[97] NOJIRI 91 argues that a heavy squark should be nearly degenerate with the gluino in minimal supergravity not to overclose the universe.

[98] ABREU 90F assume six degenerate squarks and $m_{\tilde{q}_L} = m_{\tilde{q}_R}$. $m_{\tilde{q}} < 41$ GeV is excluded at 95% CL for $m_{\rm LSP} < m_{\tilde{q}}-2$ GeV.

[99] ABREU 90F exclude $m_{\tilde{d}} < 38$ GeV at 95% for $m_{\rm LSP} < m_{\tilde{d}}-2$ GeV.

[100] ABREU 90F exclude $m_{\tilde{u}} < 36$ GeV at 95% for $m_{\rm LSP} < m_{\tilde{u}}-2$ GeV.

[101] ALITTI 90 searched for events having $\geq$ 2 jets with $E_T^1 > 25$ GeV, $E_T^2 > 15$ GeV, $|\eta| < 0.85$, and $\Delta\phi < 160°$, with a missing momentum > 40 GeV and no electrons. They assume $\tilde{q} \rightarrow q\tilde{\gamma}$ (if $m_{\tilde{q}} < m_{\tilde{g}}$) or $\tilde{q} \rightarrow q\tilde{g}$ (if $m_{\tilde{q}} > m_{\tilde{g}}$) decay and $m_{\tilde{\gamma}} \lesssim 20$ GeV. Five degenerate squark flavors and $m_{\tilde{q}_L} = m_{\tilde{q}_R}$ are assumed. Masses below 50 GeV are not excluded by the analysis.

[102] BAER 90 limit from $\Delta\Gamma(Z) <$ 120 MeV, assuming $m_{\tilde{d}_L} = m_{\tilde{u}_L} = m_{\tilde{e}_L} = m_{\tilde{\nu}}$. Independent of decay modes. Minimal supergravity assumed.

[103] BARKLOW 90 assume 100% $\tilde{q} \rightarrow q\tilde{\gamma}$.

[104] BARKLOW 90 assume five degenerate squarks (left- and right-handed). Valid up to $m_{\tilde{\chi}_1^0} \lesssim [m_{\tilde{q}}-4$ GeV].

[105] BARKLOW 90 result valid up to $m_{\tilde{\chi}_1^0} \lesssim [m_{\tilde{d}}-5$ GeV].

[106] BARKLOW 90 result valid up to $m_{\tilde{\chi}_1^0} \lesssim [m_{\tilde{u}}-6$ GeV].

[107] DREES 90 argue that bounds from Z decay are not valid for $\tilde{t}$ for a certain range of $\tilde{t}_L$-$\tilde{t}_R$ mixing angle.

[108] ADACHI 89 assume only photon exchange, which gives a a conservative limit. The limit is only for one flavor of charge 2/3 $\tilde{q}$. $m_{\tilde{q}_L} = m_{\tilde{q}_R}$ and $m_{\tilde{\gamma}} = 0$ assumed. The limit decreases to 26.1 GeV for $m_{\tilde{\gamma}} = 15$ GeV. The limit for nondegenerate case is 24.4 GeV.

[109] NATH 88 uses Kamioka limit of $\tau(p \rightarrow \overline{\nu}K^+) > 7\times 10^{31}$ yrs to constrain squark mass $m_{\tilde{q}} > 1000$ GeV by assuming that the proton decay proceeds via an exchange of a color-triplet Higgsino of mass $< 10^{16}$ GeV in the supersymmetric SU(5) GUT. The limit applies for $m_{\tilde{\gamma}} \equiv (8/3)\sin^2\theta_W \tilde{m}_2 > 10$ GeV ($\tilde{m}_2$ is the SU(2) gaugino mass) and for a very conservative value of the three-quark proton wave function, barring cancellation between second and third generations. Lower squark mass is allowed if $m_{\tilde{\gamma}}$ as defined above is smaller.

[110] The limits of ALBAJAR 87D are from $p\overline{p} \rightarrow \tilde{q}\overline{\tilde{q}}X$ ($\tilde{q} \rightarrow q\tilde{\gamma}$) and assume 5 flavors of degenerate mass squarks each with $m_{\tilde{q}_L} = m_{\tilde{q}_R}$. They also assume $m_{\tilde{g}} > m_{\tilde{q}}$. These limits apply for $m_{\tilde{\gamma}} \lesssim 20$ GeV.

$\tilde{g}$ (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 photinos as assumed by some papers. When direct decay is assumed, realistic limits would be somewhat lower.

There is an ongoing controversy (reflected in these Listings) about whether very light $\tilde{g}$'s ($1 \lesssim m_{\tilde{g}} \lesssim 4$ GeV) are ruled out. These papers sometimes make different assumptions and use different calculational techniques.

VALUE (GeV)	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
>218	90		[111] ABE	92L	CDF	$m_{\tilde{q}} \leq m_{\tilde{g}}$; with cascade decay
>100	90		[111] ABE	92L	CDF	Any $m_{\tilde{q}}$; with cascade decay
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$<$ 1			[112] CLAVELLI	93	RVUE	quarkonia
			[113] HEBBEKER	93	RVUE	e^+e^- jet analyses
not 3–5			[114] LOPEZ	93C	RVUE	LEP
$\approx$ 4			[115] CLAVELLI	92	RVUE	α_s running
$>$100			[116] ROY	92	RVUE	$p\overline{p} \rightarrow \tilde{g}\tilde{g}$; R-parity violating
			[117] ANTONIADIS	91	RVUE	α_s running
$>$ 1			[118] ANTONIADIS	91	RVUE	$pN \rightarrow$ missing energy
$>$132	90		[119] HIDAKA	91	RVUE	
			[120] NOJIRI	91	COSM	
$>$ 79	90		[121] ALITTI	90	UA2	Any $m_{\tilde{q}}$; B($\tilde{g} \rightarrow q\overline{q}\tilde{\gamma}$) = 1
$>$106	90		[121] ALITTI	90	UA2	$m_{\tilde{q}} = m_{\tilde{g}}$; B($\tilde{g} \rightarrow q\overline{q}\tilde{\gamma}$) = 1
			[122] NAKAMURA	89	SPEC	R-Δ^{++}
none 4–53	90		[123] ALBAJAR	87D	UA1	Any $m_{\tilde{q}} > m_{\tilde{g}}$
none 4–75	90		[123] ALBAJAR	87D	UA1	$m_{\tilde{q}} = m_{\tilde{g}}$
none 16–58	90		[124] ANSARI	87D	UA2	$m_{\tilde{q}} \lesssim 100$ GeV
$>$ 3.8	90		[125] ARNOLD	87	EMUL	π^- (350 GeV). $\sigma \simeq A^1$
$>$ 3.2	90		[125] ARNOLD	87	EMUL	π^- (350 GeV). $\sigma \simeq A^{0.72}$
none 0.6–2.2	90		[126] TUTS	87	CUSB	$\Upsilon(1S) \rightarrow \gamma+$ gluinonium
none 1 –4.5	90	0	[127] ALBRECHT	86C	ARG	$1\times 10^{-11} \lesssim \tau \lesssim 1\times 10^{-9}$s
none 1–4	90	0	[128] BADIER	86	BDMP	$1\times 10^{-10} < \tau < 1\times 10^{-7}$s
none 3–5			[129] BARNETT	86	RVUE	$p\overline{p} \rightarrow$ gluino gluino gluon
none			[130] VOLOSHIN	86	RVUE	If (quasi) stable; $\tilde{g}uud$
none 0.5–2			[131] COOPER-...	85B	BDMP	For $m_{\tilde{q}}$=300 GeV
none 0.5–4			[131] COOPER-...	85B	BDMP	For $m_{\tilde{q}}$ <65 GeV
none 0.5–3			[131] COOPER-...	85B	BDMP	For $m_{\tilde{q}}$=150 GeV
none 2–4			[132] DAWSON	85	RVUE	$\tau > 10^{-7}$ s
none 1–2.5			[132] DAWSON	85	RVUE	For $m_{\tilde{q}}$=100 GeV
none 0.5–4.1	90		[133] FARRAR	85	RVUE	FNAL beam dump
$>$ 1			[134] GOLDMAN	85	RVUE	Gluononium
$>$1–2			[135] HABER	85	RVUE	
			[136] BALL	84	CALO	
			[137] BRICK	84	RVUE	
			[138] FARRAR	84	RVUE	
$>$ 2			[139] BERGSMA	83C	RVUE	For $m_{\tilde{q}}$ <100 GeV
			[140] CHANOWITZ	83	RVUE	$\tilde{g}u\overline{d}$, $\tilde{g}uud$
$>$2–3			[141] KANE	82	RVUE	Beam dump
$>$1.5–2			FARRAR	78	RVUE	R-hadron

[111] ABE 92L includes the effect of cascade decay, for a particular choice of paramters, $\mu = -250$ GeV, tanβ = 2. Results are mildly sensitive to these parameters over much of parameter space. ABE 92L limit assumes GUT relations between gaugino masses and the gauge coupling; in particular that for $|\mu|$ not small, $m_{\tilde{\chi}_1^0} \approx m_{\tilde{g}}/6$. Not sensitive to $m_{\tilde{g}} \leq 40$ GeV (but other experiments rule out that region). Limits are more substanial if B($\tilde{g} \rightarrow q\overline{q}\tilde{\gamma}$) = 1; for $m_{\tilde{q}} > m_{\tilde{g}}$ the limits are about 50 GeV greater.

[112] CLAVELLI 93 makes a two-dimensional fit to the quarkonia decay widths for $\phi(1020)$, $J/\psi(1S)$, $\psi(2S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ taking $\alpha_s(m_Z)$ and $m_{\tilde{g}}$ as variables. Claims that the fit favors $m_{\tilde{g}}$ <1 GeV, and that the fitted $\alpha_s(m_Z)$ is consistent with LEP data.

[113] HEBBEKER 93 combined jet analyses at various e^+e^- colliders. The 4-jet analyses at TRISTAN/LEP and the measured α_s at PEP/PETRA/TRISTAN/LEP are used. A constraint on effective number of quarks N=6.3 ± 1.1 is obtained, which is compared to that with a light gluino, N=8.

[114] LOPEZ 93C uses combined restraint from the radiative symmetry breaking scenario within the minimal supergravity model, and the LEP bounds on the (M_2,μ) plane. Claims that the light gluino window is strongly disfavored.

[115] CLAVELLI 92 claims that a light gluino mass around 4 GeV should exist to explain the discrepancy between α_s at LEP and at quarkonia (Υ), since a light gluino slows the running of the QCD coupling.

[116] ROY 92 reanalyzed CDF limits on di-lepton events to obtain limits on gluino production in R-parity violating models. The 100% decay $\tilde{g} \rightarrow q\overline{q}\tilde{\chi}$ where $\tilde{\chi}$ is the LSP, and the LSP decays either into $\ell q\overline{d}$ or $\ell\ell\overline{e}$ is assumed.

[117] ANTONIADIS 91 argue that possible light gluinos ($<$ 5 GeV) contradict the observed running of α_s between 5 GeV and m_Z. The significance is less than 2 s.d.

[118] ANTONIADIS 91 intrepret the search for missing energy events in 450 GeV/c pN collisions, AKESSON 91, in terms of light gluinos.

[119] HIDAKA 91 limit obtained from LEP and preliminary CDF results within minimal supersymmetry with gaugino-mass unification condition. HIDAKA 91 limit extracted from BAER 91 analysis.

[120] NOJIRI 91 argues that a heavy gluino should be nearly degenerate with squarks in minimal supergravity not to overclose the universe.

[121] ALITTI 90 searched for events having $\geq$ 2 jets with $E_T^1 > 25$ GeV, $E_T^2 > 15$ GeV, $|\eta| < 0.85$, and $\Delta\phi < 160°$, with a missing momentum > 40 GeV and no electrons. They assume $\tilde{g} \rightarrow q\overline{q}\tilde{\gamma}$ decay and $m_{\tilde{\gamma}} \lesssim 20$ GeV. Masses below 50 GeV are not excluded by the analysis.

[122] NAKAMURA 89 searched for a long-lived ($\tau \gtrsim 10^{-7}$ s) charge-($\pm$2) particle with mass $\lesssim$ 1.6 GeV in proton-Pt interactions at 12 GeV and found that the yield is less than 10^{-8} times that of the pion. This excludes R-Δ^{++} (a $\tilde{g}uuu$ state) lighter than 1.6 GeV.

[123] The limits of ALBAJAR 87D are from $p\overline{p} \rightarrow \tilde{g}\tilde{g}X$ ($\tilde{g} \rightarrow q\overline{q}\tilde{\gamma}$) and assume $m_{\tilde{q}} > m_{\tilde{g}}$. These limits apply for $m_{\tilde{\gamma}} \lesssim 20$ GeV and $\tau(\tilde{g}) < 10^{-10}$ s.

[124] The limit of ANSARI 87D assumes $m_{\tilde{q}} > m_{\tilde{g}}$ and $m_{\tilde{\gamma}} \approx 0$.

[125] The limits assume $m_{\tilde{q}} = 100$ GeV. See their figure 3 for limits vs. $m_{\tilde{q}}$.

[126] The gluino mass is defined by half the bound $\tilde{g}\tilde{g}$ mass. If zero gluino mass gives a $\tilde{g}\tilde{g}$ of mass about 1 GeV as suggested by various glueball mass estimates, then the low-mass bound can be replaced by zero. The high-mass bound is obtained by comparing the data with nonrelativistic potential-model estimates.

[127] ALBRECHT 86C search for secondary decay vertices from $\chi_{b1}(1P) \rightarrow \tilde{g}\tilde{g}g$ where $\tilde{g}$'s make long-lived hadrons. See their figure 4 for excluded region in the $m_{\tilde{g}} - m_{\tilde{q}}$ and $m_{\tilde{g}} - m_{\tilde{q}}$ plane. The lower $m_{\tilde{g}}$ region below $\sim$ 2 GeV may be sensitive to fragmentation effects. Remark that the $\tilde{g}$-hadron mass is expected to be $\sim$ 1 GeV (glueball mass) in the zero $\tilde{g}$ mass limit.

[128] BADIER 86 looked for secondary decay vertices from long-lived $\tilde{g}$-hadrons produced at 300 GeV π^- beam dump. The quoted bound assumes $\tilde{g}$-hadron nucleon total cross section of 10μb. See their figure 7 for excluded region in the $m_{\tilde{g}} - m_{\tilde{q}}$ plane for several assumed total cross-section values.

[129] BARNETT 86 rule out light gluinos (m = 3–5 GeV) by calculating the monojet rate from gluino gluino gluon events (and from gluino gluino events) and by using UA1 data from $p\overline{p}$ collisions at CERN.

[130] VOLOSHIN 86 rules out stable gluino based on the cosmological argument that predicts too much hydrogen consisting of the charged stable hadron $\tilde{g}uud$. Quasi-stable ($\tau > 1.\times 10^{-7}$s) light gluino of $m_{\tilde{g}}$ <3 GeV is also ruled out by nonobservation of the stable charged particles, $\tilde{g}uud$, in high energy hadron collisions.

[131] COOPER-SARKAR 85B is BEBC beam-dump. Gluinos decaying in dump would yield $\tilde{\gamma}$'s in the detector giving neutral-current-like interactions. For $m_{\tilde{q}}$ >330 GeV, no limit is set.

[132] DAWSON 85 first limit from neutral particle search. Second limit based on FNAL beam dump experiment.