Experimental Searches for the stop Quark in R-Parity Violating SUSY Models at the LHC

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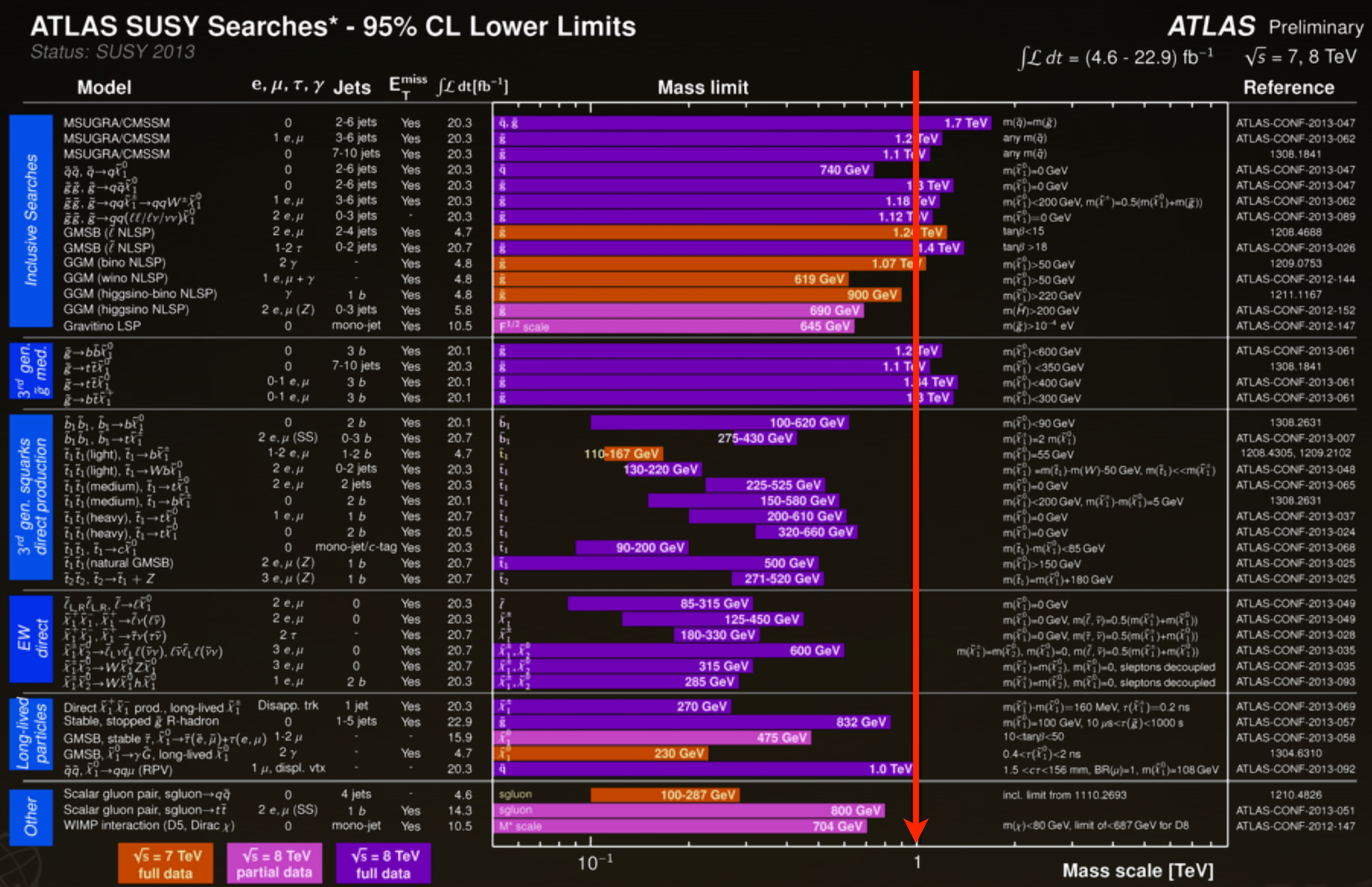
Where's SUSY?

Let's start with a rather sad picture

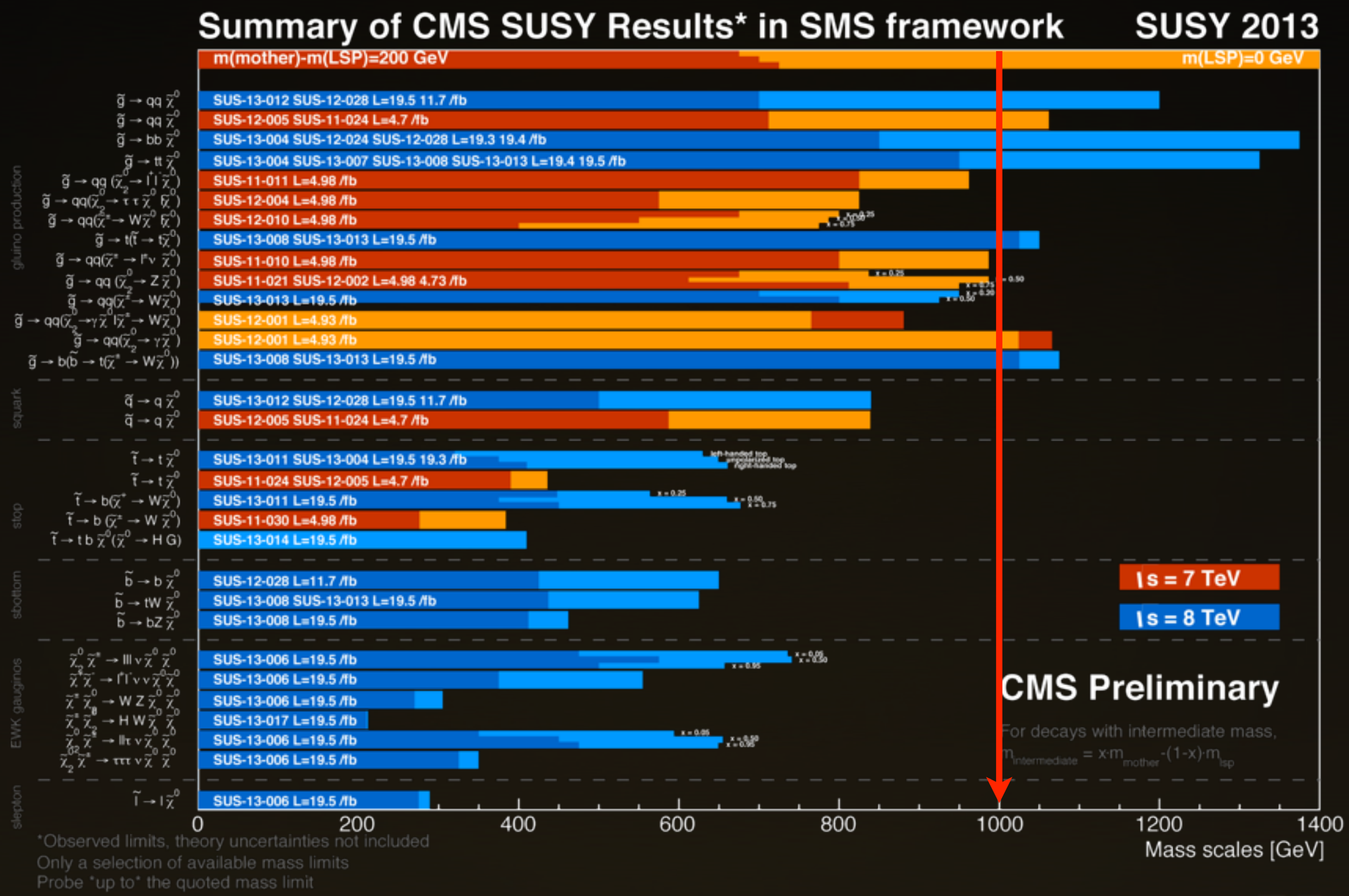
- The LHC has a world of SUSY exclusions up to the ~TeV level
- If we've failed to find new physics at this energy scale, SUSY doesn't naturally remove fine-tuning from the electroweak theory as it was originally designed to do.

Is naturalness dead?

Where's SUSY?


ATLAS SUSY Searches* - 95% CL Lower Limits
Status: SUSY 2013
ATLAS Preliminary
$\int \mathcal{L}\, dt = (4.6 - 22.9)\ \mathrm{fb}^{-1}$ $\sqrt{s} = 7, 8$ TeV
Model | e, μ, τ, γ | Jets | E_T^{miss} | $\int \mathcal{L}\, dt[\mathrm{fb}^{-1}]$ | Mass limit | Reference
Inclusive Searches
MSUGRA/CMSSM | 0 | 2-6 jets | Yes | 20.3 | $\tilde{q}, \tilde{g}$ | 1.7 TeV | $m(\tilde{q})=m(\tilde{g})$ | ATLAS-CONF-2013-047
MSUGRA/CMSSM | 1 e, μ | 3-6 jets | Yes | 20.3 | $\tilde{g}$ | 1.2 TeV | any $m(\tilde{q})$ | ATLAS-CONF-2013-062
MSUGRA/CMSSM | 0 | 7-10 jets | Yes | 20.3 | $\tilde{g}$ | 1.1 TeV | any $m(\tilde{q})$ | 1308.1841
$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$ | 0 | 2-6 jets | Yes | 20.3 | $\tilde{q}$ | 740 GeV | $m(\tilde{\chi}_1^0)=0$ GeV | ATLAS-CONF-2013-047
$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$ | 0 | 2-6 jets | Yes | 20.3 | $\tilde{g}$ | 1.3 TeV | $m(\tilde{\chi}_1^0)=0$ GeV | ATLAS-CONF-2013-047
$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$ | 1 e, μ | 3-6 jets | Yes | 20.3 | $\tilde{g}$ | 1.18 TeV | $m(\tilde{\chi}_1^0)<200$ GeV, $m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$ | ATLAS-CONF-2013-062
$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$ | 2 e, μ | 0-3 jets | - | 20.3 | $\tilde{g}$ | 1.12 TeV | $m(\tilde{\chi}_1^0)=0$ GeV | ATLAS-CONF-2013-089
GMSB ($\tilde{\ell}$ NLSP) | 2 e, μ | 2-4 jets | Yes | 4.7 | $\tilde{g}$ | 1.24 TeV | $\tan\beta<15$ | 1208.4688
GMSB ($\tilde{\ell}$ NLSP) | 1-2 τ | 0-2 jets | Yes | 20.7 | $\tilde{g}$ | 1.4 TeV | $\tan\beta>18$ | ATLAS-CONF-2013-026
GGM (bino NLSP) | 2 γ | - | Yes | 4.8 | $\tilde{g}$ | 1.07 TeV | $m(\tilde{\chi}_1^0)>50$ GeV | 1209.0753
GGM (wino NLSP) | 1 $e, \mu + \gamma$ | - | Yes | 4.8 | $\tilde{g}$ | 619 GeV | $m(\tilde{\chi}_1^0)>50$ GeV | ATLAS-CONF-2012-144
GGM (higgsino-bino NLSP) | γ | 1 b | Yes | 4.8 | $\tilde{g}$ | 900 GeV | $m(\tilde{\chi}_1^0)>220$ GeV | 1211.1167
GGM (higgsino NLSP) | 2 e, μ (Z) | 0-3 jets | Yes | 5.8 | $\tilde{g}$ | 690 GeV | $m(\tilde{H})>200$ GeV | ATLAS-CONF-2012-152
Gravitino LSP | 0 | mono-jet | Yes | 10.5 | $F^{1/2}$ scale | 645 GeV | $m(\tilde{g})>10^{-4}$ eV | ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.
$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$ | 0 | 3 b | Yes | 20.1 | $\tilde{g}$ | 1.2 TeV | $m(\tilde{\chi}_1^0)<600$ GeV | ATLAS-CONF-2013-061
$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$ | 0 | 7-10 jets | Yes | 20.3 | $\tilde{g}$ | 1.1 TeV | $m(\tilde{\chi}_1^0)<350$ GeV | 1308.1841
$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$ | 0-1 e, μ | 3 b | Yes | 20.1 | $\tilde{g}$ | 1.34 TeV | $m(\tilde{\chi}_1^0)<400$ GeV | ATLAS-CONF-2013-061
$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$ | 0-1 e, μ | 3 b | Yes | 20.1 | $\tilde{g}$ | 1.3 TeV | $m(\tilde{\chi}_1^0)<300$ GeV | ATLAS-CONF-2013-061
3rd gen. squarks direct production
$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$ | 0 | 2 b | Yes | 20.1 | $\tilde{b}_1$ | 100-620 GeV | $m(\tilde{\chi}_1^0)<90$ GeV | 1308.2631
$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$ | 2 e, μ (SS) | 0-3 b | Yes | 20.7 | $\tilde{b}_1$ | 275-430 GeV | $m(\tilde{\chi}_1^\pm)=2\, m(\tilde{\chi}_1^0)$ | ATLAS-CONF-2013-007
$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$ | 1-2 e, μ | 1-2 b | Yes | 4.7 | $\tilde{t}_1$ | 110-167 GeV | $m(\tilde{\chi}_1^0)=55$ GeV | 1208.4305, 1209.2102
$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$ | 2 e, μ | 0-2 jets | Yes | 20.3 | $\tilde{t}_1$ | 130-220 GeV | $m(\tilde{\chi}_1^0)=m(\tilde{t}_1)-m(W)-50$ GeV, $m(\tilde{t}_1)<<m(\tilde{\chi}_1^\pm)$ | ATLAS-CONF-2013-048
$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}_1^0$ | 2 e, μ | 2 jets | Yes | 20.3 | $\tilde{t}_1$ | 225-525 GeV | $m(\tilde{\chi}_1^0)=0$ GeV | ATLAS-CONF-2013-065
$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$ | 0 | 2 b | Yes | 20.1 | $\tilde{t}_1$ | 150-580 GeV | $m(\tilde{\chi}_1^0)<200$ GeV, $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)=5$ GeV | 1308.2631
$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$ | 1 e, μ | 1 b | Yes | 20.7 | $\tilde{t}_1$ | 200-610 GeV | $m(\tilde{\chi}_1^0)=0$ GeV | ATLAS-CONF-2013-037
$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$ | 0 | 2 b | Yes | 20.5 | $\tilde{t}_1$ | 320-660 GeV | $m(\tilde{\chi}_1^0)=0$ GeV | ATLAS-CONF-2013-024
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$ | 0 | mono-jet/c-tag | Yes | 20.3 | $\tilde{t}_1$ | 90-200 GeV | $m(\tilde{t}_1)-m(\tilde{\chi}_1^0)<85$ GeV | ATLAS-CONF-2013-068
$\tilde{t}_1\tilde{t}_1$(natural GMSB) | 2 e, μ (Z) | 1 b | Yes | 20.7 | $\tilde{t}_1$ | 500 GeV | $m(\tilde{\chi}_1^0)>150$ GeV | ATLAS-CONF-2013-025
$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1 + Z$ | 3 e, μ (Z) | 1 b | Yes | 20.7 | $\tilde{t}_2$ | 271-520 GeV | $m(\tilde{t}_1)=m(\tilde{\chi}_1^0)+180$ GeV | ATLAS-CONF-2013-025
EW direct
$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$ | 2 e, μ | 0 | Yes | 20.3 | $\tilde{\ell}$ | 85-315 GeV | $m(\tilde{\chi}_1^0)=0$ GeV | ATLAS-CONF-2013-049
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$ | 2 e, μ | 0 | Yes | 20.3 | $\tilde{\chi}_1^\pm$ | 125-450 GeV | $m(\tilde{\chi}_1^0)=0$ GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$ | ATLAS-CONF-2013-049
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$ | 2 τ | - | Yes | 20.7 | $\tilde{\chi}_1^\pm$ | 180-330 GeV | $m(\tilde{\chi}_1^0)=0$ GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$ | ATLAS-CONF-2013-028
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$ | 3 e, μ | 0 | Yes | 20.7 | $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ | 600 GeV | $m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)=0$, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$ | ATLAS-CONF-2013-035
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$ | 3 e, μ | 0 | Yes | 20.7 | $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ | 315 GeV | $m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)=0$, sleptons decoupled | ATLAS-CONF-2013-035
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$ | 1 e, μ | 2 b | Yes | 20.3 | $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ | 285 GeV | $m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)=0$, sleptons decoupled | ATLAS-CONF-2013-093
Long-lived particles
Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$ | Disapp. trk | 1 jet | Yes | 20.3 | $\tilde{\chi}_1^\pm$ | 270 GeV | $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)=160$ MeV, $\tau(\tilde{\chi}_1^\pm)=0.2$ ns | ATLAS-CONF-2013-069
Stable, stopped $\tilde{g}$ R-hadron | 0 | 1-5 jets | Yes | 22.9 | $\tilde{g}$ | 832 GeV | $m(\tilde{\chi}_1^0)=100$ GeV, 10 μs$<\tau(\tilde{g})<1000$ s | ATLAS-CONF-2013-057
GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$ | 1-2 μ | - | - | 15.9 | $\tilde{\chi}_1^0$ | 475 GeV | $10<\tan\beta<50$ | ATLAS-CONF-2013-058
GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$ | 2 γ | - | Yes | 4.7 | $\tilde{\chi}_1^0$ | 230 GeV | $0.4<\tau(\tilde{\chi}_1^0)<2$ ns | 1304.6310
$\tilde{q}\tilde{q}, \tilde{\chi}_1^0\to qq\mu$ (RPV) | 1 μ, displ. vtx | - | - | 20.3 | $\tilde{q}$ | 1.0 TeV | $1.5<c\tau<156$ mm, BR(μ)=1, $m(\tilde{\chi}_1^0)=108$ GeV | ATLAS-CONF-2013-092
Other
Scalar gluon pair, sgluon$\to q\bar{q}$ | 0 | 4 jets | - | 4.6 | sgluon | 100-287 GeV | incl. limit from 1110.2693 | 1210.4826
Scalar gluon pair, sgluon$\to t\bar{t}$ | 2 e, μ (SS) | 1 b | Yes | 14.3 | sgluon | 800 GeV | | ATLAS-CONF-2013-051
WIMP interaction (D5, Dirac χ) | 0 | mono-jet | Yes | 10.5 | M* scale | 704 GeV | $m(\chi)<80$ GeV, limit of<687 GeV for D8 | ATLAS-CONF-2012-147
$\sqrt{s}$ = 7 TeV full data
$\sqrt{s}$ = 8 TeV partial data
$\sqrt{s}$ = 8 TeV full data
10^{-1}
1
Mass scale [TeV]
*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

Where's SUSY?


Summary of CMS SUSY Results* in SMS framework
SUSY 2013
m(mother)-m(LSP)=200 GeV
m(LSP)=0 GeV
SUS-13-012 SUS-12-028 L=19.5 11.7 /fb
SUS-12-005 SUS-11-024 L=4.7 /fb
SUS-13-004 SUS-12-024 SUS-12-028 L=19.3 19.4 /fb
SUS-13-004 SUS-13-007 SUS-13-008 SUS-13-013 L=19.4 19.5 /fb
SUS-11-011 L=4.98 /fb
SUS-12-004 L=4.98 /fb
SUS-12-010 L=4.98 /fb
SUS-13-008 SUS-13-013 L=19.5 /fb
SUS-11-010 L=4.98 /fb
SUS-11-021 SUS-12-002 L=4.98 4.73 /fb
SUS-13-013 L=19.5 /fb
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SUS-13-006 L=19.5 /fb
gluino production
squark
stop
sbottom
EWK gauginos
slepton
√s = 7 TeV
√s = 8 TeV
CMS Preliminary
For decays with intermediate mass,
0
200
400
600
800
1000
1200
1400
Mass scales [GeV]
*Observed limits, theory uncertainties not included
Only a selection of available mass limits
Probe "up to" the quoted mass limit

R-Parity in Supersymmetry

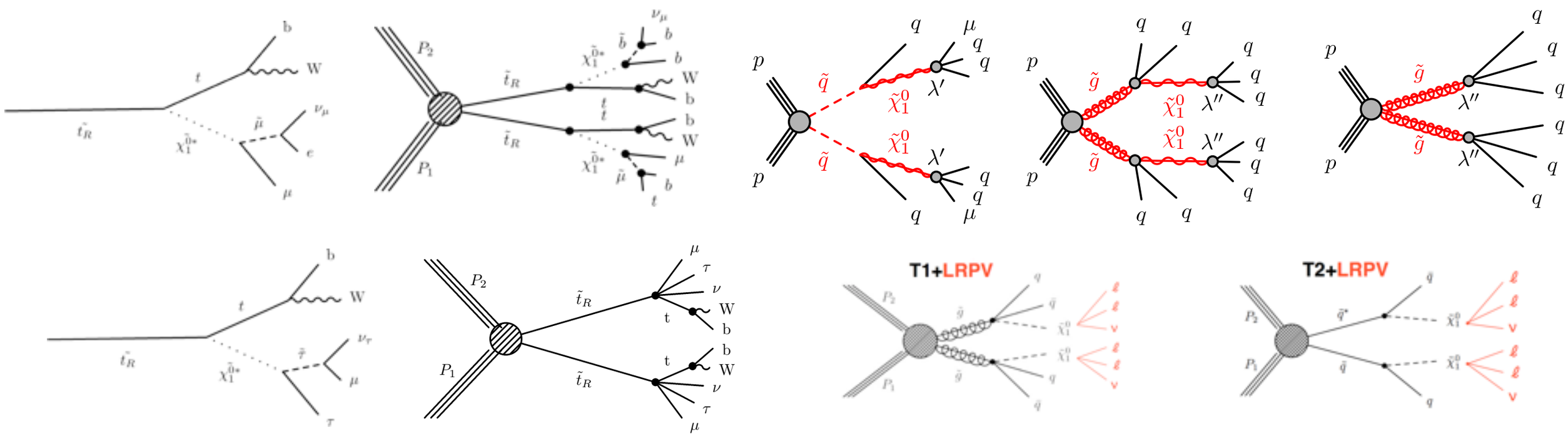
- Quantum number $R=(-1)^{3(B-L)+2S}$ takes on the value +1 for SM particles and -1 for sparticles
- All of those analyses assume R Parity Conservation (RPC)
  - RPC implies the Lightest Supersymmetric Particle (LSP) is stable → Dark matter candidate
  - *But* there is no strong reason to believe nature is RPC
    - Lack of proton decay forbids simultaneous violation of lepton number and baryon number
    - RPV (Violating) SUSY: General RPV MSSM super potential

$$W_{RPV} = \underbrace{\mu_i H_u L_i + \frac{1}{2}\lambda_{ijk} L_i L_j E^c_k + \lambda'_{ijk} L_i Q_j D^c_k}_{\text{L Violating}} + \underbrace{\frac{1}{2}\lambda''_{ijk} U^c_i D^c_j D^c_k}_{\text{B Violating}}$$

- Limited constraints to date.
- SUSY could be hiding in less-probed signatures
  - Perhaps the last hope for naturalness from SUSY

Searches for RPV SUSY at the LHC

- Most analyses search for RPC → Escaped LSP
  - Focus on SUSY signatures without an escaped LSP
- Presenting searches for stops in RPV contexts from ATLAS and CMS
  - Categorize exclusively to models with nonzero λ_{ijk}, λ'_{ijk}, and λ''_{ijk}



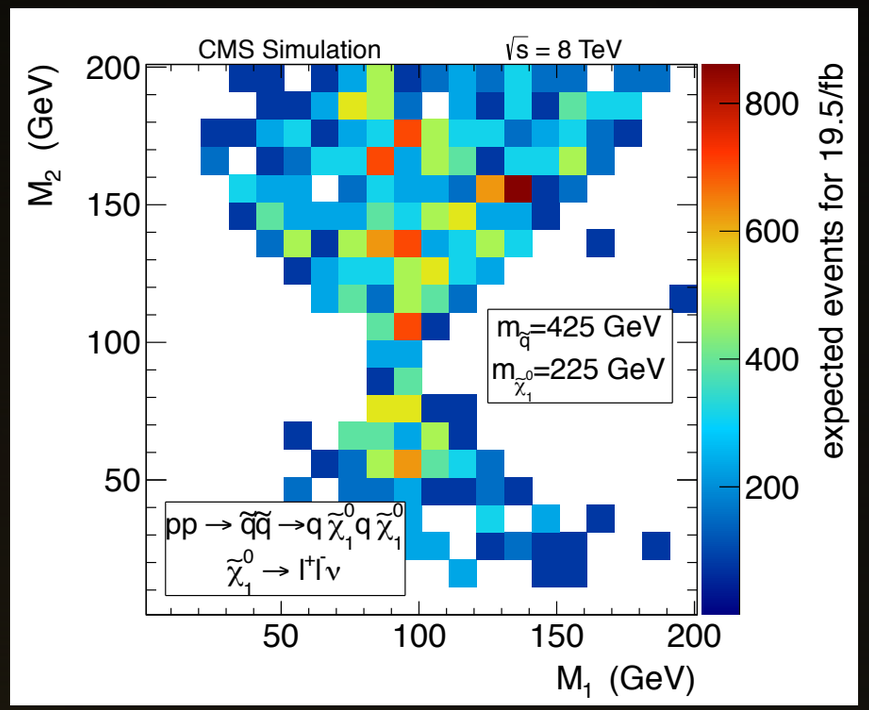
Disclaimer: This is a rough overview.
Apologies if this is not a completely comprehensive collection, especially w.r.t. CMS results

$$\lambda_{ijk}$$

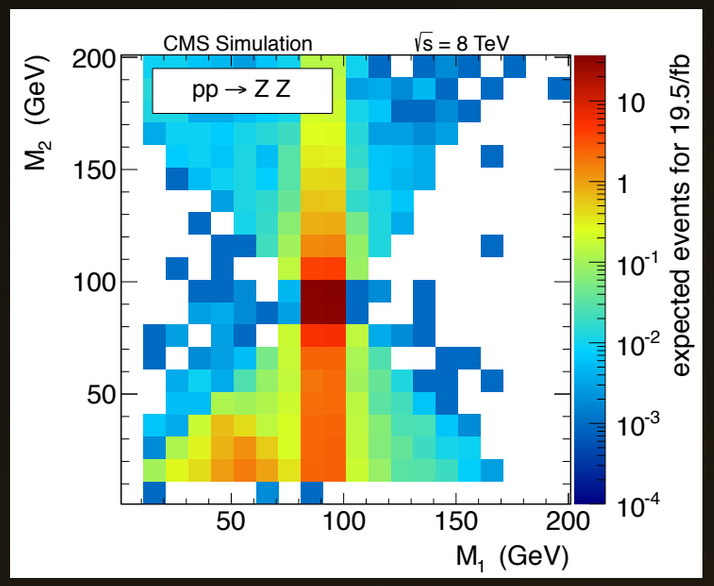
Exactly 4 Leptons

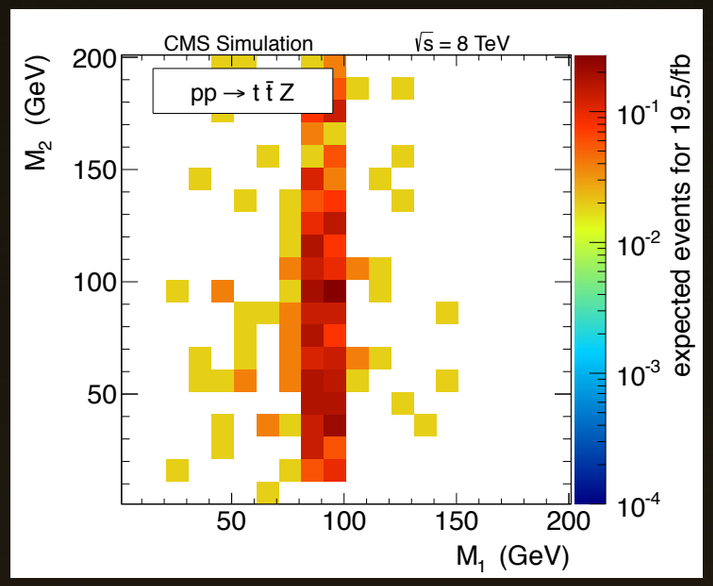
CMS - SUS-13-010-PAS

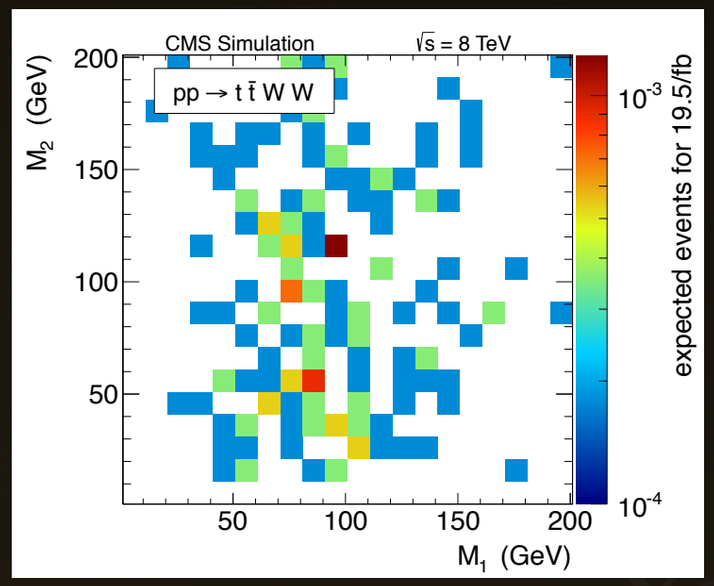
- Direct squark pair production with nonzero λ_{ijk}
- Require 4 leptons
  - At least two Opposite Sign - Same Flavor
- M1 defined as Inv Mass of OSSF pair closest to Z peak and M2 the remaining leptons
- Can veto dominant SM backgrounds (ZZ, ttZ, ttWW)



Squark pairs in LLE model







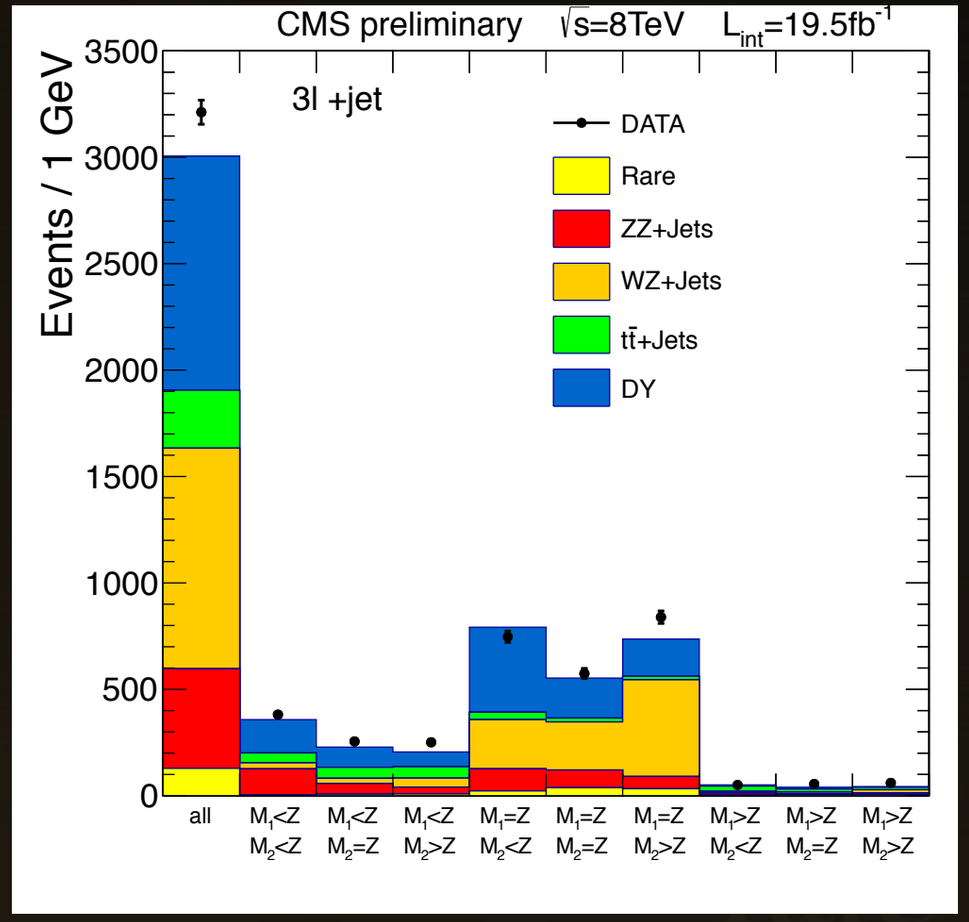
Main Backgrounds

Exactly 4 Leptons

CMS - SUS-13-010-PAS

- Signal regions constructed out of regions in M1 vs M2 space
- No significant deviation from the SM found

		$M_1 < 75\ GeV$	$75 < M_1 < 105\ GeV$	$M_1 > 105\ GeV$
$M_2 > 105\ GeV$	ZZ	0.76±0.18	15±4	0.30±0.07
	rare	0.28±0.13	2.7±1.0	0.12±0.05
	fakes	0.4±0.4	0.7±0.7	0.05±0.05
	all backgrounds	1.4±0.5	18±4	0.47±0.10
	observed	0	20	0
$75 < M_2 < 105\ GeV$	ZZ	0.10±0.03	150*	0.05±0.01
	rare	0.12±0.05	2.5±1.2	0.06±0.03
	fakes	0.3±0.3	0.6±0.6	0.05±0.05
	all backgrounds	0.52±0.34	153*	0.16±0.06
	observed	0	160	0
$M_2 < 75\ GeV$	ZZ	9.8±2.0	32±8	0.98±0.20
	rare	0.31±0.14	2.5±1.2	0.011±0.005
	fakes	0.3±0.3	0.8±0.8	0.06±0.06
	all backgrounds	10.4±2.0	35±8	1.0±0.2
	observed	14	30	1



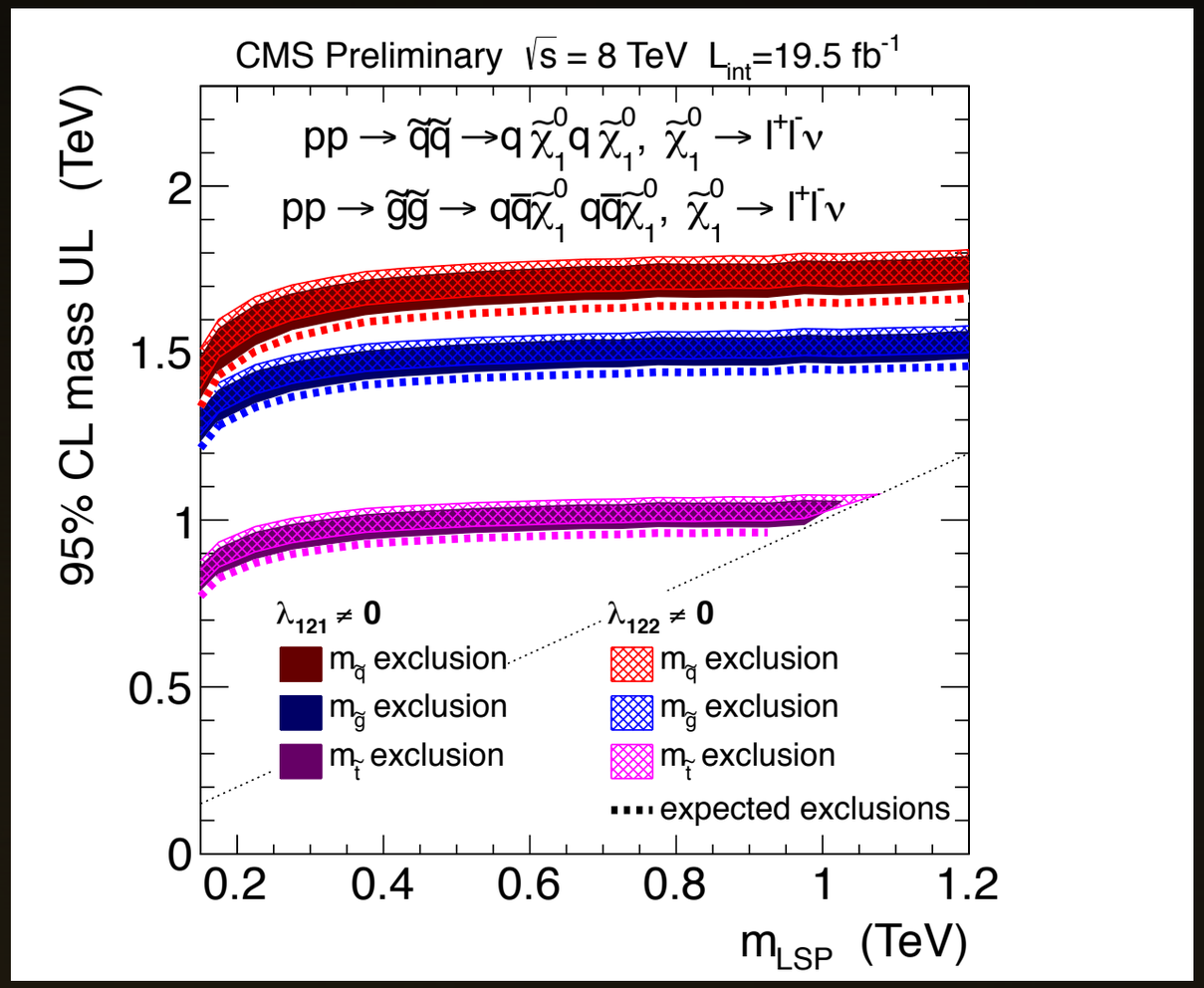
Exactly 4 Leptons

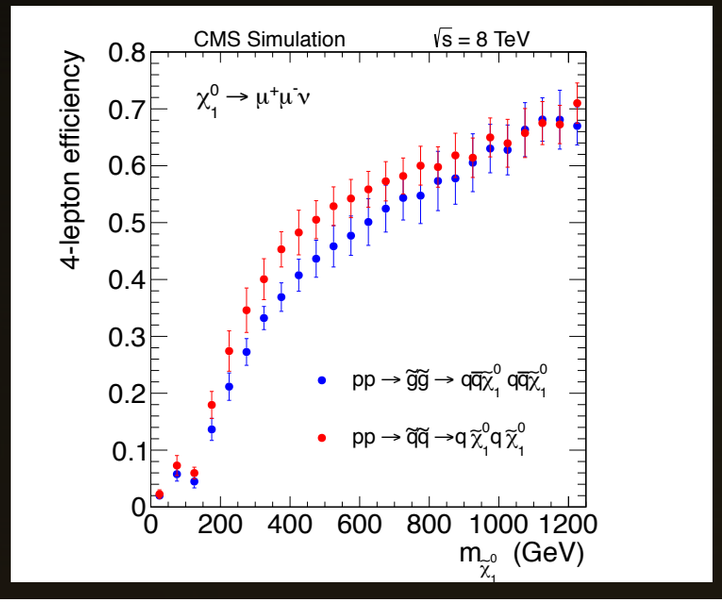
CMS - SUS-13-010-PAS

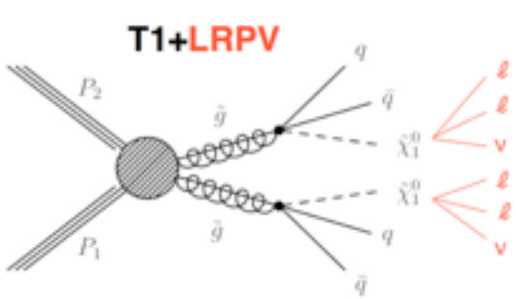
(e, mu, nu)

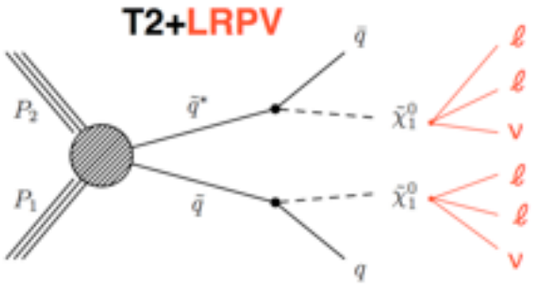
$\lambda_{121}, \lambda_{122}$

- Set limits on various pair productions
- Direct stop production excluded up to 1 TeV
- Gluino pair production could be interpreted as gluino-mediated stop constraint if change in acceptance accounted for







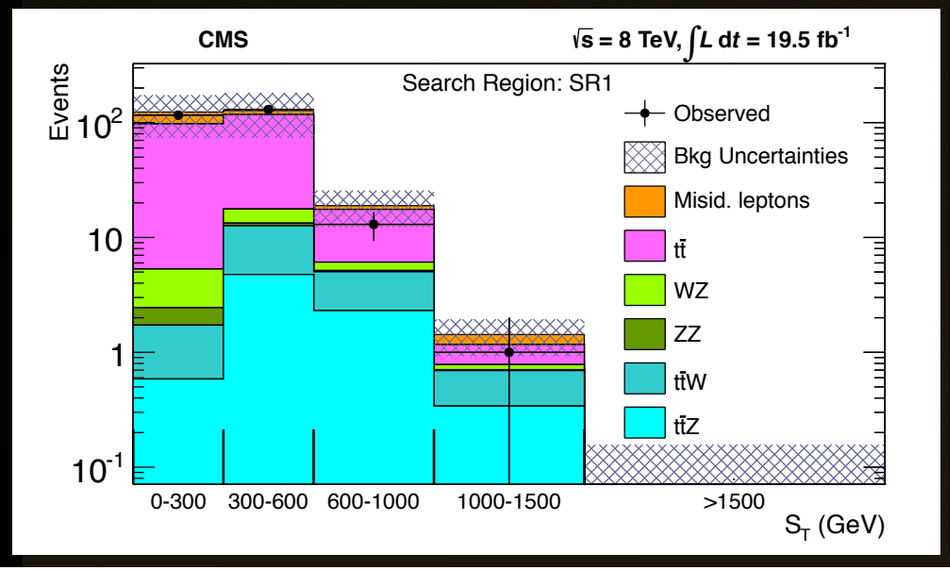


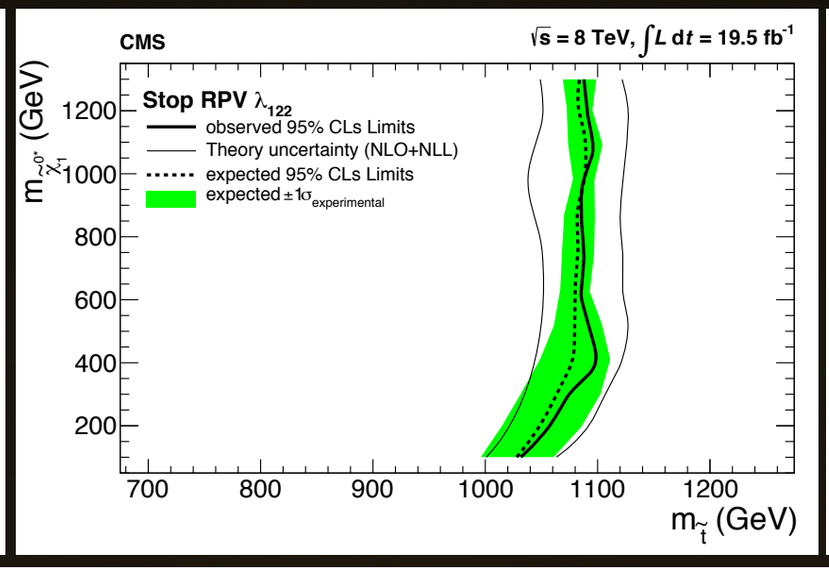
≥3 Leptons + BJets

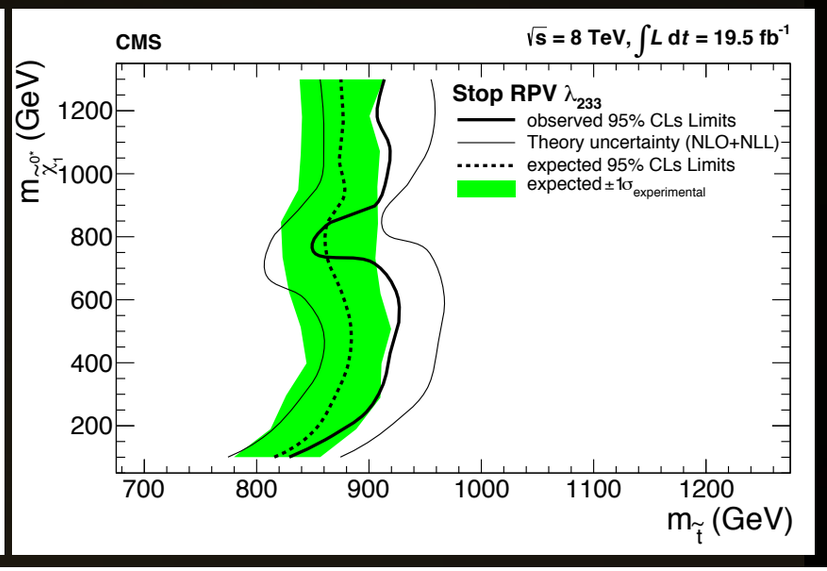
CMS - arXiv:1306.6643

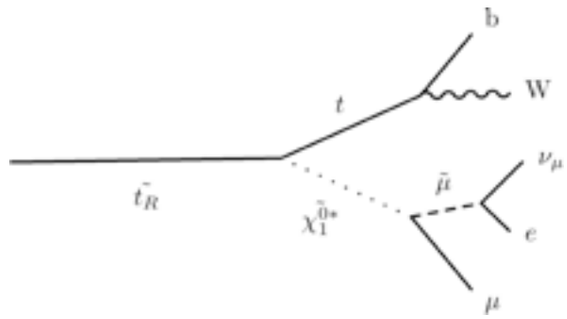
- Search for stop pair production
- Select for ≥3 Leptons and ≥1 BTags
- Observable is transverse sum of Missing E_T, Jet E_T, and Lepton E_T
- Coupling-dependent limits set on stop mass for various LSP masses as high as 0.8-1.1 TeV

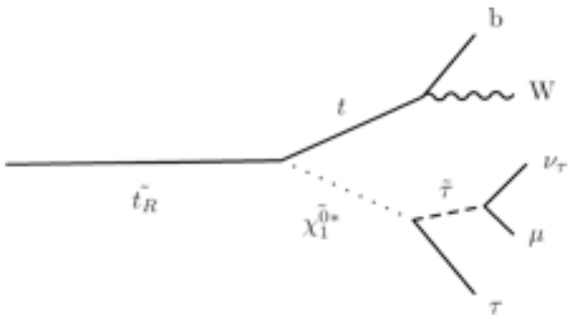
λ_{122} (e, mu, nu_mu) λ_{233} (mu, tau, nu_tau)











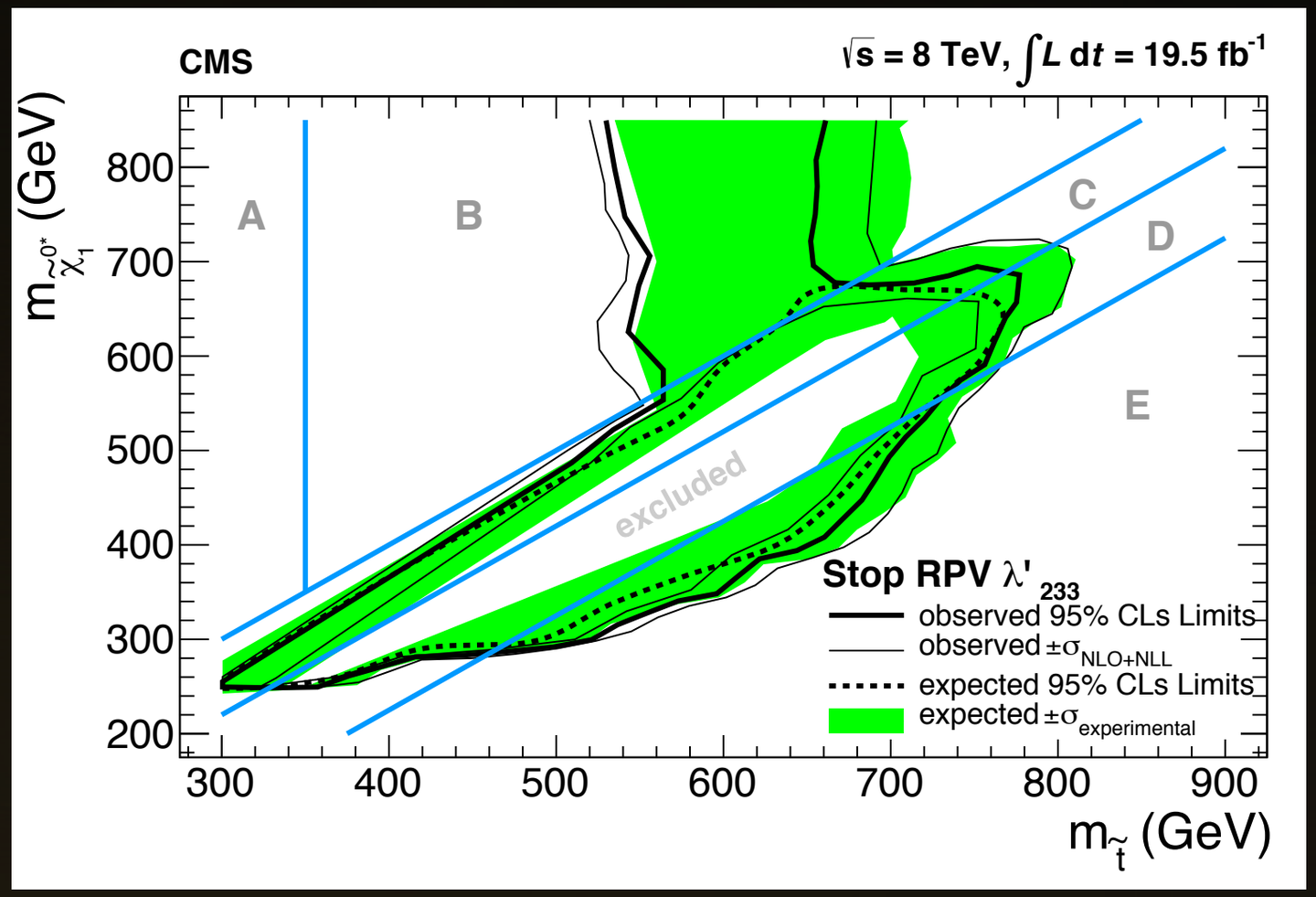
$$\lambda'_{ijk}$$

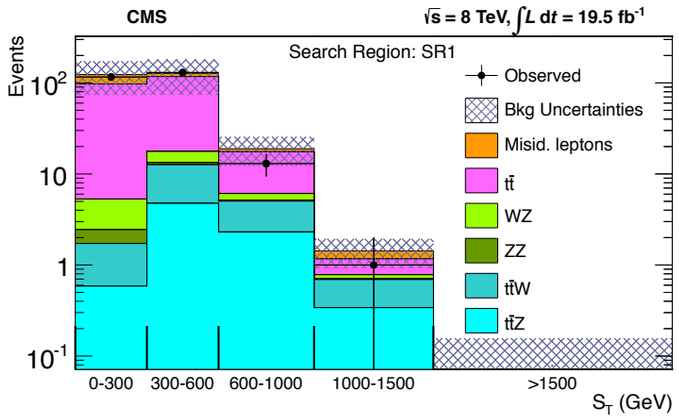
≥3 Leptons + BJets

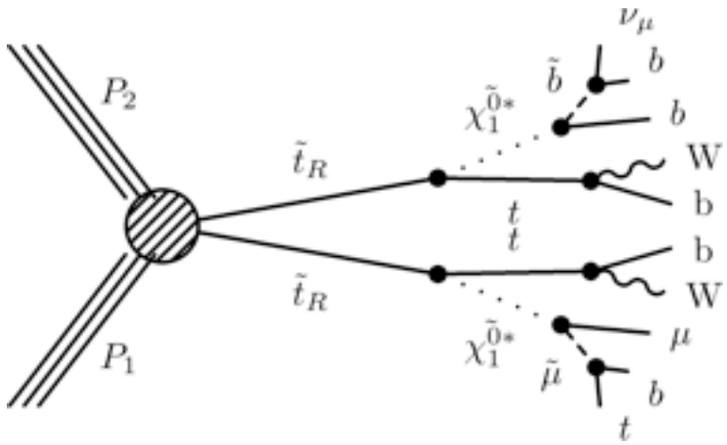
CMS - arXiv:1306.6643

λ'_{233} (mu, b, t)

- The last result also interpreted for LQD RPV stops
- Manage to exclude models with small mass difference between the stop and LSP up to ~800 GeV



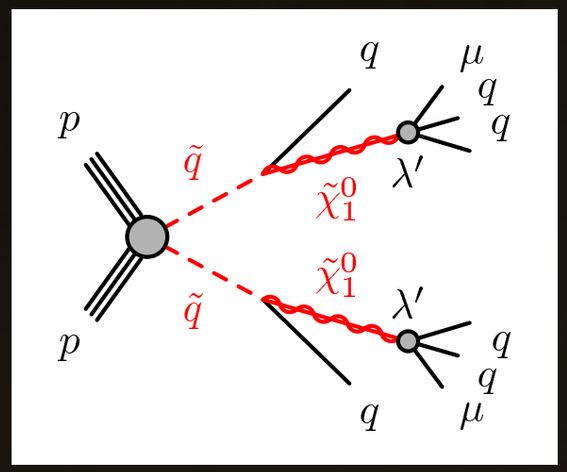




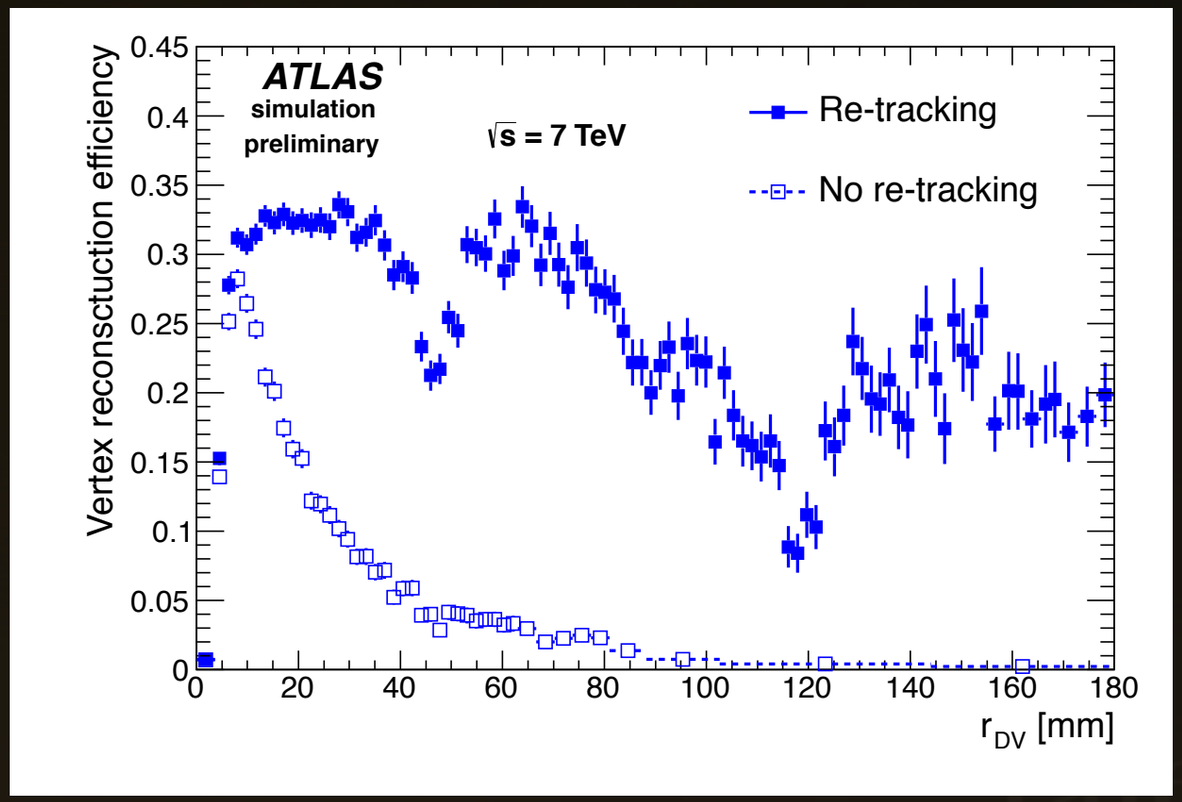
Displaced Vertex Search

ATLAS - ATLAS-CONF-2013-092

- Search for long-lived massive particles decaying within the detector
  - Non-zero but small λ'_{2ij}
  - Squark pairs with LSP decaying to a muon and a smuon
- Default track reconstruction optimized for *primary* particles
  - Custom reconstruction - "Re-tracking"



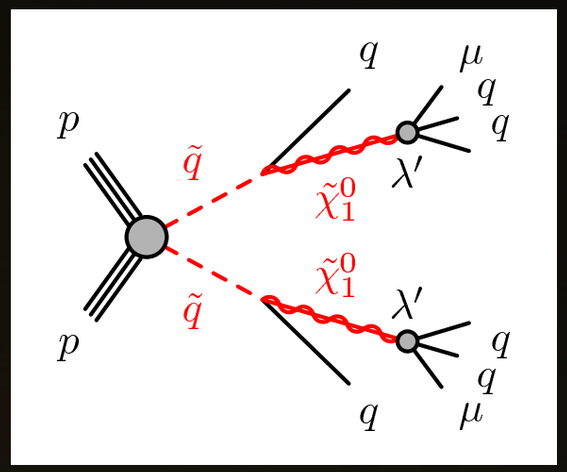
Sample	$m_{\tilde{q}}$ [GeV]	$m_{\tilde{\chi}_1^0}$ [GeV]	σ [fb]	$\langle\gamma\beta\rangle_{\tilde{\chi}_1^0}$	$c\tau_{MC}$ [mm]	λ'_{211}
MH	700	494	124.3	1.0	175	0.2×10^{-5}
ML	700	108	124.3	3.1	101	1.5×10^{-5}
HL	1000	108	11.9	5.5	220	20.0×10^{-5}



Displaced Vertex Search

ATLAS - ATLAS-CONF-2013-092

- Trigger on muon
  - $p_T > 55$ GeV, $|\eta|<1.07$, $|d_0|>1.5$mm
- Displaced Vertex (DV)
  - Re-tracking
    - High impact parameter $|d_0| > 2$mm
    - $p_T > 1$ GeV (400 MeV in default reco)
  - 2-track seed vertices combined
  - Radial distance to any primary vertex > 4 mm



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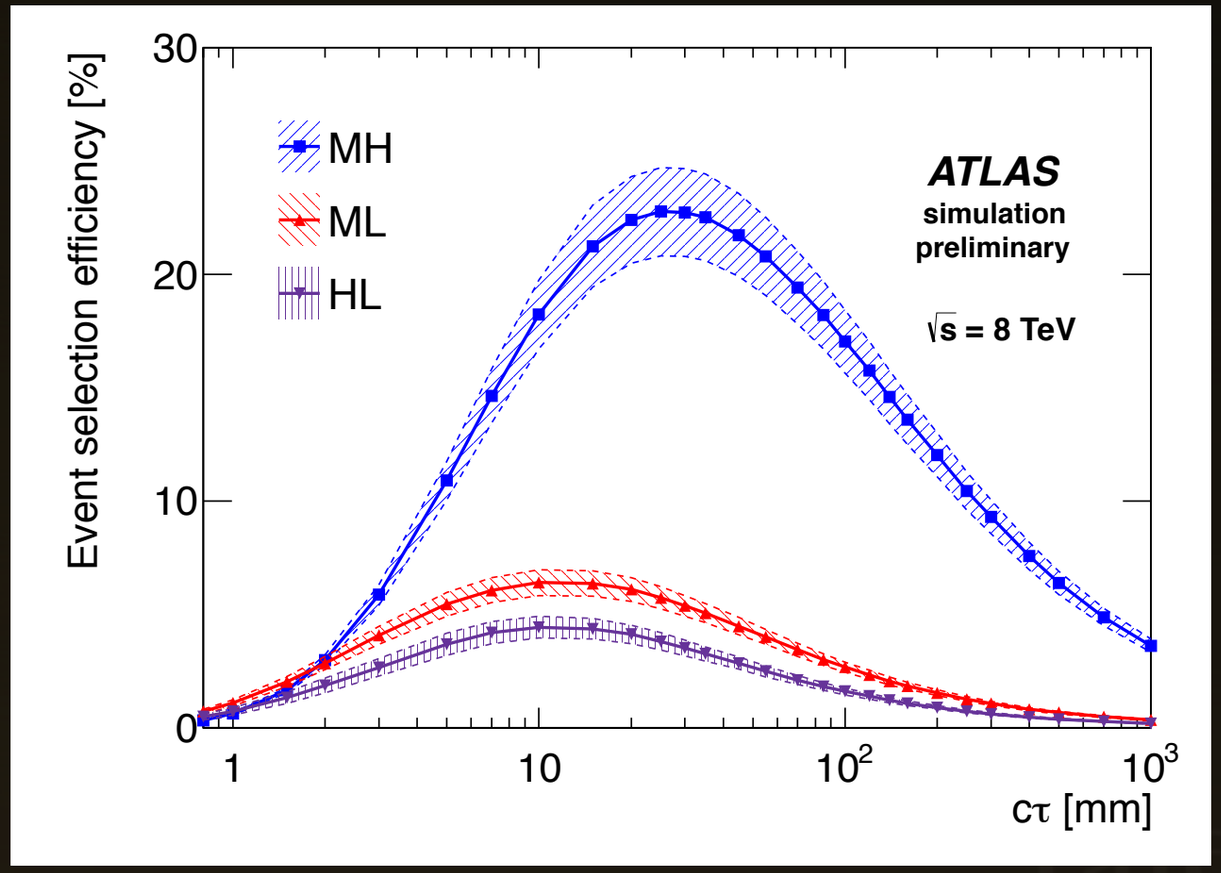
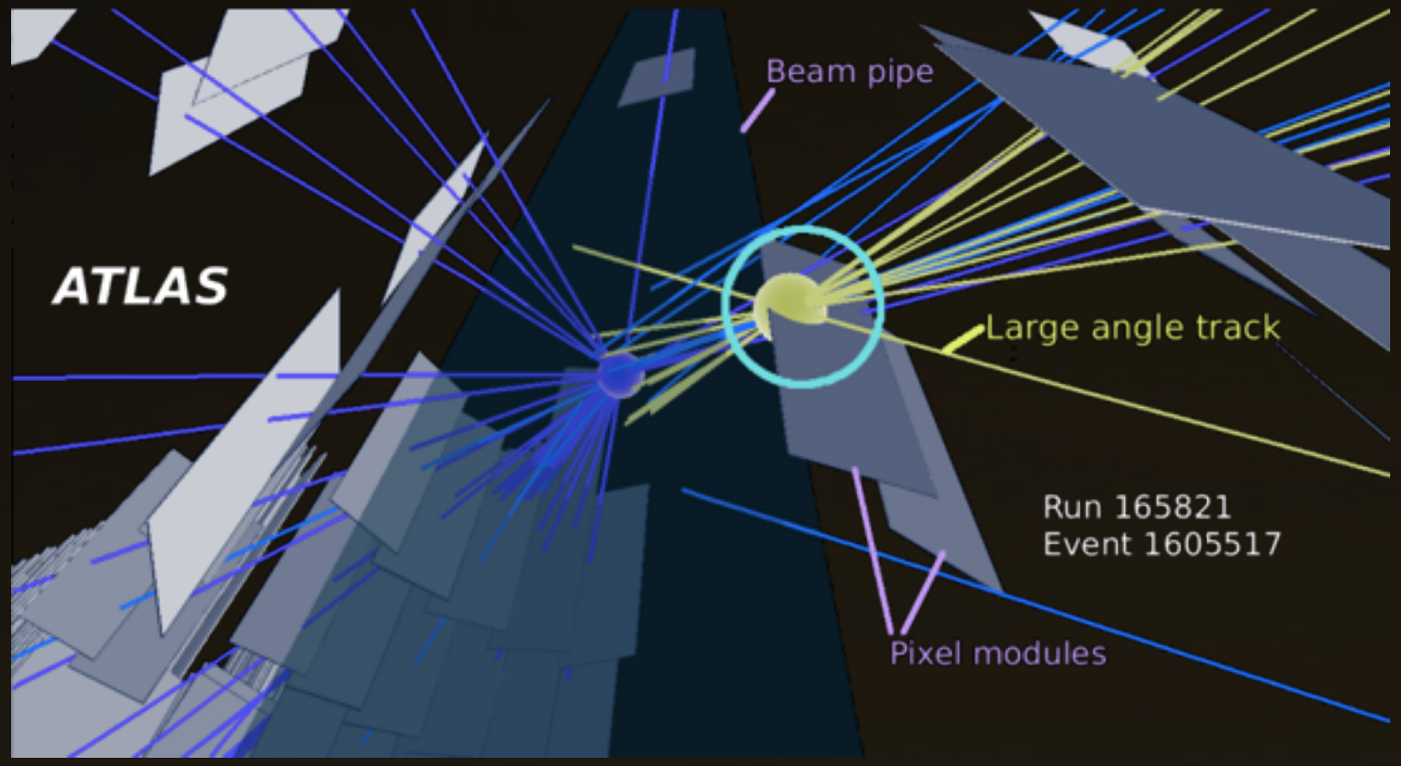
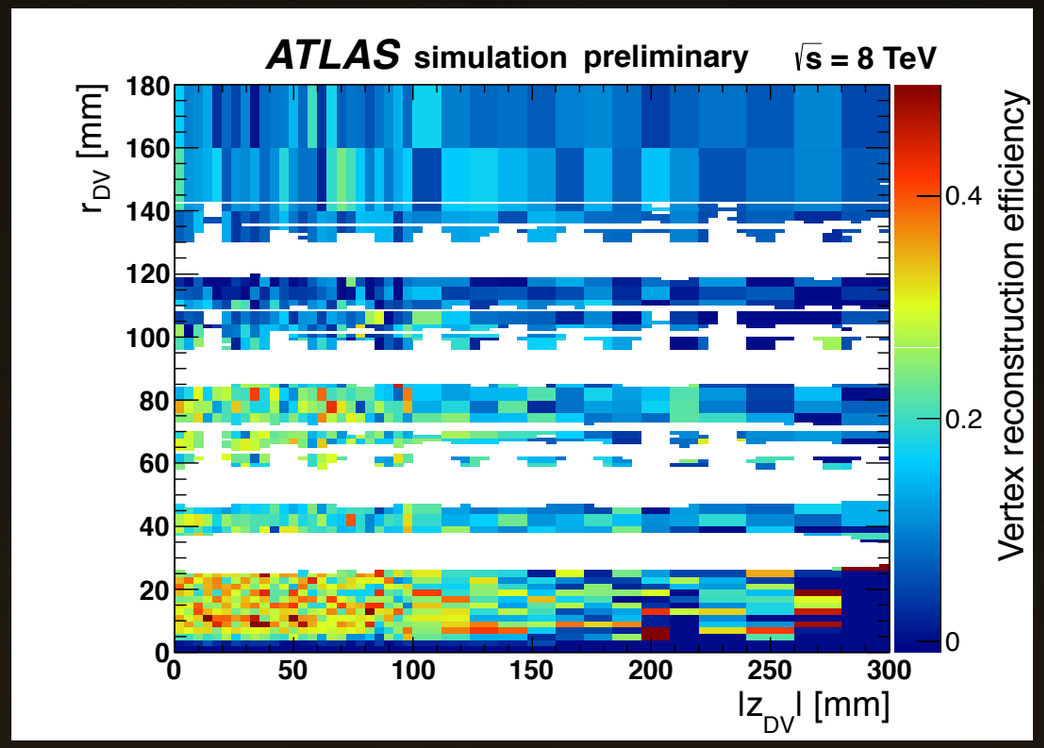


Displaced Vertex Search

ATLAS - ATLAS-CONF-2013-092

- Search for high-mass (> 10 GeV) displaced vertices with many tracks (> 4)
- Hadronic interactions with detector material
  - Veto with detailed material map from low mass vertices in data
  - Resolution: 4 mm in z, 1 mm in r
- Random track crossings
  - Largest close to beam with higher track density
- Hadronic interaction with gas molecules
  - Low mass, but high-angle track crossings give high-mass tail

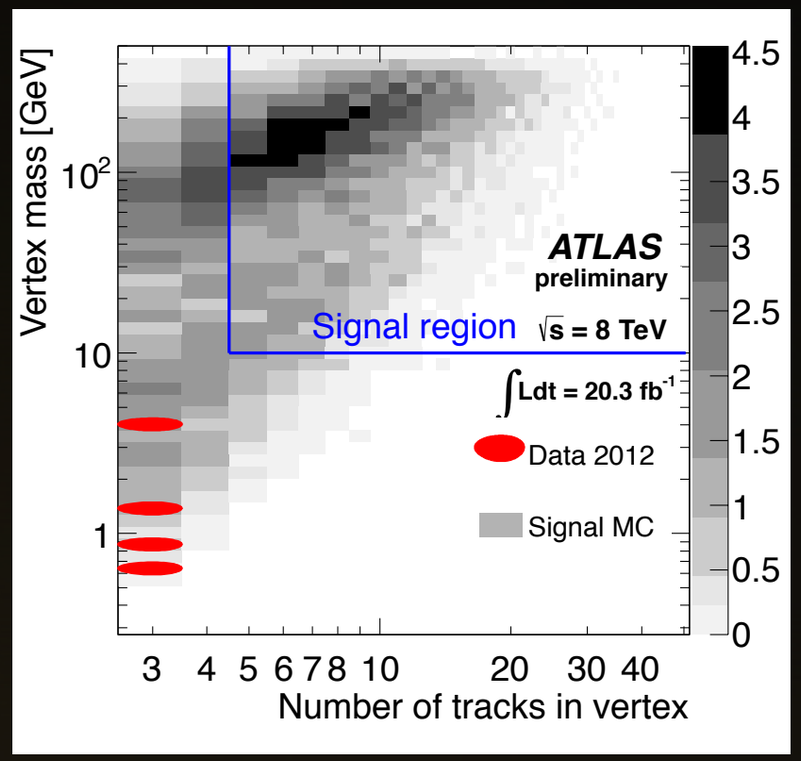


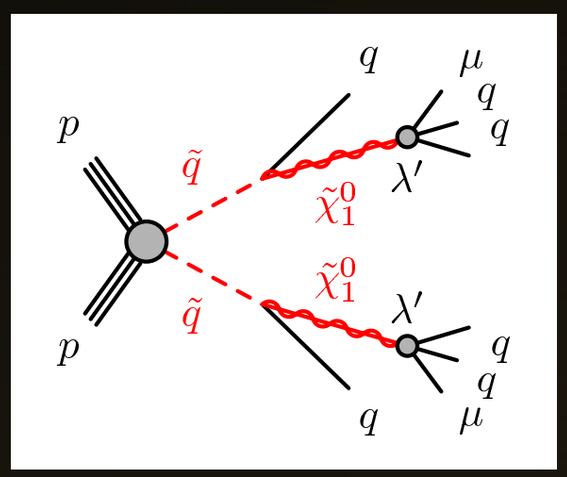


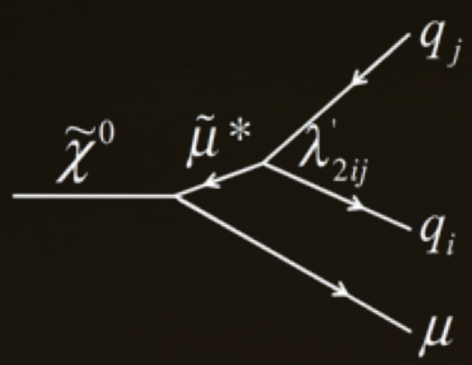
Displaced Vertex Search

ATLAS - ATLAS-CONF-2013-092

- Signal Region: > 4 Tracks, Mass > 10 GeV
- Expect (2 +/- 2) x 10^{-2} background vertices in signal region
- Observe 0 vertices in signal region in data
- Limits on cross section x BR are set on various RPV models as a function particle lifetime







λ'_{2ij} (mu, j, j)

Sample	$m_{\tilde{q}}$ [GeV]	$m_{\tilde{\chi}^0_1}$ [GeV]	σ [fb]	$\langle\gamma\beta\rangle_{\tilde{\chi}^0_1}$	$c\tau_{MC}$ [mm]	λ'_{211}
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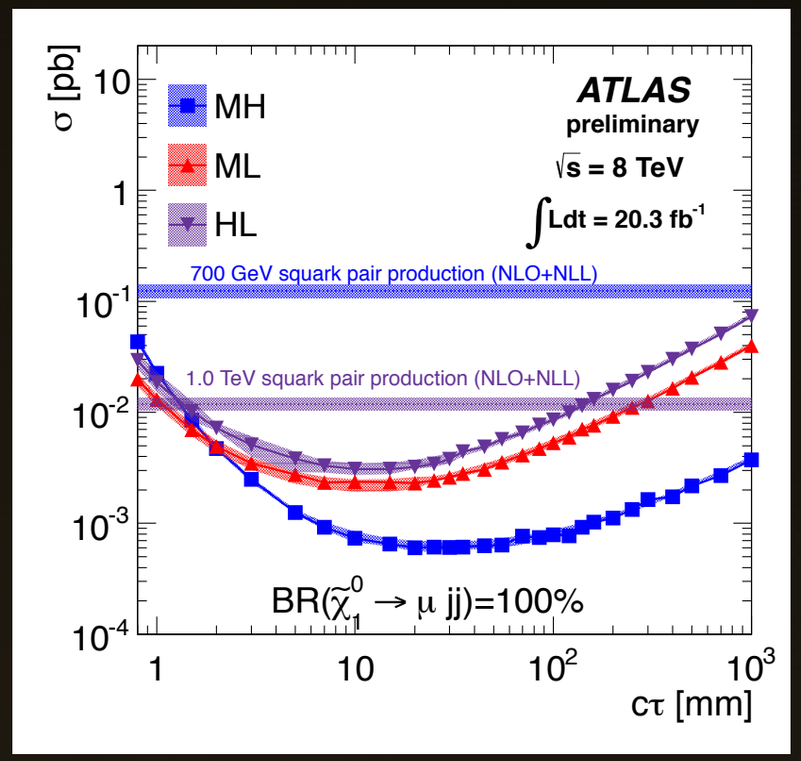
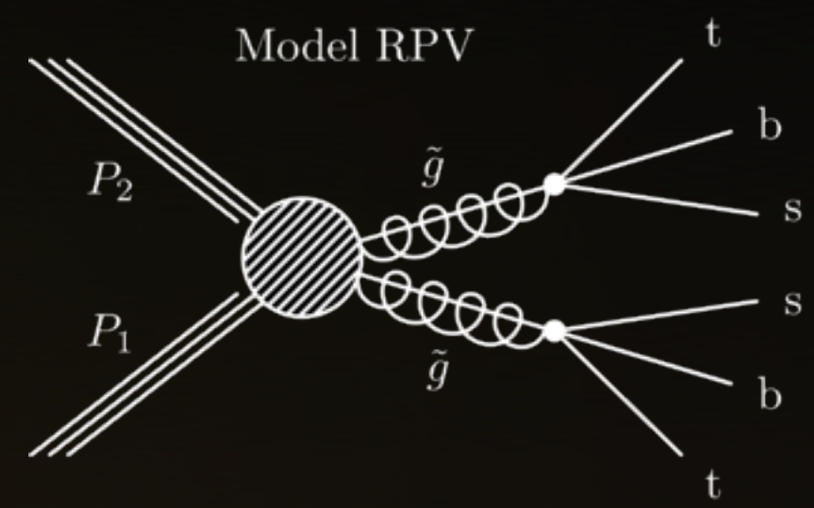


$$\lambda''_{ijk}$$

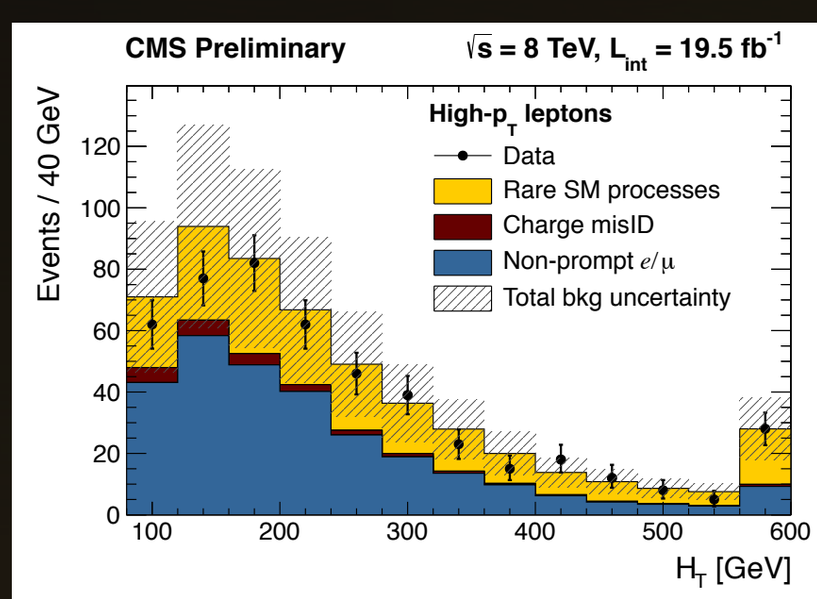
Same Sign Dilepton with B Jets

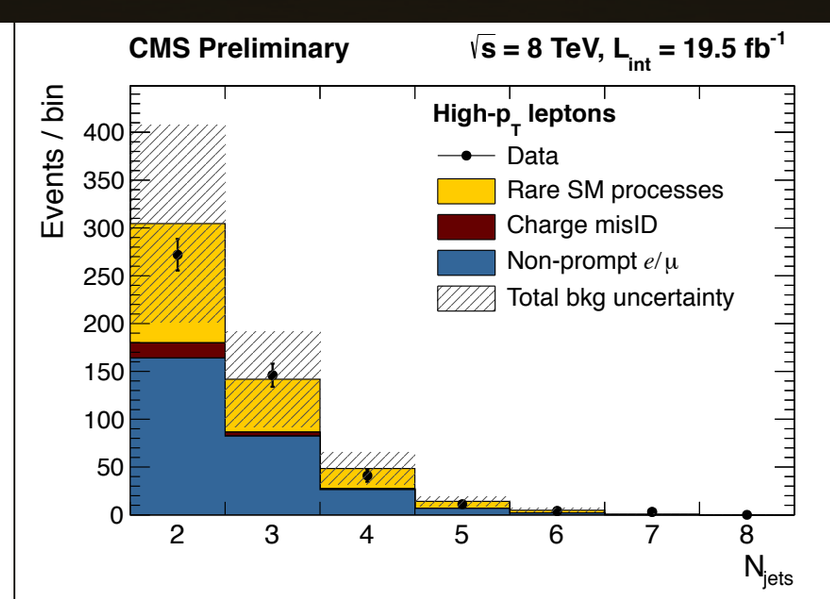
CMS - SUS-13-013-PAS

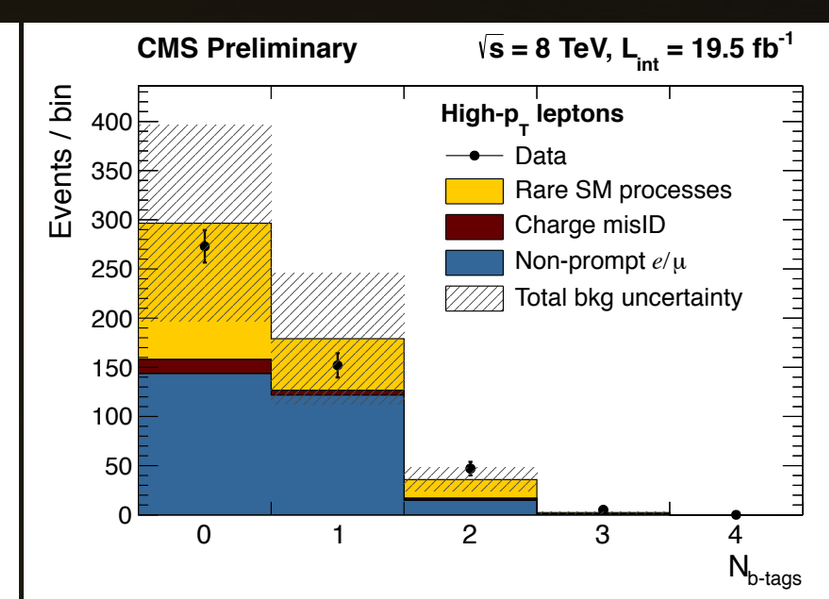


- Searching for gluino pairs decaying to tbs via an (offshell) stop
- Signal Region: ≥2 Jets, ≥2 Isolated leptons
- Observables are HT, NJets, NBTags
- Cuts are optimized for various models

λ''_{323} (t,b,s)

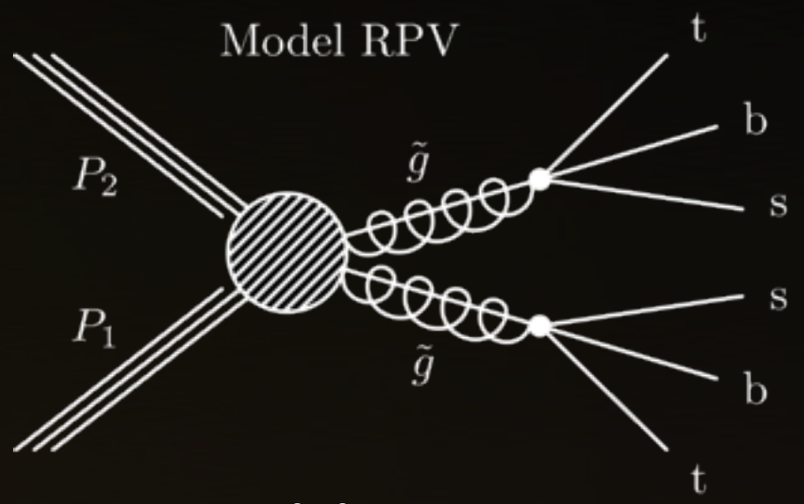






Same Sign Dilepton with B Jets

CMS - SUS-13-013-PAS

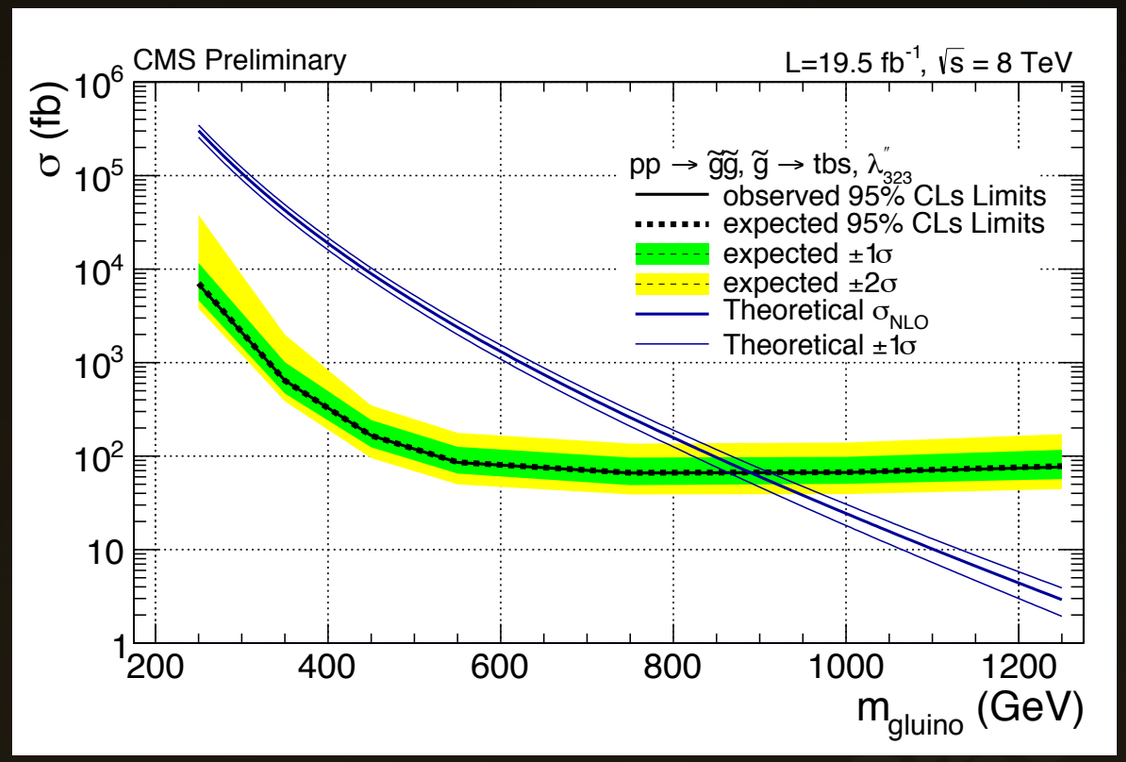


λ''_{323} (t,b,s)

- The gluino mediated stop in UDD model uses SR "RPV2"
- In the absence of signal, exclude gluinos up to ~900 GeV

N_{jets}	$N_{\text{b-jets}}$	E_T^{miss} (GeV)	H_T (GeV)	charge	SR
≥ 2	≥ 0	> 0	> 500	$++/--$	RPV0
≥ 2	≥ 2	> 0	> 500	$++/--$	RPV2

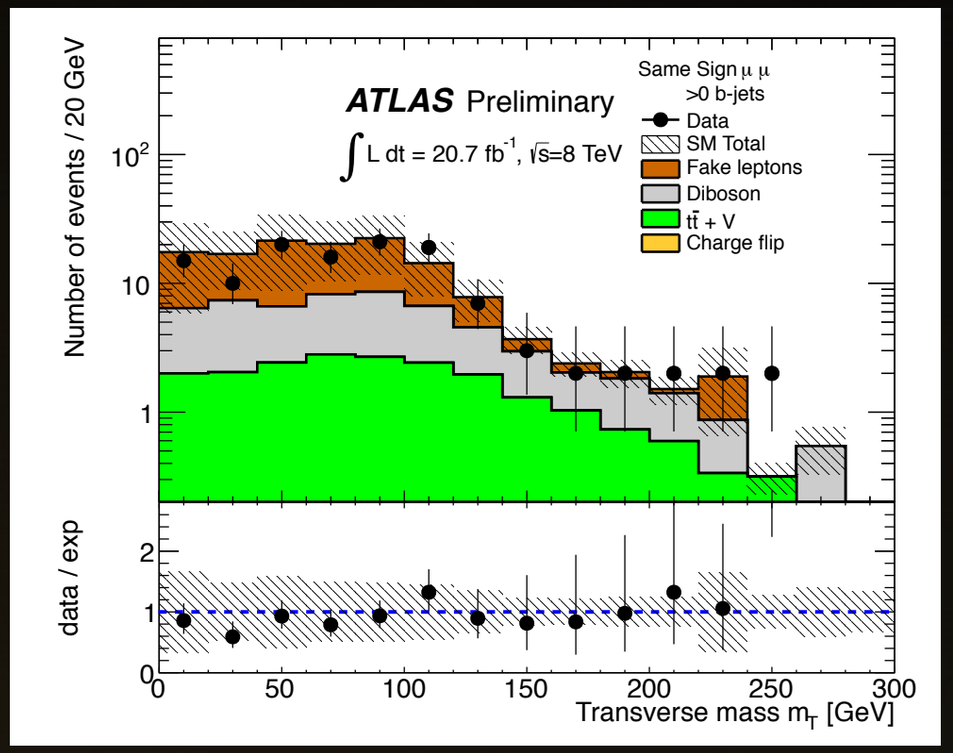
SR	Expected	Observed
RPV0	38 ± 14	35
RPV2	5.3 ± 2.1	5



Same Sign Dilepton with B Jets

ATLAS - ATLAS-CONF-2013-007

- Search with same gluino->tbs interpretation
- Select events with high jet multiplicity, high MET, reconstructed transverse mass
  - Can perform shape fit for m_eff in tails
  - m_eff = sum{leading leptons pT, selected jets pT, MET}
  - m_T = transverse mass of lepton-MET system



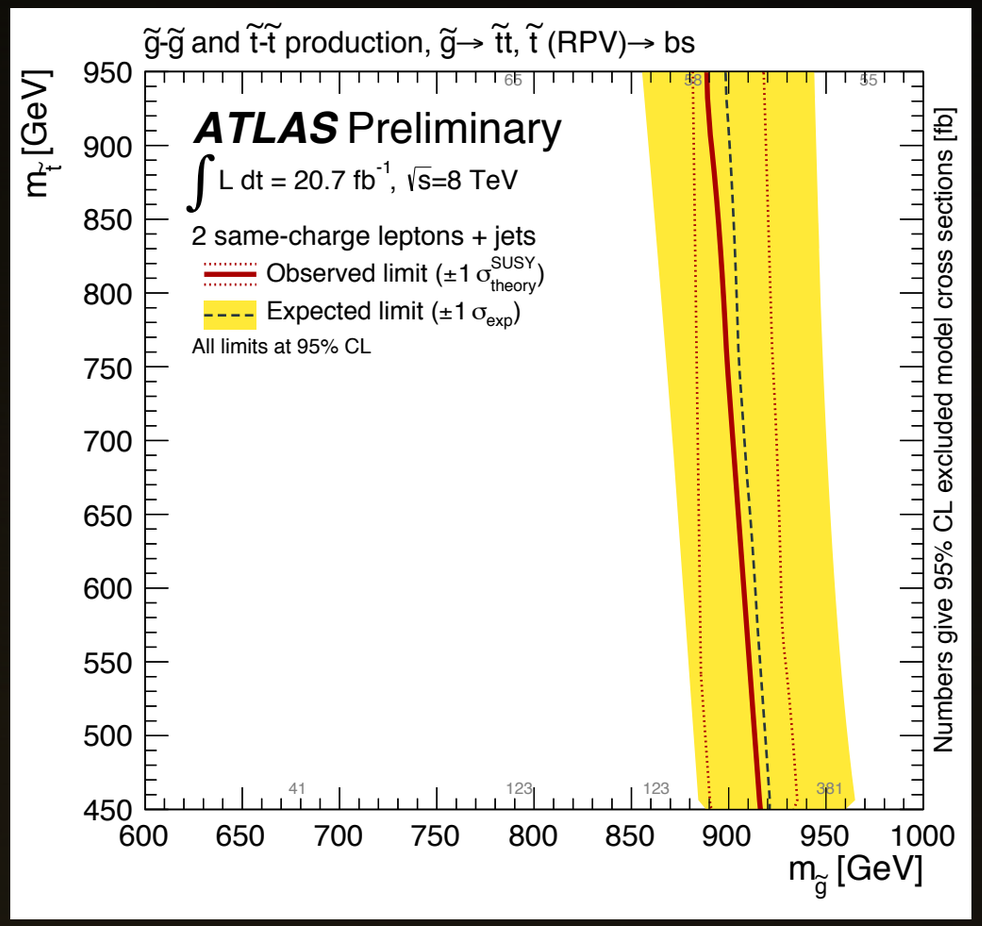
Signal region	N_{b-jets}	Signal cuts (discovery case)	Signal cuts (exclusion case)
SR0b	0	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV $m_T > 100$ GeV, $m_{eff} > 400$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV, binned shape fit in m_{eff} for $m_{eff} > 300$ GeV
SR1b	≥1	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV $m_T > 100$ GeV, $m_{eff} > 700$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV, binned shape fit in m_{eff} for $m_{eff} > 300$ GeV
SR3b	≥3	$N_{jets} \geq 4$ -	$N_{jets} \geq 5$, $E_T^{miss} < 150$ GeV or $m_T < 100$ GeV

Same Sign Dilepton with B Jets

ATLAS - ATLAS-CONF-2013-007

- Gluino mass exclusion is similar to CMS result within expected uncertainty bands
  - Excluded up to m_gluino~900 GeV for various on/off-shell stop masses

$$\lambda''_{323}$$ (t,b,s)

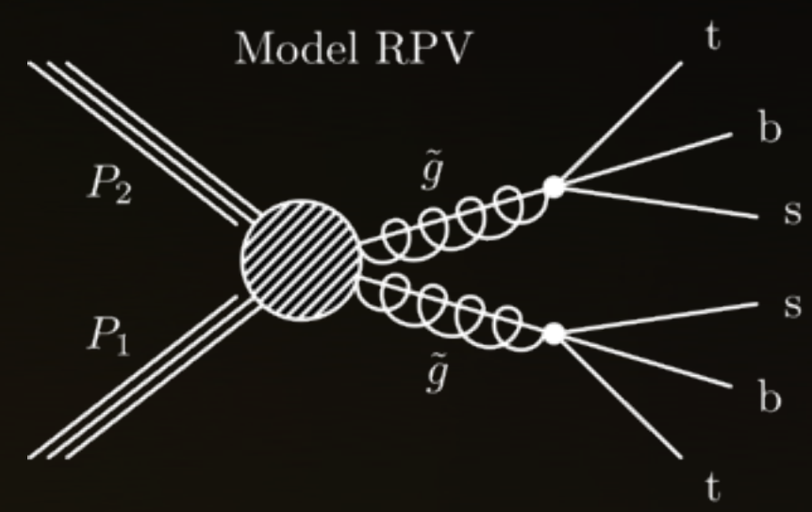


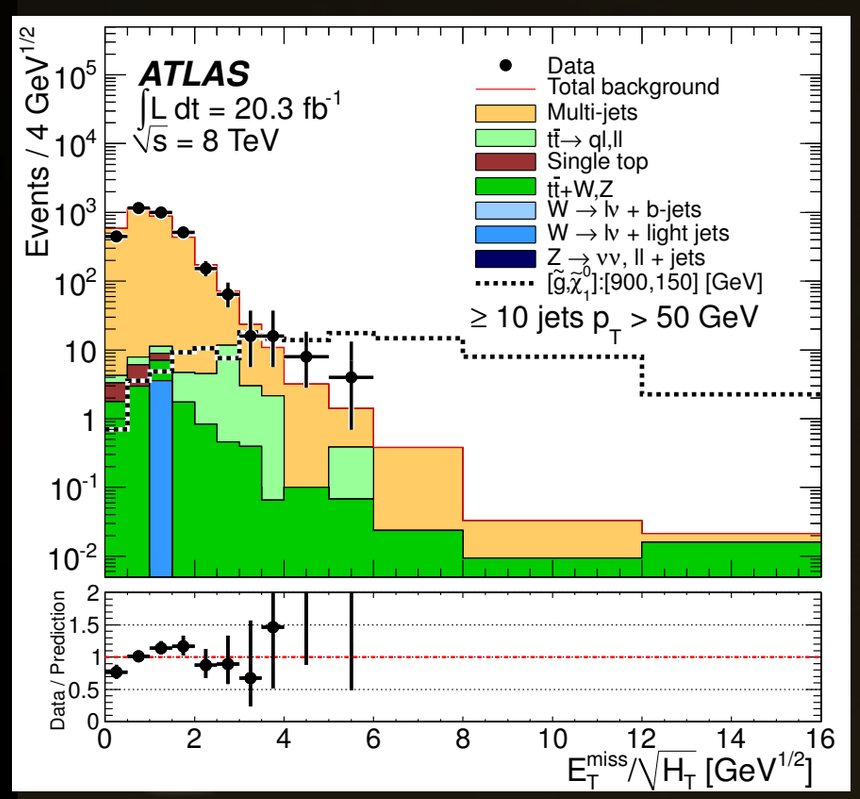
B) Exclusion case	SR0b	SR1b	SR3b
Observed events	5	11	1
Expected background events	7.5 ± 3.2	10.1 ± 3.9	1.8 ± 1.3
Expected $t\bar{t} + V$ events	0.5 ± 0.4	3.4 ± 1.5	0.6 ± 0.4
Expected diboson events	3.4 ± 1.1	1.4 ± 0.7	< 0.1
Expected fake lepton events	3.4 ± 2.9	4.4 ± 3.1	1.0 ± 1.1
Expected charge mis-measurement events	0.2 ± 0.1	0.8 ± 0.3	0.1 ± 0.1
p_0	0.5	0.39	0.5

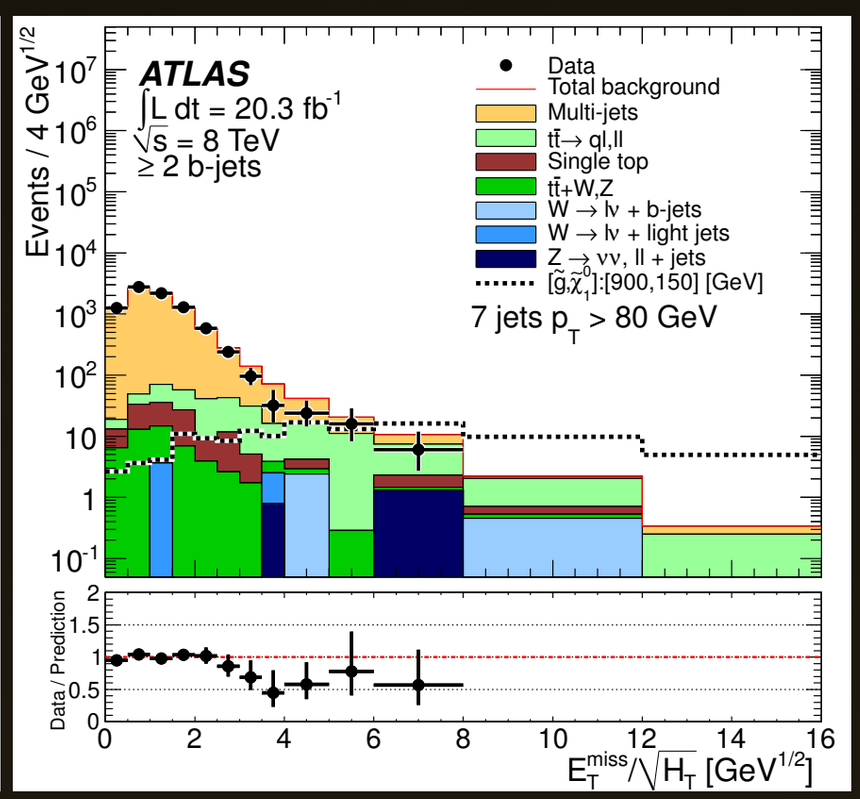
Multijet With MET

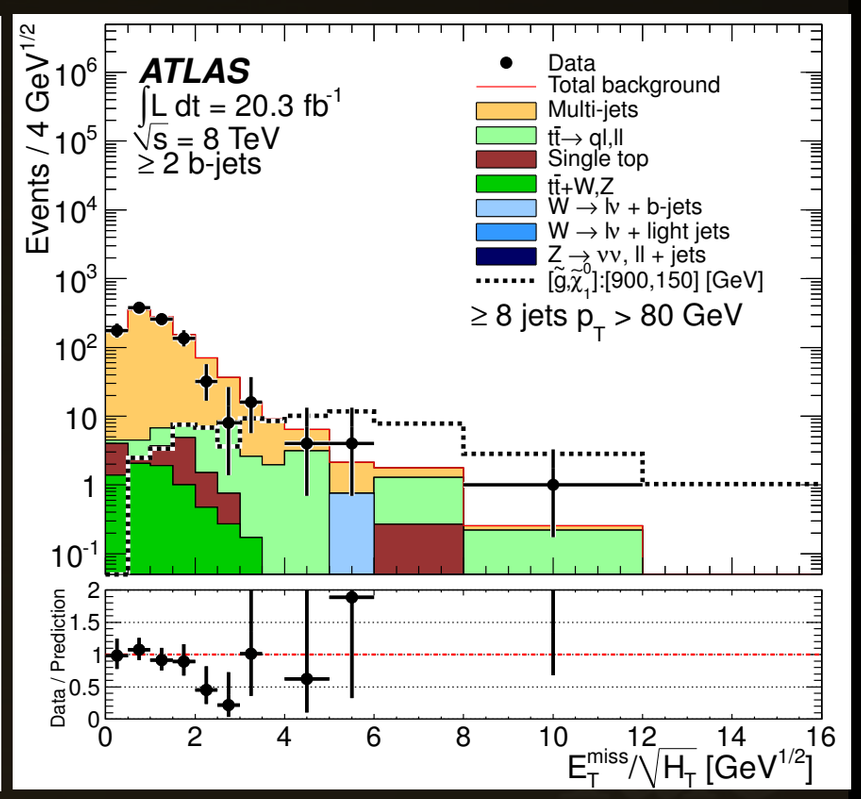
ATLAS - arXiv:1308.1841

- A very general search for supersymmetry with lots of signal regions and interpretations
- Select events with
  - High jet multiplicity (≥7-10)
  - Optional BTags
  - Sum of jet masses for reconstructed large-cone jets





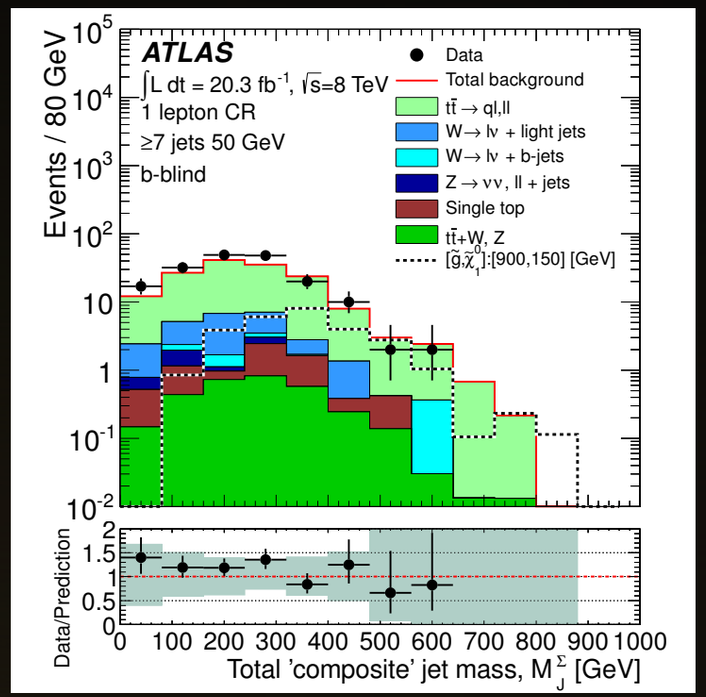




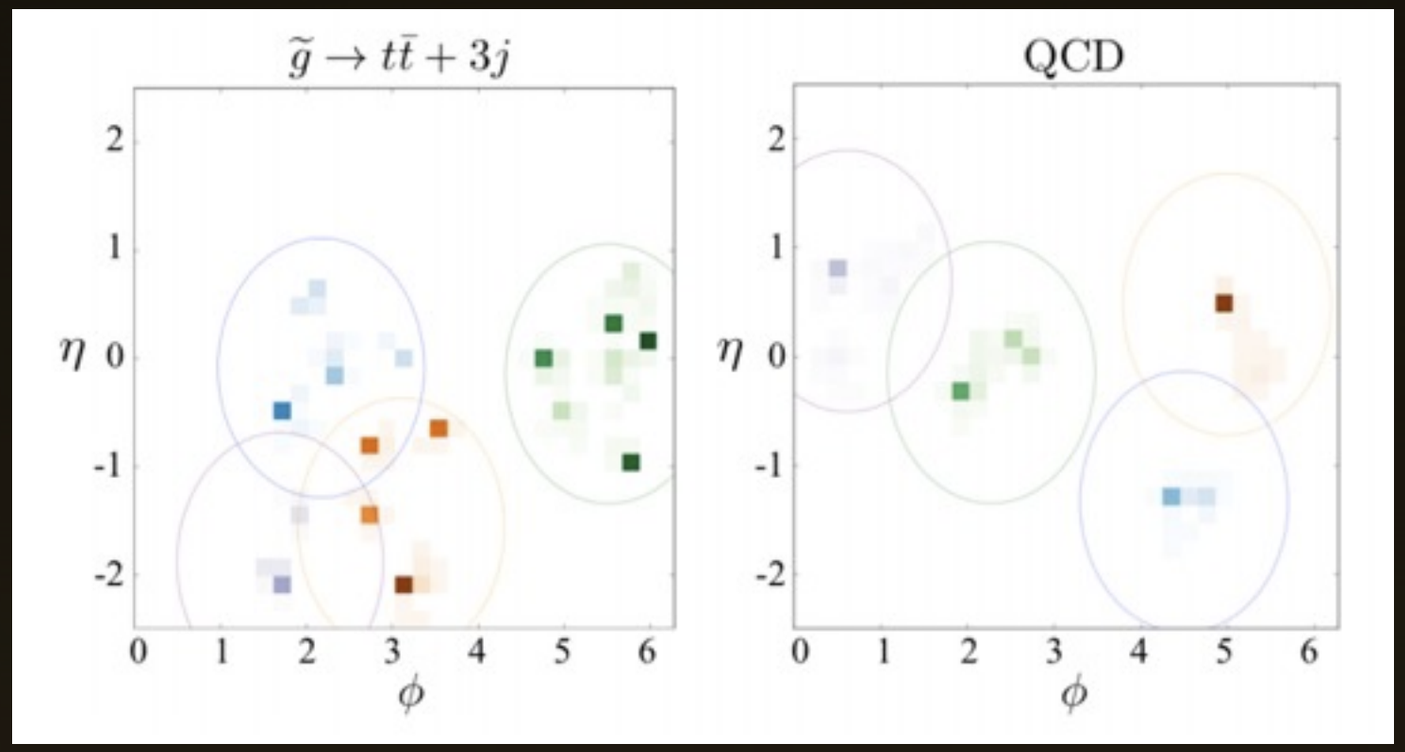
Multijet With MET

ATLAS - arXiv:1308.1841

- Using a new technique to sum the masses of each large-R jet in the event
  - Sensitive to 'accidental substructure' in large-R jets from intrinsic hardness/multiplicity in signal
  - This substructure is not from 'true' substructure due to boost, but still gives good discrimination
- Some SRs require this sum to be >340 GeV or >420 GeV for R=1.0 jets



High parton multiplicity gives rise to structure in the event as probed by the jet mass



Background doesn't have this property so much

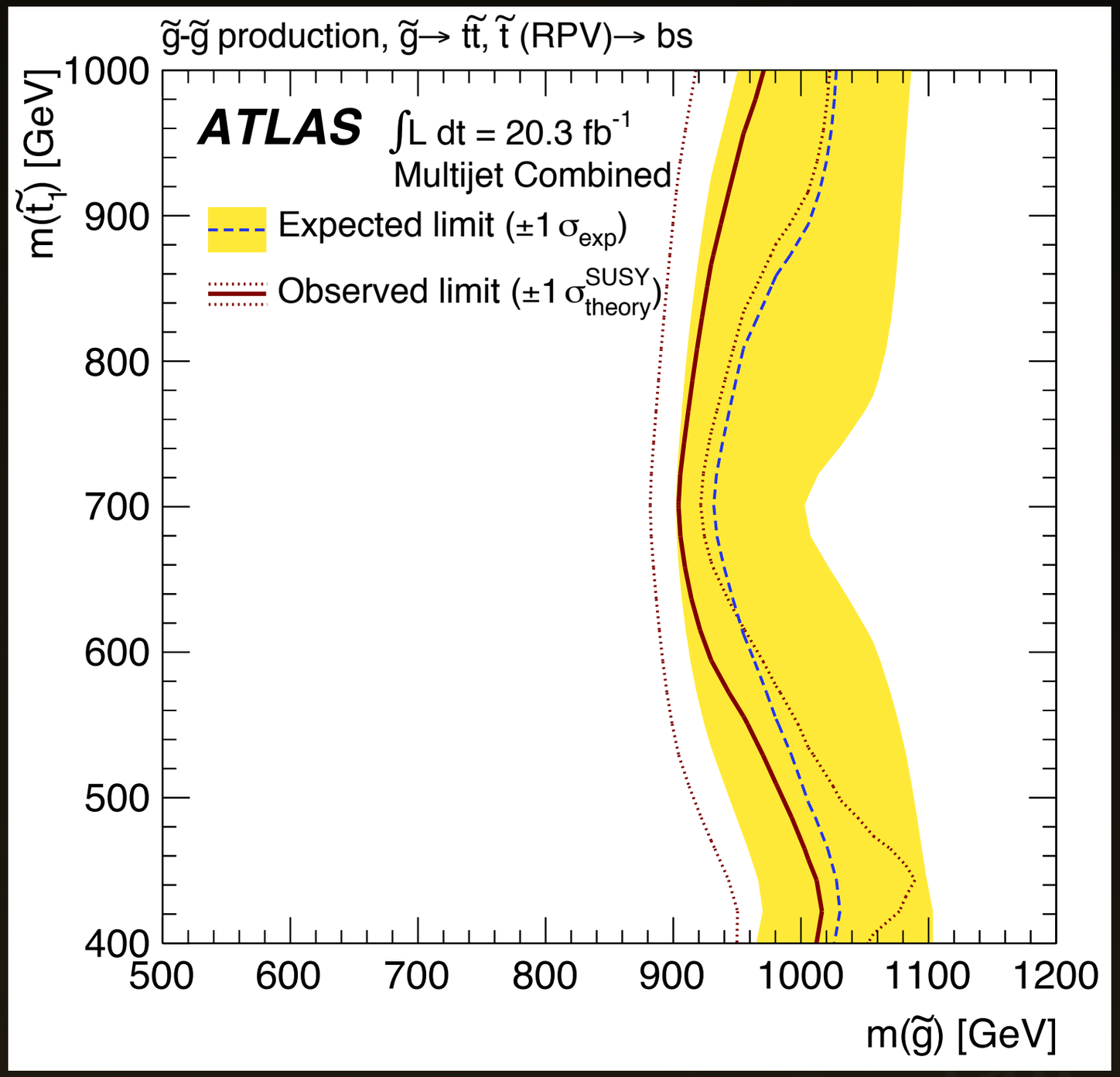
arXiv:1212.1456 [hep-ph]

Multijet With MET

ATLAS - arXiv:1308.1841

$$\lambda''_{323}$$ (t,b,s)

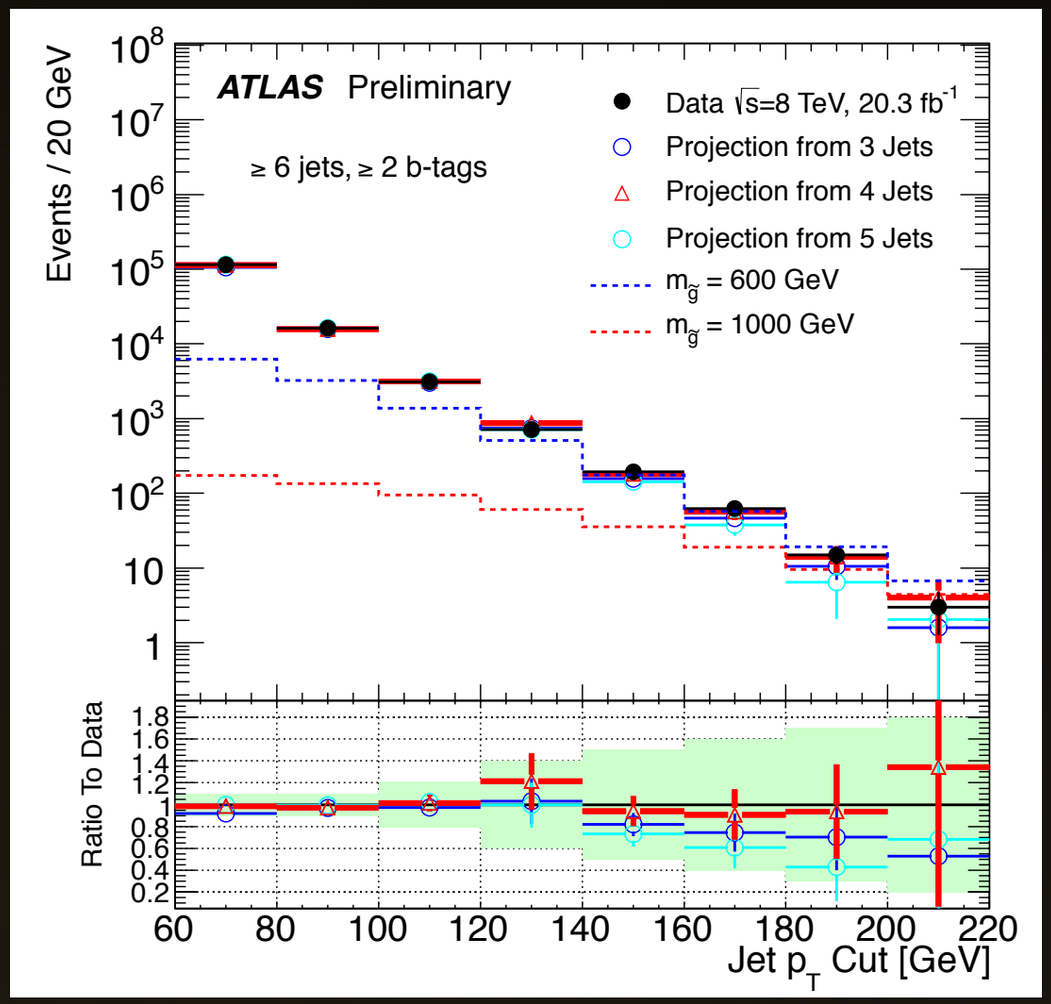
- When interpreting results in 2x(gluino->tbs) model, masses are excluded up to the 1 TeV level for various stop masses

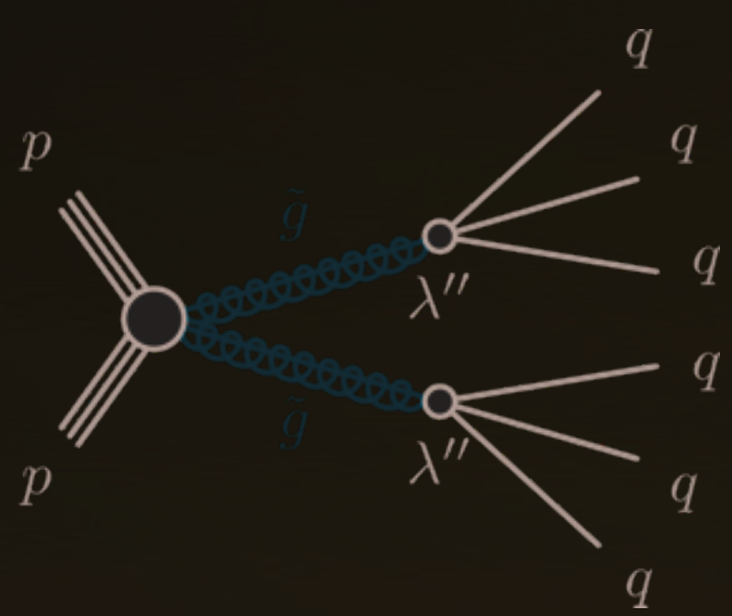


Multijet Without MET

ATLAS - ATLAS-CONF-2013-091

- Purely multijet (w/wo BTags) signal region
- Background dominated by QCD multijet production
  - Estimated in signal regions by projecting data from control regions using simulation
  - Systematic uncertainty on prediction is derived from data from many CRs

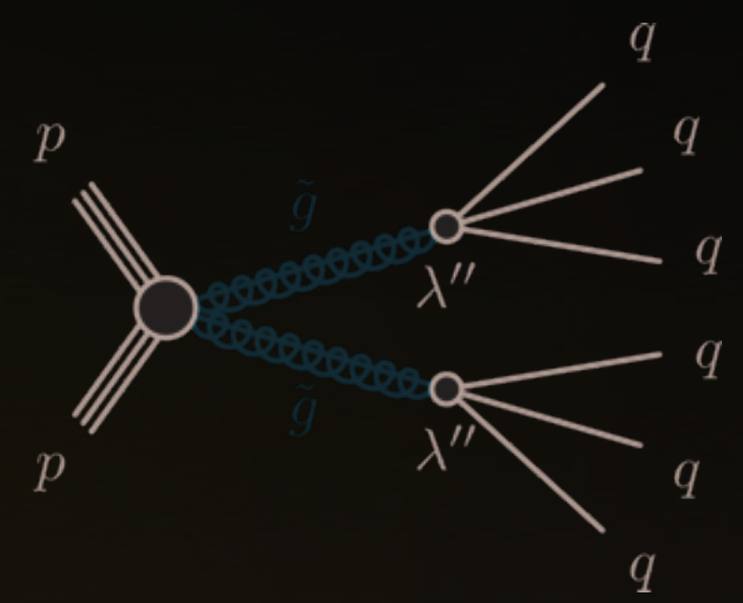




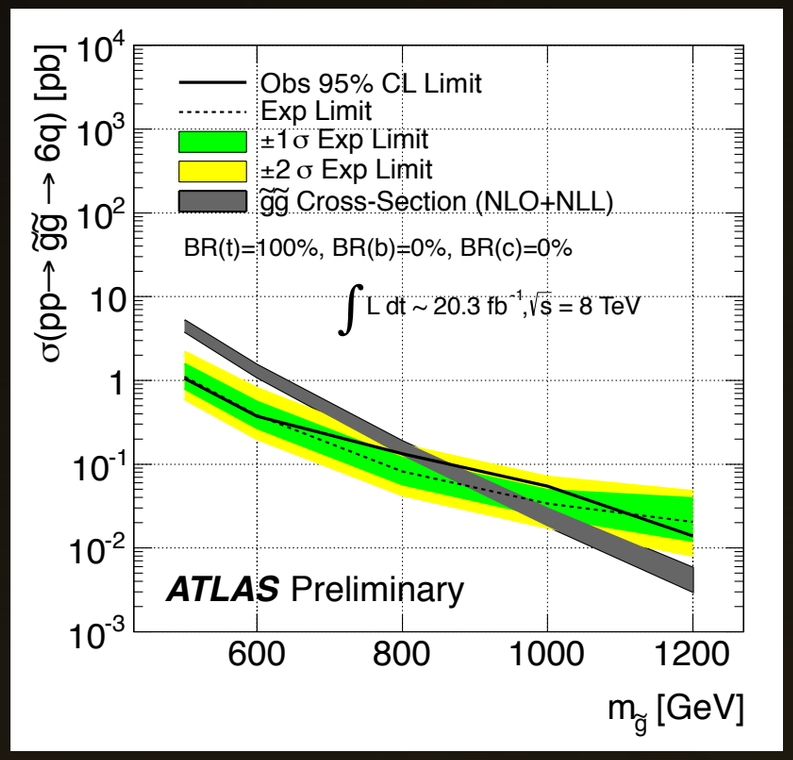
Multijet Without MET

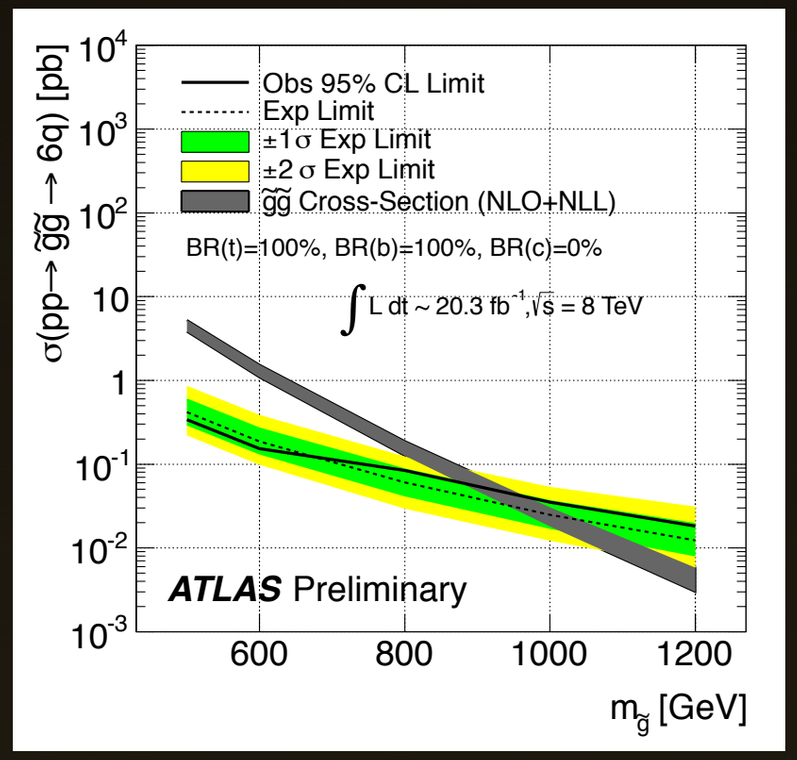
ATLAS - ATLAS-CONF-2013-091

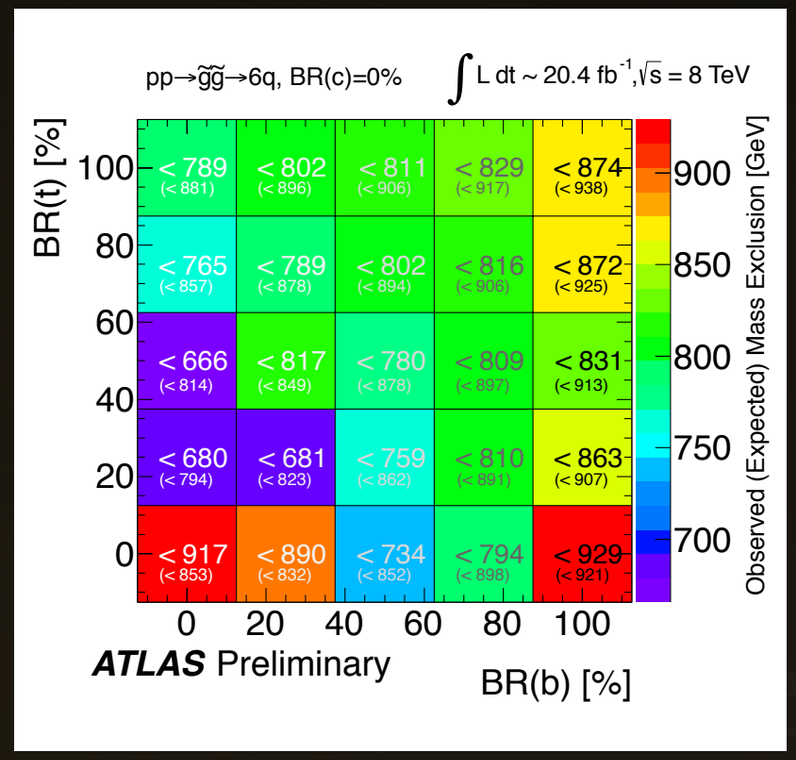
- Signal regions optimized in samples around a flavor space allowing for multiple λ''_{ijk} factors to be nonzero
  - Optimizing NJet, Jet pT cut, NBTags
- For UDD processes where gluinos often decay to top-stop*, gluino masses are excluded below the 700-900 GeV range



λ''_{312} (t,d,s) $\lambda''_{331}, \lambda''_{332}$ (t,b,d) (t,b,s) $\lambda''_{1jk}, \lambda''_{3jk}$ (u,j,j) (t,j,j)

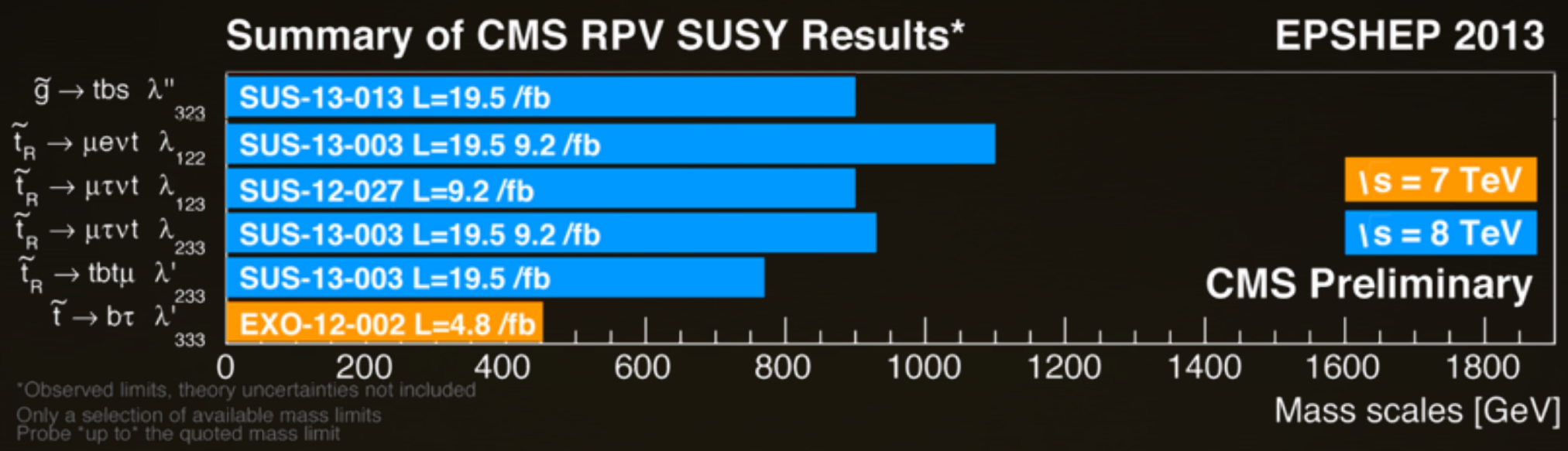






Conclusions

- Active RPV stop program at ATLAS and CMS



- All results presented to date show no deviation from SM expectations
  - Despite a wide array of creative and innovative search methods

Conclusions

- It is, of course, important to probe the last regions of compelling theory space
- But in the absence of new physics, it's difficult to see how SUSY can help restore naturalness

Thanks for your attention

Yale