SUSY PRV Searches

Xuai Zhuang (IHEP, Beijing)

On behalf of ATLAS & CMS Collaborations

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中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

RPV SUSY

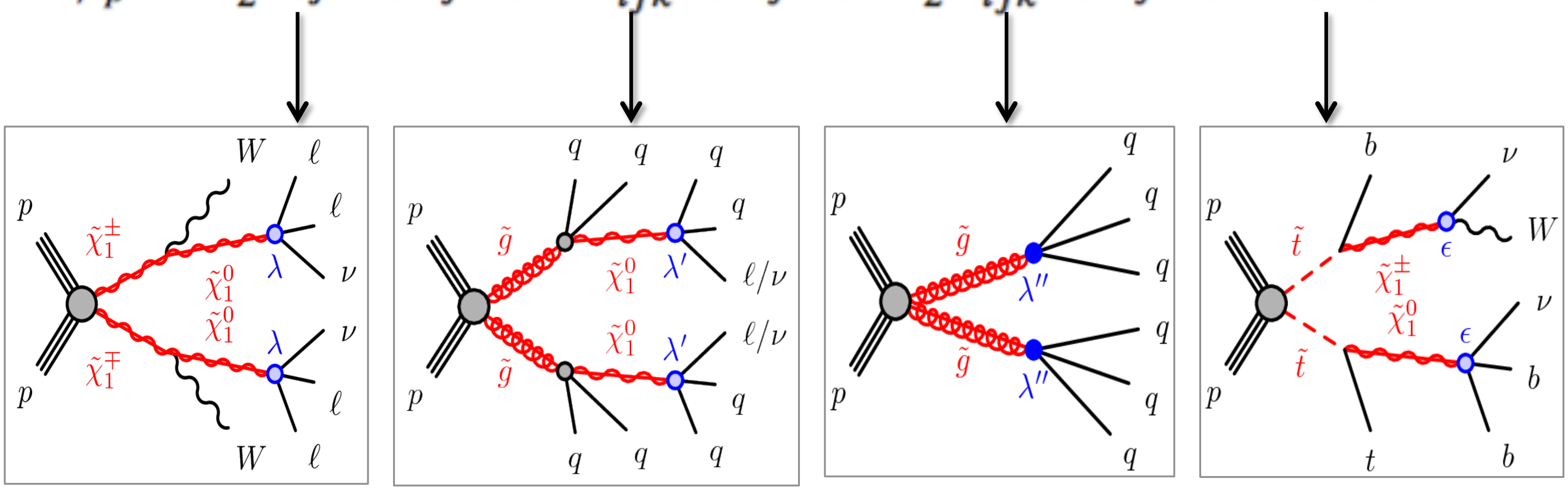
- **Precision SM measurements support baryon and lepton number conservation, while some MSSM couplings do not**
- **Search for R-parity Violating SUSY**

$$R = (-1)^{3(B-L)+2S}$$

R=+1 (SM); R=-1 (SUSY)

- **Super-potential with RPV of lepton or baryon number**

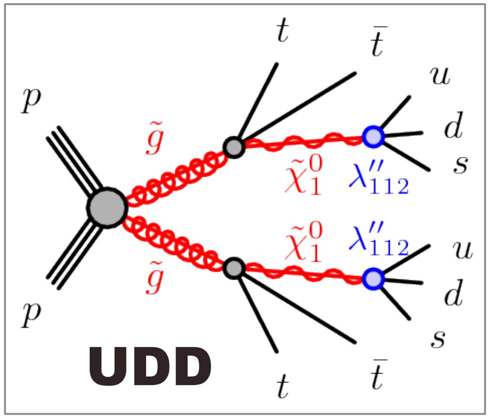
$$W_{R_p} = \frac{1}{2}\lambda_{ijk}L_iL_j\bar{E}_k + \lambda'_{ijk}L_iQ_j\bar{D}_k + \frac{1}{2}\lambda''_{ijk}\bar{U}_i\bar{D}_j\bar{D}_k + \kappa_i L_i H_2$$



LLE **LQD** **UDD** **Bilinear LH**

RPV SUSY

- **RPV SUSY signatures:**
  - Decaying LSP → lower Missing Transverse Energy (MET)
  - Many jets (or leptons) in the final states
  - QCD backgrounds are very challenging in UDD model
- **Only show results from 13 TeV data**



	Model	objects			lumi.	Mass limit	
RPV	LFV $pp \to \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \to e\mu/e\tau/\mu\tau$	$e\mu, e\tau, \mu\tau$	-	-	3.2	$\tilde{\nu}_\tau$	1.9 TeV
	Bilinear RPV CMSSM	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{q}, \tilde{g}$	1.45 TeV
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+ \to W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \to ee\nu, e\mu\nu, \mu\mu\nu$	4 e,μ	-	Yes	13.3	$\tilde{\chi}_1^\pm$	1.14 TeV
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+ \to W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \to \tau\tau\nu_e, e\tau\nu_\tau$	3 $e,\mu + \tau$	-	Yes	20.3	$\tilde{\chi}_1^\pm$	450 GeV
	$\tilde{g}\tilde{g}, \tilde{g} \to qqq$	0	4-5 large-R jets	-	14.8	$\tilde{g}$	1.08 TeV
	$\tilde{g}\tilde{g}, \tilde{g} \to qq\tilde{\chi}_1^0, \tilde{\chi}_1^0 \to qqq$	0	4-5 large-R jets	-	14.8	$\tilde{g}$	1.55 TeV
	$\tilde{g}\tilde{g}, \tilde{g} \to t\bar{t}\tilde{\chi}_1^0, \tilde{\chi}_1^0 \to qqq$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde{g}$	2.1 TeV
	$\tilde{g}\tilde{g}, \tilde{g} \to \tilde{t}_1 t, \tilde{t}_1 \to bs$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde{g}$	1.65 TeV
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \to bs$	0	2 jets + 2 b	-	15.4	$\tilde{t}_1$	410 GeV; 450-510 GeV
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \to b\ell$	2 e,μ	2 b	-	20.3	$\tilde{t}_1$	0.4-1.0 TeV

SM Background Modeling

Combined fit of all regions and bgs, and including systematic exp. and theory uncertainty as nuisance parameters

Standard Model

Top, multijets
V, *VV*, *VVV*, Higgs
& combinations of these

Reducible backgrounds

Determined from data
Backgrounds and methods depend on analyses

Irreducible backgrounds

- *Dominant sources*:
  - Mulit-jet: data-driven
  - Non-Multi-jet: normalise MC in data control regions
- *Subdominant sources*: MC

blinded

Validation

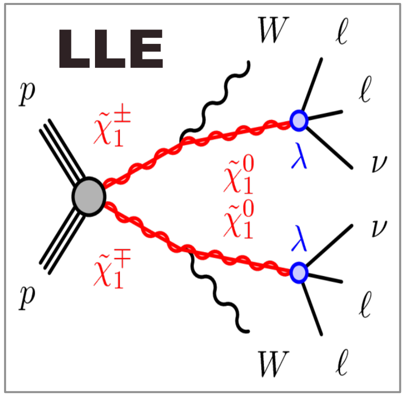
Validation regions used to cross check SM predictions with data

blinded

Signal regions

EWK SUSY: RPV 4 leptons

- **Chargino pair production** to neutralino (LSP) and decays via Lepton number-violating couplings
- Signatures: 4 leptons and MET
- Exclude chargino mass up to 1.1 TeV from m(LSP) > 400 GeV



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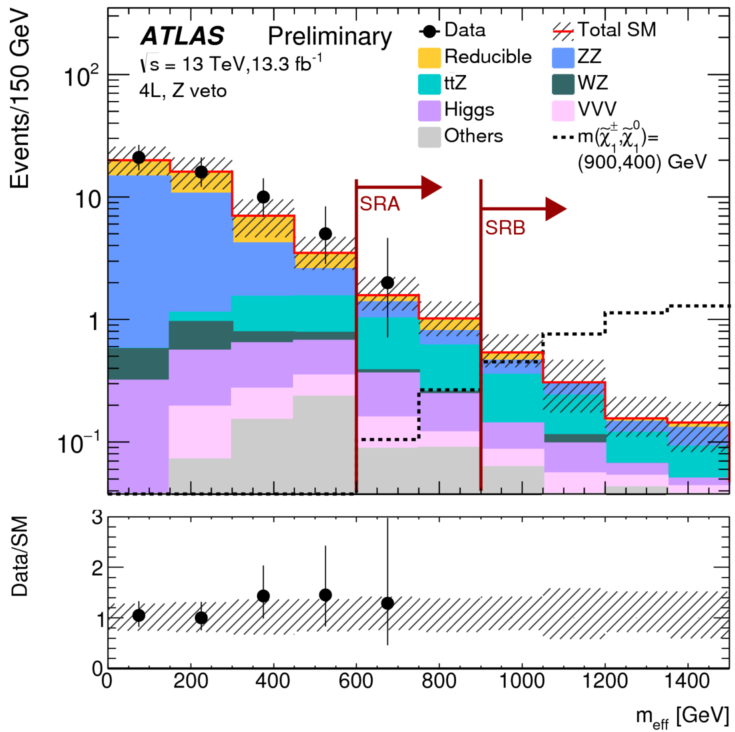
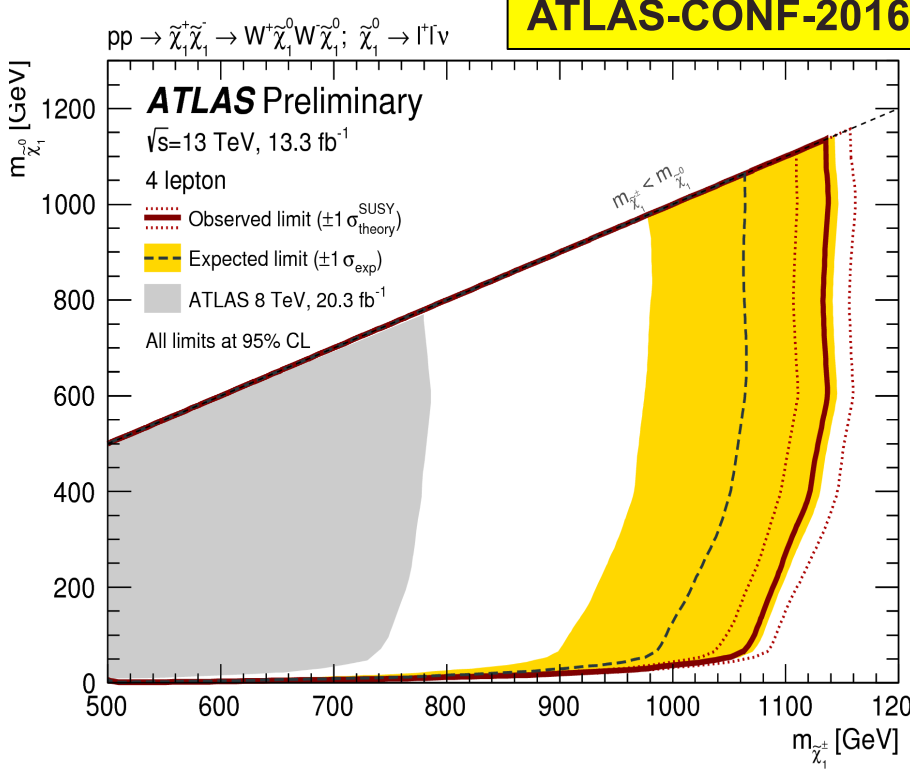
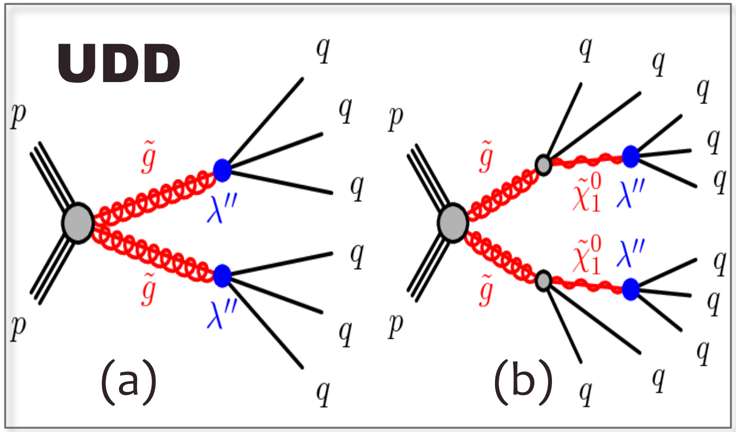




Strong SUSY: RPV multi-jets

- Gluino pair production, decays via Baryon number-violating couplings into quarks
- Signatures: 4-5 large-Radius jets
- Discriminating variable: M_J^{Σ}
- Exclude gluino mass upto 1.1-1.5 TeV



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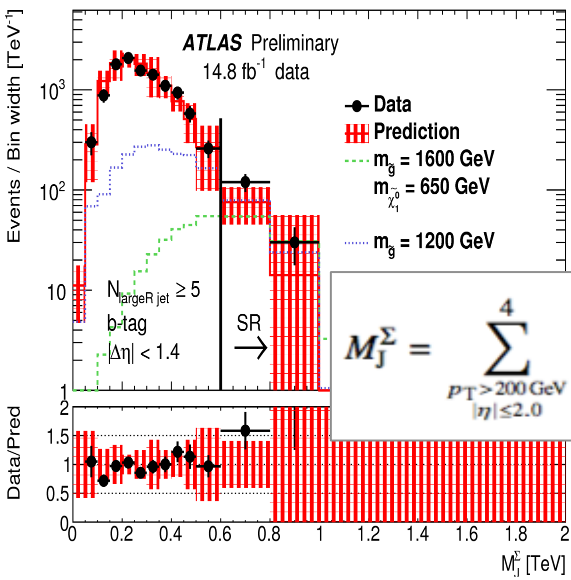
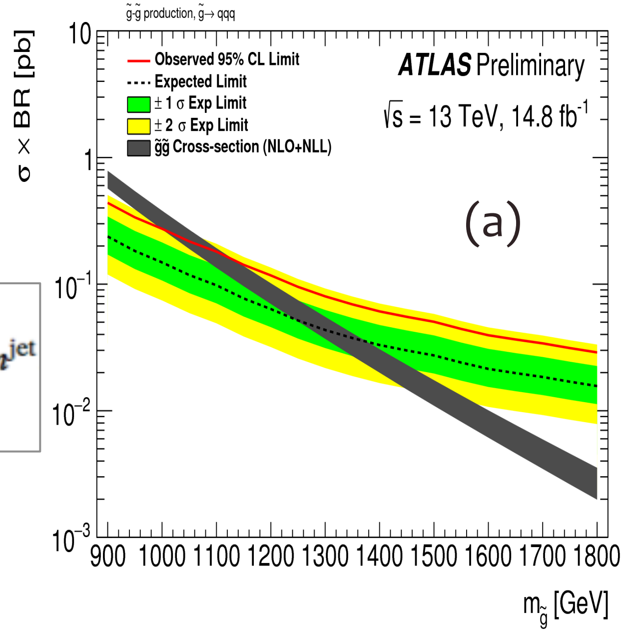
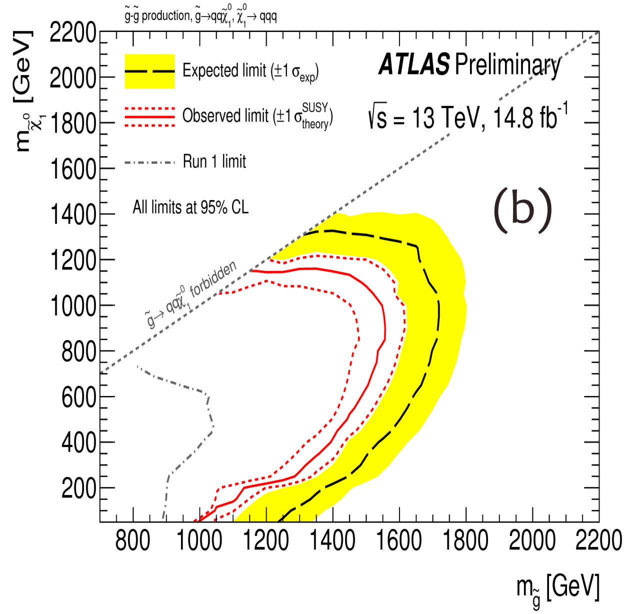


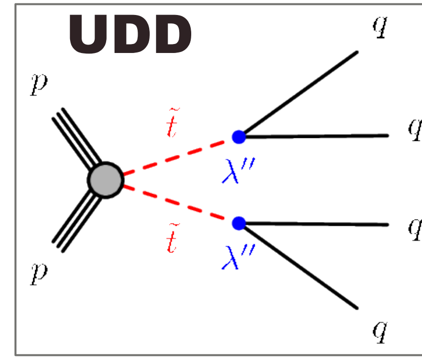
$$M_J^{\Sigma} = \sum_{\substack{p_T > 200\,\text{GeV} \\ |\eta| \leq 2.0}}^{4} m^{\text{jet}}$$



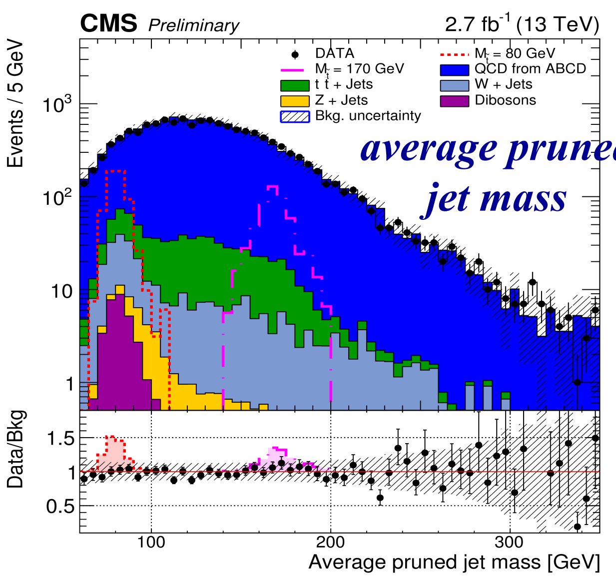


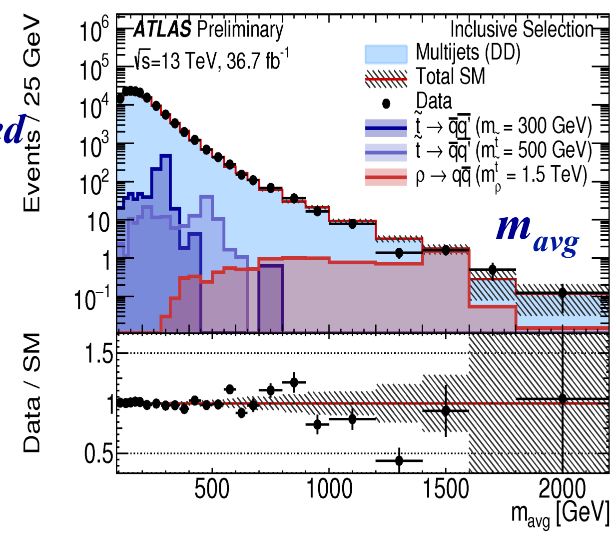
Strong SUSY: RPV multi-jets

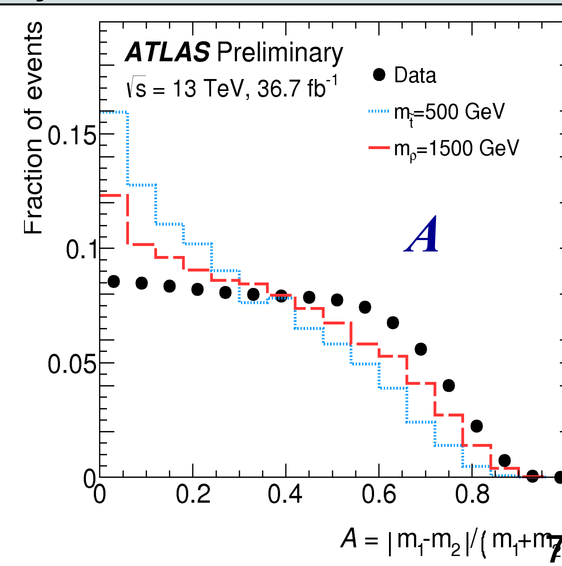
- **stop pair production**, decays via Baryon number-violating couplings into light quarks
- **Signatures: 4 high-pT jets**
- **Discriminating variables:**
  - **ATLAS**: mass asymmetry between 2 jet pairs *A=|m1-m2|/(m1+m2);* stop pair production angle *|cos(θ*)|; m_{avg}=(m1+m2)/2;*
  - **CMS**: *average pruned jet mass, $M_{asym.}$*



Dominate bgs: Multi-jet (ABCD)
- M_{asym} .Vs. Δη (j1, j2) (CMS)
- M_{asym} .vs. |cos(θ*)| (ATLAS)

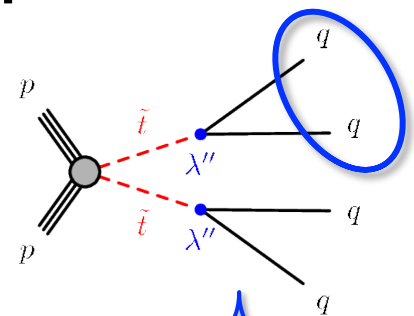


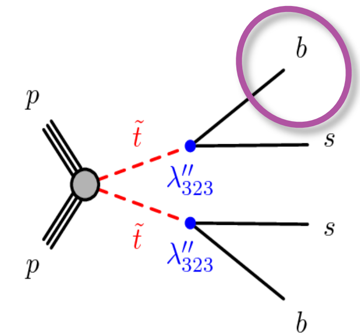


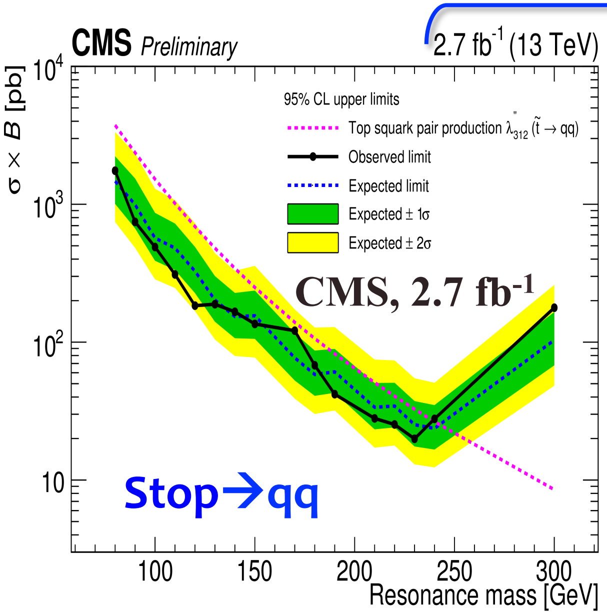


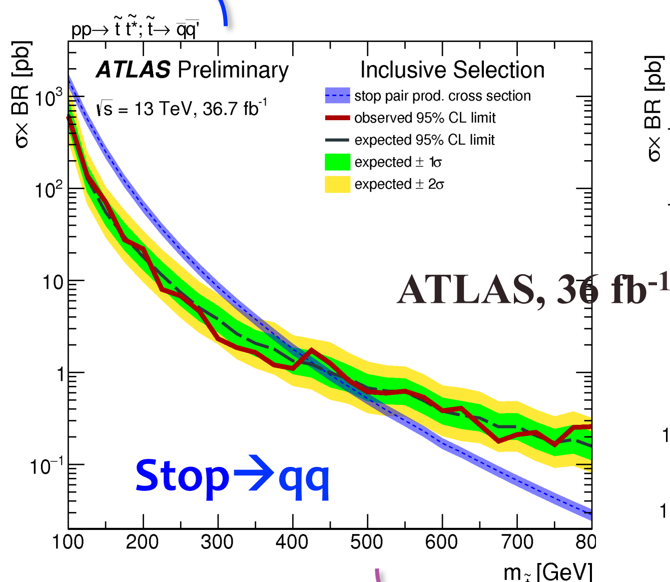
Strong SUSY: RPV multi-jets (cont.)

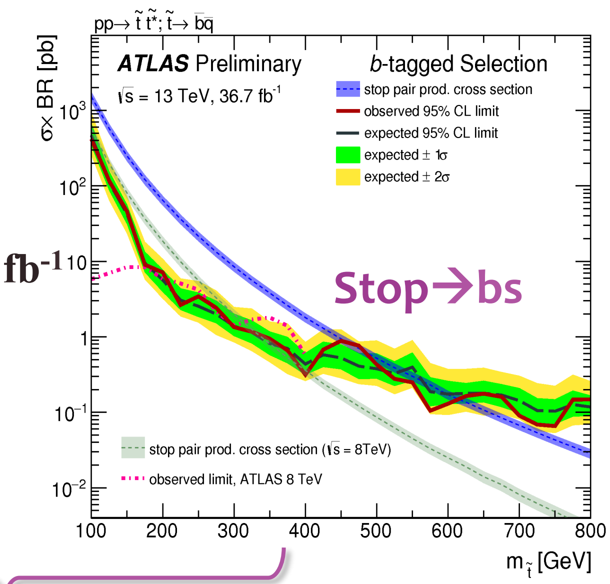
- Exclude stop mass 100-410 GeV for light quark FS
- Exclude stop mass 100-470, 480-610 GeV for heavy quark FS









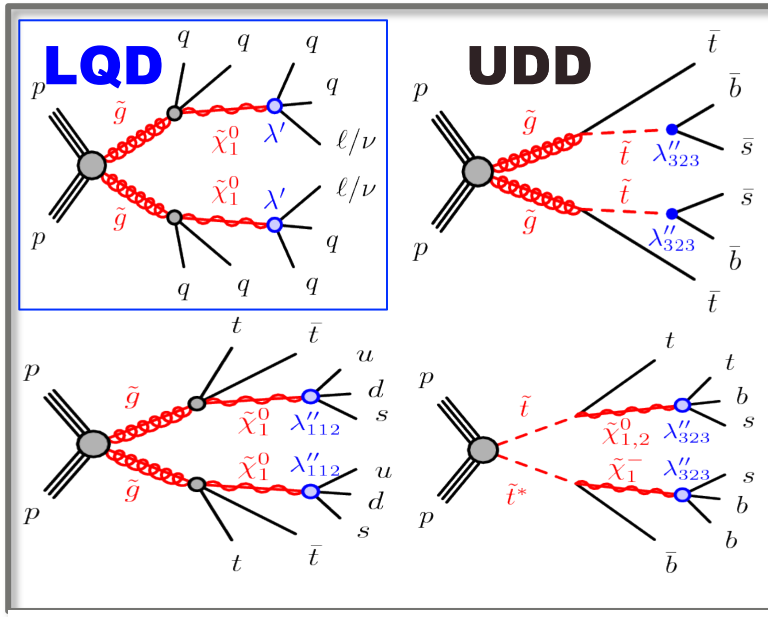


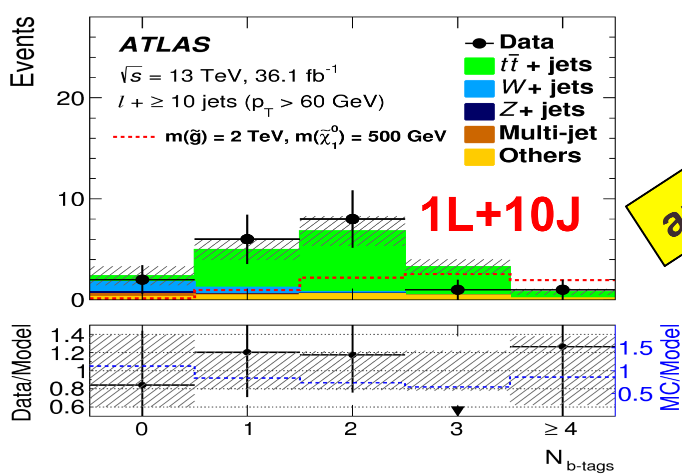
CMS-PAS-EXO-16-029

ATLAS-CONF-2017-025

Strong SUSY: RPV 1L + multi-jets (+bjets)

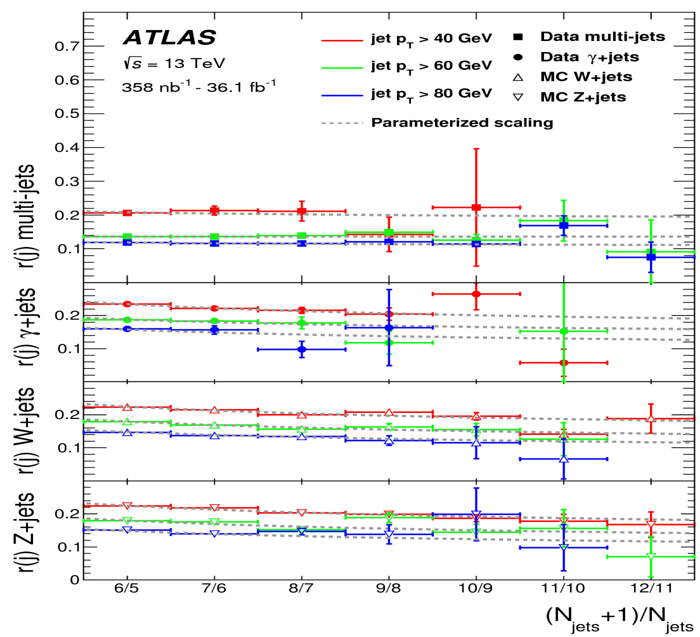
- **Gluino (stop) pair production**, decays via Lepton/Baryon number-violating couplings into quarks
- **Signatures: 1lepton + multi-jets (≥8-12) and (0, ≥3) bjets**
- **SRs are binned in N_jet, N_bjet**
- **Dominant bgs: ttbar, W/Z+jets**
  - Find b-jet multiplicity templates at lower jet multiplicities
  - Extrapolate to high jet multiplicity using scaling parameterization





arXiv:1704.08493

NEW!

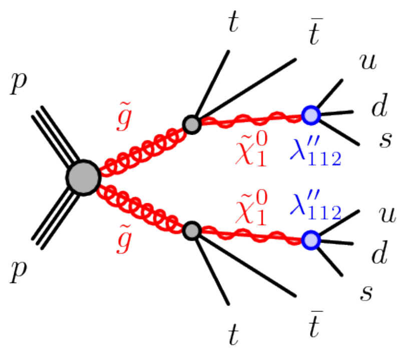


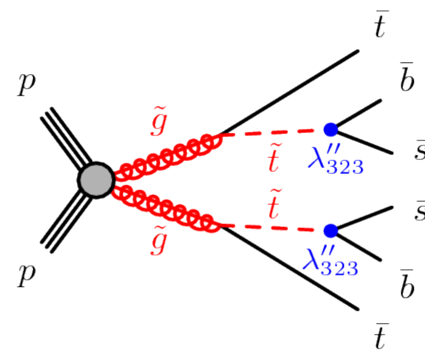
Strong SUSY: RPV 1L + multi-jets + (bjets)

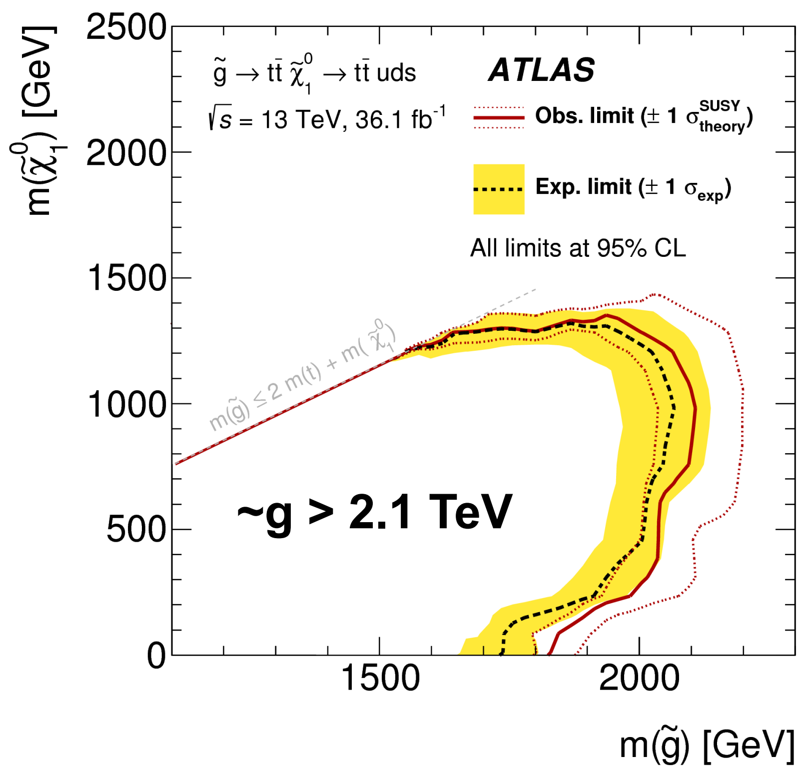
arXiv:1704.08493

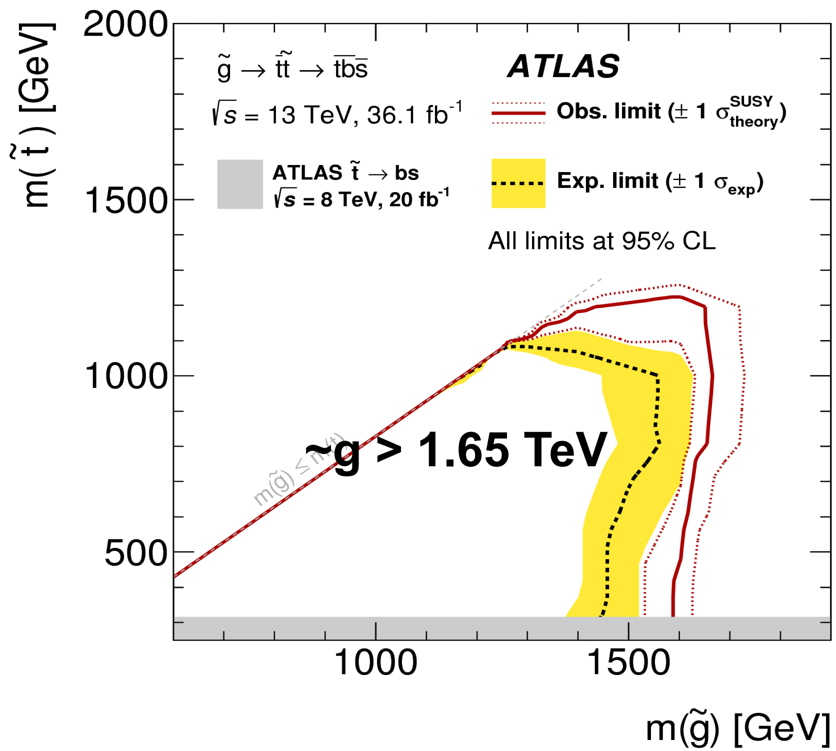
UDD

NEW!







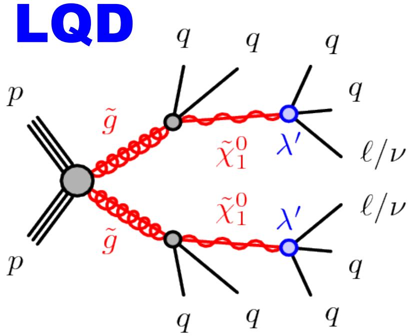


Strong SUSY: RPV 1L + multi-jets + (bjets)

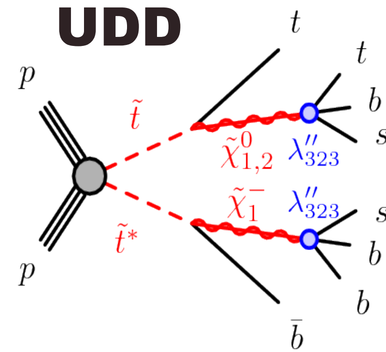
arXiv:1704.08493

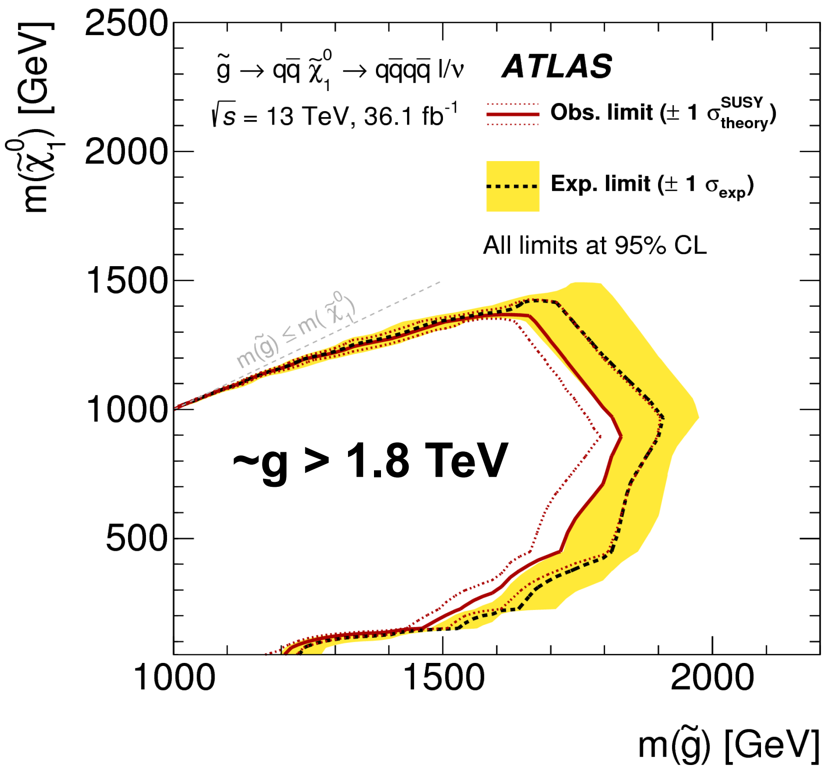
NEW!

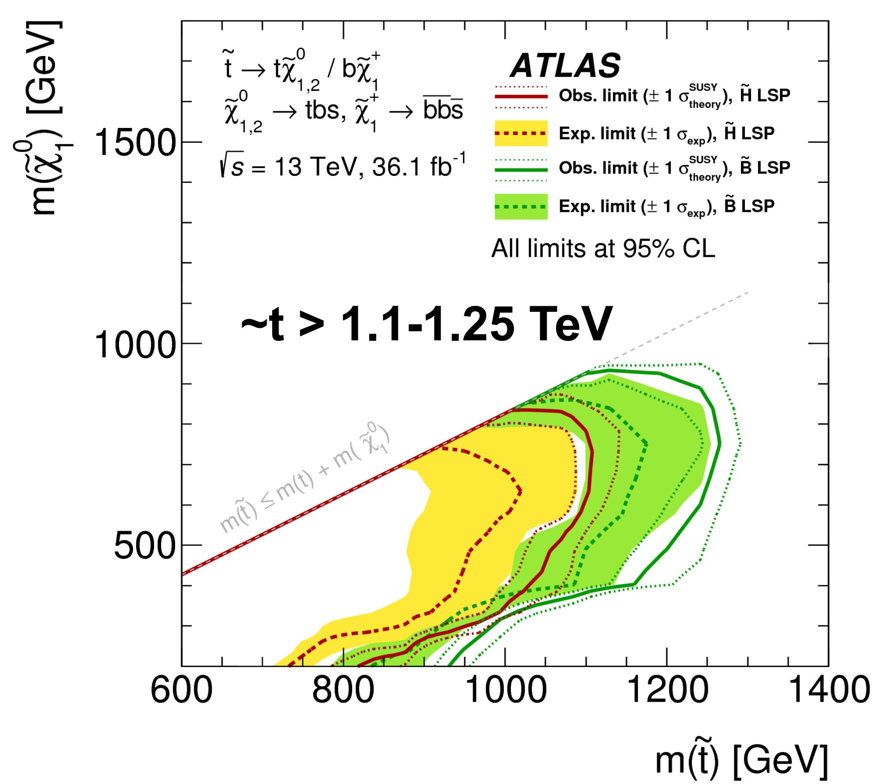
LQD



UDD

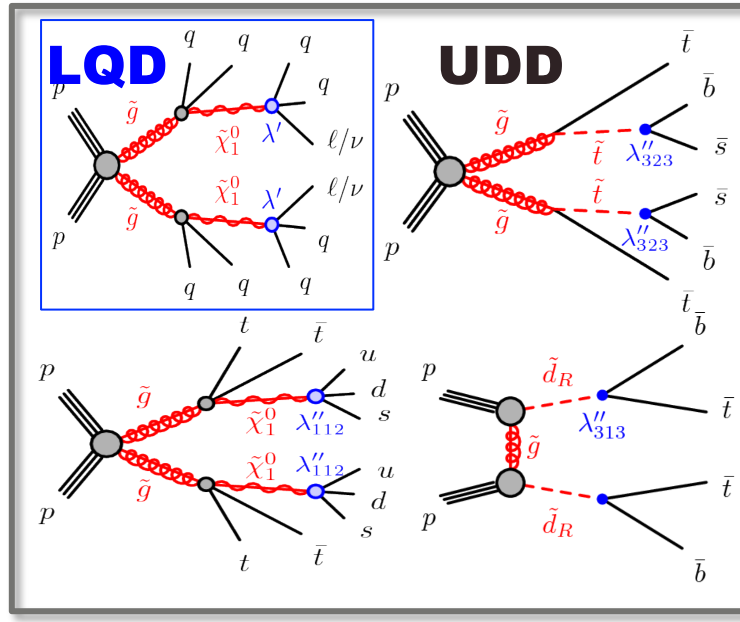






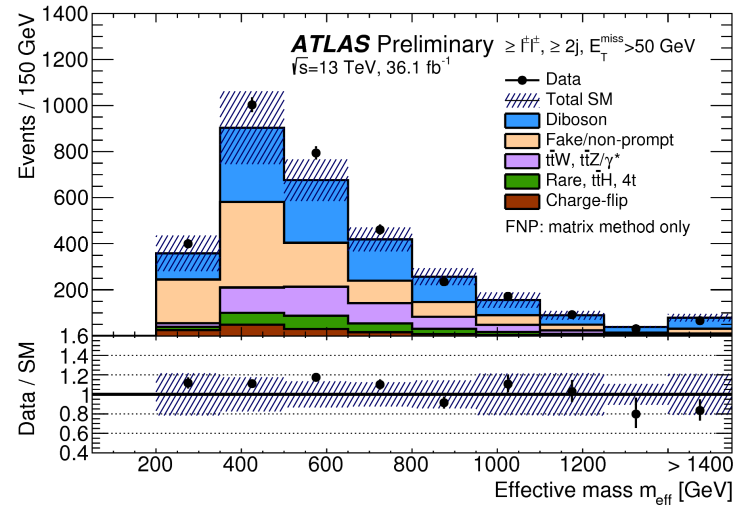
Strong SUSY: RPV SS2L +multi-jets + bjets

- **Gluino (down squark) pair production**, N1 decays via Baryon/lepton number-violating couplings into quarks
- Signatures: SS2L + (≥3-6)multi-jets + (0-2)bjets
- SRs are binned in N_jet, N_bjet + Meff cut (>1200-2200 GeV)
- Main backgrounds:
  - diboson and ttV: estimated from MC simulation, validated in VRs.
  - Fake background and charge flip: estimated in data



NEW!

ATLAS-CONF-2017-030



SS2L, 2j, MET>50GeV

Strong SUSY: RPV SS2L +multi-jets + bjets (cont.)

- Exclude gluino mass up to 1.4-1.8 TeV
- Exclude right-handed down squak mass up to 0.5 TeV

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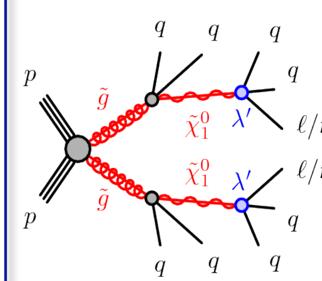
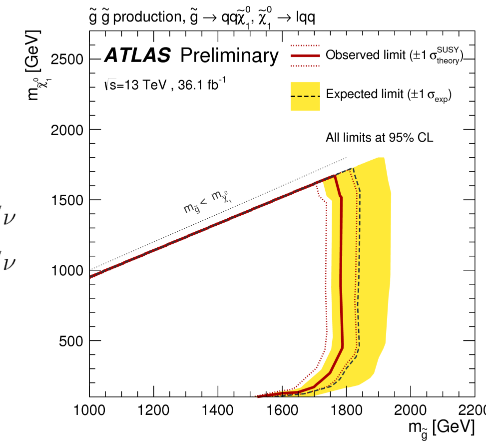
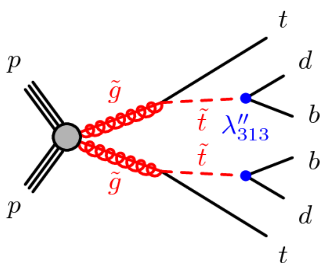
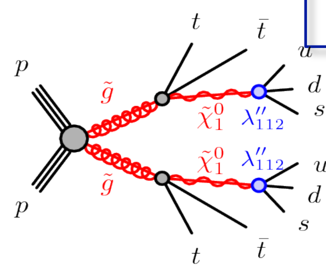
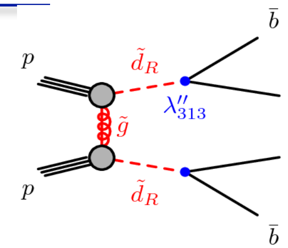
LQD











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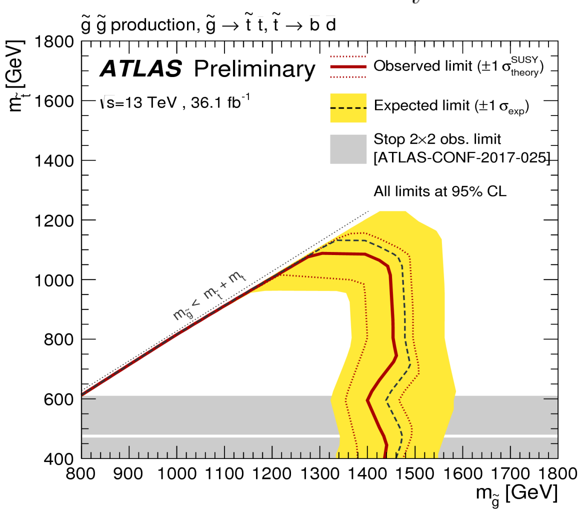
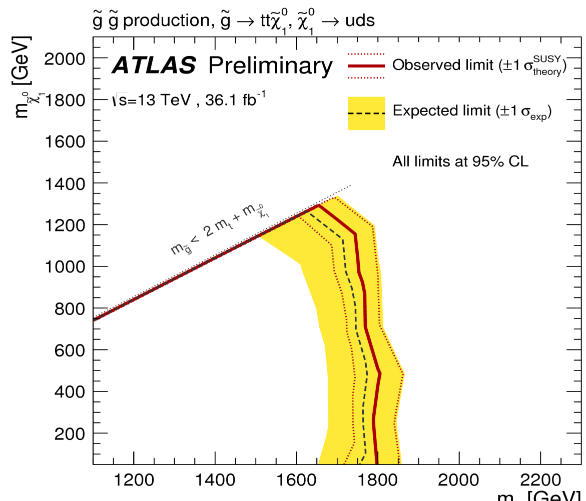
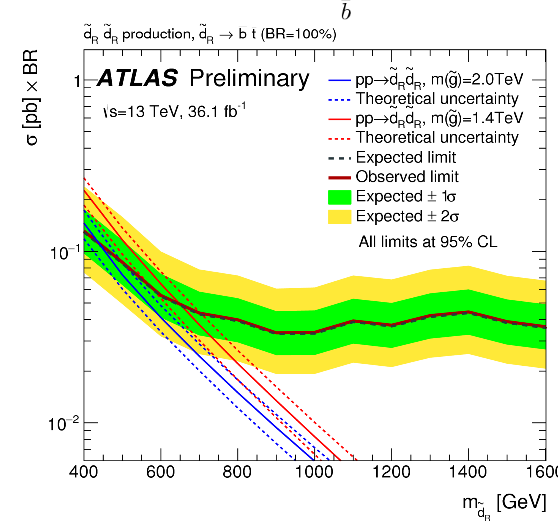
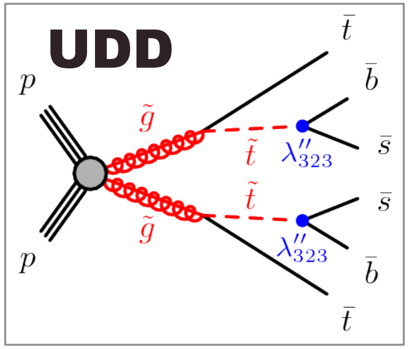






Strong SUSY: RPV 0-1L + multi-jets + bjets

- **Gluino pair production**, decays via Baryon number-violating couplings into quarks
- **Signatures: (0-1) lepton + multi- jets and bjets**
- **SRs (0-1L) are binned in N_lep (0-1), N_jet (>6-10), M_J (500-800, >800), + HT cut (>1.2-1.5 TeV)**
- **Dominant bgs :**
  - 0L: Multi-jet (data-driven)
  - 1L: ttbar (normalized MC in data CR)



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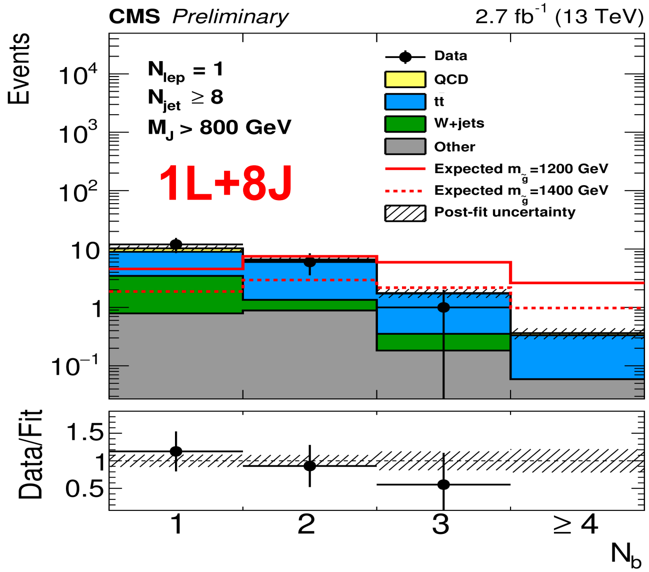
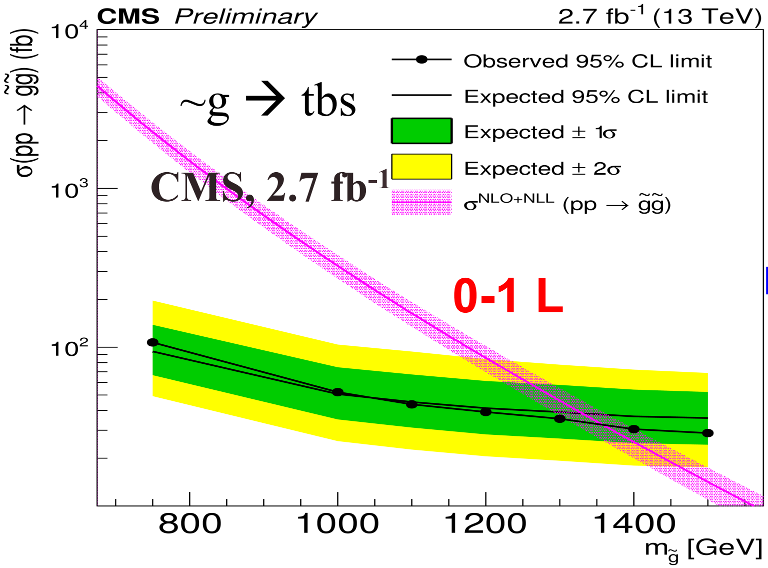


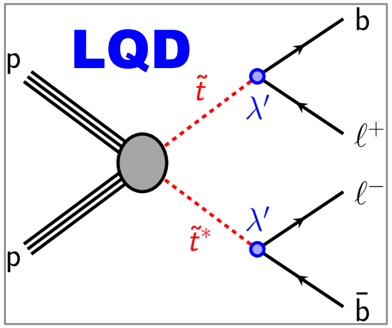


Exclude gluino mass up to 1.36 TeV

Strong SUSY: RPV 2L + 2b-jets

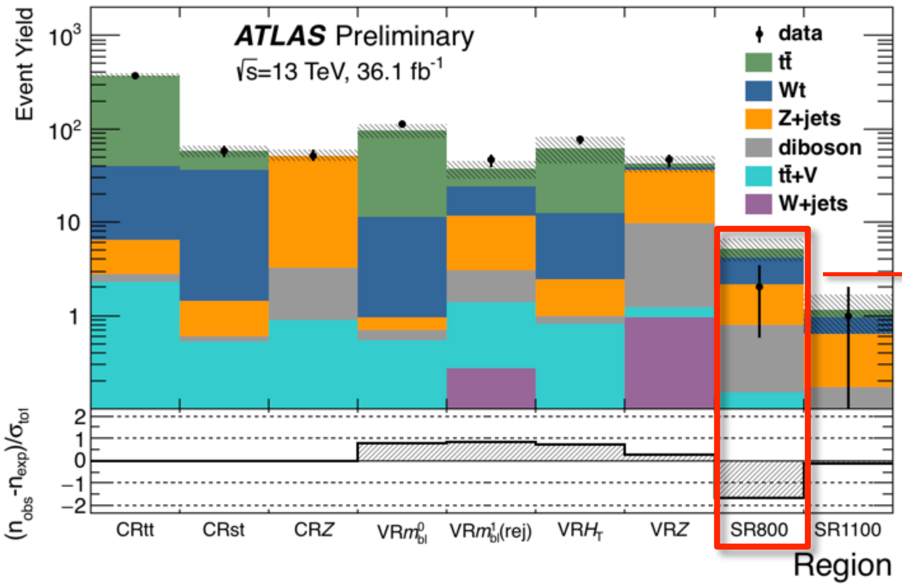
NEW!

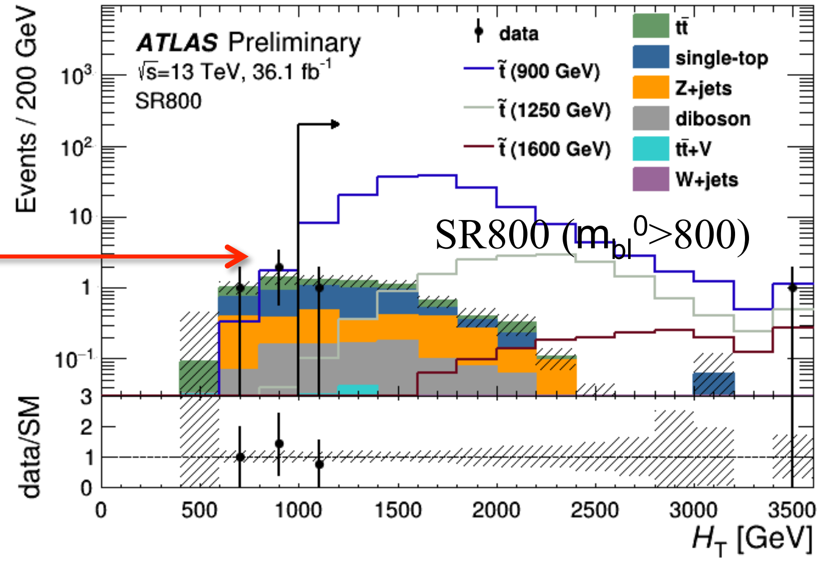
- **Stop pair production,** decays via lepton number-violating couplings into lepton+b-quarks
- **Signatures: 2leptons+ 2b-jets**
- **SRs defind on H_T, m_{bl}^0, and m_{bl} asymmetry**
- **Dominant backgrounds:**
  - **ttbar, single top, Z+jets (normalized MC to data in CRs)**



ATLAS-CONF-2017-036

$$m_{b\ell}\text{ asymmetry} = \frac{m_{b\ell}^0 - m_{b\ell}^1}{m_{b\ell}^0 + m_{b\ell}^1}$$



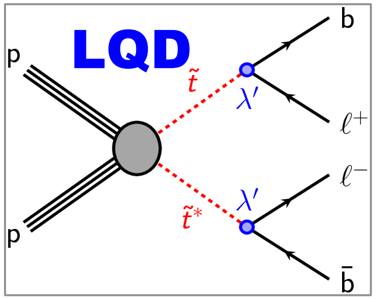


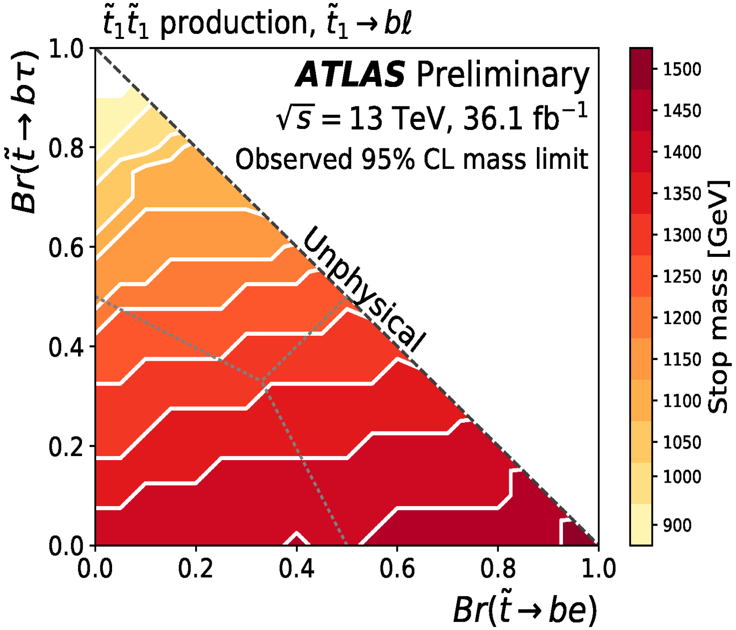
Strong SUSY: RPV 2L + 2b-jets

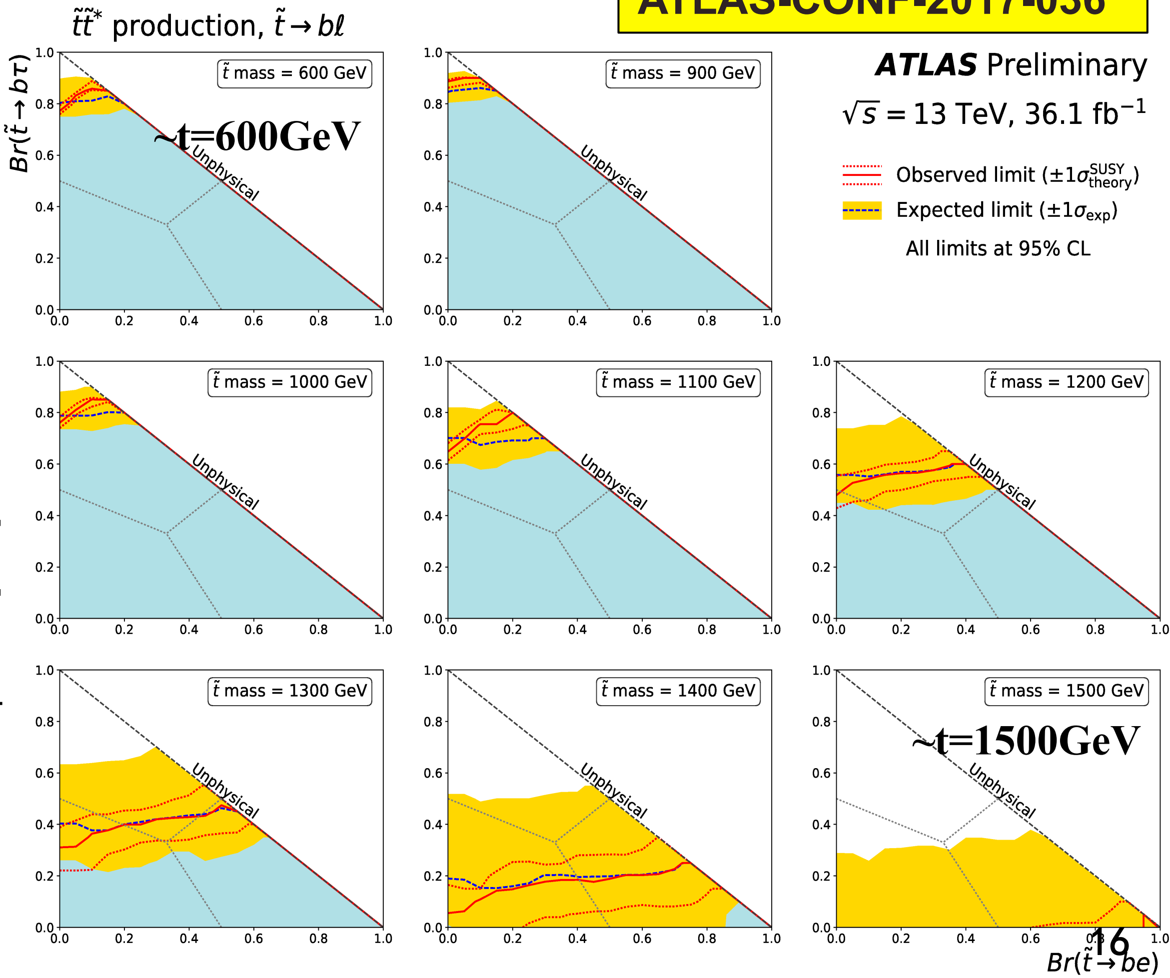
NEW!

- **Limits on top masses are set between 600 GeV for large tau branching ratios to 1.5 TeV for an e branching ratio of 100%.**
- **The limits are strongest at lower $Br(\tilde{t} \rightarrow b\tau)$**

ATLAS-CONF-2017-036

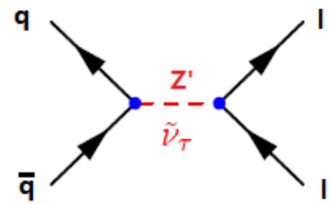


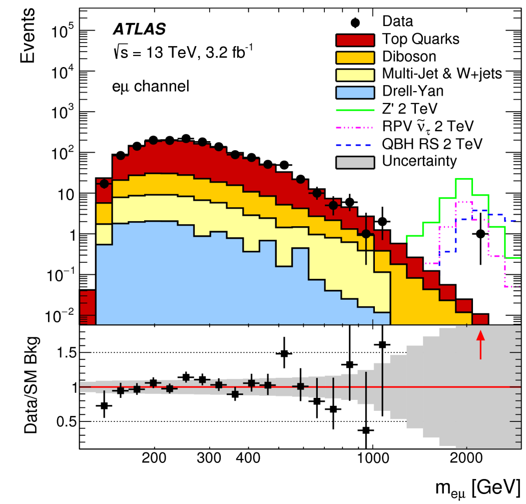


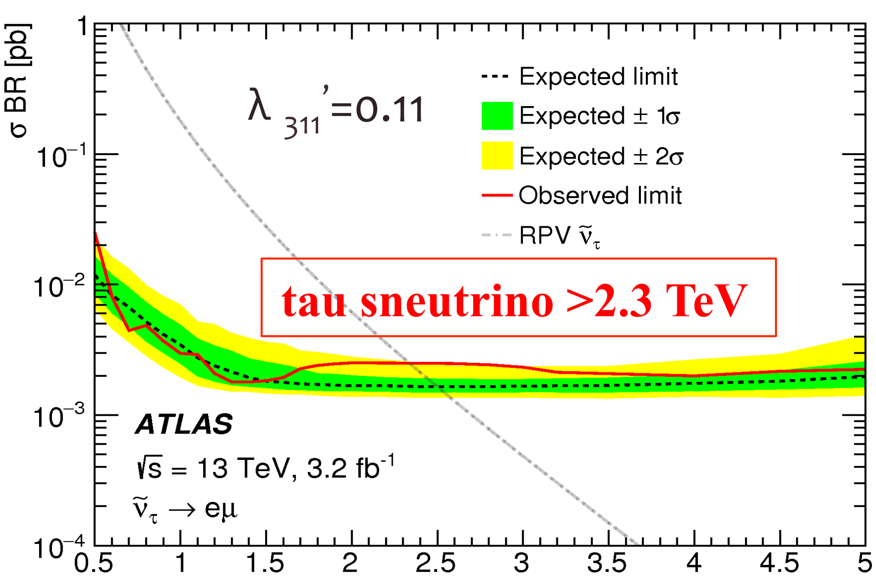


Search for LFV di-lepton Resonance

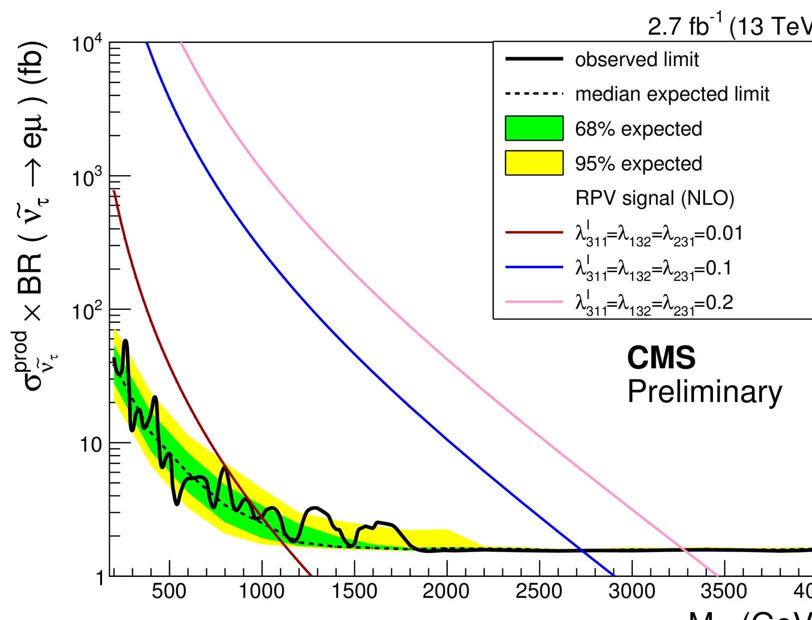
- Search for a heavy resonance from LFV di-lepton (eμ, eτ or μτ) final states, like RPV SUSY tau sneutrino, Z' etc.
- Tau sneutrino up to 2.3 (eμ), 2.2 (eτ), 1.9 (μτ) GeV excluded (ATLAS)







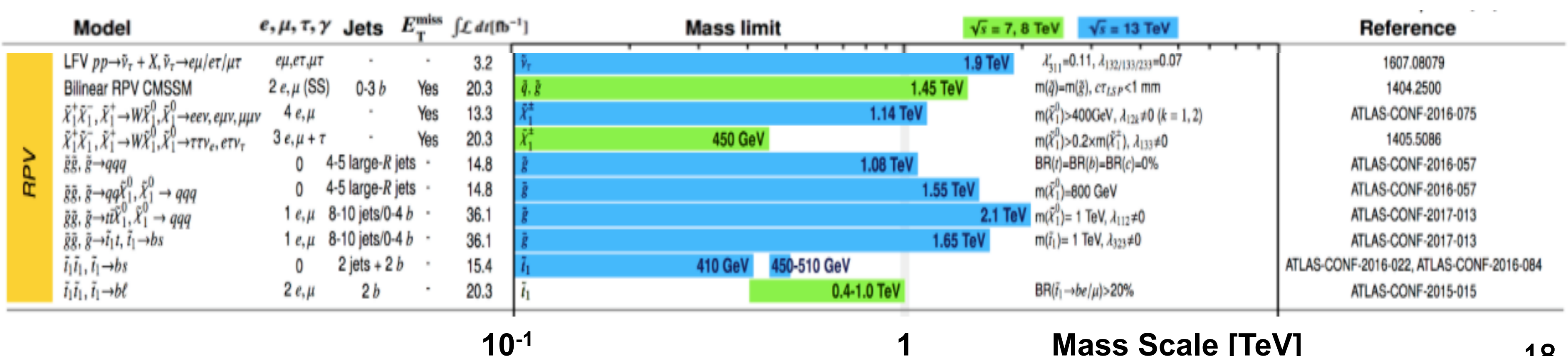
Eur. Phys. J. C76 (2016) 541



CMS-PAS-EXO-16-001

Summary and Outlook

- **ATLAS and CMS are carrying out a detailed and wide search for RPV SUSY in Run2**
- **No evidence for RPV SUSY so far**
- **Higher mass limits excluded for SUSY particles**
- **More results will coming soon. Stay tuned!**




Thanks for your attention !!!

Strong SUSY: RPV 2L + 2b-jets

Region	N_b	$m^0_{b\ell}$ [GeV]	$m^1_{b\ell}$(rej)[GeV]	H_T [GeV]	$m_{\ell\ell}$ [GeV]	m_{CT} [GeV]
SR800	≥ 1	> 800	> 150	> 1000	> 300	–
SR1100	≥ 1	> 1100	> 150	> 1000	> 300	–
CRtt	≥ 1	[200,500]	< 150	[600,800]	> 300	$< 200^*$
CRst	$= 2$	[200,500]	< 150	< 800	> 120	> 200
CRZ	≥ 1	> 700	–	> 1000	[76.2,106.2]	–
VR$m^0_{b\ell}$	≥ 1	> 500	< 150	[600,800]	> 300	–
VR$m^1_{b\ell}$(rej)	≥ 1	[200,500]	> 150	[600,800]	> 300	–
VRH_T	≥ 1	[200,500]	< 150	> 800	> 300	–
VRZ	$= 0$	[500,800]	> 150	> 1000	> 300	–

	SR800				SR1100			
	inclusive	ee	$e\mu$	$\mu\mu$	inclusive	ee	$e\mu$	$\mu\mu$
Observed yield	2	0	0	2	1	0	0	1
Total post-fit bkg yield	5.2 ± 1.4	1.8 ± 0.5	2.1 ± 0.8	1.35 ± 0.32	$1.2^{+0.6}_{-0.5}$	$0.51^{+0.22}_{-0.20}$	$0.44^{+0.39}_{-0.33}$	0.22 ± 0.13
Post-fit single-top yield	2.0 ± 1.3	0.6 ± 0.4	1.1 ± 0.7	0.32 ± 0.20	0.32 ± 0.29	0.11 ± 0.10	0.21 ± 0.19	–
Post-fit Z+jets yield	1.40 ± 0.33	0.80 ± 0.24	0.01 ± 0.01	0.59 ± 0.14	0.47 ± 0.15	0.28 ± 0.10	–	0.19 ± 0.11
Post-fit $t\bar{t}$ yield	1.0 ± 0.5	0.27 ± 0.14	0.54 ± 0.25	0.21 ± 0.10	$0.21^{+0.55}_{-0.21}$	$0.06^{+0.16}_{-0.06}$	$0.13^{+0.34}_{-0.13}$	$0.01^{+0.03}_{-0.01}$
Post-fit diboson yield	0.64 ± 0.23	0.14 ± 0.05	0.31 ± 0.12	0.19 ± 0.08	0.13 ± 0.05	0.06 ± 0.03	0.07 ± 0.03	0.01 ± 0.01
Post-fit $t\bar{t} + V$ yield	0.12 ± 0.03	0.01 ± 0.01	0.07 ± 0.02	0.04 ± 0.02	0.03 ± 0.01	–	0.01 ± 0.01	0.01 ± 0.01
Post-fit W+jets yield	0.03 ± 0.03	–	0.04 ± 0.04	–	$0.01^{+0.02}_{-0.01}$	–	$0.01^{+0.02}_{-0.01}$	–
Total MC bkg yield	4.9 ± 1.2	1.7 ± 0.4	2.0 ± 0.7	1.23 ± 0.28	$1.1^{+0.6}_{-0.5}$	$0.46^{+0.21}_{-0.19}$	$0.43^{+0.40}_{-0.33}$	0.18 ± 0.10
MC single-top yield	1.9 ± 1.0	0.57 ± 0.34	1.0 ± 0.6	0.29 ± 0.17	0.29 ± 0.25	0.10 ± 0.08	0.19 ± 0.17	–
MC Z+jets yield	1.15 ± 0.21	0.65 ± 0.17	0.01 ± 0.01	0.48 ± 0.09	0.38 ± 0.10	0.23 ± 0.07	–	0.15 ± 0.09
MC $t\bar{t}$ yield	1.1 ± 0.5	0.29 ± 0.14	0.57 ± 0.26	0.22 ± 0.10	$0.22^{+0.57}_{-0.22}$	$0.07^{+0.18}_{-0.07}$	$0.14^{+0.36}_{-0.14}$	$0.01^{+0.03}_{-0.01}$
MC diboson yield	0.64 ± 0.23	0.14 ± 0.05	0.31 ± 0.12	0.19 ± 0.08	0.13 ± 0.05	0.06 ± 0.03	0.07 ± 0.03	0.01 ± 0.01
MC $t\bar{t} + V$ yield	0.12 ± 0.03	0.01 ± 0.01	0.07 ± 0.02	0.04 ± 0.02	0.03 ± 0.01	–	0.01 ± 0.01	0.01 ± 0.01
MC W+jets yield	0.03 ± 0.03	–	0.04 ± 0.04	–	$0.01^{+0.02}_{-0.01}$	–	$0.01^{+0.02}_{-0.01}$	–
$N^{\text{limit}}_{\text{BSM}}$ exp (95% CL)	$6.4^{+3.0}_{-1.9}$	$4.1^{+1.8}_{-1.1}$	$4.0^{+2.2}_{-0.9}$	$3.9^{+1.6}_{-0.7}$	$3.9^{+2.4}_{-0.5}$	$3.0^{+1.3}_{-0.0}$	$3.0^{+1.3}_{-0.0}$	$3.1^{+0.6}_{-0.1}$
$N^{\text{limit}}_{\text{BSM}}$ obs (95% CL)	4.0	3.0	3.0	4.8	3.9	3.0	3.1	4.1
$\sigma^{\text{vis}}_{\text{BSM}}$[fb]	0.11	0.08	0.08	0.13	0.11	0.08	0.08	0.11

The mass limit shown corresponds to the highest-mass sample which is excluded.

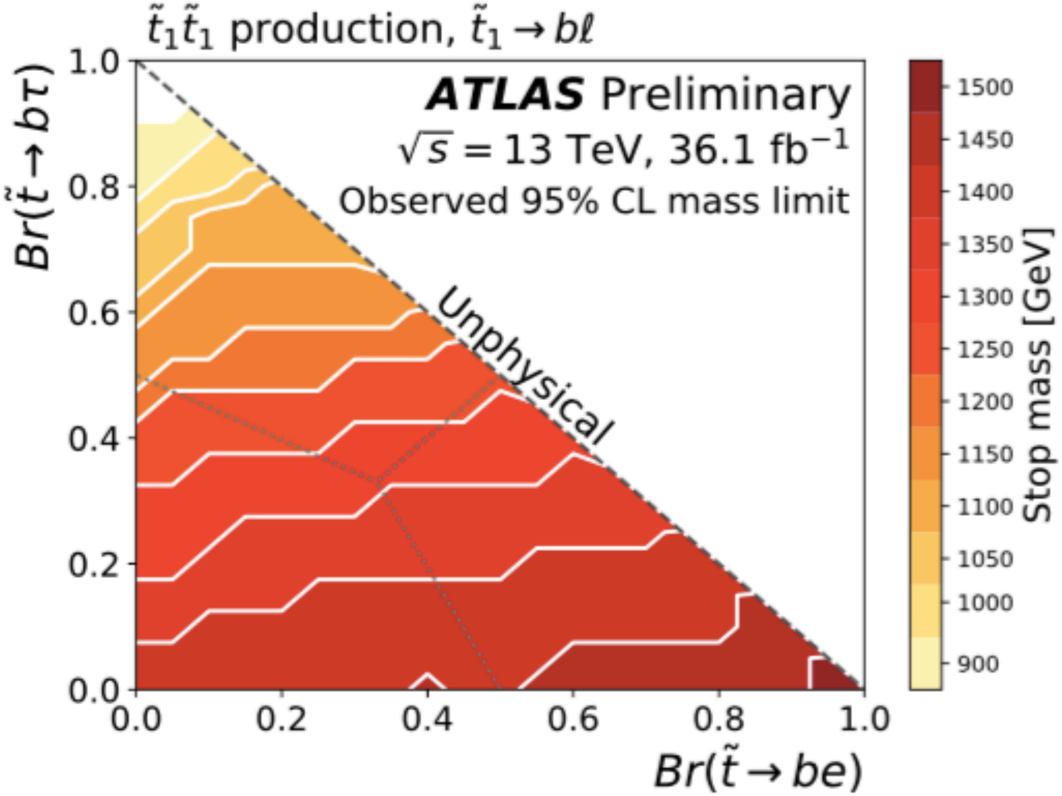


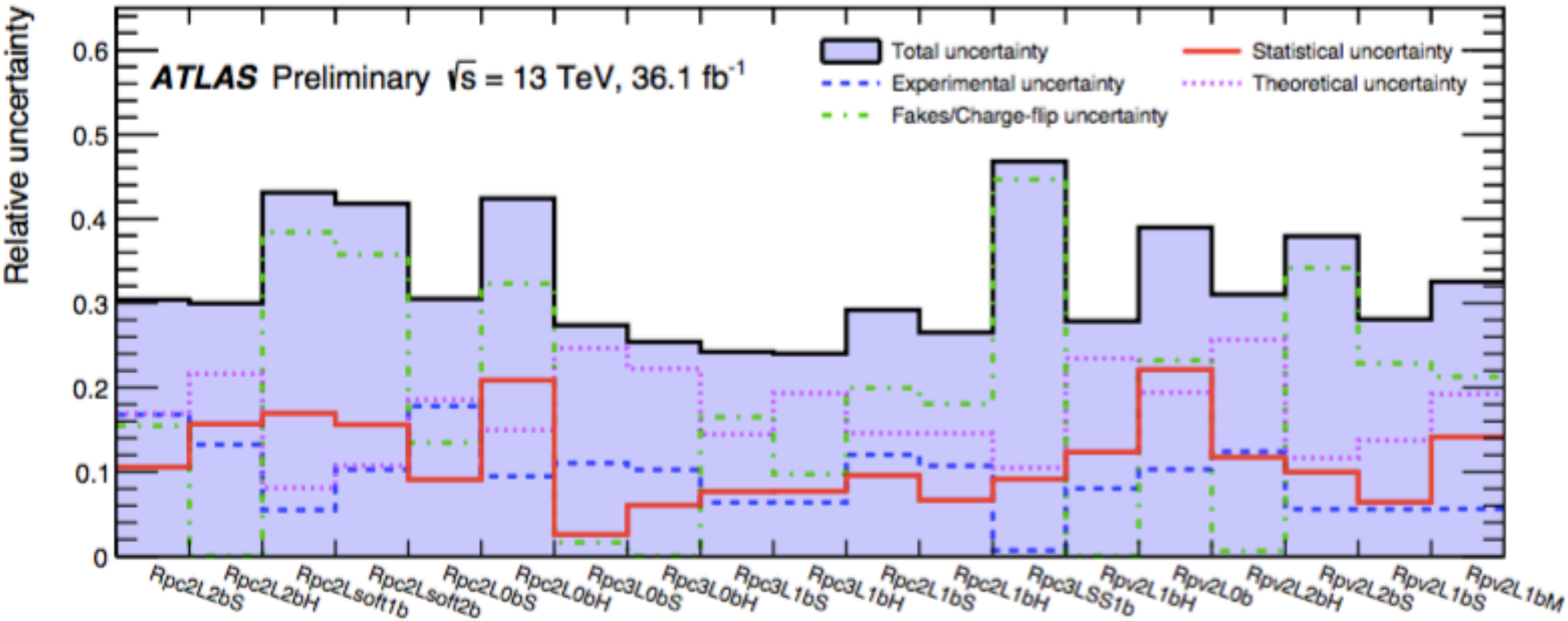
Figure 7: The observed mass limit on the $\tilde{t}$ at 95% CL as a function of $\tilde{t}$ branching ratios. The sum of $Br(\tilde{t} \to be)$, $Br(\tilde{t} \to b\tau)$, and $Br(\tilde{t} \to b\mu)$ is assumed to be unity everywhere, and points of equality are marked by a dotted gray line. This limit is obtained using the nominal $\tilde{t}$ cross section prediction. The mass limit shown corresponds to the highest-mass sample which is excluded. As the branching ratio $Br(\tilde{t} \to b\tau)$ increases, the number of expected events with electrons or muons in the final state decreases, reducing the mass reach of the exclusion.

Strong SUSY: RPV SS2L +multi-jets + bjets

Signal region	$N_{\text{leptons}}^{\text{signal}}$	$N_{b\text{-jets}}$	N_{jets}	p_T^{jet} [GeV]	E_T^{miss} [GeV]	m_{eff} [GeV]	$E_T^{\text{miss}}/m_{\text{eff}}$	Other
Rpv2L1bH	$\geq 2SS$	≥ 1	≥ 6	> 50	–	> 2200	–	–
Rpv2L0b	$= 2SS$	$= 0$	≥ 6	> 40	–	> 1800	–	veto $81 < m_{e^{\pm}e^{\pm}} < 101$ GeV
Rpv2L2bH	$\geq 2SS$	≥ 2	≥ 6	> 40	–	> 2000	–	veto $81 < m_{e^{\pm}e^{\pm}} < 101$ GeV
Rpv2L2bS	$\geq \ell^-\ell^-$	≥ 2	≥ 3	> 50	–	> 1200	–	
Rpv2L1bS	$\geq \ell^-\ell^-$	≥ 1	≥ 4	> 50	–	> 1200	–	–
Rpv2L1bM	$\geq \ell^-\ell^-$	≥ 1	≥ 4	> 50	–	> 1800	–	–

Signal Region	**Rpv2L1bH**	**Rpv2L0b**	**Rpv2L2bH**	**Rpv2L2bS**	**Rpv2L1bS**	**Rpv2L1bM**
$t\bar{t} + W/Z\gamma^*$	0.56 ± 0.14	0.14 ± 0.08	0.56 ± 0.15	6.4 ± 1.3	10.1 ± 1.7	1.4 ± 0.5
$t\bar{t}H$	0.07 ± 0.05	0.02 ± 0.02	0.12 ± 0.07	1.0 ± 0.5	1.9 ± 1.0	0.28 ± 0.15
$t\bar{t}t\bar{t}$	0.34 ± 0.17	0.01 ± 0.01	0.48 ± 0.24	1.6 ± 0.8	1.8 ± 0.9	0.53 ± 0.27
Diboson	0.14 ± 0.09	0.52 ± 0.30	0.04 ± 0.03	0.42 ± 0.24	1.7 ± 1.0	0.42 ± 0.24
Rare	0.29 ± 0.17	0.10 ± 0.06	0.19 ± 0.13	1.5 ± 0.8	2.4 ± 1.2	0.8 ± 0.4
Fake/non-prompt leptons	0.15 ± 0.15	$0.18^{+0.31}_{-0.18}$	0.15 ± 0.15	8 ± 7	6 ± 6	1.3 ± 1.2
Charge-flip	0.02 ± 0.01	0.03 ± 0.02	0.03 ± 0.01	0.46 ± 0.08	0.74 ± 0.12	0.10 ± 0.02
Total Background	1.6 ± 0.4	1.0 ± 0.5	1.6 ± 0.5	19 ± 7	25 ± 7	4.8 ± 1.6
Observed	2	2	1	20	26	9
S_{obs}^{95}	4.8	5.2	3.9	17.5	18.1	11.4
S_{exp}^{95}	$4.1^{+1.9}_{-0.4}$	$4.0^{+1.7}_{-0.3}$	$4.1^{+1.8}_{-0.4}$	$16.8^{+5.2}_{-4.2}$	$17.2^{+5.9}_{-4.2}$	$7.3^{+2.5}_{-1.8}$
σ_{vis} [fb]	0.13	0.14	0.11	0.48	0.50	0.31
p_0 (Z)	$0.33\ (0.4\sigma)$	$0.19\ (0.9\sigma)$	$0.55\ (-0.1\sigma)$	$0.48\ (0.1\sigma)$	$0.44\ (0.2\sigma)$	$0.07\ (1.5\sigma)$

Strong SUSY: RPV SS2L +multi-jets + bjets



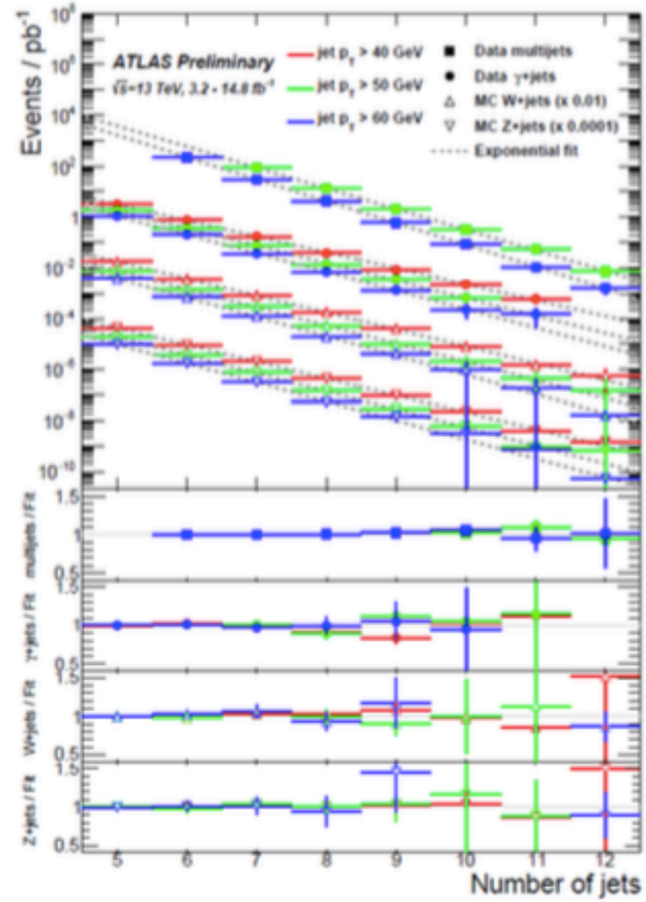
Dominant by reducible background or the theory

Strong SUSY: RPV 1L + multi-jets (+bjets)

Jet multiplicity	0b obs. [fb]	0b exp. [fb]	$\geq$ 3b obs. [fb]	$\geq$ 3b exp. [fb]
$\geq$ 10 jets ($p_T > 40$GeV)	0.32	$0.36^{+0.16}_{-0.1}$	0.57	$0.54^{+0.24}_{-0.15}$
$\geq$ 11 jets ($p_T > 40$GeV)	0.17	$0.16^{+0.08}_{-0.05}$	0.33	$0.25^{+0.12}_{-0.07}$
$\geq$ 12 jets ($p_T > 40$GeV)	0.08	$0.09^{+0.05}_{-0.01}$	0.17	$0.13^{+0.07}_{-0.04}$
$\geq$ 8 jets ($p_T > 60$GeV)	0.73	$0.71^{+0.27}_{-0.2}$	1.02	$1.03^{+0.39}_{-0.29}$
$\geq$ 9 jets ($p_T > 60$GeV)	0.35	$0.28^{+0.12}_{-0.08}$	0.19	$0.32^{+0.15}_{-0.09}$
$\geq$ 10 jets ($p_T > 60$GeV)	0.12	$0.14^{+0.07}_{-0.04}$	0.11	$0.15^{+0.08}_{-0.04}$
$\geq$ 8 jets ($p_T > 80$GeV)	0.38	$0.31^{+0.14}_{-0.09}$	0.21	$0.28^{+0.13}_{-0.08}$
$\geq$ 9 jets ($p_T > 80$GeV)	0.15	$0.13^{+0.07}_{-0.04}$	0.09	$0.13^{+0.07}_{-0.04}$
$\geq$ 10 jets ($p_T > 80$GeV)	0.1	$0.08^{+0.04}_{-0.00}$	0.08	$0.08^{+0.04}_{-0.00}$

Table 5: Observed and expected 95% CL model-independent upper limits on the product of cross-section, acceptance and efficiency (in fb) for each signal region. The limits are determined fitting the background model in a reduced set of bins as described in the text.

Background Estimation for RPV 1-lepton+Multijets



- W/Z+jets
  - b-jet multiplicity spectra is from simulation
  - Jet multiplicity spectra is from data assuming $r = N_{j+1}^{W/Z\text{+jets}} / N_{j}^{W/Z\text{+jets}}$ is constant. Then,

$$N_{j,b}^{W/Z\text{+jets}} = \frac{\mathrm{MC}_{j,b}^{W/Z\text{+jets}}}{\mathrm{MC}_{j}^{W/Z\text{+jets}}} \cdot k^{W/Z\text{+jets}} \cdot \mathrm{MC}_{5}^{W/Z\text{+jets}} \cdot r^{(j-5)}$$

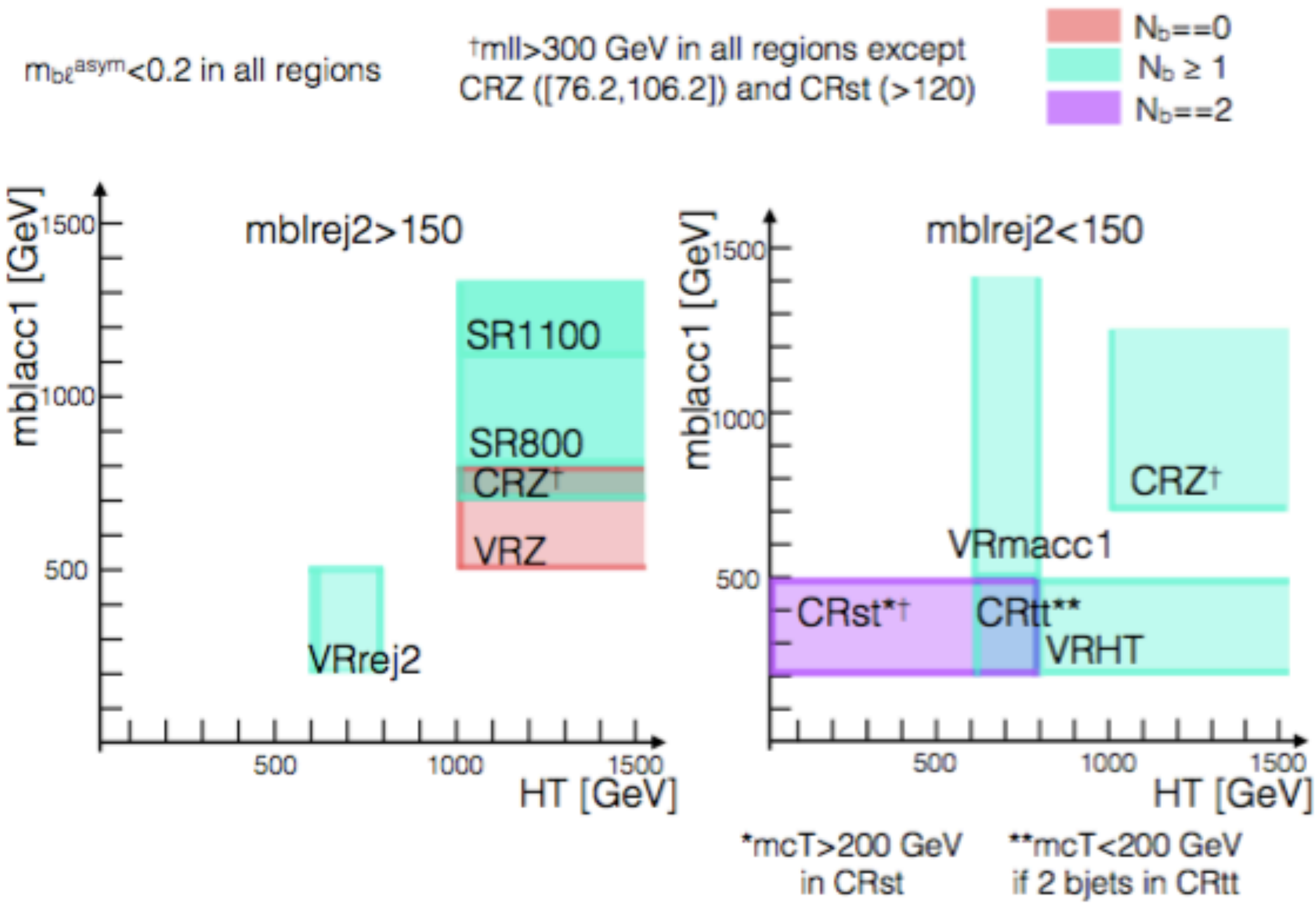
- $t\bar{t}$+jets
  - b-jet multiplicity spectra is obtained from low jet multiplicity data $N_{j,b}^{t\bar{t}\text{+jets}} = N_{j}^{t\bar{t}\text{+jets}} \cdot f_{j,b}$

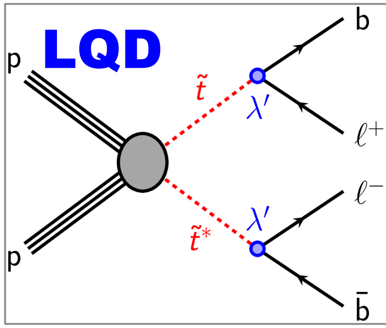
$$f_{(j+1),b} = f_{j,b} \cdot x_0 + f_{j,(b-1)} \cdot x_1 + f_{j,(b-2)} \cdot x_2$$

additional jet is not b-tagged (x_0), b-tagged (x_1), b-tagged and another jet is b-tagged (x_2)

- Background is normalized to match data separately in each N_j slice.

Strong SUSY: RPV 2L + 2b-jets



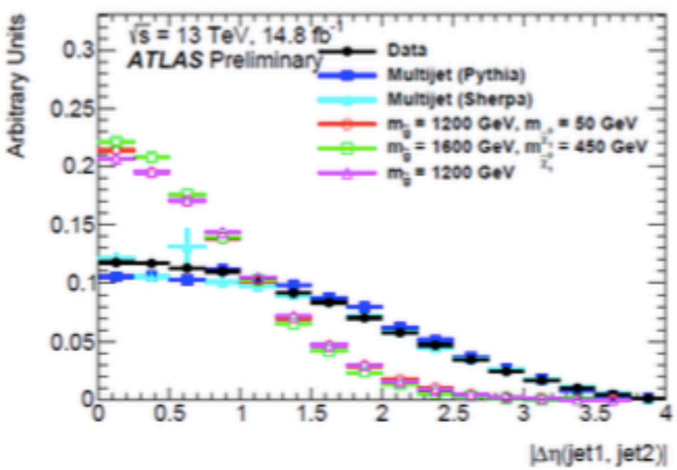


Background Estimation for RPV Multijets

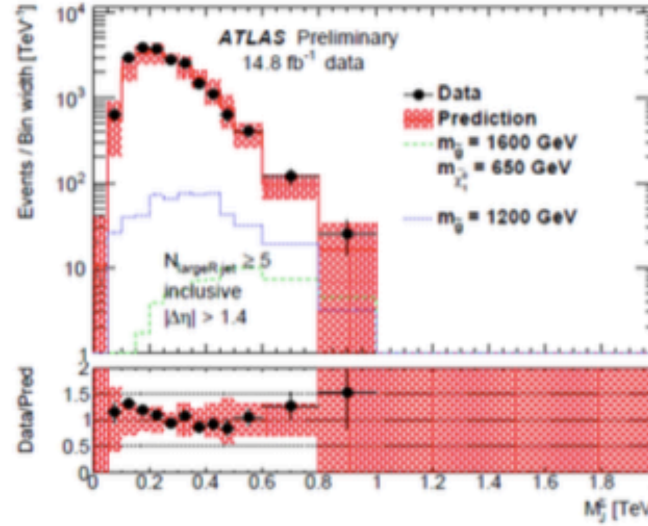
- Jet mass template is obtained from control regions as a function of jet p_T and η.
  - Soft jets with 100 GeV<p_T<200 GeV are used in CRs.

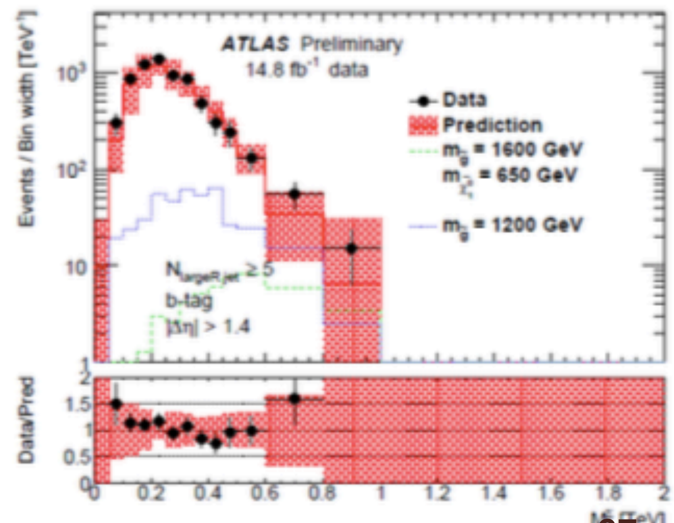
N_{jet}	b-tag $\lvert\Delta\eta_{12}\rvert > 1.4$	b-tag $\lvert\Delta\eta_{12}\rvert < 1.4$	b-veto -	inclusive $\lvert\Delta\eta_{12}\rvert > 1.4$	inclusive $\lvert\Delta\eta_{12}\rvert < 1.4$
= 3	3jCRb1_4j	-	3jCRb0_4j	3jCR_5j	
≥ 4	4jVRb1	4jSRb1	-	4jVR	4jSR
≥ 5	5jVRb1	5jSRb1	-	5jVR	5jSR

Background estimation is validated in the region with $\lvert\Delta\eta_{12}\rvert$>1.4



Validation regions





EWK SUSY: RPV 4L

Sample	$N(e,\mu)$ signal	$N(e,\mu)$ loose	Z boson	m_{eff} [GeV]
SRA	>= 4	>= 0	veto	> 600
CR-SRA	= 2	>= 2	veto	> 600
SRB	>= 4	>= 0	veto	> 900
CR-SRB	= 2	>= 2	veto	> 900
VR	>= 4	>= 0	veto	< 600
CR-VR	= 2	>= 2	veto	< 600

Experimental (% of total SM)		Theoretical (% of each process)	
e efficiency	3.9%	σ: $t\bar{t}Z$	12%
μ efficiency	1.9–2.8%	σ: $t\bar{t}W$	13%
Jet energy scale	3.0–3.4%	σ: ZZ,WZ	6%
Luminosity	2.9%	σ: VVV/tWZ	20%
MC statistics	2.7–2.5%	$A\epsilon$: ZZ	56–80%
CR statistics	4.5–6.4%	$A\epsilon$: $t\bar{t}Z$	9–12%
		$\sigma A\epsilon$: VH/VBF H	20%
		$\sigma A\epsilon$: ggF H/ $t\bar{t}$H	100%

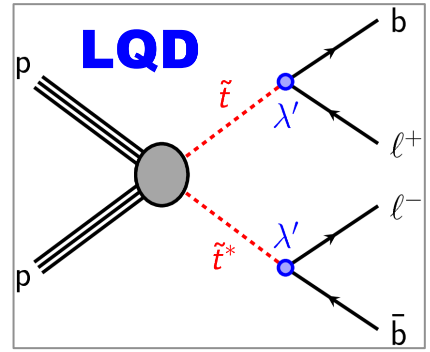
Sample	VR	SRA	SRB
Irreducible			
ZZ	29 ± 5	0.6 ± 0.4	0.20 ± 0.19
$t\bar{t}Z$	2.05 ± 0.24	1.43 ± 0.23	0.47 ± 0.09
Higgs	1.7 ± 1.4	0.4 ± 0.4	0.11 ± 0.11
VVZ	0.72 ± 0.14	0.31 ± 0.06	0.123 ± 0.027
Others	0.28 ± 0.07	0.32 ± 0.04	0.181 ± 0.022
1-fake ℓ reducible	1.14 ± 0.07	0.168 ± 0.018	0.069 ± 0.014
2-fake ℓ reducible	16 ± 6	0.48 ± 0.24	0.11 ± 0.05
Σ SM	51 ± 6	3.6 ± 0.6	1.26 ± 0.26
Data	53	2	0
p_0	—	0.64	0.80
S^{95}_{obs}	—	4.3	3.0
S^{95}_{exp}	—	$5.4^{+1.6}_{-1.3}$	$3.8^{+1.3}_{-0.8}$
$\langle\epsilon\sigma\rangle^{95}_{\text{obs}}$ [fb]	—	0.32	0.22
CL_b	—	0.21	0.15

Dominant: ttZ, ZZ

Strong SUSY: RPV 2L + 2b-jets

Run1

- **Stop pair production,** decays via lepton number-violating couplings into lepton+b-quarks
- **Signatures: 2leptons+ 2b-jets**
- SRs defind on **H_T, m_{bl}^0, and m_{bl} asymmetry**
- **As the branching ratio of t → bτ increases, the number of expected events with electrons or muons in the final state decreases**



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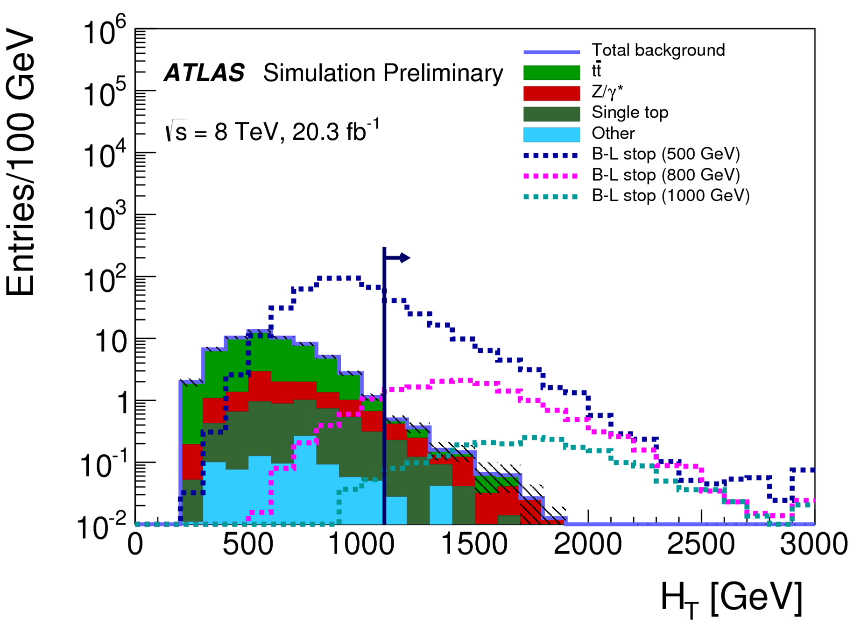
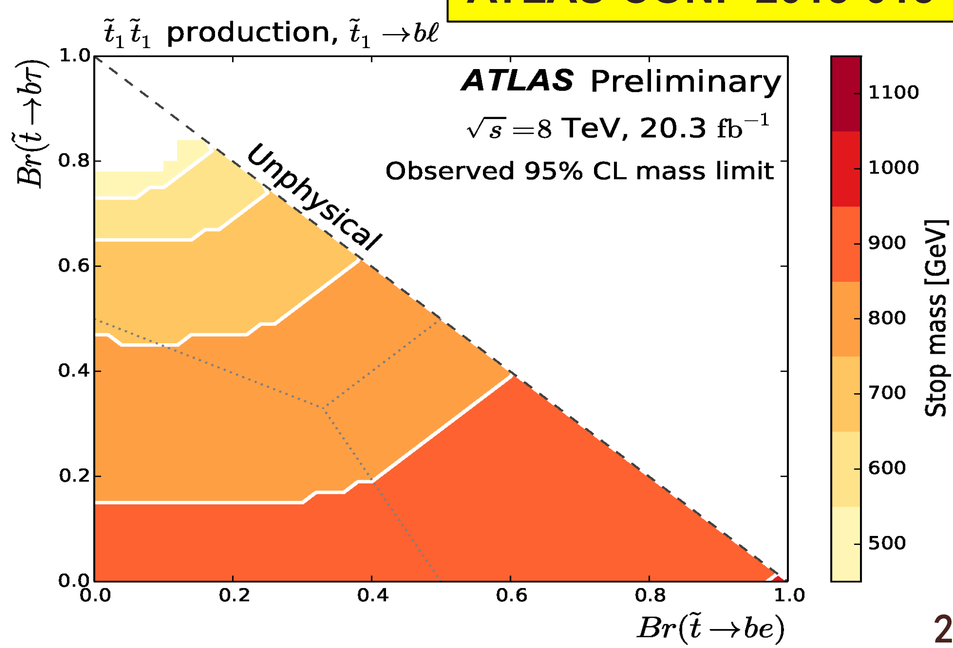
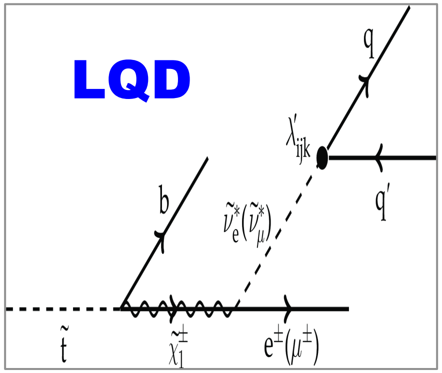




Strong SUSY: RPV 2L + 2b-jets + 2jets

Run1

- **Stop pair production,** chargino-mediated decay of stop, chargino decays to a lepton and two jets
- **Signatures: 2leptons+ b-jets + multi-jets**
- **SRs: 1bjet, 5jets, 2 leptons, Mll>130 GeV**
- **Exclude stop mass up to 890 (1000) GeV for elec (mu) channel**



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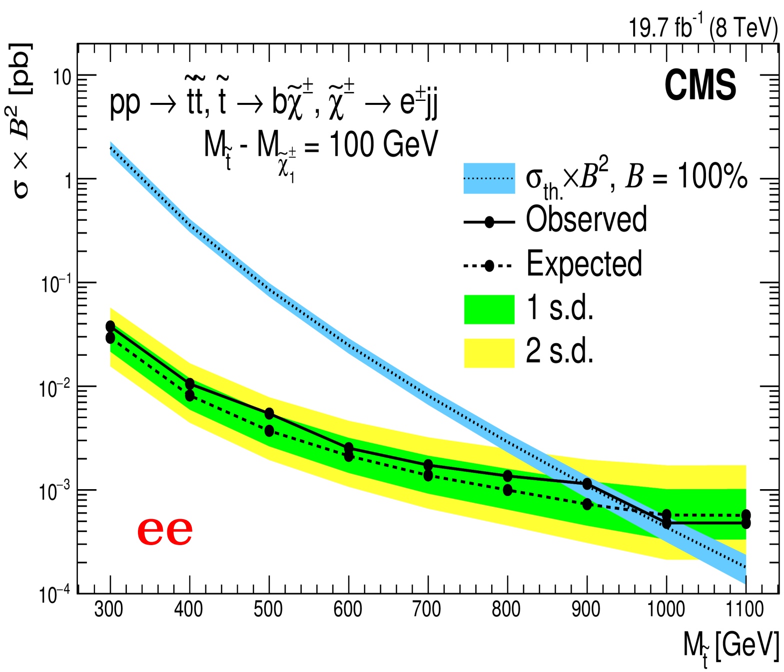
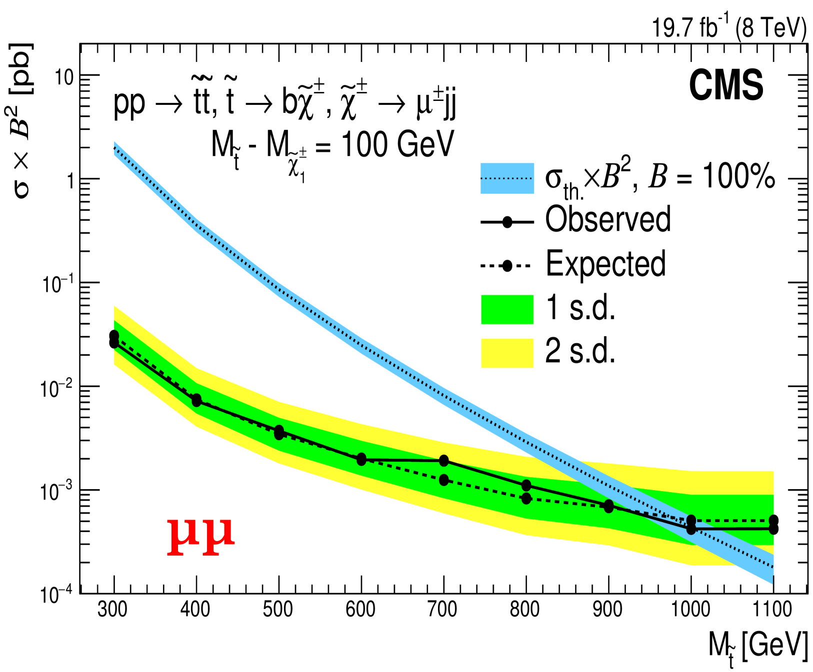
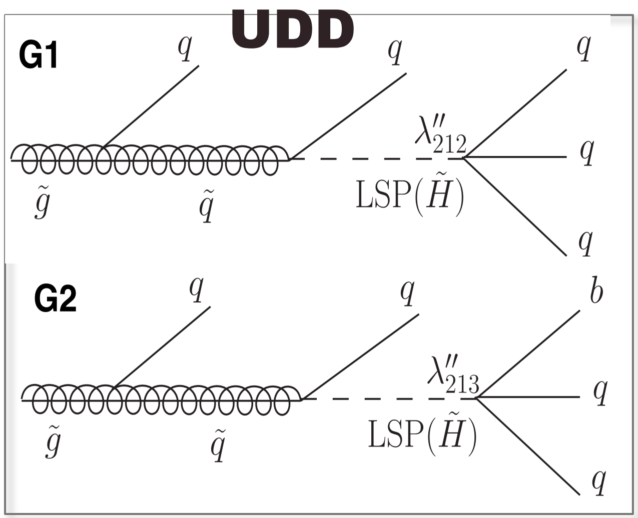




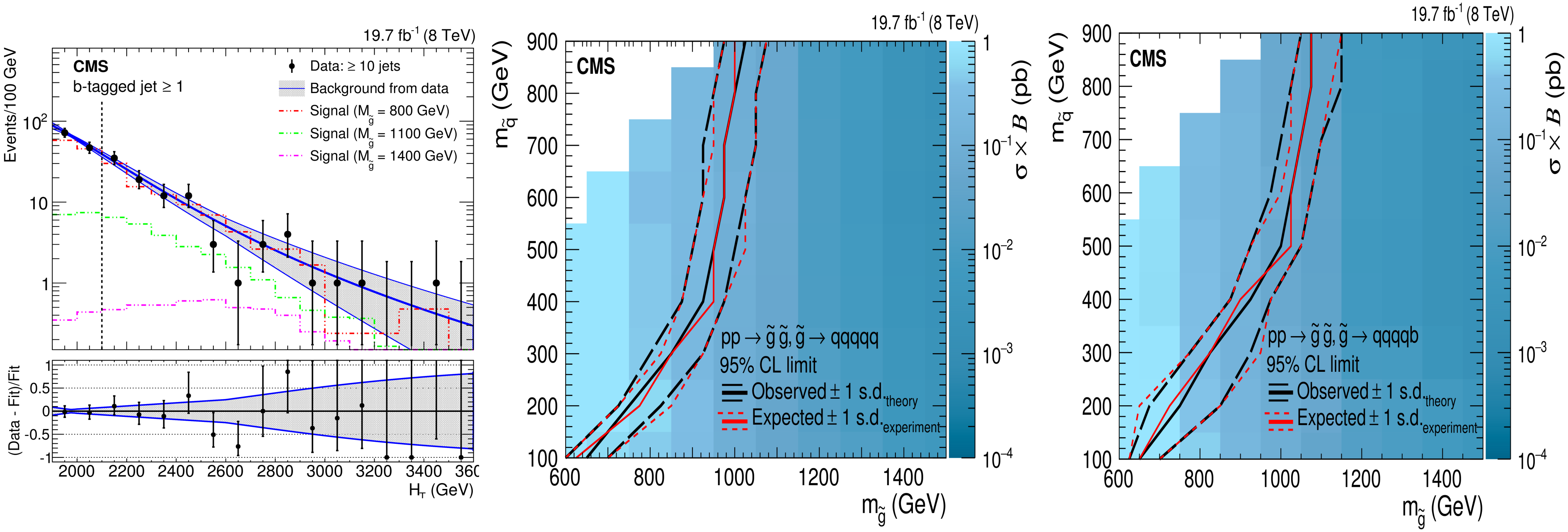
Strong SUSY: RPV multi-jets

Run1

- **Gluino pair production**, decays via Baryon number-violating couplings into quarks
- **Signatures: 8-10 jets + (0-1) b-jet**
- **Discriminating variable: sphericity (S),H_T**
- **Exclude gluino mass upto 0.6-1.1 TeV**



CMS-PAS-EXO-13-001



LLE, LQD, bRPV

Run1

- **Many RPV secnarios re-interpretated using Run1 SRs: 4L, SS/3L, 1L, 0L**

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