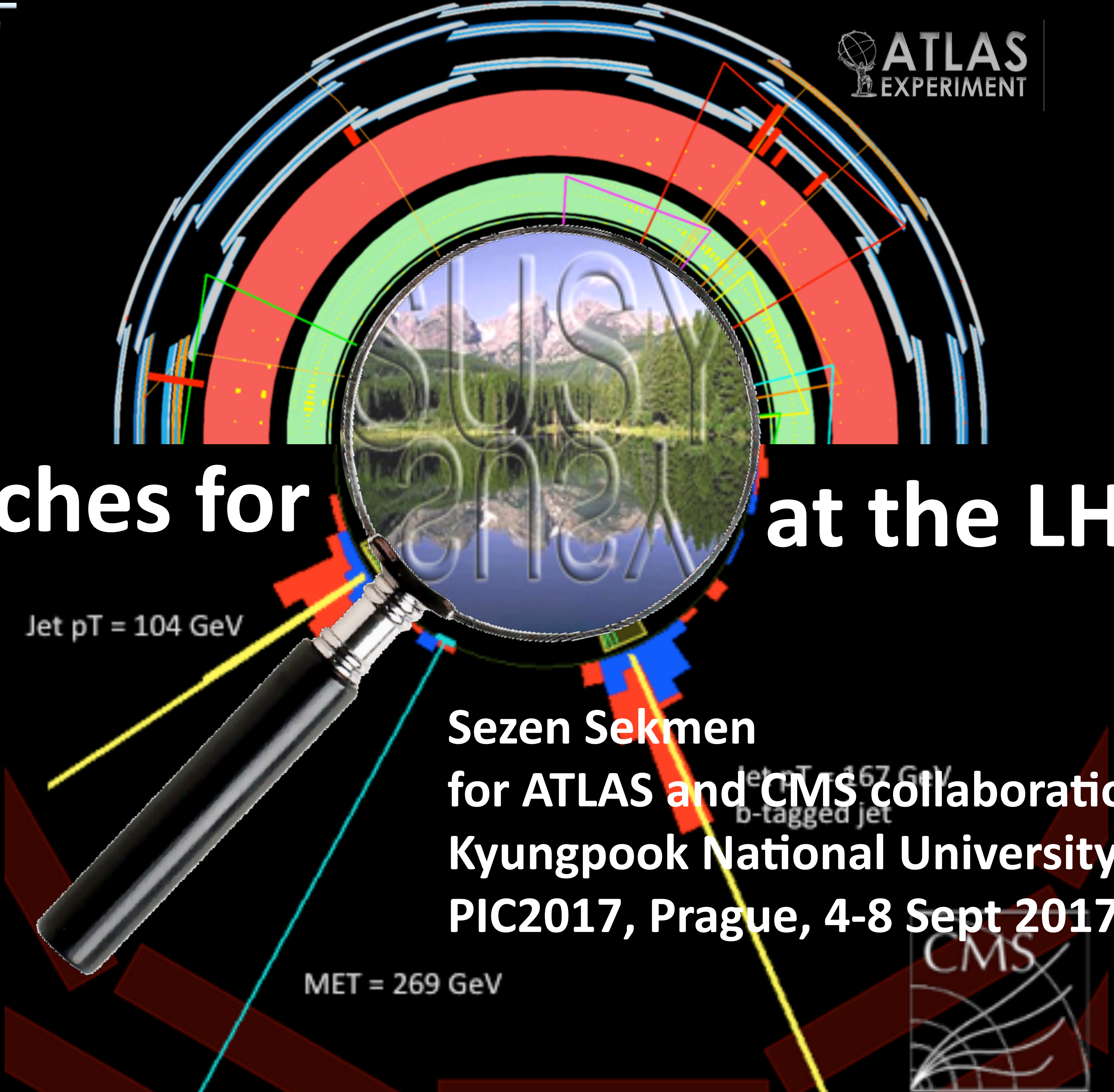
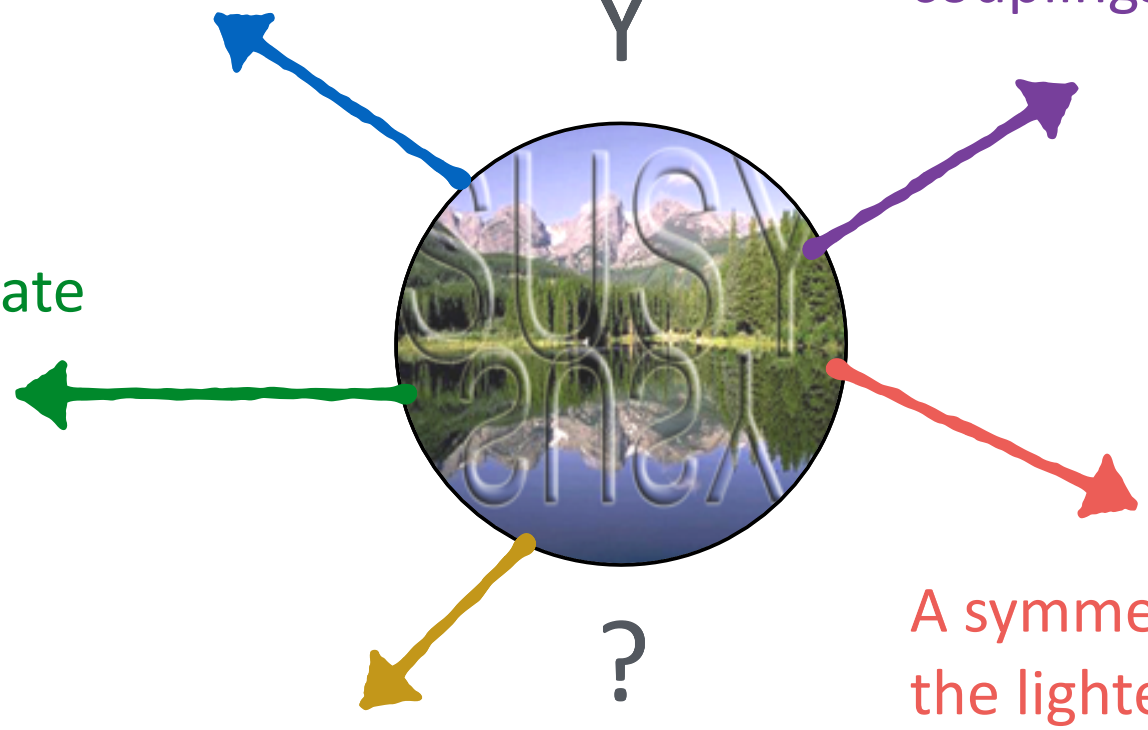


Searches for at the LHC

Sezen Sekmen
for ATLAS and CMS collaborations
Kyungpook National University
PIC2017, Prague, 4-8 Sept 2017

Why do we keep searching for SUSY?

W
H
Y
?



SM is an effective theory. We would like to understand physics in a more generic framework which completes the missing pieces.

SUSY unifies gauge couplings at the GUT scale because contributions from new particles modify running of the gauge couplings.

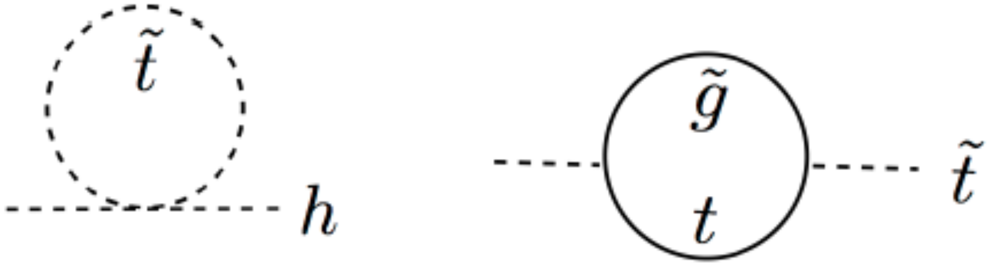
SM does not incorporate gravity. SUSY could.

A symmetry called R-parity forces the lightest supersymmetric particle (LSP) to be stable. When LSP is heavy, neutral and stable, it is a good dark matter candidate.

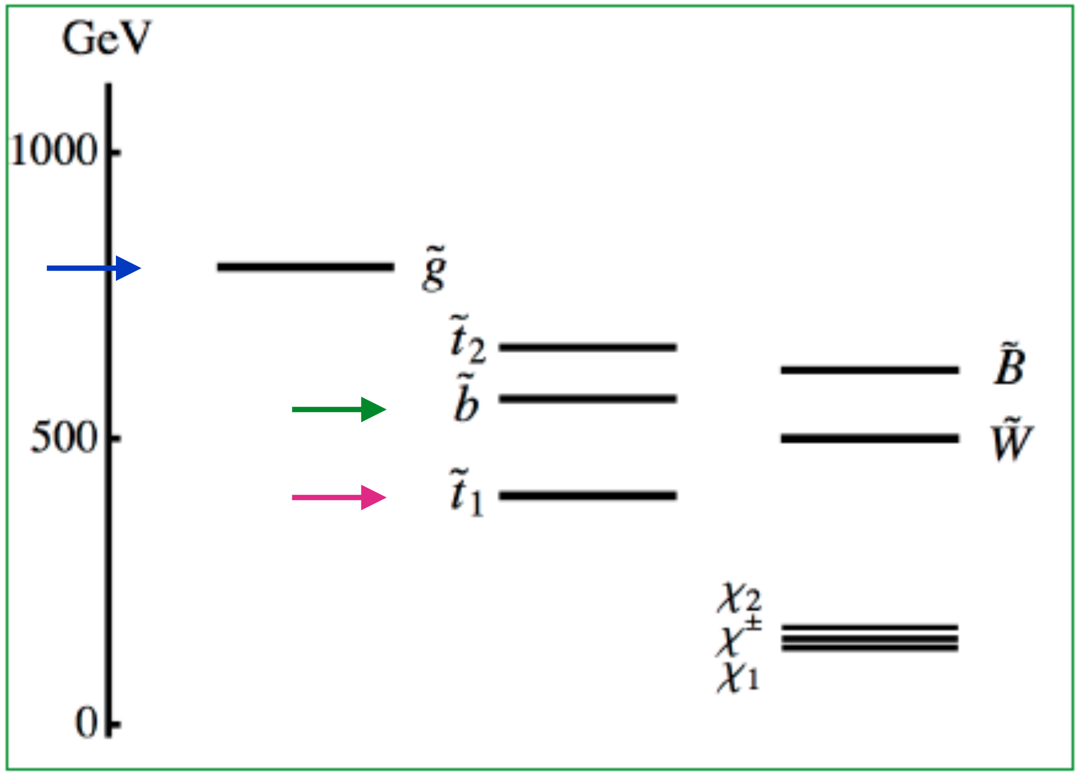
Fine tuning in the corrections to the Higgs mass can be resolved by adding new particles with different spin. SUSY contributions to Higgs mass cancel SM contributions and stabilize the EW scale.

Naturalness drives most SUSY searches

Hierarchy problem: Measured Higgs mass is 125 GeV despite the divergent corrections from the top loop. The divergencies can be cancelled and EW scale can be stabilized by contributions from SUSY particles – but this imposes requirements on the SUSY mass spectrum:



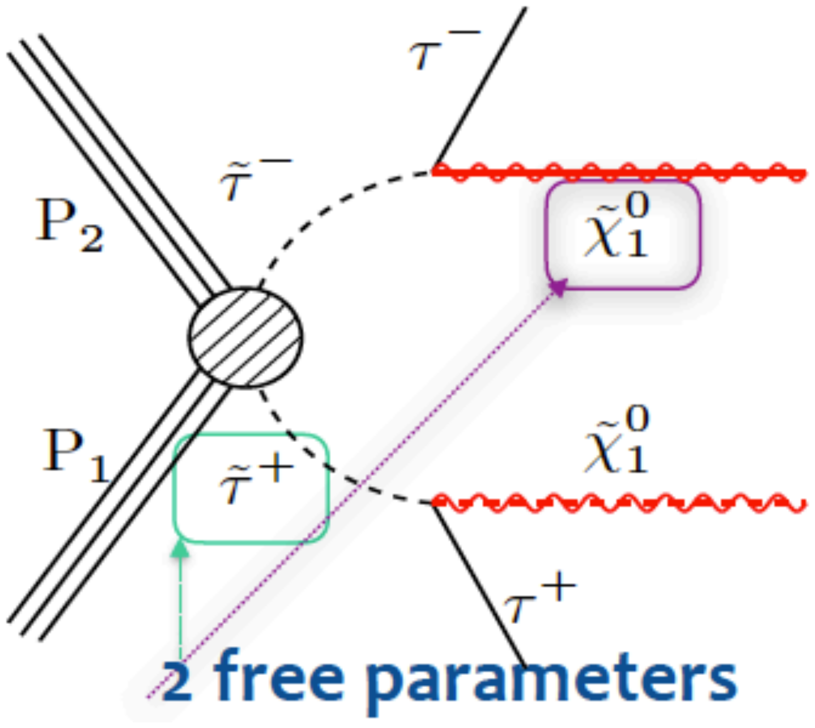
- Leading contribution to the Higgs mass comes from Higgsinos → ≤ few hundred GeV
- Stops contribute to Higgs mass via 1-loop corrections → ≤ few hundred GeV
- Sbottom left can be tied to stop left → ≤ few hundred GeV.
- Gluinos contribute to Higgs mass via 2-loop corrections → ≤ few TeV
- Rest of the spectrum can be decoupled / heavy.
- But *strained* by the current mass limits.



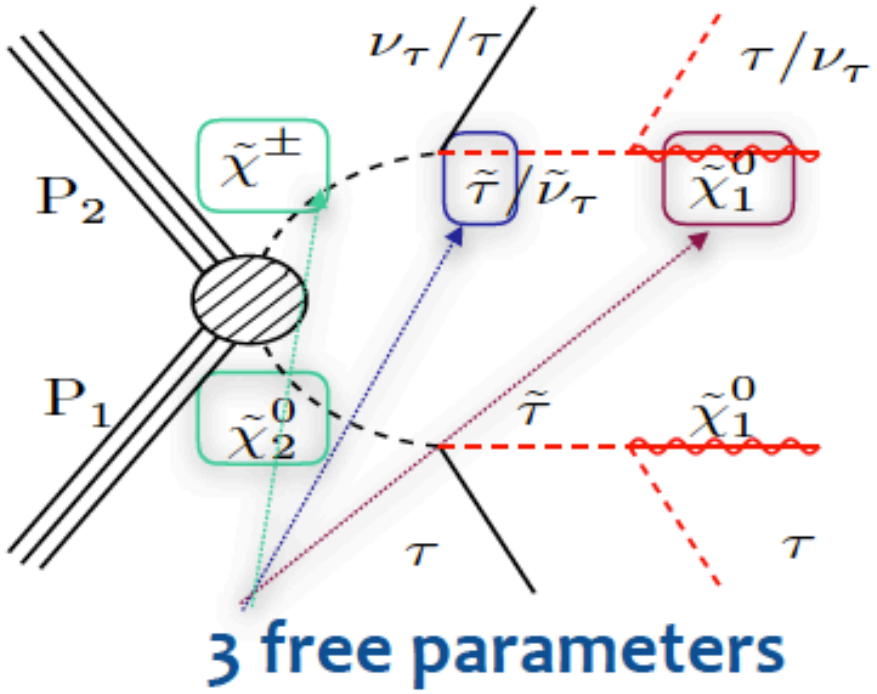
R.Barbieri & D.Pappadopulo JHEP 0910:061,2009

SUSY(-like) models for interpretation

- Use mainly simplified models. Occasional use of full models like phenomenological MSSM (generic interpretation at the end of a Run).
- A simplified model spectrum (SMS) is defined by a set of hypothetical particles and a sequence of their production and decays.
- Mainly production of 2 particles.
- Each particle decays directly or via a cascade to particles X + a neutral, undetected particle (i.e., neutralino lighterst SUSY particle), or to SM particles (for RPV).
- For each SMS point, experimental acceptance times efficiency (A X e) is calculated.
- From this information, a 95% confidence level upper limit on the product of σ x BR is derived as a function of the particle mass.

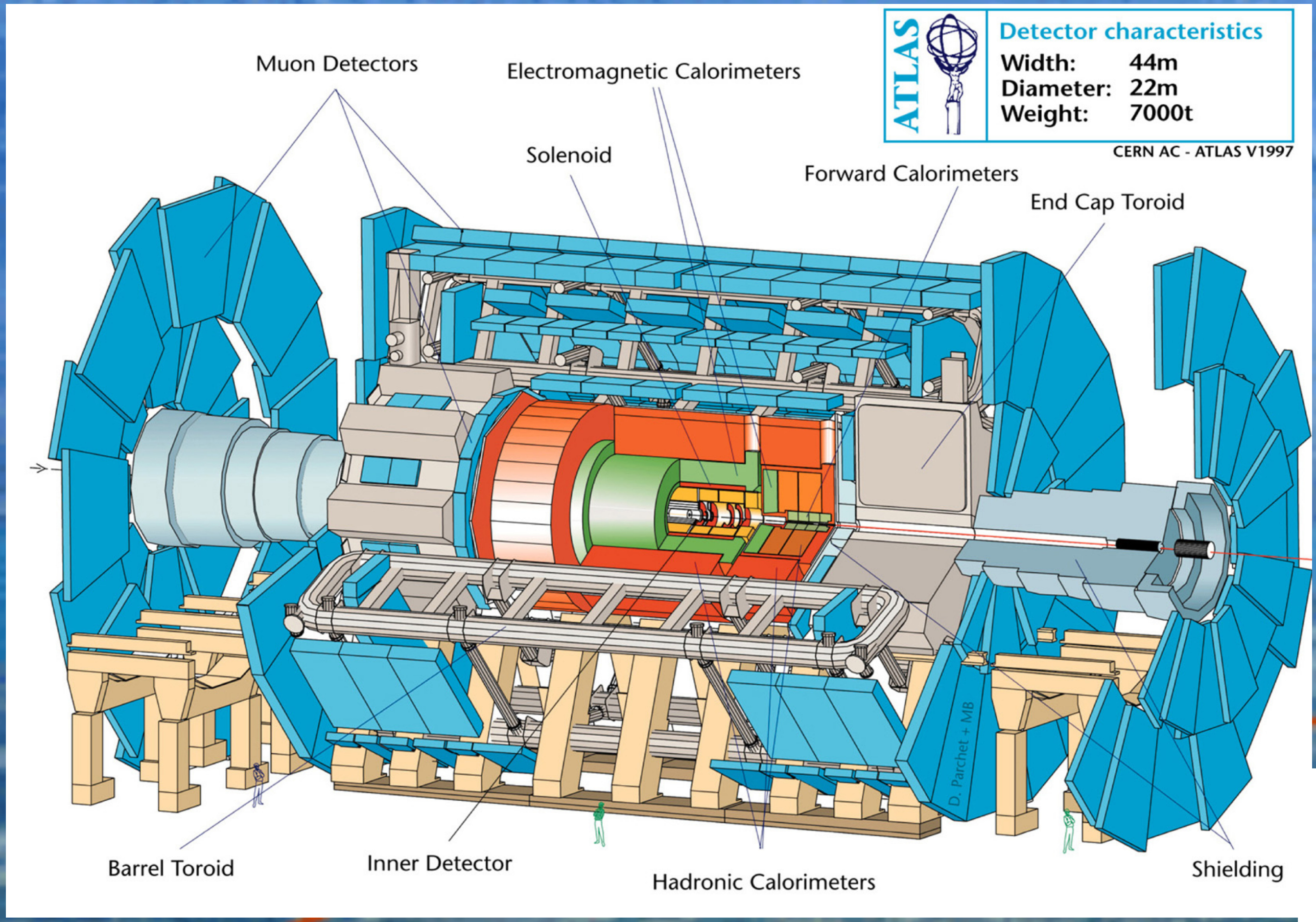


2 free parameters

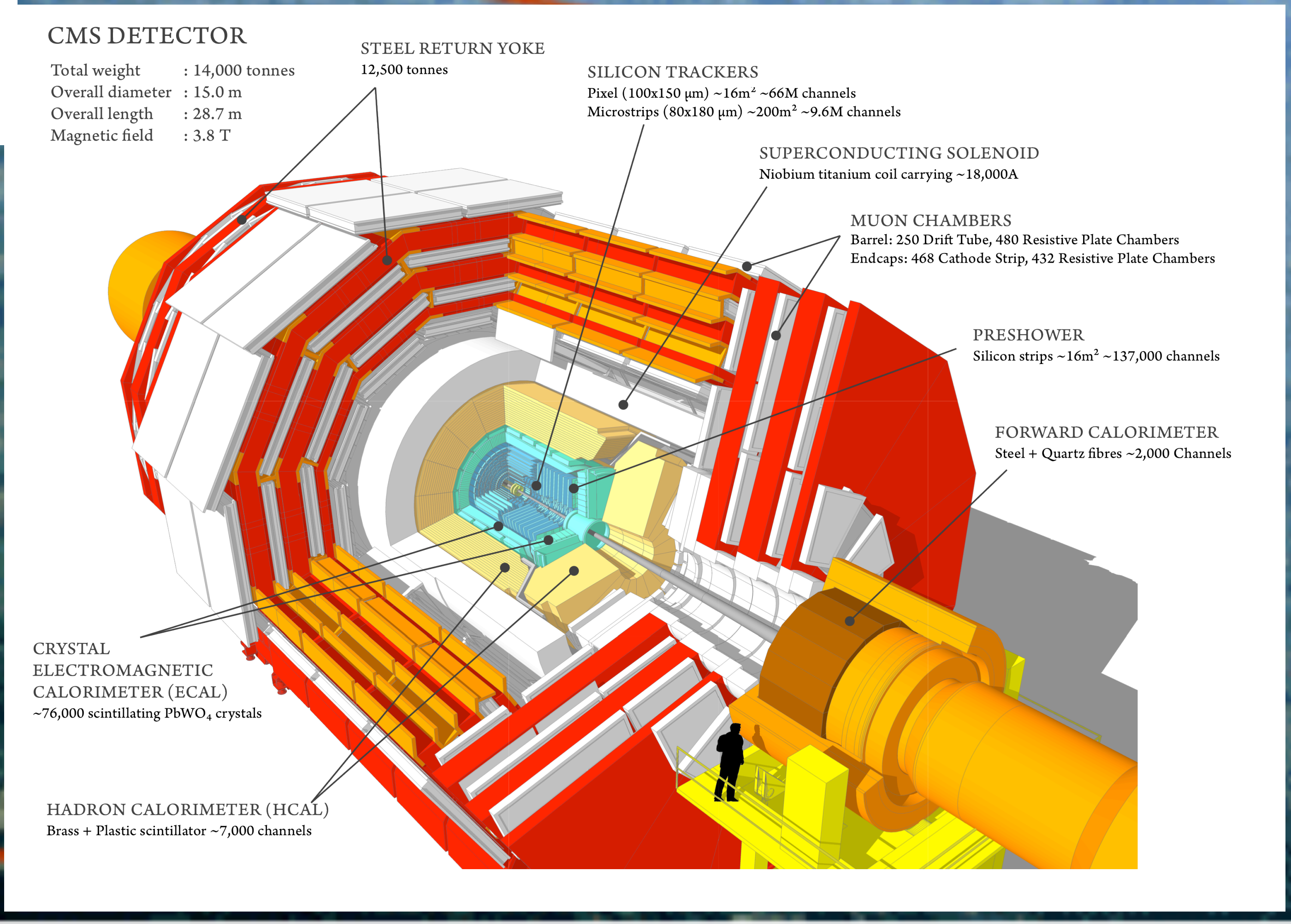


3 free parameters

A typical SUSY analysis at ATLAS and CMS



ATLAS and CMS are generic purpose LHC detectors designed to optimally make standard model measurements and new physics searches.



Run1: 2008-2013,
7TeV, ~5fb^{-1} + 8 TeV, ~20fb^{-1}

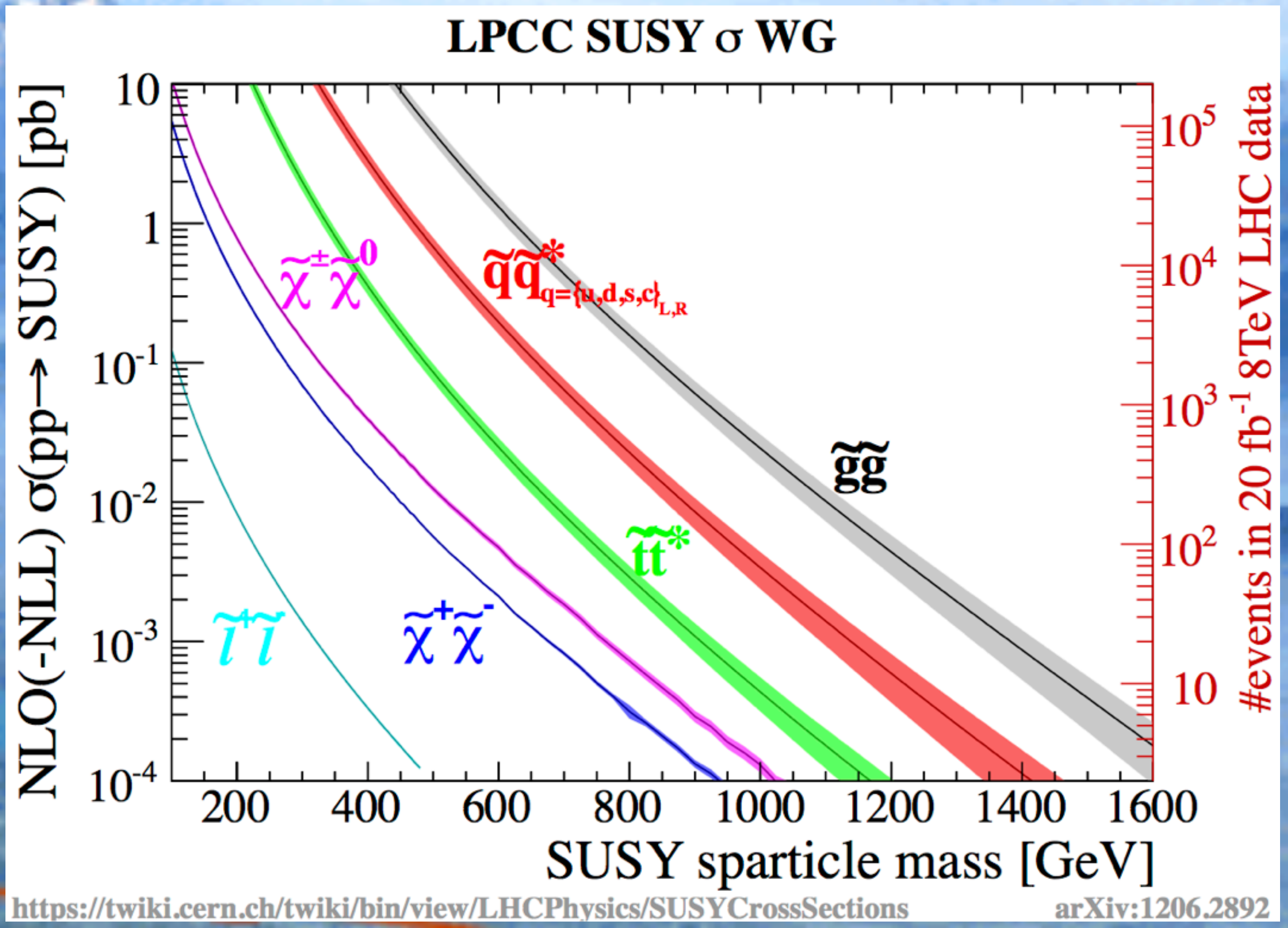
Run2: 2015-2018
13TeV, ~36 fb^{-1} (data taking continues)

~1000 papers from ATLAS and CMS.

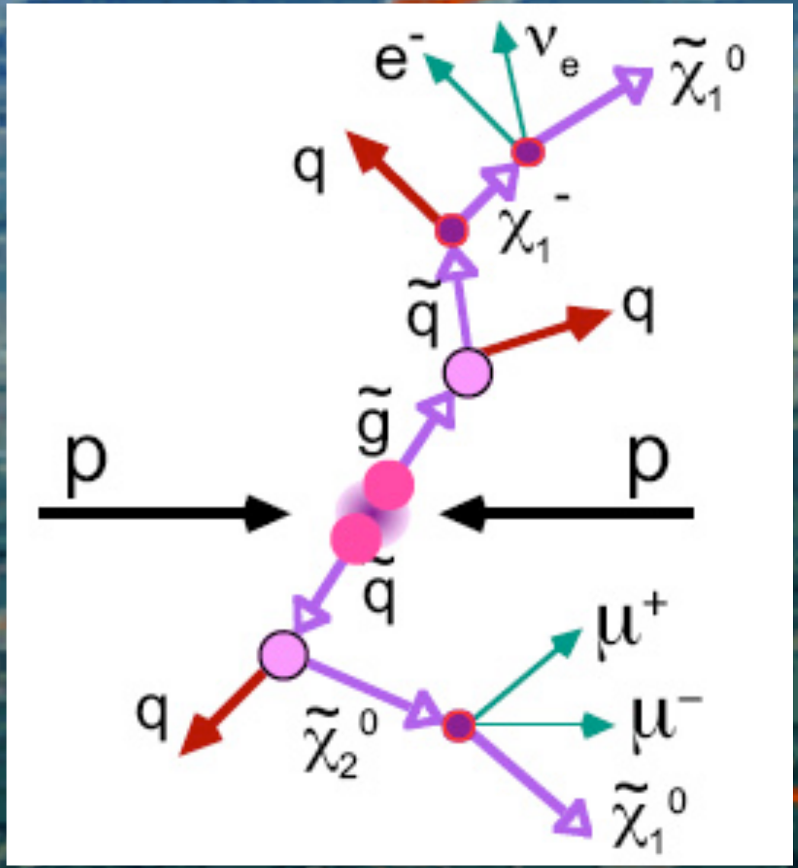
SUSY at the LHC

SUSY has O(100) free parameters. It can be realized in diverse ways: different sparticle masses, cross sections, branching ratios…

- In R parity conserving SUSY, sparticles are produced in pairs. Decay chain ends with lightest SUSY particle (LSP).
- Masses up to ~2.1 TeV are accessible at the 13 TeV LHC with ~36 fb^{-1}.

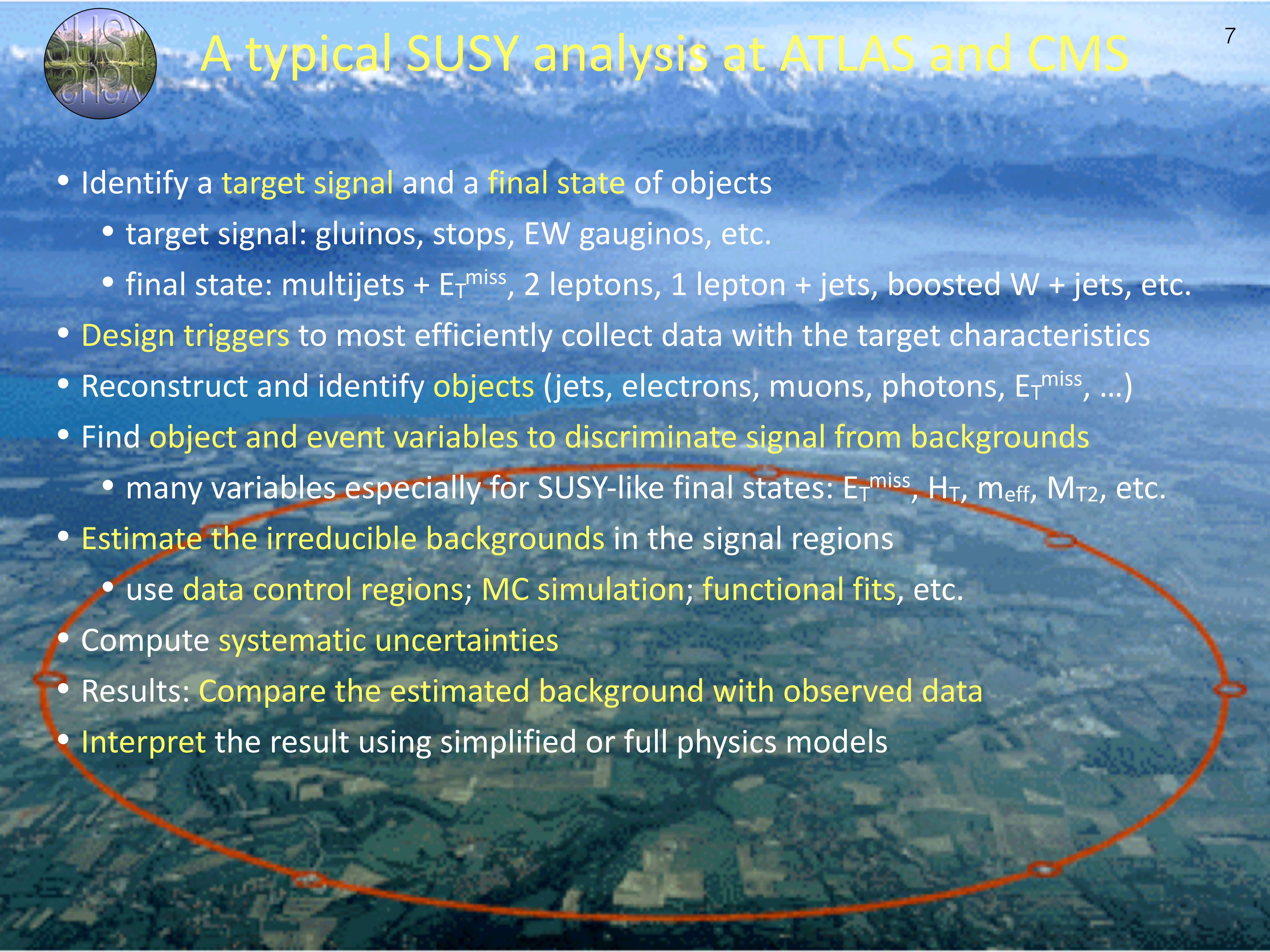


https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections arXiv:1206.2892



Heavy sparticles decay to lighter sparticles and SM particles. Can see final states with large number and diversity of particles: multijets, multi-b-jets,-t-quarks, multi-leptons.

- R parity conserving SUSY: neutralino or gravitino LSP —> high missing transverse energy (E_T^{miss}).
- R parity violating SUSY: decay to SM particles. —> reconstruct resonances, search excesses in SM.
- Suppress and estimate SM backgrounds with orders of magnitude larger cross sections.



A typical SUSY analysis at ATLAS and CMS

- Identify a target signal and a final state of objects
  - target signal: gluinos, stops, EW gauginos, etc.
  - final state: multijets + E_T^{miss}, 2 leptons, 1 lepton + jets, boosted W + jets, etc.
- Design triggers to most efficiently collect data with the target characteristics
- Reconstruct and identify objects (jets, electrons, muons, photons, E_T^{miss}, …)
- Find object and event variables to discriminate signal from backgrounds
  - many variables especially for SUSY-like final states: E_T^{miss}, H_T, m_{eff}, M_{T2}, etc.
- Estimate the irreducible backgrounds in the signal regions
  - use data control regions; MC simulation; functional fits, etc.
- Compute systematic uncertainties
- Results: Compare the estimated background with observed data
- Interpret the result using simplified or full physics models

Results in summary:

No

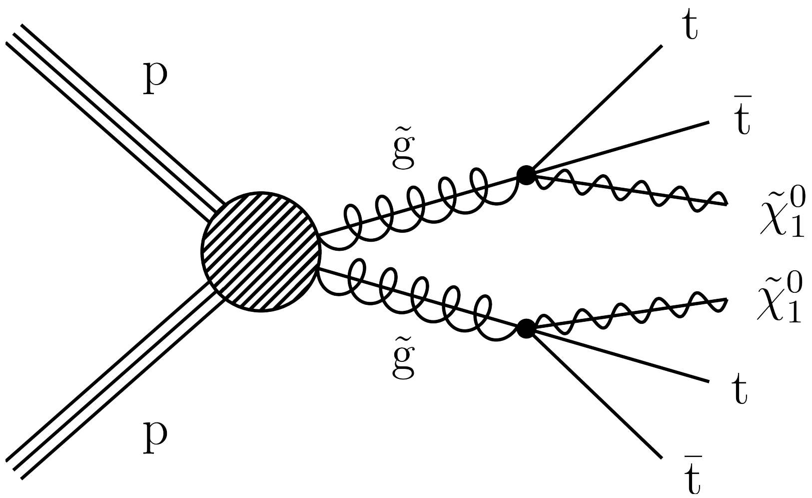
yet

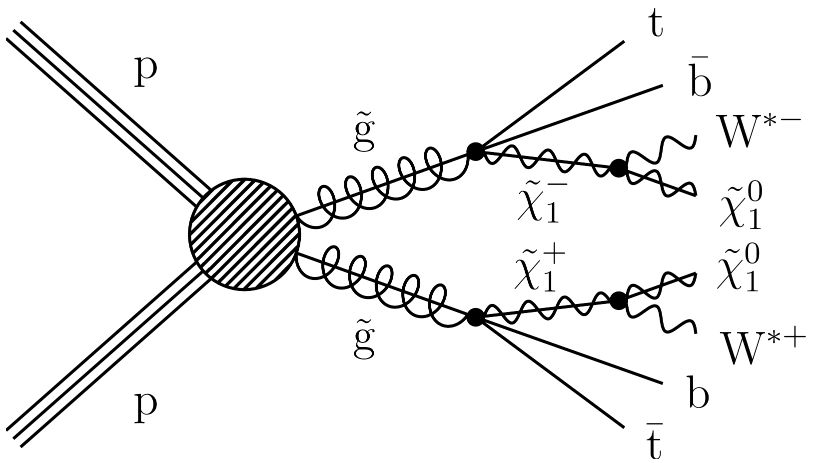
But lots of searches for lots of processes in lots of final states using lots of variables and methods, resulting in lots of limits.

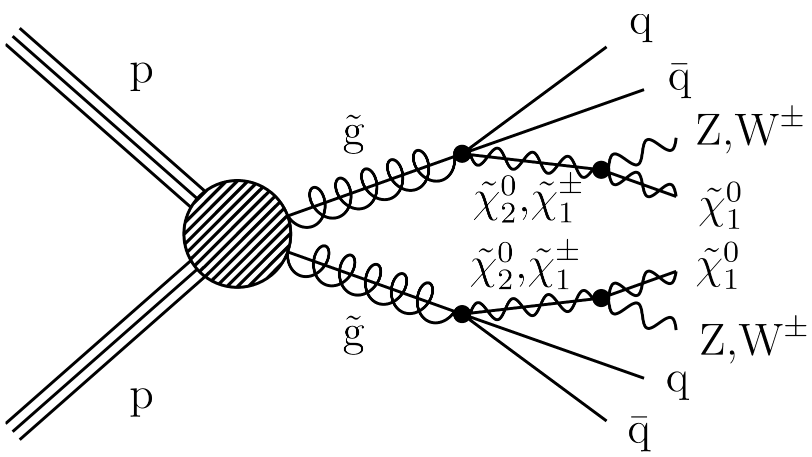
Inclusive searches

- Inclusive searches are sensitive to:
  - mainly gluinos due to their high production cross sections and diverse decay modes, simple decays or cascades.
  - also squarks and EW gauginos.
- Used multiple objects (jets, b jets, leptons, photons, E_T^{miss}).
- Final states: fully hadronic, single or dileptons, single or diphotons.
- Used kinematic variables designed to discriminate final states with heavy particles and/or E_T^{miss}:
- Used multiple search regions defined by different object multiplicities and kinematic variables.
- Current integrated luminosity allows us to work with disjoint search regions.

Gluino examples







inclusive

Kinematic variables for inclusive searches

Missing transverse energy:

$$E_T^{miss} = \left| - \sum_i^{n\,visible} \vec{p}_T^{\,visible} \right|$$

Missing hadronic transverse momentum:

$$\not{H}_T = H_T^{miss} = - \sum_i^{n\,jets} \vec{p}_T^{\,jet_i}$$

for neutral LSP: neutralinos, gravitinos…

Hadronic transverse energy

$$H_T = \sum_i^{n\,jet} p_T^{jet}$$

Effective mass:

$$m_{\rm eff} = E_T^{\rm miss} + H_T$$

Stransverse mass: For $\tilde{q} \to X \tilde{\chi}_1^0$

$$m_{T2}(m_{\tilde{\chi}}) = \min_{\vec{p}_T^{\,\tilde{\chi}1} + \vec{p}_T^{\,\tilde{\chi}2} = \vec{p}_T^{\,miss}} \left[\max\left(m_T(\vec{p}_T^{\,j1}, \vec{p}_T^{\,\tilde{\chi}1}), m_T(\vec{p}_T^{\,j2}, \vec{p}_T^{\,\tilde{\chi}2}) \right) \right] \leq m_{\tilde{q}}^2$$

where the transverse mass is:

$$\begin{aligned} m_{T,W}^2 &= m_\ell^2 + m_\nu^2 + 2(p_T^\ell p_T^\nu - \vec{p}_T^{\,\ell} \vec{p}_T^{\,\nu}) \\ (m_\ell, m_\nu \sim 0 \rightarrow) &\simeq 2 p_T^\ell p_T^\nu (1 - \cos\Delta\phi(\ell,\nu)) \end{aligned}$$

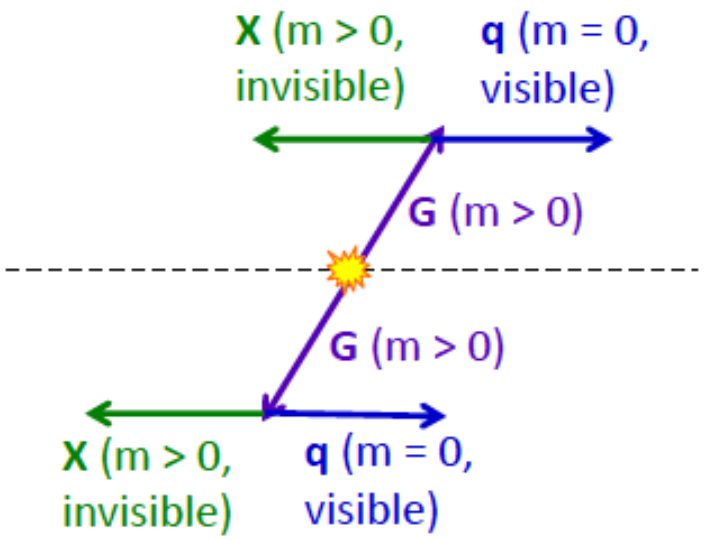
for high transverse activity

inclusive

Kinematic variables for inclusive searches

For a system with 2 massive particles decaying to
2 massless visible and 2 massive invisible particles.

Kinematic variables built by first building a dijet system.



alphaT: For a dijet system with

$$\alpha_T = E_T^{J2} / M_T(jj)$$

where m_T(jj) is the dijet transverse mass system.

Razor variables: Estimate

$$|\vec{p}^{\,q}| = (m_G^2 - m_\chi^2)/2m_G = m_\Delta/2$$

using longitudinal
lab fr. observables:

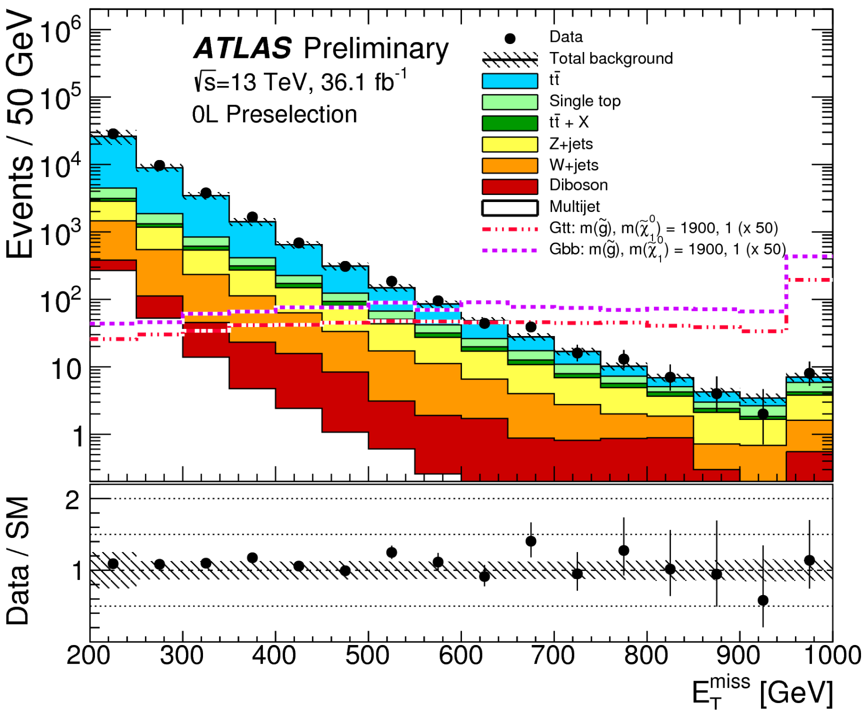
$$M_R = \sqrt{\frac{(\vec{p}_z^{\,q1} E^{q2} - \vec{p}_z^{\,q2} E^{q1})^2}{(\vec{p}_z^{\,q1} - \vec{p}_z^{\,q2})^2 - (E^{q1} - E^{q2})^2}} \approx m_\Delta$$

using transverse
lab fr. observables:

$$M_T^R = \sqrt{\frac{E_T^{miss}}{2}(p_T^{q1} + p_T^{q2}) - \frac{1}{2}\vec{E}_T^{miss} \cdot (\vec{p}_T^{\,q1} + \vec{p}_T^{\,q2})} < m_\Delta$$

$$R \equiv M_T^R / M_R$$

inclusive Variables in multijet searches

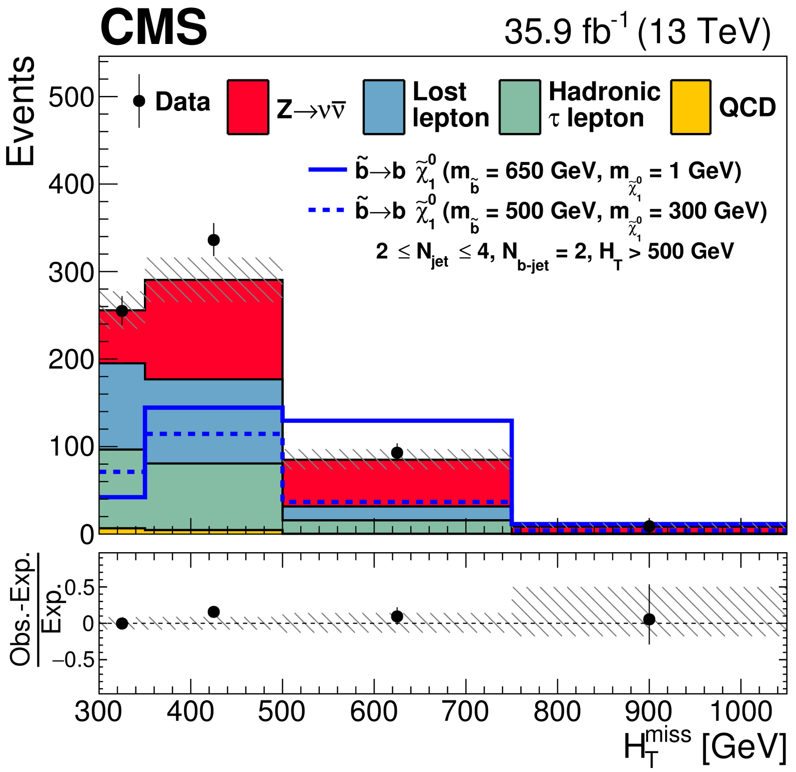


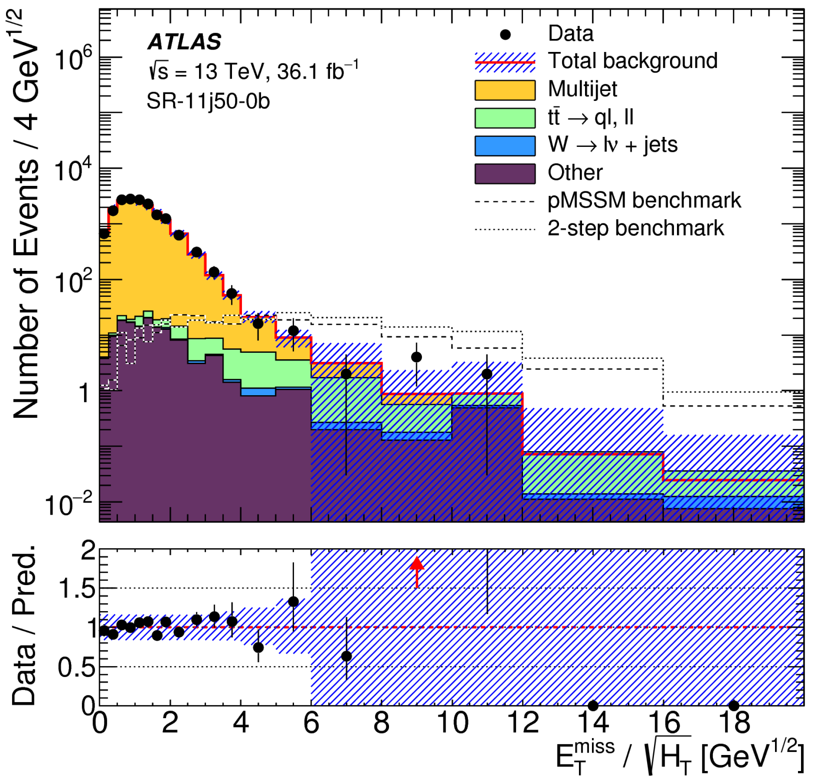
ATLAS-CONF-2017-021

Multiple b jets + E_T^{miss}.

CMS SUS-16-033

Multijets + missing transverse momentum H_T^{miss}.





ATLAS arxiv:1708.02794

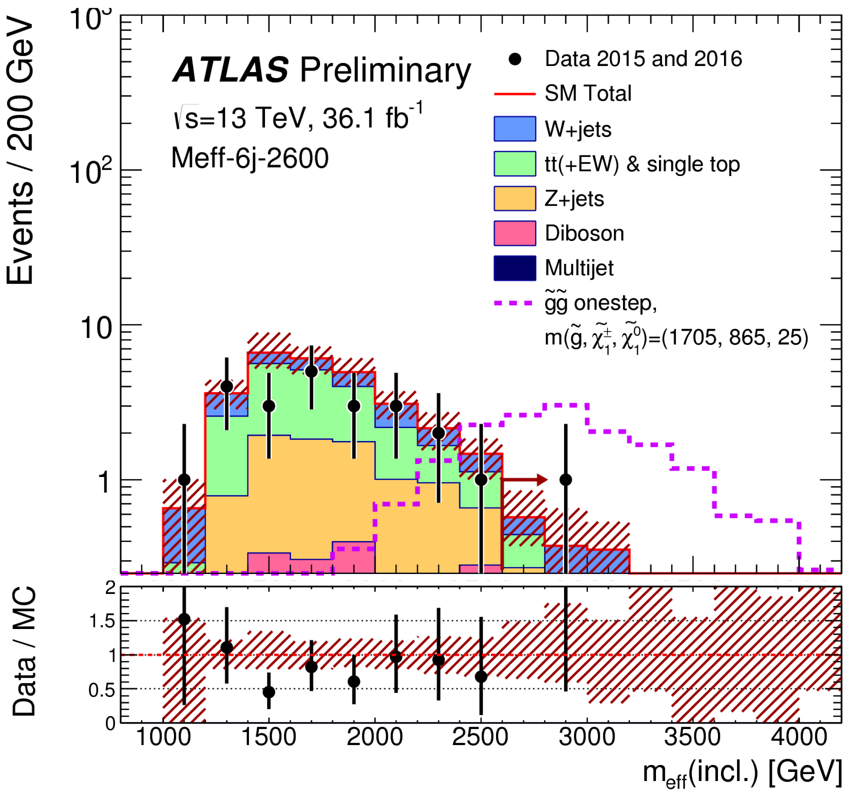
7-12 jets + E_T^{miss}.

E_T^{miss} / sqrt(H_T) in a signal region

ATLAS-CONF-2017-022

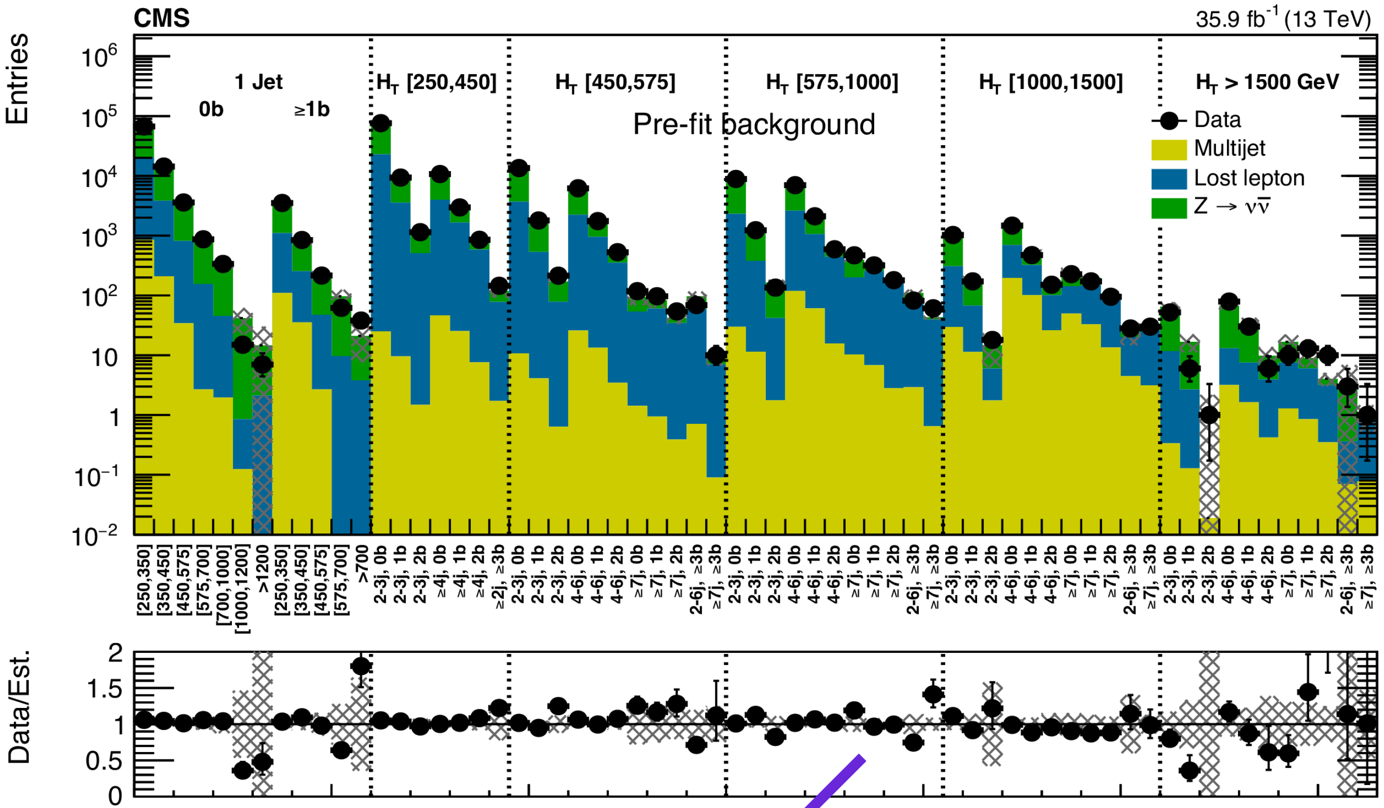
2-6 jets + E_T^{miss}.

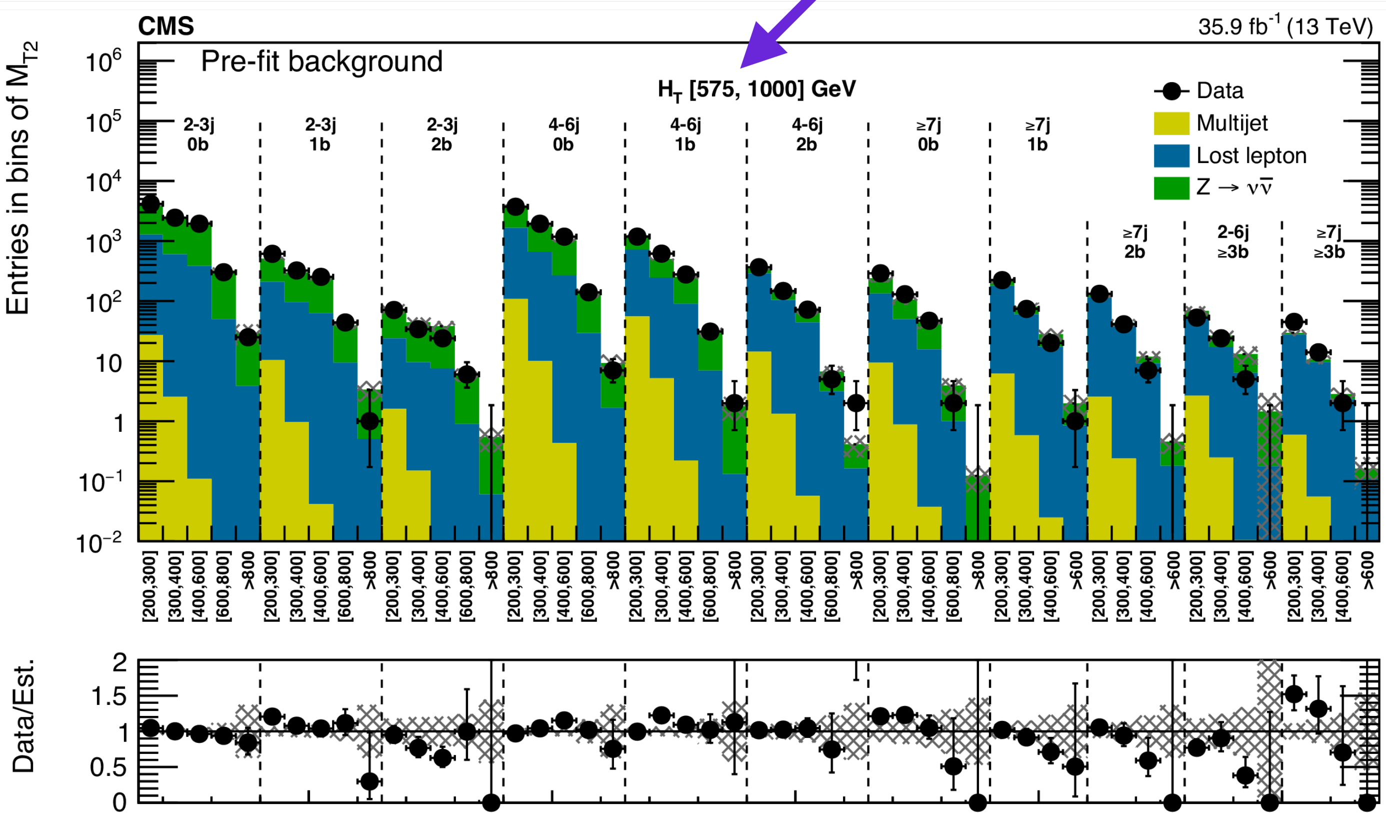
m_{eff}. in a signal region



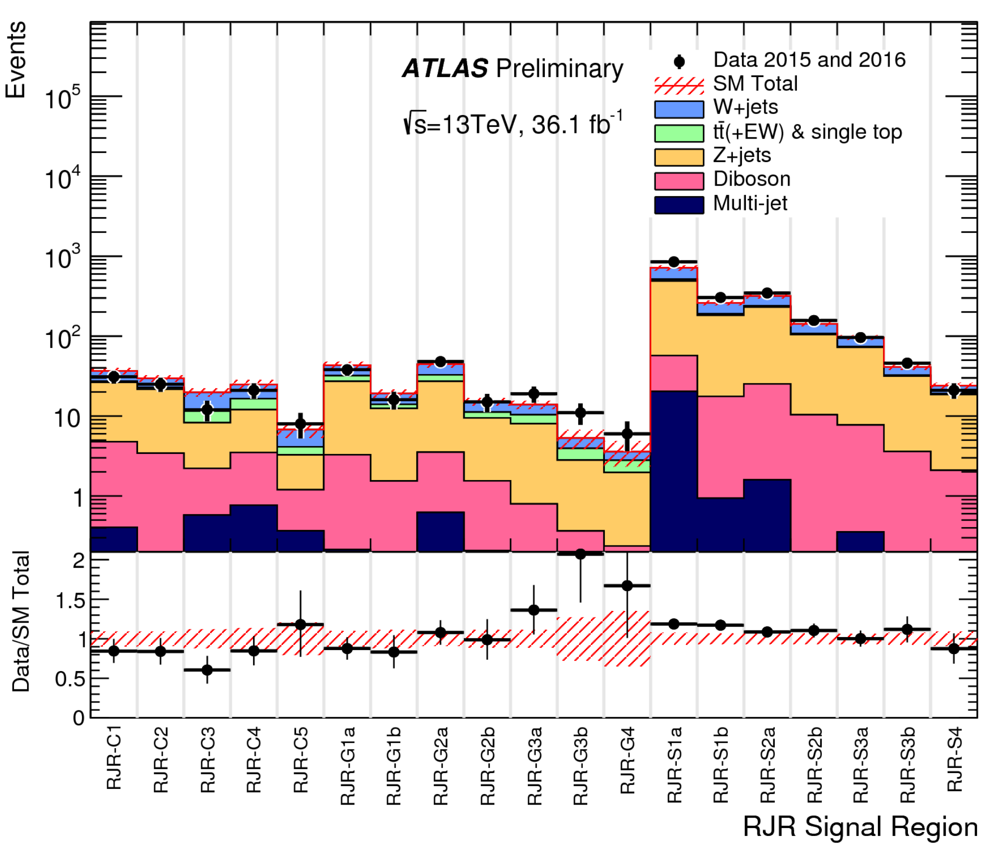
inclusive Multijet search results

CMS SUS-16-036, m_{T2} analysis.

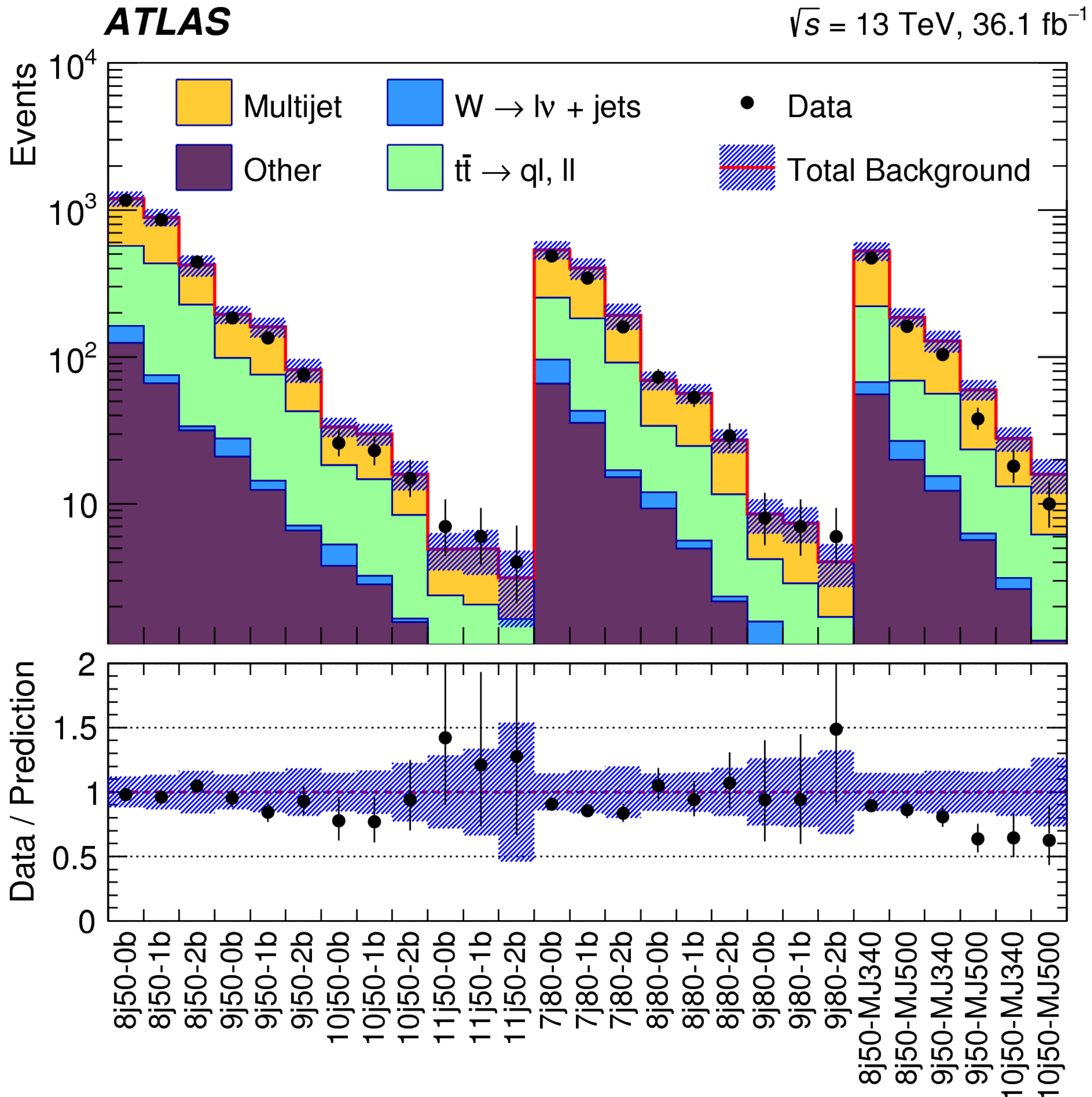




ATLAS-CONF-2017-022
2-6 jets + E_T^{miss}.

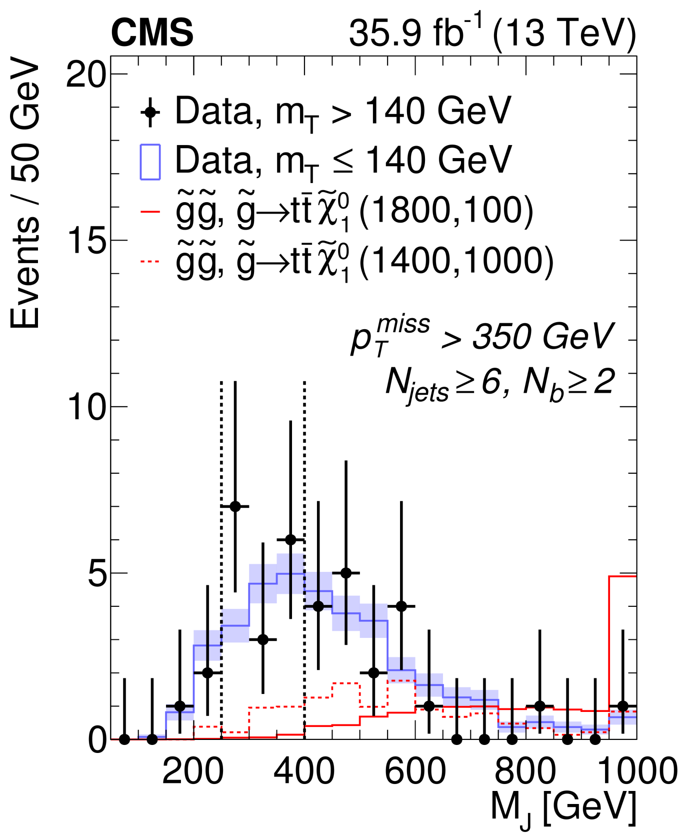


ATLAS arxiv:1708.02794, 7-11 jets + E_T^{miss}.



inclusive

Inclusive searches: 1 lepton



CMS SUS-16-037

1lep + jets + E_T^{miss}

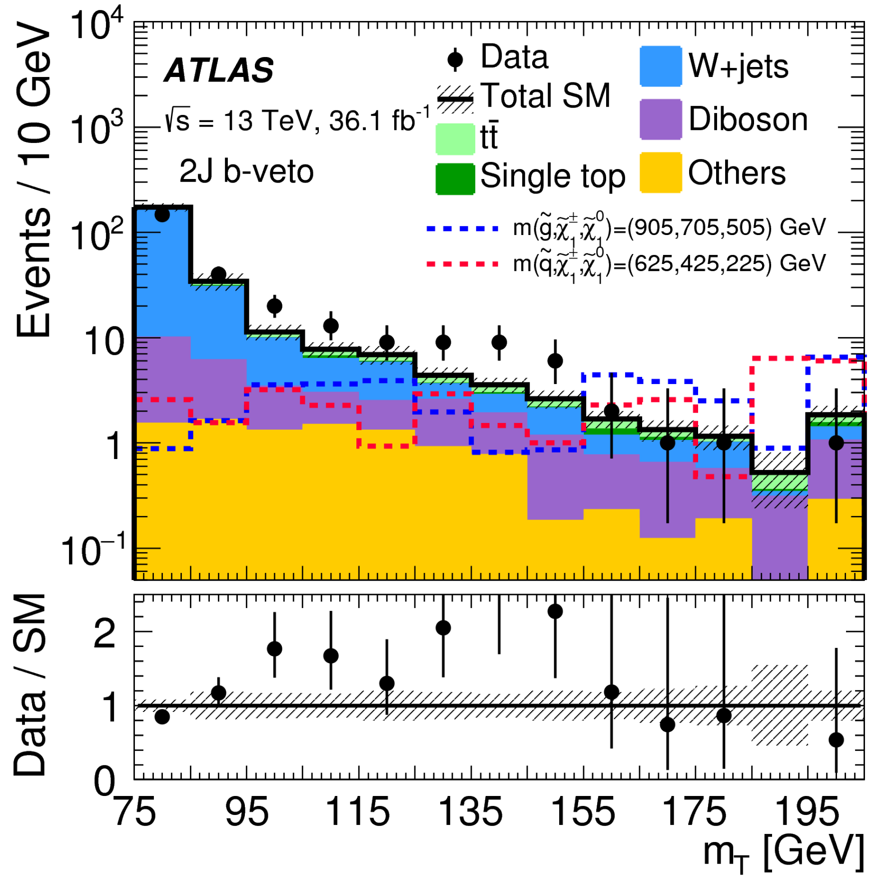
using $M_J = \Sigma_i\, m(j_i)$.

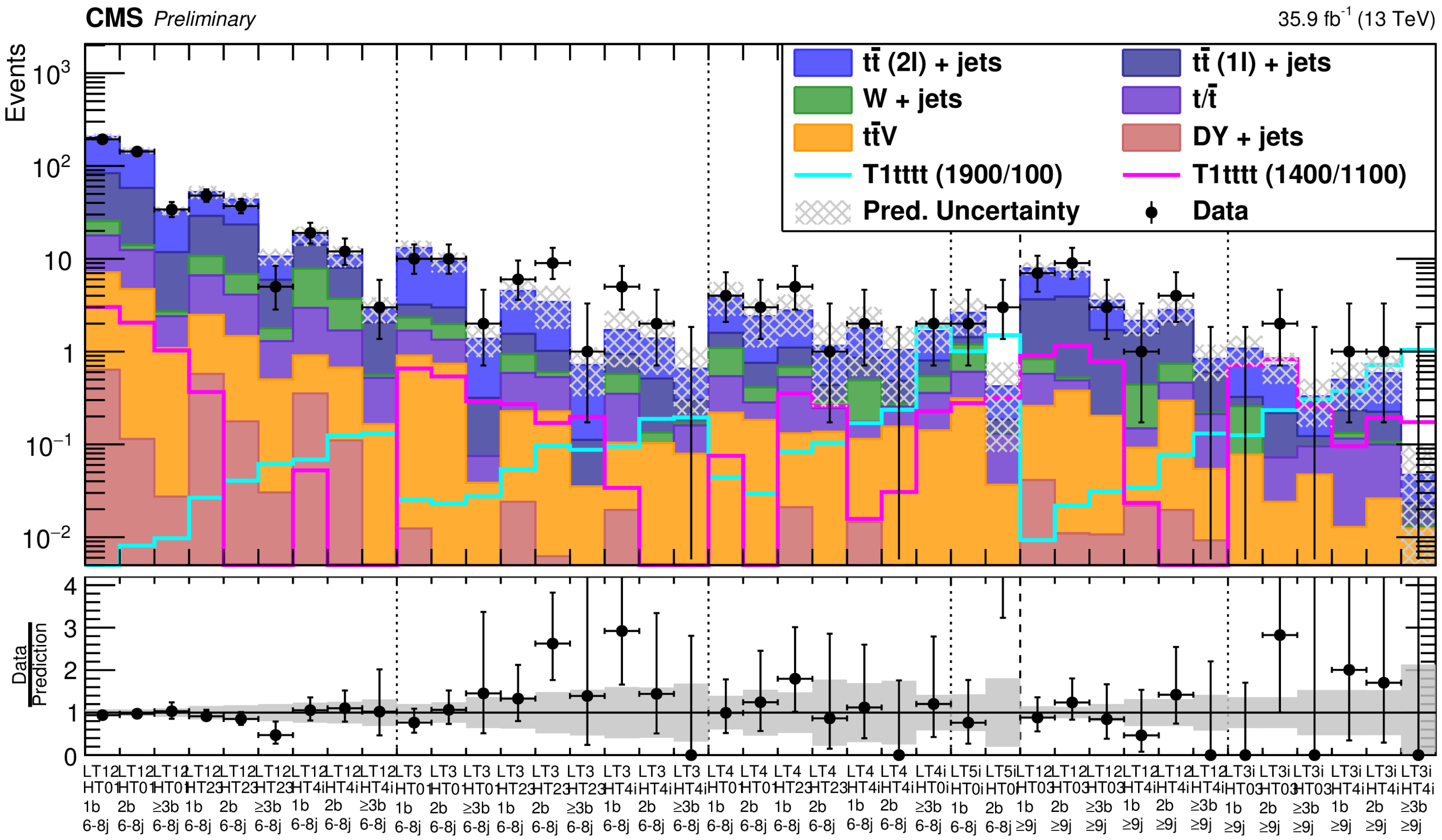
M_J distribution for a signal region.

ATLAS arXiv:1708.08232

1lep + jets + E_T^{miss}

m_T distribution for the 2jet b veto signal region.





CMS SUS-16-042

1lep + jets + E_T^{miss}.

using m_{T2}.

Data - BG estimate comparisons in 39 search regions defined by n_{jets}, n_b, H_T, $L_T = p_T^{lepton} + E_T^{miss}$

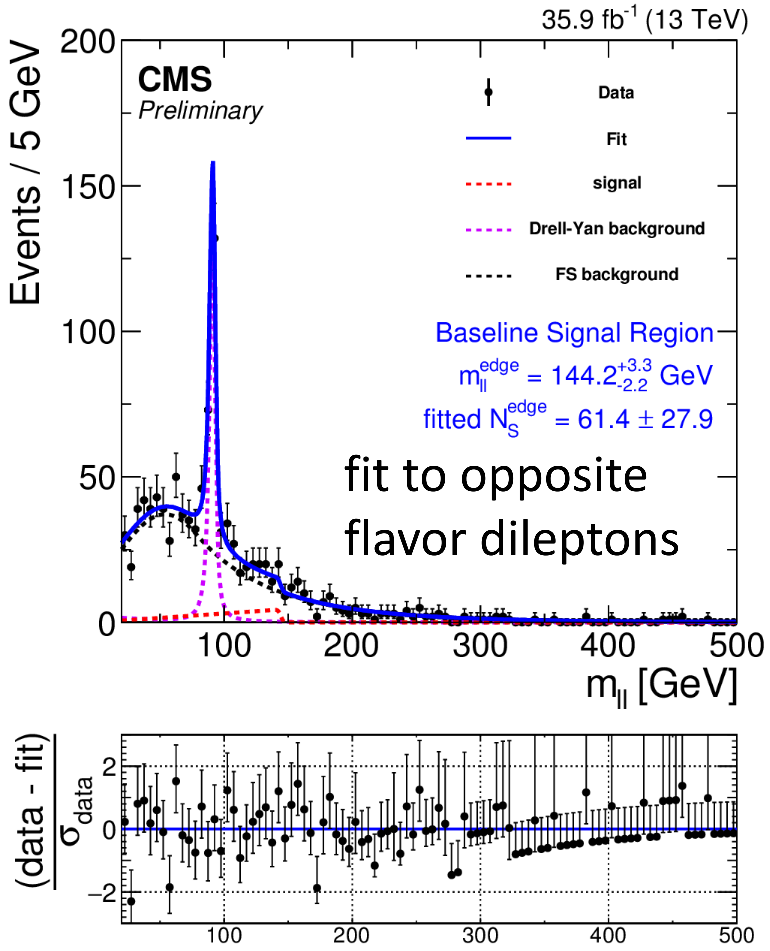
Inclusive searches: 2 leptons

CMS SUS-16-034: Opposite sign dileptons + jets + E_T^{miss}.

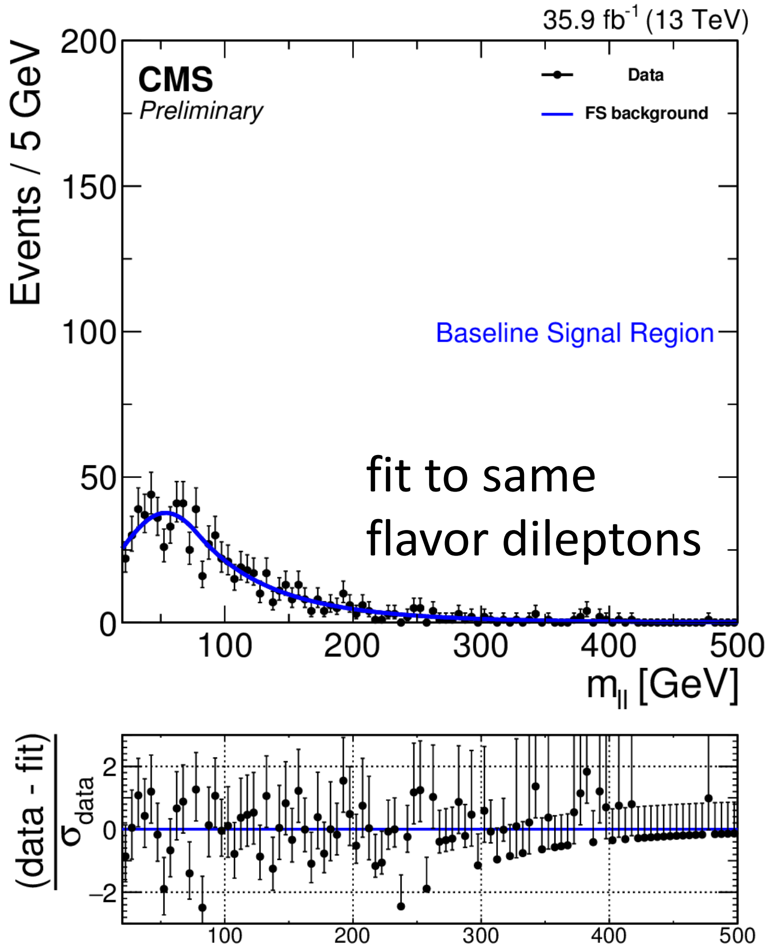
Uses dilepton invariant mass m_{ll} to search for

- a resonance-like excess compatible with the Z boson mass (targets both strongly and electroweakly produced new physics.
- or a kinematic edge (targets strong production)

Kinematic fit to m_{ll} to find an edge in the non-resonant search. Signal: triangle convoluted with a Gaussian.



fit to opposite flavor dileptons



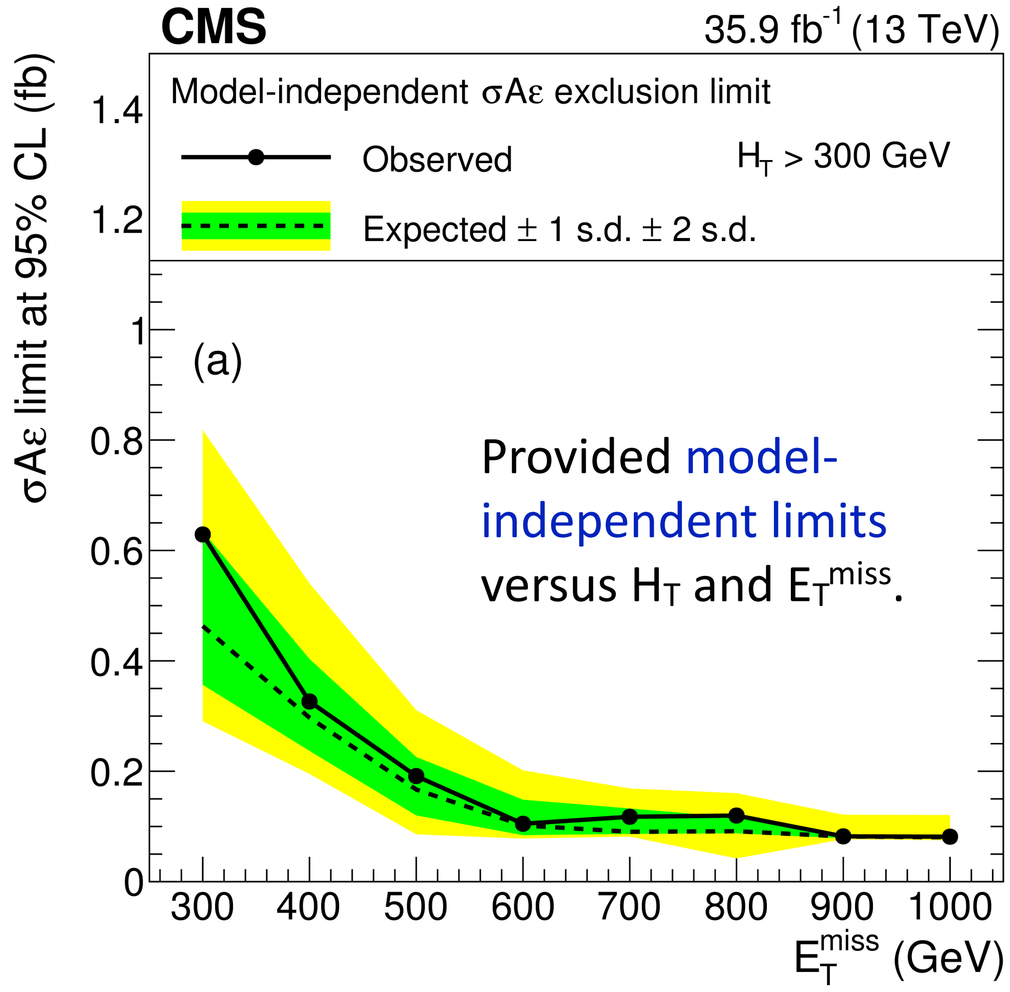
fit to same flavor dileptons

CMS SUS-16-035

Same sign dileptons + jets + E_T^{miss}.

Dominant backgrounds from non-prompt leptons.

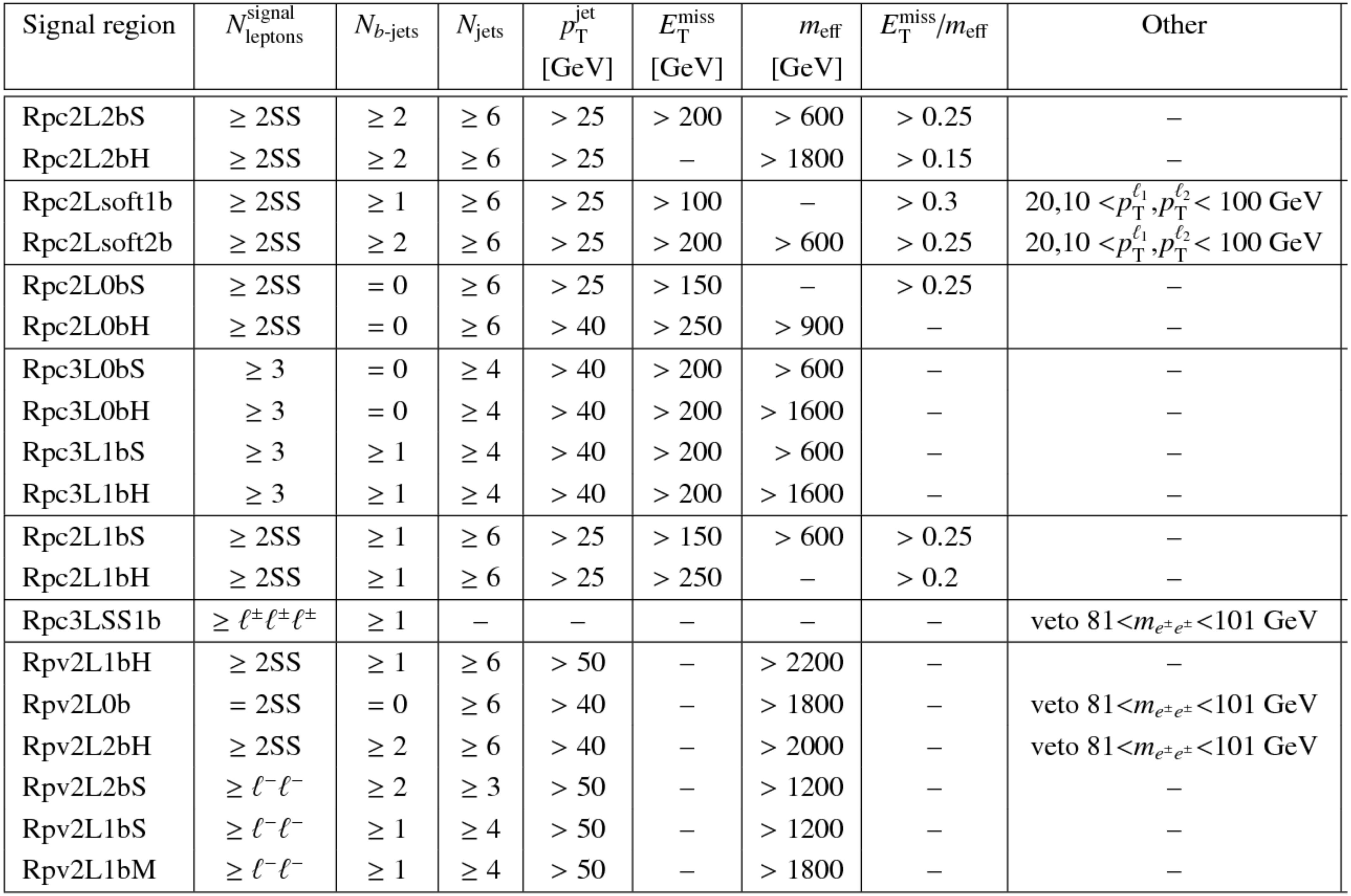
Signal regions based on H_T, E_T^{miss}, $m_T^{min}(l_1,l_2)$, n_j, n_b.



Provided model-independent limits versus H_T and E_T^{miss}.

inclusive

Inclusive searches: multileptons



Signal region	$N^{\text{signal}}_{\text{leptons}}$	$N_{b\text{-jets}}$	N_{jets}	$p_{\mathrm{T}}^{\text{jet}}$ [GeV]	$E_{\mathrm{T}}^{\text{miss}}$ [GeV]	m_{eff} [GeV]	$E_{\mathrm{T}}^{\text{miss}}/m_{\text{eff}}$	Other
Rpc2L2bS	≥ 2SS	≥ 2	≥ 6	> 25	> 200	> 600	> 0.25	–
Rpc2L2bH	≥ 2SS	≥ 2	≥ 6	> 25	–	> 1800	> 0.15	–
Rpc2Lsoft1b	≥ 2SS	≥ 1	≥ 6	> 25	> 100	–	> 0.3	$20,10 < p_{\mathrm{T}}^{\ell_1}, p_{\mathrm{T}}^{\ell_2} < 100$ GeV
Rpc2Lsoft2b	≥ 2SS	≥ 2	≥ 6	> 25	> 200	> 600	> 0.25	$20,10 < p_{\mathrm{T}}^{\ell_1}, p_{\mathrm{T}}^{\ell_2} < 100$ GeV
Rpc2L0bS	≥ 2SS	$= 0$	≥ 6	> 25	> 150	–	> 0.25	–
Rpc2L0bH	≥ 2SS	$= 0$	≥ 6	> 40	> 250	> 900	–	–
Rpc3L0bS	≥ 3	$= 0$	≥ 4	> 40	> 200	> 600	–	–
Rpc3L0bH	≥ 3	$= 0$	≥ 4	> 40	> 200	> 1600	–	–
Rpc3L1bS	≥ 3	≥ 1	≥ 4	> 40	> 200	> 600	–	–
Rpc3L1bH	≥ 3	≥ 1	≥ 4	> 40	> 200	> 1600	–	–
Rpc2L1bS	≥ 2SS	≥ 1	≥ 6	> 25	> 150	> 600	> 0.25	–
Rpc2L1bH	≥ 2SS	≥ 1	≥ 6	> 25	> 250	–	> 0.2	–
Rpc3LSS1b	$\geq \ell^\pm\ell^\pm\ell^\pm$	≥ 1	–	–	–	–	–	veto $81 < m_{e^\pm e^\pm} < 101$ GeV
Rpv2L1bH	≥ 2SS	≥ 1	≥ 6	> 50	–	> 2200	–	–
Rpv2L0b	$= 2$SS	$= 0$	≥ 6	> 40	–	> 1800	–	veto $81 < m_{e^\pm e^\pm} < 101$ GeV
Rpv2L2bH	≥ 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	–	–

ATLAS arXiv: 1706.03731: same sign dilepton / 3 lepton + E_T^{miss}.

Gluinos decaying via neutralinos/ charginos.

Sbottoms.

Signal regions.

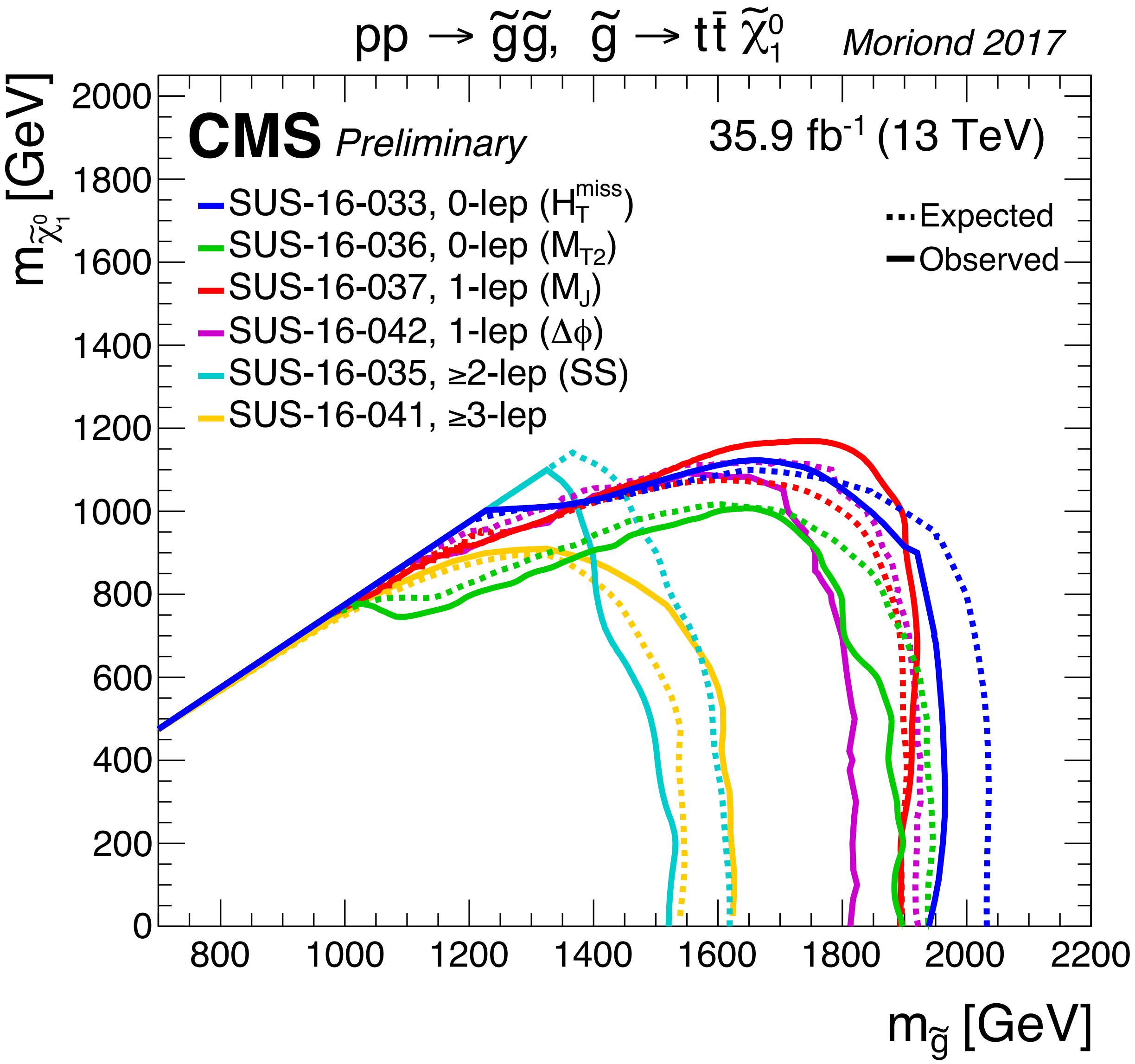
Uses many discriminating variables.

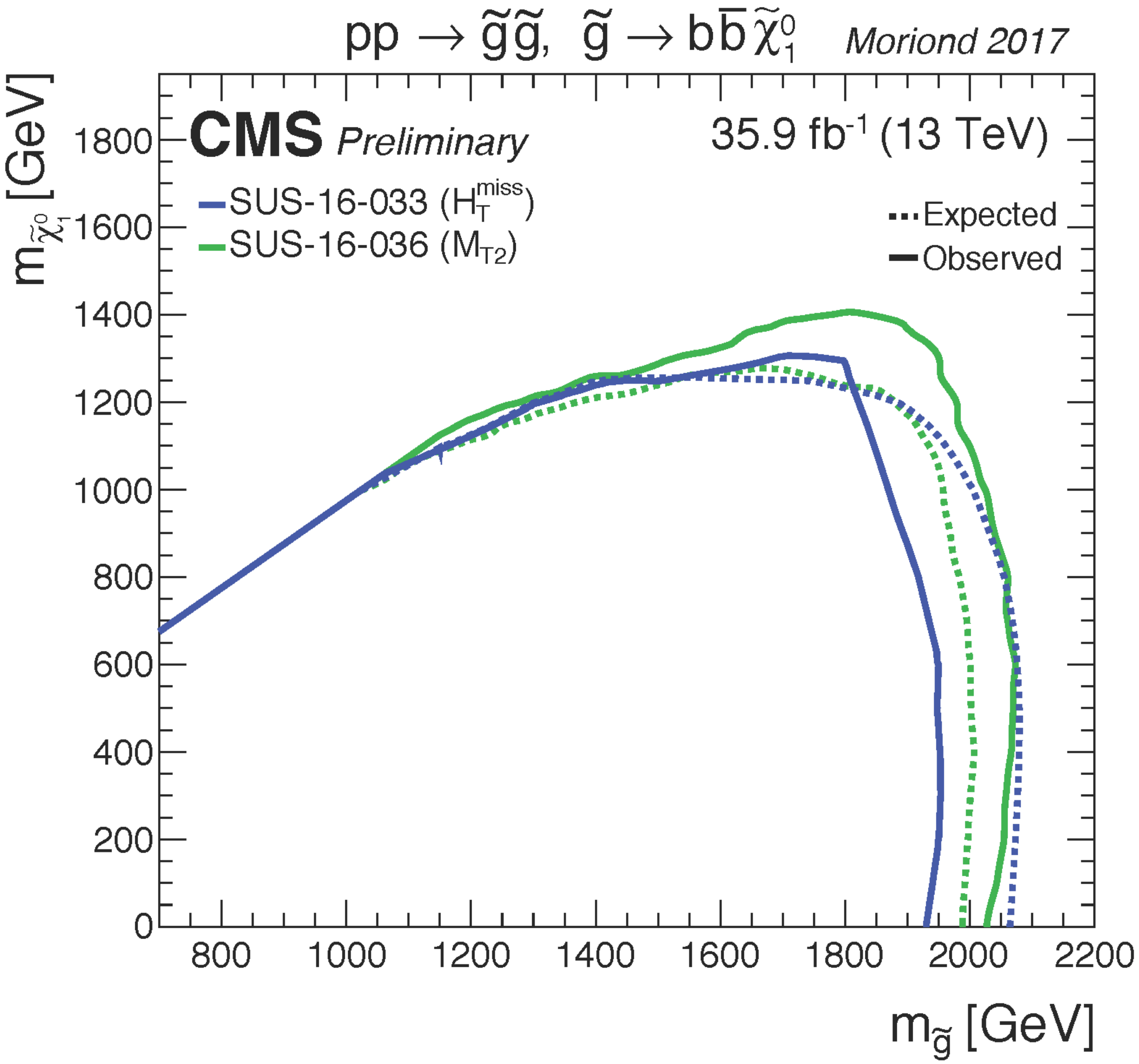
No excess.

Similar CMS search: CMS-SUS-16-041, using H_T, E_T^{miss}, m_T, n_b, and invariant mass of the opposite charge same flavor dilepton pairs. No excess observed.

inclusive

Kinematic variables for inclusive searches

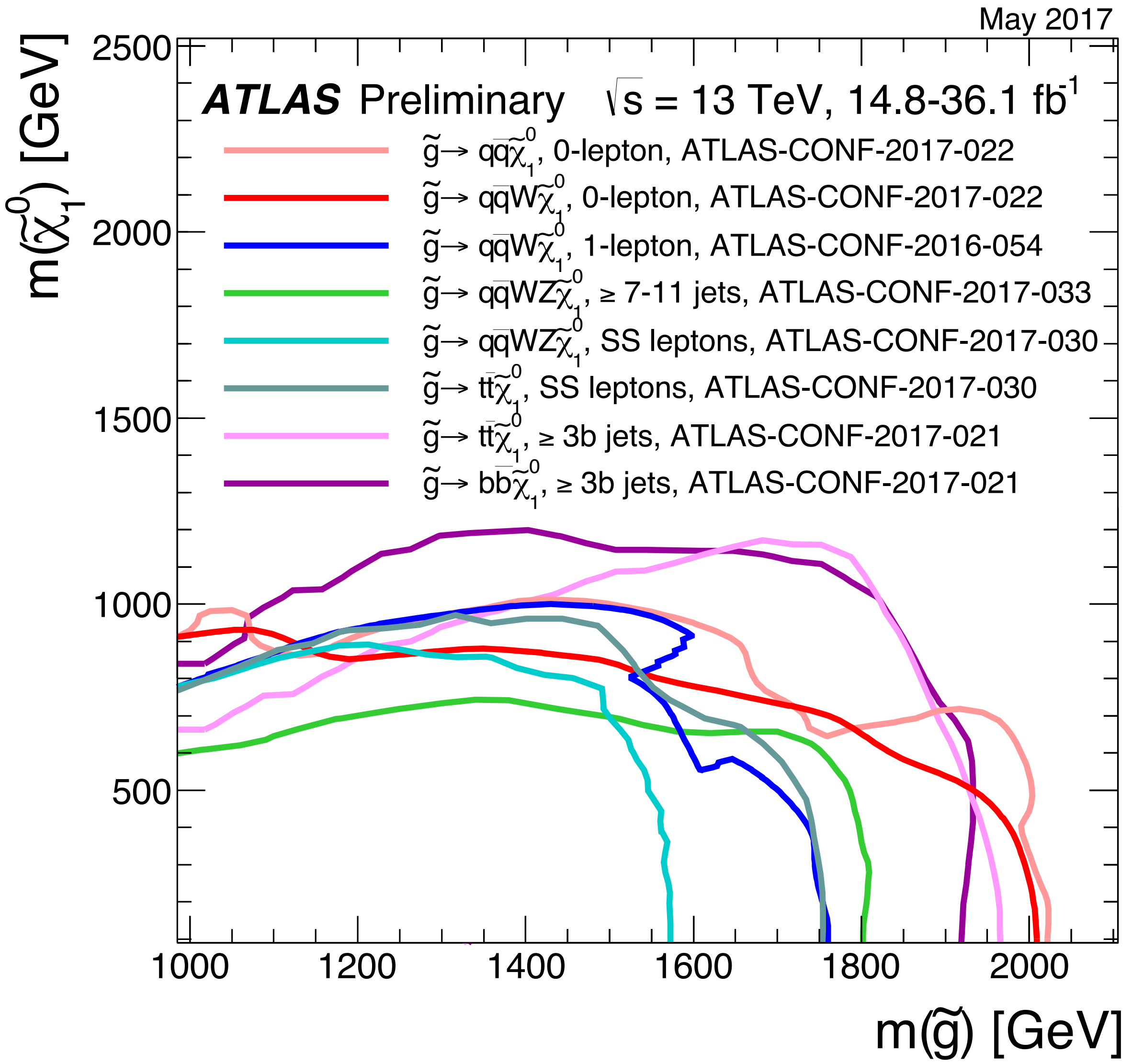


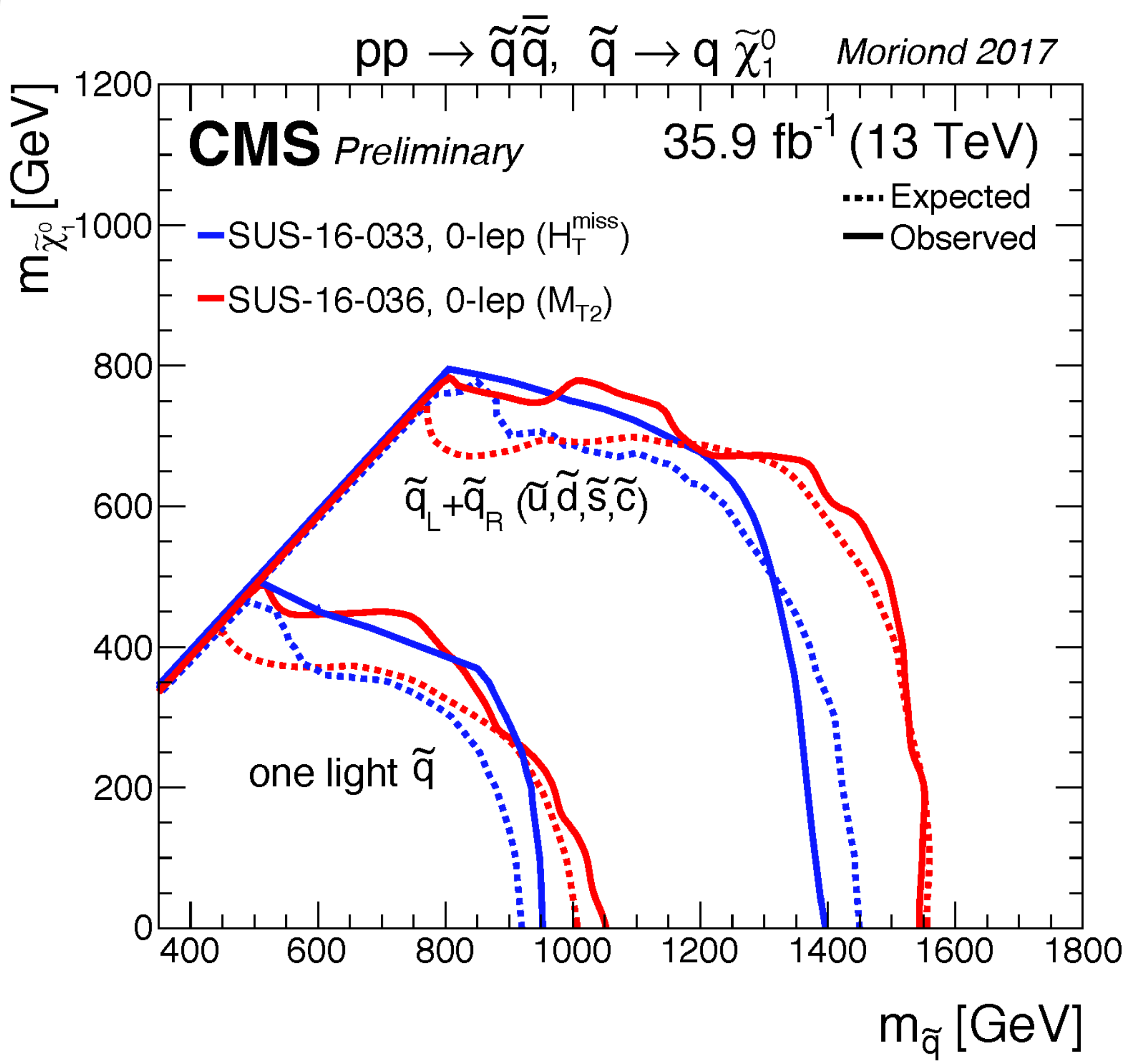


- CMS probed gluinos up to mass ~2TeV in the t/b decay channels. ATLAS has similar results.
- Having different searches provides sensitivity to different final states and kinematical regions.
- More sensitivity to gluino decays via b quarks due to better measured objects.

inclusive

Kinematic variables for inclusive searches

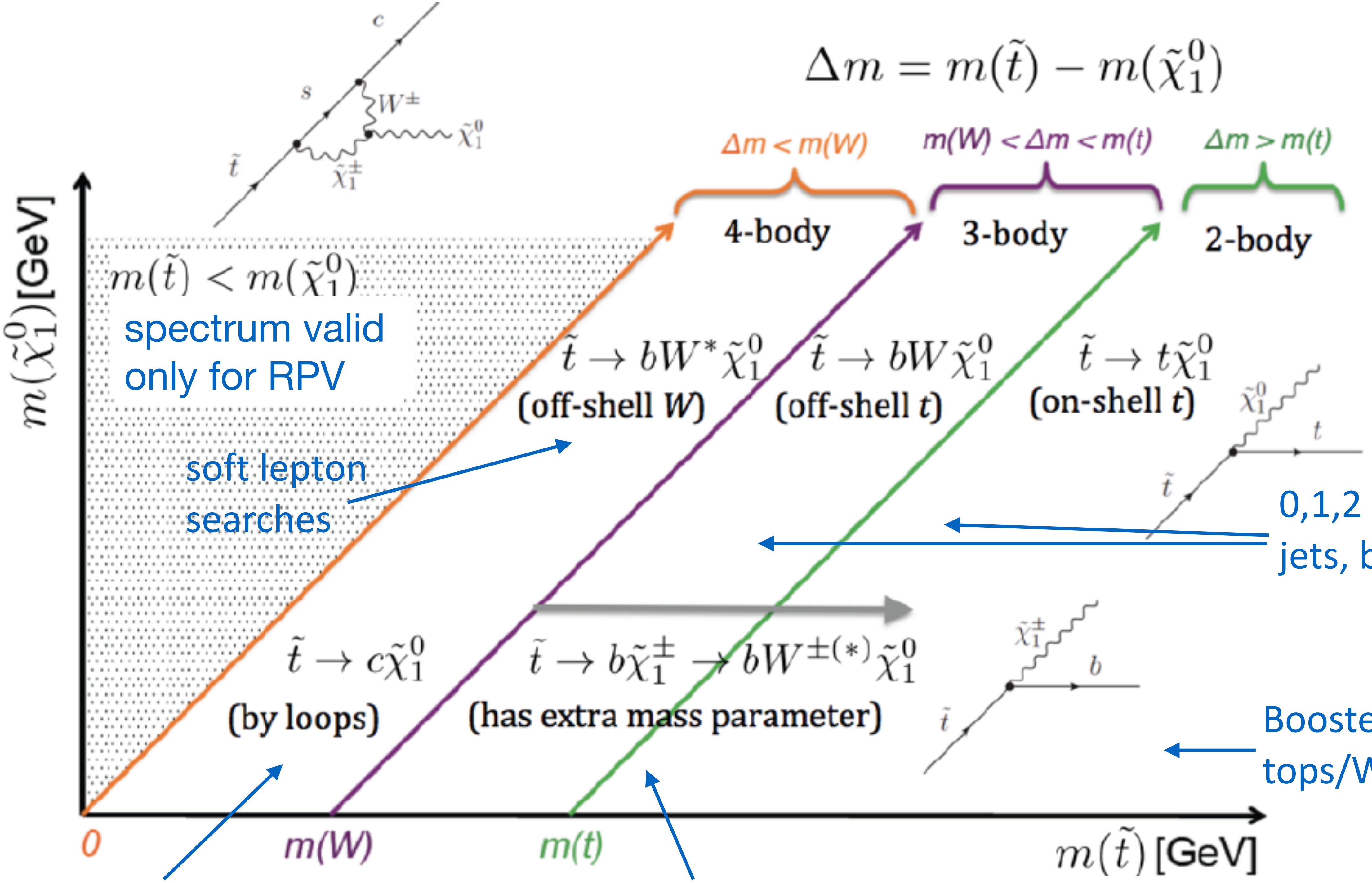




- ATLAS gluino mass limits for different decay channels.
- Highest gluino mass limits are for light quark decay channels.
- Highest neutralino mass limits are for 3rd gen decay channels.

- Probed 1st/2nd generation squarks up to ~1.6TeV in different decay channels. ATLAS and CMS similar.
- Probed by signal regions with low jet multiplicities, or by reducing the event to a dijet-like state.

Physics on the stop-neutralino plane



spectrum valid only for RPV

soft lepton searches

0,1,2 leptons + jets, b jets …

Boosted tops/Ws

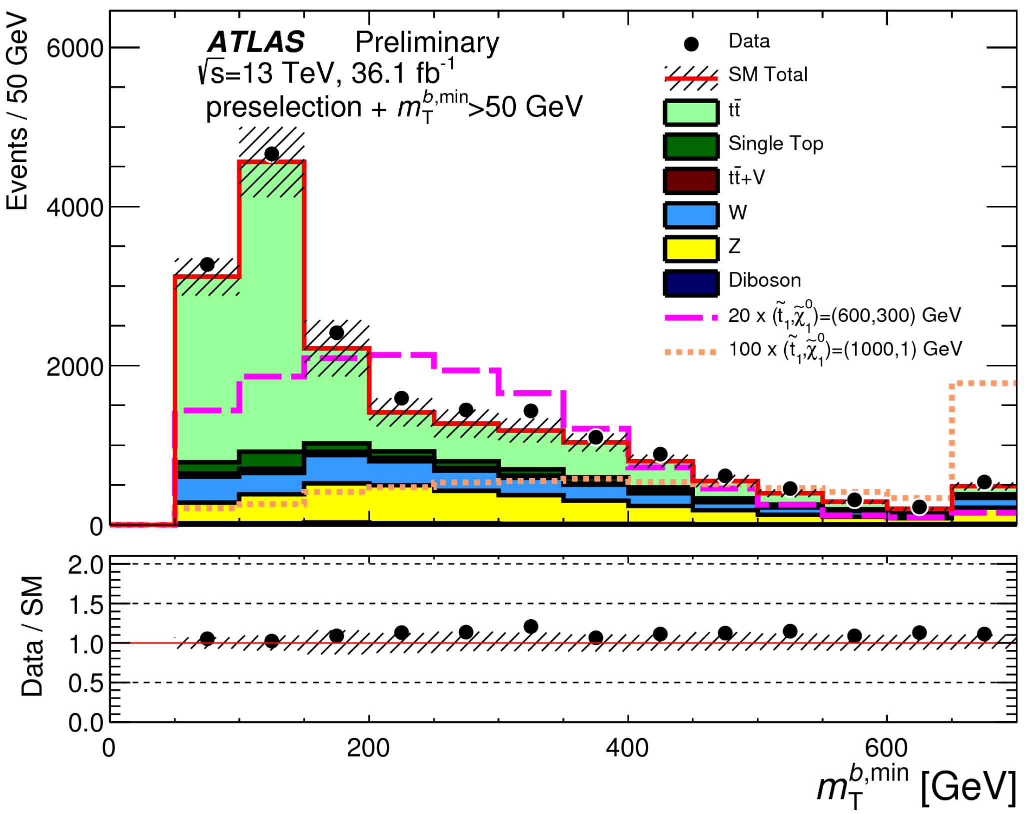
monojet searches, charm tagging

Stealth SUSY -> tt cross section and spin correlations

Differences from inclusive searches:

top reconstruction, b-tagging, softer cuts on jets and E_T^{miss}…

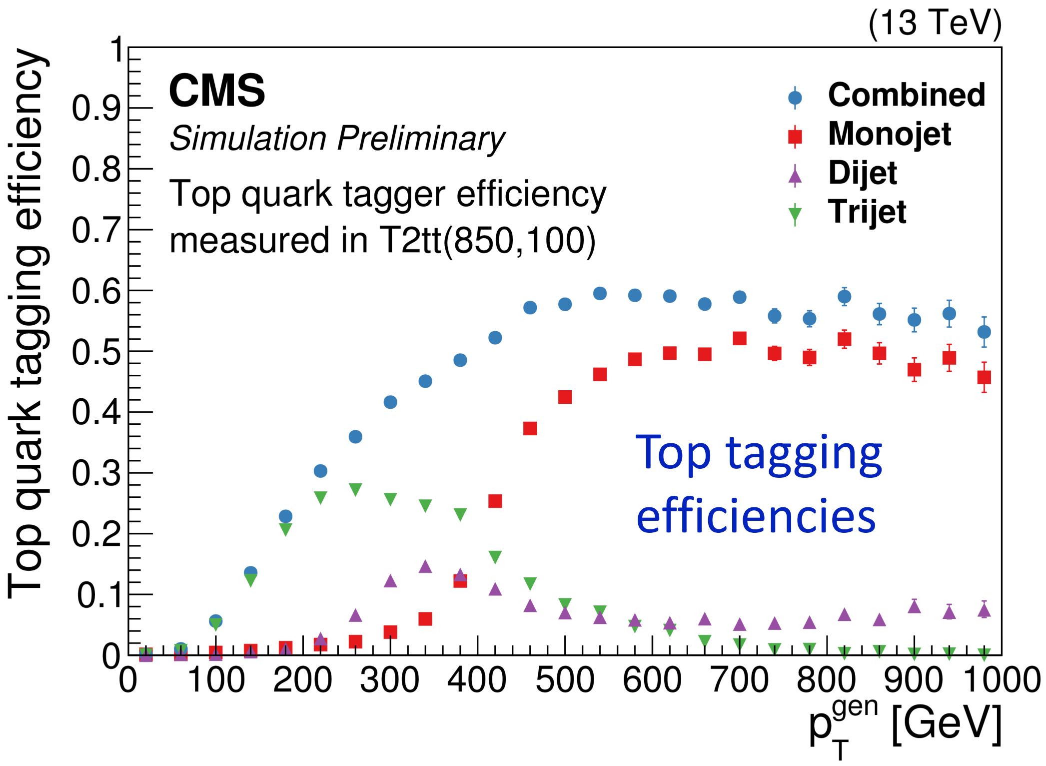
3rd gen Hadronic stop searches



CMS-SUS-16-050, Top tagging + E_T^{miss}.

Tagging both boosted tops (with n-subjettiness) and resolved tops (with random forest discriminator)

Uses M_{T2}.



ATLAS-CONF-2017-020: Resolved tops.

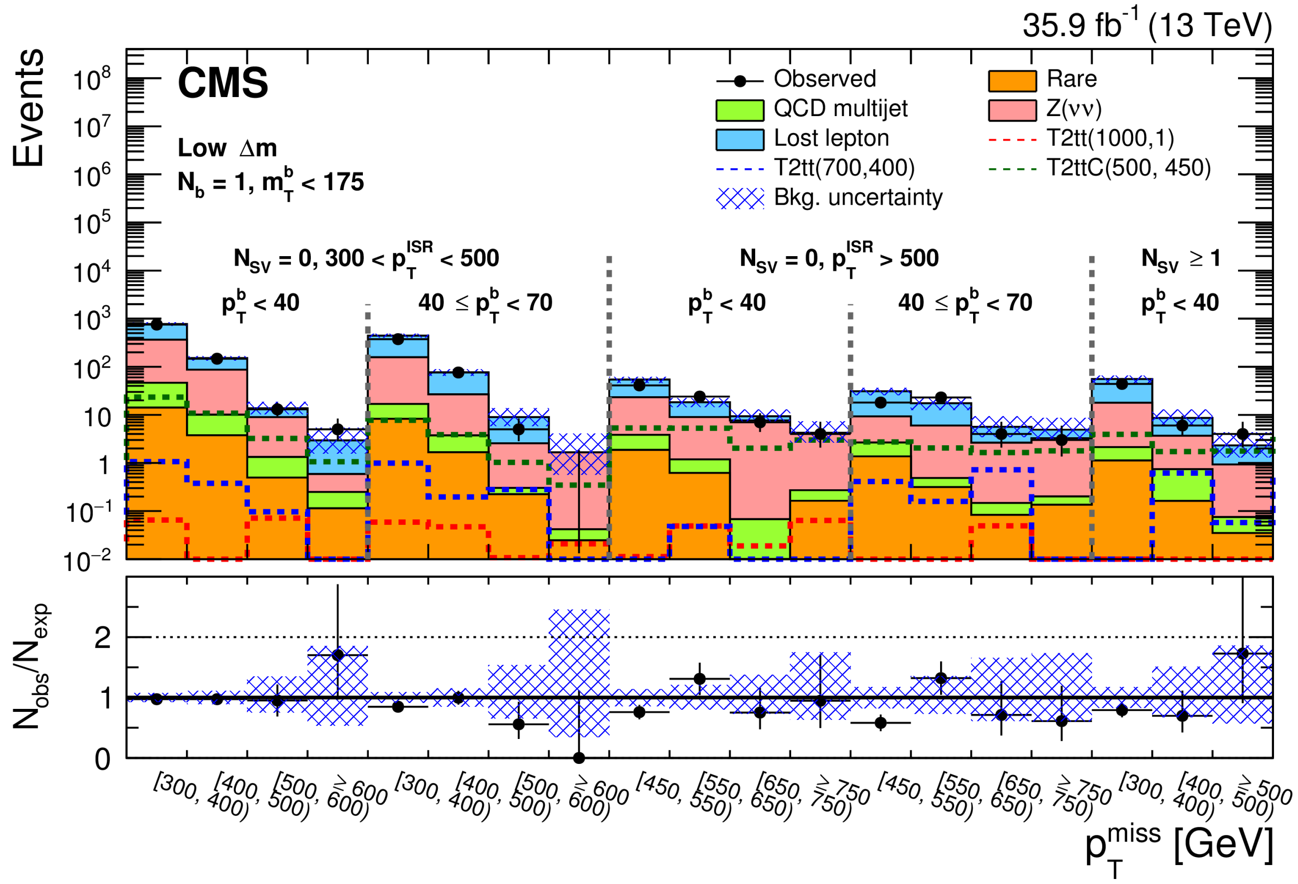
≥4 jets + 1b + E_T^{miss}.

$m_T^{b,\min}(b_{1,2},E_T^{miss})$ is an effective discriminating variable.

CMS-SUS-16-049: Top tagging + E_T^{miss}.

Tagging both resolved and merged tops using an alternative method.

Signal regions defined by n_j, n_t, n_W, n_b, $n_{\text{resolved top}}$, M_T^b, E_T^{miss}.



3rd gen

1 lepton stop searches

CMS-SUS-16-051:

1lep + jets + E_T^{miss}.

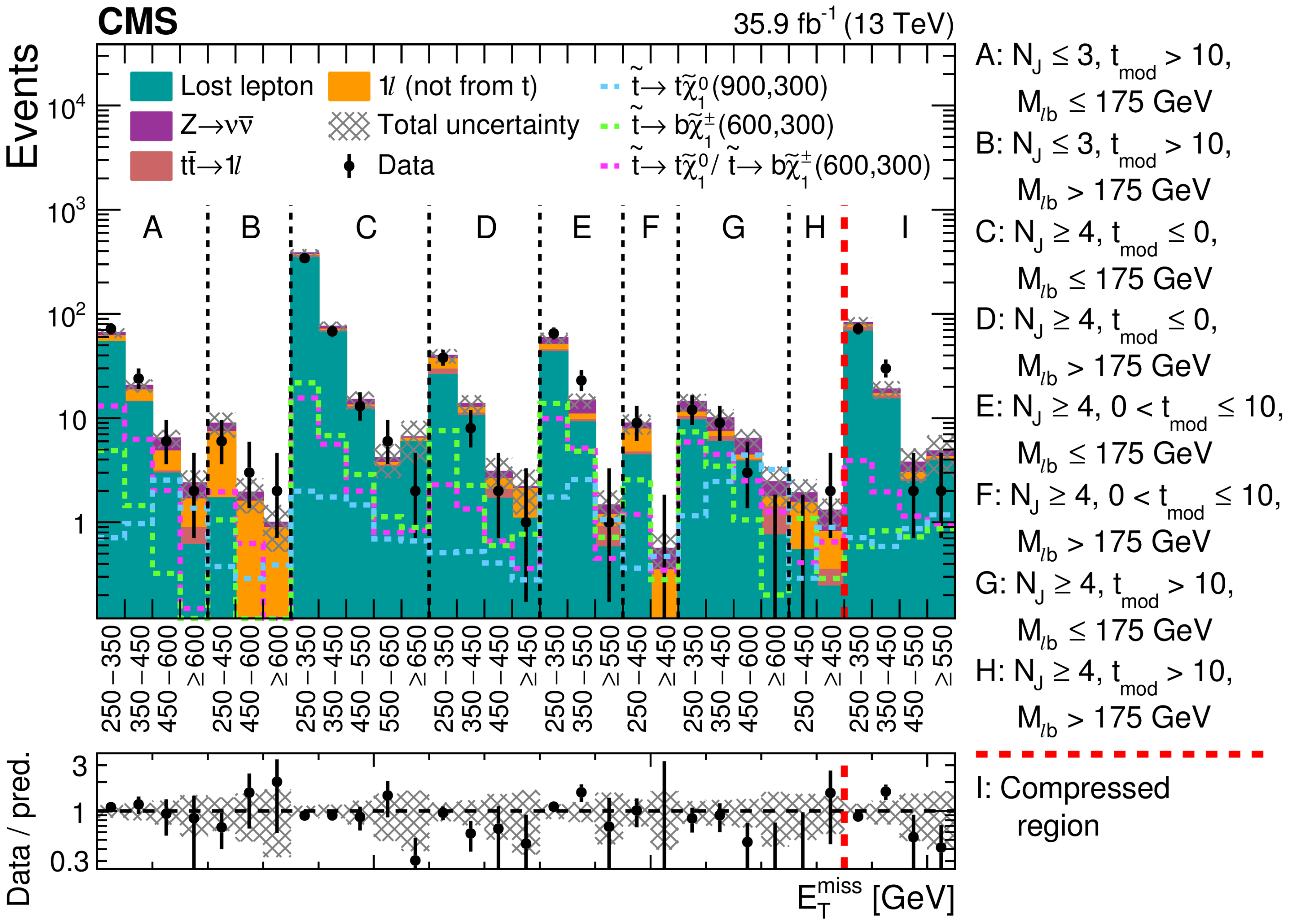
Targets stops —> top neutralino or stops —> bottom chargino.

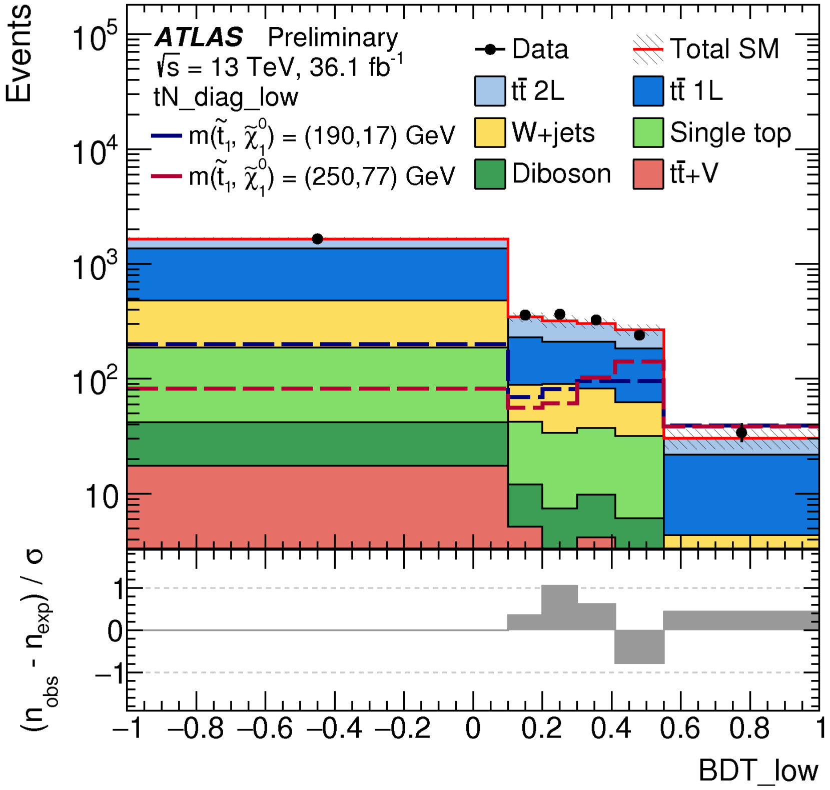
Signal regions defined by n_{jet}, M_{lb}, E_T^{miss}, t_{mod} (modified topness):

$$t_{\text{mod}} = \ln(\min S)$$

$$S(\vec{p}_W, p_z, \nu) = \frac{(m_W^2 - (p_\nu + p_\ell)^2)^2}{a_W^4} + \frac{(m_t^2 - (p_b + p_W)^2)^2}{a_t^4}$$

resolutions



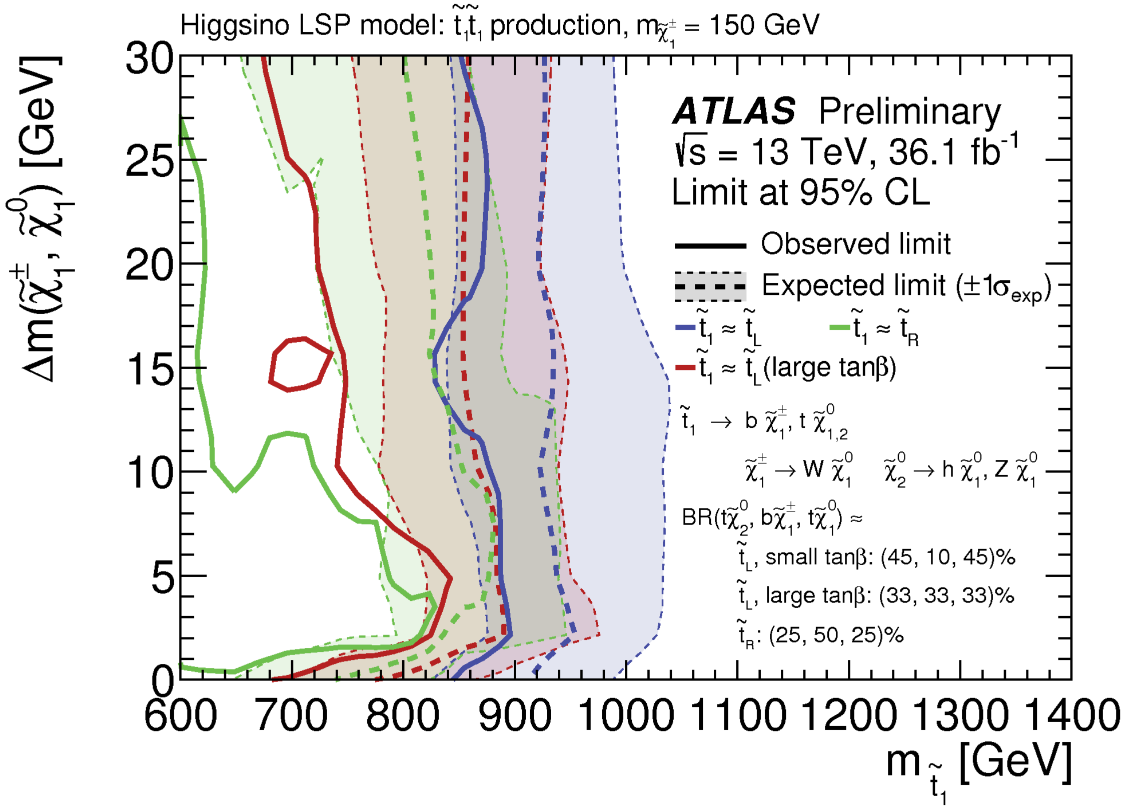


ATLAS-CONF-2017-037

1lep + jets + E_T^{miss}.

Wide range of stop scenarios with various mass splittings.

Used a boosted decision tree as a powerful signal discriminator.

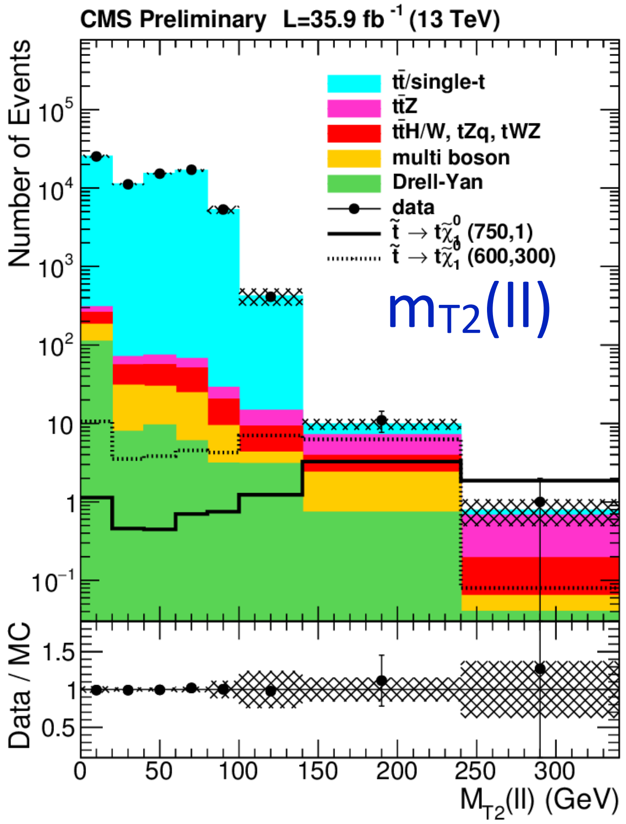


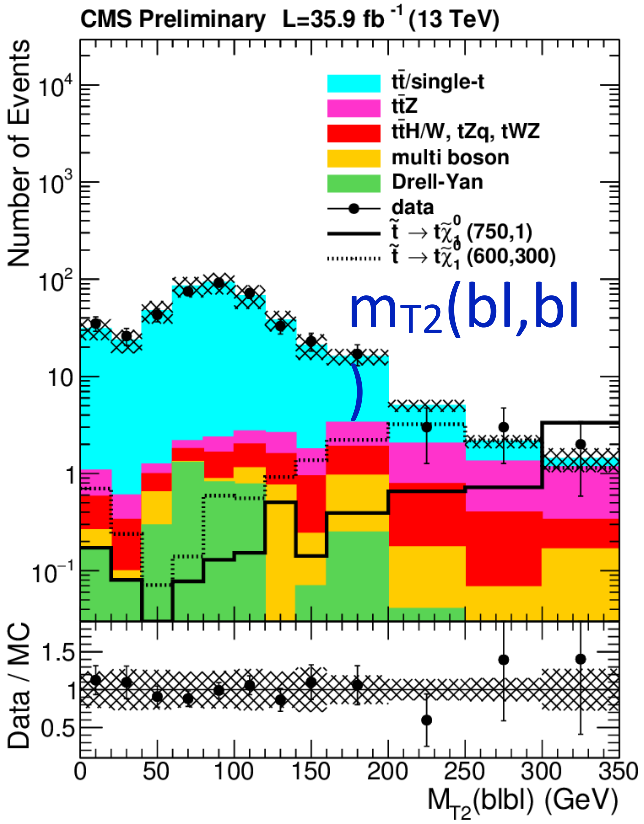
3rd gen

2 leptons stop searches

CMS-SUS-17-001: 2lep + jets + b jet + E_T^{miss}.

Longer stop cascades with charginos/sleptons.





ATLAS arXiv:1708.03247

2lep + jets + b jet + E_T^{miss}.

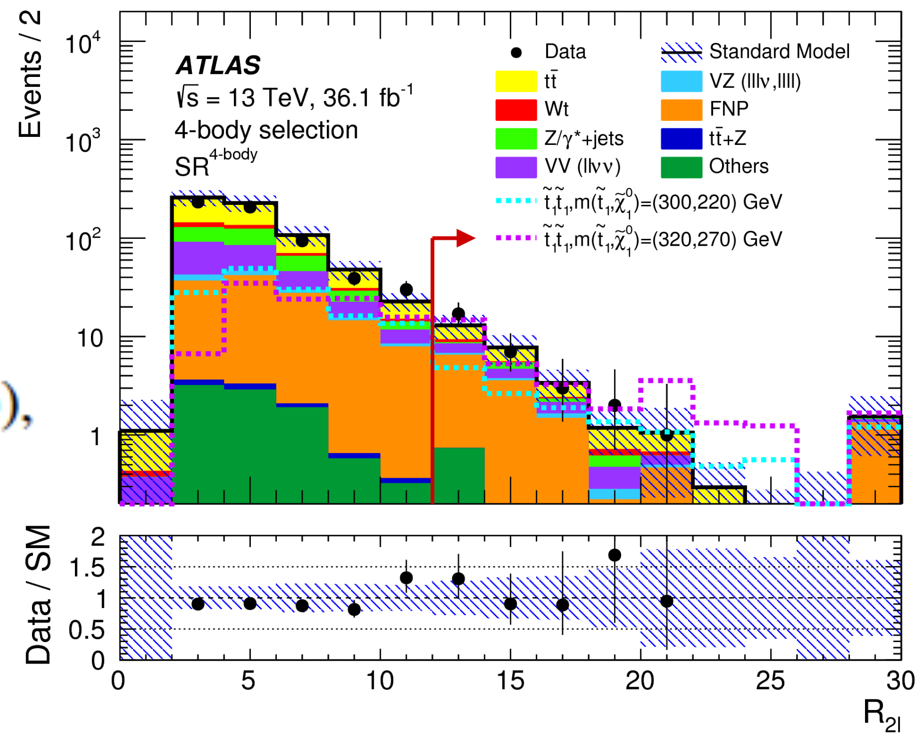
Defined several ratio variables based on $p_T(l)$, $p_T(j)$, E_T^{miss}.

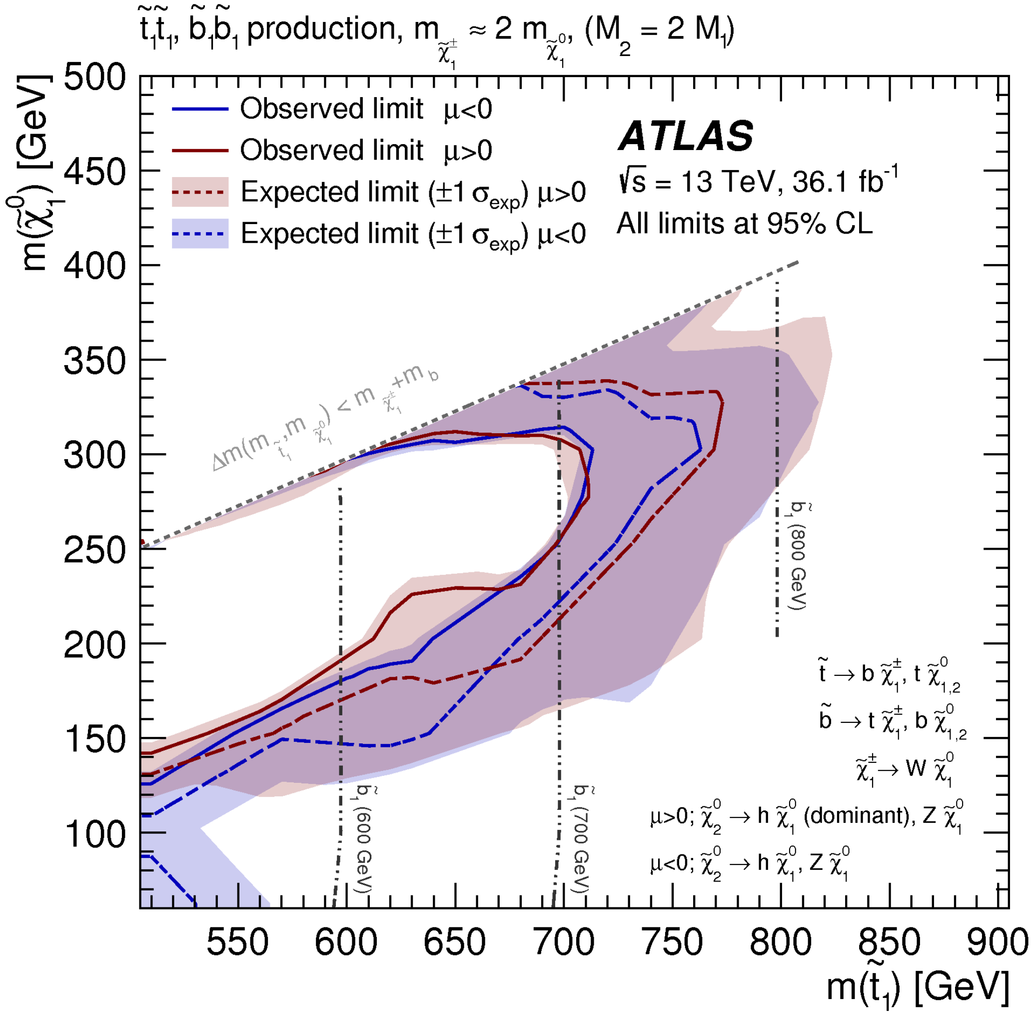
Used many other kinematic variables including super-razor.

Interpretation based on a generic phenomenological MSSM scenario.

Example ratio variable from ATLAS 1708.03247:

$$R_{2\ell} = E_T^{miss}/(p_T(\ell_1) + p_T(\ell_2)),$$



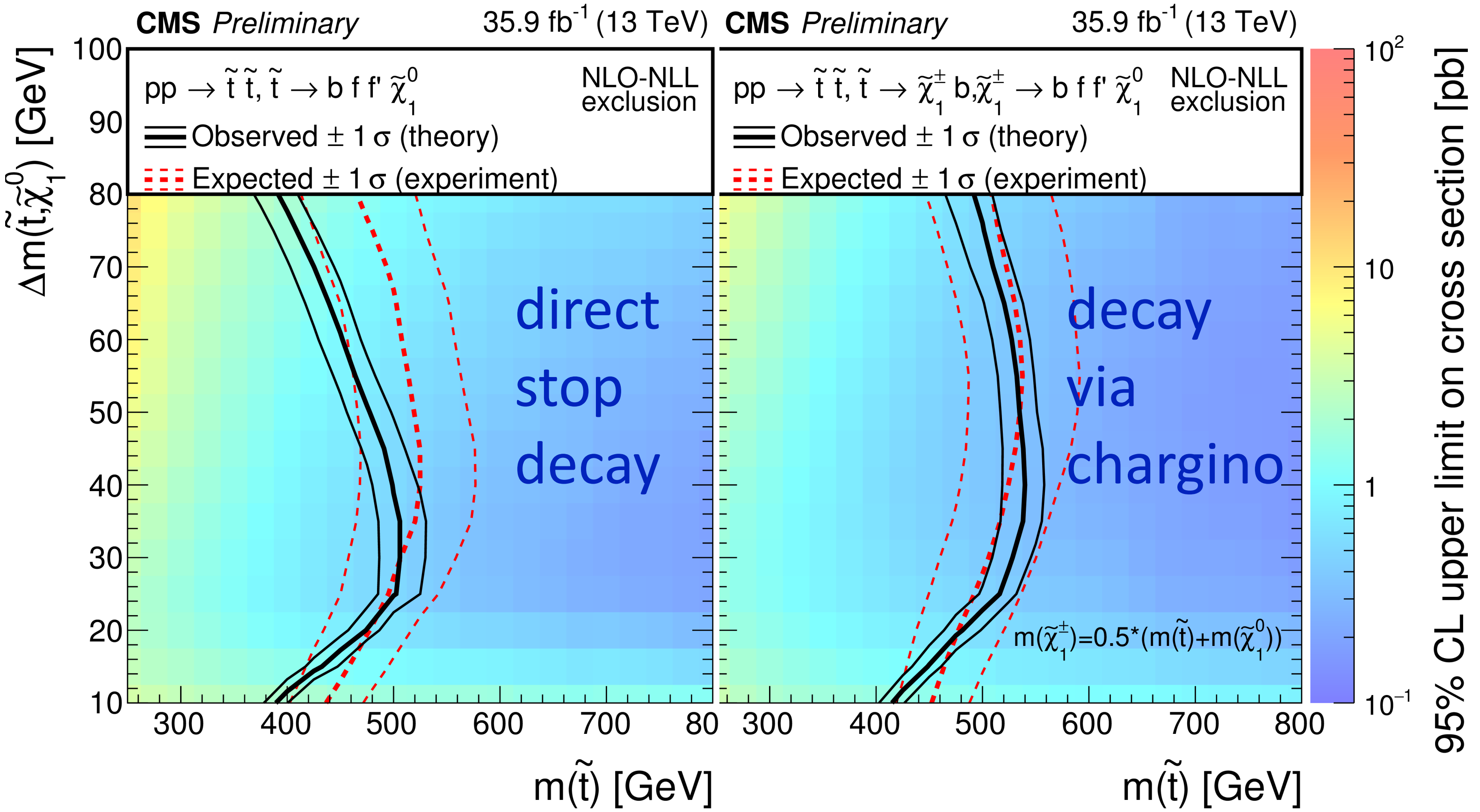


3rd gen Compressed stop; stop to Z, h

CMS-SUS-16-052:
compressed stop: low stop-neutralino mass difference leading to soft decay products.

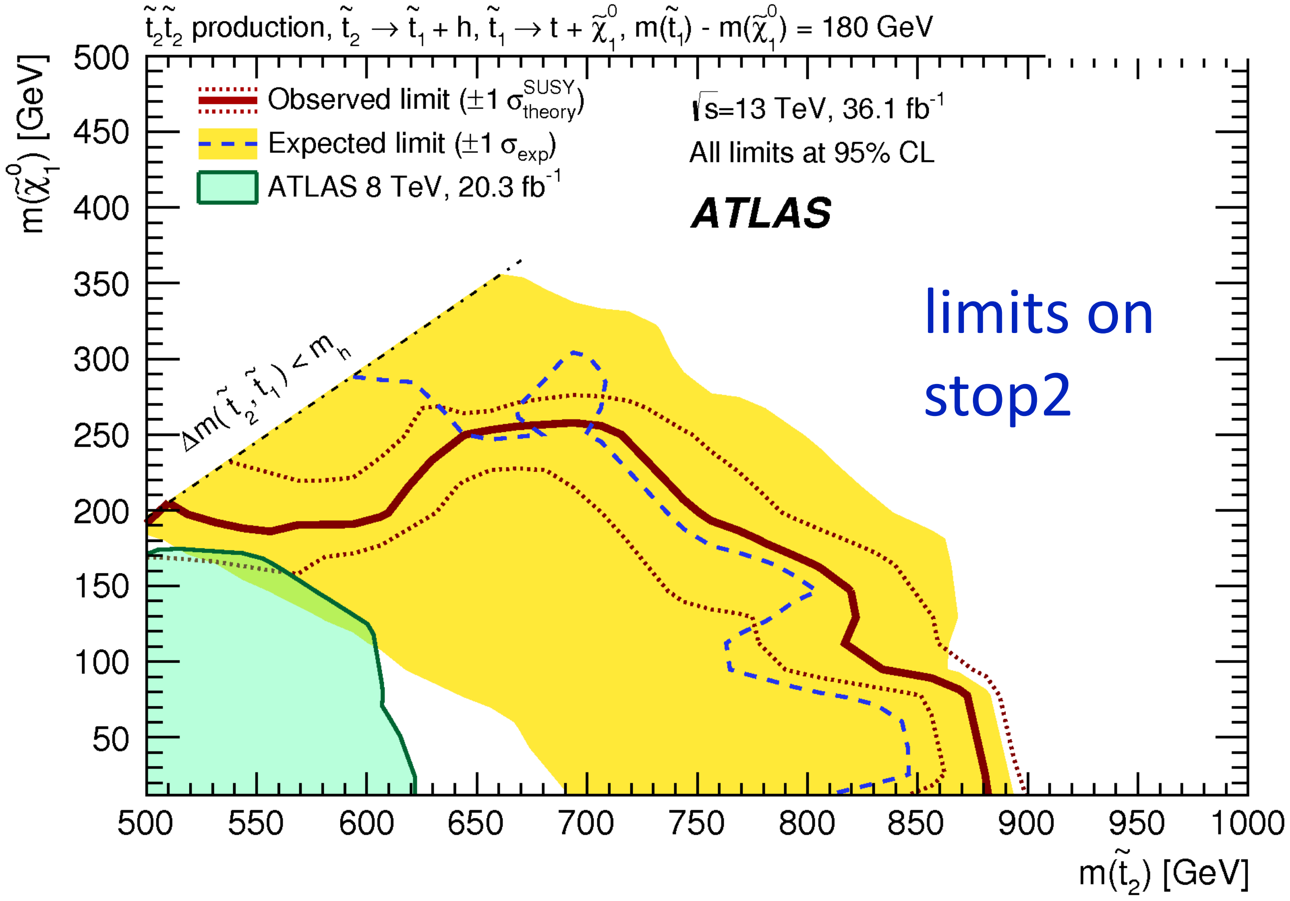
Soft lepton + 1-2 jets (ISR) + E_T^{miss}.

Use n_b, $m_T(l, E_T^{miss})$, E_T^{miss} to discriminate signal.



direct stop decay

decay via chargino



limits on stop2

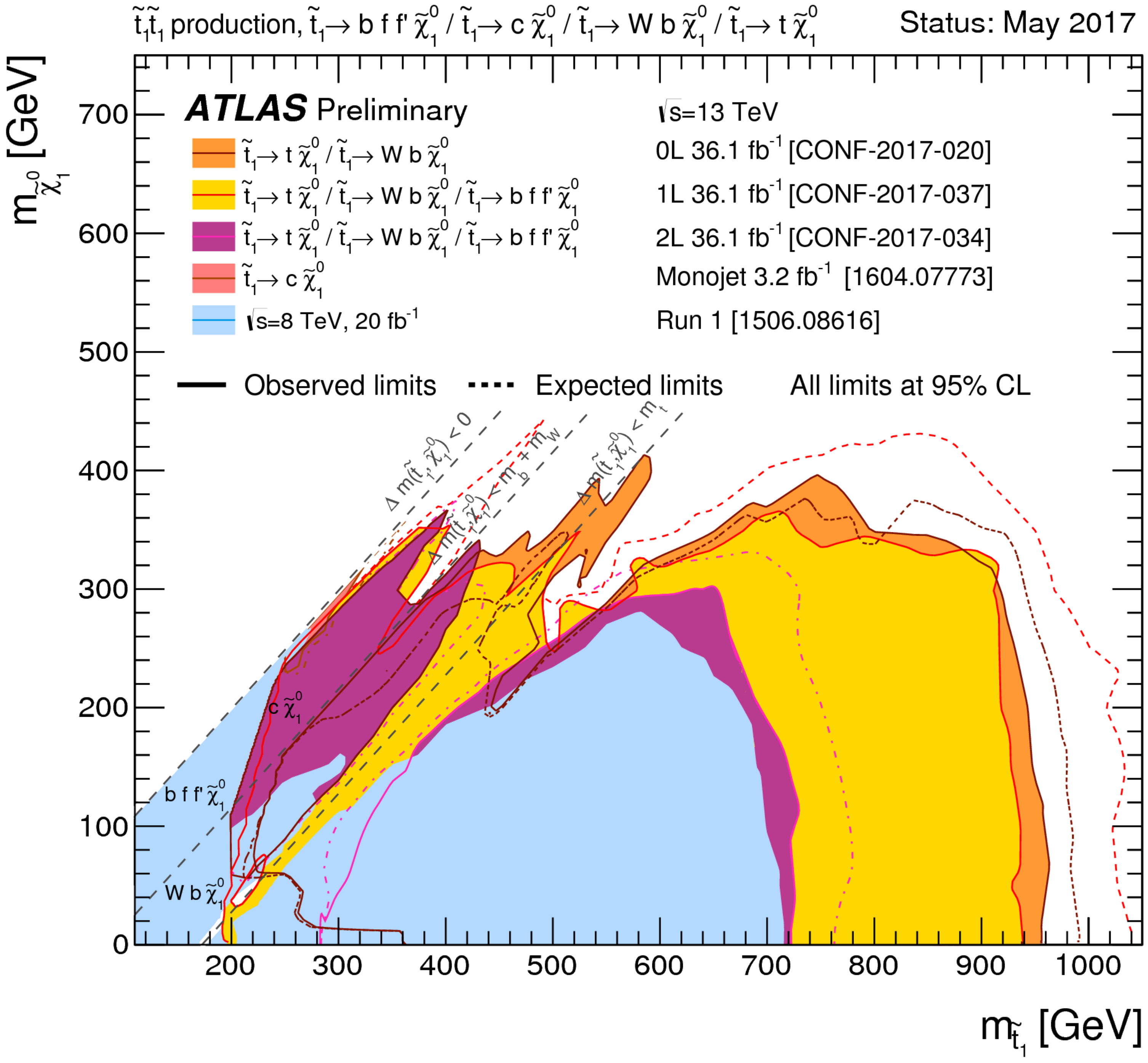
ATLAS arXiv:1706.03986:
stop with Z -> ll and h -> bb decays.

stop1 —> Z/h t neutralino or
stop2 —> Z/h stop1

Signal regions based on
3lep + 1b + E_T^{miss} : $m(ll)$, $p_T(ll)$
1lep + 4b + E_T^{miss} : $m(bb)$, $p_T(bb)$.

3rd gen

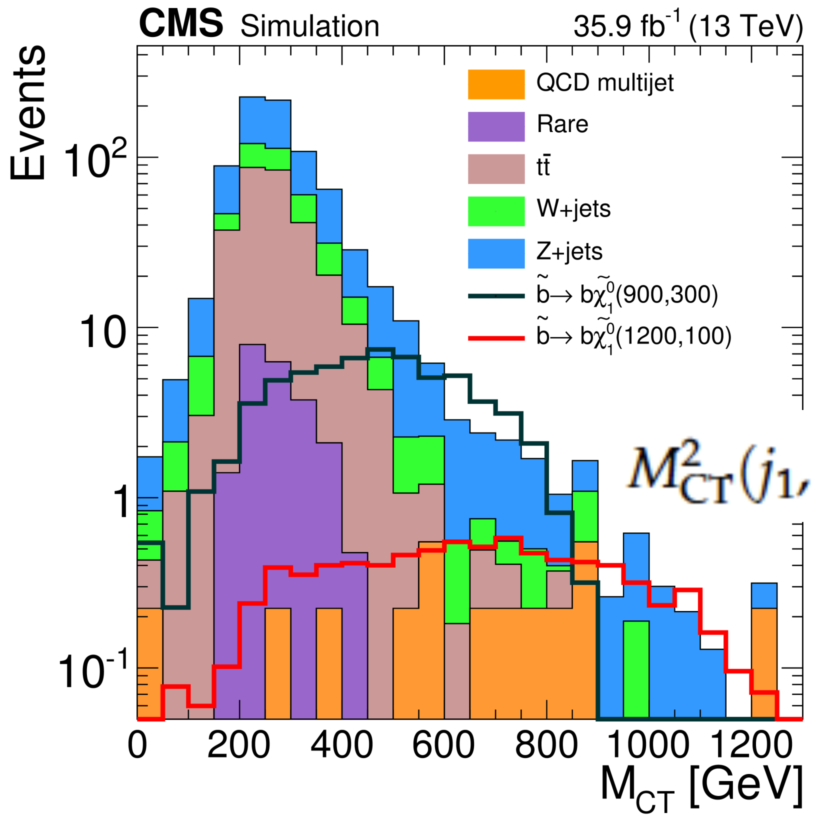
Sensitivity to stops



- Huge diversity of searches probing different regions in the stop-neutralino parameter space.
- Stop branching ratios are 100%.
- Dedicated stop searches perform better compared to inclusive.
- Very similar results in CMS.
- Most difficult region lies between m_{stop} - $m_{neutralino}$ = m_W and m_{stop} - $m_{neutralino}$ = m_{top}.
- Exploring top quark properties which would discriminate stop pair production from top pair production further could help to close the gaps.
- Increased mass limits suggest a tension with Naturalness.

3rd gen

Direct sbottom searches



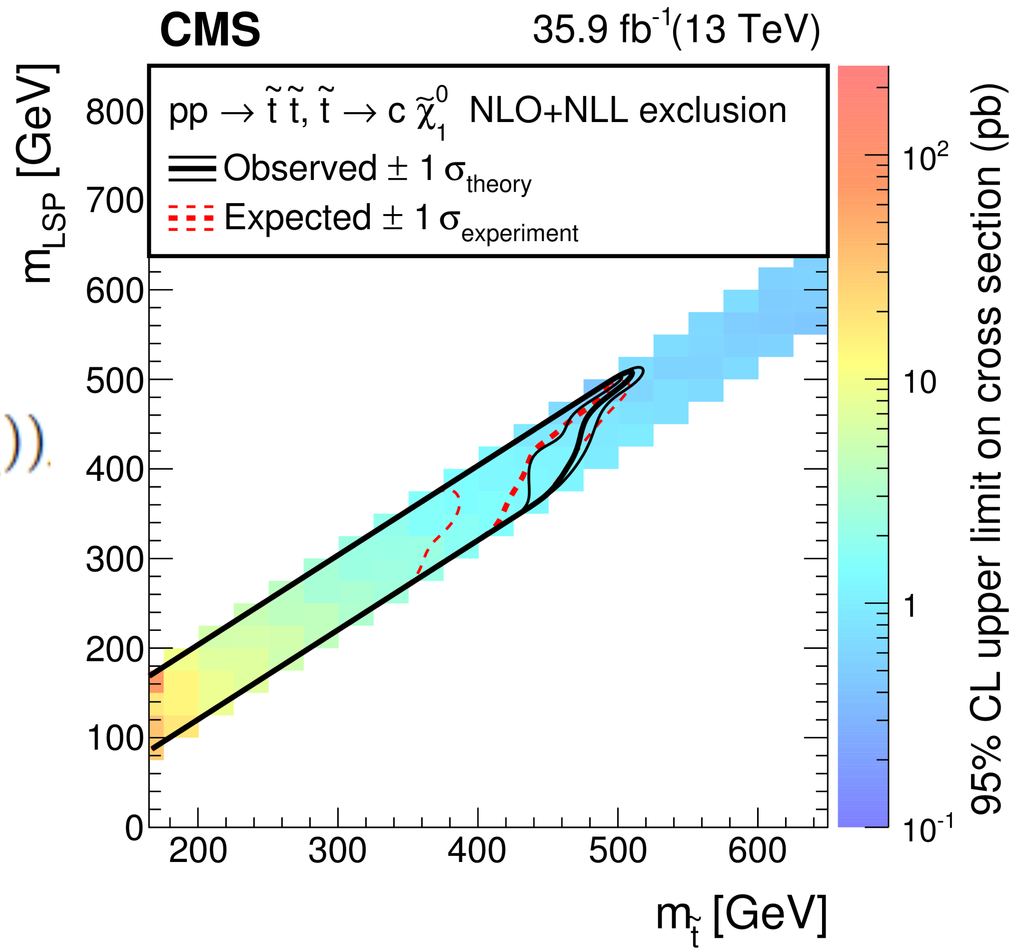
CMS-SUS-16-032: sbottom and compressed stop

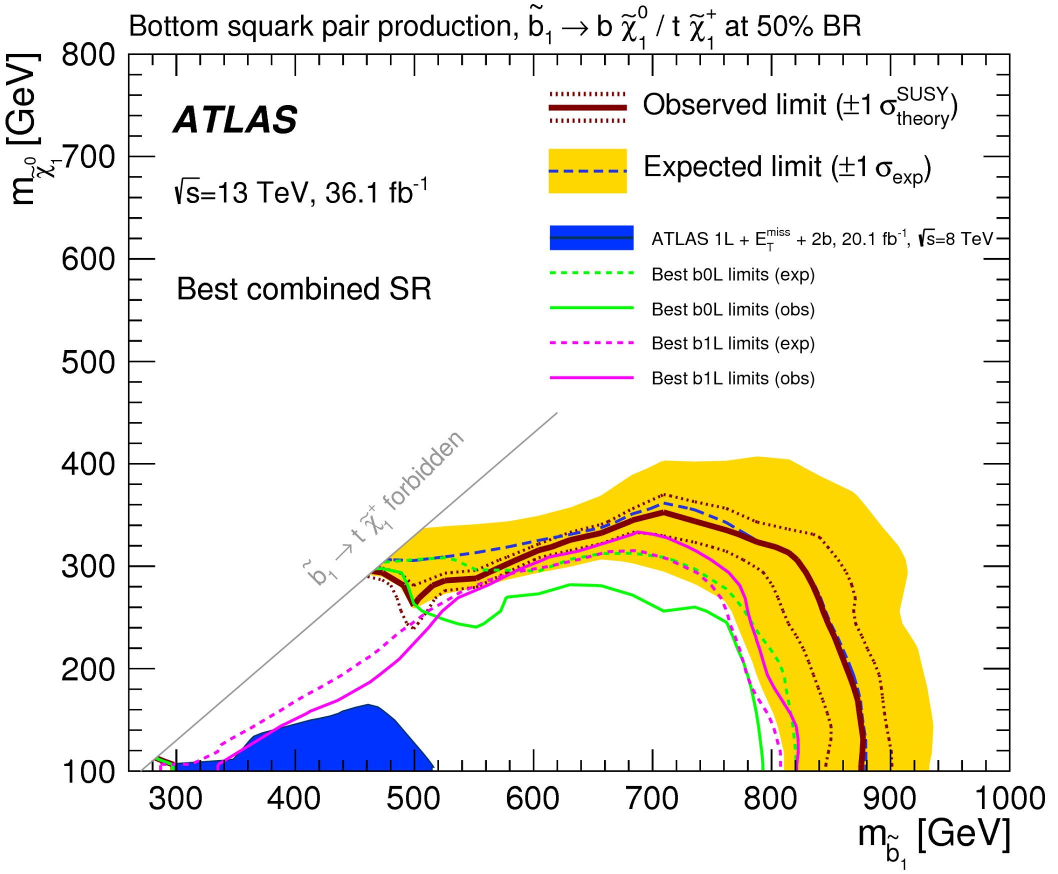
jets + b/c tags + E_T^{miss}.

Use $M_T^{min}(p_T(j_{1,2}), p_T^{miss})$, M_{CT}

$$M_{CT}^2(j_1, j_2) = 2p_T(j_1)p_T(j_2)(1 + \cos\Delta\phi(j_1, j_2)).$$

$\tilde{t}_1 \to c\tilde{\chi}_1^0$ decays: c-tagging exploited.



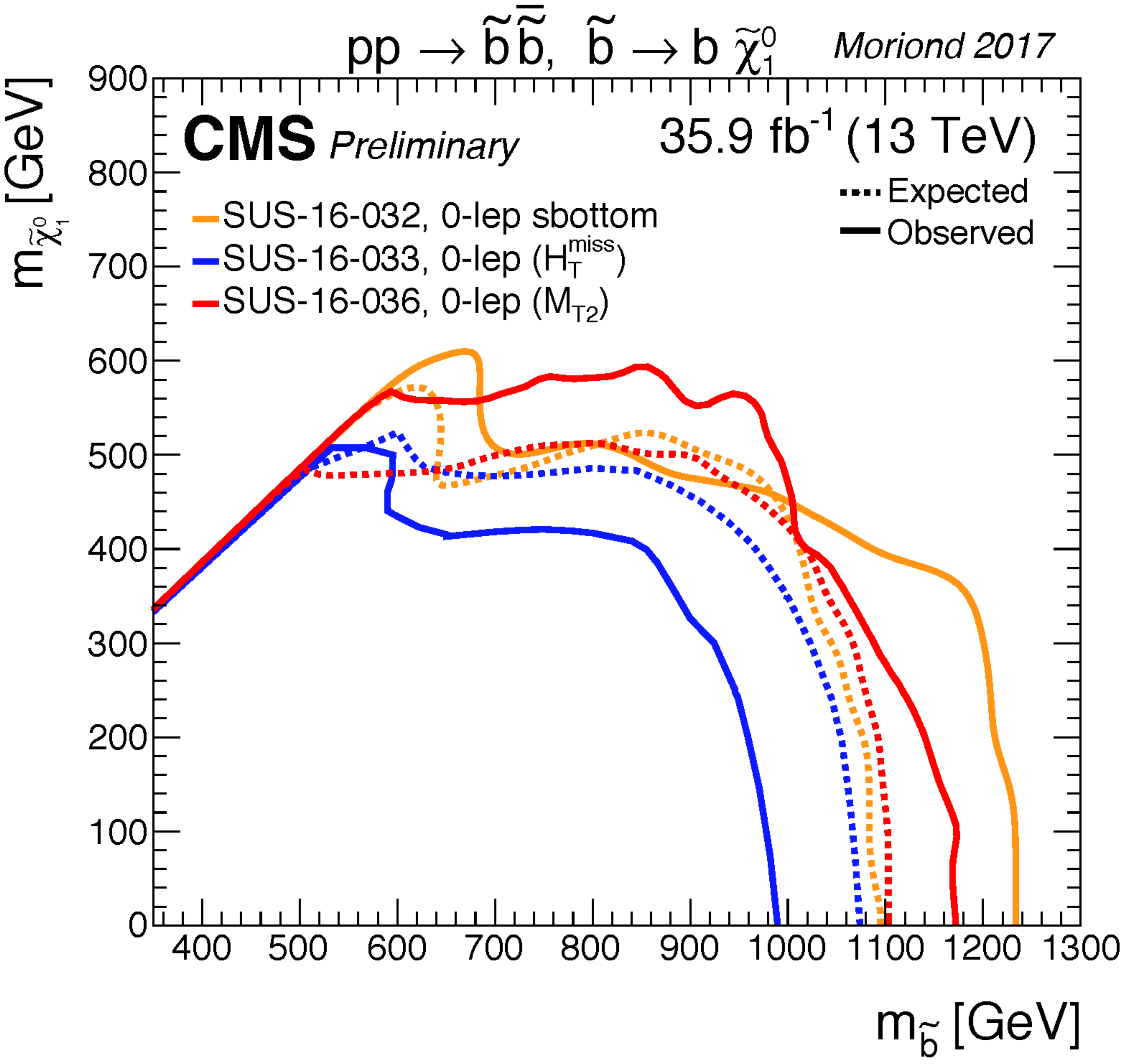


ATLAS arXiv:1708.09266:

sbottom/stop search, b jets + E_T^{miss}, 0l/1l channels.

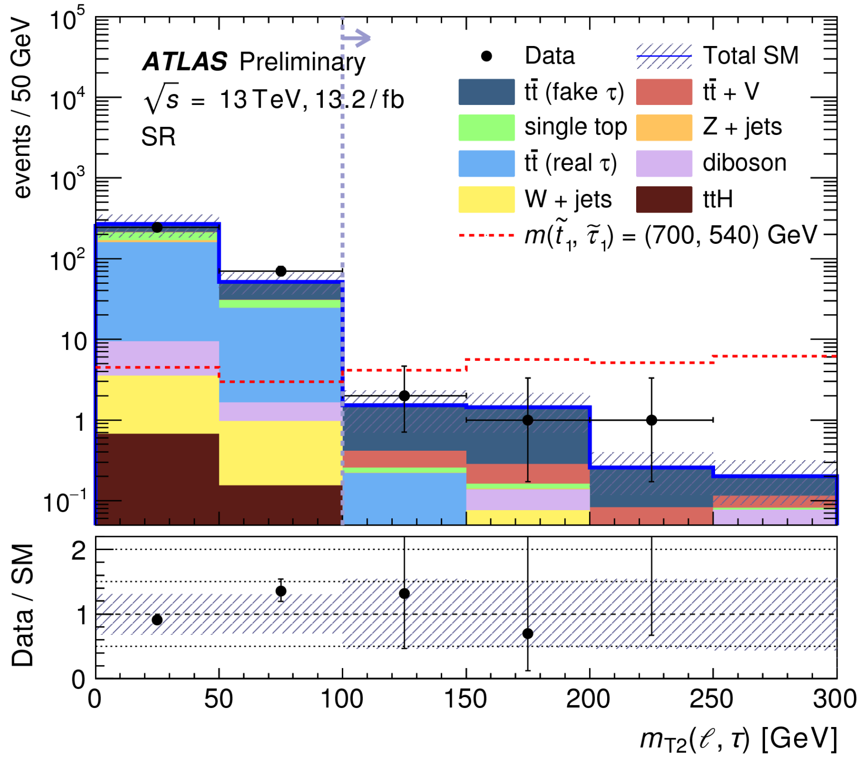
Extensive list of discriminating variables: p_Ts, invariant masses, m_{eff}, etc.

Sensitivity to sbottoms



- Probed sbottoms up to ~1.2TeV.
- Interplay of direct sbottom searches with the inclusive searches help to obtain the best sensitivity.
  - direct sbottom search reaches higher $m_{sbottom}$.
  - inclusive M_{T2} search accesses lower sbottom - neutralino mass difference.

Searches with taus

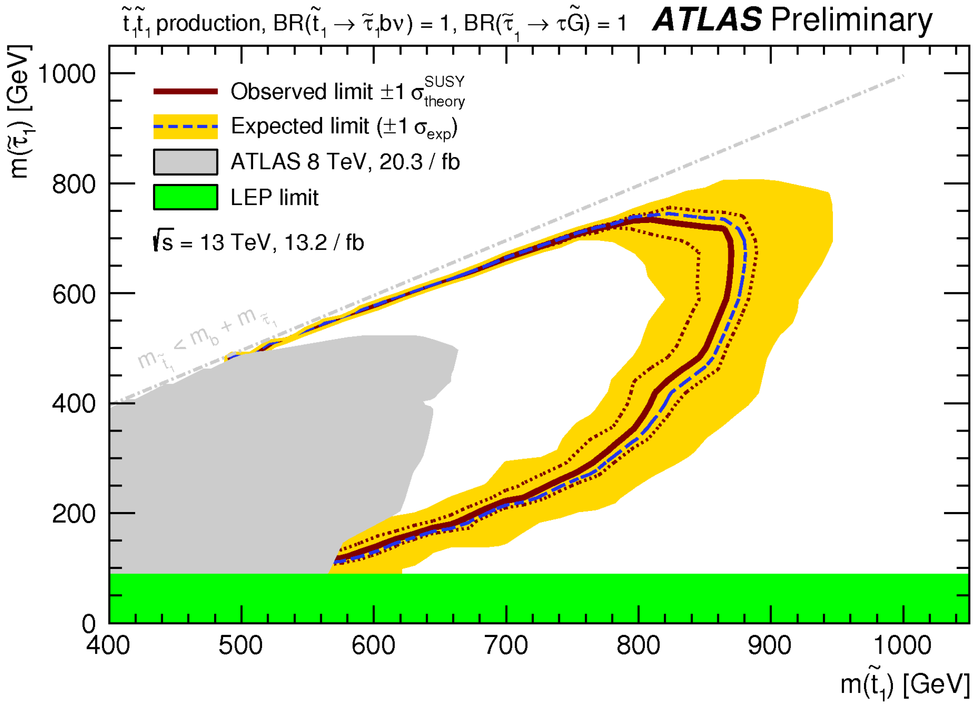


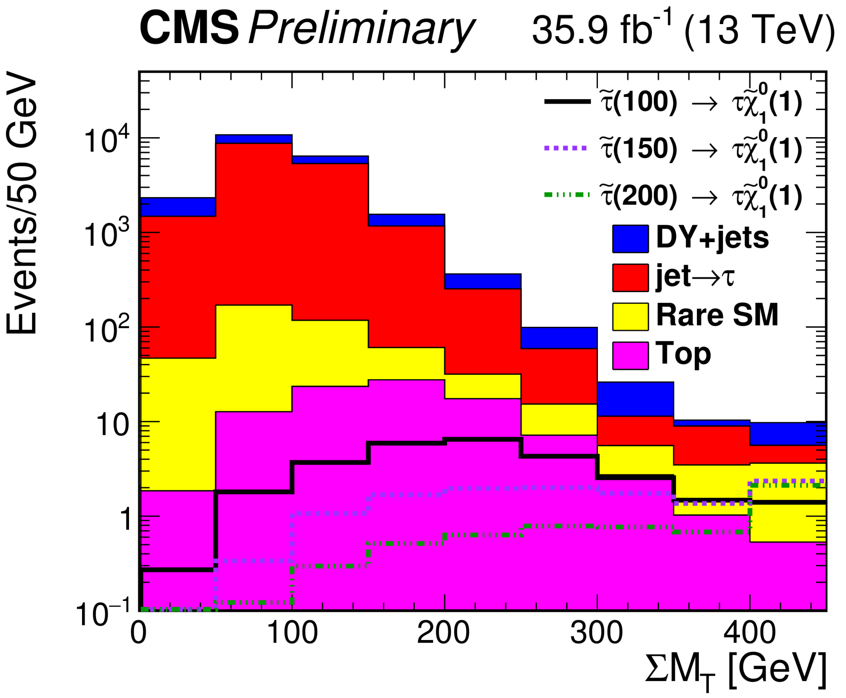
ATLAS-CONF-2016-048:

τ_{had} + 1lep + jets + E_T^{miss}.

stop —> stau —> gravitino.

Variable	SR requirement
$N_{b\text{-jet}}$	≥ 1
E_T^{miss}	$> GeV180$
$p_T(\tau)$	$> GeV70$
$m_{T2}(\ell, \tau)$	$> GeV100$



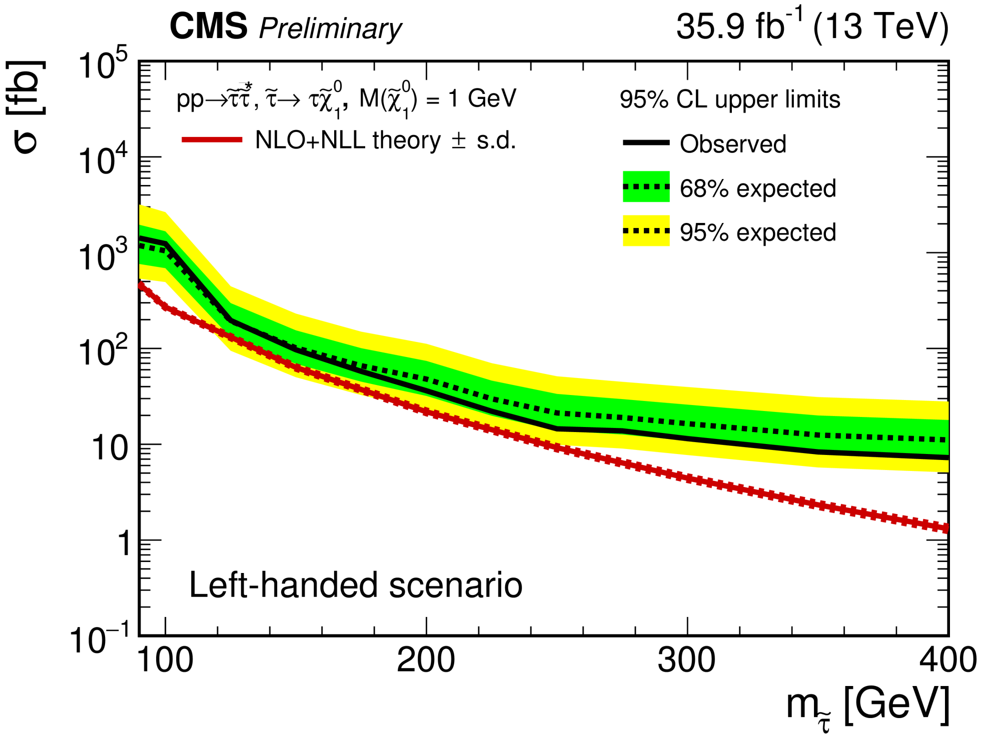


CMS-SUS-17-003

$2\tau_{had}$ + E_T^{miss}.

Discriminate using $M_{T2}(\tau_1,\tau_2)$ and ΣM_T

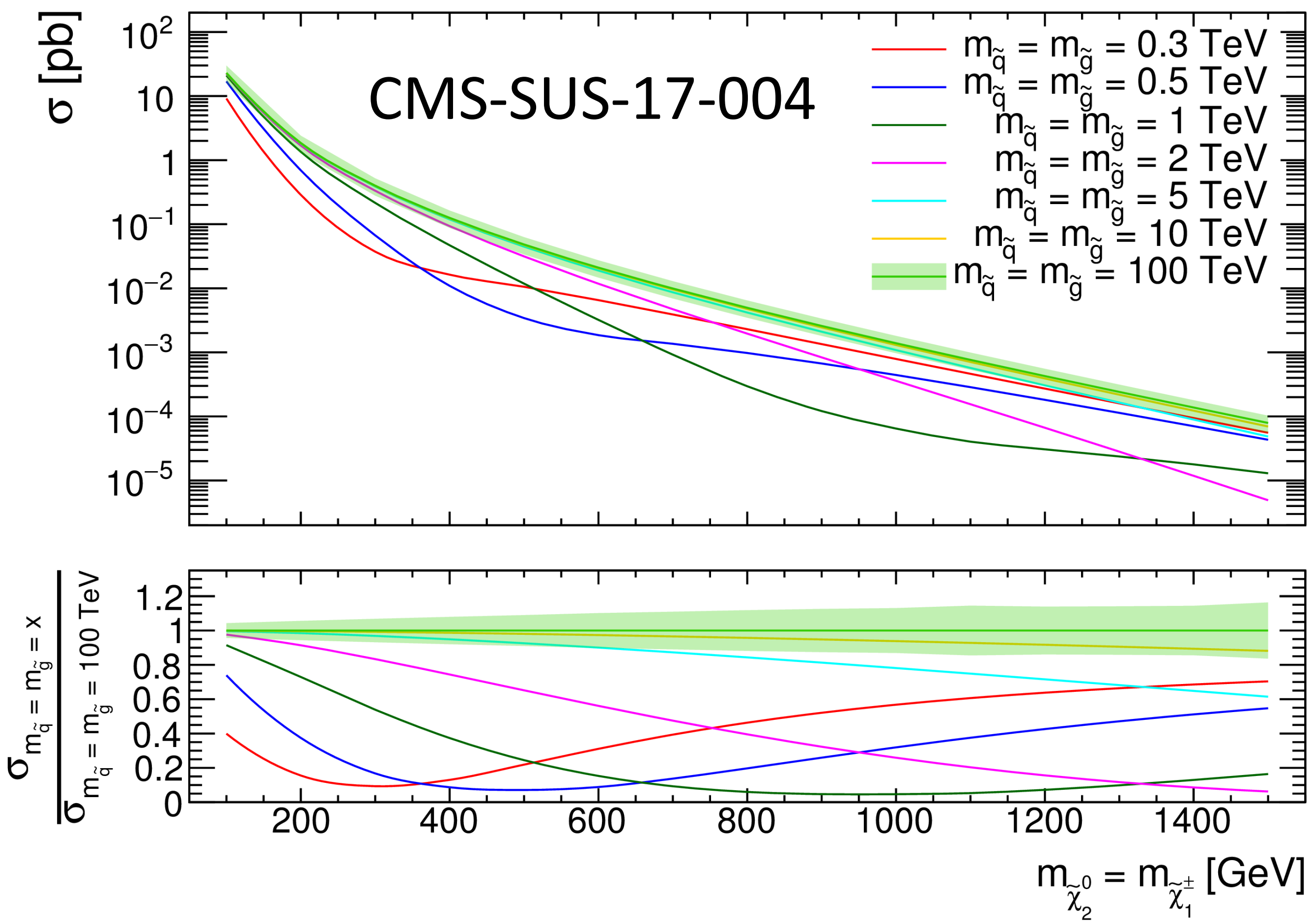
Interpret for stau pair production with different stau helicities.



$\Sigma M_T = M_T(\tau_1, E_T^{miss}) + M_T(\tau_2, E_T^{miss})$.

EWK EW production of sparticles

- SUSY can be produced via EW interactions, leading to direct production of charginos, neutralinos and sleptons.
  - Cross sections depend on the EW state composition (bino, wino, Higgsino) for charginos / neutralinos, and on chirality for sleptons.
  - EW sector could be the only accessible sector at the LHC if the colored sparticles are above 3-4 TeV.
- Complex decay structures:
  - directly via leptons
  - indirectly via lighter EW gauginos, sleptons/sneutrinos, W/Z/h.
  - Investigated cases with both neutralino and gravitino LSP.
- Searches mainly exploit the multilepton nature of the final states.



EWK EW production in multilepton searches

CMS-SUS-16-039:

Search for direct EW production of charginos and neutralinos.

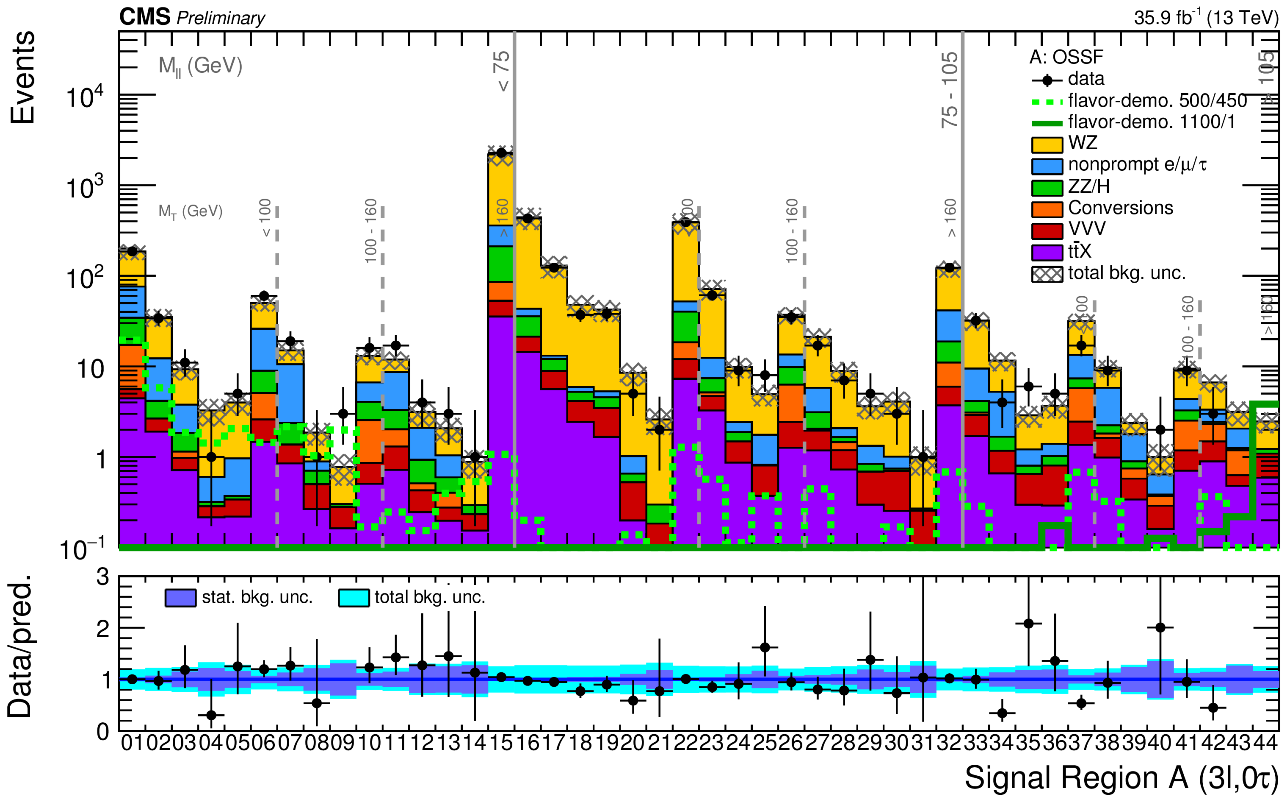
Final states with:

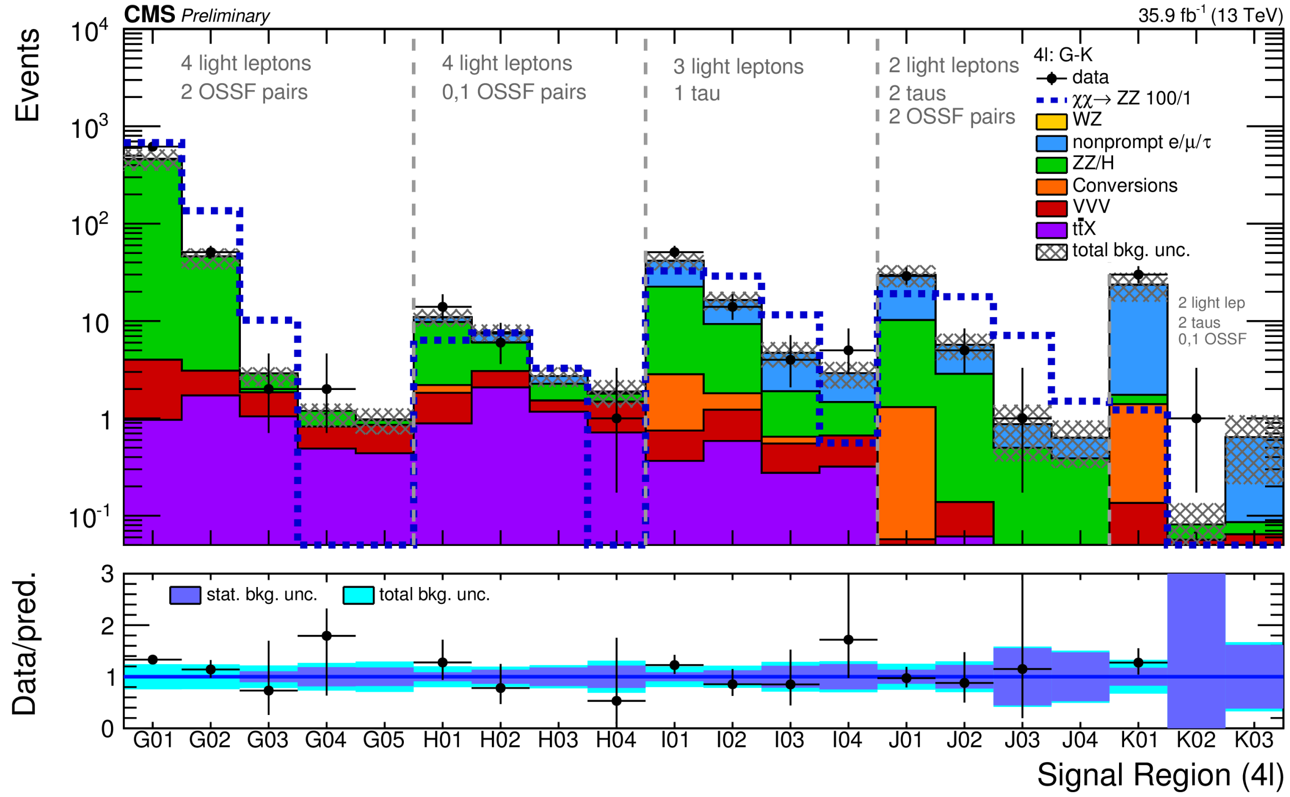
- 2 same charge light leptons + E_T^{miss}.
- ≥3 leptons including up to 2 hadronically decaying τ leptons + E_T^{miss}.

Using M_T, $p_T(ll)$, M_{ll}, E_T^{miss}, $M_{T2}(l_1, l_2)$ as discriminating variables.

No excess.

Extended the probed mass space considerably compared to the previous searches.



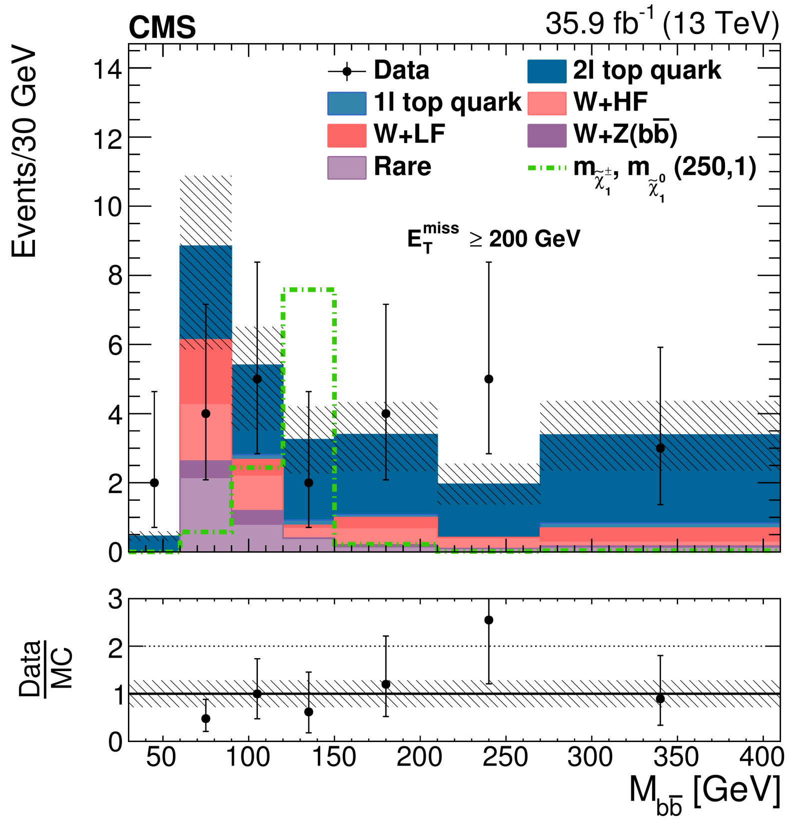


EWK $\tilde{\chi}^{\pm}_1 \tilde{\chi}^0_2$ in Wh and WZ channels

CMS-SUS-16-043: Search for chargino-neutralino2 production with decays to W(—>lν)h(—>bb).

1 lep + 2b + E_T^{miss}.

Look for an excess in m_{bb} around the Higgs mass.

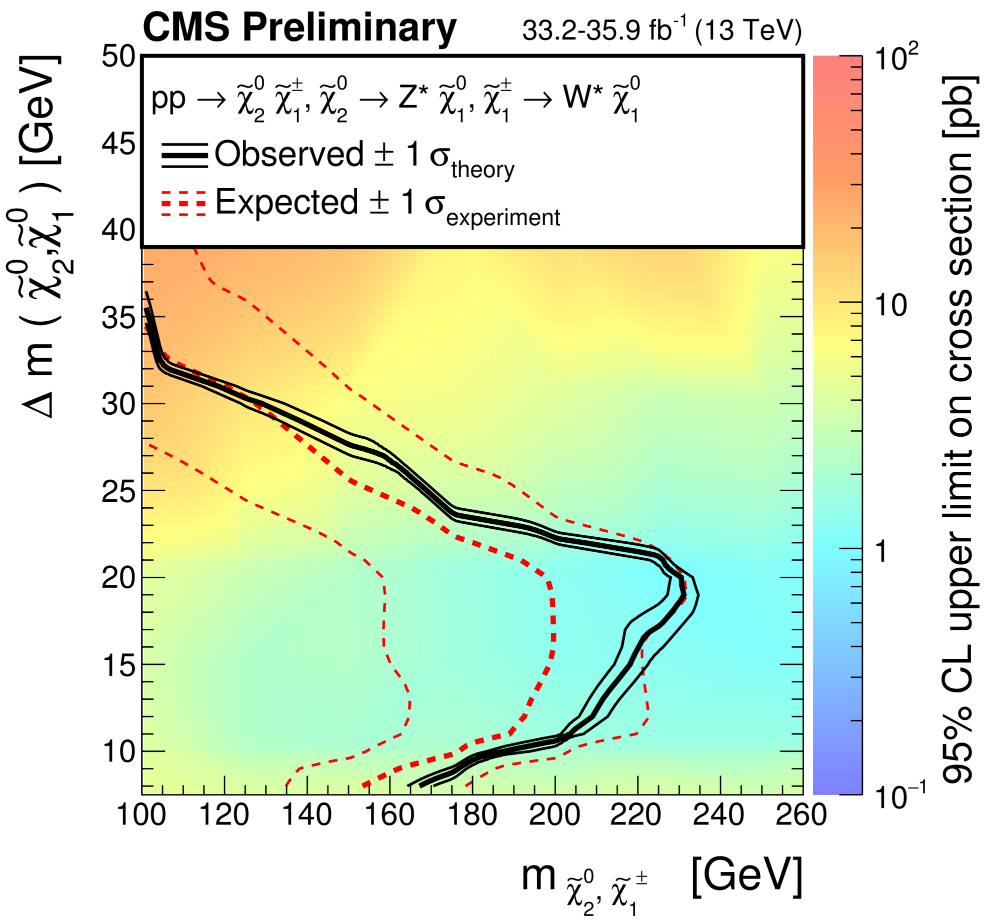


CMS-SUS-16-048:

2 opposite charge soft leptons + E_T^{miss}.

Nearly degenerate chargino-neutralino2 production, as in natural compressed higgsino models. Exploit decay to W Z(—> soft ll).

Variable	SR selection criteria
N_ℓ	$= 2$ $(ee, \mu\mu, e\mu)$
$Q(\ell_1)Q(\ell_2)$	-1
$p_T(\ell_1)$, $p_T(\ell_2)$	$[5, 30]$ GeV
$p_T(\mu_2)$ for high E_T^{miss} $\tilde{t}$-like SR	$[3.5, 30]$ GeV
$\|\eta_\mu\|$	< 2.4
$\|\eta_e\|$	< 2.5
IP_{3D}	< 0.01 cm
SIP_{3D}	< 2
$Iso_{rel}(\ell_{1,2})$& $Iso_{abs}(\ell_{1,2})$	< 0.5 && < 5 GeV
$p_T(jet1)$	> 25 GeV
$\|\eta\|(jet1)$	< 2.4
N_b (>25 GeV, CSVv2L)	$= 0$
$M(\ell\ell)$	< 50 GeV
$p_T(\ell\ell)$	> 3 GeV
E_T^{miss}	> 125 GeV
E_T^{miss} (muon subtracted)	> 125 GeV
E_T^{miss} / H_T	$[0.6, 1.4]$
H_T	> 100 GeV
$M(\ell\ell)$	> 4 GeV
$M(\ell\ell)$	veto$[9, 10.5]$ GeV
$M_{\tau\tau}$	veto$[0, 160]$ GeV
$M_T(\ell_x, E_T^{miss}), x = 1, 2$	< 70 GeV (for electroweakino selection only)



EWK Combining searches with W/Z/h

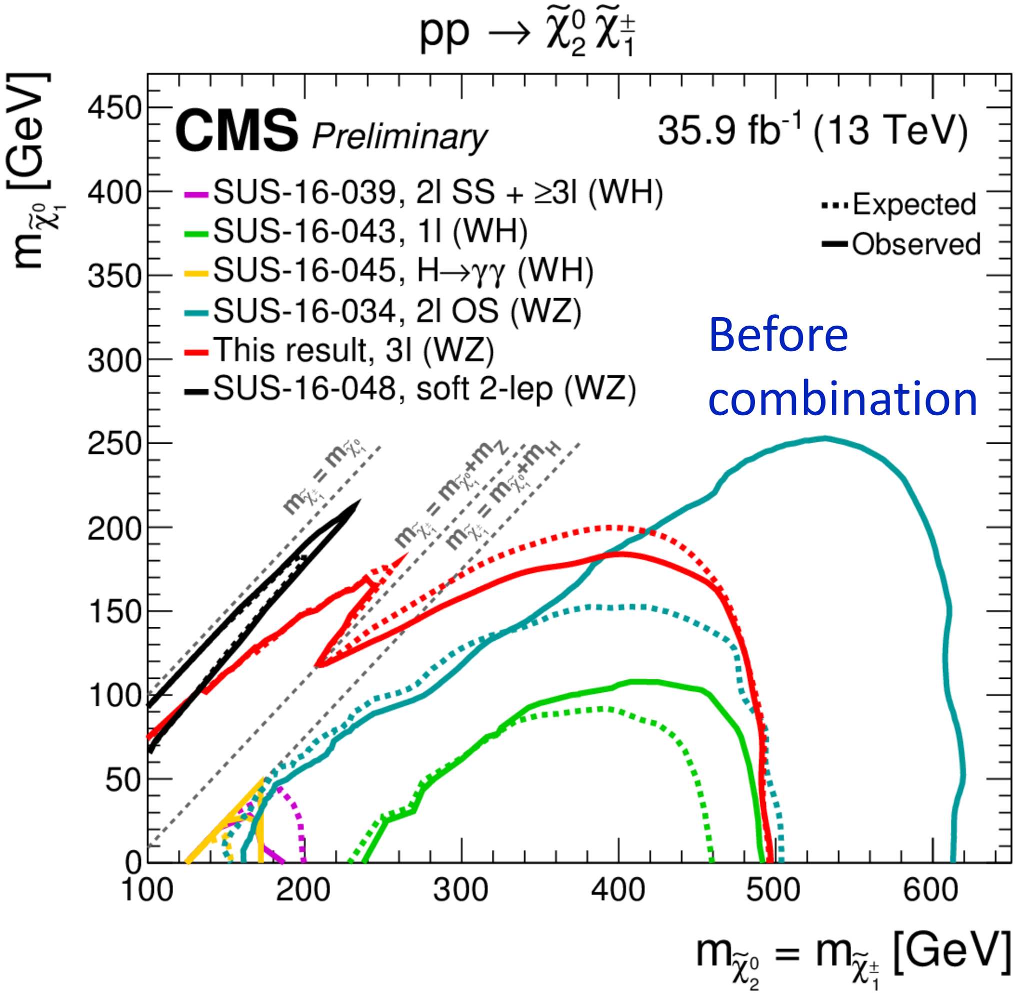
CMS-SUS-17-004: Combined search for EW production of charginos and neutralinos.

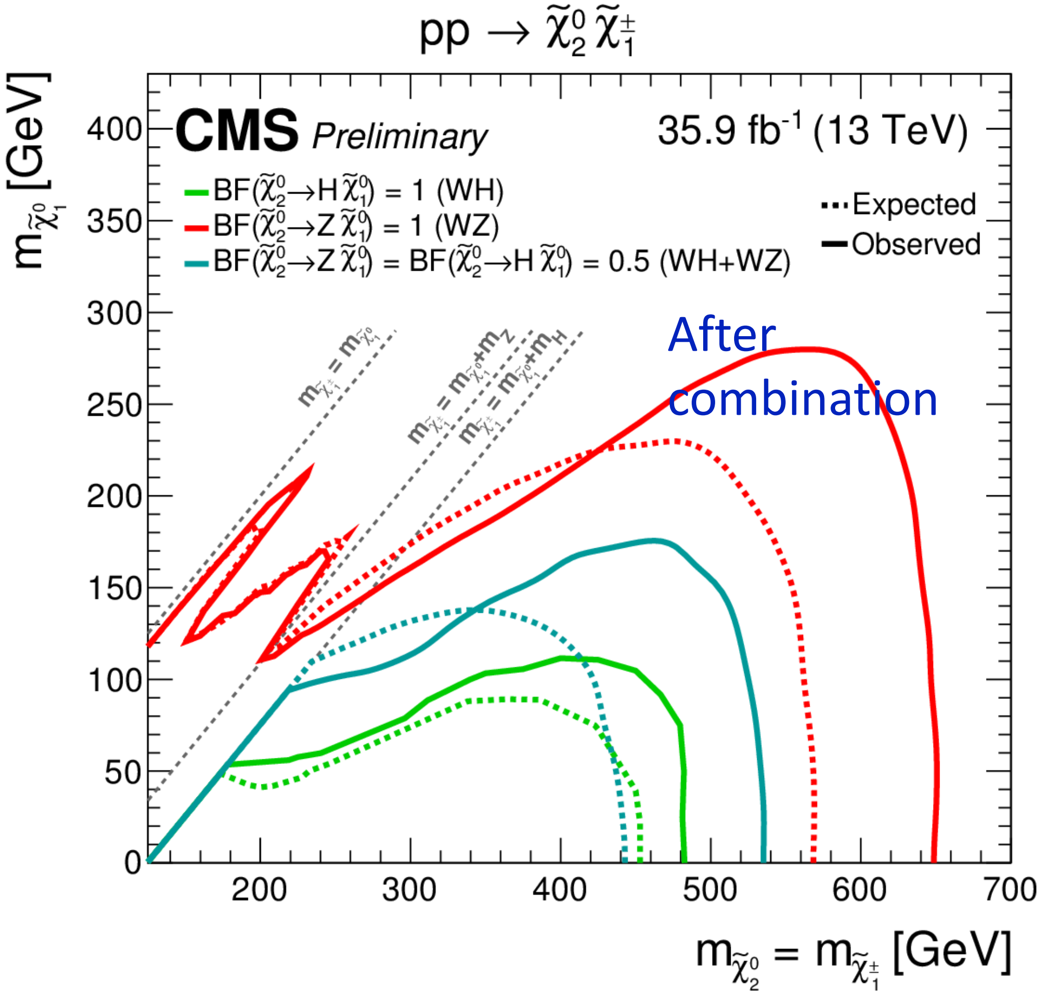
Targets decays with W/Z/h.

Additional optimized analysis with ≥3 charged leptons, for models with Δm(neutralino2-neutralino1 ~= mZ .

Searches in combination and target signal topologies

	Signal topology				
Search	WZ	WH	ZZ	ZH	HH
1ℓ 2b		✓			
4b					✓
2ℓ on-Z	✓		✓	✓	
2ℓ soft	✓				
2ℓ SS, $\geq 3\ell$	✓	✓	✓	✓	✓
$H(\gamma\gamma)$		✓		✓	✓





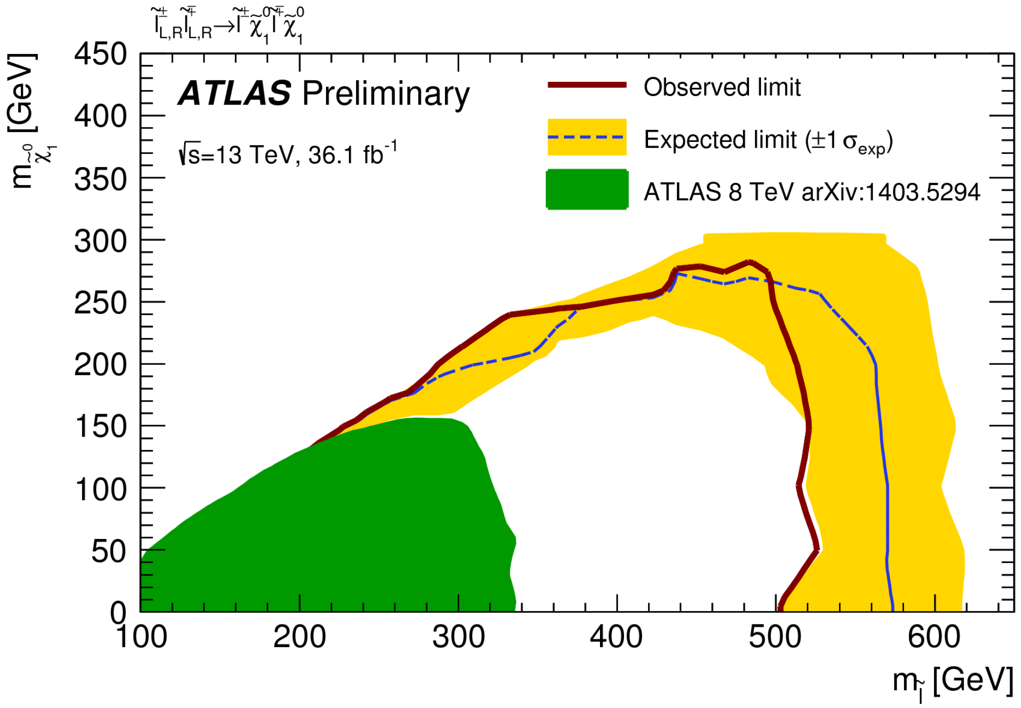
Combination significantly improved sensitivity.

EWK Searches with sleptons and staus

2ℓ+jets signal region definitions

	SR2-int	SR2-high	SR2-low-2J	SR2-low-3J
$n_{\mathrm{non-b-tagged\ jets}}$	≥ 2		2	3-5
$m_{\ell\ell}$ [GeV]	81-101		81-101	86-96
m_{jj} [GeV]	70-100		70-90	70-90
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	>150	> 250	>100	>100
p_{T}^{Z} [GeV]	>80		> 60	> 40
p_{T}^{W} [GeV]	>100			
m_{T2} [GeV]	>100			
$\Delta R_{(jj)}$	<1.5			<2.2
$\Delta R_{(\ell\ell)}$	<1.8			
$\Delta\phi_{(\vec{E}_{\mathrm{T}}^{\mathrm{miss}},Z)}$			< 0.8	
$\Delta\phi_{(\vec{E}_{\mathrm{T}}^{\mathrm{miss}},W)}$	0.5-3.0		> 1.5	< 2.2
$E_{\mathrm{T}}^{\mathrm{miss}}/p_{\mathrm{T}}^{Z}$			0.6 – 1.6	
$E_{\mathrm{T}}^{\mathrm{miss}}/p_{\mathrm{T}}^{W}$			< 0.8	
$\Delta\phi_{(\vec{E}_{\mathrm{T}}^{\mathrm{miss}},\mathrm{ISR})}$				> 2.4
$\Delta\phi_{(\vec{E}_{\mathrm{T}}^{\mathrm{miss}},\mathrm{jet1})}$				> 2.6
$E_{\mathrm{T}}^{\mathrm{miss}}/\mathrm{ISR}$				0.4-0.8
$\lvert\eta(Z)\rvert$				< 1.6
$p_{\mathrm{T}}^{\mathrm{jet3}}$ [GeV]				> 30

ATLAS-CONF-2017-039: EWK gauginos, sleptons at the 2 or 3 leptons + E_T^{miss} channel.

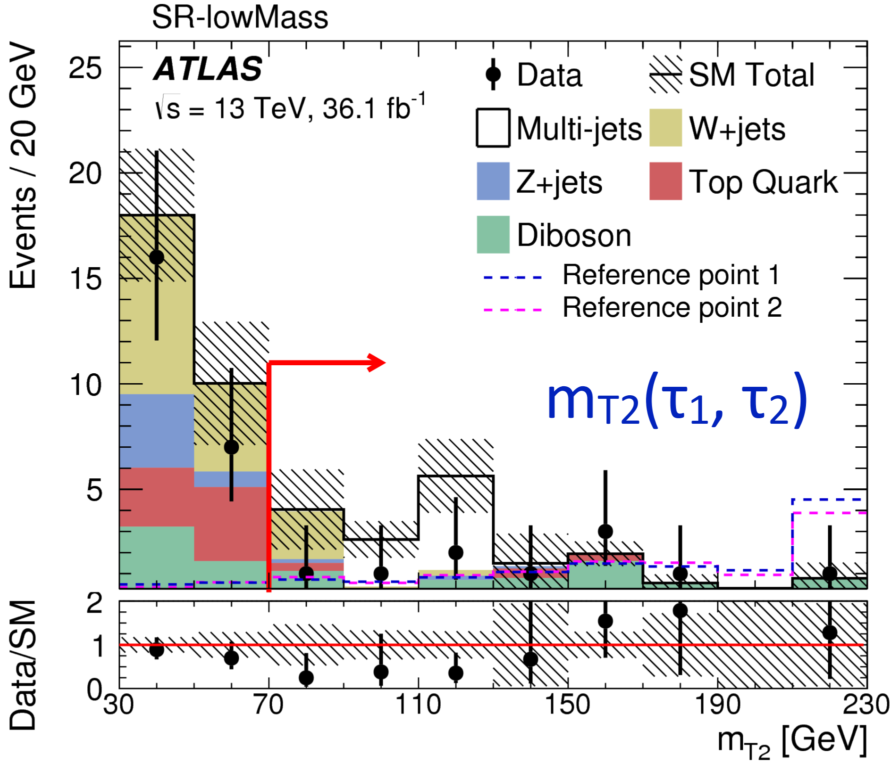


direct slepton pair production. Combining left and right-handed sleptons.

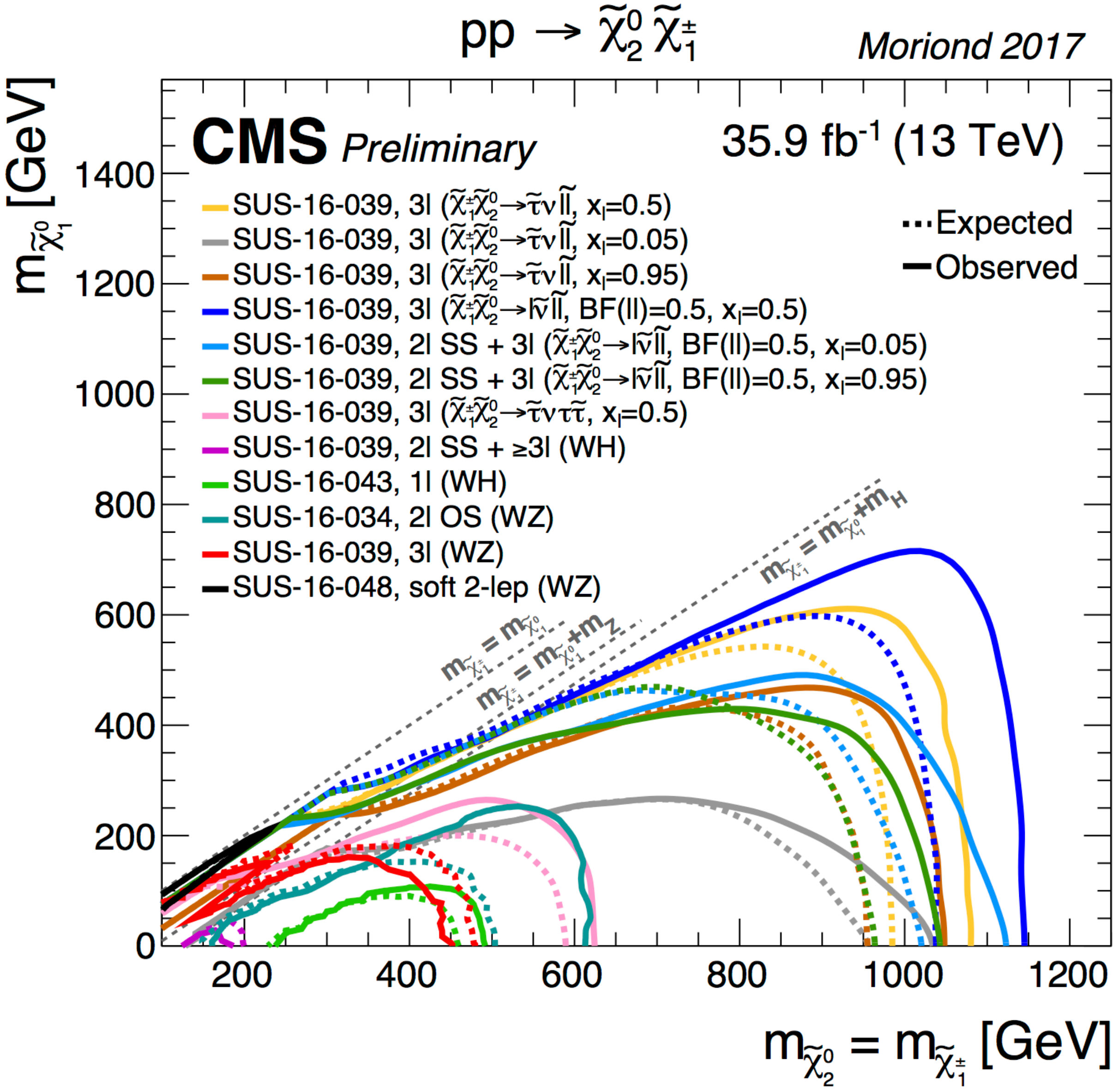
ATLAS arXiv:1708.07875: Search for charginos/ neutrainos decaying to τs. 2τs + E_T^{miss}.

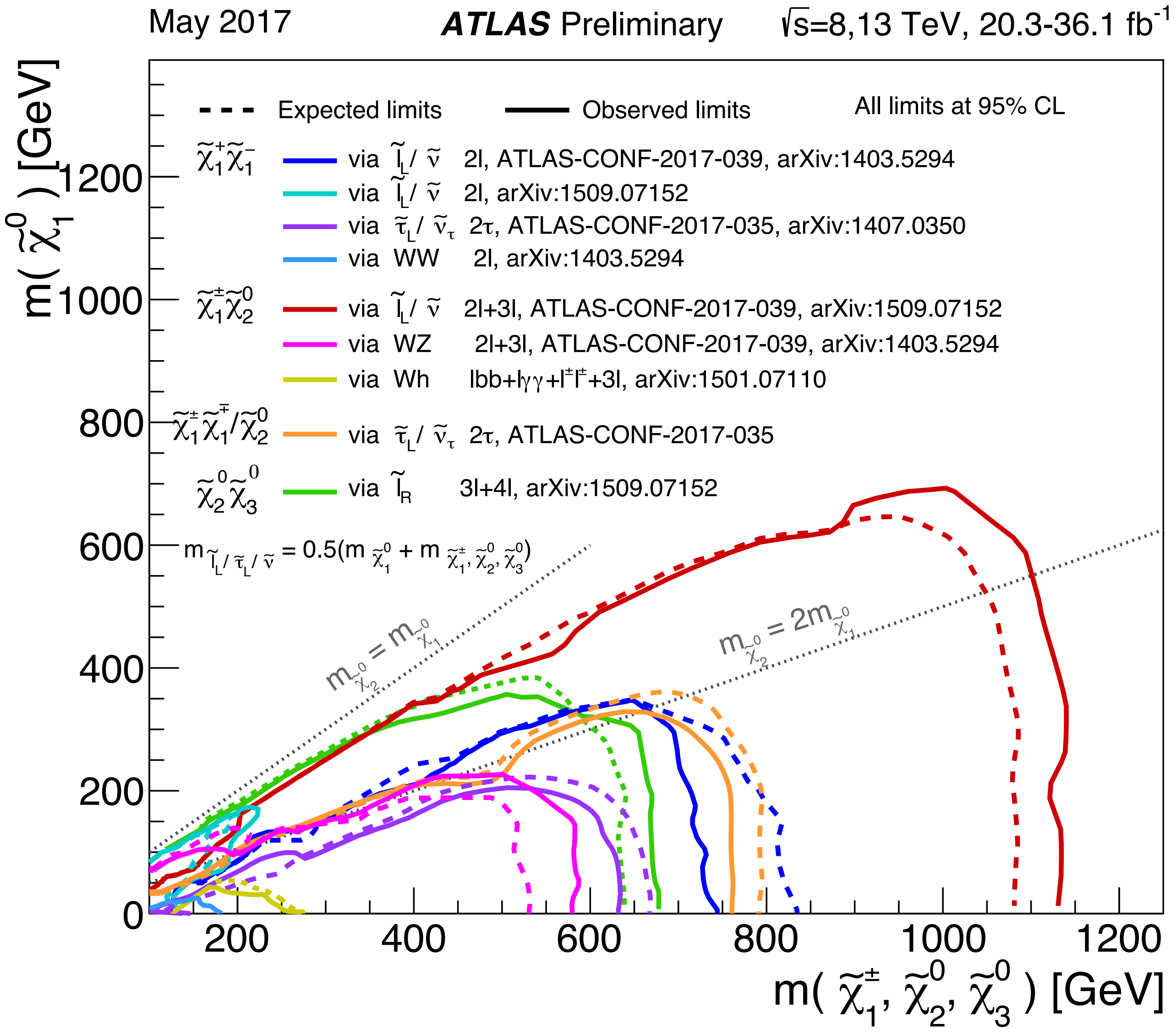
<table>
<tr><th>SR-lowMass</th><th colspan="2">SR-highMass</th></tr>
<tr><td colspan="3">At least one opposite-sign tau pair
b-jet veto
Z-veto</td></tr>
<tr><td>At least two medium tau candidates

$m_{\mathrm{T2}} > 70$ GeV</td><td colspan="2">at least one medium and one tight tau candidates
$m(\tau_1, \tau_2) > 110$ GeV
$m_{\mathrm{T2}} > 90$ GeV</td></tr>
<tr><td>Di-tau+$E_{\mathrm{T}}^{\mathrm{miss}}$ trigger
$E_{\mathrm{T}}^{\mathrm{miss}} > 150$ GeV
$p_{\mathrm{T},\tau_1} > 50$ GeV
$p_{\mathrm{T},\tau_2} > 40$ GeV</td><td>di-tau+$E_{\mathrm{T}}^{\mathrm{miss}}$ trigger
$E_{\mathrm{T}}^{\mathrm{miss}} > 150$ GeV
$p_{\mathrm{T},\tau_1} > 80$ GeV
$p_{\mathrm{T},\tau_2} > 40$ GeV</td><td>asymmetric di-tau trigger
$E_{\mathrm{T}}^{\mathrm{miss}} > 110$ GeV
$p_{\mathrm{T},\tau_1} > 95$ GeV
$p_{\mathrm{T},\tau_2} > 65$ GeV</td></tr>
</table>



EWK Sensitivity to EW gauginos





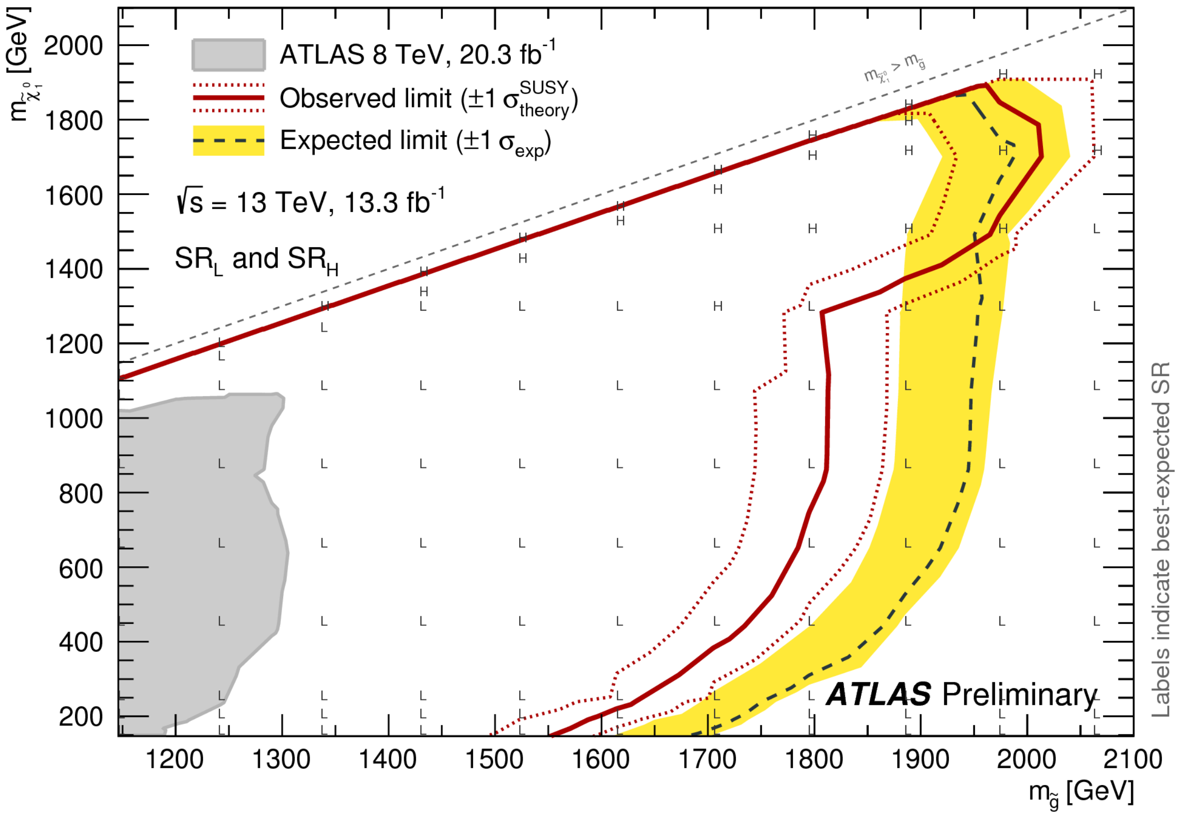
- Diversity of searches and channels give a complementary picture.
- For decays via W/Z/h bosons, sensitivity is up to ~600 GeV.
- For decays via sleptons, sensitivity is up to ~1.2 TeV. Highest sensitivity is reached in the slepton/sneutrino decays.

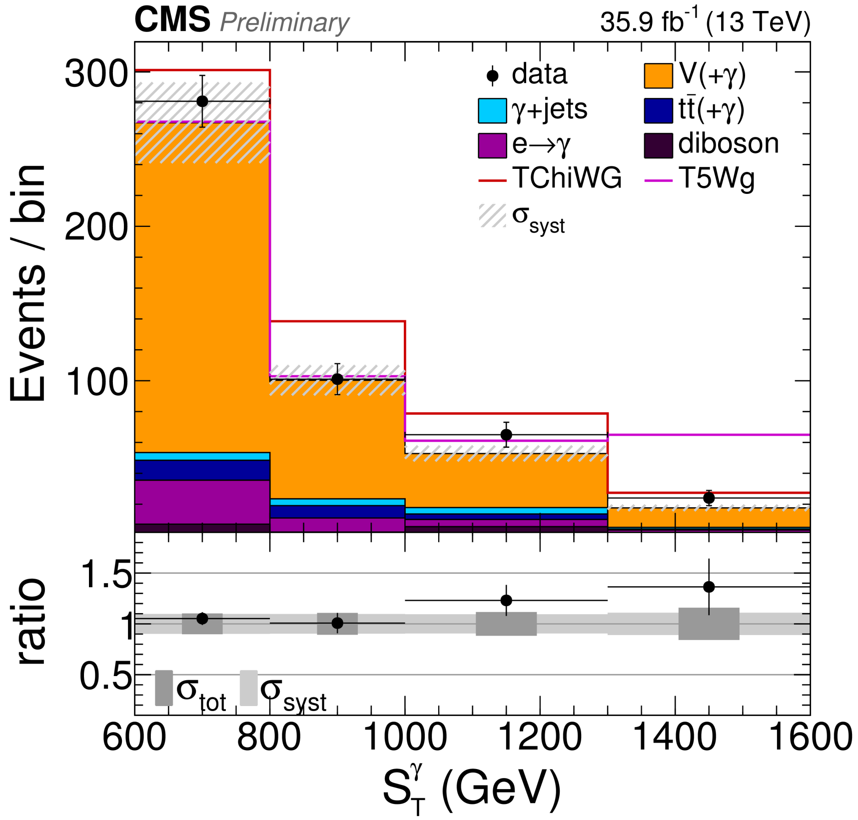
Photons + E_T^{miss} searches

Target gauge mediated SUSY breaking (GMSB) models with gravitino LSP. Neutralino next-to-LSP decays to gravitino + γ + others.

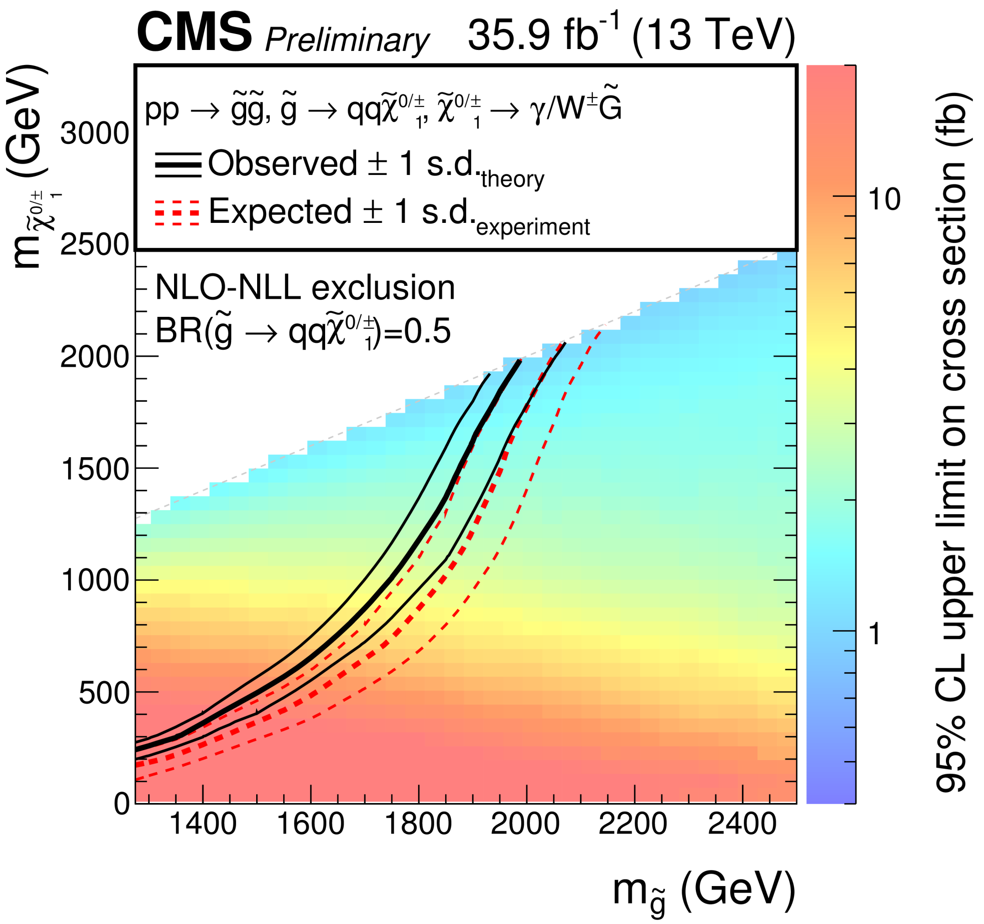
ATLAS-CONF-2016-066:
Isolated γ + jets + E_T^{miss}.
Use $\Delta\phi(\gamma, E_T^{miss})$, $\Delta\phi(j, E_T^{miss})$, E_T^{miss}, m_{eff}, etc. to discriminate.

$$pp \to \tilde{g}\tilde{g},\ \tilde{g} \to qq\tilde{\chi}_1^0,\ \tilde{\chi}_1^0 \to Z/\gamma\tilde{G}$$





$$S_T^\gamma \equiv p_T^{\text{miss}} + \textstyle\sum_{\gamma_i} p_T(\gamma_i)$$



CMS-SUS-16-046:
Isolated γ + E_T^{miss}.

Studied scenarios where neutralino has bino or wino components.

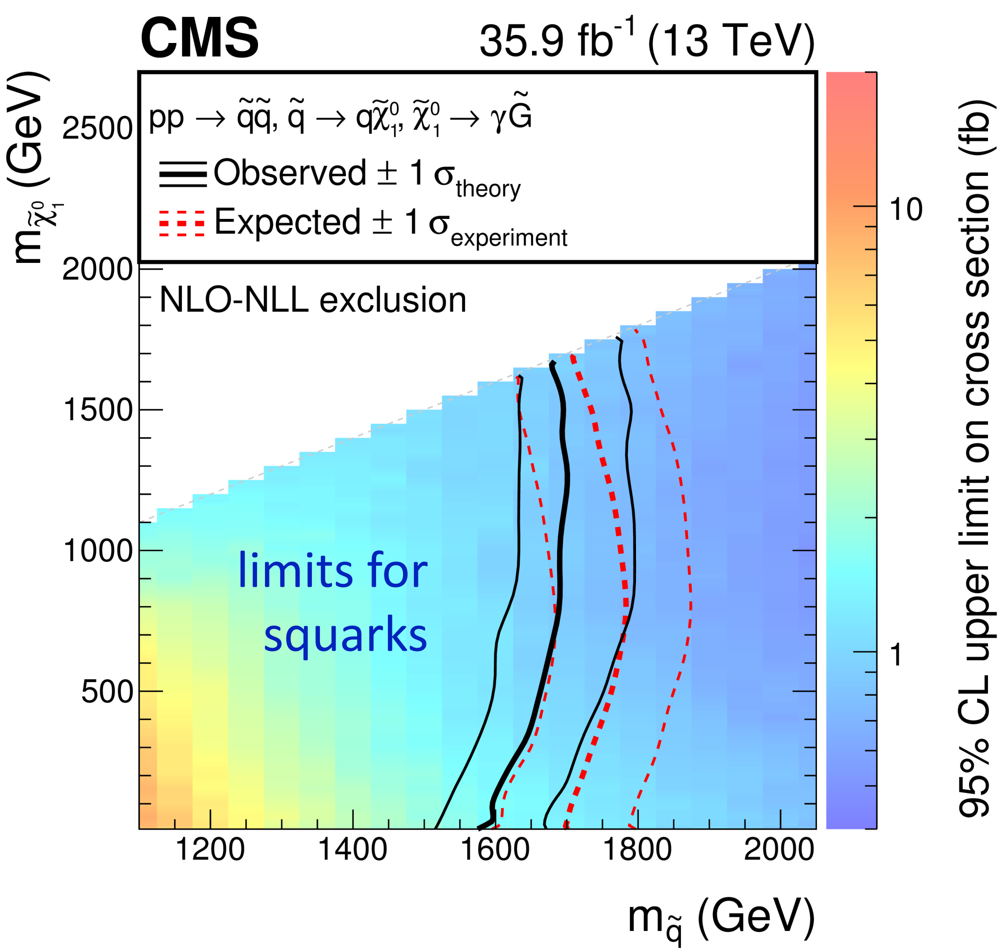
Use E_T^{miss}, S_T^γ, $m_T(\gamma, E_T^{miss})$

High H_T, decays with h —> bb

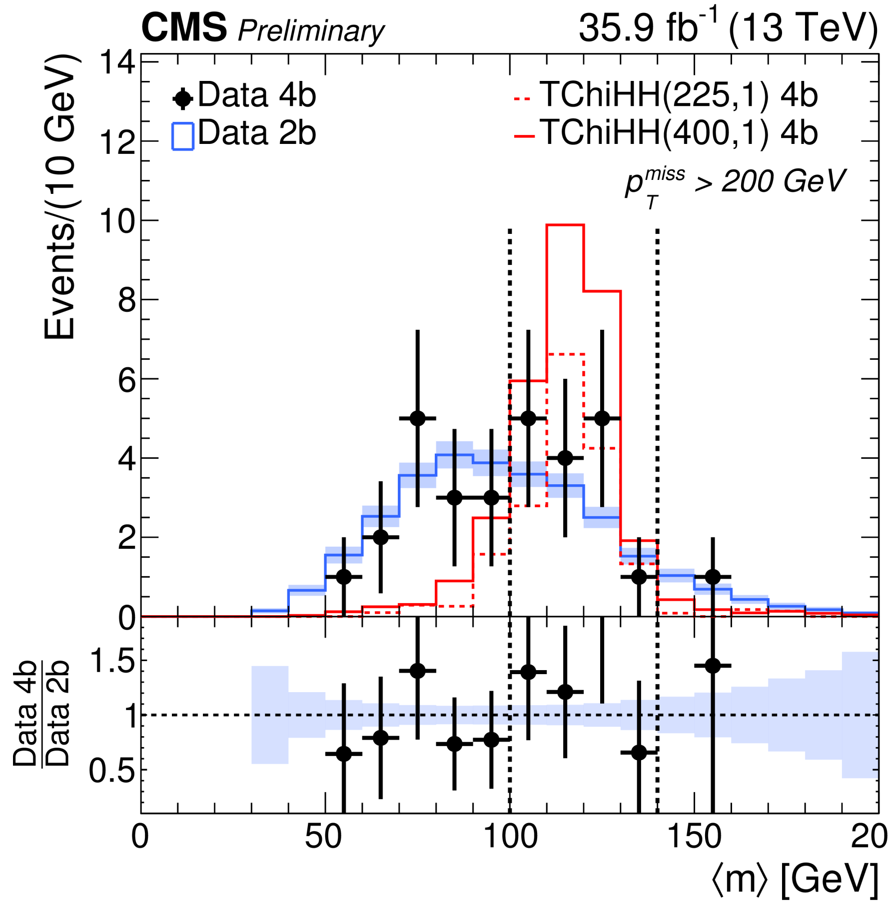
CMS-SUS-16-044: γ + E_T^{miss} + high H_T.

Targets GMSB, squarks/gluinos decaying to γs and gravitino LSP, via short lived neutralino$_1$.

Cases with high transverse activity.



limits for squarks

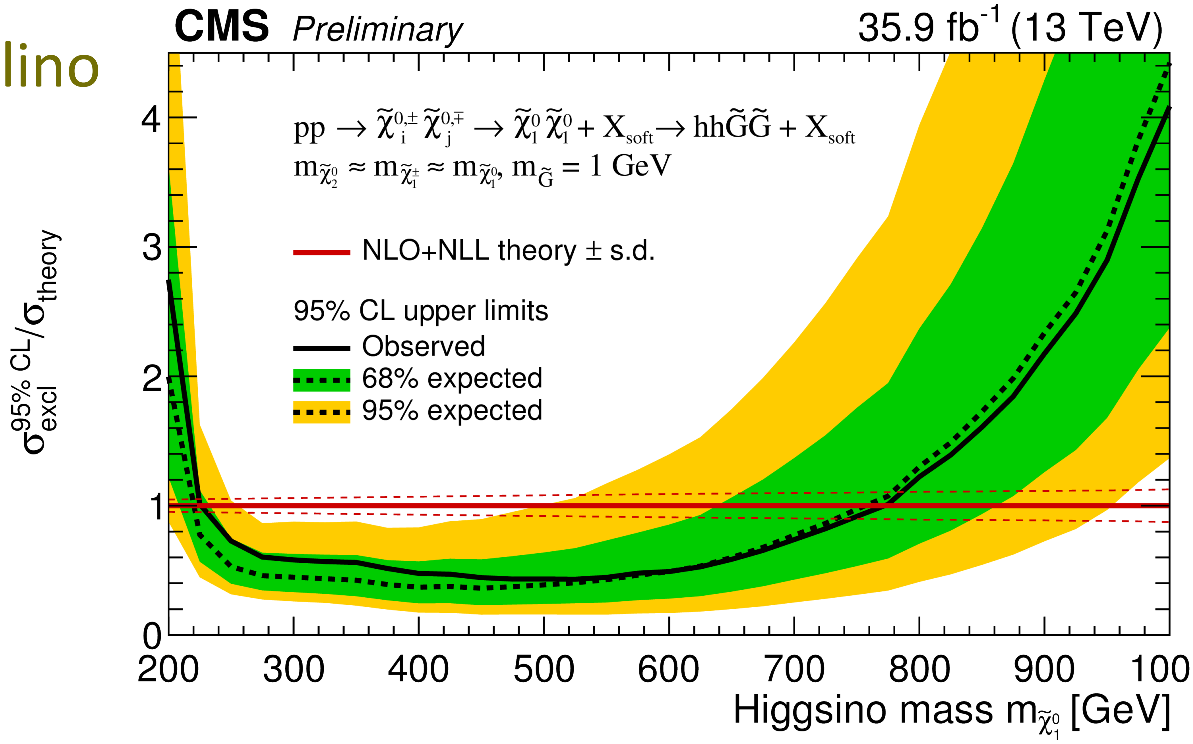


CMS-SUS-16-044: 2 Higgs bosons (h —> bb) + E_T^{miss}.

GMSB, higgsino-like neutralino —> hG —> bbG.

Small Δm|h$_1$ - h$_2$|

Bin in b jet multiplicity and average Higgs mass <m$_h$>.



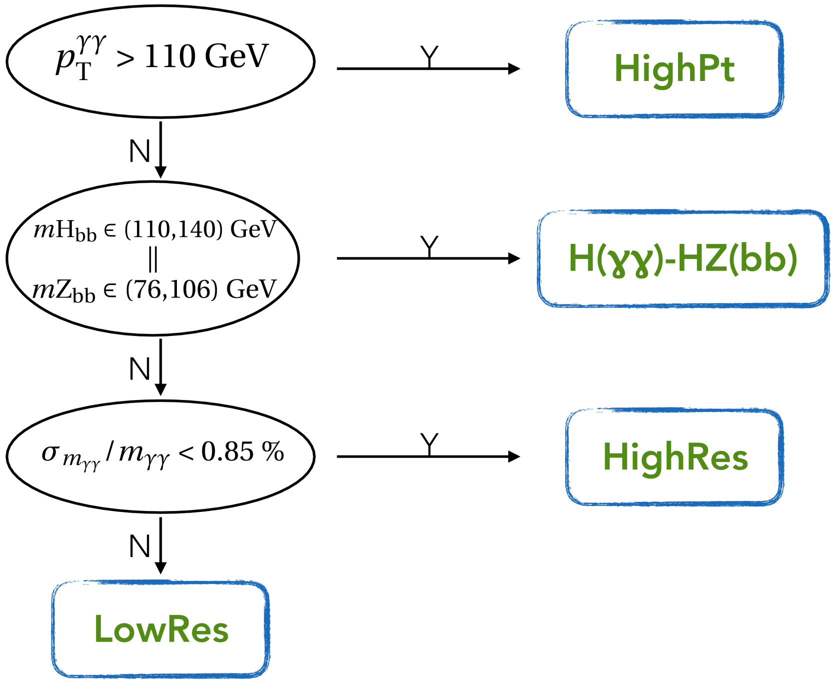
Anomalous h —> γγ

CMS-SUS-16-045:

Anomalous Higgs production in the γγ decay channel in association with >= 1 jet.

Razor variables M_R, R^2 to suppress SM.

Categorize events using M_R, R^2; momentum and mass resolution of the γγ system.



$p_T^{\gamma\gamma} > 110$ GeV —Y→ **HighPt**

N

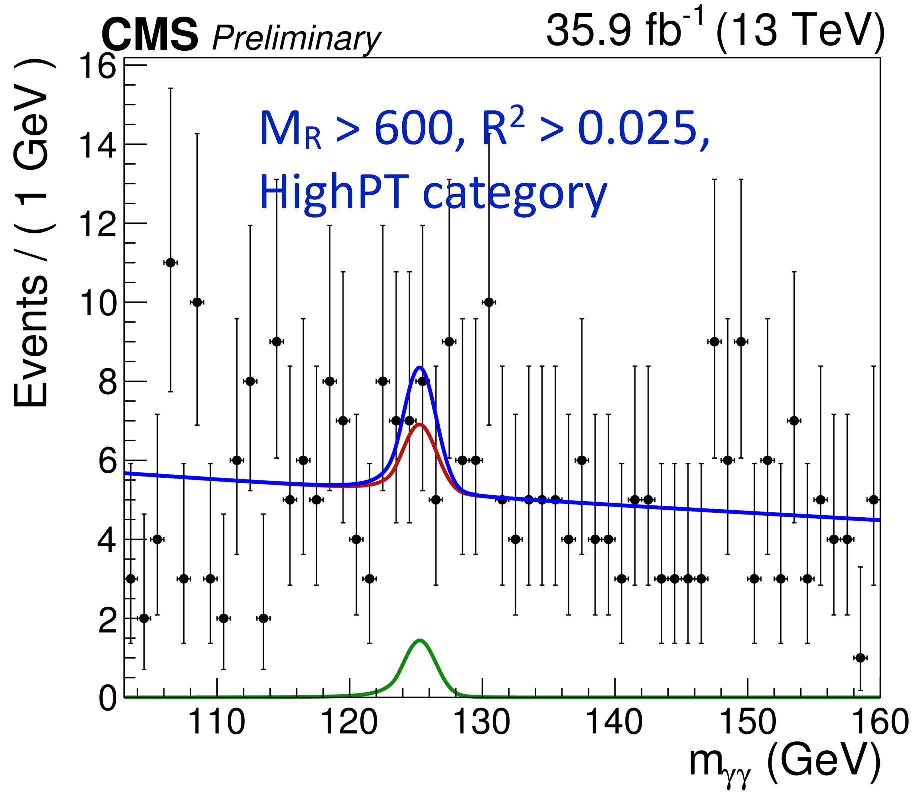
$mH_{bb} \in (110,140)$ GeV || $mZ_{bb} \in (76,106)$ GeV —Y→ **H(γγ)-HZ(bb)**

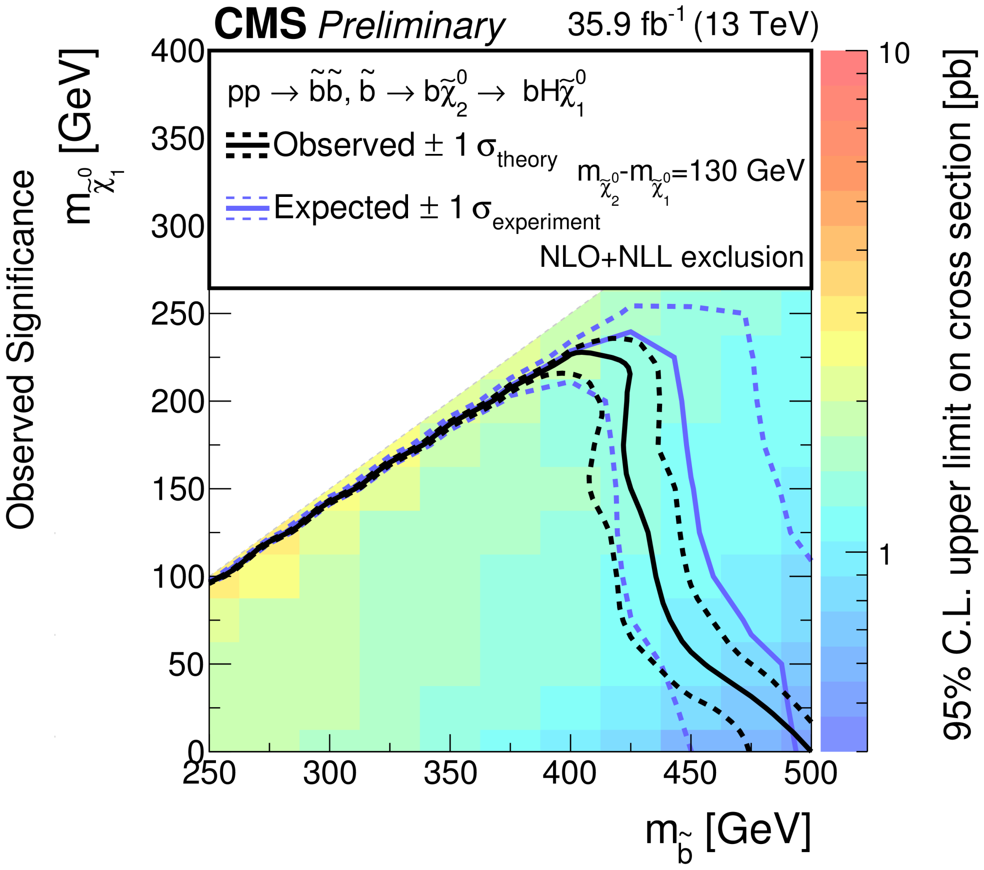
N

$\sigma_{m_{\gamma\gamma}} / m_{\gamma\gamma} < 0.85$ % —Y→ **HighRes**

N

LowRes





Extract signal from non-resonant QCD BG through a fit to the γγ mass distribution.

Interpret in terms of SMS sbottom —> h b neutralino.

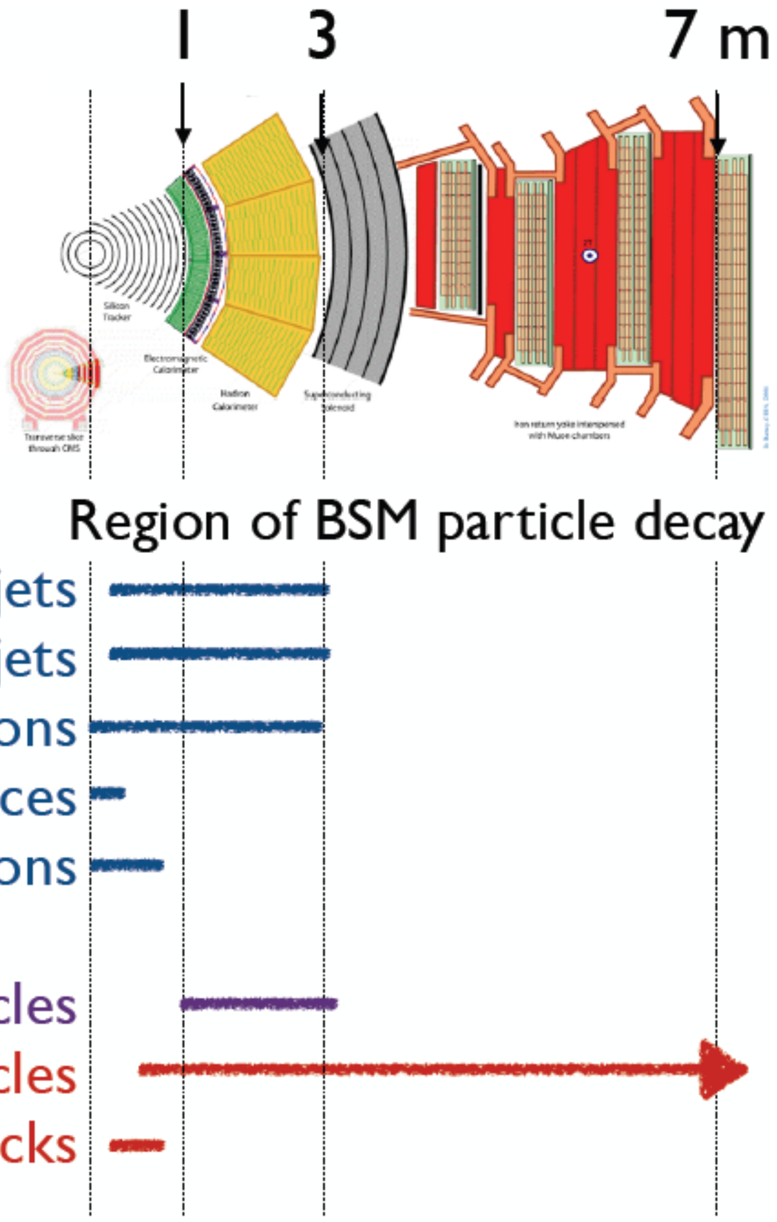
Searches for long lived particles

In many cases, particles may decay non-promptly, outside the beamspot.

- A wide diversity of searches for non-prompt particles complement the prompt searches. Improving and exploring further in Run2.
- Not much SM background outside the beamspot. Mostly detector noise, cosmic rays, reconstruction failure, etc. estimated from data.

Non-prompt signatures and target models:

from W. Wulsin



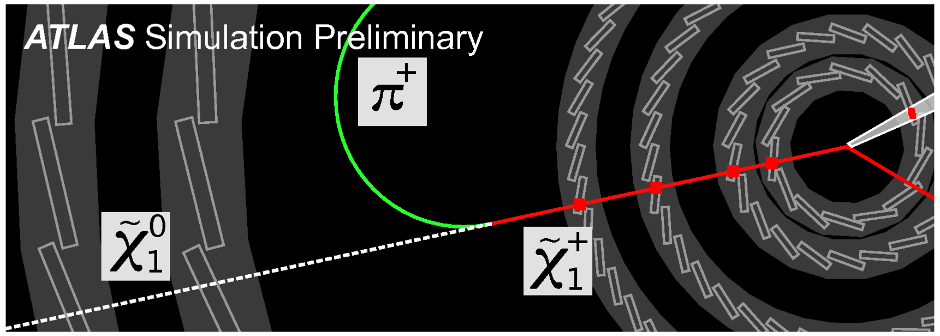
displaced jets	→ Hidden valley, RPV SUSY, stealth SUSY
lepton jets	→ dark photons
displaced leptons	→ Hidden valley, RPV SUSY, displaced SUSY
displaced vertices	→ Split SUSY, RPV, GMSB
displaced / delayed photons	→ GMSB
stopped particles	→ split SUSY gluino, stop, …
heavy stable charged particles	→ gluino, stop, GMSB slepton, chargino …
disappearing tracks	→ degenerate chargino

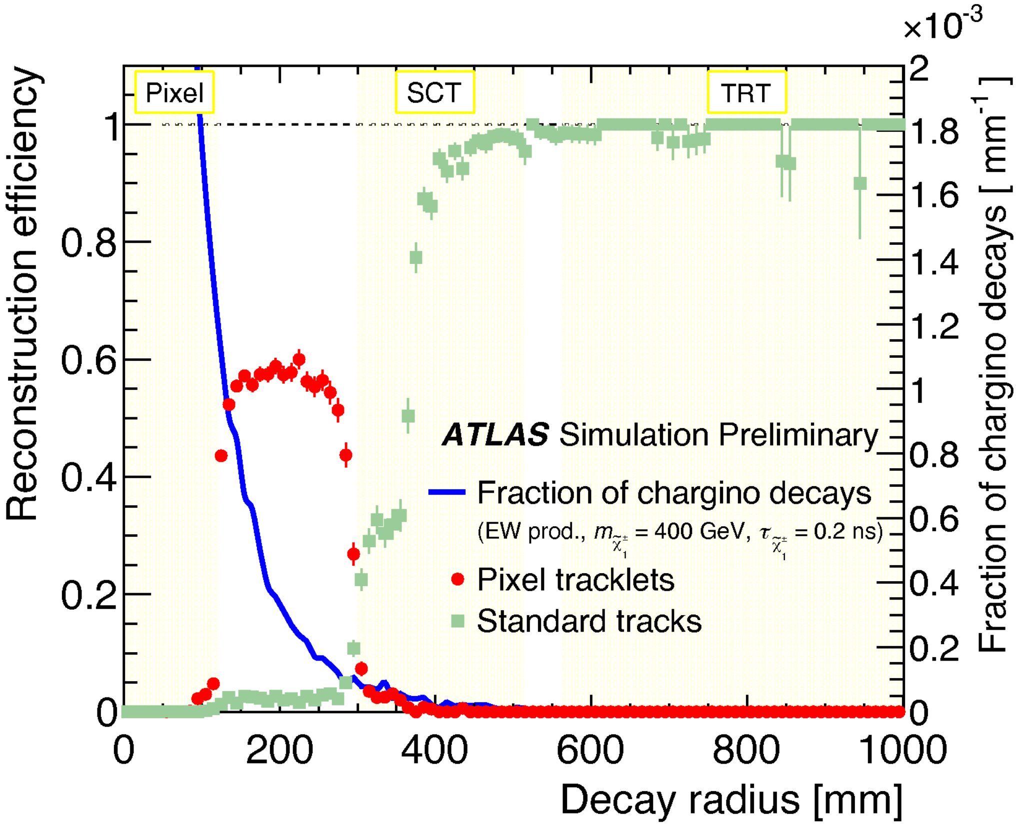
Disappearing track

ATLAS-CONF-2017-017: Short track + jets + E_T^{miss}.

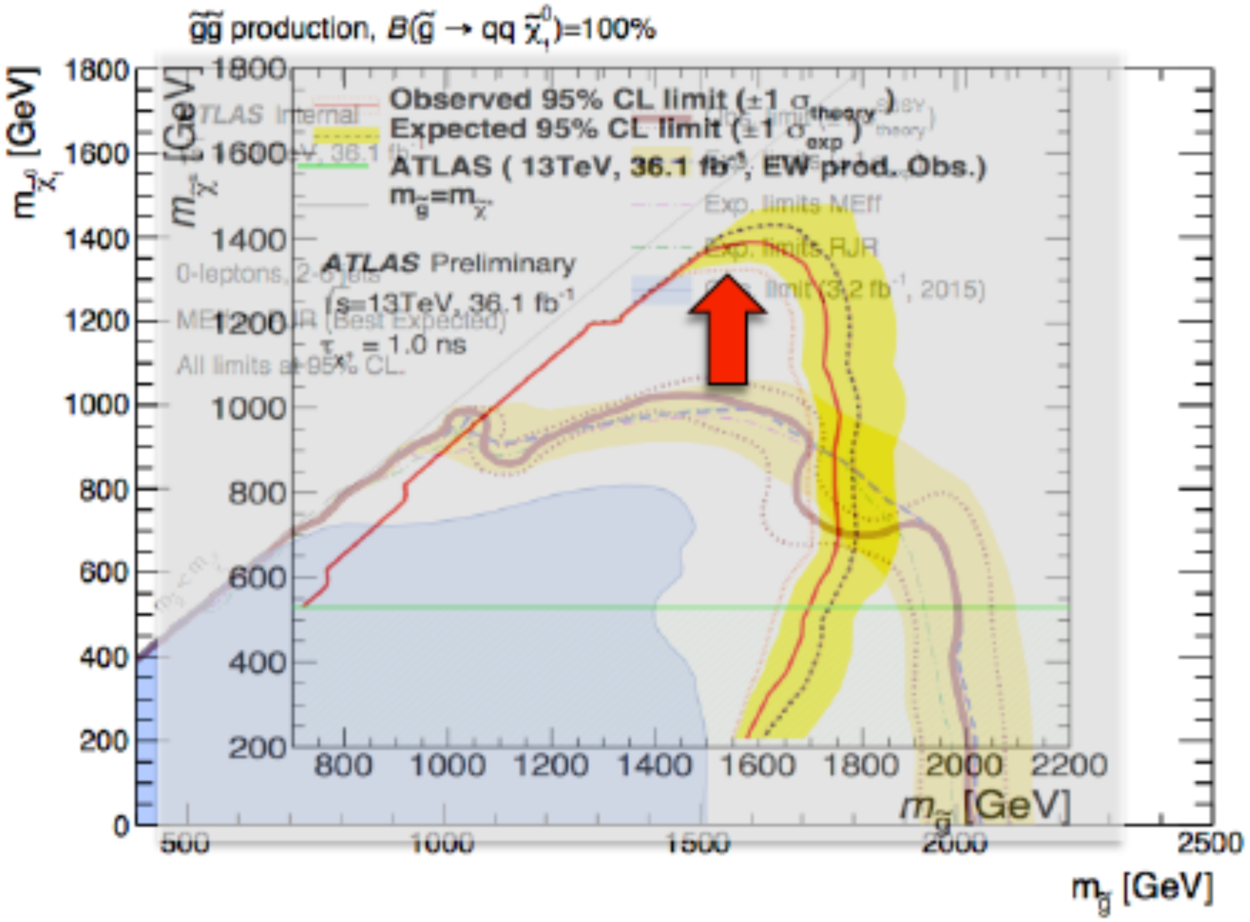
Long-lived chargino decay, common to wino LSP scenario - ~1/3 of pMSSM phase space.

$\tilde{\chi}^{\pm}$ NLSP almost degenerate with $\tilde{\chi}^{0}$ LSP
—> $\tilde{\chi}^{\pm}$ —> $\tilde{\chi}^{0}\pi^{\pm}$ (soft) —> $\pi^{\pm}$ not reconstructed
—> disappearing track.



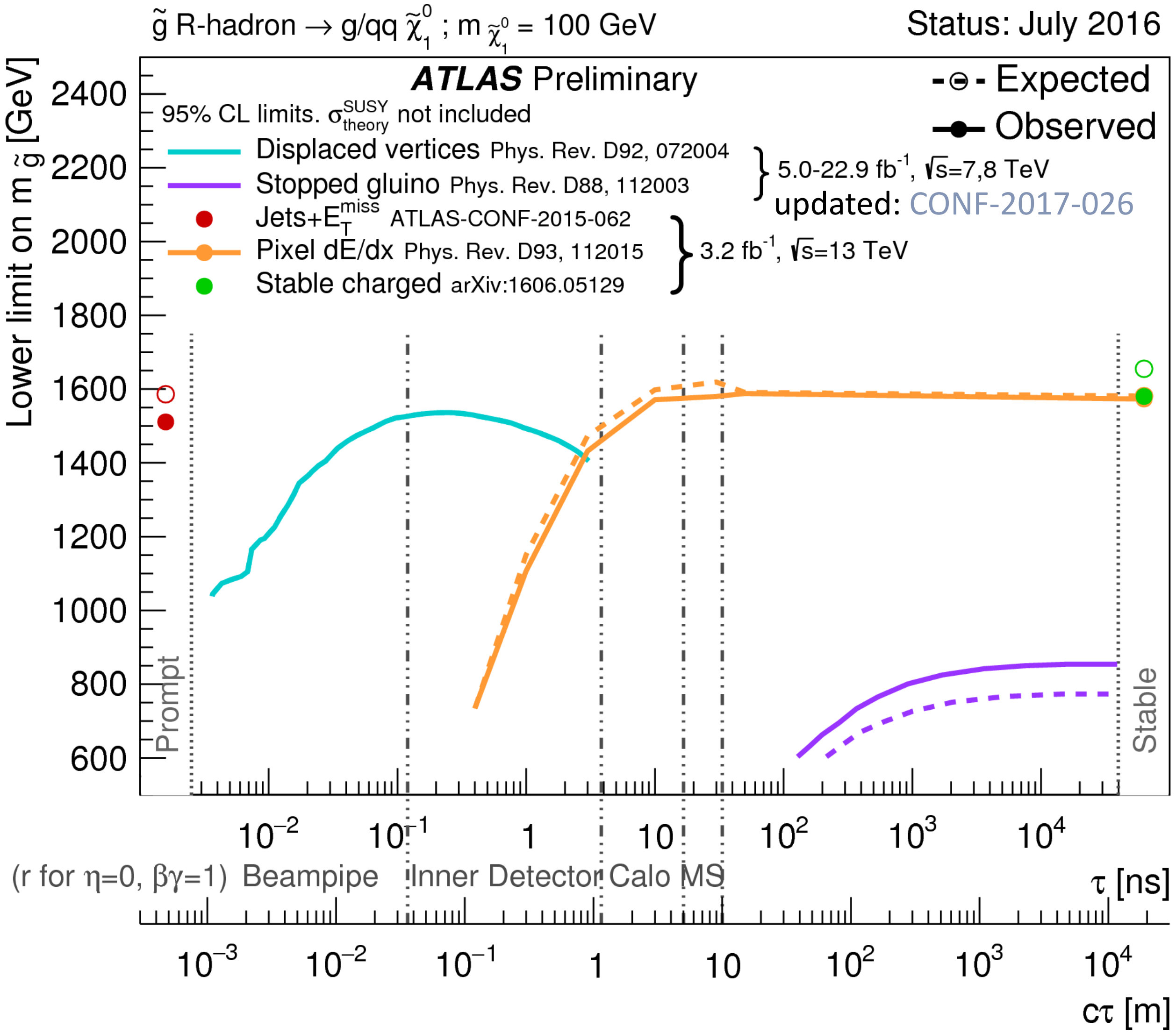


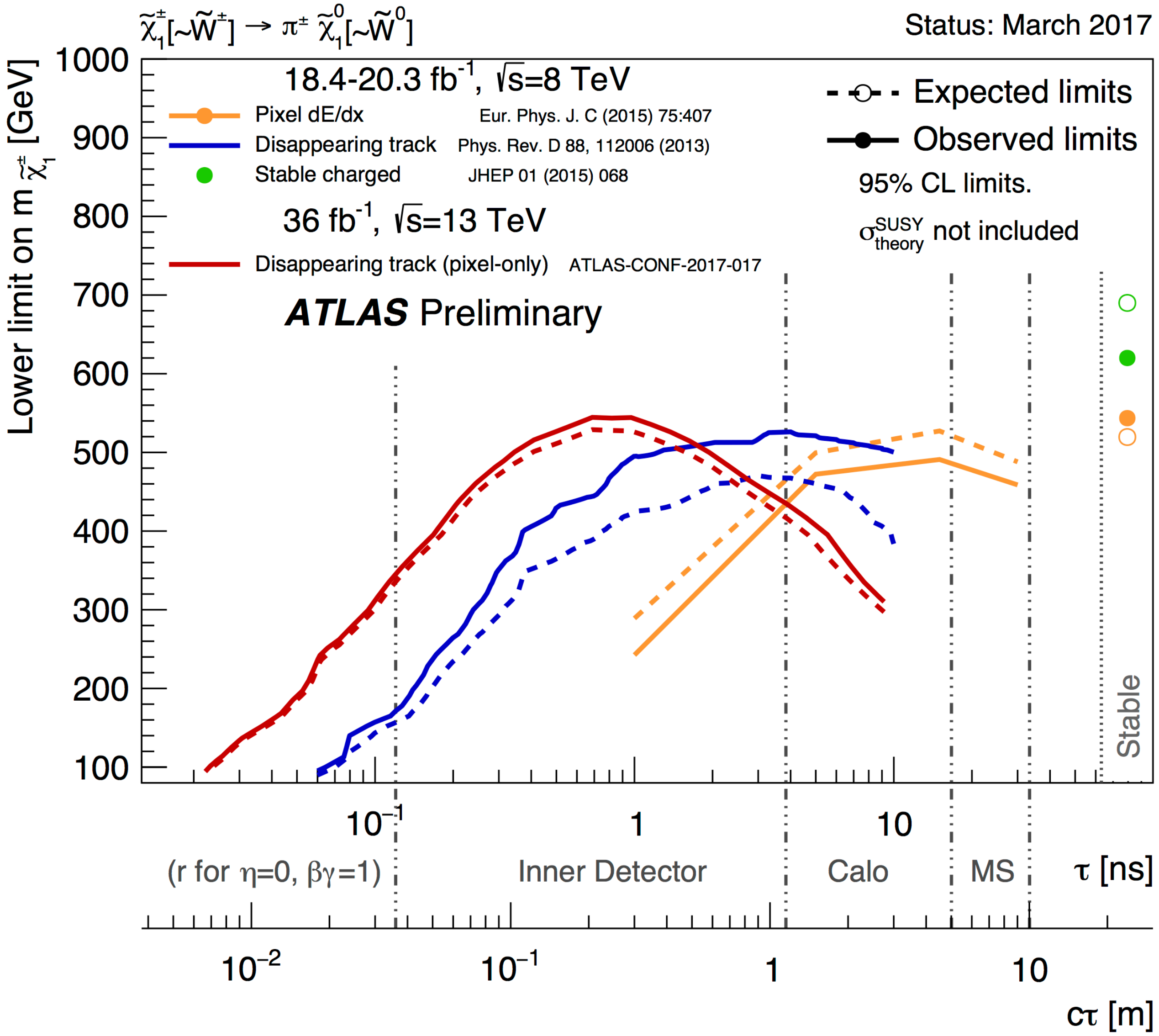
Disappearing condition: Tracking algorithm with shorter tracks than standard tracks (tracklets). Looking for tracklets with hits only in pixel-detector (pixel tracklets):



Improved sensitivity in the gluino-chargino mass plane compared to inclusive searches, specifically for low gluino-chargino mass difference.

Searches for long lived particles





- Dedicated searches for long-lived gluinos enhance sensitivity significantly as lifetime gets longer.
- For long-lived charginos, sensitivity drops for shorter lifetimes. Using additional SUSY search variables, tracker only triggers or short tracks to probe such signatures.

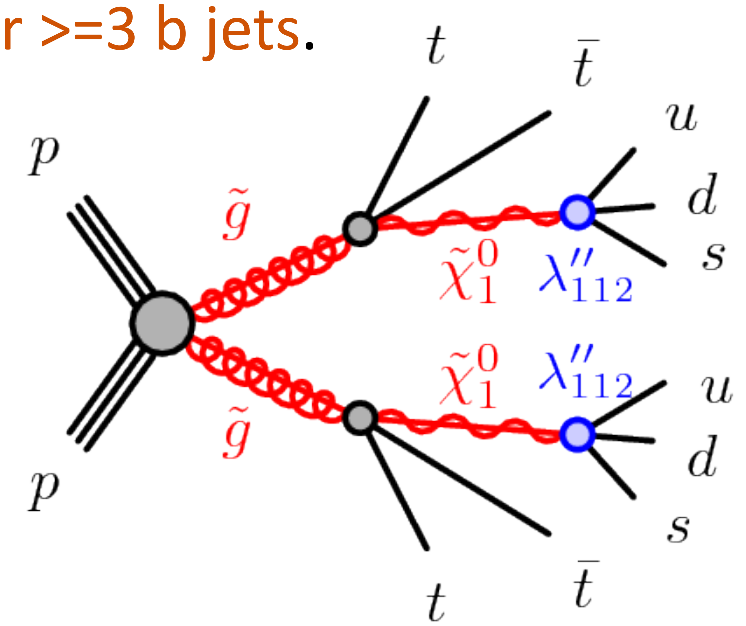
RPV Gluinos

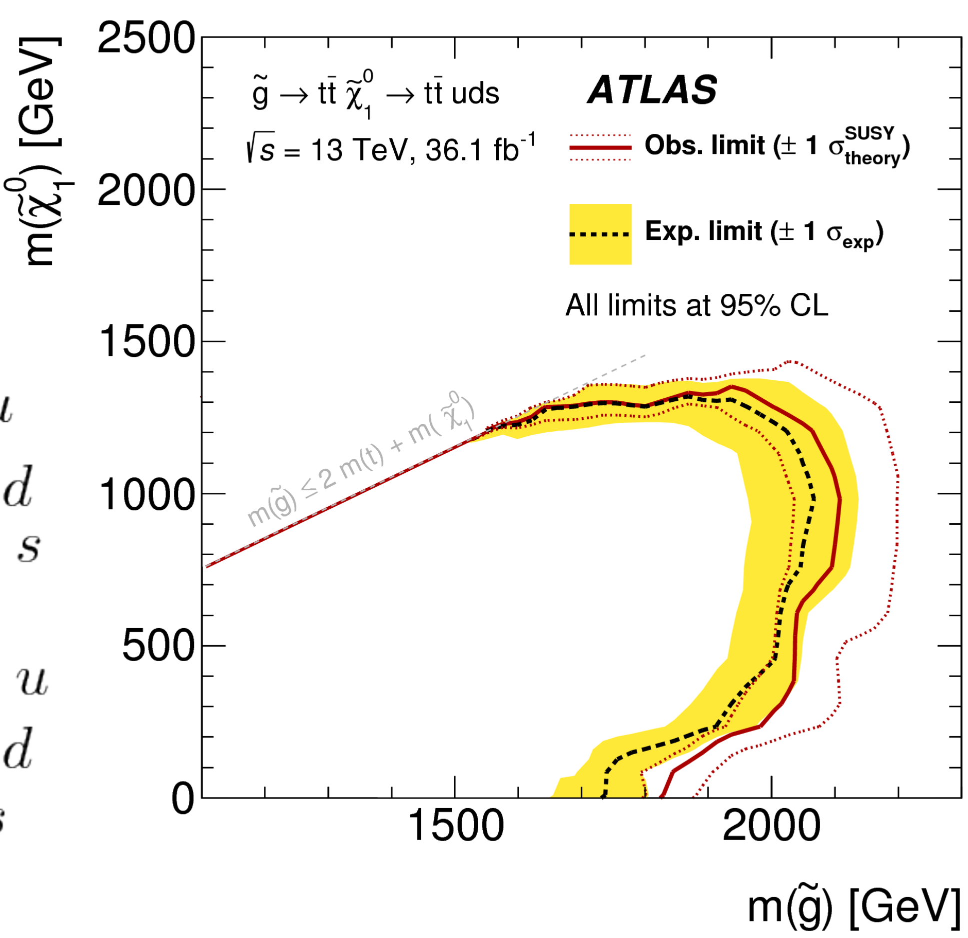
ATLAS arXiv:1704.08493: Search for
gluino —> qq/tt + RPV neutralinos
gluino —> t RPV stop

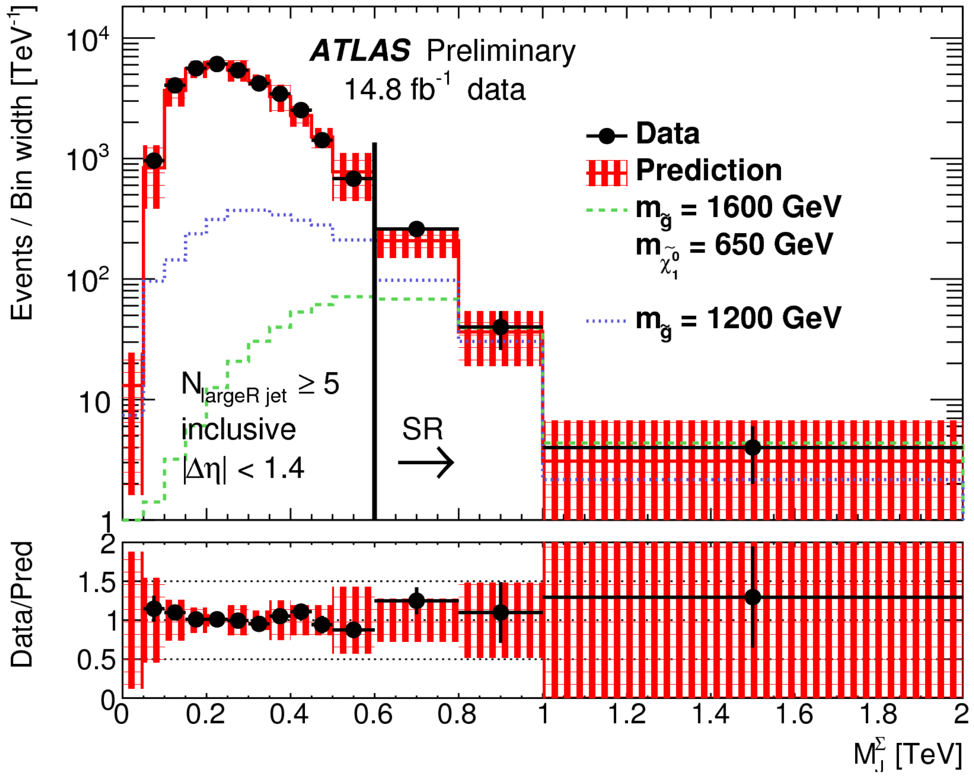
1 lepton + multijets + E_T^{miss} + 0 or >=3 b jets.

Use jet or b-jet multiplicity as discriminator.

Similar CMS RPV gluino search in the 1 lepton channel: CMS-SUS-16-040.

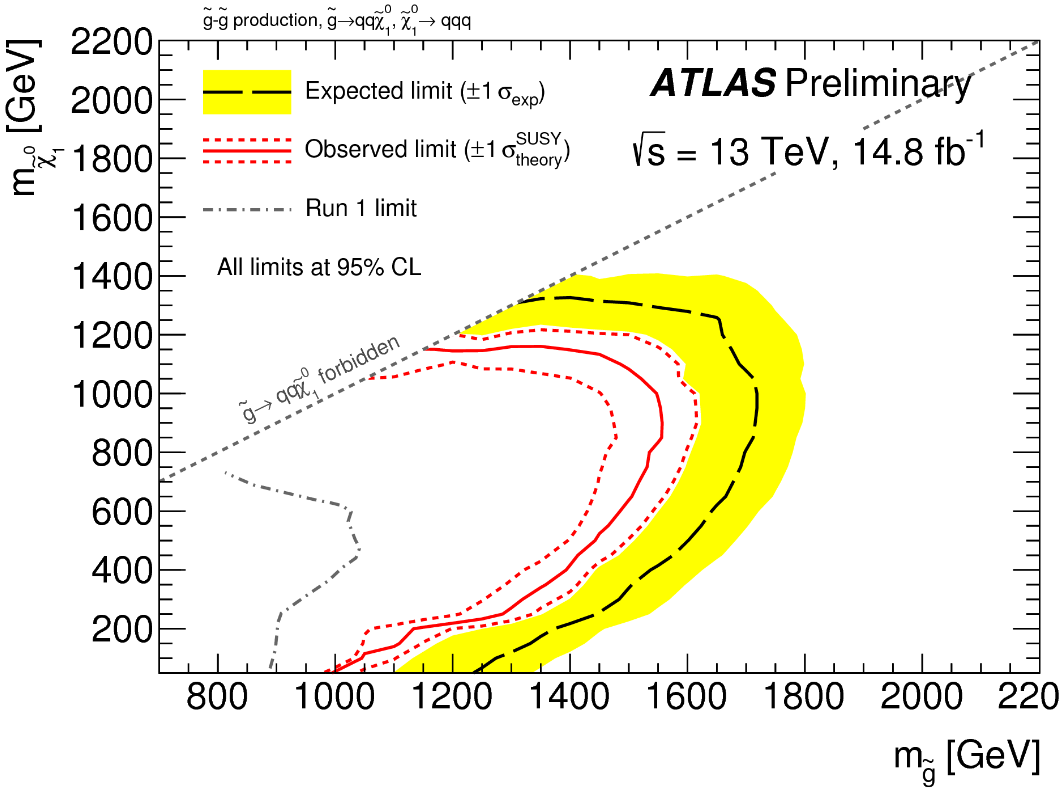






ATLAS-CONF-2016-057: Multijet search for gluino —> RPV neutralino —-> qqq.

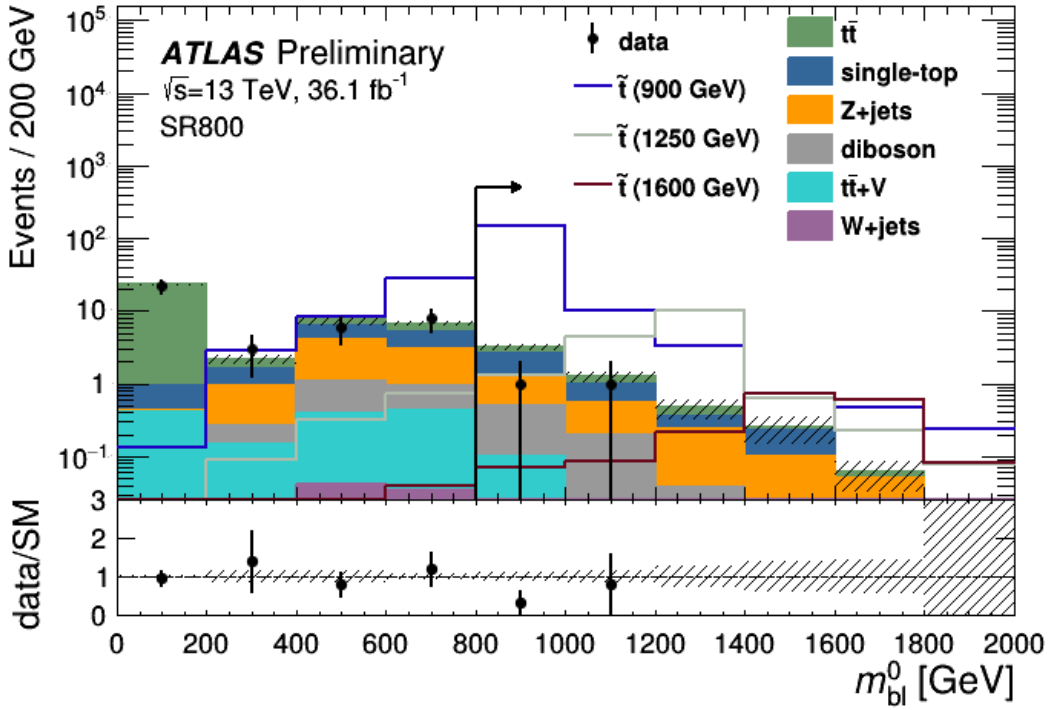
Uses b-jets and scalar sum of large radius jet masses M_j^{Σ}.

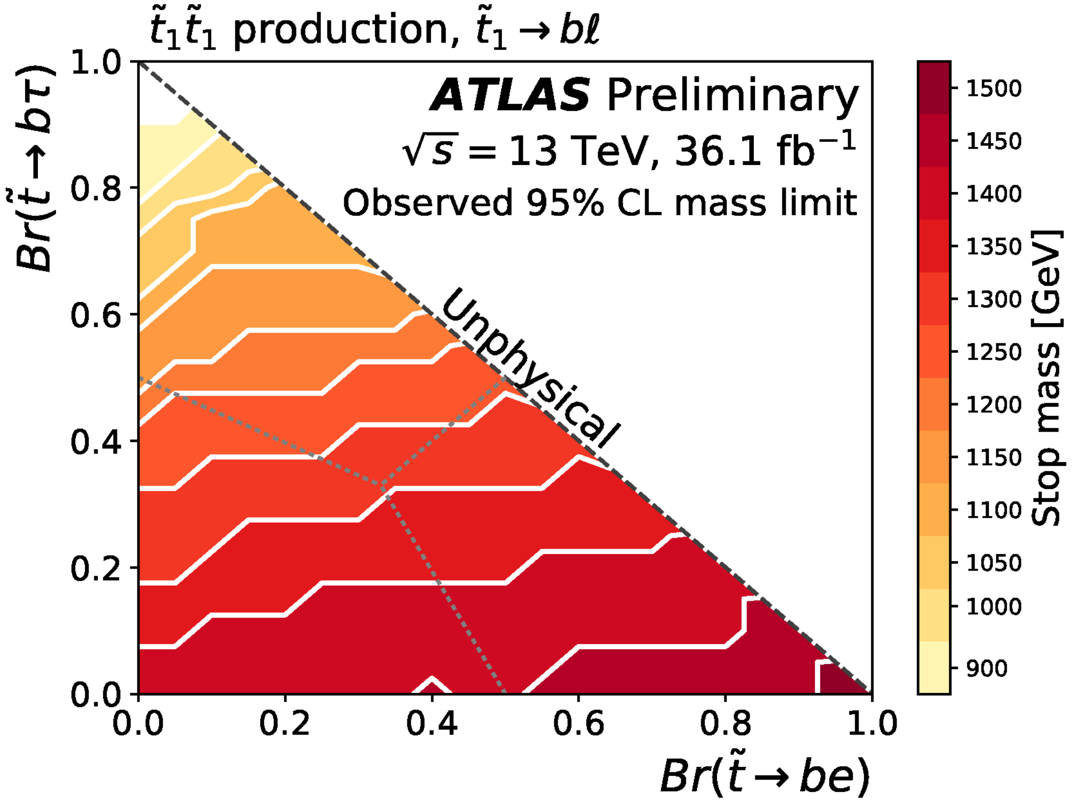


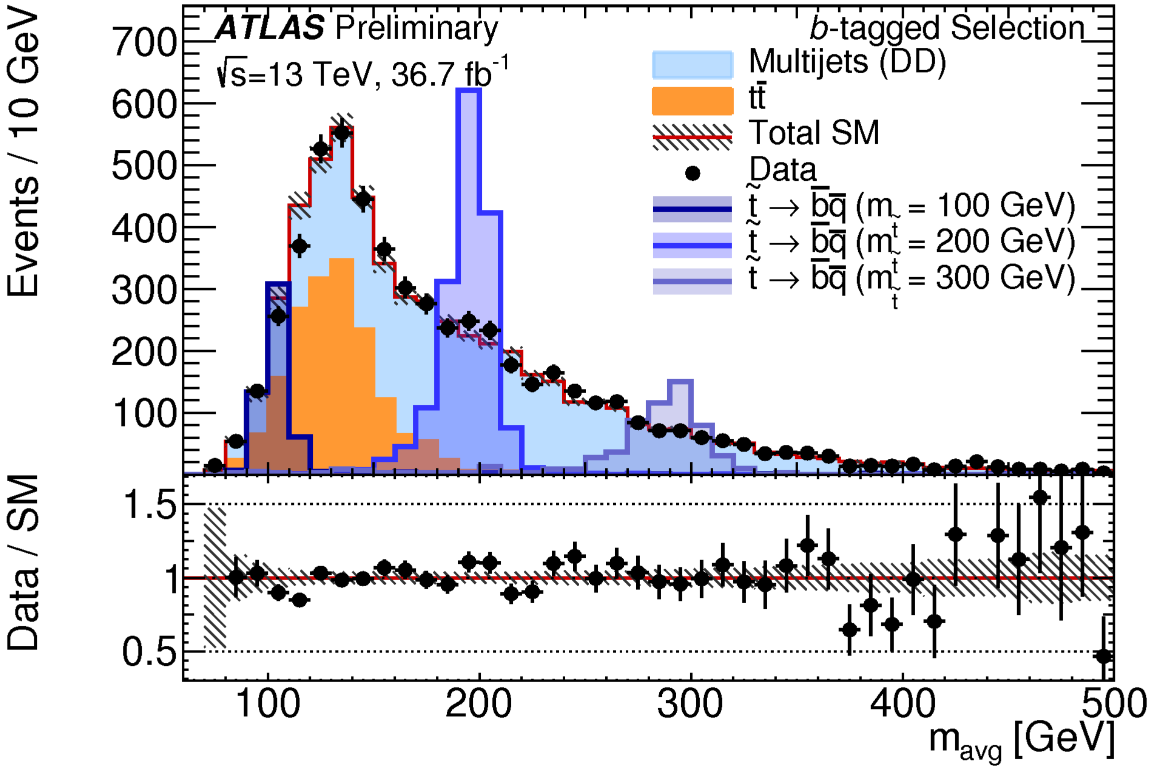
RPV Stops with 2 body decays; neutralinos

ATLAS-CONF-2017-036: RPV stop —> b l.

Upper limits on RPV stops between 600-1100 GeV.







ATLAS-CONF-2017-025: RPV stop —> jet jet.

Excluded stops between mass 100-410 GeV.

ATLAS-CONF-2016-075: Charginos decaying to RPV neutralinos. 4 leptons final state.

Excluded charginos up to mass ~1.1 GeV.

LHC impact on SUSY

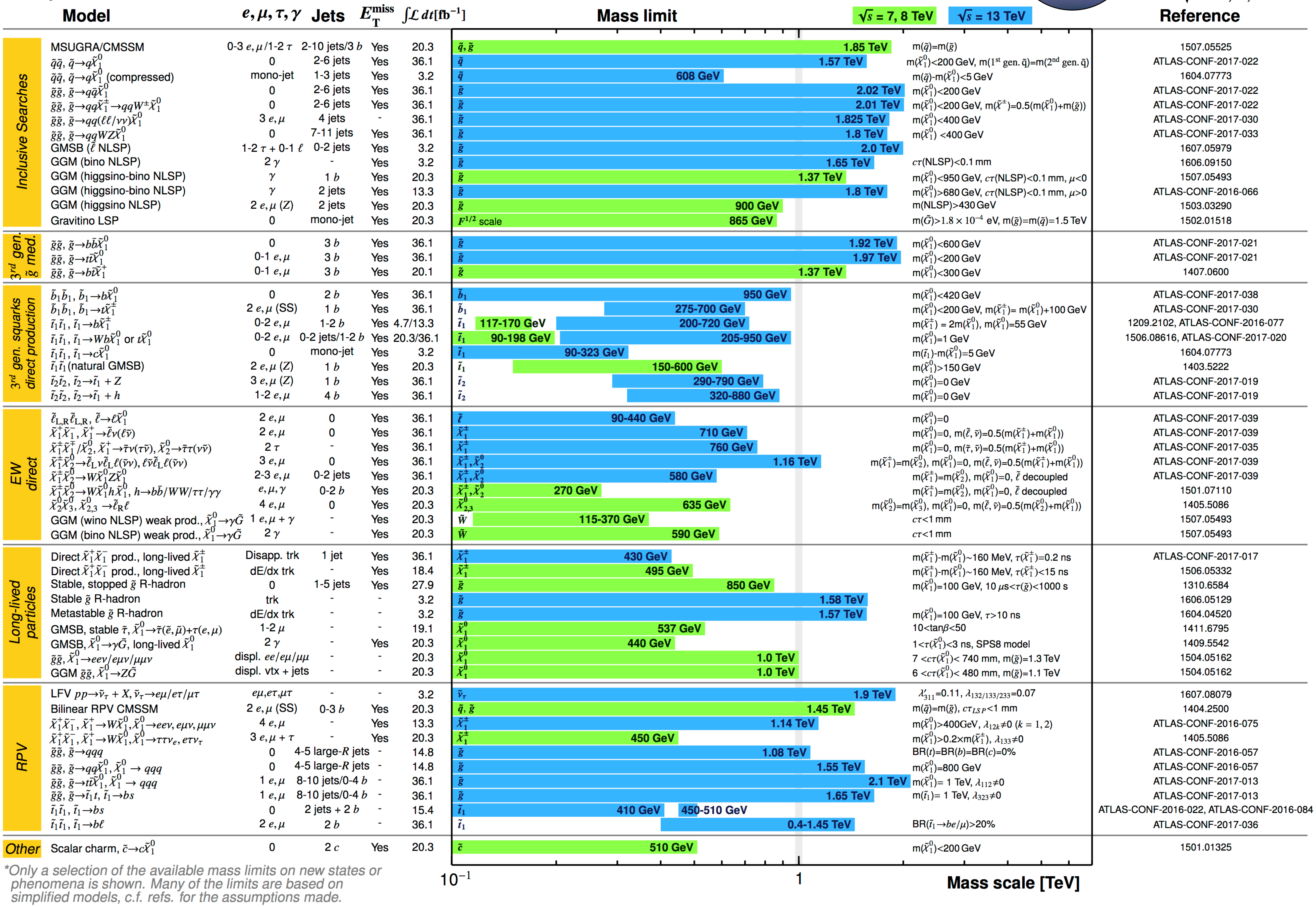
similar for CMS

ATLAS SUSY Searches* - 95% CL Lower Limits

May 2017

ATLAS Preliminary

$\sqrt{s}$ = 7, 8, 13 TeV



🟩 $\sqrt{s}$ = 7, 8 TeV 🟦 $\sqrt{s}$ = 13 TeV

	Model	e,μ,τ,γ	Jets	E_T^{miss}	$\int\mathcal{L}\,dt[\text{fb}^{-1}]$	Mass limit			Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 e,μ/1-2 τ	2-10 jets/3 b	Yes	20.3	$\tilde{q},\tilde{g}$	🟩 1.85 TeV	m($\tilde{q}$)=m($\tilde{g}$)	1507.05525
	$\tilde{q}\tilde{q}$, $\tilde{q}\rightarrow q\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{q}$	🟦 1.57 TeV	m($\tilde{\chi}_1^0$)<200 GeV, m(1st gen. q̃)=m(2nd gen. q̃)	ATLAS-CONF-2017-022
	$\tilde{q}\tilde{q}$, $\tilde{q}\rightarrow q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	3.2	$\tilde{q}$	🟦 608 GeV	m($\tilde{q}$)-m($\tilde{\chi}_1^0$)<5 GeV	1604.07773
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{g}$	🟦 2.02 TeV	m($\tilde{\chi}_1^0$)<200 GeV	ATLAS-CONF-2017-022
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow qq\tilde{\chi}_1^\pm\rightarrow qqW^\pm\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{g}$	🟦 2.01 TeV	m($\tilde{\chi}_1^0$)<200 GeV, m($\tilde{\chi}^\pm$)=0.5(m($\tilde{\chi}_1^0$)+m($\tilde{g}$))	ATLAS-CONF-2017-022
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow qq(\ell\ell/\nu\nu)\tilde{\chi}_1^0$	3 e,μ	4 jets	-	36.1	$\tilde{g}$	🟦 1.825 TeV	m($\tilde{\chi}_1^0$)<400 GeV	ATLAS-CONF-2017-030
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow qqWZ\tilde{\chi}_1^0$	0	7-11 jets	Yes	36.1	$\tilde{g}$	🟦 1.8 TeV	m($\tilde{\chi}_1^0$) <400 GeV	ATLAS-CONF-2017-033
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	3.2	$\tilde{g}$	🟦 2.0 TeV		1607.05979
	GGM (bino NLSP)	2 γ	-	Yes	3.2	$\tilde{g}$	🟦 1.65 TeV	$c\tau$(NLSP)<0.1 mm	1606.09150
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	$\tilde{g}$	🟩 1.37 TeV	m($\tilde{\chi}_1^0$)<950 GeV, $c\tau$(NLSP)<0.1 mm, μ<0	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	13.3	$\tilde{g}$	🟦 1.8 TeV	m($\tilde{\chi}_1^0$)>680 GeV, $c\tau$(NLSP)<0.1 mm, μ>0	ATLAS-CONF-2016-066
	GGM (higgsino NLSP)	2 e,μ (Z)	2 jets	Yes	20.3	$\tilde{g}$	🟩 900 GeV	m(NLSP)>430 GeV	1503.03290
	Gravitino LSP	0	mono-jet	Yes	20.3	$F^{1/2}$ scale	🟩 865 GeV	m($\tilde{G}$)>1.8×10^{-4} eV, m($\tilde{g}$)=m($\tilde{q}$)=1.5 TeV	1502.01518
3^{rd} gen. $\tilde{g}$ med.	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	36.1	$\tilde{g}$	🟦 1.92 TeV	m($\tilde{\chi}_1^0$)<600 GeV	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	36.1	$\tilde{g}$	🟦 1.97 TeV	m($\tilde{\chi}_1^0$)<200 GeV	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	🟩 1.37 TeV	m($\tilde{\chi}_1^0$)<300 GeV	1407.0600
3^{rd} gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\rightarrow b\tilde{\chi}_1^0$	0	2 b	Yes	36.1	$\tilde{b}_1$	🟦 950 GeV	m($\tilde{\chi}_1^0$)<420 GeV	ATLAS-CONF-2017-038
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\rightarrow t\tilde{\chi}_1^\pm$	2 e,μ (SS)	1 b	Yes	36.1	$\tilde{b}_1$	🟦 275-700 GeV	m($\tilde{\chi}_1^0$)<200 GeV, m($\tilde{\chi}_1^\pm$)= m($\tilde{\chi}_1^0$)+100 GeV	ATLAS-CONF-2017-030
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\rightarrow b\tilde{\chi}_1^\pm$	0-2 e,μ	1-2 b	Yes	4.7/13.3	$\tilde{t}_1$	🟩 117-170 GeV 🟦 200-720 GeV	m($\tilde{\chi}_1^\pm$) = 2m($\tilde{\chi}_1^0$), m($\tilde{\chi}_1^0$)=55 GeV	1209.2102, ATLAS-CONF-2016-077
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\rightarrow Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	0-2 e,μ	0-2 jets/1-2 b	Yes	20.3/36.1	$\tilde{t}_1$	🟩 90-198 GeV 🟦 205-950 GeV	m($\tilde{\chi}_1^0$)=1 GeV	1506.08616, ATLAS-CONF-2017-020
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\rightarrow c\tilde{\chi}_1^0$	0	mono-jet	Yes	3.2	$\tilde{t}_1$	🟦 90-323 GeV	m($\tilde{t}_1$)-m($\tilde{\chi}_1^0$)=5 GeV	1604.07773
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$	🟩 150-600 GeV	m($\tilde{\chi}_1^0$)>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\rightarrow\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	36.1	$\tilde{t}_2$	🟦 290-790 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2017-019
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\rightarrow\tilde{t}_1+h$	1-2 e,μ	4 b	Yes	36.1	$\tilde{t}_2$	🟦 320-880 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2017-019
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\rightarrow\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	36.1	$\tilde{\ell}$	🟦 90-440 GeV	m($\tilde{\chi}_1^0$)=0	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\rightarrow\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	36.1	$\tilde{\chi}_1^\pm$	🟦 710 GeV	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-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp/\tilde{\chi}_2^0$, $\tilde{\chi}_1^+\rightarrow\tilde{\tau}\nu(\tau\tilde{\nu})$, $\tilde{\chi}_2^0\rightarrow\tilde{\tau}\tau(\nu\tilde{\nu})$	2 τ	-	Yes	36.1	$\tilde{\chi}_1^\pm$	🟦 760 GeV	m($\tilde{\chi}_1^0$)=0, m($\tilde{\tau},\tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	ATLAS-CONF-2017-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\rightarrow\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	36.1	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$	🟦 1.16 TeV	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-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\rightarrow W\tilde{\chi}_1^0Z\tilde{\chi}_1^0$	2-3 e,μ	0-2 jets	Yes	36.1	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$	🟦 580 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, $\tilde{\ell}$ decoupled	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\rightarrow W\tilde{\chi}_1^0h\tilde{\chi}_1^0$, $h\rightarrow b\bar{b}/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$	🟩 270 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, $\tilde{\ell}$ decoupled	1501.07110
	$\tilde{\chi}_2^0\tilde{\chi}_3^0$, $\tilde{\chi}_{2,3}^0\rightarrow\tilde{\ell}_R\ell$	4 e,μ	0	Yes	20.3	$\tilde{\chi}_{2,3}^0$	🟩 635 GeV	m($\tilde{\chi}_2^0$)=m($\tilde{\chi}_3^0$), m($\tilde{\chi}_1^0$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}_2^0$)+m($\tilde{\chi}_1^0$))	1405.5086
	GGM (wino NLSP) weak prod., $\tilde{\chi}_1^0\rightarrow\gamma\tilde{G}$	1 e,μ + γ	-	Yes	20.3	$\tilde{W}$	🟩 115-370 GeV	$c\tau$<1 mm	1507.05493
	GGM (bino NLSP) weak prod., $\tilde{\chi}_1^0\rightarrow\gamma\tilde{G}$	2 γ	-	Yes	20.3	$\tilde{W}$	🟩 590 GeV	$c\tau$<1 mm	1507.05493
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	36.1	$\tilde{\chi}_1^\pm$	🟦 430 GeV	m($\tilde{\chi}_1^\pm$)-m($\tilde{\chi}_1^0$)~160 MeV, τ($\tilde{\chi}_1^\pm$)=0.2 ns	ATLAS-CONF-2017-017
	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^\pm$	🟩 495 GeV	m($\tilde{\chi}_1^\pm$)-m($\tilde{\chi}_1^0$)~160 MeV, τ($\tilde{\chi}_1^\pm$)<15 ns	1506.05332
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$	🟩 850 GeV	m($\tilde{\chi}_1^0$)=100 GeV, 10 μs<τ($\tilde{g}$)<1000 s	1310.6584
	Stable $\tilde{g}$ R-hadron	trk	-	-	3.2	$\tilde{g}$	🟦 1.58 TeV		1606.05129
	Metastable $\tilde{g}$ R-hadron	dE/dx trk	-	-	3.2	$\tilde{g}$	🟦 1.57 TeV	m($\tilde{\chi}_1^0$)=100 GeV, τ>10 ns	1604.04520
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\rightarrow\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}_1^0$	🟩 537 GeV	10<tanβ<50	1411.6795
	GMSB, $\tilde{\chi}_1^0\rightarrow\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$	🟩 440 GeV	1<τ($\tilde{\chi}_1^0$)<3 ns, SPS8 model	1409.5542
	$\tilde{g}\tilde{g}$, $\tilde{\chi}_1^0\rightarrow ee\nu/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	$\tilde{\chi}_1^0$	🟩 1.0 TeV	7 <$c\tau$($\tilde{\chi}_1^0$)< 740 mm, m($\tilde{g}$)=1.3 TeV	1504.05162
	GGM $\tilde{g}\tilde{g}$, $\tilde{\chi}_1^0\rightarrow Z\tilde{G}$	displ. vtx + jets	-	-	20.3	$\tilde{\chi}_1^0$	🟩 1.0 TeV	6 <$c\tau$($\tilde{\chi}_1^0$)< 480 mm, m($\tilde{g}$)=1.1 TeV	1504.05162
RPV	LFV $pp\rightarrow\tilde{\nu}_\tau+X$, $\tilde{\nu}_\tau\rightarrow e\mu/e\tau/\mu\tau$	$e\mu$,$e\tau$,$\mu\tau$	-	-	3.2	$\tilde{\nu}_\tau$	🟦 1.9 TeV	λ'_{311}=0.11, $\lambda_{132/133/233}$=0.07	1607.08079
	Bilinear RPV CMSSM	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{q},\tilde{g}$	🟩 1.45 TeV	m($\tilde{q}$)=m($\tilde{g}$), $c\tau_{LSP}$<1 mm	1404.2500
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\rightarrow W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\rightarrow ee\nu, e\mu\nu, \mu\mu\nu$	4 e,μ	-	Yes	13.3	$\tilde{\chi}_1^\pm$	🟦 1.14 TeV	m($\tilde{\chi}_1^0$)>400GeV, $\lambda_{12k}\neq0$ ($k=1,2$)	ATLAS-CONF-2016-075
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\rightarrow W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\rightarrow\tau\tau\nu_e, e\tau\nu_\tau$	3 e,μ + τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	🟩 450 GeV	m($\tilde{\chi}_1^0$)>0.2×m($\tilde{\chi}_1^\pm$), $\lambda_{133}\neq0$	1405.5086
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow qqq$	0	4-5 large-R jets	-	14.8	$\tilde{g}$	🟦 1.08 TeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow qq\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\rightarrow qqq$	0	4-5 large-R jets	-	14.8	$\tilde{g}$	🟦 1.55 TeV	m($\tilde{\chi}_1^0$)=800 GeV	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow t\bar{t}\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\rightarrow qqq$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde{g}$	🟦 2.1 TeV	m($\tilde{\chi}_1^0$)= 1 TeV, $\lambda_{112}\neq0$	ATLAS-CONF-2017-013
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow\tilde{t}_1t$, $\tilde{t}_1\rightarrow bs$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde{g}$	🟦 1.65 TeV	m($\tilde{t}_1$)= 1 TeV, $\lambda_{323}\neq0$	ATLAS-CONF-2017-013
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\rightarrow bs$	0	2 jets + 2 b	-	15.4	$\tilde{t}_1$	🟦 410 GeV 🟦 450-510 GeV		ATLAS-CONF-2016-022, ATLAS-CONF-2016-084
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\rightarrow b\ell$	2 e,μ	2 b	-	36.1	$\tilde{t}_1$	🟦 0.4-1.45 TeV	BR($\tilde{t}_1\rightarrow be/\mu$)>20%	ATLAS-CONF-2017-036
Other	Scalar charm, $\tilde{c}\rightarrow c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	$\tilde{c}$	🟩 510 GeV	m($\tilde{\chi}_1^0$)<200 GeV	1501.01325

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

To conclude...

We found no significant hint for SUSY after 7 years at the LHC...

- ~36 fb^{-1} of 13 TeV data
- ~60 searches at 13 TeV in ATLAS and CMS in a diversity of final states involving jets, b-jets, leptons, photons, E_T^{miss}. Special searches for long-lived particles and R parity violation.
- Not all results were included in this talk. Full list of results here:
  - ATLAS: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults
  - CMS: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS
- Further constraints from direct SUSY Higgs sector searches.
- Even further constraints from 125GeV Higgs, w/Z, top measurements.
- Many other searches being performed with upcoming data
- Designing refined analysis methods and tools to improve sensitivity for probing SUSY most efficiently.

Perhaps in the next Runs?

The journey looks as delightful as ever :)