

# Technicolor

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[Dynamical Electroweak Symmetry Breaking: Implications of the  \$H^0\$](#)

The latest unpublished results are described in “Dynamical Electroweak Symmetry Breaking” review.

## MASS LIMITS for Resonances in Models of Dynamical Electroweak Symmetry Breaking

VALUE (GeV)	CL%	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
>3900	95	1 AAD	20AM ATLS	top-color $Z'$
		2 AAD	20W ATLS	$\rho_T \rightarrow W\pi_T \rightarrow \ell\nu q\bar{q}$
		3 AAD	16W ATLS	color octet vector resonance
>2400	95	4 KHACHATRY...16E	CMS	top-color $Z'$
		5 AAD	15AB ATLS	$h \rightarrow \pi_V \pi_V$
>1800	95	6 AAD	15AO ATLS	top-color $Z'$
		7 AAD	15BB ATLS	$\rho\rho \rightarrow \rho_T/a_{1T} \rightarrow Wh$ or $Zh$
		8 AAD	15Q ATLS	$h \rightarrow \pi_V \pi_V$
		9 AAIJ	15AN LHCb	$h \rightarrow \pi_V \pi_V$
>1140	95	10 KHACHATRY...15C	CMS	$\rho_T \rightarrow WZ$
		11 KHACHATRY...15W	CMS	$H \rightarrow \pi_V \pi_V$
none 200–700, 750–890	95	12 AAD	14AT ATLS	$\rho\rho \rightarrow \omega_T \rightarrow Z\gamma$
none 275–960	95	12 AAD	14AT ATLS	$\rho\rho \rightarrow a_T \rightarrow W\gamma$
		13 AAD	14V ATLS	color singlet techni-vector
> 703		14 AAD	13AN ATLS	$\rho\rho \rightarrow a_T \rightarrow W\gamma$
> 494		15 AAD	13AN ATLS	$\rho\rho \rightarrow \omega_T \rightarrow Z\gamma$
none 500–1740	95	16 AAD	13AQ ATLS	top-color $Z'$
>1300	95	17 CHATRCHYAN	13AP CMS	top-color $Z'$
>2100	95	16 CHATRCHYAN	13BM CMS	top-color $Z'$
		18 BAAK	12 RVUE	QCD-like technicolor
none 167–687	95	19 CHATRCHYAN	12AF CMS	$\rho_T \rightarrow WZ$
> 805	95	16 AALTONEN	11AD CDF	top-color $Z'$
> 805	95	16 AALTONEN	11AE CDF	top-color $Z'$
		20 CHIVUKULA	11 RVUE	top-Higgs
		21 CHIVUKULA	11A RVUE	techini- $\pi$
		22 AALTONEN	10I CDF	$\rho\bar{\rho} \rightarrow \rho_T/\omega_T \rightarrow W\pi_T$
none 208–408	95	23 ABAZOV	10A D0	$\rho_T \rightarrow WZ$
		24 ABAZOV	07I D0	$\rho\bar{\rho} \rightarrow \rho_T/\omega_T \rightarrow W\pi_T$
> 280	95	25 ABULENCIA	05A CDF	$\rho_T \rightarrow e^+e^-, \mu^+\mu^-$
		26 CHEKANOV	02B ZEUS	color octet techni- $\pi$
> 207	95	27 ABAZOV	01B D0	$\rho_T \rightarrow e^+e^-$
none 90–206.7	95	28 ABDALLAH	01 DLPH	$e^+e^- \rightarrow \rho_T$

		29	AFFOLDER	00F	CDF	color-singlet techni- $\rho$ , $\rho_T \rightarrow W\pi_T, 2\pi_T$
> 600	95	30	AFFOLDER	00K	CDF	color-octet techni- $\rho$ , $\rho_{T8} \rightarrow 2\pi_{LQ}$
none 350–440	95	31	ABE	99F	CDF	color-octet techni- $\rho$ , $\rho_{T8} \rightarrow \bar{b}b$
		32	ABE	99N	CDF	techni- $\omega$ , $\omega_T \rightarrow \gamma\bar{b}b$
none 260–480	95	33	ABE	97G	CDF	color-octet techni- $\rho$ , $\rho_{T8} \rightarrow 2\text{jets}$

<sup>1</sup> AAD 20AM search for a top-color  $Z'$  decaying to  $t\bar{t}$  in  $pp$  collisions at  $\sqrt{s} = 13$  TeV. The quoted limit is for  $\Gamma_{Z'}/M_{Z'} = 0.01$ . The limit becomes  $M_{Z'} > 4700$  GeV for  $\Gamma_{Z'}/M_{Z'} = 0.03$ .

<sup>2</sup> AAD 20W search for techni- $\rho$  decaying to  $\pi_T W$  in  $pp$  collisions at  $\sqrt{s} = 13$  TeV. See their Fig. 5a for limits on  $\sigma \cdot B$ .

<sup>3</sup> AAD 16W search for color octet vector resonance decaying to  $bB$  in  $pp$  collisions at  $\sqrt{s} = 8$  TeV. The vector like quark  $B$  is assumed to decay to  $bH$ . See their Fig.3 and Fig.4 for limits on  $\sigma \cdot B$ .

<sup>4</sup> KHACHATRYAN 16E search for top-color  $Z'$  decaying to  $t\bar{t}$ . The quoted limit is for  $\Gamma_{Z'}/m_{Z'} = 0.012$ . Also exclude  $m_{Z'} < 2.9$  TeV for wider topcolor  $Z'$  with  $\Gamma_{Z'}/m_{Z'} = 0.1$ .

<sup>5</sup> AAD 15AB search for long-lived hidden valley  $\pi_V$  particles which are produced in pairs by the decay of a scalar boson.  $\pi_V$  is assumed to decay into dijets. See their Fig. 10 for the limit on  $\sigma B$ .

<sup>6</sup> AAD 15AO search for top-color  $Z'$  decaying to  $t\bar{t}$ . The quoted limit is for  $\Gamma_{Z'}/m_{Z'} = 0.012$ .

<sup>7</sup> AAD 15BB search for minimal walking technicolor (MWT) isotriplet vector and axial-vector resonances decaying to  $Wh$  or  $Zh$ . See their Fig. 3 for the exclusion limit in the MWT parameter space.

<sup>8</sup> AAD 15Q search for long-lived hidden valley  $\pi_V$  particles which are produced in pairs by the decay of scalar boson.  $\pi_V$  is assumed to decay into dijets. See their Fig. 5 and Fig. 6 for the limit on  $\sigma B$ .

<sup>9</sup> AAIJ 15AN search for long-lived hidden valley  $\pi_V$  particles which are produced in pairs by the decay of scalar boson with a mass of 120GeV.  $\pi_V$  is assumed to decay into dijets. See their Fig. 4 for the limit on  $\sigma B$ .

<sup>10</sup> KHACHATRYAN 15C search for a vector techni-resonance decaying to  $WZ$ . The limit assumes  $M_{\pi_T} = (3/4) M_{\rho_T} - 25$  GeV. See their Fig.3 for the limit in  $M_{\pi_T} - M_{\rho_T}$  plane of the low scale technicolor model.

<sup>11</sup> KHACHATRYAN 15W search for long-lived hidden valley  $\pi_V$  particles which are produced in pairs in the decay of heavy higgs boson  $H$ .  $\pi_V$  is assumed to decay into  $\ell^+ \ell^-$ . See their Fig. 7 and Fig. 8 for the limits on  $\sigma B$ .

<sup>12</sup> AAD 14AT search for techni- $\omega$  and techni- $a$  resonances decaying to  $V\gamma$  with  $V = W(\rightarrow \ell\nu)$  or  $Z(\rightarrow \ell^+ \ell^-)$ .

<sup>13</sup> AAD 14V search for vector techni-resonances decaying into electron or muon pairs in  $pp$  collisions at  $\sqrt{s} = 8$  TeV. See their table IX for exclusion limits with various assumptions.

<sup>14</sup> AAD 13AN search for vector techni-resonance  $a_T$  decaying into  $W\gamma$ .

<sup>15</sup> AAD 13AN search for vector techni-resonance  $\omega_T$  decaying into  $Z\gamma$ .

<sup>16</sup> Search for top-color  $Z'$  decaying to  $t\bar{t}$ . The quoted limit is for  $\Gamma_{Z'}/m_{Z'} = 0.012$ .

<sup>17</sup> CHATRCHYAN 13AP search for top-color leptophobic  $Z'$  decaying to  $t\bar{t}$ . The quoted limit is for  $\Gamma_{Z'}/m_{Z'} = 0.012$ .

<sup>18</sup> BAAK 12 give electroweak oblique parameter constraints on the QCD-like technicolor models. See their Fig. 28.

- 19 CHATRCHYAN 12AF search for a vector techni-resonance decaying to  $WZ$ . The limit assumes  $M_{\pi_T} = (3/4) M_{\rho_T} - 25$  GeV. See their Fig. 3 for the limit in  $M_{\pi_T} - M_{\rho_T}$  plane of the low scale technicolor model.
- 20 Using the LHC limit on the Higgs boson production cross section, CHIVUKULA 11 obtain a limit on the top-Higgs mass  $> 300$  GeV at 95% CL assuming 150 GeV top-pion mass.
- 21 Using the LHC limit on the Higgs boson production cross section, CHIVUKULA 11A obtain a limit on the technipion mass ruling out the region  $110 \text{ GeV} < m_P < 2m_t$ . Existence of color techni-fermions, top-color mechanism, and  $N_{TC} \geq 3$  are assumed.
- 22 AALTONEN 10I search for the vector techni-resonances ( $\rho_T, \omega_T$ ) decaying into  $W\pi_T$  with  $W \rightarrow \ell\nu$  and  $\pi_T \rightarrow b\bar{b}, b\bar{c},$  or  $b\bar{u}$ . See their Fig. 3 for the exclusion plot in  $M_{\pi_T} - M_{\rho_T}$  plane.
- 23 ABAZOV 10A search for a vector techni-resonance decaying into  $WZ$ . The limit assumes  $M_{\rho_T} < M_{\pi_T} + M_W$ .
- 24 ABAZOV 07I search for the vector techni-resonances ( $\rho_T, \omega_T$ ) decaying into  $W\pi_T$  with  $W \rightarrow e\nu$  and  $\pi_T \rightarrow b\bar{b}$  or  $b\bar{c}$ . See their Fig. 2 for the exclusion plot in  $M_{\pi_T} - M_{\rho_T}$  plane.
- 25 ABULENCIA 05A search for resonances decaying to electron or muon pairs in  $p\bar{p}$  collisions. at  $\sqrt{s} = 1.96$  TeV. The limit assumes Technicolor-scale mass parameters  $M_V = M_A = 500$  GeV.
- 26 CHEKANOV 02B search for color octet techni- $\pi$   $P$  decaying into dijets in  $e p$  collisions. See their Fig. 5 for the limit on  $\sigma(ep \rightarrow ePX) \cdot B(P \rightarrow 2j)$ .
- 27 ABAZOV 01B searches for vector techni-resonances ( $\rho_T, \omega_T$ ) decaying to  $e^+ e^-$ . The limit assumes  $M_{\rho_T} = M_{\omega_T} < M_{\pi_T} + M_W$ .
- 28 The limit is independent of the  $\pi_T$  mass. See their Fig. 9 and Fig. 10 for the exclusion plot in the  $M_{\rho_T} - M_{\pi_T}$  plane. ABDALLAH 01 limit on the techni-pion mass is  $M_{\pi_T} > 79.8$  GeV for  $N_D=2$ , assuming its point-like coupling to gauge bosons.
- 29 AFFOLDER 00F search for  $\rho_T$  decaying into  $W\pi_T$  or  $\pi_T\pi_T$  with  $W \rightarrow \ell\nu$  and  $\pi_T \rightarrow \bar{b}b, \bar{b}c$ . See Fig. 1 in the above Note on "Dynamical Electroweak Symmetry Breaking" for the exclusion plot in the  $M_{\rho_T} - M_{\pi_T}$  plane.
- 30 AFFOLDER 00K search for the  $\rho_{T8}$  decaying into  $\pi_{LQ}\pi_{LQ}$  with  $\pi_{LQ} \rightarrow b\nu$ . For  $\pi_{LQ} \rightarrow c\nu$ , the limit is  $M_{\rho_{T8}} > 510$  GeV. See their Fig. 2 and Fig. 3 for the exclusion plot in the  $M_{\rho_{T8}} - M_{\pi_{LQ}}$  plane.
- 31 ABE 99F search for a new particle  $X$  decaying into  $b\bar{b}$  in  $p\bar{p}$  collisions at  $E_{\text{cm}} = 1.8$  TeV. See Fig. 7 in the above Note on "Dynamical Electroweak Symmetry Breaking" for the upper limit on  $\sigma(p\bar{p} \rightarrow X) \times B(X \rightarrow b\bar{b})$ . ABE 99F also exclude top gluons of width  $\Gamma=0.3M$  in the mass interval  $280 < M < 670$  GeV, of width  $\Gamma=0.5M$  in the mass interval  $340 < M < 640$  GeV, and of width  $\Gamma=0.7M$  in the mass interval  $375 < M < 560$  GeV.
- 32 ABE 99N search for the techni- $\omega$  decaying into  $\gamma\pi_T$ . The technipion is assumed to decay  $\pi_T \rightarrow b\bar{b}$ . See Fig. 2 in the above Note on "Dynamical Electroweak Symmetry Breaking" for the exclusion plot in the  $M_{\omega_T} - M_{\pi_T}$  plane.
- 33 ABE 97G search for a new particle  $X$  decaying into dijets in  $p\bar{p}$  collisions at  $E_{\text{cm}} = 1.8$  TeV. See Fig. 5 in the above Note on "Dynamical Electroweak Symmetry Breaking" for the upper limit on  $\sigma(p\bar{p} \rightarrow X) \times B(X \rightarrow 2j)$ .

## REFERENCES FOR Technicolor

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