[133] FARRAR 85 points out that BALL 84 analysis applies only if the $\widetilde{g}$'s decay before interacting, i.e. $m_{\widetilde{q}} < 80 m_{\widetilde{g}}^{1.5}$. FARRAR 85 finds $m_{\widetilde{g}} < 0.5$ not excluded for $m_{\widetilde{q}} = 30$–1000 GeV and $m_{\widetilde{g}} < 1.0$ not excluded for $m_{\widetilde{q}} = 100$–500 GeV by BALL 84 experiment.

[134] GOLDMAN 85 use nonobservation of a pseudoscalar $\widetilde{g}$-$\widetilde{g}$ bound state in radiative ψ decay.

[135] HABER 85 is based on survey of all previous searches sensitive to low mass $\widetilde{g}$'s. Limit makes assumptions regarding the lifetime and electric charge of the lightest supersymmetric particle.

[136] BALL 84 is FNAL beam dump experiment. Observed no interactions of $\widetilde{\gamma}$ in the calorimeter, where $\widetilde{\gamma}$'s are expected to come from pair-produced $\widetilde{g}$'s. Search for long-lived $\widetilde{\gamma}$ interacting in calorimeter 56m from target. Limit is for $m_{\widetilde{q}} = 40$ GeV and production cross section proportional to $A^{0.72}$. BALL 84 find no $\widetilde{g}$ allowed below 4.1 GeV at CL = 90%. Their figure 1 shows dependence on $m_{\widetilde{q}}$ and A. See also KANE 82.

[137] BRICK 84 reanalyzed FNAL 147 GeV HBC data for R-$\Delta(1232)^{++}$ with $\tau > 10^{-9}$ s and $p_{\mathrm{lab}} > 2$ GeV. Set CL = 90% upper limits 6.1, 4.4, and 29 microbarns in pp, $\pi^+ p$, $K^+ p$ collisions respectively. R-Δ^{++} is defined as being $\widetilde{g}$ and 3 up quarks. If mass = 1.2–1.5 GeV, then limits may be lower than theory predictions.

[138] FARRAR 84 argues that $m_{\widetilde{g}} < 100$ MeV is not ruled out if the lightest R-hadrons are long-lived. A long lifetime would occur if R-hadrons are lighter than $\widetilde{\gamma}$'s or if $m_{\widetilde{q}} > 100$ GeV.

[139] BERGSMA 83C is reanalysis of CERN-SPS beam-dump data. See their figure 1.

[140] CHANOWITZ 83 find in bag-model that charged s-hadron exists which is stable against strong decay if $m_{\widetilde{g}} < 1$ GeV. This is important since tracks from decay of neutral s-hadron cannot be reconstructed to primary vertex because of missed $\widetilde{\gamma}$. Charged s-hadron leaves track from vertex.

[141] KANE 82 inferred above $\widetilde{g}$ mass limit from retroactive analysis of hadronic collision and beam dump experiments. Limits valid if $\widetilde{g}$ decays inside detector.

Unstable $\widetilde{\gamma}$ (Photino) MASS LIMIT

Unless stated otherwise, the limits below assume that the $\widetilde{\gamma}$ decays either into $\gamma\,\widetilde{G}$ (goldstino) or into $\gamma\,\widetilde{H}^0$ (Higgsino).

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[142] ACTON	93G	OPAL	$e^+e^- \to \widetilde{\gamma}\widetilde{\gamma}$ ($\widetilde{\gamma} \to \tau^{\pm}\ell^{\mp}\nu_{\ell}$)
		[143] ABE	89J	VNS	$e^+e^- \to \widetilde{\gamma}\widetilde{\gamma}$ ($\widetilde{\gamma} \to \gamma\widetilde{G}$ or $\gamma\widetilde{H}^0$)
>15	95	[144] BEHREND	87B	CELL	$e^+e^- \to \widetilde{\gamma}\widetilde{\gamma}$ ($\widetilde{\gamma} \to \gamma\widetilde{G}$ or $\gamma\widetilde{H}^0$)
		[145] ADEVA	85	MRKJ	
		[146] BALL	84	CALO	Beam dump
		[147] BARTEL	84B	JADE	
		[147] BEHREND	83	CELL	
		[148] CABIBBO	81	COSM	

[142] ACTON 93G assume R-parity violation and decays $\widetilde{\gamma} \to \tau^{\pm}\ell^{\mp}\nu_{\ell}$ ($\ell = e$ or μ). They exclude $m_{\widetilde{\gamma}} = 4$–43 GeV for $m_{\widetilde{e}_L} < 42$ GeV, and $m_{\widetilde{\gamma}} = 7$–30 GeV for $m_{\widetilde{e}_L} < 100$ GeV (95% CL). Assumes $\widetilde{e}_R$ much heavier than $\widetilde{e}_L$, and lepton family number violation but L_e-L_{μ} conservation.

[143] ABE 89J exclude $m_{\widetilde{\gamma}} = 0.15$–25 GeV (95%CL) for $d = (100\ \mathrm{GeV})^2$ and $m_{\widetilde{e}} = 40$ GeV in the case $\widetilde{\gamma} \to \gamma\widetilde{G}$, and $m_{\widetilde{\gamma}}$ up to 23 GeV for $m_{\widetilde{e}} = 40$ GeV in the case $\widetilde{\gamma} \to \gamma\widetilde{H}^0$.

[144] BEHREND 87B limit is for unstable photinos only. Assumes B($\widetilde{\gamma} \to \gamma(\widetilde{G}$or $\widetilde{H}^0)$) =1, $m_{\widetilde{G}\mathrm{or}\widetilde{H}^0} \ll m_{\widetilde{\gamma}}$ and pure $\widetilde{\gamma}$ eigenstate. $m_{\widetilde{e}_L} = m_{\widetilde{e}_R} < 100$ GeV.

[145] ADEVA 85 is sensitive to $\widetilde{\gamma}$ decay path <5 cm. With $m_{\widetilde{e}} = 50$ GeV, limit (CL = 90%) is $m_{\widetilde{\gamma}} > 20.5$ GeV. Assume $\widetilde{\gamma}$ decays to photon + goldstino and search for acoplanar photons with large missing p_T.

[146] BALL 84 is FNAL beam dump experiment. Observed no $\widetilde{\gamma}$ decay, where $\widetilde{\gamma}$'s are expected to come from $\widetilde{g}$'s produced at the target. Three possible $\widetilde{\gamma}$ lifetimes are considered. Gluino decay to goldstino + gluon is also considered.

[147] BEHREND 83 and BARTEL 84B look for 2γ events from $\widetilde{\gamma}$ pair production. With supersymmetric breaking parameter d = $(100\ \mathrm{GeV})^2$ and $m_{\widetilde{e}} = 40$ GeV the excluded regions at CL = 95% would be $m_{\widetilde{\gamma}}$ = 100 MeV – 13 GeV for BEHREND 83 $m_{\widetilde{\gamma}}$ = 80 MeV – 18 GeV for BARTEL 84B. Limit is also applicable if the $\widetilde{\gamma}$ decays radiatively within the detector.

[148] CABIBBO 81 consider $\widetilde{\gamma} \to \gamma +$ goldstino. Photino must be either light enough (<30 eV) to satisfy cosmology bound, or heavy enough (>0.3 MeV) to have disappeared at early universe.

Supersymmetry Miscellaneous Results

Results that do not appear under other headings or that make nonminimal assumptions.

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[149] BARBER	84B	RVUE	
	[150] HOFFMAN	83	CNTR	$\pi p \to n(e^+e^-)$

[149] BARBER 84B consider that $\widetilde{\mu}$ and $\widetilde{e}$ may mix leading to $\mu \to e\widetilde{\gamma}\widetilde{\gamma}$. They discuss mass-mixing limits from decay dist asym in LBL-TRIUMF data and e^+ polarization in SIN data.

[150] HOFFMAN 83 set CL = 90% limit $d\sigma/dt$ B(e^+e^-) < 3.5×10^{-32} cm^2/GeV^2 for spin-1 partner of Goldstone fermions with 140 < m < 160 MeV decaying → e^+e^- pair.

REFERENCES FOR Supersymmetric Particle Searches

ACTON 93G PL B313 333 +Akers, Alexander, Allison, Anderson+ (OPAL Collab.)
ADRIANI 93M PRPL 236 1 +Aguilar-Benitez, Ahlen, Alcaraz, Aloisio+ (L3 Collab.)
CLAVELLI 93 PR D47 1973 +Coulter, Yuan (ALAT)
DREES 93 PR D47 376 +Nojiri (DESY, SLAC)
FALK 93 PL B318 354 +Madden, Olive, Srednicki (UCB, UCSB, MINN)
HEBBEKER 93 ZPHY C60 63 (CERN)
KELLEY 93 PR D47 2461 +Lopez, Nanopoulos, Pois, Yuan (TAMU, ALAH)
LAU 93 PR D47 1087 (HOUS)
LOPEZ 93C PL B313 241 +Nanopoulos, Wang (TAMU, HARC, CERN)
MIZUTA 93 PL B298 120 +Yamaguchi (TOHO)
MORI 93 PR D48 5505 +(KEK, NIIG, TOKY, TOKA, KOBE, OSAK, TINT, GIFU)
ABE 92L PRL 69 3439 +Amidei, Anway-Wiese, Apollinari, Atac+ (CDF Collab.)
BOTTINO 92 MPL A7 733 +DeAlfaro, Fornengo, Morales, Puimedon+ (TORI, ZARA)
Also 91 PL B265 57 Bottino, de Alfaro, Fornengo, Mignola+ (TORI, INFN)
CLAVELLI 92 PR D46 2112 (ALAT)
DATTA 92 ZPHY C54 513 +Guchait, Raychaudhuri (JADA, CALC)
DECAMP 92 PRPL 216 253 +Deschizeaux, Goy, Lees, Minard+ (ALEPH Collab.)
ELLIS 92F PL B283 252 +Roszkowski (CERN)
KAWASAKI 92 PR D46 1634 +Mizuta (OSU, TOHO)
LOPEZ 92 NP B370 445 +Nanopoulos, Yuan (TAMU)
MCDONALD 92 PL B283 80 +Olive, Srednicki (LISB, MINN, UCSB)
ROY 92 PL B283 270 (CERN)
ABREU 91F NP B367 511 +Adam, Adami, Adye, Akesson+ (DELPHI Collab.)
AKESSON 91 ZPHY C52 219 +Almehed, Angelis, Atherton, Aubry+ (HELIOS Collab.)
ALEXANDER 91F ZPHY C52 175 +Allison, Allport, Anderson, Arcelli+ (OPAL Collab.)
ANTONIADIS 91 PL B262 109 +Ellis, Nanopoulos (EPOL, CERN, TAMU, HARC)
BAER 91 PR D44 207 +Tata, Woodside (FSU, HAWA, ISU)
BAER 91B PR D44 725 +Drees, Godbole+ (FSU, DESY, BOMB, UCD, HAWA)
BOTTINO 91 PL B265 57 +de Alfaro, Fornengo, Mignola+ (TORI, INFN)
DREES 91 PR D43 2971 +Tata (CERN, HAWA)
GELMINI 91 NP B351 623 +Gondolo, Roulet (UCLA, TRST)
HIDAKA 91 PR D44 927 (TGAK)
KAMIONKOW... 91 PR D44 3021 Kamionkowski (CHIC, FNAL)
MORI 91B PL B270 89 +Nojiri, Oyama, Suzuki+ (Kamiokande Collab.)
NOJIRI 91 PL B261 76 (KEK)
OLIVE 91 NP B355 208 +Srednicki (MINN, UCSB)
ROSZKOWSKI 91 PL B262 59 (CERN)
SATO 91 PR D44 2220 +Hirata, Kajita, Kifune, Kihara+ (Kamioka Collab.)
ABREU 90F PL B247 148 +Adam, Adami, Adye, Alekseev+ (DELPHI Collab.)
ABREU 90G PL B247 157 +Adam, Adami, Adye, Alekseev+ (DELPHI Collab.)
ADACHI 90C PL B244 352 +Aihara, Doser, Enomoto+ (TOPAZ Collab.)
ADEVA 90I PL B249 341 +Adriani, Aguilar-Benitez, Akbari, Alcarez+ (L3 Collab.)
AKESSON 90B PL B238 442 +Alitti, Ansari, Ansorge+ (UA2 Collab.)
AKRAWY 90D PL B240 261 +Alexander, Allison, Allport+ (OPAL Collab.)
AKRAWY 90N PL B248 211 +Alexander, Allison, Allport, Anderson+ (OPAL Collab.)
AKRAWY 90O PL B252 290 +Alexander, Allison, Allport, Anderson+ (OPAL Collab.)
ALITTI 90 PL B235 363 +Ansari, Ansorge, Bagnaia, Bareyre+ (UA2 Collab.)
BAER 90 PR D41 3414 +Drees, Tata (FSU, CERN, HAWA)
BARKLOW 90 PRL 64 2984 +Abrams, Adolphsen, Averill, Ballam+ (Mark II Collab.)
DECAMP 90C PL B236 86 +Deschizeaux, Lees, Minard, Crespo+ (ALEPH Collab.)
DECAMP 90K PL B244 541 +Deschizeaux, Goy, Lees+ (ALEPH Collab.)
DREES 90 PL B252 127 +Hikasa (CERN, KEK)
ELLIS 90 PL B245 251 +Nanopoulos, Roszkowski, Schramm (CERN, HARC, TAMU)
GRIEST 90 PR D41 3565 +Kamionkowski, Turner (UCB, CHIC, FNAL)
GRIFOLS 90 NP B331 244 +Masso (BARC)
KRAUSS 90 PRL 64 999 (YALE)
ROSZKOWSKI 90 PL B252 471 (TAMU, HARC)
SAKAI 90 PL B234 534 +Gu, Low, Abe, Fujii+ (AMY Collab.)
SODERSTROM 90 PRL 64 2980 +McKenna, Abrams, Adolphsen, Averill+ (Mark II Collab.)
TAKETANI 90 PL B234 202 +Odaka, Abe, Amako+ (VENUS Collab.)
ZHUKOVSKII 90 SJNP 52 931 +Eminov (MOSU)
Translated from YAF 52 1473.
ABE 89J ZPHY C45 175 +Amako, Arai, Fukawa+ (VENUS Collab.)
ABE 89K PL B232 431 +Amako, Arai, Asano, Chiba+ (VENUS Collab.)
ADACHI 89 PL B218 105 +Aihara, Dijkstra, Enomoto, Fujii+ (TOPAZ Collab.)
ADEVA 89B PL B233 530 +Adriani, Aguilar-Benitez, Akbari+ (L3 Collab.)
ALBAJAR 89 ZPHY C44 15 +Albrow, Allkofer, Arnison, Astbury+ (UA1 Collab.)
HEARTY 89 PR D39 3207 +Rothberg, Young, Johnson, Whitaker+ (ASP Collab.)
Also 87 PRL 58 1711 Hearty, Rothberg, Young, Johnson+ (ASP Collab.)
Also 86 PRL 56 685 Bartha, Burke, Extermann+ (ASP Collab.)
NAKAMURA 89 PR D39 1261 +Kobayashi, Konaka, Imai, Masaike+ (KYOT, TMTC)
OLIVE 89 PL B230 78 +Srednicki (MINN, UCSB)
BAER 88 PR D38 1485 +Hagiwara, Tata (FSU, KEK, WISC)
Also 89B PR D39 989 erratum Baer, Hagiwara, Tata (FSU, KEK, WISC)
BEHREND 88B PL B215 186 +Criegee, Dainton, Field+ (CELLO Collab.)
ELLIS 88B PL B215 404 +Olive, Sarkar, Sciama (CERN, MINN, RAL, CAMB)
NATH 88 PR D38 1479 +Arnowitt (NEAS, TAMU)
OLIVE 88 PL B205 553 +Srednicki (MINN, UCSB)
SREDNICKI 88 NP B310 693 +Watkins, Olive (MINN, UCSB)
ADEVA 87 PL B194 167 +Anderhub, Ansari, Becker+ (Mark-J Collab.)
ALBAJAR 87B PL B185 241 +Albrow, Allkofer, Arnison+ (UA1 Collab.)
ALBAJAR 87D PL B198 261 +Albrow, Allkofer+ (UA1 Collab.)
ANSARI 87D PL B195 613 +Bagnaia, Banner+ (UA2 Collab.)
ARNOLD 87 PL B186 435 +Barth+ (BRUX, DUUC, LOUC, BARI, AICH, CERN+)
BAER 87B PR D35 1598 +Hagiwara, Tata (KEK, ANL, WISC)
Also 86 PRL 57 294 Baer, Hagiwara, Tata (ANL, DESY, WISC)
BEHREND 87B ZPHY C35 181 +Buerger, Criegee, Dainton+ (CELLO Collab.)
HEARTY 87 PRL 58 1711 +Rothberg, Young, Johnson+ (ASP Collab.)
NG 87 PL B188 138 +Olive, Srednicki (MINN, UCSB)
TUTS 87 PL B186 233 +Franzini, Youssef, Zhao+ (CUSB Collab.)
ALBRECHT 86C PL 167B 360 +Binder, Harder+ (ARGUS Collab.)
BADIER 86 ZPHY C31 21 +Bemporad, Boucrot, Callot+ (NA3 Collab.)
BARNETT 86 NP B267 625 +Haber, Kane (LBL, UCSC, MICH)
FORD 86 PR D33 3472 +Qi, Read+ (MAC Collab.)
GAISSER 86 PR D34 2206 +Steigman, Tilav (BART, DELA)
VOLOSHIN 86 SJNP 43 495 +Okun (ITEP)
Translated from YAF 43 779.
ADEVA 85 PL 152B 439 +Becker, Becker-Szendy+ (Mark-J Collab.)
Also 84C PRPL 109 131 Adeva, Barber, Becker+ (Mark-J Collab.)
AKERLOF 85 PL 156B 271 +Bonvicini, Chapman, Errede+ (HRS Collab.)
BARTEL 85L PL 155B 288 +Becker, Cords, Felst, Hagiwara+ (JADE Collab.)
BEHREND 85 PL 161B 182 +Burger, Criegee, Fenner+ (CELLO Collab.)
COOPER-... 85B PL 160B 212 Cooper-Sarkar, Parker, Sarkar+ (WA66 Collab.)
DAWSON 85 PR D31 1581 +Eichten, Quigg (LBL, FNAL)
FARRAR 85 PRL 55 895 (RUTG)
GOLDMAN 85 Physica 15D 181 +Haber (LANL, UCSC)
HABER 85 PRPL 117 75 +Kane (UCSC, MICH)
ADEVA 84B PRL 53 1806 +Barber, Becker, Berdugo+ (Mark-J Collab.)
BALL 84 PRL 53 1314 +Coffin, Gustafson+ (MICH, FIRZ, OSU, FNAL, WISC)
BARBER 84B PL 139B 427 +Shrock (STON)
BARTEL 84B PL 139B 327 +Becker, Bowdery, Cords+ (JADE Collab.)
BARTEL 84C PL 146B 126 +Becker, Bowdery, Cords+ (JADE Collab.)
BRICK 84 PR D30 1134 + (BROW, CAVE, IIT, IND, MIT, MONS, NIJM+)
ELLIS 84 NP B238 453 +Hagelin, Nanopoulos, Olive, Srednicki (CERN)
FARRAR 84 PRL 53 1029 (RUTG)
BEHREND 83 PL 123B 127 +Chen, Fenner, Gumpel+ (CELLO Collab.)