

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

[general MSSM, non-universal gaugino masses]

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

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

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

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

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

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

Mass $m_{\tilde{\chi}_4^0} > 116$ 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 $m_{\tilde{\chi}_1^\pm} > 94$ GeV, CL = 95%

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

Mass $m_{\tilde{\chi}_1^\pm} > 1000$ GeV, CL = 95%
 [$2\ell + \cancel{E}_T$, Tchi1chi1C, $m_{\tilde{\chi}_1^0} = 0$ GeV]
 Mass $m_{\tilde{\chi}_1^\pm} > 1600$ GeV, CL = 95% [R-Parity Violating]
 [Tchi1n2l, $\tilde{\chi}_1^0 \rightarrow \ell^\pm \ell^\mp \nu$, $\lambda_{12k} \neq 0$, $m_{\tilde{\chi}_1^0} = 1200$ GeV]

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

Mass $m_{\tilde{\chi}^\pm} > 1050$ GeV, CL = 95%
 [$\tilde{\chi}^\pm \rightarrow \tilde{\chi}_1^0 \pi^\pm$, wino LSP, stable]
 Mass $m_{\tilde{\chi}^\pm} > 1050$ GeV, CL = 95%
 [$\tilde{\chi}^\pm \rightarrow \tilde{\chi}_1^0 \pi^\pm$, wino LSP, $\tau = 20$ ns]

$\tilde{\nu}$ — sneutrino

Mass $m > 41$ GeV, CL = 95% [model independent]
 Mass $m > 94$ GeV, CL = 95%
 [CMSSM, $1 \leq \tan\beta \leq 40$, $m_{\tilde{e}_R} - m_{\tilde{\chi}_1^0} > 10$ 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%
 [$2\ell + \cancel{E}_T$, $m_{\tilde{\ell}_R} = m_{\tilde{\ell}_L}$ and $\tilde{\ell} = \tilde{e}, \tilde{\mu}$, $m_{\tilde{\chi}_1^0} = 0$ GeV]
 Mass $m > 250$ GeV, CL = 95%
 [$\ell^\pm \ell^\mp + \cancel{E}_T$, \tilde{e}_R , $m_{\tilde{\chi}_1^0} = 0$ 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]
 [$\geq 4\ell$, $\lambda_{12k} \neq 0$, $m_{\tilde{\chi}_1^0} = 900$ GeV (m-degenerate $\tilde{\ell}_L, \tilde{\nu}$)]

$\tilde{\mu}$ — scalar muon (smuon)

Mass $m > 700$ GeV, CL = 95%
 [$2\ell + \cancel{E}_T$, $m_{\tilde{\ell}_R} = m_{\tilde{\ell}_L}$ and $\tilde{\ell} = \tilde{e}, \tilde{\mu}$, $m_{\tilde{\chi}_1^0} = 0$ GeV]
 Mass $m > 210$, CL = 95%
 [$\ell^\pm \ell^\mp + \cancel{E}_T$, $\tilde{\mu}_R$, $m_{\tilde{\chi}_1^0} = 0$ GeV]
 Mass $m > 94$ GeV, CL = 95%
 [CMSSM, $1 \leq \tan\beta \leq 40$, $m_{\tilde{\mu}_R} - m_{\tilde{\chi}_1^0} > 10$ 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]
 [$\geq 4\ell$, $\lambda_{12k} \neq 0$, $m_{\tilde{\chi}_1^0} = 900$ GeV (m-degenerate $\tilde{\ell}_L, \tilde{\nu}$)]

$\tilde{\tau}$ — scalar tau (stau)

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

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

Mass $m > 400$ GeV, CL = 95%

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

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

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

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

[$\geq 4\ell$, $\lambda_{12k} \neq 0$, $m_{\tilde{\chi}_1^0} = 900$ 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%

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

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

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

\tilde{q} — long-lived squark

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

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

\tilde{b} — scalar bottom (sbottom)

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

[b -jets + \cancel{E}_T , Tsb01, $m_{\tilde{\chi}_1^0} = 0$ GeV]

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

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

\tilde{t} — scalar top (stop)

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

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

Mass $m > 1100$ GeV, CL = 95% [R-Parity Violating]

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

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%

[jets + \cancel{E}_T , Tglu1A, $m_{\tilde{\chi}_1^0} < 200$ 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 TeV, CL = 95% |
| $\Lambda_{LL}^-(eeee)$ | > 10.3 TeV, CL = 95% |
| $\Lambda_{LL}^+(ee\mu\mu)$ | > 8.5 TeV, CL = 95% |
| $\Lambda_{LL}^-(ee\mu\mu)$ | > 9.5 TeV, CL = 95% |
| $\Lambda_{LL}^+(ee\tau\tau)$ | > 7.9 TeV, CL = 95% |
| $\Lambda_{LL}^-(ee\tau\tau)$ | > 7.2 TeV, CL = 95% |
| $\Lambda_{LL}^+(\ell\ell\ell\ell)$ | > 9.1 TeV, CL = 95% |
| $\Lambda_{LL}^-(\ell\ell\ell\ell)$ | > 10.3 TeV, CL = 95% |
| $\Lambda_{LL}^+(eeqq)$ | > 24 TeV, CL = 95% |
| $\Lambda_{LL}^-(eeqq)$ | > 37 TeV, CL = 95% |
| $\Lambda_{LL}^+(eeuu)$ | > 23.3 TeV, CL = 95% |
| $\Lambda_{LL}^-(eeuu)$ | > 12.5 TeV, CL = 95% |
| $\Lambda_{LL}^+(eedd)$ | > 11.1 TeV, CL = 95% |
| $\Lambda_{LL}^-(eedd)$ | > 26.4 TeV, CL = 95% |
| $\Lambda_{LL}^+(eccc)$ | > 9.4 TeV, CL = 95% |
| $\Lambda_{LL}^-(eccc)$ | > 5.6 TeV, CL = 95% |
| $\Lambda_{LL}^+(eebb)$ | > 9.4 TeV, CL = 95% |

$$\begin{aligned} \Lambda_{LL}^-(e e b b) &> 10.2 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^+(\mu \mu q q) &> 23.3 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^-(\mu \mu q q) &> 40.0 \text{ TeV, CL} = 95\% \\ \Lambda(\ell \nu \ell \nu) &> 3.10 \text{ TeV, CL} = 90\% \\ \Lambda(e \nu q q) &> 2.81 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^+(q q q q) &> 13.1 \text{ none } 17.4\text{--}29.5 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^-(q q q q) &> 21.8 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^+(\nu \nu q q) &> 5.0 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^-(\nu \nu q q) &> 5.4 \text{ TeV, CL} = 95\% \end{aligned}$$

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

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

$\mu^{*\pm}$ — excited muon

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

$\tau^{*\pm}$ — excited tau

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

ν^* — excited neutrino

$$\begin{aligned} \text{Mass } m &> 1.600 \times 10^3 \text{ GeV, CL} = 95\% \quad (\text{from } \nu^* \nu^*) \\ \text{Mass } m &> 213 \text{ GeV, CL} = 95\% \quad (\text{from } \nu^* X) \end{aligned}$$

q^* — excited quark

$$\begin{aligned} \text{Mass } m &> 338 \text{ GeV, CL} = 95\% \quad (\text{from } q^* q^*) \\ \text{Mass } m &> 6700 \text{ GeV, CL} = 95\% \quad (\text{from } q^* X) \end{aligned}$$

Color Sextet and Octet Particles

Color Sextet Quarks (q_6)

$$\text{Mass } m > 84 \text{ GeV, CL} = 95\% \quad (\text{Stable } q_6)$$

Color Octet Charged Leptons (ℓ_8)

$$\text{Mass } m > 86 \text{ GeV, CL} = 95\% \quad (\text{Stable } \ell_8)$$

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.