See key on page 1343

$\widetilde{\chi}^\pm_1$, $\widetilde{\chi}^\pm_2$ (Charginos) MASS LIMITS

Charginos ($\widetilde{\chi}^\pm$'s) are unknown mixtures of w-inos and charged higgsinos (the supersymmetric partners of W and Higgs bosons). Mass limits are relatively model dependent, so assumptions concerning branching ratios need to be specified. When specific assumptions are made, e.g. the chargino is a pure w-ino ($\widetilde{W}$) or pure charged higgsino ($\widetilde{H}^\pm$), the charginos will be labelled as such.

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>44.0	95	[36] ADRIANI	93M	L3	$Z \to \widetilde{\chi}^+\widetilde{\chi}^-$, $\Gamma(Z)$
>45.2	95	[37] DECAMP	92	ALEP	$Z \to \widetilde{\chi}^+\widetilde{\chi}^-$, all $m_{\widetilde{\chi}^0_1}$
>47	95	[37] DECAMP	92	ALEP	$Z \to \widetilde{\chi}^+\widetilde{\chi}^-$, $m_{\widetilde{\chi}^0_1}$ <41 GeV
>99	95	[38] HIDAKA	91	RVUE	$\widetilde{\chi}^\pm_2$
>44.5	95	[39] ABREU	90G	DLPH	$Z \to \widetilde{\chi}^+\widetilde{\chi}^-$, $m_{\widetilde{\gamma}}$ < 20 GeV
>45	95	[40] AKRAWY	90D	OPAL	$e^+e^- \to \widetilde{\chi}^+\widetilde{\chi}^-$; $m_{\widetilde{\gamma}}$ < 20 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[41] DATTA	92	RVUE	$Z \to \widetilde{\chi}^+\widetilde{\chi}^-$, $\widetilde{\chi}^0\widetilde{\chi}^0$
>43	90	[42] DREES	91	RVUE	$\widetilde{\chi}^\pm_1$
>45	95	ABREU	90G	DLPH	Stable $\widetilde{\chi}^\pm$, $\widetilde{\chi}^+\widetilde{\chi}^-$
>28.2	95	ADACHI	90C	TOPZ	Stable $\widetilde{\chi}^\pm$, $\widetilde{\chi}^+\widetilde{\chi}^-$
>45	95	[43] AKESSON	90B	UA2	$p\overline{p} \to ZX$ ($Z \to \widetilde{W}^+\widetilde{W}^-$)
>37	90	[44] BAER	90	RVUE	$\Gamma(Z)$; $\tan\beta$ > 1
>45	95	[45] BARKLOW	90	MRK2	$Z \to \widetilde{W}^+\widetilde{W}^-$
>42	95	[46] BARKLOW	90	MRK2	$Z \to \widetilde{H}^+\widetilde{H}^-$
>44.5	95	[47] DECAMP	90C	ALEP	$e^+e^- \to \widetilde{\chi}^+\widetilde{\chi}^-$; $m_{\widetilde{\gamma}}$ < 28 GeV
>25.5	95	[48] ADACHI	89	TOPZ	$e^+e^- \to \widetilde{\chi}^+\widetilde{\chi}^-$
>44	95	[49] ADEVA	89B	L3	$e^+e^- \to \widetilde{W}^+\widetilde{W}^-$, $\widetilde{W} \to \ell\widetilde{\nu}$ or $\ell\nu\widetilde{\gamma}$
>45	90	[50] ANSARI	87D	UA2	$p\overline{p} \to ZX$ ($Z \to \widetilde{W}^+\widetilde{W}^-$, $\widetilde{W}^\pm \to e^\pm\widetilde{\nu}$)
>40		[51] BAER	87B	RVUE	$p\overline{p} \to W/ZX$ ($W/Z \to \widetilde{W}$, $\widetilde{Z}$, $\widetilde{\gamma}$)

[36] ADRIANI 93M limit from $\Delta\Gamma(Z)$< 35.1 MeV. For pure wino, the limit is 45.5 GeV.

[37] DECAMP 92 limit is for a general $\widetilde{\chi}^\pm$ (all contents).

[38] HIDAKA 91 limit obtained from LEP and preliminary CDF results (as analyzed in BAER 91) within minimal supersymmetry with gaugino-mass unification condition.

[39] ABREU 90G limit is for a general $\widetilde{\chi}^\pm$. They assume charginos have a three-body decay such as $\ell^+\nu\widetilde{\gamma}$.

[40] AKRAWY 90D assume charginos have three-body decay such as $\ell^+\nu\widetilde{\gamma}$ (i.e. $m_{\widetilde{\nu}} > m_{\widetilde{\chi}^+}$). A two-body decay, $\widetilde{\chi}^+ \to \ell\widetilde{\nu}$ would have been seen by their search for acoplanar leptons. The result is independent of the hadronic branching ratio. They search for acoplanar electromagnetic clusters and quark jets.

[41] DATTA 92 exclude some regions in chargino-gluino mass plane from LEP experiments.

[42] DREES 91 limit obtained from LEP results within minimal supersymmetry with gaugino-mass unification condition. They make use of DECAMP 90C analysis plus additional constraint from total Z width. The bound can only be evaded if the chargino mixes with other charged singlets or with gauginos of a right-handed gauge group.

[43] AKESSON 90B assume $\widetilde{W} \to e\widetilde{\nu}$ with B > 20% and $m_{\widetilde{\nu}} = 0$. The limit disappears if $m_{\widetilde{\nu}}$ > 30 GeV.

[44] BAER 90 is independent of decay modes. Limit from analysis of supersymmetric parameter space restrictions implied by $\Delta\Gamma(Z)$ < 120 MeV. These result from decays of Z to all combinations of $\widetilde{\chi}^\pm_i$ and $\widetilde{\chi}^0_i$. Minimal supersymmetry with $\tan\beta$ > 1 is assumed.

[45] BARKLOW 90 assume 100% $\widetilde{W} \to W^*\widetilde{\chi}^0_1$. Valid up to $m_{\widetilde{\chi}^0_1} \lesssim [m_{\widetilde{W}}-5\text{ GeV}]$.

[46] BARKLOW 90 assume 100% $\widetilde{H} \to H^*\widetilde{\chi}^0_1$. Valid up to $m_{\widetilde{\chi}^0_1} \lesssim [m_{\widetilde{H}}-8\text{ GeV}]$.

[47] DECAMP 90C assume charginos have three-body decay such as $\ell^+\nu\widetilde{\gamma}$ (i.e. $m_{\widetilde{\nu}} > m_{\widetilde{\chi}^+}$), and branching ratio to each lepton is 11%. They search for acoplanar dimuons, dielectrons, and μe events. Limit valid for $m_{\widetilde{\gamma}}$ < 28 GeV.

[48] ADACHI 89 assume only single photon annihilation in the production. The limit applies for arbitrary decay branching ratios with $B(\widetilde{\chi} \to e\nu\widetilde{\gamma})$ + $B(\widetilde{\chi} \to \mu\nu\widetilde{\gamma})$ + $B(\widetilde{\chi} \to \tau\nu\widetilde{\gamma})$ + $B(\widetilde{\chi} \to q\overline{q}\widetilde{\gamma})$ = 1 (lepton universality is *not* assumed). The limit is for $m_{\widetilde{\gamma}}$ = 0 but a very similar limit is obtained for $m_{\widetilde{\gamma}}$ = 10 GeV. For $B(\widetilde{\chi} \to q\overline{q}\widetilde{\gamma})$ = 1, the limit increases to 27.8 GeV.

[49] ADEVA 89B assume for $\ell\nu\widetilde{\gamma}$ ($\ell\widetilde{\nu}$) mode that $B(e) = B(\mu) = B(\tau)$ = 11% (33%) and search for acoplanar dimuons, dielectrons, and μe events. Also assume $m_{\widetilde{\gamma}}$ < 20 GeV and for $\ell\widetilde{\nu}$ mode that $m_{\widetilde{\nu}}$ = 10 GeV.

[50] ANSARI 87D looks for high p_T e^+e^- pair with large missing p_T at the CERN $p\overline{p}$ collider at E_{cm} = 546–630 GeV. The limit is valid when $m_{\widetilde{\nu}} \lesssim$ 20 GeV, $B(\widetilde{W} \to e\widetilde{\nu}_e)$ = 1/3, and $B(Z \to \widetilde{W}^+\widetilde{W}^-)$ is calculated by assuming pure gaugino eigenstate. See their Fig. 3(b) for excluded region in the $m_{\widetilde{W}} - m_{\widetilde{\nu}}$ plane.

[51] BAER 87B argue that the charged heavy lepton mass limit of 41 GeV obtained by UA1 collaboration (ALBAJAR 87B) corresponds to the mass limit of 40 GeV under the assumptions that the LSP (photino) has a mass smaller than 8 GeV and that the gaugino-higgsino mixing is parametrized by the three minimal supergravity model parameters. In grand unified theories $m_{\widetilde{\gamma}}$ < 8 implies $m_{\widetilde{g}}$ < 50 GeV. For larger gluino masses, this limit can be evaded as discussed in BAER 88.

$\widetilde{\nu}$ (Sneutrino) MASS LIMIT

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

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>41.8	95	[52] ADRIANI	93M	L3	$\Gamma(Z \to \text{invisible})$; $N(\widetilde{\nu})$=3
>37.1	95	[52] ADRIANI	93M	L3	$\Gamma(Z \to \text{invisible})$; $N(\widetilde{\nu})$=1
>41	95	[53] DECAMP	92	ALEP	$\Gamma(Z \to \text{invisible})$; $N(\widetilde{\nu})$=3
>36	95	ABREU	91F	DLPH	$\Gamma(Z \to \text{invisible})$; $N(\widetilde{\nu})$=1
>32	95	[54] ABREU	91F	DLPH	$\Gamma(Z)$; $N(\widetilde{\nu})$=1
>31.2	95	[55] ALEXANDER	91F	OPAL	$\Gamma(Z \to \text{invisible})$; $N(\widetilde{\nu})$=1
>31.4	95	[56] ADEVA	90I	L3	$\Gamma(Z \to \text{invisible})$; $N(\widetilde{\nu})$=1
>39.4	95	[56] ADEVA	90I	L3	$\Gamma(Z \to \text{invisible})$; $N(\widetilde{\nu})$=3
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>38.4	90	[57] DREES	91	RVUE	$\Gamma(Z)$; $N(\widetilde{\nu})$=3
>28.9	90	[57] DREES	91	RVUE	$\Gamma(Z)$; $N(\widetilde{\nu})$=1
none 3–90	90	[58] SATO	91	KAMI	Stable $\widetilde{\nu}_e$ or $\widetilde{\nu}_\mu$, dark matter
none 4–90	90	[58] SATO	91	KAMI	Stable $\widetilde{\nu}_\tau$, dark matter
>36.5	90	[59] BAER	90	RVUE	$\Gamma(Z)$; $N(\widetilde{\nu})$=3

[52] ADRIANI 93M limit from $\Delta\Gamma(Z)$(invisible)< 16.2 MeV.

[53] DECAMP 92 limit is from $\Gamma(\text{invisible})/\Gamma(\ell\ell)$ = 5.91 ± 0.15 (N_ν = 2.97 ± 0.07).

[54] ABREU 91F limit (>32 GeV) is independent of sneutrino decay mode.

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

[56] ADEVA 90I limit is from ΔN_ν < 0.19.

[57] DREES 91 limits from $\Delta\Gamma(Z)$ (nonhadronic) < 38.3 MeV. Independent of decay modes. Minimal supersymmetry assumed.

[58] SATO 91 search for high-energy neutrinos from the sun produced by annihilation of sneutrinos in the sun. Sneutrinos are assumed to be stable and to constitute dark matter in our galaxy. SATO 91 follow the analysis of NG 87, OLIVE 88, and GAISSER 86.

[59] BAER 90 limit from $\Delta\Gamma(Z)$ (nonhadronic) < 53 MeV. Independent of decay modes. Mininal supersymmetry assumed. The 95%CL bound is 35.6 GeV.

$\widetilde{e}$ (Selectron) MASS LIMIT

Limits assume $m_{\widetilde{e}_L} = m_{\widetilde{e}_R}$ unless otherwise stated.

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
> 45	95	[60] ADRIANI	93M	L3	$m_{\widetilde{\chi}^0_1}$ <40 GeV, $\widetilde{e}^+\widetilde{e}^-$
> 45	95	[61] DECAMP	92	ALEP	$m_{\widetilde{\chi}^0_1}$ <41 GeV, $\widetilde{e}^+\widetilde{e}^-$
> 65	95	[62,63] HEARTY	89	RVUE	$m_{\widetilde{\gamma}}$=0; $\gamma\widetilde{\gamma}\widetilde{\gamma}$
> 50	95	HEARTY	89	ASP	$m_{\widetilde{\gamma}}$ <5 GeV; $\gamma\widetilde{\gamma}\widetilde{\gamma}$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
> 42	95	ABREU	90G	DLPH	$m_{\widetilde{\gamma}}$ < 40 GeV; $\widetilde{e}^+\widetilde{e}^-$
> 38	95	[64] AKESSON	90B	UA2	$m_{\widetilde{\gamma}}$ = 0; $p\overline{p} \to ZX$ ($Z \to \widetilde{e}^+\widetilde{e}^-$)
> 43.4	95	[65] AKRAWY	90D	OPAL	$m_{\widetilde{\gamma}}$ < 30 GeV; $\widetilde{e}^+\widetilde{e}^-$
> 38.1	90	[66] BAER	90	RVUE	$\widetilde{e}_L$; $\Gamma(Z)$; $\tan\beta$ > 1
> 43.5	95	[67] DECAMP	90C	ALEP	$m_{\widetilde{\gamma}}$ < 36 GeV; $\widetilde{e}^+\widetilde{e}^-$
>830		GRIFOLS	90	ASTR	$m_{\widetilde{\gamma}}$ < 1 MeV
> 29.9	95	SAKAI	90	AMY	$m_{\widetilde{\gamma}}$ < 20 GeV; $\widetilde{e}^+\widetilde{e}^-$
> 29	95	TAKETANI	90	VNS	$m_{\widetilde{\gamma}}$ < 25 GeV; $\widetilde{e}^+\widetilde{e}^-$
> 60		[68] ZHUKOVSKII	90	ASTR	$m_{\widetilde{\gamma}}$ = 0
> 32	90	[69] ABE	89K	VNS	$e^+e^- \to \gamma\widetilde{\gamma}\widetilde{\gamma}$
> 28	95	[70] ADACHI	89	TOPZ	$m_{\widetilde{\gamma}} \lesssim 0.85 m_{\widetilde{e}}$; $\widetilde{e}^+\widetilde{e}^-$
> 41	95	[71] ADEVA	89B	L3	$m_{\widetilde{\gamma}}$ < 20 GeV; $\widetilde{e}^+\widetilde{e}^-$
> 32	90	[72] ALBAJAR	89	UA1	$p\overline{p} \to W^\pm X$ ($W^\pm \to \widetilde{e}_L\widetilde{\nu}$) ($\widetilde{e}_L \to e\widetilde{\gamma}$)
> 14	90	[73] ALBAJAR	89	UA1	$Z \to \widetilde{e}^+\widetilde{e}^-$
> 53	95	[62,74] HEARTY	89	ASP	$m_{\widetilde{\gamma}}$=0; $\gamma\widetilde{\gamma}\widetilde{\gamma}$
> 35	95	HEARTY	89	ASP	$m_{\widetilde{\gamma}}$ <10 GeV; $\gamma\widetilde{\gamma}\widetilde{\gamma}$
> 51.5	90	[75,76] BEHREND	88B	CELL	$m_{\widetilde{\gamma}}$ = 0 GeV; $\gamma\widetilde{\gamma}\widetilde{\gamma}$
> 64	95	[75,77] BEHREND	88B	RVUE	$m_{\widetilde{\gamma}}$ = 0 GeV; $\gamma\widetilde{\gamma}\widetilde{\gamma}$
> 48	90	BEHREND	88B	CELL	$m_{\widetilde{\gamma}}$ < 5 GeV; $\gamma\widetilde{\gamma}\widetilde{\gamma}$

[60] ADRIANI 93M limit is for $m_{\widetilde{e}_L} \gg m_{\widetilde{e}_R}$ using acolinear di-lepton events.

[61] DECAMP 92 limit is for $m_{\widetilde{e}_L} \gg m_{\widetilde{e}_R}$; for equal masses the limit would improve. They looked for acoplanar electrons.

[62] HEARTY 89 assume $m_{\widetilde{\gamma}}$ = 0. The limit is very sensitive to $m_{\widetilde{\gamma}}$; no limit can be placed for $m_{\widetilde{\gamma}} \gtrsim$ 13 GeV.

[63] Results of HEARTY 89, BEHREND 88B, ADEVA 87, and FORD 86 are combined. The limit is reduced to 53 GeV if only one $\widetilde{e}$ state is produced ($\widetilde{e}_L$ or $\widetilde{e}_R$ very heavy).

[64] AKESSON 90B assume $m_{\widetilde{\gamma}}$ = 0. Very similar limits hold for $m_{\widetilde{\gamma}} \lesssim$ 20 GeV.

[65] AKRAWY 90D look for acoplanar electrons. For $m_{\widetilde{e}_L} \gg m_{\widetilde{e}_R}$, limit is 41.5 GeV, for $m_{\widetilde{\gamma}}$ < 30 GeV.

[66] BAER 90 limit from $\Delta\Gamma(Z)$ (nonhadronic) < 53 MeV. Independent of decay modes. Minimal supersymmetry and $\tan\beta$ > 1 assumed.

[67] DECAMP 90C look for acoplanar electrons. For $m_{\widetilde{e}_L} \gg m_{\widetilde{e}_R}$ limit is 42 GeV, for $m_{\widetilde{\gamma}}$ < 33 GeV.