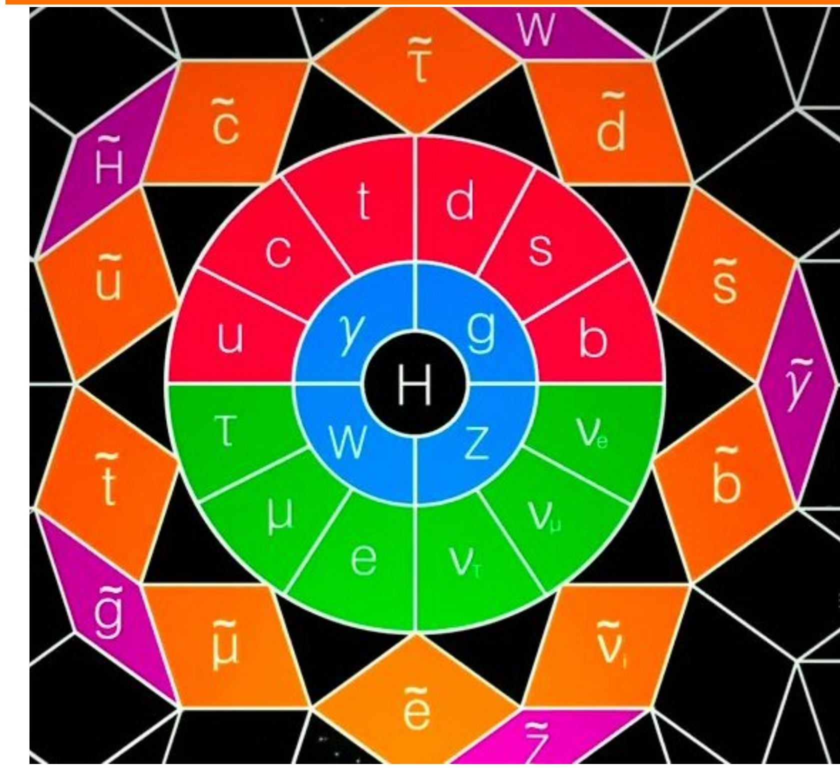
SUSY SEARCHES OVERVIEW

DM@LHC 2017

UC Irvine, April 3-5

Cristián H. Peña

On Behalf of the ATLAS and CMS collaborations

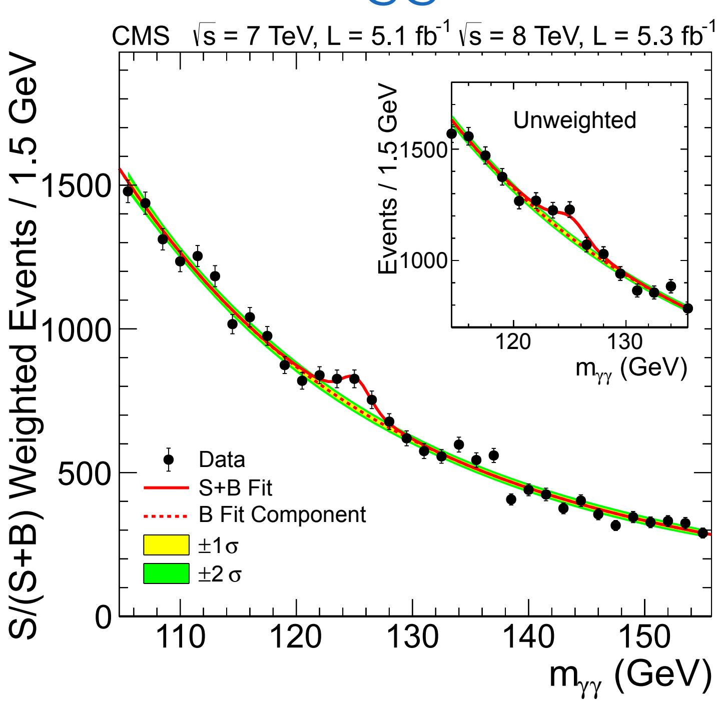


SUSY is a very compelling extension of the SM

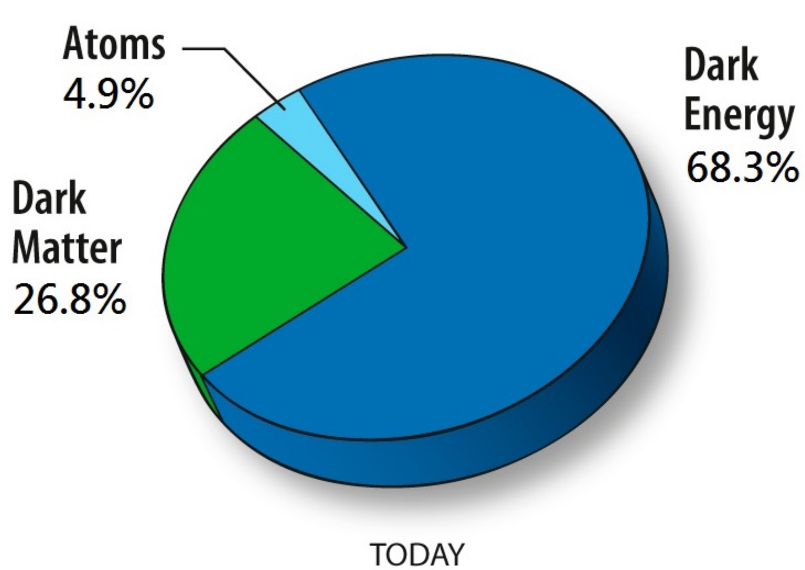
Predicts the existence of new particles; possibly at ~TeV scale (natural SUSY)

Rich in experimental signatures

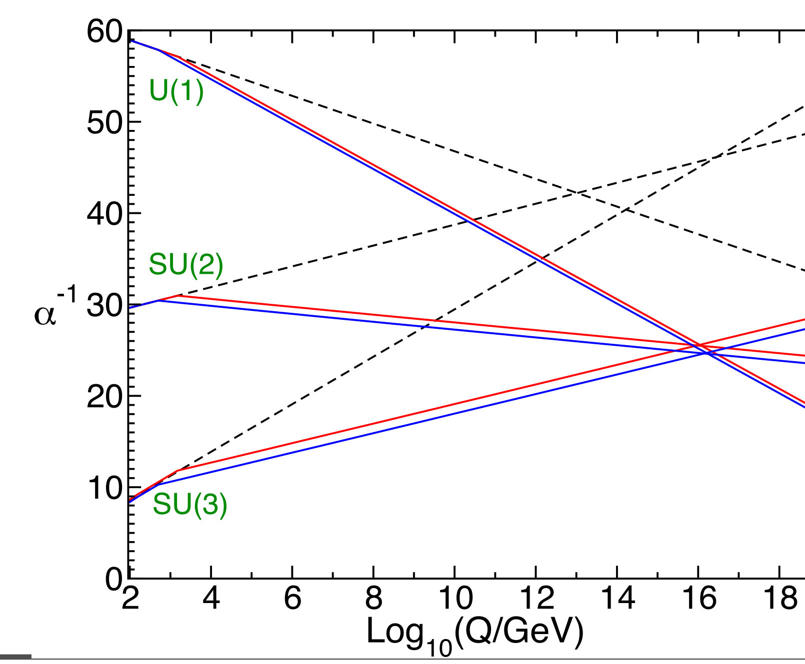
Helps explain the lightness of the Higgs mass



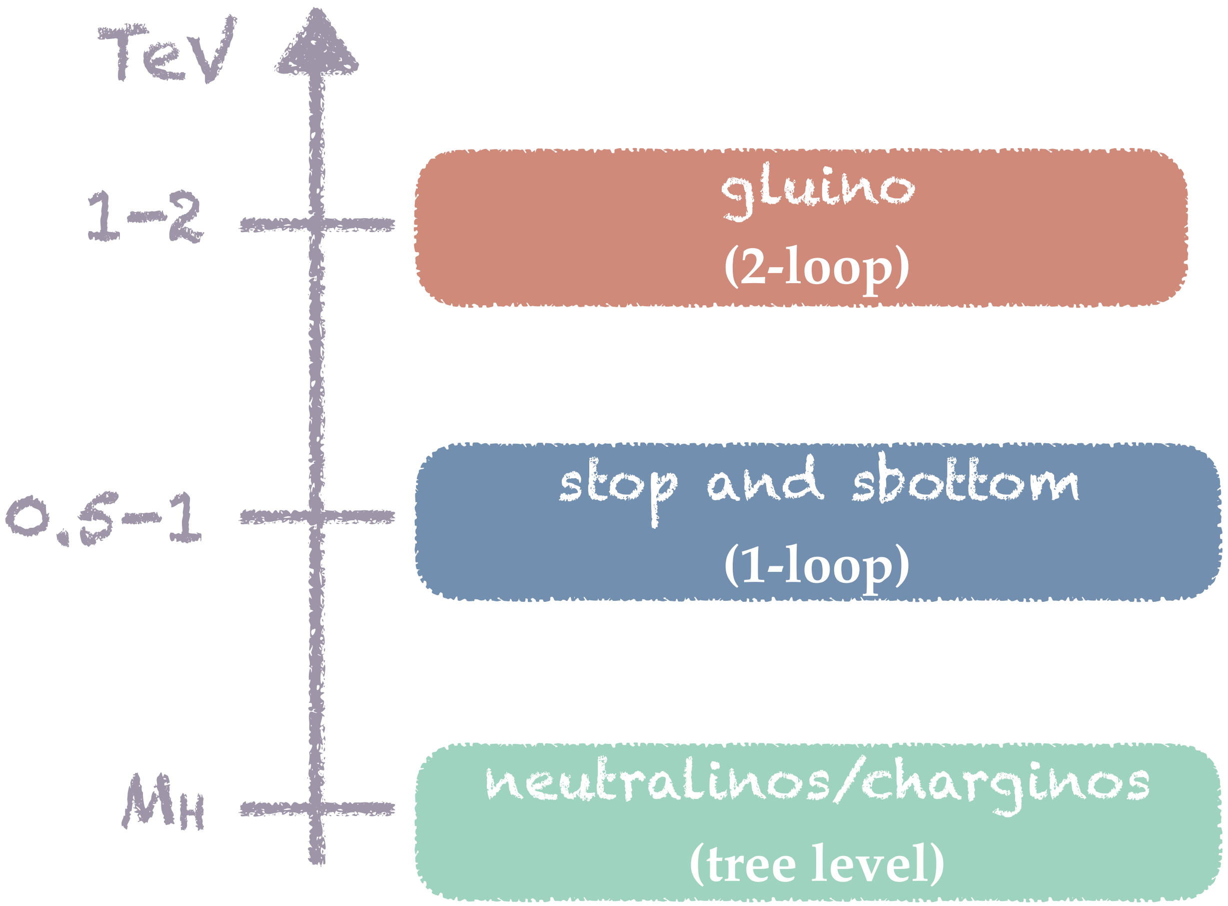
provides a good dark matter candidate

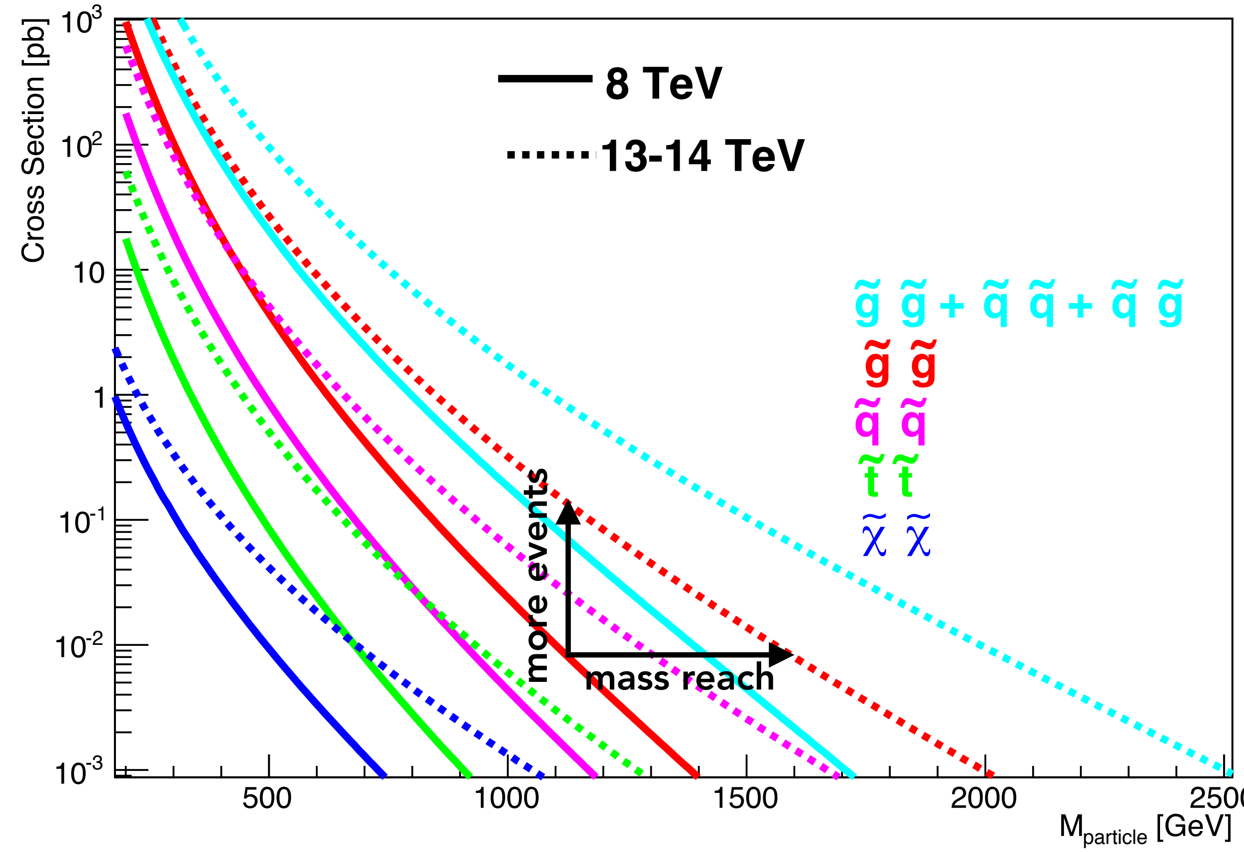


Unifies gauge couplings at ~M_{planck}



WHAT TO LOOK FOR





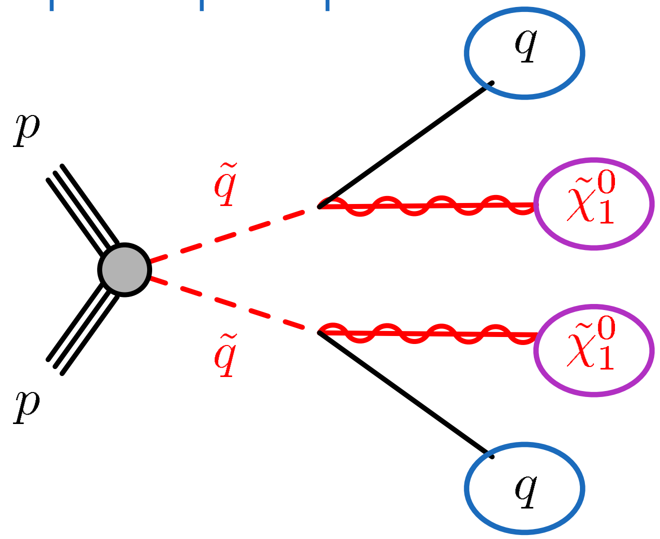
Higgsino masses are close to Higgs mass

LHC strategy: first go after larger cross section particles

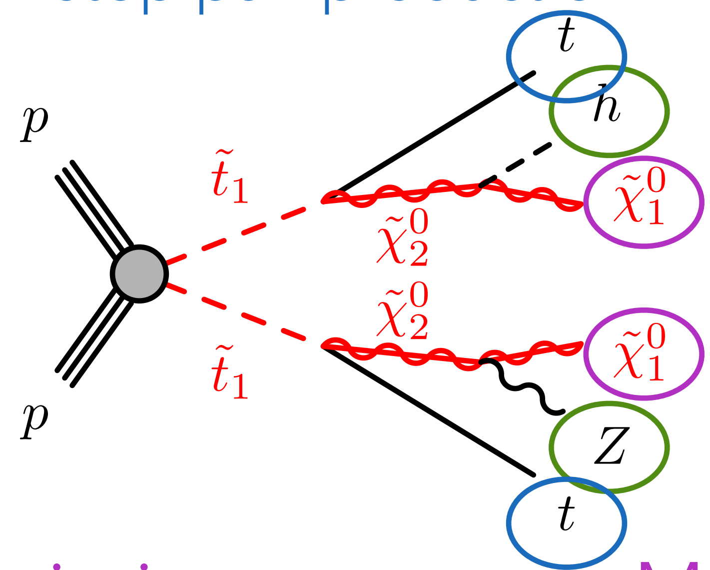
1. gluinos and squarks
2. stop and sbottoms
3. electroweakinos

EXPERIMENTAL CONSIDERATIONS

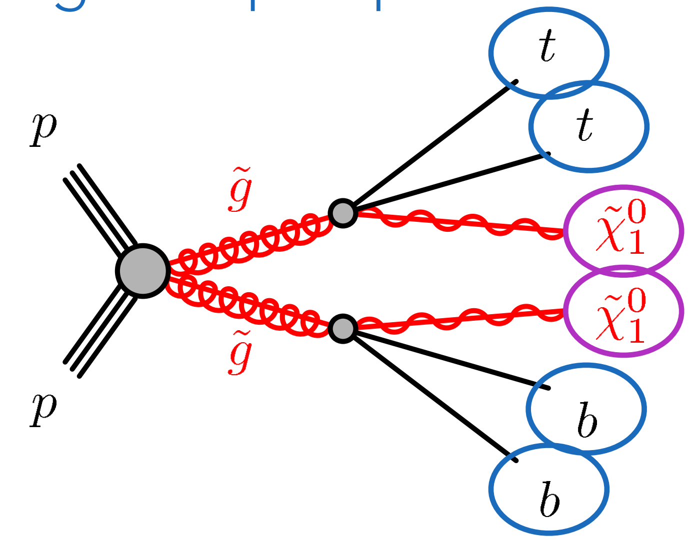
squark pair production



stop pair production



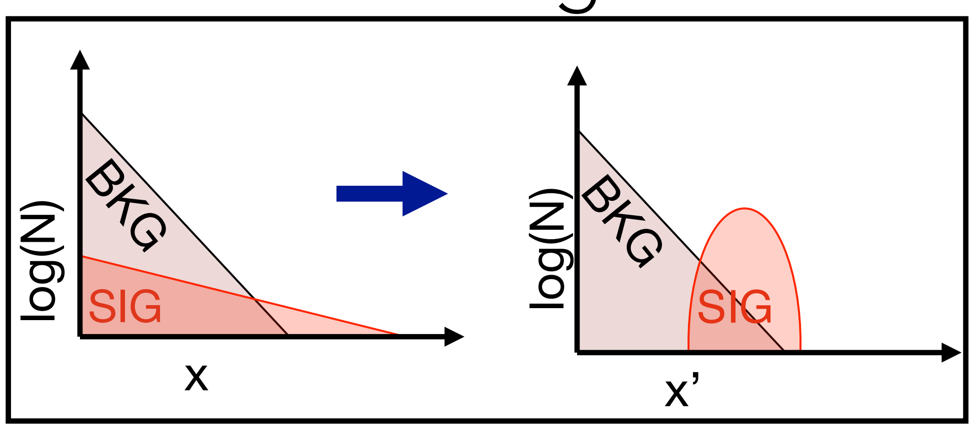
gluino pair production



LSPs: missing energy → MET

large hadronic activity, multiple jets, multiple b-jets, leptons, photons …

Missing information: impossible to fully reconstruct event



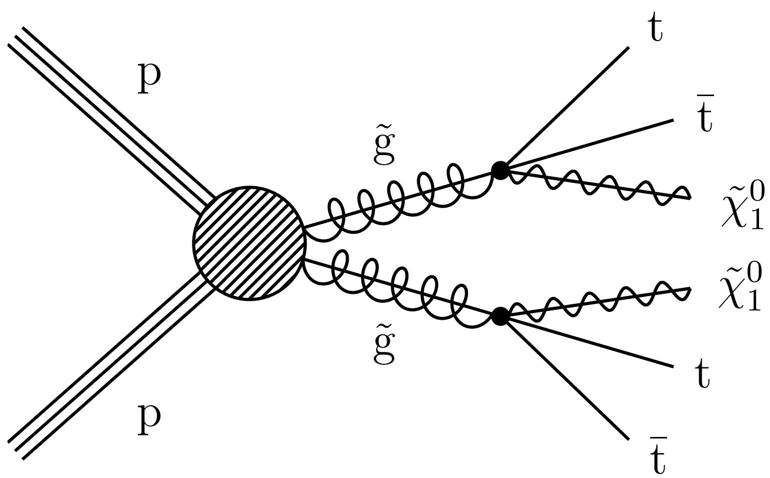
most analyses use kinematic discriminating variables to improve S/B ratio

Summary: large phase-space to cover (signal regions), large number of signatures (different analyses), possible to use different discriminating variables

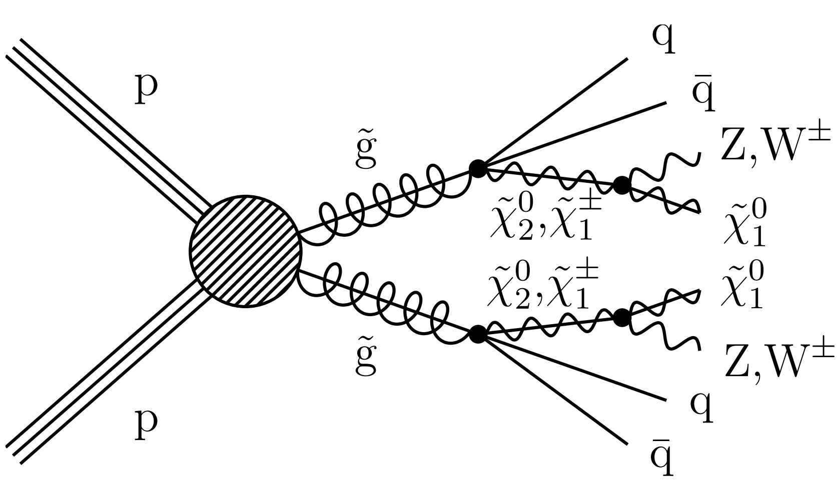
Crucial and ambitious program by LHC experiments

CMS multijet, zero-lepton

SUS-16-033

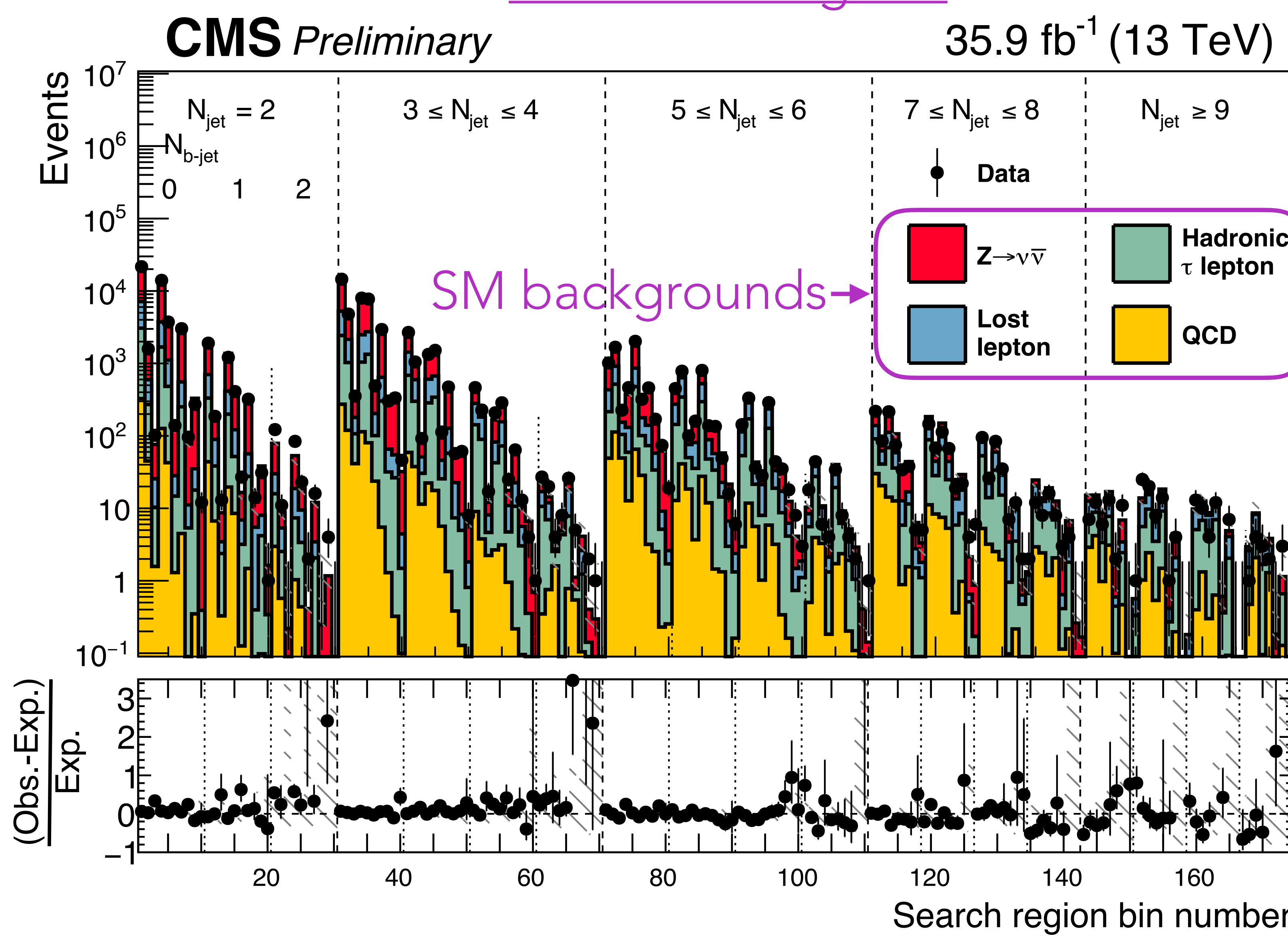


Probe different gluino decays



4-dimensional search in: N_{jets}, $N_{b\text{-}jets}$, H_T, H_T^{Miss}

174 search regions

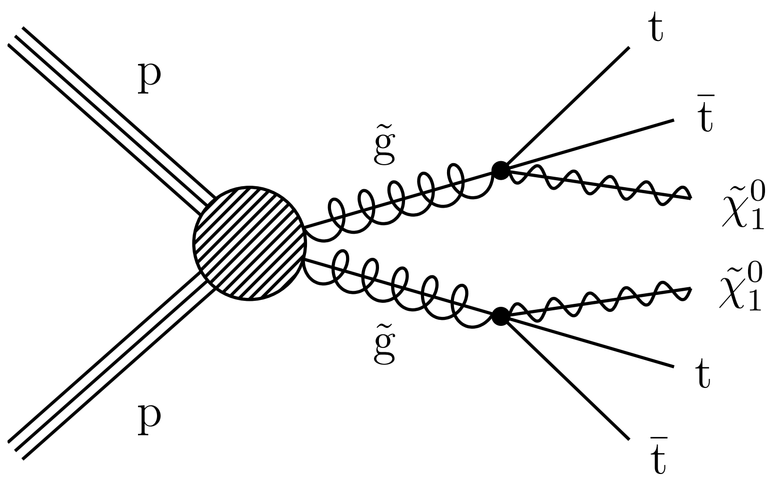


No significant deviations from SM expectation

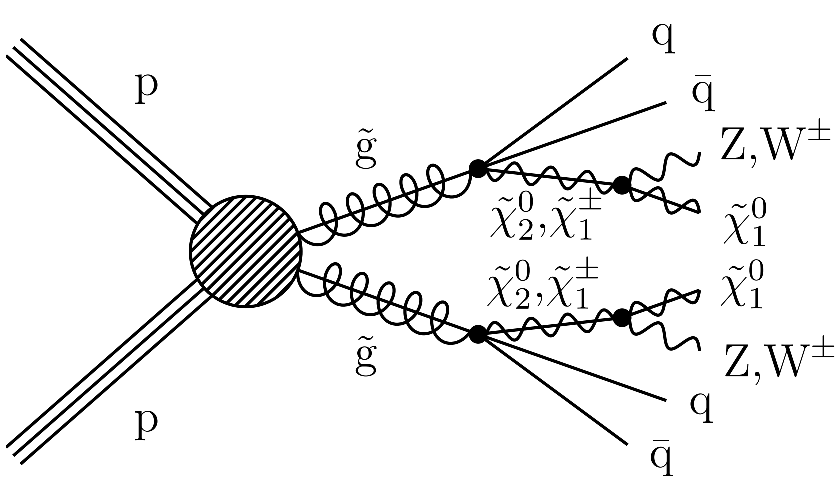
CMS GLUINO/SQUARK SEARCHES

CMS multijet, zero-lepton

SUS-16-033

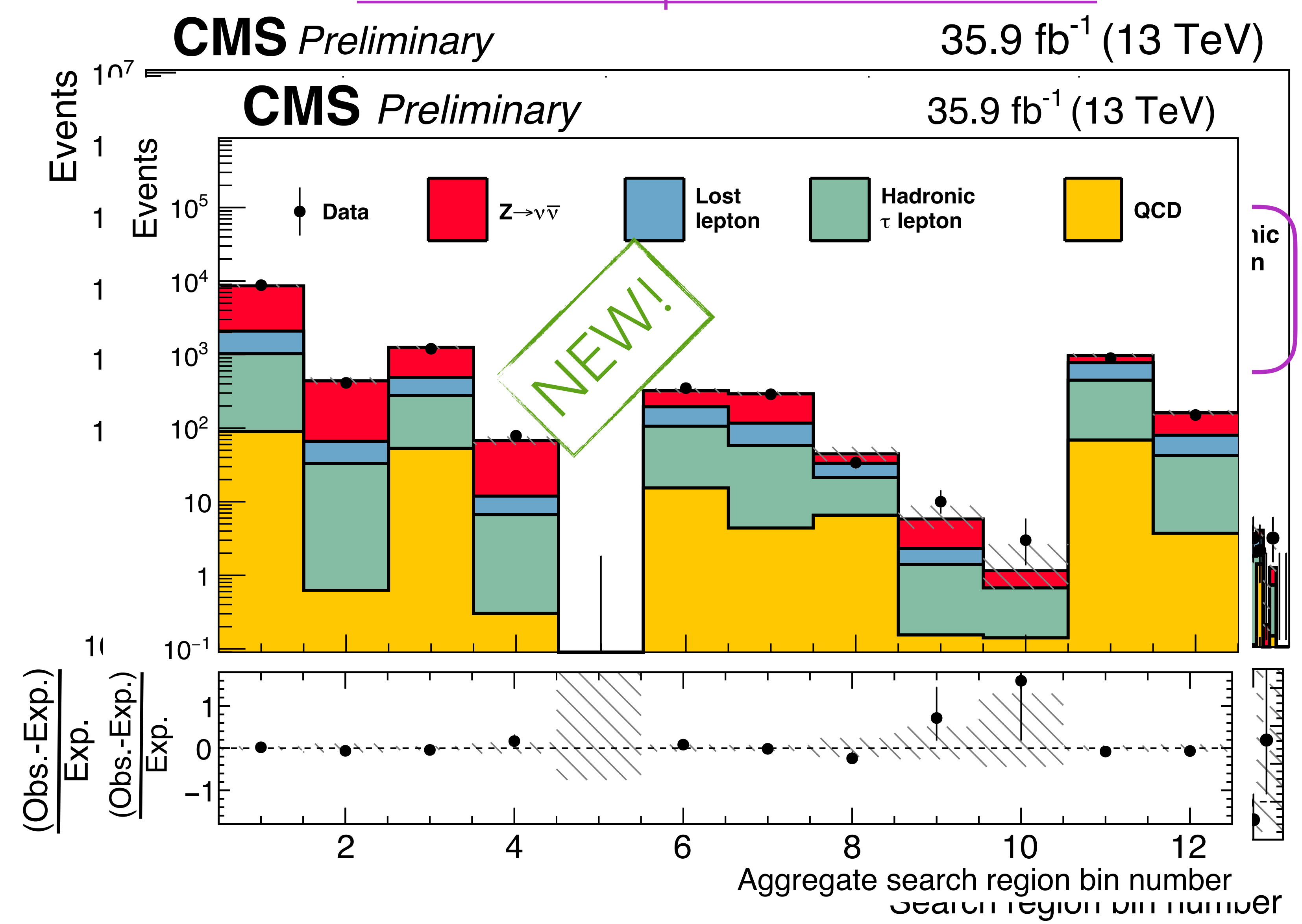


Probe different gluino decays



12 aggregate search regions

easier reinterpretation of results

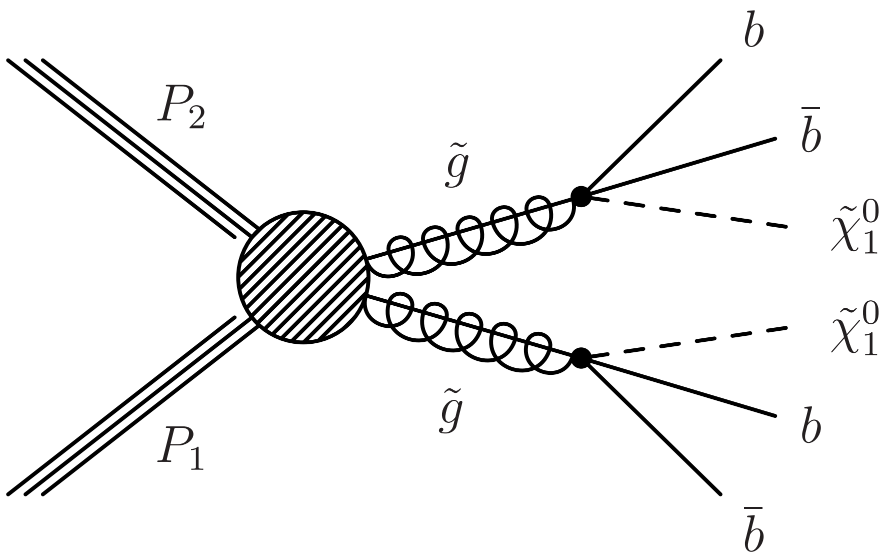


No significant deviations from SM expectation

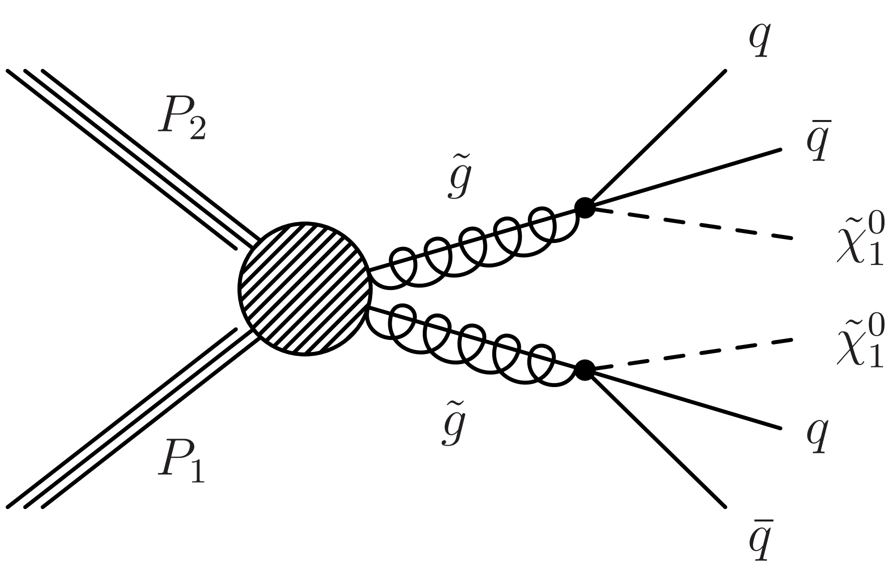
CMS search using M_{T2}

SUS-16-036

$$M_{\mathrm{T2}} = \min_{\vec{p}_{\mathrm{T}}^{\,\mathrm{miss}X(1)} + \vec{p}_{\mathrm{T}}^{\,\mathrm{miss}X(2)} = \vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}} \left[\max\left(M_{\mathrm{T}}^{(1)}, M_{\mathrm{T}}^{(2)} \right) \right]$$



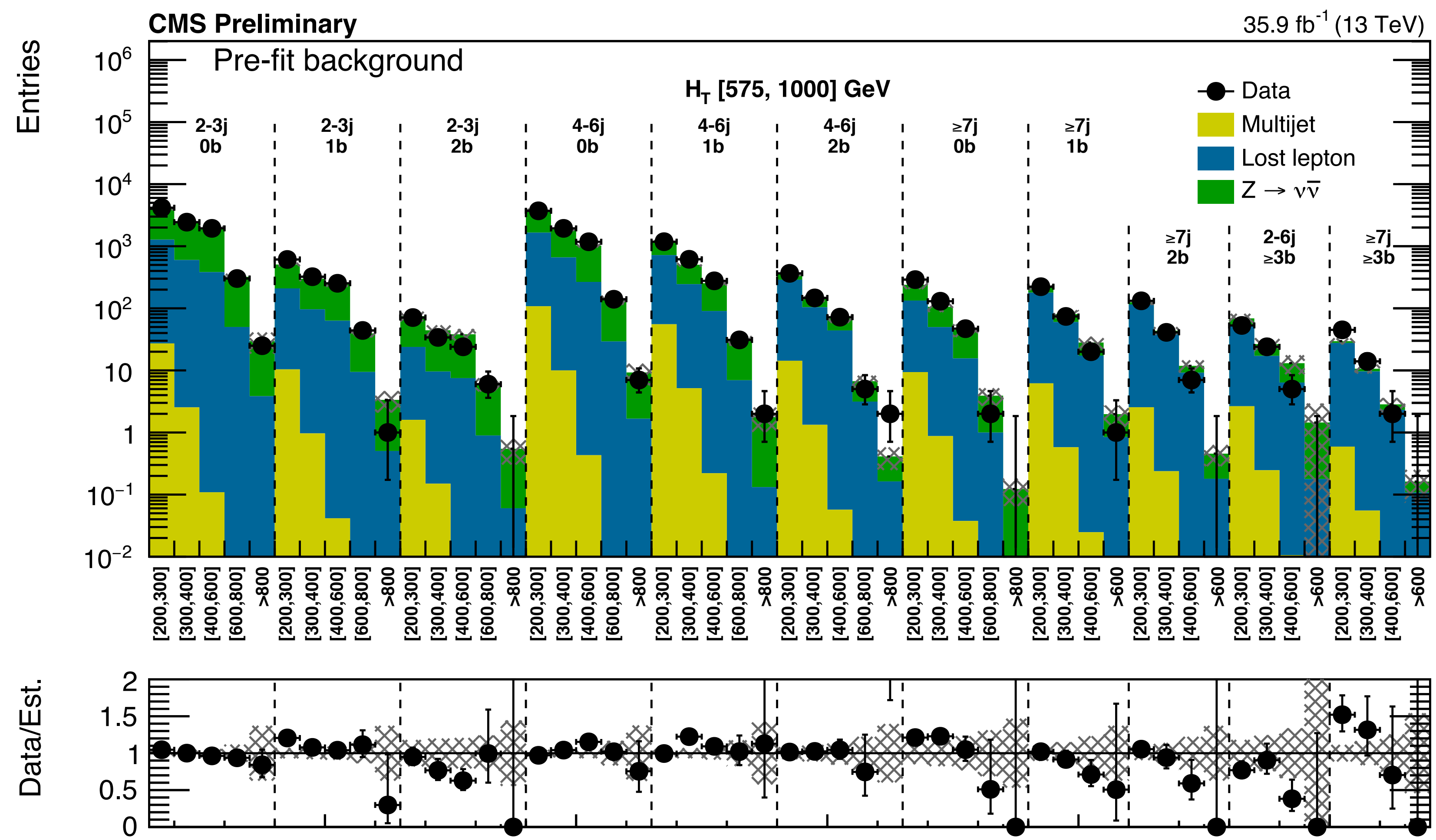
Probe different gluino decays



4-dimensional search in: N_{jets}, $N_{b\text{-}jets}$, H_T, M_{T2}

Also contains a mono-jet bin

Large phase space → Large number of SRs

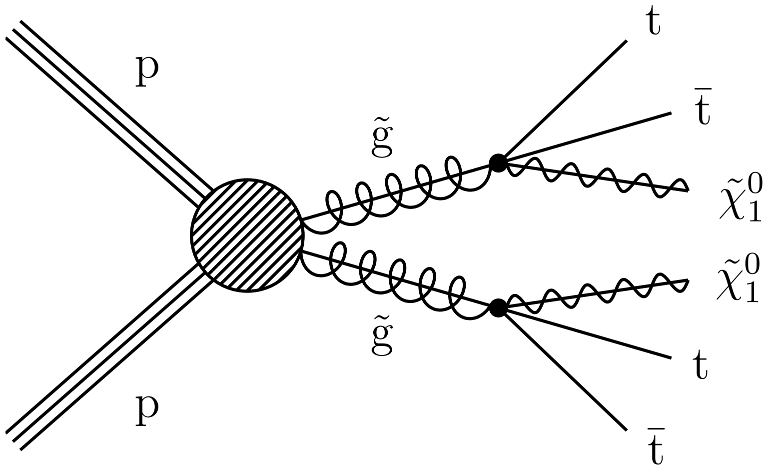


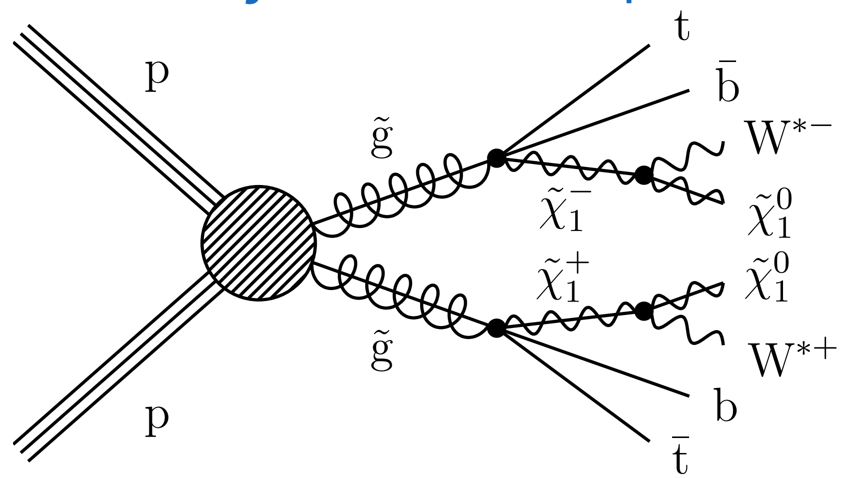
No significant deviations from SM expectation

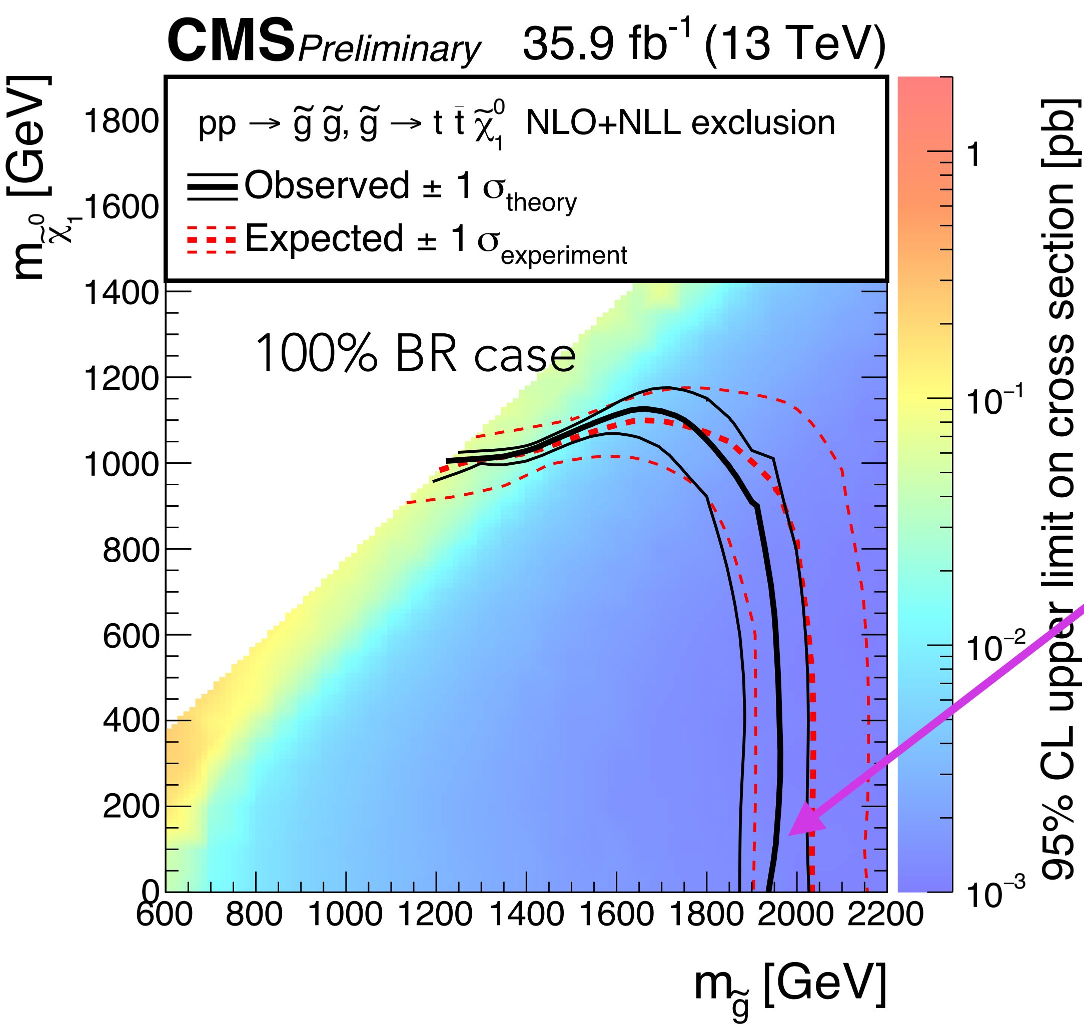
GLUINO INTERPRETATIONS

CMS multijet, zero-lepton

SUS-16-033





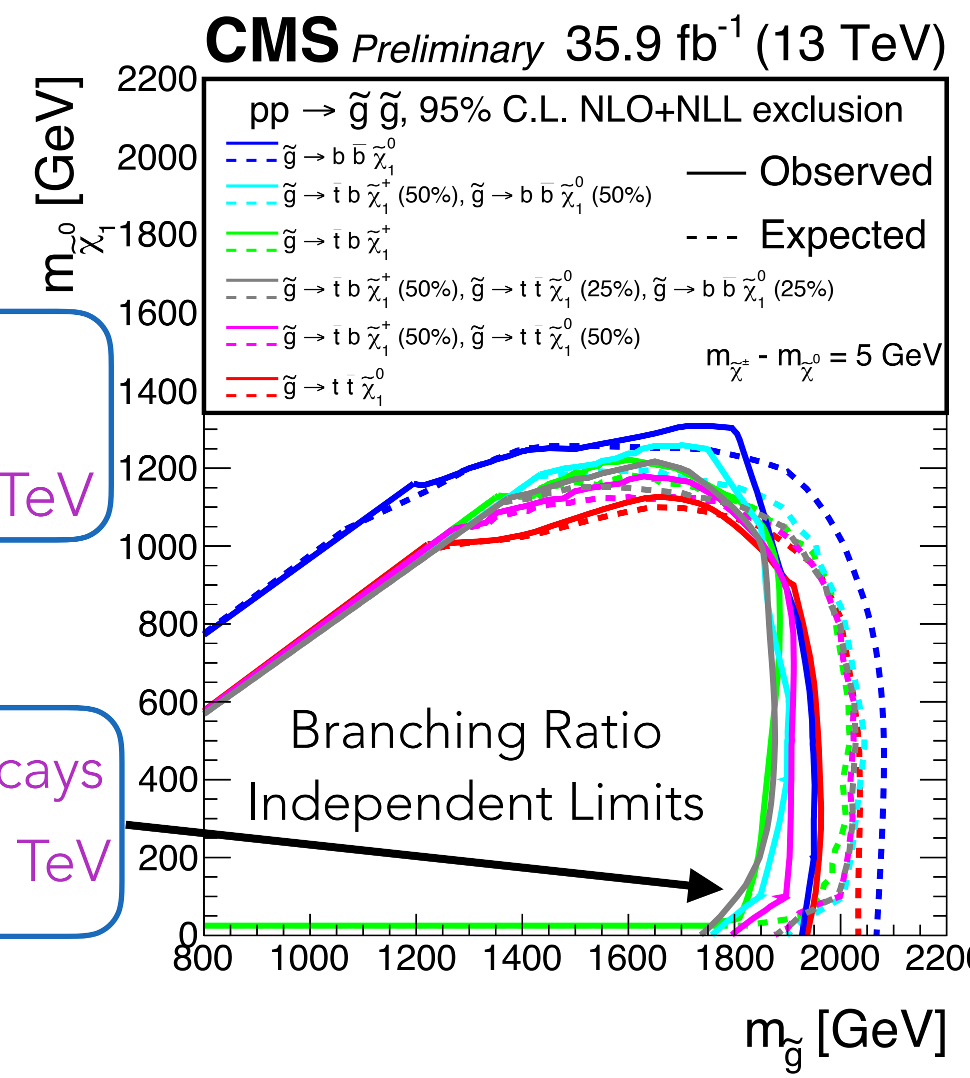


$\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$

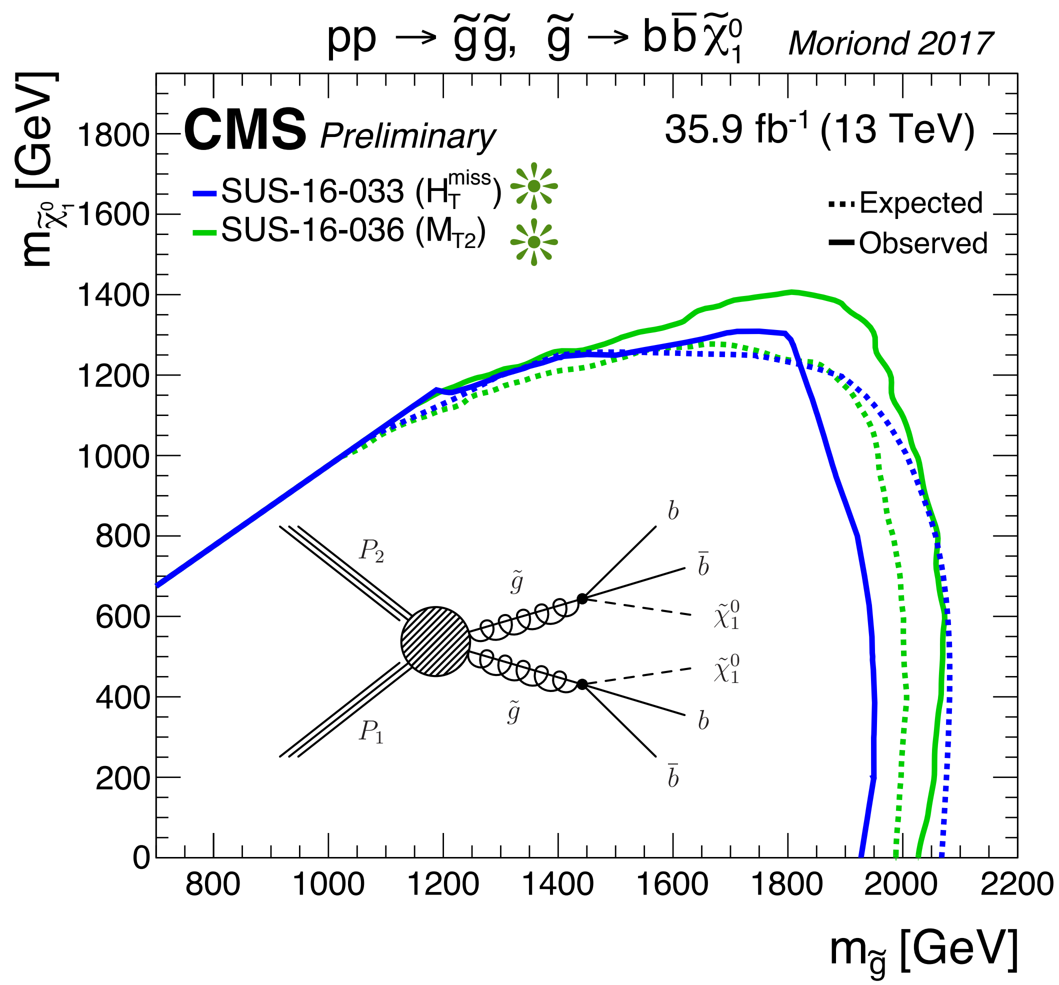
Exclude gluinos at ~ 2 TeV

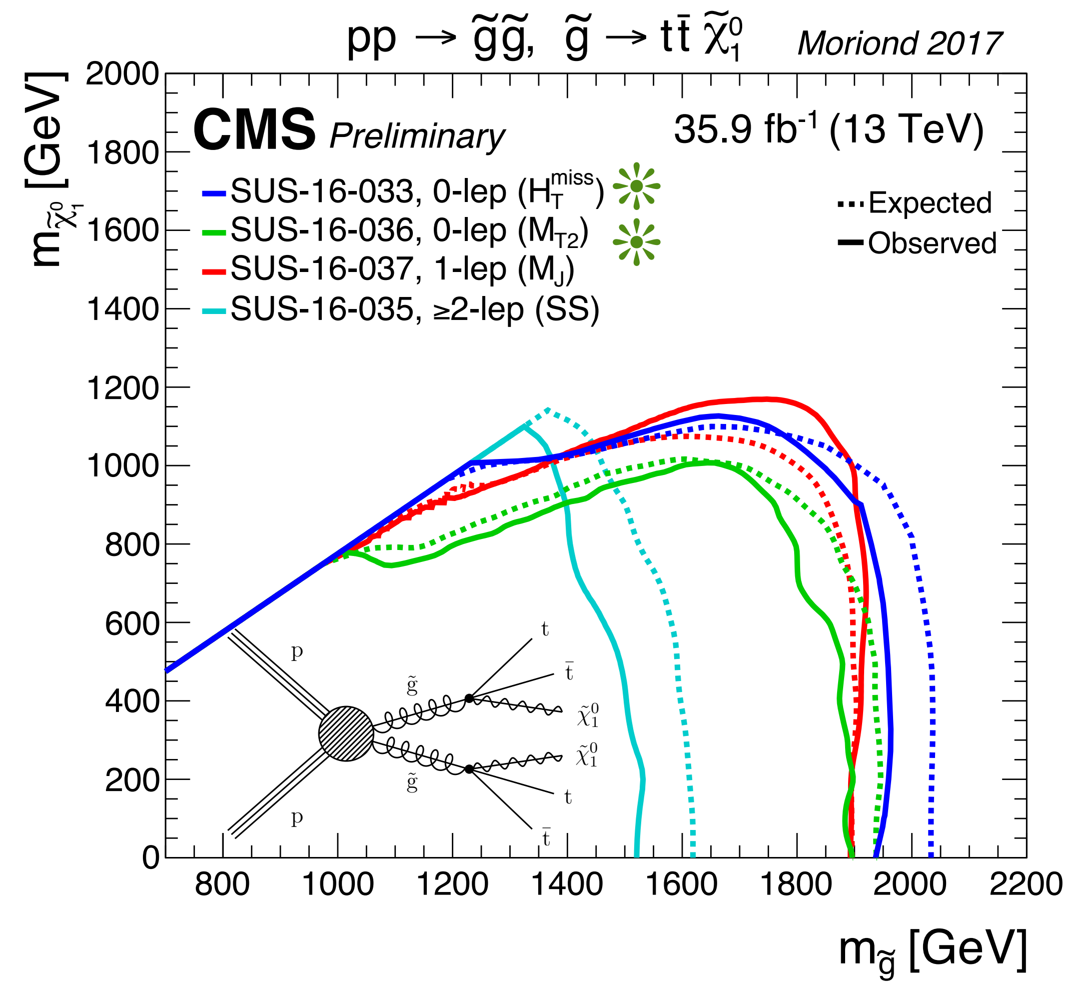
when allowing more decays

Exclude gluinos at ~ 1.8 TeV



summarize information from different analyses





All-hadronic inclusive analyses very sensitive to gluino pair production

lepton SUSY analyses sensitive to gluinos decaying to stops

All-hadronic analyses exclude gluinos up to about 2 TeV

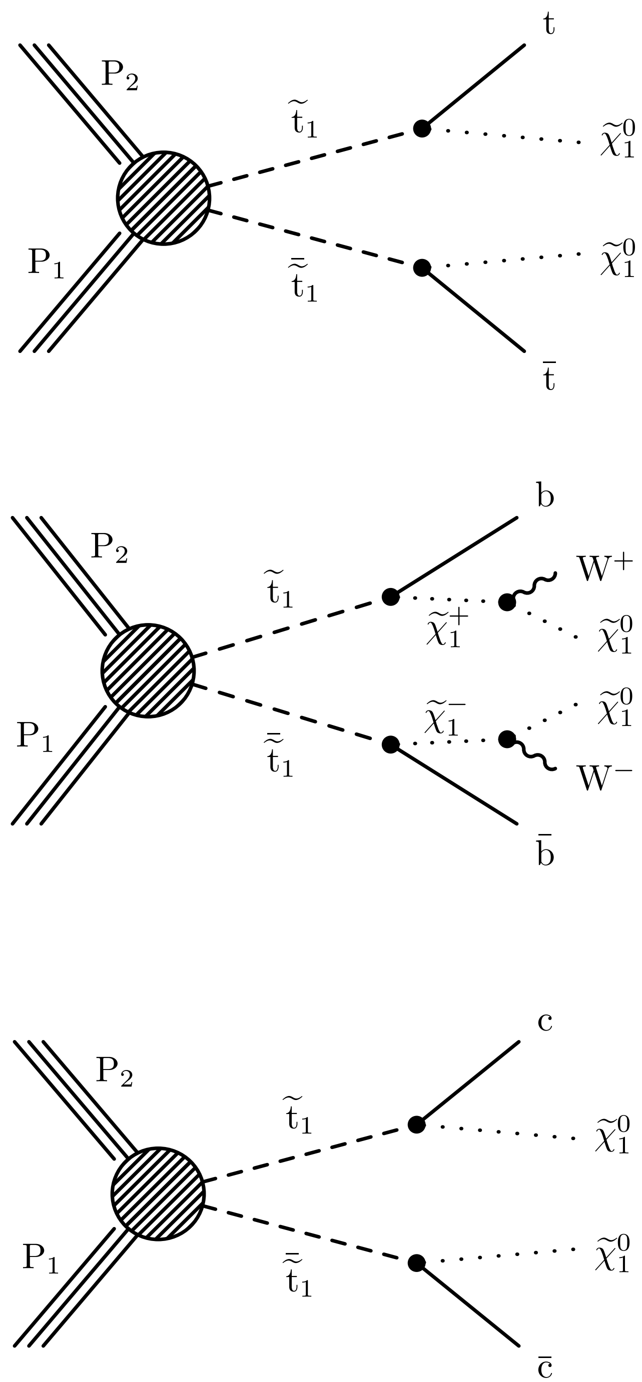
more in formation at: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

CMS STOP ZERO-LEPTON

CMS multijet, targeted stop search

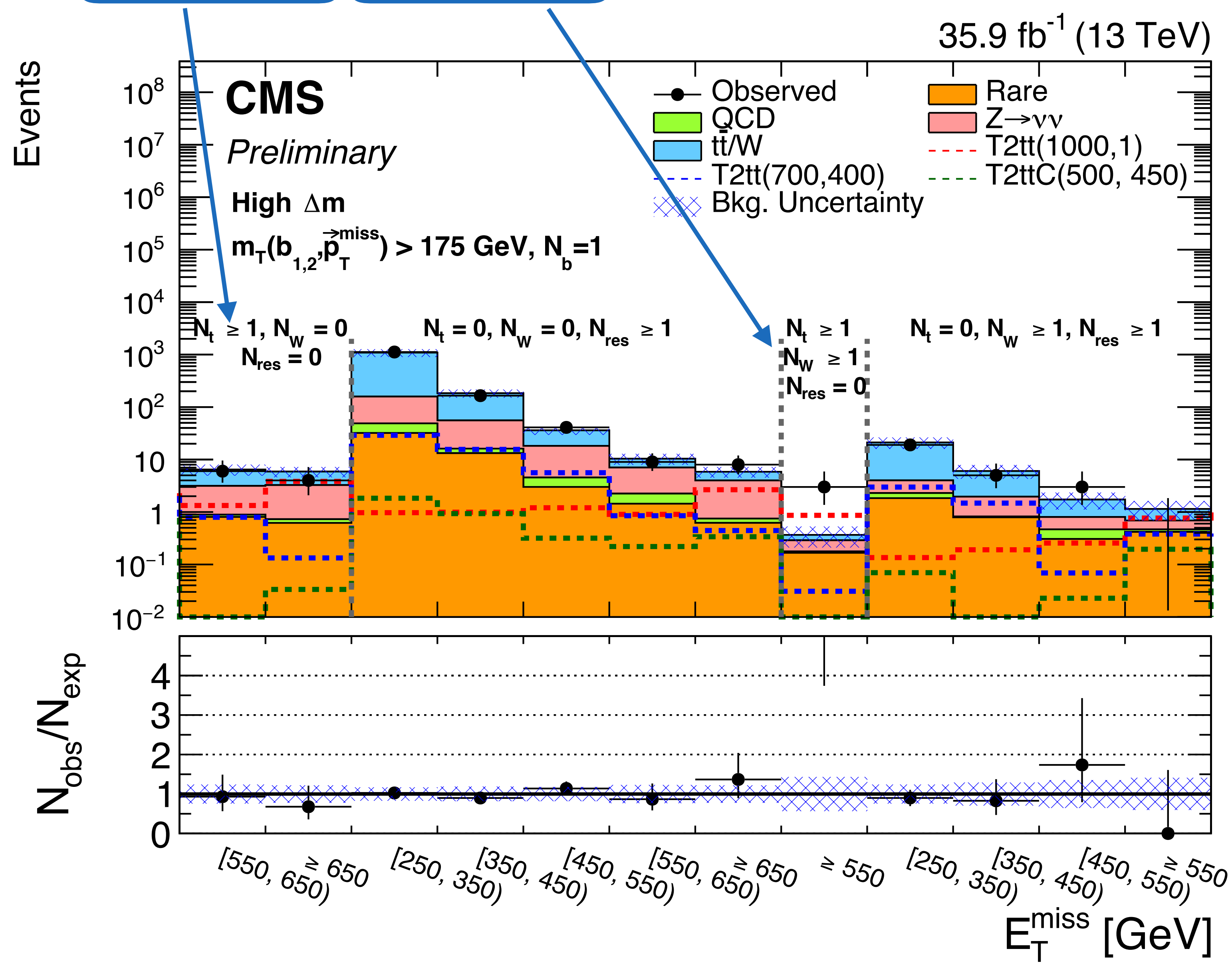
SUS-16-049

probe different stop decays



Based on m_T, $N_{b\text{-jets}}$, E_T^{Miss}

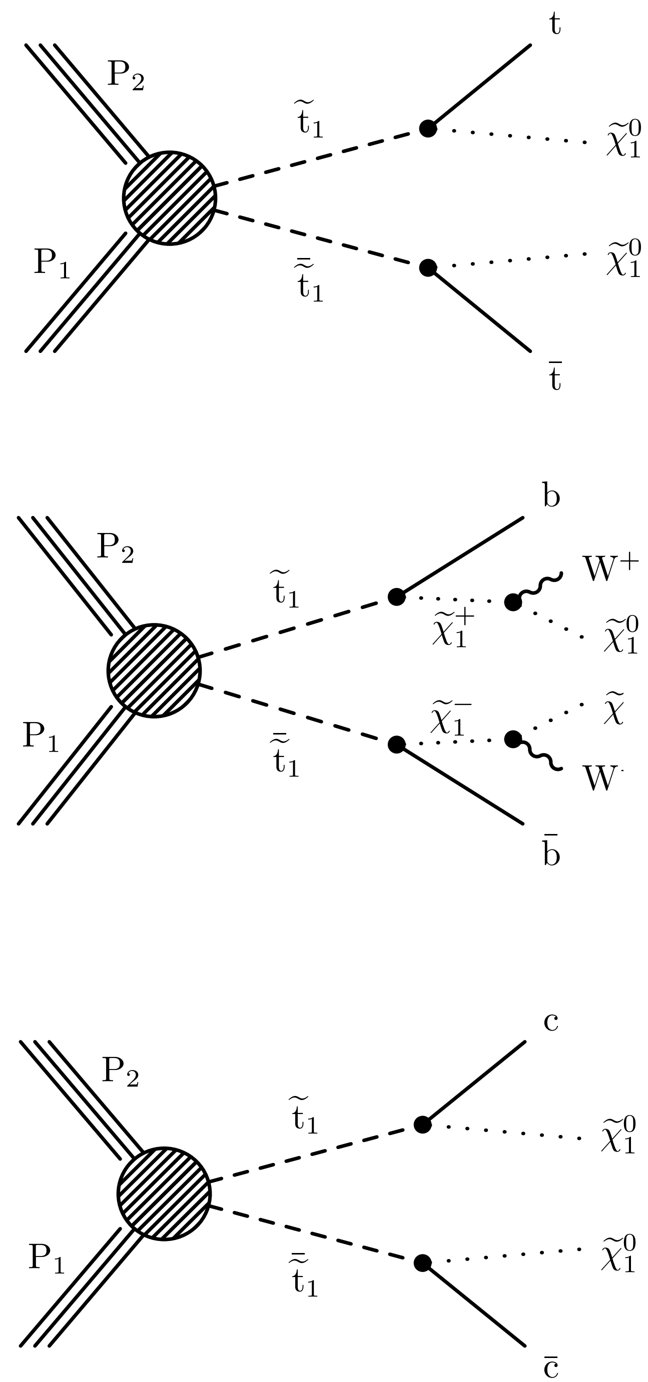
top-tagger, W-tagger, low p_T b-jet reconstruction



CMS multijet, targeted stop search

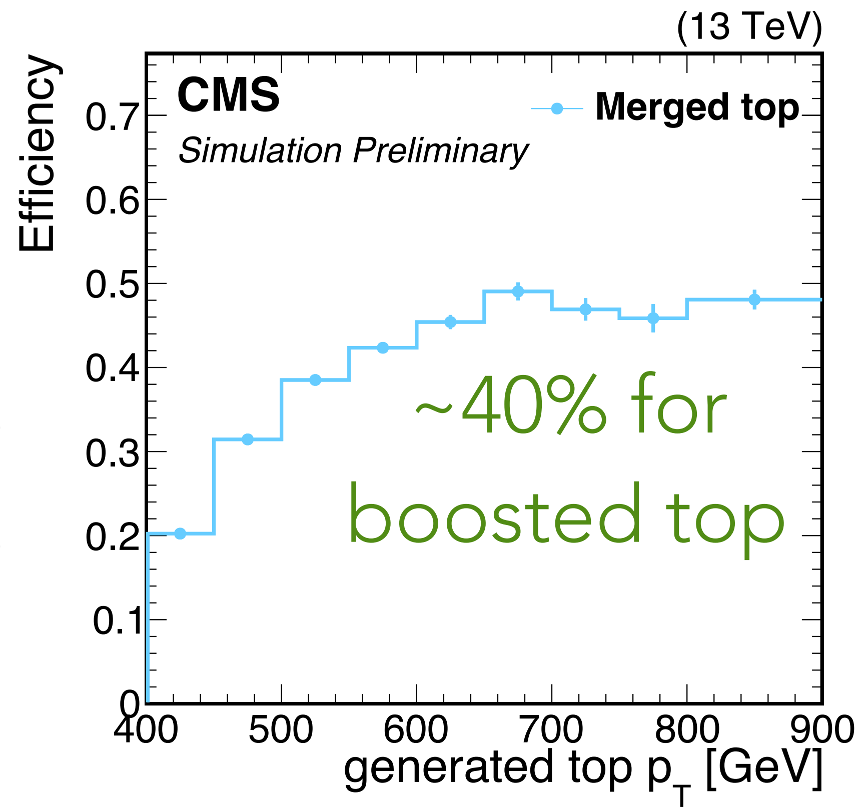
SUS-16-049

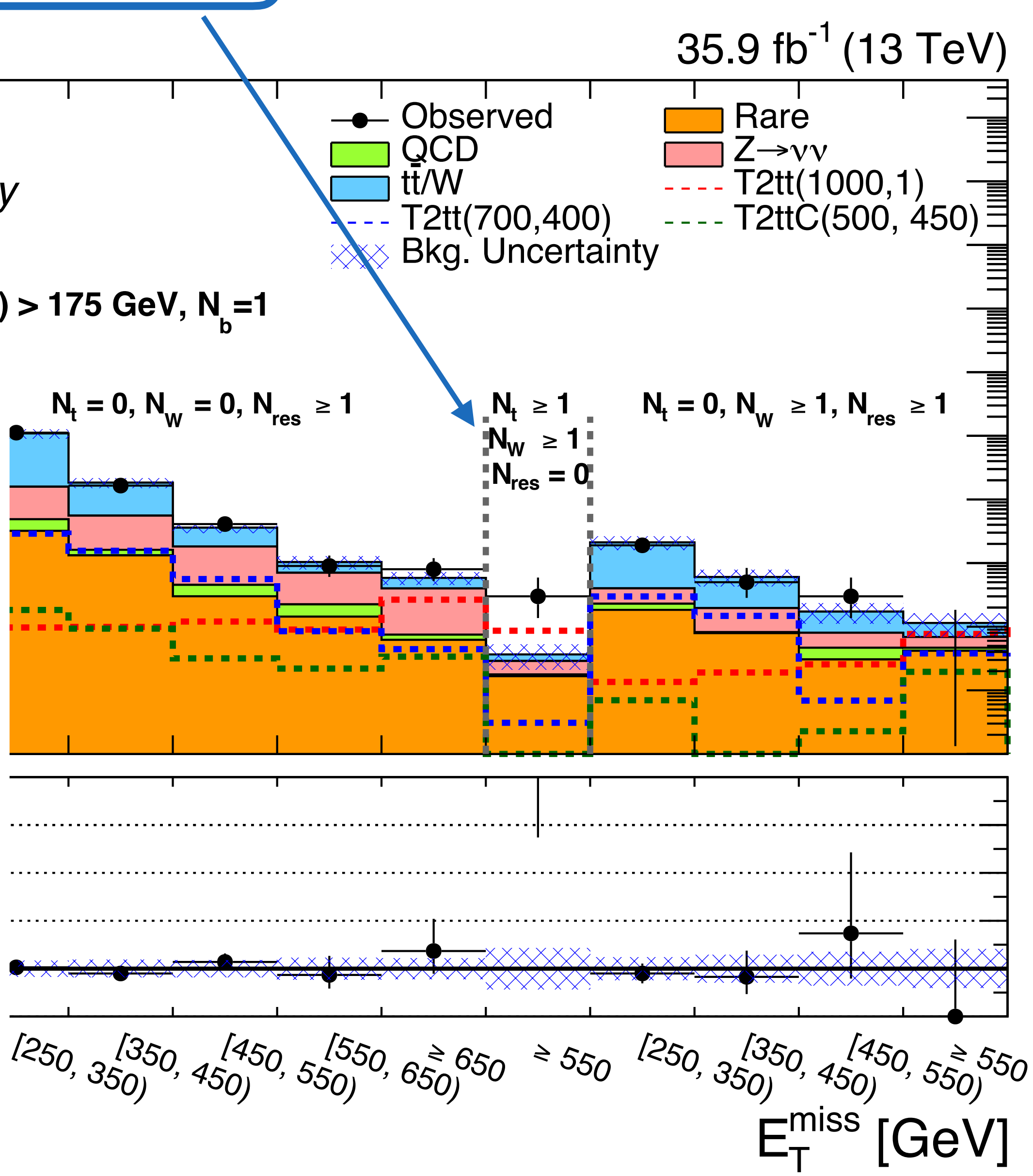
probe different stop decays



Based on m_T, $N_{b\text{-jets}}$, E_T^{Miss}

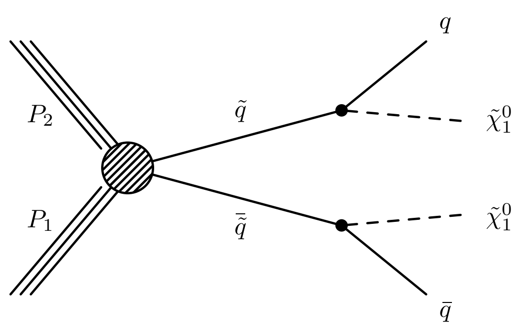
top-tagger, W-tagger, low p_T b-jet reconstruction

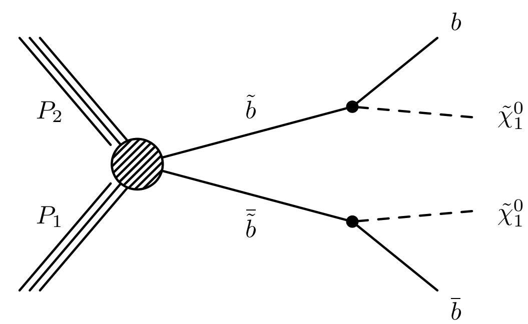


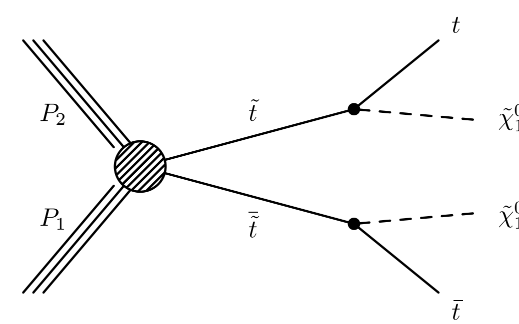


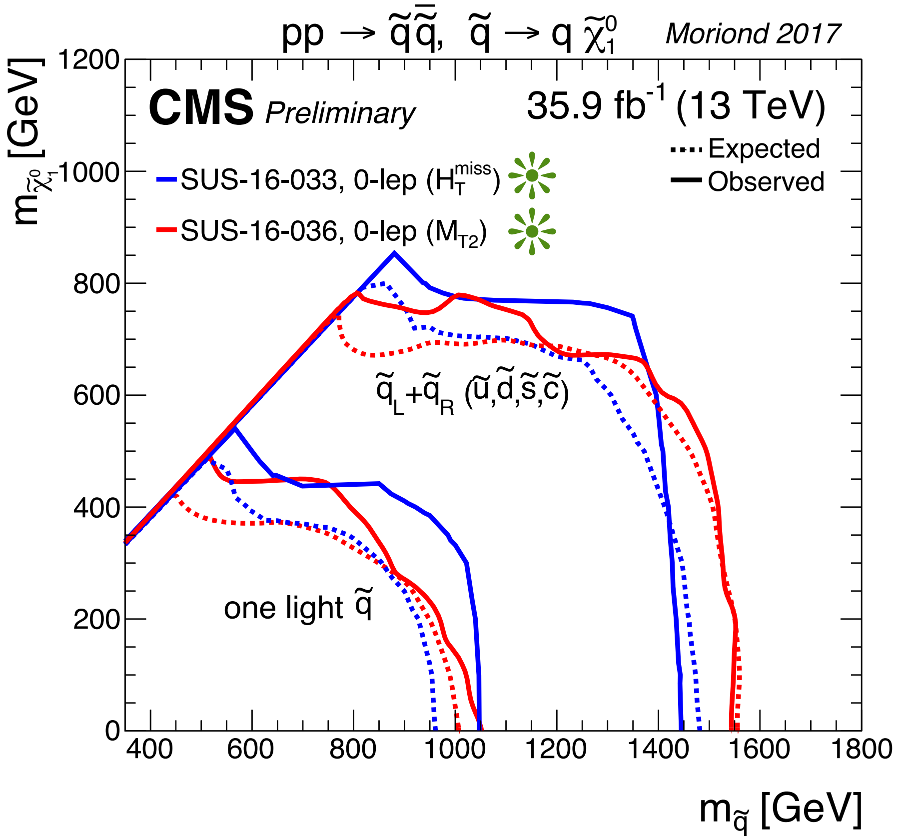
CMS multijet, zero-lepton

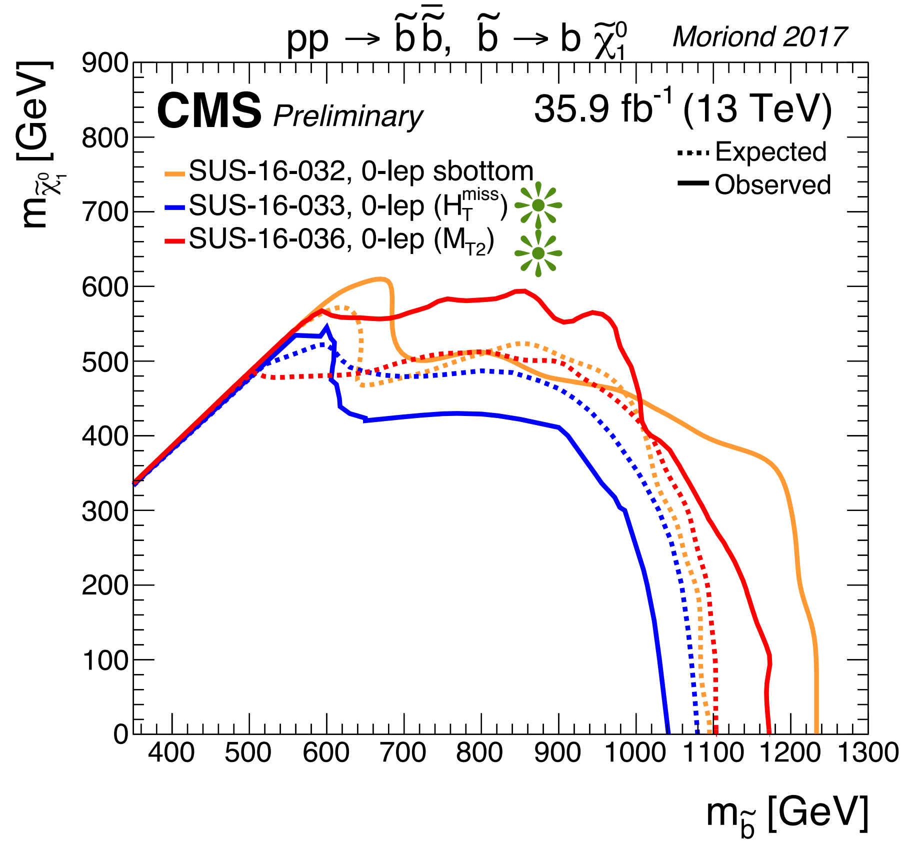
Same analysis is also sensitive to squarks

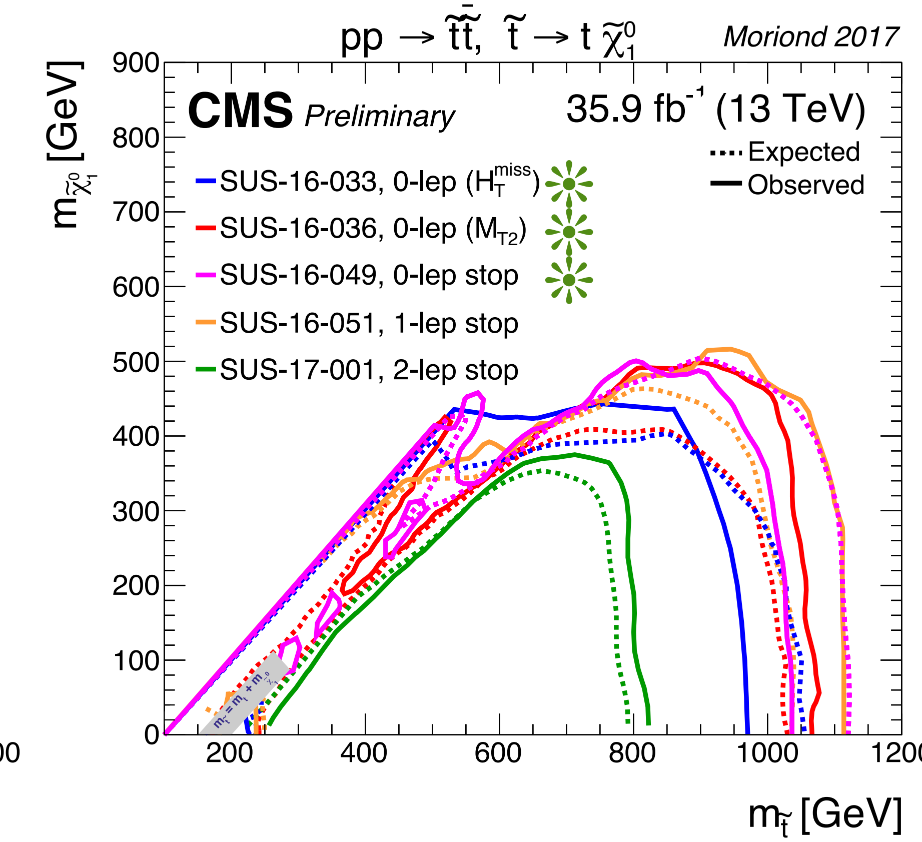












light squarks excluded at ~1.6 TeV

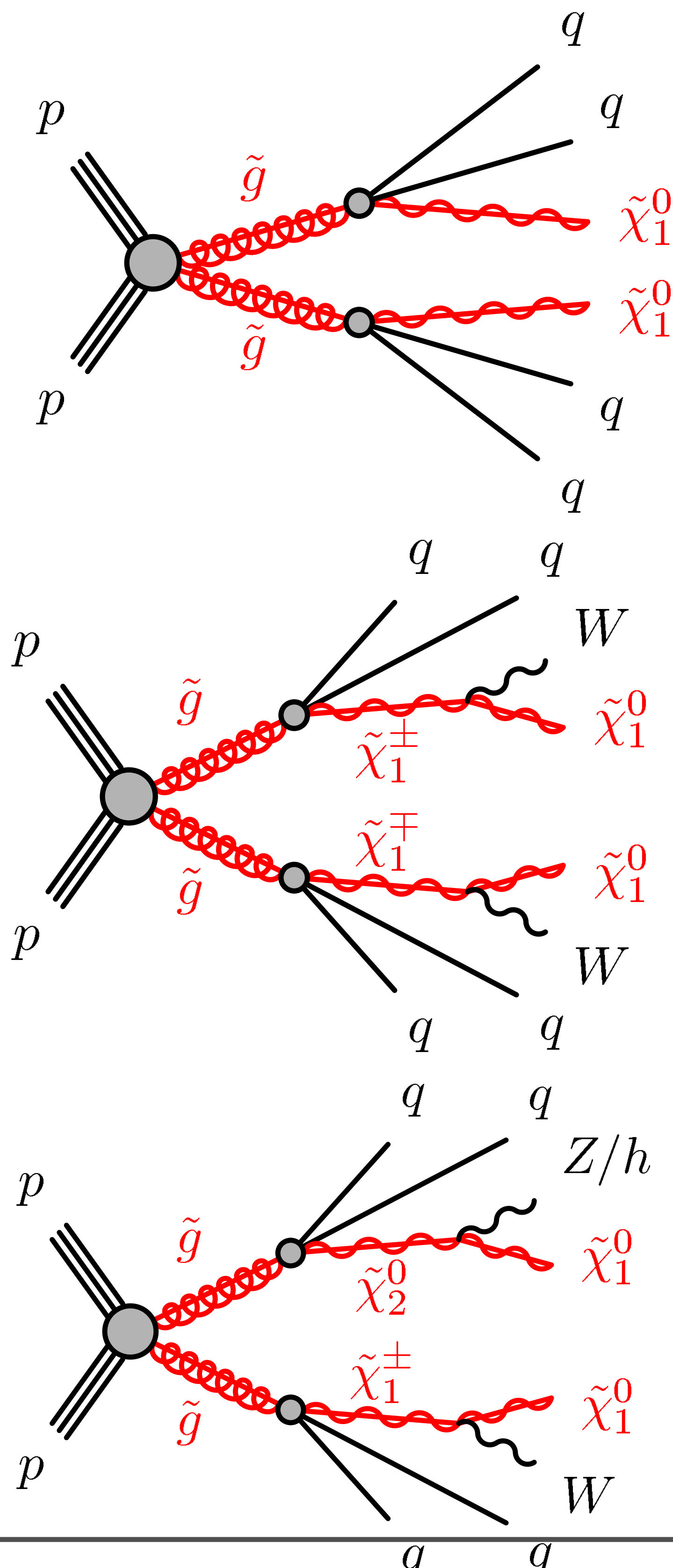
sbottom excluded at ~1.2 TeV

stop excluded at ~1.1 TeV

ATLAS multijet, zero-lepton

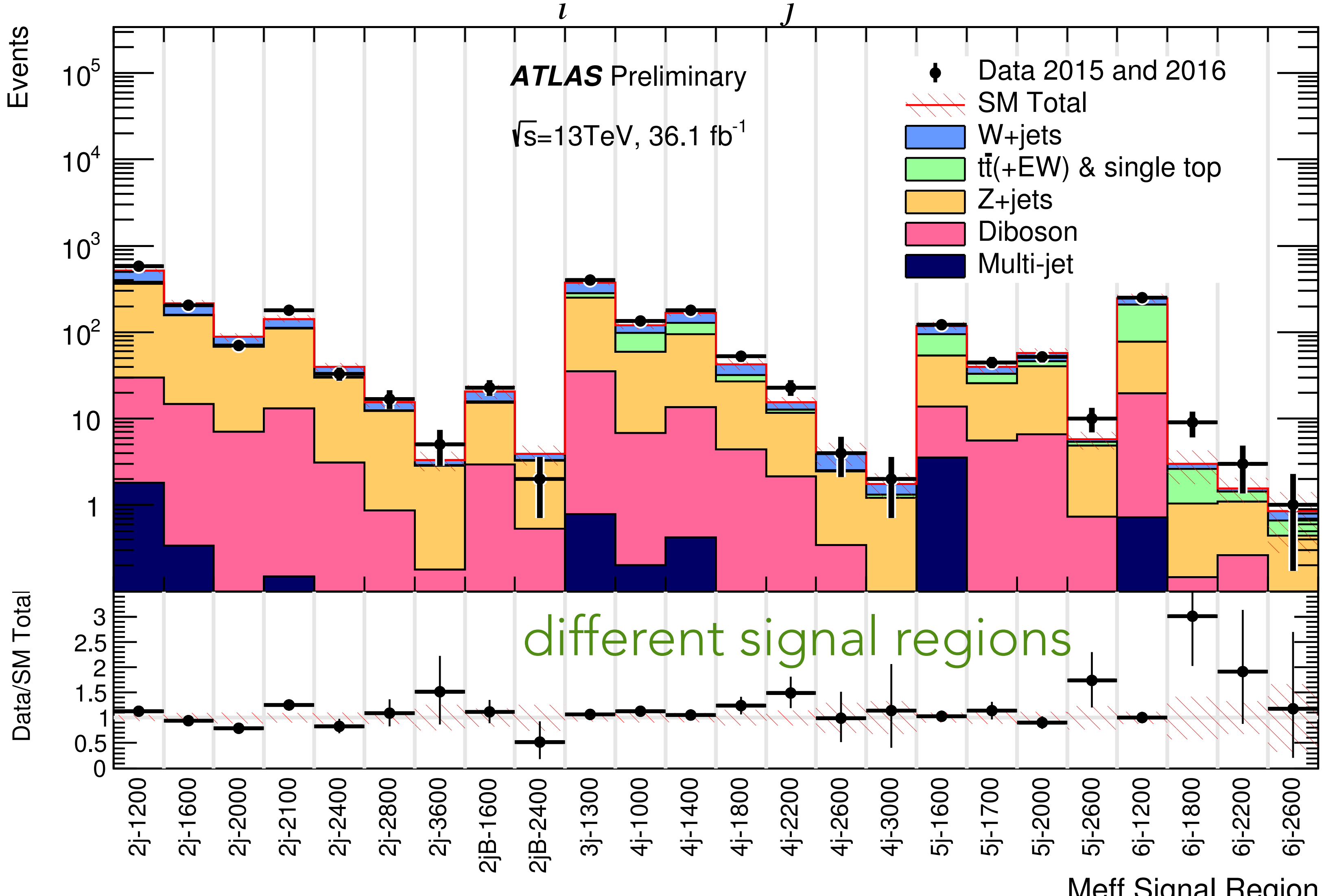
ATLAS-CONF-2017-022

probe different gluino decays



based on m_{eff}, N_{jets}, $N_{b\text{-}jets}$

$$m_{\text{eff}} = \sum_i p_T^{\text{jet}_i} + \sum_j p_T^{\ell_j} + E_T^{\text{miss}}$$



different signal regions

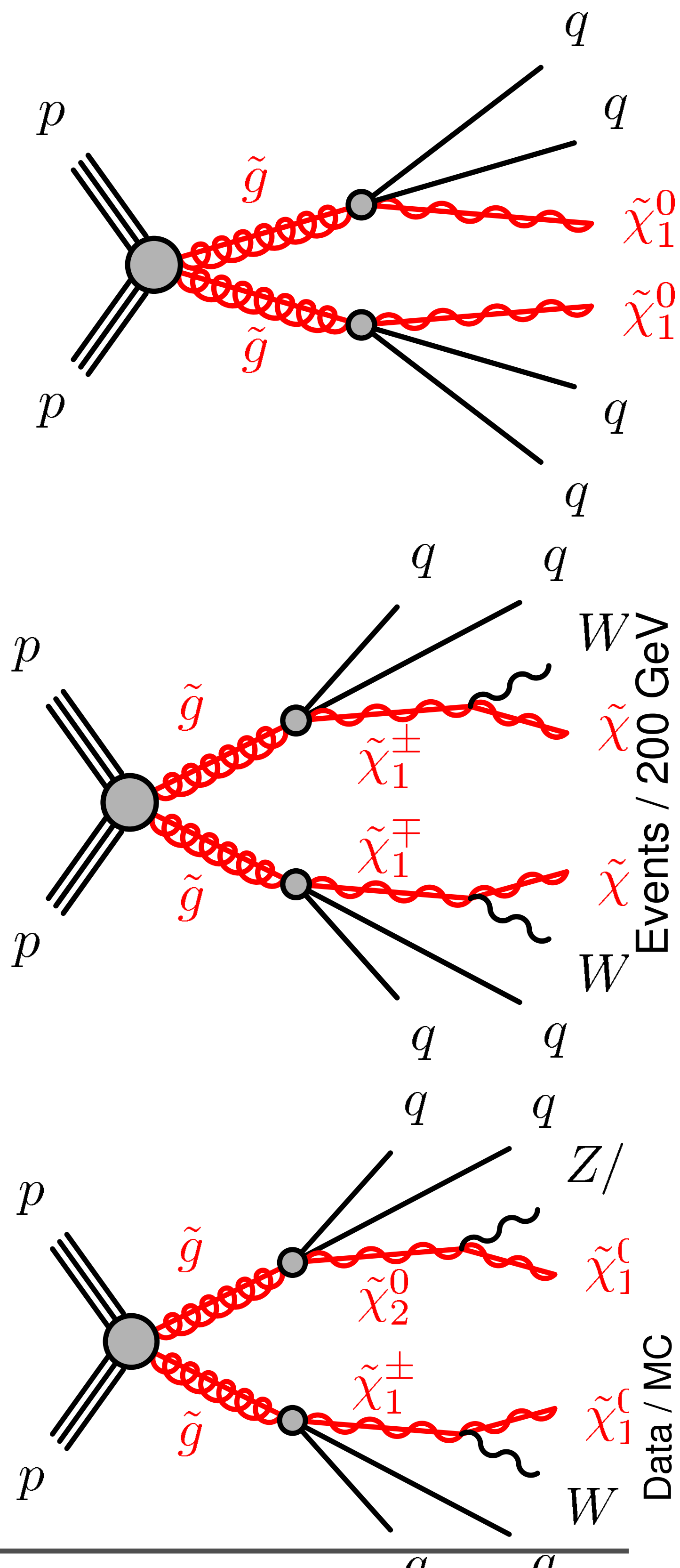
No significant deviations from SM expectation

ATLAS GLUINO/SQUARK SEARCHES

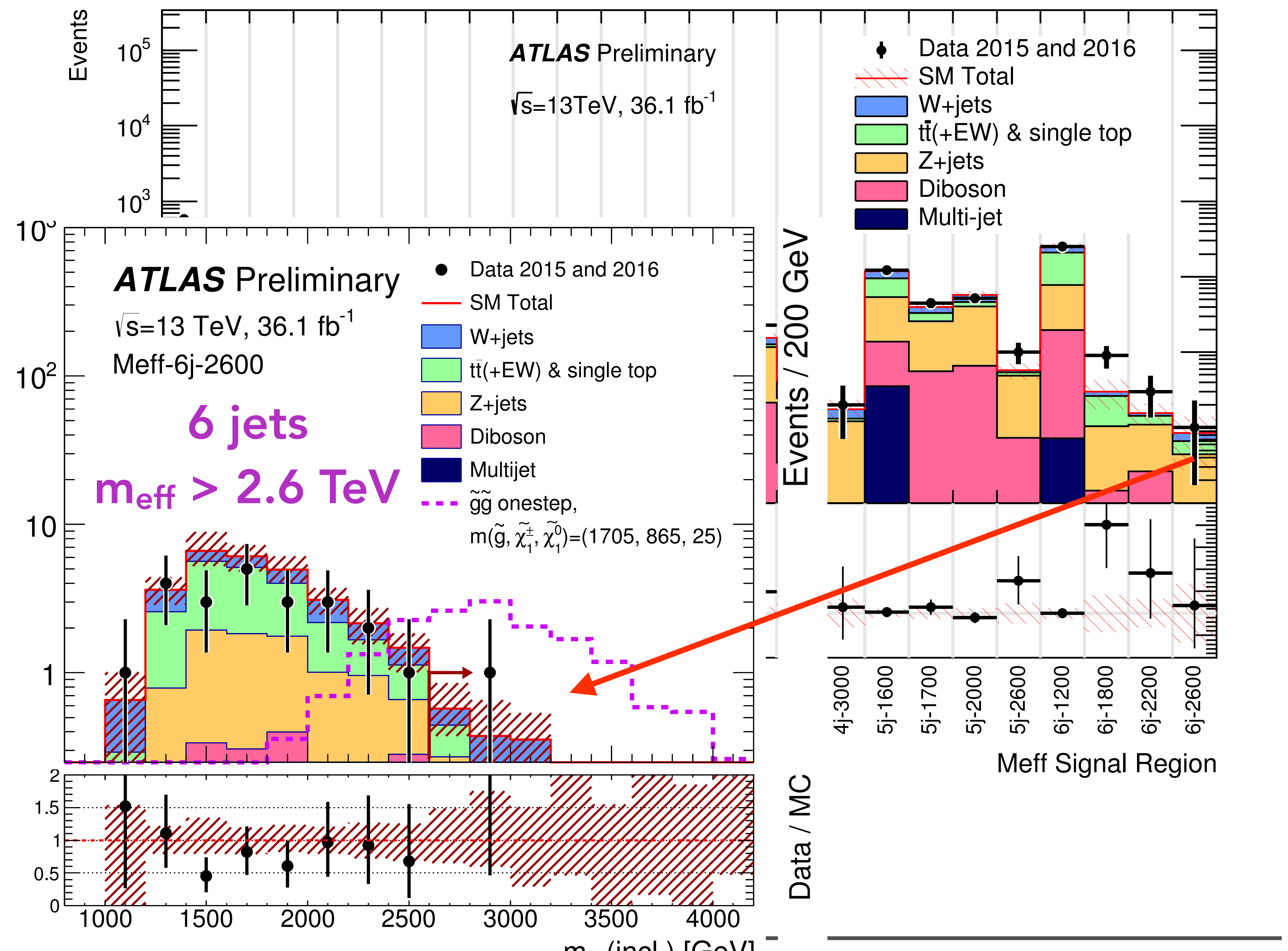
ATLAS multijet, zero-lepton

ATLAS-CONF-2017-022

probe different gluino decays



based on m_{eff}, N_{jets}, $N_{b\text{-jets}}$

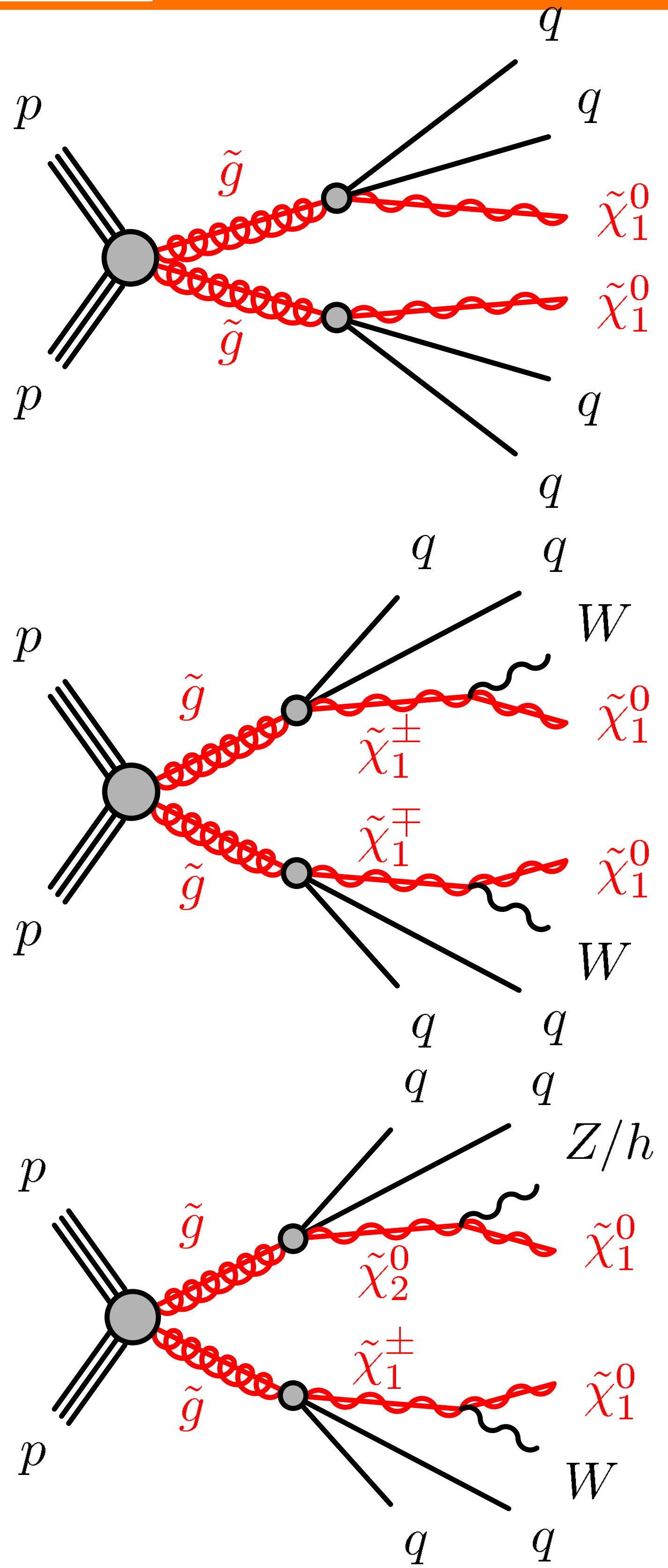


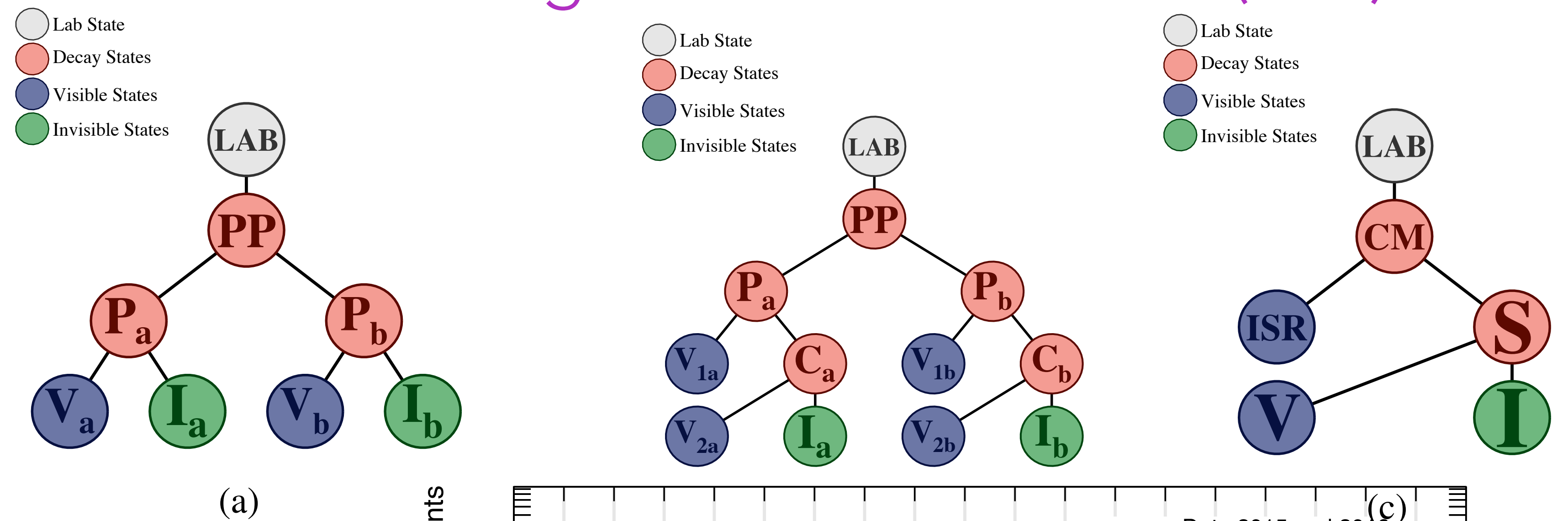
ATLAS multijet, zero-lepton

ATLAS-CONF-2017-022

Recursive Jigsaw Reconstruction (RJR)

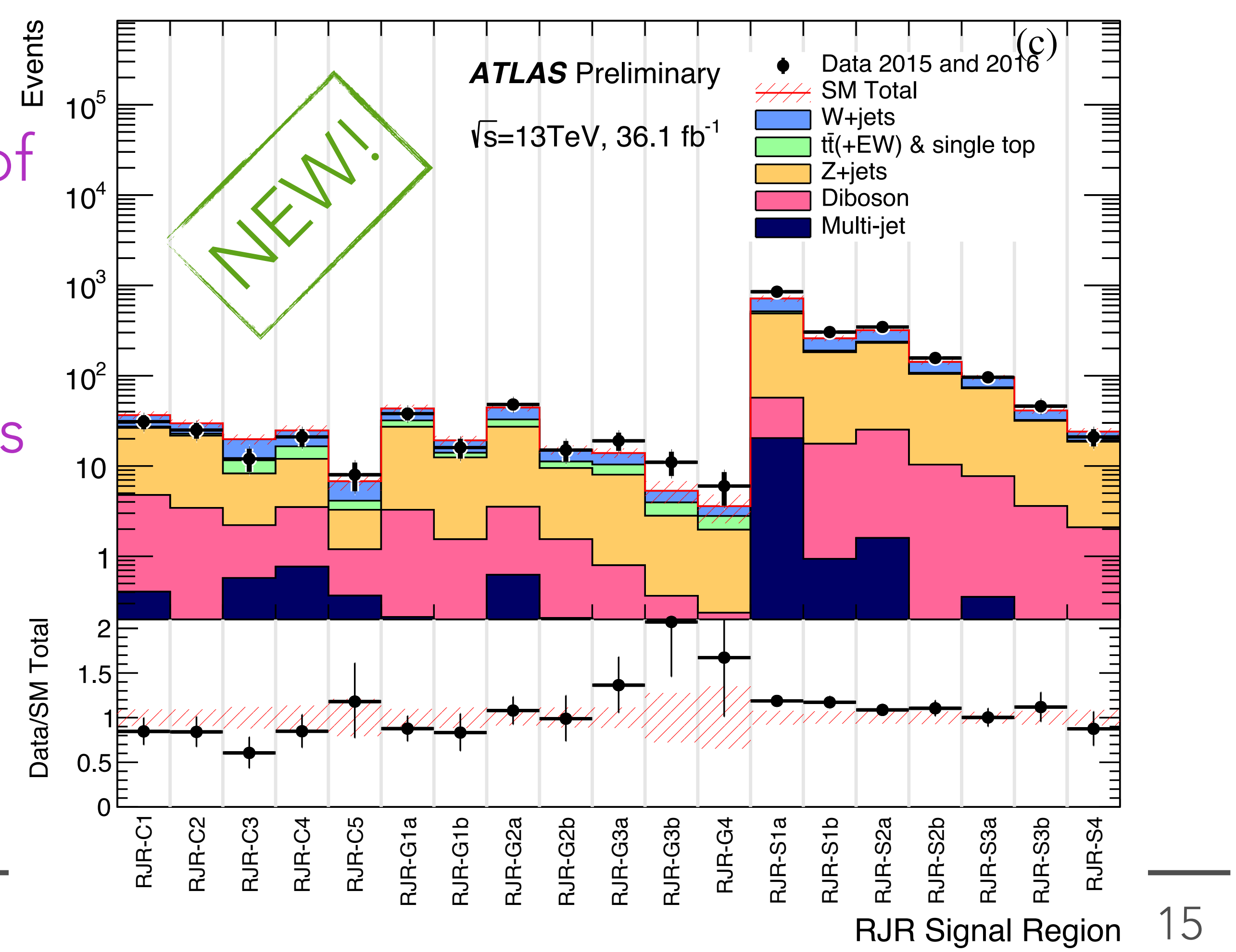
probe different gluino decays





exploit topology of the decay chain

useful observables include: p_T^{CM}

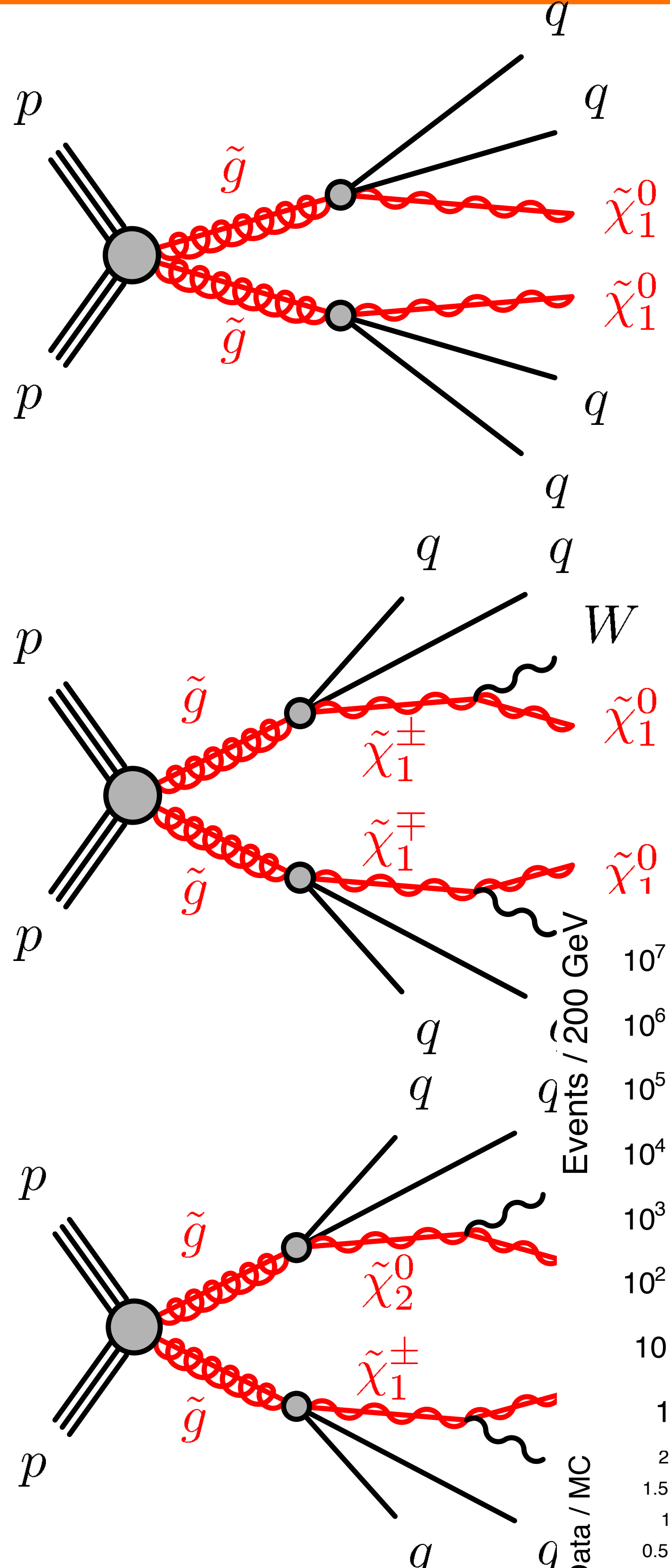


ATLAS GLUINO/SQUARK SEARCHES

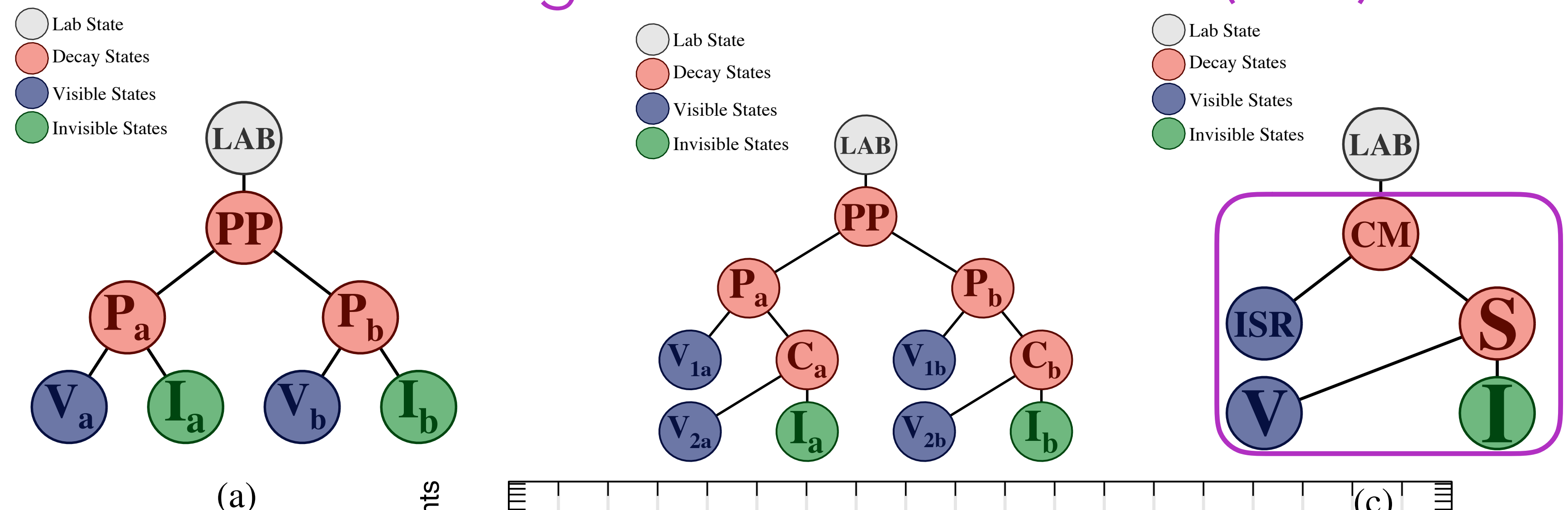
ATLAS multijet, zero-lepton

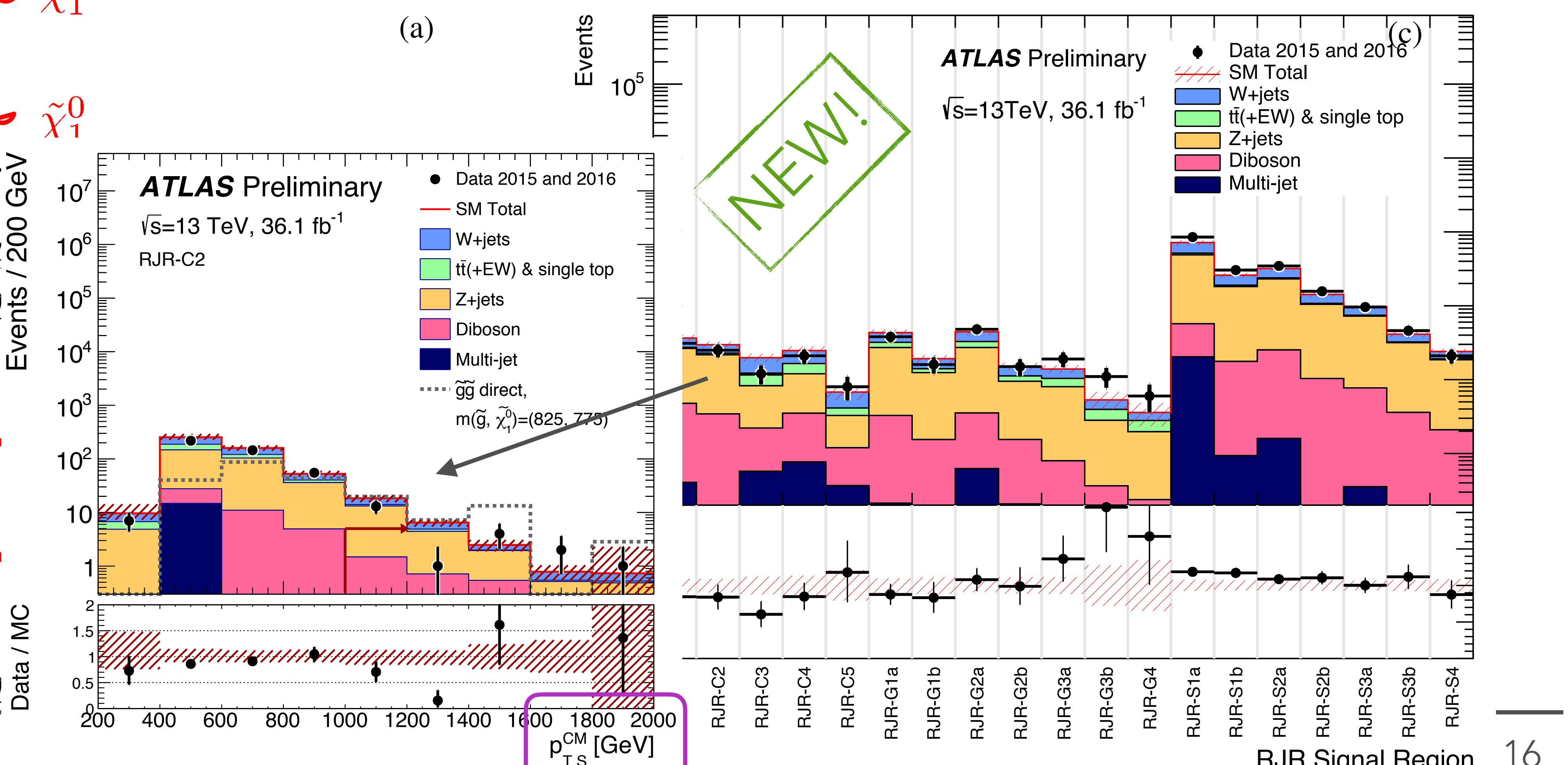
ATLAS-CONF-2017-022

probe different gluino decays



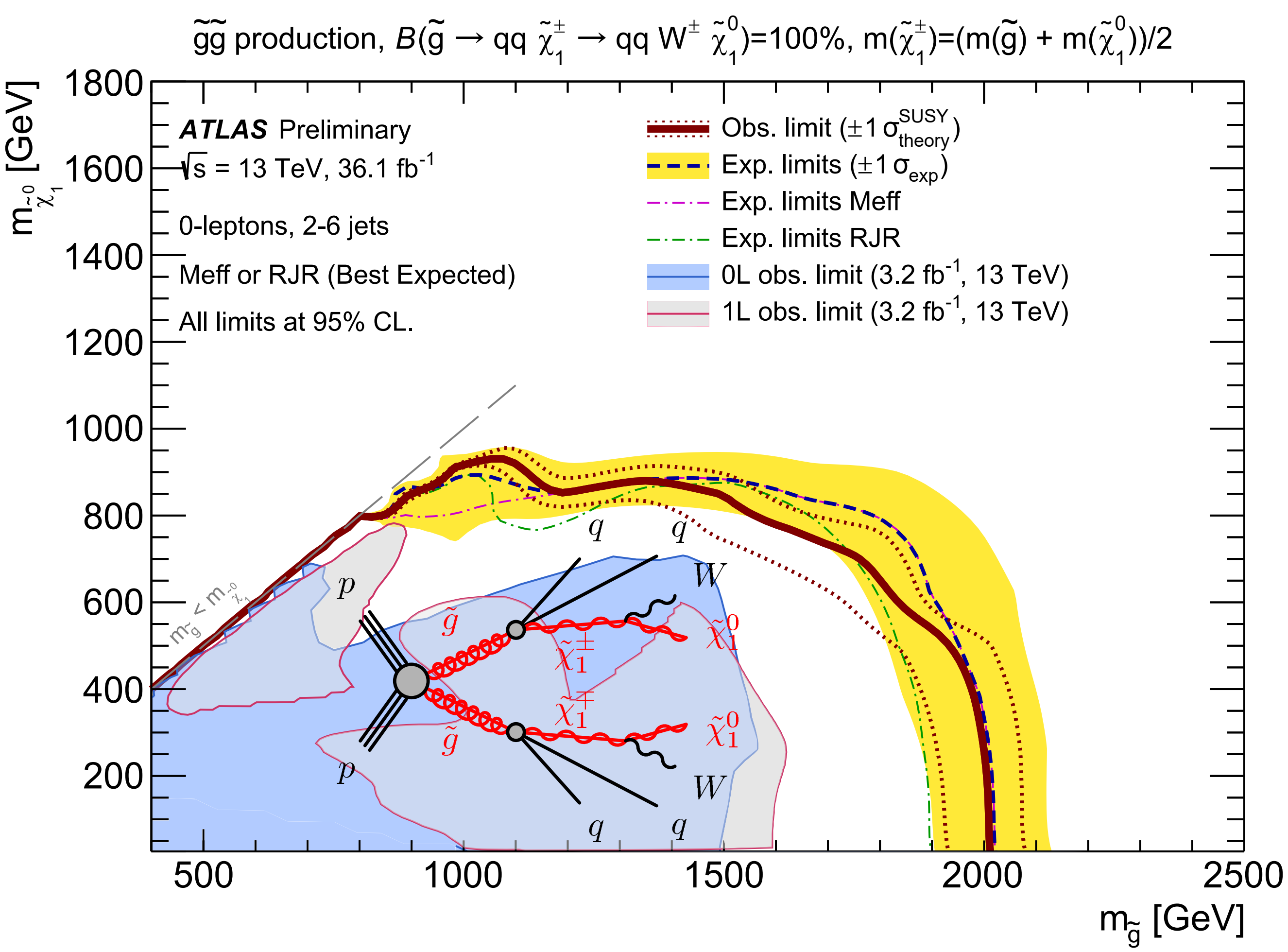
Recursive Jigsaw Reconstruction (RJR)

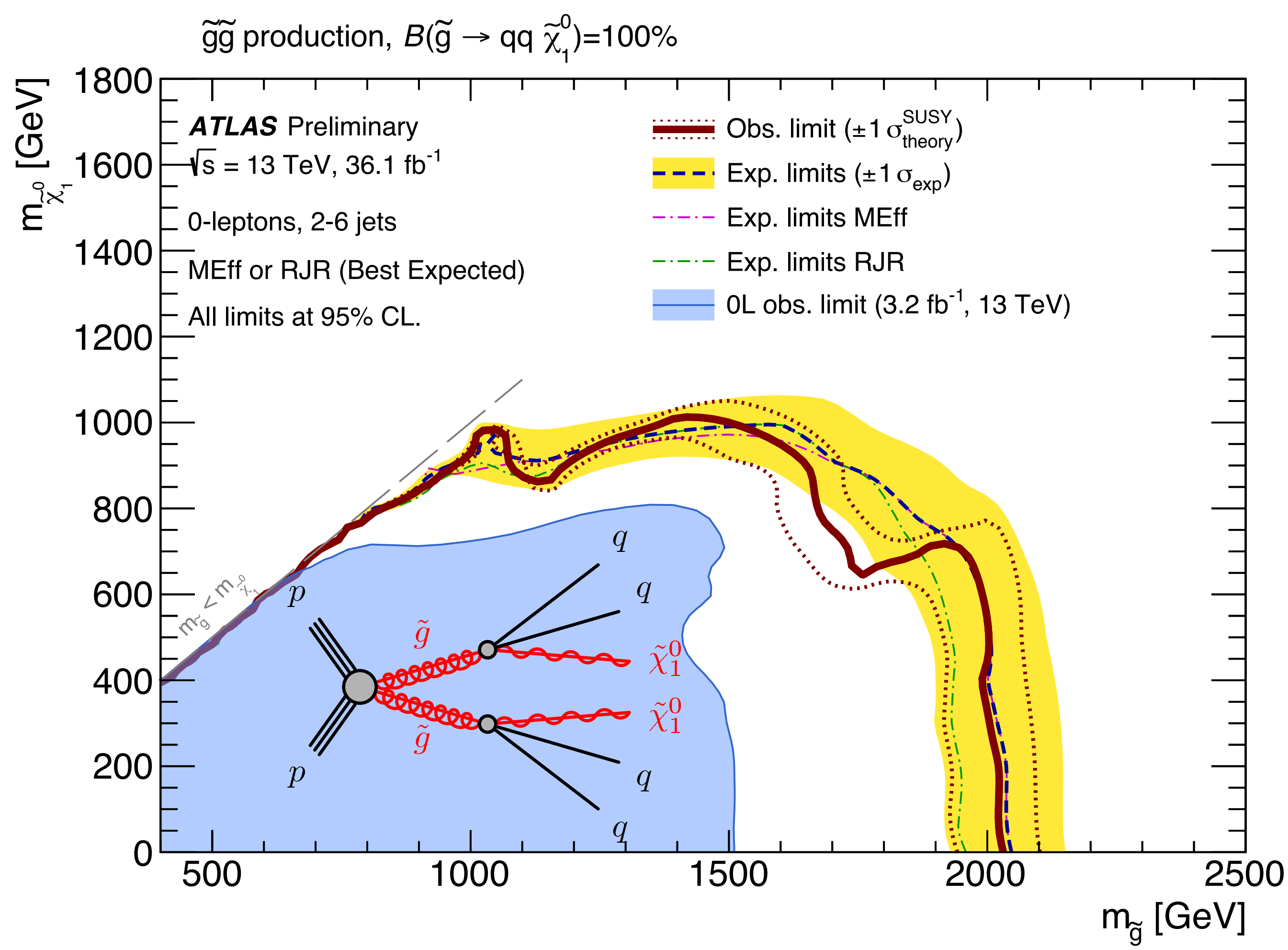




ATLAS GLUINO EXCLUSIONS

best limits between m_{eff} and RJR analyses





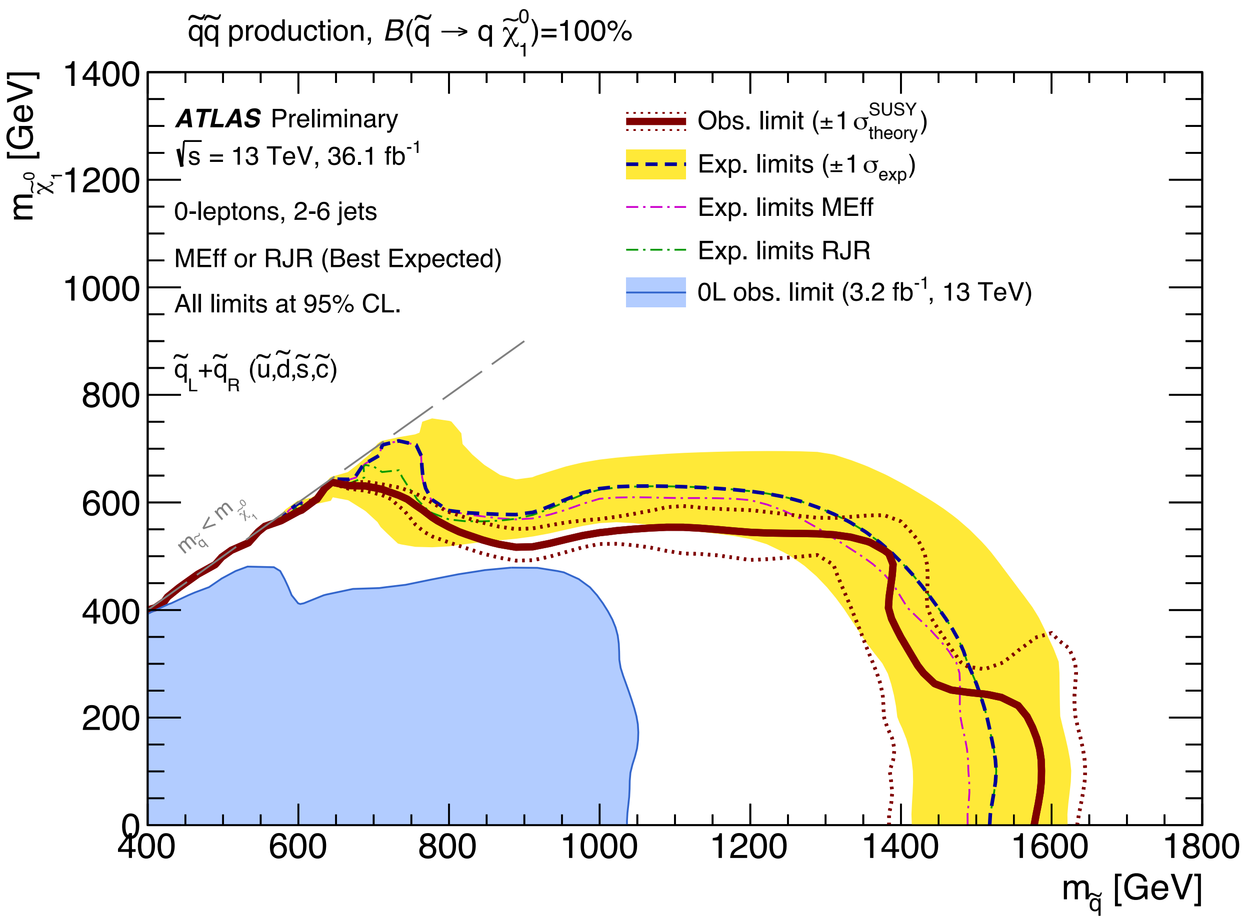
exclude gluinos at ~2 TeV

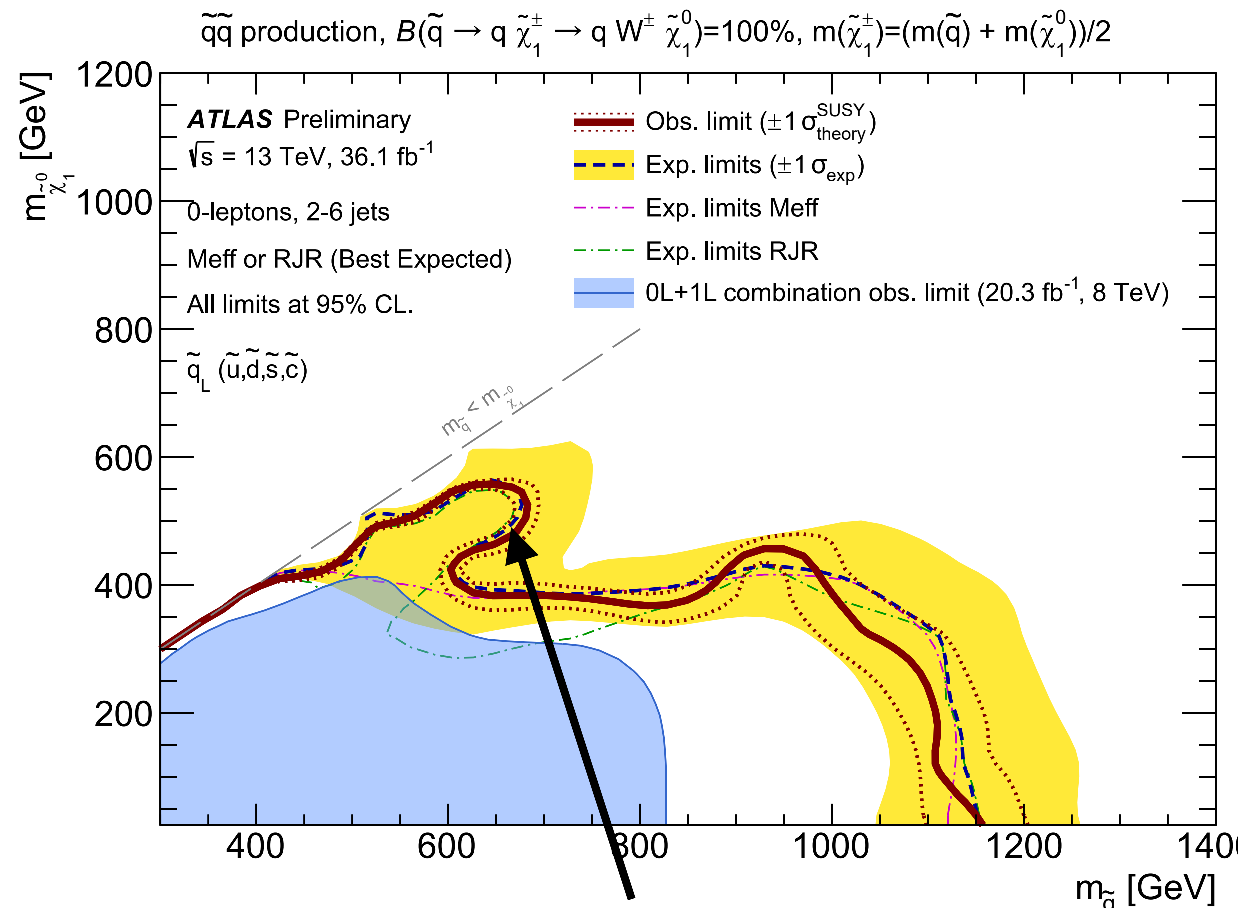
significantly improved the reach wrt to 2015 dataset (about 500 GeV on gluino mass)

ATLAS-CONF-2017-022

ATLAS SQUARK EXCLUSIONS

best limits between m_{eff} and RJR analyses





RJR provides extra sensitivity at smaller mass splitting

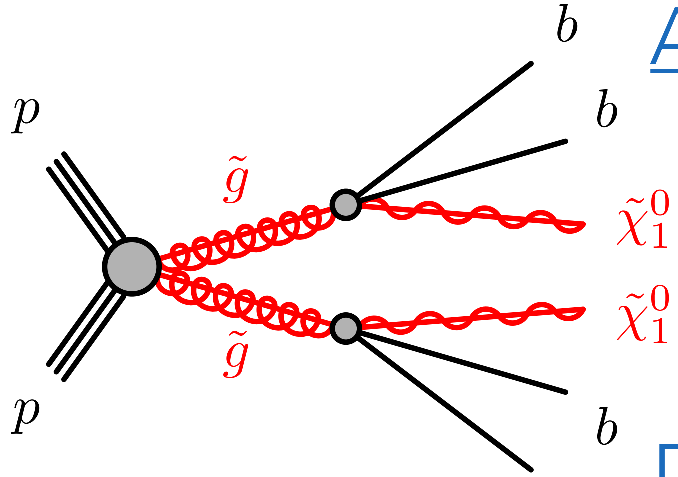
exclude squarks at ~1.6 TeV

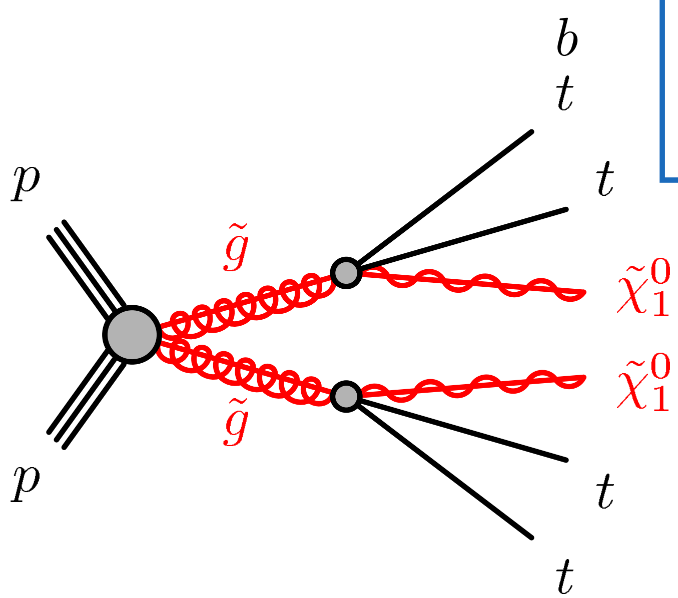
exclude squarks at ~1.2 TeV

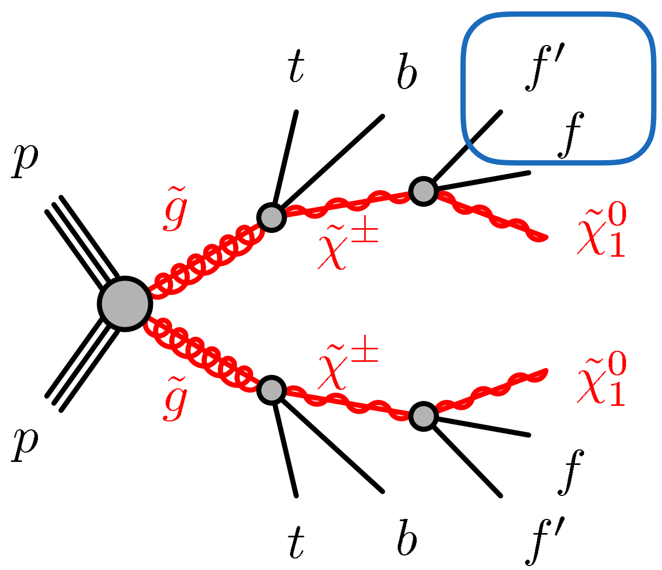
significantly improved the reach wrt to 2015 dataset (about 400 GeV on squark mass)

ATLAS GLUINO/SQUARK SEARCHES

probe different gluino decays







ATLAS multijet, b-jets, 0/1lepton

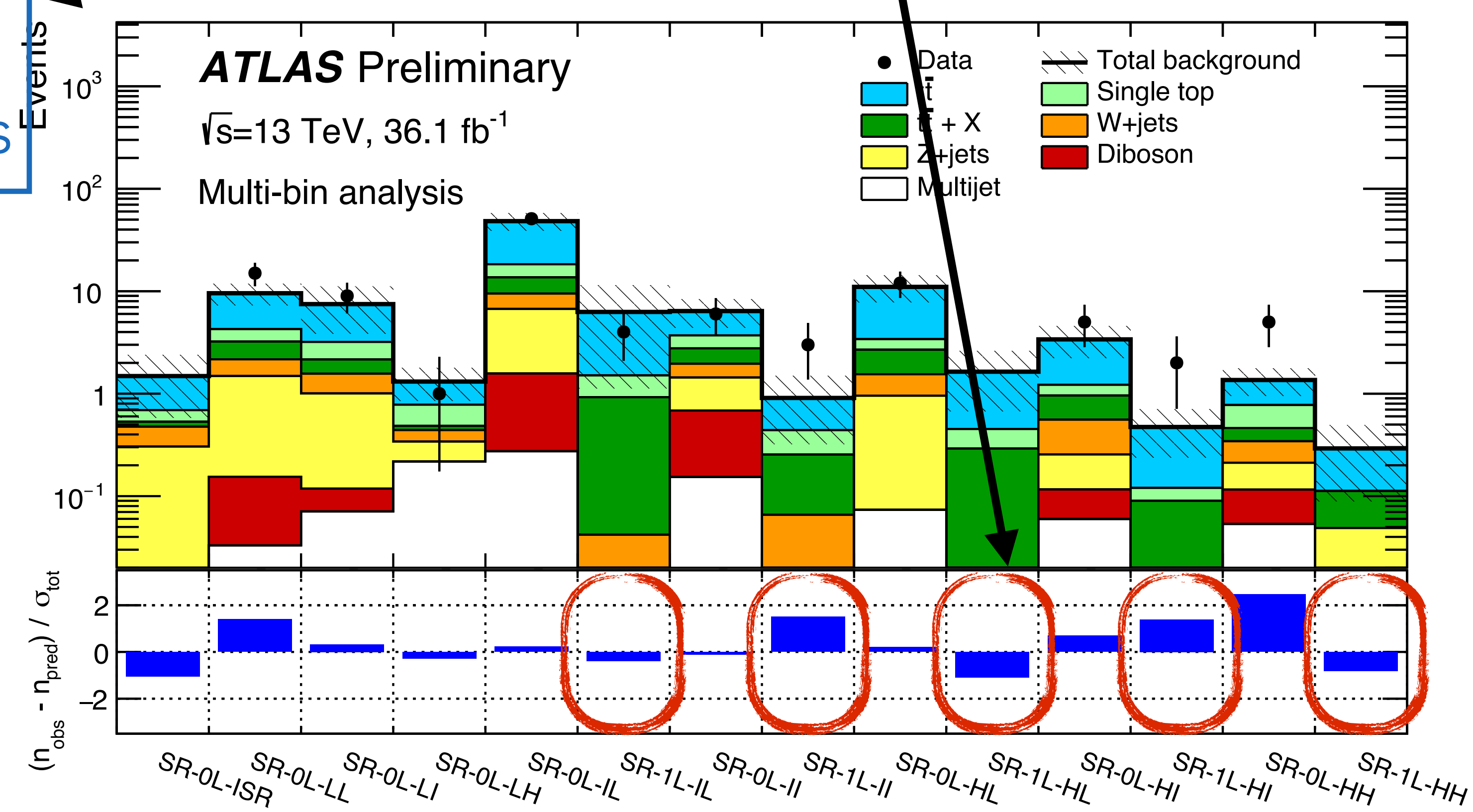
ATLAS-CONF-2017-021

targeting 3rd gen squarks

based on m_{eff}, N_{jets}, $N_{b\text{-}jets}$, $N_{leptons}$, m_T, E_T^{miss}

larger due to b and t quarks

soft fermions



No significant deviations from SM expectation

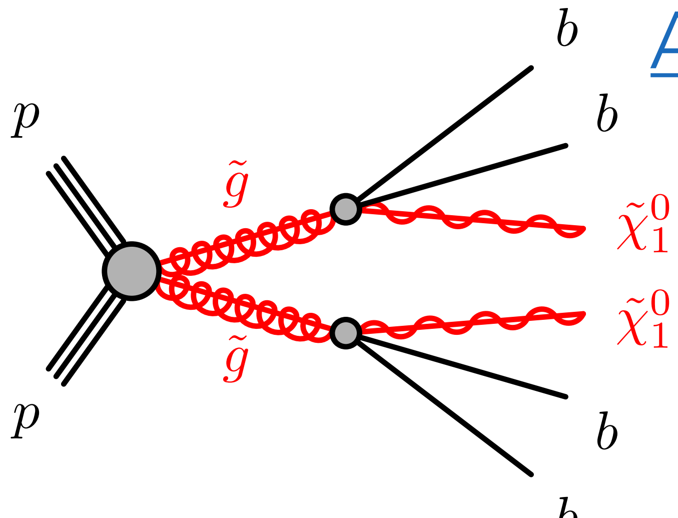
GLUINO SEARCHES (4)

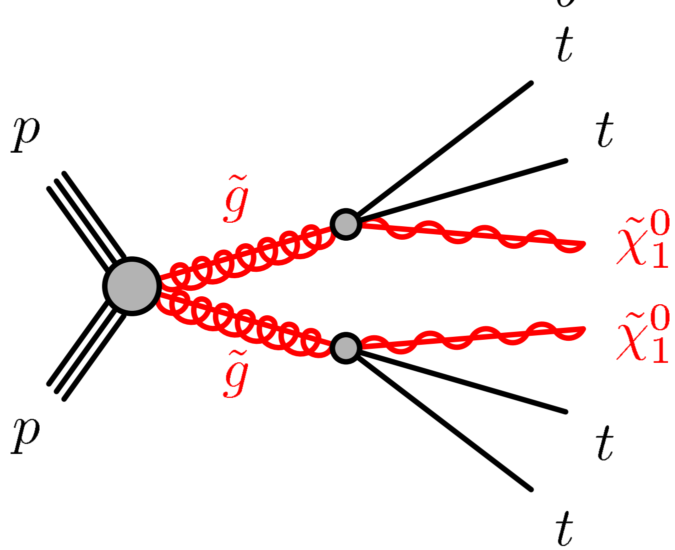
ATLAS multijet, b-jets, 0/1lepton

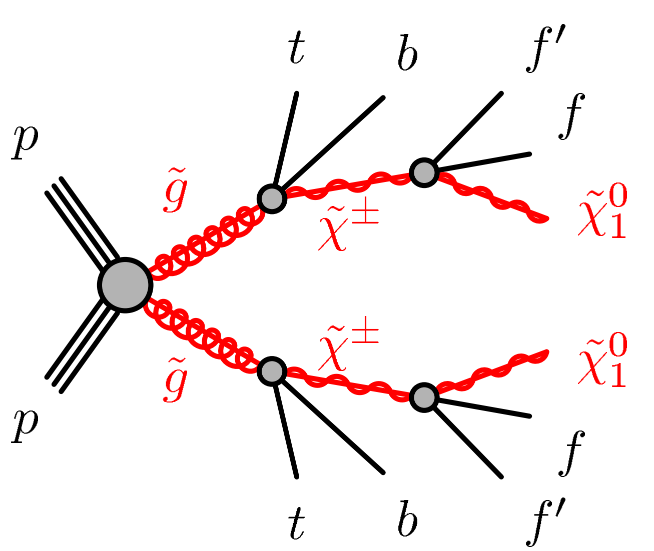
ATLAS-CONF-2017-021

targeting 3rd gen squarks

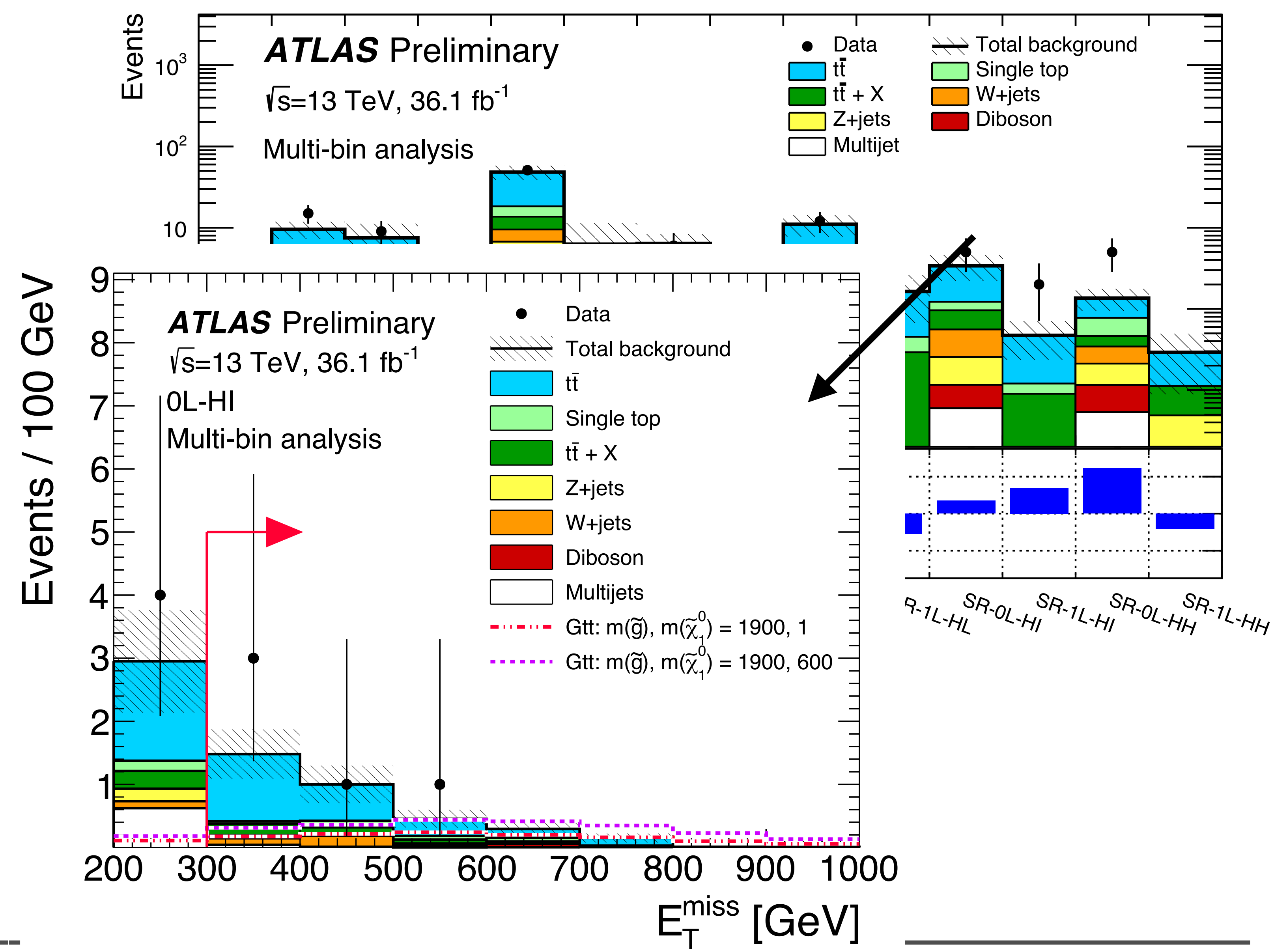
probe different gluino decays







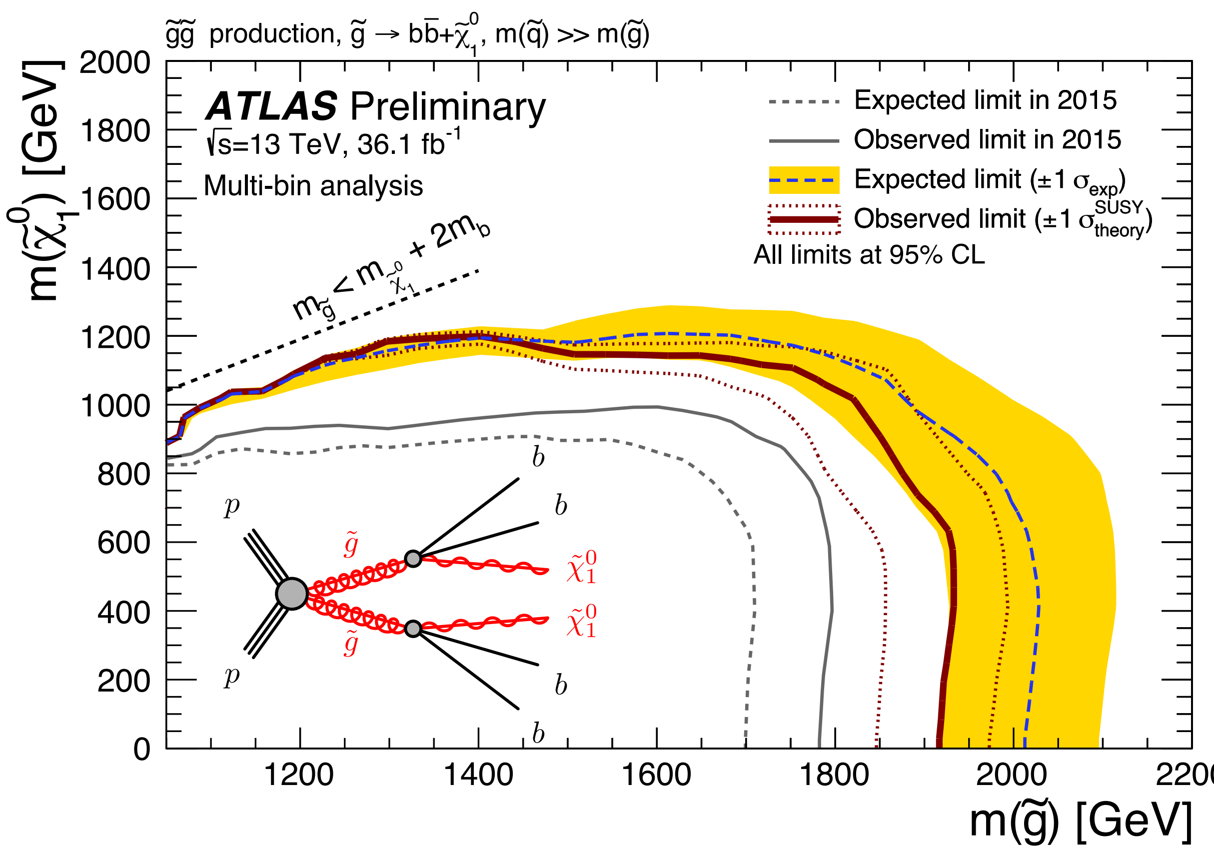
based on m_{eff}, N_{jets}, $N_{b\text{-}jets}$, $N_{leptons}$, m_T, E_T^{miss}



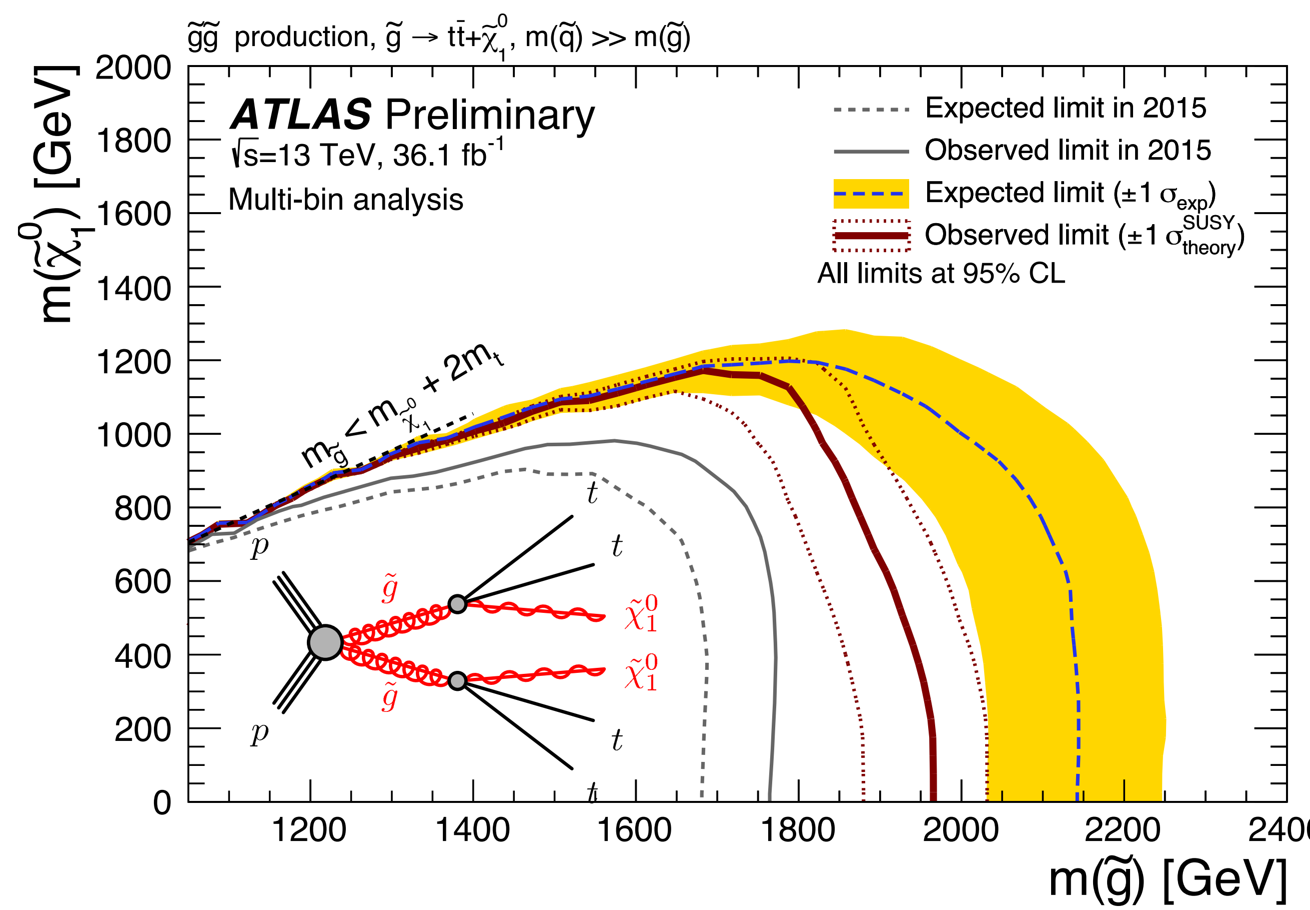
ATLAS GLUINO EXCLUSIONS

Gluino limits with 100 BR to specific SMS

exclude gluino at ~1.9 TeV



exclude squarks at ~1.95 TeV

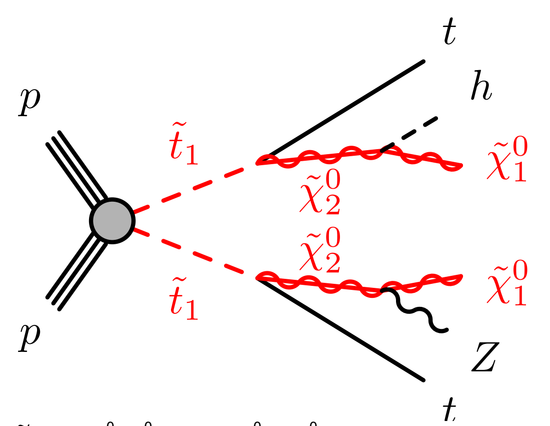


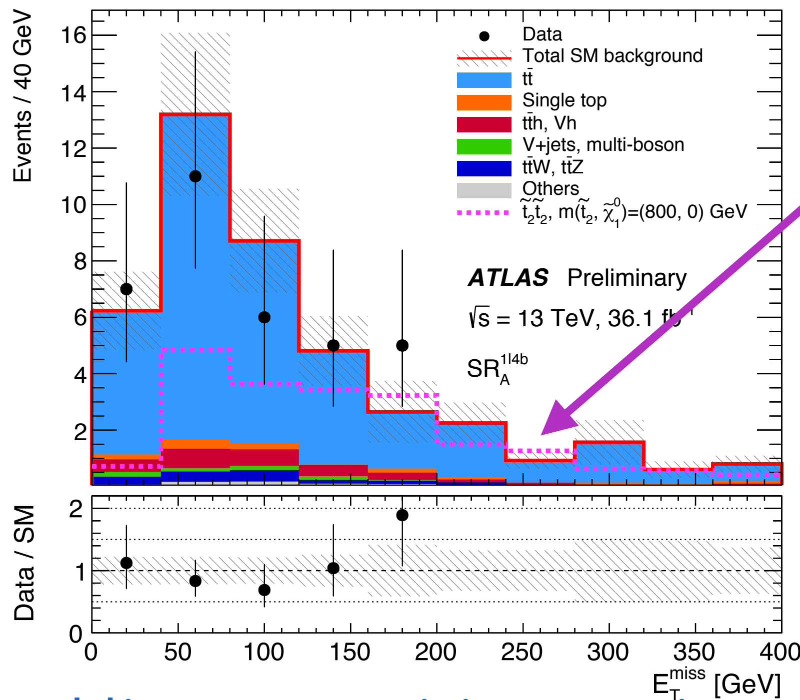
improvement wrt 2015 dataset (about 300/400 GeV on gluino mass)

allowing BR to float decreases the gluino exclusion to be as low as 1.5 TeV

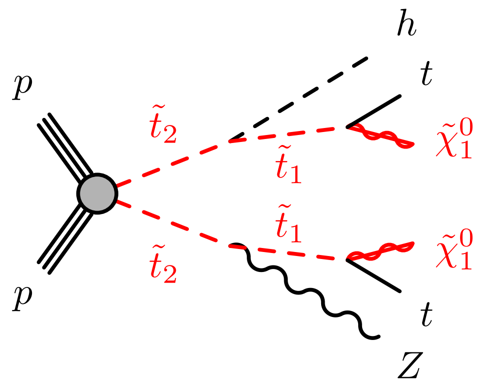
3leptons +bjet/ 1lepton+4b-jets

Higgs is a SM background, interesting to possibly see some Higgs enhancement

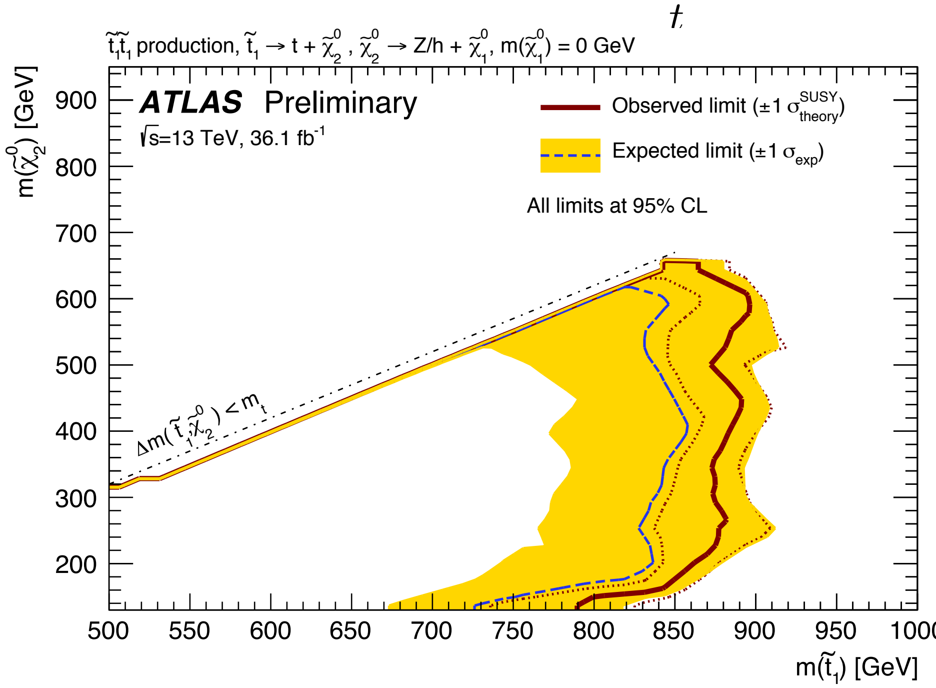




relatively low MET



Higgs sensitive region



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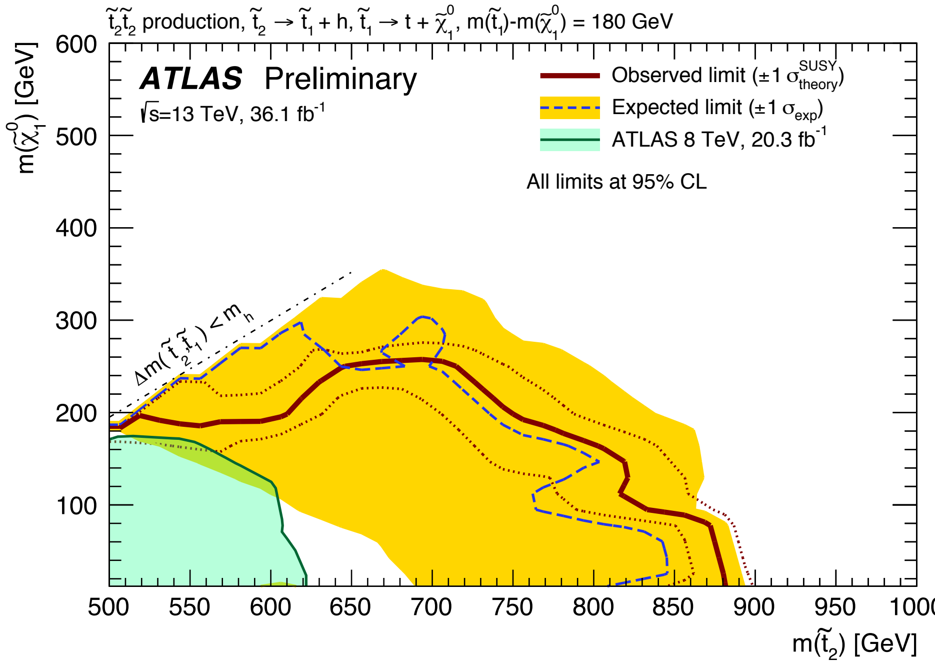
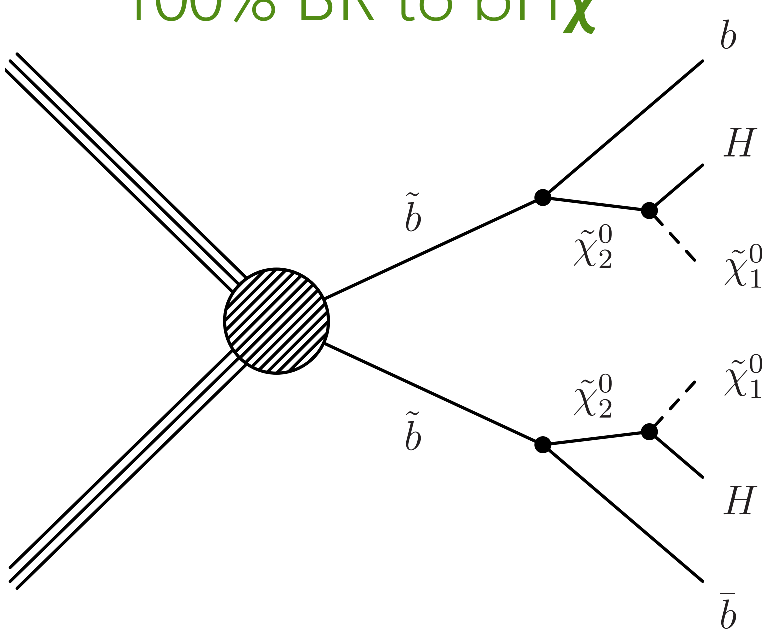


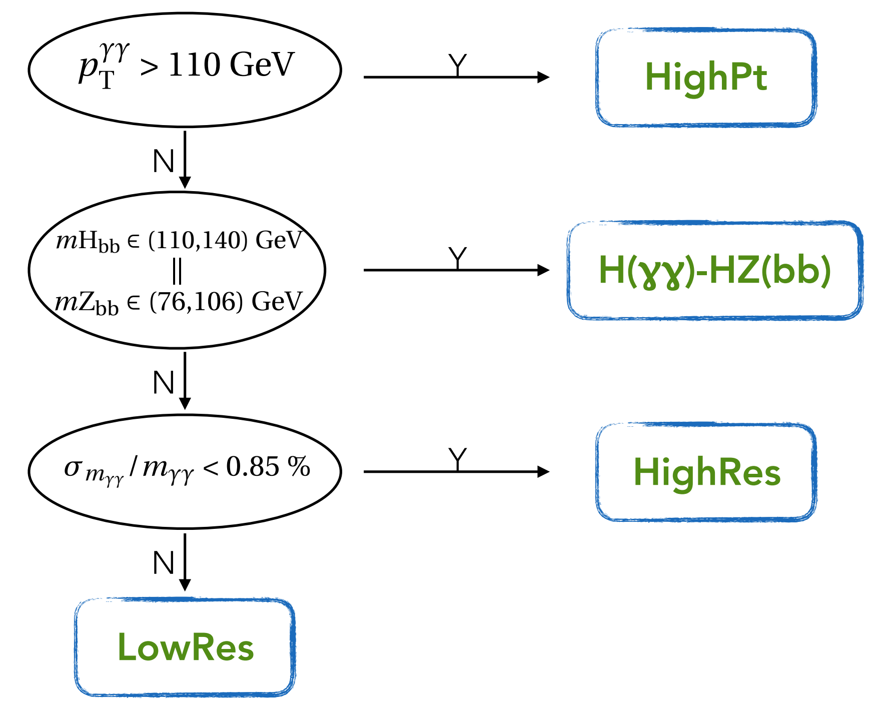
CMS SBOTTOM TO H+MET

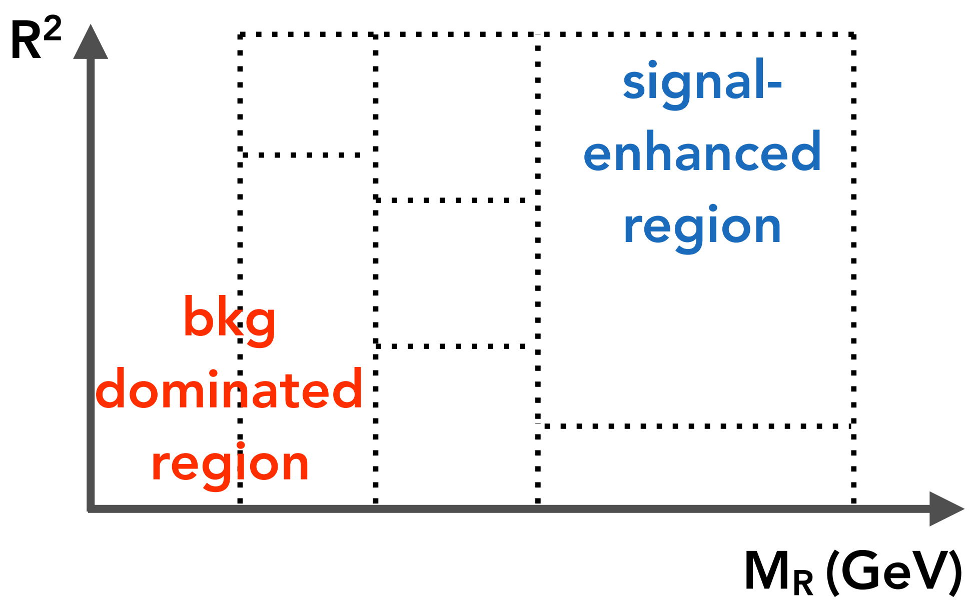
100% BR to bHχ



H→γγ + MET +Jets
razor variables

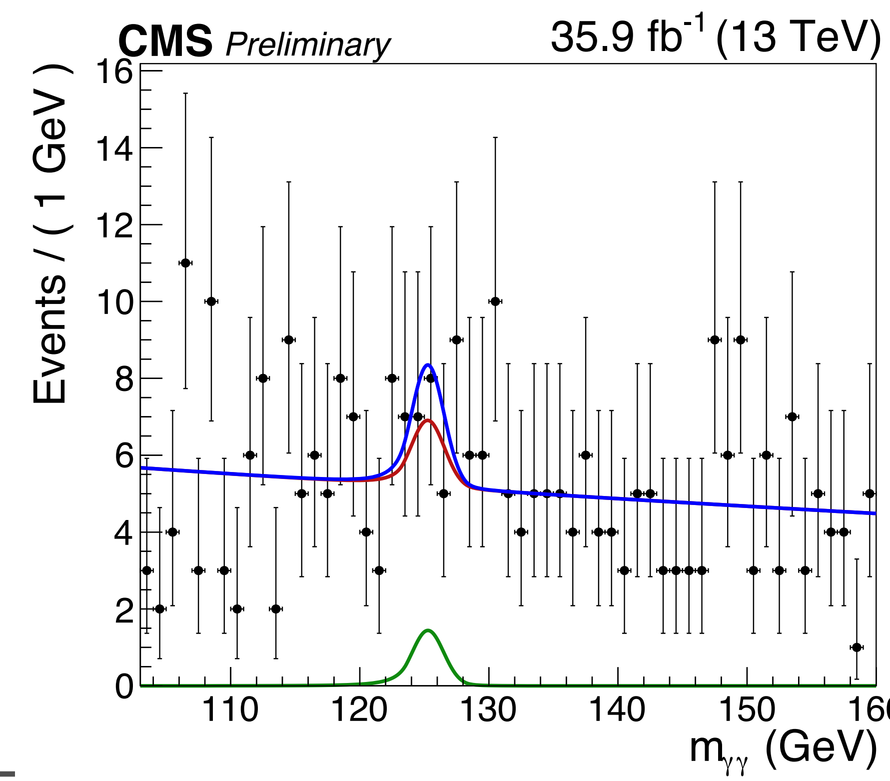
categorize events based in Higgs properties



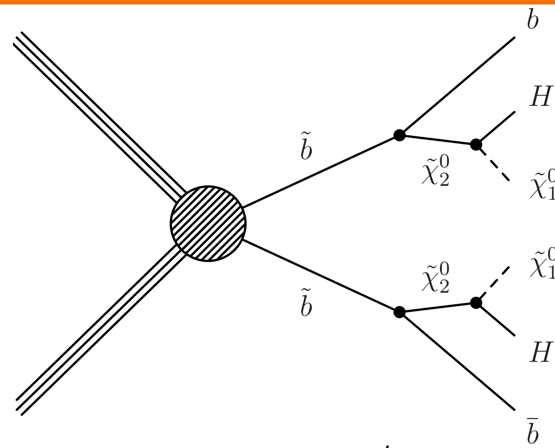


s+b fit in each bin

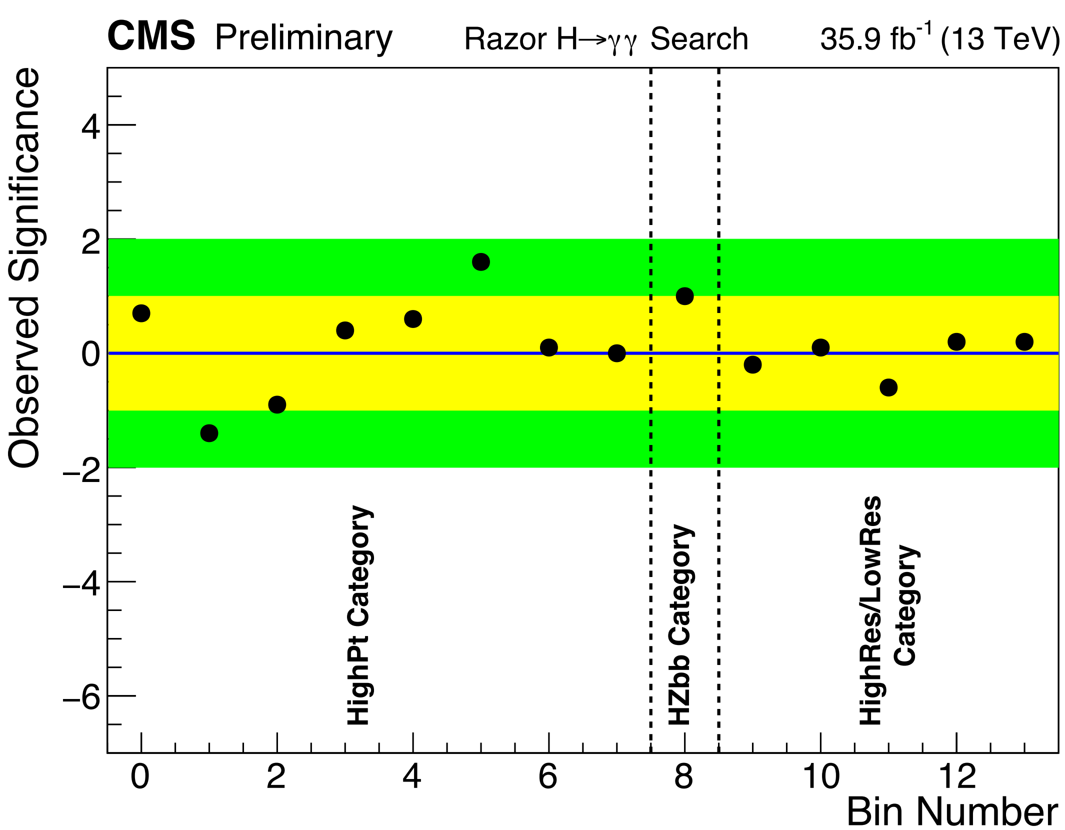
take into account Higgs bkg.

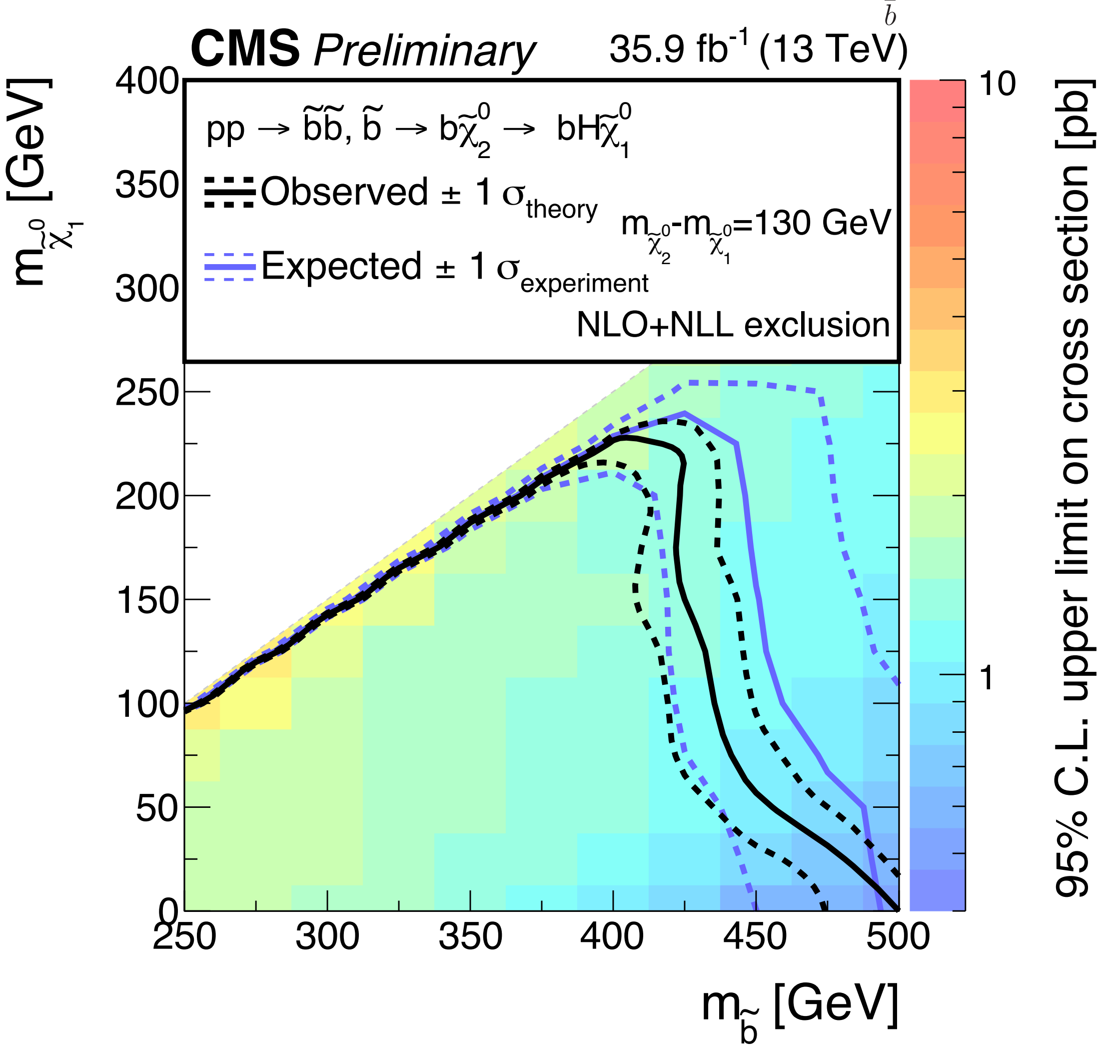


H→γγ + MET +Jets
razor variables



No significant deviations from SM expectation



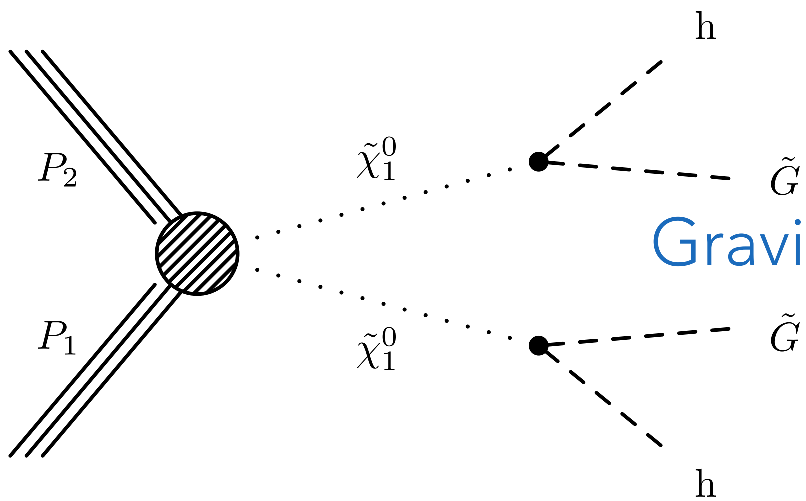


Exclude sbotom ~ 450 GeV

note: this analysis is also sensitive to EWKinos

HH→bbbb + MET

di-higgs production

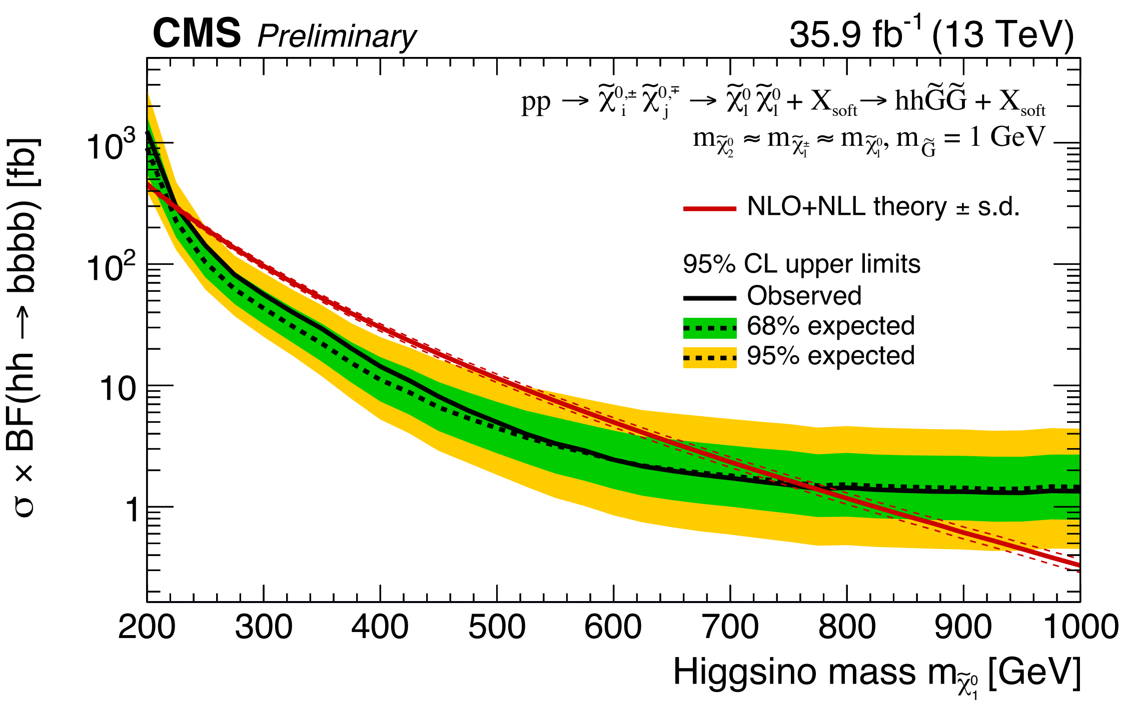


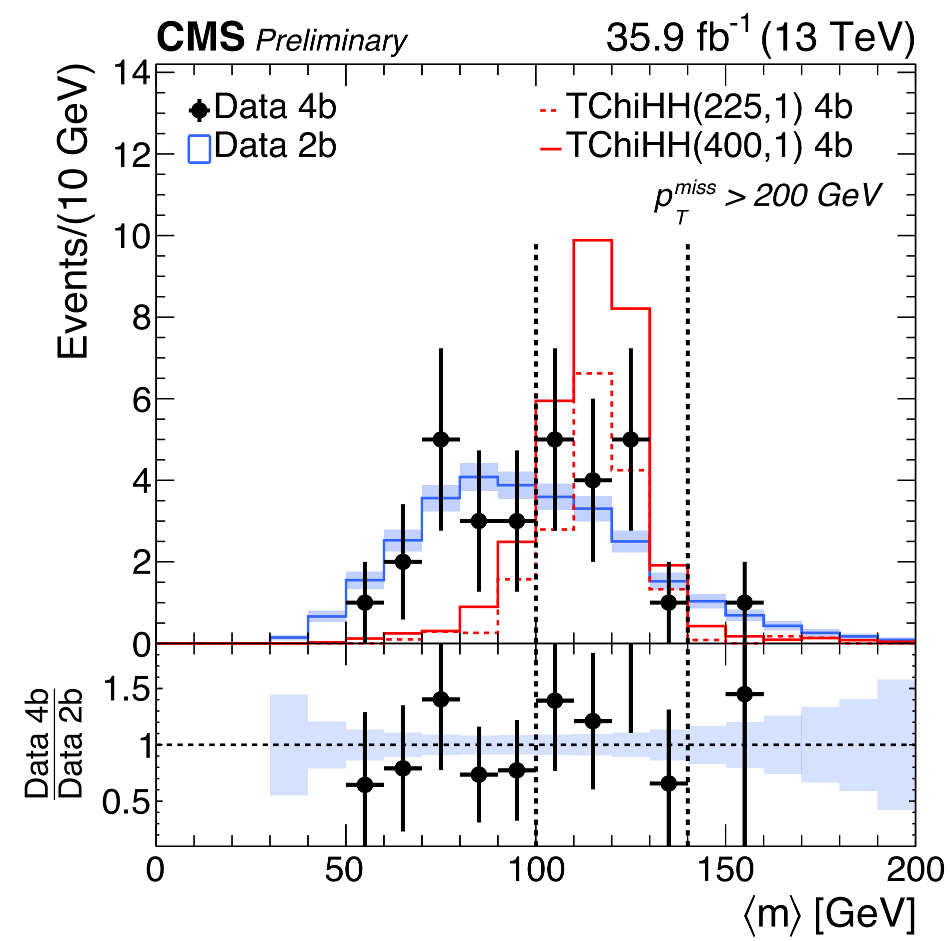
Gravitino LSP (1 GeV)

$$\Delta m \equiv |m_{H_1} - m_{H_2}|$$

keep configuration with smallest Δm

$$\langle m \rangle \equiv \frac{m_{H_1} + m_{H_2}}{2}.$$

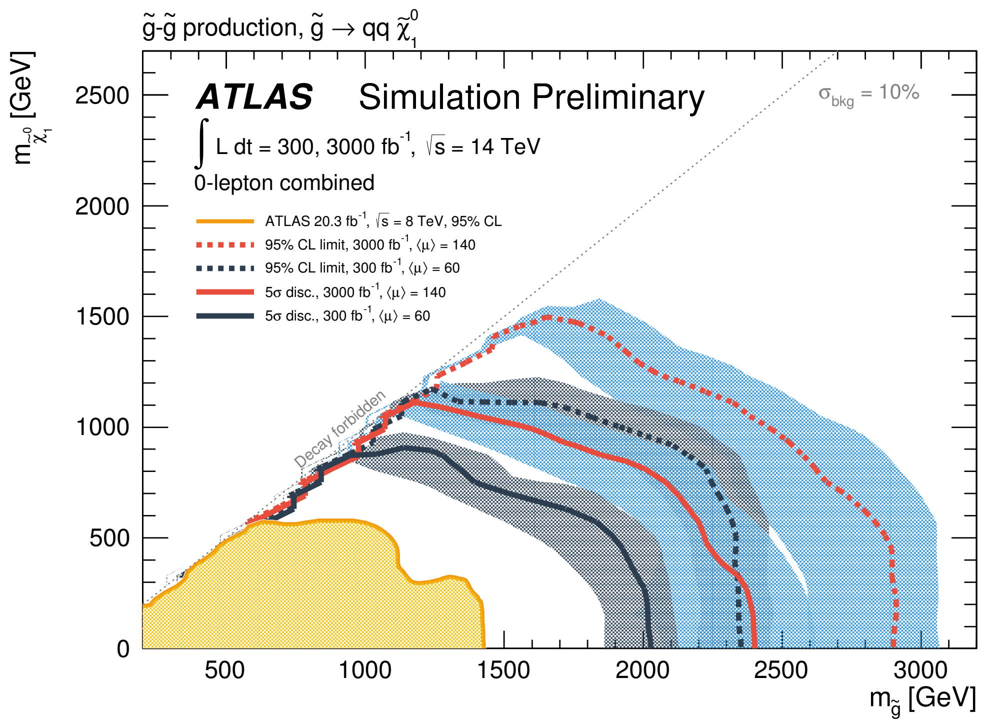




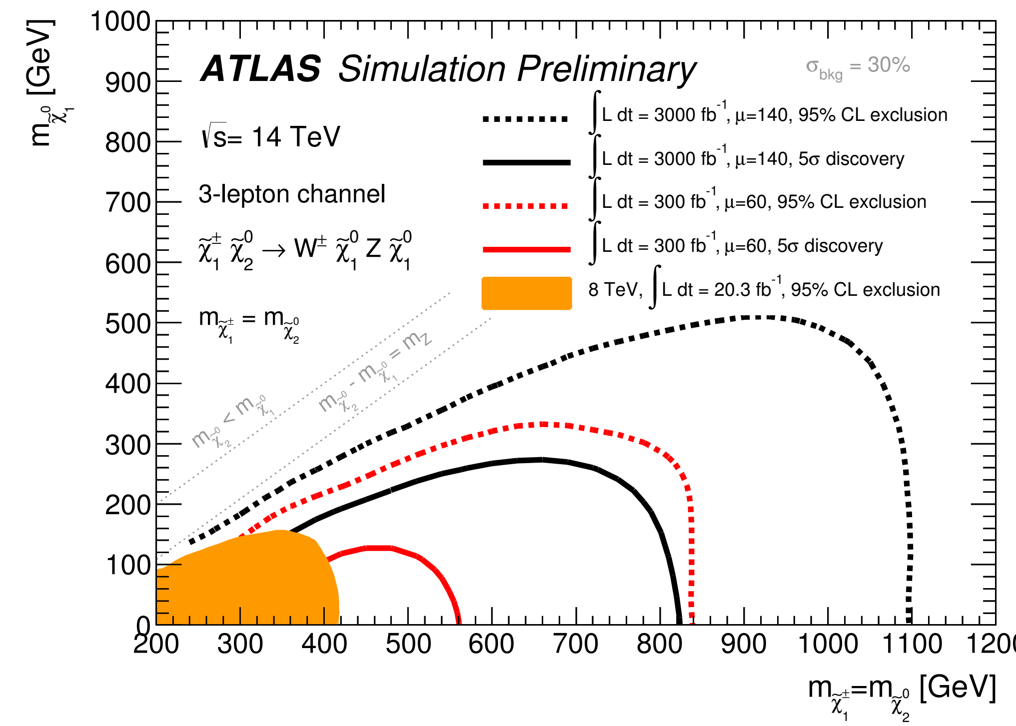
exclude higgsino mass ∋ [225,770] GeV

no excess over SM expectations

SUMMARY



similar picture from CMS



- Overviewed some of the newest SUSY results from ATLAS and CMS collaborations
- Have not observed deviations from SM in the "obvious" places
- Significant leap on exclusion limits compared to 2015; we now produce BR independent statements about limits
- We are expected to significantly gain in mass reach by using all the projected integrated luminosity. (Keep on going in the main road.)

SUMMARY

- Started by looking at the obvious places; gone the main road (gluinos, squarks, all hadronic)
- Now starting too look to the sides and to different roads (EWK SUSY, RPV, displaced topologies, out-of-time objects, disappearing tracks, etc)
- So don't be discouraged; we still have a lot of exciting ground to cover
- Stay tuned for possible updates on more exotic signatures

RJR SIGNAL REGIONS

Targeted signal	$\tilde{g}\tilde{g}, \tilde{g} \to q\tilde{\chi}_1^0$						
Requirement	Signal Region						
	RJR-S1		RJR-S2		RJR-S3		RJR-S4
$H_{1,1}^{PP}/H_{2,1}^{PP} \geq$	0.55		0.5		0.45		-
$H_{1,1}^{PP}/H_{2,1}^{PP} \leq$	0.9		0.95		0.98		-
$p_{Tj2}^{PP}/H_{T\,2,1}^{PP} \geq$	0.16		0.14		0.13		0.13
$\lvert\eta_{j1,j2}\rvert \leq$	0.8		1.1		1.4		2.8
$\Delta_{QCD} \geq$	0.1		0.05		0.025		0
$p_{PP,\,T}^{lab}/\left(p_{PP,\,T}^{lab} + H_{T\,2,1}^{PP}\right) \leq$	0.08						
	RJR-S1a	RJR-S1b	RJR-S2a	RJR-S2b	RJR-S3a	RJR-S3b	RJR-S4
$H_{T\,2,1}^{PP}$ [GeV] $>$	1000	1200	1400	1600	1800	2100	2400
$H_{1,1}^{PP}$ [GeV] $>$	800	1000	1200	1400	1700	1900	2100

Targeted signal	$\tilde{g}\tilde{g}, \tilde{g} \to q\bar{q}\tilde{\chi}_1^0$						
Requirement	Signal Region						
	RJR-G1		RJR-G2		RJR-G3		RJR-G4
$H_{1,1}^{PP}/H_{4,1}^{PP} \geq$	0.45		0.3		0.2		-
$H_{T\,4,1}^{PP}/H_{4,1}^{PP} \geq$	0.7		0.7		0.65		0.65
$\min\left(p_{Tj2i}^{PP}/H_{T\,2,1\,i}^{PP}\right) \geq$	0.12		0.1		0.08		0.07
$\max\left(H_{1,\,0}^{Pi}/H_{2,\,0}^{Pi}\right) \leq$	0.96		0.97		0.98		0.98
$\lvert\eta_{j1,2,a,b}\rvert \leq$	1.4		2.0		2.4		2.8
$\Delta_{QCD} \geq$	0.05		0.025		0		0
$p_{z,\,PP}^{lab}/\left(p_{z,\,PP}^{lab} + H_{T\,4,1}^{PP}\right) \leq$	0.5		0.55		0.6		0.65
$p_{PP,\,T}^{lab}/\left(p_{PP,\,T}^{lab} + H_{T\,4,1}^{PP}\right) \leq$	0.08						
	RJR-G1a	RJR-G1b	RJR-G2a	RJR-G2b	RJR-G3a	RJR-G3b	RJR-G4
$H_{T\,4,1}^{PP}$ [GeV] $>$	1200	1400	1600	2000	2400	2800	3000
$H_{1,1}^{PP}$ [GeV] $>$	700		800		900		1000

Targeted signal	compressed spectra in $\tilde{g}\tilde{g}$ ($\tilde{g} \to q\tilde{\chi}_1^0$); $\tilde{g}\tilde{g}$ ($\tilde{g} \to q\bar{q}\tilde{\chi}_1^0$)				
Requirement	Signal Region				
	RJR-C1	RJR-C2	RJR-C3	RJR-C4	RJR-C5
$R_{ISR} \geq$	0.95	0.9	0.8	0.7	0.7
p_{TS}^{CM} [GeV] $\geq$	1000	1000	800	700	700
$\Delta\phi_{ISR,\,I}/\pi \geq$	0.95	0.97	0.98	0.95	0.95
$\Delta\phi(\text{jet}_{1,2}, \vec{E}_T^{miss})_{min} >$	-	-	-	0.4	0.4
M_{TS} [GeV] $\geq$	–	100	200	450	450
$N_{jet}^{V} \geq$	1	1	2	2	3
$\lvert\eta_{jV}\rvert \leq$	2.8	1.2	1.4	1.4	1.4