

FlexibleFuture

Alexander Voigt

RWTH Aachen

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Current limits on SUSY particle masses

ATLAS SUSY Searches* - 95% CL Lower Limits

May 2017

ATLAS Preliminary

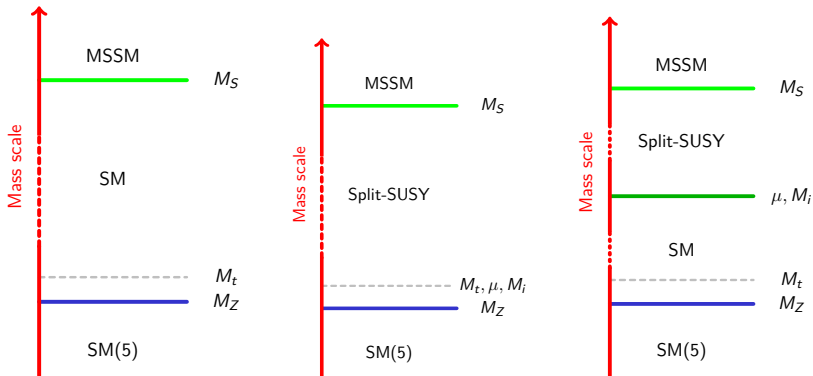
$\sqrt{s} = 7, 8, 13 \text{ TeV}$

Model	$\epsilon, \mu, \tau, \gamma$	Jets	E_T^{miss}	$\int \mathcal{L} d\text{th}^{-1}$	Mass limit	$\sqrt{s} = 7, 8 \text{ TeV}$	$\sqrt{s} = 13 \text{ TeV}$	Reference	
Inclusive Searches	MSUGRA/CMSSM	$0.3 \epsilon, \mu^{1/2} \tau$	2-10 jets/3 b	Yes	20.3	#	1.85 TeV	$m(\tilde{g})=m(\tilde{u})$ 1507.05525	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0	2-6 jets	Yes	36.1	#	1.57 TeV	$m(\tilde{g})=200 \text{ GeV}, m(\tilde{t}^*) \text{ gen. q}(j)=m(\tilde{t}^*) \text{ gen. d}$ ATLAS-CONF-2017-022	
	$\tilde{g}, \tilde{u}, \tilde{d}$ (compressed)	mono-jet	1-3 jets	Yes	3.2	#	908 GeV	$m(\tilde{g})=m(\tilde{t}^*)=5 \text{ GeV}$ 1604.07773	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0	2-6 jets	Yes	36.1	#	2.02 TeV	$m(\tilde{g})=200 \text{ GeV}$ ATLAS-CONF-2017-022	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0	2-6 jets	Yes	36.1	#	2.01 TeV	$m(\tilde{g})=200 \text{ GeV}, m(\tilde{t}^*)=0.5 m(\tilde{t}^*)+m(\tilde{g})$ ATLAS-CONF-2017-022	
	$\tilde{g}, \tilde{u}, \tilde{d}$	3	4 jets	Yes	36.1	#	1.825 TeV	$m(\tilde{g})=400 \text{ GeV}$ ATLAS-CONF-2017-030	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0	7-11 jets	Yes	36.1	#	1.8 TeV	$m(\tilde{g})=400 \text{ GeV}$ ATLAS-CONF-2017-033	
	$\tilde{g}, \tilde{u}, \tilde{d}$	1-2 $\tau + 0, 1 \ell$	0-2 jets	Yes	3.2	#	2.0 TeV	$m(\tilde{g})=200 \text{ GeV}$ 1607.05979	
	GMSB (if NLSP)	2 γ	-	Yes	3.2	#	1.65 TeV	$\tau \rightarrow \text{NLSP} \rightarrow 0, 1 \text{ mm}$ 1606.09150	
	GGM (Higgsino-bino NLSP)	7	1 jet	Yes	20.3	#	1.37 TeV	$m(\tilde{g})=950 \text{ GeV}, m(\text{NLSP}) \leq 0, 1 \text{ mm}, \mu=0$ 1507.05493	
	GGM (Higgsino-bino NLSP)	7	2 jets	Yes	13.8	#	1.8 TeV	$m(\tilde{g})=600 \text{ GeV}, m(\text{NLSP}) < 0, 1 \text{ mm}, \mu=0$ ATLAS-CONF-2016-066	
	GGM (Higgsino NLSP)	2 ϵ, μ (Z)	2 jets	Yes	20.3	#	900 GeV	$m(\tilde{g})=430 \text{ GeV}$ 1503.03390	
Gravitino LSP	0	mono-jet	Yes	20.3	# ¹⁷ scale	865 GeV	$m(\tilde{G}) > 1.8 \times 10^{13} \text{ eV}, m(\tilde{g})=m(\tilde{g})=1.5 \text{ TeV}$ 1502.01518		
if \tilde{g} gen. squark direct	$\tilde{g}, \tilde{u}, \tilde{d}$	0	3 b	Yes	36.1	#	1.92 TeV	$m(\tilde{g})=600 \text{ GeV}$ ATLAS-CONF-2017-021	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0-1 ϵ, μ	3 b	Yes	36.1	#	1.97 TeV	$m(\tilde{g})=200 \text{ GeV}$ ATLAS-CONF-2017-021	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0-1 ϵ, μ	3 b	Yes	20.1	#	1.37 TeV	$m(\tilde{g})=300 \text{ GeV}$ 1407.8600	
if \tilde{g} gen. squark direct production	$\tilde{g}, \tilde{u}, \tilde{d}$	0	2 b	Yes	36.1	#	990 GeV	$m(\tilde{g})=420 \text{ GeV}$ ATLAS-CONF-2017-038	
	$\tilde{g}, \tilde{u}, \tilde{d}$	2 ϵ, μ (SS)	1 b	Yes	36.1	#	275-700 GeV	$m(\tilde{g})=200 \text{ GeV}, m(\tilde{t}^*)=m(\tilde{t}^*)+100 \text{ GeV}$ ATLAS-CONF-2017-030	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0-2 ϵ, μ	1-2 b	Yes	4.71/3.13	#	117-170 GeV	$m(\tilde{g})=200 \text{ GeV}$ 1309.2102, ATLAS-CONF-2016-077	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0-2 ϵ, μ	0-2 jets/1-2 b	Yes	20.3/36.1	#	199-950 GeV	$m(\tilde{g})=200 \text{ GeV}, m(\tilde{t}^*)=55 \text{ GeV}$ 1506.08616, ATLAS-CONF-2017-020	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0	mono-jet	Yes	3.2	#	90-323 GeV	$m(\tilde{g}), m(\tilde{t}^*) \leq \text{GeV}$ 1604.07773	
	$\tilde{g}, \tilde{u}, \tilde{d}$ (natural GMSB)	2 ϵ, μ (Z)	1 b	Yes	20.3	#	150-600 GeV	$m(\tilde{g}) > 150 \text{ GeV}$ 1403.5222	
	$\tilde{g}, \tilde{u}, \tilde{d}$	3 ϵ, μ (Z)	1 b	Yes	36.1	#	290-790 GeV	$m(\tilde{g})=0 \text{ GeV}$ ATLAS-CONF-2017-019	
	$\tilde{g}, \tilde{u}, \tilde{d}$	1-2 ϵ, μ	4 b	Yes	36.1	#	320-850 GeV	$m(\tilde{g})=0 \text{ GeV}$ ATLAS-CONF-2017-019	
	$\tilde{g}, \tilde{u}, \tilde{d}$	2 ϵ, μ	0	Yes	36.1	#	90-440 GeV	$m(\tilde{g})=0$ ATLAS-CONF-2017-039	
	$\tilde{g}, \tilde{u}, \tilde{d}$	2 ϵ, μ	0	Yes	36.1	#	719 GeV	$m(\tilde{g})=0, m(\tilde{t}^*)=0.5 m(\tilde{t}^*)+m(\tilde{t}^*)$ ATLAS-CONF-2017-038	
$\tilde{g}, \tilde{u}, \tilde{d}$	2 ϵ, μ	0	Yes	36.1	#	760 GeV	$m(\tilde{g})=0, m(\tilde{t}^*)=0.5 m(\tilde{t}^*)+m(\tilde{t}^*)$ ATLAS-CONF-2017-035		
EW direct	$\tilde{g}, \tilde{u}, \tilde{d}$	2 ϵ, μ	0	Yes	36.1	#	1.16 TeV	$m(\tilde{g})=m(\tilde{t}^*), m(\tilde{t}^*)=0, m(\tilde{t}^*)=0.5 m(\tilde{t}^*)+m(\tilde{t}^*)$ ATLAS-CONF-2017-039	
	$\tilde{g}, \tilde{u}, \tilde{d}$	2-3 ϵ, μ	0-2 jets	Yes	36.1	#	580 GeV	$m(\tilde{g})=m(\tilde{t}^*), m(\tilde{t}^*)=0, \tilde{f} \text{ decoupled}$ ATLAS-CONF-2017-039	
	$\tilde{g}, \tilde{u}, \tilde{d}$	3 ϵ, μ	0	Yes	20.3	#	270 GeV	$m(\tilde{g})=m(\tilde{t}^*), m(\tilde{t}^*)=0, \tilde{f} \text{ decoupled}$ 1501.07110	
	$\tilde{g}, \tilde{u}, \tilde{d}$	4 ϵ, μ	0	Yes	20.3	#	635 GeV	$m(\tilde{g})=m(\tilde{t}^*), m(\tilde{t}^*)=0, m(\tilde{t}^*)=0.5 m(\tilde{t}^*)+m(\tilde{t}^*)$ 1405.5086	
	GGM (wino NLSP) weak prod., $\tilde{t}^* \rightarrow \tilde{t}^* \tilde{G}$	1 $\epsilon, \mu + \gamma$	-	Yes	20.3	#	115-370 GeV	$\tau \rightarrow 1 \text{ mm}$ 1507.05493	
	GGM (bino NLSP) weak prod., $\tilde{t}^* \rightarrow \tilde{t}^* \tilde{G}$	2 γ	-	Yes	20.3	#	590 GeV	$\tau \rightarrow 1 \text{ mm}$ 1507.05493	
	Long-lived particles	Direct $\tilde{t}^* \tilde{t}^* \text{ prod., long-lived } \tilde{t}^*$	Disapp. trk	1 jet	Yes	36.1	#	430 GeV	$m(\tilde{g})=m(\tilde{t}^*)=160 \text{ MeV}, m(\tilde{t}^*) \leq 2 \text{ ns}$ ATLAS-CONF-2017-017
		Direct $\tilde{t}^* \tilde{t}^* \text{ prod., long-lived } \tilde{t}^*$	dE/dx trk	-	Yes	18.4	#	405 GeV	$m(\tilde{g})=m(\tilde{t}^*)=180 \text{ MeV}, m(\tilde{t}^*) \leq 15 \text{ ns}$ 1506.09332
		Stable \tilde{g} R-hadron	0	1-5 jets	Yes	27.9	#	850 GeV	$m(\tilde{g})=100 \text{ GeV}, 10 \text{ ps} < \tau < 1000 \text{ s}$ 1310.6504
		Metastable \tilde{g} R-hadron	trk	-	3.2	#	-	1.58 TeV	$m(\tilde{g})=100 \text{ GeV}, \tau > 10 \text{ ns}$ 1606.05129
Metastable \tilde{g} R-hadron		dE/dx trk	-	3.2	#	-	1.57 TeV	$m(\tilde{g})=100 \text{ GeV}, \tau > 10 \text{ ns}$ 1604.04520	
GMSB, stable $\tilde{t}^*, \tilde{t}^* \rightarrow (\tilde{t}^*, \tilde{t}^*) + (\epsilon, \mu)$		1-2 μ	-	Yes	19.1	#	537 GeV	$10 \text{ - decay } \rightarrow 50$ 1411.6795	
GMSB, $\tilde{t}^* \rightarrow \tilde{t}^* \tilde{G}$, long-lived \tilde{t}^*		2 γ	-	Yes	20.3	#	440 GeV	$1 \text{ cm} < \tau < 2 \text{ ns}, \text{SPS8 model}$ 1409.5942	
GGM $\tilde{g}, \tilde{t}^* \rightarrow \tilde{t}^* \tilde{G}$		displ. vtx μ / μ / μ	-	Yes	20.3	#	1.0 TeV	$7 \text{ cm} < \tau < 740 \text{ mm}, m(\tilde{t}^*)=1.3 \text{ TeV}$ 1504.05162	
GGM $\tilde{g}, \tilde{t}^* \rightarrow \tilde{t}^* \tilde{G}$		displ. vtx μ - jets	-	Yes	20.3	#	1.0 TeV	$6 \text{ cm} < \tau < 480 \text{ mm}, m(\tilde{t}^*)=1.1 \text{ TeV}$ 1504.05162	
RPV		LFV $\tilde{g} \tilde{g} \tilde{g} + X, \tilde{t}^* \rightarrow \tilde{t}^* \nu \tau / \mu \tau$	$\mu \nu \tau, \mu \tau$	-	Yes	3.2	#	1.9 TeV	$A_{12} < 0.11, A_{13} < 0.0000007$ 1607.28079
	Bilinear RPV CMSSM	2 ϵ, μ (SS)	0-3 b	Yes	20.3	#	1.45 TeV	$m(\tilde{g})=m(\tilde{t}^*), \tau_{\text{RPV}} < 1 \text{ mm}$ 1404.2500	
	$\tilde{g}, \tilde{u}, \tilde{d}$	4 $\epsilon, \mu + \tau$	-	Yes	13.3	#	1.14 TeV	$m(\tilde{g})=400 \text{ GeV}, A_{13} \neq 0 (\delta = 1, 2)$ ATLAS-CONF-2016-075	
	$\tilde{g}, \tilde{u}, \tilde{d}$	3 $\epsilon, \mu + \tau$	-	Yes	20.3	#	450 GeV	$m(\tilde{g}) > 0.2 \text{ mm}, A_{13} \neq 0$ 1405.5086	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0	4-5 large θ jets	-	14.8	#	1.08 TeV	$\text{BR}(\tilde{g} \rightarrow \text{RPV}) = \text{BR}(\tilde{t}^* \rightarrow \text{RPV}) = 0.75$ ATLAS-CONF-2016-057	
	$\tilde{g}, \tilde{u}, \tilde{d}$	1 ϵ, μ	8-10 jets/0-4 b	-	36.1	#	1.55 TeV	$m(\tilde{g})=800 \text{ GeV}$ ATLAS-CONF-2016-057	
	$\tilde{g}, \tilde{u}, \tilde{d}$	1 ϵ, μ	8-10 jets/0-4 b	-	36.1	#	2.1 TeV	$m(\tilde{g})=1 \text{ TeV}, A_{12} \neq 0$ ATLAS-CONF-2017-013	
	$\tilde{g}, \tilde{u}, \tilde{d}$	1 ϵ, μ	8-10 jets/0-4 b	-	15.4	#	1.65 TeV	$m(\tilde{g})=1 \text{ TeV}, A_{12} \neq 0$ ATLAS-CONF-2017-013	
	$\tilde{g}, \tilde{u}, \tilde{d}$	0	2 jets + 2 b	-	36.1	#	410 GeV	$\text{BR}(\tilde{g} \rightarrow \text{RPV}) = 20\%$ ATLAS-CONF-2016-022, ATLAS-CONF-2016-084	
	$\tilde{g}, \tilde{u}, \tilde{d}$	2 ϵ, μ	2 τ	-	36.1	#	0.4-1.45 TeV	$m(\tilde{g})=200 \text{ GeV}$ ATLAS-CONF-2017-036	
Other	Scalar charm, $\tilde{c} \rightarrow c \tilde{t}^*$	0	2 τ	Yes	20.3	#	510 GeV	$m(\tilde{g})=200 \text{ GeV}$ 1501.01325	

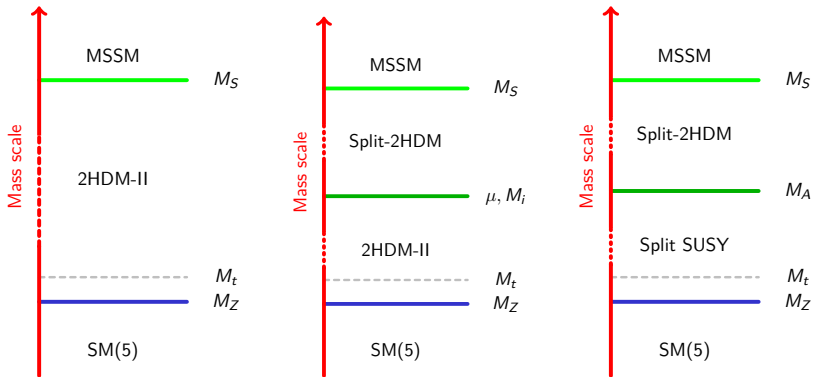
*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

10⁻¹ 1 Mass scale [TeV]

EFT towers with low-scale SM



EFT towers with low-scale 2HDM



Requirements for uncertainty estimate

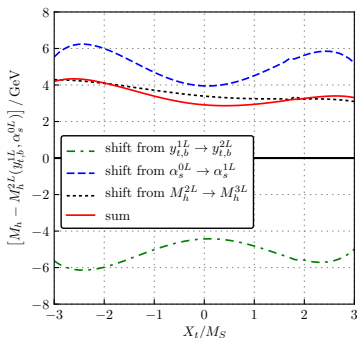
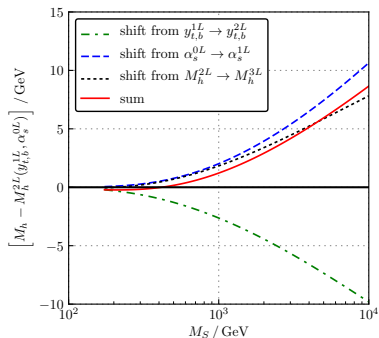
- reasonable
- code specific
- flag specific
- generic (MSSM, NMSSM, THDM, ...)
- $M_S \lesssim 1$ TeV: envelope fixed order 3-loop calculation
- $M_S \gtrsim 1$ TeV: envelope EFT 2-loop calculation

Debatable ways to calculate ΔM_h

fixed order	1L	2L	3L
Q_{pole}	$[M_S/2, 2M_S]$	$[M_S/2, 2M_S]$	$[M_S/2, 2M_S]$
$y_t(M_Z)$	0L vs. 1L	1L vs. 2L	2L vs. 3L
$\alpha_s(M_Z)$	0L vs. 1L	1L vs. 2L	2L vs. 3L
EFT/mixed	$\Delta\lambda^{0L}$	$\Delta\lambda^{1L}$	$\Delta\lambda^{2L}$
Q_{match}	$[M_S/2, 2M_S]$	$[M_S/2, 2M_S]$	$[M_S/2, 2M_S]$
$\lambda(M_S)$	0 vs. $\frac{v^2}{M_S^2}$	0 vs. $\frac{v^2}{M_S^2}$	0 vs. $\frac{v^2}{M_S^2}$
EFT/mixed	$\Delta M_h^{1L}, \beta^{1L}$	$\Delta M_h^{2L}, \beta^{2L}$	$\Delta M_h^{3L}, \beta^{3L}$
Q_{pole}	$[M_t/2, 2M_t]$	$[M_t/2, 2M_t]$	$[M_t/2, 2M_t]$
$y_t(M_Z)$	0L vs. 1L	1L vs. 2L	2L vs. 3L
$\alpha_s(M_Z)$	0L vs. 1L	1L vs. 2L	2L vs. 3L

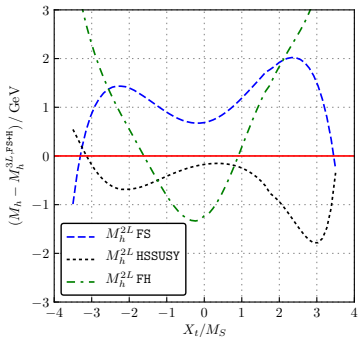
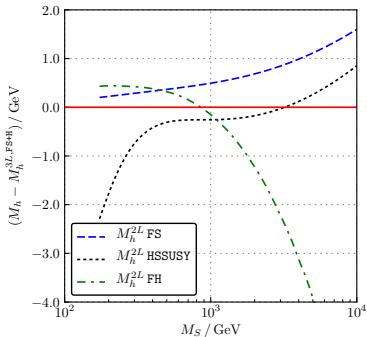
M_h in the MSSM at fixed loop order

Large cancellations:



$\tan \beta = 5$, $X_t = 0$, $M_S = 2 \text{ TeV}$

M_h in the MSSM at fixed loop order



$\tan \beta = 5$, $X_t = 0$, $M_S = 2 \text{ TeV}$