[91] ADRIANI 92F search for $Z \rightarrow q^* \overline{q}^*$ followed with $q^* \rightarrow q\gamma$ decays and give the limit $\sigma_Z \cdot B(Z \rightarrow q^* \overline{q}^*) \cdot B^2(q^* \rightarrow q\gamma) <2$ pb at 95%CL. Assuming five flavors of degenerate q^* of homodoublet type, $B(q^* \rightarrow q\gamma) <4\%$ is obtained for $m_{q^*} <45$ GeV.
[92] BARDADIN-OTWINOWSKA 92 limit based on $\Delta\Gamma(Z)<36$ MeV.
[93] These limits are independent of decay modes.
[94] BEHREND 86C search for $e^+ e^- \rightarrow q^* \overline{q}^*$ for $m_{q^*} >5$ GeV. But $m < 5$ GeV excluded by total hadronic cross section. The limits are for point-like photon couplings of excited quarks.

Limits for Excited q (q^*) from Single Production

These limits are from $e^+ e^- \rightarrow q^* \overline{q}$ or $p\overline{p} \rightarrow q^* X$ and depend on transition magnetic couplings between q and q^*. Assumptions about q^* decay mode are given in the footnotes and comments.

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>540 (CL = 95%) OUR EVALUATION					
none 80–540	95	[95] ABE	94	CDF	$p\overline{p} \rightarrow q^* X$, $q^* \rightarrow q\gamma$, qW
>288	90	[96] ALITTI	93	UA2	$p\overline{p} \rightarrow q^* X$, $q^* \rightarrow qg$
> 88	95	[97] DECAMP	92	ALEP	$Z \rightarrow qq^*$, $\lambda_Z >1$
$>$ 86	95	[97] AKRAWY	90J	OPAL	$Z \rightarrow qq^*$, $\lambda_Z >1.2$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$>$ 79	95	[98] ADRIANI	93M	L3	λ_Z(L3)>0.06
		[99] ABREU	92D	DLPH	$Z \rightarrow qq^*$
		[100] ADRIANI	92F	L3	$Z \rightarrow qq^*$
$>$ 75	95	[98] DECAMP	92	ALEP	$Z \rightarrow qq^*$, $\lambda_Z >1$
		[101] ALBAJAR	89	UA1	$p\overline{p} \rightarrow q^* X$, $q^* \rightarrow qW$
$>$ 39	95	[102] BEHREND	86C	CELL	$e^+ e^- \rightarrow q^* \overline{q}$ ($q^* \rightarrow qg, q\gamma$), $\lambda_\gamma=1$

[95] ABE 94 search for resonances in jet-γ and jet-W invariant mass in $p\overline{p}$ collisions at $E_{cm} = 1.8$ TeV. The limit is for $f_s = f = f' = \Lambda/m_{q^*}$ and u^* and d^* are assumed to be degenerate. See their Fig. 4 for the excluded region in m_{q^*}-f plane.
[96] ALITTI 93 search for resonances in the two-jet invariant mass. The limit is for $f_s = f = f' = \Lambda/m_{q^*}$. u^* and d^* are assumed to be degenerate. If not, the limit for u^* (d^*) is 277 (247) GeV if $m_{d^*} \gg m_{u^*}$ ($m_{u^*} \gg m_{d^*}$).
[97] Assumes $B(q^* \rightarrow q\gamma) = 0.1$.
[98] Assumes $B(q^* \rightarrow qg) = 1$.
[99] ABREU 92D give $\sigma(e^+ e^- \rightarrow Z \rightarrow q^* \overline{q}$ or $q\overline{q}^*) \times B(q^* \rightarrow q\gamma) <15$ pb (95% CL) for $m_{q^*} <80$ GeV.
[100] ADRIANI 92F search for $Z \rightarrow qq^*$ with $q^* \rightarrow q\gamma$ and give the limit $\sigma_Z \cdot B(Z \rightarrow qq^*) \cdot B(q^* \rightarrow q\gamma) <$(2–10) pb (95%CL) for $m_{q^*} =$ (46–82) GeV.
[101] ALBAJAR 89 give $\sigma(q^* \rightarrow W + \text{jet})/\sigma(W) < 0.019$ (90% CL) for $m_{q^*} > 220$ GeV.
[102] BEHREND 86C has $E_{cm} = 42.5$–46.8 GeV. See their Fig. 3 for excluded region in the $m_{q^*}-(\lambda_\gamma/m_{q^*})^2$ plane. The limit is for $\lambda_\gamma = 1$ with $\eta_L = \eta_R = 1$.

MASS LIMITS for Color Sextet Quarks (q_6)

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>84	95	[103] ABE	89D	CDF	$p\overline{p} \rightarrow q_6 \overline{q}_6$

[103] ABE 89D look for pair production of unit-charged particles which leave the detector before decaying. In the above limit the color sextet quark is assumed to fragment into a unit-charged or neutral hadron with equal probability and to have long enough lifetime not to decay within the detector. A limit of 121 GeV is obtained for a color decuplet.

MASS LIMITS for Color Octet Charged Leptons (ℓ_8)

$\lambda \equiv m_{\ell_8}/\Lambda$

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>86	95	[104] ABE	89D	CDF	Stable ℓ_8: $p\overline{p} \rightarrow \ell_8 \overline{\ell}_8$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[105] ABT	93	H1	e_8: $ep \rightarrow e_8 X$
none 3.0–30.3	95	[106] KIM	90	AMY	e_8: $e^+ e^- \rightarrow ee +$ jets
none 3.5–30.3	95	[106] KIM	90	AMY	μ_8: $e^+ e^- \rightarrow \mu\mu +$ jets
		[107] KIM	90	AMY	e_8: $e^+ e^- \rightarrow gg$; R
>19.8	95	[108] BARTEL	87B	JADE	e_8, μ_8, τ_8: $e^+ e^-$; R
none 5–23.2	95	[108] BARTEL	87B	JADE	μ_8: $e^+ e^- \rightarrow \mu\mu +$ jets
		[109] BARTEL	85K	JADE	e_8: $e^+ e^- \rightarrow gg$; R

[104] ABE 89D look for pair production of unit-charged particles which leave the detector before decaying. In the above limit the color octet lepton is assumed to fragment into a unit-charged or neutral hadron with equal probability and to have long enough lifetime not to decay within the detector. The limit improves to 99 GeV if it always fragments into a unit-charged hadron.
[105] ABT 93 search for e_8 production via e-gluon fusion in ep collisions with $e_8 \rightarrow eg$. See their Fig. 3 for exclusion plot in the m_{e_8}–Λ plane for $m_{e_8} = 35$–220 GeV.
[106] KIM 90 is at $E_{cm} = 50$–60.8 GeV. The same assumptions as in BARTEL 87B are used.
[107] KIM 90 result $(m_{e_8}\Lambda_M)^{1/2} >$ 178.4 GeV (95%CL, $\alpha_s = 0.16$ used) is subject to the same restriction as for BARTEL 85K.
[108] BARTEL 87B is at $E_{cm} = 46.3$–46.78 GeV. The limits assume ℓ_8 pair production cross sections to be eight times larger than those of the corresponding heavy lepton pair production.
[109] In BARTEL 85K, R can be affected by $e^+ e^- \rightarrow gg$ via e_q exchange. Their limit $m_{e_8} >173$ GeV (CL=95%) at $\lambda = m_{e_8}/\Lambda_M = 1$ ($\eta_L = \eta_R = 1$) is not listed above because the cross section is sensitive to the product $\eta_L \eta_R$, which should be absent in ordinary theory with electronic chiral invariance.

MASS LIMITS for Color Octet Neutrinos (ν_8)

$\lambda \equiv m_{\ell_8}/\Lambda$

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>110	90	[110] BARGER	89	RVUE	ν_8: $p\overline{p} \rightarrow \nu_8 \overline{\nu}_8$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
none 3.8–29.8	95	[111] KIM	90	AMY	ν_8: $e^+ e^- \rightarrow$ acoplanar jets
none 9–21.9	95	[112] BARTEL	87B	JADE	ν_8: $e^+ e^- \rightarrow$ acoplanar jets

[110] BARGER 89 used ABE 89B limit for events with large missing transverse momentum. Two-body decay $\nu_8 \rightarrow \nu g$ is assumed.
[111] KIM 90 is at $E_{cm} = 50$–60.8 GeV. The same assumptions as in BARTEL 87B are used.
[112] BARTEL 87B is at $E_{cm} = 46.3$–46.78 GeV. The limit assumes the ν_8 pair production cross section to be eight times larger than that of the corresponding heavy neutrino pair production. This assumption is not valid in general for the weak couplings, and the limit can be sensitive to its $SU(2)_L \times U(1)_Y$ quantum numbers.

MASS LIMITS for W_8 (Color Octet W Boson)

VALUE (GeV)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[113] ALBAJAR	89	UA1	$p\overline{p} \rightarrow W_8 X$, $W_8 \rightarrow Wg$

[113] ALBAJAR 89 give $\sigma(W_8 \rightarrow W + \text{jet})/\sigma(W) < 0.019$ (90% CL) for $m_{W_8} > 220$ GeV.

Limits on $ZZ\gamma$ Coupling

Limits are for the electric dipole transition form factor for $Z \rightarrow \gamma Z^*$ parametrized as $f(s') = \beta(s'/m_Z^2 - 1)$, where s' is the virtual Z mass. In the Standard Model $\beta \sim 10^{-5}$.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.80	95	ADRIANI	92J	L3	$Z \rightarrow \gamma\nu\overline{\nu}$

REFERENCES FOR Searches for Quark and Lepton Compositeness

ABE	94	PRL 72 3004	+Albrow, Amidei, Anway-Wiese, Apollinari+	(CDF Collab.)
DIAZCRUZ	94	PR D49 R2149	Diaz Cruz, Sampayo	(CINV)
ABE	93G	PRL 71 2542	+Albrow, Akimoto, Amidei, Anway-Wiese+	(CDF Collab.)
ABT	93	NP B396 3	+Andreev, Andrieu, Appuhn, Arpagaus+	(H1 Collab.)
ADRIANI	93M	PRPL 236 1	+Aguilar-Benitez, Ahlen, Alcaraz, Aloisio+	(L3 Collab.)
ALITTI	93	NP B400 3	+Ambrosini, Ansari, Autiero, Bareyre+	(UA2 Collab.)
BUSKULIC	93Q	ZPHY C59 215	+Decamp, Goy, Lees, Minard, Mours+	(ALEPH Collab.)
DERRICK	93B	PL B316 207	+Krakauer, Magill, Musgrave, Repond+	(ZEUS Collab.)
ABE	92B	PRL 68 1463	+Amidei, Apollinari, Atac, Auchincloss+	(CDF Collab.)
ABE	92D	PRL 68 1104	+Amidei, Apollinari, Atac, Auchincloss+	(CDF Collab.)
ABE	92M	PRL 69 2896	+Amidei, Anway-Wiese, Apollinari, Atac+	(CDF Collab.)
ABREU	92C	ZPHY C53 41	+Adam, Adami, Adye, Akesson+	(DELPHI Collab.)
ABREU	92D	ZPHY C53 555	+Adam, Adami, Adye, Akesson, Alekseev+	(DELPHI Collab.)
ADRIANI	92B	PL B288 404	+Aguilar-Benitez, Ahlen, Akbari, Alcaraz+	(L3 Collab.)
ADRIANI	92F	PL B292 472	+Aguilar-Benitez, Ahlen, Akbari, Alcarez+	(L3 Collab.)
ADRIANI	92J	PL B297 469	+Aguilar-Benitez, Ahlen, Alcarez, Aloisio+	(L3 Collab.)
BARDADIN-...	92	ZPHY C55 163	Bardadin-Otwinowska	(CLER)
DECAMP	92	PRPL 216 253	+Deschizeaux, Goy, Lees, Minard+	(ALEPH Collab.)
HOWELL	92	PL B291 206	+Koltick, Tauchi, Miyamoto, Kichimi+	(TOPAZ Collab.)
KROHA	92	PR D46 58		(ROCH)
PDG	92	PR D45, 1 June, Part II	Hikasa, Barnett, Stone+	(KEK, LBL, BOST+)
SHIMOZAWA	92	PL B284 144	+Fujimoto, Abe, Adachi, Doser+	(TOPAZ Collab.)
ABE	91D	PRL 67 2418	+Amidei, Apollinari, Atac, Auchincloss+	(CDF Collab.)
ABREU	91E	PL B268 296	+Adam, Adami, Adye, Akesson+	(DELPHI Collab.)
ABREU	91F	NP B367 511	+Adam, Adami, Adye, Akesson+	(DELPHI Collab.)
ADACHI	91	PL B255 613	+Anazawa, Doser, Enomoto+	(TOPAZ Collab.)
AKRAWY	91F	PL B257 531	+Alexander, Allison, Allport, Anderson+	(OPAL Collab.)
ALITTI	91B	PL B257 232	+Ansari, Autiero, Bareyre, Blaylock+	(UA2 Collab.)
BEHREND	91B	ZPHY C51 143	+Criegee, Field, Franke, Jung+	(CELLO Collab.)
BEHREND	91C	ZPHY C51 149	+Criegee, Field, Franke, Jung, Meyer+	(CELLO Collab.)
Also	91B	ZPHY C51 143	Behrend, Criegee, Field, Franke, Jung+	(CELLO Collab.)
ABE	90I	ZPHY C48 13	+Amako, Arai, Asano, Chiba+	(VENUS Collab.)
ADEVA	90F	PL B247 177	+Adriani, Aguilar-Benitez, Akbari, Alcaraz+	(L3 Collab.)
ADEVA	90K	PL B250 199	+Adriani, Aguilar-Benitez, Akbari, Alcarez+	(L3 Collab.)
ADEVA	90L	PL B250 205	+Adriani, Aguilar-Benitez, Akbari, Alcaraz+	(L3 Collab.)
ADEVA	90O	PL B252 525	+Adriani, Aguilar-Benitez, Akbari, Alcaraz+	(L3 Collab.)
AKRAWY	90F	PL B241 133	+Alexander, Allison, Allport+	(OPAL Collab.)
AKRAWY	90I	PL B244 135	+Alexander, Allison, Allport, Anderson+	(OPAL Collab.)
AKRAWY	90J	PL B246 285	+Alexander, Allison, Allport, Anderson+	(OPAL Collab.)
DECAMP	90G	PL B236 501	+Deschizeaux, Lees, Minard+	(ALEPH Collab.)
DECAMP	90O	PL B250 172	+Deschizeaux, Goy, Lees+	(ALEPH Collab.)
KIM	90	PL B240 243	+Breedon, Ko, Lander, Maeshima, Malchow+	(AMY Collab.)
ABE	89	PRL 62 613	+Amidei, Apollinari, Ascori, Atac+	(CDF Collab.)
ABE	89B	PRL 62 1825	+Amidei, Apollinari, Ascoli, Atac+	(CDF Collab.)
ABE	89D	PRL 63 1447	+Amidei, Apollinari, Ascoli, Atac+	(CDF Collab.)
ABE	89H	PRL 62 3020	+Amidei, Apollinari, Ascoli, Atac+	(CDF Collab.)
ABE	89J	ZPHY C45 175	+Amako, Arai, Fukawa+	(VENUS Collab.)
ABE	89L	PL B232 425	+Amako, Arai, Asano, Chiba+	(VENUS Collab.)
ADACHI	89B	PL B228 553	+Aihara, Doser, Enomoto, Fujii+	(TOPAZ Collab.)
ALBAJAR	89	ZPHY C44 15	+Albrow, Allkofer, Arnison, Astbury+	(UA1 Collab.)