Inclusive SUSY Particle Searches with Jets and E_T^{miss} in ATLAS

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on behalf of the ATLAS collaboration

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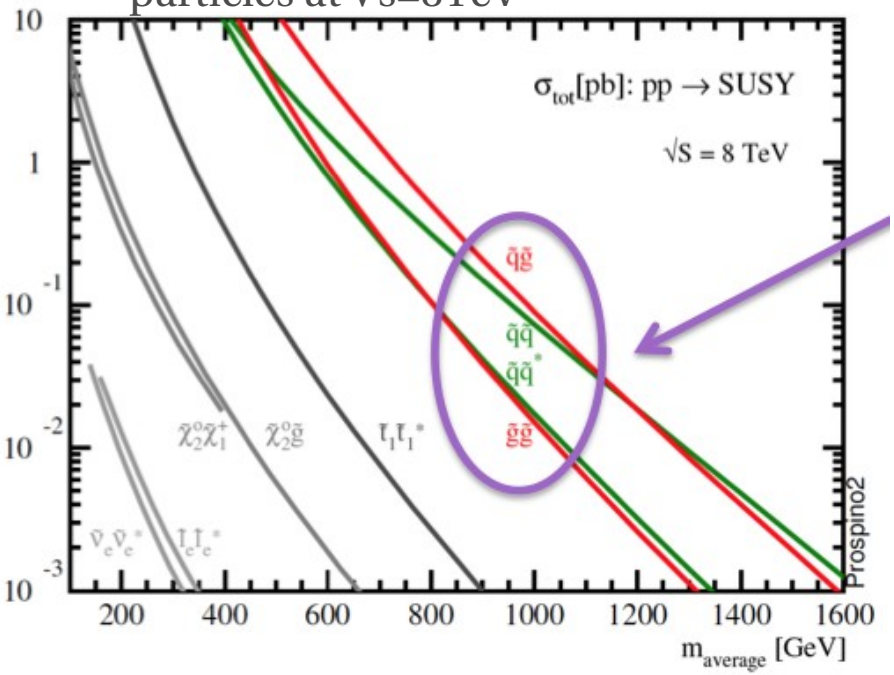
Physics motivation

NLO cross-sections for production of SUSY particles at √s=8TeV



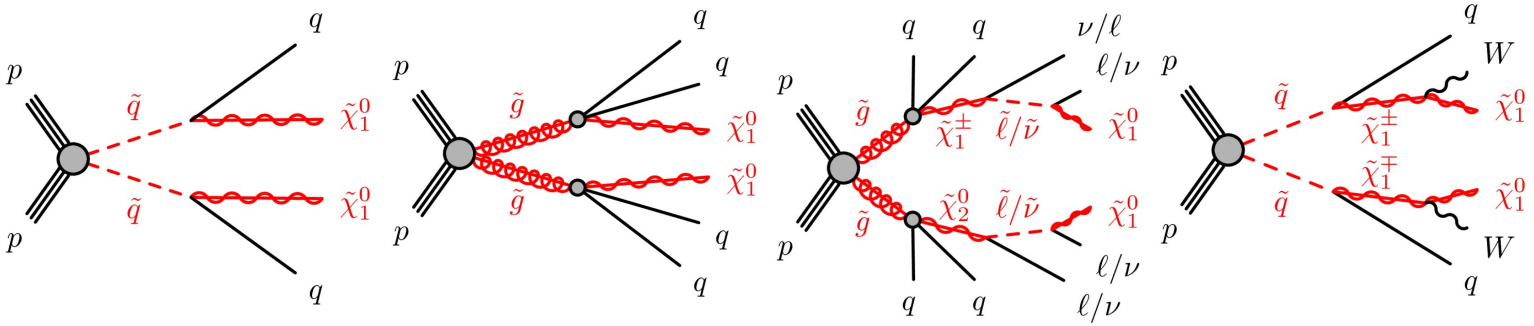
gluino and squark searches strongly motivated at LHC due to their high cross-sections

- Mainly SUSY R-parity conserving scenarios (LSP stable ==> missing Et (MET)) covered by this talk
- Many possible sparticle decays ==> necessary to explore many final state signatures in order increase sensitivity to various models
- This talk focuses on signatures with jets + MET with or without leptons

Covered analyses

0 lepton + 2-6 jets + MET	arXiv:1405.7875
0 lepton + 7-10 jets +MET	arXiv:1308.1841 (JHEP 10 (2013) 130)
1-2 lepton + jets + MET	ATLAS-CONF-2013-062
2 lepton razor	ATLAS-CONF-2013-89
2 SS leptons/3 leptons	arXiv:1404.2500 (JHEP 06 (2014) 035)
taus + jets + MET	arXiv:1407.0603

- All based on full 8TeV data sample (L≈20 fb^{-1})
- Interpretations provided in terms of:
  - Complete SUSY models - mSUGRA/CMSSM, GGM (general gauge mediation), GMSB, mUED, ...
  - Simplified models - various production processes (assuming 100% BRs to a given decay chain)



and many more...

Search strategy

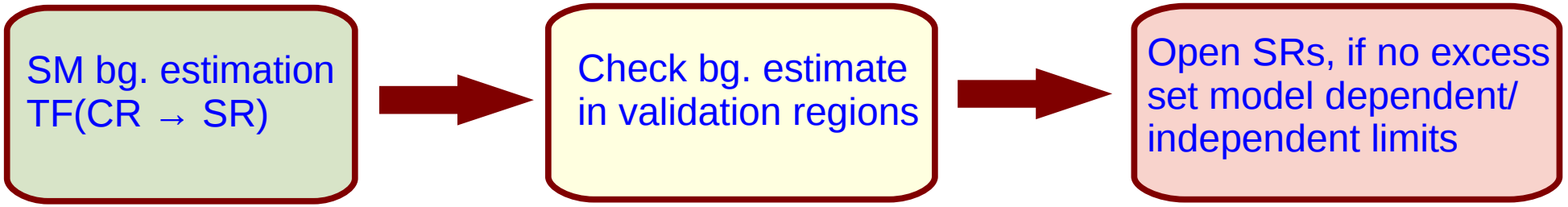
- What's important:

1) discriminating variables which disentangle signal/background (Signal regions SR):

$$m_{\mathrm{eff}}^{\mathrm{inc}} = \sum_{i=1}^{\mathrm{N}_\ell} p_{\mathrm{T,i}}^{\ell} + \sum_{j=1}^{\mathrm{N_{jet}}} p_{\mathrm{T,j}} + E_{\mathrm{T}}^{\mathrm{miss}} \qquad m_{\mathrm{T}} = \sqrt{2 p_{\mathrm{T}}^{\ell} E_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos(\Delta\phi(\vec{\ell}, \boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}})))}$$

2) having SM background (ttbar, W/Z boson, QCD, diboson) under control (dedicated control regions CR kinematically close to SRs)

- Background estimation:
  done via transfer factors TF (CR → SR) (sys. errors reduced)
  - semi data-driven: relies on the MC shape, but likelihood fit performed simultanously in all CRs in order to obtain normalization of all background components
  - fully data-driven: jet-smearing (multijet background), matrix method for fakes (leptons, photons, b-jets)



0 lepton + 2-6 jets + MET

NEW!

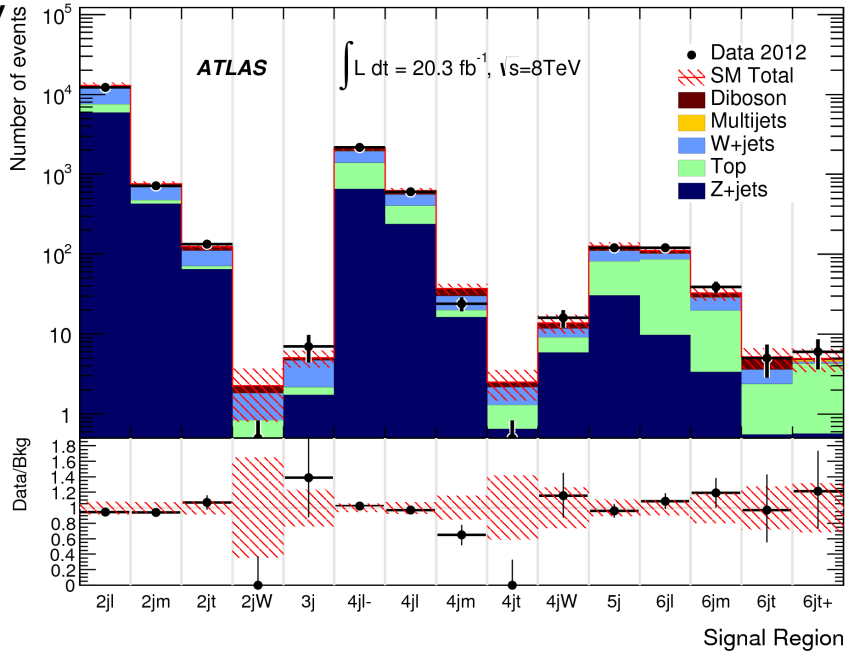
- **Target signals:** strong production of first and second generation squarks and gluinos
- "workhorse" SUSY analysis – quite universal in its reach

Signal regions:

- defined with inclusive jet multiplicity bins (e, μ veto)
- loose, medium and tight cuts on m_{eff}(incl), MET/m_{eff} or MET/$\sqrt{H_T}$
- 2 SRs with 2 tagged boosted Ws introduced in order to improve sensitivity for models with chargino in decay chain

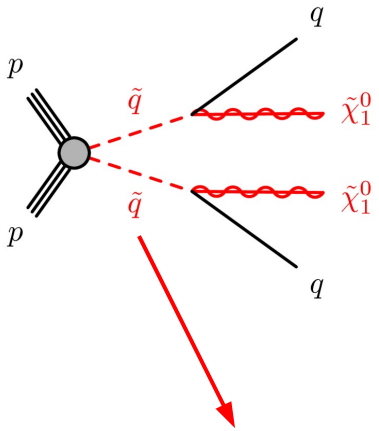
- Low jet multiplicity channels dominated by W/Z+jet background, high jet multiplicities by top production
- Multijet background estimated via fully data-driven jet smearing method,
Z, W, top background constrained via CRs

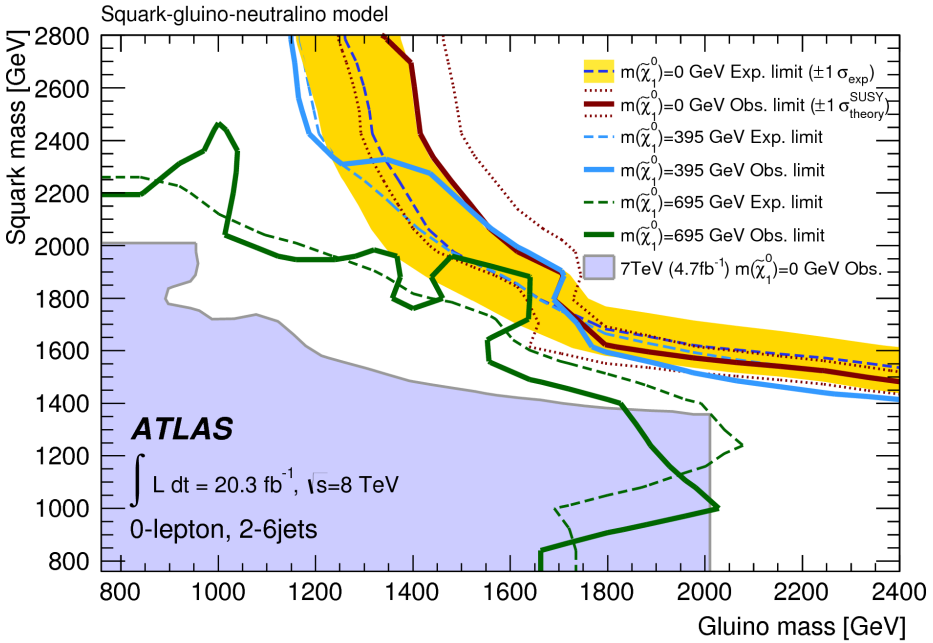
Observed and expected event yields as function of SR

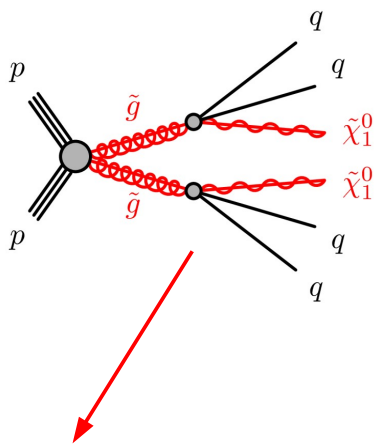


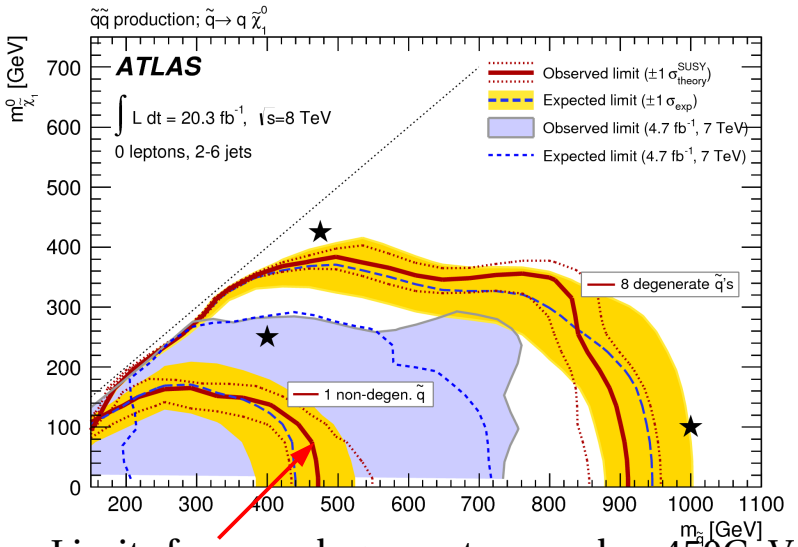
0 lepton + 2-6 jets + MET

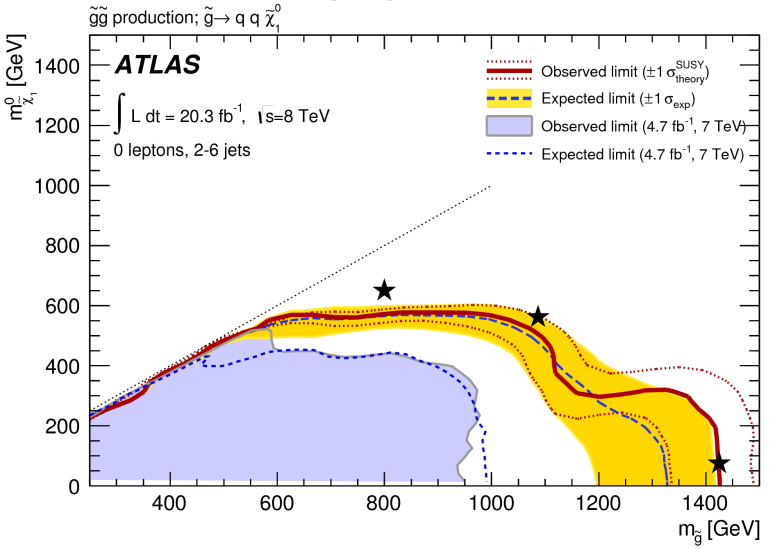
- Grids with direct sparticle decays: squark → q+LSP, gluino → qq+LSP
(dominant channels: 2-jet direct squark-squark, 4-jet direct gluino-gluino)







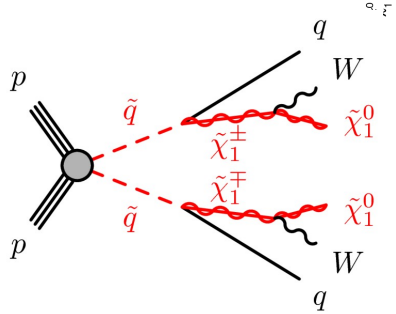


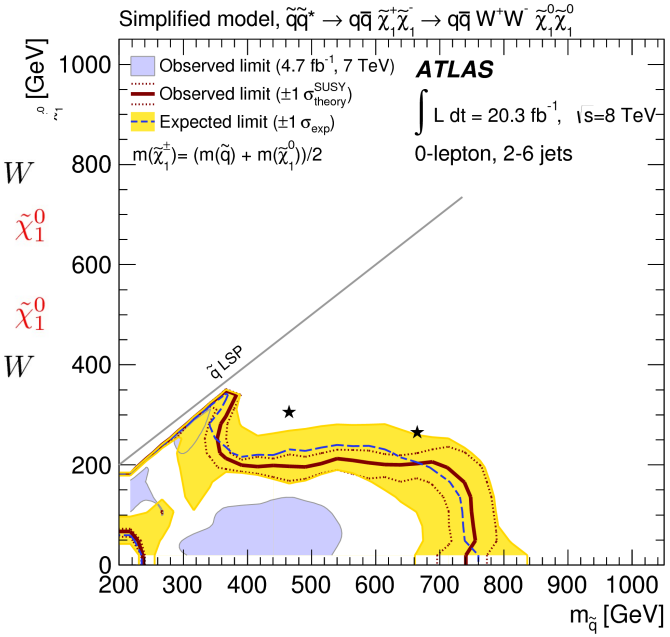


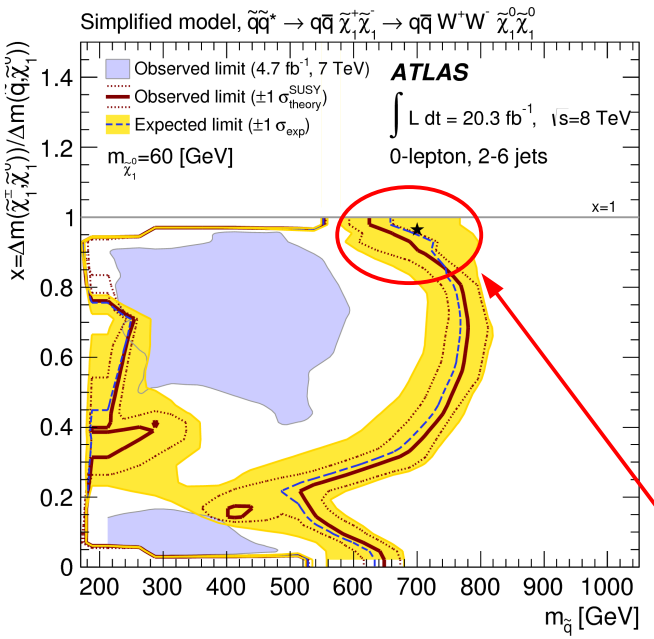
Limits for non-degenerate squarks ~450GeV

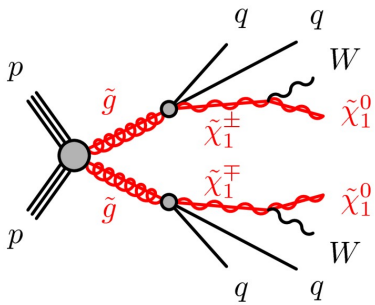
0 lepton + 2-6 jets + MET

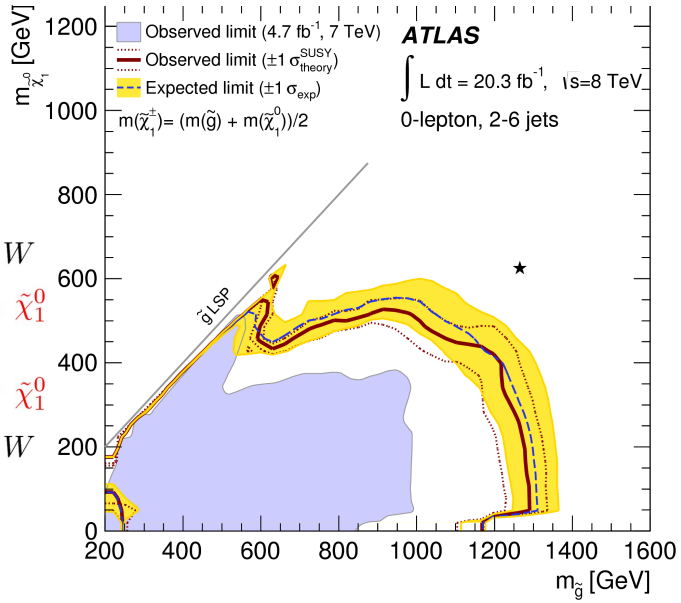
- Simplified squark-squark and gluino-gluino grids with one-step decays via chargino: (dominant channels: 5-jet and 6-jet)

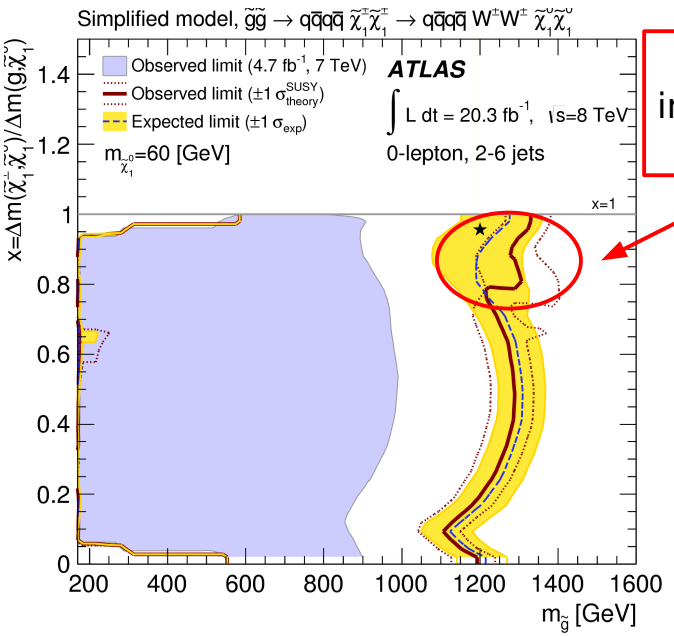












Boosted W regions improve limits at x → 1

0 lepton + 7-10 jets + MET & 2 same sign and 3 lepton + MET

- **Target signals for both analyses:** models with sparticles decaying via long chains (eg: gluino → stop, gluino → squark followed by chargino or chargino & neutralino2)

- **0 lepton multijet SRs:**
  - multijet + flavour stream (0,1,2 b-jets)
  - multijet + M_J^{Σ} stream (R=0.4 jets reclustered into R=1.0 jets, and cuts on fat jet mass applied to isolate signal $M_J^{\Sigma} = \Sigma m_j^{R=1}$)

7j	8j	9j	10j	8j	9j	10j
0, 1 or 2>= 2 b-jets				M_J^{Σ}>340, >420 GeV		
$MET/\sqrt{H_T}$>4 $\sqrt{}$ GeV						

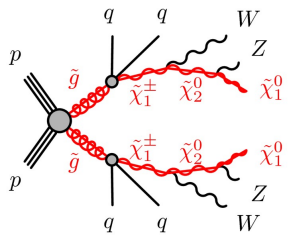
- **2 lepton SS & 3 lepton SRs:**
  - very clean channels with only tiny SM background (mainly top+V, diboson and triboson production)
  - Data driven estimates of fake lepton and charge flip backgrounds

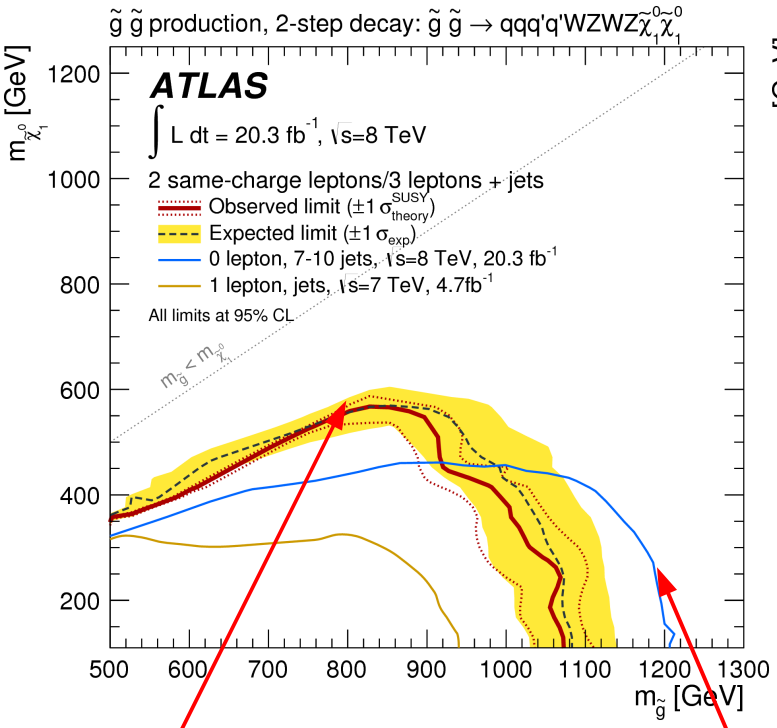
	SR0b	SR1b	SR3b	SR3L low	SR3L high
lepton	SS	SS	SS or 3L	3L	3L
MET [GeV]	>150	>150	---	[50,150	>150
N(b-jet)	0	>=1	>=3	---	---
m_{eff} [GeV]	>400	>700	>350	>400	>400

SRs with b-jets used for 3rd generation searches - see Maria Fiascaris presentation in SUSY phenomenology session.

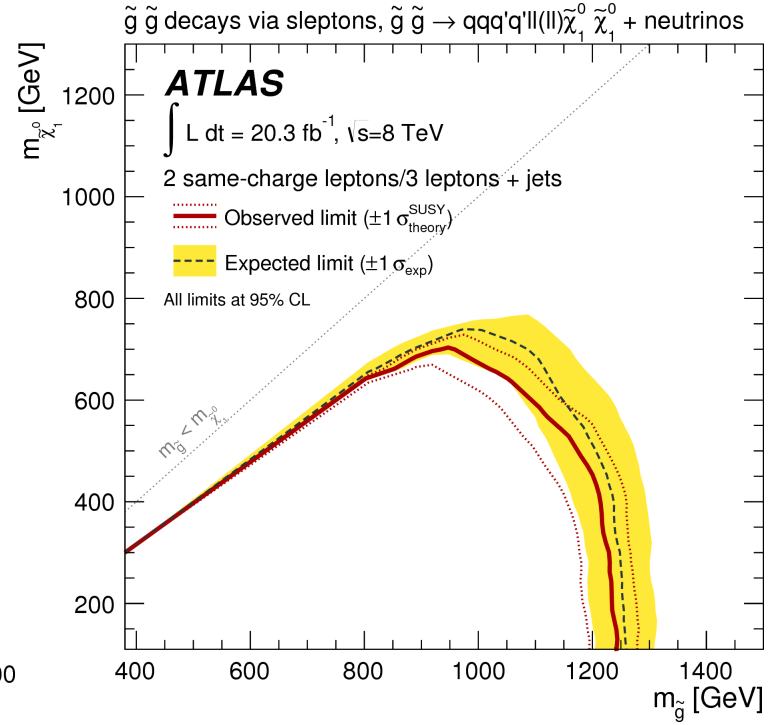
0 lepton + 7-10 jets +MET & 2 same sign and 3 lepton +MET

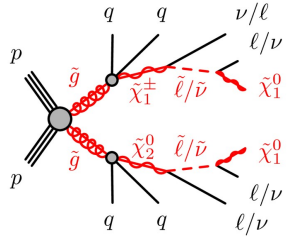
Gluino two-step





Gluino two-step via sleptons



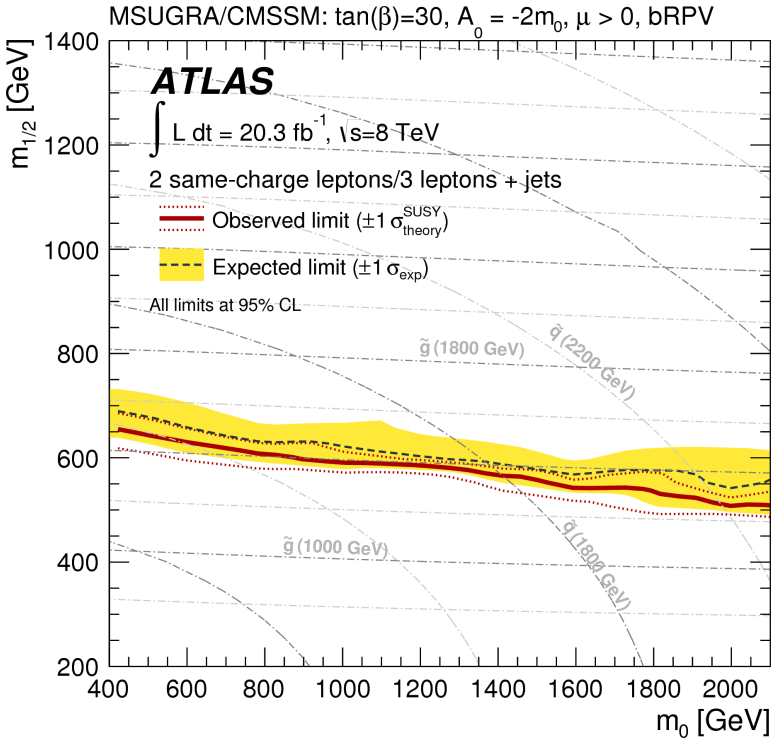


2SS lepton and 3 lepton analysis better in compressed region

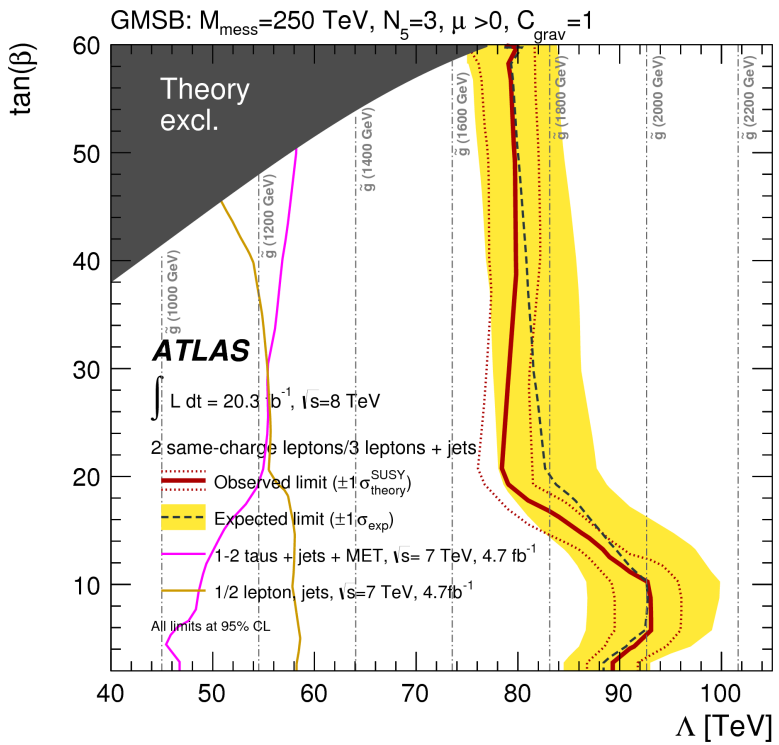
0 lepton multijet analysis better at high gluino mass

2 same sign or 3 leptons + MET

bRPV
(mSUGRA with bilinear R-parity violating terms)



GMSB
(with sleptons as NLSPs and gravitino as LSP)

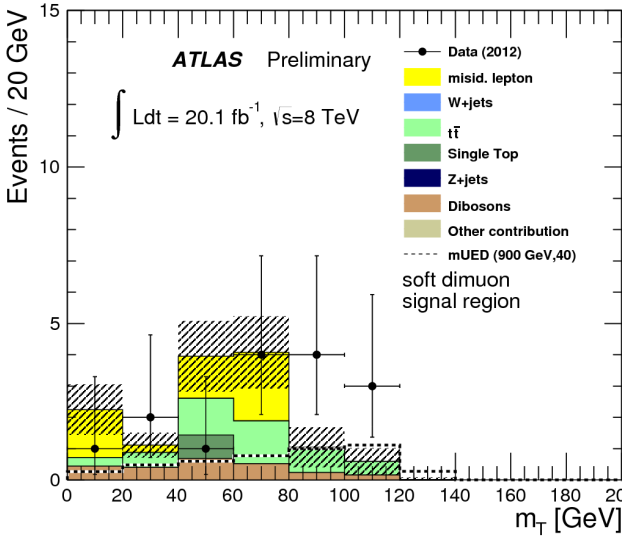


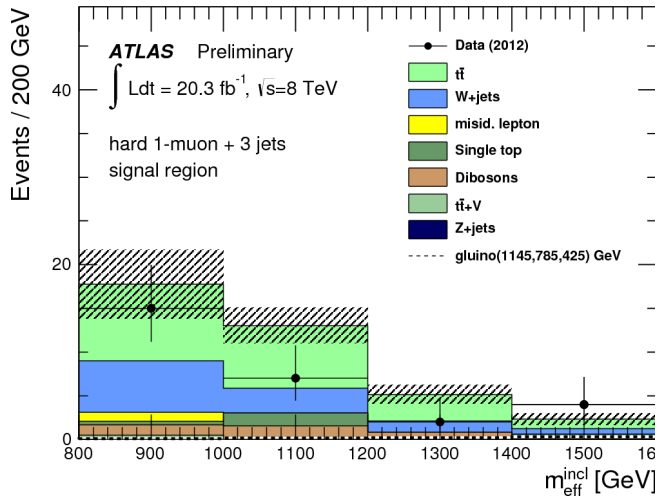
1-2 leptons + 3-6 jets + MET

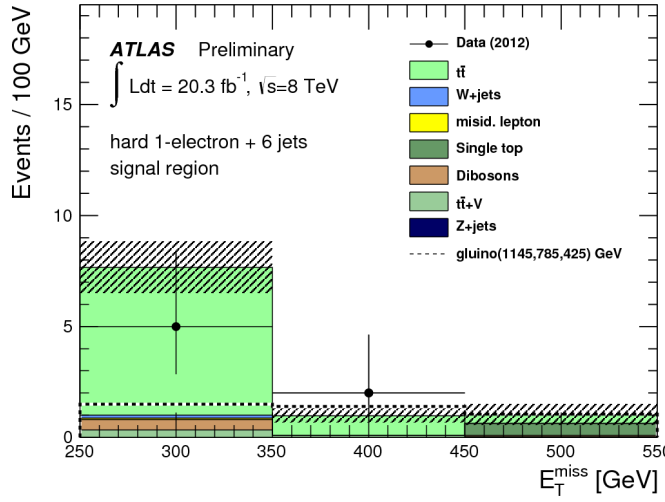
- **Target signals:** simplified squark/gluino production models with decay chains containing leptons from chargino or neutralino decays

	Soft single lepton		Soft di-muon	Hard single lepton		
Lepton pt	e or μ Pt<25GeV		μ Pt<25GeV	e or μ Pt>25 GeV		
N jet	3 jet	5 jet	2 jet	3 jet	5 jet	6 jet
MET [GeV]	>400	>200	>170	>500	>300	>350
m_T [GeV]	>100		>80	>150	>200	>150

- Soft lepton channels designed to cover compressed mass scenarios (SUSY, mUED)
- W and top background constraint via CRs, fake leptons via matrix method

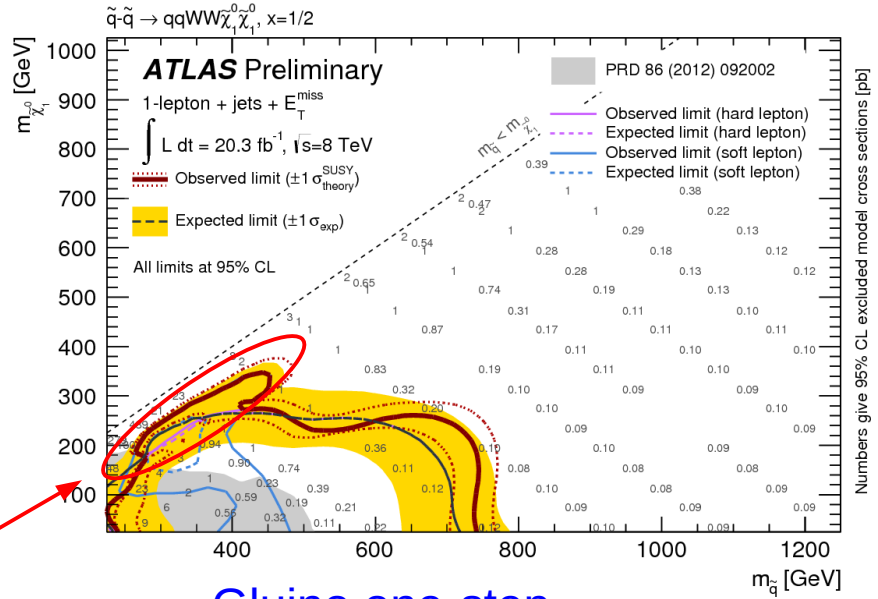




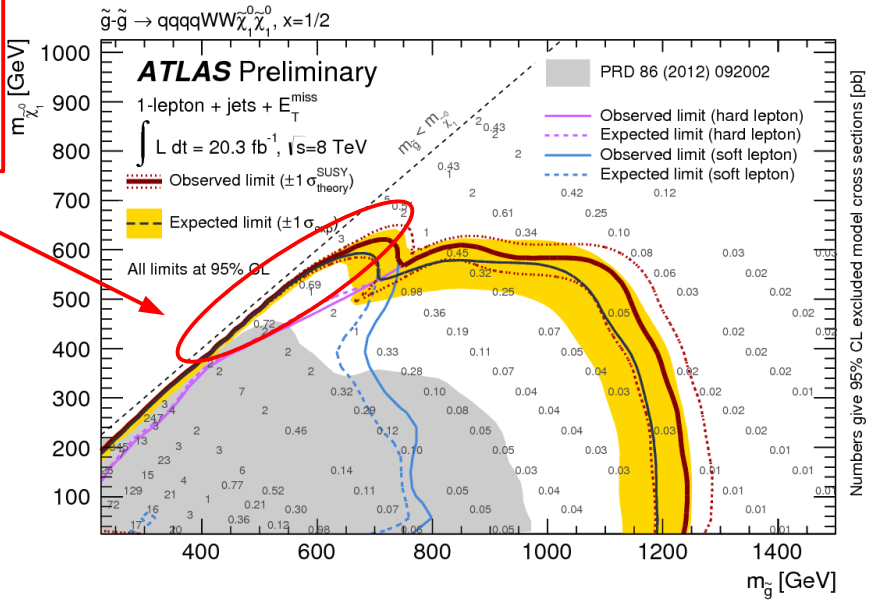


1-2 leptons + 3-6 jets + MET

Squark one-step



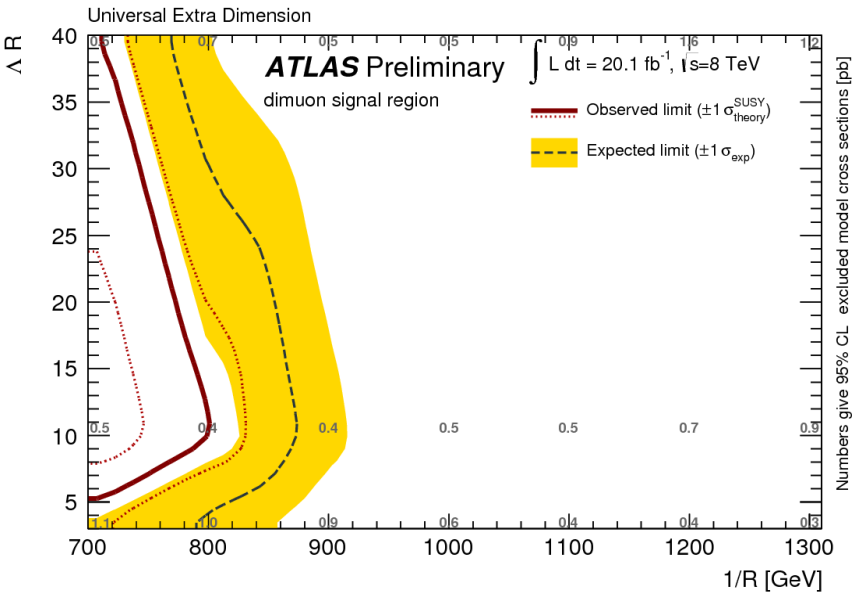
Gluino one-step



Compressed region improved by soft lepton channels

mUED

(universal extra dimension model similar to compressed SUSY models)



2 lepton razor

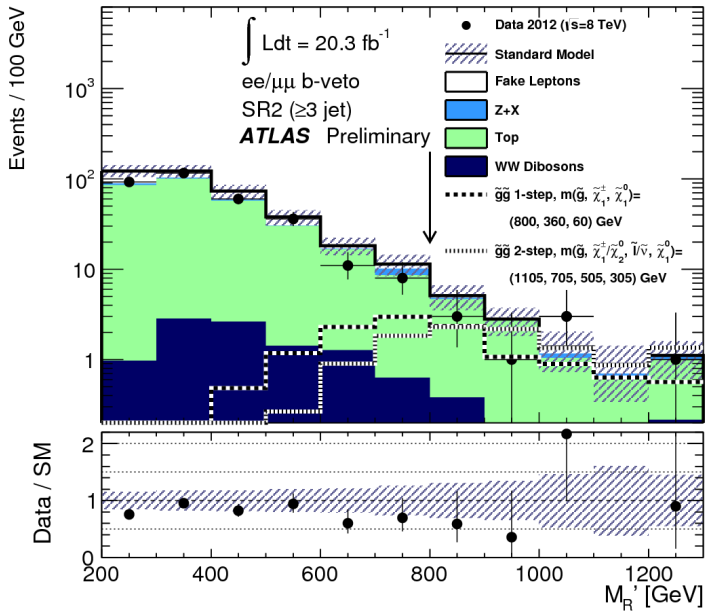
- **Target signals:** strong production simplified models, direct sbottom production
- Exploits transverse and longitudinal event information (razor variable $R=M^R_T/M'_R$):

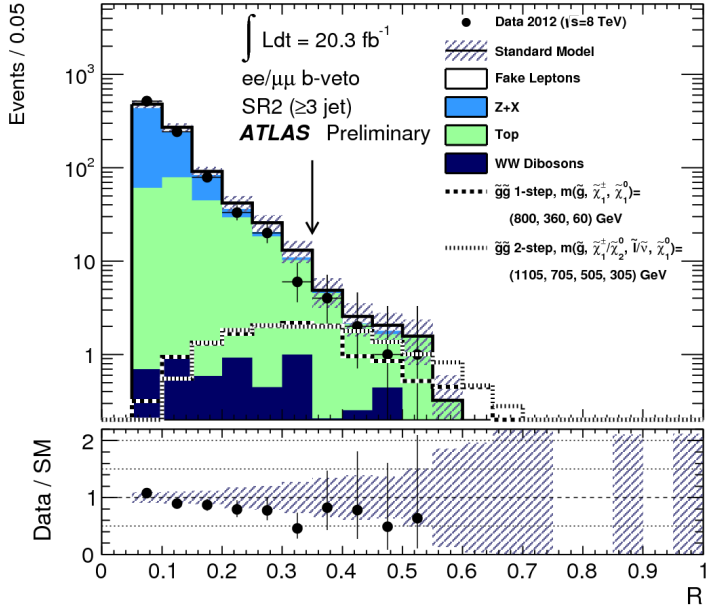
	SR1		SR2	
leptons	eμ	ee/μμ	eμ	ee/μμ
M'_R [GeV]	>400		>800	
R	>0.5		>0.35	
N(jet)	<3		>=3	

$$M'_R = \sqrt{(j_{1,E} + j_{2,E})^2 - (j_{1,L} + j_{2,L})^2}$$

← Measures how longitudinally splitted the events are

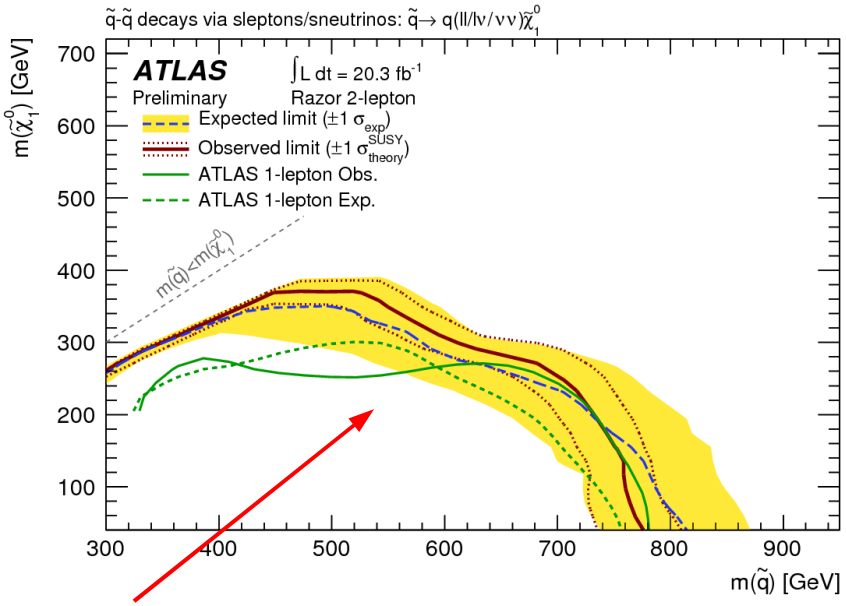
$$M_T^R = \sqrt{\frac{|\vec{E}_{\mathrm{T}}^{\mathrm{miss}}|(|\vec{j}_{1,\mathrm{T}}| + |\vec{j}_{2,\mathrm{T}}|) - \vec{E}_{\mathrm{T}}^{\mathrm{miss}} \cdot (\vec{j}_{1,\mathrm{T}} + \vec{j}_{2,\mathrm{T}})}{2}}$$



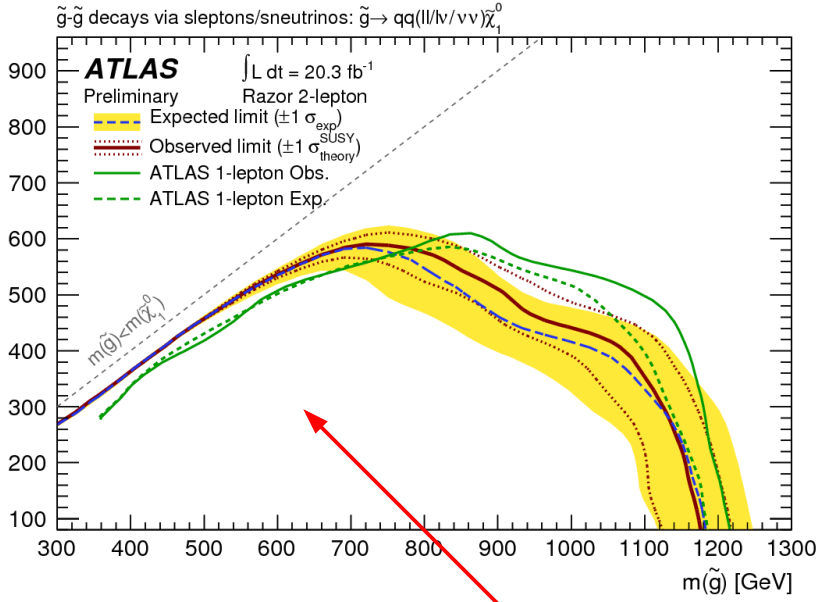


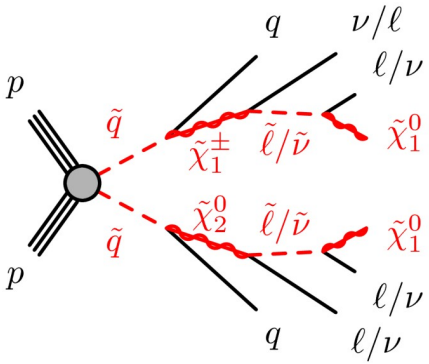
2 lepton razor

Squark two-step via sleptons

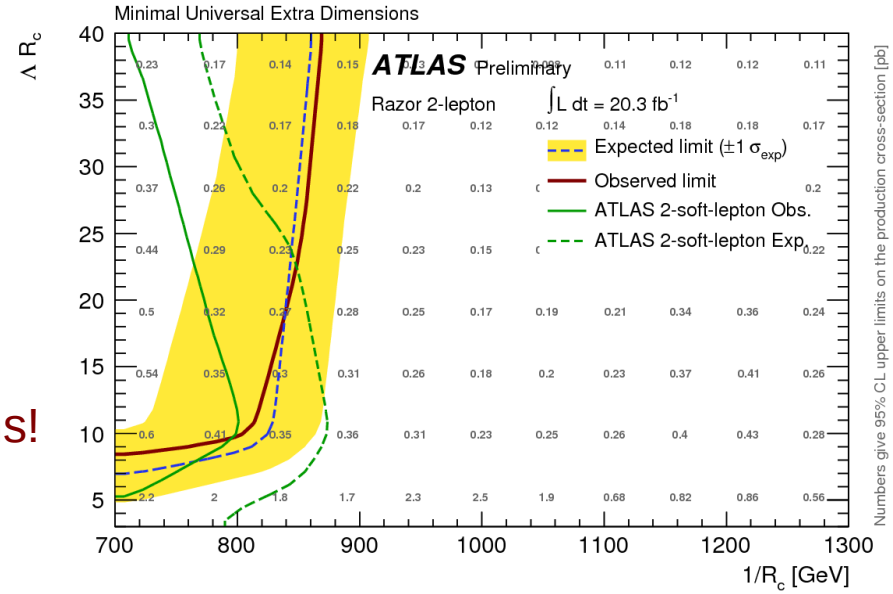


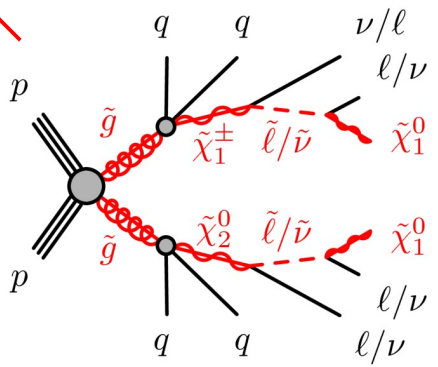
Gluino two-step via sleptons





mUED

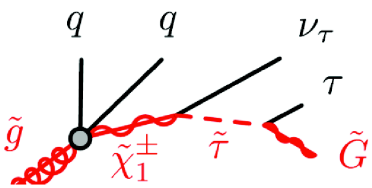


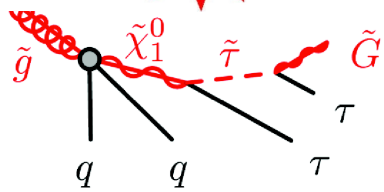


Razor analysis particularly strong in compressed regions!

taus + jets + MET

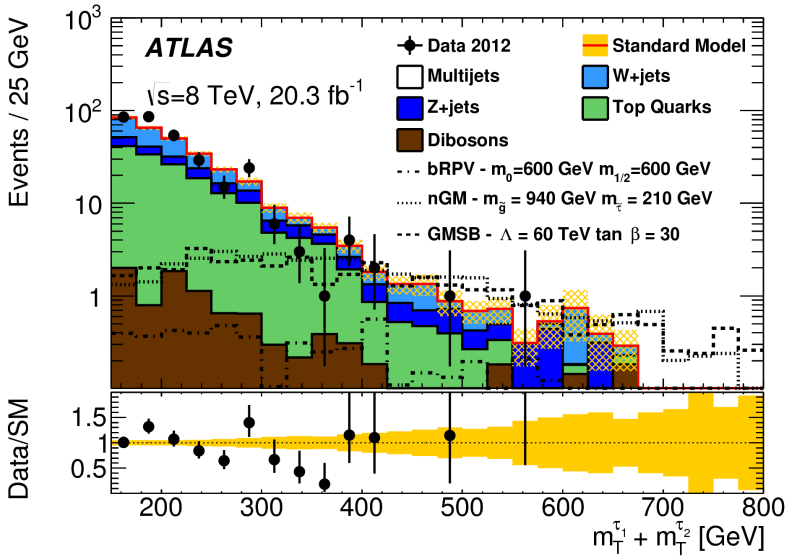
- **Target signals:** GMSB, natural gauge mediated nGM model (tuned version of GGM to avoid fine tuning in Higgs sector) with stau as NLSP

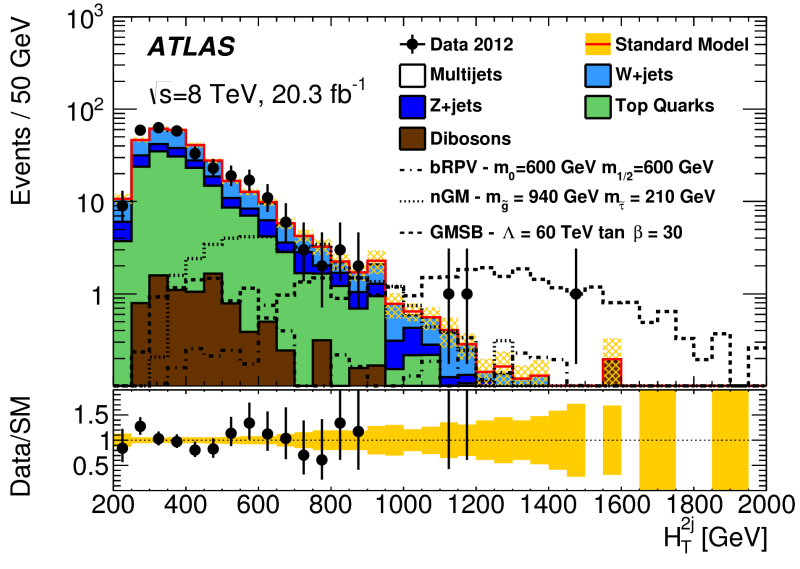




- Hadronically decaying taus (with veto on e/μ in pure τ-channels)
- Data driven estimate of fake taus events

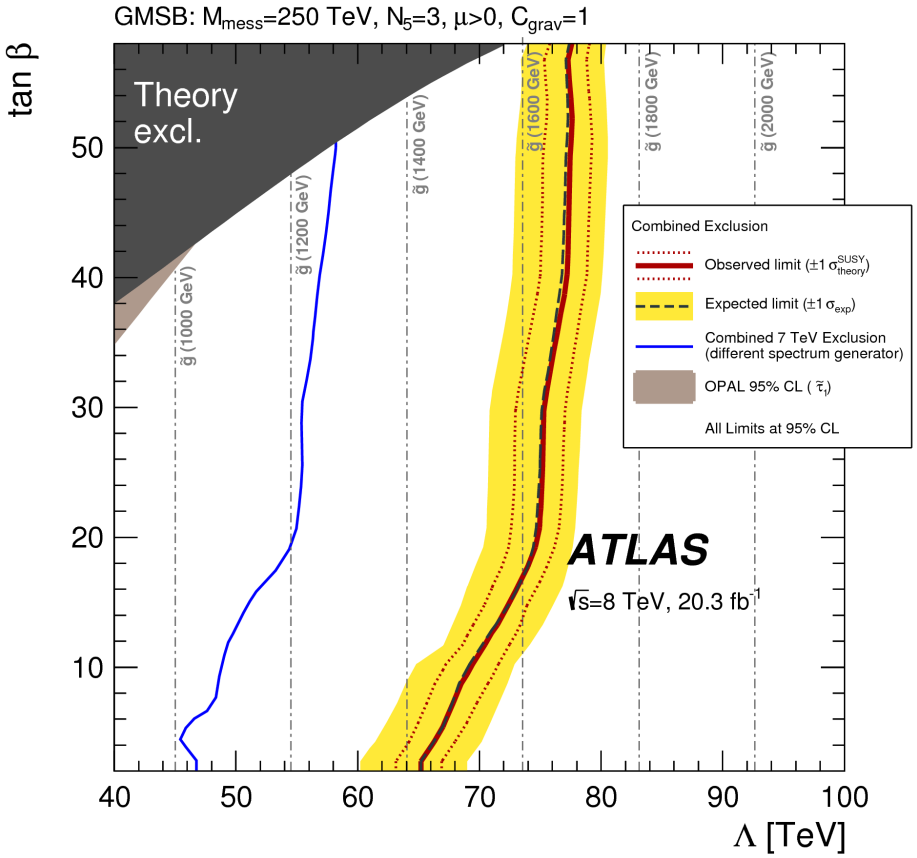
	1τ SR	2τ GMSB SR	2τ nGM	τ+l nGM SR
m_T [GeV]	$m_T^{\tau}>140$	$m_T^{\tau 1} + m_T^{\tau 2}>250$		$m_T^{l}>100$
H_T^{2j} [GeV]	>800	>900	>600	
MET [GeV]	>200			>350
N(jet)		>=4	>=4	>=3



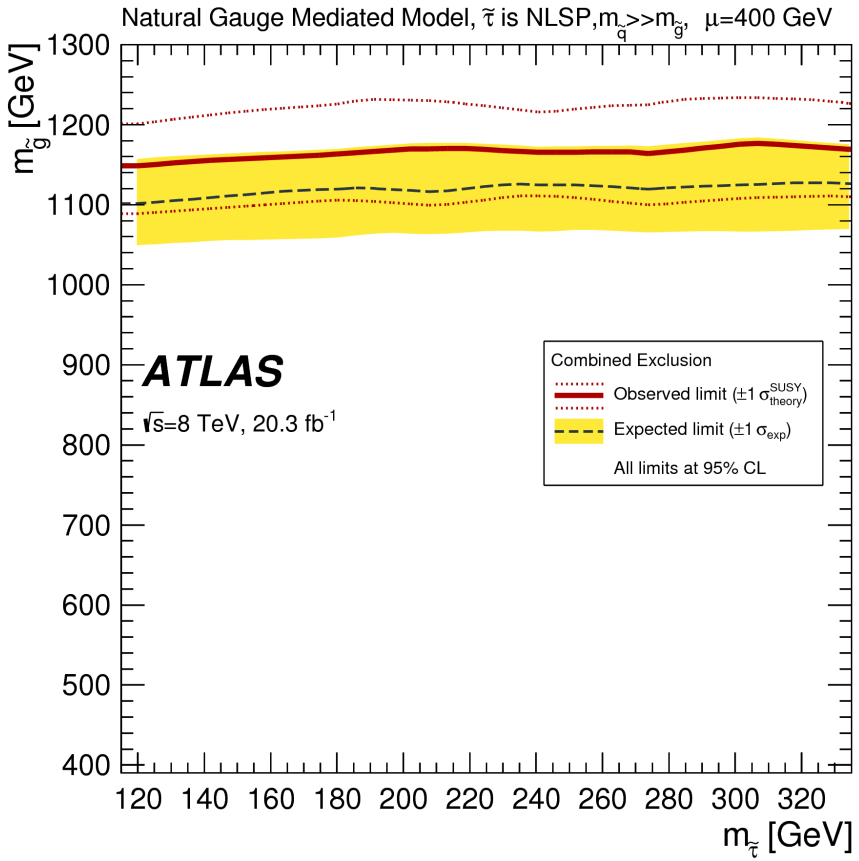


taus + jets + MET

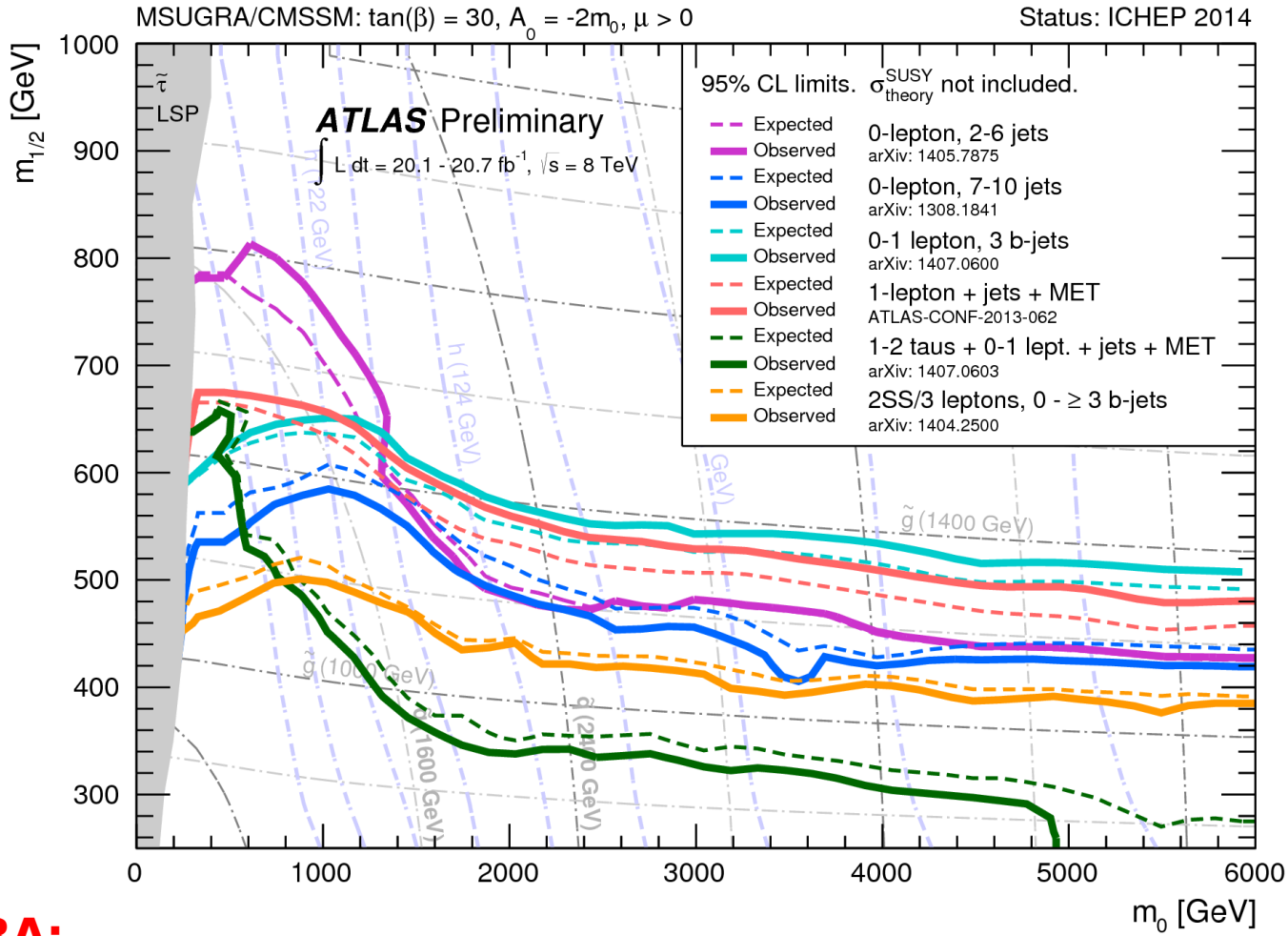
GMSB
(better exclusion limits at tanβ>20 where stau is NLSP)



nGM
(gluino mass limits independent from stau mass)



Summary results



- **mSUGRA:**

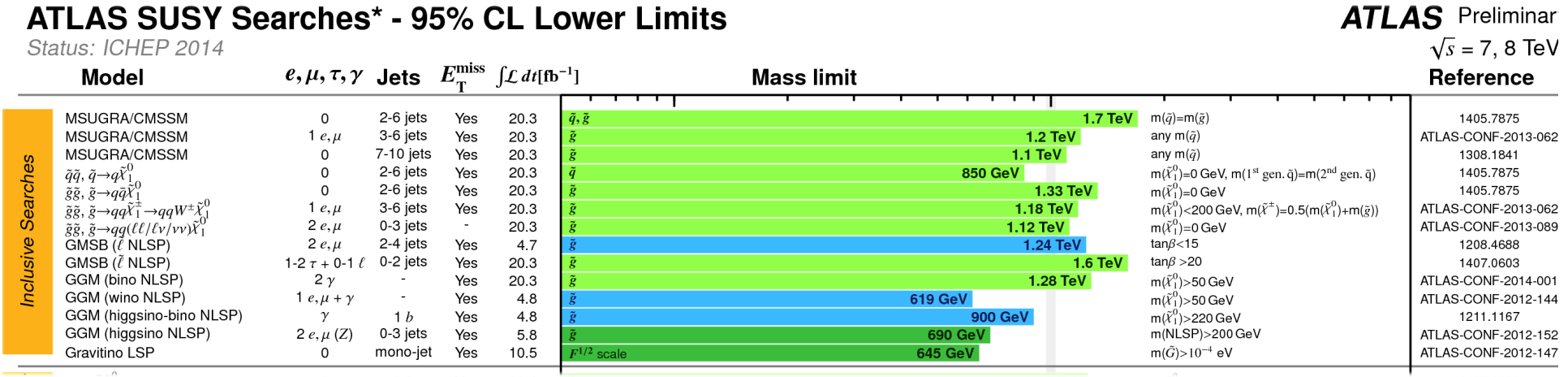
  0-lepton + 2-6 jets +MET drives the exclusion at small m_0 and high $m_{1/2}$

  0-1 lepton +3 b-jets + MET drives the exclusion at medium and large m_0

Summary & Conclusions

Summary:

- No indication for SUSY particles yet
- Exclusion limits derived for many models (large parameter space excluded)
- Let's see what LHC RUN II with increased √s=13GeV and luminosity will bring !
- Going from 8 to 13 TeV SUSY cross-sections increase rapidly, eg:
  m(gluino)= 1.5 (2.5)TeV by factor 46(2700)
  top production only by factor 4



Backup