

# 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  $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$ ]

$\tilde{\chi}_i^\pm$  — 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  $m_{\tilde{\chi}_1^\pm} > 810$  GeV, CL = 95%

[ $\ell^\pm \ell^\mp$ , Tchi1chi1C,  $m_{\tilde{\chi}_1^0} = 0$  GeV]

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

Mass  $m_{\tilde{\chi}^\pm} > 620$  GeV, CL = 95% [stable  $\tilde{\chi}^\pm$ ]

$\tilde{\nu}$  — 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  $m > 3400$  GeV, CL = 95% [R-Parity Violating]

$[\tilde{\nu}_\tau \rightarrow e\mu, \lambda_{312} = \lambda_{321} = 0.07, \lambda'_{311} = 0.11]$

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

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

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

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

$\tilde{\mu}$  — scalar muon (smuon)

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]

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

$\tilde{\tau}$  — scalar tau (stau)

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

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

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

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

Mass  $m > 1.450 \times 10^3$  GeV, CL = 95%

[CMSSM,  $\tan\beta = 30$ ,  $A_0 = -2\max(m_0, m_{1/2})$ ,  $\mu > 0$ ]

Mass  $m > 1630$  GeV, CL = 95%

[mass degenerate squarks]

Mass  $m > 1130$  GeV, CL = 95%

[single light squark bounds]

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

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

$\tilde{q}$  — 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  $m > 1230$  GeV, CL = 95%

[ $\text{jets} + \cancel{E}_T$ , Tsbott1,  $m_{\tilde{\chi}_1^0} = 0$  GeV]

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

[ $\tilde{b} \rightarrow t d$  or  $t s$ ,  $\lambda''_{332}$  or  $\lambda''_{331}$  coupling]

$\tilde{t}$  — scalar top (stop)

Mass  $m > 1190$  GeV, CL = 95%

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

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

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

$\tilde{g}$  — gluino

Mass  $m > 2.000 \times 10^3$  GeV, CL = 95%

[ $\text{jets} + \cancel{E}_T$ , Tglu1A,  $m_{\tilde{\chi}_1^0} = 0$  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 $\Lambda$ 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 definition 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.

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

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

$\Lambda_{LL}^+(e e \mu \mu)$	> 8.5 TeV, CL = 95%
$\Lambda_{LL}^-(e e \mu \mu)$	> 9.5 TeV, CL = 95%
$\Lambda_{LL}^+(e e \tau \tau)$	> 7.9 TeV, CL = 95%
$\Lambda_{LL}^-(e e \tau \tau)$	> 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%
$\Lambda_{LL}^+(e e q q)$	> 24 TeV, CL = 95%
$\Lambda_{LL}^-(e e q q)$	> 37 TeV, CL = 95%
$\Lambda_{LL}^+(e e u u)$	> 23.3 TeV, CL = 95%
$\Lambda_{LL}^-(e e u u)$	> 12.5 TeV, CL = 95%
$\Lambda_{LL}^+(e e d d)$	> 11.1 TeV, CL = 95%
$\Lambda_{LL}^-(e e d d)$	> 26.4 TeV, CL = 95%
$\Lambda_{LL}^+(e e c c)$	> 9.4 TeV, CL = 95%
$\Lambda_{LL}^-(e e c c)$	> 5.6 TeV, CL = 95%
$\Lambda_{LL}^+(e e b b)$	> 9.4 TeV, CL = 95%
$\Lambda_{LL}^-(e e b b)$	> 10.2 TeV, CL = 95%
$\Lambda_{LL}^+(\mu \mu q q)$	> 20 TeV, CL = 95%
$\Lambda_{LL}^-(\mu \mu q q)$	> 30 TeV, CL = 95%
$\Lambda(\ell \nu \ell \nu)$	> 3.10 TeV, CL = 90%
$\Lambda(e \nu q q)$	> 2.81 TeV, CL = 95%
$\Lambda_{LL}^+(q q q q)$	> 13.1 none 17.4–29.5 TeV, CL = 95%
$\Lambda_{LL}^-(q q q q)$	> 21.8 TeV, CL = 95%
$\Lambda_{LL}^+(\nu \nu q q)$	> 5.0 TeV, CL = 95%
$\Lambda_{LL}^-(\nu \nu q q)$	> 5.4 TeV, CL = 95%

## Excited Leptons

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

$e^{*\pm}$  — excited electron

Mass  $m > 103.2$  GeV, CL = 95% (from  $e^* e^*$ )

Mass  $m > 4.800 \times 10^3$  GeV, CL = 95% (from  $e e^*$ )

Mass  $m > 356$  GeV, CL = 95% (if  $\lambda_\gamma = 1$ )

$\mu^{*\pm}$  — excited muon

Mass  $m > 103.2$  GeV, CL = 95% (from  $\mu^* \mu^*$ )

Mass  $m > 3.800 \times 10^3$  GeV, CL = 95% (from  $\mu \mu^*$ )

$\tau^{*\pm}$  — excited tau

Mass  $m > 103.2$  GeV, CL = 95% (from  $\tau^* \tau^*$ )

Mass  $m > 2.500 \times 10^3$  GeV, CL = 95% (from  $\tau \tau^*$ )

$\nu^*$  — excited neutrino

Mass  $m > 1.600 \times 10^3$  GeV, CL = 95% (from  $\nu^* \nu^*$ )

Mass  $m > 213$  GeV, CL = 95% (from  $\nu^* X$ )

$q^*$  — excited quark

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

Mass  $m > 6.000 \times 10^3$  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 ( $\ell_8$ )

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

Color Octet Neutrinos ( $\nu_8$ )

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

$R < 30 \text{ } \mu\text{m}$ , CL = 95% (direct tests of Newton's law)

$R < 4.8 \text{ } \mu\text{m}$ , CL = 95% ( $pp \rightarrow jG$ )

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

### Constraints on the fundamental gravity scale

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

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

### Constraints on the Kaluza-Klein graviton in warped extra dimensions

$M_G > 4.25 \text{ TeV}$ , CL = 95% ( $pp \rightarrow \gamma\gamma$ )

## Constraints on the Kaluza-Klein gluon in warped extra dimensions

$M_{g_{KK}} > 3.8 \text{ TeV}$ , 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  $1 \times 10^{-10} \text{ pb}$  spin independent cross section at M = 100 GeV.

---