

SEARCHES

not in other sections

Magnetic Monopole Searches

The most sensitive experiments obtain negative results.

Best cosmic-ray supermassive monopole flux limit:

$$< 1.4 \times 10^{-16} \text{ cm}^{-2} \text{sr}^{-1} \text{s}^{-1} \quad \text{for } 1.1 \times 10^{-4} < \beta < 1$$

Supersymmetric Particle Searches

All supersymmetric mass bounds here are model dependent.

The limits assume:

1) $\tilde{\chi}_1^0$ is the lightest supersymmetric particle; 2) R -parity is conserved, unless stated otherwise;

See the Particle Listings for a Note giving details of supersymmetry.

$\tilde{\chi}_i^0$ — neutralinos (mixtures of $\tilde{\gamma}$, $\tilde{Z}^0$, and $\tilde{H}_i^0$)

Mass $m_{\tilde{\chi}_1^0} > 0 \text{ GeV}$, CL = 95%

[general MSSM, non-universal gaugino masses]

Mass $m_{\tilde{\chi}_1^0} > 46 \text{ GeV}$, CL = 95%

[all $\tan\beta$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}_2^0} > 62.4 \text{ GeV}$, CL = 95%

[$1 < \tan\beta < 40$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}_3^0} > 99.9 \text{ GeV}$, CL = 95%

[$1 < \tan\beta < 40$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}_4^0} > 116 \text{ GeV}$, CL = 95%

[$1 < \tan\beta < 40$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}}$ none 200–670 GeV, CL = 95% [R-Parity Violating]

[wino production, $\tilde{\chi} \rightarrow b + \ell/\nu + t/b$ via λ'_{i33} coupling]

$\tilde{\chi}_i^\pm$ — charginos (mixtures of $\tilde{W}^\pm$ and $\tilde{H}_i^\pm$)

Mass $m_{\tilde{\chi}_1^\pm} > 94 \text{ GeV}$, CL = 95%

[$\tan\beta < 40$, $m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0} > 3 \text{ GeV}$, all m_0]

Mass $m_{\tilde{\chi}_1^\pm} > 1000$ GeV, CL = 95%

$[2\ell + \cancel{E}_T, \text{Tchi1chi1C}, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}]$

Mass $m_{\tilde{\chi}_1^\pm} > 1600$ GeV, CL = 95% [R-Parity Violating]

$[\text{Tchi1n2l}, \tilde{\chi}_1^0 \rightarrow \ell^\pm \ell^\mp \nu, \lambda_{12k} \neq 0, m_{\tilde{\chi}_1^0} = 1200 \text{ GeV}]$

$\tilde{\chi}^\pm$ — long-lived chargino

Mass $m_{\tilde{\chi}^\pm} > 1050$ GeV, CL = 95%

$[\tilde{\chi}^\pm \rightarrow \tilde{\chi}_1^0 \pi^\pm, \text{wino LSP, stable}]$

Mass $m_{\tilde{\chi}^\pm} > 1050$ GeV, CL = 95%

$[\tilde{\chi}^\pm \rightarrow \tilde{\chi}_1^0 \pi^\pm, \text{wino LSP, } \tau = 20 \text{ ns}]$

$\tilde{\nu}$ — sneutrino

Mass $m > 41$ GeV, CL = 95% [model independent]

Mass $m > 94$ GeV, CL = 95%

$[\text{CMSSM}, 1 \leq \tan\beta \leq 40, m_{\tilde{e}_R} - m_{\tilde{\chi}_1^0} > 10 \text{ GeV}]$

Mass $m > 4200$ GeV, CL = 95% [R-Parity Violating]

$[1e + 1\mu, \nu_\tau \rightarrow e\mu, \lambda = \lambda' = 0.1]$

$\tilde{e}$ — scalar electron (selectron)

Mass $m > 107$ GeV, CL = 95% [all $m_{\tilde{e}_L} - m_{\tilde{\chi}_1^0}$]

Mass $m > 700$ GeV, CL = 95%

$[2\ell + \cancel{E}_T, m_{\tilde{\ell}_R} = m_{\tilde{\ell}_L} \text{ and } \tilde{\ell} = \tilde{e}, \tilde{\mu}, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}]$

Mass $m > 250$ GeV, CL = 95%

$[\ell^\pm \ell^\mp + \cancel{E}_T, \tilde{e}_R, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}]$

Mass $m > 410$ GeV, CL = 95% [R-Parity Violating]

$[\geq 4\ell^\pm, \tilde{\ell} \rightarrow l \tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \ell^\pm \ell^\mp \nu]$

Mass $m > 1200$ GeV, CL = 95% [R-Parity Violating]

$[\geq 4\ell, \lambda_{12k} \neq 0, m_{\tilde{\chi}_1^0} = 900 \text{ GeV (m-degenerate } \tilde{\ell}_L, \tilde{\nu})]$

$\tilde{\mu}$ — scalar muon (smuon)

Mass $m > 700$ GeV, CL = 95%

$[2\ell + \cancel{E}_T, m_{\tilde{\ell}_R} = m_{\tilde{\ell}_L} \text{ and } \tilde{\ell} = \tilde{e}, \tilde{\mu}, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}]$

Mass $m > 210$, CL = 95%

$[\ell^\pm \ell^\mp + \cancel{E}_T, \tilde{\mu}_R, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}]$

Mass $m > 94$ GeV, CL = 95%

$[\text{CMSSM}, 1 \leq \tan\beta \leq 40, m_{\tilde{\mu}_R} - m_{\tilde{\chi}_1^0} > 10 \text{ GeV}]$

Mass $m > 410$ GeV, CL = 95% [R-Parity Violating]

$[\geq 4\ell^\pm, \tilde{\ell} \rightarrow l \tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \ell^\pm \ell^\mp \nu]$

Mass $m > 1200$ GeV, CL = 95% [R-Parity Violating]

$[\geq 4\ell, \lambda_{12k} \neq 0, m_{\tilde{\chi}_1^0} = 900 \text{ GeV (m-degenerate } \tilde{\ell}_L, \tilde{\nu})]$

$\tilde{\tau}$ — scalar tau (stau)

Mass $m > 81.9$ GeV, CL = 95%

$[m_{\tilde{\tau}_R} - m_{\tilde{\chi}_1^0} > 15 \text{ GeV, all } \theta_\tau, \text{B}(\tilde{\tau} \rightarrow \tau \tilde{\chi}_1^0) = 100\%]$

Mass $m > 500$ GeV, CL = 95%

$[2 \text{ hadronic } \tau + \cancel{E}_T, \tilde{\tau}_{R,L} \rightarrow \tau \tilde{\chi}_1^0, m_{\tilde{\chi}_1^0} = 1 \text{ GeV}]$

Mass $m > 90$ GeV, CL = 95% [R-Parity Violating]

$[\tilde{\tau}_R, \text{indirect, } \Delta m > 5 \text{ GeV}]$

Mass $m > 1200$, CL = 95% [R-Parity Violating]

$[\geq 4\ell, \lambda_{12k} \neq 0, m_{\tilde{\chi}_1^0} = 900 \text{ GeV (m-degenerate } \tilde{\ell}_L, \tilde{\nu})]$

Mass $m > 286$ GeV, CL = 95% [long-lived $\tilde{\tau}$]

$\tilde{q}$ – squarks of the first two quark generations

Mass $m > 1.220 \times 10^3$ GeV, CL = 95%

$[\text{jets} + \cancel{E}_T, \text{Tsqk1, 1 non-degenerate } \tilde{q}, m_{\tilde{\chi}_1^0} = 0 \text{ GeV}]$

Mass $m > 1.600 \times 10^3$ GeV, CL = 95% [R-Parity Violating]

$[\tilde{q} \rightarrow q \tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \ell \ell \nu, \lambda_{121}, \lambda_{122} \neq 0, m_{\tilde{g}} = 2400 \text{ GeV}]$

Mass $m > 1000$ GeV, CL = 95% [R-Parity Violating]

$[\text{jets, } \tilde{q} \rightarrow q \tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \ell q q, m_{\tilde{\chi}_1^0} = 108 \text{ GeV and } 2.5 < c\tau_{\tilde{\chi}_1^0} < 200 \text{ mm}]$

$\tilde{q}$ — long-lived squark

Mass $m > 1340$ GeV, CL = 95% [$\tilde{t}$ R-hadrons]

Mass $m > 1250$ GeV, CL = 95% [$\tilde{b}$ R-hadrons]

Mass $m > 1350$ GeV, CL = 95%

[long-lived $\tilde{t}$, RPV, $\tilde{t} \rightarrow b\ell$, $7 \text{ mm} < c\tau < 110 \text{ mm}]$

$\tilde{b}$ — scalar bottom (sbottom)

Mass $m > 1.270 \times 10^3$ GeV, CL = 95%

$[b\text{-jets} + \cancel{E}_T, \text{Tsb0t1, } m_{\tilde{\chi}_1^0} = 0 \text{ GeV}]$

Mass $m > 307$ GeV, CL = 95% [R-Parity Violating]

$[\tilde{b} \rightarrow td \text{ or } ts, \lambda_{332}'' \text{ or } \lambda_{331}'' \text{ coupling}]$

$\tilde{t}$ — scalar top (stop)

Mass $m > 1.310 \times 10^3$ GeV, CL = 95%

$[\text{jets} + \cancel{E}_T, \text{Tstop1, } m_{\tilde{\chi}_1^0} < 300 \text{ GeV}]$

Mass $m > 1900$ GeV, CL = 95% [R-Parity Violating]

$[\tilde{t} \rightarrow be, \text{prompt, Tstop2RPV}]$

Mass $m > 1800$ GeV, CL = 95% [R-Parity Violating]

$[\tilde{t} \rightarrow b\mu, \text{prompt, Tstop2RPV}]$

Mass $m > 800$ GeV, CL = 95% [R-Parity Violating]

$[\tilde{t} \rightarrow b\tau, \text{prompt}, T_{\text{stop2RPV}}]$

Mass $m > 460$ GeV, CL = 95%

[R-Parity Violating, long-lived $\tilde{t}$, $\tilde{t} \rightarrow d\bar{\ell}$, $0.01\text{cm} < c\tau < 1000$ cm]

$\tilde{g}$ — gluino

Mass $m > 2.300 \times 10^3$ GeV, CL = 95%

$[\text{jets} + \cancel{E}_T, T_{\text{glu1A}}, m_{\tilde{\chi}_1^0} < 200$ GeV]

Mass $m > 2.260 \times 10^3$ GeV, CL = 95% [R-Parity Violating]

$[\geq 4\ell, \lambda_{12k} \neq 0, m_{\tilde{\chi}_1^0} > 1000$ GeV]

Technicolor

The limits for technicolor (and top-color) particles are quite varied depending on assumptions. See the Technicolor section of the full *Review* (the data listings).

Quark and Lepton Compositeness, Searches for

Scale Limits Λ for Contact Interactions (the lowest dimensional interactions with four fermions)

If the Lagrangian has the form

$$\pm \frac{g^2}{2\Lambda^2} \bar{\psi}_L \gamma_\mu \psi_L \bar{\psi}_L \gamma^\mu \psi_L$$

(with $g^2/4\pi$ set equal to 1), then we define $\Lambda \equiv \Lambda_{LL}^\pm$. For the full definitions and for other forms, see the Note in the Listings on Searches for Quark and Lepton Compositeness in the full *Review* and the original literature.

$$\Lambda_{LL}^+(eeee) > 8.3 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^-(eeee) > 10.3 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^+(ee\mu\mu) > 8.5 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^-(ee\mu\mu) > 9.5 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^+(ee\tau\tau) > 7.9 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^-(ee\tau\tau) > 7.2 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^+(\ell\ell\ell\ell) > 9.1 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^-(\ell\ell\ell\ell) > 10.3 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^+(eeqq) > 24 \text{ TeV, CL} = 95\%$$

$\Lambda_{LL}^-(eeqq)$	$> 37 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^+(eeuu)$	$> 23.3 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^-(eeuu)$	$> 12.5 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^+(eedd)$	$> 11.1 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^-(eedd)$	$> 26.4 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^+(eccc)$	$> 9.4 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^-(eccc)$	$> 5.6 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^+(eebb)$	$> 9.4 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^-(eebb)$	$> 10.2 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^+(\mu\mu qq)$	$> 23.3 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^-(\mu\mu qq)$	$> 40.0 \text{ TeV, CL} = 95\%$
$\Lambda(\ell\nu\ell\nu)$	$> 3.10 \text{ TeV, CL} = 90\%$
$\Lambda(e\nu qq)$	$> 2.81 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^+(qqqq)$	$> 13.1 \text{ none } 17.4\text{--}29.5 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^-(qqqq)$	$> 21.8 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^+(\nu\nu qq)$	$> 5.0 \text{ TeV, CL} = 95\%$
$\Lambda_{LL}^-(\nu\nu qq)$	$> 5.4 \text{ TeV, CL} = 95\%$

Excited Leptons

The limits from $\ell^{*+}\ell^{*-}$ do not depend on λ (where λ is the $\ell\ell^*$ transition coupling). The λ -dependent limits assume chiral coupling.

$e^{*\pm}$ — excited electron

- Mass $m > 103.2 \text{ GeV, CL} = 95\%$ (from e^*e^*)
- Mass $m > 5.600 \times 10^3 \text{ GeV, CL} = 95\%$ (from ee^*)
- Mass $m > 356 \text{ GeV, CL} = 95\%$ (if $\lambda_\gamma = 1$)

$\mu^{*\pm}$ — excited muon

- Mass $m > 103.2 \text{ GeV, CL} = 95\%$ (from $\mu^*\mu^*$)
- Mass $m > 5.700 \times 10^3 \text{ GeV, CL} = 95\%$ (from $\mu\mu^*$)

$\tau^{*\pm}$ — excited tau

- Mass $m > 103.2 \text{ GeV, CL} = 95\%$ (from $\tau^*\tau^*$)
- Mass $m > 4.600 \times 10^3 \text{ GeV, CL} = 95\%$ (from $\tau\tau^*$)

ν^* — excited neutrino

- Mass $m > 1.600 \times 10^3 \text{ GeV, CL} = 95\%$ (from $\nu^*\nu^*$)
- Mass $m > 213 \text{ GeV, CL} = 95\%$ (from ν^*X)

q^* — excited quark

Mass $m > 338$ GeV, CL = 95% (from $q^* q^*$)

Mass $m > 6700$ GeV, CL = 95% (from $q^* X$)

Color Sextet and Octet Particles

Color Sextet Quarks (q_6)

Mass $m > 84$ GeV, CL = 95% (Stable q_6)

Color Octet Charged Leptons (ℓ_8)

Mass $m > 86$ GeV, CL = 95% (Stable ℓ_8)

Color Octet Neutrinos (ν_8)

Mass $m > 110$ GeV, CL = 90% ($\nu_8 \rightarrow \nu g$)

Extra Dimensions

Please refer to the Extra Dimensions section of the full *Review* for a discussion of the model-dependence of these bounds, and further constraints.

Constraints on the radius of the extra dimensions, for the case of two-flat dimensions of equal radii

(direct tests of Newton's law)

$R < 3.8 \mu\text{m}$, CL = 95% ($pp \rightarrow jG$)

$R < 0.16\text{--}916$ nm (astrophysics; limits depend on technique and assumptions)

Constraints on the fundamental gravity scale

$M_{TT} > 9.02$ TeV, CL = 95% ($pp \rightarrow$ dijet, angular distribution)

$M_c > 4.16$ TeV, CL = 95% ($pp \rightarrow \ell\bar{\ell}$)

Constraints on the Kaluza-Klein graviton in warped extra dimensions

$M_G > 4.78$ TeV, CL = 95% ($pp \rightarrow e^+e^-, \mu^+\mu^-$)

Constraints on the Kaluza-Klein gluon in warped extra dimensions

$M_{g_{KK}} > 3.8$ TeV, CL = 95% ($g_{KK} \rightarrow t\bar{t}$)

WIMP and Dark Matter Searches

No confirmed evidence found for galactic

WIMPs from the GeV to the TeV mass scales and down to 1×10^{-10}

pb spin independent cross section at $M = 100$ GeV.