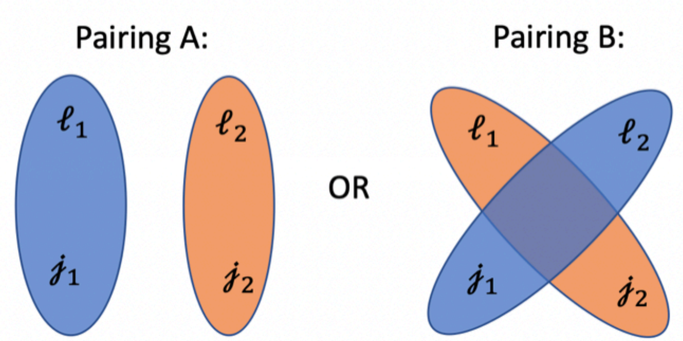




Early Run 2 Analysis: ATLAS Collab, Phys. Rev. D 97 (2018) 032003

Analysis Strategy

- Experimental signature: 2 opposite charged leptons and 2 b-jets (fully reconstructable in ATLAS)
- Target Signal:
  - 2 opposite sign leptons (e or μ)
  - 2 jets ($\geq$1 b-tag)
- Kinematic variables: H_T m_{ll} m_{asym} m_{bl}
- Variable bin-width signal region
- Two exclusion fits for each stop mass + lepton BR combination: 15 bin agnostic fit and 45 bin flavor aware

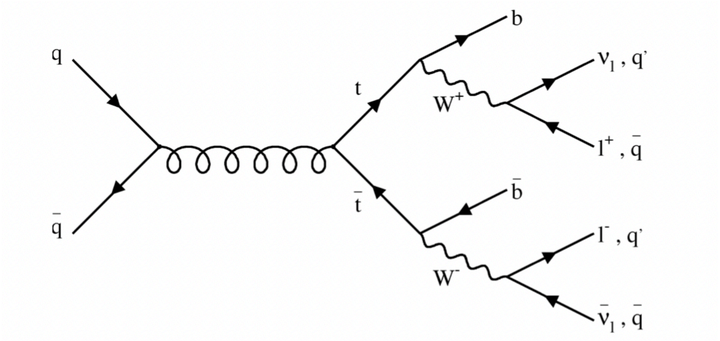


$$m_{b\ell} \text{ asymmetry} = \frac{\left(m^0_{b\ell} - m^1_{b\ell}\right)}{\left(m^0_{b\ell} + m^1_{b\ell}\right)}$$

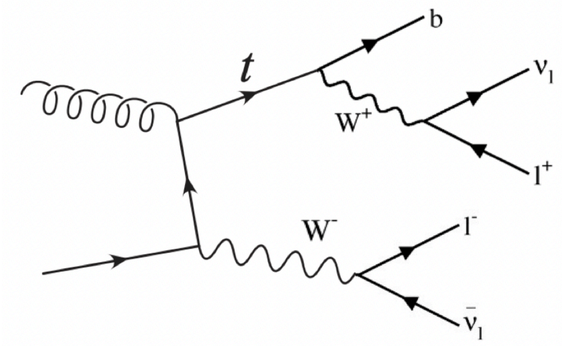
Primary Backgrounds

- Developed Control Regions (CRs) to constrain primary backgrounds: $t\bar{t}$, Single-top, and Z+jets
- Top Backgrounds
  - 2 leptons from W decay, $\geq$ 1 b-jet
  - CRtt -events with mis-paired jets and leptons
  - CRst- separation of $t\bar{t}$ and single-top
- Z+jets + heavy flavor
  - 2 leptons from Z decay, jets from ISR/FSR
  - CRZ- isolate leptons from Z boson decay

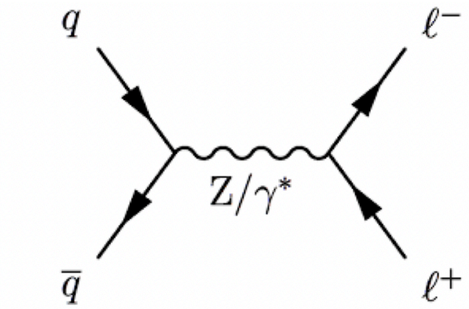
$t\bar{t}$



Single-top

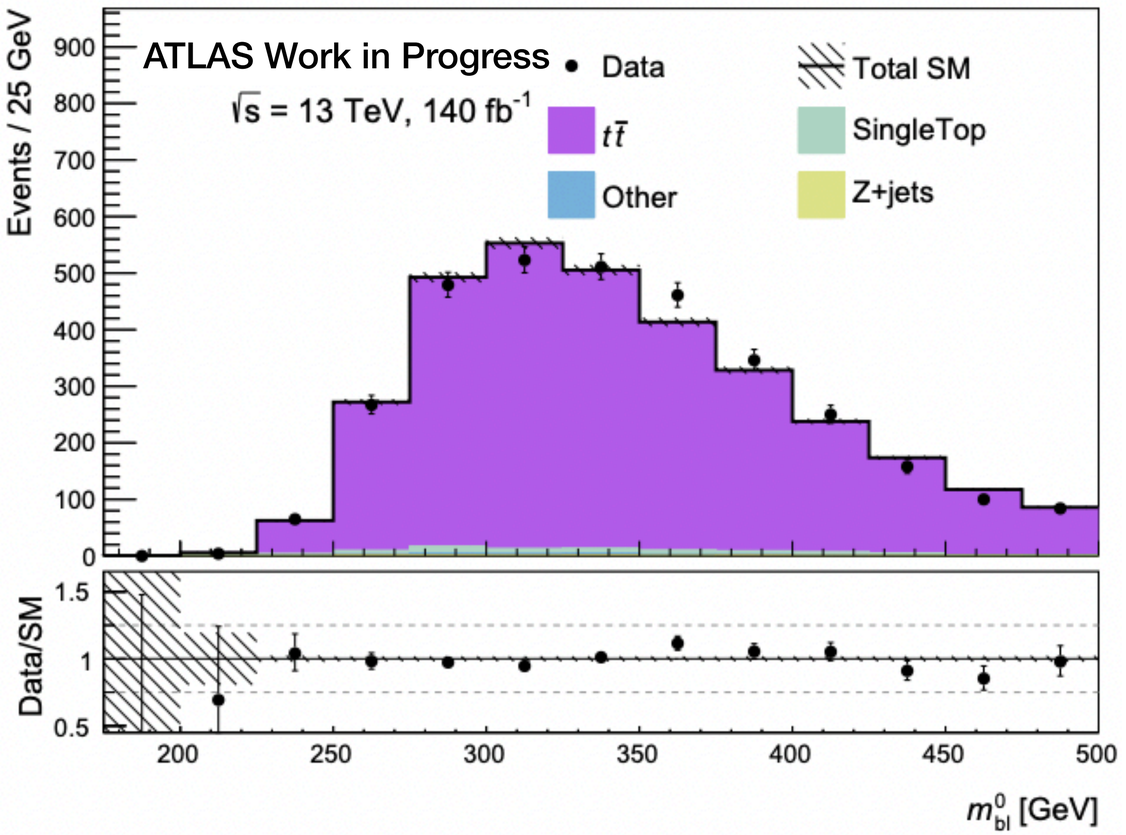


Drell-Yan

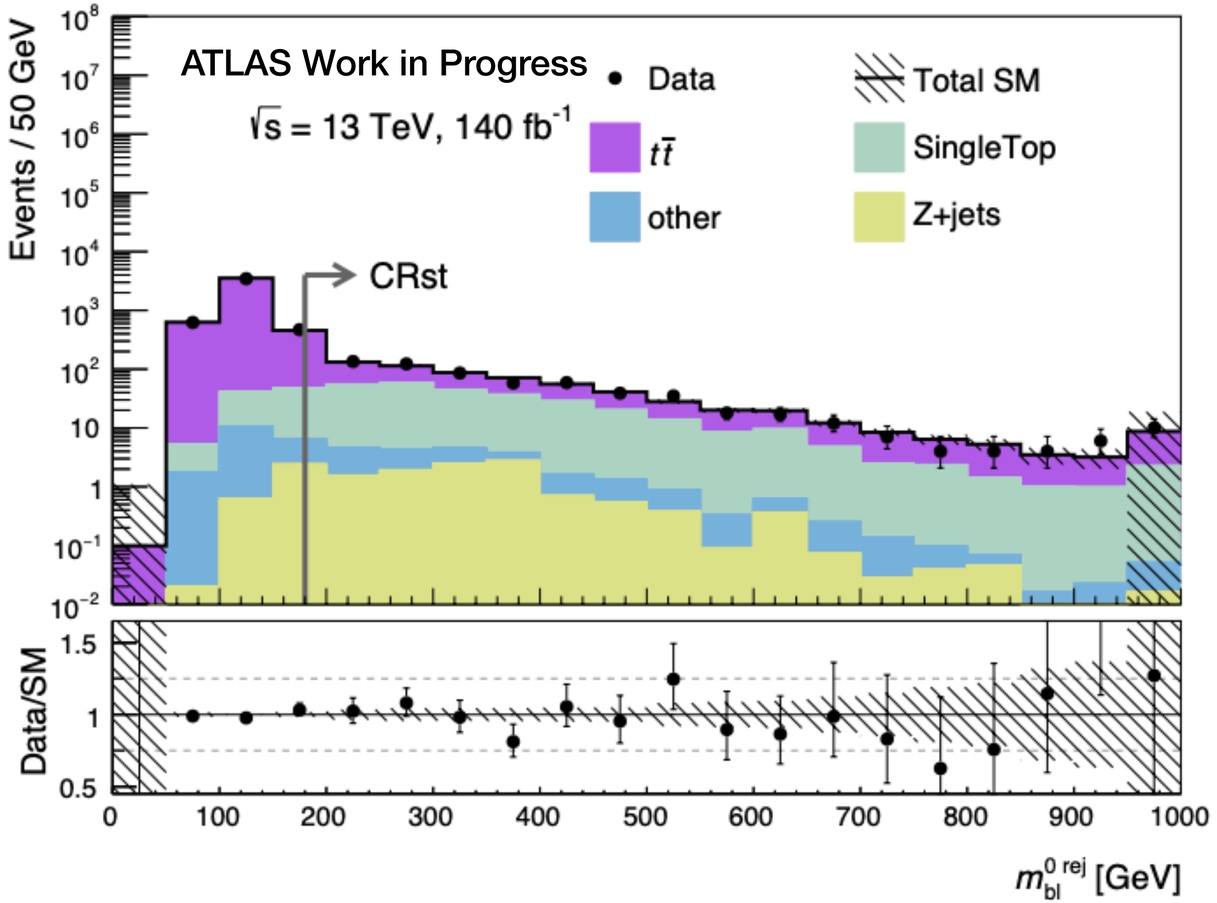


Control and Validation regions

CRtt



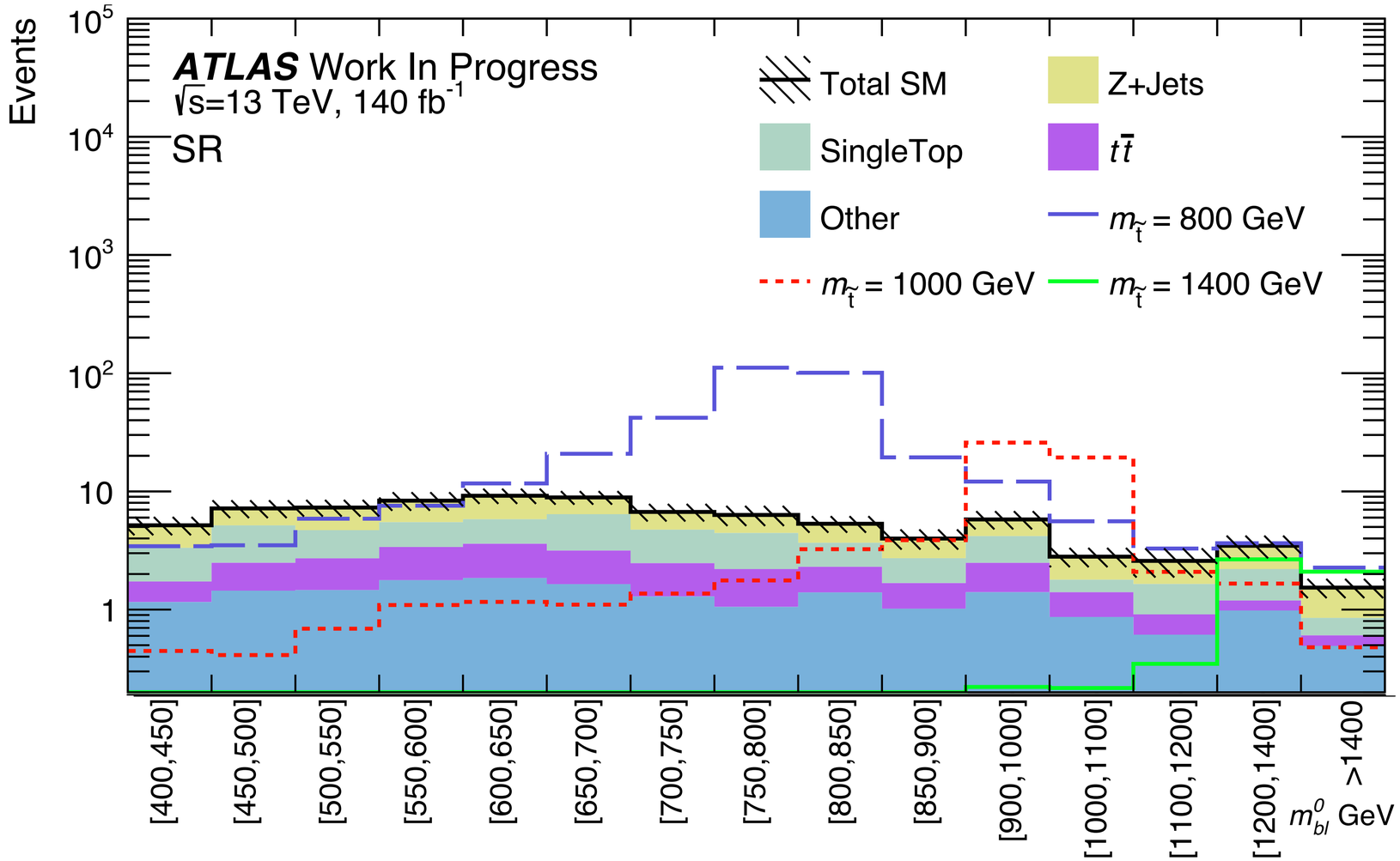
CRst



CRs show backgrounds are well modeled.

Signal Region

- Variable bin-width:
  Optimization study over m_{bl}^{0} bins
- Two exclusion fits for each stop mass + lepton BR combination:
  - 15 bin agnostic fit
  - 45 bin flavor aware (EE, EM, MM)
- Choose configuration with strictest expected limits for each BR and mass point



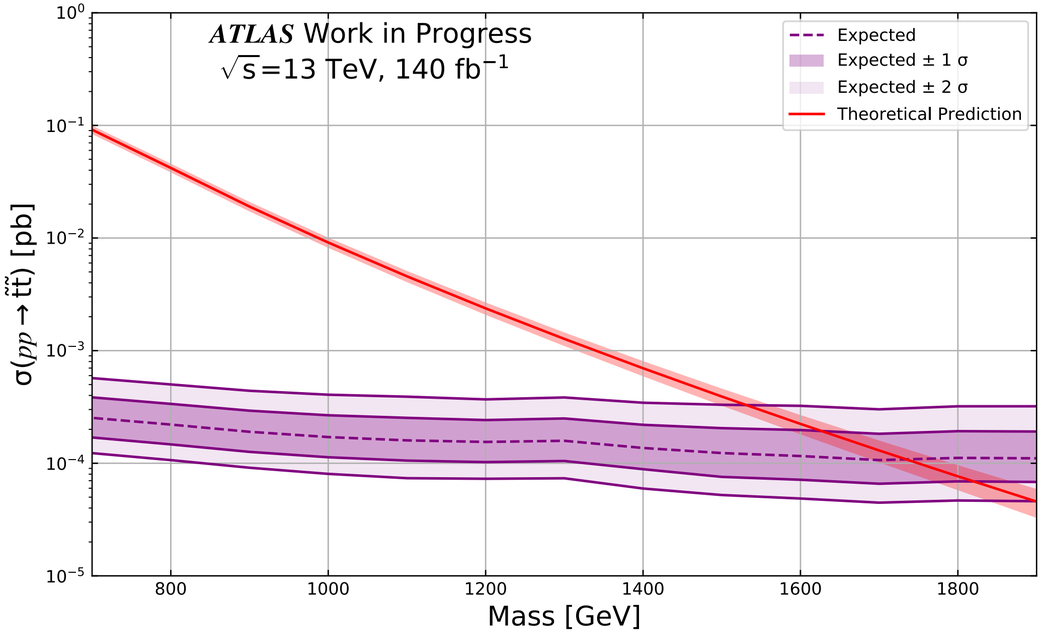
Results

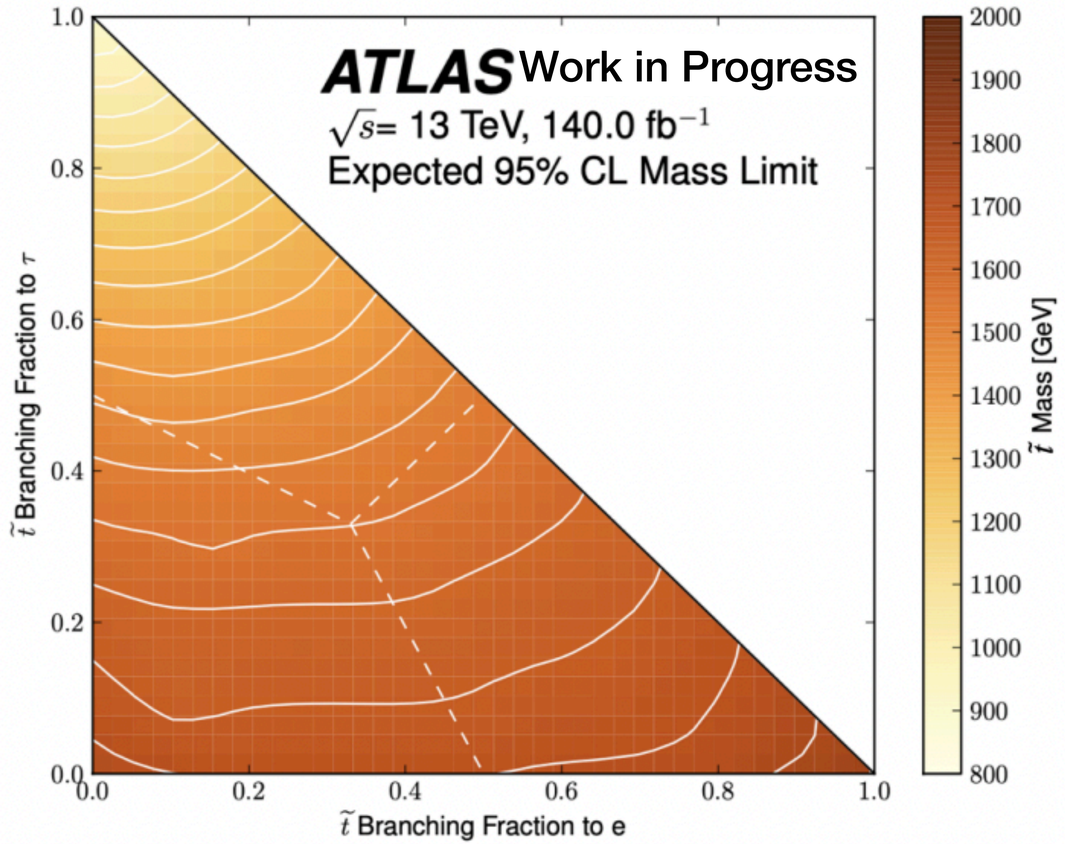
- Expected improvement of early Run 2 limits:

1400 GeV →1800 GeV for BR($\tilde{t} \rightarrow \mu b$) =100%

1500 GeV → 1900 GeV for BR($\tilde{t} \rightarrow e$) = 100%

600 GeV → 1100 GeV for BR($\tilde{t} \rightarrow \tau$) = 90%





Conclusions

- Expected increased sensitivity from:
  - Larger dataset
  - Fit to the mass distribution of the leading lepton-jet pair
  - Improved systematics below ~20% for all m_{bl} bins in the distribution

Thanks for listening!

Backup

Region Selection

Region	N_b	m_{bl}^{0} [GeV]	$m_{bl}^{1,\mathrm{rej}}$ [GeV]	H_T [GeV]	m_{bl} asym	m_{ll} [GeV]	$m_{bl}^{0,\mathrm{rej}}$ [GeV]
SR	≥ 1	> 400	> 150	> 1000	< 0.2	>300 GeV	–
CRtt	≥ 1	[180,500]	< 150	[500,800]	< 0.2	>200 GeV	< 180
CRst	$= 2$	[180,500]	< 150	[400, 800]	< 0.2	>200 GeV	> 180
CRZ	≥ 1	> 700	–	> 1000	< 0.2	[76.2,106.2]	–
VR m_{bl}^{0}	≥ 1	> 500	< 150	[600,800]	< 0.2	>300 GeV	–
VR $m_{bl}^{1,\mathrm{rej}}$	≥ 1	[200,500]	> 150	[600,800]	< 0.2	>300 GeV	–
VR H_T	≥ 1	[200,500]	< 150	> 800	< 0.2	>300 GeV	–
VRZ	$= 0$	[500,800]	> 150	> 1000	< 0.2	>300 GeV	–