New Heavy Bosons (W', Z', leptoquarks, etc.), Searches for

NODE=S056

NODE=S056

We list here various limits on charged and neutral heavy vector bosons (other than W's and Z's), heavy scalar bosons (other than Higgs bosons), vector or scalar leptoquarks, and axigluons. The latest unpublished results are described in "W' Searches" and "Z' Searches" reviews. For recent searches on scalar bosons which could be identified as Higgs bosons, see the listings in the Higgs boson section.

CONTENTS:

NODE=S056CNT

NODE=S056CNT

NODE=S056CNT

See the related review(s):

W'-Boson Searches

MASS LIMITS for W' (Heavy Charged Vector Boson Other Than W) in Hadron Collider Experiments

NODE=S056W1C

Couplings of W' to quarks and leptons are taken to be identical with those of W. The following limits are obtained from $p\overline{p}$ or $pp \to W'X$ with W' decaying to the mode indicated in the comments. New decay channels (*e.g.*, $W' \to WZ$) are assumed to be suppressed. The most recent preliminary results can be found in the "W'-boson searches" review above.

NODE=S056W1C

NODE=S056W1C

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>6000 (CL = 95%) OUR LIMIT					
none 500–5000	95	[1] AAD	24T	ATLS	$W' \to \tau\nu$
none 2000–4300	95	[2] HAYRAPETY...	24X	CMS	$W' \to tb$
>2500	95	[3] AAD	23AH	ATLS	$W' \to WZ$
none 500–4600	95	[4] AAD	23CC	ATLS	$W' \to tb$
>1200	95	[5] AAD	23L	ATLS	$W' \to ZX$
none 400–3300	95	[6] AAD	23O	ATLS	$W' \to WH$
>4400	95	[7] TUMASYAN	23AP	CMS	$W' \to WZ$
>4000	95	[8] TUMASYAN	23AP	CMS	$W' \to WH$
none 600–4800	95	[9] TUMASYAN	23AW	CMS	$W' \to \tau\nu$
>5700	95	[10] TUMASYAN	22AC	CMS	$W' \to e\nu,\ \mu\nu$
>3900	95	[11] TUMASYAN	22D	CMS	$W' \to WZ$

→ UNCHECKED ←

OCCUR=2

>4000	95	[11] TUMASYAN	22D	CMS	$W' \rightarrow WH$	OCCUR=2
none 1000–4000	95	[12] TUMASYAN	22J	CMS	$W' \rightarrow WZ$	
none 500–2000	95	[13] TUMASYAN	22R	CMS	$W' \rightarrow WZ$	
none 1000–3400	95	[14] SIRUNYAN	21Y	CMS	$W' \rightarrow tb$	
>3200	95	[15] AAD	20AJ	ATLS	$W' \rightarrow WH$	
>4300	95	[16] AAD	20AT	ATLS	$W' \rightarrow WZ$	
none 1100–4000	95	[17] AAD	20T	ATLS	$W' \rightarrow q\overline{q}$	
none 1800–3600	95	[18] SIRUNYAN	20AI	CMS	$W' \rightarrow q\overline{q}$	
none 1200–3800	95	[19] SIRUNYAN	20Q	CMS	$W' \rightarrow WZ$	
none 500–3250	95	[20] AABOUD	19E	ATLS	$W' \rightarrow tb$	
>6000	95	[21] AAD	19C	ATLS	$W' \rightarrow e\nu,\ \mu\nu$	
none 1300–3600	95	[22] AAD	19D	ATLS	$W' \rightarrow WZ$	
none 400–4000	95	[23] SIRUNYAN	19AY	CMS	$W' \rightarrow \tau\nu$	
>4300	95	[24] SIRUNYAN	19CP	CMS	$W' \rightarrow WZ,\ WH,\ \ell\nu$	
>2600	95	[25] SIRUNYAN	19I	CMS	$W' \rightarrow WH$	
none 1000–3000	95	[26] AABOUD	18AF	ATLS	$W' \rightarrow tb$	
none 500–2820	95	[27] AABOUD	18AI	ATLS	$W' \rightarrow WH$	
none 300–3000	95	[28] AABOUD	18AK	ATLS	$W' \rightarrow WZ$	
none 800–3200	95	[29] AABOUD	18AL	ATLS	$W' \rightarrow WZ$	
>5100	95	[30] AABOUD	18BG	ATLS	$W' \rightarrow e\nu,\ \mu\nu$	
none 250–2460	95	[31] AABOUD	18CH	ATLS	$W' \rightarrow WZ$	
none 1200–3300	95	[32] AABOUD	18F	ATLS	$W' \rightarrow WZ$	
none 500–3700	95	[33] AABOUD	18K	ATLS	$W' \rightarrow \tau\nu$	
none 1000–3600	95	[34] SIRUNYAN	18	CMS	$W' \rightarrow tb$	
none 1000–3050	95	[35] SIRUNYAN	18AX	CMS	$W' \rightarrow WZ$	
none 400–5200	95	[36] SIRUNYAN	18AZ	CMS	$W' \rightarrow e\nu,\ \mu\nu$	
none 1000–3400	95	[37] SIRUNYAN	18BK	CMS	$W' \rightarrow WZ$	
none 600–3300	95	[38] SIRUNYAN	18BO	CMS	$W' \rightarrow q\overline{q}$	
none 800–2330	95	[39] SIRUNYAN	18DJ	CMS	$W' \rightarrow WZ$	
>2800	95	[40] SIRUNYAN	18ED	CMS	$W' \rightarrow WH$	
none 1200–3200, 3300–3600	95	[41] SIRUNYAN	18P	CMS	$W' \rightarrow WZ$	
>3600	95	[42] AABOUD	17AK	ATLS	$W' \rightarrow q\overline{q}$	
none 1100–2500	95	[43] AABOUD	17AO	ATLS	$W' \rightarrow WH$	
>2220	95	[44] AABOUD	17B	ATLS	$W' \rightarrow WH$	
>2300	95	[45] KHACHATRY...	17J	CMS	$W' \rightarrow N_\tau \tau \rightarrow \tau\tau jj$	
none 600–2700	95	[46] KHACHATRY...	17W	CMS	$W' \rightarrow q\overline{q}$	
>4100	95	[47] KHACHATRY...	17Z	CMS	$W' \rightarrow e\nu,\ \mu\nu$	
>2200	95	[48] SIRUNYAN	17A	CMS	$W' \rightarrow WZ$	
>2300	95	[49] SIRUNYAN	17AK	CMS	$W' \rightarrow WZ,\ WH$	
>2900	95	[50] SIRUNYAN	17H	CMS	$W' \rightarrow \tau N$	
>2600	95	[51] SIRUNYAN	17I	CMS	$W' \rightarrow tb$	
>2450	95	[52] SIRUNYAN	17R	CMS	$W' \rightarrow WH$	
none 2780–3150	95	[52] SIRUNYAN	17R	CMS	$W' \rightarrow WH$	OCCUR=2
>2600	95	[53] AABOUD	16AE	ATLS	$W' \rightarrow WZ$	
>4070	95	[54] AABOUD	16V	ATLS	$W' \rightarrow e\nu,\ \mu\nu$	
>1810	95	[55] AAD	16R	ATLS	$W' \rightarrow WZ$	
>2600	95	[56] AAD	16S	ATLS	$W' \rightarrow q\overline{q}$	
>2150	95	[57] KHACHATRY...	16AO	CMS	$W' \rightarrow tb$	
none 1000–1600	95	[58] KHACHATRY...	16AP	CMS	$W' \rightarrow WH$	
none 800–1500	95	[59] KHACHATRY...	16BD	CMS	$W' \rightarrow WH \rightarrow b\overline{b}\ell\nu$	
none 1500–2600	95	[60] KHACHATRY...	16K	CMS	$W' \rightarrow q\overline{q}$	
none 500–1600	95	[61] KHACHATRY...	16L	CMS	$W' \rightarrow q\overline{q}$	
none 300–2700	95	[62] KHACHATRY...	16O	CMS	$W' \rightarrow \tau\nu$	
none 400–1590	95	[63] AAD	15AU	ATLS	$W' \rightarrow WZ$	
none 1500–1760	95	[64] AAD	15AV	ATLS	$W' \rightarrow tb$	
none 300–1490	95	[65] AAD	15AZ	ATLS	$W' \rightarrow WZ$	
none 1300–1500	95	[66] AAD	15CP	ATLS	$W' \rightarrow WZ$	
none 500–1920	95	[67] AAD	15R	ATLS	$W' \rightarrow tb$	
none 800–2450	95	[68] AAD	15V	ATLS	$W' \rightarrow q\overline{q}$	
>1470	95	[69] KHACHATRY...	15C	CMS	$W' \rightarrow WZ$	
>3710	95	[70] KHACHATRY...	15T	CMS	$W' \rightarrow e\nu,\ \mu\nu$	
none 1000–3010	95	[71] KHACHATRY...	14O	CMS	$W' \rightarrow N\ell \rightarrow \ell\ell jj$	

• • • We do not use the following data for averages, fits, limits, etc. • • •

		[72] AAD	25AX	ATLS	$W' \to JJ$
$>$4400	95	[73] AAD	24AE	ATLS	$M_{W'} = M_{Z'}$
		[74] AAD	24CM	ATLS	Dark $\rho^{\pm}_{D}$
		[75] HAYRAPETY...	24AV	CMS	$X \to W\gamma$
		[76] AAD	23BF	ATLS	$W' \to WZ' \to \ell\nu q\overline{q}$
		[77] AAD	23CG	ATLS	$W' \to N\ell \to \ell\ell jj$
		[78] AAD	23CK	ATLS	$W' \to XH$
		[79] AAD	23U	ATLS	$W' \to W\gamma$
		[80] TUMASYAN	22	CMS	$W' \to WR \to WWW$
		[81] TUMASYAN	22AL	CMS	$W' \to tB,\ bT$
		[82] TUMASYAN	22B	CMS	$W' \to W\gamma$
		[83] TUMASYAN	22I	CMS	$W' \to WR \to WWW$
		[84] TUMASYAN	22P	CMS	$W' \to N\ell \to \ell\ell jj$
		[85] AAD	20AD	ATLS	$W' \to JJ$
		[86] AAD	20W	ATLS	$W' \to WZ' \to \ell\nu q\overline{q}$
		[87] AABOUD	19B	ATLS	$W' \to N\ell \to \ell\ell jj$
		[88] AABOUD	19BB	ATLS	$W' \to N\ell \to j\ell\ell$
		[89] SIRUNYAN	19V	CMS	$W' \to Bt,\ Tb$
		[90] AABOUD	18AA	ATLS	$W' \to W\gamma$
		[91] AABOUD	18AD	ATLS	$W' \to HX$
$>$4500	95	[92] AABOUD	18CJ	ATLS	$W' \to WZ,\ WH,\ \ell\nu$
none 900–4400	95	[93] SIRUNYAN	18CV	CMS	$W' \to N\ell \to \ell\ell jj$
		[94] KHACHATRY...	17U	CMS	$W' \to WH$
		[95] AAD	15BB	ATLS	$W' \to WH$
none 300–880	95	[96] AALTONEN	15C	CDF	$W' \to tb$
none 1200–1900 and 2000–2200	95	[97] KHACHATRY...	15V	CMS	$W' \to q\overline{q}$
$>$3240	95	AAD	14AI	ATLS	$W' \to e\nu,\ \mu\nu$
		[98] AAD	14AT	ATLS	$W' \to W\gamma$
none 200–1520	95	[99] AAD	14S	ATLS	$W' \to WZ$
none 1000–1700	95	[100] KHACHATRY...	14	CMS	$W' \to WZ$
		[101] KHACHATRY...	14A	CMS	$W' \to WZ$
none 500–950	95	[102] AAD	13AO	ATLS	$W' \to WZ$
none 1100–1680	95	AAD	13D	ATLS	$W' \to q\overline{q}$
none 1000–1920	95	CHATRCHYAN	13A	CMS	$W' \to q\overline{q}$
		[103] CHATRCHYAN	13AJ	CMS	$W' \to WZ$
$>$2900	95	[104] CHATRCHYAN	13AQ	CMS	$W' \to e\nu,\ \mu\nu$
none 800–1510	95	[105] CHATRCHYAN	13E	CMS	$W' \to tb$
none 700–940	95	[106] CHATRCHYAN	13U	CMS	$W' \to WZ$
none 700–1130	95	[107] AAD	12AV	ATLS	$W' \to tb$
none 200–760	95	[108] AAD	12BB	ATLS	$W' \to WZ$
		[109] AAD	12CK	ATLS	$W' \to \overline{t}q$
$>$2550	95	[110] AAD	12CR	ATLS	$W' \to e\nu,\ \mu\nu$
		[111] AAD	12M	ATLS	$W' \to N\ell \to \ell\ell jj$
		[112] AALTONEN	12N	CDF	$W' \to \overline{t}q$
none 200–1143	95	[108] CHATRCHYAN	12AF	CMS	$W' \to WZ$
		[113] CHATRCHYAN	12AR	CMS	$W' \to \overline{t}q$
		[114] CHATRCHYAN	12BG	CMS	$W' \to N\ell \to \ell\ell jj$
$>$1120	95	AALTONEN	11C	CDF	$W' \to e\nu$
none 180–690	95	[115] ABAZOV	11H	D0	$W' \to WZ$
none 600–863	95	[116] ABAZOV	11L	D0	$W' \to tb$
none 285–516	95	[117] AALTONEN	10N	CDF	$W' \to WZ$
none 280–840	95	[118] AALTONEN	09AC	CDF	$W' \to q\overline{q}$
$>$1000	95	ABAZOV	08C	D0	$W' \to e\nu$
none 300–800	95	ABAZOV	04C	D0	$W' \to q\overline{q}$
none 225–536	95	[119] ACOSTA	03B	CDF	$W' \to tb$
none 200–480	95	[120] AFFOLDER	02C	CDF	$W' \to WZ$
$>$ 786	95	[121] AFFOLDER	01I	CDF	$W' \to e\nu,\ \mu\nu$
none 300–420	95	[122] ABE	97G	CDF	$W' \to q\overline{q}$
$>$ 720	95	[123] ABACHI	96C	D0	$W' \to e\nu$
$>$ 610	95	[124] ABACHI	95E	D0	$W' \to e\nu,\ \tau\nu$
none 260–600	95	[125] RIZZO	93	RVUE	$W' \to q\overline{q}$

[1] AAD 24T limit is for W' with SM-like coupling from pp collisions at $\sqrt{s}$ =1 3 TeV. Bosonic decays of W' and $W - W'$ interference are neglected. See their Fig. 7a for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=ZD

[2] HAYRAPETYAN 24X search for right-handed W' decaying to tb in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 7 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=AE

[3] AAD 23AH search for resonances produced through Drell-Yan and vector-boson-fusion processes in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 7 and Fig. 8 for limits on $\sigma \cdot B$. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$ produced mainly via Drell-Yan. NODE=S056W1C;LINKAGE=ND

[4] AAD 23CC search for resonances decaying to tb in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above is for right-handed W' assuming a W' coupling equal to the SM W coupling. The limit becomes $M_{W'} > 4200$ GeV for left-handed W'. See their Figs. 12 and 13 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=UD

[5] AAD 23L perform a generic search for resonances with events containing a Z decaying into $e^+ e^-$ or $\mu^+ \mu^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. See their Figs. 6, 7, 8 for model independent limits on $\sigma \cdot B$ for Gaussian-shaped resonances. The limit above is for heavy-vector-triplet W' decaying to WZ with $g_V = 3$ as well as with $g_V = 1$. NODE=S056W1C;LINKAGE=PD

[6] AAD 23O search for resonances decaying to HW in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 2950 GeV for $g_V = 1$. NODE=S056W1C;LINKAGE=QD

[7] TUMASYAN 23AP search for resonances decaying to WZ in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} > 4.8$ TeV assuming $M_{W'} = M_{Z'}$ and combining $W' \rightarrow WZ$, $W' \rightarrow WH$, $Z' \rightarrow WW$, $Z' \rightarrow ZH$ channels. NODE=S056W1C;LINKAGE=SD

[8] TUMASYAN 23AP search for resonances decaying to WH in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} > 4.8$ TeV assuming $M_{W'} = M_{Z'}$ and combining $W' \rightarrow WZ$, $W' \rightarrow WH$, $Z' \rightarrow WW$, $Z' \rightarrow ZH$ channels. NODE=S056W1C;LINKAGE=TD

[9] TUMASYAN 23AW search for SSM W' resonance decaying to $\tau\nu$ in pp collisions at $\sqrt{s}$ = 13 TeV. W–W' intereference and bosonic decays of W' are not included. See their Fig. 6 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=XD

[10] TUMASYAN 22AC search for W' with SM-like couplings in pp collisions at $\sqrt{s}$ = 13 TeV. The diboson decays of W' are assumed to be suppressed. See their Fig. 5 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=DD

[11] TUMASYAN 22D search for resonances produced through Drell-Yan and vector-boson-fusion processes in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 8 for limits on $\sigma \cdot B$. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$ produced mainly via Drell-Yan. NODE=S056W1C;LINKAGE=FD

[12] TUMASYAN 22J search for resonances produced through Drell-Yan and vector-boson-fusion processes in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$, produced mainly via Drell-Yan. See their Fig. 9 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=ID

[13] TUMASYAN 22R search for resonances decaying to WZ in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet W' produced mainly via Drell-Yan. See their Fig. 8 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=KD

[14] SIRUNYAN 21Y search for resonances decaying to tb in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 2 for limits on $\sigma \cdot$ B($W' \rightarrow tb$). NODE=S056W1C;LINKAGE=CD

[15] AAD 20AJ search for resonances decaying to HW in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 2900 GeV for $g_V = 1$. See their Fig. 6 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=ZC

[16] AAD 20AT search for resonances decaying to WZ in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 3900 GeV for $g_V = 1$. See their Fig. 13 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=BD

[17] AAD 20T search for W' with SM-like couplings in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 4(c) for limits on the product of the cross section, acceptance, and branching fraction. NODE=S056W1C;LINKAGE=TC

[18] SIRUNYAN 20AI limit is for W' with SM-like coupling using pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056W1C;LINKAGE=WC

[19] SIRUNYAN 20Q search for resonances decaying to WZ in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. NODE=S056W1C;LINKAGE=XC

[20] AABOUD 19E search for right-handed W' in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 8 for limit on on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=JC

[21] AAD 19C search for W' with SM-like couplings in pp collisions at $\sqrt{s}$ = 13 TeV. Bosonic decays and $W - W'$ interference are neglected. The limits on e and μ separately are 6.0 and 5.1 TeV respectively. See their Fig. 2 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=QC

[22] AAD 19D search for resonances decaying to WZ in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 3400 GeV for $g_V = 1$. If we assume $M_{W'} = M_{Z'}$, the limit increases $M_{W'} > 3800$ GeV and $M_{W'} > 3500$ GeV for $g_V = 3$ and $g_V = 1$, respectively. See their Fig. 9 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=RC

[23] SIRUNYAN 19AY limits shown for W' with SM-like coupling using pp collisions at $\sqrt{s}$ = 13 TeV. $W - W'$ interference and bosonic decays of W' are not included. See their Fig. 5 for limits on $\sigma \cdot B$. Limits in the context of a nonuniversal gauge interaction are shown in Fig. 7. Model independent limits on $\sigma B A \epsilon$ can be seen in Fig. 8. NODE=S056W1C;LINKAGE=MC

[24] SIRUNYAN 19CP present a statistical combinations of searches for W' decaying to pairs of bosons or leptons in pp collisions at $\sqrt{s} = 13$ TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. If we assume $M_{W'} = M_{Z'}$, the limit becomes $M_{W'} >$ 4500 GeV for $g_V = 3$ and $M_{W'} >$ 5000 GeV for $g_V = 1$. See their Figs. 2 and 3 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=SC

[25] SIRUNYAN 19I search for resonances decaying to HW in pp collisions at $\sqrt{s} = 13$ TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 2800 GeV if we assume $M_{W'} = M_{Z'}$. NODE=S056W1C;LINKAGE=NC

[26] AABOUD 18AF give the limit above for right-handed W' using pp collisions at $\sqrt{s} = 13$ TeV. These limits also exclude W bosons with left-handed couplings with masses below 2.9 TeV, at the 95% confidence level. $W' \rightarrow \ell \nu_R$ is assumed to be forbidden. See their Fig.5 for limits on $\sigma \cdot B$ for both cases of left- and right-handed W'. NODE=S056W1C;LINKAGE=TB

[27] AABOUD 18AI search for resonances decaying to HW in pp collisions at $\sqrt{s} = 13$ TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 2670 GeV for $g_V = 1$. If we assume $M_{W'} = M_{Z'}$, the limit increases $M_{W'} >$ 2930 GeV and $M_{W'} >$ 2800 GeV for $g_V = 3$ and $g_V = 1$, respectively. See their Fig. 5 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=UB

[28] AABOUD 18AK search for resonances decaying to WZ in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 2800 GeV for $g_V = 1$. NODE=S056W1C;LINKAGE=VB

[29] AABOUD 18AL search for resonances decaying to WZ in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 2900 GeV for $g_V = 1$. NODE=S056W1C;LINKAGE=WB

[30] AABOUD 18BG limit is for W' with SM-like couplings using pp collisions at $\sqrt{s} = 13$ TeV. Bosonic decays of W' and $W - W'$ interference are neglected. See Fig. 2 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=XB

[31] AABOUD 18CH search for resonances decaying to WZ in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 2260 GeV for $g_V = 1$. NODE=S056W1C;LINKAGE=GC

[32] AABOUD 18F search for resonances decaying to WZ in pp collisions at $\sqrt{s} = 13$ TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 3000 GeV for $g_V = 1$. If we assume $M_{Z'} = M_{W'}$, the limit increases $M_{W'} >$ 3500 GeV and $M_{W'} >$ 3100 GeV for $g_V = 3$ and $g_V = 1$, respectively. See their Fig.5 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=MB

[33] AABOUD 18K limit is for W' with SM-like coupling using pp collisions at $\sqrt{s} = 13$ TeV. $W - W'$ interference and bosonic decays of W' are not included. See their Fig. 4 for limit on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=YB

[34] SIRUNYAN 18 limit is for right-handed W' using pp collisions at $\sqrt{s} = 13$ TeV. $W' \rightarrow \ell \nu_R$ decay is assumed to be forbidden. The limit becomes $M_{W'} > 3.4$ TeV if $M_{\nu_R} \ll M_{W'}$. See their Fig. 5 for exclusion limits on W' models having both left- and right-handed couplings. NODE=S056W1C;LINKAGE=RB

[35] SIRUNYAN 18AX search for resonances decaying to WZ in pp collisions at $\sqrt{s} = 13$ TeV. The quoted limit is for heavy-vector-triplet W' with $g_V = 3$. See their Fig.6 for limits on $\sigma \cdot$ B. NODE=S056W1C;LINKAGE=ZB

[36] SIRUNYAN 18AZ limit is derived for W' with SM-like coupling using pp collisions at $\sqrt{s}$ = 13 TeV. No interference with SM W process is considered. The bosonic decays are assumed to be negligible. See their Fig.6 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=AC

[37] SIRUNYAN 18BK search for resonances decaying to WZ in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes M$_{W'} >$ 3100 GeV for $g_V = 1$. NODE=S056W1C;LINKAGE=BC

[38] SIRUNYAN 18BO limit is for W' with SM-like coupling using pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056W1C;LINKAGE=CC

[39] SIRUNYAN 18DJ search for resonances decaying to WZ in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above is for heavy-vector-triplet W' with $g_V = 3$. The limit becomes $M_{W'} >$ 2270 GeV for $g_V = 1$. NODE=S056W1C;LINKAGE=KC

[40] SIRUNYAN 18ED search for resonances decaying to HW in pp collisions at $\sqrt{s} = 13$ TeV. The limit above is for heavy-vector-triplet W' with $g_V = 3$. If we assume $M_{W'} = M_{Z'}$, the limit increases $M_{W'} >$ 2900 GeV and $M_{W'} >$ 2800 GeV for $g_V = 3$ and $g_V = 1$, respectively. NODE=S056W1C;LINKAGE=LC

[41] SIRUNYAN 18P give this limit for a heavy-vector-triplet W' with $g_V = 3$. If they assume $M_{Z'} = M_{W'}$, the limit increases to $M_{W'} >$ 3800 GeV. NODE=S056W1C;LINKAGE=EC

[42] AABOUD 17AK search for a new resonance decaying to dijets in pp collisions at $\sqrt{s} = 13$ TeV. The limit above is for a W' boson having axial-vector SM couplings and decaying to quarks with 75% branching fraction. NODE=S056W1C;LINKAGE=KB

[43] AABOUD 17AO search for resonances decaying to HW in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is for a W' in the heavy-vector-triplet model with $g_V=3$. See their Fig.4 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=LB

[44] AABOUD 17B search for resonances decaying to HW ($H \to b\overline{b}$, $c\overline{c}$; $W \to \ell\nu$) in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet W' with $g_V=3$. The limit becomes $M_{W'} > 1750$ GeV for $g_V=1$. If we assume $M_{W'}=M_{Z'}$, the limit increases $M_{W'} > 2310$ GeV and $M_{W'} > 1730$ GeV for $g_V=3$ and $g_V=1$, respectively. See their Fig.3 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=BB

[45] KHACHATRYAN 17J search for right-handed W_R in pp collisions at $\sqrt{s}=13$ TeV. W_R is assumed to decay into τ and hypothetical heavy neutrino N_τ, with N_τ decaying into τjj. The quoted limit is for $M_{N_\tau}=M_{W_R}/2$. The limit becomes $M_{W_R} > 2350$ GeV (1630 GeV) for $M_{W_R}/M_{N_\tau}=0.8$ (0.2). See their Fig. 4 for excluded regions in the $M_{W_R}-M_{N_\tau}$ plane. NODE=S056W1C;LINKAGE=CB

[46] KHACHATRYAN 17W search for resonances decaying to dijets in pp collisions at $\sqrt{s}=13$ TeV. NODE=S056W1C;LINKAGE=FB

[47] KHACHATRYAN 17Z limit is for W' with SM-like coupling using pp collisions at $\sqrt{s}=13$ TeV. The bosonic decays of W' and the interference with SM W process are neglected. NODE=S056W1C;LINKAGE=GB

[48] SIRUNYAN 17A search for resonances decaying to WZ with $WZ \to \ell\nu q\overline{q}$, $q\overline{q}q\overline{q}$ in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet W' with $g_V=3$. The limit becomes $M_{W'} > 2000$ GeV for $g_V=1$. If we assume $M_{Z'}=M_{W'}$, the limit increases $M_{W'} > 2400$ GeV and $M_{W'} > 2300$ GeV for $g_V=3$ and $g_V=1$, respectively. See their Fig.6 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=HB

[49] SIRUNYAN 17AK search for resonances decaying to WZ or HW in pp collisions at $\sqrt{s}=8$ and 13 TeV. The quoted limit is for heavy-vector-triplet W' with $g_V=3$. The limit becomes $M_{W'} > 2300$ GeV for $g_V=1$. If we assume $M_{W'}=M_{Z'}$, the limit increases $M_{W'} > 2400$ GeV for both $g_V=3$ and $g_V=1$. See their Fig.1 and 2 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=NB

[50] SIRUNYAN 17H search for right-handed W' in pp collisions at $\sqrt{s}=13$ TeV. W' is assumed to decay into τ and a heavy neutrino N, with N decaying to $\tau q\overline{q}$. The limit above assumes $M_N = M_{W'}/2$. NODE=S056W1C;LINKAGE=IB

[51] SIRUNYAN 17I limit is for a right-handed W' using pp collisions at $\sqrt{s}=13$ TeV. The limit becomes $M_{W'} > 2400$ GeV for $M_{\nu_R} \ll M_{W'}$. NODE=S056W1C;LINKAGE=JB

[52] SIRUNYAN 17R search for resonances decaying to HW in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet W' with $g_V=3$. Mass regions $M_{W'} <$ 2370 GeV and $2870 < M_{W'} < 2970$ GeV are excluded for $g_V=1$. If we assume $M_{Z'}=M_{W'}$, the excluded mass regions are $1000 < M_{W'} < 2500$ GeV and $2760 < M_{W'} <$ 3300 GeV for $g_V=3$; $1000 < M_{W'} < 2430$ GeV and $2810 < M_{W'} < 3130$ GeV for $g_V=1$. See their Fig.5 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=PB

[53] AABOUD 16AE search for resonances decaying to VV ($V = W$ or Z) in pp collisions at $\sqrt{s}=13$ TeV. Results from $\nu\nu qq$, $\nu\ell qq$, $\ell\ell qq$ and $qqqq$ final states are combined. The quoted limit is for a heavy-vector-triplet W' with $g_V=3$ and $M_{W'}=M_{Z'}$. NODE=S056W1C;LINKAGE=ZA

[54] AABOUD 16V limit is for W' with SM-like coupling using pp collisions at $\sqrt{s}=13$ TeV. The bosonic decays of W' and the interference with SM W process are neglected. NODE=S056W1C;LINKAGE=AB

[55] AAD 16R search for $W' \to WZ$ in pp collisions at $\sqrt{s}=8$ TeV. $\ell\nu\ell'\ell'$, $\ell\ell q\overline{q}$, $\ell\nu q\overline{q}$, and all hadronic channels are combined. The quoted limit assumes $g_{W'WZ}/g_{WWZ} = (M_W/M_{W'})^2$. NODE=S056W1C;LINKAGE=RA

[56] AAD 16S search for a new resonance decaying to dijets in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is for a W' having SM-like couplings to quarks. NODE=S056W1C;LINKAGE=SA

[57] KHACHATRYAN 16AO limit is for a SM-like right-handed W' using pp collisions at $\sqrt{s}=8$ TeV. The quoted limit combines $t \to qqb$ and $t \to \ell\nu b$ events. NODE=S056W1C;LINKAGE=TA

[58] KHACHATRYAN 16AP search for a resonance decaying to HW in pp collisions at $\sqrt{s}=8$ TeV. Both H and W are assumed to decay to fat jets. The quoted limit is for heavy-vector-triplet W' with $g_V=3$. NODE=S056W1C;LINKAGE=UA

[59] KHACHATRYAN 16BD search for resonance decaying to HW in pp collisions at $\sqrt{s}=8$ TeV. The quoted limit is for heavy-vector-triplet (HVT) W' with $g_V=3$. The HVT model $m_{W'}=m_{Z'} > 1.8$ TeV is also obtained by combining $W'/Z' \to WH/ZH \to \ell\nu bb$, $qq\tau\tau$, $qq\overline{b}b$, and $qqqqqq$ channels. NODE=S056W1C;LINKAGE=VA

[60] KHACHATRYAN 16K search for resonances decaying to dijets in pp collisions at $\sqrt{s}=13$ TeV. NODE=S056W1C;LINKAGE=WA

[61] KHACHATRYAN 16L search for resonances decaying to dijets in pp collisions at $\sqrt{s}=8$ TeV with the data scouting technique, increasing the sensitivity to the low mass resonances. NODE=S056W1C;LINKAGE=XA

[62] KHACHATRYAN 16O limit is for W' having universal couplings. Interferences with the SM amplitudes are assumed to be absent. NODE=S056W1C;LINKAGE=YA

[63] AAD 15AU search for W' decaying into the WZ final state with $W \to q\overline{q}'$, $Z \to \ell^+\ell^-$ using pp collisions at $\sqrt{s}=8$ TeV. The quoted limit assumes $g_{W'WZ}/g_{WWZ} = (M_W/M_{W'})^2$. NODE=S056W1C;LINKAGE=FA

[64] AAD 15AV limit is for a SM like right-handed W' using pp collisions at $\sqrt{s}$ = 8 TeV. $W' \to \ell\nu$ decay is assumed to be forbidden. NODE=S056W1C;LINKAGE=HA

[65] AAD 15AZ search for W' decaying into the WZ final state with $W \to \ell\nu$, $Z \to q\overline{q}$ using pp collisions at $\sqrt{s}$ = 8 TeV. The quoted limit assumes $g_{W' WZ}/g_{WWZ} = (M_W/M_{W'})^2$. NODE=S056W1C;LINKAGE=JA

[66] AAD 15CP search for W' decaying into the WZ final state with $W \to q\overline{q}$, $Z \to q\overline{q}$ using pp collisions at $\sqrt{s}$ = 8 TeV. The quoted limit assumes $g_{W' WZ}/g_{WWZ} = (M_W/M_{W'})^2$. NODE=S056W1C;LINKAGE=KA

[67] AAD 15R limit is for a SM like right-handed W' using pp collisions at $\sqrt{s}$ = 8 TeV. $W' \to \ell\nu$ decay is assumed to be forbidden. NODE=S056W1C;LINKAGE=LA

[68] AAD 15V search for new resonance decaying to dijets in pp collisions at $\sqrt{s}$ = 8 TeV. NODE=S056W1C;LINKAGE=MA

[69] KHACHATRYAN 15C search for W' decaying via WZ to fully leptonic final states using pp collisions at $\sqrt{s}$=8 TeV. The quoted limit assumes $g_{W' WZ}/g_{WWZ} = M_W M_Z/M^2_{W'}$. NODE=S056W1C;LINKAGE=GA

[70] KHACHATRYAN 15T limit is for W' with SM-like coupling which interferes the SM W boson constructively using pp collisions at $\sqrt{s}$ = 8 TeV. For W' without interference, the limit becomes > 3280 GeV. NODE=S056W1C;LINKAGE=OA

[71] KHACHATRYAN 14O search for right-handed W_R in pp collisions at $\sqrt{s}$ = 8 TeV. W_R is assumed to decay into ℓ and hypothetical heavy neutrino N, with N decaying into ℓjj. The quoted limit is for $M_{\nu_{eR}} = M_{\nu_{\mu R}} = M_{W_R}/2$. See their Fig. 3 and Fig. 5 for excluded regions in the $M_{W_R} - M_\nu$ plane. NODE=S056W1C;LINKAGE=DA

[72] AAD 25AX search for a narrow resonance decaying to a pair of large-radius-jets using a machine-learning approach. See their Fig. 7 for limits on $\sigma \cdot B$ obtained with different classifier feature sets. NODE=S056W1C;LINKAGE=DE

[73] AAD 24AE search for resonances decaying to qq, tt, tb, VV, VH, $\ell\ell$, $\ell\tau$, $\tau\nu$, $\tau\tau$ in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet W' with g_V = 3. $M_{W'} = M_{Z'}$ is assumed. The limit becomes $M_{W'}$ > 5.8 TeV for g_V = 1. NODE=S056W1C;LINKAGE=YD

[74] AAD 24CM search for pair productions of dark pions $\pi^{\pm}_D \pi^0_D$ in $ttbb$ events of pp collisions at $\sqrt{s}$ = 13 TeV. $\pi^{\pm}_D \to tb$ and $\pi^0_D \to tt$ decays are assumed. The production cross section is computed in a model with dark $\rho^{\pm}_D$ assuming dark isospin symmetry $m_{\rho^{\pm}_D} = m_{\rho^0_D}$, $m_{\pi^{\pm}_D} = m_{\pi^0_D}$. See their Fig. 12 for limits on the production cross sections. NODE=S056W1C;LINKAGE=BE

[75] HAYRAPETYAN 24AV search for a spin-0 particle X decaying to $W\gamma$ in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 8 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=CE

[76] AAD 23BF search for W' decaying to WZ' in pp collisions at $\sqrt{s}$ = 13 TeV. The mass difference between W' and Z' is assumed to be 250 GeV. See their Fig. 9(a) for limits on $\sigma \cdot B$ as a function of $M_{W'}$. NODE=S056W1C;LINKAGE=OD

[77] AAD 23CG search for right-handed W_R in pp collisions at $\sqrt{s}$ = 13 TeV. W_R is assumed to decay into ℓ and hypothetical heavy neutrino N, with N decaying into ℓjj. See their Fig. 9 for limits in m_N–m_{W_R} plane. NODE=S056W1C;LINKAGE=VD

[78] AAD 23CK search for a new resonance decaying to HX ($H \to b\overline{b}$, $X \to q\overline{q}'$) in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 12 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=WD

[79] AAD 23U search for a narrow charged vector boson decaying to $W\gamma$. See their Fig. 8(d) for the exclusion limit in $m_{W'} - \sigma \cdot B$ plane. NODE=S056W1C;LINKAGE=RD

[80] TUMASYAN 22 search for KK excited W decaying in cascade to three W via a scalar radion R. See their Fig. 4 for limits in $M_{W'} - M_R$ plane. NODE=S056W1C;LINKAGE=LD

[81] TUMASYAN 22AL search for resonances decaying to tB or bT with vector-like quarks B (T) subsequently decaying to bH or bZ (tH or tZ). See their Fig. 7 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=MD

[82] TUMASYAN 22B search for a narrow charged vector boson decaying to $W\gamma$. See their Fig. 5 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=ED

[83] TUMASYAN 22I search for KK excited W decaying in cascade to three W via a scalar radion R. See their Fig. 10 for limits in $M_{W'} - M_R$ plane. NODE=S056W1C;LINKAGE=HD

[84] TUMASYAN 22P search for right handed W_R in pp collisiions at $\sqrt{s}$ = 13 TeV. W_R is assumed to decay into ℓ and hypothetical heavy neutrino N, with N decaying to ℓjj. See their Fig. 7 for excluded regions in $M_{W_R} - M_N$ plane. NODE=S056W1C;LINKAGE=JD

[85] AAD 20AD search for a narrow resonance decaying to a pair of large-radius-jets J_1 and J_2 employing a machine-learning procedure. See their Fig. 3 for limits on $\sigma \cdot B$ depending on assumptions about invariant masses for J_1, J_2, and $J_1 J_2$. NODE=S056W1C;LINKAGE=YC

[86] AAD 20W search for W' decaying to WZ' in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 5(b) for limits on $\sigma \cdot B$ as a function of $m_{Z'}$. The $W' \to WZ'$ branching fraction was chosen to be 0.5 and the mass difference between the W' and Z' was set to 250 GeV. NODE=S056W1C;LINKAGE=VC

[87] AABOUD 19B search for right-handed W_R in pp collisions at $\sqrt{s}$ = 13 TeV. W_R is assumed to decay into ℓ and hypothetical heavy neutrino N, with N decaying to ℓjj. See their Figs. 7 and 8 for excluded regions in $M_{W_R} - M_N$ plane. NODE=S056W1C;LINKAGE=IC

[88] AABOUD 19BB search for right handed W_R in pp collisions at $\sqrt{s}$ = 13 TeV. W_R is assumed to decay into ℓ and a boosted hypothetical heavy neutrino N, with N decaying to ℓ and a large radius jet $j = q\overline{q}$. See their Fig. 7 for excluded regions in $M_{W_R} - M_N$ plane. NODE=S056W1C;LINKAGE=PC

[89] SIRUNYAN 19V search for a new resonance decaying to a top quark and a heavy vector-like bottom partner B decaying to Hb (or a bottom quark and a heavy vector-like top partner T decaying to Ht) in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 8 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=OC

[90] AABOUD 18AA search for a narrow charged vector boson decaying to $W\gamma$. See their Fig. 9 for the exclusion limit in $\mathrm{M}_{W'} - \sigma\mathrm{B}$ plane. NODE=S056W1C;LINKAGE=QB

[91] AABOUD 18AD search for resonances decaying to HX ($H \rightarrow b\overline{b}$, $X \rightarrow q\overline{q}'$) in pp collisions at $\sqrt{s}$ = 13 TeV. See their Figs. 3–5 for limits on $\sigma \cdot \mathrm{B}$. NODE=S056W1C;LINKAGE=SB

[92] AABOUD 18CJ search for heavy-vector-triplet W' in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above is for model with $g_V = 3$ assuming $M_{W'} = M_{Z'}$. The limit becomes $M_{W'} > 5500$ GeV for model with $g_V = 1$. NODE=S056W1C;LINKAGE=HC

[93] SIRUNYAN 18CV search for right-handed W_R in pp collisions at $\sqrt{s}$ = 13 TeV. W_R is assumed to decay into ℓ and hypothetical heavy neutrino N, with N decaying to ℓjj. The quoted limit is for $M_N = M_{W_R}/2$. See their Fig. 6 for excluded regions in the $M_{W_R} - M_N$ plane. NODE=S056W1C;LINKAGE=DC

[94] KHACHATRYAN 17U search for resonances decaying to HW ($H \rightarrow b\overline{b}$; $W \rightarrow \ell\nu$) in pp collisions at $\sqrt{s}$ = 13 TeV. The limit on the heavy-vector-triplet model is $M_{Z'} = M_{W'} > 2$ TeV for $g_V = 3$, in which constraints from the $Z' \rightarrow HZ$ ($H \rightarrow b\overline{b}$; $Z \rightarrow \ell^+\ell^-$, $\nu\overline{\nu}$) are combined. See their Fig.3 and Fig.4 for limits on $\sigma \cdot B$. NODE=S056W1C;LINKAGE=EB

[95] AAD 15BB search for W' decaying into WH with $W \rightarrow \ell\nu$, $H \rightarrow b\overline{b}$. See their Fig. 4 for the exclusion limits in the heavy vector triplet benchmark model parameter space. NODE=S056W1C;LINKAGE=IA

[96] AALTONEN 15C limit is for a SM-like right-handed W' assuming $W' \rightarrow \ell\nu$ decays are forbidden, using $p\overline{p}$ collisions at $\sqrt{s}$=1.96 TeV. See their Fig. 3 for limit on $g_{W'}/g_W$. NODE=S056W1C;LINKAGE=NA

[97] KHACHATRYAN 15V search new resonance decaying to dijets in pp collisions at $\sqrt{s}$ = 8 TeV. NODE=S056W1C;LINKAGE=PA

[98] AAD 14AT search for a narrow charged vector boson decaying to $W\gamma$. See their Fig. 3a for the exclusion limit in $m_{W'} - \sigma B$ plane. NODE=S056W1C;LINKAGE=EA

[99] AAD 14S search for W' decaying into the WZ final state with $W \rightarrow \ell\nu$, $Z \rightarrow \ell\ell$ using pp collisions at $\sqrt{s}$=8 TeV. The quoted limit assumes $g_{W'WZ}/g_{WWZ} = (M_W/M_{W'})^2$. NODE=S056W1C;LINKAGE=CA

[100] KHACHATRYAN 14 search for W' decaying into WZ final state with $W \rightarrow q\overline{q}$, $Z \rightarrow q\overline{q}$ using pp collisions at $\sqrt{s}$=8 TeV. The quoted limit assumes $g_{W'WZ}/g_{WWZ} = (M_W/M_{W'})^2$. NODE=S056W1C;LINKAGE=Z

[101] KHACHATRYAN 14A search for W' decaying into the WZ final state with $W \rightarrow \ell\nu$, $Z \rightarrow q\overline{q}$, or $W \rightarrow q\overline{q}$, $Z \rightarrow \ell\ell$. pp collisions data at $\sqrt{s}$=8 TeV are used for the search. See their Fig. 13 for the exclusion limit on the number of events in the mass−width plane. NODE=S056W1C;LINKAGE=BA

[102] AAD 13AO search for W' decaying into the WZ final state with $W \rightarrow \ell\nu$, $Z \rightarrow 2j$ using pp collisions at $\sqrt{s}$=7 TeV. The quoted limit assumes $g_{W'WZ}/g_{WWZ} = (M_W/M_{W'})^2$. NODE=S056W1C;LINKAGE=Y

[103] CHATRCHYAN 13AJ search for resonances decaying to WZ pair, using the hadronic decay modes of W and Z, in pp collisions at $\sqrt{s}$=7 TeV. See their Fig. 7 for the limit on the cross section. NODE=S056W1C;LINKAGE=X

[104] CHATRCHYAN 13AQ limit is for W' with SM-like coupling which interferes with the SM W boson using pp collisions at $\sqrt{s}$=7 TeV. NODE=S056W1C;LINKAGE=V

[105] CHATRCHYAN 13E limit is for W' with SM-like coupling which intereferes with the SM W boson using pp collisions at $\sqrt{s}$=7 TeV. For W' with right-handed coupling, the bound becomes >1850 GeV (>1910 GeV) if W' decays to both leptons and quarks (only to quarks). If both left- and right-handed couplings are present, the limit becomes >1640 GeV. NODE=S056W1C;LINKAGE=T

[106] CHATRCHYAN 13U search for W' decaying to the WZ final state, with W decaying into jets, in pp collisions at $\sqrt{s}$=7 TeV. The quoted limit assumes $g_{W'WZ}/g_{WWZ} = (M_W/M_{W'})^2$. NODE=S056W1C;LINKAGE=M

[107] The AAD 12AV quoted limit is for a SM-like right-handed W' using pp collisions at $\sqrt{s}$=7 TeV. $W' \rightarrow \ell\nu$ decay is assumed to be forbidden. NODE=S056W1C;LINKAGE=N

[108] AAD 12BB use pp collisions data at $\sqrt{s}$=7 TeV. The quoted limit assumes $g_{W'WZ}/g_{WWZ} = (M_W/M_{W'})^2$. NODE=S056W1C;LINKAGE=R

[109] AAD 12CK search for $pp \rightarrow tW'$, $W' \rightarrow \overline{t}q$ events in pp collisions. See their Fig. 5 for the limit on $\sigma \cdot \mathrm{B}$. NODE=S056W1C;LINKAGE=O

[110] AAD 12CR use pp collisions at $\sqrt{s}$=7 TeV. NODE=S056W1C;LINKAGE=QA

[111] AAD 12M search for right-handed W_R in pp collisions at $\sqrt{s}$ = 7 TeV. W_R is assumed to decay into ℓ and hypothetical heavy neutrino N, with N decaying into ℓjj. See their Fig. 4 for the limit in the $m_N - m_{W'}$ plane. NODE=S056W1C;LINKAGE=AD

[112] AALTONEN 12N search for $p\overline{p} \rightarrow tW'$, $W' \rightarrow \overline{t}d$ events in $p\overline{p}$ collisions. See their Fig. 3 for the limit on $\sigma \cdot \mathrm{B}$. NODE=S056W1C;LINKAGE=P

[113] CHATRCHYAN 12AR search for $pp \to tW'$, $W' \to \bar{t}d$ events in pp collisions. See their Fig. 2 for the limit on $\sigma \cdot$ B. NODE=S056W1C;LINKAGE=S

[114] CHATRCHYAN 12BG search for right-handed W_R in pp collisions $\sqrt{s}$ = 7 TeV. W_R is assumed to decay into ℓ and hypothetical heavy neutrino N, with N decaying into ℓjj. See their Fig. 3 for the limit in the $m_N - m_{W'}$ plane. NODE=S056W1C;LINKAGE=CH

[115] ABAZOV 11H use data from $p\bar{p}$ collisions at $\sqrt{s}$=1.96 TeV. The quoted limit is obtained assuming $W'WZ$ coupling strength is the same as the ordinary WWZ coupling strength in the Standard Model. NODE=S056W1C;LINKAGE=K

[116] ABAZOV 11L limit is for W' with SM-like coupling which interferes with the SM W boson, using $p\bar{p}$ collisions at $\sqrt{s}$=1.96 TeV. For W' with right-handed coupling, the bound becomes >885 GeV (>890 GeV) if W' decays to both leptons and quarks (only to quarks). If both left- and right-handed couplings present, the limit becomes >916 GeV. NODE=S056W1C;LINKAGE=L

[117] AALTONEN 10N use $p\bar{p}$ collision data at $\sqrt{s}$=1.96 TeV. The quoted limit assumes $g_{W'WZ}/g_{WWZ} = (M_W/M_{W'})^2$. See their Fig. 4 for limits in mass-coupling plane. NODE=S056W1C;LINKAGE=AL

[118] AALTONEN 09AC search for new particle decaying to dijets using $p\bar{p}$ collisions at $\sqrt{s}$=1.96 TeV. NODE=S056W1C;LINKAGE=AA

[119] The ACOSTA 03B quoted limit is for $M_{W'} \gg M_{\nu_R}$, using $p\bar{p}$ collisions at $\sqrt{s}$=1.8 TeV. For $M_{W'} < M_{\nu_R}$, $M_{W'}$ between 225 and 566 GeV is excluded. NODE=S056W1C;LINKAGE=CT

[120] The quoted limit is obtained assuming $W'WZ$ coupling strength is the same as the ordinary WWZ coupling strength in the Standard Model, using $p\bar{p}$ collisions at $\sqrt{s}$=1.8 TeV. See their Fig. 2 for the limits on the production cross sections as a function of the W' width. NODE=S056W1C;LINKAGE=FC

[121] AFFOLDER 01I combine a new bound on $W' \to e\nu$ of 754 GeV, using $p\bar{p}$ collisions at $\sqrt{s}$=1.8 TeV, with the bound of ABE 00 on $W' \to \mu\nu$ to obtain quoted bound. NODE=S056W1C;LINKAGE=FK

[122] ABE 97G search for new particle decaying to dijets using $p\bar{p}$ collisions at $\sqrt{s}$=1.8 TeV. NODE=S056W1C;LINKAGE=SZ

[123] For bounds on W_R with nonzero right-handed mass, see Fig. 5 from ABACHI 96C. NODE=S056W1C;LINKAGE=J

[124] ABACHI 95E assume that the decay $W' \to WZ$ is suppressed and that the neutrino from W' decay is stable and has a mass significantly less $m_{W'}$. NODE=S056W1C;LINKAGE=I

[125] RIZZO 93 analyses CDF limit on possible two-jet resonances. The limit is sensitive to the inclusion of the assumed K factor. NODE=S056W1C;LINKAGE=RZ

W_R (Right-Handed W Boson) MASS LIMITS

NODE=S056MR

Assuming a light right-handed neutrino, except for BEALL 82, LANGACKER 89B, and COLANGELO 91. $g_R = g_L$ assumed. [Limits in the section MASS LIMITS for W' below are also valid for W_R if $m_{\nu_R} \ll m_{W_R}$.] Some limits assume manifest left-right symmetry, *i.e.*, the equality of left- and right Cabibbo-Kobayashi-Maskawa matrices. For a comprehensive review, see LANGACKER 89B. Limits on the W_L-W_R mixing angle ζ are found in the next section. Values in brackets are from cosmological and astrophysical considerations and assume a light right-handed neutrino. NODE=S056MR

NODE=S056MR

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
> 592	90	[1] BUENO	11	TWST	μ decay
> 715	90	[2] CZAKON	99	RVUE	Electroweak
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>4000	95	[3] ALVES	24	RVUE	K and π decays
> 235	90	[4] PRIEELS	14	PIE3	μ decay
> 245	90	[5] WAUTERS	10	CNTR	^{60}Co β decay
>2500		[6] ZHANG	08	THEO	$m_{K^0_L} - m_{K^0_S}$
> 180	90	[7] MELCONIAN	07	CNTR	^{37}K β^+ decay
> 290.7	90	[8] SCHUMANN	07	CNTR	Polarized neutron decay
[> 3300]	95	[9] CYBURT	05	COSM	Nucleosynthesis; light ν_R
> 310	90	[10] THOMAS	01	CNTR	β^+ decay
> 137	95	[11] ACKERSTAFF	99D	OPAL	τ decay
>1400	68	[12] BARENBOIM	98	RVUE	Electroweak, Z-Z' mixing
> 549	68	[13] BARENBOIM	97	RVUE	μ decay
> 220	95	[14] STAHL	97	RVUE	τ decay
> 220	90	[15] ALLET	96	CNTR	β^+ decay
> 281	90	[16] KUZNETSOV	95	CNTR	Polarized neutron decay
> 282	90	[17] KUZNETSOV	94B	CNTR	Polarized neutron decay
> 439	90	[18] BHATTACH...	93	RVUE	Z-Z' mixing
> 250	90	[19] SEVERIJNS	93	CNTR	β^+ decay
		[20] IMAZATO	92	CNTR	K^+ decay
> 475	90	[21] POLAK	92B	RVUE	μ decay
> 240	90	[22] AQUINO	91	RVUE	Neutron decay

$>$ 496	90	[22] AQUINO	91	RVUE	Neutron and muon decay	OCCUR=2
$>$ 700		[23] COLANGELO	91	THEO	$m_{K^0_L} - m_{K^0_S}$	
$>$ 477	90	[24] POLAK	91	RVUE	μ decay	
[none 540–23000]		[25] BARBIERI	89B	ASTR	SN 1987A; light ν_R	
$>$ 300	90	[26] LANGACKER	89B	RVUE	General	
$>$ 160	90	[27] BALKE	88	CNTR	$\mu \rightarrow e \nu \overline{\nu}$	
$>$ 406	90	[28] JODIDIO	86	ELEC	Any ζ	
$>$ 482	90	[28] JODIDIO	86	ELEC	$\zeta = 0$	OCCUR=2
$>$ 800		MOHAPATRA	86	RVUE	$SU(2)_L \times SU(2)_R \times U(1)$	
$>$ 400	95	[29] STOKER	85	ELEC	Any ζ	
$>$ 475	95	[29] STOKER	85	ELEC	ζ <0.041	OCCUR=2
		[30] BERGSMA	83	CHRM	$\nu_\mu e \rightarrow \mu \nu_e$	
$>$ 380	90	[31] CARR	83	ELEC	μ^+ decay	
$>$1600		[32] BEALL	82	THEO	$m_{K^0_L} - m_{K^0_S}$	

[1] BUENO 11 limit is for manifest left-right symmetric model. NODE=S056MR;LINKAGE=D

[2] CZAKON 99 perform a simultaneous fit to charged and neutral sectors. NODE=S056MR;LINKAGE=ZP

[3] ALVES 24 limit quoted above is from $B(\pi \rightarrow e\nu)/B(\pi \rightarrow \mu\nu)$ assuming $m_{\nu_R} = 50$ MeV in vanishing $W_L - W_R$ mixing limit. $g_L = g_R$ is assumed. See their Fig. 2 for limits in $m_{\nu_R} - m_{W_R}$ plane. NODE=S056MR;LINKAGE=O

[4] PRIEELS 14 limit is from $\mu^+ \rightarrow e^+ \nu \overline{\nu}$ decay parameter ξ'', which is determined by the positron polarization measurement. NODE=S056MR;LINKAGE=M

[5] WAUTERS 10 limit is from a measurement of the asymmetry parameter of polarized ^{60}Co β decays. The listed limit assumes no mixing. NODE=S056MR;LINKAGE=WA

[6] ZHANG 08 limit uses a lattice QCD calculation of the relevant hadronic matrix elements, while BEALL 82 limit used the vacuum saturation approximation. NODE=S056MR;LINKAGE=G

[7] MELCONIAN 07 measure the neutrino angular asymmetry in β^+-decays of polarized ^{37}K, stored in a magneto-optical trap. Result is consistent with SM prediction and does not constrain the $W_L - W_R$ mixing angle appreciably. NODE=S056MR;LINKAGE=ME

[8] SCHUMANN 07 limit is from measurements of the asymmetry $\langle \vec{p}_\nu \cdot \sigma_n \rangle$ in the β decay of polarized neutrons. Zero mixing is assumed. NODE=S056MR;LINKAGE=SC

[9] CYBURT 05 limit follows by requiring that three light ν_R's decouple when $T_{dec} > 140$ MeV. For different T_{dec}, the bound becomes $M_{W_R} > 3.3$ TeV $(T_{dec}$ / 140 MeV$)^{3/4}$. NODE=S056MR;LINKAGE=CB

[10] THOMAS 01 limit is from measurement of β^+ polarization in decay of polarized ^{12}N. The listed limit assumes no mixing. NODE=S056MR;LINKAGE=TH

[11] ACKERSTAFF 99D limit is from τ decay parameters. Limit increase to 145 GeV for zero mixing. NODE=S056MR;LINKAGE=RD

[12] BARENBOIM 98 assumes minimal left-right model with Higgs of $SU(2)_R$ in $SU(2)_L$ doublet. For Higgs in $SU(2)_L$ triplet, m_{W_R} >1100 GeV. Bound calculated from effect of corresponding Z_{LR} on electroweak data through Z–Z_{LR} mixing. NODE=S056MR;LINKAGE=B6

[13] The quoted limit is from μ decay parameters. BARENBOIM 97 also evaluate limit from K_L-K_S mass difference. NODE=S056MR;LINKAGE=MW

[14] STAHL 97 limit is from fit to τ-decay parameters. NODE=S056MR;LINKAGE=S

[15] ALLET 96 measured polarization-asymmetry correlation in $^{12}N\beta^+$ decay. The listed limit assumes zero L-R mixing. NODE=S056MR;LINKAGE=R

[16] KUZNETSOV 95 limit is from measurements of the asymmetry $\langle \vec{p}_\nu \cdot \sigma_n \rangle$ in the β decay of polarized neutrons. Zero mixing assumed. See also KUZNETSOV 94B. NODE=S056MR;LINKAGE=N

[17] KUZNETSOV 94B limit is from measurements of the asymmetry $\langle \vec{p}_\nu \cdot \sigma_n \rangle$ in the β decay of polarized neutrons. Zero mixing assumed. NODE=S056MR;LINKAGE=L

[18] BHATTACHARYYA 93 uses Z-Z' mixing limit from LEP '90 data, assuming a specific Higgs sector of $SU(2)_L \times SU(2)_R \times U(1)$ gauge model. The limit is for m_t=200 GeV and slightly improves for smaller m_t. NODE=S056MR;LINKAGE=K

[19] SEVERIJNS 93 measured polarization-asymmetry correlation in $^{107}In\,\beta^+$ decay. The listed limit assumes zero L-R mixing. Value quoted here is from SEVERIJNS 94 erratum. NODE=S056MR;LINKAGE=IS

[20] IMAZATO 92 measure positron asymmetry in $K^+ \rightarrow \mu^+ \nu_\mu$ decay and obtain $\xi P_\mu > 0.990$ (90% CL). If W_R couples to $u\overline{s}$ with full weak strength (V^R_{us}=1), the result corresponds to m_{W_R} >653 GeV. See their Fig. 4 for m_{W_R} limits for general $|V^R_{us}|^2 = 1 - |V^R_{ud}|^2$. NODE=S056MR;LINKAGE=IM

[21] POLAK 92B limit is from fit to muon decay parameters and is essentially determined by JODIDIO 86 data assuming ζ=0. Supersedes POLAK 91. NODE=S056MR;LINKAGE=PK

[22] AQUINO 91 limits obtained from neutron lifetime and asymmetries together with unitarity of the CKM matrix. Manifest left-right symmetry assumed. Stronger of the two limits also includes muon decay results. NODE=S056MR;LINKAGE=F

[23] COLANGELO 91 limit uses hadronic matrix elements evaluated by QCD sum rule and is less restrictive than BEALL 82 limit which uses vacuum saturation approximation. Manifest left-right symmetry assumed. NODE=S056MR;LINKAGE=H

[24] POLAK 91 limit is from fit to muon decay parameters and is essentially determined by JODIDIO 86 data assuming ζ=0. Superseded by POLAK 92B. NODE=S056MR;LINKAGE=PZ

[25] BARBIERI 89B limit holds for $m_{\nu_R} \leq 10$ MeV. NODE=S056MR;LINKAGE=BB

[26] LANGACKER 89B limit is for any ν_R mass (either Dirac or Majorana) and for a general class of right-handed quark mixing matrices. NODE=S056MR;LINKAGE=I

[27] BALKE 88 limit is for $m_{\nu_{eR}} = 0$ and $m_{\nu_{\mu R}} \leq$ 50 MeV. Limits come from precise measurements of the muon decay asymmetry as a function of the positron energy. NODE=S056MR;LINKAGE=Q

[28] JODIDIO 86 is the same TRIUMF experiment as STOKER 85 (and CARR 83); however, it uses a different technique. The results given here are combined results of the two techniques. The technique here involves precise measurement of the end-point e^+ spectrum in the decay of the highly polarized μ^+. NODE=S056MR;LINKAGE=J

[29] STOKER 85 is same TRIUMF experiment as CARR 83. Here they measure the decay e^+ spectrum asymmetry above 46 MeV/c using a muon-spin-rotation technique. Assumed a light right-handed neutrino. Quoted limits are from combining with CARR 83. NODE=S056MR;LINKAGE=C

[30] BERGSMA 83 set limit m_{W_2}/m_{W_1} >1.9 at CL = 90%. NODE=S056MR;LINKAGE=A

[31] CARR 83 is TRIUMF experiment with a highly polarized μ^+ beam. Looked for deviation from $V-A$ at the high momentum end of the decay e^+ energy spectrum. Limit from previous world-average muon polarization parameter is m_{W_R} >240 GeV. Assumes a light right-handed neutrino. NODE=S056MR;LINKAGE=B

[32] BEALL 82 limit is obtained assuming that W_R contribution to K^0_L–K^0_S mass difference is smaller than the standard one, neglecting the top quark contributions. Manifest left-right symmetry assumed. NODE=S056MR;LINKAGE=E

Limit on W_L-W_R Mixing Angle ζ

NODE=S056WRZ

Lighter mass eigenstate $W_1 = W_L\cos\zeta - W_R\sin\zeta$. Light ν_R assumed unless noted. Values in brackets are from cosmological and astrophysical considerations. NODE=S056WRZ

NODE=S056WRZ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
−0.020 to 0.017	90	BUENO	11	TWST	$\mu \to e\nu\overline{\nu}$	
< 0.022	90	MACDONALD	08	TWST	$\mu \to e\nu\overline{\nu}$	
< 0.12	95	[1] ACKERSTAFF	99D	OPAL	τ decay	
< 0.013	90	[2] CZAKON	99	RVUE	Electroweak	
< 0.0333		[3] BARENBOIM	97	RVUE	μ decay	
< 0.04	90	[4] MISHRA	92	CCFR	νN scattering	
−0.0006 to 0.0028	90	[5] AQUINO	91	RVUE		
[none 0.00001–0.02]		[6] BARBIERI	89B	ASTR	SN 1987A	
< 0.040	90	[7] JODIDIO	86	ELEC	μ decay	
−0.056 to 0.040	90	[7] JODIDIO	86	ELEC	μ decay	OCCUR=2

[1] ACKERSTAFF 99D limit is from τ decay parameters. NODE=S056WRZ;LINKAGE=RD

[2] CZAKON 99 perform a simultaneous fit to charged and neutral sectors. NODE=S056WRZ;LINKAGE=ZP

[3] The quoted limit is from μ decay parameters. BARENBOIM 97 also evaluate limit from K_L-K_S mass difference. NODE=S056WRZ;LINKAGE=MW

[4] MISHRA 92 limit is from the absence of extra large-x, large-y $\overline{\nu}_\mu N \to \overline{\nu}_\mu X$ events at Tevatron, assuming left-handed ν and right-handed $\overline{\nu}$ in the neutrino beam. The result gives $\zeta^2(1-2m^2_{W_1}/m^2_{W_2}) < 0.0015$. The limit is independent of ν_R mass. NODE=S056WRZ;LINKAGE=A

[5] AQUINO 91 limits obtained from neutron lifetime and asymmetries together with unitarity of the CKM matrix. Manifest left-right asymmetry is assumed. NODE=S056WRZ;LINKAGE=C

[6] BARBIERI 89B limit holds for $m_{\nu_R} \leq 10$ MeV. NODE=S056WRZ;LINKAGE=BB

[7] First JODIDIO 86 result assumes $m_{W_R}=\infty$, second is for unconstrained m_{W_R}. NODE=S056WRZ;LINKAGE=B

See the related review(s):

Z'-Boson Searches

MASS LIMITS for Z' (Heavy Neutral Vector Boson Other Than Z)

NODE=S056216

Limits for Z'_{SM}

NODE=S056Z1C

Z'_{SM} is assumed to have couplings with quarks and leptons which are identical to those of Z, and decays only to known fermions. The most recent preliminary results can be found in the "Z'-boson searches" review above. NODE=S056Z1C

NODE=S056Z1C

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>5150 (CL = 95%) OUR LIMIT					
>3500	95	[1] HAYRAPETY...	25M	CMS	pp; $Z'_{SM} \to \tau^+\tau^-$
none 1800–2400	95	[2] TUMASYAN	23AF	CMS	pp; $Z'_{SM} \to b\overline{b}$
>4400	95	[3] TUMASYAN	22AE	CMS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$
>5150	95	[4] SIRUNYAN	21N	CMS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$
none 1133–2700	95	[5] AAD	20T	ATLS	pp, $Z'_{SM} \to b\overline{b}$

→ UNCHECKED ←

none 1800–2900, 3100–3300	95	[6] SIRUNYAN 20AI	CMS	pp; $Z'_{SM} \to q\overline{q}$	
none 250–5100	95	[7] AAD 19L	ATLS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
none 600–2000	95	[8] AABOUD 18AB	ATLS	pp; $Z'_{SM} \to b\overline{b}$	
>2420	95	[9] AABOUD 18G	ATLS	pp; $Z'_{SM} \to \tau^+\tau^-$	
none 200–4500	95	[10] SIRUNYAN 18BB	CMS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
none 600–2700	95	[11] SIRUNYAN 18BO	CMS	pp; $Z'_{SM} \to q\overline{q}$	
>4500	95	[12] AABOUD 17AT	ATLS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
>2100	95	[13] KHACHATRY... 17H	CMS	pp; $Z'_{SM} \to \tau^+\tau^-$	
>3370	95	[14] KHACHATRY... 17T	CMS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
none 600–2100, 2300–2600	95	[15] KHACHATRY... 17W	CMS	pp; $Z'_{SM} \to q\overline{q}$	
>3360	95	[16] AABOUD 16U	ATLS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
>2900	95	[17] KHACHATRY... 15AE	CMS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
none 1200–1700	95	[18] KHACHATRY... 15V	CMS	pp; $Z'_{SM} \to q\overline{q}$	
>2900	95	[19] AAD 14V	ATLS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[20] BOBOVNIKOV 18	RVUE	pp, $Z'_{SM} \to W^+W^-$	
>1900	95	[21] AABOUD 16AA	ATLS	pp; $Z'_{SM} \to \tau^+\tau^-$	
>2020	95	[22] AAD 15AM	ATLS	pp; $Z'_{SM} \to \tau^+\tau^-$	
>1400	95	[23] AAD 13S	ATLS	pp; $Z'_{SM} \to \tau^+\tau^-$	
>1470	95	[24] CHATRCHYAN 13A	CMS	pp; $Z'_{SM} \to q\overline{q}$	
>2590	95	[25] CHATRCHYAN 13AF	CMS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
>2220	95	[26] AAD 12CC	ATLS	pp; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
>1400	95	[27] CHATRCHYAN 12O	CMS	pp; $Z'_{SM} \to \tau^+\tau^-$	OCCUR=2
>1071	95	[28] AALTONEN 11I	CDF	$p\overline{p}$; $Z'_{SM} \to \mu^+\mu^-$	
>1023	95	[29] ABAZOV 11A	D0	$p\overline{p}$, $Z'_{SM} \to e^+e^-$	
none 247–544	95	[30] AALTONEN 10N	CDF	$Z' \to WW$	
none 320–740	95	[31] AALTONEN 09AC	CDF	$Z' \to q\overline{q}$	
> 963	95	[29] AALTONEN 09T	CDF	$p\overline{p}$, $Z'_{SM} \to e^+e^-$	
>1403	95	[32] ERLER 09	RVUE	Electroweak	
>1305	95	[33] ABDALLAH 06C	DLPH	e^+e^-	
> 399	95	[34] ACOSTA 05R	CDF	$\overline{p}p$: $Z'_{SM} \to \tau^+\tau^-$	
none 400–640	95	ABAZOV 04C	D0	$p\overline{p}$: $Z'_{SM} \to q\overline{q}$	
>1018	95	[35] ABBIENDI 04G	OPAL	e^+e^-	
> 670	95	[36] ABAZOV 01B	D0	$p\overline{p}$, $Z'_{SM} \to e^+e^-$	
>1500	95	[37] CHEUNG 01B	RVUE	Electroweak	
> 710	95	[38] ABREU 00S	DLPH	e^+e^-	
> 898	95	[39] BARATE 00I	ALEP	e^+e^-	
> 809	95	[40] ERLER 99	RVUE	Electroweak	
> 690	95	[41] ABE 97S	CDF	$p\overline{p}$; $Z'_{SM} \to e^+e^-$, $\mu^+\mu^-$	
> 398	95	[42] VILAIN 94B	CHM2	$\nu_\mu e \to \nu_\mu e$ and $\overline{\nu}_\mu e \to \overline{\nu}_\mu e$	
> 237	90	[43] ALITTI 93	UA2	$p\overline{p}$; $Z'_{SM} \to q\overline{q}$	
none 260–600	95	[44] RIZZO 93	RVUE	$p\overline{p}$; $Z'_{SM} \to q\overline{q}$	
> 426	90	[45] ABE 90F	VNS	e^+e^-	OCCUR=4

[1] HAYRAPETYAN 25M search for resonances decaying to $\tau^+\tau^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 4 for limits on $\sigma\cdot B$. NODE=S056Z1C;LINKAGE=RA

[2] TUMASYAN 23AF search for resonance decaying to $b\overline{b}$ in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig. 4 for limits on $\sigma\cdot B$. NODE=S056Z1C;LINKAGE=QA

[3] TUMASYAN 22AE set limits on Z' from the measurements of the forward-backward asymmetry in e^+e^- and $\mu^+\mu^-$ events in pp collisions at $\sqrt{s} = 13$ TeV. The quoted limit is for the sequential SM Z'. See their Fig. 6 for limits in mass-coupling plane. NODE=S056Z1C;LINKAGE=PA

[4] SIRUNYAN 21N search for resonance decaying to e^+e^-, $\mu^+\mu^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056Z1C;LINKAGE=OA

[5] AAD 20T search for resonances decaying to $b\overline{b}$ in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig. 7(b) for limits on the product of the cross section, acceptance, b-tagging efficiency, and branching fraction. NODE=S056Z1C;LINKAGE=MA

[6] SIRUNYAN 20AI search for resonances decaying into dijets in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056Z1C;LINKAGE=NA

[7] AAD 19L search for resonances decaying to $\ell^+\ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056Z1C;LINKAGE=LA

[8] AABOUD 18AB search for resonances decaying to $b\overline{b}$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056Z1C;LINKAGE=HA

[9] AABOUD 18G search for resonances decaying to $\tau^+\tau^-$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056Z1C;LINKAGE=GA

[10] SIRUNYAN 18BB search for resonances decaying to $\ell^+\ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig.5 for limits on the Z' coupling strengths with light quarks. NODE=S056Z1C;LINKAGE=IA

[11] SIRUNYAN 18BO search for resonances decaying to dijets in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056Z1C;LINKAGE=JA
[12] AABOUD 17AT search for resonances decaying to $\ell^+ \ell^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056Z1C;LINKAGE=FA
[13] KHACHATRYAN 17H search for resonances decaying to $\tau^+ \tau^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056Z1C;LINKAGE=CA
[14] KHACHATRYAN 17T search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s}$ = 8, 13 TeV. NODE=S056Z1C;LINKAGE=DA
[15] KHACHATRYAN 17W search for resonances decaying to dijets in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056Z1C;LINKAGE=EA
[16] AABOUD 16U search for resonances decaying to $\ell^+ \ell^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056Z1C;LINKAGE=BA
[17] KHACHATRYAN 15AE search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s}$ = 8 TeV. NODE=S056Z1C;LINKAGE=T
[18] KHACHATRYAN 15V search for resonances decaying to dijets in pp collisions at $\sqrt{s}$ = 8 TeV. NODE=S056Z1C;LINKAGE=X
[19] AAD 14V search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s}$ = 8 TeV. NODE=S056Z1C;LINKAGE=R
[20] BOBOVNIKOV 18 use the ATLAS limits on $\sigma(pp \rightarrow Z')\cdot$B$(Z' \rightarrow W^+ W^-)$ to constrain the Z-Z' mixing parameter ξ. See their Fig. 11 for limits in $M_{Z'} - \xi$ plane. NODE=S056Z1C;LINKAGE=KA
[21] AABOUD 16AA search for resonances decaying to $\tau^+ \tau^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056Z1C;LINKAGE=Z
[22] AAD 15AM search for resonances decaying to $\tau^+ \tau^-$ in pp collisions at $\sqrt{s}$ = 8 TeV. NODE=S056Z1C;LINKAGE=S
[23] AAD 13S search for resonances decaying to $\tau^+ \tau^-$ in pp collisions at $\sqrt{s}$ = 7 TeV. NODE=S056Z1C;LINKAGE=N
[24] CHATRCHYAN 13A use pp collisions at $\sqrt{s}$=7 TeV. NODE=S056Z1C;LINKAGE=Y
[25] CHATRCHYAN 13AF search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s}$ = 7 TeV and 8 TeV. NODE=S056Z1C;LINKAGE=P
[26] AAD 12CC search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s}$ = 7 TeV. NODE=S056Z1C;LINKAGE=L
[27] CHATRCHYAN 12O search for resonances decaying to $\tau^+ \tau^-$ in pp collisions at $\sqrt{s}$ = 7 TeV. NODE=S056Z1C;LINKAGE=O
[28] AALTONEN 11I search for resonances decaying to $\mu^+ \mu^-$ in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. NODE=S056Z1C;LINKAGE=F
[29] ABAZOV 11A, AALTONEN 09T, AALTONEN 07H, and ABULENCIA 06L search for resonances decaying to $e^+ e^-$ in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. NODE=S056Z1C;LINKAGE=BU
[30] The quoted limit assumes $g_{WWZ'}/g_{WWZ} = (M_W/M_{Z'})^2$. See their Fig. 4 for limits in mass-coupling plane. NODE=S056Z1C;LINKAGE=TO
[31] AALTONEN 09AC search for new particle decaying to dijets. NODE=S056Z1C;LINKAGE=AL
[32] ERLER 09 give 95% CL limit on the Z-Z' mixing $-0.0026 < \theta < 0.0006$. NODE=S056Z1C;LINKAGE=ER
[33] ABDALLAH 06C use data $\sqrt{s}$ = 130–207 GeV. NODE=S056Z1C;LINKAGE=HL
[34] ACOSTA 05R search for resonances decaying to tau lepton pairs in $\overline{p}p$ collisions at $\sqrt{s}$ = 1.96 TeV. NODE=S056Z1C;LINKAGE=AC
[35] ABBIENDI 04G give 95% CL limit on Z-Z' mixing $-0.00422 < \theta < 0.00091$. $\sqrt{s}$ = 91 to 207 GeV. NODE=S056Z1C;LINKAGE=AB
[36] ABAZOV 01B search for resonances in $p\overline{p} \rightarrow e^+ e^-$ at $\sqrt{s}$=1.8 TeV. They find $\sigma \cdot$ B$(Z' \rightarrow ee) <$ 0.06 pb for $M_{Z'} > 500$ GeV. NODE=S056Z1C;LINKAGE=ZB
[37] CHEUNG 01B limit is derived from bounds on contact interactions in a global electroweak analysis. NODE=S056Z1C;LINKAGE=QK
[38] ABREU 00S uses LEP data at $\sqrt{s}$=90 to 189 GeV. NODE=S056Z1C;LINKAGE=TG
[39] BARATE 00I search for deviations in cross section and asymmetries in $e^+ e^- \rightarrow$ fermions at $\sqrt{s}$=90 to 183 GeV. Assume θ=0. Bounds in the mass-mixing plane are shown in their Figure 18. NODE=S056Z1C;LINKAGE=BI
[40] ERLER 99 give 90%CL limit on the Z-Z' mixing $-0.0041 < \theta < 0.0003$. ρ_0=1 is assumed. NODE=S056Z1C;LINKAGE=JE
[41] ABE 97S find $\sigma(Z')\times$B$(e^+ e^-,\mu^+ \mu^-) <$ 40 fb for $m_{Z'} > 600$ GeV at $\sqrt{s}$= 1.8 TeV. NODE=S056Z1C;LINKAGE=AS
[42] VILAIN 94B assume m_t = 150 GeV. NODE=S056Z1C;LINKAGE=ZV
[43] ALITTI 93 search for resonances in the two-jet invariant mass. The limit assumes B$(Z' \rightarrow q\overline{q})$=0.7. See their Fig. 5 for limits in the $m_{Z'}-$B$(q\overline{q})$ plane. NODE=S056Z1C;LINKAGE=GG
[44] RIZZO 93 analyses CDF limit on possible two-jet resonances. NODE=S056Z1C;LINKAGE=RZ
[45] ABE 90F use data for R, $R_{\ell\ell}$, and $A_{\ell\ell}$. They fix $m_W = 80.49 \pm 0.43 \pm 0.24$ GeV and $m_Z = 91.13 \pm 0.03$ GeV. NODE=S056Z1C;LINKAGE=I

Limits for Z_{LR}

NODE=S056ZLR

Z_{LR} is the extra neutral boson in left-right symmetric models. $g_L = g_R$ is assumed unless noted. Values in parentheses assume stronger constraint on the Higgs sector, usually motivated by specific left-right symmetric models (see the Note on the W'). Values in brackets are from cosmological and astrophysical considerations and assume a light right-handed neutrino. Direct search bounds assume decays to Standard Model fermions only, unless noted. NODE=S056ZLR

NODE=S056ZLR;CHECK LIMITS

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>1162	95	[1] DEL-AGUILA	10	RVUE	Electroweak
> 630	95	[2] ABE	97S	CDF	$p\overline{p}$; $Z'_{LR} \rightarrow e^+ e^-, \mu^+ \mu^-$

• • • We do not use the following data for averages, fits, limits, etc. • • •

		[3] TUMASYAN	23BE	CMS	pp; $Z'_{LR} \to N\overline{N}$, $N \to \ell q \overline{q}'$	
		[4] BOBOVNIKOV	18	RVUE	pp, $Z'_{LR} \to W^+ W^-$	
$>$ 998	95	[5] ERLER	09	RVUE	Electroweak	
$>$ 600	95	SCHAEL	07A	ALEP	$e^+ e^-$	
$>$ 455	95	[6] ABDALLAH	06C	DLPH	$e^+ e^-$	
$>$ 518	95	[7] ABBIENDI	04G	OPAL	$e^+ e^-$	
$>$ 860	95	[8] CHEUNG	01B	RVUE	Electroweak	
$>$ 380	95	[9] ABREU	00S	DLPH	$e^+ e^-$	
$>$ 436	95	[10] BARATE	00I	ALEP	Repl. by SCHAEL 07A	
$>$ 550	95	[11] CHAY	00	RVUE	Electroweak	
		[12] ERLER	00	RVUE	Cs	
		[13] CASALBUONI	99	RVUE	Cs	
($>$ 1205)	90	[14] CZAKON	99	RVUE	Electroweak	OCCUR=2
$>$ 564	95	[15] ERLER	99	RVUE	Electroweak	
($>$ 1673)	95	[16] ERLER	99	RVUE	Electroweak	OCCUR=2
($>$ 1700)	68	[17] BARENBOIM	98	RVUE	Electroweak	
$>$ 244	95	[18] CONRAD	98	RVUE	$\nu_\mu N$ scattering	
$>$ 253	95	[19] VILAIN	94B	CHM2	$\nu_\mu e \to \nu_\mu e$ and $\overline{\nu}_\mu e \to \overline{\nu}_\mu e$	
none 200–600	95	[20] RIZZO	93	RVUE	$p\overline{p}$; $Z_{LR} \to q\overline{q}$	
[$>$ 2000]		WALKER	91	COSM	Nucleosynthesis; light ν_R	
none 200–500		[21] GRIFOLS	90	ASTR	SN 1987A; light ν_R	
none 350–2400		[22] BARBIERI	89B	ASTR	SN 1987A; light ν_R	

[1] DEL-AGUILA 10 give 95% CL limit on the Z-Z' mixing $-0.0012 < \theta < 0.0004$. NODE=S056ZLR;LINKAGE=AG

[2] ABE 97S find $\sigma(Z')\times$B$(e^+ e^-,\mu^+ \mu^-) <$ 40 fb for $m_{Z'} >$ 600 GeV at $\sqrt{s}=$ 1.8 TeV. NODE=S056ZLR;LINKAGE=AS

[3] TUMASYAN 23BE search for pair production of heavy Majorana neutrinos via the decay of a Z' boson in a final state with $\ell^+ \ell^-$ and at least two jets. For cases with $m_N = M_{Z'}/4$, their 95% CL limits are $M_{Z'}$ $>$ 3.59 TeV ($>$ 4.10 TeV) in the dielectron (dimuon) channel. See their Fig. 5 for limits on $\sigma \cdot B$. NODE=S056ZLR;LINKAGE=D

[4] BOBOVNIKOV 18 use the ATLAS limits on $\sigma(pp \to Z')\cdot$B$(Z' \to W^+ W^-)$ to constrain the Z-Z' mixing parameter ξ. See their Fig. 10 for limits in $M_{Z'} - \xi$ plane. NODE=S056ZLR;LINKAGE=C

[5] ERLER 09 give 95% CL limit on the Z-Z' mixing $-0.0013 < \theta < 0.0006$. NODE=S056ZLR;LINKAGE=ER

[6] ABDALLAH 06C give 95% CL limit $|\theta| < 0.0028$. See their Fig. 14 for limit contours in the mass-mixing plane. NODE=S056ZLR;LINKAGE=HL

[7] ABBIENDI 04G give 95% CL limit on Z-Z' mixing $-0.00098 < \theta < 0.00190$. See their Fig. 20 for the limit contour in the mass-mixing plane. $\sqrt{s}$ = 91 to 207 GeV. NODE=S056ZLR;LINKAGE=AB

[8] CHEUNG 01B limit is derived from bounds on contact interactions in a global electroweak analysis. NODE=S056ZLR;LINKAGE=QK

[9] ABREU 00S give 95% CL limit on Z-Z' mixing $|\theta| < 0.0018$. See their Fig. 6 for the limit contour in the mass-mixing plane. $\sqrt{s}$=90 to 189 GeV. NODE=S056ZLR;LINKAGE=TG

[10] BARATE 00I search for deviations in cross section and asymmetries in $e^+ e^- \to$ fermions at $\sqrt{s}$=90 to 183 GeV. Assume θ=0. Bounds in the mass-mixing plane are shown in their Figure 18. NODE=S056ZLR;LINKAGE=BI

[11] CHAY 00 also find $-0.0003 < \theta < 0.0019$. For g_R free, $m_{Z'} >$ 430 GeV. NODE=S056ZLR;LINKAGE=CY

[12] ERLER 00 discuss the possibility that a discrepancy between the observed and predicted values of Q_W(Cs) is due to the exchange of Z'. The data are better described in a certain class of the Z' models including Z_{LR} and Z_χ. NODE=S056ZLR;LINKAGE=LE

[13] CASALBUONI 99 discuss the discrepancy between the observed and predicted values of Q_W(Cs). It is shown that the data are better described in a class of models including the Z_{LR} model. NODE=S056ZLR;LINKAGE=CS

[14] CZAKON 99 perform a simultaneous fit to charged and neutral sectors. Assumes manifest left-right symmetric model. Finds $|\theta| < 0.0042$. NODE=S056ZLR;LINKAGE=ZP

[15] ERLER 99 give 90% CL limit on the Z-Z' mixing $-0.0009 < \theta < 0.0017$. NODE=S056ZLR;LINKAGE=JE

[16] ERLER 99 assumes 2 Higgs doublets, transforming as 10 of SO(10), embedded in E_6. NODE=S056ZLR;LINKAGE=EJ

[17] BARENBOIM 98 also gives 68% CL limits on the Z-Z' mixing $-0.0005 < \theta < 0.0033$. Assumes Higgs sector of minimal left-right model. NODE=S056ZLR;LINKAGE=H

[18] CONRAD 98 limit is from measurements at CCFR, assuming no Z-Z' mixing. NODE=S056ZLR;LINKAGE=ZC

[19] VILAIN 94B assume m_t = 150 GeV and θ=0. See Fig. 2 for limit contours in the mass-mixing plane. NODE=S056ZLR;LINKAGE=ZV

[20] RIZZO 93 analyses CDF limit on possible two-jet resonances. NODE=S056ZLR;LINKAGE=RZ

[21] GRIFOLS 90 limit holds for $m_{\nu_R} \lesssim$ 1 MeV. A specific Higgs sector is assumed. See also GRIFOLS 90D, RIZZO 91. NODE=S056ZLR;LINKAGE=Z2

[22] BARBIERI 89B limit holds for $m_{\nu_R} \leq$ 10 MeV. Bounds depend on assumed supernova core temperature. NODE=S056ZLR;LINKAGE=BB

Limits for Z_χ

NODE=S056ZCH

Z_χ is the extra neutral boson in SO(10) $\rightarrow$ SU(5) $\times$ U(1)$_\chi$. $g_\chi = e/\cos\theta_W$ is assumed unless otherwise stated. We list limits with the assumption $\rho = 1$ but with no further constraints on the Higgs sector. Values in parentheses assume stronger constraint on the Higgs sector motivated by superstring models. Values in brackets are from cosmological and astrophysical considerations and assume a light right-handed neutrino.

NODE=S056ZCH

NODE=S056ZCH

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>4800 (CL = 95%) OUR LIMIT					
none 250–4800	95	[1] AAD	19L	ATLS	pp; $Z'_\chi \rightarrow e^+e^-$, $\mu^+\mu^-$
>4100	95	[2] AABOUD	17AT	ATLS	pp; $Z'_\chi \rightarrow e^+e^-$, $\mu^+\mu^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[3] HERBERMANN	25	COSM	$\Delta N_{\rm eff}$; light ν_R
		[4] BOBOVNIKOV	18	RVUE	pp, $Z'_\chi \rightarrow W^+W^-$
>3050	95	[5] AABOUD	16U	ATLS	pp; $Z'_\chi \rightarrow e^+e^-$, $\mu^+\mu^-$
>2620	95	[6] AAD	14V	ATLS	pp, $Z'_\chi \rightarrow e^+e^-$, $\mu^+\mu^-$
>1970	95	[7] AAD	12CC	ATLS	pp, $Z'_\chi \rightarrow e^+e^-$, $\mu^+\mu^-$
> 930	95	[8] AALTONEN	11I	CDF	$p\overline{p}$; $Z'_\chi \rightarrow \mu^+\mu^-$
> 903	95	[9] ABAZOV	11A	D0	$p\overline{p}$, $Z'_\chi \rightarrow e^+e^-$
>1022	95	[10] DEL-AGUILA	10	RVUE	Electroweak
> 862	95	[9] AALTONEN	09T	CDF	$p\overline{p}$, $Z'_\chi \rightarrow e^+e^-$
> 892	95	[11] AALTONEN	09V	CDF	Repl. by AALTONEN 11I
>1141	95	[12] ERLER	09	RVUE	Electroweak
> 822	95	[9] AALTONEN	07H	CDF	Repl. by AALTONEN 09T
> 680	95	SCHAEL	07A	ALEP	e^+e^-
> 545	95	[13] ABDALLAH	06C	DLPH	e^+e^-
> 740		[9] ABULENCIA	06L	CDF	Repl. by AALTONEN 07H
> 690	95	[14] ABULENCIA	05A	CDF	$p\overline{p}$; $Z'_\chi \rightarrow e^+e^-$, $\mu^+\mu^-$
> 781	95	[15] ABBIENDI	04G	OPAL	e^+e^-
>2100		[16] BARGER	03B	COSM	Nucleosynthesis; light ν_R
> 680	95	[17] CHEUNG	01B	RVUE	Electroweak
> 440	95	[18] ABREU	00S	DLPH	e^+e^-
> 533	95	[19] BARATE	00I	ALEP	Repl. by SCHAEL 07A
> 554	95	[20] CHO	00	RVUE	Electroweak
		[21] ERLER	00	RVUE	Cs
		[22] ROSNER	00	RVUE	Cs
> 545	95	[23] ERLER	99	RVUE	Electroweak
(> 1368)	95	[24] ERLER	99	RVUE	Electroweak
> 215	95	[25] CONRAD	98	RVUE	$\nu_\mu N$ scattering
> 595	95	[26] ABE	97S	CDF	$p\overline{p}$; $Z'_\chi \rightarrow e^+e^-$, $\mu^+\mu^-$
> 190	95	[27] ARIMA	97	VNS	Bhabha scattering
> 262	95	[28] VILAIN	94B	CHM2	$\nu_\mu e \rightarrow \nu_\mu e$; $\overline{\nu}_\mu e \rightarrow \overline{\nu}_\mu e$
[>1470]		[29] FARAGGI	91	COSM	Nucleosynthesis; light ν_R
> 231	90	[30] ABE	90F	VNS	e^+e^-
[> 1140]		[31] GONZALEZ...	90D	COSM	Nucleosynthesis; light ν_R
[> 2100]		[32] GRIFOLS	90	ASTR	SN 1987A; light ν_R

NODE=S056ZCH
→ UNCHECKED ←
OCCUR=2
OCCUR=3

[1] AAD 19L search for resonances decaying to $\ell^+\ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056ZCH;LINKAGE=Z

[2] AABOUD 17AT search for resonances decaying to $\ell^+\ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056ZCH;LINKAGE=V

[3] HERBERMANN 25 limit is from Atacama Cosmology Telescope (ACT) DR6 limit on effective number of light neutrino species $\Delta N_{\rm eff} < 0.17$. See their Fig. 1 for limits in mass-coupling plane. NODE=S056ZCH;LINKAGE=BA

[4] BOBOVNIKOV 18 use the ATLAS limits on $\sigma(pp \rightarrow Z')\cdot B(Z' \rightarrow W^+W^-)$ to constrain the Z-Z' mixing parameter ξ. See their Fig. 9 for limits in $M_{Z'} - \xi$ plane. NODE=S056ZCH;LINKAGE=W

[5] AABOUD 16U search for resonances decaying to $\ell^+\ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056ZCH;LINKAGE=N

[6] AAD 14V search for resonances decaying to e^+e^-, $\mu^+\mu^-$ in pp collisions at $\sqrt{s} = 8$ TeV. NODE=S056ZCH;LINKAGE=J

[7] AAD 12CC search for resonances decaying to e^+e^-, $\mu^+\mu^-$ in pp collisions at $\sqrt{s} = 7$ TeV. NODE=S056ZCH;LINKAGE=H

[8] AALTONEN 11I search for resonances decaying to $\mu^+\mu^-$ in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. NODE=S056ZCH;LINKAGE=G

[9] ABAZOV 11A, AALTONEN 09T, AALTONEN 07H, and ABULENCIA 06L search for resonances decaying to e^+e^- in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. NODE=S056ZCH;LINKAGE=BU

[10] DEL-AGUILA 10 give 95% CL limit on the Z-Z' mixing $-0.0011 < \theta < 0.0007$. NODE=S056ZCH;LINKAGE=AG

[11] AALTONEN 09V search for resonances decaying to $\mu^+\mu^-$ in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. NODE=S056ZCH;LINKAGE=LO

[12] ERLER 09 give 95% CL limit on the Z-Z' mixing $-0.0016 < \theta < 0.0006$. NODE=S056ZCH;LINKAGE=ER

[13] ABDALLAH 06C give 95% CL limit $|\theta| < 0.0031$. See their Fig. 14 for limit contours in the mass-mixing plane. NODE=S056ZCH;LINKAGE=HL

[14] ABULENCIA 05A search for resonances decaying to electron or muon pairs in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. NODE=S056ZCH;LINKAGE=AU

[15] ABBIENDI 04G give 95% CL limit on Z-Z' mixing $-0.00099 < \theta < 0.00194$. See their Fig. 20 for the limit contour in the mass-mixing plane. $\sqrt{s}$ = 91 to 207 GeV. NODE=S056ZCH;LINKAGE=AB

[16] BARGER 03B limit is from the nucleosynthesis bound on the effective number of light neutrino δN_ν <1. The quark-hadron transition temperature T_c=150 MeV is assumed. The limit with T_c=400 MeV is >4300 GeV. NODE=S056ZCH;LINKAGE=GR

[17] CHEUNG 01B limit is derived from bounds on contact interactions in a global electroweak analysis. NODE=S056ZCH;LINKAGE=QK

[18] ABREU 00S give 95% CL limit on Z-Z' mixing $|\theta| < 0.0017$. See their Fig. 6 for the limit contour in the mass-mixing plane. $\sqrt{s}$=90 to 189 GeV. NODE=S056ZCH;LINKAGE=TG

[19] BARATE 00I search for deviations in cross section and asymmetries in $e^+e^- \rightarrow$ fermions at $\sqrt{s}$=90 to 183 GeV. Assume θ=0. Bounds in the mass-mixing plane are shown in their Figure 18. NODE=S056ZCH;LINKAGE=BI

[20] CHO 00 use various electroweak data to constrain Z' models assuming m_H=100 GeV. See Fig. 3 for limits in the mass-mixing plane. NODE=S056ZCH;LINKAGE=6Z

[21] ERLER 00 discuss the possibility that a discrepancy between the observed and predicted values of Q_W(Cs) is due to the exchange of Z'. The data are better described in a certain class of the Z' models including Z_{LR} and Z_χ. NODE=S056ZCH;LINKAGE=LE

[22] ROSNER 00 discusses the possibility that a discrepancy between the observed and predicted values of Q_W(Cs) is due to the exchange of Z'. The data are better described in a certain class of the Z' models including Z_χ. NODE=S056ZCH;LINKAGE=RC

[23] ERLER 99 give 90% CL limit on the Z-Z' mixing $-0.0020 < \theta < 0.0015$. NODE=S056ZCH;LINKAGE=JE

[24] ERLER 99 assumes 2 Higgs doublets, transforming as 10 of SO(10), embedded in E_6. NODE=S056ZCH;LINKAGE=EJ

[25] CONRAD 98 limit is from measurements at CCFR, assuming no Z-Z' mixing. NODE=S056ZCH;LINKAGE=ZC

[26] ABE 97S find $\sigma(Z')\times$B(e^+e^-,$\mu^+\mu^-$)< 40 fb for $m_{Z'}$ > 600 GeV at $\sqrt{s}$= 1.8 TeV. NODE=S056ZCH;LINKAGE=AS

[27] Z-Z' mixing is assumed to be zero. $\sqrt{s}$= 57.77 GeV. NODE=S056ZCH;LINKAGE=Q

[28] VILAIN 94B assume m_t = 150 GeV and θ=0. See Fig. 2 for limit contours in the mass-mixing plane. NODE=S056ZCH;LINKAGE=ZV

[29] FARAGGI 91 limit assumes the nucleosynthesis bound on the effective number of neutrinos ΔN_ν < 0.5 and is valid for m_{ν_R} < 1 MeV. NODE=S056ZCH;LINKAGE=M

[30] ABE 90F use data for R, $R_{\ell\ell}$, and $A_{\ell\ell}$. ABE 90F fix m_W = 80.49 ± 0.43 ± 0.24 GeV and m_Z = 91.13 ± 0.03 GeV. NODE=S056ZCH;LINKAGE=I

[31] Assumes the nucleosynthesis bound on the effective number of light neutrinos (δN_ν < 1) and that ν_R is light ($\lesssim$ 1 MeV). NODE=S056ZCH;LINKAGE=Z1

[32] GRIFOLS 90 limit holds for $m_{\nu_R} \lesssim$ 1 MeV. See also GRIFOLS 90D, RIZZO 91. NODE=S056ZCH;LINKAGE=Z2

Limits for Z_ψ

NODE=S056ZPS

Z_ψ is the extra neutral boson in $E_6 \rightarrow$ SO(10) × U(1)$_\psi$. $g_\psi = e/\cos\theta_W$ is assumed unless otherwise stated. We list limits with the assumption $\rho = 1$ but with no further constraints on the Higgs sector. Values in brackets are from cosmological and astrophysical considerations and assume a light right-handed neutrino. NODE=S056ZPS

NODE=S056ZPS

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>4560 (CL = 95%) OUR LIMIT					→ UNCHECKED ←
>4560	95	[1] SIRUNYAN	21N	CMS	pp; $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
none 250–4500	95	[2] AAD	19L	ATLS	pp; $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
none 200–3900	95	[3] SIRUNYAN	18BB	CMS	pp; $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
>3800	95	[4] AABOUD	17AT	ATLS	pp; $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
>2820	95	[5] KHACHATRY...	17T	CMS	pp; $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
>1100	95	[6] CHATRCHYAN	12O	CMS	pp, $Z'_\psi \rightarrow \tau^+\tau^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[7] BOBOVNIKOV	18	RVUE	pp, $Z'_\psi \rightarrow W^+W^-$
>2740	95	[8] AABOUD	16U	ATLS	pp; $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
>2570	95	[9] KHACHATRY...	15AE	CMS	pp; $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
>2510	95	[10] AAD	14V	ATLS	pp, $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
>2260	95	[11] CHATRCHYAN	13AF	CMS	pp, $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
>1790	95	[12] AAD	12CC	ATLS	pp, $Z'_\psi \rightarrow e^+e^-$, $\mu^+\mu^-$
>2000	95	[13] CHATRCHYAN	12M	CMS	Repl. by CHATRCHYAN 13AF
> 917	95	[14] AALTONEN	11I	CDF	$p\overline{p}$; $Z'_\psi \rightarrow \mu^+\mu^-$

$>$ 891	95	[15] ABAZOV	11A	D0	$p\overline{p}$, $Z'_{\psi} \rightarrow e^+ e^-$
$>$ 476	95	[16] DEL-AGUILA	10	RVUE	Electroweak
$>$ 851	95	[15] AALTONEN	09T	CDF	$p\overline{p}$, $Z'_{\psi} \rightarrow e^+ e^-$
$>$ 878	95	[17] AALTONEN	09V	CDF	Repl. by AALTONEN 11I
$>$ 147	95	[18] ERLER	09	RVUE	Electroweak
$>$ 822	95	[15] AALTONEN	07H	CDF	Repl. by AALTONEN 09T
$>$ 410	95	SCHAEL	07A	ALEP	$e^+ e^-$
$>$ 475	95	[19] ABDALLAH	06C	DLPH	$e^+ e^-$
$>$ 725		[15] ABULENCIA	06L	CDF	Repl. by AALTONEN 07H
$>$ 675	95	[20] ABULENCIA	05A	CDF	Repl. by AALTONEN 11I and AALTONEN 09T
$>$ 366	95	[21] ABBIENDI	04G	OPAL	$e^+ e^-$
$>$ 600		[22] BARGER	03B	COSM	Nucleosynthesis; light ν_R
$>$ 350	95	[23] ABREU	00S	DLPH	$e^+ e^-$
$>$ 294	95	[24] BARATE	00I	ALEP	Repl. by SCHAEL 07A
$>$ 137	95	[25] CHO	00	RVUE	Electroweak
$>$ 146	95	[26] ERLER	99	RVUE	Electroweak
$>$ 54	95	[27] CONRAD	98	RVUE	$\nu_{\mu} N$ scattering
$>$ 590	95	[28] ABE	97S	CDF	$p\overline{p}$; $Z'_{\psi} \rightarrow e^+ e^-, \mu^+ \mu^-$
$>$ 135	95	[29] VILAIN	94B	CHM2	$\nu_{\mu} e \rightarrow \nu_{\mu} e$; $\overline{\nu}_{\mu} e \rightarrow \overline{\nu}_{\mu} e$
$>$ 105	90	[30] ABE	90F	VNS	$e^+ e^-$
[$>$ 160]		[31] GONZALEZ...	90D	COSM	Nucleosynthesis; light ν_R
[$>$ 2000]		[32] GRIFOLS	90D	ASTR	SN 1987A; light ν_R

[1] SIRUNYAN 21N search for resonance decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056ZPS;LINKAGE=V

[2] AAD 19L search for resonances decaying to $\ell^+ \ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056ZPS;LINKAGE=U

[3] SIRUNYAN 18BB search for resonances decaying to $\ell^+ \ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056ZPS;LINKAGE=R

[4] AABOUD 17AT search for resonances decaying to $\ell^+ \ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056ZPS;LINKAGE=Q

[5] KHACHATRYAN 17T search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s} = 8$, 13 TeV. NODE=S056ZPS;LINKAGE=O

[6] CHATRCHYAN 12O search for resonances decaying to $\tau^+ \tau^-$ in pp collisions at $\sqrt{s} =$ 7 TeV. NODE=S056ZPS;LINKAGE=G

[7] BOBOVNIKOV 18 use the ATLAS limits on $\sigma(pp \rightarrow Z')\cdot$B$(Z' \rightarrow W^+ W^-)$ to constrain the Z-Z' mixing parameter ξ. See their Fig. 10 for limits in $M_{Z'} - \xi$ plane. NODE=S056ZPS;LINKAGE=T

[8] AABOUD 16U search for resonances decaying to $\ell^+ \ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056ZPS;LINKAGE=N

[9] KHACHATRYAN 15AE search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s} = 8$ TeV. NODE=S056ZPS;LINKAGE=M

[10] AAD 14V search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s} = 8$ TeV. NODE=S056ZPS;LINKAGE=L

[11] CHATRCHYAN 13AF search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s} = 7$ TeV and 8 TeV. NODE=S056ZPS;LINKAGE=H

[12] AAD 12CC search for resonances decaying to $e^+ e^-$, $\mu^+ \mu^-$ in pp collisions at $\sqrt{s} = 7$ TeV. NODE=S056ZPS;LINKAGE=F

[13] CHATRCHYAN 12M search for resonances decaying to $e^+ e^-$ or $\mu^+ \mu^-$ in pp collisions at $\sqrt{s} = 7$ TeV. NODE=S056ZPS;LINKAGE=E

[14] AALTONEN 11I search for resonances decaying to $\mu^+ \mu^-$ in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. NODE=S056ZPS;LINKAGE=C

[15] ABAZOV 11A, AALTONEN 09T, AALTONEN 07H, and ABULENCIA 06L search for resonances decaying to $e^+ e^-$ in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. NODE=S056ZPS;LINKAGE=BU

[16] DEL-AGUILA 10 give 95% CL limit on the Z-Z' mixing $-0.0019 < \theta < 0.0007$. NODE=S056ZPS;LINKAGE=AG

[17] AALTONEN 09V search for resonances decaying to $\mu^+ \mu^-$ in $p\overline{p}$ collisions at $\sqrt{s} =$ 1.96 TeV. NODE=S056ZPS;LINKAGE=LO

[18] ERLER 09 give 95% CL limit on the Z-Z' mixing $-0.0018 < \theta < 0.0009$. NODE=S056ZPS;LINKAGE=ER

[19] ABDALLAH 06C give 95% CL limit $\left|\theta\right| < 0.0027$. See their Fig. 14 for limit contours in the mass-mixing plane. NODE=S056ZPS;LINKAGE=HL

[20] ABULENCIA 05A search for resonances decaying to electron or muon pairs in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. NODE=S056ZPS;LINKAGE=AU

[21] ABBIENDI 04G give 95% CL limit on Z-Z' mixing $-0.00129 < \theta < 0.00258$. See their Fig. 20 for the limit contour in the mass-mixing plane. $\sqrt{s} = 91$ to 207 GeV. NODE=S056ZPS;LINKAGE=AB

[22] BARGER 03B limit is from the nucleosynthesis bound on the effective number of light neutrino δN_{ν} <1. The quark-hadron transition temperature T_c=150 MeV is assumed. The limit with T_c=400 MeV is >1100 GeV. NODE=S056ZPS;LINKAGE=GR

[23] ABREU 00S give 95% CL limit on Z-Z' mixing $\left|\theta\right| < 0.0018$. See their Fig. 6 for the limit contour in the mass-mixing plane. $\sqrt{s}$=90 to 189 GeV. NODE=S056ZPS;LINKAGE=TG

[24] BARATE 00I search for deviations in cross section and asymmetries in $e^+ e^- \rightarrow$ fermions at $\sqrt{s}$=90 to 183 GeV. Assume θ=0. Bounds in the mass-mixing plane are shown in their Figure 18. NODE=S056ZPS;LINKAGE=BI

[25] CHO 00 use various electroweak data to constrain Z' models assuming m_H=100 GeV. See Fig. 3 for limits in the mass-mixing plane. NODE=S056ZPS;LINKAGE=6Z

[26] ERLER 99 give 90% CL limit on the Z-Z' mixing $-0.0013 < \theta < 0.0024$. NODE=S056ZPS;LINKAGE=JE
[27] CONRAD 98 limit is from measurements at CCFR, assuming no Z-Z' mixing. NODE=S056ZPS;LINKAGE=ZC
[28] ABE 97S find $\sigma(Z')\times$B(e^+e^-,$\mu^+\mu^-$)$<$ 40 fb for $m_{Z'} >$ 600 GeV at $\sqrt{s}$= 1.8 TeV. NODE=S056ZPS;LINKAGE=AS
[29] VILAIN 94B assume m_t = 150 GeV and θ=0. See Fig. 2 for limit contours in the mass-mixing plane. NODE=S056ZPS;LINKAGE=ZV
[30] ABE 90F use data for R, $R_{\ell\ell}$, and $A_{\ell\ell}$. ABE 90F fix m_W = 80.49 $\pm$ 0.43 $\pm$ 0.24 GeV and m_Z = 91.13 $\pm$ 0.03 GeV. NODE=S056ZPS;LINKAGE=I
[31] Assumes the nucleosynthesis bound on the effective number of light neutrinos ($\delta N_\nu < 1$) and that ν_R is light ($\lesssim$ 1 MeV). NODE=S056ZPS;LINKAGE=Z1
[32] GRIFOLS 90D limit holds for $m_{\nu_R} \lesssim$ 1 MeV. See also RIZZO 91. NODE=S056ZPS;LINKAGE=Z2

Limits for Z_η

NODE=S056ZET

Z_η is the extra neutral boson in E$_6$ models, corresponding to $Q_\eta = \sqrt{3/8}\ Q_\chi - \sqrt{5/8}\ Q_\psi$. $g_\eta = e/\cos\theta_W$ is assumed unless otherwise stated. We list limits with the assumption $\rho = 1$ but with no further constraints on the Higgs sector. Values in parentheses assume stronger constraint on the Higgs sector motivated by superstring models. Values in brackets are from cosmological and astrophysical considerations and assume a light right-handed neutrino. NODE=S056ZET

NODE=S056ZET

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>3900	95	[1] AABOUD	17AT	ATLS	pp; $Z'_\eta \rightarrow e^+e^-$, $\mu^+\mu^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[2] BOBOVNIKOV	18	RVUE	pp, $Z'_\eta \rightarrow W^+W^-$
>2810	95	[3] AABOUD	16U	ATLS	pp; $Z'_\eta \rightarrow e^+e^-$, $\mu^+\mu^-$
>1870	95	[4] AAD	12CC	ATLS	pp, $Z'_\eta \rightarrow e^+e^-$, $\mu^+\mu^-$
> 938	95	[5] AALTONEN	11I	CDF	$p\overline{p}$; $Z'_\eta \rightarrow \mu^+\mu^-$
> 923	95	[6] ABAZOV	11A	D0	$p\overline{p}$, $Z'_\eta \rightarrow e^+e^-$
> 488	95	[7] DEL-AGUILA	10	RVUE	Electroweak
> 877	95	[6] AALTONEN	09T	CDF	$p\overline{p}$, $Z'_\eta \rightarrow e^+e^-$
> 904	95	[8] AALTONEN	09V	CDF	Repl. by AALTONEN 11I
> 427	95	[9] ERLER	09	RVUE	Electroweak
> 891	95	[6] AALTONEN	07H	CDF	Repl. by AALTONEN 09T
> 350	95	SCHAEL	07A	ALEP	e^+e^-
> 360	95	[10] ABDALLAH	06C	DLPH	e^+e^-
> 745		[6] ABULENCIA	06L	CDF	Repl. by AALTONEN 07H
> 720	95	[11] ABULENCIA	05A	CDF	Repl. by AALTONEN 11I and AALTONEN 09T
> 515	95	[12] ABBIENDI	04G	OPAL	e^+e^-
>1600		[13] BARGER	03B	COSM	Nucleosynthesis; light ν_R
> 310	95	[14] ABREU	00S	DLPH	e^+e^-
> 329	95	[15] BARATE	00I	ALEP	Repl. by SCHAEL 07A
> 619	95	[16] CHO	00	RVUE	Electroweak
> 365	95	[17] ERLER	99	RVUE	Electroweak
> 87	95	[18] CONRAD	98	RVUE	$\nu_\mu N$ scattering
> 620	95	[19] ABE	97S	CDF	$p\overline{p}$; $Z'_\eta \rightarrow e^+e^-$, $\mu^+\mu^-$
> 100	95	[20] VILAIN	94B	CHM2	$\nu_\mu e \rightarrow \nu_\mu e$; $\overline{\nu}_\mu e \rightarrow \overline{\nu}_\mu e$
> 125	90	[21] ABE	90F	VNS	e^+e^-
[> 820]		[22] GONZALEZ...	90D	COSM	Nucleosynthesis; light ν_R
[> 3300]		[23] GRIFOLS	90	ASTR	SN 1987A; light ν_R
[> 1040]		[22] LOPEZ	90	COSM	Nucleosynthesis; light ν_R

OCCUR=2

[1] AABOUD 17AT search for resonances decaying to $\ell^+\ell^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056ZET;LINKAGE=G
[2] BOBOVNIKOV 18 use the ATLAS limits on $\sigma(pp \rightarrow Z')\cdot$B$(Z' \rightarrow W^+W^-)$ to constrain the Z-Z' mixing parameter ξ. See their Fig. 9 for limits in $M_{Z'} - \xi$ plane. NODE=S056ZET;LINKAGE=H
[3] AABOUD 16U search for resonances decaying to $\ell^+\ell^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056ZET;LINKAGE=F
[4] AAD 12CC search for resonances decaying to e^+e^-, $\mu^+\mu^-$ in pp collisions at $\sqrt{s}$ = 7 TeV. NODE=S056ZET;LINKAGE=E
[5] AALTONEN 11I search for resonances decaying to $\mu^+\mu^-$ in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. NODE=S056ZET;LINKAGE=D
[6] ABAZOV 11A, AALTONEN 09T, AALTONEN 07H, and ABULENCIA 06L search for resonances decaying to e^+e^- in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. NODE=S056ZET;LINKAGE=BU
[7] DEL-AGUILA 10 give 95% CL limit on the Z-Z' mixing $-0.0023 < \theta < 0.0027$. NODE=S056ZET;LINKAGE=AG
[8] AALTONEN 09V search for resonances decaying to $\mu^+\mu^-$ in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. NODE=S056ZET;LINKAGE=LO
[9] ERLER 09 give 95% CL limit on the Z-Z' mixing $-0.0047 < \theta < 0.0021$. NODE=S056ZET;LINKAGE=ER
[10] ABDALLAH 06C give 95% CL limit $|\theta| < 0.0092$. See their Fig. 14 for limit contours in the mass-mixing plane. NODE=S056ZET;LINKAGE=HL

[11] ABULENCIA 05A search for resonances decaying to electron or muon pairs in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. NODE=S056ZET;LINKAGE=AU

[12] ABBIENDI 04G give 95% CL limit on Z-Z' mixing $-0.00447 < \theta < 0.00331$. See their Fig. 20 for the limit contour in the mass-mixing plane. $\sqrt{s}$ = 91 to 207 GeV. NODE=S056ZET;LINKAGE=AB

[13] BARGER 03B limit is from the nucleosynthesis bound on the effective number of light neutrino $\delta N_\nu < 1$. The quark-hadron transition temperature T_c=150 MeV is assumed. The limit with T_c=400 MeV is >3300 GeV. NODE=S056ZET;LINKAGE=GR

[14] ABREU 00S give 95% CL limit on Z-Z' mixing $|\theta| < 0.0024$. See their Fig. 6 for the limit contour in the mass-mixing plane. $\sqrt{s}$=90 to 189 GeV. NODE=S056ZET;LINKAGE=TG

[15] BARATE 00I search for deviations in cross section and asymmetries in $e^+e^- \rightarrow$ fermions at $\sqrt{s}$=90 to 183 GeV. Assume θ=0. Bounds in the mass-mixing plane are shown in their Figure 18. NODE=S056ZET;LINKAGE=BI

[16] CHO 00 use various electroweak data to constrain Z' models assuming m_H=100 GeV. See Fig. 3 for limits in the mass-mixing plane. NODE=S056ZET;LINKAGE=6Z

[17] ERLER 99 give 90% CL limit on the Z-Z' mixing $-0.0062 < \theta < 0.0011$. NODE=S056ZET;LINKAGE=JE

[18] CONRAD 98 limit is from measurements at CCFR, assuming no Z-Z' mixing. NODE=S056ZET;LINKAGE=ZC

[19] ABE 97S find $\sigma(Z')\times$B(e^+e^-,$\mu^+\mu^-$)< 40 fb for $m_{Z'}$ > 600 GeV at $\sqrt{s}$= 1.8 TeV. NODE=S056ZET;LINKAGE=AS

[20] VILAIN 94B assume m_t = 150 GeV and θ=0. See Fig. 2 for limit contours in the mass-mixing plane. NODE=S056ZET;LINKAGE=ZV

[21] ABE 90F use data for R, $R_{\ell\ell}$, and $A_{\ell\ell}$. ABE 90F fix m_W = 80.49 ± 0.43 ± 0.24 GeV and m_Z = 91.13 ± 0.03 GeV. NODE=S056ZET;LINKAGE=I

[22] These authors claim that the nucleosynthesis bound on the effective number of light neutrinos ($\delta N_\nu < 1$) constrains Z' masses if ν_R is light ($\lesssim$ 1 MeV). NODE=S056ZET;LINKAGE=Z1

[23] GRIFOLS 90 limit holds for $m_{\nu_R} \lesssim$ 1 MeV. See also GRIFOLS 90D, RIZZO 91. NODE=S056ZET;LINKAGE=Z2

Limits for other Z'

NODE=S056ZOT
NODE=S056ZOT

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*	
>2450	95	[1] HAYRAPETY...	25AB	CMS	VBF; $Z' \rightarrow \tau^+\tau^-$,$WW$	
>3000	95	[2] HAYRAPETY...	25Q	CMS	$Z' \rightarrow ZH$	
none 300–3200	95	[3] AAD	23O	ATLS	$Z' \rightarrow ZH$	
none 1800–2400	95	[4] TUMASYAN	23AF	CMS	$Z' \rightarrow b\overline{b}$	
none 1300–3100, 3300–3500	95	[5] TUMASYAN	23AP	CMS	$Z' \rightarrow WW$	
>3900	95	[6] TUMASYAN	23AP	CMS	$Z' \rightarrow ZH$	OCCUR=2
>4000	95	[7] TUMASYAN	22D	CMS	$Z' \rightarrow WW$	
none 800–3700	95	[8] SIRUNYAN	21X	CMS	$Z' \rightarrow HZ$	
>2650	95	[9] AAD	20AJ	ATLS	$Z' \rightarrow HZ$	
>3900	95	[10] AAD	20AM	ATLS	$Z' \rightarrow t\overline{t}$	
>3900	95	[11] AAD	20AT	ATLS	$Z' \rightarrow WW$	
none 1200–3500	95	[12] SIRUNYAN	20Q	CMS	$Z' \rightarrow WW$	
none 580–3100	95	[13] AABOUD	19AS	ATLS	$Z' \rightarrow t\overline{t}$	
none 1300–3100	95	[14] AAD	19D	ATLS	$Z' \rightarrow WW$	
>3800	95	[15] SIRUNYAN	19AA	CMS	$Z' \rightarrow t\overline{t}$	
>3700	95	[16] SIRUNYAN	19CP	CMS	$Z' \rightarrow WW$, HZ,$\ell^+\ell^-$	
>1800	95	[17] SIRUNYAN	19I	CMS	$Z' \rightarrow HZ$	
none 600–2100	95	[18] AABOUD	18AB	ATLS	$Z' \rightarrow b\overline{b}$	
none 500–2830	95	[19] AABOUD	18AI	ATLS	$Z' \rightarrow HZ$	
none 300–3000	95	[20] AABOUD	18AK	ATLS	$Z' \rightarrow WW$	
>1300	95	[21] AABOUD	18B	ATLS	$Z' \rightarrow WW$	
none 400–3000	95	[22] AABOUD	18BI	ATLS	$Z' \rightarrow t\overline{t}$	
none 1200–2800	95	[23] AABOUD	18F	ATLS	$Z' \rightarrow WW$	
>2300	95	[24] SIRUNYAN	18ED	CMS	$Z' \rightarrow HZ$	
none 1200–2700	95	[25] SIRUNYAN	18P	CMS	$Z' \rightarrow WW$	
>2900	95	[26] AABOUD	17AK	ATLS	$Z' \rightarrow q\overline{q}$	
none 1100–2600	95	[27] AABOUD	17AO	ATLS	$Z' \rightarrow HZ$	
>2300	95	[28] SIRUNYAN	17AK	CMS	$Z' \rightarrow WW$, HZ	
>2500	95	[29] SIRUNYAN	17Q	CMS	$Z' \rightarrow t\overline{t}$	
>1190	95	[30] SIRUNYAN	17R	CMS	$Z' \rightarrow HZ$	
none 1210–2260	95	[30] SIRUNYAN	17R	CMS	$Z' \rightarrow HZ$	OCCUR=2
• • • We do not use the following data for averages, fits, limits, etc. • • •						
		[31] AAD	25AZ	ATLS	$Z' \rightarrow q\overline{q}$	
		[32] AAD	25BA	ATLS	$Z' \rightarrow$ dark Higgs+ Z'	
		[33] AAD	25BB	ATLS	$b\overline{b} \rightarrow Z' \rightarrow \tau^+\tau^-$	
		[34] AAD	25C	ATLS	$Z' \rightarrow S\chi\chi \rightarrow b\overline{b}\chi\chi$	
		[35] AAD	25F	ATLS	pp; $\ell^+\ell^-\ell^+\ell^-$	
		[36] AAD	25N	ATLS	$Z' \rightarrow q_d\overline{q}_d$	
		[37] AAD	25Q	ATLS	$Z' \rightarrow q\overline{q}$	
>1050	95	[38] CHEKHOVSKY	25J	CMS	$Z' \rightarrow H\chi\chi$	

>4030	95	[39] HAYRAPETY...25V	CMS	$Z' \rightarrow \tau' \tau'$
		[40] AAD 24AA	ATLS	$Z' \rightarrow q_d \overline{q}_d$
>4400	95	[41] AAD 24AE	ATLS	$M_{Z'} = M_{W'}$
		[42] AAD 24AY	ATLS	$Z' \rightarrow q\overline{q}$
		[43] AAD 24BJ	ATLS	top-philic Z'
		[44] AAD 24BR	ATLS	$L_\mu - L_\tau$
		[45] AAD 24CD	ATLS	DM simplified Z'
		[46] AAD 24CI	ATLS	DM simplified Z'
		[47] AAD 24CM	ATLS	Dark ρ^0_D
		[48] ABLIKIM 24G	BES3	$J/\psi \rightarrow \mu^+\mu^- Z'$
		[49] ADACHI 24F	BEL2	$e^+e^- \rightarrow \mu^+\mu^- Z'$, $Z' \rightarrow \mu^+\mu^-$
		[50] AKITA 24	ASTR	SN1987A
		[51] ANDREEV 24	NA64	μ-nucleus scattering
		[52] ANDREEV 24B	NA64	e-nucleus scattering
		[53] ANDREEV 24E	NA64	μ-nucleus scattering
		[54] BISWAS 24	BELL	$e^+e^- \rightarrow \tau^+\tau^- \phi(\rightarrow e^+e^-, \mu^+\mu^-)$
		[55] HAYRAPETY...24AZ	CMS	$Z' \rightarrow s_D \overline{s}_D \rightarrow 4\mu$
		[56] HAYRAPETY...24G	CMS	$Z' \rightarrow ggg$
		[57] HAYRAPETY...24W	CMS	$Z' \rightarrow \chi\chi S$, $S \rightarrow W^+W^-$
		[58] AAD 23BF	ATLS	DM simplified Z'
		[59] AAD 23W	ATLS	dark Higgs Z'
		[60] AAD 23X	ATLS	$L_\mu - L_\tau$
		[61] ADACHI 23B	BEL2	$L_\mu - L_\tau$
		[62] ADACHI 23F	BEL2	$L_\mu - L_\tau$
		[63] HAYRAPETY...23D	CMS	$Z' \rightarrow \mu^+\mu^-$
		[64] HAYRAPETY...23G	CMS	$Z' \rightarrow \mu^+\mu^-$
		[65] LI 23I	ASTR	Steller cooling
		[66] MANZARI 23	ASTR	DM mediator Z'
		[67] AAD 22	ATLS	$pp \rightarrow b\overline{b}Z' \rightarrow b\overline{b}b\overline{b}$
		[68] AAD 22D	ATLS	DM mediator Z'
		[69] ANDREEV 22	CALO	electron beam dump
		[70] BONET 22	HPGE	ν-nucleus scattring
		[71] COLOMA 22	RVUE	ν-nucleus scattering
		[72] COLOMA 22A	RVUE	ν-e scattering
		[73] CZANK 22	BELL	$e^+e^- \rightarrow \mu^+\mu^- Z'(\rightarrow \mu^+\mu^-)$
		[74] TUMASYAN 22AA	CMS	$Z' \rightarrow$ SVJs
		[75] AAD 21AQ	ATLS	pp, $\ell^+\ell^-\ell^+\ell^-$
		[76] AAD 21AZ	ATLS	DM mediator Z'
		[77] AAD 21BB	ATLS	$Z' \rightarrow AH$
		[78] AAD 21D	ATLS	dark Higgs Z'
		[79] AAD 21K	ATLS	$Z' \rightarrow \chi\chi$
		[80] BURAS 21	RVUE	leptophilic Z'
		[81] CADEDDU 21	RVUE	ν-nucleus scattering
		[82] COLARESI 21	HPGE	ν-nucleus scattering
		[83] KRIBS 21	RVUE	ep scattering
		[84] TUMASYAN 21D	CMS	$Z' \rightarrow \chi\chi$
		[85] AAD 20AF	ATLS	$Z' \rightarrow H\gamma$
		[86] AAD 20T	ATLS	DM simplified Z'
		[87] AAD 20W	ATLS	DM simplified Z'
		[88] AAIJ 20AL	LHCB	$Z' \rightarrow \mu^+\mu^-$
		[89] ADACHI 20	BEL2	$e^+e^- \rightarrow \mu^+\mu^- Z'$, $e^\pm\mu^\mp Z'$
		[90] SIRUNYAN 20AI	CMS	$Z' \rightarrow q\overline{q}$
		[91] SIRUNYAN 20AQ	CMS	$Z' \rightarrow \mu^+\mu^-$
		[92] SIRUNYAN 20M	CMS	$Z' \rightarrow q\overline{q}$
		[93] AABOUD 19AJ	ATLS	$Z' \rightarrow q\overline{q}$
		[94] AABOUD 19D	ATLS	$Z' \rightarrow q\overline{q}$
		[95] AABOUD 19V	ATLS	DM simplified Z'
		[96] AAD 19L	ATLS	$Z' \rightarrow e^+e^-$, $\mu^+\mu^-$
		[97] LONG 19	RVUE	Electroweak
		[98] PANDEY 19	RVUE	neutrino NSI

		[99] SIRUNYAN	19AL	CMS	$Z' \rightarrow tT$, $T \rightarrow Ht$, Zt, Wb	
		[100] SIRUNYAN	19AN	CMS	DM simplified Z'	
		[101] SIRUNYAN	19CB	CMS	$Z' \rightarrow q\overline{q}$	
		[102] SIRUNYAN	19CD	CMS	$Z' \rightarrow q\overline{q}$	
		[103] SIRUNYAN	19D	CMS	$Z' \rightarrow H\gamma$	
		[104] AABOUD	18AA	ATLS	$Z' \rightarrow H\gamma$	
>4500	95	[105] AABOUD	18CJ	ATLS	$Z' \rightarrow WW, HZ, \ell^+\ell^-$	
		[106] AABOUD	18N	ATLS	$Z' \rightarrow q\overline{q}$	
		[107] AAIJ	18AQ	LHCB	$Z' \rightarrow \mu^+\mu^-$	
		[108] SIRUNYAN	18DR	CMS	$Z' \rightarrow \mu^+\mu^-$	
		[109] SIRUNYAN	18G	CMS	$Z' \rightarrow q\overline{q}$	
		[110] SIRUNYAN	18I	CMS	$Z' \rightarrow b\overline{b}$	
>1580	95	[111] AABOUD	17B	ATLS	$Z' \rightarrow HZ$	
		[112] KHACHATRY...	17AX	CMS	$Z' \rightarrow \ell\ell\ell\ell$	
		[113] KHACHATRY...	17U	CMS	$Z' \rightarrow HZ$	
>1700	95	[114] SIRUNYAN	17A	CMS	$Z' \rightarrow WW$	
		[115] SIRUNYAN	17AP	CMS	$Z' \rightarrow HA$	
		[116] SIRUNYAN	17T	CMS	$Z' \rightarrow q\overline{q}$	
		[117] SIRUNYAN	17V	CMS	$Z' \rightarrow Tt$	
none 1100–1500	95	[118] AABOUD	16	ATLS	$Z' \rightarrow b\overline{b}$	OCCUR=2
		[119] AAD	16L	ATLS	$Z' \rightarrow a\gamma$, $a \rightarrow \gamma\gamma$	
none 1500–2600	95	[120] AAD	16S	ATLS	$Z' \rightarrow q\overline{q}$	
none 1000–1100, none 1300–1500	95	[121] KHACHATRY...	16AP	CMS	$Z' \rightarrow HZ$	
>2400	95	[122] KHACHATRY...	16E	CMS	$Z' \rightarrow t\overline{t}$	
		[123] AAD	15AO	ATLS	$Z' \rightarrow t\overline{t}$	
		[124] AAD	15AT	ATLS	monotop	
		[125] AAD	15CD	ATLS	$H \rightarrow ZZ'$, $Z'Z'$; $Z' \rightarrow \ell^+\ell^-$	
		[126] KHACHATRY...	15F	CMS	monotop	
		[127] KHACHATRY...	15O	CMS	$Z' \rightarrow HZ$	OCCUR=2
		[128] AAD	14AT	ATLS	$Z' \rightarrow Z\gamma$	
		[129] KHACHATRY...	14A	CMS	$Z' \rightarrow VV$	
		[130] MARTINEZ	14	RVUE	Electroweak	
none 500–1740	95	[131] AAD	13AQ	ATLS	$Z' \rightarrow t\overline{t}$	
>1320 or 1000–1280	95	[132] AAD	13G	ATLS	$Z' \rightarrow t\overline{t}$	
> 915	95	[132] AALTONEN	13A	CDF	$Z' \rightarrow t\overline{t}$	
>1300	95	[133] CHATRCHYAN	13AP	CMS	$Z' \rightarrow t\overline{t}$	
>2100	95	[132] CHATRCHYAN	13BM	CMS	$Z' \rightarrow t\overline{t}$	
		[134] AAD	12BV	ATLS	$Z' \rightarrow t\overline{t}$	
		[135] AAD	12K	ATLS	$Z' \rightarrow t\overline{t}$	
		[136] AALTONEN	12AR	CDF	Chromophilic	
		[137] AALTONEN	12N	CDF	$Z' \rightarrow \overline{t}u$	
> 835	95	[138] ABAZOV	12R	D0	$Z' \rightarrow t\overline{t}$	
		[139] CHATRCHYAN	12AI	CMS	$Z' \rightarrow t\overline{u}$	
		[140] CHATRCHYAN	12AQ	CMS	$Z' \rightarrow t\overline{t}$	
>1490	95	[132] CHATRCHYAN	12BL	CMS	$Z' \rightarrow t\overline{t}$	
		[141] AALTONEN	11AD	CDF	$Z' \rightarrow t\overline{t}$	
		[142] AALTONEN	11AE	CDF	$Z' \rightarrow t\overline{t}$	
		[143] CHATRCHYAN	11O	CMS	$pp \rightarrow tt$	
		[144] AALTONEN	08D	CDF	$Z' \rightarrow t\overline{t}$	
		[144] AALTONEN	08Y	CDF	$Z' \rightarrow t\overline{t}$	
		[144] ABAZOV	08AA	D0	$Z' \rightarrow t\overline{t}$	
		[145] ABAZOV	04A	D0	Repl. by ABAZOV 08AA	
		[146] BARGER	03B	COSM	Nucleosynthesis; light ν_R	
		[147] CHO	00	RVUE	E_6-motivated	
		[148] CHO	98	RVUE	E_6-motivated	
		[149] ABE	97G	CDF	$Z' \rightarrow \overline{q}q$	

[1] HAYRAPETYAN 25AB search for Z' with nonuniversal fermion couplings produced via vector boson fusion (VBF) processes in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above assumes Z' couplings with first- and second-generation fermion are zero, and $g_{Z'WW} = (5.3 \times M_W/M_{Z'})^2$, B$(\tau^+\tau^-) = 0.5$. See their Fig. 2 for exclusion limits on $M_{Z'}$ under various model assumptions. NODE=S056ZOT;LINKAGE=VE

[2] HAYRAPETYAN 25Q search for resonances decaying to ZH in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above is for heavy-vector-triplet Z' with $g_V = 3$. See their Fig. 6 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=WE

[3] AAD 23O search for resonances decaying to HZ in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $M_{Z'}>2800$ GeV for $g_V=1$. NODE=S056ZOT;LINKAGE=ND

[4] TUMASYAN 23AF search for resonance decaying to $b\overline{b}$ in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is for heavy-vector-triplet Z' with $g_V=1$. See their Fig. 4 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=RD

[5] TUMASYAN 23AP search for resonances decaying to WW in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $M_{Z'}>4.8$ TeV assuming $M_{W'}=M_{Z'}$ and combining $W'\rightarrow WZ$, $W'\rightarrow WH$, $Z'\rightarrow WW$, $Z'\rightarrow ZH$ channels. NODE=S056ZOT;LINKAGE=SD

[6] TUMASYAN 23AP search for resonances decaying to ZH in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $M_{Z'}>4.8$ TeV assuming $M_{W'}=M_{Z'}$ and combining $W'\rightarrow WZ$, $W'\rightarrow WH$, $Z'\rightarrow WW$, $Z'\rightarrow ZH$ channels. NODE=S056ZOT;LINKAGE=TD

[7] TUMASYAN 22D search for resonances produced through Drell-Yan and vector-boson-fusion processes in pp collisions at $\sqrt{s}=13$ TeV. See their Fig. 8 for limits on $\sigma\cdot B$. The quoted limit is for heavy-vector-triplet W' with $g_V=3$ produced mainly via Drell-Yan. NODE=S056ZOT;LINKAGE=LD

[8] SIRUNYAN 21X search for resonances decaying to HZ in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $M_{Z'}>3500$ GeV for $g_V=1$. NODE=S056ZOT;LINKAGE=XC

[9] AAD 20AJ search for resonances decaying to HZ in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $\mathrm{M}_{Z'}>2200$ GeV for $g_V=1$. See their Fig. 6 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=MC

[10] AAD 20AM search for a resonance decaying to $t\overline{t}$ in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for a leptophobic top-color Z' with $\Gamma_{Z'}/\mathrm{M}_{Z'}=0.01$. The limit becomes $\mathrm{M}_{Z'}>4700$ GeV for $\Gamma_{Z'}/\mathrm{M}_{Z'}=0.03$. NODE=S056ZOT;LINKAGE=NC

[11] AAD 20AT search for resonances decaying to WW in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $M_{Z'}>3500$ GeV for $g_V=1$. See their Fig. 14 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=OC

[12] SIRUNYAN 20Q search for resonances decaying to WW in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V=3$. NODE=S056ZOT;LINKAGE=KC

[13] AABOUD 19AS search for a resonance decaying to $t\overline{t}$ in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for a top-color Z' with $\Gamma_{Z'}/M_{Z'}=0.01$. Limits are also set on Z' masses in simplified Dark Matter models. NODE=S056ZOT;LINKAGE=PB

[14] AAD 19D search for resonances decaying to WW in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $M_{Z'}>2900$ GeV for $g_V=1$. If we assume $M_{Z'}=M_{W'}$, the limit increases $M_{Z'}>3800$ GeV and $M_{Z'}>3500$ GeV for $g_V=3$ and $g_V=1$, respectively. See their Fig. 9 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=XB

[15] SIRUNYAN 19AA search for a resonance decaying to $t\overline{t}$ in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for a leptophobic top-color Z' with $\Gamma_{Z'}/M_{Z'}=0.01$. NODE=S056ZOT;LINKAGE=TB

[16] SIRUNYAN 19CP present a statistical combinations of searches for Z' decaying to pairs of bosons or leptons in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V=3$. If we assume $M_{Z'}=M_{W'}$, the limit becomes $M_{Z'}>4500$ GeV for $g_V=3$ and $M_{Z'}>5000$ GeV for $g_V=1$. See their Figs. 2 and 3 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=CC

[17] SIRUNYAN 19I search for resonances decaying to ZW in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $M_{Z'}>2800$ GeV if we assume $M_{Z'}=M_{W'}$. NODE=S056ZOT;LINKAGE=WB

[18] AABOUD 18AB search for resonances decaying to $b\overline{b}$ in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is for a leptophobic Z' with SM-like couplings to quarks. See their Fig. 6 for limits on $\sigma\cdot B$. Additional limits on a Z' axial-vector mediator in a simplified dark-matter model are shown in Fig. 7. NODE=S056ZOT;LINKAGE=BB

[19] AABOUD 18AI search for resonances decaying to HZ in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $M_{Z'}>2650$ GeV for $g_V=1$. If we assume $M_{W'}=M_{Z'}$, the limit increases $M_{Z'}>2930$ GeV and $M_{Z'}>2800$ GeV for $g_V=3$ and $g_V=1$, respectively. See their Fig. 5 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=CB

[20] AABOUD 18AK search for resonances decaying to WW in pp collisions at $\sqrt{s}=1$3 TeV. The limit quoted above is for heavy-vector-triplet Z' with $g_V=3$. The limit becomes $M_{Z'}>2750$ GeV for $g_V=1$. NODE=S056ZOT;LINKAGE=DB

[21] AABOUD 18B search for resonances decaying to WW in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V=1$. See their Fig.11 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=QA

[22] AABOUD 18BI search for a resonance decaying to $t\overline{t}$ in pp collisions at $\sqrt{s}=13$ TeV. The quoted limit is for a top-color assisted TC Z' with $\Gamma_{Z'}/M_{Z'}=0.01$. The limits for wider resonances are available. See their Fig. 14 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=EB

[23] AABOUD 18F search for resonances decaying to WW in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet Z' with g_V = 3. The limit becomes $M_{Z'}$ > 2200 GeV for g_V = 1. If we assume $M_{Z'}$ = $M_{W'}$, the limit increases $M_{Z'}$ > 3500 GeV and $M_{Z'}$ > 3100 GeV for g_V = 3 and g_V = 1, respectively. See their Fig.5 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=RA

[24] SIRUNYAN 18ED search for resonances decaying to HZ in pp collisions at $\sqrt{s}$ = 13 TeV. The limit above is for heavy-vector-triplet Z' with g_V = 3. If we assume $M_{Z'}$ = $M_{W'}$, the limit increases $M_{Z'}$ > 2900 GeV and $M_{Z'}$ > 2800 GeV for g_V = 3 and g_V = 1, respectively. NODE=S056ZOT;LINKAGE=KB

[25] SIRUNYAN 18P give this limit for a heavy-vector-triplet Z' with g_V = 3. If they assume $M_{Z'}$ = $M_{W'}$, the limit increases to $M_{Z'}$ > 3800 GeV. NODE=S056ZOT;LINKAGE=HB

[26] AABOUD 17AK search for a new resonance decaying to dijets in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above is for a leptophobic Z' boson having axial-vector coupling strength with quarks g_q = 0.2. The limit is 2100 GeV if g_q = 0.1. NODE=S056ZOT;LINKAGE=OA

[27] AABOUD 17AO search for resonances decaying to HZ in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above is for a Z' in the heavy-vector-triplet model with g_V = 3. See their Fig.4 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=PA

[28] SIRUNYAN 17AK search for resonances decaying to WW or HZ in pp collisions at $\sqrt{s}$ = 8 and 13 TeV. The quoted limit is for heavy-vector-triplet Z' with g_V = 3. The limit becomes $M_{Z'}$ > 2200 GeV for g_V =1. If we assume $M_{Z'}$ = $M_{W'}$, the limit increases $M_{Z'}$ > 2400 GeV for both g_V = 3 and g_V = 1. See their Fig.1 and 2 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=TA

[29] SIRUNYAN 17Q search for a resonance decaying to $t\bar{t}$ in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above is for a resonance with relative width $\Gamma_{Z'}$ / $M_{Z'}$ = 0.01. Limits for wider resonances are available. See their Fig.6 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=NA

[30] SIRUNYAN 17R search for resonances decaying to HZ in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet Z' with g_V = 3. Mass regions $M_{Z'}$ < 1150 GeV and 1250 GeV < $M_{Z'}$ < 1670 GeV are excluded for g_V = 1. If we assume $M_{Z'}$ = $M_{W'}$, the excluded mass regions are 1000 < $M_{Z'}$ < 2500 GeV and 2760 < $M_{Z'}$ < 3300 GeV for g_V = 3; 1000 < $M_{Z'}$ < 2430 GeV and 2810 < $M_{Z'}$ < 3130 GeV for g_V = 1. See their Fig.5 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=VA

[31] AAD 25AZ search for a narrow resonance decaying to $q\overline{q}$ in pp collisions at $\sqrt{s}$ = 13 TeV, using trigger level analysis to enhance sensitivity in the low mass region. See their Fig. 9 for mass-coupling limits in the Z' mass range 375–1800 GeV. NODE=S056ZOT;LINKAGE=YE

[32] AAD 25BA set limits on Z' mediated dark Higgs scenarios with mass between 250–400 GeV and Z' masses $M_{Z'}$ < 2.3 TeV. Dark Higgs s is assumed to decay into HH. See their Fig. 7 for limits in $M_{Z'} - M_s$ plane. NODE=S056ZOT;LINKAGE=ZE

[33] AAD 25BB search for $\tau^+\tau^-$ production from s-channel Z' exchange via $b\overline{b}$ annhilation in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 12 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=AF

[34] AAD 25C search for a dark Higgs model spin-1 mediator Z' in pp collisions at $\sqrt{s}$ = 13 TeV using large $\not{E}_T$ and resonant $b\overline{b}$ production events. Z' decays to dark Higgs S and a pair of DM particles χ, and the dark Higgs S decays to $b\overline{b}$ subsequently. See their Fig. 3 for limits in $m_{Z'}$–m_S plane. NODE=S056ZOT;LINKAGE=RE

[35] AAD 25F search a new scalar particle S in pp collisions at $\sqrt{s}$ = 13 TeV. S decays to $Z'Z'$ with Z' subsequently decaying to $\ell^+\ell^-$. See their Fig. 5 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=SE

[36] AAD 25N search for Z' production in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay into a pair of dark quarks $q_d\overline{q}_d$ with q_d generating semivisible jet topology upon decay. See their Fig. 8 for limits on $\sigma \cdot B$ as a function of $M_{Z'}$. NODE=S056ZOT;LINKAGE=TE

[37] AAD 25Q search for a low mass Z' produced in association with γ in pp collisions at $\sqrt{s}$ = 13 TeV. The decay products of $Z' \rightarrow q\overline{q}$ are reconstructed as a single large-radius jet. See their Fig. 5 for exclusion limits in the $m_{Z'} - g_q$ plane in the mass range 20 GeV < $m_{Z'}$ < 200 GeV. NODE=S056ZOT;LINKAGE=UE

[38] CHEKHOVSKY 25J search for "mono-Higgs" events produced from s-channel Z' exchange in pp collisions at $\sqrt{s}$ = 13 TeV, in which the SM Higgs H is reconstructed through $H \rightarrow \tau^+\tau^-$. The limit quoted above is for a baryonic Z' model with g_q = 0.25, g_χ = 1.0, m_χ = 1 GeV. NODE=S056ZOT;LINKAGE=BF

[39] HAYRAPETYAN 25V search for resonances decaying to a pair of heavy, stable (long-lived), charged particles (HSCPs) in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above assumes doubly-charged HSCP τ' with $m_{\tau'}$ = 600 GeV and Z'_ψ production cross section. NODE=S056ZOT;LINKAGE=XE

[40] AAD 24AA search for Z' production in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay into a pair of dark quarks which hadronise into dark hadrons before promptly decaying back as SM particles. The dark pions are either assumed to decay directly to SM quarks or through dark photons. See their Fig. 7 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=ZD

[41] AAD 24AE search for resonances decaying to qq, tt, tb, VV, VH, $\ell\ell$, $\ell\tau$, $\tau\nu$, $\tau\tau$ in pp collisions at $\sqrt{s}$ = 13 TeV. The quoted limit is for heavy-vector-triplet Z' with g_V = 3. $M_{Z'}$ = $M_{W'}$ is assumed. The limit becomes $M_{Z'}$ > 5.8 TeV for g_V = 1. NODE=S056ZOT;LINKAGE=AE

[42] AAD 24AY search for a low-mass leptophobic Z' produced in association of high p_T ISR photon or jet in pp collisions at $\sqrt{s}$ = 13 TeV. The Z' coupling with quarks g_q is constrained below 0.07 for 250 < $M_{Z'}$ < 650 GeV. See their Fig. 8 for exclusion limit in the mass-coupling plane. NODE=S056ZOT;LINKAGE=BE

[43] AAD 24BJ search for top-philic Z' in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 9 for limits on $\sigma(pp \rightarrow t(\overline{t})Z')\cdot$B$(Z' \rightarrow t\overline{t})$. NODE=S056ZOT;LINKAGE=CE

[44] AAD 24BR search for $L_\mu - L_\tau$ Z' in 3μ final states in pp collisions at $\sqrt{s}$ = 13 TeV. Limits are combined with previous search results in the 4μ final states reported in AAD 23X. See their Fig. 4 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=LE

[45] AAD 24CD search for a DM simplified Z' produced in association with W or Z in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay invisibly. See their Fig. 13 for limits in $M_{Z'} - M_{DM}$ plane. NODE=S056ZOT;LINKAGE=ME

[46] AAD 24CI give a summary of searches for DM simplified Z' in pp collisions at $\sqrt{s}$ = 13 TeV. See their Figs. 6–11 for the limits. NODE=S056ZOT;LINKAGE=NE

[47] AAD 24CM search for pair productions of dark pions $\pi^+_D \pi^-_D$ in $t\,t\,b\,b$ events of pp collisions at $\sqrt{s}$ = 13 TeV. $\pi^\pm_D \rightarrow t\,b$ decay is assumed. The production cross section is computed in a model with dark ρ^0_D assuming dark isospin symmetry $m_{\rho^\pm_D} = m_{\rho^0_D}$, $m_{\pi^\pm_D} = m_{\pi^0_D}$. See their Fig. 12 for limits on the production cross sections. NODE=S056ZOT;LINKAGE=OE

[48] ABLIKIM 24G search for a muonphilic Z' and a muonphilic scalar X_0 in decays of $J/\psi \rightarrow \mu^+\mu^- +$ invisible. See their Fig. 3 for limits in the mass coupling plane. NODE=S056ZOT;LINKAGE=DE

[49] ADACHI 24F for a muonphilic Z' and a muonphilic scalar X_0 in $\mu^+\mu^-\mu^+\mu^-$ events of e^+e^- collisions at $\sqrt{s}$ = 10.58 GeV. See their Fig. 14 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=EE

[50] AKITA 24 limit is from no events of high-energy SN1987A neutrinos. The Z' coupling down to $g \sim 3 \times 10^{-10}$ is excluded for $M_{Z'}$ < 400 MeV in the $L_\mu - L_\tau$ Z' model. See their Fig. 3 and Fig. 4 for exclusion limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=FE

[51] ANDREEV 24 search for Z' production in μ-nucleus scattering. Z' is assumed to decay invisibly. See their Fig. 4 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=GE

[52] ANDREEV 24B search for Z' production in $e^\pm$-nucleus scattering. Z' is assumed to decay invisibly. See their Fig. 4 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=HE

[53] ANDREEV 24E search for Z' production in μ-nucleus scattering. Invisible decays of Z' are assumed. See their Fig. 17 and Fig. 19 for limits in mass-coupling plane for Z' masses from 0.001 to 1 GeV. NODE=S056ZOT;LINKAGE=PE

[54] BISWAS 24 search for leptophilic scalar X_0 produced in association with $\tau^+\tau^-$ in e^+e^- collisions near $\sqrt{s}$ = 10.58 GeV. X_0 is assumed to decay into e^+e^- or $\mu^+\mu^-$. See their Fig. 7 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=IE

[55] HAYRAPETYAN 24AZ search for Z' resonances produced via kinetic mixing parameter ϵ and decaying to $s_D\overline{s}_D$ in pp collisions at $\sqrt{s}$ = 13 TeV. Both s_D and $\overline{s}_D$ are assumed to decay into $\mu^+\mu^-$. See their Fig. 7 for limits on ϵ^2B$(Z' \rightarrow s_D\overline{s}_D)B^2(s_D \rightarrow \mu^+\mu^-)$. NODE=S056ZOT;LINKAGE=QE

[56] HAYRAPETYAN 24G search for singly produced narrow resonances decaying to $j\,j\,j$ in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 2 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=JE

[57] HAYRAPETYAN 24W search for $W^+W^- + \not{E}_T$ events in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay into dark Higgs S ($\rightarrow W^+W^-$) and DM particles $\chi\chi$. See their Fig. 5 for exclusion limits on the production cross section. NODE=S056ZOT;LINKAGE=KE

[58] AAD 23BF search for a Dark Matter (DM) simplified Z' produced in association with W in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 9(c) for limits on $\sigma\cdot B$ as a function of $M_{Z'}$. NODE=S056ZOT;LINKAGE=MD

[59] AAD 23W set limits on a dark Higgs model with a spin-1 mediator Z' and a dark Higgs s. Dark Higgs s is assumed to decay into $W\,W$. See their Fig. 9 for limits in $M_{Z'} - M_s$ plane. NODE=S056ZOT;LINKAGE=OD

[60] AAD 23X set limits on $L_\mu - L_\tau$ of Z' using four-muon final states in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 7 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=PD

[61] ADACHI 23B search for Z' produced in association with $\mu^+\mu^-$ and decaying invisibly in e^+e^- collisions at $\sqrt{s}$ = 10.58 GeV. See their Fig. 3 and Fig. 4 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=QD

[62] ADACHI 23F search for resonances decaying to $\tau^+\tau^-$ in $\mu^+\mu^-\tau^+\tau^-$ events in e^+e^- collisions at $\sqrt{s}$ = 10.58 GeV. See their Fig. 3 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=UD

[63] HAYRAPETYAN 23D search for $\mu^+\mu^-$ resonance produced in association with one or more b-jets in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 8 for limits in the mass-coupling plane of the B_3–L_2 Z' model. NODE=S056ZOT;LINKAGE=WD

[64] HAYRAPETYAN 23G search for spin-0 and spin-1 resonances decaying to $\mu^+\mu^-$ in pp collisions at $\sqrt{s}$ = 13 TeV in the mass ranges of 1.1–2.6 GeV and 4.2–7.9 GeV. See their Fig. 5 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=XD

[65] LI 23I limits on light Z' couplings are dervied from the steller cooling bounds in the mass range of 10^4–10^6 eV. See their Fig. 4 for limits on dark photon, B–L, L_μ–L_τ, and L_e–$L_{\mu(\tau)}$ models. NODE=S056ZOT;LINKAGE=YD

[66] MANZARI 23 study supernova cooling induced by the emission of light dark fermions χ assumed to couple with leptons via a new massive vector boson Z'. See their Figs. 4 and 5 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=VD

[67] AAD 22 search for $b\overline{b}Z'$ productions in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay into $b\overline{b}$. See their Fig.4 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=AD

[68] AAD 22D search for DM mediator Z' produced in association with a Z boson in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay invisibly $Z' \rightarrow \chi\chi$. See their Fig. 4 for limits in $M_{Z'}$–M_{χ} plane. NODE=S056ZOT;LINKAGE=DD

[69] ANDREEV 22 search for missing energy in CERN NA64-e experiment. See their Fig. 7 for limits on couplings of *U(1)* gauge $L_{\mu} - L_{\tau}$ Z' models, in the mass range of 1 MeV $< M_{Z'} <$ 600 MeV with the kinetic $Z' - \gamma$ mixing being determined by μ and τ loops. NODE=S056ZOT;LINKAGE=FD

[70] BONET 22 obtain limits on Z' coupling from ν-nucleus scattering data collected by the CONUS experiment at the nuclear power plant in Brokdorf. See their Fig. 5 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=GD

[71] COLOMA 22 set limits on Z' coupling from ν-nucleus and ν-e scattering data collected by a Ge detector at the Dresden-II power reactor and the COHERENT experiment. See their Fig. 6 for limits in mass-coupling plane in the mass range of 1 keV $< M_{Z'} <$ 5 GeV. NODE=S056ZOT;LINKAGE=HD

[72] COLOMA 22A use Borexino Phase-II spectral data to constrain Z' couplings. See their Fig. 5 for limits in mass-coupling plane in the mass range of 10 keV $< M_{Z'} <$ 100 MeV. NODE=S056ZOT;LINKAGE=ID

[73] CZANK 22 search for Z' produced in association with $\mu^+\mu^-$ in e^+e^- collisions at and near Υ resonances. Z' is assumed to decay into $\mu^+\mu^-$. See their Fig. 8 for limits on $Z'\mu\mu$ couplings. NODE=S056ZOT;LINKAGE=JD

[74] TUMASYAN 22AA search for Z' production in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay into two "semivisible" jets (SVJ), i.e., collimated mixtures of visible and invisible particles. See their Fig. 7 and 8 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=KD

[75] AAD 21AQ limits are for a $B - L$ gauge boson model derived from their measurements on four-lepton differential cross sections. See their Fig. 13 for exclusion limits on the $B - L$ breaking Higgs boson mass. NODE=S056ZOT;LINKAGE=QC

[76] AAD 21AZ search for DM mediator Z' produced in association with a SM Higgs boson in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay invisibly $Z' \rightarrow \chi\chi$. See their Fig.7 for limits in $M_{Z'} - M_{\chi}$ plane. NODE=S056ZOT;LINKAGE=YC

[77] AAD 21BB search for Z' productions in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay into a SM Higgs boson H and an invisible particle A. See their Fig.7 for limits in $M_{Z'} - M_A$ plane. NODE=S056ZOT;LINKAGE=ZC

[78] AAD 21D set limits on a dark Higgs model with a spin-1 mediator Z' and a scalar dark Higgs boson s. Dark Higgs s is assumed to decay into WW or ZZ. See their Fig.4 for limits in $M_{Z'} - M_s$ plane. NODE=S056ZOT;LINKAGE=RC

[79] AAD 21K search for $\gamma + \not{E}_T$ events in pp collision at $\sqrt{s}$ = 13 TeV. See their Fig. 5 for limits on Z' particle invisibly decaying to $\chi\chi$. NODE=S056ZOT;LINKAGE=SC

[80] BURAS 21 performed global fit to leptophilic Z' models using a large number of observables. NODE=S056ZOT;LINKAGE=TC

[81] CADEDDU 21 obtain limits on Z' coupling $g_{Z'}$ from coherent ν-nucleus scattering data collected by COHERENT experiment. For limits in the $M_{Z'}$–$g_{Z'}$ plane, see their Figures 3 and 4 for the universal Z' model and Figures 5 and 6 for the $B - L$ model. NODE=S056ZOT;LINKAGE=UC

[82] COLARESI 21 obtain limits on Z' coupling from coherent ν-nucleus scattering data collected by a Ge detector at the Dresden-II power reactor. See their Fig.7 for limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=BD

[83] KRIBS 21 set decay-agnostic limits on kinetic mixing parameter between U(1)$_Y$ field and new heavy abelian vector boson (dark photon) field using the HERA ep collision data. See their Fig. 3 for limits in mass-mixing plane. NODE=S056ZOT;LINKAGE=VC

[84] TUMASYAN 21D search for energetic jets + $\not{E}_T$ events in pp collisions at $\sqrt{s}$ = 13 TeV. Z' is assumed to decay into a pair of invisible particles $\chi\chi$. See their Fig. 7 for limits on signal strength in $M_{Z'} - M_{\chi}$ plane, and Fig. 8 for limits on signal strength in quark and dark matter coupling vs mediator mass. NODE=S056ZOT;LINKAGE=CD

[85] AAD 20AF search for resonances decaying to $H\gamma$ in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 1c for limits on $\sigma\cdot B$ for the mass range 0.7 $< m_{Z'} <$ 4 TeV. NODE=S056ZOT;LINKAGE=LC

[86] AAD 20T search for Dark Matter mediator Z' decaying invisibly or decaying to $q\overline{q}$ in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 5 for limits in $M_{Z'} - g_q$ plane from the inclusive category. See their Fig. 7(a) for limits on the product of the cross section, acceptance, b-tagging efficiency, and branching fraction from the 2 b-tag category. NODE=S056ZOT;LINKAGE=DC

[87] AAD 20W search for a Dark Matter (DM) simplified model Z' produced in association with W in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 5 for limits on Z' production cross section. NODE=S056ZOT;LINKAGE=FC

[88] AAIJ 20AL search for spin-0 and spin-1 resonances decaying to $\mu^+\mu^-$ in pp collisions at $\sqrt{s}$ = 13 TeV in the mass regions M$_{Z'} <$ 60 GeV, with non-negligible widths considered above 20 GeV. See their Figs. 7, 8, and 9 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=PC

[89] ADACHI 20 search for production of Z' in e^+e^- collisions. The Z' is assume to decay invisibly. See their Fig. 3 and Fig. 5 for limits on Z' coupling and $\sigma(e^+e^- \rightarrow e^{\pm}\mu^{\mp}Z')$. NODE=S056ZOT;LINKAGE=GC

[90] SIRUNYAN 20AI search for broad resonances decaying into dijets in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 11 for exclusion limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=HC

[91] SIRUNYAN 20AQ search for a narrow resonance lighter than 200 GeV decaying to $\mu^+\mu^-$ in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig. 3 for limits on Z' kinetic mixing coefficient. NODE=S056ZOT;LINKAGE=IC

[92] SIRUNYAN 20M search for a narrow resonance with a mass between 350 and 700 GeV in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig.3 for exclusion limits in mass-coupling plane. NODE=S056ZOT;LINKAGE=JC

[93] AABOUD 19AJ search in pp collisions at $\sqrt{s} = 13$ TeV for a new resonance decaying to $q\overline{q}$ and produced in association with a high p_T photon. For a leptophobic axial-vector Z' in the mass region 250 GeV $< M_{Z'} <$ 950 GeV, the Z' coupling with quarks g_q is constrained below 0.18. See their Fig.2 for limits in $M_{Z'} - g_q$ plane. NODE=S056ZOT;LINKAGE=OB

[94] AABOUD 19D search in pp collisions at $\sqrt{s} = 13$ TeV for a new resonance decaying to $q\overline{q}$ and produced in association with a high-p_T photon or jet. For a leptophobic axial-vector Z' in the mass region 100 GeV $< M_{Z'} <$ 220 GeV, the Z' coupling with quarks g_q is constrained below 0.23. See their Fig. 6 for limits in $M_{Z'} - g_q$ plane. NODE=S056ZOT;LINKAGE=IB

[95] AABOUD 19V search for Dark Matter simplified Z' decaying invisibly or decaying to fermion pair in pp collisions at $\sqrt{s} = 13$ TeV. NODE=S056ZOT;LINKAGE=RB

[96] AAD 19L search for resonances decaying to $\ell^+\ell^-$ in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig. 4 for limits in the heavy vector triplet model couplings. NODE=S056ZOT;LINKAGE=QB

[97] LONG 19 uses the weak charge data of Cesium and proton to constrain mass of Z' in the 3-3-1 models. NODE=S056ZOT;LINKAGE=SB

[98] PANDEY 19 obtain limits on Z' induced neutrino non-standard interaction (NSI) parameter ϵ from LHC and IceCube data. See their Fig.2 for limits in $M_{Z'} - \epsilon$ plane, where $\epsilon = g_q\, g_\nu\, v^2 / (2\, M^2_{Z'})$. NODE=S056ZOT;LINKAGE=YB

[99] SIRUNYAN 19AL search for a new resonance decaying to a top quark and a heavy vector-like top partner in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig. 8 for limits on Z' production cross section. NODE=S056ZOT;LINKAGE=UB

[100] SIRUNYAN 19AN search for a Dark Matter (DM) simplified model Z' decaying to H DM DM in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig. 7 for limits on the signal strength modifiers. NODE=S056ZOT;LINKAGE=VB

[101] SIRUNYAN 19CB search in pp collisions at $\sqrt{s} = 13$ TeV for a new resonance decaying to $q\overline{q}$. For a leptophobic Z' in the mass region 50–300 GeV, the Z' coupling with quarks g'_q is constrained below 0.2. See their Figs. 4 and 5 for limits on g'_q in the mass range $50 < M_{Z'} <$ 450 GeV. NODE=S056ZOT;LINKAGE=ZB

[102] SIRUNYAN 19CD search in pp collisions at $\sqrt{s}$=13 TeV for a leptophobic Z' produced in association of high p_T ISR photon and decaying to $q\overline{q}$. See their Fig. 2 for limits on the Z' coupling strength g'_q to $q\overline{q}$ in the mass range between 10 and 125 GeV. NODE=S056ZOT;LINKAGE=BC

[103] SIRUNYAN 19D search for a narrow neutral vector resonance decaying to $H\gamma$. See their Fig. 3 for exclusion limit in $M_{Z'} - \sigma\cdot B$ plane. Upper limits on the production of $H\gamma$ resonances are set as a function of the resonance mass in the range of 720–3250 GeV. NODE=S056ZOT;LINKAGE=LB

[104] AABOUD 18AA search for a narrow neutral vector boson decaying to $H\gamma$. See their Fig. 10 for the exclusion limit in $M_{Z'} - \sigma B$ plane. NODE=S056ZOT;LINKAGE=WA

[105] AABOUD 18CJ search for heavy-vector-triplet Z' in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above is for model with $g_V = 3$ assuming $M_{Z'} = M_{W'}$. The limit becomes $M_{Z'} >$ 5500 GeV for model with $g_V = 1$. NODE=S056ZOT;LINKAGE=MB

[106] AABOUD 18N search for a narrow resonance decaying to $q\overline{q}$ in pp collisions at $\sqrt{s} =$ 13 TeV using trigger level analysis to improve the low mass region sensitivity. See their Fig. 5 for limits in the mass-coupling plane in the Z' mass range 450–1800 GeV. NODE=S056ZOT;LINKAGE=FB

[107] AAIJ 18AQ search for spin-0 and spin-1 resonances decaying to $\mu^+\mu^-$ in pp collisions at $\sqrt{s} = 7$ and 8 TeV in the mass region near 10 GeV. See their Figs. 4 and 5 for limits on $\sigma\cdot B$. NODE=S056ZOT;LINKAGE=JB

[108] SIRUNYAN 18DR searches for $\mu^+\mu^-$ resonances produced in association with b-jets in the pp collision data with $\sqrt{s} = 8$ TeV and 13 TeV. An excess of events near $m_{\mu\mu} =$ 28 GeV is observed in the 8 TeV data. See their Fig. 3 for the measured fiducial signal cross sections at $\sqrt{s} = 8$ TeV and the 95% CL upper limits at $\sqrt{s} = 13$ TeV. NODE=S056ZOT;LINKAGE=NB

[109] SIRUNYAN 18G search for a new resonance decaying to dijets in pp collisions at $\sqrt{s} =$ 13 TeV in the mass range 50–300 GeV. See their Fig.7 for limits in the mass-coupling plane. NODE=S056ZOT;LINKAGE=ZA

[110] SIRUNYAN 18I search for a narrow resonance decaying to $b\overline{b}$ in pp collisions at $\sqrt{s} =$ 8 TeV using dedicated b-tagged dijet triggers to improve the sensitivity in the low mass region. See their Fig. 3 for limits on $\sigma \cdot B$ in the Z' mass range 325–1200 GeV. NODE=S056ZOT;LINKAGE=GB

[111] AABOUD 17B search for resonances decaying to HZ ($H \to b\overline{b}$, $c\overline{c}$; $Z \to \ell^+\ell^-$, $\nu\overline{\nu}$) in pp collisions at $\sqrt{s} = 13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V = 3$. The limit becomes $M_{Z'} >$ 1490 GeV for $g_V = 1$. If we assume $M_{Z'} = M_{W'}$, the limit increases $M_{Z'} >$ 2310 GeV and $M_{Z'} >$ 1730 GeV for $g_V = 3$ and $g_V = 1$, respectively. See their Fig.3 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=LA

[112] KHACHATRYAN 17AX search for lepto-phobic resonances decaying to four leptons in pp collisions at $\sqrt{s} = 8$ TeV. NODE=S056ZOT;LINKAGE=SA

[113] KHACHATRYAN 17U search for resonances decaying to HZ ($H \to b\overline{b}$; $Z \to \ell^+\ell^-$, $\nu\overline{\nu}$) in pp collisions at $\sqrt{s} = 13$ TeV. The limit on the heavy-vector-triplet model is $M_{Z'}$ NODE=S056ZOT;LINKAGE=GA

$= M_{W'} > 2$ TeV for $g_V = 3$, in which constraints from the $W' \rightarrow HW$ ($H \rightarrow b\overline{b}$; $W \rightarrow \ell\nu$) are combined. See their Fig.3 and Fig.4 for limits on $\sigma \cdot B$.

114 SIRUNYAN 17A search for resonances decaying to WW with $WW \rightarrow \ell\nu q\overline{q}$, $q\overline{q}q\overline{q}$ in pp collisions at $\sqrt{s} = 13$ TeV. The quoted limit is for heavy-vector-triplet Z' with $g_V = 3$. The limit becomes $M_{Z'} > 1600$ GeV for $g_V = 1$. If we assume $M_{Z'} = M_{W'}$, the limit increases $M_{Z'} > 2400$ GeV and $M_{Z'} > 2300$ GeV for $g_V = 3$ and $g_V = 1$, respectively. See their Fig.6 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=MA

115 SIRUNYAN 17AP search for resonances decaying into a SM-like Higgs scalar H and a light pseudo scalar A. A is assumed to decay invisibly. See their Fig.9 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=UA

116 SIRUNYAN 17T search for a new resonance decaying to dijets in pp collisions at $\sqrt{s} = 13$ TeV in the mass range 100–300 GeV. See their Fig.3 for limits in the mass-coupling plane. NODE=S056ZOT;LINKAGE=XA

117 SIRUNYAN 17V search for a new resonance decaying to a top quark and a heavy vector-like top partner T in pp collisions at $\sqrt{s} = 13$ TeV. See their table 5 for limits on the Z' production cross section for various values of $M_{Z'}$ and M_T in the range of $M_{Z'} =$ 1500–2500 GeV and $M_T =$ 700–1500 GeV. NODE=S056ZOT;LINKAGE=YA

118 AABOUD 16 search for a narrow resonance decaying into $b\overline{b}$ in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above is for a leptophobic Z' with SM-like couplings to quarks. See their Fig.6 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=HA

119 AAD 16L search for $Z' \rightarrow a\gamma$, $a \rightarrow \gamma\gamma$ in pp collisions at $\sqrt{s} = 8$ TeV. See their Table 6 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=IA

120 AAD 16S search for a new resonance decaying to dijets in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above is for a leptophobic Z' having coupling strength with quark $g_q = 0.3$ and is taken from their Figure 3. NODE=S056ZOT;LINKAGE=JA

121 KHACHATRYAN 16AP search for a resonance decaying to HZ in pp collisions at $\sqrt{s} = 8$ TeV. Both H and Z are assumed to decay to fat jets. The quoted limit is for heavy-vector-triplet Z' with $g_V = 3$. NODE=S056ZOT;LINKAGE=KA

122 KHACHATRYAN 16E search for a leptophobic top-color Z' decaying to $t\overline{t}$ using pp collisions at $\sqrt{s} = 8$ TeV. The quoted limit assumes that $\Gamma_{Z'}/m_{Z'} = 0.012$. Also $m_{Z'} < 2.9$ TeV is excluded for wider topcolor Z' with $\Gamma_{Z'}/m_{Z'} = 0.1$. NODE=S056ZOT;LINKAGE=FA

123 AAD 15AO search for narrow resonance decaying to $t\overline{t}$ using pp collisions at $\sqrt{s} = 8$ TeV. See Fig. 11 for limit on σB. NODE=S056ZOT;LINKAGE=U

124 AAD 15AT search for monotop production plus large missing E_T events in pp collisions at $\sqrt{s} = 8$ TeV and give constraints on a Z' model having $Z' u\overline{t}$ coupling. Z' is assumed to decay invisibly. See their Fig. 6 for limits on $\sigma \cdot B$. NODE=S056ZOT;LINKAGE=DA

125 AAD 15CD search for decays of Higgs bosons to 4 ℓ states via Z' bosons, $H \rightarrow ZZ' \rightarrow 4\ell$ or $H \rightarrow Z'Z' \rightarrow 4\ell$. See Fig. 5 for the limit on the signal strength of the $H \rightarrow ZZ' \rightarrow 4\ell$ process and Fig. 16 for the limit on $H \rightarrow Z'Z' \rightarrow 4\ell$. NODE=S056ZOT;LINKAGE=AA

126 KHACHATRYAN 15F search for monotop production plus large missing E_T events in pp collisions at $\sqrt{s} = 8$ TeV and give constraints on a Z' model having $Z' u\overline{t}$ coupling. Z' is assumed to decay invisibly. See Fig. 3 for limits on σB. NODE=S056ZOT;LINKAGE=CA

127 KHACHATRYAN 15O search for narrow Z' resonance decaying to ZH in pp collisions at $\sqrt{s} = 8$ TeV. See their Fig. 6 for limit on σB. NODE=S056ZOT;LINKAGE=EA

128 AAD 14AT search for a narrow neutral vector boson decaying to $Z\gamma$. See their Fig. 3b for the exclusion limit in $m_{Z'} - \sigma B$ plane. NODE=S056ZOT;LINKAGE=Z

129 KHACHATRYAN 14A search for new resonance in the WW ($\ell\nu q\overline{q}$) and the ZZ ($\ell\ell q\overline{q}$) channels using pp collisions at $\sqrt{s}$=8 TeV. See their Fig.13 for the exclusion limit on the number of events in the mass-width plane. NODE=S056ZOT;LINKAGE=R

130 MARTINEZ 14 use various electroweak data to constrain the Z' boson in the 3-3-1 models. NODE=S056ZOT;LINKAGE=S

131 AAD 13AQ search for a leptophobic top-color Z' decaying to $t\overline{t}$. The quoted limit assumes that $\Gamma_{Z'}/m_{Z'} = 0.012$. NODE=S056ZOT;LINKAGE=W

132 CHATRCHYAN 13BM search for top-color Z' decaying to $t\overline{t}$ using pp collisions at $\sqrt{s}$=8 TeV. The quoted limit is for $\Gamma_{Z'}/m_{Z'} = 0.012$. NODE=S056ZOT;LINKAGE=T

133 CHATRCHYAN 13AP search for top-color leptophobic Z' decaying to $t\overline{t}$ using pp collisions at $\sqrt{s}$=7 TeV. The quoted limit is for $\Gamma_{Z'}/m_{Z'} = 0.012$. NODE=S056ZOT;LINKAGE=V

134 AAD 12BV search for narrow resonance decaying to $t\overline{t}$ using pp collisions at $\sqrt{s}$=7 TeV. See their Fig. 7 for limit on $\sigma \cdot$ B. NODE=S056ZOT;LINKAGE=K

135 AAD 12K search for narrow resonance decaying to $t\overline{t}$ using pp collisions at $\sqrt{s}$=7 TeV. See their Fig. 5 for limit on $\sigma \cdot$ B. NODE=S056ZOT;LINKAGE=L

136 AALTONEN 12AR search for chromophilic Z' in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. See their Fig. 5 for limit on $\sigma \cdot$ B. NODE=S056ZOT;LINKAGE=M

137 AALTONEN 12N search for $p\overline{p} \rightarrow tZ'$, $Z' \rightarrow \overline{t}u$ events in $p\overline{p}$ collisions. See their Fig. 3 for the limit on $\sigma \cdot$ B. NODE=S056ZOT;LINKAGE=N

138 ABAZOV 12R search for top-color Z' boson decaying exclusively to $t\overline{t}$. The quoted limit is for $\Gamma_{Z'}/m_{Z'}$= 0.012. NODE=S056ZOT;LINKAGE=O

139 CHATRCHYAN 12AI search for $pp \rightarrow tt$ events and give constraints on a Z' model having $Z'\overline{u}t$ coupling. See their Fig. 4 for the limit in mass-coupling plane. NODE=S056ZOT;LINKAGE=P

140 Search for resonance decaying to $t\overline{t}$. See their Fig. 6 for limit on $\sigma \cdot$ B. NODE=S056ZOT;LINKAGE=Q

141 Search for narrow resonance decaying to $t\overline{t}$. See their Fig. 4 for limit on $\sigma \cdot$ B. NODE=S056ZOT;LINKAGE=G

[142] Search for narrow resonance decaying to $t\bar{t}$. See their Fig. 3 for limit on $\sigma \cdot$ B. NODE=S056ZOT;LINKAGE=I

[143] CHATRCHYAN 11O search for same-sign top production in pp collisions induced by a hypothetical FCNC Z' at $\sqrt{s} = 7$ TeV. See their Fig. 3 for limit in mass-coupling plane. NODE=S056ZOT;LINKAGE=J

[144] Search for narrow resonance decaying to $t\bar{t}$. See their Fig. 3 for limit on $\sigma \cdot$ B. NODE=S056ZOT;LINKAGE=ZO

[145] Search for narrow resonance decaying to $t\bar{t}$. See their Fig. 2 for limit on $\sigma \cdot$ B. NODE=S056ZOT;LINKAGE=AB

[146] BARGER 03B use the nucleosynthesis bound on the effective number of light neutrino δN_ν. See their Figs. 4–5 for limits in general E_6 motivated models. NODE=S056ZOT;LINKAGE=GR

[147] CHO 00 use various electroweak data to constrain Z' models assuming m_H=100 GeV. See Fig. 2 for limits in general E_6-motivated models. NODE=S056ZOT;LINKAGE=6Z

[148] CHO 98 study constraints on four-Fermi contact interactions obtained from low-energy electroweak experiments, assuming no Z-Z' mixing. NODE=S056ZOT;LINKAGE=CH

[149] Search for Z' decaying to dijets at $\sqrt{s}$=1.8 TeV. For Z' with electromagnetic strength coupling, no bound is obtained. NODE=S056ZOT;LINKAGE=BK

Searches for Z' with Lepton-Flavor-Violating decays

NODE=S056ZLF

The following limits are obtained from $p\bar{p}$ or $pp \rightarrow Z' X$ with Z' decaying to the mode indicated in the comments. NODE=S056ZLF

NODE=S056ZLF

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] HAYRAPETY...	25AK	CMS	$Z' \rightarrow e\mu$
	[2] CABARCAS	24	RVUE	$Z' \rightarrow \mu\tau$
	[3] AAD	23CB	ATLS	$Z' \rightarrow e\mu,\ e\tau,\ \mu\tau$
	[4] TUMASYAN	23H	CMS	$Z' \rightarrow e\mu$, $e\tau$, $\mu\tau$
	[5] AABOUD	18CM	ATLS	$Z' \rightarrow e\mu$, $e\tau$, $\mu\tau$
	[6] SIRUNYAN	18AT	CMS	$Z' \rightarrow e\mu$
	[7] AABOUD	16P	ATLS	$Z' \rightarrow e\mu$, $e\tau$, $\mu\tau$
	[8] KHACHATRY...	16BE	CMS	$Z' \rightarrow e\mu$
	[9] AAD	15O	ATLS	$Z' \rightarrow e\mu$, $e\tau$, $\mu\tau$
	[10] AAD	11H	ATLS	$Z' \rightarrow e\mu$
	[11] AAD	11Z	ATLS	$Z' \rightarrow e\mu$
	[12] ABULENCIA	06M	CDF	$Z' \rightarrow e\mu$

[1] HAYRAPETYAN 25AK search for a new particle with lepton-flavor violating decay in pp collisions at $\sqrt{s} = 13$ TeV in the mass range 110 < $M_{Z'}$ < 500 GeV. See their Fig. 15 for limits on $\sigma{\cdot}B$. NODE=S056ZLF;LINKAGE=I

[2] CABARCAS 24 use constraints on the non-standard neutrino interactions reported by ANTARES and IceCube expreriments to constrain Z' models with $\mu\tau$ coupling. See their Figs. 1 and 2 for limits in mass-coupling plane. NODE=S056ZLF;LINKAGE=G

[3] AAD 23CB search for a new particle with lepton-flavor violating decay in pp collisions at $\sqrt{s} = 13$ TeV. See their Figs.4, 5, and 6 for limits on $\sigma{\cdot}B$. NODE=S056ZLF;LINKAGE=F

[4] TUMASYAN 23H search for a new particle with lepton-flavor violating decay in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig. 4 for limits on $\sigma{\cdot}B$. NODE=S056ZLF;LINKAGE=D

[5] AABOUD 18CM search for a new particle with lepton-flavor violating decay in pp collisions at $\sqrt{s} = 13$ TeV. See their Figs. 4, 5, and 6 for limits on $\sigma{\cdot}B$. NODE=S056ZLF;LINKAGE=C

[6] SIRUNYAN 18AT search for a narrow resonance Z' decaying into $e\mu$ in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig.5 for limit on $\sigma \cdot B$ in the range of 600 GeV < $M_{Z'}$ < 5000 GeV. NODE=S056ZLF;LINKAGE=B

[7] AABOUD 16P search for new particle with lepton flavor violating decay in pp collisions at $\sqrt{s} = 13$ TeV. See their Figs.2, 3, and 4 for limits on $\sigma \cdot B$. NODE=S056ZLF;LINKAGE=A

[8] KHACHATRYAN 16BE search for new particle Z' with lepton flavor violating decay in pp collisions at $\sqrt{s} = 8$ TeV in the range of 200 GeV < $M_{Z'}$ < 2000 GeV. See their Fig.4 for limits on $\sigma \cdot B$ and their Table 5 for bounds on various masses. NODE=S056ZLF;LINKAGE=LA

[9] AAD 15O search for new particle Z' with lepton flavor violating decay in pp collisions at $\sqrt{s} = 8$ TeV in the range of 500 GeV < $M_{Z'}$ < 3000 GeV. See their Fig. 2 for limits on σB. NODE=S056ZLF;LINKAGE=BA

[10] AAD 11H search for new particle Z' with lepton flavor violating decay in pp collisions at $\sqrt{s} = 7$ TeV in the range of 700 GeV < $M_{Z'}$ < 1000 GeV. See their Fig. 3 for limits on $\sigma \cdot B$. NODE=S056ZLF;LINKAGE=E

[11] AAD 11Z search for new particle Z' with lepton flavor violating decay in pp collisions at $\sqrt{s} = 7$ TeV in the range 700 GeV < $M_{Z'}$ < 2000 GeV. See their Fig. 3 for limits on $\sigma \cdot B$. NODE=S056ZLF;LINKAGE=H

[12] ABULENCIA 06M search for new particle Z' with lepton flavor violating decay in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV in the range of 100 GeV < $M_{Z'}$ < 800 GeV. See their Fig. 4 for limits in the mass-coupling plane. NODE=S056ZLF;LINKAGE=UL

Indirect Constraints on Kaluza-Klein Gauge Bosons

NODE=S056KKI

Bounds on a Kaluza-Klein excitation of the Z boson or photon in d=1 extra dimension. These bounds can also be interpreted as a lower bound on $1/R$, the size of the extra dimension. Unless otherwise stated, bounds assume all fermions live on a single brane NODE=S056KKI and all gauge fields occupy the 4+d-dimensional bulk. See also the section on "Extra Dimensions" in the "Searches" Listings in this *Review*.

NODE=S056KKI

VALUE (TeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
> 4.7		[1] MUECK	02	RVUE	Electroweak
> 3.3	95	[2] CORNET	00	RVUE	$e\nu qq'$
>5000		[3] DELGADO	00	RVUE	ϵ_K
> 2.6	95	[4] DELGADO	00	RVUE	Electroweak (OCCUR=2)
> 3.3	95	[5] RIZZO	00	RVUE	Electroweak
> 2.9	95	[6] MARCIANO	99	RVUE	Electroweak
> 2.5	95	[7] MASIP	99	RVUE	Electroweak
> 1.6	90	[8] NATH	99	RVUE	Electroweak
> 3.4	95	[9] STRUMIA	99	RVUE	Electroweak

[1] MUECK 02 limit is 2σ and is from global electroweak fit ignoring correlations among observables. Higgs is assumed to be confined on the brane and its mass is fixed. For scenarios of bulk Higgs, of brane-SU(2)$_L$, bulk-U(1)$_Y$, and of bulk-SU(2)$_L$, brane-U(1)$_Y$, the corresponding limits are > 4.6 TeV, > 4.3 TeV and > 3.0 TeV, respectively. NODE=S056KKI;LINKAGE=MK

[2] Bound is derived from limits on $e\nu qq'$ contact interaction, using data from HERA and the Tevatron. NODE=S056KKI;LINKAGE=G

[3] Bound holds only if first two generations of quarks lives on separate branes. If quark mixing is not complex, then bound lowers to 400 TeV from Δm_K. NODE=S056KKI;LINKAGE=B1

[4] See Figs. 1 and 2 of DELGADO 00 for several model variations. Special boundary conditions can be found which permit KK states down to 950 GeV and that agree with the measurement of Q_W(Cs). Quoted bound assumes all Higgs bosons confined to brane; placing one Higgs doublet in the bulk lowers bound to 2.3 TeV. NODE=S056KKI;LINKAGE=B2

[5] Bound is derived from global electroweak analysis assuming the Higgs field is trapped on the matter brane. If the Higgs propagates in the bulk, the bound increases to 3.8 TeV. NODE=S056KKI;LINKAGE=H

[6] Bound is derived from global electroweak analysis but considering only presence of the KK W bosons. NODE=S056KKI;LINKAGE=F

[7] Global electroweak analysis used to obtain bound independent of position of Higgs on brane or in bulk. NODE=S056KKI;LINKAGE=E

[8] Bounds from effect of KK states on G_F, α, M_W, and M_Z. Hard cutoff at string scale determined using gauge coupling unification. Limits for d=2,3,4 rise to 3.5, 5.7, and 7.8 TeV. NODE=S056KKI;LINKAGE=A

[9] Bound obtained for Higgs confined to the matter brane with m_H=500 GeV. For Higgs in the bulk, the bound increases to 3.5 TeV. NODE=S056KKI;LINKAGE=D

See the related review(s):

Leptoquarks

MASS LIMITS for Leptoquarks from Pair Production

NODE=S056EGT

These limits rely only on the color or electroweak charge of the leptoquark. NODE=S056EGT

NODE=S056EGT;CHECK LIMITS

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*	
> 900	95	[1] AAD	25V	ATLS	Scalar LQ. B($c\nu$) = 1	
>1150	95	[2] AAD	25V	ATLS	Vector LQ. κ = 1, B($c\nu$)=0.5	OCCUR=2
>1580	95	[3] AAD	24AV	ATLS	Scalar LQ. B(te) = 1	
>1590	95	[4] AAD	24AV	ATLS	Scalar LQ. B($t\mu$) = 1	OCCUR=2
>1950	95	[5] AAD	24AV	ATLS	Vector LQ. κ = 1. B(te) = 1	OCCUR=3
>1950	95	[6] AAD	24AV	ATLS	Vector LQ. κ = 1. B($t\mu$) = 1	OCCUR=4
>1230	95	[7] AAD	24O	ATLS	Scalar LQ. B($b\nu$) = 1	
>1230	95	[8] AAD	24O	ATLS	Scalar LQ. B($t\nu$) = 1	OCCUR=2
>1480	95	[9] AAD	24O	ATLS	Scalar LQ. B($b\tau$) = 1	OCCUR=3
>1520	95	[10] AAD	24O	ATLS	Scalar LQ. B($t\tau$) = 1	OCCUR=4
>1710	95	[11] AAD	24O	ATLS	Scalar LQ. B($b\mu$) = 1	OCCUR=5
>1600	95	[12] AAD	24O	ATLS	Scalar LQ. B($t\mu$) = 1	OCCUR=6
>1730	95	[13] AAD	24O	ATLS	Scalar LQ. B(be) = 1	OCCUR=7
>1650	95	[14] AAD	24O	ATLS	Scalar LQ. B(te) = 1	OCCUR=8
>1840	95	[15] AAD	24O	ATLS	Vector LQ. κ = 1. $LQ \to t\nu,\ b\tau$	OCCUR=9
>1980	95	[16] AAD	24O	ATLS	Vector LQ. κ = 1. $LQ \to t\nu,\ b\mu$	OCCUR=10
>1900	95	[17] AAD	24O	ATLS	Vector LQ. κ = 1. $LQ \to t\nu,\ be$	OCCUR=11
>1810	95	[18] HAYRAPETY...	24O	CMS	Scalar LQ. B($b\mu$) = 1	
>2460	95	[19] HAYRAPETY...	24O	CMS	Vector LQ. κ = 1. B($b\mu$) = 1	OCCUR=2
>1216	95	[20] HAYRAPETY...	24Z	CMS	Scalar LQ. B($b\tau$) = 1	
>1820	95	[21] HAYRAPETY...	24Z	CMS	Vector LQ. κ = 1. B($b\tau$) = 1	OCCUR=2
>1300	95	[22] AAD	23BJ	ATLS	Scalar LQ. B($c\tau$) = 1	
>1460	95	[23] AAD	23CF	ATLS	Scalar LQ. B($b\tau$) = 1	
>1910	95	[24] AAD	23CF	ATLS	Vector LQ. κ = 1, B($b\tau$) = 1	OCCUR=2
>1460	95	[25] AAD	23F	ATLS	Scalar LQ. B($t\nu$)=B($b\mu$)=0.5	

>1440	95	[26] AAD	23F	ATLS	Scalar LQ. B($t\nu$)=B(be)=0.5	OCCUR=2
>1370	95	[27] AAD	23F	ATLS	Scalar LQ. B($t\mu$)=B($b\nu$)=0.5	OCCUR=3
>1390	95	[28] AAD	23F	ATLS	Scalar LQ. B(te)=B($b\nu$)=0.5	OCCUR=4
>1980	95	[29] AAD	23F	ATLS	Vector LQ. $\kappa=1$, B($t\nu$) = B($b\mu$) = 0.5	OCCUR=5
>1900	95	[30] AAD	23F	ATLS	Vector LQ. $\kappa=1$, B($t\nu$) = B(be) = 0.5	OCCUR=6
>1340	95	[31] TUMASYAN	22H	CMS	Scalar LQ. B(te) = 1	
>1420	95	[32] TUMASYAN	22H	CMS	Scalar LQ. B($t\mu$) = 1	OCCUR=2
>1120	95	[33] TUMASYAN	22H	CMS	Scalar LQ. B($t\tau$) = 1	OCCUR=3
>1480	95	[34] AAD	21AG	ATLS	Scalar LQ. B(te) = 1	
>1470	95	[35] AAD	21AG	ATLS	Scalar LQ. B($t\mu$) = 1	OCCUR=2
>1190	95	[36] AAD	21AW	ATLS	Scalar LQ. B($b\tau$) = 1	
>1030	95	[37] AAD	21AW	ATLS	Scalar LQ. B($t\tau$) = 1	OCCUR=2
>1760	95	[38] AAD	21AW	ATLS	Vector LQ. $\kappa=1$. B($b\tau$) = 1	OCCUR=3
>1260	95	[39] AAD	21S	ATLS	Scalar LQ. B($b\nu$) = 1	
>1430	95	[40] AAD	21T	ATLS	Scalar LQ. B($t\tau$) = 1	
>950	95	[41] SIRUNYAN	21J	CMS	Scalar LQ. B($t\tau$)=B($b\nu$)=0.5	
>1650	95	[42] SIRUNYAN	21J	CMS	Vector LQ. κ=1, B($t\nu$) = B($b\tau$) = 0.5	OCCUR=2
>1800	95	[43] AAD	20AK	ATLS	Scalar LQ. B(eq) = 1	
>1700	95	[44] AAD	20AK	ATLS	Scalar LQ. B(μq) = 1	OCCUR=2
>1240	95	[45] AAD	20S	ATLS	Scalar LQ. B($t\nu$) = 1	
>1185	95	[46] SIRUNYAN	20A	CMS	Scalar LQ. B(νb) = 1	
>1140	95	[47] SIRUNYAN	20A	CMS	Scalar LQ. B(νt) = 1	OCCUR=2
>1140	95	[48] SIRUNYAN	20A	CMS	Scalar LQ. B(νq) = 1 with $q = u, d, s, c$	OCCUR=3
>1925	95	[49] SIRUNYAN	20A	CMS	Vector LQ. $\kappa=1$. B(νb) = 1	OCCUR=4
>1825	95	[50] SIRUNYAN	20A	CMS	Vector LQ. $\kappa=1$. B(νt) = 1	OCCUR=5
>1980	95	[51] SIRUNYAN	20A	CMS	Vector LQ. $\kappa=1$. B(νq) = 1 with $q = u, d, s, c$	OCCUR=6
>1400	95	[52] AABOUD	19AX	ATLS	Scalar LQ. B(eq) = 1	
>1560	95	[53] AABOUD	19AX	ATLS	Scalar LQ. B(μq) = 1	OCCUR=2
>1000	95	[54] AABOUD	19X	ATLS	Scalar LQ. B($t\nu$) = 1	
>1030	95	[55] AABOUD	19X	ATLS	Scalar LQ. B($b\tau$) = 1	OCCUR=2
>970	95	[56] AABOUD	19X	ATLS	Scalar LQ. B($b\nu$) = 1	OCCUR=3
>920	95	[57] AABOUD	19X	ATLS	Scalar LQ. B($t\tau$) = 1	OCCUR=4
>1530	95	[58] SIRUNYAN	19BI	CMS	Scalar LQ. B(μq)+B(νq) = 1	
>1435	95	[59] SIRUNYAN	19BJ	CMS	Scalar LQ. B(eq)+B(νq) = 1	
>1020	95	[60] SIRUNYAN	19Y	CMS	Scalar LQ. B(τb) = 1	
none 300–900	95	[61] SIRUNYAN	18CZ	CMS	Scalar LQ. B(τt) = 1	
>1420	95	[62] SIRUNYAN	18EC	CMS	Scalar LQ. B(μt) = 1	
>1190	95	[63] SIRUNYAN	18EC	CMS	Vector LQ. μt, τt, νb	OCCUR=2
>1100	95	[64] SIRUNYAN	18U	CMS	Scalar LQ. B(νb) = 1	
>980	95	[65] SIRUNYAN	18U	CMS	Scalar LQ. B(νq) = 1 with $q = u,d,s,c$	OCCUR=2
>1020	95	[66] SIRUNYAN	18U	CMS	Scalar LQ. B(νt) = 1	OCCUR=3
>1810	95	[67] SIRUNYAN	18U	CMS	Vector LQ. κ=1. LQ$\rightarrow$ $b\nu$	OCCUR=4
>1790	95	[68] SIRUNYAN	18U	CMS	Vector LQ. κ=1. LQ$\rightarrow$ $q\nu$ with $q = u,d,s,c$	OCCUR=5
>1780	95	[69] SIRUNYAN	18U	CMS	Vector LQ. κ=1. LQ$\rightarrow$ $t\nu$	OCCUR=6
>740	95	[70] KHACHATRY...	17J	CMS	Scalar LQ. B(τb) = 1	
>850	95	[71] SIRUNYAN	17H	CMS	Scalar LQ. B(τb) = 1	
>1050	95	[72] AAD	16G	ATLS	Scalar LQ. B(eq) = 1	
>1000	95	[73] AAD	16G	ATLS	Scalar LQ. B(μq) = 1	OCCUR=2
>625	95	[74] AAD	16G	ATLS	Scalar LQ. B(νb) = 1	OCCUR=3
none 200–640	95	[75] AAD	16G	ATLS	Scalar LQ. B(νt) = 1	OCCUR=4
>1010	95	[76] KHACHATRY...	16AF	CMS	Scalar LQ. B(eq) = 1	
>1080	95	[77] KHACHATRY...	16AF	CMS	Scalar LQ. B(μq) = 1	OCCUR=2
>685	95	[78] KHACHATRY...	15AJ	CMS	Scalar LQ. B(τt) = 1	
>740	95	[79] KHACHATRY...	14T	CMS	Scalar LQ. B(τb) = 1	

• • • We do not use the following data for averages, fits, limits, etc. • • •

		[80] SIRUNYAN	19BC	CMS	Scalar LQ ($\rightarrow$ μq) LQ ($\rightarrow$ X + DM)	
>534	95	[81] AAD	13AE	ATLS	Third generation	
>525	95	[82] CHATRCHYAN	13M	CMS	Third generation	
>660	95	[83] AAD	12H	ATLS	First generation	
>685	95	[84] AAD	12O	ATLS	Second generation	
>830	95	[85] CHATRCHYAN	12AG	CMS	First generation	
>840	95	[86] CHATRCHYAN	12AG	CMS	Second generation	OCCUR=2
>450	95	[87] CHATRCHYAN	12BO	CMS	Third generation	
>376	95	[88] AAD	11D	ATLS	Superseded by AAD 12H	

>422	95	[89] AAD	11D	ATLS	Superseded by AAD 12O	OCCUR=2
>326	95	[90] ABAZOV	11V	D0	First generation	
>339	95	[91] CHATRCHYAN	11N	CMS	Superseded by CHATRCHYAN 12AG	
>384	95	[92] KHACHATRY...	11D	CMS	Superseded by CHATRCHYAN 12AG	
>394	95	[93] KHACHATRY...	11E	CMS	Superseded by CHATRCHYAN 12AG	
>247	95	[94] ABAZOV	10L	D0	Third generation	
>316	95	[95] ABAZOV	09	D0	Second generation	
>299	95	[96] ABAZOV	09AF	D0	Superseded by ABAZOV 11V	
		[97] AALTONEN	08P	CDF	Third generation	
>153	95	[98] AALTONEN	08Z	CDF	Third generation	
>205	95	[99] ABAZOV	08AD	D0	All generations	
>210	95	[98] ABAZOV	08AN	D0	Third generation	
>229	95	[100] ABAZOV	07J	D0	Superseded by ABAZOV 10L	
>251	95	[101] ABAZOV	06A	D0	Superseded by ABAZOV 09	
>136	95	[102] ABAZOV	06L	D0	Superseded by ABAZOV 08AD	
>226	95	[103] ABULENCIA	06T	CDF	Second generation	
>256	95	[104] ABAZOV	05H	D0	First generation	
>117	95	[99] ACOSTA	05I	CDF	First generation	
>236	95	[105] ACOSTA	05P	CDF	First generation	
>99	95	[106] ABBIENDI	03R	OPAL	First generation	
>100	95	[106] ABBIENDI	03R	OPAL	Second generation	OCCUR=2
>98	95	[106] ABBIENDI	03R	OPAL	Third generation	OCCUR=3
>98	95	[107] ABAZOV	02	D0	All generations	
>225	95	[108] ABAZOV	01D	D0	First generation	
>85.8	95	[109] ABBIENDI	00M	OPAL	Superseded by ABBIENDI 03R	
>85.5	95	[109] ABBIENDI	00M	OPAL	Superseded by ABBIENDI 03R	OCCUR=2
>82.7	95	[109] ABBIENDI	00M	OPAL	Superseded by ABBIENDI 03R	OCCUR=3
>200	95	[110] ABBOTT	00C	D0	Second generation	
>123	95	[111] AFFOLDER	00K	CDF	Second generation	
>148	95	[112] AFFOLDER	00K	CDF	Third generation	OCCUR=2
>160	95	[113] ABBOTT	99J	D0	Second generation	
>225	95	[114] ABBOTT	98E	D0	First generation	
>94	95	[115] ABBOTT	98J	D0	Third generation	
>202	95	[116] ABE	98S	CDF	Second generation	
>242	95	[117] GROSS-PILCH...	98		First generation	
>99	95	[118] ABE	97F	CDF	Third generation	
>213	95	[119] ABE	97X	CDF	First generation	
>45.5	95	[120,121] ABREU	93J	DLPH	First + second generation	
>44.4	95	[122] ADRIANI	93M	L3	First generation	
>44.5	95	[122] ADRIANI	93M	L3	Second generation	OCCUR=2
>45	95	[122] DECAMP	92	ALEP	Third generation	OCCUR=2
none 8.9–22.6	95	[123] KIM	90	AMY	First generation	
none 10.2–23.2	95	[123] KIM	90	AMY	Second generation	OCCUR=2
none 5–20.8	95	[124] BARTEL	87B	JADE		
none 7–20.5	95	[125] BEHREND	86B	CELL		

[1] AAD 25V search for scalar leptoquarks decaying to $c\nu$ in pp collisions at $\sqrt{s}=13$ TeV. See their Fig.10 for exclusion limits in M_{LQ}–B($c\nu$) plane. NODE=S056EGT;LINKAGE=GD

[2] AAD 25V search for vector leptoquarks decaying to $c\nu$ in pp collisions at $\sqrt{s}=13$ TeV. See their Fig. 11 for exclusion limits on σ. The limit becomes $M_{LQ} > 950$ GeV for vector LQ with minimal coupling. NODE=S056EGT;LINKAGE=HD

[3] AAD 24AV search for scalar leptoquarks decaying to te in pp collisions at $\sqrt{s}=13$ TeV. See their Fig. 9 for exclusion limit on σ. NODE=S056EGT;LINKAGE=MC

[4] AAD 24AV search for scalar leptoquarks decaying to $t\mu$ in pp collisions at $\sqrt{s}=13$ TeV. See their Fig. 9 for exclusion limit on σ. NODE=S056EGT;LINKAGE=NC

[5] AAD 24AV search for $\kappa=1$ vector leptoquarks decaying to te in pp collisions at $\sqrt{s}=13$ TeV. See their Fig. 11 for exclusion limit on σ. The limit becomes $M_{LQ} > 1.67$ TeV for minimal coupling vector LQ with $\kappa=0$. NODE=S056EGT;LINKAGE=OC

[6] AAD 24AV search for $\kappa=1$ vector leptoquarks decaying to $t\mu$ in pp collisions at $\sqrt{s}=13$ TeV. See their Fig. 11 for exclusion limit on σ. The limit becomes $M_{LQ} > 1.67$ TeV for minimal coupling vector LQ with $\kappa=0$. NODE=S056EGT;LINKAGE=PC

[7] AAD 24O search for scalar leptoquarks decaying to $b\nu$. NODE=S056EGT;LINKAGE=QC

[8] AAD 24O search for scalar leptoquarks decaying to $t\nu$. NODE=S056EGT;LINKAGE=RC

[9] AAD 24O search for scalar leptoquarks decaying to $b\tau$ or $t\nu$. See their Fig. 2a for exclusion limit on M_{LQ} as function of B($b\tau$). NODE=S056EGT;LINKAGE=SC

[10] AAD 24O search for scalar leptoquarks decaying to $t\tau$ or $b\nu$. See their Fig. 2b for exclusion limit on M_{LQ} as function of B($t\tau$). NODE=S056EGT;LINKAGE=TC

[11] AAD 24O search for scalar leptoquarks decaying to $b\mu$ or $t\nu$. See their Fig. 3a for exclusion limit on M_{LQ} as function of B($b\mu$). NODE=S056EGT;LINKAGE=UC

[12] AAD 24O search for scalar leptoquarks decaying to $t\mu$ or $b\nu$. See their Fig.4 a for exclusion limit on M_{LQ} as function of B($t\mu$). NODE=S056EGT;LINKAGE=VC

[13] AAD 24O search for scalar leptoquarks decaying to be or $t\nu$. See their Fig. 3b for exclusion limit on M_{LQ} as function of B(be). NODE=S056EGT;LINKAGE=WC

[14] AAD 24O search for scalar leptoquarks decaying to te or $b\nu$. See their Fig. 4b for exclusion limit on M_{LQ} as function of B(te). NODE=S056EGT;LINKAGE=XC

[15] AAD 24O search for vector leptoquarks decaying to $t\nu$ or $b\tau$ with $\kappa = 1$. The limit becomes $>$ 1580 GeV for $\kappa = 0$. NODE=S056EGT;LINKAGE=YC

[16] AAD 24O search for vector leptoquarks decaying to $t\nu$ or $b\mu$ with $\kappa = 1$. The limit becomes $>$ 1710 GeV for $\kappa = 0$. NODE=S056EGT;LINKAGE=ZC

[17] AAD 24O search for vector leptoquarks decaying to $t\nu$ or be with $\kappa = 1$. The limit becomes $>$ 1620 GeV for $\kappa = 0$. NODE=S056EGT;LINKAGE=BD

[18] HAYRAPETYAN 24O search for scalar leptoquarks decaying to $b\mu$. See their Fig. 7 for exclusion limit on leptoquark pair production cross section as function of M_{LQ}. NODE=S056EGT;LINKAGE=CD

[19] HAYRAPETYAN 24O search for $\kappa = 1$ vector leptoquarks decaying to $b\mu$. The limit becomes $M_{LQ} > 2120$ GeV for $\kappa = 0$. NODE=S056EGT;LINKAGE=DD

[20] HAYRAPETYAN 24Z search for scalar and vector leptoquarks decaying to $b\tau$ and produced through single, pair, and nonresonantly in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above assumes scalar leptoquarks with B($b\tau$) = 1 and leptoquark coupling strength $\lambda = 0$. See their Fig. 7 for limits in mass-coupling plane. NODE=S056EGT;LINKAGE=ED

[21] HAYRAPETYAN 24Z search for scalar and vector leptoquarks decaying to $b\tau$ and produced through single, pair, and nonresonantly in pp collisions at $\sqrt{s} = 13$ TeV. The limit quoted above assumes $\kappa = 1$ vector leptoquarks with B($b\tau$) = 1 and leptoquark coupling strength $\lambda = 0$. See their Fig. 8 for limits in mass-coupling plane and for limits with $\kappa = 0$. NODE=S056EGT;LINKAGE=FD

[22] AAD 23BJ search for scalar leptoquarks decaying to $c\tau$ in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig. 8 for exclusion limit on σ as function of M_{LQ}. NODE=S056EGT;LINKAGE=CC

[23] AAD 23CF search for scalar and vector leptoquarks decaying to $b\tau$. The limit quoted above is for scalar leptoquark. See their Fig. 9 for limits on leptoquark pair production cross sections. NODE=S056EGT;LINKAGE=KC

[24] AAD 23CF search for scalar and vector leptoquarks decaying to $b\tau$. The limit quoted above is for vector leptoquark with $\kappa = 1$. The limit becomes $M_{LQ} > 1650$ for vector leptoquark with $\kappa = 0$. See their Fig. 9 for limits on leptoquark pair production cross sections. NODE=S056EGT;LINKAGE=LC

[25] AAD 23F search for scalar leptoquarks decaying to $t\nu$ and $b\mu$ in pp collisions at $\sqrt{s} =$ 13 TeV. See their Fig. 9 for exclusion contour in B($b\mu$)$-M_{LQ}$ plane. NODE=S056EGT;LINKAGE=DC

[26] AAD 23F search for scalar leptoquarks decaying to $t\nu$ and be in pp collisions at $\sqrt{s} =$ 13 TeV. See their Fig. 9 for exclusion contour in B(be)$-M_{LQ}$ plane. NODE=S056EGT;LINKAGE=EC

[27] AAD 23F search for scalar leptoquarks decaying to $t\mu$ and $b\nu$ in pp collisions at $\sqrt{s} =$ 13 TeV. See their Fig. 9 for exclusion contour in B($t\mu$)$-M_{LQ}$ plane. NODE=S056EGT;LINKAGE=FC

[28] AAD 23F search for scalar leptoquarks decaying to te and $b\nu$ in pp collisions at $\sqrt{s} =$ 13 TeV. See their Fig. 9 for exclusion contour in B(te)$-M_{LQ}$ plane. NODE=S056EGT;LINKAGE=HC

[29] AAD 23F search for $\kappa = 1$ (YM coupling) vector leptoquarks decaying to $t\nu$ and $b\mu$ in pp collisions at $\sqrt{s} = 13$ TeV. If $\kappa = 0$ (minimal coupling) is assumed, the limit becomes $M_{LQ} > 1710$ GeV. See their Fig. 10 for exclusion contour in B($b\mu$)$-M_{LQ}$ plane. NODE=S056EGT;LINKAGE=IC

[30] AAD 23F search for $\kappa = 1$ (YM coupling) vector leptoquarks decaying to $t\nu$ and be in pp collisions at $\sqrt{s} = 13$ TeV. If $\kappa = 0$ (minimal coupling) is assumed, the limit becomes $M_{LQ} > 1620$ GeV. See their Fig. 10 for exclusion contour in B(be)$-M_{LQ}$ plane. NODE=S056EGT;LINKAGE=JC

[31] TUMASYAN 22H search for scalar leptoquarks decaying to te. See their Fig. 27 for exclusion limit on leptoquark pair production cross section as function of M_{LQ}. NODE=S056EGT;LINKAGE=YB

[32] TUMASYAN 22H search for scalar leptoquarks decaying to $t\mu$. See their Fig. 27 for exclusion limit on leptoquark pair production cross section as function of M_{LQ}. NODE=S056EGT;LINKAGE=ZB

[33] TUMASYAN 22H search for scalar leptoquarks decaying to $t\tau$. See their Fig. 27 for exclusion limit on leptoquark pair production cross section as function of M_{LQ}. NODE=S056EGT;LINKAGE=BC

[34] AAD 21AG search for scalar leptoquarks decaying to te. See their Fig. 6 for exclusion limit on B(te) as function of M_{LQ}. NODE=S056EGT;LINKAGE=OB

[35] AAD 21AG search for scalar leptoquarks decaying to $t\mu$. See their Fig. 6 for exclusion limit on B($t\mu$) as function of M_{LQ}. NODE=S056EGT;LINKAGE=PB

[36] AAD 21AW search for scalar leptoquarks decaying to $b\tau$. See their Fig. 9 for exclusion contour in B($b\tau$)$-M_{LQ}$ plane. NODE=S056EGT;LINKAGE=VB

[37] AAD 21AW search for scalar leptoquarks decaying to $t\tau$. See their Fig. 9 for exclusion contour in B($t\tau$)$-M_{LQ}$ plane. NODE=S056EGT;LINKAGE=WB

[38] AAD 21AW search for $\kappa = 1$ vector leptoquarks decaying to $b\tau$. See their Fig. 10 for exclusion contour in B($b\tau$)$-M_{LQ}$ plane and for limit on $\kappa = 0$ vector leptoquarks. NODE=S056EGT;LINKAGE=XB

[39] AAD 21S search for scalar leptoquarks decaying to $b\nu$ in pp collisions at $\sqrt{s} = 13$ TeV. The limit above assumes B($b\nu$) = 1. For B($b\nu$) = 0.05, the limit becomes 400 GeV. NODE=S056EGT;LINKAGE=QB

[40] AAD 21T search for scalar leptoquarks decaying to $t\tau$ in pp collisions at $\sqrt{s}$ = 13 TeV. The limit above assumes B($t\tau$) = 1. For B($t\tau$) = 0.5, the limit becomes 1220 GeV. See their Fig. 15b for limits on B($t\tau$) as a function of leptoquark mass. NODE=S056EGT;LINKAGE=RB

[41] SIRUNYAN 21J search for scalar leptoquarks decaying to $t\tau$ and $b\nu$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056EGT;LINKAGE=SB

[42] SIRUNYAN 21J search for vector leptoquarks decaying to $t\nu$ and $b\tau$ in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above assumes κ = 1. If we assume κ = 0, the limit becomes M_{LQ} > 1290 GeV. NODE=S056EGT;LINKAGE=UB

[43] AAD 20AK search for scalar leptoquarks decaying to eq, eb, ec, μq, μb, μc. The quoted limit assumes B(eq) = 1. See their Fig. 9 for limits on B(eq), B(eb), B(ec), B(μq), B(μb), B(μc) as a function of leptoquark mass. NODE=S056EGT;LINKAGE=MB

[44] AAD 20AK search for scalar leptoquarks decaying to eq, eb, ec, μq, μb, μc. The quoted limit assumes B(μq) = 1. See their Fig. 9 for limits on B(eq), B(eb), B(ec), B(μq), B(μb), B(μc) as a function of leptoquark mass. NODE=S056EGT;LINKAGE=NB

[45] AAD 20S search for scalar leptoquarks decaying to $t\nu$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056EGT;LINKAGE=KB

[46] SIRUNYAN 20A search for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$ (q = u, d, s, c). The limit quoted above assumes scalar leptoquark with B(νb) = 1. NODE=S056EGT;LINKAGE=DB

[47] SIRUNYAN 20A search for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$ (q = u, d, s, c). The limit quoted above assumes scalar leptoquark with B(νt) = 1. NODE=S056EGT;LINKAGE=EB

[48] SIRUNYAN 20A search for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$ (q = u, d, s, c). The limit quoted above assumes scalar leptoquark with B(νq) = 1. NODE=S056EGT;LINKAGE=FB

[49] SIRUNYAN 20A search for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$ (q = u, d, s, c). The limit quoted above assumes vector leptoquark with B(νb) = 1 and κ = 1. If we assume κ = 0, the limit becomes M_{LQ} > 1560 GeV. NODE=S056EGT;LINKAGE=GB

[50] SIRUNYAN 20A search for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$ (q = u, d, s, c). The limit quoted above assumes vector leptoquark with B(νt) = 1 and κ = 1. If we assume κ = 0, the limit becomes M_{LQ} > 1475 GeV. NODE=S056EGT;LINKAGE=HB

[51] SIRUNYAN 20A search for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$ (q = u, d, s, c). The limit quoted above assumes vector leptoquark with B(νq) = 1 and κ = 1. If we assume κ = 0, the limit becomes M_{LQ} > 1560 GeV. NODE=S056EGT;LINKAGE=IB

[52] AABOUD 19AX search for leptoquarks using $eejj$ events in pp collisions at $\sqrt{s}$ = 13 TeV. The limit above assumes B(eq) = 1. NODE=S056EGT;LINKAGE=QA

[53] AABOUD 19AX search for leptoquarks using $\mu\mu jj$ events in pp collisions at $\sqrt{s}$ = 13 TeV. The limit above assumes B(μq) = 1. NODE=S056EGT;LINKAGE=RA

[54] AABOUD 19X search for scalar leptoquarks decaying to $t\nu$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056EGT;LINKAGE=SA

[55] AABOUD 19X search for scalar leptoquarks decaying to $b\tau$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056EGT;LINKAGE=UA

[56] AABOUD 19X search for scalar leptoquarks decaying to $b\nu$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056EGT;LINKAGE=WA

[57] AABOUD 19X search for scalar leptoquarks decaying to $t\tau$ in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056EGT;LINKAGE=XA

[58] SIRUNYAN 19BI search for a pair of scalar leptoquarks decaying to $\mu\mu jj$ and to $\mu\nu jj$ final states in pp collisions at $\sqrt{s}$ = 13 TeV. Limits are shown as a function of β where β is the branching fraction to a muon and a quark. For β = 1.0 (0.5) LQ masses up to 1530 (1285) GeV are excluded. See Fig. 9 for exclusion limits in the plane of β and LQ mass. NODE=S056EGT;LINKAGE=ZA

[59] SIRUNYAN 19BJ search for a pair of scalar leptoquarks decaying to $eejj$ and $e\nu jj$ final states in pp collisions at $\sqrt{s}$ = 13 TeV. Limits are shown as a function of the branching fraction β to an electron and a quark. For β = 1.0 (0.5) LQ masses up to 1435 (1270) GeV are excluded. See Fig. 9 for exclusion limits in the plane of β and LQ mass. NODE=S056EGT;LINKAGE=BB

[60] SIRUNYAN 19Y search for a pair of third generation scalar leptoquarks, each decaying to τ and a jet. Assuming B(τb) = 1, leptoquark masses below 1.02 TeV are excluded. NODE=S056EGT;LINKAGE=CB

[61] SIRUNYAN 18CZ search for scalar leptoquarks decaying to τt in pp collisions at $\sqrt{s}$ = 13 TeV. The limit above assumes B(τt) = 1. NODE=S056EGT;LINKAGE=HA

[62] SIRUNYAN 18EC set limits for scalar and vector leptoquarks decaying to μt, τt, and νb. The limit quoted above assumes scalar leptoquark with B(μt) = 1. NODE=S056EGT;LINKAGE=LA

[63] SIRUNYAN 18EC set limits for scalar and vector leptoquarks decaying to μt, τt, and νb. The limit quoted above assumes vector leptoquark with all possible combinations of branching fractions to μt, τt, and νb. NODE=S056EGT;LINKAGE=MA

[64] SIRUNYAN 18U set limits for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$. The limit quoted above assumes scalar leptoquark with B($b\nu$) = 1. Vector leptoquarks with κ = 1 are excluded below masses of 1810 GeV. NODE=S056EGT;LINKAGE=IA

[65] SIRUNYAN 18U set limits for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$. The limit quoted above assumes scalar leptoquark with B($q\nu$) = 1. Vector leptoquarks with κ = 1 are excluded below masses of 1790 GeV. NODE=S056EGT;LINKAGE=JA

[66] SIRUNYAN 18U set limits for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$. The limit quoted above assumes scalar leptoquark with B(νt) = 1. Vector leptoquarks with κ = 1 are excluded below masses of 1780 GeV. NODE=S056EGT;LINKAGE=KA

[67] SIRUNYAN 18U set limits for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$. κ = 1 and LQ$\rightarrow$ $b\nu$ are assumed. NODE=S056EGT;LINKAGE=NA

[68] SIRUNYAN 18U set limits for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$. κ = 1 and LQ$\rightarrow$ $q\nu$ with q = u,d,s,c are assumed. NODE=S056EGT;LINKAGE=OA

[69] SIRUNYAN 18U set limits for scalar and vector leptoquarks decaying to $t\nu$, $b\nu$, and $q\nu$. κ = 1 and LQ$\rightarrow$ $t\nu$ are assumed. NODE=S056EGT;LINKAGE=PA

[70] KHACHATRYAN 17J search for scalar leptoquarks decaying to τb using pp collisions at $\sqrt{s}$ = 13 TeV. The limit above assumes B(τb) = 1. NODE=S056EGT;LINKAGE=FA

[71] SIRUNYAN 17H search for scalar leptoquarks using $\tau\tau bb$ events in pp collisions at $\sqrt{s}$ = 8 TeV. The limit above assumes B(τb) = 1. NODE=S056EGT;LINKAGE=GA

[72] AAD 16G search for scalar leptoquarks using $eejj$ events in collisions at $\sqrt{s}$ = 8 TeV. The limit above assumes $B(eq) = 1$. NODE=S056EGT;LINKAGE=X

[73] AAD 16G search for scalar leptoquarks using $\mu\mu jj$ events in collisions at $\sqrt{s}$ = 8 TeV. The limit above assumes $B(\mu q) = 1$. NODE=S056EGT;LINKAGE=Y

[74] AAD 16G search for scalar leptoquarks decaying to $b\nu$. The limit above assumes $B(b\nu)$ = 1. NODE=S056EGT;LINKAGE=Z

[75] AAD 16G search for scalar leptoquarks decaying to $t\nu$. The limit above assumes $B(t\nu)$ = 1. NODE=S056EGT;LINKAGE=AA

[76] KHACHATRYAN 16AF search for scalar leptoquarks using $eejj$ and $e\nu jj$ events in pp collisions at $\sqrt{s}$ = 8 TeV. The limit above assumes B(eq)= 1. For B(eq) = 0.5, the limit becomes 850 GeV. NODE=S056EGT;LINKAGE=DA

[77] KHACHATRYAN 16AF search for scalar leptoquarks using $\mu\mu jj$ and $\mu\nu jj$ events in pp collisions at $\sqrt{s}$ = 8 TeV. The limit above assumes B(μq) = 1. For B(μq) = 0.5, the limit becomes 760 GeV. NODE=S056EGT;LINKAGE=EA

[78] KHACHATRYAN 15AJ search for scalar leptoquarks using $\tau\tau tt$ events in pp collisions at $\sqrt{s}$ = 8 TeV. The limit above assumes $B(\tau t) = 1$. NODE=S056EGT;LINKAGE=CA

[79] KHACHATRYAN 14T search for scalar leptoquarks decaying to τb using pp collisions at $\sqrt{s}$ = 8 TeV. The limit above assumes B(τb) = 1. See their Fig. 5 for the exclusion limit as function of B(τb). NODE=S056EGT;LINKAGE=W

[80] SIRUNYAN 19BC search for scalar leptoquark (LQ) pair production in pp collisions at $\sqrt{s}$ = 13 TeV. One LQ is assumed to decay to μq, while the other decays to dark matter pair and SM particles. See their Fig. 4 for limits in $M_{\rm LQ}-M_{\rm DM}$ plane. NODE=S056EGT;LINKAGE=YA

[81] AAD 13AE search for scalar leptoquarks using $\tau\tau bb$ events in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above assumes B(τb) = 1. NODE=S056EGT;LINKAGE=V

[82] CHATRCHYAN 13M search for scalar and vector leptoquarks decaying to τb in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above is for scalar leptoquarks with B(τb) = 1. NODE=S056EGT;LINKAGE=T

[83] AAD 12H search for scalar leptoquarks using $eejj$ and $e\nu jj$ events in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above assumes B(eq) = 1. For B(eq) = 0.5, the limit becomes 607 GeV. NODE=S056EGT;LINKAGE=AD

[84] AAD 12O search for scalar leptoquarks using $\mu\mu jj$ and $\mu\nu jj$ events in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above assumes B(μq) = 1. For B(μq) = 0.5, the limit becomes 594 GeV. NODE=S056EGT;LINKAGE=U

[85] CHATRCHYAN 12AG search for scalar leptoquarks using $eejj$ and $e\nu jj$ events in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above assumes B(eq) = 1. For B(eq) = 0.5, the limit becomes 640 GeV. NODE=S056EGT;LINKAGE=Q

[86] CHATRCHYAN 12AG search for scalar leptoquarks using $\mu\mu jj$ and $\mu\nu jj$ events in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above assumes B(μq) = 1. For B(μq) = 0.5, the limit becomes 650 GeV. NODE=S056EGT;LINKAGE=R

[87] CHATRCHYAN 12BO search for scalar leptoquarks decaying to νb in pp collisions at $\sqrt{s}$ = 7 TeV. The limit above assumes B(νb) = 1. NODE=S056EGT;LINKAGE=S

[88] AAD 11D search for scalar leptoquarks using $eejj$ and $e\nu jj$ events in pp collisions at $E_{\rm cm}$ = 7 TeV.The limit above assumes B(eq) = 1. For B(eq) = 0.5, the limit becomes 319 GeV. NODE=S056EGT;LINKAGE=J

[89] AAD 11D search for scalar leptoquarks using $\mu\mu jj$ and $\mu\nu jj$ events in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above assumes B(μq) = 1. For B(μq) = 0.5, the limit becomes 362 GeV. NODE=S056EGT;LINKAGE=K

[90] ABAZOV 11V search for scalar leptoquarks using $e\nu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. The limit above assumes B(eq) = 0.5. NODE=S056EGT;LINKAGE=M

[91] CHATRCHYAN 11N search for scalar leptoquarks using $e\nu jj$ events in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above assumes B(eq) = 0.5. NODE=S056EGT;LINKAGE=N

[92] KHACHATRYAN 11D search for scalar leptoquarks using $eejj$ events in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above assumes B(eq) = 1. NODE=S056EGT;LINKAGE=O

[93] KHACHATRYAN 11E search for scalar leptoquarks using $\mu\mu jj$ events in pp collisions at $E_{\rm cm}$ = 7 TeV. The limit above assumes B(μq) = 1. NODE=S056EGT;LINKAGE=P

[94] ABAZOV 10L search for pair productions of scalar leptoquark state decaying to νb in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. The limit above assumes B(νb) = 1. NODE=S056EGT;LINKAGE=ZV

[95] ABAZOV 09 search for scalar leptoquarks using $\mu\mu jj$ and $\mu\nu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. The limit above assumes B(μq) = 1. For B(μq) = 0.5, the limit becomes 270 GeV. NODE=S056EGT;LINKAGE=OV

[96] ABAZOV 09AF search for scalar leptoquarks using $eejj$ and $e\nu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. The limit above assumes B(eq) = 1. For B(eq) = 0.5 the bound becomes 284 GeV. NODE=S056EGT;LINKAGE=BZ

[97] AALTONEN 08P search for vector leptoquarks using $\tau^+\tau^- b\overline{b}$ events in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. Assuming Yang-Mills (minimal) couplings, the mass limit is >317 GeV (251 GeV) at 95% CL for B(τb) = 1. NODE=S056EGT;LINKAGE=AN

[98] Search for pair production of scalar leptoquark state decaying to τb in $p\overline{p}$ collisions at $E_{\rm cm}$= 1.96 TeV. The limit above assumes B(τb) = 1. NODE=S056EGT;LINKAGE=LT

[99] Search for scalar leptoquarks using $\nu\nu jj$ events in $\overline{p}p$ collisions at $E_{\rm cm}$ = 1.96 TeV. The limit above assumes B(νq) = 1. NODE=S056EGT;LINKAGE=AC

[100] ABAZOV 07J search for pair productions of scalar leptoquark state decaying to νb in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. The limit above assumes B(νb) = 1. NODE=S056EGT;LINKAGE=BA

[101] ABAZOV 06A search for scalar leptoquarks using $\mu\mu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.8 TeV and 1.96 TeV. The limit above assumes B(μq) = 1. For B(μq) = 0.5, the limit becomes 204 GeV. NODE=S056EGT;LINKAGE=AV

[102] ABAZOV 06L search for scalar leptoquarks using $\nu\nu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.8 TeV and at 1.96 TeV. The limit above assumes B(νq) = 1. NODE=S056EGT;LINKAGE=VA

[103] ABULENCIA 06T search for scalar leptoquarks using $\mu\mu jj$, $\mu\nu jj$, and $\nu\nu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. The quoted limit assumes B(μq) = 1. For B(μq) = 0.5 or 0.1, the bound becomes 208 GeV or 143 GeV, respectively. See their Fig. 4 for the exclusion limit as a function of B(μq). NODE=S056EGT;LINKAGE=UL

[104] ABAZOV 05H search for scalar leptoquarks using $eejj$ and $e\nu jj$ events in $\overline{p}p$ collisions at $E_{\rm cm}$ = 1.8 TeV and 1.96 TeV. The limit above assumes B(eq) = 1. For B(eq) = 0.5 the bound becomes 234 GeV. NODE=S056EGT;LINKAGE=AZ

[105] ACOSTA 05P search for scalar leptoquarks using $eejj$, $e\nu jj$ events in $\overline{p}p$ collisions at $E_{\rm cm}$ = 1.96TeV. The limit above assumes B(eq) = 1. For B(eq) = 0.5 and 0.1, the bound becomes 205 GeV and 145 GeV, respectively. NODE=S056EGT;LINKAGE=AO

[106] ABBIENDI 03R search for scalar/vector leptoquarks in e^+e^- collisions at $\sqrt{s}$ = 189–209 GeV. The quoted limits are for charge $-4/3$ isospin 0 scalar-leptoquark with B(ℓq) = 1. See their table 12 for other cases. NODE=S056EGT;LINKAGE=AB

[107] ABAZOV 02 search for scalar leptoquarks using $\nu\nu jj$ events in $\overline{p}p$ collisions at $E_{\rm cm}$=1.8 TeV. The bound holds for all leptoquark generations. Vector leptoquarks are likewise constrained to lie above 200 GeV. NODE=S056EGT;LINKAGE=BK

[108] ABAZOV 01D search for scalar leptoquarks using $e\nu jj$, $eejj$, and $\nu\nu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$=1.8 TeV. The limit above assumes B(eq)=1. For B(eq)=0.5 and 0, the bound becomes 204 and 79 GeV, respectively. Bounds for vector leptoquarks are also given. Supersedes ABBOTT 98E. NODE=S056EGT;LINKAGE=ZE

[109] ABBIENDI 00M search for scalar/vector leptoquarks in e^+e^- collisions at $\sqrt{s}$=183 GeV. The quoted limits are for charge $-4/3$ isospin 0 scalar-leptoquarks with B(ℓq)=1. See their Table 8 and Figs. 6–9 for other cases. NODE=S056EGT;LINKAGE=TM

[110] ABBOTT 00C search for scalar leptoquarks using $\mu\mu jj$, $\mu\nu jj$, and $\nu\nu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$=1.8 TeV. The limit above assumes B(μq)=1. For B(μq)=0.5 and 0, the bound becomes 180 and 79 GeV respectively. Bounds for vector leptoquarks are also given. NODE=S056EGT;LINKAGE=GC

[111] AFFOLDER 00K search for scalar leptoquark using $\nu\nu cc$ events in $p\overline{p}$ collisions at $E_{\rm cm}$=1.8 TeV. The quoted limit assumes B(νc)=1. Bounds for vector leptoquarks are also given. NODE=S056EGT;LINKAGE=KI

[112] AFFOLDER 00K search for scalar leptoquark using $\nu\nu bb$ events in $p\overline{p}$ collisions at $E_{\rm cm}$=1.8 TeV. The quoted limit assumes B(νb)=1. Bounds for vector leptoquarks are also given. NODE=S056EGT;LINKAGE=KL

[113] ABBOTT 99J search for leptoquarks using $\mu\nu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$= 1.8TeV. The quoted limit is for a scalar leptoquark with B(μq) = B(νq) = 0.5. Limits on vector leptoquarks range from 240 to 290 GeV. NODE=S056EGT;LINKAGE=JB

[114] ABBOTT 98E search for scalar leptoquarks using $e\nu jj$, $eejj$, and $\nu\nu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$=1.8 TeV. The limit above assumes B(eq)=1. For B(eq)=0.5 and 0, the bound becomes 204 and 79 GeV, respectively. NODE=S056EGT;LINKAGE=LB

[115] ABBOTT 98J search for charge $-1/3$ third generation scalar and vector leptoquarks in $p\overline{p}$ collisions at $E_{\rm cm}$= 1.8 TeV. The quoted limit is for scalar leptoquark with B(νb)=1. NODE=S056EGT;LINKAGE=AJ

[116] ABE 98S search for scalar leptoquarks using $\mu\mu jj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$= 1.8 TeV. The limit is for B(μq)= 1. For B(μq)=B(νq)=0.5, the limit is > 160 GeV. NODE=S056EGT;LINKAGE=TG

[117] GROSS-PILCHER 98 is the combined limit of the CDF and DØ Collaborations as determined by a joint CDF/DØ working group and reported in this FNAL Technical Memo. Original data published in ABE 97X and ABBOTT 98E. NODE=S056EGT;LINKAGE=GP

[118] ABE 97F search for third generation scalar and vector leptoquarks in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.8 TeV. The quoted limit is for scalar leptoquark with B(τb) = 1. NODE=S056EGT;LINKAGE=GH

[119] ABE 97X search for scalar leptoquarks using $eejj$ events in $p\overline{p}$ collisions at $E_{\rm cm}$=1.8 TeV. The limit is for B(eq)=1. NODE=S056EGT;LINKAGE=L

[120] Limit is for charge $-1/3$ isospin-0 leptoquark with B(ℓq) = 2/3. NODE=S056EGT;LINKAGE=TA

[121] First and second generation leptoquarks are assumed to be degenerate. The limit is slightly lower for each generation. NODE=S056EGT;LINKAGE=TB

[122] Limits are for charge $-1/3$, isospin-0 scalar leptoquarks decaying to $\ell^- q$ or νq with any branching ratio. See paper for limits for other charge-isospin assignments of leptoquarks. NODE=S056EGT;LINKAGE=F

[123] KIM 90 assume pair production of charge 2/3 scalar-leptoquark via photon exchange. The decay of the first (second) generation leptoquark is assumed to be any mixture of de^+ and $u\overline{\nu}$ ($s\mu^+$ and $c\overline{\nu}$). See paper for limits for specific branching ratios. NODE=S056EGT;LINKAGE=E

[124] BARTEL 87B limit is valid when a pair of charge 2/3 spinless leptoquarks X is produced with point coupling, and when they decay under the constraint B(X $\rightarrow$ $c\overline{\nu}_\mu$) + B(X $\rightarrow$ $s\mu^+$) = 1. NODE=S056EGT;LINKAGE=C

[125] BEHREND 86B assumed that a charge 2/3 spinless leptoquark, χ, decays either into $s\mu^+$ or $c\overline{\nu}$: B($\chi \rightarrow$ $s\mu^+$) + B($\chi \rightarrow$ $c\overline{\nu}$) = 1. NODE=S056EGT;LINKAGE=D

MASS LIMITS for Leptoquarks from Single Production

NODE=S056ESP

These limits depend on the q-ℓ-leptoquark coupling g_{LQ}. It is often assumed that $g^2_{LQ}/4\pi$=1/137. Limits shown are for a scalar, weak isoscalar, charge −1/3 leptoquark.

NODE=S056ESP

NODE=S056ESP

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT	
> 3.400 × 10^3 (CL = 95%) [>1.755 × 10^3 GeV (CL = 95%) OUR 2025 BEST LIMIT]						
>3400	95	[1] AAD	25BN	ATLS	$g_{de}=1$	
>2050	95	[2] HAYRAPETY...	24C	CMS	$B(u\tau)=1$	
>1800	95	[3] HAYRAPETY...	24C	CMS	$B(d\tau)=1$	OCCUR=2
> 780	95	[4] HAYRAPETY...	24Z	CMS	Third generation	
>1280	95	[5] AAD	23BZ	ATLS	LQ → $b\tau$	
> 550	95	[6] SIRUNYAN	21J	CMS	Third generation	
none 150–740	95	[7] SIRUNYAN	18BJ	CMS	Third generation	
>1755	95	[8] KHACHATRY...	16AG	CMS	First generation	
> 660	95	[9] KHACHATRY...	16AG	CMS	Second generation	OCCUR=2
> 304	95	[10] ABRAMOWICZ	12A	ZEUS	First generation	
> 73	95	[11] ABREU	93J	DLPH	Second generation	OCCUR=3
• • • We do not use the following data for averages, fits, limits, etc. • • •						
		[12] AAD	22E	ATLS	LQ → ue^-, $c\mu^-$	
		[13] TUMASYAN	21D	CMS	First generation	
		[14] DEY	16	ICCB	νq → LQ → νq	
		[15] AARON	11A	H1	Lepton-flavor violation	OCCUR=2
> 300	95	[16] AARON	11B	H1	First generation	
		[17] ABAZOV	07E	D0	Second generation	
> 295	95	[18] AKTAS	05B	H1	First generation	
		[19] CHEKANOV	05A	ZEUS	Lepton-flavor violation	
> 298	95	[20] CHEKANOV	03B	ZEUS	First generation	
> 197	95	[21] ABBIENDI	02B	OPAL	First generation	
		[22] CHEKANOV	02	ZEUS	Repl. by CHEKANOV 05A	
> 290	95	[23] ADLOFF	01C	H1	First generation	
> 204	95	[24] BREITWEG	01	ZEUS	First generation	
		[25] BREITWEG	00E	ZEUS	First generation	
> 161	95	[26] ABREU	99G	DLPH	First generation	
> 200	95	[27] ADLOFF	99	H1	First generation	
		[28] DERRICK	97	ZEUS	Lepton-flavor violation	
> 168	95	[29] DERRICK	93	ZEUS	First generation	

[1] AAD 25BN search for single production of a scalar leptoquark in pp collisions at $\sqrt{s}=$ 13 TeV and at $\sqrt{s}=13.6$ TeV. The quoted limit assumes leptoquark production in de collisions with coupling strength $g_{de}=1$. Masses below 3.1 TeV, 4.3 TeV, and 2.8 TeV are excluded at 95% CL for $g_{be}=3.5$, $g_{s\mu}=3.5$ and $g_{b\mu}=3.5$, respectively. See their Figs. 14–17 for exclusion limits in mass-coupling plane. NODE=S056ESP;LINKAGE=S

[2] HAYRAPETYAN 24C search for single production of scalar leptoquarks decaying to $q\tau^+$ ($q=u$, d, s, b) in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is for a leptoquark produced in τu collisions and the leptoquark coupling strength $\lambda=1$. See their Fig. 4 for limits in mass-coupling plane. NODE=S056ESP;LINKAGE=P

[3] HAYRAPETYAN 24C search for single production of scalar leptoquarks decaying to $q\tau^+$ ($q=u$, d, s, b) in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is for a leptoquark produced in τd collisions and the leptoquark coupling strength $\lambda=1$. See their Fig. 4 for limits in mass-coupling plane. NODE=S056ESP;LINKAGE=Q

[4] HAYRAPETYAN 24Z search for scalar and vector leptoquarks decaying to $b\tau$ and produced through single, pair, and nonresonantly in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above is derived solely from single production limit and assumes scalar leptoquark decaying to $b\tau$. The leptoquark coupling strength $\lambda=1$ is assumed. See their Fig. 7 and Fig. 8 for combined limits in mass-coupling plane. NODE=S056ESP;LINKAGE=R

[5] AAD 23BZ search for single production of charge 4/3 scalar leptoquarks decaying to $b\tau^-$, and charge 2/3 vector leptoquarks decaying to $\overline{b}\tau^-$ in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above assumes a scalar leptoquark with $B(b\tau)=1$ and the leptoquark coupling strength $\lambda=1.0$. The limit becomes M_{LQ} > 1530 GeV for $\lambda=2.5$. NODE=S056ESP;LINKAGE=O

[6] SIRUNYAN 21J search for single production of charge −1/3 scalar leptoquarks decaying to $t\tau^-$ and $b\nu$, and charge 2/3 vector leptoquarks decaying to $t\nu$ and $b\tau^+$ in pp collisions at $\sqrt{s}=13$ TeV. The limit quoted above assumes a scalar leptoquark with $B(t\tau)=B(b\nu)=0.5$ and the leptoquark coupling strength $\lambda=1.5$. The limit becomes M_{LQ} > 750 GeV for $\lambda=2.5$. NODE=S056ESP;LINKAGE=L

[7] SIRUNYAN 18BJ search for single production of charge 2/3 scalar leptoquarks decaying to τb in pp collisions at $\sqrt{s}=13$ TeV. The limit above assumes $B(\tau b)=1$ and the leptoquark coupling strength $\lambda=1$. NODE=S056ESP;LINKAGE=K

[8] KHACHATRYAN 16AG search for single production of charge ±1/3 scalar leptoquarks using eej events in pp collisions at $\sqrt{s}=8$ TeV. The limit above assumes $B(eq)=1$ and the leptoquark coupling strength $\lambda=1$. NODE=S056ESP;LINKAGE=I

[9] KHACHATRYAN 16AG search for single production of charge $\pm1/3$ scalar leptoquarks using $\mu\mu j$ events in pp collisions at $\sqrt{s}=8$ TeV. The limit above assumes $B(\mu q)=1$ and the leptoquark coupling strength $\lambda=1$. NODE=S056ESP;LINKAGE=J

[10] ABRAMOWICZ 12A limit is for a scalar, weak isoscalar, charge $-1/3$ leptoquark coupled with e_R. See their Figs. 12–17 and Table 4 for states with different quantum numbers. NODE=S056ESP;LINKAGE=F

[11] Limit from single production in Z decay. The limit is for a leptoquark coupling of electromagnetic strength and assumes $B(\ell q)=2/3$. The limit is 77 GeV if first and second leptoquarks are degenerate. NODE=S056ESP;LINKAGE=TC

[12] AAD 22E leptoquarks decaying both to ue^- and $c\mu^-$ are constrained from the comparison of the production cross sections for $e^+\mu^-$ and $e^-\mu^+$ in pp collisions at $\sqrt{s}=$ 13 TeV. Scalar leptoquarks with $M_{LQ}<1880$ GeV are excluded for $g^{eu}=g^{\mu c}=1$. NODE=S056ESP;LINKAGE=N

[13] TUMASYAN 21D search for energetic jets + $\not\!\!E_T$ events in pp collisions at $\sqrt{s}=13$ TeV. The branching fraction for the decay of the leptoquark into an electron neutrino and up quark is assumed to be 100% ($\beta=0$). See their Fig. 12 for exclusion limits in mass-coupling plane. NODE=S056ESP;LINKAGE=M

[14] DEY 16 use the 2010-2012 IceCube PeV energy data set to constrain the leptoquark production cross section through the $\nu q \to$ LQ $\to \nu q$ process. See their Figure 4 for the exclusion limit in the mass-coupling plane. NODE=S056ESP;LINKAGE=H

[15] AARON 11A search for various leptoquarks with lepton-flavor violating couplings. See their Figs. 2–3 and Tables 1–4 for detailed limits. NODE=S056ESP;LINKAGE=D

[16] The quoted limit is for a scalar, weak isoscalar, charge $-1/3$ leptoquark coupled with e_R. See their Figs. 3–5 for limits on states with different quantum numbers. NODE=S056ESP;LINKAGE=E

[17] ABAZOV 07E search for leptoquark single production through qg fusion process in $p\overline{p}$ collisions. See their Fig. 4 for exclusion plot in mass-coupling plane. NODE=S056ESP;LINKAGE=AB

[18] AKTAS 05B limit is for a scalar, weak isoscalar, charge $-1/3$ leptoquark coupled with e_R. See their Fig. 3 for limits on states with different quantum numbers. NODE=S056ESP;LINKAGE=AK

[19] CHEKANOV 05 search for various leptoquarks with lepton-flavor violating couplings. See their Figs.6–10 and Tables 1–8 for detailed limits. NODE=S056ESP;LINKAGE=CH

[20] CHEKANOV 03B limit is for a scalar, weak isoscalar, charge $-1/3$ leptoquark coupled with e_R. See their Figs. 11–12 and Table 5 for limits on states with different quantum numbers. NODE=S056ESP;LINKAGE=PS

[21] For limits on states with different quantum numbers and the limits in the mass-coupling plane, see their Fig. 4 and Fig. 5. NODE=S056ESP;LINKAGE=B6

[22] CHEKANOV 02 search for various leptoquarks with lepton-flavor violating couplings. See their Figs. 6–7 and Tables 5–6 for detailed limits. NODE=S056ESP;LINKAGE=SE

[23] For limits on states with different quantum numbers and the limits in the mass-coupling plane, see their Fig. 3. NODE=S056ESP;LINKAGE=FE

[24] See their Fig. 14 for limits in the mass-coupling plane. NODE=S056ESP;LINKAGE=WB

[25] BREITWEG 00E search for F=0 leptoquarks in e^+p collisions. For limits in mass-coupling plane, see their Fig. 11. NODE=S056ESP;LINKAGE=FP

[26] ABREU 99G limit obtained from process $e\gamma \to LQ+q$. For limits on vector and scalar states with different quantum numbers and the limits in the coupling-mass plane, see their Fig. 4 and Table 2. NODE=S056ESP;LINKAGE=GS

[27] For limits on states with different quantum numbers and the limits in the mass-coupling plane, see their Fig. 13 and Fig. 14. ADLOFF 99 also search for leptoquarks with lepton-flavor violating couplings. ADLOFF 99 supersedes AID 96B. NODE=S056ESP;LINKAGE=DF

[28] DERRICK 97 search for various leptoquarks with lepton-flavor violating couplings. See their Figs. 5–8 and Table 1 for detailed limits. NODE=S056ESP;LINKAGE=Z1

[29] DERRICK 93 search for single leptoquark production in ep collisions with the decay eq and νq. The limit is for leptoquark coupling of electromagnetic strength and assumes $B(eq)=B(\nu q)=1/2$. The limit for $B(eq)=1$ is 176 GeV. For limits on states with different quantum numbers, see their Table 3. NODE=S056ESP;LINKAGE=K3

Indirect Limits for Leptoquarks

NODE=S056LQI
NODE=S056LQI

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE (TeV)	CL%	DOCUMENT ID		TECN	COMMENT
		[1] AAD	25BB	ATLS	$b\overline{b} \to \tau^+\tau^-$, $gb \to \tau^+\tau^- b$
		[2] HAYRAPETY...	25AN	CMS	$pp \to e^+e^-$, $\mu^+\mu^-$
		[3] AAD	24W	ATLS	$\mu\tau q t$ ($q=u$, c)
		[4] CALABRESE	23	RVUE	ν-nucleus scattering
		[5] TUMASYAN	23AW	CMS	$q\overline{q}' \to \tau\nu$
		[6] TUMASYAN	23S	CMS	$pp \to \tau\tau$
		[7] CRIVELLIN	21A	RVUE	First generation
		[8] AEBISCHER	20	RVUE	B decays
		[9] DEPPISCH	20	RVUE	$K \to \pi\nu\nu$
$>$ 3.1	95	[10] ABRAMOWICZ	19	ZEUS	First generation
		[11] MANDAL	19	RVUE	τ, μ, e, K
		[12] ZHANG	18A	RVUE	D decays
		[13] BARRANCO	16	RVUE	D decays
		[14] KUMAR	16	RVUE	neutral K mixing, rare K decays
		[15] BESSAA	15	RVUE	$q\overline{q} \to e^+e^-$
$>$ 14	95	[16] SAHOO	15A	RVUE	$B_{s,d} \to \mu^+\mu^-$

		[17] SAKAKI	13	RVUE	$B \to D^{(*)}\tau\overline{\nu}$, $B \to X_s \nu\overline{\nu}$
		[18] KOSNIK	12	RVUE	$b \to s\ell^+\ell^-$
> 2.5	95	[19] AARON	11C	H1	First generation
		[20] DORSNER	11	RVUE	scalar, weak singlet, charge 4/3
		[21] AKTAS	07A	H1	Lepton-flavor violation
> 0.49	95	[22] SCHAEL	07A	ALEP	$e^+e^- \to q\overline{q}$
		[23] SMIRNOV	07	RVUE	$K \to e\mu$, $B \to e\tau$
		[24] CHEKANOV	05A	ZEUS	Lepton-flavor violation
> 1.7	96	[25] ADLOFF	03	H1	First generation
> 46	90	[26] CHANG	03	BELL	Pati-Salam type
		[27] CHEKANOV	02	ZEUS	Repl. by CHEKANOV 05A
> 1.7	95	[28] CHEUNG	01B	RVUE	First generation
> 0.39	95	[29] ACCIARRI	00P	L3	$e^+e^- \to qq$
> 1.5	95	[30] ADLOFF	00	H1	First generation
> 0.2	95	[31] BARATE	00I	ALEP	Repl. by SCHAEL 07A
		[32] BARGER	00	RVUE	Cs
		[33] GABRIELLI	00	RVUE	Lepton flavor violation
> 0.74	95	[34] ZARNECKI	00	RVUE	S_1 leptoquark
		[35] ABBIENDI	99	OPAL	
> 19.3	95	[36] ABE	98V	CDF	$B_s \to e^\pm\mu^\mp$, Pati-Salam type
		[37] ACCIARRI	98J	L3	$e^+e^- \to q\overline{q}$
		[38] ACKERSTAFF	98V	OPAL	$e^+e^- \to q\overline{q}$, $e^+e^- \to b\overline{b}$
> 0.76	95	[39] DEANDREA	97	RVUE	$\widetilde{R}_2$ leptoquark
		[40] DERRICK	97	ZEUS	Lepton-flavor violation
		[41] GROSSMAN	97	RVUE	$B \to \tau^+\tau^-$ (X)
		[42] JADACH	97	RVUE	$e^+e^- \to q\overline{q}$
>1200		[43] KUZNETSOV	95B	RVUE	Pati-Salam type
		[44] MIZUKOSHI	95	RVUE	Third generation scalar leptoquark
> 0.3	95	[45] BHATTACH...	94	RVUE	Spin-0 leptoquark coupled to $\overline{e}_R t_L$
		[46] DAVIDSON	94	RVUE	
> 18		[47] KUZNETSOV	94	RVUE	Pati-Salam type
> 0.43	95	[48] LEURER	94	RVUE	First generation spin-1 leptoquark
> 0.44	95	[48] LEURER	94B	RVUE	First generation spin-0 leptoquark
		[49] MAHANTA	94	RVUE	P and T violation
> 1		[50] SHANKER	82	RVUE	Nonchiral spin-0 leptoquark
> 125		[50] SHANKER	82	RVUE	Nonchiral spin-1 leptoquark

OCCUR=2
OCCUR=3

[1] AAD 25BB search for $\tau^+\tau^-$ production from t-channel LQ exchange in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 11 and Fig. 12 for limits in mass-coupling plane. NODE=S056LQI;LINKAGE=IA

[2] HAYRAPETYAN 25AN use e^+e^- and $\mu^+\mu^-$ spectra in pp collisions at $\sqrt{s}$ = 13 TeV to set limits on t-channel LQ exchange amplitudes. See their Figs. 7–10 for limits in mass-coupling plane. NODE=S056LQI;LINKAGE=JA

[3] AAD 24W search for leptoquark induced $\mu\tau q t$ ($q = u$, c) contact interaction in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 7b for limits in mass-coupling plane. NODE=S056LQI;LINKAGE=GA

[4] CALABRESE 23 obtain limits on leptoquark coupling from coherent ν-nucleus scattering data collected by COHERENT experiment. See their Fig. 3 for limits in mass-coupling plane. NODE=S056LQI;LINKAGE=DA

[5] TUMASYAN 23AW search for $\tau\nu$ events mediated by t-channel leptoquark exchange in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 10 for limits in mass-coupling plane. NODE=S056LQI;LINKAGE=FA

[6] TUMASYAN 23S search for leptoquark induced $b\overline{b} \to \tau^+\tau^-$ process in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 12 for limits on a vector $b\tau$ leptoquark in mass-coupling plane. NODE=S056LQI;LINKAGE=EA

[7] CRIVELLIN 21A set limits on coupling strengths of scalar and vector leptoquarks using $K \to \pi\nu\nu$, $K \to \pi e^+e^-$, $K^0 - \overline{K}^0$ and $D^0 - \overline{D}^0$ mixings, and weak neutral current measurements. See their Fig. 2 and Fig. 3 for the limits in mass-coupling plane. NODE=S056LQI;LINKAGE=BA

[8] AEBISCHER 20 explain the B decay anomalies using four-fermion operator Wilson coefficents. See their Table 1. These Wilson coefficients may be generated by a U_1 vector leptoquark with U_1 transforming as $(3,1)_{2/3}$ under the SM gauge group. See their Figures 6, 7, 8 for the regions of the LQ parameter space which explains the B anomalies and avoids the indirect low energy constraints. NODE=S056LQI;LINKAGE=Z

[9] DEPPISCH 20 limits on the lepton-number-violating higher-dimensional-operators are derived from $K \to \pi\nu\nu$ in the standard model effective field theory. These higher-dimensional-operators may be induced from leptoquark-exchange diagrams. NODE=S056LQI;LINKAGE=AA

[10] ABRAMOWICZ 19 obtain a limit on $\lambda/M_{LQ} > 1.16$ TeV^{-1} for weak isotriplet spin-0 leptoquark S_1^L. We obtain the limit quoted above by converting the limit on λ/M_{LQ} for S_1^L assuming $\lambda = \sqrt{4\pi}$. See their Table 5 for the limits of leptoquarks with different quantum numbers. These limits are derived from bounds of eq contact interactions. NODE=S056LQI;LINKAGE=X

[11] MANDAL 19 give bounds on leptoquarks from τ-decays, leptonic dipole moments, lepton-flavor-violating processes, and K decays. NODE=S056LQI;LINKAGE=Y

[12] ZHANG 18A give bounds on leptoquark induced four-fermion interactions from $D \to K\ell\nu$. The authors inform us that the shape parameter of the vector form factor in both NODE=S056LQI;LINKAGE=W

the abstract and the conclusions of ZHANG 18A should be $r_{+1} = 2.16 \pm 0.07$ rather than ± 0.007. The numbers listed in their Table 7 are correct.

[13] BARRANCO 16 give bounds on leptoquark induced four-fermion interactions from $D \to K \ell \nu$ and $D_s \to \ell \nu$. NODE=S056LQI;LINKAGE=V

[14] KUMAR 16 gives bound on SU(2) singlet scalar leptoquark with chrge $-1/3$ from $K^0 - \overline{K}^0$ mixing, $K \to \pi \nu \overline{\nu}$, $K^0_L \to \mu^+ \mu^-$, and $K^0_L \to \mu^\pm e^\mp$ decays. NODE=S056LQI;LINKAGE=U

[15] BESSAA 15 obtain limit on leptoquark induced four-fermion interactions from the ATLAS and CMS limit on the $\overline{q} q \overline{e} e$ contact interactions. NODE=S056LQI;LINKAGE=S

[16] SAHOO 15A obtain limit on leptoquark induced four-fermion interactions from $B_{s,d} \to \mu^+ \mu^-$ for $\lambda \simeq O(1)$. NODE=S056LQI;LINKAGE=T

[17] SAKAKI 13 explain the $B \to D^{(*)} \tau \overline{\nu}$ anomaly using Wilson coefficients of leptoquark-induced four-fermion operators. NODE=S056LQI;LINKAGE=R

[18] KOSNIK 12 obtains limits on leptoquark induced four-fermion interactions from $b \to s \ell^+ \ell^-$ decays. NODE=S056LQI;LINKAGE=Q

[19] AARON 11C limit is for weak isotriplet spin-0 leptoquark at strong coupling $\lambda = \sqrt{4\pi}$. For the limits of leptoquarks with different quantum numbers, see their Table 3. Limits are derived from bounds of $e q$ contact intereractions. NODE=S056LQI;LINKAGE=P

[20] DORSNER 11 give bounds on scalar, weak singlet, charge 4/3 leptoquark from K, B, τ decays, meson mixings, LFV, $g-2$ and $Z \to b\overline{b}$. NODE=S056LQI;LINKAGE=N

[21] AKTAS 07A search for lepton-flavor violation in $e p$ collision. See their Tables 4–7 for limits on lepton-flavor violating four-fermion interactions induced by various leptoquarks. NODE=S056LQI;LINKAGE=AK

[22] SCHAEL 07A limit is for the weak-isoscalar spin-0 left-handed leptoquark with the coupling of electromagnetic strength. For the limits of leptoquarks with different quantum numbers, see their Table 35. NODE=S056LQI;LINKAGE=SC

[23] SMIRNOV 07 obtains mass limits for the vector and scalar chiral leptoquark states from $K \to e \mu$, $B \to e \tau$ decays. NODE=S056LQI;LINKAGE=SM

[24] CHEKANOV 05 search for various leptoquarks with lepton-flavor violating couplings. See their Figs.6–10 and Tables 1–8 for detailed limits. NODE=S056LQI;LINKAGE=CH

[25] ADLOFF 03 limit is for the weak isotriplet spin-0 leptoquark at strong coupling $\lambda=\sqrt{4\pi}$. For the limits of leptoquarks with different quantum numbers, see their Table 3. Limits are derived from bounds on $e^\pm q$ contact interactions. NODE=S056LQI;LINKAGE=QL

[26] The bound is derived from $B(B^0 \to e^\pm \mu^\mp) < 1.7 \times 10^{-7}$. NODE=S056LQI;LINKAGE=CA

[27] CHEKANOV 02 search for lepton-flavor violation in $e p$ collisions. See their Tables 1–4 for limits on lepton-flavor violating and four-fermion interactions induced by various leptoquarks. NODE=S056LQI;LINKAGE=SE

[28] CHEUNG 01B quoted limit is for a scalar, weak isoscalar, charge $-1/3$ leptoquark with a coupling of electromagnetic strength. The limit is derived from bounds on contact interactions in a global electroweak analysis. For the limits of leptoquarks with different quantum numbers, see Table 5. NODE=S056LQI;LINKAGE=QK

[29] ACCIARRI 00P limit is for the weak isoscalar spin-0 leptoquark with the coupling of electromagnetic strength. For the limits of leptoquarks with different quantum numbers, see their Table 4. NODE=S056LQI;LINKAGE=QQ

[30] ADLOFF 00 limit is for the weak isotriplet spin-0 leptoquark at strong coupling, $\lambda=\sqrt{4\pi}$. For the limits of leptoquarks with different quantum numbers, see their Table 2. ADLOFF 00 limits are from the Q^2 spectrum measurement of $e^+ p \to e^+ X$. NODE=S056LQI;LINKAGE=QI

[31] BARATE 00I search for deviations in cross section and jet-charge asymmetry in $e^+ e^- \to \overline{q} q$ due to t-channel exchange of a leptoquark at $\sqrt{s}$=130 to 183 GeV. Limits for other scalar and vector leptoquarks are also given in their Table 22. NODE=S056LQI;LINKAGE=BI

[32] BARGER 00 explain the deviation of atomic parity violation in cesium atoms from prediction is explained by scalar leptoquark exchange. NODE=S056LQI;LINKAGE=CS

[33] GABRIELLI 00 calculate various process with lepton flavor violation in leptoquark models. NODE=S056LQI;LINKAGE=QS

[34] ZARNECKI 00 limit is derived from data of HERA, LEP, and Tevatron and from various low-energy data including atomic parity violation. Leptoquark coupling with electromagnetic strength is assumed. NODE=S056LQI;LINKAGE=RK

[35] ABBIENDI 99 limits are from $e^+ e^- \to q \overline{q}$ cross section at 130–136, 161–172, 183 GeV. See their Fig. 8 and Fig. 9 for limits in mass-coupling plane. NODE=S056LQI;LINKAGE=BL

[36] ABE 98V quoted limit is from $B(B_s \to e^\pm \mu^\mp) < 8.2 \times 10^{-6}$. ABE 98V also obtain a similar limit on $M_{LQ} > 20.4$ TeV from $B(B_d \to e^\pm \mu^\mp) < 4.5 \times 10^{-6}$. Both bounds assume the non-canonical association of the b quark with electrons or muons under SU(4). NODE=S056LQI;LINKAGE=LV

[37] ACCIARRI 98J limit is from $e^+ e^- \to q \overline{q}$ cross section at $\sqrt{s}$= 130–172 GeV which can be affected by the t- and u-channel exchanges of leptoquarks. See their Fig. 4 and Fig. 5 for limits in the mass-coupling plane. NODE=S056LQI;LINKAGE=M

[38] ACKERSTAFF 98V limits are from $e^+ e^- \to q \overline{q}$ and $e^+ e^- \to b \overline{b}$ cross sections at $\sqrt{s}$ = 130–172 GeV, which can be affected by the t- and u-channel exchanges of leptoquarks. See their Fig. 21 and Fig. 22 for limits of leptoquarks in mass-coupling plane. NODE=S056LQI;LINKAGE=VA

[39] DEANDREA 97 limit is for $\widetilde{R}_2$ leptoquark obtained from atomic parity violation (APV). The coupling of leptoquark is assumed to be electromagnetic strength. See Table 2 for limits of the four-fermion interactions induced by various scalar leptoquark exchange. DEANDREA 97 combines APV limit and limits from Tevatron and HERA. See Fig. 1–4 for combined limits of leptoquark in mass-coupling plane. NODE=S056LQI;LINKAGE=LD

[40] DERRICK 97 search for lepton-flavor violation in $e p$ collision. See their Tables 2–5 for limits on lepton-flavor violating four-fermion interactions induced by various leptoquarks. NODE=S056LQI;LINKAGE=Z1

[41] GROSSMAN 97 estimate the upper bounds on the branching fraction $B \to \tau^+ \tau^-$ (X) from the absence of the B decay with large missing energy. These bounds can be used to constrain leptoquark induced four-fermion interactions. NODE=S056LQI;LINKAGE=K

[42] JADACH 97 limit is from $e^+ e^- \to q\overline{q}$ cross section at $\sqrt{s}$=172.3 GeV which can be affected by the t- and u-channel exchanges of leptoquarks. See their Fig. 1 for limits on vector leptoquarks in mass-coupling plane. NODE=S056LQI;LINKAGE=L

[43] KUZNETSOV 95B use π, K, B, τ decays and μe conversion and give a list of bounds on the leptoquark mass and the fermion mixing matrix in the Pati-Salam model. The quoted limit is from $K_L \to \mu e$ decay assuming zero mixing. NODE=S056LQI;LINKAGE=J

[44] MIZUKOSHI 95 calculate the one-loop radiative correction to the Z-physics parameters in various scalar leptoquark models. See their Fig. 4 for the exclusion plot of third generation leptoquark models in mass-coupling plane. NODE=S056LQI;LINKAGE=I

[45] BHATTACHARYYA 94 limit is from one-loop radiative correction to the leptonic decay width of the Z. m_H=250 GeV, $\alpha_s(m_Z)$=0.12, m_t=180 GeV, and the electroweak strength of leptoquark coupling are assumed. For leptoquark coupled to $\overline{e}_L t_R$, $\overline{\mu} t$, and $\overline{\tau} t$, see Fig. 2 in BHATTACHARYYA 94B erratum and Fig. 3. NODE=S056LQI;LINKAGE=G

[46] DAVIDSON 94 gives an extensive list of the bounds on leptoquark-induced four-fermion interactions from π, K, D, B, μ, τ decays and meson mixings, *etc.* See Table 15 of DAVIDSON 94 for detail. NODE=S056LQI;LINKAGE=E

[47] KUZNETSOV 94 gives mixing independent bound of the Pati-Salam leptoquark from the cosmological limit on $\pi^0 \to \overline{\nu}\nu$. NODE=S056LQI;LINKAGE=F

[48] LEURER 94, LEURER 94B limits are obtained from atomic parity violation and apply to any chiral leptoquark which couples to the first generation with electromagnetic strength. For a nonchiral leptoquark, universality in $\pi_{\ell 2}$ decay provides a much more stringent bound. NODE=S056LQI;LINKAGE=D

[49] MAHANTA 94 gives bounds of P- and T-violating scalar-leptoquark couplings from atomic and molecular experiments. NODE=S056LQI;LINKAGE=H

[50] From $(\pi \to e\nu)/(\pi \to \mu\nu)$ ratio. SHANKER 82 assumes the leptoquark induced four-fermion coupling $4g^2/M^2$ $(\overline{\nu}_{eL}\, u_R)$ $(\overline{d}_L\, e_R)$with g=0.004 for spin-0 leptoquark and g^2/M^2 $(\overline{\nu}_{eL}\, \gamma_\mu\, u_L)$ $(\overline{d}_R\, \gamma^\mu\, e_R)$ with $g \simeq$ 0.6 for spin-1 leptoquark. NODE=S056LQI;LINKAGE=A

MASS LIMITS for Diquarks

NODE=S056DQ
NODE=S056DQ

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>7200 (CL = 95%) OUR LIMIT					
none 600–7200	95	[1] SIRUNYAN	18BO	CMS	E_6 diquark
none 600–6900	95	[2] KHACHATRY...	17W	CMS	E_6 diquark
none 1500–6000	95	[3] KHACHATRY...	16K	CMS	E_6 diquark
none 500–1600	95	[4] KHACHATRY...	16L	CMS	E_6 diquark
none 1200–4700	95	[5] KHACHATRY...	15V	CMS	E_6 diquark
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>3750	95	[6] CHATRCHYAN	13A	CMS	E_6 diquark
none 1000–4280	95	[7] CHATRCHYAN	13AS	CMS	Superseded by KHACHATRYAN 15V
>3520	95	[8] CHATRCHYAN	11Y	CMS	Superseded by CHATRCHYAN 13A
none 970–1080, 1450–1600	95	[9] KHACHATRY...	10	CMS	Superseded by CHATRCHYAN 13A
none 290–630	95	[10] AALTONEN	09AC	CDF	E_6 diquark
none 290–420	95	[11] ABE	97G	CDF	E_6 diquark
none 15–31.7	95	[12] ABREU	94O	DLPH	SUSY E_6 diquark

→ UNCHECKED ←

[1] SIRUNYAN 18BO search for resonances decaying to dijets in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056DQ;LINKAGE=I

[2] KHACHATRYAN 17W search for resonances decaying to dijets in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056DQ;LINKAGE=H

[3] KHACHATRYAN 16K search for resonances decaying to dijets in pp collisions at $\sqrt{s}$ = 13 TeV. NODE=S056DQ;LINKAGE=F

[4] KHACHATRYAN 16L search for resonances decaying to dijets in pp collisions at $\sqrt{s}$ = 8 TeV with the data scouting technique, increasing the sensitivity to the low mass resonances. NODE=S056DQ;LINKAGE=G

[5] KHACHATRYAN 15V search for resonances decaying to dijets in pp collisions at $\sqrt{s}$ = 8 TeV. NODE=S056DQ;LINKAGE=E

[6] CHATRCHYAN 13A search for new resonance decaying to dijets in pp collisions at $\sqrt{s}$ = 7 TeV. NODE=S056DQ;LINKAGE=C

[7] CHATRCHYAN 13AS search for new resonance decaying to dijets in pp collisions at $\sqrt{s}$ = 8 TeV. NODE=S056DQ;LINKAGE=D

[8] CHATRCHYAN 11Y search for new resonance decaying to dijets in pp collisions at $\sqrt{s}$ = 7 TeV. NODE=S056DQ;LINKAGE=B

[9] KHACHATRYAN 10 search for new resonance decaying to dijets in pp collisions at $\sqrt{s}$ = 7 TeV. NODE=S056DQ;LINKAGE=KH

[10] AALTONEN 09AC search for new narrow resonance decaying to dijets. NODE=S056DQ;LINKAGE=AA

[11] ABE 97G search for new particle decaying to dijets. NODE=S056DQ;LINKAGE=SZ

[12] ABREU 94O limit is from $e^+ e^- \to \overline{c}\,\overline{s}\,c\,s$. Range extends up to 43 GeV if diquarks are degenerate in mass. NODE=S056DQ;LINKAGE=A

MASS LIMITS for g_A (axigluon) and Other Color-Octet Gauge Bosons

NODE=S056AXG

Axigluons are massive color-octet gauge bosons in chiral color models and have axial-vector coupling to quarks with the same coupling strength as gluons.

NODE=S056AXG

NODE=S056AXG

→ UNCHECKED ←

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
>6600 (CL = 95%) OUR LIMIT					
none 1800–6600	95	[1] SIRUNYAN	20AI	CMS	$pp \to g_A X$, $g_A \to 2j$
none 600–6100	95	[2] SIRUNYAN	18BO	CMS	$pp \to g_A X$, $g_A \to 2j$
none 600–5500	95	[3] KHACHATRY...	17W	CMS	$pp \to g_A X$, $g_A \to 2j$
none 1500–5100	95	[4] KHACHATRY...	16K	CMS	$pp \to g_A X$, $g_A \to 2j$
none 500–1600	95	[5] KHACHATRY...	16L	CMS	$pp \to g_A X$, $g_A \to 2j$
none 1300–3600	95	[6] KHACHATRY...	15V	CMS	$pp \to g_A X$, $g_A \to 2j$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[7] KHACHATRY...	17Y	CMS	$pp \to g_A g_A \to 8j$
		[8] AAD	16W	ATLS	$pp \to g_A X$, $g_A \to b\overline{b}b\overline{b}$
>2800	95	[9] KHACHATRY...	16E	CMS	$pp \to g_{KK} X$, $g_{KK} \to t\overline{t}$
		[10] KHACHATRY...	15AV	CMS	$pp \to \Theta^0 \Theta^0 \to b\overline{b}Zg$
		[11] AALTONEN	13R	CDF	$p\overline{p} \to g_A X$, $g_A \to \sigma\sigma$, $\sigma \to 2j$
>3360	95	[12] CHATRCHYAN	13A	CMS	$pp \to g_A X$, $g_A \to 2j$
none 1000–3270	95	[13] CHATRCHYAN	13AS	CMS	Superseded by KHACHATRYAN 15V
none 250–740	95	[14] CHATRCHYAN	13AU	CMS	$pp \to 2g_A X$, $g_A \to 2j$
> 775	95	[15] ABAZOV	12R	D0	$p\overline{p} \to g_A X$, $g_A \to t\overline{t}$
>2470	95	[16] CHATRCHYAN	11Y	CMS	Superseded by CHATRCHYAN 13A
		[17] AALTONEN	10L	CDF	$p\overline{p} \to g_A X$, $g_A \to t\overline{t}$
none 1470–1520	95	[18] KHACHATRY...	10	CMS	Superseded by CHATRCHYAN 13A
none 260–1250	95	[19] AALTONEN	09AC	CDF	$p\overline{p} \to g_A X$, $g_A \to 2j$
> 910	95	[20] CHOUDHURY	07	RVUE	$p\overline{p} \to t\overline{t}X$
> 365	95	[21] DONCHESKI	98	RVUE	$\Gamma(Z \to \text{hadron})$
none 200–980	95	[22] ABE	97G	CDF	$p\overline{p} \to g_A X$, $g_A \to 2j$
none 200–870	95	[23] ABE	95N	CDF	$p\overline{p} \to g_A X$, $g_A \to q\overline{q}$
none 240–640	95	[24] ABE	93G	CDF	$p\overline{p} \to g_A X$, $g_A \to 2j$
> 50	95	[25] CUYPERS	91	RVUE	$\sigma(e^+e^- \to \text{hadrons})$
none 120–210	95	[26] ABE	90H	CDF	$p\overline{p} \to g_A X$, $g_A \to 2j$
> 29		[27] ROBINETT	89	THEO	Partial-wave unitarity
none 150–310	95	[28] ALBAJAR	88B	UA1	$p\overline{p} \to g_A X$, $g_A \to 2j$
> 20		BERGSTROM	88	RVUE	$p\overline{p} \to \Upsilon X$ via $g_A g$
> 9		[29] CUYPERS	88	RVUE	Υ decay
> 25		[30] DONCHESKI	88B	RVUE	Υ decay

[1] SIRUNYAN 20AI search for resonances decaying into dijets in pp collisions at $\sqrt{s} = 13$ TeV.

NODE=S056AXG;LINKAGE=Y

[2] SIRUNYAN 18BO search for resonances decaying to dijets in pp collisions at $\sqrt{s} = 13$ TeV.

NODE=S056AXG;LINKAGE=X

[3] KHACHATRYAN 17W search for resonances decaying to dijets in pp collisions at $\sqrt{s} =$ 13 TeV.

NODE=S056AXG;LINKAGE=V

[4] KHACHATRYAN 16K search for resonances decaying to dijets in pp collisions at $\sqrt{s} =$ 13 TeV.

NODE=S056AXG;LINKAGE=T

[5] KHACHATRYAN 16L search for resonances decaying to dijets in pp collisions at $\sqrt{s}$ = 8 TeV with the data scouting technique, increasing the sensitivity to the low mass resonances.

NODE=S056AXG;LINKAGE=U

[6] KHACHATRYAN 15V search for resonances decaying to dijets in pp collisions at $\sqrt{s} =$ 8 TeV.

NODE=S056AXG;LINKAGE=P

[7] KHACHATRYAN 17Y search for pair production of color-octet gauge boson g_A each decaying to $4j$ in pp collisions at $\sqrt{s} = 8$ TeV.

NODE=S056AXG;LINKAGE=W

[8] AAD 16W search for a new resonance decaying to a pair of b and B_H in pp collisions at $\sqrt{s} = 8$ TeV. The vector-like quark B_H is assumed to decay to bH. See their Fig. 3 and Fig. 4 for limits on $\sigma \cdot B$.

NODE=S056AXG;LINKAGE=S

[9] KHACHATRYAN 16E search for KK gluon decaying to $t\overline{t}$ in pp collisions at $\sqrt{s} = 8$ TeV.

NODE=S056AXG;LINKAGE=R

[10] KHACHATRYAN 15AV search for pair productions of neutral color-octet weak-triplet scalar particles (Θ^0), decaying to $b\overline{b}$, Zg or γg, in pp collisions at $\sqrt{s} = 8$ TeV. The Θ^0 particle is often predicted in coloron (G', color-octet gauge boson) models and appear in the pp collisions through $G' \to \Theta^0\Theta^0$ decays. Assuming $B(\Theta^0 \to b\overline{b}) = 0.5$, they give limits $m_{\Theta^0} > 623$ GeV (426 GeV) for $m_{G'} = 2.3\ m_{\Theta^0}$ ($m_{G'} = 5\ m_{\Theta^0}$).

NODE=S056AXG;LINKAGE=Q

[11] AALTONEN 13R search for new resonance decaying to $\sigma\sigma$, with hypothetical strongly interacting σ particle subsequently decaying to 2 jets, in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV, using data corresponding to an integrated luminosity of 6.6 fb^{-1}. For 50 GeV $< m_\sigma < m_{g_A}/2$, axigluons in mass range 150–400 GeV are excluded.

NODE=S056AXG;LINKAGE=O

[12] CHATRCHYAN 13A search for new resonance decaying to dijets in pp collisions at $\sqrt{s}$ = 7 TeV. NODE=S056AXG;LINKAGE=K

[13] CHATRCHYAN 13AS search for new resonance decaying to dijets in pp collisions at $\sqrt{s}$ = 8 TeV. NODE=S056AXG;LINKAGE=M

[14] CHATRCHYAN 13AU search for the pair produced color-octet vector bosons decaying to $q\overline{q}$ pairs in pp collisions. The quoted limit is for B($g_A \rightarrow q\overline{q}$) = 1. NODE=S056AXG;LINKAGE=L

[15] ABAZOV 12R search for massive color octet vector particle decaying to $t\overline{t}$. The quoted limit assumes g_A couplings with light quarks are suppressed by 0.2. NODE=S056AXG;LINKAGE=J

[16] CHATRCHYAN 11Y search for new resonance decaying to dijets in pp collisions at $\sqrt{s}=7$ TeV. NODE=S056AXG;LINKAGE=I

[17] AALTONEN 10L search for massive color octet non-chiral vector particle decaying into $t\overline{t}$ pair with mass in the range 400 GeV < M < 800 GeV. See their Fig. 6 for limit in the mass-coupling plane. NODE=S056AXG;LINKAGE=AL

[18] KHACHATRYAN 10 search for new resonance decaying to dijets in pp collisions at $\sqrt{s}=7$ TeV. NODE=S056AXG;LINKAGE=KH

[19] AALTONEN 09AC search for new narrow resonance decaying to dijets. NODE=S056AXG;LINKAGE=AA

[20] CHOUDHURY 07 limit is from the $t\overline{t}$ production cross section measured at CDF. NODE=S056AXG;LINKAGE=CH

[21] DONCHESKI 98 compare α_s derived from low-energy data and that from Γ($Z \rightarrow$ hadrons)/Γ($Z \rightarrow$ leptons). NODE=S056AXG;LINKAGE=GD

[22] ABE 97G search for new particle decaying to dijets. NODE=S056AXG;LINKAGE=SZ

[23] ABE 95N assume axigluons decaying to quarks in the Standard Model only. NODE=S056AXG;LINKAGE=N

[24] ABE 93G assume $\Gamma(g_A) = N\alpha_s m_{g_A}/6$ with $N = 10$. NODE=S056AXG;LINKAGE=AG

[25] CUYPERS 91 compare α_s measured in Υ decay and that from R at PEP/PETRA energies. NODE=S056AXG;LINKAGE=H

[26] ABE 90H assumes $\Gamma(g_A) = N\alpha_s m_{g_A}/6$ with $N = 5$ ($\Gamma(g_A) = 0.09 m_{g_A}$). For $N = 10$, the excluded region is reduced to 120–150 GeV. NODE=S056AXG;LINKAGE=G

[27] ROBINETT 89 result demands partial-wave unitarity of $J = 0$ $t\overline{t} \rightarrow t\overline{t}$ scattering amplitude and derives a limit $m_{g_A} > 0.5\ m_t$. Assumes $m_t > 56$ GeV. NODE=S056AXG;LINKAGE=B

[28] ALBAJAR 88B result is from the nonobservation of a peak in two-jet invariant mass distribution. $\Gamma(g_A) < 0.4\ m_{g_A}$ assumed. See also BAGGER 88. NODE=S056AXG;LINKAGE=A

[29] CUYPERS 88 requires $\Gamma(\Upsilon \rightarrow g g_A) < \Gamma(\Upsilon \rightarrow ggg)$. A similar result is obtained by DONCHESKI 88. NODE=S056AXG;LINKAGE=D

[30] DONCHESKI 88B requires $\Gamma(\Upsilon \rightarrow g q\overline{q})/\Gamma(\Upsilon \rightarrow ggg) < 0.25$, where the former decay proceeds via axigluon exchange. A more conservative estimate of < 0.5 leads to $m_{g_A} > 21$ GeV. NODE=S056AXG;LINKAGE=C

MASS LIMITS for Color-Octet Scalar Bosons

NODE=S056COS
NODE=S056COS

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
none 400–1300	95	[1] AAD	25AL	ATLS	$pp \rightarrow S_8 S_8 X$, $S_8 \rightarrow t\overline{t}$
none 1800–3700	95	[2] SIRUNYAN	20AI	CMS	$pp \rightarrow S_8 X$, $S_8 \rightarrow gg$
none 600–3400	95	[3] SIRUNYAN	18BO	CMS	$pp \rightarrow S_8 X$, $S_8 \rightarrow gg$
		[4] KHACHATRY...	15AV	CMS	$pp \rightarrow \Theta^0 \Theta^0 \rightarrow b\overline{b} Z g$
none 150–287	95	[5] AAD	13K	ATLS	$pp \rightarrow S_8 S_8 X$,$S_8 \rightarrow$ 2 jets

[1] AAD 25AL search for pair production of color-octet scalar particles in pp collisions at $\sqrt{s}$ = 13 TeV. The limit quoted above assumes the $S_8 t\overline{t}$ coupling parameter 0.1. See their Fig. 12 for limits on $\sigma{\cdot}B$. NODE=S056COS;LINKAGE=D

[2] SIRUNYAN 20AI search for resonances decaying into dijets in pp collisions at $\sqrt{s} = 13$ TeV. The limit above assumes S_{8gg} coupling $k_s^2 = 1/2$. NODE=S056COS;LINKAGE=C

[3] SIRUNYAN 18BO search for color octet scalar boson produced through gluon fusion process in pp collisions at $\sqrt{s} = 13$ TeV. The limit above assumes S_{8gg} coupling $k_s^2 = 1/2$. NODE=S056COS;LINKAGE=B

[4] KHACHATRYAN 15AV search for pair productions of neutral color-octet weak-triplet scalar particles (Θ^0), decaying to $b\overline{b}$, Zg or γg, in pp collisions at $\sqrt{s} = 8$ TeV. The Θ^0 particle is often predicted in coloron (G', color-octet gauge boson) models and appear in the pp collisions through $G' \rightarrow \Theta^0 \Theta^0$ decays. Assuming B($\Theta^0 \rightarrow b\overline{b}$) = 0.5, they give limits $m_{\Theta^0} > 623$ GeV (426 GeV) for $m_{G'} = 2.3\ m_{\Theta^0}$ ($m_{G'} = 5\ m_{\Theta^0}$). NODE=S056COS;LINKAGE=A

[5] AAD 13K search for pair production of color-octet scalar particles in pp collisions at $\sqrt{s}$ = 7 TeV. Cross section limits are interpreted as mass limits on scalar partners of a Dirac gluino. NODE=S056COS;LINKAGE=AA

X^0 (Heavy Boson) Searches in Z Decays

NODE=S056ZXG

Searches for radiative transition of Z to a lighter spin-0 state X^0 decaying to hadrons, a lepton pair, a photon pair, or invisible particles as shown in the comments. The limits are for the product of branching ratios.

NODE=S056ZXG

VALUE	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				

NODE=S056ZXG

		[1] RAINBOLT	19	RVUE	$X^0 \to \ell^+\ell^-$	
		[2] SIRUNYAN	19AZ	CMS	$X^0 \to \mu^+\mu^-$	
		[3] BARATE	98U	ALEP	$X^0 \to \ell\overline{\ell}$, $q\overline{q}$, gg, $\gamma\gamma$, $\nu\overline{\nu}$	
		[4] ACCIARRI	97Q	L3	$X^0 \to$ invisible particle(s)	
		[5] ACTON	93E	OPAL	$X^0 \to \gamma\gamma$	
		[6] ABREU	92D	DLPH	$X^0 \to$ hadrons	
		[7] ADRIANI	92F	L3	$X^0 \to$ hadrons	
		[8] ACTON	91	OPAL	$X^0 \to$ anything	
$<1.1 \times 10^{-4}$	95	[9] ACTON	91B	OPAL	$X^0 \to e^+e^-$	
$<9 \times 10^{-5}$	95	[9] ACTON	91B	OPAL	$X^0 \to \mu^+\mu^-$	OCCUR=2
$<1.1 \times 10^{-4}$	95	[9] ACTON	91B	OPAL	$X^0 \to \tau^+\tau^-$	OCCUR=3
$<2.8 \times 10^{-4}$	95	[10] ADEVA	91D	L3	$X^0 \to e^+e^-$	
$<2.3 \times 10^{-4}$	95	[10] ADEVA	91D	L3	$X^0 \to \mu^+\mu^-$	OCCUR=2
$<4.7 \times 10^{-4}$	95	[11] ADEVA	91D	L3	$X^0 \to$ hadrons	OCCUR=3
$<8 \times 10^{-4}$	95	[12] AKRAWY	90J	OPAL	$X^0 \to$ hadrons	

[1] RAINBOLT 19 limits are from B($Z \to \ell^+\ell^-\ell^+\ell^-$). See their Figs. 5 and 6 for limits in mass-coupling plane. NODE=S056ZXG;LINKAGE=G

[2] SIRUNYAN 19AZ search for $pp \to Z \to X^0\mu^+\mu^- \to \mu^+\mu^-\mu^+\mu^-$ events in pp collisions at $\sqrt{s} = 13$ TeV. See their Fig. 5 for limits on $\sigma(pp \to X^0\mu^+\mu^-)$·B($X^0 \to \mu^+\mu^-$). NODE=S056ZXG;LINKAGE=H

[3] BARATE 98U obtain limits on B($Z \to \gamma X^0$)B($X^0 \to \ell\overline{\ell}$, $q\overline{q}$, gg, $\gamma\gamma$, $\nu\overline{\nu}$). See their Fig. 17. NODE=S056ZXG;LINKAGE=BU

[4] See Fig. 4 of ACCIARRI 97Q for the upper limit on B($Z \to \gamma X^0$; $E_\gamma > E_{\rm min}$) as a function of $E_{\rm min}$. NODE=S056ZXG;LINKAGE=L

[5] ACTON 93E give $\sigma(e^+e^- \to X^0\gamma)$·B($X^0 \to \gamma\gamma$)$<$ 0.4 pb (95%CL) for m_{X^0}=60 $\pm$ 2.5 GeV. If the process occurs via s-channel γ exchange, the limit translates to $\Gamma(X^0)$·B$(X^0 \to \gamma\gamma)^2$ $<$20 MeV for $m_{X^0} = 60 \pm 1$ GeV. NODE=S056ZXG;LINKAGE=E

[6] ABREU 92D give σ_Z · B($Z \to \gamma X^0$) · B($X^0 \to$ hadrons) $<$(3–10) pb for m_{X^0} = 10–78 GeV. A very similar limit is obtained for spin-1 X^0. NODE=S056ZXG;LINKAGE=X

[7] ADRIANI 92F search for isolated γ in hadronic Z decays. The limit σ_Z · B($Z \to \gamma X^0$) · B($X^0 \to$ hadrons) $<$(2–10) pb (95%CL) is given for m_{X^0} = 25–85 GeV. NODE=S056ZXG;LINKAGE=F2

[8] ACTON 91 searches for $Z \to Z^* X^0$, $Z^* \to e^+e^-$, $\mu^+\mu^-$, or $\nu\overline{\nu}$. Excludes any new scalar X^0 with $m_{X^0} <$ 9.5 GeV/c if it has the same coupling to ZZ^* as the MSM Higgs boson. NODE=S056ZXG;LINKAGE=F

[9] ACTON 91B limits are for m_{X^0} = 60–85 GeV. NODE=S056ZXG;LINKAGE=D

[10] ADEVA 91D limits are for m_{X^0} = 30–89 GeV. NODE=S056ZXG;LINKAGE=B

[11] ADEVA 91D limits are for m_{X^0} = 30–86 GeV. NODE=S056ZXG;LINKAGE=C

[12] AKRAWY 90J give $\Gamma(Z \to \gamma X^0)$·B($X^0 \to$ hadrons) $<$ 1.9 MeV (95%CL) for m_{X^0} = 32–80 GeV. We divide by $\Gamma(Z)$ = 2.5 GeV to get product of branching ratios. For nonresonant transitions, the limit is B($Z \to \gamma q\overline{q}$) $<$ 8.2 MeV assuming three-body phase space distribution. NODE=S056ZXG;LINKAGE=A

MASS LIMITS for a Heavy Neutral Boson Coupling to e^+e^-

NODE=S056HEE
NODE=S056HEE

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*	
none 55–61		[1] ODAKA	89	VNS	$\Gamma(X^0 \to e^+e^-)$ · B($X^0 \to$ had.) $\gtrsim$ 0.2 MeV	
$>$45	95	[2] DERRICK	86	HRS	$\Gamma(X^0 \to e^+e^-)$=6 MeV	
$>$46.6	95	[3] ADEVA	85	MRKJ	$\Gamma(X^0 \to e^+e^-)$=10 keV	
$>$48	95	[3] ADEVA	85	MRKJ	$\Gamma(X^0 \to e^+e^-)$=4 MeV	OCCUR=2
		[4] BERGER	85B	PLUT		
none 39.8–45.5		[5] ADEVA	84	MRKJ	$\Gamma(X^0 \to e^+e^-)$=10 keV	
$>$47.8	95	[5] ADEVA	84	MRKJ	$\Gamma(X^0 \to e^+e^-)$=4 MeV	OCCUR=2
none 39.8–45.2		[5] BEHREND	84C	CELL		
$>$47	95	[5] BEHREND	84C	CELL	$\Gamma(X^0 \to e^+e^-)$=4 MeV	OCCUR=2

[1] ODAKA 89 looked for a narrow or wide scalar resonance in $e^+e^- \to$ hadrons at $E_{\rm cm}$ = 55.0–60.8 GeV. NODE=S056HEE;LINKAGE=C

[2] DERRICK 86 found no deviation from the Standard Model Bhabha scattering at $E_{\rm cm}$= 29 GeV and set limits on the possible scalar boson e^+e^- coupling. See their figure 4 for excluded region in the $\Gamma(X^0 \to e^+e^-)$-m_{X^0} plane. Electronic chiral invariance requires a parity doublet of X^0, in which case the limit applies for $\Gamma(X^0 \to e^+e^-)$ = 3 MeV. NODE=S056HEE;LINKAGE=A2

[3] ADEVA 85 first limit is from 2γ, $\mu^+\mu^-$, hadrons assuming X^0 is a scalar. Second limit is from e^+e^- channel. $E_{\rm cm}$ = 40–47 GeV. Supersedes ADEVA 84. NODE=S056HEE;LINKAGE=B

[4] BERGER 85B looked for effect of spin-0 boson exchange in $e^+e^- \rightarrow e^+e^-$ and $\mu^+\mu^-$ at E_{cm} = 34.7 GeV. See Fig. 5 for excluded region in the $m_{X^0} - \Gamma(X^0)$ plane. NODE=S056HEE;LINKAGE=D

[5] ADEVA 84 and BEHREND 84C have E_{cm} = 39.8–45.5 GeV. MARK-J searched X^0 in $e^+e^- \rightarrow$ hadrons, 2γ, $\mu^+\mu^-$, e^+e^- and CELLO in the same channels plus τ pair. No narrow or broad X^0 is found in the energy range. They also searched for the effect of X^0 with $m_X > E_{cm}$. The second limits are from Bhabha data and for spin-0 singlet. The same limits apply for $\Gamma(X^0 \rightarrow e^+e^-)$ = 2 MeV if X^0 is a spin-0 doublet. The second limit of BEHREND 84C was read off from their figure 2. The original papers also list limits in other channels. NODE=S056HEE;LINKAGE=A

Search for X^0 Resonance in e^+e^- Collisions

NODE=S056REE

The limit is for $\Gamma(X^0 \rightarrow e^+e^-) \cdot B(X^0 \rightarrow f)$, where f is the specified final state. Spin 0 is assumed for X^0. NODE=S056REE

NODE=S056REE

VALUE (keV)	CL%	DOCUMENT ID		TECN	COMMENT	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$<10^3$	95	[1] ABE	93C	VNS	$\Gamma(ee)$	
<(0.4–10)	95	[2] ABE	93C	VNS	$f = \gamma\gamma$	OCCUR=2
<(0.3–5)	95	[3,4] ABE	93D	TOPZ	$f = \gamma\gamma$	
<(2–12)	95	[3,4] ABE	93D	TOPZ	f = hadrons	OCCUR=2
<(4–200)	95	[4,5] ABE	93D	TOPZ	$f = ee$	OCCUR=3
<(0.1–6)	95	[4,5] ABE	93D	TOPZ	$f = \mu\mu$	OCCUR=4
<(0.5–8)	90	[6] STERNER	93	AMY	$f = \gamma\gamma$	

[1] Limit is for $\Gamma(X^0 \rightarrow e^+e^-)$ m_{X^0} = 56–63.5 GeV for $\Gamma(X^0)$ = 0.5 GeV. NODE=S056REE;LINKAGE=A

[2] Limit is for m_{X^0} = 56–61.5 GeV and is valid for $\Gamma(X^0) \ll$ 100 MeV. See their Fig. 5 for limits for Γ = 1,2 GeV. NODE=S056REE;LINKAGE=B

[3] Limit is for m_{X^0} = 57.2–60 GeV. NODE=S056REE;LINKAGE=D

[4] Limit is valid for $\Gamma(X^0) \ll$ 100 MeV. See paper for limits for Γ = 1 GeV and those for J = 2 resonances. NODE=S056REE;LINKAGE=F

[5] Limit is for m_{X^0} = 56.6–60 GeV. NODE=S056REE;LINKAGE=E

[6] STERNER 93 limit is for m_{X^0} = 57–59.6 GeV and is valid for $\Gamma(X^0)$<100 MeV. See their Fig. 2 for limits for Γ = 1,3 GeV. NODE=S056REE;LINKAGE=C

Search for X^0 Resonance in ep Collisions

NODE=S056EPX
NODE=S056EPX

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] CHEKANOV	02B	ZEUS	$X \rightarrow jj$

[1] CHEKANOV 02B search for photoproduction of X decaying into dijets in ep collisions. See their Fig. 5 for the limit on the photoproduction cross section. NODE=S056EPX;LINKAGE=A

Search for X^0 Resonance in $e^+e^- \rightarrow X^0\gamma$

NODE=S056REG
NODE=S056REG

VALUE (GeV)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] ABBIENDI	03D	OPAL	$X^0 \rightarrow \gamma\gamma$
	[2] ABREU	00Z	DLPH	X^0 decaying invisibly
	[3] ADAM	96C	DLPH	X^0 decaying invisibly

[1] ABBIENDI 03D measure the $e^+e^- \rightarrow \gamma\gamma\gamma$ cross section at $\sqrt{s}$=181–209 GeV. The upper bound on the production cross section, $\sigma(e^+e^- \rightarrow X^0\gamma)$ times the branching ratio for $X^0 \rightarrow \gamma\gamma$, is less than 0.03 pb at 95%CL for X^0 masses between 20 and 180 GeV. See their Fig. 9b for the limits in the mass-cross section plane. NODE=S056REG;LINKAGE=C

[2] ABREU 00Z is from the single photon cross section at $\sqrt{s}$=183, 189 GeV. The production cross section upper limit is less than 0.3 pb for X^0 mass between 40 and 160 GeV. See their Fig. 4 for the limit in mass-cross section plane. NODE=S056REG;LINKAGE=B

[3] ADAM 96C is from the single photon production cross at $\sqrt{s}$=130, 136 GeV. The upper bound is less than 3 pb for X^0 masses between 60 and 130 GeV. See their Fig. 5 for the exact bound on the cross section $\sigma(e^+e^- \rightarrow \gamma X^0)$. NODE=S056REG;LINKAGE=A

Search for X^0 Resonance in $Z \rightarrow f\overline{f}X^0$

NODE=S056ZFR

The limit is for $B(Z \rightarrow f\overline{f}X^0) \cdot B(X^0 \rightarrow F)$ where f is a fermion and F is the specified final state. Spin 0 is assumed for X^0. NODE=S056ZFR

NODE=S056ZFR

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				

		[1] ABREU	96T	DLPH	f=e,μ,τ; F=$\gamma\gamma$	
$<3.7 \times 10^{-6}$	95	[2] ABREU	96T	DLPH	f=ν; F=$\gamma\gamma$	OCCUR=2
		[3] ABREU	96T	DLPH	f=q; F=$\gamma\gamma$	OCCUR=3
$<6.8 \times 10^{-6}$	95	[2] ACTON	93E	OPAL	f=e,μ,τ; F=$\gamma\gamma$	
$<5.5 \times 10^{-6}$	95	[2] ACTON	93E	OPAL	f=q; F=$\gamma\gamma$	OCCUR=2
$<3.1 \times 10^{-6}$	95	[2] ACTON	93E	OPAL	f=ν; F=$\gamma\gamma$	OCCUR=3
$<6.5 \times 10^{-6}$	95	[2] ACTON	93E	OPAL	f=e,μ; F=$\ell\overline{\ell}$, $q\overline{q}$, $\nu\overline{\nu}$	OCCUR=4
$<7.1 \times 10^{-6}$	95	[2] BUSKULIC	93F	ALEP	f=e,μ; F=$\ell\overline{\ell}$, $q\overline{q}$, $\nu\overline{\nu}$	
		[4] ADRIANI	92F	L3	f=q; F=$\gamma\gamma$	

[1] ABREU 96T obtain limit as a function of m_{X^0}. See their Fig. 6. NODE=S056ZFR;LINKAGE=B1

[2] Limit is for m_{X^0} around 60 GeV. NODE=S056ZFR;LINKAGE=B

[3] ABREU 96T obtain limit as a function of m_{X^0}. See their Fig. 15. NODE=S056ZFR;LINKAGE=B2

[4] ADRIANI 92F give $\sigma_Z \cdot$ B($Z \rightarrow q\overline{q}X^0$) $\cdot$ B($X^0 \rightarrow \gamma\gamma$)<(0.75–1.5) pb (95%CL) for m_{X^0} = 10–70 GeV. The limit is 1 pb at 60 GeV. NODE=S056ZFR;LINKAGE=A

Search for X^0 Resonance in $W X^0$ final state

NODE=S056PPW
NODE=S056PPW

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] AALTONEN	13AA	CDF	$X^0 \rightarrow jj$
	[2] CHATRCHYAN	12BR	CMS	$X^0 \rightarrow jj$
	[3] ABAZOV	11I	D0	$X^0 \rightarrow jj$
	[4] ABE	97W	CDF	$X^0 \rightarrow b\overline{b}$

[1] AALTONEN 13AA search for X^0 production associated with W (or Z) in $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. The upper limit on the cross section $\sigma(p\overline{p} \rightarrow W X^0)$ is 2.2 pb for M_{X^0} = 145 GeV. NODE=S056PPW;LINKAGE=D

[2] CHATRCHYAN 12BR search for X^0 production associated with W in pp collisions at E_{cm} = 7 TeV. The upper limit on the cross section is 5.0 pb at 95% CL for m_{X^0} = 150 GeV. NODE=S056PPW;LINKAGE=C

[3] ABAZOV 11I search for X^0 production associated with W in $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. The 95% CL upper limit on the cross section ranges from 2.57 to 1.28 pb for X^0 mass between 110 and 170 GeV. NODE=S056PPW;LINKAGE=B

[4] ABE 97W search for X^0 production associated with W in $p\overline{p}$ collisions at E_{cm}=1.8 TeV. The 95%CL upper limit on the production cross section times the branching ratio for $X^0 \rightarrow b\overline{b}$ ranges from 14 to 19 pb for X^0 mass between 70 and 120 GeV. See their Fig. 3 for upper limits of the production cross section as a function of m_{X^0}. NODE=S056PPW;LINKAGE=A

Search for X^0 Resonance in Quarkonium Decays

NODE=S056ONI

Limits are for branching ratios to modes shown. Spin 1 is assumed for X^0.

NODE=S056ONI
NODE=S056ONI

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
		[1] ABLIKIM	24G	BES3	$J/\psi \rightarrow \mu^+\mu^- X_{0,1}$	
$< 3 \times 10^{-5}$–6×10^{-3}	90	[2] BALEST	95	CLE2	$\Upsilon(1S) \rightarrow X^0 \overline{X}^0 \gamma$, $m_{X^0} < 3.9$ GeV	OCCUR=2

[1] ABLIKIM 24G search for a muonphilic scalar X_0 or vector X_1 boson in decays of $J/\psi \rightarrow \mu^+\mu^- +$ invisible. See their Fig. 3 for limits in the mass coupling plane. NODE=S056ONI;LINKAGE=E

[2] BALEST 95 three-body limit is for phase-space photon energy distribution and angular distribution same as for $\Upsilon \rightarrow gg\gamma$. NODE=S056ONI;LINKAGE=D

Search for X^0 Resonance in H(125) Decays

NODE=S056HDC

Spin 1 is assumed for X^0. See neutral Higgs search listing for pseudoscalar X^0.

NODE=S056HDC
NODE=S056HDC

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
	[1] AAD	24BQ	ATLS	$H \rightarrow X^0 X^0 \rightarrow b\overline{b}\tau^+\tau^-$	
	[2] HAYRAPETY...	24AA	CMS	$H \rightarrow X^0 X^0$, $X^0 \rightarrow b\overline{b}$	
	[3] AAD	22J	ATLS	$X^0 \rightarrow \ell^+\ell^-$	
	[4] AABOUD	18AP	ATLS	$H \rightarrow Z X^0$	
	[5] AABOUD	18AP	ATLS	$H \rightarrow X^0 X^0$	OCCUR=2

[1] AAD 24BQ search for X^0 production via $H \rightarrow X^0 X^0 \rightarrow b\overline{b}\tau^+\tau^-$ in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 10 for limits on $\sigma \cdot B$. NODE=S056HDC;LINKAGE=E

[2] HAYRAPETYAN 24AA search for X^0 production via $H(125) \rightarrow X^0 X^0 \rightarrow b\overline{b}b\overline{b}$ in pp collisions at $\sqrt{s}$ = 13 TeV. See their Fig. 3 for limits on $\sigma \cdot B$. NODE=S056HDC;LINKAGE=D

[3] AAD 22J search for X^0 production via $H(125) \rightarrow X^0 X^0 / Z X^0 \rightarrow 4\ell$ in pp collisions at $\sqrt{s}$ = 13 TeV. $X^0 \rightarrow \ell^+\ell^-$ decay is assumed. See their Fig. 13 and Fig. 17 for limits on $\sigma \cdot B$ in $H(125) \rightarrow X^0 X^0$ and $H(125) \rightarrow Z X^0$ channels. NODE=S056HDC;LINKAGE=C

[4] AABOUD 18AP use pp collision data at $\sqrt{s}$ = 13 TeV. $X^0 \rightarrow \ell^+\ell^-$ decay is assumed. See their Fig. 9 for limits on $\sigma_{H(125)} \cdot$ B($Z X^0$). NODE=S056HDC;LINKAGE=A

[5] AABOUD 18AP use pp collision data at $\sqrt{s}$ = 13 TeV. $X^0 \rightarrow \ell^+\ell^-$ decay is assumed. See their Fig. 10 for limits on $\sigma_{H(125)} \cdot$ B($X^0 X^0$). NODE=S056HDC;LINKAGE=B

REFERENCES FOR Searches for New Heavy Bosons (W', Z', leptoquarks, etc.)

NODE=S056

AAD	25AL	EPJ C85 573	G. Aad *et al.*	(ATLAS Collab.)	REFID=63507
AAD	25AX	PR D112 072009	G. Aad *et al.*	(ATLAS Collab.)	REFID=63679
AAD	25AZ	PR D112 092015	G. Aad *et al.*	(ATLAS Collab.)	REFID=63685
AAD	25BA	JHEP 2509 067	G. Aad *et al.*	(ATLAS Collab.)	REFID=63694
AAD	25BB	JHEP 2510 054	G. Aad *et al.*	(ATLAS Collab.)	REFID=63699
AAD	25BN	JHEP 2512 180	G. Aad *et al.*	(ATLAS Collab.)	REFID=63750
AAD	25C	PRL 134 121801	G. Aad *et al.*	(ATLAS Collab.)	REFID=63323
AAD	25F	PL B865 139472	G. Aad *et al.*	(ATLAS Collab.)	REFID=63359
AAD	25N	PR D112 012021	G. Aad *et al.*	(ATLAS Collab.)	REFID=63423
AAD	25Q	JHEP 2501 099	G. Aad *et al.*	(ATLAS Collab.)	REFID=63430
AAD	25V	JHEP 2502 193	G.Aad *et al.*	(ATLAS Collab.)	REFID=63447
CHEKHOVSKY	25J	JHEP 2510 170	V. Chekhovsky *et al.*	(CMS Collab.)	REFID=63706
HAYRAPETY...	25AB	PRL 135 061803	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63534
HAYRAPETY...	25AK	PR D112 112011	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63690
HAYRAPETY...	25AN	JHEP 2512 052	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63722
HAYRAPETY...	25M	PR D111 112004	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63405
HAYRAPETY...	25Q	JHEP 2502 089	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63441
HAYRAPETY...	25V	JHEP 2504 109	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63461
HERBERMANN	25	JCAP 2509 078	T. Herbermann, M. Lindner	(MPIK)	REFID=63735
AAD	24AA	JHEP 2402 128	G. Aad *et al.*	(ATLAS Collab.)	REFID=62836
AAD	24AE	JHEP 2404 118	G. Aad *et al.*	(ATLAS Collab.)	REFID=62846
AAD	24AV	EPJ C84 818	G. Aad *et al.*	(ATLAS Collab.)	REFID=62899
AAD	24AY	PR D110 032002	G. Aad *et al.*	(ATLAS Collab.)	REFID=62931
AAD	24BJ	EPJ C84 157	G. Aad *et al.*	(ATLAS Collab.)	REFID=62993
AAD	24BQ	PR D110 052013	G. Aad *et al.*	(ATLAS Collab.)	REFID=63081
AAD	24BR	PR D110 072008	G. Aad *et al.*	(ATLAS Collab.)	REFID=63086
AAD	24CD	JHEP 2411 126	G. Aad *et al.*	(ATLAS Collab.)	REFID=63139
AAD	24CI	EPJ C84 1102	G. Aad *et al.*	(ATLAS Collab.)	REFID=63151
AAD	24CM	JHEP 2409 005	G. Aad *et al.*	(ATLAS Collab.)	REFID=63201
AAD	24O	PL B854 138736	G. Aad *et al.*	(ATLAS Collab.)	REFID=62756
AAD	24T	PR D109 112008	G. Aad *et al.*	(ATLAS Collab.)	REFID=62809
AAD	24W	PR D110 012014	G. Aad *et al.*	(ATLAS Collab.)	REFID=62824
ABLIKIM	24G	PR D109 L031102	M. Ablikim *et al.*	(BESIII Collab.)	REFID=62657
ADACHI	24F	PR D109 112015	I. Adachi *et al.*	(BELLE II Collab.)	REFID=62814
AKITA	24	JHEP 2407 057	K. Akita *et al.*	(IBSD, CAU)	REFID=62869
ALVES	24	PRL 133 161802	G.F.S. Alves *et al.*	(USP, FNAL, UFABC)	REFID=63055
ANDREEV	24	PRL 132 211803	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=62728
ANDREEV	24B	JHEP 2407 212	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=62874
ANDREEV	24E	PR D110 112015	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=63110
BISWAS	24	PR D109 032002	D. Biswas *et al.*	(BELLE Collab.)	REFID=62769
CABARCAS	24	PL B848 138339	J.M. Cabarcas, A. Parada, N. Quinero-Poveda	(USTA+)	REFID=62606
HAYRAPETY...	24AA	JHEP 2406 097	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62864
HAYRAPETY...	24AV	JHEP 2409 186	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63124
HAYRAPETY...	24AZ	JHEP 2412 172	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63144
HAYRAPETY...	24C	PRL 132 061801	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62709
HAYRAPETY...	24G	PRL 133 011801	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62737
HAYRAPETY...	24O	PR D109 112003	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62805
HAYRAPETY...	24W	JHEP 2403 134	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62841
HAYRAPETY...	24X	JHEP 2405 046	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62850
HAYRAPETY...	24Z	JHEP 2405 311	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62861
AAD	23AH	EPJ C83 633	G. Aad *et al.*	(ATLAS Collab.)	REFID=62175
AAD	23BF	JHEP 2307 202	G. Aad *et al.*	(ATLAS Collab.)	REFID=62393
AAD	23BJ	JHEP 2306 199	G. Aad *et al.*	(ATLAS Collab.)	REFID=62117
AAD	23BZ	JHEP 2310 001	G. Aad *et al.*	(ATLAS Collab.)	REFID=62536
AAD	23CB	JHEP 2310 082	G. Aad *et al.*	(ATLAS Collab.)	REFID=62540
AAD	23CC	JHEP 2312 073	G. Aad *et al.*	(ATLAS Collab.)	REFID=62545
AAD	23CF	EPJ C83 1075	G. Aad *et al.*	(ATLAS Collab.)	REFID=62553
AAD	23CG	EPJ C83 1164	G. Aad *et al.*	(ATLAS Collab.)	REFID=62556
AAD	23CK	PR D108 052009	G. Aad *et al.*	(ATLAS Collab.)	REFID=62591
AAD	23F	JHEP 2306 188	G. Aad *et al.*	(ATLAS Collab.)	REFID=62119
AAD	23L	JHEP 2306 036	G. Aad *et al.*	(ATLAS Collab.)	REFID=62133
AAD	23O	JHEP 2306 016	G. Aad *et al.*	(ATLAS Collab.)	REFID=62136
AAD	23U	JHEP 2307 125	G. Aad *et al.*	(ATLAS Collab.)	REFID=62145
AAD	23W	JHEP 2307 116	G. Aad *et al.*	(ATLAS Collab.)	REFID=62148
AAD	23X	JHEP 2307 090	G. Aad *et al.*	(ATLAS Collab.)	REFID=62153
ADACHI	23B	PRL 130 231801	I. Adachi *et al.*	(BELLE II Collab.)	REFID=62223
ADACHI	23F	PRL 131 121802	I. Adachi *et al.*	(BELLE II Collab.)	REFID=62448
CALABRESE	23	PR D107 055039	R. Calabrese *et al.*	(NAPL, NAPLI)	REFID=62260
HAYRAPETY...	23D	JHEP 2310 043	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62538
HAYRAPETY...	23G	JHEP 2312 070	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62615
LI	23I	JCAP 2309 009	S.-P. Li, X.-J. Xu	(BHEP)	REFID=62559
MANZARI	23	PR D108 103020	C.A. Manzari *et al.*	(UCB, LBL, IAC+)	REFID=62508
TUMASYAN	23AF	PR D108 012009	A. Tumasyan *et al.*	(CMS Collab.)	REFID=62293
TUMASYAN	23AP	PL B844 137813	A. Tumasyan *et al.*	(CMS Collab.)	REFID=62406
TUMASYAN	23AW	JHEP 2309 051	A. Tumasyan *et al.*	(CMS Collab.)	REFID=62524
TUMASYAN	23BE	JHEP 2311 181	A. Tumasyan *et al.*	(CMS Collab.)	REFID=62613
TUMASYAN	23H	JHEP 2305 227	A. Tumasyan *et al.*	(CMS Collab.)	REFID=62114
TUMASYAN	23S	JHEP 2307 073	A. Tumasyan *et al.*	(CMS Collab.)	REFID=62157

AAD	22	PR D105 012001	G. Aad *et al.*	(ATLAS Collab.)	REFID=61539
AAD	22D	PL B829 137066	G. Aad *et al.*	(ATLAS Collab.)	REFID=61705
AAD	22E	PL B830 137106	G. Aad *et al.*	(ATLAS Collab.)	REFID=61706
AAD	22J	JHEP 2203 041	G. Aad *et al.*	(ATLAS Collab.)	REFID=61779
ANDREEV	22	PR D106 032015	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=61771
BONET	22	JHEP 2205 085	H. Bonet *et al.*	(CONUS Collab.)	REFID=61799
COLOMA	22	JHEP 2205 037	P. Coloma *et al.*	(IFT, OSU, STON, ICREA+)	REFID=61797
COLOMA	22A	JHEP 2207 138	P. Coloma *et al.*	(IFT, CNYIT, ICC, ICREA+)	REFID=61811
CZANK	22	PR D106 012003	T. Czank *et al.*	(BELLE Collab.)	REFID=61757
TUMASYAN	22	PRL 129 021802	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61693
TUMASYAN	22AA	JHEP 2206 156	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61807
TUMASYAN	22AC	JHEP 2207 067	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61812
TUMASYAN	22AE	JHEP 2208 063	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61816
TUMASYAN	22AL	JHEP 2209 088	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61967
TUMASYAN	22B	PL B826 136888	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61700
TUMASYAN	22D	PR D105 032008	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61720
TUMASYAN	22H	PR D105 112007	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61751
TUMASYAN	22I	PR D106 012002	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61756
TUMASYAN	22J	PR D106 012004	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61758
TUMASYAN	22P	JHEP 2204 047	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61789
TUMASYAN	22R	JHEP 2204 087	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61792
AAD	21AG	EPJ C81 313	G. Aad *et al.*	(ATLAS Collab.)	REFID=61335
AAD	21AQ	JHEP 2107 005	G. Aad *et al.*	(ATLAS Collab.)	REFID=61404
AAD	21AW	PR D104 112005	G. Aad *et al.*	(ATLAS Collab.)	REFID=61533
AAD	21AZ	JHEP 2110 013	G. Aad *et al.*	(ATLAS Collab.)	REFID=61556
AAD	21BB	JHEP 2111 209	G. Aad *et al.*	(ATLAS Collab.)	REFID=61558
AAD	21D	PRL 126 121802	G. Aad *et al.*	(ATLAS Collab.)	REFID=61173
AAD	21K	JHEP 2102 226	G. Aad *et al.*	(ATLAS Collab.)	REFID=61279
AAD	21S	JHEP 2105 093	G. Aad *et al.*	(ATLAS Collab.)	REFID=61304
AAD	21T	JHEP 2106 179	G. Aad *et al.*	(ATLAS Collab.)	REFID=61306
BURAS	21	JHEP 2106 068	A.J. Buras *et al.*	(TUM, CERN, ZURI+)	REFID=61313
CADEDDU	21	JHEP 2101 116	M. Cadeddu *et al.*	(CAGLI, CAGL, INFN+)	REFID=61277
COLARESI	21	PR D104 072003	J. Colaresi *et al.*	(MRION, FNAL, PNL+)	REFID=61587
CRIVELLIN	21A	PR D103 115023	A. Crivellin, D. Mueller, L. Schnell	(CERN, ZURI+)	REFID=61251
KRIBS	21	PRL 126 011801	G.D. Kribs, D. McKeen, N. Raj	(OREG, TRIU)	REFID=60964
SIRUNYAN	21J	PL B819 136446	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=61273
SIRUNYAN	21N	JHEP 2107 208	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=61317
SIRUNYAN	21X	EPJ C81 688	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=61386
SIRUNYAN	21Y	PL B820 136535	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=61387
TUMASYAN	21D	JHEP 2111 153	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61559
AAD	20AD	PRL 125 131801	G. Aad *et al.*	(ATLAS Collab.)	REFID=60682
AAD	20AF	PRL 125 251802	G. Aad *et al.*	(ATLAS Collab.)	REFID=60703
AAD	20AJ	PR D102 112008	G. Aad *et al.*	(ATLAS Collab.)	REFID=60743
AAD	20AK	JHEP 2010 112	G. Aad *et al.*	(ATLAS Collab.)	REFID=60755
AAD	20AM	JHEP 2010 061	G. Aad *et al.*	(ATLAS Collab.)	REFID=60757
AAD	20AT	EPJ C80 1165	G. Aad *et al.*	(ATLAS Collab.)	REFID=60774
AAD	20S	EPJ C80 737	G. Aad *et al.*	(ATLAS Collab.)	REFID=60456
AAD	20T	JHEP 2003 145	G. Aad *et al.*	(ATLAS Collab.)	REFID=60484
AAD	20W	JHEP 2006 151	G. Aad *et al.*	(ATLAS Collab.)	REFID=60507
AAIJ	20AL	JHEP 2010 156	R. Aaij *et al.*	(LHCb Collab.)	REFID=60754
ADACHI	20	PRL 124 141801	I. Adachi *et al.*	(BELLE II Collab.)	REFID=60552
AEBISCHER	20	EPJ C80 252	J. Aebischer *et al.*	(TUM, LAPTH, UCSC)	REFID=60428
DEPPISCH	20	JHEP 2012 186	F.F. Deppisch, K. Fridell, J. Harz	(LOUC, TUM)	REFID=61007
SIRUNYAN	20A	EPJ C80 3	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=60199
SIRUNYAN	20AI	JHEP 2005 033	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=60492
SIRUNYAN	20AQ	PRL 124 131802	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=60549
SIRUNYAN	20M	PL B805 135448	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=60401
SIRUNYAN	20Q	EPJ C80 237	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=60424
AABOUD	19AJ	PL B795 56	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59756
AABOUD	19AS	PR D99 092004	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59874
AABOUD	19AX	EPJ C79 733	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59964
AABOUD	19B	JHEP 1901 016	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59371
AABOUD	19BB	PL B798 134942	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=60132
AABOUD	19D	PL B788 316	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59416
AABOUD	19E	PL B788 347	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59417
AABOUD	19V	JHEP 1905 142	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59686
AABOUD	19X	JHEP 1906 144	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59695
AAD	19C	PR D100 052013	G. Aad *et al.*	(ATLAS Collab.)	REFID=59999
AAD	19D	JHEP 1909 091	G. Aad *et al.*	(ATLAS Collab.)	REFID=60081
Also		JHEP 2006 042 (errat.)	G. Aad *et al.*	(ATLAS Collab.)	REFID=60499
AAD	19L	PL B796 68	G. Aad *et al.*	(ATLAS Collab.)	REFID=59929
ABRAMOWICZ	19	PR D99 092006	H. Abramowicz *et al.*	(ZEUS Collab.)	REFID=59876
LONG	19	NP B943 114629	H.N. Long *et al.*		REFID=59824
MANDAL	19	JHEP 1912 089	R. Mandal, A. Pich	(VALE, SIEG)	REFID=60100
PANDEY	19	JHEP 1911 046	S. Pandey, S. Karmakar, S. Rakshit	(IITI)	REFID=60093
RAINBOLT	19	PR D99 013004	J.L. Rainbolt, M. Schmitt	(NWES)	REFID=59607
SIRUNYAN	19AA	JHEP 1904 031	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59667
SIRUNYAN	19AL	EPJ C79 208	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59711
SIRUNYAN	19AN	EPJ C79 280	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59716
SIRUNYAN	19AY	PL B792 107	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59749
SIRUNYAN	19AZ	PL B792 345	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59751
SIRUNYAN	19BC	PL B795 76	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59757
SIRUNYAN	19BI	PR D99 032014	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59834
SIRUNYAN	19BJ	PR D99 052002	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59839
SIRUNYAN	19CB	PR D100 112007	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=60041
SIRUNYAN	19CD	PRL 123 231803	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=60074
SIRUNYAN	19CP	PL B798 134952	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=60134
SIRUNYAN	19D	PRL 122 081804	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59551
SIRUNYAN	19I	JHEP 1901 051	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59631
SIRUNYAN	19V	JHEP 1903 127	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59660
SIRUNYAN	19Y	JHEP 1903 170	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59663
AABOUD	18AA	PR D98 032015	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58981
AABOUD	18AB	PR D98 032016	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58982
AABOUD	18AD	PL B779 24	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58998
AABOUD	18AF	PL B781 327	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59018
AABOUD	18AI	JHEP 1803 174	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59080
Also		JHEP 1811 051 (errat.)	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59360
AABOUD	18AK	JHEP 1803 042	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59092
AABOUD	18AL	JHEP 1803 009	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59093

AABOUD	18AP	JHEP 1806 166	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59107
AABOUD	18B	EPJ C78 24	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58479
AABOUD	18BG	EPJ C78 401	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59177
AABOUD	18BI	EPJ C78 565	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59191
AABOUD	18CH	PL B787 68	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59407
AABOUD	18CJ	PR D98 052008	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59441
AABOUD	18CM	PR D98 092008	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59474
AABOUD	18F	PL B777 91	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58626
AABOUD	18G	JHEP 1801 055	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58788
AABOUD	18K	PRL 120 161802	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58821
AABOUD	18N	PRL 121 081801	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58866
AAIJ	18AQ	JHEP 1809 147	R. Aaij *et al.*	(LHCb Collab.)	REFID=59345
BOBOVNIKOV	18	PR D98 095029	I.D. Bobovnikov, P. Osland, A.A. Pankov	(BERG+)	REFID=59485
SIRUNYAN	18	PL B777 39	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58625
SIRUNYAN	18AT	JHEP 1804 073	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59095
SIRUNYAN	18AX	JHEP 1805 088	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59103
SIRUNYAN	18AZ	JHEP 1806 128	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59110
SIRUNYAN	18BB	JHEP 1806 120	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59112
SIRUNYAN	18BJ	JHEP 1807 115	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59129
SIRUNYAN	18BK	JHEP 1807 075	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59131
SIRUNYAN	18BO	JHEP 1808 130	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59142
SIRUNYAN	18CV	JHEP 1805 148	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59248
SIRUNYAN	18CZ	EPJ C78 707	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59255
SIRUNYAN	18DJ	JHEP 1809 101	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59341
SIRUNYAN	18DR	JHEP 1811 161	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59367
SIRUNYAN	18EC	PRL 121 241802	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59536
SIRUNYAN	18ED	JHEP 1811 172	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59566
SIRUNYAN	18G	JHEP 1801 097	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58791
SIRUNYAN	18I	PRL 120 201801	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58825
SIRUNYAN	18P	PR D97 072006	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58918
SIRUNYAN	18U	PR D98 032005	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58974
ZHANG	18A	EPJ C78 695	J. Zhang, C.-X. Yue, C.-H. Li	(LNUDA)	REFID=59313
AABOUD	17AK	PR D96 052004	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58217
AABOUD	17AO	PL B774 494	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58292
AABOUD	17AT	JHEP 1710 182	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=58331
AABOUD	17B	PL B765 32	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=57706
KHACHATRY...	17AX	PL B773 563	V. Khachatryan *et al.*	(CMS Collab.)	REFID=58240
KHACHATRY...	17H	JHEP 1702 048	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57792
KHACHATRY...	17J	JHEP 1703 077	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57800
KHACHATRY...	17T	PL B768 57	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57891
KHACHATRY...	17U	PL B768 137	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57892
KHACHATRY...	17W	PL B769 520	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57899
KHACHATRY...	17Y	PL B770 257	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57904
KHACHATRY...	17Z	PL B770 278	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57905
SIRUNYAN	17A	JHEP 1703 162	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=57803
SIRUNYAN	17AK	PL B774 533	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58293
SIRUNYAN	17AP	JHEP 1710 180	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58332
SIRUNYAN	17H	JHEP 1707 121	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=57825
SIRUNYAN	17I	JHEP 1708 029	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=57827
SIRUNYAN	17Q	JHEP 1707 001	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58124
SIRUNYAN	17R	EPJ C77 636	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58188
SIRUNYAN	17T	PRL 119 111802	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58202
SIRUNYAN	17V	JHEP 1709 053	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=58210
AABOUD	16	PL B759 229	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=57233
AABOUD	16AA	EPJ C76 585	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=57677
AABOUD	16AE	JHEP 1609 173	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=57729
AABOUD	16P	EPJ C76 541	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=57558
AABOUD	16U	PL B761 372	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=57570
AABOUD	16V	PL B762 334	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=57574
AAD	16G	EPJ C76 5	G. Aad *et al.*	(ATLAS Collab.)	REFID=57030
AAD	16L	EPJ C76 210	G. Aad *et al.*	(ATLAS Collab.)	REFID=57156
AAD	16R	PL B755 285	G. Aad *et al.*	(ATLAS Collab.)	REFID=57172
AAD	16S	PL B754 302	G. Aad *et al.*	(ATLAS Collab.)	REFID=57206
AAD	16W	PL B758 249	G. Aad *et al.*	(ATLAS Collab.)	REFID=57227
BARRANCO	16	JP G43 115004	J. Barranco *et al.*		REFID=57584
DEY	16	JHEP 1604 187	U.K. Dey, S. Mohanty		REFID=57408
KHACHATRY...	16AF	PR D93 032004	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57249
KHACHATRY...	16AG	PR D93 032005	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57250
Also		PR D95 039906 (errat.)	V. Khachatryan *et al.*	(CMS Collab.)	REFID=58108
KHACHATRY...	16AO	JHEP 1602 122	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57319
KHACHATRY...	16AP	JHEP 1602 145	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57320
KHACHATRY...	16BD	EPJ C76 237	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57370
KHACHATRY...	16BE	EPJ C76 317	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57373
KHACHATRY...	16E	PR D93 012001	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57017
KHACHATRY...	16K	PRL 116 071801	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57181
KHACHATRY...	16L	PRL 117 031802	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57195
KHACHATRY...	16O	PL B755 196	V. Khachatryan *et al.*	(CMS Collab.)	REFID=57208
KUMAR	16	PR D94 014022	G. Kumar		REFID=57416
AAD	15AM	JHEP 1507 157	G. Aad *et al.*	(ATLAS Collab.)	REFID=56643
AAD	15AO	JHEP 1508 148	G. Aad *et al.*	(ATLAS Collab.)	REFID=56645
AAD	15AT	EPJ C75 79	G. Aad *et al.*	(ATLAS Collab.)	REFID=56661
AAD	15AU	EPJ C75 69	G. Aad *et al.*	(ATLAS Collab.)	REFID=56662
AAD	15AV	EPJ C75 165	G. Aad *et al.*	(ATLAS Collab.)	REFID=56663
AAD	15AZ	EPJ C75 209	G. Aad *et al.*	(ATLAS Collab.)	REFID=56667
Also		EPJ C75 370 (errat.)	G. Aad *et al.*	(ATLAS Collab.)	REFID=57174
AAD	15BB	EPJ C75 263	G. Aad *et al.*	(ATLAS Collab.)	REFID=56669
AAD	15CD	PR D92 092001	G. Aad *et al.*	(ATLAS Collab.)	REFID=56906
AAD	15CP	JHEP 1512 055	G. Aad *et al.*	(ATLAS Collab.)	REFID=57021
AAD	15O	PRL 115 031801	G. Aad *et al.*	(ATLAS Collab.)	REFID=56481
AAD	15R	PL B743 235	G. Aad *et al.*	(ATLAS Collab.)	REFID=56500
AAD	15V	PR D91 052007	G. Aad *et al.*	(ATLAS Collab.)	REFID=56551
AALTONEN	15C	PRL 115 061801	T. Aaltonen *et al.*	(CDF Collab.)	REFID=56486
BESSAA	15	EPJ C75 97	A. Bessaa, S. Davidson		REFID=56651
KHACHATRY...	15AE	JHEP 1504 025	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56632
KHACHATRY...	15AJ	JHEP 1507 042	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56638
KHACHATRY...	15AV	JHEP 1509 201	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56855
KHACHATRY...	15C	PL B740 83	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56269
KHACHATRY...	15F	PRL 114 101801	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56446
KHACHATRY...	15O	PL B748 255	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56528

KHACHATRY...	15T	PR D91 092005	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56533
KHACHATRY...	15V	PR D91 052009	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56535
SAHOO	15A	PR D91 094019	S. Sahoo, R. Mohanta		REFID=56578
AAD	14AI	JHEP 1409 037	G. Aad *et al.*	(ATLAS Collab.)	REFID=56007
AAD	14AT	PL B738 428	G. Aad *et al.*	(ATLAS Collab.)	REFID=56129
AAD	14S	PL B737 223	G. Aad *et al.*	(ATLAS Collab.)	REFID=55875
AAD	14V	PR D90 052005	G. Aad *et al.*	(ATLAS Collab.)	REFID=55884
KHACHATRY...	14	JHEP 1408 173	V. Khachatryan *et al.*	(CMS Collab.)	REFID=55735
KHACHATRY...	14A	JHEP 1408 174	V. Khachatryan *et al.*	(CMS Collab.)	REFID=55736
KHACHATRY...	14O	EPJ C74 3149	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56182
KHACHATRY...	14T	PL B739 229	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56335
MARTINEZ	14	PR D90 015028	R. Martinez, F. Ochoa		REFID=56044
PRIEELS	14	PR D90 112003	R. Prieels *et al.*	(LOUV, ETH, PSI+)	REFID=56329
AAD	13AE	JHEP 1306 033	G. Aad *et al.*	(ATLAS Collab.)	REFID=55033
AAD	13AO	PR D87 112006	G. Aad *et al.*	(ATLAS Collab.)	REFID=55156
AAD	13AQ	PR D88 012004	G. Aad *et al.*	(ATLAS Collab.)	REFID=55168
AAD	13D	JHEP 1301 029	G. Aad *et al.*	(ATLAS Collab.)	REFID=54792
AAD	13G	JHEP 1301 116	G. Aad *et al.*	(ATLAS Collab.)	REFID=54907
AAD	13K	EPJ C73 2263	G. Aad *et al.*	(ATLAS Collab.)	REFID=54929
AAD	13S	PL B719 242	G. Aad *et al.*	(ATLAS Collab.)	REFID=54937
AALTONEN	13A	PRL 110 121802	T. Aaltonen *et al.*	(CDF Collab.)	REFID=54893
AALTONEN	13AA	PR D88 092004	T. Aaltonen *et al.*	(CDF Collab.)	REFID=55489
AALTONEN	13R	PRL 111 031802	T. Aaltonen *et al.*	(CDF Collab.)	REFID=55220
CHATRCHYAN	13A	JHEP 1301 013	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54770
CHATRCHYAN	13AF	PL B720 63	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55070
CHATRCHYAN	13AJ	PL B723 280	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55077
CHATRCHYAN	13AP	PR D87 072002	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55139
CHATRCHYAN	13AQ	PR D87 072005	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55140
CHATRCHYAN	13AS	PR D87 114015	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55162
CHATRCHYAN	13AU	PRL 110 141802	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55202
CHATRCHYAN	13BM	PRL 111 211804	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55492
Also		PRL 112 119903 (errat.)	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55841
CHATRCHYAN	13E	PL B718 1229	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54841
CHATRCHYAN	13M	PRL 110 081801	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54945
CHATRCHYAN	13U	JHEP 1302 036	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55026
SAKAKI	13	PR D88 094012	Y. Sakaki *et al.*		REFID=55556
AAD	12AV	PRL 109 081801	G. Aad *et al.*	(ATLAS Collab.)	REFID=54231
AAD	12BB	PR D85 112012	G. Aad *et al.*	(ATLAS Collab.)	REFID=54357
AAD	12BV	JHEP 1209 041	G. Aad *et al.*	(ATLAS Collab.)	REFID=54583
AAD	12CC	JHEP 1211 138	G. Aad *et al.*	(ATLAS Collab.)	REFID=54653
AAD	12CK	PR D86 091103	G. Aad *et al.*	(ATLAS Collab.)	REFID=54699
AAD	12CR	EPJ C72 2241	G. Aad *et al.*	(ATLAS Collab.)	REFID=54781
AAD	12H	PL B709 158	G. Aad *et al.*	(ATLAS Collab.)	REFID=54120
Also		PL B711 442 (errat.)	G. Aad *et al.*	(ATLAS Collab.)	REFID=54170
AAD	12K	EPJ C72 2083	G. Aad *et al.*	(ATLAS Collab.)	REFID=54127
AAD	12M	EPJ C72 2056	G. Aad *et al.*	(ATLAS Collab.)	REFID=54129
AAD	12O	EPJ C72 2151	G. Aad *et al.*	(ATLAS Collab.)	REFID=54131
AALTONEN	12AR	PR D86 112002	T. Aaltonen *et al.*	(CDF Collab.)	REFID=54797
AALTONEN	12N	PRL 108 211805	T. Aaltonen *et al.*	(CDF Collab.)	REFID=54243
ABAZOV	12R	PR D85 051101	V.M. Abazov *et al.*	(D0 Collab.)	REFID=54347
ABRAMOWICZ	12A	PR D86 012005	H. Abramowicz *et al.*	(ZEUS Collab.)	REFID=54417
CHATRCHYAN	12AF	PRL 109 141801	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54618
CHATRCHYAN	12AG	PR D86 052013	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54619
CHATRCHYAN	12AI	JHEP 1208 110	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54560
CHATRCHYAN	12AQ	JHEP 1209 029	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54573
Also		JHEP 1403 132 (errat.)	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55975
CHATRCHYAN	12AR	PL B717 351	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54621
CHATRCHYAN	12BG	PRL 109 261802	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54771
CHATRCHYAN	12BL	JHEP 1212 015	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54776
CHATRCHYAN	12BO	JHEP 1212 055	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54778
CHATRCHYAN	12BR	PRL 109 251801	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54831
CHATRCHYAN	12M	PL B714 158	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54180
CHATRCHYAN	12O	PL B716 82	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54182
KOSNIK	12	PR D86 055004	N. Kosnik	(LALO, STFN)	REFID=54713
AAD	11D	PR D83 112006	G. Aad *et al.*	(ATLAS Collab.)	REFID=16555
AAD	11H	PRL 106 251801	G. Aad *et al.*	(ATLAS Collab.)	REFID=16563
AAD	11Z	EPJ C71 1809	G. Aad *et al.*	(ATLAS Collab.)	REFID=53941
AALTONEN	11AD	PR D84 072003	T. Aaltonen *et al.*	(CDF Collab.)	REFID=53801
AALTONEN	11AE	PR D84 072004	T. Aaltonen *et al.*	(CDF Collab.)	REFID=53802
AALTONEN	11C	PR D83 031102	T. Aaltonen *et al.*	(CDF Collab.)	REFID=16425
AALTONEN	11I	PRL 106 121801	T. Aaltonen *et al.*	(CDF Collab.)	REFID=16437
AARON	11A	PL B701 20	F. D. Aaron *et al.*	(H1 Collab.)	REFID=16691
AARON	11B	PL B704 388	F. D. Aaron *et al.*	(H1 Collab.)	REFID=53844
AARON	11C	PL B705 52	F. D. Aaron *et al.*	(H1 Collab.)	REFID=53845
ABAZOV	11A	PL B695 88	V.M. Abazov *et al.*	(D0 Collab.)	REFID=53564
ABAZOV	11H	PRL 107 011801	V.M. Abazov *et al.*	(D0 Collab.)	REFID=16473
ABAZOV	11I	PRL 107 011804	V.M. Abazov *et al.*	(D0 Collab.)	REFID=16475
ABAZOV	11L	PL B699 145	V.M. Abazov *et al.*	(D0 Collab.)	REFID=16481
ABAZOV	11V	PR D84 071104	V.M. Abazov *et al.*	(D0 Collab.)	REFID=53797
BUENO	11	PR D84 032005	J.F. Bueno *et al.*	(TWIST Collab.)	REFID=53721
Also		PR D85 039908 (errat.)	J.F. Bueno *et al.*	(TWIST Collab.)	REFID=54395
CHATRCHYAN	11N	PL B703 246	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=53723
CHATRCHYAN	11O	JHEP 1108 005	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=53767
CHATRCHYAN	11Y	PL B704 123	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=53869
DORSNER	11	JHEP 1111 002	I. Dorsner *et al.*		REFID=54018
KHACHATRY...	11D	PRL 106 201802	V. Khachatryan *et al.*	(CMS Collab.)	REFID=16621
KHACHATRY...	11E	PRL 106 201803	V. Khachatryan *et al.*	(CMS Collab.)	REFID=16623
AALTONEN	10L	PL B691 183	T. Aaltonen *et al.*	(CDF Collab.)	REFID=53311
AALTONEN	10N	PRL 104 241801	T. Aaltonen *et al.*	(CDF Collab.)	REFID=53313
ABAZOV	10L	PL B693 95	V.M. Abazov *et al.*	(D0 Collab.)	REFID=53425
DEL-AGUILA	10	JHEP 1009 033	F. del Aguila, J. de Blas, M. Perez-Victoria	(GRAN)	REFID=53603
KHACHATRY...	10	PRL 105 211801	V. Khachatryan *et al.*	(CMS Collab.)	REFID=53465
Also		PRL 106 029902	V. Khachatryan *et al.*	(CMS Collab.)	REFID=53629
WAUTERS	10	PR C82 055502	F. Wauters *et al.*	(REZ, TAMU)	REFID=53522
AALTONEN	09AC	PR D79 112002	T. Aaltonen *et al.*	(CDF Collab.)	REFID=52945
AALTONEN	09T	PRL 102 031801	T. Aaltonen *et al.*	(CDF Collab.)	REFID=52859
AALTONEN	09V	PRL 102 091805	T. Aaltonen *et al.*	(CDF Collab.)	REFID=52861
ABAZOV	09	PL B671 224	V.M. Abazov *et al.*	(D0 Collab.)	REFID=52617
ABAZOV	09AF	PL B681 224	V.M. Abazov *et al.*	(D0 Collab.)	REFID=53065

ERLER	09	JHEP 0908 017	J. Erler *et al.*		REFID=52896
AALTONEN	08D	PR D77 051102	T. Aaltonen *et al.*	(CDF Collab.)	REFID=52199
AALTONEN	08P	PR D77 091105	T. Aaltonen *et al.*	(CDF Collab.)	REFID=52348
AALTONEN	08Y	PRL 100 231801	T. Aaltonen *et al.*	(CDF Collab.)	REFID=52379
AALTONEN	08Z	PRL 101 071802	T. Aaltonen *et al.*	(CDF Collab.)	REFID=52380
ABAZOV	08AA	PL B668 98	V.M. Abazov *et al.*	(D0 Collab.)	REFID=52405
ABAZOV	08AD	PL B668 357	V.M. Abazov *et al.*	(D0 Collab.)	REFID=52523
ABAZOV	08AN	PRL 101 241802	V.M. Abazov *et al.*	(D0 Collab.)	REFID=52605
ABAZOV	08C	PRL 100 031804	V.M. Abazov *et al.*	(D0 Collab.)	REFID=52198
MACDONALD	08	PR D78 032010	R.P. MacDonald *et al.*	(TWIST Collab.)	REFID=52420
ZHANG	08	NP B802 247	Y. Zhang *et al.*	(PKGU, UMD)	REFID=56402
AALTONEN	07H	PRL 99 171802	T. Aaltonen *et al.*	(CDF Collab.)	REFID=52013
ABAZOV	07E	PL B647 74	V.M. Abazov *et al.*	(D0 Collab.)	REFID=51741
ABAZOV	07J	PRL 99 061801	V.M. Abazov *et al.*	(D0 Collab.)	REFID=51871
AKTAS	07A	EPJ C52 833	A. Aktas *et al.*	(H1 Collab.)	REFID=52035
CHOUDHURY	07	PL B657 69	D. Choudhury *et al.*		REFID=52028
MELCONIAN	07	PL B649 370	D. Melconian *et al.*	(TRIUMF)	REFID=51822
SCHAEL	07A	EPJ C49 411	S. Schael *et al.*	(ALEPH Collab.)	REFID=51743
SCHUMANN	07	PRL 99 191803	M. Schumann *et al.*	(HEID, ILLG, KARL+)	REFID=52019
SMIRNOV	07	MPL A22 2353	A.D. Smirnov		REFID=51970
ABAZOV	06A	PL B636 183	V.M. Abazov *et al.*	(D0 Collab.)	REFID=51213
ABAZOV	06L	PL B640 230	V.M. Abazov *et al.*	(D0 Collab.)	REFID=51379
ABDALLAH	06C	EPJ C45 589	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=51224
ABULENCIA	06L	PRL 96 211801	A. Abulencia *et al.*	(CDF Collab.)	REFID=51233
ABULENCIA	06M	PRL 96 211802	A. Abulencia *et al.*	(CDF Collab.)	REFID=51232
ABULENCIA	06T	PR D73 051102	A. Abulencia *et al.*	(CDF Collab.)	REFID=51269
ABAZOV	05H	PR D71 071104	V.M. Abazov *et al.*	(D0 Collab.)	REFID=50628
ABULENCIA	05A	PRL 95 252001	A. Abulencia *et al.*	(CDF Collab.)	REFID=51009
ACOSTA	05I	PR D71 112001	D. Acosta *et al.*	(CDF Collab.)	REFID=50664
ACOSTA	05P	PR D72 051107	D. Acosta *et al.*	(CDF Collab.)	REFID=50889
ACOSTA	05R	PRL 95 131801	D. Acosta *et al.*	(CDF Collab.)	REFID=50916
AKTAS	05B	PL B629 9	A. Aktas *et al.*	(H1 Collab.)	REFID=50884
CHEKANOV	05	PL B610 212	S. Chekanov *et al.*	(HERA ZEUS Collab.)	REFID=50531
CHEKANOV	05A	EPJ C44 463	S. Chekanov *et al.*	(ZEUS Collab.)	REFID=50957
CYBURT	05	ASP 23 313	R.H. Cyburt *et al.*		REFID=50710
ABAZOV	04A	PRL 92 221801	V.M. Abazov *et al.*	(D0 Collab.)	REFID=49944
ABAZOV	04C	PR D69 111101	V.M. Abazov *et al.*	(D0 Collab.)	REFID=50005
ABBIENDI	04G	EPJ C33 173	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=49915
ABBIENDI	03D	EPJ C26 331	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=49290
ABBIENDI	03R	EPJ C31 281	G. Abbiendi *et al.*	(OPAL)	REFID=50015
ACOSTA	03B	PRL 90 081802	D. Acosta *et al.*	(CDF Collab.)	REFID=49354
ADLOFF	03	PL B568 35	C. Adloff *et al.*	(H1 Collab.)	REFID=49522
BARGER	03B	PR D67 075009	V. Barger, P. Langacker, H. Lee		REFID=49347
CHANG	03	PR D68 111101	M.-C. Chang *et al.*	(BELLE Collab.)	REFID=49640
CHEKANOV	03B	PR D68 052004	S. Chekanov *et al.*	(ZEUS Collab.)	REFID=49547
ABAZOV	02	PRL 88 191801	V.M. Abazov *et al.*	(D0 Collab.)	REFID=48646
ABBIENDI	02B	PL B526 233	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=48537
AFFOLDER	02C	PRL 88 071806	T. Affolder *et al.*	(CDF Collab.)	REFID=48697
CHEKANOV	02	PR D65 092004	S. Chekanov *et al.*	(ZEUS Collab.)	REFID=48791
CHEKANOV	02B	PL B531 9	S. Chekanov *et al.*	(ZEUS Collab.)	REFID=48937
MUECK	02	PR D65 085037	A. Mueck, A. Pilaftsis, R. Rueckl		REFID=48887
ABAZOV	01B	PRL 87 061802	V.M. Abazov *et al.*	(D0 Collab.)	REFID=48208
ABAZOV	01D	PR D64 092004	V.M. Abazov *et al.*	(D0 Collab.)	REFID=48394
ADLOFF	01C	PL B523 234	C. Adloff *et al.*	(H1 Collab.)	REFID=48477
AFFOLDER	01I	PRL 87 231803	T. Affolder *et al.*	(CDF Collab.)	REFID=48438
BREITWEG	01	PR D63 052002	J. Breitweg *et al.*	(ZEUS Collab.)	REFID=48089
CHEUNG	01B	PL B517 167	K. Cheung		REFID=48289
THOMAS	01	NP A694 559	E. Thomas *et al.*		REFID=48407
ABBIENDI	00M	EPJ C13 15	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=47590
ABBOTT	00C	PRL 84 2088	B. Abbott *et al.*	(D0 Collab.)	REFID=47518
ABE	00	PRL 84 5716	F. Abe *et al.*	(CDF Collab.)	REFID=47637
ABREU	00S	PL B485 45	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47716
ABREU	00Z	EPJ C17 53	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47790
ACCIARRI	00P	PL B489 81	M. Acciarri *et al.*	(L3 Collab.)	REFID=47757
ADLOFF	00	PL B479 358	C. Adloff *et al.*	(H1 Collab.)	REFID=47621
AFFOLDER	00K	PRL 85 2056	T. Affolder *et al.*	(CDF Collab.)	REFID=47752
BARATE	00I	EPJ C12 183	R. Barate *et al.*	(ALEPH Collab.)	REFID=47537
BARGER	00	PL B480 149	V. Barger, K. Cheung		REFID=47624
BREITWEG	00E	EPJ C16 253	J. Breitweg *et al.*	(ZEUS Collab.)	REFID=47750
CHAY	00	PR D61 035002	J. Chay, K.Y. Lee, S. Nam		REFID=47348
CHO	00	MPL A15 311	G. Cho		REFID=47613
CORNET	00	PR D61 037701	F. Cornet, M. Relano, J. Rico		REFID=47888
DELGADO	00	JHEP 0001 030	A. Delgado, A. Pomarol, M. Quiros		REFID=48620
ERLER	00	PRL 84 212	J. Erler, P. Langacker		REFID=47351
GABRIELLI	00	PR D62 055009	E. Gabrielli		REFID=47701
RIZZO	00	PR D61 016007	T.G. Rizzo, J.D. Wells		REFID=47887
ROSNER	00	PR D61 016006	J.L. Rosner		REFID=47342
ZARNECKI	00	EPJ C17 695	A. Zarnecki		REFID=47883
ABBIENDI	99	EPJ C6 1	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=46533
ABBOTT	99J	PRL 83 2896	B. Abbott *et al.*	(D0 Collab.)	REFID=47210
ABREU	99G	PL B446 62	P. Abreu *et al.*	(DELPHI Collab.)	REFID=46712
ACKERSTAFF	99D	EPJ C8 3	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=47012
ADLOFF	99	EPJ C11 447	C. Adloff *et al.*	(H1 Collab.)	REFID=47307
Also		EPJ C14 553 (errat.)	C. Adloff *et al.*	(H1 Collab.)	REFID=47649
CASALBUONI	99	PL B460 135	R. Casalbuoni *et al.*		REFID=47057
CZAKON	99	PL B458 355	M. Czakon, J. Gluza, M. Zralek		REFID=47171
ERLER	99	PL B456 68	J. Erler, P. Langacker		REFID=47166
MARCIANO	99	PR D60 093006	W. Marciano		REFID=48622
MASIP	99	PR D60 096005	M. Masip, A. Pomarol		REFID=48621
NATH	99	PR D60 116004	P. Nath, M. Yamaguchi		REFID=48619
STRUMIA	99	PL B466 107	A. Strumia		REFID=47357
ABBOTT	98E	PRL 80 2051	B. Abbott *et al.*	(D0 Collab.)	REFID=45954

ABBOTT	98J	PRL 81 38	B. Abbott *et al.*	(D0 Collab.)	REFID=46089
ABE	98S	PRL 81 4806	F. Abe *et al.*	(CDF Collab.)	REFID=46495
ABE	98V	PRL 81 5742	F. Abe *et al.*	(CDF Collab.)	REFID=46697
ACCIARRI	98J	PL B433 163	M. Acciarri *et al.*	(L3 Collab.)	REFID=46075
ACKERSTAFF	98V	EPJ C2 441	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=46164
BARATE	98U	EPJ C4 571	R. Barate *et al.*	(ALEPH Collab.)	REFID=46150
BARENBOIM	98	EPJ C1 369	G. Barenboim		REFID=46143
CHO	98	EPJ C5 155	G. Cho, K. Hagiwara, S. Matsumoto		REFID=46261
CONRAD	98	RMP 70 1341	J.M. Conrad, M.H. Shaevitz, T. Bolton		REFID=46498
DONCHESKI	98	PR D58 097702	M.A. Doncheski, R.W. Robinett		REFID=46486
GROSS-PILCH...	98	hep-ex/9810015	C. Grosso-Pilcher, G. Landsberg, M. Paterno		REFID=48647;ERROR=1
ABE	97F	PRL 78 2906	F. Abe *et al.*	(CDF Collab.)	REFID=45301
ABE	97G	PR D55 5263	F. Abe *et al.*	(CDF Collab.)	REFID=45343
ABE	97S	PRL 79 2192	F. Abe *et al.*	(CDF Collab.)	REFID=45595
ABE	97W	PRL 79 3819	F. Abe *et al.*	(CDF Collab.)	REFID=45719
ABE	97X	PRL 79 4327	F. Abe *et al.*	(CDF Collab.)	REFID=45724
ACCIARRI	97Q	PL B412 201	M. Acciarri *et al.*	(L3 Collab.)	REFID=45738
ARIMA	97	PR D55 19	T. Arima *et al.*	(VENUS Collab.)	REFID=45264
BARENBOIM	97	PR D55 4213	G. Barenboim *et al.*	(VALE, IFIC)	REFID=45339
DEANDREA	97	PL B409 277	A. Deandrea	(MARS)	REFID=45662
DERRICK	97	ZPHY C73 613	M. Derrick *et al.*	(ZEUS Collab.)	REFID=45295
GROSSMAN	97	PR D55 2768	Y. Grossman, Z. Ligeti, E. Nardi	(REHO, CIT)	REFID=45274
JADACH	97	PL B408 281	S. Jadach, B.F.L. Ward, Z. Was	(CERN, INPK+)	REFID=45658
STAHL	97	ZPHY C74 73	A. Stahl, H. Voss	(BONN)	REFID=45483
ABACHI	96C	PRL 76 3271	S. Abachi *et al.*	(D0 Collab.)	REFID=44802
ABREU	96T	ZPHY C72 179	P. Abreu *et al.*	(DELPHI Collab.)	REFID=45275
ADAM	96C	PL B380 471	W. Adam *et al.*	(DELPHI Collab.)	REFID=44847
AID	96B	PL B369 173	S. Aid *et al.*	(H1 Collab.)	REFID=44831
ALLET	96	PL B383 139	M. Allet *et al.*	(VILL, LEUV, LOUV, WISC)	REFID=44854
ABACHI	95E	PL B358 405	S. Abachi *et al.*	(D0 Collab.)	REFID=44474
ABE	95N	PRL 74 3538	F. Abe *et al.*	(CDF Collab.)	REFID=44201
BALEST	95	PR D51 2053	R. Balest *et al.*	(CLEO Collab.)	REFID=44146
KUZNETSOV	95	PRL 75 794	I.A. Kuznetsov *et al.*	(PNPI, KIAE, HARV+)	REFID=44348
KUZNETSOV	95B	PAN 58 2113	A.V. Kuznetsov, N.V. Mikheev	(YARO)	REFID=44743
		Translated from YAF 58 2228.			
MIZUKOSHI	95	NP B443 20	J.K. Mizukoshi, O.J.P. Eboli, M.C. Gonzalez-Garcia		REFID=44276;ERROR=2
ABREU	94O	ZPHY C64 183	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44046
BHATTACH...	94	PL B336 100	G. Bhattacharyya, J. Ellis, K. Sridhar	(CERN)	REFID=43964
Also		PL B338 522 (errat.)	G. Bhattacharyya, J. Ellis, K. Sridhar	(CERN)	REFID=44024
BHATTACH...	94B	PL B338 522 (errat.)	G. Bhattacharyya, J. Ellis, K. Sridhar	(CERN)	REFID=44024
DAVIDSON	94	ZPHY C61 613	S. Davidson, D. Bailey, B.A. Campbell	(CFPA+)	REFID=43910
KUZNETSOV	94	PL B329 295	A.V. Kuznetsov, N.V. Mikheev	(YARO)	REFID=43947
KUZNETSOV	94B	JETPL 60 315	I.A. Kuznetsov *et al.*	(PNPI, KIAE, HARV+)	REFID=44031
		Translated from ZETFP 60 311.			
LEURER	94	PR D50 536	M. Leurer	(REHO)	REFID=43865
LEURER	94B	PR D49 333	M. Leurer	(REHO)	REFID=43981
Also		PRL 71 1324	M. Leurer	(REHO)	REFID=43464
MAHANTA	94	PL B337 128	U. Mahanta	(MEHTA)	REFID=44012
SEVERIJNS	94	PRL 73 611 (errat.)	N. Severijns *et al.*	(LOUV, WISC, LEUV+)	REFID=43880
VILAIN	94B	PL B332 465	P. Vilain *et al.*	(CHARM II Collab.)	REFID=43900
ABE	93C	PL B302 119	K. Abe *et al.*	(VENUS Collab.)	REFID=43291
ABE	93D	PL B304 373	T. Abe *et al.*	(TOPAZ Collab.)	REFID=43337
ABE	93G	PRL 71 2542	F. Abe *et al.*	(CDF Collab.)	REFID=43512
ABREU	93J	PL B316 620	P. Abreu *et al.*	(DELPHI Collab.)	REFID=43628
ACTON	93E	PL B311 391	P.D. Acton *et al.*	(OPAL Collab.)	REFID=43438
ADRIANI	93M	PRPL 236 1	O. Adriani *et al.*	(L3 Collab.)	REFID=43644
ALITTI	93	NP B400 3	J. Alitti *et al.*	(UA2 Collab.)	REFID=43544
BHATTACH...	93	PR D47 3693	G. Bhattacharyya *et al.*	(CALC, JADA, ICTP+)	REFID=43374
BUSKULIC	93F	PL B308 425	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=43431
DERRICK	93	PL B306 173	M. Derrick *et al.*	(ZEUS Collab.)	REFID=43345
RIZZO	93	PR D48 4470	T.G. Rizzo	(ANL)	REFID=43549
SEVERIJNS	93	PRL 70 4047	N. Severijns *et al.*	(LOUV, WISC, LEUV+)	REFID=43365
Also		PRL 73 611 (errat.)	N. Severijns *et al.*	(LOUV, WISC, LEUV+)	REFID=43880
STERNER	93	PL B303 385	K.L. Sterner *et al.*	(AMY Collab.)	REFID=43299
ABREU	92D	ZPHY C53 555	P. Abreu *et al.*	(DELPHI Collab.)	REFID=41957
ADRIANI	92F	PL B292 472	O. Adriani *et al.*	(L3 Collab.)	REFID=42222
DECAMP	92	PRPL 216 253	D. Decamp *et al.*	(ALEPH Collab.)	REFID=41877
IMAZATO	92	PRL 69 877	J. Imazato *et al.*	(KEK, INUS, TOKY+)	REFID=42141
MISHRA	92	PRL 68 3499	S.R. Mishra *et al.*	(COLU, CHIC, FNAL+)	REFID=42035
POLAK	92B	PR D46 3871	J. Polak, M. Zralek	(SILES)	REFID=43750
ACTON	91	PL B268 122	D.P. Acton *et al.*	(OPAL Collab.)	REFID=41617
ACTON	91B	PL B273 338	D.P. Acton *et al.*	(OPAL Collab.)	REFID=41878
ADEVA	91D	PL B262 155	B. Adeva *et al.*	(L3 Collab.)	REFID=41550
AQUINO	91	PL B261 280	M. Aquino, A. Fernandez, A. Garcia	(CINV, PUEB)	REFID=41687
COLANGELO	91	PL B253 154	P. Colangelo, G. Nardulli	(BARI)	REFID=41692
CUYPERS	91	PL B259 173	F. Cuypers, A.F. Falk, P.H. Frampton	(DURH, HARV+)	REFID=41666
FARAGGI	91	MPL A6 61	A.E. Faraggi, D.V. Nanopoulos	(TAMU)	REFID=41880
POLAK	91	NP B363 385	J. Polak, M. Zralek	(SILES)	REFID=43749
RIZZO	91	PR D44 202	T.G. Rizzo	(WISC, ISU)	REFID=41520
WALKER	91	APJ 376 51	T.P. Walker *et al.*	(HSCA, OSU, CHIC+)	REFID=41879
ABE	90F	PL B246 297	K. Abe *et al.*	(VENUS Collab.)	REFID=41337
ABE	90H	PR D41 1722	F. Abe *et al.*	(CDF Collab.)	REFID=41506
AKRAWY	90J	PL B246 285	M.Z. Akrawy *et al.*	(OPAL Collab.)	REFID=41336
GONZALEZ...	90D	PL B240 163	M.C. Gonzalez-Garcia, J.W.F. Valle	(VALE)	REFID=41814
GRIFOLS	90	NP B331 244	J.A. Grifols, E. Masso	(BARC)	REFID=41230
GRIFOLS	90D	PR D42 3293	J.A. Grifols, E. Masso, T.G. Rizzo	(BARC, CERN+)	REFID=41462
KIM	90	PL B240 243	G.N. Kim *et al.*	(AMY Collab.)	REFID=41211
LOPEZ	90	PL B241 392	J.L. Lopez, D.V. Nanopoulos	(TAMU)	REFID=41219
BARBIERI	89B	PR D39 1229	R. Barbieri, R.N. Mohapatra	(PISA, UMD)	REFID=41881
LANGACKER	89B	PR D40 1569	P. Langacker, S. Uma Sankar	(PENN)	REFID=41815
ODAKA	89	JPSJ 58 3037	S. Odaka *et al.*	(VENUS Collab.)	REFID=40971
ROBINETT	89	PR D39 834	R.W. Robinett	(PSU)	REFID=40896
ALBAJAR	88B	PL B209 127	C. Albajar *et al.*	(UA1 Collab.)	REFID=40894
BAGGER	88	PR D37 1188	J. Bagger, C. Schmidt, S. King	(HARV, BOST)	REFID=40895
BALKE	88	PR D37 587	B. Balke *et al.*	(LBL, UCB, COLO, NWES+)	REFID=40665
BERGSTROM	88	PL B212 386	L. Bergstrom	(STOH)	REFID=40980
CUYPERS	88	PRL 60 1237	F. Cuypers, P.H. Frampton	(UNCCH)	REFID=40599
DONCHESKI	88	PL B206 137	M.A. Doncheski, H. Grotch, R. Robinett	(PSU)	REFID=40898
DONCHESKI	88B	PR D38 412	M.A. Doncheski, H. Grotch, R.W. Robinett	(PSU)	REFID=40897
BARTEL	87B	ZPHY C36 15	W. Bartel *et al.*	(JADE Collab.)	REFID=40455
BEHREND	86B	PL B178 452	H.J. Behrend *et al.*	(CELLO Collab.)	REFID=40150
DERRICK	86	PL 166B 463	M. Derrick *et al.*	(HRS Collab.)	REFID=40135
Also		PR D34 3286	M. Derrick *et al.*	(HRS Collab.)	REFID=43492
JODIDIO	86	PR D34 1967	A. Jodidio *et al.*	(LBL, NWES, TRIU)	REFID=40309
Also		PR D37 237 (errat.)	A. Jodidio *et al.*	(LBL, NWES, TRIU)	REFID=40467
MOHAPATRA	86	PR D34 909	R.N. Mohapatra	(UMD)	REFID=40148
ADEVA	85	PL 152B 439	B. Adeva *et al.*	(Mark-J Collab.)	REFID=10618
BERGER	85B	ZPHY C27 341	C. Berger *et al.*	(PLUTO Collab.)	REFID=40465
STOKER	85	PRL 54 1887	D.P. Stoker *et al.*	(LBL, NWES, TRIU)	REFID=10256
ADEVA	84	PRL 53 134	B. Adeva *et al.*	(Mark-J Collab.)	REFID=10613
BEHREND	84C	PL 140B 130	H.J. Behrend *et al.*	(CELLO Collab.)	REFID=12651
BERGSMA	83	PL 122B 465	F. Bergsma *et al.*	(CHARM Collab.)	REFID=10239
CARR	83	PRL 51 627	J. Carr *et al.*	(LBL, NWES, TRIU)	REFID=10240
BEALL	82	PRL 48 848	G. Beall, M. Bander, A. Soni	(UCI, UCLA)	REFID=40597
SHANKER	82	NP B204 375	O. Shanker	(TRIU)	REFID=12502