Supersymmetry searches in ATLAS

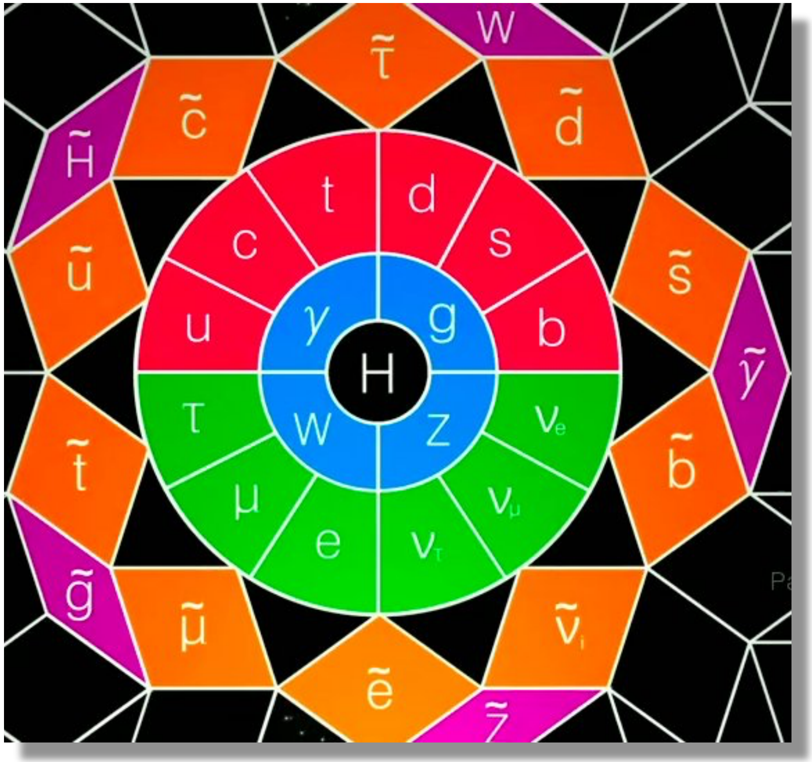
Edoardo Gorini – INFN Lecce & Università del Salento, Italy

LHC Days in Split

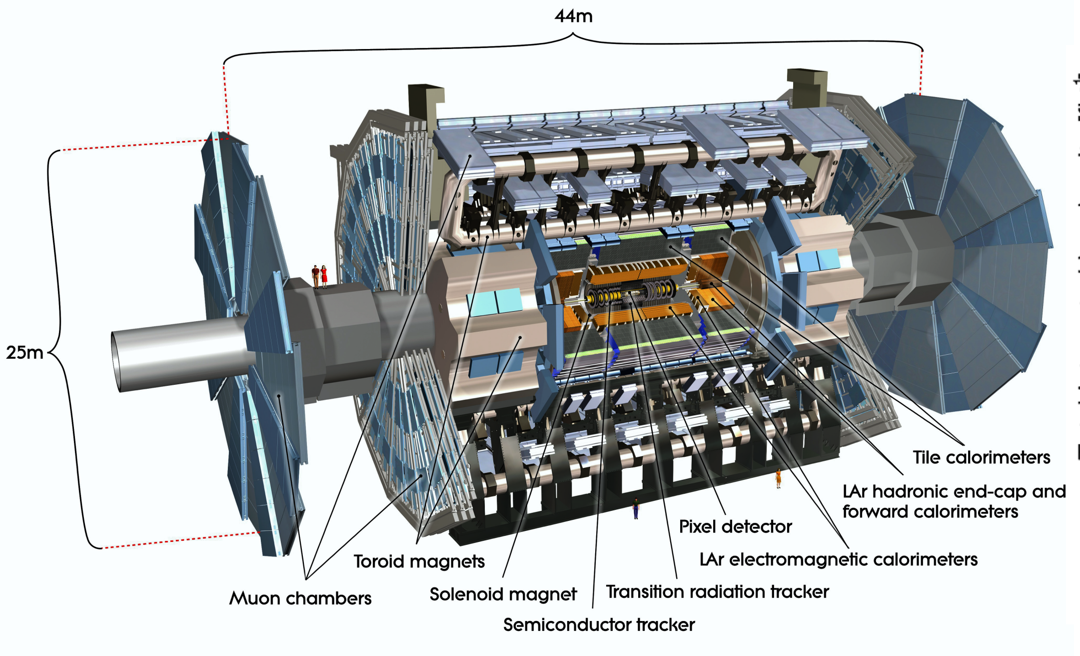
September 19th-24th 2016, Split, Croatia

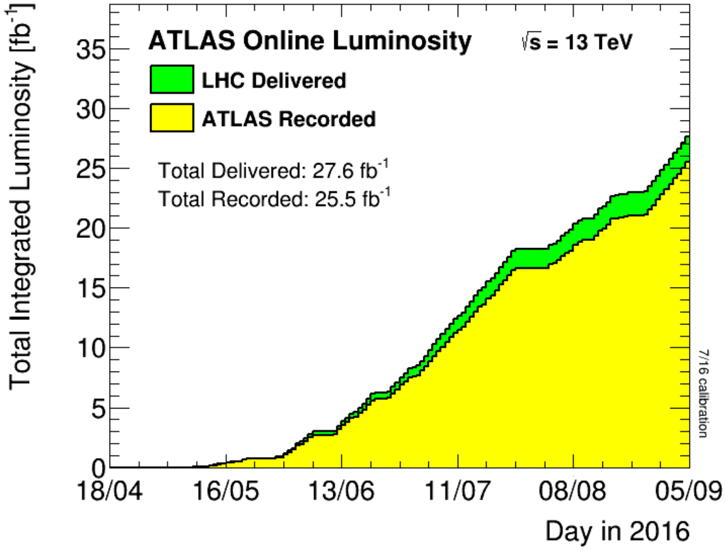
Supersymmetry (SUSY)

- Supersymmetry is the favoured extension of the Standard Model (SM)
- It would produce a compelling new Physics Scenario
- It is a fundamental theory which postulates a matter-force symmetry, introducing a super partner for each SM particle, with spin altered by ½
- Allows solutions to open questions of the SM
  - Fine tuning of the Higgs mass
  - Solution to the Hierarchy
  - Unification of fundamental interactions
- Provides an excellent candidate for the Dark Matter (Lightest Supersymmetric Particle, **LSP**) if R-parity is conserved
- In MSSM there are more than hundreds of different parameters
  - there is a huge phase space to look into, with many possible different signatures (jets/leptons/photons + MET)
- SUSY is: theoretically appealing, phenomenological rich and experimentally challenging



The ATLAS experiment





Multi-purpose collider detector for high-precision SM measurements and searches beyond SM

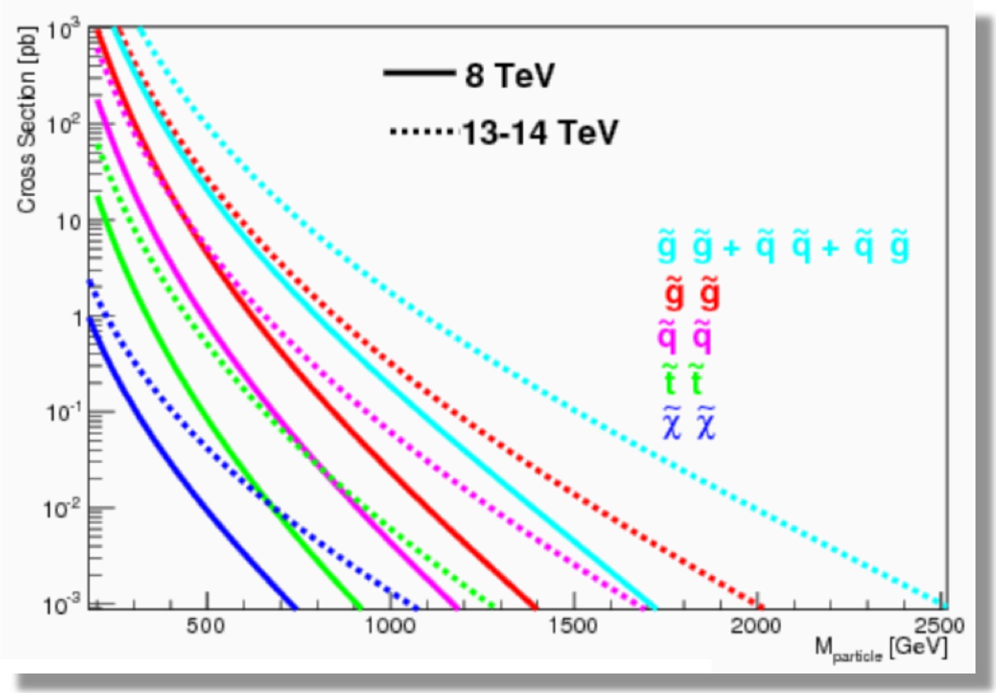
- Tracking system in $|\eta| < 2.5$ (silicon pixels/strips and TR tracker) with insertable b-layer.
- EM (liquid Ar) and Hadronic (scintillating tiles) calorimeters covering $|\eta| < 4.9$.
- Muon spectrometer for muon identification with $\Delta p_T/p_T < 10\%$ up to 1 TeV.
- Two magnet systems (toroidal and solenoidal).

Data collected in Run-2 at $\sqrt{s}$ = 13 TeV: 3.2 fb^{-1} in 2015, already 25.5 fb^{-1} in 2016

Summary of SUSY Searches

Naturalness Blocks:

- Strong Production
  - Largest cross-sections
  - Targeting Gluinos and 1° and 2° generation Squarks

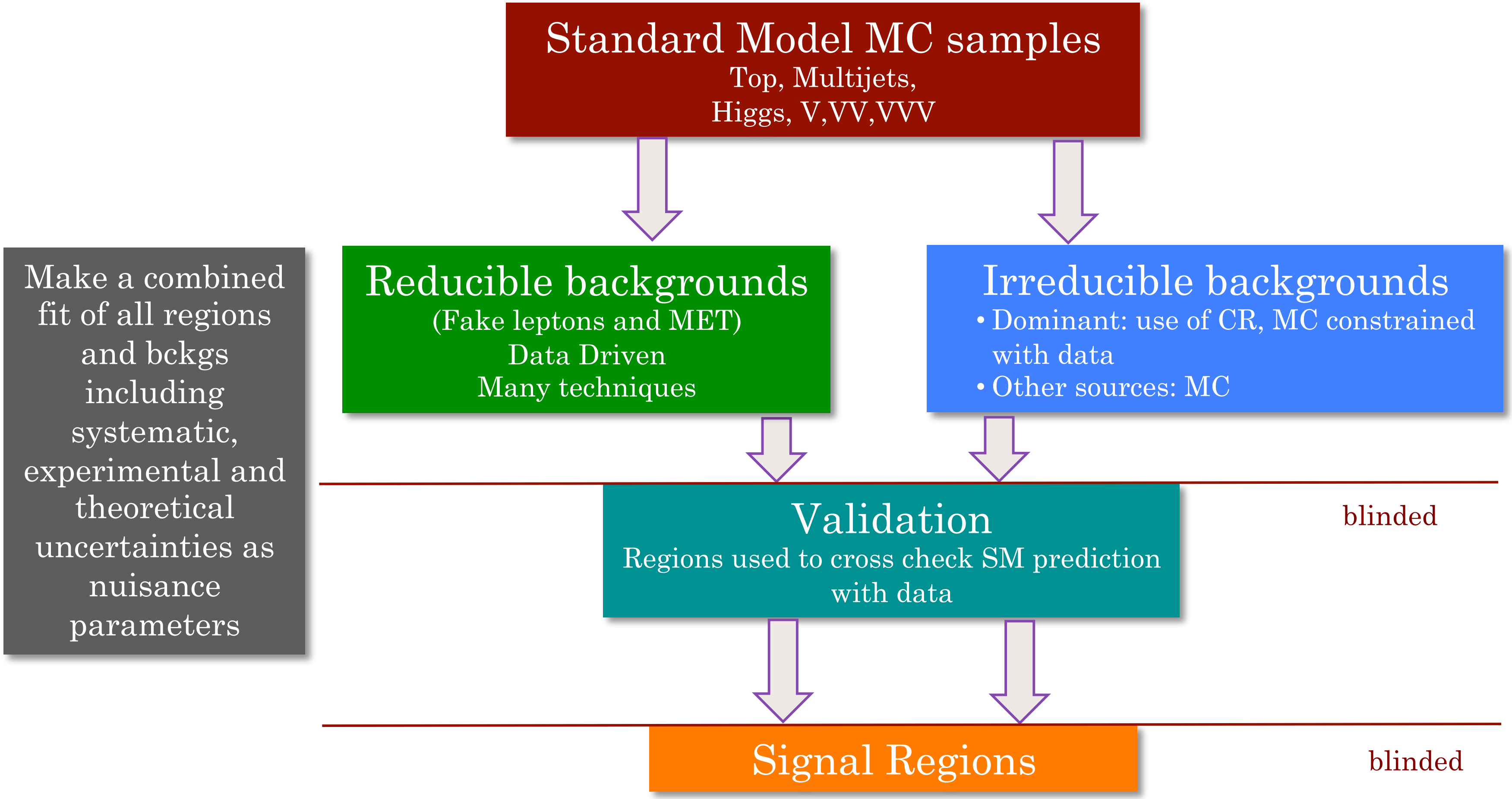


- Third Generation
  - Targeting Stop and Sbottom
  - Expected lowest squark masses for naturalness reasons with masses O(<1TeV)
- Electroweak Production
  - Direct Sleptons, Gauginos
  - Clean signatures, lowest masses

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

Typical ATLAS SUSY search strategy

- Data selected in the trigger plateau, asking for good data-taking conditions and optimal event reconstruction
- Rely on understanding of the SM backgrounds



Standard Model MC samples
Top, Multijets,
Higgs, V,VV,VVV

Make a combined fit of all regions and bckgs including systematic, experimental and theoretical uncertainties as nuisance parameters

Reducible backgrounds
(Fake leptons and MET)
Data Driven
Many techniques

Irreducible backgrounds
- Dominant: use of CR, MC constrained with data
- Other sources: MC

Validation
Regions used to cross check SM prediction with data

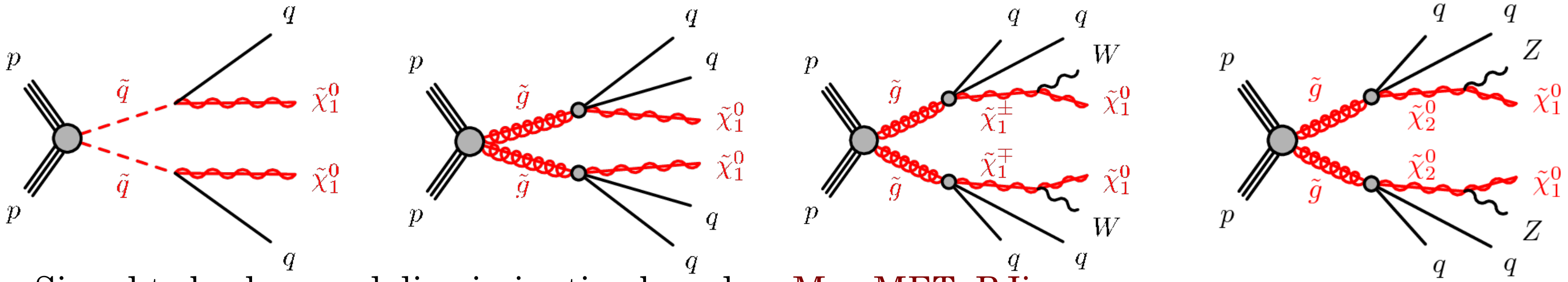
blinded

Signal Regions

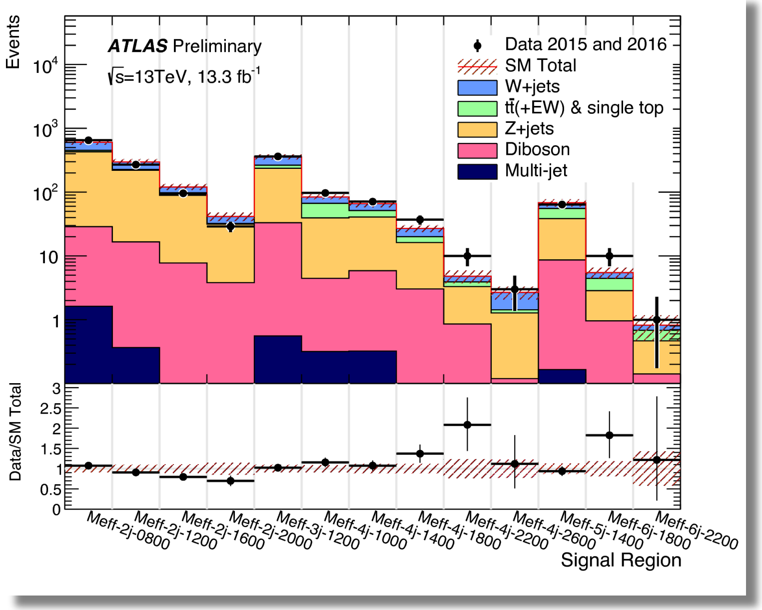
blinded

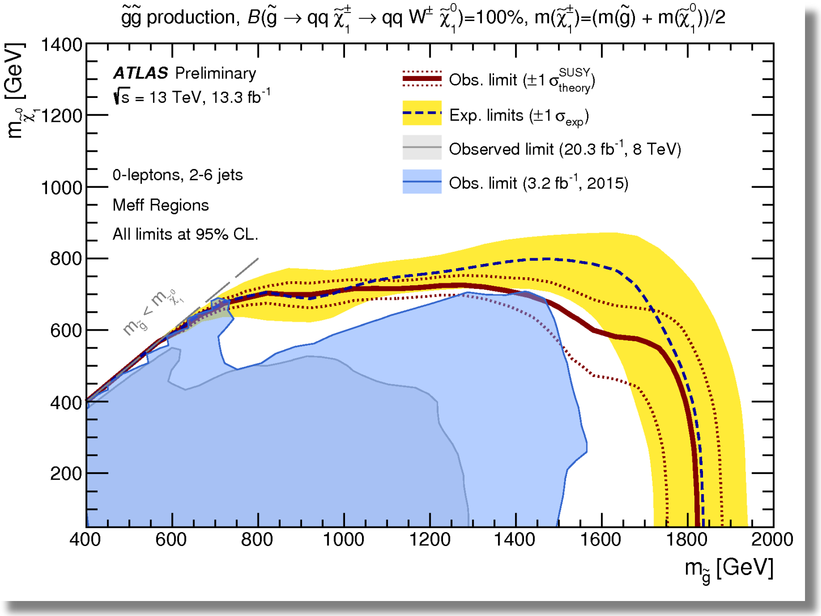
ATLAS-CONF-2016-078

Strong Prod: 0L+(2-6)Jets+MET



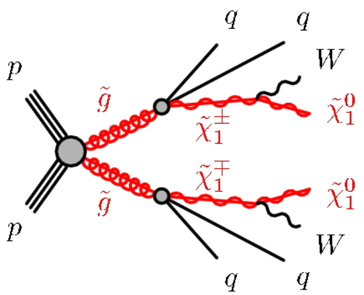
- Signal to background discrimination based on M_{eff}, MET, RJigsaw
- 13(M_{eff})+17 (RJR) signal regions, no excess found
- Gluino (Squark) masses excluded up to 1.86 (1.35) TeV for massless LSP
- For gluino decay via $\tilde{\chi}_2^0$, gluino masses below 1.9 TeV excluded for m($\tilde{\chi}_2^0$)~600 GeV

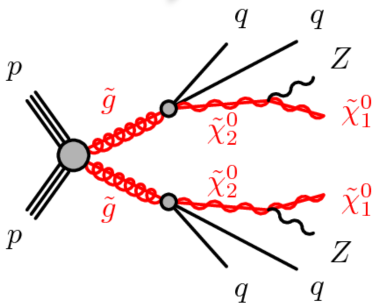




ATLAS-CONF-2016-095

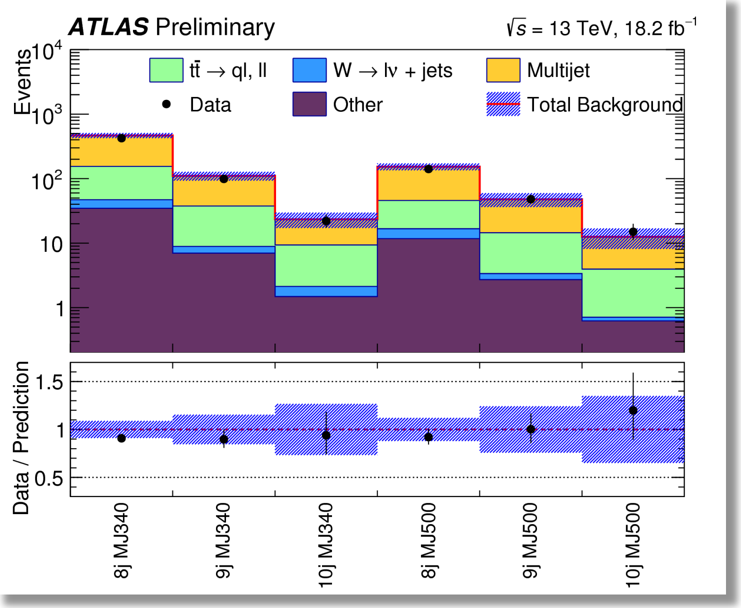
Strong Prod: 0L+(8-10)Jets+MET

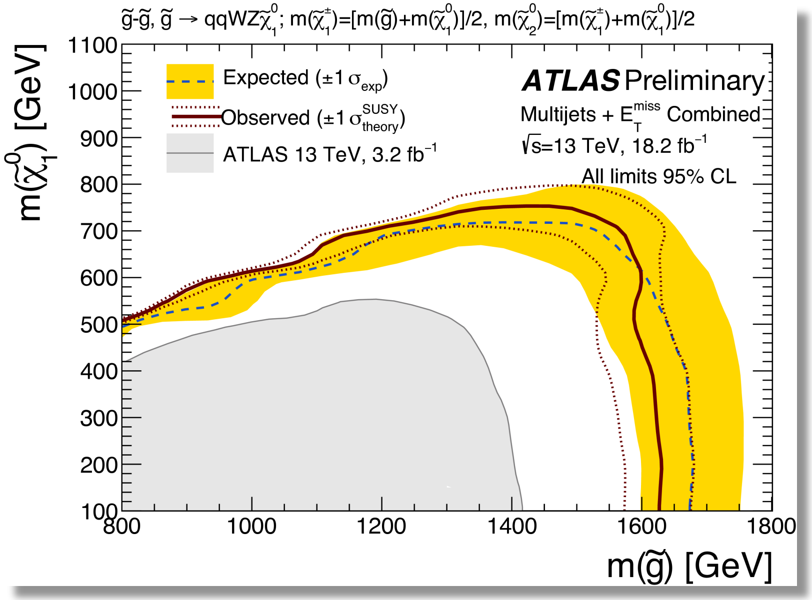




NEW

- 8 to 10 jets consistent with decays of heavy objects re-clustered into a smaller number of high-mass jets
- Signal to background discrimination based on MET, H_T and on MET significance
- 6 Signal Regions investigated, no excess found
- For 2 step simplified models gluino masses excluded up to 1.6 TeV for massless LSP

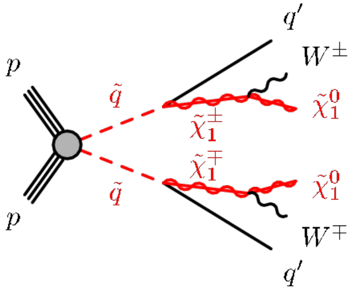


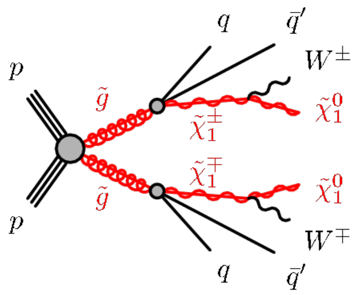


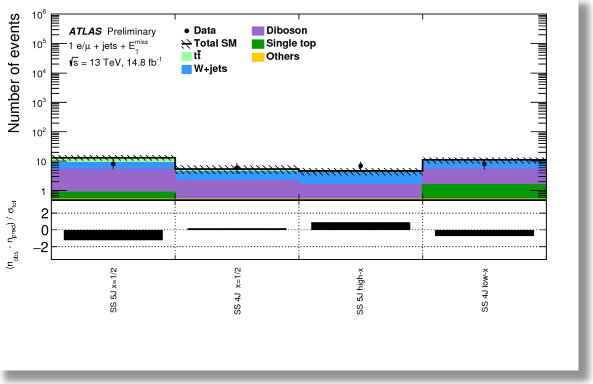
ATLAS-CONF-2016-054

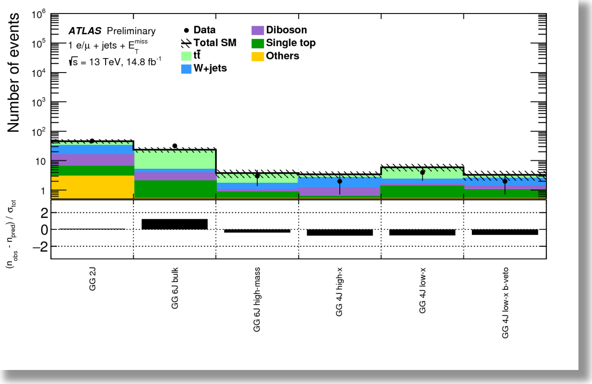
Strong Prod: 1L+(2-6)Jets+MET

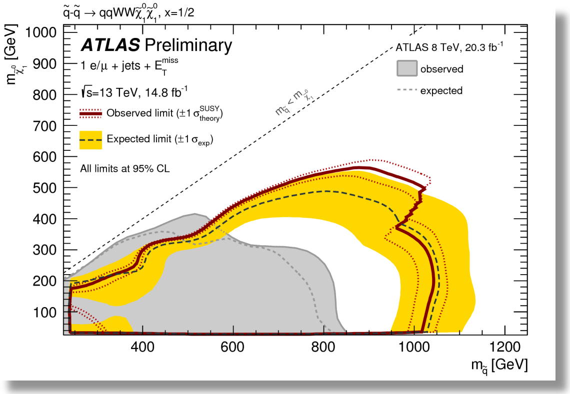
- Discrimination based on M_{eff}, MET, M_t
- 4(squark)+6(gluino) different signal regions provide sensitivity to a broad range of sparticle mass spectra for both squark and gluino pair production models
- No significant excess observed
- Masses up to 1.8 TeV (Gluino) and up to 1.1 TeV (Squarks) are excluded for low neutralino masses

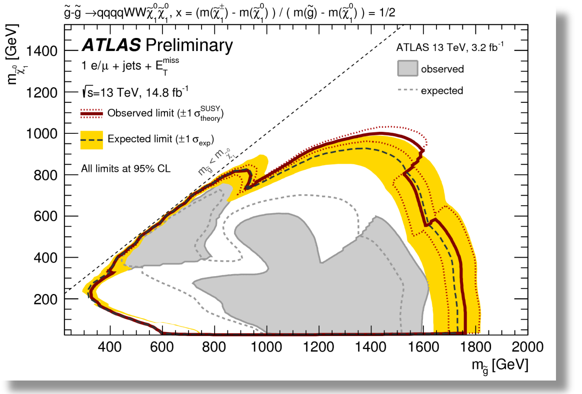












best expected sensitivity is used for each model point

ATLAS-CONF-2016-094

RPV: gluino to 1L and (b)Jets

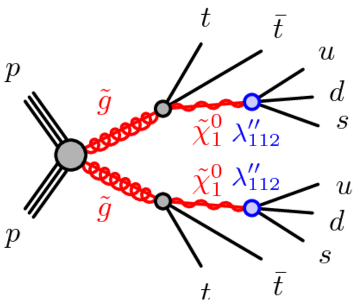
NEW

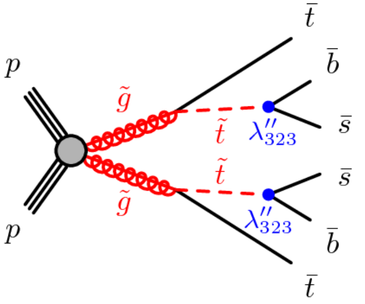
- Pair production of Gluinos decaying through the R-parity violating decay of either the neutralino into three quarks or the top squark into a anti-b and an anti-s quark

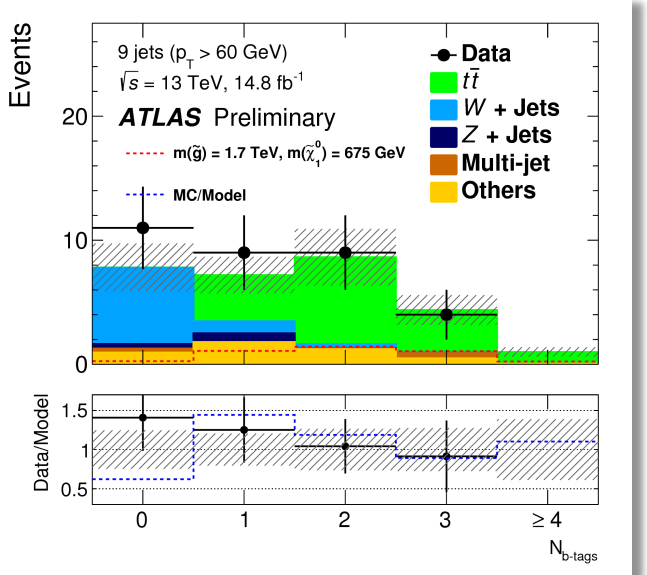
- Search for 1 lepton, >5 jets and (0 or >4)b-jets, no requirement on MET

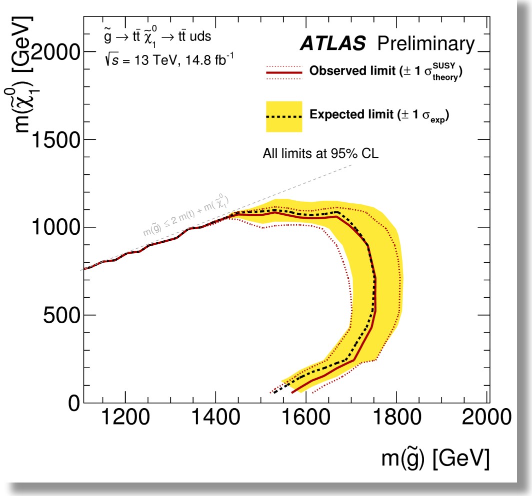
- The limits are determined fitting the background model in a reduced set of bins obtaining
  model-independent upper limits

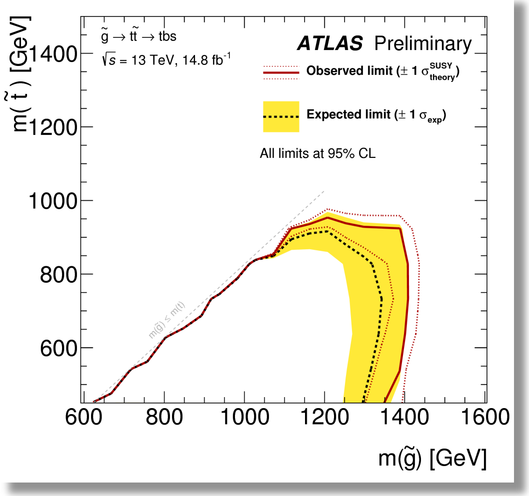
- Excluding Gluino masses up to 1.75 (1.4) TeV for the two models





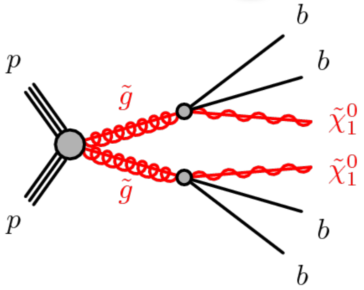


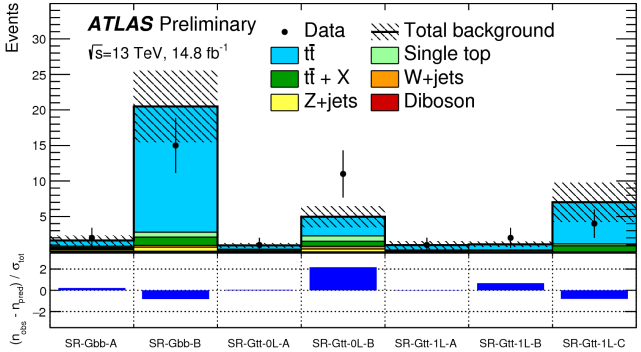


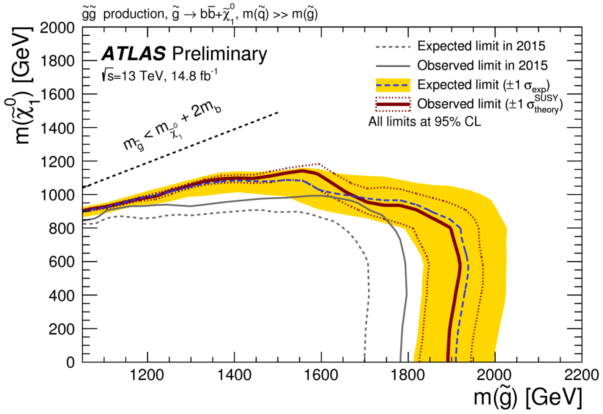


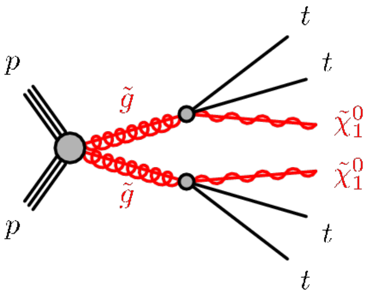
ATLAS-CONF-2016-052

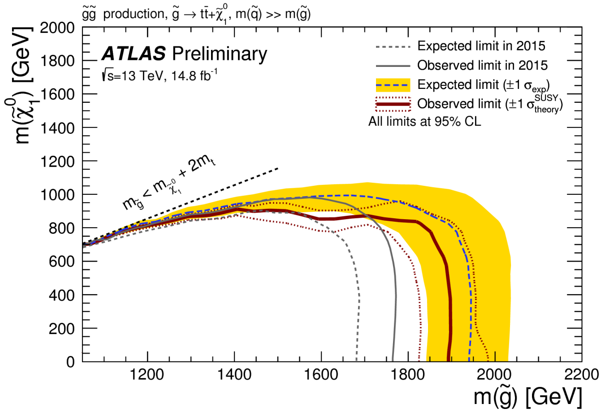
Strong Prod: b-Jets+MET









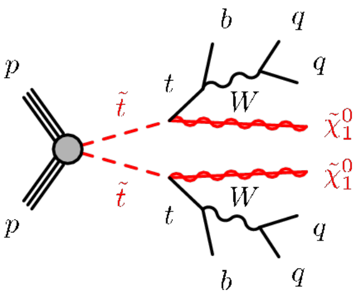


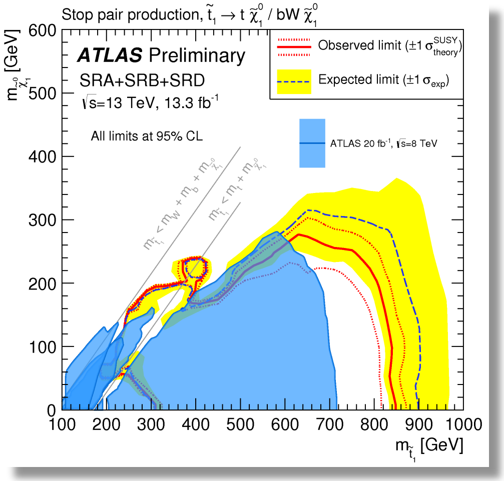
- Gluino search via bottom (Gbb) or top (Gtt) decay (simplified models)
- Final states with 0/1 light lepton (e/μ) and > 2b-jets
- At least one large-radius, trimmed jet, which is re-clustered from small-radius jets is required in some of the Gtt regions
- Discrimination of S to B with M_{eff}, MET and M_T
- 7(2Gbb+5Gtt) Signal Regions addressed
- Exclusion of gluinos up to 1.89 TeV for massless LSP

3^{rd} Gen: Stop (DM) in 0L

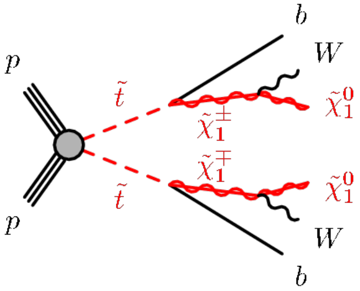
ATLAS-CONF-2016-077

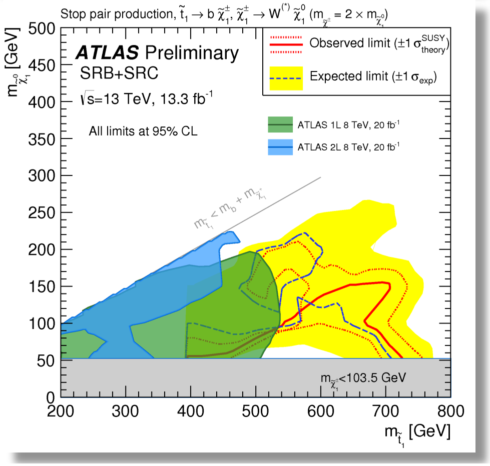
- Search for top with no leptons, $\geq$ 4 ($\geq$1b)jets and MET, all hadronic
- Signal to Background discrimination performed with MET, M_T(b) and H_T



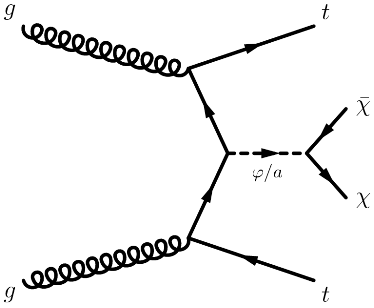


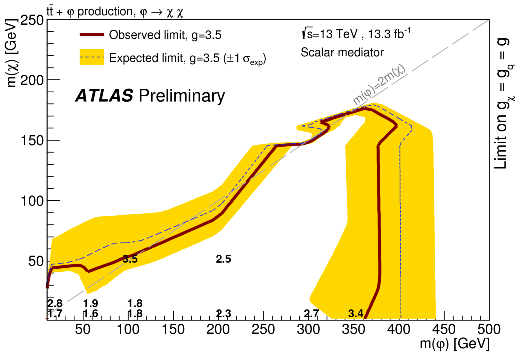
- 6 SR Sets addressed for a total of 19 signal Regions studying various masses
- Given a massless LSP the exclusion limit for $\tilde{t}1$ is 820 GeV





- For models with associated production of Dark Matter with top pairs, neutralino masses up to 40 GeV and mediator masses up to 300 GeV are excluded

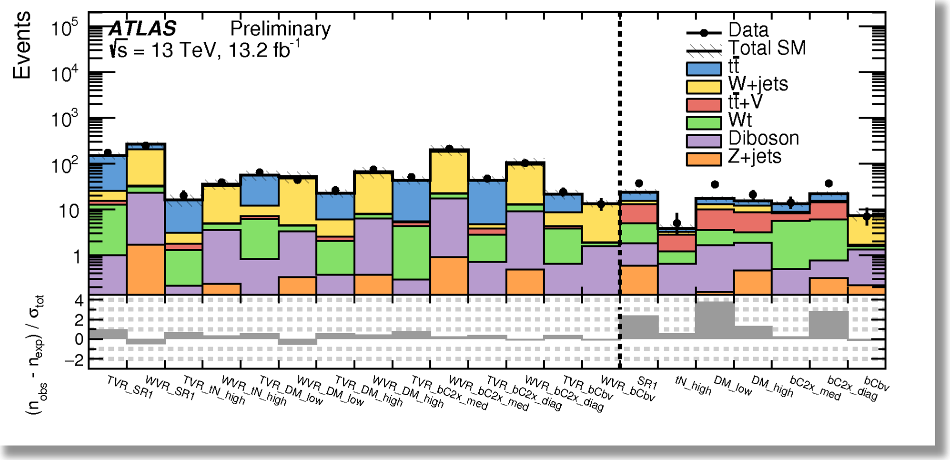


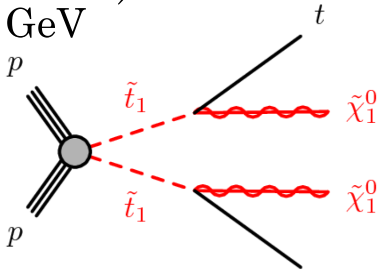


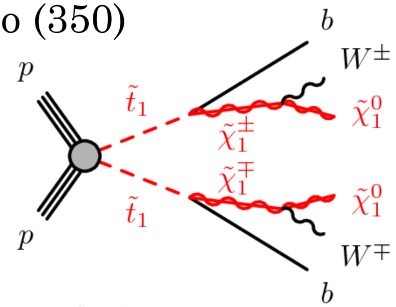
ATLAS-CONF-2016-050

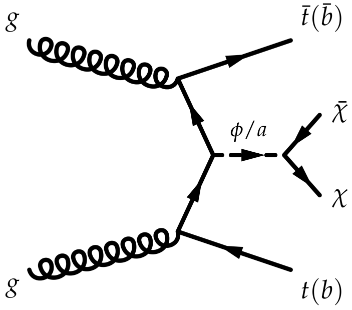
3rd Gen: Stop (DM) in 1L

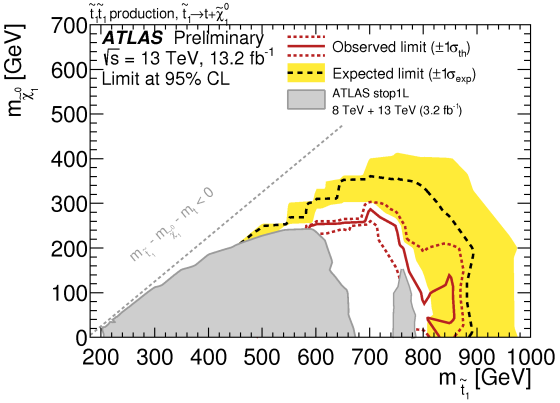
- Topology: 1 lepton , (b)Jets, MET
- Variables used: MET, M_T(b), H_T
- 7 Signal Regions (2 for DM)
- 3.3σ excess in DM_low SR
- For massless LSP limit $m(\tilde{t}1)$ at 830GeV
- Assuming a 1 GeV DM mass the maximal coupling of g = 3.5 is excluded @95% CL for a (pseudo-)scalar mediator mass up to (350) 320 GeV

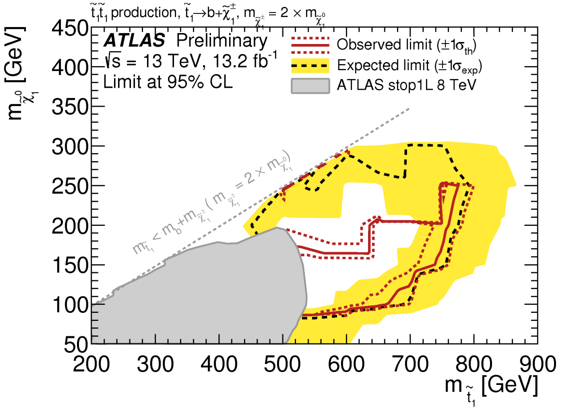


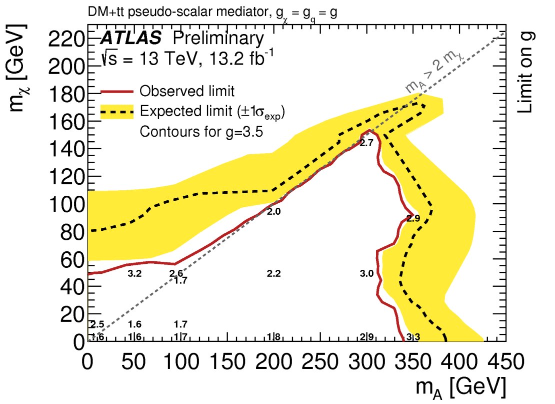








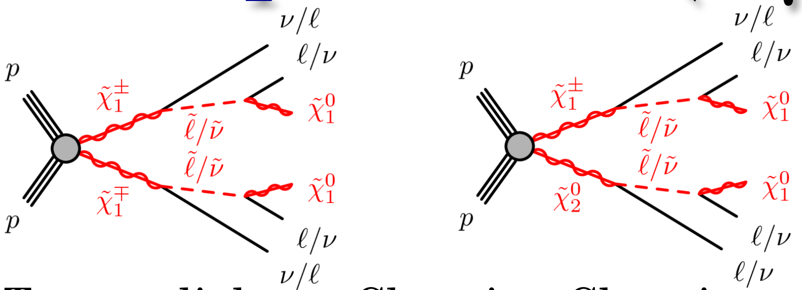




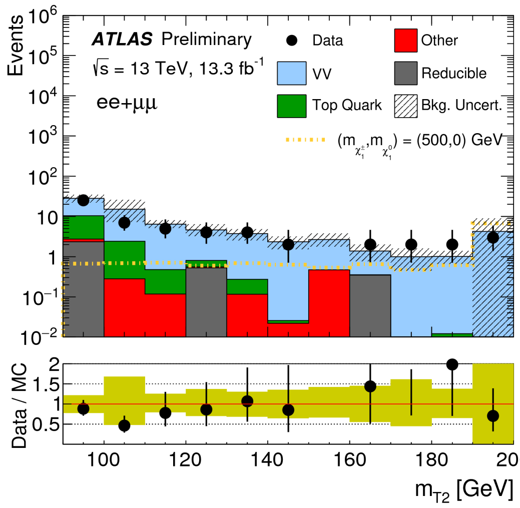
ATLAS-CONF-2016-096

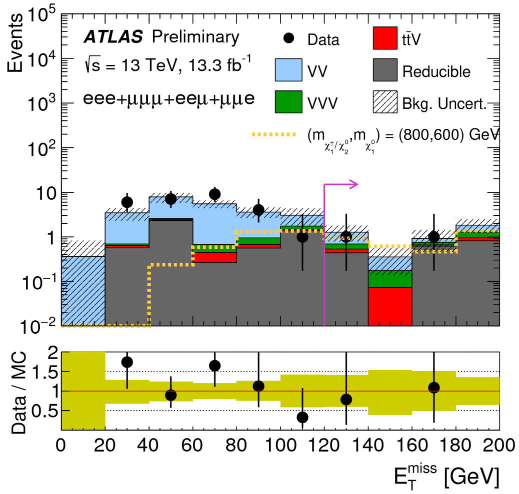
EWK prod: 2/3(e/μ)+MET

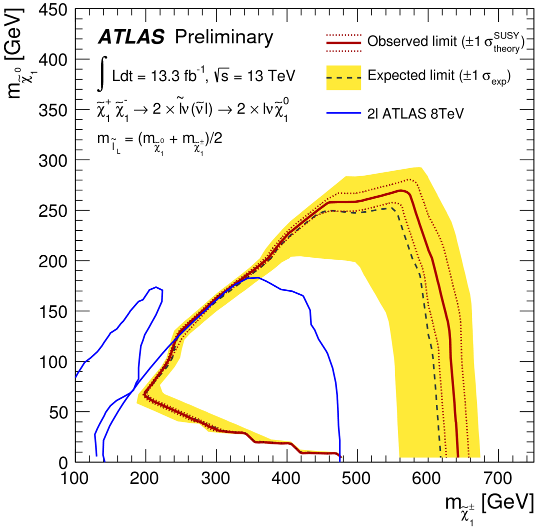
NEW

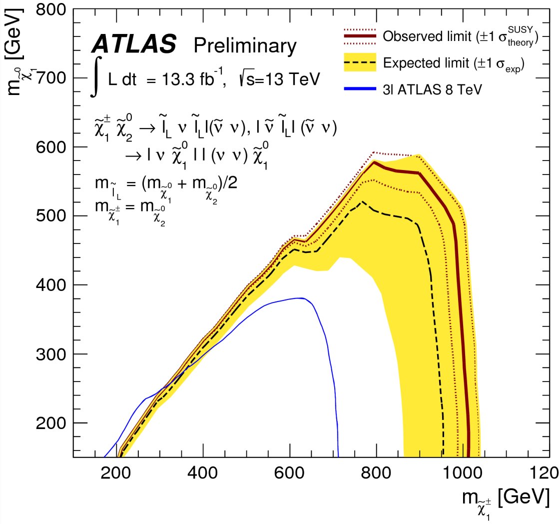


- Targets lightest Chargino-Chargino and Chargino-Neutralino slepton mediated decays
- 2(SF,DF)/3 leptons, (b)Jets Veto, Variables used: MET and MT2
- 6 SR (2l) and 2SR (3l)
- Extend previous limits by 140 GeV and 300 GeV





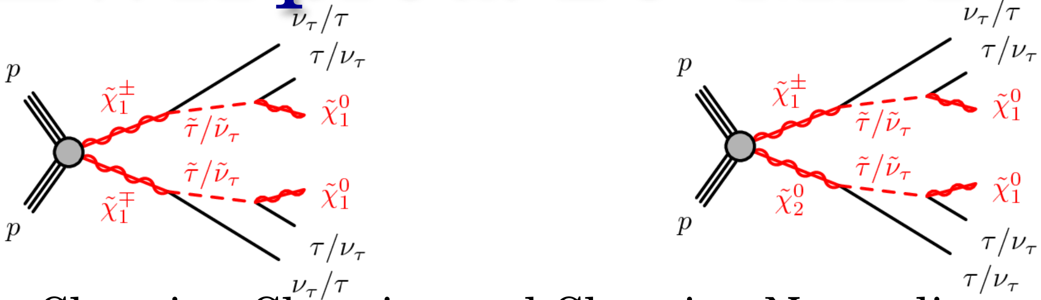




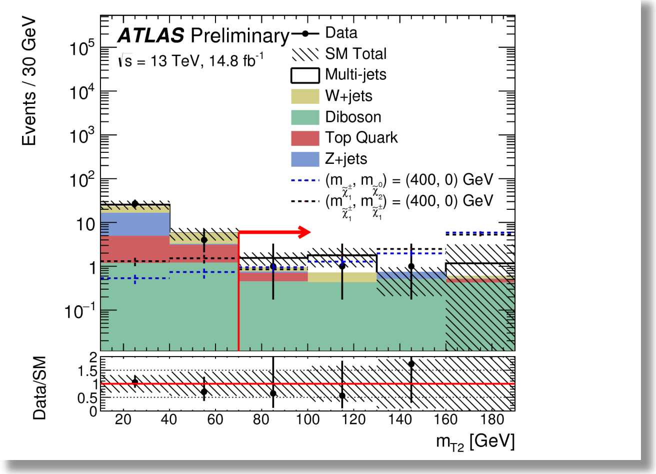
ATLAS-CONF-2016-093

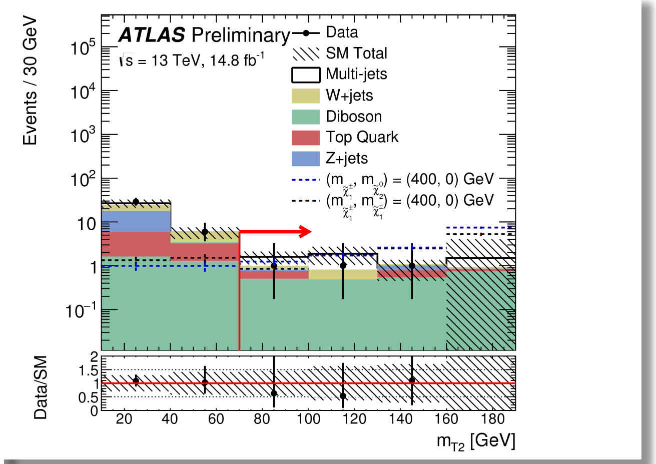
EWK prod: 2τ+MET

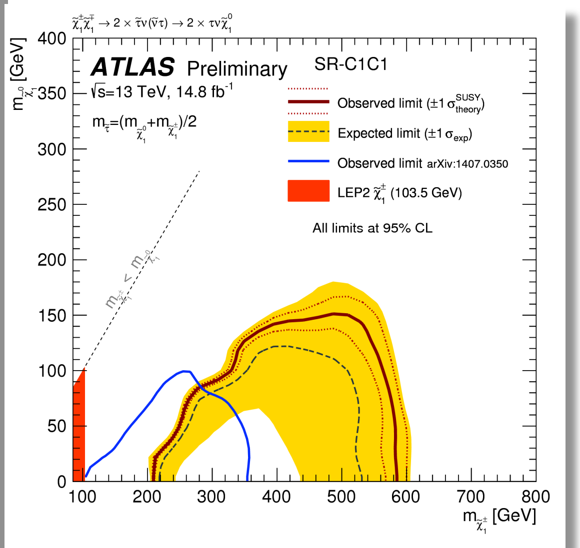
NEW

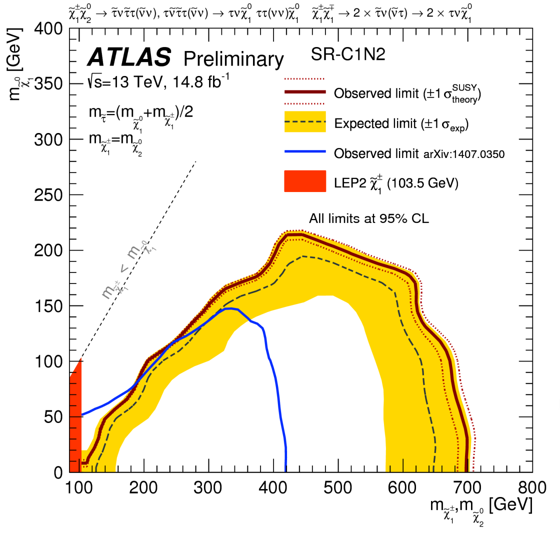


- Chargino-Chargino and Chargino-Neutralino slepton mediated decays
- 2 hadronically decaying τ, b-jets Veto and Z-Veto, variables used: MET and MT2
- 2 SR addressed in MT2, red arrow
- 580 GeV and 700 GeV common mass limits with massless LSP



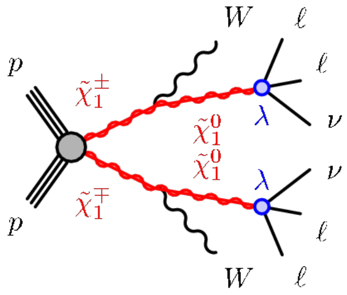




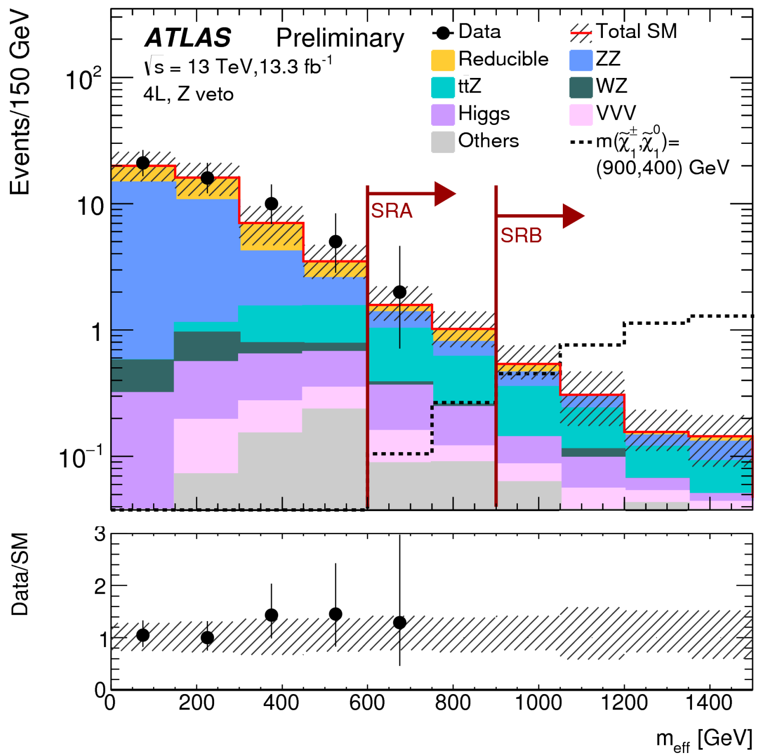


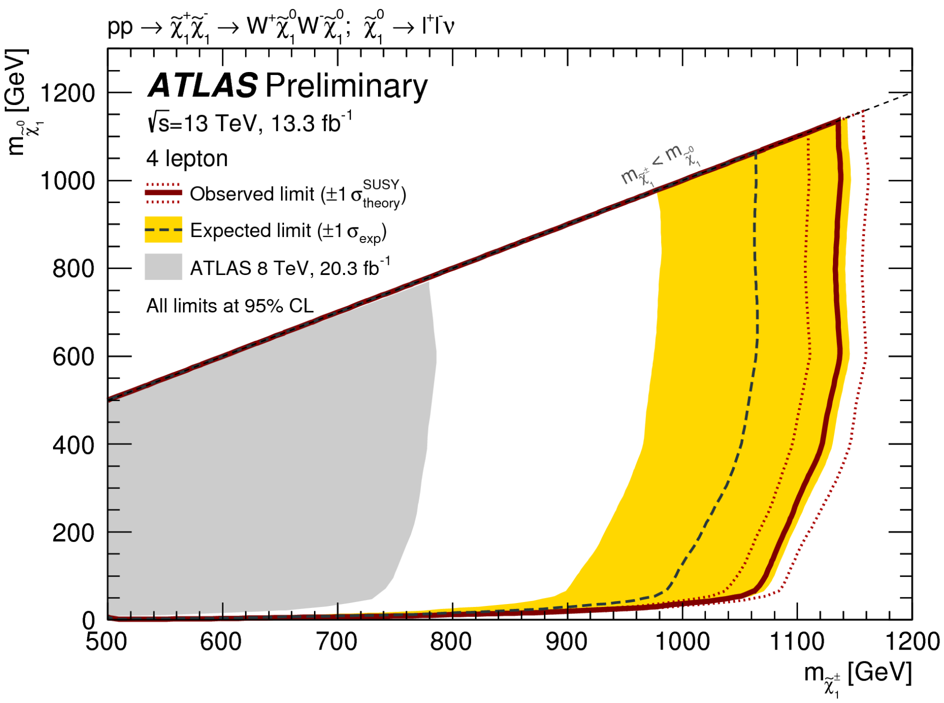
ATLAS-CONF-2016-075

EWK prod: 4L+MET with RPV decays

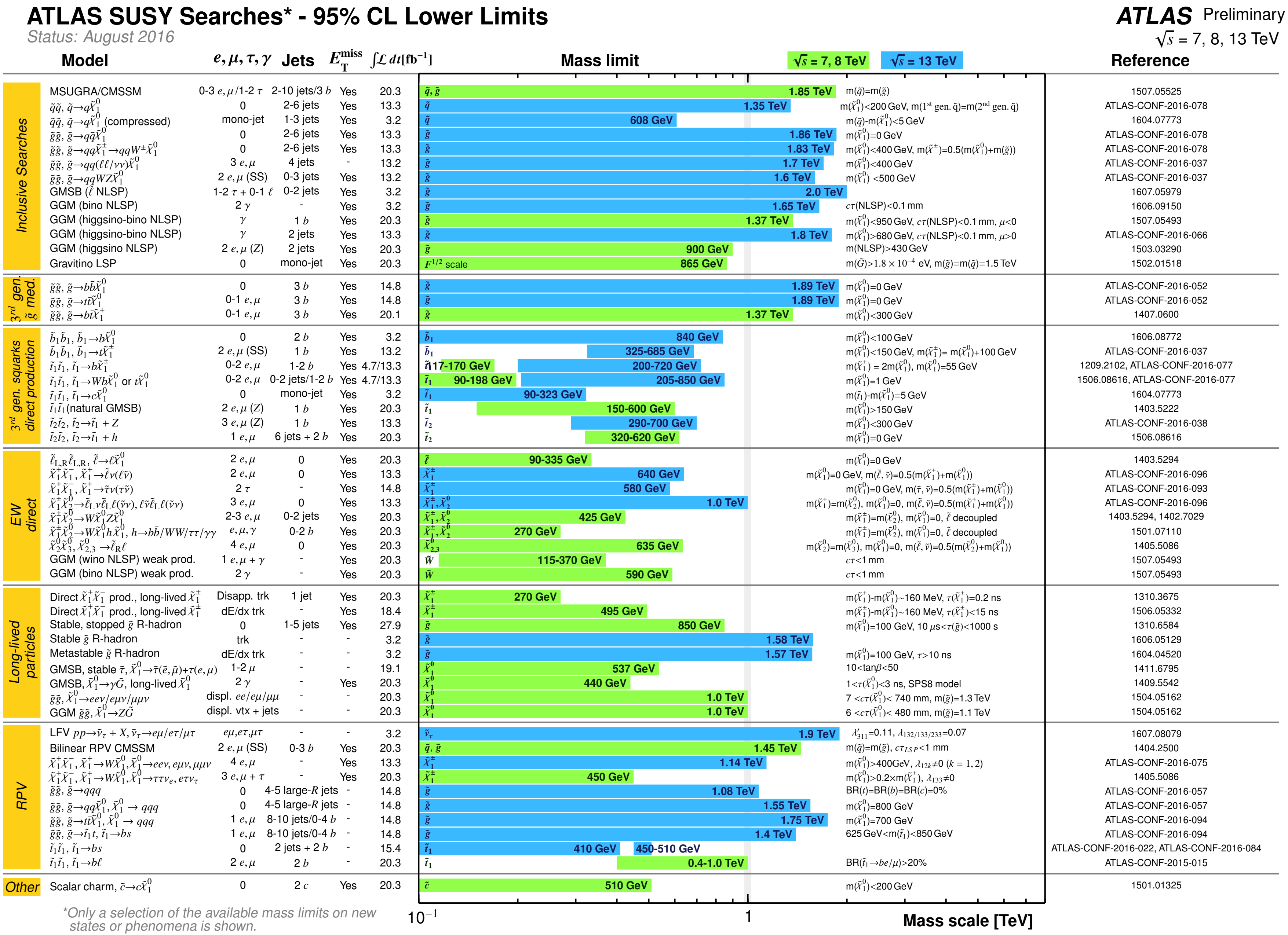


- Search for charginos, RPV decays results in high multiplicity leptons and large MET
- Search for 4 leptons, M_{eff} and MET, Z veto
- 2 signal region targeting different chargino mass ranges
- Excluding chargino masses up to 1.14 TeV for large LSP masses





ATLAS SUSY Searches 95% CL Lower Limits



ATLAS SUSY Searches* - 95% CL Lower Limits

Status: August 2016

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

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

	Model	e, μ, τ, γ	Jets	$E_T^{\rm miss}$	$\int \mathcal{L}\, dt[\mathrm{fb}^{-1}]$	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
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}^0_1$	0	2-6 jets	Yes	13.3	$\tilde{q}$	🟦 1.35 TeV	m($\tilde{\chi}^0_1$)<200 GeV, m(1$^{\rm st}$ gen. $\tilde{\rm q}$)=m(2$^{\rm nd}$ gen. $\tilde{\rm q}$)	ATLAS-CONF-2016-078
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}^0_1$ (compressed)	mono-jet	1-3 jets	Yes	3.2	$\tilde{q}$	🟦 608 GeV	m($\tilde{q}$)-m($\tilde{\chi}^0_1$)<5 GeV	1604.07773
	$\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}^0_1$	0	2-6 jets	Yes	13.3	$\tilde{g}$	🟦 1.86 TeV	m($\tilde{\chi}^0_1$)=0 GeV	ATLAS-CONF-2016-078
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}^{\pm}_1\to qqW^{\pm}\tilde{\chi}^0_1$	0	2-6 jets	Yes	13.3	$\tilde{g}$	🟦 1.83 TeV	m($\tilde{\chi}^0_1$)<400 GeV, m($\tilde{\chi}^{\pm}$)=0.5(m($\tilde{\chi}^0_1$)+m($\tilde{g}$))	ATLAS-CONF-2016-078
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq(\ell\ell/\nu\nu)\tilde{\chi}^0_1$	3 e,μ	4 jets	-	13.2	$\tilde{g}$	🟦 1.7 TeV	m($\tilde{\chi}^0_1$)<400 GeV	ATLAS-CONF-2016-037
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qqWZ\tilde{\chi}^0_1$	2 e,μ (SS)	0-3 jets	Yes	13.2	$\tilde{g}$	🟦 1.6 TeV	m($\tilde{\chi}^0_1$) <500 GeV	ATLAS-CONF-2016-037
	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($\tilde{\chi}^0_1$)<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($\tilde{\chi}^0_1$)>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.	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{b}\tilde{\chi}^0_1$	0	3 b	Yes	14.8	$\tilde{g}$	🟦 1.89 TeV	m($\tilde{\chi}^0_1$)=0 GeV	ATLAS-CONF-2016-052
	$\tilde{g}\tilde{g}$, $\tilde{g}\to t\bar{t}\tilde{\chi}^0_1$	0-1 e,μ	3 b	Yes	14.8	$\tilde{g}$	🟦 1.89 TeV	m($\tilde{\chi}^0_1$)=0 GeV	ATLAS-CONF-2016-052
	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{t}\tilde{\chi}^+_1$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	🟩 1.37 TeV	m($\tilde{\chi}^0_1$)<300 GeV	1407.0600
3^{rd} gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to b\tilde{\chi}^0_1$	0	2 b	Yes	3.2	$\tilde{b}_1$	🟦 840 GeV	m($\tilde{\chi}^0_1$)<100 GeV	1606.08772
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}^{\pm}_1$	2 e,μ (SS)	1 b	Yes	13.2	$\tilde{b}_1$	🟦 325-685 GeV	m($\tilde{\chi}^0_1$)<150 GeV, m($\tilde{\chi}^{\pm}_1$)= m($\tilde{\chi}^0_1$)+100 GeV	ATLAS-CONF-2016-037
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\tilde{\chi}^{\pm}_1$	0-2 e,μ	1-2 b	Yes	4.7/13.3	$\tilde{t}_1$	🟩 117-170 GeV 🟦 200-720 GeV	m($\tilde{\chi}^{\pm}_1$) = 2m($\tilde{\chi}^0_1$), m($\tilde{\chi}^0_1$)=55 GeV	1209.2102, ATLAS-CONF-2016-077
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to Wb\tilde{\chi}^0_1$ or $t\tilde{\chi}^0_1$	0-2 e,μ	0-2 jets/1-2 b	Yes	4.7/13.3	$\tilde{t}_1$	🟩 90-198 GeV 🟦 205-850 GeV	m($\tilde{\chi}^0_1$)=1 GeV	1506.08616, ATLAS-CONF-2016-077
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to c\tilde{\chi}^0_1$	0	mono-jet	Yes	3.2	$\tilde{t}_1$	🟦 90-323 GeV	m($\tilde{t}_1$)-m($\tilde{\chi}^0_1$)=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($\tilde{\chi}^0_1$)>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	13.3	$\tilde{t}_2$	🟦 290-700 GeV	m($\tilde{\chi}^0_1$)<300 GeV	ATLAS-CONF-2016-038
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1+h$	1 e,μ	6 jets + 2 b	Yes	20.3	$\tilde{t}_2$	🟩 320-620 GeV	m($\tilde{\chi}^0_1$)=0 GeV	1506.08616
EW direct	$\tilde{\ell}_{\rm L,R}\tilde{\ell}_{\rm L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}^0_1$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$	🟩 90-335 GeV	m($\tilde{\chi}^0_1$)=0 GeV	1403.5294
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	13.3	$\tilde{\chi}^{\pm}_1$	🟦 640 GeV	m($\tilde{\chi}^0_1$)=0 GeV, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^{\pm}_1$)+m($\tilde{\chi}^0_1$))	ATLAS-CONF-2016-096
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	14.8	$\tilde{\chi}^{\pm}_1$	🟦 580 GeV	m($\tilde{\chi}^0_1$)=0 GeV, m($\tilde{\tau},\tilde{\nu}$)=0.5(m($\tilde{\chi}^{\pm}_1$)+m($\tilde{\chi}^0_1$))	ATLAS-CONF-2016-093
	$\tilde{\chi}^{\pm}_1\tilde{\chi}^0_2\to\tilde{\ell}_{\rm L}\nu\tilde{\ell}_{\rm L}\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_{\rm L}\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	13.3	$\tilde{\chi}^{\pm}_1,\tilde{\chi}^0_2$	🟦 1.0 TeV	m($\tilde{\chi}^{\pm}_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^{\pm}_1$)+m($\tilde{\chi}^0_1$))	ATLAS-CONF-2016-096
	$\tilde{\chi}^{\pm}_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1Z\tilde{\chi}^0_1$	2-3 e,μ	0-2 jets	Yes	20.3	$\tilde{\chi}^{\pm}_1,\tilde{\chi}^0_2$	🟩 425 GeV	m($\tilde{\chi}^{\pm}_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, $\tilde{\ell}$ decoupled	1403.5294, 1402.7029
	$\tilde{\chi}^{\pm}_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1h\tilde{\chi}^0_1$, $h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	$\tilde{\chi}^{\pm}_1,\tilde{\chi}^0_2$	🟩 270 GeV	m($\tilde{\chi}^{\pm}_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, $\tilde{\ell}$ decoupled	1501.07110
	$\tilde{\chi}^0_2\tilde{\chi}^0_3$, $\tilde{\chi}^0_{2,3}\to\tilde{\ell}_{\rm R}\ell$	4 e,μ	0	Yes	20.3	$\tilde{\chi}^0_{2,3}$	🟩 635 GeV	m($\tilde{\chi}^0_2$)=m($\tilde{\chi}^0_3$), m($\tilde{\chi}^0_1$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^0_2$)+m($\tilde{\chi}^0_1$))	1405.5086
	GGM (wino NLSP) weak prod.	1 $e,\mu+\gamma$	-	Yes	20.3	$\tilde{W}$	🟩 115-370 GeV	$c\tau$<1 mm	1507.05493
	GGM (bino NLSP) weak prod.	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 $\tilde{\chi}^{\pm}_1$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}^{\pm}_1$	🟩 270 GeV	m($\tilde{\chi}^{\pm}_1$)-m($\tilde{\chi}^0_1$)~160 MeV, τ($\tilde{\chi}^{\pm}_1$)=0.2 ns	1310.3675
	Direct $\tilde{\chi}^+_1\tilde{\chi}^-_1$ prod., long-lived $\tilde{\chi}^{\pm}_1$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}^{\pm}_1$	🟩 495 GeV	m($\tilde{\chi}^{\pm}_1$)-m($\tilde{\chi}^0_1$)~160 MeV, τ($\tilde{\chi}^{\pm}_1$)<15 ns	1506.05332
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$	🟩 850 GeV	m($\tilde{\chi}^0_1$)=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($\tilde{\chi}^0_1$)=100 GeV, τ>10 ns	1604.04520
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}^0_1\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}^0_1$	🟩 537 GeV	10<tanβ<50	1411.6795
	GMSB, $\tilde{\chi}^0_1\to\gamma\tilde{G}$, long-lived $\tilde{\chi}^0_1$	2 γ	-	Yes	20.3	$\tilde{\chi}^0_1$	🟩 440 GeV	1<τ($\tilde{\chi}^0_1$)<3 ns, SPS8 model	1409.5542
	$\tilde{g}\tilde{g}$, $\tilde{\chi}^0_1\to ee\nu/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	$\tilde{\chi}^0_1$	🟩 1.0 TeV	7 <$c\tau$($\tilde{\chi}^0_1$)< 740 mm, m($\tilde{g}$)=1.3 TeV	1504.05162
	GGM $\tilde{g}\tilde{g}$, $\tilde{\chi}^0_1\to Z\tilde{G}$	displ. vtx + jets	-	-	20.3	$\tilde{\chi}^0_1$	🟩 1.0 TeV	6 <$c\tau$($\tilde{\chi}^0_1$)< 480 mm, m($\tilde{g}$)=1.1 TeV	1504.05162
RPV	LFV $pp\to\tilde{\nu}_\tau+X$, $\tilde{\nu}_\tau\to e\mu/e\tau/\mu\tau$	$e\mu$,$e\tau$,$\mu\tau$	-	-	3.2	$\tilde{\nu}_\tau$	🟦 1.9 TeV	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
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to W\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to ee\nu, e\mu\nu, \mu\mu\nu$	4 e,μ	-	Yes	13.3	$\tilde{\chi}^{\pm}_1$	🟦 1.14 TeV	m($\tilde{\chi}^0_1$)>400GeV, $\lambda_{12k}\neq0$ $(k=1,2)$	ATLAS-CONF-2016-075
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to W\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to\tau\tau\nu_e, e\tau\nu_\tau$	3 $e,\mu+\tau$	-	Yes	20.3	$\tilde{\chi}^{\pm}_1$	🟩 450 GeV	m($\tilde{\chi}^0_1$)>0.2×m($\tilde{\chi}^{\pm}_1$), $\lambda_{133}\neq0$	1405.5086
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qqq$	0	4-5 large-R jets	-	14.8	$\tilde{g}$	🟦 1.08 TeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to qqq$	0	4-5 large-R jets	-	14.8	$\tilde{g}$	🟦 1.55 TeV	m($\tilde{\chi}^0_1$)=800 GeV	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}$, $\tilde{g}\to t\bar{t}\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to qqq$	1 e,μ	8-10 jets/0-4 b	-	14.8	$\tilde{g}$	🟦 1.75 TeV	m($\tilde{\chi}^0_1$)=700 GeV	ATLAS-CONF-2016-094
	$\tilde{g}\tilde{g}$, $\tilde{g}\to\tilde{t}_1t$, $\tilde{t}_1\to bs$	1 e,μ	8-10 jets/0-4 b	-	14.8	$\tilde{g}$	🟦 1.4 TeV	625 GeV<m($\tilde{t}_1$)<850 GeV	ATLAS-CONF-2016-094
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to bs$	0	2 jets + 2 b	-	15.4	$\tilde{t}_1$	🟦 410 GeV 🟦 450-510 GeV		ATLAS-CONF-2016-022, ATLAS-CONF-2016-084
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\ell$	2 e,μ	2 b	-	20.3	$\tilde{t}_1$	🟩 0.4-1.0 TeV	BR($\tilde{t}_1\to be/\mu$)>20%	ATLAS-CONF-2015-015
Other	Scalar charm, $\tilde{c}\to c\tilde{\chi}^0_1$	0	2 c	Yes	20.3	$\tilde{c}$	🟩 510 GeV	m($\tilde{\chi}^0_1$)<200 GeV	1501.01325

*Only a selection of the available mass limits on new states or phenomena is shown.

Summary and conclusions

- Run-2 with pp collisions at **13 TeV** has been phenomenal, with more than **25** fb^{-1} of data collected from ATLAS until first week of September 2016

- Most results presented here with **13-18 fb**$^{-1}$ shown for just some signature of interest

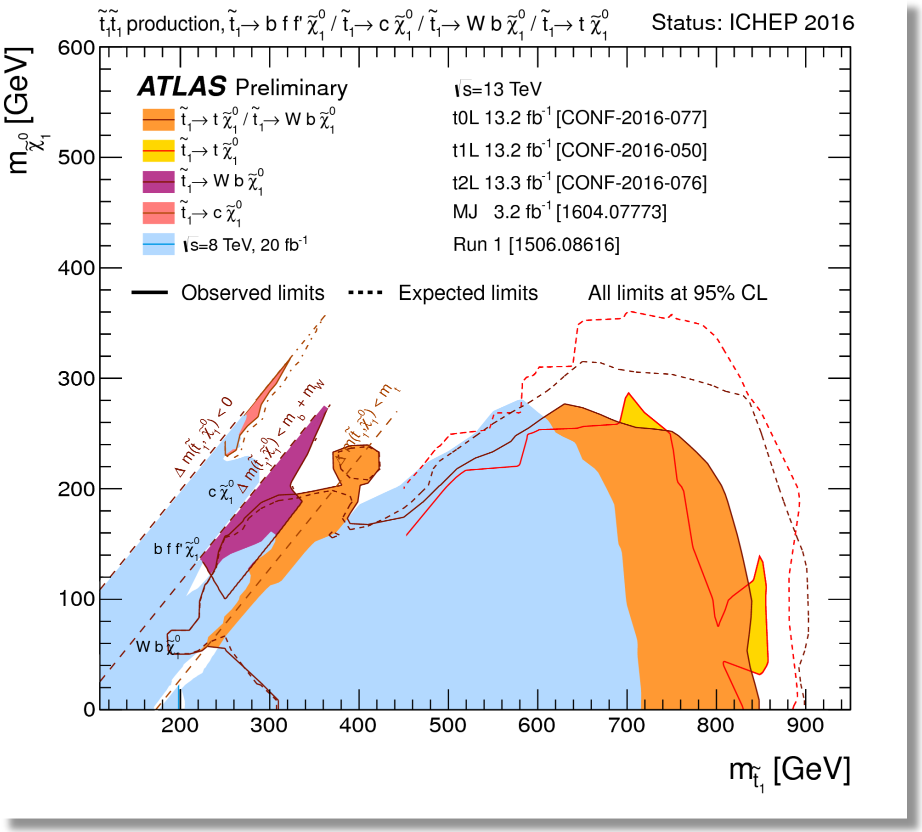
- Many other results have been produced and are reported in backup slides

- Search strategy for SUSY has been extended with respect to Run-1

- **No significant excess** of events has been found so far and all results agree well with Standard Model

- LHC is expected to deliver **up 40 fb**$^{-1}$ in 2016 and many more regions will be tested to update limits

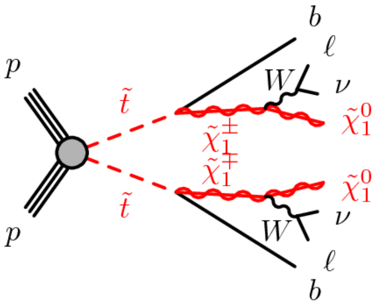
- A very challenging year for SUSY !

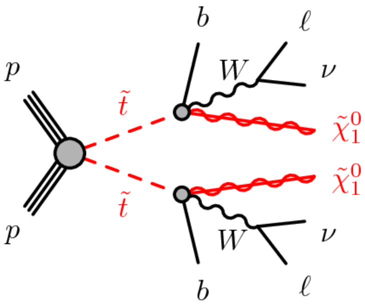


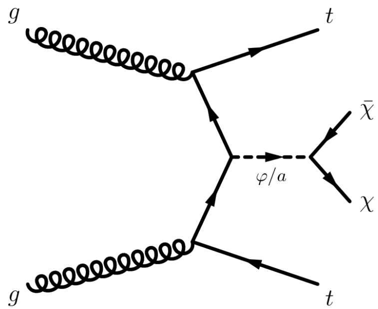
Backup slides

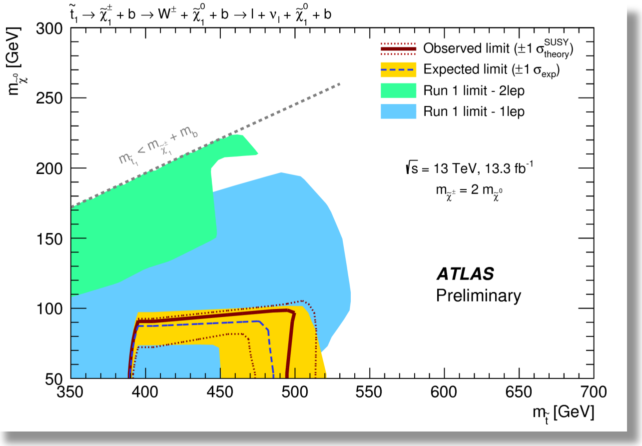
ATLAS-CONF-2016-076

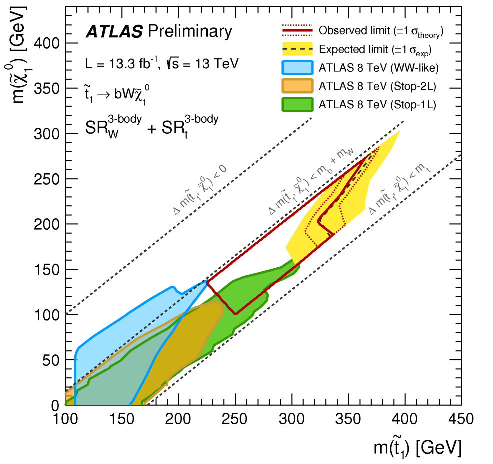
3rd Gen: Stop (DM) in 2L

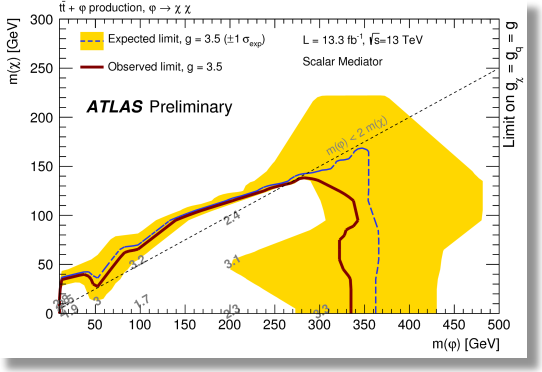










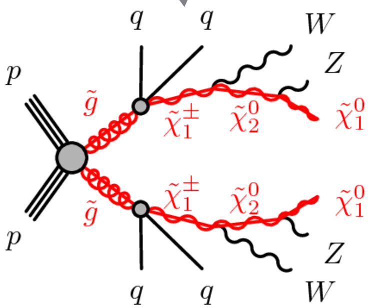


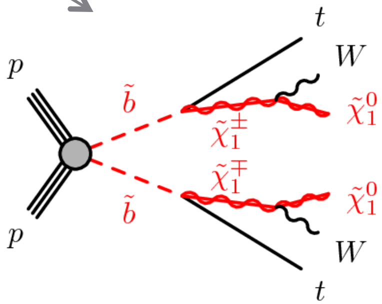
- Topology: 2 leptons+(b)Jets + MET
- discrimination based on Super-Razor(three-Body), MT2(ll)(bb), (2+4+2) Signal Regions addressed
- The chargino decay mode is excluded for a stop mass between 400 and 495 GeV, a chargino mass of 100 GeV and a neutralino mass of 50 GeV (left)
- For a mass difference of 90 GeV between the stop and the neutralino and the three body decay mode, a stop mass below 365 GeV is excluded
- For the models of the associated production of DM with top pairs, mediator mass < 330 GeV and DM particle mass < 20 GeV excluded

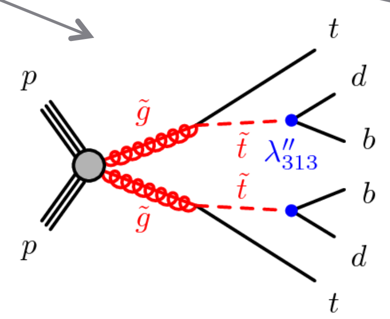
ATLAS-CONF-2016-037

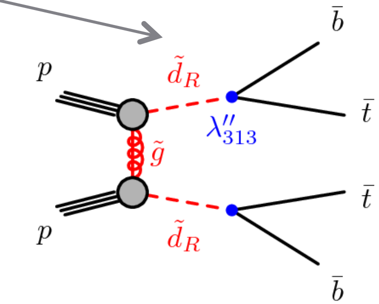
Strong Prod: SS/3L+Jets+MET

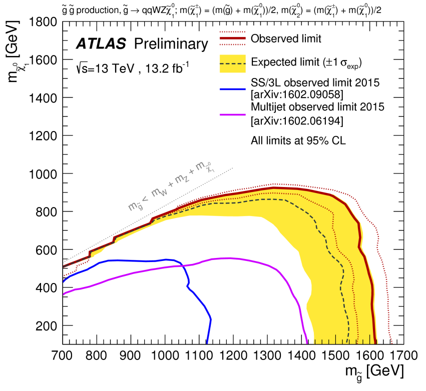
- Very clean channel, very small SM background, Sbottom prod
- Sensible to 4 R-Parity Conserving and 4 R-Parity Violating Models
- 4 RPC + 3 RPV Signal Regions addressed

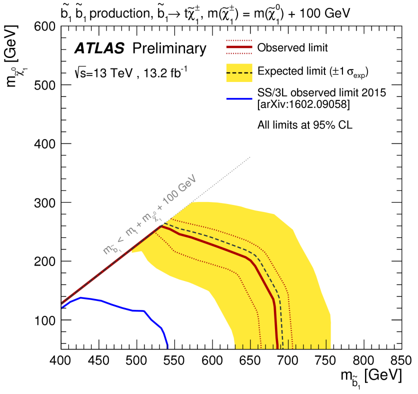


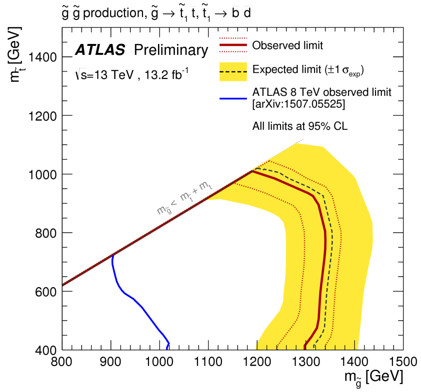


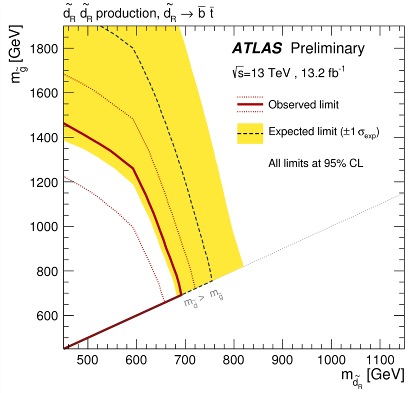






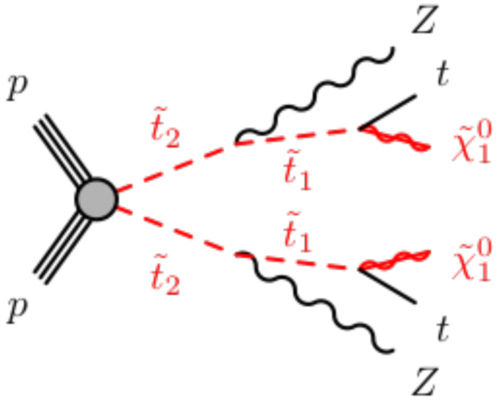






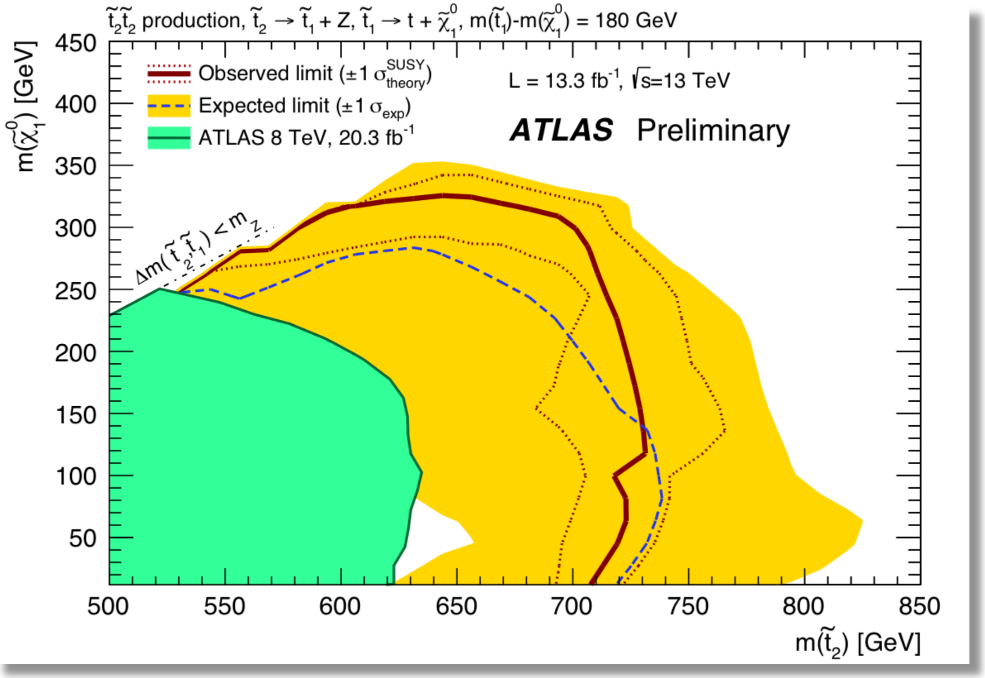
ATLAS-CONF-2016-038

3rd Gen: Stop in Z



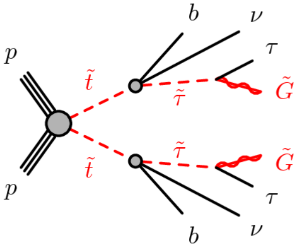
- Search for heavier stop state $\tilde{t}_2$
- Topology: Z(ll)+l+(b)Jets +MET
- Variables used: MET, p_T^{ll}
- 3 Signal Region
- Masses of the $\tilde{t}_2$ up to 730 GeV and and LSP up to 325 are excluded

Var/Region	SRL	SRH	SRE
$m_{\ell\ell}$ [GeV]	76.2–106.2	76.2–106.2	76.2–106.2
Leading lepton p_{T} [GeV]	> 40	> 40	> 40
Leading jet p_{T} [GeV]	> 60	> 100	> 80
$n_{\mathrm{b-jets}}$	≥ 1	≥ 1	≥ 1
n_{jets}	≥ 6	≥ 5	≥ 5
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 100	> 100	> 100
$p_{\mathrm{T}}^{\ell\ell}$ [GeV]	–	> 200	> 100

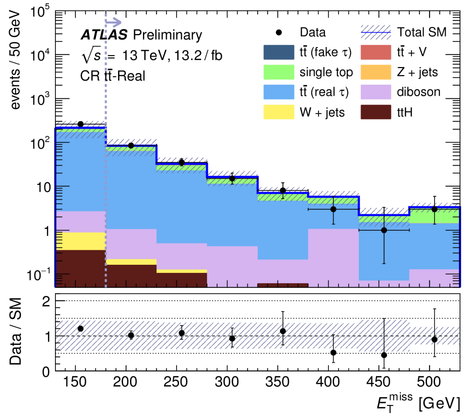


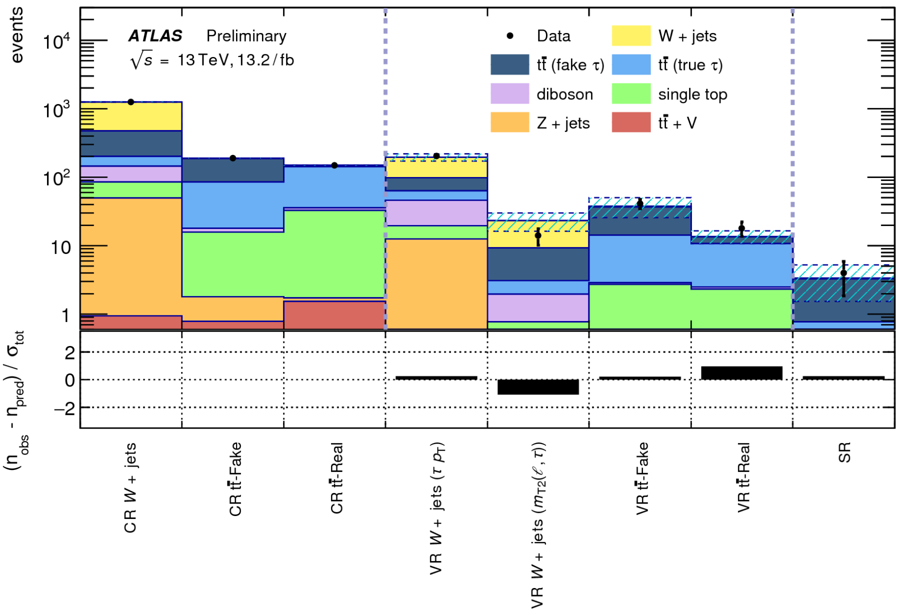
ATLAS-CONF-2016-048

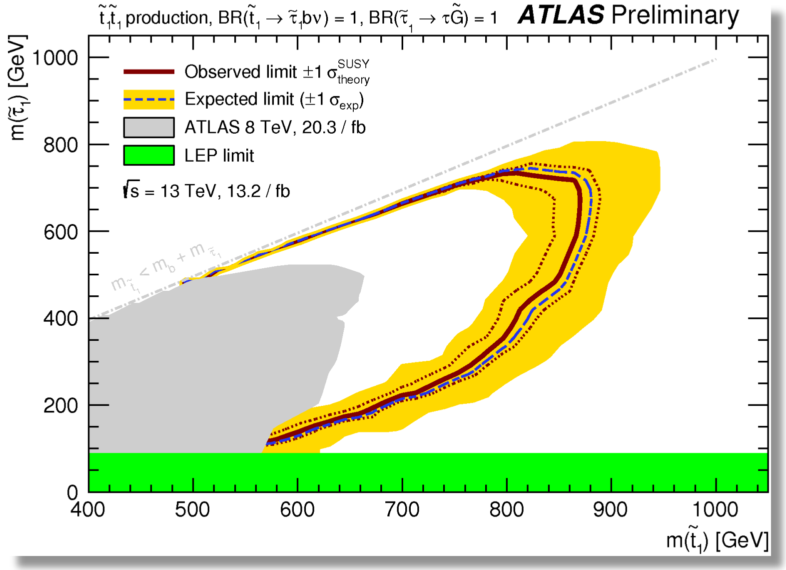
3^{rd} Gen: Stop in Stau



- Search for stop with 2τ +(b)jets +MET (GMSB, nGM)
- Signal to BG discrimination based on: MET, MT2
- 1 SR defined targeting high stop mass region
- Masses of the top squark up to 870 GeV and stau up to 730 GeV are excluded

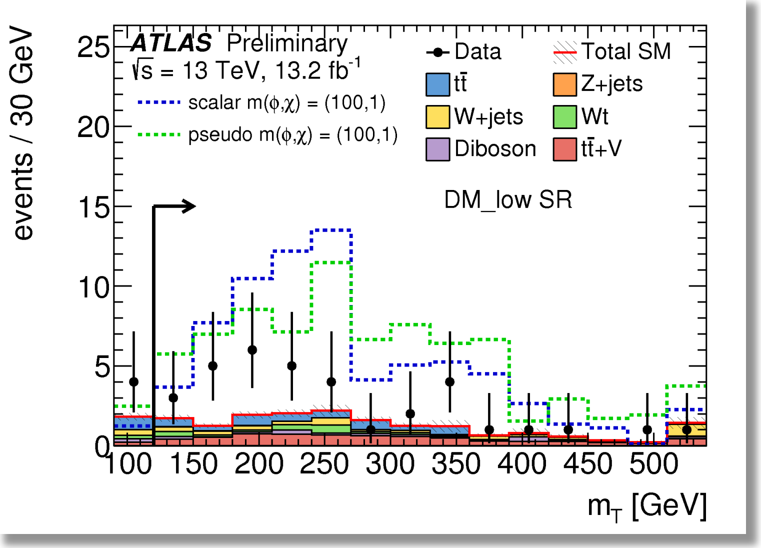


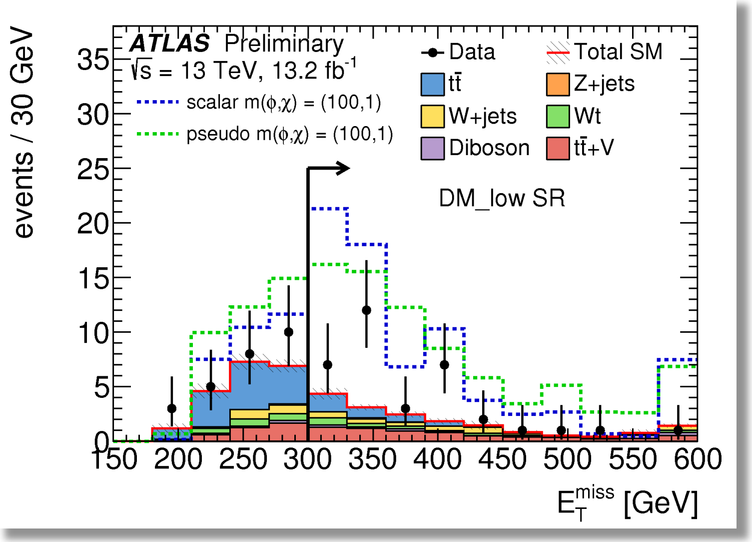


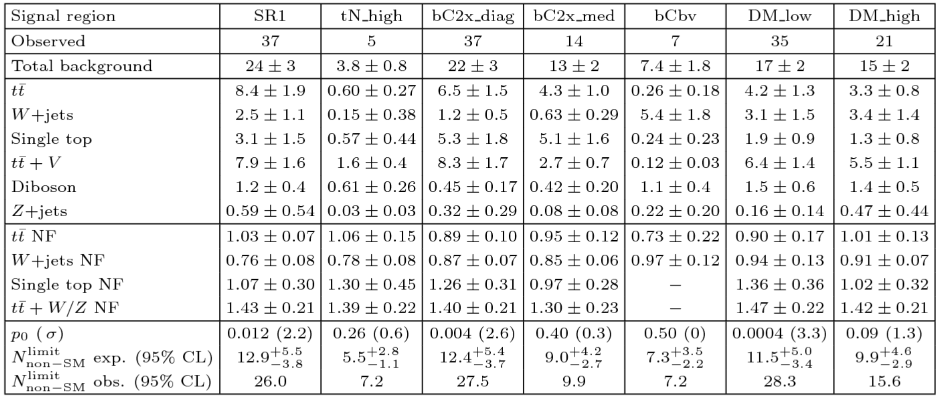


ATLAS-CONF-2016-050

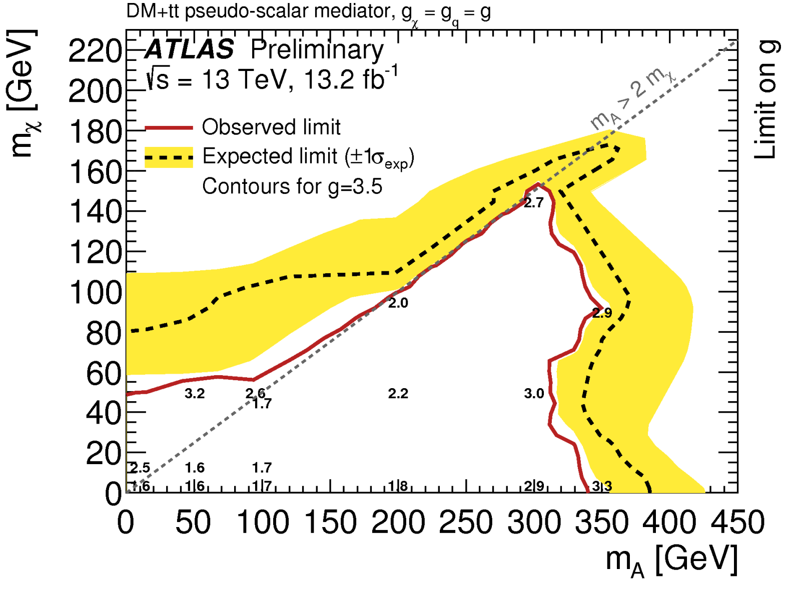
3rd Gen: Stop in 1L excess





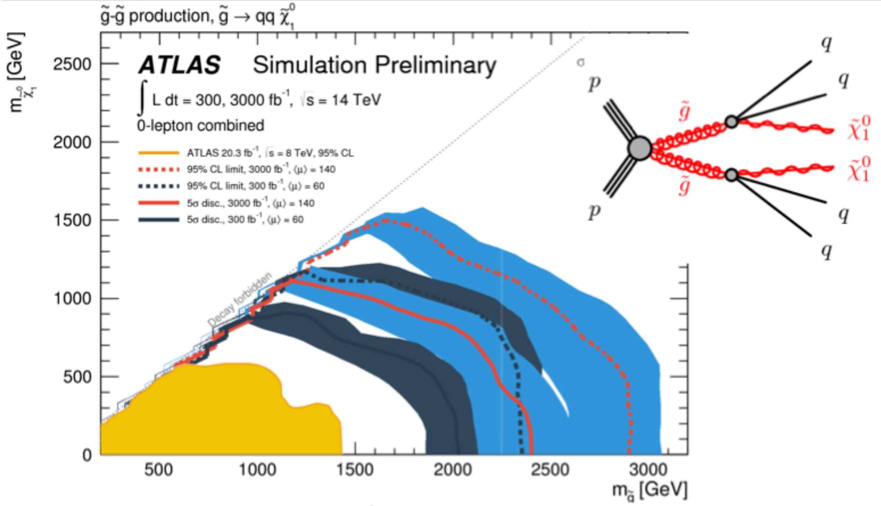


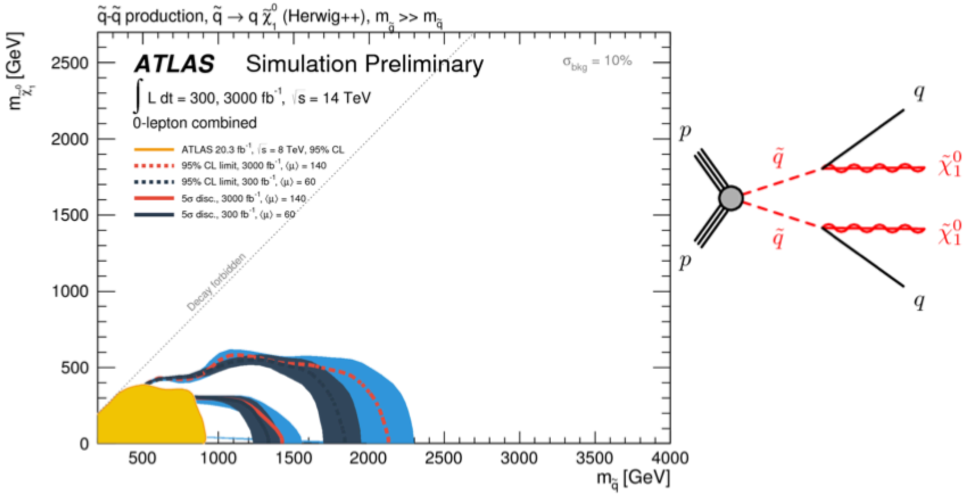
Signal region	SR1	tN_high	bC2x_diag	bC2x_med	bCbv	DM_low	DM_high
Observed	37	5	37	14	7	35	21
Total background	24 ± 3	3.8 ± 0.8	22 ± 3	13 ± 2	7.4 ± 1.8	17 ± 2	15 ± 2
$t\bar{t}$	8.4 ± 1.9	0.60 ± 0.27	6.5 ± 1.5	4.3 ± 1.0	0.26 ± 0.18	4.2 ± 1.3	3.3 ± 0.8
W+jets	2.5 ± 1.1	0.15 ± 0.38	1.2 ± 0.5	0.63 ± 0.29	5.4 ± 1.8	3.1 ± 1.5	3.4 ± 1.4
Single top	3.1 ± 1.5	0.57 ± 0.44	5.3 ± 1.8	5.1 ± 1.6	0.24 ± 0.23	1.9 ± 0.9	1.3 ± 0.8
$t\bar{t} + V$	7.9 ± 1.6	1.6 ± 0.4	8.3 ± 1.7	2.7 ± 0.7	0.12 ± 0.03	6.4 ± 1.4	5.5 ± 1.1
Diboson	1.2 ± 0.4	0.61 ± 0.26	0.45 ± 0.17	0.42 ± 0.20	1.1 ± 0.4	1.5 ± 0.6	1.4 ± 0.5
Z+jets	0.59 ± 0.54	0.03 ± 0.03	0.32 ± 0.29	0.08 ± 0.08	0.22 ± 0.20	0.16 ± 0.14	0.47 ± 0.44
$t\bar{t}$ NF	1.03 ± 0.07	1.06 ± 0.15	0.89 ± 0.10	0.95 ± 0.12	0.73 ± 0.22	0.90 ± 0.17	1.01 ± 0.13
W+jets NF	0.76 ± 0.08	0.78 ± 0.08	0.87 ± 0.07	0.85 ± 0.06	0.97 ± 0.12	0.94 ± 0.13	0.91 ± 0.07
Single top NF	1.07 ± 0.30	1.30 ± 0.45	1.26 ± 0.31	0.97 ± 0.28	–	1.36 ± 0.36	1.02 ± 0.32
$t\bar{t} + W/Z$ NF	1.43 ± 0.21	1.39 ± 0.22	1.40 ± 0.21	1.30 ± 0.23	–	1.47 ± 0.22	1.42 ± 0.21
p_0 (σ)	0.012 (2.2)	0.26 (0.6)	0.004 (2.6)	0.40 (0.3)	0.50 (0)	0.0004 (3.3)	0.09 (1.3)
$N^{\rm limit}_{\rm non-SM}$ exp. (95% CL)	$12.9^{+5.5}_{-3.8}$	$5.5^{+2.8}_{-1.1}$	$12.4^{+5.4}_{-3.7}$	$9.0^{+4.2}_{-2.7}$	$7.3^{+3.5}_{-2.2}$	$11.5^{+5.0}_{-3.4}$	$9.9^{+4.6}_{-2.9}$
$N^{\rm limit}_{\rm non-SM}$ obs. (95% CL)	26.0	7.2	27.5	9.9	7.2	28.3	15.6

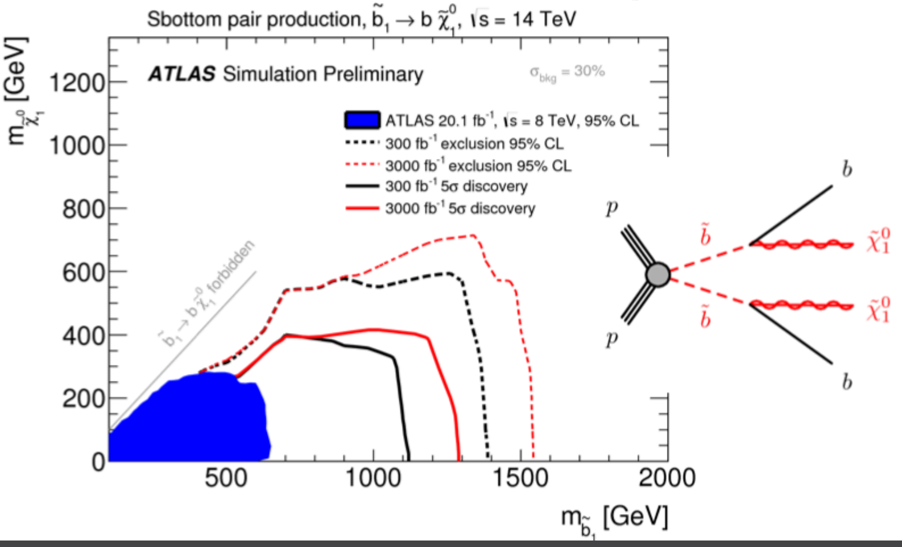


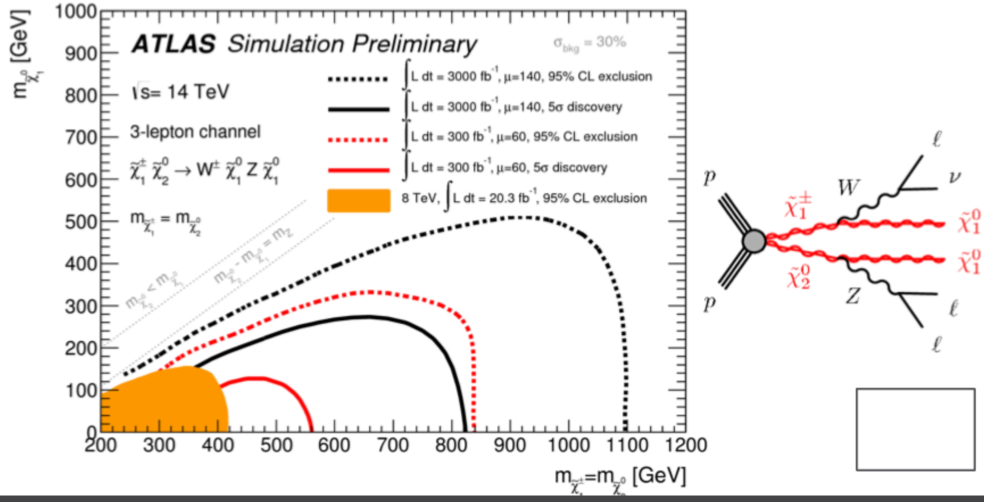
SUSY prospects (ATLAS-PHYS-PUB-2014-010)

- ATLAS studied long term prospects for the (HL-)LHC with 300, 3000 fb^{-1}@14 TeV
- Discovery potential up **to 2.5 TeV gluinos, 1.3 TeV squarks/sbottom and 800 GeV Electroweakinos**









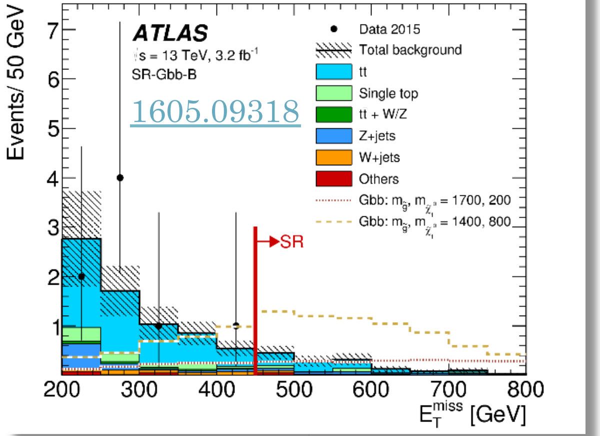
SUSY signal properties

- SUSY processes are generally characterized by large activity in the event, so they have high values of:

$$H_{\mathrm{T}} = p_{\mathrm{T}}^{\ell} + \sum_{i-1}^{N_{\mathrm{jet}}} p_{\mathrm{T},j}$$

$$m_{\mathrm{eff}}^{\mathrm{inc}} = p_{\mathrm{T}}^{\ell} + \sum_{i-1}^{N_{\mathrm{jet}}} p_{\mathrm{T},j} + E_{\mathrm{T}}^{\mathrm{miss}}$$

$$m_{\mathrm{T}} = \sqrt{2 p_{\mathrm{T}}^{\ell} E_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos[\Delta\phi(\boldsymbol{p}_{\mathrm{T}}^{\ell}, \boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}})])},$$



1605.09318

$$m_{\mathrm{T2}}(\mathbf{p}_{\mathrm{T},1}, \mathbf{p}_{\mathrm{T},2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}) = \min_{\mathbf{q}_{\mathrm{T},1}+\mathbf{q}_{\mathrm{T},2}=\mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}} \{\max[\, m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T},1}, \mathbf{q}_{\mathrm{T},1}), m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T},2}, \mathbf{q}_{\mathrm{T},2}) \,]$$

- Mass splitting between SUSY particles can be:
  - **Large** ⇒ production of boosted unstable particles (W, Z, top).
  - **Small** ⇒ presence of soft objects escaping reconstruction/detection: an additional hard jet (from ISR) is often required to get more boost, but introduces ISR systematics to be studied.

- N.B.: in the following, only $\boldsymbol{e}^{\pm}$ and $\boldsymbol{\mu}^{\pm}$ are considered as *«leptons»*

Definition of transverse masses

Transverse mass m_T

$$m_T^2(\mathbf{p}_T^1, \mathbf{p}_T^2) = [E_T^1 + E_T^2]^2 - [\mathbf{p}_T^1 + \mathbf{p}_T^2]^2$$

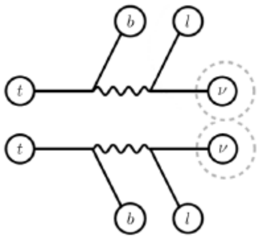
- $m_T \equiv m_T(\ell, E_T^{miss}) = \sqrt{2 p_T^\ell E_T^{miss}[1 - \cos\Delta\phi(\mathbf{p}_T^\ell, \mathbf{p}_T^{miss})]}$ bounded by m_W: reduce $WW, Wt, t\bar{t}$

Stransverse mass m_{T2}

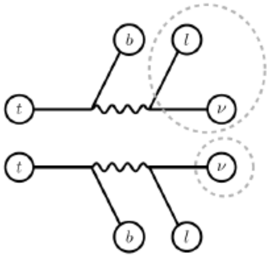
- generalization of m_T to pair decay with final state consisting of 2 visible objects and E_T^{miss}

$$m_{T2}(\mathbf{p}_T^1, \mathbf{p}_T^2, \mathbf{q}_T) = \min_{\mathbf{q}_T^1 + \mathbf{q}_T^2 = \mathbf{q}_T} \left\{ \max[m_T(\mathbf{p}_T^1, \mathbf{q}_T^1), m_T(\mathbf{p}_T^2, \mathbf{q}_T^2)] \right\}$$

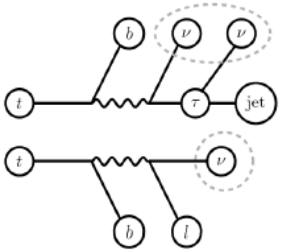
- $m_{T2} \equiv m_{T2}(\mathbf{p}_T^{l_1}, \mathbf{p}_T^{l_2}, \mathbf{p}_T^{miss})$ bounded by m_W: reduce $WW, Wt, t\bar{t} \to 2\ell$
- am_{T2} bounded by m_t: reduce $t\bar{t} \to 2\ell$ with a lost lepton
- m_{T2}^τ bounded by m_W: reduce $t\bar{t} \to \ell\tau^{had}$



m_{T2}



am_{T2}



m_{T2}^τ