Supersymmetric Particle Searches

The exclusion of particle masses within a mass range \((m_1, m_2)\) will be denoted with the notation “none \(m_1 - m_2\)” in the VALUE column of the following Listings. The latest unpublished results are described in the “Supersymmetry: Experiment” review.

See the related review(s):

- Supersymmetry, Part I (Theory)
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Supersymmetry miscellaneous results

Most of the results shown below, unless stated otherwise, are based on the Minimal Supersymmetric Standard Model (MSSM), as described in the Note on Supersymmetry. Unless otherwise indicated, this includes the assumption of common gaugino and scalar masses at the scale of Grand Unification (GUT), and use of the resulting relations in the spectrum and decay branching ratios. Unless otherwise indicated, it is also assumed that $R$-parity ($R$) is conserved and that:

1) The $\tilde{\chi}_1^0$ is the lightest supersymmetric particle (LSP)
2) $m_{\tilde{f}_L} = m_{\tilde{f}_R}$, where $\tilde{f}_{L,R}$ refer to the scalar partners of left- and right-handed fermions.

Limits involving different assumptions are identified in the Comments or in the Footnotes. We summarize here the notations used in this Chapter to characterize some of the most common deviations from the MSSM (for further details, see the Note on Supersymmetry).

Theories with $R$-parity violation ($\bar{R}$) are characterized by a superpotential of the form: $\lambda_{ijk}L_iL_je_k^c + \lambda'_{ijk}L_iQ_jd_k^c + \lambda''_{ijk}u_i^cL_j^cL_j^c$, where $i, j, k$ are generation indices. The presence of any of these couplings is often identified in the following by the symbols $LLE$, $LQD$, and $UDD$. Mass limits in the presence of $\bar{R}$ will often refer to “direct” and “indirect” decays. Direct refers to $\bar{R}$ decays of the particle in consideration. Indirect refers to cases where $\bar{R}$ appears in the decays of the LSP. The LSP need not be the $\tilde{\chi}_1^0$.

In several models, most notably in theories with so-called Gauge Mediated Supersymmetry Breaking (GMSB), the gravitino ($\tilde{G}$) is the LSP. It is usually much lighter than any other massive particle in the spectrum, and $m_{\tilde{G}}$ is then neglected in all decay processes involving gravitinos. In these scenarios,
particles other than the neutralino are sometimes considered as the next-to-lighest supersymmetric particle (NLSP), and are assumed to decay to their even-$R$ partner plus $\tilde{G}$. If the lifetime is short enough for the decay to take place within the detector, $\tilde{G}$ is assumed to be undetected and to give rise to missing energy ($E$) or missing transverse energy ($E_T$) signatures.

When needed, specific assumptions on the eigenstate content of $\tilde{\chi}^0$ and $\tilde{\chi}^{\pm}$ states are indicated, using the notation $\tilde{\gamma}$ (photino), $\tilde{H}$ (higgsino), $\tilde{W}$ (wino), and $\tilde{Z}$ (zino) to signal that the limit of pure states was used. The terms gaugino is also used, to generically indicate wino-like charginos and zino-like neutralinos.

In the listings we have made use of the following abbreviations for simplified models employed by the experimental collaborations in supersymmetry searches published in the past year.

**WARNING:** Experimental lower mass limits determined within simplified models are to be treated with extreme care as they might not be directly applicable to realistic models. This is outlined in detail in the publications and we recommend consulting them before using bounds. For example, branching ratios, typically fixed to specific values in simplified models, can vary substantially in more elaborate models.

**Simplified Models Table**

- **Tglu1A:** gluino pair production with $\tilde{g} \rightarrow q\bar{q}\tilde{\chi}^0_1$.
- **Tglu1B:** gluino pair production with $\tilde{g} \rightarrow qq'\tilde{\chi}^{\pm}_1, \tilde{\chi}^{\pm}_1 \rightarrow W^{\pm} \tilde{\chi}^0_1$.
- **Tglu1C:** gluino pair production with a 2/3 probability of having a $\tilde{g} \rightarrow qq'\tilde{\chi}^+_1, \tilde{\chi}^+_1 \rightarrow W^+ \tilde{\chi}^0_1$ decay and a 1/3 probability of having a $\tilde{g} \rightarrow qq\tilde{\chi}^0_2, \tilde{\chi}^0_2 \rightarrow Z^{\pm} \tilde{\chi}^0_1$ decay.
- **Tglu1D:** gluino pair production with one gluino decaying to $qq'\tilde{\chi}^{\pm}_1$ with $\tilde{\chi}^{\pm}_1 \rightarrow W^{\pm} + \tilde{G}$, and the other gluino decaying to $qq\tilde{\chi}^0_1$ with $\tilde{\chi}^0_1 \rightarrow \gamma + \tilde{G}$.
**Tglu1E:** gluino pair production with $\tilde{g} \to q\bar{q}\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_1^{\pm} \to W^\pm \tilde{\chi}_2^0$ and $\tilde{\chi}_2^0 \to Z^\pm \tilde{\chi}_1^0$ where $m_{\tilde{\chi}_1^\pm} = (m_{\tilde{g}} + m_{\tilde{\chi}_1^0})/2$, $m_{\tilde{\chi}_2^0} = (m_{\tilde{\chi}_1^\pm} + m_{\tilde{\chi}_1^0})/2$.

**Tglu1F:** gluino pair production with $\tilde{g} \to q\bar{q}\tilde{\chi}_1^{\pm}$ or $\tilde{g} \to q\bar{q}\tilde{\chi}_2^0$ with equal branching ratios, where $\tilde{\chi}_1^{\pm}$ decays through an intermediate scalar tau lepton or sneutrino to $\tau\nu\tilde{\chi}_1^0$ and where $\tilde{\chi}_2^0$ decays through an intermediate scalar tau lepton or sneutrino to $\tau^+\tau^-\tilde{\chi}_1^0$ or $\nu\tilde{\chi}_1^0$; the mass hierarchy is such that $m_{\tilde{\chi}_1^\pm} \sim m_{\tilde{g}}$.

**Tglu1G:** gluino pair production with $\tilde{g} \to q\bar{q}\tilde{\chi}_2^0$, and $\tilde{\chi}_2^0$ decaying through an intermediate slepton or sneutrino to $l^+l^-\tilde{\chi}_1^0$ or $\nu\tilde{\chi}_1^0$ where $m_{\tilde{\chi}_2^0} = (m_{\tilde{g}} + m_{\tilde{\chi}_1^0})/2$ and $m_{\tilde{\chi}_2^0} = (m_{\tilde{\chi}_2^0} + m_{\tilde{\chi}_1^0})/2$.

**Tglu1H:** gluino pair production with $\tilde{g} \to q\bar{q}\tilde{\chi}_2^0$, and $\tilde{\chi}_2^0 \to \chi^0_1 Z^{0(*)}$.

**Tglu1I:** gluino pair production with $\tilde{g} \to q\bar{q}\tilde{\chi}_2^0$, and $\tilde{\chi}_2^0 \to \chi^0_1 H$.

**Tglu1L:** gluino pair production where $\tilde{g} \to q\bar{q}\tilde{\chi}_1^0$ happens with 1/3 probability and $\tilde{g} \to q\bar{q}\tilde{\chi}_1^{\pm}$ happens with 2/3 probability. The $\tilde{\chi}_1^{\pm}$ is assumed to be few hundreds of MeV heavier than the $\tilde{\chi}_1^0$, and decays to $\tilde{\chi}_1^0$ via a pion.

**Tglu2A:** gluino pair production with $\tilde{g} \to bb\tilde{\chi}_1^0$.

**Tglu3A:** gluino pair production with $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$.

**Tglu3B:** gluino pair production with $\tilde{g} \to t\bar{t}$ where $\tilde{t}$ decays exclusively to $t\tilde{\chi}_1^0$.

**Tglu3C:** gluino pair production with $\tilde{g} \to t\bar{t}$ where $\tilde{t}$ decays exclusively to $t\tilde{\chi}_1^0$.

**Tglu3D:** gluino pair production with $\tilde{g} \to tb\tilde{\chi}_1^{\pm}$ with $\tilde{\chi}_1^{\pm} \to W^\pm \tilde{\chi}_1^0$.

**Tglu3E:** gluino pair production where the gluino decays 25% of the time through $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$, 25% of the time through $\tilde{g} \to bb\tilde{\chi}_1^0$ and 50% of the time through $\tilde{g} \to tb\tilde{\chi}_1^{\pm}$ with $\tilde{\chi}_1^{\pm} \to W^\pm \tilde{\chi}_1^0$.

**Tglu4A:** gluino pair production with one gluino decaying to $q\bar{q}\tilde{\chi}_1^{\pm}$ with $\tilde{\chi}_1^{\pm} \to W^\pm G$, and the other gluino decaying to $q\bar{q}\tilde{\chi}_1^0$ with $\tilde{\chi}_1^0 \to G + \tilde{G}$.

**Tglu4B:** gluino pair production with gluinos decaying to $q\bar{q}\tilde{\chi}_1^0$ and $\tilde{\chi}_1^0 \to G + \tilde{G}$.

**Tglu4C:** gluino pair production with gluinos decaying to $q\bar{q}\tilde{\chi}_1^0$ and $\tilde{\chi}_1^0 \to Z + \tilde{G}$.

**Tglu4D:** gluino pair production with $\tilde{g} \to q\bar{q}\tilde{\chi}_1^0$ where the $\tilde{\chi}_1^0$ decays with equal probability to $\tilde{\chi}_1^0 \to G + \tilde{G} = \tilde{H} + \tilde{G}$.

**Tglu4E:** gluino pair production with $\tilde{g} \to bb\tilde{\chi}_1^0$ where the $\tilde{\chi}_1^0$ decays with equal probability to $\tilde{\chi}_1^0 \to G + \tilde{G}$ or to $\tilde{\chi}_1^0 \to Z + \tilde{G}$. 

Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)
Tglu4F: gluino pair production with $\tilde{g} \to t\tilde{t}\tilde{\chi}^0_1$ where the $\tilde{\chi}^0_1$ decays with equal probability to $\tilde{\chi}^0_1 \to \gamma + \tilde{G}$ or to $\tilde{\chi}^0_1 \to Z + \tilde{G}$.

Tsqk1: squark pair production with $\tilde{q} \to q\tilde{\chi}^0_1$.

Tsqk1LL squark pair production where $\tilde{q} \to q\tilde{\chi}^0_1$ and $\tilde{q} \to q'\tilde{\chi}^\pm_1$ each happen with 50% probability. The $\tilde{\chi}^\pm_1$ is assumed to be few hundreds of MeV heavier than the $\tilde{\chi}^0_1$, and decays to $\tilde{\chi}^0_1$ via a pion.

Tsqk2: squark pair production with $\tilde{q} \to q\tilde{\chi}^0_1$ and $\tilde{q} \to Z + \tilde{\chi}^0_1$.

Tsqk3: squark pair production with $\tilde{q} \to q'\tilde{\chi}^\pm_1$, $\tilde{\chi}^\pm_1 \to W^\pm\tilde{\chi}^0_1$ (like Tglu1B but for squarks)

Tsqk4: squark pair production with squarks decaying to $q\tilde{\chi}^0_1$ and $\tilde{\chi}^0_1 \to \gamma + \tilde{G}$.

Tsqk4A: squark pair production with one squark decaying to $q\tilde{\chi}^\pm_1$ with $\tilde{\chi}^\pm_1 \to W^\pm + \tilde{\chi}^0_1$, and the other squark decaying to $q\tilde{\chi}^0_1$ with $\tilde{\chi}^0_1 \to \gamma + \tilde{G}$.

Tsqk4B: squark pair production with squarks decaying to $q\tilde{\chi}^0_1$ and $\tilde{\chi}^0_1 \to \gamma + \tilde{G}$.

Tstop1: stop pair production with $\tilde{t} \to t\tilde{\chi}^0_1$.

Tstop1LL stop pair production where $\tilde{t} \to t\tilde{\chi}^0_1$ and $\tilde{t} \to b\tilde{\chi}^\pm_1$ each happen with 50% probability. The $\tilde{\chi}^\pm_1$ is assumed to be few hundreds of MeV heavier than the $\tilde{\chi}^0_1$, and decays to $\tilde{\chi}^0_1$ via a pion.

Tstop2: stop pair production with $\tilde{t} \to b\tilde{\chi}^\pm_1$ with $\tilde{\chi}^\pm_1 \to W^\pm + \tilde{\chi}^0_1$.

Tstop3: stop pair production with the subsequent four-body decay $\tilde{t} \to bff'\tilde{\chi}^0_1$ where $f$ represents a lepton or a quark.

Tstop4: stop pair production with $\tilde{t} \to c\tilde{\chi}^0_1$.

Tstop5: stop pair production with $\tilde{t} \to b\nu\tilde{\tau}$ with $\tilde{\tau} \to \tau\tilde{G}$.

Tstop6: stop pair production with $\tilde{t} \to t + \tilde{\chi}^0_2$, where $\tilde{\chi}^0_2 \to Z + \tilde{\chi}^0_1$ or $H + \tilde{\chi}^0_1$ each with $Br=50\%$.

Tstop7: stop pair production with $\tilde{t}_2 \to \tilde{t}_1 + H/Z$, where $\tilde{t}_1 \to t + \tilde{\chi}^0_1$.

Tstop8: stop pair production with equal probability of the stop decaying via $\tilde{t} \to t\tilde{\chi}^0_1$ or via $\tilde{t} \to b\tilde{\chi}^\pm_1$ with $\tilde{\chi}^\pm_1 \to W^\pm\tilde{\chi}^0_1$.

Tstop9: stop pair production with equal probability of the stop decaying via $\tilde{t} \to c\tilde{\chi}^0_1$ or via the four-body decay $\tilde{t} \to bff'\tilde{\chi}^0_1$ where $f$ represents a lepton or a quark.

Tstop10: stop pair production with $\tilde{t} \to b\tilde{t}\tilde{\chi}^\pm_1$ and $\tilde{\chi}^\pm_1 \to W^\pm\tilde{\chi}^0_1 \to (ff') + \tilde{\chi}^0_1$ with a virtual W-boson.

Tstop11: stop pair production with $\tilde{t} \to b\tilde{\chi}^\pm_1$ with $\tilde{\chi}^\pm_1$ decaying through an intermediate slepton to $l\nu\tilde{\chi}^0_1$.

Tstop12: stop pair production with $\tilde{t} \to t\tilde{\chi}^0_1$ and $\tilde{\chi}^0_1 \to \gamma + \tilde{G}$

Tstop13: stop pair production with $\tilde{t} \to t\tilde{\chi}^0_1$ where the $\tilde{\chi}^0_1$ can decay with equal probability to $\tilde{\chi}^0_1 \to \gamma + \tilde{G}$ or to $\tilde{\chi}^0_1 \to Z + \tilde{G}$. 

Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)
Tstop1RPV: stop pair production with $\tilde{t} \rightarrow \tilde{b}s$ via RPV coupling $\lambda''_{323}$.

Tstop2RPV: stop pair production with $\tilde{t} \rightarrow b\ell$, via RPV coupling $\lambda'_{33}$.

Tbot1: sbottom pair production with $\tilde{b} \rightarrow b\tilde{\chi}^0_1$.

Tbot2: sbottom pair production with $\tilde{b} \rightarrow t\chi^-_1$, $\chi^-_1 \rightarrow W^-\tilde{\chi}^0_1$.

Tbot3: sbottom pair production with $\tilde{b} \rightarrow b\tilde{\chi}^0_2$, where one of the $\tilde{\chi}^0_2 \rightarrow Z^*(\tilde{\chi}^0_1 \rightarrow f\bar{f}\chi^0_1)$ and the other $\chi^0_2 \rightarrow l\ell^+ \rightarrow l^+\ell^-\chi^-_1$.

Tbot4: sbottom pair production with $\tilde{b} \rightarrow b\tilde{\chi}^0_2$, with $\tilde{\chi}^0_2 \rightarrow H\chi^0_1$.

Tchi1chi1A: electroweak pair and associated production of nearly mass-degenerate charginos $\tilde{\chi}^\pm_1$ and neutralinos $\tilde{\chi}^0_1$, where $\tilde{\chi}^\pm_1$ decays to $\tilde{\chi}^0_1$ plus soft radiation, and where one of the $\tilde{\chi}^0_1$ decays to $\gamma + \tilde{G}$ while the other one decays to $Z/H + \tilde{G}$ (with equal probability).

Tchi1chi1B: electroweak pair production of charginos $\tilde{\chi}^\pm_1$, where $\tilde{\chi}^\pm_1$ decays through an intermediate slepton or sneutrino to $\nu\tilde{\chi}^0_1$ and where the slepton or sneutrino mass is 5%, 25%, 50%, 75% and 95% of the $\tilde{\chi}^\pm_1$ mass.

Tchi1chi1C: electroweak pair production of charginos $\tilde{\chi}^\pm_1$, where $\tilde{\chi}^\pm_1$ decays through an intermediate slepton or sneutrino to $\nu\tilde{\chi}^0_1$ and where $m_{\tilde{\ell},\tilde{\nu}} = (m_{\tilde{\chi}^\pm_1} + m_{\tilde{\chi}^0_1})/2$.

Tchi1chi1D: electroweak associated pair production of charginos $\tilde{\chi}^\pm_1$, where $\tilde{\chi}^\pm_1$ decays through an intermediate scalar tau lepton or sneutrino to $\tau\tilde{\nu}\tilde{\chi}^0_1$ and where $m_{\tilde{\tau},\tilde{\nu}} = (m_{\tilde{\chi}^\pm_1} + m_{\tilde{\chi}^0_1})/2$.

Tchi1chi1F: electroweak pair and associated production of nearly mass-degenerate charginos $\tilde{\chi}^\pm_1$ and neutralinos $\tilde{\chi}^0_1$ (i.e. $\tilde{\chi}^\pm_1\tilde{\chi}^0_1$ and $\tilde{\chi}^\pm_1\tilde{\chi}^0_1$ production) where the $\tilde{\chi}^\pm_1$ decays exclusively to $\tilde{\chi}^0_1$ plus soft radiation and the $\tilde{\chi}^0_1$ decays to $\gamma/Z + \tilde{G}$.

Tchi1chi1G: electroweak pair production of charginos $\tilde{\chi}^\pm_1$, which are nearly mass-degenerate with neutralinos $\tilde{\chi}^0_1$. The $\tilde{\chi}^\pm_1$ decays either to $W^\pm + \tilde{G}$, or to $\tilde{\chi}^0_1$ plus soft radiation. The $\tilde{\chi}^0_1$ decays exclusively to $\gamma + \tilde{G}$.

Tchi1n1A: electroweak associated production of mass-degenerate charginos $\tilde{\chi}^\pm_1$ and neutralinos $\tilde{\chi}^0_1$, where $\tilde{\chi}^\pm_1$ decays exclusively to $W^\pm + \tilde{G}$ and $\tilde{\chi}^0_1$ decays exclusively to $\gamma + \tilde{G}$.

Tchi1n2A: electroweak associated production of mass-degenerate charginos $\tilde{\chi}^\pm_1$ and neutralinos $\tilde{\chi}^0_2$, where $\tilde{\chi}^\pm_1$ decays through an intermediate slepton or sneutrino to $\nu\tilde{\chi}^0_1$ and where $\tilde{\chi}^0_2$ decays through an intermediate slepton or sneutrino to $l^+l^-\chi^-_1$ or $\nu\bar{\nu}\chi^0_1$. 

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Tchi1n2B: electroweak associated production of mass-degenerate charginos $\tilde{\chi}_1^\pm$ and neutralinos $\tilde{\chi}_2^0$, where $\tilde{\chi}_1^\pm$ decays through an intermediate slepton or sneutrino to $l\nu\tilde{\chi}_1^0$ and where $\tilde{\chi}_2^0$ decays through an intermediate slepton or sneutrino to $l^+l^-\tilde{\chi}_1^0$ or $\nu\bar{\nu}\tilde{\chi}_1^0$ and where the slepton or sneutrino mass is 5%, 25%, 50%, 75% and 95% of the $\tilde{\chi}_1^\pm$ mass.

Tchi1n2C: electroweak associated production of mass-degenerate charginos $\tilde{\chi}_1^\pm$ and neutralinos $\tilde{\chi}_2^0$, where $\tilde{\chi}_1^\pm$ decays through an intermediate slepton or sneutrino to $l\nu\tilde{\chi}_1^0$ and where $\tilde{\chi}_2^0$ decays through an intermediate slepton or sneutrino to $l^+l^-\tilde{\chi}_1^0$ or $\nu\bar{\nu}\tilde{\chi}_1^0$ and where $m_{\tilde{\ell},\bar{\nu}} = (m_{\tilde{\chi}_1^\pm} + m_{\tilde{\chi}_1^0})/2$.

Tchi1n2D: electroweak associated production of mass-degenerate charginos $\tilde{\chi}_1^\pm$ and neutralinos $\tilde{\chi}_2^0$, where $\tilde{\chi}_1^\pm$ decays through an intermediate scalar tau lepton or sneutrino to $\tau\nu\tilde{\chi}_1^0$ and where $\tilde{\chi}_2^0$ decays through an intermediate scalar tau lepton or sneutrino to $\tau^+\tau^-\tilde{\chi}_1^0$ or $\nu\bar{\nu}\tilde{\chi}_1^0$ and where $m_{\tau,\bar{\nu}} = (m_{\tilde{\chi}_1^\pm} + m_{\tilde{\chi}_1^0})/2$.

Tchi1n2E: electroweak associated production of mass-degenerate charginos $\tilde{\chi}_1^\pm$ and neutralinos $\tilde{\chi}_2^0$, where $\tilde{\chi}_1^\pm \to W^\pm + \chi_1^0$ and $\tilde{\chi}_2^0 \to H + \chi_1^0$.

Tchi1n2F: electroweak associated production of mass-degenerate wino-like charginos $\tilde{\chi}_1^\pm$ and neutralinos $\tilde{\chi}_2^0$, where $\tilde{\chi}_1^\pm$ decays through an intermediate $W^\pm*$ to $l\nu\tilde{\chi}_1^0$ and where $\tilde{\chi}_2^0$ decays through an intermediate $Z^*$ to $l^+l^-\tilde{\chi}_1^0$ or $\nu\bar{\nu}\tilde{\chi}_1^0$.

Tchi1n2G: electroweak associated production of Higgsino-like charginos $\tilde{\chi}_1^\pm$ and neutralinos $\tilde{\chi}_2^0$, and electroweak associated production of $\tilde{\chi}_2^0$ and $\tilde{\chi}_1^0$, where $m_{\tilde{\chi}_1^\pm} = (m_{\tilde{\chi}_2^0} + m_{\tilde{\chi}_1^0})/2$ and where $\tilde{\chi}_1^\pm$ decays through an intermediate $W^\pm*$ to $l\nu\tilde{\chi}_1^0$ and where $\tilde{\chi}_2^0$ decays through an intermediate $Z^*$ to $l^+l^-\tilde{\chi}_1^0$.

Tchi1n2H: electroweak associated production of mass-degenerate charginos $\tilde{\chi}_1^\pm$ and neutralinos $\tilde{\chi}_2^0$, where $\tilde{\chi}_1^\pm$ decays through an intermediate slepton or sneutrino to $l\nu\tilde{\chi}_1^0$ and where $\tilde{\chi}_2^0$ decays through an intermediate scalar tau lepton or sneutrino to $\tau^+\tau^-\tilde{\chi}_1^0$ or $\nu\bar{\nu}\tilde{\chi}_1^0$.

Tchi1n2I: electroweak associated production of mass-degenerate charginos $\tilde{\chi}_1^\pm$ and neutralinos $\tilde{\chi}_2^0$, where $\tilde{\chi}_1^\pm$ decays to $W^\pm + \tilde{\chi}_1^0$ and where $\tilde{\chi}_2^0$ decays 50% of the time to $Z + \tilde{\chi}_1^0$ and 50% of the time to $H + \tilde{\chi}_1^0$.

Tchi1n12_GGM: in the framework of General Gauge Mediation (GGM): electroweak pair and associated production of nearly mass-degenerate charginos $\tilde{\chi}_1^\pm$ and neutralinos $\tilde{\chi}_2^0$, $\tilde{\chi}_2^0$ (i.e. $\tilde{\chi}_1^\pm$, $\tilde{\chi}_2^0$, $\tilde{\chi}_1^\pm\tilde{\chi}_1^0$, and $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ production) where the $\tilde{\chi}_1^\pm$ decays exclusively to $W^\pm + \tilde{G}$, the $\tilde{\chi}_2^0$ decays to $Z/H + \tilde{G}$ and the $\tilde{\chi}_1^0$ decays to $\chi_1^0$. 
The branching ratios depend on the composition of the gauge eigenstates of the neutralinos in the GGM scenario.

**Tn1n1A:** electroweak pair and associated production of nearly mass-degenerate Higgsino-like charginos \( \tilde{\chi}^\pm_2 \) and neutralinos \( \tilde{\chi}^0_1 \) and \( \tilde{\chi}^0_2 \), where \( \tilde{\chi}^\pm_1 \) and \( \tilde{\chi}^0_2 \) decay to \( \tilde{\chi}^0_1 \) plus soft radiation and where both of the \( \tilde{\chi}^0_1 \) decay to \( H + \tilde{G} \).

**Tn1n1B:** electroweak pair and associated production of nearly mass-degenerate Higgsino-like charginos \( \tilde{\chi}^\pm_1 \) and neutralinos \( \tilde{\chi}^0_1 \) and \( \tilde{\chi}^0_2 \), where \( \tilde{\chi}^\pm_1 \) and \( \tilde{\chi}^0_2 \) decay to \( \tilde{\chi}^0_1 \) plus soft radiation and where \( \tilde{\chi}^0_1 \) decays 50% of the time to \( H + \tilde{G} \) and 50% of the time to \( Z + \tilde{G} \).

**Tn1n1C:** electroweak pair and associated production of nearly mass-degenerate Higgsino-like charginos \( \tilde{\chi}^\pm_1 \) and neutralinos \( \tilde{\chi}^0_1 \) and \( \tilde{\chi}^0_2 \), where \( \tilde{\chi}^\pm_1 \) and \( \tilde{\chi}^0_2 \) decay to \( \tilde{\chi}^0_1 \) plus soft radiation and where both of the \( \tilde{\chi}^0_1 \) decay to \( Z + \tilde{G} \).

**Tn2n3A:** electroweak associated production of mass-degenerate neutralinos \( \tilde{\chi}^0_2 \) and \( \tilde{\chi}^0_3 \), where \( \tilde{\chi}^0_2 \) and \( \tilde{\chi}^0_3 \) decay through intermediate sleptons to \( l^+ l^- \tilde{\chi}^0_1 \) and where the slepton mass is 5%, 25%, 50%, 75% and 95% of the \( \tilde{\chi}^0_2 \) mass.

**Tn2n3B:** electroweak associated production of mass-degenerate neutralinos \( \tilde{\chi}^0_2 \) and \( \tilde{\chi}^0_3 \), where \( \tilde{\chi}^0_2 \) and \( \tilde{\chi}^0_3 \) decay through intermediate sleptons to \( l^+ l^- \tilde{\chi}^0_1 \) and where \( m_\ell = (m_{\tilde{\chi}^0_2} + m_{\tilde{\chi}^0_1})/2 \).

### \( \tilde{\chi}^0_1 \) (Lightest Neutralino) mass limit

\( \tilde{\chi}^0_1 \) is often assumed to be the lightest supersymmetric particle (LSP). See also the \( \tilde{\chi}^0_2, \tilde{\chi}^0_3, \tilde{\chi}^0_4 \) section below.

We have divided the \( \tilde{\chi}^0_1 \) listings below into five sections:

1) Accelerator limits for stable \( \tilde{\chi}^0_1 \).
2) Bounds on \( \tilde{\chi}^0_1 \) from dark matter searches,
3) \( \tilde{\chi}^0_1 - p \) elastic cross section (spin-dependent, spin-independent interactions),
4) Other bounds on \( \tilde{\chi}^0_1 \) from astrophysics and cosmology, and
5) Unstable \( \tilde{\chi}^0_1 \) (Lightest Neutralino) mass limit.

### Accelerator limits for stable \( \tilde{\chi}^0_1 \)

Unless otherwise stated, results in this section assume spectra, production rates, decay modes, and branching ratios as evaluated in the MSSM, with gaugino and sfermion mass unification at the GUT scale. These papers generally study production of \( \tilde{\chi}^0_i \tilde{\chi}^0_j \) \((i \geq 1, j \geq 2)\), \( \tilde{\chi}^+_1 \tilde{\chi}^-_1 \), and (in the
case of hadronic collisions) $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$ pairs. The mass limits on $\tilde{\chi}_1^0$ are either direct, or follow indirectly from the constraints set by the non-observation of $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_2^0$ states on the gaugino and higgsino MSSM parameters $M_2$ and $\mu$. Some cases, information is used from the nonobservation of slepton decays.

Obsolete limits obtained from $e^+e^-$ collisions up to $\sqrt{s} = 184$ GeV have been removed from this compilation and can be found in the 2000 Edition (The European Physical Journal C15 1 (2000)) of this Review.

$\Delta m = m_{\tilde{\chi}_1^0} - m_{\tilde{\chi}_2^0}$.

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1. DREINER 09 show that in the general MSSM with non-universal gaugino masses there exists no model-independent laboratory bound on the mass of the lightest neutralino. An essentially massless $\tilde{\chi}_1^0$ is allowed by the experimental and observational data, imposing some constraints on other MSSM parameters, including $M_2$, $\mu$ and the slepton and squark masses.

2. ABBIENDI 04H search for charginos and neutralinos in events with acoplanar leptons+jets and multi-jet final states in the 192–209 GeV data, combined with the results on leptonic final states from ABBIENDI 04. The results hold for a scan over the parameter space covering the region $0 < M_\tau < 5000$ GeV, $-1000 < \mu < 1000$ GeV and $\tan\beta$ from 1 to 40. This limit supersedes ABBIENDI 00H.

3. HEISTER 04 data collected up to 209 GeV. Updates earlier analysis of selectrons from HEISTER 02E, includes a new analysis of charginos and neutralinos decaying into stau and uses results on charginos with initial state radiation from HEISTER 02I. The limit is based on the direct search for charginos and neutralinos, the constraints from the slepton search and the Higgs mass limits from HEISTER 02 using a top mass of 175 GeV, interpreted in a framework with universal gaugino and sfermion masses. Assuming the mixing in the stau sector to be negligible, the limit improves to 43.1 GeV. Under the assumption of MSUGRA with unification of the Higgs and sfermion masses, the limit improves to 50 GeV, and reaches 53 GeV for $A_0 = 0$. These limits include and update the results of BARATE 01.

4. ABDALLAH 03M uses data from $\sqrt{s} = 192–208$ GeV. A limit on the mass of $\tilde{\chi}_1^0$ is derived from direct searches for neutralinos combined with the chargino search. Neutralinos are searched in the production of $\tilde{\chi}_1^0\tilde{\chi}_2^0$, $\tilde{\chi}_2^0\tilde{\chi}_1^0$, as well as $\tilde{\chi}_2^0\tilde{\chi}_3^0$ and $\tilde{\chi}_2^0\tilde{\chi}_4^0$ giving rise to cascade decays, and $\tilde{\chi}_1^0\tilde{\chi}_2^0$ and $\tilde{\chi}_1^0\tilde{\chi}_2^0$, followed by the decay $\tilde{\chi}_2^0 \rightarrow \tau \tau$. The results hold for the parameter space defined by values of $M_2 < 1$ TeV, $|\mu| \leq 2$ TeV with the $\tilde{\chi}_1^0$ as LSP. The limit is obtained for $\tan\beta = 1$ and large $m_0$, where $\tilde{\chi}_2^0\tilde{\chi}_4^0$ and chargino pair production are important. If the constraint from Higgs searches is also imposed, the limit improves to 49.0 GeV in the $m_h^{\text{max}}$ scenario with $m_t = 174.3$ GeV. These limits update the results of ABREU 00I.

5. ABDALLAH 03M uses data from $\sqrt{s} = 192–208$ GeV. An indirect limit on the mass of $\tilde{\chi}_1^0$ is derived by constraining the MSSM parameter space by the results from direct
searches for neutralinos (including cascade decays and $\tilde{\tau}\tau$ final states), for charginos (for all $\Delta m_+\gamma$) and for sleptons, stop and sbottom. The results hold for the full parameter space defined by values of $M_2 < 1$ TeV, $|\mu| \leq 2$ TeV with the $\tilde{\chi}_1^0$ as LSP. Constraints from the Higgs search in the $m_{h}^{\text{max}}$ scenario assuming $m_{h}=174.3$ GeV are included. The limit is obtained for $\tan\beta \geq 5$ when stau mixing leads to mass degeneracy between $\tilde{\tau}_1$ and $\tilde{\chi}_1^0$ and the limit is based on $\tilde{\chi}_2^0$ production followed by its decay to $\tilde{\tau}_1\tau$. In the pathological scenario where $m_0$ and $|\mu|$ are large, so that the $\tilde{\chi}_2^0$ production cross section is negligible, and where there is mixing in the stau sector but not in stop nor sbottom, the limit is based on charginos with soft decay products and an ISR photon. The limit then degrades to 39 GeV. See Figs. 40–42 for the dependence of the limit on $\tan\beta$ and $m_{\tilde{\nu}}$. These limits update the results of ABREU 00 W.

6 ACCIARRI 00D data collected at $\sqrt{s}=189$ GeV. The results hold over the full parameter space defined by $0.7 \leq \tan\beta \leq 60$, $0 \leq M_2 \leq 2$ TeV, $m_0 \leq 500$ GeV, $|\mu| \leq 2$ TeV. The minimum mass limit is reached for $\tan\beta=1$ and large $m_0$. The results of slepton searches from ACCIARRI 99W are used to help set constraints in the region of small $m_0$. The limit improves to 48 GeV for $m_0 \gtrsim 200$ GeV and $\tan\beta \gtrsim 10$. See their Figs. 6–8 for the $\tan\beta$ and $m_0$ dependence of the limits. Updates ACCIARRI 98F.

7 AAD 14K sets limits on the $\chi$–nucleon spin-dependent and spin-independent cross sections out to $m_\chi = 10$ TeV.

### Bounds on $\tilde{\chi}_1^0$ from dark matter searches

These papers generally exclude regions in the $M_2–\mu$ parameter plane assuming that $\tilde{\chi}_1^0$ is the dominant form of dark matter in the galactic halo. These limits are based on the lack of detection in laboratory experiments, telescopes, or by the absence of a signal in underground neutrino detectors. The latter signal is expected if $\tilde{\chi}_1^0$ accumulates in the Sun or the Earth and annihilates into high-energy $\nu$'s.
none 4–15 GeV

1 DI-MAURO 19 sets limits on the dark matter annihilation from gamma-ray searches in M31 and M33 galaxies using Fermi LAT data.
2 JOHNSON 19 sets limits on p-wave dark matter annihilations in the galactic center using Fermi data.
3 LI 19D sets limits on dark matter annihilation cross sections searching for line-like signals in the all-sky Fermi data.
4 ABDALLAH 18 places constraints on the dark matter annihilation cross section for annihilations into gamma-rays in the Galactic center for masses between 300 GeV to 70 TeV. This updates ABDALLAH 16.
5 AHNEN 18 uses observations of the dwarf satellite galaxy Ursa Major II to obtain upper limits on annihilation cross sections for dark matter in various channels for masses between 0.1–100 TeV.
6 ALBERT 18B sets limits on the annihilation cross section of dark matter with mass between 1 and 100 TeV from gamma-ray observations of the Andromeda galaxy.
7 ALBERT 18C sets limits on the spin-dependent coupling of dark matter to protons from dark matter annihilation in the Sun.
8 AARTSEN 17 is based on data collected during 327 days of detector livetime with IceCube. They looked for interactions of $\nu$’s resulting from neutralino annihilations in the Earth over a background of atmospheric neutrinos and set 90% CL limits on the spin independent neutralino-proton cross section for neutralino masses in the range 10–10000 GeV.
9 AARTSEN 17A is based on data collected during 532 days of livetime with the IceCube 86-string detector including the DeepCore sub-array. They looked for interactions of $\nu$’s from neutralino annihilations in the Sun over a background of atmospheric neutrinos and...
set 90% CL limits on the spin dependent neutralino-proton cross section for neutralino masses in the range 10–10000 GeV. This updates AARTSEN 16C.

AARTSEN 17C is based on 1005 days of running with the IceCube detector. They set a limit on the annihilation cross section for dark matter with masses between 10–1000 GeV annihilating in the Galactic center assuming an NFW profile. The limit is of $1.2 \times 10^{23} \text{cm}^3\text{s}^{-1}$ in the $\tau^+\tau^-$ channel. Supercedes AARTSEN 15E.

ALBERT 17A is based on data from the ANTARES neutrino telescope. They looked for interactions of $\nu$'s from neutralino annihilations in the Milky Way galaxy over a background of atmospheric neutrinos and set 90% CL limits on the muon neutrino flux. They also obtain limits on the thermally averaged cross section for neutralino masses in the range 50 to 100,000 GeV. This updates ADRIAN-MARTINEZ 15.

ARCHAMBAULT 17 performs a joint statistical analysis of four dwarf galaxies with VERITAS looking for gamma-ray emission from neutralino annihilation. They set limits on the neutralino annihilation cross section.

AARTSEN 16D is based on 329 live days of running with the DeepCore subdetector of the IceCube detector. They set a limit of $10^{-23} \text{cm}^3\text{s}^{-1}$ on the annihilation cross section to $\nu\nu$. This updates AARTSEN 15C.

ABDALLAH 16A place upper limits on the annihilation cross section with final states in the energy range of 0.1 to 2 TeV. This complements ABRAMOWSKI 13.

ADRIAN-MARTINEZ 16 is based on data from the ANTARES neutrino telescope. They looked for interactions of $\nu$'s from neutralino annihilations in the Sun over a background of atmospheric neutrinos and set 90% CL limits on the muon neutrino flux. They also obtain limits on the spin dependent and spin independent neutralino-proton cross section for neutralino masses in the range 50 to 5,000 GeV. This updates ABRAMOKWSKI 13.

Ahn 16 combines 158 hours of Segue 1 observations with MAGIC with 6 year observations of 15 dwarf satellite galaxies by Fermi-LAT to set limits on annihilation cross sections for dark matter masses between 10 GeV and 100 TeV.

AVRORIN 16 is based on 2.76 years with Lake Baikal neutrino telescope. They derive 90% upper limits on the annihilation cross section from dark matter annihilations in the Galactic center.

CIRELLI 16 and LEITE 16 derive bounds on the annihilation cross section from radio observations.

ABRAMOWSKI 15 places constraints on the dark matter annihilation cross section for annihilations in the Galactic center for masses between 300 GeV to 10 TeV.

ACKERMANN 15 is based on 5.8 years of data with Fermi-LAT and search for monochromatic gamma-rays in the energy range of 0.2–500 GeV from dark matter annihilations. This updates ACKERMANN 13A.

ACKERMANN 15A is based on 50 months of data with Fermi-LAT and search for dark matter annihilation signals in the isotropic gamma-ray background as well as galactic subhalos in the energy range of a few GeV to a few tens of TeV.

ACKERMANN 15B is based on 6 years of data with Fermi-LAT observations of Milky Way dwarf spheroidal galaxies. Set limits on the annihilation cross section from $m_\chi = 2$ GeV to 10 TeV. This updates ACKERMANN 14.

BUCKLEY 15 is based on 5 years of Fermi-LAT data searching for dark matter annihilation signals from Large Magellanic Cloud.

CHOI 15 is based on 3903 days of SuperKamiokande data searching for neutrinos produced from dark matter annihilations in the sun. They place constraints on the dark matter-nucleon scattering cross section for dark matter masses between 4–200 GeV.

ALEKSIC 14 is based on almost 160 hours of observations of Segue 1 satellite dwarf galaxy using the MAGIC telescopes between 2011 and 2013. Sets limits on the annihilation cross section out to $m_\chi = 10$ TeV.

AVRORIN 14 is based on almost 2.76 years with Lake Baikal neutrino telescope. They derive 90% upper limits on the fluxes of muons and muon neutrinos from dark matter annihilations in the Sun.

AARTSEN 13C is based on data collected during 339.8 effective days with the IceCube 59-string detector. They looked for interactions of $\nu_\mu$'s from neutralino annihilations in
nearby galaxies and galaxy clusters. They obtain limits on the neutralino annihilation cross section for neutralino masses in the range 30–100,000 GeV.

28 ABRAMOWSKI 13 place upper limits on the annihilation cross section with $\gamma \gamma$ final states in the energy range of 0.5–25 TeV.

29 BERGSTROM 13, JIN 13, and KOPP 13 derive limits on the mass and annihilation cross section using AMS-02 data. JIN 13 also sets a limit on the lifetime of the dark matter particle.

30 BOLIEV 13 is based on data collected during 24.12 years of live time with the Bakon Underground Scintillator Telescope. They looked for interactions of $\nu_\mu$ from neutralino annihilations in the Sun over a background of atmospheric neutrinos and set 90% CL limits on the muon flux. They also obtain limits on the spin dependent and spin independent neutralino-proton cross section for neutralino masses in the range 10–1000 GeV.

31 ABBASI 12 is based on data collected during 812 effective days with AMANDA II and 149 days of the IceCube 40-string detector combined with the data of ABBASI 09b. They looked for interactions of $\nu_\mu$ from neutralino annihilations in the Sun over a background of atmospheric neutrinos and set 90% CL limits on the muon flux. No excess is observed. They also obtain limits on the spin dependent neutralino-proton cross section for neutralino masses in the range 50–5000 GeV.

32 ABRAMOWSKI 11 place upper limits on the annihilation cross section with $\gamma \gamma$ final states.

33 ABDO 10 place upper limits on the annihilation cross section with $\gamma \gamma$ or $\mu^+ \mu^-$ final states.

34 ACKERMANN 10 place upper limits on the annihilation cross section with $b\bar{b}$ or $\mu^+ \mu^-$ final states.

35 ACHTERBERG 06 is based on data collected during 421.9 effective days with the AMANDA detector. They looked for interactions of $\nu_\mu$ from the centre of the Earth over a background of atmospheric neutrinos and set 90% CL limits on the muon flux. Their limit is compared with the muon flux expected from neutralino annihilations into $W^+ W^-$ and $b\bar{b}$ at the centre of the Earth for MSSM parameters compatible with the relic dark matter density, see their Fig. 7.

36 ACKERMANN 06 is based on data collected during 143.7 days with the AMANDA-II detector. They looked for interactions of $\nu_\mu$ from the Sun over a background of atmospheric neutrinos and set 90% CL limits on the muon flux. Their limit is compared with the muon flux expected from neutralino annihilations into $W^+ W^-$ in the Sun for SUSY model parameters compatible with the relic dark matter density, see their Fig. 3.

37 DEBOER 06 interpret an excess of diffuse Galactic gamma rays observed with the EGRET satellite as originating from $\pi^0$ decays from the annihilation of neutralinos into quark jets. They analyze the corresponding parameter space in a supergravity inspired MSSM model with radiative electroweak symmetry breaking, see their Fig. 3 for the preferred region in the $(m_{\tilde{U}}, m_{1/2})$ plane of a scenario with large $\tan \beta$.

38 AMBROSIO 99 and DESAI 04 set new neutrino flux limits which can be used to limit the parameter space in supersymmetric models based on neutralino annihilation in the Sun and the Earth.

39 LOSECCO 95 reanalyzed the IMB data and places lower limit on $m_{\chi_1}$ of 18 GeV if the LSP is a photino and 10 GeV if the LSP is a higgsino based on LSP annihilation in the Sun producing high-energy neutrinos and the limits on neutrino fluxes from the IMB detector.

40 MORI 93 excludes some region in $M_2 - \mu$ parameter space depending on $\tan \beta$ and lightest scalar Higgs mass for neutralino dark matter $m_{\tilde{\chi}_1^0} > m_W$, using limits on upgoing muons produced by energetic neutrinos from neutralino annihilation in the Sun and the Earth.

41 BOTTINO 92 excludes some region $M_2 - \mu$ parameter space assuming that the lightest neutralino is the dark matter, using upgoing muons at Kamiokande, direct searches by Ge detectors, and by LEP experiments. The analysis includes top radiative corrections on Higgs parameters and employs two different hypotheses for nucleon-Higgs coupling.
Effects of rescaling in the local neutralino density according to the neutralino relic abundance are taken into account.

42 BOTTINO 91 excluded a region in $M_2 - \mu$ plane using upgoing muon data from Kamioka experiment, assuming that the dark matter surrounding us is composed of neutralinos and that the Higgs boson is not too heavy.

43 GELMINI 91 exclude a region in $M_2 - \mu$ plane using dark matter searches.

44 KAMIONKOWSKI 91 excludes a region in the $M_2 - \mu$ plane using IMB limit on upgoing muons originated by energetic neutrinos from neutralino annihilation in the sun, assuming that the dark matter is composed of neutralinos and that $m_{H^0} \lesssim 50$ GeV. See Fig. 8 in the paper.

45 MORI 91 exclude a part of the region in the $M_2 - \mu$ plane with $m_{\tilde{\chi}^0_1} \lesssim 80$ GeV using a limit on upgoing muons originated by energetic neutrinos from neutralino annihilation in the earth, assuming that the dark matter surrounding us is composed of neutralinos and that $m_{H^0} \lesssim 80$ GeV.

46 OLIVE 88 result assumes that photinos make up the dark matter in the galactic halo. Limit is based on annihilations in the sun and is due to an absence of high energy neutrinos detected in underground experiments. The limit is model dependent.

---

\[ \tilde{\chi}^0_1 - p \text{ elastic cross section} \]

Experimental results on the $\tilde{\chi}^0_1 - p$ elastic cross section are evaluated at $m_{\tilde{\chi}^0_1} = 100$ GeV. The experimental results on the cross section are often mass dependent. Therefore, the mass and cross section results are also given where the limit is strongest, when appropriate. Results are quoted separately for spin-dependent interactions (based on an effective 4-Fermi Lagrangian of the form \( \bar{\chi} \gamma^\mu \gamma^5 \chi \bar{\gamma} \gamma^\mu \gamma^5 q \)) and spin-independent interactions (\( \bar{\chi} \chi q q \)). For calculational details see GRIEST 88, ELLIS 88, BARBIERI 89, DREES 93, ARNOWITT 96, BERGSTROM 96, and BAER 97 in addition to the theory papers listed in the Tables. For a description of the theoretical assumptions and experimental techniques underlying most of the listed papers, see the review on “Dark matter” in this “Review of Particle Physics,” and references therein. Most of the following papers use galactic halo and nuclear interaction assumptions from (LEWIN 96).

### Spin-dependent interactions

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1. The strongest limit is $2.5 \times 10^{-5}$ pb at $m_\chi = 25$ GeV. This updates AMOLE 17.
2. The strongest limit is $2 \times 10^{-4}$ pb at $m_\chi = 30$ GeV. For scatterings on neutrons, the strongest limit is $6.3 \times 10^{-6}$ at $m_\chi = 30$ GeV.
3. The strongest limit is $4.4 \times 10^{-4}$ pb at $m_\chi = 40$ GeV. This updates FU 17.
4. The strongest limit is $5 \times 10^{-4}$ pb at $m_\chi = 35$ GeV. The limit for scattering on neutrons is $3 \times 10^{-5}$ pb at 100 GeV and is $1.6 \times 10^{-5}$ pb at 35 GeV. This updates AKERIB 16.
5. Directional recoil detector. This updates DAW 12.
6. This result updates ARCHAMBAULT 12. The strongest limit is 0.013 pb at $m_\chi = 20$ GeV.
7. The strongest limit is $5 \times 10^{-4}$ pb at $m_\chi = 80$ GeV.
8. The strongest limit is $5.2 \times 10^{-3}$ pb at 50 GeV. The limit for scattering on neutrons is $2.8 \times 10^{-4}$ pb at 100 GeV and the strongest limit is $2.0 \times 10^{-4}$ pb at 50 GeV. This updates APRILE 13.
9. The strongest limit is 0.0043 pb and occurs at $m_\chi = 35$ GeV. FELIZARDO 14 also presents limits for the scattering on neutrons. At $m_\chi = 100$ GeV, the upper limit is 0.13 pb and the strongest limit is 0.066 pb at $m_\chi = 35$ GeV.
10. This result updates LEBEDENKO 09A. The strongest limit is $8 \times 10^{-3}$ pb at $m_\chi = 50$ GeV. Limit applies to the neutralino neutron elastic cross section.
11. The strongest limit is $6 \times 10^{-3}$ at $m_\chi = 60$ GeV.
12. The strongest limit is $5.7 \times 10^{-3}$ at $m_\chi = 35$ GeV.
13. This result updates LEE 07A. The strongest limit is at $m_\chi = 80$ GeV.
14. Predictions for the spin-dependent elastic cross section based on a frequentist approach to electroweak observables in the framework of $\mathcal{N} = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry.
15. The strongest limit is 0.6 pb and occurs at $m_\chi = 30$ GeV. The limit for scattering on neutrons is 0.01 pb at $m_\chi = 100$ GeV, and the strongest limit is 0.0045 pb at $m_\chi = 30$ GeV.
16. Limit applies to neutron elastic cross section.
17. The strongest upper limit is 0.25 pb and occurs at $m_\chi \simeq 40$ GeV.
The strongest upper limit is 4 pb and occurs at $m_{\chi} \simeq 60$ GeV. The limit on the neutron spin-dependent elastic cross section is 0.07 pb. This latter limit is improved in AHMED 09, where a limit of 0.02 pb is obtained at $m_{\chi} = 100$ GeV. The strongest limit in AHMED 09 is 0.018 pb and occurs at $m_{\chi} = 60$ GeV.

The strongest upper limit is 1.2 pb and occurs at $m_{\chi} \simeq 40$ GeV. The limit on the neutron spin-dependent cross section is 35 pb.

The strongest upper limit is 0.35 pb and occurs at $m_{\chi} \simeq 60$ GeV.

ELLIS 04 calculates the $\chi p$ elastic scattering cross section in the framework of $N=1$ supergravity models with radiative breaking of the electroweak gauge symmetry, but without universal scalar masses. In the case of universal squark and slepton masses, but non-universal Higgs masses, the limit becomes $2 \times 10^{-4}$, see ELLIS 03e.

The strongest upper limit is 0.75 pb and occurs at $m_{\chi} \approx 70$ GeV.

The strongest upper limit is 30 pb and occurs at $m_{\chi} \approx 20$ GeV.

The strongest upper limit is 8 pb and occurs at $m_{\chi} \approx 30$ GeV.

ELLIS 01c calculates the $\chi p$ elastic scattering cross section in the framework of $N=1$ supergravity models with radiative breaking of the electroweak gauge symmetry. In models with nonuniversal Higgs masses, the upper limit to the cross section is $6 \times 10^{-4}$.

The strongest upper limit is 3 pb and occurs at $m_{\chi} \approx 60$ GeV. The limits are for inelastic scattering $X^0 + ^{129}\text{Xe} \rightarrow X^0 + ^{129}\text{Xe}^* (39.58 \text{ keV})$.

The strongest upper limit is 4.4 pb and occurs at $m_{\chi} \approx 60$ GeV.

The strongest upper limit is about 35 pb and occurs at $m_{\chi} \approx 15$ GeV.

### Spin-independent interactions

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| BENETTI 08 WARP Ar  | ALNER 07A ZEP2 Xe   | AKERIB 06A CDMS Ge  | ALNER 05 NAIA NaI Spin Indep. | ALNER 05A ZEPL | AKERIB 04 CDMS Ge  | BALTZ 04 THEO      | ELLIS 04 THEO $\mu > 0$ | PIERCE 04A THEO    | AHMED 03 NAIA NaI Spin Indep. | AKERIB 03 CDMS Ge  | BAER 03A THEO       | KLAPDOR-K... 03 HDMS Ge | ABRAMS 02 CDMS Ge  | KIM 02B THEO        | MORALES 02B CSME Ge | MORALES 02C IGEX Ge | BALTZ 01 THEO       | BAUDIS 01 HDMS Ge  | BOTTINO 01 THEO     | CORSETTI 01 THEO $\tan\beta \leq 25$ | ELLIS 01C THEO $\tan\beta \leq 10$ | LAHANAS 01 THEO     | ACCOMANDO 00 THEO   | BERNABEI 00 DAMA NaI | FENG 00 THEO $\tan\beta = 10$ | MORALES 00 IGEX Ge | SPOONER 00 UKDM NaI | BAUDIS 99 HDMO $^{76}$Ge | BERNABEI 98C DAMA Xe |

1. The strongest upper limit is $2.2 \times 10^{-8}$ pb at 60 GeV.
2. This updates AMAUDRUZ 18.
3. This updates AMOLE 16.
4. The strongest limit is $2.05 \times 10^{-6}$ at $m = 60$ GeV.
5. The strongest limit is $1.09 \times 10^{-8}$ pb at $m_{\chi} = 126$ GeV. This updates AGNES 15.
6. The strongest limit is $1.0 \times 10^{-8}$ pb at $m_{\chi} = 46$ GeV. This updates AGNESE 15B.
7. Based on 278.8 days of data collection. The strongest limit is $4.1 \times 10^{-11}$ pb at $m_{\chi} = 30$ GeV. This updates APRILE 17G.
8. AKERIB 17. The strongest limit is $1.1 \times 10^{-10}$ pb at 50 GeV. This updates AKERIB 16.
9. The strongest limit is $8.6 \times 10^{-11}$ pb at 40 GeV. This updates TAN 16B.
10. The strongest limit is $1.1 \times 10^{-9}$ pb at 50 GeV. This updates APRILE 12.
11. The strongest upper limit is $7.6 \times 10^{-10}$ at $m_{\chi} = 33$ GeV.
12. Predictions for the spin-independent elastic cross section based on a frequentist approach to electroweak observables in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using the 20 fb$^{-1}$ 8 TeV and the 5 fb$^{-1}$ 7 TeV LHC data and the LUX data.
The strongest limit is $3.6 \times 10^{-6}$ pb and occurs at $m_{\chi} = 35$ GeV. Felizardo 2014 updates Felizardo 2012.

Predictions for the spin-independent elastic cross section based on a Bayesian approach to electroweak observables in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using the 20 fb$^{-1}$ LHC data and LUX.

AGNÈSE 13 presents 90% CL limits on the elastic cross section for masses in the range 7–100 GeV using the Si based detector. The strongest upper limit is $1.8 \times 10^{-6}$ pb at $m_{\chi} = 50$ GeV. This limit is improved to $7 \times 10^{-7}$ pb in AGNÈSE 13A.

This result updates LEBEDENKO 09. The strongest limit is $3.9 \times 10^{-8}$ pb at $m_{\chi} = 52$ GeV.

ANGLOHER 12 presents results of 730 kg days from the CRESST-II dark matter detector. They find two maxima in the likelihood function corresponding to best fit WIMP masses of 25.3 and 11.6 GeV with elastic cross sections of $1.6 \times 10^{-6}$ and $3.7 \times 10^{-5}$ pb respectively, see their Table 4. The statistical significance is more than 4$\sigma$. ANGLOHER 12 updates ANGLOHER 09.

Predictions for the spin-independent elastic cross section based on a frequentist approach to electroweak observables in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using the 5 fb$^{-1}$ LHC data and XENON100.

The strongest limit is $1.4 \times 10^{-7}$ at $m_{\chi} = 60$ GeV.

This result updates LEE 07A. The strongest limit is $2.1 \times 10^{-7}$ at $m_{\chi} = 70$ GeV.

AHMED 11A gives combined results from CDMS and EDELWEISS. The strongest limit is at $m_{\chi} = 90$ GeV.

ARMENGAUD 11 updates result of ARMENGAUD 10. Strongest limit at $m_{\chi} = 85$ GeV.

The strongest upper limit is $5.1 \times 10^{-8}$ pb and occurs at $m_{\chi} \approx 30$ GeV. The values quoted here are based on the analysis performed in ANGLE 08 with the update from SORENSEN 09.

The strongest upper limit is $6.6 \times 10^{-7}$ pb and occurs at $m_{\chi} \approx 65$ GeV.

AKERIB 06A updates the results of AKERIB 05. The strongest upper limit is $1.6 \times 10^{-7}$ pb and occurs at $m_{\chi} \approx 60$ GeV.

The strongest upper limit is also close to $1.0 \times 10^{-6}$ pb and occurs at $m_{\chi} \approx 70$ GeV. BENOIT 06 claim that the discrimination power of ZEPLIN-I measurement (ALNER 05A) is not reliable enough to obtain a limit better than $1 \times 10^{-3}$ pb. However, SMITH 06 do not agree with the criticisms of BENOIT 06.

AKERIB 04 is incompatible with BERNABEI 00 most likely value, under the assumption of standard WIMP-halo interactions. The strongest upper limit is $4 \times 10^{-7}$ pb and occurs at $m_{\chi} \approx 60$ GeV.

Predictions for the spin-independent elastic cross section in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry.

KIM 02 and ELLIS 04 calculate the $\chi p$ elastic scattering cross section in the framework of $N=1$ supergravity models with radiative breaking of the electroweak gauge symmetry, but without universal scalar masses.

In the case of universal squark and slepton masses, but non-universal Higgs masses, the limit becomes $2 \times 10^{-6}$ ($2 \times 10^{-11}$ when constraint from the BNL $g–2$ experiment are included), see ELLIS 03E. ELLIS 05 display the sensitivity of the elastic scattering cross section to the $\pi$-Nucleon $\Sigma$ term.

PIERCE 04A calculates the $\chi p$ elastic scattering cross section in the framework of models with very heavy scalar masses. See Fig. 2 of the paper.

The strongest upper limit is $1.8 \times 10^{-5}$ pb and occurs at $m_{\chi} \approx 80$ GeV.

Under the assumption of standard WIMP-halo interactions, Akerib 03 is incompatible with BERNABEI 00 most likely value at the 99.98% CL. See Fig. 4.
34 BAER 03A calculates the $\chi p$ elastic scattering cross section in several models including the framework of $N=1$ supergravity models with radiative breaking of the electroweak gauge symmetry.

35 The strongest upper limit is $7 \times 10^{-6}$ pb and occurs at $m_\chi \simeq 30$ GeV.

36 ABRAMS 02 is incompatible with the DAMA most likely value at the 99.9% CL. The strongest upper limit is $3 \times 10^{-6}$ pb and occurs at $m_\chi \simeq 30$ GeV.

37 The strongest upper limit is $2 \times 10^{-5}$ pb and occurs at $m_\chi \simeq 40$ GeV.

38 The strongest upper limit is $7 \times 10^{-6}$ pb and occurs at $m_\chi \simeq 46$ GeV.

39 The strongest upper limit is $1.8 \times 10^{-5}$ pb and occurs at $m_\chi \simeq 32$ GeV.

40 BOTTINO 01 calculates the $\chi - p$ elastic scattering cross section in the framework of the following supersymmetric models: $N=1$ supergravity with the radiative breaking of the electroweak gauge symmetry, $N=1$ supergravity with nonuniversal scalar masses and an effective MSSM model at the electroweak scale.

41 Calculates the $\chi - p$ elastic scattering cross section in the framework of $N=1$ supergravity models with radiative breaking of the electroweak gauge symmetry.

42 ELLIS 01C calculates the $\chi - p$ elastic scattering cross section in the framework of $N=1$ supergravity models with radiative breaking of the electroweak gauge symmetry. ELLIS 02ß finds a range $2 \times 10^{-8}$–$1.5 \times 10^{-7}$ at $\tan \beta =50$. In models with nonuniversal Higgs masses, the upper limit to the cross section is $4 \times 10^{-7}$.

43 ACCOMANDO 00 calculate the $\chi - p$ elastic scattering cross section in the framework of minimal $N=1$ supergravity models with radiative breaking of the electroweak gauge symmetry. The limit is relaxed by at least an order of magnitude when models with nonuniversal scalar masses are considered. A subset of the authors in ARNOWITT 02 updated the limit to $< 9 \times 10^{-8}$ ($\tan \beta < 55$).

44 BERNABEI 00 search for annual modulation of the WIMP signal. The data favor the hypothesis of annual modulation at 4σ and are consistent, for a particular model framework quoted there, with $m_{X^0} = 44^{+12}_{-9}$ GeV and a spin-independent $X^0$-proton cross section of $(5.4 \pm 1.0) \times 10^{-6}$ pb. See also BERNABEI 01 and BERNABEI 00C.

45 FENG 00 calculate the $\chi - p$ elastic scattering cross section in the framework of $N=1$ supergravity models with radiative breaking of the electroweak gauge symmetry with a particular emphasis on focus point models. At $\tan \beta =50$, the range is $8 \times 10^{-8}$–$4 \times 10^{-7}$.

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**Other bounds on $\tilde{\chi}_1^0$ from astrophysics and cosmology**

Most of these papers generally exclude regions in the $M_2-\mu$ parameter plane by requiring that the $\tilde{\chi}_1^0$ contribution to the overall cosmological density is less than some maximal value to avoid overclosure of the Universe. Those not based on the cosmological density are indicated. Many of these papers also include LEP and/or other bounds.

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- We do not use the following data for averages, fits, limits, etc.

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**Notes:**
- **COSM**: Cosmological context
- **Co-annihilation**
- **CP-violating phases**
- **Minimal supergravity**
- **Sfermion mixing**
- **Co-annihilation**
- **Minimal supergravity, \(m_0=A=0\)**
- **Minimal supergravity**
none 100 eV – 15 GeV SREDNICKI 88 COSM $\tilde{\gamma}$, $m_{\tilde{f}} = 100$ GeV

none 100 eV – 5 GeV ELLIS 84 COSM $\tilde{\gamma}$ for $m_{\tilde{f}} = 100$ GeV

GOLDBERG 83 COSM $\tilde{\gamma}$

KRAUSS 83 COSM $\tilde{\gamma}$

VYSOTSKII 83 COSM $\tilde{\gamma}$

1 ELLIS 00 updates ELLIS 98. Uses LEP $e^+ e^-$ data at $\sqrt{s} = 202$ and 204 GeV to improve bound on neutralino mass to 51 GeV when scalar mass universality is assumed and 46 GeV when Higgs mass universality is relaxed. Limits on $\tan\beta$ improve to $> 2.7 (\mu > 0), > 2.2 (\mu < 0)$ when scalar mass universality is assumed and $> 1.9$ (both signs of $\mu$) when Higgs mass universality is relaxed.

2 Implications of the LHC result on the Higgs mass and on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry.

3 BUCHMUELLER 14A places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using indirect experimental searches using the $20 \text{ fb}^{-1} 8$ TeV and the $5 \text{ fb}^{-1} 7$ TeV LHC and the LUX data.

4 ROSZKOWSKI 14 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using Bayesian statistics and indirect experimental searches using the $20 \text{ fb}^{-1} 8$ TeV LHC and the LUX data.

5 CABRERA 13 and STREGE 13 place constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry with and without non-universal Higgs masses using the $5.8 \text{ fb}^{-1}, \sqrt{s} = 7$ TeV ATLAS supersymmetry searches and XENON100 results.

6 ELLIS 13b place constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry with and without Higgs mass universality. Models with universality below the GUT scale are also considered.

7 BALAZS 12 and STREGE 12 place constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using the $1 \text{ fb}^{-1} 7$ TeV LHC supersymmetry searches, the $5 \text{ fb}^{-1}$ Higgs mass constraints, both with $\sqrt{s} = 7$ TeV, and XENON100 results.

8 BECHTLE 12 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using indirect experimental searches, using the $5 \text{ fb}^{-1} 7$ TeV LHC and XENON100 data.

9 BESKIDT 12 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using indirect experimental searches, the $5 \text{ fb}^{-1} 7$ TeV LHC and the XENON100 data.

10 BELANGER 04 and BOTTINO 12 (see also BOTTINO 03, BOTTINO 03A and BOTTINO 04) do not assume gaugino or scalar mass unification.

11 FENG 12 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry and large sfermion masses using the $1 \text{ fb}^{-1} 7$ TeV LHC supersymmetry searches, the $5 \text{ fb}^{-1} 7$ TeV LHC Higgs mass constraints both with $\sqrt{s} = 7$ TeV, and XENON100 results.

12 BUCHMUELLER 11 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using indirect experimental searches and including supersymmetry breaking relations between A and B parameters.
13 Places constraints on the SUSY parameter space in the framework of $N=1$ supergravity models with radiative breaking of the electroweak gauge symmetry but non-Universal Higgs masses.

14 ELLIS 10 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry with universality above the GUT scale.

15 BUCHMUELLER 09 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using indirect experimental searches.

16 DREINER 09 show that in the general MSSM with non-universal gaugino masses there exists no model-independent laboratory bound on the mass of the lightest neutralino. An essentially massless $\chi$ is allowed by the experimental and observational data, imposing some constraints on other MSSM parameters, including $M_2$, $\mu$ and the slepton and squark masses.

17 BUCHMUELLER 08 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry using indirect experimental searches.

18 CALIBBI 07 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry with universality above the GUT scale including the effects of right-handed neutrinos.

19 ELLIS 07 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry with universality below the GUT scale.

20 ALLANACH 06 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry.

21 DE-AUSTRI 06 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry.

22 BALTZ 04 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry.

23 Limit assumes a pseudo scalar mass $< 200$ GeV. For larger pseudo scalar masses, $m_\chi > 18(29)$ GeV for $\tan \beta = 50(10)$. Bounds from WMAP, $(g - 2)_\mu$, $b \to s \gamma$, LEP.

24 ELLIS 04 places constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry including supersymmetry breaking relations between A and B parameters. See also ELLIS 03d.

25 PIERCE 04 places constraints on the SUSY parameter space in the framework of models with very heavy scalar masses.

26 BAER 03, CHATTOPADHYAY 03, ELLIS 03c and LAHANAS 03 place constraints on the SUSY parameter space in the framework of $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry based on WMAP results for the cold dark matter density.

27 BOEHM 00 and ELLIS 03 place constraints on the SUSY parameter space in the framework of minimal $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry. Includes the effect of $\chi$-t co-annihilations.

28 LAHANAS 02 places constraints on the SUSY parameter space in the framework of minimal $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry. Focuses on the role of pseudo-scalar Higgs exchange.

29 BARGER 01c use the cosmic relic density inferred from recent CMB measurements to constrain the parameter space in the framework of minimal $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry.

30 ELLIS 01b places constraints on the SUSY parameter space in the framework of minimal $N = 1$ supergravity models with radiative breaking of the electroweak gauge symmetry. Focuses on models with large $\tan \beta$.

31 FENG 00 explores cosmologically allowed regions of MSSM parameter space with multi-TeV masses.
ELLI$\text{s}$ 988 assumes a universal scalar mass and radiative supersymmetry breaking with universal gaugino masses. The upper limit to the LSP mass is increased due to the inclusion of $\chi - \tilde{\tau}_R$ coannihilations.

EDSJO 97 included all coannihilation processes between neutralinos and charginos for any neutralino mass and composition.

Notes the location of the neutralino $Z$ resonance and $h$ resonance annihilation corridors in minimal supergravity models with radiative electroweak breaking.

Mass of the bino ($=\text{LSP}$) is limited to $m_{\tilde{B}} \lesssim 350$ GeV for $m_t = 174$ GeV.

DREES 93, KELLEY 93 compute the cosmic relic density of the LSP in the framework of minimal $N=1$ supergravity models with radiative breaking of the electroweak symmetry.

FALK 93 assume a universal scalar mass and radiative supersymmetry breaking with universal gaugino masses. The upper limit to the LSP mass is increased due to the inclusion of $\chi - \tilde{\tau}_R$ coannihilations.

EDSJO 97 included all coannihilation processes between neutralinos and charginos for any neutralino mass and composition.

Notes the location of the neutralino $Z$ resonance and $h$ resonance annihilation corridors in minimal supergravity models with radiative electroweak breaking.

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DREES 93, KELLEY 93 compute the cosmic relic density of the LSP in the framework of minimal $N=1$ supergravity models with radiative breaking of the electroweak symmetry.

Mass of the bino ($=\text{LSP}$) is limited to $m_{\tilde{B}} \lesssim 350$ GeV for $m_t \leq 200$ GeV. Mass of the higgsino ($=\text{LSP}$) is limited to $m_{\tilde{H}_1} \lesssim 1$ TeV for $m_t \leq 200$ GeV.

ROSZKOWSKI 91 calculates LSP relic density in mixed gaugino/higgsino region.

Mass of the bino ($=\text{LSP}$) is limited to $m_{\tilde{B}} \lesssim 550$ GeV. Mass of the higgsino ($=\text{LSP}$) is limited to $m_{\tilde{H}_1} \lesssim 3.2$ TeV.

KRAUSS 83 finds $m_{\tilde{\gamma}}$ not 30 eV to 2.5 GeV. KRAUSS 83 takes into account the gravitino decay. Find that limits depend strongly on reheated temperature. For example a new allowed region $m_{\tilde{\gamma}} = 4–20$ MeV exists if $m_{\text{gravitino}} < 40$ TeV. See figure 2.

### Unstable $\tilde{\chi}_1^0$ (Lightest Neutralino) mass limit

Unless otherwise stated, results in this section assume spectra and production rates as evaluated in the MSSM. Unless otherwise stated, the goldstino or gravitino mass $m_{\tilde{G}}$ is assumed to be negligible relative to all other masses. In the following, $G$ is assumed to be undetected and to give rise to a missing energy ($E_T$) signature.

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).

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<td>&gt;525</td>
<td>95</td>
<td>1 SIRUNYAN</td>
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<td>$\tilde{\chi}_1^0 \rightarrow \gamma G$, GMSB, SPS8, $ct=1$ m</td>
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<td>&gt;290</td>
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<tr>
<td>&gt;230</td>
<td>95</td>
<td>2 SIRUNYAN</td>
<td>CMS</td>
<td>$\geq 1\ H (\rightarrow \gamma \gamma) + \text{jets} + E_T$, Tn1n1B , GMSB</td>
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<tr>
<td>&gt;930</td>
<td>95</td>
<td>3 SIRUNYAN</td>
<td>CMS</td>
<td>$\gamma + \text{lepton} + E_T$, Tchi1n1A</td>
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HTTP://PDG.LBL.GOV  Page 23  Created: 6/1/2020 08:33
none | 130–230, 290–880
---|---
>295 | 95 | 4 AABOUD | 18CK ATLS | $2H \rightarrow bb+\ellell', Tn1n1A$, GMSB
>180 | 95 | 5 AABOUD | 18Z ATLS | $\geq 4\ell$, GMSB, Tn1n1C
>260 | 95 | 6 SIRUNYAN | 18AO CMS | $\ell^{\pm}\ell^{\pm}$ or $\geq 3\ell$, Tn1n1A
>450 | 95 | 6 SIRUNYAN | 18AO CMS | $\ell^{\pm}\ell^{\pm}$ or $\geq 3\ell$, Tn1n1B
>750 | 95 | 7 SIRUNYAN | 18AP CMS | Combination of searches, GMSB, Tn1n1A
>650 | 95 | 7 SIRUNYAN | 18AP CMS | Combination of searches, GMSB, Tn1n1B
>690 | 95 | 7 SIRUNYAN | 18AP CMS | Combination of searches, GMSB, Tn1n1C
>500 | 95 | 8 SIRUNYAN | 18AR CMS | $\ell^{\pm}\ell^{\pm}$+ jets+$E_T$, GMSB, Tn1n1B
>650 | 95 | 8 SIRUNYAN | 18AR CMS | $\ell^{\pm}\ell^{\pm}$+ jets+$E_T$, GMSB, Tn1n1C
none | 230–770
>205 | 95 | 9 SIRUNYAN | 18O CMS | $2H \rightarrow bb+\ellell', Tn1n1A$, GMSB
>130 | 95 | 10 SIRUNYAN | 18X CMS | $\geq 1H \rightarrow \gamma\gamma + $ jets+$E_T$, Tn1n1A, GMSB
>380 | 95 | 11 KHACHATRYAN | 14L CMS | $\tilde{\chi}^0_1 \rightarrow Z\tilde{G}$ simplified models, GMSB, RPV
none | 300–1000
>220 | 95 | 12 AABOUD | 19G ATLS | $\tilde{\chi}^0_1 \rightarrow \tilde{G}$ from gluinos as in Tglu1A, GMSB, depending on $c\tau$
13 AAJ | 17Z | $\tilde{\chi}^0_1 \rightarrow \mu jj$, RPV, $\lambda'_{211} \neq 0$
14 KHACHATRYAN | 16X | $\tilde{\chi}^0_1 \rightarrow \gamma\tilde{G}$, $E_T$, GMSB
none | 220–380
>220 | 95 | 15 AAD | 14BH ATLS | $\gamma + E_T$, GMSB, SPS8
16 AAD | 13AP ATLS | $\gamma + E_T$, GMSB, SPS8
17 AAD | 13Q ATLS | $\gamma + E_T$, higgsino-like neutralino, GMSB
18 AAD | 13R ATLS | $\tilde{\chi}^0_1 \rightarrow \mu jj$, RPV, $\lambda'_{211} \neq 0$
19 AALTONEN | 13I CDF | $\tilde{\chi}^0_1 \rightarrow \gamma\tilde{G}$, $E_T$, GMSB
>220 | 95 | 20 CHATRCHYAN | 13AH CMS | $\tilde{\chi}^0_1 \rightarrow \gamma\tilde{G}$, GMSB, SPS8, $c\tau < 500$ mm
21 AAD | 12CP ATLS | $2\gamma + E_T$, GMSB
22 AAD | 12CT ATLS | $\geq 4\ell^{\pm}$, RPV
23 AAD | 12R ATLS | $\tilde{\chi}^0_1 \rightarrow \mu jj$, RPV, $\lambda'_{211} \neq 0$
24 ABAZOV | 12AD D0 | $\tilde{\chi}^0_1 \rightarrow \gamma\tilde{Z}\tilde{G}$, GMSB
25 CHATRCHYAN | 12BK CMS | $2\gamma + E_T$, GMSB
26 CHATRCHYAN | 11B CMS | $W^0 \rightarrow \gamma\tilde{G}$, $W^\pm \rightarrow \ell^{\pm}\tilde{G}$, GMSB
>149 | 95 | 27 AALTONEN | 10 CDF | $\rho\tilde{\tau} \rightarrow \tilde{\chi}\tilde{\tau}, \tilde{\chi}=\tilde{\chi}_2^0, \tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$, GMSB
>175 | 95 | 28 ABAZOV | 10P D0 | $\tilde{\chi}^0_1 \rightarrow \gamma\tilde{G}$, GMSB
>125 | 95 | 29 ABAZOV | 08D D0 | $\rho\tilde{\tau} \rightarrow \tilde{\chi}\tilde{\tau}, \tilde{\chi}=\tilde{\chi}_2^0, \tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$, GMSB

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None of the following data are used for averages, fits, limits, etc.

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1 SIRUNYAN 19CA searched in 77.4 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing delayed photons in both single and diphoton plus $E_T$ final states. No excess is observed above the background expected from Standard Model processes. The results are used to set 95% C.L. exclusion limits in the context of GMSB, using the SPS8 benchmark model. For neutralino proper decay lengths of 0.1, 1, 10, and 100 m, masses up to about 320, 525, 360, and 215 GeV are excluded, respectively. See their Fig. 5. The searches involve the simplified models Tg1u1D, Tg1u4A,B,C, Tsqk4,A,B. 

2 SIRUNYAN 19CI searched in 77.5 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with one or more high-momentum Higgs bosons, decaying to pairs of photons, jets and $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in the Tsbot4A simplified model, see Figure 3, and on the wino mass in the Tchi1n2A simplified model, see their Figure 4. Limits are also set on the higgsino mass in the Tn1n1A and Tn1n1B simplified models, see their Figure 5. 

3 SIRUNYAN 19K searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with a photon, an electron or muon, and large $E_T$. No significant excess above the Standard Model expectations is observed. In the framework of GMSB, limits are set on the chargino and neutralino mass in the Tchi1n1A simplified model, see their Figure 6. Limits are also set on the gluino mass in the Tg1u4A simplified model, and on the squark mass in the Tsqk4A simplified model, see their Figure 7. 

4 AABOUD 18CK searched for events with at least 3 $b$-jets and large missing transverse energy in two datasets of $p p$ collisions at $\sqrt{s} = 13$ TeV of 36.1 fb$^{-1}$ and 24.3 fb$^{-1}$ depending on the trigger requirements. The analyses aimed to reconstruct two Higgs bosons decaying to pairs of $b$-quarks. No significant excess above the Standard Model expectations is observed. Limits are set on the Higgsino mass in the Tn1n1A simplified model, see their Figure 15(a). Constraints are also presented as a function of the BR of Higgsino decaying into an higgs boson and a gravitino, see their Figure 15(b). 

5 AABOUD 18Z searched in 36.1 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing four or more charged leptons (electrons, muons and up to two hadronically decaying taus). No significant deviation from the expected SM background is observed. Limits are set on the Higgsino mass in simplified models of general gauge mediated supersymmetry Tn1n1A/Tn1n1B/Tn1n1C, see their Figure 9. Limits are also set on the wino, slepton, sneutrino and gluino mass in a simplified model of NLSP pair production with R-parity violating decays of the LSP via $\lambda_{12k}$ or $\lambda_{133}$ to charged leptons, see their Figures 7, 8. 

6 SIRUNYAN 18A0 searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and neutralinos in events with either two or more leptons (electrons or muons) of the same electric charge, or with three or more leptons, which can include up to two hadronically decaying tau leptons. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino/neutralino mass in the Tchi1n2A, Tchi1n2H, Tchi1n2D, Tchi1n2E and Tchi1n2F simplified models, see their Figures 14, 15, 16, 17 and 18. Limits are also set on the higgsino mass in the Tn1n1A, Tn1n1B and Tn1n1C simplified models, see their Figure 19. 

7 SIRUNYAN 18AP searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and neutralinos by combining a number of previous and new searches. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino/neutralino mass in the Tchi1n2E, Tchi1n2F and Tchi1n2I simplified models, see their Figures 7, 8, 9 an 10. Limits are also set on the higgsino mass in the Tn1n1A, Tn1n1B and Tn1n1C simplified models, see their Figure 11, 12, 13 and 14.
8 SIRUNYAN 18AR searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events containing two opposite-charge, same-flavour leptons (electrons or muons), jets and \(E_T^\text{miss}\). No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu4C simplified model, see their Figure 7. Limits are also set on the chargino/neutralino mass in the Tchi1n2F simplified models, see their Figure 8, and on the higgsino mass in the Tn1n1B and Tn1n1C simplified models, see their Figure 9. Finally, limits are set on the sbottom mass in the Tsbot3 simplified model, see their Figure 10.

9 SIRUNYAN 18O searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with two Higgs bosons, decaying to pairs of \(b\)-quarks, and large \(E_T^\text{miss}\). No significant excess above the Standard Model expectations is observed. Limits are set on the higgsino mass in the Tn1n1A simplified model, see their Figure 9.

10 SIRUNYAN 18X searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with one or more high-momentum Higgs bosons, decaying to pairs of photons, jets and \(E_T^\text{miss}\). The razor variables (\(M_R^\text{var} \) and \(R^2\)) are used to categorise the events. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in the Tsbot4 simplified model and on the wino mass in the Tchi1n2E simplified model, see their Figure 5. Limits are also set on the higgsino mass in the Tn1n1A and Tn1n1B simplified models, see their Figure 6.

11 KHACHATRYAN 14L searched in 19.5 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 8\) TeV for evidence of direct pair production of neutralinos with Higgs or \(Z\)-bosons in the decay chain, leading to \(HH\), \(HZ\) and \(ZZ\) final states with missing transverse energy. The decays of 16–20. a Higgs boson to a \(b\)-quark pair, to a photon pair, and to final states with leptons are considered in conjunction with hadronic and leptonic decay modes of the \(Z\) and \(W\) bosons. No significant excesses over the expected SM backgrounds are observed. The results are interpreted in the context of GMSB simplified models where the decays \(\tilde{\chi}_1^0 \rightarrow H\tilde{G}\) or \(\tilde{\chi}_1^0 \rightarrow Z\tilde{G}\) take place either 100\% or 50\% of the time, see Figs. 16–20.

12 AABOUD 19G searched in 32.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for evidence of neutralinos decaying into a \(Z\)-boson and a gravitino, in events characterized by the presence of dimuon vertices with displacements from the \(pp\) interaction point in the range of 1400 cm. Neutralinos are assumed to be produced in the decay chain of gluinos as in Tglu1A models. No significant excess is observed in the number of vertices relative to the predicted background. In GGM with a gluino mass of 1100 GeV, neutralino masses in the range 300–1000 GeV are excluded for certain values of \(cT\), see their Figure 7.

13 AAJU 17Z searched in 1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 7\) TeV and in 2 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 8\) TeV for events containing a displaced vertex with one associated high transverse momentum \(\mu\). No excess is observed above the background expected from Standard Model processes. The results are used to set 95\% C.L. upper limits on the cross section times branching fractions of pair-produced neutralinos decaying non-promptly into a muon and two quarks. Long-lived particles in a mass range 23–198 GeV are considered, see their Fig. 5 and Fig. 6.

14 KHACHATRYAN 16BX searched in 19.5 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 8\) TeV for events containing 3 or more leptons coming from the electroweak production of wino- or higgsino-like neutralinos, assuming non-zero R-parity-violating leptonic couplings \(\lambda_{122}^\prime\), \(\lambda_{123}^\prime\), and \(\lambda_{233}^\prime\) or semileptonic couplings \(\lambda_{131}^\prime\), \(\lambda_{233}^\prime\), \(\lambda_{331}^\prime\), and \(\lambda_{333}^\prime\). No excess over the expected background is observed and limits are derived on the neutralino mass, see Figs. 24 and 25.

15 AAD 14Bh searched in 20.3 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 8\) TeV for events containing non-pointing photons in a diphoton plus missing transverse energy final state. No excess is observed above the background expected from Standard Model processes. The results are used to set 95\% C.L. exclusion limits in the contact of gauge-mediated supersymmetric breaking models, with the lightest neutralino being the next-to-lightest supersymmetric particle and decaying with a lifetime in the range from 0.25 ns to about 100 ns into a photon and a gravitino. For limits on the NLSP lifetime versus \(\Lambda\) plane, for the SPS8 model, see their Fig. 7.
AAD 13AP searched in 4.8 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 7\) TeV for events containing non-pointing photons in a diphoton plus missing transverse energy final state. No excess is observed above the background expected from Standard Model processes. The results are used to set 95\% C.L. exclusion limits in the context of gauge-mediated supersymmetric breaking models, with the lightest neutralino being the next-to-lightest supersymmetric particle and decaying with a lifetime in excess of 0.25 ns into a photon and a gravitino. For limits in the NLSP lifetime versus \(\Lambda\) plane, for the SPS8 model, see their Fig. 8.

AAD 13\(\Omega\) searched in 4.7 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 7\) TeV for events containing a high-\(p_T\) isolated photon, at least one jet identified as originating from a bottom quark, and high missing transverse momentum. Such signatures may originate from supersymmetric models with gauge-mediated supersymmetry breaking in which one of a pair of higgsino-like neutralinos decays into a photon and a gravitino while the other decays into a Higgs boson and a gravitino. No significant excess above the expected background was found and limits were set on the neutralino mass in a generalized GMSB model (GGM) with a higgsino-like neutralino NLSP, see their Fig. 4. Intermediate neutralino masses between 220 and 380 GeV are excluded at 95\% C.L, regardless of the squark and gluino masses, purely on the basis of the expected weak production.

AAD 13\(R\) looked in 4.4 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 7\) TeV for events containing new, heavy particles that decay at a significant distance from their production point into a final state containing a high-momentum muon and charged hadrons. No excess over the expected background is observed and limits are placed on the production cross-section of neutralinos via squarks for various \(m_{\tilde{q}}\), \(m_{\chi_1^0}\) in an R-parity violating scenario with \(\lambda^{\prime}_{211} \neq 0\), as a function of the neutralino lifetime, see their Fig. 6.

AAD 12\(CP\) searched in 4.8 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 7\) TeV for events with two photons and large \(E_T\) due to \(\chi_1^0 \rightarrow \gamma \tilde{G}\) decays in a GMSB framework. No significant excess above the expected background was found and limits were set on the neutralino mass in a generalized GMSB model (GGM) with a bino-like neutralino NLSP, see Figs. 6 and 7. The other sparticle masses were decoupled, \(\tan \beta = 2\) and \(c_{\tau NLSP} < 0.1\) mm. Also, in the framework of the SPS8 model, limits are presented in Fig. 8. Supersedes CHATRCHYAN 12\(BK\).

AAD 12\(CT\) searched in 4.7 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 7\) TeV for events containing four or more leptons (electrons or muons) and either moderate values of missing transverse momentum or large effective mass. No significant excess is found in the data. Limits are presented in a simplified model of R-parity violating supersymmetry in which charginos are pair-produced and then decay into a W-boson and a \(\chi_1^0\) which in turn decays through an RPV coupling into two charged leptons (\(e^\pm e^\mp\) or \(\mu^\pm \mu^\mp\)) and a neutrino. In this model, limits are set on the neutralino mass as a function of the chargino mass, see Fig. 3a. Limits are also set in an R-parity violating mSUGRA model, see Fig. 3b.

AAD 12\(R\) looked in 33 pb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 7\) TeV for events containing new, heavy particles that decay at a significant distance from their production point into a final state containing a high-momentum muon and charged hadrons. No excess over the expected background is observed and limits are placed on the production cross-section of neutralinos via squarks for various \((m_{\tilde{q}}, m_{\chi_1^0})\) in an R-parity violating scenario with \(\lambda^{\prime}_{211} \neq 0\), as a function of the neutralino lifetime, see their Fig. 8. Supersedes by AAD 13\(R\).
set a limit on the effective SUSY breaking scale $\chi$ pair production of $\tilde{\chi}$ significant excess above the expected background was found and limits were set on the $\tilde{F}$ is derived on the $\tilde{N}$ excess over the SM expectation is observed, and a limit at 95% C.L. on the cross section $\tilde{\chi}$ associated to a $\tilde{h}$, $\tilde{g}$, $\tilde{t}$, $\tilde{b}$, $\tilde{q}$ as a function of the effective SUSY breaking scale $\chi$ pair production, decaying to a $\tilde{\chi}$ with at least two isolated $e$, $\mu$ with at least three leptons ($e^{-}e^{+}e^{-}e^{+}$), see their Fig. 14. The limit on the $\tilde{\chi}$ mass range is obtained. $\tilde{\chi}$ in the GMSB model as a function of the $N$ excess of events beyond expectation. An upper limit on the cross-section is calculated $\tilde{\eta}$ events with large $\gamma$, a $Z$ from decays of other supersymmetric particles and then decay to either $Z\tilde{G}$ or $\gamma\tilde{G}$. No significant excess over the SM expectation is observed. A limit is derived $\tilde{\chi}$ mass and lifetime, see their Fig. 2. A limit is derived on the $\tilde{\chi}$ mass of 149 GeV for $\tau_{\tilde{\chi}} \ll 1$ ns, which improves the results of previous searches.

ABAZOV 10P looked in 6.3 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for diphoton events with at least two isolated $\gamma$s and large $E_T$. These could be the signature of $\tilde{\chi}_2^0$ and $\tilde{\chi}_1^\pm$ production, decaying to $\tilde{\chi}_1^0$ and finally $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$ in a GMSB framework. No significant excess was found compared to the background expectation. A limit is derived on the masses of SUSY particles in the GMSB framework for $M = 2\Lambda$, $N = 1$, $\tan\beta = 15$ and $\mu > 0$, see Figure 2. It also excludes $\Lambda < 91.5$ TeV. Supersedes the results of ABAZOV 05A. Superseded by ABAZOV 10P.

ABULENCIA 07H searched in 346 pb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for events with at least three leptons ($e$ or $\mu$) from the decay of $\tilde{\chi}_1^0$ via $LL\tilde{E}$ couplings. The results are consistent with the hypothesis of no signal. Upper limits on the cross-section are extracted and a limit is derived in the framework of mSUGRA on the masses of $\tilde{\chi}_1^0$ and $\tilde{\chi}_1^\pm$, see e.g. their Fig. 3 and Tab. II.

ABBIENDEI 06b use 600 pb$^{-1}$ of data from $\sqrt{s} = 180$–209 GeV. They look for events with diphotons + $E_T$ final states originating from prompt decays of pair-produced neutralinos in a GMSB scenario with $\tilde{\chi}_1^0$ NLSP. Limits on the cross-section are computed as a function of $m(\tilde{\chi}_1^0)$, see their Fig. 14. The limit on the $\tilde{\chi}_1^0$ mass is for a pure Bino state assuming a prompt decay, with lifetimes up to $10^{-9}$ s. Supersedes the results of ABBIENDEI 04N.
ABDALLAH 05b use data from $\sqrt{s} = 180$–209 GeV. They look for events with single photons + $\not{E}_T$ final states. Limits are computed in the plane $(m(\tilde{\chi}_1^0), m(\tilde{\chi}_2^0))$, shown in their Fig. 9b for a pure Bino state in the GMSB framework and in Fig. 9c for a no-scale supergravity model. Supersedes the results of ABREU 00z.

ABDALLAH 05b use data from $\sqrt{s} = 130$–209 GeV. They look for events with diphotons + $\not{E}_T$ final states and single photons not pointing to the vertex, expected in GMSB when the $\tilde{\chi}_1^0$ is the NLSP. Limits are computed in the plane $(m(\tilde{\chi}_1^0), m(\tilde{\chi}_2^0))$, see their Fig. 10.

The lower limit is derived on the $\tilde{\chi}_1^0$ mass for a pure Bino state assuming a prompt decay and $m_{\tilde{e}_R} = m_{\tilde{e}_L} = 2 m_{\tilde{\chi}_1^0}$. It improves to 100 GeV for $m_{\tilde{e}_R} = m_{\tilde{e}_L} = 1.1 m_{\tilde{\chi}_1^0}$.

And the limit in the plane $(m(\tilde{\chi}_1^0), m(\tilde{e}_R))$ is shown in Fig. 10b. For long-lived neutralinos, cross-section limits are displayed in their Fig 11. Supersedes the results of ABREU 00z.

### $\tilde{\chi}_2^0$, $\tilde{\chi}_3^0$, $\tilde{\chi}_4^0$ (Neutralinos) mass limits

Neutralinos are unknown mixtures of photinos, z-inos, and neutral higgsinos (the supersymmetric partners of photons and of $Z$ and Higgs bosons). The limits here apply only to $\tilde{\chi}_2^0$, $\tilde{\chi}_3^0$, and $\tilde{\chi}_4^0$. $\tilde{\chi}_1^0$ is the lightest supersymmetric particle (LSP); see $\tilde{\chi}_1^0$ Mass Limits. It is not possible to quote rigorous mass limits because they are extremely model dependent; i.e. they depend on branching ratios of various $\tilde{\chi}_1^0$ decay modes, on the masses of decay products ($\tilde{e}$, $\tilde{\gamma}$, $\tilde{q}$, $\tilde{g}$), and on the $\tilde{e}$ mass exchanged in $e^+ e^- \rightarrow \tilde{\chi}_i^0 \tilde{\chi}_j^0$. Limits arise either from direct searches, or from the MSSM constraints set on the gaugino and higgsino mass parameters $M_2$ and $\mu$ through searches for lighter charginos and neutralinos. Often limits are given as contour plots in the $m_{\tilde{\chi}_1^0} - m_{\tilde{\chi}_2^0}$ plane vs other parameters. When specific assumptions are made, e.g. the neutralino is a pure photino ($\tilde{\gamma}$), pure z-ino ($\tilde{Z}$), or pure neutral higgsino ($\tilde{H}^0$), the neutralinos will be labelled as such.

Limits obtained from $e^+ e^-$ collisions at energies up to 136 GeV, as well as other limits from different techniques, are now superseded and have not been included in this compilation. They can be found in the 1998 Edition (The European Physical Journal C3 1 (1998)) of this Review. Some later papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).
> 760 95 3 AABOUD 18AY ATLS \(2\tau + E_T, \text{Tchi1n2D and } \tau_L\)-only, \(m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 1125 95 4 AABOUD 18BT ATLS \(2,3\ell + E_T, \text{Tchi1n2C, } m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 580 95 5 AABOUD 18BT ATLS \(2,3\ell + E_T, \text{Tchi1n2F, } m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

none 130–230, 290–880 95 6 AABOUD 18CK ATLS \(2H (\rightarrow bb) + E_T, \text{Tn1n1A, GMSB}\)

none 220–600 95 7 AABOUD 18CO ATLS \(2,3\ell + E_T, \text{recursive jigsaw, Tchi1n2F, } m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 145 95 8 AABOUD 18R ATLS \(2\ell\) (soft) + \(E_T, \text{Tchi1n2G, higgsino, } m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0} = 5 \text{ GeV}\)

> 175 95 9 AABOUD 18R ATLS \(2\ell\) (soft) + \(E_T, \text{Tchi1n2F, higgsino, } m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0} = 15 \text{ GeV}\)

> 1060 95 10 AABOUD 18U ATLS \(2\gamma + E_T, \text{GGM, Tchi1chi1A, any NLSP mass}\)

> 167 95 11 SIRUNYAN 18AJ CMS \(2\ell\) (soft) + \(E_T, \text{Tchi1n2G, higgsino, } m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0} = 15 \text{ GeV}\)

> 710 95 12 SIRUNYAN 18DP CMS \(2\tau + E_T, \text{Tchi1n2D, } m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

none 220–490 95 13 SIRUNYAN 17AW CMS \(1\ell + 2\text{ b-jets} + E_T, \text{Tchi1n2E, } m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 600 95 14 AAD 16AA ATLS \(3,4\ell + E_T, \text{ Tn2n3A, } m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 670 95 14 AAD 16AA ATLS \(3,4\ell + E_T, \text{ Tn2n3B, } m_{\tilde{\chi}_1^0} < 200 \text{ GeV}\)

> 250 95 15 AAD 15BA ATLS \(m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0}, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 380 95 16 AAD 14H ATLS \(\chi_1^\pm \chi_2^0 \rightarrow \tau^\pm \nu \chi_1^0, \text{ simplified model, } m_{\chi_1^\pm} = m_{\chi_2^0}, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 700 95 16 AAD 14H ATLS \(\chi_1^\pm \chi_2^0 \rightarrow \ell^\pm \nu \chi_1^0, \text{ simplified model, } m_{\chi_1^\pm} = m_{\chi_2^0}, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 345 95 16 AAD 14H ATLS \(\chi_1^\pm \chi_2^0 \rightarrow W \chi_1^0 Z \chi_1^0, \text{ simplified model, } m_{\chi_1^\pm} = m_{\chi_2^0}, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 148 95 16 AAD 14H ATLS \(\chi_1^\pm \chi_2^0 \rightarrow W \chi_1^0 H \chi_1^0, \text{ simplified model, } m_{\chi_1^\pm} = m_{\chi_2^0}, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

> 620 95 17 AAD 14X ATLS \(\geq 4\ell^\pm, \chi_2^0, \chi_3^0 \rightarrow \ell^\pm \ell^\pm \tau^0, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}\)

18 AAD 13 ATLS \(3\ell^\pm + E_T, \text{pMSSM, SMS}\)

19 CHATRCHYAN 12B ATLS \(\geq 2\ell, \text{jets} + E_T, pp \rightarrow \chi_1^\pm \chi_2^0\)

> 624 95 20 ABREU 00W DLPH \(\chi_2^0, 1 \leq \tan \beta \leq 40, \text{all } \Delta m, \text{all } m_0\)

> 99.9 95 20 ABREU 00W DLPH \(\chi_3^0, 1 \leq \tan \beta \leq 40, \text{all } \Delta m, \text{all } m_0\)

> 116.0 95 20 ABREU 00W DLPH \(\chi_4^0, 1 \leq \tan \beta \leq 40, \text{all } \Delta m, \text{all } m_0\)
We do not use the following data for averages, fits, limits, etc.

<table>
<thead>
<tr>
<th>None</th>
<th>AAD</th>
<th>ATLS</th>
<th>$\chi_1^{+,-0} \rightarrow W\chi_1^0 Z\chi_1^0$, simplified model, $m_{\chi_1^0} = m_{\chi_2^0}, m_{\chi_1^0} = 0$</th>
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<td>180–355</td>
<td>21</td>
<td>14G</td>
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1 AABOUD 19AU searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and next-to-lightest neutralinos decaying into lightest neutralinos and a $W$ and a Higgs boson, respectively. Fully hadronic, semileptonic, di-photon, and multilepton (electrons, muons) final states with missing transverse momentum are considered in this search. Observations are consistent with the Standard Model expectations, and 95% confidence-level limits of up to 680 GeV on the chargino/next-to-lightest neutralino masses are set (Tchi1n2E model). See their Figure 14 for an overlay of exclusion contours from all searches.

2 SIRUNYAN 19B4U searched for pair production of gauginos via vector boson fusion assuming the gaugino spectrum is compressed, in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV. The final states explored included zero leptons plus two jets, one lepton plus two jets, and one hadronic tau plus two jets. A similar bound is obtained in the light slepton limit.

3 AABOUD 18AY searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and neutralinos as in Tchi1n2D models, in events characterised by the presence of at least two hadronically decaying tau leptons and large missing transverse energy. No significant deviation from the expected SM background is observed. Assuming decays via intermediate $\tilde{\tau}_L$ and $m_{\tilde{\tau}} = m_{\tilde{\chi}_0^0}$, the observed limits rule out $\tilde{\chi}_2^0$ masses up to 760 GeV for a massless $\tilde{\chi}_1^0$. See their Fig.7 (right). Interpretations are also provided in Fig 8 (bottom) for different assumptions on the ratio between $m_{\tilde{\tau}}$ and $m_{\tilde{\chi}_0^0}$.

4 AABOUD 18BT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos, chargino and next-to-lightest neutralinos and sleptons in events with two or three leptons (electrons or muons), with or without jets, and large missing transverse energy. No significant excess above the Standard Model expectations is observed. Limits are set on the next-to-lightest neutralino mass up to 1100 GeV for massless $\tilde{\chi}_1^0$ in the Tchi1n2C simplified model exploiting the 3$l$ signature, see their Figure 8(c).

5 AABOUD 18BT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos, chargino and next-to-lightest neutralinos and sleptons in events with two or three leptons (electrons or muons), with or without jets, and large missing transverse energy. No significant excess above the Standard Model expectations is observed. Limits are set on the next-to-lightest neutralino mass up to 580 GeV for massless $\tilde{\chi}_1^0$ in the Tchi1n2F simplified model exploiting the 2$l+2$ jets and 3$l$ signatures, see their Figure 8(d).

6 AABOUD 18CK searched for events with at least 3 $b$-jets and large missing transverse energy in two datasets of $pp$ collisions at $\sqrt{s} = 13$ TeV of 36.1 fb$^{-1}$ and 24.3 fb$^{-1}$ depending on the trigger requirements. The analyses aimed to reconstruct two Higgs bosons decaying to pairs of $b$-quarks. No significant excess above the Standard Model expectations is observed. Limits are set on the Higgsino mass in the T1n1n1A simplified model, see their Figure 15(a). Constraints are also presented as a function of the BR of Higgsino decaying into an higgs boson and a gravitino, see their Figure 15(b).
AABOUD 18CO searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of mass-degenerate charginos and next-to-lightest neutralinos in events with two or three leptons (electrons or muons), with or without jets, and large missing transverse energy. The search channels are based on recursive jigsaw reconstruction. Limits are set on the next-to-lightest neutralinos mass up to 600 GeV for massless neutralinos in the Tchi1n2F simplified model exploiting the statistical combination of $2\ell + 2$ jets and $3\ell$ channels. Next-to-lightest neutralinos masses below 220 GeV are not excluded due to an excess of events above the SM prediction in the dedicated regions. See their Figure 13(d).

AABOUD 18R searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for electroweak production in scenarios with compressed mass spectra in final states with two low-momentum leptons and missing transverse momentum. The data are found to be consistent with the SM prediction. Results are interpreted in Tchi1n2G higgsino models, and $\chi^0_2$ masses are excluded up to 145 GeV for $m_{\chi^0_2} - m_{\chi^0_1} = 5$ GeV. The exclusion limits extend down to mass splittings of 2.5 GeV, see their Fig. 10 (top). Results are also interpreted in terms of exclusion bounds on the production cross-sections for the NUHM2 scenario as a function of the universal gaugino mass $m_{1/2}$ and $m_{\chi^0_2} - m_{\chi^0_1}$, see their Fig. 12.

AABOUD 18R searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for electroweak production in scenarios with compressed mass spectra in final states with two low-momentum leptons and missing transverse momentum. The data are found to be consistent with the SM prediction. Results are interpreted in Tchi1n2F wino models, and $\chi^0_2$ masses are excluded up to 175 GeV for $m_{\chi^0_2} - m_{\chi^0_1} = 10$ GeV. The exclusion limits extend down to mass splittings of 2 GeV, see their Fig. 10 (bottom). Results are also interpreted in terms of exclusion bounds on the production cross-sections for the NUHM2 scenario as a function of the universal gaugino mass $m_{1/2}$ and $m_{\chi^0_2} - m_{\chi^0_1}$, see their Fig. 12.

AABOUD 18U searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with at least one isolated photon, possibly jets and significant transverse momentum targeting generalised models of gauge-mediated SUSY breaking. No significant excess of events is observed above the SM prediction. Results of the diphoton channel are interpreted in terms of lower limits on the masses of gauginos Tchi1chi1A models, which reach as high as 1.3 TeV. Gaugino masses below 1060 GeV are excluded for any NLSP mass, see their Fig. 10.

SIRUNYAN 18AJ searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing two low-momentum, oppositely charged leptons (electrons or muons) and $E_T$. No excess over the expected background is observed. Limits are derived on the wino mass in the Tchi1n2F simplified model, see their Figure 5. Limits are also set on the stop mass in the Tstop10 simplified model, see their Figure 6. Finally, limits are set on the Higgsino mass in the Tchi1n2G simplified model, see Figure 8 and in the pMSSM, see Figure 7.

SIRUNYAN 18DP searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and neutralinos or of chargino pairs in events with a tau lepton pair and significant missing transverse momentum. Both hadronic and leptonic decay modes are considered for the tau lepton. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino mass in the Tchi1chi1D and Tchi1n2 simplified models, see their Figures 14 and 15. Also, excluded stau pair production cross sections are shown in Figures 11, 12, and 13.

SIRUNYAN 17AW searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with a charged lepton (electron or muon), two jets identified as originating from a $b$-quark, and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the mass of the chargino and the next-to-lightest neutralino in the Tchi1n2E simplified model, see their Figure 6.

AAD 16AA summarized and extended ATLAS searches for electroweak supersymmetry in final states containing several charged leptons, $E_T$, with or without hadronic jets, in 20 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV. The paper reports the results of new interpretations.
and statistical combinations of previously published analyses, as well as new analyses. Exclusion limits at 95% C.L. are set on mass-degenerate $\tilde{\chi}_2^0$ and $\tilde{\chi}_3^0$ masses in the Tn2n3A and Tn2n3B simplified models. See their Fig. 15.

15. AAD 15Ba searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of charginos and neutralinos decaying to a final state containing a $W$ boson and a 125 GeV Higgs boson, plus missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models of direct chargino and next-to-lightest neutralino production, with the decays $\chi_1^{\pm} \rightarrow W^{\pm} \tilde{\chi}_1^0$ and $\tilde{\chi}_2^0 \rightarrow H \tilde{\chi}_1^0$ having 100% branching fraction, see Fig. 8. A combination of the multiple final states for the Higgs decay yields the best limits (Fig. 8d).

16. AAD 14H searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of charginos and neutralinos decaying to a final state with three leptons and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models of direct chargino and next-to-lightest neutralino production, with decays to the lightest neutralino via either all three generations of leptons, staus only, gauge bosons, or Higgs bosons, see Fig. 7. An interpretation in the pMSSM is also given, see Fig. 8.

17. AAD 14x searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least four leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the neutralino mass in an R-parity conserving simplified model where the decay $\tilde{\chi}_2^0 \rightarrow \ell^\pm \ell^\mp \tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Fig. 10.

18. AAD 13 searched in 4.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for charginos and neutralinos decaying to a final state with three leptons (e and $\mu$) and missing transverse energy. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in the phenomenological MSSM, see Fig. 2 and 3, and in simplified models, see Fig. 4. For the simplified models with intermediate slepton decays, degenerate $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_2^0$ masses up to 500 GeV are excluded at 95% C.L. for very large mass differences with the $\tilde{\chi}_1^0$. Supersedes AAD 12As.

19. CHATRCHYAN 12Bj searched in 4.98 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for direct electroweak production of charginos and neutralinos in events with at least two leptons, jets and missing transverse momentum. No significant excess over the expected SM backgrounds are observed and 95% C.L. limits on the production cross section of $\chi_1^\pm \chi_2^0$ pair production were set in a number of simplified models, see Figs. 7 to 12. Most limits are for exactly 3 jets.

20. ABREU 00w combines data collected at $\sqrt{s}=189$ GeV with results from lower energies. The mass limit is obtained by constraining the MSSM parameter space with gaugino and sfermion mass universality at the GUT scale, using the results of negative direct searches for neutralinos (including cascade decays and $\tilde{\tau} \tilde{\tau}$ final states) from ABREU 01, for charginos from ABREU 00j and ABREU 00t (for all $\Delta m_{\tilde{\tau}^0}$), and for charged sleptons from ABREU 01b. The results hold for the full parameter space defined by all values of $M_2$ and $|\mu| \leq 2$ TeV with the $\tilde{\chi}_1^0$ as LSP.

21. AAD 14G searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of chargino-neutralino pairs, decaying to a final state with two leptons (e and $\mu$) and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models of chargino and next-to-lightest neutralino production, with decays to the lightest neutralino via gauge bosons, see Fig. 7. An interpretation in the pMSSM is also given, see Fig. 10.

22. KHACHATRYAN 14i searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of charginos and neutralinos decaying to a final state with three leptons (e or $\mu$) and missing transverse momentum, or with a $Z$-boson, dijets and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models, see Figs. 12–16.
AAD 12AS searched in 2.06 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for charginos and neutralinos decaying to a final state with three leptons ($e$ and $\mu$) and missing transverse energy. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in the phenomenological MSSM, see Fig. 2 (top), and in simplified models, see Fig. 2 (bottom).

AAD 12t looked in 1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for the production of supersymmetric particles decaying into final states with missing transverse momentum and exactly two isolated leptons ($e$ or $\mu$). Same-sign dilepton events were separately studied. Additionally, in opposite-sign events, a search was made for an excess of same-flavor over different-flavor lepton pairs. No excess over the expected background is observed and limits are placed on the effective production cross section of opposite-sign dilepton events with $E_T > 250$ GeV and on same-sign dilepton events with $E_T > 100$ GeV. The latter limit is interpreted in a simplified electroweak gaugino production model.

$\tilde{\chi}^\pm_1, \tilde{\chi}^0_2$ (Charginos) mass limits

Charginos are unknown mixtures of $w$-inos and charged higgsinos (the supersymmetric partners of $W$ and Higgs bosons). A lower mass limit for the lightest chargino ($\tilde{\chi}^+_1$) of approximately 45 GeV, independent of the field composition and of the decay mode, has been obtained by the LEP experiments from the analysis of the $Z$ width and decays. These results, as well as other now superseded limits from $e^+ e^-$ collisions at energies below 136 GeV, and from hadronic collisions, can be found in the 1998 Edition (The European Physical Journal C3 1 (1998)) of this Review.

Unless otherwise stated, results in this section assume spectra, production rates, decay modes and branching ratios as evaluated in the MSSM, with gaugino and sfermion mass unification at the GUT scale. These papers generally study production of $\tilde{\chi}^0_1 \tilde{\chi}^0_2$. $\tilde{\chi}^+_1 \tilde{\chi}^-_1$ and (in the case of hadronic collisions) $\tilde{\chi}^+_1 \tilde{\chi}^0_2$ pairs, including the effects of cascade decays. The mass limits on $\tilde{\chi}^+_1$ are either direct, or follow indirectly from the constraints set by the non-observation of $\tilde{\chi}^0_2$ states on the gaugino and higgsino MSSM parameters $M_2$ and $\mu$. For generic values of the MSSM parameters, limits from high-energy $e^+ e^-$ collisions coincide with the highest value of the mass allowed by phase-space, namely $m_{\tilde{\chi}^+_1} \lesssim \sqrt{s}/2$. The still unpublished combination of the results of the four LEP collaborations from the 2000 run of LEP2 at $\sqrt{s}$ up to $\simeq 209$ GeV yields a lower mass limit of 103.5 GeV valid for general MSSM models. The limits become however weaker in certain regions of the MSSM parameter space where the detection efficiencies or production cross sections are suppressed. For example, this may happen when: (i) the mass differences $\Delta m_+ = m_{\tilde{\chi}^+_1} - m_{\tilde{\chi}^0_1}$ or $\Delta m_\mu = m_{\tilde{\chi}^+_1} - m_{\tilde{\chi}^0_2}$ are very small, and the detection efficiency is reduced; (ii) the electron sneutrino mass is small, and the $\tilde{\chi}^+_1$ production rate is suppressed due to a destructive interference between $s$ and $t$ channel exchange diagrams. The regions of MSSM parameter space where the following limits are valid are indicated in the comment lines or in the footnotes.

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).
\[ \chi^0_1 + \gamma + E_T, \ Tchi1\chi1G, \ \chi^{\pm}_1 \rightarrow \bar{\chi}^0_1 + \text{soft} \]

\[ \geq 1 \gamma + E_T, \ Tchi1n12-GGM, \ 120 \mathrm{GeV} < m_{\chi_1^-} < 720 \mathrm{GeV} \]

\[ 0, 1, 2 \text{ or more } \ell, \ H (\rightarrow \gamma \gamma, \ b \ b, \ W W^*, \ Z Z, \tau \tau) \text{ (various searches)}, \ Tchi1n2E, \ m_{\chi_1^-} = 0 \]

\[ \geq 1 \ H (\rightarrow \gamma \gamma) + \text{jets} + E_T, \ Tchi1n2E, \ m_{\chi_1^-} = 1 \mathrm{GeV} \]

\[ \gamma + \text{lepton} + E_T, \ Tchi1n1A \]

\[ \geq 1 \ H (\rightarrow \gamma \gamma) + \text{jets} + E_T, \ Tchi1n1D \text{ and } \tilde{\chi}_1^\pm \text{only}, \ m_{\chi_1^-} = 0 \mathrm{GeV} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 1 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_2 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 30 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 0 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 30 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 0 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 30 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 0 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 30 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 0 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 30 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 0 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]

\[ \ell^+ \nu \chi^0_1 \text{, heavy sleptons, } m_{\chi_1^-} - m_{\chi_0^-} = 30 \mathrm{GeV}, \ m_{\chi_1^+} = m_{\chi_0^0} \]
<table>
<thead>
<tr>
<th>Energy (GeV)</th>
<th>Mass (GeV)</th>
<th>Experiment</th>
<th>CMS Combination of searches, (m_{\tilde{\chi}_1}^0)</th>
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<tr>
<td>&gt; 980</td>
<td>95</td>
<td>17 SIRUNYAN</td>
<td>(\geq 1\gamma + E_T,) GGM, wino-like pair production, nearly degenerate wino and bino masses</td>
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<td>&gt; 780</td>
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<td>(\geq 1\gamma + E_T,) Tchi1n1A</td>
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<td>95</td>
<td>17 SIRUNYAN</td>
<td>(\geq 1\gamma + E_T,) Tchi1n1A</td>
</tr>
<tr>
<td>&gt; 230</td>
<td>95</td>
<td>18 SIRUNYAN</td>
<td>(2\ell + \text{(soft)} + E_T,) Tchi1n2F, wino, (m_{\tilde{\chi}<em>2}^0 - m</em>{\tilde{\chi}_1}^0 = 20) GeV</td>
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<tr>
<td>&gt; 1150</td>
<td>95</td>
<td>19 SIRUNYAN</td>
<td>(\ell^+\ell^\pm) or (\geq 3\ell,) Tchi1n2A, (m_{\ell^\pm})</td>
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<tr>
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<td>95</td>
<td>19 SIRUNYAN</td>
<td>(\ell^+\ell^\pm) or (\geq 3\ell,) Tchi1n2A, (m_{\ell^\pm})</td>
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<td>&gt; 1050</td>
<td>95</td>
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<td>(\ell^+\ell^\pm) or (\geq 3\ell,) Tchi1n2H, (m_{\ell^\pm})</td>
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<td>&gt; 1080</td>
<td>95</td>
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<td>(\ell^+\ell^\pm) or (\geq 3\ell,) Tchi1n2H, (m_{\ell^\pm})</td>
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<tr>
<td>&gt; 1030</td>
<td>95</td>
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<td>(\ell^+\ell^\pm) or (\geq 3\ell,) Tchi1n2H, (m_{\ell^\pm})</td>
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<td>(\ell^+\ell^\pm) or (\geq 3\ell,) Tchi1n2D, (m_{\ell^\pm})</td>
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<td>&gt; 650</td>
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<td>(\ell^+\ell^- + \text{jets} + E_T,) Tchi1n2F, (m_{\tilde{\chi}_1}^0 = 0) GeV</td>
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HTTP://PDG.LBL.GOV Page 37 Created: 6/1/2020 08:33
We do not use the following data for averages, fits, limits, etc.

- • • •

> 210  95  34 KHACHATRY...14L  CMS  \( \tilde{\chi}_1^0 \to H \chi_1^0 \) and \( \tilde{\chi}_1^\pm \to W \chi_1^0 \)

simplified models, \( m_{\chi_1^0} = m_{\chi_1^\pm} \),

\( m_{\chi_1^0} = 0 \) GeV

> 540  95  35 AAD  13 ATLS  \( 3\ell^\pm + E_T \), pMSSM, SMS

> 94  95  38 CHATRCHYAN 12BJ CMS  \( \geq 2 \ell, \text{jets} + E_T \), \( pp \to \tilde{\chi}_1^\pm \tilde{\chi}_2^0 \)

> 40  95  39 ABDALLAH  03M  DLPH  \( \tilde{\chi}_1^\pm, \tan\beta \leq 40, \Delta m_+ > 3 \) GeV, all

\( m_0 \)

- • • • We do not use the following data for averages, fits, limits, etc. • • •

> 570  95  40 KHACHATRY...16AA CMS  \( \geq 1 \gamma + \text{jets} + E_T \), Tchi1chi1A

> 680  95  40 KHACHATRY...16AA CMS  \( \geq 1 \gamma + \text{jets} + E_T \), Tchi1n1A

> 710  95  40 KHACHATRY...16AA CMS  \( \geq 1 \gamma + \text{jets} + E_T \), GGM, \( \chi_0 \chi_1^\pm \)

pair production, wino-like NLSP

> 1000  95  41 KHACHATRY...16R CMS  \( \geq 1 \gamma + 1 \ e \ or \ \mu + E_T \), Tglu1F,

\( m_{\chi_1^0} = m_{\chi_2^0} > 200 \) GeV

> 307  95  42 KHACHATRY...16Y CMS  1,2 soft \( \ell^\pm + \text{jets} + E_T \), Tchi1n2A,

\( m_{\chi_1^0} - m_{\chi_2^0} = 20 \) GeV

> 410  95  43 AAD  14AV ATLS  \( \geq 2 \tau + E_T \), direct \( \tilde{\chi}_1^\pm \tilde{\chi}_2^0 \),

\( \tilde{\chi}_1^\pm \tilde{\chi}_1^\mp \) production, \( m_{\chi_1^0} = m_{\chi_2^0} = 0 \) GeV

> 345  95  44 AAD  14AV ATLS  \( \geq 2 \tau + E_T \), direct \( \tilde{\chi}_1^\pm \tilde{\chi}_1^\mp \) production, \( m_{\chi_1^0} = 0 \) GeV

none

100–105, 120–135, 145–160

none

140–465

none

180–355

> 168  95  46 AALTONEN  14 CDF  \( 3\ell^\pm + E_T, \tilde{\chi}_1^\pm \to \ell\nu\chi_1^0 \),

mSUGRA with \( m_0 = 60 \) GeV

> 47 KHACHATRY...14I CMS  \( \tilde{\chi}_1^\pm \to W\tilde{\chi}_1^0, \tilde{\ell}\nu, \ell\tilde{\nu} \), simplified model

> 48 AALTONEN  13Q CDF  \( \tilde{\chi}_1^\pm \to \tau X \), simplified gravity- and
gauge-mediated models

> 49 AAD  12AS ATLS  \( 3\ell^\pm + E_T \), pMSSM

\( \ell^\pm \ell^\mp + E_T, pp \to \tilde{\chi}_1^\pm \tilde{\chi}_2^0 \)}
the presence of at least two hadronically decaying tau leptons and large missing transverse energy. No significant deviation from the expected SM background is observed. In the framework of GMSB, limits are set on the gluino mass in the Tglu4A simplified model, see Figure 6.

2 SIRUNYAN 19C1 searched in 77.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one or more high-momentum Higgs bosons, decaying to photons, jets and $\not{E_T}$. No significant excess above the Standard Model expectations is observed. In the framework of GMSB, limits are set on the chargino and neutralino mass in the Tchi1n1A simplified model, see their Figure 6. Limits are also set on the gluino mass in the Tglu4A simplified model, see Figure 6.

3 SIRUNYAN 19K searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with a photon, an electron or muon, and large $\not{E_T}$. No significant excess above the Standard Model expectations is observed. In the framework of GMSB, limits are set on the chargino and neutralino mass in the Tchi1n2A simplified model, see Figure 6. Limits are also set on the gluino mass in the Tglu4A simplified model, and on the squark mass in the Tsqk4A simplified model, see their Figure 7.

4 AABOUD 18AY searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and next-to-lightest neutralinos decaying into light neutralinos and a $W$, and a Higgs boson, respectively. Fully hadronic, semileptonic, diphoton, and multilepton (electrons, muons) final states with missing transverse momentum are considered in this search. Observations are consistent with the Standard Model expectations, and 95% confidence-level limits of up to 680 GeV on the chargino/next-to-lightest neutralino masses are set (Tchi1n2E model). See their Figure 14 for an overlay of exclusion contours from all searches.

5 AABOUD 19AV searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least one photon and large $\not{E_T}$. No significant excess above the Standard Model expectations is observed. Limits are set on chargino masses in a general gauge-mediated SUSY breaking (GGM) scenario Tchi1n12-GGM, see Figure 4. Limits are also set on the gluino mass in the Tglu4A simplified model, see Figure 6.

6 AABOUD 19AV searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and neutralinos in Tchi1chi1D models in events characterised by the presence of at least two hadronically decaying tau leptons and large missing transverse energy. No significant deviation from the expected SM background is observed. Assuming decays via intermediate $\tilde{\chi}^\pm_1$, the observed limits rule out $m_{\tilde{\chi}^\pm_1}$ masses up to 630 GeV for a massless $\tilde{\chi}^0_1$. See their Fig.7 (left). Interpretations are also provided in Fig 8 (top) for different assumptions on the ratio between $m_{\tilde{\tau}}$ and $m_{\tilde{\chi}^\pm_1}$.

7 AABOUD 18AY searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and neutralinos as in Tchi1n2D models, in events characterised by the presence of at least two hadronically decaying tau leptons and large missing transverse energy. No significant deviation from the expected SM background is observed. Assuming decays via intermediate $\tilde{\chi}^\pm_1$ and $m_{\tilde{\chi}^\pm_1} = m_{\tilde{\chi}^0_1}$, the observed limits rule out $\tilde{\chi}^\pm_1$ masses up to 760 GeV for a massless $\tilde{\chi}^0_1$. See their Fig.7 (right). Interpretations are also provided in Fig 8 (bottom) for different assumptions on the ratio between $m_{\tilde{\tau}}$ and $m_{\tilde{\chi}^\pm_1}$.
8 AABOUD 18BT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos, chargino and next-to-lightest neutralinos and sleptons in events with two or three leptons (electrons or muons), with or without jets and large missing transverse energy. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino mass up to 750 GeV for massless neutralinos in the Tchi1chi1C simplified model exploiting $2\ell + 0$ jets signatures, see their Figure 8(a).

9 AABOUD 18BT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos, chargino and next-to-lightest neutralinos and sleptons in events with two or three leptons (electrons or muons), with or without jets, and large missing transverse energy. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino mass up to 1100 GeV for massless neutralinos in the Tchi1n1C simplified model exploiting 3$\ell$ signature, see their Figure 8(c).

10 AABOUD 18BT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos, chargino and next-to-lightest neutralinos and sleptons in events with two or three leptons (electrons or muons), with or without jets, and large missing transverse energy. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino mass up to 580 GeV for massless neutralinos in the Tchi1n2F simplified model exploiting $2\ell + 2$ jets and 3$\ell$ signatures, see their Figure 8(d).

11 AABOUD 18CK searched for events with at least 3 $b$-jets and large missing transverse energy in two datasets of $pp$ collisions at $\sqrt{s} = 13$ TeV of 36.1 fb$^{-1}$ and 24.3 fb$^{-1}$ depending on the trigger requirements. The analyses aimed to reconstruct two Higgs bosons decaying to pairs of $b$-quarks. No significant excess above the Standard Model expectations is observed. Limits are set on the Higgsino mass in the T1n1A simplified model, see their Figure 15(a). Constraints are also presented as a function of the BR of Higgsino decaying into an higgs boson and a gravitino, see their Figure 15(b).

12 AABOUD 18CO searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of mass-degenerate charginos and next-to-lightest neutralinos in events with two or three leptons (electrons or muons), with or without jets, and large missing transverse energy. The search channels are based on recursive jigsaw reconstruction. Limits are set on the chargino mass up to 600 GeV for massless neutralinos in the Tchi1n2F simplified model exploiting the statistical combination of $2\ell + 2$ jets and 3$\ell$ channels. Chargino masses below 220 GeV are not excluded due to an excess of events above the SM prediction in the dedicated regions. See their Figure 13(d).

13 AABOUD 18R searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for electroweak production in scenarios with compressed mass spectra in final states with two low-momentum leptons and missing transverse momentum. The data are found to be consistent with the SM prediction. Results are interpreted in Tchi1n2G wino models and $\tilde{\chi}_1^\pm$ masses are excluded up to 175 GeV for $m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0} = 10$ GeV. The exclusion limits extend down to mass splittings of 2 GeV, see their Fig. 10 (bottom).

14 AABOUD 18R searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for electroweak production in scenarios with compressed mass spectra in final states with two low-momentum leptons and missing transverse momentum. The data are found to be consistent with the SM prediction. Results are interpreted in Tchi1n2G higgsino models and $\tilde{\chi}_1^\pm$ masses are excluded up to 145 GeV for $m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0} = 5$ GeV. The exclusion limits extend down to mass splittings of 2.5 GeV, see their Fig. 10 (top).

15 AABOUD 18U searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with at least one isolated photon, possibly jets and significant transverse momentum targeting generalised models of gauge-mediated SUSY breaking. No significant excess of events is observed above the SM prediction. Results of the diphoton channel are interpreted in terms of lower limits on the masses of gauginos Tchi1chi1A models, which reach as high as 1.3 TeV. Gaugino masses below 1060 GeV are excluded for any NLSP mass, see their Fig. 10.
16 AABOUD 18Z searched in 36.1 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing four or more charged leptons (electrons, muons and up to two hadronically decaying taus). No significant deviation from the expected SM background is observed. Limits are set on the Higgsino mass in simplified models of general gauge mediated supersymmetry $T_n1n1A/T_n1n1B/T_n1n1C$, see their Figure 9. Limits are also set on the wino, slepton, sneutrino and gluino mass in a simplified model of NLSP pair production with R-parity violating decays of the LSP via $\lambda_{12k}$ or $\lambda_{133}$ to charged leptons, see their Figures 7, 8.

17 SIRUNYAN 18AA searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with at least one photon and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on wino masses in a general gauge-mediated SUSY breaking (GGM) scenario with bino-like $\tilde{\chi}_1^0$ and wino-like $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_2^0$, see Figure 7. Limits are also set on the NLSP mass in the Tchi1n1A and Tchi1ch1A simplified models, see their Figure 8. Finally, limits are set on the gluino mass in the Tglu4A and Tglu4B simplified models, see their Figure 9, and on the squark mass in the Tsqk4A and Tsqk4B simplified models, see their Figure 10.

18 SIRUNYAN 18AJ searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing two low-momentum, oppositely charged leptons (electrons or muons) and $E_T$. No excess over the expected background is observed. Limits are derived on the wino mass in the Tchi1n2F simplified model, see their Figure 5. Limits are also set on the stop mass in the Tstop10 simplified model, see their Figure 6. Finally, limits are set on the Higgsino mass in the Tchi1n2F simplified model, see Figure 8 and in the pMSSM, see Figure 7.

19 SIRUNYAN 18AO searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and neutralinos in events with either two or more leptons (electrons or muons) of the same electric charge, or with three or more leptons, which can include up to two hadronically decaying tau leptons. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino/neutralino mass in the Tchi1n2A, Tchi1n2H, Tchi1n2D, Tchi1n2E and Tchi1n2F simplified models, see their Figures 14, 15, 16, 17 and 18. Limits are also set on the higgsino mass in the Tn1n1A, Tn1n1B and Tn1n1C simplified models, see their Figure 19.

20 SIRUNYAN 18AP searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and neutralinos by combining a number of previous and new searches. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino/neutralino mass in the Tchi1n2E, Tchi1n2F and Tchi1n2I simplified models, see their Figures 7, 8, 9 an 10. Limits are also set on the higgsino mass in the Tn1n1A, Tn1n1B and Tn1n1C simplified models, see their Figure 11, 12, 13 and 14.

21 SIRUNYAN 18AR searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing two opposite-charge, same-flavour leptons (electrons or muons), jets and $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu4C simplified model, see their Figure 7. Limits are also set on the chargino/neutralino mass in the Tchi1n2F simplified models, see their Figure 8, and on the higgsino mass in the Tn1n1B and Tn1n1C simplified models, see their Figure 9. Finally, limits are set on the sbottom mass in the Tsbot3 simplified model, see their Figure 10.

22 SIRUNYAN 18DN searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and for pair production of top squarks in events with two leptons (electrons or muons) of the opposite electric charge. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino mass in the Tchi1ch1C and Tchi1ch1E simplified models, see their Figure 8. Limits are also set on the stop mass in the Tstop1 and Tstop2 simplified models, see their Figure 9.
23 SIRUNYAN 18DP searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos and neutralinos or of chargino pairs in events with a tau lepton pair and significant missing transverse momentum. Both hadronic and leptonic decay modes are considered for the tau lepton. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino mass in the Tchi1chi1D and Tchi1n2 simplified models, see their Figures 14 and 15. Also, excluded stau pair production cross sections are shown in Figures 11, 12, and 13.

24 SIRUNYAN 18X searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one or more high-momentum Higgs bosons, decaying to pairs of photons, jets and $E_T$. The razor variables ($M_\text{R}$ and $R^2$) are used to categorise the events. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in the Tsbot4 simplified model and on the wino mass in the Tchi1n2E simplified model, see their Figure 20, 21 and 22.

25 KHACHATRYAN 17L searched in about 19 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with two $\tau$ (at least one decaying hadronically) and $E_T$. In the Tchi1chi1C model, assuming decays via intermediate $\tau$ or $\nu_\tau$ with equivalent mass, the observed limits rule out $\tilde{\chi}_1^\pm$ masses up to 420 GeV for a massless $\tilde{\chi}_1^0$. See their Fig. 5.

26 SIRUNYAN 17AW searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with a charged lepton (electron or muon), two jets identified as originating from a $b$-quark, and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the mass of the chargino and the next-to-lightest neutralino in the Tchi1n2E simplified model, see their Figure 6.

27 AAD 16AA summarized and extended ATLAS searches for electroweak supersymmetry in final states containing several charged leptons, $E_T$, with or without hadronic jets, in 20 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV. The paper reports the results of new interpretations and statistical combinations of previously published analyses, as well as new analyses. Exclusion limits at 95% C.L. are set on the $\tilde{\chi}_1^\pm$ mass in the Tchi1chi1B and Tchi1chi1C simplified models. See their Fig. 13.

28 AAD 16AA summarized and extended ATLAS searches for electroweak supersymmetry in final states containing several charged leptons, $E_T$, with or without hadronic jets, in 20 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV. The paper reports the results of new interpretations and statistical combinations of previously published analyses, as well as new analyses. Exclusion limits at 95% C.L. are set on mass-degenerate $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_2^0$ masses in the Tchi1n2B, Tchi1n2C, and Tchi1n2D simplified models. See their Figs. 16, 17, and 18.

29 KHACHATRYAN 16R searched in 19.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with one or more photons, one electron or muon, and $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on wino masses in a general gauge-mediated SUSY breaking model (GGM), for a wino-like neutralino NLSP scenario, see Fig. 5. Limits are also set in the Tglu1D and Tchi1n1A simplified models, see Fig. 6. The Tchi1n1A limit is reduced to 340 GeV for a branching ratio reduced by the weak mixing angle.

30 AAD 15BA searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of charginos and neutralinos decaying to a final state containing a $W$ boson and a 125 GeV Higgs boson, plus missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models of direct chargino and next-to-lightest neutralino production, with the decays $\tilde{\chi}_1^\pm \rightarrow W^{\pm} \tilde{\chi}_1^0$ and $\tilde{\chi}_2^0 \rightarrow H^{\pm} \tilde{\chi}_1^0$ having 100% branching fraction, see Fig. 8. A combination of the multiple final states for the Higgs decay yields the best limits (Fig. 8d).

31 AAD 15CA searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with one or more photons and $E_T$, with or without leptons ($e, \mu$). No significant excess above the
Standard Model expectations is observed. Limits are set on wino masses in the general gauge-mediated SUSY breaking model (GGM), for wino-like NLSP, see Fig. 9, 12

AAD 14H searched in 20.3 fb\(^{-1}\) of \(p \bar{p}\) collisions at \(\sqrt{s} = 8\) TeV for electroweak production of charginos and neutralinos decaying to a final state with three leptons and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models of direct chargino and next-to-lightest neutralino production, with decays to the lightest neutralino via either all three generations of leptons, staus only, gauge bosons, or Higgs bosons, see Fig. 7. An interpretation in the pMSSM is also given, see Fig. 8.

AAD 14x searched in 20.3 fb\(^{-1}\) of \(p \bar{p}\) collisions at \(\sqrt{s} = 8\) TeV for events with at least four leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the wino-like chargino mass in an R-parity violating simplified model where the decay \(\tilde{\chi}^\pm_i \rightarrow W^{(*)}\chi^0_1\), with \(\chi^0_0 \rightarrow \ell^\pm \ell'^\pm \nu\), takes place with a branching ratio of 100\%, see Fig. 8.

KHACHATRYAN 14l searched in 19.5 fb\(^{-1}\) of \(p \bar{p}\) collisions at \(\sqrt{s} = 8\) TeV for evidence of chargino-neutralino \(\tilde{\chi}^\pm_1 \chi_0^0\) pair production with Higgs or \(W\)-bosons in the decay chain, leading to \(HW\) final states with missing transverse energy. The decays of a Higgs boson to a photon pair are considered in conjunction with hadronic and leptonic decay modes of the \(W\) bosons. No significant excesses over the expected SM backgrounds are observed. The results are interpreted in the context of simplified models where the decays \(\tilde{\chi}^0_2 \rightarrow H \chi_1^0\) and \(\tilde{\chi}^\pm_1 \rightarrow W^\pm \chi_1^0\) take place 100\% of the time, see Figs. 22–23.

AAD 13 searched in 4.7 fb\(^{-1}\) of \(p \bar{p}\) collisions at \(\sqrt{s} = 7\) TeV for charginos and neutralinos decaying to a final state with three leptons (\(e\) and \(\mu\)) and missing transverse energy. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in the phenomenological MSSM, see Fig. 2 and 3, and in simplified models, see Fig. 4. For the simplified models with intermediate slepton decays, degenerate \(\tilde{\chi}^+_1\) and \(\chi^0_2\) masses up to 500 GeV are excluded at 95\% C.L. for very large mass differences with the \(\chi^0_1\). Supersedes AAD 12AS.

AAD 13b searched in 4.7 fb\(^{-1}\) of \(p \bar{p}\) collisions at \(\sqrt{s} = 7\) TeV for gauginos decaying to a final state with two leptons (\(e\) and \(\mu\)) and missing transverse energy. No excess beyond the Standard Model expectation is observed. Limits are derived in a simplified model of wino-like chargino pair production, where the chargino always decays to the lightest neutralino via an intermediate on-shell charged slepton, see Fig. 2(b). Chargino masses between 110 and 340 GeV are excluded at 95\% C.L. for \(m_{\chi^0_0} = 10\) GeV. Exclusion limits are also derived in the phenomenological MSSM, see Fig. 3.

AAD 12CT searched in 4.7 fb\(^{-1}\) of \(p \bar{p}\) collisions at \(\sqrt{s} = 7\) TeV for events containing four or more leptons (electrons or muons) and either moderate values of missing transverse momentum or large effective mass. No significant excess is found in the data. Limits are presented in a simplified model of R-parity violating supersymmetry in which charginos are pair-produced and then decay into a \(W\)-boson and a \(\tilde{\chi}^0_1\), which in turn decays through an RPV coupling into two charged leptons (\(e^\pm \nu^\mp\) or \(e^\mp \nu^\pm\)) and a neutrino. In this model, chargino masses up to 540 GeV are excluded at 95\% C.L. for \(m_{\chi^0_1} > 300\) GeV, see Fig. 3a. The limit deteriorates for lighter \(\chi^0_1\). Limits are also set in an R-parity violating mSUGRA model, see Fig. 3b.

CHATRCHYAN 12B searched in 4.98 fb\(^{-1}\) of \(p \bar{p}\) collisions at \(\sqrt{s} = 7\) TeV for direct electroweak production of charginos and neutralinos in events with at least two leptons, jets and missing transverse momentum. No significant excesses over the expected SM backgrounds are observed and 95\% C.L. limits on the production cross section of \(\tilde{\chi}^\pm_1 \chi^0_2\) pair production were set in a number of simplified models, see Figs. 7 to 12.

ABDALLAH 03M uses data from \(\sqrt{s} = 192–208\) GeV to obtain limits in the framework of the MSSM with gaugino and sfermion mass universality at the GUT scale. An indirect limit on the mass of charginos is derived by constraining the MSSM parameter space by
the results from direct searches for neutralinos (including cascade decays), for charginos and for sleptons. These limits are valid for values of $M_2 < 1$ TeV, $|\mu| \leq 2$ TeV with the $\tilde{\chi}_1^0$ as LSP. Constraints from the Higgs search in the $m_h^{\max}$ scenario assuming $m_\chi = 174.3$ GeV are included. The quoted limit applies if there is no mixing in the third family or when $m_\tilde{\tau}_1 - m_\tilde{\chi}_0^0 > 6$ GeV. If mixing is included the limit degrades to 90 GeV. See Fig. 43 for the mass limits as a function of $\tan\beta$. These limits update the results of ABREU 00W.

40 KALACHATRYAN 16A searched in 7.4 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with one or more photons, hadronic jets and $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on wino masses in the general gauge-mediated SUSY breaking model (GGM), for a wino-like neutralino NLSP scenario and with the wino mass fixed at 10 GeV above the bino mass, see Fig. 4. Limits are also set in the Tchi1ch1A and Tchi2n1A simplified models, see Fig. 3.

41 KALACHATRYAN 16R searched in 19.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with one or more photons, one electron or muon, and $E_T$. No significant excess above the Standard Model expectations is observed. Limits are also set in the Tglu1F simplified model, see Fig. 6.

42 KALACHATRYAN 16Y searched in 19.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with one or two soft isolated leptons, hadronic jets, and $E_T$. No significant excess above the Standard Model expectations is observed. Limits are also set in the Tchi1ch1A and Tchi2n1A simplified models, see Fig. 7.

43 AAD 14AV searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for the direct production of charginos, neutralinos and staus in events containing at least two hadronically decaying $\tau$-leptons, large missing transverse momentum and low jet activity. The quoted limit was derived for direct $\tilde{\tau}_1^{\pm} \tilde{\chi}_1^0$ and $\tilde{\tau}_1^+ \tilde{\tau}_1^- \tilde{\chi}_1^0$ production with $\tilde{\tau}_1^\pm \rightarrow \tilde{\tau}_2^\pm \rightarrow \tau \tilde{\chi}_1^0$ and $\tilde{\tau}_1^- \rightarrow \tilde{\tau}_2^- \rightarrow \tau \tilde{\chi}_1^0$. No excess over the expected SM background is observed. Limits are set in simplified models of $\tilde{\tau}_1^\pm \tilde{\chi}_1^0$ and $\tilde{\tau}_1^- \tilde{\chi}_1^0$ pair production, see their Figure 7. Upper limits on the cross section and signal strength for direct di-stau production are derived, see Figures 8 and 9. Also, limits are derived in a pMSSM model where the only light slepton is the $\tilde{\tau}_R$, see Figure 10.

44 AAD 14AV searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for the direct production of charginos, neutralinos and staus in events containing at least two hadronically decaying $\tau$-leptons, large missing transverse momentum and low jet activity. The quoted limit was derived for direct $\tilde{\tau}_1^{\pm} \tilde{\chi}_1^0$ production with $\tilde{\chi}_1^0 \rightarrow \tilde{\tau}_2^- \tilde{\nu}_{\tau} \rightarrow \tau \tau \tilde{\chi}_1^0$, $m_\tilde{\tau} = 0.5 (m_\tilde{\tau} + m_\tilde{\chi}_0^0)$, $m_\tilde{\chi}_0^0 = 0$ GeV. No excess over the expected SM background is observed. Exclusion limits are set in simplified models of $\tilde{\tau}_1^{\pm} \tilde{\chi}_1^0$ and $\tilde{\tau}_1^- \tilde{\chi}_1^0$ pair production, see their Figure 7. Upper limits on the cross section and signal strength for direct di-stau production are derived, see Figures 8 and 9. Also, limits are derived in a pMSSM model where the only light slepton is the $\tilde{\tau}_R$, see Figure 10.

45 AAD 14G searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of chargino pairs, or chargino-neutralino pairs, decaying to a final state with two leptons ($e$ and $\mu$) and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models of chargino pair production, with chargino decays to the lightest neutralino via either sleptons or gauge bosons, see Fig 5.; or in simplified models of chargino and next-to-lightest neutralino production, with decays to the lightest neutralino via gauge bosons, see Fig. 7. An interpretation in the pMSSM is also given, see Fig. 10.

46 AALTONEN 14 searched in 5.8 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for evidence of chargino and next-to-lightest neutralino associated production in final states consisting of three leptons (electrons, muons or taus) and large missing transverse momentum. The results are consistent with the Standard Model predictions within 1.85 $\sigma$. Limits on the
chargino mass are derived in an mSUGRA model with $m_0 = 60$ GeV, $\tan\beta = 3$, $A_0 = 0$ and $\mu > 0$, see their Fig. 2.

47 KHACHATRYAN 14I searched in 19.5 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of chargino pairs decaying to a final state with opposite-sign lepton pairs ($e$ or $\mu$) and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models, see Fig. 18.

48 AALTONEN 13Q searched in 6.0 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for evidence of chargino-neutralino associated production in like-sign dilepton final states. One lepton is identified as the hadronic decay of a tau lepton, while the other is an electron or muon. Good agreement with the Standard Model predictions is observed and limits are set on the chargino-neutralino cross section for simplified gravity- and gauge-mediated models, see their Figs. 2 and 3.

49 AAD 12A5 searched in 2.06 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 7$ TeV for charginos and neutralinos decaying to a final state with three leptons ($e$ and $\mu$) and missing transverse energy. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in the phenomenological MSSM, see Fig. 2 (top), and in simplified models, see Fig. 2 (bottom).

50 AAD 12T looked in 1 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 7$ TeV for the production of supersymmetric particles decaying into final states with missing transverse momentum and exactly two isolated leptons ($e$ or $\mu$). Opposite-sign and same-sign dilepton events were separately studied. Additionally, in opposite-sign events, a search was made for an excess of same-flavor over different-flavor lepton pairs. No excess over the expected background is observed and limits are placed on the effective production cross section of opposite-sign dilepton events with $E_T > 250$ GeV and on same-sign dilepton events with $E_T > 100$ GeV. The latter limit is interpreted in a simplified electroweak gaugino production model as a lower chargino mass limit.

51 CHATRCHYAN 11B looked in 35 pb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 7$ TeV for events with an isolated lepton ($e$ or $\mu$), a photon and $E_T$ which may arise in a generalized gauge mediated model from the decay of Wino-like NLSPs. No evidence for an excess over the expected background is observed. Limits are derived in the plane of squark/gluino mass versus Wino mass (see Fig. 4). Mass degeneracy of the produced squarks and gluinos is assumed.

52 CHATRCHYAN 11V looked in 35 pb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 7$ TeV for events with $\geq 3$ isolated leptons ($e$, $\mu$, or $\tau$), with or without jets and $E_T$. No evidence for an excess over the expected background is observed. Limits are derived in the CMSSM ($m_0$, $m_{1/2}$) plane for $\tan\beta = 3$ (see Fig. 5).

### Long-lived $\tilde{\chi}^{\pm}$ (Chargino) mass limit

Limits on charginos which leave the detector before decaying.

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<td>&gt;1090</td>
<td>95</td>
<td>1 AABOUD</td>
<td>19AT ATLS</td>
<td>long-lived $\tilde{\chi}_1^{\pm}$ mAMSB</td>
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<td>&gt;460</td>
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<td>18AS ATLS</td>
<td>$\tilde{\chi}^{\pm} \rightarrow \tilde{\chi}<em>1^{0} \pi^{\pm}$, lifetime 0.2 ns, $m</em>{\tilde{\chi}^{\pm}} - m_{\tilde{\chi}_1^{0}} = 160$ MeV</td>
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<td>&gt;715</td>
<td>95</td>
<td>3 SIRUNYAN</td>
<td>18BR CMS</td>
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<td>95</td>
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<td>15AE ATLS</td>
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HTTP://PDG.LBL.GOV Page 45 Created: 6/1/2020 08:33
We do not use the following data for averages, fits, limits, etc.

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1 AABOUD 19AT searched in 36.1 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for metastable $R$-hadrons. Multiple search strategies for a wide range of lifetimes, corresponding to path lengths of a few meters, are defined. No significant deviations from the expected Standard Model background are observed. Results are interpreted in terms of direct electroweak production of long-lived charginos in the context of mAMSB scenarios. Chargino masses are excluded at 95% C.L. below 1090 GeV. See their Figure 10 (right).

2 AABOUD 18AS searched in 36.1 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of long-lived charginos in the context of AMSB or phenomenological MSSM scenarios with wino-like LSP. Events with a disappearing track due to a low-momentum pion accompanied by at least one jet with high transverse momentum from initial-state radiation are considered. No significant excess above the Standard Model expectations is observed. Exclusion limits are set at 95% confidence level on the mass of charginos for different chargino lifetimes. For a pure wino with a lifetime of about 0.2 ns, corresponding to a mass-splitting between the charged and neutral wino of around 160 MeV, chargino masses up to 460 GeV are excluded, see their Fig. 8.

3 SIRUNYAN 18BR searched in 38.4 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of long-lived charginos in events containing isolated tracks with missing hits in the outer layer of the silicon tracker and little or no associated calorimetric energy deposits (disappearing tracks). No significant excess above the Standard Model expectations is observed. In an AMSB context, limits are set on the cross section of direct chargino production through $p p \to \tilde{\chi}^\pm \tilde{\chi}^\mp$ and $p p \to \tilde{\chi}^\pm \tilde{\chi}^0_1$, assuming $\text{BR}(\tilde{\chi}^\pm \to \tilde{\chi}^0_1 \pi^\pm) = 100\%$, as a function of the chargino mass and mean proper lifetime, see Figures 3, 4 and 5.

4 AAD 15AE searched in 19.1 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for heavy long-lived charged particles, measured through their specific ionization energy loss in the ATLAS pixel detector or their time-of-flight in the ALTAS muon system. In the absence of an excess of events above the expected backgrounds, limits are set on stable charginos, see Fig. 10.

5 AAD 15BM searched in 18.4 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for stable and metastable non-relativistic charged particles through their anomalous specific ionization
energy loss in the ATLAS pixel detector. In absence of an excess of events above the expected backgrounds, limits are set on stable charginos (see Table 5) and on metastable charginos decaying to $\chi_1^0 \pi^\pm$, see Fig. 11.

6 AAD 13H searched in 4.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for direct electroweak production of long-lived charginos in the context of AMSB scenarios. The search is based on the signature of a high-momentum isolated track with few associated hits in the outer part of the tracking system, arising from a chargino decay into a neutralino and a low-momentum pion. The $p_T$ spectrum of the tracks was found to be consistent with the SM expectations. Constraints on the lifetime and the production cross section were obtained, see Fig. 6. In the minimal AMSB framework with $\tan\beta = 5$, and $\mu > 0$, a chargino having a mass below 103 (85) GeV for a chargino-neutralino mass splitting $\Delta m_{\chi_1,0}$ of 160 (170) MeV is excluded at the 95% C.L. See Fig. 7 for more precise bounds.

7 AAD 12BJ looked in 1.02 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for signatures of decaying charginos resulting in isolated tracks with few associated hits in the outer region of the tracking system. The $p_T$ spectrum of the tracks was found to be consistent with the SM expectations. Constraints on the lifetime and the production cross section were obtained. In the minimal AMSB framework with $m_{3/2} < 32$ TeV, $m_0 < 1.5$ TeV, $\tan\beta = 5$, and $\mu > 0$, a chargino having a mass below 92 GeV and a lifetime between 0.5 ns and 2 ns is excluded at the 95% C.L. See their Fig. 8 for more precise bounds.

8 ABAZOV 09M searched in 1.1 fb$^{-1}$ of $pp\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for events with direct production of a pair of charged massive stable particles identified by their TOF. The number of the observed events is consistent with the predicted background. The data are used to constrain the production cross section as a function of the $\chi_1^\pm$ mass, see their Fig. 2. The quoted limit improves to 206 GeV for gaugino-like charginos.

9 ABBIENDI 03I used $e^+e^-$ data at $\sqrt{s} = 130-209$ GeV to select events with two high momentum tracks with anomalous dE/dx. The excluded cross section is compared to the theoretical expectation as a function of the heavy particle mass in their Fig. 3. The bounds are valid for colorless fermions with lifetime longer than $10^{-6}$ s. Supersedes the results from ACKERSTAFF 98P.

10 ABREU 00T searches for the production of heavy stable charged particles, identified by their ionization or Cherenkov radiation, using data from $\sqrt{s} = 130$ to 189 GeV. These limits include and update the results of ABREU 98P.

11 KHACHATRYAN 15AB searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing tracks with little or no associated calorimeter energy deposits and with missing hits in the outer layers of the tracking system (disappearing-track signature). Such disappearing tracks can result from the decay of charginos that are nearly mass degenerate with the lightest neutralino. The number of observed events is in agreement with the background expectation. Limits are set on the cross section of electroweak chargino production in terms of the chargino mass and mean proper lifetime, see Fig. 4. In the minimal AMSB model, a chargino mass below 260 GeV is excluded at 95% C.L., see their Fig. 5.

12 KHACHATRYAN 150 searched in 18.8 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for evidence of long-lived charginos in the context of AMSB and pMSSM scenarios. The results are based on a previously published search for heavy stable charged particles at 7 and 8 TeV. In the minimal AMSB framework with $\tan\beta = 5$ and $\mu \geq 0$, constraints on the chargino mass and lifetime were placed, see Fig. 5. Charginos with a mass below 800 (100) GeV are excluded at the 95% C.L. for lifetimes above 100 ns (3 ns). Constraints are also placed on the pMSSM parameter space, see Fig. 3.

13 KHACHATRYAN 15W searched in up to 20.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for evidence of long-lived neutralinos produced through $\tilde{q}$-pair production, with $\tilde{q} \rightarrow q\chi_0^0$ and $\chi_0^0 \rightarrow \ell^+\ell^-\nu$ (RPV: $\lambda_{121}, \lambda_{122} \neq 0$). 95% C.L. exclusion limits on cross section times branching ratio are set as a function of mean proper decay length of the neutralino, see Figs. 6 and 9.

14 AAD 13BD searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing tracks with no associated hits in the outer region of the tracking system resulting from the
decay of charginos that are nearly mass degenerate with the lightest neutralino, as is often the case in AMSB scenarios. No significant excess above the background expectation is observed for candidate tracks with large transverse momentum. Constraints on chargino properties are obtained and in the minimal AMSB model, a chargino mass below 270 GeV is excluded at 95% C.L., see their Fig. 7.

ABAZOV 13B looked in 6.3 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for charged massive long-lived particles in events with muon-like particles that have both speed and ionization energy loss inconsistent with muons produced in beam collisions. In the absence of an excess, limits are set at 95% C.L. on gaugino- and higgsino-like charginos, see their Table 20 and Fig. 23.

$\tilde{\nu}$ (Sneutrino) mass limit

The limits may depend on the number, $N(\tilde{\nu})$, of sneutrinos assumed to be degenerate in mass. Only $\tilde{\nu}_L$ (not $\tilde{\nu}_R$) is assumed to exist. It is possible that $\tilde{\nu}$ could be the lightest supersymmetric particle (LSP).

We report here, but do not include in the Listings, the limits obtained from the fit of the final results obtained by the LEP Collaborations on the invisible width of the $Z$ boson ($\Delta \Gamma_{\text{inv}} < 2.0$ MeV, LEP-SLC 06): $m_{\tilde{\nu}} > 43.7$ GeV ($N(\tilde{\nu})=1$) and $m_{\tilde{\nu}} > 44.7$ GeV ($N(\tilde{\nu})=3$).

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).

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We do not use the following data for averages, fits, limits, etc. • • •

1. AABOUD CM searched in 36.1 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for heavy particles decaying into an $e\mu$, $e\tau$, $\mu\tau$ final state. No significant deviation from the expected SM background is observed. Limits are set on the mass of a stau neutrino with R-parity-violating couplings. For $\bar{\nu}_\tau \rightarrow e\mu$, masses below 3.4 TeV are excluded at 95% CL, see their Figure 6(b). Upper limits on the RPV couplings $|\lambda_{312}|$ versus $|\lambda'_{311}|$ are also performed, see their Figure 8(a-b).

2. AABOUD CM searched in 36.1 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for heavy particles decaying into an $e\mu$, $e\tau$, $\mu\tau$ final state. No significant deviation from the expected SM background is observed. Limits are set on the mass of a stau neutrino with R-parity-violating couplings. For $\bar{\nu}_\tau \rightarrow e\tau$, masses below 2.9 TeV are excluded at 95% CL, see their Figure 5(b). Upper limits on the RPV couplings $|\lambda_{313}|$ versus $|\lambda'_{311}|$ are also performed, see their Figure 8(c).

3. AABOUD CM searched in 36.1 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for heavy particles decaying into an $e\mu$, $e\tau$, $\mu\tau$ final state. No significant deviation from the expected SM background is observed. Limits are set on the mass of a stau neutrino with R-parity-violating couplings. For $\bar{\nu}_\tau \rightarrow \mu\tau$, masses below 2.6 TeV are excluded at 95% CL, see their Figure 6(b). Upper limits on the RPV couplings $|\lambda_{323}|$ versus $|\lambda'_{311}|$ are also performed, see their Figure 8(d).
4. AABOUD 18Z searched in 36.1 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 13\) TeV for events containing four or more charged leptons (electrons, muons and up to two hadronically decaying taus). No significant deviation from the expected SM background is observed. Limits are set on the Higgsino mass in simplified models of general gauge mediated supersymmetry Tn1n1A/Tn1n1B/Tn1n1C, see their Figure 9. Limits are also set on the wino, slepton, sneutrino and gluino mass in a simplified model of NLSP pair production with R-parity violating decays of the LSP via \(\lambda_{12k}\) or \(\lambda_{133}\) to charged leptons, see their Figures 7, 8.

5. SIRUNYAN 18AT searched in 35.9 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 13\) TeV for heavy resonances decaying into e\(\mu\) final states. No significant excess above the Standard Model expectation is observed and 95% C.L. exclusions are placed on the cross section times branching ratio for the R-parity-violating production and decay of a supersymmetric tau sneutrino, see their Fig. 3.

6. AABOUD 16P searched in 3.2 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 13\) TeV for events with different flavour dilepton pairs (e\(\mu\), e\(\tau\), \(\mu\tau\)) from the production of \(\tilde{\nu}_\tau\) via an RPV \(\lambda'_{311}\) coupling and followed by a decay via \(\lambda_{312} = \lambda_{321} = 0.07\) for \(e + \mu\) via \(\lambda_{313} = \lambda_{331} = 0.07\) for \(e + \tau\) and via \(\lambda_{323} = \lambda_{332} = 0.07\) for \(\mu + \tau\). No evidence for a dilepton resonance over the SM expectation is observed, and limits are derived on \(m_{\tilde{\nu}}\) at 95% CL, see their Figs. 2(b), 3(b), 4(b), and Table 3.

7. AAD 14X searched in 20.3 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 8\) TeV for events with at least four leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the sneutrino mass in an R-parity violating simplified model where the decay \(\tilde{\nu} \rightarrow \nu_{1}\chi_{1}^{0}\), with \(\chi_{1}^{0} \rightarrow \ell^\pm \ell^\mp \nu\), takes place with a branching ratio of 100%, see Fig. 9.

8. AAD 11Z looked in 1.07 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 7\) TeV for events with one electron and one muon of opposite charge from the production of \(\tilde{\nu}_\tau\) via an RPV \(\lambda'_{311}\) coupling and followed by a decay via \(\lambda_{312}\) into e + \mu. No evidence for an (e, \(\mu\)) resonance over the SM expectation is observed, and a limit is derived in the plane of \(\lambda'_{311}\) versus \(m_{\tilde{\nu}}\) for three values of \(\lambda_{312}\), see their Fig. 2. Masses \(m_{\tilde{\nu}} < 1.32\) (1.45) TeV are excluded for \(\lambda'_{311} = 0.10\) and \(\lambda_{312} = 0.05\) (\(\lambda'_{311} = 0.11\) and \(\lambda_{312} = 0.07\)).

9. ABDALLAH 03M uses data from \(\sqrt{s} = 192–208\) GeV to obtain limits in the framework of the MSSM with gaugino and sfermion mass universality at the GUT scale. An indirect limit on the mass is derived by constraining the MSSM parameter space by the results of direct searches for neutralinos (including cascade decays) and for sleptons. These limits are valid for values of \(M_Z^\prime < 1\) TeV, \(|\mu| < 1\) TeV with the \(\chi_{1}^{0}\) as LSP. The quoted limit is obtained when there is no mixing in the third family. See Fig. 43 for the mass limits as a function of \(\tan\beta\). These limits update the results of ABREU 00W.

10. HEISTER 02N derives a bound on \(m_{\tilde{\nu}_{e}}\) by exploiting the mass relation between the \(\tilde{\nu}_e\) and \(\tilde{\nu}\), based on the assumption of universal GUT scale gaugino and scalar masses \(m_{1/2}\) and \(m_0\) and the search described in the \(\tilde{\nu}\) section. In the MSUGRA framework with radiative electroweak symmetry breaking, the limit improves to \(m_{\tilde{\nu}_{e}} > 130\) GeV, assuming a trilinear coupling \(A_0 = 0\) at the GUT scale. See Figs. 5 and 7 for the dependence of the limits on \(\tan\beta\).

11. DECAMP 92 limit is from \(\Gamma(\text{invisible})/\Gamma(\ell\ell) = 5.91 \pm 0.15\) (\(N_\nu = 2.97 \pm 0.07\)).

12. SIRUNYAN 19AO searched in 35.9 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 13\) TeV for events containing two same-sign muons and at least two jets, originating from resonant production of second-generation sleptons (\(\tilde{\mu}_L, \tilde{\mu}_R\)) via the R-parity violating coupling \(\lambda'_{211}\) to quarks. No significant excess above the Standard Model expectations is observed. Upper limits on cross sections are derived in the context of two simplified models, see their Figure 4. The cross section limits are translated into limits on \(\lambda'_{211}\) for a modified CMSSM, see their Figure 5.

13. KHACHATRYAN 16BE searched in 19.7 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 8\) TeV for evidence of narrow resonances decaying into e\(\mu\) final states. No significant excess above the Standard Model expectation is observed and 95% C.L. exclusions are placed on the cross section...
section times branching ratio for the production of an R-parity-violating supersymmetric tau sneutrino, see their Fig. 3.

14 AAD 150 searched in 20.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for evidence of heavy particles decaying into $e\mu$, $e\tau$ or $\mu\tau$ final states. No significant excess above the Standard Model expectation is observed, and 95% C.L. exclusions are placed on the cross section times branching ratio for the production of an R-parity-violating supersymmetric tau sneutrino, applicable to any sneutrino flavour, see their Fig. 2.

15 AAD 13α searched in 4.6 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for evidence of heavy particles decaying into $e\mu$, $e\tau$ or $\mu\tau$ final states. No significant excess above the Standard Model expectation is observed, and 95% C.L. exclusions are placed on the cross section times branching ratio for the production of an R-parity-violating supersymmetric tau sneutrino, see their Fig. 2. For couplings $\lambda^L_{311} = 0.10$ and $\lambda^L_{33k} = 0.05$, the lower limits on the $\mu_\tau$ mass are 1610, 1110, 1100 GeV in the $e\mu$, $e\tau$, and $\mu\tau$ channels, respectively.

16 AAD 11H looked in 35 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events with one electron and one muon of opposite charge from the production of $\tilde{\nu}_\tau$ via an RPV $\lambda^L_{311}$ coupling and followed by a decay via $\lambda^L_{312}$ into $e + \mu$. No evidence for an excess over the SM expectation is observed, and a limit is derived in the plane of $\lambda^L_{311}$ versus $m_{\tilde{\nu}_\tau}$ for several values of $\lambda^L_{312}$. The limits improve to 114 GeV for $\mu < 0$. The constraints are obtained from the searches for mass degenerate chargino and neutralino, for SM-like and invisible Higgs, for leptonically decaying charginos and from the limit on non-SM $Z$ width of 3.2 MeV. The limit is for $m_\chi = 174.3$ GeV (see Table 2 for other $m_{\tilde{\chi}}$ values). The limit improves to 114 GeV for $\mu < 0$.

17 AALTONEN 10Z searched in 1 fb$^{-1}$ of $p \bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for events from the production $d\bar{d} \rightarrow \tilde{\nu}_\tau$ with the subsequent decays $\tilde{\nu}_\tau \rightarrow e\mu$, $\mu\tau$, $e\tau$ in the MSSM framework with RPV. Two isolated leptons of different flavor and opposite charges are required, with $s$ identified by their hadronic decay. No statistically significant excesses are observed over the SM background. Upper limits on $\lambda^L_{312}$ times the branching ratio are listed in their Table III for various $\tilde{\nu}_\tau$ masses. Limits on the cross section times branching ratio for $\lambda^L_{311} = 0.10$ and $\lambda^L_{33k} = 0.05$, displayed in Fig. 2, are used to set limits on the $\tilde{\nu}_\tau$, mass of 558 GeV for the $e\mu$, 441 GeV for the $\mu\tau$ and 442 GeV for the $e\tau$ channels.

18 ABAZOV 10M looked in 5.3 fb$^{-1}$ of $p \bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for events with exactly one pair of high $p_T$ isolated $e\mu$ and a veto against hard jets. No evidence for an excess over the SM expectation is observed, and a limit at 95% C.L. on the cross section times branching ratio is derived, see their Fig. 3. These limits are translated into limits on couplings as a function of $m_{\tilde{\nu}_\tau}$ as shown on their Fig. 4. An example, for $m_{\tilde{\nu}_\tau} = 100$ GeV and $\lambda^L_{312} < 0.07$, couplings $\lambda^L_{311} > 7.7 \times 10^{-4}$ are excluded.

19 ABDALLAH 04H use data from LEP 1 and $\sqrt{s} = 192–208$ GeV. They re-use results or re-analyze the data from ABDALLAH 03M to put limits on the parameter space of anomaly-mediated supersymmetry breaking (AMSB), which is scanned in the region $1 < m_{3/2} < 50$ TeV, $0 < m_0 < 1000$ GeV, $1.5 < \tan\beta < 35$, both signs of $\mu$. The constraints are obtained from the searches for mass degenerate chargino and neutralino, for SM-like and invisible Higgs, for leptonically decaying charginos and from the limit on non-SM $Z$ width of 3.2 MeV. The limit is for $m_\chi = 174.3$ GeV (see Table 2 for other $m_\chi$ values). The limit improves to 114 GeV for $\mu < 0$.

20 ADRIANI 93M limit from $\Delta\Gamma(Z)(\text{invisible}) < 16.2$ MeV.

21 ALEXANDER 91F limit is for one species of $\tilde{\nu}$ and is derived from $\Gamma(\text{invisible, new})/\Gamma(\ell\ell) < 0.38$.

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**Charged sleptons**

This section contains limits on charged scalar leptons ($\tilde{\ell}$, with $\ell= e, \mu, \tau$). Studies of width and decays of the $Z$ boson (use is made here of $\Delta\Gamma_{\text{inv}} < 2.0$ MeV, LEP 00) conclusively rule out $m_{\tilde{\ell} R} < 40$ GeV (41 GeV for $\tilde{\ell}_L$), independently of decay modes, for each individual slepton. The limits improve to 43 GeV (43.5 GeV for $\tilde{\ell}_L$) assuming all 3 flavors to be degenerate. Limits on higher mass sleptons depend on model assumptions.
and on the mass splitting $\Delta m = m_{\tilde{\ell}} - m_{0}^{L1}$. The mass and composition of $\chi^{0}_1$ may affect the selectron production rate in $e^+ e^-$ collisions through $t$-channel exchange diagrams. Production rates are also affected by the potentially large mixing angle of the lightest mass eigenstate \( \ell_L = \ell_R \sin \theta_\ell + \ell_L \cos \theta_\ell \). It is generally assumed that only $\tilde{\tau}$ may have significant mixing. The coupling to the $Z$ vanishes for $\theta_\ell = 0.82$. In the high-energy limit of $e^+ e^-$ collisions the interference between $\gamma$ and $Z$ exchange leads to a minimal cross section for $\theta_\ell = 0.91$, a value which is sometimes used in the following entries relative to data taken at LEP2. When limits on $m_{\tilde{\ell}}$ are quoted, it is understood that limits on $m_{\tilde{\ell}}$ are usually at least as strong.

Possibly open decays involving gauginos other than $\chi^0_1$ will affect the detection efficiencies. Unless otherwise stated, the limits presented here result from the study of $\tilde{\ell}^+ \tilde{\ell}^-$ production, with production rates and decay properties derived from the MSSM. Limits made obsolete by the recent analyses of $e^+ e^-$ collisions at high energies can be found in previous Editions of this Review.

For decays with final state gravitinos ($\tilde{G}$), $m_{\tilde{G}}$ is assumed to be negligible relative to all other masses.

**R-parity conserving $\tilde{e}$ (Selectron) mass limit**

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics **C38** 070001 (2014) (http://pdg.lbl.gov).

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<td>$\geq 3\ell^\pm, \tilde{G} \rightarrow \ell^\pm + \tilde{G}$ simplified model, GMSB, stau (N)NLSP scenario</td>
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HTTP://PDG.LBL.GOV Page 52 Created: 6/1/2020 08:33
none 90–325 95 12 AAD 14G ATLAS \[ e^\pm + \not\!E_T \], SMS, pMSSM

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> 94.4

7 ACHARD 04 L3 \[ e_R, \Delta m > 10 \text{ GeV}, |\mu| > 200 \text{ GeV}, \tan\beta > 2 \]

> 71.3

7 ACHARD 04 L3 \[ e_R, \text{ all } \Delta m \]

none 30–94 95

8 ABDALLAH 03M DLPH \[ \Delta m > 15 \text{ GeV}, e_R^+ \bar{e}_R^- \]

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9 ABDALLAH 03M DLPH \[ \bar{e}_R, 1 \leq \tan\beta \leq 40, \Delta m > 10 \text{ GeV} \]

> 95

10 HEISTER 02N ALEP \[ \bar{e}_R, \text{ any } \Delta m \]

> 73

11 HEISTER 02N ALEP \[ \bar{e}_L, \text{ any } \Delta m \]

> 107

12 AAD 14G ATLS \[ e^\pm \to \ell^\pm \bar{\chi}^0_1 \ell^- \bar{\chi}^0_1, \text{ simplified model, } m_{\ell_L} = m_{\ell_R}, m_{\bar{\chi}^0_1} = 0 \text{ GeV} \]

13 KHACHATRYAN...14 CMS \[ \ell \to \ell \bar{\chi}^0_1, \text{ simplified model} \]

1 SIRUNYAN 19AW searched in 35.9 fb\(^{-1}\) of pp collisions at \( \sqrt{s} = 13 \) TeV for direct electroweak pair production of selectrons or smuons in events with two leptons (electrons or muons) of the opposite electric charge and same flavour, no jets and large \( \not\!E_T \). No significant excess above the Standard Model expectations is observed. Limits are set on the slepton mass assuming left-handed, right-handed or both left- and right-handed (mass degenerate) production, see their Figure 6. Similarly, limits are set on the smuon mass, see their Figure 7. Limits are also set on slepton masses under the assumption that the selectron and smuon are mass degenerate, see their Figure 5.

2 AABBOUD 18BT searched in 36.1 fb\(^{-1}\) of pp collisions at \( \sqrt{s} = 13 \) TeV for direct electroweak production of charginos, chargino and next-to-lightest neutralinos and sleptons in events with two or three leptons (electrons or muons), with or without jets, and large missing transverse energy. No significant excess above the Standard Model expectations is observed. Limits are set on the slepton mass up to 500 GeV for massless \( \tilde{\chi}^0_1 \), assuming degeneracy of \( \tilde{e}, \tilde{\mu}, \) and \( \tilde{\tau} \) and exploiting the \( 2\ell \) signature, see their Figure 8(b).

3 AABBOUD 18R searched in 36.1 fb\(^{-1}\) of pp collisions at \( \sqrt{s} = 13 \) TeV for electroweak production in scenarios with compressed mass spectra in final states with two low-momentum leptons and missing transverse momentum. The data are found to be consistent with the SM prediction. Results are interpreted in slepton pair production models with a fourfold degeneracy assumed in selectron and smuon masses. The \( \tilde{e} \) masses are excluded up to 190 GeV for \( m_{\tilde{e}} - m_{\tilde{\chi}^0_1} = 5 \text{ GeV} \). The exclusion limits extend down to mass splittings of 1 GeV, see their Fig. 11.

4 CHATRCHYAN 14R searched in 19.5 fb\(^{-1}\) of pp collisions at \( \sqrt{s} = 8 \) TeV for events with at least three leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the slepton mass in a stau (N)NLSP simplified model (GMSB) where the decay \( \tilde{\ell} \to \ell \pm \tau \pm \tau \pm 0 \) takes place with a branching ratio of 100%, see Fig. 8.

5 AAD 13B searched in 4.7 fb\(^{-1}\) of pp collisions at \( \sqrt{s} = 7 \) TeV for sleptons decaying to a final state with two leptons (\( e \) and \( \mu \)) and missing transverse energy. No excess beyond the Standard Model expectation is observed. Limits are derived in a simplified model of direct left-handed slepton pair production, where left-handed slepton masses between 85 and 195 GeV are excluded at 95% C.L. for \( m_{\tilde{\chi}^0_1} = 20 \text{ GeV} \). See also Fig. 2(a). Exclusion limits are also derived in the phenomenological MSSM, see Fig. 3.

6 AABBIENDI 04 search for \( e_R \bar{e}_R \) production in acoplanar di-electron final states in the 183–208 GeV data. See Fig. 13 for the dependence of the limits on \( m_{\tilde{\chi}^0_1} \) and for the limit at \( \tan\beta = 35 \). This limit supersedes AABBIENDI 00G.
7 ACHARD 04 search for $\tilde{e}_R \tilde{e}_L$ and $\tilde{e}_R \tilde{e}_R$ production in single- and acoplanar di-electron final states in the 192–209 GeV data. Absolute limits on $m_{\tilde{e}_R}$ are derived from a scan over the MSSM parameter space with universal GUT scale gaugino and scalar masses $m_{1/2}$ and $m_0$. $1 \leq \tan\beta \leq 60$ and $-2 \leq \mu \leq 2$ TeV. See Fig. 4 for the dependence of the limits on $m_{\tilde{e}_R}$. This limit supersedes ACCIARRI 99w.

8 ABDALLAH 03M looked for acoplanar dielectron $+E_T$ final states at $\sqrt{s} = 192–208$ GeV. The limit assumes $\mu = -200$ GeV and $\tan\beta = 1.5$ in the calculation of the production cross section and $B(\tilde{e} \rightarrow e\tilde{\chi}_1^0)$. See Fig. 15 for limits in the $(m_{\tilde{e}_R}^\prime, m_{\tilde{\chi}_1^0})$ plane. These limits include and update the results of ABREU 01.

9 ABDALLAH 03M uses data from $\sqrt{s} = 192–208$ GeV to obtain limits in the framework of the MSSM with gaugino and sfermion mass universality at the GUT scale. An indirect limit on the mass is derived by constraining the MSSM parameter space by the results from direct searches for neutralinos (including cascade decays) and for sleptons. These limits are valid for values of $M_2 < 1$ TeV, $|\mu| \leq 1$ TeV with the $\tilde{\chi}_1^0$ as LSP. The quoted limit is obtained when there is no mixing in the third family. See Fig. 43 for the mass limits as a function of $\tan\beta$. These limits update the results of ABREU 00w.

10 HEISTER 02E looked for acoplanar dielectron $+E_T$ final states from $e^+e^-$ interactions between 183 and 209 GeV. The mass limit assumes $\mu < -200$ GeV and $\tan\beta = 2$ for the production cross section and $B(\tilde{e} \rightarrow e\tilde{\chi}_1^0) = 1$. See their Fig. 4 for the dependence of the limit on $\Delta m$. These limits include and update the results of BARATE 01.

11 HEISTER 02N search for $\tilde{\tau}_R \tilde{\tau}_L$ and $\tilde{\tau}_R \tilde{\tau}_R$ production in single- and acoplanar di-electron final states in the 183–208 GeV data. Absolute limits on $m_{\tilde{\tau}_R}$ are derived from a scan over the MSSM parameter space with universal GUT scale gaugino and scalar masses $m_{1/2}$ and $m_0$. $1 \leq \tan\beta \leq 50$ and $-10 \leq \mu \leq 10$ TeV. The region of small $|\mu|$.

12 AAD 14G searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of slepton pairs, decaying to a final state with two leptons ($e$ or $\mu$) and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models of slepton pair production, see Fig. 8.

13 KHACHATRYAN 14t searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of slepton pairs decaying to a final state with opposite-sign lepton pairs ($e$ or $\mu$) and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models, see Fig. 18.

### R-parity violating $\tilde{e}$ (Selectron) mass limit

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).
• We do not use the following data for averages, fits, limits, etc.

1 AABOUD 18Z searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing four or more charged leptons (electrons, muons, and up to two hadronically decaying taus). No significant deviation from the expected SM background is observed. Limits are set on the Higgsino mass in simplified models of general gauge mediated supersymmetry $T_{n1A}/T_{n1B}/T_{n1C}$, see their Figure 9. Limits are also set on the wino, slepton, sneutrino and gluino mass in a simplified model of NLSP pair production with R-parity violating decays of the LSP via $\lambda_{12k}$ or $\lambda_{133}$ to charged leptons, see their Figures 7, 8.

2 AAD 14X searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least four leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the slepton mass in an R-parity violating simplified model where the decay $\tilde{\ell} \to \ell\tilde{\chi}_1^0$, with $\tilde{\chi}_1^0 \to \ell\tilde{\ell}^\mp\nu$, takes place with a branching ratio of 100%, see Fig. 9.

3 ABBIENDI 04F use data from $\sqrt{s} = 189–209$ GeV. They derive limits on sparticle masses under the assumption of RPV with $LL\bar{E}$ or $LQ\bar{D}$ couplings. The results are valid for $\tan\beta = 1.5$, $\mu = -200$ GeV, with, in addition, $\Delta m > 5$ GeV for indirect decays via $LQ\bar{D}$. The limit quoted applies to direct decays via $LL\bar{E}$ or $LQ\bar{D}$ couplings. For indirect decays, the limits on the $\tilde{e}_R$ mass are respectively 99 and 92 GeV for $LL\bar{E}$ and $LQ\bar{D}$ couplings and $m_{\tilde{\chi}_0^0} = 10$ GeV and degrade slightly for larger $\tilde{\chi}_1^0$ mass. Supersedes the results of ABBIENDI 00.

4 ABDALLAH 04M use data from $\sqrt{s} = 192–208$ GeV to derive limits on sparticle masses under the assumption of RPV with $LL\bar{E}$ or $UDD$ couplings. The results are valid for $\mu = -200$ GeV, $\tan\beta = 1.5$, $\Delta m > 5$ GeV and assuming a BR of 1 for the given decay. The limit quoted is for indirect $UDD$ decays using the neutralino constraint of 39.5 GeV for $LL\bar{E}$ and of 38.0 GeV for $UDD$ couplings, also derived in ABDALLAH 04M. For indirect decays via $LL\bar{E}$ the limit improves to 95 GeV if the constraint from the neutralino is used and to 94 GeV if it is not used. For indirect decays via $UDD$ couplings it remains unchanged when the neutralino constraint is not used. Supersedes the result of ABREU 00U.

**R-parity conserving $\tilde{\mu}$ (Smuon) mass limit**

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1 SIRUNYAN 19AW searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak pair production of selectrons or smuons in events with two leptons (electrons or muons) of the opposite electric charge and same flavour, no jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the selectron mass assuming left-handed, right-handed or both left- and right-handed (mass degenerate) production, see their Figure 6. Similarly, limits are set on the smuon mass, see their Figure 7. Limits are also set on slepton masses under the assumption that the selectron and smuon are mass degenerate, see their Figure 5.

2 AABOUD 18R searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for electroweak production in scenarios with compressed mass spectra in final states with two low-momentum leptons and missing transverse momentum. The data are found to be consistent with the SM prediction. Results are interpreted in slepton pair production models with a fourfold degeneracy assumed in selectron and smuon masses. The $\tilde{\mu}$ masses are excluded up to 190 GeV for $m_{\tilde{\mu}} - m_{\chi_1^0} = 5$ GeV. The exclusion limits extend down to mass splittings of 1 GeV, see their Fig. 11.

3 CHATRCHYAN 14R searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least three leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the slepton mass in a stau (N)NLSP simplified model (GMSB) where the decay $\tilde{\ell} \rightarrow \ell^{\pm} \tau^{\mp} \tau^{\mp} \tilde{G}$ takes place with a branching ratio of 100%, see Fig. 8.

4 AAD 13B searched in 4.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for sleptons decaying to a final state with two leptons ($e$ and $\mu$) and missing transverse energy. No excess beyond the Standard Model expectation is observed. Limits are derived in a simplified model of direct left-handed slepton pair production, where left-handed slepton masses between 85...
and 195 GeV are excluded at 95% C.L. for $m_{\tilde{\chi}^0_1} = 20$ GeV. See also Fig. 2(a). 

5 ABBIENDI 04 search for $\tilde{\mu}_R \tilde{\mu}_R$ production in acoplanar di-muon final states in the 183–208 GeV data. See Fig. 14 for the dependence of the limits on $m_{\tilde{\chi}^0_1}$ and for the limit at $\tan \beta = 35$. Under the assumption of 100% branching ratio for $\tilde{\mu}_R \rightarrow \mu \tilde{\chi}^0_1$, the limit improves to 94.0 GeV for $\Delta m > 4$ GeV. See Fig. 11 for the dependence of the limits on $m_{\tilde{\chi}^0_1}$ at several values of the branching ratio. This limit supersedes ABBIENDI 00G.

6 ACHARD 04 search for $\tilde{\mu}_R \tilde{\mu}_R$ production in acoplanar di-muon final states in the 192–209 GeV data. Limits on $m_{\tilde{\mu}^-_R}$ are derived from a scan over the MSSM parameter space with universal GUT scale gaugino and scalar masses $m_{1/2}^G$ and $m_0^G$, $1 \leq \tan \beta \leq 60$ and $-2 \leq \mu \leq 2$ TeV. See Fig. 4 for the dependence of the limits on $m_{\tilde{\chi}^0_1}$. This limit supersedes ACCIARRI 99W.

7 ABDALLAH 03M looked for acoplanar dimuon $+ E_T$ final states at $\sqrt{s} = 189–208$ GeV. The limit assumes $\text{B}(\tilde{\mu} \rightarrow \mu \tilde{\chi}^0_1) = 100\%$. See Fig. 16 for limits on the $(m_{\tilde{\mu}^-_R}, m_{\tilde{\chi}^0_1})$ plane. These limits include and update the results of ABREU 01.

8 ABDALLAH 03M uses data from $\sqrt{s} = 192–208$ GeV to obtain limits in the framework of the MSSM with gaugino and sfermion mass universality at the GUT scale. An indirect limit on the mass is derived by constraining the MSSM parameter space by the results from direct searches for neutralinos (including cascade decays) and for sleptons. These limits are valid for values of $M_2 < 1$ TeV, $|\mu| \leq 1$ TeV with the $\tilde{\chi}^0_1$ as LSP. The quoted limit is obtained when there is no mixing in the third family. See Fig. 43 for the mass limits as a function of $\tan \beta$. These limits update the results of ABREU 00W.

9 HEISTER 02E looked for acoplanar dimuon $+ E_T$ final states from $e^+ e^-$ interactions between 183 and 209 GeV. The mass limit assumes $\text{B}(\tilde{\mu} \rightarrow \mu \tilde{\chi}^0_1) = 1$. See their Fig. 4 for the dependence of the limit on $\Delta m$. These limits include and update the results of BARATE 01.

10 AABOUD 18B7 searched in 36.1 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos, chargino and next-to-lightest neutralinos and sleptons in events with two or three leptons (electrons or muons), with or without jets, and large missing transverse energy. No significant excess above the Standard Model expectations is observed. Limits are set on the slepton mass up to 500 GeV for massless $\tilde{\chi}^0_1$, assuming degeneracy of $\tilde{\tau}$, $\tilde{\mu}$, and $\tilde{\chi}^0_1$ and exploiting the 2$\ell$ signature, see their Figure 8(b).

11 AAD 14G searched in 20.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of slepton pairs, decaying to a final state with two leptons (e and $\mu$) and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models of slepton pair production, see Fig. 8. An interpretation in the pMSSM is also given, see Fig. 10.

12 KHACHATRYAN 14I searched in 19.5 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for electroweak production of slepton pairs decaying to a final state with opposite-sign lepton pairs (e or $\mu$) and missing transverse momentum. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in simplified models, see Fig. 18.

13 ABREU 00V use data from $\sqrt{s} = 130–189$ GeV to search for tracks with large impact parameter or visible decay vertices. Limits are obtained as function of $m_{\tilde{\chi}^0_1}$, after combining these results with the search for slepton pair production in the SUGRA framework from ABREU 01 to cover prompt decays and on stable particle searches from ABREU 00Q. For limits at different $m_{\tilde{\chi}^0_1}$, see their Fig. 12.
R-parity violating $\tilde{\mu}$ (Smuon) mass limit

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1 AABOUD 18Z searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing four or more charged leptons (electrons, muons and up to two hadronically decaying taus). No significant deviation from the expected SM background is observed. Limits are set on the Higgsino mass in simplified models of general gauge mediated supersymmetry Tn1n1A/Tn1n1B/Tn1n1C, see their Figure 9. Limits are also set on the wino, slepton, sneutrino and gluino mass in a simplified model of NLSP pair production with R-parity violating decays of the LSP via $\lambda'_{12k}$ or $\lambda'_{133}$ to charged leptons, see their Figures 7, 8.

2 AAD 14X searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least four leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the slepton mass in an R-parity violating simplified model where the decay $\tilde{\mu} \to \ell_{\tilde{\chi}_1^0}$, with $\ell_{\tilde{\chi}_1^0} \to \ell^+\ell^-\nu$, takes place with a branching ratio of 100%, see Fig. 9.

3 SIRUNYAN 19AO searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing two same-sign muons and at least two jets, originating from resonant production of second-generation sleptons ($\tilde{\mu}_{L/R}$) via the R-parity violating coupling $\lambda'_{211}$ to quarks. No significant excess above the Standard Model expectations is observed. Upper limits on cross sections are derived in the context of two simplified models, see their Figure 4. The cross section limits are translated into limits on $\lambda'_{211}$ for a modified CMSSM, see their Figure 5.

4 ABDALLAH 04M use data from $\sqrt{s} = 192–208$ GeV to derive limits on sparticle masses under the assumption of RPV with $L\bar{L}$ or $U\bar{D}D$ couplings. The results are valid for $\mu = -200$ GeV, $\tan\beta = 1.5$, $\Delta m > 5$ GeV and assuming a BR of 1 for the given decay. The limit quoted for indirect $U\bar{D}D$ decays using the neutralino constraint of 39.5 GeV for $L\bar{L}$ and of 38.0 GeV for $U\bar{D}D$ couplings, also derived in ABDALLAH 04M. For indirect decays via $L\bar{L}$ the limit improves to 90 GeV if the constraint from the neutralino is used and remains at 87 GeV if it is not used. For indirect decays via $U\bar{D}D$ couplings it degrades to 85 GeV when the neutralino constraint is not used. Supersedes the result of ABREU 000.

5 HEISTER 03c searches for the production of smuons in the case of RPV prompt decays with $L\bar{L}$, $L\bar{Q}Q$ or $U\bar{D}D$ couplings at $\sqrt{s} = 189–209$ GeV. The search is performed for direct and indirect decays, assuming one coupling at a time to be non-zero. The limit holds for direct decays mediated by RPV $L\bar{Q}Q$ couplings and improves to 90 GeV for indirect decays (for $\Delta m > 10$ GeV). Limits are also given for $L\bar{L}$ direct ($m_{\tilde{\mu}R} > 87$ GeV) and indirect decays ($m_{\tilde{\mu}R} > 96$ GeV for $m(\tilde{\chi}_1^0) > 23$ GeV from BARATE 98S) and for $U\bar{D}D$ indirect decays ($m_{\tilde{\mu}R} > 85$ GeV for $\Delta m > 10$ GeV). Supersedes the results from BARATE 01B.
R-parity conserving $\tilde{\tau}$ (Stau) mass limit

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).

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<td>2 ACHARD 04 L3</td>
<td>$\Delta m &gt; 15$ GeV, $\theta_\tau = \pi/2$, $</td>
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<td>&gt; 81.9</td>
<td>95</td>
<td>3 ABDALLAH 03M DLPH</td>
<td>$\Delta m &gt; 15$ GeV, all $\theta_\tau$</td>
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<td>&gt; 79</td>
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<td>4 HEISTER 02E ALEP</td>
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<td>4 HEISTER 02E ALEP</td>
<td>$\Delta m &gt; 15$ GeV, $\theta_\tau = 0.91$</td>
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- We do not use the following data for averages, fits, limits, etc. • • •

| >500       | 95  | 5 AABOUD 18BT ATLS | $2\ell + \not{E}_T$, $m_\tau = m_\ell^R$, $\ell = e, \mu, \tau$, $m_{\chi^0_1} = 0$ GeV |
| none       | 95  | 6 KHACHATRY...17L CMS | 2 hadronic $\tau + \not{E}_T$, $\tilde{\tau}_L \rightarrow \tau \chi^0_1$, $m_{\chi^0_1} = 0$ GeV |
| none       | 109 | 7 AAD 16AA ATLS | $2\tau + \not{E}_T$, $\tilde{\tau}_R/L \rightarrow \tau \chi^0_1$, $m_{\chi^0_1} = 0$ GeV |
| none       | 10  | 8 AAD 12AF ATLS | $2\tau + \text{jets} + \not{E}_T$, GMSB |
| none       | 9   | 9 AAD 12AG ATLS | $\gtrsim 1\tau_h + \text{jets} + \not{E}_T$, GMSB |
| none       | 10  | 10 AAD 12CM ATLS | $\gtrsim 1\tau + \text{jets} + \not{E}_T$, GMSB |
| > 87.4     | 95  | 11 ABDIENDI 06B OPAL | $\tilde{\tau}_R \rightarrow \tau \tilde{G}$, all $\tau(\tilde{\tau}_R)$ |
| > 68       | 95  | 12 ABDALLAH 04H DLPH | AMSG, $\mu > 0$ |
| none       | 95  | 3 ABDALLAH 03M DLPH | $\Delta m > m_\tau$, all $\theta_\tau$ |

1 ABDIENDI 04 search for $\tilde{\tau}\tilde{\tau}$ production in acoplanar di-tau final states in the 183–208 GeV data. See Fig. 15 for the dependence of the limits on $m_{\chi^0_1}$ and for the limit at $\tan\beta = 35$. Under the assumption of 100% branching ratio for $\tilde{\tau}_R \rightarrow \tau \chi^0_1$, the limit improves to 89.8 GeV for $\Delta m > 8$ GeV. See Fig. 12 for the dependence of the limits on $m_{\chi^0_1}$ at several values of the branching ratio and for their dependence on $\theta_\tau$. This limit supersedes ABDIENDI 00G.

2 ACHARD 04 search for $\tilde{\tau}\tilde{\tau}$ production in acoplanar di-tau final states in the 192–209 GeV data. Limits on $m_{\tilde{\tau}_R}$ are derived from a scan over the MSSM parameter space with universal GUT scale gaugino and scalar masses $m_{1/2}$ and $m_0$, $1 \leq \tan\beta \leq 60$ and $-2 \leq \mu \leq 2$ TeV. See Fig. 4 for the dependence of the limits on $m_{\chi^0_1}$.

3 ABDALLAH 03M looked for acoplanar ditau + $\not{E}_T$ final states at $\sqrt{s} = 130$–208 GeV. A dedicated search was made for low mass $\tilde{\tau}$s decoupling from the $Z^0$. The limit assumes $\text{B}(\tilde{\tau} \rightarrow \tau \chi^0_1) = 100\%$. See Fig. 20 for limits on the $(m_{\tilde{\tau}}, m_{\chi^0_1})$ plane and as function of the $\chi^0_1$ mass and of the branching ratio. The limit in the low-mass region improves to 29.6 and 31.1 GeV for $\tilde{\tau}_R$ and $\tilde{\tau}_L$, respectively, at $\Delta m > m_{\tilde{\tau}}$. The limit in the high-mass region improves to 84.7 GeV for $\tilde{\tau}_R$ and $\Delta m > 15$ GeV. These limits include and update the results of ABREU 01.

4 HEISTER 02E looked for acoplanar ditau + $\not{E}_T$ final states from $e^+e^-$ interactions between 183 and 209 GeV. The mass limit assumes $\text{B}(\tilde{\tau} \rightarrow \tau \chi^0_1) = 1$. See their Fig. 4 for the dependence of the limit on $\Delta m$. These limits include and update the results of BARATE 01.
5 AABOUD 18BT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct electroweak production of charginos, chargino and next-to-lightest neutralino and sleptons in events with two or three leptons (electrons or muons), with or without jets, and large missing transverse energy. No significant excess above the Standard Model expectations is observed. Limits are set on the slepton mass up to 500 GeV for massless $\tilde{\chi}_1^0$, assuming degeneracy of $\tilde{e}$, $\tilde{\mu}$, and $\tilde{\tau}$ and exploiting the $2\ell$ signature, see their Figure 8(b).

6 KHACHATRYAN 17L searched in about 19 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with two $\tau$ (at least one decaying hadronically) and $E_T^{\tau}$. Results were interpreted to set constraints on the cross section for production of $\tilde{\tau}_L$ pairs for $m_{\tilde{\tau}_0} = 1$ GeV. No mass constraints are set, see their Fig. 7.

7 AAD 16AA summarized and extended ATLAS searches for electroweak supersymmetry in final states containing several charged leptons, $E_T$, with or without hadronic jets, in 20 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV. The paper reports 95% C.L. exclusion limits on the cross-section for production of $\tilde{\tau}_R$ and $\tilde{\tau}_L$ pairs for various $m_{\tilde{\chi}_1^0}$, using the 2 hadronic $\tau + E_T$ analysis. The $m_{\tilde{\tau}_R/L} = 109$ GeV is excluded for $m_{\tilde{\tau}_0} = 0$ GeV, with the constraints being stronger for $\tilde{\tau}_R$. See their Fig. 12.

8 AAD 12AF searched in 2 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with at least one hadronically decaying tau lepton, jets, and large $E_T$ in a GMSB framework. No significant excess above the expected background was found and an upper limit on the visible cross section for new phenomena is set. A 95% C.L. lower limit of 32 TeV on the mGMSB breaking scale $\Lambda$ is set for $M_{mess} = 250$ TeV, $N_S = 3$, $\mu > 0$ and $C_{grav} = 1$, independent of $\tan\beta$.

9 AAD 12AG searched in 2.05 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with at least one hadronically decaying tau lepton, jets, and large $E_T$ in a GMSB framework. No significant excess above the expected background was found and an upper limit on the visible cross section for new phenomena is set. A 95% C.L. lower limit of 30 TeV on the mGMSB breaking scale $\Lambda$ is set for $M_{mess} = 250$ TeV, $N_S = 3$, $\mu > 0$ and $C_{grav} = 1$, independent of $\tan\beta$. For large values of $\tan\beta$, the limit on $\Lambda$ increases to 43 TeV.

10 AAD 12CM searched in 4.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with at least one tau lepton, zero or one additional light lepton (e/µ) jets, and large $E_T$ in a GMSB framework. No significant excess above the expected background was found and an upper limit on the visible cross section for new phenomena is set. A 95% C.L. lower limit of 54 TeV on the mGMSB breaking scale $\Lambda$ is set for $M_{mess} = 250$ TeV, $N_S = 3$, $\mu > 0$ and $C_{grav} = 1$, for $\tan\beta > 20$. Here the $\tilde{\tau}_1$ is the NLSP.

11 ABDALLAH 06B use 600 pb$^{-1}$ of data from $\sqrt{s} = 189–209$ GeV. They look for events from pair-produced staus in a GMSB scenario with $\tilde{\tau}$ NLSP including prompt $\tilde{\tau}$ decays to ditaus + $E_T$ final states, large impact parameters, kinked tracks and heavy stable charged particles. Limits on the cross-section are computed as a function of $m(\tilde{\tau})$ and the lifetime, see their Fig. 7. The limit is compared to the $\sigma \cdot BR^2$ from a scan over the GMSB parameter space.

12 ABDALLAH 04H use data from LEP 1 and $\sqrt{s} = 192–208$ GeV. They re-use results or re-analyze the data from ABDALLAH 03M to put limits on the parameter space of anomaly-mediated supersymmetry breaking (AMSB), which is scanned in the region $1 < m_{3/2} < 50$ TeV, $0 < m_0 < 1000$ GeV, $1.5 < \tan\beta < 35$, both signs of $\mu$. The constraints are obtained from the searches for mass degenerate chargino and neutralino, for SM-like and invisible Higgs, for leptonically decaying charginos and from the limit on non-SM $Z$ width of 3.2 MeV. The limit is for $m_\tau = 174.3$ GeV (see Table 2 for other $m_\tau$ values). The limit improves to 75 GeV for $\mu < 0$. 

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R-parity violating $\tilde{\tau}$ (Stau) mass limit

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).

<table>
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<td></td>
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<td>$\geq 4\ell, \text{RPV, } \lambda_{12k} \neq 0, m_{\tilde{\chi}_0^0} = \frac{\lambda_1}{\lambda_1}$</td>
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<td></td>
<td></td>
<td>$\geq 4\ell, \text{RPV, } \lambda_{133} \neq 0, m_{\tilde{\chi}_0^0} = \frac{300}{\lambda_1}$</td>
</tr>
</tbody>
</table>

• • • We do not use the following data for averages, fits, limits, etc. • • •

1 AABOUD 18Z searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing four or more charged leptons (electrons, muons and up to two hadronically decaying taus). No significant deviation from the expected SM background is observed. Limits are set on the Higgsino mass in simplified models of general gauge mediated supersymmetry Tn1n1A/Tn1n1B/Tn1n1C, see their Figure 9. Limits are also set on the wino, slepton, sneutrino and gluino mass in a simplified model of NLSP pair production with R-parity violating decays of the LSP via $\lambda_{12k}$ or $\lambda_{133}$ to charged leptons, see their Figures 7, 8.

2 ABBIENDI 04F use data from $\sqrt{s} = 189–209$ GeV. They derive limits on sparticle masses under the assumption of RPV with $LL\bar{E}$ or $LQ\bar{D}$ couplings. The results are valid for $\tan\beta = 1.5$, $\mu = -200$ GeV, with, in addition, $\Delta m > 5$ GeV for indirect decays via $LQ\bar{D}$. The limit quoted applies to direct decays with $LL\bar{E}$ couplings and improves to 75 GeV for $LQ\bar{D}$ couplings. The limit on the $\tilde{\tau}_R$ mass for indirect decays is 92 GeV for $LL\bar{E}$ couplings at $m_{\tilde{\chi}_0^0} = 10$ GeV and no exclusion is obtained for $LQ\bar{D}$ couplings. Supersedes the results of ABBIENDI 00.

3 ABDALLAH 04M use data from $\sqrt{s} = 192–208$ GeV to derive limits on sparticle masses under the assumption of RPV with $LL\bar{E}$ couplings. The results are valid for $\mu = -200$ GeV, $\tan\beta = 1.5$, $\Delta m > 5$ GeV and assuming a BR of 1 for the given decay. The limit quoted is for indirect decays using the neutralino constraint of 39.5 GeV, also derived in ABDALLAH 04M. For indirect decays via $LL\bar{E}$ the limit decreases to 86 GeV if the constraint from the neutralino is not used. Supersedes the result of ABREU 00U.

Long-lived $\tilde{\ell}$ (Slepton) mass limit

Limits on scalar leptons which leave detector before decaying. Limits from $Z$ decays are independent of lepton flavor. Limits from continuum $e^+e^-$ annihilation are also independent of flavor for smuons and staus. Selectron limits from $e^+e^-$ collisions in the continuum depend on MSSM parameters because of the additional neutralino exchange contribution.

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<td>long-lived $\tilde{\tau}$ from inclusive production, mGMSB SPS line 7 scenario</td>
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</table>

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We do not use the following data for averages, fits, limits, etc.

1 AABOUD 19AT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for metastable and stable R-hadrons. Multiple search strategies for a wide range of lifetimes, corresponding to path lengths of a few meters, are defined. No significant deviations from the expected Standard Model background are observed. Results are interpreted in terms of exclusion limits on long-lived staus in the context of GMSB models. Lower limits on the mass for direct production of staus are set at 430 GeV, see their Fig. 10 (left).

2 KHACHATRYAN 16BW searched in 2.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with heavy stable charged particles, identified by their anomalously high energy deposits in the silicon tracker and/or long time-of-flight measurements by the muon system. No evidence for an excess over the expected background is observed. Limits are derived for pair production of tau sleptons as a function of mass, depending on their direct or inclusive production in a minimal GMSB scenario along the Snowmass Points and Slopes (SPS) line 7, see Fig. 4 and Table 7.

3 AAD 15AE searched in 19.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for heavy long-lived charged particles, measured through their specific ionization energy loss in the ATLAS pixel detector or their time-of-flight in the ALTAS muon system. In the absence of an excess of events above the expected backgrounds, limits are set on stable $\tilde{\tau}$ sleptons in various scenarios, see Figs. 5-7.

4 AAIJ 15BD searched in 3.0 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ and 8 TeV for evidence of Drell-Yan pair production of long-lived $\tilde{\tau}$ particles. No evidence for such particles is observed and 95% C.L. upper limits on the cross section of $\tilde{\tau}$ pair production are derived, see Fig. 7. In the mGMSB, assuming the SPS7 benchmark scenario $\tilde{\tau}$ masses between 124 and 309 GeV are excluded at 95% C.L.

5 ABBIENDI 03L used $e^+e^-$ data at $\sqrt{s} = 130–209$ GeV to select events with two high momentum tracks with anomalous $dE/dx$. The excluded cross section is compared to the theoretical expectation as a function of the heavy particle mass in their Fig. 3. The limit improves to 98.5 GeV for $\tilde{\mu}_L$ and $\tilde{\tau}_L$. The bounds are valid for colorless spin 0 particles with lifetimes longer than $10^{-6}$ s. Supersedes the results from ACKERSTAFF 98P.

6 ABREU 00Q searches for the production of pairs of heavy, charged stable particles in $e^+e^-$ annihilation at $\sqrt{s} = 130–189$ GeV. The upper bound improves to 88 GeV for $\tilde{\mu}_L$, $\tilde{\tau}_L$. These limits include and update the results of ABREU 98P.
7 ACCIARRI 99H searched for production of pairs of back-to-back heavy charged particles at $\sqrt{s} = 130–183$ GeV. The upper bound improves to 82.2 GeV for $\tilde{\mu}L, \tilde{\tau}L$.

8 The BARATE 98K mass limit improves to 82 GeV for $\tilde{\mu}L, \tilde{\tau}L$. Data collected at $\sqrt{s} = 161–184$ GeV.

9 AAD 13AA searched in 4.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events containing long-lived massive particles in a GMSB framework. No significant excess above the expected background was found. A 95% C.L. lower limit of 300 GeV is placed on long-lived $\tilde{\tau}$'s in the GMSB model with $M_{mess} = 250$ TeV, $N_S = 3, \mu > 0$, for $\tan\beta = 5–20$. The lower limit on the GMSB breaking scale $\Lambda$ was found to be 99–110 TeV, for $\tan\beta$ values between 5 and 40, see Fig. 4 (top). Also, directly produced long-lived sleptons, or sleptons decaying to long-lived ones, are excluded at 95% C.L. up to a $\tilde{\tau}$ mass of 278 GeV for models with slepton splittings smaller than 50 GeV.

10 ABAZOV 13B looked in 6.3 fb$^{-1}$ of $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV for charged massive long-lived particles in events with muon-like particles that have both speed and ionization energy loss inconsistent with muons produced in beam collisions. In the absence of an excess, limits are set at 95% C.L. on the production cross section of stau sleptons, or sleptons produced by their anomalous $dE/dx$ in the tracker or additionally requiring that it be identified as muon in the muon chambers, from pair production of $\tilde{\tau}$'s. No evidence for an excess over the expected background is observed. Supersedes CHATRCHYAN 12L.

11 CHATRCHYAN 13AB looked in 5.0 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV and in 18.8 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with heavy stable particles, identified by their anomalous $dE/dx$ in the tracker or additionally requiring that it be identified as muon in the muon chambers, from pair production of $\tilde{\tau}$'s. No evidence for an excess over the expected background is observed. Supersedes CHATRCHYAN 12L.

12 CHATRCHYAN 13AB limits are derived for pair production of $\tilde{\tau}$ as a function of mass in minimal GMSB scenarios along the Snowmass Points and Slopes (SPS) line 7 (see Fig. 8 and Table 7). The limit given here is valid for direct pair $\tilde{\tau}$ production.

13 CHATRCHYAN 13AB limits are derived for the production of $\tilde{\tau}$ as a function of mass in minimal GMSB scenarios along the Snowmass Points and Slopes (SPS) line 7 (see Fig. 8 and Table 7). The limit given here is valid for the production of $\tilde{\tau}$ from both direct pair production and from the decay of heavier supersymmetric particles.

14 CHATRCHYAN 12L looked in 5.0 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with heavy stable particles, identified by their anomalous $dE/dx$ in the tracker or additionally requiring that it be identified as muon in the muon chambers, from pair production of $\tilde{\tau}$'s. No evidence for an excess over the expected background is observed. Limits are derived for the production of $\tilde{\tau}$ as a function of mass in minimal GMSB scenarios along the Snowmass Points and Slopes (SPS) line 7 (see Fig. 3). The limit given here is valid for the production of $\tilde{\tau}$ in the decay of heavier supersymmetric particles.

15 AAD 11P looked in 37 pb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with two heavy stable particles, reconstructed in the Inner tracker and the Muon System and identified by their time of flight in the Muon System. No evidence for an excess over the SM expectation is observed. Limits on the mass are derived, see Fig. 3, for $\tilde{\tau}$ in a GMSB scenario and for sleptons produced by electroweak processes only, in which case the limit degrades to 110 GeV.

### $\tilde{q}$ (Squark) mass limit

For $m_{\tilde{q}} > 60–70$ GeV, it is expected that squarks would undergo a cascade decay via a number of neutralinos and/or charginos rather than undergo a direct decay to photinos as assumed by some papers. Limits obtained when direct decay is assumed are usually higher than limits when cascade decays are included.

Limits from $e^+e^-$ collisions depend on the mixing angle of the lightest mass eigenstate $\tilde{q}_1 = q_R \sin\theta_q + \tilde{q}_L \cos\theta_q$. It is usually assumed that only the sbottom and stop squarks have non-trivial mixing angles (see the stop and sbottom sections). Here, unless otherwise noted, squarks are always taken to be either left/right degenerate, or purely of left or right type.
Data from $Z$ decays have set squark mass limits above 40 GeV, in the case of $\tilde{q} \rightarrow q \tilde{\chi}^0_1$ decays if $\Delta m = m_{\tilde{q}} - m_{\tilde{\chi}^0_1} \gtrsim 5$ GeV. For smaller values of $\Delta m$, current constraints on the invisible width of the $Z$ ($\Delta \Gamma_{\text{inv}} < 2.0$ MeV, LEP 00) exclude $m_{\tilde{u}_{L,R}} < 44$ GeV, $m_{\tilde{d}_{R}} < 33$ GeV, $m_{\tilde{d}_{L}} < 44$ GeV and, assuming all squarks degenerate, $m_{\tilde{q}} < 45$ GeV.

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).

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575 95 14 KHACHATRYAN CMS 1 or more jets+$E_T$, $\ell$Sk1, one light flavor state, $m_{\tilde{\chi}^0_1}=0$

1370 95 15 KHACHATRYAN CMS $\ell$ or more jets+$E_T$, GGM, $\ell$Sk4, any NLSP mass

1600 95 16 SIRUNYAN CMS $\gamma +$ jets+$E_T$, $\ell$Sk4B, $m_{\tilde{\chi}^0_1}=0$

1370 95 16 SIRUNYAN CMS $\gamma +$ jets+$E_T$, $\ell$Sk4A, $m_{\tilde{\chi}^0_1}=0$

1050 95 17 SIRUNYAN CMS $\geq 1$ jets+$E_T$, $\ell$Sk1, single light flavor state, $m_{\tilde{\chi}^0_1}=0$

1550 95 17 SIRUNYAN CMS $\geq 1$ jets+$E_T$, $\ell$Sk4B, 4(flavor) x 2(isospin) = 8 degenerate mass states, $m_{\tilde{\chi}^0_1}=0$

1390 95 18 SIRUNYAN CMS $\geq 1$ jets+$E_T$, $\ell$Sk1, 4(flavor) x 2(isospin) = 8 degenerate mass states, $m_{\tilde{\chi}^0_1}=0$

950 95 18 SIRUNYAN CMS $\geq 1$ jet + $E_T$, $\ell$Sk1, $m_{\tilde{q}}-m_{\tilde{\chi}^0_1}=5$

1030 95 20 AABOUD ATLS $\geq 2$ jets + $E_T$, $\ell$Sk1, $m_{\tilde{\chi}^0_1}=0$

608 95 21 BHACHATRYAN CMS $\ell$ or more jets+$E_T$, $\ell$Sk1, single light squark, $m_{\tilde{\chi}^0_1}=0$

1260 95 21 BHACHATRYAN CMS $\ell$ or more jets+$E_T$, $\ell$Sk1, 8 degenerate light squarks, $m_{\tilde{\chi}^0_1}=0$

850 95 22 AAD ATLS jets + $E_T$, $q \rightarrow \ell \tilde{\chi}^0_1$, $m_{\tilde{\chi}^0_1}=100$

250 95 23 AAD ATLS photon + $E_T$, $pp \rightarrow \ell \tilde{q}^* \gamma$, $\ell \rightarrow \ell \tilde{\chi}^0_1$, $m_{\tilde{q}}-m_{\tilde{\chi}^0_1}=m_c$

490 95 24 AAD ATLS $\tilde{c} \rightarrow c \tilde{\chi}^0_1$, $m_{\tilde{\chi}^0_1} < 200$

875 95 25 BHACHATRYAN CMS $\tilde{q} \rightarrow q \tilde{\chi}^0_1$, simplified model, 8 degenerate light $\tilde{q}$, $m_{\tilde{\chi}^0_1}=0$

520 95 25 BHACHATRYAN CMS $\tilde{q} \rightarrow q \tilde{\chi}^0_1$, simplified model, single light squark, $m_{\tilde{\chi}^0_1}=0$

1450 95 25 BHACHATRYAN CMS CMSSM, $\tan \beta = 30$, $A_0 = -2\max(m_0, m_{1/2}), \mu > 0$

850 95 26 AAD ATLS jets + $E_T$, $q \rightarrow q \tilde{\chi}^0_1$, simplified model, mass degenerate first and second generation squarks, $m_{\tilde{\chi}^0_1}=0$

440 95 26 AAD ATLS jets + $E_T$, $q \rightarrow q \tilde{\chi}^0_1$, simplified model, single light-flavour squark, $m_{\tilde{\chi}^0_1}=0$
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* We do not use the following data for averages, fits, limits, etc. * * * 

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* We do not use the following data for averages, fits, limits, etc. * * * 

Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)
\[ \ell^\pm, q \rightarrow q\chi_1^\pm, \chi_1^\pm \rightarrow \tilde{S}W^\pm, \]
\[ \tilde{S} \rightarrow S\tilde{G}, S \rightarrow gg, m_{\tilde{S}} = 100 \text{ GeV}, m_S = 90 \text{ GeV} \]

1 \text{ SIRUNYAN 19Ag searched in 35.9 fb}^{-1} \text{ of } pp \text{ collisions at } \sqrt{s} = 13 \text{ TeV for events with two photons and large } \not{E_T}. \text{ No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu4B simplified model and on the squark mass in the Tsqk4B simplified model, see their Figure 3.} 

2 \text{ SIRUNYAN 19Ch searched in 137 fb}^{-1} \text{ of } pp \text{ collisions at } \sqrt{s} = 13 \text{ TeV for events containing multiple jets and large } \not{E_T}. \text{ No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu1C, Tglu2A and Tglu3A simplified models, see their Figure 13. Limits are also set on squark, sbottom and stop masses in the Tsqk1, Tsbot1, Tstop1 simplified models, see their Figure 14.} 

3 \text{ SIRUNYAN 19K searched in 35.9 fb}^{-1} \text{ of } pp \text{ collisions at } \sqrt{s} = 13 \text{ TeV for events with a photon, an electron or muon, and large } \not{E_T}. \text{ No significant excess above the Standard Model expectations is observed. In the framework of GMSB, limits are set on the chargino and neutralino mass in the Tchi1n1A simplified model, see their Figure 6. Limits are also set on the gluino mass in the Tglu4A simplified model, and on the squark mass in the Tsqk4A simplified model, see their Figure 7.}
AABOUD 18BJ searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with two opposite-sign charged leptons (electrons and muons), jets and missing transverse momentum, with various requirements to be sensitive to signals with different kinematic endpoint values in the dilepton invariant mass distribution. The data are found to be consistent with the SM expectation. Results are interpreted in the Tsqk2 model in case of $m_{\chi_1^0} = 1$ GeV: for any $m_{\chi_1^0}$, squark masses below 1200 GeV are excluded, see their Fig. 14(b).

AABOUD 18BV searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least one jet identified as $c$-jet, large missing transverse energy and no leptons. Good agreement is observed between the number of events in data and Standard Model predictions. The results are translated into exclusion limits in Tsqk1 models considering only $\tilde{c}_1$. In scenarios with massless neutralinos, scharm masses below 850 GeV are excluded. If the differences of the $\tilde{c}_1$ and $\tilde{\chi}_1^0$ masses is below 100 GeV, scharm masses below 500 GeV are excluded. See their Fig.6 and Fig.7.

AABOUD 18I searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least one isolated photon, possibly jets and significant transverse momentum targeting generalised models of gauge-mediated SUSY breaking. No significant excess of events is observed above the SM prediction. Results are interpreted in terms of lower limits on the masses of squark and neutralino masses, squark masses below 710 GeV are excluded. See their Fig.10(b).

AABOUD 18V searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with at least one isolated photon, possibly jets and significant transverse momentum targeting generalised models of gauge-mediated SUSY breaking. No significant excess of events is observed above the SM prediction. Results are interpreted in the Tsqk1 model: squark masses below 1550 GeV are excluded for massless LSP, see their Fig. 13(a).

AABOUD 18V searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with at least one jet with a transverse momentum above 250 GeV and no leptons. Good agreement is observed between the number of events in data and Standard Model predictions. The results are translated into exclusion limits in Tsqk1 models considering only $\tilde{c}_1$. In scenarios with massless neutralinos, scharm masses below 850 GeV are excluded. If the differences of the $\tilde{c}_1$ and $\tilde{\chi}_1^0$ masses is below 100 GeV, scharm masses below 500 GeV are excluded. See their Fig.6 and Fig.7.

AABOUD 18U searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with at least one jet with a transverse momentum above 250 GeV and no leptons. Good agreement is observed between the number of events in data and Standard Model predictions. The results are translated into exclusion limits in Tsqk1 models. In the compressed scenario with similar squark and neutralino masses, squark masses below 710 GeV are excluded. See their Fig.9.

The results are translated into exclusion limits in Tsqk1 models. In the compressed scenario with similar squark and neutralino masses, squark masses below 710 GeV are excluded. See their Fig.9.

SIRUNYAN 18AA searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least one photon and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on wino masses in a general gauge-mediated SUSY breaking (GGM) scenario with bino-like $\tilde{\chi}_1^0$ and wino-like $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_1^0$, see Figure 7. Limits are also set on the NLSP mass in the Tchi1n1A and Tchi1chi1A simplified models, see their Figure 8. Finally, limits are set on the gluino mass in the Tglu4A and Tglu4B simplified models, see their Figure 9, and on the squark mass in the Tsqk4A and Tsqk4B simplified models, see their Figure 10.

SIRUNYAN 18AY searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing one or more jets and significant $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A and Tglu3A simplified models, see their Figure 3. Limits are also set on squark, sbottom and stop masses in the Tsqk1, Tsbot1, Tstop1 and Tstop4 simplified models, see their Figure 3. Finally, limits are set on long-lived gluino masses in a Tglu1A simplified model where the gluino is metastable or long-lived with proper decay lengths in the range $10^{-3}$ mm $< \tau < 10^5$ mm, see their Figure 4.

AABOUD 17AR searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one isolated lepton, at least two jets and large missing transverse momentum. No
significant excess above the Standard Model expectations is observed. Limits up to 1.25 TeV are set on the 1st and 2nd generation squark masses in $T_{sqk3}$ simplified models, with $x = (m_{\tilde{q}_1^0} - m_{\tilde{q}_1^0}) / (m_{\tilde{q}_0} - m_{\tilde{q}_0}) = 1/2$. Similar limits are obtained for variable $x$ and fixed neutralino mass, $m_{\tilde{\chi}_0} = 60$ GeV. See their Figure 13.

13 AABOUD 17N searched in 14.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with 2 same-flavour, opposite-sign leptons (electrons or muons), jets and large missing transverse momentum. The results are interpreted as 95% C.L. limits in $T_{sqk2}$ models, assuming $m_{\tilde{\chi}_0} = 0$ GeV and $m_{\tilde{\chi}_1^0} = 600$ GeV. See their Fig. 12 for exclusion limits as a function of $m_{\tilde{\chi}_1^0}$.

14 KHACHATRYAN 17P searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with one or more jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the $T_{glu1A}$, $T_{glu2A}$, $T_{glu3A}$, $T_{glu3B}$, $T_{glu3C}$ and $T_{glu3D}$ simplified models, see their Figures 7 and 8. Limits are also set on the squark mass in the $T_{sqk1}$ simplified model, see their Fig. 7, and on the sbottom mass in the $T_{sbot1}$ simplified model, see Fig. 8. Finally, limits are set on the stop mass in the $T_{stop1}$, $T_{stop3}$, $T_{stop4}$, $T_{stop6}$ and $T_{stop7}$ simplified models, see Fig. 8.

15 KHACHATRYAN 17V searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with two photons and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino and squark mass in the context of general gauge mediation models $T_{glu4B}$ and $T_{sqk4}$, see their Fig. 4.

16 SIRUNYAN 17AY searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with at least one photon, jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the $T_{glu4A}$ and $T_{glu4B}$ simplified models, and on the squark mass in the $T_{sqk4A}$ and $T_{sqk4B}$ simplified models, see their Figure 6.

17 SIRUNYAN 17AZ searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with one or more jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the $T_{glu1A}$, $T_{glu2A}$, $T_{glu3A}$ simplified models, see their Figures 6. Limits are also set on the squark mass in the $T_{sqk1}$ simplified model (for single light squark and for 8 degenerate light squarks), on the sbottom mass in the $T_{sbot1}$ simplified model and on the stop mass in the $T_{stop1}$ simplified model, see their Fig. 7. Finally, limits are set on the stop mass in the $T_{stop2}$, $T_{stop4}$ and $T_{stop8}$ simplified models, see Fig. 8.

18 SIRUNYAN 17P searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with multiple jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the $T_{glu1A}$, $T_{glu1C}$, $T_{glu2A}$, $T_{glu3A}$ and $T_{glu3D}$ simplified models, see their Fig. 12. Limits are also set on the squark mass in the $T_{sqk1}$ simplified model, on the stop mass in the $T_{stop1}$ simplified model, and on the sbottom mass in the $T_{sbot1}$ simplified model, see Fig. 13.

19 AABOUD 16D searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with an energetic jet and large missing transverse momentum. The results are interpreted as 95% C.L. limits on masses of first and second generation squarks decaying into a quark and the lightest neutralino in scenarios with $m_{\tilde{q}} - m_{\tilde{\chi}_1^0} < 25$ GeV. See their Fig. 6.

20 AABOUD 16N searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing hadronic jets, large $E_T$, and no electrons or muons. No significant excess above the Standard Model expectations is observed. First- and second-generation squark masses below 1030 GeV are excluded at the 95% C.L. decaying to quarks and a massless lightest neutralino. See their Fig. 7a.

21 KHACHATRYAN 16BS searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with at least one energetic jet, no isolated leptons, and significant $E_T$, using the transverse mass variable $M_T^2$ to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on
the squark mass in the Tskq1 simplified model, both in the assumption of a single light squark and of 8 degenerate squarks, see Fig. 11 and Table 3.

22 AAD 15BV summarized and extended ATLAS searches for gluinos and first- and second-generation squarks in final states containing jets and missing transverse momentum, with or without leptons or $b$-jets in the $\sqrt{s} = 8$ TeV data set collected in 2012. The paper reports the results of new interpretations and statistical combinations of previously published analyses, as well as new analyses. Exclusion limits at 95% C.L. are set on the squark mass in several R-parity conserving models. See their Figs. 9, 11, 18, 22, 24, 27, 28.

23 AAD 15CS searched in 20.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for evidence of pair production of squarks, decaying into a quark and a neutralino, where a photon was radiated either from an initial-state quark, from an intermediate squark, or from a final-state quark. No evidence was found for an excess above the expected level of Standard Model background and a 95% C.L. exclusion limit was set on the squark mass as a function of the squark-neutralino mass difference, see Fig. 19.

24 AAD 15K searched in 20.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events containing at least two jets, where the two leading jets are each identified as originating from c-quarks, and large missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the mass of superpartners of charm quarks ($\tilde{c}$). Assuming that the decay $\tilde{c} \rightarrow c\tilde{\chi}_1^0$ takes place 100% of the time, a scalar charm mass below 490 GeV is excluded for $m_{\tilde{c}} < 200$ GeV. For more details, see their Fig. 2.

25 KHACHATRYAN 15AF searched in 19.5 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events with at least two energetic jets and significant $E_T^{miss}$, using the transverse mass variable $m_{T2}$ to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the squark mass in simplified models where the decay $\bar{q} \rightarrow q\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, both for the case of a single light squark or 8 degenerate squarks, see Fig. 12. See also Table 5. Exclusions in the CMSSM, assuming $\tan \beta = 30$, $A_0 = -2\max(m_{_0}, m_{1/2})$ and $\mu > 0$, are also presented, see Fig. 15.

26 AAD 14AE searched in 20.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for strongly produced supersymmetric particles in events containing jets and large missing transverse momentum, and no electrons or muons. No excess over the expected SM background is observed. Exclusion limits are derived in simplified models containing squarks that decay via $\bar{q} \rightarrow q\tilde{\chi}_1^0$, where either a single light state or two degenerate generations of squarks are assumed, see Fig. 10.

27 CHATRCHYAN 14AH searched in 4.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events with at least two energetic jets and significant $E_T^{miss}$, using the razor variables ($M_{R}$ and $R^2$) to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on squark masses in simplified models where the decay $\bar{q} \rightarrow q\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Fig. 28. Exclusions in the CMSSM, assuming $\tan \beta = 10$, $A_0 = 0$ and $\mu > 0$, are also presented, see Fig. 26.

28 CHATRCHYAN 14I searched in 19.5 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events containing multijets and large $E_T^{miss}$. No excess over the expected SM background is observed. Exclusion limits are derived in simplified models containing squarks that decay via $\bar{q} \rightarrow q\tilde{\chi}_1^0$, where either a single light state or two degenerate generations of squarks are assumed, see Fig. 7a.

29 AAD 13L searched in 4.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for the production of squarks and gluinos in events containing jets, missing transverse momentum and no high-$p_T$ electrons or muons. No excess over the expected SM background is observed. In mSUGRA/CMSSM models with $\tan \beta = 10$, $A_0 = 0$ and $\mu > 0$, squarks and gluinos of equal mass are excluded for masses below 1360 GeV at 95% C.L. In a simplified model containing only squarks of the first two generations, a gluino octet and a massless
neutralino, squark masses below 1320 GeV are excluded at 95% C.L. for gluino masses below 2 TeV. See Figures 10–15 for more precise bounds.

30 AAD 13q searched in 4.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events containing a high-$p_T$ isolated photon, at least one jet identified as originating from a bottom quark, and high missing transverse momentum. Such signatures may originate from supersymmetric models with gauge-mediated supersymmetry breaking in events in which one of a pair of higgsino-like neutralinos decays into a photon and a gravitino while the other decays into a Higgs boson and a gravitino. No significant excess above the expected background was found and limits were set on the squark mass as a function of the neutralino mass in a generalized GMSB model (GGM) with a higgsino-like neutralino NLSP, see their Fig. 4. For neutralino masses greater than 220 GeV, squark masses below 1020 GeV are excluded at 95% C.L.

31 CHATRCHYAN 13 looked in 4.98 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events with two opposite-sign leptons ($e$, $\mu$, $\tau$), jets and missing transverse energy. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in the mSUGRA/CMSSM model with $\tan\beta = 10$, $A_0 = 0$ and $\mu > 0$, see Fig. 6.

32 CHATRCHYAN 13g searched in 4.98 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for the production of squarks and gluinos in events containing 0,1,2, $\geq 3$ b-jets, missing transverse momentum and no electrons or muons. No excess over the expected SM background is observed. In mSUGRA/CMSSM models with $\tan\beta = 10$, $A_0 = 0$, and $\mu > 0$, squarks and gluinos of equal mass are excluded for masses below 1250 GeV at 95% C.L. Exclusions are also derived in various simplified models, see Fig. 7.

33 CHATRCHYAN 13h searched in 4.96 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events with two photons, $\geq 4$ jets and low $E_T^{miss}$ due to $\tilde{q} \rightarrow \chi^0_1 \gamma$ decays in a stealth SUSY framework, where the $\chi^0_1$ decays through a singlino ($S$) intermediate state to $\gamma S \tilde{G}$, with the singllet state $S$ decaying to two jets. No significant excess above the expected background was found and limits were set in a particular R-parity conserving stealth SUSY model. The model assumes $m_{\chi^0_1} = 0.5 m_{\tilde{q}}$, $m_S = 100$ GeV and $m_{\tilde{G}} = 90$ GeV. Under these assumptions, squark masses less than 1430 GeV were excluded at the 95% C.L.

34 CHATRCHYAN 13t searched in 11.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events with at least two energetic jets and significant $E_T^{miss}$, using the $\delta_T$ variable to discriminate between processes with genuine and misreconstructed $E_T^{miss}$. No significant excess above the Standard Model expectations is observed. Limits are set on squark masses in simplified models where the decay $\tilde{q} \rightarrow q \chi^0_1$ takes place with a branching ratio of 100%, assuming an eightfold degeneracy of the masses of the first two generation squarks, see Fig. 8 and Table 9. Also limits in the case of a single light squark are given.

35 AAD 12Ax searched in 1.04 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for supersymmetry in events containing jets, missing transverse momentum and one isolated electron or muon. No excess over the expected SM background is observed and model-independent limits are set on the cross section of new physics contributions to the signal regions. In mSUGRA/CMSSM models with $\tan\beta = 10$, $A_0 = 0$ and $\mu > 0$, squarks and gluinos of equal mass are excluded for masses below 820 GeV at 95% C.L. Limits are also set on simplified models for squark production and decay via an intermediate chargino and on supersymmetric models with bilinear R-parity violation. Supersedes AAD 11c.

36 AAD 12Ci searched in 4.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events containing one or more isolated leptons (electrons or muons), jets and $E_T^{miss}$. The observations are in good agreement with the SM expectations and exclusion limits have been set in number of SUSY models. In the mSUGRA/CMSSM model with $\tan\beta = 10$, $A_0 = 0$, and $\mu > 0$, 95% C.L. exclusion limits have been derived for $m_{\tilde{q}} < 1200$ GeV, assuming equal squark and gluino masses. In minimal GMSB, values of the effective SUSY breaking scale $\Lambda < 50$ TeV are excluded at 95% C.L. for $\tan\beta < 45$. Also exclusion limits in a number of simplified models have been presented, see Figs. 10 and 12.

37 AAD 12CP searched in 4.8 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events with two photons and large $E_T^{miss}$ due to $\chi^0_1 \rightarrow \gamma \tilde{G}$ decays in a GMSB framework. No significant
excess above the expected background was found and limits were set on the squark mass as a function of the neutralino mass in a generalized GMSB model (GGM) with a bino-like neutralino NLSP. The other sparticle masses were decoupled, $\tan\beta = 2$ and $c_{TNLSP} < 0.1 \text{ mm}$. Also, in the framework of the SP58 model, a 95% C.L. lower limit was set on the breaking scale $\Lambda$ of 196 TeV.

38 AAD 12W searched in 1.04 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for the production of squarks and gluinos in events containing jets, missing transverse momentum and no electrons or muons. No excess over the expected SM background is observed. In mSUGRA/CMSSM models with $\tan\beta = 10$, $A_0 = 0$ and $\mu > 0$, squarks and gluinos of equal mass are excluded for masses below 950 GeV at 95% C.L. In a simplified model containing only squarks of the first two generations, a gluino octet and a massless neutralino, squark masses below 875 GeV are excluded at 95% C.L.

39 CHATRCHYAN 12 looked in 35 pb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with $e$ and/or $\mu$ and/or jets, a large total transverse energy, and $E_T^{miss}$. The event selection is based on the dimensionless razor variable $R$, related to the $E_T^{miss}$ and $M_R$, an indicator of the heavy particle mass scale. No evidence for an excess over the expected background is observed. Limits are derived in the CMSSM ($m_0$, $m_{1/2}$) plane for $\tan\beta = 3, 10$ and 50 (see Fig. 7 and 8). Limits are also obtained for Simplified Model Spectra.

40 CHATRCHYAN 12AE searched in 4.98 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with at least three jets and large missing transverse momentum. No significant excesses over the expected SM backgrounds are observed and 95% C.L. limits on the production cross section of squarks in a scenario where $\tilde{q} \rightarrow q\chi^0_1$ with a 100% branching ratio, see Fig. 3. For $m_{\chi^0_1} < 200$ GeV, values of $m_{\tilde{q}}$ below 760 GeV are excluded at 95% C.L. Also limits in the CMSSM are presented, see Fig. 2.

41 CHATRCHYAN 12AT searched in 4.73 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for the production of squarks and gluinos in events containing jets, missing transverse momentum and no electrons or muons. No excess over the expected SM background is observed. In mSUGRA/CMSSM models with $\tan\beta = 10$, $A_0 = 0$ and $\mu > 0$, squarks with masses below 1110 GeV are excluded at 95% C.L. Squarks and gluinos of equal mass are excluded for masses below 1180 GeV at 95% C.L. Exclusions are also derived in various simplified models, see Fig. 6.

42 AABOUD 18V searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with no charged leptons, jets and missing transverse momentum. The data are found to be consistent with the SM expectation. Results are interpreted in the $\tilde{q} \rightarrow q\chi^0_1$ model. Squark masses below 1100 GeV are excluded if $(m_{\tilde{q}} - m_{\chi^0_1})/(m_{\tilde{q}} - m_{\chi^0_1}) < 0.95$ and $m_{\tilde{q}} = 60$ GeV, see their Fig. 16(a).

43 KHACHATRYAN 16BT performed a global Bayesian analysis of a wide range of CMS results obtained with data samples corresponding to 5.0 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV and in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV. The set of searches considered, both individually and in combination, includes those with all-hadronic final states, same-sign and opposite-sign dileptons, and multi-lepton final states. An interpretation was given in a scan of the 19-parameter pMSSM. No scan points with a gluino mass less than 500 GeV survived and 98% of models with a squark mass less than 300 GeV were excluded.

44 AAD 15AI searched in 20 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing at least one isolated lepton (electron or muon), jets, and large missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the squark masses in the CMSSM/mSUGRA, see Fig. 15, in the NUHMG, see Fig. 16, and in various simplified models, see Figs. 19–21.

45 KHACHATRYAN 15AR searched in 19.7 of fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing jets, either a charged lepton or a photon, and low missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits are set on the squark mass in a stealth SUSY model where the decays $\tilde{q} \rightarrow q\chi^\pm_1$. 
$\tilde{\chi}_1^\pm \rightarrow \tilde{S} W^\pm, \tilde{S} \rightarrow \tilde{G} S$ and $S \rightarrow gg$, with $m_{\tilde{S}} = 100$ GeV and $m_S = 90$ GeV, take place with a branching ratio of 100%. See Fig. 6 for $\gamma$ or Fig. 7 for $\ell^\pm$ analyses.

46 KHACHATRYAN 15AZ searched in 19.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with either at least one photon, hadronic jets and $E_T$ (single photon channel) or with at least two photons and at least one jet and using the razor variables. No significant excess above the Standard Model expectations is observed. Limits are set on gluino masses in the general gauge-mediated SUSY breaking model (GGM), for both a bino-like and wino-like neutralino NLSP scenario, see Fig. 8 and 9.

47 AAD 14E searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for strongly produced supersymmetric particles in events containing jets and two same-sign leptons or three leptons. The search also utilises jets originating from $b$-quarks, missing transverse momentum and other variables. No excess over the expected SM background is observed. Exclusion limits are derived in simplified models containing gluinos and squarks, see Figures 5 and 6. In the $\tilde{q} \rightarrow q' \tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow W^{(+)\pm} \tilde{\chi}_2^0, \tilde{\chi}_2^0 \rightarrow Z^{(*)} \tilde{\chi}_1^0$ simplified model, the following assumptions have been made: $m_{\tilde{\chi}_1^\pm} = 0.5 (m_{\tilde{\chi}_1^0} + m_{\tilde{g}}, m_{\tilde{q}} = 0.5 (m_{\tilde{\chi}_1^0} + m_{\tilde{q}})$. In the $\tilde{q} \rightarrow q' \tilde{\chi}_2^0, \tilde{\chi}_2^0 \rightarrow \ell^\pm \nu \tilde{\chi}_2^0$ or $\tilde{\chi}_2^0 \rightarrow \ell^\pm E_T (\nu \nu) \tilde{\chi}_1^0$ simplified model, the following assumptions have been made: $m_{\tilde{\chi}_2^0} = m_{\tilde{g}} = 0.5 (m_{\tilde{\chi}_1^0} + m_{\tilde{q}}), m_{\tilde{\chi}_1^0} < 460$ GeV. Limits are also derived in the mSUGRA/CMSSM, bRPV and GMSB models, see their Fig. 8.

48 CHATRCHYAN 13AO searched in 4.98 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with two opposite-sign isolated leptons accompanied by hadronic jets and $E_T$. No significant excesses over the expected SM backgrounds are observed and 95% C.L. exclusion limits are derived in the mSUGRA/CMSSM model with $\tan \beta = 10, A_0 = 0$ and $\mu > 0$, see Fig. 8.

49 CHATRCHYAN 13AV searched in 4.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for new heavy particle pairs decaying into jets (possibly $b$-tagged), leptons and $E_T$ using the Razor variables. No significant excesses over the expected SM backgrounds are observed and 95% C.L. exclusion limits are derived in the mSUGRA/CMSSM model with $\tan \beta = 10, A_0 = 0$ and $\mu > 0$, see Fig. 3. The results are also interpreted in various simplified models, see Fig. 4.

50 CHATRCHYAN 13W searched in 4.93 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with one or more photons, hadronic jets and $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on squark masses in the general gauge-mediated SUSY breaking model (GGM), for both a wino-like and bino-like neutralino NLSP scenario, see Fig. 5.

51 DREINER 12A reassesses constraints from CMS (at 7 TeV, $\sim 4.4$ fb$^{-1}$) under the assumption that the first and second generation squarks and the lightest SUSY particle are quasi-degenerate in mass (compressed spectrum).

52 DREINER 12A reassesses constraints from CMS (at 7 TeV, $\sim 4.4$ fb$^{-1}$) under the assumption that the first and second generation squarks, the gluino, and the lightest SUSY particle are quasi-degenerate in mass (compressed spectrum).

R-parity violating $\tilde{q}$ (Squark) mass limit

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<td>jets, $\tilde{q} \rightarrow q\tilde{\chi}_1^0, \tilde{\chi}<em>1^0 \rightarrow \ell qq$, $m</em>{\tilde{q}} = 108$ GeV and $2.5 &lt; \lambda_1 &lt; 200$ mm</td>
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Long-lived $\tilde{q}$ (Squark) mass limit

The following are bounds on long-lived scalar quarks, assumed to hadronise into hadrons with lifetime long enough to escape the detector prior to a possible decay. Limits may depend on the mixing angle of mass eigenstates: $\tilde{q}_1 = \tilde{q}_L \cos \theta_q + \tilde{q}_R \sin \theta q$.

The coupling to the $Z^0$ boson vanishes for up-type squarks when $\theta_{U}=0.98$, and for down type squarks when $\theta_{d}=1.17$.

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1. **ABOUD** 19AT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for metastable and stable $R$-hadrons. Multiple search strategies for a wide range of lifetimes, corresponding to path lengths of a few meters, are defined. No significant deviations from the expected Standard Model background are observed. Stop $R$-hadrons are excluded at 95% C.L. for masses below 1340 GeV. Similar constraints are achieved with the muon-spectrometer agnostic analysis. See their Figure 9 (bottom-right).

2. **ABOUD** 19AT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for metastable and stable $R$-hadrons. Multiple search strategies for a wide range of lifetimes, corresponding to path lengths of a few meters, are defined. No significant deviations from the expected Standard Model background are observed. Sbottom $R$-hadrons are excluded at 95% C.L. for masses below 1250 GeV. Less stringent constraints are achieved with the muon-spectrometer agnostic analysis. See their Figure 9 (bottom-left).

3. **SIRUNYAN** 19BH searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for long-lived particles decaying into jets, with each long-lived particle having a decay vertex well displaced from the production vertex. The selected events are found to be consistent with standard model predictions. Limits are set on the gluino mass in a GMSB model where the gluino is decaying via $\tilde{g} \to g \tilde{G}$, see their Figure 4 and in an RPV model of supersymmetry where the gluino is decaying via $\tilde{g} \to \tilde{t} \tilde{\chi}_1^0$, see their Figures 5. Limits are also set on the stop mass in two RPV models, see their Figure 6 (for $\tilde{t} \to b \ell$ decays) and Figure 7 (for $\tilde{t} \to d \tilde{d}$ decays).

4. **ABOUD** 16b searched in 3.2 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for long-lived $R$-hadrons using observables related to large ionization losses and slow propagation velocities, which are signatures of heavy charged particles traveling significantly slower than the speed of light. Exclusion limits at 95% C.L. are set on the long-lived sbottom masses exceeding 890 GeV. See their Fig. 5.

5. **ABOUD** 16b searched in 3.2 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for long-lived $R$-hadrons using observables related to large ionization losses and slow propagation velocities, which are signatures of heavy charged particles traveling significantly slower than the speed of light. Exclusion limits at 95% C.L. are set on the long-lived stop masses exceeding 805 GeV. See their Fig. 5.
6 KHACHATRYAN 16BW searched in 2.5 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 13\) TeV for events with heavy stable charged particles, identified by their anomalously high energy deposits in the silicon tracker and/or long time-of-flight measurements by the muon system. No evidence for an excess over the expected background is observed. Limits are derived for pair production of top squarks as a function of mass, depending on the interaction model, see Fig. 4 and Table 7.

7 AAD 15AE searched in 19.1 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 8\) TeV for heavy long-lived charged particles, measured through their specific ionization energy loss in the ATLAS pixel detector or their time-of-flight in the ALTAS muon system. In the absence of an excess of events above the expected backgrounds, limits are set R-hadrons in various scenarios, see Fig. 11. Limits are also set in LeptoSUSY models where the gluino decays to stable 300 GeV leptons, see Fig. 9.

8 AAD 15BM searched in 18.4 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 8\) TeV for stable and metastable non-relativistic charged particles through their anomalous specific ionization energy loss in the ATLAS pixel detector. In absence of an excess of events above the expected backgrounds, limits are set on stable bottom and top squark R-hadrons, see Table 5.

9 KHACHATRYAN 15AK looked in a data set corresponding to fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 8\) TeV, and a search interval corresponding to 281 h of trigger lifetime, for long-lived particles that have stopped in the CMS detector. No evidence for an excess over the expected background in a cloud interaction model is observed. Assuming the decay \(\tilde{t} \rightarrow t\tilde{\chi}^0_1\) and lifetimes between 1 \(\mu s\) and 1000 s, limits are derived on \(\tilde{t}\) production as a function of \(m_{\tilde{\chi}^0_1}\), see Figs. 4 and 7. The exclusions require that \(m_{\tilde{\chi}^0_1}\) is kinematically consistent with the minimum values of the jet energy thresholds used.

10 AAD 13AA searched in 4.7 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 7\) TeV for events containing colored long-lived particles that hadronize forming R-hadrons. No significant excess above the expected background was found. Long-lived R-hadrons containing a \(\tilde{t}\) are excluded for masses up to 683 GeV at 95% C.L in a general interaction model. Also, limits independent of the fraction of R-hadrons that arrive charged in the muon system were derived, see Fig. 6.

11 AAD 13AA searched in 4.7 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 7\) TeV for events containing colored long-lived particles that hadronize forming R-hadrons. No significant excess above the expected background was found. Long-lived R-hadrons containing a \(\tilde{b}\) are excluded for masses up to 612 GeV at 95% C.L in a general interaction model. Also, limits independent of the fraction of R-hadrons that arrive charged in the muon system were derived, see Fig. 6.

12 AAD 13BC searched in 5.0 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 7\) TeV and in 22.9 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 8\) TeV for bottom squark R-hadrons that have come to rest within the ATLAS calorimeter and decay at some later time to hadronic jets and a neutralino. In absence of an excess of events above the expected backgrounds, limits are set on sbottom masses for the decay \(\tilde{b} \rightarrow b\tilde{\chi}^0_1\) for different lifetimes, and for a neutralino mass of 100 GeV, see their Table 6 and Fig 10.

13 AAD 13BC searched in 5.0 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 7\) TeV and in 22.9 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 8\) TeV for bottom squark R-hadrons that have come to rest within the ATLAS calorimeter and decay at some later time to hadronic jets and a neutralino. In absence of an excess of events above the expected backgrounds, limits are set on sbottom masses for the decay \(\tilde{t} \rightarrow t\tilde{\chi}^0_1\) for different lifetimes, and for a neutralino mass of 100 GeV, see their Table 6 and Fig 10.

14 CHATRCHYAN 13AB looked in 5.0 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 7\) TeV and in 18.8 fb\(^{-1}\) of \(p p\) collisions at \(\sqrt{s} = 8\) TeV for events with heavy stable particles, identified by their anomalous dE/dx in the tracker or additionally requiring that it be identified as muon in the muon chambers, from pair production of \(\tilde{t}_1\)'s. No evidence for an excess over the expected background is observed. Limits are derived for pair production of stops as a function of mass in the cloud interaction model (see Fig. 8 and Table 6). In the charge-suppressed model, the limit decreases to 818 GeV.
### b (Sbottom) mass limit

Limits in $e^+ e^-$ depend on the mixing angle of the mass eigenstate $\tilde{b}_1 = \tilde{b}_L \cos \theta_b + \tilde{b}_R \sin \theta_b$. Coupling to the $Z$ vanishes for $\theta_b \sim 1.17$. As a consequence, no absolute constraint in the mass region $\lesssim 40 \text{ GeV}$ is available in the literature at this time from $e^+ e^-$ collisions. In the Listings below, we use $\Delta m = m_{\tilde{b}_1} - m_{\chi_1^0}$.

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2014 (http://pdg.lbl.gov).

#### R-parity conserving $\tilde{b}$ (Sbottom) mass limit

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\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
\[ \geq 1 \mathrm{jet} \pm \ell_T, \mathrm{Tstbot}_1, m_{\tilde{\chi}_1^{\pm}} = 50 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} < 100 \mathrm{GeV}, m_{\tilde{\chi}_1^{\pm}} = 5 \mathrm{GeV} \]
We do not use the following data for averages, fits, limits, etc.

33 KHACHATRYAN...15AD CMS
\[ \ell^\pm \ell^\mp + \text{jets} + E_T \rightarrow b\ell^\pm \ell^\mp \chi_1^0 \]

none 340–600 95 34 AAD
14AX ATLS
\[ \geq 3 \text{ b-jets} + E_T, \quad b \rightarrow b\chi_1^0 \]

\[ \chi_2^0 \rightarrow h\chi_1^0, \quad m_{\chi_2^0} = 60 \text{ GeV}, \quad m_{\chi_1^0} = 300 \text{ GeV} \]

> 440 95 35 AAD
14E ATLS
\[ \ell^\pm \ell^\mp (\ell^\mp) + \text{jets}, \quad b_1 \rightarrow t\chi_1^\pm \]

\[ \chi_1^\pm \rightarrow W\pm \chi_1^0 \]

> 500 95 36 CHATRCHYAN 14H CMS
same-sign \[ \ell^\pm \ell^\mp, \quad b \rightarrow t\chi_1^\pm \]

\[ \chi_1^\pm \rightarrow W\pm \chi_1^0 \]

> 620 95 37 AAD 13AU ATLS
\[ 2 \text{ b-jets} + E_T, \quad \tilde{b}_1 \rightarrow b\chi_1^0, \quad m_{\chi_1^0} < 100 \text{ GeV} \]

> 550 95 38 CHATRCHYAN 13AT CMS
\[ \text{jets} + E_T, \quad b \rightarrow b\chi_1^0 \]

\[ m_{\chi_1^0} = 50 \text{ GeV} \]

> 600 95 39 CHATRCHYAN 13T CMS
\[ \text{jets} + E_T, \quad b \rightarrow b\chi_1^0 \]

\[ m_{\chi_1^0} = 0 \text{ GeV} \]

> 450 95 40 CHATRCHYAN 13V CMS
same-sign \[ \ell^\pm \ell^\mp + \geq 2 \text{ b-jets}, \]

\[ \tilde{b} \rightarrow t\chi_1^\pm, \quad \chi_1^\pm \rightarrow W\pm \chi_1^0 \]

> 390 95 41 AAD 12AN ATLS
\[ \tilde{b}_1 \rightarrow b\chi_1^0, \quad m_{\chi_1^0} < 60 \text{ GeV} \]

> 410 95 42 CHATRCHYAN 12AI CMS
\[ \ell^\pm \ell^\mp + \text{b-jets} + E_T \]

\[ b_1 \rightarrow b\chi_1^0, \quad m_{\chi_1^0} = 50 \text{ GeV} \]

> 294 95 43 CHATRCHYAN 12BO CMS
\[ \text{stable} \ b \]

\[ \tilde{b} \rightarrow \tilde{b}_1 b, \quad \tilde{b}_1 \rightarrow b\chi_1^0, \quad m_{\chi_1^0} = 60 \text{ GeV} \]

> 230 95 44 AAD 11K ATLS
\[ \tilde{b}_1 \rightarrow b\chi_1^0, \quad m_{\chi_1^0} < 70 \text{ GeV} \]

> 247 95 45 AAD 110 ATLS
\[ \tilde{b}_1 \rightarrow b\chi_1^0, \quad m_{\chi_1^0} = 0 \text{ GeV} \]

1 AAD 19H searched in 139 fb^{-1} of pp collisions at \[ \sqrt{s} = 13 \text{ TeV} \] for events with no charged leptons, three or more b-jets, and large \[ E_T \]. Higgs boson candidates are reconstructed as b-jet pairs. No significant excess above the Standard Model expectations is observed. Limits up to 1500 GeV are set on the sbottom mass in the Tsbottom4 simplified model, see Figure 8(a), for fixed \[ m_{\chi_1^0} = 60 \text{ GeV} \] and for \[ m_{\chi_2^0} \] up to 1200 GeV.

2 AAD 19H searched in 139 fb^{-1} of pp collisions at \[ \sqrt{s} = 13 \text{ TeV} \] for events with no charged leptons, three or more b-jets, and large \[ E_T \]. Higgs boson candidates are reconstructed as b-jet pairs. No significant excess above the Standard Model expectations is observed. Limits up to 1300 GeV are set on the sbottom mass in the Tsbottom4 simplified model, see Figure 8(b), for \[ m_{\chi_1^0} = m_{\chi_2^0} = 130 \text{ GeV} \] and \[ m_{\chi_1^0} \] from 200 to 750 GeV.
The razor variables ($M_R$ and $R^2$) are used to categorize the events. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in the Tstop4 simplified model and on the wino mass in the Tchi1n2E simplified model, see their Figure 5. Limits are also set on the higgsino mass in the Tn1n1A and Tn1n1B simplified models, see their Figure 5.
set on the bottom squark mass in Tbot2 simplified models assuming $m_{\tilde{b}_1} = 0$ GeV.

See their Figure 4(d).

12 AABOUD 17A searched in 36 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing two jets identified as originating from $b$-quarks and large missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of bottom squarks. In the Tbot1 simplified model, a $b_1$ mass below 950 GeV is excluded for $m_{\tilde{b}_1} = 0 (~<420)$ GeV. See their Fig. 7(a).

13 AABOUD 17A searched in 36 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing two jets identified as originating from $b$-quarks and large missing transverse momentum, with or without leptons. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of bottom squarks. Assuming 50% BR for Tbot1 and Tbot2 simplified models, a $b_1$ mass below 880 (860) GeV is excluded for $m_{\tilde{b}_1} = 0 (~<250)$ GeV. See their Fig. 7(b).

14 KHACHATRYAN 17A searched in 18.5 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with two forward jets, produced through vector boson fusion, and missing transverse momentum. No significant excess above the Standard Model expectations is observed. A limit is set on sbottom masses in the Tbot1 simplified model, see Fig. 3.

15 KHACHATRYAN 17A searched in 2.3 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least three charged leptons, in any combination of electrons and muons, and significant $E_T^\text{miss}$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A and Tglu1C simplified models, and on the sbottom mass in the Tbot2 simplified model, see their Figure 4.

16 KHACHATRYAN 17P searched in 2.3 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one or more jets and large $E_T^\text{miss}$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A, Tglu3A, Tglu3B, Tglu3C and Tglu3D simplified models, see their Figures 7 and 8. Limits are also set on the squark mass in the Tsk1 simplified model, see their Fig. 7, and on the sbottom mass in the Tbot1 simplified model, see Fig. 8. Finally, limits are set on the stop mass in the Tstop1, Tstop3, Tstop4, Tstop6 and Tstop7 simplified models, see Fig. 8.

17 SIRUNYAN 17A searched in 35.9 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one or more jets and large $E_T^\text{miss}$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A, Tglu3A simplified models, see their Figures 6. Limits are also set on the squark mass in the Tsk1 simplified model (for single light squark and for 8 degenerate light squarks), on the sbottom mass in the Tbot1 simplified model and on the stop mass in the Tstop1 simplified model, see their Fig. 7. Finally, limits are set on the stop mass in the Tstop2, Tstop4 and Tstop8 simplified models, see Fig. 8.

18 SIRUNYAN 17B searched in 2.3 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct production of stop or sbottom pairs in events with multiple jets and significant $E_T^\text{miss}$. A second search also requires an isolated lepton and is combined with the all-hadronic search. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1, Tstop8 and Tstop4 simplified models, see their Figures 7, 8 and 9 (for the Tstop4 limits, only the results of the all-hadronic search are used). Limits are also set on the sbottom mass in the Tbot1 simplified model, see Fig. 10 (also here, only the results of the all-hadronic search are used).

19 SIRUNYAN 17S searched in 35.9 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two isolated same-sign leptons, jets, and large $E_T^\text{miss}$. No significant excess above the Standard Model expectations is observed. Limits are set on the mass of the gluino mass in the Tglu3A, Tglu3B, Tglu3C, Tglu3D and Tglu1B simplified models, see their Figures 5 and 6, and on the sbottom mass in the Tbot2 simplified model, see their Figure 6.

20 AABOUD 16D searched in 3.2 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with an energetic jet and large missing transverse momentum. The results are interpreted as
95% C.L. limits on mass of sbottom decaying into a $b$-quark and the lightest neutralino in scenarios with $m_{\tilde{b}_1} - m_{\chi_1^0}$ between 5 and 20 GeV. See their Fig. 6.

21 AABOUĐ 16Q searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing two jets identified as originating from $b$-quarks and large missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of third-generation squarks. Assuming that the decay $\tilde{b}_1 \rightarrow b \chi_1^0$ (Tsbot1) takes place 100% of the time, a $\tilde{b}_1$ mass below 840 (800) GeV is excluded for $m_{\chi_1^0} < 100$ (360) GeV. Differences in mass above 100 GeV between the $\tilde{b}_1$ and the $\chi_1^0$ are excluded up to a $\tilde{b}_1$ mass of 500 GeV. For more details, see their Fig. 4.

22 AAD 16BB searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with exactly two same-sign leptons or at least three leptons, multiple hadronic jets, $b$-jets, and $E_T^{\text{miss}}$. No significant excess over the Standard Model expectation is found. Exclusion limits at 95% C.L. are set on the sbottom mass in the Tsbot2 simplified model, assuming $m_{\chi_1^0} = m_{\tilde{b}_1} + 100$ GeV. See their Fig. 4c.

23 KHACHATRYAN 16BJ searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with two isolated same-sign dileptons and jets in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in the Tsbot2 simplified model, see Fig. 6.

24 KHACHATRYAN 16BS searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with at least one energetic jet, no isolated leptons, and significant $E_T^{\text{miss}}$, using the transverse mass variable $M_T^2$ to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in the Tsbot1 simplified model, see Fig. 11 and Table 3.

25 KHACHATRYAN 16BY searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with two opposite-sign, same-flavour leptons, jets, and missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu4C simplified model, see Fig. 4, and on sbottom masses in the Tsbot3 simplified model, see Fig. 5.

26 AAD 15Ci searched in 20 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for evidence of third generation squarks by combining a large number of searches covering various final states. Limits on the sbottom mass are shown, either assuming the $\tilde{b} \rightarrow b \chi_1^0$ decay, see Fig. 11, or assuming the $\tilde{b} \rightarrow t \chi_1^{\pm}$ decay, with $\chi_1^{\pm} \rightarrow t + W^{(*)} \chi_1^0$, see Fig. 12a, or assuming the $\tilde{b} \rightarrow b \chi_2^0$ decay, with $\chi_2^0 \rightarrow h \chi_1^0$, see Fig. 12b. Interpretations in the pMSSM are also discussed, see Figures 13–15.

27 KHACHATRYAN 15AF searched in 19.5 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events with at least two energetic jets and significant $E_T^{\text{miss}}$, using the transverse mass variable $M_T^2$ to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in simplified models where the decay $\tilde{b} \rightarrow b \chi_1^0$ takes place with a branching ratio of 100%, see Fig. 12. See also Table 5. Exclusions in the CMSSM, assuming $\tan\beta = 30$, $A_0 = -2 \max(m_0, m_{1/2})$ and $\mu > 0$, are also presented, see Fig. 15.

28 KHACHATRYAN 15AH searched in 19.4 or 19.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events containing either a fully reconstructed top quark, or events containing dijets requiring one or both jets to originate from $b$-quarks, or events containing a mono-jet. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in simplified models where the decay $\tilde{b} \rightarrow b \chi_1^0$ takes place with a branching ratio of 100%, see Fig. 12. Limits are also set in a simplified model where the decay $\tilde{b} \rightarrow c \chi_1^0$ takes place with a branching ratio of 100%, see Fig. 12.

29 KHACHATRYAN 15I searched in 19.5 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events in which $b$-jets and four $W$-bosons are produced. Five individual search channels are

Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)
combined (fully hadronic, single lepton, same-sign dilepton, opposite-sign dilepton, multilepton). No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in a simplified model where the decay $\tilde{b} \rightarrow t\chi_1^{\pm}$, with $\chi_1^\pm \rightarrow W^\pm \chi_0^1$, takes place with a branching ratio of 100%, see Fig. 7.

30 AAD 14T searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for monojet-like events. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of third-generation squarks. Assuming $\tan\beta = 10$, $A_0 = 0$ and $\mu > 0$, are also presented, see Fig. 26.

31 CHATRCHYAN 14AH searched in 4.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with at least two energetic jets and significant $p_T$, using the razor variables ($M_R$ and $R^2$) to discriminate between signal and background processes. A second analysis requires at least one of the jets to be originating from a $b$-quark. No significant excess above the Standard Model expectations is observed. Limits are set on sbottom masses in simplified models where the decay $\tilde{b} \rightarrow b\chi_1^0$ takes place with a branching ratio of 100%, see Figs. 28 and 29. Exclusions in the CMSSM, assuming $\tan\beta = 10$, $A_0 = 0$ and $\mu > 0$, are also presented, see Fig. 26.

32 CHATRCHYAN 14R searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least three leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in a simplified model where the decay $\tilde{b} \rightarrow b\chi_1^0$ takes place with a branching ratio of 100%, see Fig. 11.

33 KHACHATRYAN 15AD searched in 19.4 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with two opposite-sign same flavor isolated leptons featuring either a kinematic edge, or a peak at the $Z$-boson mass, in the invariant mass spectrum. No evidence for a statistically significant excess over the expected SM backgrounds is observed and 95% C.L. exclusion limits are derived in a simplified model of sbottom pair production where the sbottom decays into a $b$-quark, two opposite-sign dileptons and a neutralino LSP, through an intermediate state containing either an off-shell $Z$-boson or a slepton, see Fig. 8.

34 AAD 14AX searched in 20.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for the strong production of supersymmetric particles in events containing either zero or at least one high high-$p_T$ lepton, large missing transverse momentum, high jet multiplicity and at least three jets identified as originating from $b$-quarks. No excess over the expected SM background is observed. Limits are derived in mSUGRA/CMSSM models with $\tan\beta = 30$, $A_0 = -2 m_0$ and $\mu > 0$, see their Fig. 14. Also, exclusion limits are set in simplified models containing scalar bottom quarks, where the decay $\tilde{b} \rightarrow b\chi_2^0$ and $\chi_2^0 \rightarrow h\chi_1^0$ takes place with a branching ratio of 100%, see their Figures 11.

35 AAD 14E searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for strongly produced supersymmetric particles in events containing jets and two same-sign leptons or three leptons. The search also utilises jets originating from $b$-quarks, missing transverse momentum and other variables. No excess over the expected SM background is observed. Exclusion limits are derived in simplified models containing bottom, see Fig. 7. Limits are also derived in the mSUGRA/CMSSM, bRPV and GMSB models, see their Fig. 8.

36 CHATRCHYAN 14H searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with two isolated same-sign dileptons and jets in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in a simplified models where the decay $\tilde{b} \rightarrow t\chi_1^{\pm}$, $\chi_1^\pm \rightarrow W^\pm \chi_0^1$ takes place with a branching ratio of 100%, with varying mass of the $\chi_1^\pm$, for $m_{\chi_1^0} = 50$ GeV, see Fig. 6.

37 AAD 13AU searched in 20.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing two jets identified as originating from $b$-quarks and large missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of third-generation squarks. Assuming
that the decay $\tilde{b}_1 \rightarrow b \tilde{\chi}_1^0$ takes place 100% of the time, a $\tilde{b}_1$ mass below 620 GeV is excluded for $m_{\tilde{\chi}_1^0} < 120$ GeV. For more details, see their Fig. 5.

38 CHATRCHYAN 13AT provides interpretations of various searches for supersymmetry by the CMS experiment based on 4.73–4.98 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV in the framework of simplified models. Limits are set on the sbottom mass in a simplified model where sbottom quarks are pair-produced and the decay $\tilde{b} \rightarrow b \tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Fig. 4.

39 CHATRCHYAN 13T searched in 11.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events with at least two energetic jets and significant $E_T$, using the $\alpha_T$ variable to discriminate between processes with genuine and misreconstructed $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on sbottom masses in simplified models where the decay $\tilde{b} \rightarrow b \tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Fig. 8 and Table 9.

40 CHATRCHYAN 13V searched in 10.5 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events with two isolated same-sign dileptons and at least two $b$-jets in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in a simplified model where the decay $\tilde{b} \rightarrow b \tilde{\chi}_1^0$ takes place with a branching ratio of 100%, with varying mass of the $\tilde{\chi}_1^-$, for $m_{\tilde{\chi}_1^-} = 50$ GeV, see Fig. 4.

41 AAD 12AN searched in 2.05 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for scalar bottom quarks in events with large missing transverse momentum and two $b$-jets in the final state. The data are found to be consistent with the Standard Model expectations. Limits are set in an R-parity conserving minimal supersymmetric scenario, assuming $B(\tilde{b}_1 \rightarrow b \tilde{\chi}_1^0) = 100\%$, see their Fig. 2.

42 CHATRCHYAN 12Al looked in 4.98 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events with two same-sign leptons (e, $\mu$), but not necessarily same flavor, at least 2 $b$-jets and missing transverse energy. No excess beyond the Standard Model expectation is observed. Exclusion limits are derived in a simplified model for sbottom pair production, where the sbottom decays through $\tilde{b} \rightarrow t \tilde{\chi}_1^- W$, see Fig. 8.

43 CHATRCHYAN 12Bo searched in 4.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for scalar bottom quarks in events with large missing transverse momentum and two $b$-jets in the final state. The data are found to be consistent with the Standard Model expectations. Limits are set in an R-parity conserving minimal supersymmetric scenario, assuming $B(\tilde{b}_1 \rightarrow b \tilde{\chi}_1^0) = 100\%$, see their Fig. 2.

44 AAD 11K looked in 34 pb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events with heavy stable particles, identified by their anomalous dE/dx in the tracker or time of flight in the tile calorimeter, from pair production of $\tilde{b}$. No evidence for an excess over the SM expectation is observed and limits on the mass are derived for pair production of sbottom, see Fig. 4.

45 AAD 11o looked in 35 pb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events with jets, of which at least one is a $b$-jet, and $\not{E}_T$. No excess above the Standard Model was found. Limits are derived in the $(m_{\tilde{g}}, m_{\tilde{b}_1})$ plane (see Fig. 2) under the assumption of 100% branching ratios and $\tilde{b}_1$ being the lightest squark. The quoted limit is valid for $m_{\tilde{b}_1} < 500$ GeV. A similar approach for $\tilde{t}_1$ as the lightest squark with $\tilde{g} \rightarrow \tilde{t}_1 t$ and $\tilde{t}_1 \rightarrow b \chi_1^\pm$ with 100% branching ratios leads to a gluino mass limit of 520 GeV for $130 < m_{\tilde{t}_1} < 300$ GeV. Limits are also derived in the CMSSM $(m_0, m_{1/2})$ plane for $\tan \beta = 40$, see Fig. 4, and in scenarios based on the gauge group SO(10).

46 CHATRCHYAN 11D looked in 35 pb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 7$ TeV for events with $\geq 2$ jets, at least one of which is $b$-tagged, and $\not{E}_T$, where the $b$-jets are decay products
of $\tilde{t}$ or $\tilde{b}$. No evidence for an excess over the expected background is observed. Limits are derived in the CMSSM ($m_0$, $m_{1/2}$) plane for $\tan\beta = 50$ (see Fig. 2).

AALTONEN 10R searched in 2.65 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for events with $E_T^{vis}$ and exactly two jets, at least one of which is $b$-tagged. The results are in agreement with the SM prediction, and a limit on the cross section of 0.1 pb is obtained for the range of masses $80 < m_{\tilde{b}_1} < 280$ GeV assuming that the sbottom decays exclusively to $b\tilde{\chi}_1^0$. The excluded mass region in the framework of conserved $R_p$ is shown in a plane of $(m_{\tilde{b}_1}, m_{\tilde{\chi}_1^0})$, see their Fig.2.

ABAZOV 10L looked in 5.2 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for events with at least 2 b-jets and $E_T^{vis}$ from the production of $\tilde{b}_1\tilde{b}_1$. No evidence for an excess over the SM expectation is observed, and a limit on the cross section is derived under the assumption of 100% branching ratio. The excluded mass region in the framework of conserved $R_p$ is shown in a plane of $(m_{\tilde{b}_1}, m_{\tilde{\chi}_1^0})$, see their Fig. 3b. The exclusion also extends to $m_{\tilde{\chi}_1^0} = 110$ GeV for $160 < m_{\tilde{b}_1} < 200$ GeV.

### R-parity violating $\tilde{b}$ (Sbottom) mass limit

<table>
<thead>
<tr>
<th>VALUE (GeV)</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
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<tr>
<td>&gt;307</td>
<td>95</td>
<td>1 KHACHATRYAN 16BX CMS</td>
<td>RPV, $\tilde{b} \rightarrow t d$ or $t s$, $\lambda''<em>{332}$ or $\lambda''</em>{331}$ coupling</td>
<td></td>
</tr>
</tbody>
</table>

1. KHACHATRYAN 16BX searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing 2 leptons coming from R-parity-violating decays of supersymmetric particles. No excess over the expected background is observed. Limits are derived on the sbottom mass, assuming the RPV $\tilde{b} \rightarrow t d$ or $\tilde{b} \rightarrow t s$ decay, see Fig. 15.

2. AAD 14E searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for strongly produced supersymmetric particles in events containing jets and two same-sign leptons or three leptons. The search also utilises jets originating from $b$-quarks, missing transverse momentum and other variables. No excess over the expected SM background is observed. Exclusion limits are derived in simplified models containing bottom, see Fig. 7. Limits are also derived in the mSUGRA/CMSSM, bRPV and GMSB models, see their Fig. 8.

### $\tilde{t}$ (Stop) mass limit

Limits depend on the decay mode. In $e^+e^-$ collisions they also depend on the mixing angle of the mass eigenstate $\tilde{t}_1 = \tilde{t}_L \cos\theta_t + \tilde{t}_R \sin\theta_t$. The coupling to the $Z$ vanishes when $\theta_t = 0.98$. In the Listings below, we use $\Delta m \equiv m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0}$ or $\Delta m \equiv m_{\tilde{t}_1} - m_{\tilde{\chi}_1'^0}$ depending on relevant decay mode. See also bounds in “$\tilde{q}$ (Squark) MASS LIMIT.”

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).
## R-parity conserving $\tilde{t}$ (Stop) mass limit

<table>
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<tr>
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<th>TECN</th>
<th>COMMENT</th>
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| >1110       | 95  | 1 SIRUNYAN  | 19AU CMS | $\gamma + \text{jets} + b$-jets + $E_T$, 
Tstop1, $m_{\tilde{\chi}_1^0} = 1$ GeV |
| >1230       | 95  | 1 SIRUNYAN  | 19AU CMS | $\gamma + \text{jets} + b$-jets + $E_T$, 
Tstop13, $m_{\tilde{\chi}_1^0} = 800$ GeV |
| >1190       | 95  | 2 SIRUNYAN  | 19CH CMS | jets + $E_T$, Tstop1, $m_{\tilde{\chi}_1^0} = 0$ GeV |
| >1140       | 95  | 3 SIRUNYAN  | 19S CMS | 1 or 2 $\ell$ + jets + $E_T$, Tstop1, 
$m_{\tilde{\chi}_1^0} < 200$ GeV |
| >208        | 95  | 4 SIRUNYAN  | 19U CMS | $e^\pm + \mu^\pm + \geq 1$ b-jet, Tstop1, 
$m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} = 175$ GeV |
| >235        | 95  | 4 SIRUNYAN  | 19U CMS | $e^\pm + \mu^\pm + \geq 1$ b-jet, Tstop1, 
$m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} = 182.5$ GeV |
| >242        | 95  | 4 SIRUNYAN  | 19U CMS | $e^\pm + \mu^\pm + \geq 1$ b-jet, Tstop1, 
$m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} = 167.5$ GeV |
| >940        | 95  | 5 AABOUD    | 18AQ ATLS | $1\ell$+jets+$E_T$, Tstop1, $m_{\tilde{\chi}_1^0} = 0$ GeV |
| >270        | 95  | 6 AABOUD    | 18AQ ATLS | $1\ell$+jets+$E_T$, Tstop3, $m_{\tilde{t}} - m_{\tilde{\chi}_1^0} = 20$ GeV |
| >840        | 95  | 7 AABOUD    | 18AQ ATLS | $1\ell$+jets+$E_T$, Tstop2, $m_{\tilde{t}} - m_{\tilde{\chi}_1^0} = 10$ GeV |
| >500        | 95  | 8 AABOUD    | 18BV ATLS | c-jets+$E_T$, Tstop4, $m_{\tilde{t}} - m_{\tilde{\chi}_1^0} < 100$ GeV |
| >850        | 95  | 9 AABOUD    | 18BV ATLS | c-jets+$E_T$, Tstop4, $m_{\tilde{\chi}_1^0} = 0$ GeV |
| >390        | 95  | 10 AABOUD   | 18I ATLS | $\geq 1$ jets+$E_T$, Tstop3, $m_{\tilde{t}} \sim m_{\tilde{\chi}_1^0}$ |
| >430        | 95  | 11 AABOUD   | 18I ATLS | $\geq 1$ jets+$E_T$, Tstop4, $m_{\tilde{t}} - m_{\tilde{\chi}_1^0} = 5$ GeV |
| >1160       | 95  | 12 AABOUD   | 18Y ATLS | $2\ell$ ($\geq 1$ hadronic $\tau$) + b-jets + 
$E_T$, Tstop5, $m_{\tilde{\tau}} \sim 800$ GeV |
| >450        | 95  | 13 SIRUNYAN | 18AJ CMS | $2\ell$ (soft) + $E_T$, Tstop10, $m_{\tilde{\chi}_1^0} = (m_{\tilde{t}} + m_{\tilde{\chi}_1^0})/2$, 
$m_{\tilde{t}} - m_{\tilde{\chi}_1^0} = 40$ GeV |
| >720        | 95  | 14 SIRUNYAN | 18AL CMS | $\geq 3\ell^\pm$ + jets + $E_T$, Tstop7, 
$m_{\tilde{\tau}_{1,2}} - m_{\tilde{\chi}_1^0} = 175$ GeV, 
$m_{\tilde{\tau}_{1,2}} = 200$ GeV, 
$\text{BR}(\tilde{t}_2 \rightarrow \tilde{\tau}_1 H) = 100\%$ |
| >780        | 95  | 14 SIRUNYAN | 18AL CMS | $\geq 3\ell^\pm$ + jets + $E_T$, Tstop7, 
$m_{\tilde{\tau}_{1,2}} - m_{\tilde{\chi}_1^0} = 175$ GeV, 
$m_{\tilde{\tau}_{1,2}} = 200$ GeV, 
$\text{BR}(\tilde{t}_2 \rightarrow \tilde{\tau}_1 Z) = 100\%$ |

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<td>&gt; 710</td>
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<td>$\geq 3\ell^\pm + \text{jets} + E_T$, Tstop7, $m_{\tilde{t}} - m_{\tilde{\chi}^0_1} = 175$ GeV, $m_{\tilde{t}} = 200$ GeV, BR($\tilde{t}_2 \rightarrow \tilde{t}_1 Z$) = BR($\tilde{t}_2 \rightarrow \tilde{t}_1 H$) = 50%</td>
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<td>&gt; 730</td>
<td>95</td>
<td>CMS</td>
<td>1 or 2 $\gamma + \ell + \text{jets}$, GGM, Tstop12, $m_{\tilde{\chi}^0_1} = 150$ GeV</td>
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<td>CMS</td>
<td>1 or 2 $\gamma + \ell + \text{jets}$, GGM, Tstop12, $m_{\tilde{\chi}^0_1} = 500$ GeV</td>
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<tr>
<td>&gt; 1000</td>
<td>95</td>
<td>CMS</td>
<td>jets+$E_T$, Tstop1, $m_{\tilde{\chi}^0_1} = 0$ GeV</td>
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<tr>
<td>&gt; 500</td>
<td>95</td>
<td>CMS</td>
<td>jets+$E_T$, Tstop4, $m_{\tilde{\chi}^0_1} = 420$ GeV</td>
</tr>
<tr>
<td>&gt; 510</td>
<td>95</td>
<td>CMS</td>
<td>jets+$E_T$, Tstop4, $m_{\tilde{t}} - m_{\tilde{\chi}^0_1} = 10$ GeV</td>
</tr>
<tr>
<td>&gt; 800</td>
<td>95</td>
<td>CMS</td>
<td>$\ell^\pm \ell^\mp + \text{b-jets} + E_T$, Tstop1, $m_{\tilde{\chi}^0_1} = 0$</td>
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<tr>
<td>&gt; 750</td>
<td>95</td>
<td>CMS</td>
<td>$\ell^\pm \ell^\mp + \text{b-jets} + E_T$, Tstop2, $m_{\tilde{\chi}^0_1} = (m_{\tilde{t}} + m_{\tilde{\chi}^0_1})/2$, $m_{\tilde{\chi}^0_1} = 0$</td>
</tr>
<tr>
<td>&gt; 1050</td>
<td>95</td>
<td>CMS</td>
<td>Combination of all-hadronic, 1 $\ell^\pm$ and $\ell^\pm \ell^\mp$ searches, Tstop1, $m_{\tilde{\chi}^0_1} = 0$</td>
</tr>
<tr>
<td>&gt; 1000</td>
<td>95</td>
<td>CMS</td>
<td>Combination of all-hadronic, 1 $\ell^\pm$ and $\ell^\pm \ell^\mp$ searches, Tstop2, $m_{\tilde{\chi}^0_1} = (m_{\tilde{t}} + m_{\tilde{\chi}^0_1})/2$, $m_{\tilde{\chi}^0_1} = 0$</td>
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<td>&gt; 1200</td>
<td>95</td>
<td>CMS</td>
<td>$\ell^\pm \ell^\mp + \text{b-jets} + E_T$, Tstop11, $m_{\tilde{\chi}^0_1} = 0.5 (m_{\tilde{t}} + m_{\tilde{\chi}^0_1})$, $m_{\tilde{\chi}^0_1} = 0.5 m_{\tilde{\chi}^0_1}$, $m_{\tilde{\chi}^0_1} = 0$</td>
</tr>
<tr>
<td>&gt; 1300</td>
<td>95</td>
<td>CMS</td>
<td>$\ell^\pm \ell^\mp + \text{b-jets} + E_T$, Tstop11, $m_{\tilde{\chi}^0_1} = 0.5 (m_{\tilde{t}} + m_{\tilde{\chi}^0_1})$, $m_{\tilde{\chi}^0_1} = 0.95 m_{\tilde{\chi}^0_1}$, $m_{\tilde{\chi}^0_1} = 0$</td>
</tr>
<tr>
<td>none 460–1060</td>
<td>95</td>
<td>CMS</td>
<td>Combination of all-hadronic, 1 $\ell^\pm$ and $\ell^\pm \ell^\mp$ searches, Tstop11, $m_{\tilde{\chi}^0_1} = 0.5 (m_{\tilde{t}} + m_{\tilde{\chi}^0_1})$, $m_{\tilde{\chi}^0_1} = 0.05 m_{\tilde{\chi}^0_1}$, $m_{\tilde{\chi}^0_1} = 0$</td>
</tr>
<tr>
<td>&gt; 1020</td>
<td>95</td>
<td>CMS</td>
<td>top quark (hadronically decaying) + jets + $E_T$, Tstop1, $m_{\tilde{\chi}^0_1} = 0$ GeV</td>
</tr>
<tr>
<td>&gt; 420</td>
<td>95</td>
<td>CMS</td>
<td>$\ell^\pm + \text{jet} + E_T$, Tstop3, $m_{\tilde{\chi}^0_1} = 10$ GeV</td>
</tr>
<tr>
<td>&gt; 560</td>
<td>95</td>
<td>CMS</td>
<td>$\ell^\pm + \text{jet} + E_T$, Tstop3, $m_{\tilde{\chi}^0_1} = 80$ GeV</td>
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</tbody>
</table>
\[ \chi_\pm \]

\[ m_{\tilde{t}} - m_{\tilde{\chi}^0} = 40 \text{ GeV} \]

\[ m_{\tilde{t}} - m_{\tilde{\chi}^0} = 30 \text{ GeV} \]

\[ m_{\tilde{t}} - m_{\tilde{\chi}^0} = 60 \text{ GeV} \]

\[ m_{\tilde{\chi}^0} = 0 \text{ GeV} \]

\[ m_{\tilde{\chi}^0} = 0 \text{ GeV} \]

\[ m_{\tilde{\chi}^0} = 10 \text{ GeV} \]

\[ m_{\tilde{\chi}^0} = 1 \text{ GeV} \]

\[ m_{\tilde{\chi}^0} = 100 \text{ GeV} \]
jets+$b$-jets+$E_T$, mixture
Tstop1 and Tstop2 with
BR=50%, $\chi^-_1 - m^-_0 = 100$ GeV

1 or more jets+$E_T$, Tstop8,
$m^-_1 - \chi^-_1 = 5$ GeV, $m^-_0 - \chi^-_1 = 0$

1 or more jets+$E_T$, Tstop1,
$m^-_1 - \chi^-_1 = 0$ GeV

1 or more jets+$E_T$, Tstop4, 10
GeV $< m^-_1 - \chi^-_1 < 80$

1 or more jets+$E_T$, Tstop1,
$m^-_1 - \chi^-_1 = 10$ GeV

1 or more jets+$E_T$, Tstop3, 10
GeV $< m^-_1 - \chi^-_1 < 80$

1 or more jets+$E_T$, Tstop9, 10
GeV $< m^-_1 - \chi^-_1 < 80$

jets+$E_T$, Tstop4, $m^-_1 - m^-_0 = 10$ GeV

jets+$E_T$, Tstop3, $m^-_1 - m^-_0 = 10$ GeV

jets+$E_T$, Tstop2, $m^-_1 + 0.25 m^-_0 - m^-_0 = 225$

jets+$E_T$, Tstop2, $m^-_1 + 0.25 m^-_0 - m^-_0 = 0$

jets+$E_T$, Tstop1, $m^-_1 - m^-_0 = 0$

jets+$E_T$, Tstop1, $m^-_1 - m^-_0 = 0$

jets+$E_T$, Tstop8, $m^-_1 - m^-_0 = 5$ GeV, $m^-_0 - \chi^-_1 = 0$

jets+$E_T$, Tstop1, $m^-_1 - m^-_0 = 0$

jets+$E_T$, Tstop2, $m^-_1 = (m^-_0 + m^-_0)/2$, $m^-_0 - \chi^-_1 = 0$

jets+$E_T$, Tstop8, $m^-_1 - m^-_0 = 100$ GeV

jets+$E_T$, Tstop3, 10 GeV $< m^-_1 - m^-_0 < 80$ GeV
> 480 95 40 SIRUNYAN 17AT CMS jets+$E_T$, Tstop4, $10 \text{ GeV} < m_{\tilde{t}_1^+}-m_{\tilde{\chi}_1^0} < 80 \text{ GeV}$

> 530 95 40 SIRUNYAN 17AT CMS jets+$E_T$, Tstop10, $m_{\tilde{\tau}_1^\pm} = (m_{\tilde{\tau}_1} + m_{\tilde{\chi}_1^0})/2$, $10 \text{ GeV} < m_{\tilde{\tau}_1}-m_{\tilde{\chi}_1^0} < 80 \text{ GeV}$

> 1070 95 41 SIRUNYAN 17AZ CMS $\geq 1$ jets+$E_T$, Tstop1, $m_{\tilde{\chi}_1^0} = 0 \text{ GeV}$

> 900 95 41 SIRUNYAN 17AZ CMS $\geq 1$ jets+$E_T$, Tstop2, $m_{\tilde{\chi}_1^0} = (m_{\tilde{\tau}_1} + m_{\tilde{\chi}_1^0})/2$, $m_{\tilde{\tau}_1} = 0$

> 1020 95 41 SIRUNYAN 17AZ CMS $\geq 1$ jets+$E_T$, Tstop8, $m_{\tilde{\tau}_1} - m_{\tilde{\chi}_1^0} = 5 \text{ GeV}$, $m_{\tilde{\chi}_1^0} = 100 \text{ GeV}$

none 280–830 95 42 SIRUNYAN 17K CMS 0, 1 $\ell^\pm +$jets+$E_T$ (combination), Tstop1, $m_{\tilde{\chi}_1^0} = 0 \text{ GeV}$

> 700 95 42 SIRUNYAN 17K CMS 0, 1 $\ell^\pm +$jets+$E_T$ (combination), Tstop8, $m_{\tilde{\tau}_1} - m_{\tilde{\chi}_1^0} = 5 \text{ GeV}$, $m_{\tilde{\chi}_1^0} = 100 \text{ GeV}$

> 160 95 42 SIRUNYAN 17K CMS jets+$E_T$, Tstop4, $10 < m_{\tilde{\tau}_1} - m_{\tilde{\chi}_1^0} < 80 \text{ GeV}$

none 230–960 95 43 SIRUNYAN 17P CMS jets+$E_T$, Tstop1, $m_{\tilde{\chi}_1^0} = 0 \text{ GeV}$

> 990 95 43 SIRUNYAN 17P CMS jets+$E_T$, Tstop1, $m_{\tilde{\chi}_1^0} = 0 \text{ GeV}$

> 323 95 44 AABOU 16D ATLS $\geq 1$ jet + $E_T$, Tstop4, $m_{\tilde{\tau}_1} - m_{\tilde{\chi}_1^0} = 5 \text{ GeV}$

none, 745–780 95 45 AABOU 16J ATLS 1 $\ell^\pm$ + $\geq 4$ jets + $E_T$, Tstop1, $m_{\tilde{\chi}_1^0} = 0 \text{ GeV}$

> 490–650 95 46 AAD 16AY ATLS $2\ell$ (including hadronic $\tau$) + $E_T$, Tstop5, $87 \text{ GeV} < m_{\tilde{\tau}_1} < m_{\tilde{\chi}_1^0}$

> 700 95 47 KHACHATRYAN 16AV CMS 1 or 2 $\ell^\pm +$jets$+b$-jets+$E_T$, Tstop1, $m_{\tilde{\chi}_1^0} < 250 \text{ GeV}$

> 700 95 47 KHACHATRYAN 16AV CMS 1 or 2 $\ell^\pm +$jets$+b$-jets+$E_T$, Tstop2, $m_{\tilde{\chi}_1^0} = 0 \text{ GeV}$, $m_{\tilde{\tau}_1^\pm} = 0.75 m_{\tilde{\tau}_1} + 0.25 m_{\tilde{\chi}_1^0}$

> 775 95 48 KHACHATRYAN 16BK CMS jets+$E_T$, Tstop1, $m_{\tilde{\chi}_1^0} < 200 \text{ GeV}$

> 620 95 48 KHACHATRYAN 16BK CMS jets+$E_T$, Tstop2, $m_{\tilde{\chi}_1^0} = 0 \text{ GeV}$

> 800 95 49 KHACHATRYAN 16BS CMS jets+$E_T$, Tstop1, $m_{\tilde{\chi}_1^0} = 0 \text{ GeV}$

> 316 95 50 KHACHATRYAN 16Y CMS 1 or 2 soft $\ell^\pm$ + jets + $E_T$, Tstop3, $m_{\tilde{\tau}_1}-m_{\tilde{\chi}_1^0} = 25 \text{ GeV}$
\midrule
$> 250$ & 95 & 51 AAD & 15CJ ATLS & \(\tilde{\tau} \rightarrow \phi_{\tilde{b}}\); \(m_{\tilde{\tau}} - m_{\tilde{b}} = 60 \text{ GeV}\) \(\chi_1\) & \\
$> 270$ & 95 & 51 AAD & 15CJ ATLS & \(\tilde{\tau} \rightarrow \phi_{\tilde{b}}\); \(m_{\tilde{\tau}} - m_{\tilde{b}} = 80 \text{ GeV}\) \(\chi_1\) & \\
none; 200–700 & 95 & 51 AAD & 15CJ ATLS & \(\tilde{\tau} \rightarrow t^0, m_{\tilde{\tau}} > m_{\tilde{t}}\) \(\chi_1\) & \\
$> 500$ & 95 & 51 AAD & 15CJ ATLS & \(\tilde{\tau} \rightarrow \chi_1\); \(m_{\tilde{\tau}} = 0\) \(\chi_1\) & \\
$> 600$ & 95 & 51 AAD & 15CJ ATLS & \(\tilde{t}_2 \rightarrow Z\tilde{t}_1, m_{\tilde{t}} > m_{\tilde{t}} = 180\) \(\chi_1\) & \\
none, 172.5–191 & 95 & 52 AAD & 15J ATLS & \(\tilde{\tau} \rightarrow t^0, m_{\tilde{t}} - m_{\tilde{t}} = 1 \text{ GeV}\) \(\chi_1\) & \\
$> 450$ & 95 & 53 KHACHATRY...15AF CMS & \(\tilde{\tau} \rightarrow \chi_1\); \(m_{\tilde{\tau}} > m_{\tilde{t}}\) \(\chi_1\) & \\
$> 560$ & 95 & 54 KHACHATRY...15AH CMS & \(\tilde{\tau} \rightarrow \chi_1\); \(m_{\tilde{\tau}} > m_{\tilde{t}}\) \(\chi_1\) & \\
$> 250$ & 95 & 55 KHACHATRY...15AH CMS & \(\tilde{\tau} \rightarrow \phi_{\tilde{b}}\); \(m_{\tilde{\tau}} - m_{\tilde{b}} < 10 \text{ GeV}\) \(\chi_1\) & \\
none, 200–350 & 95 & 56 KHACHATRY...15L CMS & \(\tilde{\tau} \rightarrow q\tilde{q}, \text{ RPV, } \lambda_{312}'' \neq 0\) \(\chi_1\) & \\
none, 200–385 & 95 & 56 KHACHATRY...15L CMS & \(\tilde{\tau} \rightarrow q\tilde{b}, \text{ RPV, } \lambda_{323}'' \neq 0\) \(\chi_1\) & \\
$> 730$ & 95 & 57 KHACHATRY...15X CMS & \(\tilde{\tau} \rightarrow \chi_1\); \(m_{\tilde{\tau}} > m_{\tilde{t}}\) \(\chi_1\) & \\
none 400–645 & 95 & 57 KHACHATRY...15X CMS & \(\tilde{\tau} \rightarrow \chi_1\) or \(\tilde{\tau} \rightarrow \phi_{\tilde{b}}\); \(m_{\tilde{\tau}} > m_{\tilde{b}}\) \(\chi_1\) & \\
none 270–645 & 95 & 58 AAD & 14AJ ATLS & \(\geq 4\) jets + \(E_T\), \(\tilde{t}_1 \rightarrow \chi_1^0\); \(m_{\tilde{\tau}} < 30 \text{ GeV}\) \(\chi_1\) & \\
none 250–550 & 95 & 58 AAD & 14AJ ATLS & \(\geq 4\) jets + \(E_T\), \(B(\tilde{t}_1 \rightarrow \phi_{\tilde{b}}) = 50\%\); \(m_{\tilde{\tau}} > 2 m_{\tilde{b}}\) \(\chi_1\) & \\
none 210–640 & 95 & 59 AAD & 14BD ATLS & \(\ell^\pm + \text{jets} + E_T\), \(\tilde{t}_1 \rightarrow \chi_1^0\); \(m_{\tilde{\tau}} > 0 \text{ GeV}\) \(\chi_1\) & \\
$> 500$ & 95 & 59 AAD & 14BD ATLS & \(\ell^\pm + \text{jets} + E_T\), \(\tilde{t}_1 \rightarrow \phi_{\tilde{b}}\); \(m_{\tilde{\tau}} > 2 m_{\tilde{b}}\) \(\chi_1\) & \\
none 150–445 & 95 & 60 AAD & 14F ATLS & \(\ell^\pm \ell^\mp\) final state, \(\tilde{t}_1 \rightarrow \phi_{\tilde{b}}\); \(m_{\tilde{\tau}} > 1 \text{ GeV}\) \(\chi_1\) & \\

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none 215–530 95 60 AAD 14F ATLS \[ \ell^\pm \ell^\mp \text{ final state, } \tilde{\tau}_1 \to t \chi^0_1, \]
\[ m_{\chi^0_1} = 1 \text{ GeV} \]

> 270 95 61 AAD 14T ATLS \[ \tilde{t}_1 \to c \chi^0_1, m_{\chi^0_1} = 200 \text{ GeV} \]

> 240 95 61 AAD 14T ATLS \[ \tilde{t}_1 \to c \chi^0_1, m_{\tau_1} - m_{\chi^0_1} < 85 \text{ GeV} \]

> 255 95 61 AAD 14T ATLS \[ \tilde{t}_1 \to b f f' \tilde{\chi}^0_1, m_{\tau_1} - m_{\chi^0_1} \approx m_b \]

> 400 95 62 CHATRCHYAN14AH CMS jets + $E_T$, $\tilde{\tau} \to t \chi^0_1$ simplified model, $m_{\chi^0_1} = 50$ GeV

63 CHATRCHYAN14R CMS \[ \tilde{\tau} \to (b \chi^\pm_1 / t \chi^0_1), \]
\[ \chi^\pm_1 \to (q q' / \ell \nu) \tilde{\chi}^0_1, \tilde{\chi}^0_1 \to (H/Z) \tilde{G}, \text{ GMSB, natural higgsino NLSP scenario} \]

> 740 95 64 KHACHATRY...14T CMS $\tau + b$-jets, RPV, $LQD$, $\chi^j_{33} \neq 0$, $\tilde{\tau} \to \tau b$ simplified model

> 580 95 64 KHACHATRY...14T CMS $\tau + b$-jets, RPV, $LQD$, $\chi^j_{3jk} \neq 0 \ (j \neq = 3)$, $\tilde{\tau} \to \tilde{\chi}_j^\pm b$, $\tilde{\chi}_j^\pm \to a q \tau^- \tilde{\chi}_j$ simplified model

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 850 95 65 AABOUD 17AF ATLS $2\ell + \text{jets} + b$-jets+$E_T$, $T\text{stop}6$, $m_{\chi^0_1} = 0$

> 800 95 66 AABOUD 17AF ATLS $2\ell + \text{jets} + b$-jets+$E_T$, $T\text{stop}7$ with 100% decays via $Z$, $m_{\chi^0_1} = 50$ GeV

> 880 95 67 AABOUD 17AF ATLS $2\ell + \text{jets} + b$-jets+$E_T$, $T\text{stop}7$ with 100% decays via higgs, $m_{\chi^0_1} = 50$ GeV

68 AABOUD ROLBIECKI 15 THEO jets+$E_T$, pMSSM-inspired

> 230 95 69 AAD 14B ATLS $Z + b$ $E_T$, $\tilde{\tau}_2 \to Z \tilde{t}_1, \tilde{t}_1 \to t \chi^0_1, m_{\chi^0_1} < 200$ GeV

> 600 95 69 AAD 14B ATLS $Z + b$ $E_T$, $\tilde{\tau}_1 \to t \chi^0_1, \tilde{t}_1 \rightarrow Z \tilde{G}$, natural GMSB, 100 GeV $< m_{\chi^0_1} < m_{\tilde{t}_1} - 10$ GeV

> 360 95 70 CHATRCHYAN14U CMS $\tilde{\tau}_1 \rightarrow b \tilde{\chi}^\pm_1, \tilde{\chi}^\pm_1 \rightarrow f f' \tilde{\chi}^0_1$, $\chi^0_1 \rightarrow H \tilde{G}$ simplified model, $m_{\chi^0_1} - m_{\tilde{t}_1} = 5$ GeV, GMSB

> 215 95 CZAKON 14 $\tilde{\tau} \to t \chi^0_1, m_{\chi^0_1} < 10$ GeV

71 KHACHATRY...14C CMS $\tilde{t}_2 \rightarrow H \tilde{t}_1$ or $t \tilde{t}_2 \rightarrow Z \tilde{t}_1$ simplified model
1. SIRUNYAN 19AU searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with at least one photon, jets, some of which are identified as originating from b-quarks, and large \(E_T\). No significant excess above the Standard Model expectations is observed. In the framework of GMSB, limits are set on the gluino mass in the Tglu4C, Tglu4D and Tglu4E simplified models, and on the top squark mass in the Tstop13 simplified model, see their Figure 5.

2. SIRUNYAN 19CH searched in 137 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events containing multiple jets and large \(E_T\). No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu1C, Tglu2A and Tglu3A simplified models, see their Figure 13. Limits are also set on squark, sbottom and stop masses in the Tsqk1, Tsbot1, Tstop1 simplified models, see their Figure 14.

3. SIRUNYAN 19S searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with zero or one charged leptons, jets and \(E_T\). The razor variables \((M_R^2, R^2)\) are used to categorize the events. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A and Tglu3C simplified models, see Figures 22 and 23, and on the stop mass in the Tstop1 simplified model, see their Figure 24.

4. SIRUNYAN 19U searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events containing one electron-muon pair with opposite charge. The search targets a region of parameter space where the kinematics of top squark pair production and top quark pair production is very similar, due to the mass difference between the top squark and the neutralino being close to the top quark mass. No excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1 model, with \(m_{\tilde{t}} - m_{\chi_1^0}\) close to \(m_t\), see Figure 5.

5. AABOUD 18AQ searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for top squark pair production in final states with one isolated electron or muon, several energetic jets, and missing transverse momentum. No significant excess over the Standard Model prediction is observed. In case of Tstop1 models, top squark masses up to 940 GeV are excluded assuming \(m_{\chi_1^0} = 0\) GeV, see their Fig. 20. If the top quark is not on-shell (3-body) decay, exclusions up to 500 GeV are obtained for \(m_{\chi_1^0} = 300\) GeV. Exclusions as a function of \(m_{\tilde{t}} - m_{\chi_1^0}\) are given in their Fig. 21.

6. AABOUD 18AQ searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for top squark pair production in final states with one isolated electron or muon, several energetic jets, and missing transverse momentum. No significant excess over the Standard Model prediction is observed. In case of Tstop3 models (4-body), top squark masses up to 370 GeV are excluded for \(m_{\tilde{t}} - m_{\chi_1^0}\) as low as 20 GeV. Top squark masses below 195 GeV are excluded for all \(m_{\chi_1^0}\), see their Fig. 20 and Fig. 21.

7. AABOUD 18AQ searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for top squark pair production in final states with one isolated electron or muon, several energetic jets, and missing transverse momentum. No significant excess over the Standard Model prediction is observed. In case of Tstop2 models, top squark masses up to 840 GeV are excluded for \(m_{\tilde{t}} - m_{\chi_1^0} = 10\) GeV. See their Fig. 23. Exclusion limits for this decay mode are presented also in the context of Higgsino-LSP phenomenological MSSM models, where \(m_{\tilde{t}} - m_{\chi_1^0} = 5\) GeV, see their Fig. 26.

8. AABOUD 18BV searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with at least one jet identified as c-jet, large missing transverse energy and no leptons. Good agreement is observed between the number of events in data and Standard Model predictions. The results are translated into exclusion limits in Tstop4 models. In scenarios with differences of the stop and neutralino masses below 100 GeV, stop masses below 500 GeV are excluded. See their Fig. 6 and Fig. 7.
9. **AABOUD** 18BV searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least one jet identified as $c$-jet, large missing transverse energy and no leptons. Good agreement is observed between the number of events in data and Standard Model predictions. The results are translated into exclusion limits in Tstop1 models. In scenarios with massless neutralinos, top squark masses below 850 GeV are excluded. See their Fig.6.

10. **AABOUD** 18I searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least one jet with a transverse momentum above 250 GeV and no leptons. Good agreement is observed between the number of events in data and Standard Model predictions. The results are translated into exclusion limits in Tstop3 models. Stop masses below 390 GeV are excluded for $m_\tau - m_{\tilde{\chi}^0_1} = m_b$. See their Fig.9(b).

11. **AABOUD** 18I searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least one jet with a transverse momentum above 250 GeV and no leptons. Good agreement is observed between the number of events in data and Standard Model predictions. The results are translated into exclusion limits in Tstop4 models. In scenarios with differences of the stop and neutralino masses around 5 GeV, stop masses below 430 GeV are excluded. See their Fig.9(a).

12. **AABOUD** 18Y searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct pair production of top squarks in final states with two tau leptons, $b$-jets, and missing transverse momentum. At least one hadronic $\tau$ is required. No significant deviation from the SM predictions is observed in the data. The analysis results are interpreted in Tstop5 models with a nearly massless gravitino. Top squark masses up to 1.16 TeV and tau slepton masses up to 1 TeV are excluded, see their Fig.7.

13. **SIRUNYAN** 18AJ searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing two low-momentum, oppositely charged leptons (electrons or muons) and $E_T$. No excess over the expected background is observed. Limits are derived on the wino mass in the Tchi1n2F simplified model, see their Figure 5. Limits are also set on the stop mass in the Tstop10 simplified model, see their Figure 6. Finally, limits are set on the Higgsino mass in the Tchi1n2G simplified model, see Figure 8 and in the mPSSM, see Figure 7.

14. **SIRUNYAN** 18AL searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least three charged leptons, in any combination of electrons and muons, jets and significant $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A and Tglu1C simplified models, see their Figure 5. Limits are also set on the sbottom mass in the Tsbot2 simplified model, see their Figure 6, and on the stop mass in the Tstop7 simplified model, see their Figure 7.

15. **SIRUNYAN** 18AN searched in 19.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing one or two photons and a pair of top quarks from the decay of a pair of top squark in a natural gauge-mediated scenario. The final state consists of a lepton (electron or muon), jets and one or two photons. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop12 simplified model, see their Figure 6.

16. **SIRUNYAN** 18AY searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing one or more jets and significant $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A and Tglu3A simplified models, see their Figure 3. Limits are also set on squark, sbottom and stop masses in the Tsqk1, Tsbot1, Tstop1 and Tstop4 simplified models, see their Figure 3. Finally, limits are set on long-lived gluino masses in a Tglu1A simplified model where the gluino is metastable or long-lived with proper decay lengths in the range $10^{-3}$ mm $< \tau < 10^5$ mm, see their Figure 4.

17. **SIRUNYAN** 188 searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for the pair production of third-generation squarks in events with jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the sbottom mass in the Tsbot1 simplified model, see their Figure 5, and on the stop mass in the Tstop4 simplified model, see their Figure 6.
18 SIRUNYAN 18c searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for the pair production of top squarks in events with two oppositely charged leptons (electrons or muons), jets identified as originating from a \(b\)-quark and large \(E_T\). No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1, Tstop2 and Tstop11 simplified models, see their Figures 11 and 12. The Tstop1 and Tstop2 results are combined with complementary searches in the all-hadronic and single lepton channels, see their Figures 13 and 14.

19 SIRUNYAN 18b searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events containing identified hadronically decaying top quarks, no leptons, and \(E_T\). No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1 simplified model, see their Figure 8, and on the gluino mass in the Tglu3A, Tglu3B, Tglu3C and Tglu3E simplified models, see their Figure 9.

20 SIRUNYAN 18d searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for pair production of top squarks in events with a low transverse momentum lepton (electron or muon), a high-momentum jet and significant missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits in the range 250–1000 GeV are set on the stop mass in the Tstop1 and Tstop10 simplified models, see their Figures 7 and 8. A combination of this search with the all-hadronic search is presented in Figure 9.

21 SIRUNYAN 18e searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for direct electroweak production of charginos and for pair production of top squarks in events with two leptons (electrons or muons) of the opposite electric charge. No significant excess above the Standard Model expectations is observed. Limits are set on the chargino mass in the Tchi1chi1C and Tchi1chi1E simplified models, see their Figure 8. Limits are also set on the stop mass in the Tstop1 and Tstop2 simplified models, see their Figure 9.

22 AABOUD 17a searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with two same-sign or three leptons, jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 700 GeV are set on the top squark mass in Tstop11 simplified models, assuming \(m_{\chi^0_2} = m_{\chi^0_1} + 100\) GeV. See their Figure 4(e).

23 AABOUD 17d searched in 36 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events containing two jets identified as originating from \(b\)-quarks and large missing transverse momentum, with or without leptons. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of top squarks. Assuming 50% BR for Tstop1 and Tstop2 simplified models, a \(t\bar{t}\) mass below 880 (860) GeV is excluded for \(m_{\chi^0_1} = 0 (<250)\) GeV. See their Fig. 7(b).

24 AABOUD 17y searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with at least four jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits in the range 250–1000 GeV are set on the top squark mass in Tstop1 simplified models. For the first time, additional constraints are set for the region \(m_{\chi^0_1} \sim m_t + m_{\chi^0_1}\) with exclusion of the \(t\bar{t}\) mass range 235–590 GeV. See their Figure 8.

25 AABOUD 17y searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with at least four jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits in the range 450-850 GeV are set on the top squark mass in a mixture of Tstop1 and Tstop2 simplified models with BR=50% and assuming \(m_{\chi^0_1 - \chi^0_1} = 1\) GeV and \(m_{\chi^0_1} < 240\) GeV. Constraints are given for various values of the BR. See their Figure 9.

26 AABOUD 17e searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with two opposite-charge leptons (electrons and muons) and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 720 GeV are set on the stop mass in Tstop1 simplified models, assuming massless neutralinos. See their Figure 9 (2-body area).

27 AABOUD 17e searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with two opposite-charge leptons (electrons and muons) and large missing transverse momentum.
No significant excess above the Standard Model expectations is observed. Limits up to 400 GeV are set on the top squark mass in Tstop simplified models, assuming $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} = 40$ GeV. See their Figure 9 (4-body area).

28 AABOUD 17BE searched in 36.1 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two opposite-charge leptons (electrons and muons) and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 430 GeV are set on the top squark mass in Tstop1 simplified models where top squarks are offshell, assuming $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0}$ close to the $W$ mass. See their Figure 9 (3-body area).

29 AABOUD 17BE searched in 36.1 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two opposite-charge leptons (electrons and muons) and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 700 GeV are set on the top squark mass in Tstop2 simplified models, assuming $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^\pm} = 10$ GeV and massless neutralinos. See their Figure 10.

30 KHACHATRYAN 17 searched in 2.3 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing four or more jets, no more than one lepton, and missing transverse momentum, using the razor variables ($M_R$ and $R^2$) to discriminate between signal and background processes. No evidence for an excess over the expected background is observed. Limits are derived on the stop mass in the Tstop1 simplified model, see Fig. 17.

31 KHACHATRYAN 17AD searched in 2.3 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing at least four jets (including b-jets), missing transverse momentum and tagged top quarks. No evidence for an excess over the expected background is observed. Top squark masses in the range 250–740 GeV and neutralino masses up to 240 GeV are excluded at 95% C.L. See Fig. 12.

32 KHACHATRYAN 17AD searched in 2.3 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing at least four jets (including b-jets), missing transverse momentum and tagged top quarks. No evidence for an excess over the expected background is observed. Limits are derived on the stop mass in simplified models that are a mixture of Tstop1 and Tstop2 with branching fractions 50% for each of the two decay modes: top squark masses of up to 610 GeV and neutralino masses up to 190 GeV are excluded at 95% C.L. The $\tilde{\chi}_1^\pm$ and the $\tilde{\chi}_1^0$ are assumed to be nearly degenerate in mass, with a 5 GeV difference between their masses. See Fig. 12.

33 KHACHATRYAN 17P searched in 2.3 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing one or more jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A, Tglu3A, Tglu3B, Tglu3C and Tglu3D simplified models, see their Figures 7 and 8. Limits are also set on the squark mass in the Tsqk1 simplified model, see their Fig. 7, and on the sbottom mass in the Tsbot1 simplified model, see Fig. 8. Finally, limits are set on the stop mass in the Tstop1, Tstop3, Tstop4, Tstop6 and Tstop7 simplified models, see Fig. 8.

34 KHACHATRYAN 17S searched in 18.5 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing multiple jets and missing transverse momentum, using the $\alpha_T$ variable to discriminate between signal and background processes. No evidence for an excess over the expected background is observed. Limits are derived on the stop mass in the Tstop4 model: for $\Delta m = m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0}$ equal to 10 and 80 GeV, masses of stop below 240 and 260 GeV are excluded, respectively. See their Fig.3.

35 KHACHATRYAN 17S searched in 18.5 $fb^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing multiple jets and missing transverse momentum, using the $\alpha_T$ variable to discriminate between signal and background processes. No evidence for an excess over the expected background is observed. Limits are derived on the stop mass in the Tstop3 model: for $\Delta m = m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0}$ equal to 10 and 80 GeV, masses of stop below 225 and 130 GeV are excluded, respectively. See their Fig.3.
36 KHACHATRYAN 17S searched in 18.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing multiple jets and missing transverse momentum, using the $\alpha_T$ variable to discriminate between signal and background processes. No evidence for an excess over the expected background is observed. Limits are derived on the stop mass in the Tstop2 model: assuming $m_{\tilde{t}} = 0.25 m_{\chi_1^\pm} + 0.75 m_{\tilde{\chi}_1^0}$, masses of stop up to 325 GeV and masses of the neutralino up to 225 GeV are excluded. See their Fig.3.

37 KHACHATRYAN 17S searched in 18.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing multiple jets and missing transverse momentum, using the $\alpha_T$ variable to discriminate between signal and background processes. No evidence for an excess over the expected background is observed. Limits are derived on the stop mass in the Tstop2 model: assuming $m_{\tilde{t}} = 0.75 m_{\chi_1^\pm} + 0.25 m_{\tilde{\chi}_1^0}$, masses of stop up to 400 GeV are excluded for low neutralino masses. See their Fig.3.

38 KHACHATRYAN 17S searched in 18.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing multiple jets and missing transverse momentum, using the $\alpha_T$ variable to discriminate between signal and background processes. No evidence for an excess over the expected background is observed. Limits are derived on the stop mass in the Tstop1 model: assuming masses of stop up to 500 GeV and masses of the neutralino up to 105 GeV are excluded. See their Fig.3.

39 SIRUNYAN 17AS searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with a single lepton (electron or muon), jets, and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1, Tstop2 and Tstop8 simplified models, see their Figures 5, 6 and 7.

40 SIRUNYAN 17AT searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct production of top squarks in events with jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1, Tstop2, Tstop3, Tstop4, Tstop8 and Tstop10 simplified models, see their Figures 9 to 14.

41 SIRUNYAN 17AZ searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one or more jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A, Tglu3A simplified models, see their Figures 6. Limits are also set on the squark mass in the Tsqk1 simplified model (for single light squark and for 8 degenerate light squarks), on the sbottom mass in the Tsbot1 simplified model and on the stop mass in the Tstop1 simplified model, see their Fig. 7. Finally, limits are set on the stop mass in the Tstop2, Tstop4 and Tstop8 simplified models, see Fig. 8.

42 SIRUNYAN 17K searched in 2.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for direct production of stop or sbottom pairs in events with multiple jets and significant $E_T$. A second search also requires an isolated lepton and is combined with the all-hadronic search. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1, Tstop8 and Tstop4 simplified models, see their Figures 7, 8 and 9 (for the Tstop4 limits, only the results of the all-hadronic search are used). Limits are also set on the sbottom mass in the Tsbot1 simplified model, see Fig. 10 (also here, only the results of the all-hadronic search are used).

43 SIRUNYAN 17P searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with multiple jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu1C, Tglu2A, Tglu3A and Tglu3D simplified models, see their Fig. 12. Limits are also set on the squark mass in the Tsqk1 simplified model, on the stop mass in the Tstop1 simplified model, and on the sbottom mass in the Tsbot1 simplified model, see Fig. 13.

44 AABOUD 16D searched in 3.2 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with an energetic jet and large missing transverse momentum. The results are interpreted as 95% C.L. limits on mass of stop decaying into a charm-quark and the lightest neutralino in scenarios with $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0}$ between 5 and 20 GeV. See their Fig. 5.

45 AABOUD 16J searched in 3.2 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in final states with one isolated electron or muon, jets, and missing transverse momentum. For the direct
stop pair production model where the stop decays via top and lightest neutralino, the results exclude at 95% C.L. stop masses between 745 GeV and 780 GeV for a massless \( \tilde{\chi}_1^0 \). See their Fig. 8.

46 AAD 16AY searched in 20 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for events with either two hadronically decaying tau leptons, one hadronically decaying tau and one light lepton, or two light leptons. No significant excess over the Standard Model expectation is found. Exclusion limits at 95% C.L. on the mass of top squarks decaying via \( \tilde{t} \) to a nearly massless gravitino are placed depending on \( m_{\tilde{t}} \) which is ranging from the 87 GeV LEP limit to \( m_{\tilde{t}} \). See their Figs. 9 and 10.

47 KHACHATRYAN 16AY searched in 19.7 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for events with one or two isolated leptons, hadronic jets, \( b \)-jets and \( E_T \). No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1 and Tstop2 simplified models, see Fig. 11.

48 KHACHATRYAN 16BK searched in 18.9 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for events with hadronic jets and \( E_T \). No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1 and Tstop2 simplified models, see Fig. 16.

49 KHACHATRYAN 16BS searched in 2.3 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 13 \) TeV for events with at least one energetic jet, no isolated leptons, and significant \( E_T \), using the transverse mass variable \( M_T \) to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1 simplified model, see Fig. 11 and Table 3.

50 KHACHATRYAN 16Y searched in 19.7 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for events with one or two soft isolated leptons, hadronic jets, and \( E_T \). No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1 and Tstop2 simplified models, see Fig. 3.

51 AAD 15Ci searched in 20 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for evidence of third generation squarks by combining a large number of searches covering various final states. Stop decays with and without charginos in the decay chain are considered and summaries of all ATLAS Run 1 searches for direct stop production can be found in Fig. 4 (no intermediate charginos) and Fig. 7 (intermediate charginos). Limits are set on stop masses in compressed mass regions, with \( \mathcal{B}(\tilde{t} \rightarrow c \tilde{\chi}_1^0) + \mathcal{B}(\tilde{t} \rightarrow b \tilde{f} f' \tilde{\chi}_1^0) = 1 \), see Fig. 5. Limits are also set on stop masses assuming that both the decay \( t \rightarrow t \tilde{\chi}_1^0 \) and \( \tilde{t} \rightarrow b \tilde{\chi}_1^0 \) are possible, with both their branching ratios summing up to 1, assuming \( \tilde{\chi}_1^+ \rightarrow W^+ \tilde{\chi}_1^0 \) and \( m_{\tilde{\chi}_1^\pm} = 2 m_{\tilde{\chi}_1^0} \), see Fig. 6. Limits on the mass of the next-to-lightest stop \( \tilde{t}_2 \), decaying either to \( Z \tilde{t}_1 \) or \( t \tilde{\chi}_1^0 \), are also presented, see Figs. 9 and 10. Interpretations in the pMSSM are also discussed, see Figs 13–15.

52 AAD 15J interpreted the measurement of spin correlations in \( t \tilde{t} \) production using 20.3 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV in exclusion limits on the pair production of light \( \tilde{t}_1 \) squarks with masses similar to the top quark mass. The \( \tilde{t}_1 \) is assumed to decay through \( \tilde{t}_1 \rightarrow t \tilde{\chi}_1^0 \) with predominantly right-handed top and a 100% branching ratio. The data are found to be consistent with the Standard Model expectations and masses between the top quark mass and 191 GeV are excluded, see their Fig. 2.

53 KHACHATRYAN 15AF searched in 19.5 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for events with at least two energetic jets and significant \( E_T \), using the transverse mass variable \( M_T \) to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in simplified models where the decay \( \tilde{t} \rightarrow t \tilde{\chi}_1^0 \) takes place with a branching ratio of 100%, see Fig. 12. See also Table 5. Exclusions in the CMSSM, assuming \( \tan \beta = 30 \), \( A_0 = -2 \max(m_{\tilde{b}}, m_{\tilde{t}_1/2}) \) and \( \mu > 0 \), are also presented, see Fig. 15.

54 KHACHATRYAN 15AH searched in 19.4 or 19.7 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for events containing either a fully reconstructed top quark, or events containing dijets.
requiring one or both jets to originate from b-quarks, or events containing a mono-jet. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in simplified models where the decay $\tilde{t} \rightarrow t\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Fig. 9. Limits are also set in simplified models where the decays $\tilde{t} \rightarrow t\tilde{\chi}_1^0$ and $\tilde{t} \rightarrow b\tilde{\chi}_1^±$, with $m_{\tilde{\chi}_1^±} - m_{\tilde{\chi}_1^0} = 5$ GeV, each take place with a branching ratio of 50%, see Fig. 10. Finally, limits are set in a simplified model where the decay $\tilde{t} \rightarrow c\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Figs. 9, 10 and 11.

56. KHACHATRYAN 15AH searched in 19.4 or 19.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing either a fully reconstructed top quark, or events containing dijets requiring one or both jets to originate from b-quarks, or events containing a mono-jet. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in simplified models where the decay $\tilde{t} \rightarrow t\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Fig. 9. Limits are also set in simplified models where the decays $\tilde{t} \rightarrow t\tilde{\chi}_1^0$ and $\tilde{t} \rightarrow b\tilde{\chi}_1^±$, with $m_{\tilde{\chi}_1^±} - m_{\tilde{\chi}_1^0} = 5$ GeV, each take place with a branching ratio of 50%, see Fig. 10. Finally, limits are set in a simplified model where the decay $\tilde{t} \rightarrow c\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Figs. 9, 10 and 11.

57. KHACHATRYAN 15X searched in 19.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least two energetic jets, at least one of which is required to originate from a b quark, possibly a lepton, and significant $E_T$, using the razor variables ($M_R$ and $R^2$) to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in simplified models where the decay $\tilde{t} \rightarrow t\tilde{\chi}_1^0$ and the decay $\tilde{t} \rightarrow b\tilde{\chi}_1^±$, with $m_{\tilde{\chi}_1^±} - m_{\tilde{\chi}_1^0} = 5$ GeV, take place with branching ratios varying between 0 and 100%, see Figs. 15, 16 and 17.

58. AAD 14AJ searched in 20.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing four or more jets and large missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of third-generation squarks in simplified models which either assume that the decay $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$ takes place 100% of the time, see Fig. 8, or that this decay takes place 50% of the time, while the decay $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^±$ takes place the other 50% of the time, see Fig. 9.

59. AAD 14BD searched in 20 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing one isolated lepton, jets and large missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of third-generation squarks in simplified models which either assume that the decay $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$ takes place 100% of the time, see Fig. 15, or the decay $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^±$ takes place 100% of the time, see Fig. 16–22. For the mixed decay scenario, see Fig. 23.

60. AAD 14F searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing two leptons ($e$ or $\mu$), and possibly jets and missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of third-generation squarks in simplified models which either assume that the decay $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^±$ takes place 100% of the time, see Figs.
14–17 and 20, or that the decay $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$ takes place 100% of the time, see Figs. 18 and 19.

AAD 14T searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for monojet-like and $c$-tagged events. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the masses of third-generation squarks in simplified models which assume that the decay $\tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$ takes place 100% of the time, see Fig. 9 and 10. The results of the monojet-like analysis are also interpreted in terms of stop pair production in the four-body decay $\tilde{t}_1 \rightarrow b\tilde{t}'\tilde{\chi}_1^0$, see Fig. 11.

CHATRCHYAN 14AH searched in 4.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with at least two energetic jets and significant $E_T$, using the razor variables ($M_R$ and $R^2$) to discriminate between signal and background processes. A second analysis requires at least one of the jets to be originating from a $b$-quark. No significant excess above the Standard Model expectations is observed. Limits are set on stop masses in RPV models where the decay $\tilde{t} \rightarrow t\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Figs. 28 and 29. Exclusions in the CMSSM, assuming $\tan\beta = 10$, $A_0 = 0$ and $\mu > 0$, are also presented, see Fig. 26.

CHATRCHYAN 14r searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least three leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in a natural higgsino NLSP simplified model (GMSB) where the decay $\tilde{t} \rightarrow b\tilde{\chi}_1^\pm$, with $\tilde{\chi}_1^\pm \rightarrow (q'q/\ell\ell')H$, $ZG$, takes place with a branching ratio of 100% (the particles between brackets have a soft $p_T$ spectrum), see Figs. 4–6.

KHACHATRYAN 14T searched in 19.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with $\tau$-leptons and $b$-quark jets, possibly with extra light-flavour jets. No excess above the Standard Model expectations is observed. Limits are set on stop masses in RPV SUSY models with LQD couplings, in two simplified models. In the first model, the decay $\tilde{t} \rightarrow \tau b$ is considered, with $m_{333}^\prime \neq 0$, see Fig. 3. In the second model, the decay $\tilde{t} \rightarrow \tilde{\chi}_1^\pm b$, with the subsequent decay $\tilde{\chi}_1^\pm \rightarrow q'q\tau^\pm$ is considered, with $m_{3jk}^\prime \neq 0$ and the mass splitting between the top squark and the charging chosen to be 100 GeV, see Fig. 4.

AABOUD 17AF searched in 36 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for evidence of top squarks in events containing 2 leptons, jets, $b$-jets and $E_T$. In Tstop6 model, assuming $m_{\tilde{\chi}_1^0} = 0$ GeV, $\tilde{t}_1$ masses up to 850 GeV are excluded for $m_{\tilde{\chi}_2^0} > 200$ GeV.

AABOUD 17AF searched in 36 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for evidence of $\tilde{t}_2$ in events containing 2 leptons, jets, $b$-jets and $E_T$. In Tstop7 model, assuming $m_{\tilde{\chi}_1^0} = 50$ GeV and 100% decays via $Z$ boson, $\tilde{t}_2$ masses up to 800 GeV are excluded. Exclusion limits are also shown as a function of the $\tilde{t}_2$ branching ratios in their Figure 7.

AABOUD 17AF searched in 36 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for evidence of $\tilde{t}_2$ in events containing 2 leptons, jets, $b$-jets and $E_T$. In Tstop7 model, assuming $m_{\tilde{\chi}_1^0} = 50$ GeV and 100% decays via higgs boson, $\tilde{t}_2$ masses up to 880 GeV are excluded. Exclusion limits are also shown as a function of the $\tilde{t}_2$ branching ratios in their Figure 7.

AABOUD 17AY searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least four jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits are set on the top squark mass assuming three pMSSM-inspired models. The first one, referred to as Higgsino LSP model, assumes $m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0} = 5$ GeV and $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0} = 10$ GeV, with a mixture of decay modes as in Tstop1, Tstop2 and Tstop6. See their Figure 10. The second and third models are referred to as Wino NLSP and well-tempered pMSSM models, respectively. See their Figure 11 and Figure 12, and text for details on assumptions.
AAD 14B searched in 20.3 fb⁻¹ of pp collisions at √s = 8 TeV for events containing a Z boson, with or without additional leptons, plus jets originating from b-quarks and significant missing transverse momentum. No excess over the expected SM background is observed. Limits are derived in simplified models featuring t̃2 production, with t̃2 → Z t̃1, t̃1 → t̃χ̄₁⁰ with a 100% branching ratio, see Fig. 4, and in the framework of natural GMSB, see Fig. 6.

CHATRCHYAN 14U searched in 19.7 fb⁻¹ of pp collisions at √s = 8 TeV for evidence of direct pair production of top squarks, with Higgs bosons in the decay chain. The search is performed using a selection of events containing two Higgs bosons, each decaying to a photon pair, missing transverse energy and possibly b-quark jets. No significant excesses over the expected SM backgrounds are observed. The results are interpreted in the context of a “natural SUSY” simplified model where the decays t̃1 → b̃χ̄₁±, with t̃χ̄₁± → f f' χ̄₁⁰, and χ̄₁⁰ → H G, all happen with 100% branching ratio, see Fig. 4.

KHACHATRYAN 14C searched in 19.5 fb⁻¹ of pp collisions at √s = 8 TeV for evidence of direct pair production of top squarks, with Higgs or Z-bosons in the decay chain. The search is performed using a selection of events containing leptons and b-quark jets. No significant excesses over the expected SM backgrounds are observed. The results are interpreted in the context of a simplified model with pair production of a heavier top-squark mass eigenstate t̃2 decaying to a lighter top-squark eigenstate t̃1 via either t̃2 → H t̃1 or t̃2 → Z t̃1, followed in both cases by t̃1 → t̃χ̄₁⁰. The interpretation is performed in the region where the mass difference between the t̃1 and χ̄₁⁰ is approximately equal to the top-quark mass, which is not probed by searches for direct t̃1 pair production, see Figs. 5 and 6. The analysis excludes top squarks with masses m_{t̃2} < 575 GeV and m_{t̃1} < 400 GeV at 95% C.L.

### R-parity violating t̃ (Stop) mass limit

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<thead>
<tr>
<th>VALUE (GeV)</th>
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<th>DOCUMENT ID</th>
<th>TECN</th>
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<tr>
<td>&gt;1150</td>
<td>95</td>
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<td>2 SIRUNYAN</td>
<td>19BJ CMS</td>
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<tr>
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<td>3 AABOUD</td>
<td>18BB ATLS</td>
<td>4 jets, Tstop1RPV, λ₁³₂₃ coupling</td>
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<tr>
<td>none 100–470, 480–610</td>
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<td>18BB ATLS</td>
<td>4 jets, Tstop1RPV, λ₁³₂₃ coupling</td>
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<tr>
<td>≥ 600–1500</td>
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<td>18P ATLS</td>
<td>2e + b-jets, Tstop2RPV, depending on λ₁³³ coupling (i = 1, 2, 3)</td>
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<td>18AD CMS</td>
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<td>17AI ATLS</td>
<td>t̃ → bℓ, long-lived, cτ = 70–100 mm</td>
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<tr>
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<td>95</td>
<td>10 AAD</td>
<td>16AMATLS</td>
<td>2 large-radius jets, Tstop1RPV</td>
</tr>
</tbody>
</table>

Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)
• • • We do not use the following data for averages, fits, limits, etc. • • •

\[ e^+ e^- \geq 5 \text{ jets}; \tilde{t} \rightarrow b \tilde{\chi}_1^\pm; \]

\[ \tilde{\chi}_1^\pm \rightarrow \ell^+ \ell^- j j; \lambda^t \]

\[ \mu^+ \mu^- \geq 5 \text{ jets}; \tilde{t} \rightarrow b \tilde{\chi}_1^\pm; \]

\[ \tilde{\chi}_1^\pm \rightarrow \ell^+ \ell^- j j; \lambda^t \]

\[ \tilde{t} \rightarrow t \tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \ell \ell \nu, \lambda_{121} \text{ or } \lambda_{122} \neq 0 \]

\[ b \ell, c \tau = 2 \text{ cm} \]

1 SIRUNYAN 1B \( \chi \) searched in 35.9 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 13 \) TeV in final states with two muons and two jets, or with one muon, two jets, and missing transverse momentum. Limits are set in a model of pair-produced, prompt or long-lived top squarks with R-parity violating decays to a b-quark and a lepton (Tstop2RPV), branching fraction of \( t \rightarrow b \mu \) equal to 1/3 and \( c \tau \) between 0.1 cm and 10 cm in the case of long-lived top squarks. See their Fig. 10.

2 SIRUNYAN 1B \( \chi \) searched in 35.9 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 13 \) TeV in final states with two electrons and two jets, or with one electron, two jets, and missing transverse momentum. Limits are set in a model of pair-produced, prompt top squarks with R-parity violating decays to a b-quark and a lepton (Tstop2RPV), assuming branching fraction of \( t \rightarrow b e \) equal to 1/3 and \( c \tau = 0 \) cm. See their Fig.10.

3 AABOUD 1B \( \chi \) searched in 36.7 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 13 \) TeV for massive colored resonances which are pair-produced and decay into two jets. No significant deviation from the background prediction is observed. Results are interpreted in a SUSY simplified model as Tstop1RPV with \( \tilde{t} \rightarrow d s \). Top squarks with masses in the range 100–410 GeV are excluded, see their Figure 10(a). The \( \lambda_{312}'' \) coupling is assumed to be sufficiently large for the decays to be prompt, but small enough to neglect the single-top-squark resonant production through RPV couplings.

4 AABOUD 1B \( \chi \) searched in 36.7 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 13 \) TeV for massive coloured resonances which are pair-produced and decay into two jets. No significant deviation from the background prediction is observed. Results are interpreted in Tstop1RPV. Top squarks with masses in the range 100–470 GeV or 480–610 GeV are excluded, see their Figure 9(b). The \( \lambda_{323}'' \) coupling is assumed to be sufficiently large for the decays to be prompt, but small enough to neglect the single-top-squark resonant production through RPV couplings.

5 AABOUD 1B \( \chi \) searched in 36.1 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 13 \) TeV for pair-produced top squarks that decay through RPV \( \lambda_{i33}^1 \) \((i = 1, 2, 3)\) couplings to a final state with two leptons and two jets, at least one of which is identified as a b-jet. No significant excess is observed over the SM background. In the Tstop2RPV model, lower limits on the top squark masses between 600 and 1500 GeV are set depending on the branching fraction to \( b e, b \mu, \) and \( b \tau \) final states. See their Figs 6 and 7.

6 SIRUNYAN 1A \( \chi \) searched in 2.6 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 13 \) TeV for long-lived particles by exploiting the multiplicity of displaced jets to search for the presence of signal decays occurring at distances between 1 and 1000 mm. Limits are set in a model of pair-produced, long-lived top squarks with R-parity violating decays to a b-quark and a lepton, see their Figure 3.

7 SIRUNYAN 1D \( \chi \) searched in 38.5 fb\(^{-1} \) of \( pp \) collisions at \( \sqrt{s} = 13 \) TeV for long-lived particles in events with multiple jets and two displaced vertices composed of many tracks. No events with two well-separated high-track-multiplicity vertices were observed. Limits are set on the stop and the gluino mass in RPV models of supersymmetry where the stop (gluino) is decaying solely into dijet (multijet) final states, see their Figures 6 and 7.
Heavy $\tilde{g}$ (Gluino) mass limit

For $m_{\tilde{g}} > 60$–70 GeV, it is expected that gluinos would undergo a cascade decay via a number of neutralinos and/or charginos rather than undergo a direct decay to photons as assumed by some papers. Limits obtained when direct decay is assumed are usually higher than limits when cascade decays are included.

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).

### R-parity conserving heavy $\tilde{g}$ (Gluino) mass limit

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<tr>
<td>&gt;1975</td>
<td>95</td>
<td>1 SIRUNYAN</td>
<td>20B</td>
<td>$\geq 1\gamma + E_T, \ Tglu4A, \ BR(\tilde{g} \to q\tilde{\chi}<em>1^{\pm})=0.5, \ m</em>{\tilde{g}} \simeq m_{\tilde{\chi}_1^0}$</td>
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</tbody>
</table>

Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)
>2000 95 2 AABOUD 19i ATL $\geq 2$ jets + 1 or 2 $\tau + E_T$, Tglu1F, $m_{\tilde{\chi}_1^0} = 100$ GeV

>1860 95 3 SIRUNYAN 19AG CMS $2\gamma + E_T$, Tglu4B, 500 GeV $<m_{\tilde{\chi}_1^0} < 1500$ GeV

>1920 95 4 SIRUNYAN 19AU CMS $\gamma +$ jets + $b$-jets + $E_T$, Tglu4D, $m_{\tilde{\chi}_1^0} = 127$ GeV

>1950 95 4 SIRUNYAN 19AU CMS $\gamma +$ jets + $b$-jets + $E_T$, Tglu4E, $m_{\tilde{\chi}_1^0} = 1$ GeV

>1800 95 4 SIRUNYAN 19AU CMS $\gamma +$ jets + $b$-jets + $E_T$, Tglu4F, $m_{\tilde{\chi}_1^0} = 1200$ GeV

>2090 95 4 SIRUNYAN 19AU CMS $\gamma +$ jets + $b$-jets + $E_T$, Tglu4D, $m_{\tilde{\chi}_1^0} = 1200$ GeV

>2120 95 4 SIRUNYAN 19AU CMS $\gamma +$ jets + $b$-jets + $E_T$, Tglu4E, $m_{\tilde{\chi}_1^0} = 1200$ GeV

>1970 95 4 SIRUNYAN 19AU CMS $\gamma +$ jets + $b$-jets + $E_T$, Tglu4F, $m_{\tilde{\chi}_1^0} = 1200$ GeV

>2000 95 6 SIRUNYAN 19CH CMS $\gamma +$ $\ell +$ $E_T$, Tglu1A, $m_{\tilde{\chi}_1^0} = 0$ GeV

>2030 95 6 SIRUNYAN 19CH CMS $\gamma +$ $\ell +$ $E_T$, Tglu1C, $m_{\tilde{\chi}_1^0} = 0$ GeV

>2270 95 6 SIRUNYAN 19CH CMS $\gamma +$ $\ell +$ $E_T$, Tglu2A, $m_{\tilde{\chi}_1^0} = 0$ GeV

>2180 95 6 SIRUNYAN 19CH CMS $\gamma +$ $\ell +$ $E_T$, Tglu3A, $m_{\tilde{\chi}_1^0} = 0$ GeV

>1750 95 7 SIRUNYAN 19K CMS $\gamma +$ $\ell +$ $E_T$, Tglu4A, $m_{\tilde{\chi}_1^0} = 1500$ GeV

>2000 95 8 SIRUNYAN 19S CMS 1 or 2 $\ell +$ jets + $E_T$, Tglu3A, $m_{\tilde{\chi}_1^0} < 700$ GeV

>1900 95 8 SIRUNYAN 19S CMS 1 or 2 $\ell +$ jets + $E_T$, Tglu3C, $150$ GeV $< m_{\tilde{\chi}_1^0} < 950$ GeV

>1970 95 9 AABOUD 18AR ATLS $\gamma +$ $3b$-jets + $E_T$, Tglu3A, $m_{\tilde{\chi}_1^0} < 300$ GeV

>1920 95 10 AABOUD 18AR ATLS $\gamma +$ $3b$-jets + $E_T$, Tglu3A, $m_{\tilde{\chi}_1^0} < 600$ GeV

>1650 95 11 AABOUD 18AS ATLS $\geq 4$ jets and disappearing tracks from $\tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0 \pi^\pm$, modified Tglu1A or Tglu1B, $\tilde{\chi}_1^0$ lifetime 0.2 ns, $m_{\tilde{\chi}_1^0} = 460$ GeV

>1850 95 12 AABOUD 18BJ ATLS $\ell^\pm + E_T$, Tglu1G, $m_{\tilde{\chi}_1^0} = 100$ GeV

>1650 95 13 AABOUD 18BJ ATLS $\ell^\pm + E_T$, Tglu1H, $m_{\tilde{\chi}_1^0} = 100$ GeV

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2150 95 14 AABOUD 18u ATLS $2\gamma + E_T$, GGM, Tglu4B, any NLSP mass

1600 95 15 AABOUD 18u ATLS $\gamma + $jets + $E_T$, GGM higgsino-bino, mix of Tglu4B and Tglu4C, any NLSP mass

2030 95 16 AABOUD 18v ATLS jets+$E_T$, Tglu1A, $m_{\tilde{\chi}^0_1} = 0$ GeV

1980 95 17 AABOUD 18v ATLS jets+$E_T$, Tglu1B, $m_{\chi^\pm_1} = 0.5(m_{\tilde{g}}+m_{\tilde{\chi}^0_1})$, $m_{\tilde{\chi}^0_1} = 0$ GeV

1750 95 18 AABOUD 18v ATLS jets+$E_T$, Tglu1C, $m_{\tilde{\chi}^0_1} = 1$ GeV, any $m_{\tilde{\chi}^0_2} > 100$ GeV

2000 95 19 SIRUNYAN 18AA CMS $\geq 1\gamma + E_T$, Tglu4A

2100 95 19 SIRUNYAN 18AA CMS $\geq 1\gamma + E_T$, Tglu4B

1800 95 20 SIRUNYAN 18AC CMS 1$\ell$+jets, Tglu3A, $m_{\tilde{\chi}^0_1} < 650$ GeV

1700 95 20 SIRUNYAN 18AC CMS 1$\ell$+jets, Tglu3A, $m_{\tilde{\chi}^0_1} < 1040$ GeV

1900 95 20 SIRUNYAN 18AC CMS 1$\ell$ + jets, Tglu1B, $m_{\tilde{\chi}^\pm_1} = (m_{\tilde{g}} + m_{\tilde{\chi}^0_1})/2$, $m_{\tilde{\chi}^0_1} < 300$ GeV

1250 95 20 SIRUNYAN 18AC CMS 1$\ell$ + jets, Tglu1B, $m_{\tilde{\chi}^\pm_1} = (m_{\tilde{g}} + m_{\tilde{\chi}^0_1})/2$, $m_{\tilde{\chi}^0_1} < 950$ GeV

1610 95 21 SIRUNYAN 18AL CMS $\geq 3\ell^\pm$ + jets + $E_T$, Tglu3A, $m_{\tilde{\chi}^0_1} = 0$ GeV

1160 95 21 SIRUNYAN 18AL CMS $\geq 3\ell^\pm$ + jets + $E_T$, Tglu1C, $m_{\chi^0_1} = m_{\chi^\pm_1} = (m_{\tilde{g}} + m_{\tilde{\chi}^0_1})/2$, $m_{\tilde{\chi}^0_1} = 0$ GeV

1500 95 22 SIRUNYAN 18AR CMS $\ell^\pm E_T^\tau$ + jets + $E_T$, GMSB, Tglu4C, $m_{\tilde{\chi}^0_1} = 100$ GeV

1770 95 22 SIRUNYAN 18AR CMS $\ell^\pm E_T^\tau$ + jets + $E_T$, GMSB, Tglu4C, $m_{\tilde{\chi}^0_1} = 1400$ GeV

1625 95 23 SIRUNYAN 18AY CMS jets+$E_T$, Tglu1A, $m_{\tilde{\chi}^0_1} = 0$ GeV

1825 95 23 SIRUNYAN 18AY CMS jets+$E_T$, Tglu2A, $m_{\tilde{\chi}^0_1} = 0$ GeV

1625 95 23 SIRUNYAN 18AY CMS jets+$E_T$, Tglu3A, $m_{\tilde{\chi}^0_1} = 0$ GeV

2040 95 24 SIRUNYAN 18B CMS top quark (hadronically decaying) + jets + $E_T$, Tglu3A, $m_{\tilde{\chi}^0_1} = 0$ GeV

1930 95 24 SIRUNYAN 18B CMS top quark (hadronically decaying) + jets + $E_T$, Tglu3B, $m_{\chi^1_1} - m_{\tilde{\chi}^0_1} = 175$ GeV, $m_{\tilde{\chi}^0_1} = 200$ GeV

1690 95 24 SIRUNYAN 18B CMS top quark (hadronically decaying) + jets + $E_T$, Tglu3C, $m_{\chi^1_1} - m_{\tilde{\chi}^0_1} = 20$ GeV, $m_{\tilde{\chi}^0_1} = 0$ GeV
1990 95 24 Sirunyan 18d CMS top quark (hadronically decaying) + jets + $E_T$, Tglu3E, $m_{\chi_1^0} = 50 \pm 5$ GeV, $m_{\chi_1^\pm} = 100$ GeV

2010 95 25 Sirunyan 18m CMS $\geq 1$ ($\to b\bar{b}$) + $E_T$, Tglu1I

1825 95 25 Sirunyan 18m CMS $\geq 1$ ($\to b\bar{b}$) + $E_T$, Tglu1J

1750 95 26 Aaboud 17a ATLS same-sign $\ell^+\ell^-$ / 3 $\ell$ + jets + $E_T$, Tglu3A, $m_{\chi_1^0} = 100$ GeV

1570 95 27 Aaboud 17a ATLS same-sign $\ell^+\ell^-$ / 3 $\ell$ + jets + $E_T$, Tglu1E, $m_{\chi_1^0} = 100$ GeV

1860 95 28 Aaboud 17a ATLS same-sign $\ell^+\ell^-$ / 3 $\ell$ + jets + $E_T$, Tglu1G, $m_{\chi_1^0} = 200$ GeV

2100 95 29 Aaboud 17a ATLS $1\ell+$jets+$E_T$, Tglu1B, $m_{\chi_1^0} = 0$ GeV

1740 95 30 Aaboud 17a ATLS $1\ell+$jets+$E_T$, Tglu1E, $m_{\chi_1^0} = 0$ GeV

1800 95 31 Aaboud 17a ATLS jets+$E_T$, Tglu3A, $m_{\chi_1^0} - m_{\chi_1^0} = 5$ GeV

1800 95 32 Aaboud 17a ATLS $\geq 7$ jets+$E_T$, large R-jets and/or $b$-jets, Tglu1E, $m_{\chi_1^0} = 100$ GeV

1540 95 33 Aaboud 17a ATLS $\geq 7$ jets+$E_T$, large R-jets and/or $b$-jets, Tglu3A, $m_{\chi_1^0} = 0$ GeV

1340 95 34 Aaboud 17a ATLS 2 same-flavor, opposite-sign $\ell$ + jets + $E_T$, Tglu1H, $m_{\chi_1^0} = 0$ GeV

1310 95 35 Aaboud 17a ATLS 2 same-flavor, opposite-sign $\ell$ + jets + $E_T$, Tglu1H, $m_{\chi_1^0} = (m_{\tilde{g}} + m_{\tilde{\chi}_1^0})/2$, $m_{\chi_1^0} < 400$ GeV

1700 95 36 Aaboud 17a ATLS 2 same-flavor, opposite-sign $\ell$ + jets + $E_T$, Tglu1G, $m_{\chi_1^0} \sim 1$ GeV

1400 95 37 Khachatryan 17a CMS jets+$E_T$, Tglu1A, $m_{\chi_1^0} < 200$ GeV

1650 95 37 Khachatryan 17a CMS jets+$E_T$, Tglu2A, $m_{\chi_1^0} < 200$ GeV

1600 95 37 Khachatryan 17a CMS jets+$E_T$, Tglu3A, $m_{\chi_1^0} = 200$ GeV

1550 95 38 Khachatryan 17a ATLS jets+$b$-jets+$E_T$, Tglu3A, $m_{\chi_1^0} = 0$ GeV

1450 95 39 Khachatryan 17a ATLS jets+$b$-jets+$E_T$, Tglu3C, 200 < $m_{\chi_1^0} < 400$ GeV

1570 95 40 Khachatryan 17a ATLS 1$\ell$, Tglu3A, $m_{\chi_1^0} < 600$ GeV

1500 95 40 Khachatryan 17a ATLS 1$\ell$, Tglu3A, $m_{\chi_1^0} < 775$ GeV
>1400 95 40 KHACHATRY...17AS CMS 1ℓ, Tglu1B, $m_{\pm} = (m_{\tilde{g}} + m_{\chi_1^0})/2$, $m_{\tilde{g}} < 725$ GeV

none 1050–1350 95 40 KHACHATRY...17AS CMS 1ℓ, Tglu1B, $m_{\pm} = (m_{\tilde{g}} + m_{\chi_1^0})/2$, $m_{\tilde{g}} < 850$ GeV

>1175 95 41 KHACHATRY...17AW CMS $\geq 3\ell^{\pm}$, 2 jets, Tglu3A, $m_{\tilde{g}} = 0$ GeV

> 825 95 41 KHACHATRY...17AW CMS $\geq 3\ell^{\pm}$, 2 jets, Tglu1C, $m_{\tilde{g}} = 0$ GeV

>1350 95 42 KHACHATRY...17P CMS 1 or more jets+$E_T$, Tglu1A, $m_{\tilde{g}} = 0$ GeV

>1545 95 42 KHACHATRY...17P CMS 1 or more jets+$E_T$, Tglu2A, $m_{\tilde{g}} = 0$ GeV

>1120 95 42 KHACHATRY...17P CMS 1 or more jets+$E_T$, Tglu3A, $m_{\tilde{g}} = 0$ GeV

>1300 95 42 KHACHATRY...17P CMS 1 or more jets+$E_T$, Tglu3D, $m_{\tilde{g}} = 100$ GeV

> 780 95 42 KHACHATRY...17P CMS 1 or more jets+$E_T$, Tglu3B, $m_{\tilde{g}} = 50$ GeV

> 790 95 42 KHACHATRY...17P CMS 1 or more jets+$E_T$, Tglu3C, $m_{\tilde{g}} = 0$ GeV

>1650 95 43 KHACHATRY...17V CMS 2 $\gamma + E_T$, GGM, Tglu4B, any NLSP mass

>1900 95 44 SIRUNYAN 17AF CMS 1ℓ+jets+b-jets+$E_T$, Tglu3A, $m_{\tilde{g}} = 0$ GeV

>1600 95 44 SIRUNYAN 17AF CMS 1ℓ+jets+b-jets+$E_T$, Tglu3B, $m_{\tilde{g}} = 50$ GeV

>1800 95 45 SIRUNYAN 17AY CMS $\gamma + jets + E_T$, Tglu4B, $m_{\tilde{g}} = 0$ GeV

>1600 95 45 SIRUNYAN 17AY CMS $\gamma + jets + E_T$, Tglu4A, $m_{\tilde{g}} = 0$ GeV

>1860 95 46 SIRUNYAN 17AZ CMS $\geq 1$ jets + $E_T$, Tglu1A, $m_{\tilde{g}} = 0$ GeV

>2025 95 46 SIRUNYAN 17AZ CMS $\geq 1$ jets + $E_T$, Tglu2A, $m_{\tilde{g}} = 0$ GeV

>1900 95 46 SIRUNYAN 17AZ CMS $\geq 1$ jets + $E_T$, Tglu3A, $m_{\tilde{g}} = 0$ GeV

>1825 95 47 SIRUNYAN 17P CMS jets+$E_T$, Tglu1A, $m_{\tilde{g}} = 0$ GeV

>1950 95 47 SIRUNYAN 17P CMS jets+$E_T$, Tglu2A, $m_{\tilde{g}} = 0$ GeV

>1960 95 47 SIRUNYAN 17P CMS jets+$E_T$, Tglu3A, $m_{\tilde{g}} = 0$ GeV
jets + $E_T$, TgluIC, $m_{\chi^\pm} = m_{\chi^0}$

= \left(\frac{m_{\tilde{g}} + m_{\chi^0}}{2}\right)$, $m_{\chi^0} = 0$ GeV

jets + $E_T$, Tglu3D, $m_{\chi^\pm} = m_{\chi^0}$

+ 5 GeV, $m_{\chi^0} = 1000$ GeV

same-sign $\ell^\pm \ell^\pm$ + jets + $E_T$, Tglu3A, $m_{\chi^\pm} = m_{\chi^0} + 5$ GeV, $m_{\chi^0} = 100$ GeV

same-sign $\ell^\pm \ell^\pm$ + jets + $E_T$, Tglu3B, $m_{t_1} - m_{\chi^0} = 175$ GeV, $m_{\chi^0} = 50$ GeV

same-sign $\ell^\pm \ell^\pm$ + jets + $E_T$, Tglu3C, $m_{t_1} - m_{\chi^0} = 20$ GeV, $m_{\chi^0} = 0$ GeV

same-sign $\ell^\pm \ell^\pm$ + jets + $E_T$, Tglu1B, $m_{\chi^0} = \left(\frac{m_{\tilde{g}} + m_{\chi^0}}{2}\right)$, $m_{\chi^0} = 0$ GeV

= \left(\frac{m_{\tilde{g}} + m_{\chi^0}}{2}\right)$, $m_{\chi^0} = 200$ GeV

$\geq 2$ jets + 1 or 2 $\tau$ + $E_T$, Tglu1F, $m_{\chi^0} = 100$ GeV

$\ell^\pm + \geq 4$ jets + $E_T$, Tglu3C, $m_{t_1} - m_{\chi^0} = 5$ GeV

$\gamma + E_T$, Tglu1D, any NLSP mass

$\geq 4$ jets + $E_T$, Tglu1A, $m_{\chi^0} = 0$ GeV

$\geq 4$ jets + $E_T$, Tglu1B, $m_{\chi^0} = \left(\frac{m_{\tilde{g}} + m_{\chi^0}}{2}\right)$, $m_{\chi^0} = 200$ GeV

$\geq 3$ b-jets + $E_T$, Tglu2A, $m_{\chi^0} < 800$ GeV

$\ell, \geq 3$ b-jets + $E_T$, Tglu3A, $m_{\chi^0} < 700$ GeV

same-sign/3$\ell$ + jets + $E_T$, Tglu1D, $m_{\chi^0} < 600$ GeV

same-sign/3$\ell$ + jets + $E_T$, Tglu1E, $m_{\chi^0} < 300$ GeV

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\textgreater 1200 & 95 & 56 AAD & 16B8 ATLS & 2 same-sign $3\ell + \text{jets} + \slashed{E}_T$, Tglu3A, $m_{\tilde{\chi}_1^0} < 600$ GeV \\
\textgreater 1600 & 95 & 57 AAD & 16B8 ATLS & $1\ell, \geq 4$ jets, $\slashed{E}_T$, Tglu1B, $m_{\tilde{\chi}_1^0} = (m_{\tilde{g}} + m_{\tilde{\chi}_1^0})/2$, $m_{\chi_1^0} = 100$ GeV \\
\textgreater 1400 & 95 & 58 AAD & 16V ATLS & $\geq 7$ to $\geq 10$ jets + $\slashed{E}_T$, Tglu1E, $m_{\tilde{\chi}_1^0} < 200$ GeV \\
\textgreater 1400 & 95 & 58 AAD & 16V ATLS & $\geq 7$ to $\geq 10$ jets + $\slashed{E}_T$, pMSSM $M_1 = 60$ GeV, $M_2 = 3$ TeV, $\tan\beta = 10$, $\mu < 0$ \\
\textgreater 1100 & 95 & 59 KHACHATRY...16AM CMS & boosted $W+b$, Tglu3C, $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} < 80$ GeV, $m_{\tilde{\chi}_1^0} < 400$ GeV \\
\textgreater 700 & 95 & 59 KHACHATRY...16AM CMS & boosted $W+b$, Tglu3B, $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} = 175$ GeV, $m_{\tilde{\chi}_1^0} = 0$ GeV \\
\textgreater 1050 & 95 & 60 KHACHATRY...16BJ CMS & same-sign $\ell^\pm \ell^\pm$, Tglu3A, $m_{\tilde{\chi}_1^0} < 800$ GeV \\
\textgreater 1300 & 95 & 60 KHACHATRY...16BJ CMS & same-sign $\ell^\pm \ell^\pm$, Tglu3A, $m_{\tilde{\chi}_1^0} = 0$ \\
\textgreater 1140 & 95 & 60 KHACHATRY...16BJ CMS & same-sign $\ell^\pm \ell^\pm$, Tglu3B, $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} = 20$ GeV, $m_{\tilde{\chi}_1^0} = 0$ \\
\textgreater 850 & 95 & 60 KHACHATRY...16BJ CMS & same-sign $\ell^\pm \ell^\pm$, Tglu3B, $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} = 20$ GeV, $m_{\tilde{\chi}_1^0} < 700$ GeV \\
\textgreater 950 & 95 & 60 KHACHATRY...16BJ CMS & same-sign $\ell^\pm \ell^\pm$, Tglu3D, $m_{\tilde{\chi}_1^0}$ \\
& & & $= m_{\tilde{\chi}_1^0} + 5$ GeV \\
\textgreater 1100 & 95 & 60 KHACHATRY...16BJ CMS & same-sign $\ell^\pm \ell^\pm$, Tglu1B, $m_{\tilde{\chi}_1^0}$ \\
& & & $= 0.5(m_{\tilde{g}} + m_{\tilde{\chi}_1^0}), m_{\tilde{\chi}_1^0} < 400$ GeV \\
\textgreater 830 & 95 & 60 KHACHATRY...16BJ CMS & same-sign $\ell^\pm \ell^\pm$, Tglu1B, $m_{\tilde{\chi}_1^0}$ \\
& & & $= 0.5(m_{\tilde{g}} + m_{\tilde{\chi}_1^0}), m_{\tilde{\chi}_1^0} < 700$ GeV \\
\textgreater 1300 & 95 & 60 KHACHATRY...16BJ CMS & same-sign $\ell^\pm \ell^\pm$, Tglu3B, $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} = m_{\tilde{t}_1}, m_{\tilde{\chi}_1^0} = 0$ \\
\textgreater 1050 & 95 & 60 KHACHATRY...16BJ CMS & same-sign $\ell^\pm \ell^\pm$, Tglu3B, $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} = m_{\tilde{t}_1}, m_{\tilde{\chi}_1^0} < 800$ GeV \\
\textgreater 1725 & 95 & 61 KHACHATRY...16BS CMS & jets + $\slashed{E}_T$, Tglu1A, $m_{\tilde{\chi}_1^0} = 0$ \\
\textgreater 1750 & 95 & 61 KHACHATRY...16BS CMS & jets + $\slashed{E}_T$, Tglu2A, $m_{\tilde{\chi}_1^0} = 0$ \\
\textgreater 1550 & 95 & 61 KHACHATRY...16BS CMS & jets + $\slashed{E}_T$, Tglu3A, $m_{\tilde{\chi}_1^0} = 0$ \\
\textgreater 1280 & 95 & 62 KHACHATRY...16BY CMS & opposite-sign $\ell^\pm \ell^\pm$, Tglu4C, $m_{\tilde{\chi}_1^0} = 1000$ GeV \\
\textgreater 1030 & 95 & 62 KHACHATRY...16BY CMS & opposite-sign $\ell^\pm \ell^\pm$, Tglu4C, $m_{\tilde{\chi}_1^0} = 0$ GeV \\
\textgreater 1440 & 95 & 63 KHACHATRY...16V CMS & jets + $\slashed{E}_T$, Tglu1A, $m_{\tilde{\chi}_1^0} = 0$
$\eta > 1600$ 95 63 KHACHATRY...16v CMS 
jets + $E_T$, Tglu2A, $m_{\chi_1}^0 = 0$

$\eta > 1550$ 95 63 KHACHATRY...16v CMS 
jets + $E_T$, Tglu3A, $m_{\chi_1}^0 = 0$

$\eta > 1450$ 95 63 KHACHATRY...16v CMS 
jets + $E_T$, Tglu1C, $m_{\chi_1}^0 = 0$

$\eta > 820$ 95 64 AAD 15BG ATLS 
GGM, $\bar{g} \rightarrow q\bar{q}Z\bar{G}$, $\tan\beta = 30$, $\mu > 600$ GeV

$\eta > 850$ 95 64 AAD 15BG ATLS 
GGM, $\bar{g} \rightarrow q\bar{q}Z\bar{G}$, $\tan\beta = 1.5$, $\mu > 450$ GeV

$\eta > 1150$ 95 65 AAD 15BV ATLS 
general RPC $\bar{g}$ decays, $m_{\chi_1}^0 <$

$\eta > 700$ 95 66 AAD 15BX ATLS 
$g \rightarrow X\chi_1^0$, independent of $m_{\chi_1}^0$

$\eta > 1290$ 95 67 AAD 15CA ATLS 
$\geq 2 \gamma + E_T$, GGM, bino-like NLSP, any NLSP mass

$\eta > 1260$ 95 67 AAD 15CA ATLS 
$\geq 1 \gamma + b$-jets + $E_T$, GGM, higgsino-bino admixture NLSP, and $\mu < 0$, $m(NLSP) > 450$ GeV

$\eta > 1140$ 95 67 AAD 15CA ATLS 
$\geq 1 \gamma + $ jets + $E_T$, GGM, higgsino-bino admixture NLSP, all $\mu > 0$

$\eta > 1225$ 95 68 KHACHATRY...15AF CMS 
$\bar{g} \rightarrow q\bar{q}\chi_1^0$, $m_{\chi_1}^0 = 0$

$\eta > 1300$ 95 68 KHACHATRY...15AF CMS 
$\bar{g} \rightarrow b\bar{b}\chi_1^0$, $m_{\chi_1}^0 = 0$

$\eta > 1225$ 95 68 KHACHATRY...15AF CMS 
$\bar{g} \rightarrow t\bar{t}\chi_1^0$, $m_{\chi_1}^0 = 0$

$\eta > 1550$ 95 68 KHACHATRY...15AF CMS 
CMSSM, $\tan\beta = 30$, $m_{\tilde{q}} = m_{\tilde{q}}$, $A_0 = -2\max(m_0,m_{1/2})$, $\mu > 0$

$\eta > 1150$ 95 68 KHACHATRY...15AF CMS 
CMSSM, $\tan\beta = 30$, $A_0 = -2\max(m_0,m_{1/2})$, $\mu > 0$

$\eta > 1280$ 95 69 KHACHATRY...15l CMS 
$\bar{g} \rightarrow t\bar{t}\chi_1^0$, $m_{\chi_1}^0 = 0$

$\eta > 1310$ 95 70 KHACHATRY...15X CMS 
$\bar{g} \rightarrow b\bar{b}\chi_1^0$, $m_{\chi_1}^0 = 100$ GeV

$\eta > 1175$ 95 70 KHACHATRY...15X CMS 
$\bar{g} \rightarrow t\bar{t}\chi_1^0$, $m_{\chi_1}^0 = 100$ GeV

$\eta > 1330$ 95 71 AAD 14AE ATLS 
jets + $E_T$, $\tilde{g} \rightarrow q\bar{q}\chi_1^0$ simplified model, $m_{\chi_1}^0 = 0$ GeV

$\eta > 1700$ 95 71 AAD 14AE ATLS 
jets + $E_T$, mSUGRA/CMSSM, $m_{\tilde{g}} = m_{\tilde{g}}$

$\eta > 1090$ 95 72 AAD 14AG ATLS 
$\tau$ + jets + $E_T$, natural Gauge Mediation

$\eta > 1600$ 95 72 AAD 14AG ATLS 
$\tau$ + jets + $E_T$, mGMSB, $M_{mess} = 250$ GeV, $N_5 = 3$, $\mu > 0$, $C_{grav} = 1$

$\eta > 640$ 95 73 AAD 14X ATLS 
$\geq 4\ell^\pm$, $\tilde{g} \rightarrow q\bar{q}\chi_1^0$, $m_{\chi_1}^0 \rightarrow$

$\eta > 1000$ 95 74 CHATRCHYAN14AH CMS 
jets + $E_T$, $\tilde{g} \rightarrow q\bar{q}\chi_1^0$ simplified model, $m_{\chi_1}^0 = 50$ GeV

$\eta > 1350$ 95 74 CHATRCHYAN14AH CMS 
jets + $E_T$, CMSSM, $m_{\tilde{g}} = m_{\tilde{g}}$

$\eta > 1000$ 95 75 CHATRCHYAN14AH CMS 
jets + $E_T$, $\tilde{g} \rightarrow b\bar{b}\chi_1^0$ simplified model, $m_{\chi_1}^0 = 50$ GeV
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<td>jets + $E_T$, $g \rightarrow q\bar{q}\chi_0$, simplified model, $m_{\chi_0} &lt; 100$ GeV</td>
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<td>CHATRCHYAN 14i CMS</td>
<td>$1\ell^\pm +$ jets + $≥ 2b$-jets, $g \rightarrow t\bar{t}\chi_0$, simplified model, $m_{\chi_0} = 0$ GeV, $m_t &gt; m_g$</td>
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<td>CHATRCHYAN 14R CMS</td>
<td>$≥ 3\ell^\pm$, $(g/q) \rightarrow q\ell^\pm + G$, simplified model, GMSB, slepton co-NLSP scenario</td>
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<td>AABOUD 18BJ ATLS</td>
<td>$\ell^\pm +$ jets + $E_T$, Tglu1H, $m_{\chi_0} = 1$ GeV, any $m_{\chi_0}$</td>
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<td>$≥ 7$ jets+$E_T$, large R-jets and/or b-jets, pMSSM, $m_{\chi_0} = 0$ GeV</td>
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<td>KHACHATRYAN 16AY CMS</td>
<td>$\ell^\pm +$ jets + $b$-jets + $E_T$, Tglu3A, $m_{\chi_0} = 0$ GeV</td>
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<td>AAD 15AB ATLS</td>
<td>$\bar{g} \rightarrow Sg$, $c\tau = 1$ m, $S \rightarrow S\bar{G}$ and $S \rightarrow gg$, BR = 100%</td>
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<td>1600</td>
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<td>pMSSM, $M_1 = 60$ GeV, $m_{\chi_0} &lt; 1500$ GeV</td>
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<td>87</td>
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<td>via $\tau$, natural GMSB, all $m_{\chi_0}$</td>
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<td>88</td>
<td>1330</td>
<td>AAD 15BV ATLS</td>
<td>jets + $E_T$, $\tilde{g} \rightarrow q\bar{q}\chi_0$, $m_{\chi_0} = 1$ GeV</td>
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<td>jets + $E_T$, $\tilde{g} \rightarrow g\chi_0$, $m_{\chi_0} = 1$ GeV</td>
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<td>AAD 15BV ATLS</td>
<td>jets + $E_T$, $\tilde{g} \rightarrow g\chi_0$, $m_{\chi_0} &lt; 550$ GeV</td>
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>1270  95  65  AAD  15BV ATLS  jets + \vec{E}_T, \bar{g} \rightarrow q\bar{q}W_{\chi_1^0}, m_{\chi_1^0} = 100 \text{ GeV}

>1150  95  65  AAD  15BV ATLS  jets + \ell^{\pm} \ell^{\mp} , \bar{g} \rightarrow q\bar{q}WZ_{\chi_1^0}, m_{\chi_1^0} = 100 \text{ GeV}

>1320  95  65  AAD  15BV ATLS  jets + \ell^{\pm} \ell^{\mp} , \bar{g} \text{ decays via sleptons}, m_{\chi_1^0} = 100 \text{ GeV}

>1220  95  65  AAD  15BV ATLS  \tau, \bar{q} \text{ decays via staus}, m_{\chi_1^0} = 100 \text{ GeV}

>1310  95  65  AAD  15BV ATLS  b-jets, \bar{g} \rightarrow t\bar{T}_{\chi_1^0}, m_{\chi_1^0} < 400 \text{ GeV}

>1220  95  65  AAD  15BV ATLS  b-jets, \bar{g} \rightarrow \tilde{t}_1 t and \tilde{t}_1 \rightarrow t\bar{\chi}_1^0, m_{T_1} < 1000 \text{ GeV}

>1180  95  65  AAD  15BV ATLS  b-jets, \bar{g} \rightarrow \tilde{t}_1 t and \tilde{t}_1 \rightarrow b\bar{\chi}_1^0 , m_{T_1} < 1000 \text{ GeV},

>1260  95  65  AAD  15BV ATLS  b-jets, \bar{g} \rightarrow \tilde{t}_1 t and \tilde{g} \rightarrow c\bar{\chi}_1^0

>1200  95  65  AAD  15BV ATLS  b-jets, \bar{g} \rightarrow b_1 b and \tilde{b}_1 \rightarrow b\bar{\chi}_1^0 , m_{b_1} < 1000 \text{ GeV}

>1250  95  65  AAD  15BV ATLS  b-jets, \bar{g} \rightarrow b\bar{\chi}_1^0 , m_{b_1} < 400 \text{ GeV}

none, 750–1250

>1100  95  88  AAD  15CB ATLS  jets, \bar{g} \rightarrow q\bar{q}\chi_1^0, \chi_1^0 \rightarrow Z \bar{G}, GGM, m_{\chi_1^0} = 400 \text{ GeV} and 3 < c_{\ell} < 500 \text{ mm}

>1400  95  88  AAD  15CB ATLS  jets or \vec{E}_T, \bar{g} \rightarrow q\bar{q}\chi_1^0, \text{ Split SUSY, } m_{\chi_1^0} = 100 \text{ GeV} and 15 < c_{\ell} < 300 \text{ mm}

>1500  95  88  AAD  15CB ATLS  \vec{E}_T, \bar{g} \rightarrow q\bar{q}\chi_1^0, \text{ Split SUSY, } m_{\chi_1^0} = 100 \text{ GeV} and 20 < c_{\ell} < 250 \text{ mm}

89 KHACHATRYAN...15AD CMS  \ell^{\pm} + \text{jets} + \vec{E}_T, \text{ GMSB, } \bar{g} \rightarrow q\bar{q}Z \bar{G}

>1300  95  90  KHACHATRYAN...15AZ CMS  \geq 2 \gamma, \geq 1 \text{ jet, (Razor), bino-like NLSP, } m_{\chi_1^0} = 375 \text{ GeV}

> 800  95  90  KHACHATRYAN...15AZ CMS  \geq 1 \gamma, \geq 2 \text{ jet, wino-like NLSP, } m_{\chi_1^0} = 375 \text{ GeV}

>1280  95  91  AAD  14AX ATLS  \geq 3 \text{ b-jets} + \vec{E}_T, \text{ CMSSM}

>1250  95  91  AAD  14AX ATLS  \geq 3 \text{ b-jets} + \vec{E}_T, \bar{g} \rightarrow \tilde{b}_1 b\chi_1^0, \text{ simplified model, } \tilde{b}_1 \rightarrow b\bar{\chi}_1^0, m_{\chi_1^0} = 60 \text{ GeV, } m_{\tilde{b}_1} < 900 \text{ GeV}
$\ell^\pm \ell'^\pm (\ell^\mp) + \text{jets}, \ \tilde{g} \rightarrow \tau_1 \tau_1^0$ simplified model, $\tau_1 \rightarrow t\chi_1^0$ with $m_{\tau_1} = 60 \text{ GeV}$, $m_{\chi_1^0} < 1000 \text{ GeV}$

$\geq 3 \ b$-jets + $E_T$, $\tilde{g} \rightarrow \tau_1 \tau_1^0$ simplified model, $m_{\tau_1} = 60 \text{ GeV}$, $m_{\chi_1^0} < 400 \text{ GeV}$

$\ell^\pm \ell'^\pm (\ell^\mp) + \text{jets}, \ \tilde{g} \rightarrow \tau_1 \tau_1^0$ simplified model, $m_{\chi_1^0} = 118 \text{ GeV}$, $m_{\tau_1} = 60 \text{ GeV}$

$\geq 3 \ b$-jets + $E_T$, $\tilde{g} \rightarrow \tau_1 \tau_1^0$ simplified model, $m_{\chi_1^0} = 118 \text{ GeV}$, $m_{\tau_1} = 60 \text{ GeV}$

$\ell^\pm \ell'^\pm (\ell^\mp) + \text{jets}, \ \tilde{g} \rightarrow \tau_1 \tau_1^0$ simplified model, $m_{\chi_1^0} = 118 \text{ GeV}$, $m_{\tau_1} = 60 \text{ GeV}$

$\ell^\pm \ell'^\pm (\ell^\mp) + \text{jets}, \ \tilde{g} \rightarrow q\bar{q}'\chi_1^\pm$, $\chi_1^\pm \rightarrow W^{(*)}\chi_1^0$ simplified model, $m_{\chi_1^0} = m_{\chi_1^0} + 20 \text{ GeV}$

$\ell^\pm \ell'^\pm (\ell^\mp) + \text{jets}, \ \tilde{g} \rightarrow q\bar{q}'\chi_1^\pm$, $\chi_1^\pm \rightarrow W^{(*)}\chi_1^0$ simplified model, $m_{\chi_1^0} = 400 \text{ GeV}$

$\ell^\pm \ell'^\pm (\ell^\mp) + \text{jets}, \ \tilde{g} \rightarrow q\bar{q}'\chi_1^\pm$, $\chi_1^\pm \rightarrow W^{(*)}\chi_1^0$ simplified model, $m_{\chi_1^0} < 520 \text{ GeV}$

$\ell^\pm \ell'^\pm (\ell^\mp) + \text{jets}, \ \tilde{g} \rightarrow q\bar{q}'\chi_1^\pm$, $\chi_1^\pm \rightarrow W^{(*)}\chi_1^0$ simplified model, $m_{\chi_1^0} < 520 \text{ GeV}$
> 900 95 94 CHATRCHYAN 14H CMS same-sign $e^\pm e^\pm$, $\tilde{g} \rightarrow q q'$ $\tilde{\chi}_1^\pm$,

\[ \tilde{\chi}_1^\pm \rightarrow W^{\pm} \chi_1^0 \]

simplified model, $m_{\tilde{\chi}_1^\pm} = 0.5 m_{\tilde{g}}$, mass-

less $\chi_1^0$

> 1050 95 95 CHATRCHYAN 14H CMS same-sign $e^\pm e^\pm$, $\tilde{g} \rightarrow b\bar{t} \tilde{\chi}_1^\pm$.

\[ \tilde{\chi}_1^\pm \rightarrow W^{\pm} \chi_1^0 \]

simplified model, $m_{\tilde{\chi}_1^\pm} = 300$ GeV, $m_{\chi_1^0} = 50$ GeV

1 SIRUNYAN 20B searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=13$ TeV for events with at least one photon and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on chargino masses in a general gauge-mediated SUSY breaking (GGM) scenario Tchi1n12-GGM, see Figure 4. Limits are also set on the NLSP mass in the Tchi1chi1F and Tchi1chi1G simplified models, see their Figure 5. Finally, limits are set on the gluino mass in the Tglu4A simplified model, see Figure 6.

2 AABOUD 19I searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=13$ TeV in final states with hadronic jets, 1 or two hadronically decaying $\tau$ and $E_T$. In Tglu1F, gluino masses are excluded at 95% C.L. up to 2000 GeV for neutralino masses of 100 GeV or below. Neutralino masses up to 1000 GeV are excluded for all gluino masses below 1400 GeV. See their Fig. 9. Limits are also presented in the context of Gauge-Mediated Symmetry Breaking models: in this case, values of $\tan\beta$ below 110 TeV are excluded at the 95% CL for all values of $\Lambda$ in the range $2<\tan\beta<60$, see their Fig 10.

3 SIRUNYAN 19AG searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=13$ TeV for events with two photons and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu4B simplified model and on the squark mass in the Tsqk4B simplified model, see their Figure 3.

4 SIRUNYAN 19AU searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=13$ TeV for events with at least one photon, jets, some of which are identified as originating from $b$-quarks, and large $E_T$. No significant excess above the Standard Model expectations is observed. In the framework of GMSB, limits are set on the gluino mass in the Tglu4C, Tglu4D and Tglu4E simplified models, and on the top squark mass in the Tstop13 simplified model, see their Figure 5.

5 SIRUNYAN 19CE searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=13$ TeV for new particles decaying to a photon and two gluons in events with at least three large-radius jets of which two have substructure and are composed of a photon and two gluons. No statistically significant excess is observed above the SM background expectation. Upper limits at 95% confidence level on the cross section for gluino pair production are set, using a simplified Tglu1A-like stealth SUSY model. Gluino masses up to 1500-1700 GeV are excluded, depending on the neutralino mass, with the highest exclusion set for $m_{\chi_1^0} = 200$ GeV. See their Fig 4.

6 SIRUNYAN 19CH searched in 137 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=13$ TeV for events containing multiple jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu1C, Tglu2A and Tglu3A simplified models, see their Figure 13. Limits are also set on squark, sbottom and stop masses in the Tsqk1, Tsbot1, Tstop1 simplified models, see their Figure 14.

7 SIRUNYAN 19K searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=13$ TeV for events with a photon, an electron or muon, and large $E_T$. No significant excess above the Standard Model expectations is observed. In the framework of GMSB, limits are set on the chargino and neutralino mass in the Tchi1n1A simplified model, see their Figure 6. Limits are also set on the gluino mass in the Tglu4A simplified model, and on the squark mass in the Tsqk4A simplified model, see their Figure 7.
SIRUNYAN 19S searched in 35.9 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for events with zero or one charged leptons, jets and \(E_T\). The razor variables (\(M_R\) and \(R^2\)) are used to categorize the events. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A and Tglu3C simplified models, see Figures 22 and 23, and on the stop mass in the Tstop1 simplified model, see their Figure 24.

AABOUD 18AR searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for gluino pair production in events containing large missing transverse momentum and several energetic jets, at least three of which must be identified as originating from \(b\)-quarks. No excess is found above the predicted background. In Tglu3A models, gluino masses of less than 1.97 TeV are excluded for \(m_{\tilde{\chi}^0_1}\) below 300 GeV, see their Fig. 10(a). Interpretations are also provided for scenarios where Tglu3A modes mix with Tglu2A and Tglu3D, see their Fig. 11.

AABOUD 18AR searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for gluino pair production in events containing large missing transverse momentum and several energetic jets, at least three of which must be identified as originating from \(b\)-quarks. No excess is found above the predicted background. In Tglu2A models, gluino masses of less than 1.92 TeV are excluded for \(m_{\tilde{\chi}^0_1}\) below 600 GeV, see their Fig. 10(b). Interpretations are also provided for scenarios where Tglu2A modes mix with Tglu3A and Tglu3D, see their Fig. 11.

AABOUD 18AS searched for in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV for gluino pair production in the context of AMSB or phenomenological MSSM scenarios with wino-like LSP and long-lived charginos. Events with a disappearing track due to a low-momentum pion accompanied by at least four jets are considered. No significant excess above the Standard Model expectations is observed. Exclusion limits are set at 95% confidence level on the mass of gluinos for different chargino lifetimes. Gluino masses up to 1.65 TeV are excluded assuming a chargino mass of 460 GeV and lifetime of 0.2 ns, corresponding to a mass-splitting between the charged and neutral wino of around 160 MeV. See their Fig. 9.

AABOUD 18BJ searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV in events with two opposite-sign charged leptons (electrons and muons), jets and missing transverse momentum, with various requirements to be sensitive to signals with different kinematic endpoint values in the dilepton invariant mass distribution. The data are found to be consistent with the SM expectation. Results are interpreted in the Tglu1G model: gluino masses below 1850 GeV are excluded for \(m_{\tilde{\chi}^0_1} = 100\) GeV, see their Fig. 12(a).

AABOUD 18BJ searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV in events with two opposite-sign charged leptons (electrons and muons), jets and missing transverse momentum, with various requirements to be sensitive to signals with different kinematic endpoint values in the dilepton invariant mass distribution. The data are found to be consistent with the SM expectation. Results are interpreted in the Tglu1H model: gluino masses below 1650 GeV are excluded for \(m_{\tilde{\chi}^0_1} = 100\) GeV, see their Fig. 13(a).

AABOUD 18U searched in 36.1 fb\(^{-1}\) of \(pp\) collisions at \(\sqrt{s} = 13\) TeV in events with at least one isolated photon, possibly jets and significant transverse momentum targeting generalised models of gauge-mediated SUSY breaking. No significant excess of events is observed above the SM prediction. Results for the di-photon channel are interpreted in terms of lower limits on the masses of gluinos in Tglu4B models, which reach as high as 2.3 TeV. Gluinos with masses below 2.15 TeV are excluded for any NLSP mass, see their Fig. 8.
15 AABOUD 18U searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with at least one isolated photon, possibly jets and significant transverse momentum targeting generalised models of gauge-mediated SUSY breaking. No significant excess of events is observed above the SM prediction. Results of the $\gamma + \text{jets} + \not{p_T}$ channel are interpreted in terms of lower limits on the masses of gluinos in GGM higgsino-bino models (mix of Tglu4B and Tglu4C), which reach as high as 2050 GeV. Gluino masses below 1600 GeV are excluded for any NLSP mass provided that $m_{\tilde{g}} - m_{\tilde{\chi}^0_1} > 50$ GeV. See their Fig. 11.

16 AABOUD 18V searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with no charged leptons, jets and missing transverse momentum. The data are found to be consistent with the SM expectation. Results are interpreted in the Tglu1A model: gluino masses below 2030 GeV are excluded for massless LSP, see their Fig. 13(b).

17 AABOUD 18V searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with no charged leptons, jets and missing transverse momentum. The data are found to be consistent with the SM expectation. Results are interpreted in the Tglu1E model. Assuming that $m_{\tilde{\chi}^\pm_1} = 0.5 (m_{\tilde{g}} + m_{\tilde{\chi}^0_1})$, gluino masses below 1980 GeV are excluded for massless LSP, see their Fig. 14(c). Exclusions are also shown assuming $m_{\tilde{\chi}^0_1} = 60$ GeV, see their Fig. 14(d).

18 AABOUD 18V searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with no charged leptons, jets and missing transverse momentum. The data are found to be consistent with the SM expectation. Results are interpreted in the Tglu3A and Tglu1B simplified models, see their Figure 5. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A and Tglu1B simplified models, see their Figure 5. Limits are also set on the sbottom mass in the Tsbot2 simplified model, see their Figure 6, and on the stop mass in the Tstop7 simplified model, see their Figure 7.

19 SIRUNYAN 18A searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least one photon and large $\not{p_T}$. No significant excess above the Standard Model expectations is observed. Limits are set on wino masses in a general gauge-mediated SUSY breaking (GGM) scenario with bino-like $\tilde{\chi}^0_1$ and wino-like $\tilde{\chi}^\pm_1$ and $\tilde{\chi}_2^0$, see Figure 7. Limits are also set on the NLSP mass in the Tchi1n1A and Tchi1chi1A simplified models, see their Figure 8. Finally, limits are set on the gluino mass in the Tglu4A and Tglu4B simplified models, see their Figure 9, and on the squark mass in the Tskq4A and Tskq4B simplified models, see their Figure 10.

20 SIRUNYAN 18AC searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with a single electron or muon and multiple jets. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A and Tglu1B simplified models, see their Figure 5.

21 SIRUNYAN 18AL searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least three charged leptons, in any combination of electrons and muons, jets and significant $\not{p_T}$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A and Tglu1C simplified models, see their Figure 5. Limits are also set on the sbottom mass in the Tsbot2 simplified model, see their Figure 6, and on the stop mass in the Tstop7 simplified model, see their Figure 7.

22 SIRUNYAN 18AR searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing two opposite-charge, same-flavour leptons (electrons or muons), jets and $\not{p_T}$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu4C simplified model, see their Figure 7. Limits are also set on the chargino/neutralino mass in the Tchi1n2F simplified models, see their Figure 8, and on the higgsino mass in the Th1n1B and Th1n1C simplified models, see their Figure 9. Finally, limits are set on the sbottom mass in the Tsbot3 simplified model, see their Figure 10.
23 SIRUNYAN 18AY searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing one or more jets and significant $E_T^{miss}$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A and Tglu3A simplified models, see their Figure 3. Limits are also set on squark, sbottom and stop masses in the Tsqk1, Tsbot1, Tstop1 and Tstop4 simplified models, see their Figure 3. Finally, limits are set on long-lived gluino masses in a Tglu1A simplified model where the gluino is metastable or long-lived with proper decay lengths in the range $10^{-3}$ mm $< \tau < 10^5$ mm, see their Figure 4.

24 SIRUNYAN 18B searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing identified hadronically decaying top quarks, no leptons, and $E_T^{miss}$. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1 simplified model, see their Figure 8, and on the gluino mass in the Tglu3A, Tglu3B, Tglu3C and Tglu3E simplified models, see their Figure 9.

25 SIRUNYAN 18M searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one or more high-momentum Higgs bosons, decaying to pairs of $b$-quarks, and large $E_T^{miss}$. No significant excess above the Standard Model expectations is observed. Limits up to 1.75 TeV are set on the gluino mass in Tglu3A simplified models in case of off-shell top squarks and for $m_{\tilde{\chi}^0_1} = 100$ GeV. See their Figure 4(a).

26 AABOUD 17AJ searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two same-sign or three leptons, jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 1.57 TeV are set on the gluino mass in Tglu1E simplified models (2-step models) for $m_{\tilde{\chi}^0_1} = 100$ GeV. See their Figure 4(c).

27 AABOUD 17AJ searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with same-sign or three leptons, jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 1.86 TeV are set on the gluino mass in Tglu1G simplified models for $m_{\tilde{\chi}^0_1} = 200$ GeV. See their Figure 4(c).

28 AABOUD 17AR searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one isolated lepton, at least two jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 2.1 TeV are set on the gluino mass in Tglu1B simplified models, with $x = (m_{\tilde{\chi}^0_1} - m_{\tilde{\chi}^0_1}) / (m_\chi - m_{\tilde{\chi}^0_1})$ = 1/2. Similar limits are obtained for variable $x$ and fixed neutralino mass, $m_{\tilde{\chi}^0_1} = 60$ GeV. See their Figure 13.

29 AABOUD 17AR searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one isolated lepton, at least two jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 1.74 TeV are set on the gluino mass in Tglu1E simplified model. Limits up to 1.7 TeV are also set on pMSSM models leading to similar signal event topologies. See their Figure 13.

30 AABOUD 17AY searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least four jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 1.8 TeV are set on the gluino mass in Tglu3A simplified models assuming $m_{\tilde{\chi}^0_1} - m_{\tilde{\chi}^0_1} = 5$ GeV. See their Figure 13.

31 AABOUD 17AZ searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least seven jets and large missing transverse momentum. Selected events are further classified based on the presence of large R-jets or b-jets and no leptons. No significant excess above the Standard Model expectations is observed. Limits up to 1.8 TeV are set on the gluino mass in Tglu1E simplified models. See their Figure 6b.
33 AABOUD 17AZ searched in 36.1 fb⁻¹ of pp collisions at √s = 13 TeV for events with at least seven jets and large missing transverse momentum. Selected events are further classified based on the presence of large R-jets or b-jets and no leptons. No significant excess above the Standard Model expectations is observed. Limits up to 1.54 TeV are set on the gluino mass in Tglu3A simplified models. See their Figure 7a.

34 AABOUD 17n searched in 14.7 fb⁻¹ of pp collisions at √s = 13 TeV in final states with 2 same-flavor, opposite-sign leptons (electrons or muons), jets and large missing transverse momentum. In Tglu1J models, gluino masses are excluded at 95% C.L. up to 1300 GeV for mχ₀⁻ = 0 GeV and mχ₀⁺ = 1100 GeV. See their Fig. 12 for exclusion limits as a function of mχ₀⁻. Limits are also presented assuming mχ₀⁻ = mχ₀⁺ + 100 GeV, see their Fig. 13.

35 AABOUD 17n searched in 14.7 fb⁻¹ of pp collisions at √s = 13 TeV in final states with 2 same-flavor, opposite-sign leptons (electrons or muons), jets and large missing transverse momentum. In Tglu1H models, gluino masses are excluded at 95% C.L. up to 1310 GeV for mχ₀⁻ < 400 GeV and assuming mχ₀⁻ = (mχ₀⁺ + mχ₀⁻)/2. See their Fig. 15.

36 AABOUD 17n searched in 14.7 fb⁻¹ of pp collisions at √s = 13 TeV in final states with 2 same-flavor, opposite-sign leptons (electrons or muons), jets and large missing transverse momentum. In Tglu1G models, gluino masses are excluded at 95% C.L. up to 1700 GeV for small mχ₀⁻. The results probe kinematic endpoints as small as mχ₀⁻ - mχ₁⁻ = (mχ₂⁻ - mχ₀⁻)/2 = 50 GeV. See their Fig. 14.

37 KHACHATRYAN 17 searched in 2.3 fb⁻¹ of pp collisions at √s = 13 TeV for events containing four or more jets, no more than one lepton, and missing transverse momentum, using the razor variables (MR and R²) to discriminate between signal and background processes. No evidence for an excess over the expected background is observed. Limits are derived on the gluino mass in the Tglu1A, Tglu2A and Tglu3A simplified models, see Figs. 16 and 17. Also, assuming gluinos decay only via three-body processes involving third-generation quarks plus a neutralino/chargino, and assuming mχ₂⁻ = mχ₁⁻ + 5 GeV, a branching ratio-independent limit on the gluino mass is given, see Fig. 16.

38 KHACHATRYAN 17AD searched in 2.3 fb⁻¹ of pp collisions at √s = 13 TeV for events containing at least four jets (including b-jets), missing transverse momentum and tagged top quarks. No evidence for an excess over the expected background is observed. Gluino masses up to 1550 GeV and neutralino masses up to 900 GeV are excluded at 95% C.L. See Fig. 13.

39 KHACHATRYAN 17AD searched in 2.3 fb⁻¹ of pp collisions at √s = 13 TeV for events containing at least four jets (including b-jets), missing transverse momentum and tagged top quarks. No evidence for an excess over the expected background is observed. Gluino masses up to 1450 GeV and neutralino masses up to 820 GeV are excluded at 95% C.L. See Fig. 13.

40 KHACHATRYAN 17AS searched in 2.3 fb⁻¹ of pp collisions at √s = 13 TeV for events with a single electron or muon and multiple jets. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A and Tglu1B simplified models, see their Fig. 7.

41 KHACHATRYAN 17AV searched in 2.3 fb⁻¹ of pp collisions at √s = 13 TeV for events with at least three charged leptons, in any combination of electrons and muons, and significant ET. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A and Tglu1C simplified models, and on the sbottom mass in the Tsb1C simplified model, see their Figure 4.

42 KHACHATRYAN 17P searched in 2.3 fb⁻¹ of pp collisions at √s = 13 TeV for events with one or more jets and large ET. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A, Tglu3A, Tglu3B, Tglu3C, Tglu3D simplified models, see their Figures 7 and 8. Limits are also set on the squark mass in the Tsqk1 simplified model, see their Fig. 7, and on the sbottom mass in the Tsb1 simplified model, see Fig. 8. Finally, limits are set on
the stop mass in the Tstop1, Tstop3, Tstop4, Tstop6 and Tstop7 simplified models, see Fig. 8.

43. KHACHATRYAN 17V searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with two photons and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino and squark mass in the context of general gauge mediation models Tglu4B and Tsqk4, see their Fig. 4.

44. SIRUNYAN 17AF searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with at least one photon, jets, including at least one jet originating from a $b$-quark, and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A, Tglu3A simplified models, see their Figures 6. Limits are also set on the squark mass in the Tsqk1 simplified model (for single light squark and for 8 degenerate light squarks), on the sbottom mass in the Tstop1 simplified model and on the stop mass in the Tstop1 simplified model, see their Fig. 7. Finally, limits are set on the stop mass in the Tstop2, Tstop4 and Tstop8 simplified models, see Fig. 8.

45. SIRUNYAN 17AY searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with at least one photon, jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A, Tglu3A simplified models, see their Figures 6. Limits are also set on the squark mass in the Tsqk1 simplified model, on the stop mass in the Tstop1 simplified model, and on the sbottom mass in the Tstop1 simplified model, see Fig. 12. Limits are also set on the squark mass in the Tstop1 simplified model, on the stop mass in the Tstop1 simplified model, and on the sbottom mass in the Tstop1 simplified model, see Fig. 13.

46. SIRUNYAN 17Z searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with one or more jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A, Tglu3A simplified models, see their Figures 5 and 6, and on the sbottom mass in the Tstop2 simplified model, see their Fig. 6.

47. SIRUNYAN 17P searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with multiple jets and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A, Tglu3A and Tglu3D simplified models, see their Fig. 12. Limits are also set on the squark mass in the Tsqk1 simplified model, on the stop mass in the Tstop1 simplified model, and on the sbottom mass in the Tstop1 simplified model, see Fig. 13.

48. SIRUNYAN 17S searched in 35.9 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with two isolated same-sign leptons, jets, and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the mass of the gluino mass in the Tglu3A, Tglu3B, Tglu3C, Tglu3D and Tglu1B simplified models, see their Figures 5 and 6. Limits are also set on the mass of the gluino mass in the Tglu3A, Tglu3B, Tglu3C, Tglu3D and Tglu1B simplified models, see their Figures 5 and 6. Limits are also set on the mass of the gluino mass in the Tglu3A, Tglu3B, Tglu3C, Tglu3D and Tglu1B simplified models, see their Figures 5 and 6. Limits are also set on the mass of the gluino mass in the Tglu3A, Tglu3B, Tglu3C, Tglu3D and Tglu1B simplified models, see their Figures 5 and 6.
Standard Model expectations is observed. Gluino masses below 1510 GeV are excluded at the 95% C.L. in a simplified model with only gluinos and the lightest neutralino. See their Fig. 7b.

AABOU'D 16N searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing hadronic jets, large $E_T$, and no electrons or muons. No significant excess above the Standard Model expectations is observed. Gluino masses below 1500 GeV are excluded at the 95% C.L. in a simplified model with gluinos decaying via an intermediate $\tilde{\chi}^\pm_1$ to two quarks, a $W$ boson and a $\tilde{\chi}^0_1$, for $m_\tilde{\chi}^0_1 = 200$ GeV. See their Fig 8.

AAD 16AD searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing several energetic jets, of which at least three must be identified as $b$-jets, large $E_T$ and no electrons or muons. No significant excess above the Standard Model expectations is observed. For $\tilde{\chi}^0_1$ below 800 GeV, gluino masses below 1780 GeV are excluded at 95% C.L. for gluinos decaying via bottom squarks. See their Fig. 7a.

AAD 16AD searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events containing several energetic jets, of which at least three must be identified as $b$-jets, large $E_T$ and one electron or muon. Large-radius jets with a high mass are also used to identify highly boosted top quarks. No significant excess above the Standard Model expectations is observed. For $\tilde{\chi}^0_1$ below 700 GeV, gluino masses below 1760 GeV are excluded at 95% C.L. for gluinos decaying via top squarks. See their Fig. 7b.

AAD 16BB searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with exactly two same-sign leptons or at least three leptons, multiple hadronic jets, $b$-jets, and $E_T$. No significant excess over the Standard Model expectation is found. Exclusion limits at 95% C.L. are set on the gluino mass in various simplified models (Tglu1D, Tglu1E, Tglu3A). See their Figs. 4.a, 4.b, and 4.d.

AAD 16CG searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV in final states with one isolated electron or muon, hadronic jets, and $E_T$. The data agree with the SM background expectation in the six signal selections defined in the search, and the largest deviation is a 2.1 standard deviation excess. Gluinos are excluded at 95% C.L. up to 1600 GeV assuming they decay via the lightest chargino to the lightest neutralino as in the model Tglu1B for $m_\tilde{\chi} = 100$ GeV, assuming $m_\tilde{\chi} = (m_\tilde{g} + m_\tilde{\chi}^0_1)/2$. See their Fig. 6.

AAD 16V searched in 3.2 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with $E_T$ various hadronic jet multiplicities from $\geq 7$ to $\geq 10$ and with various $b$-jet multiplicity requirements. No significant excess over the Standard Model expectation is found. Exclusion limits at 95% C.L. are set on the gluino mass in one simplified model (Tglu1E) and a pMSSM-inspired model. See their Fig. 5.

KHACHATRYAN 16AM searched in 19.7 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 8$ TeV for events with highly boosted W-bosons and $b$-jets, using the razor variables ($M_{R_j}$ and $R^2$) to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3C and Tglu3B simplified models, see Fig. 12.

KHACHATRYAN 16BJ searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with two isolated same-sign dileptons and jets in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the following simplified models: Tglu3A and Tglu3D, see Fig. 4, Tglu3B and Tglu3C, see Fig. 5, and Tglu1B, see Fig. 7.

KHACHATRYAN 16BS searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with at least one energetic jet, no isolated leptons, and significant $E_T$, using the transverse mass variable $M_{T2}$ to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu2A and Tglu3A simplified models, see Fig. 10 and Table 3.

KHACHATRYAN 16BY searched in 2.3 fb$^{-1}$ of $p p$ collisions at $\sqrt{s} = 13$ TeV for events with two opposite-sign, same-flavour leptons, jets, and missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits are set
on the gluino mass in the Tglu4C simplified model, see Fig. 4, and on sbottom masses in the Tsbot3 simplified model, see Fig. 5.

63 KHACHATRYAN 16v searched in 2.3 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 13\) TeV for events with at least four energetic jets and significant \(\not{E}_T\), no identified isolated electron or muon or charged track. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu1A, Tglu1C, Tglu2A, and Tglu3A simplified models, see Fig. 8.

64 AAD 15BG searched in 20.3 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 8\) TeV for events with jets, missing \(\not{E}_T\), and two opposite-sign same flavor isolated leptons featuring either a kinematic edge, or a peak at the Z-boson mass, in the invariant mass spectrum. No evidence for a statistically significant excess over the expected SM backgrounds are observed and 95% C.L. exclusion limits are derived in a GGM simplified model of gluino pair production where the gluino decays into quarks, a Z-boson, and a massless gravitino LSP, see Fig. 12. Also, limits are set in simplified models with slepton/sneutrino intermediate states, see Fig. 13.

65 AAD 15BV summarized and extended ATLAS searches for gluinos and first- and second-generation squarks in final states containing jets and missing transverse momentum, with or without leptons or b-jets in the \(\sqrt{s} = 8\) TeV data set collected in 2012. The paper reports the results of new interpretations and statistical combinations of previously published analyses, as well as new analyses. Exclusion limits at 95% C.L. are set on the gluino mass in several R-parity conserving models, leading to a generalized constraint on gluino masses exceeding 1150 GeV for lightest supersymmetric particle masses below 100 GeV. See their Figs. 10, 19, 20, 21, 23, 25, 26, 29-37.

66 AAD 15BX interpreted the results of a wide range of ATLAS direct searches for supersymmetry, during the first run of the LHC using the \(\sqrt{s} = 7\) TeV and \(\sqrt{s} = 8\) TeV data set collected in 2012, within the wider framework of the phenomenological MSSM (pMSSM). The integrated luminosity was up to 20.3 fb\(^{-1}\). From an initial random sampling of 500 million pMSSM points, generated from the 19-parameter pMSSM, a total of 310,327 model points with \(\chi_{1}^0\) LSP were selected each of which satisfies constraints from previous collider searches, precision measurements, cold dark matter energy density measurements and direct dark matter searches. The impact of the ATLAS Run 1 searches on this space was presented, considering the fraction of model points surviving, after projection into two-dimensional spaces of sparticle masses. Good complementarity is observed between different ATLAS analyses, with almost all showing regions of unique sensitivity. ATLAS searches have good sensitivity at LSP mass below 800 GeV.

67 AAD 15CA searched in 20.3 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 8\) TeV for events with one or more photons, hadronic jets or b-jets and \(\not{E}_T\). No significant excess above the Standard Model expectations is observed. Limits are set on gluino masses in the general gauge-mediated SUSY breaking model (GGM), for bino-like or higgsino-bino admixtures NLSP, see Figs. 8, 10, 11.

68 KHACHATRYAN 15AF searched in 19.5 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 8\) TeV for events with at least two energetic jets and significant \(\not{E}_T\), using the transverse mass variable \(M_{T2}\) to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in simplified models where the decay \(\tilde{g} \rightarrow q\chi_{1}^0\) takes place with a branching ratio of 100%, see Fig. 13(a), or where the decay \(\tilde{g} \rightarrow b\chi_{1}^0\) takes place with a branching ratio of 100%, see Fig. 13(b), or where the decay \(\tilde{g} \rightarrow t\chi_{1}^0\) takes place with a branching ratio of 100%, see Fig. 13(c). See also Table 5. Exclusions in the CMSSM, assuming \(\tan\beta = 30, A_0 = -2 \max(m_0, m_{1/2})\) and \(\mu > 0\), are also presented, see Fig. 15.

69 KHACHATRYAN 15I searched in 19.5 fb\(^{-1}\) of pp collisions at \(\sqrt{s} = 8\) TeV for events in which b-jets and four W-bosons are produced. Five individual search channels are combined (fully hadronic, single lepton, same-sign dilepton, opposite-sign dilepton, multilepton). No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in a simplified model where the decay \(\tilde{g} \rightarrow t\chi_{1}^0\) takes
place with a branching ratio of 100%, see Fig. 5. Also a simplified model with gluinos decaying into on-shell top squarks is considered, see Fig. 6.

KHACHATRYAN 15x searched in 19.3 fb^{-1} of pp collisions at \( \sqrt{s} = 8 \) TeV for events with at least two energetic jets, at least one of which is required to originate from a b quark, and significant \( E_T \), using the razor variables \( (M_R) \) and \( R^2 \) to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in simplified models where the decay \( \tilde{g} \rightarrow b\tilde{\chi}^0_1 \) and the decay \( \tilde{g} \rightarrow t\tilde{\chi}^0_1 \) take place with branching ratios varying between 0, 50 and 100%, see Figs. 13 and 14.

AAD 14AE searched in 20.3 fb^{-1} of pp collisions at \( \sqrt{s} = 8 \) TeV for strongly produced supersymmetric particles in events containing jets and large missing transverse momentum, and no electrons or muons. No excess over the expected SM background is observed. Exclusion limits are derived in simplified models containing gluinos and squarks, see Figures 5, 6 and 7. Limits are also derived in the mSUGRA/CMSSM with parameters \( \tan\beta = 30, A_0 = -2 m_0 \) and \( \mu > 0 \), see their Fig. 8.

AAD 14AG searched in 20.3 fb^{-1} of pp collisions at \( \sqrt{s} = 8 \) TeV for events containing one hadronically decaying \( \tau \)-lepton, zero or one additional light leptons (electrons or muons), jets and large missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set in several SUSY scenarios. For an interpretation in the minimal GMSB model, see their Fig. 8. For an interpretation in the mSUGRA/CMSSM with parameters \( \tan\beta = 30, A_0 = -2 m_0 \) and \( \mu > 0 \), see their Fig. 9. For an interpretation in the framework of natural Gauge Mediation, see Fig. 10. For an interpretation in the bRPV scenario, see their Fig. 11.

AAD 14x searched in 20.3 fb^{-1} of pp collisions at \( \sqrt{s} = 8 \) TeV for events with at least four leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in a general gauge-mediation model (GGM) where the decay \( \tilde{g} \rightarrow q\tilde{\chi}^0_1 \), with \( \tilde{\chi}^0_1 \rightarrow \ell\pm\ell^\mp\tilde{G} \), takes place with a branching ratio of 100%, for two choices of \( \tan\beta = 1.5 \) and 30, see Fig. 11. Also some constraints on the higgsino mass parameter \( \mu \) are discussed.

CHATRCHYAN 14AH searched in 4.7 fb^{-1} of pp collisions at \( \sqrt{s} = 7 \) TeV for events with at least two energetic jets and significant \( E_T \), using the razor variables \( (M_R) \) and \( R^2 \) to discriminate between signal and background processes. No significant excess above the Standard Model expectations is observed. Limits are set on sbottom masses in simplified models where the decay \( \tilde{g} \rightarrow q\tilde{\chi}^0_1 \) takes place with a branching ratio of 100%, see Fig. 28. Exclusions in the CMSSM, assuming \( \tan\beta = 10, A_0 = 0 \) and \( \mu > 0 \), are also presented, see Fig. 26.

CHATRCHYAN 14AH searched in 4.7 fb^{-1} of pp collisions at \( \sqrt{s} = 7 \) TeV for events with at least two energetic jets and significant \( E_T \), using the razor variables \( (M_R) \) and \( R^2 \) to discriminate between signal and background processes. A second analysis requires at least one of the jets to be originating from a b-quark. No significant excess above the Standard Model expectations is observed. Limits are set on sbottom masses in simplified models where the decay \( \tilde{g} \rightarrow b\tilde{\chi}^0_1 \) takes place with a branching ratio of 100%, see Figs. 28 and 29. Exclusions in the CMSSM, assuming \( \tan\beta = 10, A_0 = 0 \) and \( \mu > 0 \), are also presented, see Fig. 26.

CHATRCHYAN 14AH searched in 4.7 fb^{-1} of pp collisions at \( \sqrt{s} = 7 \) TeV for events with at least two energetic jets and significant \( E_T \), using the razor variables \( (M_R) \) and \( R^2 \) to discriminate between signal and background processes. A second analysis requires at least one of the jets to be originating from a b-quark. No significant excess above the Standard Model expectations is observed. Limits are set on sbottom masses in simplified models where the decay \( \tilde{g} \rightarrow t\tilde{\chi}^0_1 \) takes place with a branching ratio of 100%, see Figs. 28 and 29. Exclusions in the CMSSM, assuming \( \tan\beta = 10, A_0 = 0 \) and \( \mu > 0 \), are also presented, see Fig. 26.

CHATRCHYAN 14i searched in 19.5 fb^{-1} of pp collisions at \( \sqrt{s} = 8 \) TeV for events containing multijets and large \( E_T \). No excess over the expected SM background is
observed. Exclusion limits are derived in simplified models containing gluinos that decay via $\tilde{g} \to q\tilde{\chi}_1^0$ with a 100% branching ratio, see Fig. 7b, or via $\tilde{g} \to \tau\tilde{\chi}_1^0$ with a 100% branching ratio, see Fig. 7c, or via $\tilde{g} \to q\bar{q}W/Z\tilde{\chi}_1^0$, see Fig. 7d.

78 CHATRCHYAN 14n searched in 19.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing a single isolated electron or muon and multiple jets, at least two of which are identified as originating from a $b$-quark. No significant excesses over the expected SM backgrounds are observed. The results are interpreted in three simplified models of gluino pair production with subsequent decay into virtual or on-shell top squarks, where each of the top squarks decays in turn into a top quark and a $\tilde{\chi}_1^0$, see Fig. 4. The models differ in which masses are allowed to vary.

79 CHATRCHYAN 14r searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least three leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in a slepton co-NLSP simplified model (GMSB) where the decay $\tilde{g} \to q\ell^\pm \ell^\mp G$ takes place with a branching ratio of 100%, see Fig. 8.

80 CHATRCHYAN 14r searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least three leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in a simplified model where the decay $\tilde{g} \to t\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, see Fig. 11.

81 AABOUD 18Bj searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with two opposite-sign charged leptons (electrons and muons), jets and missing transverse momentum, with various requirements to be sensitive to signals with different kinematic endpoint values in the dilepton invariant mass distribution. The data are found to be consistent with the SM expectation. Results are interpreted in the Tglu1H model in case of $m_{\tilde{\chi}_1^0} = 1$ GeV: for any $m_{\tilde{\chi}_2^0}$, gluino masses below 1500 GeV are excluded, see their Fig. 14(a).

82 AABOUD 18B searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV in events with no charged leptons, jets and missing transverse momentum. The data are found to be consistent with the SM expectation. Results are interpreted in a Tglu1C-like model, assuming 50% BR for each gluino decay mode. Gluino masses below 1770 GeV are excluded for any $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$ and $m_{\tilde{\chi}_1^0} = 60$ GeV, see their Fig. 16(b).

83 AABOUD 17AZ searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least seven jets and large missing transverse momentum. Selected events are further classified based on the presence of large R-jets or $b$-jets and no leptons. No significant excess above the Standard Model expectations is observed. Limits are set for pMSSM models with $M_1 = 60$ GeV, $\tan(\beta) = 10$, $\mu < 0$ varying the soft-breaking parameters $M_3$ and $\mu$. Gluino masses up to 1600 GeV are excluded for $m_{\tilde{\chi}_1^\pm} = 200$ GeV. See their Fig. 6a and text for details on the model.

84 KHACHATRYAN 16AY searched in 2.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one isolated high transverse momentum lepton ($\ell$ or $\mu$), hadronic jets of which at least one is identified as coming from a $b$-quark, and large $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tglu3A simplified model, see Fig. 10, and in the Tglu3B model, see Fig. 11.

85 KHACHATRYAN 16BT performed a global Bayesian analysis of a wide range of CMS results obtained with data samples corresponding to 5.0 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV and in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV. The set of searches considered, both individually and in combination, includes those with all-hadronic final states, same-sign and opposite-sign dileptons, and multi-lepton final states. An interpretation was given in a scan of the 19-parameter pMSSM. No scan points with a gluino mass less than 500 GeV survived and 98% of models with a squark mass less than 300 GeV were excluded.
AAD 15AB searched for the decay of neutral, weakly interacting, long-lived particles in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=8$ TeV. Signal events require at least two reconstructed vertices possibly originating from long-lived particles decaying to jets in the inner tracking detector and muon spectrometer. No significant excess of events over the expected background was found. Results were interpreted in Stealth SUSY benchmark models where a pair of gluinos to long-lived singlinos, $\tilde{S}$, which in turn each decay to a low-mass gravitino and a pair of jets. The 95% confidence-level limits are set on the cross section $\times$ branching ratio for the decay $\tilde{g} \rightarrow \tilde{S}g$, as a function of the singlino proper lifetime $(\tau)$. See their Fig. 10(f).

AAD 15AI searched in 20 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=8$ TeV for events containing at least one isolated lepton (electron or muon), jets, and large missing transverse momentum. No excess of events above the expected level of Standard Model background was found. Exclusion limits at 95% C.L. are set on the gluino mass in the CMSSM/mSUGRA, see Fig. 15, in the NUHMG, see Fig. 16, and in various simplified models, see Figs. 18–22.

AAD 15CB searched for events containing at least one long-lived particle that decays at a significant distance from its production point (displaced vertex, DV) into two leptons or into five or more charged particles in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=8$ TeV. The dilepton signature is characterised by DV formed from at least two lepton candidates. Four different final states were considered for the multitrack signature, in which the DV must be accompanied by a high-transverse momentum muon or electron candidate that originates from the DV, jets or missing transverse momentum. No events were observed in any of the signal regions. Results were interpreted in SUSY scenarios involving $R$-parity violation, split supersymmetry, and gauge mediation. See their Fig. 12–20.

KHACHATRYAN 15AD searched in 19.4 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=8$ TeV for events with two opposite-sign same flavor isolated leptons featuring either a kinematic edge, or a peak at the Z-boson mass, in the invariant mass spectrum. No evidence for a statistically significant excess over the expected SM backgrounds is observed and 95% C.L. exclusion limits are derived in a simplified model of gluino pair production where the gluino decays into quarks, a Z-boson, and a massless gravitino LSP, see Fig. 9.

KHACHATRYAN 15AZ searched in 19.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=8$ TeV for events with either at least one photon, hadronic jets and $E_T^\gamma$ (single photon channel) or with at least two photons and at least one jet and using the razor variables. No significant excess above the Standard Model expectations is observed. Limits are set on gluino masses in the general gauge-mediated SUSY breaking model (GGM), for both a bino-like and wino-like neutralino NLSP scenario, see Fig. 8 and 9.

AAD 14AX searched in 20.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=8$ TeV for the strong production of supersymmetric particles in events containing either zero or at least one high $p_T$ lepton, large missing transverse momentum, high jet multiplicity and at least three jets identified as originating from $b$-quarks. No excess over the expected SM background is observed. Limits are derived in mSUGRA/CMSSM models with $\tan\beta=30$, $A_0=\pm 2m_0$ and $\mu > 0$, see their Fig. 14. Also, exclusion limits in simplified models containing gluinos and scalar top and bottom quarks are set, see their Figures 12, 13.

AAD 14E searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s}=8$ TeV for strongly produced supersymmetric particles in events containing jets and two same-sign leptons or three leptons. The search also utilises jets originating from $b$-quarks, missing transverse momentum and other variables. No excess over the expected SM background is observed. Exclusion limits are derived in simplified models containing gluinos and squarks, see Figures 5 and 6. In the $\tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^\pm$, $\tilde{\chi}_1^\pm \rightarrow W(\pm)\tilde{\chi}_2^0$, $\tilde{\chi}_2^0 \rightarrow Z(\pm)\tilde{\chi}_1^0$ simplified model, the following assumptions have been made: $m_{\tilde{\chi}_1^\pm} = 0.5 m_{\tilde{g}}$, $m_{\tilde{\chi}_2^0} = 0.5 (m_{\tilde{\chi}_1^0} + m_{\tilde{\chi}_2^0})$, $m_{\tilde{\chi}_1^0} < 520$ GeV. In the $\tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^\pm$, $\tilde{\chi}_1^\pm \rightarrow \ell^\pm \nu\tilde{\chi}_1^0$ or $\tilde{g} \rightarrow q\bar{q}\tilde{\chi}_2^0$, $\tilde{\chi}_2^0 \rightarrow \ell^\pm \nu\tilde{\chi}_1^0$ simplified model, the following assumptions have been made: $m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0} = 0.5 (m_{\tilde{\chi}_1^0} + m_{\tilde{\chi}_2^0})$, $m_{\tilde{\chi}_1^0} < 660$ GeV. Limits are also derived in the mSUGRA/CMSSM, bRPV and GMSB models, see their Fig. 8.
93 CHATRCHYAN 14H searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with two isolated same-sign dileptons and jets in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in simplified models where the decay $\tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, or where the decay $\tilde{g} \rightarrow \tilde{b}\tilde{b} \rightarrow t\tilde{t}\tilde{\chi}_1^0$ takes place with a branching ratio of 100%, with varying mass of the $\tilde{\chi}_1^0$, or where the decay $\tilde{g} \rightarrow \tilde{b}\tilde{b} \rightarrow t\tilde{t}\tilde{\chi}_1^0 \rightarrow W^\pm \chi_1^0$ takes place with a branching ratio of 100%, with varying mass of the $\chi_1^0$, see Fig. 5.

94 CHATRCHYAN 14H searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with two isolated same-sign dileptons and jets in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in simplified models where the decay $\tilde{g} \rightarrow q\tilde{q}^{\pm} \tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow W^\pm \chi_1^0$ takes place with a branching ratio of 100%, with varying mass of the $\tilde{\chi}_1^\pm$ and $\chi_1^0$, see Fig. 7.

95 CHATRCHYAN 14H searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with two isolated same-sign dileptons and jets in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in simplified models where the decay $\tilde{g} \rightarrow b\tilde{b} \rightarrow t\tilde{t}\tilde{\chi}_1^0 \rightarrow W^\pm \chi_1^0$ takes place with a branching ratio of 100%, for two choices of $m_{\tilde{\chi}_1^0}$, see Fig. 6.

### R-parity violating heavy $\tilde{g}$ (Gluino) mass limit

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<th>DOCUMENT ID</th>
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<tr>
<td>$&gt;1500$</td>
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<td>1 SIRUNYAN</td>
<td>$\tilde{g} \rightarrow j j j$</td>
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<td>$&gt;2260$</td>
<td>95</td>
<td>2 AABOUD</td>
<td>$\geq 4\ell, \lambda_{12k} \neq 0, m_{\tilde{\chi}_1^0} &gt; 1000$</td>
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<td>95</td>
<td>2 AABOUD</td>
<td>$\tilde{g} \rightarrow j j j$</td>
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<td>$&gt;1610$</td>
<td>95</td>
<td>3 SIRUNYAN</td>
<td>$\tilde{g} \rightarrow t \tilde{t} s, \chi''_{332}$ coupling</td>
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<tr>
<td>$&gt;1690$</td>
<td>95</td>
<td>4 SIRUNYAN</td>
<td>top quark (hadronically decaying) + jets + $E_T$, Tglu3C, $m_{\tilde{\chi}<em>1^0} - m</em>{\tilde{\chi}<em>1^0} = 20$ GeV, $m</em>{\tilde{\chi}_1^0} = 0$ GeV</td>
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<td>5 SIRUNYAN</td>
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Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)
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>1280 95 18 AAD 15BV ATLS mSUGRA, $m_0 > 2$ TeV

>1100 95 18 AAD 15BV ATLS via $\tilde{\tau}$, natural GMSB, all $m_{\tilde{\tau}}$

>1220 95 18 AAD 15BV ATLS $b$-jets, $\tilde{g} \rightarrow \tilde{t}_1 t$ and $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$, $m_{\tilde{t}_1} < 1000$ GeV

>1180 95 18 AAD 15BV ATLS $b$-jets, $\tilde{g} \rightarrow \tilde{t}_1 t$ and $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$, $m_{\tilde{t}_1} < 1000$ GeV, $m_{\tilde{\chi}_1^0} = 60$ GeV

> 880 95 18 AAD 15BV ATLS jets, $\tilde{g} \rightarrow \tilde{t}_1 t$ and $\tilde{t}_1 \rightarrow s b$, $400 < m_{\tilde{t}_1} < 1000$ GeV

23 AAD 15CB ATLS $\ell, \tilde{g} \rightarrow (e/\mu)qq$, benchmark gluino, neutralino masses

> 600 95 23 AAD 15CB ATLS $\ell\ell/Z, \tilde{g} \rightarrow (e e/\mu \mu/\mu \mu)qq$, $m_{\tilde{\chi}_1^0} = 400$ GeV and $0.7 < \cos \theta_{\tilde{\chi}_1^0} < 3 \times 10^5$ mm

>1000 95 24 AAD 15X ATLS $\geq 10$ jets, $\tilde{g} \rightarrow q\tilde{\chi}_1^\pm, \chi_1^0 \rightarrow q qq$, $m_{\tilde{\chi}_1^0} = 500$ GeV

> 917 95 24 AAD 15X ATLS $\geq 6,7$ jets, $\tilde{g} \rightarrow q qq$, (light-quark, $\lambda''$ couplings)

> 929 95 24 AAD 15X ATLS $\geq 6,7$ jets, $\tilde{g} \rightarrow q qq$, (b-quark, $\lambda''$ couplings)

>1180 95 25 AAD 14AX ATLS $\geq 3 b$-jets + $E_T^{miss}, \tilde{g} \rightarrow \tilde{t}_1 t\tilde{\chi}_1^0$ simplified model, $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$, $m_{\tilde{\chi}_1^\pm} = 2m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_1^0} = 60$ GeV, $m_{\tilde{t}_1} < 1000$ GeV

> 850 95 26 AAD 14E ATLS $\ell^\pm/\ell^0(\ell^\mp) +$ jets, $\tilde{g} \rightarrow t\tilde{t}_1$ with $\tilde{t}_1 \rightarrow bs$ simplified model

> 900 95 27 CHATRCHYAN14H same-sign $\ell^\pm/\ell^0(\ell^\mp), \tilde{g} \rightarrow tbs$ simplified model

1 SIRUNYAN 19F searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for three-jet resonances produced in the decay of a gluino in R-parity violating supersymmetric models. The mass range from 200 to 2000 GeV is explored in four separate mass regions. The observations show agreement with standard model expectations. The results are interpreted within the framework of R-parity violating SUSY, where pair-produced gluinos decay to a six quark final state. Gluino masses below 1500 GeV are excluded at 95% C.L. See their Fig.5.

2 AABOUD 18Z searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing four or more charged leptons (electrons, muons and up to two hadronically decaying taus). No significant deviation from the expected SM background is observed. Limits are set on the Higgsino mass in simplified models of general gauge mediated supersymmetry Tn1n1A/Tn1n1B/Tn1n1C, see their Figure 9. Limits are also set on the wino, slepton, sneutrino and gluino mass in a simplified model of NLSP pair production with R-parity violating decays of the LSP via $\lambda_{12k}$ or $\lambda_{133}$ to charged leptons, see their Figures 7, 8.

3 SIRUNYAN 18AK searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing a single lepton, large jet and b-quark jet multiplicities, coming from R-parity violating decays of gluinos. No excess over the expected background is observed. Limits are derived on the gluino mass, assuming the RPV $\tilde{g} \rightarrow tbs$ decay, see their Figure 9.
4 SIRUNYAN 18D searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing identified hadronically decaying top quarks, no leptons, and $E_T^{miss}$. No significant excess above the Standard Model expectations is observed. Limits are set on the stop mass in the Tstop1 simplified model, see their Figure 8, and on the gluino mass in the Tglu3A, Tglu3B, Tglu3C and Tglu3E simplified models, see their Figure 9.

5 SIRUNYAN 18A searched in 38.2 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for the pair production of resonances, each decaying to at least four quarks. Reconstructed particles are clustered into two large jets of similar mass, each consistent with four-parton substructure. No statistically significant excess over the Standard Model expectation is observed. Limits are set on the squark and gluino mass in RPV supersymmetry models where squarks (gluinos) decay, through intermediate higgsinos, to four (five) quarks, see their Figure 4.

6 AABOUD 17A searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one or more isolated lepton, at least eight jets, either zero or many $b$-jets, for evidence of R-parity violating decays of the gluino. No significant excess above the Standard Model expectations is observed. Limits up to 2.1 TeV are set on the gluino mass in R-parity-violating supersymmetry models as Tglu1 with LSP decay through the non-zero $\lambda'_{112}$ coupling as $\chi_0^1 \rightarrow u d s$. See their Figure 9.

7 AABOUD 17A searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one or more isolated lepton, at least eight jets, either zero or many $b$-jets, for evidence of R-parity violating decays of the gluino. No significant excess above the Standard Model expectations is observed. Limits up to 1.65 TeV are set on the gluino mass in R-parity-violating supersymmetry models with $\tilde{g} \rightarrow t \bar{t}$, $t \rightarrow b s$ through the non-zero $\lambda''_{323}$ coupling. See their Figure 9.

8 AABOUD 17A searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with one or more isolated lepton, at least eight jets, either zero or many $b$-jets, for evidence of R-parity violating decays of the gluino. No significant excess above the Standard Model expectations is observed. Limits up to 1.8 TeV are set on the gluino mass in R-parity-violating supersymmetry models as Tglu1A with the LSP decay through the non-zero $\lambda'_{112}$ coupling as $\chi_0^1 \rightarrow q q \ell$. See their Figure 9.

9 AABOUD 17A searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two same-sign or three leptons, jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 1.8 TeV are set on the gluino mass in R-parity-violating supersymmetry models as Tglu3A with LSP decaying through the non-zero $\lambda''_{112}$ coupling as $\chi_0^1 \rightarrow u d s$. See their Figure 5(d).

10 AABOUD 17A searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two same-sign or three leptons, jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 1.75 TeV are set on the gluino mass in R-parity-violating supersymmetry models as Tglu1A with LSP decaying through the non-zero $\lambda''_{112}$ coupling as $\chi_0^1 \rightarrow q q \ell$. See their Figure 5(c).

11 AABOUD 17A searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two same-sign or three leptons, jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 1.45 TeV are set on the gluino mass in R-parity-violating supersymmetry models where $\tilde{g} \rightarrow t \bar{t} \tilde{t}_1$ and $\tilde{t}_1 \rightarrow s d$ through the non-zero $\lambda''_{321}$ coupling. See their Figure 5(b).

12 AABOUD 17A searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two same-sign or three leptons, jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 1.45 TeV are set on the gluino mass in R-parity-violating supersymmetry models where $\tilde{g} \rightarrow t \bar{t} \tilde{t}_1$ and $\tilde{t}_1 \rightarrow b d$ through the non-zero $\lambda''_{313}$ coupling. See their Figure 5(a).

13 AABOUD 17A searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two same-sign or three leptons, jets and large missing transverse momentum. No significant excess above the Standard Model expectations is observed. Limits up to 400 GeV are set.
on the down type squark $\tilde{d}_R$ mass in R-parity-violating supersymmetry models where $\tilde{d}_R \to t b$ through the non-zero $\lambda''_{313}$ coupling or $\tilde{d}_R \to t s$ through the non-zero $\lambda''_{321}$.

See their Figure 5(e) and 5(f).

14 AABOUD 17A2 searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with at least seven jets and large missing transverse momentum. Selected events are further classified based on the presence of large R-jets or b-jets and no leptons. No significant excess above the Standard Model expectations is observed. Limits are set for R-parity violating decays of the gluino assuming $g \to t t_1$ and $t_1 \to b s$ through the non-zero $\lambda''_{323}$ couplings. The range 625–1375 GeV is excluded for $m_{t_1} = 400$ GeV. See their Figure 7b.

15 KHACHATRYAN 17Y searched in 19.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing at least 8 or 10 jets, possibly b-tagged, coming from R-parity-violating decays of supersymmetric particles. No excess over the expected background is observed. Limits are derived on the gluino mass, assuming various RPV decay modes, see Fig. 7.

16 KHACHATRYAN 16BJ searched in 2.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with two isolated same-sign dileptons and jets in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the following simplified models: Tglu3A and Tglu3D, see Fig. 4, Tglu3B and Tglu3C, see Fig. 5, and Tglu1B, see Fig. 7.

17 KHACHATRYAN 16BX searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing 0 or 1 leptons and b-tagged jets, coming from R-parity-violating decays of supersymmetric particles. No excess over the expected background is observed. Limits are derived on the gluino mass, assuming the RPV $g \to t b s$ decay, see Fig. 7 and 10.

18 AAD 15BV summarized and extended ATLAS searches for gluinos and first- and second-generation squarks in final states containing jets and missing transverse momentum, with or without leptons or b-jets in the $\sqrt{s} = 8$ TeV data set collected in 2012. The paper reports the results of new interpretations and statistical combinations of previously published analyses, as well as new analyses. Exclusion limits at 95% C.L. are set on the gluino mass in several R-parity conserving models, leading to a generalized constraint on gluino masses exceeding 1150 GeV for lightest supersymmetric particle masses below 100 GeV. See their Figs. 10, 19, 20, 21, 23, 25, 26, 29-37.

19 AAD 14X searched in 20.3 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with at least four leptons (electrons, muons, taus) in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in an R-parity violating simplified model where the decay $g \to q \chi^0_1$, with $\chi^0_1 \to \ell^\pm \ell^\mp \nu$, takes place with a branching ratio of 100%, see Fig. 8.

20 CHATRCHYAN 14P searched in 19.4 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for three-jet resonances produced in the decay of a gluino in R-parity violating supersymmetric models. No excess over the expected SM background is observed. Assuming a 100% branching ratio for the gluino decay into three light-flavour jets, limits are set on the cross section of gluino pair production, see Fig. 7, and gluino masses below 650 GeV are excluded at 95% C.L. Assuming a 100% branching ratio for the gluino decaying to one b-quark jet and two light-flavour jets, gluino masses between 200 GeV and 835 GeV are excluded at 95% C.L.

21 AABOUD 18CF searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with several jets, possibly b-jets, and large-radius jets for evidence of R-parity violating decays of the gluino. No significant excess above the Standard Model expectations is observed. Limits between 1000 and 1875 GeV are set on the gluino mass in R-parity-violating supersymmetry models as Tglu2RPV with the LSP decay through the non-zero $\lambda''_{20}$ coupling as $\chi^0_1 \to q q q$. The most stringent limit is obtained for $m_{\chi^0_1} = 1000$ GeV, the weakest for $m_{\chi^0_1} = 50$ GeV. See their Figure 7(b). Figure 7(a) presents results for gluinos directly decaying into 3 quarks, Tglu1RPV.

22 KHACHATRYAN 16BX searched in 19.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events containing 4 leptons coming from R-parity-violating decays of $\chi^0_1 \to \ell \ell \nu$ with $\lambda_{121} \neq$...
0 or \( \lambda_{122} \neq 0 \). No excess over the expected background is observed. Limits are derived on the gluino, squark and stop masses, see Fig. 23.

AAD 15CB searched for events containing at least one long-lived particle that decays at a significant distance from its production point (displaced vertex, DV) into two leptons or into five or more charged particles in 20.3 fb\(^{-1}\) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV. The dilepton signature is characterised by DV formed from at least two lepton candidates. Four different final states were considered for the multitrack signature, in which the DV must be accompanied by a high-transverse momentum muon or electron candidate that originates from the DV, jets or missing transverse momentum. No events were observed in any of the signal regions. Results were interpreted in SUSY scenarios involving R-parity violation, split supersymmetry, and gauge mediation. See their Fig. 12–20.

AAD 15X searched in 20.3 fb\(^{-1}\) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for \( R \)-parity violating decay of the gluino, squark and stop quarks. No excess over the expected SM background is observed. Limits are derived in mSUGRA/CMSSM models containing gluinos and squarks, see Fig. 11–16.

AAD 14AX searched in 20.1 fb\(^{-1}\) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for the strongly produced supersymmetric particles in events containing either zero or at least one high-p\(_T\) lepton, large missing transverse momentum, high jet multiplicity and at least three jets identified as originating from b-quarks. No excess over the expected SM background is observed. Limits are derived in mSUGRA/CMSSM models with \( \tan \beta = 30, A_0 = -2m_0 \) and \( \mu > 0 \), see their Fig. 14. Also, exclusion limits in simplified models containing gluinos and scalar top and bottom quarks are set, see their Figures 12, 13.

AAD 14E searched in 20.3 fb\(^{-1}\) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for strongly produced supersymmetric particles in events containing jets and two same-sign leptons or three lepton candidates. The search also utilises jets originating from b-quarks, missing transverse momentum and other variables. No excess over the expected SM background is observed. Exclusion limits are derived in simplified models containing gluinos and squarks, see Figures 5 and 6. In the \( \tilde{g} \to qq'\tilde{\chi}_1^0 \), \( \tilde{\chi}^\pm_1 \to W(\mp)\tilde{\chi}_2^0, \tilde{\chi}_2^0 \to Z(\pm)\tilde{\chi}_1^0 \) simplified model, the following assumptions have been made: \( m_\pm = 0.5 m_0, m_{\tilde{g}}, m_{\tilde{\chi}_1^0} = 0.5 (m_{\tilde{\chi}_2^0} + m_{\tilde{\chi}_1^0}), m_{\tilde{\chi}_2^0} < 520 \) GeV. In the \( \tilde{g} \to qq'\tilde{\chi}_1^0 \), \( \tilde{\chi}^\pm_1 \to \ell^\mp \nu\tilde{\chi}_1^0 \) or \( \tilde{g} \to qq'\tilde{\chi}_2^0, \tilde{\chi}_2^0 \to \ell^\pm \nu\tilde{\chi}_1^0 \) simplified model, the following assumptions have been made: \( m_\pm = m_{\tilde{\chi}_1^0} = 0.5 (m_{\tilde{\chi}_0} + m_{\tilde{\chi}_2^0}), m_{\tilde{\chi}_0} < 660 \) GeV. Limits are also derived in the mSUGRA/CMSSM, BRPV and GMSB models, see their Fig. 8.

CHATRCHYAN 14H searched in 19.5 fb\(^{-1}\) of \( pp \) collisions at \( \sqrt{s} = 8 \) TeV for events with two isolated same-sign dileptons and jets in the final state. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in simplified models where the R-parity violating decay \( \tilde{g} \to tbs \) takes place with a branching ratio of 100\%, see Fig. 8.

Long-lived \( \tilde{g} \) (Gluino) mass limit

Limits on light gluinos \( m_{\tilde{g}} < 5 \) GeV were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 070001 (2014) (http://pdg.lbl.gov).

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>1890 95  2 AABOUD 19C ATLS R-hadrons, Tglu1A, stable

>2400 95  3 SIRUNYAN 19BH CMS long-lived $\tilde{g}$, RPV, $\tilde{g} \rightarrow t\bar{b}\tilde{s}$, $10 \text{ mm} < c\tau < 250 \text{ mm}$

>2300 95  3 SIRUNYAN 19BH CMS long-lived $\tilde{g}$, GMSB, $\tilde{g} \rightarrow g\tilde{G}$, $20 \text{ mm} < c\tau < 110 \text{ mm}$

>2100 95  4 SIRUNYAN 19BT CMS long-lived $\tilde{g}$, GMSB, $\tilde{g} \rightarrow g\tilde{G}$, $0.3 \text{ m} < c\tau < 30 \text{ m}$

>2500 95  4 SIRUNYAN 19BT CMS long-lived $\tilde{g}$, GMSB, $\tilde{g} \rightarrow g\tilde{G}$, $c\tau = 1 \text{ m}$

>1900 95  4 SIRUNYAN 19BT CMS long-lived $\tilde{g}$, GMSB, $\tilde{g} \rightarrow g\tilde{G}$, $c\tau = 100 \text{ m}$

>2370 95  5 AABOUD 18S ATLS displaced vertex + $\slashET$, long-lived Tglu1A, $m_{\tilde{\chi}_1^0} = 100$ GeV, and $\tau = 0.17 \text{ ns}$

>1600 95  6 SIRUNYAN 18AY CMS jets+ $\slashET$, Tglu1A, $c\tau < 0.1$ mm, $m_{\tilde{\chi}_1^0} = 100$ GeV

>1750 95  6 SIRUNYAN 18AY CMS jets+ $\slashET$, Tglu1A, $c\tau = 1$ mm, $m_{\tilde{\chi}_1^0} = 100$ GeV

>1640 95  6 SIRUNYAN 18AY CMS jets+ $\slashET$, Tglu1A, $c\tau = 10$ mm, $m_{\tilde{\chi}_1^0} = 100$ GeV

>1490 95  6 SIRUNYAN 18AY CMS jets+ $\slashET$, Tglu1A, $c\tau = 100$ mm, $m_{\tilde{\chi}_1^0} = 100$ GeV

>1300 95  6 SIRUNYAN 18AY CMS jets+ $\slashET$, Tglu1A, $c\tau = 1 \text{ m}$, $m_{\tilde{\chi}_1^0} = 100$ GeV

> 960 95  6 SIRUNYAN 18AY CMS jets+ $\slashET$, Tglu1A, $c\tau = 10 \text{ m}$, $m_{\tilde{\chi}_1^0} = 100$ GeV

> 900 95  6 SIRUNYAN 18AY CMS jets+ $\slashET$, Tglu1A, $c\tau = 100 \text{ m}$, $m_{\tilde{\chi}_1^0} = 100$ GeV

>2200 95  7 SIRUNYAN 18DV CMS long-lived $\tilde{g}$, RPV, $\tilde{g} \rightarrow t\bar{b}\tilde{s}$, $0.6 \text{ mm} < c\tau < 80 \text{ mm}$

>1000 95  8 KHACHATRY...17AR CMS long-lived $\tilde{g}$, RPV, $\tilde{g} \rightarrow t\bar{b}\tilde{s}$, $c\tau = 0.3 \text{ mm}$

>1300 95  8 KHACHATRY...17AR CMS long-lived $\tilde{g}$, RPV, $\tilde{g} \rightarrow t\bar{b}\tilde{s}$, $c\tau = 1.0 \text{ mm}$

>1400 95  8 KHACHATRY...17AR CMS long-lived $\tilde{g}$, RPV, $\tilde{g} \rightarrow t\bar{b}\tilde{s}$, $2 \text{ mm} < c\tau < 30 \text{ mm}$

>1580 95  9 AABOUD 16B ATLS long-lived R-hadrons

> 740–1590 95 10 AABOUD 16C ATLS R-hadrons, Tglu1A, $\tau \geq 0.4$ ns, $m_{\tilde{\chi}_1^0} = 100$ GeV

>1570 95  10 AABOUD 16C ATLS R-hadrons, Tglu1A, stable

>1610 95  11 KHACHATRY...16BWCMS long-lived $\tilde{g}$ forming R-hadrons, $f = 0.1$, cloud interaction model

>1580 95  11 KHACHATRY...16BWCMS long-lived $\tilde{g}$ forming R-hadrons, $f = 0.1$, charge-suppressed interaction model
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• • • We do not use the following data for averages, fits, limits, etc. • • •
1 AABOUD 19AT searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for metastable and stable $R$-hadrons. Multiple search strategies for a wide range of lifetimes, corresponding to path lengths of a few meters, are defined. No significant deviations from the expected Standard Model background are observed. Gluino $R$-hadrons with lifetimes of the order of 50 ns are excluded at 95% C.L. for masses below 1980 GeV using the muon-spectrometer agnostic analysis. Using the full-detector search, the observed lower limits on the mass are 2000 GeV. See their Figure 9 (top).

2 AABOUD 19C searched in 36.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for metastable and stable $R$-hadrons arising as excesses in the mass distribution of reconstructed tracks with high transverse momentum and large $dE/dx$. Gluino $R$-hadrons with lifetimes above 10 ns are excluded at 95% C.L. with lower mass limit range between 1000 GeV and 2060 GeV, see their Figure 5(a). Masses smaller than 1290 GeV are excluded for a lifetime of 1 ns, see their Figure 6. In the case of stable $R$-hadrons, the lower mass limit is 1890 GeV, see their Figure 5(b).

3 SIRUNYAN 19BH searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for long-lived particles decaying into jets, with each long-lived particle having a decay vertex well displaced from the production vertex. The selected events are found to be consistent with standard model predictions. Limits are set on the gluino mass in a GMSB model where the gluino is decaying via $\tilde{g} \rightarrow g G$, see their Figure 4 and in an RPV model of supersymmetry where the gluino is decaying via $\tilde{g} \rightarrow T\bar{b}S$, see their Figures 5. Limits are also set on the stop mass in two RPV models, see their Figure 6 (for $t \rightarrow b\ell$ decays) and Figure 7 (for $t \rightarrow d\bar{d}$ decays).

4 SIRUNYAN 19BT searched in 137 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for long-lived particles decaying to displaced, nonprompt jets and missing transverse momentum. Candidate signal events are identified using the timing capabilities of the CMS electromagnetic calorimeter. The results of the search are found to be consistent with the background predictions. Limits are set on the gluino mass in a GMSB model where long-lived gluinos are pair produced and decaying via $\tilde{g} \rightarrow g G$, see their Figures 4 and 5.

5 AABOUD 18S searched in 32.8 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for long-lived gluinos in final states with large missing transverse momentum and at least one high-mass displaced vertex with five or more tracks. The observed yield is consistent with the expected background. Exclusion limits are derived for Tglu1A models predicting the existence of long-lived gluinos reaching roughly $m(\tilde{g}) = 2000$ GeV to $2370$ GeV for $m(\tilde{\chi}^0_1) = 100$ GeV and gluino lifetimes between 0.02 and 10 ns, see their Fig. 8. Limits are presented also as a function of the lifetime (for a fixed gluino-neutralino mass difference of 100 GeV) and of the gluino and neutralino masses (for a fixed lifetime of 1 ns). See their Fig. 9 and 10 respectively.

6 SIRUNYAN 18AY searched in 35.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events containing one or more jets and significant $E_T$. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass in the Tgлу1A, Tgлу2A and Tgлу3A simplified models, see their Figure 3. Limits are also set on squark, sbottom and stop masses in the Tsqk1, Tsbot1, Tstop1 and Tstop4 simplified models, see their Figure 3. Finally, limits are set on long-lived gluino masses in a Tgлу1A simplified model where the gluino is metastable or long-lived with proper decay lengths in the range $10^{-3}$ mm $< ct < 10^5$ mm, see their Figure 4.

7 SIRUNYAN 18DV searched in 38.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for long-lived particles in events with multiple jets and two displaced vertices composed of many tracks. No events with two well-separated high-track-multiplicity vertices were observed. Limits are set on the stop and the gluino mass in RPV models of supersymmetry where the stop (gluino) is decaying solely into dijet (multijet) final states, see their Figures 6 and 7.
KHACHATRYAN 17AR searched in 17.6 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for R-parity-violating SUSY in which long-lived neutralinos or gluinos decay into multijet final states. No significant excess above the Standard Model expectations is observed. Limits are set on the gluino mass for a range of mean proper decay lengths ($c\tau$), see their Fig. 7. The upper limits on the production cross section times branching ratio squared (Fig. 7) are also applicable to long-lived neutralinos.

AABOUD 16b searched in 3.2 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for long-lived $R$-hadrons using observables related to large ionization losses and slow propagation velocities, which are signatures of heavy charged particles traveling significantly slower than the speed of light. Exclusion limits at 95% C.L. are set on the long-lived gluino masses exceeding 1580 GeV. See their Fig. 5.

AABOUD 16c searched in 3.2 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for long-lived and stable $R$-hadrons identified by anomalous specific ionization energy loss in the ATLAS Pixel detector. Gluino $R$-hadrons with lifetimes above 0.4 ns are excluded at 95% C.L. with lower mass limit range between 740 GeV and 1590 GeV. In the case of stable $R$-hadrons, the lower mass limit is 1570 GeV. See their Figs. 5 and 6.

KHACHATRYAN 16BW searched in 2.5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 13$ TeV for events with heavy stable charged particles, identified by their anomalously high energy deposits in the silicon tracker and/or long time-of-flight measurements by the muon system. No evidence for an excess over the expected background is observed. Limits are derived for pair production of gluinos as a function of mass, depending on the interaction model and on the fraction of produced gluinos hadronizing into a $g\to g$ - gluon state, see Fig. 4 and Table 7.

AAD 15AE searched in 19.1 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for heavy long-lived charged particles, measured through their specific ionization energy loss in the ATLAS pixel detector or their time-of-flight in the ALTAS muon system. In the absence of an excess of events above the expected backgrounds, limits are set on $R$-hadrons in various scenarios, see Fig. 11. Limits are also set in LeptoSUSY models where the gluino decays to stable 300 GeV leptons, see Fig. 9.

AAD 15BM searched in 18.4 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for stable and metastable non-relativistic charged particles through their anomalous specific ionization energy loss in the ATLAS pixel detector. In absence of an excess of events above the expected backgrounds, limits are set within a generic $R$-hadron model, on stable gluino $R$-hadrons (see Table 5) and on metastable gluino $R$-hadrons decaying to ($g/q\pi\ell$) plus a light $\tilde{\chi}^0_1$ (see Fig. 7) and decaying to $t\bar{t}$ plus a light $\tilde{\chi}^0_1$ (see Fig. 9).

KHACHATRYAN 15AK looked in a data set corresponding to 18.6 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV and a search interval corresponding to 281 h of trigger lifetime, for long-lived particles that have stopped in the CMS detector. No evidence for an excess over the expected background in a cloud interaction model is observed. Assuming the decay $g \to g\tilde{\chi}^0_1\tilde{\chi}^0_1$ and lifetimes between 1 $\mu$s and 1000 s, limits are derived on $g$ production as a function of $m_{\tilde{\chi}^0_1}$, see Figs. 4 and 6. The exclusions require that $m_{\tilde{\chi}^0_1}$ is kinematically consistent with the minimum values of the jet energy thresholds used.

AAD 13AA searched in 4.7 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events containing colored long-lived particles that hadronize forming $R$-hadrons. No significant excess above the expected background was found. Long-lived $R$-hadrons containing a $g$ are excluded for masses up to 985 GeV at 95% C.L. in a general interaction model. Also, limits independent of the fraction of $R$-hadrons that arrive charged in the muon system were derived, see Fig. 6.

AAD 13BC searched in 5.0 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV and in 22.9 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for bottom squark $R$-hadrons that have come to rest within the ATLAS calorimeter and decay at some later time to hadronic jets and a neutralino. In absence of an excess of events above the expected backgrounds, limits are set on gluino masses for different decays, lifetimes, and neutralino masses, see their Table 6 and Fig. 10.

CHATRCHYAN 13AB looked in 5.0 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV and in 18.8 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV for events with heavy stable particles, identified
by their anomalous $dE/dx$ in the tracker or additionally requiring that it be identified as muon in the muon chambers, from pair production of $g$'s. No evidence for an excess over the expected background is observed. Limits are derived for pair production of gluinos as a function of mass (see Fig. 8 and Table 5), depending on the fraction, $f$, of formation of $\tilde{g} \rightarrow g \chi_1^0$ (R-gluonball) states. The quoted limit is for $f = 0.1$, while for $f = 0.5$ it degrades to 1276 GeV. In the conservative scenario where every hadronic interaction causes it to become neutral, the limit decreases to 928 GeV for $f = 0.1$.

AAD 12p looked in 31 pb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with pair production of long-lived gluinos. The hadronization of the gluinos leads to $R$-hadrons which may stop inside the detector and later decay via $\tilde{g} \rightarrow g \chi_1^0$ during gaps between the proton bunches. No significant excess over the expected background is observed. From a counting experiment, a limit at 95% C.L. on the cross section as a function of $m_{\tilde{g}}$ is derived for $m_{\chi_1^0} = 100$ GeV, see Fig. 4. The limit is valid for lifetimes between $10^{-5}$ and $10^3$ seconds and assumes the Generic matter interaction model for the production cross section.

CHATRCHYAN 12AN looked in 4.0 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with pair production of long-lived gluinos. The hadronization of the gluinos leads to $R$-hadrons which may stop inside the detector and later decay via $\tilde{g} \rightarrow g \chi_1^0$ during gaps between the proton bunches. No significant excess over the expected background is observed. Limits are derived for pair production of gluinos as a function of mass (see Fig. 3), depending on the fraction, $f$, of formation of $\tilde{g} \rightarrow g \chi_1^0$ (R-gluonball) states. The quoted limit is for $f = 0.1$, while for $f = 0.5$ it degrades to 1046 GeV. In the conservative scenario where every hadronic interaction causes it to become neutral, the limit decreases to 928 GeV for $f = 0.1$. Supersedes KHACHATRYAN 11.

CHATRCHYAN 12L looked in 5.0 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with heavy stable particles, identified by their anomalous $dE/dx$ in the tracker or additionally requiring that it be identified as muon in the muon chambers, from pair production of $g$'s. No evidence for an excess over the expected background is observed. Limits are derived for pair production of gluinos as a function of mass (see Fig. 4), for a fraction, $f = 10\%$, of formation of $\tilde{g} \rightarrow g \chi_1^0$ (R-glueball). If instead of a phase space driven approach for the hadronic scattering of the $R$-hadrons, a triple-Regge model or a bag-model is used, the limit degrades to 566 and 562 GeV, respectively.

AAD 11K looked in 34 pb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with heavy stable particles, identified by their anomalous $dE/dx$ in the tracker or time of flight in the tile calorimeter, from pair production of $g$. No evidence for an excess over the SM expectation is observed. Limits are derived for pair production of gluinos as a function of mass (see Fig. 4), for a fraction, $f = 10\%$, of formation of $\tilde{g} \rightarrow g$ (R-glueball). No evidence for an excess over the SM expectation is observed. Limits are derived as a function of mass (see Fig. 4), for $f=0.1$. For fractions $f = 0.5$ and $1.0$ the limit degrades to 537 and 530 GeV, respectively.

AAD 11p looked in 37 pb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with heavy stable particles, reconstructed and identified by their time of flight in the Muon System. There is no requirement on their observation in the tracker to increase the sensitivity to cases where gluinos have a large fraction, $f$, of formation of neutral $\tilde{g} \rightarrow g$ (R-glueball). No evidence for an excess over the SM expectation is observed. Limits are derived as a function of mass (see Fig. 4), for $f=0.1$. For fractions $f = 0.5$ and $1.0$ the limit degrades to 537 and 530 GeV, respectively.

KHACHATRYAN 11 looked in 10 pb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for events with pair production of long-lived gluinos. The hadronization of the gluinos leads to $R$-hadrons which may stop inside the detector and later decay via $\tilde{g} \rightarrow g \chi_1^0$ during gaps between the proton bunches. No significant excess over the expected background is observed. From a counting experiment, a limit at 95% C.L. on the cross section times branching ratio is derived for $m_{\tilde{g}} - m_{\chi_1^0} > 100$ GeV, see their Fig. 2. Assuming 100% branching ratio, lifetimes between 75 ns and $3 \times 10^5$ s are excluded for $m_{\tilde{g}} = 300$ GeV. The $\tilde{g}$

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mass exclusion is obtained with the same assumptions for lifetimes between 10 μs and 1000 s, but shows some dependence on the model for R-hadron interactions with matter, illustrated in Fig. 3. From a time-profile analysis, the mass exclusion is 382 GeV for a lifetime of 10 μs under the same assumptions as above.

KHACHATRYAN 11c looked in 3.1 pb⁻¹ of pp collisions at √s = 7 TeV for events with heavy stable particles, identified by their anomalous dE/dx in the tracker or additionally requiring that it be identified as muon in the muon chambers, from pair production of G. No evidence for an excess over the expected background is observed. Limits are derived for pair production of gluinos as a function of mass (see Fig. 3), depending on the fraction, f, of formation of G - g (R-gluonball). The quoted limit is for f=0.1, while for f=0.5 it degrades to 357 GeV. In the conservative scenario where every hadronic interaction causes it to become neutral, the limit decreases to 311 GeV for f=0.1.

Light G (Gravitino) mass limits from collider experiments

The following are bounds on light (≪ 1 eV) gravitino indirectly inferred from its coupling to matter suppressed by the gravitino decay constant.

Unless otherwise stated, all limits assume that other supersymmetric particles besides the gravitino are too heavy to be produced. The gravitino is assumed to be undetected and to give rise to a missing energy (Eₜ) signature.

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020) (http://pdg.lbl.gov).

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1 AAD 15BH searched in 20.3 fb⁻¹ of pp collisions at √s = 8 TeV for associated production of a light gravitino and a squark or gluino. The squark (gluino) is assumed to decay exclusively to a quark (gluon) and a gravitino. No evidence was found for an excess above the expected level of Standard Model background and 95% C.L. lower limits were set on the gravitino mass as a function of the squark/gluino mass, both in the case of degenerate and non-degenerate squark/gluino masses, see Figs. 14 and 15.

2 ABDALLAH 05b use data from √s = 180–208 GeV. They look for events with a single photon + \( \tilde{E}_T \) final states from which a cross section limit of \( \sigma < 0.18 \) pb at 208 GeV is obtained, allowing a limit on the mass to be set. Supersedes the results of ABREU 00z.

3 ACHARD 04E use data from √s = 189–209 GeV. They look for events with a single photon + \( \tilde{E}_T \) final states from which a limit on the Gravitino mass is set corresponding to √\( \tilde{F} \) > 238 GeV. Supersedes the results of ACCIARRI 99r.

4 HEISTER 03C use the data from √s = 189–209 GeV to search for γ\( \tilde{E}_T \) final states.

5 ACOSTA 02H looked in 87 pb⁻¹ of pp collisions at \( \sqrt{s} = 1.8 \) TeV for events with a high-\( \tilde{E}_T \) photon and \( \tilde{E}_T \). They compared the data with a GMSB model where the final
state could arise from $q\bar{q} \to \tilde{G} \tilde{G} \gamma$. Since the cross section for this process scales as $1/|F|^4$, a limit at 95% CL is derived on $|F|^{1/2} > 221$ GeV. A model independent limit for the above topology is also given in the paper.

6 ABBIENDI, G. 000 searches for $\gamma E$ final states from $\sqrt{s}=189$ GeV.

Supersymmetry miscellaneous results

Results that do not appear under other headings or that make nonminimal assumptions.

Some earlier papers are now obsolete and have been omitted. They were last listed in our PDG 14 edition: K. Olive, et al. (Particle Data Group), Chinese Physics C38 (2014) (http://pdg.lbl.gov).

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1 AAD 20C uses a statistical combination of six final states $b\bar{b}b\bar{b}$, $b\bar{b}WW$, $b\bar{b}\tau\tau$, $WWWW$, $b\bar{b}\gamma\gamma$, and $WW\gamma\gamma$ to search for non-resonant and resonant production of Higgs boson pairs. The search uses 36.1 fb$^{-1}$ of $pp$ collisions data at $\sqrt{s} = 13$ TeV. Constraints in the habemus Minimal Supersymmetric Standard Model in the $(m_A, \tan\beta)$ parameter space are placed, see their Figure 7(b).

2 AABOUD 16AF uses a selection of searches by ATLAS for the electroweak production of SUSY particles studying resulting constraints on dark matter candidates. They use 20 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV. A likelihood-driven scan of an effective model focusing on the gaugino-higgsino and Higgs sector of the pMSM is performed. The ATLAS searches impact models where $m_{\chi_0^1} < 65$ GeV, excluding 86% of them. See their Figs. 2, 4, and 6.

3 AAD 16AG searches for prompt lepton-jets using 20 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 8$ TeV collected with the ATLAS detector. Lepton-jets are expected from decays of low-mass dark photons in SUSY-portal and Higgs-portal models. No significant excess of events is observed and 95% CL upper limits are computed on the production cross section times branching ratio for two prompt lepton-jets in models predicting 2 or 4 $\gamma_d$ via SUSY-portal topologies, for $\gamma_d$ mass values between 0 and 2 GeV. See their Figs 9 and 10. The results are also interpreted in terms of a 90% CL exclusion region in kinetic mixing and dark-photon mass parameter space. See their Fig. 13.

4 AAD 13P searched in 5 fb$^{-1}$ of $pp$ collisions at $\sqrt{s} = 7$ TeV for single lepton-jets with at least four muons; pairs of lepton-jets, each with two or more muons; and pairs of lepton-jets with two or more electrons. All of these could be signatures of Hidden Valley supersymmetric models. No statistically significant deviations from the Standard Model expectations are found. 95% C.L. limits are placed on the production cross section times branching ratio of dark photons for several parameter sets of a Hidden Valley model.

5 AALTONEN 12AB looked in 5.1 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for anomalous production of multiple low-energy leptons in association with a $W$ or $Z$ boson. Such events may occur in hidden valley models in which a supersymmetric Higgs boson is produced in association with a $W$ or $Z$ boson, with $H \to \chi_0^0\chi_1^0$ pair and with the $\chi_1^0$.
further decaying into a dark photon ($\gamma_D$) and the unobservable lightest SUSY particle of the hidden sector. As the $\gamma_D$ is expected to be light, it may decay into a lepton pair. No significant excess over the SM expectation is observed and a limit at 95% C.L. is set on the cross section for a benchmark model of supersymmetric hidden-valley Higgs production.

6 AAD 11AA looked in 34 pb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 7$ TeV for events with $\geq 4$ jets originating from pair production of scalar gluons, each decaying to two gluons. No two-jet resonances are observed over the SM background. Limits are derived on the cross section times branching ratio (see Fig. 3). Assuming 100% branching ratio for the decay to two gluons, the quoted exclusion range is obtained, except for a 5 GeV mass window around 140 GeV.

7 CHATRCHYAN 11e looked in 35 pb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 7$ TeV for events with collimated $\mu$ pairs (leptonic jets) from the decay of hidden sector states. No evidence for new resonance production is found. Limits are derived and compared to various SUSY models (see Fig. 4) where the LSP, either the $\tilde{\chi}_1^0$ or a $\tilde{g}$, decays to dark sector particles.

8 ABAZOV 10n looked in 5.8 fb$^{-1}$ of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for events from hidden valley models in which a $\tilde{\chi}_1^0$ decays into a dark photon, $\gamma_D$, and the unobservable lightest SUSY particle of the hidden sector. As the $\gamma_D$ is expected to be light, it may decay into a tightly collimated lepton pair, called lepton jet. They searched for events with $E_T$ and two isolated lepton jets observable by an opposite charged lepton pair $e\mu$ or $\mu\mu$. No significant excess over the SM expectation is observed, and a limit at 95% C.L. on the cross section times branching ratio is derived, see their Table I. They also examined the invariant mass of the lepton jets for a narrow resonance, see their Fig. 4, but found no evidence for a signal.

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