Neutral Higgs Bosons, Searches for

CONTENTS:

MASS LIMITS FOR NEUTRAL HIGGS BOSONS IN SUPERSYMMETRIC MODELS

The minimal supersymmetric model has two complex doublets of Higgs bosons. The resulting physical states are two scalars [H_1^0 and H_2^0, where we define $m_{H_1^0} < m_{H_2^0}$], a pseudoscalar (A^0), and a charged Higgs pair ($H^\pm$). H_1^0 and H_2^0 are also called h and H in the literature. There are two free parameters in the Higgs sector which can be chosen to be m_{A^0} and $\tan\beta = v_2/v_1$, the ratio of vacuum expectation values of the two Higgs doublets. Tree-level Higgs masses are constrained by the model to be $m_{H_1^0} \leq m_Z$, $m_{H_2^0} \geq m_Z$, $m_{A^0} \geq m_{H_1^0}$, and $m_{H^\pm} \geq m_W$. However, as described in the review on "Status of Higgs Boson Physics" in this Volume these relations are violated by radiative corrections.

Unless otherwise noted, the experiments in e^+e^- collisions search for the processes $e^+e^- \rightarrow H_1^0 Z^0$ in the channels used for the Standard Model Higgs searches and $e^+e^- \rightarrow H_1^0 A^0$ in the final states $b\overline{b}b\overline{b}$ and $b\overline{b}\tau^+\tau^-$. In $p\overline{p}$ and pp collisions the experiments search for a variety of processes, as explicitly specified for each entry. Limits on the A^0 mass arise from these direct searches, as well as from the relations valid in the minimal supersymmetric model between m_{A^0} and $m_{H_1^0}$. As discussed in the review on "Status of Higgs Boson Physics" in this Volume, these relations depend, via potentially large radiative corrections, on the mass of the t quark and on the supersymmetric parameters, in particular those of the stop sector. These indirect limits are weaker for larger t and $\widetilde{t}$ masses. To include the radiative corrections to the Higgs masses, unless otherwise stated, the listed papers use theoretical predictions incorporating two-loop corrections, and the results are given for the $m_h^{\rm max}$ benchmark scenario, which gives rise to the most conservative upper bound on the mass of H_1^0 for given values of m_{A^0} and $\tan\beta$, see CARENA 99B, CARENA 03, and CARENA 13.

Limits in the low-mass region of H_1^0, as well as other by now obsolete limits from different techniques, have been removed from this compilation, and can be found in earlier editions of this Review. Unless otherwise stated, the following results assume no invisible H_1^0 or A^0 decays.

The observed signal at about 125 GeV, see section "H^0", can be interpreted as one of the neutral Higgs bosons of supersymmetric models.

Mass Limits for H_1^0 (Higgs Boson) in Supersymmetric Models

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>89.7		[1] ABDALLAH	08B	DLPH	$E_{cm} \leq 209$ GeV
>92.8	95	[2] SCHAEL	06B	LEP	$E_{cm} \leq 209$ GeV
>84.5	95	[3,4] ABBIENDI	04M	OPAL	$E_{cm} \leq 209$ GeV
>86.0	95	[3,5] ACHARD	02H	L3	$E_{cm} \leq 209$ GeV, $\tan\beta > 0.4$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[6] AAD	14AW	ATLS	$pp \to H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \to \tau\tau$
		[7] KHACHATRY...	14M	CMS	$pp \to H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \to \tau\tau$
		[8] AAD	13O	ATLS	$pp \to H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \to \tau^+\tau^-$, $\mu^+\mu^-$
		[9] AAIJ	13T	LHCB	$pp \to H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \to \tau^+\tau^-$
		[10] CHATRCHYAN	13AG	CMS	$pp \to H_{1,2}^0/A^0 + b + X$, $H_{1,2}^0/A^0 \to b\overline{b}$
		[11] AALTONEN	12AQ	TEVA	$p\overline{p} \to H_{1,2}^0/A^0 + b + X$, $H_{1,2}^0/A^0 \to b\overline{b}$
		[12] AALTONEN	12X	CDF	$p\overline{p} \to H_{1,2}^0/A^0 + b + X$, $H_{1,2}^0/A^0 \to b\overline{b}$
		[13] ABAZOV	12G	D0	$p\overline{p} \to H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \to \tau^+\tau^-$
		[14] CHATRCHYAN	12K	CMS	$pp \to H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \to \tau^+\tau^-$
		[15] ABAZOV	11K	D0	$p\overline{p} \to H_{1,2}^0/A^0 + b + X$, $H_{1,2}^0/A^0 \to b\overline{b}$
		[16] ABAZOV	11W	D0	$p\overline{p} \to H_{1,2}^0/A^0 + b + X$, $H_{1,2}^0/A^0 \to \tau^+\tau^-$
		[17] AALTONEN	09AR	CDF	$p\overline{p} \to H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \to \tau^+\tau^-$
		[18] ABBIENDI	03G	OPAL	$H_1^0 \to A^0 A^0$
>89.8	95	[3,19] HEISTER	02	ALEP	$E_{cm} \leq 209$ GeV, $\tan\beta > 0.5$

[1] ABDALLAH 08B give limits in eight CP-conserving benchmark scenarios and some CP-violating scenarios. See paper for excluded regions for each scenario. Supersedes ABDALLAH 04.

[2] SCHAEL 06B make a combined analysis of the LEP data. The quoted limit is for the $m_h^{\max}$ scenario with m_t = 174.3 GeV. In the CP-violating CPX scenario no lower bound on $m_{H_1^0}$ can be set at 95% CL. See paper for excluded regions in various scenarios. See Figs. 2–6 and Tabs. 14–21 for limits on $\sigma(Z H^0)\cdot$ B($H^0 \to b\overline{b}, \tau^+\tau^-$) and $\sigma(H_1^0 H_2^0)\cdot$ B($H_1^0,H_2^0 \to b\overline{b},\tau^+\tau^-$).

[3] Search for $e^+e^- \to H_1^0 A^0$ in the final states $b\overline{b}b\overline{b}$ and $b\overline{b}\tau^+\tau^-$, and $e^+e^- \to H_1^0 Z$. Universal scalar mass of 1 TeV, SU(2) gaugino mass of 200 GeV, and $\mu = -200$ GeV are assumed, and two-loop radiative corrections incorporated. The limits hold for m_t=175 GeV, and for the $m_h^{\max}$ scenario.

[4] ABBIENDI 04M exclude $0.7 < \tan\beta < 1.9$, assuming m_t = 174.3 GeV. Limits for other MSSM benchmark scenarios, as well as for CP violating cases, are also given.

[5] ACHARD 02H also search for the final state $H_1^0 Z \to 2A^0 q\overline{q}$, $A^0 \to q\overline{q}$. In addition, the MSSM parameter set in the "large-μ" and "no-mixing" scenarios are examined.

[6] AAD 14AW search for production of a Higgs boson followed by the decay $H_{1,2}^0/A^0 \to \tau^+\tau^-$ in 19.5–20.3 fb^{-1} of pp collisions at $E_{\rm cm}$ = 8 TeV. See their Fig. 11 for the limits on cross section times branching ratio and their Figs. 9 and 10 for the excluded region in the MSSM parameter space. For m_{A^0} = 140 GeV, the region $\tan\beta > 5.4$ is excluded at 95% CL in the $m_h^{\max}$ scenario.

[7] KHACHATRYAN 14M search for production of a Higgs boson in gluon fusion and in association with a b quark followed by the decay $H_{1,2}^0/A^0 \to \tau^+\tau^-$ in 4.9 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and 19.7 fb^{-1} at $E_{\rm cm}$ = 8 TeV. See their Figs. 7 and 8 for one- and two-dimensional limits on cross section times branching ratio and their Figs. 5 and 6 for the excluded region in the MSSM parameter space. For m_{A^0} = 140 GeV, the region $\tan\beta > 3.8$ is excluded at 95% CL in the $m_h^{\max}$ scenario.

[8] AAD 13O search for production of a Higgs boson in the decay $H_{1,2}^0/A^0 \to \tau^+\tau^-$ and $\mu^+\mu^-$ with 4.7–4.8 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. See their Fig. 6 for the excluded region in the MSSM parameter space and their Fig. 7 for the limits on cross section times branching ratio. For m_{A^0} = 110–170 GeV, $\tan\beta \gtrsim 10$ is excluded, and for $\tan\beta = 50$, m_{A^0} below 470 GeV is excluded at 95% CL in the $m_h^{\max}$ scenario.

[9] AAIJ 13T search for production of a Higgs boson in the forward region in the decay $H_{1,2}^0/A^0 \to \tau^+\tau^-$ in 1.0 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. See their Fig. 2 for the limits on cross section times branching ratio and the excluded region in the MSSM parameter space.

[10] CHATRCHYAN 13AG search for production of a Higgs boson in association with a b quark in the decay $H_{1,2}^0/A^0 \to b\overline{b}$ in 2.7–4.8 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. See their Fig. 6 for the excluded region in the MSSM parameter space and Fig. 5 for the limits on cross section times branching ratio. For m_{A^0} = 90–350 GeV, upper bounds on $\tan\beta$ of 18–42 at 95% CL are obtained in the $m_h^{\max}$ scenario with $\mu = +200$ GeV.

[11] AALTONEN 12AQ combine AALTONEN 12X and ABAZOV 11K. See their Table I and Fig. 1 for the limit on cross section times branching ratio and Fig. 2 for the excluded region in the MSSM parameter space.

[12] AALTONEN 12X search for associated production of a Higgs boson and a b quark in the decay $H_{1,2}^0/A^0 \to b\overline{b}$, with 2.6 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. See their

Table III and Fig. 15 for the limit on cross section times branching ratio and Figs. 17, 18 for the excluded region in the MSSM parameter space.

[13] ABAZOV 12G search for production of a Higgs boson in the decay $H^0_{1,2}/A^0 \to \tau^+\tau^-$ with 7.3 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV and combine with ABAZOV 11W and ABAZOV 11K. See their Figs. 4, 5, and 6 for the excluded region in the MSSM parameter space. For m_{A^0} = 90–180 GeV, tan$\beta \gtrsim$ 30 is excluded at 95% CL. in the m_h^{max} scenario.

[14] CHATRCHYAN 12K search for production of a Higgs boson in the decay $H^0_{1,2}/A^0 \to \tau^+\tau^-$ with 4.6 fb^{-1} of pp collisions at E_{cm} = 7 TeV. See their Fig. 3 and Table 4 for the excluded region in the MSSM parameter space. For m_{A^0} = 160 GeV, the region tanβ > 7.1 is excluded at 95% CL in the m_h^{max} scenario. Superseded by KHACHATRYAN 14M.

[15] ABAZOV 11K search for associated production of a Higgs boson and a b quark, followed by the decay $H^0_{1,2}/A^0 \to b\overline{b}$, in 5.2 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. See their Fig. 5/Table 2 for the limit on cross section times branching ratio and Fig. 6 for the excluded region in the MSSM parameter space for $\mu = -200$ GeV.

[16] ABAZOV 11W search for associated production of a Higgs boson and a b quark, followed by the decay $H^0_{1,2}/A^0 \to \tau\tau$, in 7.3 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. See their Fig. 2 for the limit on cross section times branching ratio and for the excluded region in the MSSM parameter space.

[17] AALTONEN 09AR search for Higgs bosons decaying to $\tau^+\tau^-$ in two doublet models in 1.8 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. See their Fig. 2 for the limit on $\sigma \cdot$ B($H^0_{1,2}/A^0 \to \tau^+\tau^-$) for different Higgs masses, and see their Fig. 3 for the excluded region in the MSSM parameter space.

[18] ABBIENDI 03G search for $e^+e^- \to H^0_1 Z$ followed by $H^0_1 \to A^0 A^0$, $A^0 \to c\overline{c}$, gg, or $\tau^+\tau^-$. In the no-mixing scenario, the region $m_{H^0_1}$ = 45-85 GeV and m_{A^0} = 2-9.5 GeV is excluded at 95% CL.

[19] HEISTER 02 excludes the range 0.7 <tanβ < 2.3. A wider range is excluded with different stop mixing assumptions. Updates BARATE 01C.

Mass Limits for A^0 (Pseudoscalar Higgs Boson) in Supersymmetric Models

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>90.4		[1] ABDALLAH	08B	DLPH	$E_{cm} \leq$ 209 GeV
>93.4	95	[2] SCHAEL	06B	LEP	$E_{cm} \leq$ 209 GeV
>85.0	95	[3,4] ABBIENDI	04M	OPAL	$E_{cm} \leq$ 209 GeV
>86.5	95	[3,5] ACHARD	02H	L3	$E_{cm} \leq$ 209 GeV, tanβ > 0.4
>90.1	95	[3,6] HEISTER	02	ALEP	$E_{cm} \leq$ 209 GeV, tanβ > 0.5
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[7] AAD	14AW	ATLS	$pp \to H^0_{1,2}/A^0 + X$, $H^0_{1,2}/A^0 \to \tau\tau$
		[8] KHACHATRY...	14M	CMS	$pp \to H^0_{1,2}/A^0 + X$, $H^0_{1,2}/A^0 \to \tau\tau$
		[9] AAD	13O	ATLS	$pp \to H^0_{1,2}/A^0 + X$, $H^0_{1,2}/A^0 \to \tau^+\tau^-$, $\mu^+\mu^-$
		[10] AAIJ	13T	LHCB	$pp \to H^0_{1,2}/A^0 + X$, $H^0_{1,2}/A^0 \to \tau^+\tau^-$

[11] CHATRCHYAN	13AG	CMS	$pp \to H^0_{1,2}/A^0 + b + X$, $H^0_{1,2}/A^0 \to b\overline{b}$
[12] AALTONEN	12AQ	TEVA	$p\overline{p} \to H^0_{1,2}/A^0 + b + X$, $H^0_{1,2}/A^0 \to b\overline{b}$
[13] AALTONEN	12X	CDF	$p\overline{p} \to H^0_{1,2}/A^0 + b + X$, $H^0_{1,2}/A^0 \to b\overline{b}$
[14] ABAZOV	12G	D0	$p\overline{p} \to H^0_{1,2}/A^0 + X$, $H^0_{1,2}/A^0 \to \tau^+\tau^-$
[15] CHATRCHYAN	12K	CMS	$pp \to H^0_{1,2}/A^0 + X$, $H^0_{1,2}/A^0 \to \tau^+\tau^-$
[16] ABAZOV	11K	D0	$p\overline{p} \to H^0_{1,2}/A^0 + b + X$, $H^0_{1,2}/A^0 \to b\overline{b}$
[17] ABAZOV	11W	D0	$p\overline{p} \to H^0_{1,2}/A^0 + b + X$, $H^0_{1,2}/A^0 \to \tau^+\tau^-$
[18] AALTONEN	09AR	CDF	$p\overline{p} \to H^0_{1,2}/A^0 + X$, $H^0_{1,2}/A^0 \to \tau^+\tau^-$
[19] ACOSTA	05Q	CDF	$p\overline{p} \to H^0_{1,2}/A^0 + X$
[20] ABBIENDI	03G	OPAL	$H^0_1 \to A^0 A^0$
[21] AKEROYD	02	RVUE	

[1] ABDALLAH 08B give limits in eight CP-conserving benchmark scenarios and some CP-violating scenarios. See paper for excluded regions for each scenario. Supersedes ABDALLAH 04.

[2] SCHAEL 06B make a combined analysis of the LEP data. The quoted limit is for the m_h^{max} scenario with $m_t = 174.3$ GeV. In the CP-violating CPX scenario no lower bound on $m_{H_1^0}$ can be set at 95% CL. See paper for excluded regions in various scenarios. See Figs. 2–6 and Tabs. 14–21 for limits on $\sigma(Z H^0)\cdot$ B($H^0 \to b\overline{b}, \tau^+\tau^-$) and $\sigma(H^0_1 H^0_2)\cdot$ B($H^0_1,H^0_2 \to b\overline{b},\tau^+\tau^-$).

[3] Search for $e^+e^- \to H^0_1 A^0$ in the final states $b\overline{b}b\overline{b}$ and $b\overline{b}\tau^+\tau^-$, and $e^+e^- \to H^0_1 Z$. Universal scalar mass of 1 TeV, SU(2) gaugino mass of 200 GeV, and $\mu = -200$ GeV are assumed, and two-loop radiative corrections incorporated. The limits hold for m_t=175 GeV, and for the m_h^{max} scenario.

[4] ABBIENDI 04M exclude $0.7 < \tan\beta < 1.9$, assuming $m_t = 174.3$ GeV. Limits for other MSSM benchmark scenarios, as well as for CP violating cases, are also given.

[5] ACHARD 02H also search for the final state $H^0_1 Z \to 2A^0 q\overline{q}$, $A^0 \to q\overline{q}$. In addition, the MSSM parameter set in the "large-μ" and "no-mixing" scenarios are examined.

[6] HEISTER 02 excludes the range $0.7 < \tan\beta < 2.3$. A wider range is excluded with different stop mixing assumptions. Updates BARATE 01C.

[7] AAD 14AW search for production of a Higgs boson followed by the decay $H^0_{1,2}/A^0 \to \tau^+\tau^-$ in 19.5–20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. See their Fig. 11 for the limits on cross section times branching ratio and their Figs. 9 and 10 for the excluded region in the MSSM parameter space. For $m_{A^0} = 140$ GeV, the region $\tan\beta > 5.4$ is excluded at 95% CL in the m_h^{max} scenario.

[8] KHACHATRYAN 14M search for production of a Higgs boson in gluon fusion and in association with a b quark followed by the decay $H^0_{1,2}/A^0 \rightarrow \tau^+\tau^-$ in 4.9 fb^{-1} of pp collisions at E_{cm} = 7 TeV and 19.7 fb^{-1} at E_{cm} = 8 TeV. See their Figs. 7 and 8 for one- and two-dimensional limits on cross section times branching ratio and their Figs. 5 and 6 for the excluded region in the MSSM parameter space. For m_{A^0} = 140 GeV, the region $\tan\beta > 3.8$ is excluded at 95% CL in the m_h^{max} scenario.

[9] AAD 13O search for production of a Higgs boson in the decay $H^0_{1,2}/A^0 \rightarrow \tau^+\tau^-$ and $\mu^+\mu^-$ with 4.7–4.8 fb^{-1} of pp collisions at E_{cm} = 7 TeV. See their Fig. 6 for the excluded region in the MSSM parameter space and their Fig. 7 for the limits on cross section times branching ratio. For m_{A^0} = 110–170 GeV, $\tan\beta \gtrsim 10$ is excluded, and for $\tan\beta = 50$, m_{A^0} below 470 GeV is excluded at 95% CL in the m_h^{max} scenario.

[10] AAIJ 13T search for production of a Higgs boson in the forward region in the decay $H^0_{1,2}/A^0 \rightarrow \tau^+\tau^-$ in 1.0 fb^{-1} of pp collisions at E_{cm} = 7 TeV. See their Fig. 2 for the limits on cross section times branching ratio and the excluded region in the MSSM parameter space.

[11] CHATRCHYAN 13AG search for production of a Higgs boson in association with a b quark in the decay $H^0_{1,2}/A^0 \rightarrow b\overline{b}$ in 2.7–4.8 fb^{-1} of pp collisions at E_{cm} = 7 TeV. See their Fig. 6 for the excluded region in the MSSM parameter space and Fig. 5 for the limits on cross section times branching ratio. For m_{A^0} = 90–350 GeV, upper bounds on $\tan\beta$ of 18–42 at 95% CL are obtained in the m_h^{max} scenario with $\mu = +200$ GeV.

[12] AALTONEN 12AQ combine AALTONEN 12X and ABAZOV 11K. See their Table I and Fig. 1 for the limit on cross section times branching ratio and Fig. 2 for the excluded region in the MSSM parameter space.

[13] AALTONEN 12X search for associated production of a Higgs boson and a b quark in the decay $H^0_{1,2}/A^0 \rightarrow b\overline{b}$, with 2.6 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. See their Table III and Fig. 15 for the limit on cross section times branching ratio and Figs. 17, 18 for the excluded region in the MSSM parameter space.

[14] ABAZOV 12G search for production of a Higgs boson in the decay $H^0_{1,2}/A^0 \rightarrow \tau^+\tau^-$ with 7.3 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV and combine with ABAZOV 11W and ABAZOV 11K. See their Figs. 4, 5, and 6 for the excluded region in the MSSM parameter space. For m_{A^0} = 90–180 GeV, $\tan\beta \gtrsim 30$ is excluded at 95% CL. in the m_h^{max} scenario.

[15] CHATRCHYAN 12K search for production of a Higgs boson in the decay $H^0_{1,2}/A^0 \rightarrow \tau^+\tau^-$ with 4.6 fb^{-1} of pp collisions at E_{cm} = 7 TeV. See their Fig. 3 and Table 4 for the excluded region in the MSSM parameter space. For m_{A^0} = 160 GeV, the region $\tan\beta > 7.1$ is excluded at 95% CL in the m_h^{max} scenario. Superseded by KHACHATRYAN 14M.

[16] ABAZOV 11K search for associated production of a Higgs boson and a b quark, followed by the decay $H^0_{1,2}/A^0 \rightarrow b\overline{b}$, in 5.2 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. See their Fig. 5/Table 2 for the limit on cross section times branching ratio and Fig. 6 for the excluded region in the MSSM parameter space for $\mu = -200$ GeV.

[17] ABAZOV 11W search for associated production of a Higgs boson and a b quark, followed by the decay $H^0_{1,2}/A^0 \rightarrow \tau\tau$, in 7.3 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. See their Fig. 2 for the limit on cross section times branching ratio and for the excluded region in the MSSM parameter space.

[18] AALTONEN 09AR search for Higgs bosons decaying to $\tau^+\tau^-$ in two doublet models in 1.8 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. See their Fig. 2 for the limit on

$\sigma \cdot$ B($H^0_{1,2}/A^0 \rightarrow \tau^+\tau^-$) for different Higgs masses, and see their Fig. 3 for the excluded region in the MSSM parameter space.

[19] ACOSTA 05Q search for $H^0_{1,2}/A^0$ production in $p\overline{p}$ collisions at E_{cm} = 1.8 TeV with $H^0_{1,2}/A^0 \rightarrow \tau^+\tau^-$. At m_{A^0} = 100 GeV, the obtained cross section upper limit is above theoretical expectation.

[20] ABBIENDI 03G search for $e^+e^- \rightarrow H^0_1 Z$ followed by $H^0_1 \rightarrow A^0 A^0$, $A^0 \rightarrow c\overline{c}$, gg, or $\tau^+\tau^-$. In the no-mixing scenario, the region $m_{H^0_1}$ = 45-85 GeV and m_{A^0} = 2-9.5 GeV is excluded at 95% CL.

[21] AKEROYD 02 examine the possibility of a light A^0 with tanβ <1. Electroweak measurements are found to be inconsistent with such a scenario.

MASS LIMITS FOR NEUTRAL HIGGS BOSONS IN EXTENDED HIGGS MODELS

This Section covers models which do not fit into either the Standard Model or its simplest minimal Supersymmetric extension (MSSM), leading to anomalous production rates, or nonstandard final states and branching ratios. In particular, this Section covers limits which may apply to generic two-Higgs-doublet models (2HDM), or to special regions of the MSSM parameter space where decays to invisible particles or to photon pairs are dominant (see the review on "Status of Higgs Boson Physics"). Concerning the mass limits for H^0 and A^0 listed below, see the footnotes or the comment lines for details on the nature of the models to which the limits apply.

The observed signal at about 125 GeV, see section "H^0", can be interpreted as one of the neutral Higgs bosons of an extended Higgs sector.

Mass Limits in General two-Higgs-doublet Models

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] AAD	14M	ATLS	$H^0_2 \rightarrow H^\pm W^\mp \rightarrow H^0 W^\pm W^\mp$, $H^0 \rightarrow b\overline{b}$
		[2] KHACHATRY...	14Q	CMS	$H^0_2 \rightarrow H^0 H^0$, $A^0 \rightarrow Z H^0$
		[3] AALTONEN	09AR	CDF	$p\overline{p} \rightarrow H^0_{1,2}/A^0 + X$, $H^0_{1,2}/A^0 \rightarrow \tau^+\tau^-$
none 1–55	95	[4] ABBIENDI	05A	OPAL	H^0_1, Type II model
>110.6	95	[5] ABDALLAH	05D	DLPH	$H^0 \rightarrow$ 2 jets
		[6] ABDALLAH	04O	DLPH	$Z \rightarrow f\overline{f}H$
		[7] ABDALLAH	04O	DLPH	$e^+e^- \rightarrow H^0 Z$, $H^0 A^0$
		[8] ABBIENDI	02D	OPAL	$e^+e^- \rightarrow b\overline{b}H$
none 1–44	95	[9] ABBIENDI	01E	OPAL	H^0_1, Type-II model
> 68.0	95	[10] ABBIENDI	99E	OPAL	tanβ > 1
		[11] ABREU	95H	DLPH	$Z \rightarrow H^0 Z^*$, $H^0 A^0$
		[12] PICH	92	RVUE	Very light Higgs

[1] AAD 14M search for the decay cascade $H_2^0 \rightarrow H^{\pm} W^{\mp} \rightarrow H^0 W^{\pm} W^{\mp}$, H^0 decaying to $b\overline{b}$ in 20.3 fb^{-1} of pp collisions at $E_{\rm cm}$ = 8 TeV. See their Table IV for limits in a two-Higgs-doublet model for $m_{H_2^0}$= 325–1025 GeV and m_{H^+}= 225–825 GeV.

[2] KHACHATRYAN 14Q search for $H_2^0 \rightarrow H^0 H^0$ and $A^0 \rightarrow Z H^0$ in 19.5 fb^{-1} of pp collisions at $E_{\rm cm}$ = 8 TeV. See their Figs. 4 and 5 for limits on cross section times branching ratio for m_{H_2,A^0}= 260–360 GeV and their Figs. 7–9 for limits in two-Higgs-doublet models.

[3] AALTONEN 09AR search for Higgs bosons decaying to $\tau^+\tau^-$ in two doublet models in 1.8 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. See their Fig. 2 for the limit on $\sigma \cdot$ B$(H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-)$ for different Higgs masses, and see their Fig. 3 for the excluded region in the MSSM parameter space.

[4] ABBIENDI 05A search for $e^+e^- \rightarrow H_1^0 A^0$ in general Type-II two-doublet models, with decays H_1^0, $A^0 \rightarrow q\overline{q}$, gg, $\tau^+\tau^-$, and $H_1^0 \rightarrow A^0 A^0$.

[5] ABDALLAH 05D search for $e^+e^- \rightarrow H^0 Z$ and $H^0 A^0$ with H^0, A^0 decaying to two jets of any flavor including gg. The limit is for SM $H^0 Z$ production cross section with B$(H^0 \rightarrow jj) = 1$.

[6] ABDALLAH 04O search for $Z \rightarrow b\overline{b}H^0$, $b\overline{b}A^0$, $\tau^+\tau^- H^0$ and $\tau^+\tau^- A^0$ in the final states $4b$, $b\overline{b}\tau^+\tau^-$, and 4τ. See paper for limits on Yukawa couplings.

[7] ABDALLAH 04O search for $e^+e^- \rightarrow H^0 Z$ and $H^0 A^0$, with H^0, A^0 decaying to $b\overline{b}$, $\tau^+\tau^-$, or $H^0 \rightarrow A^0 A^0$ at $E_{\rm cm}$ = 189–208 GeV. See paper for limits on couplings.

[8] ABBIENDI 02D search for $Z \rightarrow b\overline{b}H_1^0$ and $b\overline{b}A^0$ with $H_1^0/A^0 \rightarrow \tau^+\tau^-$, in the range $4 < m_H < 12$ GeV. See their Fig. 8 for limits on the Yukawa coupling.

[9] ABBIENDI 01E search for neutral Higgs bosons in general Type-II two-doublet models, at $E_{\rm cm} \leq$ 189 GeV. In addition to usual final states, the decays H_1^0, $A^0 \rightarrow q\overline{q}$, gg are searched for. See their Figs. 15,16 for excluded regions.

[10] ABBIENDI 99E search for $e^+e^- \rightarrow H^0 A^0$ and $H^0 Z$ at $E_{\rm cm}$ = 183 GeV. The limit is with $m_H = m_A$ in general two Higgs-doublet models. See their Fig. 18 for the exclusion limit in the m_H–m_A plane. Updates the results of ACKERSTAFF 98S.

[11] See Fig. 4 of ABREU 95H for the excluded region in the $m_{H^0} - m_{A^0}$ plane for general two-doublet models. For $\tan\beta > 1$, the region $m_{H^0} + m_{A^0} \lesssim 87$ GeV, $m_{H^0} < 47$ GeV is excluded at 95% CL.

[12] PICH 92 analyse H^0 with $m_{H^0} < 2m_\mu$ in general two-doublet models. Excluded regions in the space of mass-mixing angles from LEP, beam dump, and $\pi^{\pm}$, η rare decays are shown in Figs. 3,4. The considered mass region is not totally excluded.

Mass Limits for H^0 with Vanishing Yukawa Couplings

These limits assume that H^0 couples to gauge bosons with the same strength as the Standard Model Higgs boson, but has no coupling to quarks and leptons (this is often referred to as "fermiophobic").

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
	95	[1] AALTONEN	13K	CDF	$H^0 \rightarrow WW^{(*)}$
none 100–113	95	[2] AALTONEN	13L	CDF	$H^0 \rightarrow \gamma\gamma$, WW^*, ZZ^*
none 100–116	95	[3] AALTONEN	13M	TEVA	$H^0 \rightarrow \gamma\gamma$, WW^*, ZZ^*
		[4] ABAZOV	13G	D0	$H^0 \rightarrow WW^{(*)}$
none 100–113	95	[5] ABAZOV	13H	D0	$H^0 \rightarrow \gamma\gamma$
		[6] ABAZOV	13I	D0	$H^0 \rightarrow WW^{(*)}$
		[7] ABAZOV	13J	D0	$H^0 \rightarrow WW^{(*)}$, $ZZ^{(*)}$
none 100–114	95	[8] ABAZOV	13L	D0	$H^0 \rightarrow \gamma\gamma$, WW^*, ZZ^*

none 110–147	95	[9] CHATRCHYAN	13AL	CMS	$H^0 \to \gamma\gamma$
none 110–118, 119.5–121	95	[10] AAD	12N	ATLS	$H^0 \to \gamma\gamma$
none 100–114	95	[11] AALTONEN	12AN	CDF	$H^0 \to \gamma\gamma$
none 110–194	95	[12] CHATRCHYAN	12AO	CMS	$H^0 \to \gamma\gamma$, $WW^{(*)}$, $ZZ^{(*)}$
none 70–106	95	[13] AALTONEN	09AB	CDF	$H^0 \to \gamma\gamma$
none 70–100	95	[14] ABAZOV	08U	D0	$H^0 \to \gamma\gamma$
$>$105.8	95	[15] SCHAEL	07	ALEP	$e^+e^- \to H^0 Z$, $H^0 \to WW^*$
$>$104.1	95	[16,17] ABDALLAH	04L	DLPH	$e^+e^- \to H^0 Z$, $H^0 \to \gamma\gamma$
$>$107	95	[18] ACHARD	03C	L3	$H^0 \to WW^*$,ZZ^*, $\gamma\gamma$
$>$105.5	95	[16,19] ABBIENDI	02F	OPAL	$H^0 \to \gamma\gamma$
$>$105.4	95	[20] ACHARD	02C	L3	$H^0 \to \gamma\gamma$
none 60–82	95	[21] AFFOLDER	01H	CDF	$p\overline{p} \to H^0 W/Z$, $H^0 \to \gamma\gamma$
$>$ 94.9	95	[22] ACCIARRI	00S	L3	$e^+e^- \to H^0 Z$, $H^0 \to \gamma\gamma$
$>$100.7	95	[23] BARATE	00L	ALEP	$e^+e^- \to H^0 Z$, $H^0 \to \gamma\gamma$
$>$ 96.2	95	[24] ABBIENDI	99O	OPAL	$e^+e^- \to H^0 Z$, $H^0 \to \gamma\gamma$
$>$ 78.5	95	[25] ABBOTT	99B	D0	$p\overline{p} \to H^0 W/Z$, $H^0 \to \gamma\gamma$
		[26] ABREU	99P	DLPH	$e^+e^- \to H^0\gamma$ and/or $H^0 \to \gamma\gamma$

[1] AALTONEN 13K search for $H^0 \to WW^{(*)}$ in 9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (1.3–6.6) times the expected cross section is given in the range m_{H^0} = 110–200 GeV at 95% CL.

[2] AALTONEN 13L combine all CDF searches with 9.45–10.0 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV.

[3] AALTONEN 13M combine all Tevatron data from the CDF and D0 Collaborations of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV.

[4] ABAZOV 13G search for $H^0 \to WW^{(*)}$ in 9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (2–9) times the expected cross section is given for m_{H^0} = 100–200 GeV at 95% CL.

[5] ABAZOV 13H search for $H^0 \to \gamma\gamma$ in 9.6 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV.

[6] ABAZOV 13I search for H^0 production in the final state with one lepton and two or more jets plus missing E_T in 9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. The search is sensitive to WH^0, ZH^0 and vector-boson fusion Higgs production with $H^0 \to WW^{(*)}$. A limit on cross section times branching ratio which corresponds to (8–30) times the expected cross section is given in the range m_{H^0} = 100–200 GeV at 95% CL.

[7] ABAZOV 13J search for H^0 production in the final states $ee\mu$, $e\mu\mu$, $\mu\tau\tau$, and $e^{\pm}\mu^{\pm}$ in 8.6–9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. The search is sensitive to WH^0, ZH^0 production with $H^0 \to WW^{(*)}$, $ZZ^{(*)}$, decaying to leptonic final states. A limit on cross section times branching ratio which corresponds to (2.4–13.0) times the expected cross section is given in the range m_{H^0} = 100–200 GeV at 95% CL.

[8] ABAZOV 13L combine all D0 results with up to 9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV.

[9] CHATRCHYAN 13AL search for $H^0 \to \gamma\gamma$ in 5.1 fb^{-1} and 5.3 fb^{-1} of pp collisions at E_{cm} = 7 and 8 TeV.

[10] AAD 12N search for $H^0 \to \gamma\gamma$ with 4.9 fb^{-1} of pp collisions at E_{cm} = 7 TeV in the mass range m_{H^0} = 110–150 GeV.

[11] AALTONEN 12AN search for $H^0 \to \gamma\gamma$ with 10 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV in the mass range m_{H^0} = 100–150 GeV.

[12] CHATRCHYAN 12AO use data from CHATRCHYAN 12G, CHATRCHYAN 12E, CHATRCHYAN 12H, CHATRCHYAN 12I, CHATRCHYAN 12D, and CHATRCHYAN 12C.

[13] AALTONEN 09AB search for $H^0 \to \gamma\gamma$ in 3.0 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV in the mass range m_{H^0} = 70–150 GeV. Associated $H^0 W$, $H^0 Z$ production and WW, ZZ fusion are considered.

[14] ABAZOV 08U search for $H^0 \to \gamma\gamma$ in $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV in the mass range m_{H^0} = 70–150 GeV. Associated $H^0 W$, $H^0 Z$ production and WW, ZZ fusion are considered. See their Tab. 1 for the limit on $\sigma \cdot$ B($H^0 \to \gamma\gamma$), and see their Fig. 3 for the excluded region in the m_{H^0} — B($H^0 \to \gamma\gamma$) plane.

[15] SCHAEL 07 search for Higgs bosons in association with a fermion pair and decaying to WW^*. The limit is from this search and HEISTER 02L for a H^0 with SM production cross section.

[16] Search for associated production of a $\gamma\gamma$ resonance with a Z boson, followed by $Z \to q\overline{q}$, $\ell^+\ell^-$, or $\nu\overline{\nu}$, at $E_{\rm cm} \leq$ 209 GeV. The limit is for a H^0 with SM production cross section.

[17] Updates ABREU 01F.

[18] ACHARD 03C search for $e^+e^- \to ZH^0$ followed by $H^0 \to WW^*$ or ZZ^* at $E_{\rm cm}$= 200-209 GeV and combine with the ACHARD 02C result. The limit is for a H^0 with SM production cross section. For B($H^0 \to WW^*$) + B($H^0 \to ZZ^*$) = 1, m$_{H^0}$ > 108.1 GeV is obtained. See fig. 6 for the limits under different BR assumptions.

[19] For B($H^0 \to \gamma\gamma$)=1, m_{H^0} >117 GeV is obtained.

[20] ACHARD 02C search for associated production of a $\gamma\gamma$ resonance with a Z boson, followed by $Z \to q\overline{q}$, $\ell^+\ell^-$, or $\nu\overline{\nu}$, at $E_{\rm cm} \leq$ 209 GeV. The limit is for a H^0 with SM production cross section. For B($H^0 \to \gamma\gamma$)=1, m_{H^0} >114 GeV is obtained.

[21] AFFOLDER 01H search for associated production of a $\gamma\gamma$ resonance and a W or Z (tagged by two jets, an isolated lepton, or missing E_T). The limit assumes Standard Model values for the production cross section and for the couplings of the H^0 to W and Z bosons. See their Fig. 11 for limits with B($H^0 \to \gamma\gamma$)< 1.

[22] ACCIARRI 00S search for associated production of a $\gamma\gamma$ resonance with a $q\overline{q}$, $\nu\overline{\nu}$, or $\ell^+\ell^-$ pair in e^+e^- collisions at $E_{\rm cm}$= 189 GeV. The limit is for a H^0 with SM production cross section. For B($H^0 \to \gamma\gamma$)=1, m_{H^0} > 98 GeV is obtained. See their Fig. 5 for limits on B($H \to \gamma\gamma$)$\cdot\sigma$($e^+e^- \to Hf\overline{f}$)/$\sigma$($e^+e^- \to Hf\overline{f}$) (SM).

[23] BARATE 00L search for associated production of a $\gamma\gamma$ resonance with a $q\overline{q}$, $\nu\overline{\nu}$, or $\ell^+\ell^-$ pair in e^+e^- collisions at $E_{\rm cm}$= 88–202 GeV. The limit is for a H^0 with SM production cross section. For B($H^0 \to \gamma\gamma$)=1, m_{H^0} > 109 GeV is obtained. See their Fig. 3 for limits on B($H \to \gamma\gamma$)$\cdot\sigma$($e^+e^- \to Hf\overline{f}$)/$\sigma$($e^+e^- \to Hf\overline{f}$) (SM).

[24] ABBIENDI 99O search for associated production of a $\gamma\gamma$ resonance with a $q\overline{q}$, $\nu\overline{\nu}$, or $\ell^+\ell^-$ pair in e^+e^- collisions at 189 GeV. The limit is for a H^0 with SM production cross section. See their Fig. 4 for limits on σ($e^+e^- \to H^0 Z^0$)$\times$B($H^0 \to \gamma\gamma$)$\times$B($X^0 \to f\overline{f}$) for various masses. Updates the results of ACKERSTAFF 98Y.

[25] ABBOTT 99B search for associated production of a $\gamma\gamma$ resonance and a dijet pair. The limit assumes Standard Model values for the production cross section and for the couplings of the H^0 to W and Z bosons. Limits in the range of σ(H^0+Z/W)$\cdot$B($H^0 \to \gamma\gamma$)= 0.80–0.34 pb are obtained in the mass range m_{H^0}= 65–150 GeV.

[26] ABREU 99P search for $e^+e^- \to H^0\gamma$ with $H^0 \to b\overline{b}$ or $\gamma\gamma$, and $e^+e^- \to H^0 q\overline{q}$ with $H^0 \to \gamma\gamma$. See their Fig. 4 for limits on $\sigma\times$B. Explicit limits within an effective interaction framework are also given.

Mass Limits for H^0 Decaying to Invisible Final States

These limits are for a neutral scalar H^0 which predominantly decays to invisible final states. Standard Model values are assumed for the couplings of H^0 to ordinary particles unless otherwise stated.

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] AAD	14BA	ATLS	secondary vertex
		[2] AAD	14O	ATLS	$pp \to H^0 Z X$
		[3] CHATRCHYAN	14B	CMS	$pp \to H^0 Z X$, $q q H^0 X$
		[4] AAD	13AG	ATLS	secondary vertex
		[5] AAD	13AT	ATLS	electron jets
		[6] CHATRCHYAN	13BJ	CMS	
		[7] AAD	12AQ	ATLS	secondary vertex
		[8] AALTONEN	12AB	CDF	secondary vertex
		[9] AALTONEN	12U	CDF	secondary vertex
>108.2	95	[10] ABBIENDI	10	OPAL	
		[11] ABBIENDI	07	OPAL	large width
>112.3	95	[12] ACHARD	05	L3	
>112.1	95	[12] ABDALLAH	04B	DLPH	
>114.1	95	[12] HEISTER	02	ALEP	$E_{cm} \leq 209$ GeV
>106.4	95	[12] BARATE	01C	ALEP	$E_{cm} \leq 202$ GeV
> 89.2	95	[13] ACCIARRI	00M	L3	

[1] AAD 14BA search for H^0 production in the decay mode $H^0 \to X^0 X^0$, where X^0 is a long-lived particle which decays to collimated pairs of $e^+ e^-$, $\mu^+ \mu^-$, or $\pi^+ \pi^-$ plus invisible particles, in 20.3 fb^{-1} of pp collisions at $E_{cm} = 8$ TeV. See their Figs. 15 and 16 for limits on cross section times branching ratio.

[2] AAD 14O search for $pp \to H^0 Z X$, $Z \to \ell\ell$, with H^0 decaying to invisible final states in 4.5 fb^{-1} at $E_{cm} = 7$ TeV and 20.3 fb^{-1} at $E_{cm} = 8$ TeV. See their Fig. 3 for a limit on the cross section times branching ratio for $m_{H^0} = 110$–400 GeV.

[3] CHATRCHYAN 14B search for $pp \to H^0 Z X$, $Z \to \ell\ell$ and $Z \to b\overline{b}$, and also $pp \to q q H^0 X$ with H^0 decaying to invisible final states using data at $E_{cm} = 7$ and 8 TeV. See their Figs. 10, 11 for limits on the cross section times branching ratio for $m_{H^0} =$ 100–400 GeV.

[4] AAD 13AG search for H^0 production in the decay mode $H^0 \to X^0 X^0$, where X^0 is a long-lived particle which decays to $\mu^+ \mu^- X'^0$, in 1.9 fb^{-1} of pp collisions at $E_{cm} = 7$ TeV. See their Fig. 7 for limits on cross section times branching ratio.

[5] AAD 13AT search for H^0 production in the decay $H^0 \to X^0 X^0$, where X^0 eventually decays to clusters of collimated $e^+ e^-$ pairs, in 2.04 fb^{-1} of pp collisions at $E_{cm} = 7$ TeV. See their Fig. 3 for limits on cross section times branching ratio.

[6] CHATRCHYAN 13BJ search for H^0 production in the decay chain $H^0 \to X^0 X^0$, $X^0 \to \mu^+ \mu^- X'^0$ in 5.3 fb^{-1} of pp collisions at $E_{cm} = 7$ TeV. See their Fig. 2 for limits on cross section times branching ratio.

[7] AAD 12AQ search for H^0 production in the decay mode $H^0 \to X^0 X^0$, where X^0 is a long-lived particle which decays mainly to $b\overline{b}$ in the muon detector, in 1.94 fb^{-1} of pp collisions at $E_{cm} = 7$ TeV. See their Fig. 3 for limits on cross section times branching ratio for $m_{H^0} = 120$, 140 GeV, $m_{X^0} = 20$, 40 GeV in the $c\tau$ range of 0.5–35 m.

[8] AALTONEN 12AB search for H^0 production in the decay $H^0 \to X^0 X^0$, where X^0 eventually decays to clusters of collimated $\ell^+ \ell^-$ pairs, in 5.1 fb^{-1} of $p\overline{p}$ collisions at $E_{cm} = 1.96$ TeV. Cross section limits are provided for a benchmark MSSM model incorporating the parameters given in Table VI.

[9] AALTONEN 12U search for H^0 production in the decay mode $H^0 \rightarrow X^0 X^0$, where X^0 is a long-lived particle with $c\tau \approx 1$ cm which decays mainly to $b\overline{b}$, in 3.2 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. See their Figs. 9 and 10 for limits on cross section times branching ratio for m_{H^0} = (130–170) GeV, m_{X^0} = 20, 40 GeV.

[10] ABBIENDI 10 search for $e^+ e^- \rightarrow H^0 Z$ with H^0 decaying invisibly. The limit assumes SM production cross section and B($H^0 \rightarrow$ invisible) = 1.

[11] ABBIENDI 07 search for $e^+ e^- \rightarrow H^0 Z$ with $Z \rightarrow q\overline{q}$ and H^0 decaying to invisible final states. The H^0 width is varied between 1 GeV and 3 TeV. A limit $\sigma \cdot$B($H^0 \rightarrow$ invisible) < (0.07–0.57) pb (95%CL) is obtained at E_{cm} = 206 GeV for m_{H^0} = 60–114 GeV.

[12] Search for $e^+ e^- \rightarrow H^0 Z$ with H^0 decaying invisibly. The limit assumes SM production cross section and B($H^0 \rightarrow$ invisible) = 1.

[13] ACCIARRI 00M search for $e^+ e^- \rightarrow Z H^0$ with H^0 decaying invisibly at E_{cm}=183–189 GeV. The limit assumes SM production cross section and B($H^0 \rightarrow$ invisible)=1. See their Fig. 6 for limits for smaller branching ratios.

Mass Limits for Light A^0

These limits are for a pseudoscalar A^0 in the mass range below $\mathcal{O}(10)$ GeV.

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] LEES	13C	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
		[2] LEES	13L	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
		[3] LEES	13R	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
		[4] CHATRCHYAN	12V	CMS	$A^0 \rightarrow \mu^+ \mu^-$
		[5] AALTONEN	11P	CDF	$t \rightarrow b H^+$, $H^+ \rightarrow W^+ A^0$
		[6,7] ABOUZAID	11A	KTEV	$K_L \rightarrow \pi^0 \pi^0 A^0$, $A^0 \rightarrow \mu^+ \mu^-$
		[8] DEL-AMO-SA...	11J	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
		[9] LEES	11H	BABR	$\Upsilon(2S, 3S) \rightarrow A^0 \gamma$
		[10] ANDREAS	10	RVUE	
		[7,11] HYUN	10	BELL	$B^0 \rightarrow K^{*0} A^0$, $A^0 \rightarrow \mu^+ \mu^-$
		[7,12] HYUN	10	BELL	$B^0 \rightarrow \rho^0 A^0$, $A^0 \rightarrow \mu^+ \mu^-$
		[13] AUBERT	09P	BABR	$\Upsilon(3S) \rightarrow A^0 \gamma$
		[14] AUBERT	09Z	BABR	$\Upsilon(2S) \rightarrow A^0 \gamma$
		[15] AUBERT	09Z	BABR	$\Upsilon(3S) \rightarrow A^0 \gamma$
		[7,16] TUNG	09	K391	$K_L \rightarrow \pi^0 \pi^0 A^0$, $A^0 \rightarrow \gamma\gamma$
		[17] LOVE	08	CLEO	$\Upsilon(1S) \rightarrow A^0 \gamma$
		[18] BESSON	07	CLEO	$\Upsilon(1S) \rightarrow \eta_b \gamma$
		[19] PARK	05	HYCP	$\Sigma^+ \rightarrow p A^0$, $A^0 \rightarrow \mu^+ \mu^-$
$<1.5 \times 10^{-5}$	90	[20] BALEST	95	CLE2	$\Upsilon(1S) \rightarrow A^0 \gamma$, $m_{A^0} < 5$ GeV
$<5.6 \times 10^{-5}$	90	[21] ANTREASYAN	90C	CBAL	$\Upsilon(1S) \rightarrow A^0 \gamma$, $m_{A^0} < 7.2$ GeV

[1] LEES 13C search for the process Υ(2S, 3S)$\rightarrow \Upsilon(1S) \pi^+ \pi^- \rightarrow A^0 \gamma \pi^+ \pi^-$ with A^0 decaying to $\mu^+ \mu^-$ and give limits on B($\Upsilon(1S) \rightarrow A^0 \gamma$)$\cdot$B($A^0 \rightarrow \mu^+ \mu^-$) in the range (0.3–9.7) $\times 10^{-6}$ (90% CL) for 0.212 $\leq m_{A^0} \leq$ 9.20 GeV. See their Fig. 5(e) for limits on the $b-A^0$ Yukawa coupling derived by combining this result with AUBERT 09Z.

[2] LEES 13L search for the process $\Upsilon(2S) \rightarrow \Upsilon(1S) \pi^+ \pi^- \rightarrow A^0 \gamma \pi^+ \pi^-$ with A^0 decaying to $g g$ or $s\overline{s}$ and give limits on B($\Upsilon(1S) \rightarrow A^0 \gamma$)$\cdot$B($A^0 \rightarrow g g$) between 10^{-6} and 10^{-2} (90% CL) for 0.5 $\leq m_{A^0} \leq$ 9.0 GeV, and B($\Upsilon(1S) \rightarrow A^0 \gamma$)$\cdot$B($A^0 \rightarrow s\overline{s}$) between 10^{-5} and 10^{-3} (90%CL) for 1.5 $\leq m_{A^0} \leq$ 9.0 GeV.

[3] LEES 13R search for the process $\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^- \rightarrow A^0\gamma\pi^+\pi^-$ with A^0 decaying to $\tau^+\tau^-$ and give limits on B($\Upsilon(1S) \rightarrow A^0\gamma$)·B($A^0 \rightarrow \tau^+\tau^-$) in the range 0.9–13 $\times 10^{-5}$ (90% CL) for 3.6 $\leq m_{A^0} \leq$ 9.2 GeV. See their Fig. 4 for limits on the $b - A^0$ Yukawa coupling derived by combining this result with AUBERT 09P.

[4] CHATRCHYAN 12V search for A^0 production in the decay $A^0 \rightarrow \mu^+\mu^-$ with 1.3 fb^{-1} of pp collisions at E_{cm} = 7 TeV. A limit on $\sigma(A^0)$·B($A^0 \rightarrow \mu^+\mu^-$) in the range (1.5–7.5) pb is given for m_{A^0} = (5.5–8.7) and (11.5–14) GeV at 95% CL.

[5] AALTONEN 11P search in 2.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV for the decay chain $t \rightarrow bH^+$, $H^+ \rightarrow W^+A^0$, $A^0 \rightarrow \tau^+\tau^-$ with m_{A^0} between 4 and 9 GeV. See their Fig. 4 for limits on B($t \rightarrow bH^+$) for 90 $< m_{H^+} <$ 160 GeV.

[6] ABOUZAID 11A search for the decay chain $K_L \rightarrow \pi^0\pi^0A^0$, $A^0 \rightarrow \mu^+\mu^-$ and give a limit B($K_L \rightarrow \pi^0\pi^0A^0$) · B($A^0 \rightarrow \mu^+\mu^-$) $<$ 1.0 $\times 10^{-10}$ at 90% CL for m_{A^0} = 214.3 MeV.

[7] The search was motivated by PARK 05.

[8] DEL-AMO-SANCHEZ 11J search for the process $\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^- \rightarrow A^0\gamma\pi^+\pi^-$ with A^0 decaying to invisible final states. They give limits on B($\Upsilon(1S) \rightarrow A^0\gamma$)·B($A^0 \rightarrow$ invisible) in the range (1.9–4.5) $\times 10^{-6}$ (90% CL) for 0 $\leq m_{A^0} \leq$ 8.0 GeV, and (2.7–37) $\times 10^{-6}$ for 8.0 $\leq m_{A^0} \leq$ 9.2 GeV.

[9] LEES 11H search for the process $\Upsilon(2S, 3S) \rightarrow A^0\gamma$ with A^0 decaying hadronically and give limits on B($\Upsilon(2S, 3S) \rightarrow A^0\gamma$)·B($A^0 \rightarrow$ hadrons) in the range 1×10^{-6}–8×10^{-5} (90% CL) for 0.3 $< m_{A^0} <$ 7 GeV. The decay rates for $\Upsilon(2S)$ and $\Upsilon(3S)$ are assumed to be equal up to the phase space factor.

[10] ANDREAS 10 analyze constraints from rare decays and other processes on a light A^0 with $m_{A^0} < 2m_\mu$ and give limits on its coupling to fermions at the level of 10^{-4} times the Standard Model value.

[11] HYUN 10 search for the decay chain $B^0 \rightarrow K^{*0}A^0$, $A^0 \rightarrow \mu^+\mu^-$ and give a limit on B($B^0 \rightarrow K^{*0}A^0$) · B($A^0 \rightarrow \mu^+\mu^-$) in the range (2.26–5.53) $\times 10^{-8}$ at 90%CL for m_{A^0} = 212–300 MeV. The limit for m_{A^0} = 214.3 MeV is 2.26 $\times 10^{-8}$.

[12] HYUN 10 search for the decay chain $B^0 \rightarrow \rho^0A^0$, $A^0 \rightarrow \mu^+\mu^-$ and give a limit on B($B^0 \rightarrow \rho^0A^0$) · B($A^0 \rightarrow \mu^+\mu^-$) in the range (1.73–4.51) $\times 10^{-8}$ at 90%CL for m_{A^0} = 212–300 MeV. The limit for m_{A^0} = 214.3 MeV is 1.73 $\times 10^{-8}$.

[13] AUBERT 09P search for the process $\Upsilon(3S) \rightarrow A^0\gamma$ with $A^0 \rightarrow \tau^+\tau^-$ for 4.03 $< m_{A^0} <$ 9.52 and 9.61 $< m_{A^0} <$ 10.10 GeV, and give limits on B($\Upsilon(3S) \rightarrow A^0\gamma$)·B($A^0 \rightarrow \tau^+\tau^-$) in the range (1.5–16) $\times 10^{-5}$ (90% CL).

[14] AUBERT 09Z search for the process $\Upsilon(2S) \rightarrow A^0\gamma$ with $A^0 \rightarrow \mu^+\mu^-$ for 0.212 $< m_{A^0} <$ 9.3 GeV and give limits on B($\Upsilon(2S) \rightarrow A^0\gamma$)·B($A^0 \rightarrow \mu^+\mu^-$) in the range (0.3–8) $\times 10^{-6}$ (90% CL).

[15] AUBERT 09Z search for the process $\Upsilon(3S) \rightarrow A^0\gamma$ with $A^0 \rightarrow \mu^+\mu^-$ for 0.212 $< m_{A^0} <$ 9.3 GeV and give limits on B($\Upsilon(3S) \rightarrow A^0\gamma$)·B($A^0 \rightarrow \mu^+\mu^-$) in the range (0.3–5) $\times 10^{-6}$ (90% CL).

[16] TUNG 09 search for the decay chain $K_L \rightarrow \pi^0\pi^0A^0$, $A^0 \rightarrow \gamma\gamma$ and give a limit on B($K_L \rightarrow \pi^0\pi^0A^0$) · B($A^0 \rightarrow \gamma\gamma$) in the range (2.4–10.7) $\times 10^{-7}$ at 90%CL for m_{A^0} = 194.3–219.3 MeV. The limit for m_{A^0} = 214.3 MeV is 2.4 $\times 10^{-7}$.

[17] LOVE 08 search for the process $\Upsilon(1S) \rightarrow A^0\gamma$ with $A^0 \rightarrow \mu^+\mu^-$ (for $m_{A^0} < 2m_\tau$) and $A^0 \rightarrow \tau^+\tau^-$. Limits on B($\Upsilon(1S) \rightarrow A^0\gamma$) · B($A^0 \rightarrow \ell^+\ell^-$) in the range 10^{-6}–10^{-4} (90% CL) are given.

[18] BESSON 07 give a limit $B(\Upsilon(1S) \rightarrow \eta_b \gamma) \cdot B(\eta_b \rightarrow \tau^+ \tau^-) < 0.27\%$ (95% CL), which constrains a possible A^0 exchange contribution to the η_b decay.

[19] PARK 05 found three candidate events for $\Sigma^+ \rightarrow p \mu^+ \mu^-$ in the HyperCP experiment. Due to a narrow spread in dimuon mass, they hypothesize the events as a possible signal of a new boson. It can be interpreted as a neutral particle with $m_{A^0} = 214.3 \pm 0.5$ MeV and the branching fraction $B(\Sigma^+ \rightarrow p A^0) \cdot B(A^0 \rightarrow \mu^+ \mu^-) = (3.1^{+2.4}_{-1.9} \pm 1.5) \times 10^{-8}$.

[20] BALEST 95 two-body limit is for pseudoscalar A^0. The limit becomes $< 10^{-4}$ for $m_{A^0} < 7.7$ GeV.

[21] ANTREASYAN 90C assume that A^0 does not decay in the detector.

Other Mass Limits

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] AAD	14AP	ATLS	$H^0 \rightarrow \gamma\gamma$
		[2] AAD	14M	ATLS	$H^0_2 \rightarrow H^\pm W^\mp \rightarrow H^0 W^\pm W^\mp$, $H^0 \rightarrow b\overline{b}$
		[3] CHATRCHYAN	14G	CMS	$H^0 \rightarrow W W^{(*)}$
		[4] KHACHATRY...	14P	CMS	$H^0 \rightarrow \gamma\gamma$
		[5] AALTONEN	13P	CDF	$H'^0 \rightarrow H^\pm W^\mp \rightarrow H^0 W^+ W^-$
		[6] CHATRCHYAN	13BJ	CMS	$H^0 \rightarrow A^0 A^0$
		[7] AALTONEN	11P	CDF	$t \rightarrow b H^+$, $H^+ \rightarrow W^+ A^0$
		[8] ABBIENDI	10	OPAL	$H^0 \rightarrow \widetilde{\chi}^0_1 \widetilde{\chi}^0_2$
		[9] SCHAEL	10	ALEP	$H^0 \rightarrow A^0 A^0$
		[10] ABAZOV	09V	D0	$H^0 \rightarrow A^0 A^0$
none 3–63	95	[11] ABBIENDI	05A	OPAL	A^0, Type II model
>104	95	[12] ABBIENDI	04K	OPAL	$H^0 \rightarrow$ 2 jets
		[13] ABDALLAH	04	DLPH	$H^0 V V$ couplings
>110.3	95	[14] ACHARD	04B	L3	$H^0 \rightarrow$ 2 jets
		[15] ACHARD	04F	L3	Anomalous coupling
		[16] ABBIENDI	03F	OPAL	$e^+ e^- \rightarrow H^0 Z$, $H^0 \rightarrow$ any
		[17] ABBIENDI	03G	OPAL	$H^0_1 \rightarrow A^0 A^0$
>105.4	95	[18,19] HEISTER	02L	ALEP	$H^0_1 \rightarrow \gamma\gamma$
>109.1	95	[20] HEISTER	02M	ALEP	$H^0 \rightarrow$ 2 jets or $\tau^+ \tau^-$
none 12–56	95	[21] ABBIENDI	01E	OPAL	A^0, Type-II model
		[22] ACCIARRI	00R	L3	$e^+ e^- \rightarrow H^0 \gamma$ and/or $H^0 \rightarrow \gamma\gamma$
		[23] ACCIARRI	00R	L3	$e^+ e^- \rightarrow e^+ e^- H^0$
		[24] GONZALEZ-G..	98B	RVUE	Anomalous coupling
		[25] KRAWCZYK	97	RVUE	$(g-2)_\mu$
		[26] ALEXANDER	96H	OPAL	$Z \rightarrow H^0 \gamma$

[1] AAD 14AP search for a second H^0 state decaying to $\gamma\gamma$ in addition to the state at about 125 GeV in 20.3 fb^{-1} of pp collisions at $E_{cm} = 8$ TeV. See their Fig. 4 for limits on cross section times branching ratio for $m_{H^0} = 65$–600 GeV.

[2] AAD 14M search for the decay cascade $H^0_2 \rightarrow H^\pm W^\mp \rightarrow H^0 W^\pm W^\mp$, H^0 decaying to $b\overline{b}$ in 20.3 fb^{-1} of pp collisions at $E_{cm} = 8$ TeV. See their Table III for limits on cross section times branching ratio for $m_{H^0_2} = 325$–1025 GeV and $m_{H^+} = 225$–925 GeV.

[3] CHATRCHYAN 14G search for a second H^0 state decaying to $W W^{(*)}$ in addition to the observed signal at about 125 GeV using 4.9 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and 19.4 fb^{-1} at $E_{\rm cm}$ = 8 TeV. See their Fig. 21 (right) for cross section limits in the mass range 110–600 GeV.

[4] KHACHATRYAN 14P search for a second H^0 state decaying to $\gamma\gamma$ in addition to the observed signal at about 125 GeV using 5.1 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and 19.7 fb^{-1} at $E_{\rm cm}$ = 8 TeV. See their Figs. 27 and 28 for cross section limits in the mass range 110–150 GeV.

[5] AALTONEN 13P search for production of a heavy Higgs boson H'^0 that decays into a charged Higgs boson $H^\pm$ and a lighter Higgs boson H^0 via the decay chain $H'^0 \rightarrow H^\pm W^\mp$, $H^\pm \rightarrow W^\pm H^0$, $H^0 \rightarrow b\overline{b}$ in the final state $\ell\nu$ plus 4 jets in 8.7 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. See their Fig. 4 for limits on cross section times branching ratio in the $m_{H^\pm} - m_{H'^0}$ plane for m_{H^0} = 126 GeV.

[6] CHATRCHYAN 13BJ search for H^0 production in the decay chain $H^0 \rightarrow A^0 A^0$, $A^0 \rightarrow \mu^+\mu^-$ in 5.3 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. See their Fig. 2 for limits on cross section times branching ratio.

[7] AALTONEN 11P search in 2.7 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV for the decay chain $t \rightarrow bH^+$, $H^+ \rightarrow W^+ A^0$, $A^0 \rightarrow \tau^+\tau^-$ with m_{A^0} between 4 and 9 GeV. See their Fig. 4 for limits on B($t \rightarrow bH^+$) for $90 < m_{H^+} < 160$ GeV.

[8] ABBIENDI 10 search for $e^+e^- \rightarrow ZH^0$ with the decay chain $H^0 \rightarrow \widetilde{\chi}^0_1 \widetilde{\chi}^0_2$, $\widetilde{\chi}^0_2 \rightarrow \widetilde{\chi}^0_1 + (\gamma$ or $Z^*)$, when $\widetilde{\chi}^0_1$ and $\widetilde{\chi}^0_2$ are nearly degenerate. For a mass difference of 2 (4) GeV, a lower limit on m_{H^0} of 108.4 (107.0) GeV (95% CL) is obtained for SM ZH^0 cross section and B($H^0 \rightarrow \widetilde{\chi}^0_1 \widetilde{\chi}^0_2$) = 1.

[9] SCHAEL 10 search for the process $e^+e^- \rightarrow H^0 Z$ followed by the decay chain $H^0 \rightarrow A^0 A^0 \rightarrow \tau^+\tau^-\tau^+\tau^-$ with $Z \rightarrow \ell^+\ell^-$, $\nu\overline{\nu}$ at $E_{\rm cm}$ = 183–209 GeV. For a $H^0 ZZ$ coupling equal to the SM value, B($H^0 \rightarrow A^0 A^0$) = B($A^0 \rightarrow \tau^+\tau^-$) = 1, and m_{A^0} = 4–10 GeV, m_{H^0} up to 107 GeV is excluded at 95% CL.

[10] ABAZOV 09V search for H^0 production followed by the decay chain $H^0 \rightarrow A^0 A^0 \rightarrow \mu^+\mu^-\mu^+\mu^-$ or $\mu^+\mu^-\tau^+\tau^-$ in 4.2 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. See their Fig. 3 for limits on $\sigma(H^0)\cdot$B($H^0 \rightarrow A^0 A^0$) for m_{A^0} = 3.6–19 GeV.

[11] ABBIENDI 05A search for $e^+e^- \rightarrow H^0_1 A^0$ in general Type-II two-doublet models, with decays H^0_1, $A^0 \rightarrow q\overline{q}$, gg, $\tau^+\tau^-$, and $H^0_1 \rightarrow A^0 A^0$.

[12] ABBIENDI 04K search for $e^+e^- \rightarrow H^0 Z$ with H^0 decaying to two jets of any flavor including gg. The limit is for SM production cross section with B($H^0 \rightarrow jj$) = 1.

[13] ABDALLAH 04 consider the full combined LEP and LEP2 datasets to set limits on the Higgs coupling to W or Z bosons, assuming SM decays of the Higgs. Results in Fig. 26.

[14] ACHARD 04B search for $e^+e^- \rightarrow H^0 Z$ with H^0 decaying to $b\overline{b}$, $c\overline{c}$, or gg. The limit is for SM production cross section with B($H^0 \rightarrow jj$) = 1.

[15] ACHARD 04F search for H^0 with anomalous coupling to gauge boson pairs in the processes $e^+e^- \rightarrow H^0\gamma$, $e^+e^- H^0$, $H^0 Z$ with decays $H^0 \rightarrow f\overline{f}$, $\gamma\gamma$, $Z\gamma$, and $W^* W$ at $E_{\rm cm}$ = 189–209 GeV. See paper for limits.

[16] ABBIENDI 03F search for $H^0 \rightarrow$ anything in $e^+e^- \rightarrow H^0 Z$, using the recoil mass spectrum of $Z \rightarrow e^+e^-$ or $\mu^+\mu^-$. In addition, it searched for $Z \rightarrow \nu\overline{\nu}$ and $H^0 \rightarrow e^+e^-$ or photons. Scenarios with large width or continuum H^0 mass distribution are considered. See their Figs. 11–14 for the results.

[17] ABBIENDI 03G search for $e^+e^- \rightarrow H^0_1 Z$ followed by $H^0_1 \rightarrow A^0 A^0$, $A^0 \rightarrow c\overline{c}$, gg, or $\tau^+\tau^-$ in the region $m_{H^0_1}$ = 45-86 GeV and m_{A^0} = 2-11 GeV. See their Fig. 7 for the limits.

[18] Search for associated production of a $\gamma\gamma$ resonance with a Z boson, followed by $Z \to q\overline{q}$, $\ell^+\ell^-$, or $\nu\overline{\nu}$, at $E_{cm} \leq 209$ GeV. The limit is for a H^0 with SM production cross section and B($H^0 \to f\overline{f}$)=0 for all fermions f.

[19] For B($H^0 \to \gamma\gamma$)=1, $m_{H^0} > 113.1$ GeV is obtained.

[20] HEISTER 02M search for $e^+e^- \to H^0 Z$, assuming that H^0 decays to $q\overline{q}$, gg, or $\tau^+\tau^-$ only. The limit assumes SM production cross section.

[21] ABBIENDI 01E search for neutral Higgs bosons in general Type-II two-doublet models, at $E_{cm} \leq 189$ GeV. In addition to usual final states, the decays H^0_1, $A^0 \to q\overline{q}$, gg are searched for. See their Figs. 15,16 for excluded regions.

[22] ACCIARRI 00R search for $e^+e^- \to H^0\gamma$ with $H^0 \to b\overline{b}$, $Z\gamma$, or $\gamma\gamma$. See their Fig. 3 for limits on $\sigma \cdot$B. Explicit limits within an effective interaction framework are also given, for which the Standard Model Higgs search results are used in addition.

[23] ACCIARRI 00R search for the two-photon type processes $e^+e^- \to e^+e^- H^0$ with $H^0 \to b\overline{b}$ or $\gamma\gamma$. See their Fig. 4 for limits on $\Gamma(H^0 \to \gamma\gamma)\cdot$B($H^0 \to \gamma\gamma$or $b\overline{b}$) for m_{H^0}=70–170 GeV.

[24] GONZALEZ-GARCIA 98B use DØ limit for $\gamma\gamma$ events with missing E_T in $p\overline{p}$ collisions (ABBOTT 98) to constrain possible ZH or WH production followed by unconventional $H \to \gamma\gamma$ decay which is induced by higher-dimensional operators. See their Figs. 1 and 2 for limits on the anomalous couplings.

[25] KRAWCZYK 97 analyse the muon anomalous magnetic moment in a two-doublet Higgs model (with type II Yukawa couplings) assuming no $H^0_1 ZZ$ coupling and obtain $m_{H^0_1} \gtrsim 5$ GeV or $m_{A^0} \gtrsim 5$ GeV for $\tan\beta > 50$. Other Higgs bosons are assumed to be much heavier.

[26] ALEXANDER 96H give B($Z \to H^0\gamma$)$\times$B($H^0 \to q\overline{q}$) < 1–4×10^{-5} (95%CL) and B($Z \to H^0\gamma$)$\times$B($H^0 \to b\overline{b}$) < 0.7–2×10^{-5} (95%CL) in the range $20 < m_{H^0} < 80$ GeV.

SEARCHES FOR A HIGGS BOSON WITH STANDARD MODEL COUPLINGS

These listings are based on experimental searches for a scalar boson whose couplings to W, Z and fermions are precisely those of the Higgs boson predicted by the three-generation Standard Model with the minimal Higgs sector.

For a review and a bibliography, see the review on "Status of Higgs Boson Physics."

Direct Mass Limits for H^0

The mass limits shown below apply to a Higgs boson H^0 with Standard Model couplings whose mass is a priori unknown. These mass limits are compatible with and independent of the observed signal at about 125 GeV. In particular, the symbol H^0 employed below does not in general refer to the observed signal at about 125 GeV.

The cross section times branching ratio limits quoted in the footnotes below are typically given relative to those of a Standard Model Higgs boson of the relevant mass. These limits can be reinterpreted in terms of more general models (e.g. extended Higgs sectors) in which the Higgs couplings to W, Z and fermions are re-scaled from their Standard Model values.

All data that have been superseded by newer results are marked as "not used" or have been removed from this compilation, and are documented in previous editions of this *Review* of Particle Physics.

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
> 122 and none 128–710 (CL = 95%)					
none 90–102, 149–172	95	[1] AALTONEN	13L	CDF	$pp \to H^0 X$, combined
none 90–109, 149–182	95	[2] AALTONEN	13M	TEVA	Tevatron combined
none 90–101, 157–178	95	[3] ABAZOV	13L	D0	$p\overline{p} \to H^0 X$, combined
none 145–710	95	[4] CHATRCHYAN	13Q	CMS	$pp \to H^0 X$ combined
none 110–121.5, 128–145	95	[5] CHATRCHYAN	12N	CMS	$pp \to H^0 X$ combined
>114.1	95	[6] ABDALLAH	04	DLPH	$e^+ e^- \to H^0 Z$
>112.7	95	[6] ABBIENDI	03B	OPAL	$e^+ e^- \to H^0 Z$
>114.4	95	[6,7] HEISTER	03D	LEP	$e^+ e^- \to H^0 Z$
>111.5	95	[6,8] HEISTER	02	ALEP	$e^+ e^- \to H^0 Z$
>112.0	95	[6] ACHARD	01C	L3	$e^+ e^- \to H^0 Z$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[9] AAD	15G	ATLS	$pp \to H^0 W/Z X$, $H^0 \to b\overline{b}$
		[10] AAD	14AS	ATLS	$pp \to H^0 X$, $H^0 \to \mu\mu$
		[11] AAD	14J	ATLS	$pp \to H^0 X$, $H^0 \to Z\gamma$
none 114.5–119, 129.5–832	95	[12] CHATRCHYAN	14AA	CMS	$pp \to H^0 X$, $H^0 \to 4\ell$
		[13] CHATRCHYAN	14AI	CMS	$pp \to H^0 W/Z X$, $H^0 \to b\overline{b}$
none 127–600	95	[14] CHATRCHYAN	14G	CMS	$pp \to H^0 X$, $H^0 \to WW^{(*)}$
		[15] AALTONEN	13B	CDF	$p\overline{p} \to H^0 W/Z X$, $H^0 \to b\overline{b}$
		[16] AALTONEN	13C	CDF	$p\overline{p} \to H^0 X$, $H^0 \to b\overline{b}$
none 149–172	95	[17] AALTONEN	13K	CDF	$p\overline{p} \to H^0 X$, $H^0 \to WW^{(*)}$
		[18] ABAZOV	13E	D0	$p\overline{p} \to H^0 X$, 4ℓ
		[19] ABAZOV	13F	D0	$p\overline{p} \to H^0 X$, $\ell\tau jj$
none 159–176	95	[20] ABAZOV	13G	D0	$p\overline{p} \to H^0 X$, $H^0 \to WW^{(*)}$
		[21] ABAZOV	13H	D0	$p\overline{p} \to H^0 X$, $H^0 \to \gamma\gamma$
		[22] ABAZOV	13I	D0	$p\overline{p} \to H^0 X$, $\ell\nu jj$
		[23] ABAZOV	13J	D0	$p\overline{p} \to H^0 X$, leptonic
		[24] ABAZOV	13K	D0	$p\overline{p} \to H^0 Z X$
		[25] CHATRCHYAN	13AL	CMS	$pp \to H^0 X$, $H^0 \to \tau\tau$, $WW^{(*)}$, $ZZ^{(*)}$
		[26] CHATRCHYAN	13BK	CMS	$pp \to H^0 X$, $H^0 \to Z\gamma$
		[27] CHATRCHYAN	13X	CMS	$pp \to H^0 t\overline{t} X$
none 113–122, 128–133, 138–149	95	[28] CHATRCHYAN	13Y	CMS	$pp \to H^0 X$, $H^0 \to \gamma\gamma$
none 130–164, 170–180	95	[29] CHATRCHYAN	13Y	CMS	$pp \to H^0 X$, $H^0 \to ZZ^*$
none 129–160	95	[30] CHATRCHYAN	13Y	CMS	$pp \to H^0 X$, $H^0 \to WW^*$
none 111–122, 131–559	95	[31] AAD	12AI	ATLS	$pp \to H^0 X$ combined
none 133–261	95	[32] AAD	12AJ	ATLS	$pp \to H^0 X$, $H^0 \to WW^{(*)}$
		[33] AAD	12BU	ATLS	$pp \to H^0 X$, $H^0 \to \tau^+\tau^-$
none 319–558	95	[34] AAD	12BZ	ATLS	$pp \to H^0 X$, $H^0 \to ZZ$

none 300–322, 353–410	95	[35] AAD	12CA	ATLS	$p p \to H^0 X$, $H^0 \to Z Z$
		[36] AAD	12CN	ATLS	$p p \to H^0 W/Z X$, $H^0 \to b\overline{b}$
		[37] AAD	12CO	ATLS	$p p \to H^0 X$, $H^0 \to W W$
none 134–156, 182–233, 256–265, 268–415	95	[38] AAD	12D	ATLS	$p p \to H^0 X$, $H^0 \to Z Z^{(*)}$
none 113–115, 134.5–136	95	[39] AAD	12G	ATLS	$p p \to H^0 X$, $H^0 \to \gamma\gamma$
		[40] AALTONEN	12AK	CDF	$p\overline{p} \to H^0 t\overline{t} X$
		[41] AALTONEN	12AM	CDF	$p\overline{p} \to H^0 X$, inclusive 4ℓ
		[42] AALTONEN	12AN	CDF	$p\overline{p} \to H^0 X$, $H^0 \to \gamma\gamma$
		[43] AALTONEN	12J	CDF	$p\overline{p} \to H^0 X$, $H^0 \to \tau\tau$
		[44] AALTONEN	12Q	CDF	$p\overline{p} \to H^0 Z X$, $H^0 \to b\overline{b}$
none 100–106	95	[45] AALTONEN	12T	TEVA	$p\overline{p} \to H^0 W/Z X$, $H^0 \to b\overline{b}$
		[46] ABAZOV	12K	D0	$p\overline{p} \to H^0 W/Z X$, $H^0 \to b\overline{b}$
		[47,48] CHATRCHYAN	12AY	CMS	$p p \to H^0 W X$, $H^0 Z X$
		[49] CHATRCHYAN	12C	CMS	$p p \to H^0 X$, $H^0 \to Z Z$
		[50] CHATRCHYAN	12D	CMS	$p p \to H^0 X$, $H^0 \to Z Z^{(*)}$
none 129–270	95	[51] CHATRCHYAN	12E	CMS	$p p \to H^0 X$, $H^0 \to W W^{(*)}$
		[52] CHATRCHYAN	12F	CMS	$p p \to H^0 W X$, $H^0 Z X$
none 128–132	95	[53] CHATRCHYAN	12G	CMS	$p p \to H^0 X$, $H^0 \to \gamma\gamma$
none 134–158, 180–305, 340–465	95	[54] CHATRCHYAN	12H	CMS	$p p \to H^0 X$, $H^0 \to Z Z^{(*)}$
none 270–440	95	[55] CHATRCHYAN	12I	CMS	$p p \to H^0 X$, $H^0 \to Z Z$
		[56] CHATRCHYAN	12K	CMS	$p p \to H^0 X$, $H^0 \to \tau^+\tau^-$
		[57] ABAZOV	11G	D0	$p\overline{p} \to H^0 X$, $H^0 \to W W^{(*)}$
		[58] CHATRCHYAN	11J	CMS	$p p \to H^0 X$, $H^0 \to W W$
none 162–166	95	[59] AALTONEN	10F	TEVA	$p\overline{p} \to H^0 X$, $H^0 \to W W^{(*)}$
		[60] AALTONEN	10M	TEVA	$p\overline{p} \to g g X \to H^0 X$, $H^0 \to W W^{(*)}$
		[61] AALTONEN	09A	CDF	$p\overline{p} \to H^0 X$, $H^0 \to W W^{(*)}$
		[62] ABAZOV	09U	D0	$H^0 \to \tau^+\tau^-$
		[63] ABAZOV	06	D0	$p\overline{p} \to H^0 X$, $H^0 \to W W^*$
		[64] ABAZOV	06O	D0	$p\overline{p} \to H^0 W X$, $H^0 \to W W^*$

[1] AALTONEN 13L combine all CDF searches with 9.45–10.0 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (0.45–4.8) times the expected Standard Model cross section is given for m_{H^0} = 90–200 GeV at 95 %CL. An excess of events over background is observed with a local significance of 2.0 σ at m_{H^0} = 125 GeV. In the Standard Model with an additional generation of heavy quarks and leptons which receive their masses via the Higgs mechanism, m_{H^0} values between 124 and 203 GeV are excluded at 95% CL.

[2] AALTONEN 13M combine all Tevatron data from the CDF and D0 Collaborations. A limit on cross section times branching ratio which corresponds to (0.37–3.1) times the expected Standard Model cross section is given for m_{H^0} = 90–200 GeV at 95% CL. An excess of events over background is observed with a local significance of 3.0σ at m_{H^0} = 125 GeV. In the Standard Model with an additional generation of heavy quarks and leptons which receive their masses via the Higgs mechanism, m_{H^0} values between 121 and 225 GeV are excluded at 95% CL.

[3] ABAZOV 13L combine all D0 results with up to 9.7 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (0.66–3.1) times the expected Standard Model cross section is given in the range m_{H^0} = 90–200 GeV at 95% CL. An excess of events over background is observed with a local significance of 1.7σ at m_{H^0} = 125 GeV. In the Standard Model with an additional generation of heavy quarks and leptons which receive their masses via the Higgs mechanism, m_{H^0} values between 125 and 218 GeV are excluded at 95% CL.

[4] CHATRCHYAN 13Q search for H^0 production in the decays $H \rightarrow W^+ W^- \rightarrow \ell\nu\ell\nu$, $\ell\nu q q$ and $H \rightarrow ZZ \rightarrow 4\ell$, $\ell\ell\tau\tau$, $\ell\ell\nu\nu$, and $\ell\ell q q$ in up to 5.1 fb^{-1} of pp collisions at $E_{\rm cm}$=7 TeV and up to 5.3 fb^{-1} at $E_{\rm cm}$=8 TeV in the range m_{H^0} = 145–1000 GeV.

[5] CHATRCHYAN 12N search for H^0 production in the decays $H \rightarrow \gamma\gamma$, $ZZ^* \rightarrow 4\ell$, $WW^* \rightarrow \ell\nu\ell\nu$, $\tau\tau$, and $b\overline{b}$ in 4.9–5.1 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and 5.1–5.3 fb^{-1} at $E_{\rm cm}$ = 8 TeV. The expected exclusion region for no signal is 110–145 GeV at 99.9% CL. See also CHATRCHYAN 13Y.

[6] Search for $e^+ e^- \rightarrow H^0 Z$ at $E_{\rm cm} \leq$ 209 GeV in the final states $H^0 \rightarrow b\overline{b}$ with $Z \rightarrow \ell\overline{\ell}$, $\nu\overline{\nu}$, $q\overline{q}$, $\tau^+\tau^-$ and $H^0 \rightarrow \tau^+\tau^-$ with $Z \rightarrow q\overline{q}$.

[7] Combination of the results of all LEP experiments.

[8] A 3σ excess of candidate events compatible with m_{H^0} near 114 GeV is observed in the combined channels $q\overline{q}q\overline{q}$, $q\overline{q}\ell\overline{\ell}$, $q\overline{q}\tau^+\tau^-$.

[9] AAD 15G search for WH^0 and ZH^0 production followed by $H^0 \rightarrow b\overline{b}$ in 4.7 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and 20.3 fb^{-1} at $E_{\rm cm}$ = 8 TeV. A limit on the cross section times branching ratio which corresponds to (0.8–2.6) times the expected Standard Model cross section is given for m_{H^0} = 110–140 GeV at 95% CL.

[10] AAD 14AS search for $H^0 \rightarrow \mu^+\mu^-$ in 4.5 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and 20.3 fb^{-1} at $E_{\rm cm}$ = 8 TeV. A limit on the cross section times branching ratio which corresponds to (6.5–16.8) times the expected Standard Model cross section is given for m_{H^0} = 120–150 GeV at 95% CL.

[11] AAD 14J search for $H^0 \rightarrow Z\gamma \rightarrow \ell\ell\gamma$ in 4.5 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and 20.3 fb^{-1} at $E_{\rm cm}$ = 8 TeV. A limit on cross section times branching ratio which corresponds to (4–18) times the expected Standard Model cross section is given for m_{H^0} = 120–150 GeV at 95% CL.

[12] CHATRCHYAN 14AA search for H^0 production in the decay mode $H^0 \rightarrow ZZ^{(*)} \rightarrow 4\ell$ in 5.1 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and 19.7 fb^{-1} at $E_{\rm cm}$ = 8 TeV. The expected exclusion region for no signal is 115–740 GeV at the 95% CL. See their Fig. 18 for cross section limits for m_{H^0} = 110–1000 GeV.

[13] CHATRCHYAN 14AI search for WH^0 and ZH^0 production followed by $H^0 \rightarrow b\overline{b}$ in up to 5.1 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and up to 18.9 fb^{-1} at $E_{\rm cm}$ = 8 TeV. A limit on the cross section times branching ratio which corresponds to (1–3) times the expected Standard Model cross section is given for m_{H^0} = 110–135 GeV at 95% CL.

[14] CHATRCHYAN 14G search for H^0 production in the decay mode $H^0 \rightarrow WW^{(*)} \rightarrow \ell\nu\ell\nu$ in 4.9 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV and 19.4 fb^{-1} at $E_{\rm cm}$ = 8 TeV. The expected exclusion region for no signal is 115–600 GeV at the 95% CL. See their Fig. 21 (left) for cross section limits for m_{H^0} = 110–600 GeV.

[15] AALTONEN 13B search for associated $H^0 Z$ production in the final state $H^0 \rightarrow b\overline{b}$, $Z \rightarrow \nu\overline{\nu}$, and $H^0 W$ production in $H^0 \rightarrow b\overline{b}$, $W \rightarrow \ell\nu$ (ℓ not identified) with an improved b identification algorithm in 9.45 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (0.72–11.8) times the expected Standard Model cross section is given for m_{H^0} = 90–150 GeV at 95%CL. The limit for m_{H^0} = 125 GeV is 3.06, where 3.33 is expected for no signal.

[16] AALTONEN 13C search for associated $H^0 W$ and $H^0 Z$ as well as vector-boson fusion $H^0 q \overline{q}'$ production in the final state $H^0 \rightarrow b\overline{b}$, $W/Z \rightarrow q\overline{q}$ with 9.45 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. A limit on cross section times branching ratio which is (7.0–64.6) times larger than the expected Standard Model cross section is given in the range m_{H^0} = 100–150 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 9.0, where 11.0 is expected for no signal.

[17] AALTONEN 13K search for H^0 production (with a possible additional W or Z) in the final state $H^0 \rightarrow W W^{(*)} \rightarrow \ell\nu\ell\nu$ in 9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (0.49–14.1) times the expected Standard Model cross section is given in the range m_{H^0} = 110–200 GeV at 95% CL. The limit at m_{H^0} = 125 GeV is 3.26, where 3.25 is expected for no signal. In the Standard Model with an additional generation of heavy quarks and leptons which receive their masses via the Higgs mechanism, m_{H^0} values between 124 and 200 GeV are excluded at 95% CL.

[18] ABAZOV 13E search for H^0 production in four-lepton final states from $H^0 \rightarrow Z Z^{(*)}$ and $H^0 Z$ in 9.6–9.8 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (8.6–78.9) times the expected Standard Model cross section is given in the range m_{H^0} = 115–200 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 42.3, where 42.8 is expected for no signal.

[19] ABAZOV 13F search for H^0 production in final states $e\tau jj$ and $\mu\tau jj$ in 9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. The search is sensitive to $H \rightarrow \tau\tau$ and $H \rightarrow W W^{(*)}$. A limit on cross section times branching ratio which corresponds to (9.4–17.9) times the expected Standard Model cross section is given in the range m_{H^0} = 105–150 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 11.3, where 9.0 is expected for no signal.

[20] ABAZOV 13G search for H^0 production in final states $H^0 \rightarrow W W^{(*)} \rightarrow \ell^+ \nu \ell^- \nu$ in 9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV and give a limit on cross section times branching ratio for m_{H^0} = 100–150 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 4.1, where 3.4 is expected for no signal. In the Standard Model with an additional generation of heavy quarks and leptons which receive their masses via the Higgs mechanism, m_{H^0} values between 125 and 218 GeV are excluded at 95% CL.

[21] ABAZOV 13H search for H^0 production with the decay $H^0 \rightarrow \gamma\gamma$ in 9.6 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (8.3–25.4) times the expected Standard Model cross section is given in the range m_{H^0} = 100–150 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 12.8, where 8.7 is expected for no signal.

[22] ABAZOV 13I search for H^0 production in the final state with one lepton and two or more jets plus missing E_T with b identification in 9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. The search is mainly sensitive to $H^0 W \rightarrow b\overline{b}\ell\nu$, $H^0 \rightarrow W W^{(*)} \rightarrow \ell\nu q\overline{q}$, and $H^0 V \rightarrow V W W^{(*)} \rightarrow \ell\nu q\overline{q} q\overline{q}$ ($V = W$, Z). A limit on cross section times branching ratio which corresponds to (1.3–11.4) times the expected Standard Model cross section is given in the range m_{H^0} = 90–200 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 5.8, where 4.7 is expected for no signal. In the Standard Model with an additional generation of heavy quarks and leptons which receive their masses via the Higgs mechanism, m_{H^0} values between 150 and 188 GeV are excluded at 95% CL.

[23] ABAZOV 13J search for H^0 production in the final states $ee\mu$, $e\mu\mu$, $\mu\tau\tau$, and $e^{\pm}\mu^{\pm}$ in 8.6–9.7 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. The search is sensitive to $W H^0$, $Z H^0$ and gluon fusion production with $H^0 \rightarrow W W^{(*)}$, $Z Z^{(*)}$, decaying to leptonic final states, and to $W H^0$, $Z H^0$ production with $H^0 \rightarrow \tau^+\tau^-$. A limit on cross section times branching ratio which corresponds to (4.4–12.7) times the expected Standard Model cross section is given in the range m_{H^0} = 100–200 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 8.4, where 6.3 is expected for no signal.

[24] ABAZOV 13K search for associated $H^0 Z$ production in the final states $\ell\ell b b$ with b identification in 9.7 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (1.8–53) times the expected Standard Model cross section is given for m_{H^0} = 90–150 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 7.1, where 5.1 is expected for no signal.

[25] CHATRCHYAN 13AL search for $H^0 \rightarrow \tau^+\tau^-$, $W W^{(*)}$, and $Z Z^{(*)}$ in 5.1 fb^{-1} and 5.3 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 and 8 TeV. In the Standard Model with an additional generation of heavy quarks and leptons which receive their masses via the Higgs mechanism, m_{H^0} values between 110 and 600 GeV are excluded at 99% CL.

[26] CHATRCHYAN 13BK search for $H^0 \rightarrow Z\gamma \rightarrow \ell\ell\gamma$ in 5.0 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 TeV and 19.6 fb^{-1} at $E_{\rm cm}$ = 8 TeV. A limit on cross section times branching ratio which corresponds to (4–25) times the expected Standard Model cross section is given in the range m_{H^0} = 120–160 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 9.5, where 10 is expected for no signal.

[27] CHATRCHYAN 13X search for $H^0 t\overline{t}$ production followed by $H^0 \rightarrow b\overline{b}$, one top decaying to $\ell\nu$ and the other to either $\ell\nu$ or $q\overline{q}$ in 5.0 fb^{-1} and 5.1 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 and 8 TeV. A limit on cross section times branching ratio which corresponds to (4.0–8.6) times the expected Standard Model cross section is given for m_{H^0} = 110–140 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 5.8, where 5.2 is expected for no signal.

[28] CHATRCHYAN 13Y search for H^0 production in the decay $H \rightarrow \gamma\gamma$ in 5.1 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 TeV and 5.3 fb^{-1} at $E_{\rm cm}$ = 8 TeV. The expected exclusion region for no signal is 110–144 GeV at 95% CL.

[29] CHATRCHYAN 13Y search for H^0 production in the decay $H \rightarrow Z Z^* \rightarrow 4\ell$ in 5.0 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 TeV and 5.3 fb^{-1} at $E_{\rm cm}$ = 8 TeV. The expected exclusion region for no signal is 120–180 GeV at 95% CL.

[30] CHATRCHYAN 13Y search for H^0 production in the decay $H \rightarrow W W^* \rightarrow \ell\nu\ell\nu$ in 4.9 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 TeV and 5.3 fb^{-1} at $E_{\rm cm}$ = 8 TeV. The expected exclusion region for no signal is 122–160 GeV at 95% CL.

[31] AAD 12AI search for H^0 production in $p p$ collisions for the final states $H^0 \rightarrow Z Z^{(*)}$, $\gamma\gamma$, $W W^{(*)}$, $b\overline{b}$, $\tau\tau$ with 4.6–4.8 fb^{-1} at $E_{\rm cm}$ = 7 TeV, and $H^0 \rightarrow Z Z^{(*)} \rightarrow 4\ell$, $\gamma\gamma$, $W W^{(*)} \rightarrow e\nu\mu\nu$ with 5.8–5.9 fb^{-1} at $E_{\rm cm}$ = 8 TeV. The 99% CL excluded range is 113–114, 117–121, and 132–527 GeV. An excess of events over background with a local significance of 5.9 σ is observed at m_{H^0} = 126 GeV.

[32] AAD 12AJ search for H^0 production in the decay $H^0 \rightarrow W W^{(*)} \rightarrow \ell\nu\ell\nu$ with 4.7 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which corresponds to (0.2–10) times the expected Standard Model cross section is given for m_{H^0} = 110–600 GeV at 95% CL.

[33] AAD 12BU search for H^0 production in the decay $H \rightarrow \tau^+\tau^-$ with 4.7 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which is (2.9–11.7) times larger than the expected Standard Model cross section is given for m_{H^0} = 100–150 GeV at 95% CL.

[34] AAD 12BZ search for H^0 production in the decay $H \rightarrow Z Z \rightarrow \ell^+\ell^-\nu\overline{\nu}$ with 4.7 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which corresponds to (0.2–4) times the expected Standard Model cross section is given for m_{H^0} = 200–600 GeV at 95% CL.

[35] AAD 12CA search for H^0 production in the decay $H \rightarrow Z Z \rightarrow \ell^+\ell^- q\overline{q}$ with 4.7 fb^{-1} of $p p$ collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which corresponds to (0.7–9) times the expected Standard Model cross section is given for m_{H^0} = 200–600 GeV at 95% CL.

[36] AAD 12CN search for associated $H^0 W$ and $H^0 Z$ production in the channels $W \rightarrow \ell\nu$, $Z \rightarrow \ell^+\ell^-$, $\nu\overline{\nu}$, and $H^0 \rightarrow b\overline{b}$, with 4.7 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which is (2.5–5.5) times larger than the expected Standard Model cross section is given for m_{H^0} = 110–130 GeV at 95% CL.

[37] AAD 12CO search for H^0 production in the decay $H \rightarrow WW \rightarrow \ell\nu q\overline{q}$ with 4.7 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which is (1.9–10) times larger than the expected Standard Model cross section is given for m_{H^0} = 300–600 GeV at 95% CL.

[38] AAD 12D search for H^0 production with $H \rightarrow ZZ^{(*)} \rightarrow 4\ell$ in 4.8 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV in the mass range m_{H^0} = 110–600 GeV. An excess of events over background with a local significance of 2.1 σ is observed at 125 GeV.

[39] AAD 12G search for H^0 production with $H \rightarrow \gamma\gamma$ in 4.9 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV in the mass range m_{H^0} = 110–150 GeV. An excess of events over background with a local significance of 2.8 σ is observed at 126.5 GeV.

[40] AALTONEN 12AK search for associated $H^0 t\overline{t}$ production in the decay chain $t\overline{t} \rightarrow WWbb \rightarrow \ell\nu qqbb$ with 9.45 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which is (10–40) times larger than the expected Standard Model cross section is given for m_{H^0} = 100–150 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 20.5, where 12.6 is expected.

[41] AALTONEN 12AM search for H^0 production in inclusive four-lepton final states coming from $H^0 \rightarrow ZZ$, $H^0 Z \rightarrow WW^{(*)}\ell\ell$, or $H^0 Z \rightarrow \tau\tau\ell\ell$, with 9.7 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which is (7.2–42.4) times larger than the expected Standard Model cross section is given for m_{H^0} = 120–300 GeV at 95% CL. The best limit is for m_{H^0} = 200 GeV.

[42] AALTONEN 12AN search for H^0 production in the decay $H^0 \rightarrow \gamma\gamma$ with 10 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which is (7.7–21.3) times larger than the expected Standard Model cross section is given for m_{H^0} = 100–150 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 17.0, where 9.9 is expected.

[43] AALTONEN 12J search for H^0 production in the decay $H^0 \rightarrow \tau^+\tau^-$ (one leptonic, the other hadronic) with 6.0 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which is (14.6–70.2) times larger than the expected Standard Model cross section is given for m_{H^0} = 100–150 GeV at 95% CL. The best limit is for m_{H^0} = 120 GeV.

[44] AALTONEN 12Q search for associated $H^0 Z$ production in the final state $H^0 \rightarrow b\overline{b}$, $Z \rightarrow \ell^+\ell^-$ with 9.45 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which corresponds to (1.0–37.5) times the expected Standard Model cross section is given for m_{H^0} = 90–150 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 7.1, where 3.9 is expected. A broad excess of events for m_{H^0} > 110 GeV is observed, with a local significance of 2.4 σ at m_{H^0} = 135 GeV.

[45] AALTONEN 12T combine AALTONEN 12Q, AALTONEN 12R, AALTONEN 12S, ABAZOV 12O, ABAZOV 12P, and ABAZOV 12K. An excess of events over background is observed which is most significant in the region m_{H^0} = 120–135 GeV, with a local significance of up to 3.3 σ. The local significance at m_{H^0} = 125 GeV is 2.8 σ, which corresponds to $(\sigma(H^0 W) + \sigma(H^0 Z))\ {\rm B}(H^0 \rightarrow b\overline{b})) = (0.23^{+0.09}_{-0.08})$ pb, compared to the Standard Model expectation at m_{H^0} = 125 GeV of 0.12 ± 0.01 pb.

[46] ABAZOV 12K search for associated $H^0 Z$ production in the final state $H^0 \rightarrow b\overline{b}$, $Z \rightarrow \nu\overline{\nu}$, and $H^0 W$ production with $W \rightarrow \ell\nu$ (ℓ not identified) with 9.5 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV. A limit on cross section times branching ratio which is (1.9–16.8) times larger than the expected Standard Model cross section is given for m_{H^0} = 100–150 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 4.3, where 3.9 is expected.

[47] CHATRCHYAN 12AY search for associated $H^0 W$ and $H^0 Z$ production in the channels $W \rightarrow \ell\nu$, $Z \rightarrow \ell^+\ell^-$, and $H^0 \rightarrow \tau\tau$, $W W^{(*)}$, with 5 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which is (3.1–9.1) times larger than the expected Standard Model cross section is given for m_{H^0} = 110–200 GeV at 95% CL.

[48] CHATRCHYAN 12AY combine CHATRCHYAN 12F and CHATRCHYAN 12AO in addition and give a limit on cross section times branching ratio which is (2.1–3.7) times larger than the expected Standard Model cross section for m_{H^0} = 110–170 GeV at 95% CL. The limit for m_{H^0} = 125 GeV is 3.3.

[49] CHATRCHYAN 12C search for H^0 production with $H \rightarrow ZZ \rightarrow \ell^+\ell^-\tau^+\tau^-$ in 4.7 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which is (4–12) times larger than the expected Standard Model cross section is given for m_{H^0} = 190–600 GeV at 95% CL. The best limit is at m_{H^0} = 200 GeV.

[50] CHATRCHYAN 12D search for H^0 production with $H \rightarrow ZZ^{(*)} \rightarrow \ell^+\ell^- q\overline{q}$ in 4.6 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which corresponds to (1–22) times the expected Standard Model cross section is given for m_{H^0} = 130–164 GeV, 200–600 GeV at 95% CL. The best limit is at m_{H^0} = 230 GeV. In the Standard Model with an additional generation of heavy quarks and leptons which receive their masses via the Higgs mechanism, m_{H^0} values in the ranges m_{H^0} = 154–161 GeV and 200–470 GeV are excluded at 95% CL.

[51] CHATRCHYAN 12E search for H^0 production with $H \rightarrow W W^{(*)} \rightarrow \ell^+\nu\ell^-\overline{\nu}$ in 4.6 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV in the mass range m_{H^0} = 110–600 GeV.

[52] CHATRCHYAN 12F search for associated $H^0 W$ and $H^0 Z$ production followed by $W \rightarrow \ell\nu$, $Z \rightarrow \ell^+\ell^-$, $\nu\overline{\nu}$, and $H^0 \rightarrow b\overline{b}$, in 4.7 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which is (3.1–9.0) times larger than the expected Standard Model cross section is given for m_{H^0} = 110–135 GeV at 95% CL. The best limit is at m_{H^0} = 110 GeV.

[53] CHATRCHYAN 12G search for H^0 production with $H \rightarrow \gamma\gamma$ in 4.8 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV in the mass range m_{H^0} = 110–150 GeV. An excess of events over background with a local significance of 3.1 σ is observed at 124 GeV.

[54] CHATRCHYAN 12H search for H^0 production with $H \rightarrow ZZ^{(*)} \rightarrow 4\ell$ in 4.7 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV in the mass range m_{H^0} = 110–600 GeV. Excesses of events over background are observed around 119, 126 and 320 GeV. The region m_{H^0} = 114.4–134 GeV remains consistent with the expectation for the production of a SM-like Higgs boson.

[55] CHATRCHYAN 12I search for H^0 production with $H \rightarrow ZZ \rightarrow \ell^+\ell^-\nu\overline{\nu}$ in 4.6 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV in the mass range m_{H^0} = 250–600 GeV.

[56] CHATRCHYAN 12K search for H^0 production in the decay $H \rightarrow \tau^+\tau^-$ with 4.6 fb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. A limit on cross section times branching ratio which is (3.2–7.0) times larger than the expected Standard Model cross section is given for m_{H^0} = 110–145 GeV at 95% CL.

[57] ABAZOV 11G search for H^0 production in 5.4 fb^{-1} of $p\overline{p}$ collisions at $E_{\rm cm}$ = 1.96 TeV in the decay mode $H^0 \rightarrow W W^{(*)} \rightarrow \ell\nu q\overline{q}'$ (and processes with similar final states). A limit on cross section times branching ratio which is (3.9–37) times larger than the expected Standard Model cross section is given for m_{H^0} = 115–200 GeV at 95% CL. The best limit is at m_{H^0} = 160 GeV.

[58] CHATRCHYAN 11J search for H^0 production with $H \rightarrow W^+W^- \rightarrow \ell\ell\nu\nu$ in 36 pb^{-1} of pp collisions at $E_{\rm cm}$ = 7 TeV. See their Fig. 6 for a limit on cross section times branching ratio for m_{H^0} = 120–600 GeV at 95% CL. In the Standard Model with an additional generation of heavy quarks and leptons which receive their masses via the Higgs mechanism, m_{H^0} values between 144 and 207 GeV are excluded at 95% CL.

[59] AALTONEN 10F combine searches for H^0 decaying to $W^+ W^-$ in $p\overline{p}$ collisions at E_{cm} = 1.96 TeV with 4.8 fb^{-1} (CDF) and 5.4 fb^{-1} (DØ).

[60] AALTONEN 10M combine searches for H^0 decaying to $W^+ W^-$ in $p\overline{p}$ collisions at E_{cm} = 1.96 TeV with 4.8 fb^{-1} (CDF) and 5.4 fb^{-1} (DØ) and derive limits $\sigma(p\overline{p} \rightarrow H^0)\cdot$ B($H^0 \rightarrow W^+ W^-$) $<$ (1.75–0.38) pb for m_H = 120–165 GeV, where H^0 is produced in gg fusion. In the Standard Model with an additional generation of heavy quarks, m_{H^0} between 131 and 204 GeV is excluded at 95% CL.

[61] AALTONEN 09A search for H^0 production in $p\overline{p}$ collisions at E_{cm} =1.96 TeV in the decay mode $H^0 \rightarrow WW^{(*)} \rightarrow \ell^+ \ell^- \nu\overline{\nu}$. A limit on $\sigma(H^0)$ · B($H^0 \rightarrow WW^{(*)}$) between 0.7 and 2.5 pb (95% CL) is given for m_{H^0} = 110–200 GeV, which is 1.7–45 times larger than the expected Standard Model cross section. The best limit is obtained for m_{H^0} = 160 GeV.

[62] ABAZOV 09U search for $H^0 \rightarrow \tau^+ \tau^-$ with $\tau \rightarrow$ hadrons in 1 fb^{-1} of $p\overline{p}$ collisions at E_{cm} = 1.96 TeV. The production mechanisms include associated W/Z+H^0 production, weak boson fusion, and gluon fusion. A limit (95% CL) is given for m_{H^0} = 105–145 GeV, which is 20–82 times larger than the expected Standard Model cross section. The limit for m_{H^0} = 115 GeV is 29 times larger than the expected Standard Model cross section.

[63] ABAZOV 06 search for Higgs boson production in $p\overline{p}$ collisions at E_{cm} = 1.96 TeV with the decay chain $H^0 \rightarrow WW^* \rightarrow \ell^\pm \nu \ell'^\mp \overline{\nu}$. A limit $\sigma(H^0)\cdot$B($H^0 \rightarrow WW^*$) $<$ (5.6–3.2) pb (95 %CL) is given for m_{H^0} = 120–200 GeV, which far exceeds the expected Standard Model cross section.

[64] ABAZOV 06O search for associated $H^0 W$ production in $p\overline{p}$ collisions at E_{cm} = 1.96 TeV with the decay $H^0 \rightarrow WW^*$, in the final states $\ell^\pm \ell'^\mp \nu\nu' X$ where $\ell = e, \mu$. A limit $\sigma(H^0 W)\cdot$ B($H^0 \rightarrow WW^*$) $<$ (3.2–2.8) pb (95 %CL) is given for m_{H^0} = 115–175 GeV, which far exceeds the expected Standard Model cross section.

Indirect Mass Limits for H^0 from Electroweak Analysis

The mass limits shown below apply to a Higgs boson H^0 with Standard Model couplings whose mass is a priori unknown.

For limits obtained before the direct measurement of the top quark mass, see the 1996 (Physical Review **D54** 1 (1996)) Edition of this Review. Other studies based on data available prior to 1996 can be found in the 1998 Edition (The European Physical Journal **C3** 1 (1998)) of this Review.

VALUE (GeV)	*DOCUMENT ID*		*TECN*
$\mathbf{94^{+25}_{-22}}$	[1] BAAK	12A	RVUE
• • • We do not use the following data for averages, fits, limits, etc. • • •			
91^{+30}_{-23}	[2] BAAK	12	RVUE
91^{+31}_{-24}	[3] ERLER	10A	RVUE
129^{+74}_{-49}	[4] LEP-SLC	06	RVUE

[1] BAAK 12A make Standard Model fits to Z and neutral current parameters, m_t, m_W, and Γ_W measurements available in 2012 (using also preliminary data). The quoted result is obtained from a fit that does not include the measured mass value of the signal observed at the LHC and also no limits from direct Higgs searches.

[2] BAAK 12 make Standard Model fits to Z and neutral current parameters, m_t, m_W, and Γ_W measurements available in 2010 (using also preliminary data). The quoted result is obtained from a fit that does not include the limit from the direct Higgs searches. The result including direct search data from LEP2, the Tevatron and the LHC is $120^{+12}_{-\ 5}$ GeV.

[3] ERLER 10A makes Standard Model fits to Z and neutral current parameters, m_t, m_W measurements available in 2009 (using also preliminary data). The quoted result is obtained from a fit that does not include the limits from the direct Higgs searches. With direct search data from LEP2 and Tevatron added to the fit, the 90% CL (99% CL) interval is 115–148 (114–197) GeV.

[4] LEP-SLC 06 make Standard Model fits to Z parameters from LEP/SLC and m_t, m_W, and Γ_W measurements available in 2005 with $\Delta\alpha^{(5)}_{\text{had}}(m_Z) = 0.02758 \pm 0.00035$. The 95% CL limit is 285 GeV.

SEARCHES FOR NEUTRAL HIGGS BOSONS REFERENCES

AAD	15G	JHEP 1501 069	G. Aad *et al.*	(ATLAS Collab.)
AAD	14AP	PRL 113 171801	G. Aad *et al.*	(ATLAS Collab.)
AAD	14AS	PL B738 68	G. Aad *et al.*	(ATLAS Collab.)
AAD	14AW	JHEP 1411 056	G. Aad *et al.*	(ATLAS Collab.)
AAD	14BA	JHEP 1411 088	G. Aad *et al.*	(ATLAS Collab.)
AAD	14J	PL B732 8	G. Aad *et al.*	(ATLAS Collab.)
AAD	14M	PR D89 032002	G. Aad *et al.*	(ATLAS Collab.)
AAD	14O	PRL 112 201802	G. Aad *et al.*	(ATLAS Collab.)
CHATRCHYAN	14AA	PR D89 092007	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14AI	PR D89 012003	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14B	EPJ C74 2980	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	14G	JHEP 1401 096	S. Chatrchyan *et al.*	(CMS Collab.)
KHACHATRY...	14M	JHEP 1410 160	V. Khachatryan *et al.*	(CMS Collab.)
KHACHATRY...	14P	EPJ C74 3076	V. Khachatryan *et al.*	(CMS Collab.)
KHACHATRY...	14Q	PR D90 112013	V. Khachatryan *et al.*	(CMS Collab.)
AAD	13AG	PL B721 32	G. Aad *et al.*	(ATLAS Collab.)
AAD	13AT	NJP 15 043009	G. Aad *et al.*	(ATLAS Collab.)
AAD	13O	JHEP 1302 095	G. Aad *et al.*	(ATLAS Collab.)
AAIJ	13T	JHEP 1305 132	R. Aaij *et al.*	(LHCb Collab.)
AALTONEN	13B	PR D87 052008	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13C	JHEP 1302 004	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13K	PR D88 052012	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13L	PR D88 052013	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	13M	PR D88 052014	T. Aaltonen *et al.*	(CDF and D0 Collab.)
AALTONEN	13P	PRL 110 121801	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	13E	PR D88 032008	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	13F	PR D88 052005	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	13G	PR D88 052006	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	13H	PR D88 052007	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	13I	PR D88 052008	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	13J	PR D88 052009	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	13K	PR D88 052010	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	13L	PR D88 052011	V.M. Abazov *et al.*	(D0 Collab.)
CARENA	13	EPJ C73 2552	M. Carena *et al.*	
CHATRCHYAN	13AG	PL B722 207	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13AL	PL B725 36	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13BJ	PL B726 564	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13BK	PL B726 587	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13Q	EPJ C73 2469	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13X	JHEP 1305 145	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	13Y	JHEP 1306 081	S. Chatrchyan *et al.*	(CMS Collab.)
LEES	13C	PR D87 031102	J.P. Lees *et al.*	(BABAR Collab.)
LEES	13L	PR D88 031701	J.P. Lees *et al.*	(BABAR Collab.)
LEES	13R	PR D88 071102	J.P. Lees *et al.*	(BABAR Collab.)
AAD	12AI	PL B716 1	G. Aad *et al.*	(ATLAS Collab.)

AAD	12AJ	PL B716 62	G. Aad *et al.*	(ATLAS Collab.)
AAD	12AQ	PRL 108 251801	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BU	JHEP 1209 070	G. Aad *et al.*	(ATLAS Collab.)
AAD	12BZ	PL B717 29	G. Aad *et al.*	(ATLAS Collab.)
AAD	12CA	PL B717 70	G. Aad *et al.*	(ATLAS Collab.)
AAD	12CN	PL B718 369	G. Aad *et al.*	(ATLAS Collab.)
AAD	12CO	PL B718 391	G. Aad *et al.*	(ATLAS Collab.)
AAD	12D	PL B710 383	G. Aad *et al.*	(ATLAS Collab.)
AAD	12G	PRL 108 111803	G. Aad *et al.*	(ATLAS Collab.)
AAD	12N	EPJ C72 2157	G. Aad *et al.*	(ATLAS Collab.)
AALTONEN	12AB	PR D85 092001	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12AK	PRL 109 181802	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12AM	PR D86 072012	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12AN	PL B717 173	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12AQ	PR D86 091101	T. Aaltonen *et al.*	(CDF and D0 Collabs.)
AALTONEN	12J	PRL 108 181804	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12Q	PRL 109 111803	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12R	PRL 109 111804	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12S	PRL 109 111805	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12T	PRL 109 071804	T. Aaltonen *et al.*	(CDF and D0 Collab.)
AALTONEN	12U	PR D85 012007	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	12X	PR D85 032005	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	12G	PL B710 569	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	12K	PL B716 285	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	12O	PRL 109 121803	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	12P	PRL 109 121804	V.M. Abazov *et al.*	(D0 Collab.)
BAAK	12	EPJ C72 2003	M. Baak *et al.*	(Gfitter Group)
BAAK	12A	EPJ C72 2205	M. Baak *et al.*	(Gfitter Group)
CHATRCHYAN	12AO	JHEP 1209 111	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12AY	JHEP 1211 088	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12C	JHEP 1203 081	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12D	JHEP 1204 036	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12E	PL B710 91	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12F	PL B710 284	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12G	PL B710 403	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12H	PRL 108 111804	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12I	JHEP 1203 040	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12K	PL B713 68	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12N	PL B716 30	S. Chatrchyan *et al.*	(CMS Collab.)
CHATRCHYAN	12V	PRL 109 121801	S. Chatrchyan *et al.*	(CMS Collab.)
AALTONEN	11P	PRL 107 031801	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	11G	PRL 106 171802	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11K	PL B698 97	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	11W	PRL 107 121801	V.M. Abazov *et al.*	(D0 Collab.)
ABOUZAID	11A	PRL 107 201803	E. Abouzaid *et al.*	(KTeV Collab.)
CHATRCHYAN	11J	PL B699 25	S. Chatrchyan *et al.*	(CMS Collab.)
DEL-AMO-SA...	11J	PRL 107 021804	P. del Amo Sanchez *et al.*	(BABAR Collab.)
LEES	11H	PRL 107 221803	J.P. Lees *et al.*	(BABAR Collab.)
AALTONEN	10F	PRL 104 061802	T. Aaltonen *et al.*	(CDF and D0 Collab.)
AALTONEN	10M	PR D82 011102	T. Aaltonen *et al.*	(CDF and D0 Collab.)
ABBIENDI	10	PL B682 381	G. Abbiendi *et al.*	(OPAL Collab.)
ANDREAS	10	JHEP 1008 003	S. Andreas *et al.*	(DESY)
ERLER	10A	PR D81 051301	J. Erler	(UNAM)
HYUN	10	PRL 105 091801	H.J. Hyun *et al.*	(BELLE Collab.)
SCHAEL	10	JHEP 1005 049	S. Schael *et al.*	(ALEPH Collab.)
AALTONEN	09A	PRL 102 021802	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09AB	PRL 103 061803	T. Aaltonen *et al.*	(CDF Collab.)
AALTONEN	09AR	PRL 103 201801	T. Aaltonen *et al.*	(CDF Collab.)
ABAZOV	09U	PRL 102 251801	V.M. Abazov *et al.*	(D0 Collab.)
ABAZOV	09V	PRL 103 061801	V.M. Abazov *et al.*	(D0 Collab.)
AUBERT	09P	PRL 103 181801	B. Aubert *et al.*	(BABAR Collab.)
AUBERT	09Z	PRL 103 081803	B. Aubert *et al.*	(BABAR Collab.)
TUNG	09	PRL 102 051802	Y.C. Tung *et al.*	(KEK E391a Collab.)
ABAZOV	08U	PRL 101 051801	V.M. Abazov *et al.*	(D0 Collab.)
ABDALLAH	08B	EPJ C54 1	J. Abdallah *et al.*	(DELPHI Collab.)
Also		EPJ C56 165 (errat)	J. Abdallah *et al.*	(DELPHI Collab.)
LOVE	08	PRL 101 151802	W. Love *et al.*	(CLEO Collab.)
ABBIENDI	07	EPJ C49 457	G. Abbiendi *et al.*	(OPAL Collab.)
BESSON	07	PRL 98 052002	D. Besson *et al.*	(CLEO Collab.)
SCHAEL	07	EPJ C49 439	S. Schael *et al.*	(ALEPH Collab.)
ABAZOV	06	PRL 96 011801	V.M. Abazov *et al.*	(D0 Collab.)

ABAZOV	06O	PRL 97 151804	V.M. Abazov *et al.*	(D0 Collab.)
LEP-SLC	06	PRPL 427 257	ALEPH, DELPHI, L3, OPAL, SLD and working groups	
SCHAEL	06B	EPJ C47 547	S. Schael *et al.*	(LEP Collabs.)
ABBIENDI	05A	EPJ C40 317	G. Abbiendi *et al.*	(OPAL Collab.)
ABDALLAH	05D	EPJ C44 147	J. Abdallah *et al.*	(DELPHI Collab.)
ACHARD	05	PL B609 35	P. Achard *et al.*	(L3 Collab.)
ACOSTA	05Q	PR D72 072004	D. Acosta *et al.*	(CDF Collab.)
PARK	05	PRL 94 021801	H.K. Park *et al.*	(FNAL HyperCP Collab.)
ABBIENDI	04K	PL B597 11	G. Abbiendi *et al.*	(OPAL Collab.)
ABBIENDI	04M	EPJ C37 49	G. Abbiendi *et al.*	(OPAL Collab.)
ABDALLAH	04	EPJ C32 145	J. Abdallah *et al.*	(DELPHI Collab.)
ABDALLAH	04B	EPJ C32 475	J. Abdallah *et al.*	(DELPHI Collab.)
ABDALLAH	04L	EPJ C35 313	J. Abdallah *et al.*	(DELPHI Collab.)
ABDALLAH	04O	EPJ C38 1	J. Abdallah *et al.*	(DELPHI Collab.)
ACHARD	04B	PL B583 14	P. Achard *et al.*	(L3 Collab.)
ACHARD	04F	PL B589 89	P. Achard *et al.*	(L3 Collab.)
ABBIENDI	03B	EPJ C26 479	G. Abbiendi *et al.*	(OPAL Collab.)
ABBIENDI	03F	EPJ C27 311	G. Abbiendi *et al.*	(OPAL Collab.)
ABBIENDI	03G	EPJ C27 483	G. Abbiendi *et al.*	(OPAL Collab.)
ACHARD	03C	PL B568 191	P. Achard *et al.*	(L3 Collab.)
CARENA	03	EPJ C26 601	M.S. Carena *et al.*	
HEISTER	03D	PL B565 61	A. Heister *et al.*	(ALEPH, DELPHI, L3+)
ALEPH, DELPHI, L3, OPAL, LEP Higgs Working Group				
ABBIENDI	02D	EPJ C23 397	G. Abbiendi *et al.*	(OPAL Collab.)
ABBIENDI	02F	PL B544 44	G. Abbiendi *et al.*	(OPAL Collab.)
ACHARD	02C	PL B534 28	P. Achard *et al.*	(L3 Collab.)
ACHARD	02H	PL B545 30	P. Achard *et al.*	(L3 Collab.)
AKEROYD	02	PR D66 037702	A.G. Akeroyd *et al.*	
HEISTER	02	PL B526 191	A. Heister *et al.*	(ALEPH Collab.)
HEISTER	02L	PL B544 16	A. Heister *et al.*	(ALEPH Collab.)
HEISTER	02M	PL B544 25	A. Heister *et al.*	(ALEPH Collab.)
ABBIENDI	01E	EPJ C18 425	G. Abbiendi *et al.*	(OPAL Collab.)
ABREU	01F	PL B507 89	P. Abreu *et al.*	(DELPHI Collab.)
ACHARD	01C	PL B517 319	P. Achard *et al.*	(L3 Collab.)
AFFOLDER	01H	PR D64 092002	T. Affolder *et al.*	(CDF Collab.)
BARATE	01C	PL B499 53	R. Barate *et al.*	(ALEPH Collab.)
ACCIARRI	00M	PL B485 85	M. Acciarri *et al.*	(L3 Collab.)
ACCIARRI	00R	PL B489 102	M. Acciarri *et al.*	(L3 Collab.)
ACCIARRI	00S	PL B489 115	M. Acciarri *et al.*	(L3 Collab.)
BARATE	00L	PL B487 241	R. Barate *et al.*	(ALEPH Collab.)
ABBIENDI	99E	EPJ C7 407	G. Abbiendi *et al.*	(OPAL Collab.)
ABBIENDI	99O	PL B464 311	G. Abbiendi *et al.*	(OPAL Collab.)
ABBOTT	99B	PRL 82 2244	B. Abbott *et al.*	(D0 Collab.)
ABREU	99P	PL B458 431	P. Abreu *et al.*	(DELPHI Collab.)
CARENA	99B	hep-ph/9912223	M.S. Carena *et al.*	
CERN-TH/99-374				
ABBOTT	98	PRL 80 442	B. Abbott *et al.*	(D0 Collab.)
ACKERSTAFF	98S	EPJ C5 19	K. Ackerstaff *et al.*	(OPAL Collab.)
ACKERSTAFF	98Y	PL B437 218	K. Ackerstaff *et al.*	(OPAL Collab.)
GONZALEZ-G...	98B	PR D57 7045	M.C. Gonzalez-Garcia, S.M. Lietti, S.F. Novaes	
PDG	98	EPJ C3 1	C. Caso *et al.*	(PDG Collab.)
KRAWCZYK	97	PR D55 6968	M. Krawczyk, J. Zochowski	(WARS)
ALEXANDER	96H	ZPHY C71 1	G. Alexander *et al.*	(OPAL Collab.)
PDG	96	PR D54 1	R. M. Barnett *et al.*	(PDG Collab.)
ABREU	95H	ZPHY C67 69	P. Abreu *et al.*	(DELPHI Collab.)
BALEST	95	PR D51 2053	R. Balest *et al.*	(CLEO Collab.)
PICH	92	NP B388 31	A. Pich, J. Prades, P. Yepes	(CERN, CPPM)
ANTREASYAN	90C	PL B251 204	D. Antreasyan *et al.*	(Crystal Ball Collab.)